ATRAD PTY LTD   ABN 72 112 121 801

ATRAD RADAR SYSTEM

Display and Analysis software reference manual

Software version 4.5

Document version 1.2

Table of Contents

1. INTRODUCTION

1.1 About This Manual

This manual is provided as a reference for the display and analysis software packages supplied with ATRAD radar systems. Many aspects of the material contained herein may be addressed more conveniently using the on-line manuals available with the software itself. The manner in which these help pages may be accessed is described in this manual. The user is encouraged to take advantage of the interactive and graphical nature of the software suites in order to further and reinforce their understanding of the way in which the software performs its tasks.

It should be noted that ATRAD's radar systems are very modular, and tend to be extensively adapted to meet the end-users' needs. This manual is intended to describe a super set of the functionality provided with the software for any given system. For this reason it is possible that some, or even many sections included in this manual are not applicable to the local radar system.

1.2 Typeface Conventions

The following typeface conventions are used throughout this manual:

Bold-italic is used for the names of executable programs.

Italics is used for internet addresses, URLs and names, or for program states.

Italics within double quotes ("*Italics*") is used for on-screen computer menu entries, buttons and other forms of information entry.

Normal text within single quotes ('Normal text') is used for extracts from other text, such as computer commands or command output.

`Courier font` is used for file names and directories, computer output and command line syntax examples.

`<Substitute text>` indicates an item whose actual text content may vary, depending either on the user's choice, or on the content of a computer response.

`<ABBR>`- indicates the use of a keyboard modifier, (such as `<ALT>`- or `<CTRL>`-) to be used in conjunction with another key or keys.

2. REPORTING PROBLEMS

Software problems should be reported to ATRAD in writing using the supplied Software Field Performance Report forms, or via electronic mail and addressed to:

Postal: The QA Manager,
ATRAD Pty Ltd
1/26 Stirling Street
Thebarton,
South Australia, 5031

Fax: +61 8 8303 3489

email: *bugrep@atrad.com.au*
web page: http://www.atrad.com.au

3. Administrative issues

3.1 IDL license file

If the hostname of the radar analysis computer is changed, the "SERVER" line in the IDL license file should be changed. Please refer to Appendix H: IDL License information for further information. Since the hostname is normally associated with the Radar Network and the Radar Network configuration rarely changes this will not usually be an issue.

3.2 What happens to the radar data?

With reference to the Acquisition computer ('radar-acq') and the Analysis computer ('radar-ana'):

a)   On 'radar-acq', after successfully acquiring a complete data set, the raw data is written to the `RawSpool/` directory. The filename consists of the date and time, followed by `_<tag>`, (where `<tag>` is specified as part of the respective experiment's configuration in radarcfg), with a `.raw` extension.

Raw data is not written if:
i)   an internal acquisition error occurred during the experiment. An error will be displayed and also written to the log.

ii)   The 'analysis_IP' parameter in the `sysparam.cf` file is set to "none"

If the raw data is written, the acquisition program tries to FTP the data to 'radar-ana', the machine and directory specified in the `sysparam.cf` file. If the transfer cannot proceed due to network interruption, the raw data file remains queued in the `RawSpool/` directory until the network is re-established. If any of the system parameters, analysis_IP, analysis_directory, analysis_u or analysis_p specified in the sysparam.cf file change while raw data files are queued in the `RawSpool/` directory, they are removed from the queue and remain in the `RawSpool/` directory. They must be transferred manually if required, as it is assumed the destination for all new raw data files is different.

Each file which has been successfully transferred is deleted from the `RawSpool/` directory and the transfer queue.

b)   On radar-ana, if the **analysis.sh** script is invoked and the analysis is running (see page 10), the analysis monitor looks for raw data files (see page 13), normally in the `/home/RadarData/AcqSpool` directory. If the tag for a raw data file matches (including case) a "Experiment Tag Name" specified in the "Analysis Control" section, and that analysis is invoked, the raw data file will be analysed and the analysed results appended to the daily analysis file created in the `/home/RadarData/AnalysedData` directory.

If archiving is enabled, the raw data is appended to the archived data file(s) in the `/home/RadarData/Archive` directory. The raw data files are then deleted from the `AcqSpool` directory.

Further details about the `/home/RadarData` directories can be found in the `Radar system reference manual'.

4. DATA ANALYSIS AND DISPLAY SUITE

4.1 Introduction

The Data analysis and display suite proceeds under the control of the user by means of graphical user interfaces. The functionality of each component of the suite and their relationship is illustrated on the following page. The Analysis and Display Control Graphical User Interface (ADCG) provides the interface for the control of all data analysis and display, and is described on page 10. The "Analysis monitor" is responsible for the analysis of all incoming raw data, and is described on page 15. The "Postanalysis monitor" is responsible for the postanalysis of data produced by the analysis monitor, and is described on page 15. The suite is designed in such a way that new analyses and their corresponding display modules may be added to the software suite in a modular, seamless manner, thus allowing users and third party software authors to add their own code to the ATRAD suite without recourse to the manufacturer. To further this aim, the entire analysis and display suite is coded with the use of RSI's Interactive Data Language (IDL), thus allowing non-professional programmers the means to create their own program modules.

In order to achieve independence between the three components of the suite, each component executes within its own IDL session. The display IDL session is invoked only whenever the user requests the display session. The analysis and postanalysis IDL sessions execute in the background and are usually only invoked when the host computer boots. Each IDL session records routine logging messages and error conditions to its own log file located in the `/home/radar/analysis/log` directory. Additionally, more serious errors are logged using the system *logger* program.

The "Control" directory is used as a common directory for communications between the three IDL sessions. The control files and their purpose are described in `Control files used by the analysis and display suite'. These files include the analysis "configuration files", which instruct the analysis monitor about which raw data files should be analysed and which particular analysis should be used, and the postanalysis configuration files, which instruct the postanalysis monitor about which analysed data files should be postanalysed and which particular postanalysis should be used.

The "Data directory" hierachy contains all data used by the suite. The directories are specified in terms of environment variables. The settings for these environment variables can be found in the file `/home/radar/analysis/lib/analysisvars`. The solid lines in the diagram indicate "active" file operations , such as data transfer between the data directories and the configuration of analysis and postanalysis configuration files. The dashed lines indicate "passive" or read-only file operations. For instance, the analysis and postanalysis configuration files can be configured by the ADCG, but can only be read by the analysis and postanalysis monitors.

The following sections describe the analysis and display control interface and the analysis and postanalysis monitor programs. Following these are sections describing the analysis and/or display modules provided with this radar system.

ATRAD
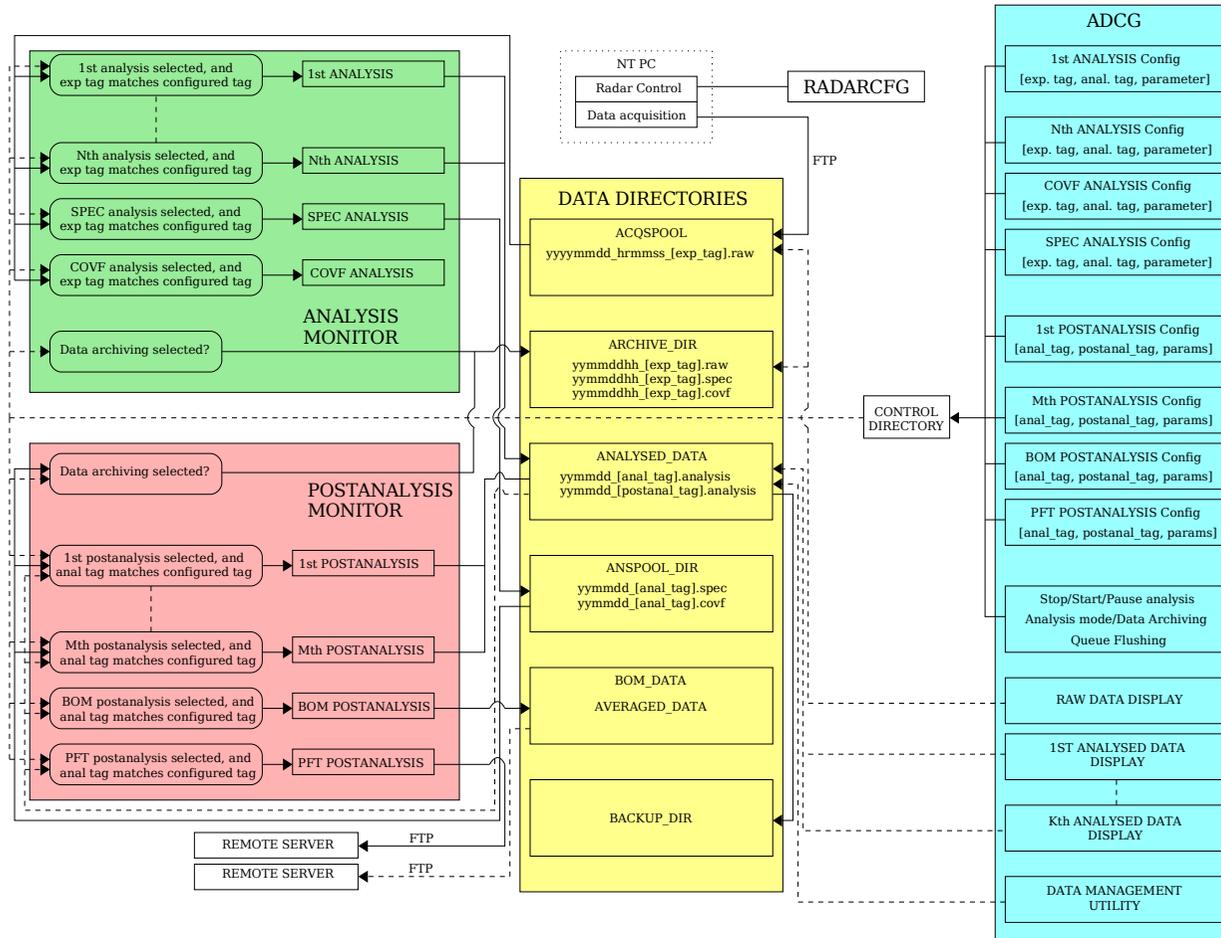
The IDL analysis and display suite

4.2 Analysis and Display Control Interface

4.2.1 Description

The Analysis and Display Control Graphical User Interface (ADCG) is used to configure and enable the various installed data analysis and postanalysis modules as well as invoke their corresponding displays. The ADCG is invoked by clicking the ATRAD logo with the label "*Analysis*" located in the on-screen menu bar on the right of the screen. Only one instance of the ADCG may be invoked at a time. The ADCG master window will appear showing a set of menu headings across the top of the window and a number of informative labels and graphs within its main body.

On invocation, the ADCG firstly determines the installed analysis, postanalysis and display modules. Those modules present appear under the pull down menu headings "*Analysis Control*", "*Postanalysis Control*" and "*Display Control*". Secondly, the ADCG checks which control files are present and configures the relevant pull down menu labels to reflect the current analysis state. This state is preserved from one incarnation of the ADCG to the next. Once invoked, the ADCG monitors the data spool directories (SPOOL_DIR and ANSPOOL_DIR) for newly acquired data sets and reflects any changes in four ways. First, the file name of the latest raw data set appears in the title bar of the ADCG window. Second, the time stamp of the latest data set (assuming that it is the latest acquired) appears in the "*Latest Acquired Data Set*" field. Third, the number of raw data sets awaiting analysis in the analysis queue is reported in the "*Number of Analysis Queued Data Sets*" field, and fourth, the number of analysed data sets awaiting postanalysis in the postanalysis queue is reported in the "*Number of Postanalysis Queued Data Sets*" field. Note that the last two fields are also updated as older data sets are processed and disappear from the queue.
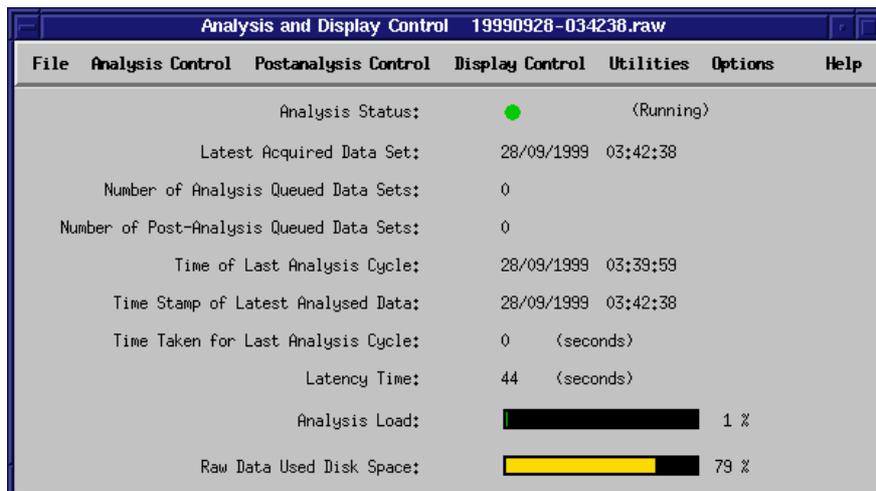
The Analysis and Display Control Interface

The complete list of diagnostic information included in the ADCG window below the menu bar includes:

- The analysis monitor status

- The time at which the most recent data set was acquired (radar time stamp).

- The number of raw data sets awaiting analysis in the acquisition spool directory (SPOOL_DIR).

- The number of analysed data sets awaiting analysis in the analysed spool directory (ANSPOOL_DIR).

- The time at which the last analysis cycle began (computer system time).

- The time at which the last analysed data set was acquired (radar time stamp).

- The time taken for the last analysis cycle (seconds).

● The amount of free time between analysis cycles - the latency time (seconds).

● A measure of the analysis load on the CPU's time.

● The percentage of disk space consumed by the disk partition containing the raw data spool.

● The percentage of disk space consumed by the disk partition containing the raw data archive (only displayed if on a different partition to the raw data spool).

Used disk space and analysis CPU load are indicated as percentages with the use of bar graphs. When the occupied disk space reaches 75%, the bar graph changes from green (ok) to yellow (warning). If the amount of disk space used reaches 90%, the bar graph changes colour to red (critical). For the analysis load bar graph, the "warning" and "critical" thresholds are also 75% and 90% respectively. If the analysis load exceeds 100%, acquired data sets will accumulate in the acquisition spool directory more rapidly than the analysis session can process them. Ultimately, this may result in the radar controller hard disk filling with raw data at which point the system will cease collecting new data.

Pull down menus are provided with headings *"File"*, *"Analysis Control"*, *"Postanalysis Control"*, *"Display Control"*, *"Utilities"*, *"Options"*, and *"Help"*. The *"File"* menu gives the user control over the execution of the analysis session. At boot time, a Unix script called **analysis.sh** is automatically invoked to start the analysis IDL session. If the analysis session exits for any reason (such as a user-requested termination, or if an error is encountered) the Unix script resumes execution. Since the **analysis.sh** script places the statement invoking the analysis IDL session inside an endless loop, the analysis session is restarted a short time after it exits. This is always true unless the user-requested termination control file is present in the control directory. Upon invocation, the analysis script calls a script called **postanal.sh** which handles the postanalysis IDL session in the same manner as the analysis script handles the analysis session. The functions of the ADCG *"File"* menu are interpreted as

"Invoke Analysis Script":	Spawn the analysis script **analysis.sh**. This will subsequently restart the analysis and postanalysis IDL sessions and spawn the **postanal.sh** script.
"Start Analysis Session":	Instruct the analysis script to remove the `.terminate` control file and restart the analysis and postanalysis IDL session.
"Stop Analysis Session":	Instruct the analysis and postanalysis IDL sessions to exit and not restart until instructed to restart, or the system is rebooted.
"Pause Analysis Session":	The analysis and postanalysis sessions cease processing data files until the user instructs it to continue using the "Unpause Analysis Session" menu entry, or terminates the sessions using the "Exit Analysis Session" menu entry.
"Unpause Analysis Session":	Instruct the analysis and postanalysis sessions to continue processing data files.
"Analyse Archived Data":	Instruct the analysis and postanalysis IDL sessions to apply all configured analyses to a nominated archived raw data file.
"Exit":	Close the ADCG and all associated display windows.

The ADCG frequently checks to see if the analysis IDL session is still running, and sets the analysis status indicator and sensitises the analysis session invocation and termination pull down menu options appropriately.

The *"Analysis Control"* menu allows the user to instruct the analysis IDL session to *"Invoke"*, *"Disable"*, or *"Configure"* any of the available analysis modules. The current status of each analysis is also reported. The possible states of an analysis are: `Running`, `Halted - Error`, and `Not Selected`. These three states are explained in the analysis monitor description on page 15. The *"Configure"* option launches a configuration utility allowing the user to configure the analysis

to their own specifications. This facility allows a particular raw data file to be analysed by a number of different analyses, and by the same analysis in a different configuration. The configuration utility is described on page 13. The "*Postanalysis Control*" menu allows the user the same functionality for the postanalysis IDL session as the "*Analysis Control*" menu does for the analysis IDL session.

The "*Display Control*" menu allows the user to launch any of the display programs installed - only one instance of each is allowed. If additional analysis or display modules are installed after the ADCG has been invoked, then they will not be accessible from the ADCG until it is restarted. Note that the settings of any display widgets are not retained from session to session.

The "*Utilities*" menu provides the "*Housekeeping Utility*", allowing the experiment parameters of raw data files to be viewed, and the "*Data Management Utility*", allowing analysed data to be backed up to a portable medium. If the ADCG is configured for offline use, the "*Analysis utility*", allowing analysis of archived raw data files, and the "*Postanalysis utility*", allowing postanalysis of analysed data files, will also be available from the "*Utilities*" menu.

The "*Options*" menu allows the user to specify acquired data set handling and display program options. "*Analysis Mode*" specifies whether the analysis should be performed on all acquired data-sets in temporal order ("Queued") or only on the latest data-sets ("Real Time"). "*Data Management*" provides several options allowing the user to specify how data should be archived. "*Archiving*" specifies whether data is to be archived ("Invoked") or deleted ("Disabled") after analysis and postanalysis. "*Archiving Period*" specifies the duration for each archived data-set if data archiving is set. The "*Archiving utility*" allows more sophisticated archiving options to be selected, and is described in section 4.6. The Archiving utility can be invoked by choosing the "*Invoke*", and disabled by selecting "*Disable*". Note that data archiving is automatically disabled when the percentage of disk space consumed by the disk partition containing the raw data archive exceeds 95%. The "*archiving monitor*" allows the user to specify how long archived data files are kept on the file system, and is described in section 4.7. The archiving monitor can be invoked by choosing the "*Invoke*", and disabled by selecting "*Disable*". "*Flush Analysis Queue*" performs removal of queued raw data-sets awaiting analysis, while "*Flush Postanalysis Queue*" performs removal of queued raw data-sets waiting postanalysis. If the ADCG is configured to discard data-sets after analysis and postanalysis rather than archiving them, flushing the queue results in permanent data loss over the duration of the queue. "*Color Table*" specifies the color table to be used for all display module image plots. If the ADCG includes the interference removal utility (see section 4.8), "*Interference Removal*" allows control of this feature via a submenu: it can be started by choosing the "*Invoke*" item stopped by choosing the "*Disable*" item and configured by choosing "*Configure*". "*Raw Data Transfer*" enables the transfer of raw data files to remote computers as described in section 4.9. Raw data transfer can be invoked by choosing "*Invoke*", disabled by selecting "*Disable*" and configured by choosing "*Configure*". If the ADCG is configured for remote configuration, the "*Remote Configuration*" menu will also be available from the "*Options*" menu. This allows the user to configure remote on-line analyses and postanalyses.

Finally, the "*Help*" pull down menu allows the user to obtain version information for the software and to display the on-line manual page.

4.2.2 Keyboard Accelerators

Two keyboard accelerators are available with the ADCG. These are:

        `<ALT>-X`   Exit the ADCG (and all display widgets).

        `<ALT>-H`   Display the on-line manual page.

4.3 Configuration Utilities

4.3.1 Description

All analyses and postanalyses have configuration utilities installed, and each utility allows the user to provide parameters relevant to the analysis concerned. Pull-down menus are provided with the headings "*File*" and "*Help*". Below the menu bar are left and right arrows allowing the user to scroll through the existing configurations. The index of the currently displayed configuration and the total number of configurations is indicated between the arrow keys. The "*File*" menu contains the options "*Save Changes*", "*Add Configuration*", "*Copy Configuration*" and "*Remove Configuration*". The "*Save Changes*" option allows the user to save any changes made to any of the currently defined configurations. "*Add Configuration*" allows the user to add a new configuration, while "*Copy Configuration*" allows the user to copy the currently displayed configuration to a new configuration. The "*Remove Configuration*" option removes the currently displayed configuration. The *"Help"* pull down menu allows the user to obtain information on the use of the configuration utility. As an example, the configuration utility for the FCA analysis is displayed on the right.

The configuration utilities allow the user to nominate the experiment tag name the raw data should possess in order for the analysis to process the file, and the analysed data tag name to append to the data file that the analysed data are to be written to. Similarly, the postanalysis configuration utilities allow the user to nominate the analysed data tag name the analysed data should possess in order for the postanalysis to process the file, and the postanalysed data tag name to append to the data file that the postanalysed data are to be written to. Other configuration options are analysis- and postanalysis-specific, and are documented in the on-line help accessed from the *"File"* pull-down menu. The postanalysis configuration utilities contain time fields which the postanalysis monitor uses to determine when a particular postanalysis should occur and which analysed data-sets it should use: the "processing interval", "offset", and "duration". The processing interval specifies the interval between successive invocations of a particular postanalysis. The offset specifies the offset from the multiple of the processing interval for the postanalysis to be performed. The processing duration specifies the duration of data to use for the postanalysis. The *"Processing Interval Multiple"* specifies whether the postanalysed data should have time stamps with *"Integer"* or *"Integer + 0.5"* multiples of the processing interval.

The FCA Configuration Utility

The "*Experiment tag*" field in any analysis configuration can include one wildcard character, specified by "*". For instance, if the experiment tag for a particular analysis is set to "dbs7*", all data whose experiment tag includes the string "dbs7" will be analysed according to this configuration entry. This also applies to the "*Analysed data tag*" field in any postanalysis configuration utility.

Additionally, the "hyphen" character "-" can be used in the analysed data tag field of the analysis configuration utility to specify that the analysed data tag should be set to experiment tag, and in the postanalysed data tag field of the postanalysis configuration utility to specify that the postanalysed data tag should be set to the analysed data tag.

Additionally, the analysed data tag field of the analysis configuration utility and the postanalysed data tag field of the postanalysis configuration utility allow the results from a single analysis or postanalysis to be written to two different analysed or postanalysed data files. This is achieved by specifying the required tags sepeated by a comma. This facility is of use if the user requires that data from the analysis of two different experiment tags (e.g. low_mode and high_mode) are to be
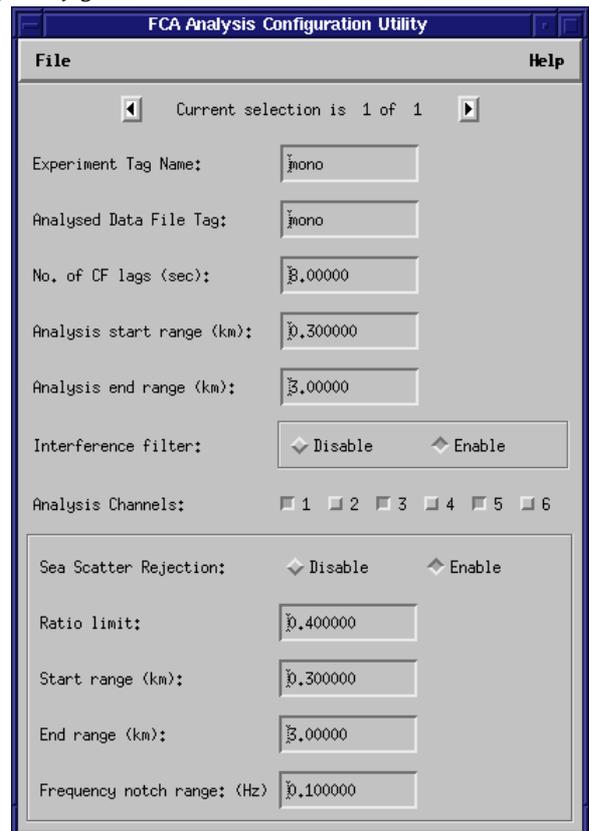
written to both individual (e.g. low_mode and high_mode), and combined (e.g. "both_modes") analysed data tags. In this case, the analysed data tag specified for the experiment tag "low_mode" will be set to `"low_mode,both_modes"`, while the analysed data tag specified for the experiment tag "high_mode" will be set to `"high_mode,both_modes"`.

Furthermore, the "hyphen" character `"-"` can be used in the analysed data tag field of the analysis configuration utility to specify that the analysed data tag should be set to experiment tag, and in the postanalysed data tag field of the postanalysis configuration utility to specify that the postanalysed data tag should be set to the analysed data tag.

The configuration information is stored in IDL savefiles in "`/home/radar/analysis/control`."

The configuration options available depend upon which control files are present. Information on the control files used by the analysis and display suite are provided in `Control files used by the analysis and display suite'. Configuration options dependent on the presence of control files include specification of height/range limits, sea scatter removal, extra coherent integrations, processing intervals and durations, and analysis specific thresholds. If the analysis and display suite is configured for a radar system allowing interleaved polarisation, all analysis configurations (except DAE) allow the selection of the appropriate mode for analysis.

4.3.2 Keyboard Accelerators

Three keyboard accelerators are available with the configuration utilities. These are:

`<ALT>-W`	Exit the configuration utility.
`<ALT>-H`	Display the on-line manual page.
`<ALT>-S`	Save the configuration

4.4 Analysis Monitor

4.4.1 Description

The Analysis Monitor is designed to poll for the arrival of newly-acquired raw data files, and then to sequentially invoke each installed and enabled analysis module once the presence of a new data set is detected. The analysis monitor executes within its own IDL session, and is configured through the use of configuration files written to the "Control" directory. Each configuration file may contain one or more configuration, allowing each raw data file to be analysed by each analysis in a number of different manners.

Upon the arrival of new data in the raw data spool directory (SPOOL_DIR), the analysis monitor reads the raw data and the experiment parameter information from the data file, checks which analyses are enabled, and looks for a configuration file for each of these analyses. The configuration information includes the experimental tag name on which the analysis should run, the analysed data tag name for the output data file, and information regarding how the analysis should be applied. Configurations for each analysis are defined with the use of the corresponding configuration utility (if installed), as described on page 13. If a configuration file exists, and any of the configured experiment tags match the experiment tag of the raw data file, the raw data, experiment parameter information and the configuration information are passed to the analysis module for analysis. If a configuration file is not found, the enabled analysis is called once and is analysed using the default setup for this analysis.

The analysed data is then written to file. For COVF and SPEC analyses, the data is written to the ANSPOOL_DIR directory, where it is spooled for postanalysis. The filename convention is

`[year][month][day]-[hour][minute]_[analysed data tag].analysis,`

where [year] is a four character field, [month], [day], [hour], and [minute] are two character fields, the analysed data tag is specified in the analysis configuration utility, as described on page 13, and "analysis" is the analysis type (covf or spec). For the remaining analyses, the data is appended to daily files within the ANALYSED_DATA directory with filename convention

`[year][month][day]_[analysed data tag].analysis.`

Once the analysis cycle has been completed for the current data set, the raw data file is either archived into the ARCHIVE_DIR (which may be specified as a mass storage device) or removed from the file system. The archived data filename convention is

`[year][month][day][hour]_[experiment tag].raw,`

where hour is a multiple of the "archival period", which is configured from the "Options" menu of the ADCG as described on page 10. Once the now-analysed raw data file has been dealt with appropriately, the analysis monitor waits for the arrival of the next data set.

At the beginning of each pass through the analysis cycle, the analysis monitor checks for files within the control directory corresponding with the installed analysis. Thus, it is not necessary to restart the analysis monitor after installing new analysis modules, nor after enabling an existing analysis module from the ADCG. This behaviour contrasts with that of the ADCG, which must be restarted after installing new analysis and/or display modules.

In the event of an analysis module continually producing an error, the analysis monitor automatically disables that analysis and records the details of the module's faulty nature in the log file. This functionality is intended to prevent faulty third party analysis modules from adversely affecting execution of more stable analyses.

From version 4 onwards, the analysis monitor allows analyses other than DAE to be applied interleaved polarisation data.

4.5 Postanalysis Monitor

4.5.1 Description

The Postanalysis Monitor is designed to schedule the postanalysis of analysed data produced by the analysis monitor. After the analysis monitor has completed the analysis of each raw data file, a

control file is produced containing the timestamp of the latest analysed raw data set. The Postanalysis Monitor detects this file, and uses the timestamp information together with the configured invocation times for each installed postanalysis to determine whether any of the postanalyses should be invoked. The postanalysis monitor executes within its own IDL session, and is configured through the use control files.

Upon detecting the timestamp control file, the postanalysis monitor checks which postanalyses are enabled, and looks for a configuration file for each of these postanalyses. The configuration information includes the analysed data tag name on which the postanalysis should run, the postanalysed data tag name for the output data file, scheduling information, and information regarding how the postanalysis should be applied. The scheduling information is specified by the "*processing interval*", "*processing offset*", and "*data duration*". The "*processing interval*" specifies the interval between successive invocations of a particular postanalysis. The "*processing offset*" specifies the offset from each [integer + half] multiple of the processing interval for the postanalysis to be performed. The "*data duration*" specifies the duration of data to use for the postanalysis. The scheduling process is illustrated on the following page. Some postanalyses (e.g. VEL) can be configured to be called at the completion of every experiment cycle. This facility can for instance be used to apply VEL postanalysis to the DBS analysed data obtained over a complete sysle of beam directions.

Each postanalysis is defined with the use of the corresponding configuration utility, as described on page 13. If the scheduling information for any enabled postanalysis indicates the postanalysis should be performed, the appropriate analysed data is read from file, and the analysed data, experiment parameter information and the configuration information are passed to the postanalysis module for postanalysis.

For postanalyses producing postanalysed data, the data is then appended to daily files within the ANALYSED_DATA directory with filename convention

`[year][month][day]_[postanalysed data tag].postanalysis,`

where `[year]` is a four character field, `[month]` and `[day]` are two character fields, and `"postanalysis"` is the postanalysis type.

Once the postanalysis cycle has been completed, any spooled COVF or SPEC analysed data not required for subsequent postanalysis is either archived into the ARCHIVE_DIR (which may be specified as a mass storage device) or removed from the file system. The archived data filename convention is

`[year][month][day][hour]_[analysed data tag].suffix,`

where `[hour]` is a multiple of the "archival period" configured from the "Options" menu of the ADCG as described on page 10, and suffix is the suffix of the spooled data in question ("covf" or "spec"). The postanalysis monitor then waits for the arrival of the control timestamp file.

In the event of a postanalysis module continually producing an error, the postanalysis monitor automatically disables that postanalysis and records the details of the module's faulty nature in the log file. This functionality is intended to prevent faulty third party postanalysis modules from adversely affecting execution of more stable postanalyses.

Example of the scheduling process and data requirements used by the postanalysis monitor

```
(N+0.5)I-D ............ ●  ── Data for Nth processing time
            I      D
(N+0.5)I   ............ ●
                   O
(N+0.5)I + O ......... ●     Nth processing time

(N+1+0.5)I-D ......... ●  ── Data for (N+1)th processing time
            I      D
(N+1+0.5)I ........... ●
                   O
(N+1 +0.5)I+O ........ ●     (N+1)th processing time

(N+2+0.5)I-D ......... ●  ── Data for (N+2)th processing time
            I      D
(N+2+0.5)I ........... ●
                   O
(N+2+0.5)I+O ......... ●     (N+2)th processing time

(N+3+0.5)I-D ......... ●  ── Data for (N+3)th processing time
            I      D
(N+3+0.5)I+O ......... ●
                   O
(N+3+0.5)I ........... ●     (N+3)th processing time

                   time
```

Processing interval (I):   ⟵————————⟶

Processing offset (O):   ⟵—⟶

Data duration (D):   ⟵——⟶
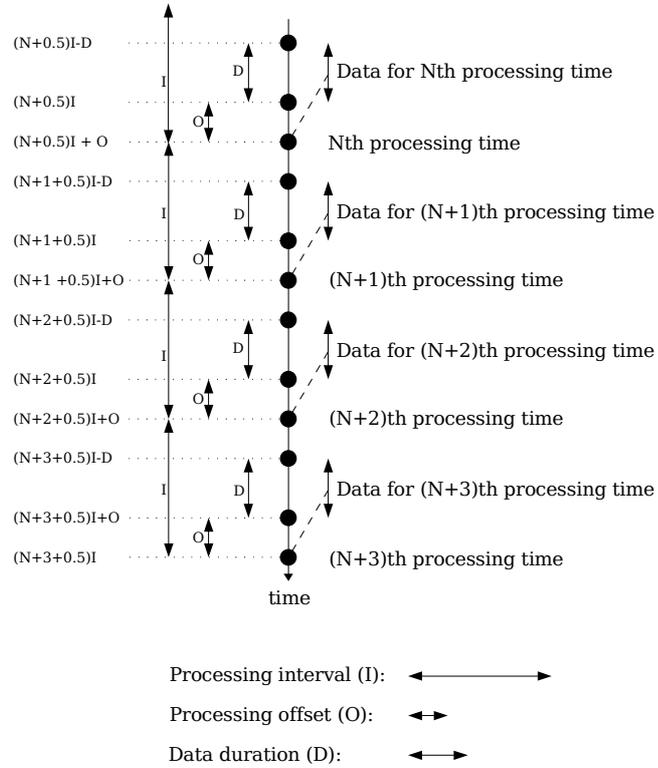
4.6 Archiving Utility

4.6.1 Description

The archiving utility (AU) allows the user to specify how analysed raw data files and postanalysed spectra, covariance function, and AOA files should handled on the completion of their analysis/postanalysis. Archiving of range subsets of raw data files can also be selected.

The AU allows the use to specify which tags and data types should be archived. The tag can be specified in the "*Tag Name*" field, while the data type can be chosen by enabling the appropriate selection from the "*Raw Data*", "*Spec Data*"*, "*Covf Data*" and "*AOA Data*" fields. For instance, if archiving of raw data with tag "fca" and is required, the user would enter "fca" in the "*Tag Name*" field, and enable "*Raw Data*". If archiving of raw and spectral data with the tag "pmse" is required, the user would enter "fca" in the "Tag Name" field, and enable "*Raw Data*" and "*Spec Data*". The archiving period can be selected using the "*Archiving Period*" slider.

The AU also allows the archiving of a range subset of a raw data file. The user can select this option by enabling the "*Raw Data Range Subset*" field. This allows selection of the start and end ranges of the range subset (from the "*Archiving start range*" and "*Archiving end range*" fields), and the tag name to use for archiving ("*Archived Data Tag*" field). Note that one raw data file can be archived in full byselecting "*Raw Data Archiving*", and archived as a range subset by selecting "*Raw Data Range Subset*". It is recommended that the "*Archived Data Tag*" field is not set to the same value as "*Tag name*", as this will result in two different data-sets being written to one archived data file if "*Raw Data Archiving*" is also selected.

The AU can be configured by selecting "*Options|Data Management|Archiving Monitor| Configuration*" from the Analysis and Display control GUI (ADCG). The AU is invoked by selecting "*Options|Data Management|Archiving Monitor|Invoke*", and is disabled by selecting the "*Options| Data Management|Archiving Monitor|Disable*" option. The "*Invoke*" option is only available if the AU has been configured.

If the AU is invoked, it is called once analysis (postanalysis) of a raw (spec, covf or AOA) data file is complete. The AU checks the data archiving configuration settings to determine whether the data tag names match any of the values specified "*Tag*" field. If this is the case, the data is archived if the corresponding data type is enabled, and is deleted otherwise. If the AU is invoked, the AU configuration overrides the default archiving ("*Options|Data Management|Archiving*") and archiving period ("*Options|Data Management|Archiving Period*") settings. If the AU is disabled, archiving reverts to that specified by the default archiving and archiving periods.

The following describes some applications of the AU:

1. In the case where the user requires all raw data to be archived expect for a specific tag, this can be enabled by defining a configuration where the experiment tag is specified in the "*Tag Name*" field, and the "*Raw Data*" field is disabled. This can be useful for a meteor experiment, where raw data detection archiving can be configured in meteor analysis to save only the raw data for each detection.

2. In the case where a user wants to archive spectral or covariance function data rather than raw data, this can be enabled by defining a configuration where the required spec or covf data tags are specified in the "*Tag Name*" field, and the "*Spec Data*" or "*Covf Data*" field is disabled. This can provide a means of data compression for offline analysis in comparison to archiving raw data.

3. In the case where a user wants to archive only a specified range subset of a raw data file, this can be enabled by enabling the "*Raw Range Data Subset*" field and choosing the tag, and start and end ranges. This can provide a means of data compression for offline analysis.

4.6.1.1 Keyboard Accelerators

Only the "*Close*" and "*Manual Page*" options are accessible through keyboard accelerators. The appropriate keystrokes for these two options are `<ALT>-W` and `<ALT>-H` respectively.

4.6.1.2 Log files

All use of the AU is logged to the file `$ANALYSIS_DIR/log/display.log`, while the resulting data analysis is logged to the file `$ANALYSIS_DIR/log/analysis.log`. Users should consult these files for further information on any problems observed using the AU or the analysis of the selected data.

For on-line Linux operation, the size of this file is controlled by "`logrotate`" as specified in the file `/etc/logrotate.d/radarlogs`.

Information about logrotate can be obtained from the command line using "`man logrotate`".

4.6.1.3 Files

The configuration file `$ANALYSIS_DIR/control/.arch_util_config` contains the configuration information.

4.7 Archiving Monitor

4.7.1 Description

The archiving monitor (AM) allows the user to specify how long archived raw data, spectra, covariance function, and AOA files should be maintained in the archived data directory.

The AM allows the use to specify which tags and data types should be archived. The tag can be specified in the "*Tag Name*" field, while the data type can be chosen by enabling the appropriate selection from the "*Raw Data*", "*Spec Data*", "*Covf Data*" and "*AOA Data*" fields. For instance, if the user wishes to limit the amount of time raw data with tag "`fca`" and is kept for, the user would enter "`fca`" in the "*Tag Name*" field, and enable "*Raw Data*". The data lifetime can be selected using the "*Data Lifetime*" slider.

The AM can be configured by selecting "*Options|Data Management|Archiving Monitor| Configuration*" from the Analysis and Display control GUI (ADCG). The AM is invoked by selecting "*Options|Data Management|Archiving Monitor|Invoke*", and is disabled by selecting the "*Options| Data Management|Archiving Monitor|Disable*" option. The "*Invoke*" option is only available if the AM has been configured.

If the AM is invoked, it is called at the commencement of each UT day, as determined from the timestamps of the data analysed by the analysis monitor. The AM checks the AM configuration to determine whether the existing archived raw, spectral, covariance function and AOA files match any of the values specified "*Tag*" field, and whether the appropriate data type is enabled. If this is the case, the data is deleted if it's age exceeds the corresponding value from the "*Data Lifetime*" field.

4.7.1.1 Keyboard Accelerators

Only the "*Close*" and "*Manual Page*" options are accessible through keyboard accelerators. The appropriate keystrokes for these two options are `<ALT>-W` and `<ALT>-H` respectively.

4.7.1.2 Log files

All use of the archiving monitor configuration is logged to the file `$ANALYSIS_DIR/log/display.log`, while the actions of the archiving monitor is logged to the file `$ANALYSIS_DIR/log/analysis.log`.

Users should consult these files for further information on any problems observed using the archiving monitor configuration and archiving monitor.

For on-line Linux operation, the size of this file is controlled by "`logrotate`" as specified in the file `/etc/logrotate.d/radarlogs`

Information on `logrotate` can be obtained from the command line using "`man logrotate`".

4.7.1.3 Files

The configuration file `$ANALYSIS_DIR/control/.arch_mon_config` contains the configuration information.

4.8 Interference Removal

The interference removal procedure is based on the "sidelobe canceler", described in the paper "Adaptive Arrays" by S. P. Applebaum, IEEE Transactions on Antennas and Propagation, vol. AP-24, No. 5, Sep. 1976, pp. 585-598. This technique is used to reduce the interference received through the sidelobes of a main antenna with a narrow antenna pattern using the signals received by multiple smaller antennas with near-isotropic antenna patterns. The correlation between the signals received on the large and smaller arrays is exploited to estimate the optimal linear combination of smaller array signals required to remove the interference received by the main array through the sidelobes.

In the current application, the same technique is used to remove interference correlated in range. The interference received at "secondary ranges" (i.e. ranges containing interference only) is used to remove the interference observed at the "primary ranges" (i.e. those ranges containing the desired atmospheric signal) by determining the correlation between signals in the primary and secondary ranges.

Interference removal can be configured by selecting "*Options|Interference Removal| Configuration*" from the Analysis and Display control GUI (ADCG). Interference removal is invoked by selecting "*Options|Interference Removal|Invoke*", and is disabled by selecting the "*Options| Interference Removal|Disable*" option.

If interference removal is invoked, it is called by the analysis immediately after each raw data file is read in. The analysis checks the configuration settings to determine whether the data tag names match any of the values specified "*Experiment Tag*" field. If this is the case, interference removal is applied.

The interference removal technique is applied to each receiver separately. The power spectra are calculated at each range to produce a range-Doppler (RD) spectrum. In order to determine the correlation between signals in the primary and secondary ranges it is necessary to preclude any "desired" (i.e. non interfering signal) from the correlation estimate. This is achieved using a normalisation technique whereby the spectral values at each Doppler are divided by the median value over all ranges, and the spectral values at each range are divided by the median value over all Dopplers to produce a "whitened" RD spectrum. The whitened spectrum shows only the desired signal, allowing the range-Dopplers of the desired signals to be estimated, and the corresponding spectral values set to zero to preclude their use in the correlation estimates. In the ideal implementation of this technique the secondary ranges should contain only interference. If this is not the case, it is possible that correlation between the signals observed in secondary and primary ranges can result in some signal cancellation in the primary ranges, or signal from one range being copied into other ranges. Fortunately, the whitening technique described above presents some protection against this effect. This is supported by the fact that no cases of signal cancellation has been observed in the development of the current interference removal algorithm. To further guard against this possibility, the user can indicate whether there may be possible atmospheric signal in the secondary ranges.

Despite this, it is recommended that ranges where the least amount of desired is expected are selected as the secondary ranges. For MF radar systems, secondary ranges below 50 km are optimal, but secondary ranges between 50 and 60 km should be adequate. For tropospheric VHF systems, secondary ranges above 20 km are desirable. For mesospheric VHF systems, ranges between 65 and 75 km are desirable, bearing in mind that PMSE and meteors (PMWE) are usually observed are ranges above (below) this. For meteor systems, the technique is not recommended for radars operating with PRFs above 100 Hz. This is because meteors can be range aliased and appear at any range, so that no secondary ranges can be selected which contain only interference.

The interference removal procedure is called by the analysis. If the tag of the raw data file to be analysed matched any of the tags setup in the interference removal configuration, interference removal is applied to produce "cleaned" data (i.e. Data with any interference removed). The analysis can then be performed using the "cleaned" data, or the cleaned data can be written to a new raw data file which can be analysed.

The interference removal procedure can be configured using "*Options|Interference Removal*" from the "*Options*" menu of the analysis and display control GUI (ADCG). The use has the ability to set the following options:

- *Experiment tag*: the experiment tag of the raw data files that the interference removal procedure is to be applied to.

- *Secondary Data Start Range*: the lowest range to be used for secondary data

- *Secondary Data End Range*: the largest range to be used for secondary data

- *Spool interference removed data*: instructs the analysis what to do with the "cleaned" data. If this is set to "Invoke", the analysis analyses the "uncleaned" data, and writes the "cleaned" data to a new file in the directory specified by the SPOOL_DIR environment variable, where it will then be spooled for analysis. This allows the use to analyse both "cleaned" and "uncleaned" data to assess the effectiveness of the interference removal procedure, and also to archive the "cleaned" raw data to an archived data file.

- *Cleaned data tag*: the experiment tag of the raw data file containing the cleaned data.

- *Allow for atmospheric signal*: allows the user to indicate that there may be some atmospheric signal in the secondary data. If this is set, the interference removal procedure checks whether the signal characteristics match those of an atmospheric signal, and precludes this data from the correlation procedure to avoid cancellation of this signal

- *Frequency range*: the one-sided frequency range over which the atmospheric signal is expected. For example, if atmospheric signal may occupy the frequency range +/- 0.2 Hz, this value should be set to 0.2.

The optimal values for the interference removal procedure can be tested using the "*Interference Removal*" option from the "*Options*" menu of the raw data display module, which can be selected from the "*Display Control|RAW Display*" option of the ADCG. It is highly recommended that the user tests their intended settings using the raw data display to verify their values are sensible.

4.8.1.1 Keyboard Accelerators

Only the "*Close*" and "*Manual Page*" options are accessible through keyboard accelerators. The appropriate keystrokes for these two options are `<ALT>-W` and `<ALT>-H` respectively.

4.8.1.2 Log files

All use of the interference removal configuration utility is logged to the file `$ANALYSIS_DIR/log/display.log`.

Users should consult this file for further information on any problems observed using the interference removal configuration utility.

4.8.1.3 Files

The interference removal configuration information is written to the file `$ANALYSIS_DIR/control/.interf_removal_config`.

4.9 Raw data transfer

The Raw Data Transfer configuration utility allows the user to transfer spooled raw data files to a remote location. Specifically, the utility allows the user to select which experiment tags to use, the remote IP address and directory to which the data is to be transfered. The IP address requires an entry in the radar user's ".netrc" file with the username and password for ftp for use (see Remote file transfer issues).

The Raw Data Transfer configuration utility allows raw data files to be transfered to multiple sites. Additional configurations are composed by choosing the "*Add Configuration*" or "*Copy Configuration*" options under the "*File*" menu. "*Add Configuration*" allows the user to configure a new Raw Data Transfer, while "*Copy Configuration*" allows the user to copy the currently displayed postanalysis configuration and reconfigure it. Unwanted configurations may be deleted with the "*Remove Configuration*" option. Different configurations may be examined one at a time by clicking on the left and right selection buttons near the top of the window.

Raw data transfer can be configured by selecting "*Options|Raw Data Transfer|Configuration*" from the Analysis and Display control GUI (ADCG). Raw data transfer is invoked by selecting "*Options| Raw Data Transfer|Invoke*", and is disabled by selecting the "*Options|Raw Data Transfer|Disable*" option.

4.9.1.1 Keyboard Accelerators

Only the "*Close*" and "*Manual Page*" options are accessible through keyboard accelerators. The appropriate keystrokes for these two options are `<ALT>-W` and `<ALT>-H` respectively.

4.9.1.2 Log files

All use of the Raw Data Transfer configuration utility is logged to the file `/home/radar/analysis/log/display.log`, while the Raw Data Transfer is logged to the file `/home/radar/analysis/log/ftp_transfer.log`.

Users should consult these files for further information on any problems observed using the Raw Data Transfer configuration utility and Raw Data Transfer.

4.9.1.3 Files

The raw data transfer configuration information is written to the file `$ANALYSIS_DIR/control/.pft2_config`.

4.10 Installable Software Modules

4.10.1 Introduction

The existence of a particular software module within the ATRAD Analysis and Display suite (ADS), be it an analysis, postanalysis or a display module, is dependent upon which modules are compiled into the IDL savefiles used by the ADS. Some analysis and postanalysis modules may be installed without a corresponding display module (e.g. AFT and PFT postanalyses). Additionally, not every display module need have a corresponding analysis or postanalysis module (e.g., the raw data display module). Installation of new modules requires the generation of a revised savefile with the appropriate modules compiled in. Alternatively, third party analysis modules may be included into the suite. The `Coding New Software Modules' section, gives some brief information concerning coding third party analysis modules. Once installed, a new analysis module will be recognised by the ADCG on its next invocation by the user, and must then be enabled via the ADCG before the analysis monitor will execute it.

4.10.2 The Raw Data Display Module

4.10.2.1 Description

The raw data display module (RDDM) is a compound widget which allows the user to display acquired radar data in one of several different statistical forms. These display formats include displaying data as time-series of data samples (as in-phase and quadrature components), as spectra, correlation functions, in-phase and quadrature components histogram and ball-of-wool plots, and power profile plots. Time-series and spectra may also be displayed as stacked or image plots. The raw data display module can also display spectral or covariance function data produced by SPEC or COVF analyses.

The widget is divided into six main areas. At the top of the widget is the motif-style pull-down menu, which provides access to all functionality. The menu headings are "*File*", "*Format*", "*View*", "*Options*", and "*Help*". The currently selected menu options indicated by an arrow in many cases.

The data set required for display can be selected from the "*View*" menu. Options include the most recent data-set (Latest data mode), data awaiting analysis in the analysis queue (Queued data mode), and archived data sets (Archived data mode). In latest data mode the widget automatically updates the display of latest data to arrive in the queue if the experiment tag matches the selected tag. In latest and queued data mode the user is able to select the experiment tag of the data to be displayed using the "*Select Experiment Tag*" option from the "*View*" menu. Selecting this option launches a widget allowing the selection of any of the available experiment tags. The "*All tags*" option allows data with any tag to be displayed, while the "*Current Tag*" option allows data with the same tag as the current experiment tag to be displayed. On selecting archived data mode the user is able to browse through the file system and select archived raw data files for display.

Immediately below the menu bar appears the time selection thumbwheel slider. In archived data mode, this slider provides access to data records from various acquisitions within the file. In queued data mode, the slider provides access to different data files within the queue. The time of the data currently selected for display is centered immediately above the time slider. In queued or archived data mode the start and end times are also shown immediately above the slider on the left and right hand sides, respectively.
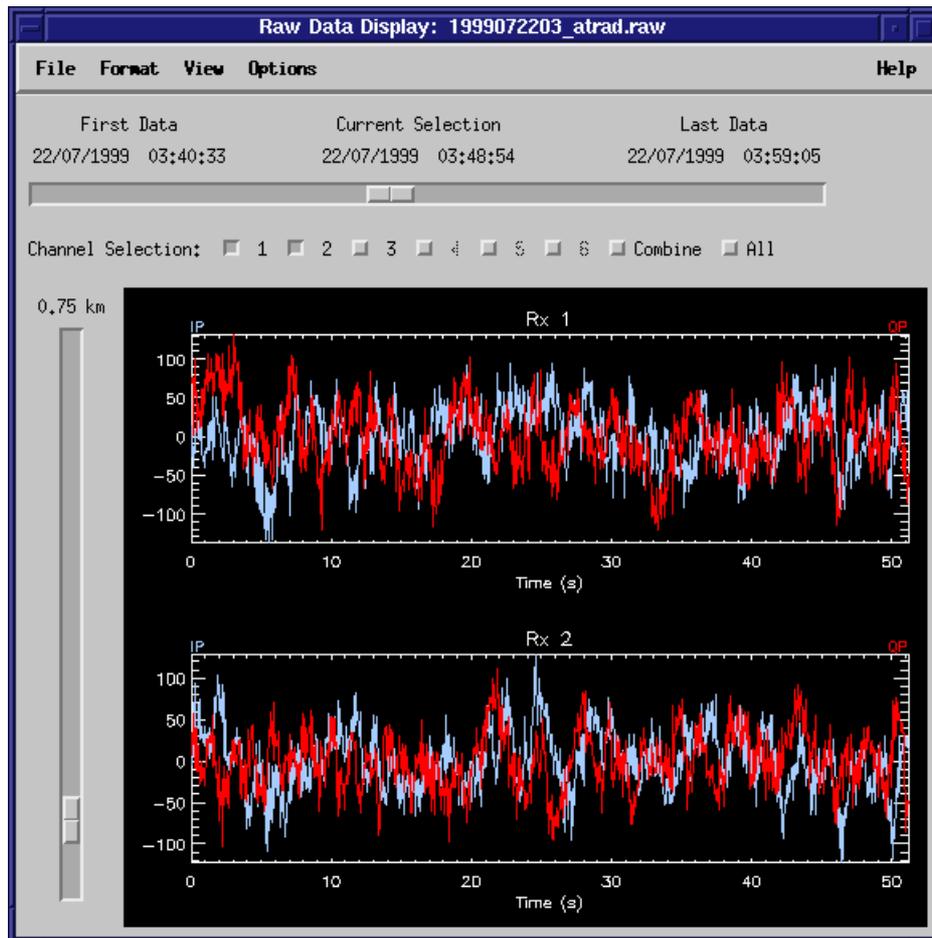
The Raw Data Display Module

For multiple receiver channel systems a set of receiver channel selection buttons appear below the time selection slider. Different channels may be displayed on-screen by clicking on the appropriate channel selector button. Up to 16 channels may be displayed simultaneously - unavailable channels are not selectable and have a "grey" appearance. The "*Combine*" button combines the data from all selected channels into a single channel. If a receiver calibration record is contained in the raw data-set this information is used to correct any complex receiver gain differences in each channel prior to combining. The "*All*" button allows the display of all available channels. If all available channels are already selected, the "*All*" button resets the channel selection so only the first channel is selected.

At the bottom of the widget appear the vertically-oriented range selection slider and, to the right of the range slider, the display window itself. In all display formats besides stacked, image, and power profile plots the data sampled from various ranges are selectable by the range slider. The range currently selected for display appears above the slider and is scaled in units of kilometres. If the slider is moved while the mouse button remains depressed, the range label is updated without updating the display. The display is then updated when the mouse button is released.

The display format can be selected from the "*Format*" menu. Data are displayed in various colors depending on the properties of the data concerned. For Cartesian time series and amplitude distribution display formats the in-phase data are displayed using a light blue shade, while the quadrature data are shown in red. For display formats in polar form the magnitude is shown in yellow while the phase is shown in green. In these cases the "tick marks" for the two axes are keyed by means of the corresponding color. Display formats where the data is displayed as a single component (e.g. Power spectra) are displayed using the light blue shade. The color scheme is extended for display of data from multi-mode experiments, where one of the experimental parameters is modified on a point-to-point basis throughout the record (e.g. beam direction,

polarisation mode, and transmission frequency). In all cases, information on the data component being displayed appears at the bottom left and/or the right of the display window and is keyed by the appropriate color.

The "*Options*" menu provides control over many features of the displayed data, including scaling of both axes (in some cases), and the size of the informative labels included with the display. In addition, the user may elect to display or hide arbitrary components of the data. For example, the user can configure the widget to plot only the quadrature component of the time series and ignore the in-phase component. Many of the display formats also support panning of the display once the ordinate axis scale has been expanded. This allows the user the magnify sections of the display not situated near the display origin.

Sea echo removal may be configured using the "Sea Scatter Removal Utility", which can be invoked from the "*Sea Scatter Removal*" option of the "*Options*" menu. The Sea Scatter Removal Utility is available from the "*Help*" menu of the Sea Scatter Removal Utility, and is also described in the Sea Scatter Removal Utility section below.

If provided, interference removal may be configured using the "*Interference Removal Utility*", which can be invoked from the "*Interference Removal*" option of the "*Options*" menu. The "*Interference Removal Utility*" manual page is available from the "*Help*" menu of the "*Interference Removal Utility*", and is also described in the Interference Removal Utility manual page (see section 4.8).

Hardcopies of the display can be obtained by selecting the "*Print*" option under the "*File*" pull down menu heading. This invokes the "Print Utility", allowing the current plot to be either be saved to file in any of a number of different formats, or sent to any nominated print queue along with any additional command line options to "***lpr***".

The default display on invoking the RDDM can be selected by choosing the "*Set Display as Default*" option from the "*File*" menus once the required parameter and display format has been selected. This saves the default parameters to a savefile which is restored on invocation of the RDDM. If a default parameter savefile does not exist, the default display on invocation is Cartesian time-series display in latest data mode. If a default parameter savefile exists, the default display can be returned to Cartesian time-series display in latest data mode by selecting the "*Delete Default Settings*" from the "*File*" menu.

4.10.2.2 Keyboard Accelerators

Many of the pull-down menu options are accessible from the keyboard with the use of `<ALT>-<single key>` combinations. For example, the File menu options can be accessed using `<ALT>-P` to invoke the Print Utility, `<ALT>-S` to save the current display options as default, `<ALT>-K` to revert to the default options, and `<ALT>-W` to close the widget. In addition, the user may use `<ALT>-L` to quickly display the latest data set acquired, `<ALT>-Q` to access queued data sets, and `<ALT>-A` to allow the selection of archive data sets. In latest data mode, the `<ALT>-T` option can be used to change the experiment tag to be viewed. The Sea Scatter Removal Utility can be invoked using the `<ALT>-E` option. This manual page may be displayed by pressing `<ALT>-H`.

Of particular use are the keyboard accelerators used for changing the scaling of the various data displays. The up and down arrows control the scale of the abscissa axis for all plots other than stacked, image and ball of wool plots, and the display range for stacked and image plots. The left and right arrows control the scale of the ordinate axis, and the magnification of the ball-of-wool diagrams along both orthogonal axes. Abscissa panning for stacked and image plots is accomplished using up and down arrow key in combination with the shift key. Ordinate panning is accomplished with the use of the left/right arrow keys in combination with the shift key.

4.10.2.3 Resizing Facility

The raw data display module may be resized as desired.

4.10.2.4 Environment variables

ANALYSIS_DIR: The root directory of the analysis distribution.

ARCHIVE_DIR: The directory in which archived data are stored.

SPOOL_DIR: The raw data file spool directory.

SUFFIX: The file name suffix stub to search for in the queue.

TMP: A temporary directory for spooling print jobs etc.

4.10.2.5 Files

RDDM usage is logged to the file "`$ANALYSIS_DIR/log/display.log`". Users should consult this file for further information on any problems observed using the RDDM.

For on-line Linux operation, the size of this file is controlled by "**logrotate**" as specified in the file "`/etc/logrotate/radarlogs`". Information on **logrotate** can be obtained from the command line using "man logrotate".

Savefiles of default parameters for use on invocation of RDDM are stored in "`$ANALYSIS_DIR/control/.rddm_default`".

The default filename for files produced by the "Print Utility" is "`$TMP/rddm000.<ext>`" where `<ext>` is the file extension appropriate to the file format.

4.10.2.6 Limitations

The data files in the queue must be ATRAD data format (ADF) files. This limitation is due to the way in which timestamps are extracted from queued files.

4.10.2.7 The Sea Scatter Removal Utility

The RAW data display sea scatter removal configuration utility allows the evaluation of the performance of different sets of parameter settings for sea scatter removal. This allows suitable parameters to be determined for analysis and postanalysis configurations.

The sea echo removal algorithm routine measures the ratio of the amplitudes of the sea echo peak to the maximum amplitude of the atmospheric echo component. (The atmospheric echo component is defined as that part of the frequency spectrum lying between, but not inclusive of, the positive and negative sea echo frequency bands.) The "*Ratio limit*" defines the threshold for determining whether the sea echo peak should be removed. If the actual ratio exceeds the ratio limit, the sea echo removal algorithm is applied. The "*Frequency Notch Range*" is the full-width frequency range (in Hz) over which the sea echo removal algorithm is applied. The "*Start range*" and "*End range*" define the ranges over which the removal algorithm is applied. The algorithm is applied inclusive of these end point ranges. The range of frequencies over which the notching is applied can be displayed for spectral plots by selecting the "*Enable*" option of "*Display Frequency Notch Range*". The dashed line denotes the sea scatter frequency, while the dotted line denotes the notching range.

The "*Apply*" and "*Disable*" buttons allow the algorithm to be applied and disabled, respectively. The "*Save*" button allows the currently configured parameters to be saved to a configuration file to be used whenever the sea scatter removal configuration utility is invoked. The "*Close*" button exits the utility.

On exiting the utility, the parameters used immediately prior to exiting are thereafter used for all raw data display formats.

4.10.3 The FCA Analysis Module

4.10.3.1 Description

The FCA analysis module embodies the full correlation analysis as described in *"The Analysis of Spaced Sensor Records by Correlation Techniques"*, by B. H. Briggs, Handbook for Middle Atmosphere Program, **13**, pp 166 - 186, 1984. A large amount of literature is available describing the FCA technique and its practical application to the analysis of radar data. It is beyond the scope of this manual to describe the analysis itself, apart from such aspects as output data formats and the meanings of the various error codes produced.

The FCA can be configured to store mean angles of arrival (MAOAs). This option allows the determination of "corrected vertical velocities", whereby the vertical velocity is corrected for leakage from the horizontal velocity due to non zero MAOAs, as described in "*VHF radar measurements of in-beam incidence angles and associated vertical-beam radial velocity corrections*", by. M. F. Larsen and J. Rottger, Journal of Atmospheric and Oceanic Technology, vol 8, 1991. As the MAOAs are affected by phase calibration errors, it is important that receiver calibration has been performed prior to analysis. Receiver calibration is described in Including receiver calibration estimates in the analysis and display suite.

FCA analysis can be configured to be performed using 3 or 4 antennas. For three antennas, the analysis is restricted to configurations where the angles between antenna baselines are all within 30 to 90 degrees. For four antennas, the analysis is restricted to rectangular or Y- configurations, where the vector sum of the inner to outer spacings sum to zero. For alternative antenna configurations, the analysis will report that the antenna configuration is unsuitable for analysis.

The FCA analysis can be configured to be applied over a limited height range, with extra coherent integration, and with access to additional analysis, as described in Control files used by the analysis and display suite.

4.10.3.2 Analysed Data File Format

FCA analysed data are written to disk in a binary format. Individual data files hold up to 24 hours of analysed data and are identified by the year, month, and day during which the data were recorded. During continuous data acquisition, each analysed data file begins at midnight, UTC. The FCA analysed data format is described in detail in Appendix C: ATRAD Analysed Data Format.

4.10.3.3 Error Codes

The following table describes the types of error codes produced by the FCA analysis. Note that criteria 3, 5, and 10 may be reconfigured by the user if required by creating the appropriate control file, as described in Control files used by the analysis and display suite.

0	No error - analysis result ok.
1	Time series unsuitable for analysis (signal amplitude too low, or interference present)
2	Signal to noise ratio < -3 dB
3	Fading time > 6 s
4	At least one cross correlation function maxima lies outside end points
5	Percentage time discrepancy > 35%
6	$V_c{}^2 < 0$
7	Ground diffraction pattern analysis breaks down
8	Apparent velocity magnitude $V_a > 400$ ms^{-1} OR True velocity magnitude $V_t > 200$ ms^{-1}
9	Difference between apparent V_a and true V_t direction exceeds 40 degrees.
10	$V_a > 10 V_t$
11	$V_t > 1.5 V_a$
12	Poor fit to cross-correlation function (CCF) maximum
13	At least one CCF maximum < 0.2
14	Poor zero-lag auto-correlation function (ACF) interpolation
15	Insufficient number of lags on main peak of mean auto-correlation function (MACF) to estimate fading time
16	Poor fit to MACF

17	Secondary maxima in MACF > 0.5 (oscillatory)
18	Mean ACF > 0.5 at end lags
19	One or more CCF maxima exceeds 1.0

4.10.4 The FCA Display Module

4.10.4.1 Description

The Full Correlation Analysis Display Module (FCADM) is a compound widget allowing Full Correlation Analysis (FCA) analysed data to be displayed in one of a number of different statistical forms. The FCA provides estimates of the horizontal and vertical wind velocities, and parameters relating to the spatial and temporal properties of the irregularities responsible for the radar backscatter. As a by-product of the analysis the returned signal powers and signal-to-noise ratios (SNR) of all receiving channels are also estimated.
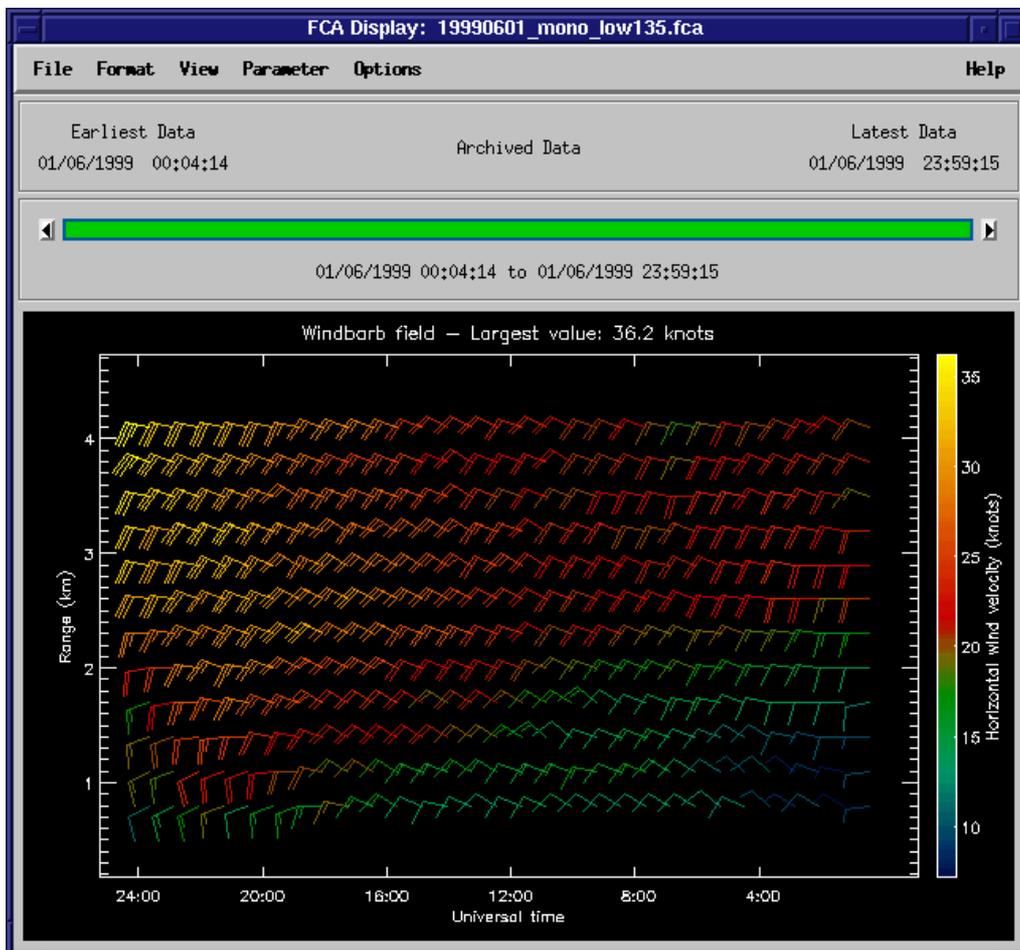
The FCA Display Module

The FCADM widget is divided into four main areas. At the top of the widget is a row of motif-style pull-down menus which provide access to all FCADM functionality. The menu headings include "*File*", "*Format*", "*View*", "*Parameter*", "*Options*", and "*Help*". Immediately below the menu bar (from left to right) appear the time of the initial available ("Earliest Data") record, the time-duration mode, and the time of the final available record ("Latest Data"). Below these labels

appears the point-and-click time-selection window and the display window. The time-selection window displays the start and end times for the data currently on display in the display window.

The FCADM allows the display of the estimated horizontal and vertical wind velocities, the returned signal power, and the SNR. The display parameter is selected from the "*Parameters*" menu.

The display formats used for the FCADM include profile averages, time-series profiles, and image plots for all parameters, plus vector flow field plots of horizontal and vertical velocities, and windbarb plots of horizontal velocities. Image plots can be performed with or without contours or smoothing. The display format is selected from the "*Format*" menu. The default display on entering the FCADM is the average horizontal wind velocity profile for the last hour.

The FCADM allows the display of the FCA results over the last 24 hours, the last hour, and for the last analysed record. The required duration is selected from the "*View*" menu. Recently analysed data are automatically read into the FCADM. The analysed data tag to display can be selected using the "*Select Analysed Data Tag*" option from the "*View*" menu. Selecting this option launches a widget allowing the use to select any of the analysed data tags of FCA analysed data stored in the directory specified by the environment variable ANALYSED_DATA (see under the ENVIRONMENT VARIABLES heading below). Archived FCA-analysed data-sets for previous days can also be selected and viewed from the "*Archived Data*" option of the "*View*" menu. Selecting this option launches a pickfile menu allowing the user to select the required file.

In last 24 hour and archived modes the duration over which the results are displayed can be selected using the time-selection window. The left and right mouse buttons may be used to select the initial and final times, respectively, of the required time-selection window duration, while the middle mouse button may be used to select an individual record. The required time-selection window duration can also be specified from the "*Window Averaging*" option of the "*Options*" menu.

The user also has control over many features of the displayed data, including scaling of the horizontal axes for profile average plots, and selection of the size of the informative labels included with the display. These features may be chosen from the "*Options*" menu. Hardcopies of the display can be obtained by selecting the "*Print*" option under the "*File*" pull down menu heading. This invokes the "Print Utility", allowing the current plot to be either be saved to file in any of a number of different formats, or sent to any nominated print queue along with any additional command line options to "*lpr*".

The default display on invoking the FCADM can be selected by choosing the "*Set Display as Default*" option from the "*File*" menus once the required parameter and display format has been selected. This saves the default parameters to a savefile which is restored on invocation of the FCADM. If a default parameter savefile does not exist, the default display on invocation is the average horizontal wind velocity profile for the last hour. If a default parameter savefile exists, the default display can be returned to average horizontal wind velocity profile for the last hour by selecting the "*Delete Default Settings*" from the "*File*" menu.

4.10.4.2 Keyboard Accelerators

Many of the pull-down menu options are accessible from the keyboard with the use of `<ALT>`-`<single key>` combinations. For example, the File menu options can be accessed using `<ALT>-P` to invoke the Print Utility, `<ALT>-S` to save the current display options as default, `<ALT>-K` to revert to the original default options, and `<ALT>-W` to close the widget. In addition, the user may use `<ALT>-L` to display the results of the last analysed record, `<ALT>-R` to display the last hour of analysed records, `<ALT>-D` to display the last 24 Hours of analysed data records, and `<ALT>-A` to allow the selection of archived analysed data sets. If archived data is not being viewed, the `<ALT>-T` option can be used to change the analysed data tag to be viewed. Outlier rejection can be enabled and disabled using `<ALT>-Y`. A text print-out of the results of the last analysed record can be obtained using `<Alt>-N`. This manual page may be displayed using `<ALT>-H`.

Of particular use are the keyboard accelerators used for changing the scaling of the various data displays. The up and down arrows control the scale of the vertical axis. Vertical panning is accomplished using up and down arrow key in combination with the shift key. The left and right

control the scale of the horizontal axis for profile average plots and the appropriate parameter scale for other formats.

4.10.4.3 Resizing facility

The widget may be resized as desired.

4.10.4.4 Environment variables

`ANALYSIS_DIR:`   The root directory of the analysis distribution.

`ANALYSED_DATA:`   The directory where analysed data files are placed.

`PRINT_CMD:`   The command line switches to pass to lpr.

`TMP:`   A temporary directory for spooling print jobs etc.

4.10.4.5 Files

FCADM usage is logged to the file "`$ANALYSIS_DIR/log/display.log`". Users should consult this file for further information on any problems observed using FCADM.

For on-line Linux operation, the size of this file is controlled by "***logrotate***" as specified in the file "`/etc/logrotate.d/radarlogs`". Information on ***logrotate*** can be obtained from the command line using "man logrotate".

Savefiles of default parameters for use on invocation of FCADM are stored in "`$ANALYSIS_DIR/control/.fcadm_default`".

The default filename for files produced by the "Print Utility" is "`$TMP/fcadm000.<ext>`" where `<ext>` is the file extension appropriate to the file format.

4.10.5 The DAE/DPE Analysis Module

4.10.5.1 Description

The differential absorption experiment (DAE) and the differential phase experiment (DPE) are employed to estimate mesospheric electron densities. The DAE uses the amplitude ratio of the extraordinary (E) to ordinary (O) mode backscattered signals, while the DPE uses the phase differences between the E- and O-mode signals.

The techniques require collision frequency and the magnetic field profiles, which are both site dependent. The collision frequency for each site is determined using pressure profiles interpolated from the COSPAR International Reference Atmosphere (CIRA86) model (see `http://nssdc.gsfc.nasa.gov/space/model/atmos/cospar1.html`), while the magnetic field profile is determined using the International Geomagnetic Reference Field (IGRF) model (see `http://nssdc.gsfc.nasa.gov/space/models/igrf.html`). The collision frequency and magnetic field profiles are then employed to calculate the complex refractive index profile, from which the reflection coefficient profiles are derived.

The DAE technique uses the differences in the amplitude ratios of the signal and reflection coefficients between adjacent heights to determine the electron density within the intermediate height interval. The DPE uses the difference in the phase differences of the signal and reflection coefficients. The height coverage of both experiments is limited at upper heights by small signal amplitude ratios due to a lack of E-mode returns, and at lower heights by small signal to noise ratios.

Although the height coverage for the DPE is the same as for the DAE, the numerator and denominator of the equation used for the DPE calculation usually pass through zero at about 66 km. Spurious large electron densities can therefore result if the numerator and denominator do not pass through zero at the same height. To avoid this possibility, the DPE electron density is not calculated for heights where the magnitude of the denominator is less than a preset threshold.

4.10.5.2 References:

A.H. Manson and C. E. Meek (1984),
Partial reflection D-region electron densities,
MAP Handbook **13**, p113 - 123.

J. S. Belrose (1970),
Radio wave probing of the ionosphere by the partial reflection of radio waves (from heights below 100 km),
JATP, **32**, 567-597

4.10.5.3 Analysed Data File Format

DAE analysed data are written to disk in a binary format. Individual data files hold up to 24 hours of analysed data and are identified by the year, month, and day during which the data were recorded. During continuous data acquisition, each analysed data file begins at midnight, UTC. The FCA analysed data format is described in detail in Appendix C.

4.10.5.4 Error codes - SNR

0	Both O and E mode SNRs acceptable
1	Time series unsuitable for analysis (signal amplitude too low, or interference present , or saturation percentage too high)
2	One or both mode's SNR is less than -3 dB

4.10.5.5 Error codes - DAE

0	Analysis successful
1	No calculation performed for this height. (DAE analysis requires information from adjacent ranges. There is therefore always a loss of one range at the edge of the sampling regime.)
2	SNR too low for this or next height
3	SNR too low for this and next height
4	DAE estimate of electron density less than 10 cm^{-3}
5	Amplitude ratio below user selected threshold

4.10.5.6 Error codes - DPE

0	Analysis successful
1	No calculation performed for this height. (DPE analysis requires information from adjacent ranges. There is therefore always a loss of one range at the edge of the sampling regime.)
2	SNR too low for this or next height.
3	SNR too low for this and next height
4	DPE estimate of electron density less than 10 cm^{-3}
5	Amplitude ratio below user selected threshold
6	Denominator for DPE calculation too small

4.10.6 The DAE/DPE Display Module

4.10.6.1 Description

The Differential Absorption Experiment Display Module (DAEDM) is a compound widget allowing the analysed data produced by the Differential Absorption Experiment (DAE) and Differential Phase Experiment (DPE) to be displayed in one of a number of different statistical forms. The Differential absorption and phase experiments each provide an estimate of the electron density in the range region where both O- and E-mode polarisation returns are appreciable. The DAE calculates the electron density using the ratio of the amplitudes of the E- to O- mode returns, while the DPE uses the phase difference between the E- and O- mode returns.
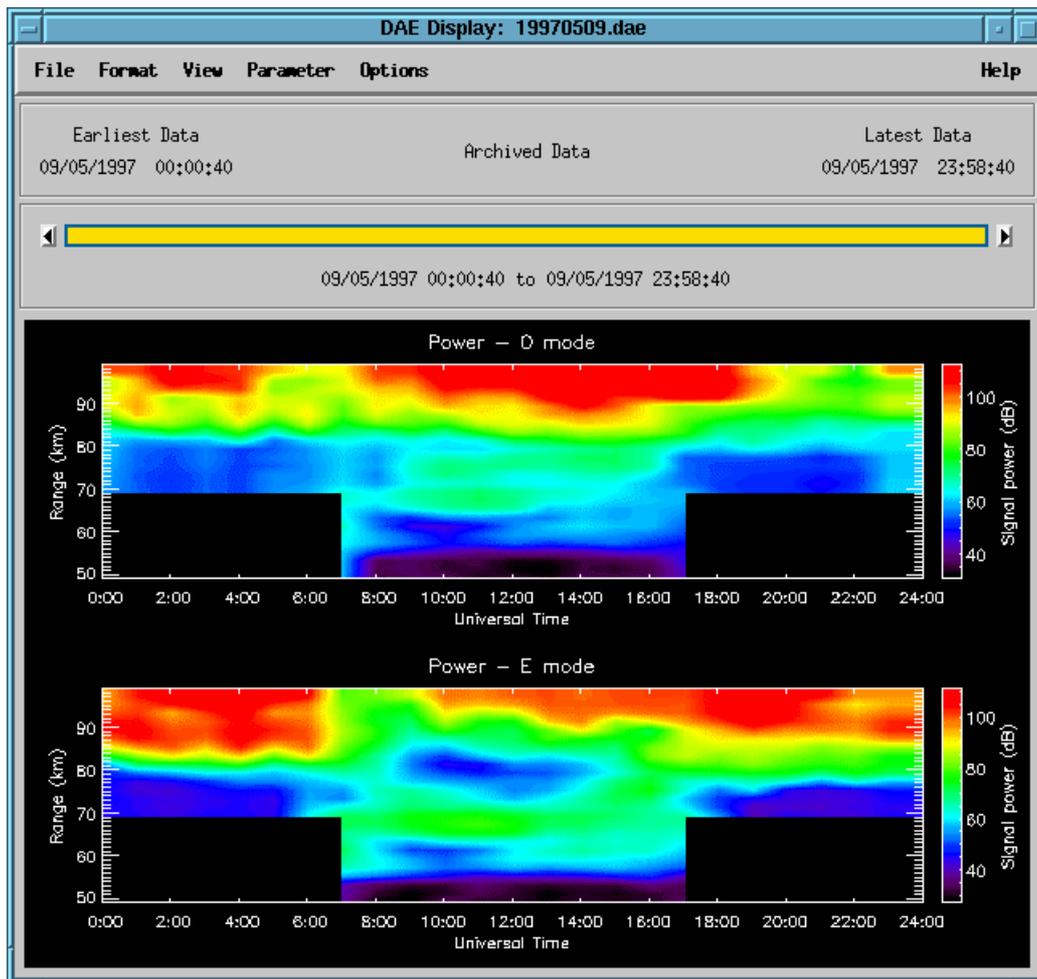
The DAE/DPE Display Module

The DAEDM widget is divided into four main areas. At the top of the widget is a row of motif-style pull-down menus which provide access to all DAEDM functionality. The menu headings include "File", "Format", "View", "Parameter", "Options", and "Help". Immediately below the menu bar (from left to right) appear the time of the initial available ("Earliest Data") record, the time-duration mode, and the time of the final available record ("Latest Data"). Below these labels appears the point-and-click time-selection window and the display window. The time-selection window displays the start and end times for the data currently on display in the display window.

The DAEDM allows the display of the estimated DAE and DPE electron density, the signal and reflection coefficient amplitude ratios and phase differences, and the O- and E-mode signal powers. The display parameter is selected from the "Parameters" menu.

The display formats used for the DAEDM include profile averages, time-series profiles, and image plots. Image plots can be performed with or without contours or smoothing. The display format is selected from the "Format" menu. The default display on entering the DAEDM is the average DAE and DPE electron density profile for the last hour.

The DAEDM allows the display of the DAE results over the last 24 hours, the last hour, and for the last analysed record. The required duration is selected from the "View" menu. Recently analysed data are automatically read into the DAEDM. The analysed data tag to display can be selected using the "Select Analysed Data Tag" option from the "View" menu. Selecting this option launches a widget allowing the use to select any of the analysed data tags of DAE analysed data stored in the directory specified by the environment variable ANALYSED_DATA (see under the ENVIRONMENT VARIABLES heading below). Archived DAE-analysed data-sets for previous days can also be selected and viewed from the "Archived Data" option of the "View" menu. Selecting this option launches a pickfile menu allowing the user to select the required file.

In last 24 hour and archived modes the duration over which the results are displayed can be selected using the time-selection window. The left and right mouse buttons may be used to select the initial and final times, respectively, of the required time-selection window duration, while the middle mouse button may be used to select an individual record. The required time-selection window duration can also be specified from the "Window Averaging" option of the "Options" menu.

The user also has control over many features of the displayed data, including scaling of the horizontal axes for profile average plots, and selection of the size of the informative labels included with the display, and the overplotting of DAE and DPE electron densities or O- and E-mode signal powers. These features may be chosen from the "Options" menu. Hardcopies of the display can be obtained by selecting the "Print" option under the "File" pull down menu heading. This invokes the "Print Utility", allowing the current plot to be either be saved to file in any of a number of different formats, or sent to any nominated print queue along with any additional command line options to "lpr".

The default display on invoking the DAEDM can be selected by choosing the "Set Display as Default" option from the "File" menus once the required parameter and display format has been selected. This saves the default parameters to a savefile which is restored on invocation of the DAEDM. If a default parameter savefile does not exist, the default display on invocation is the average DAE and DPE electron density profile for the last hour. If a default parameter savefile exists, the default display can be returned to the average DAE and DPE electron density profile for the last hour by selecting the "Delete Default Settings" from the "File" menu.

4.10.6.2 Keyboard Accelerators

Many of the pull-down menu options are accessible from the keyboard with the use of `<ALT>`-`<single key>` combinations. For example, the File menu options can be accessed using `<ALT>`-P to invoke the Print Utility, `<ALT>`-S to save the current display options as default, `<ALT>`-K to revert to the default options, and `<ALT>`-W to close the widget. In addition, the user may use `<ALT>`-L to display the results of the last analysed record, `<ALT>`-R to display the last hour of analysed records, `<ALT>`-D to display the last 24 Hours of analysed data records, and `<ALT>`-A to allow the selection of archived analysed data sets. If archived data is not being viewed, the `<ALT>`-T option can be used to change the analysed data tag to be viewed. Outlier rejection can be enabled and disabled using `<ALT>`-Y. A text print-out of the results of the last analysed record can be obtained using `<Alt>`-N. This manual page may be displayed using `<ALT>`-H.

Of particular use are the keyboard accelerators used for changing the scaling of the various data displays. The up and down arrows change the scale of the vertical axis. Vertical panning is accomplished using the up and down arrow key in combination with the shift key. The left and right arrows control the scale of the horizontal axis for average plots and the appropriate parameter scale for other formats.

4.10.6.3 Resizing Facility

The DAE display module may be resized as desired.

4.10.6.4 Environment variables

`ANALYSIS_DIR:`   The root directory of the analysis distribution.

`ANALYSED_DATA:`   The directory in which analysed data are stored.

`PRINT_CMD:`   The command line switches to pass to lpr SPOOL_DIR:

`TMP:`   A temporary directory for spooling print jobs etc.

4.10.6.5 Files

DAEDM usage is logged to the file "`$ANALYSIS_DIR/log/display.log`". Users should consult this file for further information on any problems observed using the DAEDM.

For on-line Linux operation, the size of this file is controlled by "newsyslog" as specified in the file "`/etc/newsyslog.conf`". Information on newsyslog can be obtained from the command line using "man newsyslog".

Savefiles of default parameters for use on invocation of DAEDM are stored in "`$ANALYSIS_DIR/control/.daedm_default`".

The default filename for files produced by the "Print Utility" is "`$TMP/daedm000.<ext>`" where `<ext>` is the file extension appropriate to the file format.

4.10.7 The SCA Analysis Module

4.10.7.1 Description

The SCA analysis module embodies the spatial correlation analysis as described in *"Spatial Correlation analysis revistied : Theory, and application using "radar backscatter model data"*, by D. A. Holdsworth, Radio Sci., 34(3), 629 - 642,. Although a relatively new analysis, its advantage lies in its relative insensitivity to measurement biases introduced through inappropriate antenna spacings and characteristic differences between different channels.

SCA analysis can only be configured to be performed using 4 antennas. The antenna configuration allowed is limited to two general possibilities: 1) the case where the antennas are arranged in a "Y-configuration", such that the vector sum of the inner to outer antenna separations sum to zero, and the angles between antenna baselines for the "outside" antennas are within 30 to 90 degrees. 2) The case where the antennas are arranged in a rectangle, such that the ratio of the largest to smallest baselines are less than 1.5. For alternative antenna configurations, the analysis will report that the antenna configuration is unsuitable for analysis.

The SCA can be configured to store mean angles of arrival (MAOAs). This option allows the determination of "corrected vertical velocities", whereby the vertical velocity is corrected for leakage from the horizontal velocity due to non zero MAOAs, as described in *"VHF radar measurements of in-beam incidence angles and associated vertical-beam radial velocity corrections"*, by. M. F. Larsen and J. Rottger, Journal of Atmospheric and Oceanic Technology, vol 8, 1991. As the MAOAs are affected by phase calibration errors, it is important that receiver calibration has been performed prior to analysis. Receiver calibration is described in Including receiver calibration estimates in the analysis and display suite.

The SCA analysis can be configured to be applied over a limited height range, with extra coherent integration, and with access to additional analysis, as described in Control files used by the analysis and display suite.

4.10.7.2 Analysed Data File Format

FCA analysed data are written to disk in a binary format. Individual data files hold up to 24 hours of analysed data and are identified by the year, month, and day during which the data were recorded. During continuous data acquisition, each analysed data file begins at midnight, UTC. The FCA analysed data format is described in detail in Appendix C: ATRAD Analysed Data Format.

4.10.7.3 Error Codes

The following table describes the types of error codes produced by the SCA analysis.

0	No error - analysis result ok.
1	Poor zero-lag interpolation
2	Signal to noise ratio less than 0 dB
3	Mean auto-correlation function (MACF) half-width exceeds 6 s, or is oscillatory
4	Spatial correlation maxima lie more than twice antenna spacing from zero spatial lag
5	Estimate of characteristic ellipse axis parameter negative (not implemented)
6	Fitted spatial correlation maxima exceed unity
7	Significant difference in correlation for middle spatial lags
8	Significant difference in widths of Gaussian fits to parallel arm
9	Poor Gaussian fit to at least one spatial lag arm of spatial correlations
10	Gaussian fit to one more arms locates a minimum
11	Poor intersection of lines through the spatial correlation maxima (not implemented)
12	Velocity > 200 ms^{-1}

4.10.8 The SCA Display Module

4.10.8.1 Description

The Spatial Correlation Analysis Display Module (SCADM) is a compound widget allowing Spatial Correlation Analysis (SCA) analysed data to be displayed in one of a number of different statistical forms. The SCA provides estimates of the horizontal and vertical wind velocities. As a by-product of the analysis the returned signal powers and signal-to-noise ratios (SNR) of all receiving channels are also estimated.
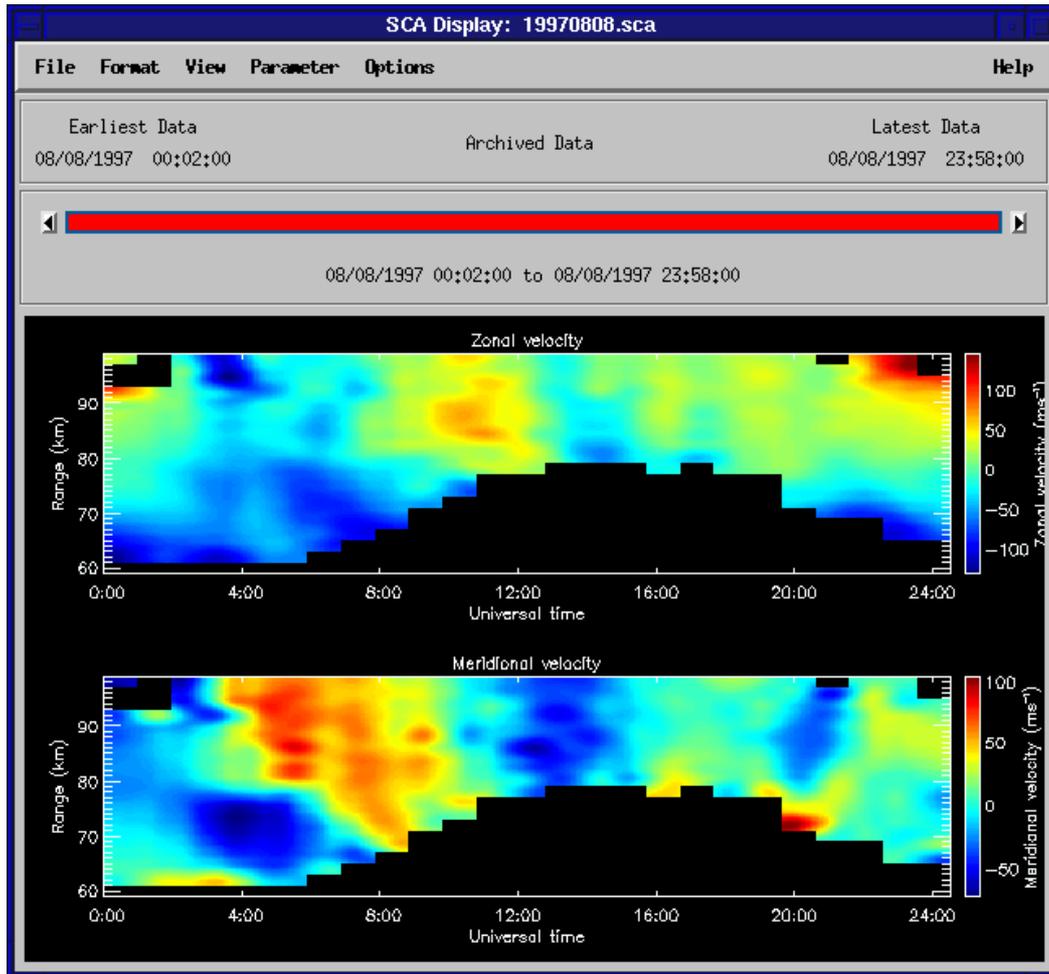
The SCA Display Module

The SCADM widget is divided into four main areas. At the top of the widget is a row of motif-style pull-down menus which provide access to all SCADM functionality. The menu headings include "*File*", "*Format*", "*View*", "*Parameter*", "*Options*", and "*Help*". Immediately below the menu bar (from left to right) appear the time of the initial available ("Earliest Data") record, the time-duration mode, and the time of the final available record ("Latest Data"). Below these labels appear the point-and-click time-selection window and the display window. The time-selection window displays the start and end times for the data currently on display in the display window.

The SCADM allows the display of the estimated horizontal and vertical wind velocities, the returned signal power, and the SNR. The display parameter is selected from the "*Parameters*" menu.

The display formats used for the SCADM include profile averages, time-series profiles, and image plots for all parameters, plus vector flow field plots for horizontal and vertical velocities, and windbarb

plots of horizontal velocities. Image plots can be performed with or without contours or smoothing. The display format is selected from the "*Format*" menu. The default display on entering the SCADM is the average horizontal wind velocity profile for the last hour.

The SCADM allows the display of the SCA results over the last 24 hours,the last hour, and for the last analysed record. The required duration is selected from the "*View*" menu. Recently analysed data are automatically read into the SCADM. The analysed data tag to display can be selected using the "*Select Analysed Data Tag*" option from the "*View*" menu. Selecting this option launches a widget allowing the use to select any of the analysed data tags of SCA analysed data stored in the directory specified by the environment variable ANALYSED_DATA (see under the

ENVIRONMENT VARIABLES heading below). Archived SCA-analysed data-sets for previous days can also be selected and viewed from the "*Archived Data*" option of the "*View*" menu. Selecting this option launches a pickfile menu allowing the user to select the required file.

In last 24 hour and archived modes the duration over which the results are displayed can be selected using the time-selection window. The left and right mouse buttons may be used to select the initial and final times, respectively, of the required time-selection window duration, while the middle mouse button may be used to select an individual record. The required time-selection window duration can also be specified from the "*Window Averaging*" option of the "*Options*" menu.

The user also has control over many features of the displayed data, including scaling of the horizontal axes for profile average plots, and selection of the size of the informative labels included with the display. These features may be chosen from the "*Options*" menu. Hardcopies of the display can be obtained by selecting the "*Print*" option under the "*File*" pull down menu heading. This invokes the "Print Utility", allowing the current plot to be either be saved to file in any of a number of different formats, or sent to any nominated print queue along with any additional command line options to "**lpr**".

The default display on invoking the SCADM can be selected by choosing the "*Set Display as Default*" option from the "*File*" menus once the required parameter and display format has been selected. This saves the default parameters to a savefile which is restored on invocation of the SCADM. If a default parameter savefile does not exist, the default display on invocation is the average horizontal wind velocity profile for the last hour. If a default parameter savefile exists, the default display can be returned to average horizontal wind velocity profile for the last hour by selecting the "*Delete Default Settings*" from the "*File*" menu.

4.10.8.2 Keyboard Accelerators

Many of the pull-down menu options are accessible from the keyboard with the use of `<ALT>`-`<single key>` combinations. For example, the File menu options can be accessed using `<ALT>-P` to invoke the Print Utility, `<ALT>-S` to save the current display options as default, `<ALT>-K` to revert to the default options, and `<ALT>-W` to close the widget. In addition, the user may use `<ALT>-L` to display the results of the last analysed record, `<ALT>-R` to display the last hour of analysed records, `<ALT>-D` to display the last 24 Hours of analysed data records, and `<ALT>-A` to allow the selection of archived analysed data sets. If archived data is not being viewed, the `<ALT>-T` option can be used to change the analysed data tag to be viewed. Outlier rejection can be enabled and disabled using `<ALT>-Y`. A text print-out of the results of the last analysed record can be obtained using `<Alt>-N`. This manual page may be displayed using `<ALT>-H`.

Of particular use are the keyboard accelerators used for changing the scaling of the various data displays. The up and down arrows control the scale of the vertical axis. Vertical panning is accomplished using up and down arrow key in combination with the shift key. The left and right control the scale of the horizontal axis for profile average plots and the appropriate parameter scale for other formats.

4.10.8.3 Resizing facility

The widget may be resized as desired.

4.10.8.4 Environment variables

`ANALYSIS_DIR`: The root directory of the analysis distribution.

`ANALYSED_DATA`:   The directory where analysed data files are placed.

`PRINT_CMD`:   The command line switches to pass to lpr.

`TMP`:   A temporary directory for spooling print jobs etc.

4.10.8.5 Files

SCADM usage is logged to the file: "`$ANALYSIS_DIR/log/display.log`". Users should consult this file for further information on any problems observed using SCADM.

For on-line Linux operation, the size of this file is controlled by "**logrotate**" as specified in the file "/etc/logrotate.d/radarlogs". Information on **logrotate** can be obtained from the command line using "man logrotate".

Savefiles of default parameters for use on invocation of SCADM are stored in "$ANALYSIS_DIR/control/.scadm_default".

The default filename for files produced by the "Print Utility" is "$TMP/scadm000.<ext>" where "<ext>" is the file extension appropriate to the file format.

4.10.9 The IDI Analysis and Postanalysis Modules

4.10.9.1 Description

The IDI analysis module embodies the imaging Doppler interferometry analysis as described in *"Mesospheric Observations using a 2.66 MHz Radar as an Imaging Doppler interferometer: Description and first results"*, G. W. Adams et al, J. Geophys. Res 91(A2), 1671-1683. A large amount of literature is available describing the IDI technique and its practical application to the analysis of radar data. It is beyond the scope of this manual to describe the specifics of the analysis itself, apart from such aspects as output data formats and the meanings of the various error codes produced.

The first step in the IDI analysis is the determination of the angles of the effective scattering positions (ESPs). The second step is the determination of the analysis parameters. The ESP can be written to file and spooled for IDI postanalysis for the determination of the analysis parameters from multiple data acquisitions. As the ESP are affected by phase calibration errors, it is important that receiver calibration has been performed prior to analysis. Receiver calibration is described in Including receiver calibration estimates in the analysis and display suite.

IDI analysis can be configured to be performed using either 3 or 4 antennas. For 3-antenna analysis, the analysis is restricted to configurations where the angles between antenna baselines are all within 30 to 90 degrees. For 4 antenna analysis, the antenna configuration allowed is limited to the case where the antennas are arranged in a "Y-configuration", such that the vector sum of the inner to outer antenna separations sum to zero, and the angles between antenna baselines for the "outside" antennas are within 30 to 90 degrees. For alternative antenna configurations, the analysis will report that the antenna configuration is unsuitable for analysis.

The IDI analysis can be configured to be applied over a limited height range, with extra coherent integration, and with access to additional analysis thresholds, as described in Control files used by the analysis and display suite. If access to additional analysis thresholds is available, and the 4 antenna Y-configuration is selected, the IDI analysis configuration module allows an extra control allowing the user to enable the use of normalised phase discrepancy threshold. This threshold is applied as a plane wave criterion to verify that the ESP for any frequency bin results from a single discrete scatterer. No plane wave criterion is available for 3-antenna analysis.

IDI analysed (and postanalysed) data can be calculated as *height* profiles rather than *range* profiles. Strictly speaking, the analysis is intended for calculating height profiles, but calculation of range profiles may prove more useful for comparison with FCA and SCA analyses, which necessarily use range profiles since they are applied to data collected from a single range gate.

4.10.9.2 Analysed Data File Format

IDI analysed data are written to disk in a binary format. Individual data files hold up to 24 hours of analysed data and are identified by the year, month, and day during which the data were recorded. During continuous data acquisition, each analysed data file begins at midnight, UTC. The IDI analysed data format is described in detail in Appendix C: ATRAD Analysed Data Format.

4.10.9.3 Error Codes

The following table describes the types of error codes produced by the IDI analysis.

0	No error - analysis result ok.
1	Time series unsuitable for analysis (signal amplitude too low, or interference

	present)
2	Fewer than three scatterers available at this height (IDI requires a minimum of three scatterers for wind velocity determination)
3	Velocity > 200 ms^{-1}
4	Vertical velocity > 10 ms^{-1}
5	Scatterer azimuth estimate not available (note, parameters other than scatterer azimuth are still valid)
6	Turbulent velocity estimate not available (note, parameters other than turbulent velocity are still valid)

4.10.10 The DBS Analysis Module

4.10.10.1 Description

The DBS analysis can be performed using two different techniques. The combined analysis combines the signals from each receiving channel and performs a standard single channel Doppler analysis to estimate the radial velocity, spectral width, SNR and Power. This analysis may be succeptible to the effects of aspect sensitivity, which acts to produce effective beam directions biased towards the zenith, thereby resulting in the underestimation of the estimated radial velocities.

The Hybrid Doppler interferometry (HDI) uses of poststatistics steering (PSS) to steer the receive antenna beam pattern through a series of preselected beam directions. The effective returned power is estimated for each receive beam, and the direction of maximum power is estimated from the resulting power variation. If a Gaussian form is assumed for the transmit and receive beam patterns the resulting direction of maximum power can be shown to correspond the effective beam direction (EBD). The receive beam is re-steered into the EBD, and the standard Doppler analysis is applied to estimate the radial velocity, spectral width, SNR and Power. The aspect sensitivity parameter (θ_s) is calculated for off-zenith beams provided the zenith component of the EBD lies between the zenith and the transmitted beam zenith angle, and the EBD azimuth component of the EBD lies within 45° of the transmit beam azimuth.

For transmission on rows and columns, the HDI receive beam is steered in an array of 21 directions between the 1/e full-width angles of the transmit beam along the azimuth of the transmit beam direction. The EBD is estimated by performing Gaussian fit to the returned signal powers calculated for each receive beam direction. For transmission on spaced antennas, the HDI receive beam is steered in an 11 by 11 grid bounded by the 1/e full-width angles in the cardinal directions. The EBD is estimated by performing a two-dimensional Gaussian fit to the returned signal powers calculated for each receive beam direction.

Both the combined and HDI analyses can be applied using either correlation or spectral analyses. The choice of analysis (i.e. HDI or combined) and domain (i.e. correlation or spectral) can be made using the DBS analysis configuration utility. It is recommended that the spectral analysis is used for sites with interference problems, such as clutter, sea scatter, and aircraft echoes, as spectral analysis is better suited to coping with such problems. Prior to analysis, the time-series can have extra coherent integration applied, and be combined into a single receiver channel. Spectral smoothing can be applied by splitting the time-series, and then calculating and combining the "split" spectra.

The DBS analysed data can subsequently be used to produce three-dimensional wind velocities using the VEL postanalysis. Please refer to the description of the VEL postanalysis on page 51 for further information.

4.10.10.2 Analysed Data File Format

DBS analysed data are written to disk in a binary format. Individual data files hold up to 24 hours of analysed data and are identified by the year, month, and day during which the data were recorded. During continuous data acquisition, each analysed data file begins at midnight, UTC. The DBS analysed data format is described in more detail in Appendix C: ATRAD Analysed Data Format.

4.10.10.3 Error codes

Please note that criteria 4 to 7 are applicable for HDI analysis only:

0	Analysis OK
1	Low dynamic range, or interference rejection (data contaminated by non-atmospheric signals)
2	SNR less than -6 dB
3	Projected horizontal velocity based on EBD and radial velocity > 200 ms^{-1} (off zenith beams only)
4	Maxima in power estimates is too close to edge of receive beam directions to allow estimation the EBD.
5	Azimuth angle of the EBD not within 45 degrees of the transmitted beam azimuth.
6	Zenith angle of EBD < 0
7	Zenith angle of EBD > transmitted beam zenith
8	Insufficient good power estimates with received beam angle to estimate the EBD

4.10.11 The DBS Display Module

4.10.11.1 Description

The Doppler Beam Steering Display Module (DBSDM) is a compound widget allowing Doppler Beam Steering (DBS) analysed data to be displayed in one of a number of different statistical forms. The DBS analysis provides estimates of the radial velocity, spectral width, effective beam pointing direction, aspect sensitivity, signal-to-noise ratio (SNR), and power for a number of transmitted beam directions.
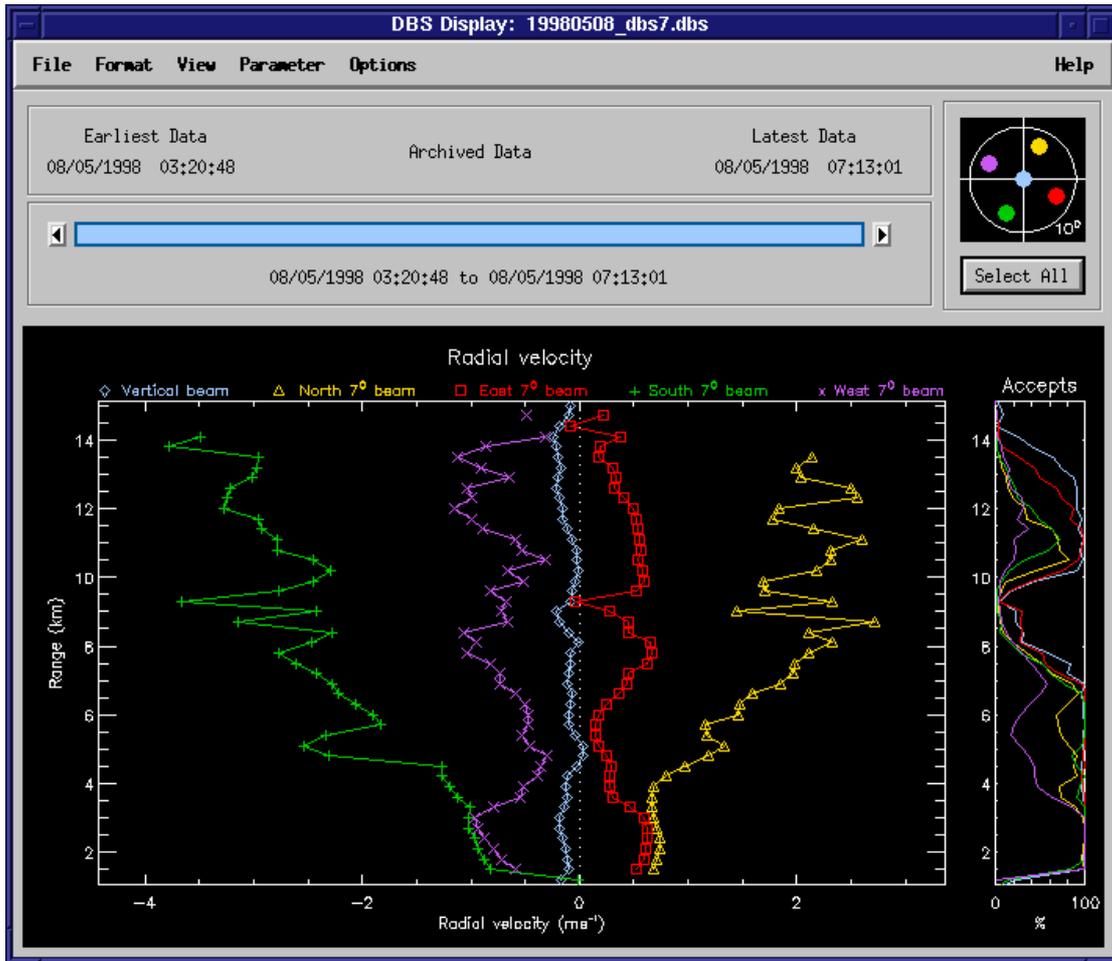
The DBS Display Module

The DBSDM widget is divided into five main areas. At the top of the widget is a row of motif-style pull-down menus which provide access to all DBSDM functionality. The menu headings include "*File*", "*Format*", "*View*", "*Parameter*", "*Options*", and "*Help*". Immediately below the menu bar (from left to right) appear the time of the initial available ("Earliest Data") record, the time-duration mode, the time of the final available record ("Latest Data"), and the point-and-click beam selector widget, which allows the user to display any of the available beam directions. Below these labels appears the point-and-click time-selection window and the display window. The time-selection window displays the start and end times for the data currently on display in the display window.

The DBSDM allows the display of the estimated radial wind velocities, spectral widths, effective beam zenith angles, aspect sensitivity parameters, returned signal power, and the SNR. The display parameter is selected from the "*Parameters*" menu. The display formats used for the DBSDM include profile averages, time-series profiles, and image plots. Image plots can be plotted with and without smoothing and contours. The display format is selected from the "*Format*" menu. The default display on entering the DBSDM is the average radial velocity profile for the last hour.

The DBSDM allows the display of the DBS results over the last 24 hours, the last hour, and for the last analysed record. The required duration is selected from the "*View*" menu. Recently analysed data are automatically read into the DBSDM. The analysed data tag to display can be selected using the "*Select Analysed Data Tag*" option from the "*View*" menu. Selecting this option launches a widget allowing the use to select any of the analysed data tags of DBS analysed data stored in the directory specified by the environment variable ANALYSED_DATA (see under the ENVIRONMENT VARIABLES heading below). Archived DBS-analysed data-sets for previous days

can also be selected and viewed from the "*Archived Data*" option of the "*View*" menu. Selecting this option launches a pickfile menu allowing the user to select the required file.

In last 24 hour and archived modes the duration over which the results are displayed can be selected using the time-selection window. The left and right mouse buttons may be used to select the initial and final times, respectively, of the required time-selection window duration, while the middle mouse button may be used to select an individual record. The required time-selection window duration can also be specified from the "*Window Averaging*" option of the "*Options*" menu.

The user also has control over many features of the displayed data, including scaling of the horizontal axes for profile average plots, and selection of the size of the informative labels included with the display. These features may be chosen from the "*Options*" menu. Hardcopies of the display can be obtained by selecting the "*Print*" option under the "*File*" pull down menu heading. This invokes the "Print Utility", allowing the current plot to be either be saved to file in any of a number of different formats, or sent to any nominated print queue along with any additional command line options to "*lpr*".

The default display on invoking the DBSDM can be selected by choosing the "*Set Display as Default*" option from the "*File*" menus once the required parameter and display format has been selected. This saves the default parameters to a savefile which is restored on invocation of the DBSDM. If a default parameter savefile does not exist, the default display on invocation is the average radial velocity profile for the nominal "first" beam (usually vertical) for the last hour. If a default parameter savefile exists, the default display can be returned to average radial velocity profile for the last hour by selecting the "*Delete Default Settings*" from the "*File*" menu.

4.10.11.2 Keyboard Accelerators

Many of the pull-down menu options are accessible from the keyboard with the use of `<ALT>`-`<single key>` combinations. For example, the File menu options can be accessed using `<ALT>-P` to invoke the Print Utility, `<ALT>-S` to save the current display options as default, `<ALT>-K` to revert to the default options, and `<ALT>-W` to close the widget. In addition, the user may use `<ALT>-L` to display the results of the last analysed record, `<ALT>-R` to display the last hour of analysed records, `<ALT>-D` to display the last 24 Hours of analysed data records, and `<ALT>-A` to allow the selection of archived analysed data sets. If archived data is not being viewed, the `<ALT>-T` option can be used to change the analysed data tag to be viewed. Outlier rejection can be enabled and disabled using `<ALT>-Y`. A text print-out of the results of the last analysed record can be obtained using `<Alt>-N`. This manual page may be displayed using `<ALT>-H`.

Of particular use are the keyboard accelerators used for changing the scaling of the various data displays. The up and down arrows control the scale of the vertical axis. Vertical panning is accomplished using up and down arrow key in combination with the shift key. The left and right control the scale of the horizontal axis for profile average plots and the appropriate parameter scale for other formats.

4.10.11.3 Resizing facility

The widget may be resized as desired.

4.10.11.4 Environment Variables

`ANALYSIS_DIR:`	The root directory of the analysis distribution.
`ANALYSED_DATA:`	The directory where analysed data files are placed.
`PRINT_CMD:`	The command line switches to pass to lpr.
`TMP:`	A temporary directory for spooling print jobs etc.

4.10.11.5 Files

DBSDM usage is logged to the file: `$ANALYSIS_DIR/log/display.log`. Users should consult this file for further information on any problems observed using DBSDM.

For on-line Linux operation, the size of this file is controlled by "*logrotate*" as specified in the file "`/etc/logrotate.d/radarlogs`". Information on **logrotate** can be obtained from the command line using "`man logrotate`".

Savefiles of default parameters for use on invocation of DBSDM are stored in "`$ANALYSIS_DIR/control/.dbsdm_default`".

The default filename for files produced by the "Print Utility" is "`$TMP/dbsdm000.<ext>`" where `<ext>` is the file extension appropriate to the file format.

4.10.12 The IDBS Analysis module

4.10.12.1 Description

The IDBS analysis is a Doppler beam steering (DBS) analysis configured for collection of ionospheric E- and F-region echoes. The analysis is applied in the frequency (or spectral) domain, and can be applied to data recorded using co-linear (or Hybrid Doppler interferometry (HDI)) or meteor antennas. The IDBS analysis estimates the radial velocity, spectral width, SNR and Power. If the SNR exceeds -12 dB, the effective beam direction of the echoes is determined.

For co-linear antennas, the effective beam direction cannot be unambiguously determined, and can only be determined in the plane of the antenna configuration. Poststatistics steering (PSS) is used to steer the receive antenna beam pattern through a series of preselected beam directions. The effective returned power is estimated for each receive beam, and the effective beam direction (or direction of maximum power) is estimated by performing Gaussian fit to the returned signal powers calculated for each receive beam direction. from the resulting power variation. For meteor antennas, the effective beam direction is unambiguously determined using the same method as applied for MET analysis.

In the event that there are multiple spectral peaks at any range, the analysis estimates parameters for the combined spectral peaks, and also the individual spectral peaks. At any range where there are N (> 1) spectral peaks, the analysed data contains (N + 1) entries. The first entry will contain parameters estimated from the combined spectral peaks. The 2nd to (N+1)th entries will contain parameters estimated from the individual spectral peaks. The error code for the 2nd to (N+1)th are set to values of 100 + the actual error code to denote that they are multiple spectral peaks. The actual error codes are therefore determined using the error code modulus 100. Note that the IDBS display module will only display the the combined spectral peak results at ranges where there are multiple spectral peaks.

4.10.12.2 Analysed Data File Format

IDBS analysed data are written to disk in a binary format. Individual data files hold up to 24 hours of analysed data and are identified by the year, month, and day during which the data were recorded. During continuous data acquisition, each analysed data file begins at midnight, UTC. The IDBS analysed data format is described in more detail in Appendix C: ATRAD Analysed Data Format.

4.10.12.3 Error codes

Please note:

- criteria 3 is applicable to meteor antenna only

- criteria 4 to 7 are applicable for HDI antennas only

- as described above, the actual error codes are the error code modulus 100

0	Analysis OK
1	Low dynamic range, or interference rejection (data contaminated by non-atmospheric signals)
2	SNR less than -12 dB
3	EBD cannot be estimated (meteor antennas only)
4	Maxima in power estimates is too close to edge of receive beam directions to allow estimation the EBD.
5	Not used (maintained for compatibility with DBS analysis)
6	Not used (maintained for compatiblity with DBS analysis)
7	Zenith angle of EBD > transmitted beam zenith
8	Insufficient good power estimates with received beam angle to estimate the EBD

4.10.13 The IDBS Display module

4.10.13.1 Description

The Ionospheric Doppler Beam Steering Display Module (IDBSDM) is a compound widget allowing Ionospheric Doppler Beam Steering (IDBS) analysed data to be displayed in one of a number of different statistical forms. The IDBS analysis provides estimates of the radial velocity, spectral width, signal-to-noise ratio (SNR), and power for a number of transmitted beam directions.

The IDBSDM widget proivides identical functionality to the DBSDM widget, and is divided into five main areas. At the top of the widget is a row of motif-style pull-down menus which provide access to all IDBSDM functionality. The menu headings include "File", "Format", "View", "Parameter", "Options", and "Help". Immediately below the menu bar (from left to right) appear the time of the initial available ("Earliest Data") record, the time-duration mode, the time of the final available record ("Latest Data"), and the point-and-click beam selector widget, which allows the user to display any of the available beam directions. Below these labels appears the point-and-click time-selection window and the display window. The time-selection window displays the start and end times for the data currently on display in the display window.

The IDBSDM allows the display of the estimated radial wind velocities, spectral widths, effective beam zenith angles, aspect sensitivity parameters, returned signal power, and the SNR. The display parameter is selected from the "Parameters" menu. Note that although the IDBS analysis is capable of estimating multiple spectral peaks at any range, the IDBS display module will only display the the combined spectral peak results at these ranges.

The display formats used for the IDBSDM include profile averages, time-series profiles, and image plots. Image plots can be plotted with and without smoothing and contours. The display format is selected from the "Format" menu. The default display on entering the IDBSDM is the average radial velocity profile for the last hour.

The IDBSDM allows the display of the IDBS results over the last 24 hours, the last hour, and for the last analysed record. The required duration is selected from the "View" menu. Recently

analysed data are automatically read into the IDBSDM. The analysed data tag to display can be selected using the "Select Analysed Data Tag" option from the "View" menu. Selecting this option launches a widget allowing the use to select any of the analysed data tags of IDBS analysed data stored in the directory specified by the environment variable ANALYSED_DATA (see under the ENVIRONMENT VARIABLES heading below). Archived IDBS-analysed data-sets for previous days can also be selected and viewed from the "Archived Data" option of the "View" menu. Selecting this option launches a pickfile menu allowing the user to select the required file.

In last 24 hour and archived modes the duration over which the results are displayed can be selected using the time-selection window. The left and right mouse buttons may be used to select the initial and final times, respectively, of the required time-selection window duration, while the middle mouse button may be used to select an individual record. The required time-selection window duration can also be specified from the "Window Averaging" option of the "Options" menu.

The user also has control over many features of the displayed data, including scaling of the horizontal axes for profile average plots, and selection of the size of the informative labels included with the display. These features may be chosen from the "Options" menu. Hardcopies of the display can be obtained by selecting the "Print" option under the "File" pull down menu heading. This invokes the "Print Utility", allowing the current plot to be either be saved to file in any of a number of different formats, or sent to any nominated print queue along with any additional command line options to "lpr".

The default display on invoking the IDBSDM can be selected by choosing the "Set Display as Default" option from the "File" menus once the required parameter and display format has been selected. This saves the default parameters to a savefile which is restored on invocation of the IDBSDM. If a default parameter savefile does not exist, the default display on invocation is the average radial velocity profile for the nominal "first" beam (usually vertical) for the last hour. If a default parameter savefile exists, the default display can be returned to average radial velocity profile for the last hour by selecting the "Delete Default Settings" from the "File" menu.

4.10.13.2 Keyboard accelerators

Many of the pull-down menu options are accessible from the keyboard with the use of `<ALT>-<single key>` combinations. For example, the File menu options can be accessed using `<ALT>-P` to invoke the Print Utility, `<ALT>-S` to save the current display options as default, `<ALT>-K` to revert to the default options, and `<ALT>-W` to close the widget. In addition, the user may use `<ALT>-L` to display the results of the last analysed record, `<ALT>-R` to display the last hour of analysed records, `<ALT>-D` to display the last 24 Hours of analysed data records, and `<ALT>-A` to allow the selection of archived analysed data sets. If archived data is not being viewed, the `<ALT>-T` option can be used to change the analysed data tag to be viewed. Outlier rejection can be enabled and disabled using `<ALT>-Y`. A text print-out of the results of the last analysed record can be obtained using `<Alt>-N`. This manual page may be displayed using `<ALT>-H`.

Of particular use are the keyboard accelerators used for changing the scaling of the various data displays. The up and down arrows control the scale of the vertical axis. Vertical panning is accomplished using up and down arrow key in combination with the shift key. The left and right control the scale of the horizontal axis for profile average plots and the appropriate parameter scale for other formats.

4.10.13.3 Resizing facility

The widget may be resized as desired.

4.10.13.4 Environment variables

ANALYSIS_DIR	The root directory of the analysis distribution.
ANALYSED_DATA	The directory where analysed data files are placed.
PRINT_CMD	The command line switches to pass to lpr.
TMP	A temporary directory for spooling print jobs etc.

4.10.13.5 Files

IDBSDM usage is logged to the file $ANALYSIS_DIR/log/display.log. Users should consult this file for further information on any problems observed using IDBSDM.

For on-line Linux operation, the size of this file is controlled by "*logrotate*" as specified in the file "/etc/logrotate.d/radarlogs". Information on *logrotate* can be obtained from the command line using "man logrotate".

Savefiles of default parameters for use on invocation of IDBSDM are stored in "$ANALYSIS_DIR/control/.idbsdm_default".

The default filename for files produced by the "Print Utility" is "$TMP/idbsdm000.<ext>" where <ext> is the file extension appropriate to the file format.

4.10.14 The SPEC Analysis and DBS Postanalysis modules

The SPEC analysis is used to produce spectral (.spec) data files. These files are written to the ANSPOOL_DIR directory, where they are queued for postanalysis. The files are written in ADF raw data format, as described in Appendix B: ATRAD SPEC, AOA and COVF Data Format. The SPEC analysis configuration utility specifies how the spectral data is calculated. The time-series can have extra coherent integration applied, and be combined into a single receiver channel. Spectral smoothing can be applied by splitting the time-series, and then calculating and combining the "split" spectra. The spectral data files can be archived in the same manner as raw data files; they are archived into the ARCHIVE directory if data archiving is selected. The spectral data files can also be viewed using the Raw Display module (RDDM) in archived data mode.

The DBS postanalysis performs postanalysis on spectra produced by incoherently averaging spectra from individual data acquisitions over an extended time interval. The DBS postanalysis uses the same processing procedures as the spectral DBS analysis. The only major difference is that the DBS postanalysis is called from the postanalysis monitor rather than the analysis monitor, and processes incoherently spectra rather than spectra calculated from individual raw data records. The analysed data format and error codes for DBS postanalysis are the same as described for the DBS analysis, as described on page 41. As such, the DBS postanalysis results can be displayed using the DBS display module.

Archiving of the incoherently averaged spectra used for DBS postanalysis can be selected from the DBS postanalysis configuration utility.

The processing times and spectral data requirements for the DBS postanalysis are specified by the DBS postanalysis configuration utility, as described on page 15.

4.10.15 The MET Analysis Module

4.10.15.1 Description

The MET analysis was written for application to antenna arranged in the 5-antenna "Jones et al" configuration, as described in "*An improved interferometer design for use with meteor radars*", Jones et al., Radio Science 33(1), 55-66, 1998. This arrangement allows unambiguous AOAs to be determined. The analysis has also been adapted for use in alternative antenna configurations, such as hybrid Doppler interferometer (HDI) configurations. However, such configurations may not produce an unambiguous AOA. Furthermore, the HDI configuration only allows AOAs to be estimated in the plane perpendicular to the inter-antenna separation. The analysis is described in an article "*The Buckland Park meteor radar - description and initial results*", by Holdsworth and Reid, which is available from the web page `http://www.atrad.com.au/publications.html`.

The MET analysis is used to detect underdense meteor echoes and to determine their angles of arrival (AOAs), radial velocities, and decay times. The decay times are subsequently used to estimate diffusion coefficients. Meteor detection can be performed using one of two techniques. "Incoherent detection" involves coherently averaging the time-series for each range to produce an effective sampling time of approximately 0.01 seconds, and then averaging the resulting power time-series over all receivers. The mean noise level is determined for each range, and events where two or more successive points exceed a threshold "D" times the noise level are recorded. "Coherent detection" involves splitting the time-series data into separate small (typically 1 second) segments and applying criteria to determine the presence of a coherent signal. If a coherent signal is found, the phase differences between receivers are determined, and the time-series are combined taking the phase differences into account. At this point, the mean noise level is determined for each range, and events where two or more successive points exceed a threshold "D" times the noise level are recorded. The detection type and value of D can be configured by the user using the MET analysis configuration utility. The AOA for these events are then determined, and the time-series are combined and steered to the AOA estimate to improve the SNR and determine the mean power time-series. The mean power time-series is subjected to a number of criteria in order to reject data which are not indicative of an underdense meteor echo. For the events considered underdense, the decay time is estimated using an exponential fit to power time-series and a linear fit is applied to the phase time-series.

The AOA is calculated as follows. For the 5-antenna Jones et al. configuration, the zero-lag cross-correlation phases calculated for the appropriate antenna pairs are used to determine the AOA. For the HDI configuration, post-statistics steering is used to steer the receive beam through an array of directions spanning the range of unambiguous AOAs. The AOA is determined by applying a Gaussian fit to the power estimated at each receive beam direction to estimate the direction of maximum power. As the AOAs are affected by phase calibration errors, it is important that receiver calibration has been performed prior to analysis. Receiver calibration is described in "Including receiver calibration estimates in the analysis and display suite" (Appendix G).

The meteor analysis is capable of resolving events where the PRF may result in range aliasing of the meteor echo. For instance, at a PRF of 2 kHz, the data is ranged aliased to the actual range modulus 75 km. The analysis software is capable of resolving range ambiguity for most meteor events up to PRFs of 2 kHz, but cannot be guaranteed to unambiguously resolve range at PRFs above this.

The analysis applies criteria to assess the likelihood that any detected event is indeed a meteor. This includes checking the rise and decay times of the event, and checking the power levels before and after the event to ensure there are no coherent signals present. This latter criteria is used to reject coherent mesospheric and ionospheric echoes.

ADF version subsequent to version 4.2 support some new analysis parameters. Meteoroid speeds are estimated using the Fresnel transform technique, as described in the article "Radar observations of meteor trails, and their interpretation using Fresnel holography: a new tool in meteor science", *Atmos. Chem. Phys.*, 4, 911-921, 2004, by W. G. Elford. In the case where a meteoroid speed cannot be estimated, a value of zero is written to the analysed data file. Range fitting can be used to increase the accuracy of echo range by applying a Gaussian fit to the echo range profile. In order to make best use of this facility it is advisable to use PRFs of the order of 500 Hz to avoid range aliasing, and a range sampling interval small enough to allow each meteor

echo to be observed over 4-5 contiguous ranges. Range accuracy can be further enhanced using frequency agility, using two frequencies around 10-20 kHz apart.

The MET analysed data can subsequently be used to produce three-dimensional wind velocities using the VEL postanalysis. Please refer to the description of the VEL postanalysis on page 51 for further information.

Raw data archiving of detected meteor events, both underdense and otherwise, and archiving of estimated receiver phase differences can be selected from the MET analysis configuration utility. Interference removal may also be selected from the MET analysis configuration utility.

4.10.15.2 Analysed Data File Format

MET analysed data are written to disk in a binary format. Individual data files hold up to 24 hours of analysed data and are identified by the year, month, and day during which the data were recorded. During continuous data acquisition, each analysed data file begins at midnight, UTC. The MET analysed data format is described in more detail in Appendix C: ATRAD Analysed Data Format.

4.10.15.3 Error Codes

The following table describes the types of error codes produced by the MET analysis.

0	No error - analysis result ok.
1	Low SNR
2	Meteor angle of arrival (AOA) may be unambiguously determined (HDI only)
3	No feasible AOA can be determined (all sky only)
4	Large difference in AOAs obtained from different antenna baselines (all sky only)
5	Meteor event cannot be analysed because at start or end of time-series
6	Length of event too short for analysis
7	Event rise time too long to be a meteor
8	Decay time less than twice rise time
9	Power level before meteor event too large
10	Power level after meteor event too large
11	Poor fit to meteor event amplitude variation for estimation of decay time
12	Poor fit to meteor event phase variation for estimation of radial velocity
13	Range and AOA estimate does not yield a height lying within the expected height range for a meteor (70 to 110 km for VHF radars, 80 - 140 km for MF radars)
14	Range and AOA estimate yield more than one height within the expected height range for a meteor
15	Radial velocity (or projected horizontal velocity) exceeds 200 m/s
16	Oscillatory event, indicating event is most likely not an underdense meteor
17	Event is most likely a "spike" rather than a meteor

4.10.16 The MET Display Module

4.10.16.1 Description

The meteor display module (METDM) is a compound widget allowing meteor analysed data to be displayed in one of a number of different statistical forms. The MET provides displays of radial wind velocities, decay times and diffusion coefficients, SNRs and detection skymaps, and histograms of the range, time, zenith and azimuth distributions of the meteor detections.
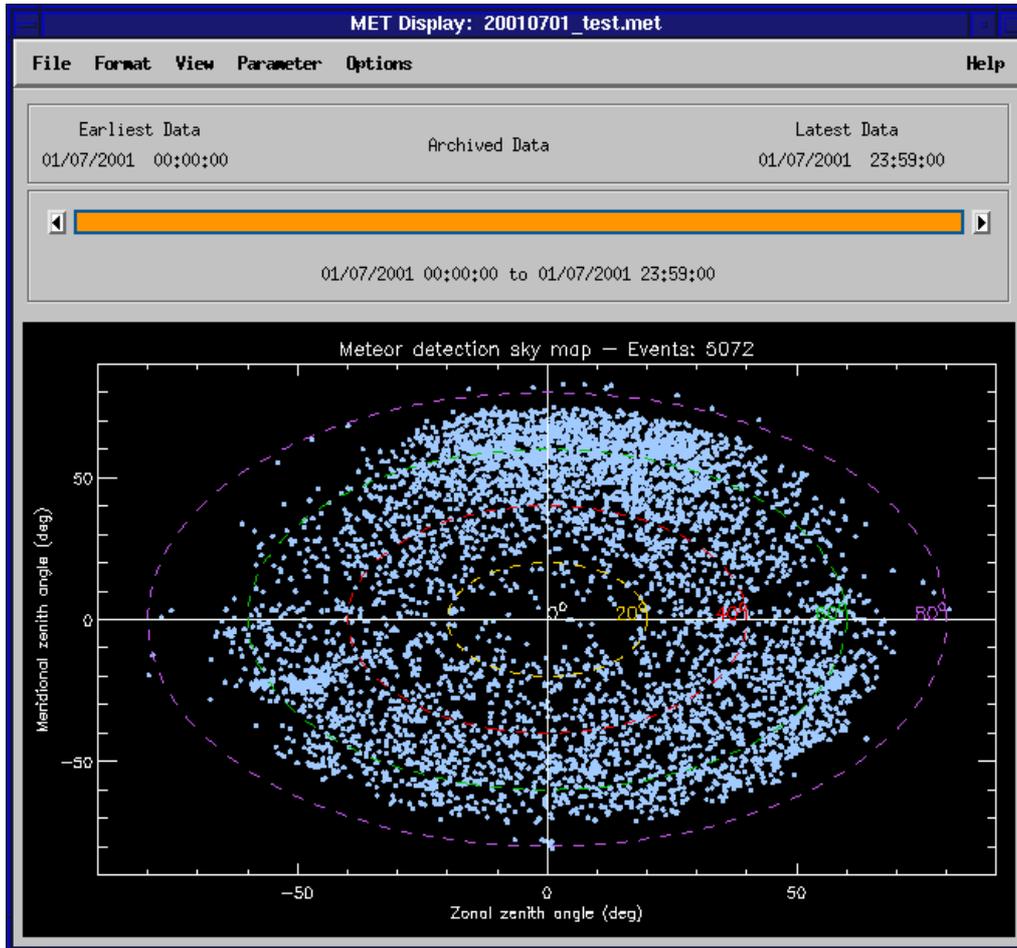
The MET Display Module

The METDM widget is divided into four main areas. At the top of the widget is a row of motif-style pull-down menus which provide access to all METDM functionality. The menu headings include *"File", "Format", "View", "Parameter", "Options"*, and *"Help"*. Immediately below the menu bar (from left to right) appear the time of the initial available ("Earliest Data") record, the time-duration mode, and the time of the final available record ("Latest Data"). Below these labels appears the point-and-click time window and the display window. The time-window displays the start and end times for the data currently on display in the display window.

The METDM allows the display of the estimated horizontal wind velocities, the decay times and diffusion coefficients, the returned signal power and the SNR, the skymap of meteor angles of arrival, and histograms of the height, range, time, azimuth and zenith angle distributions. The wind velocity components displayed are calculated using all meteor echoes within 20 degrees of the cardinal directions. The display parameter is selected from the *"Parameters"* menu. The METDM also allows the display of the MET results over the last 24 hours, the last hour, and for the last analysed record. The required time-duration is selected from the *"View"* menu. Recently analysed data are automatically read into the display module. In last 24 hour mode the duration over which the results are displayed can be selected using the time window. The left and right mouse buttons may be used to select the initial and final times, respectively, of the required time-duration, while the middle mouse button may be used to select an individual record. Archived

MET-analysed data-sets for previous days can be viewed and selected using a file selection menu. The display formats used for the METDM include average profiles, time-series profiles, and contour plots for all parameters, plus vector flow field plots for horizontal and vertical velocities. The display format is selected from the "*Format*" menu. The default display on entering the METDM is the average horizontal wind velocity profile for the last hour.

The user also has control over many features of the displayed. This includes scaling and panning of vertical axes, scaling of horizontal axes for average profile plots, the thickness of the lines used in the plots, and the size of informative labels included with the display. These features may be chosen from the "*Options*" menu. Hardcopies of the display can be obtained by selecting the "*Print*" option under the "*File*" pull down menu heading. This invokes the "*Print Utility*", allowing the current plot to be either be saved to file, or sent to any nominated print queue along with any additional command line options to **lpr**.

The default display on invoking the DBSDM can be selected by the "*Set Display as Default*" option of the "*Options*" menu once the required parameter and display format has been selected. This saves the default parameters to a savefile which is restored on invocation of the DBSDM. If a default parameter savefile does not exist, the default display on invocation is the average horizontal wind velocity profile for the last hour. If a default parameter savefile exists, the default display can be returned to average horizontal wind velocity profile for the last hour by selecting the "*Delete Default Settings*" from "*Options*" menu.

4.10.16.2 Keyboard Accelerators

Many of the pull-down menu options are accessible from the keyboard with the use of `<ALT>`–`<single key>` combinations. For example, the "*File*" menu options may be invoked with the use of `<ALT>`-`O` (while in archived data mode) for "*Open*", `<ALT>`-`P` for "*Print*", and `<ALT>`-`W` to "*Close*" the FCADM window. In addition, the user may use `<ALT>`-`R` to display the results of the last analysed record, `<ALT>`-`L` to display the last hour of analysed records, `<ALT>`-`D` to display the last 24 hours of analysed data records, and `<ALT>`-`A` to allow the selection of archived analysed data records. Once in archived data mode, the `<ALT>`-`O` option must be used to view other archived data sets. If archived data is not being viewed, the `<ALT>`-`T` option can be used to change the analysed data tag to be viewed. A text print-out of the results of the last analysed record can be obtained using `<ALT>`-`N`. Outlier rejection can be enabled and disabled using `<ALT>`-`Y`. The current display format and parameter combination can be saved as the default combination on invocation using `<ALT>`-`S`. If a default combination has been saved, the default combination can be returned to the original values using `<ALT>`-`K`. This manual page may be displayed by pressing `<ALT>`-`H`.

Of particular use are the keyboard accelerators used for changing the scaling of the various data displays. The up and down arrows change the scale of the vertical axis. Rapid vertical panning is accomplished using the up and down arrow key in combination with the shift key. The left and right control the scale of the horizontal axis for average plots and the appropriate parameter scale for other formats.

4.10.17   The DSC Analysis Module

4.10.17.1 Description

The Doppler simulator calibration (DSC) analysis determines receiver amplitudes, phases, and zero-mean in-phase and quadrature offsets for data collected using the Doppler simulator. The results are written in ascii format to the text file "`/home/radar/analysis/lib/dopp_sim.dat`".

DSC analysis first estimates the zero-mean mean in-phase and quadrature offsets by taking the mean values for each receiver over all height and time samples collected. These values are then subtracted from each sample, and the mean amplitude and phase over all height and time samples are then determined.

4.10.18 The MPC Postanalysis Module

The meteor phase correlation (MPC) postanalysis uses the technique described in the paper "*Interferometric meteor radar phase calibration using meteor echoes*", by D. A. Holdsworth, M. Tsutsumi, I. M. Reid, T. Nakamura, and T. Tsuda (2004), Radio Science, 39, RS5012, doi:10.1029/2003RS003026. This technique is applicable to data collected using the Jones et al. configuration. The relative phase offsets between the outside and inside antennas on each antenna arm are first determined. This information is then used to produce a grid of phase offsets. At each grid position, the echo heights are determined, and the grid position which maximises the number of echo height estimates within expected height limits is determined. This process is repeated using a new grid of phase offsets centered on the previous phase offset estimate. Once the difference between subsequent phase offset estimates is determined, a smaller grid size is used. This process is repeated until the difference between subsequent phase offset estimates has not converged on a stable solution in five iterations, indicating that the phase offsets have been determined as accurately as possible. The grid sizes (and maximum differences) used (in degrees) are 180 (10), 45 (10), 20 (5), 10 (3), 5 (1), and 2 (0.5).

The configuration of the MPC postanalysis is handled by the MPC postanalysis configuration utility, allowing the postanalysis to be configured to run in a number of different manners. The simplest form involves using a single stage analysis which maximises the number of echoes with heights between the "*Minimum Height*" and "*Maximum Height*". For a VHF meteor radar, values of 70 and 110 km, respectively, are typically used.

A more involved analysis can be configured by selecting "*Perform Secondary Calibration*". This analysis makes use of the fact that reducing the height limits used has been shown to improve the accuracy of the phase calibration estimates. Two types of secondary calibration are available: "*Median*", and "*Height limit*". If "*Median*" is selected, the calibration is re-performed using all heights within the mean plus or minus the standard deviation of the height distribution. If "*Height limit*" is selected, the calibration is re-performed using all heights within the "*Minimum Height*" and "*Maximum Height*". In this case, it is necessary that these height limits are set to values smaller than those used in the initial stage of the calibration. At this stage insufficient testing has been performed for determining which mode of secondary calibration yields the best calibration estimates, hence the availability of both "*Median*" and "*Height limit*" options.

The MPC postanalysis has one subtle difference from other postanalyses: in that it is performed in a separate IDL session. This is necessary since the MPC postanalysis can take up to 10 minutes to perform. Information on the MPC postanalysis is logged to the file:

$ANALYSIS_DIR/log/mpc_postanal.log.

The MPC analysed data format is described in in Appendix C: ATRAD Analysed Data Format. As for all analysed and postanalysed data, the results from the MPC postanalysis are written to daily files. To ensure that the data used for MPC postanalysis is performed using data from a single UTC day the following postanalysis options must be set: Processing interval = 24 hours, Processing duration = 24 hours, Processing interval multiple: Integer + 0.5. This ensures that analysis is performed using data from +/- 12 hours centered on 12 UTC.

4.10.19 The VEL Postanalysis Module

4.10.19.1 Description

The VEL postanalysis is used to determine three dimensional wind velocities from radial velocities and angles of arrivals (AOAs) or effective beam directions produced by DBS (both HDI and combined) and MET analyses. The analysis can be performed using radial velocities and AOAs determined over selected intervals, including over an complete sequence of experiments, or over a fixed time interval; for instance, half-hourly, hourly, or two-hourly intervals.

For VEL postanalysis on DBS-HDI and MET radial velocities and effective beam direction/AOA pairs, a least squares fit is used to determine the three dimensional wind component at each height. A recursive outlier rejection technique is used to remove bad data from the postanalysis. An initial estimate of the three dimensional wind velocity is determined, and a "projected" radial velocity is obtained by projecting the fitted wind component onto each AOA. The differences between the radial velocity and projected radial velocity are calculated, and the standard deviation of the differences is calculated. Data whose differences are more than 2.5 times the standard deviation are rejected, and the least squares fit is repeated using all remaining good data. This process is continued until there are no data where the differences lie outside 2.5 times the standard deviation, or until there are less than three points remaining. In the latter case, no velocity estimate is possible as a minimum of three radial velocity and AOA pairs is required to estimate the three dimensional wind velocity. The VEL postanalysis can be configured to use data with SNRs above a selected threshold if required.

For VEL postanalysis of DBS-combined radial velocities, consensus averaging is used to determine the average radial velocity from each beam direction. The average radial velocities and beam pointing directions are then used in a least squares fit to determine the three dimensional wind velocity.

The VEL postanalysis calculates winds from DBS analysed data at all heights where data is acquired, and for MET analysed data at 2 km intervals from 70 to 110 km. For DBS analysed data, the average SNR and power estimated for each beam direction are determined.

It should be noted that the VEL postanalysed data are stored as *height* profiles rather than *range* profiles.

4.10.19.2 Analysed Data File Format

VEL analysed data are written to disk in a binary format. Individual data files hold up to 24 hours of analysed data and are identified by the year, month, and day during which the data were recorded. During continuous data acquisition, each analysed data file begins at midnight, UTC. The VEL analysed data format is described in more detail in Appendix C: ATRAD Analysed Data Format.

4.10.19.3 Error Codes

There are two error codes for VEL postanalysis: 0 indicates the VEL analysis had sufficient data to calculate a velocity estimate, while 1 indicates the VEL analysis had insufficient data to calculate a velocity estimate.

4.10.20 The VEL Display Module

4.10.20.1 Description

The velocity analysis display module (VELDM) is a compound widget allowing VEL analysed data to be displayed in one of a number of different statistical forms. The VELDM is essentially identical to the Full Correlation Analysis Display module (FCADM), as described on page 29.The widget is divided into four main areas. At the top is a row of motif-style pull-down menus which provide access to all VELDM functionality. The menu headings include "*File*", "*Format*", "*View*", "*Parameter*", "*Options*", and "*Help*". Immediately below the menu bar (from left to right) appear the time of the initial available ("Earliest Data") record, the time-duration mode, and the time of the final available record ("Latest Data"). Below these labels appear the point-and-click time selection window and the display window. The time-window displays the start and end times for the data currently on display in the display window.

The required display parameter is selected from the "*Parameter*" menu. The VELDM also allows the display of the VEL results over the last 24 hours, the last hour, or for the last analysed record. The required time-duration for the display is selected from the "*View*" menu. Recently analysed data are automatically read into and displayed by the display module as they become available. In the last 24 hour mode the duration over which the results are displayed can be selected using the time selection window. By placing the mouse cursor within the time selection window, the left and right mouse buttons may be used to select the initial and final times, respectively, of the required time-duration, while the middle mouse button may be used to select an individual record. Archived VEL-analysed data-sets for previous days can be viewed and selected using a file selection menu. The display formats used for the VELDM include average profiles, range- and time-series profiles, and image-intensity plots for all parameters, plus monochrome and colour vector flow field and "windbarb" plots for horizontal velocities. The display format required is selected from the "*Format*" menu. The default display format and time interval on entering the VELDM is the average horizontal wind velocity profile for the last hour.

The user also has control over many features of the displayed data, including scaling of the horizontal axes for profile average plots, and selection of the size of the informative labels included with the display. These features may be chosen from the "*Options*" menu. Hardcopies of the display can be obtained by selecting the "*Print*" option under the "*File*" pull down menu heading. This invokes the "Print Utility", allowing the current plot to be either be saved to file in any of a number of different formats, or sent to any nominated print queue along with any additional command line options to "*lpr*".

The default display on invoking the VELDM can be selected by the "*Set Display as Default*" option from the "*Options*" menu once the required parameter and display format has been selected. This saves the default parameters to a savefile which is restored on invocation of the VELDM. If a default parameter savefile does not exist, the default display on invocation is the average horizontal wind velocity profile for the last hour. If a default parameter savefile exists, the default display can be returned to average horizontal wind velocity profile for the last hour by selecting the "*Delete Default Settings*" from "*Options*" menu.

4.10.20.2 Keyboard Accelerators

Many of the pull-down menu options are accessible from the keyboard with the use of `<ALT>`–`<single key>` combinations. For example, the "*File*" menu options may be invoked with the use of `<ALT>`–`O` (while in archived data mode) for "*Open*", `<ALT>`–`P` for "*Print Postscript*", and `<ALT>`–`W` to "*Close*" the FCADM window. In addition, the user may use `<ALT>`–`R` to display the results of the last analysed record, `<ALT>`–`L` to display the last hour of analysed records, `<ALT>`–`D` to display the last 24 hours of analysed data records, and `<ALT>`–`A` to allow the selection of archived analysed data records. Once in archived data mode, the `<ALT>`–`O` option must be used to view other archived data sets. If archived data is not being viewed, the `<ALT>`–`T` option can be used to change the analysed data tag to be viewed. A text print-out of the results of the last analysed record can be obtained using `<ALT>`–`N`. Outlier rejection can be enabled and disabled using `<ALT>`–`Y`. The current display format and parameter combination can be saved as the default combination on invocation using `<ALT>`–`S`. If a default combination has been saved, the default combination can be returned to the original values using `<ALT>`–`K`. This manual page may be displayed by pressing `<ALT>`–`H`.

Of particular use are the keyboard accelerators used for changing the scaling of the various data displays. The up and down arrows change the scale of the vertical axis. Vertical panning is accomplished using the up and down arrow key in combination with the shift key. The left and right arrows control the scale of the horizontal axis for average plots and the appropriate parameter scale for other formats.

4.10.21   The BUFR Postanalysis Module

4.10.21.1 Description

The BUFR postanalysis produces files of averaged data from FCA and DBS analyses. BUFR is an acronym for Binary Universal Format for the Representation of Meteorological data, as administered by the World Meteorological Organisation (WMO).

The BUFR postanalysis configuration utility specifies the output of the BUFR postanalysis. The utility allows the user to select which form of analysed data (FCA, DBS, or RASS) and which analysed data tag to use, the processing duration, and the file type, and whether the file should be ftp'd to a remote location. If ftp is required, the remote IP address and directory can be specified.

The processing interval specifies when the BUFR postanalysis should occur, and the relevant data to use. For instance, if processing interval is 900 (seconds), the BOM postanalysis will run at 7.5, 22.5, 37.5 and 52.5 minutes past every even hour, using all the previous 15 minutes of analyed data.

The World Meteorological Organisation (WMO) block number, station number and station prefix can be specified, as can the station type (usually 2 for a wind profiler), radar beam width, latitude, longitude and height above sea level. Data averaging options can also be specified. Either a "*mean*" or "*median*" velocity components can be estimated. If "*mean*" is selected, the mean (M) and standard deviation (SD) are estimated. Data outside M +/- N*SD are rejected, where M is "*Standard Deviation multiple*". The mean and standard deviation are then recalculated. This process is repeated until there is no data outside M +/- N*SD, or until the percentage of data remaining is below the "*Minimum Data Percentage*", in which case a velocity component estimate is not made. If the final standard deviation exceeds the "*Deviation Threshold*" a velocity component estimate is not made. If "median" is selected, the median velocity is determined using all data within the upper and lower quartiles. If the percentage of data remaining is below the "*Minimum Data Percentage*" a velocity component estimate is not made. If the difference between the median and the upper and lower quartiles exceeds the "*Deviation Threshold*" a velocity component estimate is not made. For both "*Mean*" and "*Median*" averages, a velocity is reported only if an estimate is possible for both velocity components. Only data with SNR exceeding "*Minimum SNR*" are used in the processing.

If ftp is required, the remote IP address can be specified. The specified IP address requires an entry in the radar users ".netrc" file with the username and password for ftp for use. Remote file transfer issues provides information on the use of the ".netrc" file. If ftp is required, the file destination corresponds to the directory to store the file on the remote ftp site. If ftp is not required, file destination corresponds to the directory to store the file locally.

Multiple configurations may be configured to allow the BUFR postanalysis to run at different times with different averaging intervals and analysis types. Multiple copies of the BUFR postanalysis may be configured to act on each data set, each with its own unique parameters. For example, it is possible to perform two or more BUFR postanalyses on the same analysed data-set, allowing, for instance, files to be produced and sent to different destinations, or borh display and pilot files to be generated for the same processing interval. Additional configurations are composed by choosing the "*Add Configuration*" or "*Copy Configuration*" options under the "*File*" menu. "*Add Configuration*" allows the user to configure a new PFT postanalysis, while "*Copy Configuration*" allows the user to copy the currently displayed postanalysis configuration and reconfigure it. Unwanted configurations may be deleted with the "*Remove Configuration*" option. Different configurations may be examined one at a time by clicking on the left and right selection buttons the top of the window.

4.10.22 The BOM Postanalysis Module

4.10.22.1 Description

The Bureau of Meteorology (BOM) postanalysis produces files of averaged data from FCA, DBS, and RASS analyses. The files can be written in one of two different formats specified by the Australian Bureau of Meteorology.

The BOM postanalysis configuration utility specifies the output of the BOM postanalysis. The utility allows the user to select which form of analysed data (FCA, DBS, or RASS) and which analysed data tag to use, the processing duration, and the file type, and whether the file should be ftp'd to a remote location. If ftp is required, the remote IP address and directory can be specified.

The processing interval specifies when the BOM postanalysis should occur, and the relevant data to use. For instance, if processing interval is 900 (seconds), the BOM postanalysis will run at 7.5, 22.5, 37.5 and 52.5 minutes past every even hour, using all the previous 15 minutes of analyed data.

The World Meteorological Organisation (WMO) number and station name can be specified, along with the required file type. The available file types are "Pilot" and "Display" files. The specifies WMO station number and name are used in the display file header information and filenames. If ftp is required, the remote IP address can be specified. The specified IP address requires an entry in the radar users ".netrc" file with the username and password for ftp for use. Remote file transfer issues provides information on the use of the ".netrc" file. If ftp is required, the file destination corresponds to the directory to store the file on the remote ftp site. If ftp is not required, file destination corresponds to the directory to store the file locally. The files are also locally stored in the directory specified by the "AVERAGE_DATA" environment variable, which is setup in the file "/home/radar/analysis/lib/analysisvars" . The default value of the "AVERAGE_DATA" environment variable is "/home/RadarData/BomData/".

Multiple configurations may be configured to allow the BOM postanalysis to run at different times with different averaging intervals and analysis types. Multiple copies of the BOM postanalysis may be configured to act on each data set, each with its own unique parameters. For example, it is possible to perform two or more BOM postanalyses on the same analysed data-set, allowing, for instance, files to be produced and sent to different destinations, or borh display and pilot files to be generated for the same processing interval. Additional configurations are composed by choosing the "*Add Configuration*" or "*Copy Configuration*" options under the "*File*" menu. "*Add Configuration*" allows the user to configure a new PFT postanalysis, while "*Copy Configuration*" allows the user to copy the currently displayed postanalysis configuration and reconfigure it. Unwanted configurations may be deleted with the "*Remove Configuration*" option. Different configurations may be examined one at a time by clicking on the left and right selection buttons the top of the window.

4.10.23 The MTMP Postanalysis module

4.10.23.1 Description

The MTMP postanalysis is used to determine temperatures from decay times produced by the MET analysis. The postanalysis is based on the analysis described in the paper by Holdsworth et al., "Antarctic mesospheric temperature estimation using the Davis VHF radar", Journal of Geophysical Research, 111, D05108, doi:10.1029/2005JD006589., 2006. Two temperature estimates are made: "pressure climatology" (PC) and "temperature gradient climatology" (TGC) estimates. PC estimates are made using the mean decay time at the peak height and the climatological pressure estimate at that height. TGC estimates are made using the estimated slope of the log diffusion coefficient versus height scatter plot and the height distribution weighted climatological temperature gradient.

The pressure and temperature gradient climatologies are derived using the NRLMSIS model (Picone et al., "Enhanced Empirical Models of the Thermosphere", Physics and Chemistry of the Earth, Part C: Solar, Terrestrial & Planetary Science, 25(5), 2000, 537-542) derived using the latitude and longitude of the radar site. The NRLMSIS model data is stored as an array of daily values at heights between 60 and 120 km at 1 km intervals. The model data is stored as IDL

savefiles in the mtmp_press.dat and mtmp_temp.dat files, located in `$ANALYSIS_DIR/lib` directory.

The option for users to create their own pressure and temperature gradient climatologies is also available. This may be desireable where locally derived pressure and temperature gradient measurements are available, such as those derived from in-situ measurements. First, a peak height model can be setup in the file mtmp_peak_height.dat, containing a 365 element array "`peak_ht_model`" containing the peak heights for each day of the year. Use of this climatology can be configured invoking the "User Peak Height Climatology" option. Second, a pressure climatology at the peak height can be setup in the file "`mtmp_pres_peak_height.dat`", containing a 365 element array "`press_peak_ht_model`" containing the pressure climatology at the peak height for each day of the year. Use of this climatology can be configured invoking the "User Pressure Climatology" option. Third, a temperature gradient climatology at the peak height can be setup in the file "`mtmp_temp_grad_peak_height.dat`", containing a 365 element array "`temp_grad_peak_ht_model`" containing the temperature gradient climatology at the peak height for each day of the year. Use of this climatology can be configured invoking the "User Temp. Gradient Climatology" option.

The processing interval, offset, and duration specify when the post-analysis should occur, and the relevant data to use. All of these times are specified in seconds. The processing interval specifies the interval between successive postanalyses. The processing offset specifies the offset from the multiple of the processing interval for the postanalysis to be performed. The processing duration specifies the duration of data to use for the postanalysis. The processing interval multiple specifies whether the analysed data should be centered on a multiple of the processing multiple, or an integer plus half multiple. For instance, if meteor temperature estimation is to be performed on the data from a single universal time day, the processing interval should be set to 24 hours, the processing duration to 24 hours, and the processing multiple to an integer plus half multiple (i.e. centered on the middle of the day). The postanalysis is ideally performed using 24 hours of MET analysed data to ensure there is sufficient data for a statistically accurate temperature estimate to be made. The analysis can be performed over selected intervals; for instance, half-hourly, hourly, or two-hourly intervals. However, no guarantees are given for the reliability of temperature estimates made at such short time intervals.

Multiple copies of the postanalysis may be configured to act on each data set, each with its own unique parameters. For example, it is possible to perform two or more MTMP post-analyses on the same analysed data-set, allowing, for instance, plot files of velocity profiles and power image plots to be produced. Additional configurations are composed by choosing the "Add Configuration" or "Copy Configuration" options under the "File" menu. "Add Configuration" allows the user to configure a new MTMP postanalysis, while "Copy Configuration" allows the user to copy the currently displayed postanalysis configuration and reconfigure it. Unwanted configurations may be deleted with the "Remove Configuration" option. Different configurations may be examined one at a time by clicking on the left and right selection buttons near the top of the window.

4.10.23.2 Analysed Data File Format

MTMP postanalysed data are written to disk in a binary format. Individual data files hold up to 24 hours of analysed data and are identified by the year, month, and day during which the data were recorded. During continuous data acquisition, each postanalysed data file begins at midnight, UTC. The MTMP analysed data format is described in more detail in Appendix C: ATRAD Analysed Data Format.

4.10.23.3 Error codes

There are no error codes for MTMP postanalysis. When a temperature estimate is not made the pressure and temperature gradient climatology temperatures is set to zero. Pressure and temperature gradient climatology temperature estimates are not made if there are less than 100 echoes available for processing. A temperature climatology temperature estimate is not made if the slope of the log diffusion coefficient Vs height variation cannot be estimated.

4.10.24 The MRAD Postanalysis Module

The meteor radiant determination (MRAD) postanalysis uses meteor (MET) analysis observations for measuring meteor radiants. This postanalysis is based on the technique described in Jones, J.,

Jones, W. Meteor radiant activity mapping using single-station radar observations. Mon. Not. R. Astron. Soc. 367 (3), 1050-1056, doi:10.1111/j.1365-2966.2006.10025.x, 2006.

The meteor radiant of an echo lies on a great circle aligned perpendicularly to the vector from the radar to the meteor trail. The MRAD postanalysis exploits the perpendicularity condition by forming a two-dimensional histogram in right ascension (RA) and declination (DEC) of the great circle for each echo. Well-defined sources of meteors, such as meteor showers, result in a narrow maximum in the RA/DEC histogram. In the standard implementation of this technique, the great circle for each echo is assigned a finite "passband" width to account for angle of arrival errors and the finite width of radiant sources. This is effectively equivalent to convolving the great circle with a "top-hat" convolution function, which is non-ideal since the response for a point radiant has a very diffuse halo, which has the potential to obscure weak radiants. This led Jones and Jones (2006) to propose a new convolution function which enhances the apparent activity of meteor shower radiants, allowing the detection of a number of weak showers that have not been previously catalogued. The MRAD postanalysis RA-DEC histogram uses 1 degree intervals in RA and DEC. The RA dimension is dependent on the location of the radar and covers the range of RAs from which the radar can receive meteor echoes, while the DEC dimension is 360. A "pass band width" of 4 degrees is used.

The MRAD postanalysis requires a site file:

    $ANALYSIS_DIR/lib/site.dat

This is an IDL savefile that contains the PRF, antenna coordinates, radar frequency (for MPC postanalysis) and latitude and longitude (for MRAD postanalysis). This file is required as this information is not contained in the MET analysed data files used for MRAD postanalysis.

The configuration of the MRAD postanalysis is handled by the MRAD postanalysis configuration utility, allowing the postanalysis to be configured to run in a number of different manners.

Like the MPC postanalysis, the MRAD postanalysis is performed in a separate IDL session. This is necessary since the MRAD postanalysis can take up to 4 minutes to perform. Information on the MRAD postanalysis is logged to the file:

    $ANALYSIS_DIR/log/mrad_postanal.log

The MRAD analysed data format is described in in Appendix C: ATRAD Analysed Data Format. As for all analysed and postanalysed data, the results from the MRAD postanalysis are written to daily files. To ensure that the data used for MRAD postanalysis is performed using data from a single UTC day the following postanalysis options must be set: Processing interval = 24 hours, Processing duration = 24 hours, Processing interval multiple: Integer + 0.5. This ensures that analysis is performed using data from +/- 12 hours centered on 12 UTC.

4.10.25 The AFT Postanalysis Module

4.10.25.1 Description

The Analysis File Transfer (AFT) postanalysis produces files of averaged data from FCA, DBS, and RASS analyses.

The AFT postanalysis configuration utility specifies the output of the AFT postanalysis. The utility allows the user to select which form of analysed data (FCA or DBS) and which analysed data tag to use, the processing duration, and the file type, and whether the file should be ftp'd to a remote location. If ftp is required, the remote IP address and directory can be specified.

The processing interval specifies when the AFT postanalysis should occur, and the relevant data to use. For instance, if processing interval is 900 (seconds) , the AFT postanalysis will run at 7.5, 22.5, 37.5 and 52.5 minutes past every even hour, using the previous 15 minutes of analyed data.

Data averaging options can be specified. Either a "*mean*" or "*median*" velocity components can be estimated. If "*mean*" is selected, the mean (M) and standard deviation (SD) are estimated. Data outside M +/- N*SD are rejected, where M is "*Standard Deviation multiple*". The mean and standard deviation are then recalculated. This process is repeated until there is no data outside M +/- N*SD, or until the percentage of data remaining is below the "*Minimum Data Percentage*", in which case a velocity component estimate is not made. If the final standard deviation exceeds the "*Deviation Threshold*" a velocity component estimate is not made. If "median" is selected, the

median velocity is determined using all data within the upper and lower quartiles. If the percentage of data remaining is below the "*Minimum Data Percentage*" a velocity component estimate is not made. If the difference between the median and the upper and lower quartiles exceeds the "*Deviation Threshold*" a velocity component estimate is not made. For both "*Mean*" and "*Median*" averages, a velocity is reported only if an estimate is possible for both velocity components. Only data with SNR exceeding "*Minimum SNR*" are used in the processing.

If ftp is required, the remote IP address can be specified. The specified IP address requires an entry in the radar users ".`netrc`" file with the username and password for ftp for use. Remote file transfer issues provides information on the use of the ".`netrc`" file. If ftp is required, the file destination corresponds to the directory to store the file on the remote ftp site. If ftp is not required, file destination corresponds to the directory to store the file locally. The files are also locally stored in the directory specified by the "AVERAGE_DATA" environment variable, which is setup in the file "`/home/radar/analysis/lib/analysisvars`" . The default value of the "AVERAGE_DATA" environment variable is "`/home/RadarData/AverageData/`".

Multiple configurations may be configured to allow the AFT postanalysis to run at different times with different averaging intervals and analysis types. Multiple copies of the AFT postanalysis may be configured to act on each data set, each with its own unique parameters. For example, it is possible to perform two or more AFT postanalyses on the same analysed data-set, allowing, for instance, files to be produced and sent to different destinations, or borh display and pilot files to be generated for the same processing interval. Additional configurations are composed by choosing the "*Add Configuration*" or "*Copy Configuration*" options under the "*File*" menu. "*Add Configuration*" allows the user to configure a new PFT postanalysis, while "*Copy Configuration*" allows the user to copy the currently displayed postanalysis configuration and reconfigure it. Unwanted configurations may be deleted with the "*Remove Configuration*" option. Different configurations may be examined one at a time by clicking on the left and right selection buttons the top of the window.

4.10.26   The PFT Postanalysis Module

4.10.26.1 Description

The Plot File Transfer (PFT) postanalysis produces files containing plots of analysed data. Any plot available from the relevant display module (e.g. FCA Display for FCA data) can be selected.

The PFT postanalysis configuration utility specifies the output of the PFT postanalysis, as described on page 15. The analysed data type, analysis parameter, display format, color table, file format and processing and data time information used for PFT postanalysis are configured through the PFT postanalysis configuration utility. The plots can be stored in "*Postscript*", "*Greyscale Postscript*", "*PNG*", "*TIFF*", "*BMP*" and "*JPEG*" file formats. If ftp of the files is required, the remote IP address can be specified. The specified IP address requires an entry in the radar users ".netrc" file with the username and password for ftp for use. Remote file transfer issues provides information on the use of the ".netrc" file. If ftp is required, the file destination corresponds to the directory to store the file on the remote ftp site. If ftp is not required, file destination corresponds to the directory to store the file locally. The files can also be time-stamped if required.

Multiple configurations may be configured to allow the PFT postanalysis to run at different times with different averaging intervals and analysis types. Multiple copies of the PFT postanalysis may be configured to act on each data set, each with its own unique parameters. For example, it is possible to perform two or more PFT postanalyses on the same analysed data-set, allowing, for instance, display and pilot files to be produced and sent to different destinations, or various plots of same or different parameters from the same data-set to be produced. Additional configurations are composed by choosing the "*Add Configuration*" or "*Copy Configuration*" options under the "*File*" menu. "*Add Configuration*" allows the user to configure a new PFT postanalysis, while "*Copy Configuration*" allows the user to copy the currently displayed postanalysis configuration and reconfigure it. Unwanted configurations may be deleted with the "*Remove Configuration*" option. Different configurations may be examined one at a time by clicking on the left and right selection buttons near the top of the window.

Note that if the PFT postanalysis produced files are to be used for display on a web page, PNG format is recommended as it is the most efficient format in terms of file size.

4.10.27 The Data Management Utility

4.10.27.1 Description

The Data Management Utility (DMU) is a compound widget allowing the management of Analysed data. The utility allows the data to be backed up to a backup medium and to a local backup directory, and also allows the data from the local backup directory to be deleted once the data has been archived off-site.

The DMU is divided into four main areas. At the top of the widget are four motif-style pull-down menus which provides access to DMU functionality. This includes the "*File*" menu, including the "*Close*" option for closing the widget, and the "*Help*" menu, which includes information about the Data Management Utility version number and this help information. Below this is the "*Backup Information Area*" Below this is the "*Analysed data selection area*", which is a text display window in which the relevant analysed data files are displayed. The bottom area is the "*Hint Display Area*" which provides useful information about the functionality of the area over which the cursor is placed.

The DMU has two modes of operation, namely "*Backup*" and "*Delete*". The appropriate mode can be selected from the "*Data Mode*" option of the "*Control*" menu. If "*Backup*" Data Mode is selected, the "*Backup*" option allows data backup once file selection is made from the analysed data files list. File selection is made using the left mouse "*Backup*" option allows data backup once file selection is made from the analysed data files list. File selection is made using the left mouse button. Multiple files can be selected by dragging the mouse with the left mouse button held down. Holding down the `<SHIFT>` key and an item selects the range from the previously selected item to the item. Holding down the `<CTRL>` key and clicking an item toggles item between the selected and unselected state. Data is copied to a configured backup medium (e.g. JAZ disk, ZIP disk), and also moved to a backup directory on the local machine. If "*Delete*" Data Mode is selected, the analysed data file list shows the contents of the local backup directory, and allows these to be deleted once file selection is made. The user is asked to confirm the deletion once the Display option is chosen.

The "*Backup Information Area*" provides information on the available disk space, the analysed and local backup directory sizes, the specified backup directories, the mount status of the backup medium and it's available disk space, and the selected file sizes. If the Backup Medium Mount Directory or the Local Backup Directory are labelled "*Undefined*", they may be defined from the "Options" pull down menu via the "*Change Backup Medium Mount Directory*'" and "*Change Local Backup Directory*" options. This launches a "pickfile" widget allowing the user to select the desired directory. The default directories of the backup medium and local backup directories are specified by the environment variables BACKUP_DIR and ANALYSED_BACKUP, respectively. These environment variables are defined in the file "`/home/radar/analysis/lib/analysisvars`".

4.10.27.2 Keyboard Accelerators

The pull-down menu options are accessible from the keyboard ith the use of `<ALT>-<single key>` combinations. For example, the "*File*" menu options may be invoked with the use of `<ALT>-W` to close the widget. This manual page may be displayed by pressing `<ALT>-H`.

4.10.28 The Housekeeping Raw Data Utility

4.10.28.1 Description

The Housekeeping Utility is a compound widget allowing raw data file housekeeping data to be displayed.

The Housekeeping Utility is divided into four main areas. At the top of the widget are two motif-style pull-down menus which provides access to Housekeeping Utility functionality. Below this is a text display window in which the housekeeping data is displayed. Below this are the "*Update*" button and "*Auto Update*" check-box. Pressing update button results in the housekeeping data from the most recent raw data file being displayed. Selecting "*Auto Update*" check-box results in the text display being continually updated with the housekeeping data of the most recent raw data file. The bottom area is the "*Hint Display Area*" which provides useful information about the functionality of the area over which the cursor is placed.

The "*File*" menu includes the "*Open*" option for opening a raw data file of display, the "*Save As*..." option for saving the current text display window contents to file, the "*Print*" option for printing the current text display window contents to file, and the "*Close*" option for closing the widget. The "*Help*" menu includes this information about the Housekeeping Utility version number and this help information.

4.10.28.2 Keyboard Accelerators

The pull-down menu options are accessible from the keyboard with the use of `<ALT>-<single key>` combinations. For example, the File menu options may be invoked with the use of `<ALT>-O` for Open File, `<ALT>-P` for Print File, and `<ALT>-W` to close the widget. This manual page may be displayed by pressing `<ALT>-H`.

4.10.29 The Analysis Utility

4.10.29.1 Description

The Analysis Utility (AU) is a compound widget allowing archived raw data to be analysed by the analysis monitor.

The Analysis Utility is divided into five main areas. At the top of the widget is a row of motif-style pull-down menus which provide access to some AU functionality. The menu headings include "*File*" and "*Help*". The "*File*" menu includes the "*Close*" option for closing the widget. The "*Help*" menu allows access to information about the Analysis Utility, the version number, and this help information. Immediately below the menu bar appears the data selection pull-down menus, and the "*Spool raw data*" selector. Below these appears the file list allowing selection of raw data files to be analysed. Immediately below this are a row of three buttons allowing the analysis to be started and stopped, and the window to be closed. The bottom area is the "*Hint Display Area*" which provides useful information about the functionality of the area over which the cursor is placed.

The data selection pull-down menus allow the selection of the data directory and data filename particulars. The "*Archived Data Directory*" menu provides a "*pickfile*" window allowing the user to select the directory containing the archived data to be analysed. The required directory can be selected by either manually entering the directory name in the "*Filter*" window, or by selecting the appropriate directory from the "*Directories*" field using the left mouse button, which allows the user to step through the directory structure. Once the required directory is selected, the "*OK*" button should selected, and the window will disappear. The "*Filter*" menu provides a dialog window allowing a file filter to be selected. The "*Experiment tag*" menu provides a window allowing the selection of any of the available experiment tags existing in the archived data directory. The "*Spool raw data*" option specifies how the data is to be presented for analysis. If the "*Enable*" option is chosen, the data from the selected files is written to individual raw data files which are spooled in temporal order in the ACQSPOOL directory. This is analogous to the way raw data is analysed on-line. If the "*Disable*" option is chosen, the data from each selected archived data file is analysed in sequence before proceeding to the next selected archived data file. This is analogous to the way raw data is analysed by selecting the "*File|Analyse Archived Data*" from the

"*Analysis and Display Control*" window, with the exception that more than one archived data file can be selected. The appropriate selection for the "*Spool raw data*" option depends on the analysis is required. If the resulting analysed data is to be postanalysed, it is important that the data is analysed in sequence. In this case, the "*Enable*" option should be selected. If the resulting analysed data is not to be postanalysed, the "*Disable*" option should be chosen, as it will result in quicker analysis without unnecessarily writing the data to individual raw data files.

The file list allows the selection of archived raw data files to be analysed. This list is updated if any of the data selection pull-down menus are used. File selection is made using the left mouse button. Multiple files can be selected by dragging the mouse with the left mouse button held down. Holding down the `<SHIFT>` key and clicking an item selects the range from the previously selected item to the new item. Holding down the `<CTRL>` key and clicking an item toggles that item between the selected and unselected state. All files on the list can be selected using the "*Select All*" button at the end of the list.

The "*Start Analysis*" button commences the analysis of the selected raw data files. This button becomes active once a selection has been made. The "*Stop Analysis*" button stops the analysis. This button becomes active when analysis of archived raw data has commenced. The "*Close Utility*" button allows the utility to be closed.

4.10.29.2 Keyboard Accelerators

The pull-down menu options are accessible from the keyboard with the use of `<ALT>-<single key>` combinations. `<ALT>-W` closes the widget. This manual page may be displayed using `<ALT>-H`.

4.10.29.3 Resizing Facility

The widget may be resized as desired.

4.10.29.4 Environment Variables

`ACQSPOOL`:   The directory where individual raw data files are placed.

4.10.29.5 Files

Analysis Utility usage is logged to the file `$ANALYSIS_DIR/log/display.log`. A background process `$ANALYSIS_DIR/libexec/analyse_archived.sh` is started to handle the production of raw data for analysis. This processing is logged to the file `$ANALYSIS_DIR/log/analyse_archived.log` The analysis of the raw data is handled by the analysis monitor. This processing is logged to the file: `$ANALYSIS_DIR/log/analysis.log`

4.10.30 The Postanalysis Utility

4.10.30.1 Description

The Postanalysis Utility (PU) is a compound widget allowing analysed data to be postanalysed by the postanalysis monitor.

The Postanalysis Utility is divided into five main areas. At the top of the widget is a row of motif-style pull-down menus which provide access to some PU functionality. The menu headings include "*File*" and "*Help*". The "*File*" menu includes the "*Close*" option for closing the widget.The "*Help*" menu allows access to information about the Analysis Utility, the version number, and this help information.

Immediately below the menu bar appears the data selection pull-down menus. Below these appears the file list allowing selection of analysed data files to be analysed. Immediately below this are a row of three buttons allowing the analysis to be started and stopped, and the window to be closed. The bottom area is the "*Hint Display Area*" which provides useful information about the functionality of the area over which the cursor is placed.

The data selection pull-down menus allow the selection of the data directory and data filename particulars. The "*Analysed Data Directory*" menu provides a "pickfile" window allowing the user to select the directory containing the analysed data to be analysed. The required directory can be selected by either manually entering the directory name in the "*Filter*" window, or by selecting the appropriate directory from the "*Directories*" field using the left mouse button, which allows the user to step through the directory structure. Once the required directory is selected, the "*OK*" button should selected, and the window will disappear. The "*Filter*" menu provides a dialog window allowing a file filter to be selected. The "*Experiment tag*" menu provides a window allowing the selection of any of the available experiment tags existing in the analysed data directory. The "*Suffix*" menu provides a dialog window allows a suffix to be selected.

The file list allows the selection of analysed analysed data files to be postanalysed. This list is updated if any of the data selection pull-down menus are used. File selection is made using the left mouse button. Multiple files can be selected by dragging the mouse with the left mouse button held down. Holding down the <SHIFT> key and clicking an item selects the range from the previously selected item to the new item. Holding down the <CTRL> key and clicking an item toggles that item between the selected and unselected state. All files on the list can be selected using the "*Select All*" button at the end of the list.

The "*Start Postanalysis*" button commences the analysis of the selected analysed data files. This button becomes active once a selection has been made. The "*Stop Postanalysis*" button stops the analysis. This button becomes active when postanalysis of analysed data has commenced. The "*Close Utility*" button allows the utility to be closed.

4.10.30.2 Keyboard Accelerators

The pull-down menu options are accessible from the keyboard with the use of `<ALT>-<single key>` combinations. `<ALT>-W` closes the widget. This manual page may be displayed using `<ALT>-H`.

4.10.30.3 Resizing Facility

The widget may be resized as desired.

4.10.30.4 Files

Postanalysis Utility usage is logged to the file `$ANALYSIS_DIR/log/display.log`. The postanalysis of the analysed data is handled by the postanalysis monitor. This processing is logged to the file `$ANALYSIS_DIR/log/postanal.log`. Users should consult these log file for further information on any problems observed using Postanalysis Utility.

5. APPENDICES

5.1 Appendix A: ATRAD Raw Data Format

The following notes describe the raw data file format used for ATRAD radar systems. This format is known as "ATRAD Data Format" (ADF). Each ADF raw data file consists of a sequence of "records". Each file includes "Sequence", "Experiment", "Site Parameter", "Acquisition", and raw data records. Raw data files written by radars with extra functionality (e.g. beam steering) include extra records describing the parameters relevant to this functionality. The order in which parameter records appear is not defined, except that the raw data record is guaranteed to appear last.

Individual data records are written to separate files by the acquisition software, but may be appended to larger, contiguous data sets if raw data archiving is selected from the Analysis and Display Control GUI.

5.1.1 Explanatory Notes

1. Each ADF raw data file begins with a four longword information header made up of [File magic number, Number of ADF records in file, Time stamp, Not used]. The first element (32 bits) is the magic number and revision number. The file magic number is 0x1200xxxx, where xxxx is the revision number of the file as a whole. The number of ADF records refers to the total number of information records (each type of which is detailed below) contained in the entire file. For archived raw data files, the fourth element of the header contains the time stamp of the last raw data record contained in the file.

2. Each parameter record is preceded by a four longword information header. The first element is the magic number and revision number for that parameter block. The second element is the length (in bytes) of the parameter block. The third longword is the time at which the parameter block was written (Unix format). The fourth longword is the offset (in bytes) in the file of the beginning of the parameters.

3. A "Sequence" is defined as a set of different acquisition configurations which are to be scheduled in some way and repeated some number of times. A Sequence is initiated by the user through the Radar Configuration , and no hardware needs to be manually configured during the lifetime of a Sequence.

4. Each different experimental configuration within a sequence is defined as an "Experiment". An Experiment is defined by the user through the Radar Configuration, and selected for scheduling in some order (relative to other experiments) within the Sequence. Once defined, an Experiment may be scheduled as often or as rarely as the user desires.

5. An "Acquisition" is defined as a single complete data set acquired under a certain configuration. One or more Acquisitions make up an Experiment. At this time, the only difference in configuration between Acquisitions within a single Experiment is the beam pointing direction.

6. The boolean data type specified in the following list may take values of zero, corresponding to "false", or "no", or it may be non-zero, signifying "true", or "yes".

7. Data sizes are given as 8-bit bytes, and all data types are integer multiples of 4 bytes.

8. Multiple-byte integers are written as signed, network order entities.

9. Floating point numbers are written as 4-byte IEEE floats.

10. The raw data are written as 16-bit signed quantities.

11. Strings are null-terminated and thus may store one less character than the allotted space in bytes.

12. Receiver test parameters are hard-coded and do not appear in the data

13. Data format revisions are recorded in the magic number system using the least significant 16 bit of the number. Header revision numbers are independent of each other.

5.1.2 Sequence Parameter Record

Magic number: 0x1201xxxx where "xxxx" is the revision number of the record.

Revision 0x0001:

Parameter	Description	Data Type	Data Size	Allowable Values
File ID	An identification number for radar system consisting of radar model and serial number.	Integer	4	E.g., 7004, 1201
Sequence Name	The name for the sequence of experiments specified for this data set.	String	80	E.g., Spring Rocket sequence, 1997.
Number of Background Events	The number of background events for the complete sequence (1 - based).	Integer	4	1 - ?
Number of Scheduled Events	The number of scheduled events for this sequence	Integer	4	0 - ?
Scheduling interval	The number of seconds between experiment starts (or a multiple of this number of seconds).	Integer	4	$20 - 2^{31}$
Rx Test Schedule	The number of Sequence cycles between Rx calibration tests. (Zero implies no testing.)	Integer	4	$0 - 2^{31}$

5.1.3 Experiment Parameter Record

Magic number: 0x1202xxxx where "xxxx" is the revision number of the record.

Revision 0x0001:

Parameter	Description	Data Type	Data Size	Allowable Values
Experiment Name	The name and/or description of the experiment corresponding to the following data.	String	80	E.g., Tropospheric wind profiling using FCA.
Experiment Tag	The tag name given to the following experiment.	String	80	E.g., TRWP
Number of Repetitions	The number of times the experiment is to run.	Integer	4	$1 - 2^{31}$
Pulse Repetition Frequency	The PRF used for this experiment in Hertz.	Integer	4	$1 - 5 \times 10^5$
Number of Data Points	The number of coherently-averaged data points collected in each acquisition cycle for this experiment.	Integer	4	$1 - 2^{31}$
Number of Coherent Integrations	The number of coherent integrations performed on each acquired data point for this experiment	Integer	4	1 (none) - 4096
Zero Range Calibration	The value of the software-specified range marker calibration delay in nanoseconds.	Integer	4	0 - ?
Number of Receiving Channels	The number of receiving channels used for data acquisition	Integer	4	1 - 16
Active	The active receiving channels used	Integer	4 x 16	1 - 16

Parameter	Description	Data Type	Data Size	Allowable Values
Receiving Channels	for data acquisition (1-based).	Array		
Number of Transmitting Channels	The number of receiving channels used for data acquisition	Integer	4	1 - 16
Active Transmitting Channels	The active transmitting channels used for data acquisition (1-based).	Integer Array	4 x 16	1 - 16
Transmitter output amplitude percentage	The output amplitude percentage (relative to maximum amplitude) of the active Tx channels	Integer	4	0 - 100
Dual Range Sampling Active	Whether two sampling regions are active or not	Boolean	4	0, 1
Phase inversion Active	Whether or not phase is inverted on Successive Tx pulses	Boolean	4	0, 1
Tx Polarisation Inversion Active	Whether of not the transmitted polarisation is inverted for successive acquired data points.	Boolean	4	0, 1
Rx Polarisation Inversion Active	Whether of not the received polarisation is inverted for successive acquired data points.	Boolean	4	0, 1
Lowest Range 1	The first (lowest) sampled range for the first sampling region (m).	Integer	4	0 - ?
Range Interval 1	The range interval between samples in the first sampling region (m).	Integer	4	0 - ?
Range extent 1	The range of sampled ranges in the first sampling region (m).	Integer	4	0 - ?
Lowest Range 2[1]	The first (lowest) sampled range for the second sampling region (m).	Integer	4	0 - ?
Range Interval 2	The range interval between samples in the second sampling region.	Integer	4	0 - ?
Range extent 2	The range of sampled ranges in the second sampling region (m).	Integer	4	0 - ?
Tx Polarisation	The polarisation used for transmission. (0 = "O", 1 = "E", 2 = interleaved O and E).	Integer	4	0, 1, 2, 3
Rx Polarisation	The polarisation used for reception. (0 = "O", 1 = "E", 2 = interleaved O and E).	Integer	4	0, 1, 2, 3
Receiver Filter width	The receiver filter width (= receiver bandwidth/2) (Hz)	Float	4	?

5.1.4 Site Parameter Record

Magic number: 0x1203xxxx where "xxxx" is the revision number of the record.

Revision number: 0x0002

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[1] Note that Lowest Range2 is higher than Lowest Range 1 and that the two regions may not overlap. If dual range sampling is not active (or if dual range sampling is not implemented) then all "Range 2" values will be zero.

Parameter	Description	Data Type	Data Size	Allowable Values
Site Name	The name of the physical location of the radar system	String	80 chars	?
Nominal Frequency	The nominal operating frequency (Hz)	Float	4	?
Latitude	The latitude of the site (+ = North, - = South)	Integer Array	3 x 4	?
Longitude	The longitude of the (+ = East, - = West)	Integer Array	3 x 4	?
Altitude	The altitude of the site above sea level (in meters)	Float	4	?
GPS present	Timing handled by GPS	Boolean	4	0,1
Number Tx	Number of transmit antenna groups.	Integer	4	1 - ?
Number Rx	Number of receive antenna groups.	Integer	4	1 - ?
Tx Antenna Coordinates	The antenna coordinates of the Tx antennas in (range, bearing) pairs. (Number Tx) Pairs, metres and degrees relative to any arbitrary zero.	Float Array	4 x (Number Tx) x 2	Range: 0.0 - $\pm 10^{38}$ metres Bearing: 0.0 - 360.0°
Tx Antenna Names	The names or descriptions of the transmitter antenna groups.	String Array	80 x (Number Tx)	E.g. Folded dipole array
Rx Antenna Coordinates	The antenna coordinates of the Rx antennas in (range, bearing) pairs. (Number Rx) Pairs, metres and degrees relative to any arbitrary zero.	Float Array	4 x (Number Rx) x 2	Range: 0.0 - $\pm 10^{38}$ m Bearing: 0.0 - 360.0°
Rx Antenna orientation	The orientation of the receiving antennas in (azimuth, zenith) pairs	Float Array	4 x (Number Rx) x 2	Azimuth: 0.0 – 360.0° Zenith:, 0.0 – 90.0°
Rx Antenna Names	The names or descriptions of the receiver antenna groups.	String Array	80 x (Number Rx)	E.g. Meteor array

5.1.5 Gain Control Record

Magic number: 0x1204xxxx where "xxxx" is the revision number of the record.

Revision 0x0002:

Parameter	Description	Data Type	Data Size	Allowable Values
Gain Algorithm Number	The number of the gain calculation algorithm to use. (Zero implies no dynamic gain control.)	Integer	4	0 (in the first instance)
Dual Gain Regime Active`	Whether dual gain regimes are in use.	Boolean	4	0 (in the first instance)
Rx Gains1	The Rx gains applicable to this data set (16 values in dB). If dual gain regime active, then these gains correspond to the lower range gain range.	Integer Array	4 x 16 = 64	E.g., 62 - 122
Rx Gains2	The Rx gains applicable to this data set (16 values in dB) if dual gain regime active. These gains correspond to the upper range gain range.	Integer Array	4 x 16 = 64	E.g., 62 - 122
Rx Gain Minimum	The minimum gain supported by the hardware (dB).	Ìnteger	4	E.g., 0 dB
Rx Gain Maximum	The maximum gain supported by the hardware (dB).	Ìnteger	4	E.g., 80 dB

5.1.6 Acquisition Parameter Record

Magic number: 0x1206xxxx where "xxxx" is the revision number of the record.

Revision 0x0002:

Parameter	Description	Data Type	Data Size	Allowable Values
Time Stamp	The time at which the acquisition began (Unix time format).	Time	4	0 -
Time Stamp – Vector	The time stamp of the acquisition stored as a six element integer vector; [Year, Month, Date, Hour, Min, Sec]. Year is 4-digit, month and date are 1-based. The format is GMT.	Integer Array	4 x 6 = 24	E.g., [1996, 12, 31, 23, 59, 59]
Acquisition Number	The number of the current acquisition	Integer	4	$1 - 2^{32}$
Background or scheduled event	Whether the experiment is a background or scheduled event.	Integer	4	0 = Background 1 = Scheduled
Sequence Event Number	The number of the experiment in the sequence (1-based)	Integer	4	1 - ?
GPS locked	Indicates whether GPS was locked through acquisition of data-set	Boolean	4	0,1

5.1.7 Tx Pulse Record

Magic number: 0x1207xxxx where "xxxx" is the revision number of the record.

Revision 0x0001:

Parameter	Description	Data Type	Data Size	Allowable Values
Pulse Mode	The mode of Tx pulse operation. 0 = normal or coded pulses, 1 = pulse pair transmission.	Integer	4	0 or 1
Pulse Width	The width of the Tx pulse in metres. This is the baud length if coded pulses are in use.	Integer	4	100, 125, 150,....
Tx Pulse Shape	The pulse shape used for transmission. (For example, 1 = Gaussian, 2 = Square, 3 = Triangular, 4 = "Normal")	Integer	4	1, 2, 3, 4
Pulse Separation	The distance (in metres) between the two pulses if pulse pair mode is selected.	Integer	4	15000 typical, but 0 in the first instance
Number of Codes	The number of codes transmitted. 0 = uncoded, 1 = Barker code, 2 = Complementary codes.	Integer	4	0, 1, 2
Code Length	The number of "bits" or "bauds" in the code.	Integer	4	2 - 64
Pulse Codes	The pulse codes themselves. These are two 64-bit values, least significant bit corresponds to the LAST code element transmitted.	Long-Integer array	8 x 2 = 16	0 - (2^{64}-1)
External Triggering Active	Whether external triggering of Tx pulses enabled	Boolean	4	0, 1

5.1.8 RASS Generator Record

Magic number: 0x1209xxxx where "xxxx" is the revision number of the record.

Revision 0x0001:

Parameter	Description	Data Type	Data Size	Allowable Values
RASS Mode	The mode of operation of the RASS generator.	Integer	4	1 = Triangular Sweep 2 = Sawtooth Sweep
Start Frequency	The start frequency of the audio sweep in Hertz.	Float	4	100 Hz typical
Step Size	The frequency interval between successive frequencies in the sweep in Hertz.	Float	4	0.5 Hz typical
Number of Steps	The number of discrete frequency steps used in the sweep.	Integer	4	40 steps typical
Step Dwell Time	The amount of time spent on each frequency in the sweep or in the pseudo-random spectrum in ms.	Integer	4	20 ms typical

5.1.9 Beam steering record

Magic number: 0x120axxxx where "xxxx" is the revision number of the record.

Revision 0x0000:

Parameter	Description	Data Type	Data Size	Allowable Values
Number of beam directions	The number (N) of point-to-point beam directions present in this acquisition	Integer	4	1 - ?
Beam directions	An array of [azimuth, zenith] pairs indicating the beam directions present in this acquisition.	Float Array	4 x N x 2	Azimuth = 0 - 360 degrees, Zenith = 0 to 90 degrees

5.1.10 Frequency Agility record

Magic number: 0x120cxxxx where "xxxx" is the revision number of the record.

Revision 0x0000:

Parameter	Description	Data Type	Data Size	Allowable Values
Number of frequencies	The number (N) of frequencies present in this acquisition	Integer	4	1 - ?
Frequencies	An array of frequencies present in this acquisition.	Float Array	4 x N	Frequency (Hz)

5.1.11 Receiver calibration record (ADAC)

Magic number: 0x120dxxxx where "xxxx" is the revision number of the record.

Revision 0x0000:

Parameter	Description	Data Type	Data Size	Allowable Values
Number of phases	The number (N) of phases present in this acquisition (default = 3)	Integer	4	3 - ?
Phases	An array of phases present in this acquisition.	Float Array	4 x N	Phases (degrees)

5.1.12 Beam offset record (ADAC)

Magic number: 0x120exxxx where "xxxx" is the revision number of the record.

Revision 0x0000:

Parameter	Description	Data Type	Data Size	Allowable Values
Offset	Direction offset introduced by cable delays in the antenna array	Integer	4	-90 – 90 degrees

5.1.13 Phase table record

Magic number: 0x120fxxxx where "xxxx" is the revision number of the record.

Revision 0x0000:

Parameter	Description	Data Type	Data Size	Allowable Values
Number of phase tables	The number (N) of phases present in this acquisition (default = 3)	Integer	4	3 - ?
Rx Phase flag	Flag to indicate whether Rx phases are equal to Tx phases.	Integer	4	0: all rx phases = 0 1: rx phases equal to tx phases
Transmitter phases [1-N]	An array of [phase table number] [Transmitters 1-M] indicating the phases of the transmitter. For corssed dipoles, phases are the reference phase values (N-S default)	Float array	N x 4 x M (1)	Phase = 0-360° Set to -1 if tx is disabled

Revision 0x0001:

Parameter	Description	Data Type	Data Size	Allowable Values
Number of phase tables	The number (N) of phases present in this acquisition (default = 3)	Integer	4	3 - ?
Rx Phase flag	Flag to indicate whether Rx phases are equal to Tx phases.	Integer	4	0: all rx phases = 0 1: rx phases equal to tx phases
Transmitter phases [1-N]	An array of [phase table number] [Transmitters 1-M] indicating the phases of the transmitter. For corssed dipoles, phases are the reference phase values (N-S default)	Float array	N x 4 x M (1)	Phase = 0-360° Set to -1 if tx is disabled
Effective beam direction	The effective beam direction (azimth, zenith) of the beam formed by each phase table	Float array	N x 4 x 2	Azimuth: 0-180° Zenith: 0-90°
Effective beam width	The effecitve beam width of the beam formed by each phase table	Float array	N x 4	0-180°

Notes:

1) M is the number of tx, as written to site parameter record.

2) Currently the phase table record is written only by APAC MF radars using a hardware type of 4, 5 or 6.

3) For APAC MF radars (hardware types 4, 5 or 6), the phase table is always written if a beam steering record is written. It is also written if the beam direction is specified in terms of 1 or more phase tables.

5.1.14 Interference Removal Data Record

Magic number: 0x1250xxxx where "xxxx" is the revision number of the record.

Revision 0x0000:

Parameter	Description	Data Type	Data Size	Allowable Values
Secondary data start range	The start of the secondary data range in kilometres.	Float	4	0 - ?
Secondary data end range	The end of the secondary data range in kilometres.	Float	4	0 - ?

5.1.15 Raw Data Record

Magic number: 0x1280xxxx where "xxxx" is the revision number of the record.

Revision 0x0000: IP/QP components appear in the data with QP data records preceding IP data records.

Revision 0x0001: IP/QP components appear in the data with IP data records preceding QP data records.

Dimensionally the data record is arranged in majority order as follows; Range (lowest first), Channel, Component, Point. In the case of multiplexed data, each receiver channel's data (from more than one antenna input) is stored as a single channel. No de-multiplexing is performed by the acquisition software. Similarly, for point-to-point beam steered data acquisition, sequential beam directions appear in the raw data in an interleaved fashion.

Data is written as 2-byte integers.

The following table illustrates the order in which data are stored:

Lowest Range	Channel 1	Component 1 (IP)	Point 1, Point 2,.....
		Component 2 (QP)	....
	Channel 2	....	
	....		
Next Range	Channel 1		
	Channel 2		
	....		
....			

5.1.16 Coded Raw Data Record

Magic number: 0x1281xxxx where "xxxx" is the revision number of the record.

Revision 0x0001: IP/QP components appear in the data with IP data records preceding QP data records.

The coded data are arranged identically to the "normal" raw data. For two part codes, the second set of coded data immediately follows the first, and the number of points stored in the coded data record will be twice as many as the number of decoded points. The number of ranges written to the experiment is N-1 larger than the number of heights that would be present in the decoded data as configured using the experiment editor, where N is the bit-length of the code in use. The additional ranges correspond to range gates above those configured as required by the decoding process.

5.2 Appendix B: ATRAD SPEC, AOA and COVF Data Format

The following notes describe the data file format produced by SPEC, COVF and IDI analyses, which are available with version 3 of the ATRAD IDL analysis and display suite (ADS). This format uses the same conventions as the ATRAD Raw data format (or ADF) as discussed in Appendix A: ATRAD Raw Data Format. Each file includes "Sequence", "Experiment", "Site Parameter", "Acquisition", and SPEC, AOA, and COVF data records. Data files written by radars with extra functionality (e.g. beam steering) include extra records describing the parameters relevant to this functionality. The order in which parameter records appear is not defined, except that the data record is guaranteed to appear last.

Individual data records are written to separate files by the analysis monitor, but may be appended to larger, contiguous data sets if data archiving is selected from the Analysis and Display Control GUI.

5.2.1 SPEC parameter Record

Magic number: 0x1220xxxx where "xxxx" is the revision number of the record.

Revision 0x0000:

Parameter	Description	Data Type	Data Size	Allowable Values
Interference rejection	Whether interference rejection applied in analysis	Boolean	4	0 = NO, 1 = YES
Sea scatter flag.	Whether sea scatter removal applied in analysis	Boolean	4	0 = NO, 1 = YES
Sea scatter ratio threshold	The ratio threshold for sea scatter removal	Float	4	0.5 Hz typical
Sea scatter frequency width	The frequency (full-) width used for sea scatter removal	Integer	4	? m/s
Sea scatter application ranges	The ranges between which sea scatter removal applied (inclusive)	Integer Array	4 x 2	? km
Splitting flag	The number of time-series split to produce spectra	Integer	4	1 - ?
Time-series combining flag	Indicates whether time-series have been combined	Boolean	4	0 = NO, 1 = YES
Combine map	The active receiving channels used for time-series combining (1-based).	Integer Array	4 x 2	? km

5.2.2 SPEC Magnitude Data Record

Magic number: 0x1221xxxx where "xxxx" is the revision number of the record.

Revision 0x0000: Dimensionally the data record is arranged in majority order as follows: Beam direction, Split Index, Range (lowest first), Channel, Spectral point.

5.2.3 SPEC Complex Data Record

Magic number: 0x1222xxxx where "xxxx" is the revision number of the record.

Revision 0x0000: Dimensionally the data record is arranged in majority order as follows: Beam direction, Split Index, Range (lowest first), Channel, Component (IP first), Spectral point.

5.2.4 SPEC information Record

Magic number: 0x1223xxxx where "xxxx" is the revision number of the record.

Revision 0x0000:

Parameter	Description	Data Type	Data Size	Allowable Values
Number of spectra averaged	Number of spectra averaged to produce spectra	Integer	As below	1-?
Error flag	Error status of spectra	Integer	As below	0 = good data, 1 = bad data

Dimensionally the data record is arranged in majority order as follows: Beam direction, Split Index, Range (lowest first), Channel, Component (IP first), Data.

5.2.5 AOA parameter Record

Magic number: 0x1230xxxx where "xxxx" is the revision number of the record.

Revision 0x0000:

Parameter	Description	Data Type	Data Size	Allowable Values
Number of AOAs	The number of AOAs (and radial velocities) included in file	Boolean	4	1 - ?
Interference rejection	Whether interference rejection applied in analysis	Boolean	4	0 = NO, 1 = YES
Sea scatter flag.	Whether sea scatter removal applied in analysis	Boolean	4	0 = NO, 1 = YES
Sea scatter ratio threshold	The ratio threshold for sea scatter removal	Float	4	0.5 Hz typical
Sea scatter frequency width	The frequency (full-) width used for sea scatter removal	Integer	4	? m/s
Sea scatter application ranges	The ranges between which sea scatter removal applied (inclusive)	Integer Array	4 x 2	? km

5.2.6 AOA SNR/Power Record

Magic number: 0x1231xxxx where "xxxx" is the revision number of the record.

Revision 0x0000:

Parameter	Description	Data Type	Data Size	Allowable Values
SNR array	Array containing estimated SNR for each range gate	Float	4 x No. of heights	?
Power array	Array containing estimated power for each range gate	Float	4 x No. of heights	?

5.2.7 AOA Data Record

Magic number: 0x1232xxxx where "xxxx" is the revision number of the record.

Revision 0x0000:

Parameter	Description	Data Type	Data Size	Allowable Values
Radial velocity array	Array containing radial velocities	Float	4 x No. of AOAs	?
Scatterer positions array	Array containing (x, y, z) positions of scattering locations	Float	4 x No. of AOAs	?

5.2.8 COVF parameter Record

Magic number: 0x1240xxxx where "xxxx" is the revision number of the record.

Revision 0x0000:

Parameter	Description	Data Type	Data Size	Allowable Values
Number of lags	The number of lags calculated for covariance functions	Integer	4	1 - ?
Number of pairs	Number of receiver channel pairs used to calculate covariance functions	Integer	4	1 - ?
ACOVF map	Map of channels for which auto covariance functions calculated	Integer Array	4 x ?	1 - ?
COVF map	Map of channels for which cross-covariance functions calculated	Integer Array	4 x ?	1 - ?
Interference rejection	Whether interference rejection applied in analysis	Boolean	4	0 = NO, 1 = YES
Sea scatter flag.	Whether sea scatter removal applied in analysis	Boolean	4	0 = NO, 1 = YES
Sea scatter ratio threshold	The ratio threshold for sea scatter removal	Float	4	0.5 Hz typical
Sea scatter frequency width	The frequency (full-) width used for sea scatter removal	Integer	4	? m/s
Sea scatter application ranges	The ranges between which sea scatter removal applied (inclusive)	Integer Array	4 x 2	? km
Splitting flag	The number of time-series split to produce spectra	Integer	4	1 - ?
Time-series combining flag	Indicates whether time-series have been combined	Boolean	4	0 = NO, 1 = YES
Combine map	The active receiving channels used for time-series combining (1-based).	Integer Array	4 x 2	? km
Number of ACOVFs	The number of auto-covariance functions calculated	Integer	4	1 - ?
Number of CCOVFs	The number of cross-covariance functions calculated	Integer	4	1 - ?

5.2.9 COVF Autocovariance Function Data Record

Magic number: 0x1241xxx where "xxxx" is the revision number of the record.

Revision 0x0000: Dimensionally the data record is arranged in majority order as follows: Beam direction, Split Index, Range (lowest first), Channel, Component (IP first) , Lag (zero to largest positive).

5.2.10 COVF Cross-covariance Data Record

Magic number: 0x1242xxxx where "xxxx" is the revision number of the record.

Revision 0x0000: Dimensionally the data record is arranged in majority order as follows: Beam direction, Split Index, Range (lowest first), Channel, Component (IP first), Lag (zero to largest positive).

5.3 Appendix C: ATRAD Analysed Data Format

A new analysed data format has been introduced with version 3 of the ATRAD IDL analysis and display suite (ADS). This format uses similar conventions to the ATRAD raw data format (ADF). The revised data format has several advantages over the previous data format:

1. the data is stored more economically. File sizes for some analyses are reduced by up to 40%.

2. the display modules are able to read in the data faster. This is a result of the information required for reading in the data being more readily accessible, and due to the more economical format.

3. the use of "revision numbers" for different analysis versions. This allows the ADS to handle data written by analyses updated to include extra output parameters. For instance, with version 3 the ADS, the full correlation analysis (FCA) can be used to calculate and store the mean angle of arrival (MAOA) and the vertical velocity corrected for the effects of the MAOA being off-zenith if receiver calibration is used. There is no simple manner for including such extra information using the previous data format.

4. the use of "revision numbers" also means that fields not used in a particular analysis (e.g. aspect sensitivity and effective beam direction for "combined" DBS) which are necessarily stored (as zero fields) in the previous data format are not included in the revised analysed data records.

5. the storage of housekeeping information, such as the receiver channels used for analysis, which is not stored in the previous format, can be stored in the revised format.

The following notes describe the analysed data file. The analysed data is written to daily files as described on page 15. The files are written in external data representation (XDR) for cross-platform compatibility.

5.3.1 Explanatory Notes

Each ADF analysed data file begins with a four longword information header made up of [File magic number, Number of ADF records in file, Time stamp of first record in file, Time stamp of last record in file]. The first element (32 bits) is the magic number and revision number. The file magic number is 0x2000xxxx, where xxxx is the revision number of the file as a whole. The number of AADF records refers to the total number of information records (each type of which is detailed below) contained in the entire file.

Each parameter record is preceded by a four longword information header. The first element is the magic number and revision number for that parameter block. The second element is the length (in bytes) of the parameter block. The third longword is the time at which the parameter block was written (Unix format). The fourth longword is the offset (in bytes) in the file of the beginning of the parameters.

An analysed data record is stored after its applicable parameter record. Since an analysed data file usually contains more than one data point, a single analysed data file will typically contain multiple sets of parameter and analysed data records.

All data sizes are given as 8-bit bytes, and all data types are integer multiples of 4 bytes.

Multiple-byte integers are written as signed, network order entities.

Data format revisions are recorded in the magic number system using the least significant 16 bit of the number. Header revision numbers are independent of each other.

Note that all velocities are specified in terms of the direction in which the wind is heading. All vertical and radial velocities are specified as positive in the direction away from the radar, such that positive vertical velocities are upwards.

All analysed data records are stored from lowest to highest range.

5.3.2 FCA parameter Record.

Magic number: 0x2010xxxx where "xxxx" is the revision number of the record.

Revision 0x0001:

Parameter	Description	Data Type	Data Size	Allowable Values
Number of Receiving Channels	The number of receiving channels used for data analysis (N)	Integer	4	1 - 16
Active Receiving Channels	The active receiving channels used for data acquisition (and hence SNR calculation) (1-based)	Integer Array	4 x N	1 - ?
FCA Receiving channels	The four receiving channels used for full correlation analysis (1-based)	Integer Array	4 x 4	1- ?
Lowest Range 1	The first (lowest) sampled range for the first sampling region (m).	Integer	4	0 - ?
Range Interval 1	The range interval between samples in the first sampling region (m).	Integer	4	0 - ?
Range extent 1	The range of sampled ranges in the first sampling region (m).	Integer	4	0 - ?
Radar frequency	The operating frequency of the radar in Hz during this experiment.	Float	4	0 - ?, Hz

5.3.3 FCA Analysed Data Records

Magic number: 0x2011xxxx where "xxxx" is the revision number of the record.

Revision 0x0000:

Parameter	Description	Data Type	Data Size	Allowable Values
Error code	Analysis error code	Integer	4	01/19/09
Apparent velocity	Apparent velocity components (Zonal, Meridional)	Float Array	4 x 2	?, ms^{-1}
True velocity	True velocity components (Zonal, Meridional)	Float Array	4 x 2	?, ms^{-1}
Vertical velocity	Vertical velocity (upwards = positive)	Float	4	?, ms^{-1}
Fading time	Mean auto-correlation function half-width	Float	4	0 - ?, s
Pattern lifetime	Fading time in the frame of the ground diffraction pattern	Float	4	0 - ?, s
Pattern scale	Major axis of the characteristic ellipse	Float	4	0 - ?, m
Axial ratio	Ratio of the major to minor axes of the characteristic ellipse	Float	4	1 - ?
Axial rotation	Direction of major axis of characteristic ellipse, East of North	Float	4	0 - ?, degrees
Percentage time discrepancy	Ratio of sum of cross-correlation function maximum delay times to sum of absolute cross-correlation function delay times.	Integer	4	0 - 100, %
SNR	The signal to noise ratios for each receiver channel data collected on	Float Array	4 x Number of Channels	?, dB
Amplitude	The amplitude for each receiver channel data collected on	Float Array	4 x Number of Channels	?, Square root of digitisation units

Revision number 0x0001: This includes fields for the mean angle of arrival and corrected vertical velocity if these quantities are calculated in the analysis.

Parameter	Description	Data Type	Data Size	Allowable Values
Error code	Analysis error code	Integer	4	1 - 18
Apparent velocity	Apparent velocity components (Zonal, Meridional)	Float Array	4 x 2	?, ms^{-1}
True velocity	True velocity components (Zonal, Meridional)	Float Array	4 x 2	?, ms^{-1}
Vertical velocity	Vertical velocity (upwards = positive)	Float	4	?, ms^{-1}
Corrected Vertical velocity	Vertical velocity corrected for effects of off-zenith mean angle of arrival (upwards = positive)	Float	4	?, ms^{-1}
Mean angle of arrival	Mean angle of arrival in cartesian coordinates	Float Array	4 x 2	-90 – 90, degrees
Fading time	Mean auto-correlation function half-width	Float	4	0 - ?, s
Pattern lifetime	Fading time in the frame of the ground diffraction pattern	Float	4	0 - ?, s
Pattern scale	Major axis of the characteristic ellipse	Float	4	0 - ?, m
Axial ratio	Ratio of the major to minor axes of the characteristic ellipse	Float	4	1 - ?
Axial rotation	Direction of major axis of characteristic ellipse, East of North	Float	4	0 - ?, degrees
Percentage time discrepancy	Ratio of sum of cross-correlation function maximum delay times to sum of absolute cross-correlation function delay times.	Integer	4	0 - 100 %
SNR	The signal to noise ratios for each receiver channel data collected on	Float Array	4 x Number of channels	?, dB
Amplitude	The amplitude for each receiver channel data collected on	Float Array	4 x Number of channels	?, Square root of digitisation units

5.3.4 DAE/DPE Analysed Data Records

Magic number: 0x2021xxxx where "xxxx" is the revision number of the record.

Revision 0x0000:

Parameter	Description	Data Type	Data Size	Allowable Values
Error code	Overall analysis error code	Integer	4	0 - 2
DAE Error code	DAE error code	Integer	4	0 - 5
DPE Error code	DPE error code	Integer	4	0 - 6
DAE electron density	Electron density calculated by DAE analysis	Float	4	?, Electrons per cm^{-3}
DPE electron density	Electron density calculated by DPE analysis	Float	4	?, Electrons per cm^{-3}
Amplitude ratio	Amplitude ratio of X- to O-mode signal amplitudes	Float	4	0 - ?
Reflection coefficient ratio	Reflection coefficient ratio of X- to O-mode signal amplitudes	Float	4	0 - ?
Phase difference	Difference of X- minus O-mode signal phases	Float	4	?, degrees
Reflection coefficient phase difference	Difference of X- minus O-mode reflection coefficient phases	Float	4	0 - ?, degrees
O-mode power	Ordinary mode power	Float	4	0 - ?, W
X-mode power	Extraordinary mode power	Float	4	0 - ?, W

Revision 0x0001: Applicable to systems without point-to-point mode interleaving

Parameter	Description	Data Type	Data Size	Allowable Values
Error code	Overall analysis error code	Integer	4	0 - 2
DAE Error code	DAE error code	Integer	4	0 - 5
DAE electron density	Electron density calculated by DAE analysis	Float	4	?, Electrons per cm^{-3}
Amplitude ratio	Amplitude ratio of X- to O-mode signal amplitudes	Float	4	0 - ?
Reflection coefficient ratio	Reflection coefficient ratio of X- to O-mode signal amplitudes	Float	4	0 - ?
O-mode power	Ordinary mode power	Float	4	0 - ?, W
X-mode power	Extraordinary mode power	Float	4	0 - ?, W

5.3.5 Beam Steering Data Record.

Magic number: 0x2030xxxx where "xxxx" is the revision number of the record. Applicable for DBS and RASS analyses.

Parameter	Description	Data Type	Data Size	Allowable Values
Number of Receiving Channels	The number of receiving channels used for data analysis (N)	Integer	4	1 - 16
Receiving Channels	The receiving channels used for data analysis (1-based).	Integer Array	4 x N	1 - ?
Lowest Range 1	The first (lowest) sampled range for the first sampling region (m).	Integer	4	0 - ?
Range Interval 1	The range interval between samples in the first sampling region (m).	Integer	4	0 - ?
Range extent 1	The range of sampled ranges in the first sampling region (m).	Integer	4	0 - ?
Radar frequency	The operating frequency of the radar in MHz during this experiment.	Float	4	0 - ?
Transmit Beam direction	The transmit beam direction used during this experiment in polar coordinates.	Float array	4 x 2	Azimuth = 0 – 360 Zenith = 0 - 90
Nyquist velocity	The maximum unambiguous radial velocity used in the analysis	Float	4	0 - ? ms^{-1}

5.3.6 DBS Analysed Data Records

Magic number: 0x2031xxxx where "xxxx" is the revision number of the record.

Revision 0x0000: used for hybrid Doppler interferometer DBS analysis

Parameter	Description	Data Type	Data Size	Allowable Values
Error code	Analysis error code	Integer	4	0 - 2
Effective beam direction	The effective beam pointing direction	Float Array	4 x 2	Azimuth = 0 – 360, Zenith = 0 – 90, degrees
Radial velocity	Radial velocity	Float	4	?, ms^{-1}
Aspect sensitivity	Aspect sensitivity parameter (e^{-1} half width of effective polar diagram)	Float	4	0 - ?, degrees
Spectral width	Spectral width	Float	4	0 - ?, ms^{-1}
SNR	Signal to noise ratio	Float	4	?, dB
Power	Signal power	Float	4	0 - ?, dB

Revision 0x0001: used for single channel or combined DBS analysis:

Parameter	Description	Data Type	Data Size	Allowable Values
Error code	Analysis error code	Integer	4	0 - 2
Radial velocity	Radial velocity	Float	4	?, ms^{-1}
Spectral width	Spectral width	Float	4	0 - ?, ms^{-1}

Parameter	Description	Data Type	Data Size	Allowable Values
SNR	Signal to noise ratio	Float	4	?, dB
Power	Signal power	Float	4	0 - ?, dB

5.3.7 MET Parameter Record

Magic number: 0x2050xxxx where "xxxx" is the revision number of the record.

Revision 0x0001: phase differences not stored

Parameter	Description	Data Type	Data Size	Allowable Values
Number of Ranges	The number of ranges included in the analysed data record	Integer	4	0 - ?[2]
Radar frequency	The operating frequency of the radar in Hz during this experiment.	Float	4	0 - ?
Transmit Beam direction	The transmit beam direction used during this experiment.	Integer array	4 x 2	Azimuth = 0 – 360 Zenith = 0 - 90
Nyquist velocity	The maximum unambiguous radial velocity used in the analysis	Float	4	0 - ? ms^{-1}
GPS locked	Indicates whether GPS was locked through acquisition of data-set	Boolean	4	0,1
Number of Receiving Channels	The number of receiving channels used for data analysis (N)	Integer	4	1 - 16
Receiving Channels	The receiving channels used for data analysis (1-based).	Integer Array	4 x N	1 - ?

Revision 0x0002: phase differences stored

Parameter	Description	Data Type	Data Size	Allowable Values
Number of Ranges	The number of ranges included in the analysed data record	Integer	4	0 - ?84
Radar frequency	The operating frequency of the radar in Hz during this experiment.	Float	4	0 - ?
Transmit Beam direction	The transmit beam direction used during this experiment.	Integer array	4 x 2	Azimuth = 0 – 360 Zenith = 0 - 90
Nyquist velocity	The maximum unambiguous radial velocity used in the analysis	Float	4	0 - ? ms^{-1}
Phase Difference Pairs	The number of pairs (N_p) of phase differences stored to file	Integer	4	0 - ?
GPS locked	Indicates whether GPS was locked through acquisition of data-set	Boolean	4	0,1
Number of Receiving Channels	The number of receiving channels used for data analysis (N)	Integer	4	1 - 16
Receiving Channels	The receiving channels used for data analysis (1-based).	Integer Array	4 x N	1 - ?
Antenna Pairs	The antenna pairs used for phase	Integer	4 x 2 x N_p	0 - ?

[2] A number of ranges equals zero means there were no detected meteor events in this record. In this case, a MET analysed data record will not follow the parameter record.

Parameter	Description	Data Type	Data Size	Allowable Values
	differences			

5.3.8 MET Analysed Data Records

Magic number: 0x2051xxxx where "xxxx" is the revision number of the record.

Revision 0x0001: phase differences not stored

Parameter	Description	Data Type	Data Size	Allowable Values
Event Start Time	The start time of the event from the start of the data acquisition period (as recorded in MET parameter record)	Float	4	0 - ?, s
Range	Range	Float	4	0 - ?, km
Error code	Analysis error code	Integer	4	0 - 2
SNR	Signal to noise ratio of detected event	Float	4	?, dB
Power	Signal power of detected event. Note: Power(dB) = 20log(Power)	Float	4	0 - ?, (ADC units)^2
Angle of arrival	The angle of arrival of the detected meteor	Float Array	4 x 2	Azimuth = 0 – 360, Zenith = 0 – 90, degrees
Decay time	Decay time	Float	4	0 - ?, s
Decay time error	Error in decay time estimate	Float	4	0 - ?, s
Diffusion coefficient	Diffusion coefficient	Float	4	0 - ?, s
Diffusion coefficient error	Error in diffusion coefficient estimate	Float	4	0 - ?, s
Radial velocity	Radial velocity	Float	4	?, ms^{-1}
Radial velocity error	Error in radial velocity estimate	Float	4	?, ms^{-1}

Revision 0x0002: phase differences stored

Parameter	Description	Data Type	Data Size	Allowable Values
Event Start Time	The start time of the event from the start of the data acquisition period	Float	4	0 - ?, s
Range	Range	Float	4	0 - ?, km
Error code	Analysis error code	Integer	4	0 - 17
SNR	Signal to noise ratio of detected event	Float	4	?, dB
Power	Signal power of detected event. Note: Power(dB) = 20log(Power)	Float	4	0 - ?, (ADC units)^2
Angle of arrival	The angle of arrival of the detected meteor	Float Array	4 x 2	Azimuth = 0 – 360, Zenith = 0 – 90, degrees

Parameter	Description	Data Type	Data Size	Allowable Values
Decay time	Decay time	Float	4	0 - ?, s
Decay time error	Error in decay time estimate	Float	4	0 - ?, s
Diffusion coefficient	Diffusion coefficient	Float	4	0 - ?, s
Diffusion coefficient error	Error in diffusion coefficient estimate	Float	4	0 - ?, s
Radial velocity	Radial velocity	Float	4	?, ms^{-1}
Radial velocity error	Error in radial velocity estimate	Float	4	?, ms^{-1}
Phase Differences	Phase differences for the number of pairs used (N_p), and mean phase difference error	Float Array	4 x (N_p +1)	0 to 360 degrees

Revision 0x0003: meteoroid speeds stored

Parameter	Description	Data Type	Data Size	Allowable Values
Event Start Time	The start time of the event from the start of the data acquisition period	Float	4	0 - ?, s
Range	Range	Float	4	0 - ?, km
Error code	Analysis error code	Integer	4	0 - 2
SNR	Signal to noise ratio of detected event	Float	4	?, dB
Power	Signal power of detected event. Note: Power(dB) = 20log(Power)	Float	4	0 - ?, (ADC units)^2
Angle of arrival	The angle of arrival of the detected meteor	Float Array	4 x 2	Azimuth = 0 – 360, Zenith = 0 – 90, degrees
Decay time	Decay time	Float	4	0 - ?, s
Decay time error	Error in decay time estimate	Float	4	0 - ?, s
Diffusion coefficient	Diffusion coefficient	Float	4	0 - ?, s
Diffusion coefficient error	Error in diffusion coefficient estimate	Float	4	0 - ?, s
Radial velocity	Radial velocity	Float	4	?, ms^{-1}
Radial velocity error	Error in radial velocity estimate	Float	4	?, ms^{-1}
Meteoroid speed	Meteoroid speed	Float	4	0 - ?, ms^{-1}
Meteoroid speed error	Meteoroid speed error	Float	4	0 - ?, ms^{-1}
"Fitted" range estimate	Range estimate obtained by Gaussian fit to echo range profile	Float	4	0 to ? km
"Frequency agility" range estimate	Range estimate obtained using frequency agility	Float	4	0 to ? km

Revision 0x0004: phase differences and meteoroid speeds stored

Parameter	Description	Data Type	Data Size	Allowable Values
Event Start Time	The start time of the event from the start of the data acquisition period	Float	4	0 - ?, s
Range	Range	Float	4	0 - ?, km
Error code	Analysis error code	Integer	4	0 - 2
SNR	Signal to noise ratio of detected event	Float	4	?, dB
Power	Signal power of detected event. Note: Power(dB) = 20log(Power)	Float	4	0 - ?, (ADC units)^2
Angle of arrival	The angle of arrival of the detected meteor	Float Array	4 x 2	Azimuth = 0 – 360, Zenith = 0 – 90, degrees
Decay time	Decay time	Float	4	0 - ?, s
Decay time error	Error in decay time estimate	Float	4	0 - ?, s
Diffusion coefficient	Diffusion coefficient	Float	4	0 - ?, s
Diffusion coefficient error	Error in diffusion coefficient estimate	Float	4	0 - ?, s
Radial velocity	Radial velocity	Float	4	?, ms^{-1}
Radial velocity error	Error in radial velocity estimate	Float	4	?, ms^{-1}
Meteoroid speed	Meteoroid speed	Float	4	0 - ?, ms^{-1}
Meteoroid speed error	Meteoroid speed error	Float	4	0 - ?, ms^{-1}
"Fitted" range estimate	Range estimate obtained by Gaussian fit to echo range profile	Float	4	0 to ? km
"Frequency agility" range estimate	Range estimate obtained using frequency agility	Float	4	0 to ? km
Phase Differences	Phase differences for the number of pairs used (N_p), and mean phase difference error	Float Array	4 x (N_p +1)	0 to 360 degrees

5.3.9 VEL Record (non beam steering)

Magic number: 0x2070xxxx where "xxxx" is the revision number of the record. Used if VEL analysis is applied to vertical beam DBS or all sky meteor system MET analysed data.

Revision 0x0000: Used for results which do not use beam steering (e.g. all sky meteor)

Parameter	Description	Data Type	Data Size	Allowable Values
Lowest height 1	The first (lowest) sampled height for the first sampling region (m).	Integer	4	0 - ?
Height Interval 1	The height interval between samples in the first sampling region (m).	Integer	4	0 - ?

Parameter	Description	Data Type	Data Size	Allowable Values
Height extent 1	The range of sampled heights in the first sampling region (m).	Integer	4	0 - ?

5.3.10 VEL Parameter Record (beam steering)

Magic number: 0x2080xxxx where "xxxx" is the revision number of the record. Used if VEL analysis is applied to multi-beam DBS or MET analysed data.

Revision 0x0000:

Parameter	Description	Data Type	Data Size	Allowable Values
Lowest height 1	The first (lowest) sampled height for the first sampling region (m).	Integer	4	0 - ?
Height Interval 1	The height interval between samples in the first sampling region (m).	Integer	4	0 - ?
Height extent 1	The range of sampled heights in the first sampling region (m).	Integer	4	0 - ?
Number of beam directions	The number (N) of beam directions used to produce results	Integer	4	1 - ?
Beam directions	The transmit beam direction used during this experiment in polar coordinates.	Float Array	4 x N x 2	Azimuth = 0 – 360 Zenith = 0 - 90

5.3.11 VEL-MET Postanalysed Data Record

Magic number: 0x2071xxxx where "xxxx" is the revision number of the record.

Revision 0x0001:

Parameter	Description	Data Type	Data Size	Allowable Values
Error code	Analysis error code	Integer	4	1 - 18
Horizontal Velocity	Horizontal velocity components (Zonal, Meridional)	Float Array	4 x 2	?, ms^{-1}
Vertical velocity	Vertical velocity (upwards = positive)	Float	4	?, ms^{-1}
Number of accepted data	Number of data used for velocity estimate	Integer	4	0 -
SNR	Signal to noise ratio of detected event	Float	4	?, dB
Power	Signal power of detected event	Float	4	0 - ?, dB

Revision 0x0002: two dimensional velocity estimation

Parameter	Description	Data Type	Data Size	Allowable Values
Error code	Analysis error code	Integer	4	1 - 18
Horizontal Velocity	Horizontal velocity components (Zonal, Meridional)	Float Array	4 x 2	?, ms^{-1}
Number of accepted data	Number of data used for velocity estimate	Integer	4	0 -

Parameter	Description	Data Type	Data Size	Allowable Values
SNR	Signal to noise ratio of detected event	Float	4	?, dB
Power	Signal power of detected event	Float	4	0 - ?, dB

Revision 0x0003: two dimensional velocity and "turbulent velocity" estimation

Parameter	Description	Data Type	Data Size	Allowable Values
Error code	Analysis error code	Integer	4	1 - 18
Horizontal Velocity	Horizontal velocity components (Zonal, Meridional)	Float Array	4 x 2	?, ms^{-1}
Turbulent Velocity	Turbulent (residual RMS) velocity	Float	4	?, ms^{-1}
Number of accepted data	Number of data used for velocity estimate	Integer	4	0 -
SNR	Signal to noise ratio of detected event	Float	4	?, dB
Power	Signal power of detected event	Float	4	0 - ?, dB

5.3.12 VEL-DBS Postanalysed Data Records

Magic number: 0x2081xxxx where "xxxx" is the revision number of the record.

Revision 0x0000:

Parameter	Description	Data Type	Data Size	Allowable Values
Error code	Analysis error code	Integer	4	1 - 18
Velocity	Velocity components (Zonal, Meridional)	Float Array	4 x 2	?, ms^{-1}
Vertical velocity	Vertical velocity (upwards = positive)	Float	4	?, ms^{-1}
Acceptance rate	The percentage of data used for each beam direction	Float Array	4 x No. of Beams	0 - 100, %
SNR	The signal to noise ratios for each beam direction	Float Array	4 x No. of Beams	?, dB
Power	The power for each receiver each beam direction	Float Array	4 x No. of Beams	?, dB

Magic number: 0x2081xxxx where "xxxx" is the revision number of the record.
Revision 0x0001: radial velocity included

Parameter	Description	Data Type	Data Size	Allowable Values
Error code	Analysis error code	Integer	4	1 - 18
Velocity	Velocity components (Zonal, Meridional)	Float Array	4 x 2	?, ms^{-1}
Vertical velocity	Vertical velocity (upwards = positive)	Float	4	?, ms^{-1}
Radial velocity	The radial velocity for each beam direction	Float Array	4 x No. of Beams	?, ms^{-1}
Acceptance rate	The percentage of data used for each beam direction	Float Array	4 x No. of Beams	0 - 100, %

Parameter	Description	Data Type	Data Size	Allowable Values
SNR	The signal to noise ratios for each beam direction	Float Array	4 x No. of Beams	?, dB
Power	The power for each beam direction	Float Array	4 x No. of Beams	?, dB

Magic number: 0x2081xxxx where "xxxx" is the revision number of the record.

Revision 0x0002: radial and turbulent velocity included

Parameter	Description	Data Type	Data Size	Allowable Values
Error code	Analysis error code	Integer	4	1 - 18
Velocity	Velocity components (Zonal, Meridional)	Float Array	4 x 2	?, ms^{-1}
Vertical velocity	Vertical velocity (upwards = positive)	Float	4	?, ms^{-1}
Radial velocity	The radial velocity for each beam direction	Float Array	4 x No. of Beams	?, ms^{-1}
Turbulent velocity	The turbulent velocity for beam direction	Float Array	4 x No. of Beams	?, ms^{-1}
Acceptance rate	The percentage of data used for each beam direction	Float Array	4 x No. of Beams	0 - 100, %
SNR	The signal to noise ratios for each beam direction	Float Array	4 x No. of Beams	?, dB
Power	The power for each beam direction	Float Array	4 x No. of Beams	?, dB

5.3.13 IDI parameter Record.

Magic number: 0x2090xxxx where "xxxx" is the revision number of the record.

Revision 0x0000, 0x0001:

Parameter	Description	Data Type	Data Size	Allowable Values
Number of Receiving Channels	The number of receiving channels used for data analysis (N)	Integer	4	1 - 16
Active Receiving Channels	The active receiving channels used for data acquisition (and hence SNR calculation) (1-based)	Integer Array	4 x N	1 - ?
FCA Receiving channels	The four receiving channels used for full correlation analysis (1-based)	Integer Array	4 x 4	1- ?
Lowest Range 1	The first (lowest) sampled range for the first sampling region (m).	Integer	4	0 - ?
Range Interval 1	The range interval between samples in the first sampling region (m).	Integer	4	0 - ?
Range extent 1	The range of sampled ranges in the first sampling region (m).	Integer	4	0 - ?
Radar frequency	The operating frequency of the radar in Hz during this experiment.	Float	4	0 - ?, Hz

5.3.14 IDI Analysed Data Records

Magic number: 0x2091xxxx where "xxxx" is the revision number of the record.

Revision 0x0000:

Parameter	Description	Data Type	Data Size	Allowable Values
Error code	Analysis error code	Integer	4	1 - 18
Velocity	True velocity components (Zonal, Meridional)	Float Array	4 x 2	?, ms^{-1}
Vertical velocity	Vertical velocity (upwards = positive)	Float	4	?, ms^{-1}
Turbulent velocity	Turbulent (residual RMS) velocity	Float	4	?, ms^{-1}
Scatterer azimth	Mean azimuth angle of scatterers	Float	4	0 – 360 degrees
Scatterer zenith	RMS zenith angle of scatterers	Float	4	0 – 20 degrees
Number of scatterers	Number of scatterers located	Integer	4	1 - ?
SNR	Signal to noise ratio	Float	4	?, dB
Power	Signal power	Float	4	?, dB

5.3.15 IDBS Parameter Record

Magic number: 0x20a0xxxx where "xxxx" is the revision number of the record.

Revision 0x0000:

Parameter	Description	Data Type	Data Size	Allowable Values
Number of Ranges	The number of ranges included in the analysed data record	Integer	4	0 - ?[3]
Radar frequency	The operating frequency of the radar in Hz during this experiment.	Float	4	0 - ?
Transmit Beam direction	The transmit beam direction used during this experiment.	Integer array	4 x 2	Azimuth = 0 – 360 Zenith = 0 - 90
Nyquist velocity	The maximum unambiguous radial velocity used in the analysis	Float	4	0 - ? ms^{-1}
GPS locked	Indicates whether GPS was locked through acquisition of data-set	Boolean	4	0,1
Number of Receiving Channels	The number of receiving channels used for data analysis (N)	Integer	4	1 - 16
Receiving Channels	The receiving channels used for data analysis (1-based).	Integer Array	4 x N	1 - ?

5.3.16 IDBS Analysed Data Record

Magic number: 0x20a1xxxx where "xxxx" is the revision number of the record.

Revision 0x0000:

---

[3] A number of ranges equals zero means there were no detected meteor events in this record. In this case, a MET analysed data record will not follow the parameter record.

Parameter	Description	Data Type	Data Size	Allowable Values
Range	Range	Float	4	0 - ?, km
Error code	Analysis error code	Integer	4	0 - 2
Effective beam direction	The effective beam pointing direction	Float Array	4 x 2	Azimuth = 0 – 360, Zenith = 0 – 90, degrees
Radial velocity	Radial velocity	Float	4	?, ms^{-1}
Spectral width	Spectral width	Float	4	0 - ?, ms^{-1}
SNR	Signal to noise ratio	Float	4	?, dB
Power	Signal power	Float	4	0 - ?, dB

5.3.17 MRAD Postanalysed Parameter Record

Magic number: 0x20b0xxxx where "xxxx" is the revision number of the record.

Revision 0x0000:

Parameter	Description	Data Type	Data Size	Allowable Values
Number of latitudes (Nlat)	The number of lattitudes used in the radiant count array	Integer	4	90 to 180
Minimum lattitude	The minimum latitude used in the radiant count array	Integer	4	-90 to 0 degrees

5.3.18 MRAD Postanalysed Data Record

Magic number: 0x20b1xxxx where "xxxx" is the revision number of the record.

Revision 0x0000:

Parameter	Description	Data Type	Data Size	Allowable Values
Radiant counts	Radiant count data	Float Array	4 x Nlat x 360	0 - ?

5.3.19 MPC Postanalysed Parameter Record

Magic number: 0x2100xxxx where "xxxx" is the revision number of the record.

Revision 0x0000:

Parameter	Description	Data Type	Data Size	Allowable Values
Start time	Unix time stamp of earliest data used in postanalysis	Long Integer	4	?
End time	Unix time stamp of latest data used in postanalysis	Long Integer	4	?
Number of receivers (Nr)	Number of receivers present	Integer	4	5 - 16
Number of receiver pairs (Np)	Number of receiver pairs used in MET analysis	Integer	4	4 - 6
Receiver pairs	Receiver pairs used in MET analysis	Integer Array	Np x 2 x 4	1 - 16
Minimum height	Minimum acceptable height used	Float	4	? km

Parameter	Description	Data Type	Data Size	Allowable Values
Maximum height	Maximum acceptable height used	Float	4	? km
Number of echoes used	The number of echoes used in the analysis	Long integer	4	?
Number of good echoes	The number of echoes for which a height between the minimum and maximum height is obtained	Long integer	4	?
Secondary calibration	Indicates whether secondary calibration used	Integer	4	? km
Minimum height for secondary calibration	Minimum acceptable height used for secondary calibration (if used)	Float	4	? km
Maximum height for secondary calibration	Maximum acceptable height used for secondary calibration (if used)	Float	4	? km
Grid size	Grid size used for final calibration estimates	Float	4	?

5.3.20 MPC Postanalysed Data Records

Magic number: 0x2101xxxx where "xxxx" is the revision number of the record.

Revision 0x0000:

Parameter	Description	Data Type	Data Size	Allowable Values
Phase offsets[4]	Array of estimated phase offsets	Float	4 x 4	0 – 360 deg
Phase offset error	Array of estimated phase offset errors	Float	4 x 4	0 – 360 deg
Phase calibration values	Phase calibration values stored in analysis/lib/rx_cal.dat (only present if this file exists)	Float	4 x Nr	0 – 360 deg

5.3.21 MTMP Postanalysis Parameter Records

Magic number: 0x2110xxxx where "xxxx" is the revision number of the record.

Revision 0x0000:

Parameter	Description	Data Type	Data Size	Allowable Values
Height model flag	Indicates whether a peak height model assumed	Integer	4	0 or 1
Pressure Model climatogy at peak height flag	Array of estimated phase offset errorsIndicates whether a pressure/temperature gradient climatogy at the peak height is used	Integer	4	0 or 1
Temperature gradient climatogy at peak height flag	Indicates whether a pressure/temperature gradient climatogy atthe peak height is used	Integer	4	0 or 1

---

[4] Note that the phase offsets reported are those obtained once the phase calibration values stored in analysis/lib/rx_cal.dat have been applied to the data.

Parameter	Description	Data Type	Data Size	Allowable Values
Maximum zenith angle	Indicates the maximum allowable zenith angle used for temperature	Integer	4	60° (currently hardwired)

5.3.22 MTMP Postanalysis Data Records

Magic number: 0x2111xxxx where "xxxx" is the revision number of the record.

Revision 0x0000

Parameter	Description	Data Type	Data Size	Allowable Values
Pressure climatology temperature	Temperature derived using the pressure climatology technique	Float	4	?? (0 = no estimate)
Temperature gradient climatology temperature	Temperature derived using the temperature gradient climatology technique	Float	4	?? (0 = no estimate)
Peak height	The peak height of the meteor height distribution	Float	4	85 - 95 km
Height width	The standard deviation of the meteor height distribution	Float	4	3 - 5 km
Peak height pressure	The pressure at the peak height	Float	4	?? Pa
Peak height log D	The (10-based) log diffusion coefficient at the peak height	Float	4	??
Log D slope	The slope of the (10-based) log diffusion coefficient vs height scatter plot at the peak height	Float	4	??
Temperature gradient	The temperature gradient at the peak height	Float	4	?? K/km
		Float	4 x Nr	0 – 360 deg

5.4 Appendix D: Control files used by the analysis and display suite

The following table lists the control files used by the ADCG and analysis monitor for communication. These files may be found in the directory `/home/radar/analysis/control`. Note that the file names all begin with a "." and will not be visible unless the "-a" option is specified with the **ls** command.

"Zero length" control files may be created using the **touch** command. For example, to create the ".sea_scatter" file, type: "`touch ~radar/analysis/control/.sea_scatter`".

Control File	File Type	Purpose
`.<name>_config`	IDL save file	Contains configuration structure providing information for the "name" analysis module.
`.<name>_halted`	Zero length	Indicates Analysis Monitor has stopped invoking "name" analysis due to excessive errors.
`.<name>_invoke`	Zero length	Instructs Analysis Monitor to call analysis "name" during each analysis cycle.
`.<name>dm_default`	IDL save file	Contains structure providing default initial parameters for the "name" display module
`.<name>2_ config`	IDL save file	Contains configuration structure providing information for the "name" postanalysis module.
`.<name>2_halted`	Zero length	Indicates Postanalysis Monitor has stopped invoking "name" postanalysis due to excessive errors.
`.<name>2_invoke`	Zero length	Instructs Postanalysis Monitor to call postanalysis "name" during each postanalysis cycle.
`.<ip address> <name>_config`	IDL save file	Contains configuration structure providing information for the "name" analysis module, as transferred from the IP address "IP address".
`.<ip address> <name>_2config`	IDL save file	Contains configuration structure providing information for the "name" analysis module, as transferred from the IP address "IP address".
`.analyse_archive`	IDL save file	Instructs the analysis monitor to apply the currently enabled and configured analyses to the data file located in the directory specified by the string "dir" and name specified by the string "file".
`.analyse_archive_done`	IDL save file	Renamed ".analyse_archive" file produced after completion of analysis. Allows reanalysis of file by renaming to ".analyse_archive"
`.analysis_lock`	Zero length	Indicates the analysis is running.
`.analysis_utility`	Zero length	Contains names of archived raw data files selected for analysis using the analysis utility
`.analysis_utility_done`	IDL save file	Renamed ".analysis_utility" file produced after completion of analysis. Allows reanalysis of file by renaming to ".analysis_utility"
`.archive_period`	IDL save file	Contains parameter "archive_period" denoting time period for data archiving by the analysis and postanalysis.
`.arch_mon_config`	IDL save file	Archiving monitor configuration file.
`.arch_mon_invoke`	Zero length	Archiving monitor invocation file
`.arch_util_config`	IDL save file	Archiving utility configuration file.
`.arch_util_invoke`	Zero length	Archiving utility invocation file
`.cache_post_time`	Zero length	Indicates that .post_time files should be written

Control File	File Type	Purpose
		(with time stamps) to the cache directory rather than the control directory. Applicable to offline analysis only.
.cadm_ranges	IDL savefile	Specifies default plotting ranges for FCA, SCA, IDI and VEL display
.ci_extra	Zero length	Allows the user to configure the extra coherent integrations for applicable analysis modules (FCA, DAE, SCA).
.config_extra	Zero Length	Allows configuration of extra acceptance criteria thresholds for FCA, SCA and IDI analysis
.config_range	Zero length	Allows the user to configure the ranges over which each analysis or postanalysis takes place in the analysis and postanalysis configuration.
.daedm_ranges	IDL savefile	Specifies default plotting ranges for DAE display
.dbsdm_ranges	IDL savefile	Specifies default plotting ranges for DBS display
.debug	Zero length	Execute display suite in debug mode - enables more accurate error messages to be generated during widget application crashes.
.default printer	Text	Name of default printer. Used in the "Print utility" if plot to be sent directly to printer.
.disable_archiving	Zero length	Instructs analysis and postanalysis that archiving should not be performed due to low disk space (e.g. storing raw data of detections in MET analysis, and incoherently averaged spectra in DBS postanalysis)
.discard_raw	Zero length	Instruct Analysis Monitor to delete raw data files once analysed. The default is to archive raw data.
.display_lock	Zero length	Indicates the display is running.
.display_name	Text	Contains the DISPLAY environment variable used by the IDL analysis and postanalysis sessions
.flush_full	Zero Length	Instructs Analysis Monitor to remove analysed data files awaiting analysis. Purged data files are either deleted or archived depending on the existence of the ".discard_raw" control file.Contains the DISPLAY environment variable used by the IDL analysis and postanalysis sessions
.flush_partial	Text	Contains the DISPLAY environment variable used by the IDL analysis and postanalysis sessions
.local_time	Zero length	Set to indicate data time reference is local time (LT) rather than universal time (UTC)
.max_disk_perc	IDL save file	Contains parameter "max_disk_perc " which indicates at what percentage of disk space that raw data archiving should be disabled. Default value is 95%.
.met_vel	Zero length	Enable meteor velocity analysis if MET analysis module is present.
.mode_swap	Zero length	Indicates first mode of a mode-interleaved data set is E-mode (applicable to RD12 radars only)
.new_data	IDL save file	Contains structure providing information on latest data set in analysis queue.
.offline	Zero length	Set to indicate display and analysis suite is for offline use.
.post_analysis	Zero length	Indicates to the analysis and display sessions that postanalysis is present.

Control File	File Type	Purpose
`.postanalysis_utility`	IDL save file	Contains names of analysed data files selected for analysis using the analysis utility
`.postanalysis_utility_done`	IDL save file	Renamed ".postanalysis_utility" file after completion of analysis. Allows reanalysis of file by renaming to ".postanalysis_utility"
`.post_flush_full`	Zero length	Instructs Postanalysis Monitor to remove analysed data files awaiting postanalysis. Purged data files are either deleted or archived depending on the existence of the ".discard_raw" control file.
`.post_flush_partial`	IDL save file	Contains structure providing the names of the analysed spooled data files to be removed from the postanalysis queue.
`.post_time`	IDL save file	Contains parameters providing time and acquisition information supplied by analysis monitor for postanalysis monitor.
`.proc_int`	IDL save file	Contains arrays "processing_interval" and "processing_duration" of user defined values (in seconds) for processing interval and duration for postanalysis.
`.pause`	Zero length	Pause analysis and postanalysis sessions.
`.rddm_ss_config`	IDL save file	Contains configuration structure default parameter information used by raw data display sea scatter removal utility
`.real_time`	Zero length	Instruct Analysis Monitor to offer the most recent raw data file to enabled analyses for analysis (i.e. Real time mode). Default behaviour is to offer the oldest raw data file for analysis (Queued mode).
`.remote_config`	Zero length	Instructs Display software to make remote configuration options available if they are installed.
`.restart_analysis`	Zero length	Instructs Analysis Monitor to exit, then restart.
`.restart_display`	Zero length	Instructs Display to exit, then restart.
`.restart_postanal`	Zero length	Instructs Postanalysis Monitor to exit, then restart.
`.sea_scatter`	Zero length	Instructs analysis configuration widget to allow Sea Scatter Rejection to be configured for analysis.
`.terminate`	Zero length	Instructs the Analysis and Postanalysis Monitors to exit.
`.time_info`	IDL save file	Contains timing information on the most recent analysis cycle to the ADCG.
`.time_unambig`	Zero length	Indicates all times are to be displayed in the form "Month Day Year" (e.g. August 25 2004).
`.transfer`	Text	Contains IP addresses and destination directories detailing where spooled raw data should be transferred to after analysis.
`.version`	Text	Indicates version number and date of the analysis and display suite.

5.5 Appendix E: Remote file transfer issues

To allow automated ftp to a remote location from the PFT or AFT postanalyses, the file ".netrc" file must be present in the radar users home directory (/home/radar). This file requires read and write permissions to be set for the radar user (i.e. rw-------, or 600), and must contain an entry for each remote location used by the PFT or AFT postanalyses. An example of the entries required for the use of these files:

```
machine <IP number> login <login name> password <password>.
```

For security reasons, it is suggested that these entries relate to anonymous ftp accounts rather than individual users accounts. For example, the appropriate entries to allow remote ftp into the anonymous ftp server aaa.bbb.ccc.ddd by a user with email address "radar@atrad.com.au" would be:

```
machine aaa.bbb.ccc.ddd  login anonymous password radar@atrad.com.au
```

5.6 Appendix F: Coding New Software Modules

The following explains the procedure to be followed for a user to include an third party analysis within the ATRAD IDL analysis and display suite. This involves the generation of an IDL "savefile". This savefile must be generated using the same version of IDL as that used for the analysis and display suite. At present, user analyses cannot use analysis configuration information. This will be addressed in a later version of the IDL suite.

The user analysis must be an IDL function stored in a file with name of the form "abc_analysis.pro". The result to be written to file should be returned from the function. The inputs are assumes to be the complex raw data array "data" of format [Number of time-series samples, Number of receivers, Number of ranges], and the "data_state" structure, which contains the parameters written to the "parameter records" as described in the "ATRAD raw data format" shown in Appendix A: ATRAD Raw Data Format. The various "tags" of the data_state structure are shown in 5.6.3. These tags can be accessed in the following manner:

e.g.

Number of samples: data_state.n_pts

Number of receivers: data_state.n_rx

  ...etc.

An example of a simple third party analysis is shown in 5.6.2.

5.6.1 Producing the savefile

To produce the save file for user analyses, type the following from an IDL session:

```
IDL> resolve_routine, "abc_analysis", /is_function

IDL> resolve_all
IDL> save, /routines, file = "user_abc_analysis.sav"
```

This will produce an IDL savefile "user_abc_analysis.sav". This file should be placed in the directory "/home/radar/analysis/lib". The ACDG will need to be restarted to recognise the presence of the analysis. The analysis should appear in the "Analysis Control" options as "*USER_ABC Analysis*". The "*Invoke*" and "*Disable*" options are available, but the "*Configuration*" option will not be available. The analysed data will be written to files of the form "19990823.abc"

5.6.2 Example of a third party analysis

The following provides an example of a simple analysis that determines the zero mean values of each receiver time-series at each range level.

```
function zma_analysis, data, data_state, config
;
; Zero-mean analysis. This takes zero mean and writes it to the
;"result" structure, which is then written to the analysed data
; file with name [year][month][day].[zma]
;
; First, set result structure to be written to file
;
  result = {TIME:  0L,  $              ; Unix time – long int.
            RANGE:  0., $              ; Range - floating point
            ZERO_MEAN: complexarr(data_state.n_rx)}
;
; Replicate this structure over all ranges
;
  result = replicate(result, data_state.n_ht)
;
; Set time
;
  result.time = data_state.unix_time
;
; Set range array
;
  result.range = data_state.ht_interval*indgen(data_state.n_ht) + $
                  data_state.ht_start
;
; For loop over each range
;
  for ht = 0, data_state.n_ht-1 do $
  begin
;
; Take zero mean value for each receiver, and store it
;
      for n = 0, data_state.n_rx-1 $
      do $
          result(ht).zero_mean(n) = $
                    total(data(*, n, ht))/data_state.n_pts
  endfor

  return, result

end
```

5.6.3 Data_state structure definition

The following provides information of the available tags for the data_state structure definition.
Note that the values of these tags for any raw data file can be viewed using the Housekeeping raw
data utility described on page 62.

5.6.3.1 Parameter types

```
max_rx = 32          ; Maximum number of Rx channels
max_tx = 32          ; Maximum number of Tx channels
max_bs = 64          ; Maximum number of PTPBS directions
int = 0              ; Integer type (2-byte integer)
lint = 0L            ; Long int type (4-byte integer)
flt = 0.             ; Float type (4-byte float)
dflt = 0D            ; Double prec. float (8-byte)
str = ''             ; String type (null)
bool = 0             ; Boolean flag type (an integer: 0 = NO, 1 = YES)
```

5.6.3.2 File parameters

DATA_FILE	:	str	; data file name
DATA_DIRECTORY	:	str	; data path (ends in /)
LUN	:	lint	; lun of opened file.
DATA_FORMAT	:	int	; format (1 to 7)
FORMAT_NAME	:	str	; format abbreviation
FORMAT_REVISION	:	lint	; Rev. no. of data format
DATA_REVISION	:	lint	; Raw data revision.
DATA_RANGE	:	lonarr(2)	; min and max data value
FILE_SIZE	:	lint	; file size in bytes
FILE_PTR	:	lint	; current file position.

5.6.3.3 Sequence parameters

MAX_RX	:	max_rx	; 32 Rx channel. maximum
MAX_TX	:	max_tx	; 32 Rx channel. maximum
FILE_ID	:	lint	; Equipment/Site ID.
SITE_NAME	:	str	; Radar site name
CAMPAIGN_NAME	:	str	; Campaign name
N_EXPT	:	lint	; Number. of expteriments in sequence
ACQ_INTERVAL	:	lint	; Experiment scheduling interval (s)

5.6.3.4 Experiment parameters

EXPERIMENT_NAME	:	str	; Verbose experiment. name
EXPERIMENT_TAG	:	str	; Experiment. tag name
EXPERIMENT_NO	:	lint	; Sequence no. of experiment.
EXPERIMENT_REPS	:	lint	; No. of reps. of experiment.
FREQ	:	flt	; radar frequency (Hz)
LIGHT_SPEED	:	3e8	; speed of light (m/s)
LAMBDA	:	flt	; radar wavelength (m)
PRF	:	lint	; pulse rep. freq. (Hz)
N_PTS	:	lint	; no of data points
N_CI	:	lint	; no coherent integrations.
DELTA	:	flt	; interpulse period (s)
RANGE_CAL	:	lint	; Radar range cal. (ns)
N_RX	:	int	; no of active channels
CHAN_MAP	:	intarr(max_rx)	; Which channels are sampled and in ; what order (1 - based).
N_BEAMS	:	int	; no of tx beam dirs.
DUAL_SAMP	:	bool	; Dual range samp. flag
PHASE_FLIP	:	bool	; Phase inversion flag
POL_FLIP_TX	:	bool	; Pol. flip Tx?
POL_FLIP_RX	:	bool	; Pol. flip Rx?
HT_START	:	flt	; lowest range1 (km)
HT_INTERVAL	:	flt	; sampling interval1 (km) < 0 if lowest ; range appears first in data.
N_HT	:	int	; no. ranges1 in data.
HT_START2	:	flt	; lowest range2 (km)
HT_INTERVAL2	:	flt	; sampling interval2 (km) < 0 if lowest ; range appears first in data.
N_HT2	:	int	; no. ranges2 in data.
RX_POLARISATION	:	int	; Mode of reception ; 0=O, 1=E, 2=NS, 3=EW
TX_POLARISATION	:	int	; Mode of transmission ; 0=O, 1=E, 2=NS, 3=EW

5.6.3.5 Gain parameters

GAIN_ALG_NO	:	int	; ID of gain algorithm in use for dynamic ; gain calculations. 0 => no dynamic ; control.
DUAL_GAIN	:	bool	; Dual gain regimes?
GAIN	:	intarr(max_rx)	; gain settings (units depend on data)
GAIN2	:	intarr(max_rx)	; gain settings for upper gain ranges.
GAIN_MIN	:	int	; Min. possible gain
GAIN_MAX	:	int	; Max. possible gain

RX_FILTER   :   int   ; Rx filter setting

5.6.3.6 Site parameters

N_TX_ANT	:	int	; No. of Tx groups.
N_RX_ANT	:	int	; No. of Rx groups.
TX_COORD	:	fltarr(max_tx,2); (range in m, bearing in deg)	
TX_ANT_LABELS	:	strarr(max_tx) ; Names of Tx antennas	
RX_COORD	:	fltarr(max_rx,2); (range in m, bearing in deg)	
RX_ANT_LABELS	:	strarr(max_rx) ; Names of Rx antennas	

5.6.3.7 Transmit pulse parameters

TX_PULSE_MODE	:	int	; 0 = normal,1 = coded, 2 = pulse pairs.
TX_PULSE_WIDTH	:	lint	; Pulse width in metres
TX_PULSE_SHAPE	:	int	; 1 = Gauss, 2 = Square, 3 = coded.
TX_PULSE_SEP	:	lint	; Distance (m) between pulses in pulse ; pair transmission.
CODE_NO	:	int	; No. codes to trans.
CODE_BITLEN	:	int	; No. of bits in code.
CODE_1	:	bytarr(8)	; Code 1. MSB -> LSB
CODE_2	:	bytarr(8)	; Code 2. MSB -> LSB

5.6.3.8 Acquisition parameters

UNIX_TIME	:	lint	; unix-style time stamp
TIME	:	intarr(6)	; [SS, MM, HH, DD, MM, YYYY]
ACQ_NO	:	lint	; Acquisition number
CUR_BEAM	:	int	; which Tx beam direction (1 to ; no_beams)
BEAM_DIR	:	fltarr(2)	; Tx beam direction (azimuth, zenith) in ; degrees

5.6.3.9 Receiver calibration parameters

RX_CAL_NO	:	int	; No. channels tested.
RX_CAL_DC	:	lonarr(max_rx,2); Channel offsets.
RX_CAL_AMP	:	lonarr(max_rx) ; receiver test amps. in digitizer units
RX_CAL_PHASE	:	fltarr(max_rx) ; receiver test phases in degrees

5.6.3.10 Beam steering parameters

PTPBS	:	bool	; PTPBS active?
PTPBS_NO	:	int	; Number of beam directions.
PTPBS_DIRS	:	fltarr(max_bs,2); (Azimuth, Zenith) pairs.

5.6.3.11 RASS parameters

RASS_MODE	:	int	; Mode: 0,1,2,3
RASS_SW_START	:	flt	; Sweep start frequency
RASS_SW_STEP	:	flt	; Frequency sweep step
RASS_SW_NO	:	int	; Number of steps.
RASS_SW_DWELL	:	int	; Dwell time (ms)
RASS_PR_CENTRE	:	flt	; pseudorandom centre frequency
RASS_PR_PEAKDEV	:	flt	; pseudorandom peak deviation

5.6.3.12 SPECTRAL and COVARIANCE parameters

CORR_FNS	:	bool	; Denotes whether data-set is ; covariance functions or not
SPECTRA	:	bool	; Denotes whether data-set spectral or ; not
COMBINE	:	int	; Indicates whether receiver ; combination used in data-set
N_SPLIT	:	int	; Indicates time-series splitting factor
N_LAG	:	int	; Number of lags
N_PAIRS	:	int	; Number of cross-covariance pairs
ACF	:	intarr(max_rx) ; Index of auto-covariance functions ; present
CCF	:	intarr(max_rx) ; Index of cross-covariance functions ; present

5.6.3.13 Various other parameters

ACQ_MULTIPLE	:	lint	
DAY_FLAG	:	bool	; set if daytime
DAWN	:	intarr(2)	; dawn time [minute, hour]
DUSK	:	intarr(2)	; dusk time [minute, hour]
PCM_ZERO	:	intarr(max_tx)	; PCM phase zero steps
PCM_SETTING	:	intarr(max_tx)	; PCM phase setting
RX_TEST	:	bool	; set if test data possibly available.
RX_TEST_VALID	:	bool	; set if Rx test data valid
RX_TEST_TIME	:	intarr(6)	; time of last Rx test
RX_PTS	:	lint	; no of Rx phase samples

5.7 Appendix G: Including receiver calibration estimates in the analysis and display suite

This appendix explains how to include receiver calibration estimates within the ATRAD IDL analysis and display suite. This involves the generation of an IDL "savefile". This savefile must be generated using the same version of IDL as that used for the analysis and display suite.

The use of receiver calibration estimates is important for analyses requiring addition of time-series acquired on individual receiving channels (such as DAE, DBS and RASS analyses), and those requiring estimation of the phase difference between receiving channels to measure angles of arrival (such as MET, and from version 3 of the analysis and display suite onwards, FCA and SCA analyses). The need for using estimated receiver calibration values results from the fact that the hardware receiver calibration procedure calculates complex gain differences through the transmitting and receiving hardware only. If complex gain differences are introduced prior to the transmitting and receiving hardware, such as through the antennas, combiners, and cabling, the hardware estimated gain estimates will not apply to gain differences throughout the entire radar system.

The receiver calibration values are stored in an IDL savefile 'rx_cal.dat', which should be placed in the '/home/radar/analysis/lib' directory. The analysis will use the values stored in this file in preference to the values estimated using receiver calibration testing. The savefile generation procedures differ for radars with and without beam steering capabilities.

5.7.1 Radar without beam steering capabilities

Consider the case for a three receiver radar system where the amplitude ratios with respect to receiver channel 1 are a12 and a13, and the phase differences with respect to receiver channel 1 are p12 and p13 (in degrees). The following steps should be followed to produce a receiver calibration savefile for this case:

```
IDL> amp_corr = 1./[1., a12, a13]

IDL> phase_corr = -[0, p12, p13]

IDL> save, file = 'rx_cal.dat', amp_corr, phase_corr
```

On restoring a configuration file with this information included, the analysis will multiply the amplitudes of each receiver channel by amp_corr, and correct the phases by phase_corr, thereby resulting in each channel having the same (average) amplitude ratio and zero relative phase difference.

5.7.2 Radar with beam steering capabilities

If a single set of receiver calibration estimates are considered applicable for each antenna configuration (i.e. Spaced antenna, Doppler NS and Doppler EW), the procedure for a radar without beam steering capabilities outlined in 5.7.1 should be followed.

However, if the receiver calibration estimates are not the same for each antenna configuration, the following steps should be followed to produce a receiver calibration savefile for this case:

Firstly, three dimensional amp_corr and phase_corr arrays must be setup

```
IDL> amp_corr = fltarr(3, n)

IDL> phase_corr = fltarr(3, n)
```

where n is the number of receiving channels present (usually 6)

The amplitude ratios [a11_sa,..,a1n_sa] and phase differences [p11_sa,..,p1n_sa] with respect to channel 1 for the spaced antenna configuration are stored into the first index of the first dimension of the arrays:

```
IDL> amp_corr(0, *) = 1./[a11_sa,..,a1n_sa]

IDL> phase_corr(0, *) = -[p11_sa,..,p1n_sa]
```

The amplitude ratios `[a11_dns,..,a1n_dns]` and phase differences `[p11_dns,..,p1n_dns]` with respect to channel 1 for the Doppler NS configuration are stored into the second index of the first dimension of the arrays:

```
IDL> amp_corr(1, *) = 1./[a11_dns,..,a1n_dns]
```

```
IDL> phase_corr(1, *) = -[p11_dns,..,p1n_dns]
```

The amplitude ratios `[a11_dew,..,a1n_dew]` and phase differences `[p11_dew,..,p1n_dew]` with respect to channel 1 for the Doppler EW configuration are stored into the third index of the first dimension of the arrays:

```
IDL> amp_corr(2, *) = 1./[a11_dew,..,a1n_dew]
```

```
IDL> phase_corr(2, *) = -[p11_dew,..,p1n_dew]
```

Finally, the savefile is produced by

```
IDL> save, file = 'rx_cal.dat', amp_corr, phase_corr
```

5.7.3 Radar with beam steering capabilities and separate meteor antennas

If a single set of receiver calibration estimates are considered applicable for each antenna configuration (i.e. Spaced antenna, Doppler NS and Doppler EW), the procedure for a radar without beam steering capabilities outlined in 5.7.1 should be followed.

However, if the receiver calibration estimates are not the same for each antenna configuration or for the meteor antennas, the following steps should be followed to produce a receiver calibration savefile for this case:

Firstly, four dimensional `amp_corr` and `phase_corr` arrays must be setup

```
IDL> amp_corr = fltarr(4, n)
```

```
IDL> phase_corr = fltarr(4, n)
```

where n is the number of receiving channels present (usually 6)

The amplitude ratios `[a11_sa,..,a1n_sa]` and phase differences `[p11_sa,..,p1n_sa]` with respect to channel 1 for the spaced antenna configuration are stored into the first index of the first dimension of the arrays:

```
IDL> amp_corr(0, *) = 1./[a11_sa,..,a1n_sa]
```

```
IDL> phase_corr(0, *) = -[p11_sa,..,p1n_sa]
```

The amplitude ratios `[a11_dns,..,a1n_dns]` and phase differences `[p11_dns,..,p1n_dns]` with respect to channel 1 for the Doppler NS configuration are stored into the second index of the first dimension of the arrays:

```
IDL> amp_corr(1, *) = 1./[a11_dns,..,a1n_dns]
```

```
IDL> phase_corr(1, *) = -[p11_dns,..,p1n_dns]
```

The amplitude ratios `[a11_dew,..,a1n_dew]` and phase differences `[p11_dew,..,p1n_dew]` with respect to channel 1 for the Doppler EW configuration are stored into the third index of the first dimension of the arrays:

```
IDL> amp_corr(2, *) = 1./[a11_dew,..,a1n_dew]
```

```
IDL> phase_corr(2, *) = -[p11_dew,..,p1n_dew]
```

The amplitude ratios `[a11_met,..,a1n_met]` and phase differences `[p11_met,..,p1n_met]` with respect to channel 1 for the meteor antennas are stored into the fourth index of the first dimension of the arrays:

```
IDL> amp_corr(4, *) = 1./[a11_met,..,a1n_met]
```

```
IDL> phase_corr(4, *) = -[p11_met,..,p1n_met]
```

Finally, the savefile is produced by

```
IDL> save, file = 'rx_cal.dat', amp_corr, phase_corr
```

5.8 Appendix H: IDL License information

The analysis and display software suite supplied with the ATRAD [ADAC] radar system uses Interactive Data Language (IDL), which is marketed by Research Systems Inc., Boulder, Colorado. The analysis and display software uses the IDL 5.5 distribution with a runtime license. The runtime license uses "savefiles" which are analogous to compiled executables.

The IDL license manager is invoked during the normal booting process and uses the license file `/usr/local/rsi/license/license.dat`. A typical license file is shown below.

```
#################### license.dat ###############################
############ license file comments, do not delete ##############
# Installation Number(s): 15518
SERVER baxter.atrad.com.au 008048e83548 1700
DAEMON idl_lmgrd /usr/local/rsi/idl_5/bin
FEATURE idl idl_lmgrd 5.100 1-jan-0000 6 DBE670F1E4B93CD90AF7 \
VENDOR_STRING="15518Atmospheric radar systems" \
HOSTID=008048e83548 \
ck=71
INCREMENT insight idl_lmgrd 2.000 1-jan-0000 1 DB16F021106C64559882 \
VENDOR_STRING="15518Atmospheric radar systems" ck=225
FEATURESET idl_lmgrd CC626AC76CCF325A
##################### end of license file ######################
```

The validity of the license is assessed by comparing the identification of the first installed network card (eth0, normally used to connect to the Radar Network) with the information stored in the license file. If the network card is replaced it will be necessary to obtain another license file for use with the new card. This license be obtained by contacting ATRAD using the email address shown on the front page of this manual

If the Linux PC is renamed it is necessary to edit the license file to reflect this change. To do this, make a copy of the license file and edit the SERVER line to reflect the change. The format of the license file is easily corrupted, so it is essential maintain a correctly formatted file to ensure your license continues to be valid. The IDL license manager should be terminated before the license file is edited (using the `/usr/local/rsi/idl/bin/lmdown` command), and restarted after the license file is edited (using the `/usr/local/rsi/idl/bin/lmgrd` command).

The expiration date of the license is shown in the "`FEATURE idl`" line. An expiry date with a year of `0000` indicates there is no expiry date and this will be the case for most licenses supplied by ATRAD. ATRAD maintains a list of the licenses with expiration dates and will organise the supply of a new license file prior to the expiration date when appropriate.

5.9 Appendix I: Acronyms

ACF	Auto Correlation Function
ADF	ATRAD Data Format
ADCG	Analysis and Display Control GUI
ALT	The "Alt" key on the computer keyboard.
ATABS	Acquisition-to-Acquisition Beam Steering
CCF	Cross Correlation Function
CIRA	COSPAR International Reference Atmosphere
COSPAR	Committee for Space Research
CPU	Central Processor Unit
DAE	Differential Absorption Experiment
DAEDM	DAE Display Module
dB	Decibel - logarithmic power units.
DBS	Doppler Beam Steering
DBSDM	Doppler Beam Steering Display Module
DPE	Differential Phase Experiment
EBD	Effective Beam Direction
IDL	Interactive Data Language (produced by RSI)
IGRF	International Geomagnetic Reference Field
FCA	Full Correlation Analysis
FCADM	FCA Display Module
FTP	File Transfer Protocol
GPS	Global Positioning System
GUI	Graphical User Interface
MF	Medium Frequency (300 kHz - 3 MHz)
NT	Windows NT Workstation
PBS	Post-set Beam Steering
PRF	Pulse Repetition Frequency
PSS	Post-statistics Beam Steering
PTD	Percentage Time Discrepancy
PTPBS	Point-to-Point Beam Steering
RDAS	Radar Data Acquisition System
RSI	Research Systems Inc.
SCA	Spatial Correlation Analysis
SCADM	SCA Display Module
SNR	Signal-to-Noise Ratio
SWR	Standing Wave Ratio (often a voltage ratio: "VSWR")
TR	Transmit/Receive (usually "TR switch")
TX	Transmitter
URL	Universal Resource Locater
UTC	Coordinated Universal Time
VHF	Very High Frequency (30 MHz - 300 MHz)
XDR	eXternal Data Representation