

Technical Manual for PRECIS

The Met Office Hadley Centre regional climate modelling system

Version 2.0.0

www.metoffice.gov.uk/precis

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Chapter 1

Introduction

Timely access to detailed climate change scenarios is particularly vital in developing countries, where economic stresses are likely to increase vulnerability to potentially damaging impacts of climate change. In order to help address this need the Met Office Hadley Centre has developed PRECIS, a regional climate modelling system which can be run on a personal computer (PC). The aim of PRECIS (Providing Regional Climates for Impacts Studies) is to allow developing countries, or groups of developing countries, to generate their own national scenarios of climate change for use in impacts studies. This will allow transfers of technology and ownership resulting in much more timely and effective dissemination of expertise and awareness than if results are simply handed out from climate model experiments run in developed countries. In addition, countries using PRECIS are in a better position to validate the model using their own historical meteorological observations.

An important aspect of PRECIS is the availability of training and training materials explaining its role and how to make the best use of it. One of the main materials is this technical manual (also available as on-line help as part of the PRECIS user interface software) which discusses the steps needed to install, configure and use PRECIS. This is designed both to guide users of PRECIS and as resource for the PRECIS training workshop. It should be read in conjunction with the PRECIS Scientific Handbook (hereafter referred to simply as PRECIS Handbook).

1.1 Background

Countries require assessments of the impacts of climate change on their territories under Article 4.8 of the United Nations Framework Convention on Climate Change (UNFCCC). The consequences of changes in climate are potentially most

damaging in the poorest regions, where the prospect of limited economic growth, high population growth and a lack of resources to develop adaptation strategies imply a high level of vulnerability. In order to make impact assessments climate projections are required on a more detailed scale than can be provided from global climate models (which have a typical resolution of about 150-300km). In addition, reliable information is needed on changes to extremes (of rainfall, temperature, etc) to estimate changing frequencies of floods or droughts. One of the best options for adding this detail to global projections is to use a regional climate model (RCM).

In view of the vulnerability outlined above, it is imperative that developing countries, or groups of countries, can be provided with a means of generating detailed, high quality climate projections for their own regions. Building a dedicated RCM specifically formulated for every region of the world would be very time consuming and inefficient. Hence, the Met Office Hadley Centre, under contract from the UK Department for Environment, Food & Rural Affairs (DEFRA, www.defra.gov.uk) and Department for International Development (DfID, www.dfid.gov.uk) and from the United Nations Development Programme (UNDP, www.undp.org), has developed a PC-based regional climate modelling system to provide countries classed as non-Annex II by the UNFCCC with a practical tool to create their own projections of national patterns of climate change and hence assess their vulnerability.

1.2 Objectives and structure of the manual

The technical manual describes the practical details of how to set up, run and generate regional model experiments using PRECIS. It does not discuss any background on climate change science, modelling in general or generating high resolution climate change scenarios, as this is contained in the PRECIS Handbook. However, it does include explanations of or references to relevant scientific issues where necessary to provide context.

The manual starts with a description of the computing environment in Chapter 2 and the PRECIS software and its installation in Chapter 3. Chapter 4 puts the main features of the PRECIS user interface into scientific context by explaining their relevance when designing experiments. A detailed explanation of the functionality of the PRECIS user interface, i.e. how to configure PRECIS experiments, is presented in Chapter 5 while section 5.7 explains what happens as a PRECIS experiment runs and what action is required of the user. The main body of the technical manual concludes with a description of the tools supplied with PRECIS to manipulate and display data produced by the PRECIS RCM.

Chapter 2

Hardware, operating system and software environment

2.1 Recommended Hardware Configurations

PRECIS runs on a PC with an Intel-compatible processor under the Linux¹ operating system.

Please note: PRECIS will only run on Intel (x86) compatible Linux based systems, and not under Microsoft Windows®, Apple OS X®, nor on other Unix systems (e.g. FreeBSD).

It is possible to make use of PRECIS from within Windows or OSX by using a Linux virtual machine (with PRECIS pre-installed) in Oracle Virtualbox ®. This is useful at the post-processing stage in order to have access to all post-processing software, but it is not recommended for running the actual model as the model will run less than 50% as fast as it would on a dedicated Linux PC. This is due to the fact that the host operating system will use the majority of the CPU and Memory, reducing what PRECIS is able to utilise.

The recommended hardware follows.

- The general processor purchase advice is to buy the fastest dual core, quad core, or dual quad core system as possible. Shared memory multi-core systems can run PRECIS in parallel over all cores. Single CPU PCs are not supported starting from PRECIS 2.0 and onwards.
- At least 512MB of memory is needed, and 1GB or more is recommended.

¹The correct term is GNU/Linux, see <http://www.gnu.org/gnu/gnu-linux-faq.html>, but we shall use “Linux” for the sake of readability.

Faster RAM gives a small increase in performance.

- At least 100GB of disk space is required, and the more the better. PRECIS will work with systems using one or multiple hard drives (or multiple partitions). On systems with multiple partitions/ drives, it is often useful for one of the partitions to be solely dedicated to PRECIS data.
- PRECIS input data is usually delivered on external USB hard drives, thus at least one free USB 2.0 (or USB 3.0) port is needed to attach the external drive to the PC.
- A three button mouse is useful when using the PRECIS user interface.
- A keyboard and monitor are needed at the experimental design phase. Note that PRECIS is happy to run on PCs *without* keyboard, mouse or monitor, as long the experimental design can be carried out on a remotely connected system (e.g. via ssh). This type of configuration is common when using shared memory clusters - the model is designed, initiated and monitored from a remotely connected PC.
- A UPS (uninterruptible power supply) may be useful for those regions where the electricity supply is unreliable. A backup time of at least half an hour is recommended to enable the experiment to stop cleanly after the user has stopped the PRECIS run by hand.

2.2 Multi-processor systems

Multiprocessor machines are now standard on all PC systems. PRECIS requires a minimum of two cores to run. It is possible to run PRECIS experiments side by side. For example, on a quad core system, two PRECIS experiments can be run concurrently, each using two cores. Or one PRECIS experiment could be run on the same system using all four cores. The user may wish to carry out speed tests to see which option is most preferable.

2.3 Installation of Linux

Linux is a form of Unix which runs on Intel compatible PCs. There are several distributions of Linux available with RedHat², SUSE³ and Debian (including Ubuntu)⁴ among the most popular. While PRECIS should be able to run under

²<http://www.redhat.com>

³<http://www.novell.com/linux/>

⁴<http://www.debian.org>, <http://www.ubuntu.com>

any Linux distribution, OpenSuse Linux is the officially supported version of Linux with PRECIS. OpenSUSE is distributed at PRECIS training workshops for this reason.

Linux is freely downloadable from the Internet. For users new to Linux, it may be advisable to purchase a commercial Linux package for approximately \$100. Commercial packages include hundreds of software packages conveniently available on DVD. Printed documentation on Linux installation and use are also provided, as well as email and web based support.

Installation of Linux is now fairly straightforward, especially if it is a clean installation on a new machine. If the PC comes with Microsoft Windows® already installed, then ideally Linux should be installed as a clean installation, overwriting (and deleting) the Microsoft Windows® installation. Although it is possible to configure the PC so that it can boot into either Microsoft Windows® or Linux, we recommend that this not be done for PCs whose purpose is to run PRECIS experiments, as any instance in which the PC is booted into Windows will mean by default that the PRECIS experiment has to stop.

PRECIS will work under the standard installation scheme for the vast majority of Linux distributions, with some additions. When installing Linux, the following non-standard options should be selected:

- On a dual disk system, the first disk should be partitioned as suggested in the Linux installation process. Ideally, the second disk should have a mount point set, `/data` for example, and partitioned as one large partition.
- A user account named `precis` should be created. This is where the PRECIS experiments will be run. **PRECIS should never be run as administrator/superuser/root!**
- X11 windows is required to run PRECIS.
- `pdcksh` (the public domain Korn shell) is required by PRECIS. It not normally installed by default, and should be picked as part of the individual package selection available in both SUSE and RedHat. In RedHat it is under “System Environment - Shells” in the “Individual Package Selection” screen during the installation. Note that the package name is `pdcksh` rather than `ksh`, which is a different form of the Korn shell that is incompatible with PRECIS. The `pdcksh rpm` install package for 32 bit OpenSuse Linux is located on the PRECIS DVD in the `/utils/` directory.

Assuming you are connected to the Internet from the PC you will use to run PRECIS, you can use online package managers. Before doing this, it’s useful to make sure `ksh` is uninstalled. Type `sudo rpm -e ksh` for RedHat, Fedora, or OpenSUSE, and `sudo apt-get remove ksh` in Debian and Ubuntu.

In RedHat and Fedora, you may attempt to use the software package manager yum to retrieve pdksh, using `sudo yum install pdksh`.

In OpenSUSE, you may attempt to use the software package manager zypper to retrieve pdksh, using `sudo zypper install pdksh`.

In Debian and Ubuntu, you may attempt to use the software package manager apt-get to retrieve pdksh, using `sudo apt-get install pdksh`.

- PRECIS will work equally well under the Gnome and KDE window managers (or any window manager).

Once Linux has been installed, devices such as printers will have to be configured. Details on how to do this will be in the printed documentation or on the distribution's web site.

The standard default installation for a given Linux release should install the majority of third party software required for PRECIS.

In principle, the PC can still be used for non-CPU intensive work such as word-processing and Internet access; there is a range of Linux programs equivalent to common Microsoft Windows® applications. However, the user should be aware that this could affect PRECIS's performance. In addition, we cannot guarantee that other applications will not conflict with PRECIS.

Once all integrations have finished and the output data archived, it is perfectly possible to remove the Linux operating system and install Microsoft Windows® instead.

2.4 Compilers

A Fortran compiler will not be required to run the model as all executables will be supplied on the DVDs. However, expert users who wish to build their own versions of the model executables will require a Fortran compiler.

PRECIS is guaranteed to work under two Fortran compilers, PGI Fortran⁵ and Intel Fortran⁶. Both compilers are suitable for both AMD and Intel processors.

The Intel compiler is free to non-profit making organisations and can be downloaded from the Intel website.

PRECIS will not compile with the GNU Fortran compiler supplied with gcc as it is not Fortran90 compliant. It will also not compile under the NAG Fortran

⁵<http://www.pgroup.com/>

⁶<http://www.intel.com/software/products/compilers/>

compiler. Standard compilation files for the PGI and Intel Fortran compilers are included as part of PRECIS. The Gnu General Compiler (gcc) is also required to compile PRECIS.

If a Fortran90 compliant compiler is required for work with PRECIS output data (such as scenario construction or impact studies) then this compiler may have to be purchased. The free GNU/Fortran compiler may be available, but this has not been tested with PRECIS output data.

2.5 System setup before installing PRECIS

All of the following should be performed by the superuser/administrator account root.

Install the Korn shell (pdksh) from the pdksh package. PRECIS will not work unless this Korn shell is installed. There is another Korn shell called ksh or ksh93. THIS WILL NOT WORK with PRECIS, so please do not use it (see previous section for information on how to uninstall ksh).

Note: The Korn shell should not be used as the default login shell.

- In the PRECIS default directory layout (which can be easily changed by the user), all the PRECIS system software and input and output data areas are under the `/home/precis` directory. If you want to separate the data and system areas, you can create a directory called `/data/precis`, and change the ownership of this directory to `precis`, with the appropriate group ID, with the `chown` command, so that the `precis` account can write to this area. This should be also done on a dual disk system, where one of the disks is being used for data storage.
- The SUSE linux distribution does not automatically start the `at` daemon after installation. This must be enabled for PRECIS to run correctly. To enable the `at` daemon, start YaST, then go to System, Runlevel Editor, and then enable `atd`. In Redhat, you can switch on the `at` daemon manually, using `sudo service atd start`. Type `sudo chkconfig atd on` to set the `at` daemon to start automatically at boot up.
- PRECIS requires the following software. With the exception of `pdksh`, these items should have been installed as part of the default Linux installation. Items which are not present on the Linux DVD may have to be installed from the PRECIS DVD.

- Tcl
 - Tk
 - Python
 - Perl
 - ImageMagick
 - ghostscript
 - pdksh (included on the PRECIS DVD)
 - gawk
 - Fortran compiler, if required.
- Other potentially useful programs which may not be part of a default installation are gv (Ghostview, for visualising postscript files), Mozilla Firefox (a web browser) and gnuplot (a graphics and analysis tools package). The Team Viewer (www.teamviewer.com) remote desktop software is also useful as it allows the PRECIS team to connect to your system (provided your system is connected to the internet) if necessary.

Chapter 3

PRECIS software and installation

3.1 Introduction

PRECIS can be supplied as a download or on one single-layer (4.7GB) DVD. The installation process is semi-automated, the user being prompted for such inputs as base disk location for the installation and data locations. All the software needed to configure and run PRECIS via its user interface is installed, complete with sufficient input data to perform short test runs¹.

One year of sample input/driving data is supplied with the PRECIS installation package.

The PRECIS release includes a suite of software. Brief details follow.

- The core climate model code used by PRECIS is based on the Met Office's Portable UM, which in turn is based on the UM (Unified model). This code is mainly written in Fortran90 with some C for I/O.
- A series of shell scripts is required to run the model. These control aspects such as starting, stopping and re-starting a model run, data archiving and log-file writing.

¹For reference, the three classes of input data are listed here:

- The **initial dump**, containing a self-consistent set of initial conditions for PRECIS's prognostic variables. The initial dump is usually derived from a previous model run; in the case of PRECIS, initial dumps are derived from the driving model.
- **Boundary Data** or "**driving**" **data**, used to generate the regional model's **lateral boundary conditions (LBCs)**.
- **Ancillary data** files, containing other prescribed fields and surface boundary conditions, both constant, such as land height, and time-varying, such as sea-surface temperature. (A complete list of the ancillary fields required by PRECIS is given in Section 5.8.1.)

- Other programs are required to configure the input data, that is, to regrid the initial dump and ancillary data files from the global grid on which they are supplied to the grid of the user's chosen domain. Similarly, a set of programs controls the generation of lateral boundary conditions particular to the domain from the global driving data supplied. These are written in a combination of Fortran code, Perl and Korn shell scripts.
- The running of these scripts and executables is controlled via a graphical user interface (GUI) with which the experiment can be defined and run.
- Analysis software tools are installed with PRECIS. These allow the user to post-process the RCM output data as needed. See chapter 6 for a comprehensive list.

Please note that the following sections assume some knowledge of Unix operating systems, such as their directory structure and environment variables. Instruction on the use of Unix will be given in the training courses, and introductory guides are available on the web and as books. UNIXHelp (<http://unixhelp.ed.ac.uk/>) is a good starting point.

3.2 Disk layout

It is a very good idea to have a plan for the location of the data directories used by PRECIS to make best use of available disk space. Use this section and section 3.4 to aid your decision.

Before PRECIS is installed, some thought should be given to the layout of the data directories on the hard drives(s). The PRECIS system files are relatively small, and should be installed under the `/home/precis` directory. There are three classes of data associated with a PRECIS simulation: input data, work data used by PRECIS whilst it is running, and output data. The individual directories are discussed further in Section 3.4.

The global model boundary data used to generate the lateral boundary conditions (LBCs) for RCM experiments are supplied separately by the Met Office.

The work data directories are used to hold processed input data and temporary data directories required by PRECIS whilst it is running. These should not occupy more than 5 Gb in total.

The output data directory contains all the PRECIS output. This can be between 50 Gigabytes and 1 Terabyte in size, depending on the output data options chosen

Output data type	Size for 1 year	Size for 30 years
Monthly dumps	1.1 Gb	33 Gb
Hourly data	13.9 Gb	417 Gb
Daily data	2.1 Gb	63 Gb
Climate meaning	1.1 Gb	33 Gb

Table 3.1: Sizes for different PRECIS output data types for 1 year and 30 years for a 106×111 grid.

when PRECIS is run. Table 3.1 shows the approximate size of different output data types. The output data should be archived then deleted on a regular basis so that the disk does not become full. Output data may be deleted while the model is running, as the model executable does not require the past output data to be present in order to run. A good way of keeping data volumes down is to run a script that deletes all variables not needed once a day using a `cron` job. Contact the PRECIS team for sample scripts to do this.

On a PC with a single hard drive, the system and data directories must share a disk. The system directories should be installed under `/home/precis`. All the directories for the data can be set up under this directory also. Alternatively, if you want to keep the system and data directories separate they can all be stored under another top-level directory, such as `/data/precis`. This directory will have to be created by `root`, as detailed in section 2.5.

For systems with one or more disks, one suggested setup is to put the system directories, input directories and work directories on one disk, and the output directory on the second disk. Again `root` will have to create a directory to which the `precis` user has write access on the second disk.

3.3 Main steps in installation process

There are several steps required to install PRECIS. These are listed below; this list may be used as a checklist during installation.

1. Install the main PRECIS software from the supplied DVD or zipped tarball.
2. Install the supplied input data from DVD/tarball or a hard drive.

3.4 Installation of PRECIS software and data

1. Log in to the account from which PRECIS will be run. This would normally be `precis`. **PRECIS should be run in a user account only, not in superuser mode (i.e. as root).**
2. Insert the PRECIS DVD into the computer. It should automount; if not, mount it by hand. Different Linux distributions use different mount points for DVD drives. Under SUSE the DVD drive is mounted on either `/media/cdrom`, `/media/cdrecorder` or `/media/dvd`. For RedHat the mount point will be `/mnt/cdrom`. Please refer to your distribution documentation.
3. Type

```
$> export DVDDIR=/media/dvd #This is for SUSE,
                                #please alter for your distribution.
$> cp $DVDDIR/install_precis $HOME
```

where `$DVDDIR` is the top-level directory of the DVD-ROM.

4. To install from a zipped tarball, first download the PRECIS files to your PC. The tarball will need to be unzipped and then installed via the following commands:

```
$> tar xvzf PRECIS_vn2.0.tgz
$> export INSTDIR=$PWD/PRECIS_vn2.0/
$> cp $INSTDIR/install_precis $HOME
```

5. Next type

```
$> cd $HOME
$> ./install_precis $DVDDIR    #from a DVD
or
$> ./install_precis $INSTDIR  #from an unzipped tarball
```

6. You will be taken through the PRECIS installation process. You will be prompted for the locations of necessary directories. The environment variable used by PRECIS for each directory is shown in **bold**, and the default locations are shown like **this**. The default location assume that all data is installed under the `/home/precis` directory. The user may want to want to set up the data directories in different locations, especially on systems with more than one disk. Please see section 3.2 for a discussion of possible directory layouts.

- System directories (and default values)

UMDIR /home/precis/um

The PRECIS system code. All the required files are copied to this directory at the end of the installation process.

\$UMDIR contains the following directory:

CDATABASE /home/precis/um

Directory under which the CDAT analysis tools will be built. These tools are required for (optional) real time PRECIS graphical monitoring.

- Work directories (and default values)

DATADIR /home/precis/precis_expt

Directory used by PRECIS when it is running to store control and intermediate files. This includes the current output data files and log files. A directory named \$DATADIR/*RUNID*, where *RUNID* is the five letter internal PRECIS run ID of the experiment, will be created when PRECIS is run.

\$DATADIR includes the following directories:

MY_OUTPUT /home/precis/precis_expt/precis_out

Output directory for PRECIS run-time messages. These log files are useful for diagnosing model failures.

ANCILDIR /home/precis/precis_expt/ancil

Directory where the processed ancillaries for the selected region are stored. For a given run ID, *RUNID*, the ancillaries will be located in \$ANCILDIR/*RUNID*.

LBCDIR /home/precis/precis_expt/lbc

Directory where the processed input LBCs are stored. For a given run ID, *RUNID*, the LBCs will be located in \$LBCDIR/*RUNID*.

TMPDIR /home/precis/precis_expt/tmp

Directory where the temporary files generated when PRECIS is running are located.

- Input data directories (and default values)

ANCIL_MASTER /home/precis/ancil/master

Contains global master ancillary files. All the required files are copied at the end of the installation process.

PP4LBCDIR /home/precis/pp4lbc

Contains the files required to generate the LBCs used by PRECIS, as provided by the Met Office. Each driving experiment is identified by a separate five-letter ID, and the corresponding data

should be placed in a subdirectory with the same name. For example, the input data from the driving experiment with ID `addfa` should be copied to `$PP4LBCDIR/addfa/`.

DUMPSDIR `/home/precis/dumps`

Location of the model's initial dump files. These files have to be obtained from the Met Office. All initial dumps should be copied to this directory. Do not use subdirectories.

- Output directory (and default values)

ARCHIVEDIR `/home/precis/archive`

Directory into which the output diagnostic files are copied. For a given run ID, *RUNID*, the output files will be copied to `$ARCHIVEDIR/RUNID`. `$ARCHIVEDIR` contains the following directory

GLOBALDIR `/home/precis/pp4lbc/global_data`

Location of selected GCM/Re-analysis data which can be used for model validation. The data is stored in subdirectories, named after the GCM/Re-analysis run from which it was generated.

7. One further input is required, a three-letter code which will identify all the experiments run following a particular installation. It suggested that the first two letters identify the institute where the experiments are run, while the third be unique to the computer system on which they are run.
8. The PRECIS system files will then be copied from the DVD or install directory. All the required files will be copied automatically. The user is given the option to install the full PRECIS/Portable UM documentation, and the PRECIS source code. Neither of these are required to run the standard version of PRECIS.
9. A directory called `$HOME/umui_jobs2` will be created. This contains the default experiment definition files used by PRECIS. Another directory, `$HOME/precis_save`, where all of the saved experiments are stored, is also created. DO NOT REMOVE THESE DIRECTORIES. See Appendix B.1 for a full description of the PRECIS directory structure.
10. CDAT is then installed automatically.
This copies a pre-compiled version of CDAT 3.3 onto the user's system.
11. When the installation is complete a file called `setvars` will be created in the `precis` home directory. This is the general PRECIS configuration file. It contains the environment variables defined above, and other environment

²The directories with "umui" as part of their name are a legacy of the Portable UM, of which PRECIS is an extension.

variables needed by PRECIS. If there has been any mistake in defining the environment variables for the data directories during the installation process, then this file can be edited to set the environment variables to their correct values. **setvars** can also be edited at a later date if the directory structure changes for any reason.

12. **setvars** has to be *sourced* every time PRECIS is run.

To do this type

```
$> . $HOME/setvars
```

Note the “.”.

At the end of installation process you will be asked if the call to **setvars** should be appended to `$HOME/.profile`. If this is done, then **setvars** will be sourced automatically at every login. The line can be added to the end of `$HOME/.bashrc` so that **setvars** is sourced every time the **precis** account is used (e.g. when a terminal window is opened).

When **setvars** is sourced a soft link `/home/precis/userprestash` is created. Do not delete this link.

Remember, setvars has to be <i>sourced</i> every time PRECIS is run.

13. Install the sample global driving data (i.e. boundary data) required to generate the LBCs, the initial dump files and the master ancillary files by typing

```
$> cp $DVDDIR/install_data $HOME
$> $HOME/install_data $DVDDIR
```

or

```
$> cp $INSTDIR/install_data $HOME
$> $HOME/install_data $INSTDIR
```

Make sure that **setvars** has been sourced before installing the data.

The GCM driving data and initial dump files will be installed in `$PP4LBCDIR` and `$DUMPSDIR` respectively. This may take up to half an hour.

3.5 Installation of Met Office data

3.5.1 Boundary data supplied on hard drive

The boundary data used to drive the PRECIS regional model is supplied on a 500GB or larger internal IDE or SATA hard drive or external USB drive after the PRECIS user has installed PRECIS and done a test run with the sample data included with the PRECIS installation software.

(The following instructions assume that you have already installed PRECIS and have received a hard drive containing boundary data).

1. The drive should physically be put in the system - either internally or externally (if a USB hard drive enclosure is used). Take care to modify the Master or Slave status on the hard drive by moving the jumper on the back of the drive.
2. Once the computer boots up, you might go into the BIOS (if you connected the drive internally) to make sure the hard drive has been detected.
3. Boot into Linux.
4. Mount the disk. Linux should assign a device number to the drive (or to the external USB device). For example, a hard drive connected internally as the master on the secondary IDE port will be `/dev/hdc1` (mounted as slave on the secondary port, it would be `/dev/hdd1`). For a USB device, it is likely to be something like `/dev/sda1`.
5. Create a mount point `*as root*` - if you want the disk mounted as `/precis-data`, type something like

```
mkdir -m 0777 /precisdata
```

6. Mount the disk - the file system should be autodetected, so something like this should work:

```
mount /dev/hdc1 /precisdata
```

7. modify the `/etc/fstab` file if you want the drive to mount automatically each time the computer is booted.
8. Now you have two choices that depend upon whether you want to keep the disk as it is or copy the data on the hard drive to another location.

Either way, the relevant information is found in the \$HOME/setvars file of the base install directory (e.g.: /home/precis/setvars).

You are looking for two variables in setvars:

```
PP4LBCDIR=  
DUMPSDIR=
```

Your two choices are to:

1. Copy the files from the mounted disk to wherever \$PP4LBCDIR and \$DUMPSDIR are set to (by default, they will be \$HOME/pp4lbc/ and \$HOME/dumps/)
2. Edit the setvars file (using vi/emacs/pico etc) and change PP4LBCDIR= and DUMPSDIR= to the newly mounted drive, example:

```
PP4LBCDIR=/precisdata  
DUMPSDIR=/precisdata/dumps
```

Be sure to save the changes to the setvars file, close it and then source setvars again to apply the changes.

Whatever you decide, make sure that you unzip the boundary data files as they may be gzipped if space was needed on the hard drive. PRECIS requires that the boundary files are unzipped. You can use

```
gunzip -frv $PP4LBCDIR  
gunzip -frv $DUMPSDIR
```

to unzip the files.

9. \$PP4LBCDIR is set up to expect the runids as subdirectories. So if you copy an experiment from /precisdata to \$PP4LBCDIR, then copy it as a subdirectory - for example,

```
mkdir /home/precis/pp4lbc/addfa  
cp -v /precisdata/addfa/* /home/precis/pp4lbc/addfa/
```

Conversely, if you modify setvars, set \$PP4LBCDIR to be one directory above where the runids live. PRECIS will expect to see the directories in that directory that are named as runids.

i.e. PP4LBCDIR=/precisdata (since /precisdata will have all the runids). DUMPSDIR is the opposite - it expects all the dumps to be in one directory.

10. If you edit setvars, make sure you source the file before you restart PRECIS.

3.6 Installation verification

The PRECIS installation can be tested. For this to work you must have installed PRECIS, CDAT (which is automatically installed with PRECIS) and the sample input data from the supplied installation package.

1. If it hasn't already been done, type

```
$> . $HOME/setvars
```

2. Start the PRECIS GUI with

```
$> precis
```

3. The GUI will start. The Benchmark experiment will be loaded automatically.
4. Click on the red "Run PRECIS" button, then click on the confirmation button ("Run from beginning") in the window which appears.
5. The model should start to run.
6. Click on "Monitor PRECIS" button in the main window.
7. The experiment monitoring window will appear. The text at the bottom of the window indicates the state of the experiment. After one model day fully completes (approximately fifteen to thirty minutes, depending on the speed of the PC), output graphics from the experiment may appear (although this is optional).
8. Without intervention, the experiment should run for one month model time. To stop the immediately, close the runtime monitor, and click on the "Stop PRECIS", and then the "Kill PRECIS" buttons.

The Unix command `top` can be used to monitor PRECIS's CPU usage.

3.7 Installation of CDAT

A static executable version of CDAT 3.3 should be installed by default, so only use this section if you want to re-install CDAT 3.3, fully compiling it. Note that this can be challenging as CDAT 3.3 has many software dependencies!

CDAT 3.3 is required for normal PRECIS operation. It is supplied on the installation DVD/tarball as `cdat-3.3-everything.tar.gz`. Use the following commands in order.

```
$> cd $HOME # or into the directory you wish to install CDAT into

#This unpacks CDAT into $/HOME/cdat-3.3
$> tar zxvf $DVDDIR/cdat/cdat-3.3-everything.tar.gz
or
$> tar zxvf $INSTDIR/cdat/cdat-3.3-everything.tar.gz

$> cd cdat-3.3
$> ./express_install 'pwd' #This will take about 10 minutes
$> ./test_script 'pwd' #This tests the installation
```

Note the type of quotation mark used (i.e. a backtick - “`” rather than “”).

If everything has worked properly, then there should be no errors when `test_script` is run, and VCDAT, the CDAT interactive plotting interface, should have started. Quit out of VCDAT to continue.

`$HOME/setvars` has to be edited to set `CDATDIR` to the directory into which CDAT has been installed. In the above example, `CDATDIR` should be set to `$HOME/cdat-3.3`. Then uncomment the line.

If you have problems with the CDAT installation, please look at the help files in the CDAT top level directory. The CDAT website can be viewed at <http://www2-pcmdi.llnl.gov/cdat> and is also useful.

Chapter 4

Experimental design and setup

4.1 Experimental design

A well-designed suite of PRECIS experiments is crucial, as inappropriately designed experiments may not address the relevant issues or might provide insufficient data. This section is intended to expand on the factors which need to be considered when choosing a particular PRECIS setup. The corresponding panel in the GUI is referred to where appropriate.

4.1.1 Regional climate model

The HadRM3P regional climate model within PRECIS is descended from the third generation Met Office Hadley Centre coupled climate model HadCM3. There are two regional models with PRECIS, HadRMP-MOSES1 and HadRM3P-MOSES2.2, which are activated automatically when the choice of land surface scheme is made (see section 4.1.6).

4.1.2 Choice of driving model and forcing scenario

GUI panel: see section 5.2.3

Depending on the application, PRECIS will be required to downscale recent and one or more future climates. The climate of a particular region is determined by local and remote processes with external forcing provided by solar radiation. The effect of the radiation is modulated by the composition of the atmosphere and various feedback processes within the global climate system. Thus a regional climate model requires, as input, boundary conditions providing the remote forcing of the regional climate and consistent information on atmospheric composition.

More specifically, the boundary conditions comprise lateral boundary conditions of surface pressure, winds, temperature and humidity (and aerosol concentrations if available) and surface boundary conditions for sea surface temperature and sea-ice fraction. The atmospheric composition is represented by prescribed concentrations of the most important greenhouse and other gases derived from scenarios of their emissions. These values can be provided upon request.

The climate state obtained by incorporating these emissions in global and regional climate models is called a climate scenario, while the difference between a future and current or recent climate state resulting from the consequent changes in atmospheric composition is called a climate change scenario.

The different climates that can be simulated by PRECIS are as follows and are defined in terms of the source of the boundary data and the relevant emissions/concentrations data. These are of course inextricably linked, as the emission and concentration forcings are used in the driving models that produce the boundary conditions as well as in an RCM.

- **Quasi-observed climates of the recent past.** These are recreations of observed climate derived from GCM reanalysis systems.

1. **Assimilated ERA15 (1979–1993)**

A quasi-observed set of boundary data has been derived from ERA15, an ECMWF (European Centre for Medium-Range Weather Forecasting) reanalysis dataset available for the years 1979-1993 inclusive. The ERA15 data was assimilated into a 15 year integration of the Hadley Centre's HadAM3 GCM, a process which provides a consistent transformation and interpolation of the ERA15 variables to those required in the lateral boundary conditions. In the assimilation, sea surface temperatures (SSTs) and sea-ice fractions are taken from the AMIP II observational dataset¹; these are also used as surface boundary conditions for the RCM. The model uses the standard Gregorian calendar (see section 4.1.14).

Average values of various greenhouse gases for this period are used to provide relevant information on atmospheric composition.

There is no explicit representation of atmospheric aerosols in the assimilated ERA15 GCM. Therefore, when using these LBCs from this model only emissions from within the RCM region are included as source terms, and zero aerosols are assumed to be advected into the domain via the lateral boundary conditions.

2. **ERA40 (1957–2002)**

¹<http://www-pcmdi.llnl.gov/projects/amip/AMIP2EXPDSN/BCS/bcsintro.php>

A quasi-observed set of boundary data has been derived from ERA40, an ECMWF (European Centre for Medium-Range Weather Forecasting) reanalysis dataset available for the years 1957-2002 inclusive². This reanalysis dataset was produced with an improved GCM compared to that used in the construction of ERA15. Unlike the ERA15 boundary conditions, the ERA40 data has undergone no post processing through the Hadley Centre GCM. The sea surface temperatures (SSTs) and sea-ice fractions are taken from a combination of the monthly HadISST³ and weekly NCEP observed datasets. The model uses the standard Gregorian calendar (see section 4.1.14).

Observed values of various greenhouse gases for this period are used to provide relevant information on atmospheric composition (as opposed to the average values used with ERA15).

There is no explicit representation of atmospheric aerosols in ERA40. Therefore, when using these LBCs from this model only emissions from within the RCM region are included as source terms, and zero aerosols are assumed to be advected into the domain via the lateral boundary conditions.

3. ERA Interim (1979–2011)

As ERA40, but with an improved and higher resolution GCM⁴.

4. 20th Century Reanalysis version 2c (1851–2011)

Three ensemble members from 56 ensemble runs of the 20th Century Reanalysis version 2c are available to drive PRECIS. The 20th Century Reanalysis⁵ uses a Kalman filter-based technique to produce a global tropospheric circulation data set at four-times-daily resolution back to 1851⁶. Previously, the only data set available for the early 20th century consisted of error-ridden hand-drawn analyses of the mean sea level pressure field over the Northern Hemisphere. Modern data assimilation systems have the potential to improve upon these maps, but prior to 1948, few digitized upper-air sounding observations are available for such a reanalysis. The global tropospheric circulation data set created by the 20th Century Reanalysis version 2c provides an important validation check on the climate models used to make 21st century climate projections.

The analyses are generated by assimilating only surface pressures and using monthly SST and sea ice distributions as boundary conditions

²<http://www.ecmwf.int/products/data/archive/descriptions/e4/>

³<http://www.metoffice.gov.uk/hadobs/hadisst/>

⁴<http://www.ecmwf.int/research/era/do/get/era-interim>

⁵<http://rda.ucar.edu/datasets/ds131.1/>

⁶<http://portal.nersc.gov/project/20C.Reanalysis/>

within a deterministic Ensemble Kalman Filter (EKF). A unique feature of the 20th Century Reanalysis is that estimates of uncertainty are derived using a 56 member ensemble (three of which are available to drive PRECIS).

20th Century Reanalysis Version 2c uses the same model as version 2 with new sea ice boundary conditions from the COBE-SST2, new pentad Simple Ocean Data Assimilation with sparse input, and sea surface temperature fields and additional observations from ISPD version 3.2.9.

The model uses the standard Gregorian calendar (see section 4.1.14). Observed values of various greenhouse gases for this period are used to provide relevant information on atmospheric composition.

There is no explicit representation of atmospheric aerosols in the 20th Century Reanalysis version 2c. Therefore, when using these LBCs from this model only emissions from within the RCM region are included as source terms, and zero aerosols are assumed to be advected into the domain via the lateral boundary conditions.

5. NCEP R2 (1979–2004)

A quasi-observed set of boundary data has been derived from the NCEP/DOE (National Centers for Environmental Prediction) reanalyses, available for the years 1979 to 2004 inclusive⁷. This reanalysis dataset was produced with an assimilation system different to that used in the construction of ERA40. Similarly to ERA40 boundary conditions, the data has undergone no post processing through the Hadley Centre GCM. The sea surface temperatures (SSTs) and sea-ice fractions are taken from a combination of the monthly HadISST⁸ and weekly NCEP observed datasets. The model uses the standard Gregorian calendar (see section 4.1.14).

Observed values of various greenhouse gases for this period are used to provide relevant information on atmospheric composition.

There is no explicit representation of atmospheric aerosols in NCEP R2. Therefore, when using these LBCs from this model only emissions from within the RCM region are included as source terms, and zero aerosols are assumed to be advected into the domain via the lateral boundary conditions.

- **Modelled climates of the recent past.** These are GCM simulations of recent decades, which either employ observed sea surface temperatures and ice extents, or use those from coupled ocean-atmosphere GCMs.

⁷<http://www.cpc.noaa.gov/products/wesley/reanalysis2/>

⁸<http://www.metoffice.gov.uk/hadobs/hadisst/>

1. **HadAM3P (1960–1990)**

Boundary data is provided by three 31 year integrations of HadAM3P, a 150km resolution atmosphere-only version of the Hadley Centre’s HadCM3 global atmosphere-only model. Each is started from different initial conditions but all used observed time series of HadISST⁹ sea-surface temperatures and sea-ice for 1960–1990. The three integrations form an initial condition ensemble (see section 4.1.5).

The observed evolution of greenhouse gas concentrations over this period is used to provide relevant information on atmospheric composition. Also, the estimated evolution of anthropogenic emissions of sulphur dioxide (and natural background emissions of this and other relevant chemicals) are prescribed and their evolution and impact on atmospheric composition are simulated within the GCM’s sulphur cycle model component. The model uses an idealised 360-day calendar (see section 4.1.14).

The aerosol models in this GCM and the PRECIS regional models are wholly compatible, so when using LBCs from this model, emissions from within the RCM region are included as source terms, and aerosols may be advected into the domain via the lateral boundary conditions.

2. **ECHAM4 (1960–1990)**

Boundary data is available from a 1960-1990 integration of ECHAM4, the Max Plank Institute’s fourth generation coupled ocean-atmosphere general circulation model¹⁰. The sea-surface boundary conditions are taken directly from the ocean component of ECHAM4 (OPYC3). The model uses an idealised 360-day calendar (see section 4.1.14).

There is no explicit representation of atmospheric aerosols in ECHAM4. Therefore, when using these LBCs from this model only emissions from within the RCM region are included as source terms, and zero aerosols are assumed to be advected into the domain via the lateral boundary conditions.

3. **HadGEM2-ES (1950–2006)**

Boundary data is available from a historical period for the CMIP5 global model HadGEM2-ES.

There is no explicit representation of atmospheric aerosols in HadGEM2-ES. Therefore, when using these LBCs from this model only emissions from within the RCM region are included as source terms, and zero aerosols are assumed to be advected into the domain via the lateral boundary conditions.

⁹<http://www.metoffice.gov.uk/hadobs/hadisst/>

¹⁰http://www-pcmdi.llnl.gov/projects/modeldoc/amip1/26mpi_ToC_b.html

- **Future climates of 2070–2100.**

The methodology behind constructing scenarios for future climates is described in the PRECIS Handbook chapters 2 and 3. A range of different (but equally plausible) future emissions scenarios is available to help estimate the range of possible future climates. It is important to consider running RCMs to generate more than one of the future climate scenarios implied by these different emissions scenarios in order to start to quantify the “emissions” uncertainty in the predictions.

1. **HadAM3P (2070–2100)**

Boundary data is available from four 31 year integrations of the HadAM3P atmosphere-only atmosphere global model. Three of these provide an initial condition ensemble of three different simulations of the climate of 2070–2100 consistent with the SRES A2 emissions scenario (see section 4.1.5) and a single realization the SRES B2 emissions scenario. The sea-surface boundary conditions are derived by combining changes in sea-surface temperature and sea-ice simulated in integrations of the coupled ocean atmosphere model HadCM3^{11,12} (using the same emissions scenarios as and providing the initial conditions for the corresponding HadAM3P integrations) with the HadISST¹³ observed 1960–1990 time series.

The evolutions of greenhouse gas concentrations prescribed in this model over this period, calculated off-line from the SRES emission scenario data, are the same as in the corresponding HadCM3 experiment. The SRES emissions scenarios also prescribe the evolution of anthropogenic emissions of sulphur dioxide which, along with natural background emissions of this and other relevant chemicals, are input into the sulphur cycle model component of HadAM3P. The model uses an idealised 360-day calendar (see section 4.1.14).

The aerosol models in this GCM and the PRECIS regional models are wholly compatible, so when using LBCs from this model, emissions from within the RCM region are included as source terms, and aerosols may be advected into the domain via the lateral boundary conditions.

2. **ECHAM4 (2070–2100)**

Boundary data is available from a 2070 to 2100 integration of ECHAM4, the Max Plank Institute’s fourth generation coupled ocean-atmosphere

¹¹Gordon C, Cooper C, Senior CA, Banks HT, Gregory JM, Johns TC, Mitchell JFB, Wood RA (2000) The simulation of SST, sea ice extents and ocean heat transports in a version of the Hadley Centre coupled model without flux adjustments. *Clim Dyn* 16: 147–168

¹²Pope VD, Gallani ML, Rowntree PR, Stratton RA (2000) The impact of new physical parametrizations in the Hadley Centre climate model: HadAM3. *Clim Dyn* 16: 123–146

¹³<http://hadobs.metoffice.com/hadisst/>

general circulation model¹⁴. The data follows the SRES B2 emissions scenario. The sea-surface boundary conditions are taken directly from the ocean component of ECHAM4 (OPYC3). The model uses an idealised 360-day calendar (see section 4.1.14).

There is no explicit representation of atmospheric aerosols in ECHAM4. Therefore, when using these LBCs from this model only emissions from within the RCM region are included as source terms, and zero aerosols are assumed to be advected into the domain via the lateral boundary conditions.

- **Transient climates from the recent past to 2100.**

These scenarios allow an RCM to be integrated continuously from the recent past to the end of the the 21st century, thus allowing periods such as the 2050s to be downscaled directly by the regional climate model, rather than relying on pattern scaling techniques.

1. **HadCM3Q0 (1950–2099)**

Boundary data is available from a single 1950-2099 integration of the HadCM3Q0 GCM, a version of the Hadley Centre’s third generation coupled ocean-atmosphere general circulation model. This model is different from the standard HadCM3^{15,16} model in two ways. Firstly, it uses flux adjustments to ensure that the SSTs remain close to climatological values during a control period, while allowing SSTs to vary from natural variability and from atmospheric forcings, such as increasing CO₂. Secondly, it includes an atmospheric sulphur cycle.

The external forcing is from the SRES A1B emissions scenario. The sea-surface boundary conditions are taken directly from the ocean component of HadCM3Q0. The model uses an idealised 360-day calendar (see section 4.1.14).

The aerosol models in this GCM and the PRECIS regional models are wholly compatible, so when using LBCs from this model, emissions from within the RCM region are included as source terms, and aerosols may be advected into the domain via the lateral boundary conditions.

2. **HadCM3Q1, . . . , HadCM3Q16 (1950–2099)**

Boundary data is available from sixteen 1950-2099 integrations. The sixteen GCMs are based on the standard HadCM3Q0 model, but each

¹⁴http://www-pcmdi.llnl.gov/projects/modeldoc/amip1/26mpi_ToC.b.html

¹⁵Gordon C, Cooper C, Senior CA, Banks HT, Gregory JM, Johns TC, Mitchell JFB, Wood RA (2000) The simulation of SST, sea ice extents and ocean heat transports in a version of the Hadley Centre coupled model without flux adjustments. *Clim Dyn* 16: 147–168

¹⁶Pope VD, Gallani ML, Rowntree PR, Stratton RA (2000) The impact of new physical parametrizations in the Hadley Centre climate model: HadAM3. *Clim Dyn* 16: 123–146

model has a set of perturbations to its dynamical and physical formulation. These perturbations are made within the known bounds of modelling uncertainty and so this set of models, along with HadCM3Q0, provide an ensemble of GCMs which may be used to estimate i) the uncertainty in regional climate model results due to uncertainty in driving GCM formulation and ii) the uncertainty in fine-scale climate change due to uncertainties in global and regional model formulation. The external forcing is from the SRES A1B emissions scenario. The sea-surface boundary conditions are taken directly from the GCMs' ocean components. Note that each of the models has its own unique pattern of flux adjustments. The model uses an idealised 360-day calendar (see section 4.1.14).

The aerosol models in these GCMs and the PRECIS regional models are wholly compatible, so when using LBCs from these models, emissions from within the RCM region are included as source terms, and aerosols may be advected into the domain via the lateral boundary conditions.

3. ECHAM5 (1950–2100)

Boundary data is available from one 1950 to 2100 integration of ECHAM5, the Max Plank Institute's fifth generation coupled ocean-atmosphere general circulation model¹⁷. The external forcing is from the SRES A1B emissions scenario. The sea-surface boundary conditions are taken directly from the ocean component of ECHAM5. The model uses the standard Gregorian calendar (see section 4.1.14).

ECHAM5 predicts the evolution of an ensemble of aerosol modes: sulphate, black carbon, particulate organic matter, sea salt and mineral dust. However, this aerosol model is incompatible with that used in the PRECIS regional models, so when using these LBCs from this model only emissions from within the RCM region are included as source terms, and zero aerosols are assumed to be advected into the domain via the lateral boundary conditions.

4.1.3 CMIP5 Driving GCMs and Representative Concentration Pathways

PRECIS version 2.0 and future versions contain a major upgrade in that a subset of the newest General Circulation Models (GCMs) used to inform the newest Intergovernmental Panel on Climate Change report, AR5¹⁸ will be downscaleable.

¹⁷http://www-pcmdi.llnl.gov/ipcc/model_documentation/ECHAM5_MPI-OM.htm

¹⁸<http://www.ipcc.ch/report/ar5/>

Phase 5 of the Coupled Model Intercomparison Project (CMIP5) is a standard experimental protocol for studying the output of coupled ocean-atmosphere GCMs. The purposes of CMIP5 are to address outstanding scientific questions that arose as part of the IPCC Fourth Assessment report (AR4) process, to improve understanding of climate, and to provide estimates of future climate change that will be useful to those considering its possible consequences and the effect of mitigation strategies. CMIP5 is meant to provide a framework for coordinated climate change experiments over a five year period and includes simulations for assessment in the IPCC Fifth Assessment Report (AR5) as well as others that extend beyond the AR5. All CMIP5 model simulations were published in 2013.

Representative Concentration Pathways

The CMIP5 simulations include 4 future scenarios referred to as Representative Concentration Pathways or RCPs. CMIP5 GCMs run according to three of the RCPs (8.5, 4.5 and 2.6) produced the necessary input data for regional models and are thus available within the PRECIS system. The RCPs describe a wide range of potential futures for the main drivers of climate change: greenhouse gases, air-pollutant emissions and land use changes. The lower RCP 4.5 and higher RCP 8.5 emission scenarios are defined in terms of radiative forcings of 4.5 and 8.5 watts per square metre by the end of the 21st century. RCP 8.5 represents the upper range of concentrations, while RCP 4.5 is near the lower range of concentrations. The RCP 2.6 scenario (also known as the RCP3-PD, has radiative forcing levels decline towards 2.6 watts per square metre by 2100. Comparing with previous SRES emission scenarios, RCP 8.5 approximately follows the A1FI SRES emission scenario and RCP 4.5 follows the B1 SRES emission scenario.

Note that these radiative forcing levels are illustrative only, because greenhouse gas concentrations, aerosol and tropospheric ozone precursors are prescribed, resulting in a wide spread in radiative forcings across different models. See table 4.1.3 for an overview of the RCPs.

- **HadGEM2-ES**

HadGEM2-ES is one of the Met Office Hadley Centre models used to provide climate simulations to CMIP5. HadGEM2 stands for the Hadley Centre Global Environment Model version 2. The HadGEM2 family of models comprises a range of specific model configurations incorporating different levels of complexity but with a common physical framework. The HadGEM2 family includes a coupled atmosphere-ocean configuration, with or without a vertical extension in the atmosphere to include a well-resolved stratosphere. HadGEM2-ES is an Earth-System configuration of HadGEM2 which is a coupled atmospheric and ocean GCM (AOGCM) including dynamic vegetation, ocean biology and atmospheric chemistry. Its horizontal resolution is 1.25 degrees of latitude by 1.875 degrees of longitude, which

Scenario (PRECIS modelling period)	Forcing Pathway	Concentration (ppm)	Emission (Kyoto protocol greenhouse gases)	Radiative forcing (W/m ²)
RCP8.5 (2006-2099)	Rising	>1370 CO ₂ -eq in 2100	Rising continues until 2100	> 8.5
RCP4.5 (2006-2099)	Stabilization without overshoot	650 CO ₂ -eq (at stabilization after 2100)	Decline from mid-century	> 4.5
RCP2.6 (2006-2099)	Peak and decline scenario	Peak at 490 CO ₂ -eq before 2100 and then decline	Decline in the first quarter of century	3.0 before 2100, then 2.6 from 2100

Table 4.1: Overview of Representative Concentrations Pathways used in CMIP5

gives a global grid of 192 x 145 grid cells (N96). This is equivalent to a surface resolution of about 208 km x 139 km at the Equator, reducing to 120 km x 139 km at 55 degrees of latitude. Vertically, there are 38 vertical levels using a hybrid height vertical coordinate system which extends to an approximately 40 kilometre altitude. The oceanic component utilizes a latitude-longitude grid with a longitudinal resolution of 1 degree, and latitudinal resolution of 1 degree between the poles and 30 degrees North/South, from which it increases smoothly to one third of a degree at the equator. The model timestep is 30 minutes (atmosphere and land) and 1 hour (ocean).

HadGEM2-ES was designed to run major scenarios for IPCC AR5 and comprises Earth System components such as terrestrial and ocean carbon cycle and troposphere chemistry. HadGEM2-ES also represents interactive land and ocean carbon cycles and dynamic vegetation with an option to prescribe either atmospheric CO₂ concentrations or to prescribe anthropogenic CO₂ emissions and simulate CO₂ concentrations. To simulate the evolution of atmospheric composition and interactions with atmospheric aerosols, an interactive tropospheric chemistry scheme is also included. Extensive diagnostic output has been made available to the CMIP5 multi-model archive¹⁹. Output is available either at certain prescribed frequencies or as time-average values over certain periods as detailed in the CMIP5

¹⁹<http://cmip-pcmdi.llnl.gov/cmip5/>

output guidelines. Six hourly instantaneous values of required surface and three dimensional atmospheric prognostic variables for further downscaling are among those outputs which are used for the regional climate model within the PRECIS system.

Annual concentrations of CO₂, CH₄, N₂O and Halocarbons in HadGEM2-ES were derived from the CMIP5 data portal. These data are inputs to the model via namelist file and were interpolated linearly at each model time step during the model run. In PRECIS 2.0, the CO₂, CH₄, NO₂ and Halocarbons are treated in the same way as HadGEM2-ES. The CO₂ concentrations used were taken from the CMIP5 dataset. The historical part of the concentrations (1860-2005) is derived from a combination of the Law Dome ice core, NOAA global mean and measurements from Mauna Loa. After 2005, CO₂ concentrations recommended for CMIP5 were calculated for the 21st century from harmonized CO₂ emissions of the four Integrated Assessment Models that underlie the four RCPs. Beyond 2100, these concentrations were extended, so that the CO₂ concentrations under the highest RCP, RCP8.5, stabilize just below 2000 ppm by 2250. Both the medium RCPs smoothly stabilize around 2150, with RCP4.5 stabilizing close to the 2100 value of the former SRES B1 scenario (540 ppm). The lower RCP 2.6 illustrates a world with net negative emissions after 2070 and sees declining CO₂ concentrations after 2050, with a decline of 0.5 ppm per year around 2100. These CO₂ concentrations are prescribed in HadGEM2-ESs historical and RCP simulations.

The HadGEM2-ES experiments for CMIP5 involve performing a historical simulation (defined as 1860 to 2005) using the historical record of climate forcing factors such as greenhouse gases, aerosols and natural forcings such as solar and volcanic changes. The model state at 2005 is then used as the initial condition for the 4 future RCP simulations.

Prognostic aerosol data is not provided in CMIP5, so only aerosol climatologies are used in HadGEM2-ES to provide aerosol concentrations to the RCM via three dimensional atmospheric ancillary data. The climatologies also include an annual cycle by providing data for each month of the year.

4.1.4 Simulation length

The word “climate” describes a statistical distribution of meteorological occurrences which occur at a particular place, or area. Therefore, a reliable simulation of climate must be long enough to sample as wide a range of meteorological phenomena as possible. It is well known that fluctuations in climate occur naturally over seasonal, annual, decadal time scales and beyond (see PRECIS Handbook, Chapter 3), and model climates reflect this internal variability. At the minimum,

an element of the decadal variability must be captured for a reliable estimate of the climate in question. Therefore an integration length of 31 years is recommended, i.e. a thirty-year simulation following a 1 year spinup (see section 4.1.8).

The case of simulations driven by the quasi-observed (reanalysis) boundary conditions is slightly different. In this case model output can be compared directly with observations for the corresponding period. (though no model would be expected to reproduce all aspects of the observed evolution of weather over in a deterministic manner). This allows a more direct comparison with particular aspects of climate, e.g. interannual variability, ENSO-related phenomena.

For initial testing and sensitivity experiments (e.g. sensitivity of RCM performance to domain size) simulation lengths of only a few months or a few years may be sufficient. Determining the constraint that the boundary conditions apply to the seasonal circulation patterns within the RCM domain may be done using a few seasonal cycles, or even by performing a few single-season runs for the most interesting season (e.g. three three-month runs starting 1st December 1960, 1st December 1961 and 1st December 1962) and averaging the results.

GUI panel: see section 5.2.5

4.1.5 Initial condition ensembles

An alternative method of exploring a model's internal variability is to use ensembles, effectively increasing simulation length while minimising the effect of the change in external forcing due to atmospheric composition. To increase the range of climate states captured, a set of realisations of a particular climate can be produced, each using the same evolution of atmospheric composition (recent or future). The individual members of the driving model ensemble are initialised with different (but equally plausible) states. The deterministic nature of the model produces a different (but again equally plausible) representation of the subsequent climate for each initial state. An RCM is then used to downscale each member of the ensemble.

Initial condition ensembles of lateral boundary conditions for two scenarios (see section 4.1.2) are currently available from the Met Office Hadley Centre:

- Baseline: Three members, each spanning 01 January 1960 – 01 January 1991 (addf[abc])
- SRES A2 scenario: Three members, each spanning 01 January 2070 – 01 January 2101 (adj[aef])

GUI panel: see section 5.2.3

4.1.6 Choice of land surface scheme

When using the HadRM3P regional climate model, there is the option of using a more advanced land surface scheme than the default MOSES I (see appendix H). The alternative scheme is MOSES 2.2. Note that MOSES 2.2 outputs some different diagnostics to MOSES I. See appendix C for details.

GUI panel: see section 5.2.4

4.1.7 Output data

It is essential that an RCM outputs sufficient data for inputs to impact models and for any direct analysis of the RCM behaviour. The standard output data are available as hourly and daily values (both optional) and also as ‘climatic means’ (mean values over timescales of longer than a day) for the wide range of variables listed in appendix C. It is possible to add non standard diagnostics (i.e. any required variables that are not in the standard lists, or any variables that are listed but are not being output at the desired frequency) by contacting the PRECIS team for a new configuration file, provided the desired diagnostics are available in the Unified Model.

Note that output data volumes can be large (see table 3.2), which may need to be taken into account when choosing the diagnostic types.

GUI panel: see section 5.2.6

4.1.8 Spinup

Before commencing a simulation of climate, it is necessary to allow the atmosphere and land surface to adjust, or “spin up” to a mutual equilibrium state. While the atmosphere of the RCM interior only takes a few model days to achieve equilibrium with its lateral boundary conditions, the temperature and moisture in the deep soil levels can take many months to reach equilibrium. As a result we recommend that the spinup period should be at least 12 months. As the RCM’s climate will experience some drift during the spinup period, the output data during the spinup period should not be used as inputs to impact models nor in any part of the analysis of RCM results.

Spinup example: Running the ECHAM5 GCM beginning on 1st December 2069 and ending on 31 December 2100 yields 30 years of useable RCM output data spanning 1st December 2070 to 31 December 2100. The output data during the period 1st December 2069 to 30 November 2070 should be discarded as model spinup.

4.1.9 Choice of region

The factors to consider when choosing a suitable model domain are described in the PRECIS Handbook (Section 5.1). Assessing the validity of a particular domain is best done by assessing the relative merits of different possible domains, all of which encompass the area of interest. A sequence of short test experiments may be required: a) to ensure consistency over large scales between each domain of the PRECIS model and the driving data; b) to check the levels of mesoscale activity over important regions within the domain and c) to provide an estimate of the run time (or rate of simulation). The results of these tests then allow a suitable domain to be chosen.

GUI panel: see section 5.2.1

4.1.10 Land-sea mask

The influence of land and sea on the evolution of climate over all scales is very different, and equally, land and sea respond to climate in a very different way. An accurate specification of land and sea grid boxes with the RCM domain is therefore crucial. This is done via an input field known as the land-sea mask. The RCM automatically creates a land-sea mask for the chosen domain. The source data for creating the land-sea mask is a 10' resolution global dataset of boolean values (i.e. TRUE for land points and FALSE for sea points).

The RCM land-sea mask may, however, contain inaccuracies or undesirable inland water characteristics.

- Inaccuracies can arise during the rotation and regridding of the logical source data to the RCM's grid (see section 5.8.1).
- Inland water points require surface temperature, and possibly ice fraction, input data, which is often not readily available. Therefore values are interpolated from the nearest open ocean grid points. This may give unrealistic results and therefore make the inclusion of the inland water undesirable. (See below for more details.)

Modifying the automatically created land-sea mask should therefore be considered before starting any experiments and this can be done from within the GUI. The underlying principle to apply when editing the land-sea mask is that a grid point should be a land point if and only if at least half of the grid box area is land in reality. The coastal outline acts as a guide for assessing this.

However, there are some notable exceptions to this rule:

- Inland water areas should be switched to land points (see section 5.2.2) except in two cases:
 1. For inland water points less than 200 kilometres from the ocean, between 55 degrees North latitude and 55 degrees south latitude, and which are at less than 500 metres in elevation, the interpolation of surface data from nearby open ocean points to inland waters may give realistic results. To verify this, the sea surface temperature and sea ice ancillary files should be checked at the end of the NRUN (see Section 5.8.4). In order to set the orographic height of such points correctly, click on the data point using the left mouse button while holding the control button on the keyboard. This will set the correct height and the points will turn cyan.
 2. The following inland water areas have surface data provided and, therefore, are always allowed:
 - Lake Victoria (Central east Africa)
 - The Great Lakes of North America (Superior, Michigan, Huron, Erie, Ontario)
 - Caspian Sea (Central Asia)
 - Aral Sea (Central Asia) when ECHAM5, ERA40, ERA-Interim and NCEP R2 are used as the driving GCM.

Please refer to the inland water flowchart accessible online ²⁰ for more information.

- Islands in close proximity which in total would fill over half a grid box but which lie in adjacent ones
- Peninsulae similarly split over grid boxes
- Major cities or other important coastal or island sites which are otherwise ocean points may be converted
- All land points (with the exception of single grid box islands) should share at least one grid box edge with another land point.

As the above exceptions suggest, some judgement needs to be applied to achieve the ‘best’ land-sea mask, i.e. one which has the best balance between reality and the requirements of the user.

GUI panel: see section 5.2.2

²⁰<http://www.metoffice.gov.uk/media/pdf/b/i/Criteria-inland-water.pdf>

4.1.11 Altitude

The altitude of land grid box is the mean topographic height of the area covered by that grid box. Each grid point's altitude is calculated from a global source dataset of mean topographic heights at 10 minute resolution. In certain circumstances, it may be desirable to override the default altitude for a land grid point. This should only be done when a land point has been inserted for a grid box which is mainly ocean in reality (see section 4.1.10). In this case the default altitude for this grid point as calculated by PRECIS will be unrealistically low, and so a more realistic grid box mean altitude for the land area being represented should be used.

GUI panel: see section 5.2.2

4.1.12 Altitude of inland waters

By default, PRECIS sets the height above mean sea level of all water grid boxes to (0 meters above) mean sea level. This is likely to be inappropriate for some inland water areas. It is therefore possible, and advisable, to give such inland water areas realistic heights above (or below) mean sea level by filling in such points as land points.

GUI panel: see section 5.2.2

4.1.13 Soil and land cover

- **When using the MOSES I land surface scheme**

For all land grid boxes, the model derives the parameters which describe the characteristics of the soil and land surface from a source dataset of soil and land cover types. However, these parameters may be inaccurate if the land area in question is not accurately represented by the relatively coarse resolution source data (which contains present day, annual mean data in $1^\circ \times 1^\circ$ grid boxes). To overcome this deficiency, the default soil and land cover types for a land grid box may be set in the GUI to those which are more representative of the area in question.

In particular, this deficiency is often true for small islands. For islands which are not resolved in the source data, the model parameters are derived from the nearest resolved land points, which are usually continental and not appropriate.

This functionality also allows for the setting up of sensitivity experiments, whereby the climatic response over a particular area to a hypothetical land

surface may be investigated. For example, soil moisture and precipitation levels may be estimated before and after deforestation.

See appendix H for full details on the source data and how to correctly apply soil and land cover overrides.

- **When using MOSES 2.2 land surface scheme**

It is not possible to edit the land-use and soil characteristics when using MOSES 2.2. See appendix I for more details.

GUI panel: see section 5.2.2

4.1.14 RCM calendar and clock

The RCM is able to adhere to one of two types of calendar, the standard Gregorian calendar or an artificial calendar consisting of 360 days per year (hereafter the 360-day calendar, see below). The choice of calendar is determined by the calendar implicit in the driving data, which in turn is determined by the choice of scenario. The choice of calendar is made automatically by PRECIS and is displayed in the GUI.

Note that the RCM's clock is always based on Universal Time (UTC), denoted Z e.g. 03:00Z.

The 360-day calendar

The 360-day calendar divides a year up into 12 months, each of 30 days in length. It is used in long climate simulations for internal organizational convenience. The introduced distortions of the seasonal cycle are minimized by altering the average date of perihelion²¹, shifting it from 2.5 days after the beginning of the year (0Z 1st January) to 3.2 days after the beginning of the year. This ensures that monthly and seasonal mean values diagnosed from the RCM are comparable with their equivalent observed quantities.

4.1.15 RCM Resolution

The RCMs are able to run at two different horizontal resolutions: $0.44^\circ \times 0.44^\circ$ and $0.22^\circ \times 0.22^\circ$, giving grid boxes of approximately $50\text{km} \times 50\text{km}$ and $25\text{km} \times 25\text{km}$ respectively. While a more realistic land-sea mask topography is expected at 25km resolution, the time taken to complete a simulation is approximately six times longer than for a 50km resolution run covering the same area. Two-thirds of this increase comes from the fourfold increase in the number of grid points and

²¹The point nearest the sun in the orbit of a planet

the rest from a halving of the timestep used in solving the dynamical equations. In this case, the timestep associated with the physical parameterizations in the model remains the same (five minutes) for both resolutions. This both reduces the cost of a high resolution version RCM and also ensures that the influence of possible timestep dependencies in these parameterizations is removed.

4.1.16 Output format

Output data from PRECIS is written in the Met Office's own PP binary data format (see section 6.3.1).

The tools supplied with PRECIS to process PP data are described in section 6.3.2. PP format is easily read and processed by Fortran, as described in section 6.3.1. Users will have to obtain a Fortran90 compiler to use their own code, however.

PP format data can be reformatted into either CF compliant NetCDF²² or GRIB. The freely available CF-Python Tools software²³ is able convert from PP format to CF compliant netcdf (and in some cases, the reverse).

4.1.17 Checklist

There are several stages in setting up a new experiment. The following can be used as a check list to aid the setting up, running and monitoring of experiments.

- Make sure that PRECIS is properly installed.
- Design initial configuration tests and climate experiments, choosing the appropriate scenarios.
- Obtain and install boundary data for the chosen scenarios.
- Select a region to run. Remember to do test runs to decide between different regions. (One years worth of quasi-observed reanalysis boundary data is supplied on the installation DVDs to enable this.)
- Decide on the start time and run length.
- Decide on the output diagnostics.
- Use the PRECIS GUI to set up an experiment with the required attributes.
- Start the experiment, taking note of the five-letter run ID (RUNID)

²²<http://www.cgd.ucar.edu/cms/eaton/cf-metadata/>

²³<http://cfpython.bitbucket.org>

- The experiment will run for a month (the NRUN period) and then stop automatically. Inspect the output data with the appropriate visualization tools. All output data is written to the archive directory and filenames include the run ID.
- If the chosen region is unstable, then choose a new region, and run a new experiment with that region. Otherwise restart the experiment with the GUI. The experiment should now run continuously (in the CRUN phase).
- If there is an ensemble of experiments to be run on a suite of PCs, start these making sure they are run over exactly to same region.
- Periodically check the state of the experiment with supplied monitoring software.

Chapter 5

Configuring an experiment with PRECIS

5.1 Introduction

All PRECIS operation is controlled by a Graphical User Interface (GUI). The PRECIS GUI allows the user to select the attributes of

- Region
- Regional Model
- Driving Data and Scenario
- Diagnostic Output
- Integration Length

which define an experiment. Once the user is happy with the chosen attribute combination, the experiment can be saved. Previously defined experiments can also be loaded, altered and re-saved.

As well as defining an experiment, the PRECIS GUI provides a straightforward method of controlling (starting, stopping and restarting) and monitoring a simulation. Note however that the PRECIS model itself is independent of the GUI, in the sense that the model does not require the GUI to be running.

The interface is started with the

```
$> precis
```



Figure 5.1: The main PRECIS window

command. The main PRECIS window, figure 5.1, should appear.

Note that the PRECIS GUI has been built not to allow more than one “child window” to be open at any one time. If the main window appears to be insensitive to mouse clicks, first look for and close any other PRECIS windows.

5.2 The Main PRECIS Window

At the centre of the main window is a list of items which describe the current experiment: the current experiment name, the internal RUNID, the region name, grid details, the regional model, the driving GCM/Re-analysis, the greenhouse gas forcing scenario, the start date, run length, the type of calendar used, the type of output to be produced, the land surface scheme and a further description of the experiment. If these fields are blank, then the current attribute combination hasn't been saved.

5.2.1 Selecting a region

When starting a new experiment, the user can choose whether to define a new region or to work with a previously defined region.

Defining a new region

To choose a new region, click on the “New Region” button, and a map of the world is displayed, as shown in figure 5.2.

Now click on the centre of the approximate area of the required region. Once the area has been chosen a new window appears, figure 5.3, where the user can alter the position and size of the region precisely. This application is based on the LAMPOS tool written by Jeff Cole at Reading University. It is initially centred over the point clicked on the world map.

The window consists of an upper panel in which the region is displayed over a map of the world. Below this are the control panels. The upper control panel allows quick navigation around the application using the mouse pointer and buttons. The lower panels provide the user with the ability to specify the region using exact numerical values.

The region is shown bounded by two concentric rectangular boxes on a rotated latitude-longitude grid. When choosing a region, all areas of interest should be contained within the inner box; the outer area corresponds to the model's full simulation area and includes the boundary rim (see section 4.1.9).

The position of the box and the position of the pole are both important when choosing a region, as in order to have a quasi-uniform grid (as described in Annex II of the PRECIS Handbook), the region should lie approximately symmetrically across the rotated equator. In practice this can easily be achieved by using the **New Origin** function to select a point near the centre of the intended region before specifying the region's bounding box. This point, marked by a cross, is the position where the zero-th meridian crosses the rotated equator. Do not set the origin outside the region bounded by the rectangular black box.

A detailed description of each of the map and region manipulation functions follows. Both functions can be performed either by eye (using the mouse) or by entering numerical values into the appropriate input boxes.

New Origin The origin of the coordinate system (depicted by a cross) may be repositioned as follows:

First click on "New Origin"; then place the mouse pointer over the centre of the new region and press the left hand button. This process can be repeated until you are happy with the new position. Press the right hand button to confirm this option. The coordinates of the new pole are displayed in the "Coords of Rotated Pole" section of the control panel. The new values for the location of the pole can also be entered into these boxes directly. The new values will not be applied until the "Apply" button under "Coords of Rotated Pole" is clicked. The cross marking the pole should change from red to black, and the grid and map shown will change so that the new pole is in the centre of the region displayed.

Marking out a New Area You can use the mouse controls to mark out a new region. First click on "New Area" with the left mouse button; then move the mouse pointer to the location of the top left hand corner of the new area you wish to mark out. Press the left hand button and, keeping it depressed, drag the mouse to the location of the opposite corner of the desired area. Release the left hand button to display the new area. This process can be repeated until you are satisfied. Press the right hand mouse button to leave this option; the border of the box will change from shaded red to solid red. The coordinates of the top left hand corner and the dimensions of the chosen area are displayed in the "Region Size and Position" panel. The new values for the location of the pole can also be entered into the boxes in this panel directly. The new values will not be applied until the "Apply" button under "Region Size and Position" is clicked. The box bounding the area should change from red to black.

Changing resolution To change between resolutions of 0.22° and 0.44° click on the drop-down menu next to "Grid" under "Region Size and Position", then click "Apply" to implement the change.

NB: Remember to press both Apply buttons after making any changes with the mouse or changing the values by hand.

Other functions are available:

Zooming You can “Zoom In” to or “Zoom Out” from the centre of the display. Several quick clicks on the left hand mouse button are an effective way of quickly focusing into or out from the region of interest.

Panning The map may be moved in any direction by holding down the central button and moving the mouse. This allows the area of interest to be easily centred in the window. The same effect can be obtained by pressing the *up*, *down*, *left* and *right* arrow keys.

Grids Clicking on “Grids” displays a pull-down menu which allows the user to select new or different grids for display. The options, which can be selected and deselected individually, are:

- displaying a latitude-longitude grid at 10 degrees
- displaying the model grid instead of the black rectangle defining the domain
- using a high resolution coastline
- displaying political boundaries.

The pointer coordinates (latitude and longitude) in both the rotated and non-rotated coordinate systems are displayed in the lower right hand corner of the application in the “Pointer position” panel.

Once the user is happy with the region, the region details can be named and saved, by clicking on the “Done” button. You are asked to name the region. If another region has the chosen name, it can be overwritten, or a new name chosen. To abandon the region, click on the “Quit” button to discard all changes.

In some situations, especially if small monitors are used, the LAMPOS screen can get corrupted. If this occurs, try clicking on the maximize window button in the window decoration.

The regions are saved in a directory called `$HOME/precis_save`. Each region has several files associated with it, and they are all stored in a directory called

`$HOME/precis_save/regions/region_name`

where `region_name` is the name the user gave to the region. The land-sea mask generated by PRECIS for the region will now be displayed automatically, together with its name. The user should review the default land/sea assignments, as described in section 5.2.2 below, before proceeding.

Loading a previously defined region

Any of the saved regions can be selected by selecting the “All Region Archive” item under the Menu section “Region tools” . A window (figure 5.4) will be displayed which shows all defined and saved regions.

Regions can either be selected by pressing the image, be reconfigured by selecting Edit Region, or be deleted by clicking Delete.

Adjusting a previously defined region

Clicking on the Edit Region button in the main PRECIS window followed by the Open Region in LAMPOS button will bring up the LAMPOS window (figure 5.3), with the selection of pole coordinates and region already made. This makes a good starting point for adjusting a previously defined region, using the functions described above.

5.2.2 Configuring a region

PRECIS defines grid boxes as being land or sea points by interpolating high-resolution (10') topographical data onto the defined grid. There are several valid physical reasons, discussed in section 4.1.10, for the user to review and change the default assignments. The “Edit region” tool is automatically opened after setting up a new region. It can also be started by clicking on the “Edit region” button on the main PRECIS interface. It shows the generated land-sea mask for the region, with a high resolution map overlaid (see figure 5.5). A second window with grid box information is also displayed.

Land points are shown in green and sea points in blue. The rim is shown in darker blue and green. The height of the point is indicated by its colour: the darker the box, the higher the grid-point. If required, the land-sea mask can now be edited. Land points can be converted to sea points and vice versa just by clicking on a grid box with the left hand mouse button. The point can be set to its original state by clicking the grid box a second time. The map can be toggled on and off, and all changes can be undone. Moving the pointer over any point in the region causes the latitude and longitude, the grid co-ordinates, grid box number, orographic height and rotated grid co-ordinates to be displayed in the grid box information window.

If an inland water area which has surface data provided is included in the region, click on its data points using the left mouse button, whilst holding the control button on the keyboard, and the points will turn cyan. Only “sea” points can be altered this way.

The orographic height and (for the MOSES1 land surface scheme) vegetation and soil type of any land point can be edited by holding the control key, and pressing the middle mouse button on the point to be altered. A window, figure 5.6, then appears where the values can be edited.

A point which being edited in this way is indicated by an orange square, with a purple cross on the map. For the orographic height, the required height, in metres, can entered, or the grid point reset to its original height. See section 4.1.11 for guidance on using this feature. The vegetation and soil type for the point can also be edited in this window. There are three parameters which can be altered, “Soil type”, “Veg(P)” and “Veg(S)”. Please see section 4.1.13 for a description of these parameters.

It is possible to change either the soil or vegetation types separately, but both vegetation types must be changed together.

Clicking on the “WHS” button displays the WHS dataset soil and land cover properties for the $1^\circ \times 1^\circ$ region which contains the grid box.

Any grid point with altered height, or the veg/soil type is coloured orange on the map. Table 5.1 summarises the behaviour of the “Height” field of the information line when the pointer is moved over one of these orange grid boxes.

The map can be zoomed (centred on a point) by clicking the middle mouse button on that point (on some systems with a two-button mouse, both mouse buttons have to be clicked simultaneously). Further middle mouse clicks will zoom the map even more. Note: all zooms are centred on the point where the zoom was first started. To zoom out, click the right mouse button. To return the map to its complete state, click the right mouse button whilst holding the “control” key on the keyboard.

Table 5.2 gives a list of all mouse controls available.

When satisfied with the land-sea mask, click on “Done”. If any changes have been made, you can either overwrite the existing region information (by keeping the same region name) or supply a new name to save the changes as a separate region. To abandon changes, click “Cancel”.

Edited values	Appearance of “Height” field
Height	New value with old value in brackets
Veg/Soil	Yellow text
Height and Veg/Soil	New value with old value in brackets all in yellow text

Table 5.1: Height and Veg/Soil type indication

Mouse/keyboard buttons	Action
Left	Toggle point between land and sea
Ctl-Left	Set correct orographic height for inland water
Middle	Zoom in
Ctl-Middle	Set orographic height or veg soil type
Right	Zoom out
Ctl-Right	Full zoom out

Table 5.2: Mouse/keyboard button functions in the ‘Edit Region’ window

5.2.3 Selecting the regional model and driving data

Selection of the regional model and driving data is straightforward. Click on the “Models” button in the main window, and the Regional Model and Driving GCM window will appear.

Each available regional model is shown (if a regional model is greyed-out then it is not available). Select the regional model to be used by clicking on the radio button to the left of the regional model name.

In the drop-down list to the right of each regional model name are listed the available GCM/Re-analysis driving data sources (see section 4.1.2). Only the sources for which driving data have been installed will be listed in the drop-down list. The interface checks \$PP4LBCDIR and \$DUMPSDIR for the boundary files and initial dumps respectively, and only allows selection of scenarios where both exist. Each GCM/Re-analysis driving data source is labelled by the five-letter run ID of the driving experiment, which can be used to distinguish different ensemble members for a given emissions scenario.

If the regional model or driving data selection is changed, then on closing the Regional Models and Driving GCM window, the Start Date and Run Length window (figure 5.8) is automatically displayed to allow selection of the start date. This is discussed in the following section.

5.2.4 Selecting the land surface scheme

When using the HadRM3P regional climate model, there is the option of using a more advanced land surface scheme (MOSES2.2) than the default MOSES1 (see appendix H). The choice of land surface scheme is made in the land surface scheme window, accessed from the configuration pull down menu in the main user interface window. See figure 5.7.

5.2.5 Selecting a start time and run length

Clicking on the “Time” button allows the user to alter the start date and run length (figure 5.8).

The user can select the start date for the experiment. Only dates for which there is a valid initial dump installed in \$DUMPSDIR can be selected. The number of years, months and days for which the experiment is run can also be altered. Note that the number of days is limited to 0, 10 or 20 days due to PRECIS model requirements. If the chosen run length is greater than the run time of the experiment for the GCM driving data, then it is automatically changed to the longest possible run time (that is, the total archived at the Hadley Centre from the GCM, not all of which may be supplied or online as the experiment runs).

5.2.6 Selecting diagnostic output

The diagnostic output data from PRECIS is selected by pressing the “Output” button in the main window. The corresponding window, shown in figure 5.9, then appears.

With this window the user is able to select hourly surface, daily surface and upper air diagnostics, and sub-daily diagnostics used for the CORDEX project and for Storm Tracking experiments. Standard “climate meaning” diagnostics, discussed below, are automatically supplied). See section 5.11 and appendix C for more details on diagnostic types.

Certain daily mean diagnostics are available on upper air pressure levels, namely those in Table C.2 with domain ‘PL’. These pressure levels may be specified by the user in the diagnostics window (figure 5.9) as a comma separated list of values in hPa, up to a maximum of 20 different pressure levels. The default values are 850, 700, 500, 250 and 50 hPa. Note also that climate mean data will also be produced automatically on all of the pressure levels chosen for daily mean output, as well as on the standard list of seventeen pressure levels for climatic means specified in appendix C.

For models adhering to the 360-day calendar (see section 4.1.14), up to four climatic meaning periods may also be set, which allow long timescale means to be calculated internally within the model. The choice of means is determined by the comma-separated list of numbers in the diagnostics window: w,x,y,z , where $w-z$ represent the length of period_1 means (the shortest) to period_4 means (the longest) respectively. The meaning periods are nested, and each one is specified by how many multiples of the previous (shorter) period it is. The shortest meaning period (period_1) is specified as a number of whole days.

Climatic meaning period examples for 360-day calendar experiments:

1. Climatic meaning periods of 10 days, 1 month and 3 months are required \Rightarrow the climate meaning periods will be specified as 10,3,3, i.e. 10×1 day, $3 \times 10 = 30$ days and $3 \times 30 = 90$ days.
2. Climatic meaning periods of 1 month, 4 months, 1 year and 10 years are required \Rightarrow the climate meaning periods will be specified as 30,4,3,10, i.e. 30×1 day, 4×30 days, 3×120 days, 10×360 days.

When a Gregorian calendar is in use (e.g. when running with the ERA quasi-observed boundary conditions), there is no choice of climatic meaning periods. Only monthly, 3-month seasonal and annual means are available and the selection panel will be greyed out. In this case, however, you may still set the base date (see below).

The final choice in the diagnostics window is the ‘base date’ for climate meaning. This date should be chosen as any date which coincides with the beginning of all climatic mean periods chosen. For example, if the base date is set to 01 April 1960 and the climatic mean periods 1–4 have been set as 30,4,3,5 (monthly, 4-month seasonal, annual, 5 yearly means), then in a hypothetical infinite timeseries of these mean periods, one monthly mean, one seasonal mean, one annual mean and one 5 yearly mean will each begin at 0Z on this date, and all previous and subsequent means will lead up to or follow on without gaps in the timeseries. When choosing a base date, remember that no data from the initial spin-up period should be included in any mean period which you wish to use for analysis.

The output PP format is also specified in this window. Please see sections 4.1.16 and 5.11 for a more detailed discussion.

Users who wish to include extra diagnostics, not included in the standard PRECIS release, should contact PRECIS support via email.

5.3 The Menu Bar

At the top of the PRECIS user interface window, there is a menu bar from which various commands can be called.

File Contains options to save and load defined experiments.

Region Tools Allows defined Regions to be saved and loaded.

Configuration Contains options to be used by advanced users.

Analysis Tools Contains graphical versions of some of the pp analysis tools.

Monitor Allows the run-time monitor to be used.

Help Displays technical and scientific documentation.

These are discussed, in turn, in the following sections.

5.3.1 File

This menu allows experiment definition, saving and loading.

Experiments are constructed by combining the region, regional model and driving data, run length, and output data selections detailed above. Experiments are saved by clicking on the “Save Experiment” tab under the file menu. When an experiment is saved, the current combination of region, regional model and driving data, period and diagnostics, together with any user overrides is written to the save file. The user is asked to name the saved experiment, and when it is saved, the experiment is given a unique five letter run ID. Note that experiments are identified by their saved name. A description of the saved experiment can also be saved and is strongly advised to be completed for future reference.

When an experiment is overwritten, the existing run ID is retained only if the overwritten experiment has not been run, or it has been run, but for less than a day. If the experiment has been run for over a day, then a new run ID is generated. Be careful not to overwrite an experiment that has data which may be needed at a later date. If that does happen, then the experiment can be retrieved from the `$$SAVEDIR/.deleted` directory

Clicking on “Load Experiment” causes a window detailing all saved experiments, figure 5.10, to be displayed. All saved experiments are listed alphabetically, together with all of the information which defines each experiment. Any experiment can be loaded by clicking on its name, or deleted by clicking on the “Delete” button.

When an experiment is loaded, its name and description appears at the centre of the main PRECIS window, figure 5.1. Whenever any aspect of the experiment is altered in the PRECIS user interface, then the experiment name and description disappears to indicate that the last loaded experiment has been altered.

When the user interface is started, the last saved experiment is displayed.

“Load Default Experiment” will load a predefined default experiment. When starting a new experiment it is best to use this experiment as its basis.

To prevent accidental overwriting of a previously saved experiment, it can be “locked”. The button at the end of each line in the load window can be toggled between “Locked” and “Unlocked”. When the button is set to “Locked”, the experiment details cannot be altered, or the experiment deleted. When button is set to “Unlocked”, then they can be both altered and deleted.

You can also quit without saving the experiment currently displayed, or exit and save the displayed experiment.

5.3.2 Region Tools

Regions can be exported or imported using the “Export Region” and “Import Region” tabs. A region can be exported by selecting the “Export Region” tab. Doing so opens a Save window. All the files associated with that region (such as gridnamelist, land-sea mask and bitmap file) are collected into a file called *region_name.rgn* and written to the `$HOME/precis_save` directory by default. This file can be sent to another PRECIS user to run experiments over the same region. It is imported via the “Import Region” tabs. The user is asked to select the required region, via a load window. Once the region is imported it is then stored as one of the saved regions in the GUI.

The “Write Grid Details” tab will produce the rotated and unrotated latitudes and longitude values for each grid point of the region currently loaded in the interface. Selection of the “Write Grid Details” tab opens a Save window allowing the user to choose the output file name and location. The data is written to an ASCII file called `$HOME/region_name.ll`, where *region_name* is the name of the current region. Each line of the file describes the location of a grid point with seven columns:

Box no.: the index of the grid point, counting along rows from the top left hand corner of the grid

BoxNS: the row of the grid point counting from the top of the grid

BoxEW: the column of the grid point counting from the left of the grid

Grid lat: the latitude of the grid point in rotated coordinates

Grid lon: the longitude of the grid point in rotated coordinates

Real lat: the latitude of the grid point in unrotated coordinates

Real lon: the longitude of the grid point in unrotated coordinates

For example:

Box no.	BoxNS	BoxEW	Grid lat	Grid lon	Real Lat	Real lon
1	1	1	335.0000	20.0000	49.8355	37.7832
2	1	2	335.4400	20.0000	50.3502	37.8582

5.3.3 Extras

The Monitor Window Plot Configuration tab opens a window which controls which variables and what scale are plotted in the real time monitor. Please see section 5.10.2 for instructions. Note that the production of output plots in the Real Time monitoring windows as seen in figure 5.16 is NOT required for the model to be running.

The Multiprocessor Configuration tab enable multiprocessor mode across multiple cores on PCs with shared memory multiple core CPUs (e.g. dual core systems). Select this tab to open the “Number of processors for MPP PRECIS” window (see figure 5.11). You can find the precise number of cores in your CPU by referring to your system documentation. The minimum number of cores PRECIS requires is 2 (on a dual core system). On multicore systems, it is possible to submit multiple PRECIS experiments side-by-side using all available cores. For example, a CPU with eight cores could run one experiment with 2 cores, another with 4 cores, and a third with 2 cores (for a total of 8 cores). Do NOT set the number of cores for the experiment to a higher number than what your CPU has, as this will significantly slow down the PRECIS experiment.

5.3.4 Monitor

The “Experiment Monitor” tab will start the experiment runtime monitor. (Note that you may also do this by clicking the orange “Monitor PRECIS” button on the main window). Please see section 5.10 for a complete description.

The “Currently Running experiments” tab shows any PRECIS experiment(s) that is/are currently running on the system (see an example in figure 5.12). The user may click on the **Load (RUNID)** button in order to load the currently that job into the main user interface window. Users should take care as any unsaved changes made to any current design created in the user interface will be lost.

5.3.5 Help

Clicking on “Help” in the main windows gives access to the following resources listed in table 5.3.

Most other windows have also a help menu, but without access to the UM documentation.

5.4 Starting an experiment

An experiment is started by clicking on the red “Run PRECIS” button at the right of the main window. To start a saved experiment, load it via the load window, and then press the Run button. When “Run PRECIS” is pressed a window (figure 5.13) is displayed with the experiment details. Please examine this window to see if these are correct. If they are incorrect, close this window and re-edit the experiment.

See section 5.7 for full details of the PRECIS run procedure. If the current PRECIS setup hasn’t been saved the user is prompted for a save name. It is impossible to run PRECIS from a combination which hasn’t been saved.

It is useful to make a note of the five-letter run ID when the experiment is run, as this is used by the PRECIS system to name all experiment output files.

PRECIS will continue to run, even if the user logs out, so it is possible to log in as another user, and not interfere with PRECIS. If the machine is rebooted, however, PRECIS will have to be restarted from the user interface.

5.5 Rerun an experiment

It is possible to rerun a PRECIS experiment from an already completed previous time. Choose “Run PRECIS” and then “Rerun from completed time”. The rerun window will be displayed (figure 5.15). From the drop down list the user may choose an available time from which to rerun. In the second section the user may input a new run length *from the the rerun time* in years, months and days. Note that rerunning from an already completed time will not overwrite any existing archived data. An existing data file will be automatically (and uniquely) renamed before a new data file is archived.

This is an option in the event a stopped PRECIS job will not restart normally (i.e. as a continuation CRUN).

Menu item	Description
PRECIS technical manual	This manual as HTML in a web browser
PRECIS scientific handbook	The PRECIS model full description
UM documentation	The science/tech manual of the Unified Model
About	General PRECIS information

Table 5.3: Options from the Help menu.

5.6 Stopping an experiment

Pressing the “Stop PRECIS” button displays a window with two options, either to stop or kill the experiment, as in figure 5.14.

- The **Stop** option will cause the experiment to halt cleanly at 0z on the 1st, 11th or 21st of a month, whichever is soonest. The model may be restarted from exactly this point using the “restart” button. The time until the model stops may take up to an hour, depending on both the speed of the simulation and the point in the model month at which the stop request is made. The Monitor window estimates the actual time until the model will stop.
- The **Kill** button causes all PRECIS processes to be killed immediately. Restarting the experiment is then only possible from the beginning of the current model month.

Again, the experiment which is to be either stopped or killed has to be loaded before the button can be used.

Exiting or quitting from the PRECIS GUI (even logging out of the precis account) does not stop an experiment if it is currently running. The only way to stop an experiment is to load it (if necessary) and use the “Stop PRECIS” button.

5.7 Useful user interface tips

- This manual is available via the help menu at the top right hand corner of most windows.
- Experiments are identified by their **saved name** in the user interface. If you overwrite an experiment with other with the same experiment name, then the first one is deleted.
- When the experiment is run it is identified by the five-letter **run ID** which it is allocated when the experiment is saved. All output data and log files will have the run ID as part of their file name.
- All output data is written to **\$ARCHIVEDIR**.
- All PRECIS experiment log files are written to **\$MY_OUTPUT**.

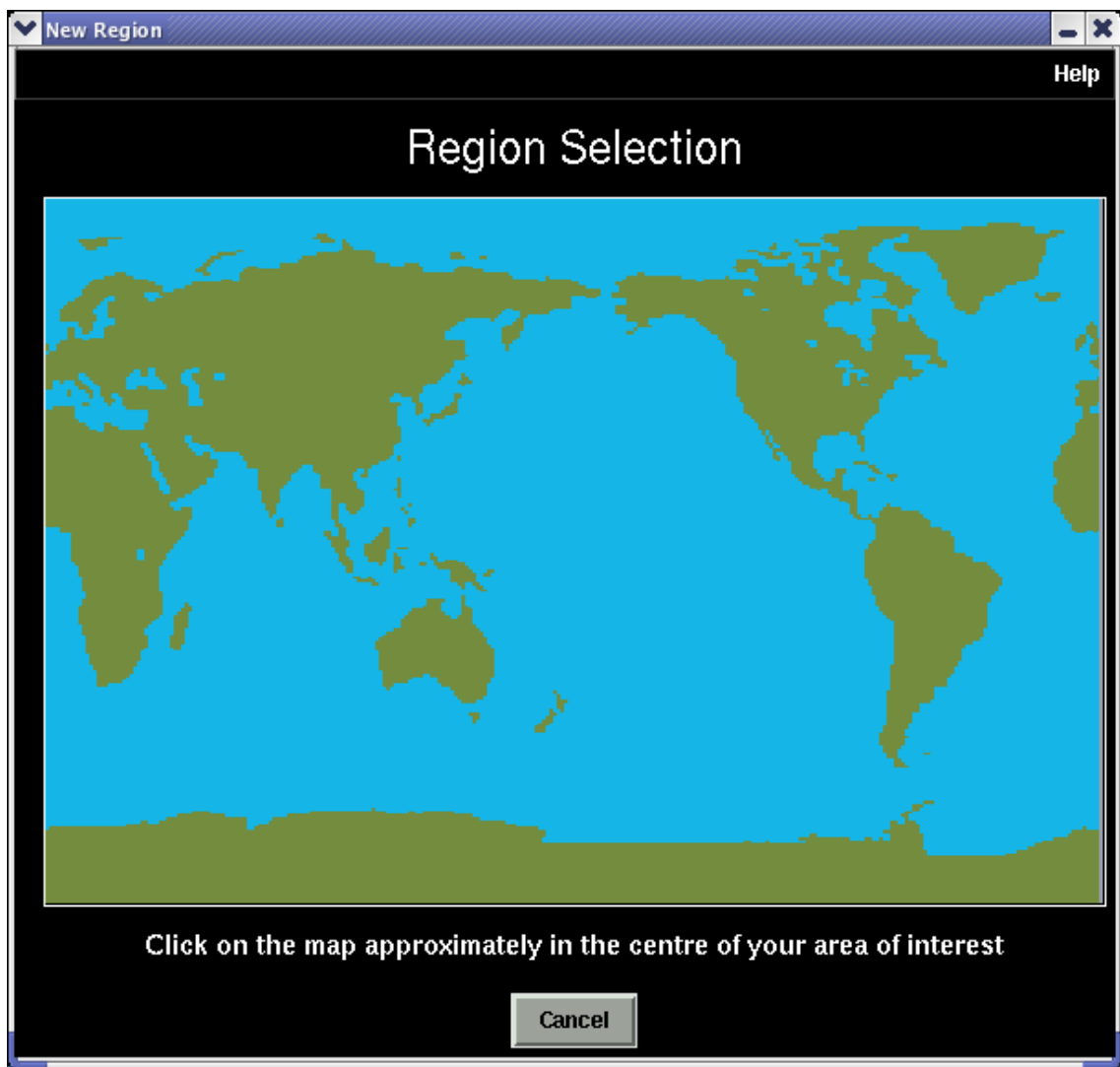


Figure 5.2: The Region Selection window

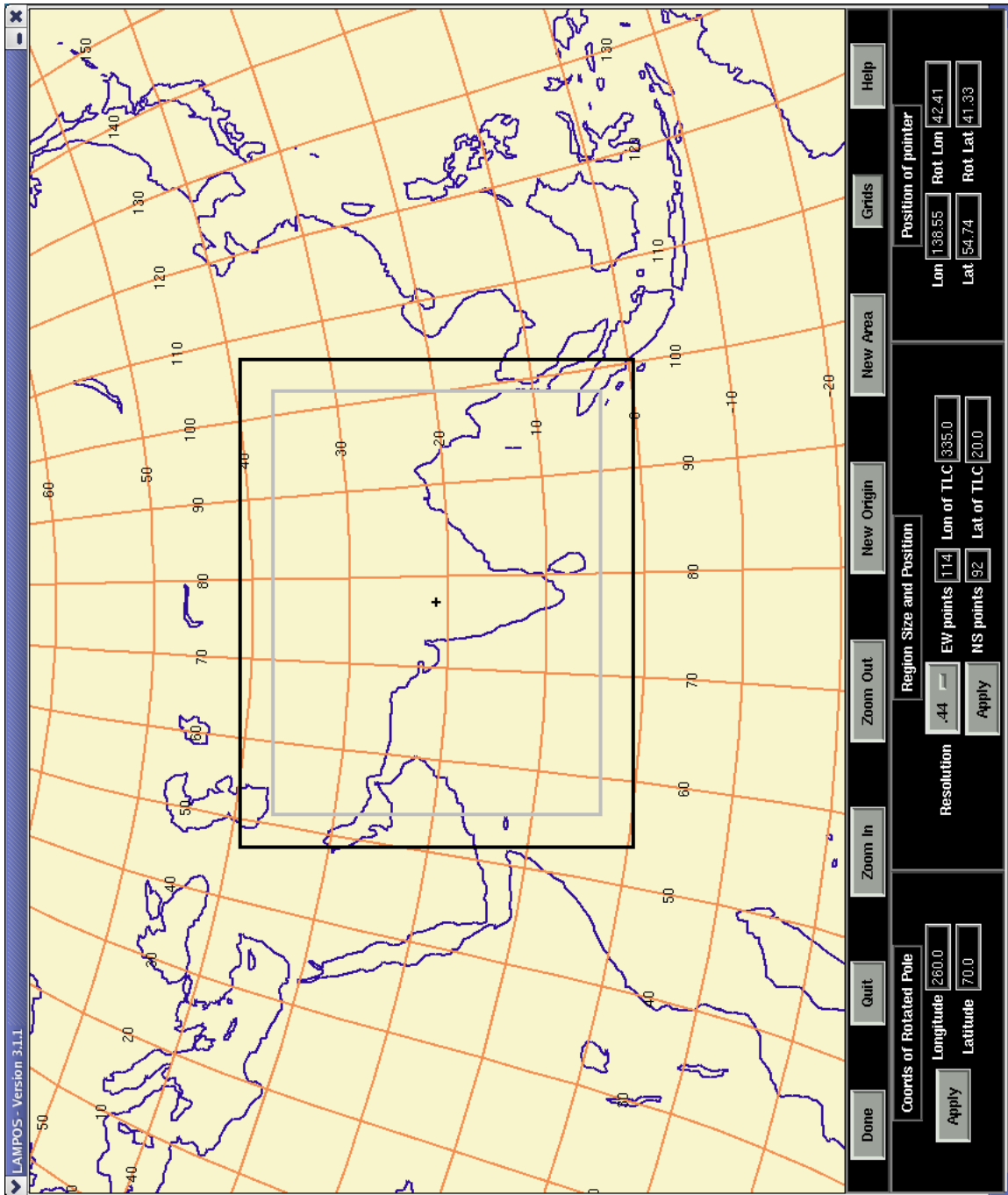


Figure 5.3: Detailed Region Selection



Figure 5.4: Region Archive

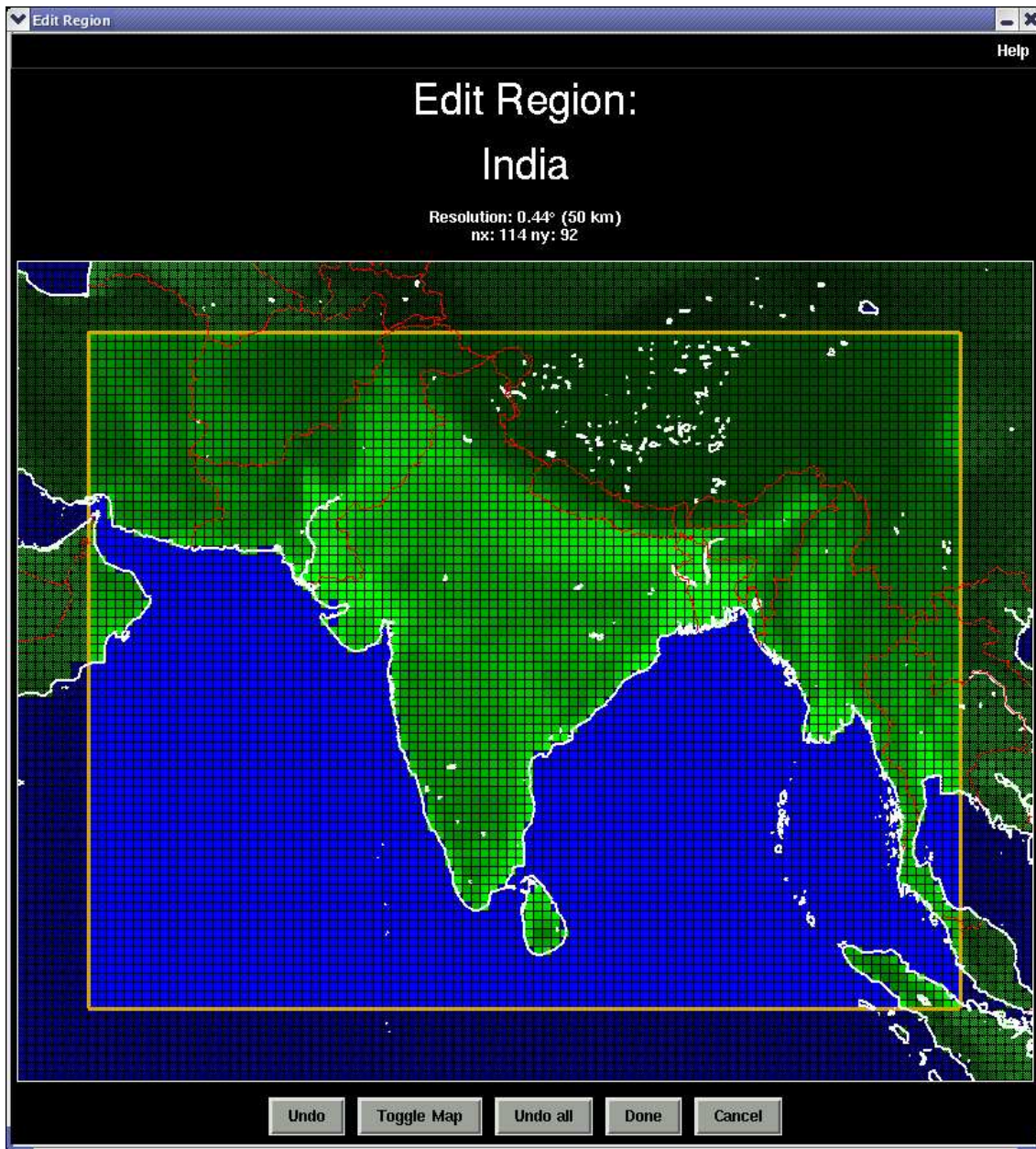


Figure 5.5: The Edit Region window

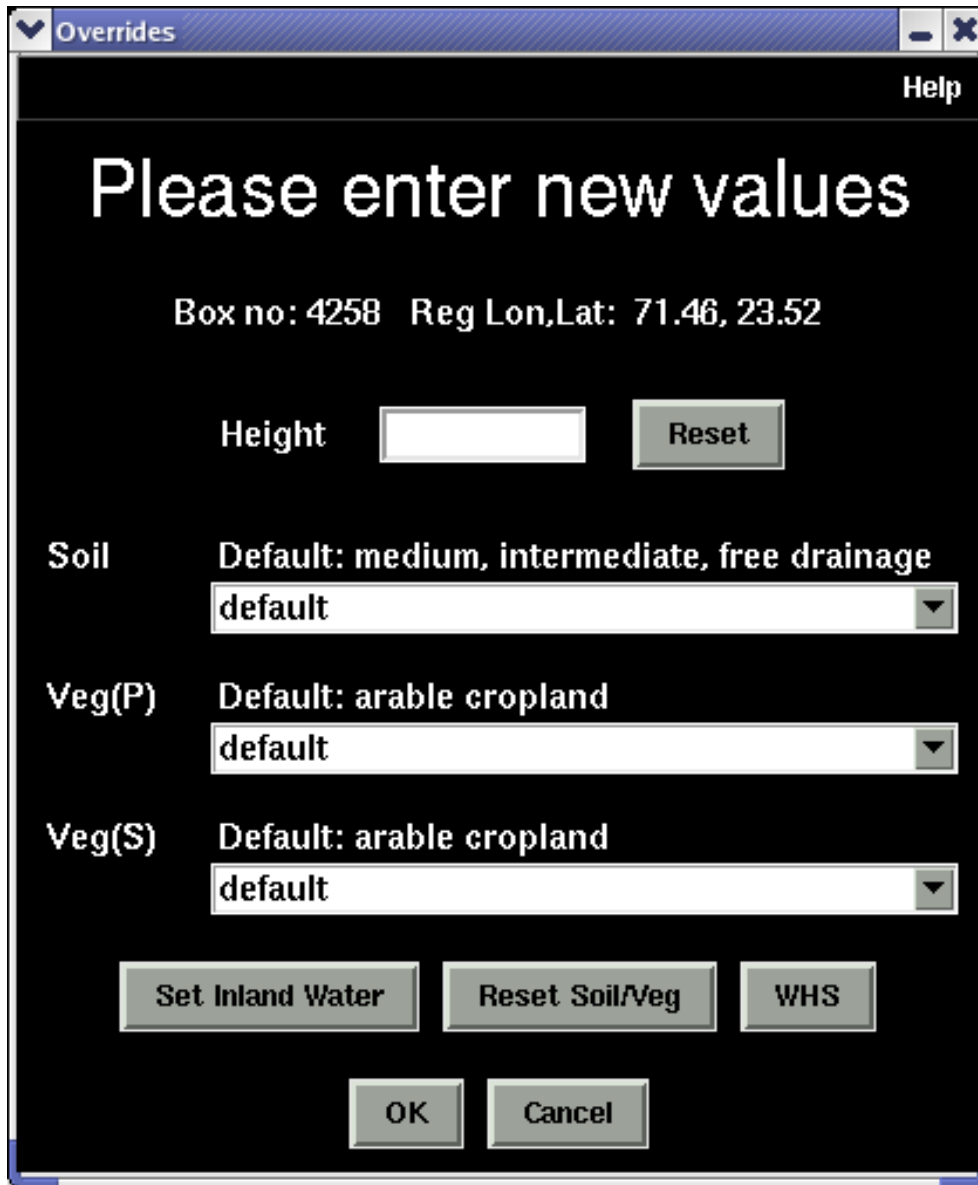


Figure 5.6: The height and veg/soil edit window (MOSES1 land surface scheme selected)



Figure 5.7: The Land Surface Scheme Window

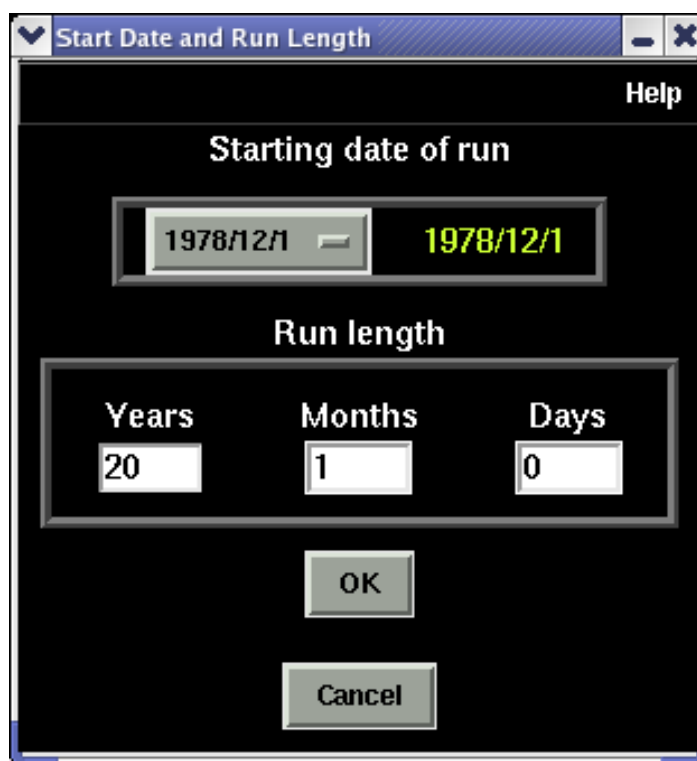


Figure 5.8: The Start Date and Run Length window

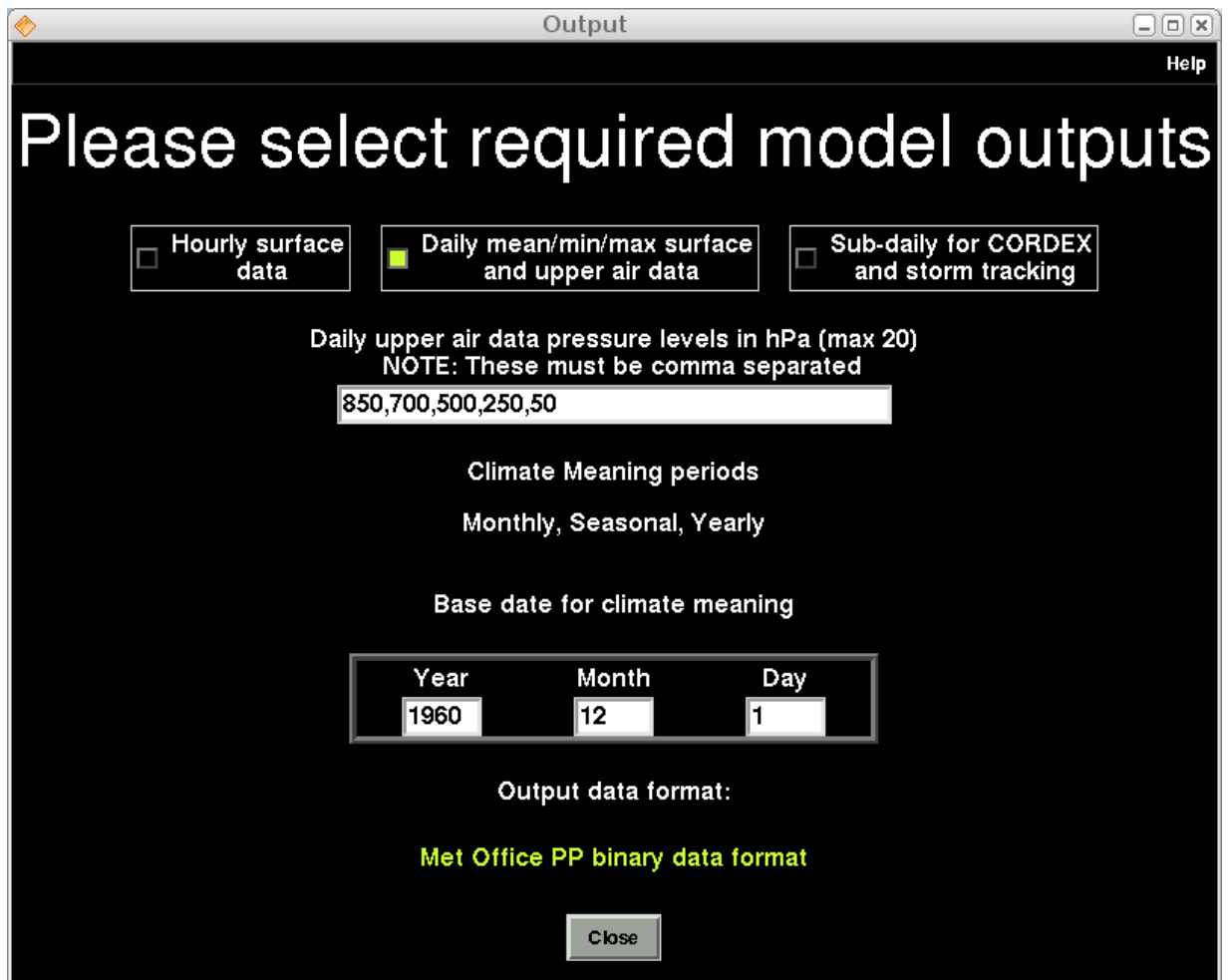


Figure 5.9: The Output window



Figure 5.10: The load experiment window

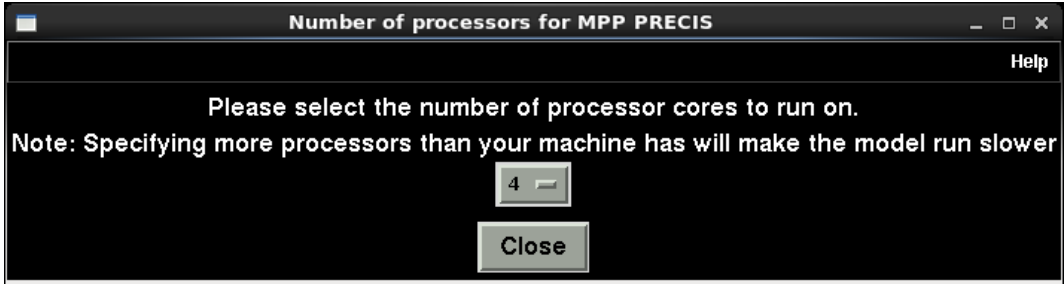


Figure 5.11: Multiprocessor Configuration window

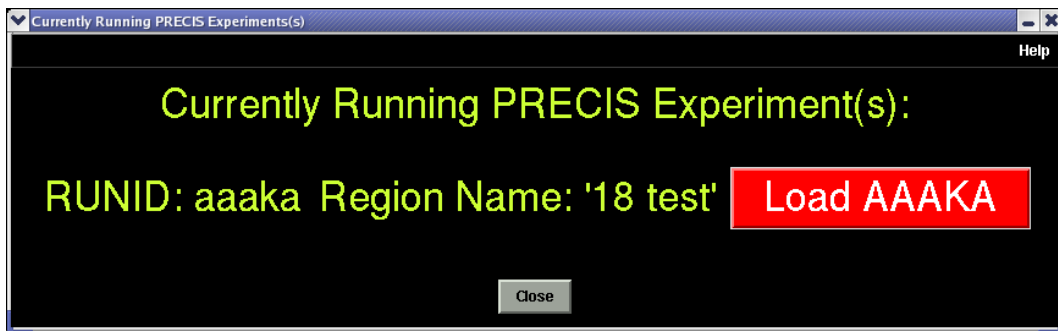


Figure 5.12: Currently Running experiment window

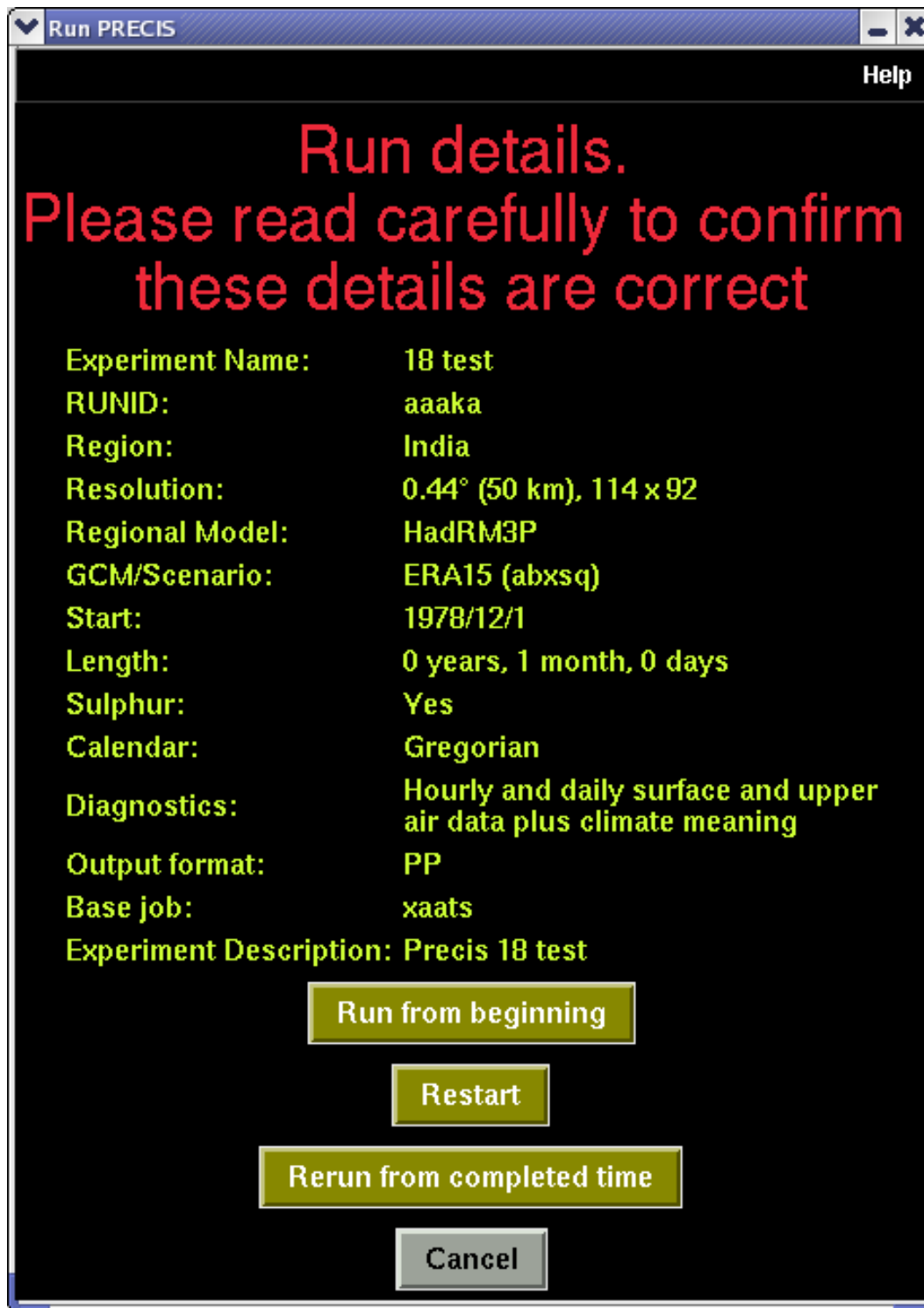


Figure 5.13: The Run PRECIS window

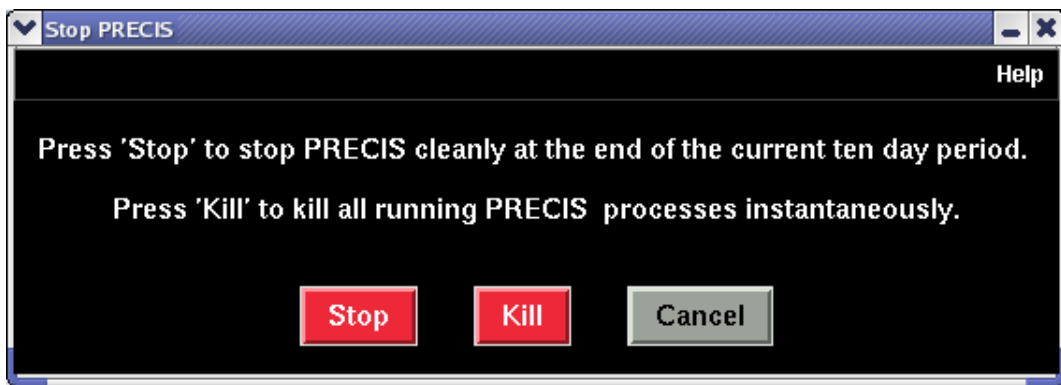


Figure 5.14: The stop window

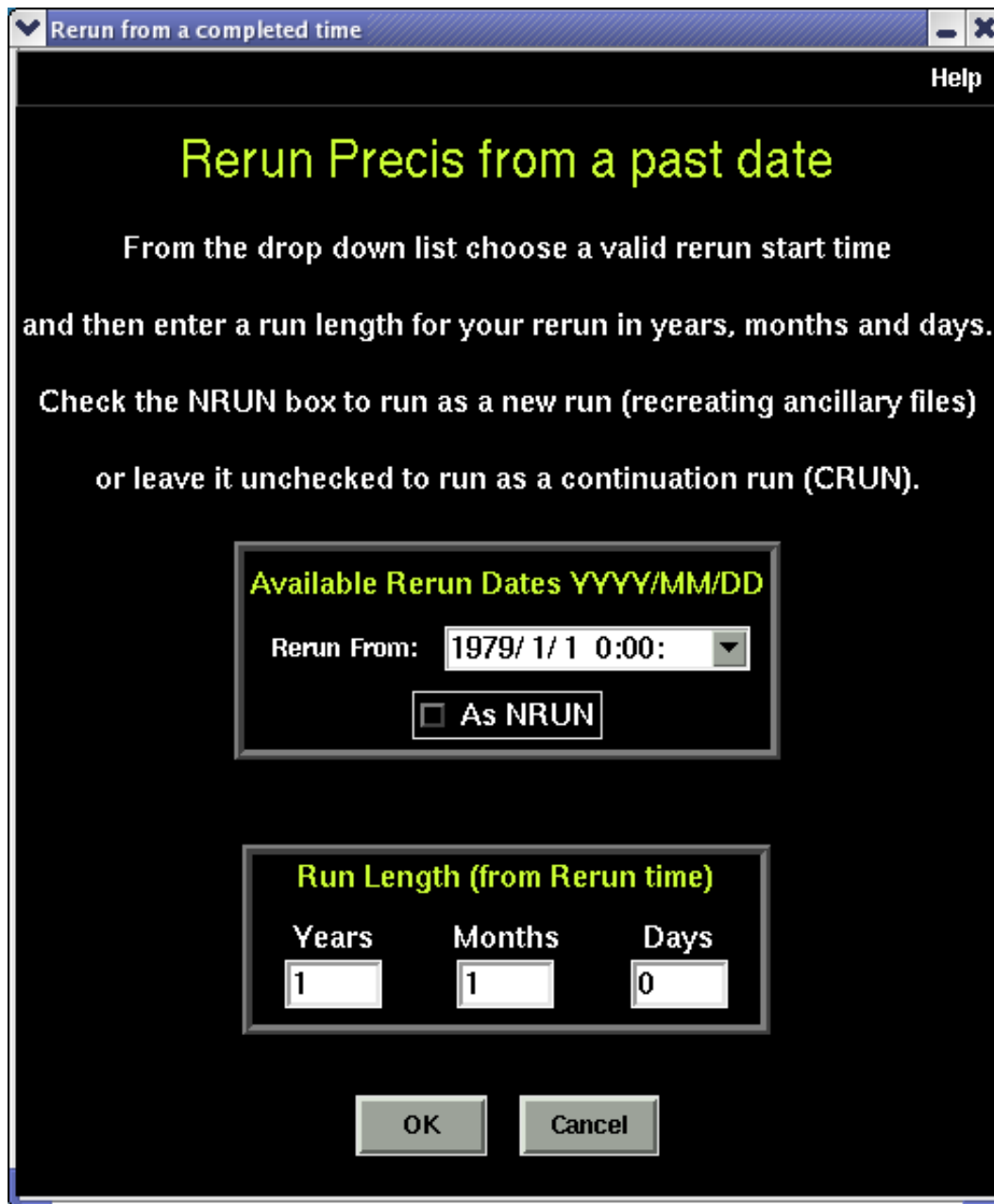


Figure 5.15: The Rerun Window

5.8 The PRECIS run-time sequence

When an experiment is started with the “RUN Precis” button of the GUI, several procedures are performed, ending with the model integration. These are, in order of occurrence:

1. Ancillary file creation
2. Lateral boundary condition (LBC) file creation
3. Reconfiguration of initial conditions
4. Model integration (first section)
5. Model integration (continuation).

5.8.1 Ancillary file creation

Background

The model requires certain boundary conditions at the surface and through the depth of the atmosphere which are supplied by “ancillary files”. These binary files are in UM format and contain constant, time-series or annual cycle data which are read as the model progresses. (The lateral boundary condition files are considered separately in section 5.8.2). There are eight files required with the sulphur cycle included. The files contain:

- Land-sea mask (constant in time)
- Orographic fields (constant in time)
- Vegetation and soil fields (constant in time)
- Sea Surface temperature and sea ice fraction (time series of monthly means)
- Ozone (time series of monthly means for each model level)
- Anthropogenic dimethyl sulphide (DMS) and sulphur dioxide (SO₂) emissions (time series of monthly means, sulphur cycle only)
- Atmospheric chemical oxidants (annual cycle of monthly means, sulphur cycle only)
- Volcanic SO₂ emissions (constant in time for each model level, sulphur cycle only).

The data in the ancillary files must cover the same area and have the same grid as the RCM. The source data for the ancillary data is, however, stored as global fields on a regular latitude-longitude grid.

At run time

Before the integration begins, the RCM's ancillary files are created from the source data by bilinear interpolation to the RCM grid (with special consideration being given to RCM coastal points). For time series and annual cycle files, data for the length of the entire scenario are created.

5.8.2 Lateral boundary condition (LBC) file creation

Background

The lateral boundary conditions are the meteorological boundary conditions at the lateral, or side, boundaries of the domain. They are data on the RCM grid which have been derived from the driving GCM (or analyses). These boundary conditions are strictly necessary at the outermost grid points on each atmospheric level of the RCM domain, but in order to damp down instabilities, the driving data is provided over a boundary rim (or buffer zone) of 4 grid points. See the PRECIS Handbook for further details. Similar to ancillary files, the source data for these files exists on a regular latitude-longitude grid which fully encompasses the RCM domain. The LBC data is provided every 6 hours of model time (with linear interpolation within the RCM integration to intervening time steps) throughout the depth of the atmospheric lateral boundary zone. Due to the large amounts of data involved, the source data are split into separate files of equal length (a constant number of days or months).

At run time

Before the integration can begin, the first LBC file needs to be created from the source boundary data (i.e. the subsequent source data is interpolated to the RCM grid). When the model reaches the end of data in a LBC file, the model pauses briefly whilst the next LBC file is created before continuing. This always occurs at CRUN checkpoints (see section 5.8.4).

5.8.3 Reconfiguration of initial conditions

Background

As well as the ancillary and lateral boundary conditions, initial conditions are required throughout the atmosphere, surface and deep soil. These initial conditions are derived from instantaneous data from the driving model. The file containing the source data is known as the “initial dump”. In the reconfiguration process scalar and vector quantities are interpolated to the regional model grid as well as adjustments being made to account for the higher resolution (e.g. surface pressure is adjusted to account for the different heights of terrain between the driving model and the RCM). The file containing the initial conditions on the RCM grid is referred to as the RCM’s “start dump”.

The topography in the boundary zone is necessarily degraded to that of the driving model¹. It is also degraded further into the domain by a number of grid points equal to the rim width to further suppress numerical noise.

At run time

The initial data is reconfigured onto the RCM’s grid. This is the last step to occur before the model starts integrating.

5.8.4 Model integration

The model does not run continuously from start to finish. Rather, it is split into smaller section of model time (typically of 1 month in length). The principle purpose of this is to allow a dump describing the state of the atmosphere and soil to be saved at regular intervals. The model can be restarted from any one of these checkpoints (see section 5.5).

First section (NRUN)

When the model is first submitted, it runs up to the first check point and then stops cleanly. At this point, the model output should be checked for any problems with the model setup or ancillary files. The first checkpoint occurs after one model month, or when the user first stops the model by hand, whichever is the sooner.

¹This is to ensure that the topographic height at each point in the RCM’s boundary zone is roughly consistent with the prescribed values of surface pressure and the mass of the atmospheric column.

Continuation (CRUN)

Assuming that there are no problems with the NRUN, the model may be resubmitted for its continuation runs. From this point onwards the restarting after each checkpoint occurs automatically until the model end date.

5.9 Copying an experiment to another machine

Sometimes it may be desirable to continue an incomplete experiment on a different machine. To move an experiment from machine A to machine B:

1. If the experiment is still running on machine A, then stop the experiment cleanly (see section 5.6). Proceed to the next step only when the experiment has actually stopped running, which may take a few minutes.
2. On machine A, export the region (see section 5.3.2).
3. Copy the directory `$DATADIR/RUNID` from machine A to `$DATADIR/RUNID` on machine B. An easy way to do this is to tar the whole directory, copy the tar file, and then untar on the second machine. On machine A:

```
$> cd $DATADIR
$> tar zcvf dataw.tgz RUNID
```

Copy the file `$DATADIR/dataw.tgz` to directory `$DATADIR` on machine B, then on machine B:

```
$> cd $DATADIR
$> tar zxvf dataw.tgz
```

4. Copy the directory `$ANCILDIR/RUNID` from machine A to `$ANCILDIR/RUNID` on machine B.
5. Copy the directory `$LBCDIR/RUNID` from machine A to `$LBCDIR/RUNID` on machine B.
6. Copy the directory `$SAVEDIR/experiments/name` from machine A to `$SAVEDIR/experiments/name` on machine B, where *name* is the name under which you saved the experiment on machine A.
7. Start PRECIS on machine B, load the experiment (see section 5.3.1) and then restart the experiment.

Note that this leaves the output data split between the archive directories (`$ARCHIVEDIR`) on each machine. Climate mean output will be unaffected by the transfer, and will be archived on the machine which is running the experiment at the end of the meaning period.

5.10 Experiment Monitoring

The runtime monitoring software is part of the standard PRECIS GUI. To use it:

1. Start the PRECIS GUI.
2. Load the experiment which is to be monitored using “Load Experiment” under the “File” menu option.
3. Click on the “Runtime Monitor” tab under the “Monitor” menu item.

When the “Runtime Monitor” tab is clicked, the monitor window shown in figure 5.16 is displayed. Note that if CDAT 3.3 is not functional, the plots will not appear, only the runtime information at the bottom. The appearance of the plots in the window (or lack thereof) does not affect the running of the model.

There are two sections to the monitor window. The buttons on the upper section allow the user to display plots of model output over previous days of integration. There are two types of plot available:

- Hourly mean values every 6 hours, starting at 0Z, 6Z, 12Z, 18Z, for the three most recent completed model days.
- Daily mean values, starting at 0Z, for the twelve most recent completed model days.

The default plot is precipitation as a block plot, with contours of pressure at mean sea level (at 2 hPa intervals) overlaid. Different variables and intervals may be selected, as described in section 5.10.2.

The text beneath the plots in the main monitor window shows the current status of the experiment (see figure 5.16). It is updated every 5 seconds of real time and the information available is given in table 5.10.

5.10.1 Maximum wind limit exceeded (MWLE)

If the wind speed exceeds the maximum wind limit of 150ms^{-1} (at which speed a parcel of air will travel approximately one grid length in one timestep) then the

model is likely to become numerically unstable. To prevent this from happening, the model halves the dynamics timestep until the wind speed drops below the maximum wind limit.

However, the length of the dynamics timestep is implicit in the tuning of all of the physical parameters which gives the model a stable and plausible climate. Therefore, if the dynamics timestep is shortened too often, the climatology of the model will be altered in a non-physical (non-realistic) manner. The **MWLE** field in the runtime monitoring window allows you to assess whether or not the maximum wind limit is being exceeded too often.

As a guide, if the value at the *end* of an experiment is less than 0.28% (approximately 1 day per year) then the impact will almost certainly not be significant. In any case, a summary of when in the simulation these events occurred may be found in the file:

`$PRECIS_EXPT/RUNID/RUNID.mwle`

and this file should be checked, particularly for prolonged periods of maximum wind limit exceedance.

5.10.2 Modifying the graphical output plots

The user can choose which fields to plot by activating the “Monitor Window Plot Configuration” window (figure 5.17). From the main user interface window menu bar, choose **Configuration** and then **Monitor Window Plot Configuration**.

The default fields plotted in the experiment monitor are precipitation rate as a box plot and pressure at mean sea level (PMSL) overlaid as a contour plot. The user can choose from among 26 variables to plot as a box plot and from 26 variables to plot as a contour plot overlay. For each chosen variable, the user may also modify the minimum and maximum value, which will affect the range of valid data used to create the plot. Also, for contour plots, the user may modify the number of contour lines used in the contour plot overlay by changing the value in the **# Contours** box.

The box plot variable may be plotted over land points only (as opposed to at every point in the domain) by checking the **Plot values over land points only** button.

By pressing the **Restore Defaults** button, the default values for all variables are loaded up. Press **OK** to save your changes.

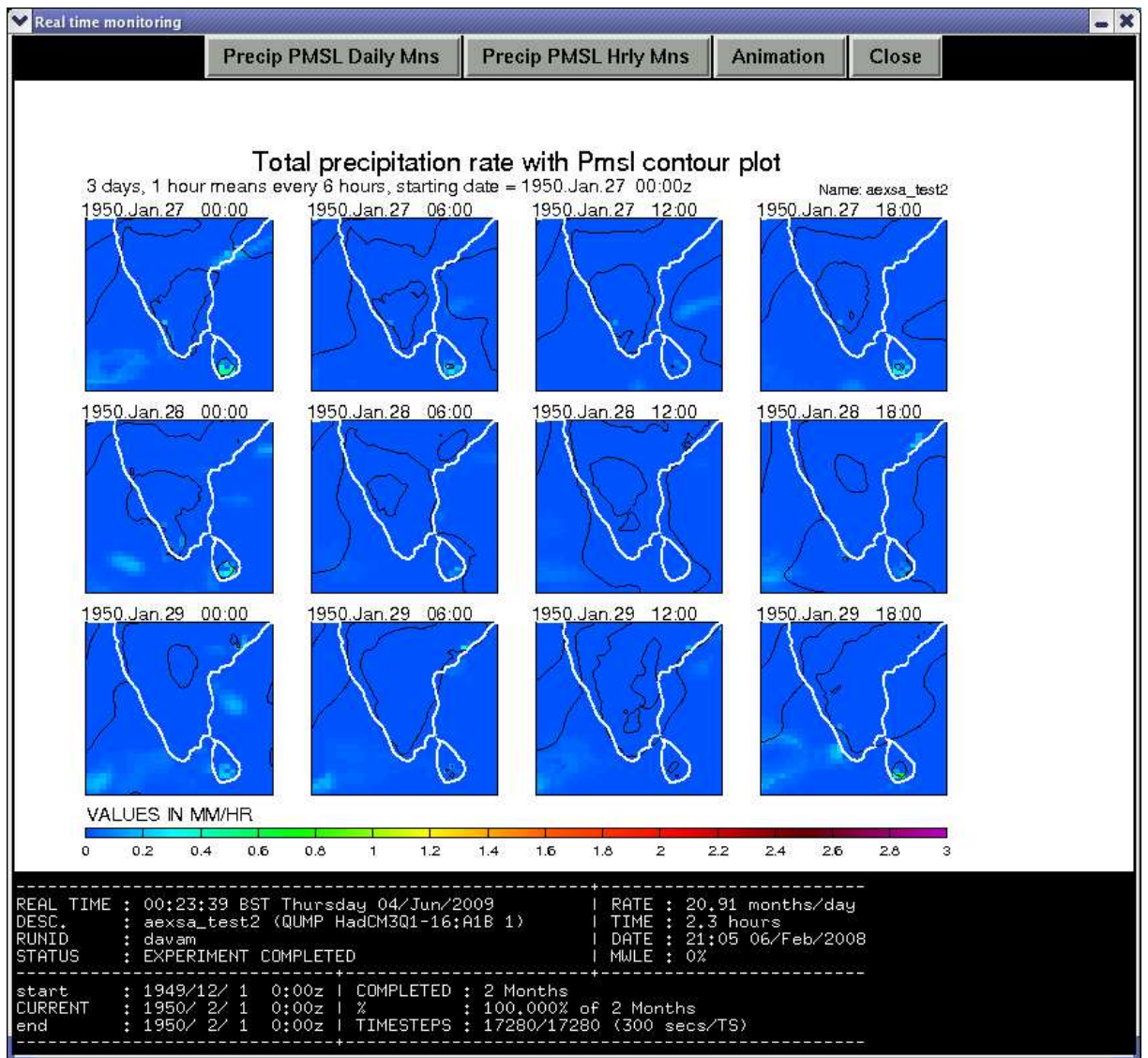


Figure 5.16: An example of the runtime monitoring window

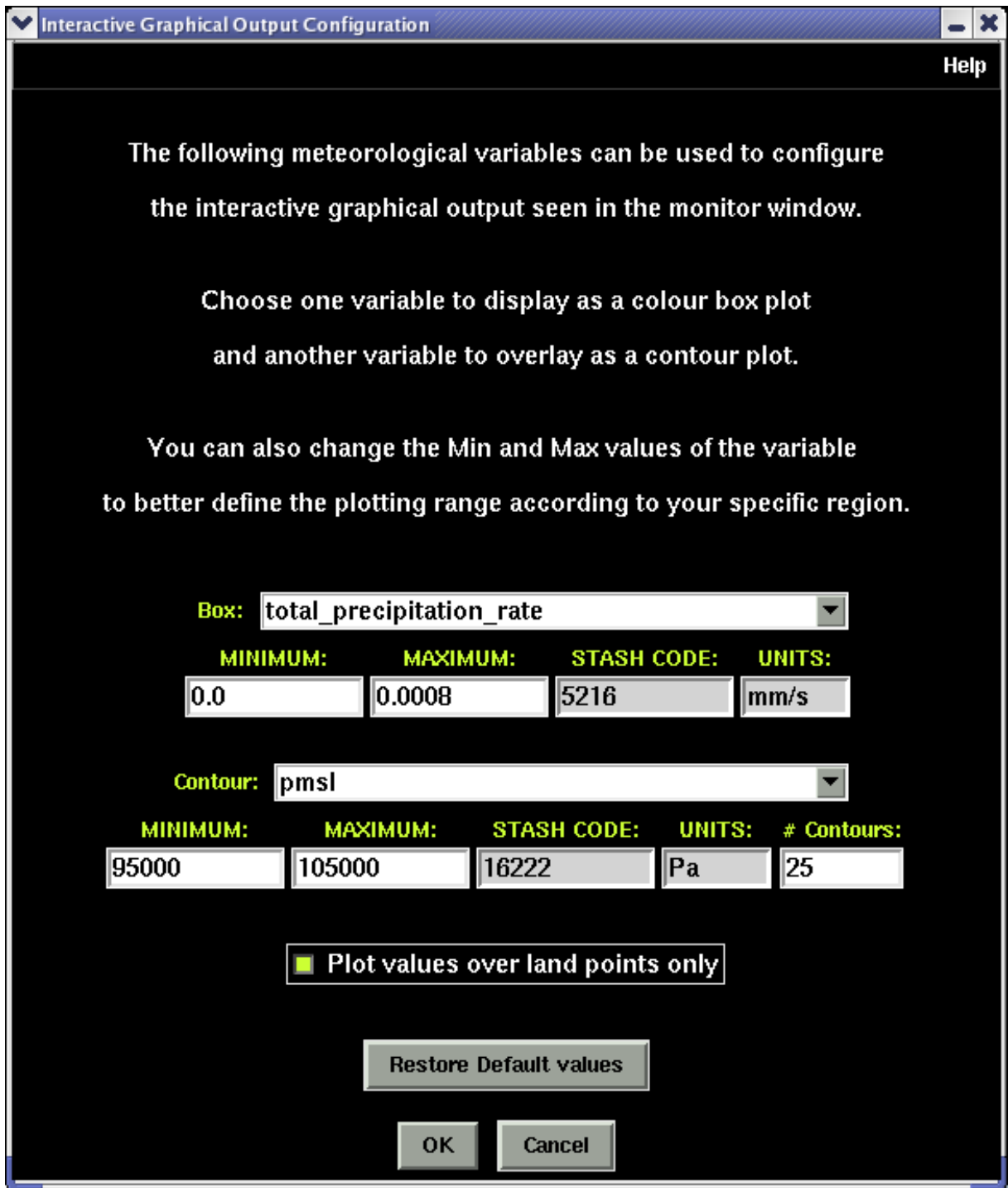


Figure 5.17: Interactive Graphical Output configuration window

5.11 Archiving

PRECIS has an automatic archiving system where the model output can be copied to and stored on a separate data area on the PC disk. From this area the data can be backed up on tape, or onto other systems.

The main archive/output directory for an experiment with run ID *RUNID* is `$ARCHIVEDIR/RUNID`. The output data under this directory will be in the PP binary data format. Data files are written to subdirectories under the archive directory, each named after the “stash code” of the variable which they contain. See appendix C for a list of stash codes. The naming convention is:

`$ARCHIVEDIR/RUNID/STASH/RUNIDa.TYPEDATE.STASH.pp`

where *RUNID* is the experiment ID assigned by PRECIS and *STASH* is the stash code of the data type. *TYPE* is the type of data in the files, indicated by a two-letter code in their filename (see table in appendix D). *DATE* is the 5-character UM date stamp (see appendix D). Please note the extra *a* after the second *RUNID*. This signifies that the data is from the atmosphere or surface.

Each file therefore only contains data for a single stash code, data type and valid date.

For instance, a data file may have a name of

`$ARCHIVEDIR/aaadb/00001/aaadba.pag0sep.00001.pp`

In the above, the experiment has a ID of `aaadb` and the stash code is `00001` (surface pressure), for daily data (`pa`) for September 1960 (`g0sep`).

For output files where the diagnostic is a daily minimum or maximum value, the directory name has `.min` or `.max` appended to it respectively. For example,

`$ARCHIVEDIR/aaadb/03236.max/aaadba.pag0sep.03236.pp`

contains the daily maximum values for stash code `3236` (1.5m temperature)

At the end of a run sequence it is possible that the final set of output data has not been archived in the subdirectories under `$ARCHIVEDIR`. If this the case the `archive_end` command can be used:

```
archive_end RUNID
```

5.12 What to do if something goes wrong

The PRECIS model is not immune to failure (technical or numerical), although such failures are rare. The standard action to take after a model failure is to

simply restart the experiment with the “Restart” button in the GUI. This will restart the model from the last successful checkpoint, which is always no further back in time than the beginning of the current model month. In the event that this does not work, it is possible to restart in the same manner as rerunning a section (see section 5.5). If this does not work, consult the PRECIS website for further help. If the experiment persists in not restarting, register as a user on the PRECIS technical support forum <http://forum.precisrcm.com> and post a request for assistance. It is useful to include the most recent log file from the PRECIS experiment which is failing as an attachment to the forum post. You can obtain this file by typing in these commands on your PRECIS user account:

```
$> cd $MY_OUTPUT  
$> ls -rt | tail -1 | xargs gzip -v
```

Attach the resulting *.gz file to your forum post.

For other questions about PRECIS, you may email the PRECIS team at precis@metoffice.gov.uk.

Similar steps should be taken in the event of a sudden power failure.

Field	Description
REAL TIME	The current wallclock time
DESC.	The experiment's description
RUNID	The RUNID of the experiment
STATUS	The status of the experiment (i.e. what the experiment is doing at this instant in time)
start	The experiment's start date
CURRENT	The experiment's current date
end	The experiment's completion date
COMPLETED	The length of time completed by the experiment
%	The percentage of the experiment completed
TIMESTEPS	The number of dynamics timesteps completed
Estimated 'X' remaining	The wallclock time remaining to the event specified on the output line below (see the next three fields in this table). 'X' will be an appropriate unit of time (months, days, hours, minutes, seconds).
Estimated end of NRUN	The wallclock completion end of the NRUN
Estimated stoprun time	The wallclock time of the end of the current CRUN if a stoprun has been issued. This will be the time of the next model dump.
Estimated completion time	The wallclock time of the end of the experiment.
MWLE	The percentage of the run so far in which the wind speed exceeds 150ms^{-1} and so the dynamics timestep is halved to preserve numerical stability. Values are rounded to 3 decimal places and a value of '0%' means exactly zero percent.
	WARNING: If the MWLE value gets too large then the climatology of the model will be adversely affected. See section 5.10.1 for details.

Table 5.4: Description of the text fields in the runtime monitor window

Chapter 6

Data formats, post-processing and displaying PRECIS data

6.1 Introduction

This chapter describes the tools supplied with PRECIS to allow the user to process the output data, and to visualize the results. There are many different tools which are used by the meteorological community for this purpose, and people should use those with which they are most familiar.

It is at present beyond the scope of the PRECIS project to supply advanced data processing and visualization tools beyond those which exist in the general releases of meteorological analysis software. It is hoped that the PRECIS technical support forum (Chapter 7) will become a forum for the exchange of processing tools and expertise amongst PRECIS users.

All PRECIS output data is located under the `$ARCHIVEDIR/RUNID` directory. Please see section 5.11 for a full description. Certain driving data fields are available for comparison in `$GLOBALDIR`.

The `/analysis_tools` directory on the PRECIS installation package contains example code for processing PP data in Fortran and Perl, together with example CDAT and GrADS scripts.

6.2 Data formats overview

There are three output data formats which are relevant to PRECIS: PP, GRIB and NetCDF. There are advantages and disadvantages to each.

PP The default file format for PRECIS diagnostic output is the Met Office's PP

format. In a PP format file, fields are stored sequentially and each field consists of a **header record** followed by the **data record** itself.

- Advantages:
 - The data format used by the Met Office, and the one we have most experience with.
 - The only data format for which PRECIS regridding software exists.
 - Supplied tools allows data I/O and processing with Fortran and Perl
 - PP format can be converted into GRIB or NetCDF at any time.
- Disadvantages:
 - Minimal data and graphical analysis tools.

GRIB GRIB is a WMO format for gridded data and is officially designated as FM 92-VIII Ext. GRIB (GRIdded Binary). Each field consists of a **header record** followed by the **data record** itself.

- Advantages:
 - A mature data format.
 - Suitable for GrADS, a commonly used plotting tool.
 - Suitable for CDAT, a suite of data analysis and plotting tools.
- Disadvantages:
 - GrADS requires three files which have to be used concurrently.
 - Cannot be converted into PP format

NetCDF NetCDF (network Common Data Form) is self describing, direct-access data format. We recommend tools which utilise the CF (Climate and Forecast) metadata convention¹

- Advantages:
 - Most flexible of the data formats
 - The CF convention is likely to become the standard data transfer format within the international meteorological community.
 - Suitable for GrADS, a commonly used plotting tool.
 - Suitable for CDAT, a suite of data analysis and plotting tools.
 - Suitable for CDO, a commonly used data analysis tool.
 - Suitable for NCL, a commonly used data visualisation tool.

¹<http://cf-pcmdi.llnl.gov/>

- Disadvantages:
 - Structure of NetCDF files is more complex than PP or GRIB

All data is output from PRECIS in PP format, as this is the format most easily regridded. If required, the data can then be converted into GRIB or NetCDF.

6.3 PP Format in PRECIS

6.3.1 PP Format description

The PP header

The PP header is 64 words in length and is partitioned into 45 integers followed by 19 reals. Each word of the header describes a particular aspect of the data field which follows. For example, one of the most commonly used header entries is number 42 – the STASH code of the attached data. For a full description of each header entry, see appendix E.

Reading and writing PP fields

Due to their sequential nature, reading and writing PP format files is straightforward in high level programming languages (e.g. Fortran90). To this end, some sample Fortran code which can read and write PRECIS is available upon request to precis@metoffice.gov.uk. Note that a Fortran compiler will be necessary to compile the code.

6.3.2 Manipulating PP fields

PRECIS has a number of tools for manipulating PP format data, all of which are run from the command line. In all cases, the commands have a `-help`] [`-helpx` option which displays a comprehensive guide to using the command.

For any of the tools, to view the full manual, including a description of all command line options, use the `-help` or `-helpx` option. The `-helpx` option opens the manual in a web browser page.

pp2ascii

Convert binary PP fields into various ASCII plain text formats. The PP header and the data array are converted. Supports Arc/Info ASCII Grid Format.

USAGE: pp2ascii [-e dir] [-f format] [-help] [-helpx] [-H criteria] [-I include] [-o ASCIIout] [-O log] [-s suffix] [-X exclude] [-Z] PP1 [PP2 ...]

ppaggregate

Aggregate or disaggregate PP fields from one regular latitude-longitude grid to another regular latitude-longitude grid using, where appropriate, area-weighted averaging.

USAGE: ppagegregate [-a] [-b buffer] [-d dx,dy] [-e dir] [-g grid] [-help] [-helpx] [-H criteria] [-I include] [-l lat,lon] [-m] [-M] [-n nx,ny] [-o PPout] [-O log] [-r PPref] [-s suffix] [-u] [-v vary] [-B] [-x] [-X exclude] [-y] [-Z] PP1 [PP2 ...]

ppdata

Produce area averages or area totals, and basic statistics on the output data, from input PP fields with options to include or exclude:

- Grid boxes identified by column and row numbers
- Grid boxes containing UK national grid locations
- Grid boxes containing latitude-longitude locations
- Masked or unmasked Grid boxes
- Grid boxes inside a particular region

USAGE: ppdata [-c crdata] [-C CRdata] [-d fmt] [-e dir] [-f factor] [-g grid] [-help] [-helpx] [-H criteria] [-I include] [-l lldata] [-L LLdata] [-m] [-M] [-o data] [-O log] [-q PPmask] [-r w,s,e,n] [-R W,S,E,N] [-s sort] [-t] [-u ukdata] [-U UKdata] [-v vary] [-w weight] [-x] [-X exclude] [-y options] [-Z] PP1 [PP2 ...]

ppdf2tcrit

Given a PP field containing degrees of freedom of the Student's t-distribution, a significance level and whether a one- or a two-tailed test is being used, returns a PP field of critical t-values.

USAGE: ppdf2tcrit [-help] [-helpx] -o PPout [-O log] -s -t PP1

ppendian

Identify PP files which have the incorrect (non-native) byte order, and optionally byte-swap them to correct (native) byte order.

To view the full manual, including a description of all command line options, use the `-h` option.

USAGE: `ppendian [-b] [-help] [-helpx] [-I include] [-O log] [-s] [-X exclude] [-Z] PP1 [PP2 ...]`

ppexpr

Operate on and combine PP fields and/or numbers according to a mathematical expression.

USAGE: `ppexpr [-e dir] [-help] [-helpx] [-H criteria] [-I include] [-m] [-o PPout] [-O log] [-s suffix] -x expression [-X exclude] [-B] [-Z] [PP1 [PP2 ...]]`

ppextract

Extract a rectangular subregion from PP fields.

USAGE: `ppextract -a area [-b buffer] [-e dir] [-help] [-helpx] [-H criteria] [-I include] [-o PPout] [-O log] [-p] [-s suffix] [-X exclude] [-Z] PP1 [PP2 ...]`

ppfile

Display a summary of a selected subset of the contents of PP or UM format files with the option of copying the selected fields to a new PP file.

USAGE: `ppfile [-c cols] [-d index] [-e edit] [-BF] [-E] [-f] [-help] [-helpx] [-H criteria] [-I include] [-o PPout] [-O log] [-r ranges] [-s] [-u] [-X exclude] [-Z] PP1 [PP2 ...]`

ppll

Find the latitude-longitude locations of the grid box centres or grid box corners of a PP field. The locations are given in grid (native) and also unrotated coordinates. The row and column numbers and array index of the point are also given. The grid may also be specified from a UM grid namelist.

USAGE: `ppll [-c] [-help] [-helpx] [-H criteria] [-o outfile] infile`

ppmerge

Merge multiple PP fields into a single PP field.

USAGE: `ppmerge [-e dir] [-help] [-helpx] [-H criteria] [-I include]`
`-o PPout [-O log] -t type [-X exclude] [-Z] PP1 [PP2 ...]`

ppmove

Move PP files which are valid before and/or after specified dates to another directory.

USAGE: `ppmove [-a date] [-b date] -e dir [-help] [-helpx] [-I include]`
`[-O log] [-X exclude] [-z] [-Z] PP1 [PP2 ...]`

ppregrid

Regrid PP fields from one regular latitude-longitude grid (the 'source' grid) to another regular latitude-longitude grid (the 'target' grid) using weighted bi-linear interpolation.

For all transformations, the resolution of the target grid must not exceed twice that of the source grid in either longitudinal or latitudinal directions. This is because excessive information will be lost if the target grid is too coarse relative to the source grid.

See appendix J for examples of the types of regrid that are possible.

USAGE: `ppregrid [-b buffer] [-c n] [-d dx,dy] [-e dir] [-g grid] [-help]`
`[-helpx] [-H criteria] [-I include] [-l lat,lon] [-m] [-M] [-n nx,ny]`
`[-o PPout] [-O log] [-r PPref] [-s suffix] [-X exclude] [-B] [-Z] PP1 [PP2 ...]`

pprr

Remove a rim from PP fields. A number of grid boxes will be removed from each edge and different edges may have different numbers of grid boxes removed.

USAGE: `pprr [-d] [-e dir] [-help] [-helpx] [-H criteria] [-I include]`
`[-o PPout] [-O log] -r rim [-s suffix] [-B] [-X exclude] [-Z] PP1 [PP2 ...]`

ppss

Split the PP fields in input PP files into subdirectories based on each field's STASH code (or the field code if the STASH code is not set) and processing code.

USAGE: `ppss [-a] [-e dir] [-help] [-helpx] [-O log] PP1 [PP2 ...]`

ppstats

Create fields of basic statistical quantities from PP fields.

USAGE: ppstats [-e dir] [-help] [-helpx] [-H criteria] [-I include]
-o PPout [-O log] -t type [-X exclude] [-B] [-Z] PP1 [PP2 ...]

ppwhere

Return values from PP fields which pass a numerical test and/or where they coincide with a data mask. Also count the number of PP fields which return data each location.

USAGE: ppwhere [-e dir] [-help] [-helpx] [-H criteria] [-I include]
[-m] [-M] [-o PPout] [-O log] [-q PPmask] [-r x] [-s suffix] [-v vary]
[-w where] [-X exclude] [-B] [-z] [-Z] PP1 [PP2 ...]

stash

Display a description of STASH or field codes or find the STASH codes matching a particular description.

USAGE: stash [-f] [-r] [-s] x1 [x2 ...]

6.4 GRIB format in PRECIS

6.4.1 Provided GRIB format tools

pp2ctl

The pp2ctl will translate PP format data in GRIB format, complete with the control (.ctl) and index (.idx) files required by GrADS to process the GRIB format file. Usage:

```
$> pp2ctl inputfile.pp
```

Three output files are generated: `inputfile.grb`, `inputfile.ctl` and `inputfile.idx`. The output files are located in the same directory as the input data.

6.5 Post Processing and visualization with GrADS

There is no formal support for GrADS in PRECIS, but users are free to use it if they are familiar with it. The latest GrADS distribution is included on the PRECIS DVDs. GrADS can read both NetCDF format and GRIB format files. pp2ctl will translate PP files in GRIB, and will also generate the control files needed by GrADS to read in the GRIB files. As with CDAT, GrADS does not recognize rotated coordinates as standard.

6.5.1 Provided GrADS scripts

By default GrADS will plot a incorrect map overlay. The correct overlay can be plotted with the following:

1. Start GrADS and load in the field to be plotted.
2. turn off the internal map plotting with

```
ga-> set mpdraw off
```

3. Plot the field
4. Run the `/analysis_tools/grads/grads_map.gs` script on the PRECIS DVD with the RUNID as an argument e.g.

```
ga-> /media/dvd/analysis_tools/grads/grads_map.gs runid
```

The correct map should now be overlaid.

The file `/analysis_tools/grads/plot_example.gs` on the PRECIS DVD is an example GrADS script which reads in output PRECIS data and plots it with a corresponding climatology. This file can be used as a basis for user's own GrADS script.

Please note, when data is plotted with the rotated grid, the latitude and displayed longitude values will be for this grid, and not the non-rotated values

6.6 Other visualization tools

PP, GRIB, NetCDF and dump format files can be visualized by using `xconv`², written by Jeff Cole at the University of Reading. Note: this package has limited functionality.

²<http://www.met.rdg.ac.uk/~jeff/xconv/>

6.7 Global Datasets

The global datasets of output from the driving GCMs and climatologies can be found under the `$GLOBALDIR` directory. They are split into subdirectories, named after the five letter experiment ID of the GCM, or the name of the climatology. These are full field global files in PP format.

Chapter 7

The PRECIS web site

The PRECIS web site, <http://www.metoffice.gov.uk/precis>, is intended for both experienced and prospective users of PRECIS. It contains a variety of material and links, such as introductory explanations, news, a FAQ, Precis related publications, workshop information and more. The site is continually under development.

A dedicated technical support forum for PRECIS to post scientific questions or request technical support can be found at <http://forum.precisrcm.com>

To contact the Met Office Hadley Centre PRECIS team directly, please use the PRECIS email address precis@metoffice.gov.uk.

Appendix A

Contents of the PRECIS DVD

A.1 PRECIS DVD

- Files used in the standard PRECIS installation process
 - install_precis** : The main installation software
 - install_data** : The boundary data and dumps installation software
 - changelog.txt** : File listing changes to PRECIS between versions
 - setvarscreate2.0** : Program which sets up `$HOME/setvars`
 - um.tgz** : The main PRECIS software
 - umui_jobs.tgz** : Standard processed PRECIS control files
 - precis_save.tgz** : Example PRECIS experiments
- Ancillary files
 - ancil** : Directory containing ancillary files required by PRECIS
- Dump files
 - dumps** : Yearly initial dumps
- Global files used for verification
 - global** : Output from climate meaning of driving data
- Files for advanced users
 - umui.tgz** The full UMUI, for Portable UM experts
 - um_source.tgz** The full PRECIS source tree, for Portable UM experts

- CDAT files

cdat : CDAT distribution from PCMDI

- cdat-3.3-everything.tar.gz - CDAT distribution
- cdat.pdf - CDAT beginners guide
- cdat_tutorials-3.3.tgz - Tutorials from the standard CDAT release
- cdat_data_tutorials.tgz - Data for tutorials
- cdms_main.pdf, cdms_quick_start.pdf, vcs_quick_start.pdf, cdat_utilities.pdf - other CDAT user guides
- python-doc-2.2.2.tgz Full python documentation

- Directories with useful documentation and utilities

docs : Directory containing this documentation and the full UM documentation

utils : Directory containing programs which are useful for the PRECIS system.

pp4lbc : Directory containing boundary data files required by PRECIS

Appendix B

Directory layout and environment variables

B.1 Directory layout of the PRECIS system

```
$UMDIR
|
|-bin           Stand-alone and third party utilities
|
|-docs         Full PRECIS and UM documentation
|
|-ui           The PRECIS user interface
|
|-source      Useful source code which can be used as part
|             user written PRECIS analysis code.
|
|-vn4.5       The main PRECIS code tree
|
|   |-ctldata  Data and parameters required to control PRECIS
|   |
|   |-exec     Executables used by the PRECIS system
|   |
|   |-scripts  Scripts which are used in the PRECIS system
|   |
|   |-utils    Scripts which are used in the PRECIS system
|             which can also be used on the command line
```

```

$HOME
|
| -precis_out           Main output directory
|
| -precis_save         Directory where the GUI saves details of
|                       regions and experiments
|
| -umui_jobs           Directory where the control files generated
|                       by the GUI are stored. These files are then
|                       used by PRECIS when it runs.
|
| -analysis_tools     Various tools to aid processing and visualization
|                       of PRECIS output

```

B.2 Environment variables used by PRECIS

UMDIR The PRECIS system code. All the required files are copied to this directory at the end of the installation process.

ANCIL_MASTER The global master ancillary files. All the required files are copied at the end of the installation process.

PP4LBCDIR The files required to generate the LBCs used by PRECIS. These files have to be installed by the user. The files required to generate the LBCs for each driving experiment should be placed in their own subdirectory, e.g. the LBCs for GCM with ID `addfa` should be copied to `$PP4LBCDIR/addfa`.

DUMPSDIR Location of the initial PRECIS dumps. These files have to be installed by the user. All initial dumps should be copied to this directory. Do not use subdirectories.

GLOBALDIR Location of global GCM climatological data to be used for model validation. The fields are stored in subdirectories, named after the GCM run from which they are generated.

DATADIR Directory used by PRECIS when it is running to store control and intermediate files. This includes the current output data files and log files. A directory named `$DATADIR/RUNID`, where *RUNID* is the five-letter internal PRECIS run ID of the experiment, will be created when PRECIS is run.

ANCILDIR Directory where the processed ancillaries for the selected region are stored. For a given run ID, *RUNID*, the ancillaries will be located in `$ANCILDIR/RUNID`.

LBCDIR Directory where the processed input LBCs are stored. For a given run ID, *RUNID*, the LBCs will be located in `$LBCDIR/RUNID`.

MY_OUTPUT Output directory for PRECIS experiment log files, ending in `*.leave`.

ARCHIVEDIR Directory into which the output diagnostic files are copied. For a given run ID, *RUNID*, the output files will be copied to `$ARCHIVEDIR/RUNID`.

TMPDIR Directory where the temporary files generated when PRECIS is run are located.

CDATDIR Top level directory of the CDAT software tree.

Internal environment variables. These are set to the values given in brackets as part of the PRECIS installation process, and should not be changed by the user.

VN (4.5) The version of the Unified Model on which PRECIS is based.

UPATH (`$UMDIR/vn4.5/utills`) The directory where PRECIS utilities and scripts which may be run from the command line are stored

SPATH (`$UMDIR/vn4.5/scripts`) The directory where internal PRECIS utilities and scripts are stored

EPATH (`$UMDIR/vn4.5/exec`) The directory where executable files for internal PRECIS utilities are stored

B.3 Configuration files

These files are used to configure the PRECIS user interface and runtime system. When PRECIS functionality is updated, by for example adding extra driving GCMs or diagnostics, these files may have to be updated. Details will appear on the web site.

- `$UIDIR/etc/data`

General data files

base_jobs.dat : The standard experiments on which all PRECIS experiments are based. There are separate run IDs for each RCM.

models.dat : This file contains the names of all regional models followed by a list of the runids from the GCM/reanalysis experiments which are valid as driving data for that regional model.

default.job : The experiment loaded by the UI when the “Default Job” tab is clicked.

map.dat, maph.dat, mapl.dat : Map data, at different resolutions. Used by the UI and the experiment monitor.

scenario.dat : File which details the experiment setup of all the available driving GCMs.

- **\$UIDIR/etc/scenario**

Contains files detailing the concentrations of radiatively active atmospheric gases for each of the GCM and reanalysis experiments.

- **\$UIDIR/etc/stash**

Contains files which specify the possible output diagnostics from the RCM.

STASHA : Daily mean diagnostics

STASHJ : Hourly mean diagnostics

STASHB : CORDEX and storm tracking diagnostics

STASHC : CORDEX and storm tracking diagnostics

STASHM : Diagnostics used for climate meaning

STASHS : Sulphur diagnostics

B.4 Global data

During the installation process, selected global diagnostic data fields from the assimilated ECMWF reanalysis (ERA) driving experiment are copied to **\$GLOBALDIR**. In addition, surface fields from the Climatic Research Unit (CRU) at UEA¹ are supplied. The data from the driving experiment is located in **\$GLOBALDIR/abxsq**, and the CRU data are in **\$GLOBALDIR/crudat**.

The data are seasonal means, written as PP files in stashsplit format. Please see section 6.7 for details on how to translate this data into other formats.

Data covering the period December 1979 to December 1980 (inclusive) are supplied.

¹<http://www.cru.uea.ac.uk/cru/data/>

B.4.1 ECMWF reanalysis diagnostic data

The following global diagnostic data from the assimilated ECMWF reanalysis driving experiment fields are available, with stash codes in bold:

00001 Surface pressure
03225 10m U wind
03226 10m V wind
03236 1.5m temperature
03249 10m wind speed
15201 U wind at 850, 700, 500, 250, 50 hPa
15202 V wind at 850, 700, 500, 250, 50 hPa
16202 Geopotential height at 850, 700, 500, 250, 50 hPa
16222 Pressure at mean sea level

B.4.2 CRU global data

The following CRU data are available. Please note that some fields are indexed by field codes as they have no equivalent UM STASH codes. These fields have `fcxxx`, where each `x` is a digit, in place of a STASH code. Also note, at present, these cannot be translated to NetCDF format.

01235 Surface radiation
02204 Cloud cover
03236 1.5m Temperature
03249 Wind speed
05226 Precipitation
fc16 Diurnal temperature range
fc239 Vapour pressure
fc242 Wet-day frequency
fc308 Ground frost frequency

Appendix C

Standard diagnostic list

The PRECIS model diagnostics (output variables) are available for a range of temporal periods and for various vertical extents. PRECIS will always output variables as climate means, and in addition daily and/or hourly data may be added via the GUI.

With help from the Met Office Hadley Centre, it may also be possible to configure PRECIS to output variables not listed below. Existing variables may also be output at different frequencies and over different meaning periods.

Key to tables:

STASH code : A unique positive integer which is assigned to each different variable in the PRECIS model. It is encoded as word 42 in the PP header (LBUSER(4), see appendix E).

Description : The meteorological variable

Units : The units of the variable. Nearly all PRECIS diagnostics are in SI units, with the exception of mass, which is usually in kilograms. An entry of ‘—’ means that that the quantity is dimensionless.

Time :

- **Inst** = Instantaneous data output at a given frequency.
- **Mean** = Time average, sampled every timestep.
- **Max** = Maximum value over a given period, sampled every timestep.
- **Min** = Minimum value over a given period, sampled every timestep.
- **MDmax** = Mean daily maximum, sampled every timestep.
- **MDmin** = Mean daily minimum, sampled every timestep.

Domain :

- **Single** = Diagnostic on a single unspecified, but unambiguous level or surface.
- **Vert mean** = Diagnostic is a mass-weighted average over all atmospheric vertical levels.
- **MLC n** = Diagnostic on atmospheric model level centres 1 (surface level) to n .
- **MLB n** = Diagnostic on atmospheric model level **lower** boundaries 1 (at the surface of the earth) to n .
- **SL n** = Soil levels 1 (surface level) to n .
- **PL 17+** = Diagnostic on the 17 standard atmospheric pressure levels for climate means: 1000, 925, 850, 700, 600, 500, 400, 300, 250, 200, 150, 100, 70, 50, 30, 20, 10, plus any extra levels specified in the GUI for daily output.
- **PL** = Atmospheric pressure levels for daily diagnostics. The levels are specified in the GUI.
- **TL 5** = Diagnostic on 5 levels of constant potential temperature (theta): 315, 330, 350, 380, 405 K .

Items in **bold** type face are only available when using the MOSES I land surface scheme.

Items in *italics* type face are only available when using the MOSES 2.2 land surface scheme.

Note on grids: Diagnostics are on the horizontal ‘pressure’ grid, unless it is stated that they are on the horizontal ‘wind’ grid (WIND GRID). See appendix F

Important note on wind diagnostics: The wind components involved in all diagnostics apart from STASH codes 2 and 3 have directions aligned with the standard (unrotated) lines of latitude and longitude. For STASH codes 2 and 3 the components are aligned with the rotated lines latitude and longitude on the RCM grid.

Can’t find the appropriate diagnostic? The contents of tables C.1, C.2, C.3, C.4, and C.5 have two possible limitations: **1)** a required variable is not output at the desired temporal frequency or meaning period and **2)** a required variable is not listed.

Table C.1: Standard diagnostics: Climate means

STASH code	Description	Units	Time	Domain
1	SURFACE PRESSURE	Pa	Mean	Single
2	WIND U-COMPONENT (=U) (WIND GRID)	ms^{-1}	Mean	MLC 19
3	WIND V-COMPONENT (=V) (WIND GRID)	ms^{-1}	Mean	MLC 19
4	POTENTIAL TEMPERATURE (THETA)	K	Mean	MLC 19
10	SPECIFIC HUMIDITY	$kg\ kg^{-1}$	Mean	MLC 19
10	SPECIFIC HUMIDITY	$kg\ kg^{-1}$	Mean	Vert mean
24	SURFACE (SKIN) TEMPERATURE	K	Mean	Single
24	SURFACE (SKIN) TEMPERATURE	K	MDmin	Single
24	SURFACE (SKIN) TEMPERATURE	K	MDmax	Single
25	BOUNDARY LAYER (=BL) DEPTH	m	Mean	Single
31	SEA ICE FRACTION ($0 \leq x \leq 1$)	—	Mean	Single
58	SULPHUR DIOXIDE EMISSIONS	$kg\ m^{-2}s^{-1}$	Mean	Single
59	DIMETHYL SULPHIDE EMISSIONS	$kg\ m^{-2}s^{-1}$	Mean	Single
101	SO ₂ MASS MIXING RATIO	$kg\ kg^{-1}$	Mean	MLC 19
102	DIMETHYL SULPHIDE MIXING RATIO	$kg\ kg^{-1}$	Mean	MLC 19
103	SO ₄ AITKEN MODE AEROSOL	$kg\ kg^{-1}$	Mean	MLC 19
104	SO ₄ ACCUM. MODE AEROSOL	$kg\ kg^{-1}$	Mean	MLC 19
105	SO ₄ DISSOLVED AEROSOL	$kg\ kg^{-1}$	Mean	MLC 19
106	H ₂ O ₂ MASS MIXING RATIO	$kg\ kg^{-1}$	Mean	MLC 19
121	NATURAL SO ₂ EMISSIONS	$kg\ m^{-2}s^{-1}$	Mean	MLC 19
122	OH CONCENTRATIONS	molecules cm^{-3}	Mean	MLC 19
123	HO ₂ CONCENTRATIONS	molecules cm^{-3}	Mean	MLC 19
124	H ₂ O ₂ CONCENTRATIONS	$kg\ kg^{-1}$	Mean	MLC 19
125	OZONE FOR SULPHUR CYCLE	$kg\ kg^{-1}$	Mean	MLC 19
126	HIGH LEVEL SO ₂ EMISSIONS	$kg\ m^{-2}s^{-1}$	Mean	Single
1201	NET DOWN SURFACE SW FLUX	Wm^{-2}	Mean	Single
1203	NET DOWN SW RAD FLUX: OPEN SEA	Wm^{-2}	Mean	Single
1204	NET DOWN SURFACE SW FLUX BELOW 690NM	Wm^{-2}	Mean	Single
1207	INCOMING SW FLUX AT TOA	Wm^{-2}	Mean	Single
1208	OUTGOING SW FLUX AT TOA	Wm^{-2}	Mean	Single
1209	CLEAR-SKY UPWARD SW FLUX AT TOA	Wm^{-2}	Mean	Single
1210	CLEAR-SKY DOWN SURFACE SW FLUX	Wm^{-2}	Mean	Single
1211	CLEAR-SKY UP SURFACE SW FLUX	Wm^{-2}	Mean	Single
1221	LAYER CLD LIQ RE × LAYER CLD AMOUNT	—	Mean	MLC 18
1223	LAYER CLD AMT IN SWRAD (MICROPHYSICS)	—	Mean	MLC 18
1235	TOTAL DOWNWARD SURFACE SW FLUX	Wm^{-2}	Mean	Single
1241	DROPLET NUMBER CONC × CLOUD AMOUNT	—	Mean	MLC 18
1242	LAYER CLOUD LWC × CLOUD AMOUNT	—	Mean	MLC 18
1243	SO ₄ CCN MASS CONC × COND SAMP WEIGHT	—	Mean	MLC 18
1244	CONDITIONAL SAMPLING WEIGHT	—	Mean	MLC 18
1245	2-D EFFECTIVE RADIUS × 2-D RE WEIGHT	—	Mean	Single

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Table C.1: *Climate mean diagnostics continued*

STASH code	Description	Units	Time	Domain
1246	WEIGHT FOR 2-D EFFECTIVE RADIUS	—	Mean	Single
2201	NET DOWN SURFACE LW FLUX	Wm^{-2}	Mean	Single
2203	NET DOWN LW FLUX: OPEN SEA	Wm^{-2}	Mean	Single
2204	TOTAL CLOUD AMOUNT ($0 \leq x \leq 1$)	—	Mean	Single
2205	OUTGOING LW FLUX AT TOA	Wm^{-2}	Mean	Single
2206	CLEAR-SKY UPWARD LW FLUX AT TOA	Wm^{-2}	Mean	Single
2207	TOTAL DOWNWARD SURFACE LW FLUX	Wm^{-2}	Mean	Single
2208	CLEAR-SKY DOWN SURFACE LW FLUX	Wm^{-2}	Mean	Single
2278	OZONE CONCENTRATION	$kg\ kg^{-1}$	Mean	MLC 19
3026	ROUGHNESS LENGTH	m	Mean	Single
3201	HEAT FLUX THROUGH SEA ICE	Wm^{-2}	Mean	Single
3202	HEAT FLUX FROM SURF TO DEEP SOIL LEV	Wm^{-2}	Mean	Single
3217	SURFACE & BL HEAT FLUXES	Wm^{-2}	Mean	MLB 5
3219	X-COMP OF SURF & BL WIND STRESS	Nm^{-2}	Mean	Single
3220	Y-COMP OF SURF & BL WIND STRESS	Nm^{-2}	Mean	Single
3223	SURFACE & BL MOISTURE FLUXES	$kg\ m^{-2}s^{-1}$	Mean	MLB 5
3224	WIND MIXING ENERGY FLUX INTO SEA	Wm^{-2}	Mean	Single
3225	WIND U-COMPONENT AT 10 METRES (WIND GRID)	ms^{-1}	Mean	Single
3226	WIND V-COMPONENT AT 10 METRES (WIND GRID)	ms^{-1}	Mean	Single
3228	SURFACE SENSIBLE HEAT FLUX FROM SEA	Wm^{-2}	Mean	Single
3232	EVAPORATION FROM SEA	$kg\ m^{-2}s^{-1}$	Mean	Single
3234	SURFACE LATENT HEAT FLUX	Wm^{-2}	Mean	Single
3236	TEMPERATURE AT 1.5 METRES	K	Mean	Single
3236	TEMPERATURE AT 1.5 METRES	K	MDmin	Single
3236	TEMPERATURE AT 1.5 METRES	K	MDmax	Single
3237	SPECIFIC HUMIDITY AT 1.5 METRES	$kg\ kg^{-1}$	Mean	Single
3245	RELATIVE HUMIDITY AT 1.5 METRES	%	Mean	Single
3249	WIND SPEED AT 10 METRES (WIND GRID)	ms^{-1}	Mean	Single
3249	WIND SPEED AT 10 METRES (WIND GRID)	ms^{-1}	MDmax	Single
3250	DEWPOINT AT 1.5 METRES	K	Mean	Single
3254	THETA _L AT 1.5 METRES	K	Mean	Single
3255	Q _T AT 1.5 METRES	kg/kg	Mean	Single
3259	CANOPY CONDUCTANCE M/S		Mean	Single
3270	SO ₂ SURFACE DRY DEP FLUX	$kg\ m^{-2}s^{-1}$	Mean	Single
3271	SO ₄ AIT SURF DRY DEP FLUX	$kg\ m^{-2}s^{-1}$	Mean	Single
3272	SO ₄ ACC SURF DRY DEP FLUX	$kg\ m^{-2}s^{-1}$	Mean	Single
3273	SO ₄ DIS SURF DRY DEP FLUX	$kg\ m^{-2}s^{-1}$	Mean	Single
<i>3287</i>	<i>CANOPY EVAPORATION ON TILES</i>	$kg\ m^{-2}s^{-1}$	Mean	Single
<i>3288</i>	<i>TRANSPIRATION + SOIL EVAPORATION ON TILES</i>	$kg\ m^{-2}s^{-1}$	Mean	Single

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Table C.1: *Climate mean diagnostics continued*

STASH code	Description	Units	Time	Domain
3289	GROSS PRIMARY PRODUCTIVITY ON PFTS ¹	$kg\ m^{-2}\ s^{-1}$	Mean	Single
3290	SURFACE SENSIBLE HEAT FLUX ON TILES	$kg\ m^{-2}\ s^{-1}$	Mean	Single
3291	NET PRIMARY PRODUCTIVITY ON PFTS	$kg\ m^{-2}\ s^{-1}$	Mean	Single
3293	SOIL RESPIRATION	$kg\ C\ m^{-2}\ s^{-1}$	Mean	Single
3296	EVAPORATION FROM SOIL SURFACE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
3297	EVAPORATION FROM CANOPY RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
3298	SUBLIMATION FROM SURFACE RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
3299	TRANSPIRATION RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
3312	POTENTIAL EVAPORATION RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
3313	SOIL MOISTURE AVAILABILITY FACTOR		Mean	Single
3314	SURFACE NET RADIATION ON TILES	Wm^{-2}	Mean	Single
3316	SURFACE TEMP ON SNOW-ADJUSTED TILES	K	Mean	Single
3321	CANOPY WATER ON TILES	$kg\ m^{-2}$	Mean	Single
3328	TEMPERATURE AT 1.5 OVER TILES	K	Mean	Single
3328	TEMPERATURE AT 1.5 OVER TILES	K	MDmin	Single
3328	TEMPERATURE AT 1.5 OVER TILES	K	MDmax	Single
3329	SPECIFIC HUMIDITY AT 1.5 METRES OVER TILES	$kg\ kg^{-1}$	Mean	Single
3330	SURFACE LATENT HEAT FLUX ON TILES	$kg\ m^{-2}\ s^{-1}$	Mean	Single
3331	SUBLIMATION HEAT FLUX ON TILES	$kg\ m^{-2}\ s^{-1}$	Mean	Single
3463	PANOFSKY PEAK GUST (WIND GRID)	ms^{-1}	MDmax	Single
4203	LARGE SCALE RAINFALL RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
4204	LARGE SCALE SNOWFALL RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
4205	CLOUD LIQUID WATER CONTENT		Mean	MLC 19
4206	CLOUD ICE CONTENT		Mean	MLC 19
4216	SO ₂ SCAVENGED BY LS PPN	$kg\ m^{-2}\ s^{-1}$	Mean	Single
4217	SO ₄ AITKEN SCAVNGD BY LS PPN	$kg\ m^{-2}\ s^{-1}$	Mean	Single
4218	SO ₄ ACCUMULATION SCAVNGD BY LS PPN	$kg\ m^{-2}\ s^{-1}$	Mean	Single
4219	SO ₄ DISSOLVED SCAVNGD BY LS PPN	$kg\ m^{-2}\ s^{-1}$	Mean	Single
5205	CONVECTIVE RAINFALL RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
5206	CONVECTIVE SNOWFALL RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
5209	TEMPERATURE (AFTER CONVECTION)	K	Mean	MLC 19
5209	TEMPERATURE (AFTER CONVECTION)	K	Mean	Vert mean
5212	CONVECTIVE CLOUD AMOUNT ($0 \leq x \leq 1$)	—	Mean	MLC 19
5216	TOTAL PRECIPITATION RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
5234	CONVECTIVE CLOUD WATER PATH	$kg\ m^{-2}$	Mean	Single
5238	SO ₂ SCAVENGED BY CONV PPN	$kg\ m^{-2}\ s^{-1}$	Mean	Single
5239	SO ₄ AIT SCAVENGED BY CONV PPN	$kg\ m^{-2}\ s^{-1}$	Mean	Single
5240	SO ₄ ACC SCAVENGED BY CONV PPN	$kg\ m^{-2}\ s^{-1}$	Mean	Single
5241	SO ₄ DIS SCAVENGED BY CONV PPN	$kg\ m^{-2}\ s^{-1}$	Mean	Single

*continued on next page*¹PFTS = Plant functional types

Table C.1: *Climate mean diagnostics continued*

STASH code	Description	Units	Time	Domain
8023	SNOW MASS	$kg\ m^{-2}$	Mean	Single
8208	AVAIL SOIL MOIST CONT IN ROOT ZONE ²	$kg\ m^{-2}$	Mean	Single
8209	CANOPY WATER CONTENT	$kg\ m^{-2}$	Mean	Single
8223	SOIL MOISTURE CONTENT IN A LAYER	$kg\ m^{-2}$	Mean	SL 4
8225	DEEP SOIL TEMPERATURE	K	Mean	SL 4
8229	UNFROZEN SOIL MOISTURE FRACTION ($0 \leq x \leq 1$)	—	Mean	SL 4
8230	FROZEN SOIL MOISTURE FRACTION ($0 \leq x \leq 1$)	—	Mean	SL 4
8231	SNOW MELT RATE (LAND)	$kg\ m^{-2}s^{-1}$	Mean	Single
8233	CANOPY THROUGHFALL RATE	$kg\ m^{-2}s^{-1}$	Mean	Single
8234	SURFACE RUNOFF RATE	$kg\ m^{-2}s^{-1}$	Mean	Single
8235	SUB-SURFACE RUNOFF RATE	$kg\ m^{-2}s^{-1}$	Mean	Single
9201	LAYER CLOUD AMOUNT ($0 \leq x \leq 1$)	—	Mean	MLC 19
9206	CLOUD LIQUID WATER CONTENT	$kg\ kg^{-1}$	Mean	MLC 19
9207	CLOUD ICE CONTENT	$kg\ kg^{-1}$	Mean	MLC 19
9282	CRITICAL RELATIVE HUMIDITY ($0 \leq x \leq 1$)	—	Mean	MLC 19
12201	WIND W-COMPONENT (=W) (WIND GRID)	ms^{-1}	Mean	MLC 19
15201	WIND U-COMPONENT (=U) (WIND GRID)	ms^{-1}	Mean	PL 17+
15202	WIND V-COMPONENT (=V) (WIND GRID)	ms^{-1}	Mean	PL 17+
15214	ERTEL POTENTIAL VORTICITY	$Kkg^{-1}m^2s^{-1}$	Mean	TL 5
15215	$U \times V$ (WIND GRID)	m^2s^{-2}	Mean	PL 17+
15216	TEMPERATURE (=T) (WIND GRID)	K	Mean	PL 17+
15217	$U \times T$ (WIND GRID)	$ms^{-1}K$	Mean	PL 17+
15218	$V \times T$ (WIND GRID)	$ms^{-1}K$	Mean	PL 17+
15219	T^2 (WIND GRID)	K^2	Mean	PL 17+
15220	U^2 (WIND GRID)	m^2s^{-2}	Mean	PL 17+
15221	V^2 (WIND GRID)	m^2s^{-2}	Mean	PL 17+
15222	WIND W-COMPONENT (=W) (WIND GRID)	$Pa\ s^{-1}$	Mean	PL 17+
15223	$W \times T$ (WIND GRID)	$ms^{-1}K$	Mean	PL 17+
15224	$W \times U$ (WIND GRID)	m^2s^{-2}	Mean	PL 17+
15225	$W \times V$ (WIND GRID)	m^2s^{-2}	Mean	PL 17+
15226	SPECIFIC HUMIDITY (=Q) (WIND GRID)	$kg\ kg^{-1}$	Mean	PL 17+
15227	$Q \times U$ (WIND GRID)	$kg\ kg^{-1}ms^{-1}$	Mean	PL 17+
15228	$Q \times V$ (WIND GRID)	$kg\ kg^{-1}ms^{-1}$	Mean	PL 17+
15235	$Q \times W$ (WIND GRID)	$kg\ kg^{-1}ms^{-1}$	Mean	PL 17+
15238	GEOPOTENTIAL HEIGHT (=Z) (WIND GRID)	m	Mean	PL 17+
15239	$U \times Z \times 10^6$ (WIND GRID)	m^2s^{-1}	Mean	PL 17+
15240	$V \times Z \times 10^6$ (WIND GRID)	m^2s^{-1}	Mean	PL 17+
15242	W^2 (WIND GRID)	m^2s^{-2}	Mean	PL 17+
16202	GEOPOTENTIAL HEIGHT (=Z)	m	Mean	PL 17+

*continued on next page*²See appendix H.5

Table C.1: *Climate mean diagnostics continued*

STASH code	Description	Units	Time	Domain
16203	TEMPERATURE (PRESSURE GRID)	K	Mean	PL 17+
16204	RELATIVE HUMIDITY	%	Mean	PL 17+
16222	PRESSURE AT MEAN SEA LEVEL	Pa	Mean	Single
16224	Z^2	m^2	Mean	PL 17+

Table C.2: Standard diagnostics: Daily

STASH code	Description	Units	Time	Domain
1	SURFACE PRESSURE	Pa	Mean	Single
10	SPECIFIC HUMIDITY	$kg\ kg^{-1}$	Mean	MLC 19
23	SNOW AMOUNT AFTER TIMESTEP	$kg\ m^{-2}$	Mean	Single
24	SURFACE (SKIN) TEMPERATURE	K	Mean	Single
24	SURFACE (SKIN) TEMPERATURE	K	Max	Single
24	SURFACE (SKIN) TEMPERATURE	K	Min	Single
25	BOUNDARY LAYER (=BL) DEPTH	m	Mean	Single
31	SEA ICE FRACTION ($0 \leq x \leq 1$)	—	Mean	Single
1201	NET DOWN SURFACE SW FLUX	Wm^{-2}	Mean	Single
1204	NET DOWN SURFACE SW FLUX BELOW 690NM	Wm^{-2}	Mean	Single
1207	INCOMING SW FLUX (TOA)	Wm^{-2}	Mean	Single
1208	OUTGOING SW FLUX (TOA)	Wm^{-2}	Mean	Single
1235	TOTAL DOWNWARD SURFACE SW FLUX	Wm^{-2}	Mean	Single
2201	NET DOWN SURFACE LW FLUX	Wm^{-2}	Mean	Single
2204	TOTAL CLOUD AMOUNT ($0 \leq x \leq 1$)	—	Mean	Single
2205	OUTGOING LW FLUX (TOA)	Wm^{-2}	Mean	Single
2207	TOTAL DOWNWARD SURFACE LW FLUX	Wm^{-2}	Mean	Single
3217	SURFACE & BL HEAT FLUXES	Wm^{-2}	Mean	MLB 5
3219	X-COMP OF SURF & BL WIND STRESS	Nm^{-2}	Mean	Single
3220	Y-COMP OF SURF & BL WIND STRESS	Nm^{-2}	Mean	Single
3223	SURFACE & BL MOISTURE FLUXES	$kg\ m^{-2}s^{-1}$	Mean	MLB 5
3224	WIND MIXING ENERGY FLUX INTO SEA	Wm^{-2}	Mean	Single
3225	WIND U-COMPONENT AT 10 METRES (WIND GRID)	ms^{-2}	Mean	Single
3226	WIND V-COMPONENT AT 10 METRES (WIND GRID)	ms^{-2}	Mean	Single
3228	SURFACE SENSIBLE HEAT FLUX FROM SEA	Wm^{-2}	Mean	Single
3234	SURFACE LATENT HEAT FLUX	Wm^{-2}	Mean	Single
3236	TEMPERATURE AT 1.5 METRES	K	Mean	Single
3236	TEMPERATURE AT 1.5 METRES	K	Max	Single
3236	TEMPERATURE AT 1.5 METRES	K	Min	Single
3237	SPECIFIC HUMIDITY AT 1.5 METRES	$kg\ kg^{-1}$	Mean	Single
3245	RELATIVE HUMIDITY AT 1.5 METRES	%	Mean	Single
3249	WIND SPEED AT 10 METRES (WIND GRID)	ms^{-1}	Mean	Single
3249	WIND SPEED AT 10 METRES (WIND GRID)	ms^{-1}	Max	Single
3250	DEWPOINT AT 1.5 METRES	K	Mean	Single
3259	CANOPY CONDUCTANCE		Mean	Single
<i>3287</i>	<i>CANOPY EVAPORATION ON TILES</i>	$kg\ m^{-2}s^{-1}$	Mean	Single
<i>3288</i>	<i>TRANSPIRATION + SOIL EVAPORATION ON TILES</i>	$kg\ m^{-2}s^{-1}$	Mean	Single
<i>3289</i>	<i>GROSS PRIMARY PRODUCTIVITY ON PFTS³</i>	$kg\ m^{-2}s^{-1}$	Mean	Single
<i>3290</i>	<i>SURFACE SENSIBLE HEAT FLUX ON TILES</i>	$kg\ m^{-2}s^{-1}$	Mean	Single

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³PFTS = Plant functional types

Table C.2: *Daily diagnostics continued*

STASH code	Description	Units	Time	Domain
3291	NET PRIMARY PRODUCTIVITY ON PFTS	$kg\ m^{-2}\ s^{-1}$	Mean	Single
3293	SOIL RESPIRATION	$kg\ C\ m^{-2}\ s^{-1}$	Mean	Single
3296	EVAPORATION RATE FROM SOIL SURFACE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
3297	EVAPORATION RATE FROM CANOPY	$kg\ m^{-2}\ s^{-1}$	Mean	Single
3298	SUBLIMATION RATE AT SURFACE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
3299	TRANSPIRATION	$kg\ m^{-2}\ s^{-1}$	Mean	Single
3312	POTENTIAL EVAPORATION RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
3314	SURFACE NET RADIATION ON TILES	Wm^{-2}	Mean	Single
3316	SURFACE TEMPERATURE ON SNOW-ADJUSTED TILES	K	Mean	Single
3316	SURFACE TEMPERATURE ON SNOW-ADJUSTED TILES	K	Max	Single
3316	SURFACE TEMPERATURE ON SNOW-ADJUSTED TILES	K	Min	Single
3321	CANOPY WATER ON TILES	$kg\ m^{-2}$	Mean	Single
3328	TEMPERATURE AT 1.5 OVER TILES	K	Mean	Single
3328	TEMPERATURE AT 1.5 OVER TILES	K	Max	Single
3328	TEMPERATURE AT 1.5 OVER TILES	K	Min	Single
3329	SPECIFIC HUMIDITY AT 1.5 METRES OVER TILES	$kg\ kg^{-1}$	Mean	Single
3330	SURFACE LATENT HEAT FLUX ON TILES	$kg\ m^{-2}\ s^{-1}$	Mean	Single
3331	SUBLIMATION HEAT FLUX ON TILES	$kg\ m^{-2}\ s^{-1}$	Mean	Single
3463	PANOFSKY PEAK GUST (WIND GRID)	ms^{-1}	Max	Single
4203	LARGE SCALE RAINFALL RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
4204	LARGE SCALE SNOWFALL RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
5205	CONVECTIVE RAINFALL RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
5206	CONVECTIVE SNOWFALL RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
5215	TOTAL SNOWFALL RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
5216	TOTAL PRECIPITATION RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
8023	SNOW MASS	$kg\ m^{-2}$	Mean	Single
8208	AVAIL SOIL MOIST CONT IN ROOT ZONE ⁴	$kg\ m^{-2}$	Mean	Single
8209	CANOPY WATER CONTENT	$kg\ m^{-2}$	Mean	Single
8223	SOIL MOISTURE CONTENT IN A LAYER	$kg\ m^{-2}$	Mean	SL 4
8225	DEEP SOIL TEMPERATURE	K	Mean	SL 4
8230	FROZEN SOIL MOISTURE FRACTION ($0 \leq x \leq 1$)	—	Mean	SL 4
8231	LAND SNOW MELT RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
8233	CANOPY THROUGHFALL RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
8234	SURFACE RUNOFF RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
8235	SUB-SURFACE RUNOFF RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
9206	CLOUD LIQUID WATER CONTENT	$kg\ kg^{-1}$	Mean	Vert mean
9207	CLOUD ICE CONTENT	$kg\ kg^{-1}$	Mean	Vert mean
15201	WIND U-COMPONENT (=U) (WIND GRID)	ms^{-1}	Mean	PL
15202	WIND V-COMPONENT (=V) (WIND GRID)	ms^{-1}	Mean	PL

*continued on next page*⁴See appendix H.5

Table C.2: *Daily diagnostics continued*

STASH code	Description	Units	Time	Domain
15216	TEMPERATURE (=T) (WIND GRID)	K	Mean	PL
15222	OMEGA (=W) (WIND GRID)	$Pa\ s^{-1}$	Mean	PL
15226	SPECIFIC HUMIDITY (=Q) (WIND GRID)	$kg\ kg^{-1}$	Mean	PL
15227	$Q \times U$ (WIND GRID)	$kg\ kg^{-1}ms^{-1}$	Mean	PL
15228	$Q \times V$ (WIND GRID)	$kg\ kg^{-1}ms^{-1}$	Mean	PL
15235	$Q \times W$ (WIND GRID)	$kg\ kg^{-1}ms^{-1}$	Mean	PL
15242	W^2 (WIND GRID)	m^2s^{-2}	Mean	PL
16202	GEOPOTENTIAL HEIGHT (=Z)	m	Mean	PL
16203	TEMPERATURE (PRESSURE GRID)	K	Mean	PL
16204	RELATIVE HUMIDITY	%	Mean	PL
16222	PRESSURE AT MEAN SEA LEVEL	Pa	Mean	Single

Table C.3: Standard diagnostics: Six-hourly

STASH code	Description	Units	Time	Domain
10	SPECIFIC HUMIDITY	$kg\ kg^{-1}$	Inst	Vert mean
23	SNOW AMOUNT AFTER TIMESTEP	$kg\ m^{-2}$	Inst	Single
24	SURFACE (SKIN) TEMPERATURE	K	Inst	Single
25	BOUNDARY LAYER (=BL) DEPTH	m	Inst	Single
1207	INCOMING SW FLUX AT TOA	Wm^{-2}	Mean	Single
1208	OUTGOING SW FLUX AT TOA	Wm^{-2}	Mean	Single
2205	OUTGOING LW FLUX AT TOA	Wm^{-2}	Mean	Single
3219	X-COMP OF SURF & BL WIND STRESS	Nm^{-2}	Mean	Single
3220	Y-COMP OF SURF & BL WIND STRESS	Nm^{-2}	Mean	Single
3223	SURFACE & BL MOISTURE FLUXES	Wm^{-2}	Mean	MLB 1
3225	WIND U-COMPONENT AT 10 METRES (WIND GRID)	ms^{-1}	Inst	Single
3226	WIND V-COMPONENT AT 10 METRES (WIND GRID)	ms^{-1}	Inst	Single
8223	SOIL MOISTURE CONTENT IN A LAYER	$kg\ m^{-2}$	Inst	SL 4
8230	FROZEN SOIL MOISTURE FRACTION ($0 \leq x \leq 1$)	—	Inst	SL 4
8231	LAND SNOW MELT RATE	$kg\ m^{-2}s^{-1}$	Mean	Single
8234	SURFACE RUNOFF RATE	$kg\ m^{-2}s^{-1}$	Mean	Single
8235	SUB-SURFACE RUNOFF RATE	$kg\ m^{-2}s^{-1}$	Mean	Single
9206	CLOUD LIQUID WATER CONTENT	$kg\ kg^{-1}$	Inst	Vert mean
9207	CLOUD ICE CONTENT	$kg\ kg^{-1}$	Inst	Vert mean
15226	SPECIFIC HUMIDITY (=Q) (WIND GRID)	$kg\ kg^{-1}$	Inst	PL 17
16202	GEOPOTENTIAL HEIGHT (=Z)	m	Inst	PL 17
16203	TEMPERATURE (PRESSURE GRID)	K	Inst	PL 17

Table C.4: Standard diagnostics: Three-hourly

STASH code	Description	Units	Time	Domain
1	SURFACE PRESSURE	Pa	Inst	Single
1201	NET DOWN SURFACE SW FLUX	Wm^{-2}	Mean	Single
1235	TOTAL DOWNWARD SURFACE SW FLUX	Wm^{-2}	Mean	Single
2201	NET DOWN SURFACE LW FLUX	Wm^{-2}	Mean	Single
2204	TOTAL CLOUD FRACTION ($0 \leq x \leq 1$)	—	Mean	Single
2207	TOTAL DOWNWARD SURFACE LW FLUX	Wm^{-2}	Mean	Single
3217	SURFACE & BL HEAT FLUXES	Wm^{-2}	Mean	MLB 1
3234	SURFACE LATENT HEAT FLUX	Wm^{-2}	Mean	Single
3236	TEMPERATURE AT 1.5 METRES	K	Inst	Single
3237	SPECIFIC HUMIDITY AT 1.5 METRES	$kg\ kg^{-1}$	Inst	Single
3245	RELATIVE HUMIDITY AT 1.5 METRES	%	Inst	Single
3249	WIND SPEED AT 10 METRES	ms^{-1}	Inst	Single
3250	DEWPOINT AT 1.5 METRES	K	Inst	Single
5205	CONVECTIVE RAINFALL RATE	$kg\ m^{-2}s^{-1}$	Mean	Single
5206	CONVECTIVE SNOWFALL RATE	$kg\ m^{-2}s^{-1}$	Mean	Single
5216	TOTAL PRECIPITATION RATE	$kg\ m^{-2}s^{-1}$	Inst	Single
15201	WIND U-COMPONENT (=U) (WIND GRID)	ms^{-1}	Inst	PL
15202	WIND V-COMPONENT (=V) (WIND GRID)	ms^{-1}	Inst	PL
16222	PRESSURE AT MEAN SEA LEVEL	Pa	Inst	Single

Table C.5: Standard diagnostics: Hourly

STASH code	Description	Units	Time	Domain
1	SURFACE PRESSURE	Pa	Inst	Single
24	SURFACE (SKIN) TEMPERATURE	K	Inst	Single
25	BOUNDARY LAYER (=BL) DEPTH	m	Inst	Single
1201	NET DOWN SURFACE SW FLUX	Wm^{-2}	Mean	Single
1235	TOTAL DOWNWARD SURFACE SW FLUX	Wm^{-2}	Mean	Single
2201	NET DOWN SURFACE LW FLUX	Wm^{-2}	Mean	Single
2204	TOTAL CLOUD FRACTION ($0 \leq x \leq 1$)	—	Mean	Single
3217	SURFACE & BL HEAT FLUXES	Wm^{-2}	Mean	MLB 1
3223	SURFACE & BL MOISTURE FLUXES	Wm^{-2}	Mean	MLB 1
3225	WIND U-COMPONENT AT 10 METRES (WIND GRID)	ms^{-1}	Inst	Single
3226	WIND V-COMPONENT AT 10 METRES (WIND GRID)	ms^{-1}	Inst	Single
3234	SURFACE LATENT HEAT FLUX	Wm^{-2}	Mean	Single
3236	TEMPERATURE AT 1.5 METRES	K	Inst	Single
3237	SPECIFIC HUMIDITY AT 1.5 METRES	$kg\ kg^{-1}$	Inst	Single
3245	RELATIVE HUMIDITY AT 1.5 METRES	%	Inst	Single
3249	WIND SPEED AT 10 METRES	ms^{-1}	Inst	Single
3249	WIND SPEED AT 10 METRES	ms^{-1}	Max	Single
3250	DEWPOINT AT 1.5 METRES	K	Inst	Single
3296	EVAPORATION RATE FROM SOIL SURFACE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
3297	EVAPORATION RATE FROM CANOPY	$kg\ m^{-2}\ s^{-1}$	Mean	Single
3298	SUBLIMATION RATE FROM SURFACE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
4203	LARGE SCALE RAINFALL RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
4204	LARGE SCALE SNOWFALL RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
5205	CONVECTIVE RAINFALL RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
5206	CONVECTIVE SNOWFALL RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
5216	TOTAL PRECIPITATION RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
8023	SNOW MASS	$kg\ m^{-2}$	Mean	Single
8208	AVAIL SOIL MOIST CONT IN ROOT ZONE ⁵	$kg\ m^{-2}$	Inst	Single
8231	LAND SNOW MELT RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
8233	CANOPY THROUGHFALL RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
8234	SURFACE RUNOFF RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
8235	SUB-SURFACE RUNOFF RATE	$kg\ m^{-2}\ s^{-1}$	Mean	Single
16222	PRESSURE AT MEAN SEA LEVEL	Pa	Inst	Single

⁵See appendix H.5

Appendix D

Location and naming convention of diagnostic files produced by PRECIS

The output (or diagnostic) data produced by PRECIS are contained within sub-directories of the directory `$ARCHIVEDIR/RUNID`. The subdirectory names are of the form `STASH.SUFFIX` where `STASH` is the five-digit STASH code of the data contained in the directory (each subdirectory contains data for only one STASH code) and `.SUFFIX` is an optional suffix denoting the nature of any processing which has been done to the data. For time mean data there is no suffix. See the manual for the `ppss` utility (type `ppss -h`) for a full description of the possible suffixes. Example subdirectory names for experiment `RUNID` are:

- `$ARCHIVEDIR/RUNID/00001` contains all surface pressure mean data (STASH code 1) over all meaning periods.
- `$ARCHIVEDIR/RUNID/16202` contains all geopotential height on pressure levels mean data (STASH code 16202) for all pressure levels and over all meaning periods.
- `$ARCHIVEDIR/RUNID/03236.max` contains all 1.5m surface air temperature (STASH code 3236) data which are maxima over any period.

Within these subdirectories, the data are grouped into files according to the meaning period over which the data are valid. These filenames are of the form

`RUNIDa.??DATES.STASH[.SUFFIX].pp`

e.g. `aaadja.pjg02t0.00001.pp`, `aaadja.pjg02t0.16222.inst.pp`

where:

- *RUNID* (characters 1–5) is the 5-letter RUNID of the experiment.
- *a* (character 6) indicates that the file contains data for the surface or atmosphere.
- *??* (characters 8–9) indicate the time period over which the data has been processed. See table D.1.
- *DATES* (characters 10–14) is a five-character string (known as the **UM date stamp** denoting the time or times for which the data are valid. See table D.3
- *STASH* (characters 16–20) is the five-digit STASH code of the data in the file. See appendix C.
- *SUFFIX* (optional) denotes the nature of any processing which has been done to the data. See the manual for the **ppss** utility for possible values.
- *pp* indicates that the structural format of the data within the file is PP format. See appendix E.

Table D.1: *p?* (characters 8–9) values: The time period over which the data has been processed and the amount of data in the file.

??	Description
pa	Timeseries of daily data spanning 1 month (beginning 0z on the 1st day)
pj	Timeseries of hourly data spanning 1 day (0z – 24z).
pm	Monthly average data for 1 month
ps	3-month seasonal average data for 1 season
px	Decadal average data for 1 decade
p1	Period.1 climate average data (when period.1 \neq 1,3,12 or 120 months)
p2	Period.2 climate average data (when period.2 \neq 1,3,12 or 120 months)
p3	Period.3 climate average data (when period.3 \neq 1,3,12 or 120 months)
p4	Period.4 climate average data (when period.4 \neq 1,3,12 or 120 months)
mY	Multiannual mean data spanning Y years (where Y takes a value from D.2)

D.1 The UM date stamp

The UM date stamp denotes the date (or dates) for which the data within a file is valid. It can take two generic forms:

YYMMM or YYMDH

where *YY* gives the year and *MMM*, or *MDH* gives the date, month or season of that year. *YY*, *MMM* and *MDH* take values from table D.2 as follows:

YY: The year valid at either the beginning or end of data in the file. The first *Y* gives the number of whole decades since 1800 (any value from 0 to z from table D.2 allowed) and the second *Y* gives the number of years within the current decade (any value from 0 to 9). E.g. year *j1* = 1800 + (19 × 10) + 1 = 1991, year *s0* = 1800 + (28 × 10) + 0 = 2080.

MMM gives either a month (e.g. *MMM* = *jan* = January) or season (e.g. *MMM* = *jja* = June, July, August).

MDH specifies a month (*M*), a day (*D*) of that month and an hour (*H*) of that day:

M may take any value from 1 to c from table D.2

D may take any value from 1 to v from table D.2

H may take any value from 0 to n from table D.2

Table D.2: Single letter date stamp equivalences

0 → 0	a → 10 (oct)	k → 20	u → 30
1 → 1 (jan)	b → 11 (nov)	l → 21	v → 31
2 → 2 (feb)	c → 12 (dec)	m → 22	w → 32
3 → 3 (mar)	d → 13	n → 23	x → 33
4 → 4 (apr)	e → 14	o → 24	y → 34
5 → 5 (may)	f → 15	p → 25	z → 35
6 → 6 (jun)	g → 16	q → 26	
7 → 7 (jul)	h → 17	r → 27	
8 → 8 (aug)	i → 18	s → 28	
9 → 9 (sep)	j → 19	t → 29	

Files containing one day's worth of data (*RUNIDa.pi** and *RUNIDa.pj**) will have a UM date stamp of the form *YYMDH*. The time will refer to the *end* of the period for which data in the file is valid.

Files which contain one month's worth of data (*RUNIDa.pa**), files containing monthly means (*RUNIDa.pm**) and files containing 3-month means (*RUNIDa.ps**) will have a UM date stamp of the form *YYMMM*.

Climate meaning files for periods other than one or three months will have a date stamp of the form *YYMDH*. The time will refer to the *end* of the period for which data in the file is valid.

Table D.3: File content and UM date stamp examples (as seen in PRECIS output file names)

pjj22q0	Hourly data timeseries for the day 25th February 1992 i.e. 0z 25/February/1992 (j22p0) to 0z 26/February/1992 (j22q0)
par7jan	Daily data timeseries for the month of January 2077, i.e. 0z 01/January/2077 (r7110) to 0z 01/February/2077 (r7210)
pms9apr	Monthly mean data for the month of April 2089, i.e. 0z 01/April/2089 (s9410) to 0z 01/May/2089 (s9510)
psi8aso	3-month seasonal mean data for months August to October 1988, i.e. 0z 01/August/1988 (i8810) to 0z 01/November/2089 (i8b10)
psi8jja	3-month seasonal mean data for months June to August 1988, i.e. 0z 01/June/1988 (i8810) to 0z 01/September/2089 (i8b10)
pxh0c10	Decadal mean data for the decade <i>ending</i> at 01 December 1970, i.e. 0z 01/Dec/1960 (g0c10) to 0z 01/Dec/1970 (h0c10)
p1g1b10	Period_1 mean data when period_1 \neq 1,3,12 or 120 months. Here, period_1 <i>ends</i> at 0z 01/November/1961
p2g1b10	Period_2 mean data when period_2 \neq 1,3,12 or 120 months, Here, period_2 <i>ends</i> at 0z 01/November/1961
p3g1b10	Period_3 mean data when period_3 \neq 1,3,12 or 120 months, Here, period_3 <i>ends</i> at 0z 01/November/1961
p4g1b10	Period_4 mean data when period_4 \neq 1,3,12 or 120 months, Here, period_4 <i>ends</i> at 0z 01/November/1961
muj0djf	3-month seasonal mean data for the months December to February (DJF) averaged over the 30 (u) year period ending in 1990, i.e. Every DJF from Dec/1960–Feb/1961 (g1djf) to Dec/1989–Feb/1990 (j0djf)

Appendix E

PP header description

Column 1: Word number of PP header (1–45 are integers, 46–64 are reals)

Column 2: Short description of header entry

Column 3: Full description of header entry

1	LBYSR	Year (eg 1986 or 86)	\	
2	LBMON	Month (1-12)		Validity time of field,
3	LB DAT	Day of month (1-31)		- or -
4	LBHR	Hour (0-23)		Start of averaging period (for time
5	LBMIN	Minute (0-59)		mean fields).
6	LB DAY	Day number of run	/	
7	LB YRD	Year (eg 1986 or 86)	\	
8	LB MOND	Month (1-12)		Data time (for forecast fields),
9	LB DATD	Day of month (1-31)		- or -
10	LB HRD	Hour (0-23)		End of averaging period (for time
11	LB MIND	Minute (0-59)		mean fields).
12	LB DAYD	Day number of run	/	
13	LBTIM	Time indicator. This indicates what the times in words 1-12 represent. Referring to the times represented by words 1-6 and 7-12 as 'T1' and 'T2' respectively, LBTIM is coded as $(100*IA + 10*IB + IC)$ where:		

IA = 0 except for time mean fields in which case IA is the time interval in hours between the individual fields from which the mean was computed (IA may be left as zero for time-means to indicate that the time interval

is unspecified).

IB = 0 if only the validity time (T1) is valid.
= 1 if the field is a forecast from T2 valid at T1.
= 2 if the field is a time mean between T1 and T2,
or represents a sequence of times between T1
and T2.
= 3 if the field is a time mean from T1 to T2 for
each year from LBYR to LBYRD.
= 4 if the field is a difference between fields
valid at T1 and T2 (in sense T2-T1).
= 5 if the field is a mean daily cycle between
T2 and T1

IC = 0 if 'model time' is used for T1 and T2 (i.e. only day
number, hour and minute are set).
= 1 if the 'real' (i.e. Gregorian) calendar is used for T1
and T2.
= 2 if the '360-day' year calendar (i.e. 12 30-day months)
is used for T1 and T2. (This is used in Met.0.20 for
some model runs.)
= 3 if 'model time' is used for T1 and T2 (i.e. only day
number, hour and minute are valid; year, month and
day in month are to be ignored if set).

'IC' corresponds to the parameter MCAL in COMCON.

If 'IC' is 1 or 2, coding of the 'day numbers' (words 6 and 12)
is optional: code as 0 if not used.

- 14 LBFT Forecast period (hours).
- 15 LBLREC Length of data record in words (including any 'extra data').
- 16 LBCODE Grid code. This indicates the type of grid and is coded as:
- 1 Regular latitude/longitude grid.
 - 2 Regular lat/long grid boxes (grid points are box centres).
 - 3 Polar stereographic grid.
 - 4 Spectral coefficients.
 - 7 Mercator grid.
 - 8 Plane polar grid.
 - 9 Plane Cartesian grid.

For grids with non-standard polar axis, add 100 to the above numbers.

For cross sections, code as (10000 + 100*IX + IY) where IX and IY are codes for the x- and y-axes from the list below. Cross section fields indicated in this way must contain x- and y-coordinate vectors in the extra data. The following was not implemented on the IBM version. When LBCODE is coded as 30000 + 100*IX + IY, with IX and IY from the same list, the axes are given the same interpretation as for a normal cross section, but coordinate vectors need not be supplied. In this case, however, the field is not regarded as a cross section by PP cross-section routines.

Axis codes are as follows:

- 0 Sigma (or eta, for hybrid coordinate data).
- 1 Pressure (mb).
- 2 Height above sea level (km).
- 3 Eta (U.M. hybrid coordinates) only.
- 4 Depth below sea level (m).
- 5 Model level.
- 6 Theta.
- 7 Sigma only.
- 8 Sigma-theta.
- 10 Latitude (degrees N).
- 11 Longitude (degrees E).
- 12 (Horizontal) distance (km).
- 13 Site number (set of parallel rows or columns eg time series)
- 20 Time (days). (Gregorian calendar (not 360 day year) if distinction applicable)
- 21 Time (months).
- 22 Time (years).
- 23 Time (model days with 360 day model calendar)
- 31 Logarithm to base 10 of pressure in mb.
- 40 Pseudolevel
- 99 Other.

17 LBHEM Hemisphere indicator. For geographical grids (lat/long, polar stereographic, Mercator or 'Kurihara' grids), this is coded as:

- 0 Global field (i.e. covering the WHOLE globe).

- 1 Northern hemisphere polar stereographic grid, or other geographic grid covering the WHOLE northern hemisphere.
- 2 Southern hemisphere polar stereographic grid, or other geographic grid covering the WHOLE southern hemisphere.
- 3 Limited area of globe without 'wrap-around' (i.e. NOT covering the full 360-degree longitude range).
- 4 Limited area of globe with 'wrap-around' (i.e. covering the full 360-degree longitude range).

For SPECTRAL COEFFICIENTS, code 0, 1 or 2 as appropriate.

For CROSS-SECTION FIELDS, a value of 3 should be coded.

For GRAPH FIELDS, a value of 5 should be coded.

For LATERAL BOUNDARY DATA a value of 99 should be coded.

- 18 LBRW Number of rows in field.
(For spectral coefficients, code the 'n' truncation level.)
- 19 LBNPT Number of grid points in each row.
(For staggered grids, code values appropriate for the longest row. For spectral coefficients, code the 'm' truncation level.)
- 20 LBEXT Length of 'extra data' (x- and y-vectors for cross sections, and field title if any) in words.
- 21 LBPACK Packing method indicator (for fields in packed format.)
- 0 Field not packed
 - 1 Field packed using WGDOS archive method
 - 2 \ Note: 2 had been noted as "reserved for GRIB
 - 3 / code data" but the UM has used 3 for GRIB.
 - 4 Run length encoded field (Ocean)
 - 2000 unpacked Cray data
 - 2001 packed Cray data
- 22 LBREL Header release number. (Set to 2 for format described here.)
- 23 LBFC Field code. This indicates what the data in the field represents
Some of the more common field codes are listed below.
- | | |
|------------------------------|-----------------------------|
| 1 Height field | 73 Relative vorticity field |
| 8 Pressure field | 74 Divergence field |
| 16 Temperature field | 88 Relative humidity field |
| 40 Vertical velocity (dp/dt) | 90 Total Precipitation |

56 Westerly wind component 95 Specific humidity field
57 Southerly wind component

24 LBCFC Second field code. This is only used for a field which is a combination of two field types; for example, a meridional temperature flux field (a product of V and T). Coding is as for the field code above.

25 LBPROC Processing code. This indicates what processing has been done to the basic field. It should be 0 if no processing has been done: otherwise add together the relevant numbers from the list below:

1 Difference from another experiment.
2 Difference from zonal (or other spatial) mean.
4 Difference from time mean.
8 X-derivative (d/dx).
16 Y-derivative (d/dy).
32 Time derivative (d/dt).
64 Zonal mean (or spatially smoothed) field.
128 Time mean field.
256 Product of two fields.
512 Square root of a field.
1024 Difference between fields at levels BLEV and BRLEV.
2048 Mean over layer between levels BLEV and BRLEV.
4096 Minimum value of field during time period.
8192 Maximum value of field during time period.
16384 Magnitude of a vector, not specifically wind speed
32768 log₁₀ of a field.
65536 Variance of a field.
131072 Mean over an ensemble of parallel runs.
262144 Field has been band pass filtered
524288 Field has been low pass filtered

(For details of BLEV and BRLEV, see words 32 and 33.)

26 LBVC Vertical co-ordinate type. The 'vertical co-ordinate' is the one which has the same value at every grid point; e.g. 'pressure' for a 500mb height field or 'longitude' for a zonal mean cross section. The co-ordinate type is coded using the table of field codes as for word 23. Numbers 126-139 are used for special levels. The most common vertical co-ordinate types are:

1	Height (m)	8	Pressure (mb)
9	Hybrid p co-ordinates	10	Sigma (=p/p*)
65	Hybrid height co-ordinates		
128	Mean sea level	129	Surface
130	Tropopause level	131	Maximum wind level
132	Freezing level	142	Upper hybrid level
143	Lower hybrid level	176	Latitude (deg)
177	Longitude (deg)		

- 27 LBRVC Vertical co-ordinate type for reference level. Used only when a reference level is applicable as in thickness fields or layer mean fields. Coded as above. Set to 0 by the U.M. if no reference level.
- 28 LBEXP Experiment identification
- CLIMATE MODEL
- This word contains the 5-character experiment and job name in a form encoded by the UM subroutine EXPT_ENC.
- 29 LBEGIN (For fields on direct access datasets only) Address of start of field in direct access dataset.
- 30 LBNREC (For fields on direct access datasets only) Number of records occupied by field on direct access dataset.
- 31 LBPROJ (For Met Office fields file use) Fields file projection number.
- 32 LB TYP (For Met Office fields file use) Fields file field type code.
- 33 LB LEV (For Met Office fields file use) Fields file level code.
7777 = multi-level field in lateral boundary data.
- 34-37 LBRSVD(4) Reserved for future PP-package use.
- 38 LBSRCE In Met Office Unified Model, set to 1111 to indicate items 39-43 are in use as below. Otherwise, spare for user's use.
- 39-45 In the PP package in general, these words are available for the user's own purposes, and can be accessed as the integer array LBUSER or the real array BUSER. In the Met Office Unified Model, they are regarded as integer and have the

purposes described below.

- 39 LBUSER(1) In Met. Office Unified Model: Indicator for datatype, currently 1 (REAL data) for all output fields; fields of INTEGER/LOGICAL type will not be available until further development work on the diagnostic system is undertaken, as FIELDCOS does not handle them.
- 40 LBUSER(2) In Met. Office Unified Model: Start address in DATA
- 41 LBUSER(3) In Met. Office Unified Model: Unused at versions .GE. 4.0;
- 42 LBUSER(4) In Met. Office Unified Model: STASH code - section number*1000 + STASHmaster item number
- 43 LBUSER(5) In Met. Office Unified Model: Pseudolevel number for fields which have pseudolevel defined
- 44 LBUSER(6) In Met. Office Unified Model: Unused
- 45 LBUSER(7) In Met. Office Unified Model: IM_IDENT (internal model identifier) at versions .GE 4.1
- 46 BRSVD(1) Vertical coordinate of the higher boundary of layer ("higher" being in the direction of increasing model level number). For hybrid p coords (lbvc=9), this is the 'B'-value of the level. For hybrid height (lbvc=65) this is 'zsea' of the level, the height above sea points for the field. The word is referred to as BULEV in the Unified Model.
- 47 BRSVD(2) For hybrid p coords (lbvc=9), this is the 'A'-value of the vertical coordinate of the higher boundary of the layer. For hybrid height (lbvc=65) this is the 'C'-value of the upper boundary. This word is referred to as BHULEV in the Unified Model.
- 48 BRSVD(3) Reserved for future PP-package use.
- 49 BRSVD(4) Reserved for future PP-package use.
- 50 BDATUM Constant value subtracted from each value in field. This is

usually zero but would be 273.15 for a temperature field in degrees Celsius.

- 51 BACC (Packed fields only) Packing accuracy.
- 52 BLEV Level. This is the value of the vertical co-ordinate LBVC (word 26) appropriate for the field; e.g. '500.0' for a 500 mb height field. For hybrid p levels code the 'B'-value of the level. For hybrid height levels this is 'zsea' for the level. BLEV should be zero if the vertical co-ordinate type is in the range 128 to 139.
- 53 BRLEV EITHER
- Reference level. This is the value of the vertical co-ordinate LBRVC (word 27) appropriate for the field. It is used when a second level is relevant as for example with thickness fields when the 'reference level' should be the one nearest the ground. Code as for BLEV.
- OR
- Vertical coordinate of the lower boundary of layer ("lower" being in the direction of decreasing model level number). For hybrid p coordinates, code the 'B'-value of the level. For hybrid height coords, code the 'zsea'-value of the level.
- 54 BHLEV (Hybrid p levels): 'A'-value of level.
(Hybrid height levels): 'C'-value of level
- 55 BHRLEV (Hybrid levels): 'A'-value of the reference level or the lower boundary of the layer.
(Hybrid height levels): 'C'-value of the lower boundary of the layer.
- 56 BPLAT Real latitude of 'pseudo' N pole of projection. Code as '90.0' for fields on grid with normal polar axis.
- 57 BPLON Real longitude of 'pseudo' N pole of projection. Code as '0.0' for fields on grid with normal polar axis.
- 58 BGOR \
- 59 BZY | These five parameters define the grid for the field.
- 60 BDY | The coding depends on what type of grid the field is on.

61 BZX | Details for various types follow:
62 BDX /

(i) Latitude/longitude grids.
~~~~~

BGOR Not used - set to zero.  
BZY Latitude of 'zeroth' row (i.e. an imaginary row one grid length before the first row) in degrees (north positive).  
BDY Latitude interval between rows in degrees (negative if rows are north to south).  
BZX Longitude of 'zeroth' point in row (i.e. an imaginary point one grid length before the first point) in degrees (east positive).  
BDX Longitude spacing of points in each row in degrees (negative if points run from east to west).

(ii) Polar stereographic grids.  
~~~~~

BGOR Grid orientation. This is the longitude in degrees of the meridian which would be vertical with north at the top on a chart drawn for the grid.
BZY Reference latitude in degrees (see BDY).
BDY Grid length in metres at reference latitude.
BZX 'X' co-ordinate | \ These co-ordinates are in grid lengths (not necessarily whole numbers and not of the pole. | necessarily representing a point within the area covered by the grid)
BDX 'Y' co-ordinate | / counting the bottom left grid point of of the pole. | a chart as the point (1.0, 1.0).

(iii) Mercator grids.
~~~~~

For Mercator grids, the coding is the same as in (i) except that BZY and BDY are values of:

$$(\text{earth's radius}) * \log((1+\sin(\text{latitude}))/\cos(\text{latitude}))$$

instead of latitude. (The earth's radius is in metres and 'log' refers to the natural logarithm.)

(iv) Cross sections.  
~~~~~

For cross-section grids, coding is as in (i) above except that BZY and BDY are values of the 'y' co-ordinate and BZX and BDX are values of the 'x' co-ordinate. (Note that for zonal mean fields or cross sections along a meridian, BZX and BZY are longitudes.) If the cross section is

on irregularly spaced levels, BZY and BDY should both be zero.

(v) Graph fields.

~~~~~  
For graph fields, coding is as in (i) above except that BZX and BDX are values of the 'x' co-ordinate, and BDY and BZY are both coded as 1.0. If points on the graphs are not evenly spaced in the 'x' co-ordinate, BZX and BDX should both be coded as zero.

(vi) Spectral coefficients.

~~~~~  
BGOR Not used - coded as zero.
BZY Not used - coded as zero.
BDY Not used - coded as zero.
BZX Reference longitude - usually 0.0. This is the meridian which is treated as the origin of longitude for the coefficients.
BDX Not used - coded as zero.

- 63 BMDI Value used in the field to indicate missing data points. If the field contains no missing data, code a value of -1.0E30.
- 64 BMKS MKS scaling factor, equal to the size of the unit in which the field is expressed divided by the corresponding mks unit. (e.g. 10.0 for height in dam, 100.0 for pressure in mb, 0.01 for relative humidity in % etc.).

Appendix F

Horizontal and Vertical resolution

F.1 Horizontal resolution

The PRECIS model’s ‘horizontal’ resolution is specified as a fixed number of degrees in both directions (i.e. north-south and east-west relative to the rotated pole).

An Arakawa B grid layout is used, in which wind variables (said to be on the ‘wind grid’) are offset from all other variables (said to be on the ‘pressure grid’) by half a grid box in both directions.

The wind grid has the same number of points in the east-west direction as the pressure grid, but one less in the north-south direction.

The wind variables are marked ‘WIND GRID’ in the diagnostic output tables C.1, C.2, C.3, C.4, and C.5.

F.2 Vertical resolution

The PRECIS model is solved on 19 atmospheric levels in the vertical. The vertical coordinates are of the **hybrid** (or η) type. In this coordinate system the position of each vertical level (at each horizontal point) is defined as a linear combination of a terrain-following σ -coordinate and an atmospheric pressure based coordinate:

- Each η level, k ($k = 1, \dots, 19$) is a linear combination of pressure and terrain-following coordinates given by the formula

$$\eta_k = (\mathbf{A}_k/10^5\text{Pa}) + \mathbf{B}_k$$

where the coefficients A_k and B_k are given in table F.1.

- The bottom four levels of the atmosphere (levels 1–4, closest to the surface) are purely terrain following.
- The top three levels of the atmosphere (levels 17–19, top of atmosphere) are purely pressure levels.
- The pressure of each model layer, k ($k = 1, \dots, 19$) varies in the in the horizontal and is given by

$$p_k = A_k + (B_k p^*)$$

where p^* is the surface pressure (STASH code 1) and A_k, B_k are the components of the hybrid coordinate given in table F.1.

- The vertical coordinate value of a data field in PP format is encoded in words 46,47 and 52 of the PP header (see appendix E).

The hybrid coordinates for each vertical level (and also the boundaries between each level) are given in table F.1.

Note that certain diagnostic variables are output directly onto pressure levels. See appendix C.

Table F.1: Hybrid values of the PRECIS model vertical coordinate system

Layer	A (Pa) layer centre	A (Pa) layer boundary	B layer centre	B layer boundary	Hybrid coordinate $\eta = (A/10^5\text{Pa}) + B$
TOA		0.005×10^4		0.000	0.0005
19	0.046×10^4		0.000		0.005
		0.100×10^4		0.000	0.010
18	0.148×10^4		0.000		0.015
		0.200×10^4		0.000	0.020
17	0.296×10^4		0.000		0.030
		0.400×10^4		0.000	0.040
16	0.553×10^4		0.002		0.057
		0.718×10^4		0.003	0.075
15	0.886×10^4		0.011		0.100
		1.065×10^4		0.018	0.125
14	1.180×10^4		0.031		0.149
		1.300×10^4		0.045	0.175
13	1.366×10^4		0.063		0.200
		1.434×10^4		0.082	0.225
12	1.458×10^4		0.104		0.250
		1.482×10^4		0.127	0.275
11	1.469×10^4		0.153		0.300
		1.456×10^4		0.179	0.325
10	1.401×10^4		0.215		0.355
		1.345×10^4		0.251	0.385
9	1.232×10^4		0.299		0.422
		1.118×10^4		0.348	0.460
8	0.947×10^4		0.410		0.505
		0.773×10^4		0.473	0.550
7	0.581×10^4		0.541		0.599
		0.385×10^4		0.611	0.650
6	0.241×10^4		0.675		0.699
		0.094×10^4		0.741	0.750
5	0.047×10^4		0.788		0.793
		0.000×10^4		0.835	0.835
4	0.000×10^4		0.870		0.870
		0.000×10^4		0.905	0.905
3	0.000×10^4		0.930		0.930
		0.000×10^4		0.956	0.956
2	0.000×10^4		0.975		0.975
		0.000×10^4		0.994	0.994
1	0.000×10^4		0.997		0.997
Surface		0.000×10^4		1.000	1.000

Appendix G

Command line utilities

There are useful command line utilities which give the user greater flexibility when running the PRECIS model and managing and analyzing data. They exist in the directory `$UPATH` (see section B.2), which should already be defined in your environment's `$PATH` variable.

Name	Description and Usage
bigend	Byte swap a 32-bit or 64-bit binary file. [Call with no command line arguments for usage information.]
convpp	Convert a UM format file to a PP format file. [USAGE: convpp file1 file2]
cumf	Compare two UM format files at the bit level. [USAGE: cumf file1 file2]
killrcm	Kill a PRECIS experiment. The experiment should be restartable (with restart), but probably from a model date, within the current model month, previous to when it was killed. [Usage: killrcm RUNID]
convpp	Convert a UM format file to a PP file.
cumf	Compare two UM format files.
killrcm	Kill a PRECIS experiments, without waiting to produce safe restart conditions.
lbc_create	Create a lateral boundary condition (LBC) file from 32-bit PP data.
pp2ascii	See section 6.3.2
pp2ctl	See section 6.4.1
ppaggregate	See section 6.3.2
ppdata	See section 6.3.2
ppdf2tcrit	See section 6.3.2
ppendian	See section 6.3.2
ppexpr	See section 6.3.2
ppextract	See section 6.3.2
ppfile	See section 6.3.2
ppll	See section 6.3.2
ppmerge	See section 6.3.2
ppmove	See section 6.3.2
ppregrid	See section 6.3.2
pprr	See section 6.3.2
ppss	See section 6.3.2
pumf	Print a summary of contents of a UM format file.
restart	Start or restart a UM experiment as an NRUN or CRUN, whichever is appropriate.
runtime	Report on the current status and progress of an UM experiments.
stash	See section 6.3.2
stoprun	Stop the a UM experiment run cleanly at the next dump.
pumf	Print a summary of fields in a UM format file. Usage: pumf file
real2um	Convert a real date to a UM format date
restart	Start or restart PRECIS.
rerun	Rerun a section of a completed PRECIS experiment.
runtime	Monitor PRECIS experiments.
stoprun	Stop a PRECIS experiment cleanly (i.e. in a manner which allows the experiment to be restarted from exactly the point at which it stopped). The model will always complete the model day it is in before stopping. [USAGE: stoprun RUNID]
um2real	Convert a UM date to a real date
xconv	Graphically display UM, PP, NetCDF and GRIB format data

Appendix H

Soil and Land cover in MOSES I

H.1 Source data

In MOSES I¹, the model parameters which describe soil and land cover (typically vegetation) properties are calculated as geographically varying functions of the soil and land cover types specified in the datasets created by Wilson and Henderson-Sellers², hereafter referred to as WHS. The WHS datasets have global coverage and contain present day, climatological annual mean data on a $1^\circ \times 1^\circ$ grid. Details on how these source data are transformed into model parameters may be found in UM Documentation Paper 70 (vn4.0).

H.2 Soil

WHS define 22 different soil types (one of which is ice) according to colour, texture and drainage characteristics as listed in table H.2. The drainage characteristics are ignored within PRECIS. The texture has been used to define the hydrological and thermal properties of the soil and the colour has been used to define the bare soil albedo, used in the calculation of the snow free albedo.

The three colour and three texture classes from table H.2 are fully defined in the original WHS paper (see section H.1), but an approximate summary is:

light: light in colour when dry and either light or medium in colour when wet

medium: medium colour characteristics for all moisture states

¹UMDP 25: Canopy, Surface and Soil Hydrology (MOSES I)

²Wilson, M.F. and Henderson-Sellers, A. (1985). 'A global archive of land cover and soils data for use in general circulation climate models'. *Journal of Climatology*, **5**, pp119–143

dark: dark in colour when wet and medium or dark in colour when dry

fine: high in clay, low in silt

intermediate: low in clay

coarse: very low in clay, high in sand, low in silt

H.3 Land cover

WHS define 53 vegetation types as listed in table H.3. For each grid box WHS specify two codes, a primary land cover type and a secondary type which occupy greater and lesser extents of a grid box respectively. See table H.1 for definitions. The land cover type is used in the calculation of the the model parameters determining the surface albedo and surface roughness length as well as the hydraulic properties of the roots and the vegetated canopy.

Table H.1: Grid box coverage for primary and secondary land cover types

Land cover type (x)	Coverage of grid box
Primary	$50\% \leq x \leq 100\%$
Secondary	$25\% \leq x < 50\%$

H.4 Notes on usage for overriding the default soil and land cover types

1. See section 4.1.13 for the circumstances in which overrides to soil and land cover types are appropriate.
2. For each grid box where overrides are being applied, a soil type and both primary and secondary land cover types must be specified. All permissible soil and land cover types are denoted by integer codes, which are specified in tables H.2 (soil) and table H.3 (land cover).
3. For grid boxes with mixed land cover types, or where no single type is clearly dominant, choose primary and secondary types which most accurately summarize all component land types. There are a number of mixed categories in the classification (e.g. 35 = pasture + tree (see table H.3)) and it is possible to choose the same category for both types.

4. When using the urban land cover type (code 80) it must be noted that though this will certainly have an effect on the simulation (e.g. surface to atmosphere water flux rates will be very low) but the effects are **not** to be taken as being representative of a genuine climate change response for an urban environment.
5. Primary and secondary land cover types of 0 (open water) and 1 (inland water) are possible. These may be applicable to:
 - a) coastal land grid boxes
 - b) land grid boxes adjacent to resolved inland waters
 - c) land grid boxes over resolved or non-resolved inland waters. In this case, in particular, we can represent some of the surface to atmosphere water fluxes we would expect over inland waters without the problem of incorrect water surface temperatures (see section 4.1.10 for more details).
6. Soil and land cover types for a particular latitude, longitude location in the WHS source data do not necessarily correspond to the default parameter values on the RCM's grid. The correspondence will be high for RCM land grid boxes which lie inside land grid boxes of the WHS source data, but low for RCM land grid boxes which lie inside sea grid boxes of the WHS source data.
7. To find out the WHS dataset (global coverage, $1^\circ \times 1^\circ$ gridded data) soil and land cover types for a particular location within the regional model's domain, use the "WHS" button in the vegetation and soil editing window (see section 5.2.2 and figure 5.6). For any location globally, the command:


```
$> query_whs longitude latitude
```

will report that location's soil and land cover characteristics.

Note that sea grid boxes in the source data are characterized in the output of `query_whs` by a soil type of "undefined".
8. Inserting ice points adjacent to existing ice areas is acceptable, but inserting isolated ice points should be avoided, as their dynamics may become decoupled from their surrounding non-ice land points.
9. To avoid internal inconsistencies, if a point is land ice in either of the RCM's soil or land cover fields, then that point is set to land ice in both datasets. No explicit notice will be given in this case, but a warning will be given in the file `$TMPDIR/RUNID.vegsoil`, which is created at the start of the model simulation. The warning will look like:

Setting point N to land ice in veg
or
Setting point N to land ice in soil

Table H.2: WHS Soil codes and their properties

Code	Colour	Texture	Drainage
11	light	coarse	free
12	light	intermediate	free
13	light	fine	free
14	light	coarse	impeded
15	light	intermediate	impeded
16	light	fine	impeded
17	medium	coarse	free
18	medium	intermediate	free
19	medium	fine	free
20	medium	coarse	impeded
21	medium	intermediate	impeded
22	medium	fine	impeded
23	dark	coarse	free
24	dark	intermediate	free
25	dark	fine	free
26	dark	coarse	impeded
27	dark	intermediate	impeded
28	dark	fine	impeded
29	light	—	poor
30	medium	—	poor
31	dark	—	poor
34	ice	—	—

Table H.3: WHS land cover classes

Code	Land cover description
00	open water
01	inland water
02	bog or marsh
03	ice
04	paddy rice
05	mangrove (tree swamp)
10	dense needleleaf evergreen forest
11	open needleleaf evergreen forest
12	dense mixed evergreen + deciduous forest
13	open mixed evergreen + deciduous woodland
14	evergreen broadleaf woodland
15	evergreen broadleaf cropland
16	evergreen broadleaf shrub
17	open deciduous needleleaf woodland
18	dense deciduous needleleaf forest
19	dense evergreen broadleaf forest
20	dense deciduous broadleaf forest
21	open deciduous broadleaf woodland
22	deciduous tree crops (temperate)
23	open tropical woodland
24	woodland + shrub
25	dense drought deciduous forest
26	open drought deciduous woodland
27	deciduous shrub
28	thorn shrub
30	temperate meadow + permanent pasture
31	temperate rough grazing
32	tropical grassland + shrub
33	tropical pasture
34	rough grazing + shrub
35	pasture + tree
36	semi arid rough grazing
37	tropical savanna (grassland + tree)
39	pasture + shrub
40	arable cropland
41	dry farm arable
42	nursery + market gardening
43	cane sugar
44	maize
45	cotton
46	coffee
47	vineyard

continued on next page

Table H.3: *WHS land cover classes, continued*

Code	Land cover description
48	irrigated cropland
49	tea
50	equatorial rain forest
51	equatorial tree crop
52	tropical broadleaf forest (slight seasonality)
61	tundra
62	dwarf shrub (tundra transition + high altitude wasteland)
70	sand desert + barren land
71	shrub desert + semi desert
73	semi desert + scattered trees
80	urban

H.5 Definition of 'Available soil moisture in the root zone' (STASH code 8208)

The root zone is the depth of soil from the surface in which plant roots are able to extract soil moisture. This constant-in-time root depth is set differently for each surface grid box and is a function of the primary and secondary vegetation types present in each grid box. The root depth is specified in the ancillary file `$ANCILDIR/RUNID/qrpm.veg` and has STASH code 51.

For surface each grid box, the root depth (in metres) is translated to a root zone (number of deep soil levels from the surface, see table H.4) according to the rules specified in table H.5.

The diagnostic 'available soil moisture in root zone' (STASH code 8208) is in fact only the *soil moisture in the root zone which is available for evapotranspiration*, i.e. the amount of unfrozen soil moisture in the root zone above the permanent wilting point of the soil (dependent on soil type, see STASH code 40 in `$ANCILDIR/RUNID/qrpm.soil.moses`). This is clearly different to the total soil moisture content (frozen and unfrozen), which is the sum of all 4 levels of 'soil moisture content in a layer' (STASH code 8223).

Table H.4: Definition of deep soil levels (in metres from the surface).

Level	Thickness (m)	Depth (m)
1	0.10	0.00 to 0.10
2	0.25	0.10 to 0.35
3	0.65	0.35 to 1.00
4	2.00	1.00 to 3.00

Table H.5: Specification of the root zone.

Root depth	Root zone	Plant functional types
> 0.8 metres	levels 1 to 4	Broad and needle leaf trees
< 0.8 metres	levels 1 to 3	C3 and C4 grasses

Appendix I

Soil and Land cover in MOSES 2.2

In MOSES 2.2¹ separate surface temperatures, shortwave and longwave radiative fluxes sensible heat fluxes, ground heat fluxes, canopy moisture contents and snow melt rates are computed for each surface type in a grid box. Nine surface types are recognized (see table I.1). Five of these are plant functional types, i.e. plants grouped according to their function in ecosystems and their use of resources. Fractions of surface types within each land surface grid box are specified in the ancillary file `$ANCILDIR/RUNID/qrpm.veg.frac`. Within this file, the types are distinguished by the values of `LBUSER(5)` in the PP (lookup) headers (see appendix E). The area of a grid box covered by an individual type is known as a *tile*. Note that an ice tile may only have a grid box fraction of 0 or 1, therefore, grid boxes that have more than a prescribed threshold (normally 50%) of land ice are set to be entirely of land ice.

Vegetation type is determined using data from the International Geosphere and Biosphere Programme (IGBP)². The dataset being used is version 2 on the geographical latitude-longitude projection.

The dataset has been derived from advanced very high resolution radiometer (AVHRR) data covering the period April 1992 to March 1993 and provided at 30 arc-second (approximately 1km) resolution. The data have been classified using various legends and we are using the legend of the IGBP which consists of 17 classes which have been extended to 18 classes by separating 'water bodies' points into inland water and open sea using the dataset created using the Biosphere Atmosphere Transfer Scheme (BATS)³. See in table I.2.

¹UMDP 25: Canopy, Surface and Soil Hydrology (MOSES 2.2)

²http://edcdaac/usgs.gov/glcc/globe_int.html

³Dickinson, R. E., A. Henderson-Sellers and P. J. Kennedy, Biosphere Atmosphere Transfer Scheme (BATS) version 1E as coupled to the NCAR Community Climate Model, NCAR

The method of translation from the IGPB and BATS classes to the MOSES 2.2 types is described in UM Documentation Paper 70 (vn6.6).

Table I.1: Land surface types in MOSES 2.2

Type	STASH code	Pseudo level (LBUSER(5))
Broadleaf trees	216	1
Needleleaf trees	216	2
C ₃ (temperate) grass	216	3
C ₄ (tropical) grass	216	4
Shrubs	216	5
Urban	216	6
Inland water	216	7
Bare soil	216	8
Ice	216	9

Table I.2: The 16 IGBP land types + 2 *BATS* types

Evergreen needleleaf forest
Evergreen broadleaf forest
Deciduous needleleaf forest
Deciduous broadleaf forest
Mixed forest
Closed shrublands
Open shrublands
Woody savannas
Savannas
Grasslands
Permanent wetlands
Croplands
Urban and built-up
Cropland/natural vegetation mosaic
Snow and ice
Barren or sparsely vegetated
<i>Inland water</i>
<i>Open sea</i>

Appendix J

Regridding examples

Figures J.1 and J.2 contain examples of the functionality available with the `ppregrid` utility. See section 6.3.2 for more details on how this command works and how it should be used.

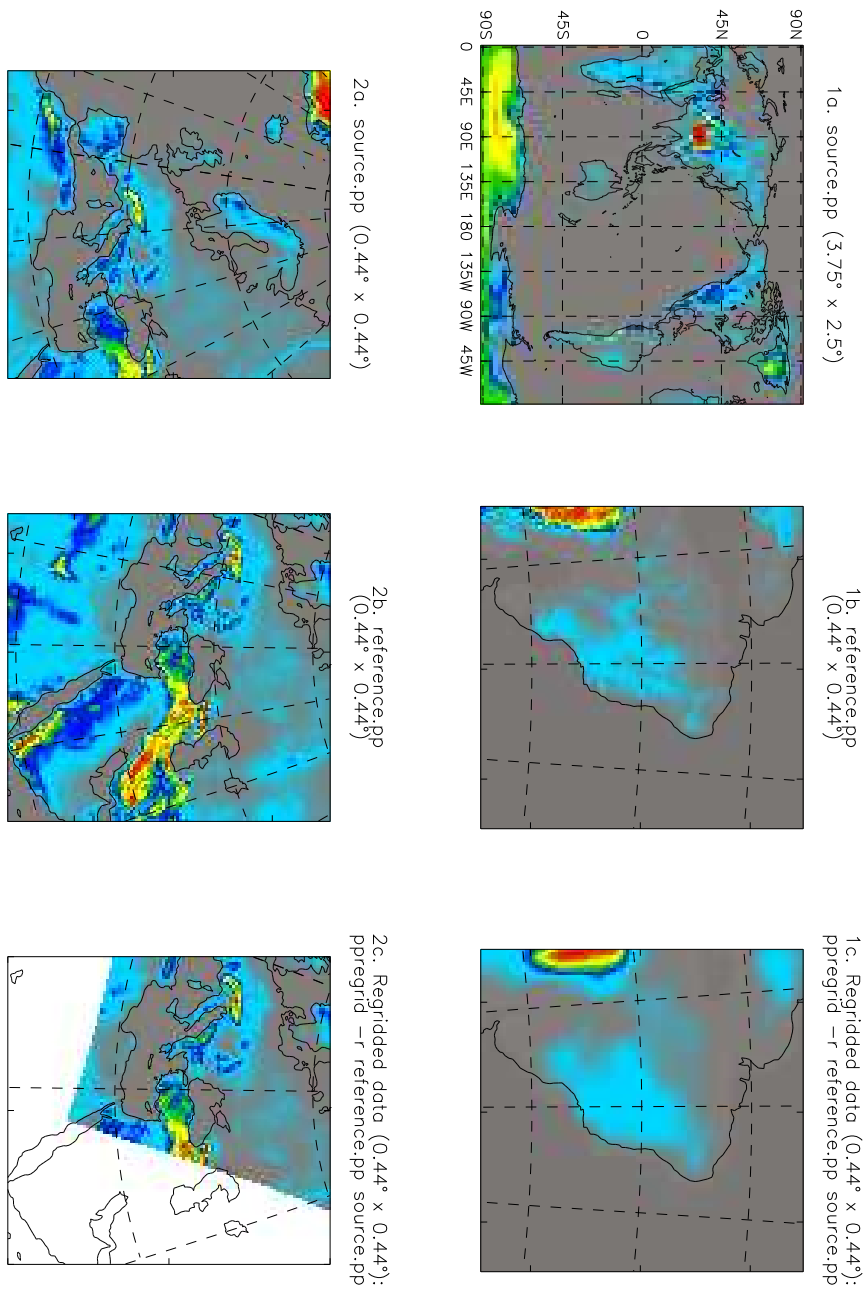


Figure J.1: Regridding examples with `ppregrid`:

1a–1c: Regridding a global field to a limited area, rotated pole grid.

2a–2c: Regridding a limited area rotated pole field to a different, only partially overlapping limited area rotated pole grid.

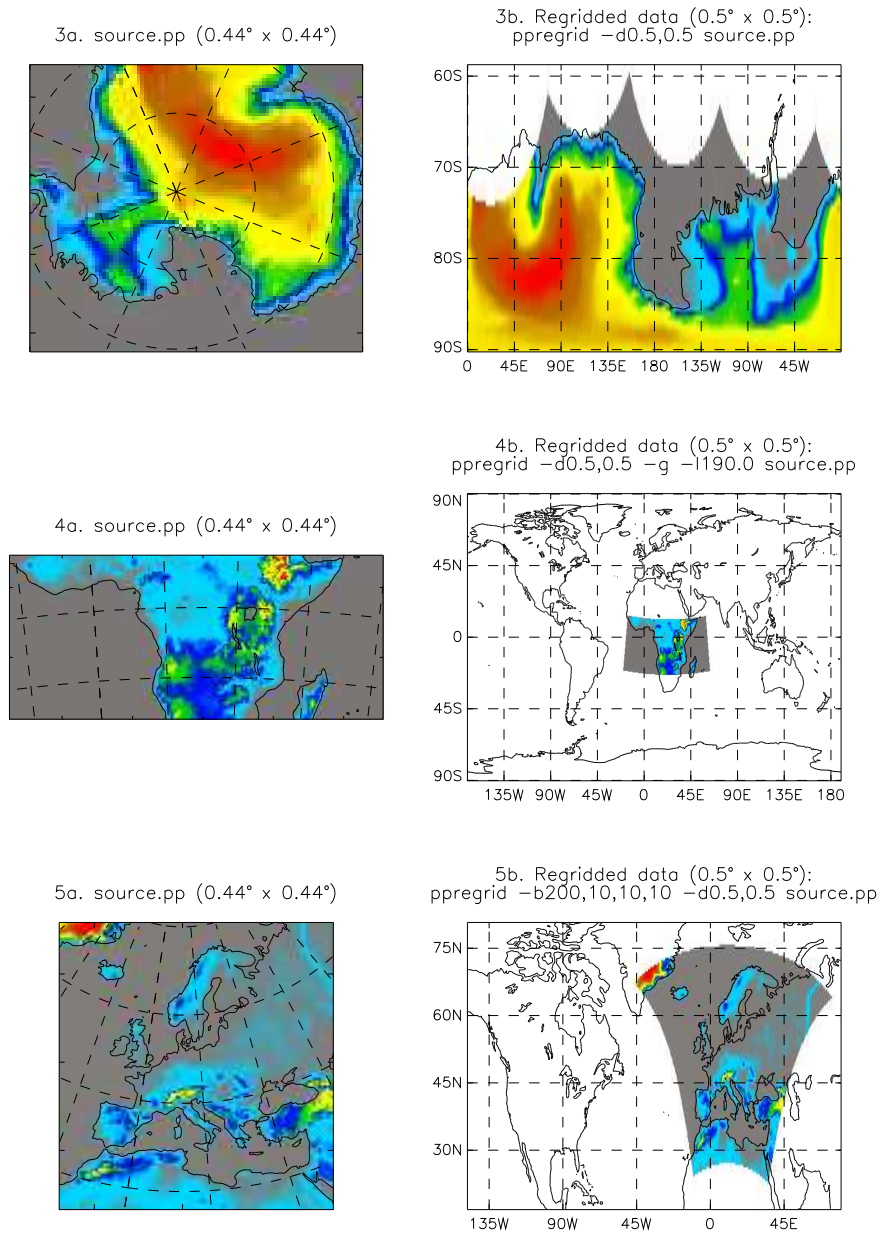


Figure J.2: More regridding examples with `ppregrid`:

3a–3b: Regridding a limited area rotated pole field to a limited area non-rotated pole grid.

4a–4b: Regridding a limited area rotated pole field to global non-rotated pole grid whose left hand edge is at 190.0°E .

5a–5b: Regridding a limited area rotated pole field to limited area non-rotated pole grid which is extended from the source grid's limits by 200 target grid boxes to the west and 10 target grid boxes to the south, east and north.

Appendix K

Aggregation examples

Figures K.1 and K.2 contain examples of the functionality available with the `ppaggregate` utility. See section 6.3.2 for more details on how this command works and how it should be used.

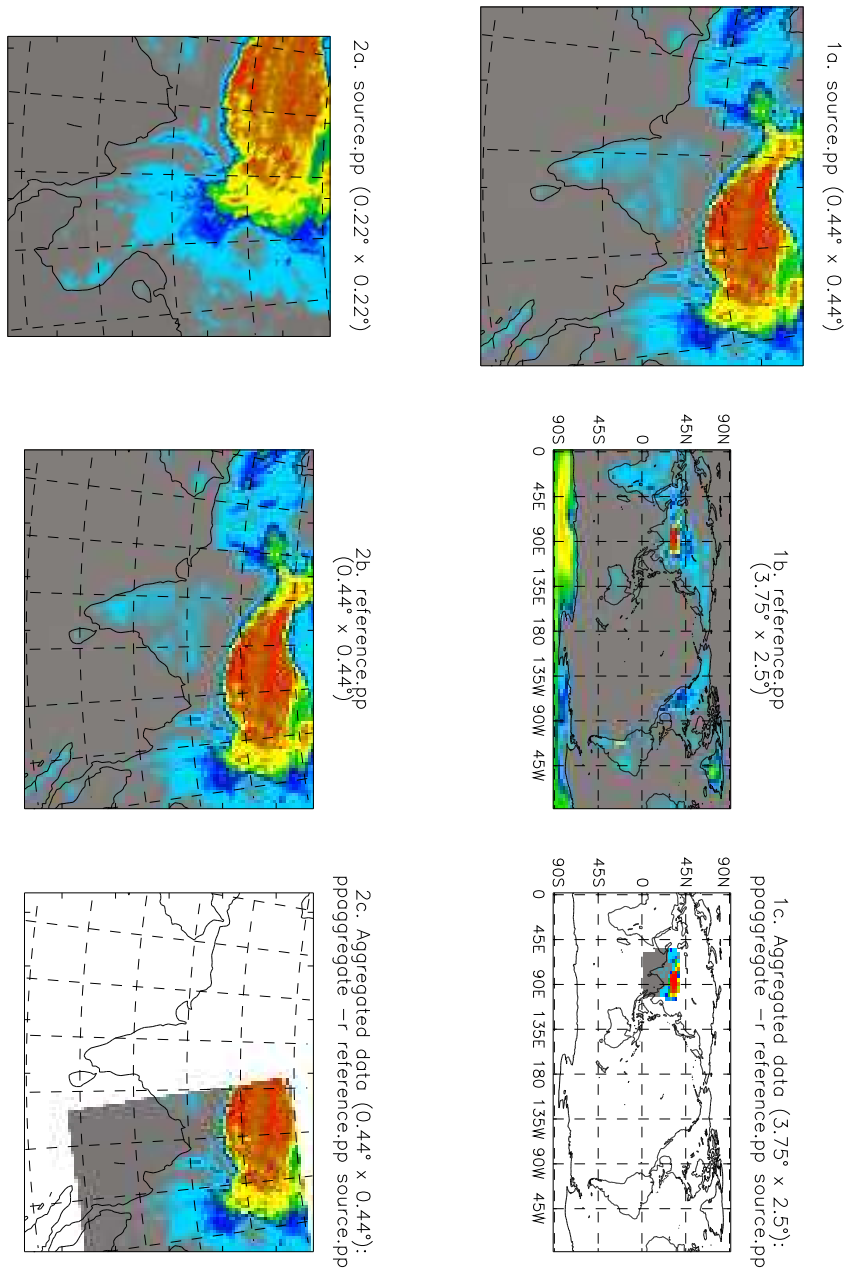


Figure K.1: Aggregation examples with `ppaggregate`:

1a–1c: Aggregating a limited area rotated pole field to a global non-rotated pole grid.

2a–2c: Aggregating a limited area rotated pole field to a different, only partially overlapping limited area rotated pole grid.

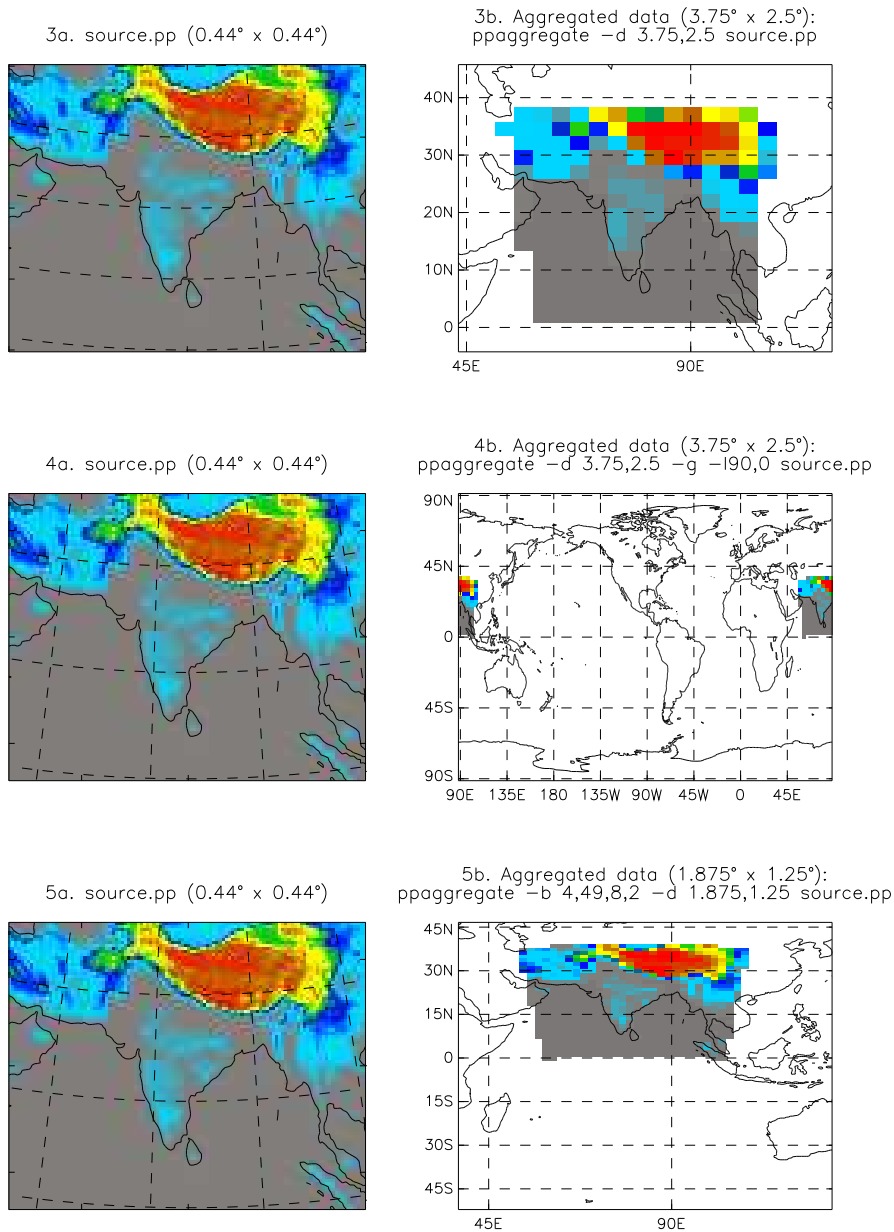


Figure K.2: More aggregation examples with `ppaggregate`:

3a–3b: Aggregating a limited area rotated pole field to a limited area non-rotated pole grid.

4a–4b: Aggregating a limited area rotated pole field to global non-rotated pole grid whose left hand edge is at 90.0°E.

5a–5b: Aggregating a limited area rotated pole field to limited area non-rotated pole grid which is extended from the source grid's limits.

Appendix L

Glossary and acronyms

AMIP : ‘Atmospheric Model Intercomparison Project’¹. An observational data set of SST and sea ice was created for this project. This data set is referred to as the ‘AMIP II’ SST and sea ice boundary conditions².

Ancillary file : File containing prescribed fields required by the PRECIS RCM.

CDAT : ‘Climate Data Analysis Tools’.

CF NetCDF : ‘Climate and Forecast NetCDF’: The standard convention used for NetCDF³ files in PRECIS.

Dump Format : Met Office data format used for dumps and ancillary files, also called UM Format.

GRIB : ‘GRid in Binary’. Binary data standard.

GUI : ‘Graphical User Interface’.

HadISST1 : The Met Office Hadley Centre’s sea ice and sea surface temperature (SST) data set. It is a unique combination of monthly globally-complete fields of SST and sea ice concentration on a 1-degree latitude-longitude grid from 1870 to date.

LBC : ‘Lateral Boundary Condition’.

NetCDF : ‘Network Common Data Form’. The NetCDF libraries define a machine-independent format for representing scientific data.

¹<http://www-pcmdi.llnl.gov/projects/amip/index.php>

²<http://www-pcmdi.llnl.gov/projects/amip/AMIP2EXPDSN/BCS/bcsintro.php>

³<http://www.cgd.ucar.edu/cms/eaton/cf-metadata/>

Orographic : Relating to the physical geography of mountains and mountain ranges.

PP Format : Met Office data format used for output data files.

PCMDI : ‘Program for Climate Model Diagnosis and Intercomparison’ at Lawrence Livermore National Laboratory the World Meteorological Organization.

Portable UM : Version of the UM on which PRECIS is based.

PRECIS : ‘Providing Regional Impacts for Climate Studies’.

RCM : ‘Regional Climate Model’.

SST : ‘Sea Surface Temperature’.

STASH : ‘Spatial and Temporal Averaging and Storage Handling’.

STASH code : A unique positive integer which is assigned to each different output diagnostic variable from the RCM. For example, mean sea level pressure has STASH code 16222. See appendix C for a listing of the standard STASH codes available from PRECIS.

TOA : ‘Top of Atmosphere’. Both the theoretical outer edge of the earth’s atmosphere and also the uppermost boundary of the top atmospheric model level (level 19) (which are not the same thing).

UM : ‘Unified Model’. The name given to the suite of atmospheric and oceanic numerical modelling software developed and used at the Met Office.

UMUI : ‘Unified Model User Interface’.