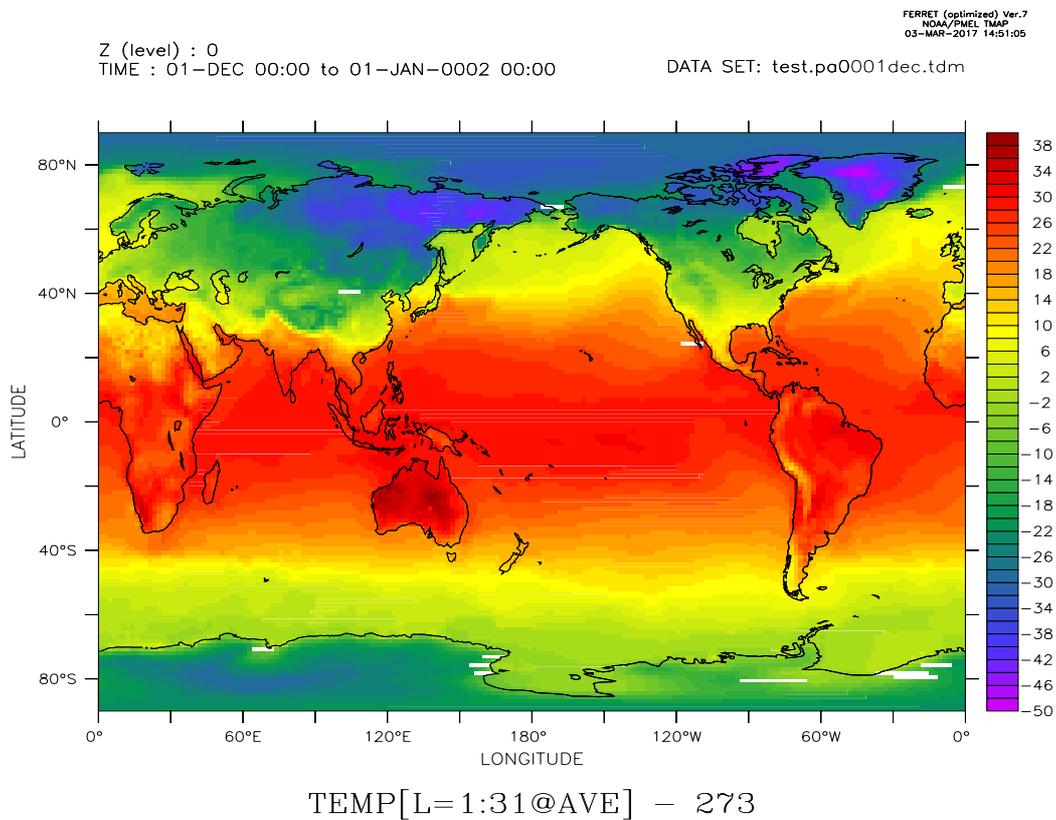


# GETTING STARTED WITH ACCESS-CM2



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# INTRODUCTION

## Background

This document is a beginner's guide to working with the ACCESS coupled model (ACCESS-CM2). It addresses these main areas:

- Getting started
- Running the model
- Model output
- Model input

It is written for a user of the ACCESS-CM2 climate model on NCI. Further, this is not a 'dummies' guide; some basic assumptions have been made concerning the user's familiarity with computer systems.

Feedback is welcome and may be incorporated into future versions.

*Caveat emptor:* Any of the links provided in this document can fail (although working at the time of writing), and many of the websites visited or linked to have some broken URL hyperlinks. Also, there is a degree of duplication across webpages and some inconsistencies.

## Model outline

ACCESS-CM is one of a family of models which have been developed for the purposes of weather forecasting and climate change by CSIRO and partner organisations. The different model arrangements reflect the needs of various operational requirements, researchers and stakeholders. Model details of the CMIP6 coupled versions are given in Bi et al. (2020)<sup>1</sup>.

ACCESS-CM2 is the current version which was used for CMIP6. The main sub models are the UKMO's Unified Model (UM) v10.6 / GA7.1 for the atmosphere, GFDL Modular Ocean Model (MOM) 5.1 for the ocean, LANL CICE 5.1 sea-ice model, CABLE 2.5 land surface model and biogeochemistry along with the OASIS3-MCT coupler. Further details can be found in the documentation for the individual sub-models.

NB: Acronyms are only partially dealt with in this document.

As well as being a coupled atmosphere–ocean general circulation model (AOGCM), ACCESS can function as an Earth System Model (ESM), that is one with an active carbon cycle that derives atmospheric carbon dioxide (CO<sub>2</sub>) concentrations from

given emissions, rather than prescribed CO<sub>2</sub> concentrations. This is referred to as ACCESS-ESM1.5. Working with the ESM version is not addressed here.

### **Document version**

This guide is a work-in-progress; it will be (and need to be) updated from time to time.

This version is dated 13 October 2020 by R. Bodman, C. Mackallah, and P. Dobrohotoff.

### **Acknowledgments**

With many thanks to Scott Wales and the accessdev help team for their assistance.

## PREPARING TO RUN ACCESS

Requirements for running ACCESS-CM2:

- A working institutional email address with an organisation that allows access to NCI, e.g. CSIRO, a university etc;
- Access to NCI compute/storage;
- A computer with an internet connection;
- A computer with a command line terminal eg:
  - Terminal on MacOS with XQuartz and command line tools installed;
  - Putty, Cygwin or similar XWindows compatible program on a PC;
  - Unix or Linux computer.

You need to setup an account with NCI, with a username and password, at <https://my.nci.org.au/mancini/signup/0>, and then join a project (for example, p66, which is the CSIRO ACCESS-CM development project).

You will also need to join the ACCESS group at <https://my.nci.org.au/mancini/project/access/join>

Once you have your NCI credentials and your ACCESS group membership has been granted, follow the instructions at <https://accessdev.nci.org.au/trac/wiki/GettingConnected> to complete your setup.

Additional steps relating to communication between accessdev and Gadi may be required; instructions can be found at <https://accessdev.nci.org.au/trac/wiki/gadi>

### Logging in to NCI

At this stage you should be able to connect to accessdev and Gadi.

accessdev is a frontend system where you prepare ACCESS jobs and then submit them to Gadi (refer <https://accessdev.nci.org.au>).

Gadi is the name of the supercomputer at NCI where ACCESS is run.

### Logging in to accessdev

```
$ ssh -Y $USER@accessdev.nci.org.au
```

The `-Y` switch is used to allow trusted X11 forwarding.

Then you can begin to work on setting up a model run. This is explained further in the next section.

Enter UKMO password at the start of a session if appropriate. It is needed for copying a suite and making any changes that affect the UM and its repository (password entry expires after 12 hours):

```
$ mosrs-auth
```

To exit:

```
$ logout; or [ctrl-d]
```

## Logging in to Gadi

Similar to `accessdev`:

```
$ ssh -Y $USER@gadi.nci.org.au
```

See also <https://opus.nci.org.au/display/Help/Preparing+for+Gadi> for more details.

For quick guide to Linux commands, see

<https://opus.nci.org.au/display/Help/Linux+Command+Quick+Reference+Guide>

NB: Aliases and shortcuts can be created to simplify these commands, refer, e.g., the section on Configuring SSH at <https://accessdev.nci.org.au/trac/wiki/Guides/SSH>

Some useful NCI commands:

```
$ hostname          # display login node details
```

```
$ nci_account -P [proj] # compute allocation details for [proj] (e.g. p66)
```

```
$ module list       # modules that are currently loaded for you
```

```
$ module avail      # available modules
```

```
$ nqstat -P [proj]  # jobs that are running/queued in [proj] (e.g. p66)
```

```
$ lquota            # storage allocation and usage for all your projects
```

Exit the same as for `accessdev`.

## ROSIE, ROSE AND CYLC

### What are these?

ACCESS-CM is a set of sub-models (eg, UM, MON, CICE, CABLE and OASIS) with a range of model parameters, input data, and computer related information, that need to be packaged together in order to run. Such a package is called a 'suite'. Typically, an existing suite is copied and then edited as needed for a particular run.

The suite resides in a directory created in the user's `accessdev` `cylc-run` directory for this purpose eg:

```
~/cylc-run/u-br565
```

where `br565` is an example of a suite name (in this case, the ACCESS-CM2 pre-industrial experiment release suite). Note that each suite directory is copied to Gadi when it is run with `cylc`, where the scripts are then sent to the PBS job queue.

There are two ways of editing a suite, approaches that can be used individually or in conjunction, whichever the user finds most useful or easier. One is to use the Rose GUI, the other is to use a text/terminal editor (e.g. `nano`, `nedit`, etc.).

### Rose

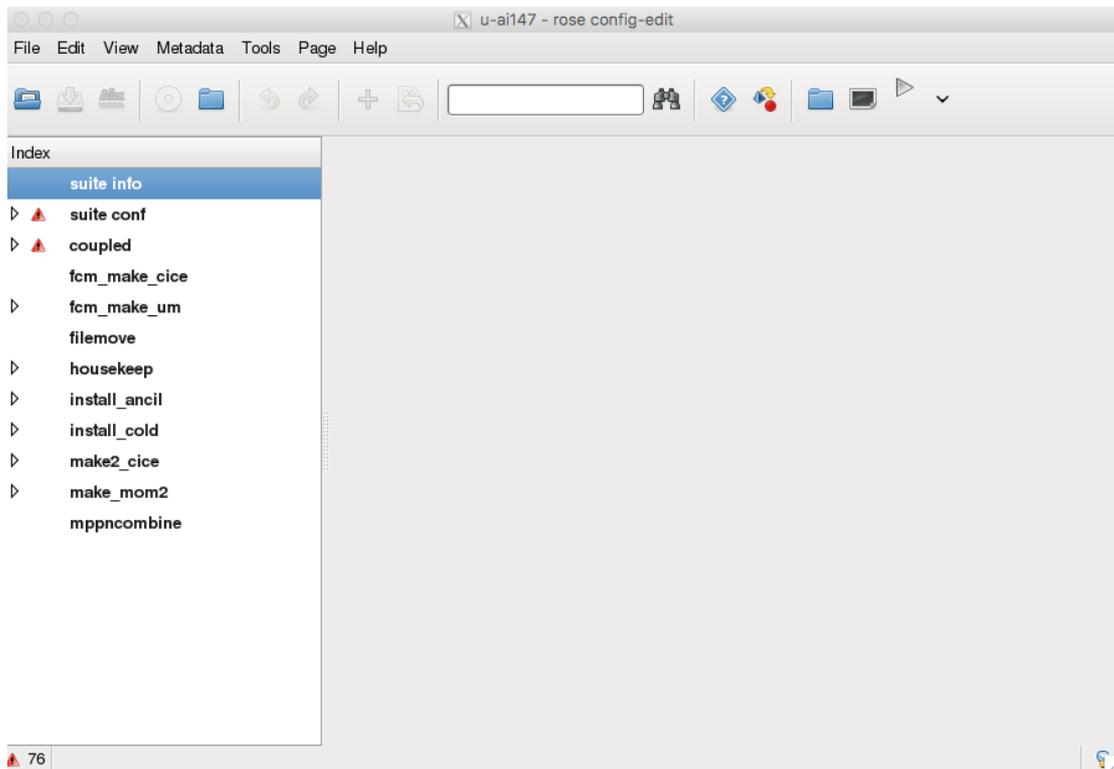
This is a program that starts a GUI to edit a rose suite; effectively a configuration editor.

It is run from your suite directory on `accessdev`:

```
$ cd ~/roses/u-[suite]
```

```
$ rose edit &
```

which will create a dialog box similar to the one shown below (the `&` is optional; it just keeps the terminal prompt active and runs the GUI as a separate process).



Alternatively, the files

`~/roses/u-[suite]/rose-suite.conf`

`~/roses/u-[suite]/rose-suite.info`

`~/roses/u-[suite]/suite.rc`

can be edited directly using a text editor. There are also files related to building the model, compiling the programs and so forth, aspects that are not addressed here.

For more details refer to: <http://metomi.github.io/rose/doc/html/index.html>

## CYLC

Pronounced 'silk', cylc is a job scheduler that deals with specifications for how the job will be run and the time steps of each sub-model.

Documentation for this can be found at: <https://cylc.github.io/documentation/>

Cylc provides important capabilities for monitoring jobs, particularly for dealing with jobs that have failed during processing but can be re-started from a previous timestep rather than starting all over again from the beginning.

## RUNNING ACCESS-CM2

This section provides a short introduction to running the model, monitoring, debugging, managing runs (shutdown, viewing status, tidying up), and managing output.

### Standardised ACCESS-CM2 CMIP6-release suites

As part of CMIP6, three ACCESS-CM2 suites have been released for general use by the ACCESS community:

br565: Pre-industrial control experiment (1850) (<http://clipc-services.ceda.ac.uk/dreq/u/f16fb9da-dd9e-11e6-b89b-ac72891c3257.html>)

bx616: Historical simulation (1850-2014) (<http://clipc-services.ceda.ac.uk/dreq/u/f16fc5c4-dd9e-11e6-b89b-ac72891c3257.html>)

bn157: AMIP simulation (atmosphere-only; 1979-2014) (<http://clipc-services.ceda.ac.uk/dreq/u/f16fc344-dd9e-11e6-b89b-ac72891c3257.html>)

### Working with suites – Rosie

Rosie is a script with a set of high level options to work with rose, handling suite storage and discovery. Commands include, eg.:

```
$ rosie copy u-[suite] # copy an existing suite (a new suite name is assigned)
$ rosie checkout u-[suite] # create a local copy of an existing suite
$ rosie go # suite management
$ rosie create # create new suite
```

Refer also to the documentation at <http://metomi.github.io/rose/doc/html/index.html> as well as <http://metomi.github.io/rose/doc/html/tutorial/rose/rosie.html>

Typically, the suite you will be working with is derived from an existing suite (like the release suites listed above), which is then modified as needed. Only a rudimentary introduction is provided here. It is likely that someone else from the project will provide an initial or test suite to begin with.

When a new suite is created (`$ rosie create`), a new name is generated within the repository system. This is populated with some descriptive information about the suite along with all the initial configuration details, much of which is generated automatically for you.

Editing a suite (`$ rose edit`) enables the specifications for a particular model run to be established in preparation for running the simulation.

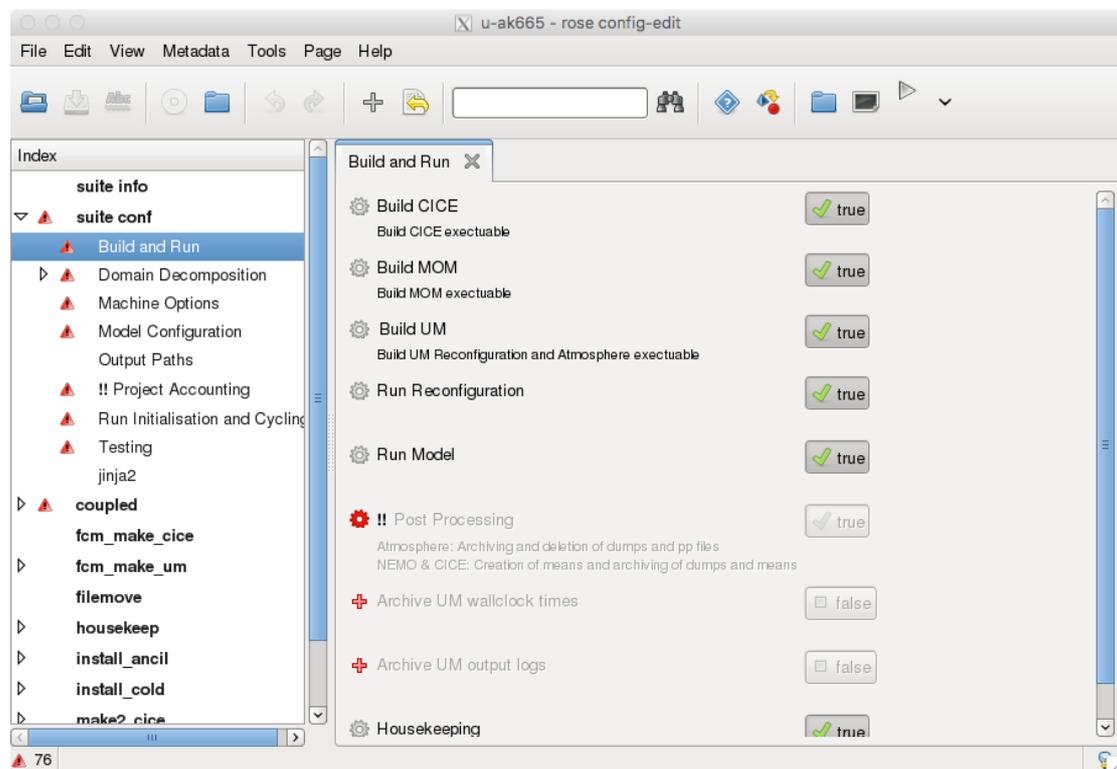
## Important run-time features

Prior to submitting a suite to Gadi, it is worth double checking some of the settings. Start the rose GUI from the roses suite directory, eg:

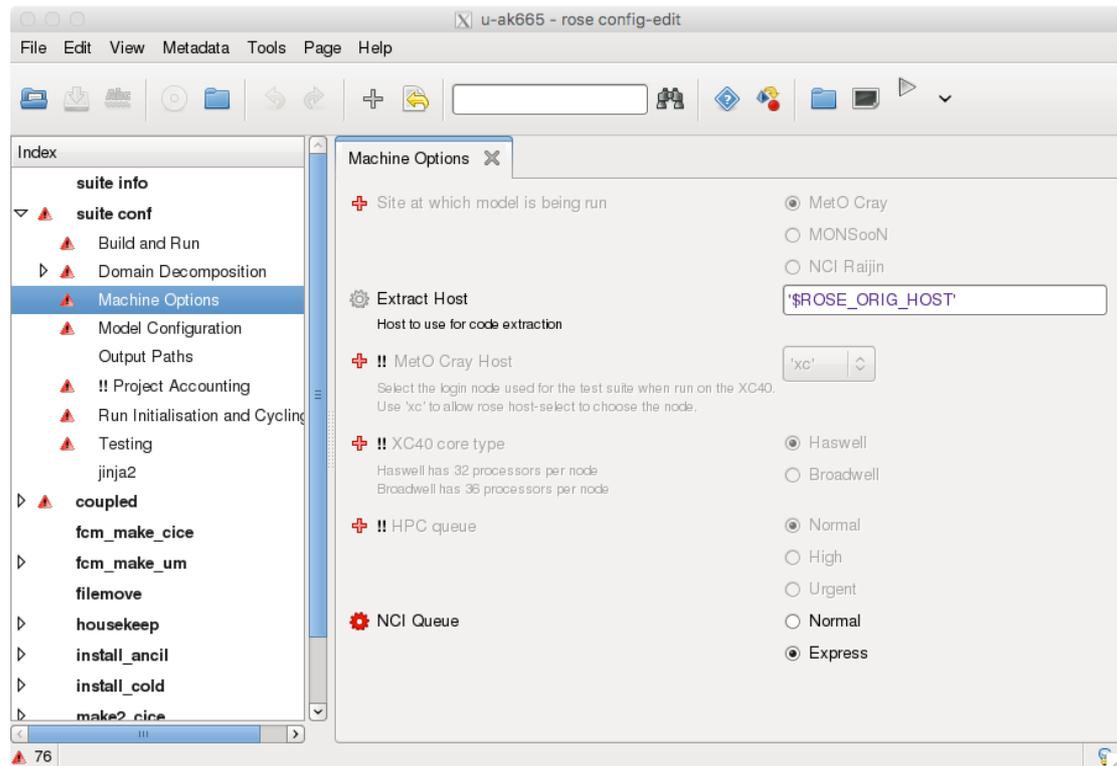
```
$ cd roses/u-[suite]
```

```
$ rose edit &
```

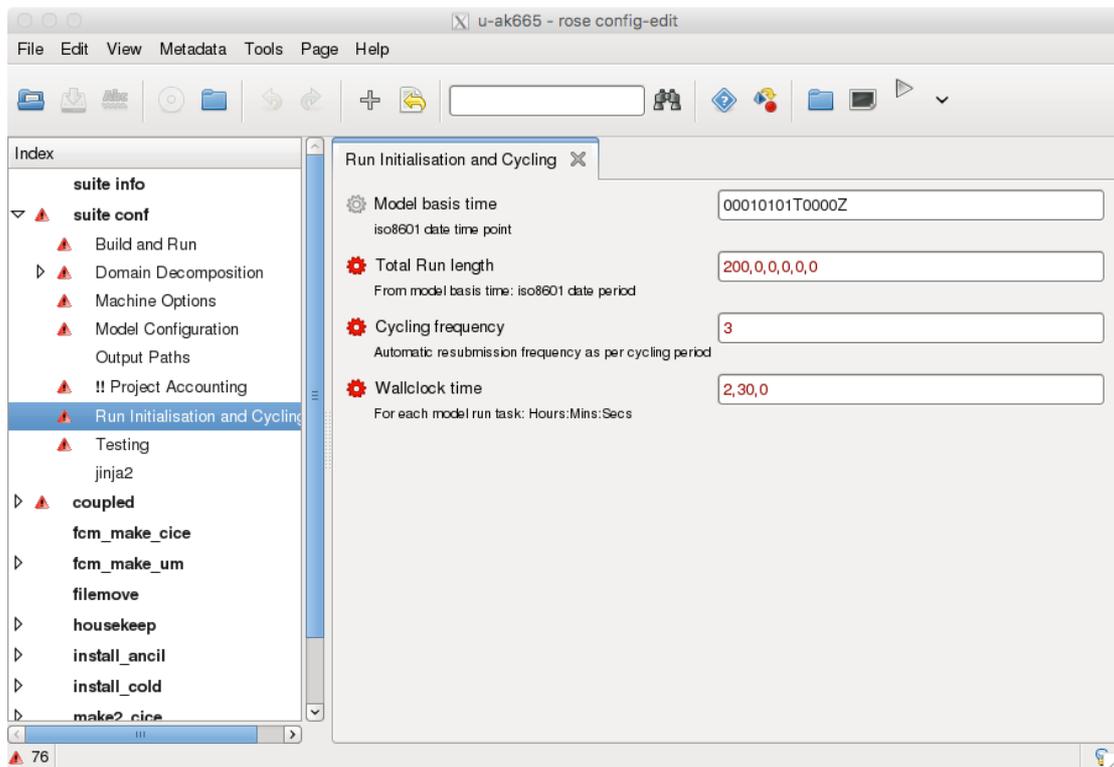
Under suite conf, Build and Run, check that the Build CICE, Build MOM, Build UM, Run Reconfiguration and Run Model are all set to true (assuming this is a fresh run), as per this screenshot:



Check that the NCI queue is correctly set, normal (recommended) or express, as in this illustration:



Check the timespan to be simulated, cycling frequency and wall clock time:



## Submitting a suite

Change to the roses suite directory e.g., ~/roses/u-[suite] (if not already there).

A suite can then be initiated using the rose command:

```
$ rose suite-run
```

This will generate a GUI that shows the suite being processed. This GUI can also be accessed at a later stage by the command `rose suite-gcontrol` or more generally:

```
$ rose suite-gcontrol --name=u-[suite]
```

For further information, refer: <https://metomi.github.io/rose/doc/html/api/command-reference.html#rose-suite-gcontrol>

An illustrative screenshot of a working model run:

task	state	host	job system	job ID	T-submit	T-start	T-finish
00140101T0000Z	succeeded						
NCI	succeeded						
LINUX_UM	succeeded						
00140401T0000Z	running						
NCI	running						
coupled	running	raijin.nci.org.au	pbs	3229506.r-man2	2017-03-19T21:21:25Z	2017-03-19T21:24:17Z	2017-03-19T21:24:17Z
filemove	waiting	*	*	*	*	*	*
mppncombine	waiting	*	*	*	*	*	*
LINUX_UM	waiting						
housekeep	waiting	*	*	*	*	*	*
00140701T0000Z	waiting						
NCI	waiting						

running to stop at 02001001T0000Z (filtered: live) 2017-03-20T08:25:30+11

## Job status, Job history

The status of a running job on Gadi can be checked using:

```
$ nqstat -P [proj]
```

Alternative commands are also provided from the rose suite-run command output, e.g.,

[INFO] To view suite daemon contact information:

```
[INFO] $ cylc get-suite-contact u-ak665
```

[INFO]

[INFO] Other ways to see if the suite is still running:

```
[INFO] $ cylc scan -n '\bu-ak665\b' accessdev.nci.org.au
```

```
[INFO] $ cylc ping -v --host=accessdev.nci.org.au u-ak665
```

```
[INFO] $ ssh accessdev.nci.org.au "pgrep -a -P 1 -fu $USER 'cylc-r.* \bu-ak665\b'"
```

In general, rose suite-gcontrol will provide an overview of the status of a suite whilst it is running. Any technical problems with the job will then show up, such as compiler or

file permission issues. These will have to be resolved in order to successfully complete the model simulation.

Model output can be checked whilst the job is running to confirm that the model is behaving sensibly. Output from a model run is discussed further in the next section.

## Stopping a job

Should the need arise, a job can be killed:

```
$ rose suite-shutdown --name=u-[suite] ; or
```

```
$ cylc stop u-[suite]
```

(ref: <https://metomi.github.io/rose/doc/html/api/command-reference.html#rose-suite-shutdown>)

## MODEL OUTPUT

Assuming the model runs without problems, a series of files are generated and saved that contain the model output. Some of these are NetCDF files, some are UKMO UM format (for which there are tools available to assist with looking at the data as well as converting some or all of the fields to NetCDF format).

The model results are stored to a directory on Gadi's /scratch disk. Initially, while the model is running, they are saved under:

```
/scratch/$PROJECT/$USER/cylc-run/u-[suite]/share/data/History_Data/
```

where \$PROJECT is the project you are working on (e.g. p66), and \$USER is your NCI username.

After each resubmission cycle (e.g. 6 months) this output is then automatically moved to separate directory, also on /scratch, called archive, e.g.:

```
/scratch/$PROJECT/$USER/archive/[suite]/history
```

Note that storage on /scratch is intended as short-term storage (and not backed up). For longer-term, backed-up storage, output needs to be transferred to a different location (refer to local technical support for further information). For p66, this is centrally managed through the Coupled Climate Modelling team at CSIRO Aspendale.

The archive/[suite]/history directory contains four folders with data for each of the sub-models: atm, ocn & ice.

The atm directory contains output from the UM, and is typically saved in the UKMO's format (however recently a netCDF conversion step has been included in the release suites) while ice and ocn contain netCDF files.

There are a range of other options for looking at and extracting information from netCDF files, including netCDF modules, Python utilities, iris, Ferret, and Matlab.

### UM atm results

The atm files are typically separated into frequency (e.g. daily and monthly results; frequency and contents of output files are set by the rose suite).

The contents of the UM files can be examined with several difference applications, including xconv, a UM utility program (on Gadi, path /projects/access/bin/xconv; an alias can be created to make this easier to use from the user's current working directory). Documentation for this program can be found at

<http://cms.ncas.ac.uk/documents/xconv/>

However, it is much easier to view, and perform analyses on, netCDF files. There is an option (controlled by NETCDF\_PP in rose-suite.conf) to convert the UM fields files to netCDF4. This can be done for selected streams and the original files can be optionally deleted.

Outputs from the UM are specified using the STASHmaster file (each version of the UM requires a specific version of this file). Variables are selected and specified as part of the suite configuration. As such, this can be achieved through the Rose GUI. Fields are output at different frequencies (e.g. daily or monthly), and are calculated differently (e.g. cumulative properties or mean values), depending on the variable and its specific set-up in the suite.

In the standard release of ACCESS-CM2 suites from CMIP6, there 4 streams of files generated, containing variables output at specific frequencies: monthly ('pm'), daily ('pd'), 6-hourly ('p7'), and 3-hourly ('p8'). The file names follow the convention "[suite]a.p[F][YYYY][MMM]", where F is the stream indicator (e.g. pm for monthly), YYYY is the 4-digit model year, and MMM indicates the month (written as e.g. 'jan' for January). For example, the first monthly file of the CMIP6-release historical simulation will be "bx616a.pm1850jan" (appended with '.nc' if a netCDF conversion has occurred within cylc).

While the UM-format files contain variable names according to internal naming conventions, our 'um2netcdf' conversion tool names each variable according to the STASH code (a unique identifier of the physical field being represented; e.g. m01s03i230 = "10 METRE WIND SPEED ON C GRID"; ref: <https://reference.metoffice.gov.uk/um/stash>).

These STASH codes are aligned to CMIP6 variables (<http://clipc-services.ceda.ac.uk/dreq/index/var.html>) through a variable map; some are directly equivalent (e.g. m01s03i230 = 'sfcWind'), while others are calculated offline in the CMIP6-based ACCESS post-processor (APP; e.g. 'rlus', which is composed of 4 STASH fields). More detail on the generation of CMIP6 variables using ACCESS will be included in the upcoming publication on our CMIP6 datasets, Mackallah et al. (2020).

## ocn results

Ocean output comprises 3 classes of NetCDF files, containing daily data, monthly data and scalar variables (a fourth class for ocean biogeochemistry from WOMBAT for the CABLE configuration is available, but is not included in the standard ACCESS-CM2 release).

The variable names are given by the 'DIAG' table, an input name-list file for MOM5 that works similar to the STASHmaster, and includes fixed variable names for all output fields.

### **ice results**

CICE5.1 outputs netCDF data on both daily and monthly frequencies, with fixed variable names for all fields, as determined by CICE.

## **MODEL INPUT**

A number of input files are required for ACCESS to create the appropriate working environment, depending on the suite configuration and experiment design. Some introductory comments are provided in this section; more detailed information will require delving into the documentation associated with each component as well as related websites; refer Appendix B for some of these links.

### **UM Science Settings**

Managed as part of the suite configuration, the UM science settings are high level settings that control parameters such as orbital parameters, carbon cycle options (e.g., fixed concentrations or interactive carbon cycle), settings related to GHG concentrations, other radiative forcing components, etc.

### **Land Surface Scheme Settings**

The model configuration also has a section for CABLE, land surface scheme (previously the land scheme was the Met Office's JULES). In the longer-term it is expected that these schemes will be interchangeable modules, but this is not currently the case.

### **CICE and MOM settings**

Not discussed here.

### **Initialisation files**

There are a number of files used to start the model (unless it's a full spin-up run), e.g.:

- a2i.nc
- i2a.nc
- o2i.nc
- monthly.sstsss.nc
- ocean\_temp\_salt.res.nc

These are the files given under the section 'install\_cold' in the rose suite and are located in the directory \$CPL\_RUNDIR.

### Ancillary files

There is also a rose configuration section called 'install\_ancil', which has a path (e.g. \$ROSE\_DATA/etc) with the file um\_ancils\_gl. This file is a script that provides links to multiple data files, with data for a variety of model inputs including land-sea mask, orography, ozone and aerosol information, land-surface albedo and emissions related to atmospheric chemistry plus others.

## APPENDIX - USER GUIDES, WIKIS ETC

A collection of links to additional resources.

### Getting started and training

<http://nci.org.au/users/training>

<http://climate-cms.wikis.unsw.edu.au/Training>

<https://code.metoffice.gov.uk/doc/um/latest/um-training/index.html> (requires login)

### Accessdev

<https://accessdev.nci.org.au/trac>

<https://accessdev.nci.org.au/trac/wiki/GettingConnected>

<https://accessdev.nci.org.au/trac/wiki/gadi>

<https://accessdev.nci.org.au/trac/wiki/access/AccessModelExperimentLibrary>

<https://accessdev.nci.org.au/trac/wiki/access/UserGuides>

### NCI user support

<https://track.nci.org.au/servicedesk/customer/portal/5>

### MetOffice account setup

<https://code.metoffice.gov.uk/trac/home>

<https://code.metoffice.gov.uk/trac/home/wiki/FAQ>

### Rose User Guide

<https://metomi.github.io/rose/doc/html/>

### CYLC Guide

<https://cylc.github.io/>

### FMC User Guide

[http://metomi.github.io/fcm/doc/user\\_guide/introduction.html](http://metomi.github.io/fcm/doc/user_guide/introduction.html)

### UM documentation

<http://cms.ncas.ac.uk/wiki/Docs/MetOfficeDocs>

[http://climate-cms.wikis.unsw.edu.au/Unified\\_Model](http://climate-cms.wikis.unsw.edu.au/Unified_Model)

<https://code.metoffice.gov.uk/doc/um/> (requires login)

### STASH documentation

[http://www.ukca.ac.uk/wiki/index.php/UKCA\\_%26\\_UMUI\\_Tutorial\\_3](http://www.ukca.ac.uk/wiki/index.php/UKCA_%26_UMUI_Tutorial_3)

<https://reference.metoffice.gov.uk/um/stash>

## **MOM**

<https://mom-ocean.github.io/>

## **CICE**

<https://github.com/CICE-Consortium/CICE/wiki>

## **OASIS Coupler**

<https://verc.enes.org/oasis>

## **REFERENCES**

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<sup>1</sup> Bi Daohua, et al. (2020) Configuration and spin-up of ACCESS-CM2, the new generation Australian Community Climate and Earth System Simulator Coupled Model. *Journal of Southern Hemisphere Earth Systems Science*

<https://doi.org/10.1071/ES19040>