National Science Challenges

THE DEEP SOUTH

Te Kōmata o Te Tonga

The role of High-Performance Computing for the Deep South National Science Challenge

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New Zealand Antarctic Research Institute

Landcare Research Manaaki Whenua

University of Otago Te Whare Wānanga o Otāgo New Zealand

Antarctica New Zealand

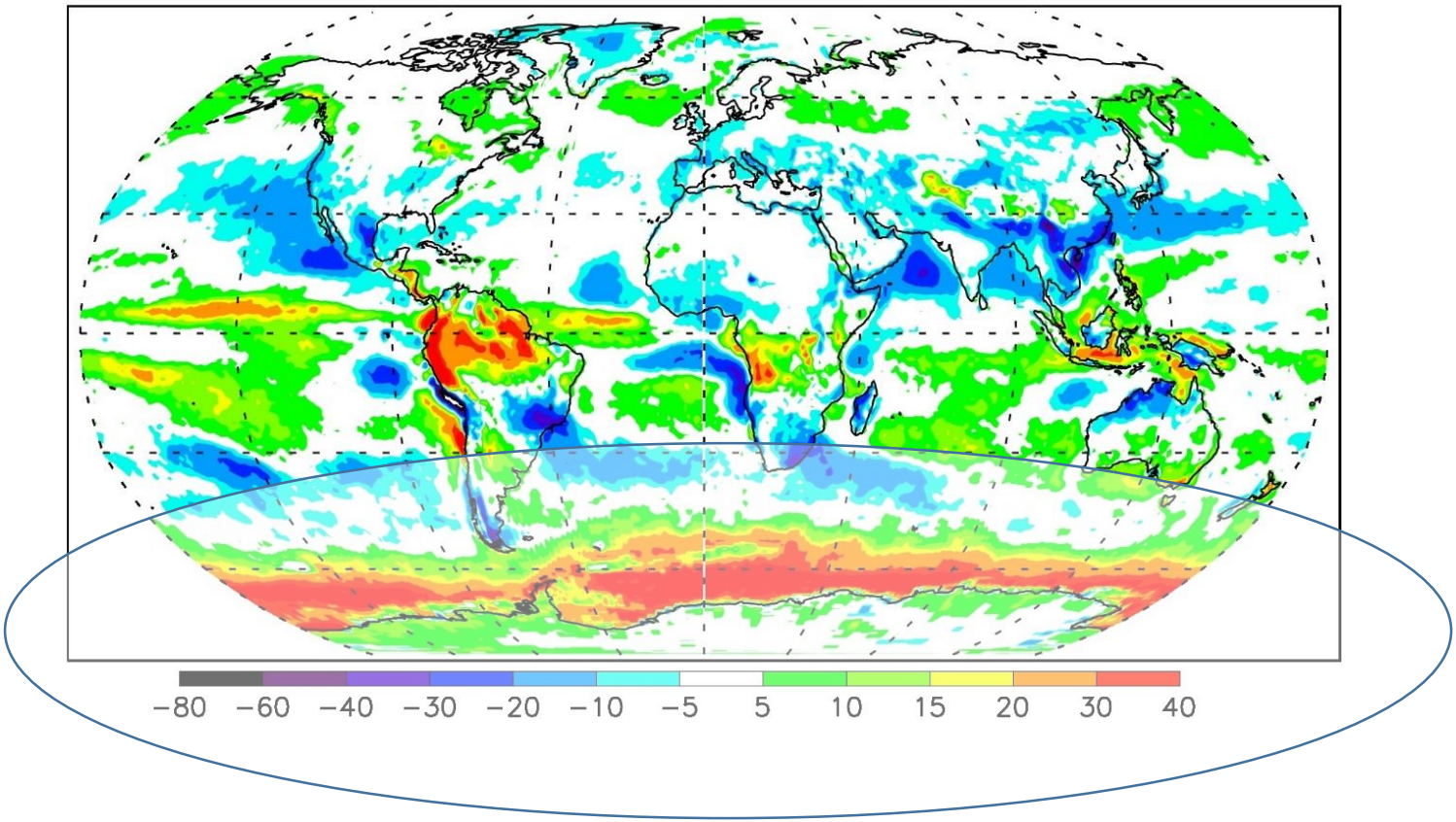
GNS Science Te Pū Ao

Victoria University of Wellington Te Whare Wānanga o Te Ūpoko o Te Ika a Māui

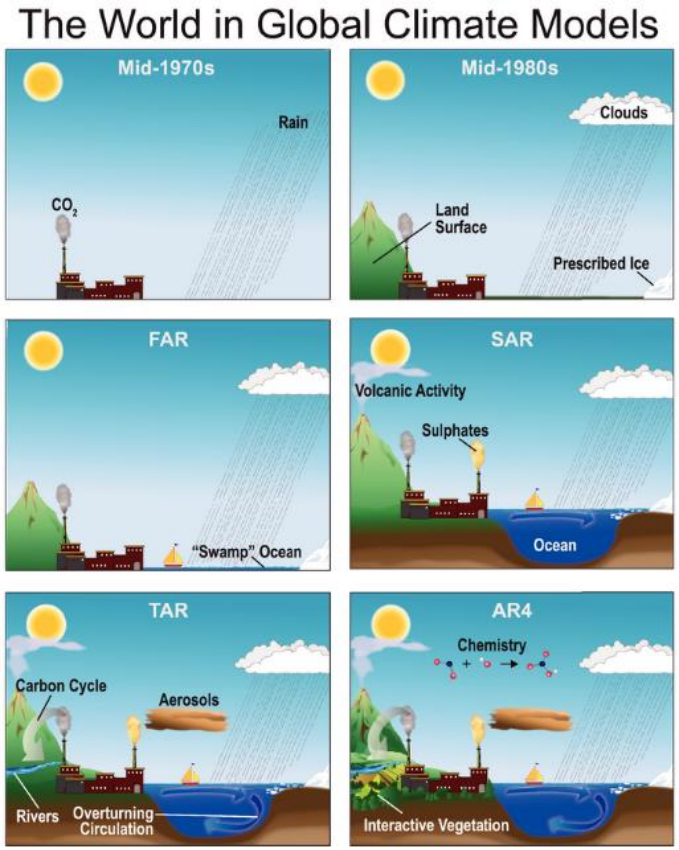
The situation

- Climate models poorly represent several processes determining Southern-Hemisphere climate.
  - ❑Atmosphere
  - ❑Ocean
  - ❑Land- and sea ice
- Processes governing climate differ between the two hemispheres.
  - ❑Industrial pollution
  - ❑Terrestrial aerosols
  - ❑Ozone depletion
- Observed climate change differs significantly between the two polar regions.
  - ❑Arctic: Warming fast, receding sea ice
  - ❑Antarctic: Some fast regional warming, expanding sea ice

Cloud-radiation error in UKCA RJ4.0

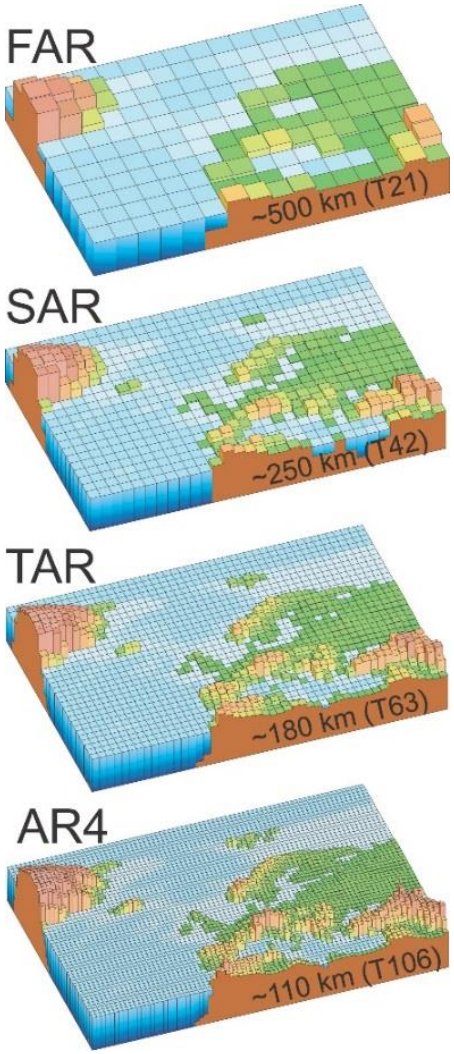


The Dilemma of Climate Modelling



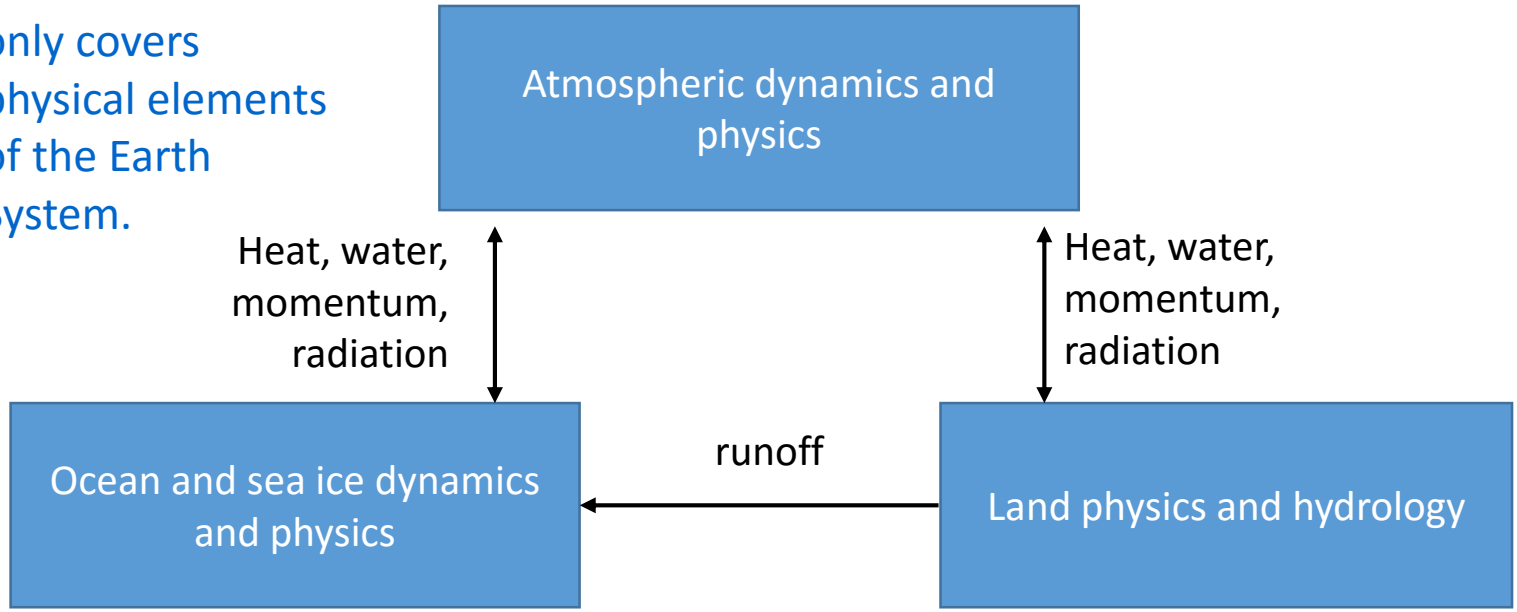
Dilemma of climate modelling: Complexity vs resolution vs length and number of simulations.

(figures from IPCC AR4)

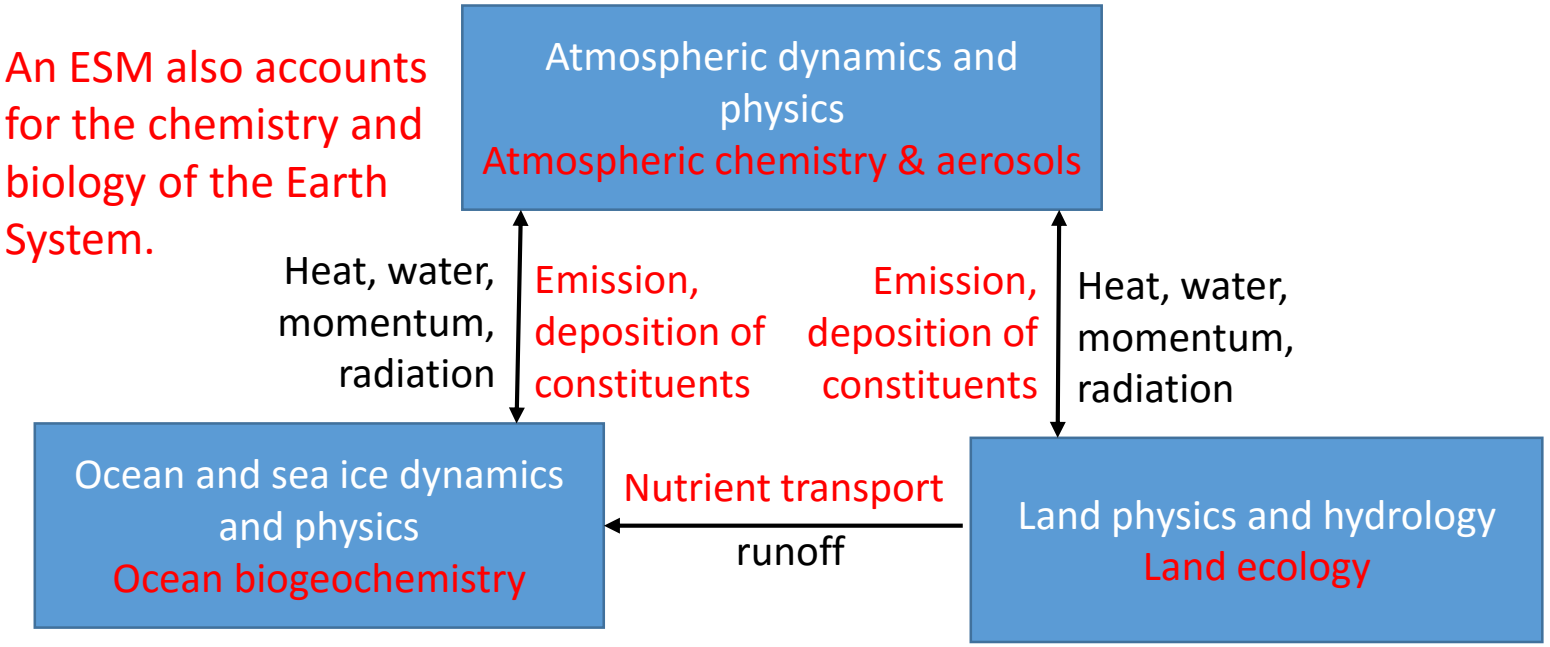


Schematic of a climate model

A climate model only covers physical elements of the Earth System.



Schematic of an Earth System Model



The Deep South objective and mission

- **Objective:**

To understand the role of the Antarctic and Southern Ocean in determining our climate and our future environment.

- **Mission:**

This Challenge will enable New Zealanders to adapt, manage risk, and thrive in a changing climate. Working with our communities and industry, we will guide planning and policy to enhance resilience and exploit opportunities. This will be built on improved predictions of future climate, supported by new understanding of Antarctic and Southern Ocean processes.

The Deep South Challenge

Improve predictions of our future climate based on:

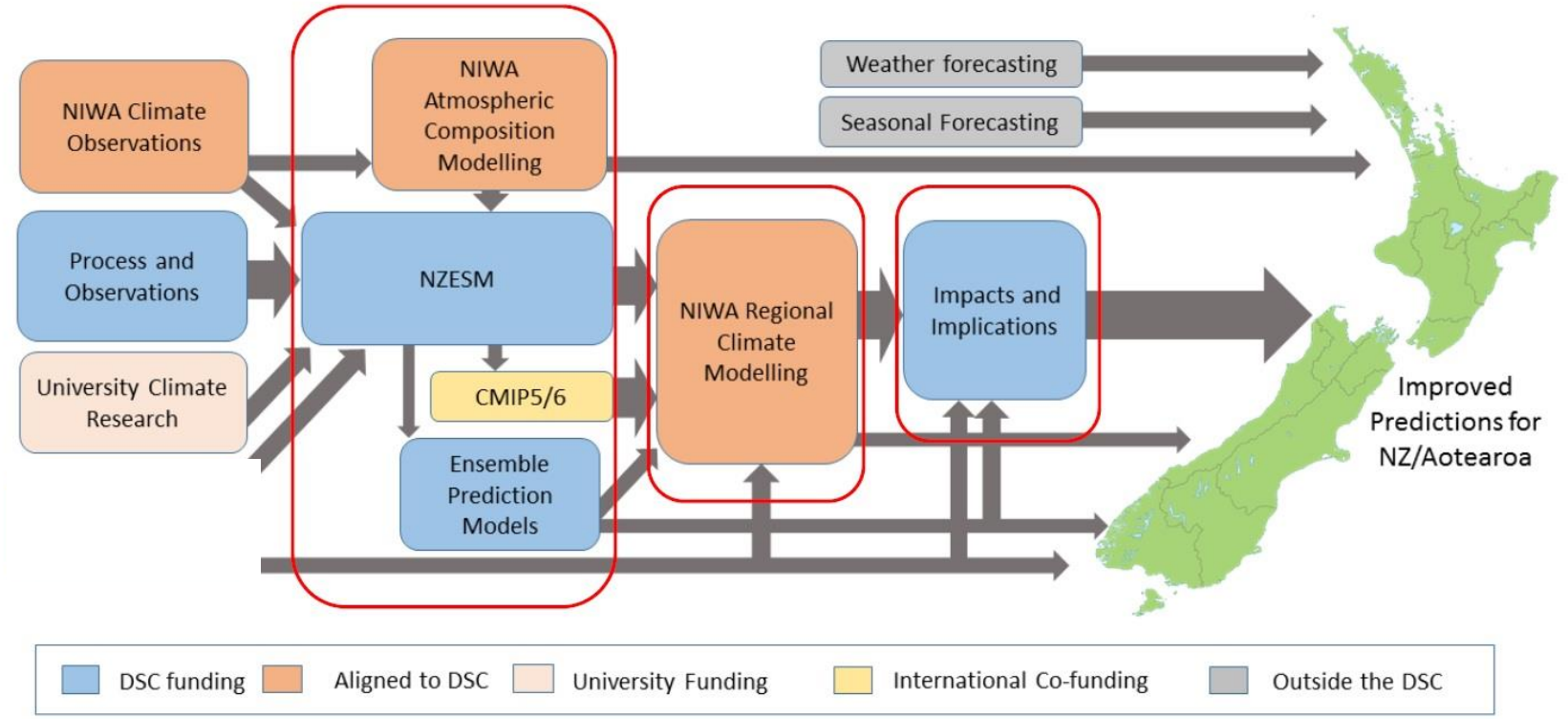
developing a world-class Earth System Modelling capability, underpinned by improved understanding of Deep South processes, to better simulate key climate drivers and impacts; and, acquiring new observations and process information from the Deep South region as required to refine/support the models.

Deep South Proposal

Research plan

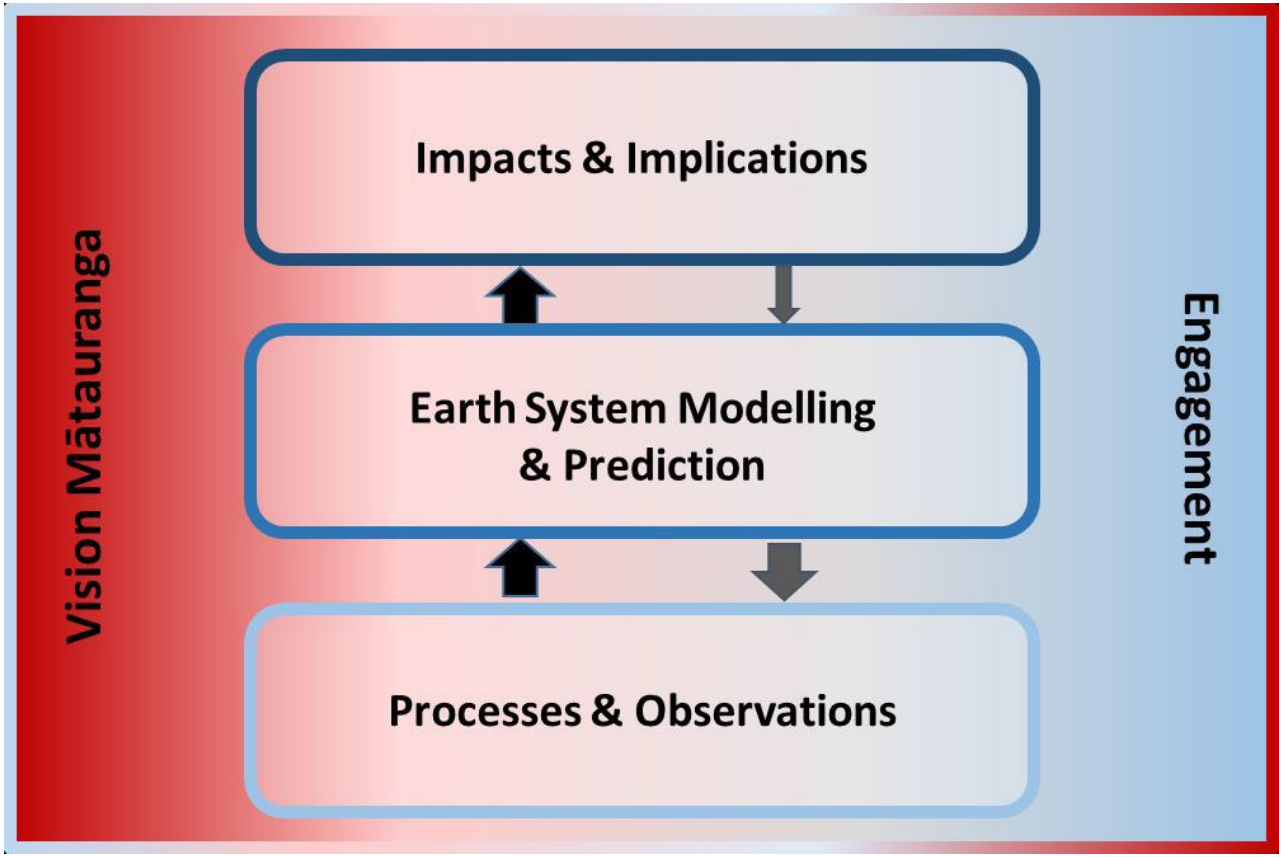
- Develop a world-class numerical Earth System Model to predict New Zealand's climate.
- The model will identify the impacts of a changing climate on our key climate-sensitive economic sectors, infrastructure and natural resources
- The model will be informed by improved knowledge and observations of climate processes in the Southern Ocean and Antarctica.

NZ's climate modelling landscape



Relationship of Deep South projects (blue) with other climate and weather modelling activities.

Deep South organization



Six projects in the ESMP and PO domains have been given the go-ahead.

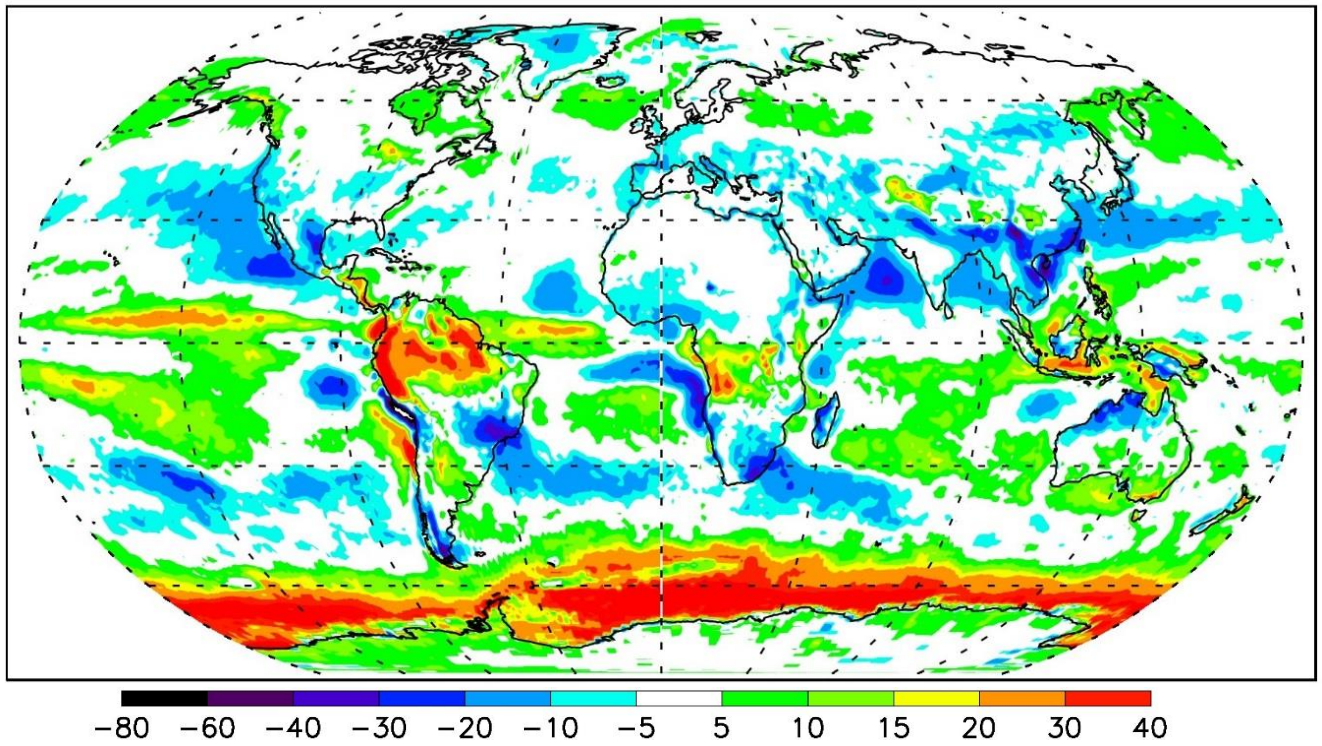
ESMP Project: "Capability"

- Maintain and develop the NZESM
- Contribute to the development of the UKESM
- Close collaboration with the UKESM team
- Coordination of model advances contributed by other Deep South projects
- Keep up-to-date with UKESM versions and progress
- CMIP6 simulations (depending on additional funding and supercomputer renewal)
- CRESCENDO – EU project on development of Earth System Models
- Contact
  - *olaf.morgenstern@niwa.co.nz*
  - *jonny.williams@niwa.co.nz*

ESMP Project: Clouds & Aerosols

- Improve representation of Southern-Ocean clouds in UKESM (cloud physics, aerosols, boundary layer,…)
- Dedicated ship- and land-based observations
- Association with SOCRATES campaign
- ModellingUpscaling using satellite data
- Contact
  - *adrian.mcdonald@canterbury.ac.nz*
  - *olaf.morgenstern@niwa.co.nz*
  - *vidya.varma@niwa.co.nz*

Cloud-radiation error in UKCA RJ4.0



Cloud-radiative forcing bias at the top of the atmosphere (W/m^2) in UKCA RJ4.0 (UM 8.4) for DJF, relative to the CERES-EBAF satellite observations.

Relationship Met Office – Deep South National Science Challenge

- NIWA is now a Tier-1 UM ('core') partner
- The NZESM will be based on, evolve with, and feed back into the UKESM.
- We will focus on southern high-latitude processes (SO clouds, sea ice, ocean circulation).
- Observational datasets will be made available to the community.

Contribution to CRESCENDO and CMIP6

- We are an Associate Partner in CRESCENDO.
- We would like to contribute to the ESMValTool.

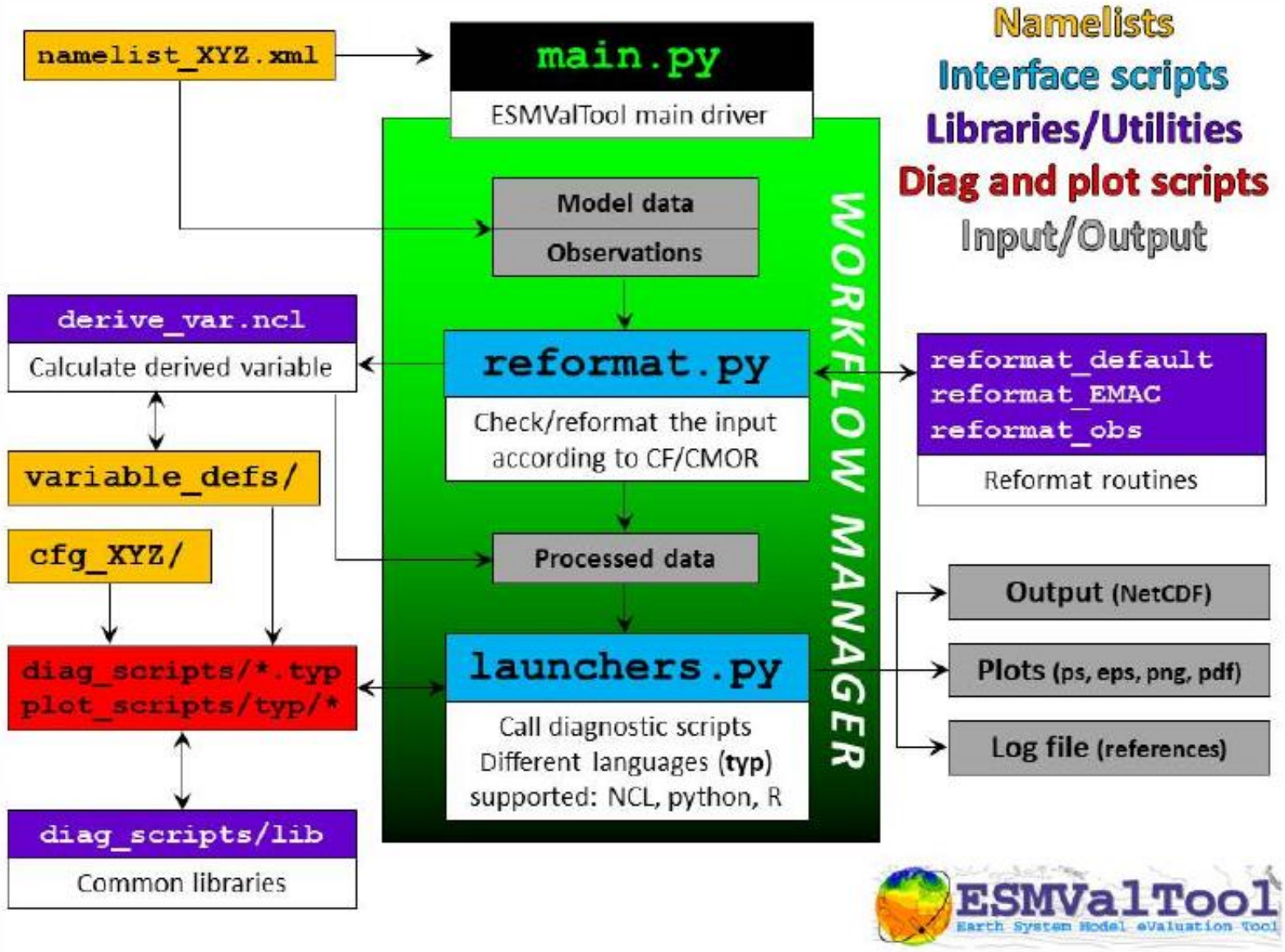
Geosci. Model Dev. Discuss., 8, 7541–7661, 2015
www.geosci-model-dev-discuss.net/8/7541/2015/
doi:10.5194/gmdd-8-7541-2015

Geoscientific Model Development Discussions
Open Access

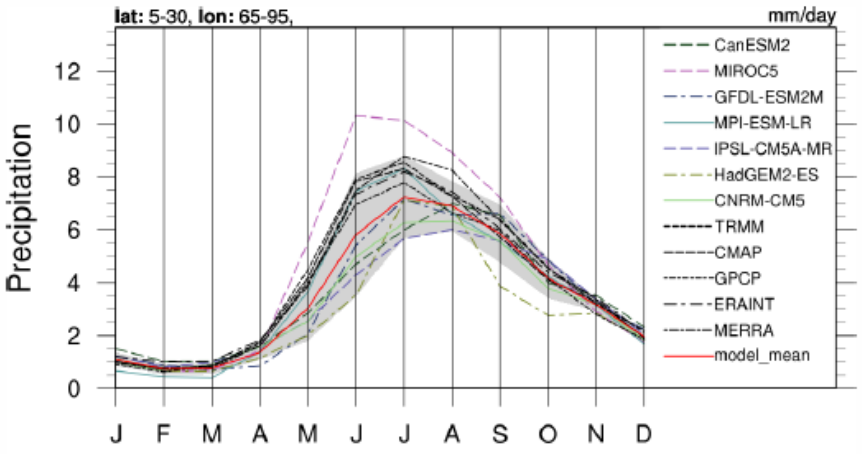
ESMValTool (v1.0) – a community diagnostic and performance metrics tool for routine evaluation of Earth System Models in CMIP

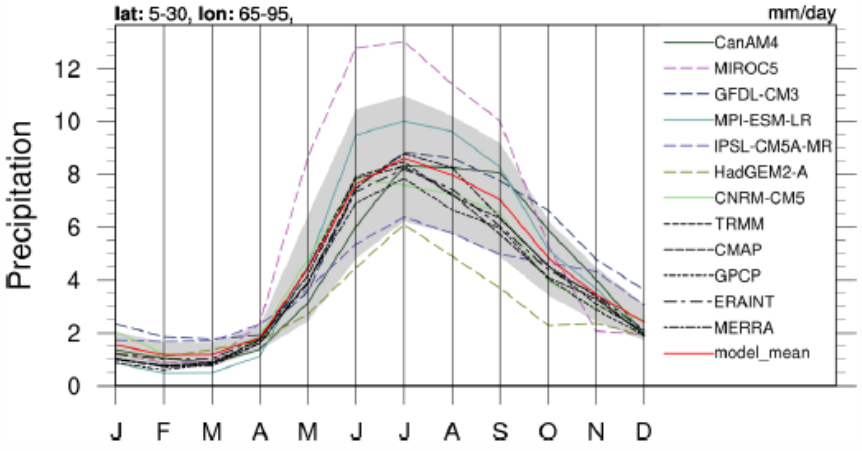
V. Eyring[1], M. Righi[1], M. Evaldsson[2], A. Lauer[1], S. Wenzel[1], C. Jones[3,4], A. Anav[5], O. Andrews[6], I. Cionni[7], E. L. Davin[8], C. Deser[9], C. Ehbrecht[10], P. Friedlingstein[5], P. Gleckler[11], K.-D. Gottschaldt[1], S. Hagemann[12], M. Juckes[13], S. Kindermann[10], J. Krasting[14], D. Kunert[1], R. Levine[4], A. Loew[15,12], J. Mäkelä[16], G. Martin[4], E. Mason[14,17], A. Phillips[9], S. Read[18], C. Rio[19], R. Roehrig[20], D. Senftleben[1], A. Sterl[21], L. H. van Ulft[21], J. Walton[4], S. Wang[2], and K. D. Williams[4]

[1]Deutsches Zentrum für Luft- und Raumfahrt (DLR), Institut für Physik der Atmosphäre, Oberpfaffenhofen, Germany
[2]Swedish Meteorological and Hydrological Institute (SMHI), 60176 Norrköping, Sweden
[3]University of Leeds, Leeds, UK
[4]Met Office Hadley Centre, Exeter, UK
[5]University of Exeter, Exeter, UK

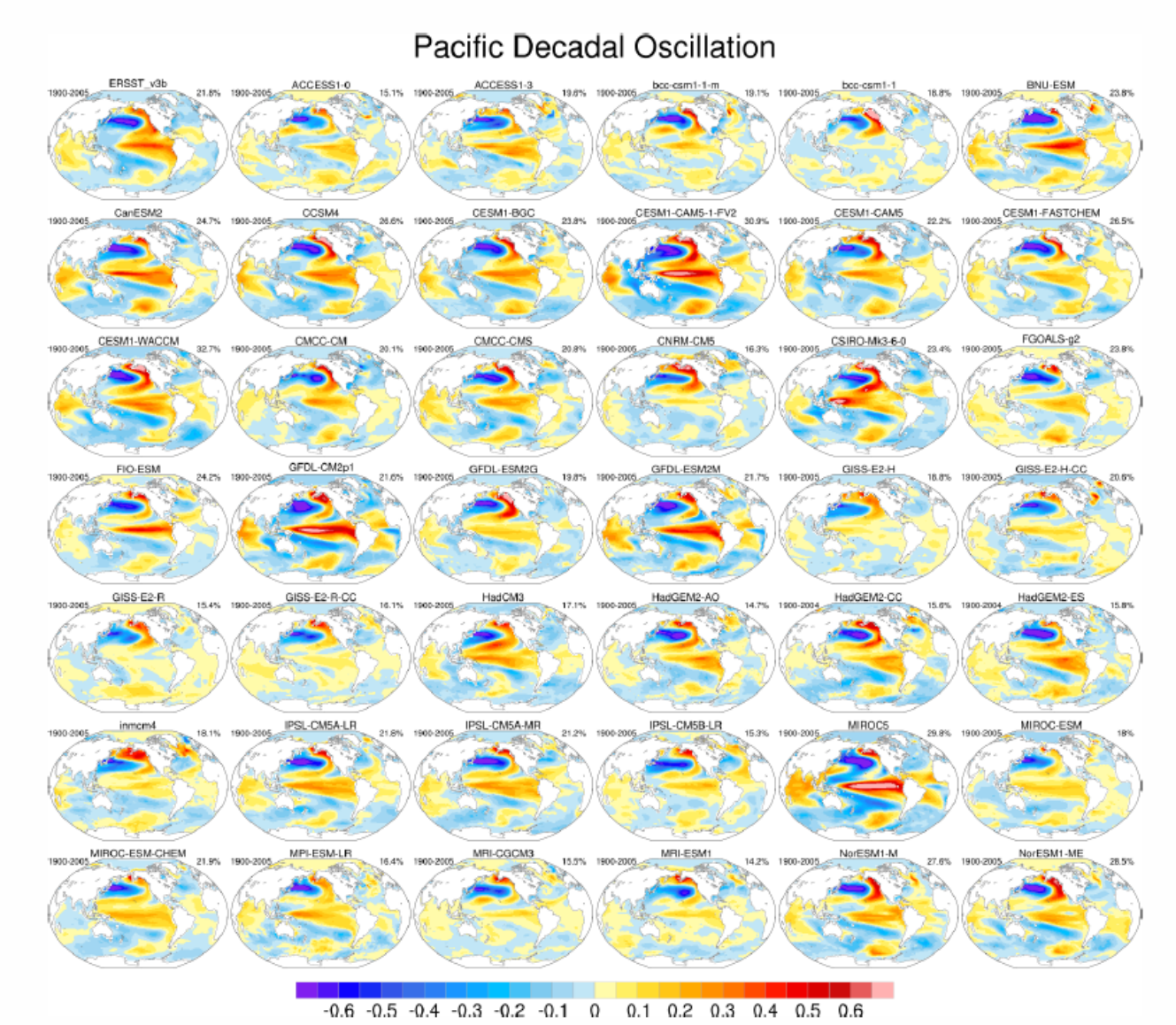

namelist_XYZ.xml
main.py
ESMValTool main driver
Namelists
Interface scripts
Libraries/Utilities
Diag and plot scripts
Input/Output
Model data
Observations
WORKFLOW MANAGER
derive_var.ncl
Calculate derived variable
reformat.py
Check/reformat the input according to CF/CMOR
reformat_default
reformat_EMAC
reformat_obs
Reformat routines
variable_defs/
cfg_XYZ/
Processed data
Output (NetCDF)
diag_scripts/*.typ
plot_scripts/typ/*
launchers.py
Plots (ps, eps, png, pdf)
Call diagnostic scripts
Different languages (typ)
supported: NCL, python, R
Log file (references)
diag_scripts/lib
Common libraries
ESMValTool
Earth System Model eValuation Tool

Indian monsoon region precipitation

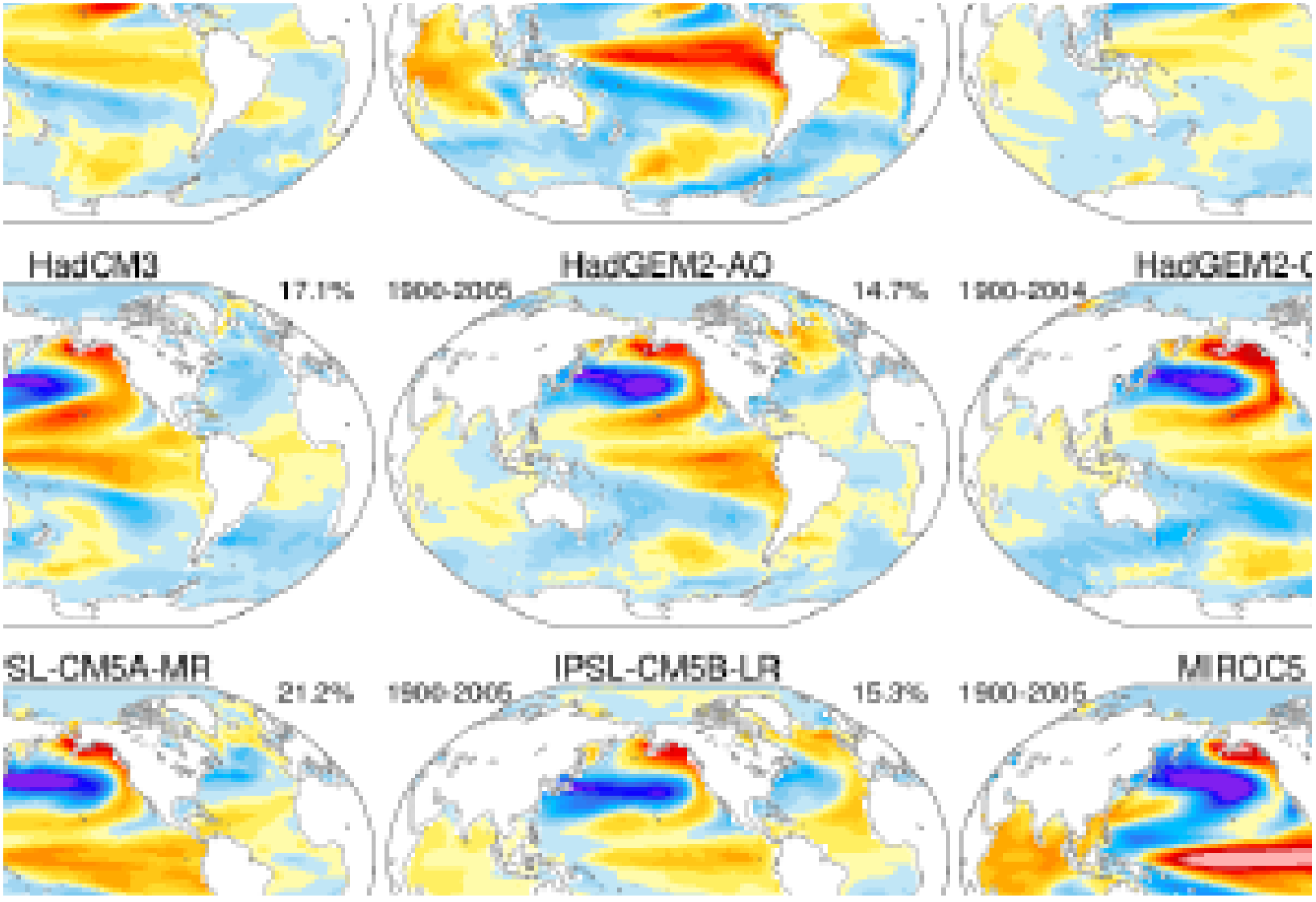




Pacific Decadal Oscillation



Pacific Decadal Oscillation

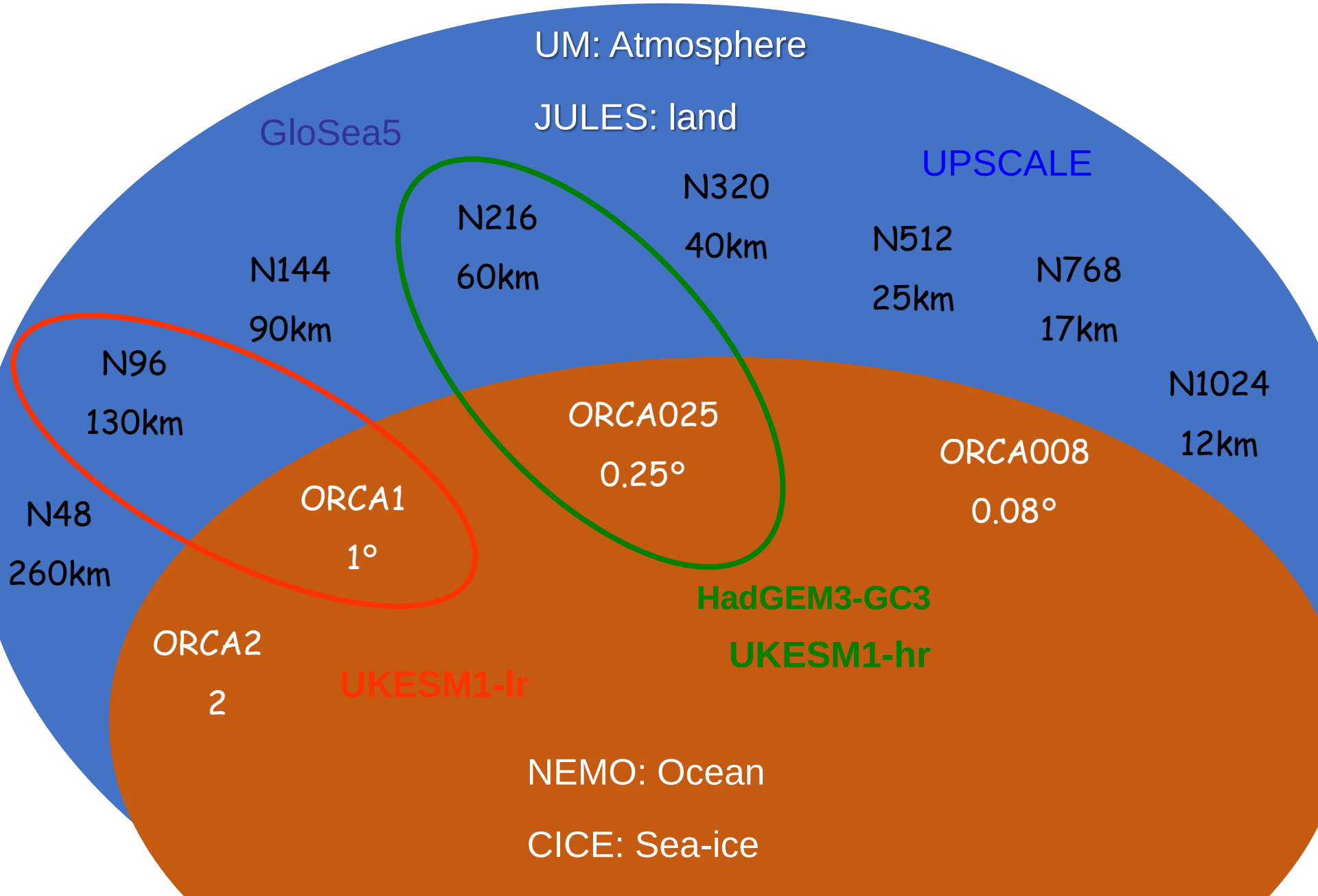


NESI Fitzroy – IBM Power 6

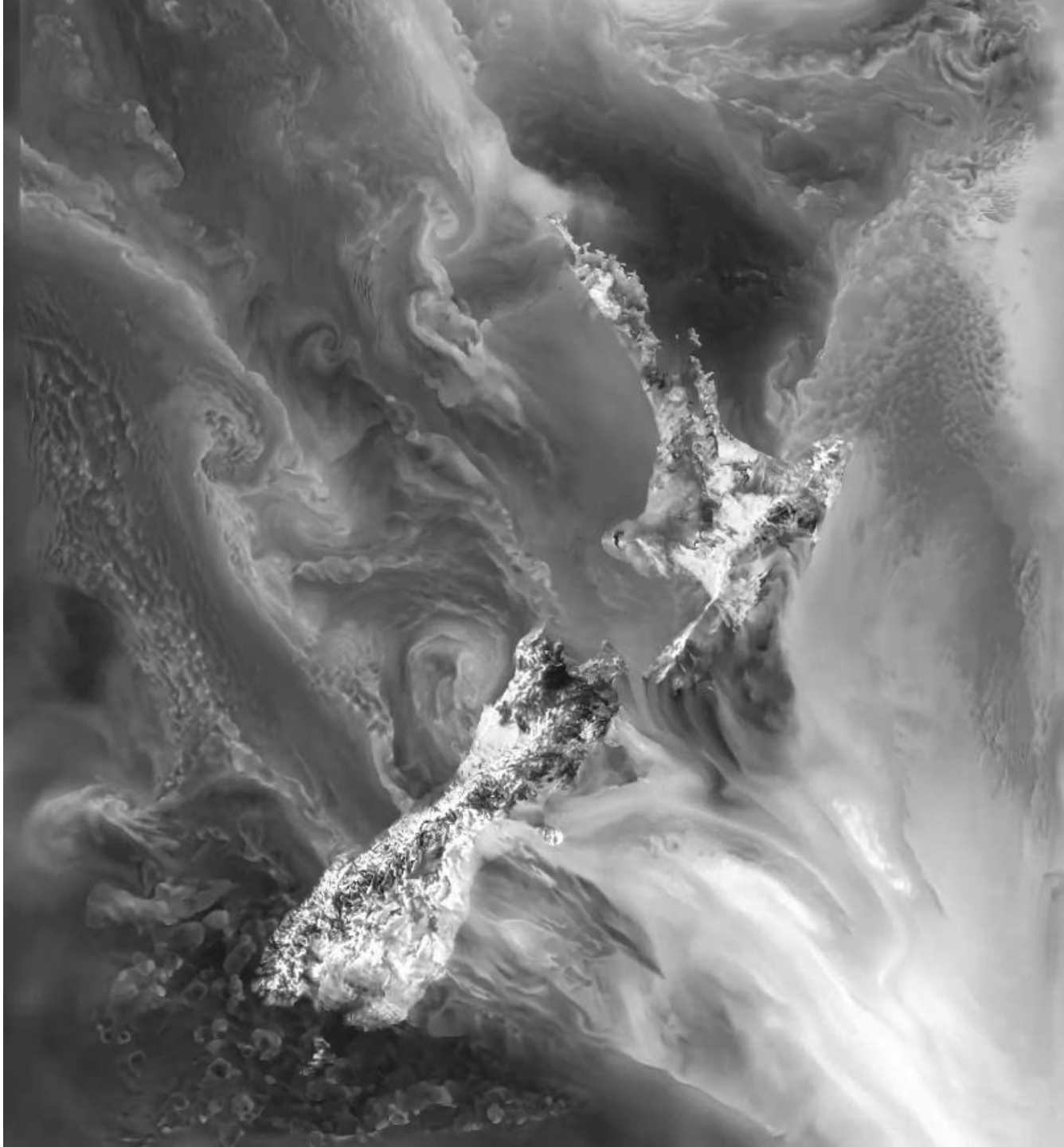
CPUs (or Cores) per node	32
Number of CPUs/Cores	3392
Total Memory (TBytes)	8.1
Total User Disk (SAS/SATA)(TBytes)	744.5

A current challenge is that the UKESM is built, run and maintained on a Cray HPC whereas NIWA currently runs an IBM machine…

Resolutions for UKESM1:



- Model or satellite observations?



Deep South Requirements for an ESM

- Deep South wants to do a small number of 200 year simulations – 1950 to 2150.
- To be useful these should take 6 months at most.
- This requires performance levels of around 1.5 model years per day

Performance on Fitzroy

- The full UKESM1-LO model will likely require on order 1000 PEs, but more than meet the desired target of 1.5 model years per day.
- The full UKESM1-HI model is likely to require 2000PEs and achieve only 1 model day/year. This represents 60% of the current capacity of Fitzroy so is likely unfeasible with current infrastructure.

But…

- The model components are essentially plug and play via the coupler so configurations can be made to suit the science questions being asked.
- Work is being done to calculate chemistry on a low resolution grid while dynamics calculated the full resolution grid. This functionality is likely to be available in UKESM2. Many other optimisations are planned.

International collaborations

- NIWA is a Core Partner of the Unified Model (UM) development consortium

KMA Korea Meteorological Administration

NCMRWF

Met Office

NIWA Taihoro Nukurangi

South African Weather Service
ISO 9001 Certified Organisation

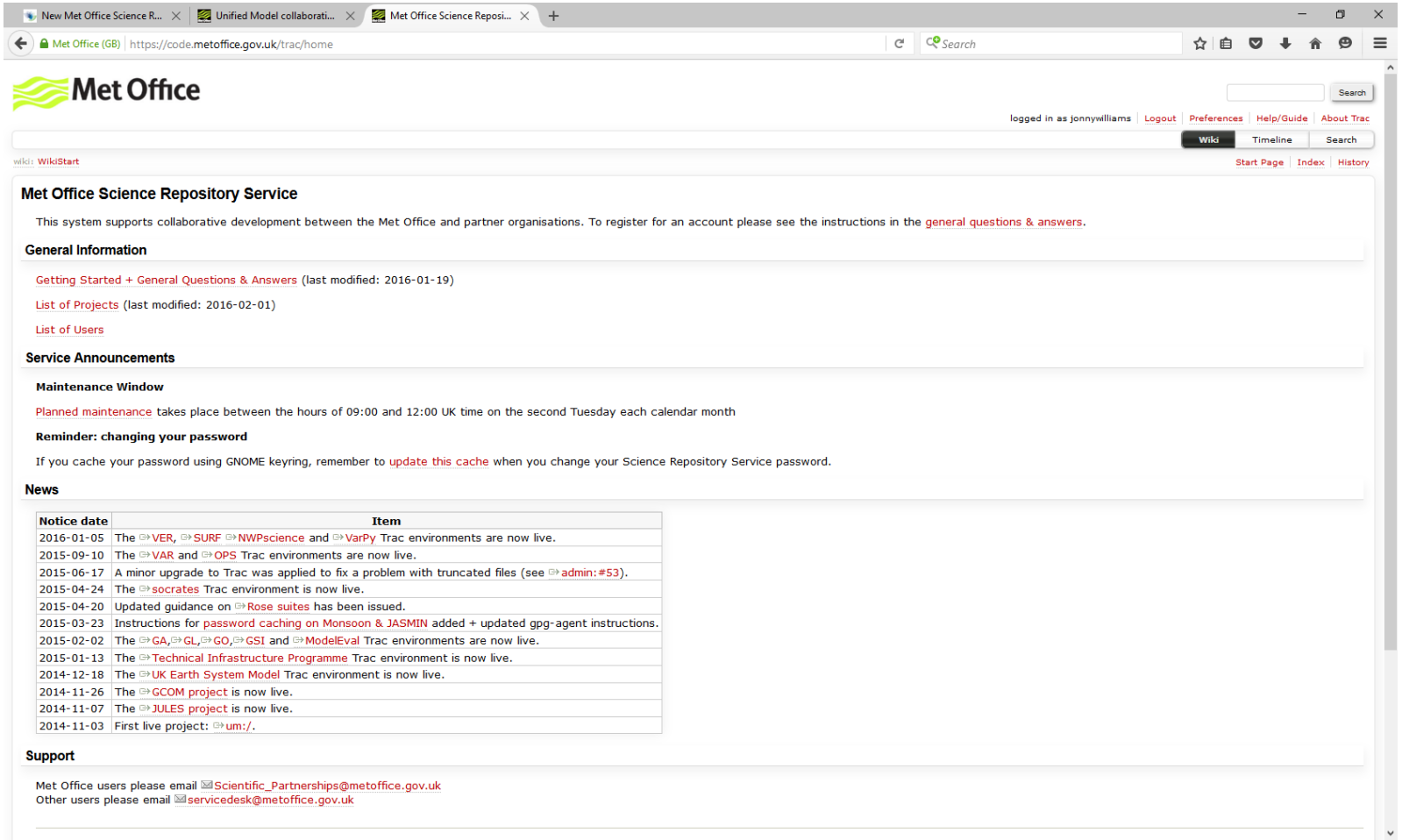
Australian Government
Bureau of Meteorology

Collaboration for Australian Weather and Climate Research
A research partnership between CSIRO and the Australian Bureau of Meteorology

CSIRO

Use of MOSRS

- MOSRS is the Met Office Science Repository Service



Met Office

Met Office Science Repository Service

This system supports collaborative development between the Met Office and partner organisations. To register for an account please see the instructions in the general questions & answers.

General Information

Getting Started + General Questions & Answers (last modified: 2016-01-19)

List of Projects (last modified: 2016-02-01)

List of Users

Service Announcements

Maintenance Window

Planned maintenance takes place between the hours of 09:00 and 12:00 UK time on the second Tuesday each calendar month

Reminder: changing your password

If you cache your password using GNOME keyring, remember to update this cache when you change your Science Repository Service password.

News

Notice date	Item
2016-01-05	The VER, SURF NWPscience and VarPy Trac environments are now live.
2015-09-10	The VAR and OPS Trac environments are now live.
2015-06-17	A minor upgrade to Trac was applied to fix a problem with truncated files (see admin:#53).
2015-04-24	The socrates Trac environment is now live.
2015-04-20	Updated guidance on Rose suites has been issued.
2015-03-23	Instructions for password caching on Monsoon & JASMIN added + updated gpg-agent instructions.
2015-02-02	The GA, GL, GO, GSI and ModelEval Trac environments are now live.
2015-01-13	The Technical Infrastructure Programme Trac environment is now live.
2014-12-18	The UK Earth System Model Trac environment is now live.
2014-11-26	The GCOM project is now live.
2014-11-07	The JULES project is now live.
2014-11-03	First live project: um:/.

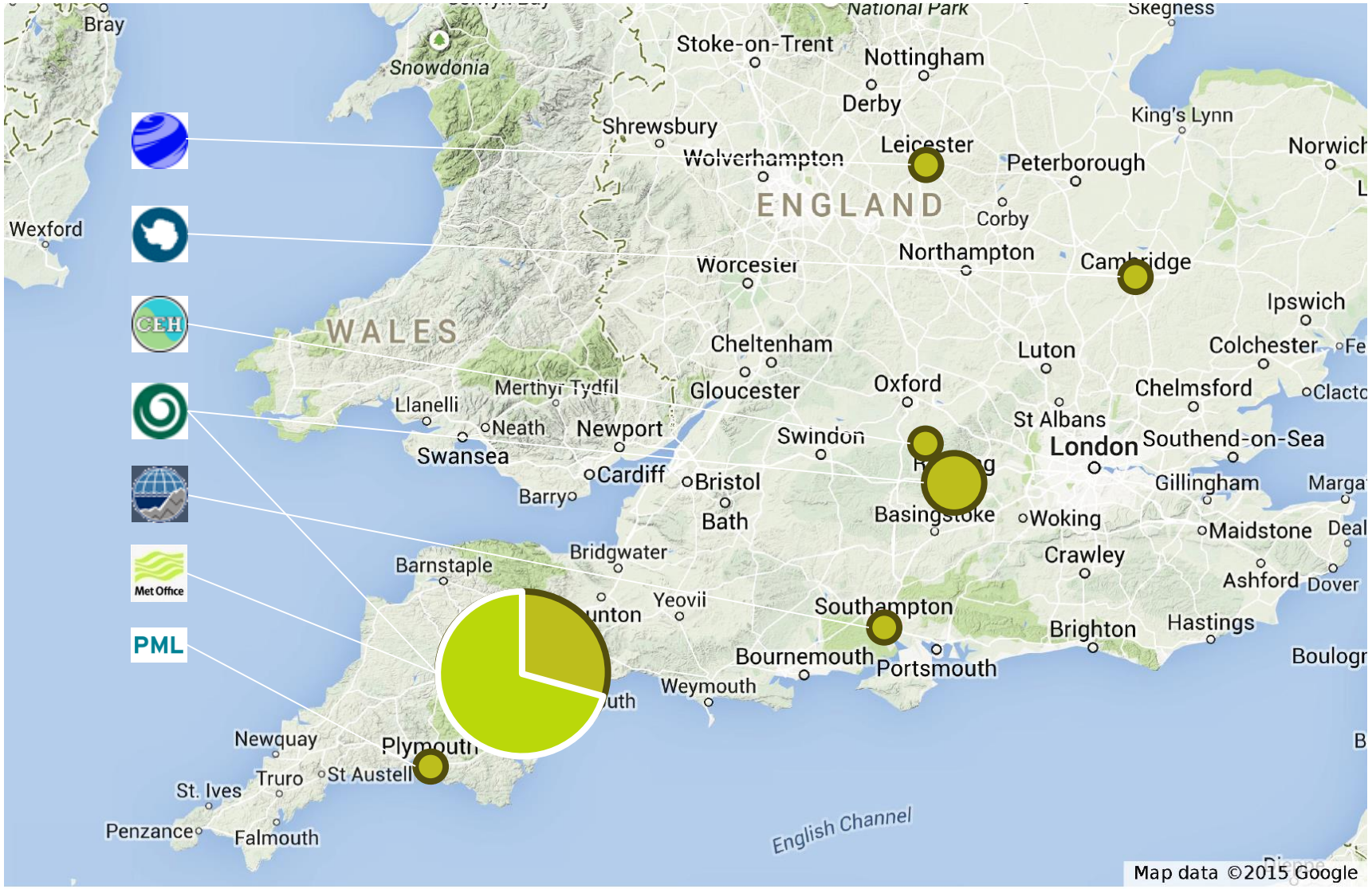
Support

Met Office users please email Scientific_Partnerships@metoffice.gov.uk
Other users please email servicedesk@metoffice.gov.uk

MOSRS

- Use of a shared code repository is a game-changer
- It enables real-time collaboration
  - Patches, bug fixes and ‘suites’ can be instantly shared between colleagues irrespective of location
- Provides a powerful tool for backing up code centrally
  - Once code has been edited to the satisfaction of the coder and committed to the repository, any local copies can be safely deleted
- Work is currently underway to make suites site-independent to further accelerate collaboration

UKESM core team



Rose & Cylc

- Climate models are made of many different components, for example:
  - Code compilation.
  - Running the model physics.
  - Archiving.
  - Checking results against ‘known good output’.
- It is important that these tasks are scheduled to take place not only in the correct order, but also to enable them to be re-scheduled should one task fail, for example.

Rose & Cylc

- These tasks are managed through the open-source tools Rose and Cylc.
- Rose is managed through the UK Met Office
  - https://github.com/metomi/rose
- Cylc is written and developed by NIWA
  - http://cylc.github.io/cylc/
- The combination of Rose and Cylc provide an intuitive visual editing system for meteorological suites.

Rose

source: a / b / 8 / 5 / 0 / trunk

Added Modified Copied or renamed

View changes

Diff		Rev	Age	Author	Log Message
○ ◉		@6191	6 minutes	jonnywilliams	Adding correct start dump file and variable name.
○ ○		@6189	74 minutes	jonnywilliams	Adding site/niwa_fitzroy.rc
○ ○		@6188	84 minutes	jonnywilliams	Turn off prebuild, change paths to ancils file, add NIWA site file.rc …
○ ○		@6187	2 hours	jonnywilliams	u-ab850: new suite, a copy of u-ab642/trunk@5855
	copied from a/b/6/4/2/trunk:				
◉ ○		@5855	7 days	paulearnshaw	Fix type in postproc build app.

Download in other formats:
RSS Feed | ChangeLog

Diff from a/b/6/4/2/trunk@5855 to a/b/8/5/0/trunk@6191 – roses-u - Mozilla Firefox

File Edit View History Bookmarks Tools Help

Diff from a/b/6/4/2/trunk@585…

Met Office (GB) https://code.metoffice.gov.uk/trac/roses-u/changeset?reponame=&new=6191%40a%2Fb%2F8%2F5%2F0%2Ftrunk&old=5855%40a%2Fb%2F6%2F4%2

Google

Rose

Search

logged in as jonnywilliams | Logout | Preferences | Help/Guide | About Trac

Wiki | Timeline | Browse Source | View Tickets | New Ticket | Search

Reverse Diff

Changes from a/b/6/4/2/trunk at r5855 to a/b/8/5/0/trunk at r6191

Location: a/b/8/5/0/trunk

Files: 1 added 5 edited

- app/fcm_make_um/rose-app.conf (1 diff)
- app/install_ancil/rose-app.conf (1 diff)
- meta/rose-meta.conf (1 diff)
- rose-suite.conf (2 diffs)
- rose-suite.info (1 diff)
- site/niwa_fitzroy.rc

View differences: side by side

Show 2 lines around each change

Show the changes in full context

Ignore:

Blank lines

Case changes

White space changes

Update

Unmodified Added Removed Modified

a/b/8/5/0/trunk/app/fcm_make_um/rose-app.conf

Tabular | Unified

Revision 5855		Revision 6191	
36	optimisation_level=$OPTIM	36	optimisation_level=$OPTIM
37	platform_config_dir=$CONFIG	37	platform_config_dir=$CONFIG
38	prebuild=$PREBUILD	38	prebuild=
39	socrates_rev=um10.3	39	socrates_rev=um10.3
40	socrates_sources=	40	socrates_sources=

a/b/8/5/0/trunk/app/install_ancil/rose-app.conf

Tabular | Unified

Revision 5855		Revision 6191	
3		3	
4	[file:$ROSE_DATA/etc/um_ancils_gl]	4	[file:$ROSE_DATA/etc/um_ancils_gl]
5	source=$UMDIR/ancil/data/ancil_versions/n96e_orca025/GA7.0_AMIP/v1/ancils	5	source=/home/williamsjh/DATA/ancil/data/ancil_versions/n96e_orca025/GA7.0_AMIP/v1/ancils

a/b/8/5/0/trunk/meta/rose-meta.conf

Tabular | Unified

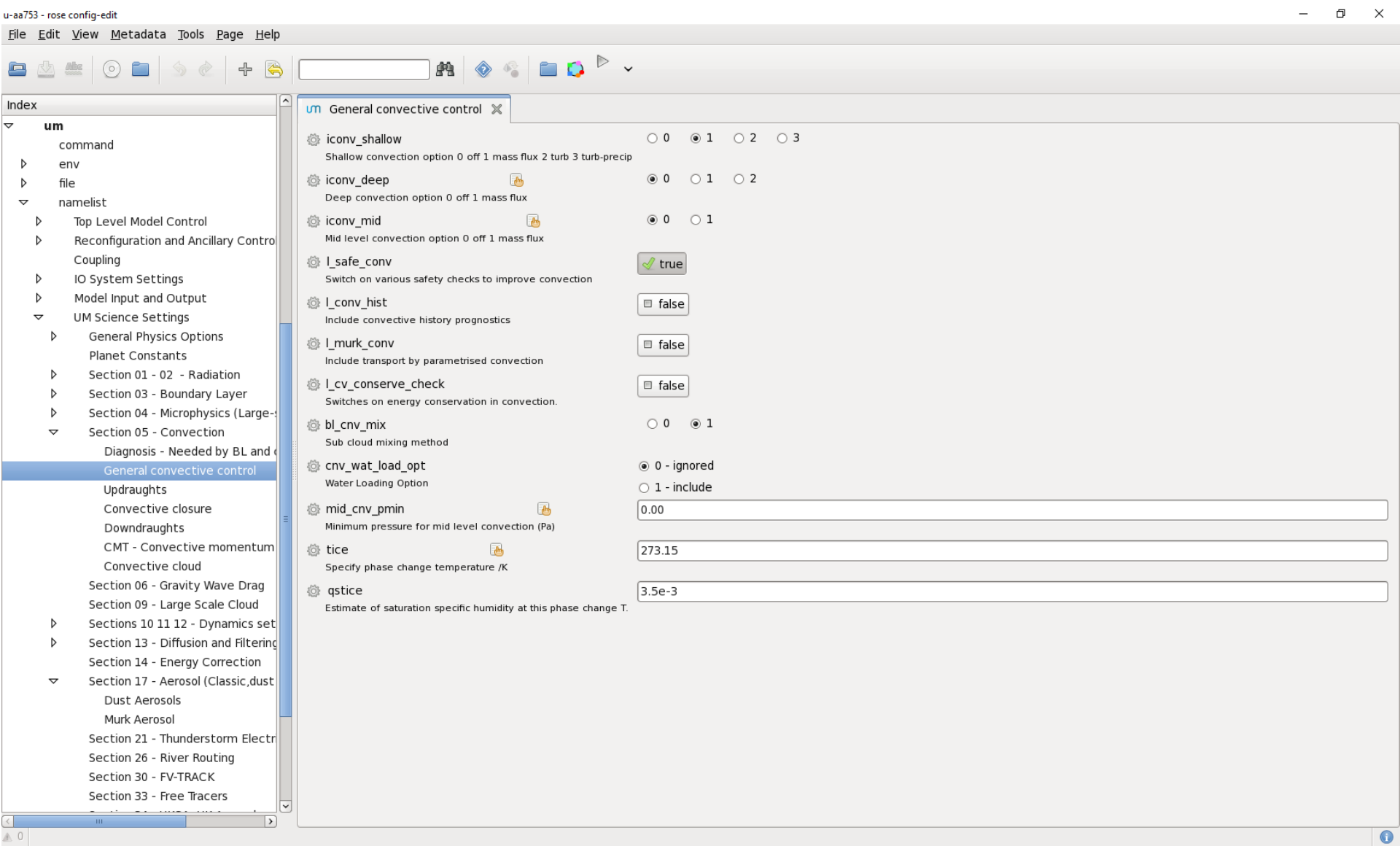
Revision 5855		Revision 6191	
295	trigger=jinja2:suite.rc=HPC_QUEUE: 'meto_cray';	295	trigger=jinja2:suite.rc=HPC_QUEUE: 'meto_cray';
296	=jinja2:suite.rc=HPC_GROUP: 'meto_cray'	296	=jinja2:suite.rc=HPC_GROUP: 'meto_cray'
297	value-titles=Met0 Cray, NCI Raijin	297	value-titles=Met0 Cray, NCI Raijin, NIWA FitzRoy
298	values='meto_cray','nci_raijin'	298	values='meto_cray','nci_raijin','niwa_fitzroy'
299		299	
300	[jinja2:suite.rc=TEST_CRUN]	300	[jinja2:suite.rc=TEST_CRUN]

a/b/8/5/0/trunk/rose-suite.conf

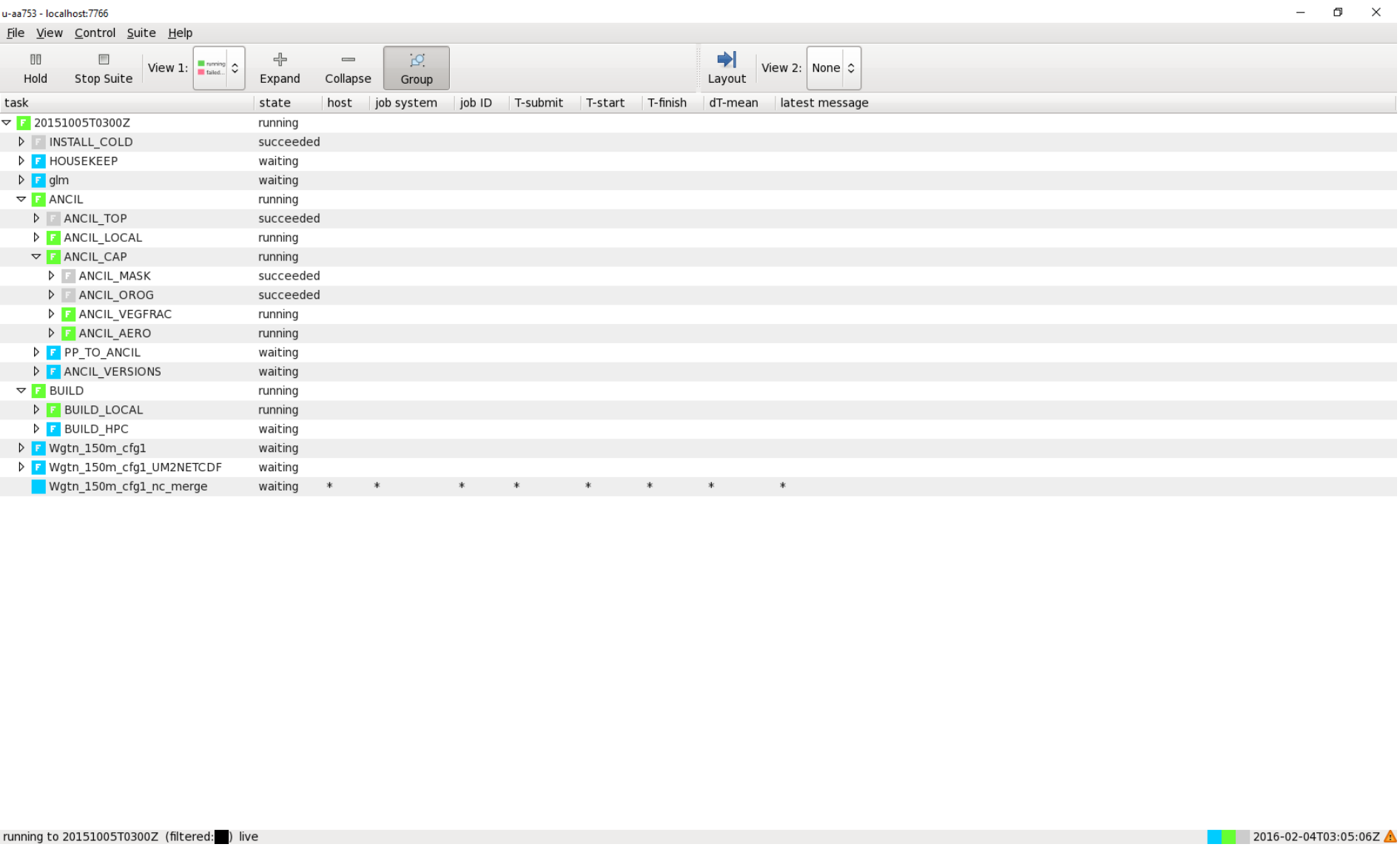
Tabular | Unified

Revision 5855		Revision 6191	

Rose config-edit



GCylc


u-aa753 - localhost:7766
File View Control Suite Help
Hold
Stop Suite
View 1:
Expand
Collapse
Group
Layout
View 2:
None
task state host job system job ID T-submit T-start T-finish dT-mean latest message
20151005T0300Z running
INSTALL_COLD succeeded
HOUSEKEEP waiting
glm waiting
ANCIL running
ANCIL_TOP succeeded
ANCIL_LOCAL running
ANCIL_CAP running
ANCIL_MASK succeeded
ANCIL_OROG succeeded
ANCIL_VEGFRAC running
ANCIL_AERO running
PP_TO_ANCIL waiting
ANCIL_VERSIONS waiting
BUILD running
BUILD_LOCAL running
BUILD_HPC waiting
Wgtn_150m_cfg1 waiting
Wgtn_150m_cfg1_UM2NETCDF waiting
Wgtn_150m_cfg1_nc_merge waiting * * * * * * * *
running to 20151005T0300Z (filtered:) live
2016-02-04T03:05:06Z

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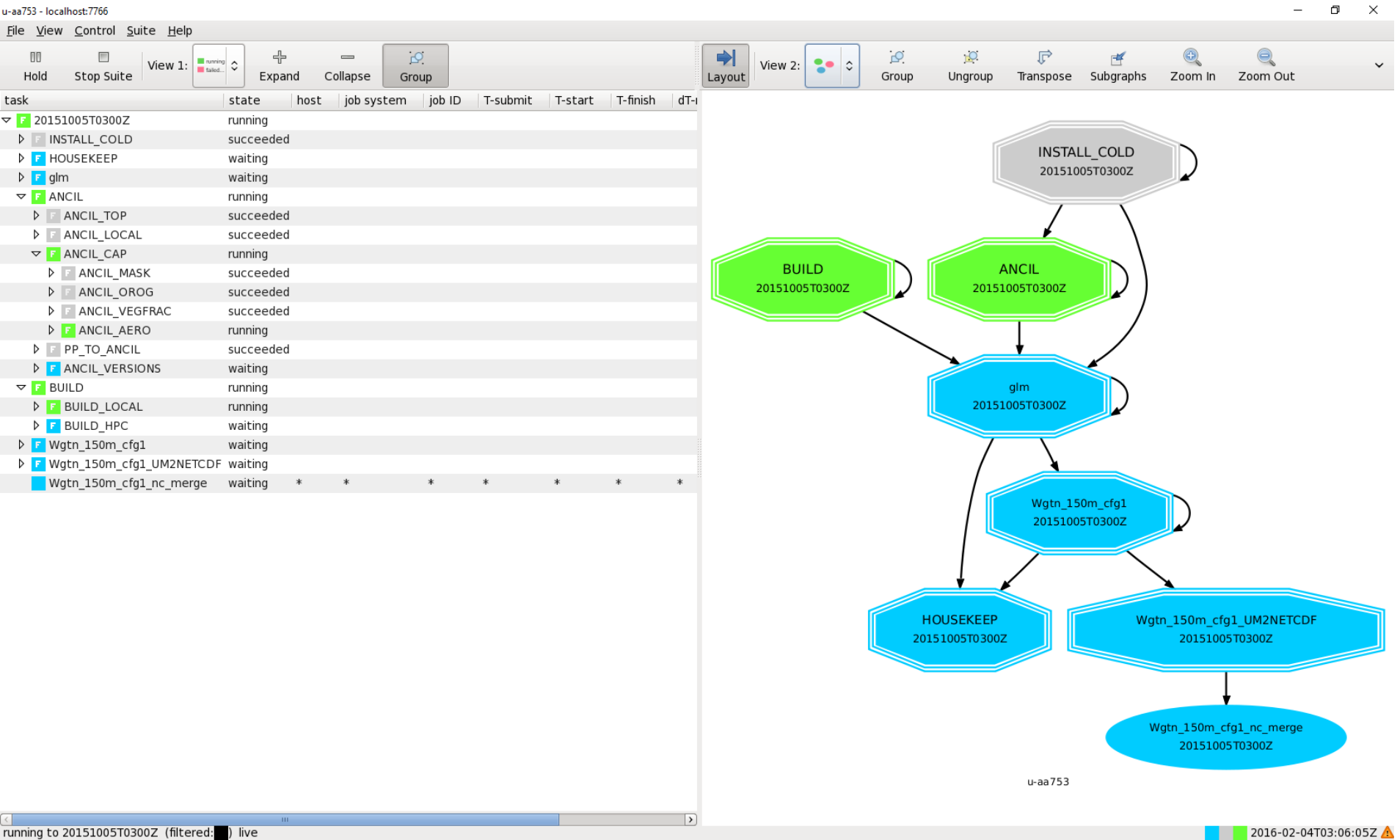
GCylc



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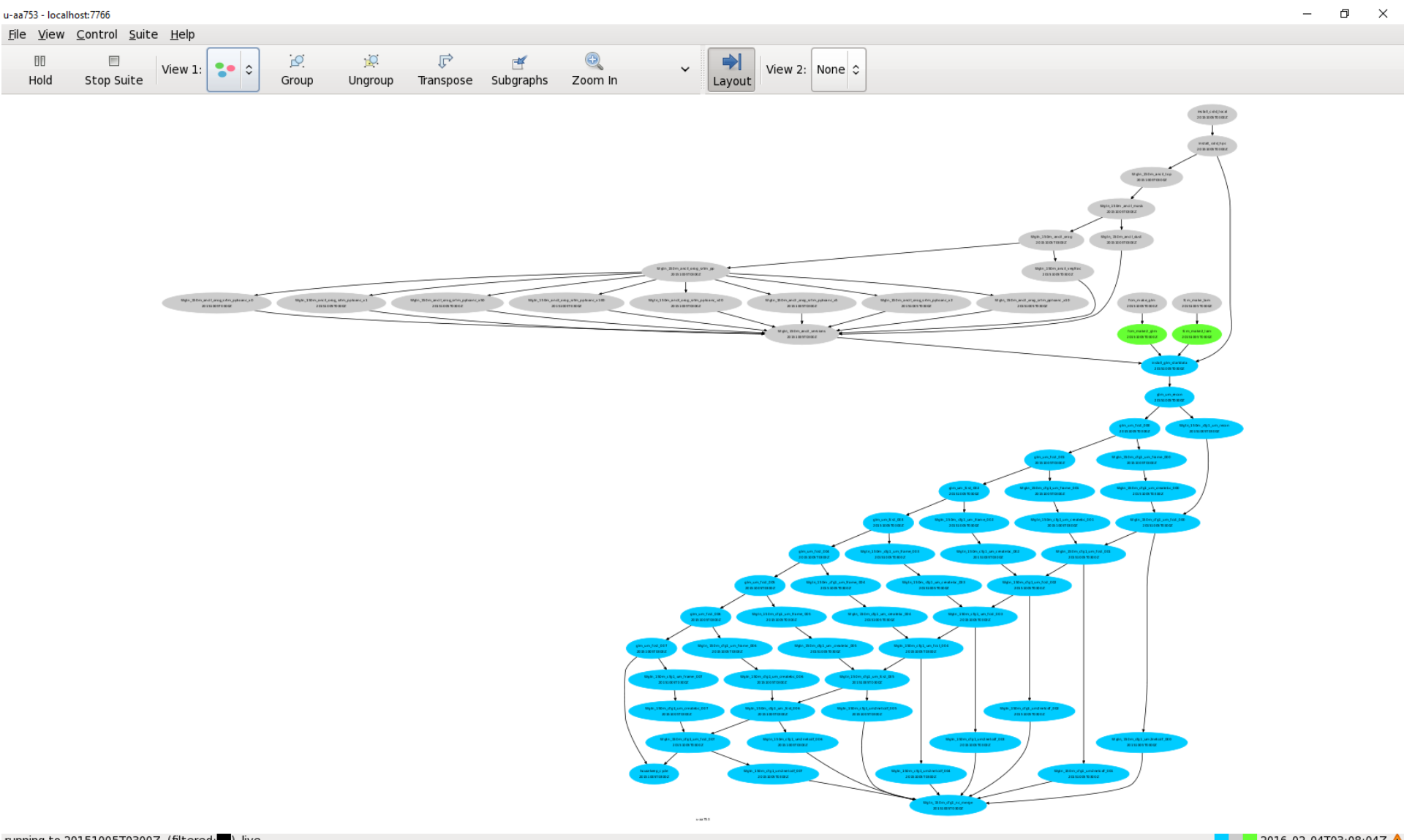
Gcylc

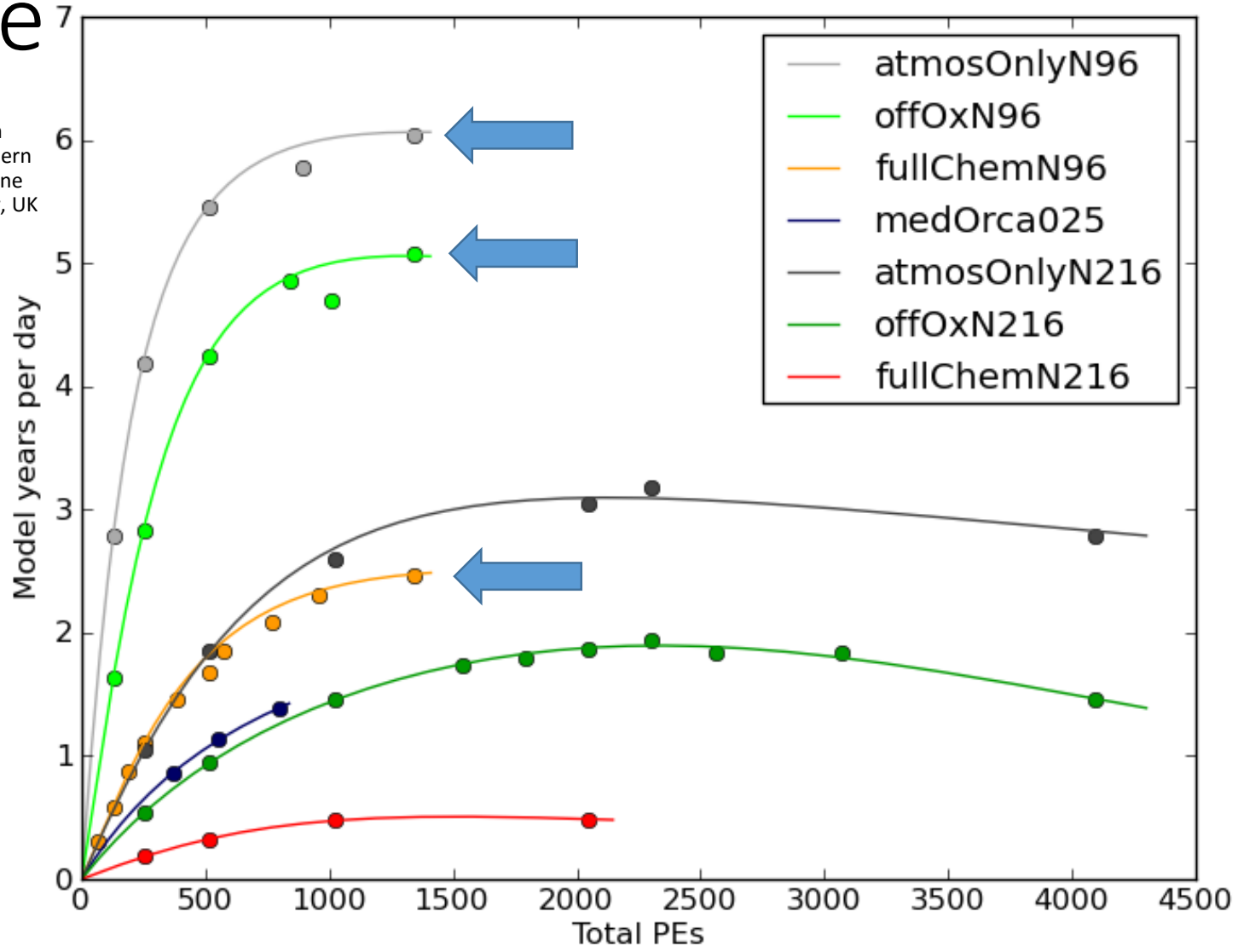


Ballpark HPC usage of the NZESM

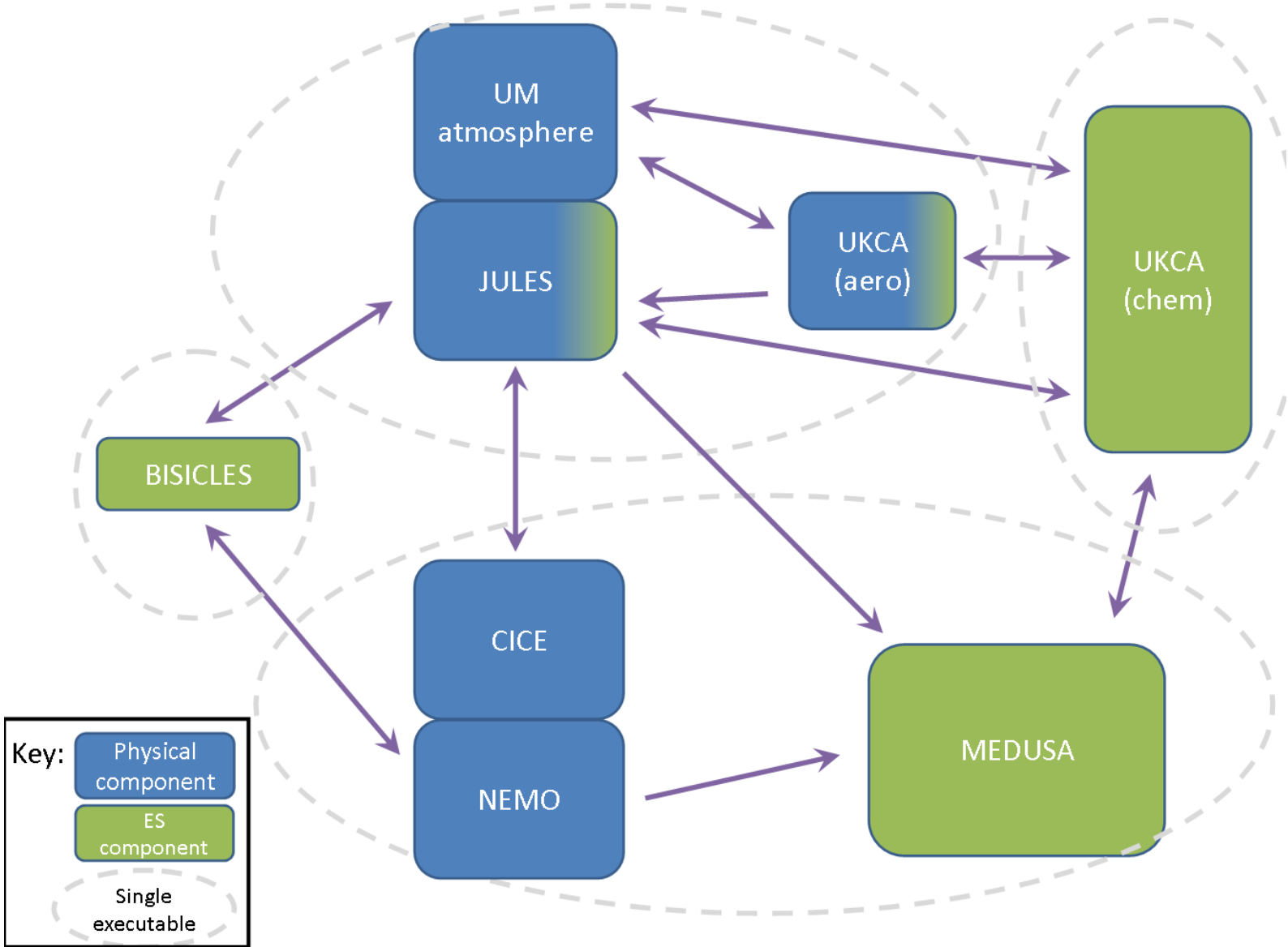
- Ballpark for two reasons
  - The NZESM is still under development across the Core Partners of the UM consortium
  - The current NIWA HPC is due to be upgraded in 12-18 months' time
- Hence any figures quoted for current operational and development runs are provisional ☺

UKESM – IBM P7, 32 cores per node

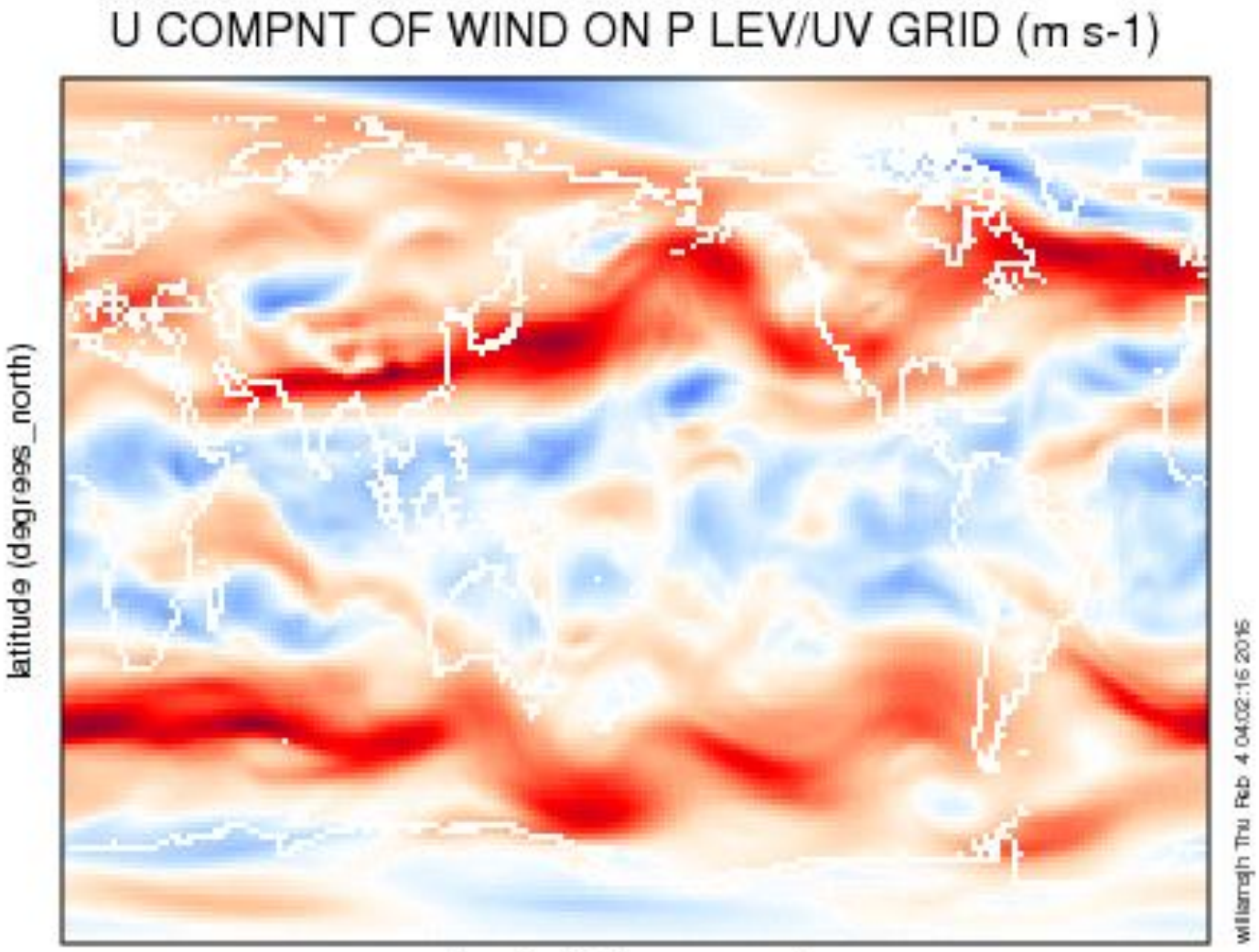
- Computational cost of running a complex Earth System Model on a modern IBM power 7 HPC machine (courtesy: Marc Stringer, UK MetOffice).



Coupling UKESM1

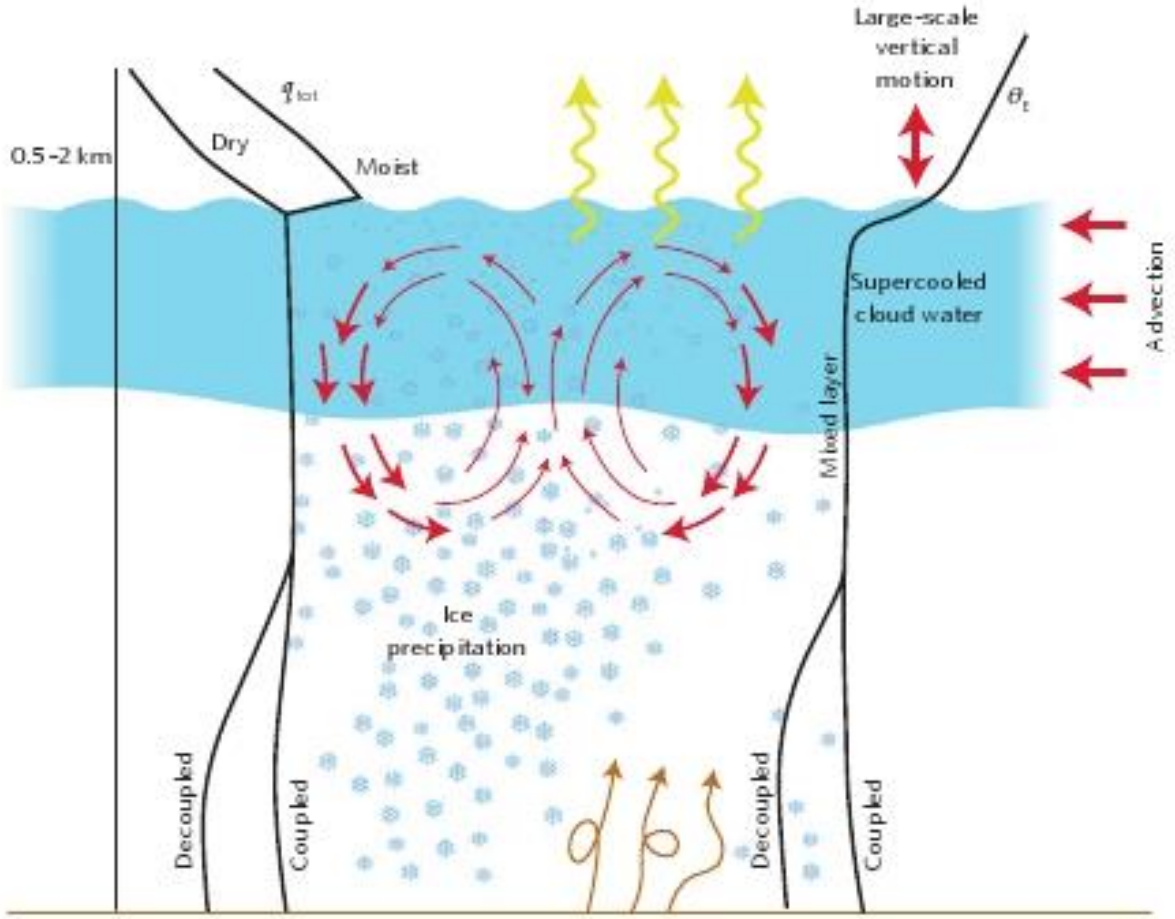


First proto-NZESM results



Current status of the UKESM

- As of last week, it was announced that the code configurations for UKESM1 have been ‘frozen’
- This means that we are now in a position to port over the code to the NIWA HPC and to begin running the NZESM ‘for real’
- Vidya Varma and Olaf Morgenstern are developing a new mixed-phase cloud parameterisation which we hope will contribute significantly to the model development and ultimately to a better understanding of the Southern Ocean bias discussed earlier
- If NIWA can contribute this to the development of the UKESM/NZESM then this will be very useful to the community as a whole given the large Southern Ocean bias



Radiative Cooling
- Drives buoyant production of turbulence
- Forces direct condensation within inversion layer
- Requires minimum amount of cloud liquid water

Microphysics
- Liquid forms in updrafts and sometimes within the inversion layer
- Ice nucleates in cloud
- Rapid ice growth promotes sedimentation from cloud

Dynamics
- Cloud-forced turbulent mixed layer with strong narrow downdrafts, weak broad updrafts, and q_{tot} and θ_l nearly constant with height
- Small-scale, weak turbulence in cloudy inversion layer
- Large-scale advection of water vapour important

Surface Layer
- Turbulence and q contributions can be weak or strong
- Sink of atmospheric moisture due to ice precipitation
- Surface type (ocean, ice, land) influences interaction with cloud

https://www.arm.gov/science/highlights/images/R00290_1.jpg

Acknowledgements

- Hilary Oliver, NIWA
- Vidya Varma, NIWA
- Wolfgang Hayek, NIWA / NeSI
- Joao Teixeira, Met Office
- Jeremy Walton, Met Office

And thank *you* for your attention!

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