

Regional Climate Modelling Techniques: Impacts on Regional Climate Change

Climate Adaptation Flagship

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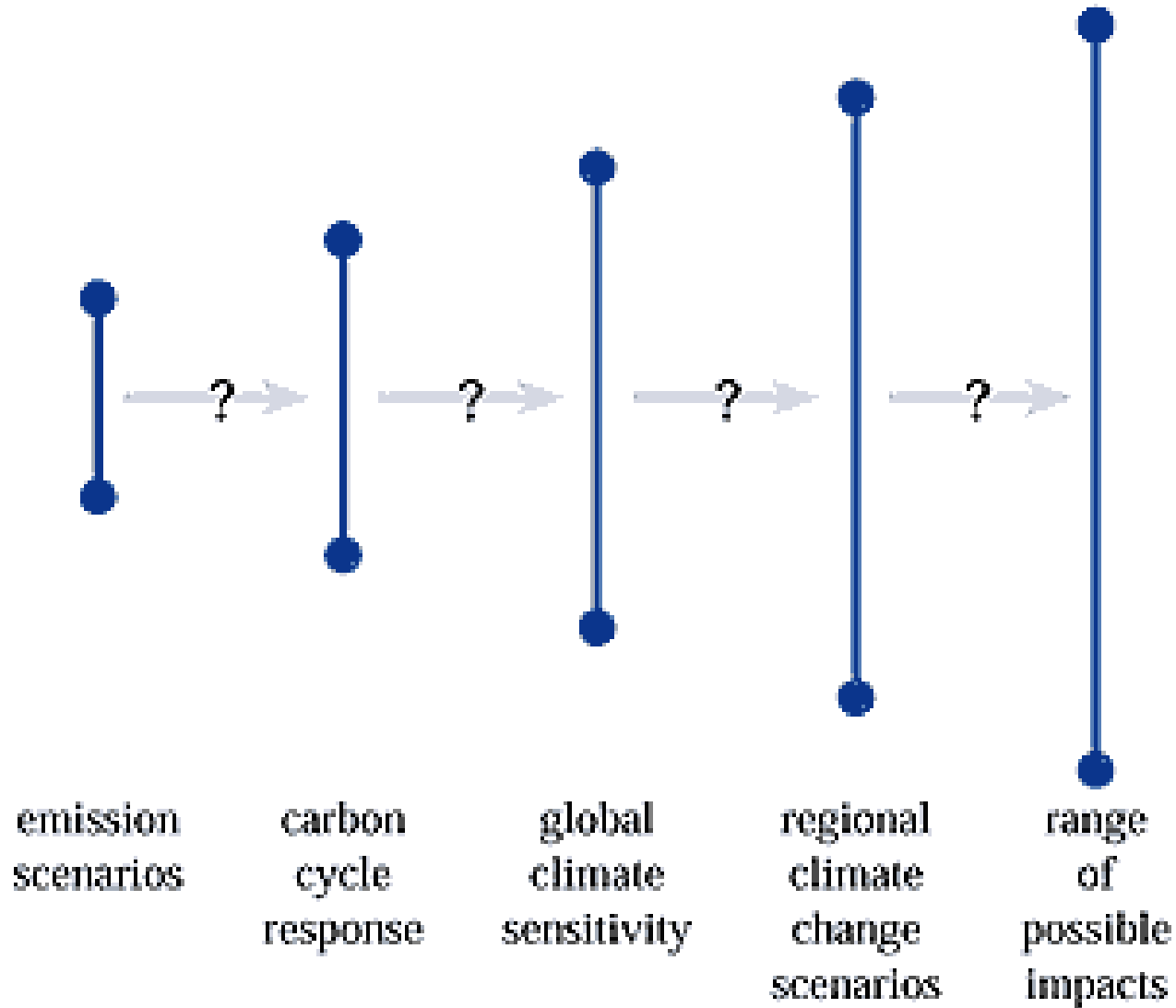
CAWCR, CMAR, Aspendale

GH2011

Outline

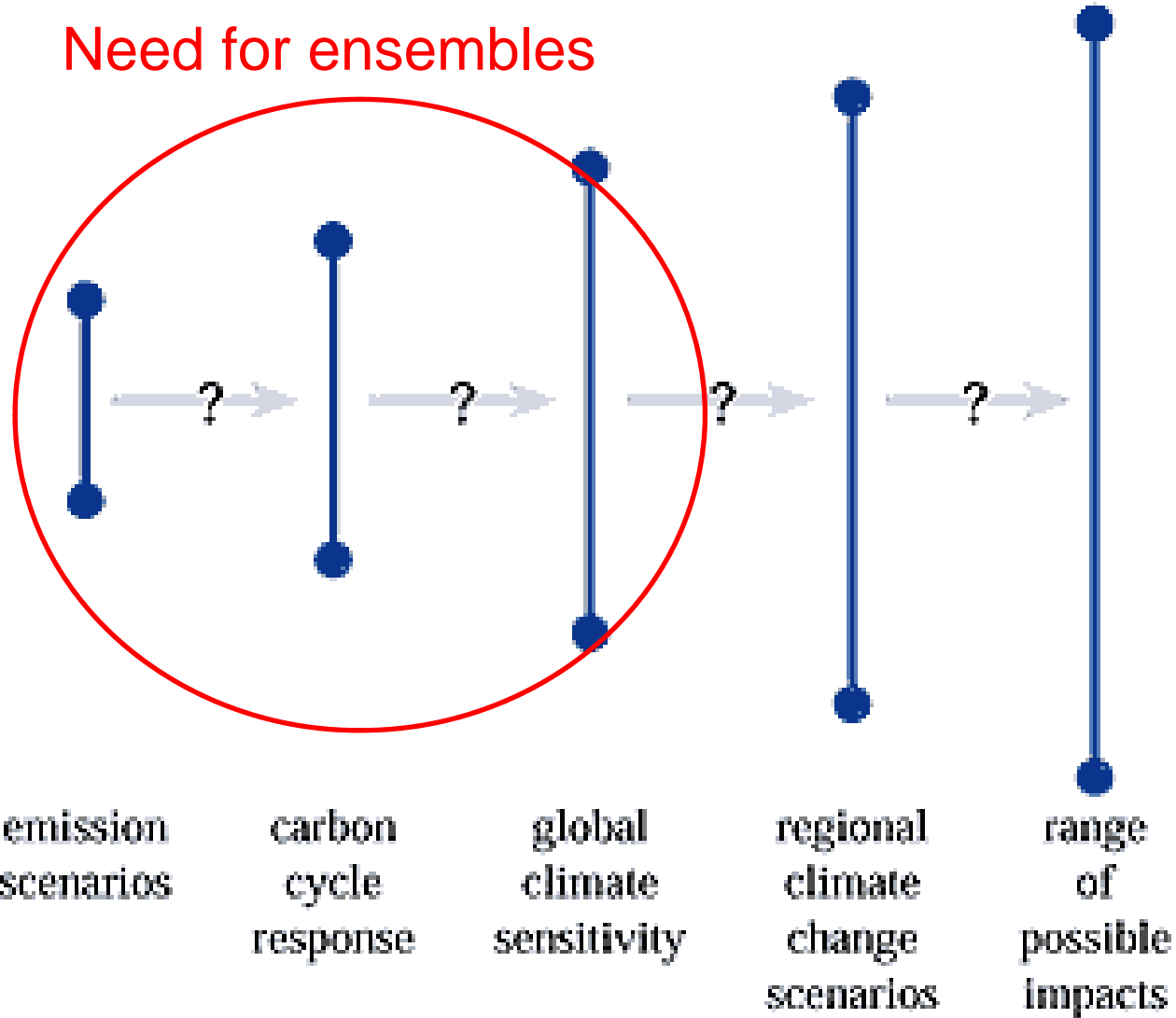
- Uncertainty and downscaling
- Our dynamical downscaling approach (and why)
- Some results – CFT and PCCSP
- Summary

Cascade of uncertainty?

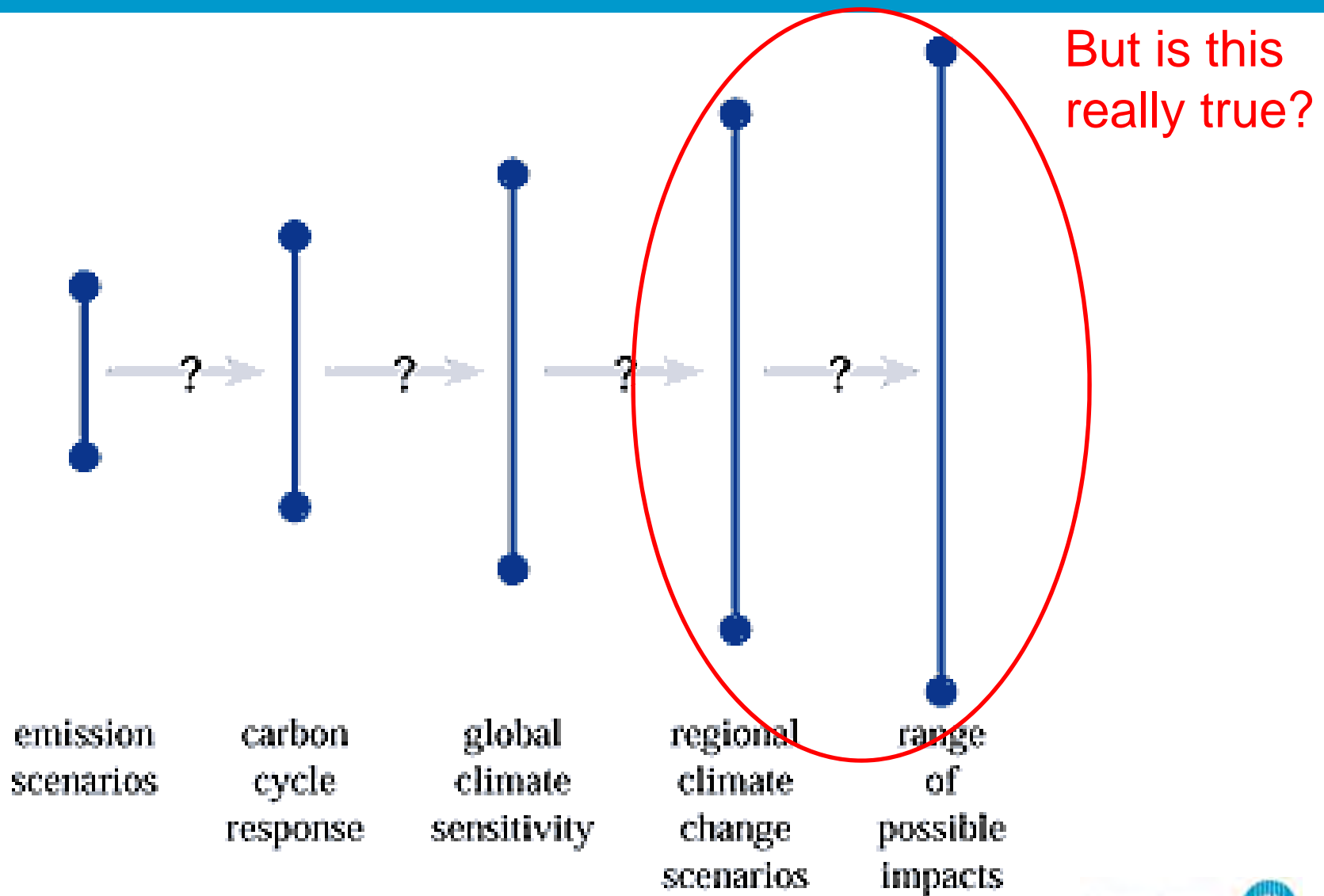


Cascade of uncertainty?

Need for ensembles

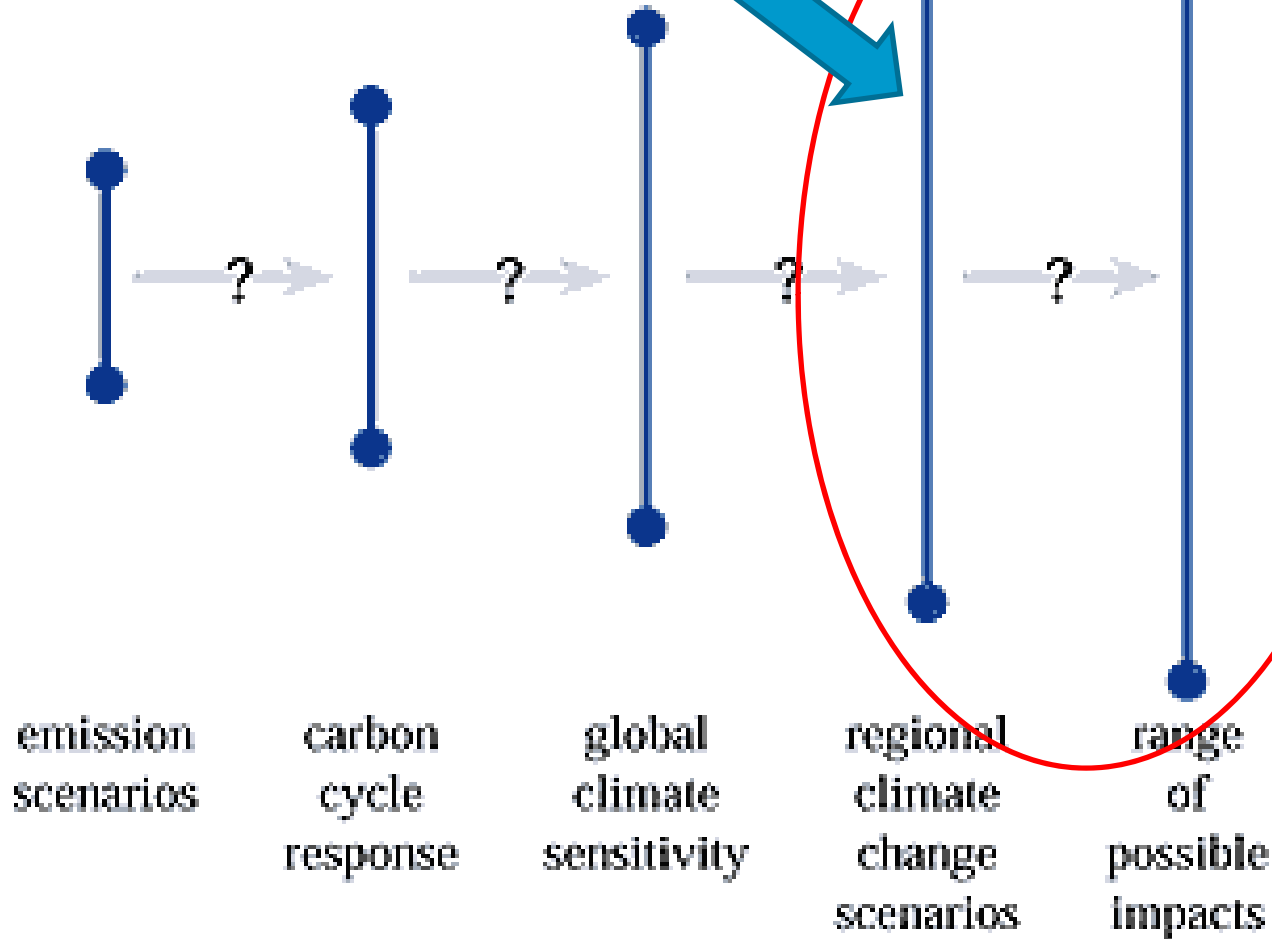


Cascade of uncertainty?



Cascade of uncertainty?

Increased resolution
Additional surface forcing



But is this
really true?
I think not!

Regional Climate Modelling

Scenario selection

- SRES - RCP

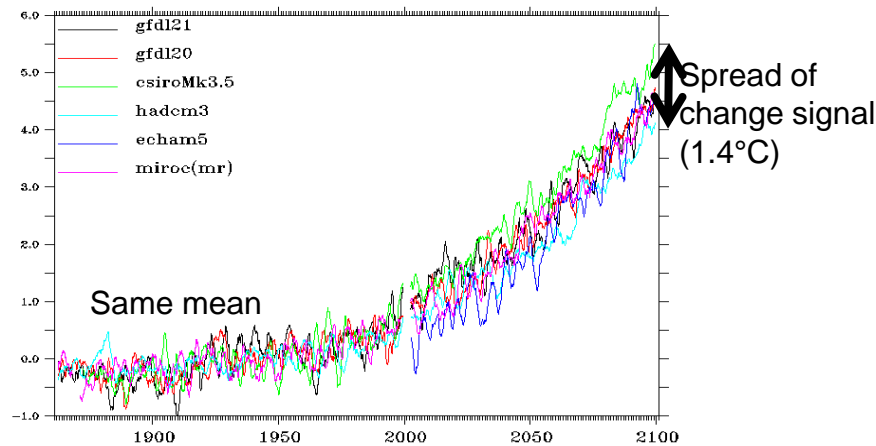
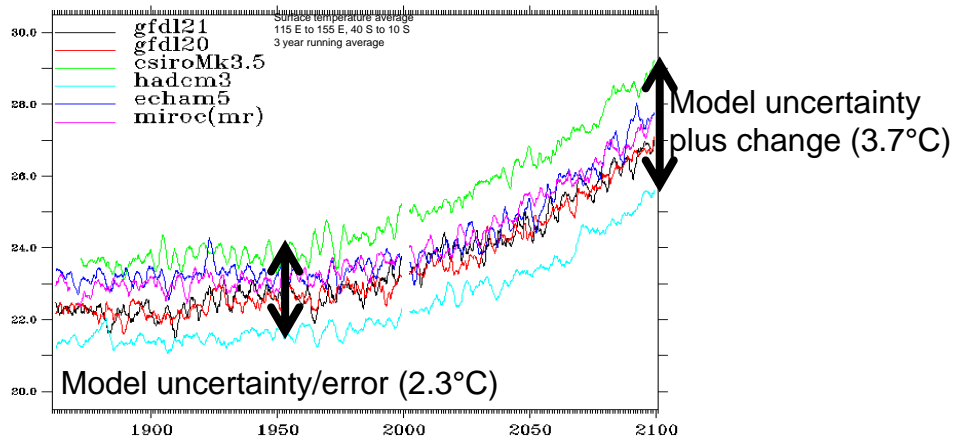
GCM selection

- Good current climate – necessary?
- Good variability – yes
- Patterns of climate change? (Whetton)

Bias correct SSTs

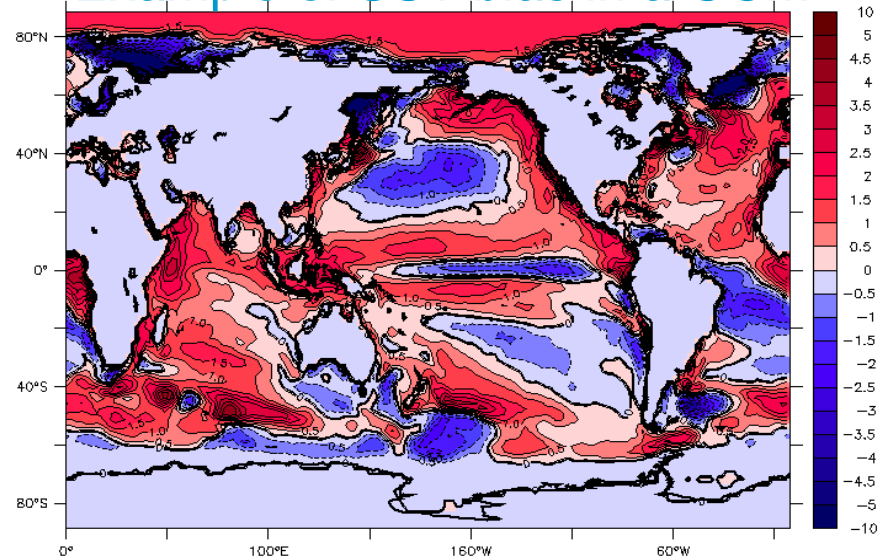
- Determine climatology for each month
- For whole run, subtract bias for each month
- Preserves variability and change signal

Large-scale bias-correction



- In addition to fixing biases, allows simulation to have more realistic weather systems and how they may change in response to climate change
- Affect on downscaling later

Example of SST bias in a GCM



Regional Climate Modelling

RCM setup

- Region of interest – domain
- Resolution
- Surface specification – land use/orography
- Physics/parameterisations chosen

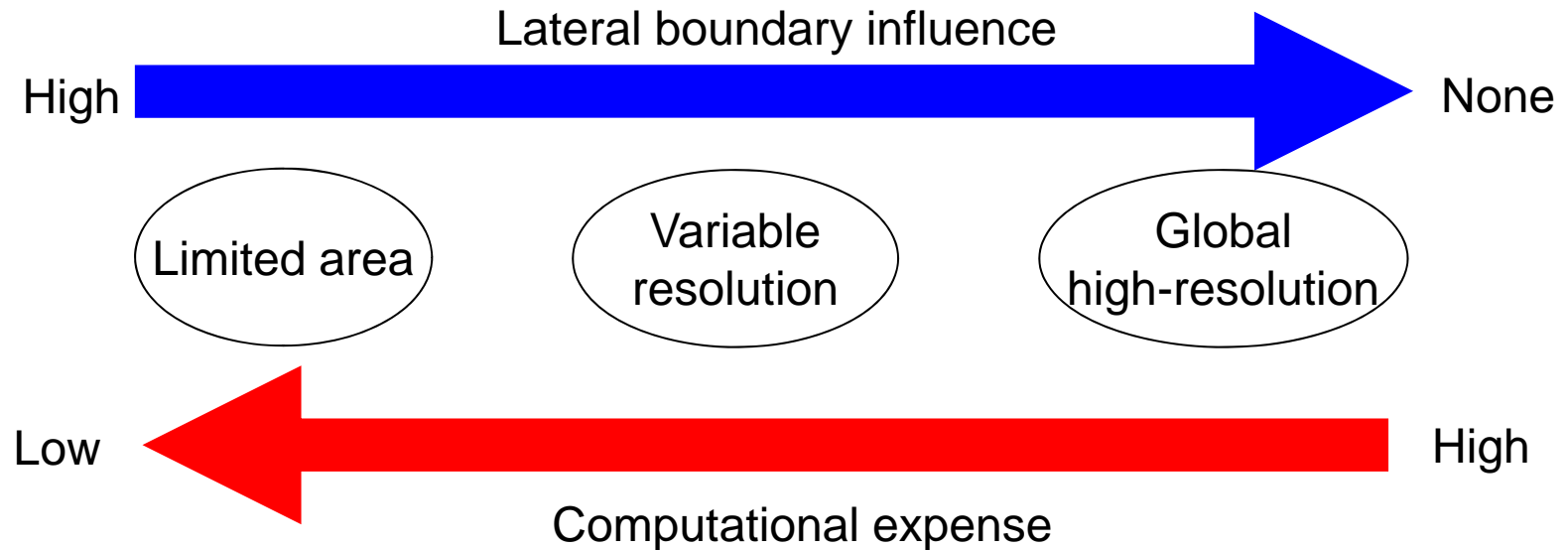
Simulation

- Time period
- Outputs
- Forcing?

Multiple downscaling

- New domain/resolution/surface inputs
- Forcing from coarser resolution simulation

Regional Climate Modelling Approaches



- Also need to consider:

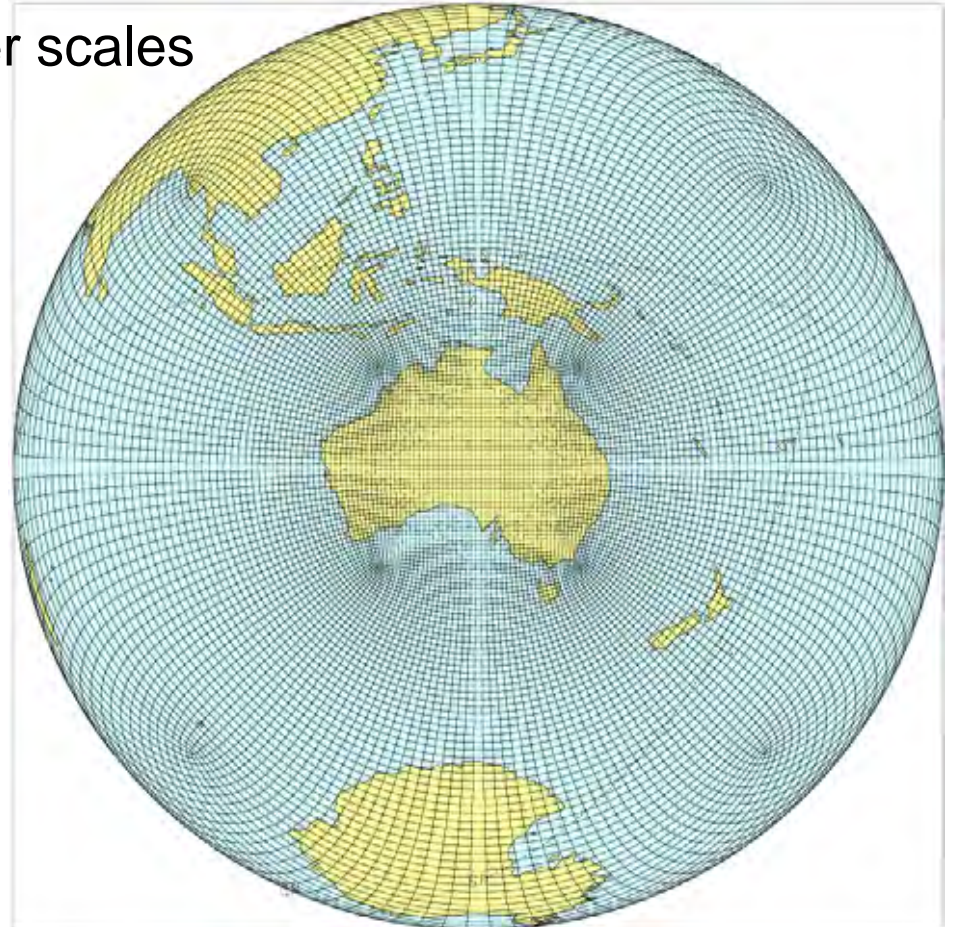
- Domain size
- Resolution
- Two-way interaction
- Internal variability

Stretched grid – No lateral boundaries

Conformal Cubic Atmospheric Model (CCAM)

Full atmospheric model – like GCMs

Allows interaction with larger scales



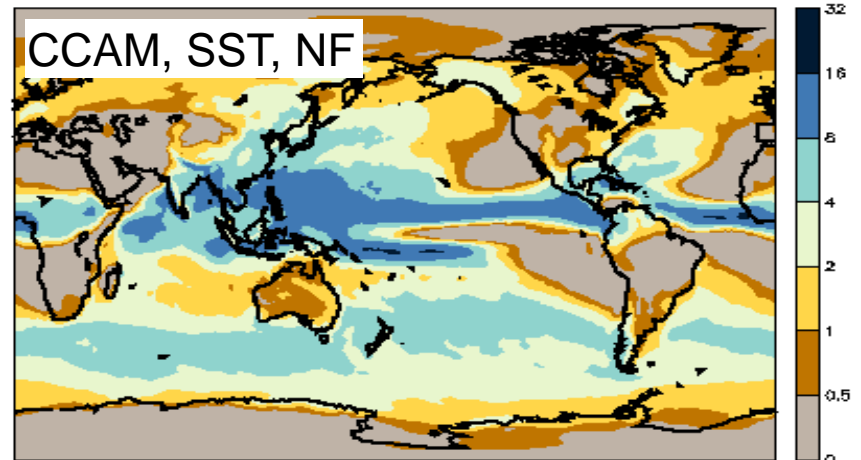
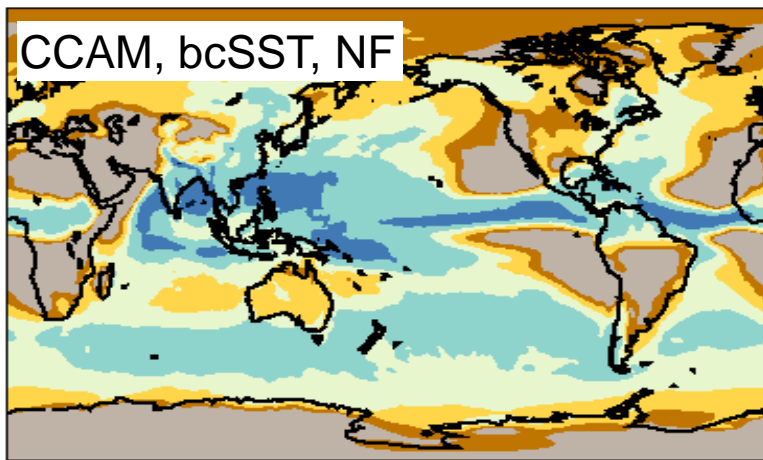
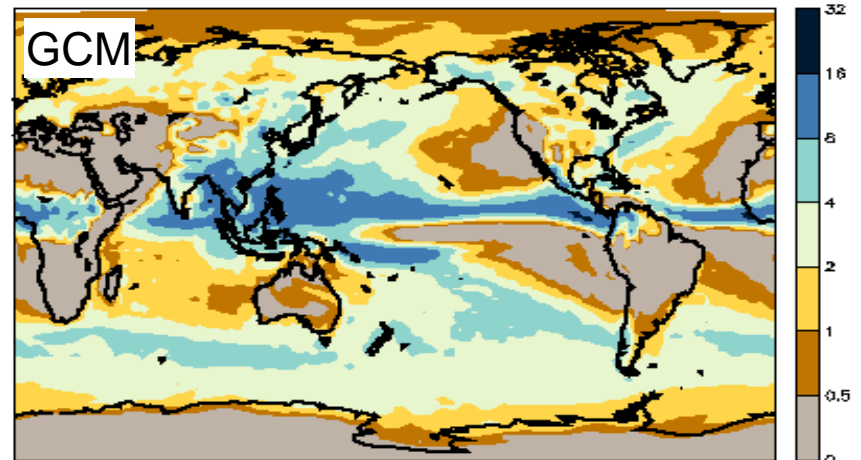
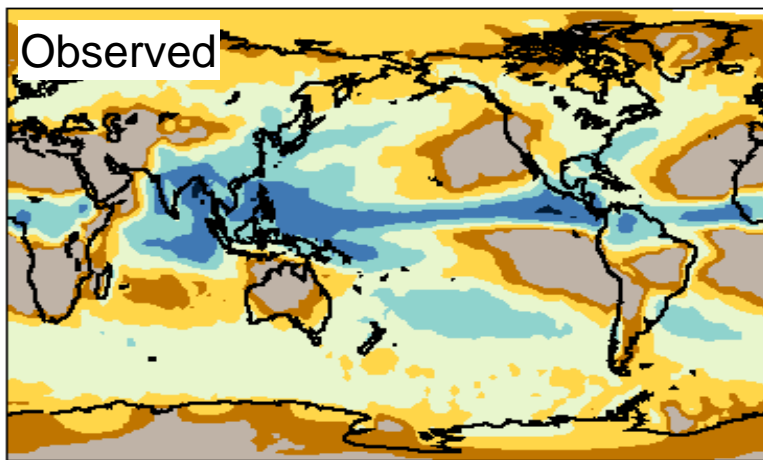
Example of variable resolution CCAM grid – 60 km over Australia

Bias adjustment of sea surface temperatures

- Sea surface temperatures main influence on climate (**ENSO, climate change**)
 - Dommengeset, Dietmar, 2009: The Ocean's Role in Continental Climate Variability and Change. *J. Climate*, **22**, 4939–4952
- Can we improve our representation of the current climate by fixing the biases? (**yes**)

Comparison of downscaling approaches: July rainfall (1970-1979)

Note the similarities of CCAM with uncorrected SSTs to the GCM (RHS)
CCAM with bias-corrected SSTs is more similar to the observed (LHS)



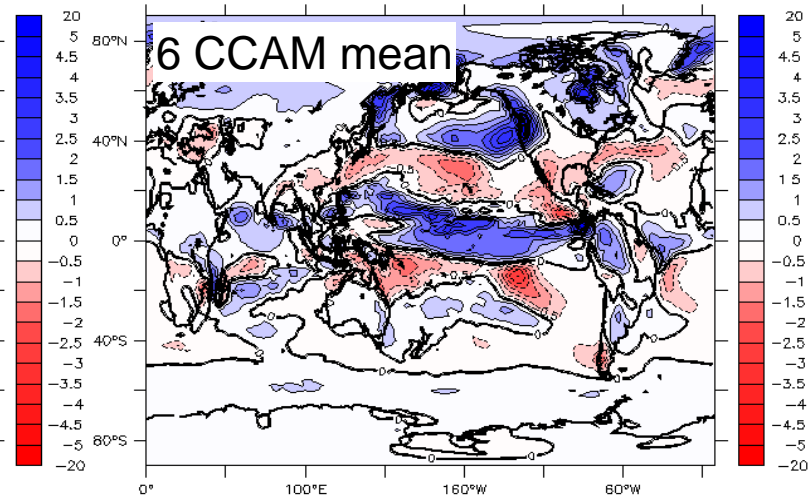
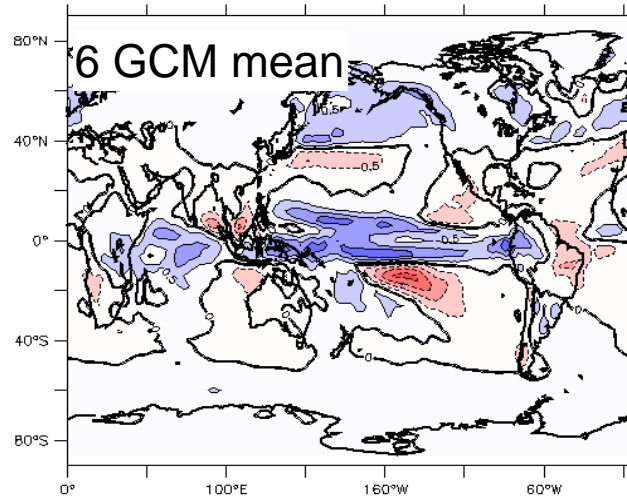
Bias adjustment of sea surface temperatures

- CCAM is an atmosphere only model – require GCMs to provide projections of sea surface temperatures
- Does using one downscale model decrease spread of climate change signal? (no)

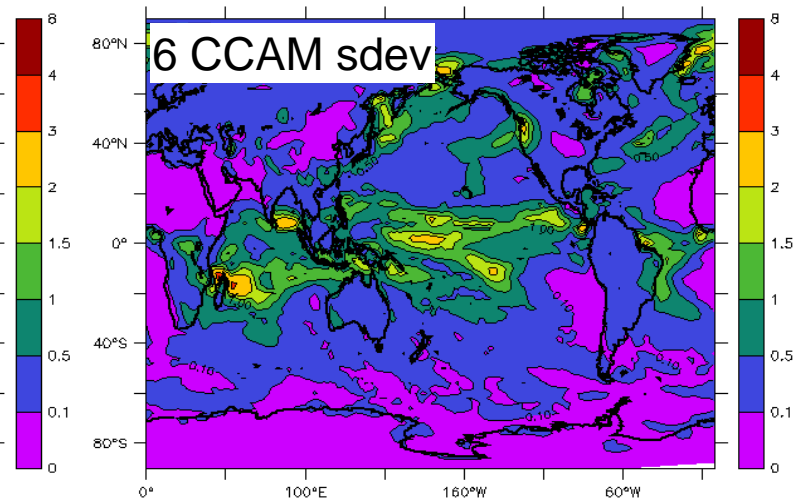
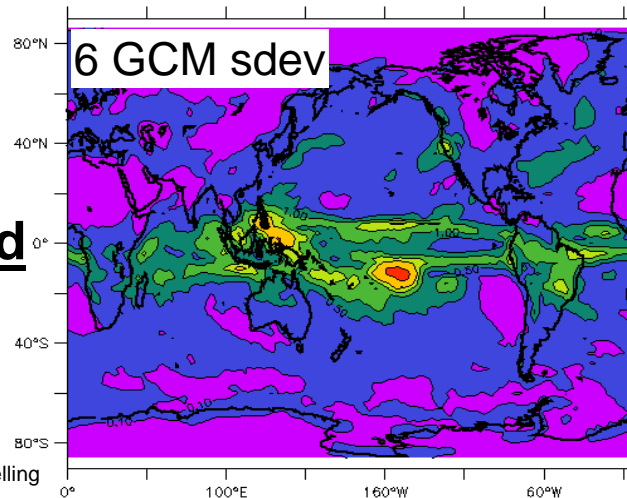
Ensemble Mean and Spread: Changes in DJF precipitation

The spread of climate change signals in CCAM is similar to that in the GCMs

**2085-1980
change**



**2070-2100
change spread
(Std.Dev.)**

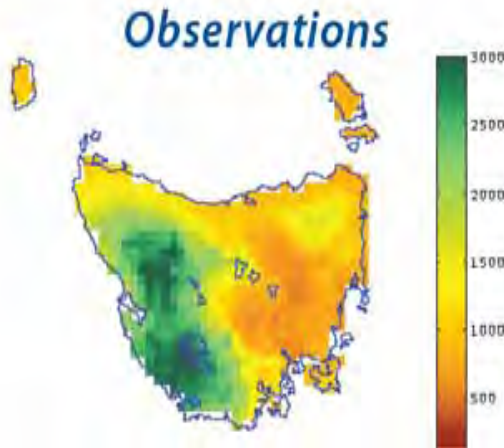


Adding more information with higher resolution

- Can multiply downscale
 - CCAM within itself
 - Other RCMs
- CCAM uses a digital filter to forcing large-scale information from coarser resolution run into higher resolution run

Multiple downscaling to higher resolution

Simulated annual rainfall for Tasmania at different resolutions



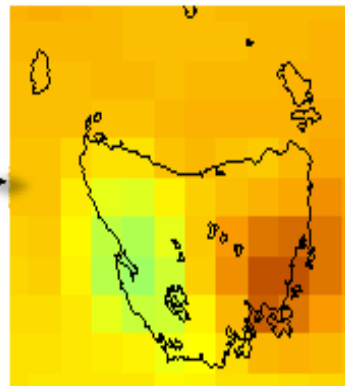
Global Model



Bias-correc.

Increased resolution

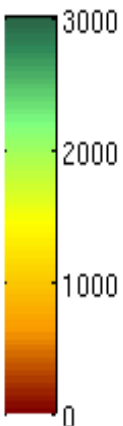
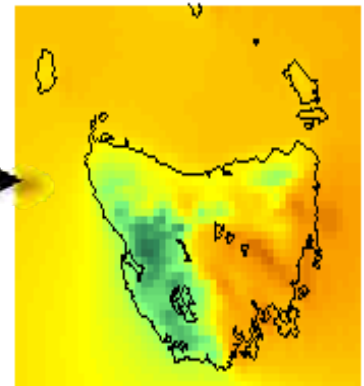
CCAM 60 km



Spectral forcing

Increased resolution

CCAM 14 km

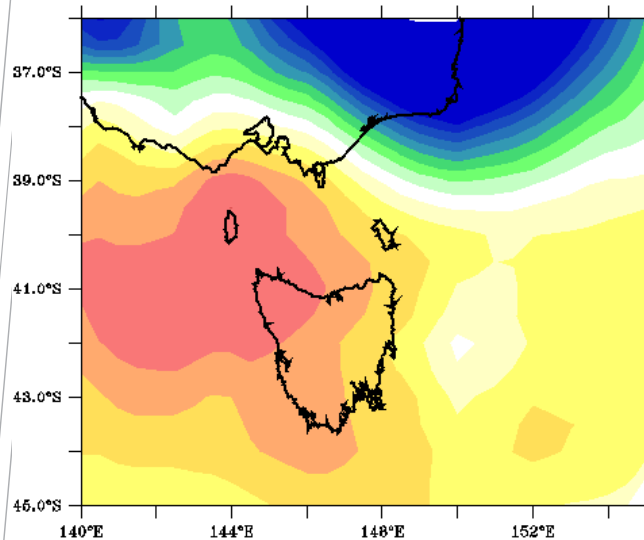


Climate Futures for Tasmania project

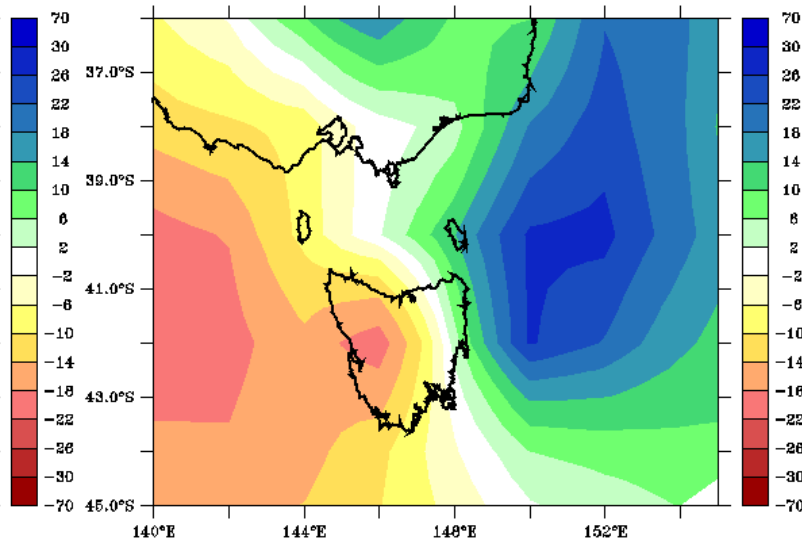
DJF rainfall: percentage change

Change in rainfall 1970:1999 to 2070:2099
6 model mean

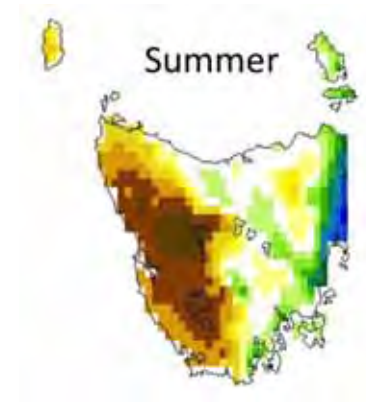
GCM



60 km RCM



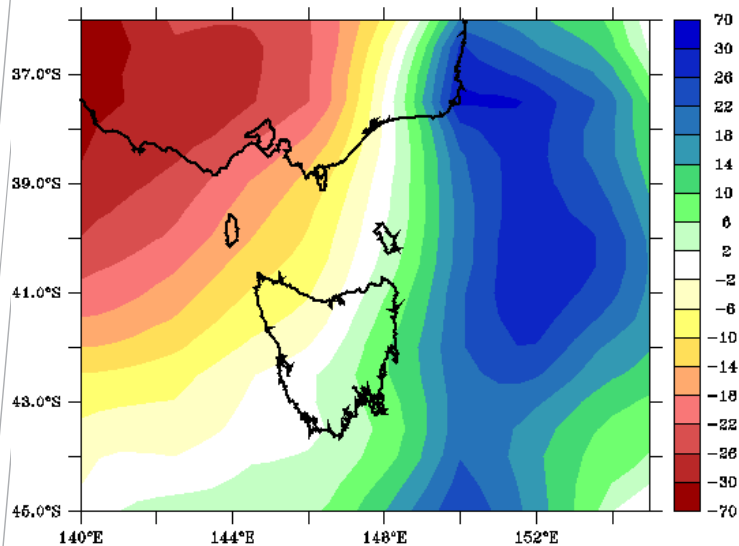
14 km RCM



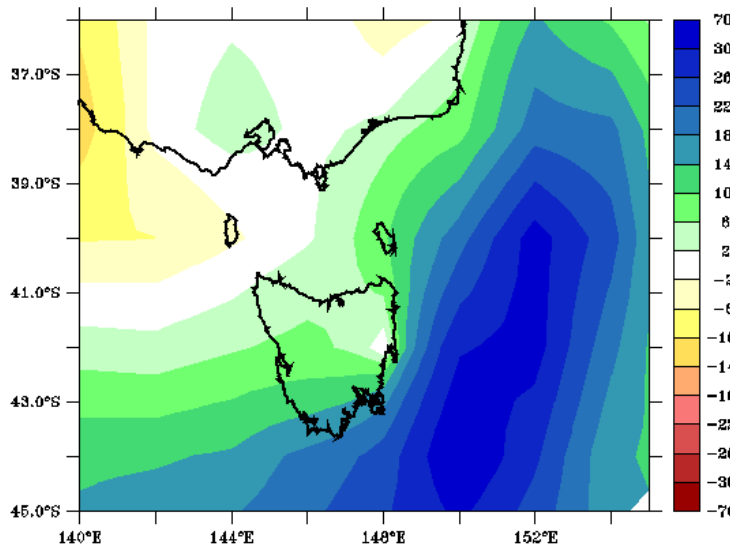
JJA rainfall: percentage change

Change in rainfall 1970:1999 to 2070:2099
6 model mean

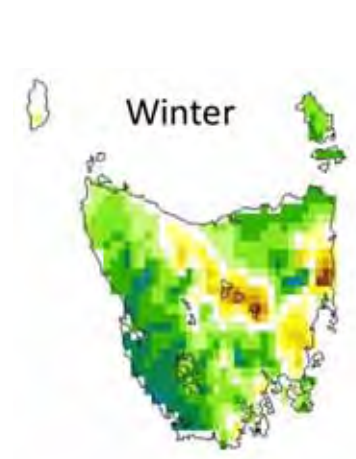
GCM



60 km RCM



14 km RCM



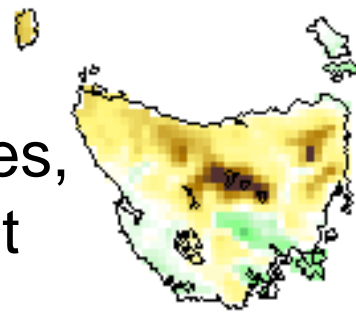
Ensembles

Change in annual rainfall 1961:1990 to 2070:2099

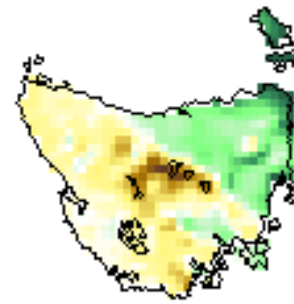
14 km results

Although mean changes, pattern fairly consistent

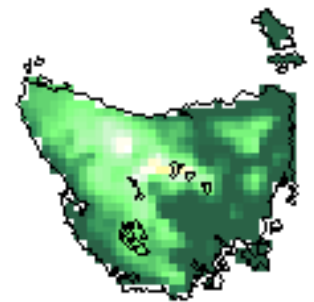
CSIRO 3.5



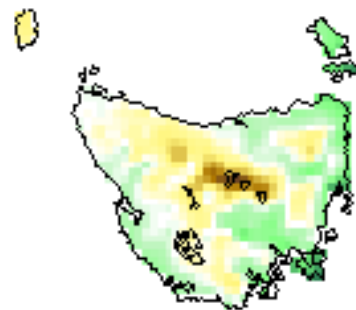
GFDL 2.0



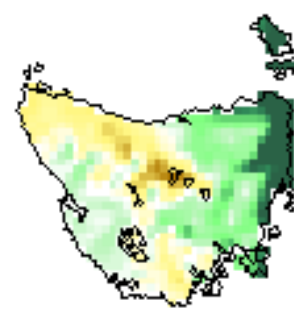
HadCM 3



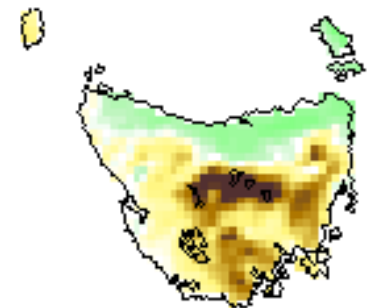
GFDL 2.1



ECHAM 5



MIROC Medres

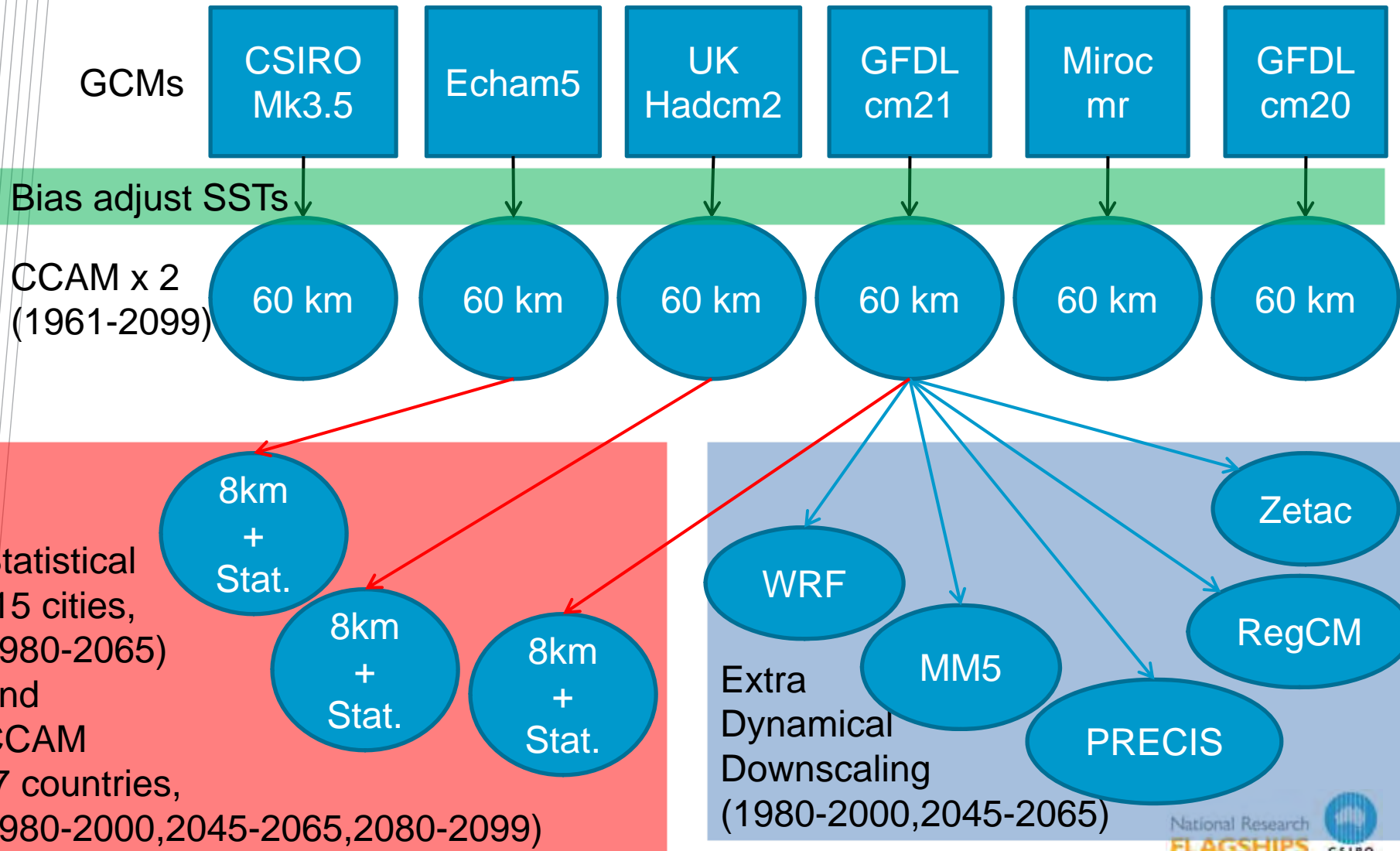


Climate Futures for Tasmania project

Downscaling for the PCCSP

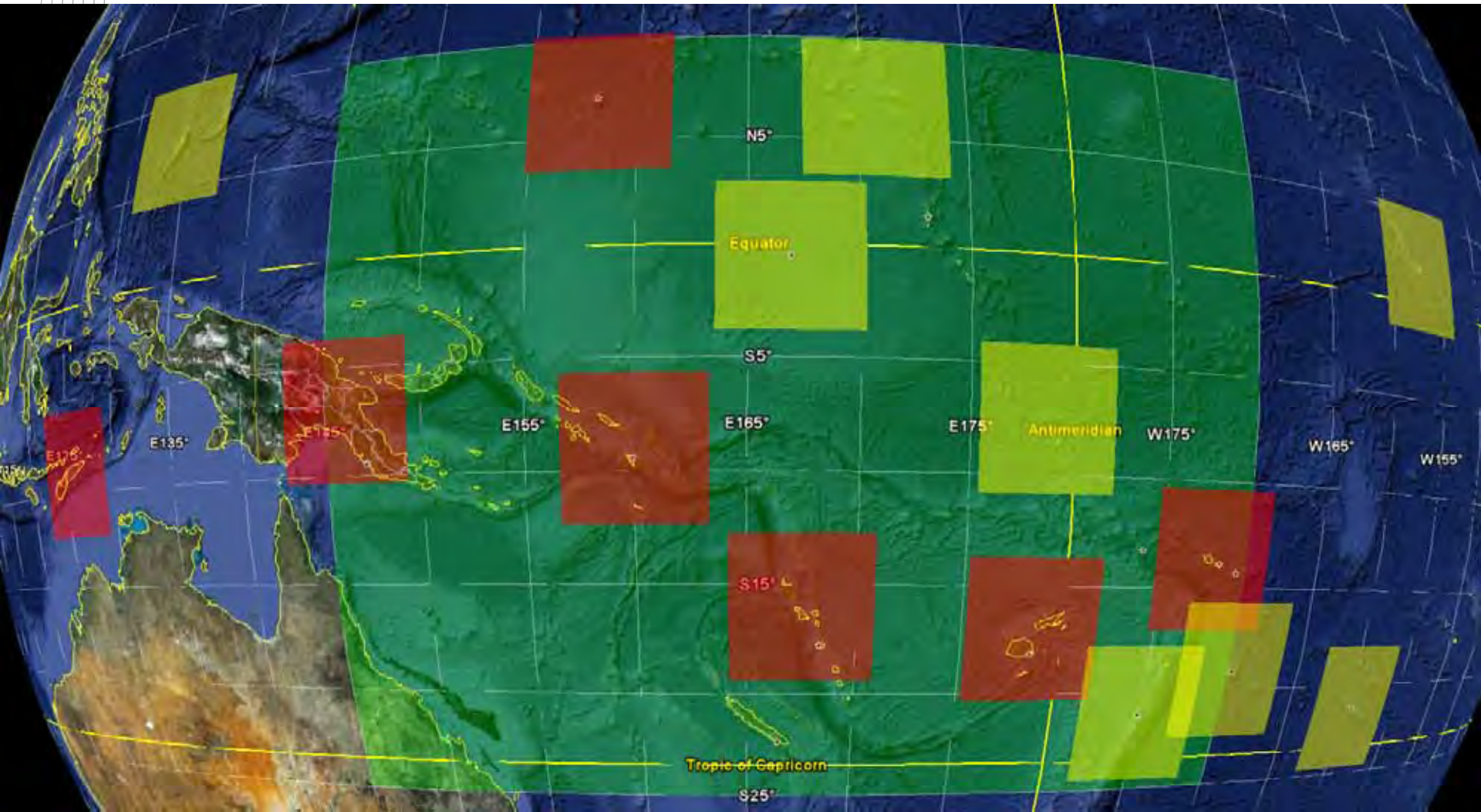
- Can multiply downscale CCAM within itself
- Use digital filter to forcing large-scale information from coarser resolution run into higher resolution run

Downscaling activities for PCCSP



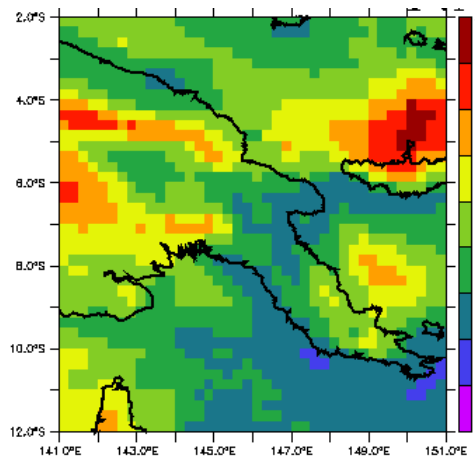
PCCSP domains

- 8 km domains in red
- Extra DDS domain in green

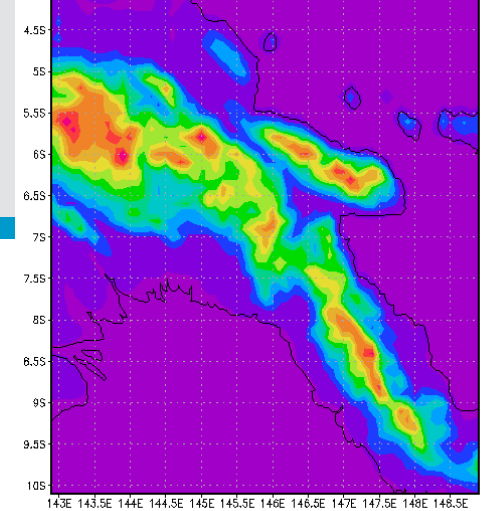
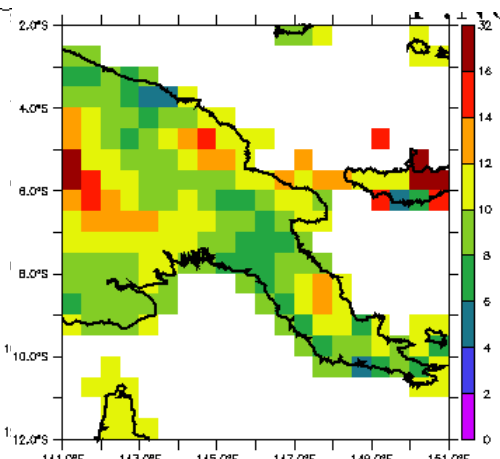


PNG JJA Rainfall

TRMM 25 km

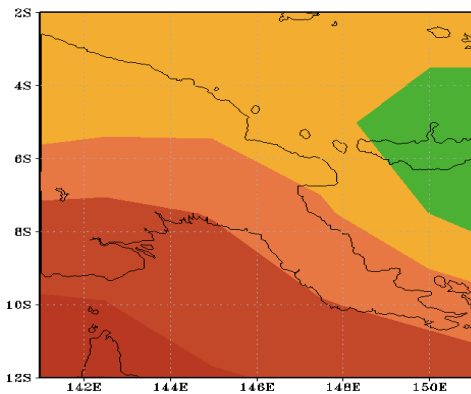


CRU 50 km

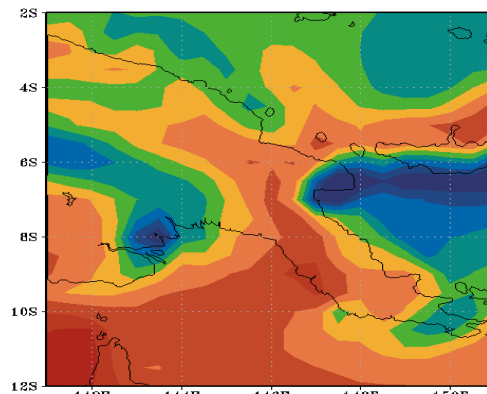


8 km Orography

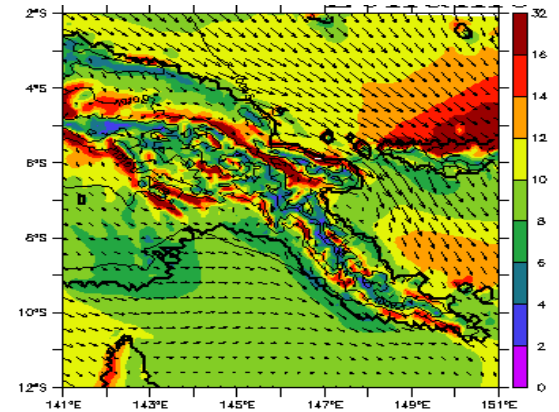
GCM



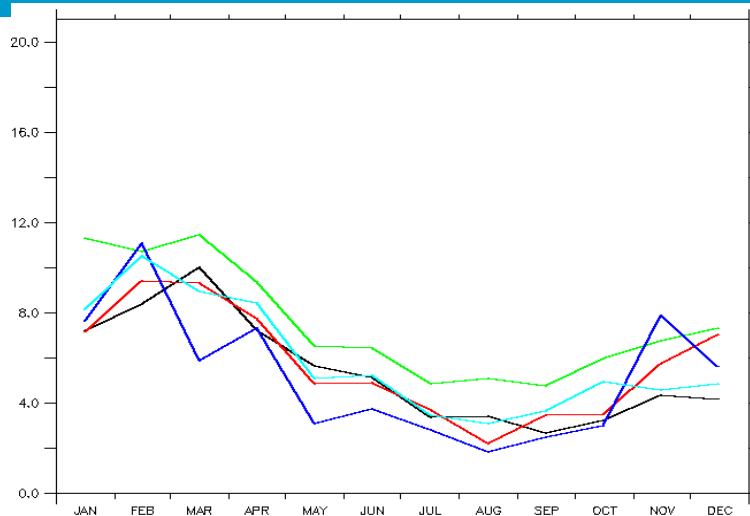
CCAM 60 km



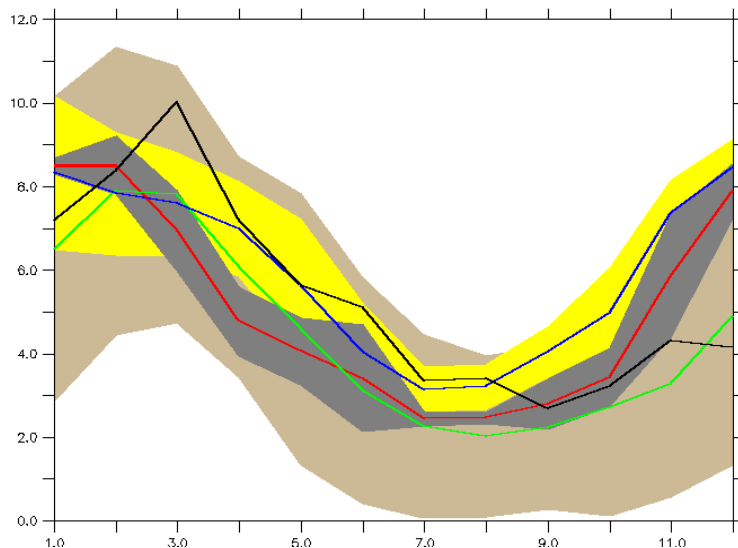
CCAM 8 km



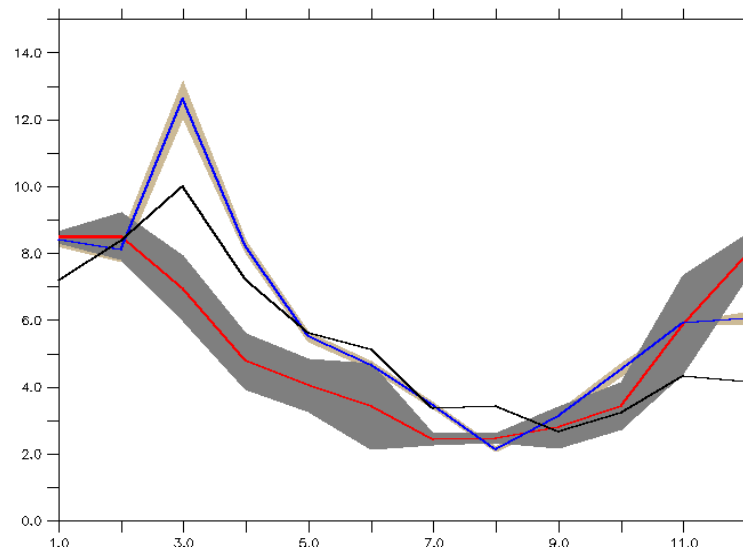
Lamap, Vanuatu: 20th Century Validation Precipitation (mm/d)



Station Obs (black),
CMAP (red), CRU
(blue), GPCP (green)
and TRMM (cyan)



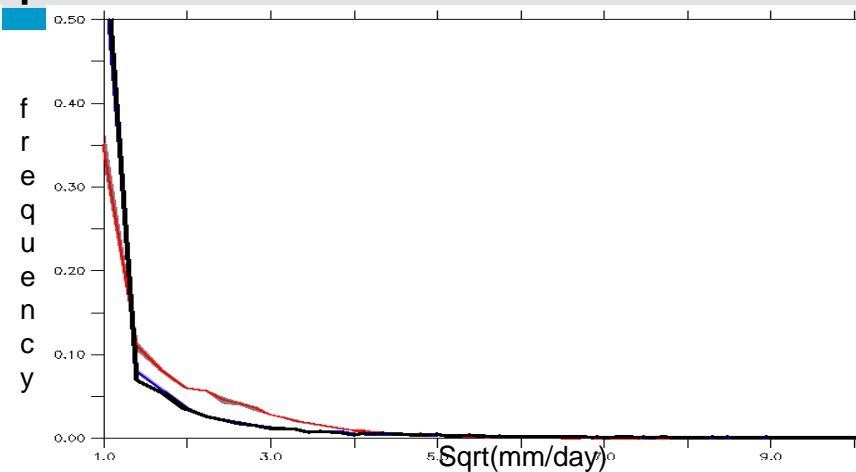
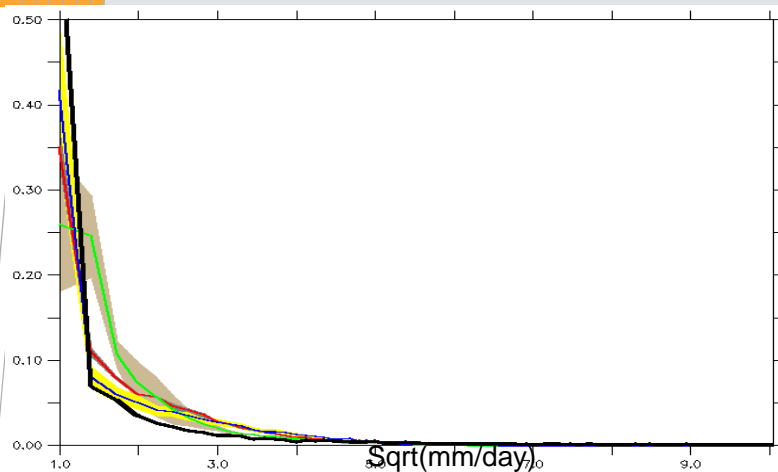
Station Obs (black), CCAM 8m(red)+2xsdev(gray),
CCAM 60km(blue)+2xsdev(yellow),
GCM(green)+2xsdev(tan)



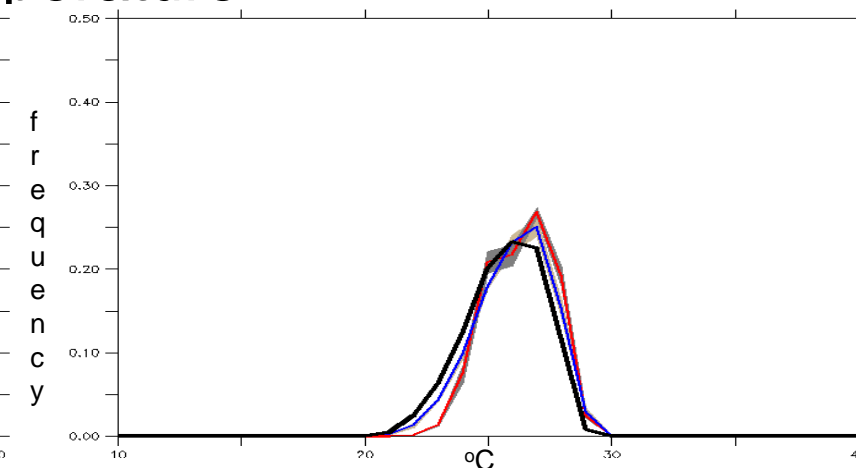
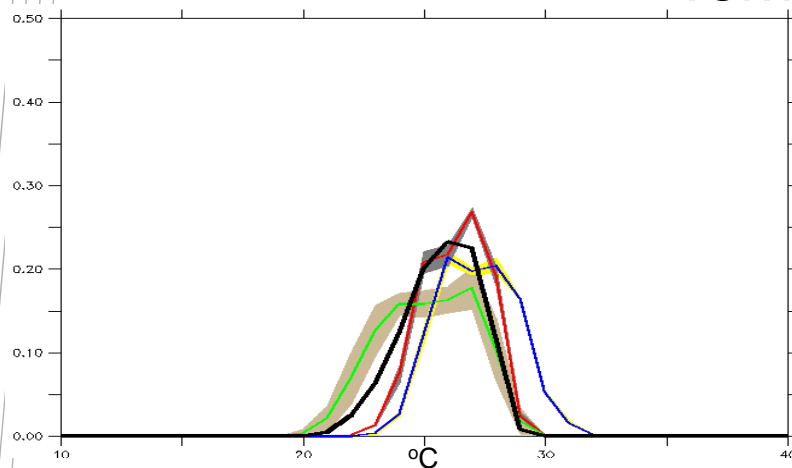
Station Obs (black), CCAM 8m(red)+2xsdev(gray),
Stats Downscale(blue)+2xsdev(tan)

Vanuatu : Lamap 20th Century PDF

Precipitation



Temperature

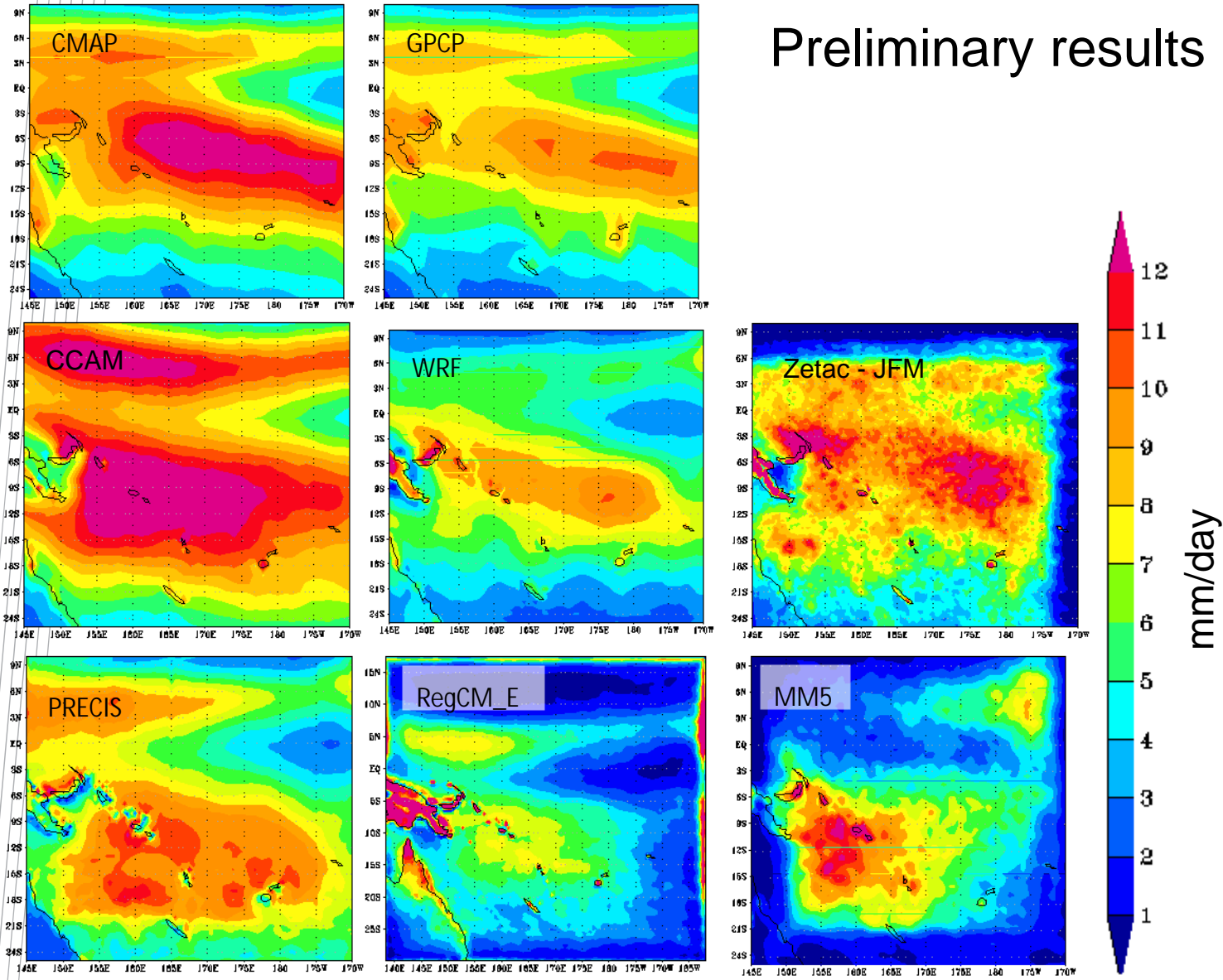


Station Obs (black), CCAM 8m(red)+2xsdev(gray), CCAM 60km(blue)+2xsdev(yellow), GCM(green)+2xsdev(tan)

Station Obs (black), CCAM 8m(red)+2xsdev(gray), Stats Downscale(blue)+2xsdev(tan)

Extra downscaling – NCEP2 – DJF rainfall

Preliminary results



Key results

- Dynamical downscaling provides physically-based and more detailed representation of the regional climate
- Bias-correction of sea surface temperatures significantly improves the representation of the current climate
- Ensemble-based downscaling
 - Multiple GCMs
 - Multiple resolutions
 - Multiple RCMs (including different model set-ups)

Key results

- Dynamical downscaling
 - Needs to be done carefully
 - Results may depend upon method, GCMs downscaled, model set-up, resolution, etc.
- Projections based upon dynamical downscaling
 - Physically-based patterns of change
 - May help reduce some of the uncertainty by providing physically-based patterns of change, but need to understand physical causes of patterns of change
 - Only sub-sample of the full range of GCMs
 - Still based upon projections of GCMs, so uncertainty still exists

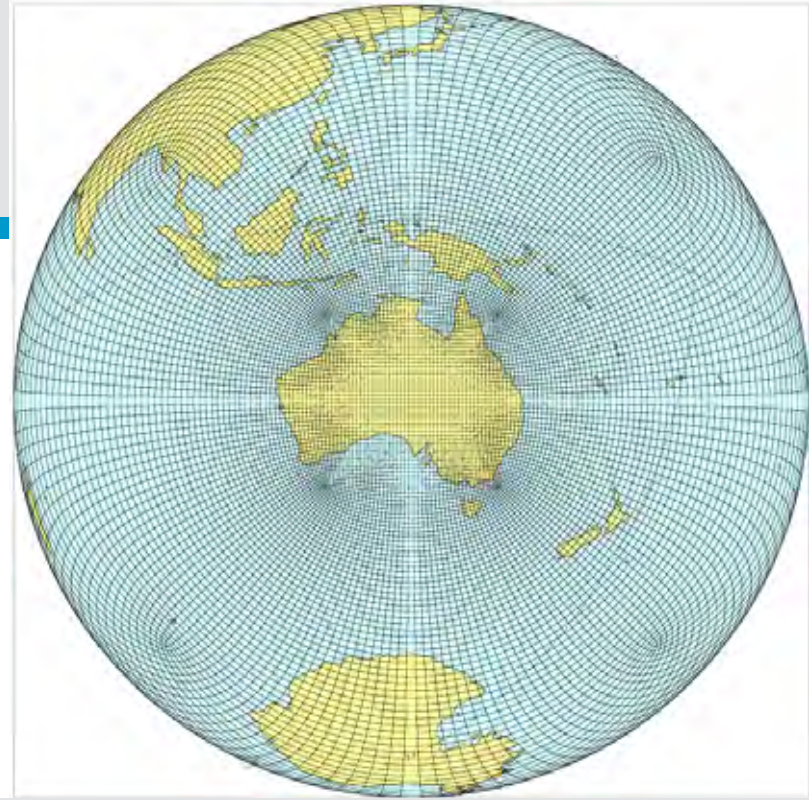
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Thank you

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