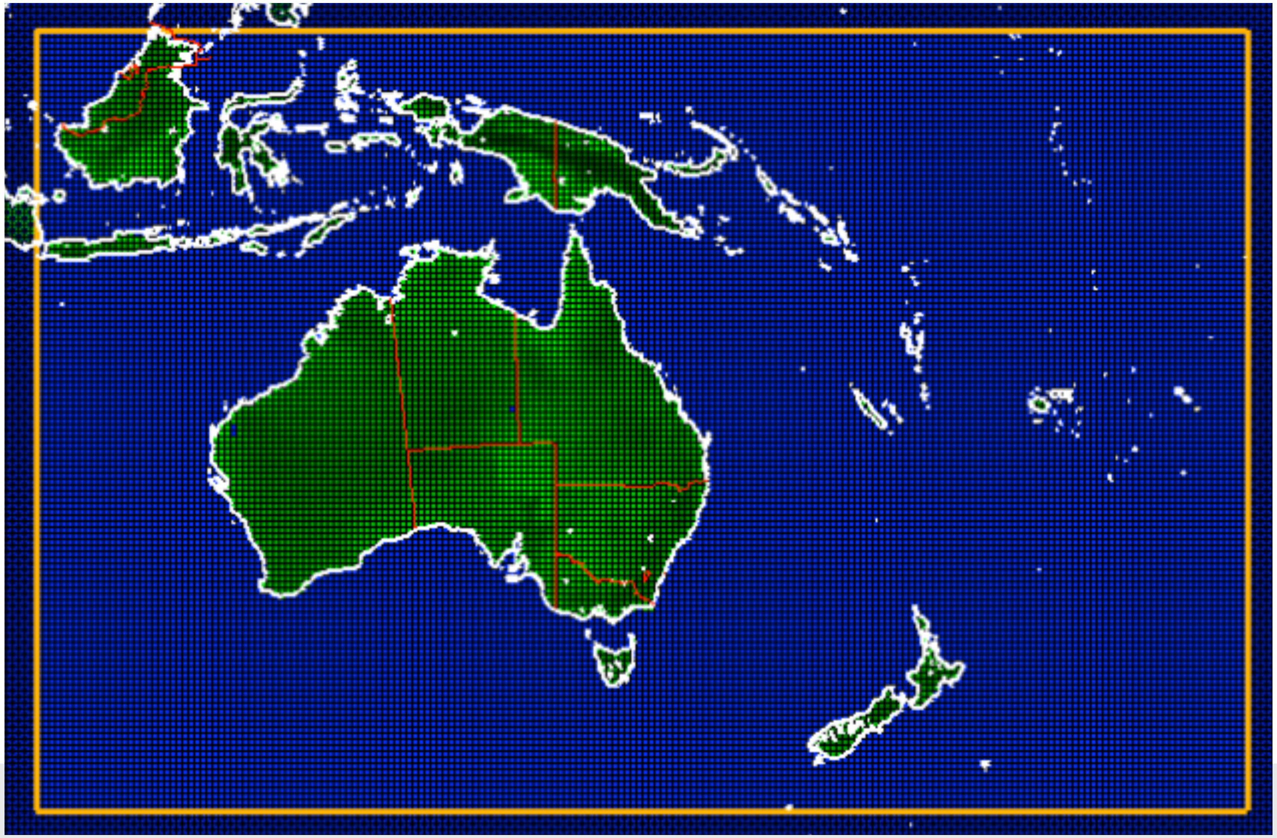


www.csiro.au

Use of high-resolution modelling techniques in Australia: examples and some issues

Climate Adaptation National Research Flagship

Penny Whetton

Acknowledgements: Jack Katzfey, John McGregor, Kevin Hennessy, John Clarke, Ian Watterson, David Kent and others

National Research FLAGSHIPS
Climate Adaptation

CSIRO

Outline

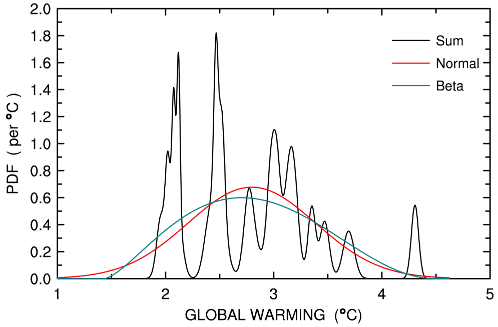
- Where I am coming from
- Australian regional modelling applications
  - CCAM
  - Other
- GCM selection issue

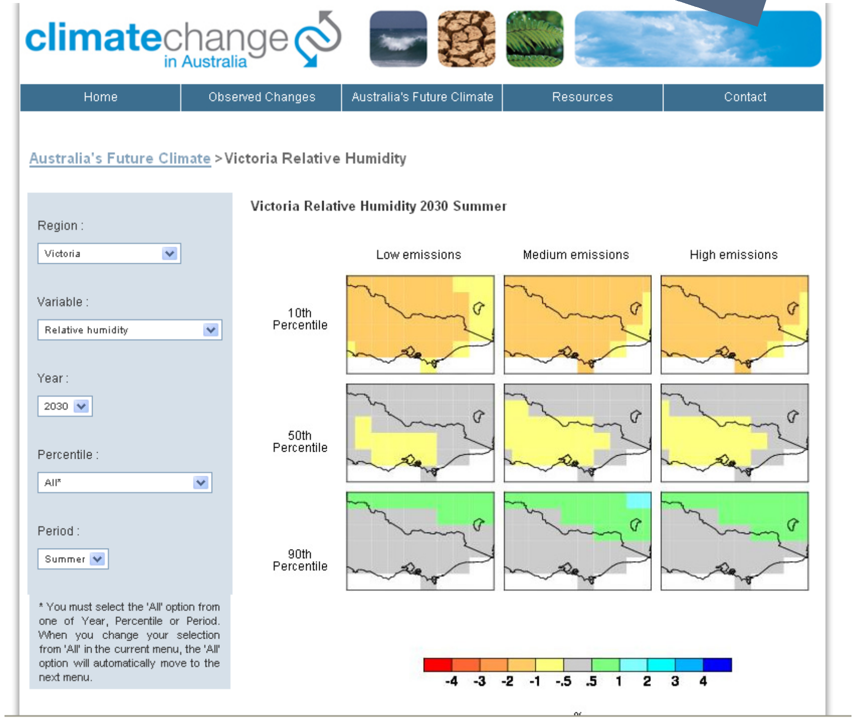
Climate change in Australia (2007)

- Probabilistic projections for seven variables
- CMIP3 database
- Full uncertainty sampling
- No downscaling

Reactions

- Multiple variable combinations
- Demand for finer resolution
- Massive demand for future application ready data sets





Where I am coming from

Planning new national projections for 2013/14

Considering the role dynamical and statistical downscaling will play in these

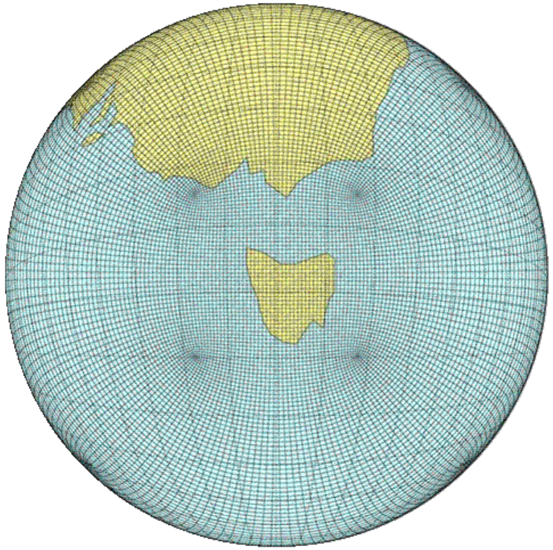
- CORDEX

Concerns regarding representation of uncertainty

- GCM selection issue
- Dependence on one or two downscaling techniques

CCAM (McGregor and Katzfey, CSIRO)

- Lateral boundaries
  - Stretched-grid
- Domain size and placement
  - Stretched-grid
  - Scale-selective filter
- Ensembles
  - Downscale multiple GCMs
- Host model forcing
  - Bias-adjusted SSTs (with or without nudging)
- Variability – internal and external (from host model)
  - External same as GCMs (ENSO)



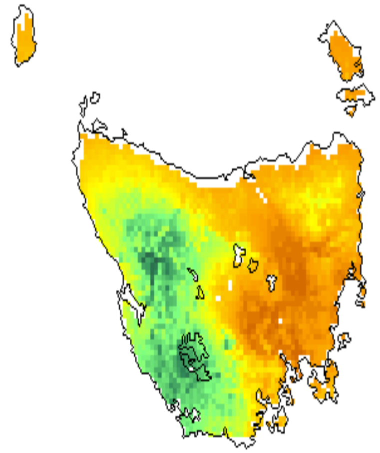
CCAM regional applications

- ‘Climate Futures Tasmania’
- Pacific
- Indonesia
- Other

Climate Futures Tasmania

- Major research program
- CCAM-based climate scenarios
- Multi-sectoral impact assessment

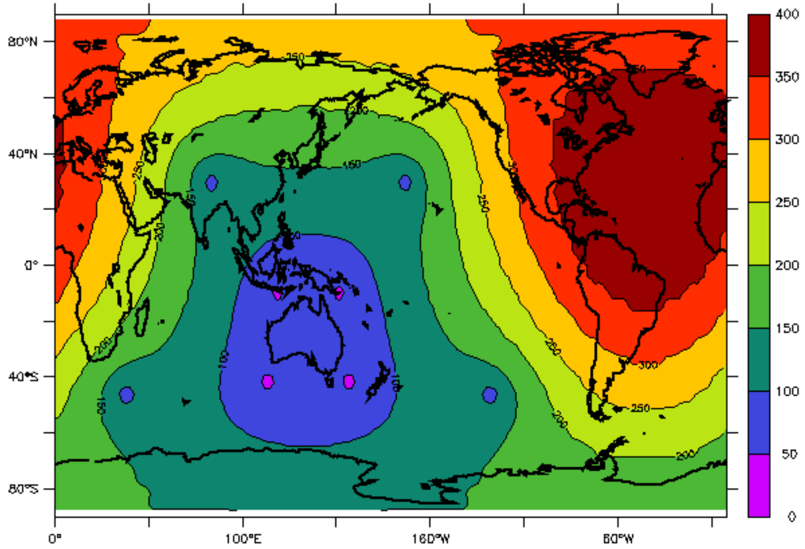
Acknowledgements: Grose, MR, Corney SP, Bennett JB, Bindoff NL, Katzfey, J, and McGregor, J.



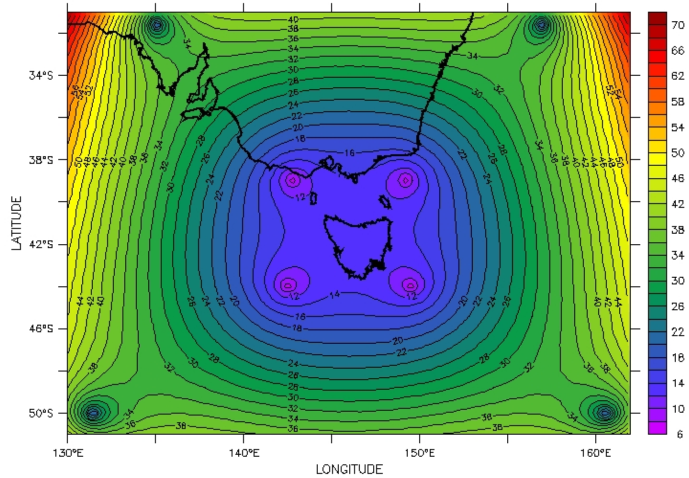
CCAM modelling for *Climate Futures Tasmania*

1) 60 km C64 runs over Australia for Climate Futures Tasmania (1961-2100) – 140 years

Mk3.5	A2	B1
GFDL 2.1	A2	B1
GFDL 2.0	A2	B1
ECHAM5	A2	B1
HADCM3	A2	B1
MIROC-Med	A2	B1

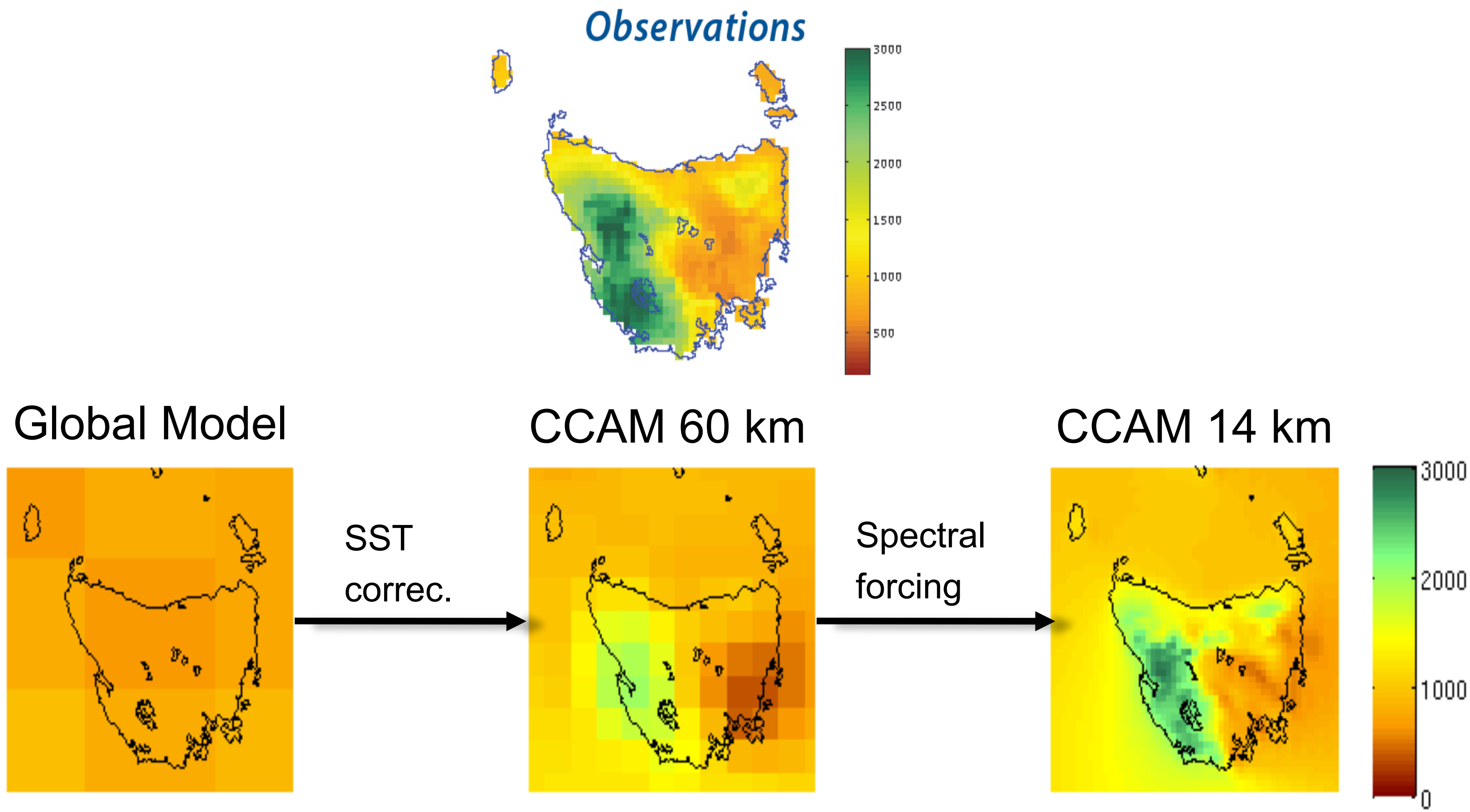


2) 14 km C48 runs over Tasmania Australia (1961-2100) – 140 years downscaled from above 60 km CCAM runs



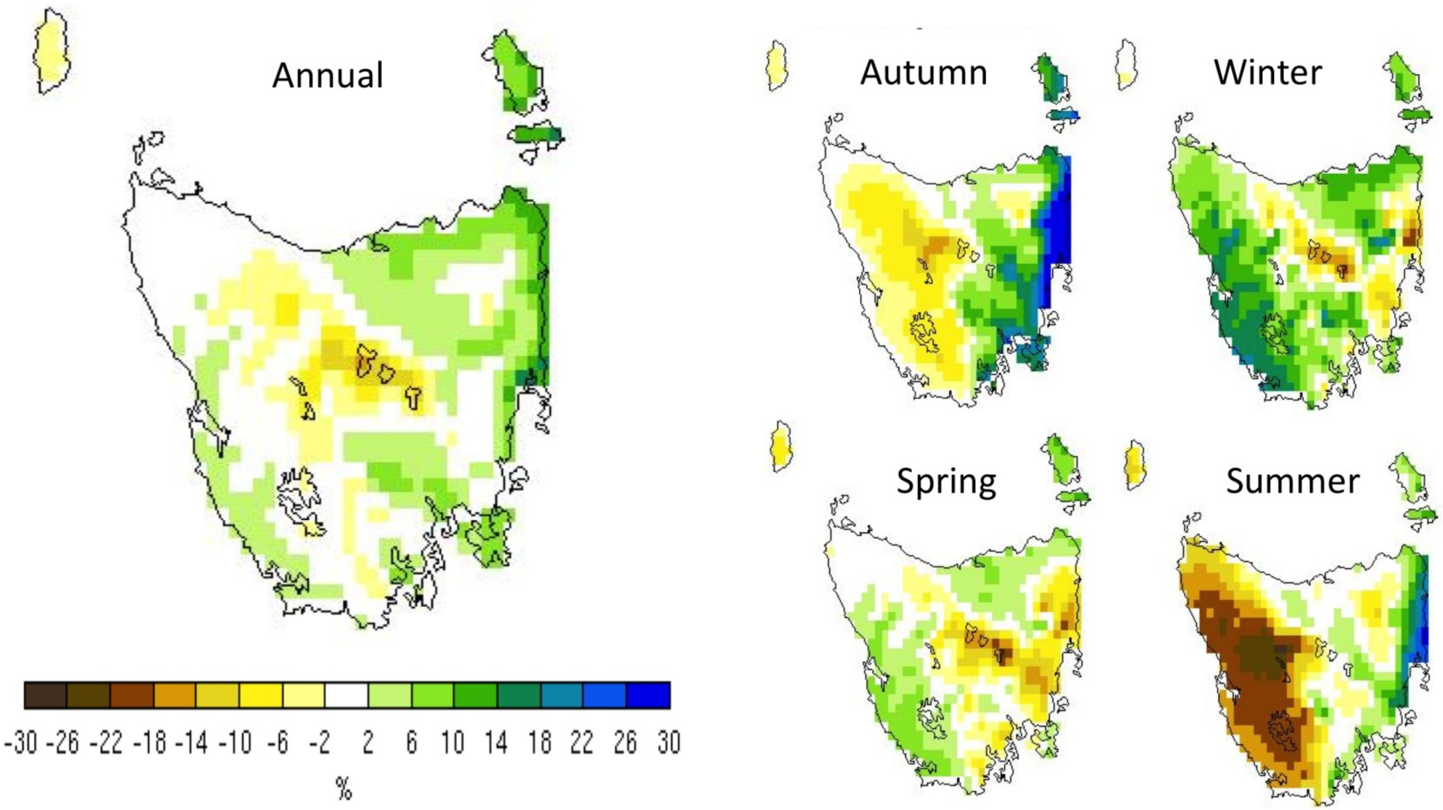
Current climate rainfall simulation

Simulated annual rainfall for Tasmania at different resolutions

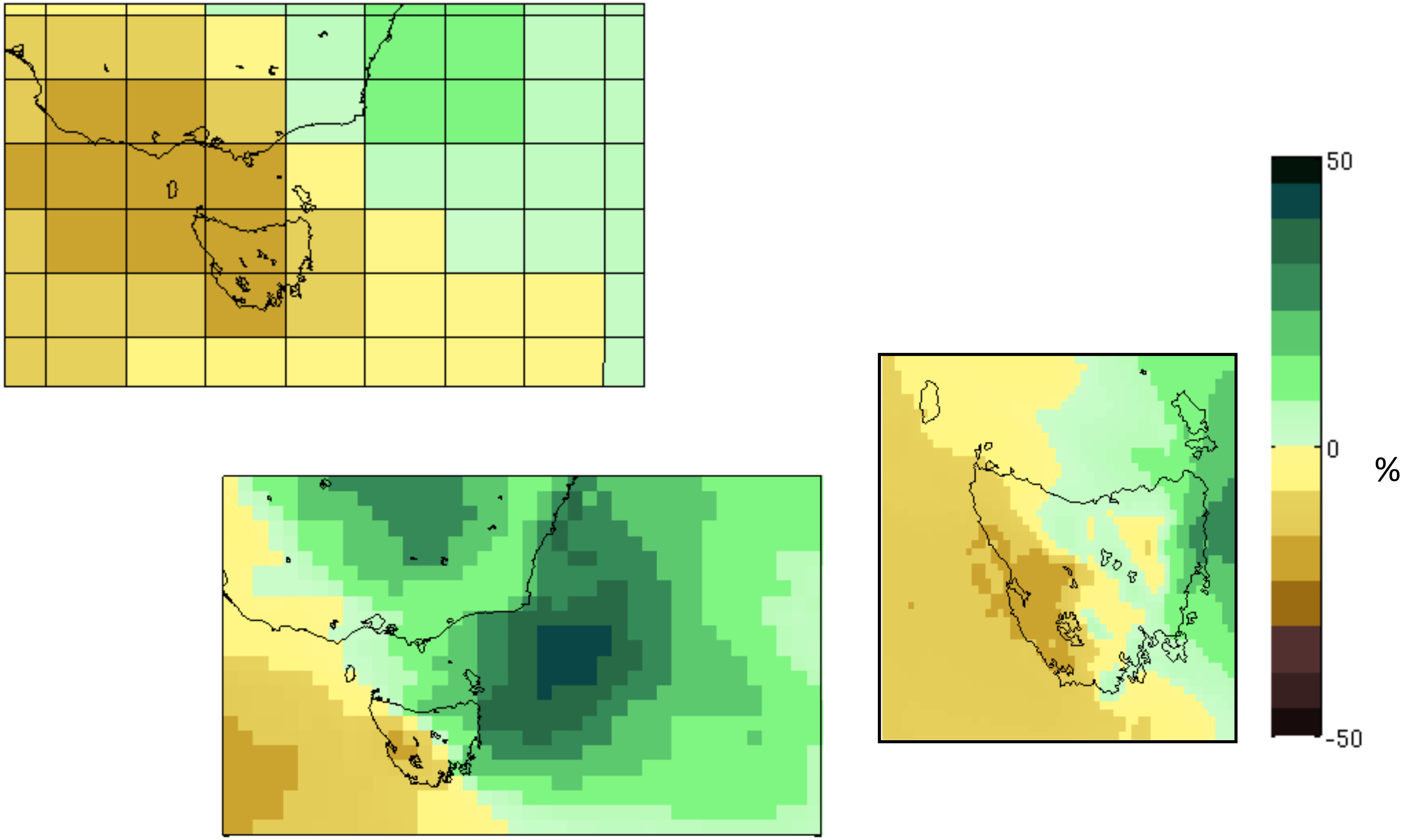


Climate projections mean rainfall (6 model mean)

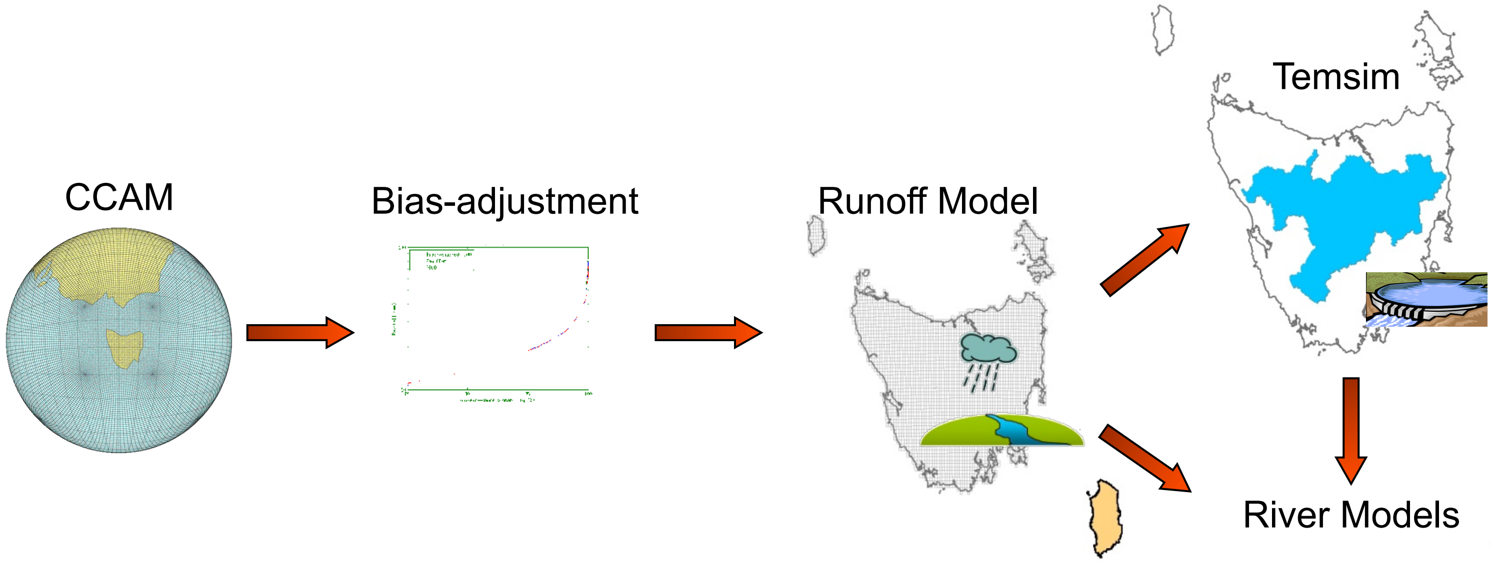
1980-1999 to 2090-2099 SRES A2

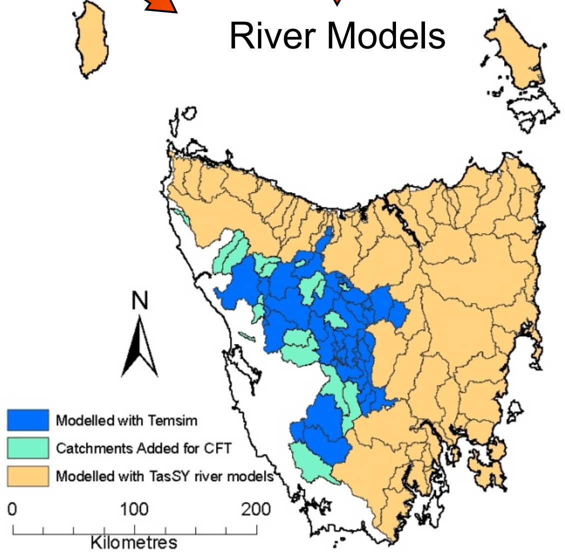


Summer rainfall response – impact of downscaling



Assessing runoff changes



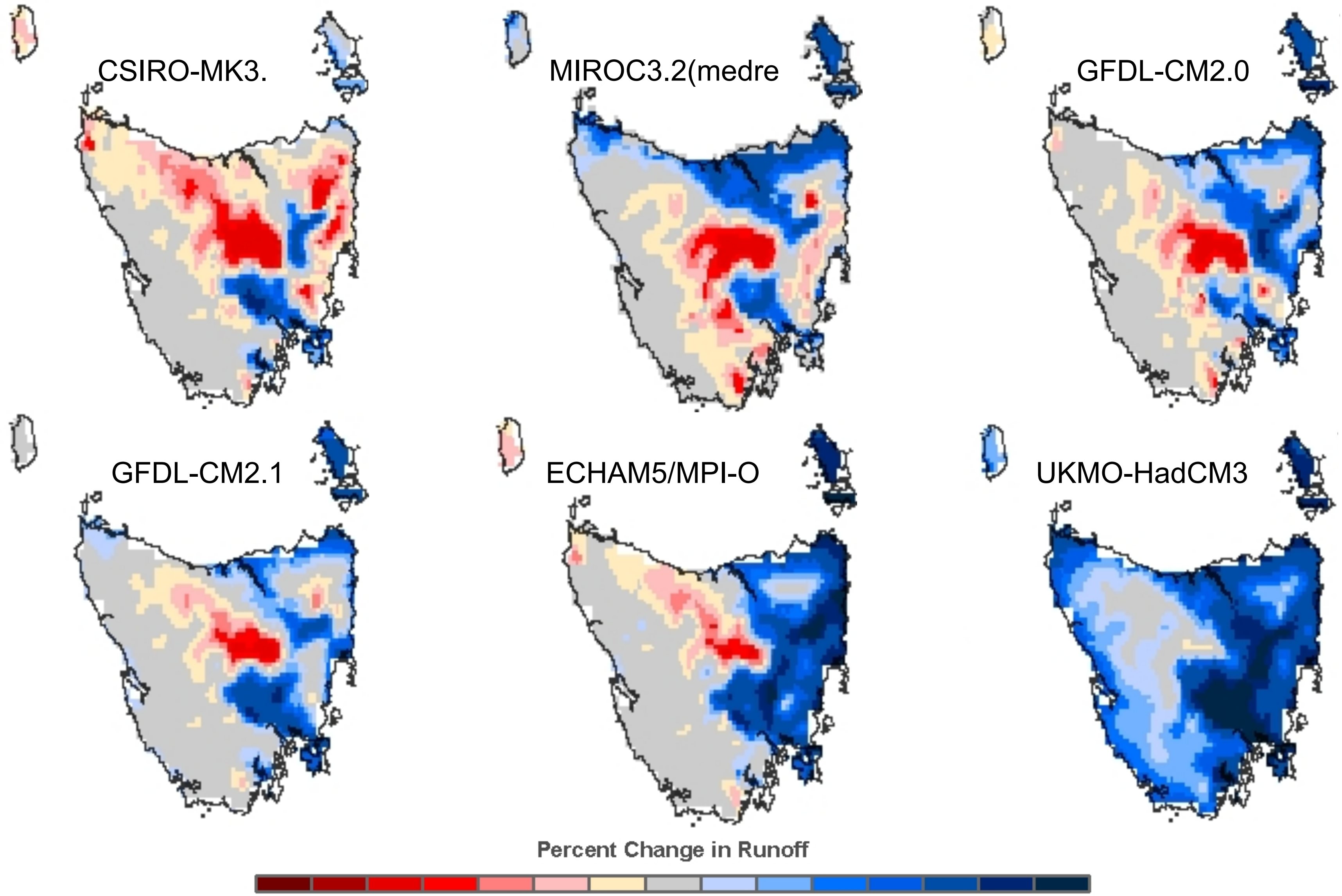


1) Statewide Gridded Runoff

2) Modelled 78 Catchments

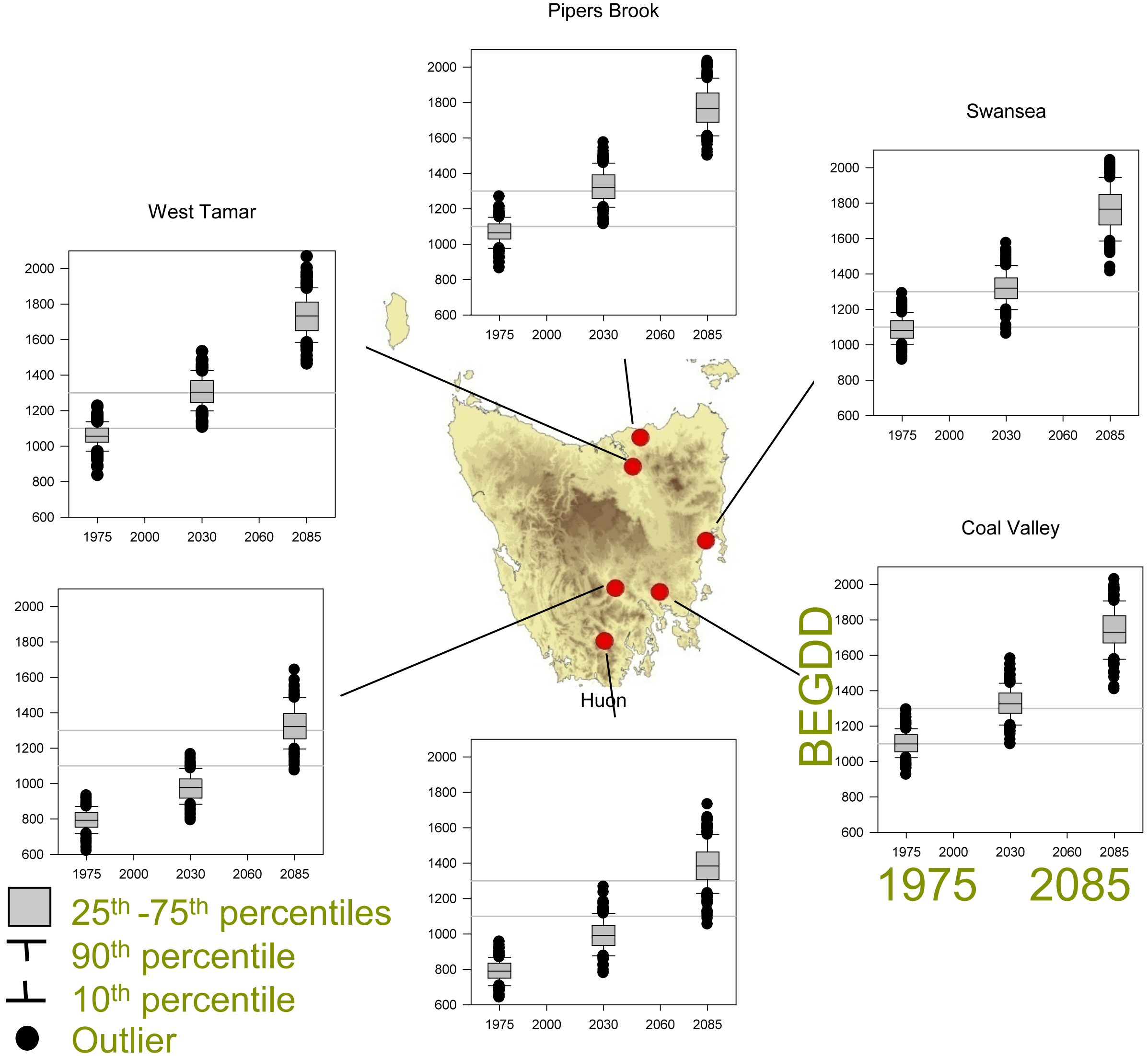
3) Modelled > 2000 subcatchments

Percent runoff change 2070-2099 v 1961-1990



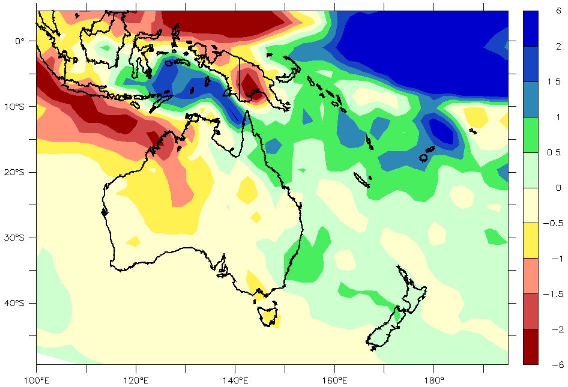
Biologically Effective Growing degree days
1975-2030-2085

Pinot Noir

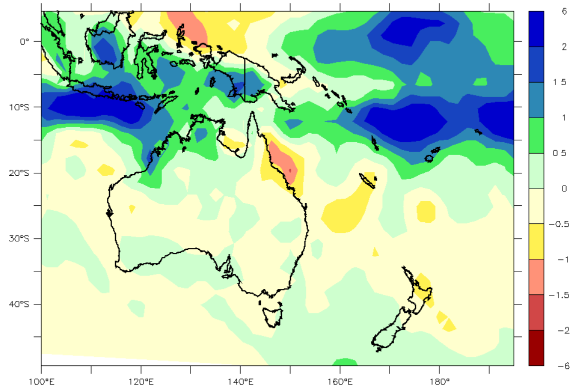


DJF rainfall chg (2085-1985) – GCMs v CCAM

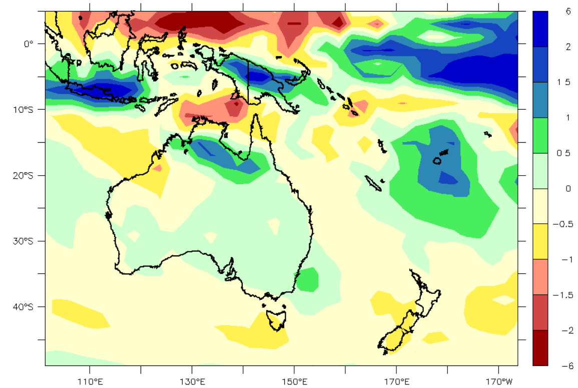
csiromk3.5



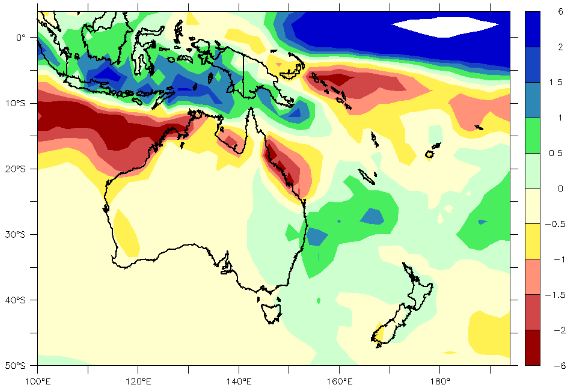
echam5



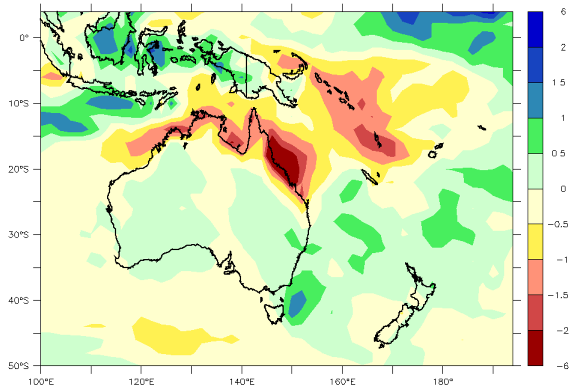
gfdlcm20



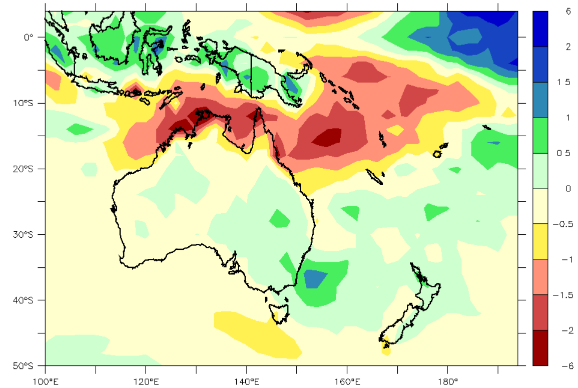
csiromk3.5 - CCAM



echam5 - CCAM

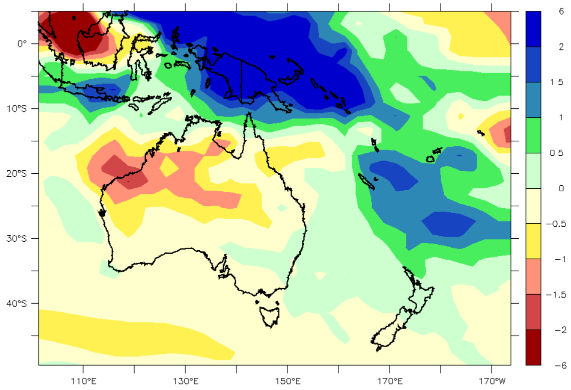


gfdlcm20 - CCAM

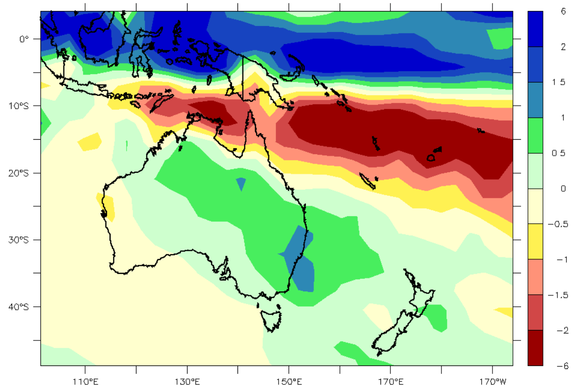


DJF rainfall chg (2085-1985) – GCMs v CCAM

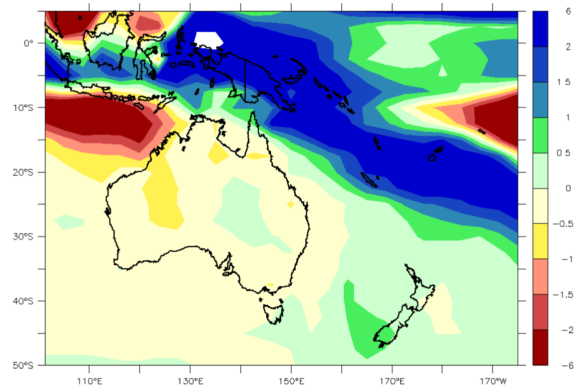
gfdlcm21



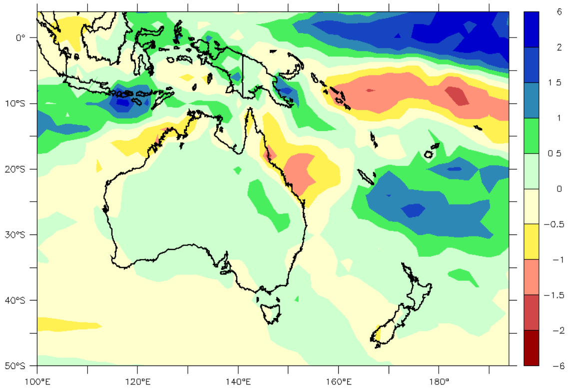
mirocmr



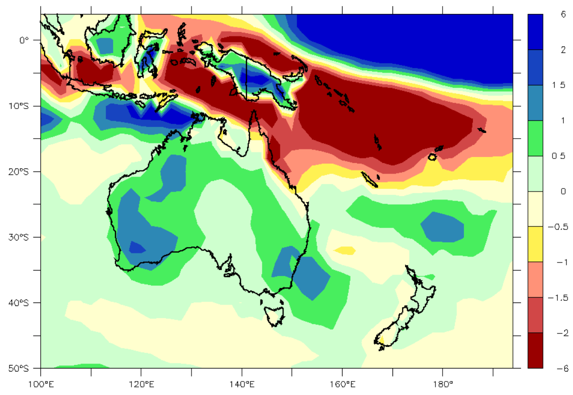
ukhadcm3



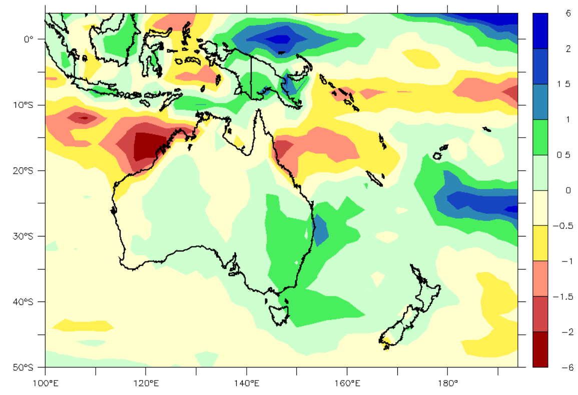
gfdlcm21 - CCAM



mirocmr - CCAM

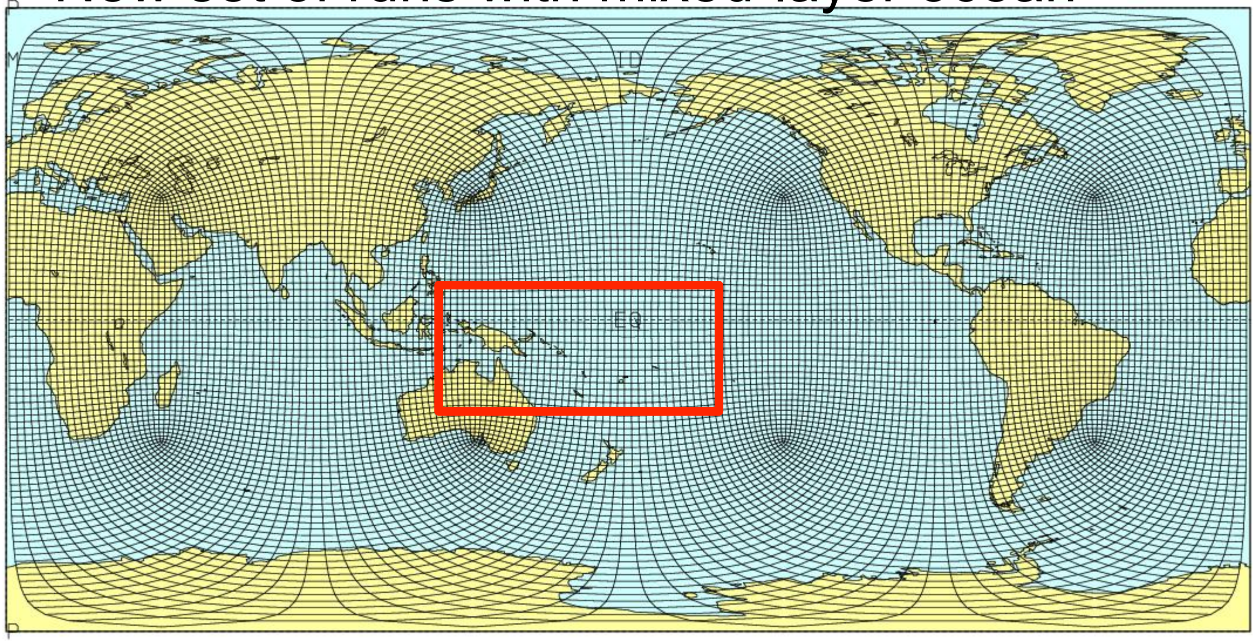


ukhadcm3 -CCAM



Pacific Climate Change Project (PCCSP)

- Same six GCMs and A2
- Uses monthly bias-corrected SSTs
- Grid resolution is about 60 km (C160)
- Simulations from 1961-2100
- Downscaled to 8 km over seven islands
  - employing digital filter
- New set of runs with mixed-layer ocean



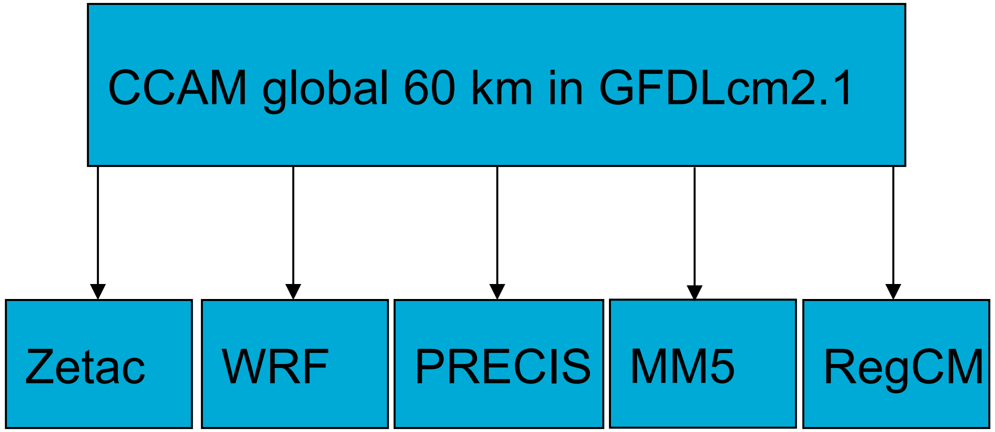
C48 grid - 200 km. Actually used C160 grid – 60 km

National Research FLAGSHIPS Climate Adaptation
CSIRO

Multi-model dynamical downscaling methodology for Pacific

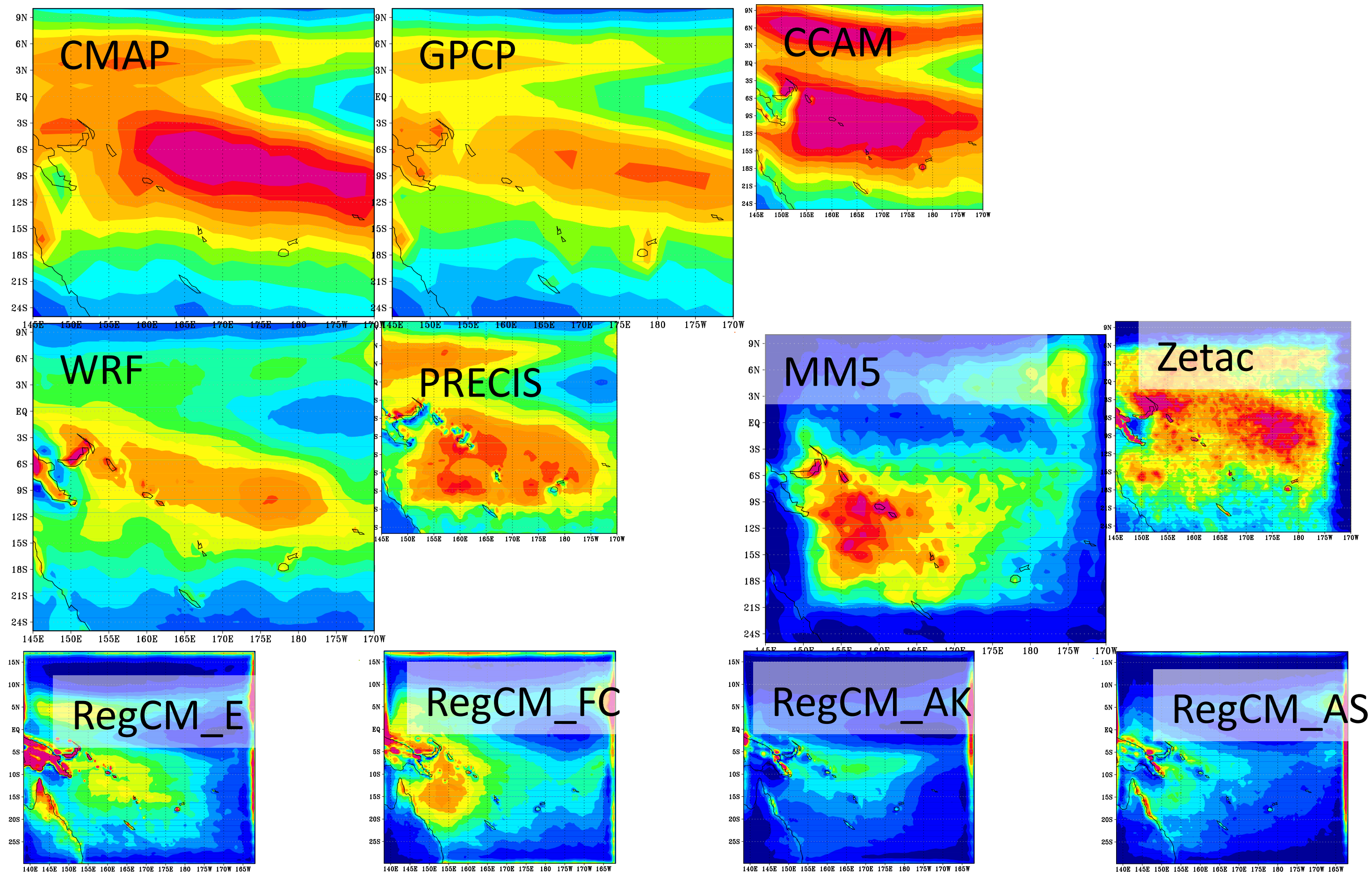
- To dynamically simulate the regional climate, we need to address:
  - **•Uncertainty in regional climate model dynamics/ physics**

- PCCSP additional downscaling
- Two time periods: 1981-2000, 2046-2065



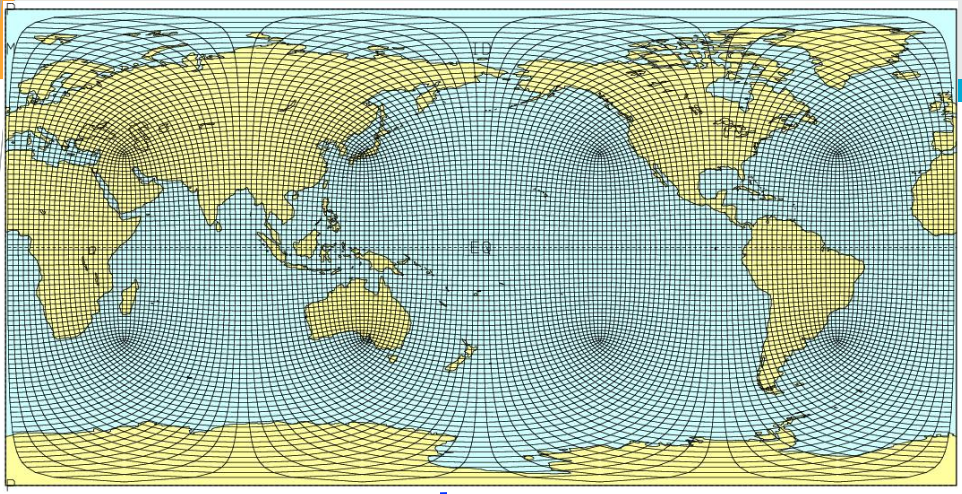
Ensemble of Regional Climate Models, in addition to CCAM

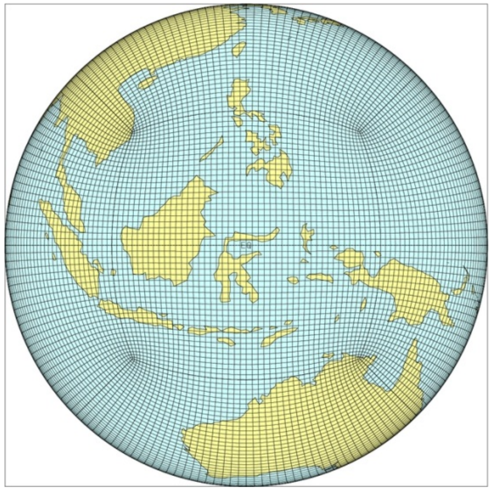
Observed DJF rainfall and NCEP-based simulations



National Research FLAGSHIPS
Climate Adaptation
CSIRO

Indonesia ensemble CCAM 60 km simulations

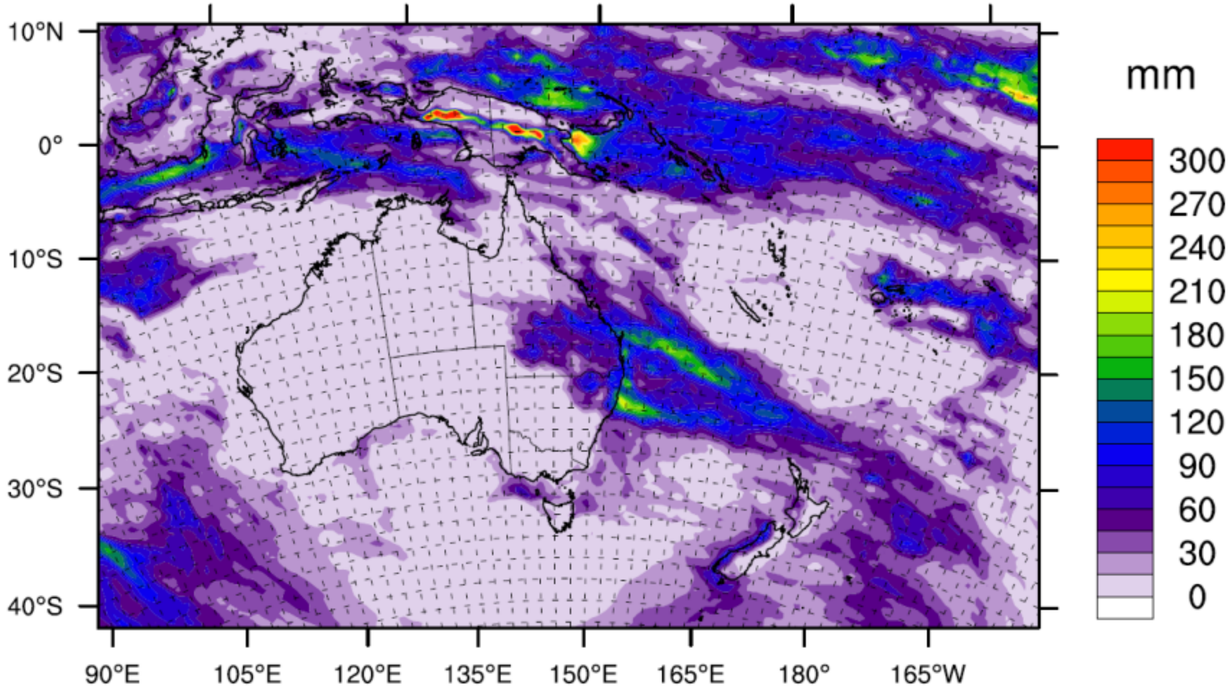




Stretched C48 grid with resolution about 60 km over Indonesia

- Same six GCMs and A2
- Uses monthly bias-corrected SSTs
- Proceeds via 200 km quasi-uniform CCAM simulations
- Final grid resolution is about 60 km
- 60 km simulations from 1971-2000, 2041-2060, 2081-2100

WRF in use at University of NSW (Jason Evans)



National Research FLAGSHIPS Climate Adaptation

CSIRO

Selecting Model Subsets

- Much interest in this issue in the region
  - Both for downscaling and other purposes
  - Attempts to pick best models
- An issue in the CCAM work

Do we know how to select a set of best models?

Smith and Chandler (2010) (updated)

	A Aus	B Aus	C Aus	D Aus	E ENSO	F North Pacific	G MDB	H MDB	I GLOBE	J NH	K SH
BCCR-BCM2.0	5	5	590	Yes		No	No		No		No
CCSM3	0	2	677	No	No	Yes	No		Yes	7	Yes
CGCM3.1(T47)	1	8	518	No	No	Yes	Yes	No	Yes	10	
CGCM3.1(T63)	1	10	478			Yes	No		Yes		Yes
CNRM-CM3	0	4	542		No	No		No	No	3	No
CSIRO-Mk3.0	1	7	601	Yes	No	No	Yes	No	No	14	Yes
ECHAM5/MPI	0	1	700	Yes	Yes	No	No	No	Yes	1	Yes
ECHO-G	0	4	632	Yes	No	Yes	Yes	No			
FGOALS-G1.0	2	2	639	No	No	No	Yes		No	15	No
GFDL-CM2.0	0	2	671	Yes	Yes	Yes	No	Yes	Yes	5	No
GFDL-CM2.1	0	2	672	Yes	Yes	Yes	No	Yes	Yes	2	Yes
GISS-AOM	1	8	564	No	No	No	Yes		No		
GISS-EH	5	14	304		No	No			No		No
GISS-ER	0	8	515	Yes	No	No	No	No	No	12	No
INM-CM3.0	1	7	627		No	No		Yes	No	8	No
IPSL-CM4	2	14	505	No	No	No	Yes		No	11	No
MIROC3.2(hires)	0	7	608		Yes	Yes	Yes		Yes		Yes
MIROC3.2(medres)	2	7	608	Yes	Yes	Yes	Yes	No	Yes	4	No
MRI-CGCM2.3.2	1	3	601	No	No	Yes	Yes	Yes	Yes		
PCM	3	11	506		No	No			No		
UKMO-HadCM3	0	6	608		Yes	Yes			Yes		
UKMO-HadGEM1	0	2	674		No	No			Yes		Yes

No!

National Research FLAGSHIPS Climate Adaptation

CSIRO

‘Reliability’ and ‘Applicability’ and a representative subset of models

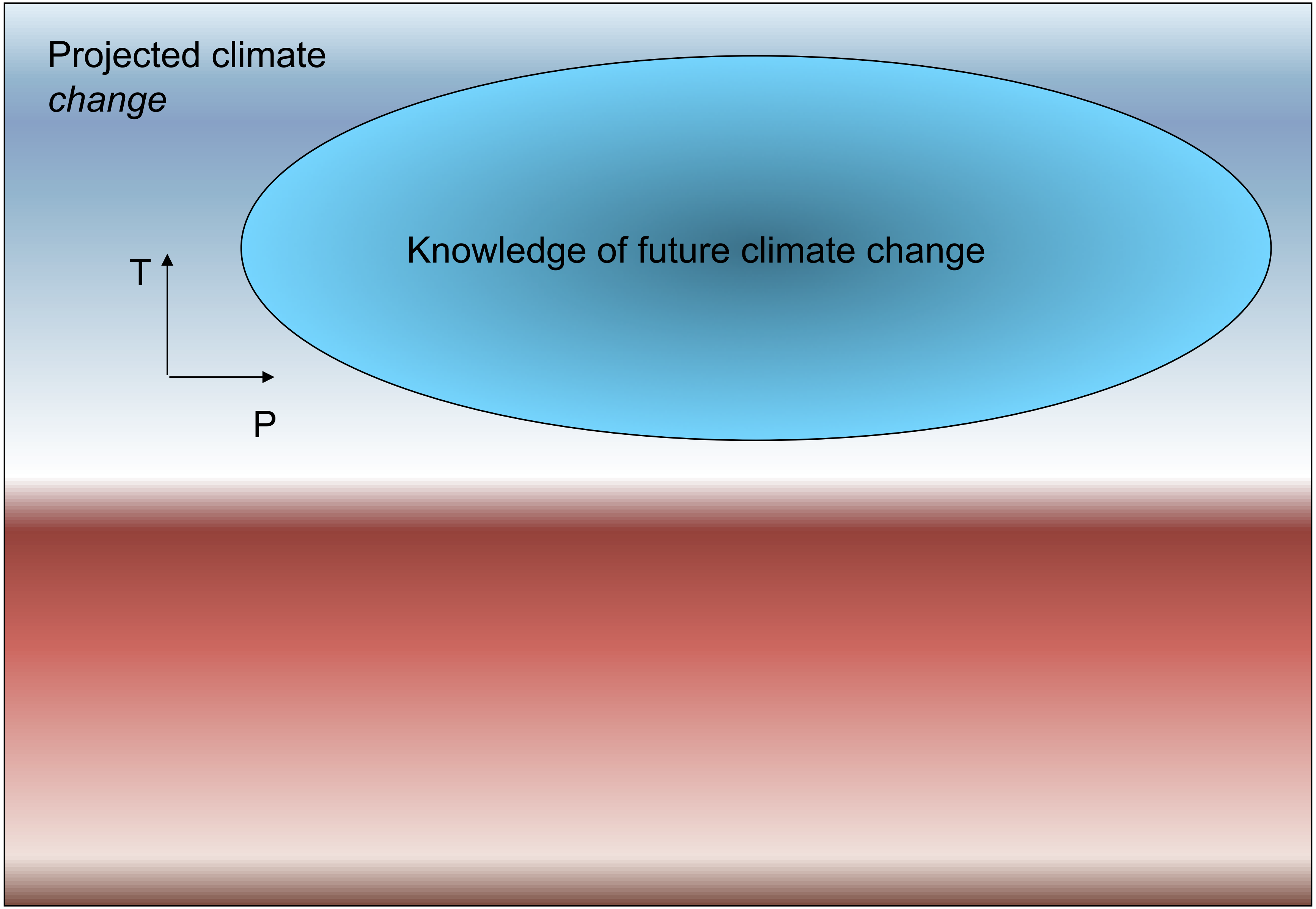
- In attempting to select we are not good at controlling for ***reliability***: the extent to which we can trust the simulated future climate *change*
- Even if we could chose more reliable models, the ‘robust decision-making*’ approach to adaptation requires the range of plausible climates to be considered, not just more likely ones.
- However some models are clearly more ***applicable****:* have greater realism of simulated surface climate in variables relevant to impact applications

➢ *Choose a subset of applicable models which are representative of the range of plausible future climates*

* Lempert & Schlesinger, 2000, Dessai 2009

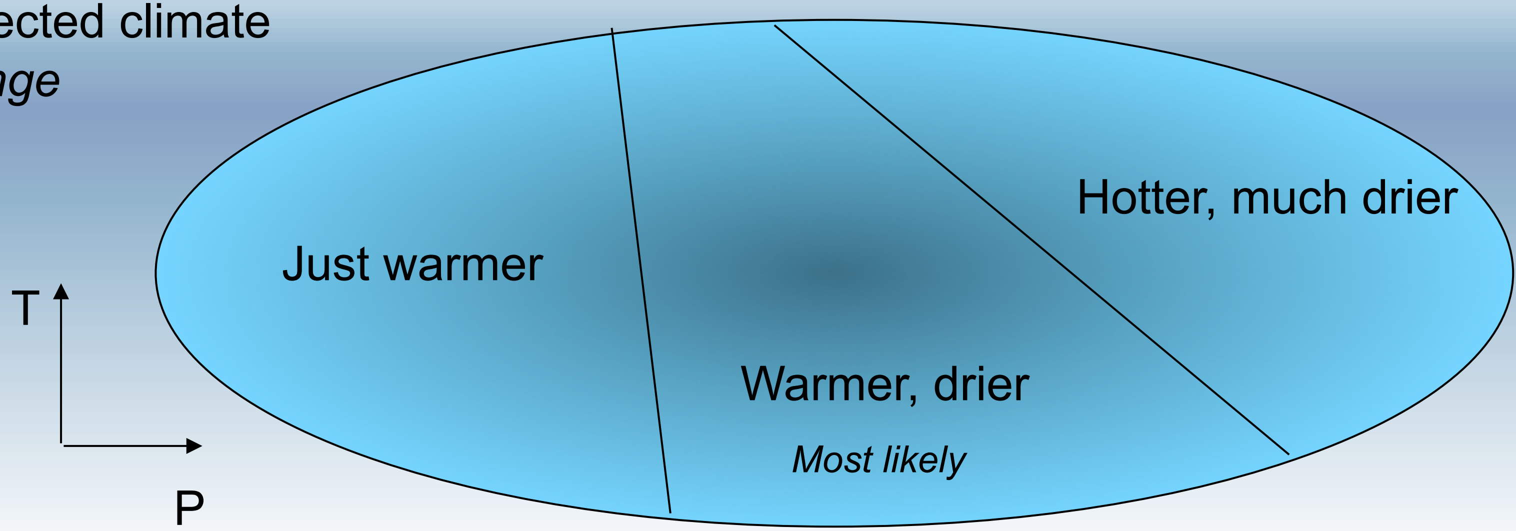
National Research FLAGSHIPS Climate Adaptation

CSIRO



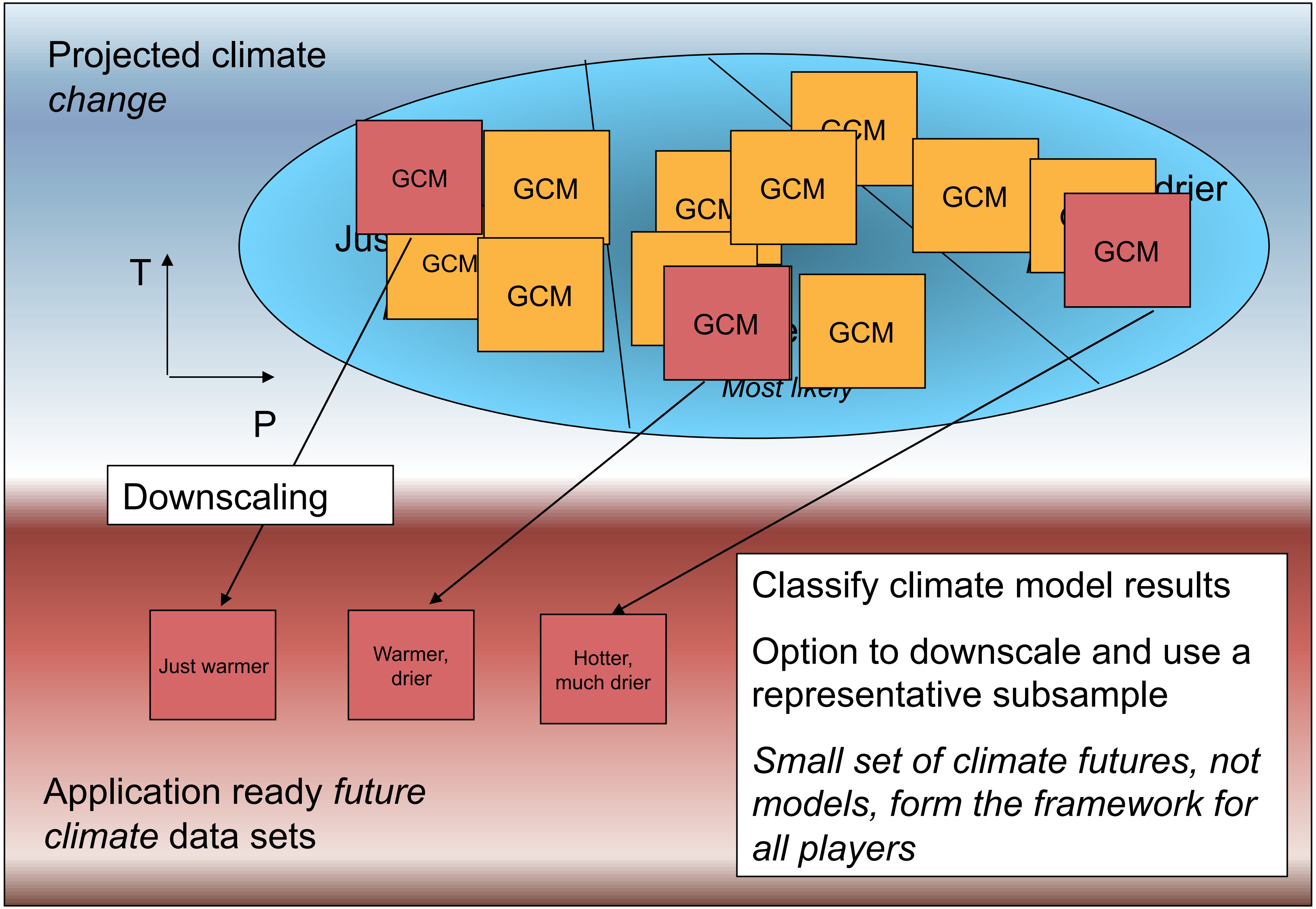
Projected climate
change
T
P
Knowledge of future climate change

Projected climate *change*

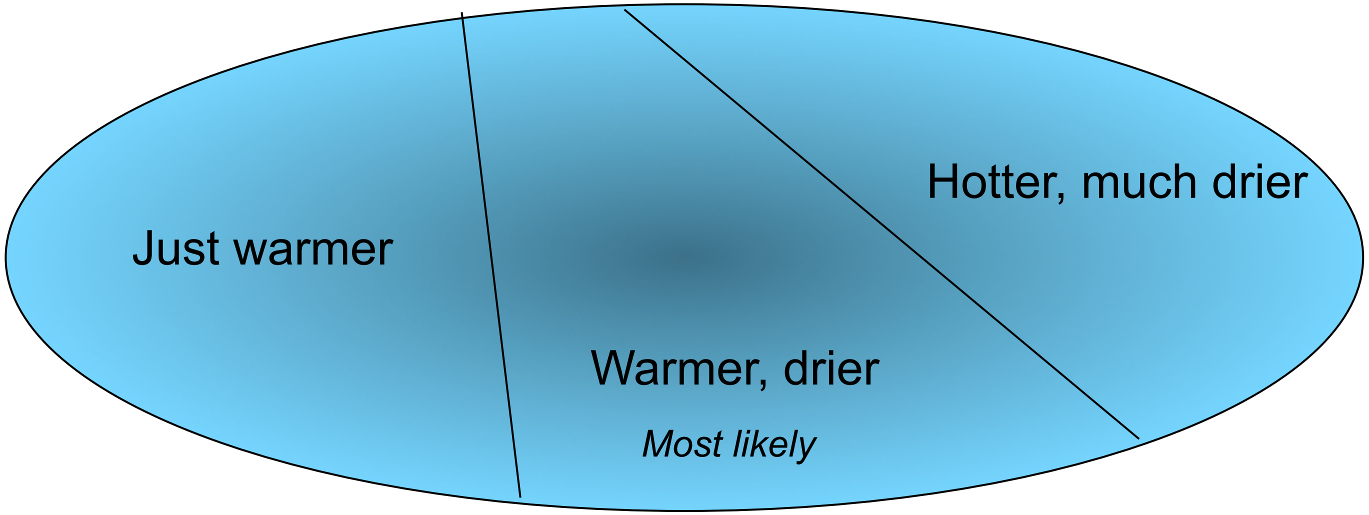


Classify future climates into small set of relevant future climates.

Climate science can add probability based on model evaluation, etc


Projected climate *change*
T
P
GCM
GCM
GCM
GCM
GCM
GCM
GCM
GCM
GCM
GCM
GCM
GCM
GCM
drier
Most likely
Downscaling
Just warmer
Warmer, drier
Hotter, much drier
Classify climate model results
Option to downscale and use a representative subsample
Small set of climate futures, not models, form the framework for all players
Application ready *future climate* data sets

Classifying future climates



How to classify?

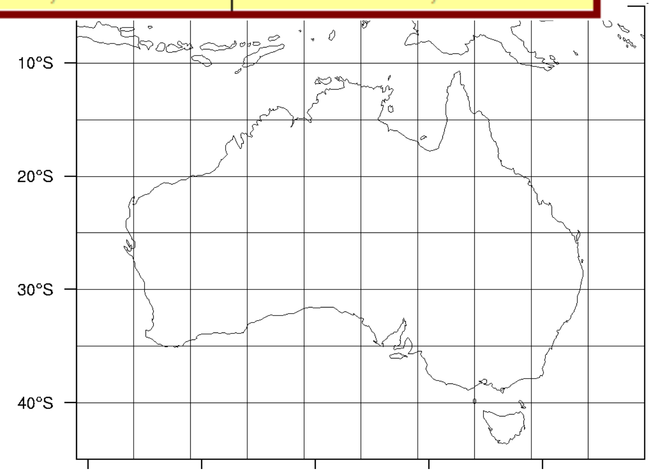
Probability?

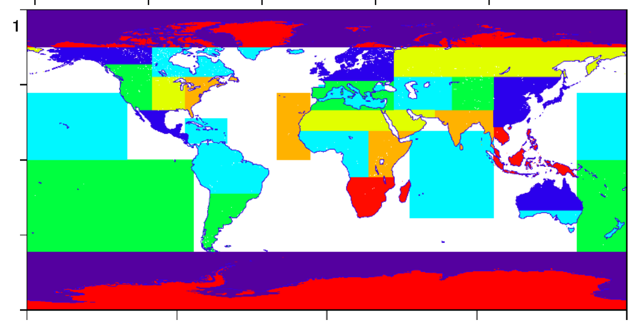
Collaboration between climate scientists and users

Classifying and using plausible future climates

	Little change up to 0.5C warmer	Warmer 0.5 to 1.5C warmer	Hotter 1.5 – 3.0C warmer	Much hotter more than 3.0C warmer
Much wetter (more than +15%)	*No evidence*	*No evidence*	*No evidence*	*No evidence*
Wetter (0 to 15% wetter)	*No evidence*	*No evidence*	Unlikely *4 models*	Very unlikely *(CGM3.1 T47)*
Drier (0 to 15% drier)	*No evidence*	Very unlikely *(GISS AOM)*	As likely as not *10 models*	Unlikely *3 models*
Much drier (More than 15% drier)	*No evidence*	*No evidence*	Very unlikely *CNRM-CM3,CSIROmk3*	Very unlikely *CSIRO Mk3.5, IPSL*

SE Australia region, A1FI, 2070

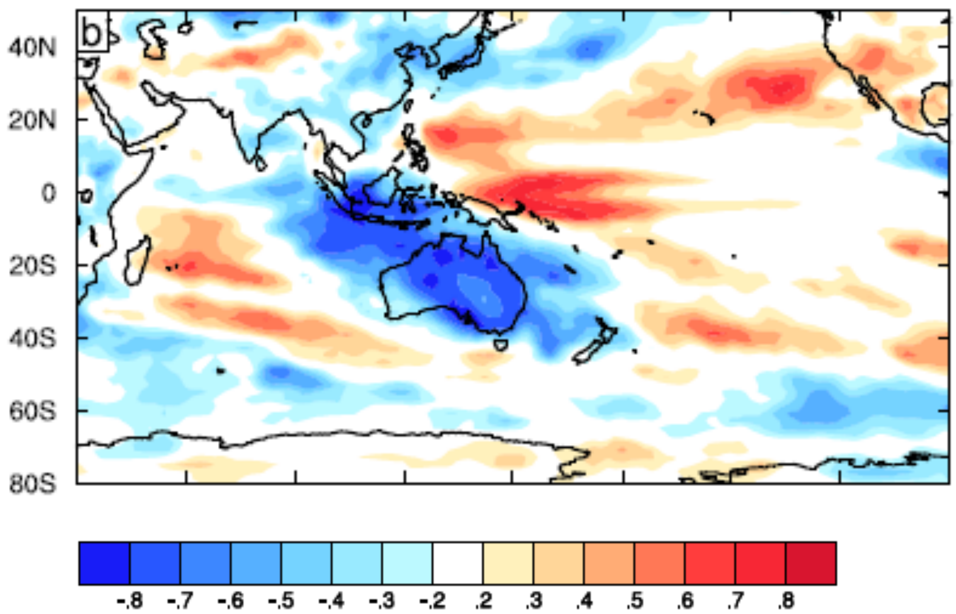




- Usually T and P, but not always
- With users, subset of climates selected and then populated with applicable data sets
- *Probability?*
- *Classifying downscaled data without seeing them?*
- *Different models selected by user and sector*

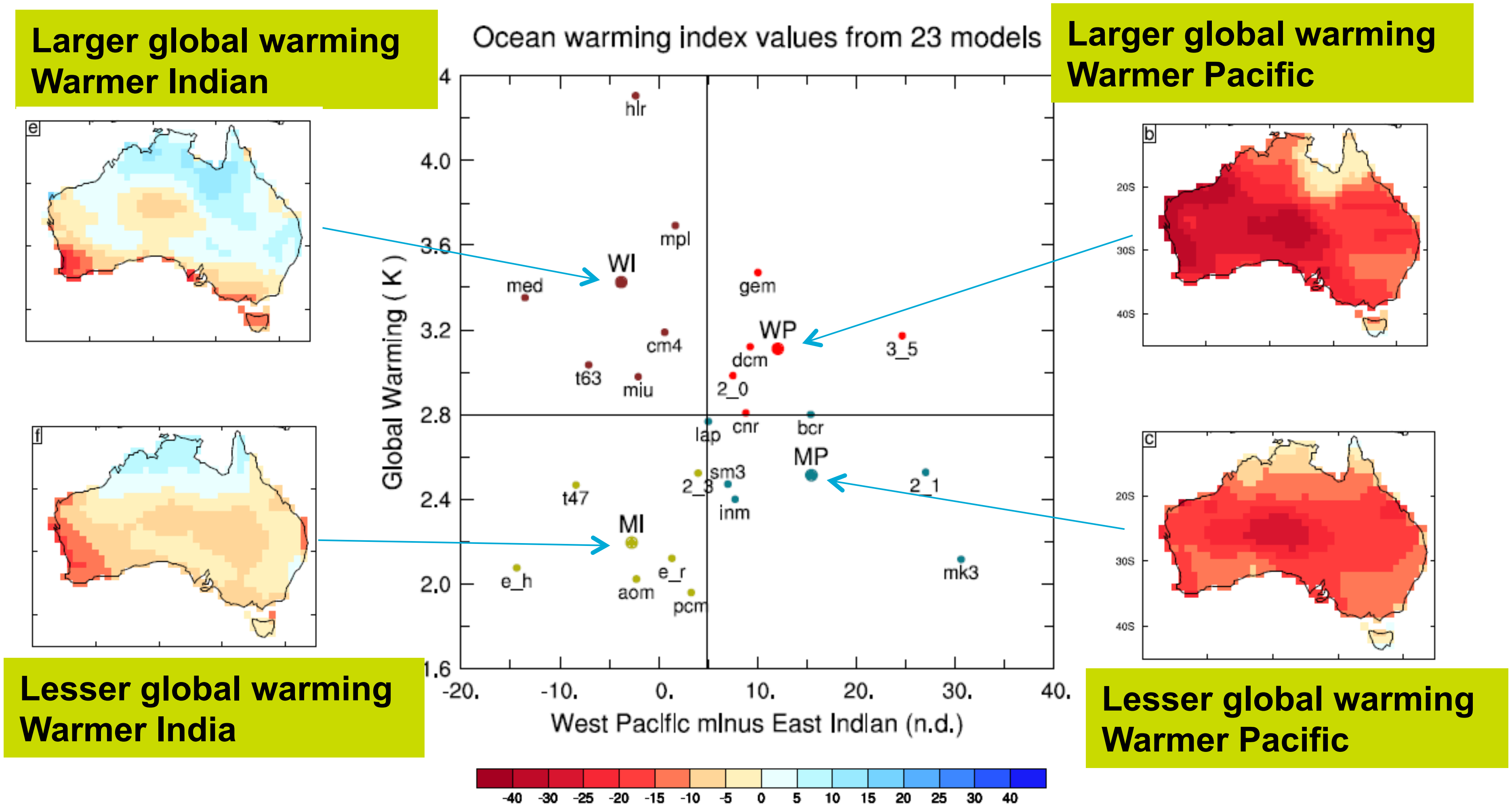
Simulated Australian climate change and regional SST (Watterson, submitted)

PID = Warming in Eq. Eastern Pacific minus waming in the Eq Western Indian



Correlation of CMIP3 simulated precipitation changes with a regional index of SST changes: 'PID'

CMIP3 model spread, PID and global SST
(I. Watterson, submitted)



In most locations 60% of range of change captured

Concluding comments

- Various recent CCAM based simulations available for the region based on six GCMs
    - Well analysed only in some sub-domains
    - Analysis under way for the Southwest Pacific region
    - Set of 60km simulations available globally (i.e. for CORDEX regions)
- Encourage simulations for the Australian region!
- Some methods for model selection presented
    - Temperature and precipitation
    - Regional climate drivers (SST warming patterns), possibly preferable