Predicting water futures: art, science, opinion

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CSIRO LAND AND WATER
www.csiro.au

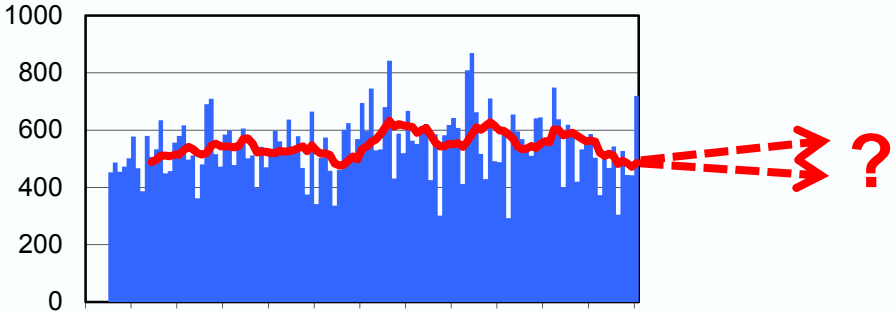
OzEWEX 2015
Gold Coast Convention Centre
2 Dec 2015

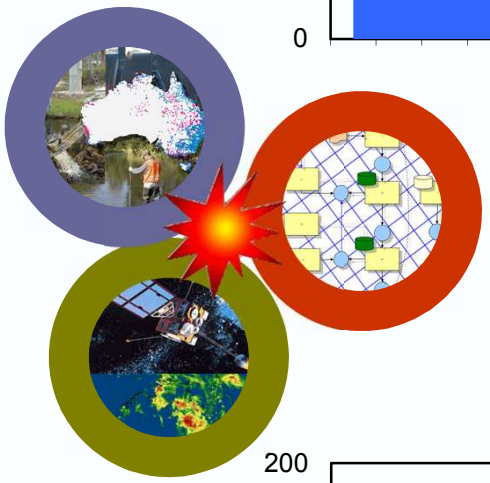
Talk Outline

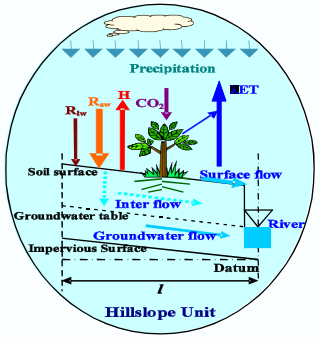
- Uncertainty in predicting water futures
- Which method(s)? Which projection(s)?
- Communication and/or confusion
- Adaptation in the water resources and related sectors

Modelling climate impact on water

RAINFALL (CLIMATE)

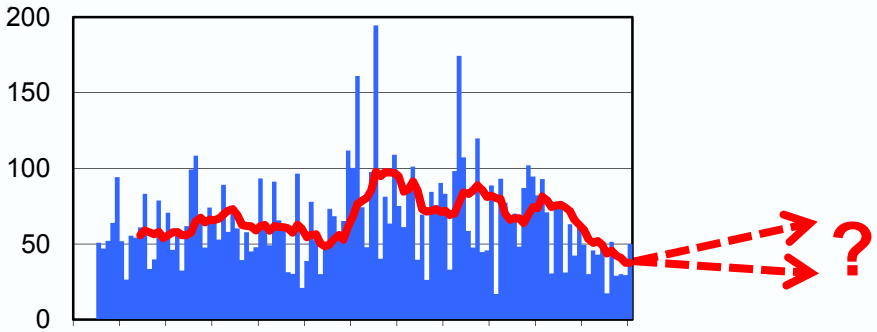




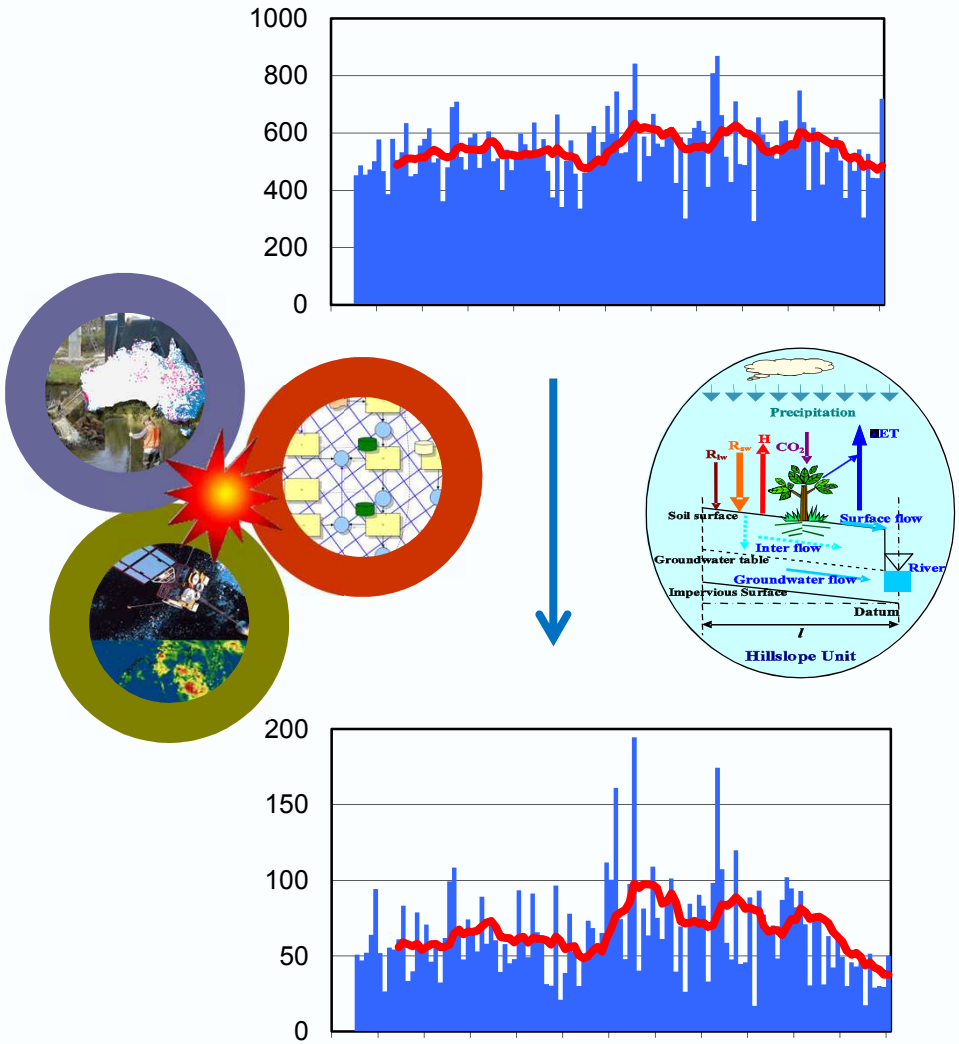


Climate-water relationship
Hydrological modelling

RUNOFF/ STREAMFLOW



Hydrologic non-stationarity



Extrapolating models under changed conditions

- Changing climate-runoff relationship.
- Extrapolating models to different hydrologic regime.
- Climate change – changed precipitation patterns, warmer climates, higher CO_2.

CLIMATE CHANGE

Stationarity Is Dead: Whither Water Management?

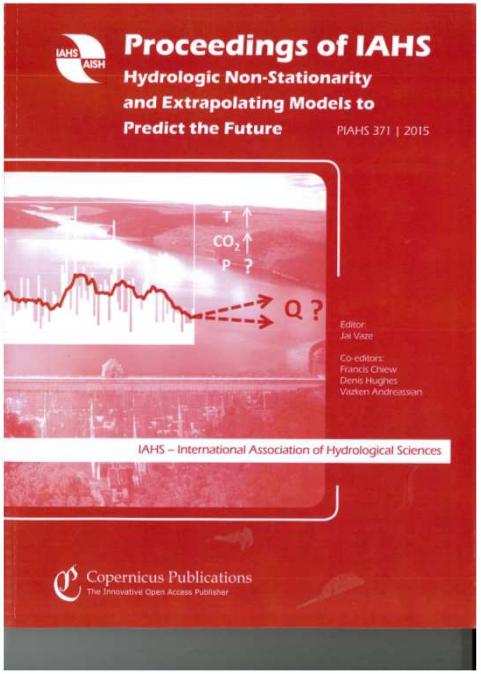
P. C. D. Milly,[1*] Julio Betancourt,[2] Malin Falkenmark,[3] Robert M. Hirsch,[4] Zbigniew W. Kundzewicz,[5] Dennis P. Lettenmaier,[6] Ronald J. Stouffer[7]

[Milly et al., Science, 2008]

Workshop on Nonstationarity, Hydrologic Frequency Analysis, and Water Management

January 13-15, 2010
Millennium Harvest House, Boulder, Colorado

[CSU, 2010]



[PIAHS, 2015]

AGU FALL MEETING
San Francisco | 3–7 December 2012

On the need to test hydrological models under changing conditions

Guillaume Thirel[a], Vazken Andréassian[a] & Charles Perrin[a]

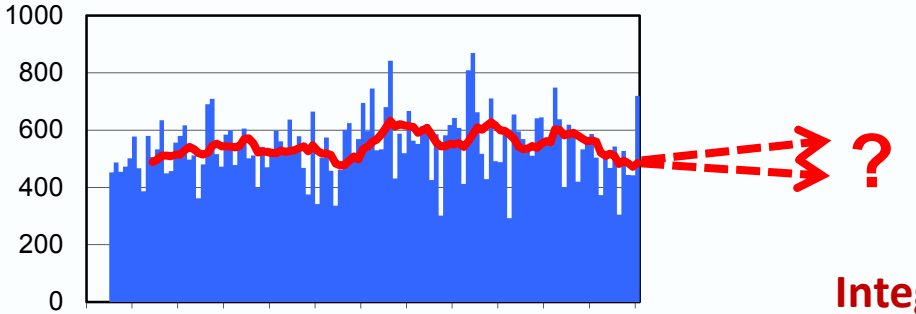
[HSJ, 2015]

Panta Rhei
IAHS AISH
Everything Flows
Change in Hydrology and Society

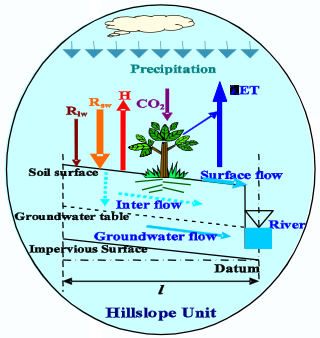
CSIRO

Modelling climate impact on water

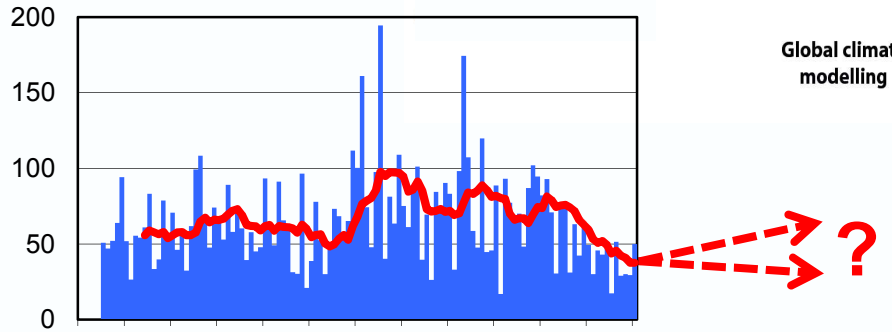
RAINFALL



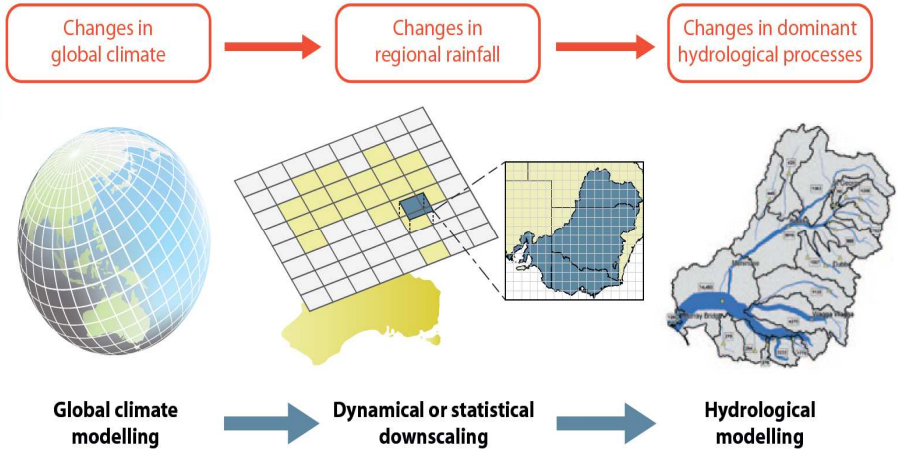
Climate-water relationship
Hydrological modelling



RUNOFF/
STREAMFLOW

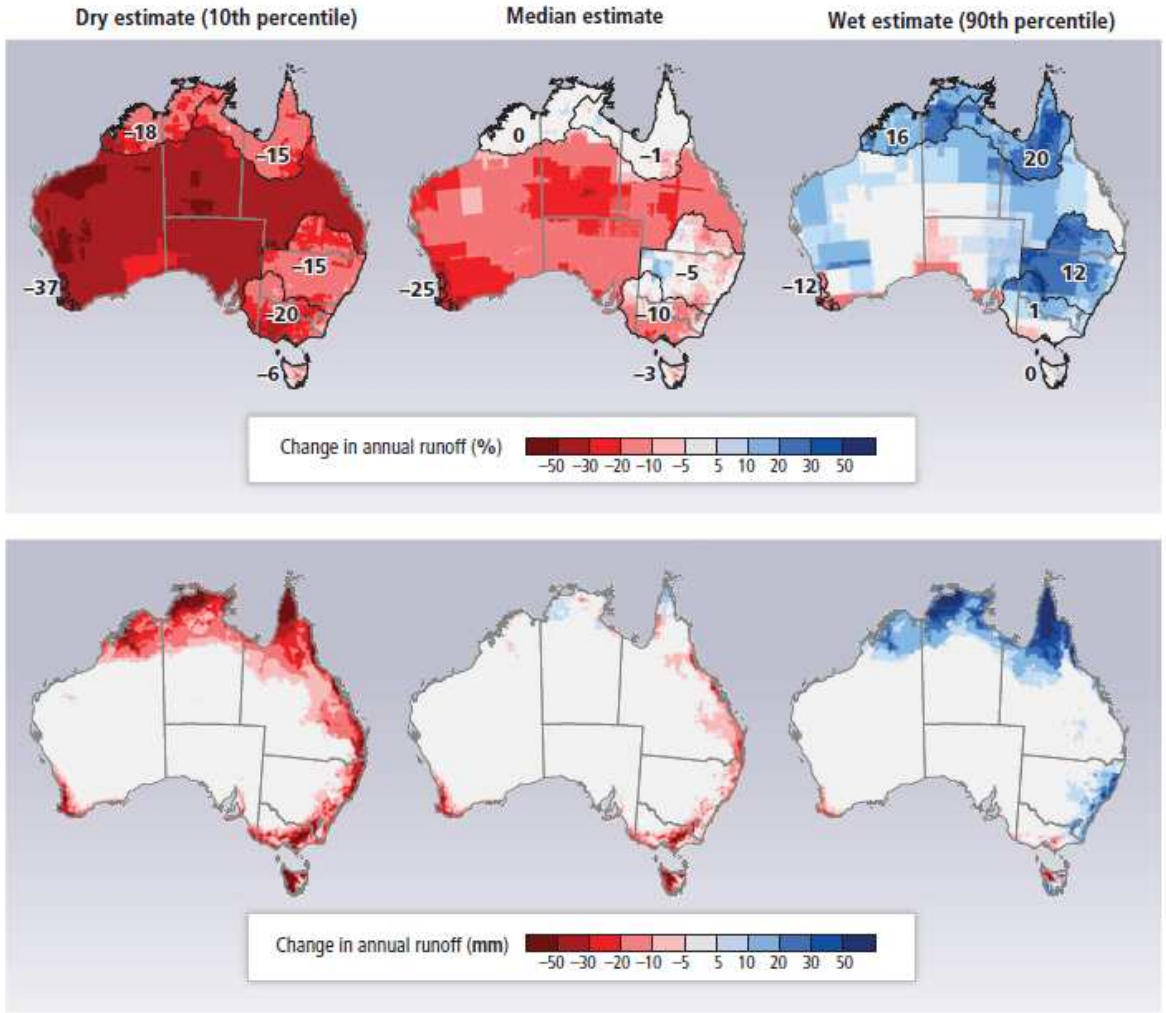


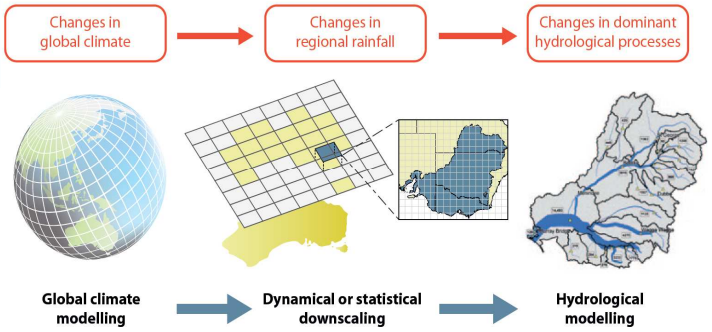
Integrated climate-water modelling

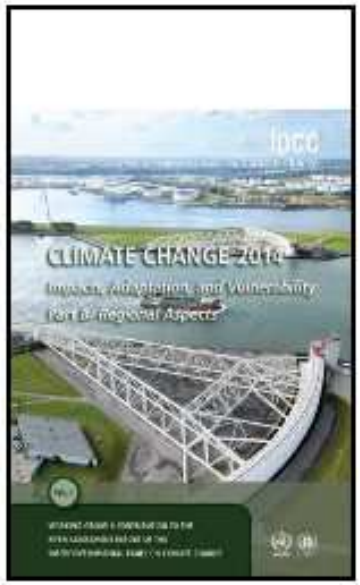


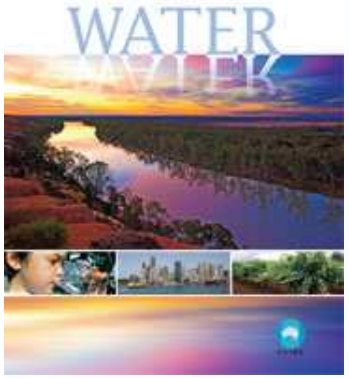
Future runoff projections

Change in future runoff for 1°C warming







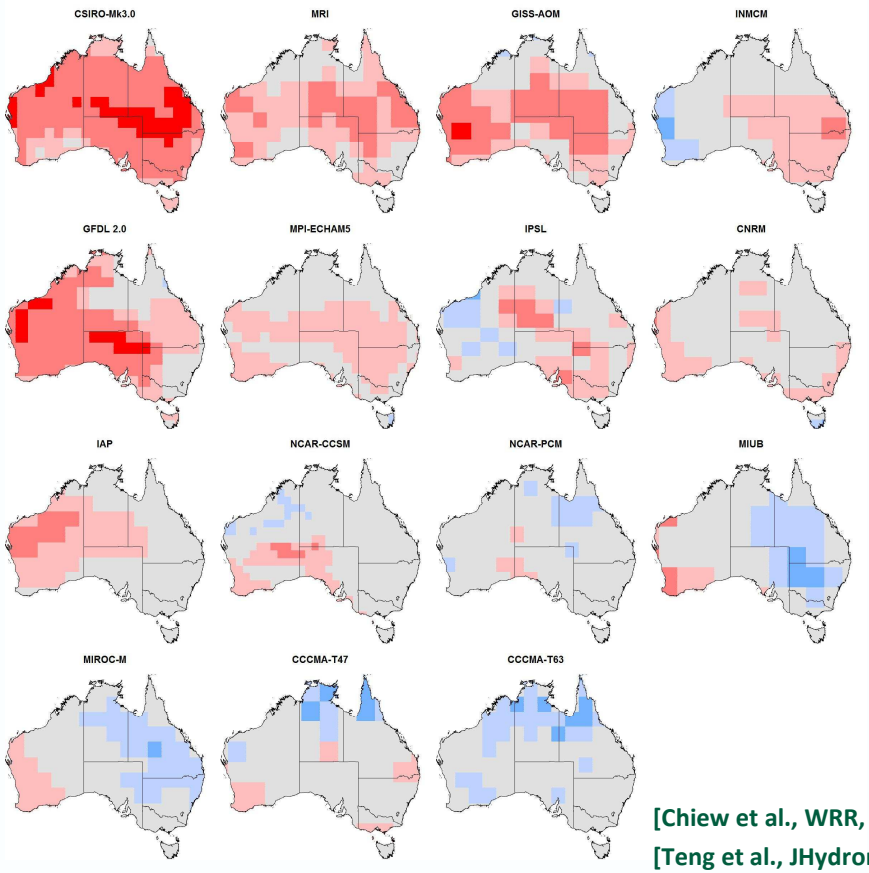


[Chiew et al., WRR, 2009]
[Petheram et al., JHydrometeorol, 2012]
[Post et al., JHydrol, 2012]
[Teng et al., JHydrometeorol, 2012]
[Chiew and Prosser, CSIRO Water Book, 2011]

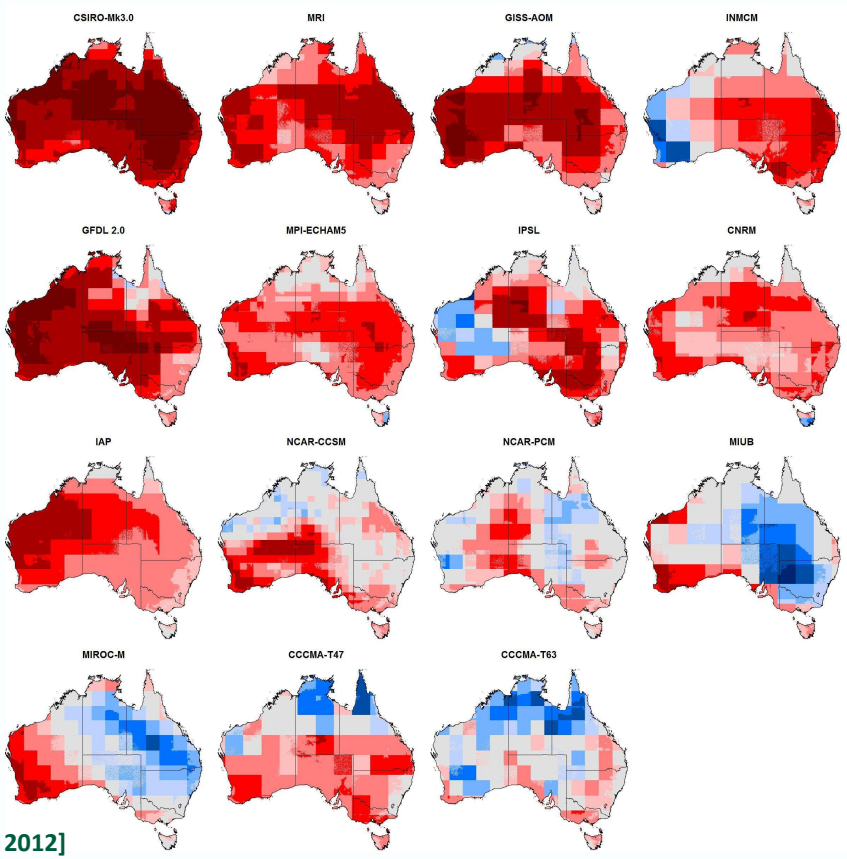
Large uncertainty in future rainfall projections
….. amplified in the runoff

Percentage change for 1°C global warming

RAINFALL

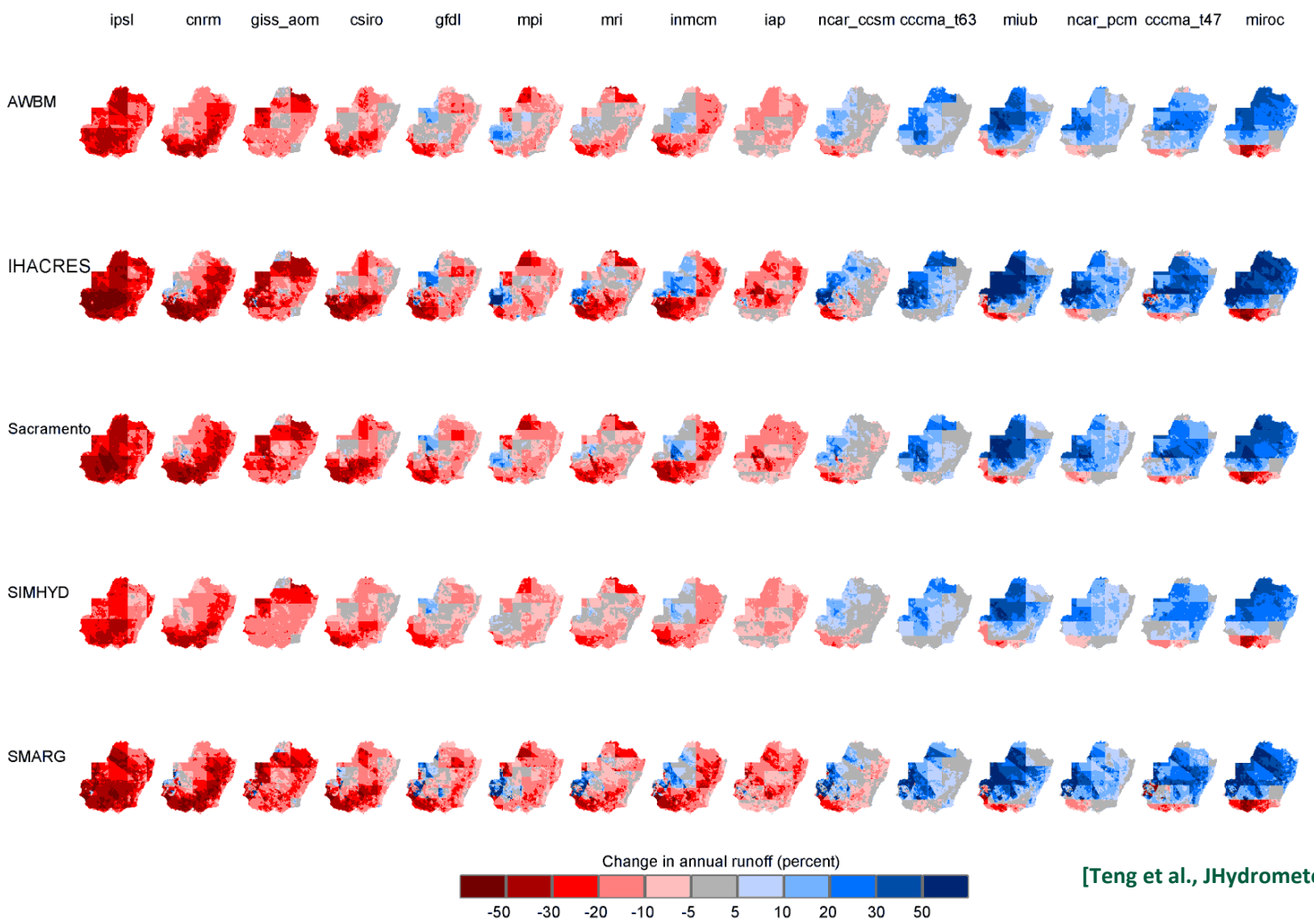


RUNOFF



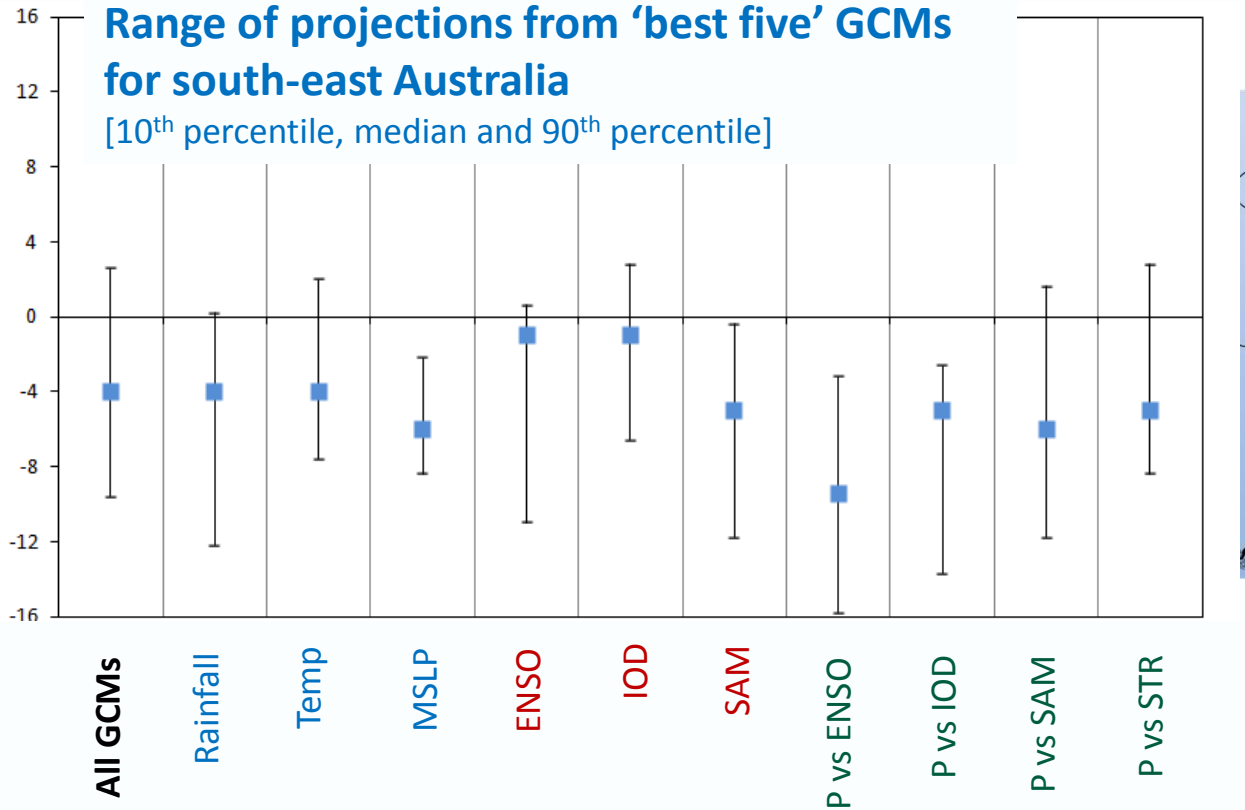
[Chiew et al., WRR, 2009]
[Teng et al., JHydrometeorol, 2012]

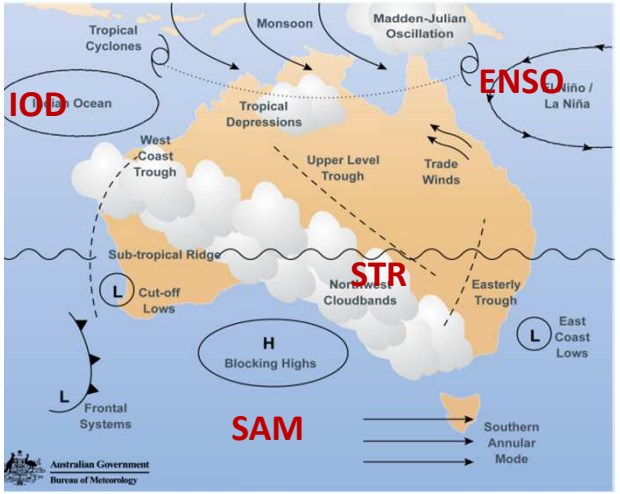
Runoff projections mainly reflect uncertainty in rainfall projections



[Teng et al., JHydrometeorol, 2012]

Reducing uncertainty by using only the better GCMs?



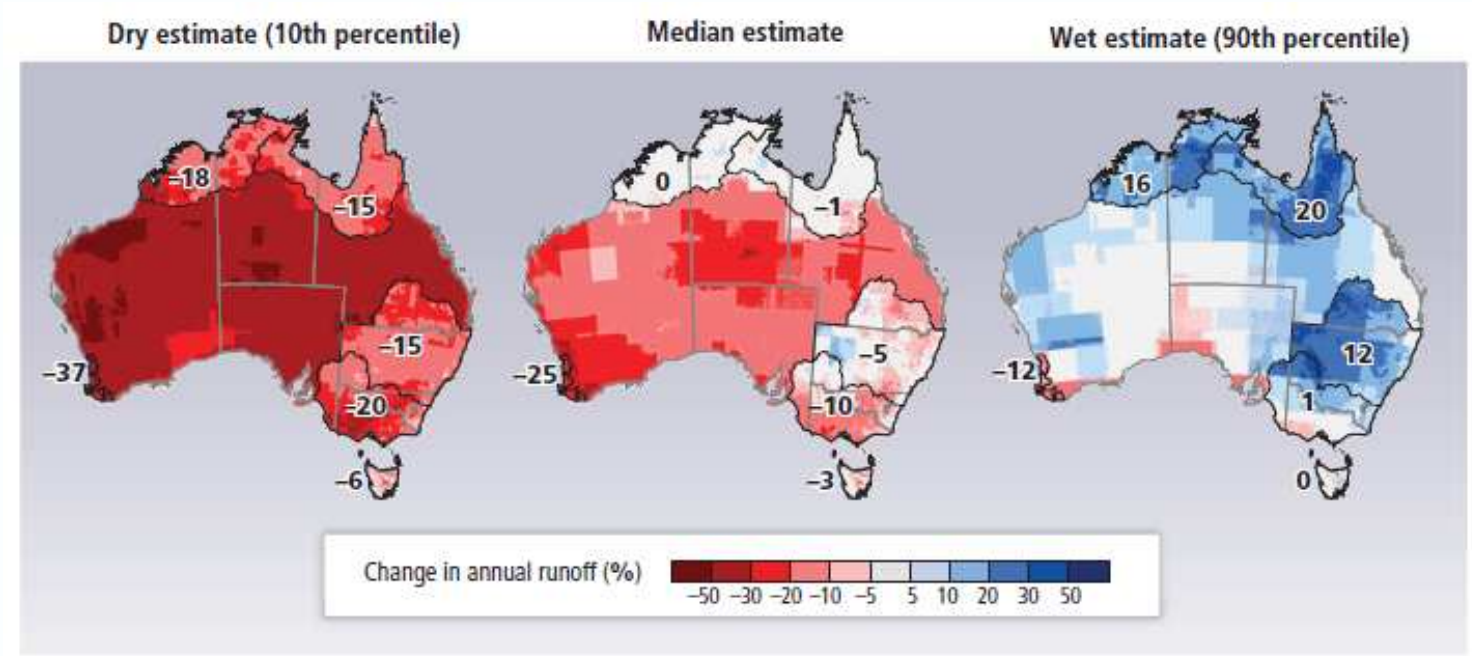


[Chiew et al., JHydrol, 2009]
[Smith & Chandler, ClimChg, 2009]
[Kirono et al., MODSIM, 2011]

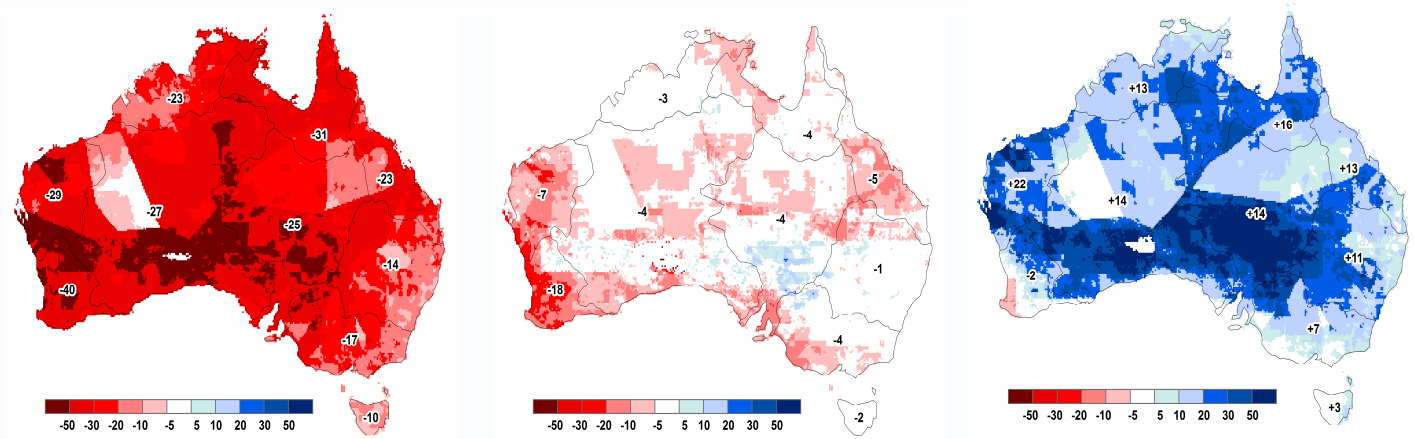
- How to assess and select GCMs, based on what criteria?
- Range of results are similarly large when fewer (better?) GCMs are used?
- Therefore, use all/most GCMs to better represent the range of uncertainty?

CMIP3 vs CMIP5

CMIP3



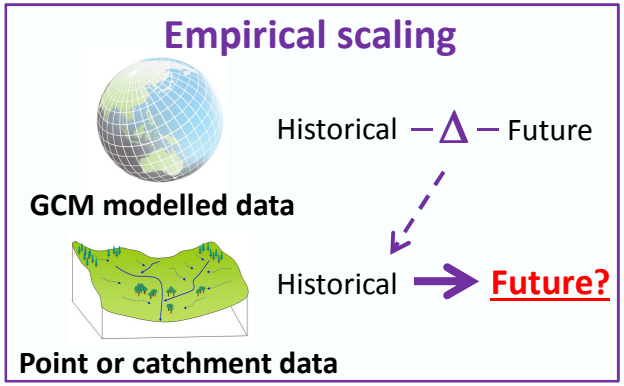
CMIP5



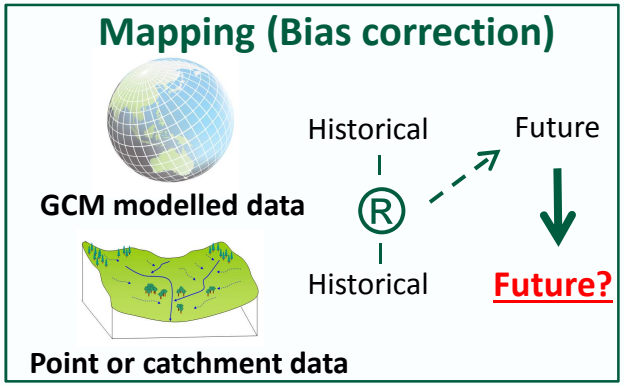
Downscaling

[Chiew et al., WRR, 2009]
[Mpelasoka & Chiew, JHydrometeorol, 2009]
[Teng et al., HESS, 2015]

Empirical scaling



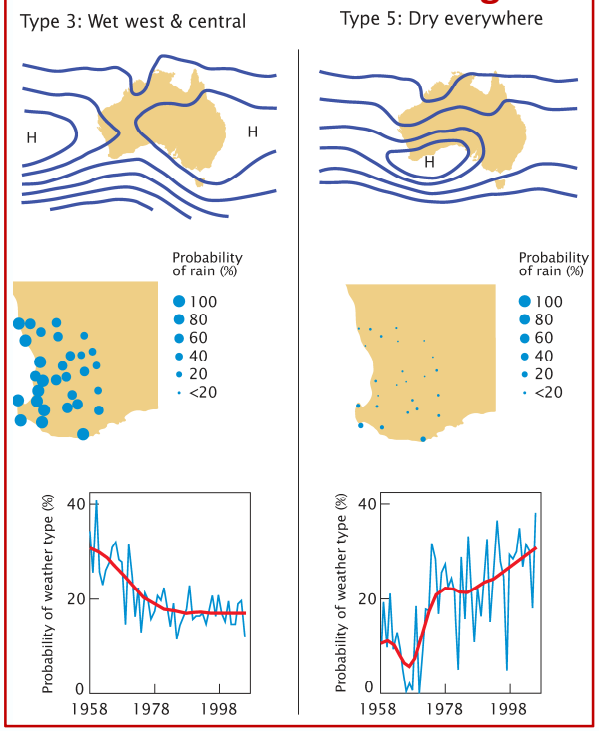
Mapping (Bias correction)



- Simplest.
- Easily applied to all GCMs (accounting for range of uncertainty).

[Bates et al., ClimChg, 2008]
[Chiew et al. JHydrol, 2010]
[Fu et al., JHydrol, 2013]

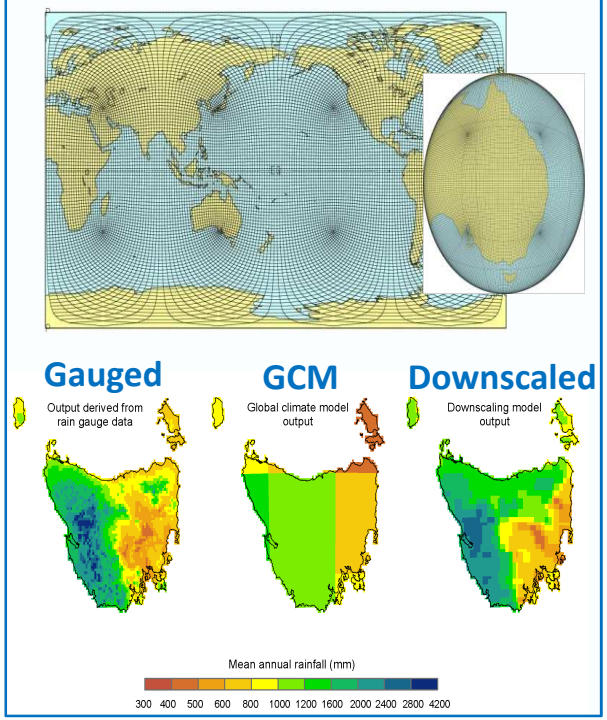
Statistical downscaling



- Uses large scale predictors which GCMs are better at simulating.
- Need to develop statistical downscaling relationship.
- Can also apply to all GCMs.

[Post et al., JHydrol, 2012]
[Bennett et al., JHydrol, 2012]

Dynamic downscaling



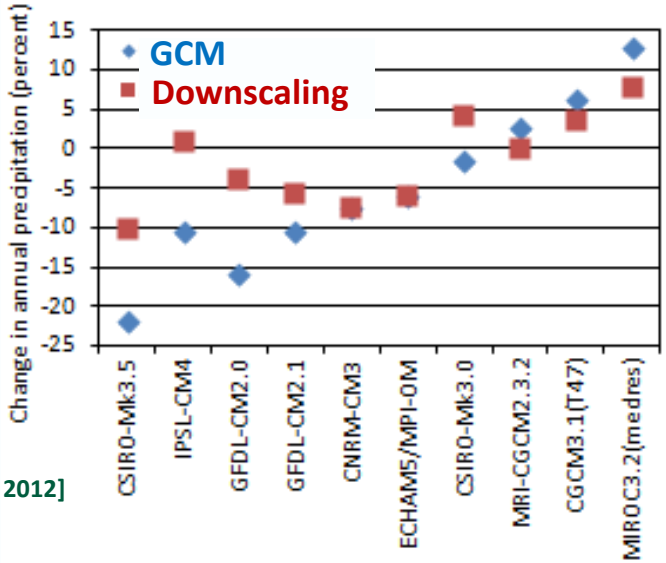
- Dynamic modelling of processes.
- Simulated rainfall needs to be bias corrected.
- Long run times, therefore limited downscaling runs.

Advantages of downscaling?

- Downscaling provides more realistic rainfall projections at finer resolutions, *but are they real*?
- Downscaling *can* reduce the range of uncertainty in the future rainfall projections.
- Downscaling considers potential changes to a larger range of rainfall characteristics.

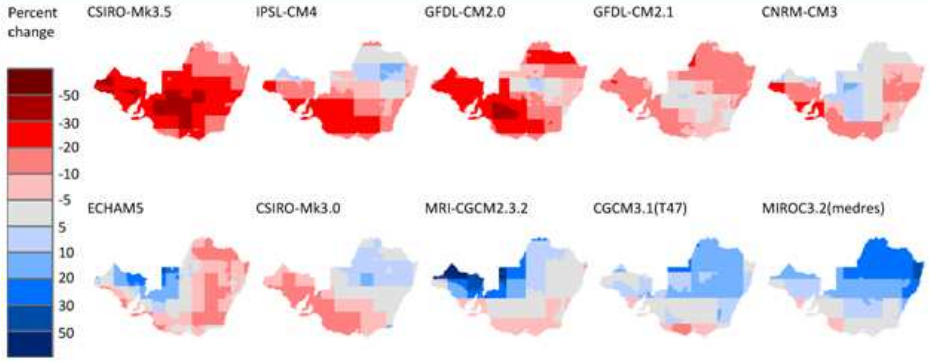
[Teng et al., JHydrometeorol, 2012]
[SEACI, 2012]

Change averaged across region

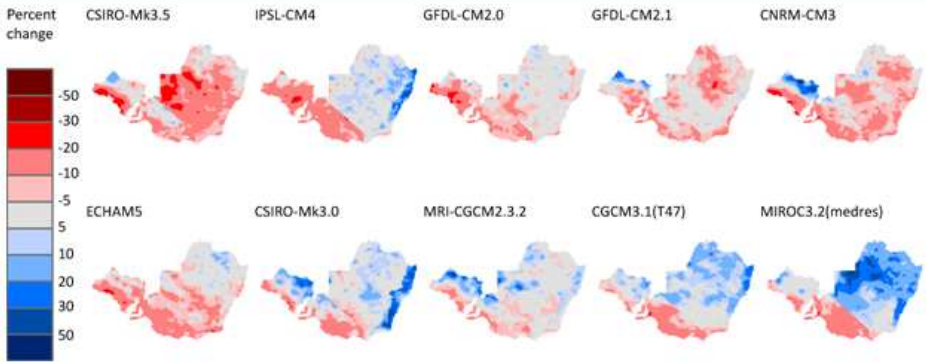


Percentage change in future mean annual rainfall

Empirical scaling of GCM

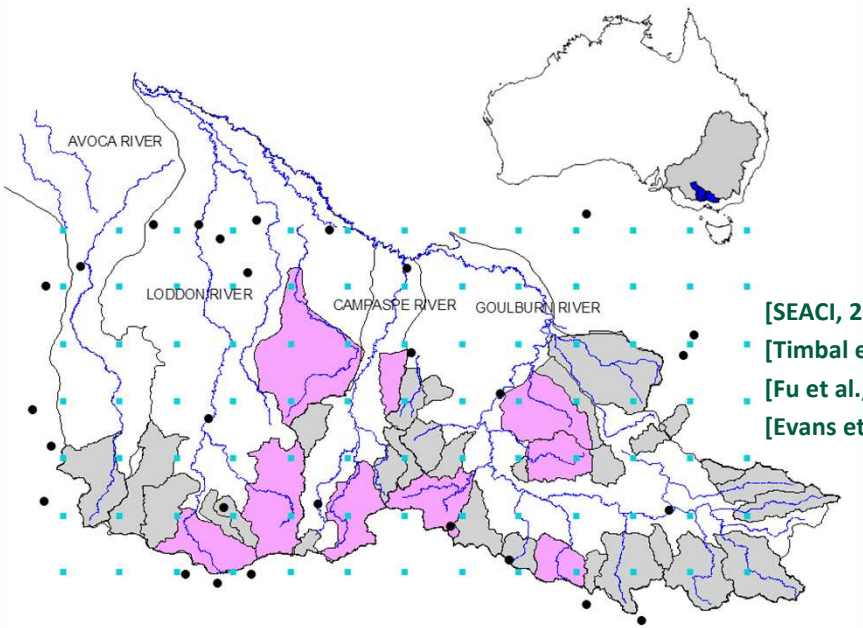


Downscaling

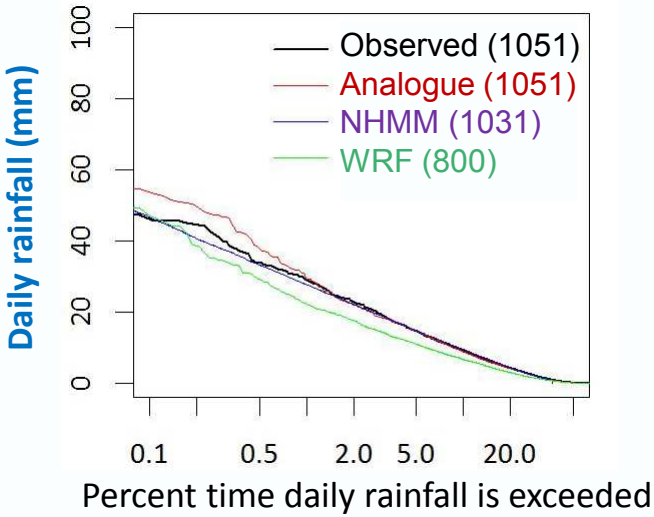


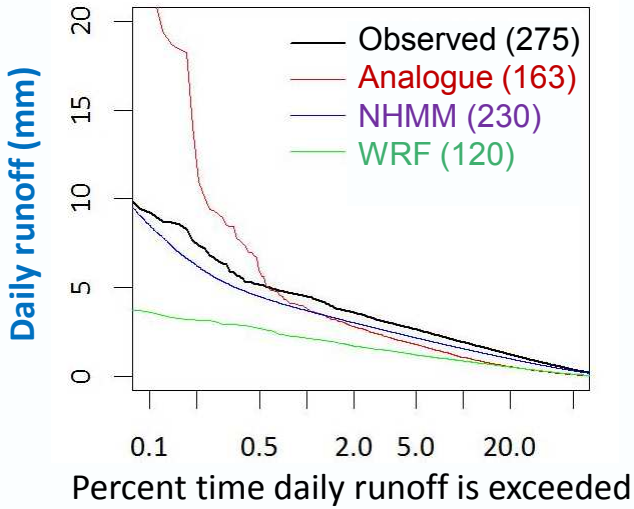
Challenges for downscaling

- Development and validation of downscaling models – simulations look good but are they real?
- Reliable bias correction of RCM outputs – how big are the RCM errors and will the bias correction be robust for future predictions?
- Satisfactory simulation of rainfall sequences and features that drive runoff generation.

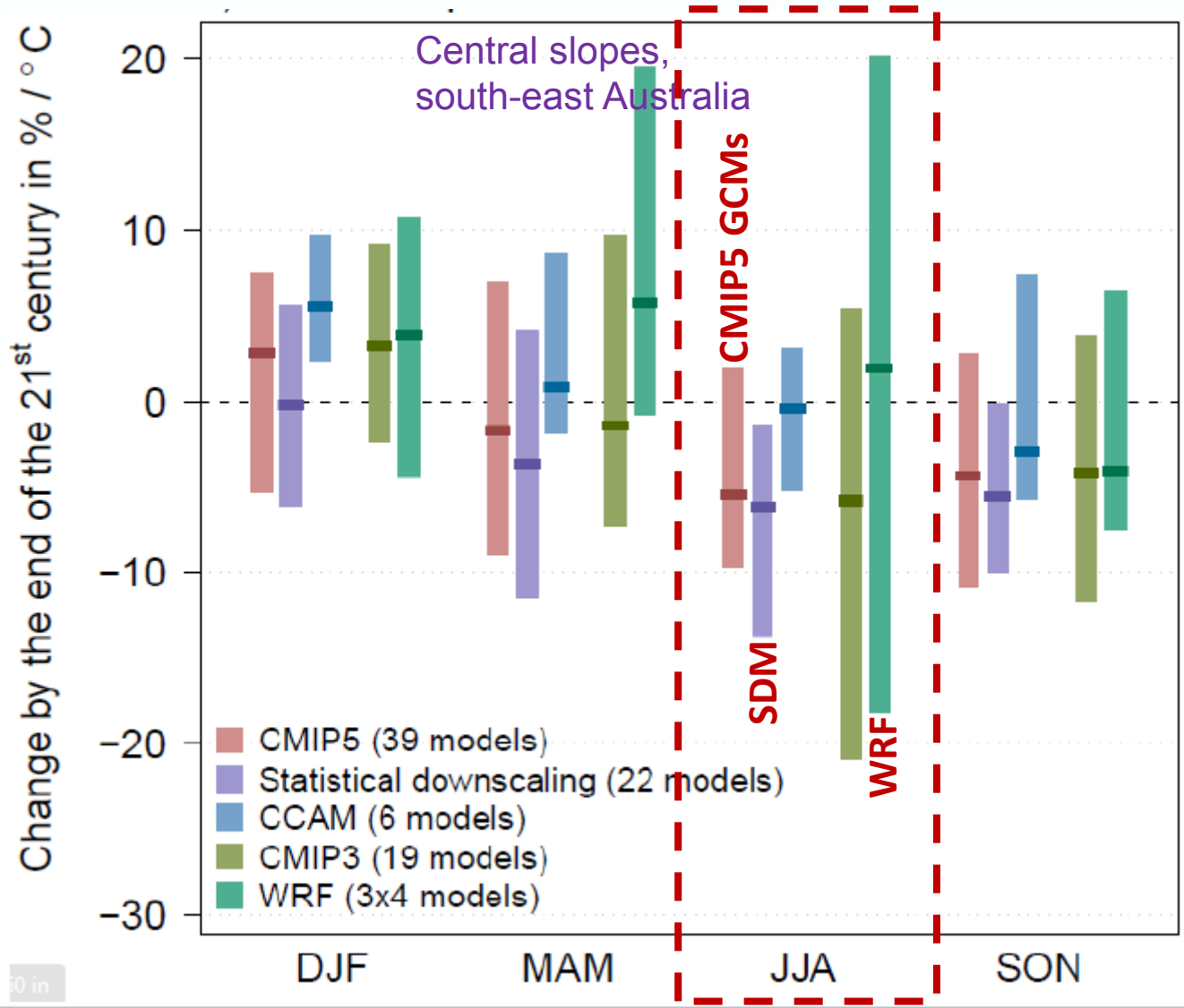


[SEACI, 2012]
[Timbal et al., EMS, 2009]
[Fu et al., JHydrol, 2013]
[Evans et al., ClimDyn, 2012]





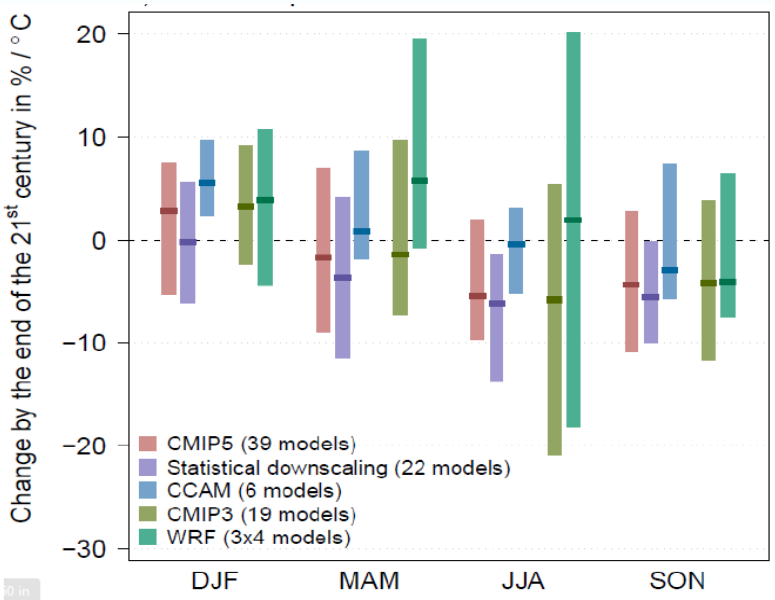
Projections from GCMs and different downscaling methods

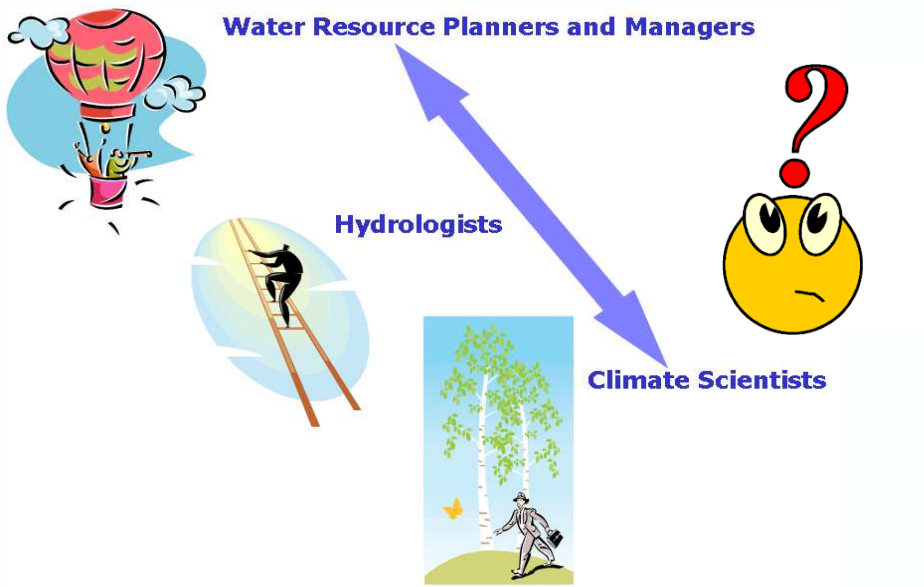


CLIMATE CHANGE IN AUSTRALIA
PROJECTIONS FOR AUSTRALIA'S NRM REGIONS

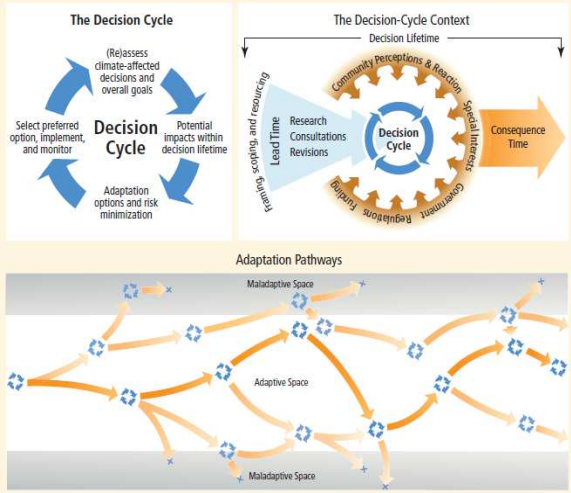
[Grose et al., AMOS, 2015]

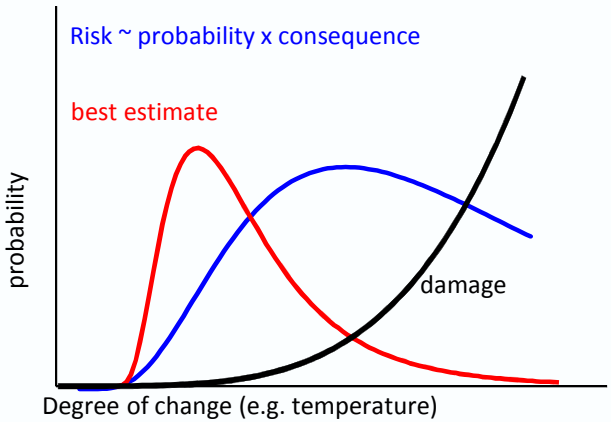
Which future projections? Does it matter?





- Bottom-up inter-disciplinary risk-reward impact-adaptation-vulnerability consideration.





Thank you

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