Predicting water futures: art, science, opinion

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OzEWEX 2015
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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

Climate-water relationship
Hydrological modelling

RAINFALL (CLIMATE)

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. Stouffer7
[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]

AGU FALL MEETING
San Francisco | 3–7 December 2012

On the need to test hydrological models under changing conditions
Guillaume Thiretª, Vazken Andréassianª & Charles Perrinª
[HSJ, 2015]
Modelling climate impact on water

Integrated climate-water modelling

Climate-water relationship
Hydrological modelling

Global climate modelling
Dynamical or statistical downscaling
Hydrological modelling

Changes in global climate
Changes in regional rainfall
Changes in dominant hydrological processes
Future runoff projections

Change in future runoff for 1°C warming

Change in annual runoff (%)

Change in annual runoff (mm)

[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

[Chiew et al., WRR, 2009]
[Teng et al., JHydrometeorol, 2012]
Runoff projections mainly reflect uncertainty in rainfall projections

[Teng et al., JHydrometeor, 2012]
Reducing uncertainty by using only the better GCMs?

Range of projections from ‘best five’ GCMs for south-east Australia
[10th percentile, median and 90th percentile]

- 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

Dry estimate (10th percentile)  Median estimate  Wet estimate (90th percentile)

CMIP3

CMIP5
Downscaling

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

**Empirical scaling**

- GCM modelled data
- Historical → Future

**Statistical downscaling**

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

**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.

Percentage change in future mean annual rainfall

Empirical scaling of GCM

Downscaling

[Teng et al., J Hydrometeorol, 2012]

[SEACI, 2012]
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

Central slopes, south-east Australia

Change by the end of the 21st century in % °C

CMIP5 GCMs
SDM
WRF

CMIP5 (39 models)
Statistical downscaling (22 models)
CCAM (6 models)
CMIP3 (19 models)
WRF (3x4 models)

DJF  MAM  JJA  SON

[Grose et al., AMOS, 2015]
Which future projections? Does it matter?

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

Risk ~ probability x consequence

Best estimate

Damage

Degree of change (e.g. temperature)
Thank you

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