CLIMATE CHANGE PROJECTIONS

FOR AUSTRALIA'S
NATURAL RESOURCE MANAGEMENT REGIONS

CSIRO

An Australian Government Initiative

Australian Government
Bureau of Meteorology

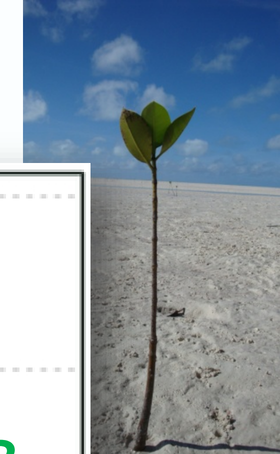
-20° -10° 0° 10° 20° 30° 40° 50°

Introduction to the *Climate Futures Framework*

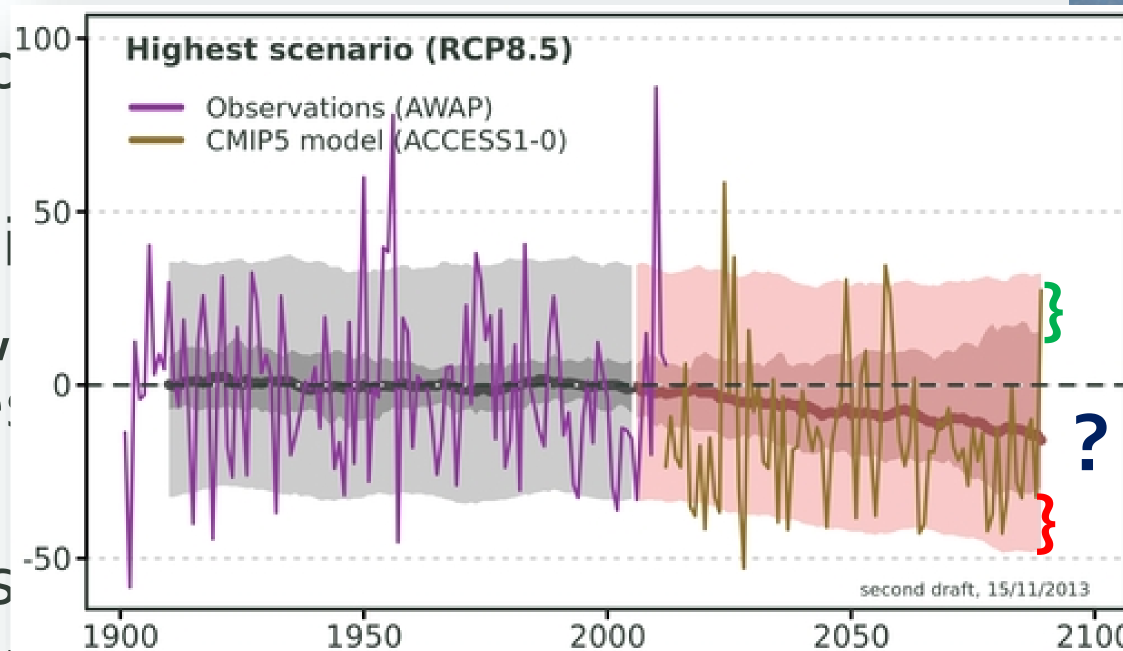
John Clarke, Tim Erwin

-20° -10° 0° 10° 20° 30° 40° 50°

Impact Assessment



- Climate projectio
  assessments
- The level of detai
  decision-makers,
  general awarenes
  road
- Not "one size fits
  to be purpose-built



- Because of the uncertainty, often use a "risk management" approach to evaluate important "cases", *e.g.*
  - "Best" Case
  - "Worst" Case
  - "Maximum Consensus" Case (if there is one)

Typical climate projections

- Typically projections are for individual climate variables for selected years and emissions scenarios
- Projections expressed as a central tendency (e.g. mean or median) with a range of uncertainty, *e.g.*
  - 2°C (1-3°C) warmer
  - 10% (5-15%) wetter
- OK for general information and working with single climate variables, but…
- What if your impact assessment needs to consider multiple variables jointly (*e.g.* crop growth, species distributions)?

Typical climate projections & Internal Consistency

Temperature change:	+1.7 (+1.1 to +2.6) °C
Rainfall change:	-2.4 (-15.0 to +12.9) %

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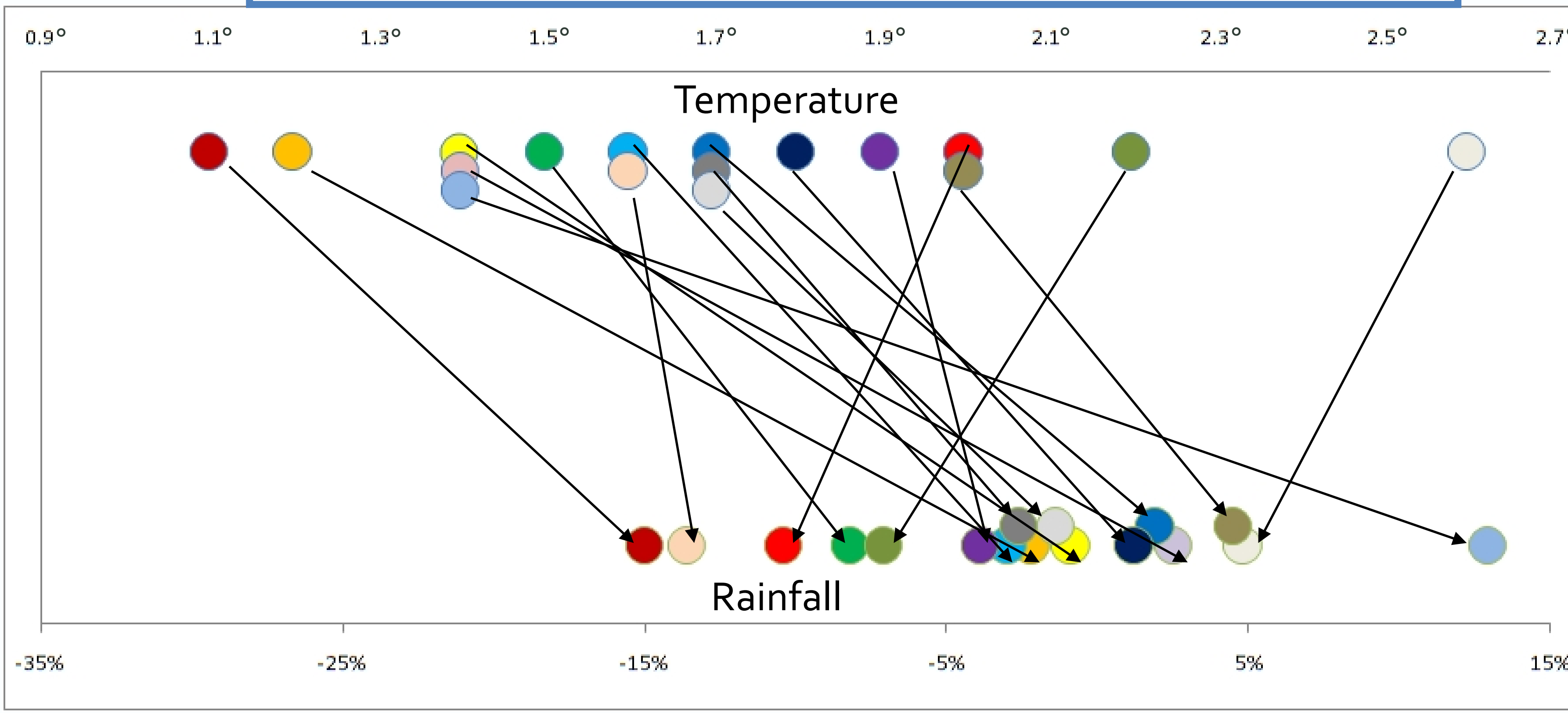

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But you know none of this if all you have is a mean and range!

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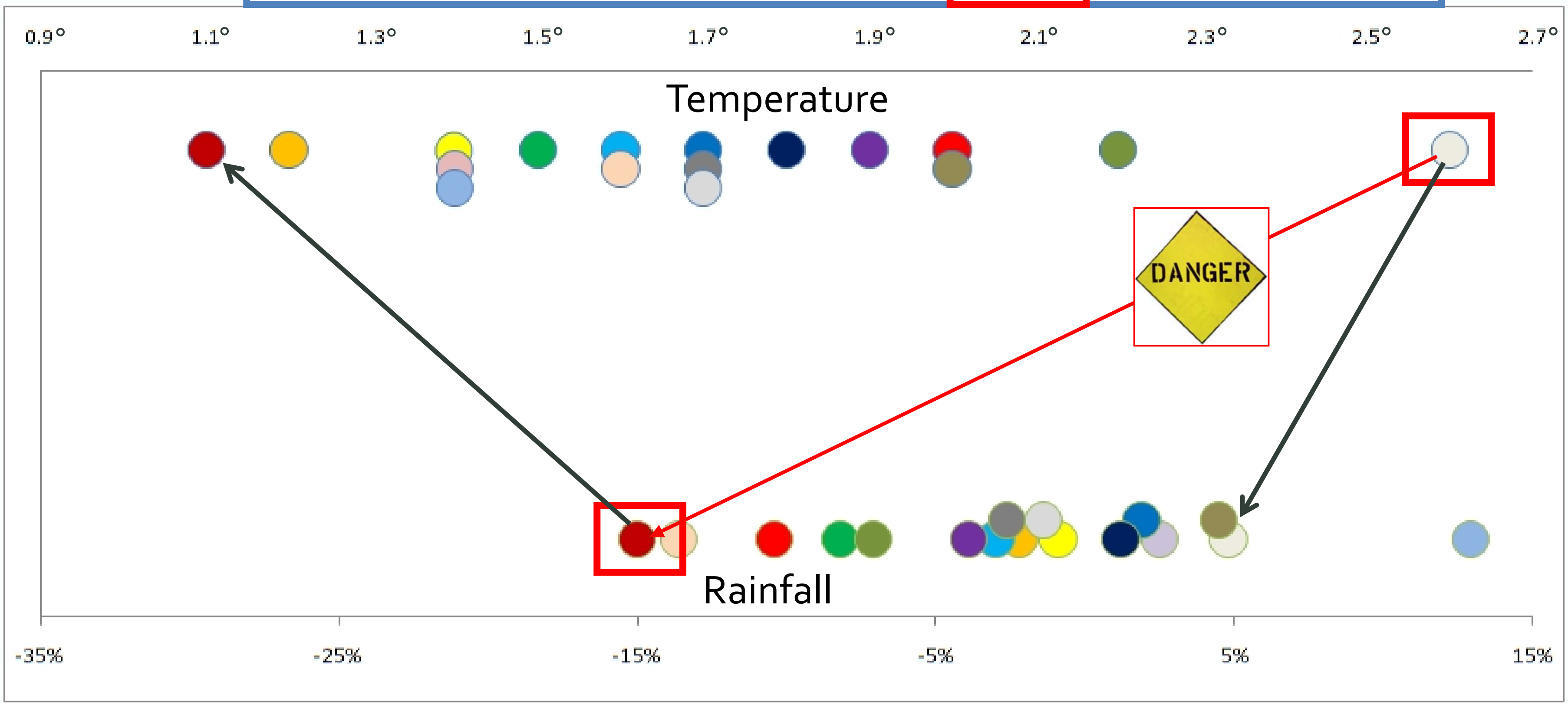

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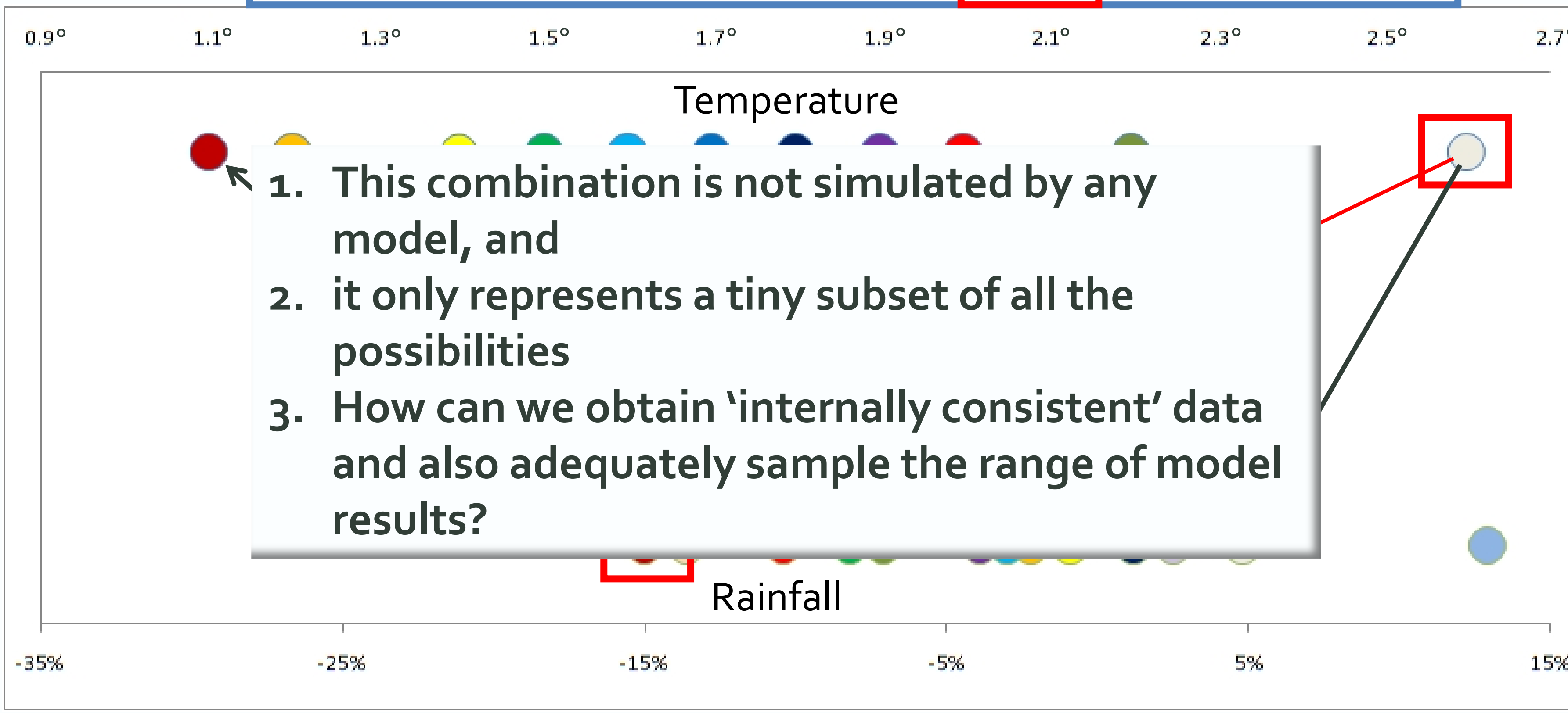
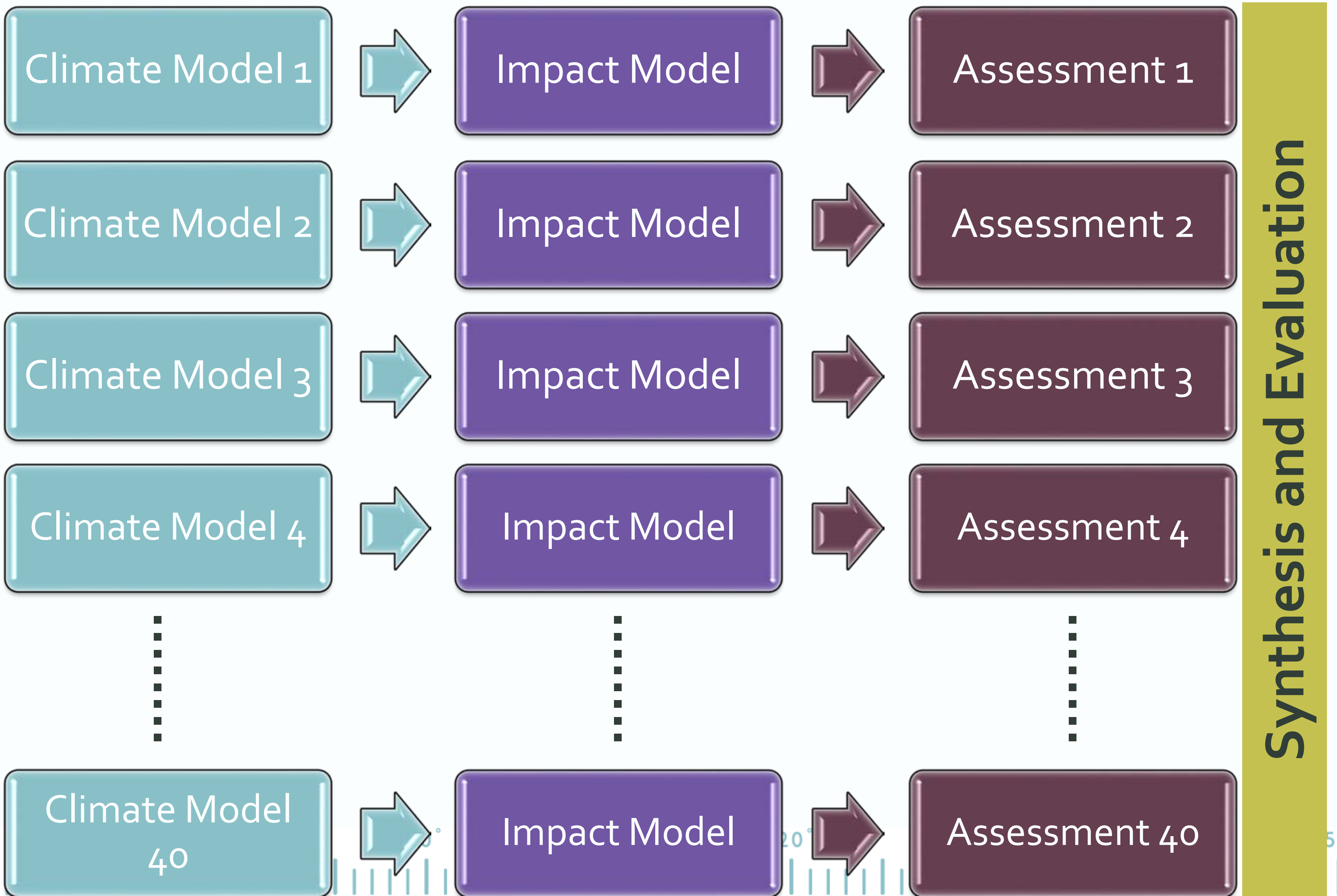


1. This combination is not simulated by any model, and
2. it only represents a tiny subset of all the possibilities
3. How can we obtain 'internally consistent' data and also adequately sample the range of model results?

What do we want from the projections?

- Internally Consistent Data
- Adequately Sample the Range
- Achievable
- Information on Model Agreement (> likelihood)
- Credibility (model **evaluation**)

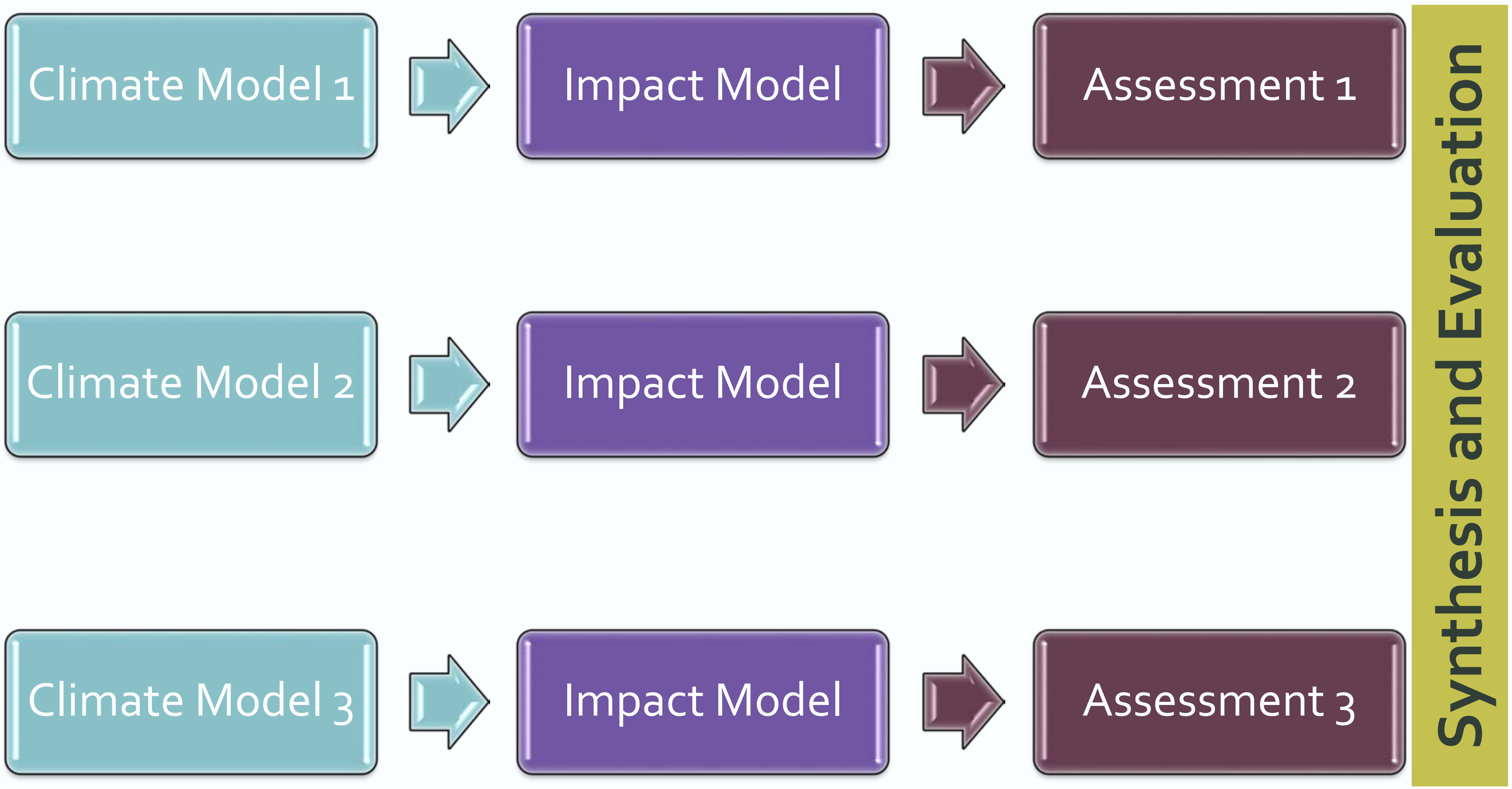
Using individual models for impact assessment – every model



What we want from projections - using every model

- ✓ Internally Consistent Data
- ✓ Adequately Sample the Range
- ? Achievable
- ✗ Information on Model Agreement

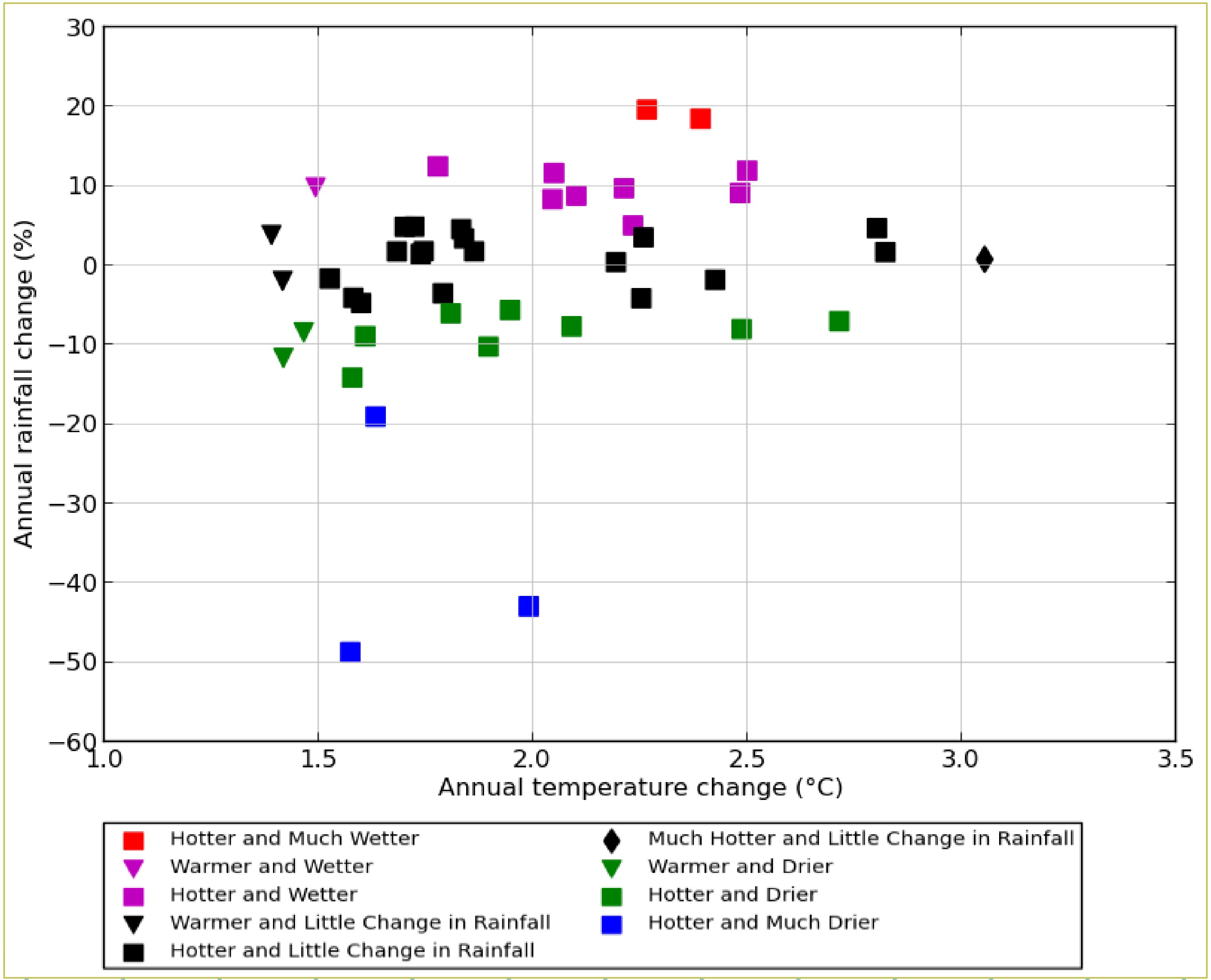
Using individual models for impact assessment – "Best" model approach



What we want from projections - ‘best’ models

- ✓ Internally Consistent Data
- ? Adequately Sample the Range
- ✓ Achievable
- ✘ Information on Model Agreement

An alternative approach



From Scatter-plot to Matrix

		ANNUAL SURFACE TEMPERATURE (C)			
		SLIGHTLY WARMER < 0.50	WARMER 0.50 TO 1.50	HOTTER 1.50 TO 3.00	MUCH HOTTER > 3.00
ANNUAL RAINFALL (%)	MUCH WETTER > 15.00			+ 2 of 39 GCMs	
	WETTER 5.00 TO 15.00		+ 1 of 39 GCMs	+ 1 of 6 RCMs 7 of 39 GCMs	
	LITTLE CHANGE -5.00 TO 5.00		+ 2 of 39 GCMs	+ 1 of 6 RCMs 17 of 39 GCMs	+ 1 of 39 GCMs
	DRIER -15.00 TO -5.00		+ 1 of 6 RCMs 1 of 39 GCMs	+ 3 of 6 RCMs 5 of 39 GCMs	
	MUCH DRIER < -15.00			+ 3 of 39 GCMs	

Consensus	Proportion of models
Not projected	No models
Very Low	< 10%
Low	10% - 33%
Moderate	33% - 66%
High	66% - 90%
Very High	> 90%

'Climate Futures' approach

- Work with the decision-makers, identify:
- Current sensitivity (what climate variables impact on the suitability of infrastructure):
- Key Cases
  - Best: future with highest rainfall and least evaporation
  - Worst: future with lowest rainfall and highest evaporation
  - Maximum Consensus (if possible) or Mid-range
- Use Representative Model Wizard to identify models to appropriately represent each Key Case
- Draw on existing information on model skill

Representative Model Selection Wizard

Models are ranked based on a multivariate ordering technique (Kokic et al., 2002). The variable/season combinations can be assigned an importance (Rank) and ranking method (mean, min, max). The mean method will find the model that is closest to multi-model mean while min and max will find the largest and smallest values for the variable/season combination.

Quick Tips

- To find a representative model that is closest to the multi-model mean for all variable/seasons leave the defaults (Method: mean, Rank: 1)
- To find a representative model that has the smallest or largest increase for a variable/season use 'min' or 'max' for the rank function.

Surface Temperature Mean 1

Variable	Season	Rank Method	Rank
Surface Temperature	Annual	Mean	1

Rainfall Mean 1

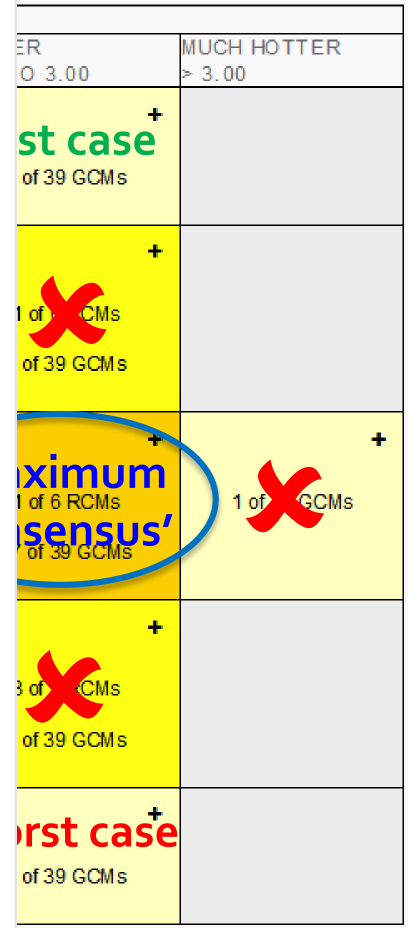
Variable	Season	Rank Method	Rank
Rainfall	Annual	Mean	1

Rank

Model Ranking Results

Model	Score	
CMIP5 - HadGEM2-CC	2.2	Export
CMIP5 - GFDL-CM3	3.5	Export
CMIP5 - CMCC-CMS	3.6	Export
CMIP5 - MPI-ESM-MR	5.1	Export
CMIP5 - HadGEM2-ES	11.0	Export
CMIP5 - GISS-E2-H	14.4	Export
CMIP5 - IPSL-CM5B-LR	15.0	Export
CMIP5 - bcc-csm1-1-m	17.4	Export
CMIP5 - ACCESS1-3	19.8	Export
CMIP5 - CSIRO-Mk3-6-0	21.6	Export
CMIP5 - GFDL-ESM2M	22.7	Export

ANNUAL RAINFALL (%)



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ANNUAL RAINFALL (%)	MUCH WETTER > 15.00			+ 2 of 39 GCMs	
	WETTER 5.00 TO 15.00		+ 1 of 39 GCMs	+ 1 of 6 RCMs 7 of 39 GCMs	
	LITTLE CHANGE -5.00 TO 5.00				
	DRIER -15.00 TO -5.00				
	MUCH DRIER < -15.00				

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Ms

-

3 of 39 GCMs

	SURFACE TEMPERATURE	RAINFALL
MODEL	ANNUAL	ANNUAL
CMIP5 - MIROC-ESM-CHEM†	1.99°C	-42.9%
CMIP5 - MIROC-ESM†	1.57°C	-48.7%
CMIP5 - GFDL-ESM2G	1.63°C	-19.0%
Mean	1.7	-36.9
Standard Deviation	0.2	12.8

☐ Use this cell for model selection

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Using the results in an impact assessment

Case	Climate Future	Consensus	Representative Model
'Best'	Hotter, Wetter	Very Low	NorESM1-ME
'Worst'	Much Hotter, Much Drier	Low	IPSL-CM5A-LR
'Maximum Consensus'	Hotter, Much Drier	Moderate	HadGEM2-ES

- Obtain required data from each model
  - From CCiA website (incl. GCM, downscaled, maps, GIS, time-series)
  - NARCliM, Climate Futures Tasmania, Goyder Institute
  - Other sources (*e.g.* Tyndall Centre, CliMond)
  - Contact us
- Run assessment for each model to evaluate each case
- Use model consensus information to assist weighing up likelihoods of each case

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Using individual models for impact assessment – key cases: Climate Futures

‘Best’ Case (with model consensus information)

Climate Model 1 → Impact Model → Assessment 1

‘Worst’ Case (with model consensus information)

Climate Model 2 → Impact Model → Assessment 2

‘Maximum Consensus’ Case

Climate Model 3 → Impact Model → Assessment 3

Synthesis and Evaluation

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What we want from projections
- key cases from Climate Futures

- ✓ Internally Consistent Data
- ✓ Adequately Sample the Range
- ✓ Achievable
- ✓ Information on Model Agreement
    - Whether using a subset or all models

Further Information

The conceptual and scientific basis of the Climate Futures Framework

Whetton P, Hennessy K, Clarke J, McInnes K, Kent D (2012) ['Use of Representative Climate Futures in impact and adaptation assessment.'] *Climatic Change* ***115, 433-442. 10.1007/s10584-012-0471-z.***

Application of the Climate Futures Framework

Clarke JM, Whetton PH, Hennessy KJ (2011) 'Providing Application-specific Climate Projections Datasets: CSIRO's Climate Futures Framework.' Peer-reviewed conference paper. In F Chan, D Marinova and RS Anderssen (eds.) MODSIM2011, 19th International Congress on Modelling and Simulation. Perth, Western Australia. December 2011 pp. 2683-2690. ISBN: 2978-2680-9872143-9872141-9872147. (Modelling and Simulation Society of Australia and New Zealand). http://www.mssanz.org.au/modsim2011/F5/clarke.pdf.

Climate Change in Australia Online Training: Module 4 The Climate Futures Framework

https://www.climatechangeinaustralia.gov.au/en/climate-campus/online-training/climate-futures-framework/

Climate Change Animations (including one on Australian Climate Futures)

https://www.climatechangeinaustralia.gov.au/en/support-and-guidance/tools-communicators/communication-resources/animations/

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