Introduction Climate Futures

Climate Futures approach to the provision of regional climate projection information

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Acknowledgements: Penny Whetton, Kevin Hennessy, John Clarke, David Kent

Outline

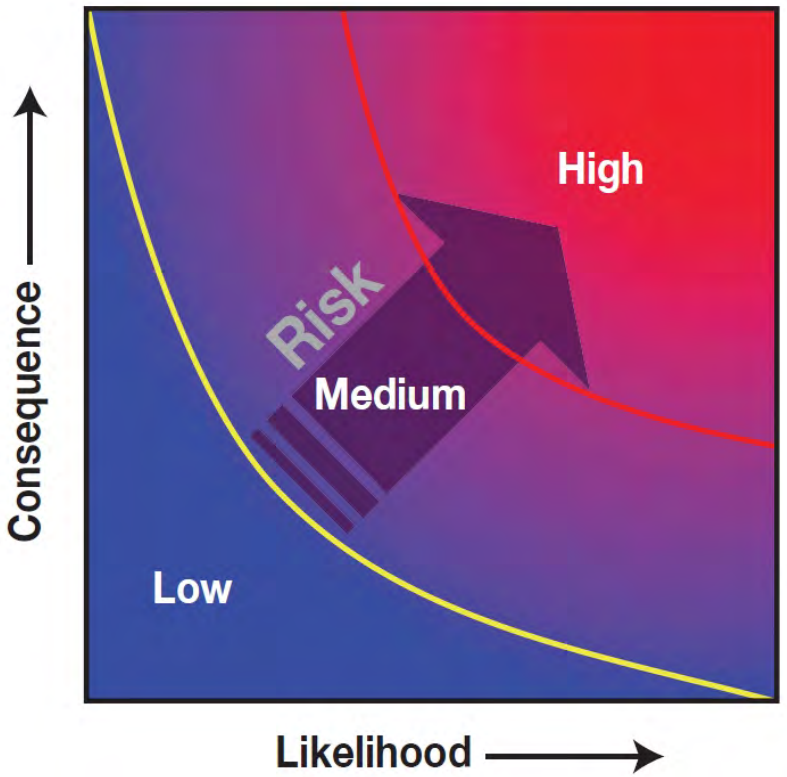
- Climate projections and impact assessment
- Typical climate projections
- A new approach: climate futures
- Conclusions
- Activity

Climate Projections

- Climate projections are used in a variety of impact assessments
- The level of detail depends on the objectives of the decision-makers, e.g. less detail is required for general awareness-raising than designing a new road

No “one size fits all”, so climate projections need to be purpose-built

Risk Assessment



CSIRO & BoM (2007)

- Risk = consequence x likelihood
- A number of climate risk assessment and management frameworks exist
- Important to consider a range
  - Worst Case
  - Most Likely

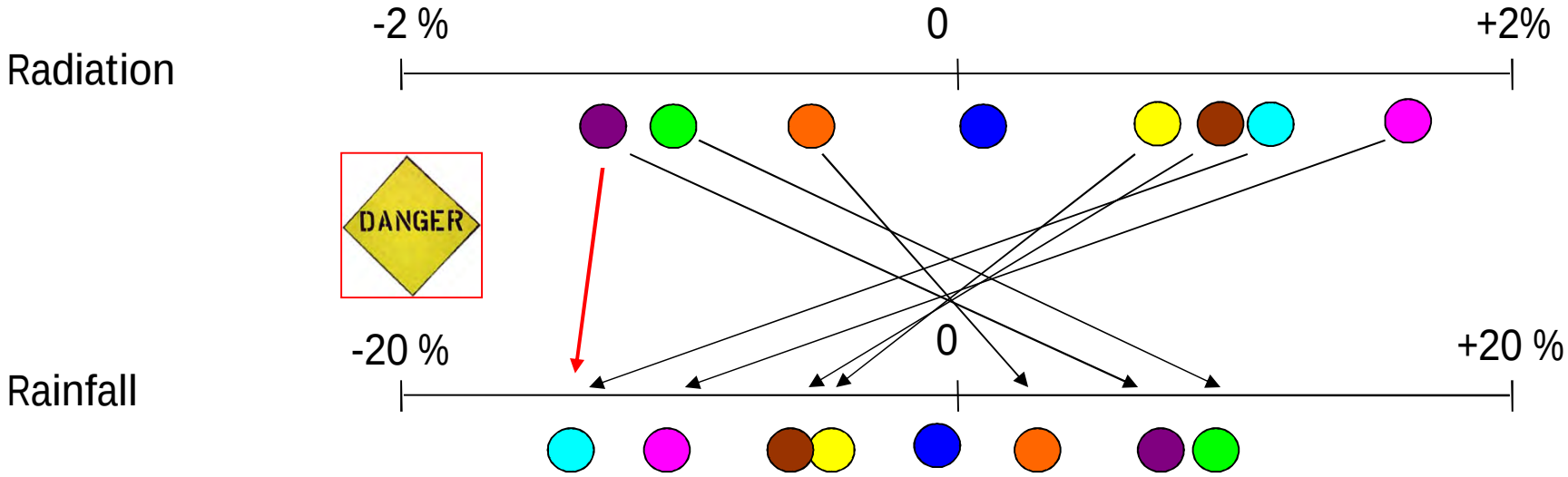
Typical Climate Projections

- Projections are often given for individual climate variables, such as rainfall, for selected years and emissions scenarios
- Projections from different climate models tend to be mixed together and expressed as an average change with a range of uncertainty,

  e.g. 2°C (1-3°C) temperature and 10% (-5%-15%) rainfall

Typical Climate Projections

Radiation:	(-1.2 to +1.8) %
Rainfall change:	(-15 to +10) %



Internally Consistent Projections

- Detailed risk assessments need projections with “internally consistent data” for multiple climate variables
- Projections based on individual climate models have internal consistency
- There will be up to 40 global climate models and 8 high resolution models available.
- Each simulation represents a plausible projection
- Too much information!
- How can we simplify communication and data delivery?

Individual Climate Model Issues

- Substantial differences between climate models in simulated future regional climate
- Rapid growth in the number of potentially relevant GCM (and downscaled) results, emission scenarios, etc
- Desire for simplicity: e.g. many users want to use a few as possible future climate scenarios in impact assessments

Much interest in model evaluation and selection

Model evaluation is not the answer

- The poorest models can be identified, but not the best
- Furthermore, less likely, but plausible, simulated future climates may be highly relevant in adaptation studies

  "robust decision making"

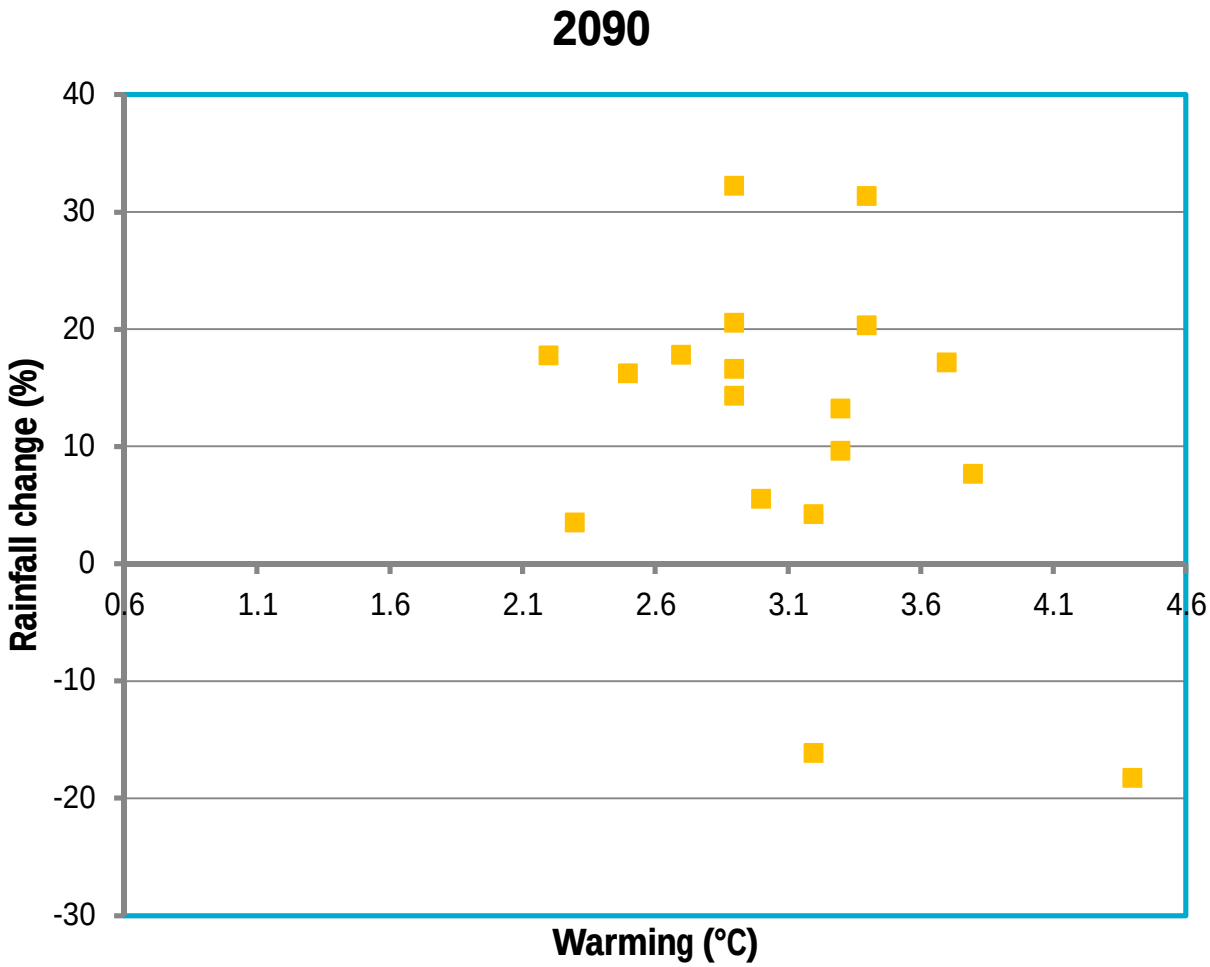
  (Lempert & Schlesinger, 2000, Dessai 2009)

How else we can reduce complexity?

A new approach: Climate Futures

- Group the projections into a set of climate futures, e.g.
  - Warmer, wetter (9 models = 50%)
  - Warmer, drier (4 models = 22%)
  - Hotter, drier (2 models)
  - Hotter, much drier (1 model)
  - Warmer, much drier (1 models)
  - Hotter, wetter (1 models)
- Changes in temperature and rainfall are often strongly linked to changes in extreme weather events as well as humidity, sunshine and evaporation

The Climate Futures Approach



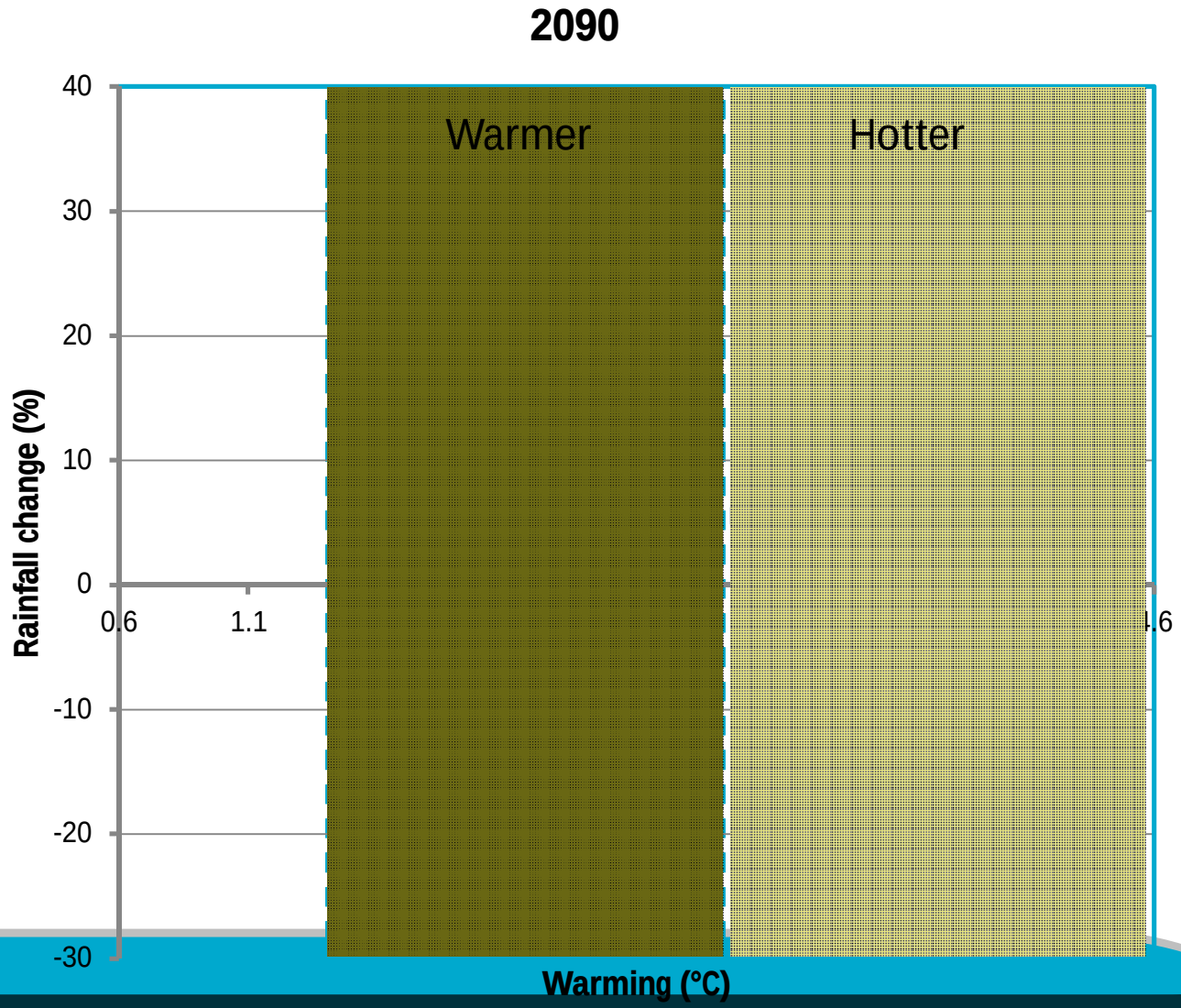
Each dot represents the change in temperature and rainfall from 1 climate model

2-4°C warmer
-20% to +30% change in rainfall

A lot of possibilities

How can we simplify this information?

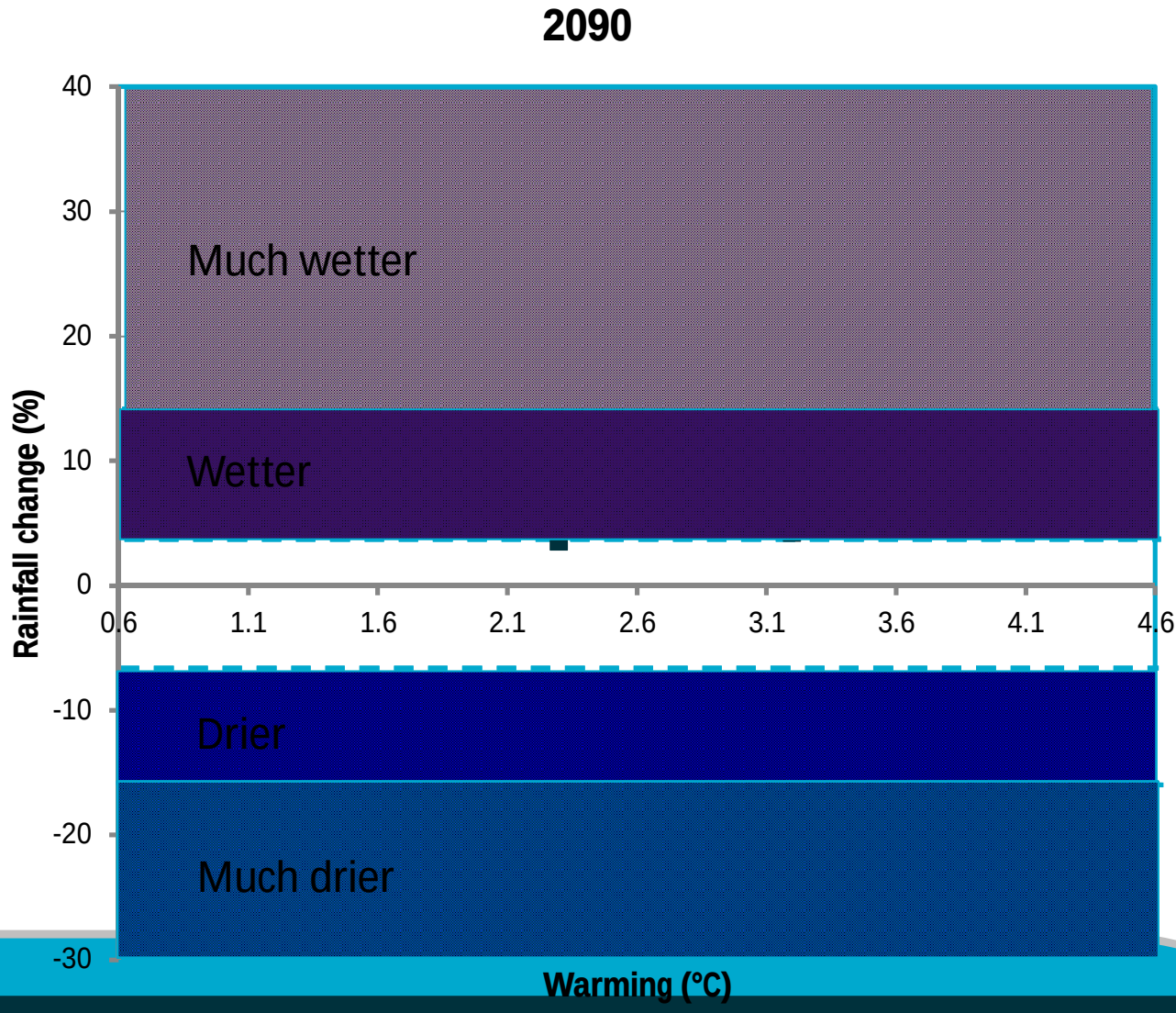
Classifying projected changes: towards ‘Climate Futures’



8 out of 18 models give a warmer climate

10 out of 18 models give a hotter climate

Classifying projected changes: towards ‘Climate Futures’

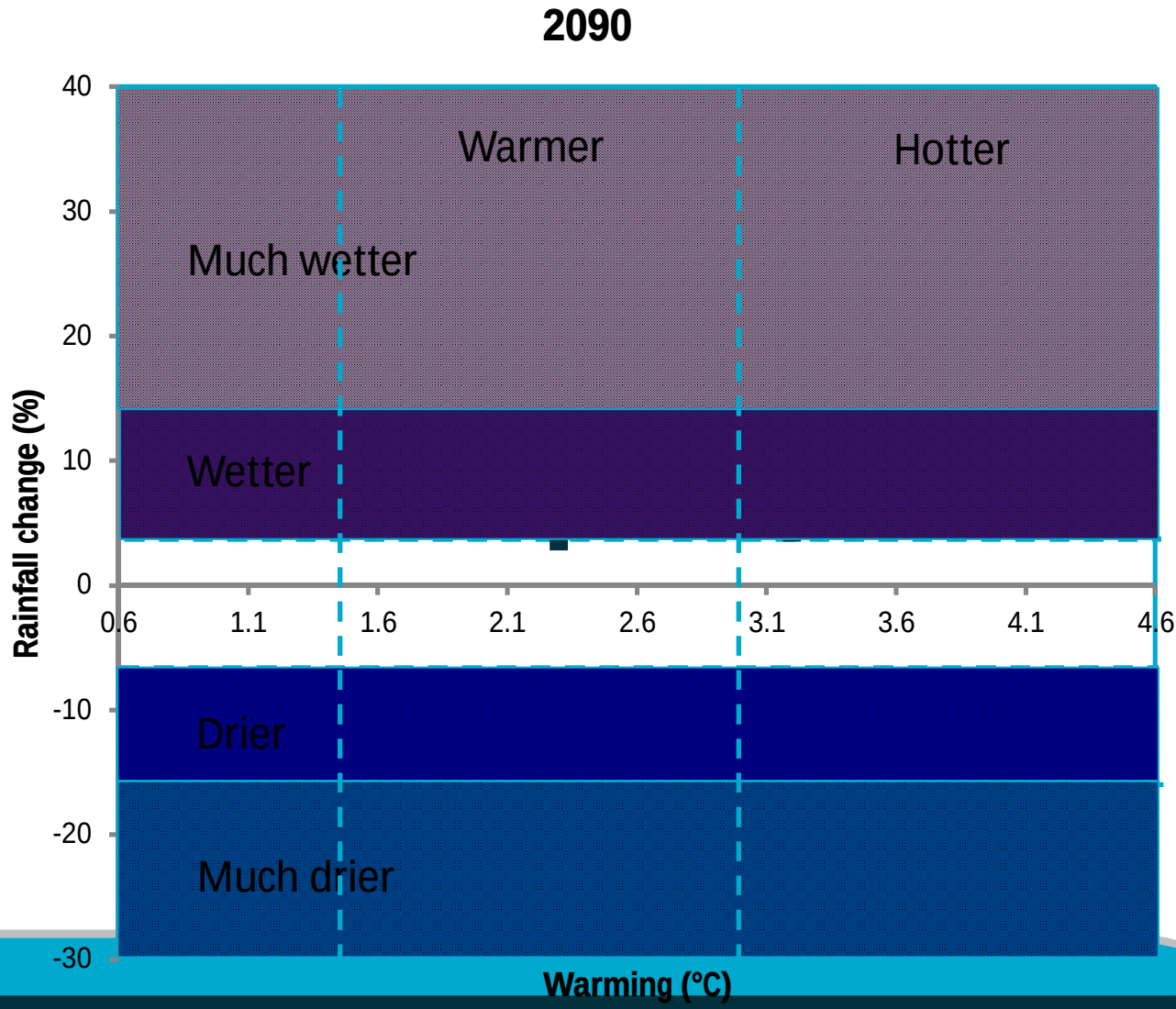


10 out of 18 models give a much wetter climate

6 out of 18 models give a wetter climate

2 out of 18 models give a much drier climate

Classifying projected changes: towards ‘Climate Futures’



3 out of 18 models give a hotter and much wetter climate

7 out of 18 models give a warmer and much wetter climate

etc…

The Climate Futures Approach

		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 Drier < -15.00				
	Drier -15.00 to -5.00		**Likelihood: 3 of 18 models** (16%)		
	Little Change -5.00 to 5.00	**Likelihood: 2 of 18 models** (11%)	**Likelihood: 12 of 18 models** (66%)		
	Wetter 5.00 to 15.00		**Likelihood: 1 of 18 models** (5%)		
	Much Wetter > 15.00				

A new approach: Climate Futures

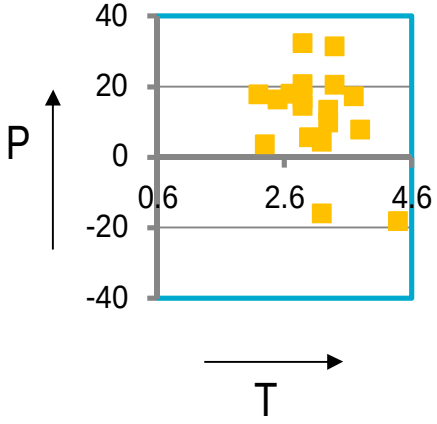
- Scientists work with decision-makers to identify climate futures of most relevance to their risk assessment, e.g.
  - the biggest negative / positive impact
  - the least impact
  - the most likely future (or medium impact)
- Each climate future has an estimated likelihood
- Within in each climate future, select a representative climate model then use projections from that model in risk assessment – don't need to use all models

Climate Futures: Terminology

- **Most Likely** Climate Future: The climate future that contains the greatest number of models
- **Best Case** Climate Future: Decided with decision-makers – 'best' impact on the system being investigated
- **Worst Case** Climate Future: Decided with decision-makers – largest negative impact on the system being investigated

Classifying future climates

Projected climate
change



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Classifying future climates

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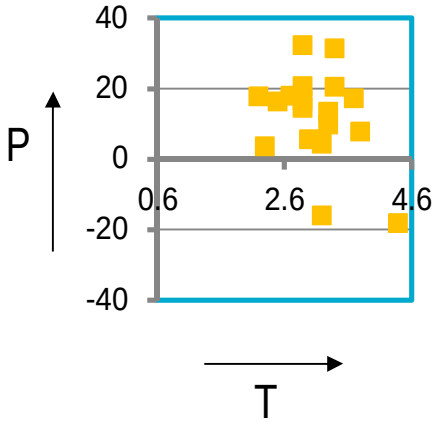

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	Much Wetter > 15.00				

Worst Case **Most Likely** **Best Case**

Classifying future climates

Projected climate
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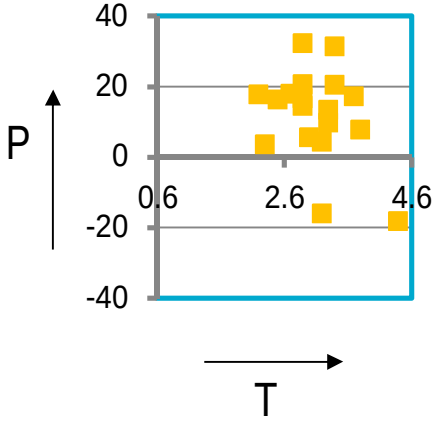

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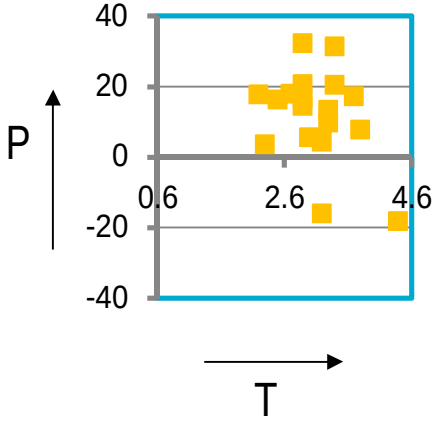
	Drier -15.00 to -5.00		RCM GCM GCM 8 models (16%)		
	Little Change -5.00 to 5.00	Likelihood: 2 of 18 models (11%)	Likelihood: GCM GCM GCM %)		
	Wetter 5.00 to 15.00		Likelihood: 1 of 18 models (5%) GCM		
	Much Wetter > 15.00				

Worst Case **Most Likely** **Best Case**

Classifying future climates

Projected climate
change



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	Wetter 5.00 to 15.00		Likelihood: 1 of 18 models (5%) GCM		
	Much Wetter > 15.00				

Worst Case

Warmer Drier

Most Likely

Just Warmer

Best Case

Warmer Wetter

Conclusions

- Detailed risk assessments need projections from individual climate models to ensure internal consistency across multiple climate variables
- Using all climate models is very resource intensive
- Need to simplify communication and data delivery
- No “one size fits all”, so climate projections need to be purpose-built

Activities

- Activity 2.1
- Presentation
- Activity 2.2
- Presentation
- Activity 3
- Design Your Own!

Terminology

Key Climate Futures

- **Best Case** Climate Future: Decided with decision-makers – 'best' impact on the system being investigated
- **Worst Case** Climate Future: Decided with decision-makers – largest negative impact on the system being investigated
- **Most Likely** Climate Future: The climate future that contains the greatest number of models
  - ...but there are some rules...

‘Most Likely’ Rules

Most Likely climate future

1. Must contain at least 33% (⅓) of the total models
2. Must contain at least 10% more models than the next most likely climate future

‘Most Likely’ Rules

		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 Drier < -15.00			**Likelihood: 1 of 18 models** (5%)	**Likelihood: 3 of 18 models** (16%)
	Drier -15.00 to -5.00			**Likelihood: 4 of 18 models** (22%)	
	Little Change -5.00 to 5.00			**Likelihood: 5 of 18 models** (27%)	**Likelihood: 2 of 18 models** (11%)
	Wetter 5.00 to 15.00			**Likelihood: 1 of 18 models** (5%)	
	Much Wetter > 15.00			**Likelihood: 1 of 18 models** (5%)	**Likelihood: 1 of 18 models** (5%)

Most Likely climate future

- Rule 1: Must contain at least 33% (⅓) of the models

‘Most Likely’ Rules

5 + 4 = 9 out of 18 models
or
50% of Models

		Annual Surface Temperature (°C)			
			Warmer 50 to 1.50	Hotter 1.50 to 3.00	Much Hotter > 3.00
Annual Rainfall (%)				Likelihood: 1 of 18 models (5%)	Likelihood: 3 of 18 models (16%)
	Drier -15.00 to -5.00			Likelihood: 4 of 18 models (22%)	
	Little Change -5.00 to 5.00			Likelihood: 5 of 18 models (27%)	Likelihood: 2 of 18 models (11%)
	Wetter 5.00 to 15.00			Likelihood: 1 of 18 models (5%)	
	Much Wetter > 15.00			Likelihood: 1 of 18 models (5%)	Likelihood: 1 of 18 models (5%)

Most Likely climate future

- Rule 1: Must contain at least 33% (⅓) of the models

1. Add adjacent cell with next highest No of models
2. If total more than 33%
    a) The *Most Likely* is the two combined

‘Most Likely’ Rules

5 + 4 = 9 out of 18 models
or
50% of Models

		Annual Surface Temperature (°C)			
			Warmer 50 to 1.50	Hotter 1.50 to 3.00	Much Hotter > 3.00
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	Wetter 5.00 to 15.00			Likelihood: 1 of 18 models (5%)	
	Much Wetter > 15.00			Likelihood: 1 of 18 models (5%)	Likelihood: 1 of 18 models (5%)

How would you describe this?

- “Hotter and Little Change to Drier”
- “9 of 18 models (50%)” = moderate likelihood

‘Most Likely’ Rules

6 + 5 = 11 out of 17 models
or
65% of Models

		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 (%)	[illegible]				
	Drier -15.00 to -5.00				
	Little Change -5.00 to 5.00		Likelihood: 5 of 17 models (29%)	Likelihood: 6 of 17 models (35%)	
	Wetter 5.00 to 15.00		Likelihood: 4 of 17 models (23%)	Likelihood: 1 of 17 models (5%)	
	Much Wetter > 15.00		Likelihood: 1 of 17 models (5%)		

Most Likely climate future

- Rule 2: Must contain at least 10% more models

1. Combined total must have 10+% more than next most likely future

‘Most Likely’ Rules

6 + 5 = 11 out of 17 models
or
65% of Models

		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 (%)	[illegible]				
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	Wetter 5.00 to 15.00		Likelihood: 4 of 17 models (23%)	Likelihood: 1 of 17 models (5%)	
	Much Wetter > 15.00		Likelihood: 1 of 17 models (5%)		

How would you describe this?

- “Warmer to Hotter and Little Change in rainfall”
- “11 of 17 models (65%)” = moderate likelihood

Activities

- Activity 2.1
- Presentation
- Activity 2.2 – Water Availability
- Presentation
- Activity 3
- Design Your Own!

Hypothetical Case Study: Rainfall Capture and Storage

- Projections for impact assessment of rainfall capture and storage in 2050 under low and high emissions
- Key variables (in order of priority)
  1. Mean rainfall
  2. Evaporation
  3. Surface temperature
  4. Humidity

Hypothetical Case Study: Rainfall Capture,

2050 A1FI

		Surface Temperature - Annual (° C)			
		Slightly Warmer < 0.50	Warmer 0.50 to 1.50	Hotter 1.50 to 3.00	Much Hotter > 3.00
Rainfall - Annual (% change)	Much Drier < -15.00			Likelihood: 12 of 24 models (50%)	Likelihood: 1 of 24 models (4%)
	Drier -15.00 to -5.00			Likelihood: 6 of 24 models (25%)	Likelihood: 2 of 24 models (8%)
	Little Change -5.00 to 5.00		Likelihood: 1 of 24 models (4%)	Likelihood: 1 of 24 models (4%)	
	Wetter 5.00 to 15.00			Likelihood: 1 of 24 models (4%)	
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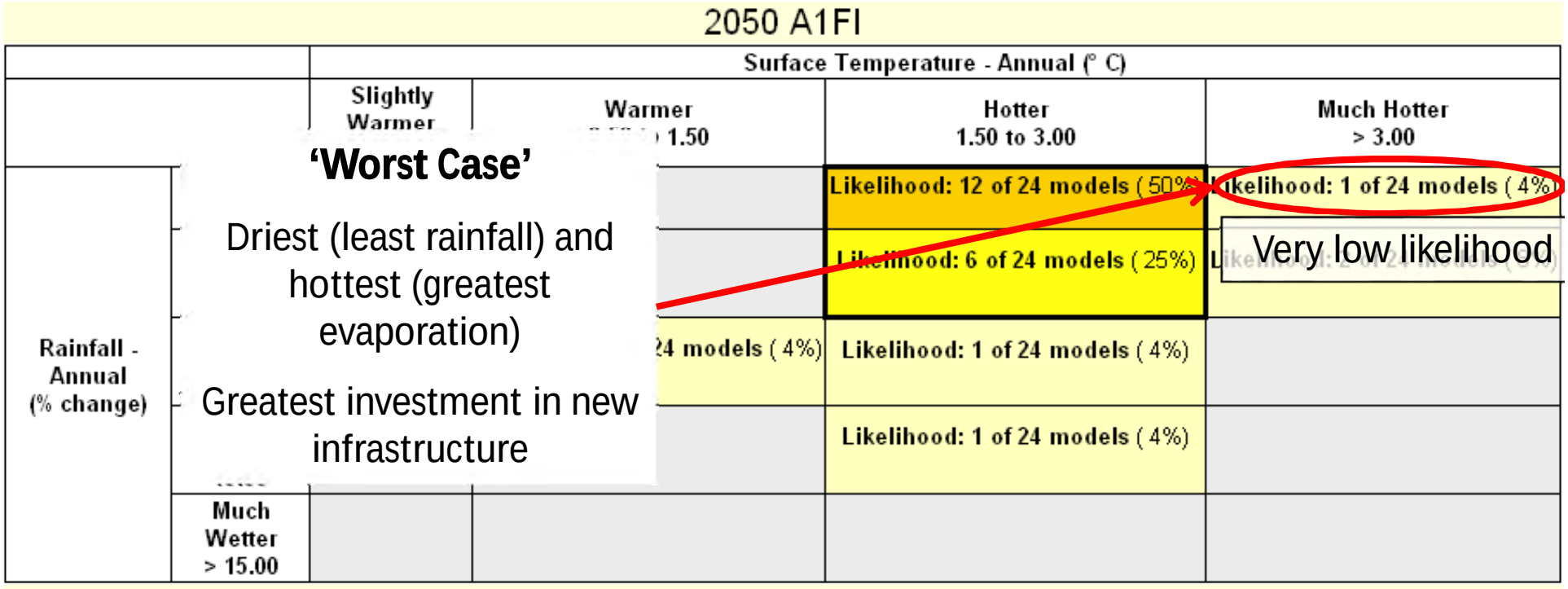
'Most Likely'

Hypothetical Case Study: Rainfall Capture,



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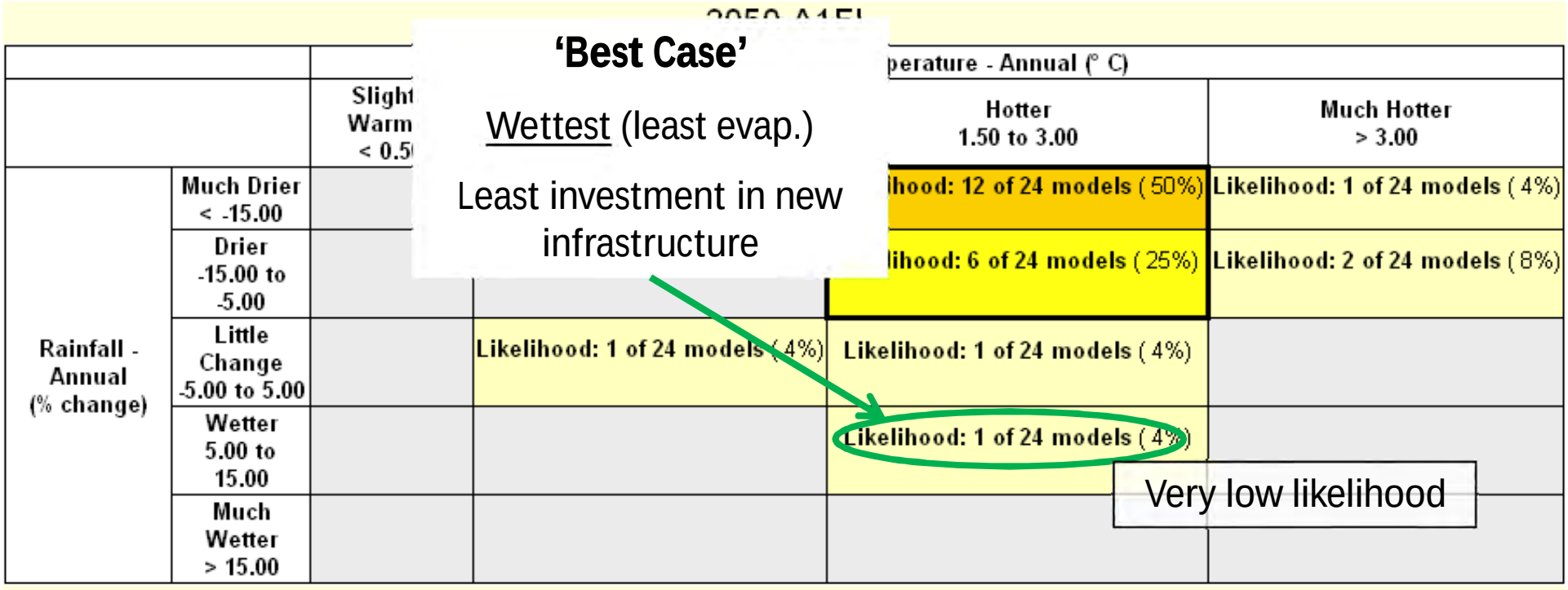

		Slight Warm < 0.5		Hotter 1.50 to 3.00	Much Hotter > 3.00
				perature - Annual (° C)	
Rainfall - Annual (% change)	Much Drier < -15.00			lihood: 12 of 24 models (50%)	Likelihood: 1 of 24 models (4%)
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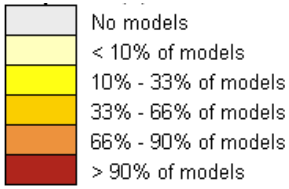
Hypothetical Case Study: Rainfall Capture



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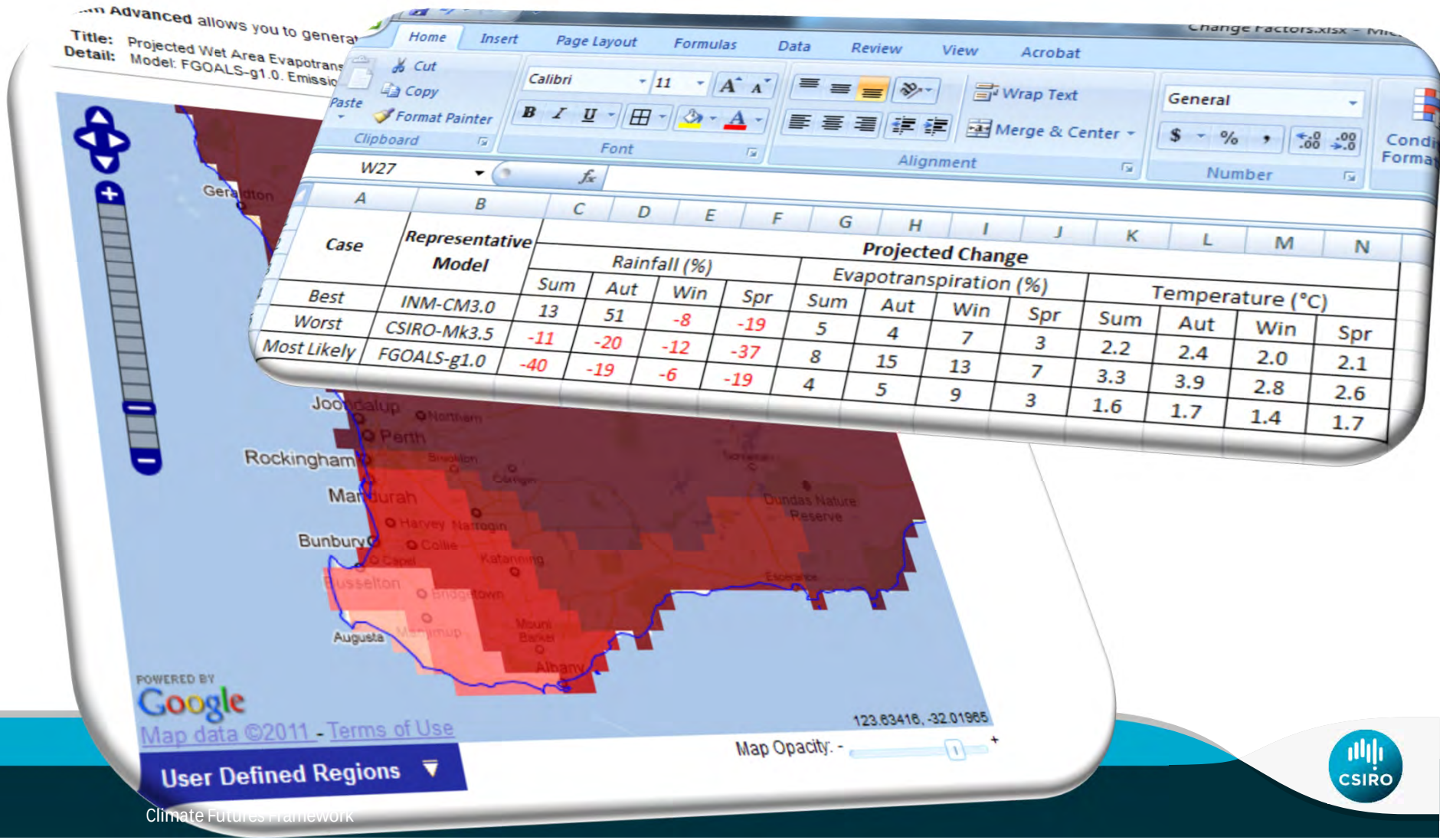
Rainfall - Annual (% change)	Much Drier < -15.00			Likelihood: 12 of 24 models (50%) 'Most Likely'	Likelihood: 1 of 24 models (4%) Worst case
	Drier -15.00 to -5.00			Likelihood: 6 of 24 models (25%)	Likelihood: 2 of 24 models (8%)
	Little Change -5.00 to 5.00		Likelihood: 1 of 24 models (4%)	Likelihood: 1 of 24 models (4%)	
	Wetter 5.00 to 15.00			Likelihood: 1 of 24 models (4%) Best case	
	Much Wetter > 15.00				

Hypothetical Case Study: Rainfall Capture

Summary

Case	Climate Future	Likelihood	Representative Model
'Best'	Hotter & Wetter	Very Low	INM-CM3.0
'Worst'	Much Hotter & Much Drier	Very Low	CSIRO-Mk3.5
'Most Likely'	Hotter & Much Drier	Moderate	FGOALS-g1.0

Hypothetical Case Study: Rainfall Capture



Case	Representative Model	Projected Change											
		Rainfall (%)				Evapotranspiration (%)				Temperature (°C)			
		Sum	Aut	Win	Spr	Sum	Aut	Win	Spr	Sum	Aut	Win	Spr
Best	INM-CM3.0	13	51	-8	-19	5	4	7	3	2.2	2.4	2.0	2.1
Worst	CSIRO-Mk3.5	-11	-20	-12	-37	8	15	13	7	3.3	3.9	2.8	2.6
Most Likely	FGOALS-g1.0	-40	-19	-6	-19	4	5	9	3	1.6	1.7	1.4	1.7

Activity 3 – Water Availability

1. Select relevant climate futures
2. Select a model to represent each future

Case	Climate Future	Likelihood	Representative Model
'Best'			
'Worst'			
'Most Likely'			

Thank you !