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# Challenges in attributing change in Australian natural hazards

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...with acknowledgements to members of the OzEWEX “Trends and Extremes” working group



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# Attribution is a ultimately a problem of causation

- Was it climate change or natural variability (or both?)
  - Is the frequency/intensity of La Niña events changing, or the pattern of rainfall during a La Niña event?
  - What is the connection with smaller-scale processes (*proximate vs distal causes*)?



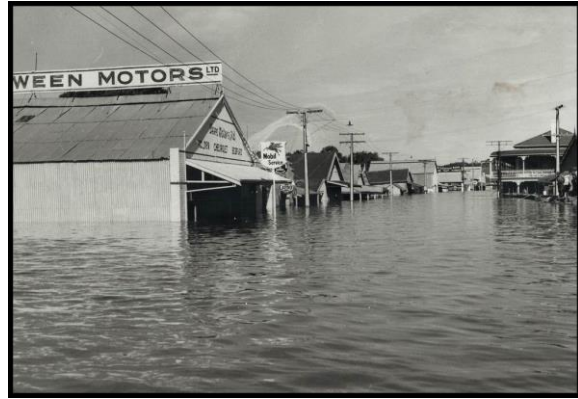
- What was the role of land use change in modifying runoff patterns, or the role of changes to land-use policy in influencing the damage?
- To what degree could alternative reservoir release decisions have averted the impact? What is the 'baseline' in making a causal statement?
- **...how do we understand and manage risk better for next time?**

What causes this match to light?



What assumptions do we implicitly make when attributing natural hazards to particular causes?

# Can a “one size fits all” methodology account for the diversity of flood processes

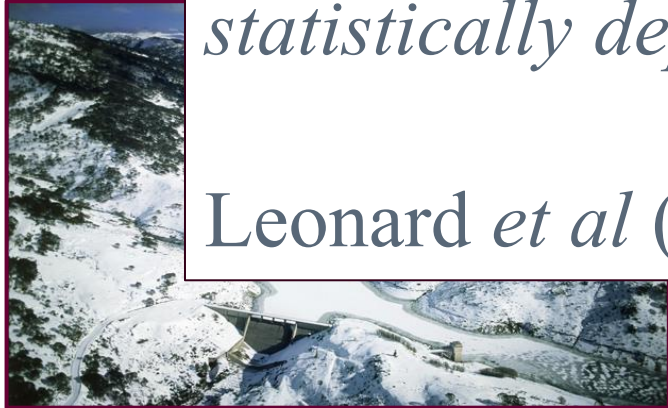


All are forms of compound events:

Flash

*“...an extreme impact that depends on multiple statistically dependent variables or events.”*

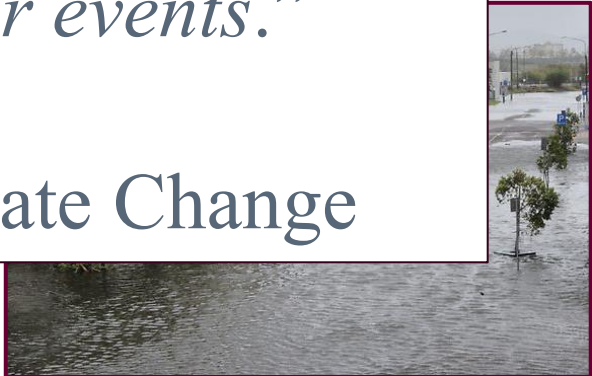
Leonard *et al* (2014) WIREs Climate Change



Snow melt floods



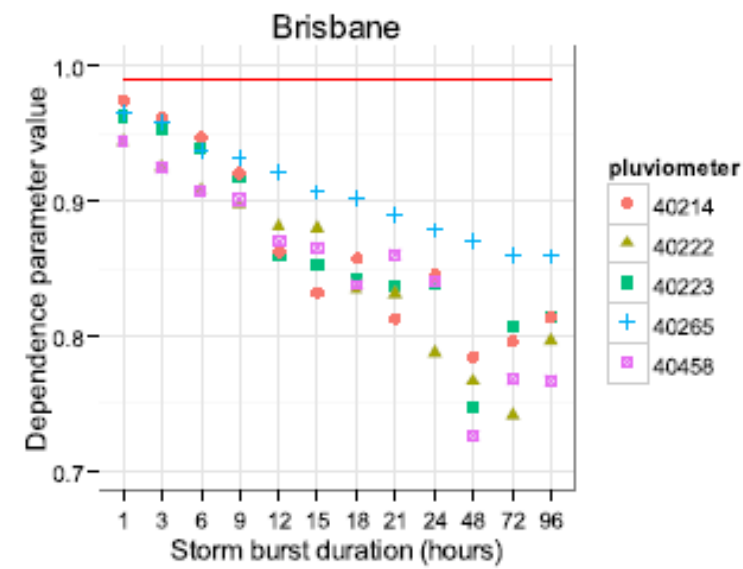
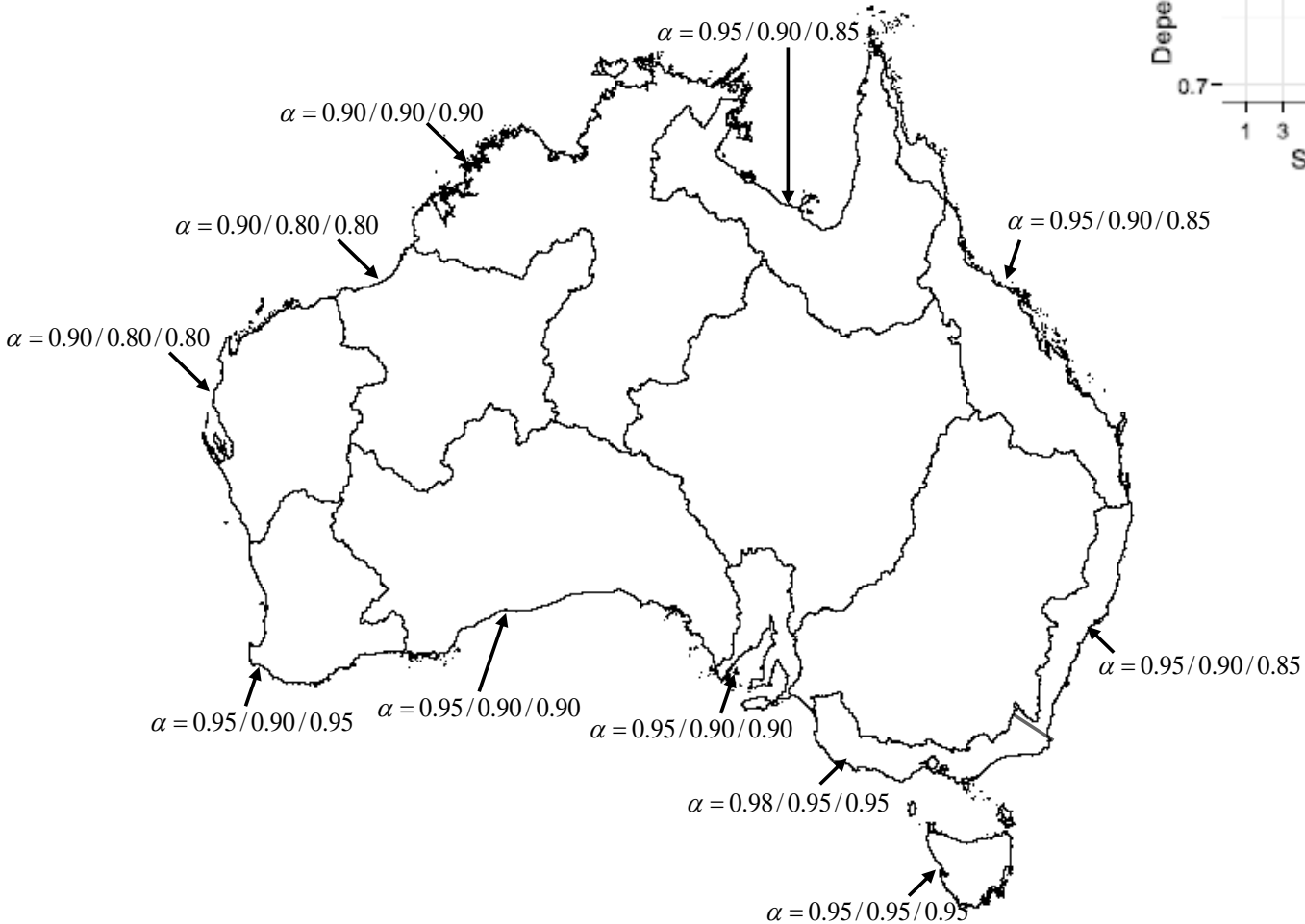
Arid zone floods



Coastal floods

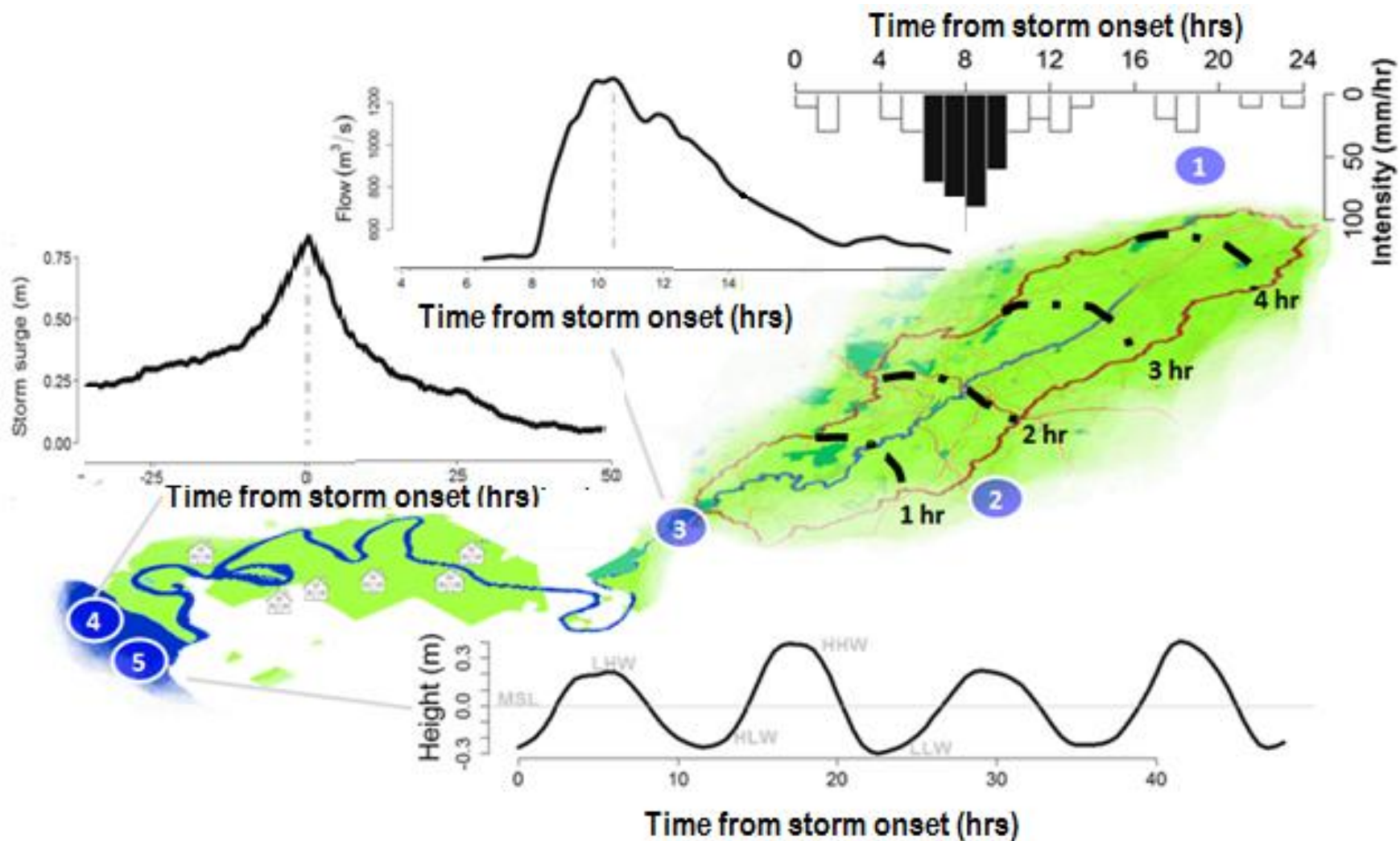


# Coastal floods in Australia are caused by the interaction of multiple processes



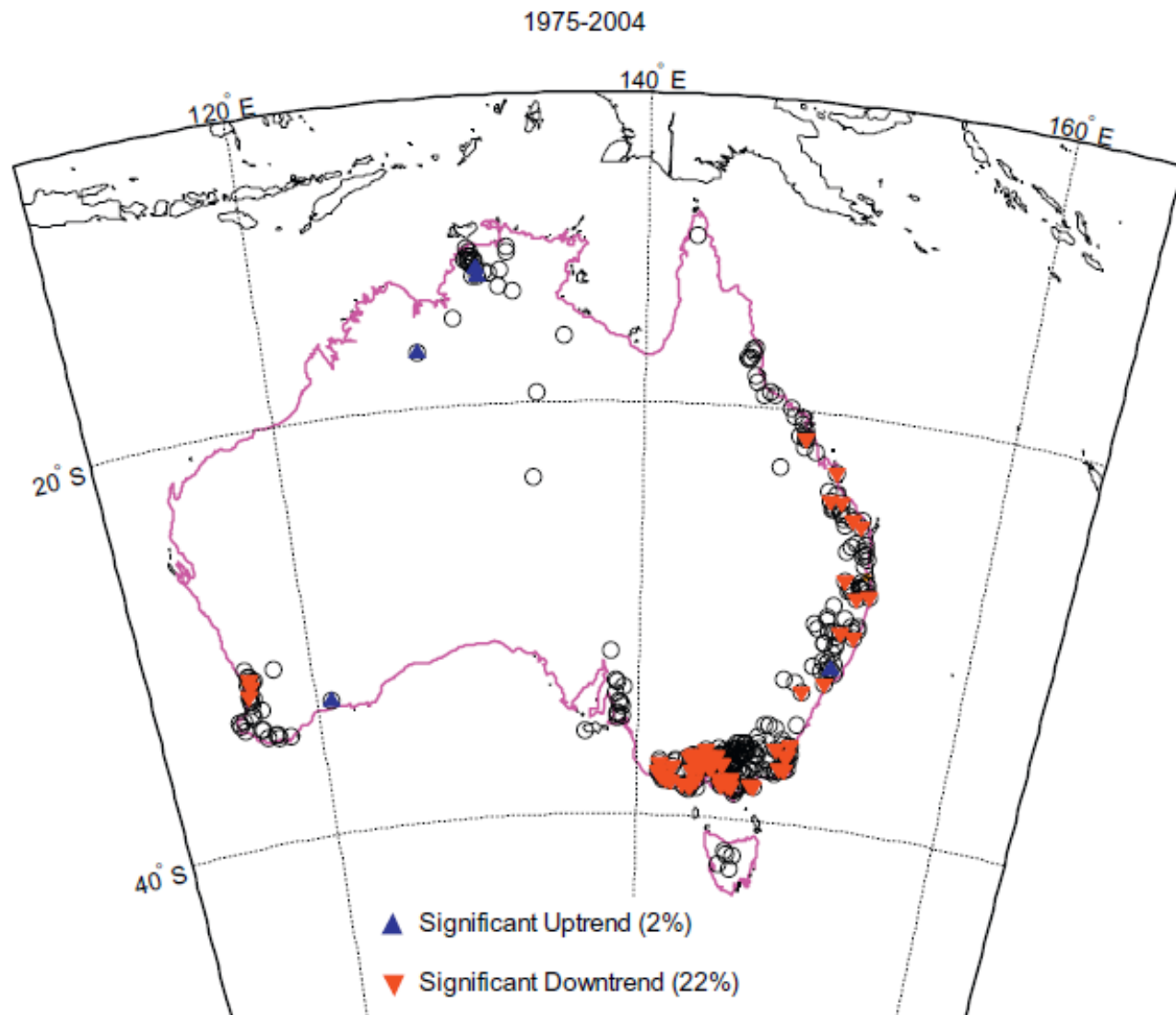
...with acknowledgements to Michael Leonard and Feifei Zheng

# The complexity of coastal floods in Australia



...with acknowledgements to Michael Leonard and Feifei Zheng

# How do we “explain” the apparent downward trend in flood risk in Southern Australia?



When does *correlation* imply *causation*?

The randomised  
experiment:

“the only scientifically  
proven method of testing  
causal relations from  
data”?

Pearl, J., 2009, “Causality – Models,  
Reasoning and Inference”, Cambridge  
University Press, 464 pp.

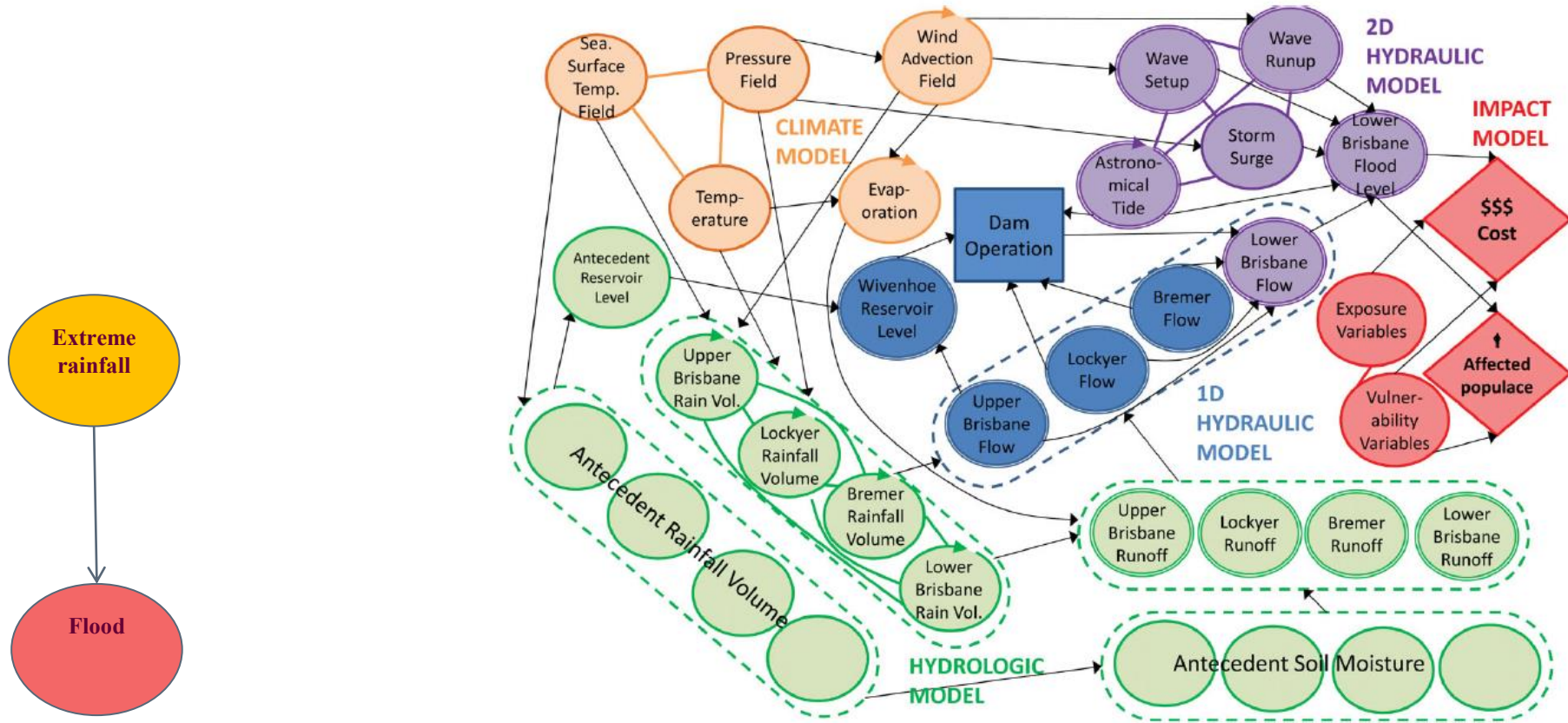




# Fraction of attributable risk – a method of probabilistic causation?

- “fraction attributable risk” =  $(p_1 - p_0) / p_1$
- An exercise in counterfactual analysis...
  - But how do we calibrate our model to counterfactuals?
  - Do we underestimate the capacity of humans to adapt to changes?

# What is the appropriate level of model complexity?

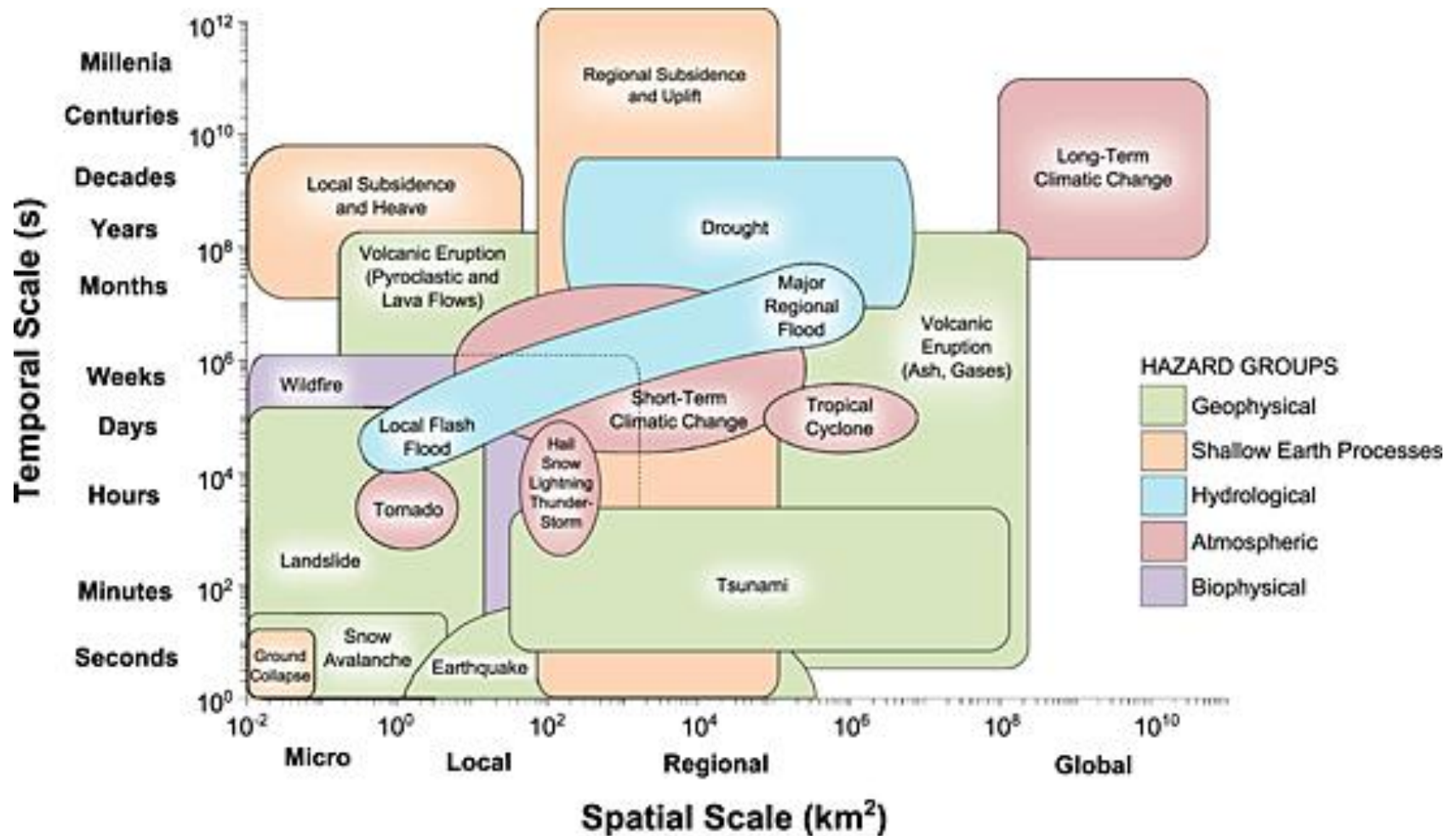


This...

...or this?

...and what tools do we use to answer this question?

# Should we build a Grand Unified Model of Everything?



Gill, J.C. & Malamud, B.D., 2014, Reviewing and visualizing the interactions of natural hazards, Reviews of Geophysics, doi:10.1002/2013RG000445

# Do we need new methods to select models?

- “The detailed evaluation of the GR4J model calibrated with different PE input scenarios showed that the model is clearly sensitive to PE input, but that it uses its two production parameters to adapt to the various PE scenarios...”
- *“The results reported here may seem evident to experienced watershed modelers, who are aware of the ability of the calibration process to compensate for biased input data, and of models to yield accurate results, as long as the application input is similarly biased.”*



# Future directions

- We are in the embryonic stages of meeting society's need:
  - There is no conceivable way that flood risk should stay unchanged in a changing climate AND
  - In many parts of Australia, we do not know whether flood risk will go up or down, and by a little bit or by a lot.
- Causal answers are critical to decision makers
- Should we have a national standard on answering causal questions?
- A Science Plan!



**Trust Me, I'm a Scientist/Engineer**

## Continuing the discussion... (aka a plan to develop a plan)

- The OzEWEX “Trends and Extremes” working group will be working on a multi-part discussion paper on what we understand about change to Australian natural hazards:
  - Floods, Drought, Coastal extremes, Bushfires, Heatwaves (including ocean heatwaves), Wind and hail, Frost and cold extremes
- Will investigate historical (including paleo) records of change, current theories on possible causes of change, historical (including paleo) records of change to ‘causative variables’, future projections, and knowledge gaps.
- The OzEWEX “Trends and Extremes” working group:
  - Lisa Alexander, Karl Braganza, Jason Evans, Doerte Jakob, Fiona Johnson, Anthony Kiem, Marc Leblanc, Alope Phatak, Bellie Sivakumar, Blair Trewin, Albert Van Dyke, Seth Westra
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