

# The effect of experiment conditioning on estimates of human influence on extreme weather

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## An extreme weather event happens



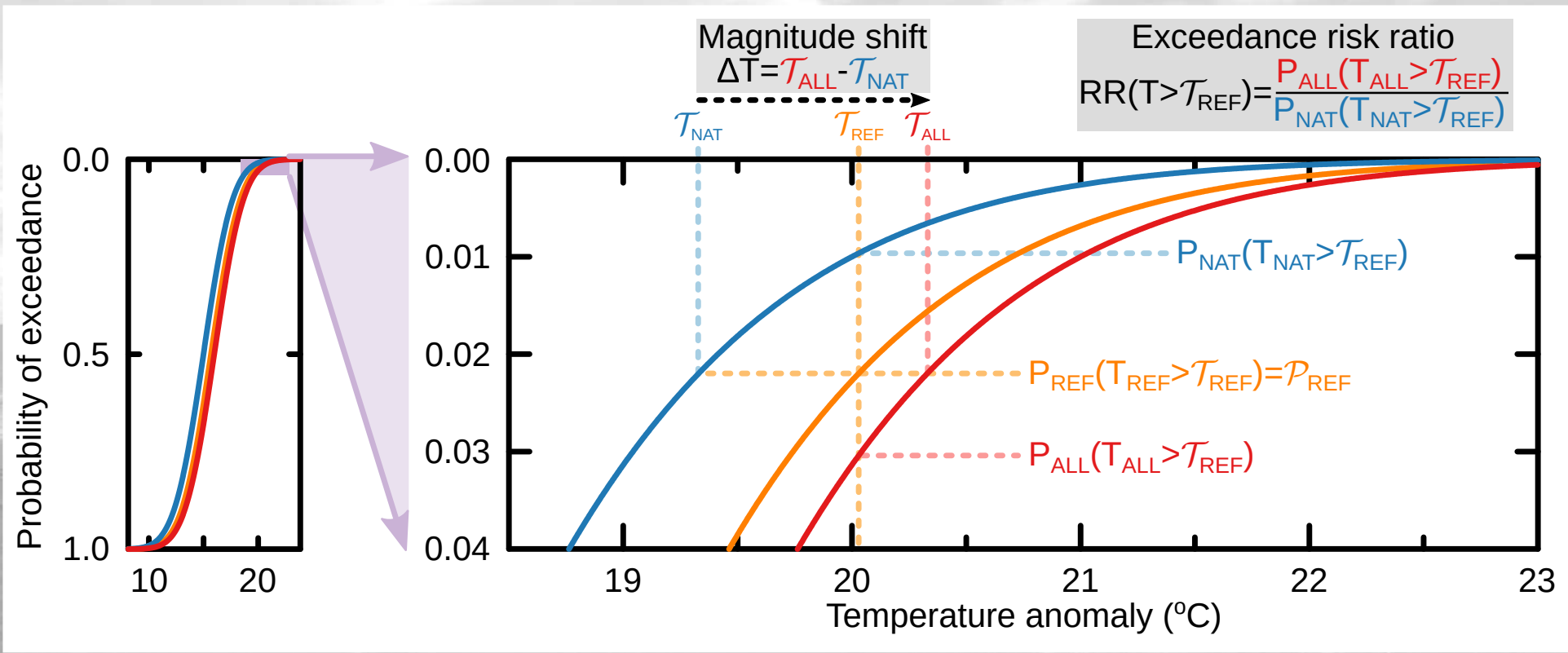
Courtesy Benedict Knill/NZ Herald

A common thought process:

- Humans are affecting the climate
- Extreme weather is part of the climate
- Are our emissions involved in this event?

# Factual/counterfactual comparison

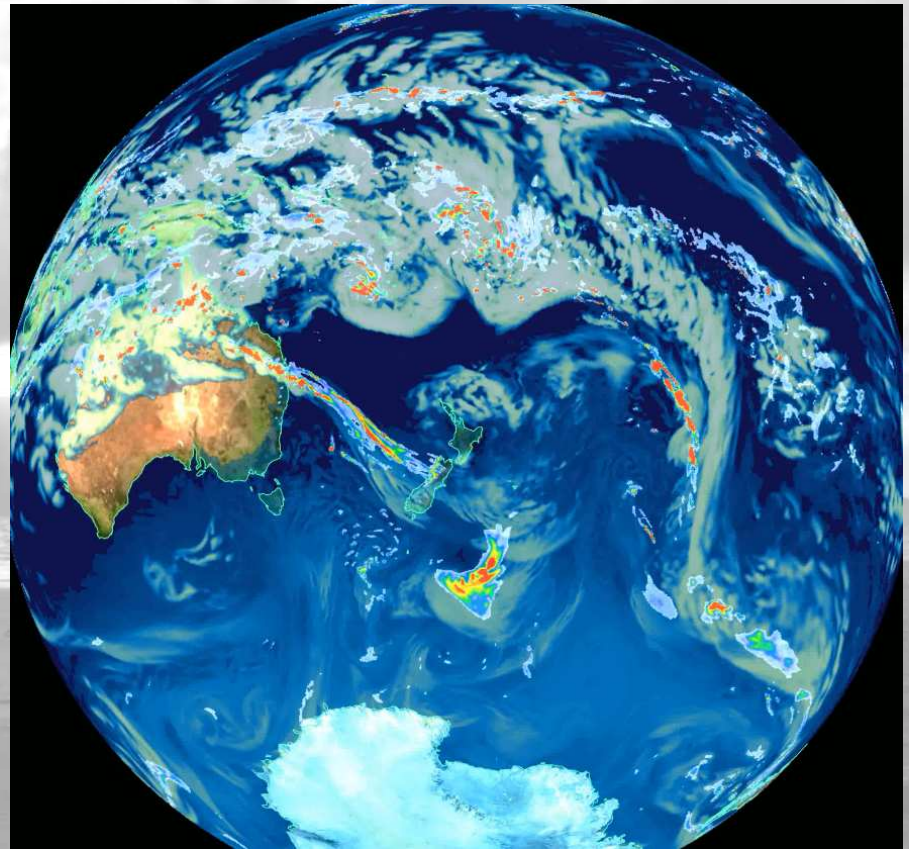
“ALL” influences (factual) versus “NAT” natural-only (counterfactual)



A shift in magnitude, or a change in probability

## This is a statistical sampling problem

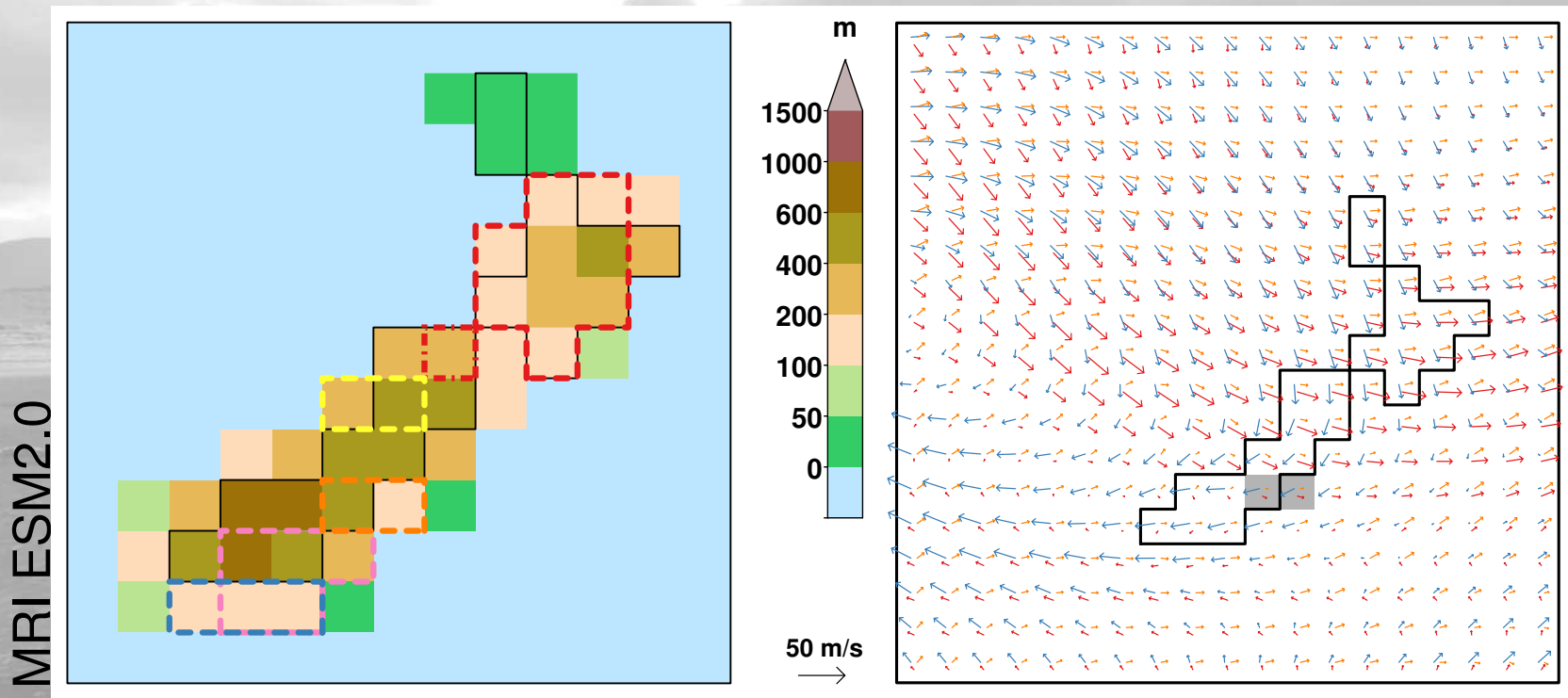
- We cannot observe a “natural” counterfactual
- We have to make one from dynamical models of the climate system



Courtesy Peter Gibson

# Experiment #1: global earth system model

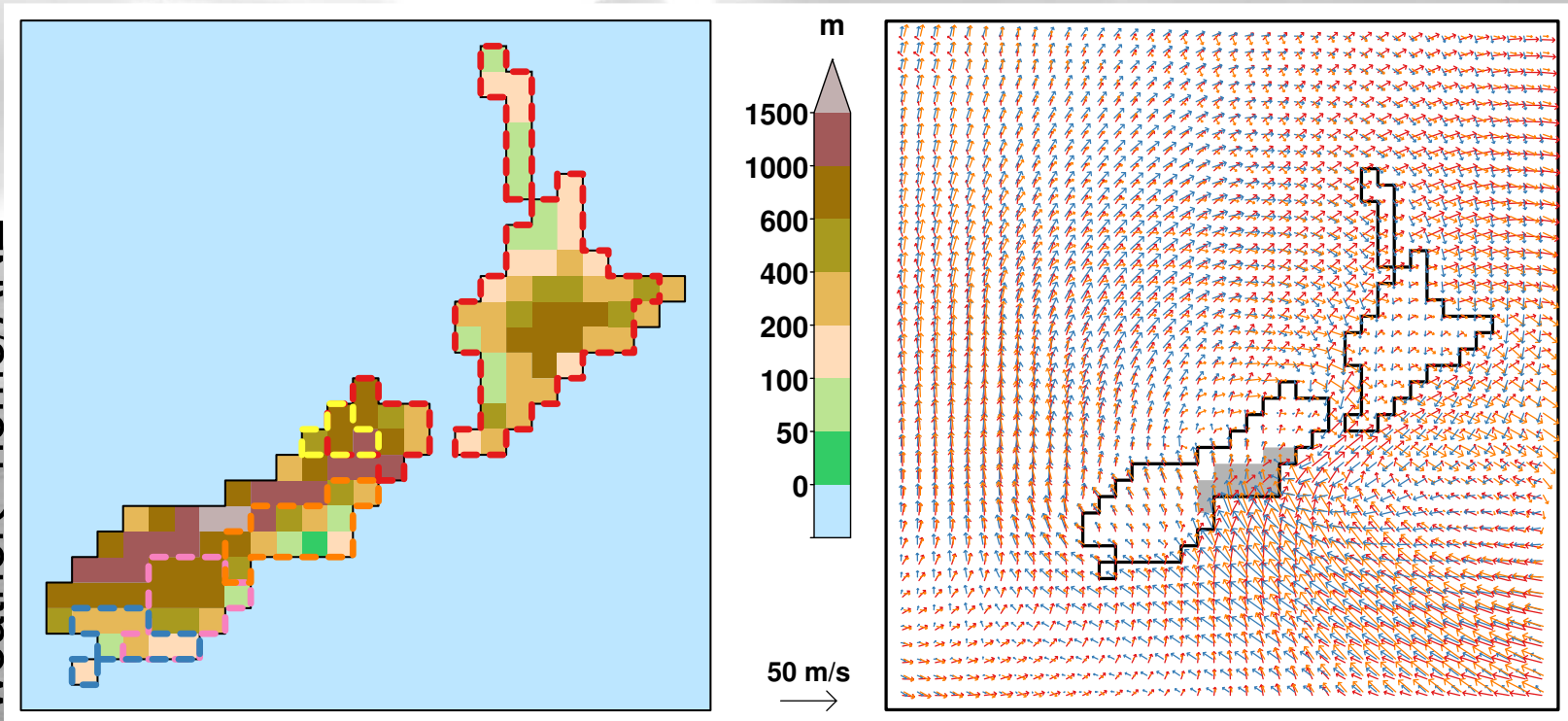
- Model everything: atmosphere, ocean, land, land ice, sea ice, chemistry, biosphere
- Addresses the most general question: effect of humans on a class of events
- *Computational limitations on spatial resolution and sample size*
- *Can have substantial biases at regional scales*



## Experiment #2: global atmosphere model

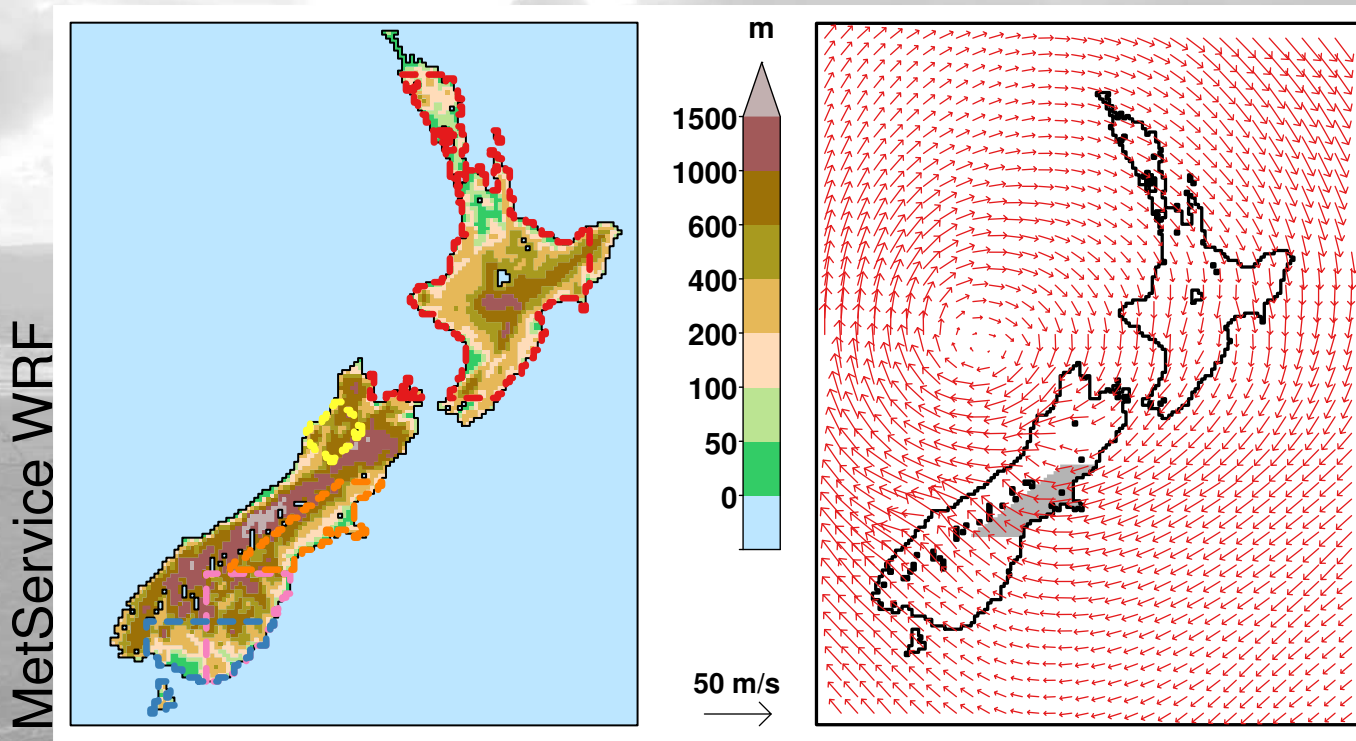
- Model usually most relevant: atmosphere, land
- Addresses a conditional question: effect on a on class of events, given current ocean state
- *Computationally parallelisable: higher resolution and larger sample size*
- *Ocean biases removed, atmospheric biases reduced*

weather@home/ANZ



## Experiment #3: weather forecast model

- “Design storm” experiment
- Addresses highly conditional question: how would this event differ without humans
- *Computationally simple: very high resolution, very rapid calculation, official forecast*
- *Is it the same storm in the counterfactual?*



# The Question of life, the Universe, and event attribution

**Each experiment is asking a different question:**

- What is the human effect on this *type* of event?
- What is the human effect on this *type* of event, *given* current oceanic state (e.g. El Niño)?
- What is the human effect on this *specific* event?

**These differences might matter!**

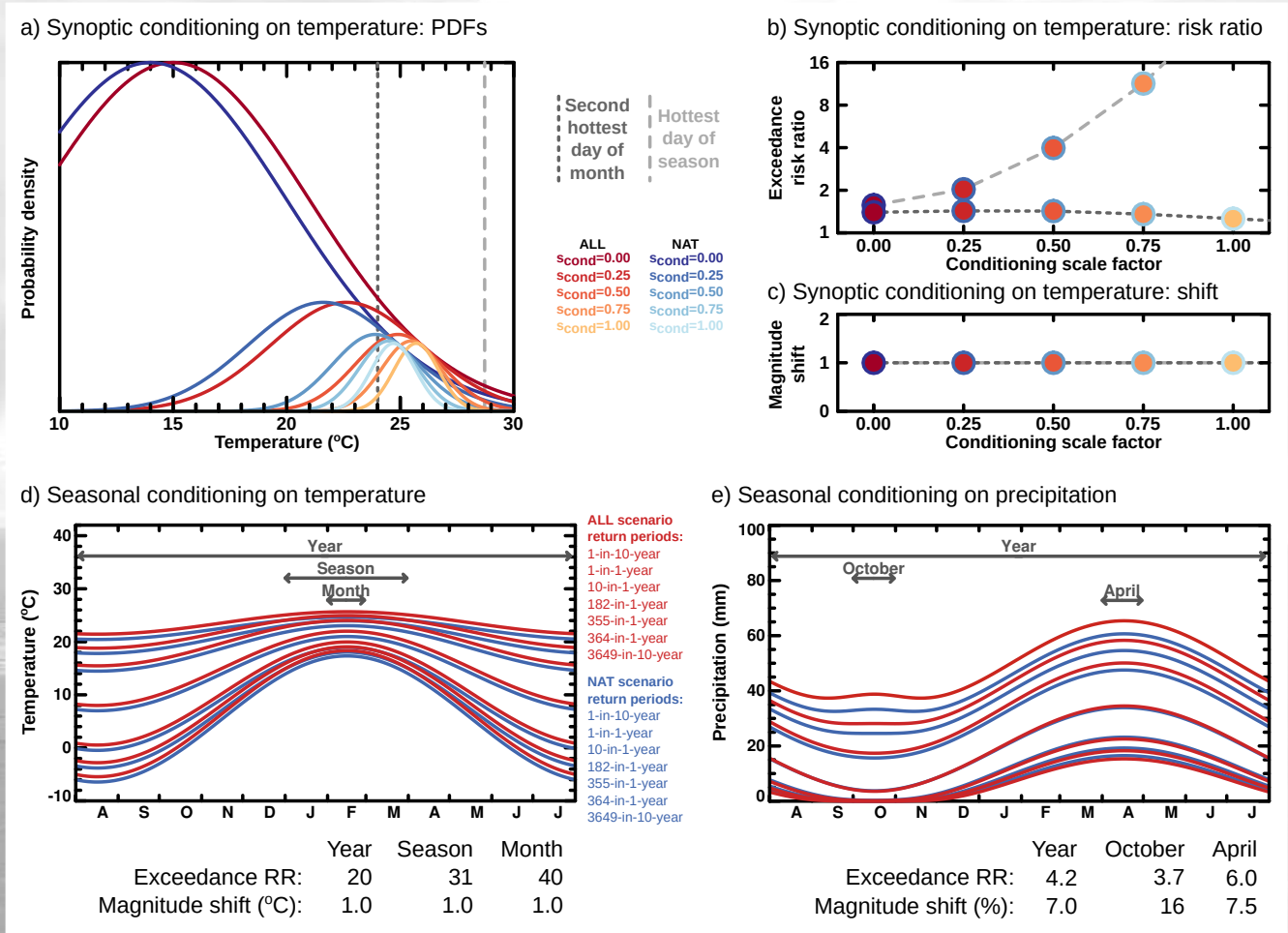


## But we cannot always be choosy

- Even if we want to ask the general question, the global earth system models might not be fit for purpose.
- Even if we want to ask the design storm question, the counterfactual forecast might produce a different event entirely.
- We might not possess the computational resources or model to perform our relevant experiment.

**How *transferable* are our experiments?**

# Theory (sort of) of transferability

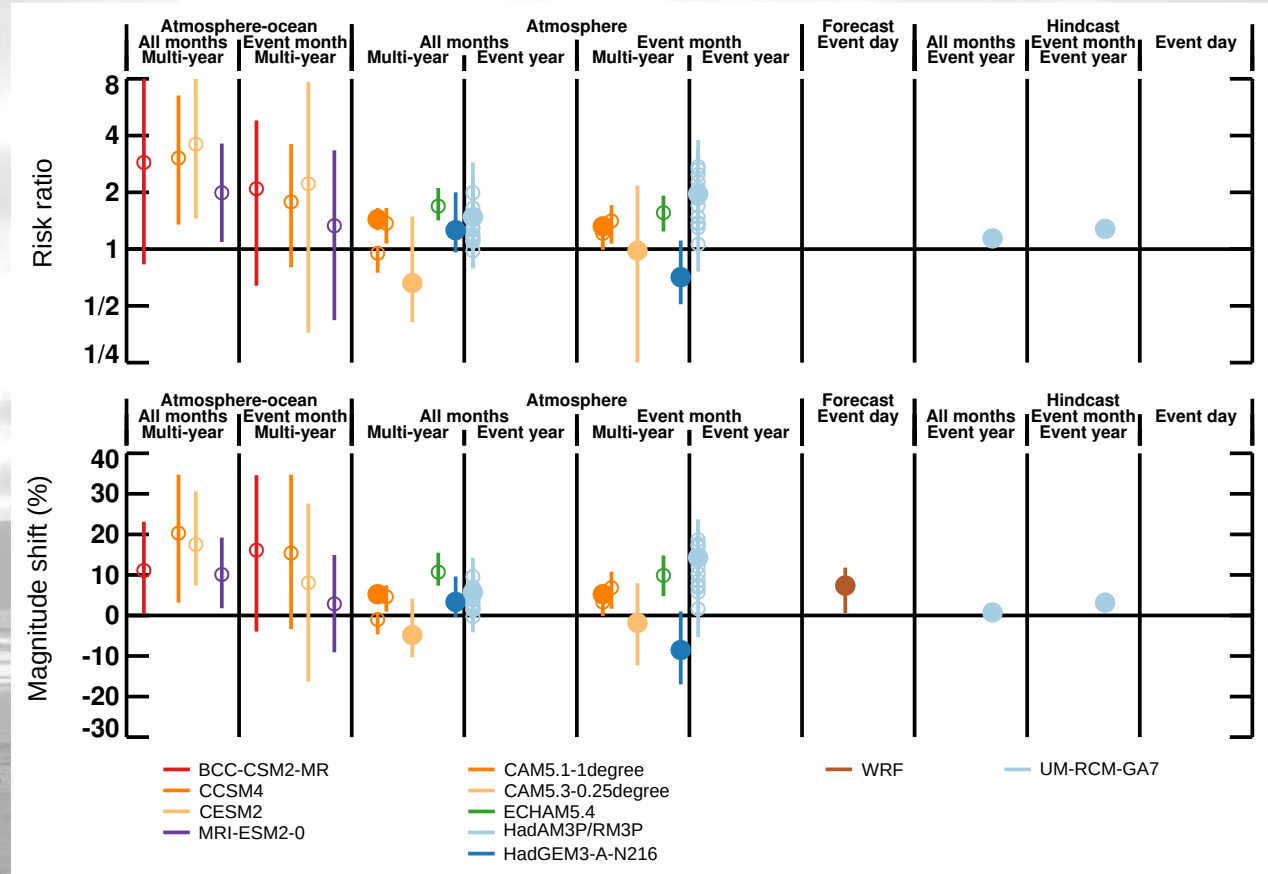


Depends on definition of event, nature of conditioning, and attribution metric

# Empirical evaluation: Buller, wet 15-16 July 2021

Climate models:  
1-in-5-year event class

Forecast models:  
actual event

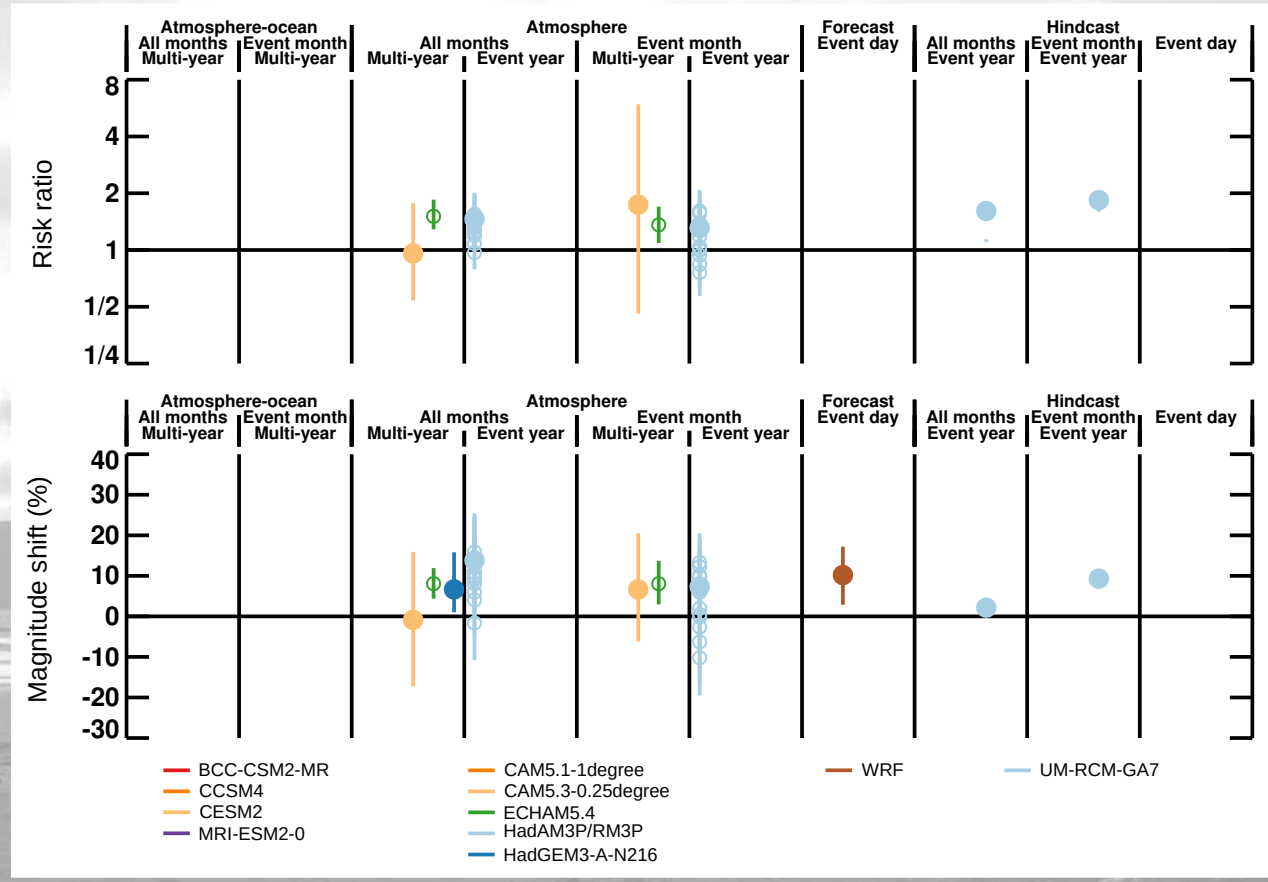


- Models appear fit for purpose: we have managed a solid test
- Attributable effect weakens with increased conditioning (unexpected)

# Empirical evaluation: Canterbury, wet 29-30 May 2021

Climate models:  
1-in-5-year event class

Forecast models:  
actual event

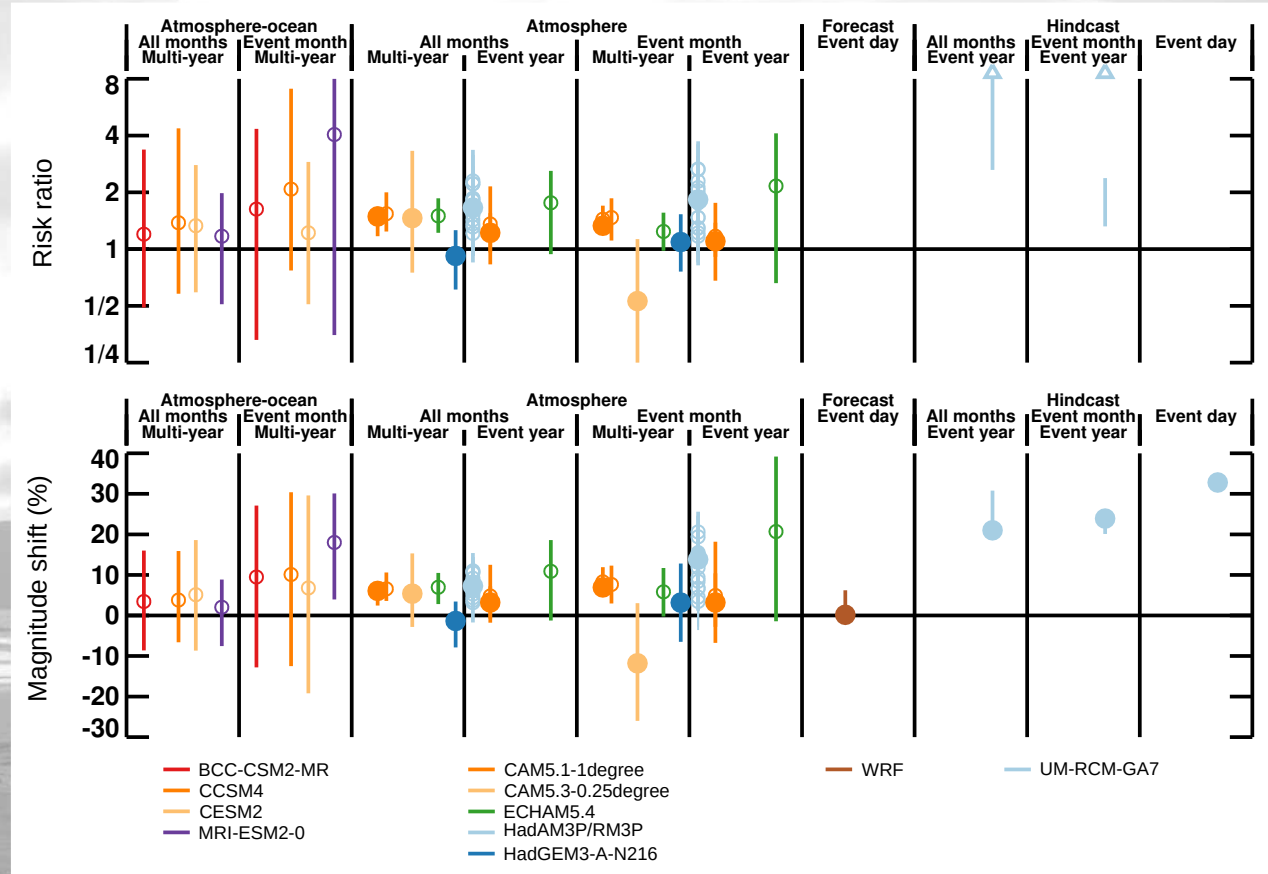


- Many models not fit for purpose: we have not managed a solid test
- Differences between conditioning level within sampling uncertainties

# Empirical evaluation: North Island, wet 4 April 2017

Climate models:  
1-in-5-year event class

Forecast models:  
actual event



- Apparent increase in attributable effect with increased conditioning
- But storm's track shifts in forecast experiments: is this the same event?

## Thoughts

- Sampling uncertainties are large enough across experiments that it is hard to identify systematic differences.
- Weather forecast experiment methodology is still at an early stage of development: but it is coming.
- Experiments appear practically transferable for NZ rainfall events.
- Weather-vs-climate: not transferable for NZ temperature event risk ratios, okay for magnitude shift.
- *We are still at an early stage of understanding our event attribution tools.*

**I hope that made sense**

Thanks.