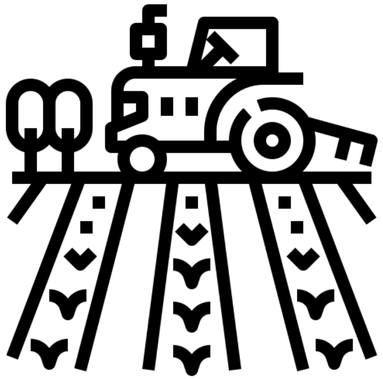
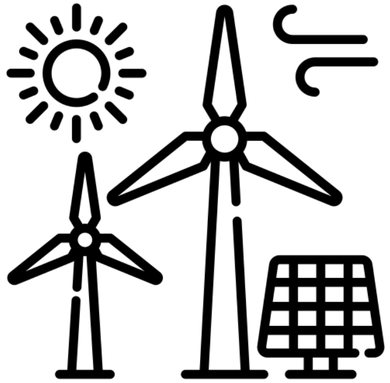
Modelling challenges in understanding weather change

Prof Christian Jakob - Bureau of Meteorology Workshop - September 2024

Weather is a key resource for human and natural systems



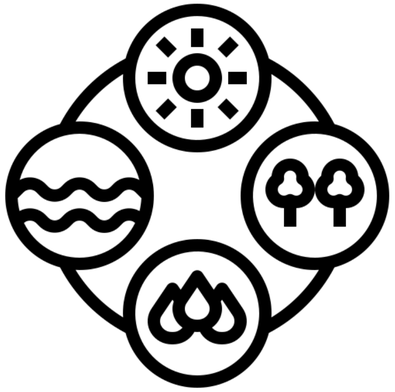
Agriculture



Renewable Energy

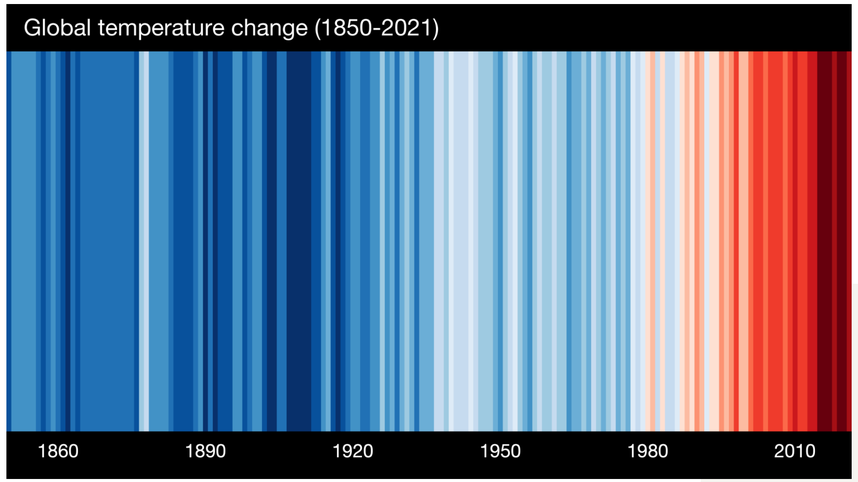
Freshwater

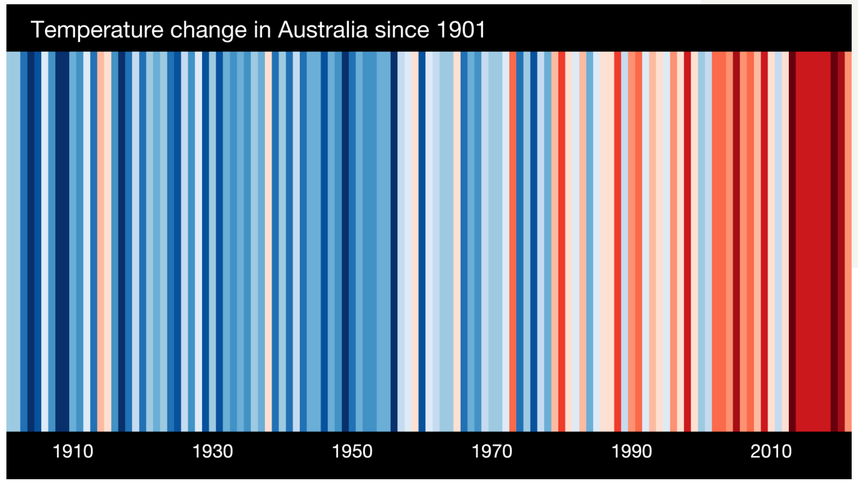
Tourism



Ecosystems

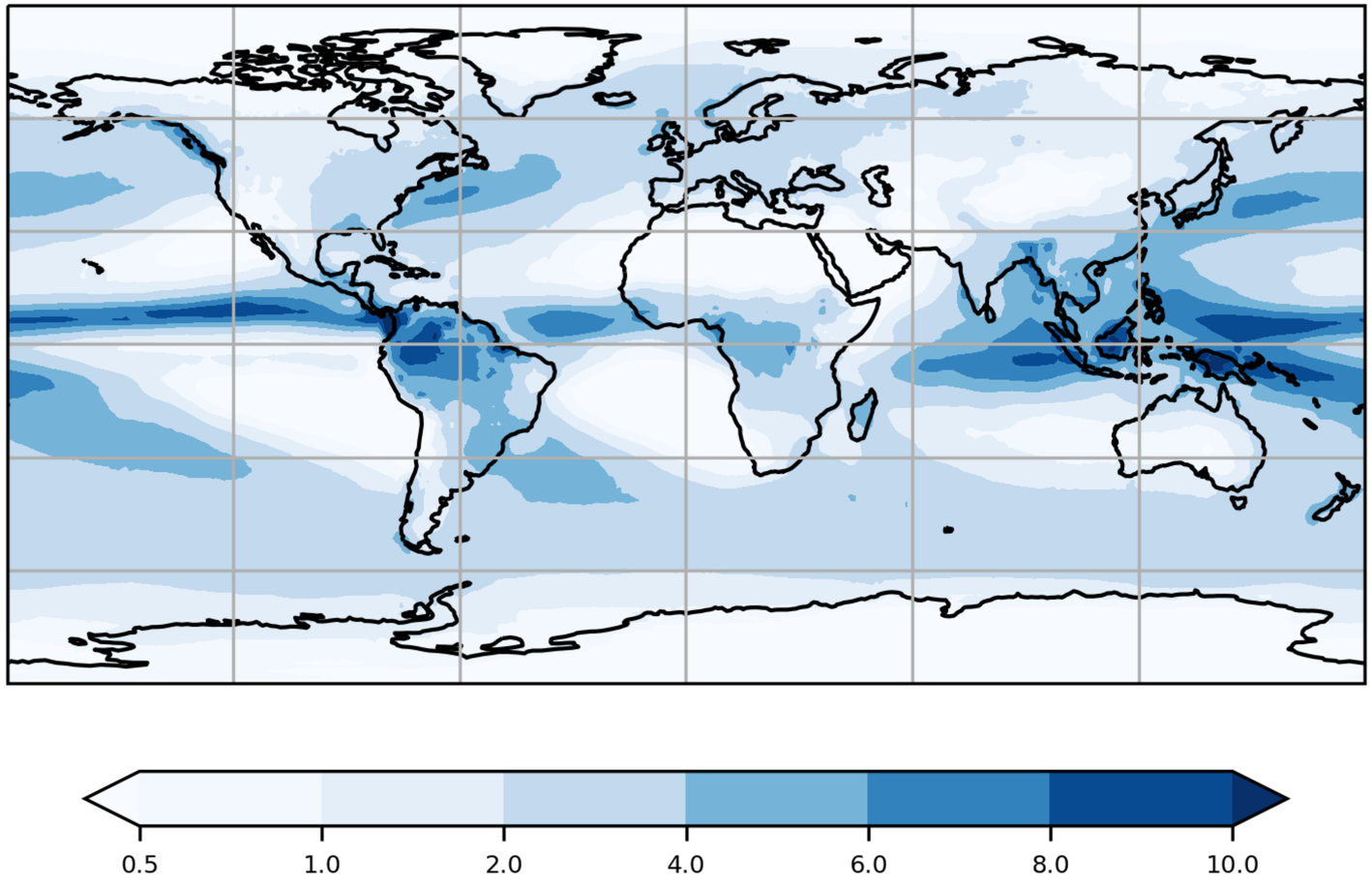
Climate change will make us more weather dependent





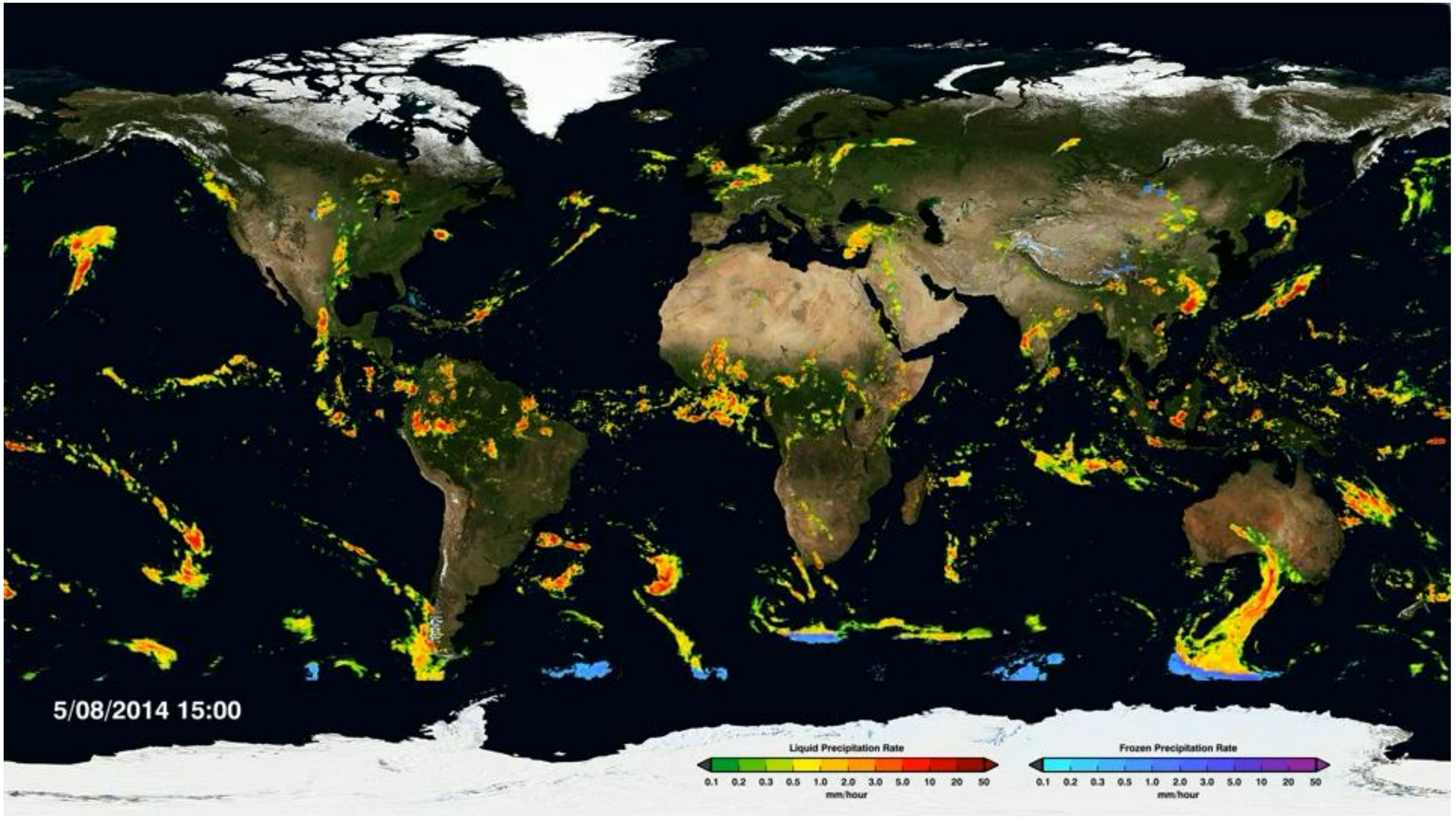
Weather change is a grand challenge of climate science

Average annual rainfall (mm/day)



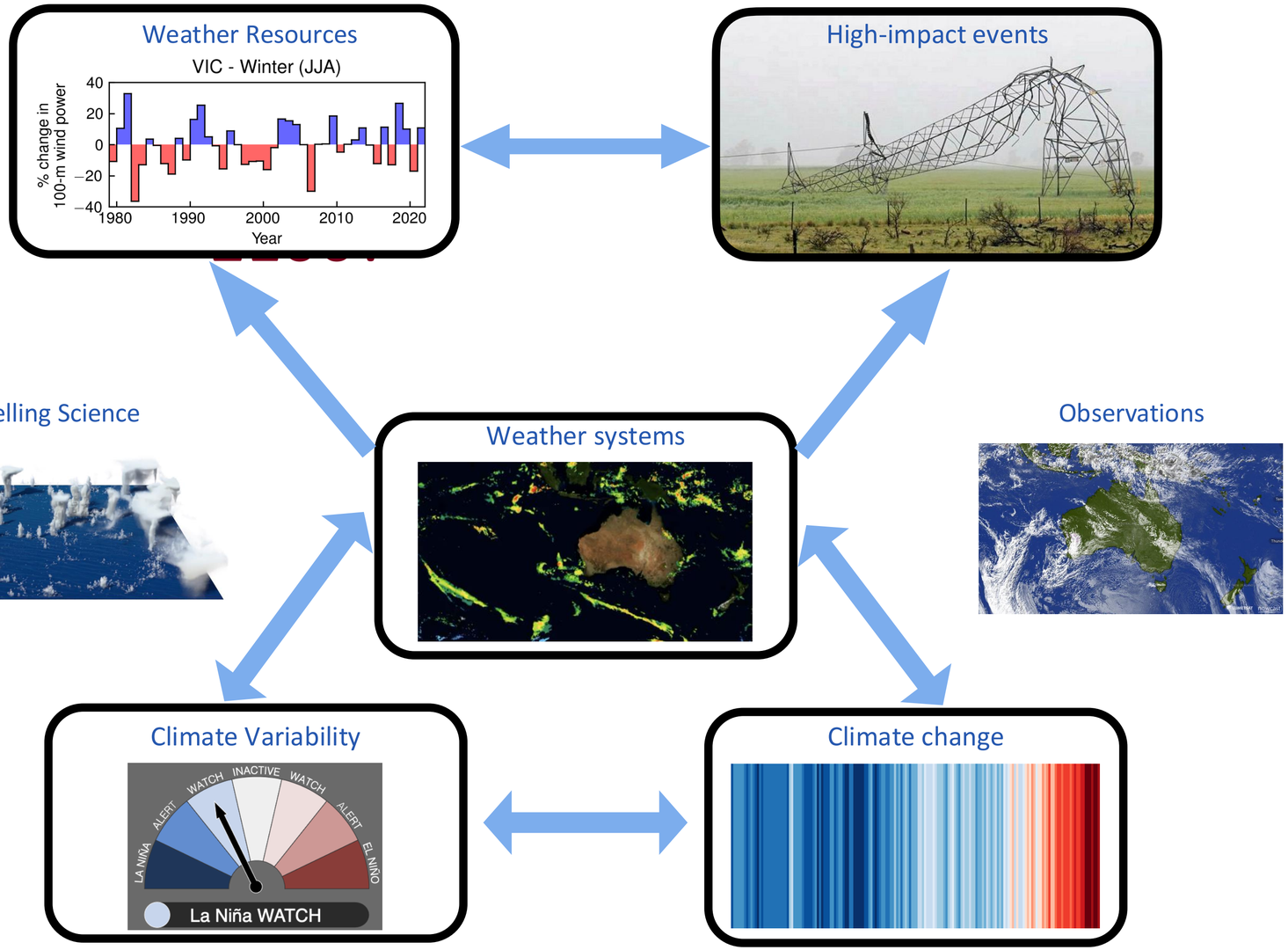
NASA

Weather change is a grand challenge of climate science



NASA

21st Century Weather Research Program



An El Niño or a La Niña like future? It matters a lot!

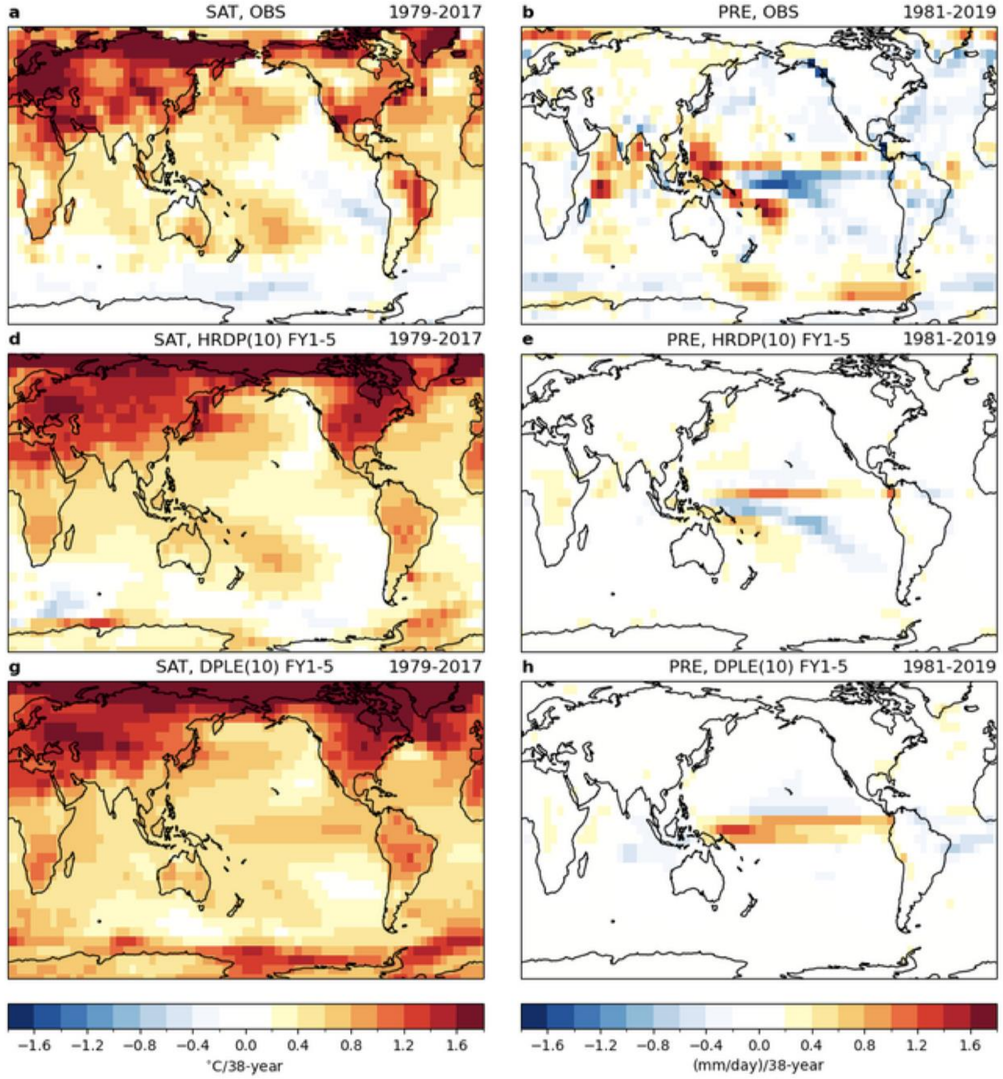
Temperature Trend

Rainfall Trend

Observation

High resolution
0.25 deg Atmosphere
0.1 deg Ocean

Low resolution
1 deg Atmosphere
and Ocean



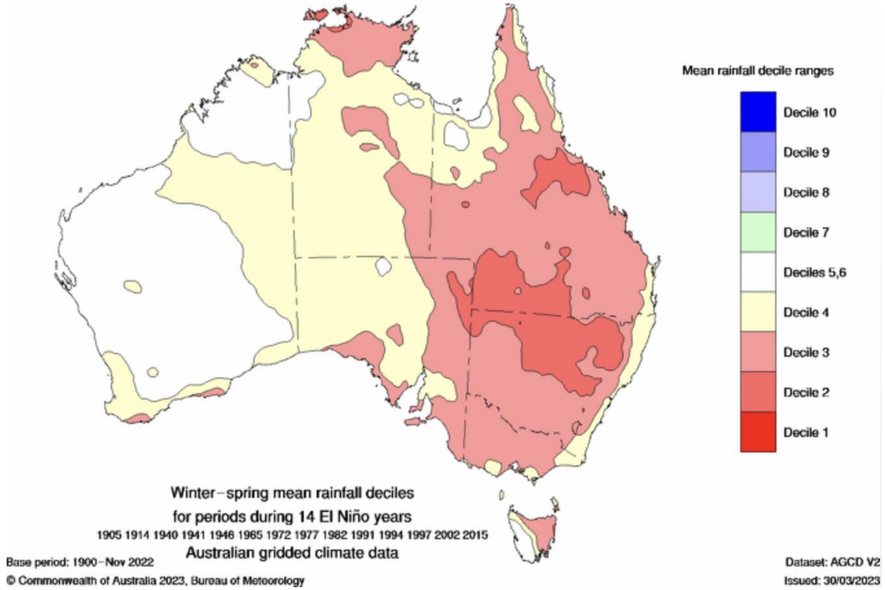
A higher resolution decadal prediction systems predicts a very different trend in SST and rainfall than its lower resolution counterpart. The higher resolution model is more in line with observations!

Yeager et al., NPJ, 2023

Need

A global model (ALO) at 25 km resolution or higher

El Niño and Australian Rainfall



The well-known statistical relationship between El Niño and a reduction in rainfall in Eastern Australia in winter and spring can vibe understood through the absence/presence of particular weather systems.

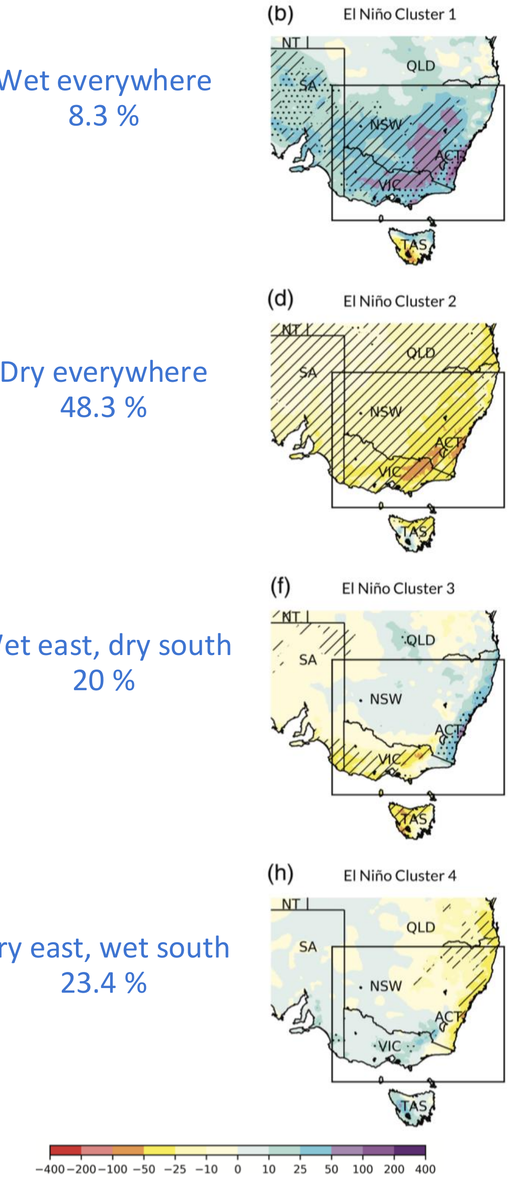
Hauser et al., QJRMS, 2020

Wet everywhere
8.3 %

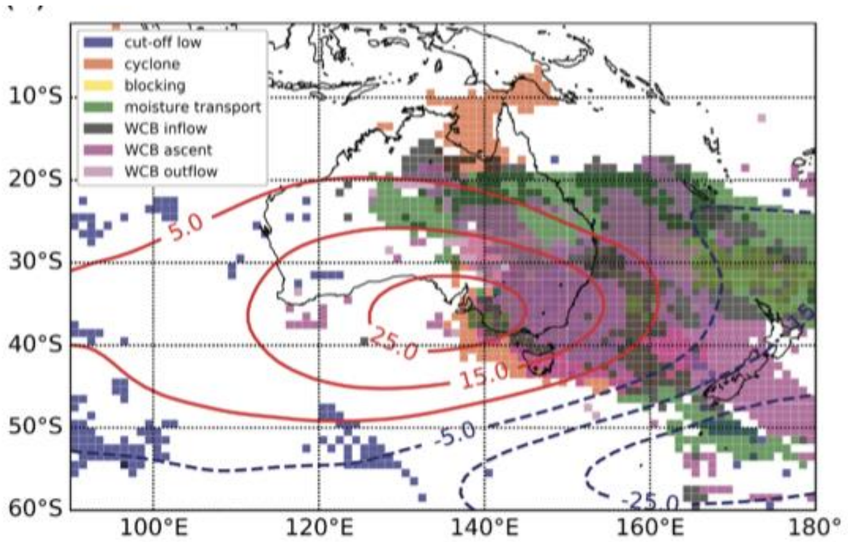
Dry everywhere
48.3 %

Wet east, dry south
20 %

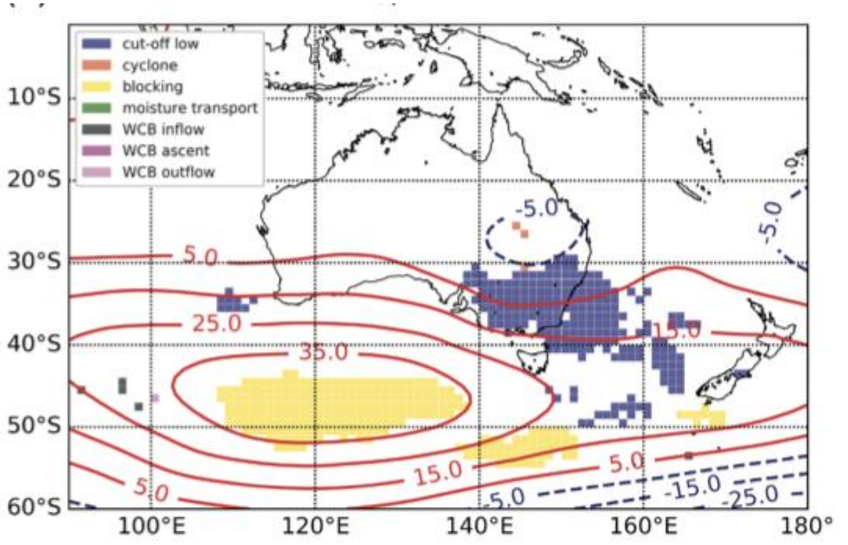
Dry east, wet south
23.4 %



Dry everywhere - Less:



Wet east, dry south - More:

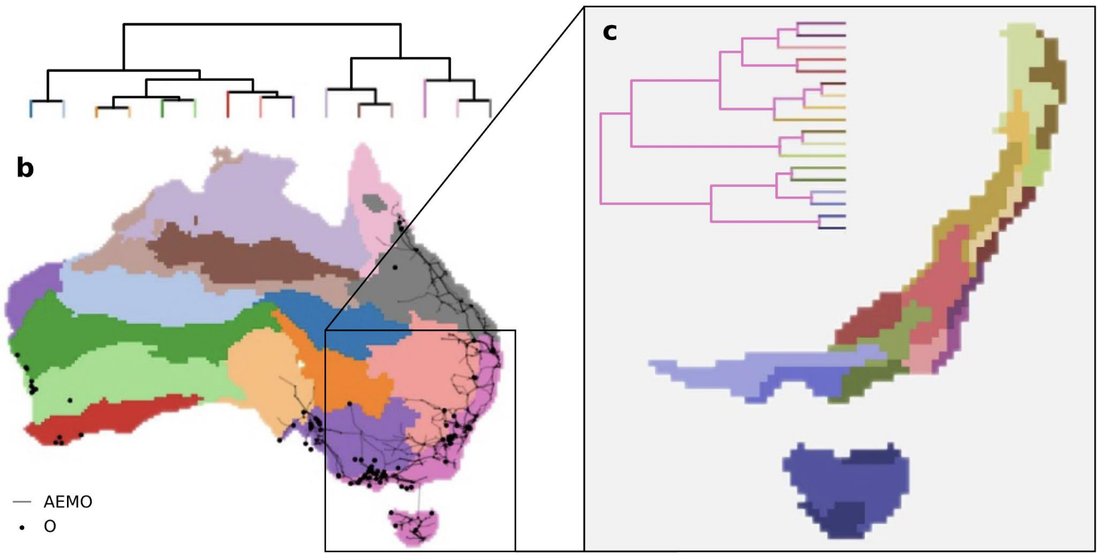


Need

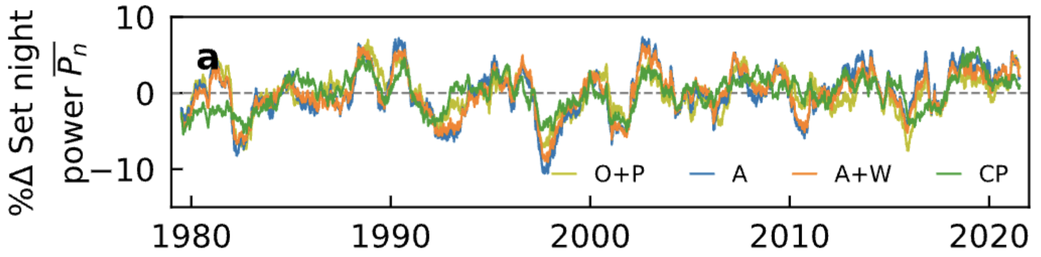
A large-domain regional model (ALO) at convection-permitting resolution (~5 km) or higher

The NetZero 2050 poses entirely new questions for weather and climate science.

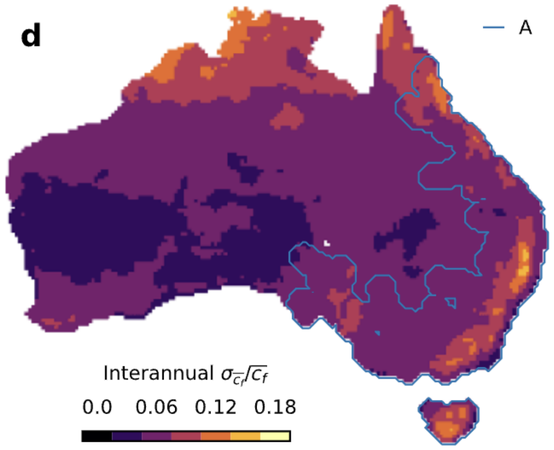
Least-correlation optimisation of wind power locations



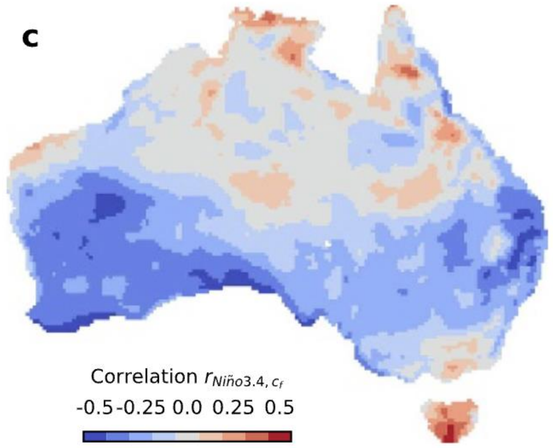
Percentage change in wind power with time (annually smoothed)



Annual mean normalised wind power variability



Correlation of annual mean wind power with Niño3.4

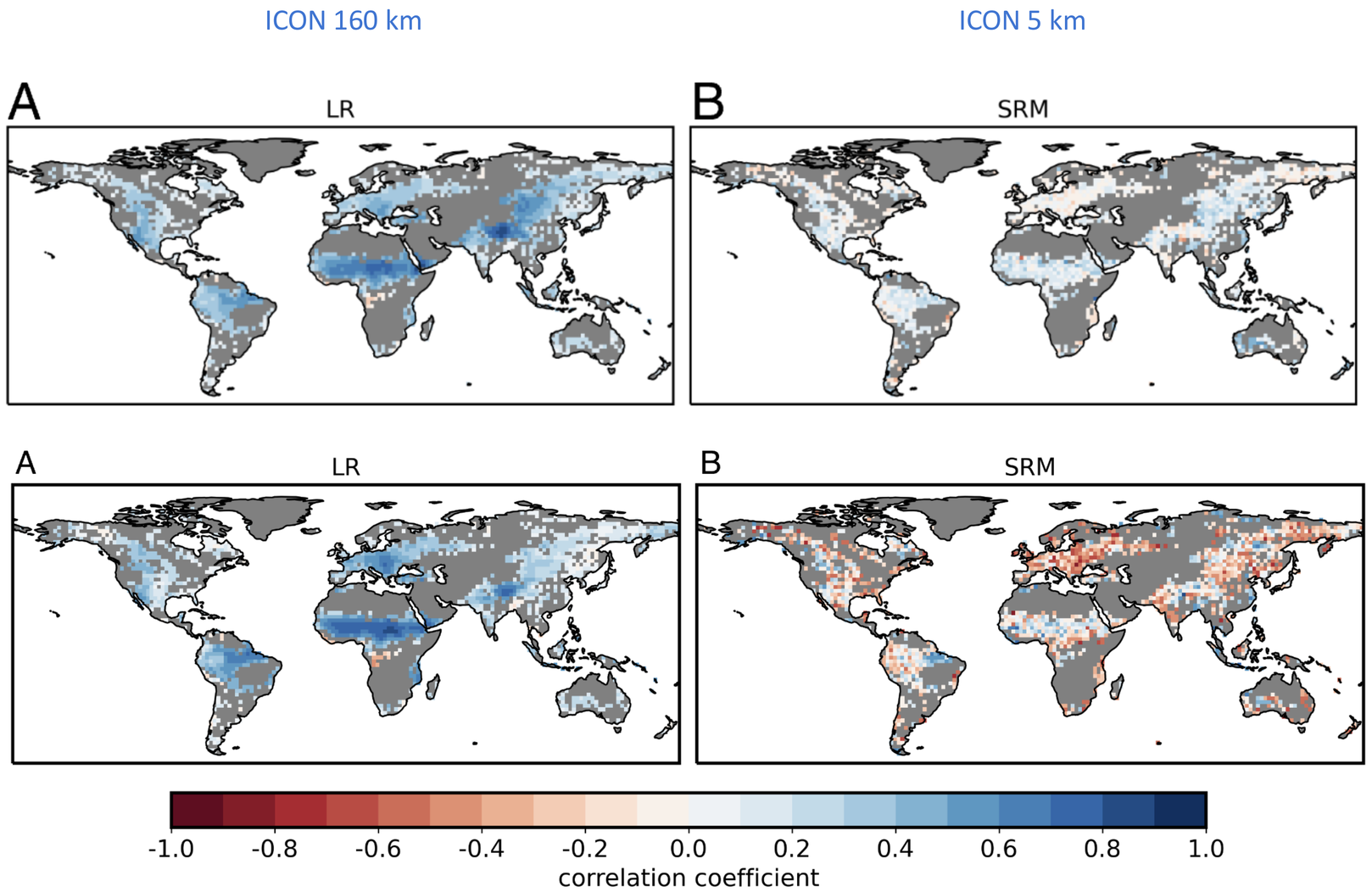


A spatially optimised nighttime wind power grid shows that current wind farms in Australia are deployed in highly correlated wind climates.
Even with a full optimisation, interannual nighttime wind power variability is substantial and strongly related to ENSO.

Gunn et al, ERL, 2023

Land-surface to rainfall feedbacks - Strong or weak? Positive or negative?

Consistent with CMIP models, the 160 km ICON model shows strong positive correlations between soil moisture and rainfall and ET. The 5 km model shows much weaker, and often negative, correlations, in agreement with observations. At least part of the explanation lies in very different ET to P relationships in the two models.

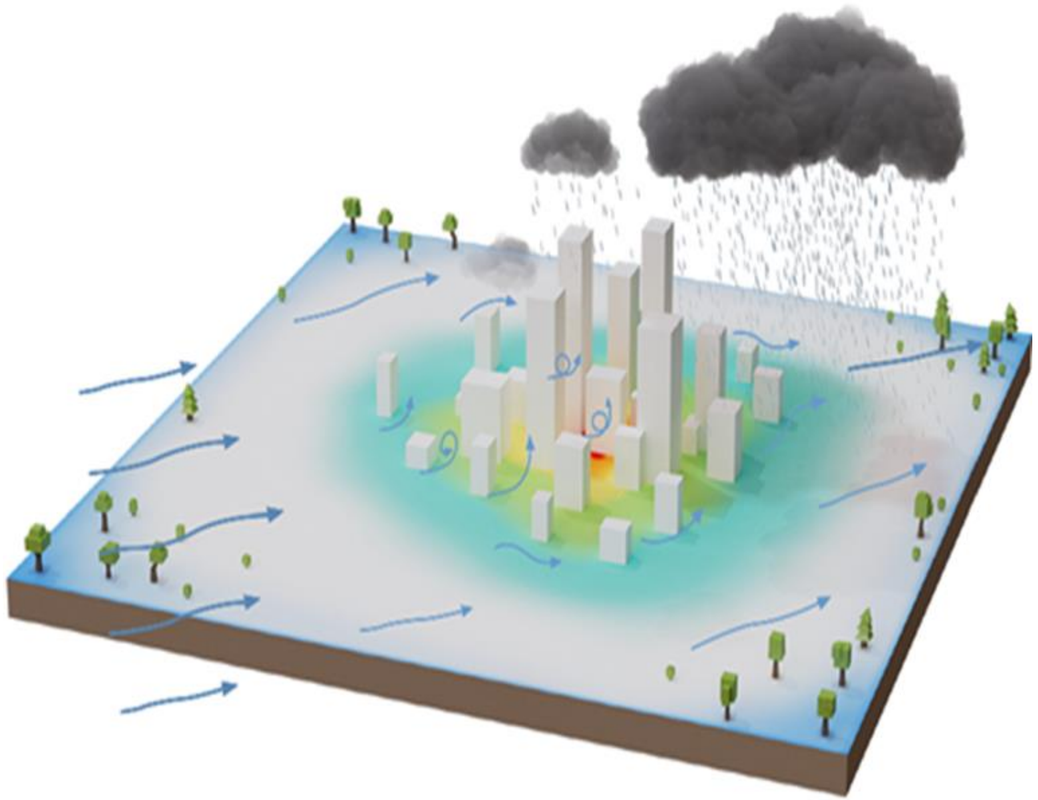


Lee and Hohenegger, PNAS, 2024

Need

An Australia-domain regional model (AL) at kilometre-scale resolution

Effects of both large and small topographical features, e.g., coasts, mountains, or cities, on weather features



Need

A flexible small domain LES resolution model to study topographic effects (orography, coastline, urban)

Summary

- Weather is both a resource and a hazard to human and natural systems
- Through the net zero agenda humans will become more weather dependent than we have been in a long time
- The weather is changing as the climate is changing and we have major gaps in our understanding how
- Models will pay a key role in gaining that understanding
- To succeed, we need a flexible modelling system that includes global models at O(10 km) resolution or better, large-domain regional ALO models, and smaller domain regional AL models all the way to LES scales