



ARC CENTRE OF EXCELLENCE FOR
CLIMATE EXTREMES

What can climate models tell us about future climate risk?

Andy Pitman

ARC Centre of Excellence for Climate Extremes

a.pitman@unsw.edu.au

What can models tell us

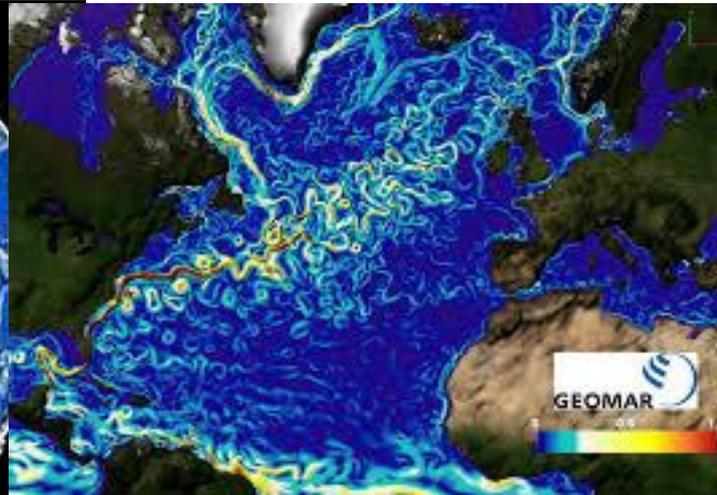
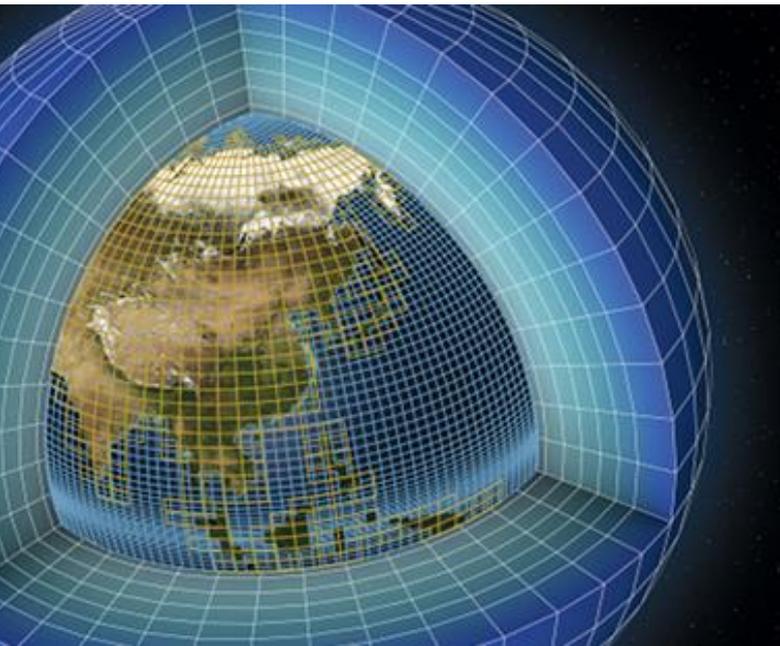
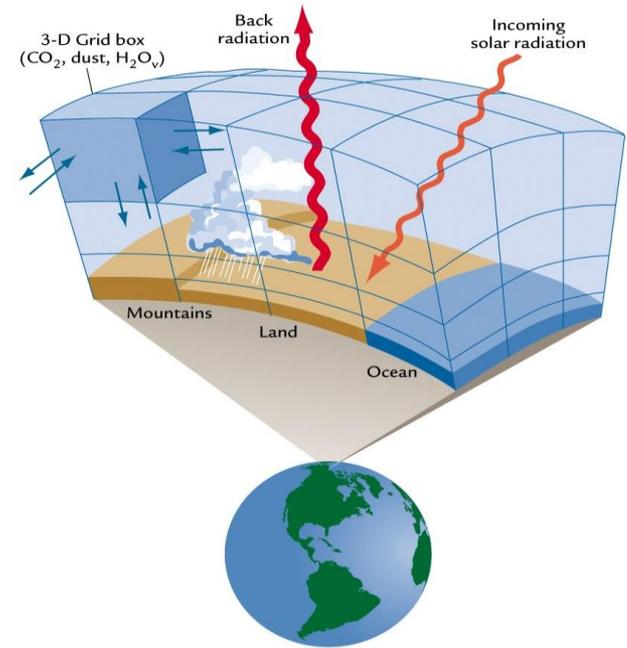
- What models are there?
- Do they work?
- What is coming?

What models are there?

- Physical models
 - Global climate models
 - Regional climate models

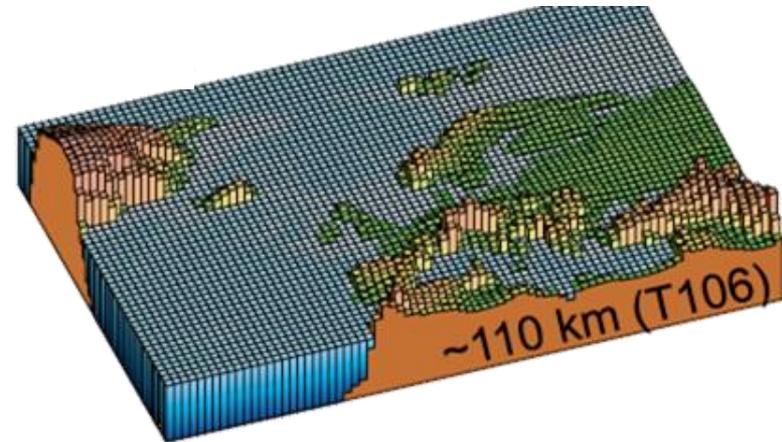
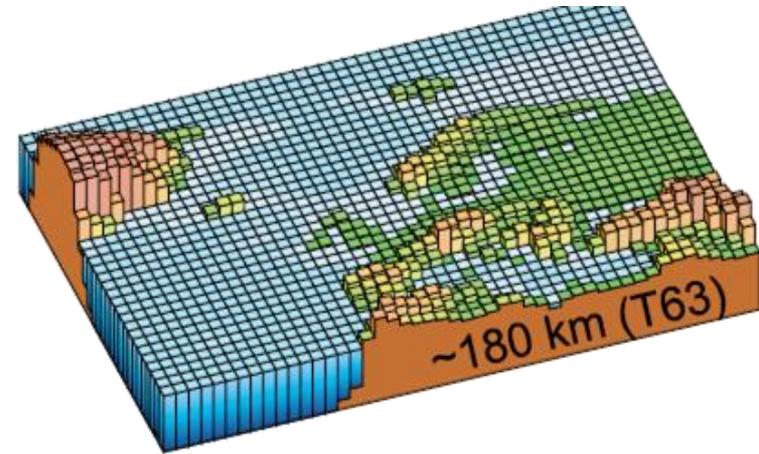
Global climate models

- Built from the laws of physics
- Conservation of mass, Newton's laws of motion ...
- Extensively evaluated



Global climate models

- For climate projections, 100 x 100 km
- Uses most powerful supercomputers available
- Takes ~12 months to do an experiment
- Resolution too coarse?
 - Regional climate models
 - Statistical downscaling

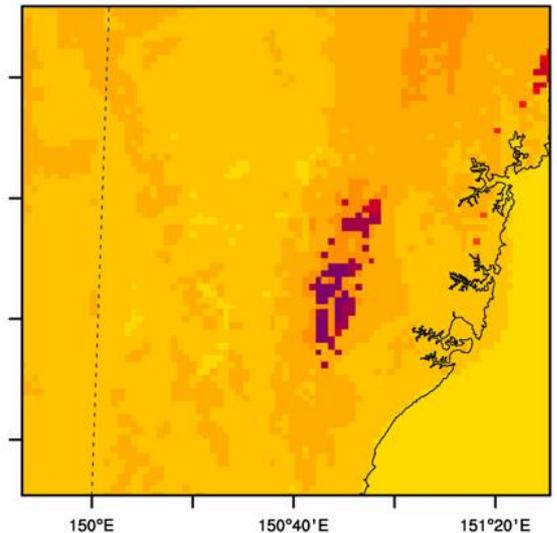
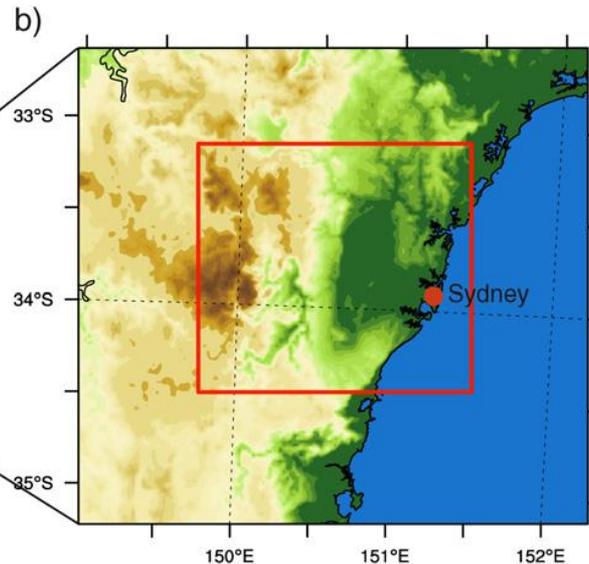
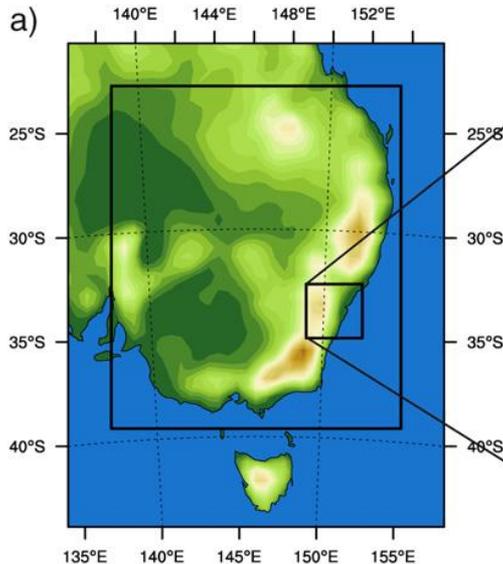
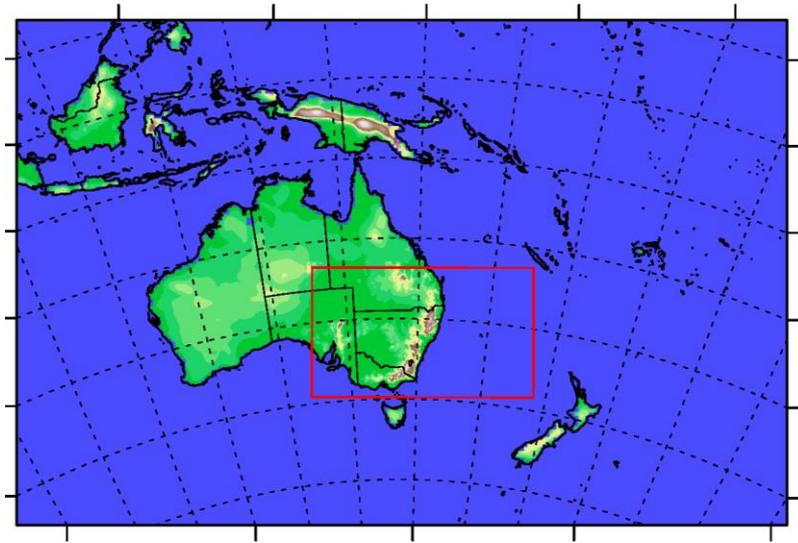


Global climate models

- Global climate models are robust tools at continental scales and above
- Data available at the National Computational Infrastructure but unlikely to be very useful
- Synthesized products exist
 - <https://www.climatechangeinaustralia.gov.au>

Regional climate models

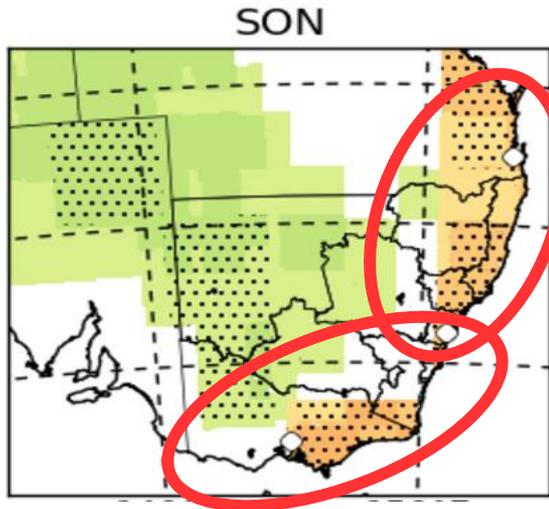
- Same physics as global models – but limited region
 - Nesting: from 100 to 1 km
 - 50 m possible



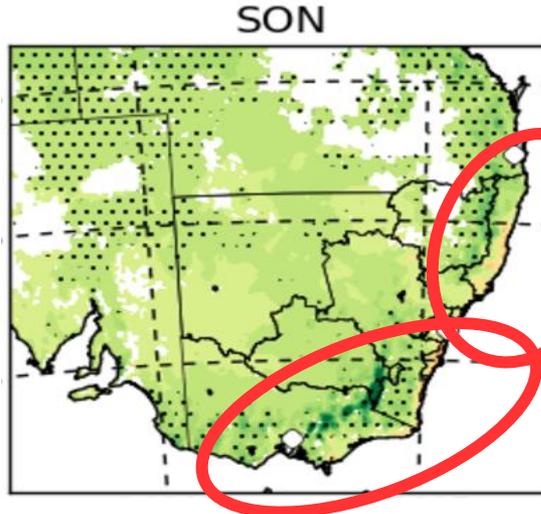
Regional climate models

- Simulate drivers of extremes
- Smaller biases than GCMs

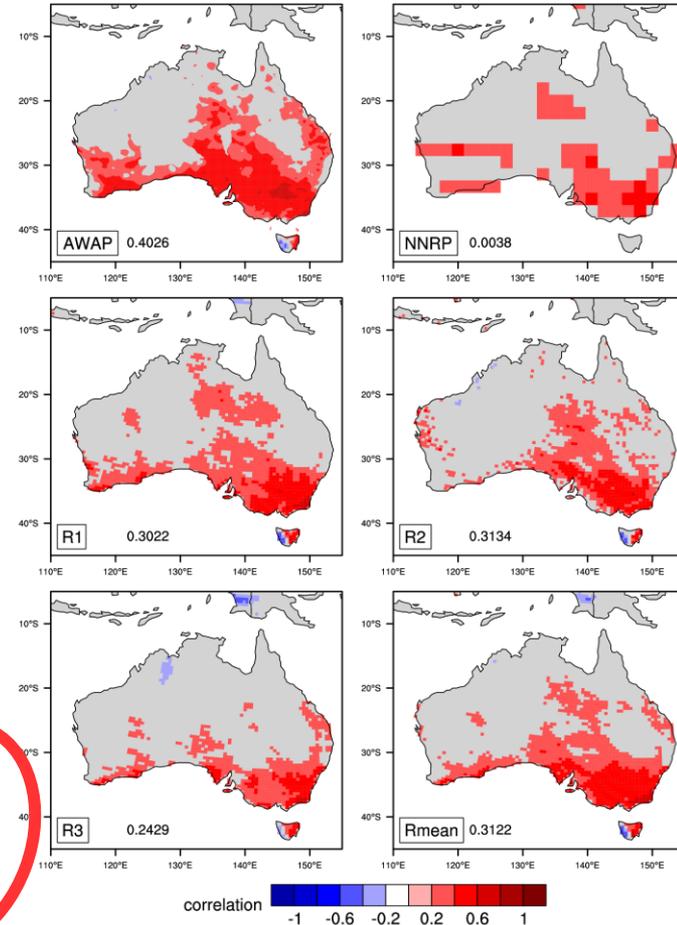
GCM Bias



RCM Bias

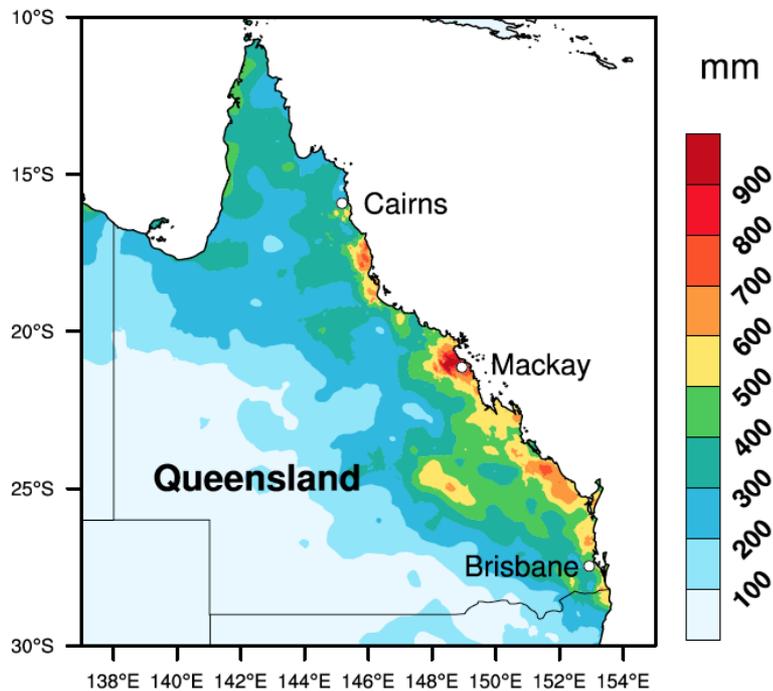


SON blocking pracc (95.0 % significance)



Regional climate models

- Very useful for specific questions
- Computationally very expensive
- rarely run for multiple decades
- Garbage in, garbage out ...don't resolve MoV



Regional climate models

- Regional climate models are useful tools for examining continental scales and below
- To be used for future predictions they need to be embedded in the global climate models
- Running regional climate models now easy
- Synthesized products exist, e.g. NARClM
 - climatechange.environment.nsw.gov.au//Climate-projections-for-NSW

Are models fit for purpose ?

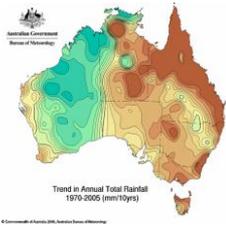


Global

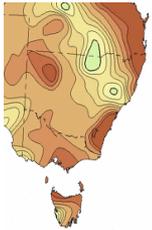
Global



Regional



Continental



State



City / catchment



If the global models
provide robust information



But what about *risk* ?

From averages to extremes

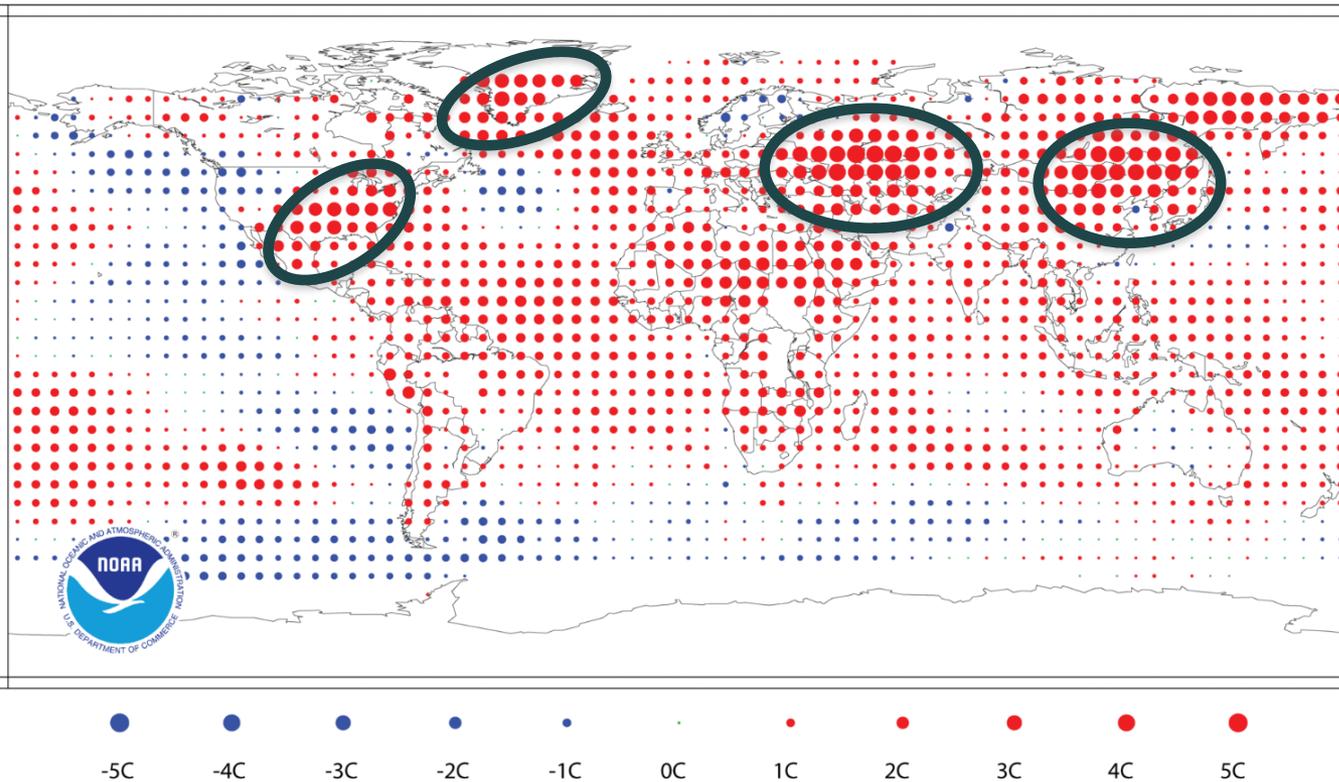


Heat wave event, 2010

Temperature Anomalies June 2010

(with respect to a 1971-2000 base period)

National Climatic Data Center/NESDIS/NOAA



Globally, only +0.66°C above average

53.6°C in SE Russia

US\$500 billion losses

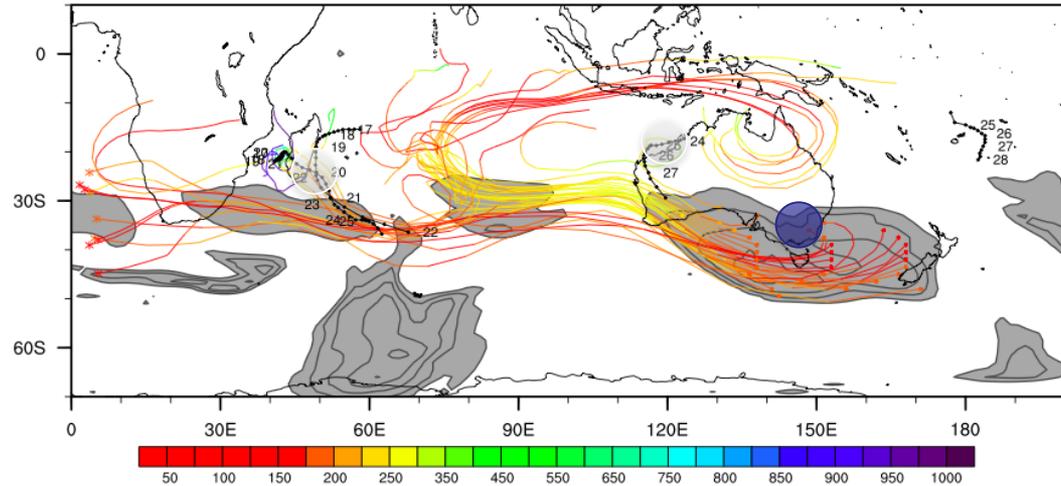
A compound event:
associated with shifts in
the jet stream

Coincident with severe
flooding in Asia

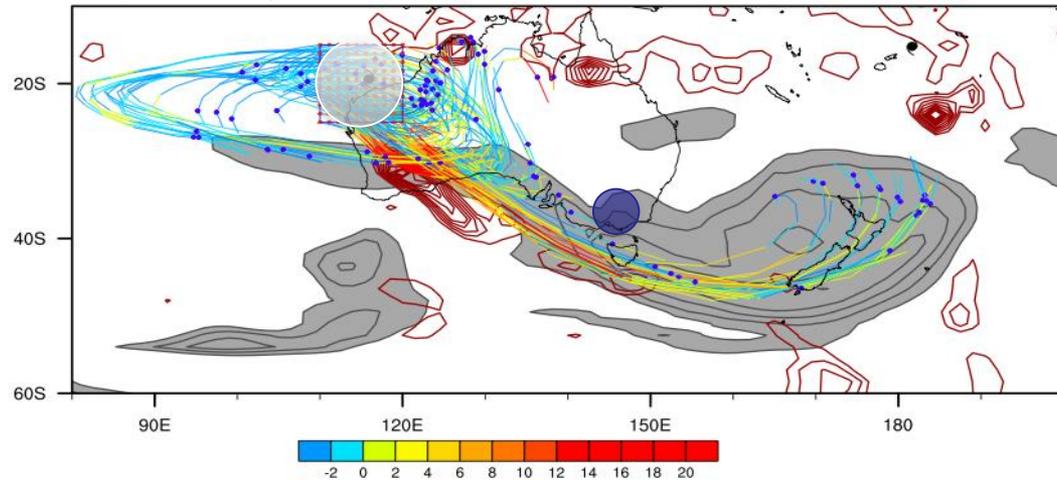
Cyclone – heat wave links

Heat Waves are related to the presence of Tropical cyclones

Tropical Cyclone ← backwards ← Heat wave



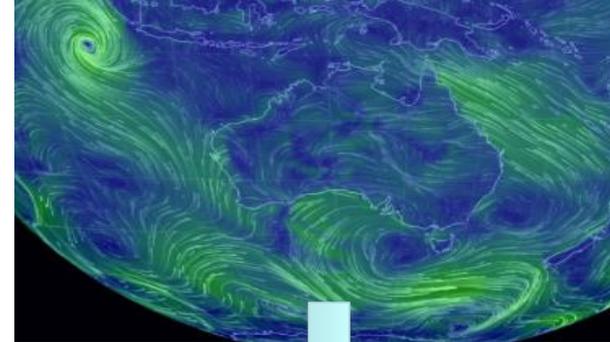
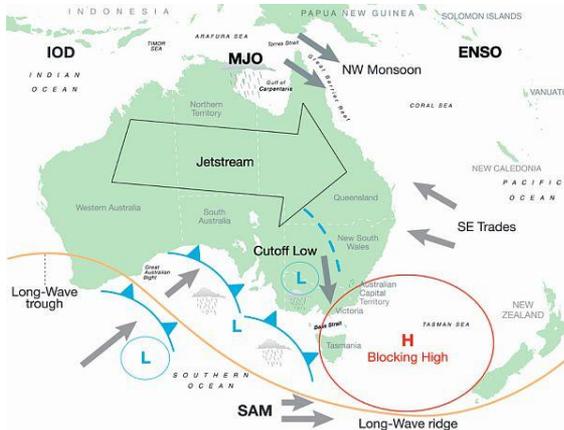
Tropical Cyclone forwards Heat wave



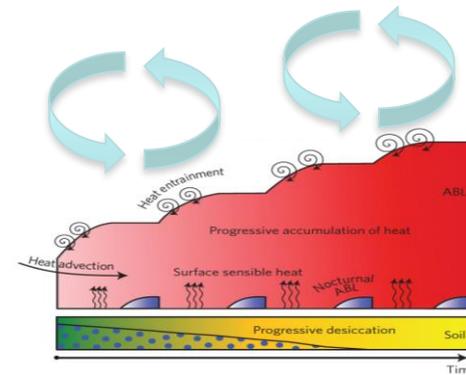
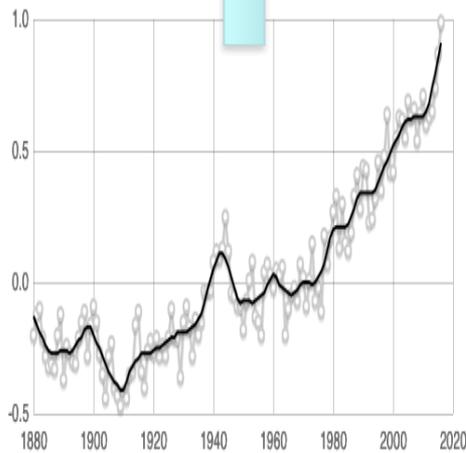
Real climate extremes

Process understanding

Synoptic scale blocking



Land – boundary layer intensification



Extremes and risk

- Hail
 - local scale, embedded in synoptic scales, on meteorological time scales
- Drought
 - Regional scale, embedded in global scales, communicated through synoptic scales, on time scales from months to years
- Heatwave
 - Local or regional scale, embedded in global scales, communicated through synoptic scales, amplified by local scales on time scales of days

Extremes and risk

Regional models likely fit for purpose.
No evidence global-scale processes will affect local
hail formation and so necessary conditions are
captured in the regional models

- Hail
 - local scale, embedded in synoptic scales, on meteorological time scales

Extremes and risk

Regional models unlikely fit for purpose unless the global models capture the right drivers of drought.

No climate model captured the Millennium Drought

Unlikely risk of changing drought can be determined

- Drought

- Regional scale, embedded in global scales, communicated through synoptic scales, on time scales from months to years

Extremes and risk

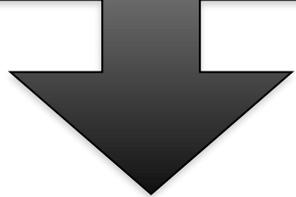
Regional models seem to capture main drivers of heat waves and are likely fit for purpose.
Reasonable prospect that the first order influence of climate change on heatwaves captured in regional and perhaps global models

- Heatwave
 - Local or regional scale, embedded in global scales, communicated through synoptic scales, amplified by local scales on time scales of days

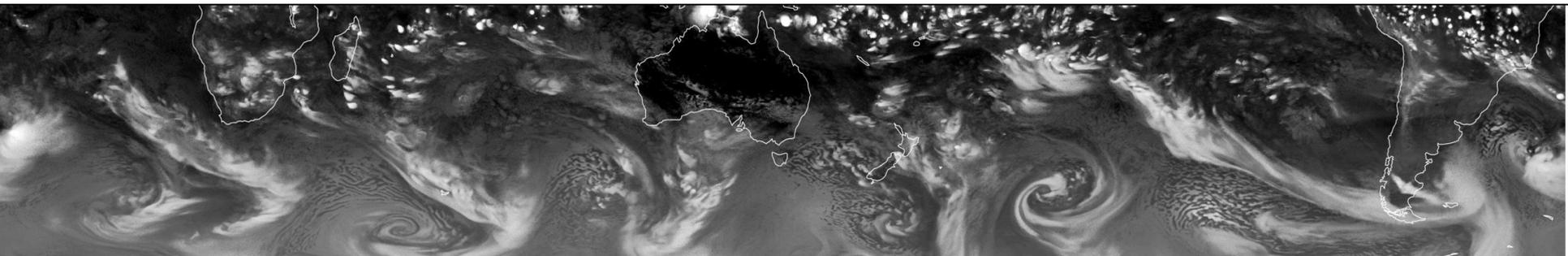
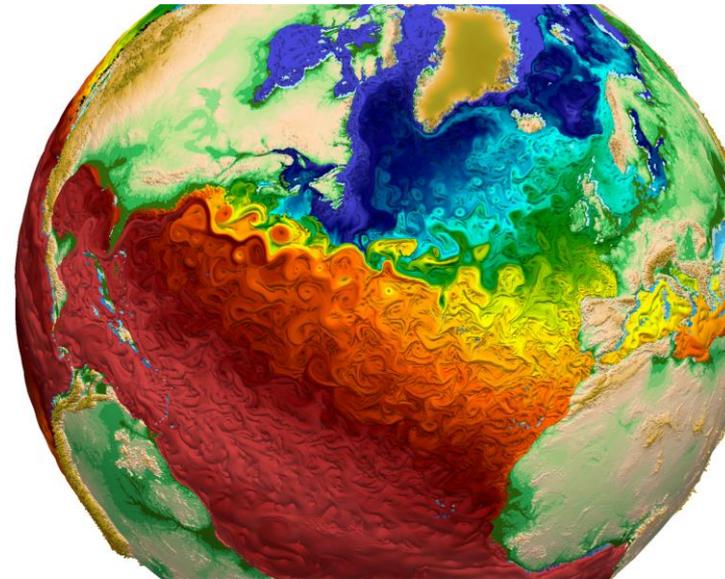
Extremes and risk

- global 20 km is computationally beyond anything currently possible, and the data created is beyond our capability to manage translation
of 100km to 20km is computationally beyond anything currently possible, and the data created is beyond our capability to manage optic
- can 100km

Next generation high performance computing is a necessary prerequisite



- Next generation will resolve global climate at ~20km; to physically connect climate, via weather, to significant extremes



Summary

- Global climate models are robust tools at continental scales and above. Robust, reliable but too coarse for many climate risks
- Regional climate models can be used to assess climate risk where data exist and are useful for risks not strongly influenced by global drivers
- Sometimes the best approach is expert judgment and scenario development with stress testing
- The choice of tools or data require expert judgment.
- The next generation of global models, woven with regional models, will be much more useful to estimate risk



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