



Future weather and climate extremes

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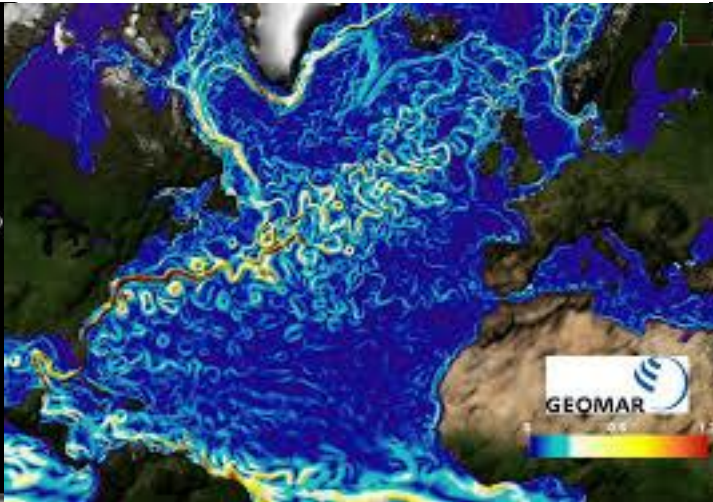
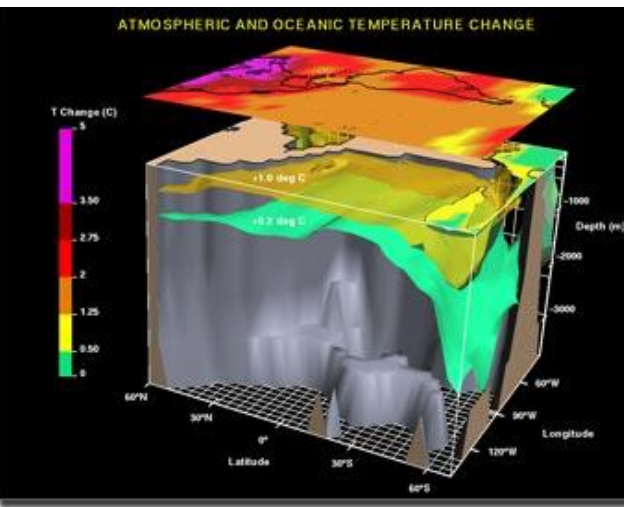
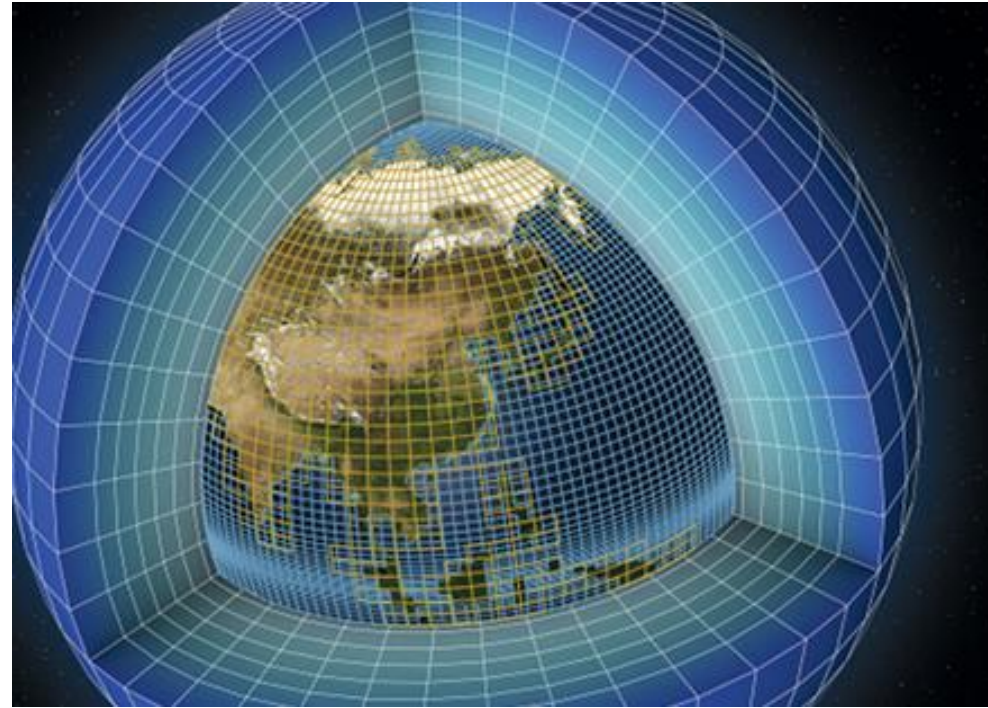
Four themes:

- Future risk of drought
- Future risk of extreme rainfall and hail
- Future risk of extreme heat
- Future developments in compound events

“Future” means beyond a few years

Climate models: used to predict climate

- Use laws of physics
- 3 million lines of code
- Robust at continental scales and above
- Not fit for purpose for extremes

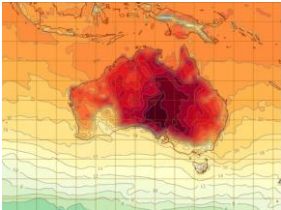


Real climate extremes

Rainfall



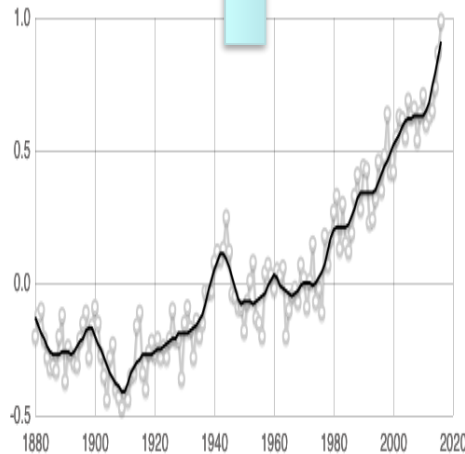
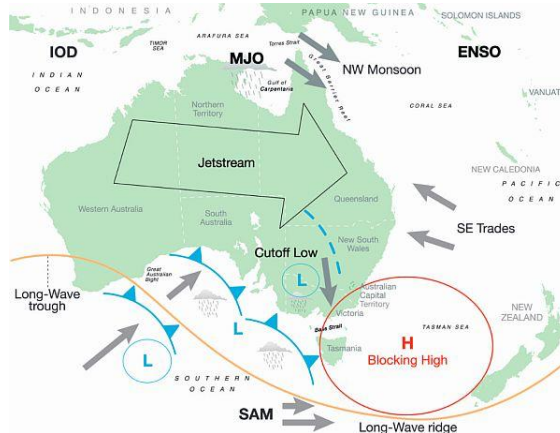
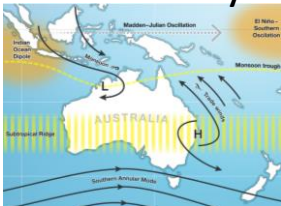
Heatwave



Drought

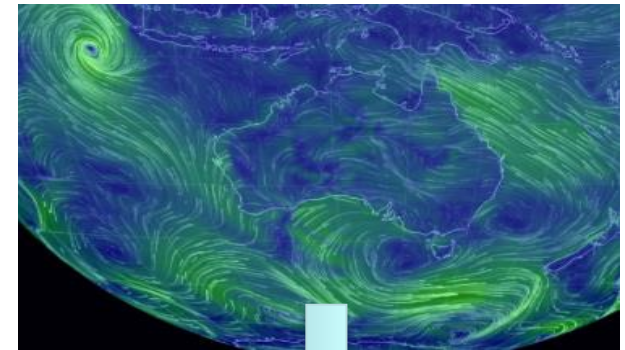


Variability

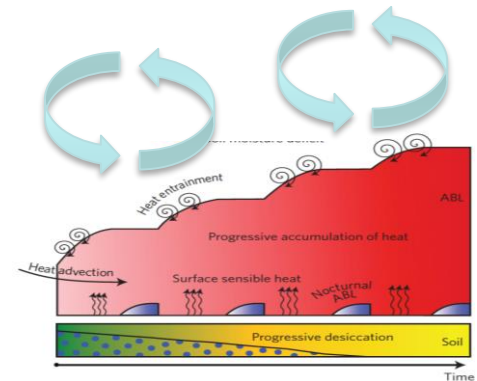


Process understanding

Synoptic scale blocking



Land – boundary layer intensification



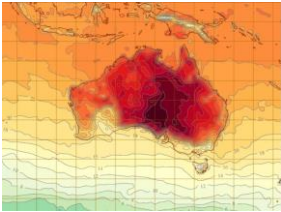
Because model limitations result from a lack of process understanding

Real climate extremes

Rainfall



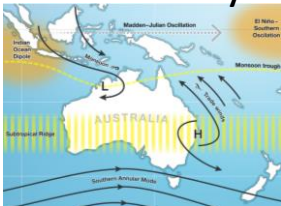
Heatwave



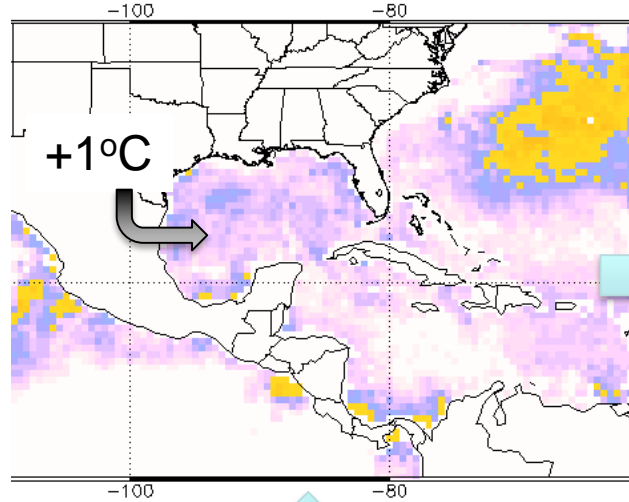
Drought



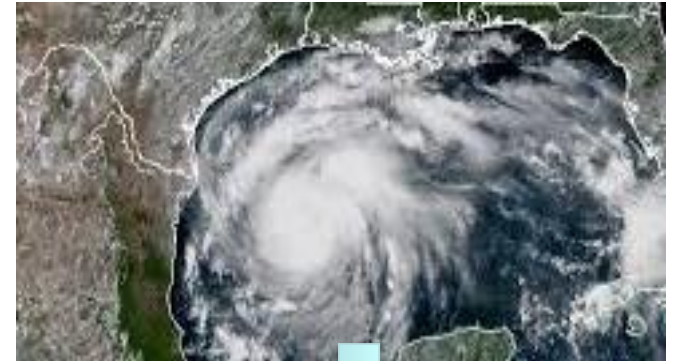
Variability



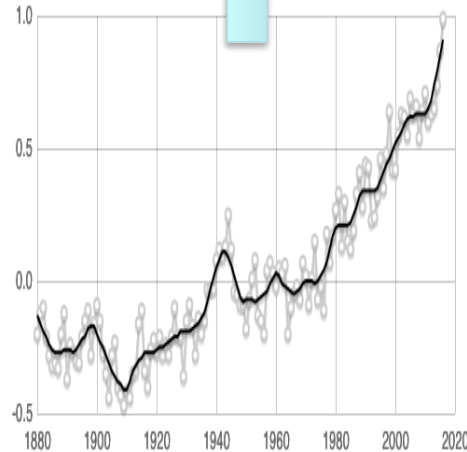
14th August. +1°C



Cyclone Harvey, ~US\$180 billion

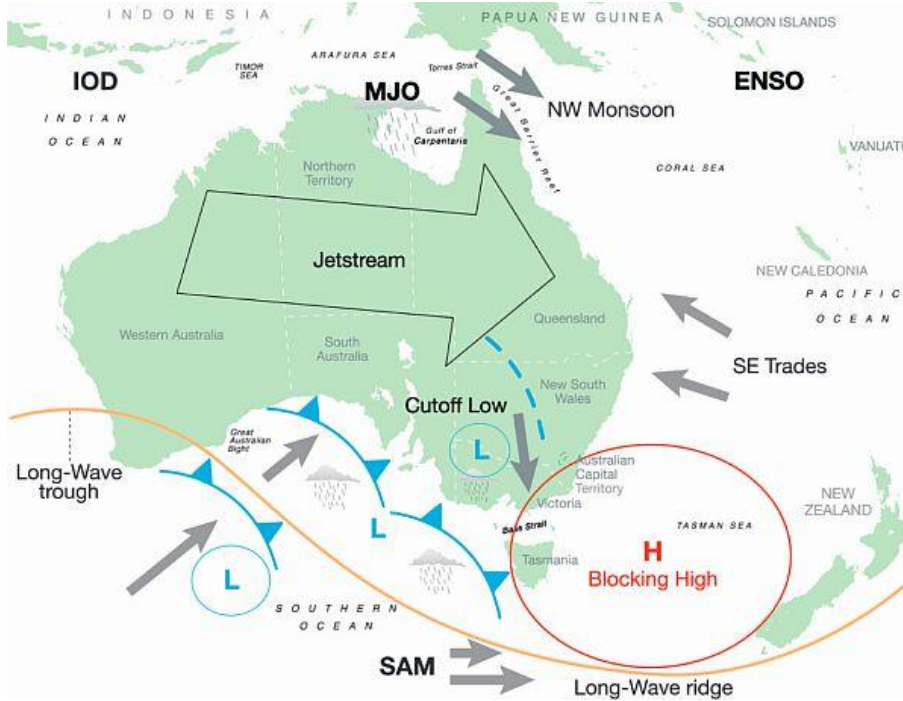


Stalled – forecast 3 days in advance



Intensity not unusual, stalling very unusual, attribution to climate change will take time

Future risk of drought



Current science cannot tell us of the **sign of the change** in future drought. Depends on changes in

- Rainfall
- CO2 and water use efficiency
- Evaporative demand
- Vegetation responses

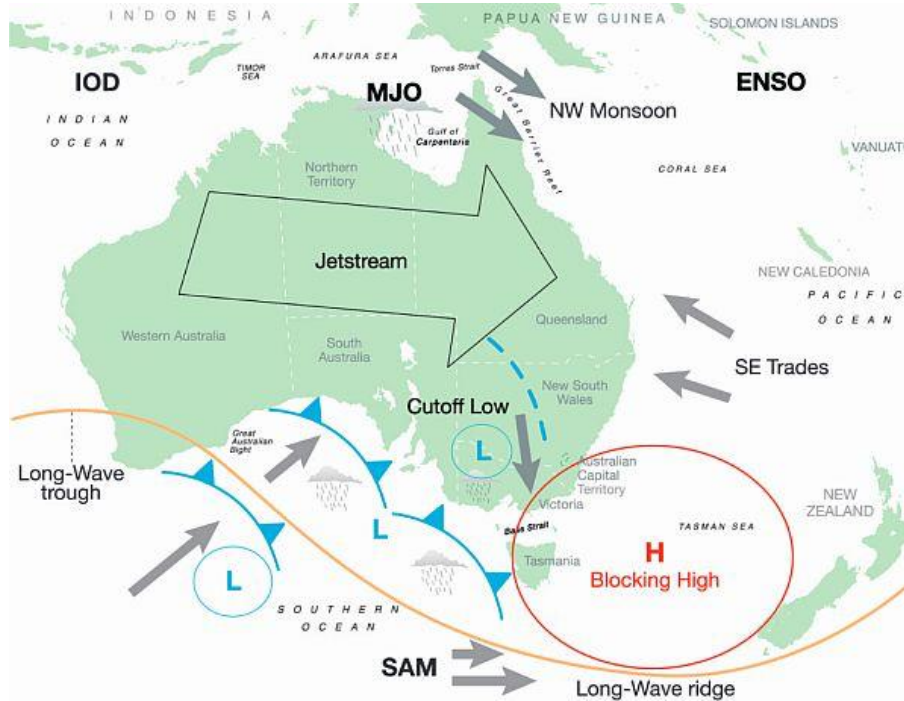
Traditional view has been drought is linked with modes of variability

To predict droughts would therefore require a model to simulate the modes, their timing, their contribution and their interdependencies

Recent thinking is that Australia is “by default” in drought, broken by major rainfall events

New research will focus on whether we can identify causes for these major rainfall events

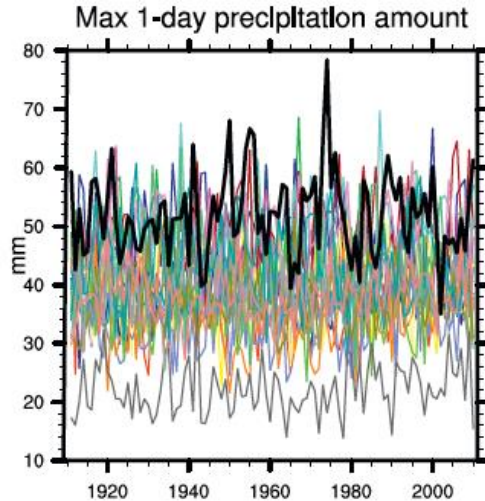
Future risk of drought



Summary: Not good

- no evidence that changes in climate will make drought risk smaller
- Some evidence of changes in teleconnections – meaning less predictive skill
- Warming climate will tend to hit dry landscapes with higher temperatures

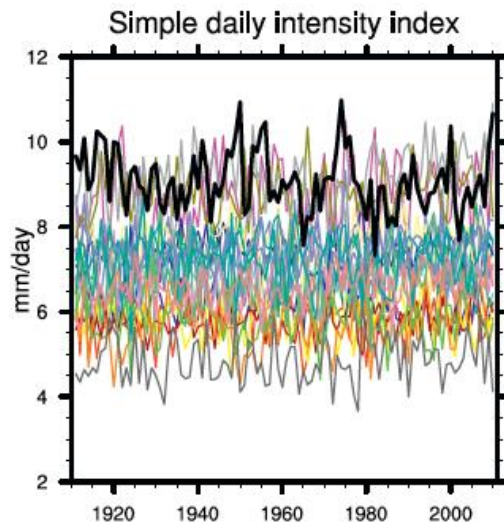
Future risk of extreme rainfall and hail



Climate Models do not simulate rainfall well, when rainfall is intense (even weakly intense)

NWP models do simulate rainfall well, even when rainfall is intense

It's a problem of spatial detail – the climate models are simply very coarse

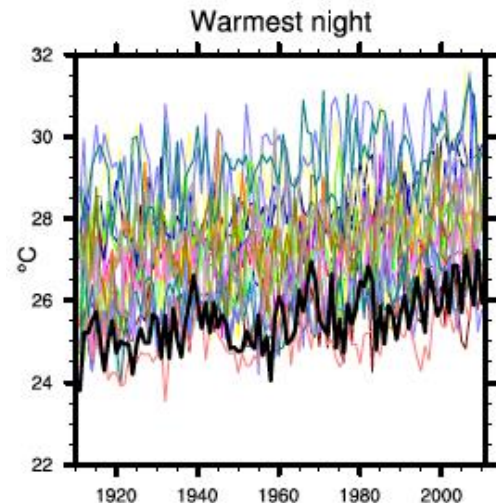
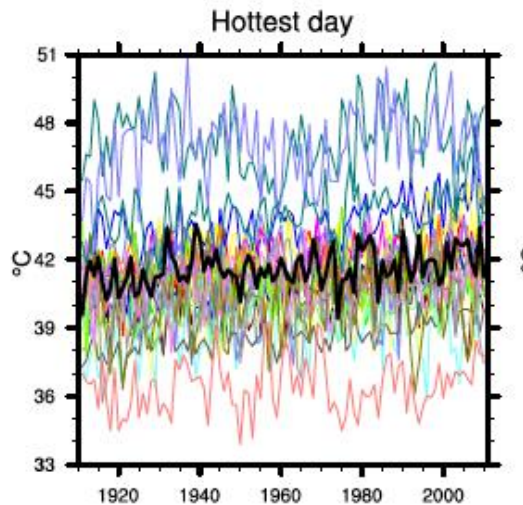


Ability to simulate hail is developing

Summary: Not good

- Major issues with intense rainfall in climate models
- Resolvable, with resolution and improved physics

Future risk of extreme heat



Some climate Models do simulate hot days well

A few are ok on night time temperatures

A key process, blocking, requires models at ~30 km resolution, not 100km

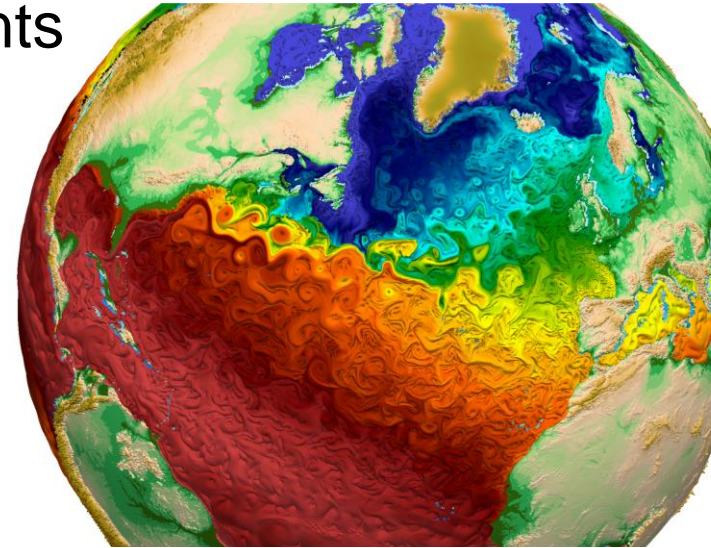
There are land feedbacks that are poorly captured in ~50% of climate models

Summary: pretty good

- Climate models are ok at simulating the magnitude of a heat event
- They do not capture the duration of heat waves well

Future risk of compound events

- Compound events are expressions of weather that translate a large-scale climate trend into simultaneous weather events
- Can be catastrophic
- Not represented in existing modelling technologies



nature
climate change

PERSPECTIVE

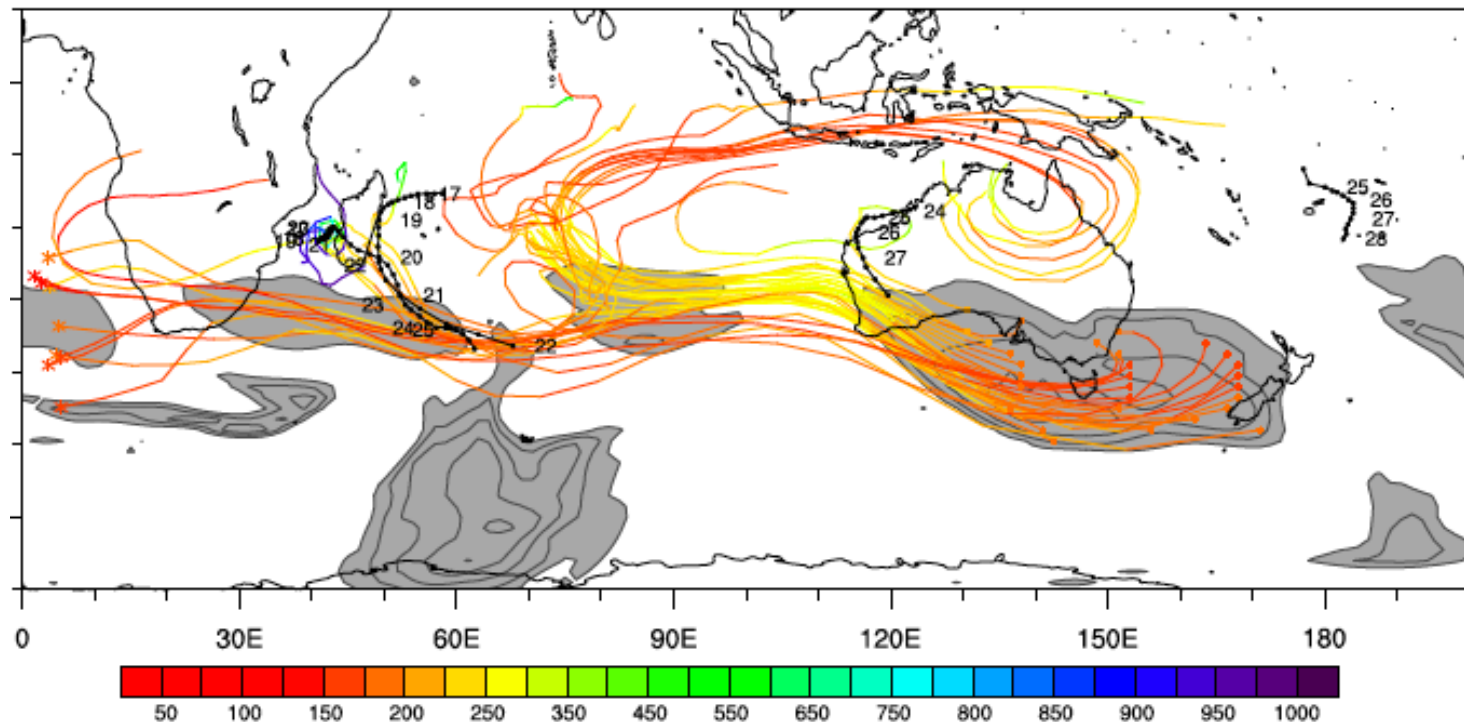
<https://doi.org/10.1038/s41558-018-0156-3>

Future climate risk from compound events

Jakob Zscheischler^{1*}, Seth Westra², Bart J. J. M. van den Hurk^{3,4}, Sonia I. Seneviratne¹, Philip J. Ward⁴, Andy Pitman⁵, Amir AghaKouchak⁶, David N. Bresch^{7,8}, Michael Leonard², Thomas Wahl⁹ and Xuebin Zhang¹⁰

Compound events – Victorian heatwaves

- Link between cyclones in the Australian tropics and heatwaves over Victoria
- Linked with PV anomalies
- Likely not just cyclones – broader to include tropical convection



Ways forward



You can **dynamically downscale** the climate models

- Often [not always] needs to be bespoke to need
- Probably more useful than the climate models
- Major errors in the climate models will not be fixed
- **Useful, with care, but not a silver bullet**

Victorian climate projections 2019

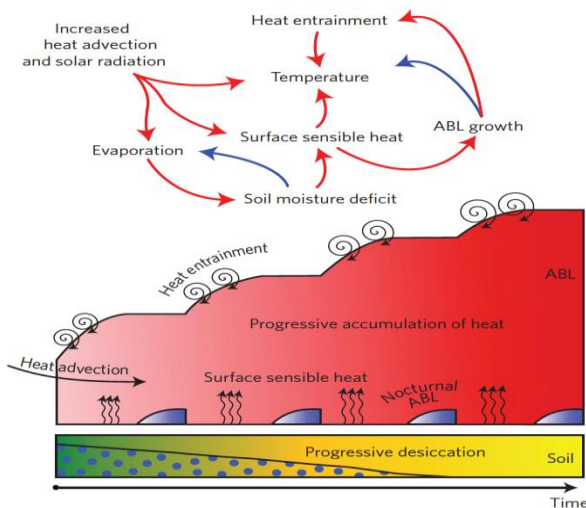


Ways forward



Major national effort to reengineer Australia's weather and climate model

- Called for in NCRIS roadmap
- Scoping study via Dept Education and Training
- Supported by key Universities, Dept Environment, BoM, CSIRO, AAD,
- To fund 5-10 year effort to software engineer the model for weather and climate research
- Enable new questions to be asked, flexibly, quickly and reproducibly
- To build new capability



- Eh what? News to me? Talk to me 😊



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