



Climate change impacts on extreme event hydrology

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Science

Climate Change Research Centre

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Outline

- How will climate change impact rainfall?
- How will different rainfall durations be impacted?
- Where in Australia will climate change impact rainfall?





How will climate change impact rainfall?

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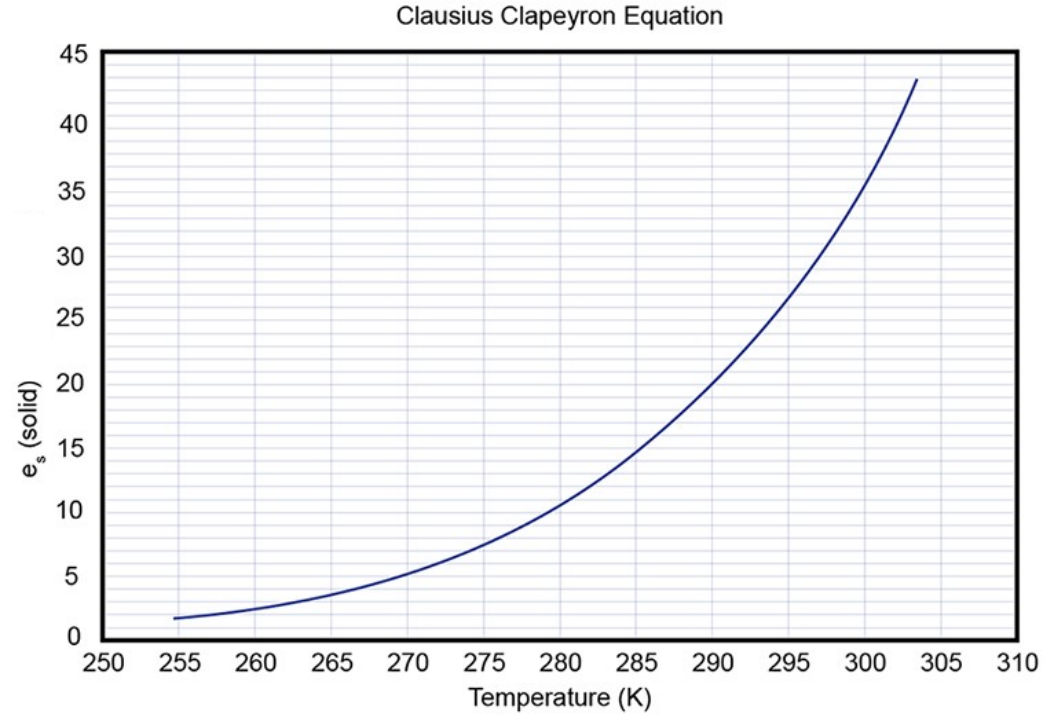
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Thermodynamics

As temperature goes up –
saturation water vapour pressure
goes up $\sim 7\%/K$

Clausius-Clapeyron eqn

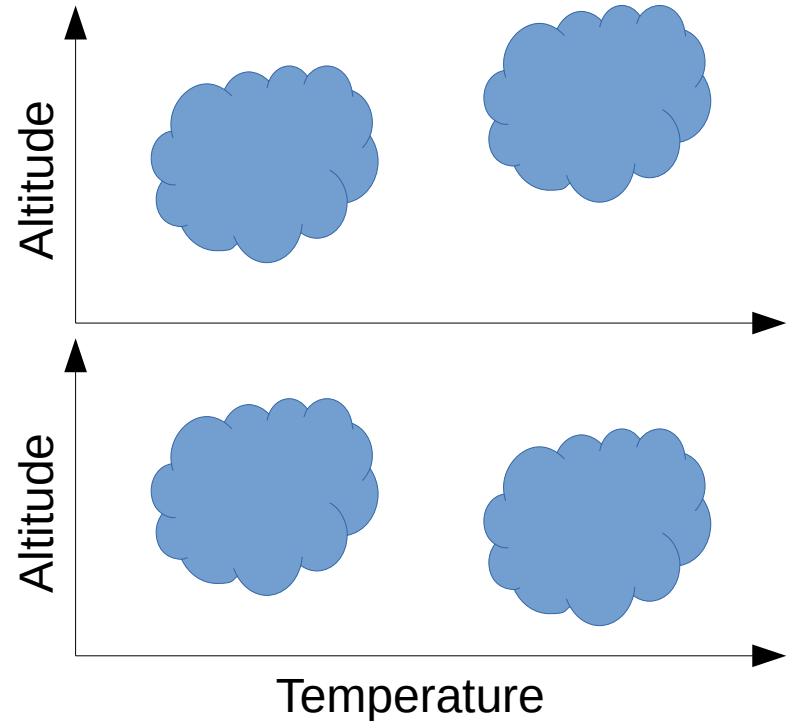
Extreme rain occurs when close
to saturation.



Vertical lapse rate

If temperature increases but moisture stays the same – cloud base heights go up (lower chance of rain)

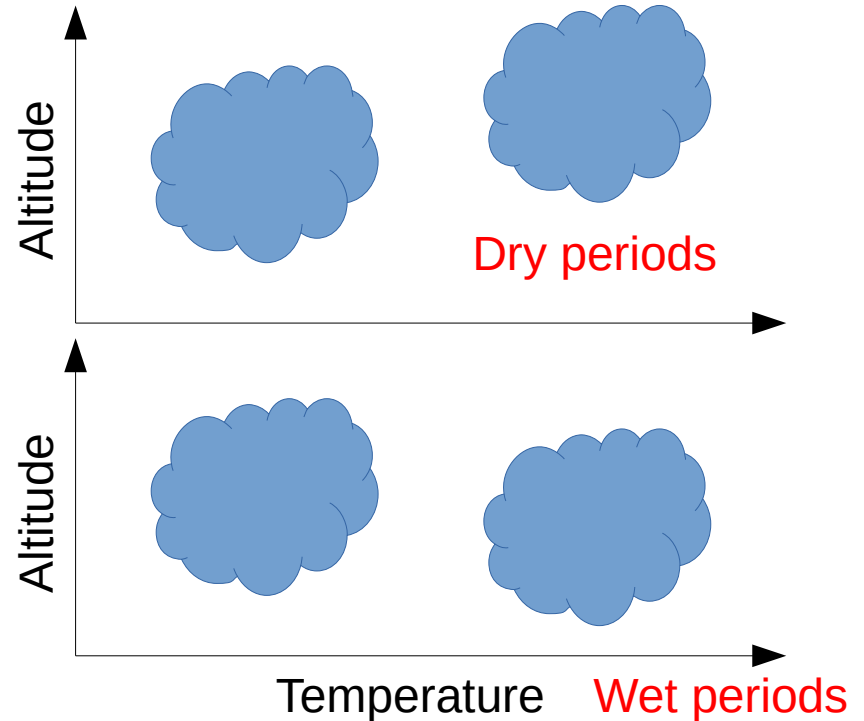
If temperature and moisture increase together – cloud base heights go down (higher chance of rain)



Vertical lapse rate

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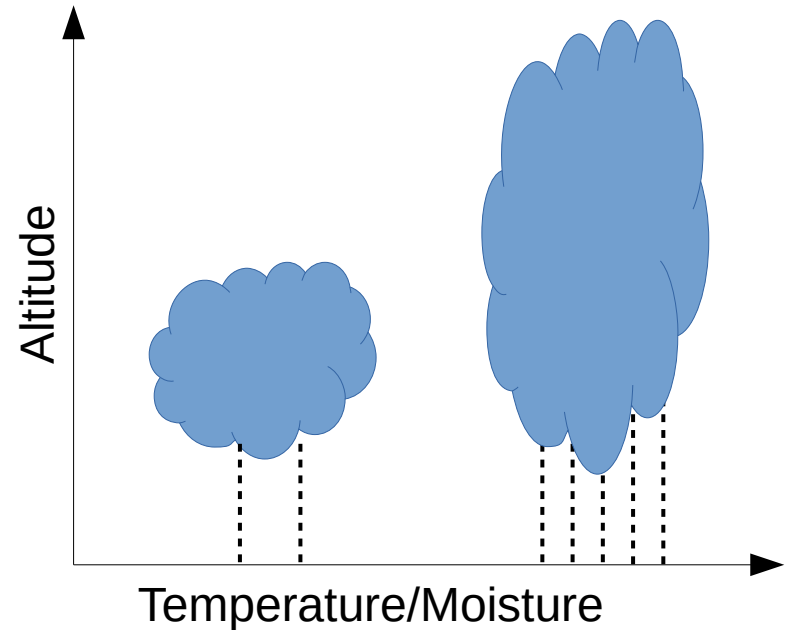
If temperature and moisture increase together – cloud base heights go down (higher chance of rain)



Condensation buoyancy

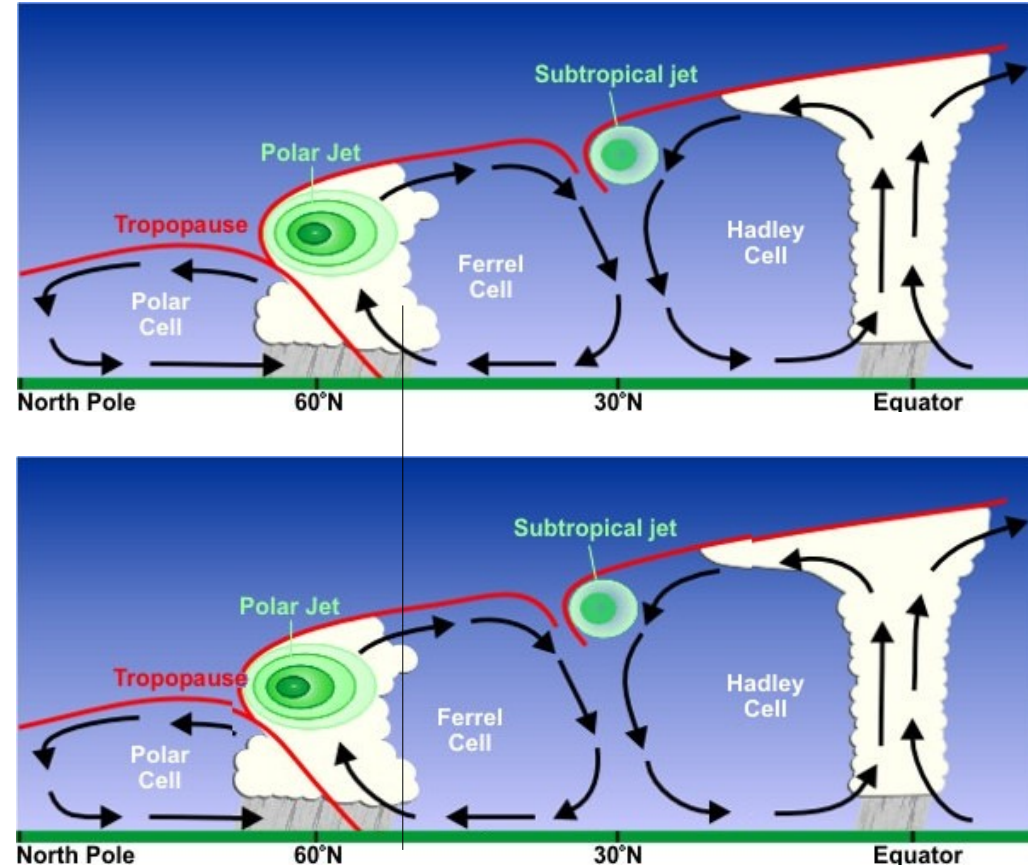
Condensation in clouds releases heat, increasing buoyancy and hence updrafts.

For systems near saturation: higher temperature means more moisture, more condensation, more buoyancy, stronger updrafts, deeper convection, more rain.



Global circulation changes

The Hadley cell is expanding poleward – pushing the mid-latitude storm tracks poleward





How will different rainfall durations be impacted?

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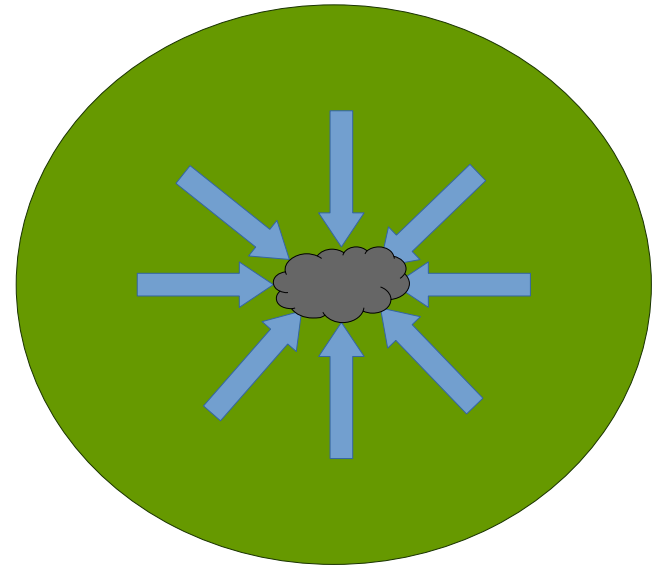
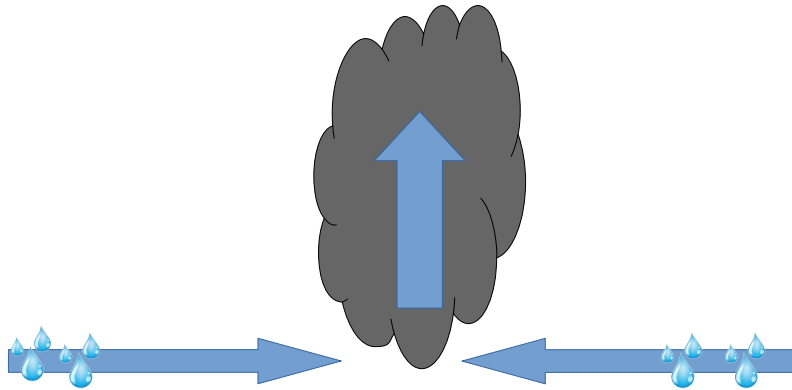
What about longer durations?

All these effects (other than global circulations changes) act on convective timescales (Instantaneous - 1 hour)

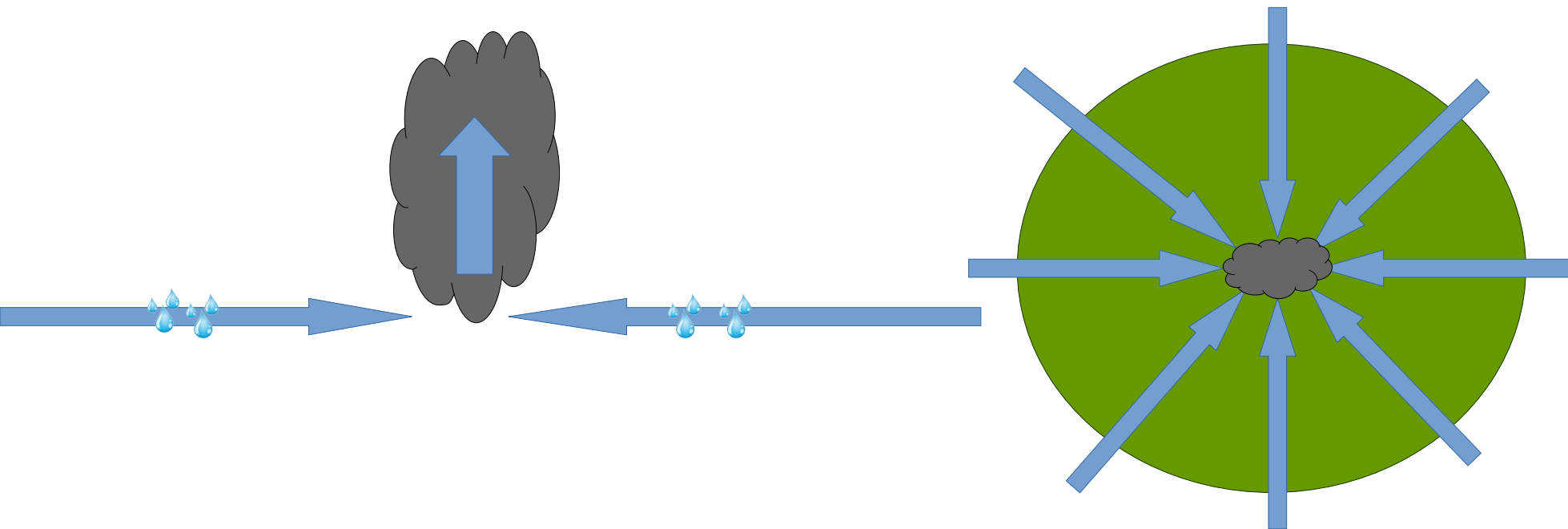
And convective space scales (100m - 1km)

Longer durations also require surrounding moist air masses to converge at the storm.

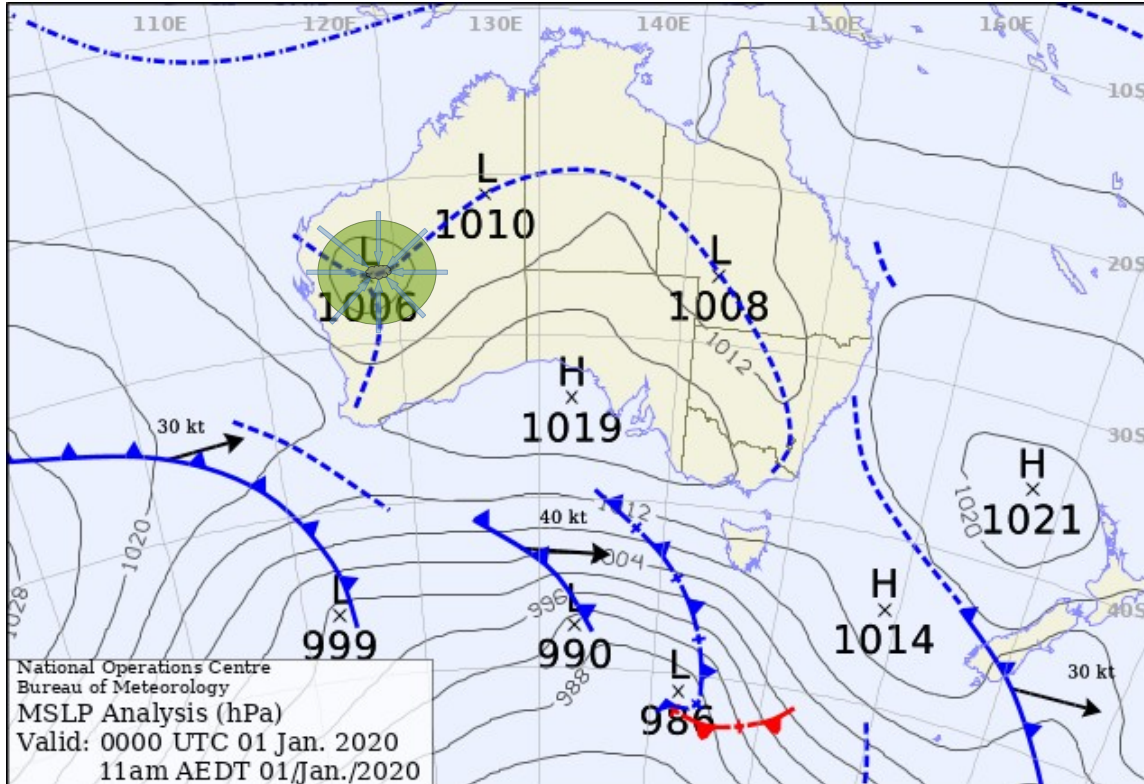
A few hours



12 hours



1 day +





Where in Australia will climate change impact rainfall?

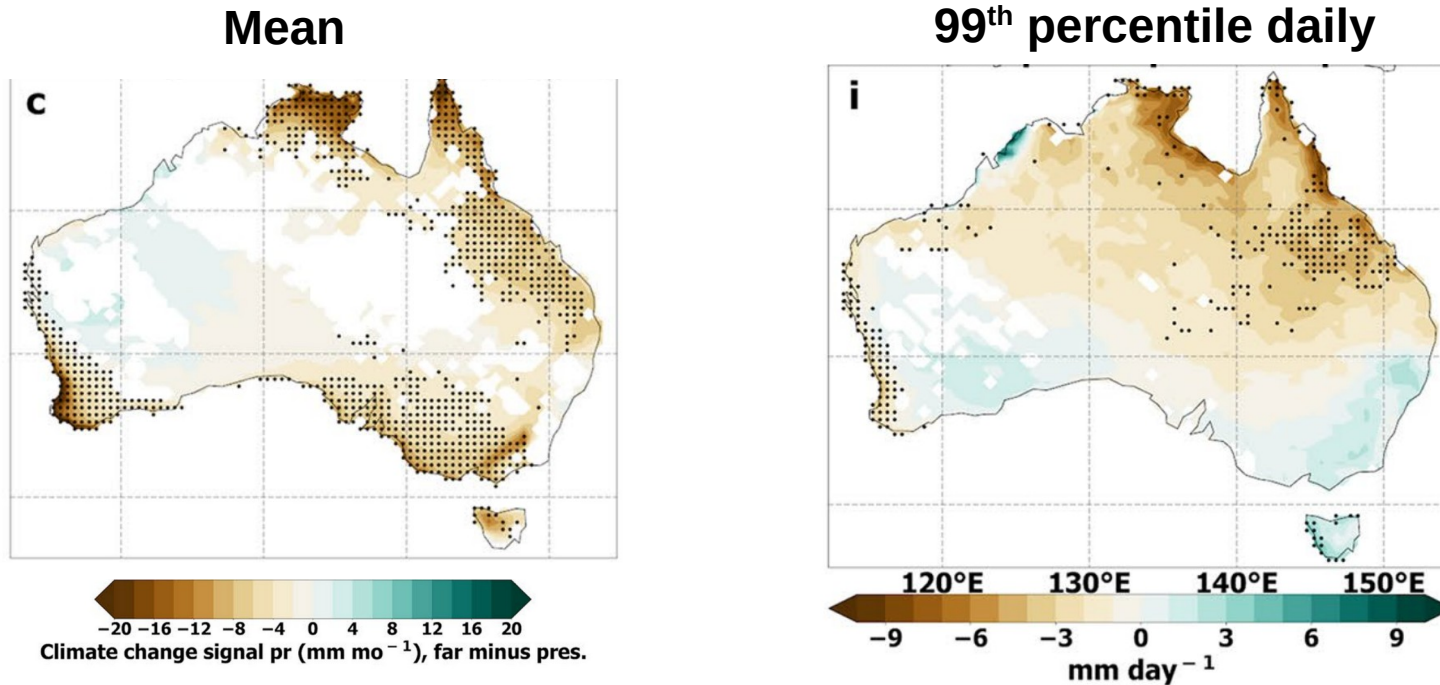
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rainfall changes to far future

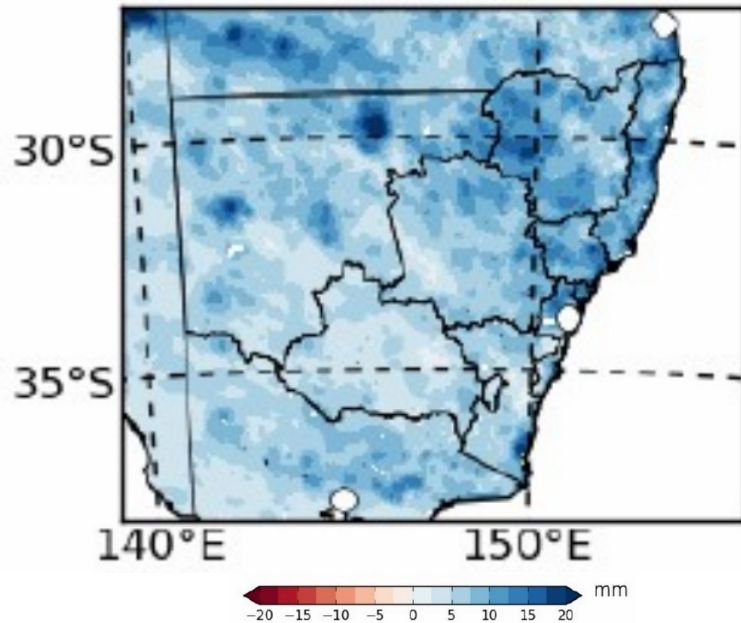
(2070-2099) minus (1976-2005)



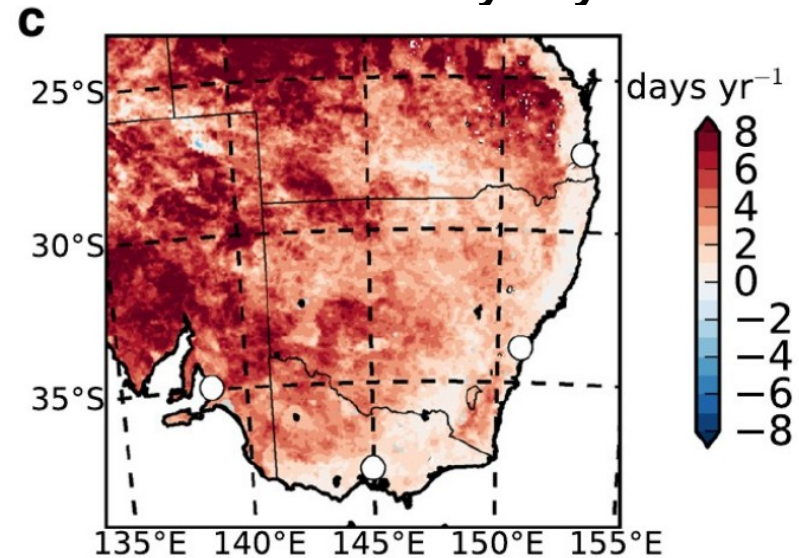
Daily rainfall changes

(2060-2079) minus (1990-2010)

Annual 1 day max



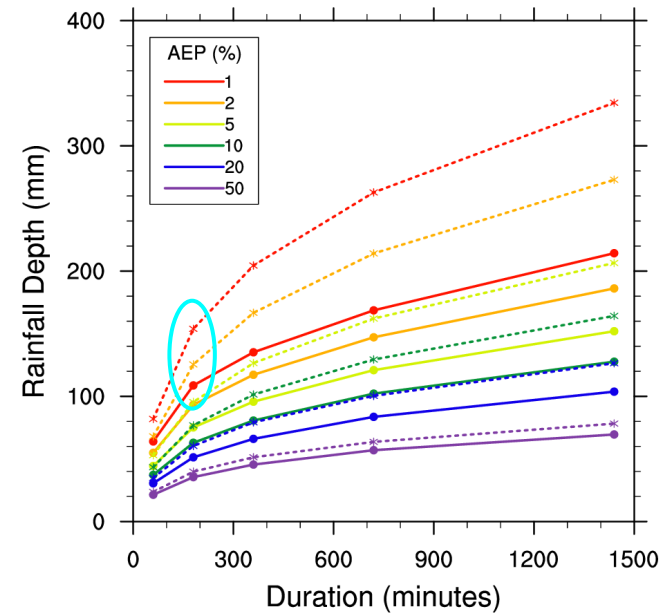
Consecutive dry days



Future sub-daily extreme precipitation?

- No robust assessment of future changes in sub-daily rainfall extremes over Australia at convective scale (~1km res)
- Early work over Sydney (with many caveats) found 3 hour 1% AEP increase ~40% by 2050 (~20%/K)

Present day (solid) vs Future (dashed)
(1990-2009) (2040-2059)



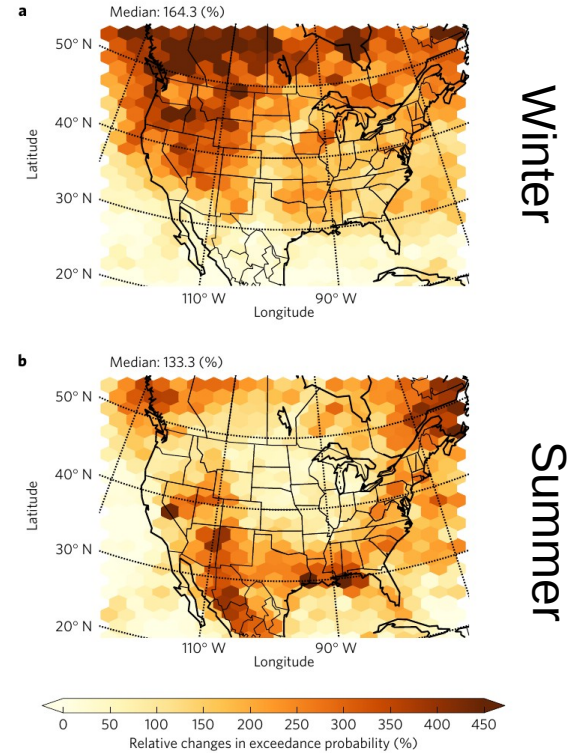
Evans, J. P., & Argueso, D. (2015). WRF simulations of future changes in rainfall IFD curves over greater Sydney (pp. 33–38). Presented at the The Art and Science of Water - 36th Hydrology and Water Resources Symposium, HWRS 2015.

Future sub-daily extreme precipitation?

Over the USA extreme hourly precipitation has been found

- to increase 50% or more in some regions
- Exceedance probabilities increase up to 400%
- For some storm types increases in precipitation rate and area under heavy precip results in 80% increases in storm volume

Prein, A. F., Liu, C., Ikeda, K., Trier, S. B., Rasmussen, R. M., Holland, G. J., & Clark, M. P. (2017). Increased rainfall volume from future convective storms in the US. *Nature Climate Change*, 7(12), 880–884. <https://doi.org/10.1038/s41558-017-0007-7>





Summary

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Summary

As the atmosphere warms many aspects of the thermodynamics & circulation of the atmosphere change.

This will impact precipitation **everywhere**.

Common future changes include:

- Increases in daily precipitation extremes
- Increases in the length of dry periods between storms (antecedent conditions)
- Larger increases in sub-daily precipitation extremes than daily (*requires more work to quantify robustly*)