Quantifying lateral boundary spin-up in regional models using an age of air diagnostic.

James Warner

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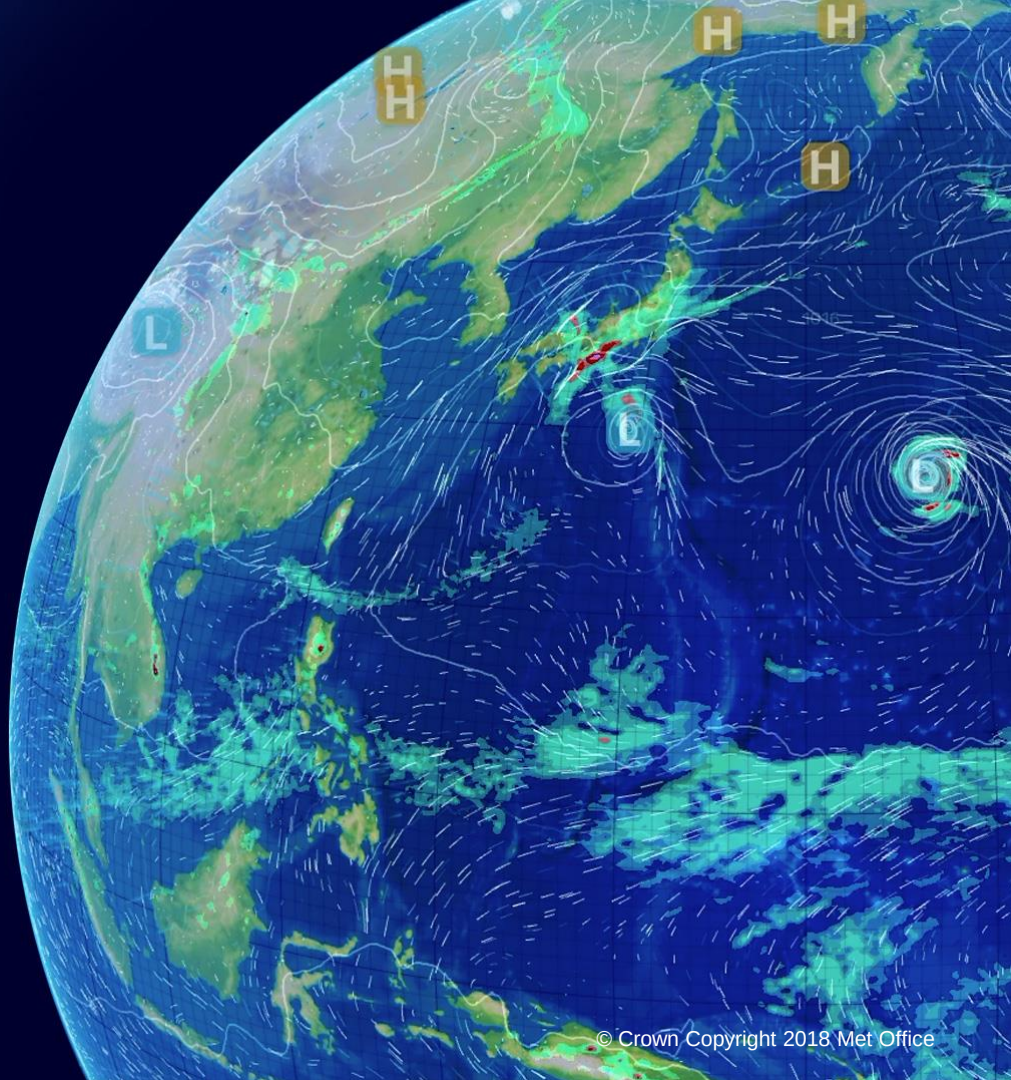

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How big should a domain be…?

“Needs to be able to spin-up remote atmospheric processes (jets, convection) which might feedback onto the area of interest”

“Large especially if the step-change in resolution at the boundary is significant”

“As large as possible considering job size in the HPC queue…”

“Depends on the weather regime…”

Worked on initial condition spin-up (focused on Africa), and implementation of warm-start. But what about lateral boundary spin-up?

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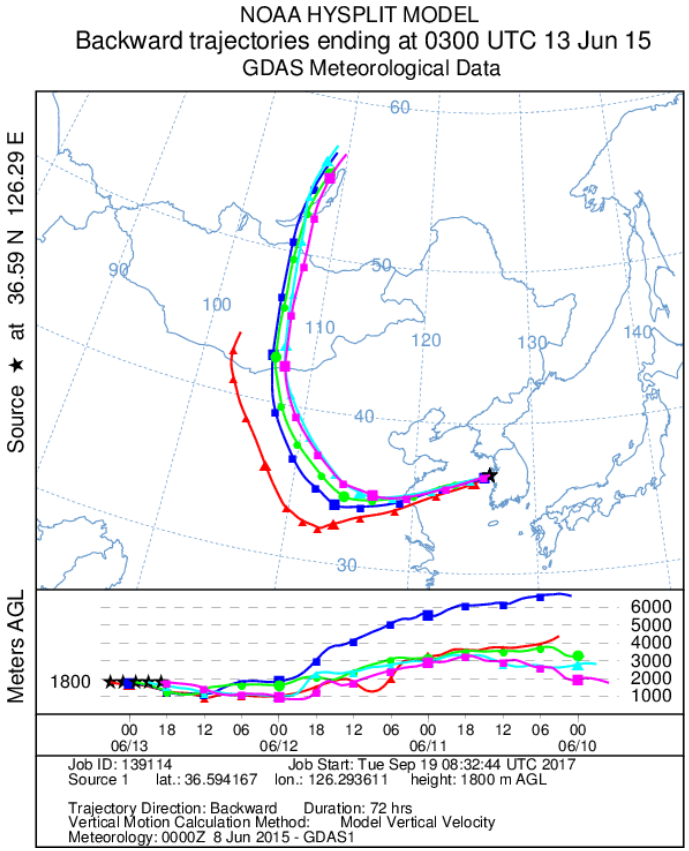
Age of air diagnostic

- Computes back trajectories using post-processed model output (U,V,W components and Z to compute displacement, on standard 16 pressure levels, 3 hourly).

- Relatively coarse temporal resolutions: strong localised winds/updrafts may produce unrealistic back-trajectories. Vertical velocities smoothed horizontally using Gaussian filter.

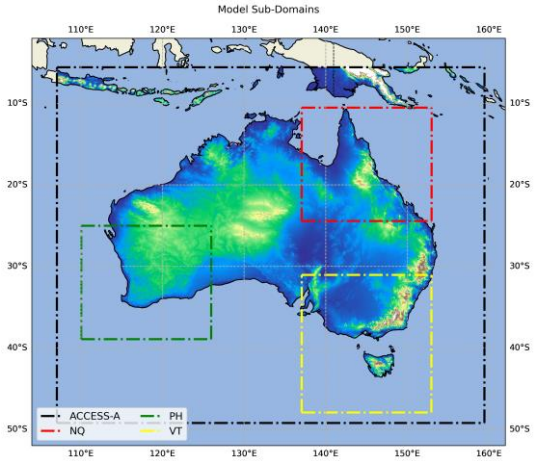
- Similar to NOAA HYSPLIT MODEL, at every grid point on some pressure level/lead-time, compute back trajectory to determine when air entered the domain through LBCs (if it does).



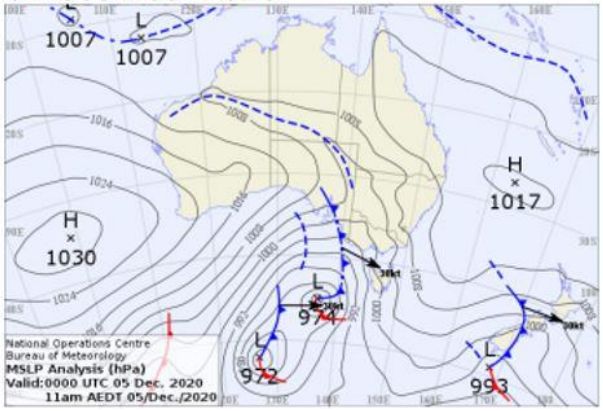
https://www.researchgate.net/figure/Back-trajectory-analysis-for-RF06_fig4_345973814

Case Studies

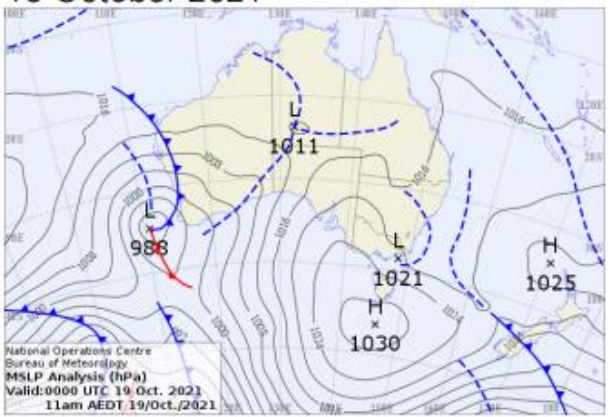
- Comparing new ACCESS-A domain to ACCESS-C regional domains for three case studies, using RAL3p2 science, and same setup.



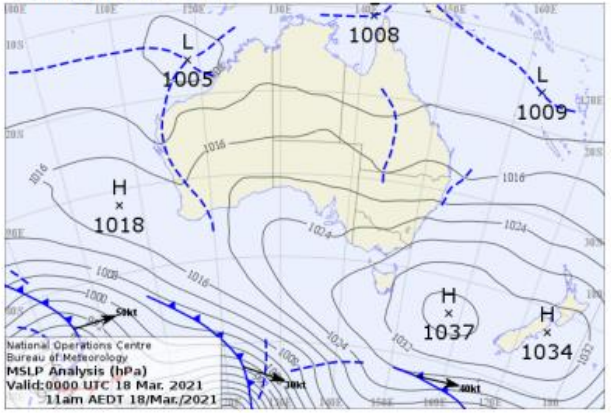
5 December 2020



19 October 2021



18 March 2021



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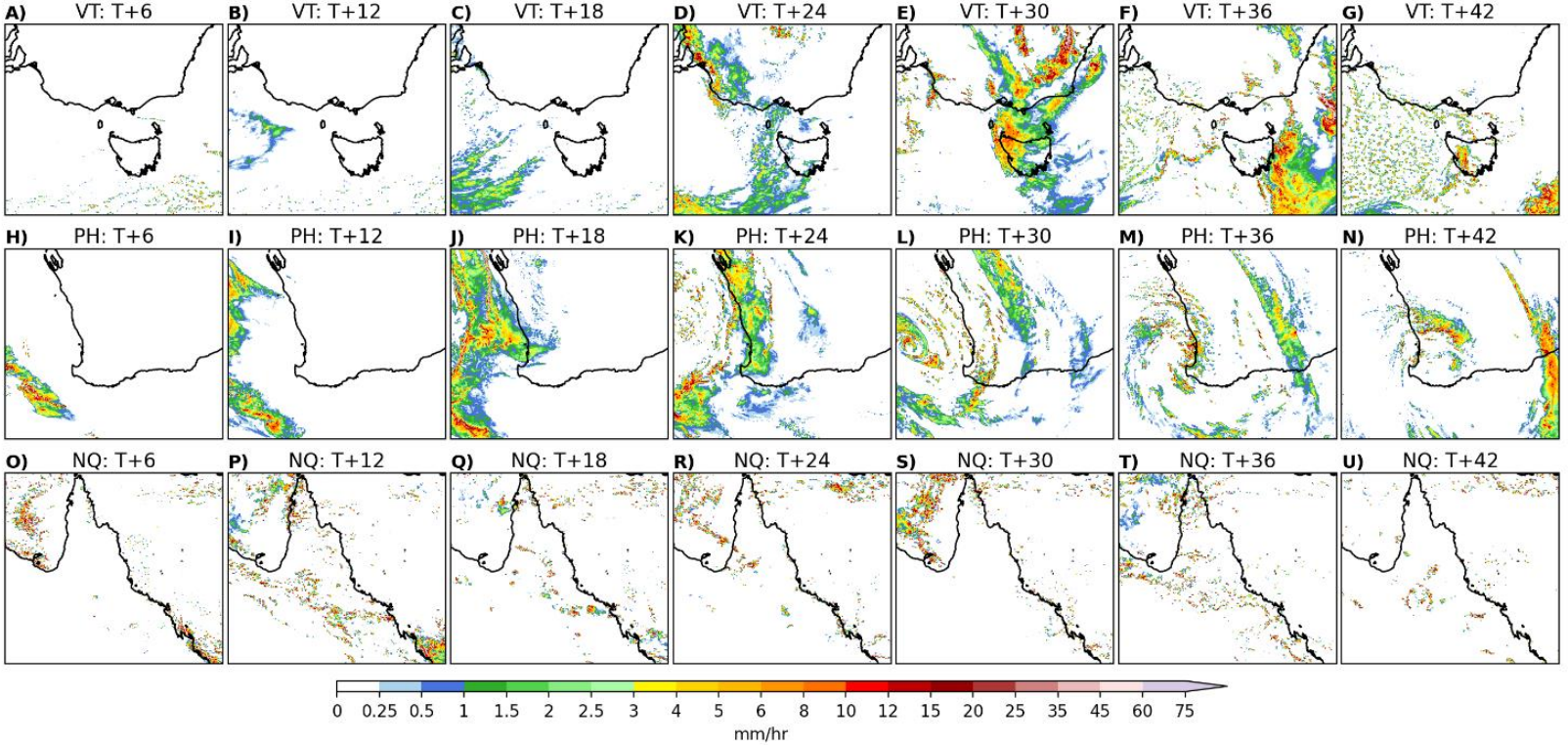
Case Study Evolution



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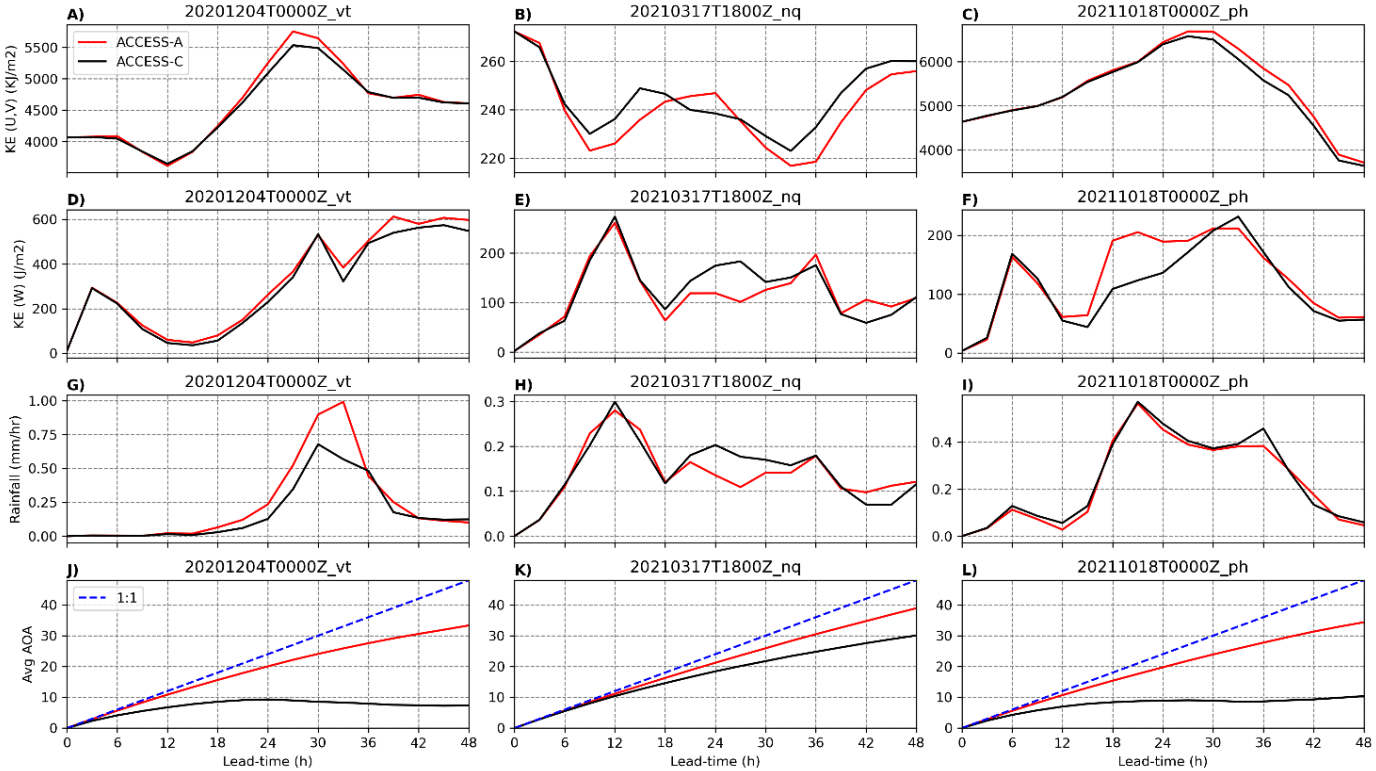
Domain Average Metrics



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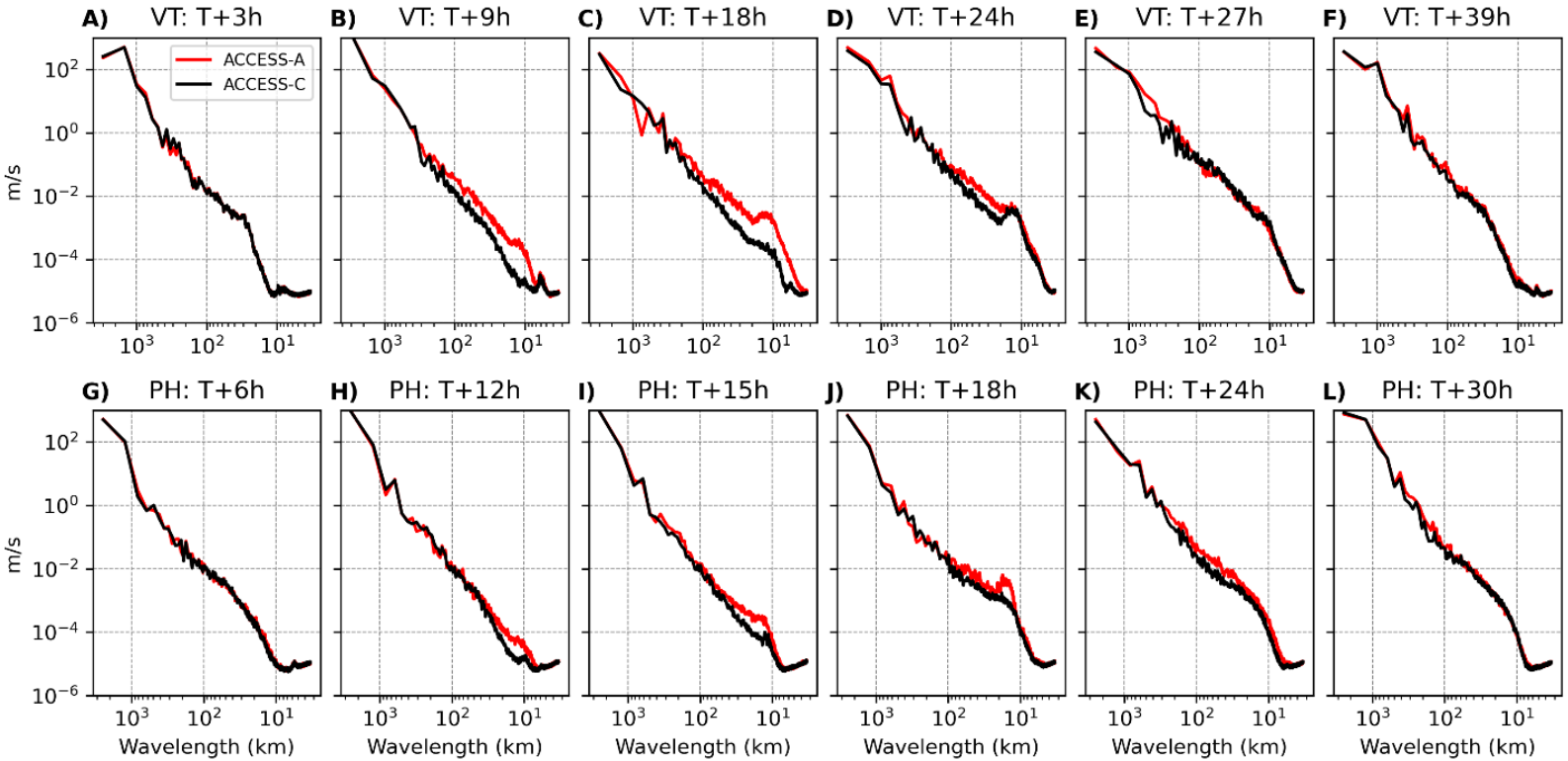
Power Spectra



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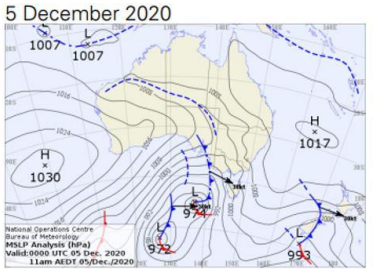
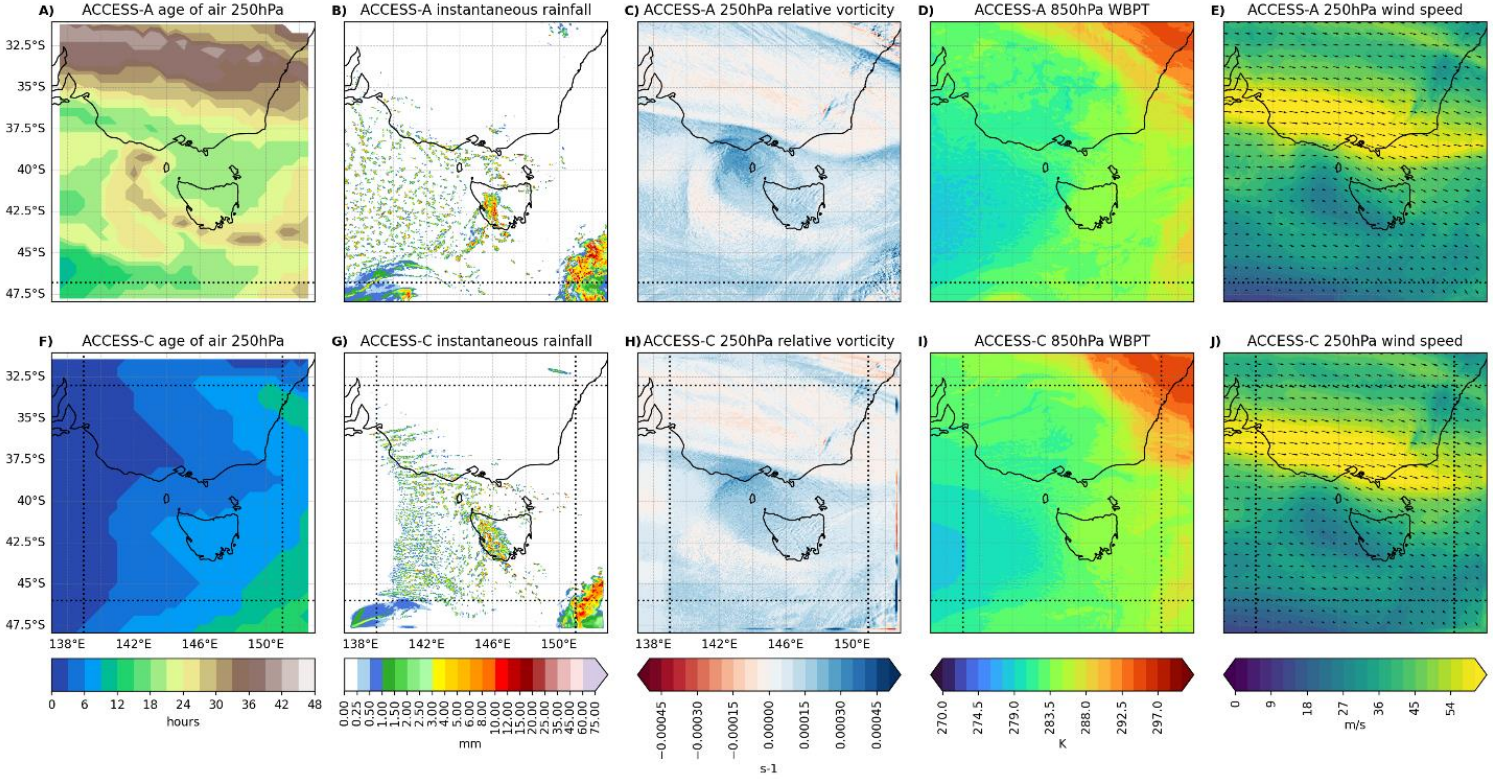
Case Study 5th December, T+42





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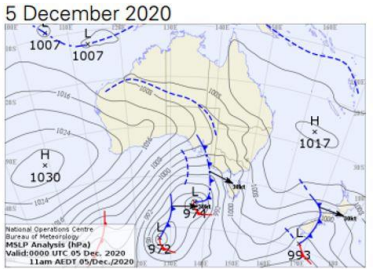

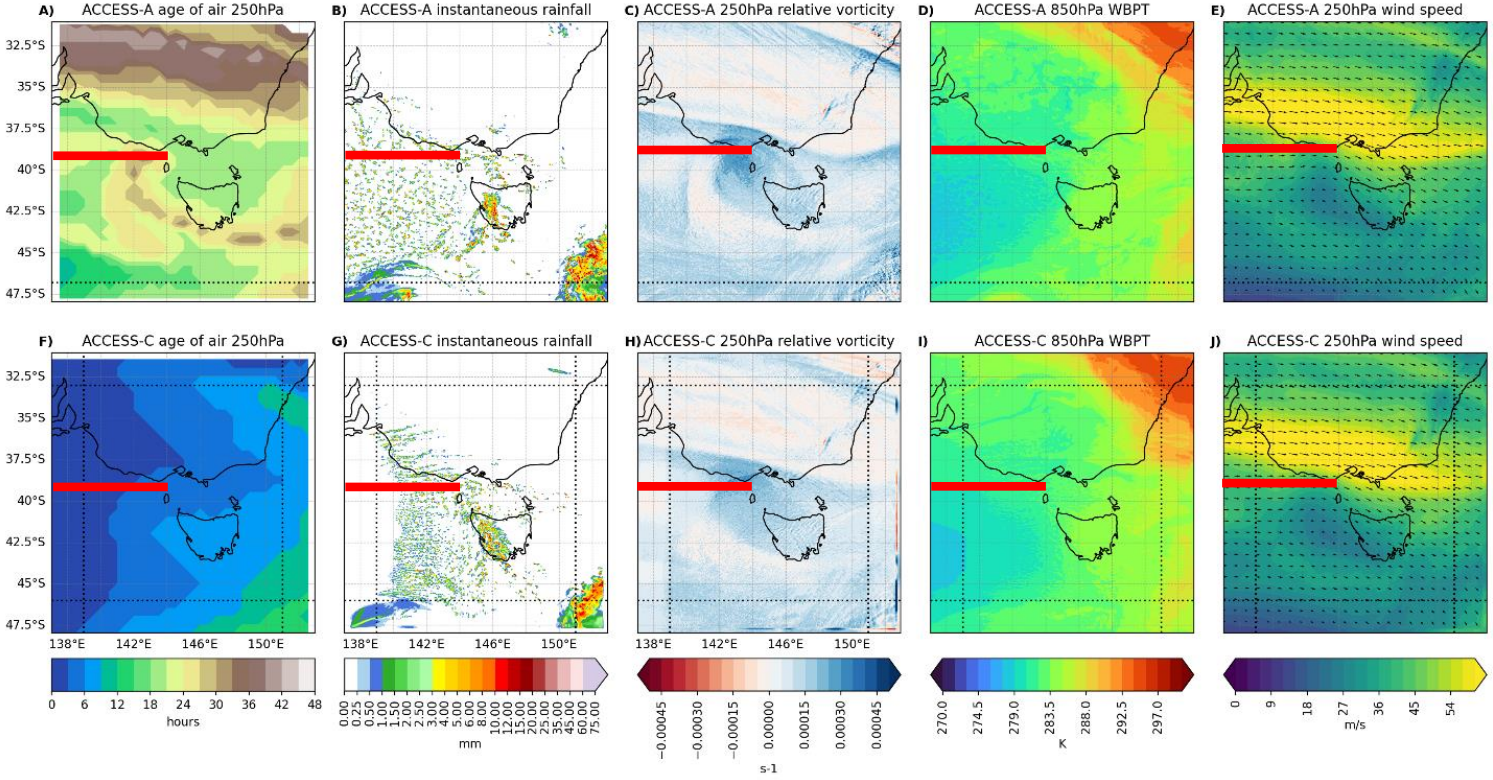

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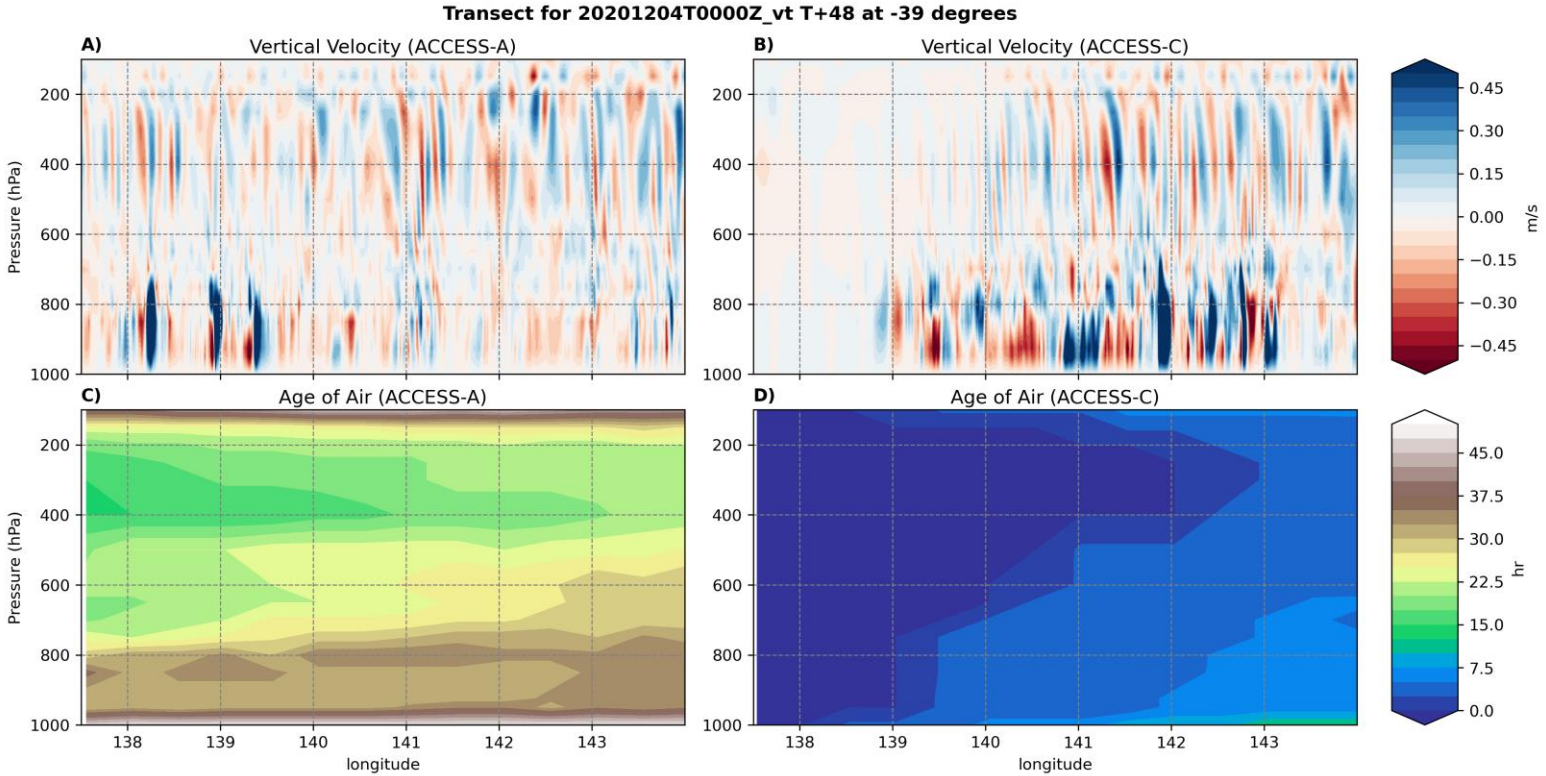

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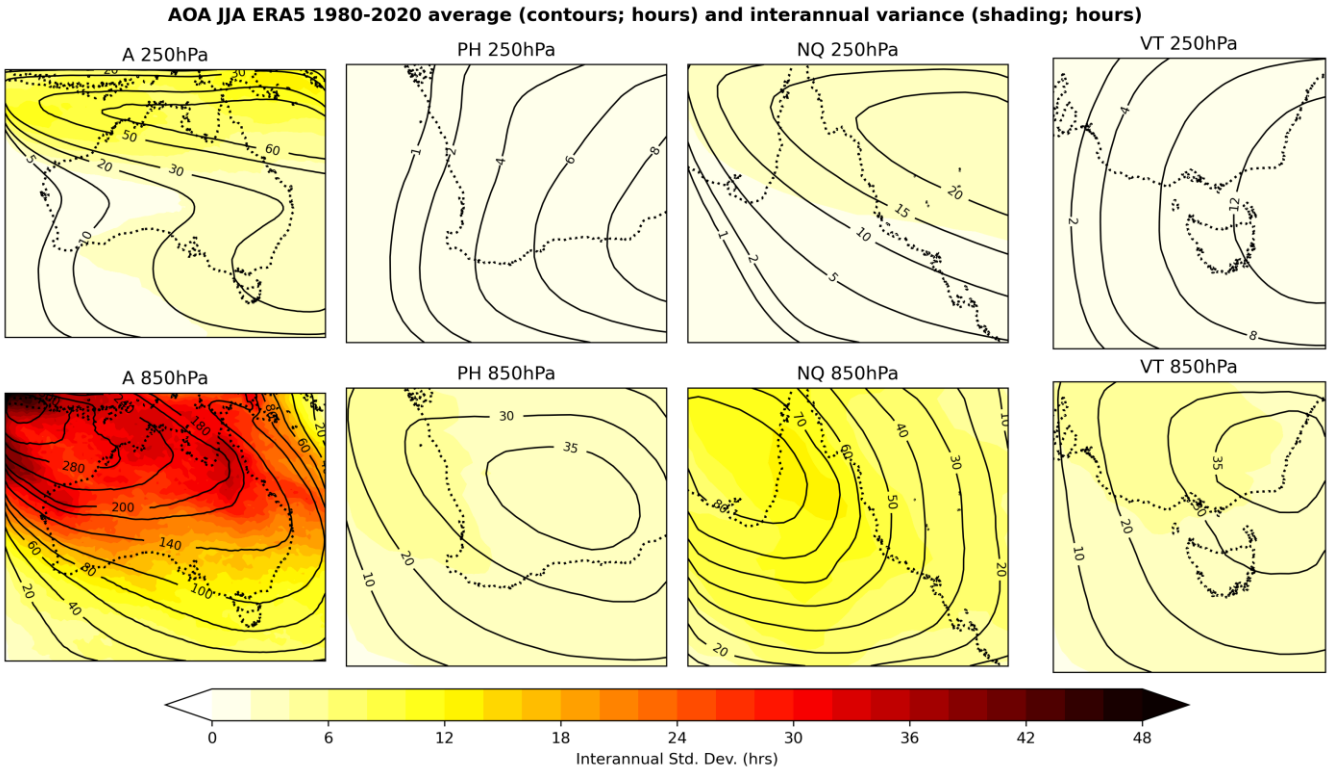
Generalisation of diagnostic



1. Each year from 1980-2020, extract ERA5 U,V 3 hourly winds for May-August inclusive.
2. For every 3 hours from 1st June, do AOA calculation at 250hPa and 850hPa.
3. Once season done, average age of air over the season.
4. Repeat for other years, average across all years (shading) and calculate standard deviation (contours).
5. Could stratify by weather regime etc..

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Conclusions

1. Age of air diagnostic useful to qualitatively compare to other metrics such as power spectra, kinetic energy to understand lateral boundary spin-up.
2. In these case studies, spin-up at boundary in post-front flow evident, and suggestion of improved up-scale of structures in larger domain.
3. Generalisation of diagnostic to other applications (compositing by regime, impact of driving model).
4. Diagnostic now in development for CSET for all partners to use.

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