Recurrent Rossby Waves in the North Atlantic

Outline:

- What are RRWPs and links to persistent weather
- Understanding dynamical drivers of RRWPs with the help of Causal Networks

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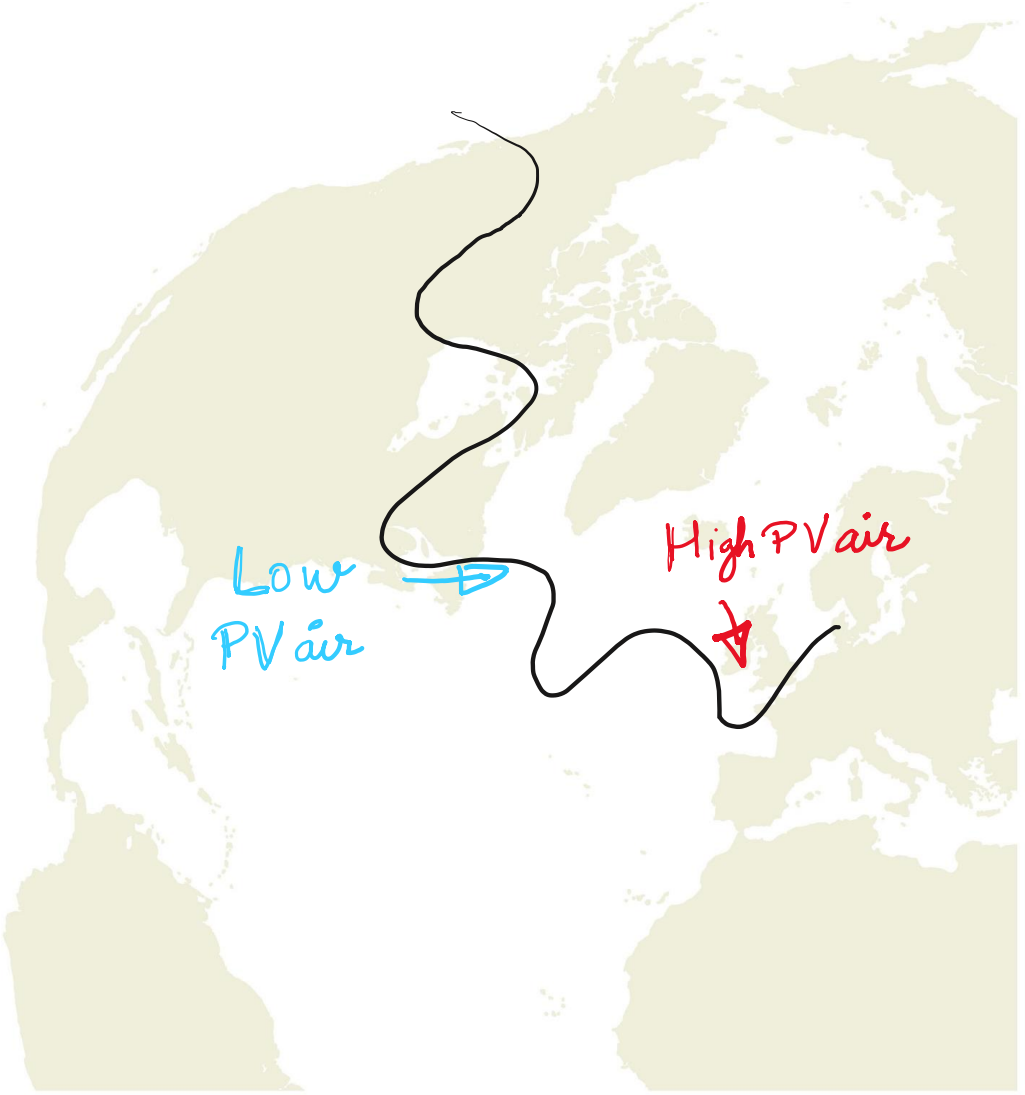
What are Recurrent Rossby Waves?

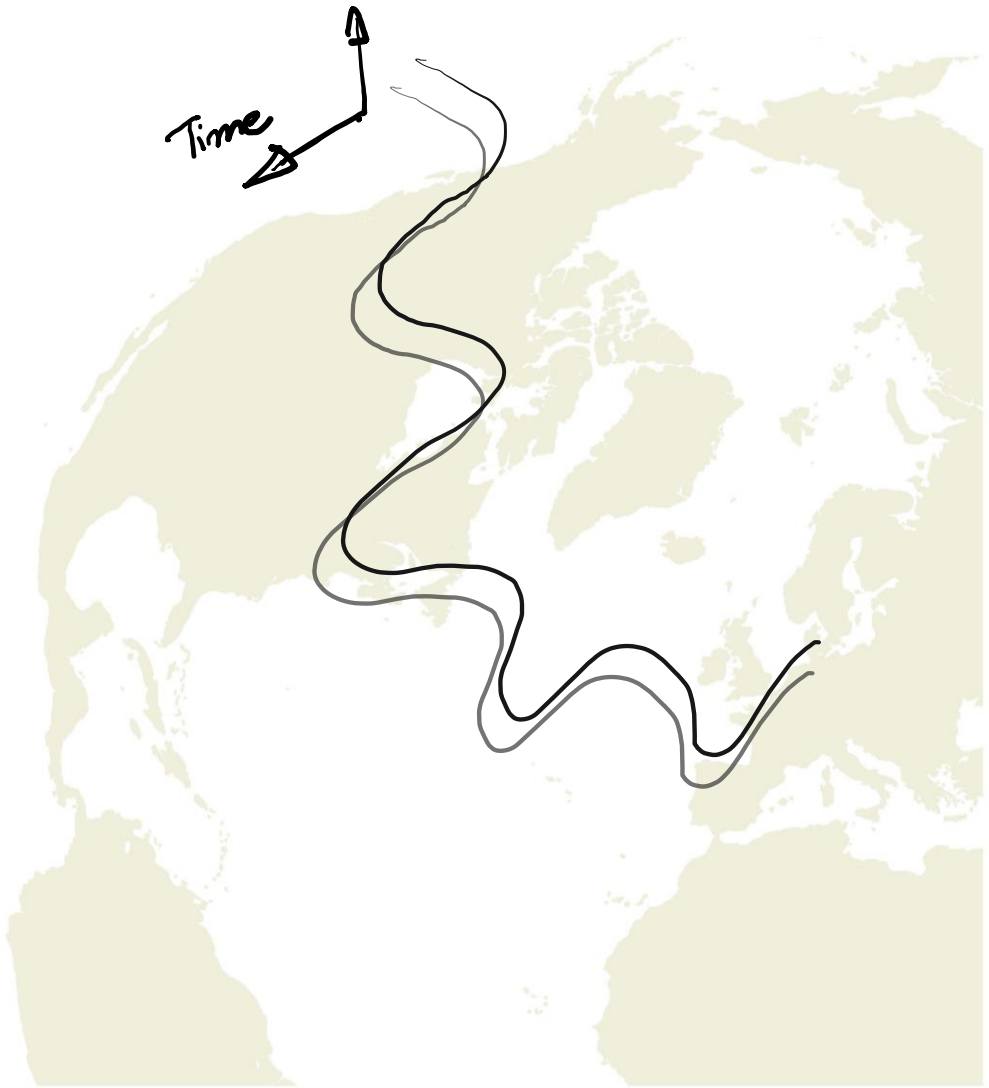


Rossby waves can be visualized by wind at upper levels.

What are Recurrent Rossby Waves?

Recurrence of Rossby waves on a weekly to bi-weekly period in the same phase at a location is termed as “Recurrent” Rossby waves (RRWs).

What are Recurrent Rossby Waves?

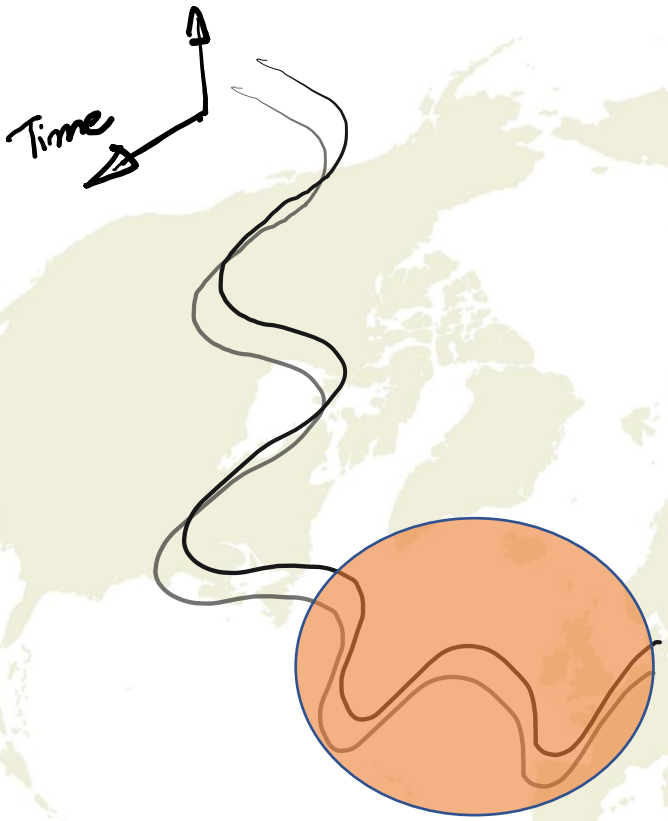


Recurrence of Rossby waves on a weekly to bi-weekly period in the same phase at a location is termed as “Recurrent” Rossby waves (RRWs).

RRW activity measured with **R-metric**: envelope of the synoptic-scale wave numbers of the meridional wind at upper levels between 35° N and 65° N (Röthlisberger et al. 2019 JClim).

Links with persistent surface weather established (Röthlisberger et al. 2019, JClim; Ali et al. 2021, GRL).

Research Question



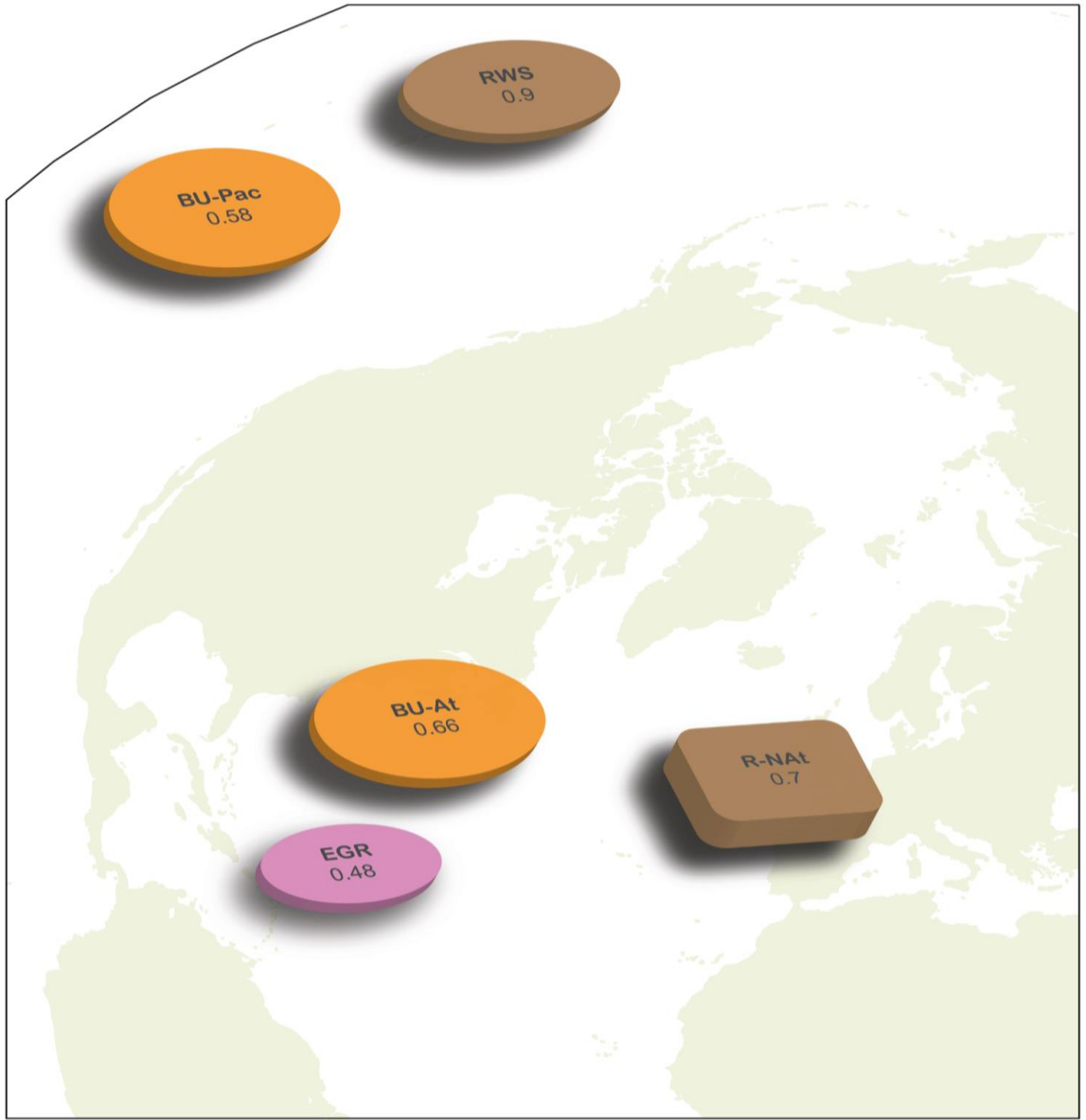
What is driving high RRW activity over the North Atlantic?

ERA 5 dataset

A set of 30 independent **high R events** to identify important drivers in DJF and JJA

Drivers are identified with time-lagged composite maps using a bootstrapping approach to identify statistically significant regions.

Possible drivers identified from composite maps

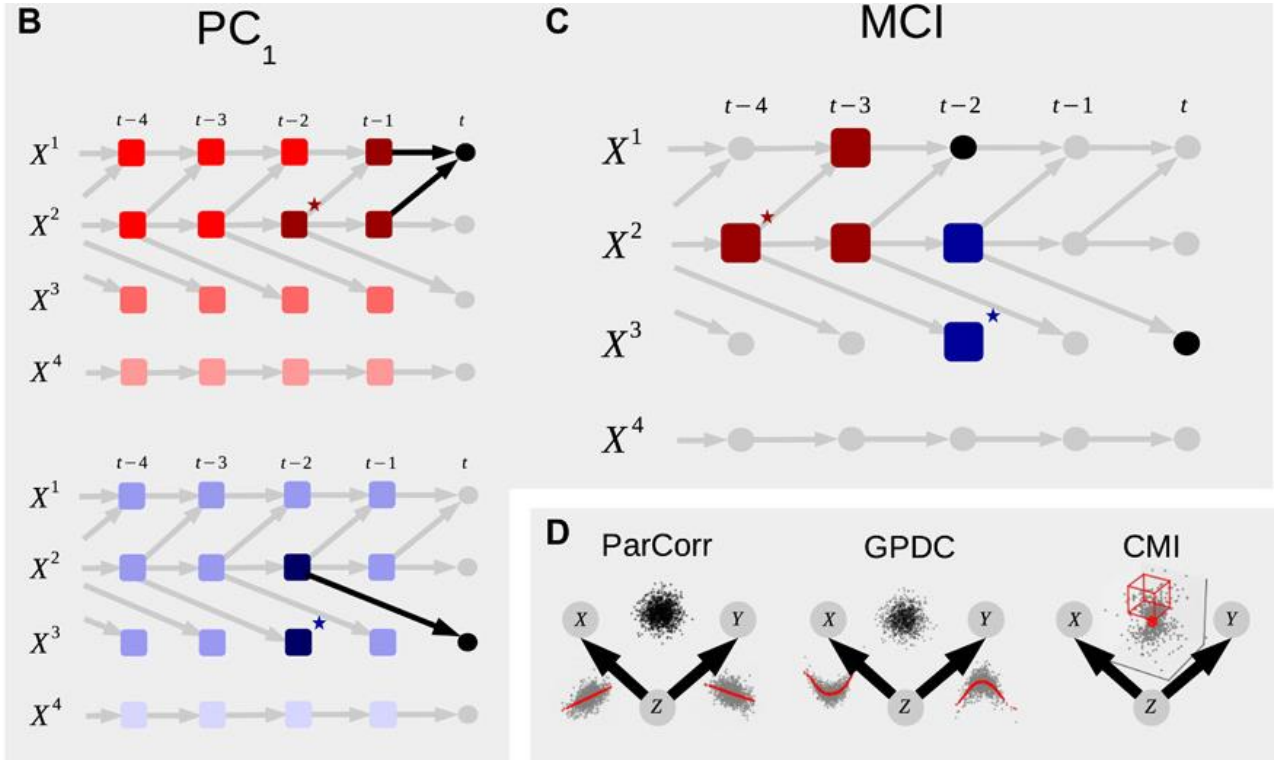


BU = background U, wavenumber (k=0 to k=3) filtered zonal wind

EGR= Eady growth rate at 700 hPa

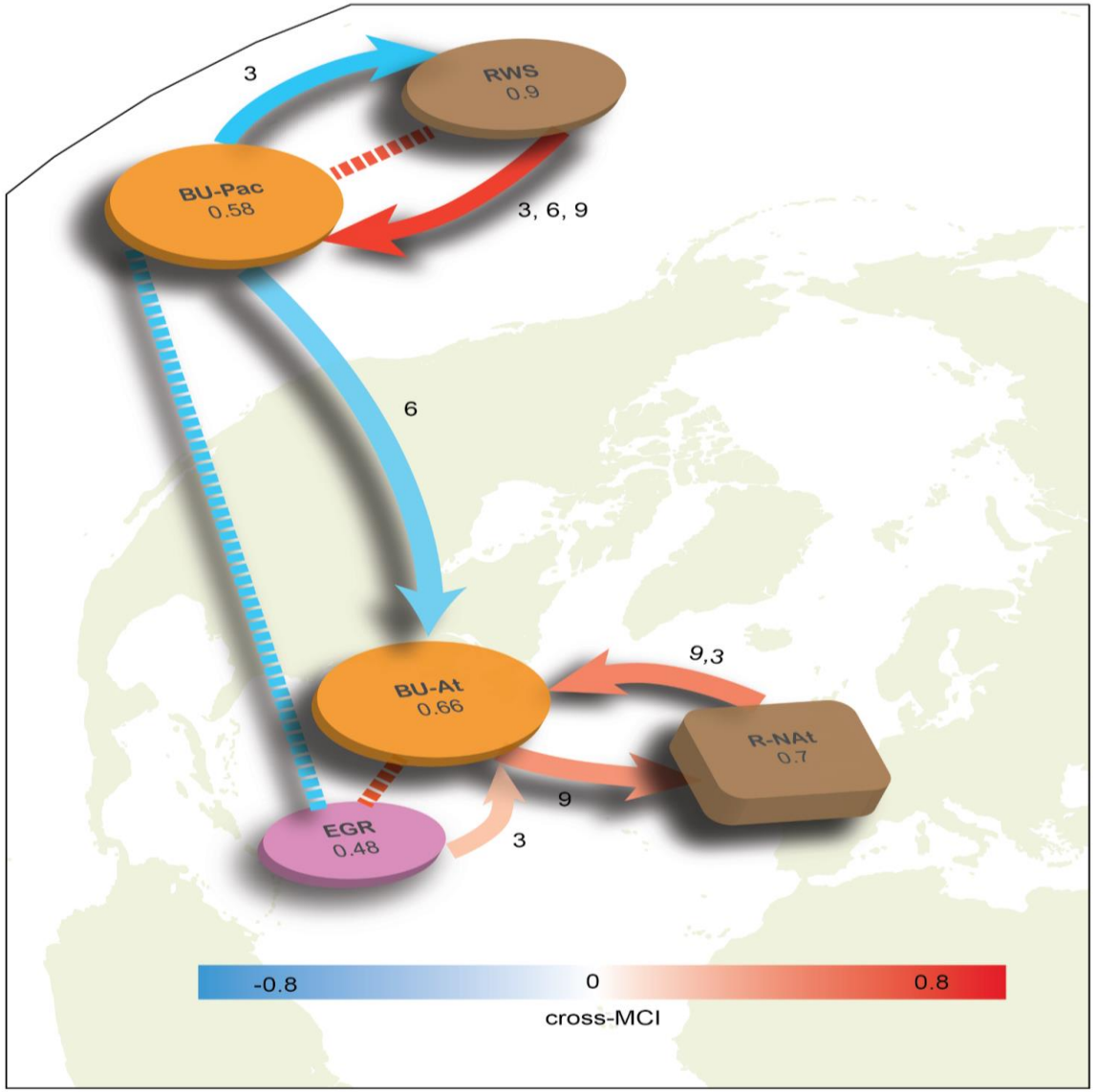
RWS= Rossby wave source due to advection

How to assess causal drivers? PC-MCI



PC-MCI uses time-lagged iterative conditional independence tests (Runge et al. 2019).

Results: Causal Network for DJF



Take home messages

- RRWs over the North Atlantic are driven by changes in low frequency flow.
- BU over Pacific and RWS is not a direct driver of R.

Thank you!
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References

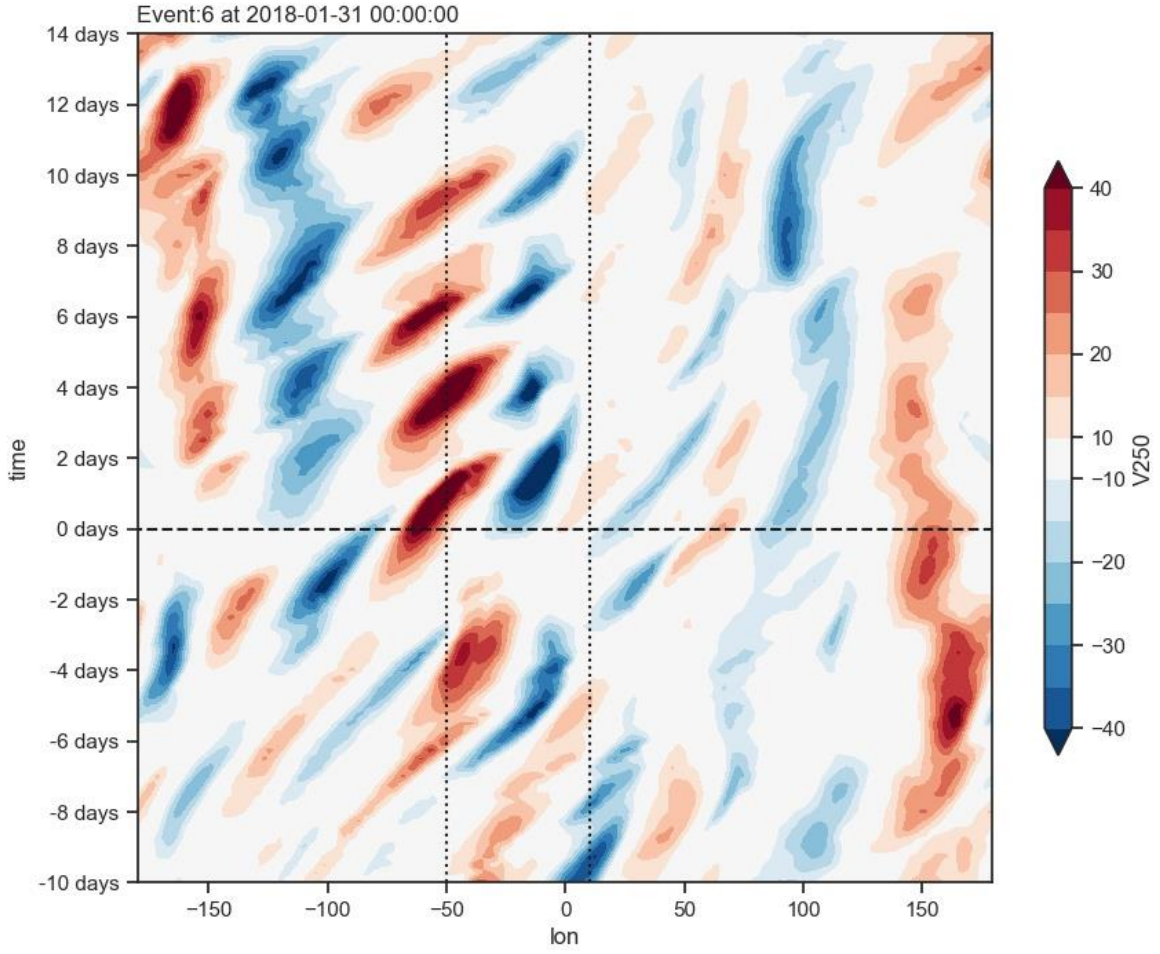
Ali, S. M., Martius, O., and Röthlisberger, M.: Recurrent Rossby Wave Packets Modulate the Persistence of Dry and Wet Spells Across the Globe, Geophys. Res. Lett., 48, e2020GL091452, https://doi.org/https://doi.org/10.1029/2020GL091452, 2021.

Ali, S. M., Röthlisberger, M., Parker, T., Kornhuber, K., and Martius, O.: Recurrent Rossby waves and South-eastern Australian heatwaves, Weather Clim. Dynam. Discuss. [preprint], https://doi.org/10.5194/wcd-2022-1, in review, 2022.

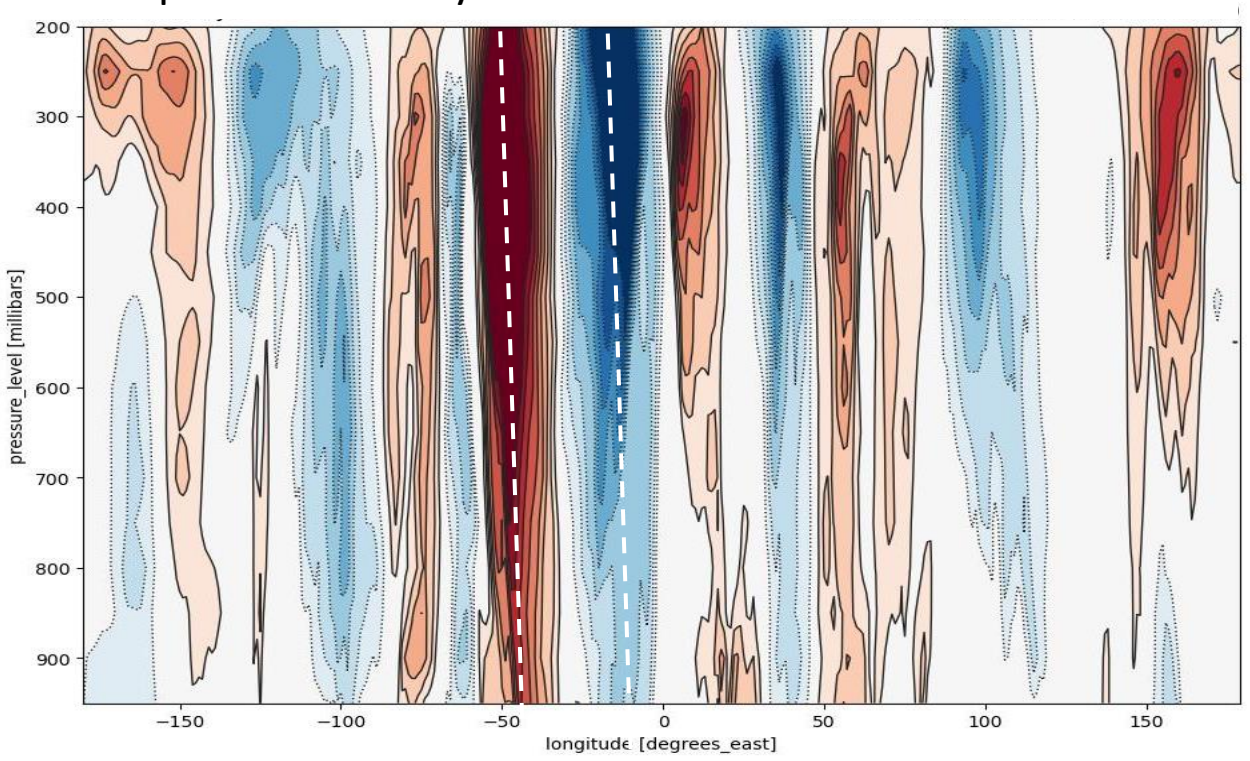
Röthlisberger, M., Frossard, L., Bosart, L. F., Keyser, D., and Martius, O.: Recurrent synoptic-scale Rossby wave patterns and their effect on the persistence of cold and hot spells, J. Clim., 32, 3207–3226, https://doi.org/10.1175/JCLI-D-18-0664.1, 2019.

Runge, J., Bathiany, S., Bollt, E. *et al.* Inferring causation from time series in Earth system sciences. *Nat Commun* **10,** 2553, https://doi.org/10.1038/s41467-019-10105-3, 2019

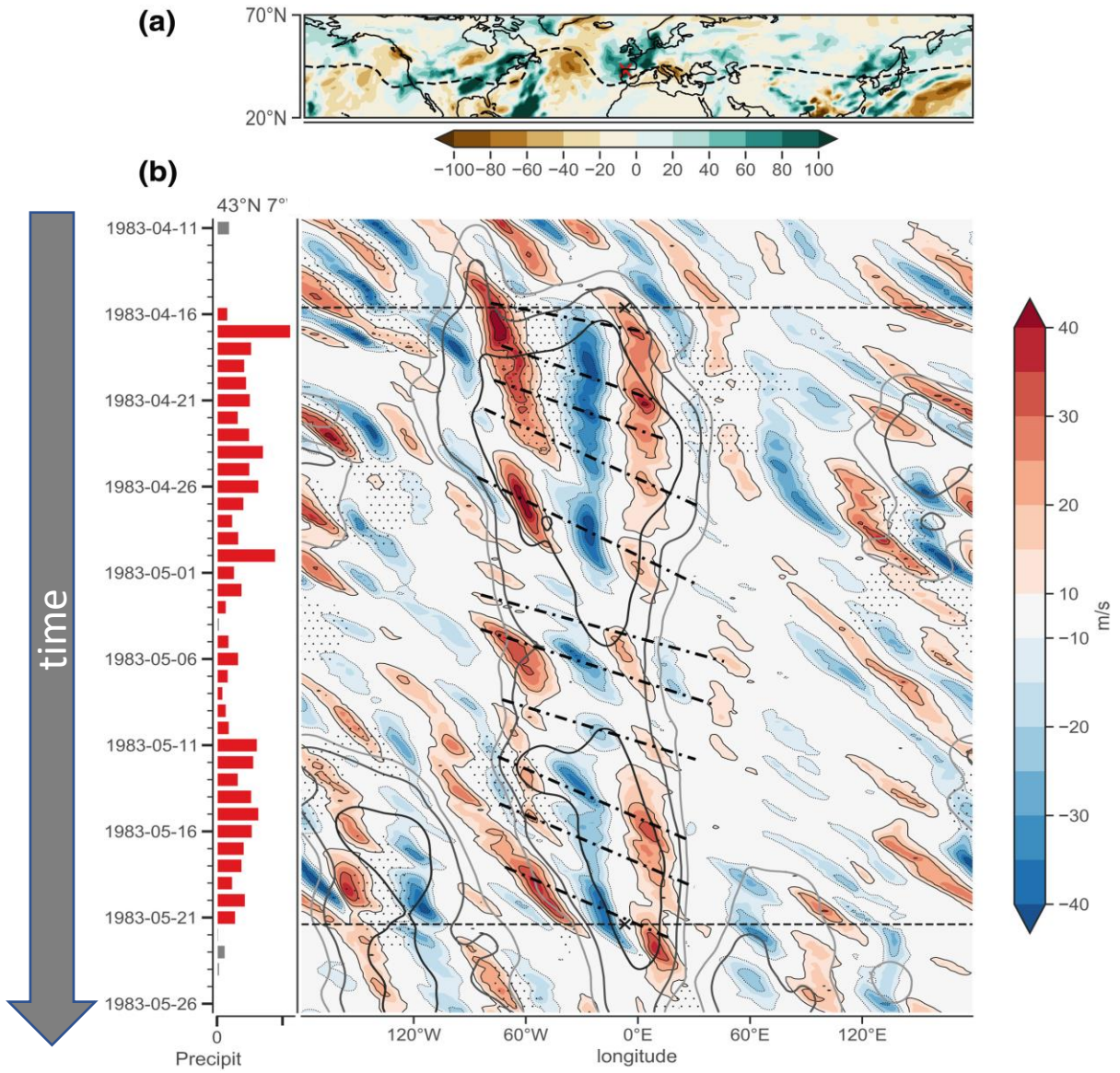
Appendix: Example event in 2018



Snapshot at t=1 day of the meridional wind in vertical



Example RRWPs and persistent weather: April-May 1983



- Anomalous precipitation over western Europe including parts of Iberia, France.

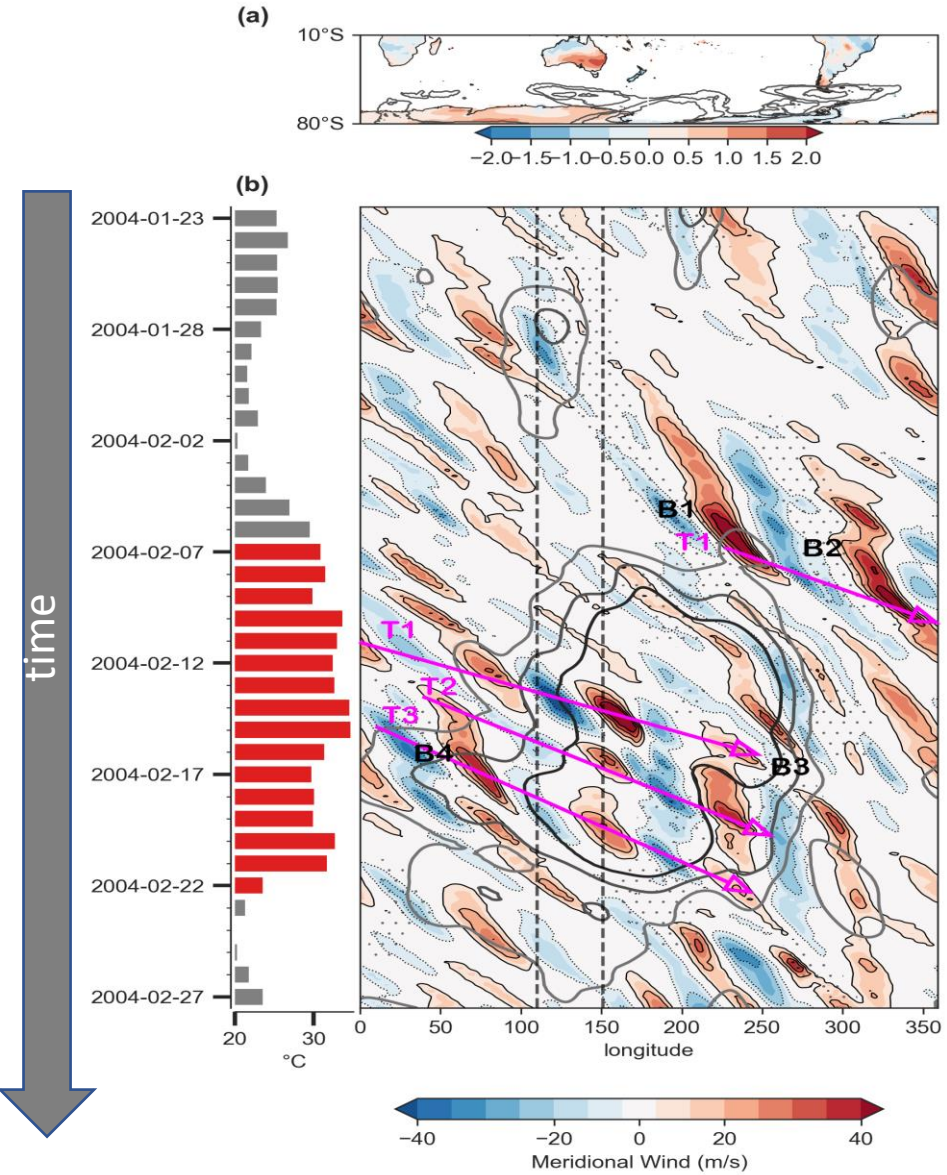
R-metric shown in black contours: A measure of RRWPs.

Extracts the envelop of the wave packets (synoptic-scale) using V250 hPa averaged between 35 and 65°N.

R-metric is a continuous metric with values at each longitudinal grid for each time step.

Ali et al. 2021 (GRL)

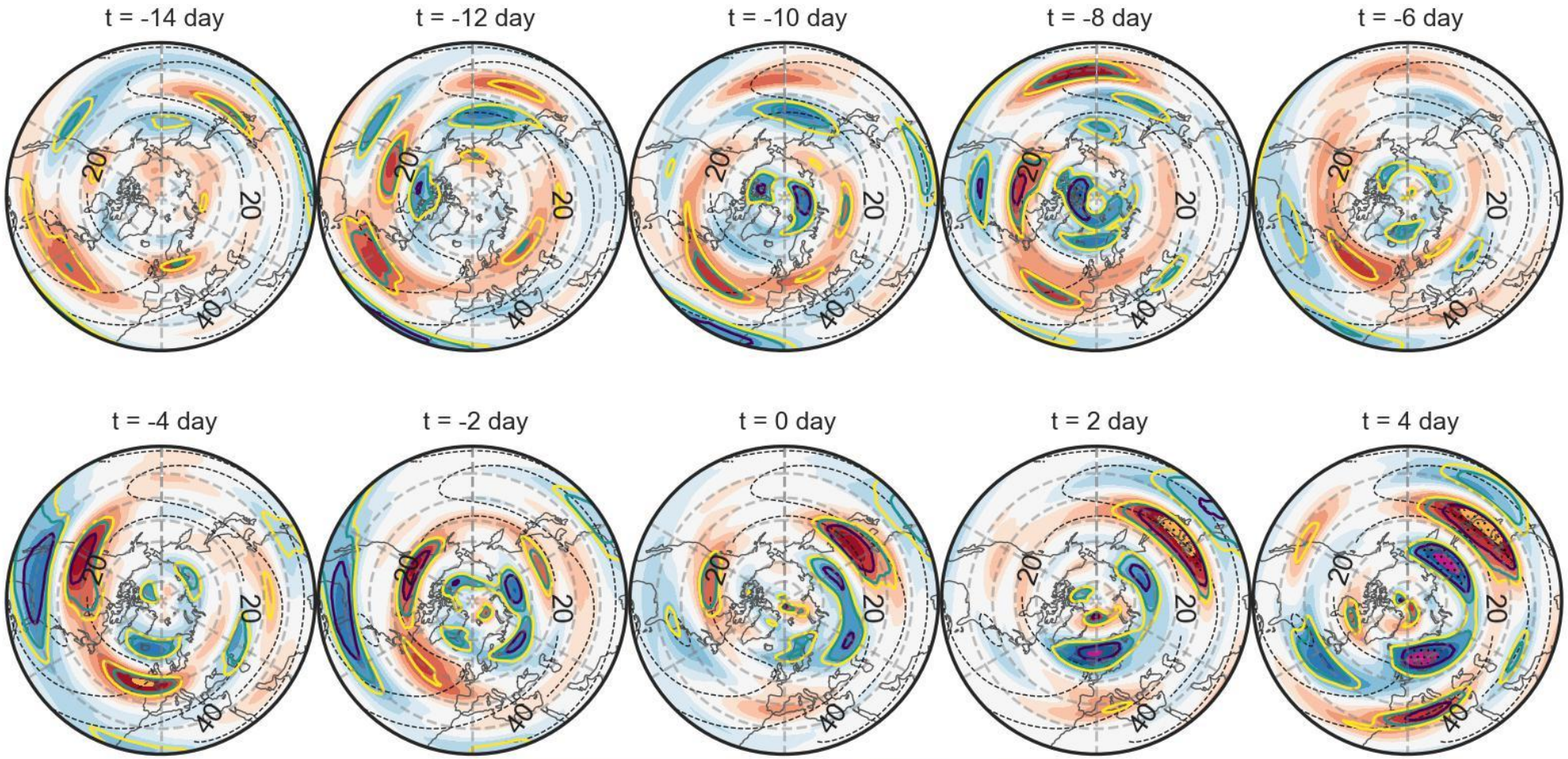
Appendix: Recurrent transient Rossby waves lead to repeated ridges

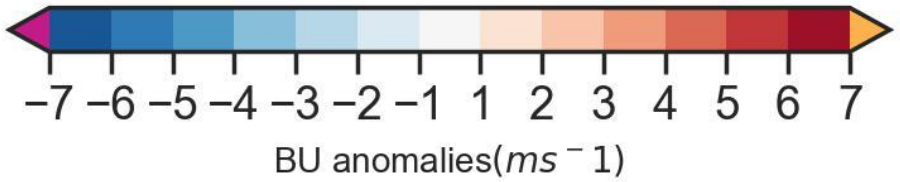


2004 south-eastern Australian Heatwave

Ali et al. 2022 (WCD in review)

Appendix: Time-lagged composite of wavenumber filtered (k=0 to k=3) zonal wind (BU) for high R events in DJF





P-value contours at 0.1, 0.05, 0.01, in yellow, green, blue contours.
Stippling show FDR corrected p-values less than 0.01