Rossby wave activity in the PRIMAVERA models

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A diagnostic for Rossby wave packets (RWPs) based on Local Finite Amplitude Wave Activity (LWA) in isentropic coordinates

$$LWA(\lambda,\phi,\theta,t)=\frac{-1}{\cos\phi}\int_{\phi}^{\phi+\Delta\phi}[(PV-Q)\sigma]a\cos\phi'\,d\phi'$$

$$PV=\frac{f+\zeta}{\sigma}$$

$$\sigma=-g^{-1}\frac{\partial p}{\partial\theta}$$

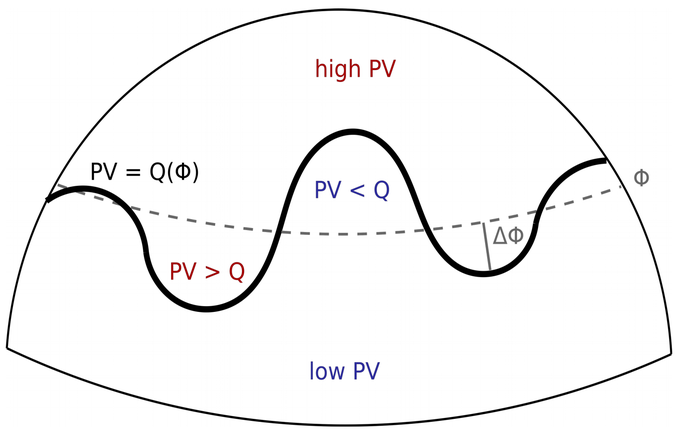

Figure 1: schematic of LWA in isentropic coordinates. Q represents a particular PV contour associated with a given latitude circle Φ such that they enclose the same isentropic layer mass.

LWA is a positive definite quantity proportional to the meridional displacement of Potential Vorticity (PV) with respect to zonal symmetry (see Figure 1). LWA can be used to quantify the local "waviness" of a given PV field: useful in case of transient Rossby wave packets (RWPs), in which the amplitude of the wave is localized in space (see Figure 2).

RWPs diagnostic consists of LWA in combination with a zonal filter to remove its phase dependence to quantify the wave packets amplitude (Figure 2).

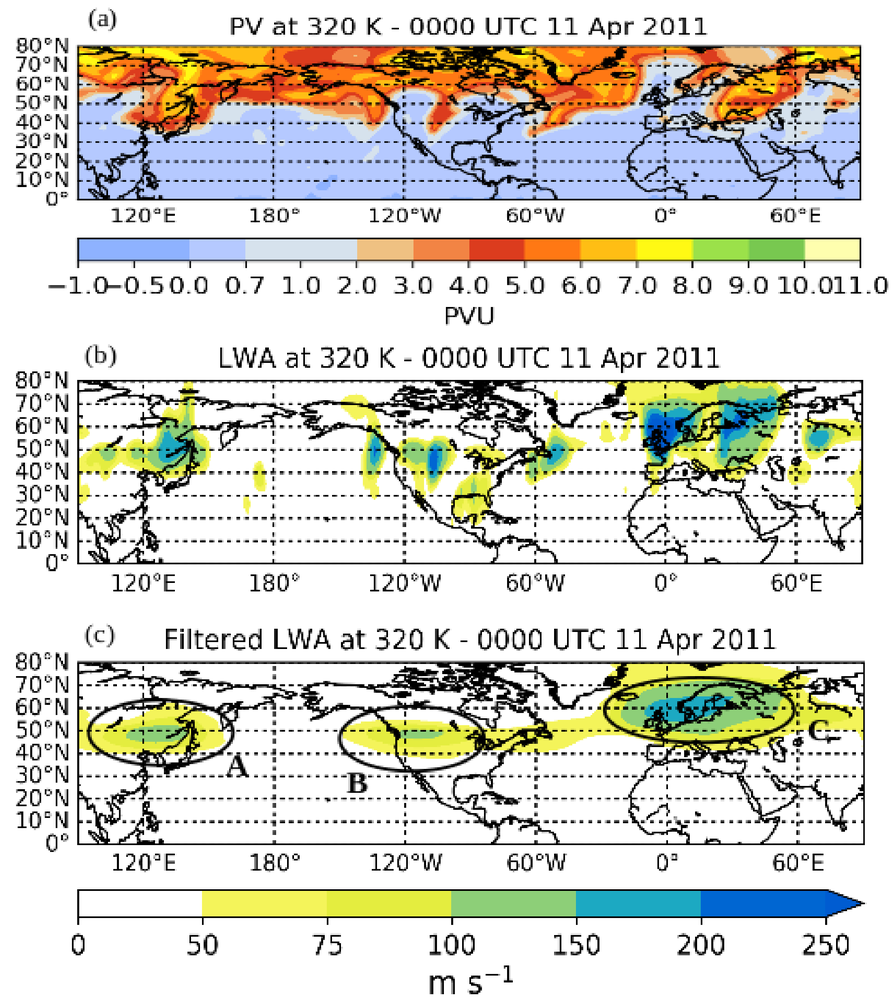

Figure 2: snapshots of PV and corresponding LWA and filtered LWA.

Euro-Atlantic Weather regimes and associated Rossby wave activity

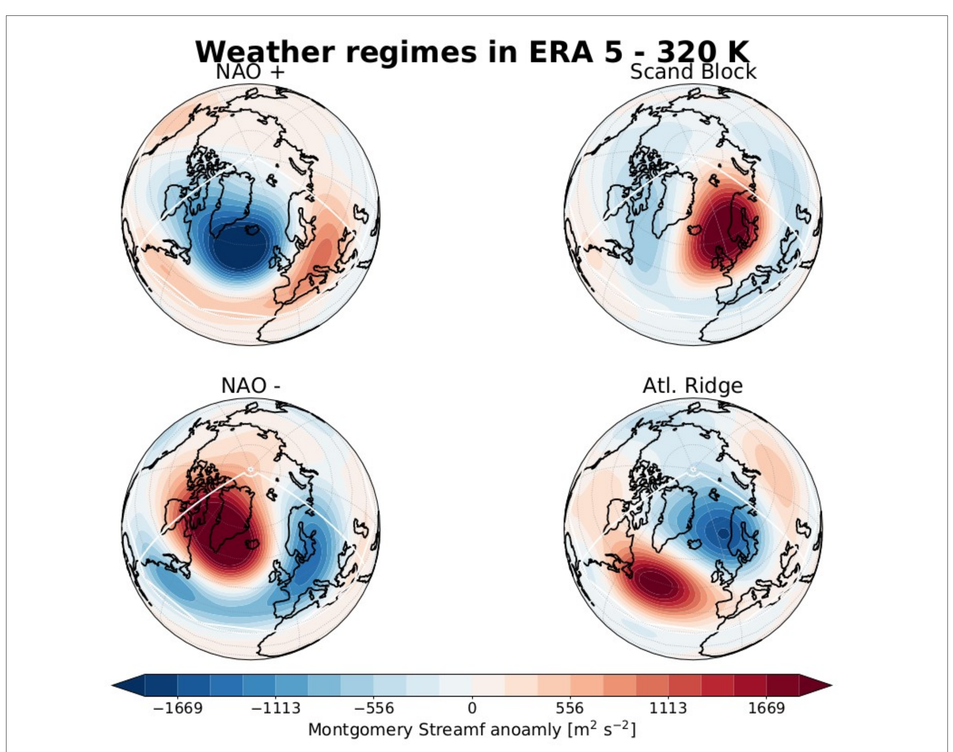

Figure 3: Observed wintertime (DJF) weather regimes in the Euro-Atlantic region for the 1979-2015 period. Weather regimes are computed using daily anomalies of the Montgomery streamfunction on the 320 K isentropic surface from ERA5 reanalysis data.

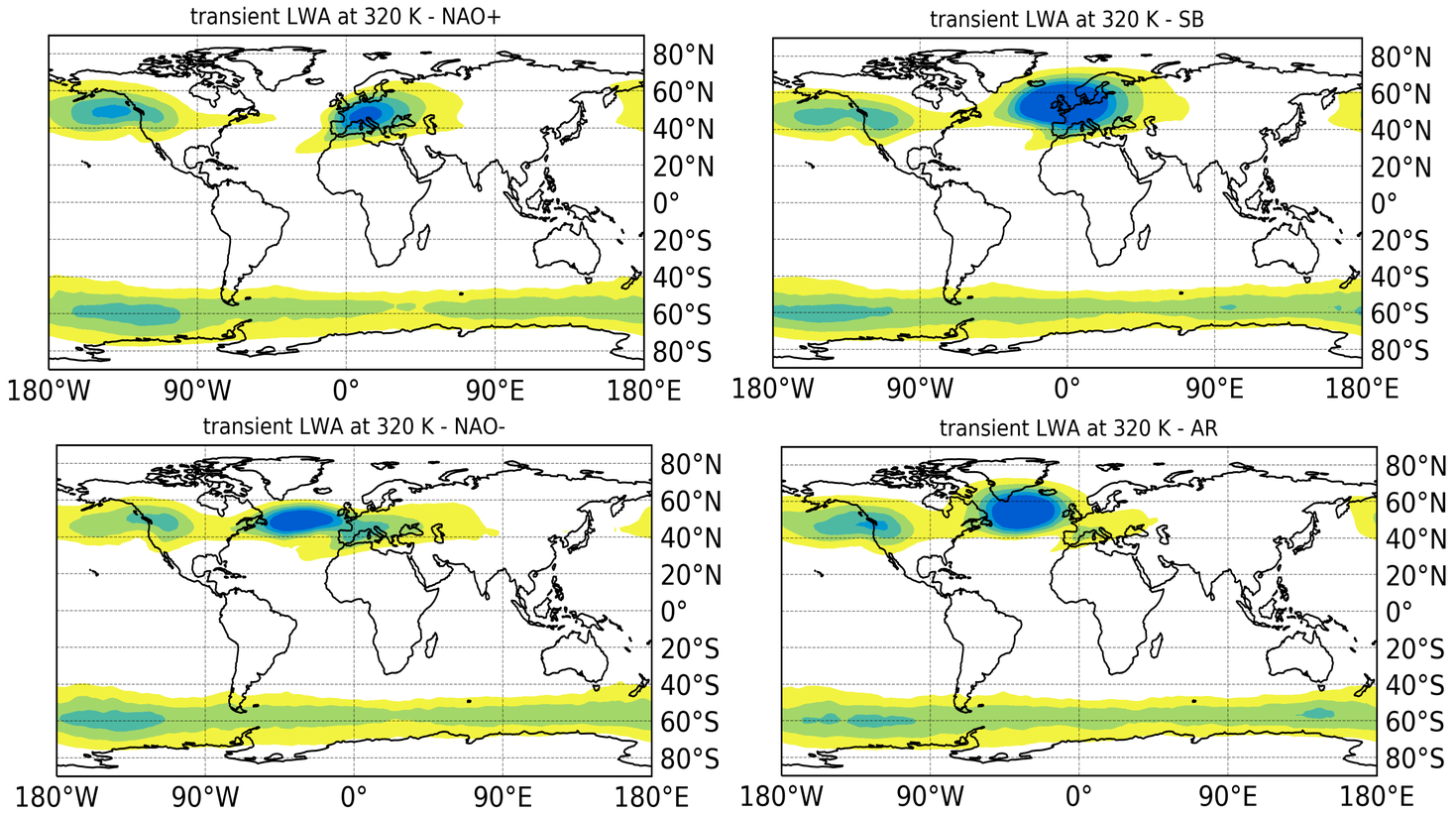

Figure 4: Observed transient LWA for each weather regime (ERA5)

This works aims to quantify the transient LWA associated with each weather regime. At first daily transient LWA is evaluated as the difference between the total, instantaneous LWA and the stationary LWA. Then, transient LWA associated with each weather regime is computed as the composite mean of the daily transient LWA (which is mainly associated with RWPs) for each weather regime (Figure 5).

The same analysis on climate models can reveal possible model biases in representing wave activity. For example, the analysis performed on EC-Earth shows that this model has a weaker wave activity in the Pacific storm track, while wave activity in the North Atlantic storm track extends too further downstream over Eurasia. In this case an increased resolution is beneficial, especially for the Scand Block weather regime (Figure 5), where Rossby wave activity appears to be more localised over Scandinavia in the high resolution simulation.

An example for the PRIMAVERA simulations: Scand Block

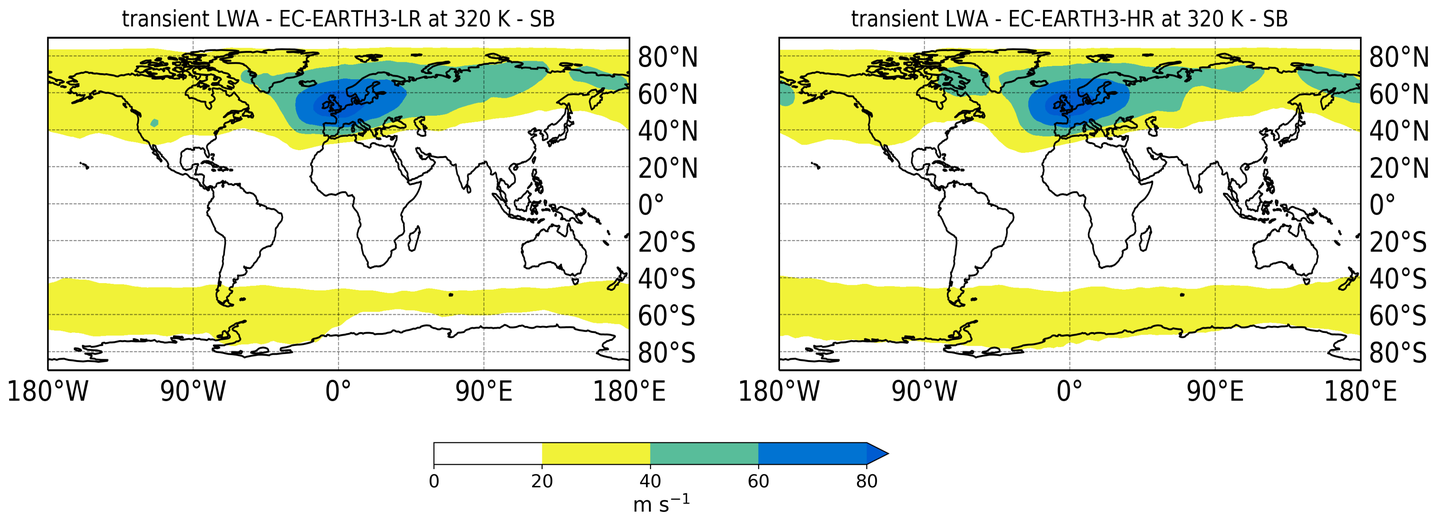

Figure 5: transient LWA for Scand Block in EC-Earth Low res (left) vs High res (right)

References:

- Ghinassi et al, 2018, *"Identifying Rossby wave packets using local finite amplitude wave activity"*, MWR.
- Huang and nakamura, 2017, *"Local wave activity budgets of the wintertime Northern Hemisphere: Implication for the Pacific and Atlantic storm tracks"*, GRL