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Rossby wave packets dynamics from a Local Wave Activity perspective

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Upper tropospheric Rossby wave packets (RWPs) have implications for the predictability of the atmosphere. Recently it has been shown that there is a link between high forecast skills in the medium and long range and long lived RWPs propagating from the Pacific region towards Europe across North America and the North Atlantic. On the other hand, this was not the case for such wave packets that deeply interacted with mesoscale phenomena in the lower and mid-troposphere over the North American continent. This contribution presents a novel diagnostic for RWPs based on local finite amplitude wave activity (LWA) in the primitive equations/isentropic coordinates framework and its application to an episode in which a propagating RWP was associated with a reduced predictability horizon.

LWA is proportional to the local (in longitude) meridional displacement of contours of potential vorticity (PV) from zonal symmetry. The advantage of using LWA consists in the fact that its formulation does not make any small amplitude assumption and it is able to identify nonlinear phenomena such as Rossby wave breaking, blocking, PV streamers, or cutoffs. Furthermore, LWA has an exact conservation relation which allows one to formulate a budget equation for its evolution, distinguishing between conservative propagation and the impact of non-conservative processes. The latter is quantified as a residual from the LWA budget equation. In addition, the conservative propagation is partitioned into the tropopause near, tropopause deep and divergent wind contribution using the Helmholtz partitioning and a piecewise potential vorticity inversion technique.

This new diagnostic is applied first to RWPs simulated in a dry general circulation model (the Portable University Model of the Atmosphere, PUMA) showing that nonconservative processes in general play a non-negligible role in their evolution. The LWA diagnostic and its budget are also applied to a specific episode containing a large amplitude wave packet propagating from North America towards Europe which was associated to very low forecast skills. This was done by using the forecasts from the European Center for Medium range Weather Forecast and the respective analyses and comparing the two. The results show that nonconservative processes played a considerable role in the RWP dynamics. In particular the operational model misrepresented the wave packet amplitude during its growth stage, leading to a wrong amplitude throughout the whole episode. This fact was associated to the very low forecast skills during that episode.