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Identifying Rossby Wave packets using Local Finite Amplitude Wave Activity

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Surface weather in the extratropics is closely associated with Rossby wave packets in the upper troposphere. In particular, strong Rossby wave packets can act as precursors to flow anomalies such as blocking or intense surface cyclones, which sometimes lead to severe weather episodes. Therefore, understanding the dynamics of such waves is of fundamental importance in the context of predictability.

A novel diagnostic based on the local finite amplitude wave activity (LWA) of Nakamura and Solomon has been derived in order to identify large amplitude Rossby wave packets in the primitive equation framework. LWA is proportional to the meridional displacement of potential vorticity contours from a zonally symmetric reference contour and thereby quantifies the waviness of the PV field. The formulation of LWA is not restricted to the small-amplitude limit; rather, it is valid for any finite amplitude eddy and can, therefore, be used to investigate non-linear 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 and to quantify the impact of non-conservative processes computed as a residuum from the LWA budget.

Following the general idea of the upscale forecast error propagation, the novel LWA diagnostic has been applied to ICON model data to quantify the error growth at the planetary scale. In addition, the LWA budget equation is applied to both idealized simulations (barotropic model on a sphere) and output from a weather forecast model in order to estimate the magnitude of the non-conservative term. It turns out that both explicit and implicit model diffusion make noticeable, albeit not dominant contributions to the LWA budget. The results quantify to what extent non-conservative processes play a non-negligible role for Rossby wave dynamics, suggesting that their misrepresentation in models can lead to poor forecasts.