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Energy, Enstrophy and the Climatological Relevance of leading Seasonal Singular Vectors

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The dynamical explanation of the long lasting observed atmospheric Rossby wave trains (RWTs) is still under discussion. Climatologically relevant RWTs have been found to be solutions of a Singular Vector (SV) analysis of a damped barotropic vorticity equation for northern winter basic flows and optimisation times of 72h and longer.

In the context of ensemble prediction it was found, that the validity of the linearisation condition of the SV-analysis is limited to development times between 24 and 48 h, which is much shorter than the optimisation time of climatologically relevant SVs.
However, if the quadratic term in the perturbation equation is small in comparison to the linear terms, than the linearisation condition is valid beyond the classical limit. It will be shown, that for SVs of a damped barotropic vorticity equation the quadratic is zero, if the energy of the SV may be expressed as a function of its enstrophy.

Using 40 DJF basic states growing SVs with a shape of a RWT (RWT modes) are found over some regions of the globe only. For development times up to 96h they exhibit remarkably constant propagation paths. The most unstable RWT mode develops over the North-Pacific (NPAC) region (within 4 days) for each of the observed DJF basic flows considered. Interestingly, the NPAC mode of some of the basic flows exhibits approximately a linear dependence of its energy and enstrophy. This result provides a justification of the climatological relevance of the RWT modes.

We further analysed, to which extent the NPAC mode may be found in observations. At initial time the NPAC-mode explains up to 1% of the global kinetic energy (KE) at 300 hPa only. However, at optimisation time of 96h the NPAC-mode explains up to 12 % of the KE and up to 70 % of the KE in the NPAC region. The comparison of the space-time structure of the NPAC-mode with its observed space-time structure provides an interesting result: two dominant types of RWTs with the shape of the NPAC mode are found in observations. One of them can be identified as the NPAC mode, the other propagates fast and grows only marginally.