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Deviations from the ideal wind: Local and zonal-mean perspectives

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This contribution introduces the non-ideal wind as the deviation from a general local wind balance, the ideal wind. The ideal wind is directed along intersection lines of Bernoulli function and potential temperature surfaces. In climatological steady state, the ideal mass flux cannot participate in net mass fluxes, because the mean position of the mentioned intersection lines does not change. A conceptional proximity of the zonal-mean non-ideal wind and the residual wind as occurring in the transformed Eulerian mean (TEM) equations suggests itself.

The zonal- and time-mean non-ideal wind is compared to the residual wind for the Held-Suarez test case. Similarities occur for the meridional components in the zone of Rossby wave breaking in the upper troposphere equatorward of the jet. The vertical components are similar, too. However, the vertical non-ideal wind is much stronger in the baroclinic zone. This is due to the missing vertical eddy flux of Ertel's potential vorticity (EPV) in the TEM equations. The largest differences are to be found in the boundary layer, where the non-ideal wind exhibits typical pattern of Ekman dynamics.

Instantaneous non-ideal wind vectors demonstrate mass-inflow for lows and mass-outflow for highs in the boundary layer. A significant non-ideal meridional wind is associated with a filamentation of EPV in the zone of Rossby wave breaking in about 300 hPa. Strong gradients of EPV act as a transport barrier.

The dynamical state index (DSI) introduced by Weber and Nevir (2008) in order to identify extreme weather events acts as a source for the divergence of the non-ideal mass flux. Hence, the DSI and the non-ideal wind could provide useful diagnostics to charaterize atmospheric dynamics from a local, zonal-mean, and time-mean perspective.

Reference

WEBER, T., P. NÉVIR, 2008: Storm tracks and cyclone development using the theoretical concept of the Dynamic State Index DSI. – Tellus 60A, 1–10.