Improved vertical and residual velocities on pressure coordinates in analysis data and application to trajectory calculations in the TTL

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Stratospheric vertical winds in analysis data and chemical transport models often suffer both from noise and errors in their mean magnitude, which in turn can introduce errors in important dynamical quantities like vertical mixing or constituent transport with the residual circulation. This is due to the fact that vertical velocities cannot be measured directly and are inferred from other quantities, typically from horizontal wind divergence by the continuity equation. We propose a method to calculate the vertical wind field from the thermodynamic equation that substantially reduces noise and overestimation of the residual circulation. It is designed to be applied in models that use pressure as a vertical coordinate. The method is only applicable for stably stratified regions like the stratosphere.

We apply the method to trajectory calculations of water vapor transport in the TTL and of polar vortex descent. The vertical dispersion of the trajectories and the magnitude of the residual circulation are substantially reduced in comparison to vertical winds from the continuity equation. The residual velocities compare well with values inferred from stratospheric tracer measurements (water vapor tape recorder in the tropics and nitrous oxide in the polar vortex). While the new wind fields have a relatively small influence on the distribution of the Lagrangian minimum temperatures and regions of largest water vapor mass flux, they considerably influence the residence time of trajectories in the TTL.