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Diagnosing the residual circulation: residual winds, mean deviations of balanced winds, and mean winds perpendicular to iso-tracer surfaces

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The discussion of the Brewer-Dobson circulation resides on the means with which it is diagnosed. This poster discusses three different ways which can be applied to model data. The well-known residual circulation residing on the TEM equations is compared to two further versions.

The first new version computes the mean deviations of a general local wind balance. This balance is close to the geostophic wind, but it decribes a wind along isentropes, and is therefore three-dimensional. Similarly to the TEM equations, which consider wave averages, a set of locally transformed Euler equations (TEL-equations) is presented. The TEL equations depend only on the deviation to this balanced wind: the active wind. Like the TEM-equations, the TEL-equations give zero accelerations for stationary and frictionless flow without diabatic heating. A close proximity of the zonal averages of the active wind to the residual wind is found in the free atmosphere including the stratosphere, but not close to the ground. Interesting insights into dynamics is given when looking at the local values of the active winds. This was not possible for the residual winds.

As the Brewer-Dobson circulation rather inspects the distribution of tracers by atmospheric wave processes, a diagnosis of TEM or TEL type is only an approximation. This is because tracer surfaces are not always parallel to isentropes, and neither the residual nor the active winds display solely wind components perpendicular to isentropes. A simple method to diagnose transport of a tracer psi is to decompose the wind into components along isosurfaces and perpendicular to them

begin{equation}

mathbf{v}=mathbf{A}timesnablapsi+alphanablapsi.

end{equation}

Only the second, perpendicular, part of the wind effectively contributes to the transport of psi.

The poster compares the three mentioned methods for $psi=theta$ and discusses similarities and differences in an artificial climate run with the ICON-IAP model.