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Direct Inversion of Circulation and Mixing from Tracer Measurements

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From a series of zonal mean global stratospheric tracer measurements sampled in altitude versus latitude, circulation and mixing patterns are inferred by the inverse solution of the continuity equation. As a first step, the continuity equation is written as a tendency equation, which is numerically integrated over time to predict a later atmospheric state, i.e. mixing ratio and air density. The integration is formally performed by multiplication of the initially measured atmospheric state vector by a linear prediction operator. Further, the derivative of the predicted atmospheric state with respect to the wind vector components and mixing coefficients is used to find the most likely wind vector components and mixing coefficients which minimize the residual between the predicted atmospheric state and the later measurement of the atmospheric state. Unless multiple tracers are used, this inversion problem is under-determined, and dispersive behavior of the prediction further destabilizes the inversion. Both these problems are fought by by regularization. For this purpose, a first order smoothness constraint has been chosen. The usefulness of this method is demonstrated by application to various tracer measurements recorded with the Michelson Interferometer for Passive Atmospheric Sounding (MIPAS). This method aims at a diagnosis of the Brewer Dobson circulation without involving the concept of the mean age of stratospheric air, and related problems like the stratospheric tape recorder or intrusions of mesospheric air into the stratosphere.