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Potential for wind extraction from 4D-Var assimilation of aerosols and moisture

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We discuss the potential of the four-dimensional variational data assimilation (4D-Var) to retrieve the unobserved wind field from observations of atmospheric tracers and the mass field through internal model dynamics and the multivariate relationships in the background-error term for 4D-Var. The presence of non-linear moist dynamics makes the wind retrieval from tracers very difficult. On the other hand, it has been shown that moisture observations strongly influence both tropical and mid-latitude wind field in 4D-Var.

We present an intermediate complexity model that describes nonlinear interactions between the wind, temperature, aerosols and moisture including their sinks and sources in the framework of the so-called first baroclinic mode atmosphere envisaged by A. Gill. Aerosol physical processes, which are included in the model, are the nonlinear advection, diffusion and sources and sinks that exist as dry and wet deposition and diffusion. Precipitation is parametrized according to the Betts-Miller scheme. The control vector for 4D-Var includes aerosols, moisture and the three dynamical variables. The former is analysed univariately whereas wind field and mass field are analysed in a multivariate fashion taking into account quasi-geostrophic and unbalanced dynamics.

The OSSE type of studies are performed for the tropical region to assess the ability of 4D-Var to extract wind-field information from the time series of observations of tracers as a function of the flow nonlinearity, the observations density and the length of the assimilation window (12 hours and 24 hours), in dry and moist environment. Results show that the 4D-Var assimilation of aerosols and temperature data is beneficial for the wind analysis with analysis errors strongly dependent on the moist processes and reliable background-error covariances.