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Wind retrieval from 4D-Var assimilation of tracers in moist atmosphere

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The study addresses the potential of the four-dimensional variational data assimilation (4D-Var) to retrieve the unobserved wind field from the observations of atmospheric tracers (moisture, aerosols) and the mass field through internal model dynamics and the balanced relationships in the background-error term for 4D-Var. The presence of discontinuous and nonlinear moist dynamics makes the wind retrieval from tracers very difficult and susceptible to errors.

The problem of wind retrieval is studied using an intermediate-complexity 4D-Var data assimilation system which simulates nonlinear interactions between the wind, temperature, aerosols and moisture. The description of moist processes includes a simple representation of condensation and the impact of the released latent heat on dynamics. Saturation humidity depends on temperature. Prognostic equation for a single mode aerosol mixing ratio describes the aerosol external processes: advection, diffusion and wet scavenging by precipitation.

The OSSE type of experiments are performed in the tropical channel domain. It is shown that wind retrieval from moisture data depends on the spatial density of observations and the frequency of their update in 4D-Var. The former is needed to describe spatial gradients of
moisture (as a necessary condition for the wind retrieval), whereas the latter provides information about the advection.

If moisture is well observed, 4D-Var can retrieve wind information from moisture observations even in the presence of precipitation. However, in case of aerosol observations in a saturated atmosphere, a small prior error in the wind (or humidity) field can amplify in a positive feedback loop, ruining the analysis. It is necessary to well simulate all other fields (temperature and humidity) affecting the aerosol in order to retrieve useful wind information.