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Improvements of weather forecast by assimilating water vapor isotopes

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Water vapor isotopes are sensible to phase transition and they have characteristics that heavier molecules such as HDO or H218O more preferentially condense and less preferentially evaporate than ordinary H_2O. Because of these characteristics, the spatio-temporal variation of water vapor isotopes emerges. These unique characteristics are used in various fields including paleo-climatology, atmospheric dynamics, and so on.

After 2000's, several general circulation models with water isotopes have been developed and improved. In parallel to this, the observation techniques for water vapor isotopes also have been invented and improved, so that the number of observation have drastically increased. For example, the satellite-based spectrometers such as Tropospheric Emission Spectrometer (TES), SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY (SCIAMACHY) and the Infrared Atmospheric Sounding Interferometer (IASI) have made us possible to observe water vapor isotopes globally and, more importantly, frequently. As a result of these development, Yoshimura et al. (2014; Y14) conducted an observation system simulation experiment (OSSE) using the isotope model and the virtual satellite observations, and they suggested the potential of the water vapor isotope to constrain atmospheric dynamics.

In this study, we first extended the OSSE in Y14 to 3 months and confirmed the performance persists as similar as Y14. Then, we tested the actual data assimilation experiment using the real one-month IASI data in April 2013. Finally, we challenged the forecast experiments for 6 days using the data-assimilated analyses as the initial conditions.

We used Isotope-incorporated Global Spectral Model (IsoGSM) as a numerical model, and local ensemble transform Kalman filter (LETKF) as a data assimilation scheme. In the data assimilation experiment using IASI observation data, we confirmed that analysis skill of many variables got better than none-assimilated experiment. In the forecast experiments, forecast skill of many variables were improved than none-assimilated forecast, but skills of some variables including surface pressure, geopotential height and some other got worse.

To overcome this issue, we need to study how the atmospheric fields behave when water vapor isotopes are assimilated. To do so, we will conduct forecast experiments assimilating not only water vapor isotopes but also other variables. We will use NOAA's prepbufr data as additional observation data for wind speed, temperature and surface pressure.