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Evaluation of ECMWF interim re–analysis and operational forecast–analysis water vapor in the UTLS using global in–situ FISH measurements

Anne Kunz (1), Nicole Spelten (2), Paul Konopka (2), Rolf Müller (2), and Heini Wernli (1)

(1) ETH Zurich, Institute for Atmospheric and Climate Science, Zurich, Switzerland (anne.kunz@env.ethz.ch), (2) Institut für Energie- und Klimaforschung: Stratosphäre (IEK-7), Forschungszentrum Jülich, Germany

An objective evaluation of the latest atmospheric re–analysis ERA–Interim water vapor in the UTLS is presented by using global in–situ measurements of a large range of airborne measurement campaigns from 2001 to 2011. At the same time, the improvement of the ECMWF operational forecast skill of water vapor is addressed for particular time periods representing different Integrated Forecast System (IFS) cycles. Water vapor measurements are derived from the Fast In–situ Stratospheric Hygrometer (FISH). The meridional extent of these measurements is from the tropics toward the poles. In the vertical, measurements cover isentropic levels from 300 to 400 K and altitudes roughly from 5 to 18 km.

The ratio $\Delta(\mathrm{H_2O}) = \mathrm{H_2O_{ERA}}/\mathrm{H_2O_{FISH}}$ is used as a simple measure for the difference between observations and the re–analysis simulations. Overall, the re–analysis data reproduce around 87% of all FISH measurements within $\Delta(\mathrm{H_2O}) = 0.5 - 2$, whereas around 27% are within $\Delta(\mathrm{H_2O}) = 0.9 - 1.1$. Nevertheless, ERA–Interim may even more strongly over- and underestimate FISH water vapor depending on the local atmospheric condition both in the troposphere and in the stratosphere. $\Delta(\mathrm{H_2O})$ values are found between 0.1 up to 10, with smaller deviations in the stratosphere ($\Delta(\mathrm{H_2O}) = 0.5 - 4$) than in the troposphere ($\Delta(\mathrm{H_2O}) = 0.5 - 10$). In the entire tropical stratosphere a ratio of better than $\Delta(\mathrm{H_2O}) = 0.5 - 2$ is found. Toward the extratropical stratosphere this ratio weakens with $\Delta(\mathrm{H_2O}) = 0.1 - 4$ through dynamical processes at the extratropical tropopause. Finally, largest deviations between ERA–Interim and the observations are found in the tropical and extratropical troposphere as well as in the extratropical lower stratosphere.

The operational forecast skill improves over the time, in particular when comparing water vapor fields for time periods before 2004 and after 2010. In any event, influences of tropical tropospheric processes as well as extratropical lower stratospheric processes on the water vapor distribution are a challenge for models resulting in an overestimation of low and underestimation of high mixing ratios