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An assessment of tropopause characteristics of the ERA5 and ERA-Interim meteorological reanalyses

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The tropopause layer plays a key role in manifold processes in atmospheric chemistry and physics. Here we compare the representation and characteristics of the lapse rate tropopause according to the definition of the World Meteorological Organization (WMO) as estimated from European Centre for Medium-Range Weather Forecasts (ECMWF) reanalysis data.

Our study is based on ten-year records (2009 to 2018) of ECMWF's state-of-the-art reanalysis ERA5 and its predecessor ERA-Interim. The intercomparison reveals notable differences between ERA5 and ERA-Interim tropopause data, in particular on small spatiotemporal scales. The monthly mean differences of ERA5 minus ERA-Interim tropopause heights vary between -300 m at the transition from the tropics to the extratropics (near 30°S and 30°N) to 150 m around the equator. Mean tropopause temperatures are mostly lower in ERA5 than in ERA-Interim, with a maximum difference of up to -1.5 K in the tropics. Monthly standard deviations of tropopause heights of ERA5 are up to 350 m or 60 % larger than for ERA-Interim. Monthly standard deviations of tropopause temperatures of ERA5 exceed those of ERA-Interim by up to 1.5 K or 30 %. The occurrence frequencies of double tropopause events in ERA5 exceed those of ERA-Interim by up to 25 percentage points at mid latitudes.

We attribute the differences between the ERA5 and ERA-Interim tropopause data and the larger, more realistic variability of ERA5 to improved spatiotemporal resolution and better representation of geophysical processes in the forecast model as well as improvements in the data assimilation scheme and the utilization of additional observations in ERA5. The improved spatiotemporal resolution of ERA5 allows for a better representation of mesoscale features, in particular of gravity waves, which affect the temperature profiles in the upper troposphere and lower stratosphere and thus the tropopause height estimates.

We evaluated the quality of the ERA5 and ERA-Interim reanalysis tropopause data by comparisons with COSMIC and MetOp Global Positioning System (GPS) satellite observations as well as high-resolution radiosonde profiles. The comparison indicates an uncertainty of the first tropopause for ERA5 (ERA-Interim) of about ±150 m to ±200 m (±250 m) based on radiosonde data and ±120 m to ±150 m (±170 m to ±200 m) based on the coarser resolution GPS data at different latitudes. Consequently, ERA5 will provide more accurate information than ERA-Interim for future tropopause-related studies.