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Quantifying latitudinal and seasonal stratospheric temperature trends using 15 years of GPS radio occultation and Aqua AMSU observations

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A variety of observations and model simulations indicate that the stratosphere has cooled in most parts since 1979. Several studies based on global-coverage satellite observations suggest a notable spatial and seasonal structure of the stratospheric temperature trend. At that, the latitude and seasonal patterns reported in the literature appear rather inconsistent with one another. Further, an accurate evaluation of lower stratospheric temperature change is hindered by the broad weighting function of space-borne microwave sounders such as MSU and SSU. Our study attempts to remedy this issue through a joint analysis of two 15-yr satellite data sets on stratospheric temperature: Aqua AMSU and GPS Radio Occultations (RO).

Evaluation of stratospheric trends using Aqua AMSU-A instrument benefits from the fixed orbit of Aqua satellite, which eliminates the tidal effect on the trends due to orbital drift. In addition, AMSU has a more vertically refined weighting functions (vertical half-width of ∼10 km) compared to those of SSU or MSU. We use IMICA version of AMSU-A measurements spanning September 2002 through September 2016.

GPS-RO is a well established technique, providing stratospheric temperature profiles at ∼1 km vertical resolution with global geographical and full diurnal coverage. We combine the observations from various RO missions processed by EUMETSAT ROM SAF facility - CHAMP, GRACE, COSMIC and Metop A/B - altogether covering 2002-2016 period. For intercomparison of AMSU and GPS-RO temperature trends the RO profiles ranging between the tropopause and 35 km were convoluted using AMSU weighting functions (channels 9-13). The altitude, latitude and seasonal patterns of temperature trends from AMSU and RO appear in good agreement, providing confidence in our estimates.

Analysis of both AMSU and RO datasets reveals a remarkable inter-hemispheric asymmetry with larger cooling trend throughout the Southern hemisphere's mid-stratosphere and a quasi-null change at the Northern midlatitudes. In contrast to that, the (sub-)tropical lower stratosphere is shown to be warming in SH during all seasons and cooling in NH from April through December. The trends in the polar regions, varying strongly with altitude, are characterized by large uncertainty due to strong dynamical variability of the polar vortices. In order to isolate the trend estimates from the effect of vortex variability, the trends are computed in the equivalent latitude space. In addition, we apply both linear and multiple regression analysis for quantifying the trends and discuss the resulting differences. Finally, we take advantage of the high vertical resolution of RO measurements