Tropopause Characteristics observed with GPS Radio Occultation Data

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We examine global tropopause characteristics on the basis of GPS radio occultation (RO) data from different data sets between 2001 and 2018. The RO technique uses GPS signals received aboard low Earth orbiting satellites for atmospheric limb sounding. Atmospheric temperature profiles are derived with high vertical resolution. Due to its long-term stability, all-weather capability and global coverage the GPS RO technique offers the possibility for global monitoring of the temperature structure in the upper troposphere and lower stratosphere and different tropopause parameters and their variability. Since May 2001 several satellite missions provide global distributed RO data, thus generating a continuous long-term data set for atmospheric and climate studies.

In this paper we discuss the variability of the tropopause height and relate the variations to upper tropospheric and lower stratospheric temperature variations and quantify the effects of the QBO and ENSO to the variability. Generally, there is an increase of the global tropopause height with a coexisting increase/decrease of tropospheric/lower stratospheric temperatures.

The high vertical resolution of RO measurements allows for the detection of double (multiple) tropopauses and the intensity of tropopause breaks. The latter is defined here as the difference between the upper (last) and lowest (first) tropopause level according the lapse rate tropopause definition of the WMO. Most intensive tropopause breaks occur in the vicinity of the subtropical and polar jet streams. An updated global climatology of the number and occurrence frequency of multiple tropopauses is given and changes over the time period between 2001 and 2018 are discussed for different regions and globally.

Finally we present some new results of a climatology of the extratropical tropopause inversion layer (TIL). Based on more than 15 years of RO data we exhibit seasonal properties of the TIL bottom, maximum, and top heights. The TIL bottom height is defined here as the level of the squared buoyancy frequency minimum N^2 below the thermal tropopause. The TIL maximum is the height of N^2 maximum just above the tropopause and finally the TIL top is located at the height of the temperature maximum above the tropopause. All characteristics are discussed relative to the thermal tropopause. A seasonal cycle of the TIL bottom and TIL top height is observed with values closer to the thermal tropopause during summer.

Key words: Tropopause, Double Tropopause, Tropopause Inversion Layer, Radio Occultation