



Atmospheric climate change detection based on GPS/Met and CHAMP radio occultation records 1995 to 2007

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Radio Occultation (RO) observations of the Earth's atmosphere are based on signals from Global Positioning (GPS) satellites via active limb sounding. Highest data quality is achieved in the Upper Troposphere and Lower Stratosphere (UTLS) region, which is reacting sensibly to climate change. Long-term stability due to intrinsic self calibration as well as the homogeneity and consistency of RO data stemming from satellites in different orbits make RO a valuable data source for atmospheric observations and climate change monitoring.

We perform a climate change detection study based on RO observations with respect to a temperature change signal in the UTLS region. RO data are available on a continuous basis only since end of 2001 from the CHAMP satellite but intermittent periods of observations from the GPS/Met proof-of-concept mission exist for the years 1995-1997. We use these RO time series based on monthly mean temperature climatologies for the month of February (1997 and 2002-2007) and for the month of October (1995 and 2001-2006), respectively. Choice of these particular months is pre-scribed by the availability of adequate monthly climatologies from GPS/Met "prime time" data only for Oct 1995 and Feb 1997. The analysis is performed for three zonal means, the tropics (20°S-20°N), the Northern Hemisphere extratropics (20°N-50°N), and the Southern

Hemisphere extratropics (20°S-50°S), for three pressure layers (300-200 hPa, 200-100 hPa, 100-30 hPa). A finer resolution (5 zonal means, 5 pressure levels) is also co-analyzed.

The trend calculation over 11 (12) years for February (October) is based on least squares fitting by taking into account the individual RO errors for each month, where we account for the sampling error, the observational error, and a conservatively estimated systematic error. The climate variability over the last 11 (12) years represented by the de-trended standard deviation and the error of the trend are used to assess the trends' signal to noise ratio (SNR) in the study period 1997–2007 (1995–2006). Furthermore, we inspect whether the trend exceeds long-term natural variability. The latter is estimated based on multi-century pre-industrial control runs of three representative global climate models for the IPCC 4th assessment report. The significance of the trend is determined by means of a Student's *t*-test. A significant warming trend, relative to noise and to natural variability, was revealed in February 1997-2007 in the tropical upper troposphere. The results are discussed based on a comparison with trends in the UTLS radiosonde temperature record, the only long-term height-resolved observational UTLS record available so far, and a multi-model multiple-realizations 2001-2020 data set from global climate model 21st century scenario runs. The evidence indicates that the trend signal is real and presumably constitutes the first occasion of un-ambiguously and directly detecting an anthropogenic temperature change signal from space.