Climate Change Detection with the GPS Radio Occultation Record

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Radio occultation (RO) provides an independent climate record of high quality and vertical resolution in the upper troposphere and lower stratosphere (UTLS) with long-term stability and consistency. We present a climate change detection study based on monthly mean zonal mean RO climatologies within 1995 to 2008. CHAMP data for Sep 2001 to Sep 2008 are complemented by intermittent GPS/Met observations for Oct 1995 and Feb 1997. In addition, consistency is checked with available GRACE and COSMIC data. We investigate the UTLS region within 9-25 km (300-30 hPa) by using different detection methods.
An optimal fingerprinting technique is applied to the whole GPS/Met and CHAMP record of RO accessible parameters refractivity, geopotential height, and temperature to detect a forced climate signal. Three representative global climate models of the 4th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) are employed to estimate natural climate variability using pre-industrial control runs. The response pattern to the external forcings is presented by an ensemble mean of the models' A2 and B1 scenario runs. Optimal fingerprinting shows that a climate change signal can be detected in the RO refractivity and in the RO temperature record (90 % significance level).

Furthermore, standard and multiple linear regression is applied to temperature time series for February and for October, taking RO errors into account. In the tropics, we also investigate the influence of stratospheric quasi-biennial oscillation (QBO) and tropospheric El Nino-Southern Oscillation (ENSO). We test whether the trend exceeds inter-annual variability in the study period, and whether the trend exceeds long-term natural variability as estimated from pre-industrial control runs. Our results show a significant cooling trend relative to inter-annual variability (90 % significance level) and to natural variability (95 % significance level) in the tropical LS in February for the period 1997-2008. In the tropical UT a strong ENSO signal explains most of the variability in the investigated period obscuring an emerging warming trend signal. The results are in agreement with trends in radiosonde records, especially newly homogenized ones. Climate model simulations basically agree as well but they show less warming/cooling contrast across the tropical tropopause.