Geophysical Research Abstracts,
Vol. 11, EGU2009-9074, 2009
EGU General Assembly 2009

Atmospheric Climate Change Detection Based on the GPS Radio Occultation Record

A. K. Steiner (1), B. C. Lackner (1), G. C. Hegerl (2), B. Pirscher (1), M. Borsche (1), U. Foelsche (1), and G. Kirchengast (1)

(1) Wegener Center for Climate and Global Change (WegCenter) and Institute for Geophysics, Astrophysics, and Meteorology (IGAM), University of Graz, Graz, Austria (andi.steiner@uni-graz.at), (2) University of Edinburgh, School of GeoSciences, Edinburgh, U.K.

Monitoring of global climate change requires high quality observations of the Earth's atmosphere. Radio occultation (RO) measurements based on signals from Global Positioning System (GPS) satellites provide a useful upper air record in this respect. RO data are considered a climate benchmark data type since they are based on timing with precise atomic clocks and tied to the international definition of the second. High quality and vertical resolution in the upper troposphere and lower stratosphere (UTLS), long-term stability, and consistency of RO data stemming from satellites in different orbits without need for inter-calibration make RO well suited for atmospheric observations and climate change detection.

RO data are available on a continuous basis since fall of 2001 from the German research satellite CHAMP (CHAllenging Minisatellite Payload for geoscientific research), establishing the first RO climate record covering more than seven years. Intermittent periods of observations from the U.S. GPS/Met proof-of-concept mission exist in the years 1995-1997, with sufficient data only for October 1995 and February 1997.

We present a climate change detection study based on monthly mean zonal mean RO climatologies in the UTLS region within 9-25 km (300-30 hPa) where we use different detection methods. An optimal fingerprinting technique is applied to the whole 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 by making use of 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 at the 90% significance level in the RO refractivity record.

Furthermore, simple linear trend analysis as well as multiple linear regression is applied to temperature time series for February (1997 and 2002 onwards) and for October (1995 and 2001 onwards). The trend calculation is based on least squares fitting by taking into account the individual RO errors for each month. In the tropics we also investigate the influence of stratospheric quasi-biennial oscillation (QBO) and tropospheric El Nino-Southern Oscillation (ENSO) signals through multiple linear regression. The climate variability represented by the de-trended standard deviation and the error of the trend are used to assess the trends' signal to noise ratio in the study period. We also inspect whether the trend exceeds long-term natural variability as estimated from pre-industrial control runs. Our results show a significant cooling trend relative to natural variability (95% significance level) and to noise (90% 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.