Atmos. Chem. Phys., 7, 3519-3536, 2007
www.atmos-chem-phys.net/7/3519/2007/

Retrieval of temperature profiles from CHAMP for climate monitoring: intercomparison with Envisat MIPAS and GOMOS and different atmospheric analyses

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Abstract. This study describes and evaluates a Global Navigation Satellite System (GNSS) radio occultation (RO) retrieval scheme particularly aimed at delivering bias-free atmospheric parameters for climate monitoring and research. The focus of the retrieval is on the sensible use of a priori information for careful high-altitude initialisation in order to maximise the usable altitude range. The RO retrieval scheme has been meanwhile applied to more than five years of data (September 2001 to present) from the German CHAllenging Minisatellite Payload for geoscientific research (CHAMP) satellite. In this study it was validated against various correlative datasets including the Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) and the Global Ozone Monitoring for Occultation of Stars (GOMOS) sensors on Envisat, five different atmospheric analyses, and the operational CHAMP retrieval product from GeoForschungsZentrum (GFZ) Potsdam. In the global mean within 10 to 30 km altitude we find that the present validation observationally constrains the potential RO temperature bias to be <0.2 K. Latitudinally resolved analyses show biases to be observationally constrained to <0.2–0.5 K up to 35 km in most cases, and up to 30 km in any case, even if severely biased (about 10 K or more) a priori information is used in the high altitude initialisation of the retrieval. No evidence is found for the 10–35 km altitude range of residual RO bias sources other than those potentially propagated downward from initialisation, indicating that the widely quoted RO promise of "unbiasedness and long-term stability due to intrinsic self-calibration" can indeed be realised given care in the data processing to strictly limit structural uncertainty. The results thus reinforce that adequate high-altitude initialisation is crucial for accurate stratospheric RO retrievals. The common method of initialising, at some altitude in the upper stratosphere, the hydrostatic integral with an upper boundary temperature or pressure value derived from meteorological analyses is prone to introduce biases from the upper boundary down to below 25 km. Also above 30 to 35 km, GNSS RO delivers a considerable amount of observed information up to around 40 km, which is particularly interesting for numerical weather prediction (NWP) systems, where direct assimilation of non-initialised observed RO bending angles (free of a priori) is thus the method of choice. The results underline the value of RO for climate applications.

Final Revised Paper (PDF, 4079 KB)   Discussion Paper (ACPD)

Citation: Gobiet, A., Kirchengast, G., Manney, G. L., Borsche, M., Retscher, C., and Stiller, G.: Retrieval of temperature profiles from CHAMP for climate monitoring: intercomparison with Envisat MIPAS and GOMOS and different atmospheric analyses, Atmos. Chem. Phys., 7, 3519-3536, 2007.   Bibtex   EndNote   Reference Manager