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Atmospheric remote sensing using spaceborne GNSS radio occultation: the feasibility of on-board data pre-processing

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Since the proof-of-concept GPS/MET mission in the mid-Nineties atmospheric remote sensing by satellite-based GNSS radio occultation (RO) has matured to become a viable measurement technique for numerical weather prediction and climate change studies. Dual wavelength carrier phase observations, recorded at sampling frequencies of typically 50 Hz are transformed to ray bending angles and subsequently Abel-inverted to yield vertical profiles of atmospheric refractivity and dry temperature. A significant cost driver in small-budget satellite missions is the data volume that has to be transmitted to the ground. Current RO instruments such as the “BlackJack” receiver aboard the CHAMP satellite accumulate about 30 megabytes of RO measurement data over the course of 24 h corresponding to about 250 setting occultation events. By shifting the ray bending angle calculation from the post-processing step on the ground towards the pre-processing stage aboard the spacecraft data volume reductions by 1–2 orders of magnitude seem feasible, allowing for lower data transfer rates and reductions in the number of downlink contacts. We simulate the on-board calculation of bending angle profiles with one month of CHAMP data using low accuracy orbit information. In the present study GFZ’s high precision GPS orbits are replaced by GPS broadcast ephemerides available aboard the LEO spacecraft in real-time and LEO orbits are degraded by adding Gaussian white noise to GFZ’s CHAMP orbit data products (precise position and velocity) with standard deviations of 10 m and 10 mm/s, respectively. The mean fractional retrieval error in terms of refractivity induced by the degraded orbits is below 0.1%, its standard deviation decreases from about 1% at 30 km altitude to 0.5% at the tropopause, a significant enhancement is observed within the troposphere. The corresponding dry temperature mean error is below 0.1 K, with standard deviations between 1 to 2 K at stratospheric altitudes.

We describe the simulation procedures and discuss correction techniques to partially compensate for the influence of the coarse resolution orbit data by taking into account GFZ's precise orbit products available during post-processing.