

# ENSEMBLE-BASED ANALYSIS OF ERRORS IN ATMOSPHERIC PROFILES RETRIEVED FROM GNSS OCCULTATION DATA

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Radio occultation observations based on Global Navigation Satellite System (GNSS) signals have great potential to globally provide key climate variables with high accuracy in the troposphere and stratosphere. High quality GNSS occultation data could support the advancement of climate monitoring and modeling as well as the improvement of numerical weather prediction and atmospheric analysis via data assimilation schemes.

In order to provide complete information on the errors of profiles retrieved from GNSS occultation data - as needed, e.g., by data assimilation schemes - we performed an ensemble-based empirical analysis of errors using an end-to-end forward-inverse simulation approach. The simulations were performed with the End-to-end GNSS Occultation Performance Simulator (EGOPS) involving realistic neutral atmosphere and ionosphere modeling. We used a T213L50 ECMWF analysis field with the highest model level at 0.1 hPa as atmospheric model input. The ionosphere was prescribed with the NeUoG model, a global empirical 3D climatological model of the ionospheric electron density field.

Occultation observations were simulated for one observational day adopting the planned European weather satellite METOP as Low Earth Orbit (LEO) satellite and its GNSS Receiver for Atmospheric Sounding (GRAS) as sensor. An ensemble of 300 occultation events, equally distributed over the globe and in time, was chosen and excess phase path profiles were computed with a sub-millimetric precision 3D ray tracer. Realistic observation system errors were superposed on the forward-modeled profiles reflecting the error characteristics of GRAS-type observation data. Atmospheric profiles were retrieved with a state-of-the-art occultation data processing chain and compared to the "true" co-located profiles of the analysis field. In the troposphere, an optimal estimation retrieval algorithm (1DVAR) was applied to refractivity using the ECMWF 24-hour short-range forecast for the analysis time as background field for temperature and humidity.

The error analysis was performed in three latitude bands (low, middle, high; 100 ensemble members per band) for each of the retrieval products bending angle, refractivity, pressure, geopotential height, temperature, and specific humidity in order to empirically estimate realistic bias profiles and covariance matrices. We obtained bias, standard deviation, and correlation functions for all these retrieval products and show and discuss selected results. We also compare the empirical results with theoretical findings and discuss the utility of the empirical covariance matrices for specifying observation error covariance matrices in data assimilation systems.