A variational combination of multi-frequency GNSS signals for stratospheric RO data processing

Tae-Kwon Wee, Ying-Hwa Kuo

COSMIC / UCAR

As the understanding on our Earth system grows, the importance of comprehending the structure and processes in the remote stratosphere is intensified and the interest in stratospheric observations mushrooms. Despite its great potential, Radio Occultation (RO) data have been underused in exploiting the stratosphere. A major cause for the underutilization is the imperfections in pre-existing RO data processing methods. We propose an advanced stratospheric RO data processing, where the variational method provides a general framework in which multiple-frequency RO measurements of different quality are effectively combined with the aid of a priori. The variational combination (VAR) is designed to extract the most information from RO measurements, where the a priori plays a role of enhancing the observation and attenuating measurement noise. The signal-to-noise ratio (SNR) is found to be a universal quality indicator, which concisely describes the uncertainty of RO measurements in diverse conditions. The measured SNR is used to parameterize a dynamic observation error, which is essential for the VAR to use the observation optimally. Tests with real data show that VAR significantly improves the accuracy of the RO retrieval even in the upper stratosphere, where the RO data were once considered to possess little observational value. When compared with independent radiosonde observations, for instance, the VAR-produced data are more accurate than the analysis from the European Center for Medium-Range Weather Forecasts (ECMWF) for which the radiosonde data have been assimilated. The VAR-produced data are also precise enough to reveal the systematic error of the radiosonde data.