Improving the Assimilation of GPS Radio Occultation Observations in the Lower Troposphere

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The National Centers for Environmental Prediction (NCEP) have been assimilating Global Positioning System (GPS) Radio Occultation (RO) observations in its global data assimilation system since 2006. The benefits of incorporating RO observations into the observing system have been demonstrated worldwide, proving that RO data contain very important information on the thermodynamic state of the atmosphere.

Despite the fact that GPS RO technology is a promising tool in recovering the Planetary Boundary Layer (PBL) structure and significant advances have been seen in the GPS RO field during the past decade, there are still some serious issues that affect the assimilation of these observations in the lower moist tropical troposphere. Indeed, Numerical Weather Prediction (NWP) centers using GPS RO data are rejecting most GPS RO observations at and below the PBL height, significantly limiting the potential benefits of this data type to improve weather forecasting in the lower troposphere. The reasons for the rejection of these observations are a combination of quality issues that affect retrievals in the lower troposphere and several challenges existing in the data assimilation algorithms. To address this problem, a methodology has been developed to enable the assimilation of GPS RO data to be extended to the lower moist troposphere.

In particular, the limitations associated with so-called super-refraction conditions, which have hitherto prevented NCEP’s forward operator NBAM (NCEP’s bending angle method) from applying to the moist lower troposphere, are partially eliminated by a reformulation that has no adverse effects at higher altitudes. Super-refraction, which refers to vertical gradients of refractivity strong enough to cause the ray curvature to exceed the local geopotential curvature, occur frequently at the top of low-latitude maritime boundary layers. While GPS RO rays coming close to tangency with these layers cannot participate in the assimilation, those that penetrate more steeply to greater depths offer valid opportunities for assimilating thermodynamic quantities at these meteorologically important levels. However, the more erratically distributed errors inherent in bending angle measurements for these deeper-penetrating rays need especially to be analyzed and interpreted carefully in order that an appropriately tuned adaptation of the nonlinear quality control technique can ensure that, through the proper attribution of relative weighting, the assimilation of information from them continues to be acquired in a robust and approximately optimal way.

During this talk, the characteristics and initial performance of NCEP’s advanced bending angle method (NABAM) over NBAM will be discussed. In addition, the use of a nonlinear quality control methodology for the assimilation of bending angle observations will be presented.