Effects of Ducting on GPS Occultations

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The Global Positioning System (GPS) satellites continuously broadcast radio signals at 1.57542 GHz and 1.22760 GHz. As these satellites rise or set behind the Earth, the signals as measured by a receiver on a low-earth orbit are directly affected by the index of refraction of the Earth's atmosphere along the signal propagation paths. These events, known as GPS occultations, provide active limb sounding of the Earth's atmosphere, with the advantages of global coverage, high vertical resolution, and the capability to operate under all-weather conditions. The basic observables in the GPS occultation are the phase and amplitude of the carrier signals. The inversion methodology generally relies on the conversion of the observables into ray bending angles and impact parameters, denoted respectively as α and a. Under the assumption of local spherical symmetry, the relation $\alpha(a)$ can be integrated using the Abel inversion formula to yield the radial refractivity profile.

Recent improvement in receiver technology has allowed the occultation signal to penetrate more deeply into the lower troposphere. The prospect of using GPS occultation to remotely sense the planetary boundary layer (PBL) from space become increasingly feasible and attractive. However, simulation studies performed with tropical radiosonde profiles show that the refractivity gradient associated with the PBL could be sufficiently large to cause ducting to take place. When this occurs, Abel inversion of the inferred $\alpha(a)$ will lead to incorrect, underbiased refractivity values within and below the ducting layer. In order to accurately sense the PBL, the ducting problem needs to be overcome. At the very least, the occultation data that are significantly affected by ducting should be identified and rejected in any PBL study. In this work, we employ the multiple phase screen forward model to investigate the sensitivity of the occultation observables to the structure of the ducting layer. We consider both the ideal case where the data are noiseless and the more realistic case with different random noise levels. Inversion strategies and identification schemes in the presence of ducting are discussed and assessed.