ERRORS IN RO OBSERVATIONS: WHAT CAUSES THEM AND HOW CAN WE ESTIMATE THEM?

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GNSS radio occultation (RO) bending angle and refractivity observations have both random and bias errors. The sources of these two types of errors are different and vary with many factors associated with the GNSS and LEO (low-Earth Orbiting) satellites, RO receiver, retrieval errors, and atmospheric structure. Accurately estimating RO errors is important in applications of RO, in particular numerical weather prediction (NWP) and climate research and monitoring. The effect of bias and random errors on these two applications is somewhat different, with biases being especially significant in climate applications. Random errors are impactful in NWP, but are less so in climate applications because they tend to cancel in the mean when large data sets are used.

Since the earliest days of RO, it has been recognized that RO observations have small biases, except in the lowest levels of the troposphere where superrefraction can produce large biases. For NWP, the biases above the atmospheric boundary layer are considered small enough that RO observations may be assimilated without bias corrections. They may also be used to correct the larger biases in radiance measurements. For climate, however, even the small biases of RO observations can be important.

This presentation reviews the sources of RO errors and several methods of estimating random error statistics, including direct comparison with other observations or models, the Desroziers method, and the three-cornered hat (3CH) method. The Desroziers method is widely used in data assimilation and uses the model background and analysis fields. The 3CH method estimates the uncertainties of three independent data sets simultaneously by using any three collocated independent data sets. Under certain conditions the Desroziers and 3CH methods give identical results. We present examples of RO bending angle and refractivity error standard deviation profiles.

In data assimilation, RO observations are weighted inversely according to their estimated random errors (uncertainties). Historically, statistical error models have been employed, which can vary with latitude, mission, or atmospheric state. Dynamic error models have been proposed in which the uncertainties of individual RO observations vary with a parameter of the occultation profile itself (e.g. local spectral width) or atmospheric state (e.g. mean temperature). A hybrid approach for estimating uncertainties in RO observations in NWP data assimilation is proposed.