Geophysical Research Abstracts
Vol. 15, EGU2013-4542-1, 2013
EGU General Assembly 2013

Systematic Residual Ionospheric Errors in Radio Occultation Data and a Potential Way to Minimize them

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Radio Occultation (RO) sensing is used to probe the Earth's atmosphere in order to obtain information about its physical properties. With a main interest in the parameters of the neutral atmosphere, there is the need to perform a correction of the ionospheric contribution to the bending angle. Since this correction is an approximation to first order, there exists an ionospheric residual, which can be expected to be larger when the ionization is high (day versus night, high versus low solar activity). The ionospheric residual systematically affects the accuracy of the atmospheric parameters at low altitudes, at high altitudes (above 25 km to 30 km) it even is an important error source. In climate applications this could lead to a time dependent bias which induces wrong trends in atmospheric parameters at high altitudes. The first goal of our work was to study and characterize this systematic residual error. In a second step we developed a simple correction method, based purely on observational data, to reduce this residual for large ensembles of RO profiles. In order to tackle this problem we analyzed the bending angle bias of CHAMP and COSMIC RO data from 2001 to 2011. We could observe that the night time bending angle bias stays constant over the whole period of 11 years, while the day time bias increases from low to high solar activity. As a result, the difference between night and day time bias increases from about $-0.05\,\mu$rad to $-0.4\,\mu$rad. This behavior paves the way to correct the solar cycle dependent bias of day time RO profiles. In order to test the newly developed correction method we performed a simulation study, which allowed to separate the influence of the ionosphere and the neutral atmosphere. Also in the simulated data we observed a similar increase in the bias in times from low to high solar activity. In this model world we performed the climatological ionospheric correction of the bending angle data, by using the bending angle bias characteristics of a solar cycle as a correction factor. After the climatological ionospheric correction the bias of the simulated data improved significantly, not only in the bending angle but also in the retrieved temperature profiles.