Effects of Atmospheric Multipath Propagation on Radio Occultation Observables

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ABSTRACT

Multipath propagation is a common source of error in radio occultation experiments in dense atmospheres. If not correctly detected and mapped into the ray asymptote structure, multipath effects produce unrecoverable errors in the inverse problem for the refractive index profile. Raytracing can be used to clearly illustrate multipath caused by interacting signals following closely spaced paths in the atmosphere. Such dynamic signals occur in connection with sharp variations in refractivity with height and result in multivalued frequency with time. Closed-loop radio receivers based on phase-locked loops that are designed to receive single-valued frequency signals will fail to track these dynamic multivalued signals.

SUMMARY

The increasing use of radio occultation to determine atmospheric structure and climate motivates a continuing examination of data collection, processing, and interpretation methods in the presence of atmospheric multipath propagation. Multipath propagation is a common source of error in radio occultation experiments in dense atmospheres. If not correctly detected and mapped into the ray asymptote structure, multipath effects produce unrecoverable errors in the inverse problem for the refractive index profile.

In order to use backprojection methods to mitigate multipath effects in the refractive index profile, it is important that there are no breaks in the collected or backprojected data. Data sets must span a continuous time series over the range of ray asymptotes required for a particular retrieval. The receivers used for radio occultation experiments are therefore expected to reliably and continuously collect data even from signals that have propagated through ducts, turbulence, or other abrupt deviations in atmospheric structure.

Both high altitude radiosonde data [1] as well as model refractive index profiles are used to illustrate an instance in which multipath occurs and to characterize the signal structures produces by multipath propagation. Multipath propagation effects, such as those in Earth's atmosphere, create dynamic signals comprising odd numbers of multiple signals of different frequencies which vary in intensity and phase in a manner unlike both ground multipath and the modulated complex signals that autonomous receivers currently are designed to handle. For example, ground multipath is usually assumed to have intensity of equal or lesser value than the original signal. This is not the case for atmospheric multipath, where closely spaced multipath signals can have rapidly changing intensities that are up to an order of magnitude larger than the original signal. Similar phenomena also occur in association with atmospheric and limb diffraction of occultation signals.

A functional representation of atmospheric multipath signal structure is used as the input to a phase locked loop. The phase locked loop simulation is representative of autonomous closed-loop receivers as opposed to those that are manually frequency-steered. The tracking performance of the phase locked loop is evaluated for these dynamic signal structure inputs. Cases where the system fails are examined to determine the extent to which closed-loop systems can be used to observe and accurately characterize such signals.

REFERENCES

[1] B. Brashers, Precision Radiosonde Data from November 1995, *Private Communication*, April 1998.