Microwave Radiometers For Deep Space Radioscience Experiments: Instrumental Internal Noise Characterization

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ABSTRACT

The BepiColombo mission to Mercury, scheduled for launch in the summer of 2014, will carry on board a radioscience experiment named MORE (Mercury Orbiter Radioscience Experiment). MORE encompasses a set of challenging experiments to investigate a wide range of physical parameters, spanning in the fields of geodesy, geophysics and fundamental physics. In order to perform the experiments, the calibration of the Earth troposphere plays a crucial role. Microwave radiometers have been identified as fundamental instruments to be used to fulfill the stringent MORE performance requirements.

The work presented here is based on a study funded by the European Space Agency (ESA) to investigate the capability of current ESA microwave radiometers to satisfy the MORE requirements. Radio science experiment requirements are defined in terms of two-way tracking Allan Standard Deviation (ADev) at different observation times. ADev was developed for a statistical analysis of the stability of an atomic time oscillator but further studies demonstrated that the theory can be applied to other time series. In particular, it is useful in the statistical characterization of the stability of a Doppler link and instrumental radiometric noise.

When computing the ADev of the measured path delay, the crucial aspect is the separation of the contributions by the atmosphere on one hand and the instrumental internal noise on the other hand. For this reason, different techniques have been developed and tested in order to estimate the internal noise ADev.

After an introduction to the deep space media calibration system and a theoretical characterization of the Adev, the paper deals with the implemented algorithms and the data analysis results. As far as the theoretical characterization of the ADev is concerned, synthetic noise time series have been generated and combined in order to evaluate the expected ADev with different data sets combinations.

The main part of the paper presents the different algorithms developed and implemented for the internal noise characterization. Most importantly, simultaneous measurements by two microwave radiometers installed close to each other and pointing toward the same direction are analyzed. Because both should view the same atmospheric characteristics while having completely different noise characteristics, information on the instrumental noise characteristics can be gained. Finally, we show the results of the characterization analysis and compare them with the MORE requirements.