

The Propagation of Stable Radio Frequency Signals Through the Atmosphere.

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Abstract:

The terrestrial troposphere and ionosphere are known to have profound effects on the radiation fields traversing them. The primary types of effects are refractive (deflection, polarization rotation, propagation velocity changes), absorption, and scattering by the turbulent structure in the media. In particular, the wet troposphere plays a very important role in precise radio propagation. The phase accuracy of VLBI measurements and spacecraft Doppler tracking at frequencies greater than 5 GHz is dominated by fluctuations in the distribution of water vapor.

The Deep Space Network is supporting the Gravitational Wave Experiment (GWE) on the Cassini spacecraft by providing atmospheric media calibration for precise Doppler tracking. The two-way communication link between the ground station and the Cassini spacecraft are in effect an "antenna" for gravitational waves that will perturb the phase of the RF signal between the Earth and the spacecraft. The experiment will be sensitive to gravitational wave perturbations larger than the noise level fluctuations of 3×10^{-15} as measured in the Allan Standard Deviation Domain.

We have designed and are testing a new atmospheric calibration system to sense line-of-sight water vapor and its physical temperature with a goal of calibrating 95% or more of water vapor fluctuation during the Cassini GWE. The calibration system consists of a newly designed water vapor radiometer having a 1 degree sensing beamwidth, a microwave temperature profiler to retrieve the vertical distribution of the vapor physical temperature, and surface meteorology. A detailed error budget has been developed to account for all of the possible sources of error during calibration of the GWE and will be discussed. Two water vapor calibration systems have been constructed in order to provide side-by-side testing capability as well as backup during the actual experiment. We will report on an independent test of these calibrations systems done by comparing them to a short baseline radio interferometric measurement at our Goldstone complex.