JF: Tropospheric path delay corrections

Calibrating Atmospheric Delay for the Cassini Gravitational Wave Experiment

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Abstract:

The Cassini spacecraft together with one of the stations of the Deep Space Network (DSN) have been instrumented to carry out extremely precise Doppler tracking that will be used to search for the direct evidence of Gravitational radiation passing through our solar system. The two-way communications link between the ground antenna and the spacecraft constitute an "antenna" for gravitational waves that would perturb the phase of the RF signal in the link. The experiments will be carried out during the long cruise phase of the spacecraft on its journey to Saturn and 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.

The use of simultaneous, coherent X- and Ka-Band up and down signals will reduce the errors associated with charged particle fluctuations in the interplanetary medium and Earth's ionosphere to a negligible level. The primary fluctuations in the phase of the signals both to and from the spacecraft are expected to be caused by fluctuations in water vapor in the Earth's atmosphere

We have designed and are testing a new atmospheric calibration system (with duplicate components) to sense line-of-sight water vapor and its physical temperature with a goal of calibrating 95% or more of tropospheric path delay fluctuations during the Cassini Gravitational Wave Experiment (GWE). The critical component of the calibration system consists of a newly designed water vapor radiometer having a 1 degree sensing beamwidth and 0.01 K brightness temperature stability over hour time scales. Auxiliary instrumentation includes 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 identical calibration systems have been constructed in order to provide capability as well as backup during the actual GWE experiment. We will report on side-by-side testing of the vapor and temperature sensing components of this calibrations system as well as a comparison with a short baseline radio interferometric measurement at our Goldstone complex.