On the feasibility of using common IR spectrometers to correct for fluctuating radio path delay due to the inhomogeneous wet troposphere

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Experiments relying on the phase of microwave interplanetary communication links suffer from a substantial source of phase noise due to the total refractivity fluctuations of water vapor in the troposphere. Many radio science experiments involving space vehicles will use Ka band in the near future, notably the Cassini mission to the Saturnian system. Cassini will exploit the Ka-band link to perform measurements of gravity fields around Saturn and its moons, attempt detection of gravitational waves, and measure solar General Relativistic effects near solar conjunction. In two-way Ka-band links, wet troposphere fluctuation dominates over space plasma and ionospheric fluctuations, and exceeds anticipated time-standard uncertainties. To approach theoretical performance of such radio science experiments requires real-time measurements of the tropospheric moisture fluctuations on time scales of minutes to hours. Others have demonstrated that high- resolution spectrometers measuring downwelling radiance are sensitive to the relevent moisture content, and can be the basis of temperature and water-vapor profiling along an arbitrary line of sight, with limited yet substantial vertical resolution. These spectrometers may be easily designed to have a beamwidth closely matching the volume of troposphere that affects large space-communications antennas.

We show through simulation using a line-by-line radiative transfer model that the information content of spectra measurable with inexpensive instruments is adequate for integrated refractivity measurements that reduce the impact of uncalibrated fluctuations by roughly a factor of ten. Initial field experiments result in plausible (but unverified) water and temperature profiles, and demonstrate that leading limitations of the method at present include errors in the HITRAN 1992 data base for pure-rotational and v-2 water lines of moderate strength, and suggest inadequacy in models for the water vapor continuum in the thermal IR band (where intensity and detector performance are particularly favorable). Techniques for overcoming these limitations are proposed.

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2. F
3. (a) Tropospheric phase calibration for interferometers (with J)
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