GPS Measurements of Precipitate Water Vapor

R S Gross, A P Freedman, and K Schulz (Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91 109; 818-354-4010; rsg@logos.jpl.nasa.gov)

The Global Positioning System (GPS) is composed of two major components: (1) a space-based component consisting of a constellation of 24 currently operating satellites, and (2) a ground-based component consisting of a network of receivers. The satellites, which are at an altitude of 20,200 ktn in orbits of 12-hour period, broadcast navigation signals at two L-band frequencies. The multi-channel receivers then detect these signals from as many satellites as are above the horizon (up to the number of channels in the receiver).

The troposphere affects the GPS broadcast signal by causing a refractive delay in the transmission time of the signal. This tropospheric path delay is typically 2.0–2.4 meters in the zenith direction and can be decomposed into two parts: (1) that part due to the presence of water vapor in the atmosphere (known as the wet delay) accounting for about 10% of the total effect, and (2) that part due to all the other constituents of the atmosphere (known as the dry delay) and accounting for about 90% of the total effect. When surface atmospheric pressure measurements are available, the dry delay, which is largely static, can be accurately modeled (to better than 1 cm) and removed from the total delay. The remaining wet tropospheric delay, a function of the time-varying distribution of water vapor along the satellite-receiver raypath, can change in the zenith direction by as much as 5 cm in an hour with typical hourly changes amounting to 1 – 2 cm. The total wet troposphere zenith delay ranges from near zero in extremely dry conditions, to as much as 50 cm (1 cm of zenith path delay corresponds roughly to 6.3 cm of precipitable water vapor).

The standard practice currently employed in modeling the tropospheric path delay uses the signals received by the GPS receivers to solve for the path delay in the zenith direction, and to use a mapping function to infer the delay along the satellite-to-receiver ray path at all other elevation angles. The GPS data reduction software (GIPSY/OASIS H) at JPL currently has this capability and its application to a global array of GPS receiving stations equipped with barometers would result in measurements every 10 minutes of the amount of precipitable water vapor in the zenith direction at each station.