Multi-Cone Model for Estimating GPS Ionospheric Delays

This model preserves the high accuracy of the conical domain model while providing superior integrity.

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The multi-cone model is a computational model for estimating ionospheric delays of Global Positioning System (GPS) signals. It is a direct descendant of the conical-domain model, which was described in “Conical-Domain Model for Estimating GPS Ionospheric Delays” (NPO-40930), Software Tech Briefs, special supplement to NASA Tech Briefs, September 2009, page 18. A primary motivation for the development of this model is the need to find alternatives for modeling slant delays at low latitudes, where ionospheric behavior poses an acute challenge for GPS signal-delay estimates based upon the thin-shell model of the ionosphere.

Since ionospheric signal delay contributes error to GPS position and time measurements, it is necessary to estimate the delay to correct and bound this error. Several national and international systems, denoted generally as satellite-based augmentation systems (SBASs), are under development worldwide to enhance the integrity and accuracy of GPS measurements for airline navigation.

A prominent example is the Wide Area Augmentation System (WAAS) of the United States, in which slant ionospheric delay errors and confidence bounds are derived from estimates of vertical ionospheric delay modeled on a grid at regularly spaced intervals of latitude and longitude. The estimate of vertical delay at each ionospheric grid point (IGP) is calculated from a planar fit of neighboring slant delay measurements, projected to vertical using a standard thin-shell model of the ionosphere.

Interpolation on the WAAS grid enables estimation of the vertical delay at the ionospheric pierce point (IPP) of any arbitrary user’s measurement. (The IPP of a given user’s measurement is the point where the ray path of the measured GPS signal intersects a reference ionospheric height.) The product of the interpolated value and the user’s thin-shell obliquity factor provides an estimate of the user’s ionospheric slant delay.

Two types of error restrict the accuracy of delay estimates based upon the thin-shell model: (1) error arising from the implicit assumption that, at the IPP, the electron density is independent of the azimuthal angle, and (2) error due to an invalid obliquity factor (e.g., error due to a suboptimal choice of shell height). Under nominal conditions at mid-latitudes, the magnitude of the error incurred from these sources is small. However, at low latitudes or at mid-latitudes under disturbed conditions, the error grows due to the presence of enhanced ionization, complex ionospheric structure, and large electron-density gradients. In the conical-domain model, these sources of error are mitigated by eliminating the use of both the thin-shell model and the vertical delay grid. Instead, a user’s slant delay to a given satellite is calculated directly by fitting measured slant delays for nearby ray paths to the same satellite.

The conical domain model is so named because the receiver and satellite positions define a cone with the

![Figure 1](https://ntrs.nasa.gov/search.jsp?R=20090035904)

Figure 1. A Conical Domain having a vertex at a given IGP is defined, and a set of pseudo-measurements for ray paths that intersect at the IGP is fit to this conical domain.

![Figure 2](https://ntrs.nasa.gov/search.jsp?R=20090035904)

Figure 2. The Slant Delay From a Satellite of Interest to a user airplane is estimated by interpolating among slant delays for ray paths between (a) the user airplane and (b) each of the four adjacent IGPs, for which pseudo-measurements have been fit to conical domains as depicted in Figure 1.
High-Sensitivity GaN Microchemical Sensors

This innovation enables remote detection of chemical/biological toxins in the air.

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Systematic studies have been performed on the sensitivity of GaN HEMT (high electron mobility transistor) sensors using various gate electrode designs and operational parameters. The results here show that a higher sensitivity can be achieved with a larger W/L ratio (W = gate width, L = gate length) at a given D (D = source-drain distance), and multi-finger gate electrodes offer a higher sensitivity than a one-finger gate electrode. In terms of operating conditions, sensor sensitivity is strongly dependent on transconductance of the sensor. The highest sensitivity can be achieved at the gate voltage where the slope of the transconductance curve is the largest.

While GaN-based microchemical sensors have shown very promising performance characteristics, there has not been much understanding on how sensor sensitivity can be engineered or improved. This work provides critical information about how the gate electrode of a GaN HEMT, which has been identified as the most sensitive among GaN microsensors, needs to be designed, and what operation parameters should be used for high sensitivity detection.

The figure shows I_Ds (source-drain current) response to SF6 exposures measured using the GaN HEMT sensors fabricated with W = 5, 10, 25, and 50 μm at L = 2 μm. The sensors clearly demonstrate a higher sensitivity with an increasing gate width. I_Ds response measured using GaN HEMT sensors fabricated with L = 5, 15, and 8 μm at W = 50 μm and with L = 2 μm at W = 25 μm; (in these sensors the source-drain distance is DS = L + 4 μm) show decreasing sensitivity with an increasing gate length.

Comparison between L4W50, L8W50 and L2W25 sensors, which correspond to DS8W50, DS12W50, and DS6W50 respectively, indicates that the sensor sensitivity is not simply proportional to I_Ds or W/L (or W/DS). The higher sensitivity achieved with the L2W25 sensor compared to the L4W50 sensor indicates that the shorter gate length plays a significant role. The results shown here suggest that sensor sensitivity is not simply proportional to the size of the gate electrode or the amount of I_Ds of the sensor, and that a short gate length and a source-drain distance are important factors in determining the sensitivity of the sensor.

The robust, high-sensitivity GaN HEMT chemical sensors can be applied to NASA missions including in-situ detection of signatures of extraterrestrial life and in-situ planetary atmosphere