The Challenges of Validating GAIM Models of the Ionosphere

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This paper addresses the often surprisingly difficult challenges that arise in conceptually simple validations of global models of the ionosphere.

AFRL has been tasked with validating the Utah State University GAIM (Global Assimilation of Ionospheric Measurements) model of the ionosphere, which is run operationally at Air Force Weather Agency. Early validations of similar models (such as PRISM) concentrated mainly on validating model values of slant TEC from stations that were withheld from the assimilation process. Keeping GPS TEC data aside for validation purposes is a reasonable approach when the voluminous TEC observations provide the bulk of the assimilated data, and when TEC specification is a primary requirement. However, validations based on GPS TEC provide very little information about the validity of the GAIM electron density profiles at locations around the Earth.

The USU-GAIM model currently assimilates, in addition to GPS TEC data, in situ densities from DMSP satellites and vertical profiles provided by a limited number of Digisondes. AFRL has performed a large number of USU-GAIM validations using values of foF2 and M(3000)F2 from non-assimilated ionograms, the in situ electron density at ~400 km provided by CHAMP, and the vertical TEC provided over ocean areas by TOPEX and JASON.

The version of USU GAIM currently being tested by AFRL will also assimilate UV radiances from SSUSI sensors on the DMSP satellites. The approach adopted for the validation of this version is to run USU-GAIM with (1) only ground-based data, (2) with ground-based + disk UV data, (3) with ground-based + limb UV data, and (4) ground-based + all UV data. The observations that can serve as ground-truth for the validations are then the Digisonde profiles, values of foF2 and M(3000)F2 from non-autoscaled (and thus not assimilated) ionograms, the CHAMP electron density, and the JASON values of vertical TEC.

Without the UV data, USU GAIM runs at AFRL at about one-third real time. For validations against ionogram characteristics, AFRL usually works with a full month of GAIM and Digisonde data, which takes ~10 days to run. However, the inclusion of UV data can significantly increase the run times, making it difficult to address essential "what if" scenarios, except for limited time intervals. Compounded with the problem of long run times is the fact that the UV observations are from a satellite that is only very rarely in near conjunction with the ground-truth satellites such as CHAMP and JASON, or near ground-based ionosondes. Exacerbating this problem is the fact that the most reliable assimilated UV data is from the evening equatorial ionosphere. It is often not possible to obtain useful ionogram characteristics for the evening equatorial ionosphere because of the occurrence of irregularities that lead to spread F echoes on the ionograms.

We will discuss the impact of these various challenges on the lessons that can and cannot be learned from validation studies of global ionospheric models.