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Assimilating Electron Density Profiles Measured by the Real Time Global Ionospheric Radio Observatory – GIRO

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Operational applications of ionospheric models, whether they are first principles or data-driven models, rely on the accuracy of the models during quiet and disturbed conditions. Of course models can correctly describe ionospheric weather only if they assimilate measured ionospheric characteristics and electron density profiles (EDPs). For the "assimilating model" to make correct predictions, the measurements in turn must be accurate and reliable. Ionosondes provide the most accurate vertical EDPs at the site locations but do not cover all parts of the globe. Ionogram-derived EDPs have become the ground truth reference for ionospheric specification, presenting the unrivaled accuracy of the data on continuous demand for validation of alternative ionospheric techniques, including radio occultation, ultraviolet, and tomography. In recent years the digisonde network of ionosondes has grown to eighty stations and is expected to expand to more than 100 stations in the next couple of years. The new Digisonde-4D is running the Automatic Real Time Ionogram Scaler with True height inversion, ARTIST-5. The ARTIST-5 autoscaling program now calculates the EDPs together with density uncertainty limits at each height, making the data products suitable for ingestion in assimilative ionospheric models. In order to specify uncertainty at each height, two boundary profiles, inner and outer, are determined. The inner and outer boundaries reflect the uncertainties of the critical frequencies of each layer, the internal uncertainty of the starting height of the profile, and the uncertainties of the E valley model representation.

The actual uncertainties are calculated from a cumulative difference characteristic representing a mismatch between automatically and manually scaled parameters (i.e., foF2, foF1) for the same ionogram. The cumulative differences are determined from statistical analysis of a large amount of ionograms for a specific station. The characteristics of interest are deduced as 95% uncertainty bounds for a histogram of the distribution of the differences between the ionogram parameters obtained manually and automatically. New ionospheric assimilation models like the Global Assimilation of Ionospheric Measurements (GAIM) differ from prior generation adaptive ionospheric models in that they analyze the uncertainty of the observational inputs before using them as constraints on the physical model drivers.

The SAO data exchange format was expanded into the SAO-XML format [Reinisch and Galkin, 2008] to accommodate the expanded data content. In August 2008 during the URSI General Assembly in Chicago, Commission G of URSI accepted SAO-XML as the standard format for ionogram data exchange. All digisonde stations are currently being updated to SAO-XML for ingestion of the scaled data together with the raw ionograms in data centers like the Digital Ionogram Data Base (DIDBase). DIDBase and the digisonde network using SAO-XML truly form a real time Global Ionospheric Radio Observatory (GIRO). Since SAO-XML can easily accommodate data from any digital ionosonde, other ionosonde models can become part of GIRO.