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On the development and testing of an ionospheric data assimilation system.

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Comprehensive, global and timely specifications of the earth's atmosphere (particularly refractivity profiles of the troposphere and ionosphere) are required to ensure the effective operation, planning and management of many radio frequency systems. One way of providing refreactivity information for the ionosphere is to employ an ionospheric data assimilation system. Such systems can produce 3D images of the ionosphere using data provided by a range of measurement techniques. Of particular note is data from the International GPS Service (IGS) receiver network. Many IGS stations provide data in hourly files with low latency (˜90 minutes), which can be used to calculate near real-time slant total electron content (TEC). Radio Occultation (RO) methods are also being increasingly investigated. RO measurements are made by monitoring transmissions from GPS satellites using receivers on Low Earth Orbiting (LEO) satellites and provide the potential of measuring refractivity profiles in regions where ground based sensors cannot easily be located, such as deep sea waters. In both cases, data assimilation can provide an optimal way of combining slant TEC measurements with an ionospheric model to provide a full 3D representation of the ionospheric electron density.

This paper will describe the main elements that are required to construct an ionospheric data assimilation system. In particular, the electron Density Assimilative Model (EDAM), developed at QinetiQ in the UK will be used as an example. EDAM has been developed as a compromise solution to the ionospheric assimilation problem that, in terms of complexity, lies between the full physical model data assimilation systems (such as the GAIM models) and the more data driven tomographic solutions (such as ART and MART). As such, it uses a median model for its background model, but does allow the analysis and background error covariance matrix to evolve in time.

EDAM is routinely run using input data from the IGS network of GPS stations and from the USAF vertical ionosonde network. It is also capable of ingesting other integrated TEC data such as from radio occultation instruments as well as in-situ measurements of electron density.

This paper will describe the testing of the EDAM electron density grids against independent validation data. The validation data includes critical frequencies from vertical ionosondes, in-situ measurements from CHAMP and TEC data from JASON-1. These results will then be related to the operational benefits that may be experienced by typical RF systems (GNSS, HF comms, etc). Furthermore, since EDAM does not contain a physical ionospheric model, forecast results must be obtained with a relatively simple persistence approach. The performance and limitations of this will be described.