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A Real-Time Assimilative Model for IRI

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Ionospheric models are mostly unable to correctly predict the effects of space weather events and atmospheric disturbances on the ionosphere. This is especially true for the International Reference Ionosphere (IRI) which by design is a monthly median (climatological) model [Bilitza et al., 2011]. We propose a Real-Time Assimilative Model "RTAM" for IRI that is ingesting, initially, the available real-time Digisonde GIRO [Reinisch and Galkin, 2011] data streams: foF2/hmF2, MUF3000F2, foF1/hmF1, and foE/hmF2 [Galkin et al., 2011]. Deviations of these characteristics, especially foF2, from the monthly median values are the main cause for errors in the IRI model prediction. The assimilative modeling will provide a high-resolution, global picture of the ionospheric response to various short-term events observed during periods of storm activity or the impact of gravity waves coupling the ionosphere to the lower atmosphere, including timelines of the vertical restructuring of the plasma distribution. GIRO currently provides reliable real-time data from 42 stations at a cadence of 15 min or 5 min. The number of stations is rapidly growing and is likely to soon be complemented by satellite borne topside sounders. IRI uses the characteristics predictions based on CCIR/URSI maps of coefficients. The diurnal variation of the foF2 characteristic, for example, is presented by the Fourier series

$$foF2(T, \phi, \lambda, \chi) = a_0(\phi, \lambda, \chi) + \sum_{n=1}^{6} (a_n(\phi, \lambda, \chi) \cos nT + b_n(\phi, \lambda, \chi) \sin nT),$$

where T is Universal Time in hours, and ϕ, λ, χ are the geographic latitude, longitude, and modified dip latitude, respectively. The coefficients a_n are in turn expanded as functions ϕ, λ, χ resulting in a set of 24 global maps of 988 coefficients each, one for each month of the year and for two levels of solar activity, R_{12}=10 and 100, where R_{12} is the 12-month running-mean of the monthly sunspot number R_m (2*12*988 = 23,712 coefficients in all) [ITU-R, 2011]. For a given point in time, 988 coefficients need to be adjusted such that the new foF2 map reproduces the 42 values measured at that time by the GIRO network and smoothly transforms the original model map. This totally underdetermined task has been approached by using the mathematical tool of Linear Programming; preliminary results are presented.

The technique can also be applied for regional modeling. Retroactive RTAM processing of the maps for an entire solar cycle will result in improved CCIR and URSI maps of the F2 peak characteristics, i.e., in an improved IRI electron density model.

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