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A new climatology for the total electron content of the ionosphere

R. Scharroo (1,2), W. H. F. Smith (2) and J. L. Lillibridge (2)

(1) Altimetrics LLC, Cornish, New Hampshire (remko@altimetrics.com), (2) NOAA/NESDIS, Laboratory for Satellite Altimetry, Silver Spring, Maryland (walter.hf.smith@noaa.gov, john.lillibridge@noaa.gov)

We have created a new climatology for the total electron content (TEC) of the ionosphere, forced by solar flux observations and based on GPS-derived global ionosphere maps (GIM). GIMs are only available since 1998, so to correct data from single-frequency altimeters (i.e. Geosat, ERS-1 and ERS-2) prior to that date, one generally relies on the International Ionosphere models of 1995 and 2001 (IRI95 and IRI2001). These IRI models, however, lack considerably in TEC accuracy compared to GIM since they are restricted in temporal and spatial resolution. Our GIM-based climatology is intended to improve upon the IRI models as far as estimating TEC is concerned.

IRI uses only monthly values of sunspot number and ionosphere index as forcing parameters which, in turn, are averaged over 12 months, thus limiting the ability to respond to variations with periods less than 1 year. Variations during the day are modelled in IRI95 by only 9 parameters (harmonics), in IRI2001 by only 13 harmonics. Finally, spatial variations in IRI95 are captured by a mere 49 spherical harmonics, in IRI2001 by 76 spherical harmonics.

The climatology is based on GIM maps from 28 September 1998 to 31 December 2006 as provided by the Jet Propulsion Laboratory. The new model is structured similarly to the IRI climatologies but improves upon their performance in terms of TEC on several points. The new climatology increases the temporal resolution by using daily forcing parameters of solar flux that are smoothed over 40 days and time shifted by 15 days for the best result. The variations during the day are modelled by 12-parameter piecewise linear functions (an improvement over IRI95). And finally, the spatial resolution is increased to the same resolution as the GIM maps (5° in longitude, 2.5° in latitude).

The climatological TEC values fit the GIM maps to about 5.5 TEC units over the fitting period. This is equivalent to an rms error of only 12 mm in one-way ionospheric path delay for Ku-band altimeters. The new climatology provides significantly more accurate TEC estimates than IRI95. The RMS difference between IRI95 and GIM is more than twice as large: 12.4 TEC units or 27 mm in path delay. These performance statistics have been confirmed using independent dual-frequency altimeter data.