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Comparison of solar-ionospheric indices for the foF2 modeling

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Using the *foF*2 database obtained from satellites and ground-based ionospheric stations, we have constructed a global empirical model of the critical frequency of the ionospheric *F*2-layer (SDMF2–Satellite and Digisonde Data Model of the *F*2 layer) for quiet geomagnetic conditions [1]. The model was based on the Legendre method for the spatial expansion of *foF*2 monthly medians to 12 in latitude and 8 in longitude of spherical harmonics. The resulting spatial coefficients have been expanded by the Fourier method in three spherical harmonics with respect to UT. The input parameters of this model are the geographical coordinates (φ – latitude and λ – longitude), UT, day, month, and year. As a solar activity proxy, different solar or ionospheric indices can be used in this model. To validate the model and evaluate it usefulness in day-to-day predictions, we used the following solar-ionospheric indices for a given day (obtained by linear interpolation): R_{12} is the 12-month smoothed number of sunspots *R*, IG_{12} is the 12-month-average value of the ionospheric index of solar activity *IG*, *T* is the Australian ionospheric index, F_{107A} is the 81-day running mean of daily F_{107} and an integral index $F_{10.7\tau}$, which accumulates the time series of $F_{10.7}$ values with exponential smoothing. Parameter τ=0.96 corresponds to the characteristic time of ~27 days (one rotation of the Sun). The calculated *foF*2 values from models International Reference Ionosphere IRI [2] and SDMF2 have been compared to the observed hour values on the 8 ionosonde stations data for *Kp* < 3 for period from January 2010 to December 2016. Table 1 shows the results of comparing the IRI (URSI-88) model with the input ionospheric index IG_{12} and the model SDMF2 with the indices for a given day: IG_{12}, R_{12}, *T*, $F_{10.7A}$ and $F_{10.7\tau}$.

Table 1. Results of models comparison with various input solar activity proxy

Station Name	φ	λ	N	RMSE, MHz					
				IRI	SDMF2				
					R_{12}	IG_{12}	T	$F_{10.7A}$	$F_{10.7\tau}$
Port Stanley	–51.7º	302.2º	30920	1.21	1.03	0.95	0.90	0.92	0.90
Hobart	–42.9º	147.3º	26543	0.90	0.92	0.86	0.79	0.82	0.78
Grahamstown	–33.3º	26.5º	26246	1.09	0.95	0.93	0.83	0.87	0.84
Townsville	–19.7º	146.9º	29802	1.19	1.23	1.14	0.99	1.07	1.01
Boulder	40.0º	254.7º	34869	0.95	0.92	0.92	0.85	0.86	0.85
Moscow	55.5º	37.3º	24673	0.86	0.89	0.90	0.79	0.81	0.79
Salekhard	66.5º	66.5º	20651	0.80	0.85	0.79	0.75	0.76	0.75
Tromsø	69.7º	19.0º	25467	0.94	0.97	0.94	0.90	0.91	0.90

The results of the validation show that the smallest RMSE was obtained with the indices *T* and $F_{10.7\tau}$. The largest improvements in a comparison with the IRI model was obtained in the Southern Hemisphere: ~26% at Port Stanley (with the indices *T* and $F_{10.7\tau}$), and ~17% (with the index *T*) and ~15% (with index $F_{10.7\tau}$) at Townsville.

1. V.N. Shubin, "Global Empirical Model of Critical Frequency of the Ionospheric *F*2-Layer for Quiet Geomagnetic Conditions", *Geomagn. Aeron.*, **57**, 4, 2017, pp. 450-462, doi: 10.1134/S0016793217040181.
2. D. Bilitza, D. Altadill, V. Truhlik, V. Shubin, I. Galkin, B. Reinisch, and X. Huang, "International Reference Ionosphere 2016: From ionospheric climate to real-time weather predictions", *Space Weather*, **15**, 2017, pp. 418–429, doi:10.1002/2016SW001593.