MODERNIZATION OF SOLAR ACTIVITY DRIVERS OF THE INTERNATIONAL REFERENCE IONOSPHERE AND PLASMASPHERE MODEL AFTER REVISION OF SUNSPOT NUMBER TIME SERIES

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The newly revised sunspot number, SSN2, since July 1, 2015 [1] presents a potential source of increased errors of the ionospheric models [2] which were built using the predecessor SSN1 index. In order to adapt the International Reference Ionosphere and Plasmasphere (IRI-Plas) model to re-calibration of the sunspot numbers, eight new options of the solar and ionospheric proxies of solar activity are incorporated into the IRI-Plas code for a period from 1948 to 2020 [3-4]: (1) the basic time series of sunspot number, SSN1; (2) renewed time series of sunspot number, SSN2; (3) the solar radio flux F10.7; (4) composite Magnesium II core-to-wing Mg II doublet (h and k ions of 279.56 and 280.27 nm); (5) the composite Lyman-α time series based on measurements from multiple instruments and models to construct a long time series history of the bright solar H I 121.6 nm emission; (6) the ionosphere total electron content TECgn-noon based index; (7) global electron content in the ionosphere and plasmasphere, GEC; (8) the effective global ionospheric index IG, derived from foF2 critical frequency measured by the ionosonde network. The updated IRI-Plas model with the above solar and ionospheric proxy indices are provided at **http://ftp.izmiran.ru/pub/izmiran/SPIM/** and **http://www.ionolab.org/**.

The solar radio flux (F10.7 index) is entered by IRI-Plas code in all solar proxy options either alone or combined with any other solar activity (SA) input option. All indices are smoothed with 12-month window centered on given month (using 6 preceding month's data and 6 following month's data) for each month from 1948 to 2018 including their prediction for 2018-2020. All indices except for F10.7 are scaled to level of SSN1 base index on which global original maps of the ionosphere F2 layer peak parameters are based [5]. In particular, the renewed series of sunspot numbers is reduced to the base index of sunspot numbers with the formula (1) [2]:

$$SSN1_{12} = 0.7 \times SSN2_{12} \quad (1)$$

Scaling coefficients for the other indices of solar and ionospheric activity are deduced from their regression dependencies on SSN1 [4].

12-month smoothing the SA indices centered on given month is ceased 6 months prior to current time so there is a need for predicting the selected indices for 6 months ahead for the real time model application or for the longer period of time with the model predictions for the future. To avoid this shortcoming of the model, one should apply the short-term effective proxy indices of SA [6-9], based on daily measurements of the source indices. In order the short-term proxy of SA could be used with the ionospheric model the daily index for the current day should be available.

The regression relation (2) of the daily value of the base $SSN1_d$ index with the daily $SSN2_d$ index is deduced with their measurements from July, 2008, to May, 2015 (Fig. 1) for the solar cycles SC23 and SC24 [10]:

$$SSN1_d = \begin{cases} 0.6925 \times SSN2_d - 0.2452 & at\ SSN2_d > 0 \\ 0 & at\ SSN2_d = 0 \end{cases} \quad (2)$$

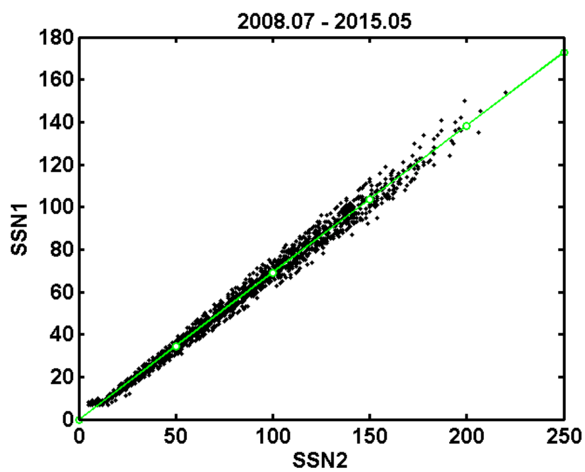

Fig. 1

Calculation of the daily index, $SSN1_d$, with formula (2) is produced daily at the Ionospheric Weather site (**http://www.izmiran.ru/ionosphere/weather/**) in the Table “Indices kp and ap and current forecast”. In the penultimate column of the Table the $SSN1_d$ index is produced with Eqn. (2). In the last column F10.7 index is provided from (**ftp://ftp.geolab.nrcan.gc.ca/data/solar_flux/daily_flux_values/**).

Starting from July, 2015, the production of the basic daily SA index SSN1 is ceased (Fig. 2, gray area), replaced by production of SSN2 at (**http://www.sidc.be/silso/datafiles**/). The measured $SSN2_d$ during SC23 and SC24 are plotted in Fig. 2 (the red lines), the measured $SSN1_d$ before July, 2015 (the green lines), and model results of $SSN1_d$ with Eqn. (2) from July, 2015, up to present time (the blue lines, gray area).

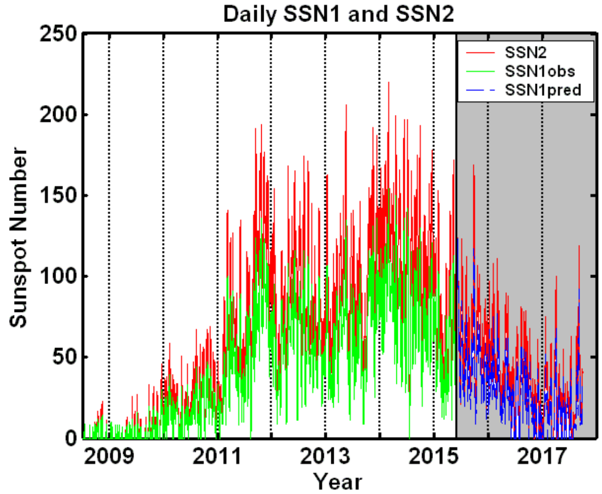

Fig. 2

The integral indices F10.7(τ), SSN1(τ), TECgn(τ) and so on are proposed [8-9] for driving the ionospheric model, which present accumulation of history of the daily index for the preceding 27 days (a solar rotation) with the exponential smoothing [7]. Implementation of the short-term integral indices of the type of SSN1(τ), F10.7(τ), TECgn(τ) instead of prediction of $SSN1_{12}$, $F10.7_{12}$, $TECgn_{12}$ for monitoring the current state of the ionosphere requires further validation of the model accuracy with the ionospheric data.

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