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IONOSPHERIC WEATHER: CLONING MISSED foF2 OBSERVATIONS FOR DERIVATION OF VARIABILITY INDEX

T.L. Gulyaeva[1,2], I. Stanislawska[2], and M. Tomasik[2]

[1] IZMIRAN, 142190 Troitsk, Moscow Region, Russia
[2] Space Research Centre PAS, Bartycka 18-A, 00-716 Warsaw, Poland

ABSTRACT

Routine ionosonde observations of the ionospheric critical frequency foF2 available via Internet are used for daily estimates of the ionosphere variability. Missed ionosonde observations are reconstructed by cloning data of another station(s) within the radius of correlation. This process assumes proportionality of the disturbance level regarding quiet background values for parent and cloned data. The quiet reference is determined as daily-hourly median for 27 days preceding the day of observation. The hourly variability indices D- and D+ are defined as logarithm of ratio of actual hourly value of NmF2 (deduced from foF2) to the quiet reference. A segmented logarithmic scale of the ionosphere state is introduced with dynamic boundaries equal to ±1 for the quiet state, ±2 for the moderate disturbance, ±3 for the ionospheric storm, and ±4 for the extreme or anomalous conditions. Web site is in preparation providing cloned foF2 data, 27-days corrected median, hourly negative D- and positive D+ indices and catalog of the ionospheric disturbances at least of 3 hrs duration. This site at IZMIRAN would complement relevant services at IDCE, Warsaw, and other ionospheric servers.

1. Introduction

Well established system of geomagnetic indices (Menveielle and Berthelier 1991) provides an objective and quantitative monitoring of the irregular variations of the transient geomagnetic field. Indices are aimed to represent degree of variability of selected physical parameter for a selected interval of time. Simple derivation and accepted thresholds of the indices are helpful for instantaneous assessment and forecasting of state of the field.

As distinct from the magnetic indices, the ionospheric instantaneous measured parameters are provided from the Data Centers on CD-ROM or via Internet to the users. From these, many different definitions of degree of the ionospheric disturbance or quietness are produced and investigated by different users (e.g., Gulyaeva 1994; Field and Rishbeth 1997; Deminova et al. 1998; Fuller-Rowell et al. 1998; Kouris et al. 1998; Forbes et al. 2000; Belehaki et al. 2000; Gulyaeva and Mahajan 2001; Rishbeth and Mendillo 2001; Gulyaeva, 2002).

In general, variability of the ionospheric parameters can be considered as superposition of two components. The well-known regular variations of natural origin are caused by solar ionizing radiation responsible for diurnal and seasonal changes depending on geodetic and geomagnetic co-ordinates, phase of the solar cycle, state of the Earth's magnetic field and neutral atmosphere. These so-called quiet (or median) variations are accompanied by the short-term ionospheric perturbations of few minutes to few hours or days duration characteristics of local, regional or global scale disturbances. The short-term ionosphere perturbations are subject of the present study with specification of segmented logarithmic scale of ionosphere disturbance indices for the F2 layer peak electron density NmF2 and the total electron content TEC.

2. Segmented ionospheric disturbance indices

The ionosonde network serves as a source of the F2 layer critical frequency foF2, MHz, related with the ionosphere peak electron density NmF2, m-3: NmF2 = 1.24.1010. (foF2)2. The GPS-derived total electron content, TEC, in the column from 100 km to 20,000 km over the Earth presents independent information on the ionosphere and plasmasphere variability. Original daily-hourly observations of foF2 and GPS-TEC are provided via Internet from the Data Centers such as Space Environment Center (SEC, NOAA, Boulder, CO, USA) and the Ionospheric Despatch Center in Europe (IDCE, Warsaw, Poland).

Deviation of instantaneous value of foF2 or TEC from quiet reference is often taken as degree of the ionosphere disturbance (Gulyaeva 1994; Forbes et al. 2000). However, linear deviations from the quiet reference show disproportion of the scales of positive and negative deviations. In particular, the negative percentage deviation cannot be less than -100% by definition reducing foF2 or TEC to zero (which is not reached in practice). On the other hand, there are no limitations for growing positive deviations which could exceed 1000% by night during a storm. To avoid disproportion of measure of negative and positive ionospheric disturbances, the logarithm of ratio of selected parameter F to its quiet reference is used as the disturbance measure (Gulyaeva 1996; Field and Rishbeth 1997):

$$\mathbf{DF = \log(F/F^*)} \qquad \mathbf{(1)}$$

where F=NmF2 or F=TEC presents instantaneous hourly value, and F* means respective quiet reference. Missed ionosonde observations are reconstructed by cloning data of another station(s) within the radius of correlation. This process assumes proportionality of the disturbance level regarding quiet background values for parent and cloned data.

Sign of DTEC and DNmF2 specifies positive or negative phase of an ionospheric perturbation, i.e. plasma density enhancement or depletion. A ‘sliding reference’ F* is defined as the time-corresponding median of 27 days preceding any given day of observation (Gulyaeva 2002). We assume that the period of 27 days corresponding to the solar rotation yields a background median value that might be valid also on 28th day. Such definition is similar to daily-hourly measure of quiet ionosphere correlated with sunspot numbers (Belehaki et al. 2000). Besides, for the forecasting purposes, in our case one has a median value one day in advance as distinct from the monthly median available only after the month has passed.

Analysis of foF2 data for more than 50 years of observations at the global network of stations (Forbes et al. 2000; Gulyaeva and Mahajan 2001; Rishbeth and Mendillo 2001) has revealed dynamic boundaries of the ionosphere variability depending on the time of day, season, solar activity, magnetic latitude zone. A segmented logarithmic scale is introduced for the both DTEC and DNmF2 indices (Gulyaeva, 1996, 2002) so that the negative disturbances are quantified as -1, -2, -3, -4 and positive disturbances take values of +1, +2, +3, +4: (±1) quiet state, (±2) moderate disturbance, (±3) ionospheric storm, and (±4) extreme or anomalous conditions. Here we take the uniform intervals of logarithmic scale (Eq.1) for the negative and positive disturbances but every level of DF implies different linear negative/positive ratio (or increment) of NmF2 or TEC to their quiet reference.

4. Conclusion

For the assessments of the ionospheric weather, the disturbance indices DNmF2 are obtained on a routine basis. These products are deduced from foF2 data available via Internet. Missed ionosonde observations are reconstructed by cloning data of another station(s) within the radius of correlation. This process assumes proportionality of the disturbance level regarding quiet background values for parent and cloned data. The background quiet median based on a history of foF2 values for 27 days preceding any given day of observation and the variability indices are produced. The deviations D+ and D- calculated as logarithm of ratio of NmF2 to the background median (Eq.1) allow to distinguish negative or positive disturbance in the ionosphere according to specification of the quiet state, slightly disturbed conditions, ionospheric storm and extreme cases.

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