Upgrade of the DIAS models for nowcast and long-term prediction of the foF2 over the European middle and high latitudes

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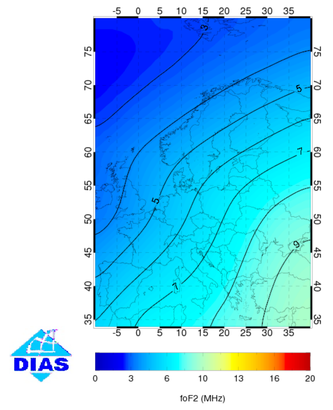
Abstract

The European Digital Upper Atmosphere Server (DIAS) provides since 2006 at a routine basis long term prediction (up to 3 months ahead) and nowcasting maps of the critical frequency foF2 over the European middle latitudes (34° - 60°N), based on the implementation of the Simplified Ionospheric Regional Model (SIRM, Zolesi et al., 1993; 1996) and the real time updating of SIRM (SIRMUP, Zolesi et al., 2004; Tsagouri et al., 2005) methods, respectively (http://dias.space.noa.gr).

Recently, the DIAS middle latitude maps were extended to cover the whole European region up to 80°N, as part of the integration of DIAS services into the ESA/SSA Space Weather Service Network (http://swe.ssa.esa.int/web/). To this effect, the background SIRM and SIRMUP methods were upgraded to expand the DIAS prediction capabilities to the high latitude ionosphere.

The paper reports the results from the development of the new models and their implementation in DIAS, as well as indicative results on their performance in each latitudinal zone.

Description of the upgraded methods and products



Long term prediction map obtained for December 2013 08:00 UT.

Long term predictions

The performance of the regional SIRM model has been proven to be successful within the European area defined as between 34° N and 60° N and -5° W and 40° E. Although the validity of the model could be extended in longitude, it could not be extended to more northerly latitudes due to the complex ionospheric behavior in that region.

To extend DIAS prediction capabilities to high European latitudes, the standard DIAS SIRM output at middle latitudes is combined with the CCIR results for the region above 60°N.

Special consideration is given to the buffer zone between the global CCIR and regional SIRM models. To avoid large gradients due to the complex behavior of the ionospheric conditions at high latitudes, an interpolation routine is applied to formulate the ionospheric predictions between 50° and 60°N. The final map is obtained as the combination of the three grids: the middle latitude, the high latitude and the buffer zone grid.

For the implementation of the algorithm in DIAS, the system receives as input the predicted sunspot number R12 provided by SWPC NOAA (http://www.swpc.noaa.gov/).

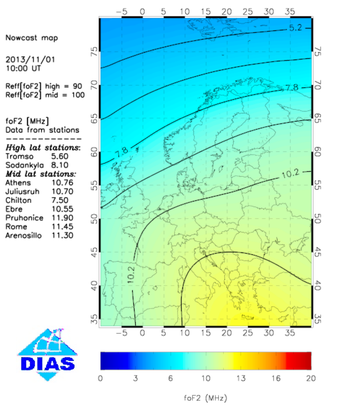
An example of the extended DIAS long term prediction maps is provided in the Figure on the left. Long term predictions are available three months in advance in hourly resolution.

Nowcasting maps

The real time updating of SIRM&CCIR grids is achieved through the SIRMUP concept. This is based on the calculation of the effective sunspot number, Reff (Houminer et al. 1993) through the comparison between actual observations with background estimates. The algorithm is now adjusted to calculate the Reff separately at middle and high latitudes.

For the implementation of the algorithm in DIAS, the system receives as input real time observations from the European Ionosonde network described in the table on the right.

An example of the extended DIAS nowcasting maps is provided in the Figure on the right.



DIAS nowcasting map on November 1, 2013 10:00UT. The Reff estimates together with observed foF2 values are also provided on the left part of the map. The maps are available in hourly resolution.

Performance assessment

Testing period: January – October 2013

Data used: foF2 actual observations, monthly median (MM) estimates, SIRM&CCIR climatological predictions and SIRMUP&CCIR nowcasts.

Stations:

Tromso (high latitudes), Juliusruh and Durbes (buffer zone), Rome and San Vito (middle latitudes).

Ionospheric station	Latitude (°N)	Longitude (°E)
Middle latitude (DIAS net)		
Arenosillo	37.1	353.3
Athens	38.0	23.5
Chilton	51.6	358.7
Ebre	40.8	0.5
Juliusruh	54.6	13.4
Moscow	55.5	37.3
Pruhonice	50.0	14.6
Rome	41.9	12.5
High latitude (Expanded)		
Sodankyla	67.4	26.6
Tromso	69.6	19.2

Climatological predictions

Figure on the right:

Time plots of the foF2 SIRM&CCIR together with monthly median (MM) estimates for the time interval January – October 2013 over three European locations representative of the latitudinal zones (high latitudes, buffer zone, middle latitudes).

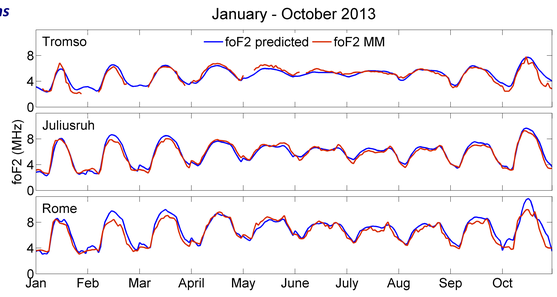
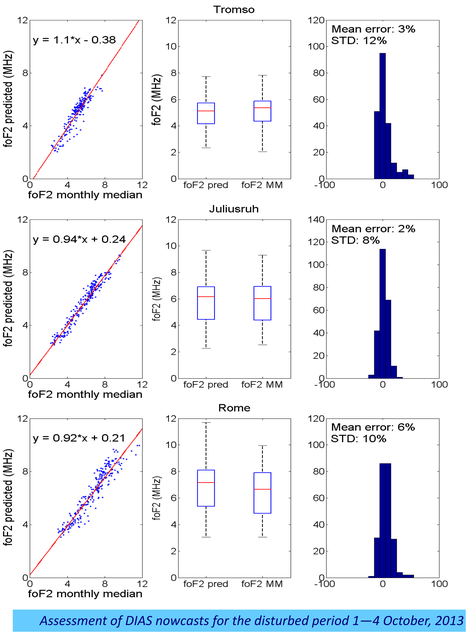
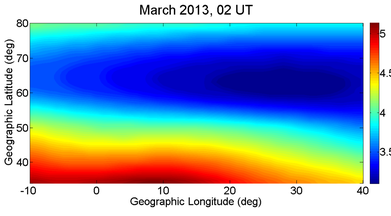


Figure below: Left: The scatter plots of the SIRM&CCIR foF2 versus the monthly median (MM) estimates over each location. Middle: The distribution of the predicted and the MM estimates in boxplot format over each station. This includes a box and whisker plot for each case. The box has lines at the lower quartile, median (red line) and upper quartile values. Whiskers extend from each end of the box to the adjacent values in the data; in our case to the most extreme values within 1.5 times the interquartile range from the ends of the box. Right: The distribution of the relative error between the predicted and the MM in respect with MM over each station.



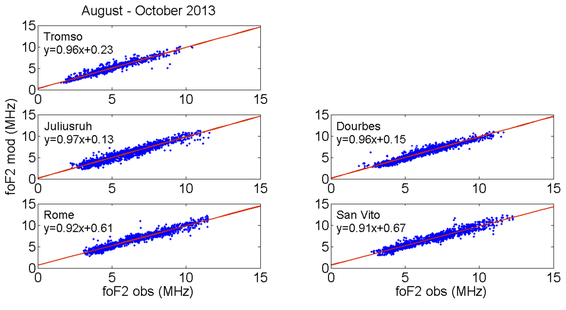
Contour plot of the foF2 climatological SIRM&CCIR predictions for the European area for March 2013, 02 UT giving evidence of ionospheric trough signatures.

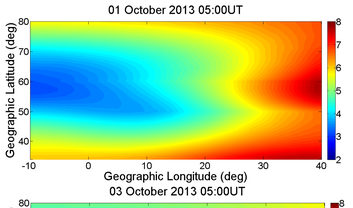


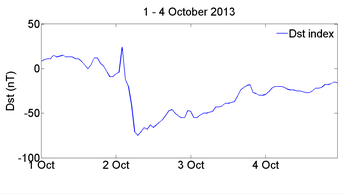
The results verify the efficiency of the SIRM&CCIR method in predicting the ionospheric climatological variation and regular structures over all European latitudinal zones. Therefore, the method provides:

- A robust tool for long term prediction applications
- A reliable background scene for nowcasting applications

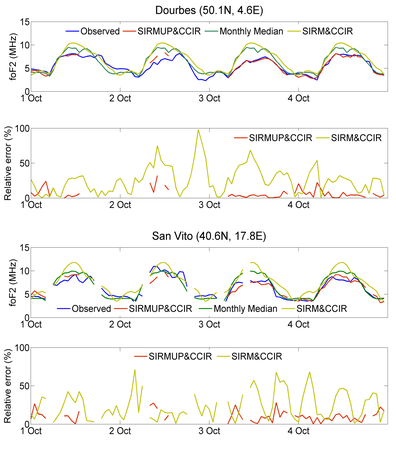
Nowcasting capabilities







Assessment of DIAS nowcasts for the disturbed period 1—4 October, 2013



The SIRMUP&CCIR results follow quite closely the observed values and succeed to reduce significantly the prediction error in respect with the background climatological estimates provided by SIRM&CCIR method.

In addition, the prediction error tends to be small (about 10%) independently on the ionospheric activity level. The method seems also capable in monitoring the development of critical structures (e.g. ionospheric trough) during disturbed conditions.

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