Regional Warning Centre Warsaw report and future perspectives

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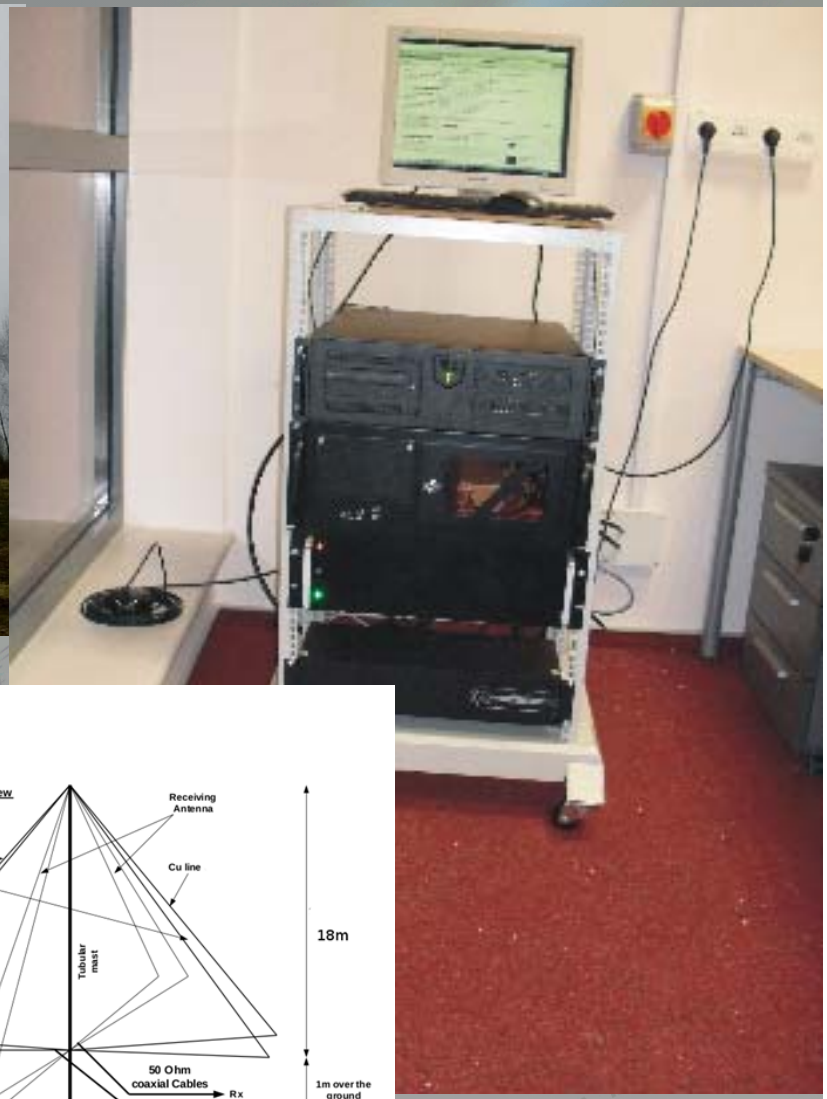
Heliogeophysical prediction service of the Space Research Centre, operating within the global ISES system, is responsible for measurements and predictions of solar activity and related Earth phenomena.

Space Research Centre exchanges data with other Warning Centers, a large portion of data is received directly from various national observatories from different countries. Data from Polish observatories are also collected. Data on terrestrial magnetic field activity are supplied by the Central Geophysical Observatory PAS in Belsk, Poland and are available on the home page in near-real time as well as Warsaw and Hornsund ionosonde data. The RWC with cooperation with Geophysical Institute PAS provides data from polar region (Polish Polar Station Hornsund) – the ionosonde data are completed by riometers and scintillation measurements GISTM

New ionosonde Olsztyn

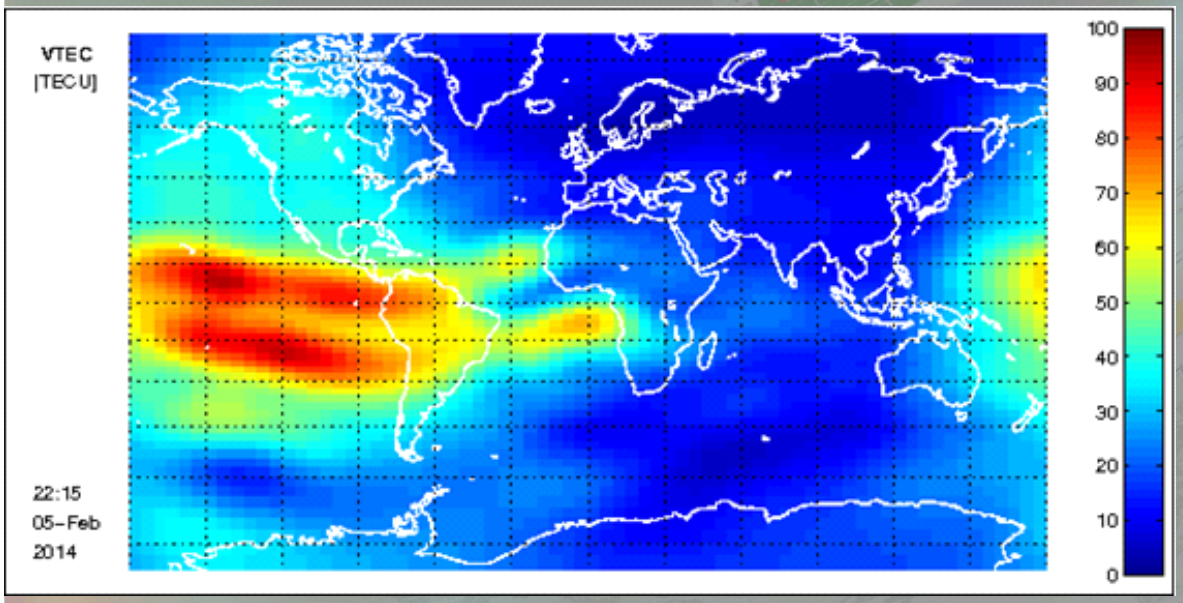


The new ionosonde has been developed for use in propagation research and associated studies of the ionosphere. The ionosonde is known as VISRC2-d and will be installed in OPN-T in Olsztyn.
It is a twin unit of Warsaw ionosonde so the GPS time synchronised shot allows to proceed oblique sounding.The ionosonde works with standard two delta antennas 18 meters high. Due to short distance between Olsztyn and Warsaw and designed propagation pattern the oblique sounding does not requires additional antennas set.

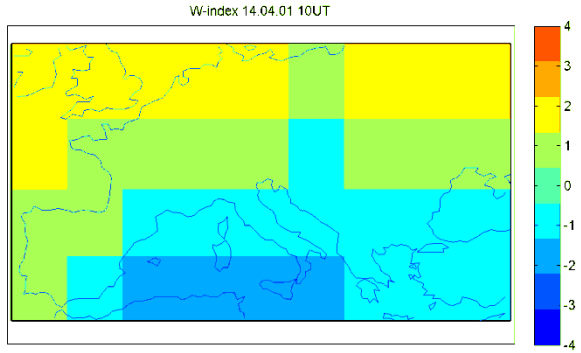
Rysunek 1

Modelling

Methods and algorithms linked directly to the radio-communication prediction and forecast domain are developed and continuously improved. The fully operational real time Vertical Total Electron Content monitoring software has been developed. The data source are selected from GNNS stations and EGNOS RIMS stations. The database was used for the new global expanded version of W-index, and for cloning missing ionospheric values like foF2 or M3000F2. The database can be used also for monitoring traveling ionospheric disturbances (TID), and prediction of TEC variations particularly in EGNOS boundaries.



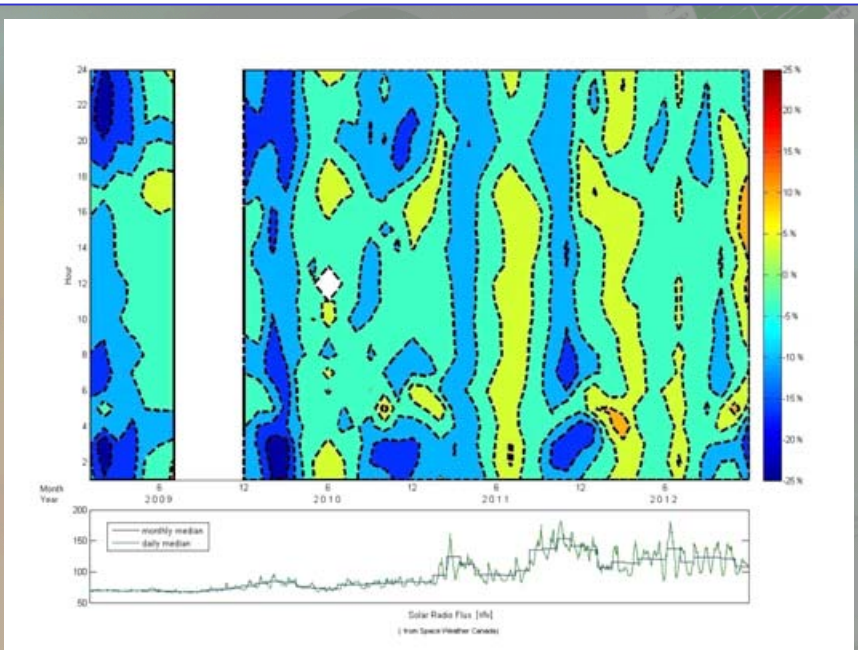
The fully operational real time Vertical Total Electron Content monitoring software has been developed



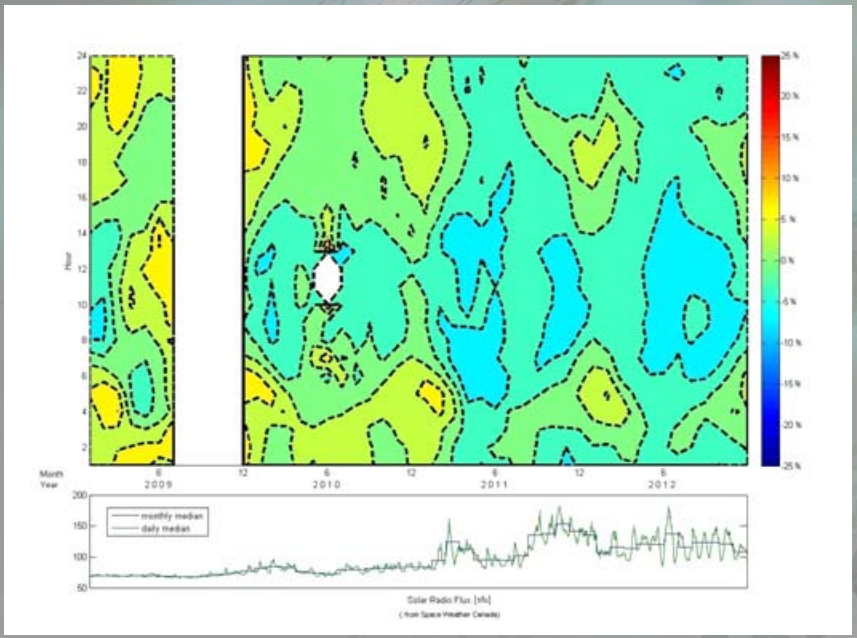
W_index map

Modelling

The variability of ionospheric parameters: foF2, hmF2, M3000F2, B0, B1 for middle latitude over Warsaw were analysed. For this study Warsaw ionosonde measurements since January 2009 to the end of 2012 were used. Specific term enabled to analyse ionospheric parameters in different conditions of solar activity. Selected data were modelled by International Reference Ionosphere IRI 2012 model. Analysis contained: trend, month median differences in twenty-four-hour variability, local minimums and maximums of specified parameters and IRI submodels. The results of the study will enable to use the IRI submodels to prepare more accurate local and global ionospheric maps in the event of lack of parameters, and the more effective forecasts and predictions of ionospheric conditions.



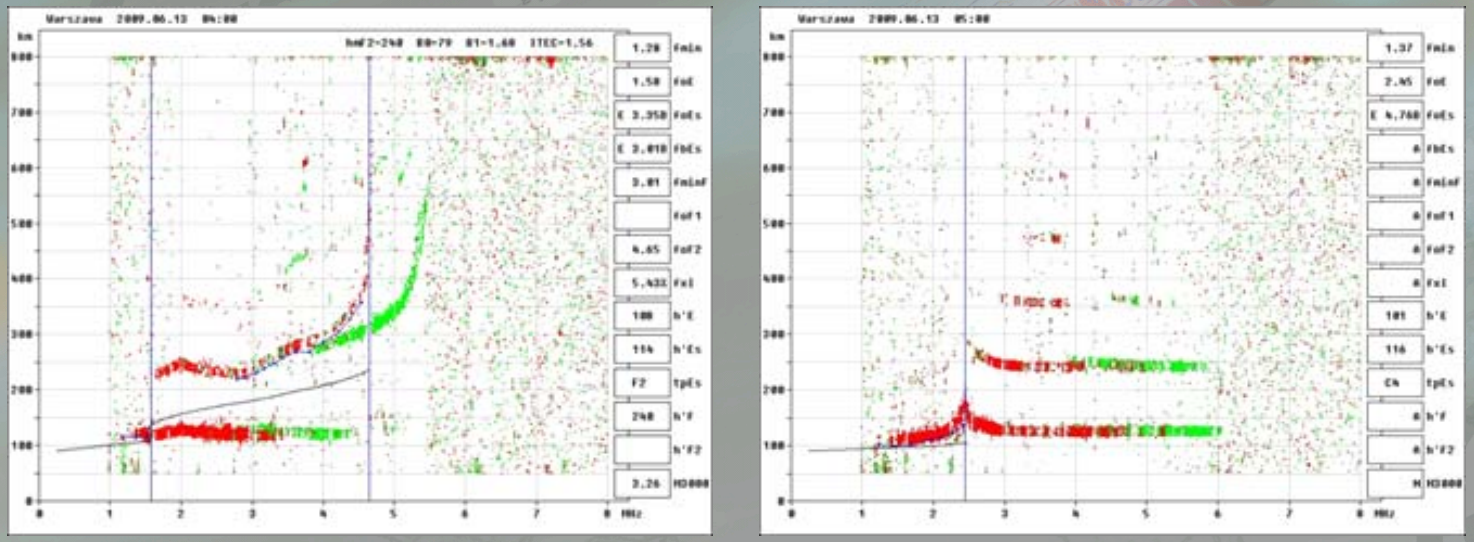
Differences between foF2 monthly medians obtained from Warsaw ionosonde and IRI 2012 model, with specified solar 10.7 cm flux level. Examination included observational data for time period of increasing solar activity from 2009 to 2012.



Differences between hmF2 monthly medians obtained from Warsaw ionosonde and IRI 2012 model, with specified solar 10.7 cm flux level. Examination included observational data for time period of increasing solar activity from 2009 to 2012.

Modelling

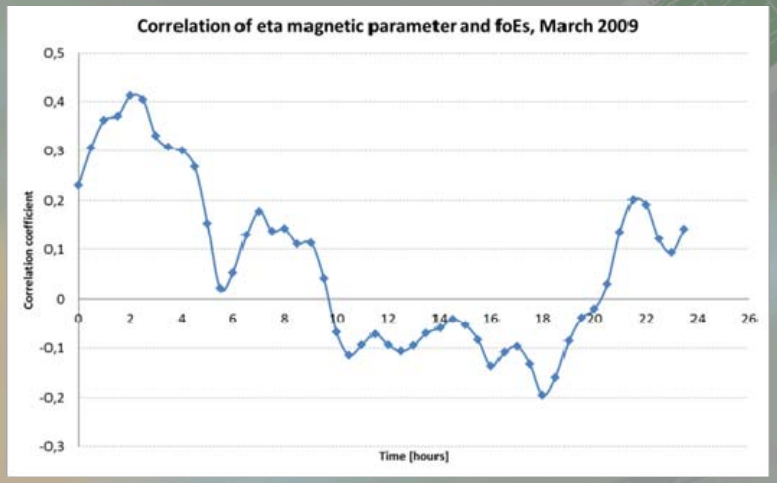
The impact of various space weather phenomena is studied. The forecast of sporadic E layer occurring locally and sometimes nontransparent is the crucial topic for radiocommunication. We propose the method of forecasting sporadic E layer appearance. This method is based on magnetic data and the changes of magnetic Eta parameter defined as the square root of a ratio of the energy of the external part of the vertical component to that of the horizontal components. The best correlation of sporadic E layer appearance occurs 1-2 hours after the increase of Eta value. The correlation between data from different European ionosondes and data from magnetic observatories lying close to the selected ionosonde was taking into account. We apply autocovariance method for prediction of the Eta index variations and in this connection the sporadic E layer appearance.



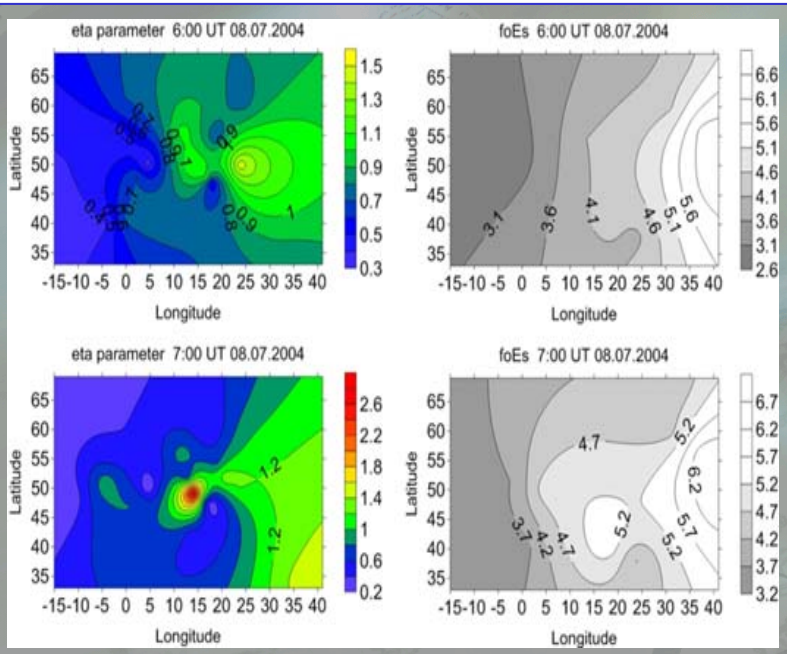
Examples of ionograms when sporadic E layer appears. First ionograms illustrates the situation when eta index has maximal value and the second ionogram shows the formed blanketing sporadic E layer 1 h after the maximum of eta index.

Modelling

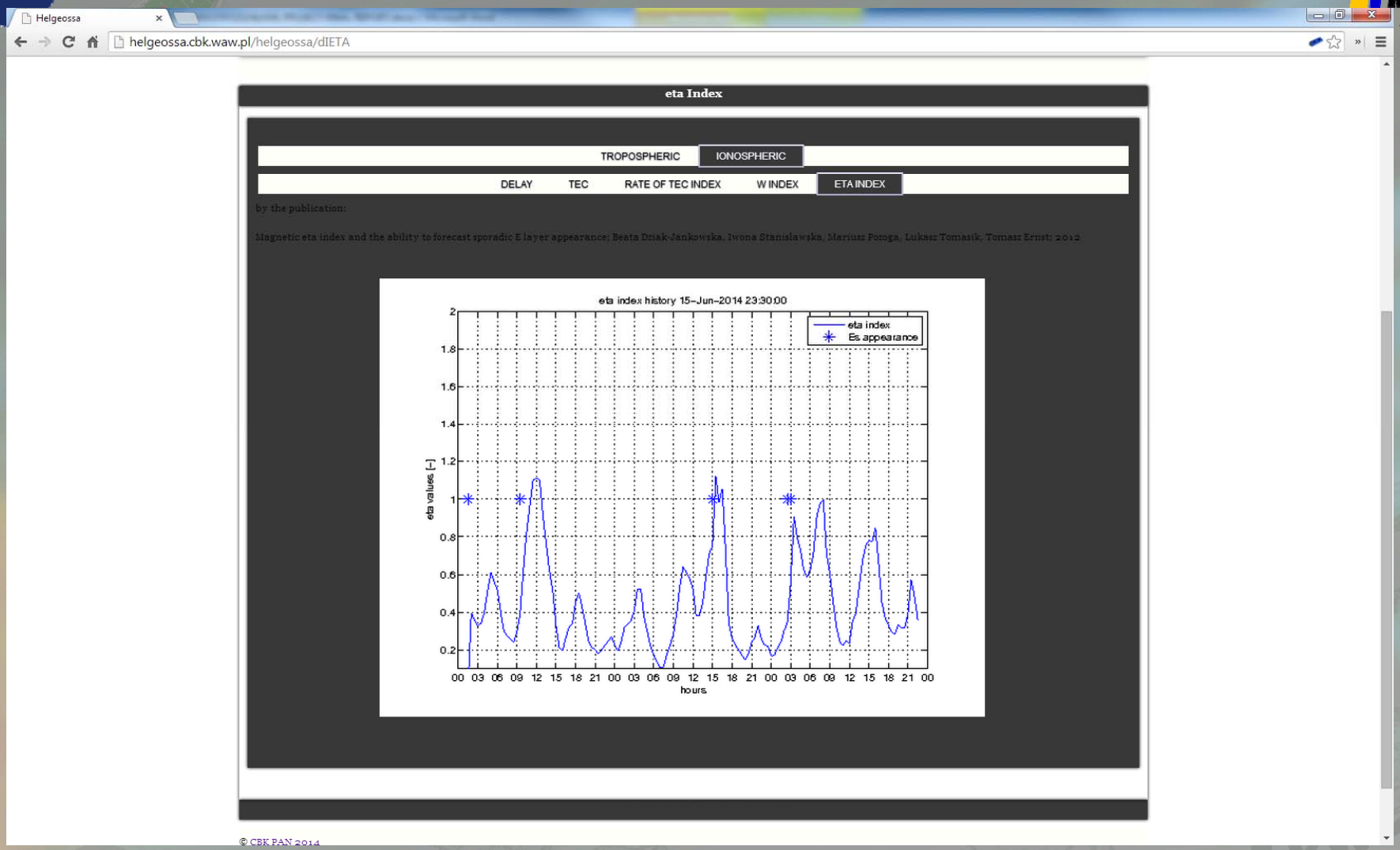
Auto-covariance method was applied in predictions of the Eta index variations and in this connection the sporadic E layer appearance. Statistics and forecasting method for Warsaw ionosonde and the data from Belsk Magnetic Observatory placed 50 km South-West from Warsaw were presented. Near real time magnetic data from Belsk (every 1 minute) allowed to predict the Eta index variations and the sporadic E layer appearance 2 hours after the increase of the eta value..



Correlation of the magnetic eta index with the critical frequency of the sporadic E layer, the best correlation appears 2 hours after the maximum value of eta. Data from Warsaw ionosonde and Belsk Magnetic Observatory



The coexistence of large values of eta and the critical frequency of sporadic E layer is shown. The amount of recorded critical frequencies, foEs, was enough to produce maps for Europe.

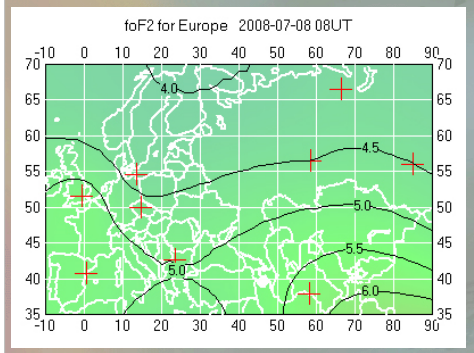


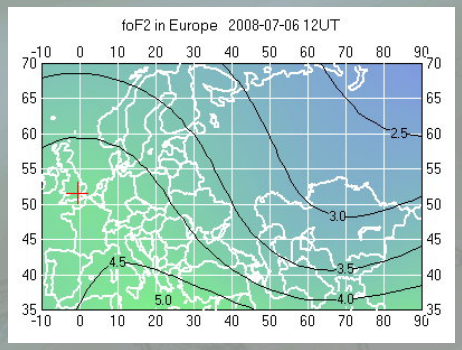
Real-time eta index calculated on the basis of 1 minute Belsk magnetic data. Asterisks show the largest gradients of eta index. Statistically after large gradient of eta index within 2 h sporadic E layer appears.

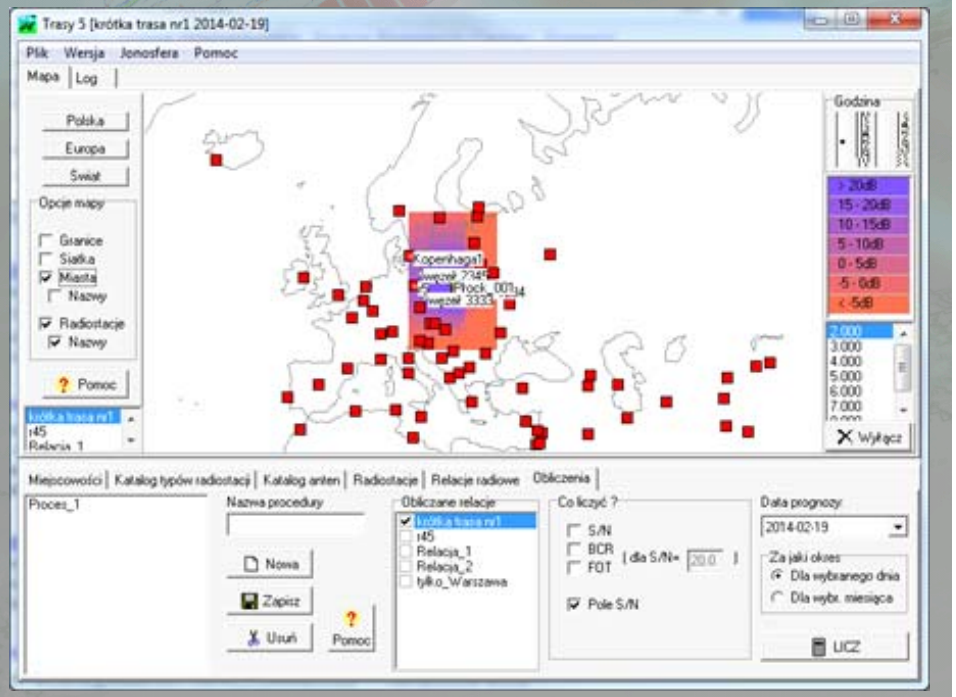
HF Communication

The RWC/IDCE (The Ionospheric Despatch Centre in Europe) web service (http://rwc.cbk. waw.pl/idce) provides on line access to data base of the critical frequency of F2 ionospheric layer forecast for all available sites. Continuous now-casting of regional ionospheric conditions over Europe, East Asia and Australia area is presented.
Space Research Centre provides forecast service for the governmental and commercial communications HF radio signal intensity. The work is carried out using software packages HELGEO and Ray-Route (six-generation version) developed at SRC. The HELGEO is an automatic system of solar-geophysical data processing for analysis and forecast of solar-geophysical phenomena and the Ray-Route is a system of forecasting of HF communications conditions, including signal to noise ratio at recommended frequencies. It organises proper data base for operational data-driven models and runs the subroutines based on such models creating at the end a set of messages and files addressed to different users requirements.

IDCE - Ionospheric Despatch Centre in Europe



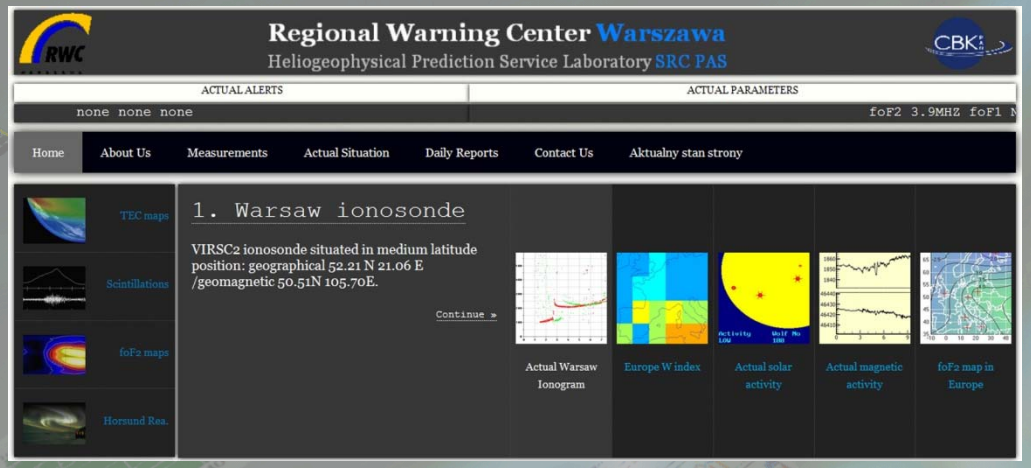


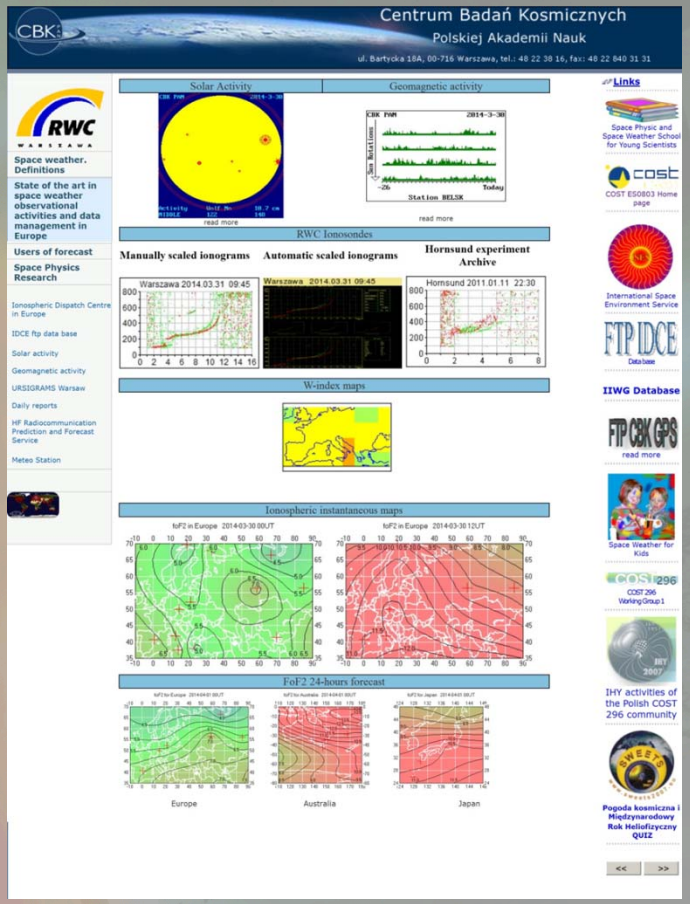


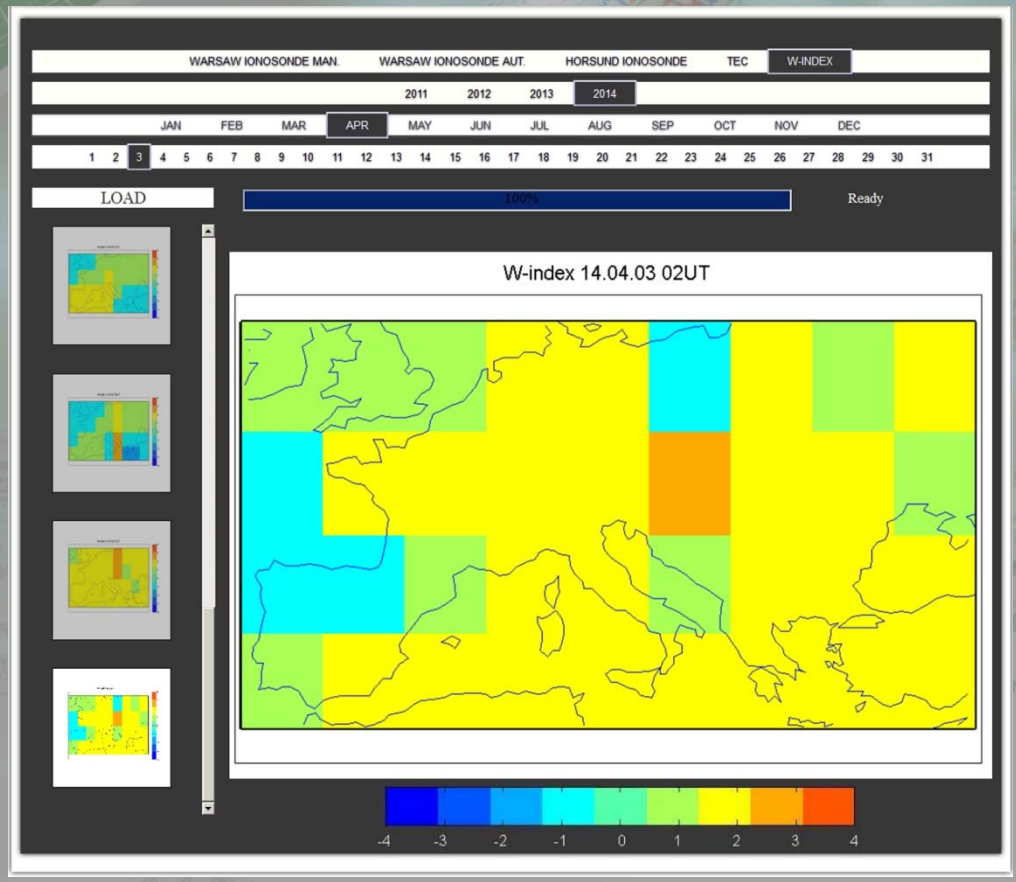
New features of the latest version of Ray-Route software: automation of operator tasks and the ability of radio propagation calculating for aviation.

Service continuously developed

http://rwc.cbk.waw.pl/RWC2/







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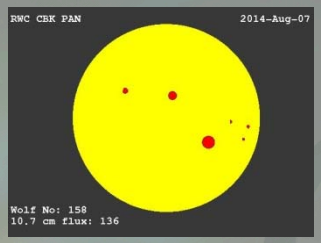
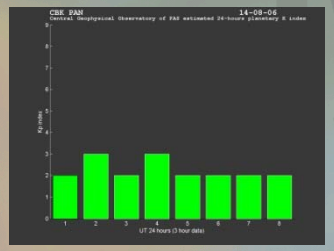
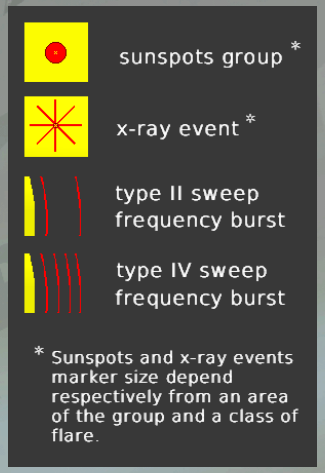
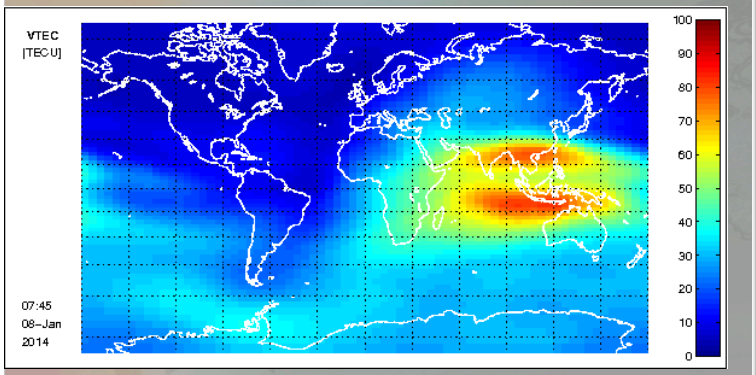
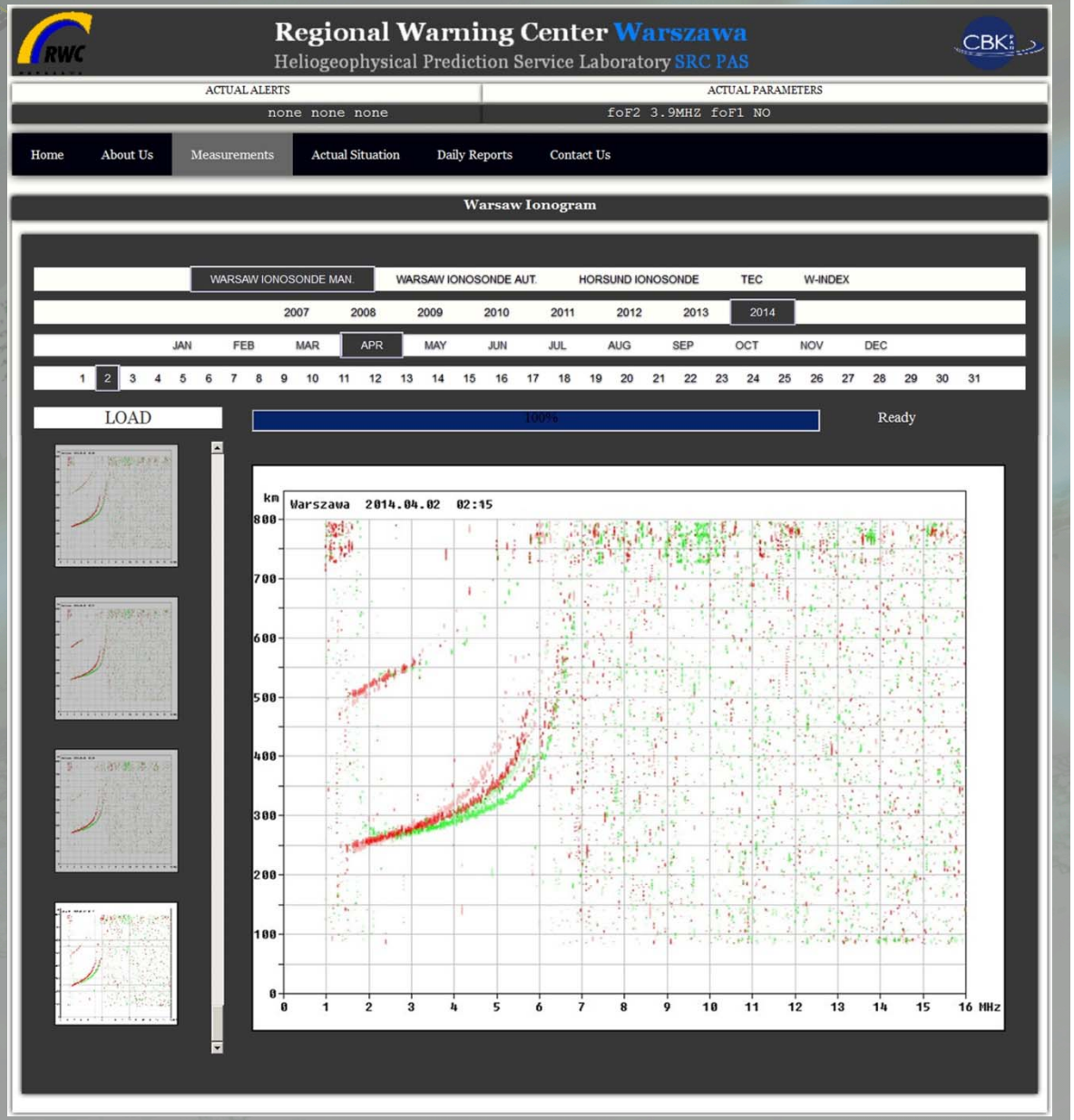










In the frame of national, European or ESA grants new applications are performed. Currently, the following projects are carried out

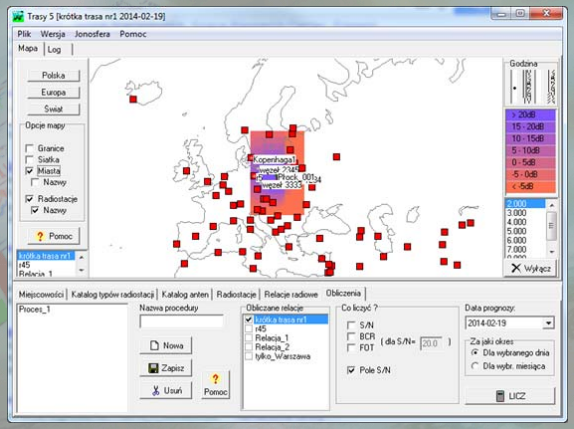
Current projects:

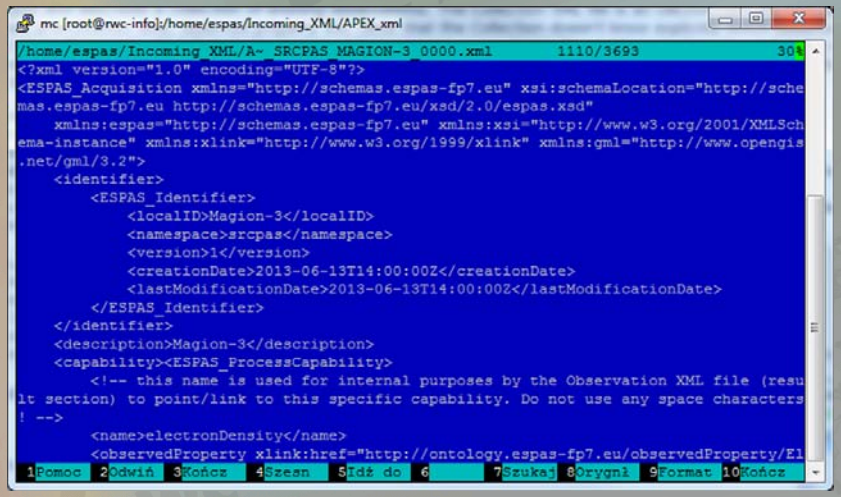
FP7 – ESPAS Near –Earth Space Data Infrastructure for e-science

NCN - Determination and research of new characteristics of the modelling of the state of ionosphe, their experimental tests and applications.

Agreement with Polish Armed Forces, Command and Communications System Directorate.

„Trasy" software





In ESPAS project data providers generates XML metadata files that describe their data.
Data Provider is going to capture its datasets based on ESPAS Data Model.

New features of the latest version of Ray-Route software: automation of operator tasks and the ability of radio propagation calculating for aviation.

Sample ESPAS XML File

Adjusted Matrix of monitoring &prediction of selected Space Weather Elements - contribution to ESA Architecture of Space Situation Awareness (SSA)

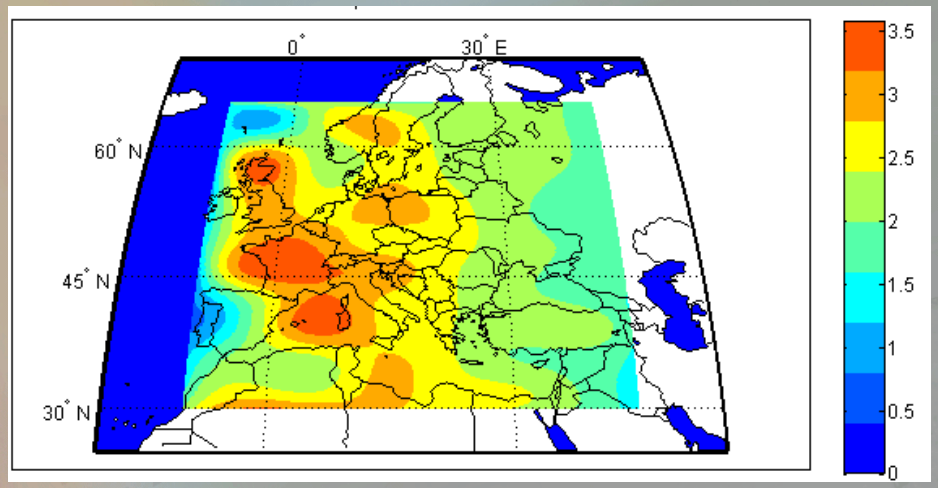
SSA Propagation Package Elements

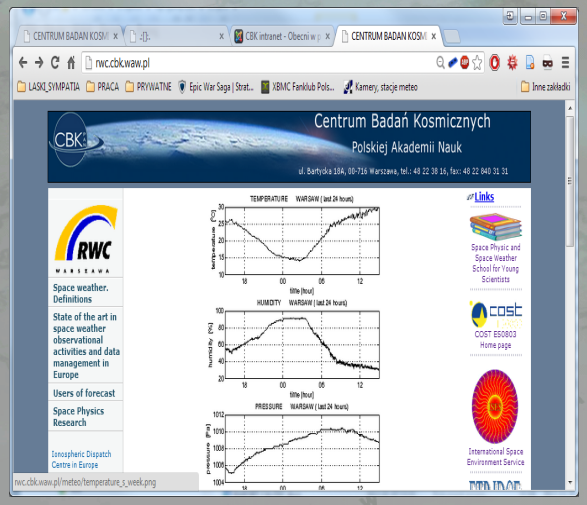
- **Tropospheric Element WP1**
- **Ionospheric Element WP2**
- **Identified specific developed products and linked to SSA Customer Requirements WP3**

Tropospheric characteristic database was created for tropospheric corrections on the basis of global (Eumetsat) and local circumstances.

Data source: Local meteo station

- Pressure
- Rain rate
- Total humidity
- Temperature





Sample Total attenuation map

Project description

The main purpose of the PECS “Adjusted Matrix of monitoring & prediction of selected Space Weather Elements - contribution to ESA Architecture of Space Situation Awareness (SSA)” project has been improvement by tools developmend for prediction and monitoring environment impact on satellite system (COM & NAV) and trans-ionospheric communication links of tracking radars systems.

The main objectives of this study were:

1.Modelling of the state of troposphere, with tropospheric return delay and attenuation.

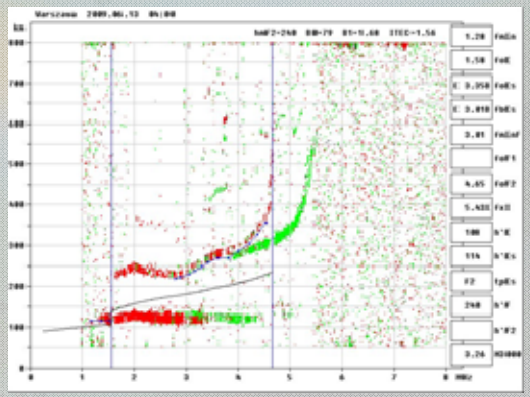
2.Modelling the current state of the ionosphere, with ionospheric return delay and attenuation.

The developed algorithms and procedures were implemented (implementation name-HelgeoSSA). Users can receive benefits/data from this project via WWW site: http://helgeossa.cbk.waw.pl.

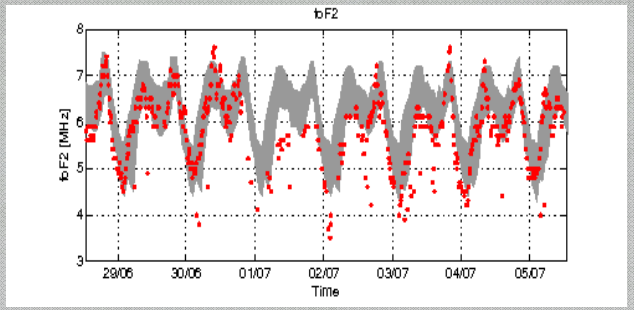
Project implementation

A. Data assimilation

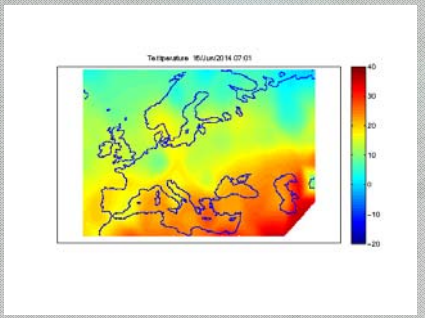
Database server for the project HelgeoSSA was created with combined ionospheric (TEC, foF2,hfo2,Es) and tropospheric (ground temperature, pressure, humidity) parameters. Current HelgeoSSA version data is stored as an hours tables of pre-selected locations. Interpolation algorithms were developed as well for the internal data upload.



Sample ionogram



Sample foF2 forecast

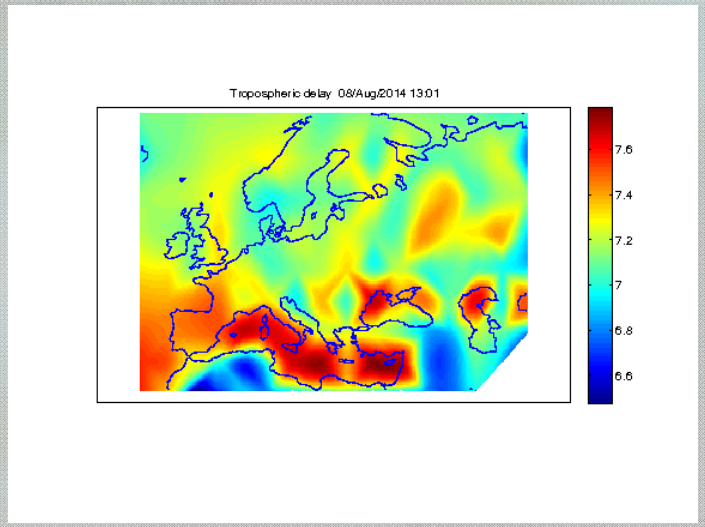


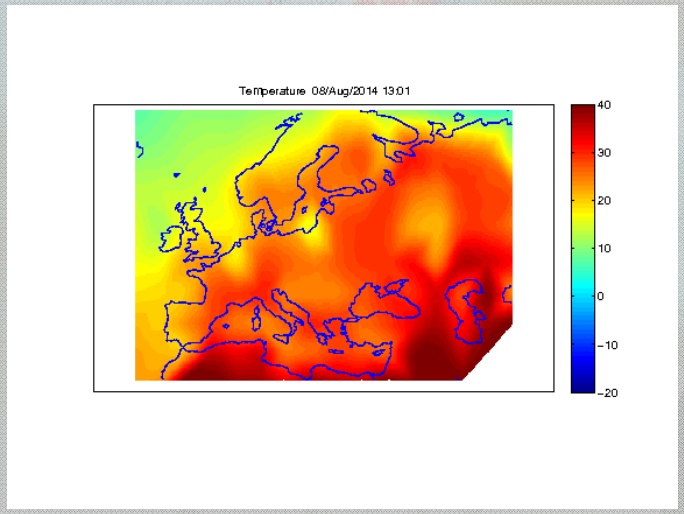
Sample temperature map

Project implementation

B. Models building (*Tropospheric elements*)

The tropospheric delay algorithm has been implemented in the same way as in EGNOS but HelgeoSSA server uses own tropospheric data



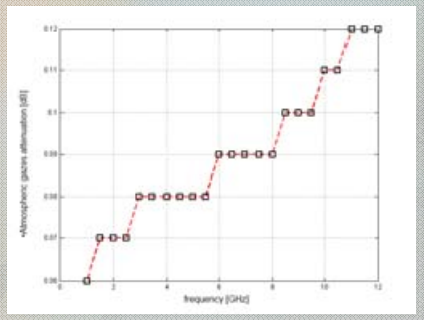
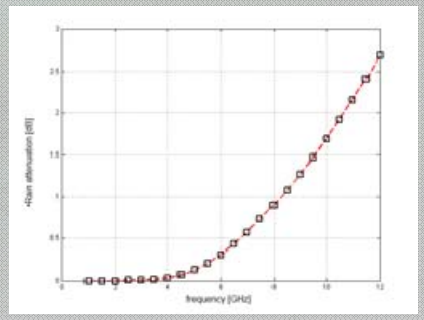
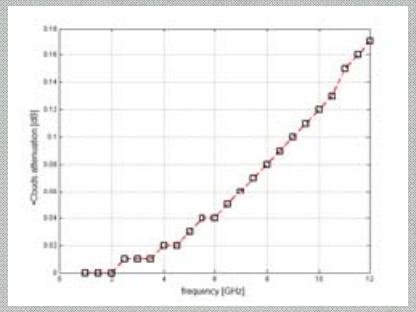
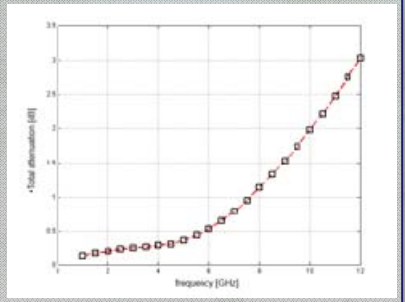


Sample map of the hypothetical vertical tropospheric delay error [cm] defined as difference between HelgeoSSA and EGNOS correction and sample temperature map.

Project implementation

B. Models building (*Tropospheric elements*)

The propagation loss on Earth-space path (relative to the free-space loss), is the sum of different contributions of atmospheric gases, rain and clouds. The forecast for tropospheric losses and delays is built from data forecast obtained from external meteorological forecast service (http://openweathermap.org/). Tropospheric delay was implemented by the usage of the ITU recommendations.

Sample attenuation solution for Space to Earth radio link frequency range from 1 to 12 GHz ,accuracy 0,01 dB : a) Atmospheric gases b) Rain, c) Clouds, d) Total

Project implementation

B. Models building (*Ionospheric elements*)

TEC model

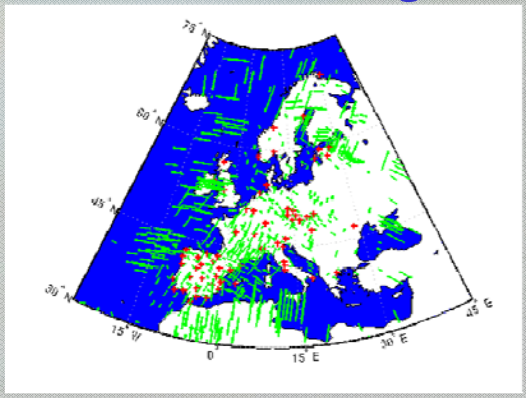
To calculate the TEC maps was used a geometrical model where the whole delay is contributed by a thin layer located at a height of maximum electron density concentration. Numerical experiments showed that the difference between this model and the model NeQuick not exceed 8%. The value of the measured slant TEC multiplied by the sinus of the elevation angle of the signal beam at the intersection with ionosphere at height of maximum concentration gives the vertical TEC value.

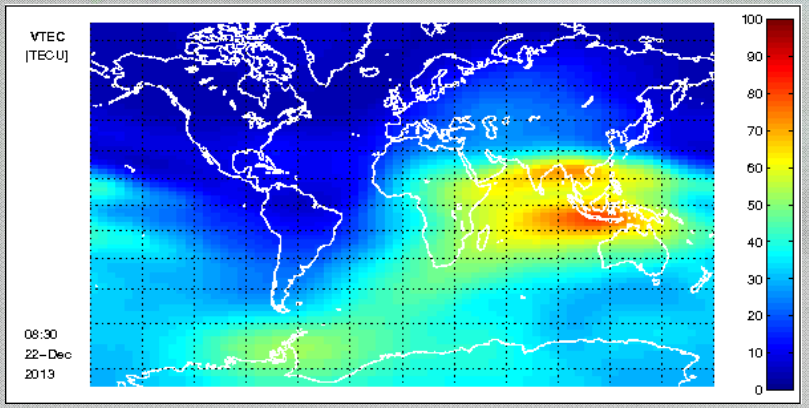
Position of EUREF stations

Project implementation

B. Models building (*Ionospheric elements*)

In the first phase using the ionosonde data and the NeQuick model the height of maximum concentration used to calculation of pierce point was determined. Then, using the GNSS satellite ephemeris and ionosphere model was determined the point of intersection of the radiation beam with the ionosphere. These parameter and the values of slant TEC are used to fit the b-spline model depended on latitude, longitude and local time.



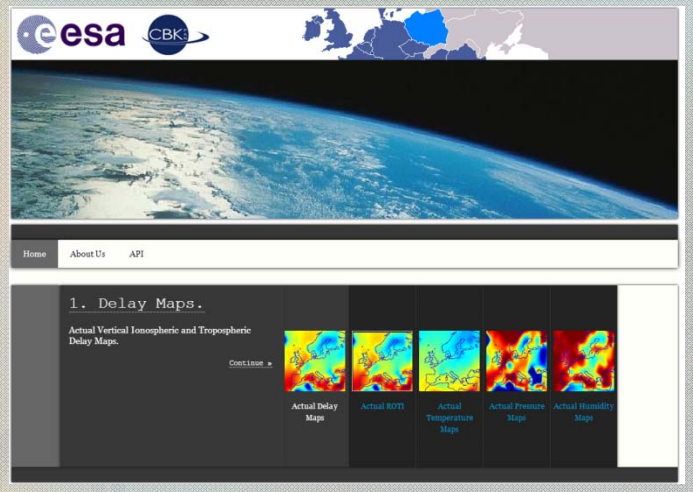


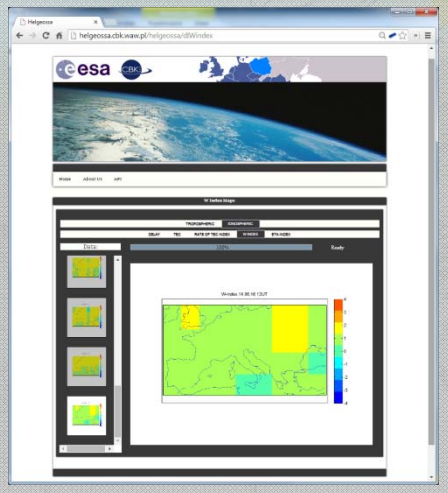
Examples of pierce points position for 15 minutes, and sample vTEC map. Model of ionosphere on the height of 350km.

Project implementation

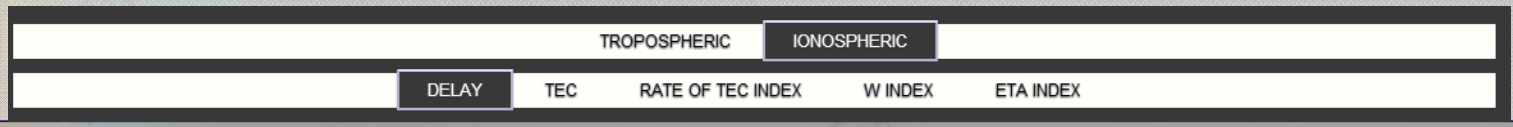
C) Developing end-user interface

The current version of HelgeoSSA web server allows to view tropospheric data as a maps of temperature pressure, humidity and delays for selected elevation angles. The ionospheric data is available as a maps of W index, vTEC and ROTI.

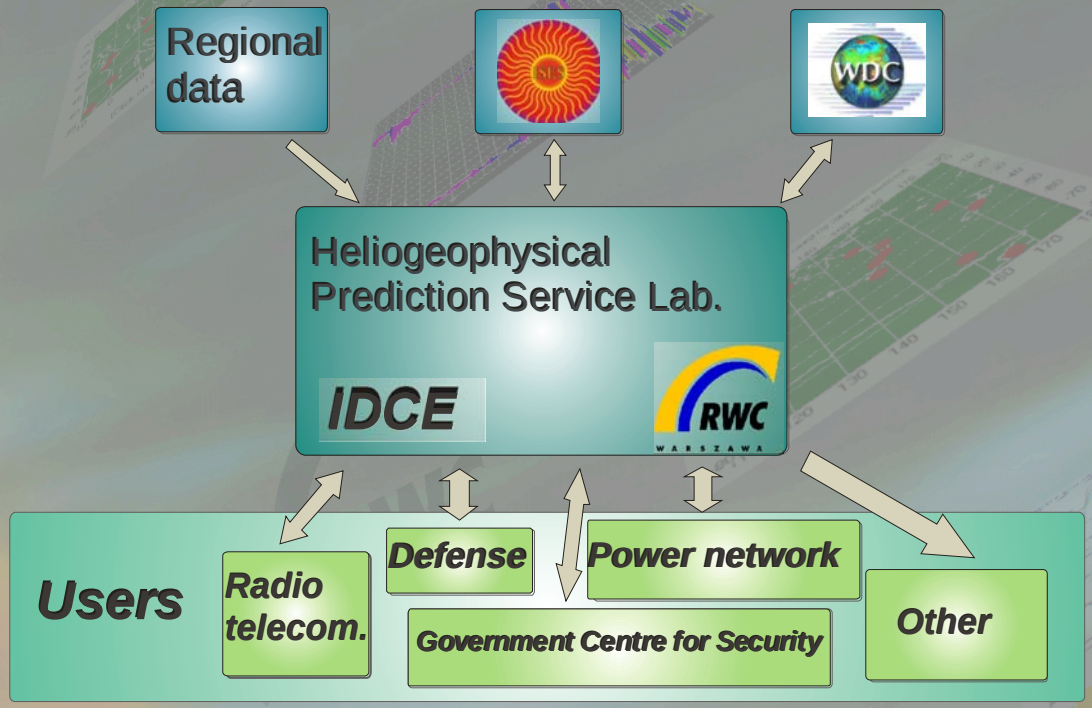




The HelgeoSSA web page
1) main menu;
2) w-index submenu;
3) product navigator;



Future perspectives



Service RWC Warszawa is constantly being developed in the near future some forecasting procedures and programs will be improved.

The new version of the RWC Warszawa website will replace the old one. Applications created and developed within current and starting projects will be implemented to our service.

ITT - Request to Compliance to Security Requirements EGEP ID 71 - phase A/B1 satellite study („G2G")

ITT - Space Situational Awareness Programme P2-SWE-1 - Space Weather Expert Service Centres: Definition and Development

FP7 MISF Mitigation of space weather threats to GNSS services