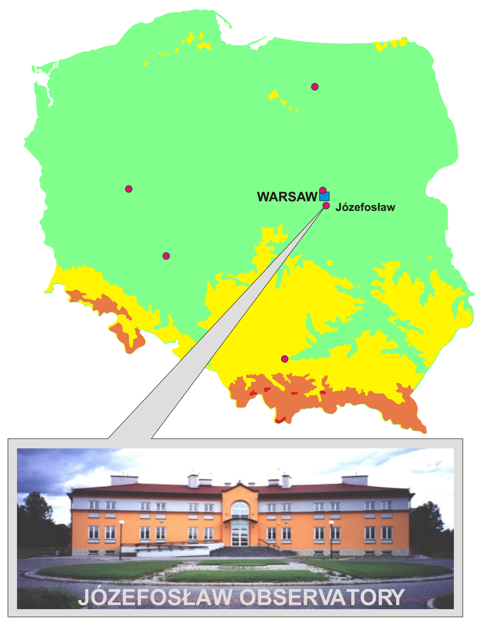
10 Year IGS
Workshop & Symposium
Berne, Switzerland, 1-5 March 2004



GPS Ionosphere Rapid Service for Europe - Suggestions and First Experiences

M. Figurski, J. B. Rogowski

Institute of Geodesy and Geodetic Astronomy
of the Warsaw University of Technology
Pl. Politechniki 1, 00-661 WARSAW, Poland

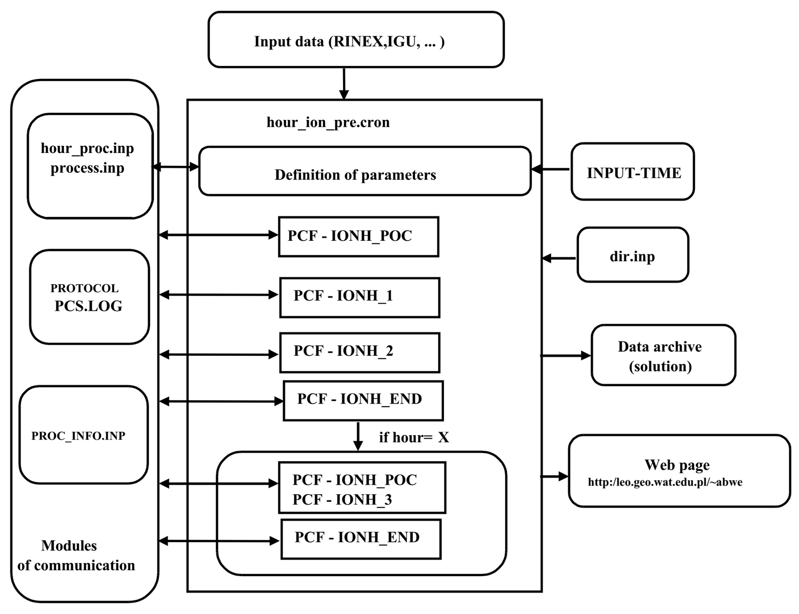
Introduction

Modeling of the ionosphere was made using GPS data since last 10 years. The great part of ionosphere services based on the daily GPS data. The alternative of them is permanent GPS data processing using hourly data upload. Utilization of the near real time GPS data for determination of ionosphere parameters by hourly data processing is insignificant now. Strategy of ionosphere modeling using near real time data is presented in the paper. This strategy base on modification of Bernese v.4.2 software. The main problem of hourly data processing for determination of ionosphere parameters is optimization geometric distribution of the GPS stations. The system elaborate by the authors was tested in the time were ionosphere was quiet as well as during ionosphere storm (f.i. 2004.01.22). Results obtained during 3 month test oh the system of rapid service for Europe was compared with CODE, JPL, UPC, ESA and IGS global TEC model. The same comparison was made with CODE model for Europe. All data was compared with TEC value obtained from JASON satellite data. The future analysis of the TEC values obtained in different way to let know precision of the rapid modeling of the ionosphere for Europe.
Assumption of the near real time data processing system for TEC modeling:

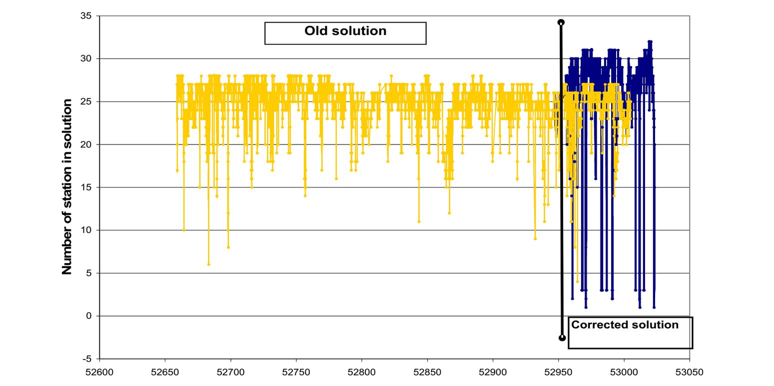
- Software BERNESE v.4.2
- Reconstructed BPE module communication with operation system was extended. Parameters can be change into PCF scripts, as well as outside on the level of control scripts of the LINUX system.
- Data base module was separate for data collection, data verification and its archiving.
- Ultra rapid IGS orbit parameters are used for data processing.
- A priory coordinates of permanent station are implemented from PPP solutions.
- TEC distribution are modeling using harmonic functions 10x8 in the area: from 30^0 to 80^0 and from 25^0 to 45^0

* Non differential code observations smoothing by phase are used
* Independent data processing for each hour of observation.
* Results of ionosphere modeling are presented in IONEX (1hour x 5deg x 2.5deg in UT x Lon. x Lat.) And BERNESE format.
* The results are distributed by the Internet Web site, actualized in the time when data processing is completed.

Scheme of ionosphere rapid service data processing system.

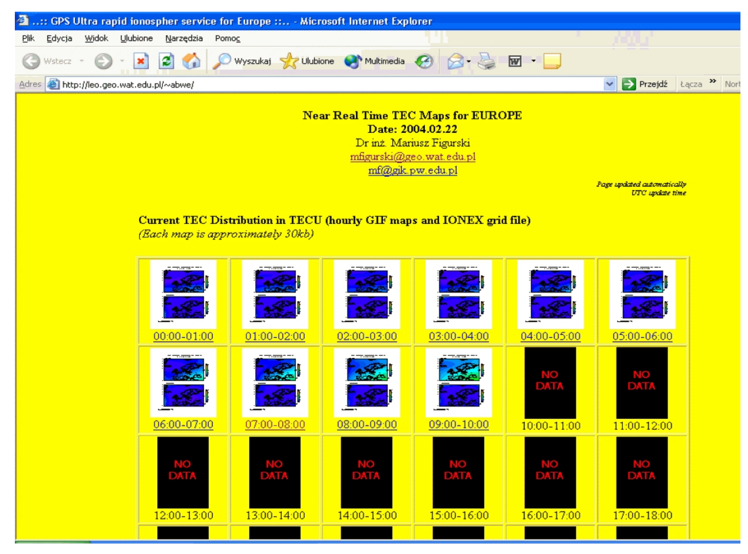


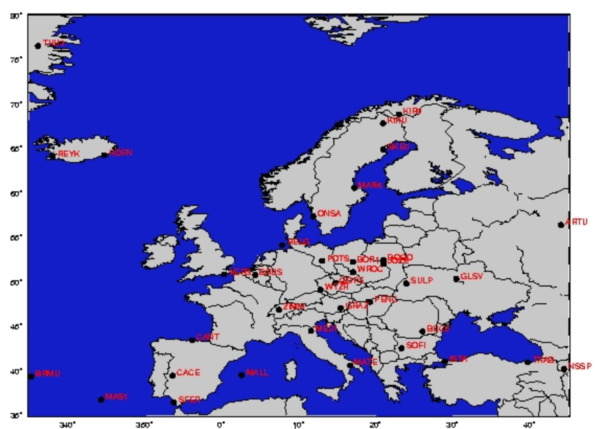
Scheme of ionosphere rapid service data processing system.



Number of GPS permanent station used in rapid service. Old solution test version of the network. Corrected solution final solution, number of stations are enlarged caused expected accuracy of TEC determination including time of ionosphere storms.

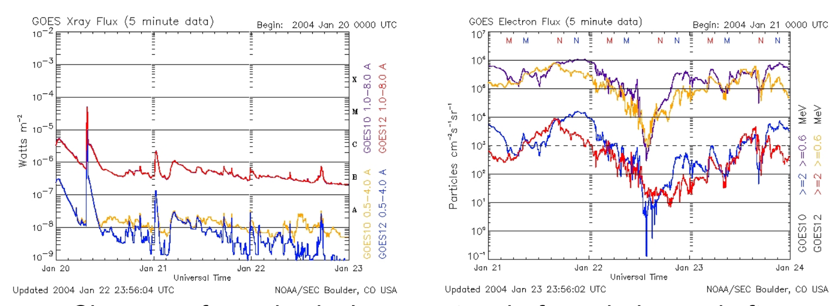
Internet Web site for presentation the results of ionosphere rapid service (time of the refreshment 1 hour)





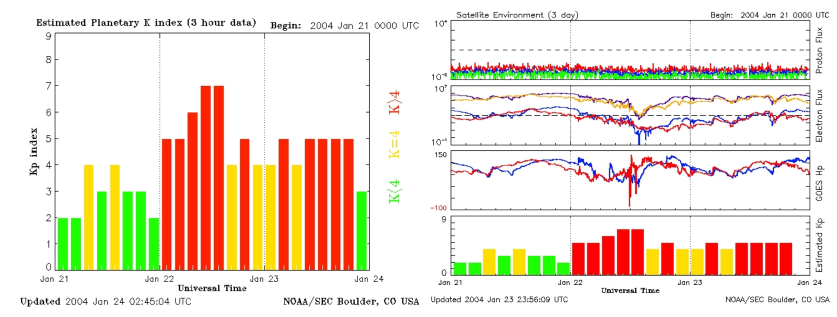
Maps of the network used in the ionosphere rapid service. Data are received from CDDIS, SIO, BKG and IGN. Caused accuracy of VTEC for Europe some stations from Asia, North America and Greenland were included.

Comparison TEC distribution (WUT rapid service) with selected geophysical indexes



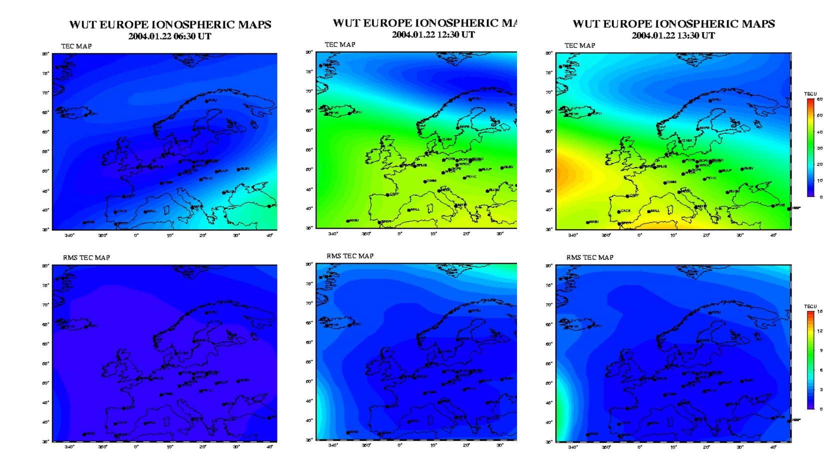
Changes of geophysical parameters before, during and after magnetic storm (20.01.2004 23.01.2004).

This phenomena was produced by the solar flare observed on 20.01.2004 at 1:10 UT in the domain of light and X radiation. This situation is presented on the left figure that you can find changes of the density of X rays with sharp flare M6.1 class. In the ionosphere this phenomena was observed few days later ((22.01.2004 15:00 UT) see right figure. *Current solar and geophysics data from NOAA.*

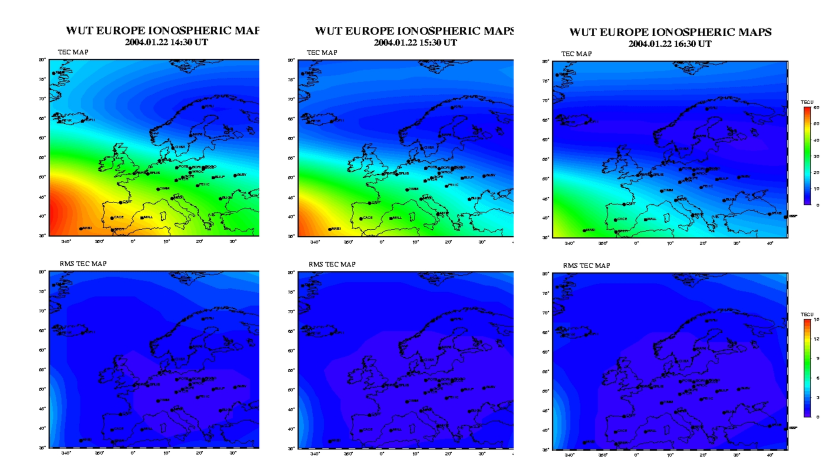


Changes of geomagnetic index K_p

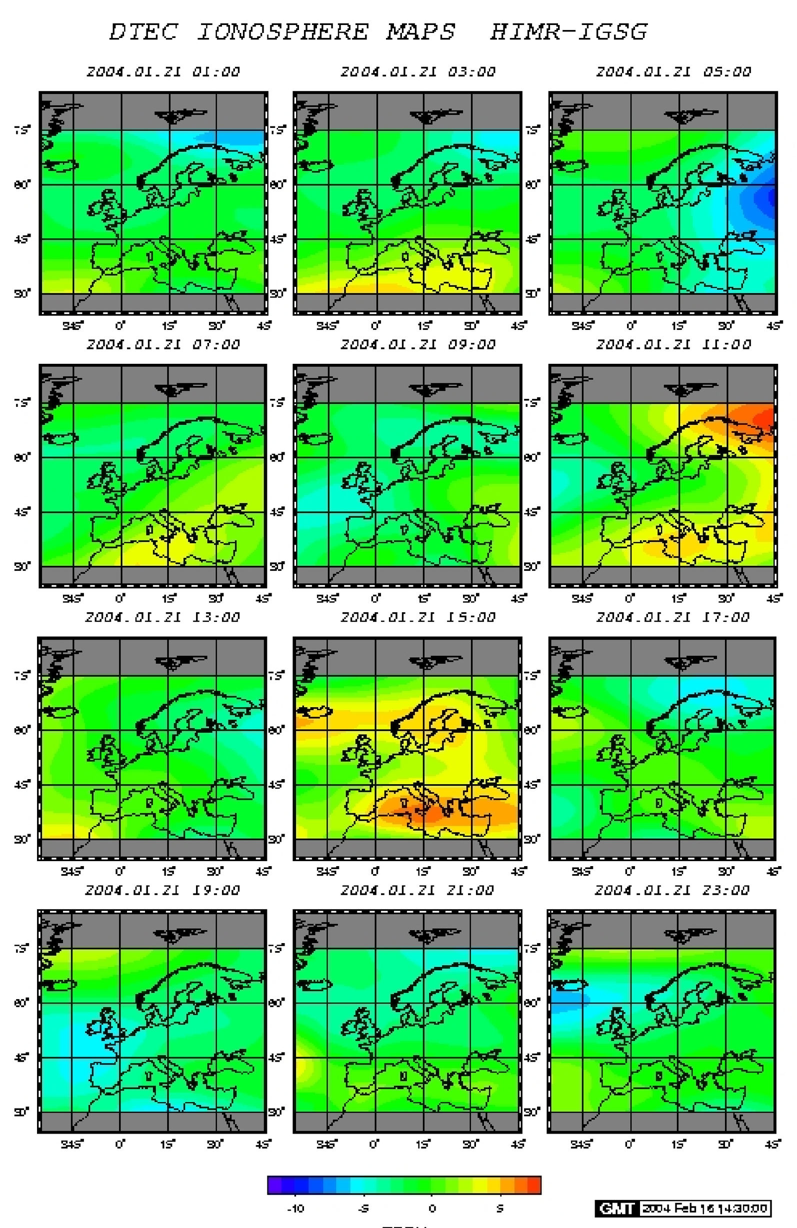
In the figure increasing of K_p is shown (22.01.2004) the value $K_p>4$ characterised geomagnetic storm. State of this phenomena to hold by the two days. *Current solar and geophysics data from NOAA.*



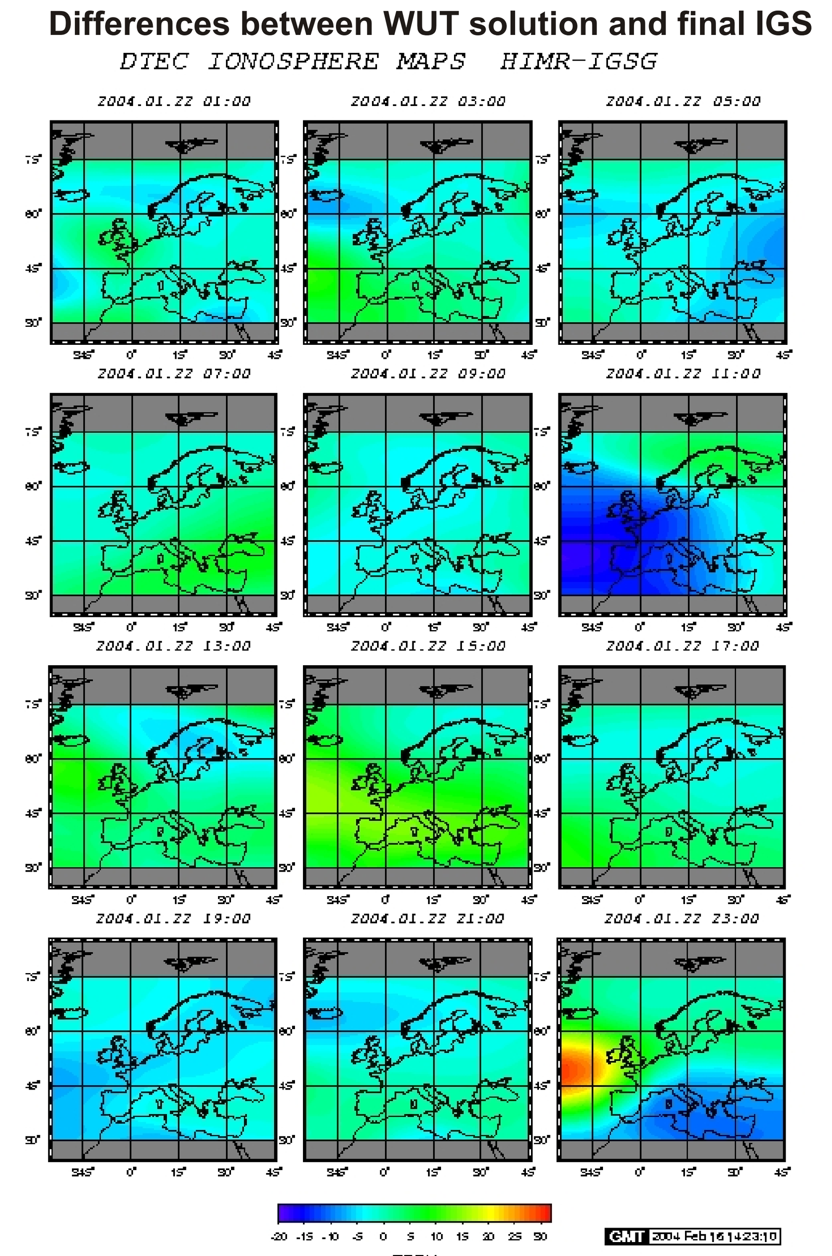
Maps of TEC distribution (WUT rapid service) obtain from one hour GPS data processing. Day 22.01.2004 is the day of ionosphere storm characterized by K_p index. Maps show succeeding phases of disturbances of the ionosphere determine using GPS. The analysis of this phenomena allow to notice that maximum of disturbances was between 14:00 and 15:00 UT. In the same time planetary index K_p to achieve maximum. You can find in the maps that RMS of TEC are from 0.5 to 2.5. Increasing of the errors between 12:30 and 13:00 UT was generated by the insufficient number of GPS data.



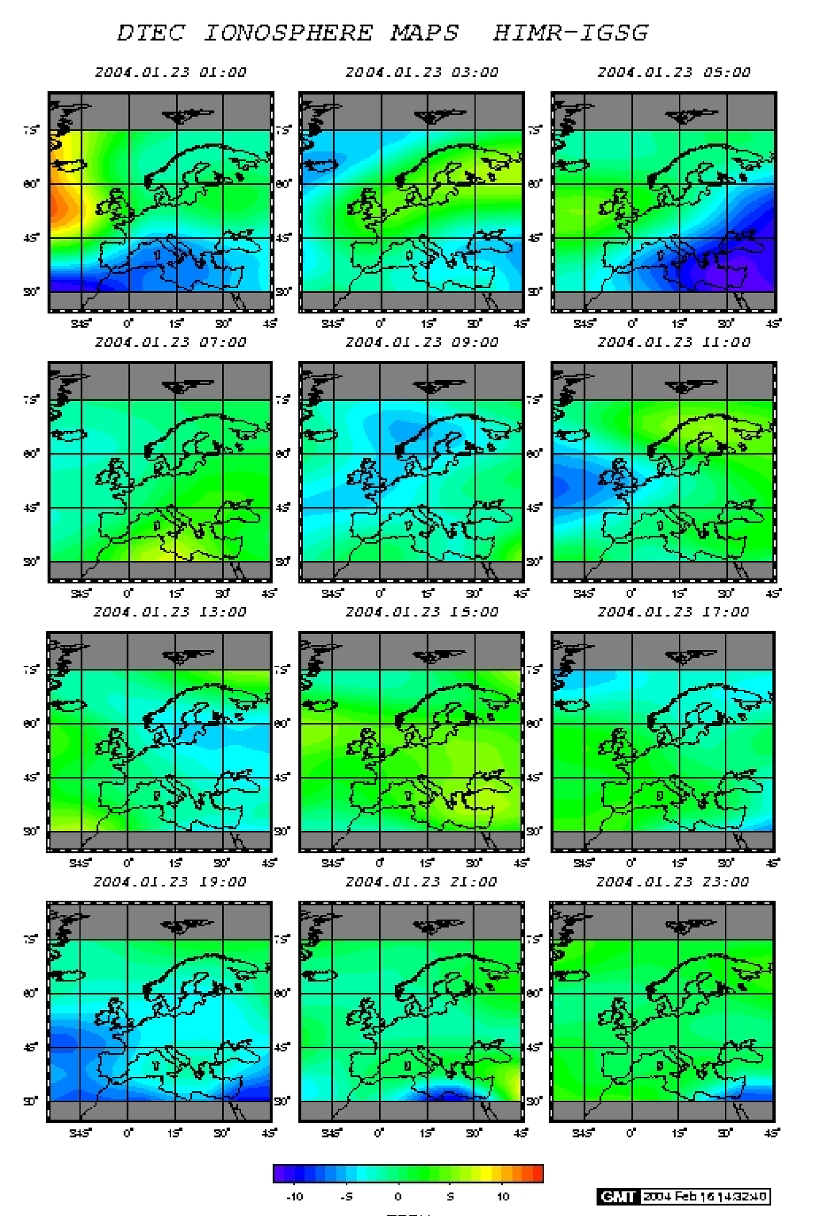
Differences between WUT solution and final IGS



Differences of VTEC between WUT rapid service results and IGS model for 21.01.2004. TEC maps present ionosphere one day before ionosphere storm. Obtained differences from 5 to +5 TECU are the results o insufficient number observations remarkable observed at the TEC maps for 5:00, 15:00 and 17:00 UT.

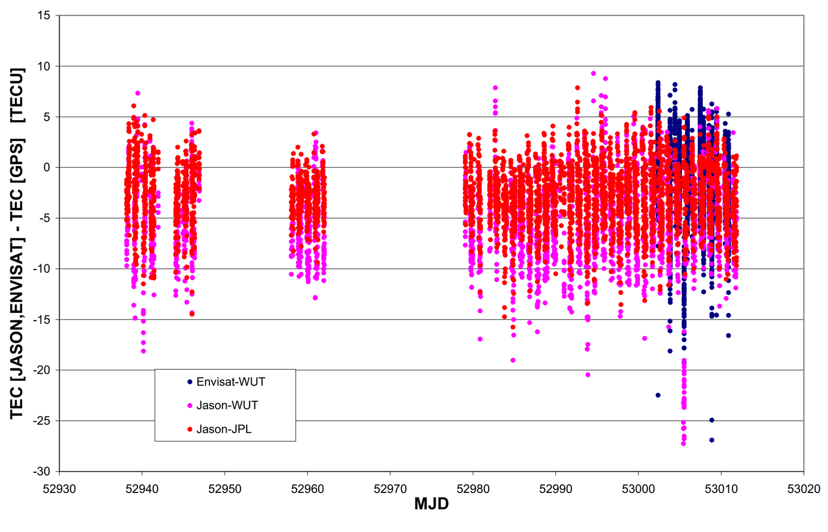


Differences of VTEC between WUT rapid service results and IGS model for 22.01.2004. TEC maps present ionosphere storm. TEC differences from 7 to +8 TECU are the results o insufficient number observations remarkable observed at the TEC maps for 5:00, 15:00 and 17:00 UT.

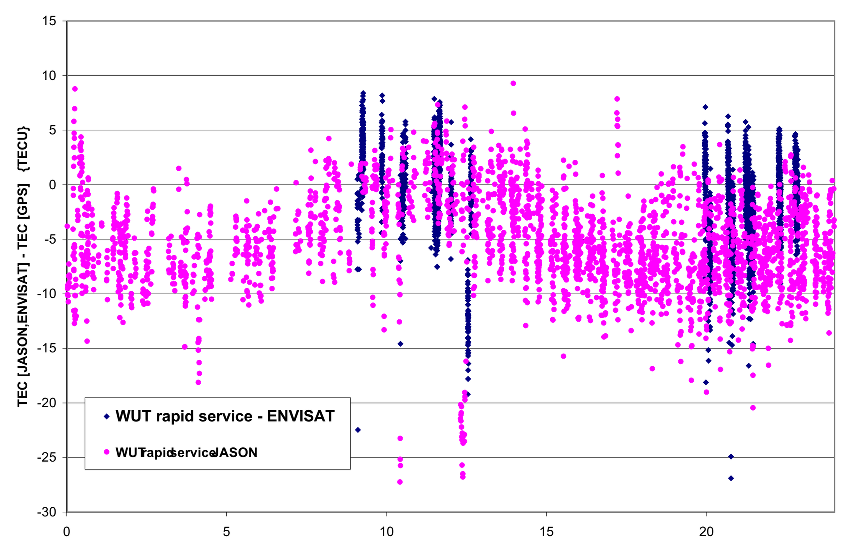


Differences of VTEC between WUT rapid service results and IGS model for 23.01.2004. TEC maps present ionosphere one day after ionosphere storm. Obtained differences from 5 to +5 TECU are the same as before the ionosphere storm.

Differences between WUT solution and satellite ENVISAT and JASON results



Differences of TEC between WUT rapid service results, JPL data and satellite altimetry results for ENVISAT and JASON for the period from 01.01.2003 to 15.01.2004.



Differences between TEC values from WUT rapid service solution and altimetry results from satellites JASON and ENVISAT have diurnal oscillation with maximum at 12 and 24 hours of UT.

	Bias	Sdev	RMS
WUT rapid service - ENVISAT	-1,4	4,5	4,6
WUT rapid service - JASON	-5,3	4,3	4,4
JPLG - TEC JASON	-1,2	4,9	5,1
CODG - TEC JASON	0,3	3,8	3,7

Value of the statistic characteristic of differences (bias, sdev and rms) are presented in the table

Analysis of diurnal changes of receivers

Determination of TEC and DCB of satellites and receiver is a main part of ionosphere modelling using GPS observations. In presented method values DCB of the satellite are adopted as a priory values from IGS or CODE solutions DCB of receivers and TEC values are determined. DCB values for selected stations are presented in the figures. Some short periodic changes you can find in this diagrams especially 12 hours changes which amplitude growing with the latitude of the station.