Internet platform for improving the EGNOS ionospheric corrections

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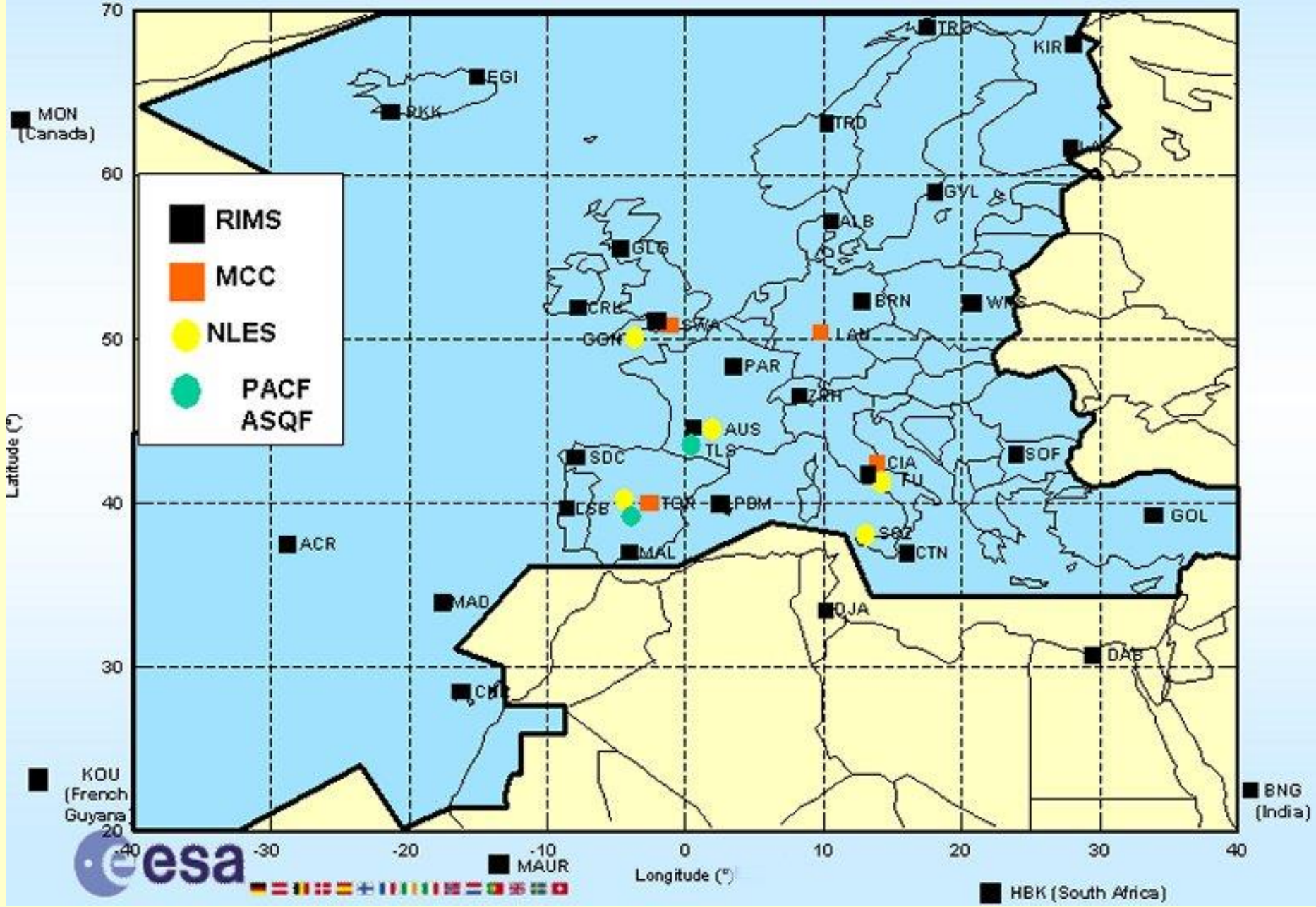
Introduction

The main objective of The EEI (EGNOS EUPOS Integration) project was to increase the efficiency and range of application of the EGNOS system, through integration with EUPOS (European Position Determination System).
The project has assumed the improvement of ionospheric corrections in EGNOS system for Eastern Poland.
The network of the Ranging and Integrity Monitoring Station (RIMS) does not provide coverage of the correction of the same quality for the entire area of Europe.

The WRS RIMS site located in Space Research Centre in Warsaw is the most easternmost station in the area of central Europe. This causes that the quality of EGNOS corrections in Eastern Poland is lower.

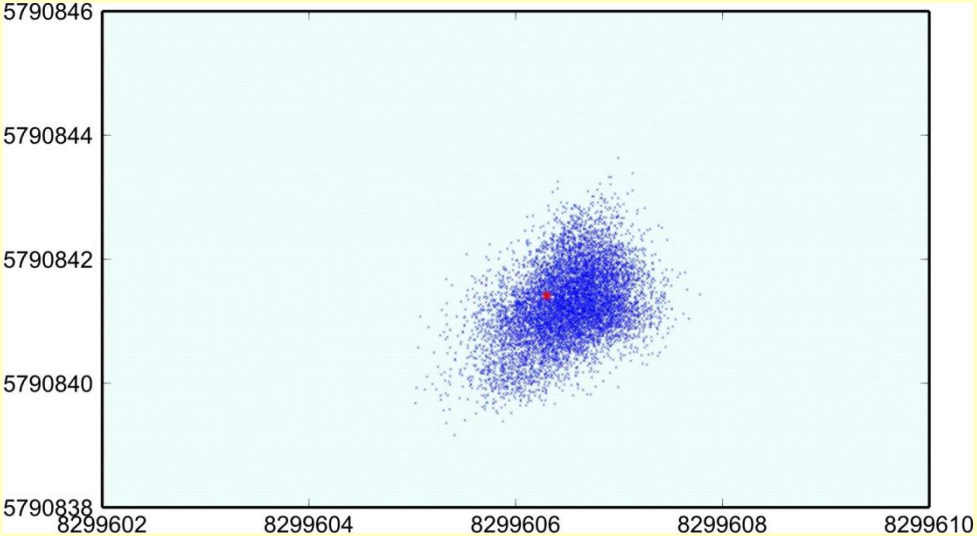
EGNOS Network Deployment

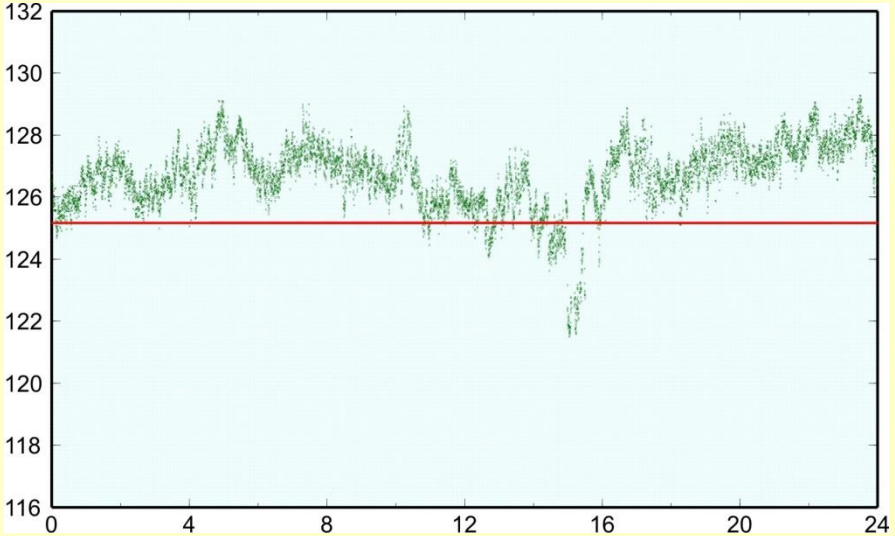


GNSS position with EGNOS correction

Considering the station located in Space Research Centre in proximity of RIMS WRS carrying out the permanent measurement and computes the position in 1 second interval using the EGNOS correction.

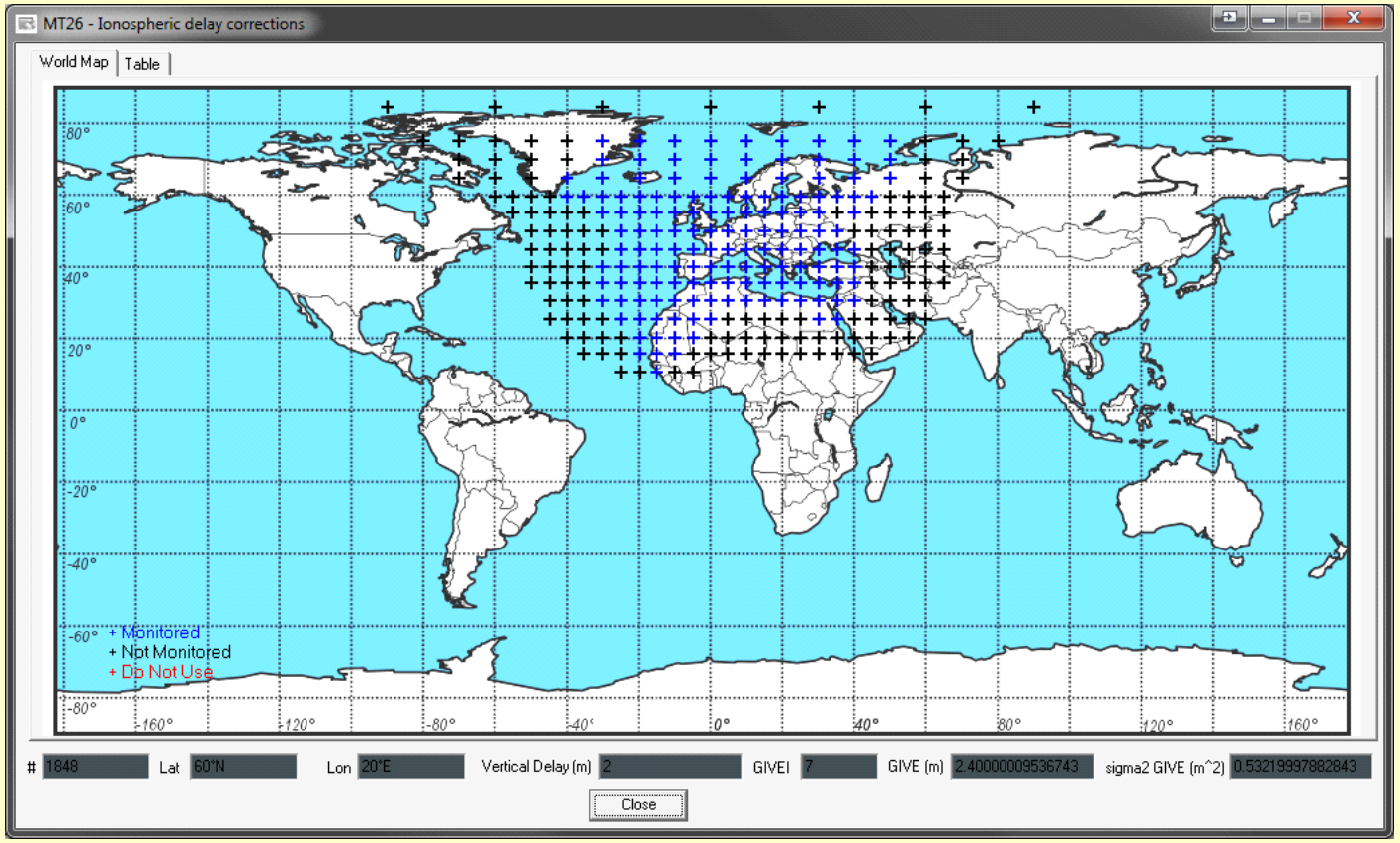
The analysis of its coordinates obtained during measurements shows the permanent shift in horizontal and vertical position as well.





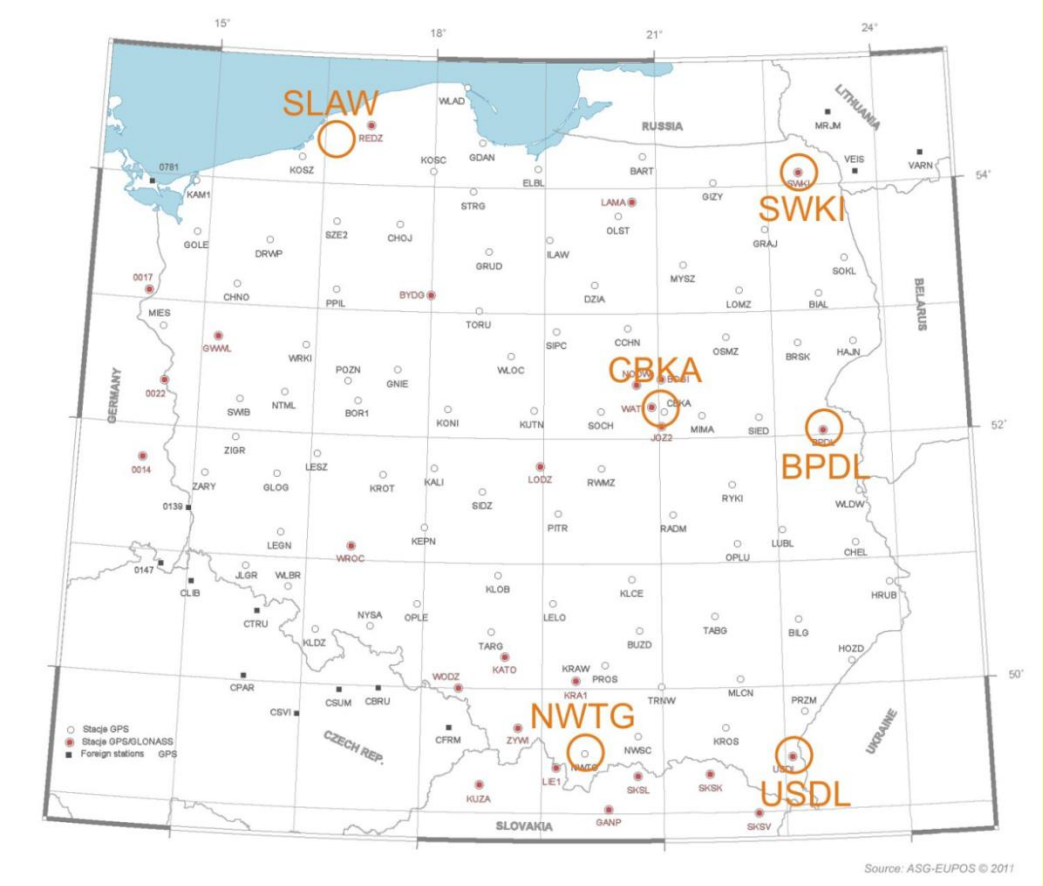
SBAS ionospheric corrections

In Satellite-based augmentation systems (SBAS), such as EGNOS the ionospheric information is transmitted in two messages. The Ionospheric Grid Point Mask and Ionospheric Delays (respectively messages 18 and 26).



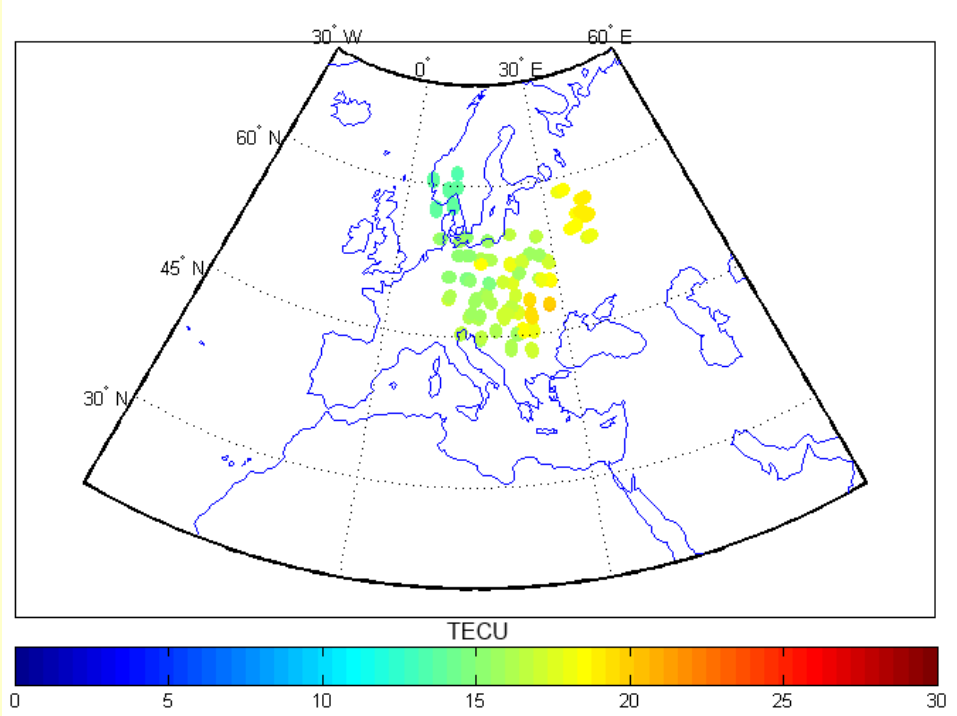
Ionospheric corrections computation$_{(1)}$

For the project purpose, as a source of GNSS observation for ionospheric corrections computation the permanent stations of ASG-EUPOS system were used.
The ASG-EUPOS system is Polish part of EUPOS system. It consist of about 100 permanent GPS or GPS/GLONASS stations. For corrections computation only few selected station of that system were used . The stations was chosen in locations guarantee a best coverage of IGP mask corresponding to eastern Poland, and gives average of 60 TEC values per measurement.



Ionospheric corrections computation$_{(2)}$

The selected permanent stations deliver the GPS data for computation of new (‘improved’) EGNOS ionospheric correction. The vertical TEC values calculated for each station, for each observed satellite, generate the field of vertical TEC (VTEC) values.

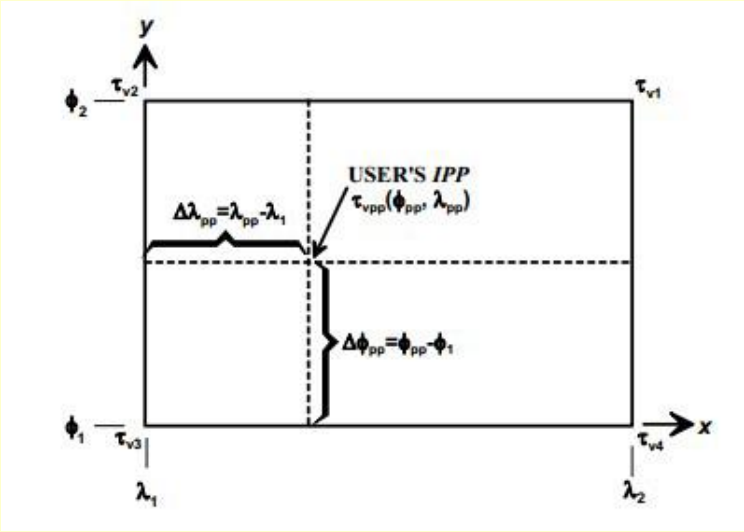


The VTEC values were interpolated for defined for SBAS grid points using procedure, which puts the same value on the point of known value and computes the new value for the point of no value. That new value is interpolating in proportion to the square of the distance between the points of known values. From resulted VTEC values the ionospheric delay for ‘improved’ EGNOS corrections were calculated.

VTEC computation

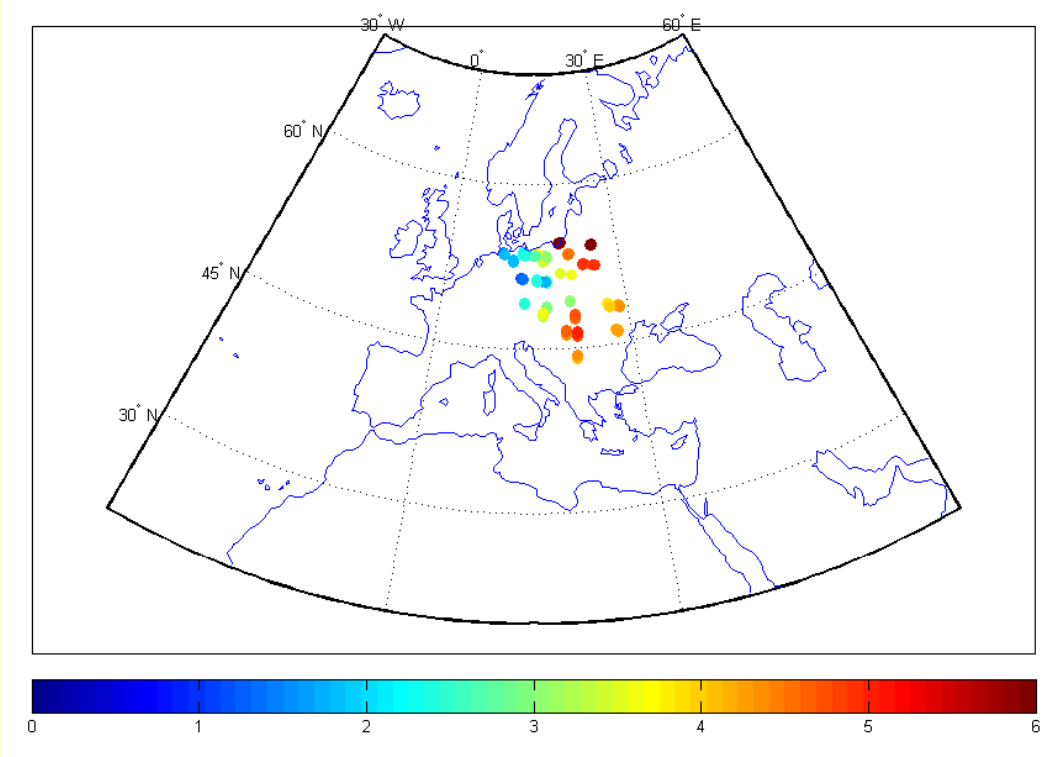
For comparative analysis, the EGNOS ionospheric corrections were computed for the same IPP as the ‚improved' corrections.
It was prepared in the same way as for the user (in receiver) to interpolate from the broadcast IGP delays to that at his computed IPP locations.

For given four nodes of a cell of the IGP grid surround the user's IPP to a satellite, the user interpolates from those nodes to his pierce point. In this work the some restrictions was applied - only the 4 point bilinear interpolation was allowed for exclude the IGP sub mask with GIVEI "don't use" value.



Ionosphere analysis

For each measurement of the IPP vertical TEC the corresponding value of EGNOS TEC was calculated



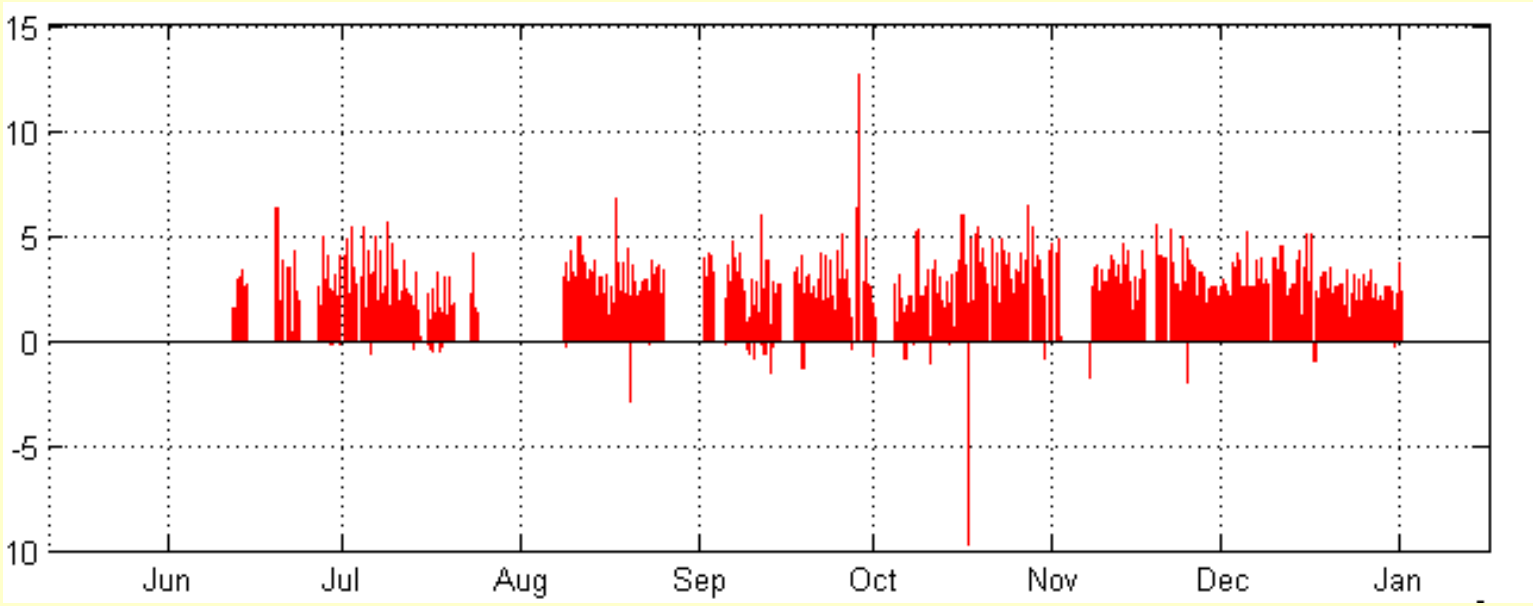
Median differences : DTEC = TEC (GNSS) –TEC (EGNOS) expressed in TECU:

all IPP - 1.8485

IPP with longitude >21 - 2.1243

IPP with longitude <=21 - 1.5794

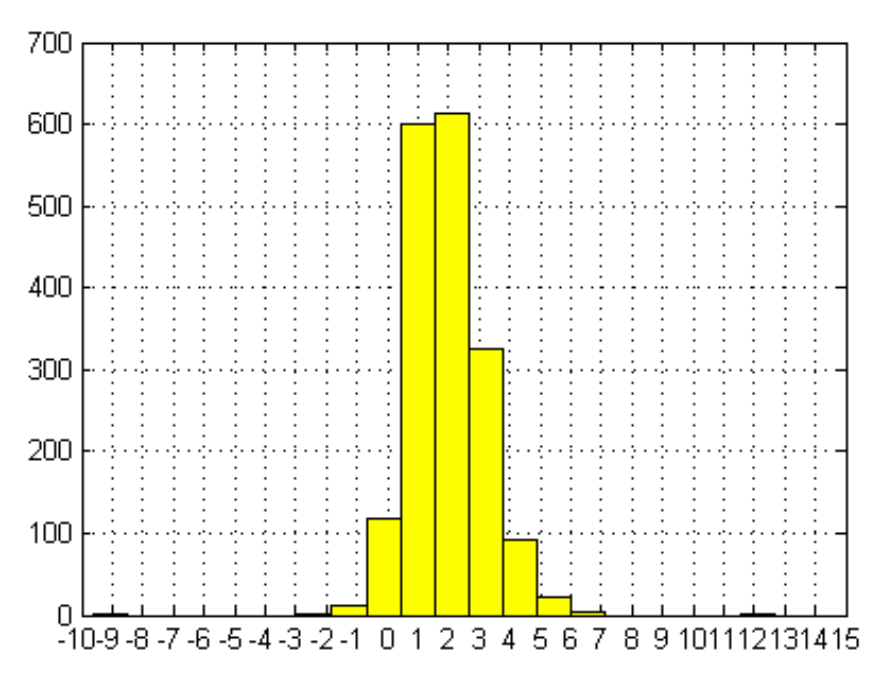
Ionosphere analysis



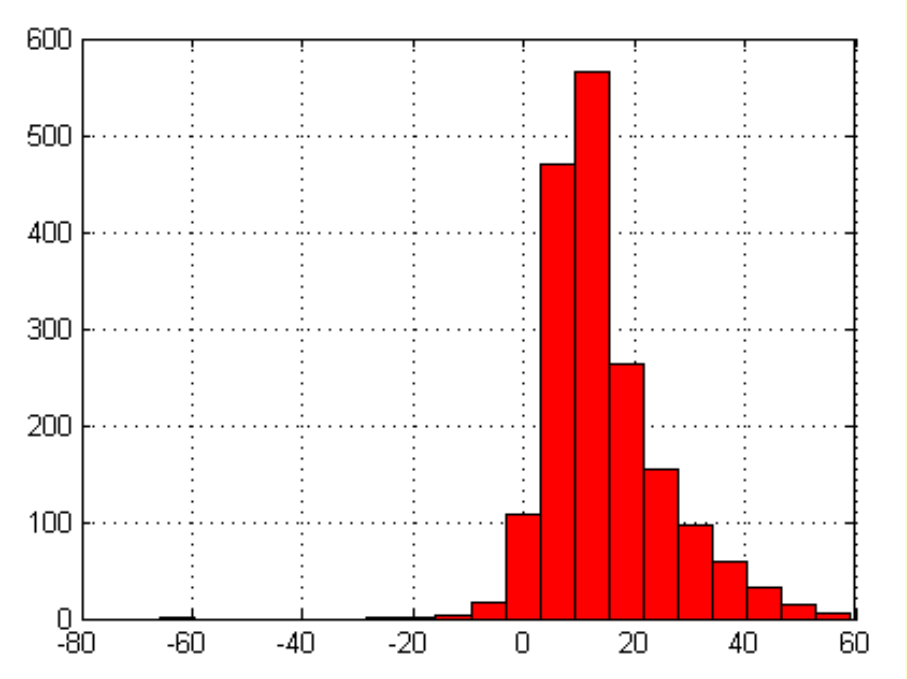
Hourly values of median for DTEC = TEC (GNSS) –TEC (EGNOS)

96.9% of results is for DTEC median as positive value

Ionosphere analysis

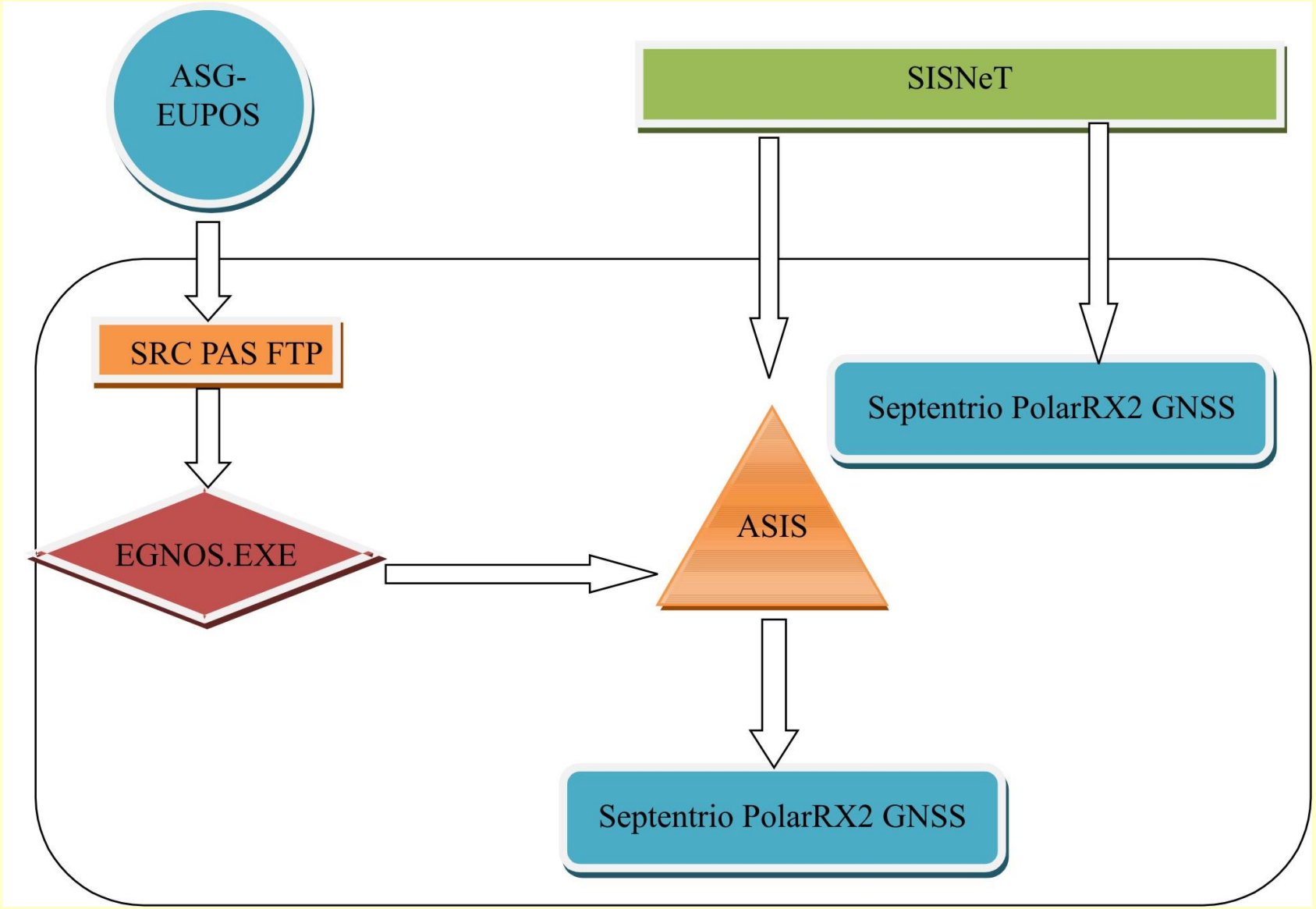


DTEC distribution [TECU]



DTEC/TEC (GNSS) [%] distribution

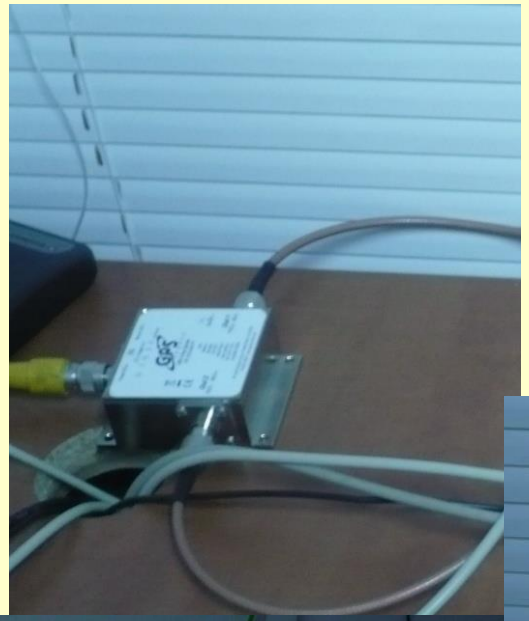
ALGORYTHM OF SISNET MESSAGE MODYFICATION

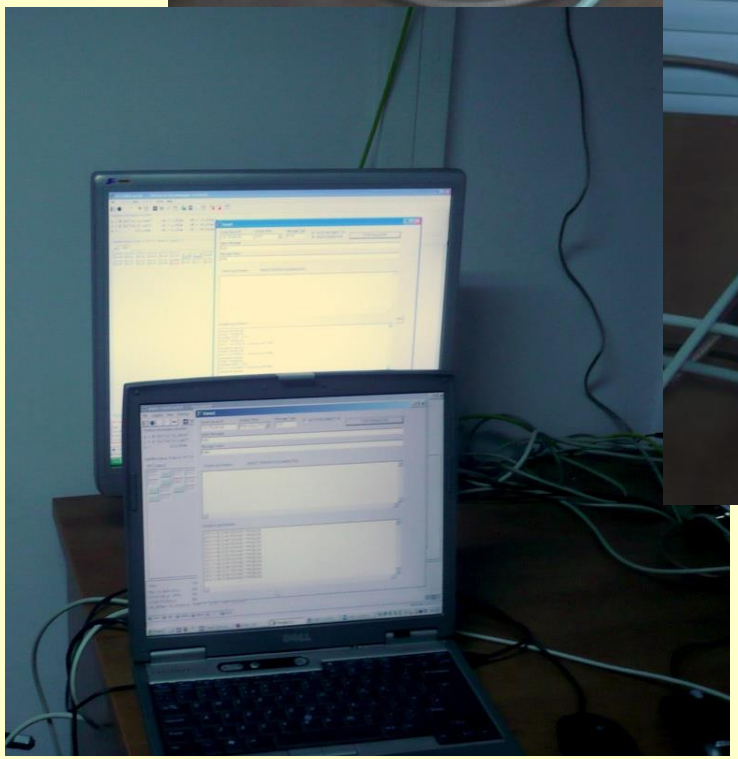


New ionospheric correction tests (places)

New ionospheric correction tests (equipment)

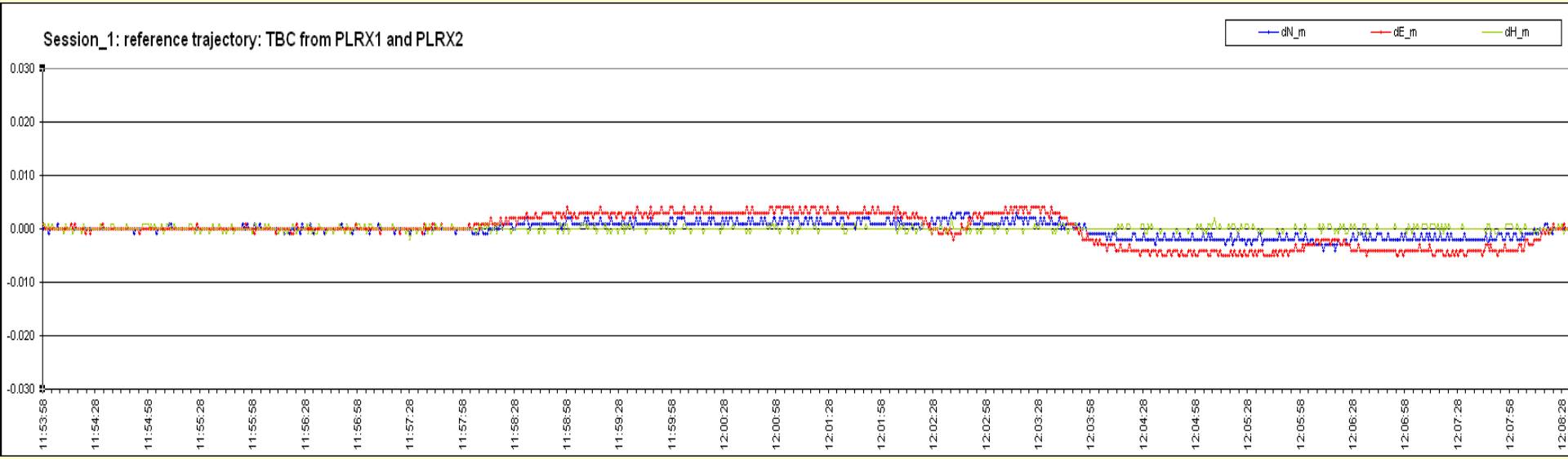
Receivers' configuration



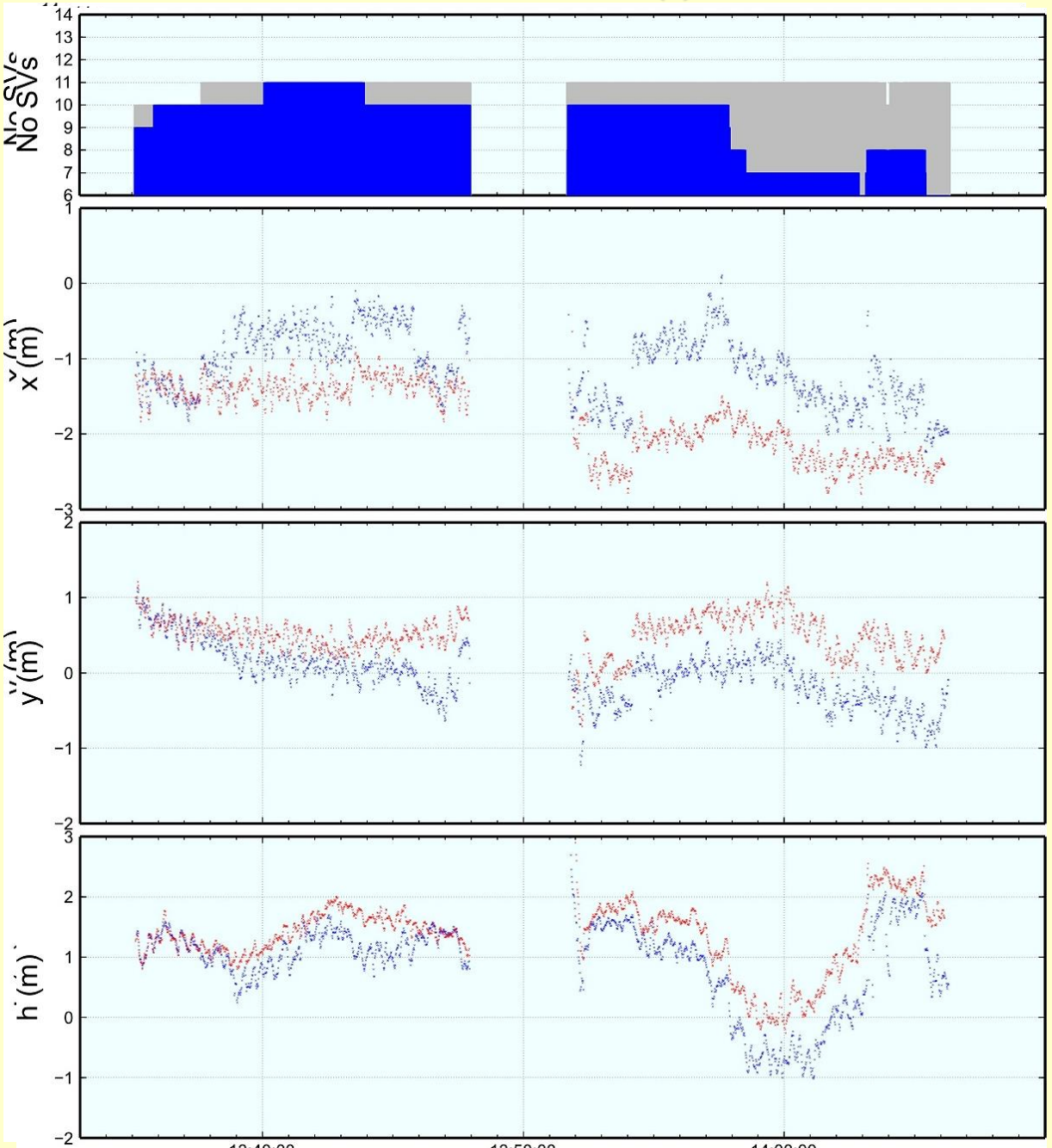


Position analysis$_{(1)}$

Precise computation (kinematic processing in TBC)



Position analysis$_{(2)}$



Position analysis$_{(3)}$

	'improved'				oryginal				Improvement			
	dx [m]	dy [m]	mp [m]	dh [m]	dx [m]	dy [m]	mp [m]	dh [m]	dx [%]	dy [%]	mp [%]	dh [%]
Ses_1	0.845	0.300	0.897	0.977	0.894	0.381	0.972	0.798	5	21	8	-22
Ses_2	0.983	0.329	1.037	1.628	1.311	0.471	1.393	2.580	25	30	26	37
Ses_3	0.738	0.405	0.841	1.499	1.479	0.590	1.593	1.489	50	31	47	0
Mean:	**0.855**	**0.345**	**0.925**	**1.368**	**1.228**	**0.481**	**1.319**	**1.622**	**27**	**27**	**27**	**8**

	'improved'				oryginal				Improvement			
	dx [m]	dy [m]	mp [m]	dh [m]	dx [m]	dy [m]	mp [m]	dh [m]	dx [%]	dy [%]	mp [%]	dh [%]
Ses_1	0.963	0.515	1.092	2.374	1.875	0.648	1.984	3.899	49	21	45	39
Ses_2	0.804	0.504	0.949	1.838	1.792	0.779	1.954	2.576	55	35	51	29
Ses_3	1.363	0.836	1.599	2.118	2.206	1.318	2.570	2.601	38	37	38	19
Ses_4	1.543	0.780	1.729	2.591	1.805	1.156	2.143	3.148	15	32	19	18
Mean:	**1.168**	**0.659**	**1.342**	**2.230**	**1.920**	**0.975**	**2.163**	**3.056**	**39**	**31**	**38**	**26**

Conclusions

The TEC analysis shows general underestimation of EGNOS TEC values for area of eastern border of EGNOS correction range.

For the original EGNOS corrections, errors of positions obtained for Biala Podlaska Airport were about two times higher than in central Poland (near Warsaw). In opposite errors with the ‘improved’ EGNOS corrections were only slightly higher on Biala Podlaska Airport than in central Poland.

The results obtained at the airport in Biala Podlaska, show a significant increase in the accuracy of the position obtained for the modified EGNOS corrections.

The systematic shift in coordinates show the area for further improving the accuracy and stability of the position by introduction of further modification of the EGNOS corrections.

Thank you for your attention