VARIATIONS OF IONOSPHERE VERSUS VARIATIONS OF VECTOR COMPONENTS DETERMINED FROM DATA OF IGS ANTARCTIC GPS STATIONS – – NEW CONTRIBUTION TO THE GIANT PROJECT "ATMOSPHERIC IMPACT ON GPS OBSERVATIONS IN ANTARCTICA"

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INTRODUCTION

The project of a GIANT program on Atmospheric Impact on GPS Observations in Antarctica has been established at the XXVI SCAR meeting in Tokyo in 2000. From very beginning the research priority was given to the effect of ionosphere. The GPS data, usually those provided by permanent GPS stations arrays are commonly used to investigate the structure and dynamics of ionosphere (Baran et al., 2001), (Feltens and Jakowsky, 2001). The main goal of the project is to investigate the iononspheric impact on the quality of GPS observations in Antarctica and possibly develop recommendations for future GPS campaigns, data post-processing strategies and modeling GPS solutions. First results were presented at AGS'01 in St Petersburg in 2001 (Krankowski at al., 2001). They concerned the influence of ionosphere over the Arctic and Antarctic regions on repeatability of co-ordinates of vectors of different length during the quiet and disturbed ionosphere (ionospheric storms). The vector co-ordinates obtained from 24 h and semidiurnal GPS sessions were analyzed. Unbelievable strong coincidence between TEC changes and the changes in all vector components were obtained. Differences in co-ordinates obtained from GPS solutions that correspond to the quiet and disturbed ionosphere reach a few dozen of millimeters even for 132 km long vector (O'Higgins - Arctowski).

To check the repeatability of this correlation the new approach of data analysis was conducted that is based on the analysis of GPS solutions obtained from the overlapped segments of data (Krynski at al., 2002). Time series of GPS solutions based on processing observations from overlapped data segments allows for investigation of atmospheric impact on GPS measurements in a new dimension. Such a series can be considered as a record of the process of variations of vector components during varying atmospheric disturbances. The experiments performed concerned the investigation of the response of the measuring system to an ionospheric storm as well as the response of the measuring system to tropospheric perturbations. The results of the time series analysis from the data of European Permanent Network as well as from Antarctic IGS stations were presented in Shanghai WGGGI meeting of XXVII SCAR. (Cisak, 2002). The data from the period that includes a few days before and after the ionospheric storm of 64DOY2001 only from three Antarctic IGS stations, i.e. Davis, Mawson, and Casey was analyzed. The analysis of time series from the European data showed much stronger correlation between TEC changes and the vector components than that from Antarctic data, but still not as strong as it was obtained from 1999 ionospheric storm presented at AGS'01. It was the reason of extending the project and to additionally process the data from larger number of Antarctic stations and to analyze longer time series of GPS solutions together with ionospheric data.

NUMERICAL EXPERIMENTS

Ionospheric data from the year 2001 was investigated in terms of detecting substantial ionospheric disturbances. Time series of TEC from IONEX files available on IGS web pages for two permanent GPS stations, i.e. BOGO – a Central European station and DAV1 – an Antarctic station are shown in Fig. 1.

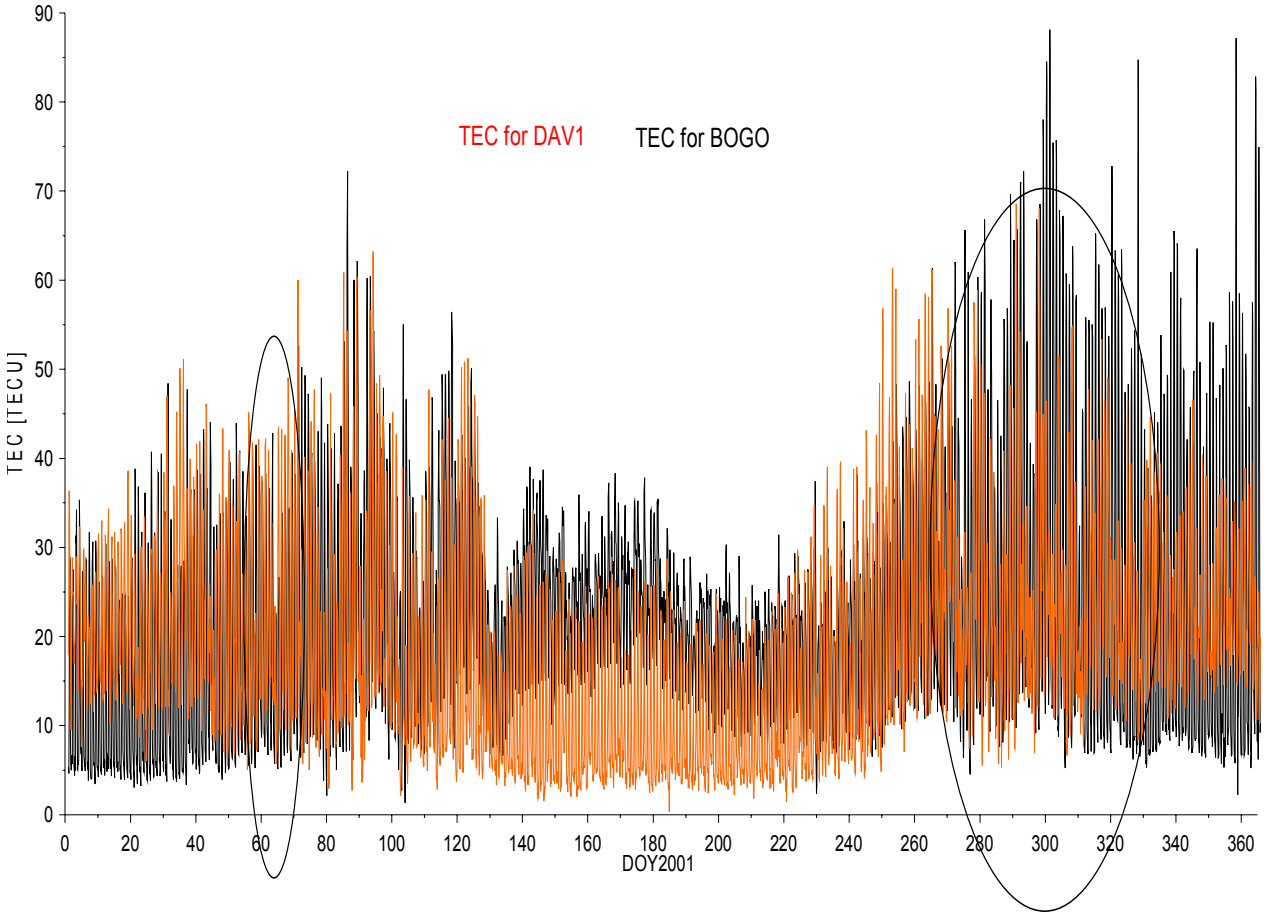

Fig. 1. Variations of TEC in 2001 for BOGO and DAV1 stations from IONEX files

Numerous ionospheric storms can easily be identified on the graph in Fig. 1. The area marked on the left hand side of the graph indicates the vicinity of 64DOY2001 where took place the ionoshperic storm already reported (Cisak, 2002). The area highlighted on the right (zoomed out in Fig. 2 with added information on periods of geomagnetic storms predicted by IPS Geomagnetic Disturbance Warning) corresponds to the series of strong ionospheric disturbances.

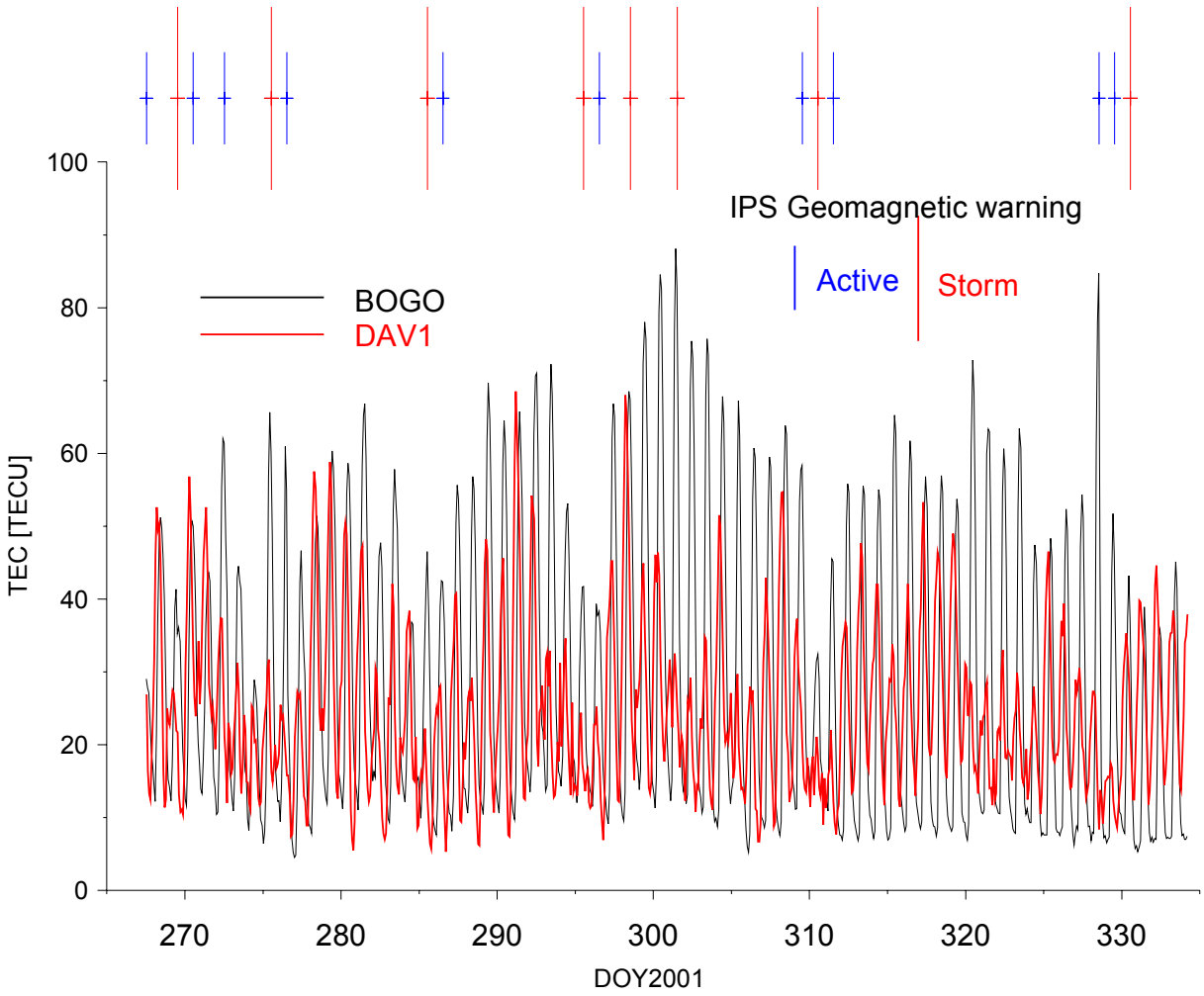

Fig. 2. Variations of TEC in October-November 2001 for BOGO and DAV1 stations from IONEX files

Data from that period for CAS1, DAV1, MAW1, MCM4, OHIG and VESL stations was processed and analysed in the framework of the reported stage of the project. GPS solutions based on 24 h sessions with overlap of 23 h (two consecutive 24h sessions shifted mutually by 1 h) were obtained using Bernese v4.2 software with QIF strategy for the vectors between those stations. Time series of GPS solutions for vector components, its length and a number of single differences used for solving a vector with indicated periods of geomagnetic storms is shown in Fig. 3 (MAW1-DAV1 vector of 636 km) and Fig. 4 (OHIG-MCM4 vector of 3983 km).

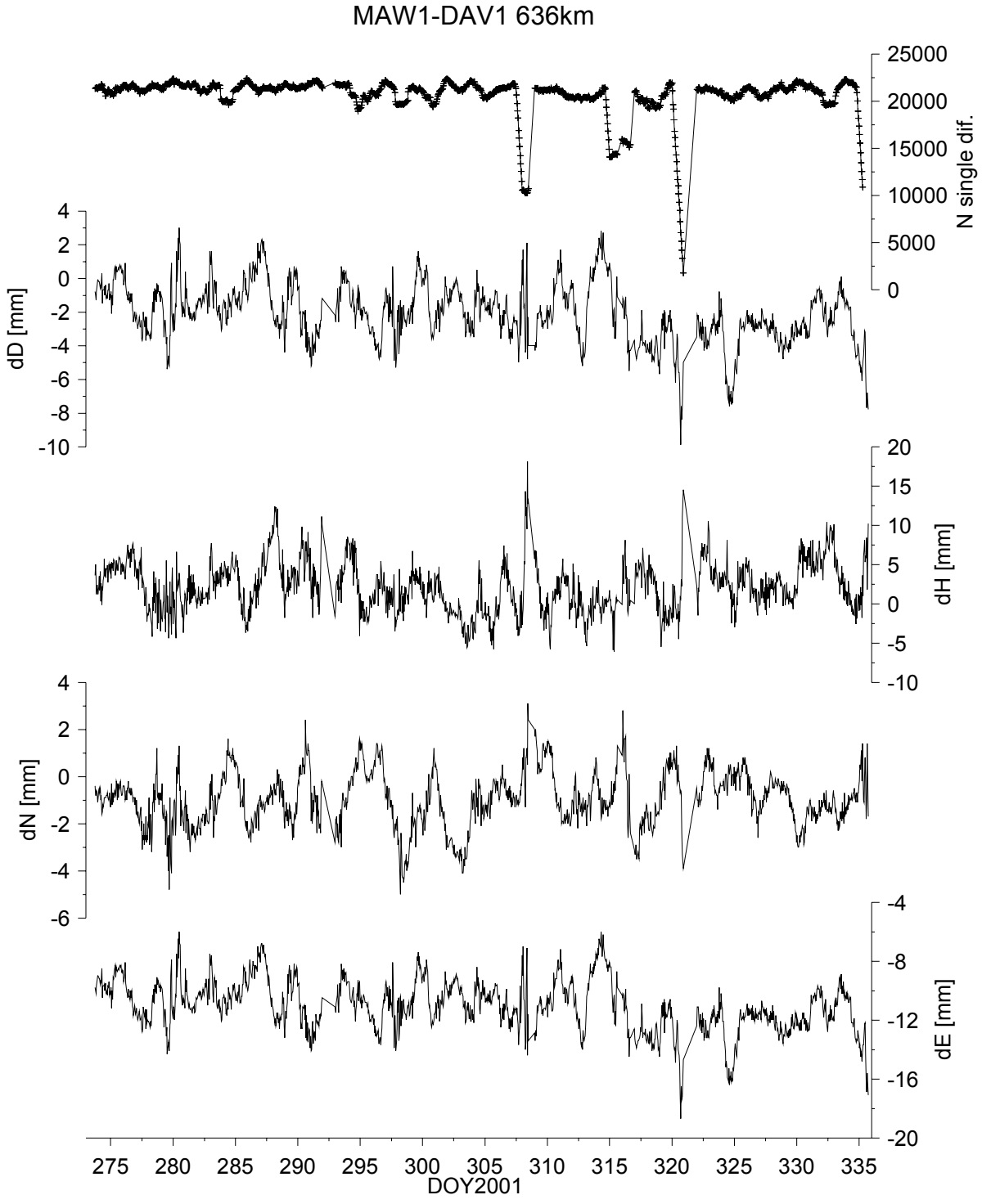

Fig. 3. Time series of GPS solutions for MAW1-DAV1 vector components, its length and a number of single differences used for solving a vector

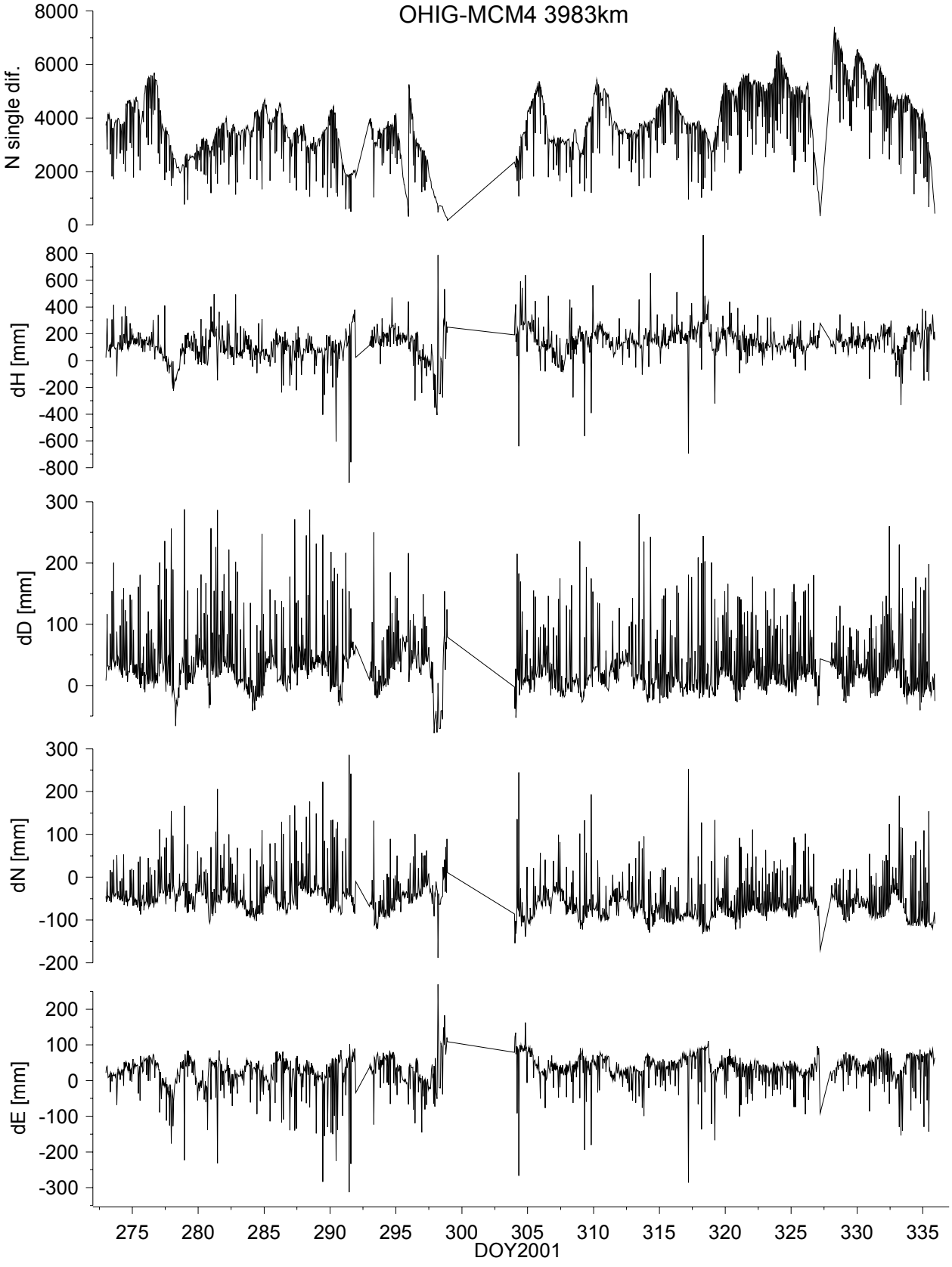

Fig. 4. Time series of GPS solutions for OHIG-MCM4 vector components, its length and a number of single differences used for solving a vector

Considerably different size of amplitudes of variations between the time series in Fig. 3 and Fig. 4 reflects the difference by a factor 6 of the lengths of the vectors investigated. It is particularly distinguished in the number of single differences used for solving a vector. In case of OHIG-MCM4 vector that number frequently decreases to a level that is no longer acceptable. It results in the solutions biased with an integer number of cycles. Therefore processing as long vectors as OHIG-MCM4 using fixed ambiguity solution strategy seems questionable. Respective spikes in time series of vector components sometime correspond to the same epochs. Moreover they also correspond to the spikes in time series of the number of single differences used for solving a vector. Those spikes coincide in addition with geomagnetic storms.

Temporal resolution of IONEX TEC data is not sufficient to describe variability of ionospheric disturbances that is required to efficiently detect and analyse the relationship between the state of ionosphere and variations in vector components derived from GPS data. In the framework of cooperation within WGGGI and IONO-WG of IGS the TEC data for four Antarctic stations CAS1, MAW1, OHIG and VESL for November 2001 with time resolution of 7 minutes was calculated from GPS data and provided by Manuel Hernandez-Pajares. Time series of TEC for CAS1 for November 2001 from IONEX and from IONO-WG are given in Fig. 5a Fig. 5b, respectively. Comparison of IONO-WG TEC data with corresponding MAV1-CAS1 vector length given in Fig. 5c shows a distinct correlation that also exists for other vector components.

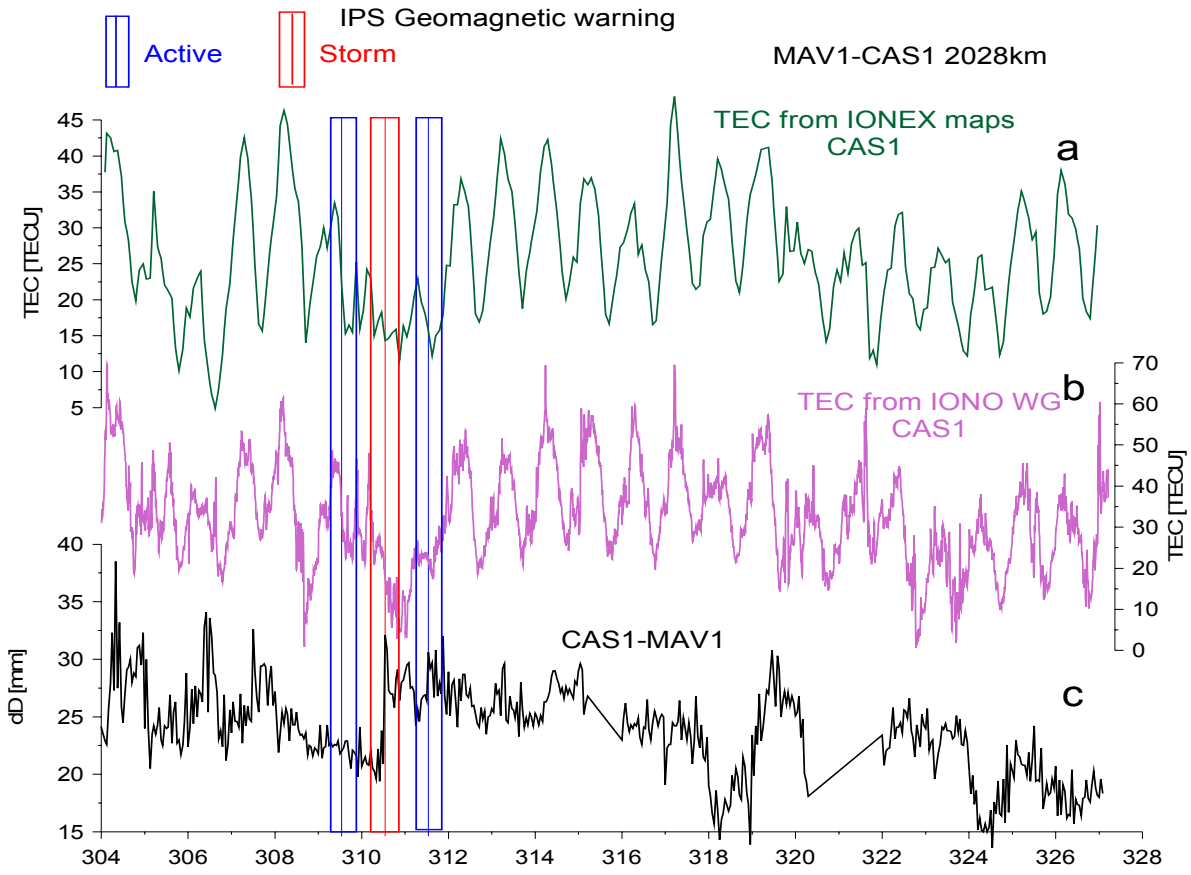

Fig. 5. Time series of TEC for CAS1 from IONEX (a), from IONO-WG (b), and MAV1-CAS1 vector length (c)

CONCLUSIONS

Time series of GPS solutions based on GPS data from overlapped segments can be considered as a record of the process of variations of vector components due to varying disturbances. Investigation of atmospheric impact on GPS measurements in a new dimension leads toward:

- modeling the influence the environmental effects and internal errors of GPS system;
- correcting GPS solutions with of the developed models;
- more reliable accuracy estimate of GPS solutions;
- studying short term variations of the environmental effects and internal errors of GPS system.

In the paper only the effects of ionospheric disturbances are discussed. The research is carried on. Large amount of meteorological data and GPS data from numerous Antarctic GPS stations, not necessarily participating in the IGS program, was collected. The next step of the project concerns the analysis of the tropospheric impact on GPS solutions obtained from processing GPS data from Antarctic stations.

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REFERENCES

Cisak, J., (2002): *Atmospheric Impact on GPS Observations in Antarctica - Project of GEODESY/GIANT program of SCAR WGGGI Report 2000 – 2002,* Presentation on WGGGI meeting of XXVII SCAR.

Baran, L.W., Wielgosz, P., Cisak, J., Shagimuratow, I.I., (2001): *The Response of Polar Ionosphere to a Magnetic Storm Obtained from GPS Observations*, SCAR Report, Publication of the Scientific Committee on Antarctic Research, Scott Polar Research Institute, Cambridge,UK

Feltens, J., Jakowsky, N., (2001): *The International GPS Service (IGS): Ionosphere Working Group activities*, SCAR Report, Publication of the Scientific Committee on Antarctic Research, Scott Polar Research Institute, Cambridge,UK.

Krankowski, A., Baran, L.W., Shagimuratow, I.I., Cisak, J., (2001): *Influence of Ionosphere in Arctic and Antarctic Regions on GPS Positioning Precision*, SCAR Report, Publication of the Scientific Committee on Antarctic Research, Scott Polar Research Institute, Cambridge,UK

Krynski, J., Cisak, J., Zanimonskiy, Y.M., Wielgosz, P., (2002): *Variations of GPS Solutions for Positions of Permanent Stations – Reality or Artifact*, Symposium of the IAG Subcommission for Europe (EUREF) held in Ponta Delgada, Portugal, 5-7 June 2002, EUREF Publication No 8/2, Mitteilungen des Bundesamtes für Kartographie und Geodäsie, Frankfurt am Main (in print).