UNITED NATIONS
Office of Outer Space Affairs

United Nations/Latvia Workshop on the
Applications of Global Navigation Satellite Systems
Riga, Latvia
14 – 18 May, 2012

CURRENT PARTICIPATION OF BULGARIA IN EUROPEAN AND REGIONAL GNSS PROJECTS

G. Milev, ***Space Research and Technology Institute, BAS***
K.Vassileva, ***European Polytechnical University, Bulgaria***

Current Participation of Bulgaria in European and Regional GNSS Projects

G. Milev, K.Vassileva

1.General

2.Development and application of *CERGOP* and *EUPOS*

2.1. *CERGOP* and *CEGRN* network

2.2. *BULiPOS*

3. Applications in geodynamic investigations of the Balkan Peninsula and Bulgaria

4. *EUMETNET - E-GVAP*

5. Conclusion

1. General

- The development and improvement of *GNSS* is multilateral and intensive in global scale.
- Along with the establishment of new global satellite systems - *GALILEO, COMPASS*
- Regional ground-based systems and reference networks – *EUREF, AFREF, SIRGAS* etc. and
- Densification networks.
- Establishment of *DGNSS* networks is also progressing – *EUPOS*.
- In this respect regional projects in Europe as *CERGOP, EPOS* and other projects have been developed.
- In their great part these projects are large-scaled and based on multilateral collaboration.

Information and results about the Bulgarian participation in some current projects have been presented here.

2. Development and application of *CERGOP* and *EUPOS*

The European regional projects *CERGOP* and *EUPOS* have got significant development since their initial phase as a result of the new challenges of the life.

All participating Central and Eastern European countries have contributed to their successful realization, improvement and further development.

CERGOP 2 project covers the geodynamic investigations of Central and Eastern Europe and in particular the ones in Balkan Peninsula with participation of 13 countries.

At present - stations of other reference networks are integrated to the established *Central European GPS Geodynamic Reference Network – CEGRN.*

EUPOS project

Started in March 2002 - 14 Central and Eastern countries actively participated for its establishment and successful operation

In March, 2012 – 10 years celebration in Bratislava, Slovakia.

- The number of participating countries is steadily growing from year to year and at present their number increased up to 20.
- Entirely established in many countries or in some countries is still under construction.
- The users and types of applications - also growing as the major part of them are real time applications.
- Many of the *EUPOS* stations operate as combined stations - part of other networks as well.
- In some countries the *EUPOS* activities are enlarged – establishment of processing and analysis centers.
- Bulgaria is one of the foundation members of *EUPOS* with active participation.

2.1. CERGOP and CEGRN network

The main research topic of the *CERGOP* projects is monitoring crust movements by using *GPS* measurements from high quality campaigns and permanent stations.

Velocity fields, geo-kinematical models and strain fields are derived as the basis for geodynamic investigations.

The focus lies on the regions of

Adriatic Microplate,

Balkan Peninsula,

Dinarides,

Carpathian Arc,

Eastern Alps and

Pannonian Basin.

All of them being active tectonic zones.

The long term project is running since 1994 and was sponsored twice by *EU* projects (*CERGOP1* and *CERGOP-2*/Environment).

Recently neighbouring regions of Central and Eastern Europe and Monitoring Oriental Network (*MON*) have been associated.

Wider spectrum of problems, which includes except *GNSS* networks of *EUREF*, *CEGRN* and partly of *EUPOS,* also local densification, reprocessing, dense networks, analysis, long time spans for intraplate anomalies, horizontal velocities are of the main interest.

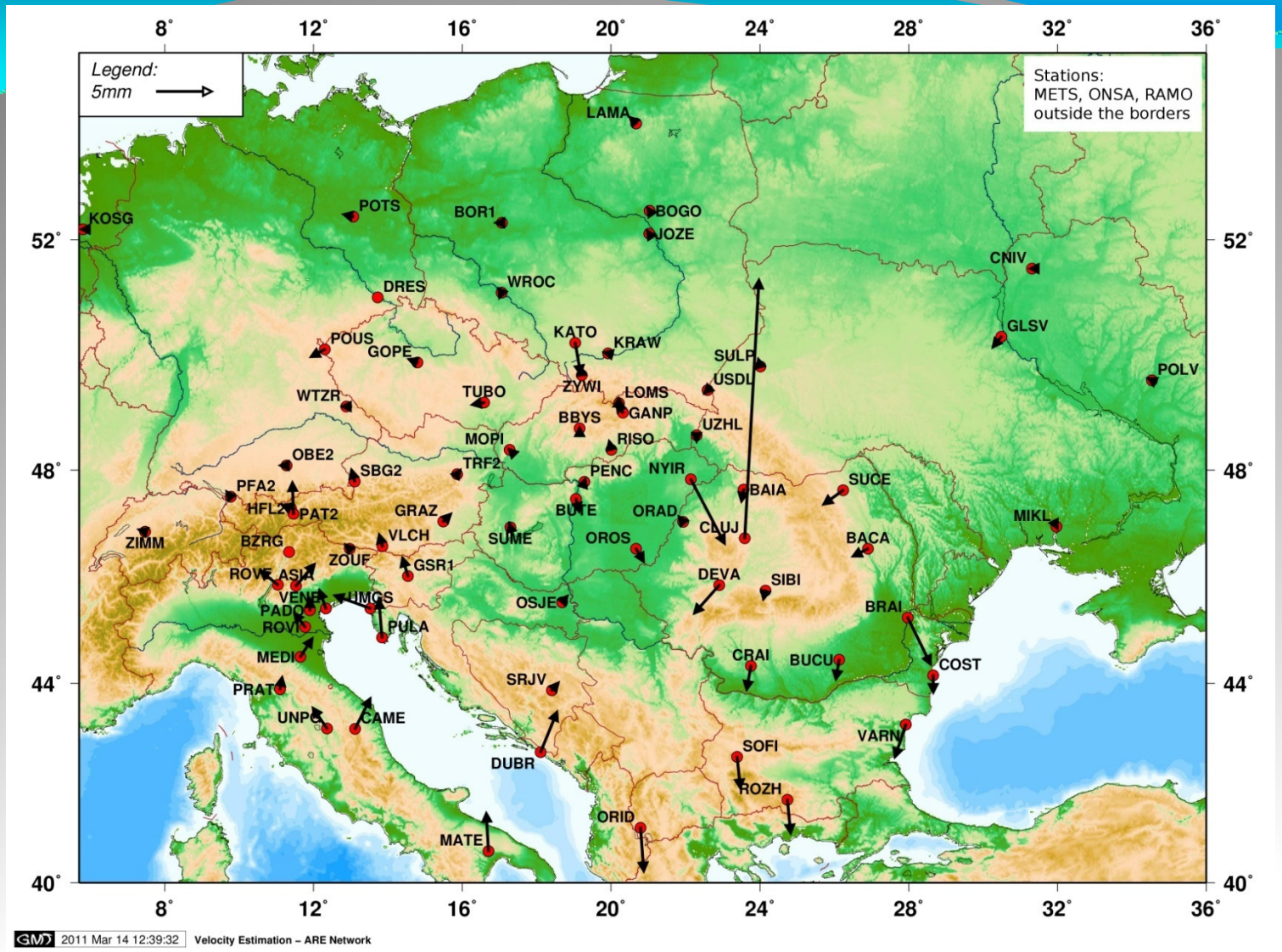


Fig. 1. *CEGRN* horizontal station velocity vectors with respect to the stable Eurasia

The analysis is done weekly according to the rules of the *EUREF* Permanent Network *EPN*. Non-*EPN* stations are provided by the *CERGOP* members.

2.2. BULiPOS

The establishment of the Bulgarian segment *BULiPOS* (*BULgarian intelligent Positioning System*) of *EUPOS* system started in 2007 with 7 reference stations.

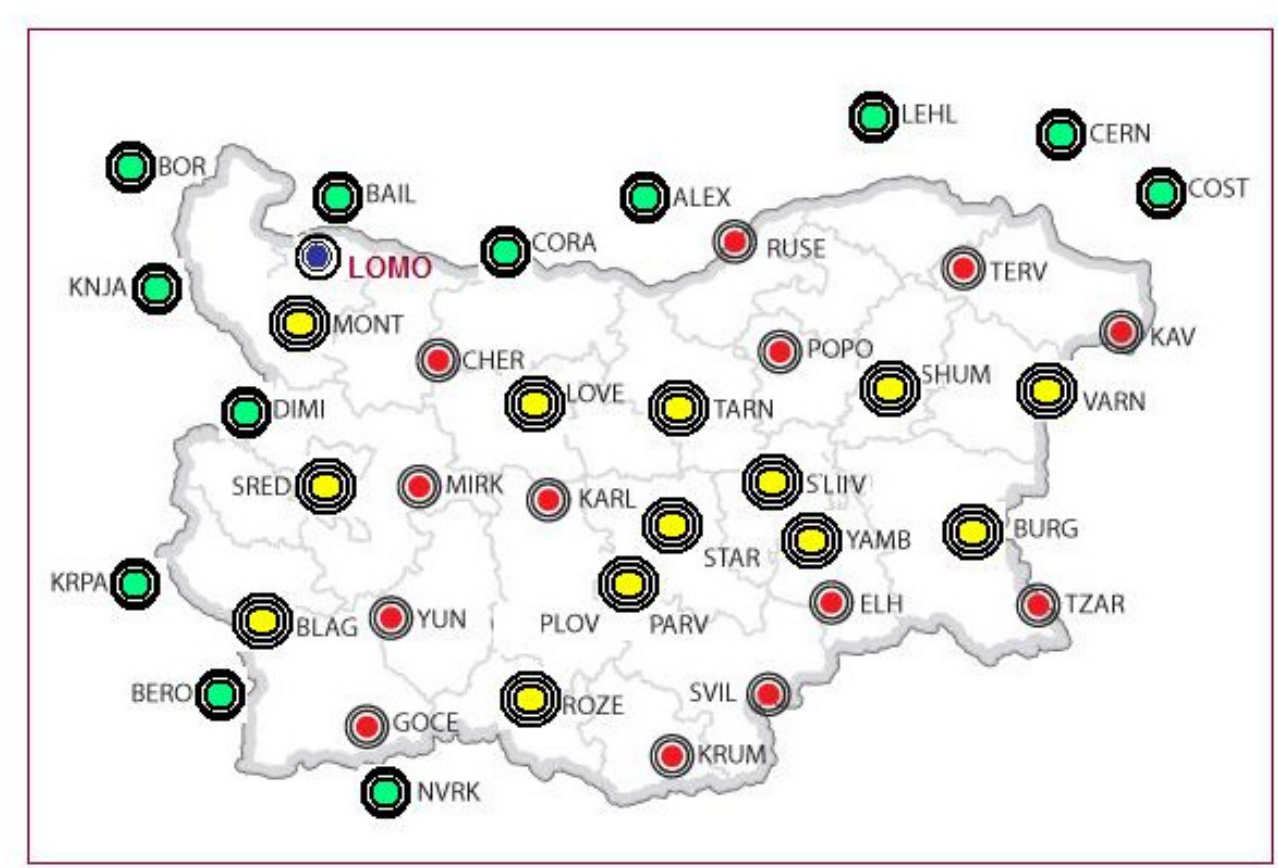


Fig. 2. Current status of *BULiPOS-Leica* Network and integrated neighboring stations

In 2009 - **12** permanent stations.

Currently - **13** permanent stations

Total number of *BULiPOS -Leica* integrated network - **29** permanent stations

12 more *EUPOS* stations from neighboring countries connected to the Bulgarian segment

Coordinates of the *BULiPOS* stations - in reference system ETRS89.

- Obtained from adjustment of *GPS* data in 2008, in the *ITRF2005*, transformed in *ETRF2005*.
- Data processing of one week *GPS* data in 2009 and 2010 have been accomplished as well and one week *GPS* data processing in 2011 and 2012 is in progress.
- For monitoring the *BULiPOS* network station behaviour a combined solution of all processed results will be done.

Application of BULiPOS in Bulgaria

- Protection and monitoring of the environment,
  - Security,
  - Engineering objects and their complexes,
  - Urban territories,
  - Forests, agriculture,
  - Flooding,
  - Archeology.

In November 2009 BLOM Group carried out laser scanning of the land and under-water relief section of 100 km^2 of the Black Sea coast between Lozenec and Primorsko by Hawk Eye laser system.

For archeological purposes it was developed *GIS*.

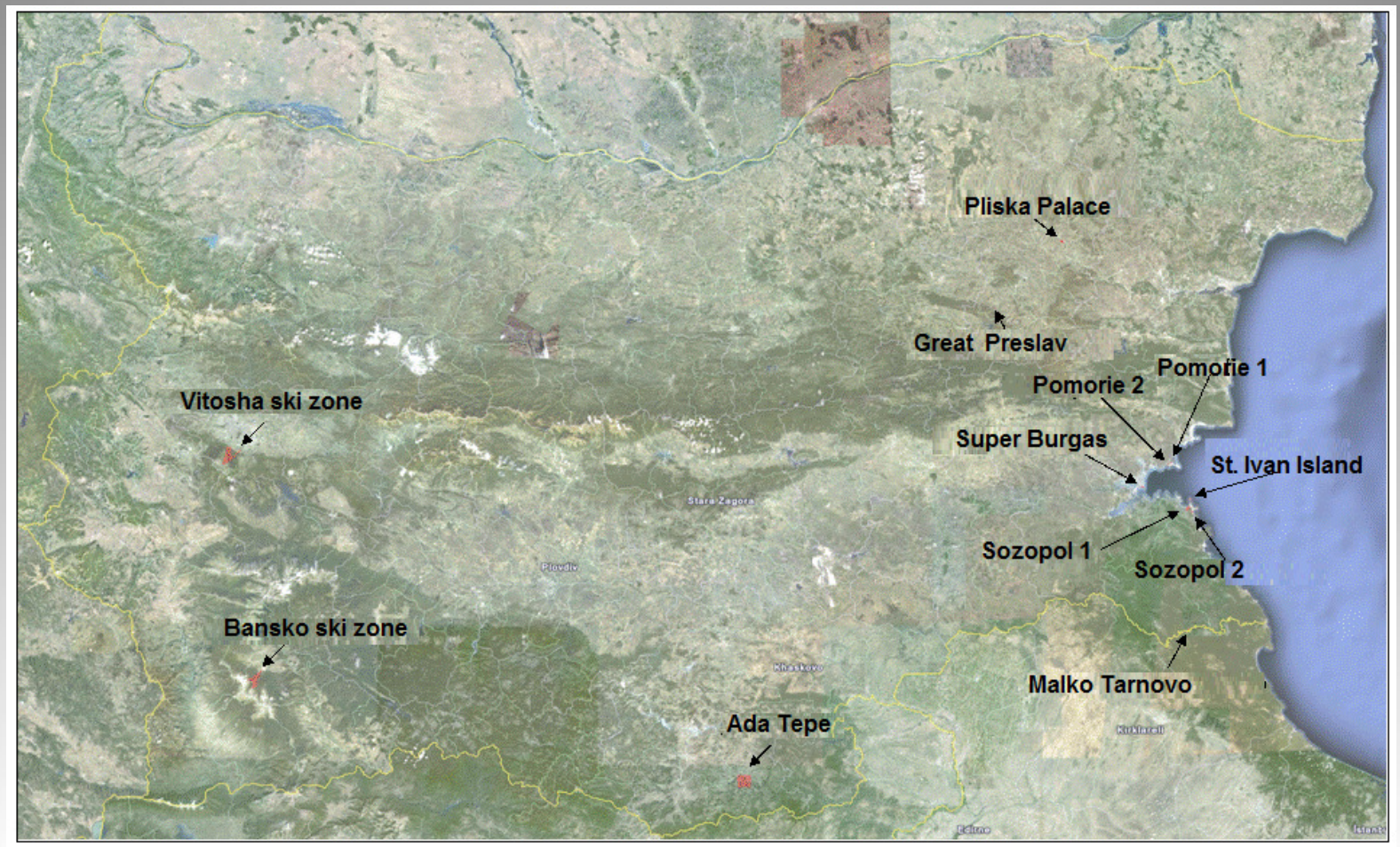


Fig. 3. Laser scanning objects in December, 2010, Bulgaria

3.Applications in geodynamic investigations of the Balkan Peninsula and Bulgaria

The region of the Balkan Peninsula as part of the entire geodynamic investigations within the *CERGOP* project is included in the study of the analysis center in Graz, Austria and in the study of the Bulgarian team of *CERGOP*.

Detail and generalized geodynamic investigations related to the Balkan Peninsula as a whole and to the geodynamics of the particular Balkan countries have been already published in the monograph “Geodynamics of the Balkan Peninsula, 2006.

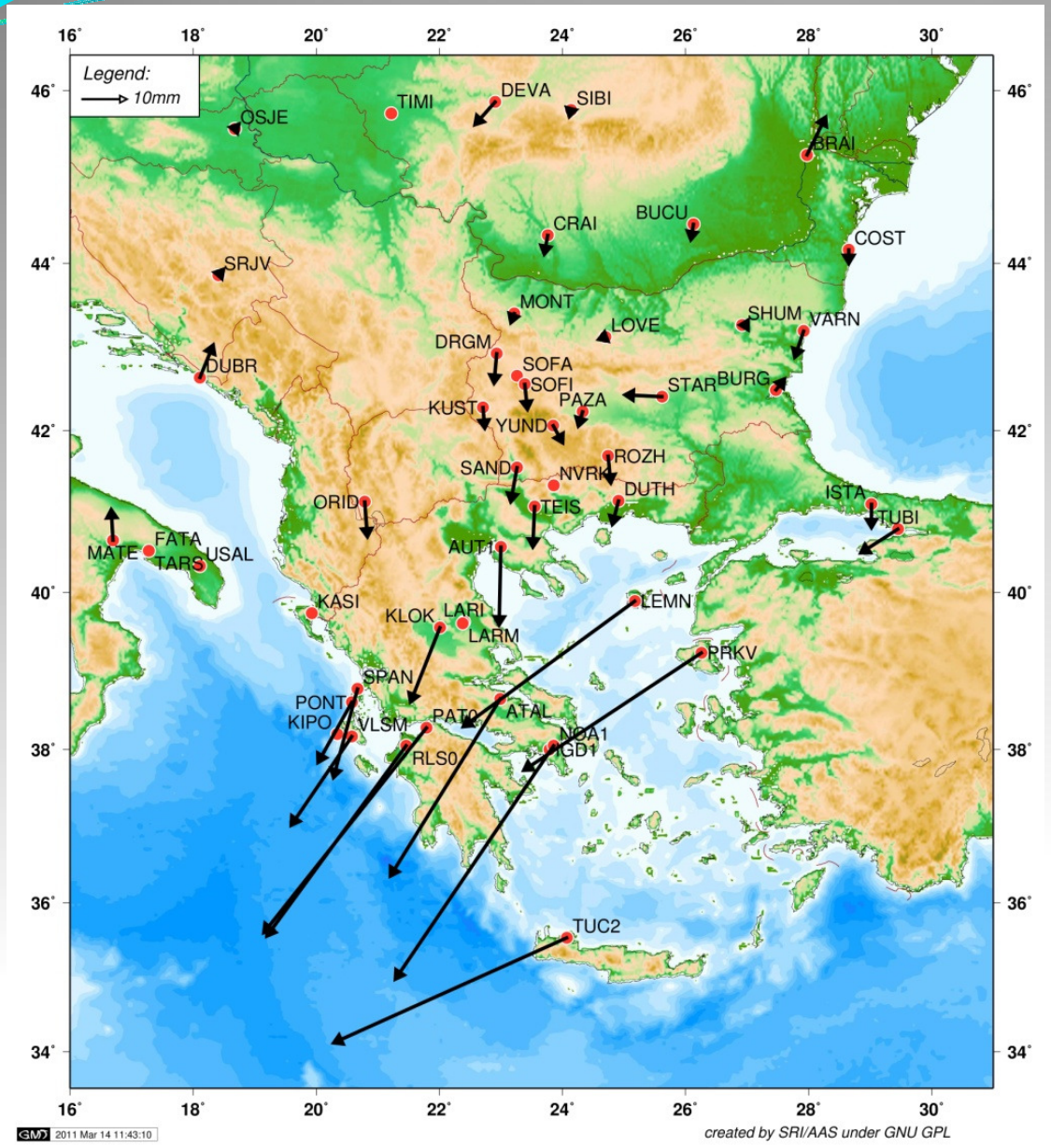


Fig. 4. *CEGRN* and *MON* horizontal station velocity vectors with respect to the stable Eurasia obtained at the Graz Analysis center

The differences of estimated velocities are between 0 and 1 mm/year at the about 10 identical points .

•The reason of these differences is the choice of different reference sites.

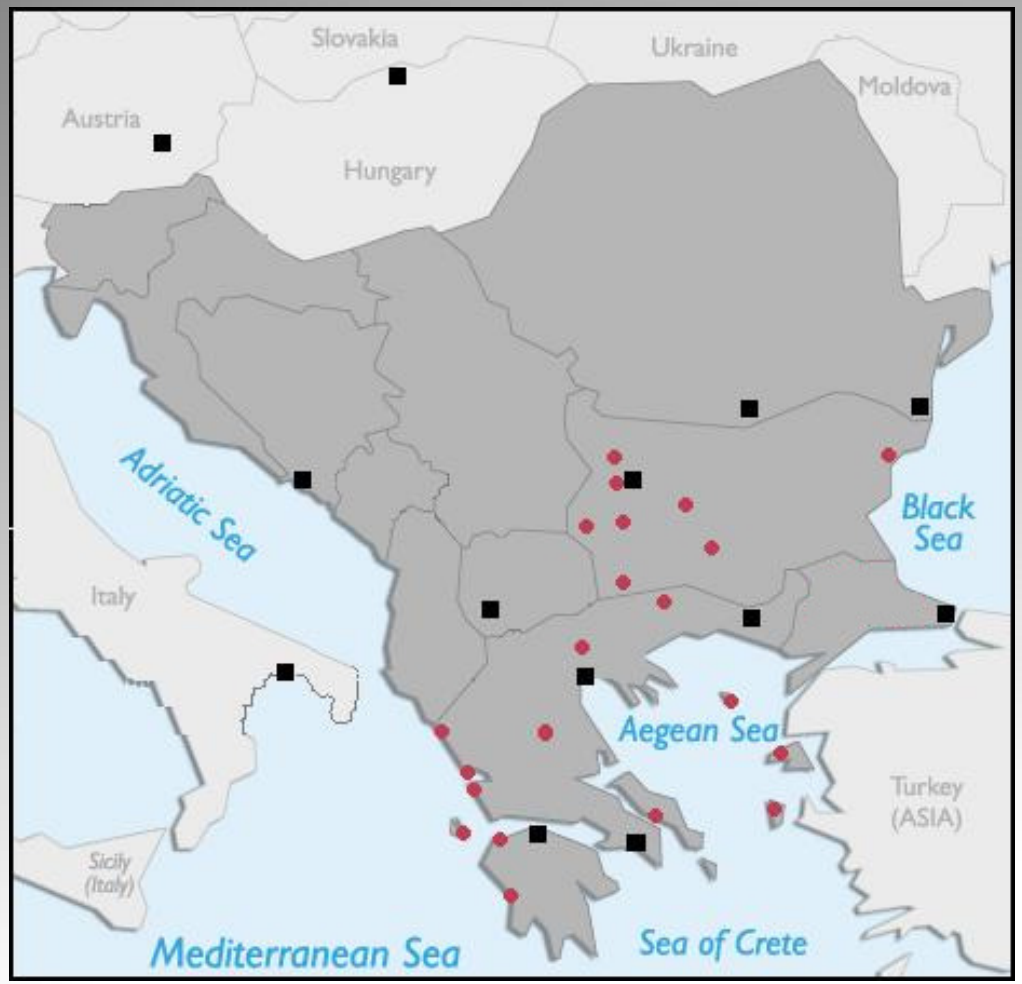
•All the analysis is done weekly according to the rules of the *EUREF* Permanent Network *EPN*.

•Non-*EPN* stations are provided by *CERGOP* members and the Hemus-Net.

•Five *EUPOS* Bulgarian stations of the *BULiPOS* network have been recently integrated to the *CEGRN* network for more exhaustive investigation of this region.

The latest Bulgarian geodynamic investigations of the Balkan Peninsula concern the seasonal behaviour of *GNSS* permanent stations on its territory.

The three season's *GPS* data – winter, spring and summer are processed and analyzed.



Total number of participated stations (including IGS /EPN stations)

in 2006 - 17

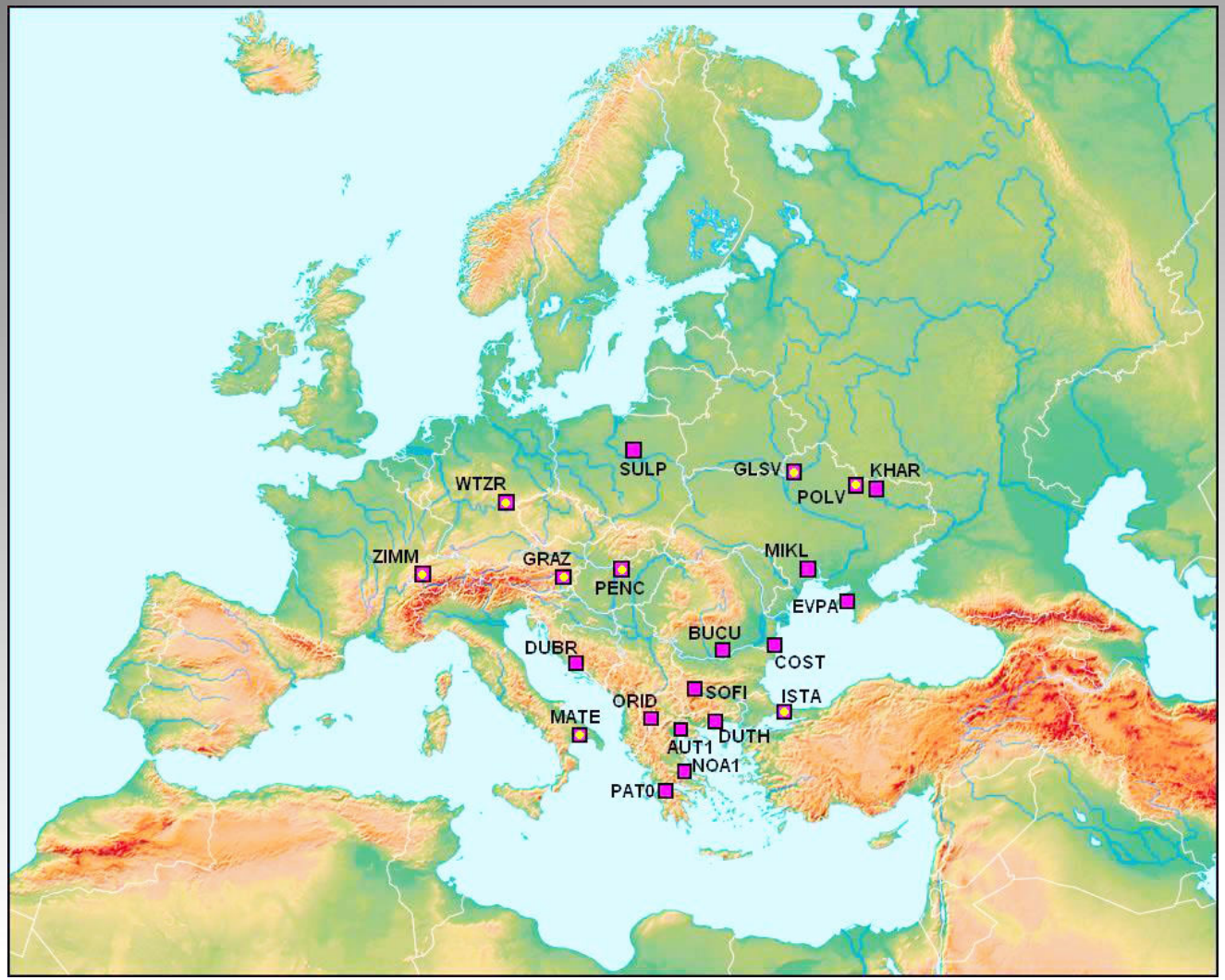
in 2010 - up to 40

Total number of Balkan Peninsula permanent stations involved - 29.

Fig. 5. Locations of the Balkan Peninsula permanent stations observed within 2006-2010

GPS data of the same weeks in January and respectively in April 2006, 2007, 2008 and 2009 have been processed with Bernese software, Version 5.0 for winter and spring seasons.

GPS data of the same summer weeks in July 2006, 2007, 2008, 2009 and 2010 have been processed with the same software.
The station coordinates are obtained in system *ITRF2005*.



By reason of comparability the same *IGS* reference stations have been used for datum definition – GLSV, GRAZ, ISTA, MATE, PENC, POLV, SOFI, WTZR, ZIMM .

Fig. 6. IGS/EPN stations involved in the study

ETRF horizontal velocity vectors as representative characteristics of the station behaviour have been obtained for each season by using *ETRF* components of the Eurasia plate rotation pole to the obtained *ITRF* velocity vectors.

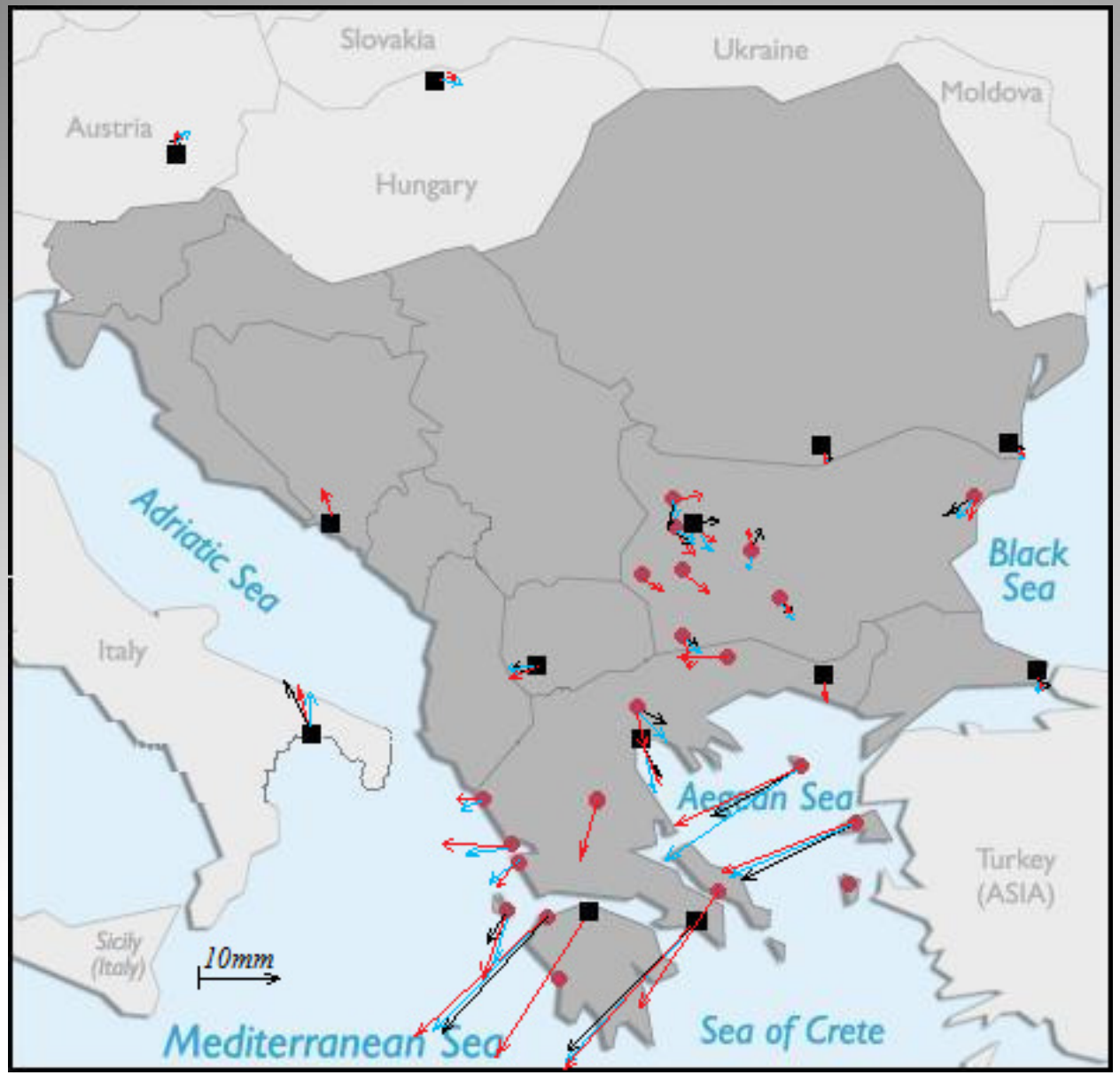


Fig. 7. Horizontal velocity vectors of BP stations relative to Eurasia plate obtained for the three seasons

For most of the stations the size and direction of the velocity vectors within the three seasons keep the same and it can be assumed that there is no impact of the seasonal variations.

The obtained differences for the other stations can be explained with the short time of observations – only two years.

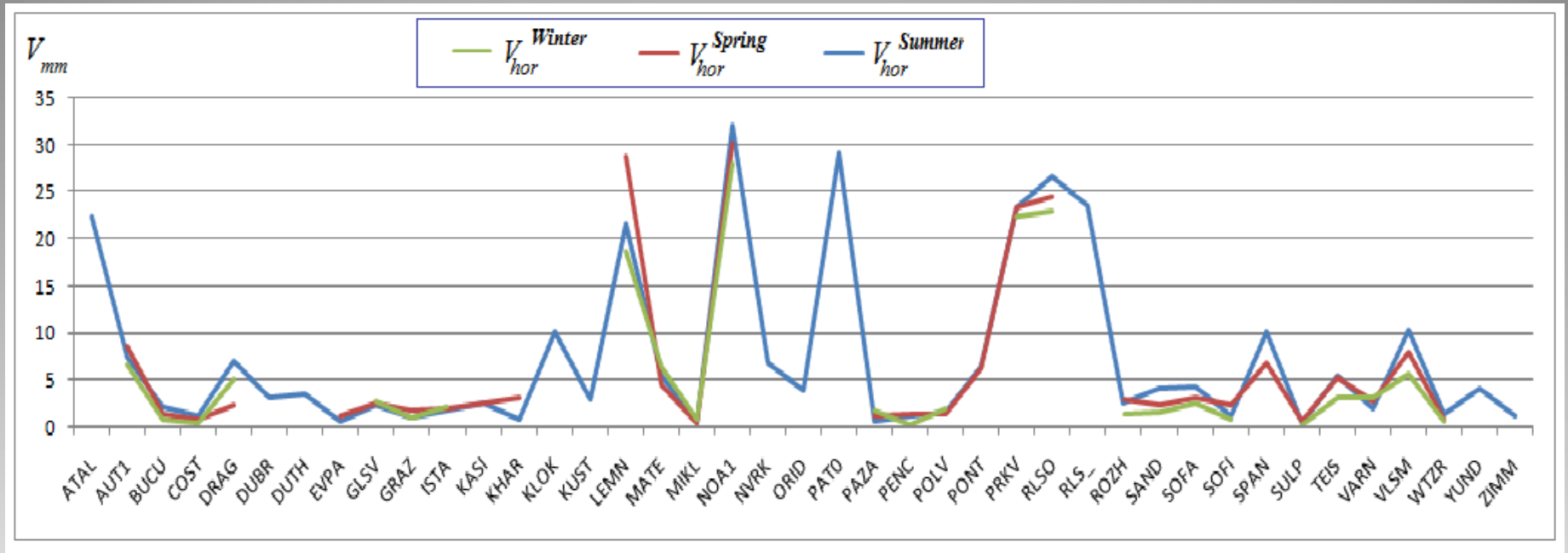


Fig.8. Horizontal velocity vectors of BP stations in winter, spring and summer time

4. *EUMETNET - E-GVAP*

An effective application of *GNSS* is in the field of meteorology.

The concept of GNSS Meteorology - the application of the Global Navigation Satellite Systems (GNSS) in Meteorology or GNSS Meteorology was first suggested by Bevis (1992).

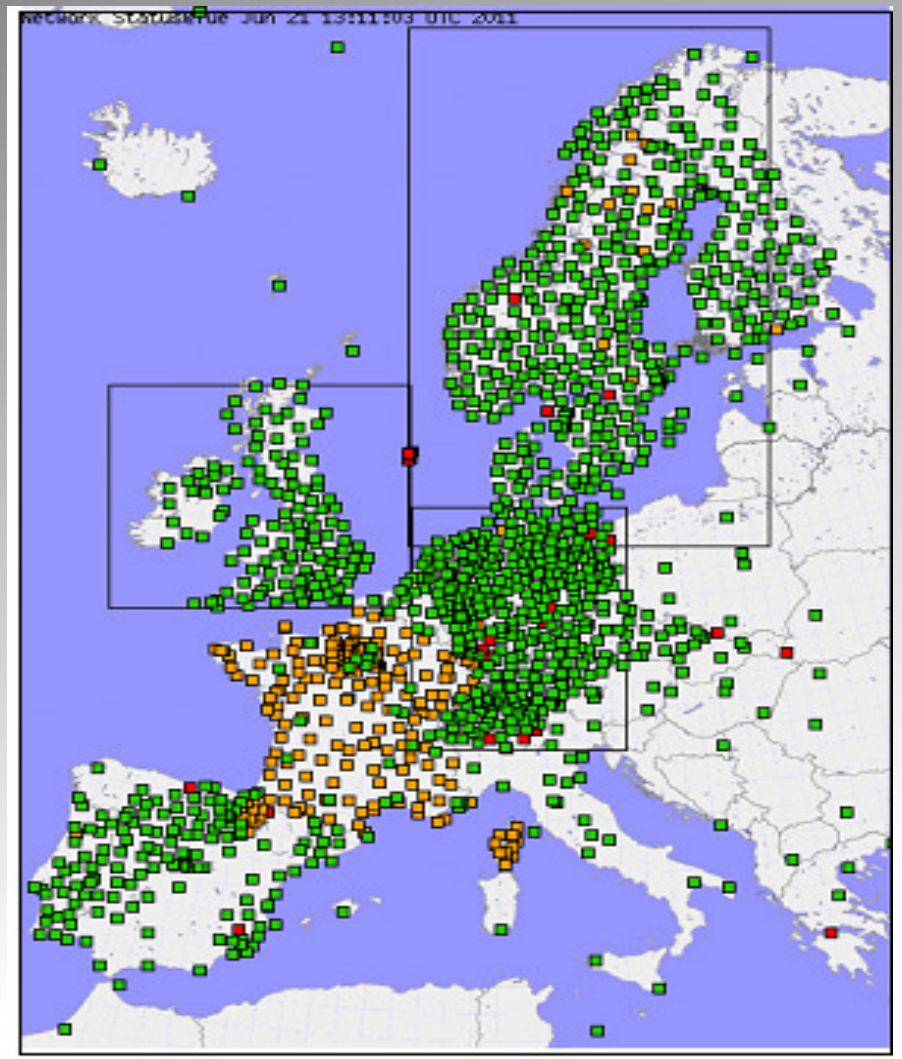
As the GNSS signal travels through the atmosphere its propagation is affected by atmospheric gases and in particular water vapour, which has high temporal variation up to 20-30% within a day.
Thus vertically integrated water vapour information with high temporal and spatial resolution can be derived from the GNSS signal time delay.

Worldwide dense ground-based networks have been developed and they collect GNSS data, from which atmospheric parameters like water vapour are derived.

On a European scale first the project *MAGIC* – Meteorological Applications of *GPS* Integrated Column Water Vapor Measurements in the Western Mediterranean investigated the contribution of *GPS* data to the I*WV* – Integrated Water Vapor.

Later on project *COST 716 GPS* data were used for numerical forecast of the weather.

In real time these data were used for verification of the accuracy of the models for numerical forecast of the weather at five meteoservices – Germany, Switzerland, Great Britain, Sweden, and Denmark.



The *E-GVAP* programme started in 2005 as continuation of *COST* and *TOUGH* projects to deliver IWV in near real time for the *EUMETNET* partners.

Fig. 9. *GNSS* stations contributed to the projects *E-GVAP*, status – June, 2011

In 2007 a memorandum for partnership was signed between *EUREF* and *EUMETNET* for collaboration between *EUREF* and national meteoservices.

GPS data acquisition and processing for meteorological purposes was started in 2001 at the British meteorological service.

Currently data from more than 400 *GPS* sites are being sent hourly to a common ftp-server at the UK Met Office.

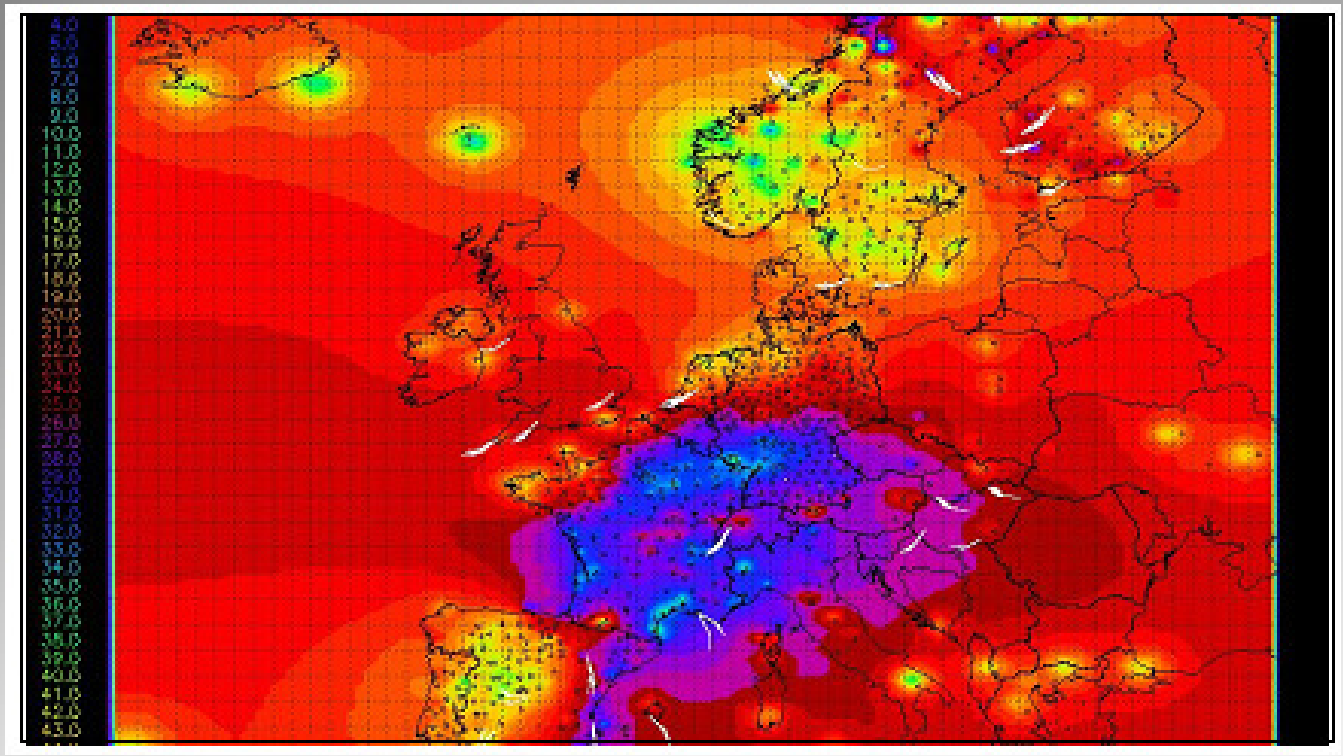


Fig. 10. *E-GVAP* field of IWV in real time - 22.06.2011, 10UTC

Over the territory of the Balkan Peninsula the field is homogeneous but with several spots.

The main reason for that is a few *GNSS* stations contributed to IWV of *E-GVAP* in this region.

In Bulgaria first study for application of *GNSS* for meteorology was done only for station SOFI due to the availability of aerological sounding only at Sofia station.

By this reason Bulgaria proposed five up to seven *BULiPOS GNSS* stations to be integrated to the *EUMETNET* for better covering the territory of Bulgaria which will contribute to the *GNSS* meteorology on its territory and Balkan Peninsula as well.

Shortly after discussion between scientists working in this field in Bulgaria the idea was enlarged and Bulgaria first proposed not only Bulgarian *EUPOS* stations to be involved in *E-GVAP* but also stations from all *EUPOS* counties.

As result a Memorandum of Understanding (MoU) was prepared which was approved and accepted at the 21th Conference of the International *EUPOS* Steering Committee in Bratislava, end of March 2012.

The signing of the Memorandum of Understanding between *EUPOS* and *EUMETNET* is forthcoming.

5. Conclusion

The presented aspects and applications of *GNSS* and *DGNSS* and the specific results achieved illustrate large capabilities and effectiveness of these systems.

Especially it concerns their complex use of geospace technologies in the field of applied geodesy.

Independent parts of them are the geodynamic applications including for large territories.

Specific applications of *DGNSS* for the meteorological purposes are also important nowadays for the weather forecasting.

Permanent complex development and improvement of the systems and technologies is a reliable precondition for their further application.

Thank You for Your Attention