

E-GVAP

The EUMETNET GPS Water Vapour Programme

Report for the period April 1'st 2005 to January 31'st 2006.

Compiled by Henrik Vedel, Danish Meteorological Institute.

1 Start of E-GVAP

E-GVAP was started April 1st following decision by the EUMETNET Council in September and December 2004. Again in April 2005 the Council debated E-GVAP, but only regarding membership in E-GVAP of Austria at a reduced price, which was rejected.

1.1 Current members of E-GVAP

The members of E-GVAP during the first year period are,

1. Belgium
2. Denmark
3. Finland
4. Iceland
5. Ireland
6. Netherlands
7. Norway
8. Spain
9. Sweden
10. Switzerland
11. United Kingdom.

1.2 Contracts and economy

Following the EUMETNET Council meeting in April 2005 a contract for E-GVAP has been written in collaboration between DMI and the EUMETNET office. Following the contracts have been signed by the E-GVAP partners.

The E-GVAP partner contributions for the first year, 20050401 to 20060331, were,

Belgium	8668 €
Denmark	5816 €
Finland	4314 €
Iceland	284 €
Ireland	2787 €
Netherlands	13468 €
Norway	5328 €
Spain	20122 €
Sweden	8167 €
Switzerland	9578 €
United Kingdom	50468 €
Total	129000 €

In E-GVAP the UK Met Office is paid 25.500 € for data processing and running of a data server, this amount was subtracted before billing the UK Met Office. KNMI has not been billed, but is receiving 25.500-13.468 € in net payment for development and running of the data validation.

Most of the past period E-GVAP was being financed by the host E-GVAP team institutes, DMI, KNMI, and MetO, as billing and payments first took place in the autumn of 2005. We are thankful to the three institutes for this service. At present most of the E-GVAP partners has paid their instalments for the first year of the programme.

Other costs, such as travel costs to be paid out of the E-GVAP budget are being calculated according to the host institute rules (e.g. Met Office rules if it is a Met Office E-GVAP representative travelling himself, or hosting an expert team meeting) and billed E-GVAP at DMI for central accounting.

1.3 Second period members of E-GVAP and budget breakdown.

During second half of 2005 work within the field of ground based GPS meteorology became more active also in a number of non E-GVAP EUMETNET countries, in particular France (at Meteo France) and in Germany (on the data processing side), and we very much hope that Meteo France and Deutsche Wetter Dienst will decide to join the programme in the second period. However, as of January 31'st 2006 the members of E-GVAP are again,

1. Belgium
2. Denmark
3. Finland
4. Iceland
5. Ireland
6. Netherlands
7. Norway
8. Spain
9. Sweden
10. Switzerland
11. United Kingdom.

Based on these members the foreseen contributions from each partner for the second period, which starts 2006-04-01, will be,

Belgium	8085 €
Denmark	5451 €
Finland	4224 €
Iceland	263 €
Ireland	3208 €
Netherlands	13248 €
Norway	5925 €
Spain	21814 €
Sweden	7749 €
Switzerland	9157 €
United Kingdom	49875 €
Total	128999 €

The contributions are determined from the GNI numbers of the partaking E-GVAP countries. It is changes in their relative size which have lead to the changes in the size of the various contributions from the first to the second period. The GNI numbers are kindly provided by the EUMETNET Office. The second year E-GVAP budget itself is the same as for the first year,

Project manager 0.5 year per year	43.0 k€	DMI
Liaison group meetings	15.0 k€	
Expert Team meetings	10.0 k€	
Contract to support hub/central processing	25.5 k€	MetO
Contract to quality control facility	25.5 k€	KNMI
Project Travel	10.0 k€	
Total	129.0 k€	

2 E-GVAP setup

2.1 E-GVAP main contact and information points

- **Information:** <http://egvap.dmi.dk>
- **Access to 'private' sector on E-GVAP homepage:** Uid = egvap, pw = gps2user
- **Contact:** egvap@dm.dk, phone: (+45) 3915 7445

2.2 E-GVAP team

The E-GVAP team has been set up as follows,

- **Management.** DMI. Henrik Vedel. Contact: egvap@dm.dk
- **Database and Met Office data processing.** MetO. Jonathan Jones, Adrian Jupp, Dave Offiler, and John Nash. Contact: dave.offiler@metoffice.gov.uk.
- **Data validation and feedback:** KNMI. Siebren de Haan. Contact: Siebren.de.Haan@knml.nl

2.3 E-GVAP database

The GPS delay data processed for E-GVAP in near real time (NRT) are being sent to and are available at an ftp-server at MetO: [thorn.meto.gov.uk](ftp://thorn.meto.gov.uk). Data are uploaded from the processing centres every hour.

- **Server:** [thorn.meto.gov.uk](ftp://thorn.meto.gov.uk) (151.170.240.16)
- **Uid:** COST716
- **Pw:** GPSCONNECT

The data are available at the server in compressed ascii COST716 format and in BUFR format. The BUFR files are also distributed via GTS. Descriptions of both formats are available at the server.

In case of problems, contact the E-GVAP staff for details on how to access the data.

2.4 E-GVAP data distribution policy

The current situation is very complex in terms of the relation between the amount and origin of the GPS delay data arriving at thorn from a given country and the E-GVAP membership of that country. For example much data arrive from Germany and also from France, neither of which are E-GVAP members.

At the first E-GVAP plenary meeting it was decided that E-GVAP as such will NOT limit access to GPS delay data. Data delivered to E-GVAP under the constraint that they are not freed will not be freed. Currently such arrangements are controlled by Dave Offiler. In the future, when TOUGH is finished, we will convert to a practise where GPS delay data which are not freely distributable are not forwarded to the thorn (E-GVAP) data server.

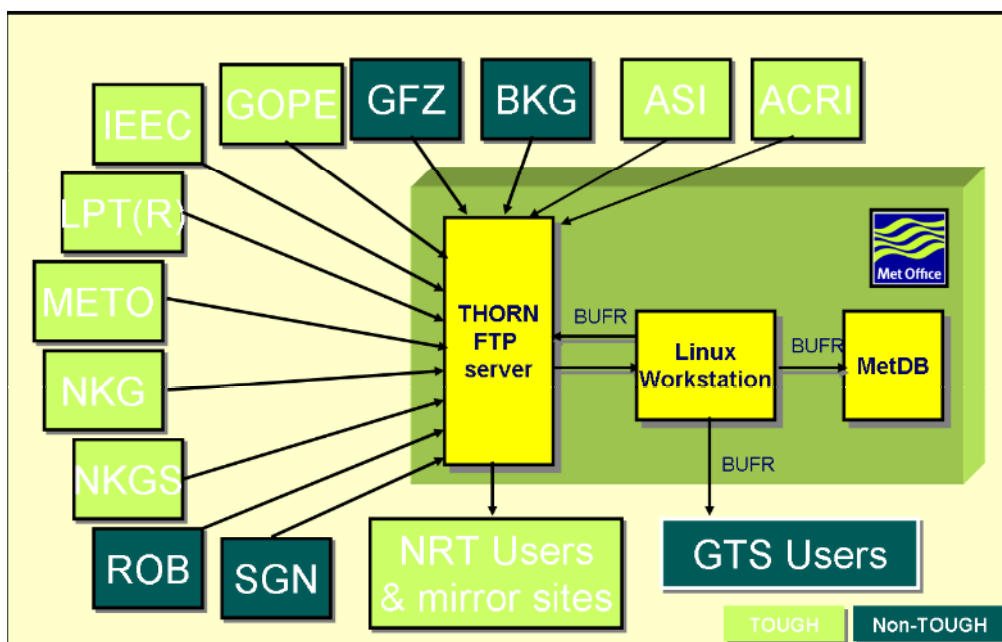


Diagram showing data-flow of NRT GPS ZTD data in and out of the E-GVAP database.

2.5 E-GVAP data processing at the UK Met Office

Processing of GPS data in near real time into GPS ZTD and IWV has been set up at the UK Met Office, with help from processing experts from University of Nottingham. The system has been updated in E-GVAP.

Currently GPS data are processed from the following GPS site owners,

- Met Office Network – 10 sites
- Ordnance Survey GB – 78 sites (resource sharing)
- UK Tide Gauge Authority – 6 sites
- IGS/IESSG – 15 sites

The processing scheme uses a sub network strategy with seven stations in each for processing the daily PPP solution, whereas the NRT and IGU06 (first QC) solutions are now processed in 3 sub-networks (number of sites in each network dependent on no. of sites available).

At the first plenary meeting it was realised that there is a potential for processing of additional GPS data at the UK Met Office. Met Office is negotiating to get data from Northern Ireland. Following the plenary meeting negotiations to get data from Ireland has started between Met Eireann and the Ordnance Survey of Ireland, those data will be processed at the Met Office. Further it is being investigated with VEDUR how to get Icelandic GPS data to the Met Office for processing.

2.6 E-GVAP monitoring, validation, and feedback

Validation of COST716/E-GVAP data takes place at KNMI. The validation software and site has been updated during the past period. Results are available via the validation link at the E-GVAP homepage, <http://egvap.dmi.dk>. The validation site itself has the address <http://www.knmi.nl/samenw/egvap/validation>.

It is an automatically updated site on which GPS NRT ZTD's delivered to the database are compared to KNMI HIRLAM data, and as well to radiosonde data in cases where a radiosonde is located nearby the GPS site in question. The following pictures give a few examples of the

presentation and usefulness of the validation site. For a complete coverage it is necessary to visit the validation site itself.

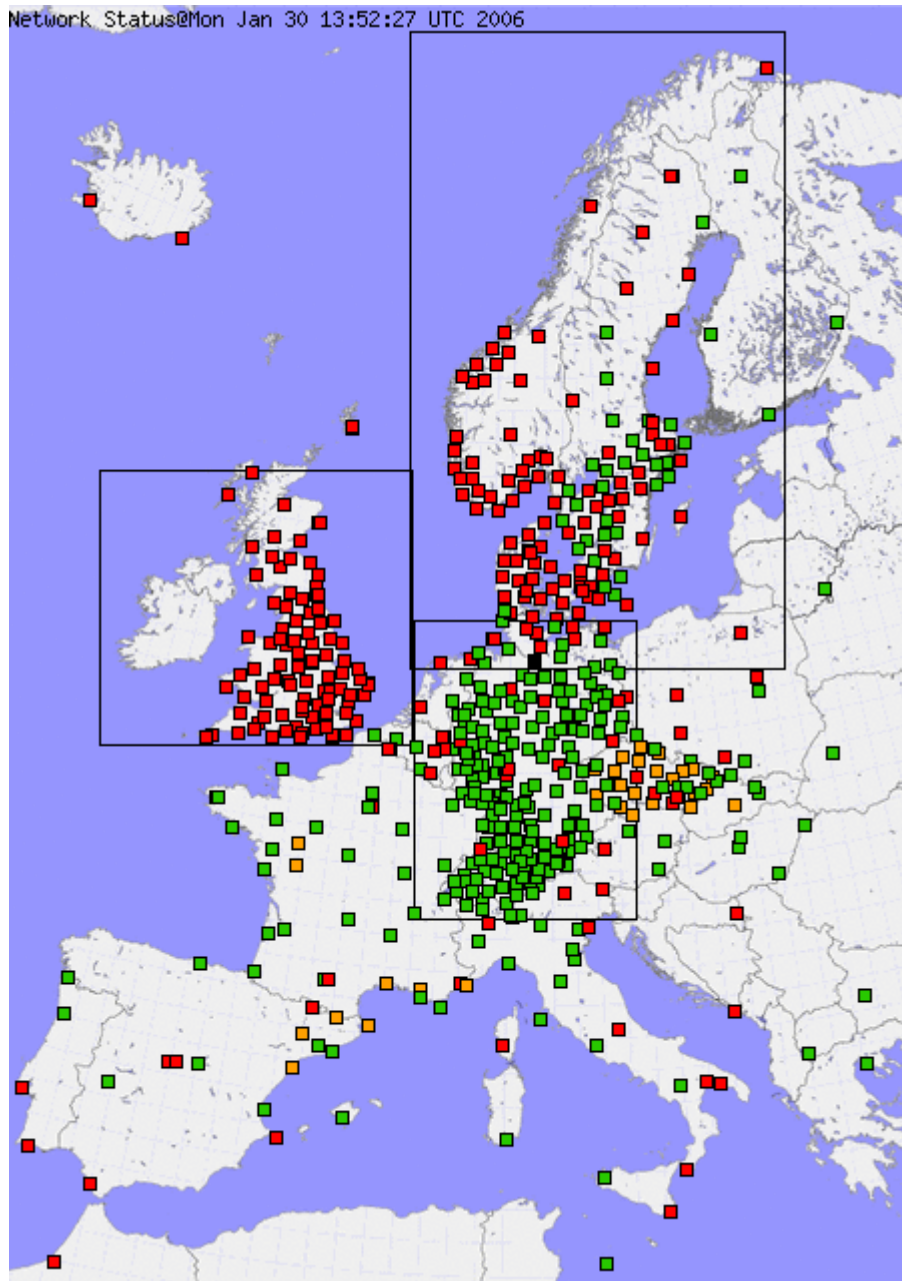


Figure showing European GPS sites included in the NRT reporting. Coloured according to latency. At the validation site each sub map and station symbol is clickable for further information about region and validation of the data from each station.

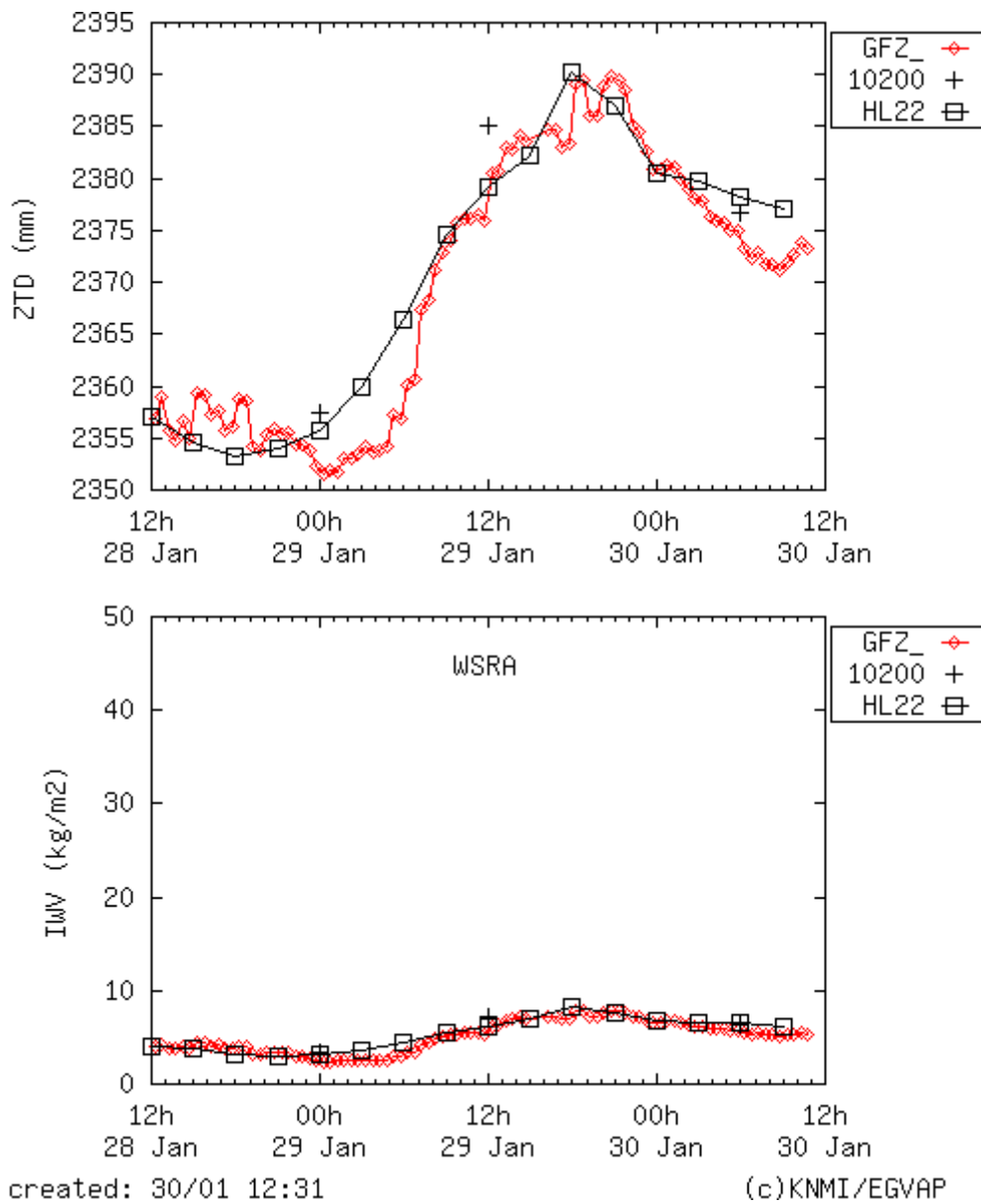


Figure comparing GFZ processed station WSRA near real time ZTD to KNMI HIRLAM 22 km resolution ZTD, as well as to radiosonde 10200 data. Below is similar, but for IWV.

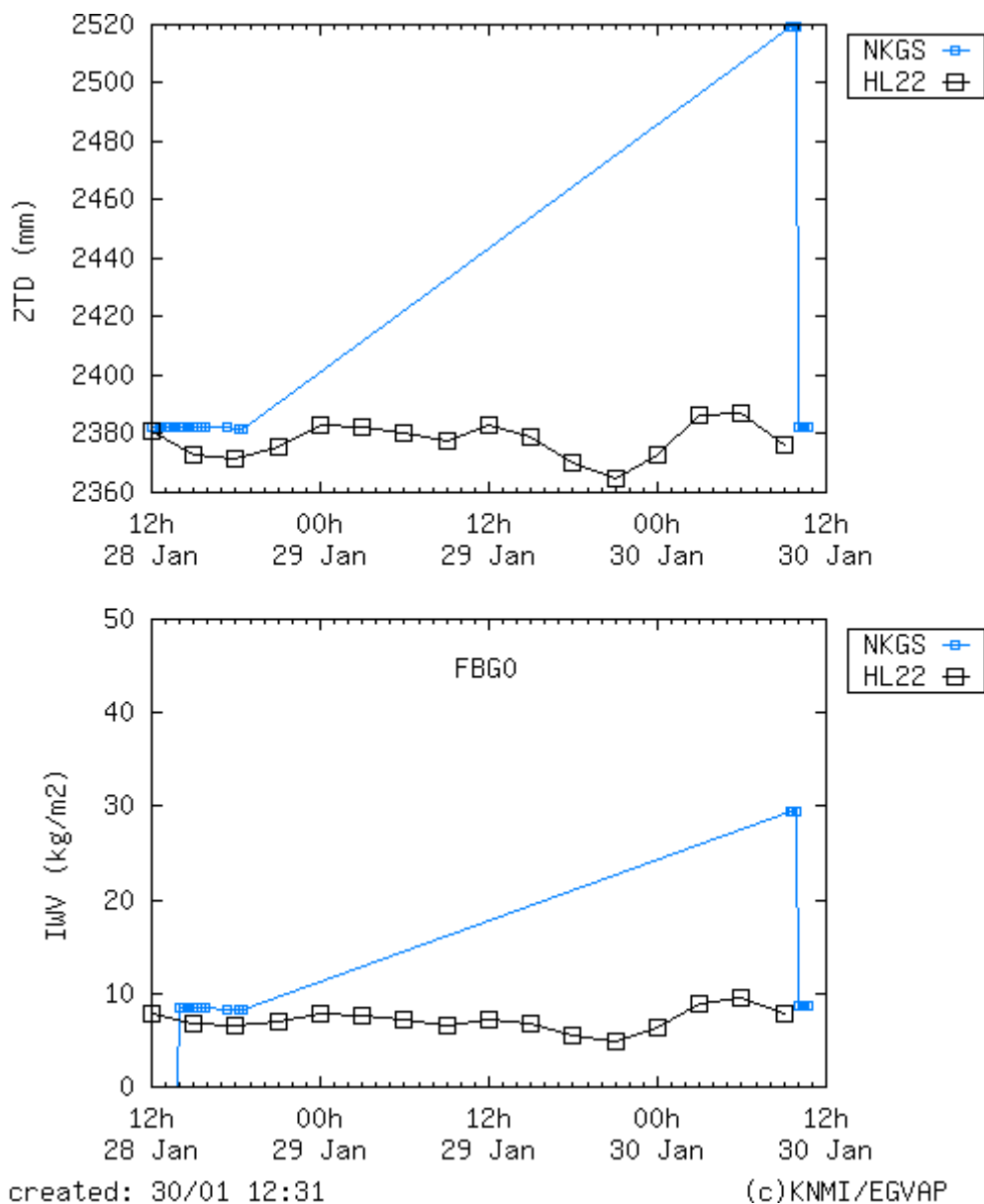


Figure comparing NKGS near real time processing of station FBG0 ZTD to ZTD of KNMI HIRLAM 22km resolution model. Bottom is similar, but for IWV. A clear case in which the monitoring reveals a problem with the GPS ZTD data, both regarding the data stream and the data quality for the particular station and period.

Currently the validation site enables continuous monitoring of the network and station performance. During the cause of E-GVAP feedback and automated feedback will be implemented.

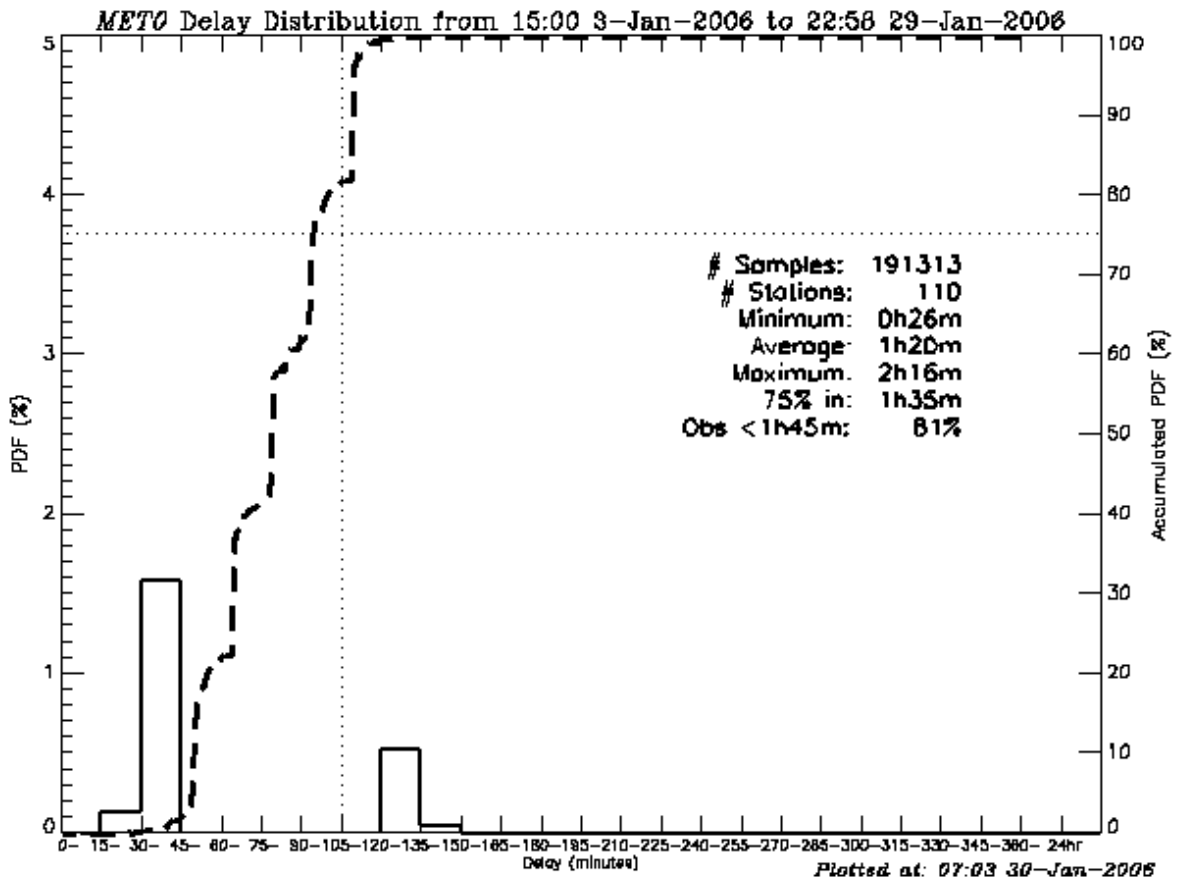
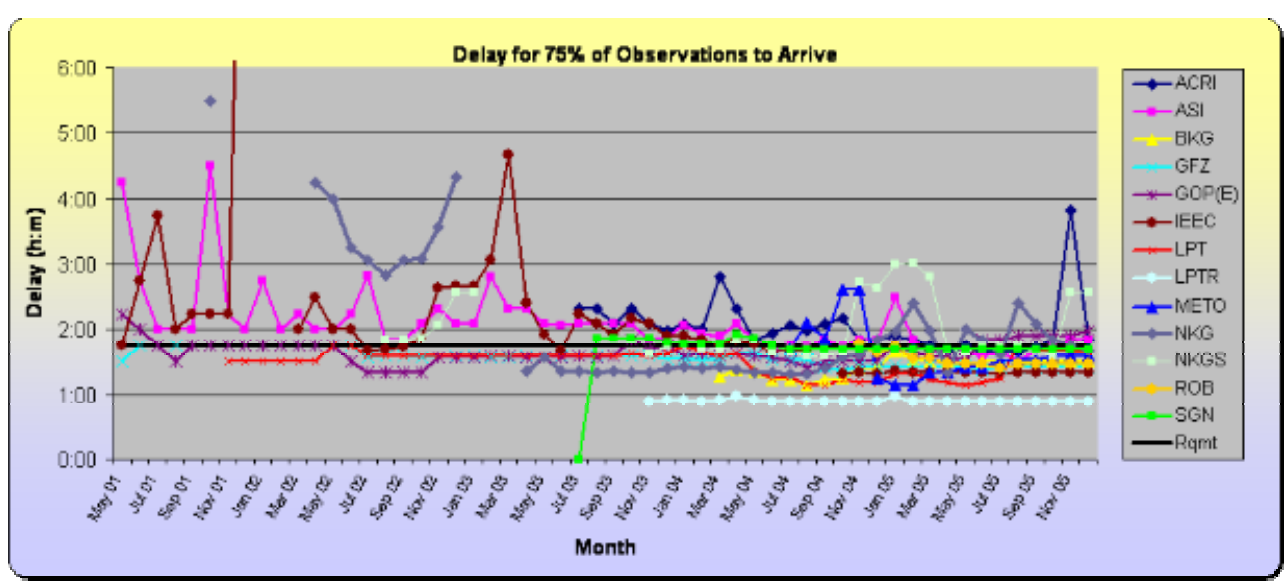
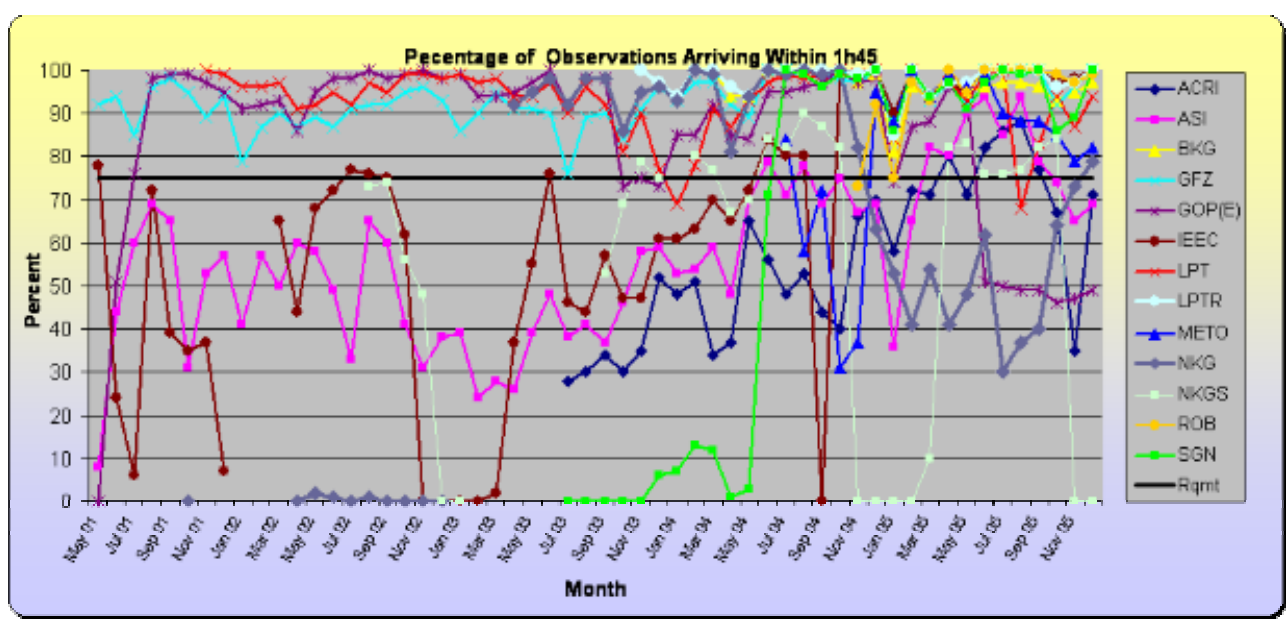


Figure from validation site showing which percentage of the NRT ZTD's have arrived as function of time during the last month. In this case for the processing centre at the UK Met Office (called METO in GPS meteorology). Similar plots can be found for each processing centre delivering data to the data server. The same thing is monitored on a daily basis, as in the example below,

For long time comparison of the extent and performance of the GPS NRT ZTD observing system a comparison is done stretching over the period since the start of the COST 716 experiment to present.



While these are compiled by Dave Officer from the UK Met Office they are made available at the monitoring and validation site at KNMI. The curve labelled 'Rqmt' represents the goal from COST716 that 75 percent of the data arrive within 1 hour 45 minutes of the time at which the observations are valid. The other right-hand names represent the different processing centres delivering data to the data server. The curve labelled 'LPTR', which is a 'real real time' product, exemplifying that a significant reduction in the processing time is possible. The extra cost and reduced accuracy of this type of product have to be monitored, before an eventual decision of a more general move in that direction. The shorter delivery time is not necessary for inclusion in most current NWP data assimilation setups, but it can be useful if the GPS data are to be used in now-casting, and in future NWP setups running with shorter cut-off times.

A marked improvement with time is visible. However, currently many GPS processing systems are run in a 'standalone' version, for example in the TOUGH project, and it is expected that yet another marked improvement will appear when more of the processing is starting to take place on system with tighter monitoring and when the E-GVAP feedback is started.

2.7 E-GVAP liaison group and expert teams

The final formation of the experts groups and their first meetings have been delayed. Both because the project had a late start, but more importantly because there is a large overlap between the people who ought to be in such teams and the people involved in the TOUGH project, in which they already meet twice a year. TOUGH is a scientific project, in part funded by the EC, involving 15 institutes, and devoted to research advancing both the processing of near real time ZTD's, the error correction and calibration of those, and utilisation of GPS data in NWP meteorology, in particular through data assimilation into regional NWP models. TOUGH ends by 2006-01-31, the final reporting will be done by 2006-03-31. It is planned that the reports from TOUGH regarding recommendations for processing of GPS data and recommendations regarding the use of GPS in NWP will form the basis for the first reports to be made in E-GVAP. (The following E-GVAP met services are involved in TOUGH: DMI, FMI, INM, KNMI, MetO, and SMHI. GPS processing centres from the following E-GVAP countries are involved in TOUGH: Norway, Sweden, United Kingdom, Netherlands, Switzerland, and Spain. In addition TOUGH includes a met institute from Italy, and GPS processing centres from Italy, France and the Czech Republic. Further GFZ has recently become involved in TOUGH as an associated partner.)

The expert teams will be formed during the next few months. Some of the candidates have been selected and have accepted, including people representing EUREF.

At the plenary meeting it was discussed whether experts should come from E-GVAP member institutes and countries (on the GPS side). It was decided that for the liaison groups it should be so, whereas for the data processing and data utilisation team it is experts need not come from E-GVAP partner institutes/countries. The possibility of including non E-GVAP members is crucial, as work which is very important to E-GVAP is being made in non E-GVAP countries.

2.8 Overview of GPS meteorological status in member countries

At the first plenary meeting an overview of the situation regarding access to and use of ground based GPS data was made. Precise knowledge of that is important for decisions on how to proceed in

E-GVAP. Below is the status as reported at the plenary meeting, larger changes are described in the section following.

BELGIUM. Currently Belgish GPS data available. Future access not secured. No work on the use of GPS data.

DENMARK No current agreements with GPS site owners. Danish data from national mapping agency and a private network, GPSnet, currently processed at Chalmers. Potential for doubling density of data by involving a second private network. Collaboration under establishment with national mapping agency. Future access to delay data not secured. Extensive work on the use of GPS data in NWP.

FINLAND. No NRT access to data from nat. mapping agency. Private network with real time access to data, but no current collaboration. No possibility of processing GPS data within Finland

in near future. Expertise on utilising GPS data in assimilation at FMI, particular regarding slant delays. Future access to delay data not secured.

ICELAND. Currently no work on GPS meteorology at institute. Two IGS stations included among thorn data. Icelandic met institute has access to data from about 20 more stations.

IRELAND. Currently no work on GPS meteorology at institute. No GPS data at thorn. Potential for data from the Ordnance Survey of Ireland.

NETHERLANDS. Will start in house production of GPS delay data from Dutch GPS sites. Future access to data secured, but processing must take place at KNMI. Work on the use of GPS data in NWP and now-casting.

NORWAY. Currently no work on GPS meteorology at met.no. Contacts starting between met.no and NMA. Future access to delay data not secured.

SPAIN. Complicated situation with many network owners. Data currently processed by IEEC, who is not willing to continue processing on a volunteer basis. Attempts to establish an agreement between INM and IGN about data processing. High interest at INM for additional data from Portugal (both mainland and islands), Morocco, and Canary Islands. Future access to delay data not secured. Extensive work on the use of GPS data in NWP.

SWEDEN. Well established collaboration between Chalmers and SMHI. Processing includes SWEPOS data and additional Danish data. Density of GPS sites to increase in northern Sweden. Future access to delay data secured. Ongoing work on the use of GPS data in NWP.

SWITZERLAND. Current operational like arrangement between MeteoSwiss and Swisstopo. Apparent future problems due to cost of GPS delay data from Swisstopo. Near future access to data secured. Limited current work at MeteoSwiss on the use of GPS data.

UNITED KINGDOM. In house processing of GPS data, set up with hired help from University of Nottingham. Extensive collaboration with national mapping agency. Future access to data secured.

Access to data from Northern Ireland being secured by UK Met Office. Extended work on the use of GPS data in NWP and now-casting.

2.9 Updates to status of GPS observing system

In connection with the first plenary meeting it became clear that from a number of E-GVAP countries the amount of existing NRT ZTD data was either very little or zero. From case to case it varies whether this is due to difficulties in obtaining the raw data, lack of processing facilities and expertise, or simply for historical reasons..

We can report that currently negotiations are taking place between Met Eireann and the Ordnance Survey of Ireland about the conditions on which Met Eireann can obtain GPS RINEX data from the Ordnance Survey of Ireland. The GPS data will be processed at the UK Met Office.

From E-GVAP we are trying to help by gathering knowledge about how such agreements have been set up between other GPS and meteorological partners. The number of existing agreements

is however quite small yet, so it is also a question about discussing within the meteorological side and with the GPS side, through the liaison group people, how this can be done in a standardised way. Though it is necessary to accept that the particular agreements will differ from country to country, as in some the data will be free, in other not. Thus a set of standard Memorandums of Understanding, useful in different circumstances shall be drafted.

On Iceland VEDUR has access to GPS data from more than a dozen additional stations, it is currently being found out how the data can be extracted and transferred to UK Met Office for processing.

In the Nordic countries SMHI in Sweden has launched an initiative to make a Nordic centre for processing in near real time of ground based GPS data from the Nordic countries into ZTD. The Danish, Finish and Norwegian institutes support this approach and the centre will be set up shortly. The processing will be based on similar methods as those used at GFZ, which appears to be the method currently producing the best and most stable results. The scientific expertise will come from Chalmers Technical University and the Norwegian Mapping Agency. It could be that Iceland decides to join this processing centre, in which case the extra processing resources at the UK Met Office might be used for processing of other additional GPS data that might become available. The amount of data from Norway and Sweden is expanding. Currently Finland represents a 'white spot' on the GPS ZTD map.

In Belgium an arrangement is being made between the meteorological and geodetic side.

In France we are aware that national arrangements are being made, between Meteo France and some data owners. The extent of this is not known.

In Spain there is an effort to identify extra Spanish GPS sites, from which data can be processed. It is a problem to INM if the data coverage over southern France becomes less good when TOUGH finishes and ACRI-ST stops its processing.

3 List of E-GVAP work in past period

The main work in E-GVAP from April 1st to January 2006 has been,

- Writing of E-GVAP contract in collaboration with the EUMETNET office, distribution of contracts, billing.
- Construction of project website (egvap.dmi.dk)
- Establishing and maintaining contacts with relevant people on both meteorological and geodetic side.
- Update and running of validation software and validation site.
- Preparation and partaking in meetings.
- Deciding on work tasks for members of E-GVAP team.
- Update, expansion, and running of processing of GPS data at MetO.
- Plenary meeting.
- Selection of (some of) the persons for the expert groups.

3.1 Meetings

- EGU annual meeting, Vienna. April 24-29. Presentation of E-GVAP in invited talk in session on GPS-meteorology.
- EUREF symposium 2005, Vienna. June 1-3. EUREF is an inter European body in geodesy, responsible for maintaining the European reference frame and contributing to the global reference frame. Invited presentation on E-GVAP. Very important meeting in establishing contacts with people from the geodetic society. To underline our seriousness three people from E-GVAP partook. Central both regarding knowledge of people with access to GPS data and data processing and in selecting people for the liaison and data processing groups. We owe much thanks to Hans van der Marel, Technical University of Delft, and others, for help in connection with the meeting.
- E-GVAP work meeting. June 2. In connection with the EUREF meeting Siebren de Haan, Jonathan Jones, and Henrik Vedel had a meeting, discussing E-GVAP and deciding which actions to take up to the first plenary E-GVAP meeting, to take place Wednesday, September 28, 2005, at the UK Met Office.
- E-GVAP first plenary meeting 2005-09-28, at UK Met Office, Exeter.
- Semi-annual meeting in the TOUGH project. 2005-09-29. At UK Met Office, Exeter. Internal TOUGH meeting, open of non-TOUGH people. Involved people from many E-GVAP institutes.
- TOUGH user workshop. 2005-09-30 A workshop with the scope of presenting the results from TOUGH to potential users of GPS data in meteorology and in climate monitoring. Held in connection with E-GVAP plenary meeting and TOUGH semi-annual meeting to give all an opportunity to partake.
- 11th PB-OBS meeting, 20051114, at Meteo France, Paris.
- Final TOUGH meeting, 20060126 to 27, San Lorenzo, Spain (hosted by INM).

3.2 Milestones

10 months into the project the current situation regarding the first year milestones is:

- *Successful setup of liaison group and two experts groups and first years reports from those:* This has been delayed. As explaining above the TOUGH project is in the first year of E-GVAP producing the required material as regards recommendations for processing and use of ground based GPS data. Most of the people who should naturally belong in the

liaison group and expert teams were already meeting twice a year in TOUGH. TOUGH final report is due end of March 2006. The first member of the expert teams have been selected, the final selection will be made shortly and meetings will take place during spring 2006.

- *Successful setup of hub to receive GPS meteorological data, distribute them and archive them.* This has been achieved.
- *Start of quality measurement/report facility.* This has been achieved.
- *An agreement with EUREF about the use of EUREF GPS data.* This has not been achieved yet. The plan is to partake in the upcoming EUREF yearly symposium, June 14-17 and make a 'resolution', the EUREF type of agreement, about the use of their data.
- *Recommendations for design regional/national networks for water vapour determination.* Based on the recommendations from the final TOUGH report and further compiling by the E-GVAP expert teams this will become available late spring, early summer 2006.

4 E-GVAP work in next period

Central in the work to be carried out in the next one year period is: Recommendation reports will be made regarding processing and use of GPS data. A very central issue is helping E-GVAP partners in setting up agreements with the GPS data owners and processing centres, here the liaison group will be central. This shall lead to more formal arrangements about GPS data delivery. Quarterly reports will be made about the quality of the GPS data arriving at thorn. In connection with the work of the expert teams this shall result in updated recommendations regarding processing of GPS data. A workshop shall be held on the production and use of GPS data.