EIG EUMETNET GNSS Water Vapour Programme

E-GVAP

Status of E-GVAP

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What is E-GVAP?

- EIG EUMETNET GNSS Water Vapour Programme.
- EUMETNET = organisation of European national meteorological offices (West European + number of East European, enlarging).
- E-GVAP is a separate observing programme under EUMETNET. Not all EUMETNET members are members of E-GVAP (currently 15). It is those members that finance E-GVAP.

Purpose of E-GVAP

- To provide quality checked, ground based GNSS delay and integrated water vapour data (ZTDs and IWVs) in near real-time (NRT) for use in operational numerical weather prediction (NWP) models and in now-casting to the participating EUMETNET members.

- To improve on the NRT GNSS ZTD data quality and enlarge data coverage

- To assist users in utilising the data for weather forecasting.

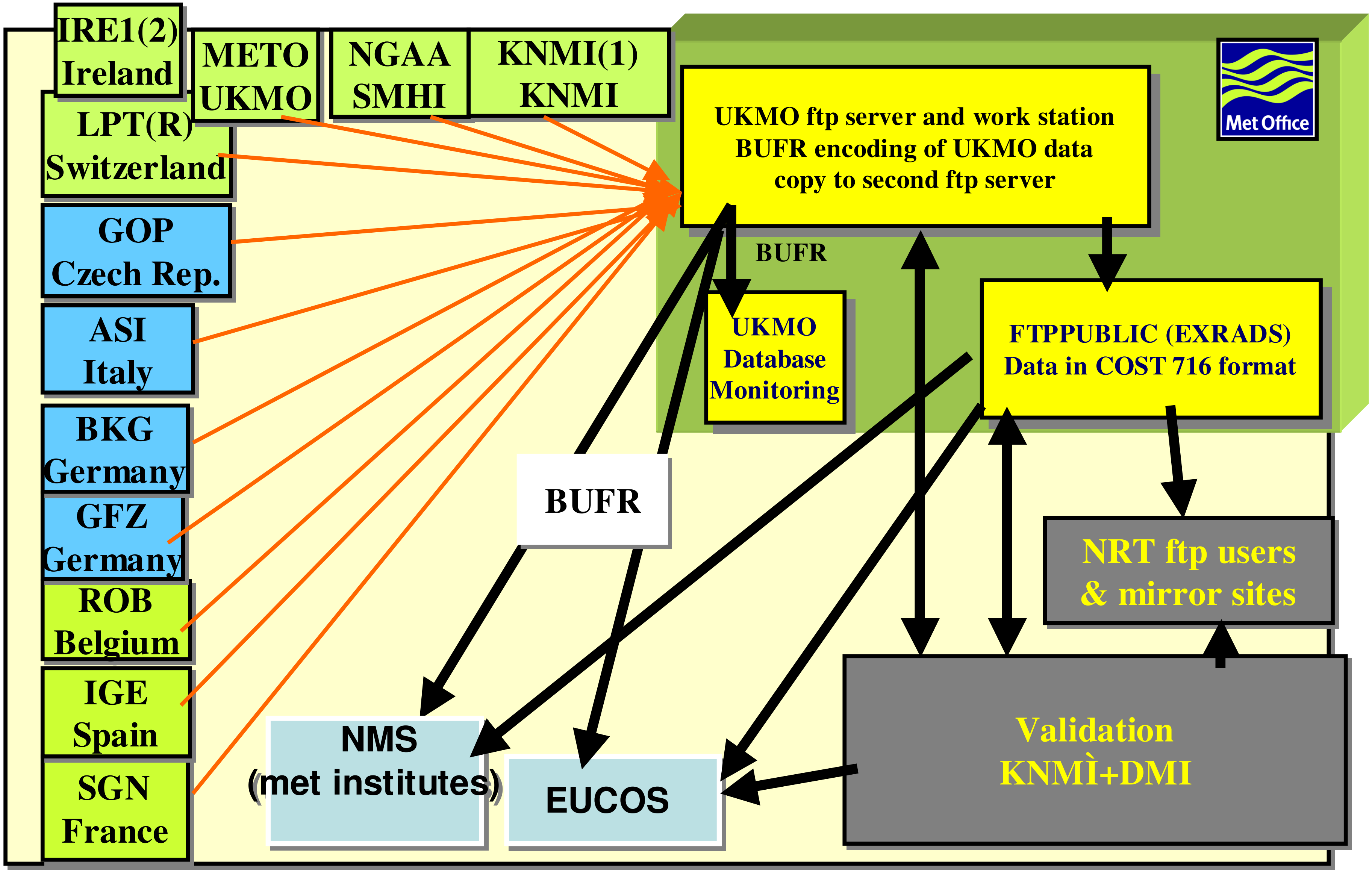
Method

Collaboration with geodesy.

Through EUREF (MoU between EUREF and EUMETNET) and on national level. Examples:

- Exchange of data.
- Exchange of knowhow
- Collaboration in national and international cross dicipline projects. From joint article level to common EU research projects.
- Sharing of facilities.

NRT GNSS ZTD data flow



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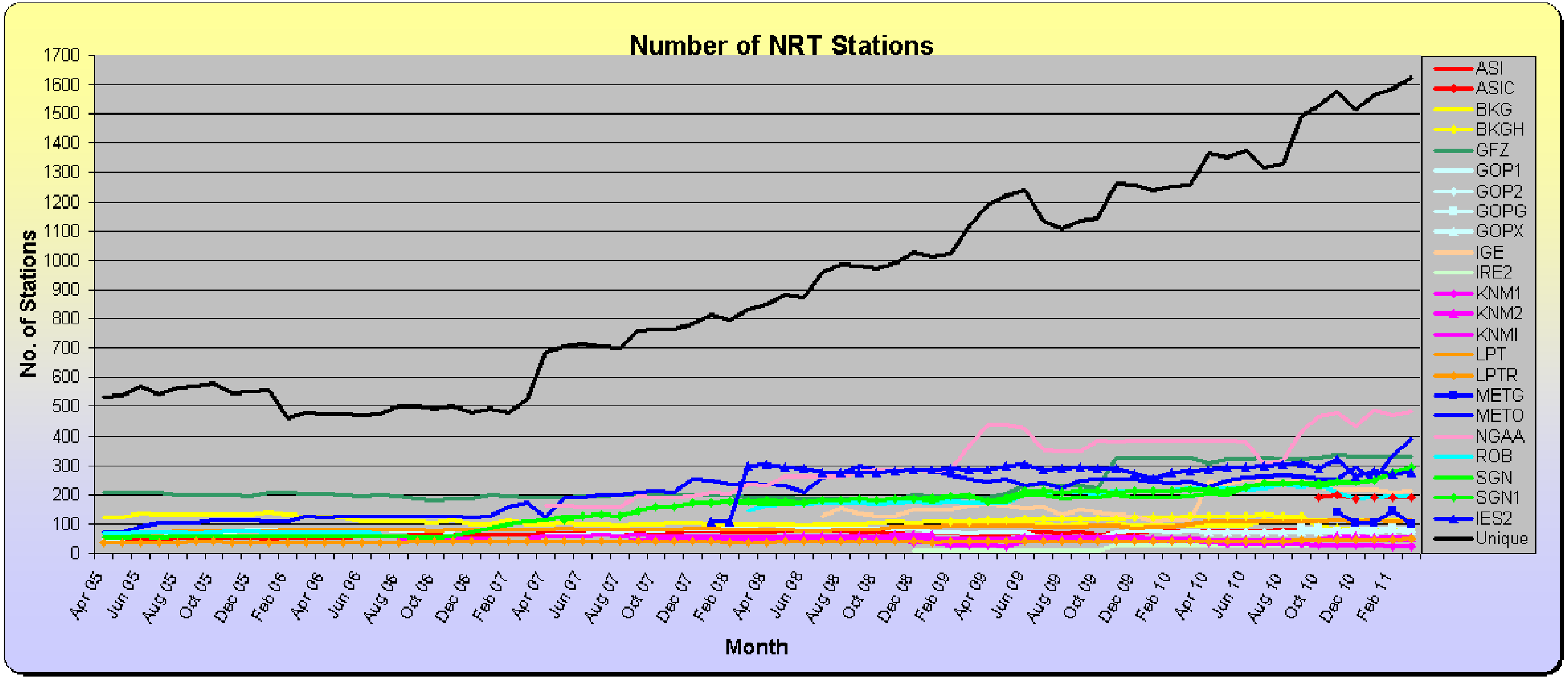

Number of GNSS sites versus time.
About 1550 unique GNSS sites by end of 2010.
Compare to about 1250 unique GNSS sites end of 2009 and about 1000 end of 2008.

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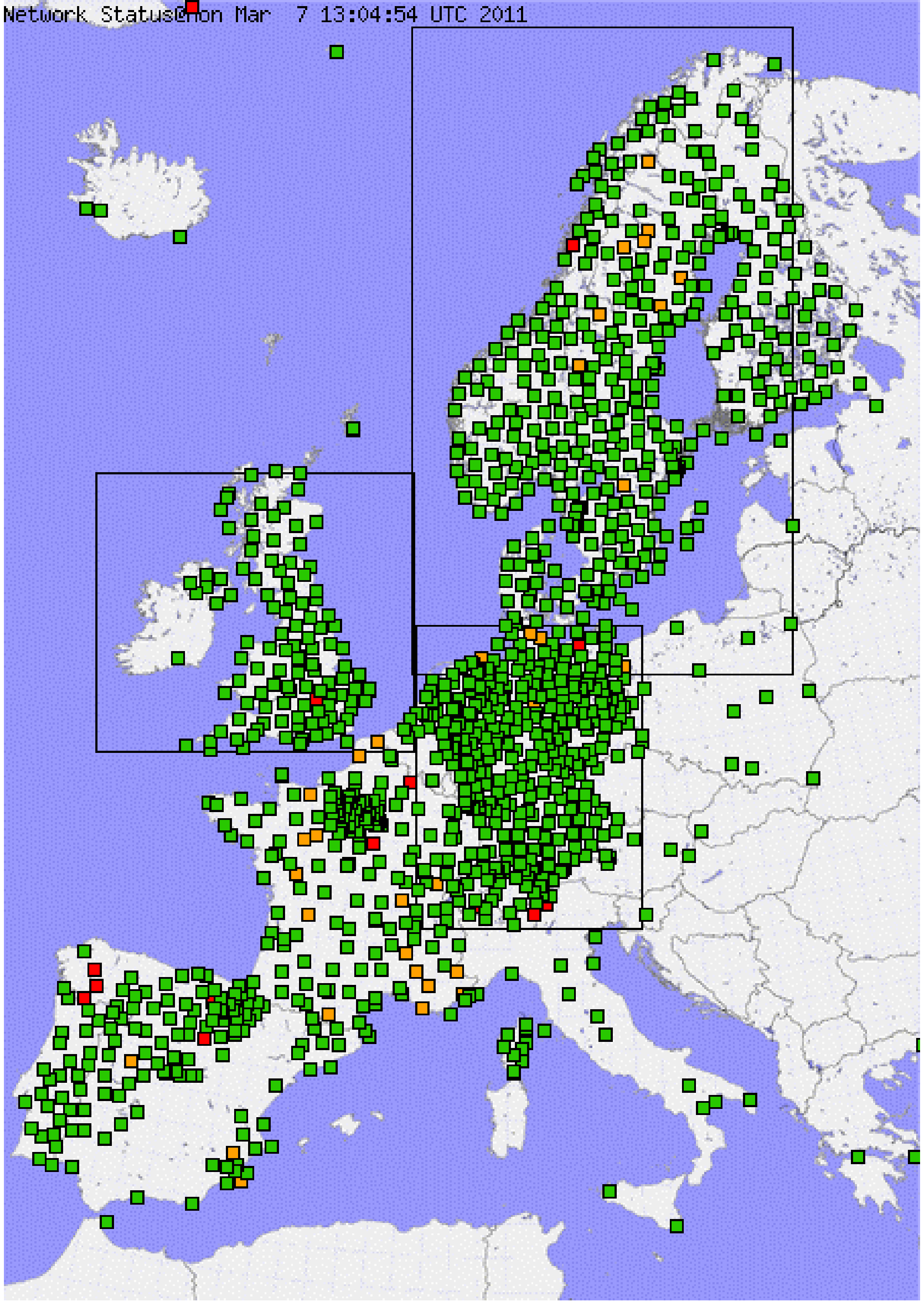
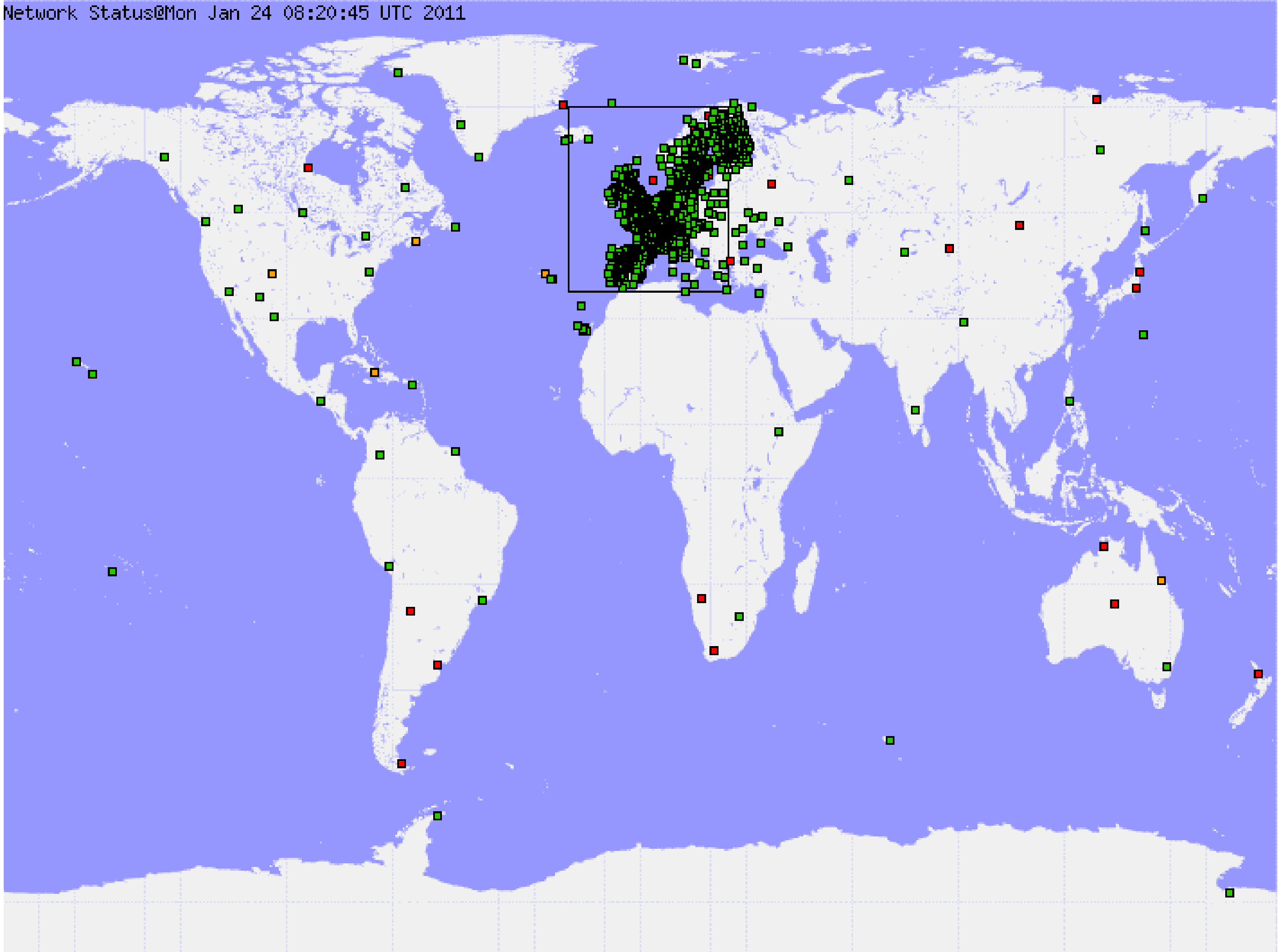
Data coverage

A new processing centre will start at met.no. Expected to improve access to Norwegian data, in particular from the oil ricks in the North Sea, which is an important area for forecasting in Netherlands, Germany and Scandinavia.





DATA COVERAGE

Some of the E-GVAP members do global forecasts. They wish to assimilate global GNSS delay data. The E-GVAP ACs GOP and METO has started to process global data.

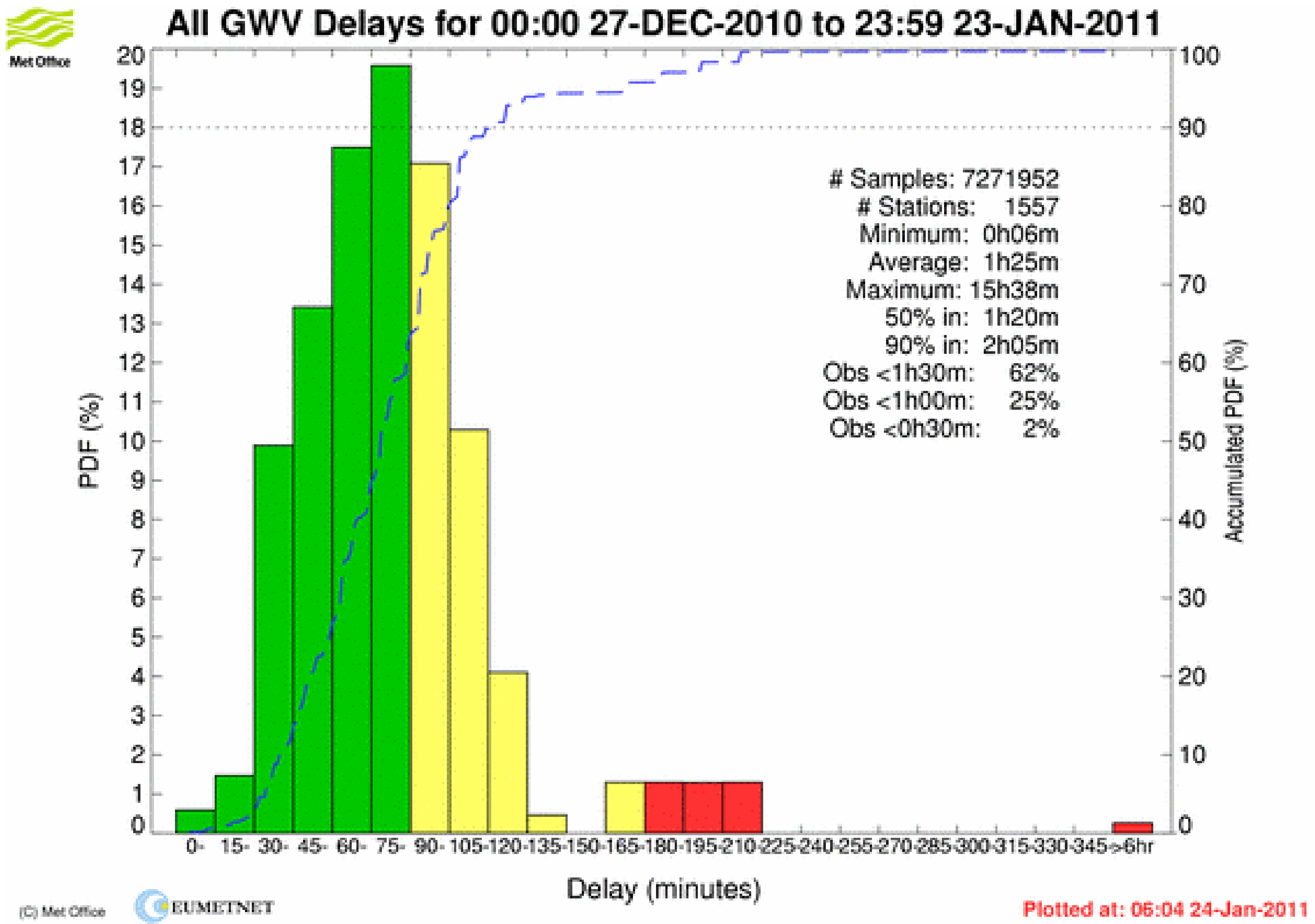
In addition we negotiate access to North American ZTD data, hoping to get those in 2011. Making MoU with NOAA about collaboration.

DATA COVERAGE

- From E-GVAP we are highly interested in NRT GNSS from even more sites in Europe. As raw data for conversion to ZTDs at existing ACs, or as ZTDs.

- The holds for all countries, but in particular Eastern and South Eastern Europe is under-represented in the E-GVAP coverage. (The metoffices of Croatia, Hungary and Serbia are members of E-GVAP.)

Timeliness



Histogram shows age of observations when arriving in UKMO database, counted in 15 min bins.

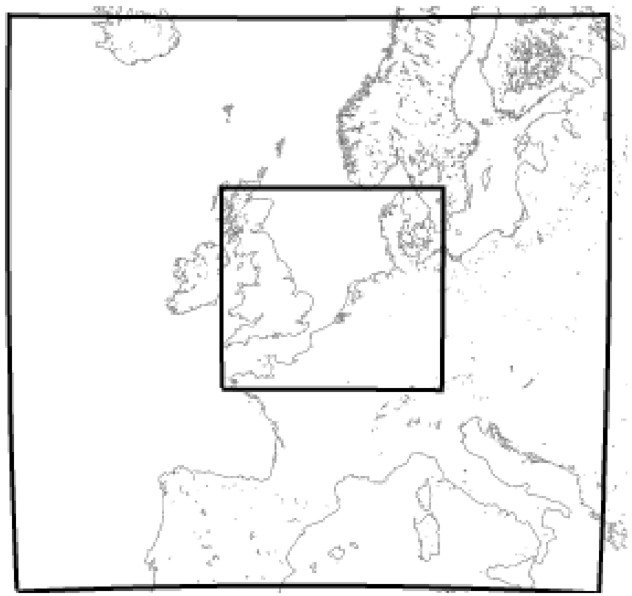
Currently data oploads are hourly, which automatically leads to ”aging” of part of the uploaded observations.

Timeliness and NWP developments

- **Timeliness is important issue to weather forecasting, where everything runs on a fixed schedule.**
- **There is a movement toward NWP models with higher resolution and more frequent runs of the models, so-called rapid-update cycling. This is expected to improve short term forecasting.**
- **To provide stating conditions for these models, observations with a high resolution in space and time are of particular interest.**
- **Ground-based GNSS delays and weather radar data are among the most promissing observations in this regard, likewise additional data from aircraft (ModeS)**
- **It will result in a wish for faster access to data = sub hourly data processing (real-time not necessary, but fine, as long as ZTD will still reflect atmospheric changes on hourly to subhourly scale.)**
- **It will increase the interest for research on using ”next generation” GNSS meteorological observations (ZTD gradients, slant delay/residuals, 3D water vapour fields from tomography) in NWP models.**

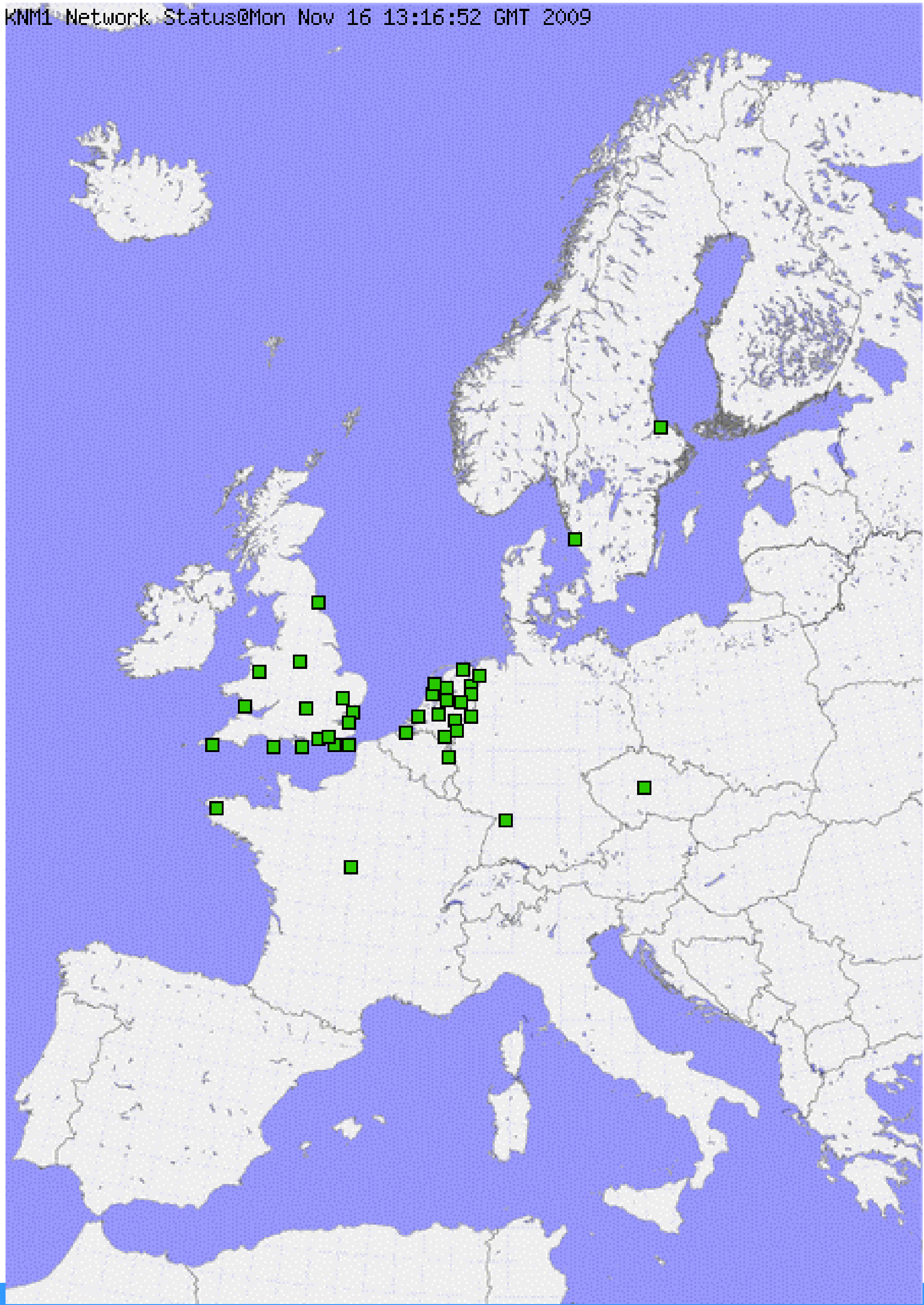
Case study: Assimilation of ModeS and GPS ZTD

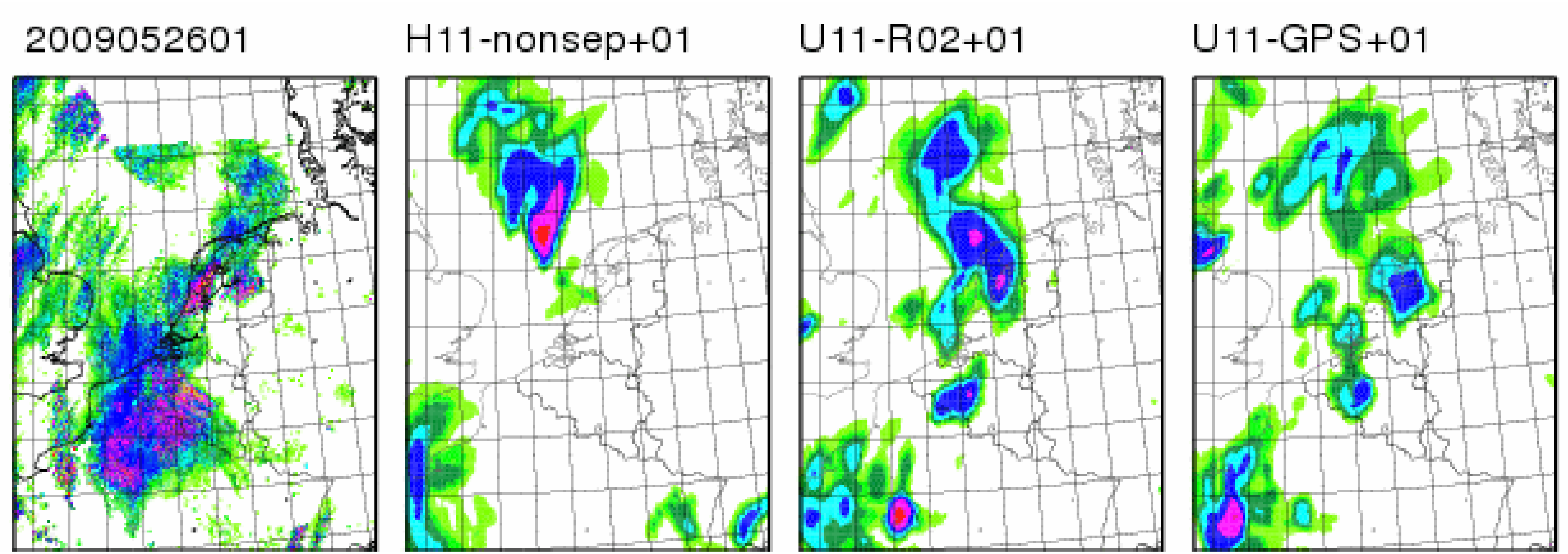
- Hourly assimilation
  - Wind/Temp from ModeS observations from aircraft (obtained via air traffic control radar).
  - GPS ZTD from KNMI
- Grid resolution 11 km
- 6 hours forecast



Near real-time ZTD

- Every 15 minutes
  - NL : Kadaster
  - GB : Ordnance Survey
- Available within 5 min.





radar ReRUN H11 U11+ModeS U11++GPS

Analysis time 2009/05/26 00UTC

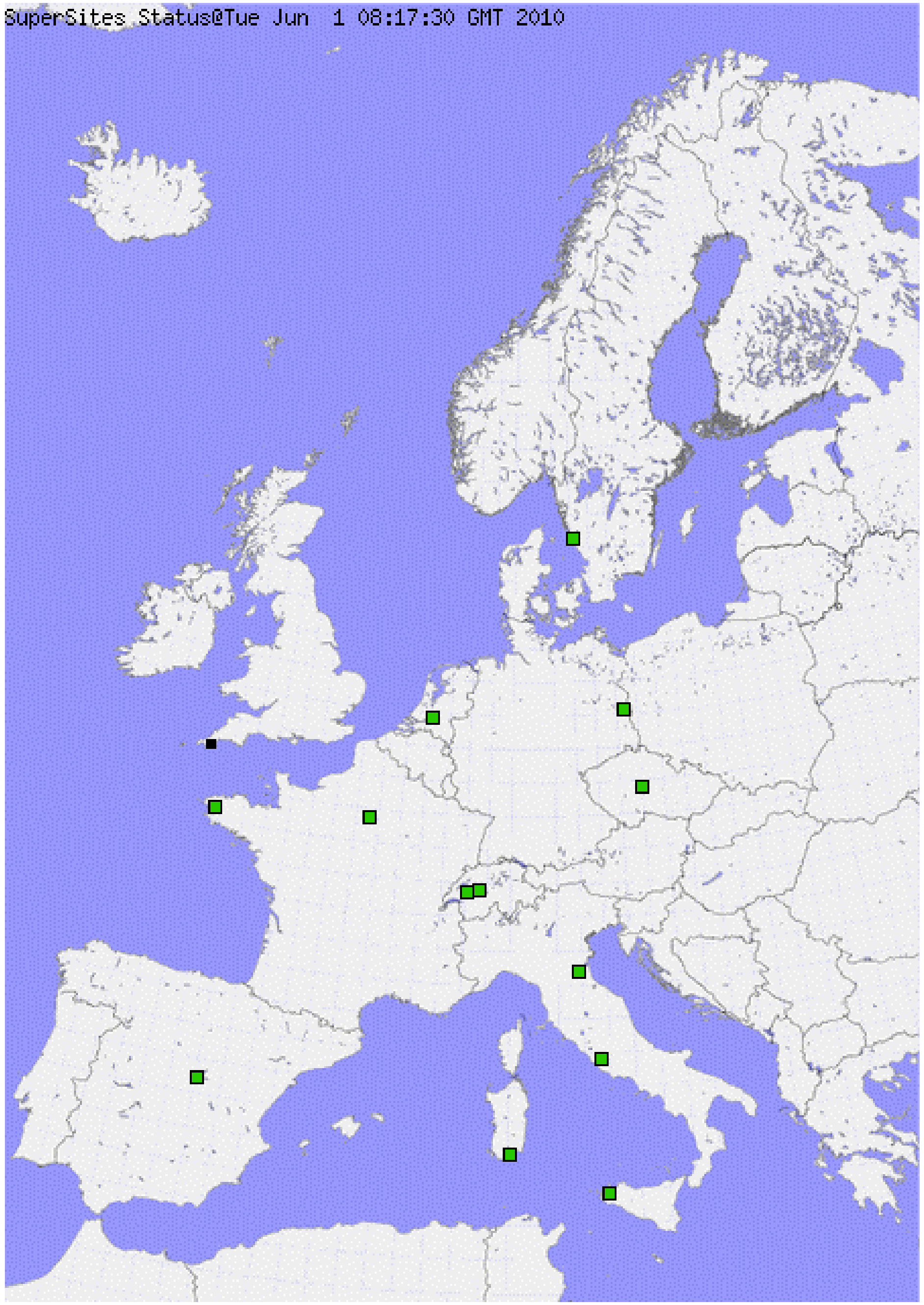
- **U11+ModeS** en **U11+ModeS+GPS** heavy convection above Belgium
- Convection North-France less extreme **U11+ModeS+GPS**

The supersites

To be processed by all ACs.

At the supersites auxiliary measurements are available, e.g. from radiosonde or WVR. This is useful in validation studies, for both meteorology and geodesy.

In addition to the above, a lot of meteorological measurements of surface pressure, temperature and humidity, as well as radiosonde data from other sites are made available via E-GVAP and the EUREF EUMETNET MoU for use by geodesist in their scientific work.



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Bias of supersite ZTDs relative to KNMI HIRLAM

Bias

AC	BRST	CABW	CAMB	CARD	CAGL	GOPE	LDB2	MOSE	MEDI	PAYE	SMNE	YEBE	ZIMM
ASI_	-3.86				1.17	3.59	18.26	24.82	-9.38		-2.20	2.92	-2.41
BKG_					0.53	10.43	16.60		-12.17			1.79	-2.83
GFZ_	6.20				-9.59	21.07	25.57		-2.37		9.60	11.58	5.16
IGE_	-4.49				-0.24	11.51	17.67				-2.25	3.25	-2.16
KNM1	-5.41					12.13							
KNMI	-3.11	0.02			-0.17		20.63	25.01	-7.93		-1.63	3.13	-4.46
LPT_	-2.65	4.50			-0.22	11.52	20.56	24.81	-10.08	-0.83	-0.94	3.63	-1.51
LPTR										-5.62			
METO	-6.75				-18.08		17.31	24.67	-11.24		-4.40	-6.39	-2.85
NGAA	9.07				8.43	20.75	25.33	32.58	-1.52			15.06	4.85
ROB_	-3.51	2.84			-1.70	12.41	20.24	23.49	-10.65		-1.53	2.33	-3.48
SGN_	-6.71				-4.09	7.97	15.24	20.81	-14.86	-2.85	-5.17	-1.26	-4.15
SGN1	-8.72				-5.25	6.89	14.53	19.55	-15.59	-3.63	-6.50	-2.61	-4.73

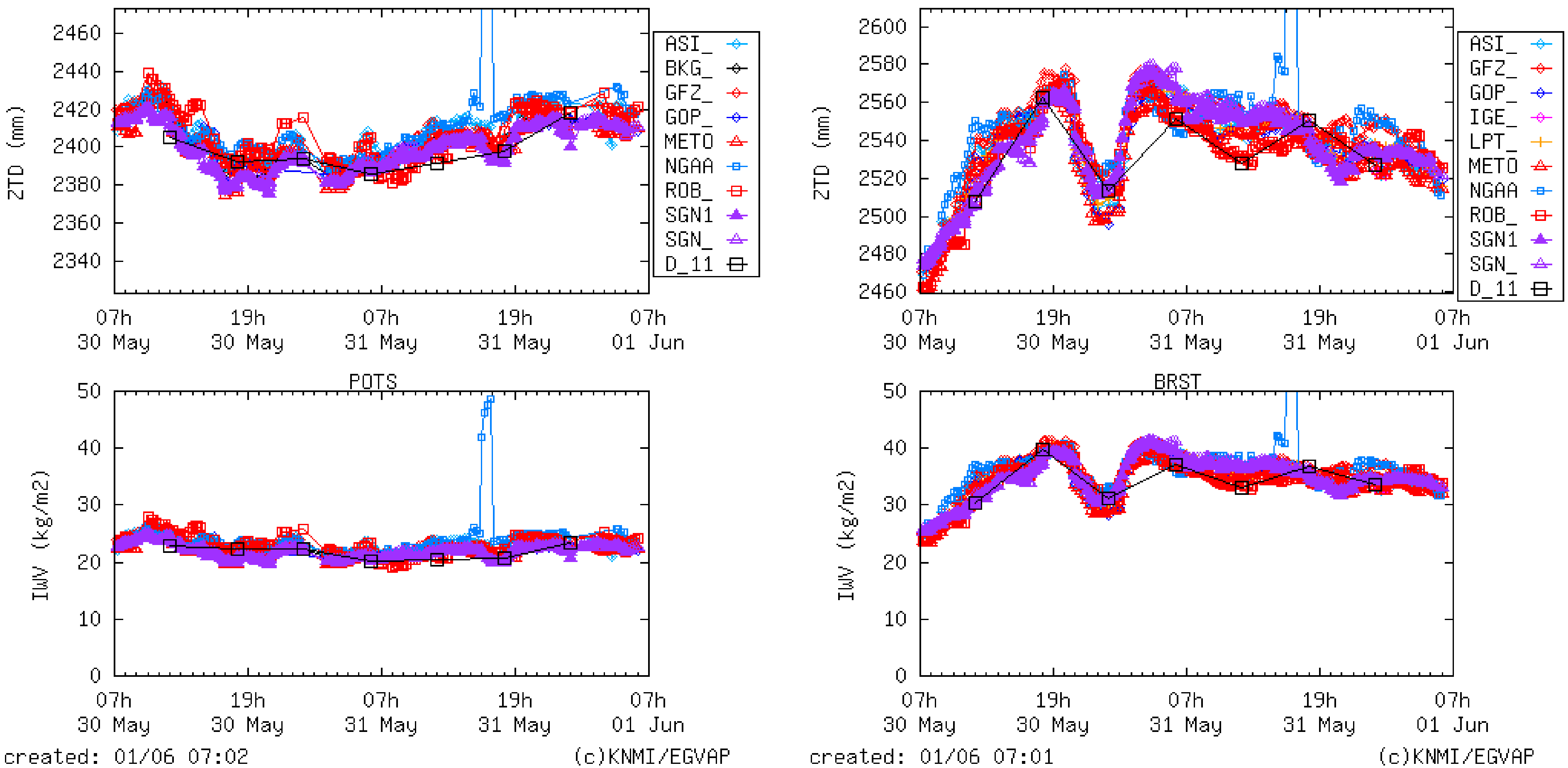
Standard deviation of supersite ZTDs against KNMI HIRLAM

Standard Deviation

AC	BRST	CABW	CAMB	CARD	CAGL	GOPE	LDB2	MOSE	MEDI	PAYE	SMNE	YEBE	ZIMM
ASI_	6.28				5.47	12.52	5.29	5.49	4.96		6.12	5.37	6.70
BKG_					4.60	4.02	6.49		4.94			7.43	6.06
GFZ_	5.81				4.76	3.91	5.51		4.74		5.84	7.22	6.08
IGE_	5.27				4.69	4.67	5.99				6.21	3.96	5.39
KNM1	8.96					9.09							
KNMI	6.54	4.82			6.08		6.77	5.84	5.31		6.59	6.14	6.33
LPT_	5.53	4.88			4.67	4.02	5.49	4.89	4.48	4.56	4.55	5.27	5.67
LPTR										5.29			
METO	4.02				29.28		4.88	6.70	4.74		6.23	9.47	6.85
NGAA	12.83				5.55	5.02	5.32	6.11	6.00			8.45	7.51
ROB_	5.89	5.43			6.07	5.11	7.25	6.35	4.75		6.76	5.41	5.18
SGN_	5.11				4.12	3.55	5.34	5.58	5.03	4.67	6.21	4.91	5.88
SGN1	4.51				3.92	3.33	5.63	5.32	5.06	4.39	5.96	5.89	5.92

Examples of NRT processing problems

Intermittent problem with NGAA solution (based on ppp processing).



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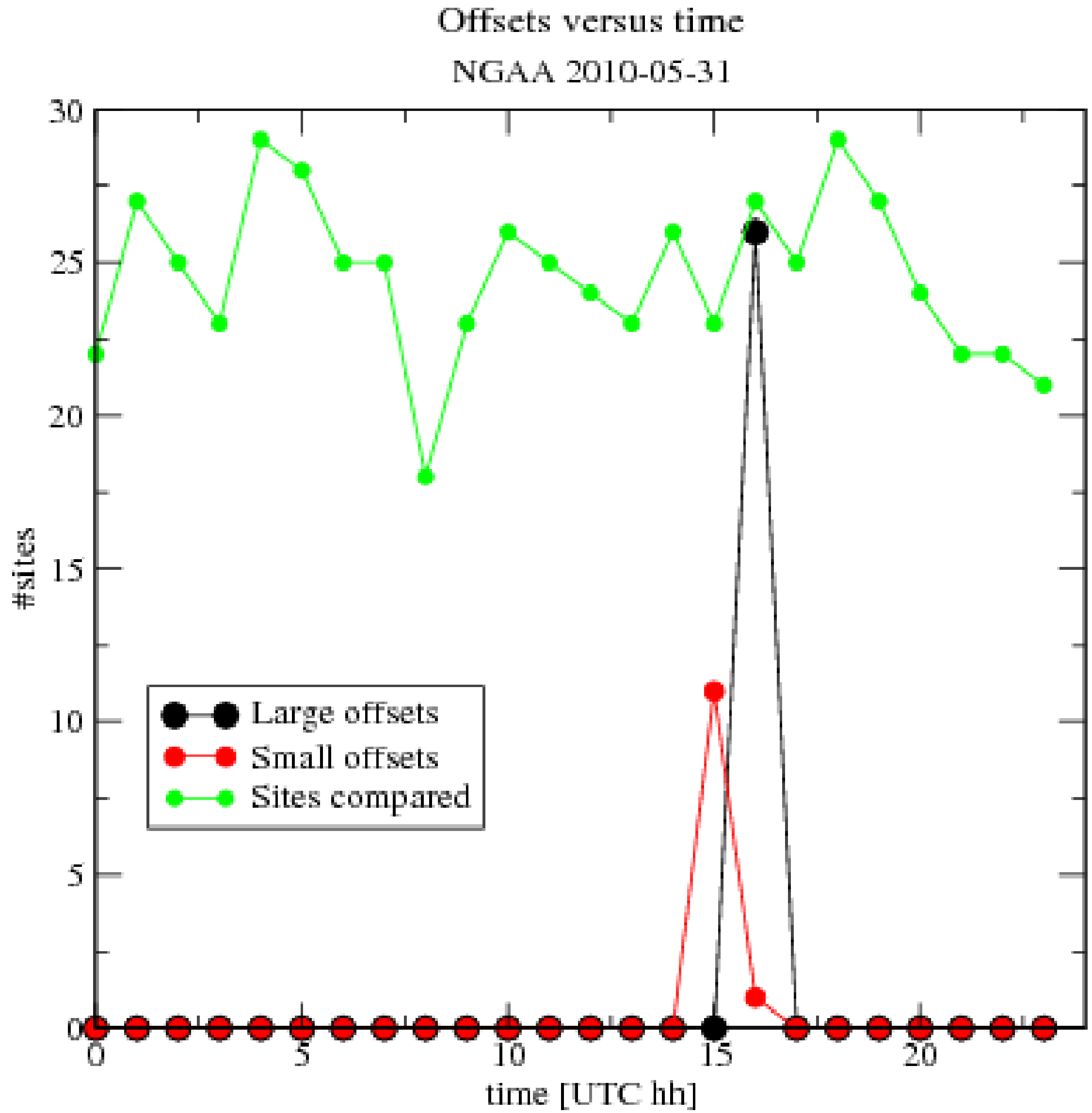
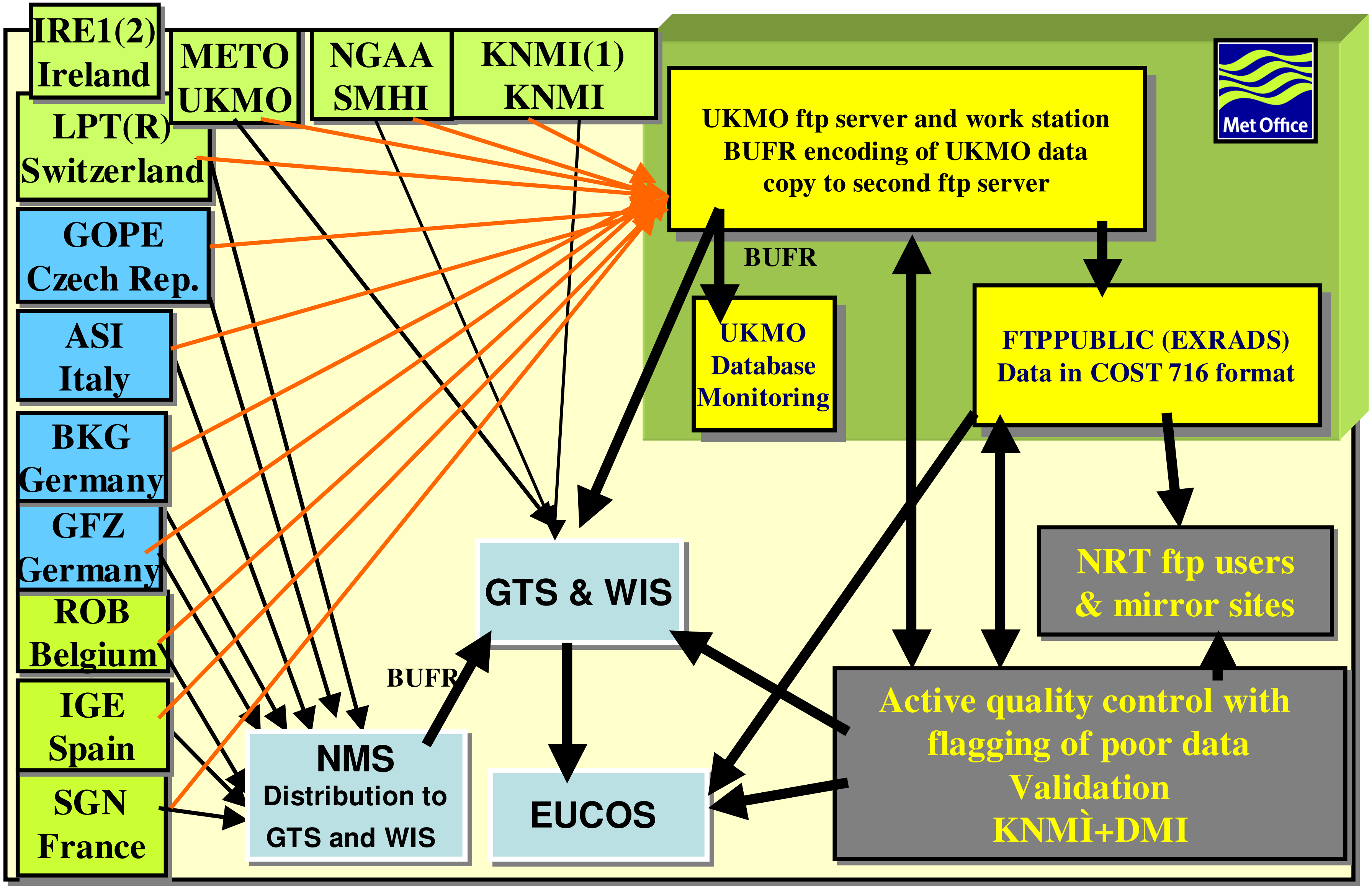
AQC, active quality control

- While the vast majority of the NRT ZTDs are of high quality, there is from time to time a few which contain significant errors.
- Due to the intrinsics of the GNSS system and processing these errors are in many cases strongly correlated.
- Correlated errors in observations are dangerous to numerical weather prediction models.
- Because NWP models are not very good at humidity, it is not robust to rely only on NWP identification of multi GNSS site errors from an AC
- To identify such events, on the fly, E-GVAP is setting up AQC, in which NRT ZTD data from super-sites, and other GNSS sites processed by many ACs, are inter compared.
- If ZTDs from one AC deviates simultaneously at many sites, it is a strong warning signal, and the ACs data of the time will be flagged accordingly



Catching the **transient** error at NGAA on day 2010-05-31.
Based on this data in the NGAA files stamped 2010053115 and 2010053116 should not be used in assimilation, but there is no reason to disregard NGAA data from other timebins.

NRT GNSS ZTD data flow Future



ACs which are not at an NMS, will have to transmit BUFR via NMS to GTS and WIS

Use of NRT GNSS data in European meteorology

- Two institutes, Météo France and UK Metoffice, use NRT ZTDs in their numerical weather predictions operations today. Each of them uses the data in three different models (global, regional, local).
- Many institutes are testing usage, a number of them plan to start operational usage this year, including DMI and KNMI.
- When AQC becomes operational, in a month or so, it is expected to lead to use of more of the NRT GNSS data.

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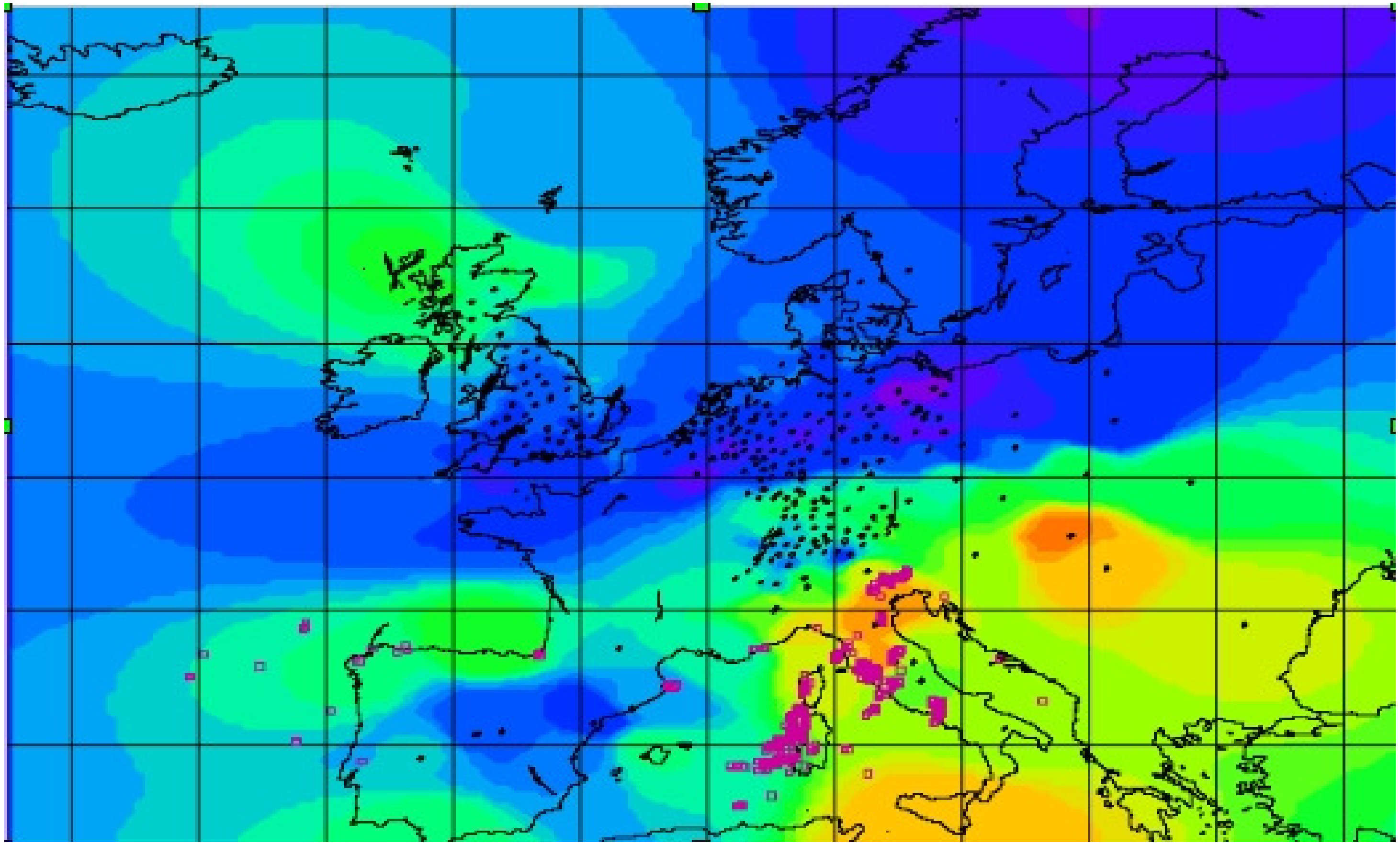
IWV maps

Based on the ZTDs and additional pressure and temperature information maps of integrated water vapour (IWV) are made.

Such maps are useful in meteorological now-casting, where they can help foresee rain events.



Purple marks on map are lightning observations

Conclusion

- **From E-GVAP we are thankful for the good coorporation with European geodetical institutions. This includes both ACs (analysis centres), the owners of the GNSS sites providing the raw data for processing, and EUREF.**
- **Today the NRT GNSS ZTDs are in practice used to improve European weather forecasts.**
- **ZTDs from additional sites and faster access will increase benefit.**
- **Through E-GVAP, meteorological data are made available for geodetic institutions.**
- **Results from E-GVAP AQC can be made available when it has become operational.**
- **The possibility of site sharing is now being used in practice.**

- **There is in EUMETNET an increasing interest for exploiting GNSS ZTD gradients, slants delays, and 3D water vapour fields from tomography.**

A new EU Cost Action on ground-based GNSS meteorology?

1) transfer of knowledge West-East, extending the legacy of COST 716 to East (E) and Southeast (SE) Europe; aiming at filling the gap of the GNSS stations contributing to EGVAP
2) application of GNSS data for Numerical Weather Prediction (NWP) in E and SE Europe; aiming at model validation and assimilation
3) demonstration of GNSS potential in now-casting; aiming at case studies for extreme events like floods etc..
4) exploiting the potential of reprocessed GNSS (15+ years) in long term monitoring
5) responding to the strong interest in the community for application of GNSS for climate research; aiming at data consistency/errors in the reprocessed data
6) GNSS gradients; aiming at validating GNSS gradients with independent IWV/ZTD measurements
7) GNSS tomography; aiming at demonstration of concept of slant path delays application in operational NWP as well as dedicated tomography campaign

Interested? Contact

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