EIG EUMETNET GNSS Water Vapour Programme

E-GVAP

About E-GVAP and the collaboration between geodesy and meteorology

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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

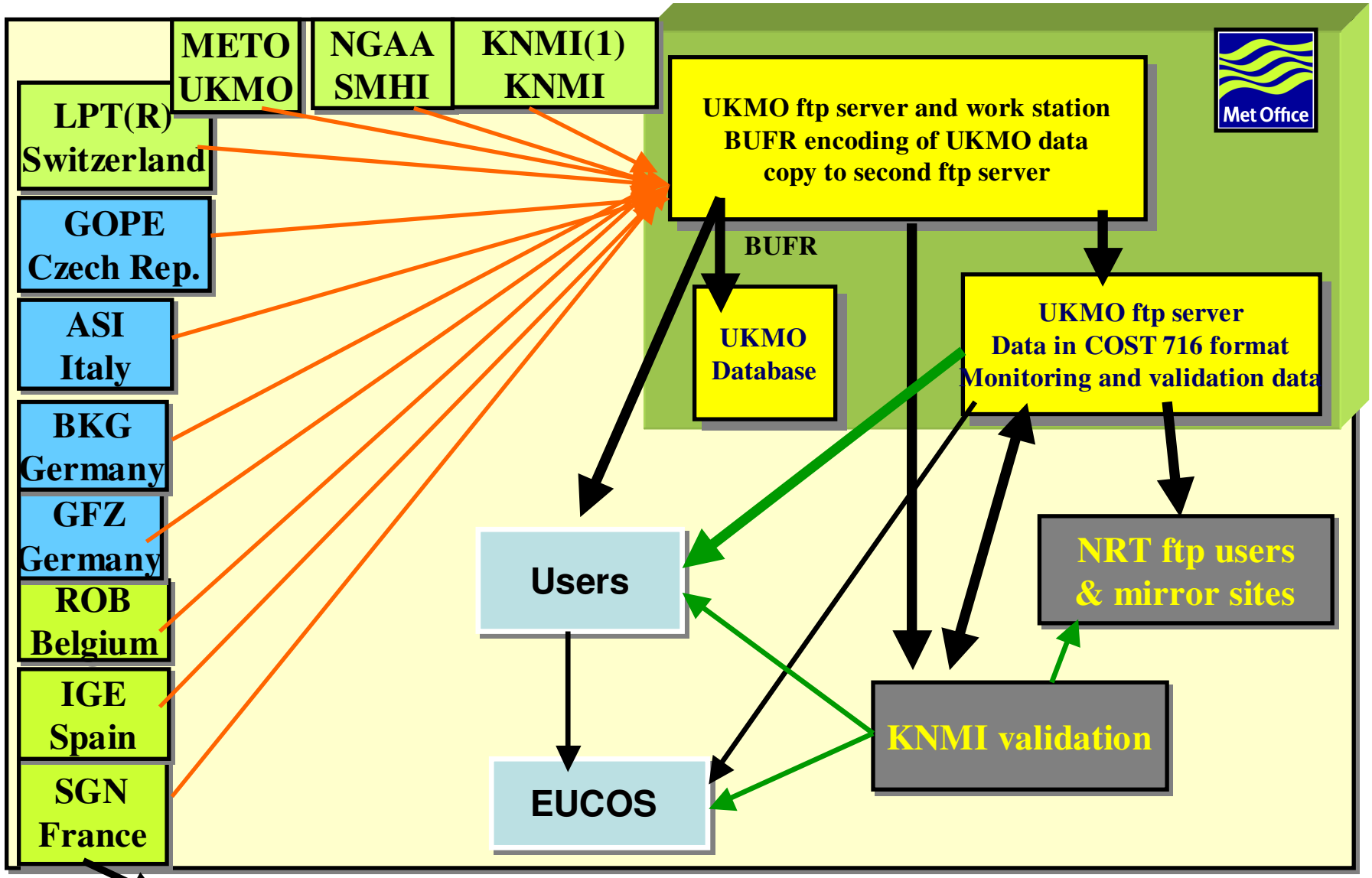
- To provide quality checked, ground based GNSS delay and integrated water vapour data (ZTDs and IWVs) in near real-time (NRT) for use in operational numerical weather prediction (NWP) models and in now-casting to the participating EUMETNET members.
- To improve on the NRT GNSS ZTD data quality and enlarge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

Method

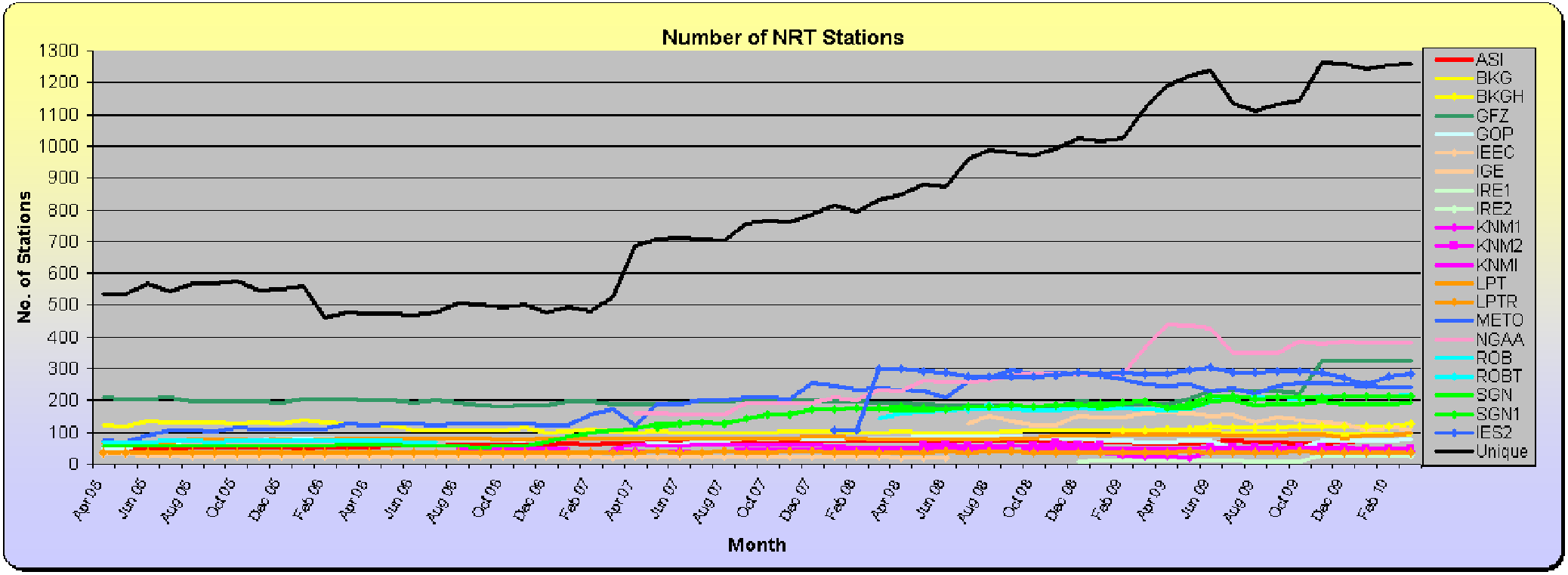
Collaboration with geodesy. Through EUREF and on national level. Examples:

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

NRT GNSS ZTD data flow Today



Analysis centres (ACs), each processing raw GNSS data from many sites.
In many cases only national AC can get access to the raw data.

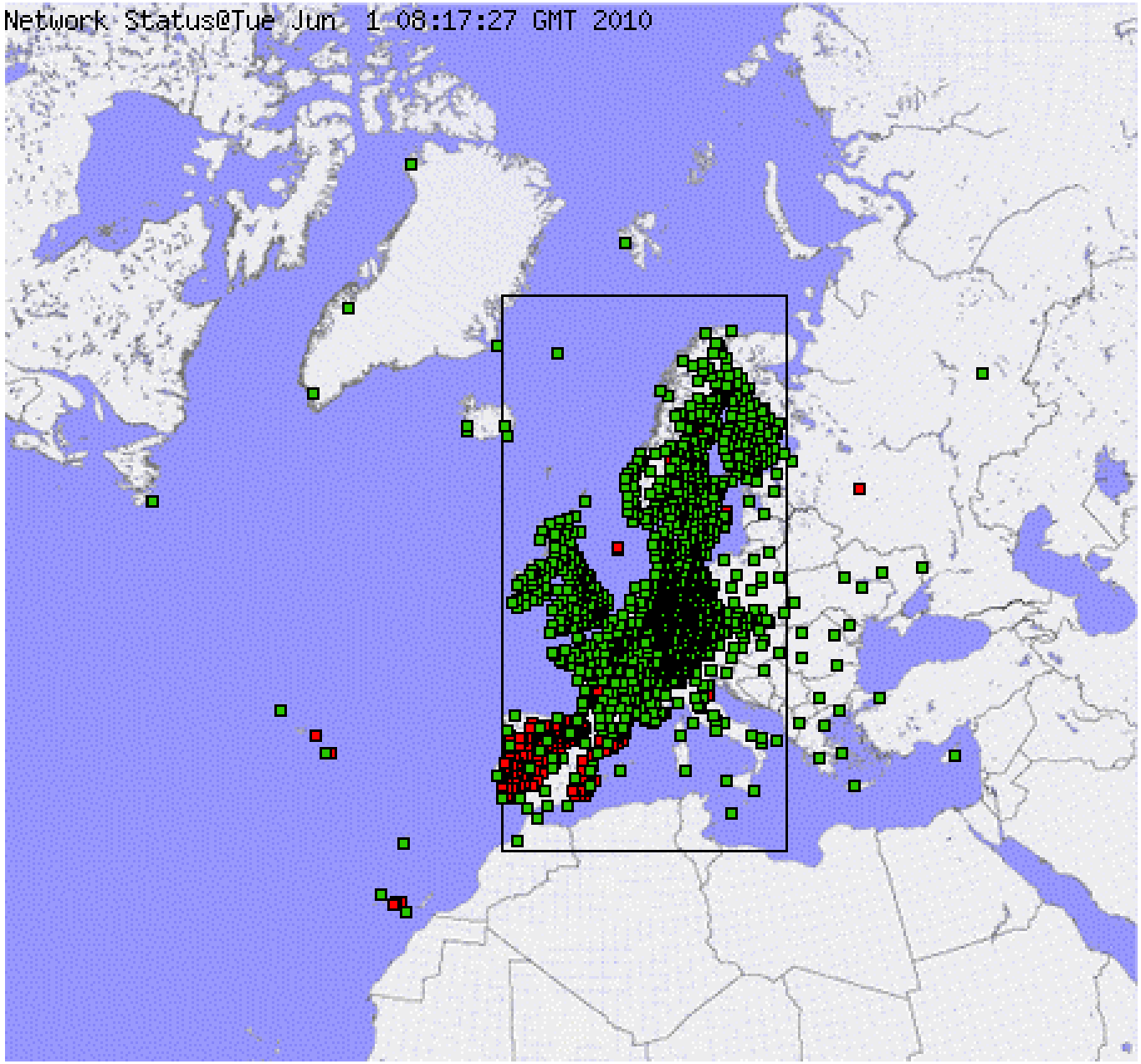


Number of GNSS sites versus time.
About 1250 unique GNSS sites end of 2009.
Increase from about 1000 during 2009.

DATA COVERAGE

Negotiating access to global NRT ZTD data, on request of members.

Expect access to North American data during this year.



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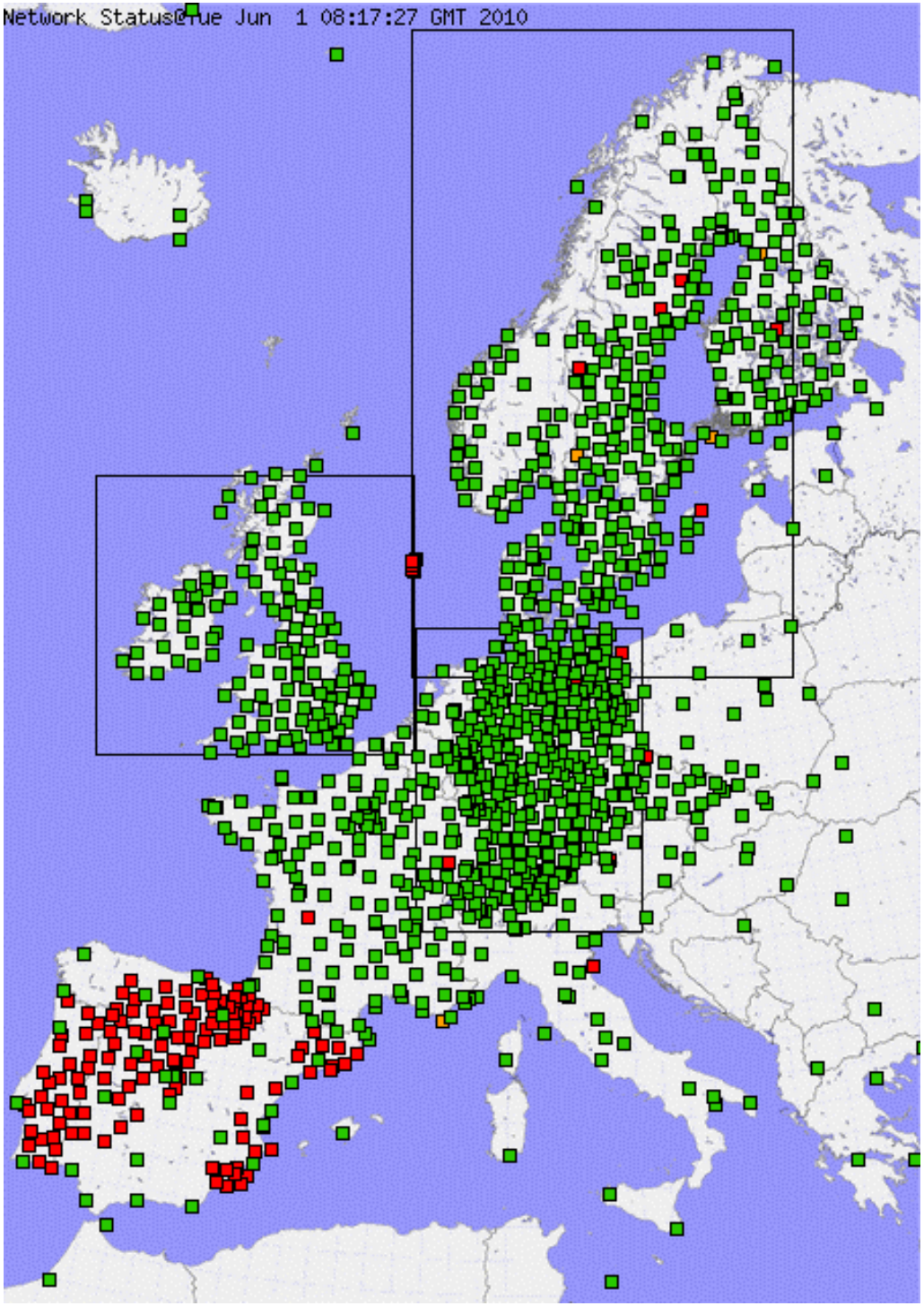
DATA COVERAGE, Europe

Colour according to latency.

Validation statistics and graphs are created automatically and shown via click at each square representing a GNSS site.

Available via homepage, egvap.dmi.dk item validation

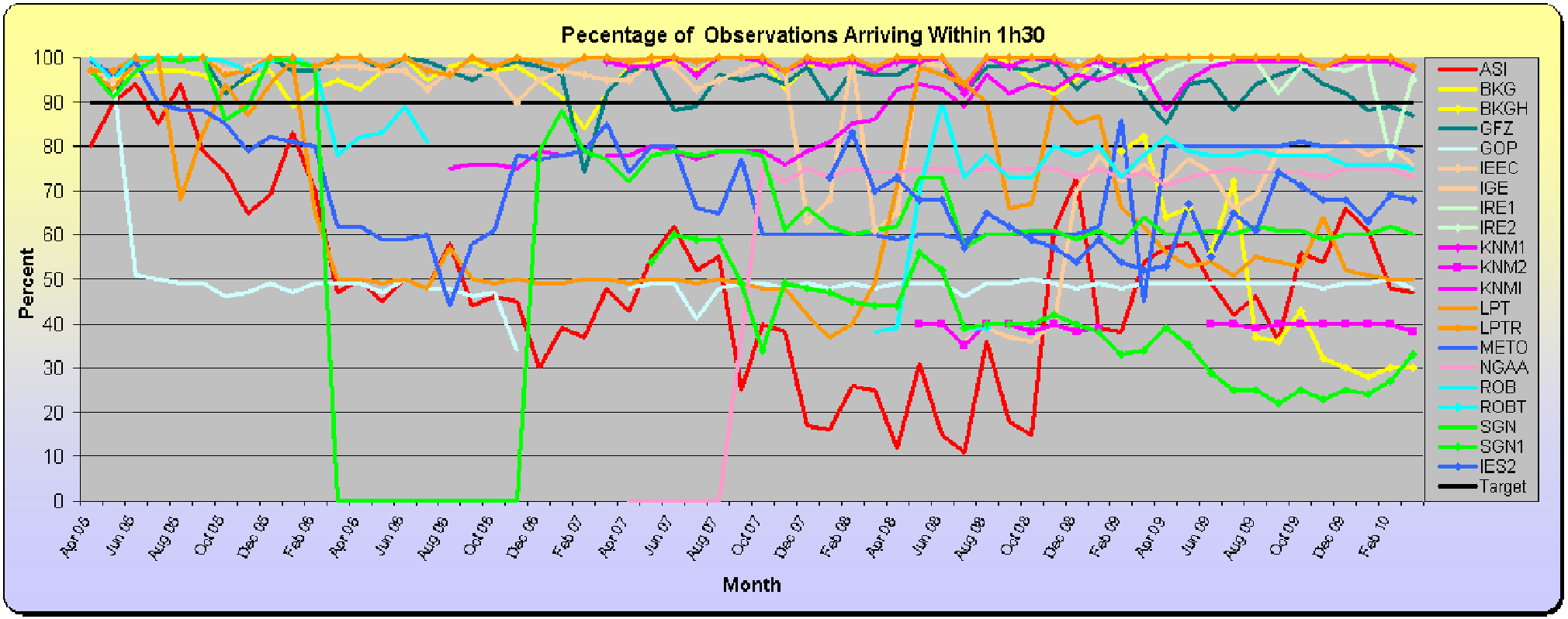


DATA COVERAGE

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

- The holds for all countries, but in particular Eastern Europe is under-represented in the E-GVAP coverage.

- The metoffices of Croatia, Hungary and Serbia have now become members of E-GVAP.

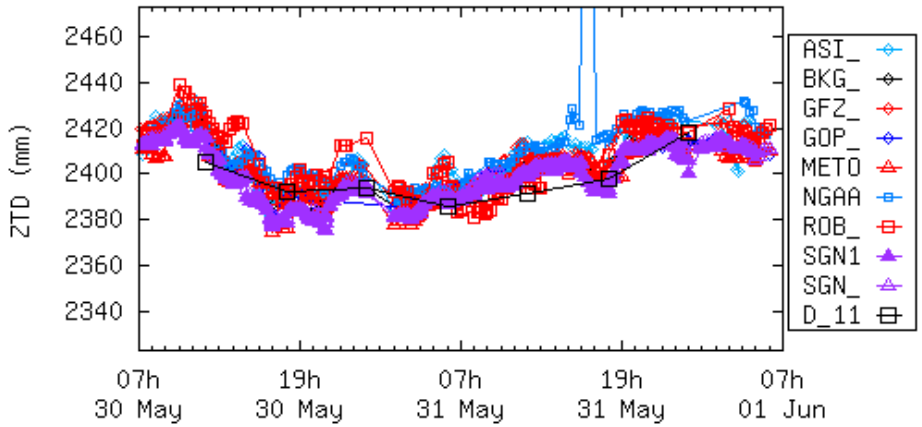


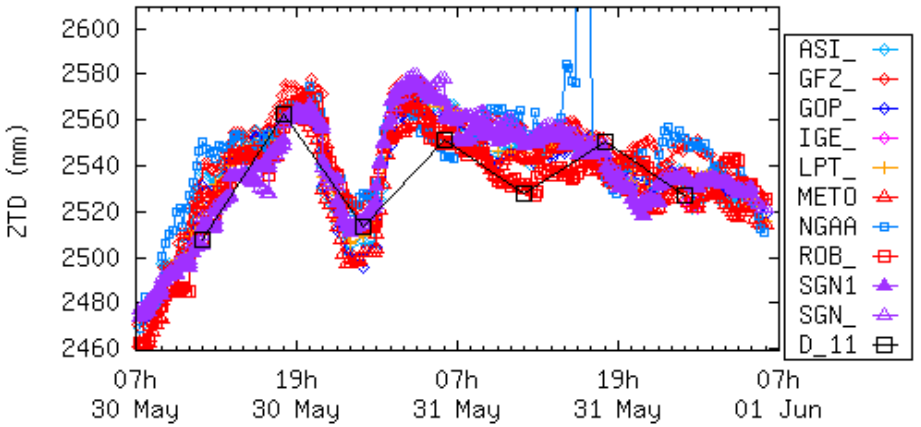
Timeliness. Percentage of NRT ZTD data arriving within 90 minutes of their valid time.

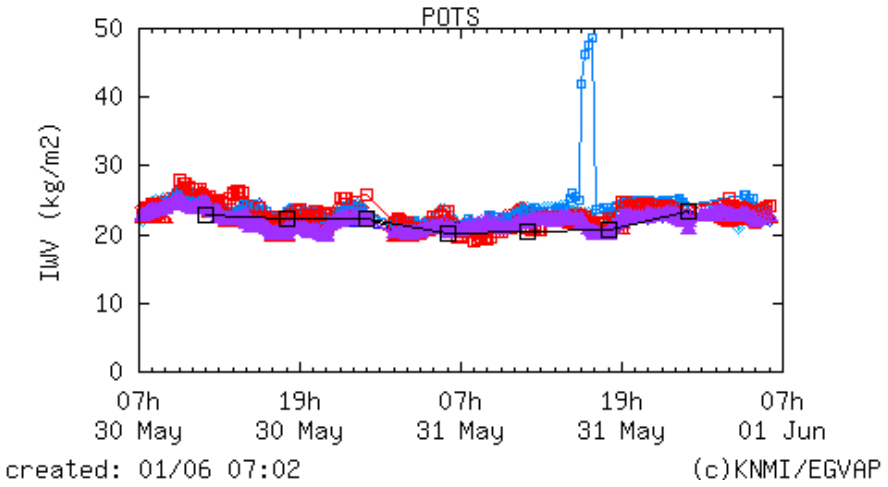
The NRT aspect of E-GVAP has implications for the quality of the processing. Most of the time it is good, but now and then there are intermittent problems.

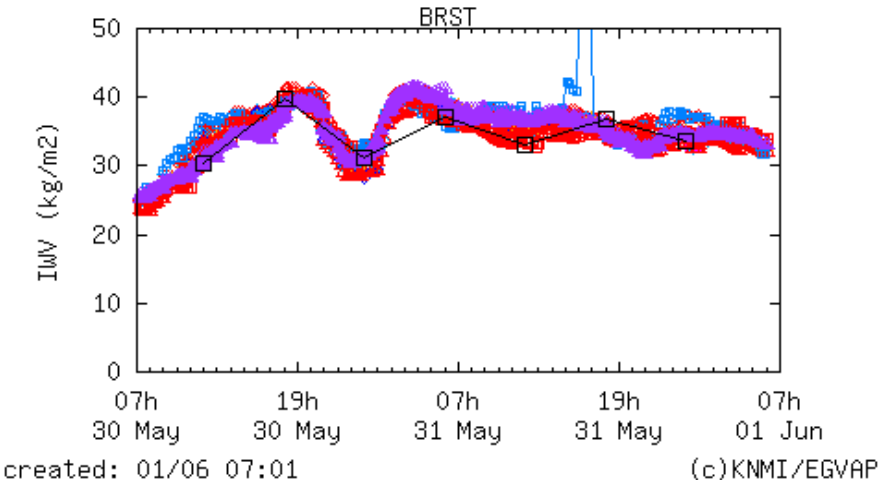
Examples of NRT processing problems

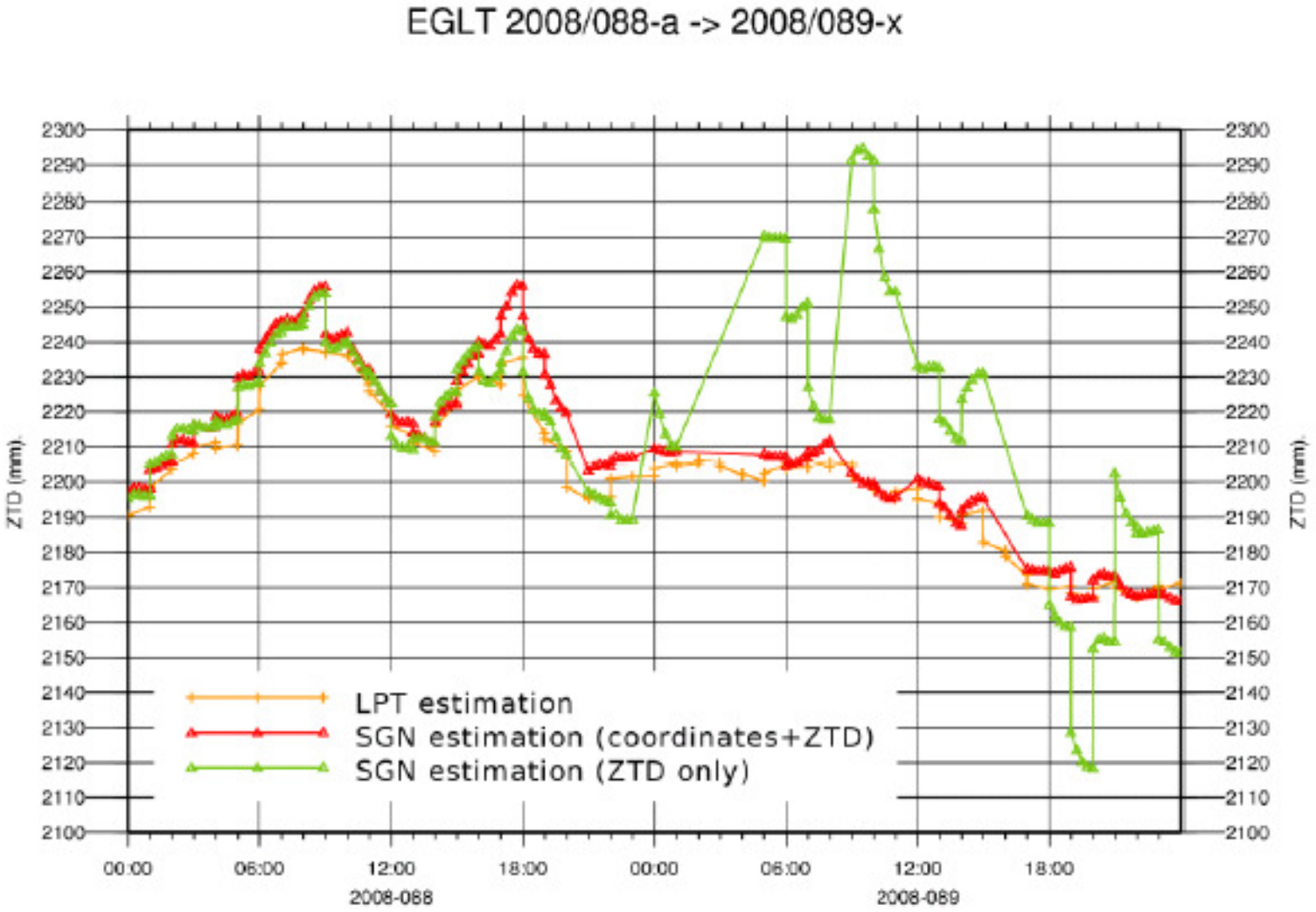
Intermittent problem with NGAA solution (based on ppp processing).











Problem in SGN/IGN network solution due the movement of a site by a site owner, without the SGN analysis centre knowning in proper advance.

AQC, active quality control

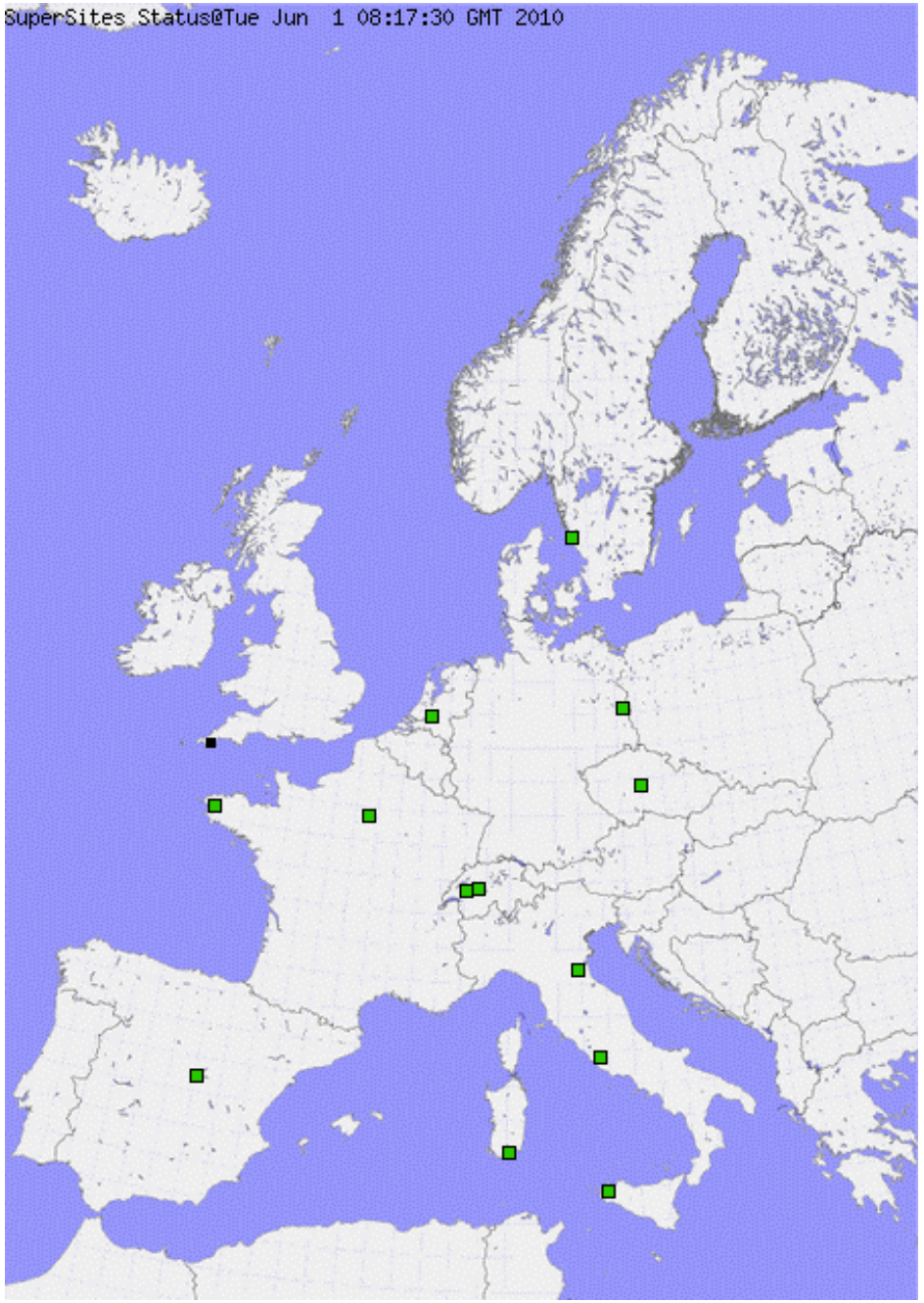
- While the vast majority of the NRT ZTDs are of high quality, there is from time to time a few which contain significant errors.
- Due to the intrinsics of the GNSS system and processing these errors are in many cases strongly correlated.
- Correlated errors in observations are poisonous to numerical 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

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.



Bias of supersite ZTDs relative to KNMI HIRLAM (over few days)

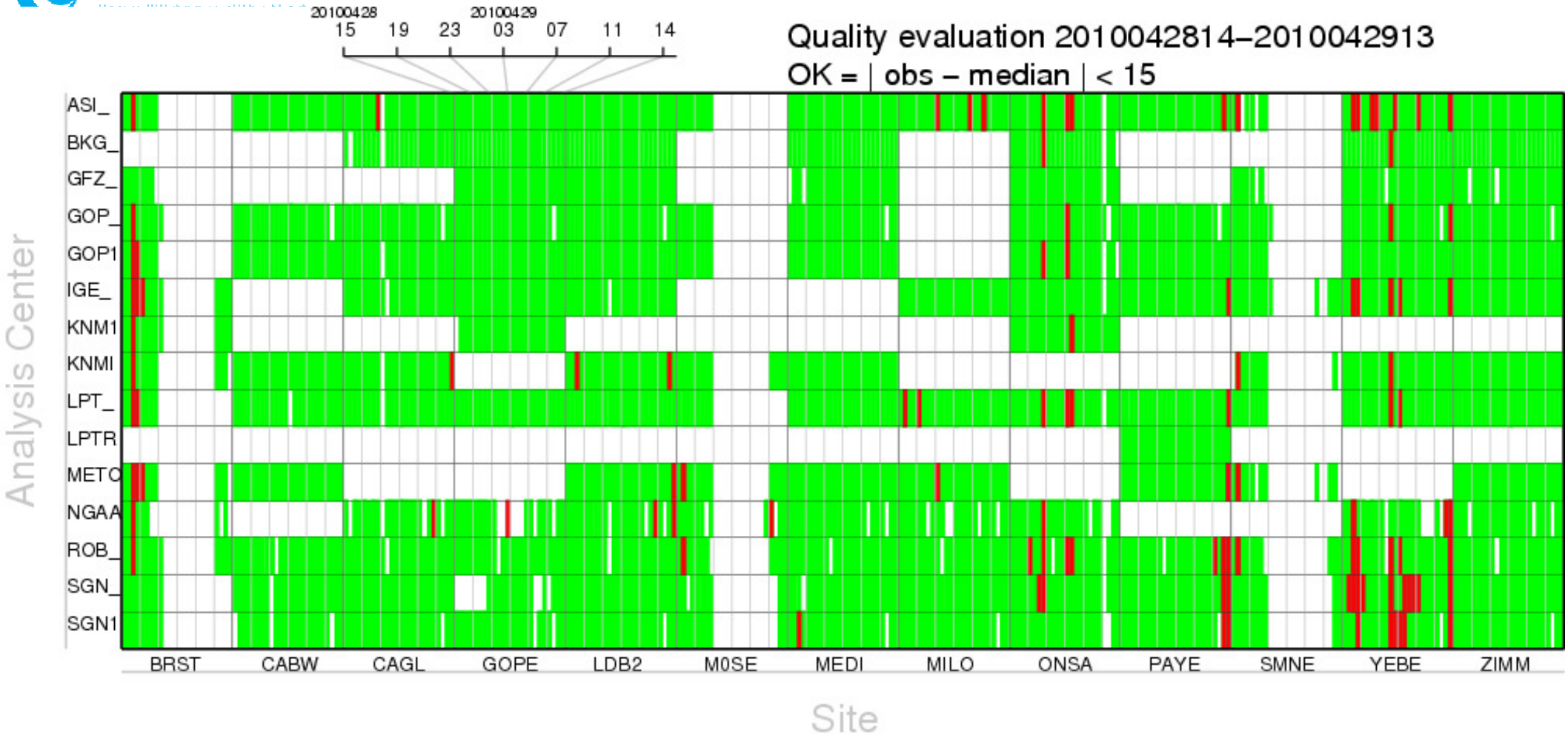
Bias

AC	BRST	CABW	CAMB	CARD	CAGL	GOPE	LDB2	M0SE	MEDI	PAYE	SMNE	YEBE	ZIMM
ASI_	2.49	1.62			0.22	5.61	4.57	5.06	-0.36	0.38	3.27	5.71	4.32
BKG_					-1.73	2.19	1.85		-6.61			0.84	3.24
GFZ_	11.53				-11.75	7.90	8.18		2.69		7.60	12.49	9.30
GOP_	2.98	4.80			-2.29	2.72	4.02	2.67	-3.54	3.62	0.37	3.38	2.14
IGE_	2.23				-0.92	3.46	2.02			4.27	3.43	2.60	3.60
KNM1	13.16					14.18							
KNMI	9.56	-11.74			-0.44		4.41	8.81	2.54		-3.85	13.09	12.76
LPT_	4.09	5.00			-2.41	5.69	6.81	1.40	-4.24	2.86	3.86	2.53	4.33
LPTR										5.34			
METO	1.28	1.95					1.57	1.21	-4.43	-0.06		10.39	0.36
NGAA	7.54				1.63	11.48	9.88	7.49	4.03			9.36	4.71
ROB_	2.50	5.04			-3.05	4.41	1.90	1.05	-6.13	1.77	2.72	3.33	2.54
SGN_	3.73	3.94			-8.00	11.38	2.67	-2.89	-10.62	-1.66	4.59	-1.80	1.18
SGN1	1.94	3.20			-8.32	12.09	3.19	-3.41	-10.51	-3.21	3.39	-2.46	-0.25

Standard deviation of supersite ZTDs against KNMI HIRLAM (Over few days)

Standard Deviation

AC	BRST	CABW	CAMB	CARD	CAGL	GOPE	LDB2	MOSE	MEDI	PAYE	SMNE	YEBE	ZIMM
ASI_	11.43	8.28			11.65	6.45	11.88	12.94	12.81	9.25	10.19	8.89	9.19
BKG_					11.80	7.23	7.41		12.36			7.92	9.74
GFZ_	8.57				14.06	4.64	7.68		13.34		13.12	8.79	10.04
GOP_	9.61	6.02			13.13	5.95	8.86	11.79	12.02	9.96	9.99	8.34	9.43
IGE_	7.26				13.62	5.79	8.26			7.25	9.30	9.61	8.96
KNM1	0.00					0.00							
KNMI	0.00	0.00			0.00		nan	0.00	0.00		nan	0.00	0.00
LPT_	9.00	6.42			12.11	6.18	9.55	11.43	12.58	9.26	11.26	6.86	9.13
LPTR										14.63			
METO	8.96	7.43					10.56	10.93	10.85	10.46		11.25	9.28
NGAA	13.91				15.84	9.41	11.60	14.17	13.00			27.33	13.49
ROB_	9.14	5.96			12.86	6.17	11.32	13.25	14.16	8.97	11.84	9.32	11.00
SGN_	9.09	5.98			12.43	5.11	8.23	12.16	13.48	9.39	9.13	8.22	9.94
SGN1	8.59	6.53			12.27	5.22	8.26	12.01	13.24	11.06	8.56	8.72	11.24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15 19 23
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Analysis Center
ASI_
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IGE_
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BRST
CABW
CAGL
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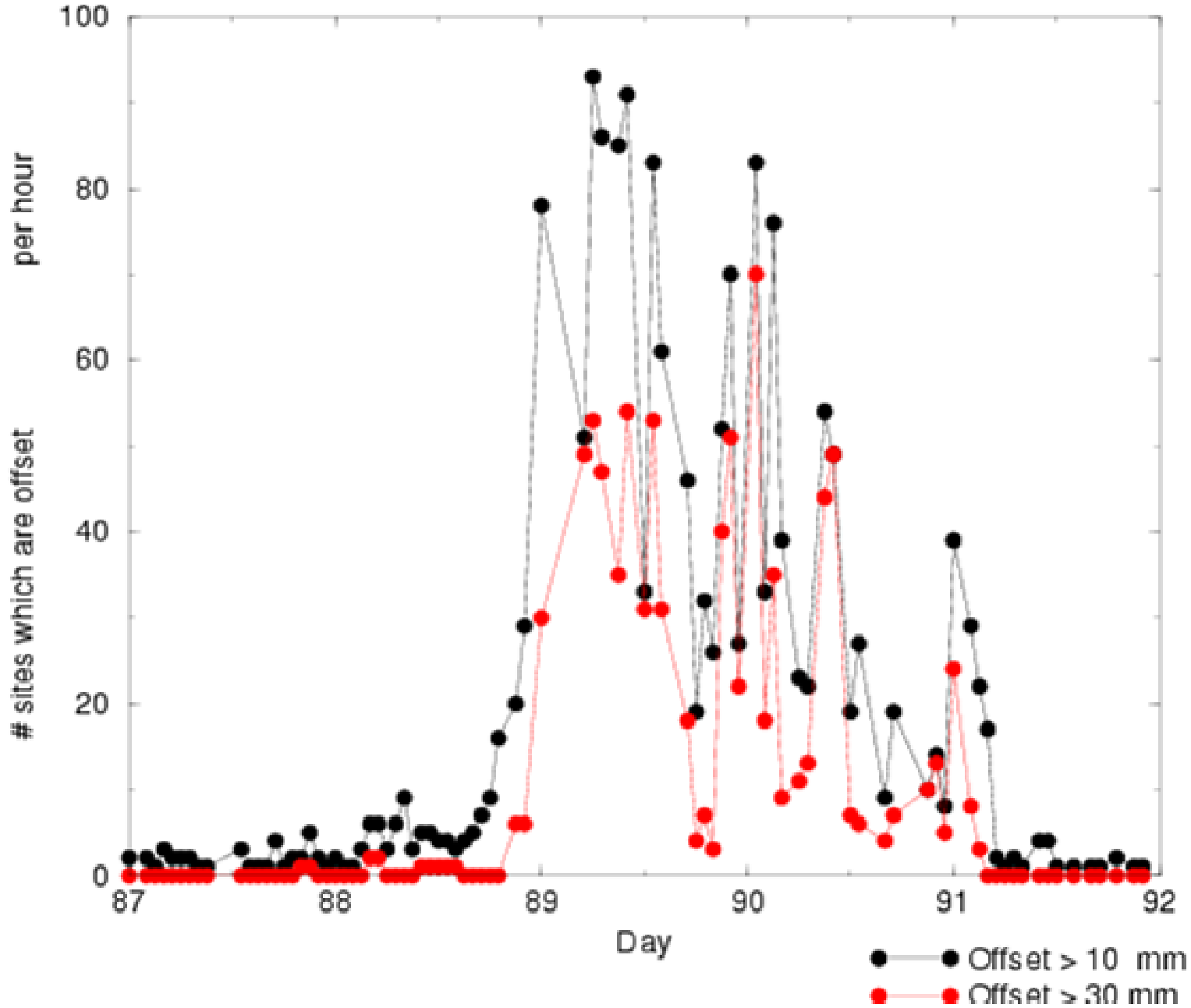
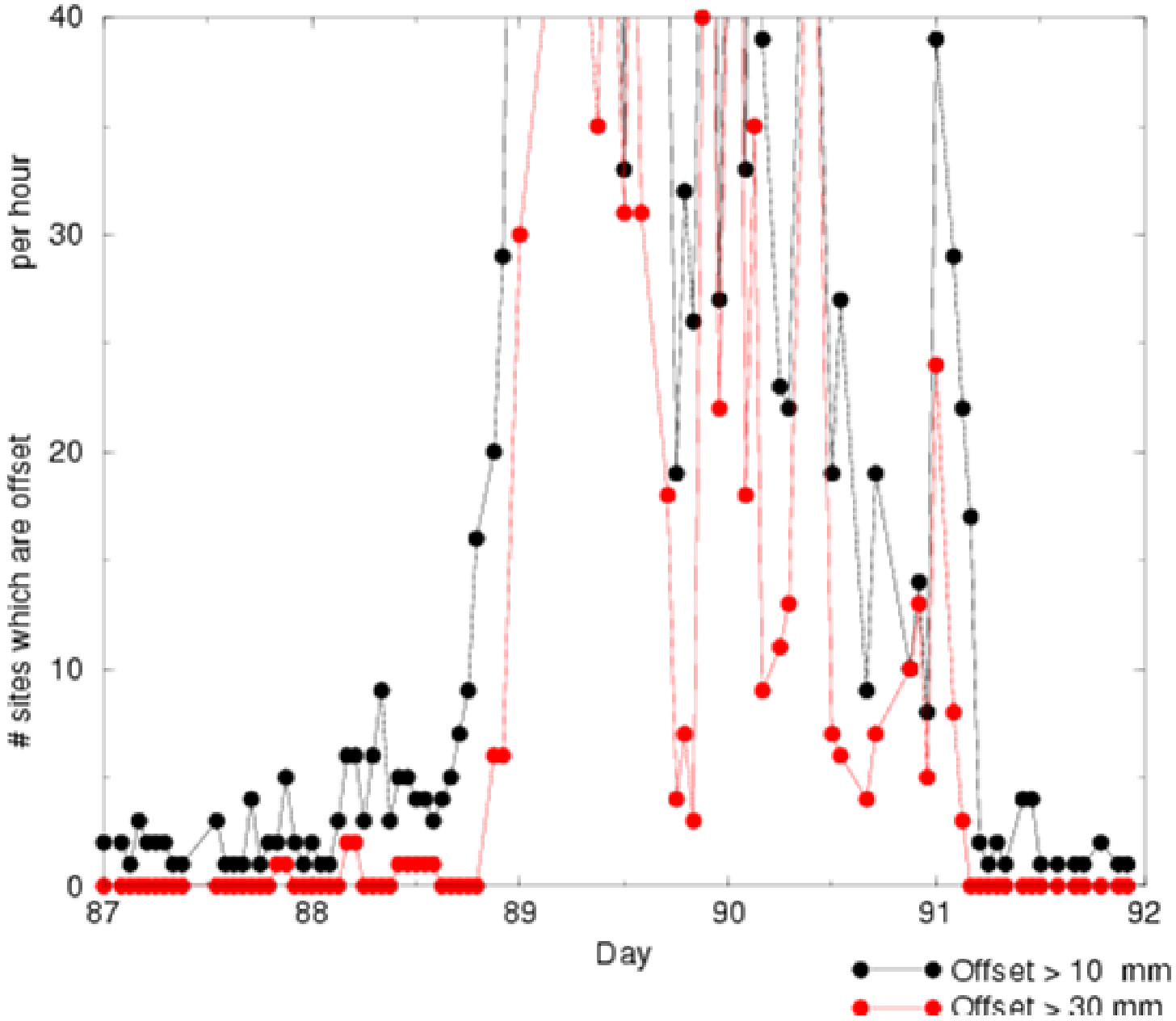
YEBE
ZIMM
Site

For SGN 2008. Days 87 to 92.



For SGN 2008. Days 87 to 92.



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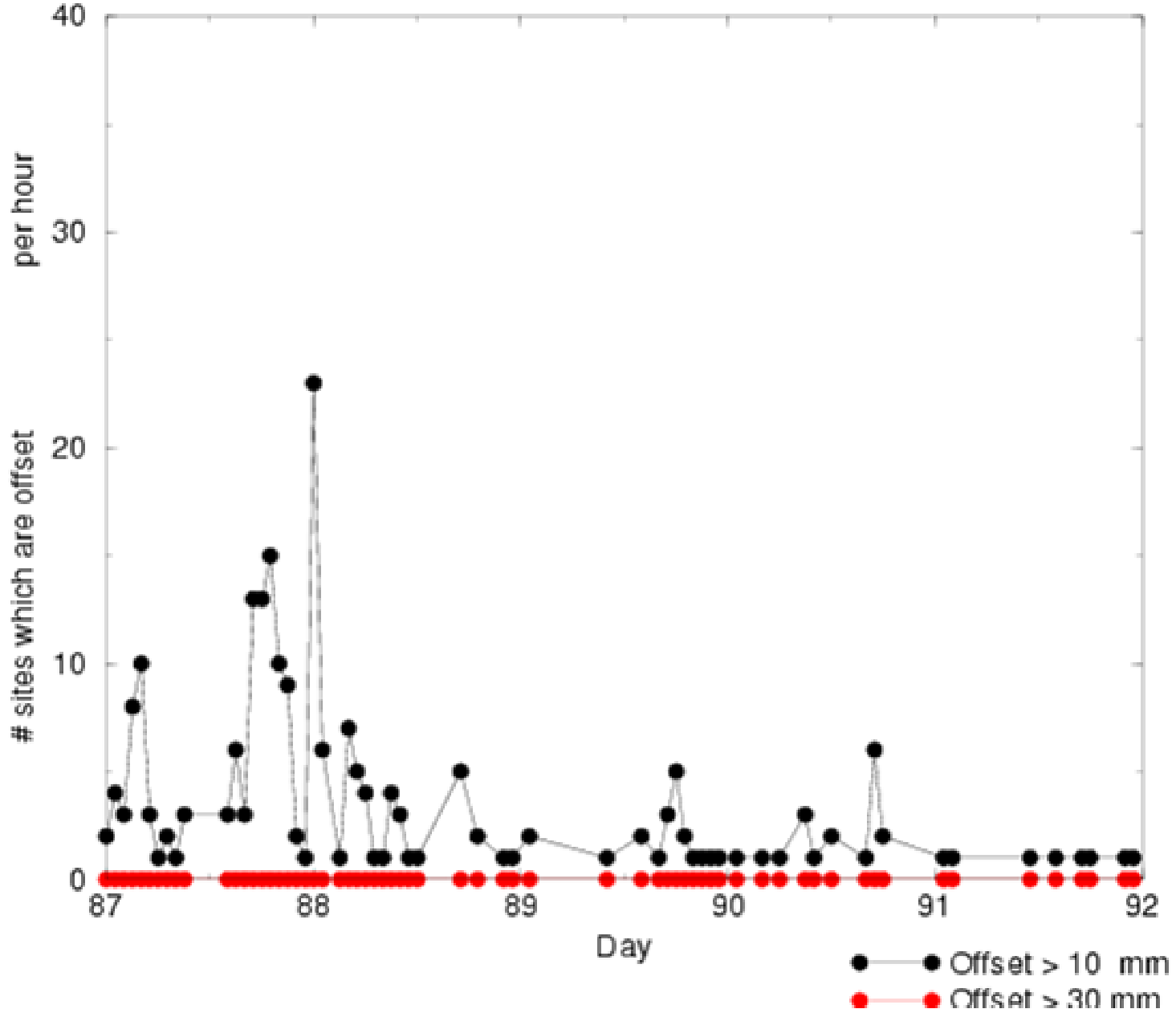
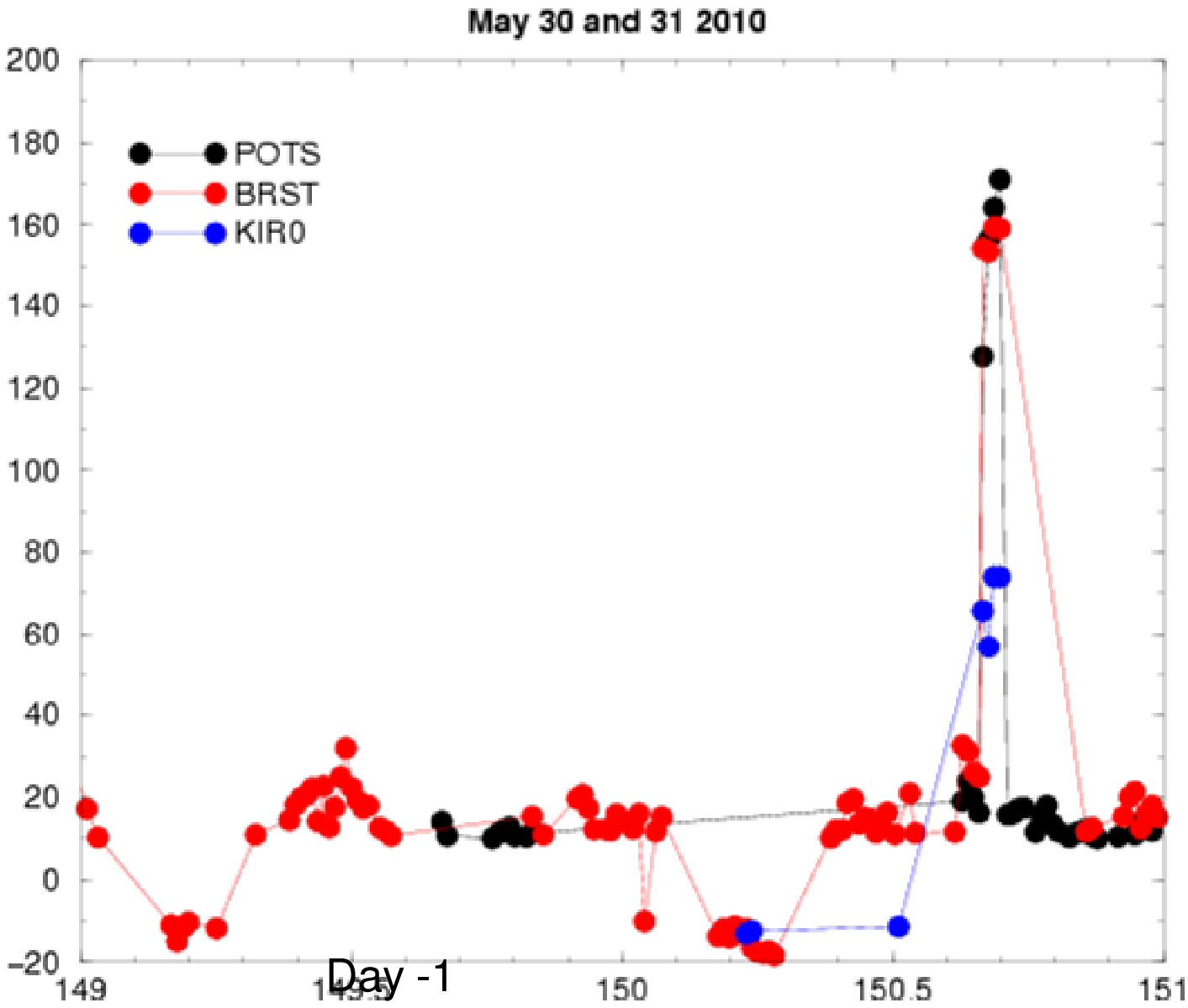


Deviations larger than 10 mm with respect to median of medians of ACs. Unit is mm.



Clearly the AQC is effective in picking out the correlated large offsets in the afternoon of May 31.

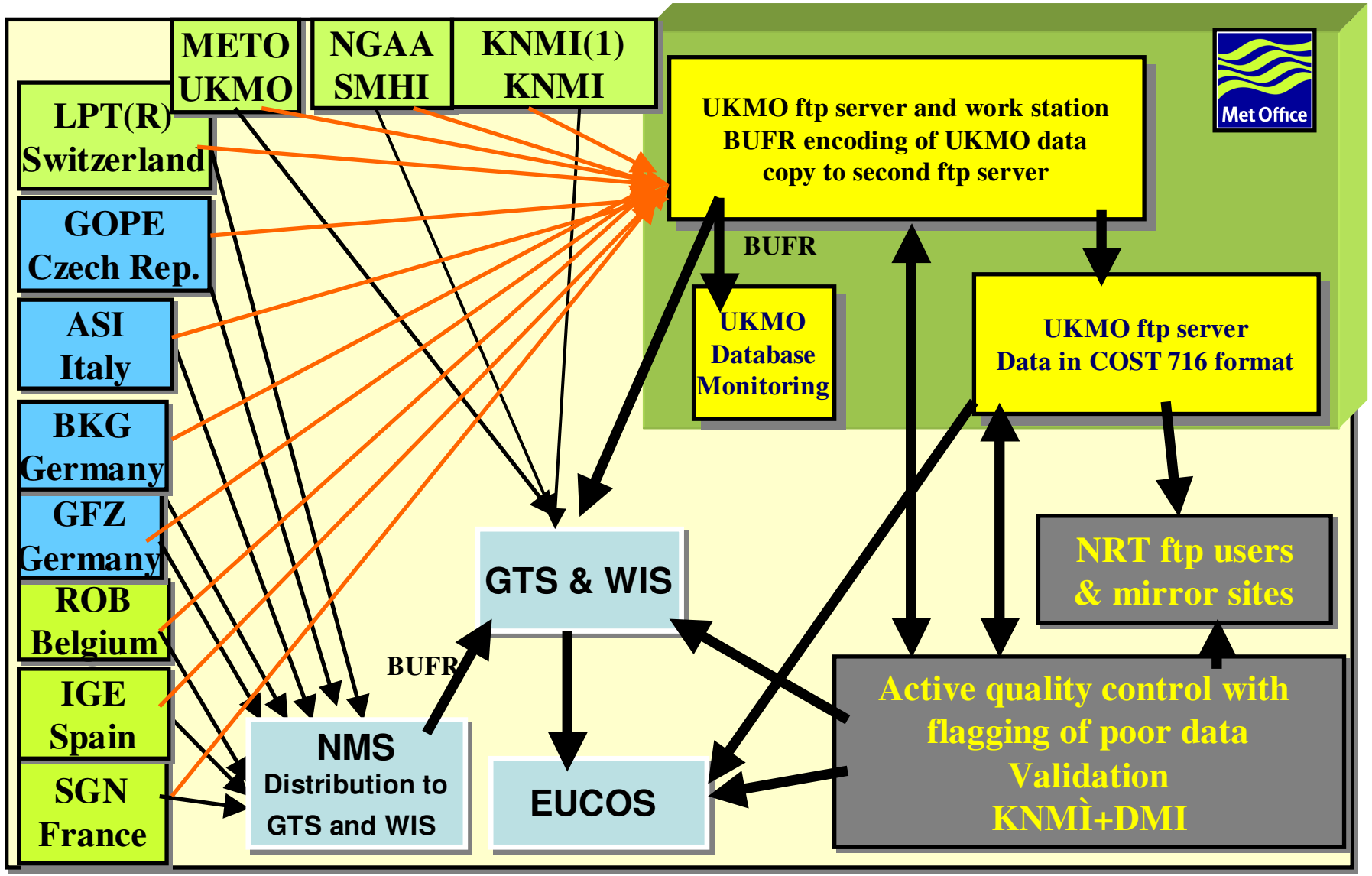
- Clearly this type of multiple error detection will be useful in NWP and in notifying ACs in case of errors.
- The plan is to include also other types of offsets (with respect to NWP forecasts, e.g.) and make real-time flagging of AC performance available to users.

- It certainly shows the strength of having different ACs processing common sites using slightly different methods.

- Is this type of early inter comparison and multiple error detection of NRT ZTD data useful also on the geodesy side?

- In addition ”combined solutions” will be made available by ASI and KNMI, based on two different combination methods. Rosa Pacione described the ASI approach at the previous EUREF Symposium.

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 meteorology

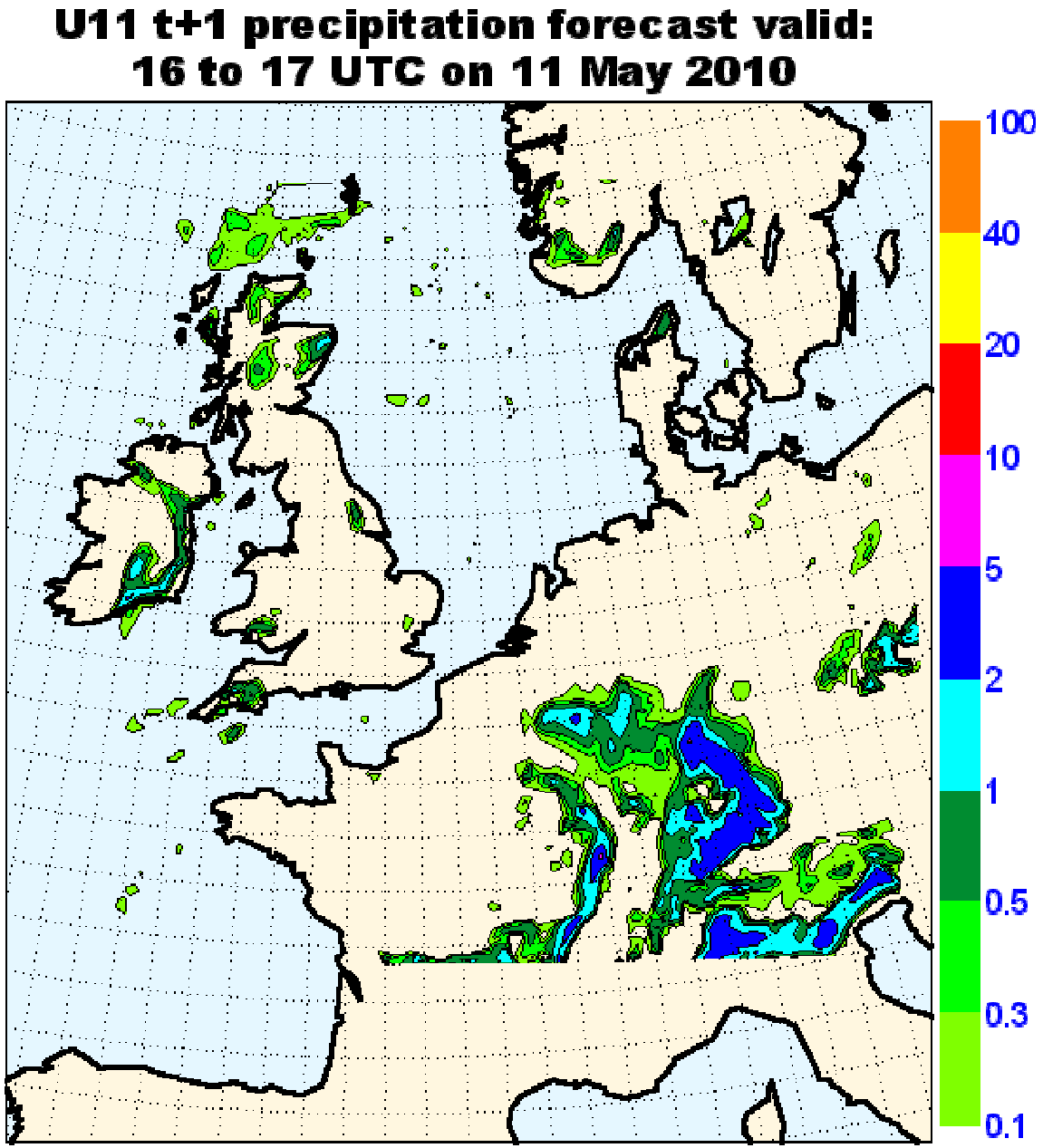
- Two institutes, Météo France and UK Metoffice, use NRT ZTDs in their numerical weather predictions operations today.
- A number of institutes are expected to follow with assimilation of NRT ZTDs this year, in particular those using the ”HIRLAM” and ”HARMONIE” model setups.
- When AQC becomes operational, later this year, it is expected to lead to use of more of the NRT GNSS data.

Impact study from KNMI (the Netherlands)

by Siebren de Haan

Precipitation in KNMI HIRLAM with hourly assimilation cycle, so-called *rapid update cycle.*

Surface pressure and profiles of temperature and wind from landing and ascenting aircraft assimilated. No GNSS data



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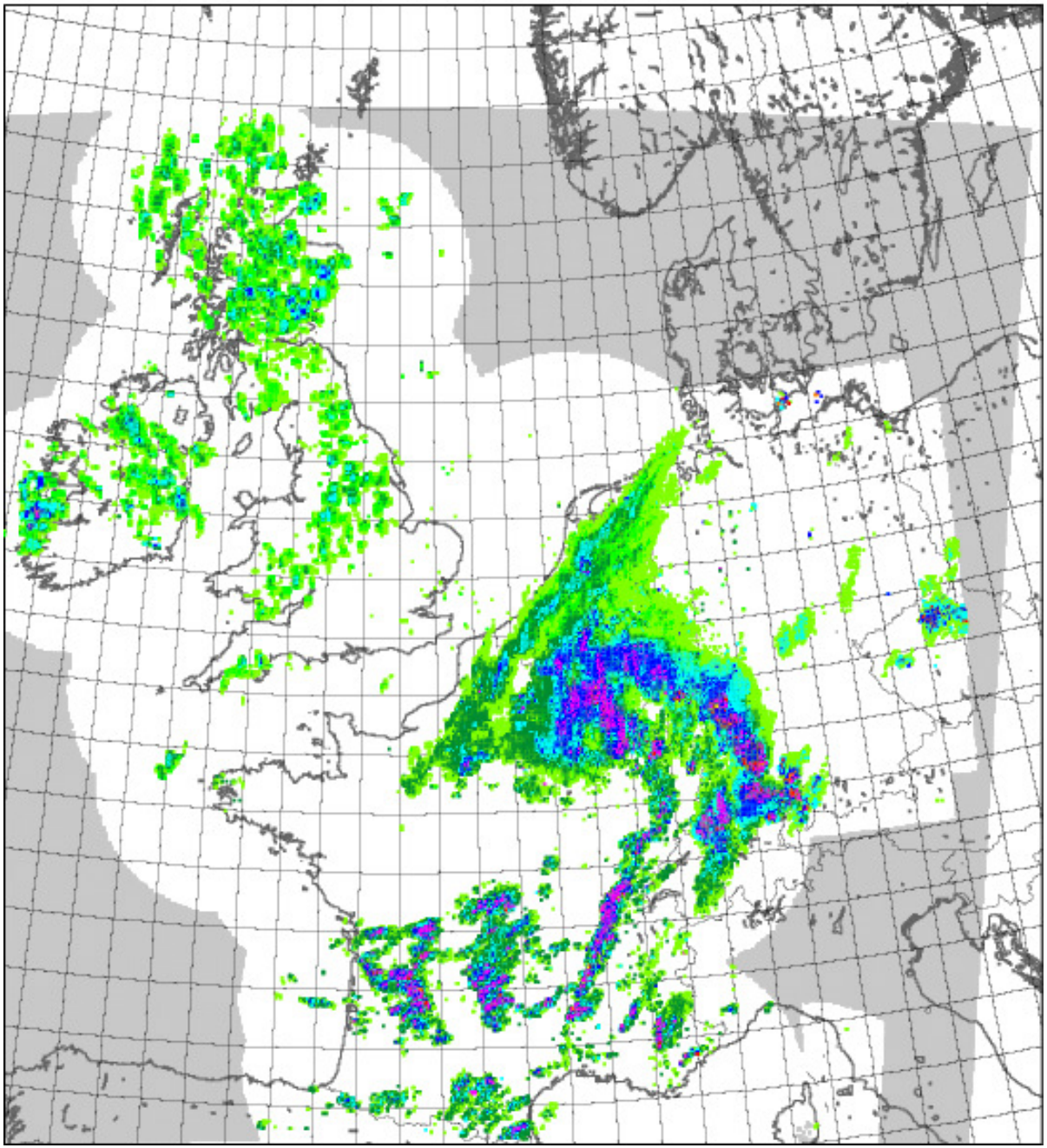
radar uursom 2010051117



Precipitation measured by radar.

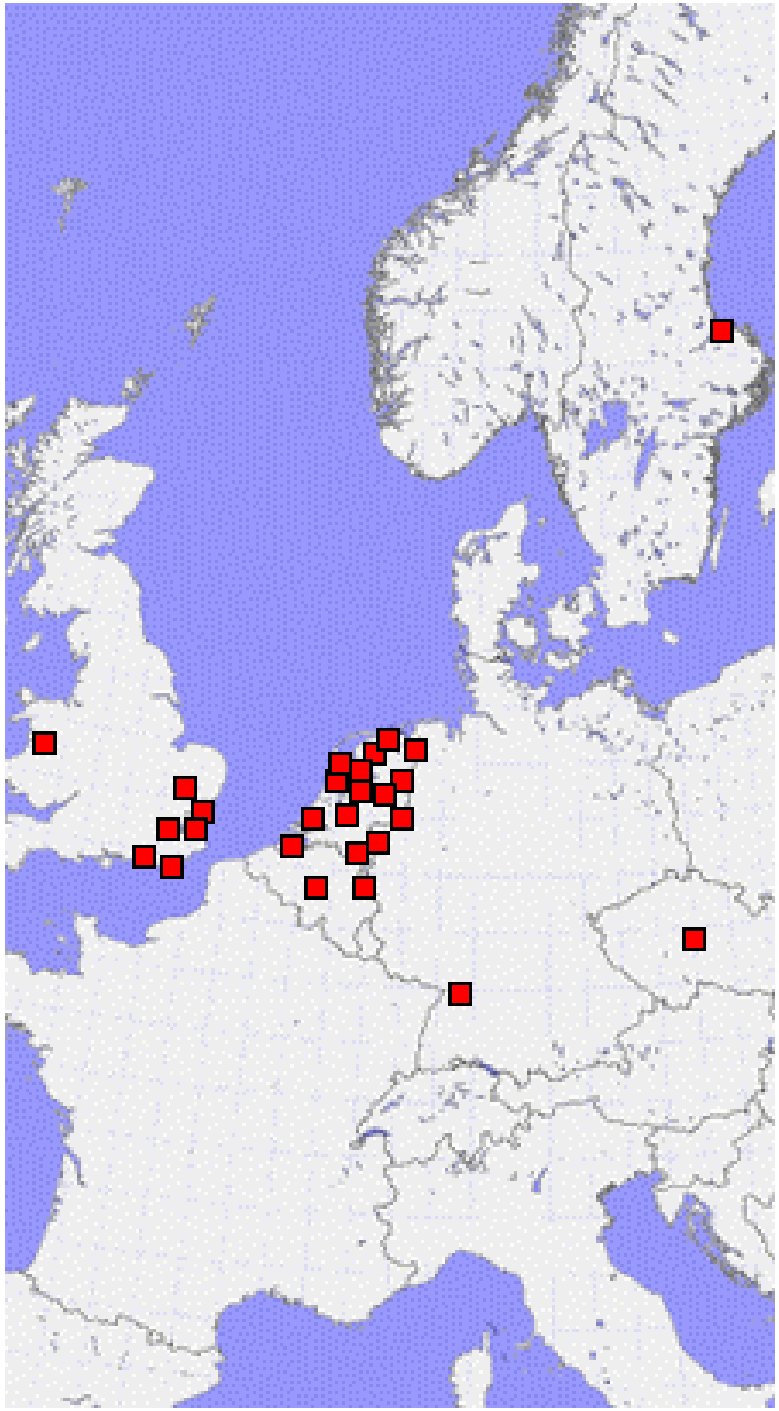
From Siebren de Haan.

EUMETNET

Included ZTDs from shown sites in data assimilation

Surface pressure and profiles of temperature and wind still assimilated

From Siebren de Haan.



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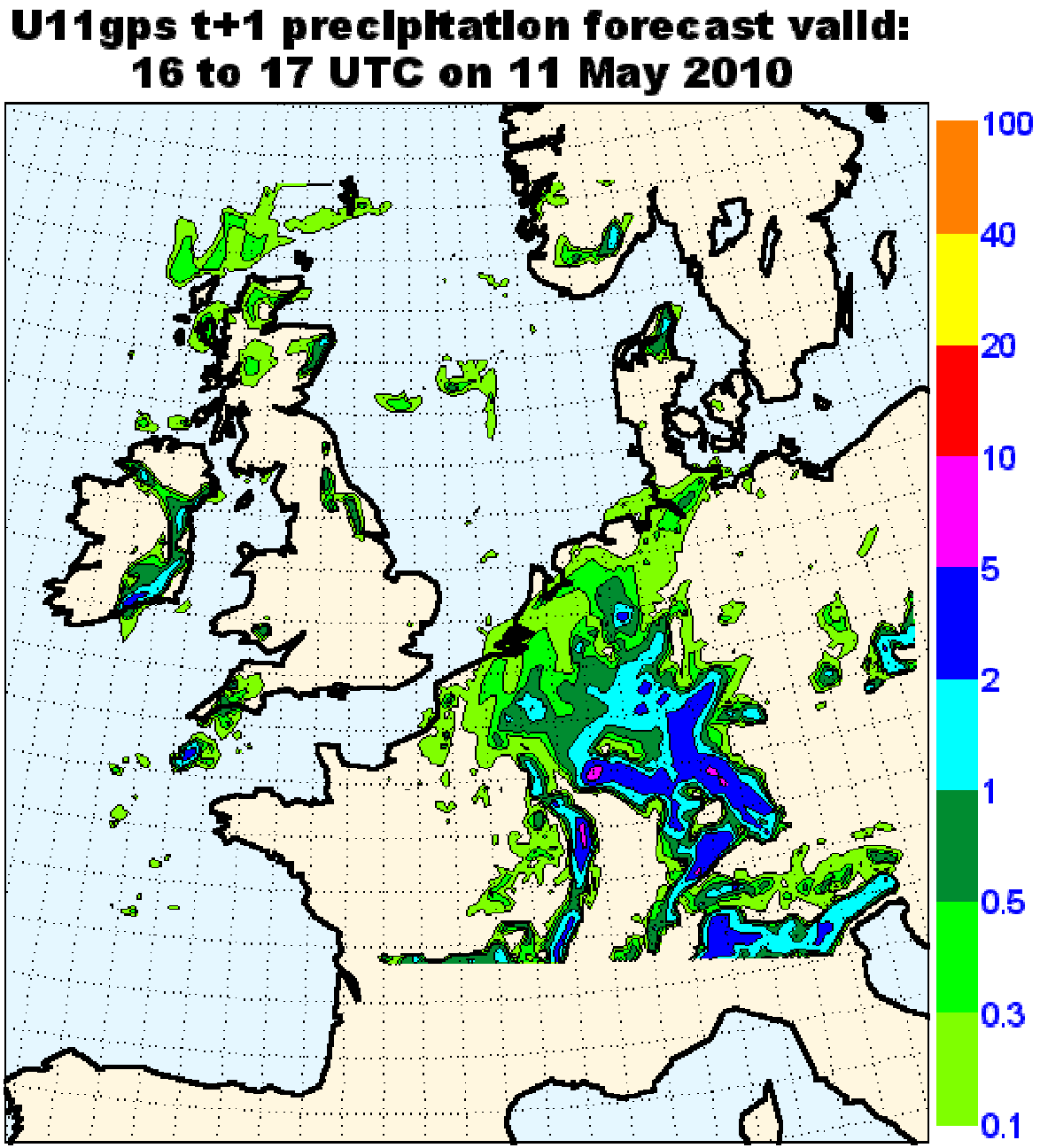
Precipitation in KNMI HIRLAM with hourly assimilation cycle

Surface pressure and profiles of temperature and wind from landing and ascenting aircraft assimilated, but now with NRT GNSS ZTDs from mainly Dutch sites included.

Notice improvement over Dutch area

From Siebren de Haan.

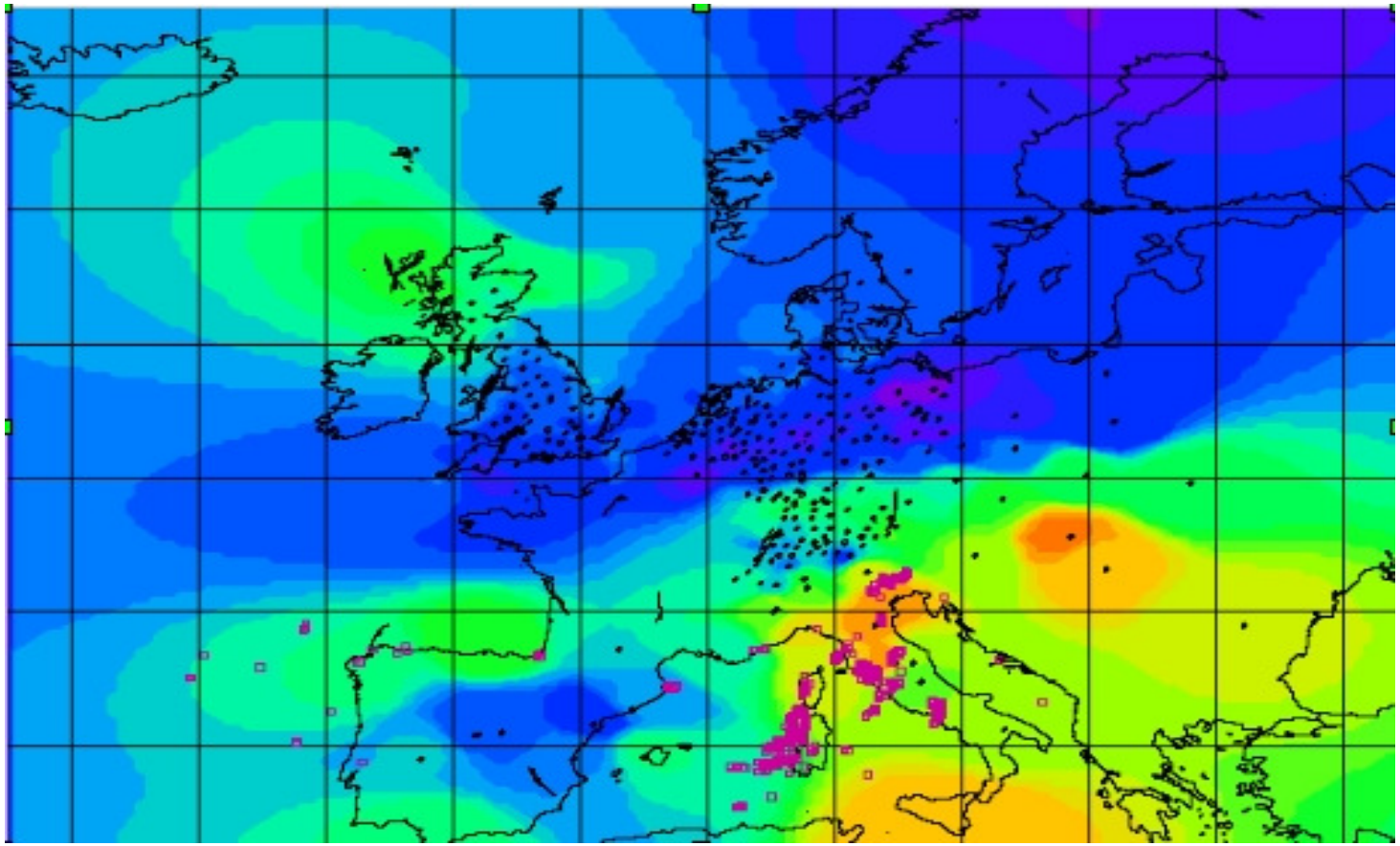


X. Yan et al, *The benefit of GPS zenith delay assimilation to high-resolution quantitative precipitation forecasts: A case-study from COPS IOP 9,* Quarterly Journal of the Royal Met. Soc., 2009, vol 135, p 1788 – 1800. "Clear positive effect on short-range quantitative precipitation forecasts." "Assimilation of ZTD induces changes in the low-to-middle tropospheric water vapour vertical structure that are consistent with water vapour measurements from radiosonde and lidar."

Reima Eresmaa, *Impact of ground-based GPS ZTD data assimilation in HIRLAM: 3D-var analyses and forecasts,* HIRLAM Newsletter, 2009, no 55, p 29 -36. "Small impact on standard verification scores.. ..without bias correction there is a systematic moistening impact..and increase in temperatures and upper tropospheric geopotential height." "Impact appear most positive in the regions of Europe where GPS station density is highest."

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

Final words

- 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.
- The NRT GNSS ZTDs are a benefit to NWP forecasts. ZTDs from additional sites will increase benefit.
- Through E-GVAP meteorological data are made available for geodetic institutions. Useful in validation and improvement of processing methods.
- 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 a growing pressure for access to GNSS data for climate monitoring. It is a joint interest to ensure climate researches utilise a type of GNSS data which are processed suited to their intended use.

THANK YOU

Contact Details

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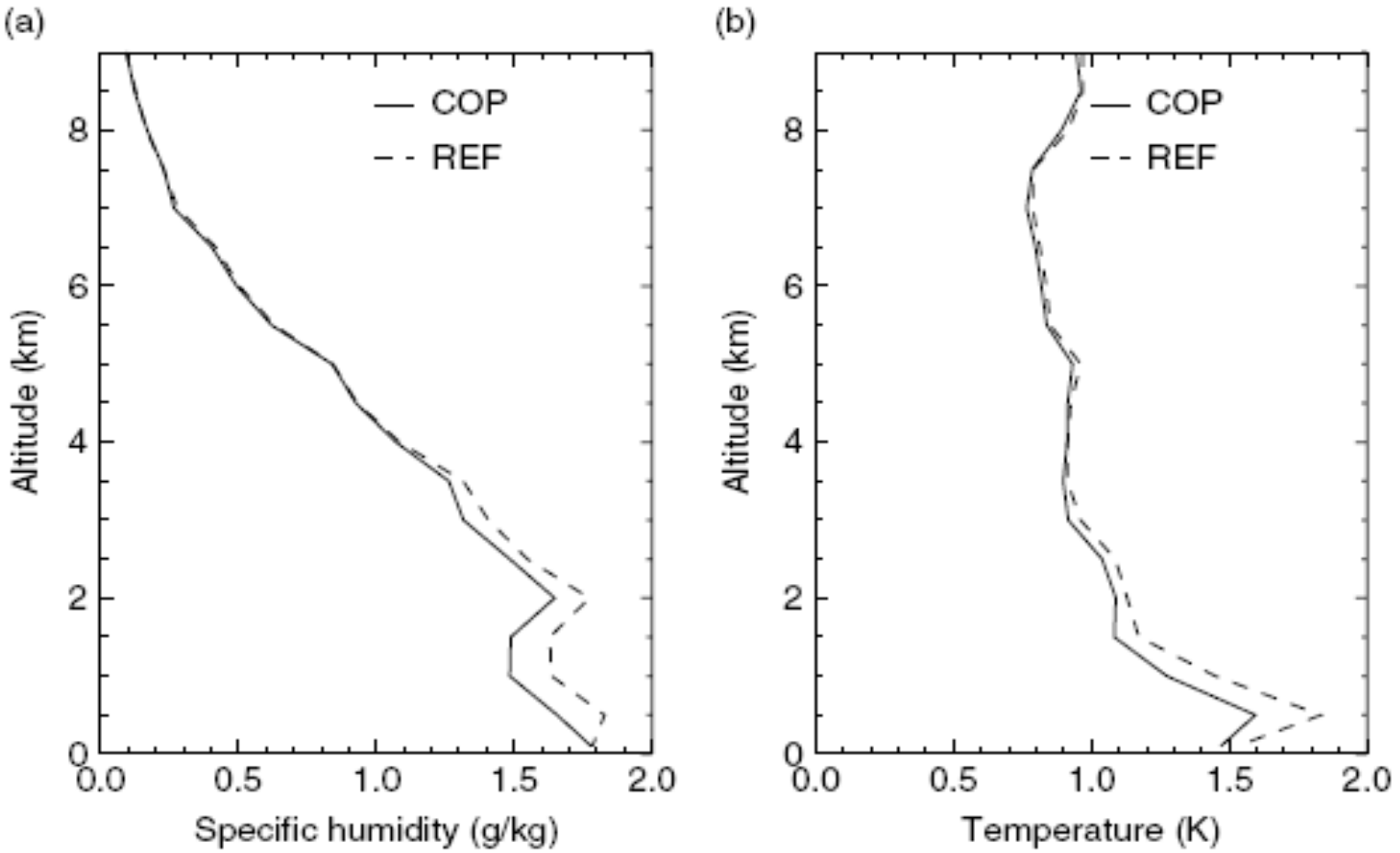
Comparison against radiosonde data of AROME NWP forecasts with and without GNSS data.
From Yan et al., Quar. Jour. Roy. Met. Soc, 2009, vol 135, p 1788.



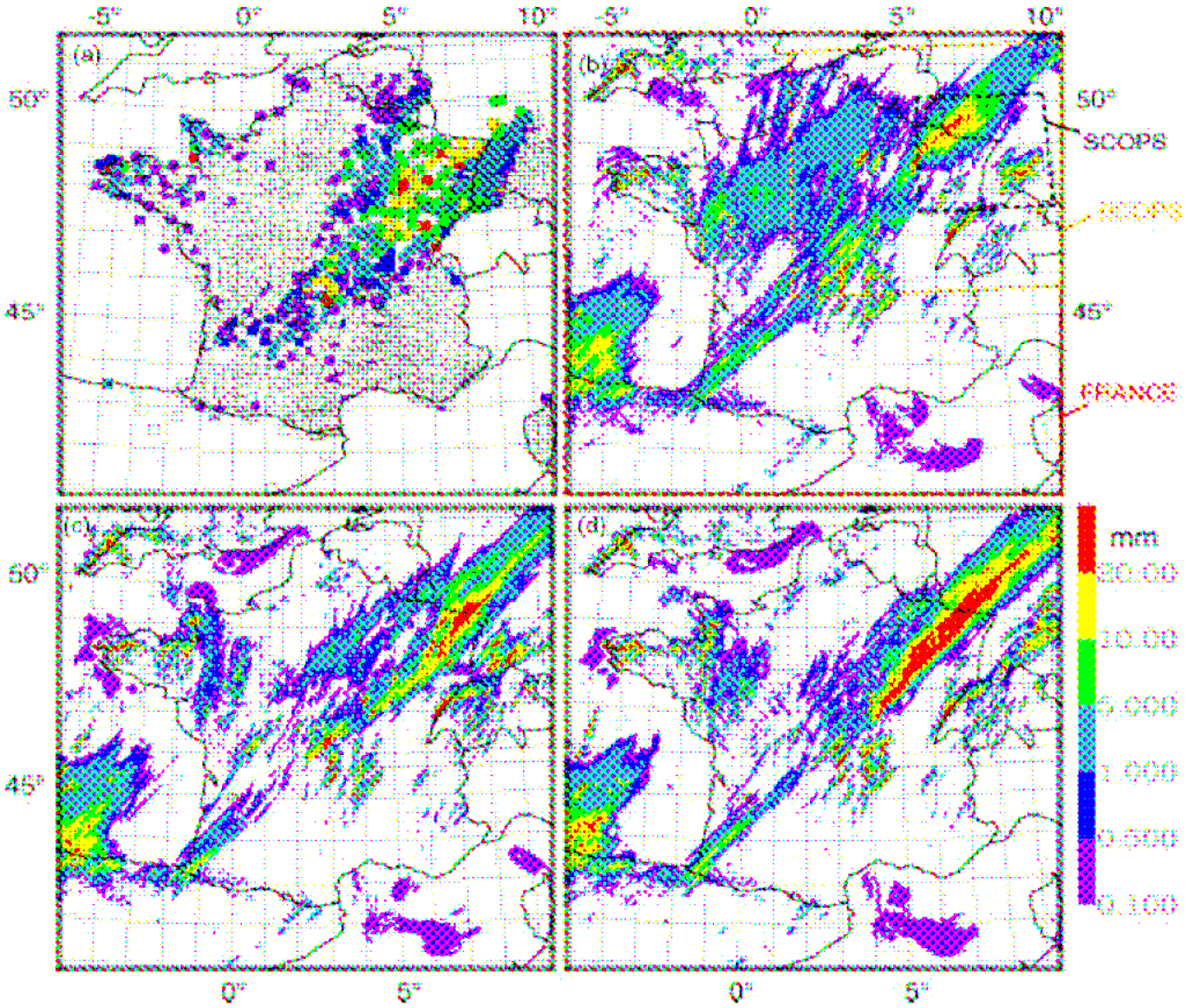


Figure 5. Accumulated precipitation (mm) over 12 h from 0300 to 1500 UTC on 19 July 2007 from: (a) raingauge observations, (b) the REF AROME forecast, (c) the COP AROME forecast, and (d) the OPR AROME forecast. The AROME forecasts all start at 0000 UTC on 19 July 2007. In (b), the domains used for computing the scores displayed in Figures 6, 7, 8, 12 are marked. This figure is available in colour online at www.interscience.wiley.com/journal/qj