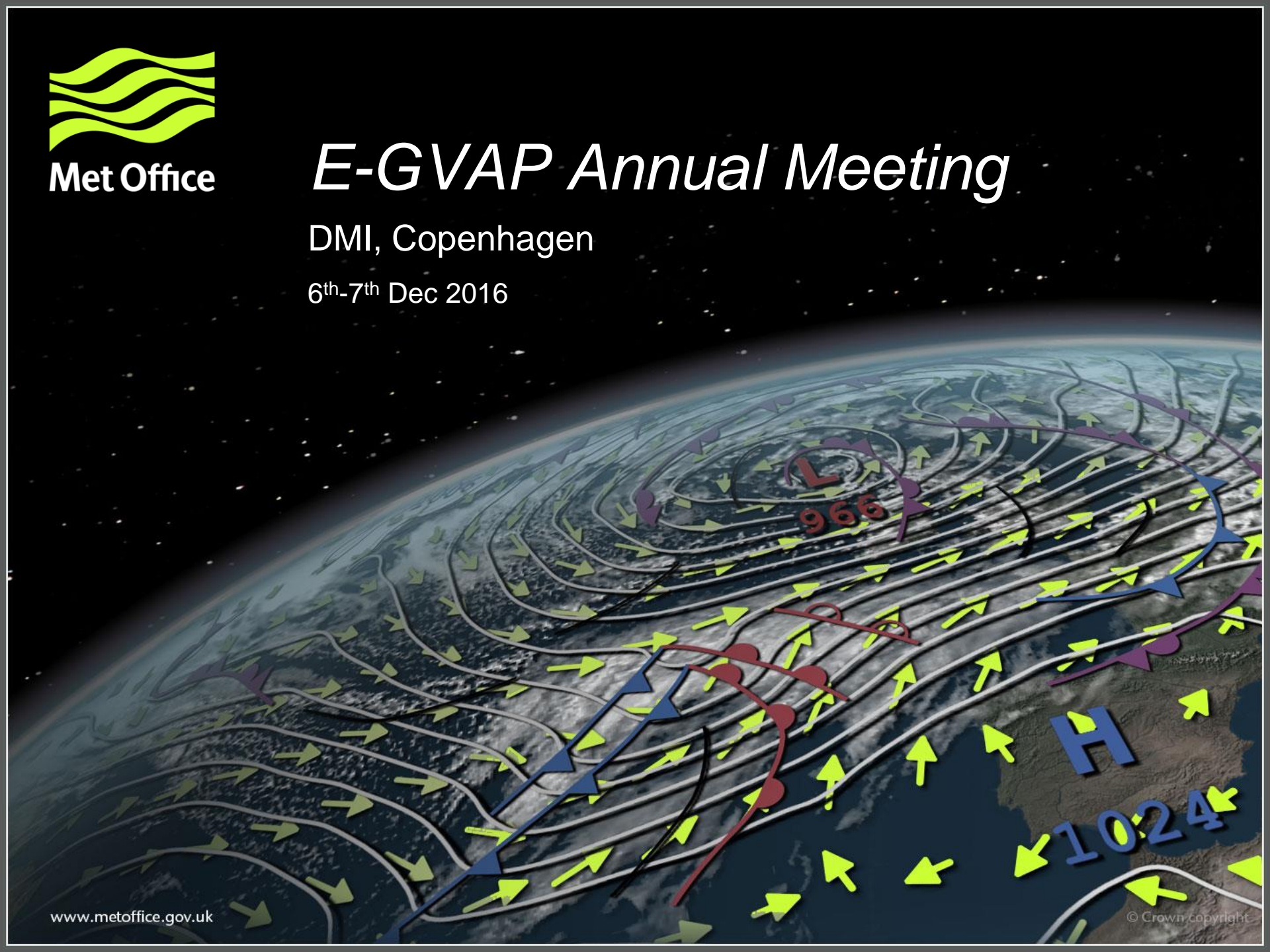


E-GVAP Annual Meeting

DMI, Copenhagen

6th-7th Dec 2016





GPS Processing @ UKMO

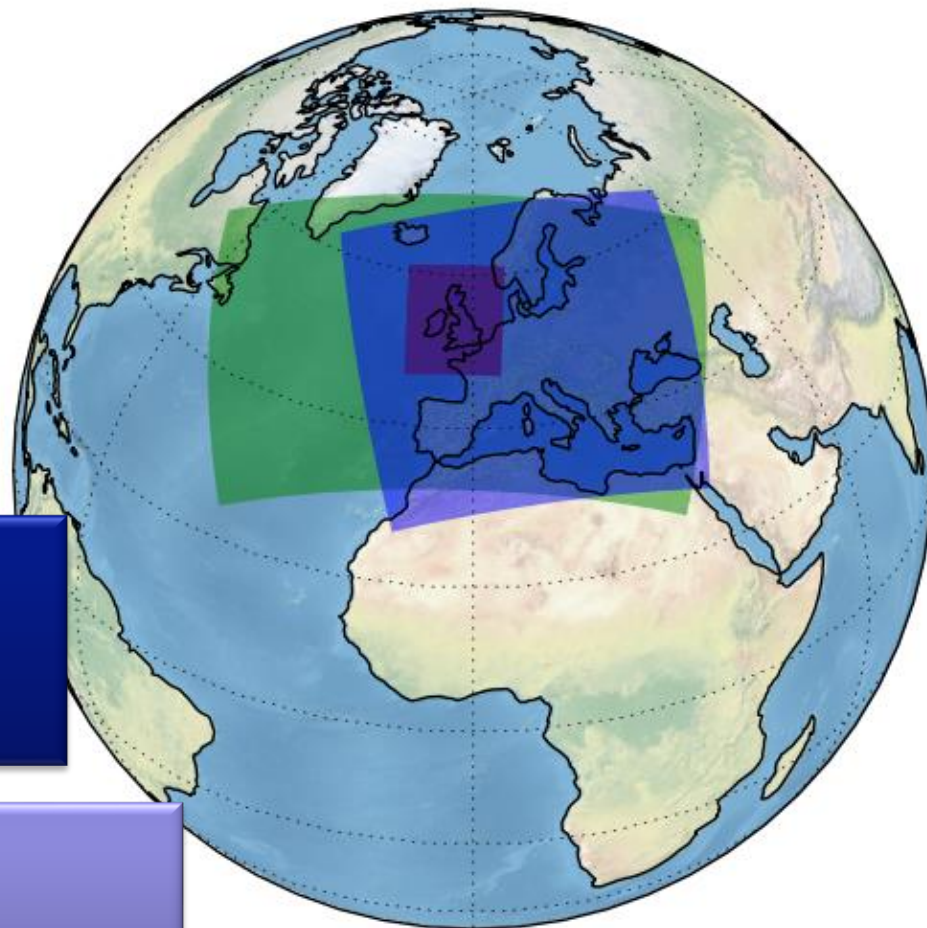
Met Office NWP Models

Global
17km model
4D-VAR

Old NAE model -
retired

EURO4
4km
No DA

UKV
1.5km
3D-VAR



UKMO GPS Processing

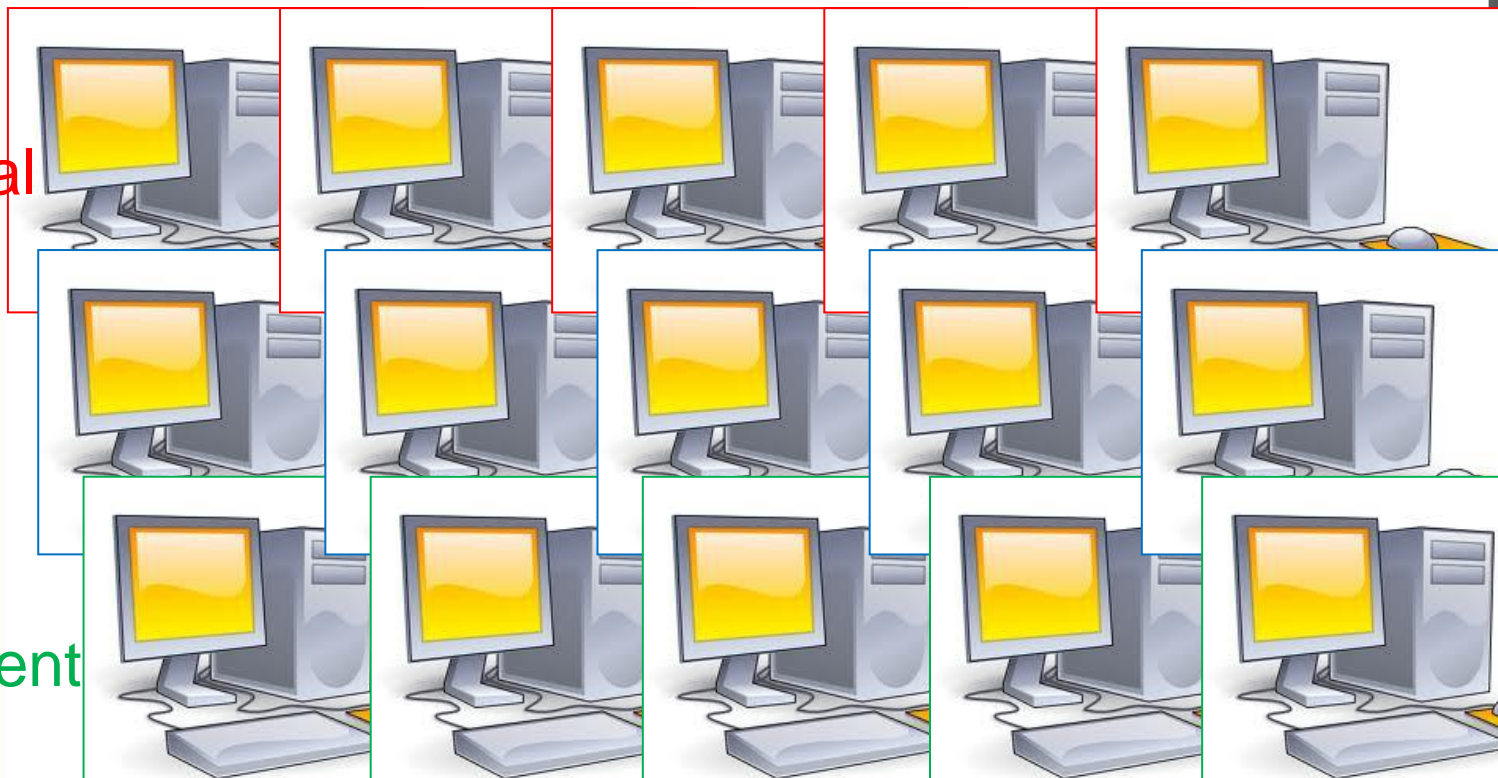
- In-house GPS processing systems:
 - METO, hourly, European, ZTD/IWV, ~41min delay
 - METG, hourly, Global, ZTD/IWV, ~56min delay
 - METR, 15min, UK, ZTD/IWV, ~5min delay
 - METI01, hourly, Global, TEC
 - METI02, 15min, UK-specific, TEC
 - All systems based on Bernese v5.0 in DD mode, 4-5hrs NEQ files, AAPCVs, FES2004 etc
- METO operational since 2007, METG since ~2013
- METI01 operational early 2017
- Formal agreements in place with national mapping agencies - guaranteed long-term data access etc

Server Architecture

Tropospheric

Ionospheric

- Operational
- Test
- Development



METO

METG

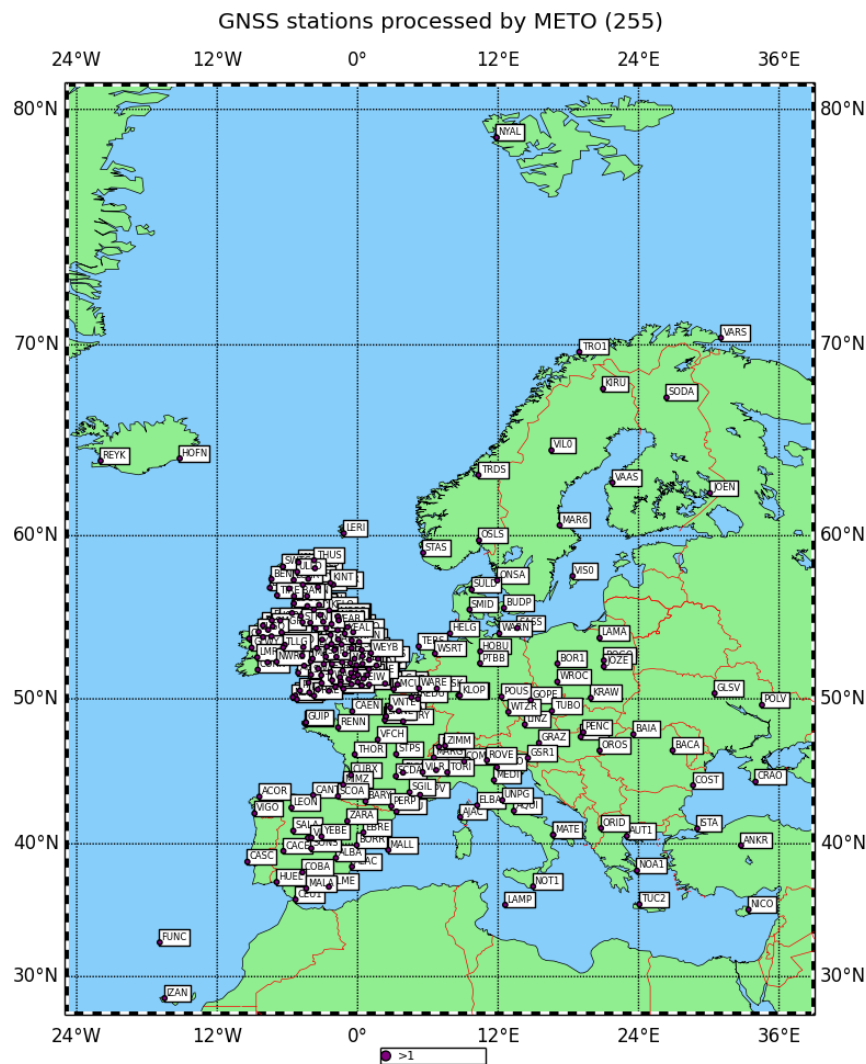
METR

METI01

METI02

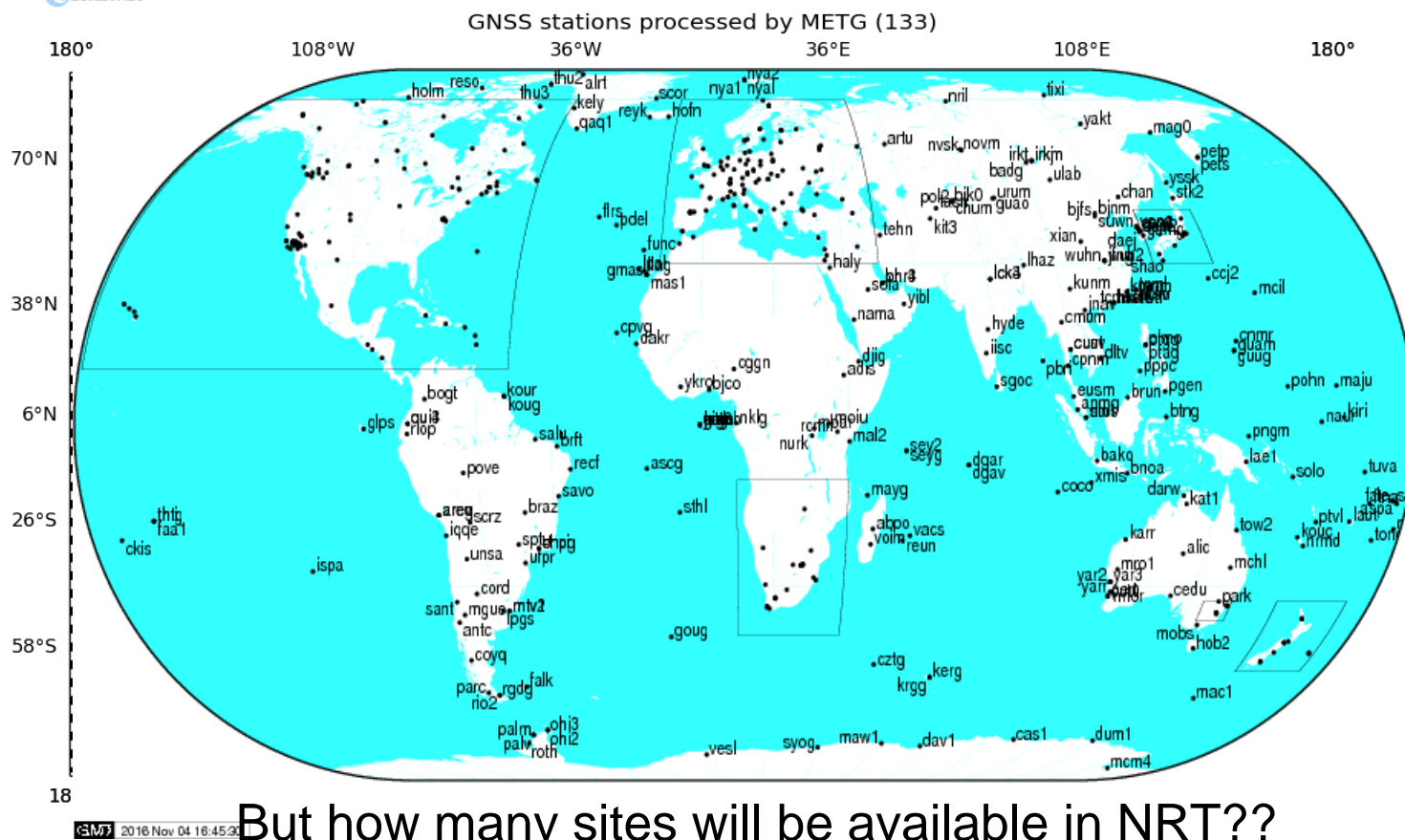
2016 METO Developments

- Slightly amended network of stations.... that's it!



2016 METG Developments

- Increasing stations from 221 (~130 available in NRT) to 475 to include up to date IGS station list



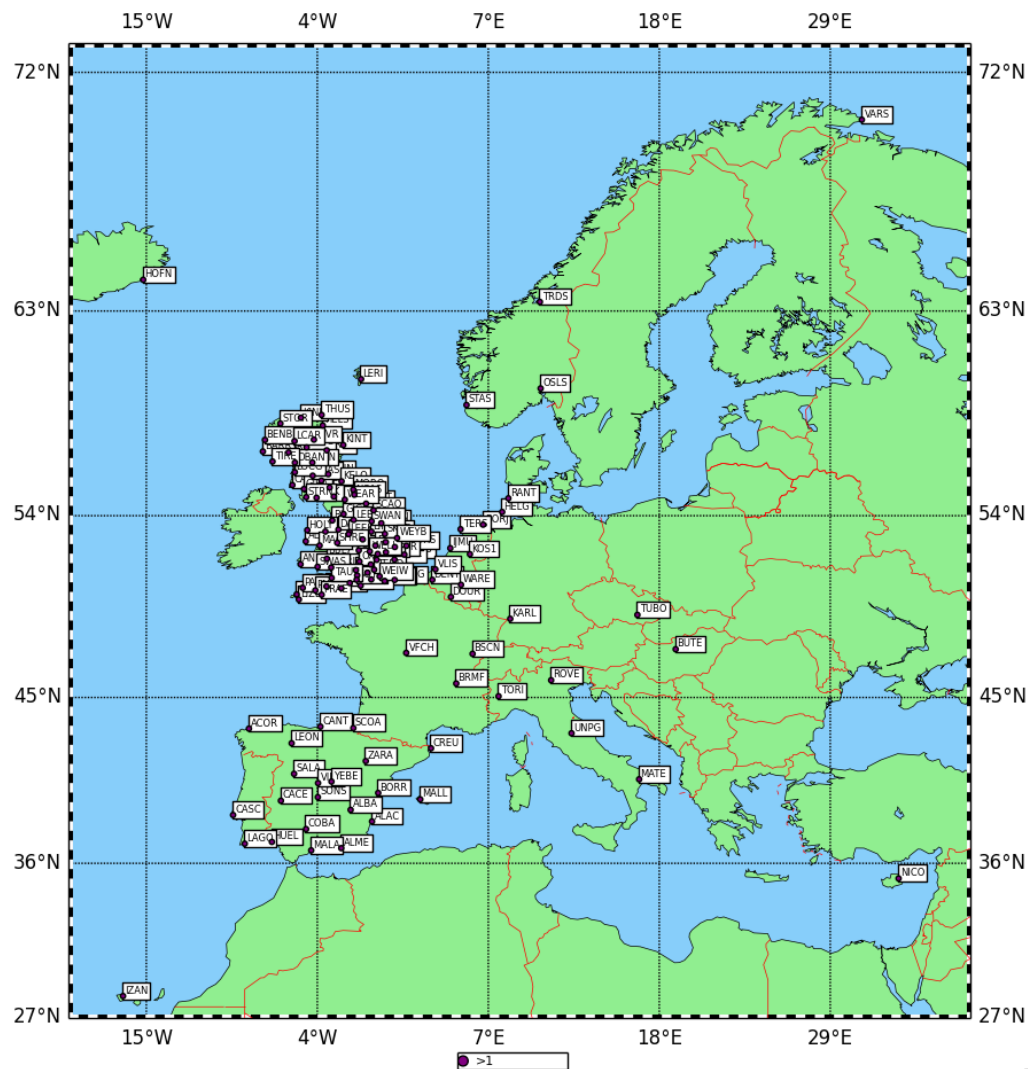
2016 METR Developments

- Increased network of stations from 214 to 250 (but typically only ~110 stations available in RT)
- Increased stations from European area to better meet requirements of increased UKV domain
- Multiple instances of BNC adding stability – EUREF, Osi, OSNI, OSGB and Iceland
- Icelandic data streams now available – retrieving 1 station on test basis, hope to add more soon
- Shortly to be processing 36 Irish stations (just waiting on daily RINEX)
- Hope to hand over to operational support in 2017

METR Network



GNSS stations processed by METR (134)



Current Activities

- Complete installation of Met Office GNSS network
- Move to BSW52 incl. multi-GNSS (incl. comparison of Niell vs. VMF)
- Move METI02+METR to operational support
- Move IWV+TEC plotting to operational support
- Refresh MoUs with Osi, OSNI and OSGB
- Many proposals to Met Office management...

Proposals for GNSS work

1. Justification for Met Office GNSS network
 2. Move to PPP
 3. Azimuthal anisotropy – gradients or quadrant approach
 4. Vertical resolution (slant delays, profiles and 3D tomography)
 5. Water vapour trends as precursor for fog formation
 6. Dense single frequency GNSS networks
 7. GNSS-Reflectometry for satellite verification
 8. TEC as adaptive waveguide for ATD
 9. TEC anomalies as earthquake precursors
-however comes from backdrop of cuts....



COST Action ES1206: GNSS4SWEC



Main COST 1206 Activities

Date	Activity	Location
MAY 2013	KICK-OFF MEETING	BRUSSELS, BELGIUM
OCT 2013	WORKING GROUP AND MC MEETING	VALENCIA, SPAIN
FEB 2014	1 ST WORKSHOP	MUNICH, GERMANY
SEPT 2014	SUMMER SCHOOL, WG AND MC MEETING	VARNA, BULGARIA
MAY 2015	2 ND WORKSHOP	THESSALONIKI, GREECE
SEPT 2015	WORKING GROUP AND MC MEETING	WROCLAW, POLAND
MARCH 2016	3 RD WORKSHOP	REYKJAVIK, ICELAND
AUG 2016	SUMMER SCHOOL, WG AND MC MEETING	POTSDAM, GERMANY
MARCH 2017	FINAL WORKSHOP	ESTEC, NETHERLANDS

Minutes and presentations can be found at: <http://gnss4swec.knmi.nl>

New ACs/Networks

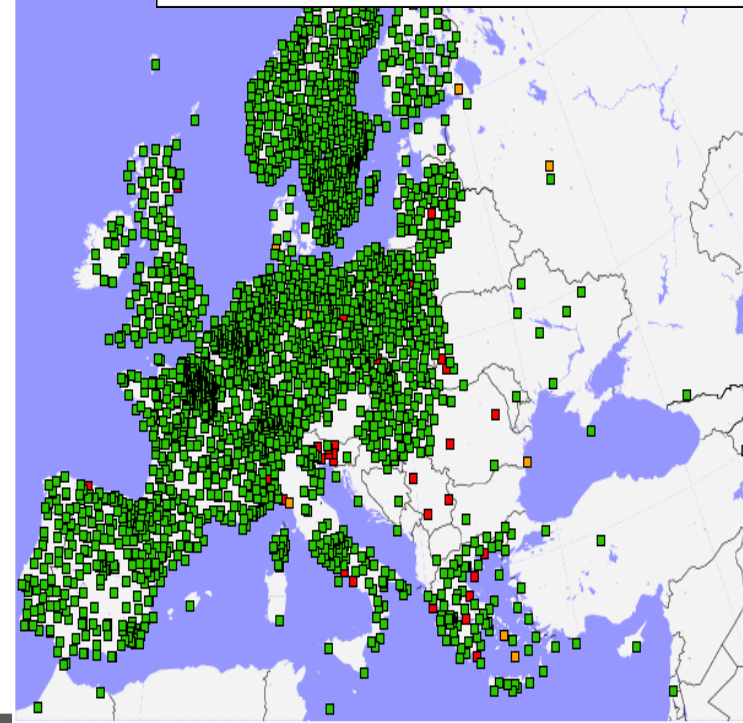
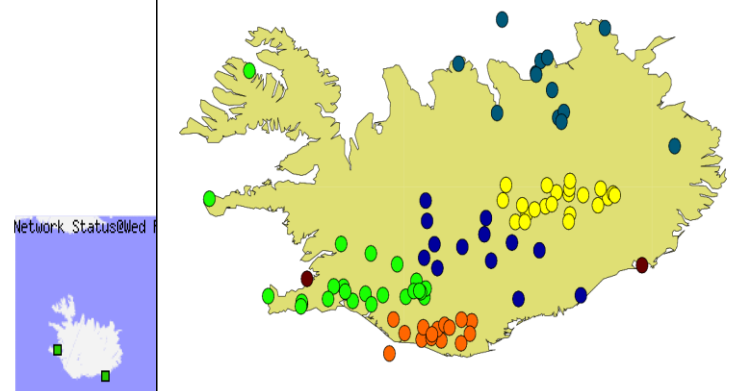
8 new ACs:

- Satellite Geodetic Observatory, Hungary
- Karadeniz Technical University, Turkey
- Aristotle University, Greece
- Bulent Ecevit University, Turkey
- Icelandic Meteorological Office
- MUT, Poland
- Sophia University, Bulgaria

8 new GNSS networks:

- Italy, Hungary, Greece, Lithuania, Latvia, Slovakia, Turkey, Iceland
- + others expected: Turkey(+), Greece(+), Austria, Denmark, ...
- + re-vitalised: Norway, Sweden, Finland, Poland

Sites processed for TropNET / IMO



Benchmark Campaign

Preparation phase: design & data collection

May-June 2013 - floods of Danube
/Moldau/ Elbe rivers

GNSS: ~500 stations

SYNOP: ~200 stations

NWM: regional (Aladin-CZ), global
(ERA-Interim, NCEP GFS)

RS OBS: E-GVAP + 2x high-
resolution

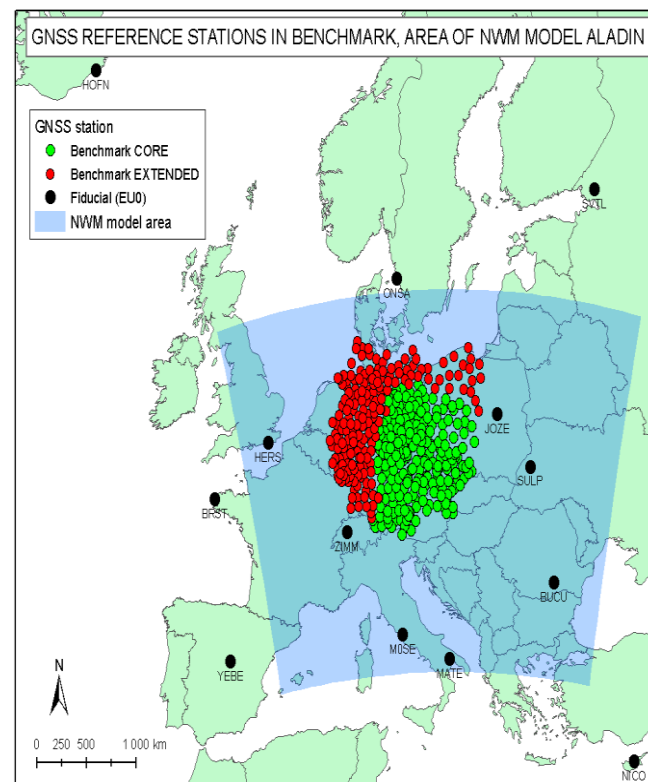
2x WVR

RADAR images

Reference products

GNSS: Bernese (GOP), EPOS (GFZ)

NWM: G-Nut/Shu (GOP), DNS (GFZ)



Real-Time Processing Evaluation

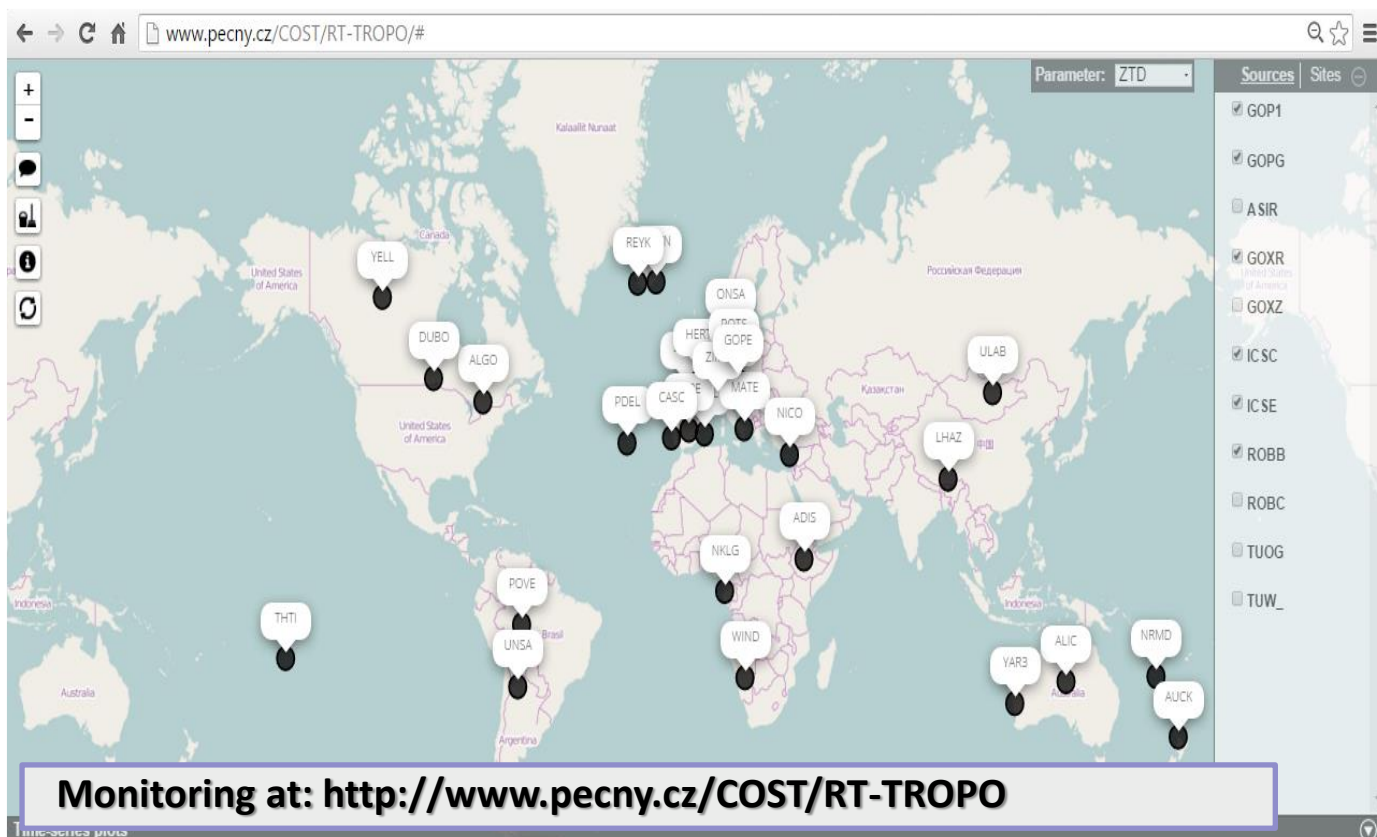
- Use of IGS RT global products for PPP (GNSS satellite orbits & clocks)
- Developing and assessing new software and strategies

RT Demo campaign

Scope: Europe (15) + Globe (17)

Software: 6+1 types

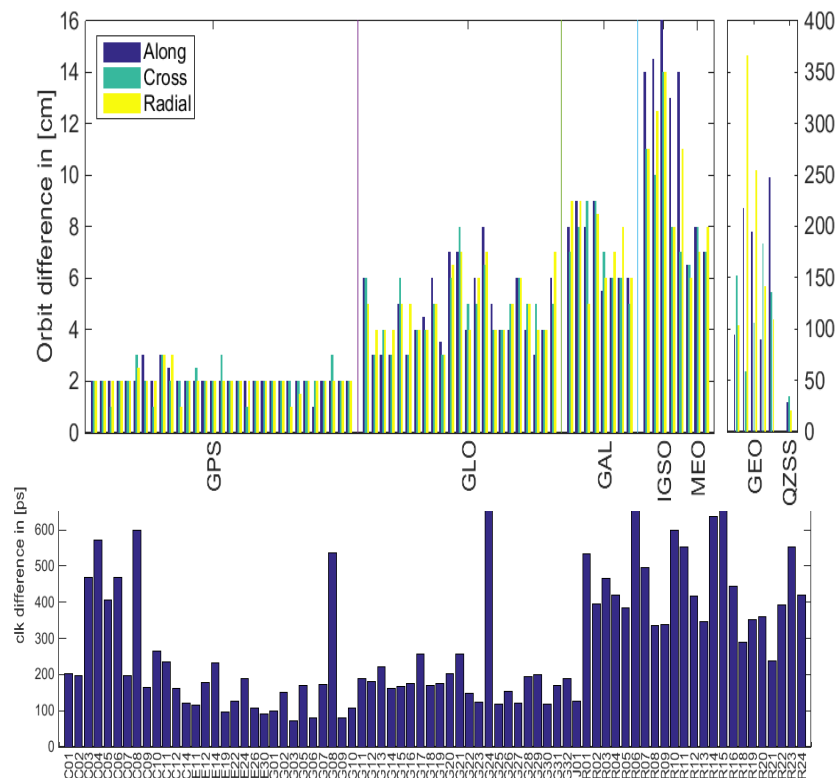
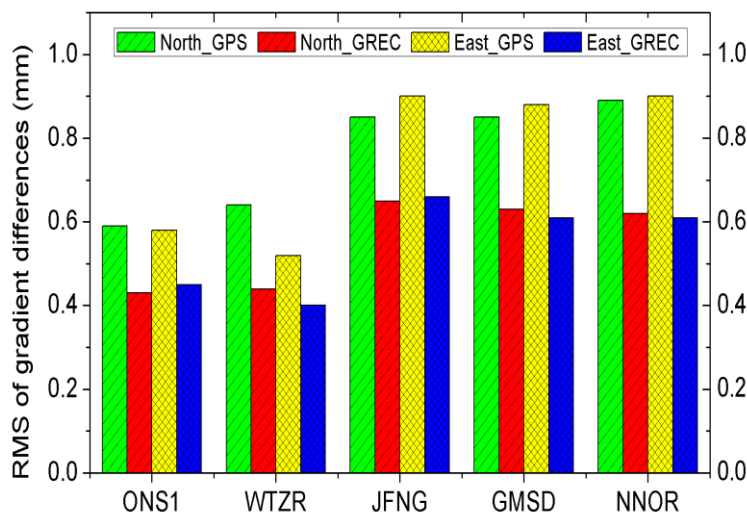
Contributions: 7+1 ACs



Multi-GNSS Tropo Products

- Several software developed/adapted for multi-GNSS data processing
- GLONASS partly integrated in various NRT & RT-Demo solutions, GLONASS used within Benchmark campaign
- Since November 2015 GFZ provides ultra-rapid multi-GNSS orbit and clock product (GBU) for every 3 hour
 - Includes GPS, GLO, GAL, BDS and QZSS satellites
 - Latency is less than 2 hours since the **last observation**

Multi-GNSS tropospheric horizontal linear gradients compared to those derived from NWM refractivity field (ECMWF analysis)





Asymmetry Monitoring

201305

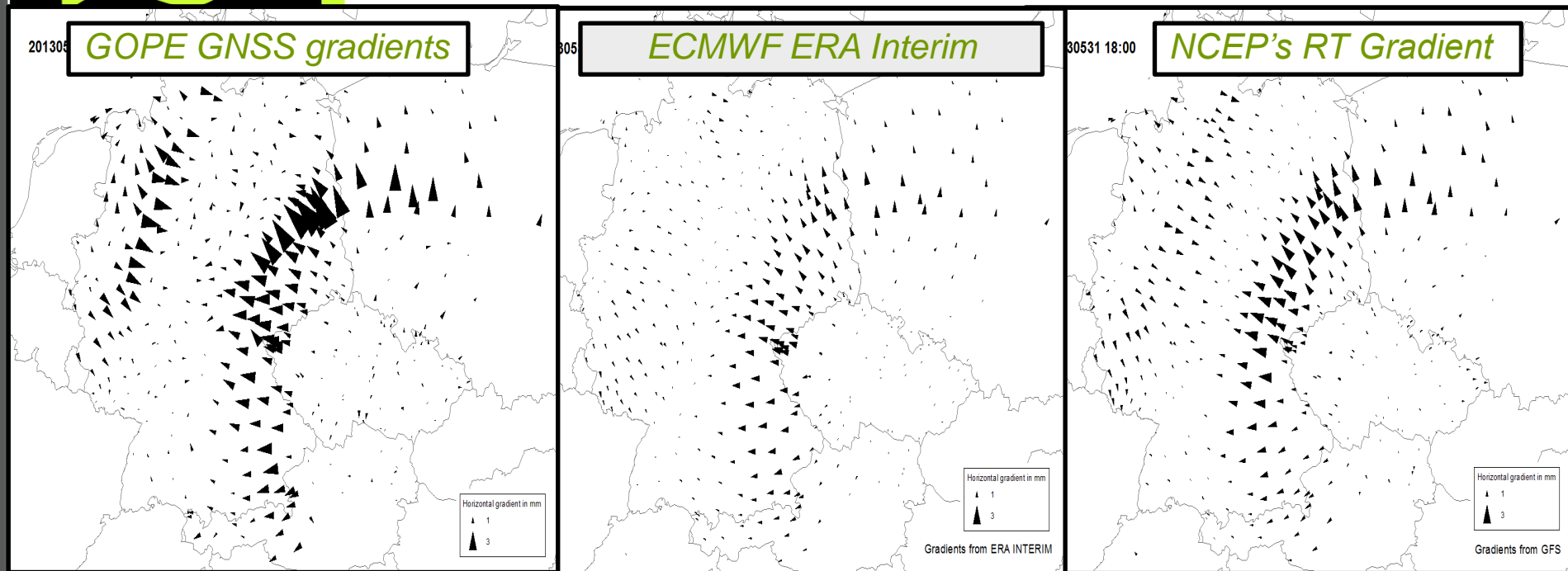
GOPE GNSS gradients

305

ECMWF ERA Interim

30531 18:00

NCEP's RT Gradient

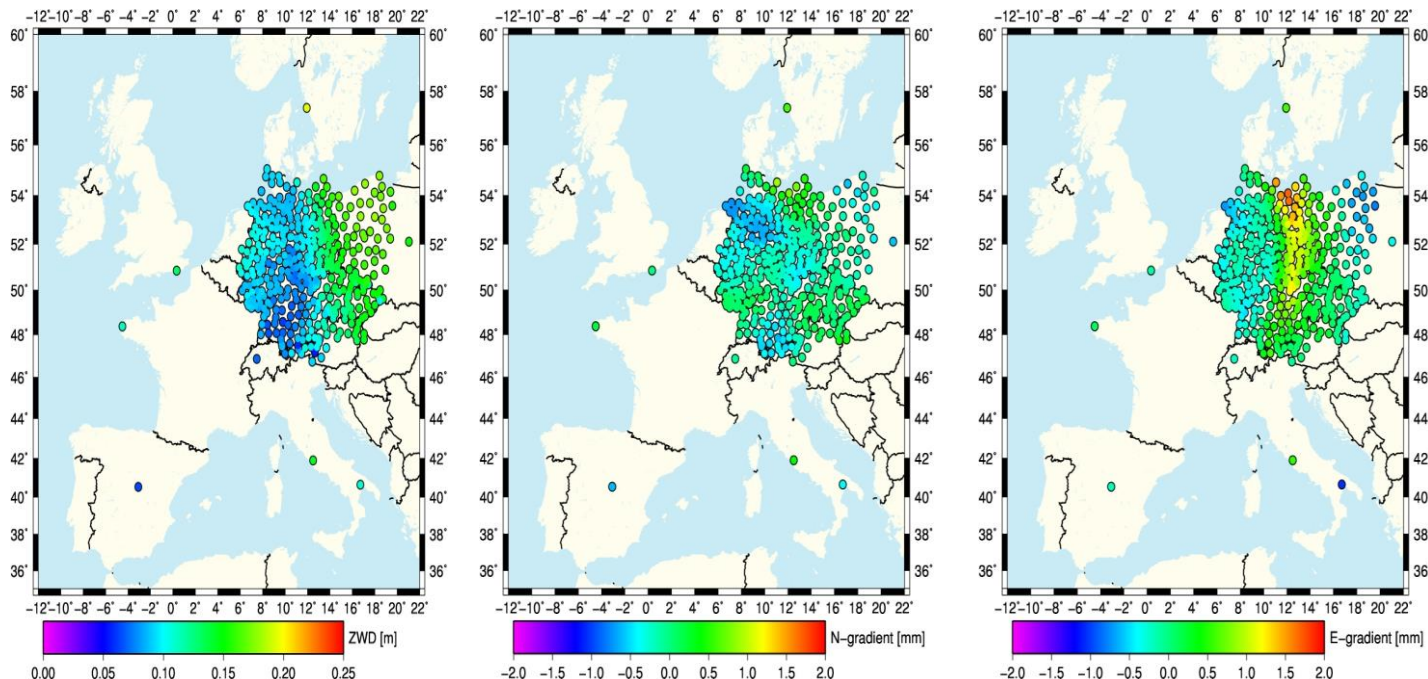


May 31, 2013 (Benchmark) – estimates of tropospheric gradients from GNSS & NWM

Advanced tropo-products: horizontal tropospheric gradients & slant delays

- Development of NRT/RT high-resolution gradients
- Development of NRT/RT slant delay retrievals including definition for new Tro-SINEX format standards
- Derivation of 1st and 2nd order troposphere gradients from NWM
- Inter-comparison of gradients and slant delays from GNSS, NWM and WVR

NWP-Based Positioning

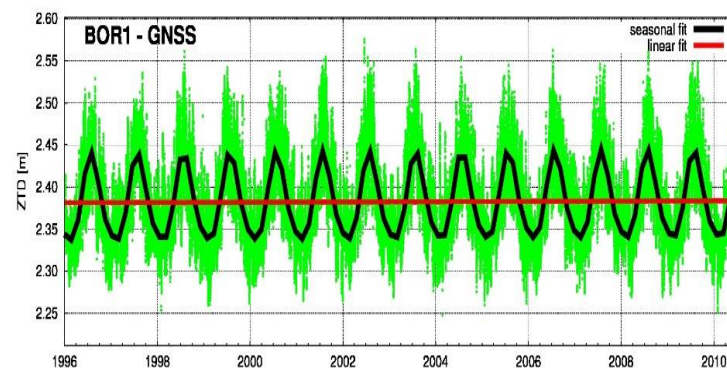
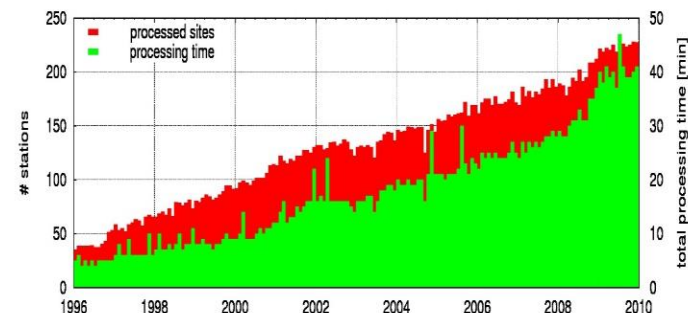


NWP-derived tropospheric parameters

- *to strengthen & accelerate GNSS real-time processing*
- *to improve re-analysis solutions*
- *to assess quality of NWP models*
- *to compare GNSS-troposphere with independent data*

Reprocessed GNSS Products

- Database established at GOP
- **EUREF Repro2: 1996-2014**
- 3 ACs process full EUREF Permanent Network (EPN)
 - ASI /E-GEOS (Gipsy/Oasis)
 - GOPE – Geodetic Observatory Pecny (BSW)
 - MUT – Military University of Technology (GAMIT)
- 2 ACs contribute with EPN subnetworks
 - LPT – Swisstopo
 - IGN – Instituto Geografico National



- **IGS Repro2:** waiting for IGS final PPP, available troposphere from CODE, GFZ (TIGA)
- **GRUAN:** focus on few stations – instrument collocation – activities in GFZ & ASI

Current Activities

- Preparation for Final Workshop
- Core Team meeting in Vienna (week of EGU)
- Starting work on Final Report
 - Made available to WG Chairs before Christmas
 - Made available to all Action members early 2017
 - Extra 10k Euro requested from COST for publication costs (has to be invoiced <1yr after end of Action)



Met Office

Questions

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