Current status and future of ground-based GNSS-meteorology in Europe

PS04-10

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Abstract

GNSS is a well established atmospheric observing technique which can accurately sense atmospheric water vapour, the most abundant greenhouse gas, accounting for up to 70% of atmospheric warming. Water vapour is typically under-sampled in modern operational meteorological observing systems and obtaining and exploiting additional high-quality humidity observations is essential to improve weather forecasting and climate monitoring.

This presentation will give an overview of COST Action ES1206 plus an overview of ground-based GNSS-meteorology in Europe in general, including current status and future opportunities.

Current Status (E-GVAP)

E-GVAP is the EUMETNET EIG GNSS water vapour programme. Established in 2005, it's aim is to provide EUMETNET members with European GNSS delay and water vapour estimates for operational meteorology in near real-time. The core of E-GVAP is a close collaboration between geodesy and meteorology. Raw data from GNSS sites are collected by a number (>10) of GNSS analysis centres, which process the data to Zenith Total Delay (ZTD). The ZTDs are forwarded to a central server, for distribution to meteorological institutes and for quality control and verification. Additionally, E-GVAP contributes meteorological data to the geodetic community, which can be used to validate GNSS delay estimates and also to improve GNSS positioning in the future.

- NRT delivery of around 22 Million ZTDs per month from around 3400 global sites
- 13 operational ACs with 18 in testing
- Focus is on GPS-only, hourly processing delivering only ZTDs in near real-time (90mins)
- Operational assimilation underway at a number of Euro NMHSs and testing underway at many more (incl. ECMWF) with a positive impact on NWP scores
- Surface T and P used for conversion from ZTD to IWV with NRT IWV maps made available for scientific and forecaster use

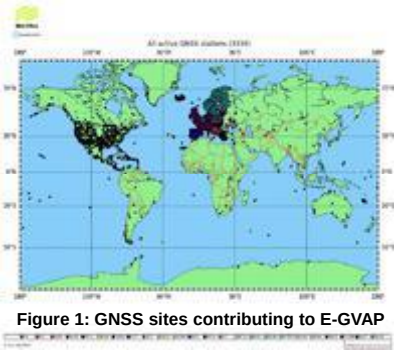

Figure 1: GNSS sites contributing to E-GVAP

COST Action ES1206

COST Action ES1206 is a 4-year project, running from 2013 to 2017, which is coordinating the research activities and improved capabilities from concurrent developments in the GNSS, meteorological and climate communities. For the first time, the synergy of multi-GNSS constellations is used to develop new, more advanced tropospheric products, exploiting the full potential of multi-GNSS on a wide range of temporal and spatial scales - from real-time products monitoring and forecasting severe weather, to the highest quality post-processed products suitable for climate research.

Figure 2: European participation in GNSS4SWEC

The Action also promotes the use of meteorological data as an input to real-time GNSS services and is stimulating the transfer of knowledge and data throughout Europe and beyond. For example, Through expertise sharing and close collaboration with the geodetic community and national mapping agencies, the Action has assisted in the creation of 8 new ACs and 8 new national GNSS networks delivering 250+ additional operational ZTDs for assimilation into numerical weather prediction models.

The Action consists of over 160 experts from over 40 countries, including collaboration/cooperation with several international programmes and organisations such as the IGS, EUREF, ECMWF, E-GVAP, GRUAN, HYMEX and EPOS. The Action also supports and integrates into a number of nationally funded research projects in the field of GNSS Meteorology. In addition to the European members, a number of institutes from around the World are also involved in the Action (Canada, USA, Tunisia, Hong Kong, and Australia), and we encourage additional participation from all parts of the globe from relevant meteorological, geodetic and climate communities. For more information see:

http://gnss4swec.knmi.nl/ and http://www.cost.eu/COST_Actions/essem/Actions/ES1206

Real-Time Processing Evaluation

- Use of IGS Real-Time global products for PPP (GNSS satellite orbits & clocks)
- Main aim is to develop and assess new software and strategies

http://www.pecny.cz/COST/RT-TROPO

Scope: Europe (15) + Globe (17)
Software: 6+1 types
Contributions: 7+1 Acs

AC	Software	Start	Update	Solutions
GOP	G-Nut/Tefnut	9.4. 2015	real-time	GPS, GLO, gradients
TUW	TUW software	15.4. 2015	real-time	GPS
ROB	G-Nut/Tefnut	23.4. 2015	real-time	GPS, GLO, gradients
ASI	Gipsy-Oasis	5.5. 2015	hourly	GPS, gradients
UL	*(PPP-wizard)*	*15.6. 2015*	*real-time*	*GPS*
ICS	G-Nut/Shu	12.7.2015	forecast	WRF model (EU, CZ)
TUO	RTKLib	5.11.2015	real-time	GPS
BKG	*BNC*	*1.3.2016*	*real-time*	*GPS, GLO*

Figure 3: Table of RT GNSS solutions

Figure 4: RT Tropospheric GNSS monitoring

Multi-GNSS Tropospheric Products

- Several software developed/adapted for multi-GNSS data processing
- GLONASS partly integrated in various NRT & RT-Demo solutions

- Since November 2015 GFZ is providing ultra-rapid multi-GNSS orbit and clock product (GBU) every 3 hours:
- Products include GPS, GLO, GAL, BDS and QZSS satellites
- Latency is less than 2 hours since the last observation

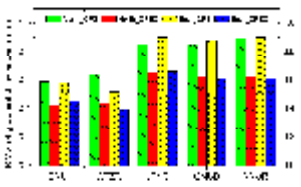

Figure 5: RMS of multi-GNSS tropo. gradients vs. those from NWP

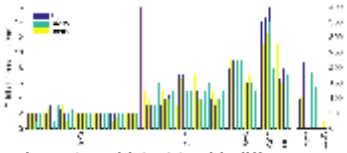

Figure 6: Multi GNSS orbit differences

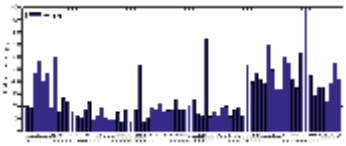

Figure 7: Multi GNSS clock differences

EUREF Repro2

- 1996-2014 reprocessed GNSS data database established at GOP

- 3 ACs process full EUREF Permanent Network
  - ASI /E-GEOS (Gipsy/Oasis)
  - GOPE – Geodetic Observatory Pecny (BSW)
  - MUT – Military University of Technology (GAMIT)
- 2 ACs contribute with EPN sub-networks
  - LPT – Swisstopo
  - IGN – Instituto Geografico National

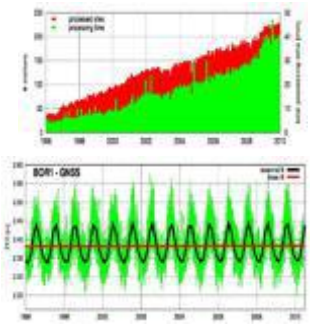

Figure 8: No. of sites and BOR1 ZTD trend

Long Term NCEP Model Validation

NCEP model - good seasonal and inter-annual variations but underestimates IWV of <40% in tropics and <25% in Antarctica. http://publications.lib.chalmers.se/records/fulltext/57389.pdf

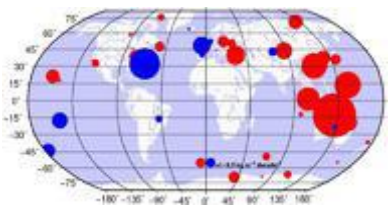

Figure 9: Global IWV trend: -1.65 to +2.32 kg/m² per decade

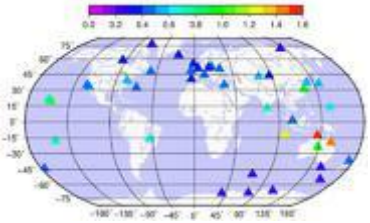

Figure 10: Global trend uncertainty: 0.21 to +1.52 kg/m² per decade

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