NEAR REAL TIME GPS ZENITH TOTAL DELAY ESTIMATION IN THE MEDITERRANEAN AREA: RESULTS OF 3 YEARS OF ROUTINE PROCESSING

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Outlook of the talk

- Ground Based GPS Meteorology: Fundamenta{l Equation Activities at CGS
- GPS processing strategies for ZTD estimation
- GPS ZTD validation
  - NRT versus “precise” Post Processed ZTD
  - NRT within COST-716 & TOUGH
A mapping function is applied to determine how the signal delay changes with elevation angle. The results are averaged over all the satellites to give the ZTD.

\[ L_s = 10^{-6} \int N(s) \, ds \]

\[ N = k_1 \cdot \left( \frac{P_d}{T} \right) + k_2 \cdot \left( \frac{e}{T} \right) + k_3 \cdot \left( \frac{e}{T^2} \right) \]
Tropospheric Delay

GPS Atmospheric Delay

TOTAL ATMOSPHERIC DELAY

IONOSPHERIC DELAY

HYDROSTATIC DELAY

TROPOSPHERIC DELAY

WET DELAY

ZTD vs ZHD

ZTD vs ZWD

Most of the variability in the ZTD is caused by water vapor in the lower troposphere.
From GPS Observable to Meteo Forecast

\[ \lambda_i \phi_i = \rho + d_{\text{clock}} - d_{\text{iono}_i} + d_{\text{tropo}} + \lambda_i N_i + \epsilon_i \]

GPS observable

data reduction → ZTD

Noise for Geodesy
Signal for Meteorology

ZTD = ZHD + ZWD

assimilation

IPWV

Forecast rain with GPS -DMI

Meteo Forecasts

EUREF 2004 Symposium, Bratislava, 2-5 June 2004
ASI Ground-Based GPS Met Activities

GPS Orbits
ERP
GPS sat. clocks

Nominal latency 15 days

January 1999

Post-Processing
Daily PPP solution
•ZTD
•Site Position

Nominal latency 1h45min

GPS RNX files

Near-Real Time
Network solution, SLW
•ZTD

IGU Orbits
ERP
Site Position

June 2001

GPS Met Products

VALIDATION
•WVR
•RADIOSONDES
•VLBI
•NRT vs PPP
•NRT vs NRT

February 2003

USERS
•NWP
•ENVISAT Sensor CAL/VAL

EUREF 2004 Symposium, Bratislava, 2-5 June 2004
Near Real Time Processing

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<td>Output</td>
<td>ZTD in COST V2 format</td>
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<td>4 scores per hourly solution every 15 min (at h:00, h:15, h:30, h:45)</td>
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Processing Schedule in Operation NRT Mode

-1h  h
Data recording

h:15
Waiting time

h:45
Data ftp and Processing

ZTD deliver to MetO

IGU obits not available

ZTD (mm)

04 Oct 05 Oct 06 Oct
04 Oct 05 Oct 06 Oct
2330 2340 2350 2360 2370 2380 2390 2400 2410 2420 2430 2440
06h 18h 05h 18h 06h

GF2  GOPE  IIEC  ASI  LPT  NKGS  ACR1  HL22

(c) KNMI/COST716

Created: 06/10 06:34
Ground-Based GPS Network

GPS Data Provider

ASI, EPN LDC, Italy
BKGE, EPN RDC, Germany
BKGI, IGS RDC, Germany
ESOC, Germany
IGN, EPN LDC, France
IGNI, IGS GDC, France
OLG, EPN LDC, Austria

80 stations in Post-Processing
40 stations in NRT
NRT Solution Statistics

% hourly solutions - average 93%

% analyzed stations in each hourly solutions - average 78%

Processing time – average 48 min
Ground-Based GPS Meteorology

The basic principles of the technique are briefly explained here. The GPS ground network covers the central and southern Europe. Over Italy it has a spatial resolution higher than in other regions since all available Italian permanent sites are included in these analyses. All the stations are analyzed in Post-Processing Mode (i.e. for climate research, 15 days latency), most of them in Near-Real Time Mode (i.e. for meteorological applications, 1h45 latency).

Click on the list of names to see Post-Processing and Near-Real Time ZTD estimates:

- Hourly check Import solution file - 2003, 2004
- Hourly solution statistics - 2003, 2004
- Site Coordinates - Monthly update

These activities have been developed in the framework of:

- MAGIC EC Project
- Demonstration Campaign of the EC COST Action 716
- TOUGH EC Project. TOUGH is a shared-cost project (contract EVG1-CT-2000-00080) co-funded by the Research DG of the European Commission within the RTD activities of the Environment and Sustainable Development sub-programme (5th Framework Programme)
- CERGOS 1 EC Project
- MAGIC_2 Project

Available Products

For questions and comments, please contact:

Back to:

- Introduction
- Space-Based GPS
MATERA

Site ID: MATE (ITALY)
Lat: 40.648131
Lon: 10.701450
H.WGS84: 535.638m
H.EL: 490.058m
Receiver Type: IDM MtL E 4UU/SS
Antenna Type: TRM 26650 00
Pressure Sensor Model: DPI 141 DRUCK
Temperature Sensor Model: VAISALA HMD70Y
Humidity Sensor Model: VAISALA HMD70Y

Post-Processed ZTD available since 99jan01
Near-Real Time ZTD available since 01jun08

Quality Check

TEQC Output - Daily update

Hourly files per day

Hourly files analyzed for each day - Daily update

Coord. Repeatability

Monthly update

Post-Processed ZTD

Nominal Latency 15 days

Near-Real Time ZTD

Nominal Latency 1h 45min

Pressure

Latest 24h Pressure - Hourly update

Temperature

Latest 24h Temperature - Hourly update

Relative Humidity

Latest 24h Relative Humidity - Hourly update

July 1993 - October 2003
- Pressure
- Temperature
- Relative Humidity

January 1999 - October 2003
- ZTD time series

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Station coordinate repeatability

Heights coordinate repeatability as indicator for ZTD quality

9mm H → 3mm ZTD → 0.45mm PW
NRT versus Post-Processed ZTD
Monthly mean bias and std
June 2001-April 2004

[6mm ZTD ≈ 1mm IPWV]
Daily ZTD variation w.r.t Post-Processed

2002-2003 bias and std

No daily cycle observed in ZTD bias

Slight increasing observed in ZTD std
TOUGH is an interdisciplinary project between 15 institutes with expertise in the GPS system and numerical weather prediction. It runs from February 2003 to February 2006.

TOUGH is a shared-cost project (contract EVG1-CT-2002-00080) co-funded by the Research DG of the European Commission within the RTD activities of the Environment and Sustainable Development sub-programme (5'th Framework Programme).
NRT ZTD in TOUGH - Monthly bias & sdt

- ASI-GOPE bias
- ASI-LPT bias
- ASI-GOPE std
- ASI-LPT std
NRT ZTD in TOUGH – Daily bias & sdt

Mate bias

Useful to detect ‘bad’ daily solution

Mall bias

Mate std

Mall std
MALL station

Why are there \( \approx 12 \text{mm} \) ZTD bias w.r.t EUREF and GOPE?

Site coordinates (01jun03-04mar24)
Weekly Euref – Weekly PPP N, E, U

Station Equipment
TRIMBLE 4000SSI+TRM29699.00Dome

1. Same phase center correction?
2. Different response of different sw (Bernese and Gipsy)?
Plans For The Future

- We will continue GPS data processing in NRT and PP within TOUGH & CERGOP2;
- We are establishing a regional network of permanent GPS receivers;
- We are studying new algorithms to integrate ground based GPS and RO.