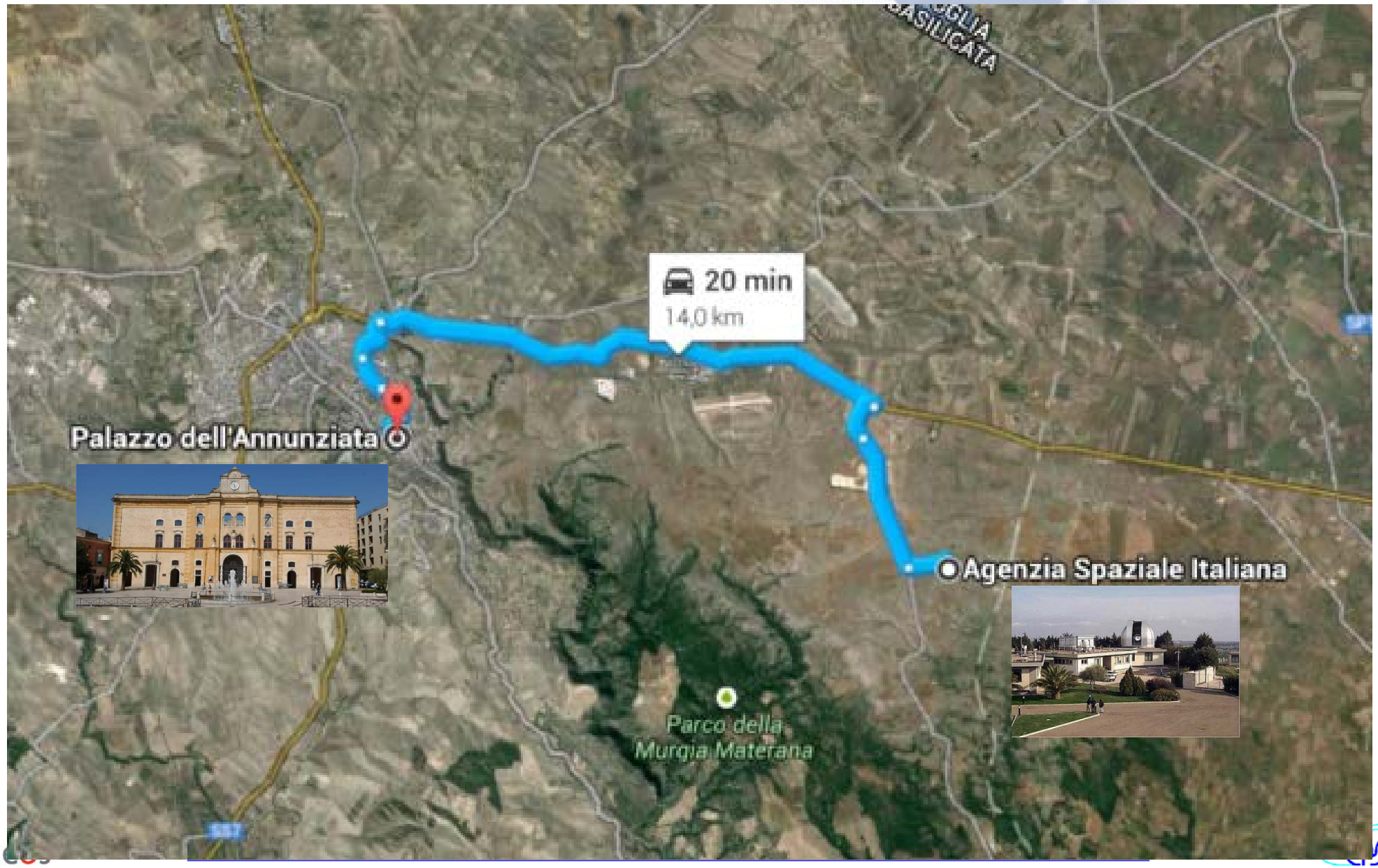
GNSS Analysis for Climate Monitoring and Meteorological Applications at ASI/CGS, Matera

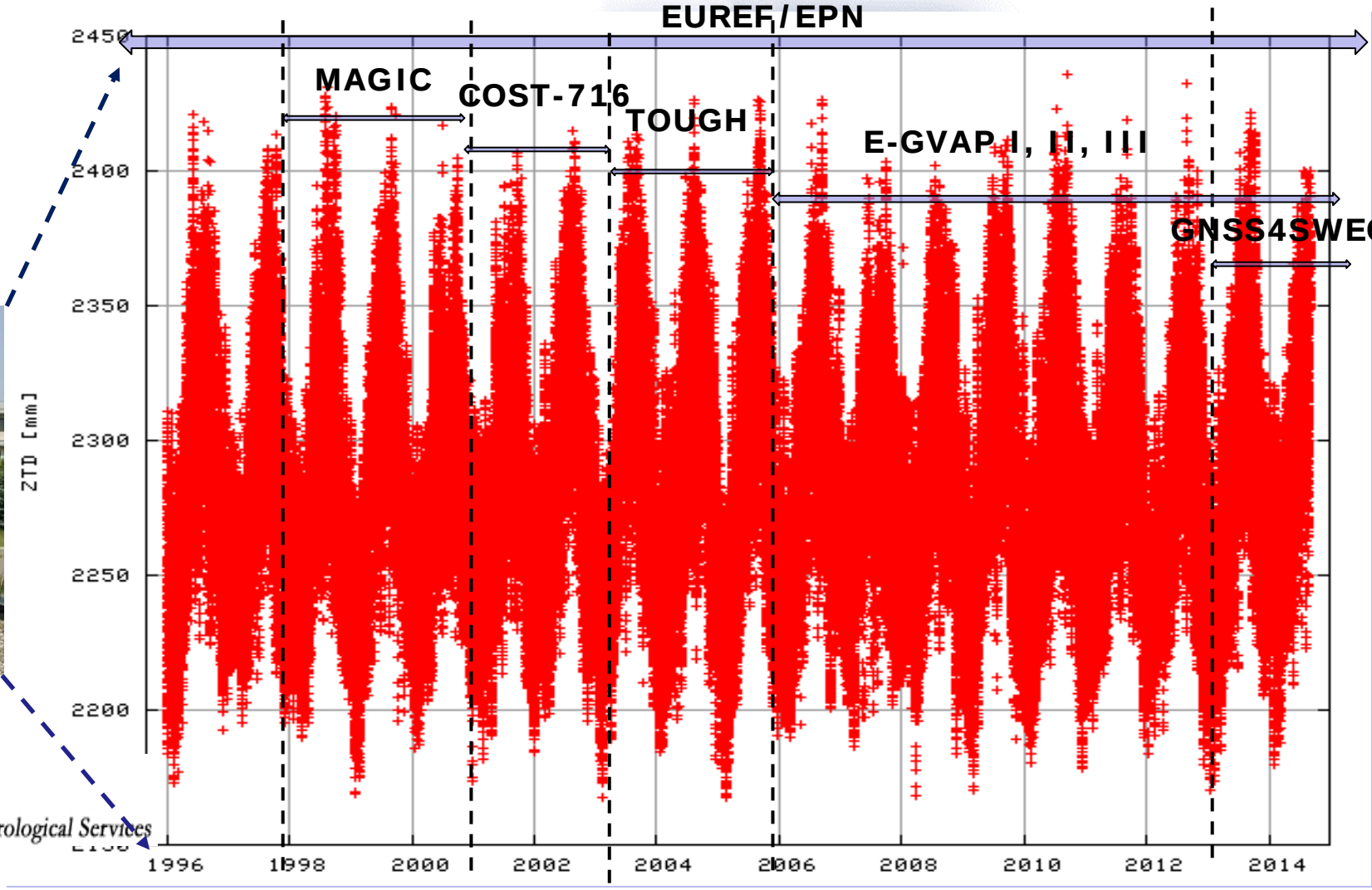
R. Pacione, B. Pace e-geos ASI/CGS Matera, Italy

G. Bianco, Agenzia Spaziale Italiana, CGS – Matera, Italy

Where ASI / CGS is located



Matera ZTD time series



EUMETNET
The Network of European Meteorological Services

Tropospheric solutions to E-GVAP

4 solutions delivered to E-GVAP

EUMETNET
The Network of European Meteorological Services

ASI_

Available from June 2001
Input: hourly RNX files/IGU
Update cycle: hourly
Purpose: NWP data assimilation

Operational
4 scores per hour every 15 min
COSTV2.0/ZTD + gradients

ASIC

Available from November 2008
Input: hourly operational cost solutions
Update cycle: hourly
Purpose: NWP data assimilation + QC

Operational
4 scores per hour every 15 min
COSTV2.0/ZTD

ASIS

Available from January 2014
Input: RT GNSS observation/IGS RT
Update cycle: 15min
Purpose: test RT obs+prod in sub-hourly PPP for nowcastiong

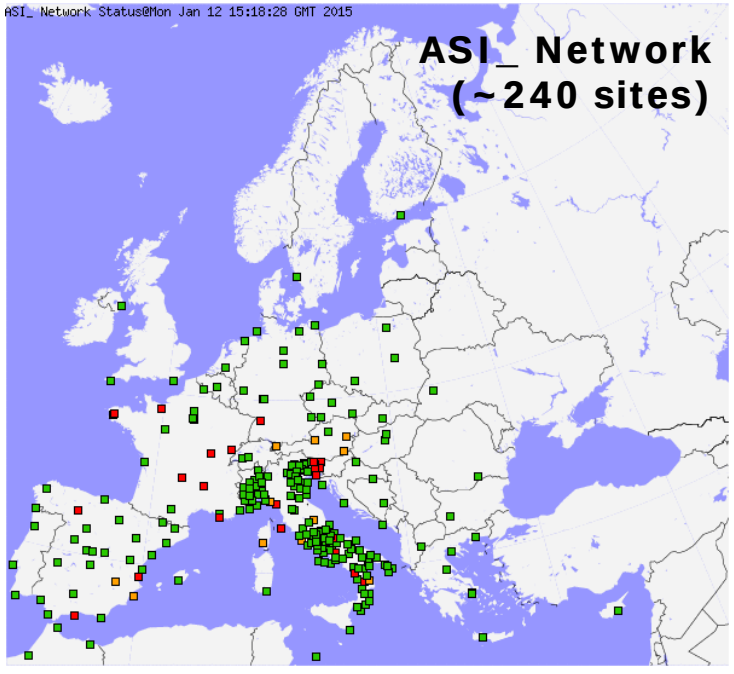
Test
4 scores per hour every 15 min
COSTV2.2/ZTD + gradients

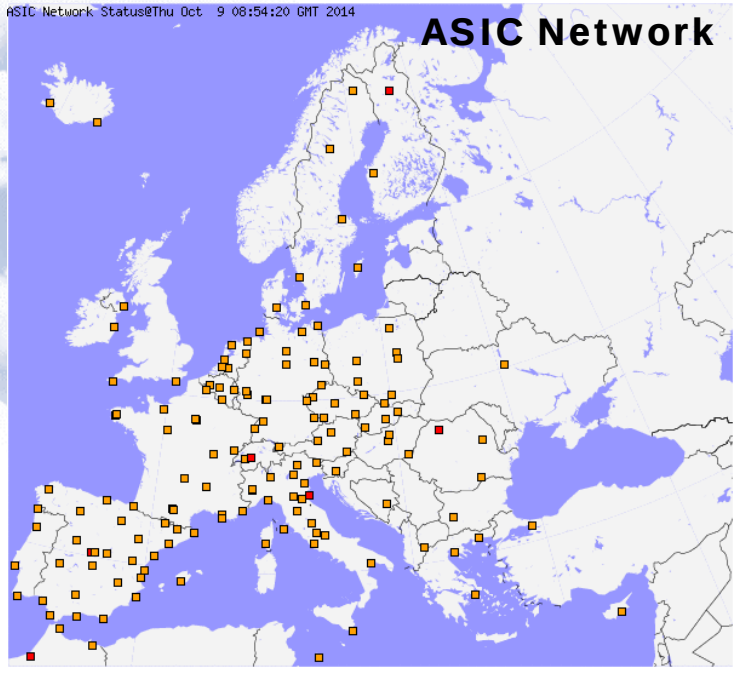
ASIR

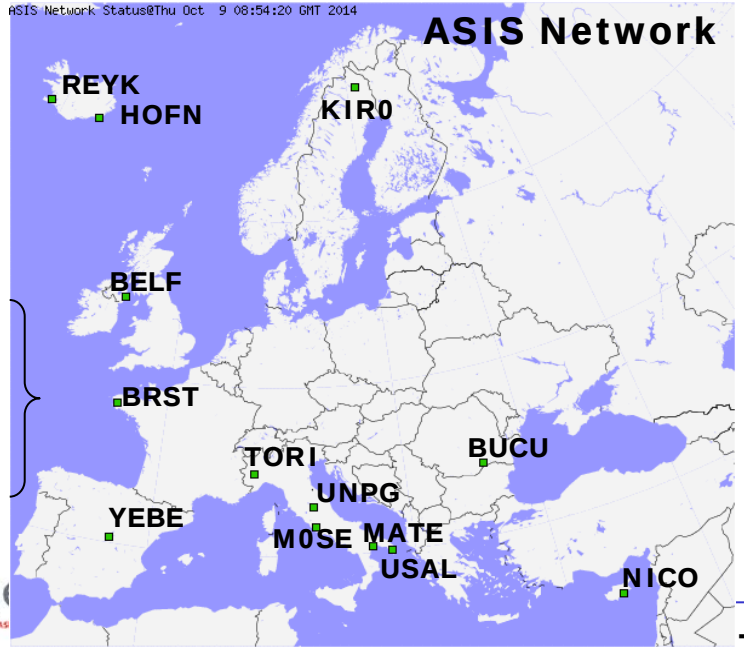
Available from March 2014
Input: Hourly RNX files/IGS RT
Update cycle: hourly
Purpose: test IGS RT prod in hourly PPP for NWP

Test
4 scores per hour every 15 min
COSTV2.2/ZTD + gradients

GNSS Networks analyzed for E-GVAP

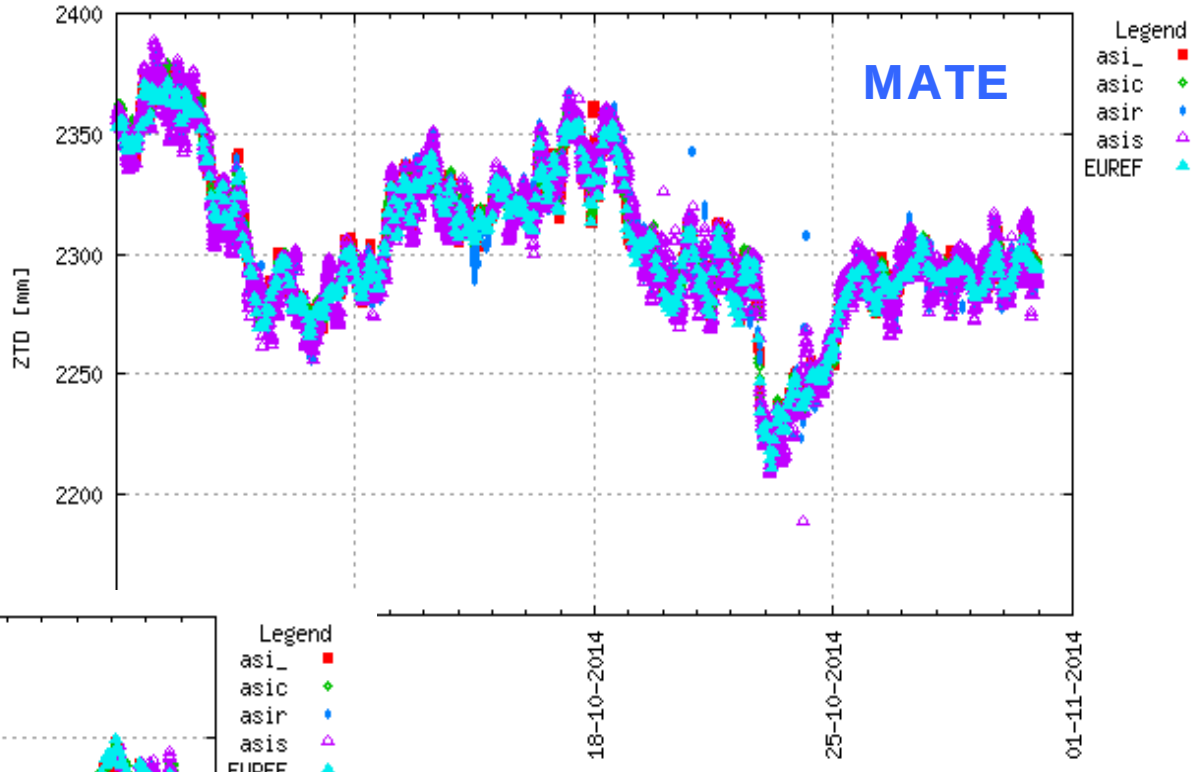






ZTD time series ASI_, ASIC, ASIR and ASIS

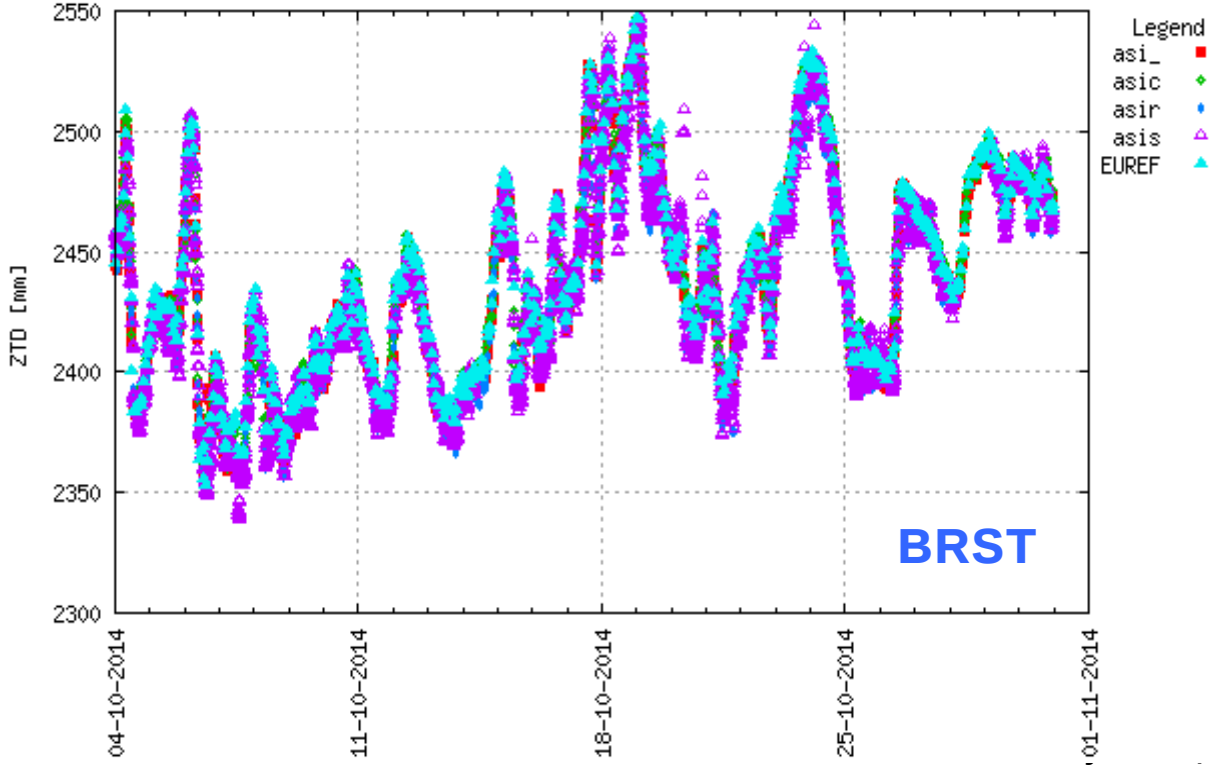
Period: October, 2014



MATE Comparison Table

Units are mm

MATE	#	MEAN	STD
EUREF-ASIC	643	-2,2	2,6
EUREF-ASI_	617	-1,7	3,3
EUREF-ASIR	623	-1,3	8,5
EUREF-ASIS	622	-0,3	7,6



BRST Comparison Table

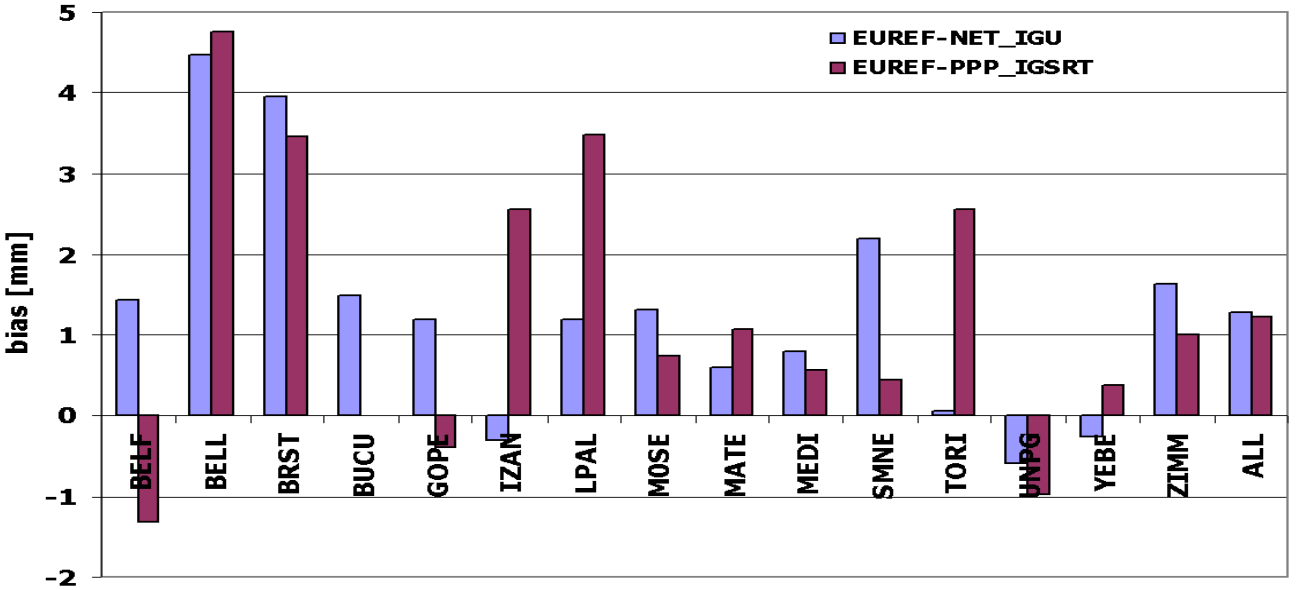
Units are mm

BRST	#	MEAN	STD
EUREF-ASIC	642	0,3	3,8
EUREF-ASI_	609	2,6	3,7
EUREF-ASIR	622	5,0	7,6
EUREF-ASIS	606	4,5	9,0

ASIR performance

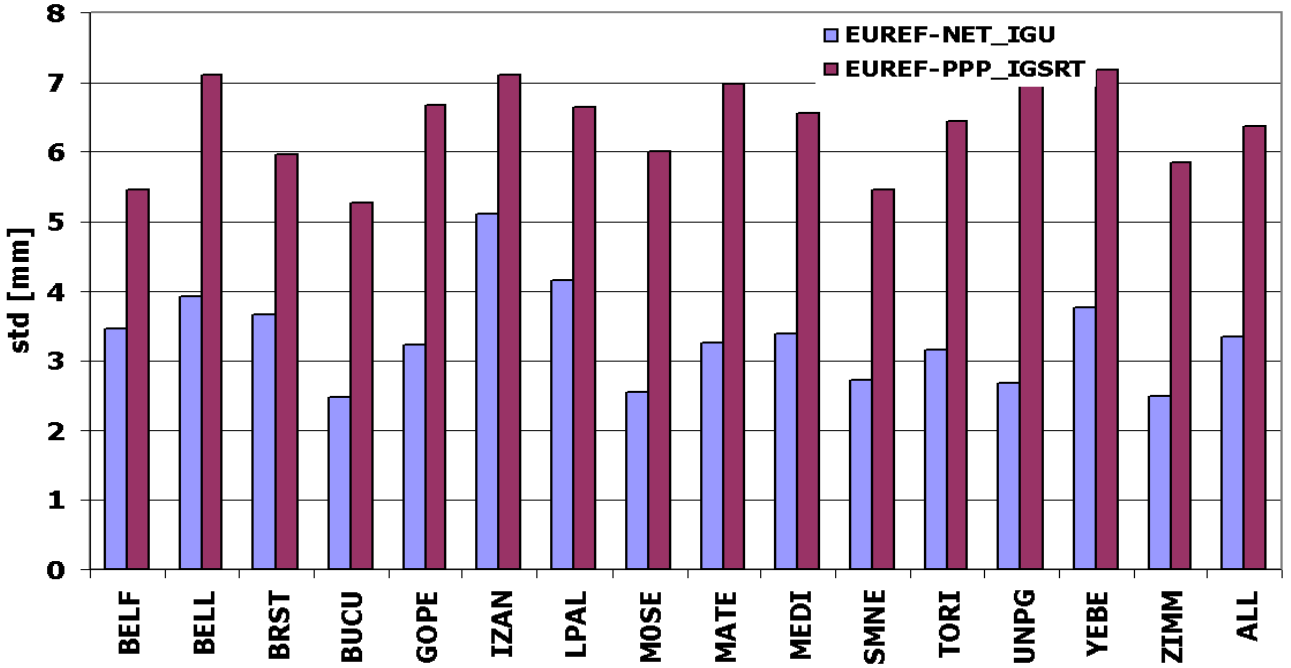
	IWV		
	Threshold	Breakthrough	Goal
Horizontal Domain	Regional (e.g. Europe, N. America)		
Horizontal Sampling	250 km	25 km	3 km
Observation Cycle	12 h	6 h	1 h
Accuracy	5 kg m^{-2}	2 kg m^{-2}	1 kg m^{-2}
Timeliness	6 h	30 min	5 min

GNSS-Met Observational requirements for Regional NWP



	IWV		
	Threshold	Breakthrough	Goal
Horizontal Domain	Sub-regional (a few 100 km)		
Horizontal Sampling	50 km	10 km	5 km
Observation Cycle	30 min	10 min	5 min
Accuracy	5 kg m^{-2}	2 kg m^{-2}	1 kg m^{-2}
Timeliness	30 min	10 min	5 min

GNSS-Met Observational requirements for Now-Casting

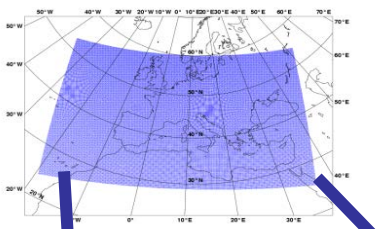


E-GVAP II Product Requirements Document

CNMCA NWP SYSTEM since June 2011

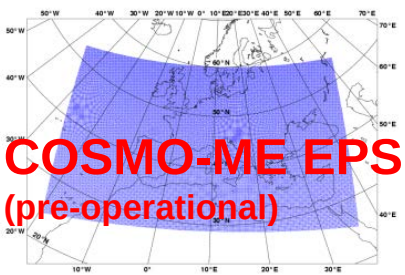
LETKF analysis ensemble (40+1 members) every 6h using RAOB (also 4D), PILOT, SYNOP, SHIP, BUOY, Wind Profilers, AMDAR-ACAR-AIREP, MSG3-MET7 AMV, MetopA-B/Oceansat2 scatt. winds, NOAA/MetopA-B AMSUA/MHS/ATMS radiances
+ Land SAF snow mask,
IFS SST analysis once a day

Ensemble Data Assimilation:



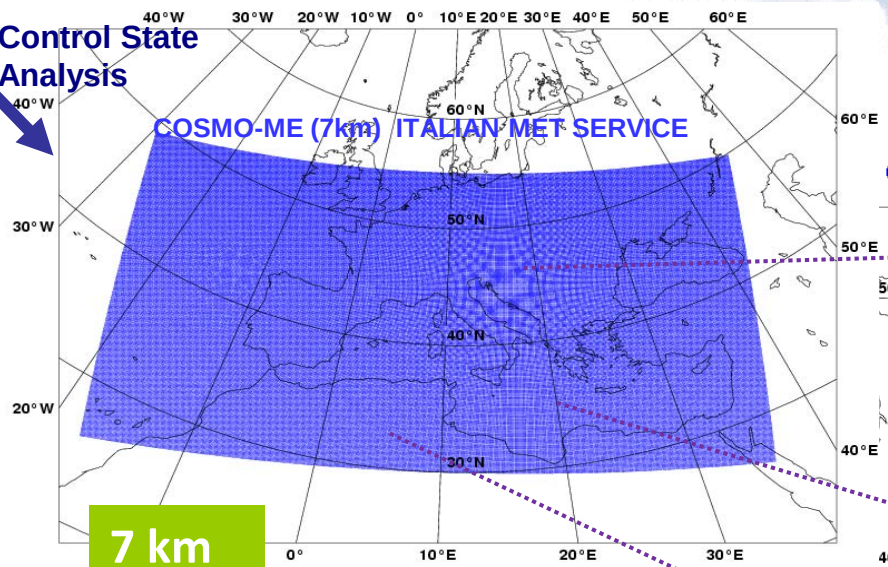
10 km
45 v.l.

LETKF Analysis



COSMO-ME EPS
(pre-operational)

Control State Analysis

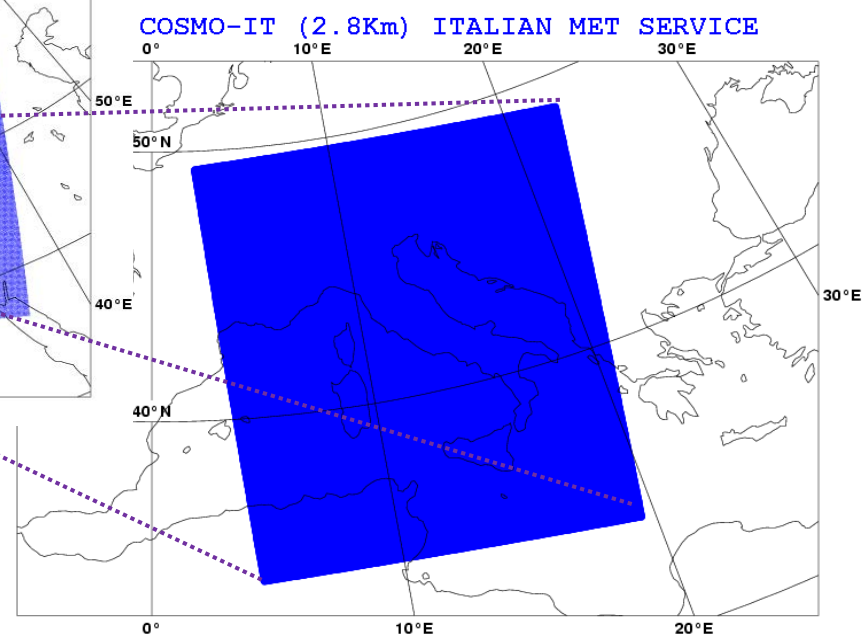


7 km
40 v.l.

- compressible equations
- parameterized convection

2.8 km
65 v.l.

- compressible equations
- explicit convection

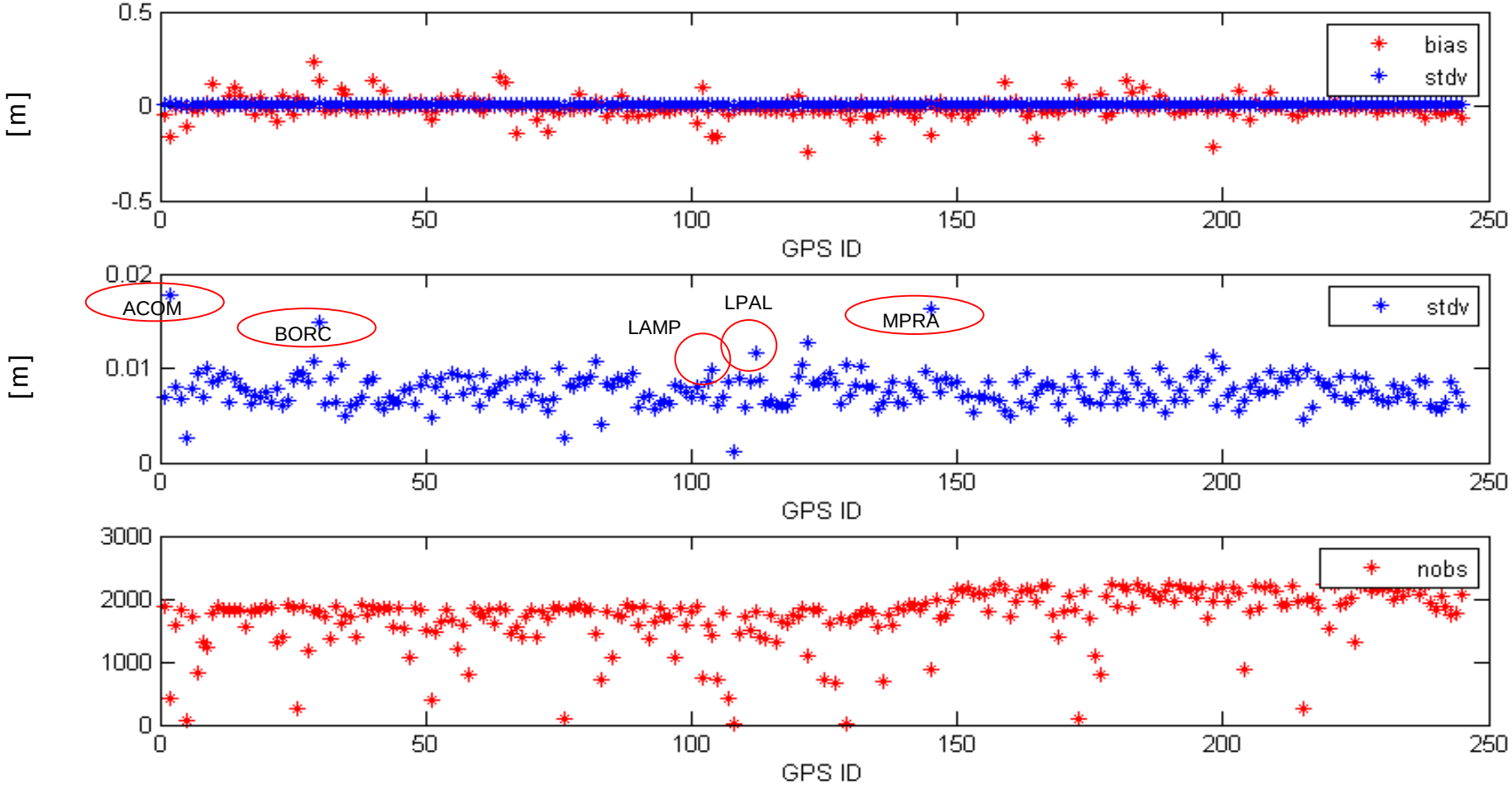


Contribution from
Lucio Torrisi and Francesca Marcucci
Centro Nazionale di Meteorologia e Climatologia Aeronautica (CNMCA), Italian National Met Center

Italian GPS stations monitoring statistics (ZTD)

Monitoring using CNMCA-LETKF system

Period : February 01-28, 2014

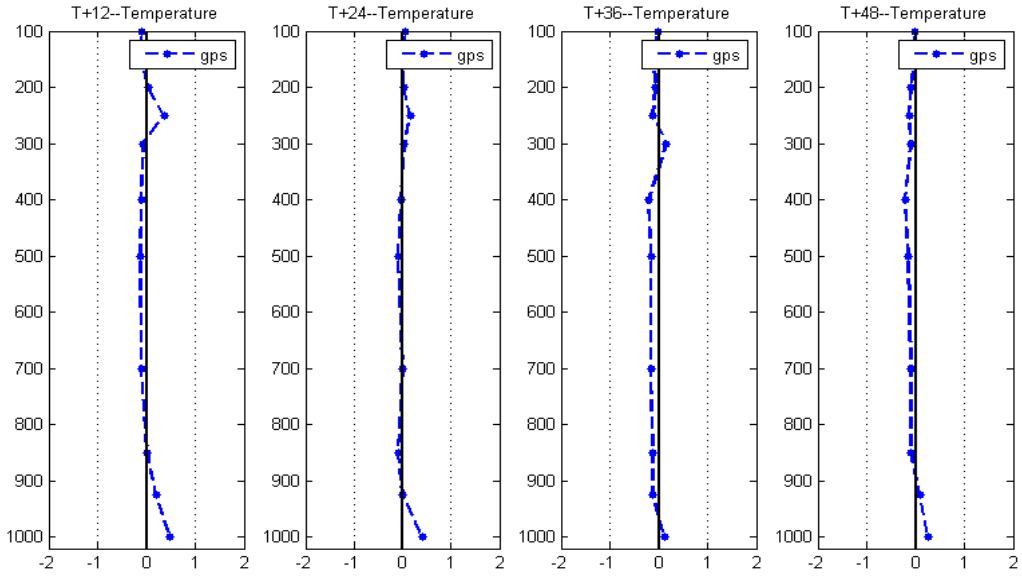


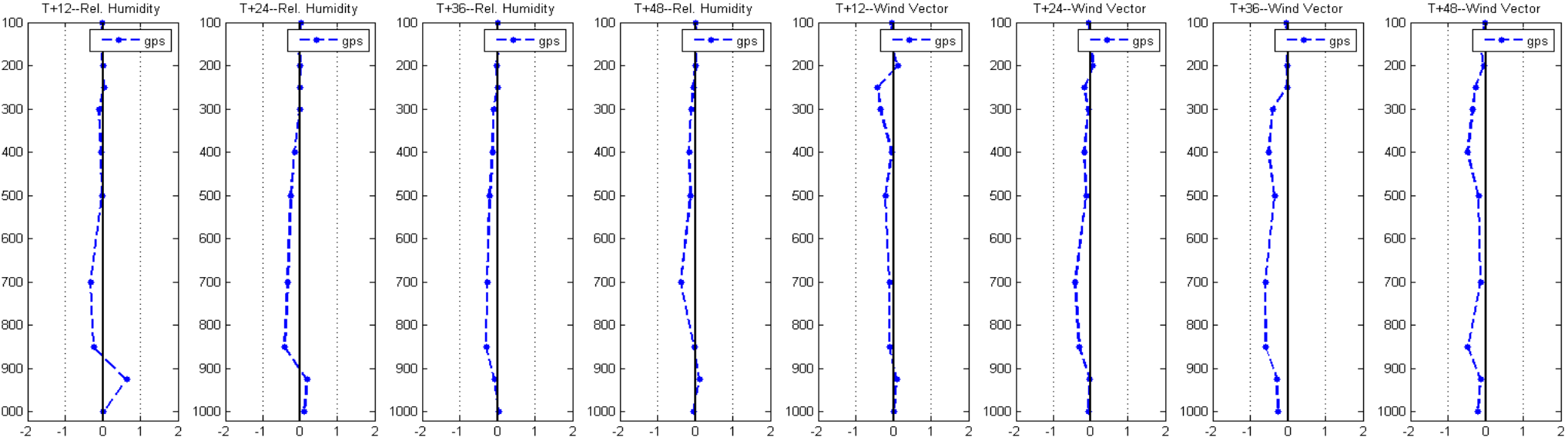
GPS Station Assimilation

Thinning=60km

Relative difference (%) in RMSE computed against IFS analysis for 00 UTC COSMO runs from 11-01-2014 to 30-01-2014

negative value = positive impact





Tropospheric solutions to EUREF

3 solutions delivered to EUREF

ASI

From 2001 to today
Input: daily RNX files of ASI LAC EPN sub-network/IGS final
Update cycle: daily — 12 scores per day every h
Purpose climate monitoring — SINEX/ZTD + gradients

EUR

From July 2014 to today
Input: daily operational EPN LAC solutions — 12 scores per day every h
Update cycle: daily
Purpose *climate monitoring + QC* — SINEX/ZTD

Repro2

Available from 1996 to 2014
Input:daily RNX files of EPN network/IGS final
Update cycle: daily — 12 scores per day every h
Purpose climate monitoring — SINEX/ZTD + gradients

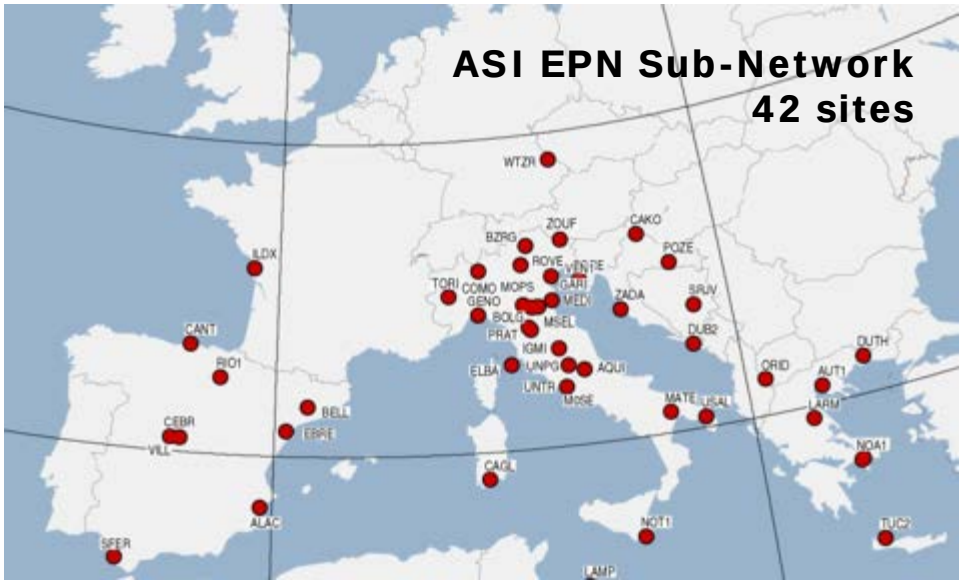
1 solution for internal use only

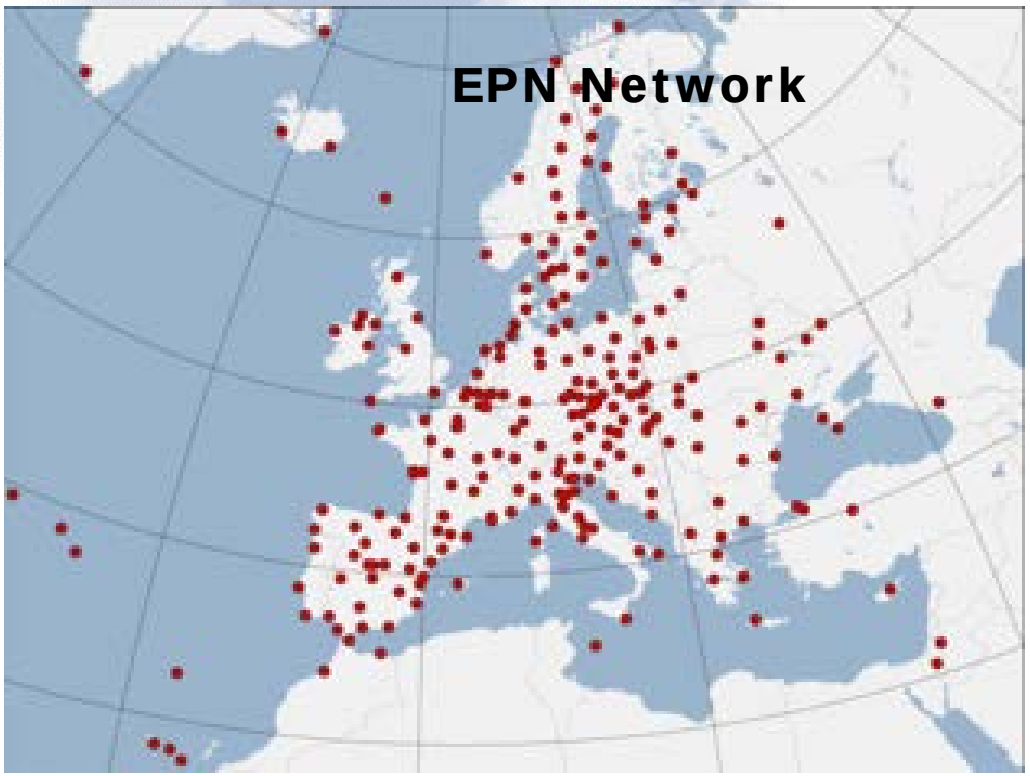
ASIP

Available from 2000 to today
Input:daily RNX files of Italian network/JPL final
Update cycle: daily — scores every 5 min
Purpose coordinates monitoring — SINEX/ZTD + gradients

GNSS Networks analysed for EUREF

http://www.epncb.oma.be/





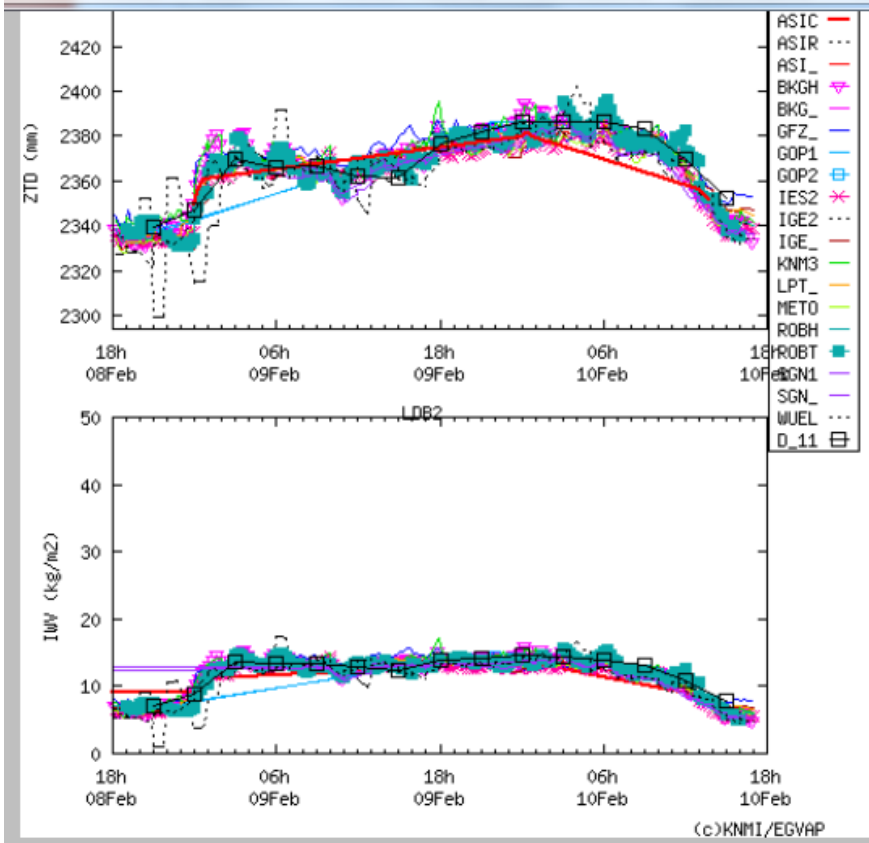
Why a Combined ZTD Solution

The driver of a *combined solution* is the need of having an internally consistent ZTD product on the basis of several individual solutions, obtained from parallel processing.

Combining these solutions:

- ➢allows to give feedback to the individual AC in case of problems,
- ➢is a tool for Quality Control.

LDB2 E-GVAP Processing



ZTD

7day stat. 2013/05/19 - 2013/05/27

AC	num	bias	RMS	stddev
ASIC	54	-0.2	9.0	9.0
BKG	54	-1.3	8.3	8.2
GFZ	54	3.4	9.8	9.2
KNM3	54	0.2	9.9	9.9
LPT	51	-1.1	8.4	8.3
METO	54	-0.6	10.8	10.7
NGAA	54	-2.4	11.0	10.7
ROBH	54	-0.3	9.6	9.6
SGN1	54	-1.9	8.5	8.2
SGN	54	-2.3	8.6	8.3
TEST				
ASI1	54	1.9	7.9	7.7
BKGH	54	-2.2	10.9	10.7
GOP3	54	-1.5	8.0	7.9
IES2	50	1.3	8.6	8.5
ROBT	54	0.6	10.7	10.6
WUEL	46	-2.4	10.3	10.0

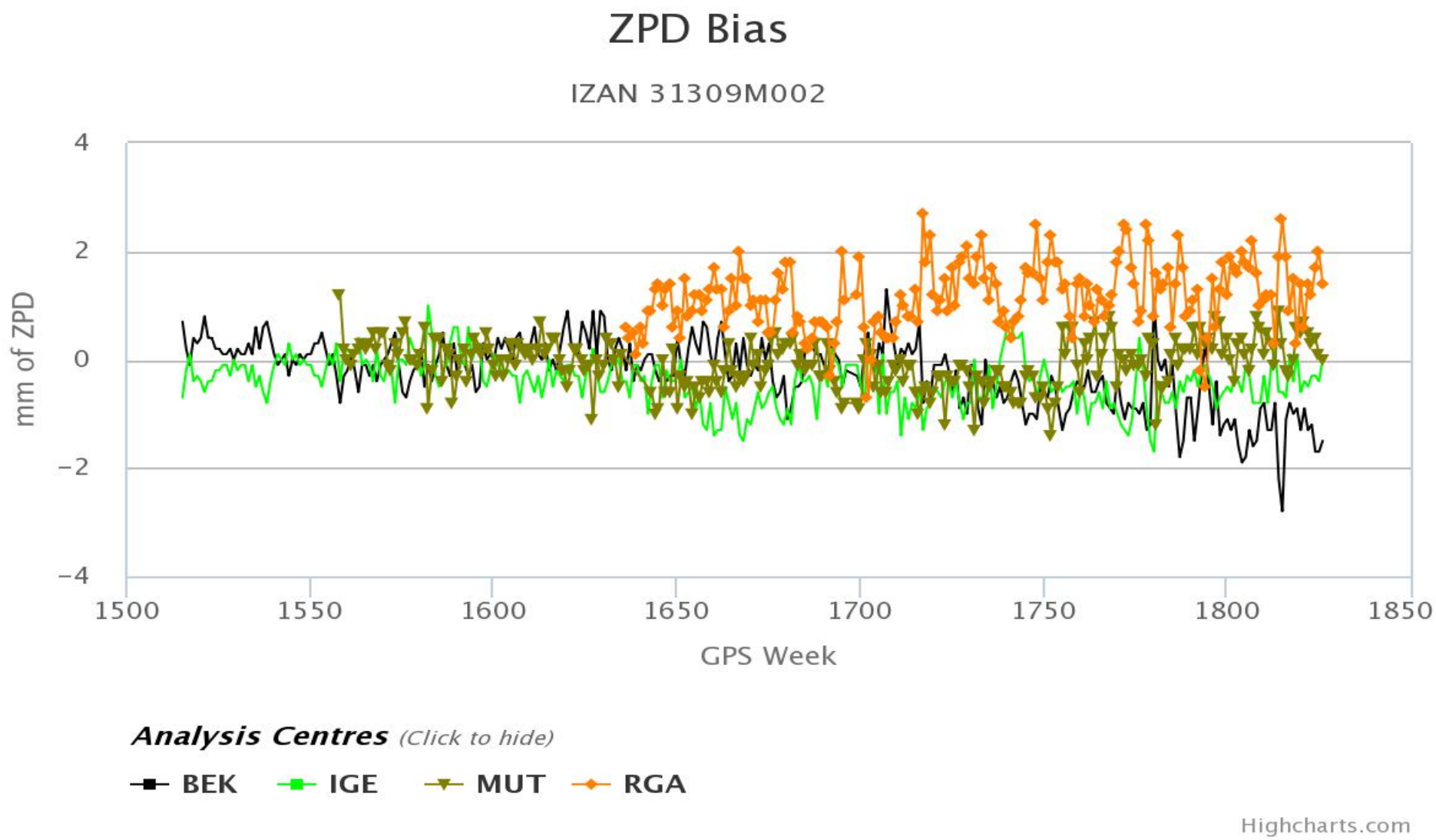
Graphical location of the site

latitude	52.20910
longitude	14.12090
altitude	183.45

Notes

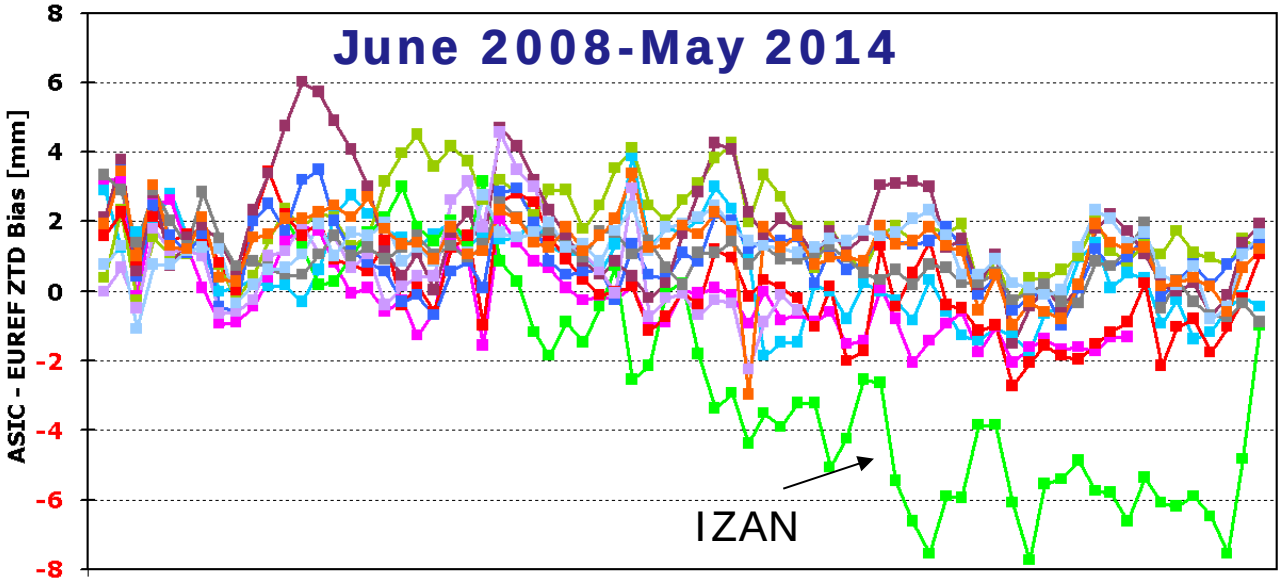
- Statistics are updated daily
- GPS ZTD are interpolated to NWP analysis time

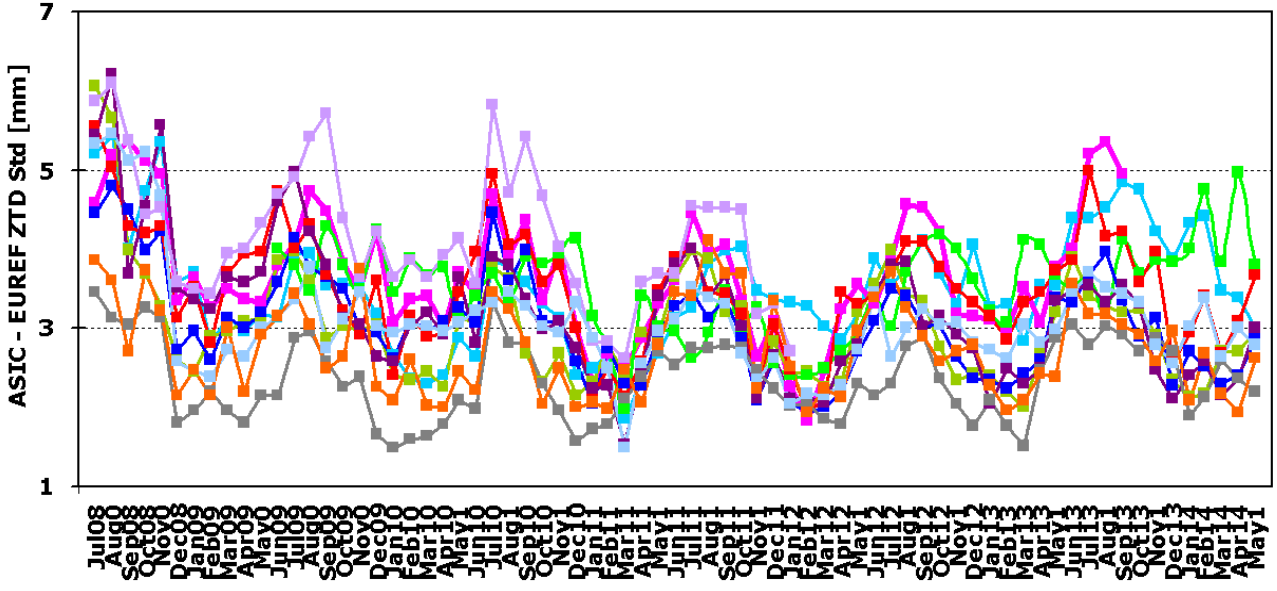
Combined solution in EUREF Processing



http://www.epncb.oma.be/_productsservices/troposphere/daily_zpd_biases.php?station=IZAN_31309M002

E-GVAP Combined versus EUREF combined





BRST CAGL GOPE IZAN MATE MOSE

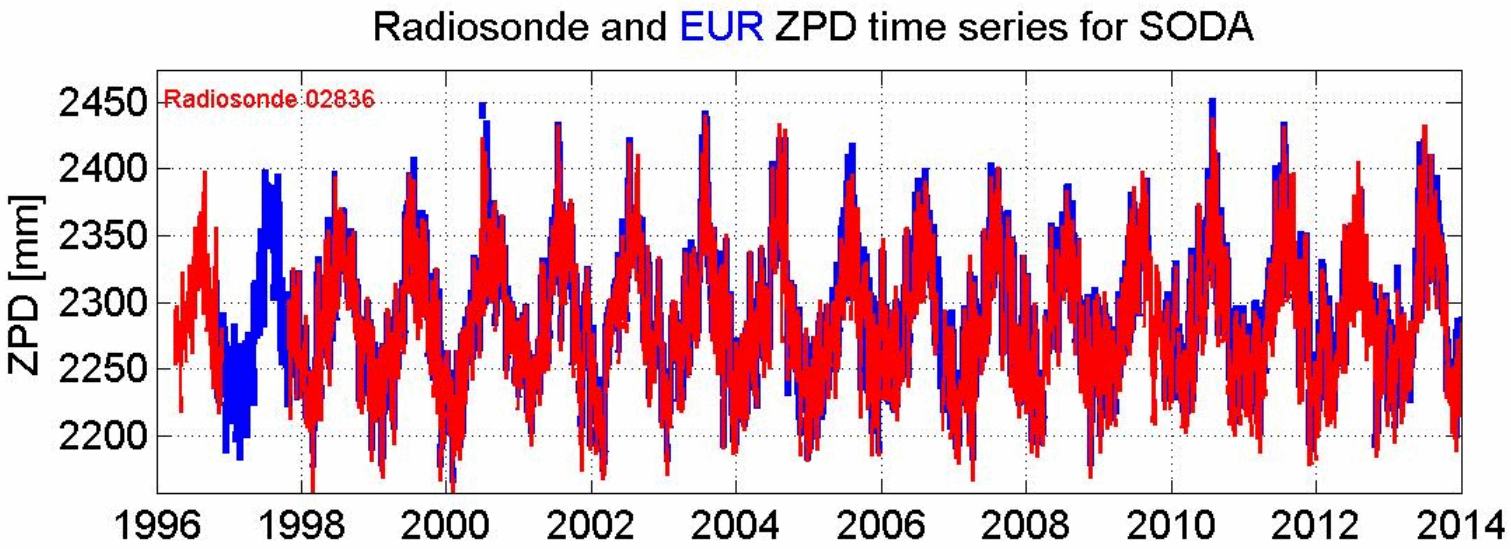
MEDI MILO ONSA YEBE ZIMM

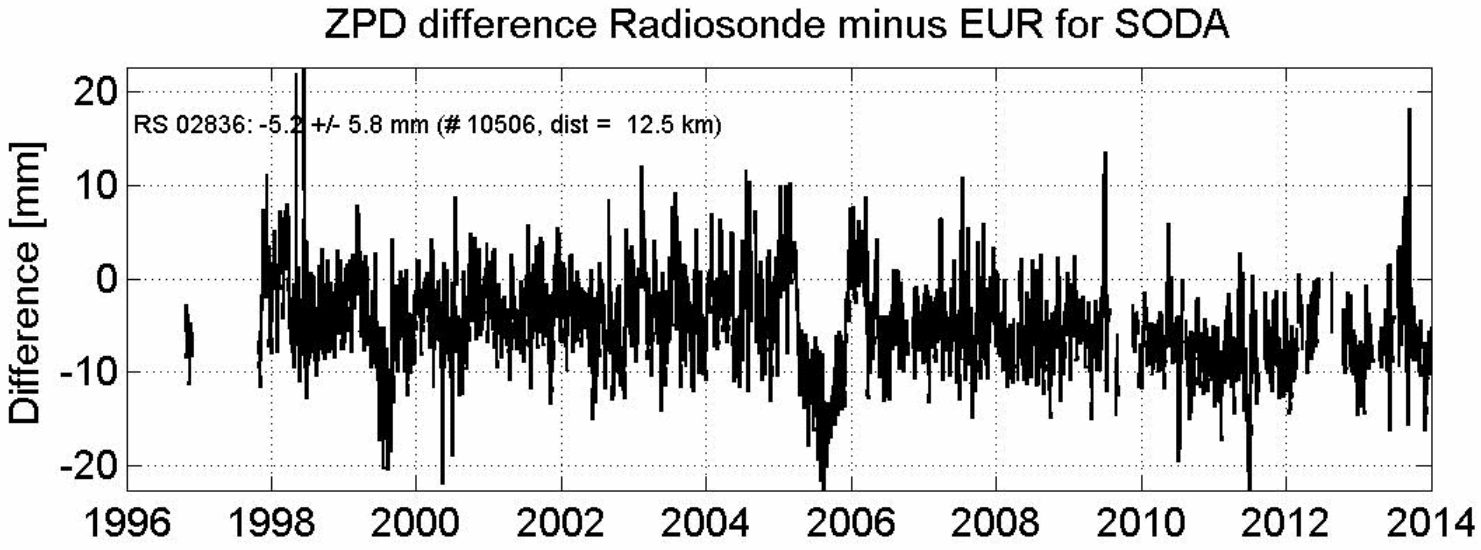
E-GVAP Super Sites and EPN stations

Same sw used for NRT E-GVAP & daily EUREF combination from GPS week 1800 (06 July 2014)

[Pacione et al., JASR 47 (2011) 323–335]

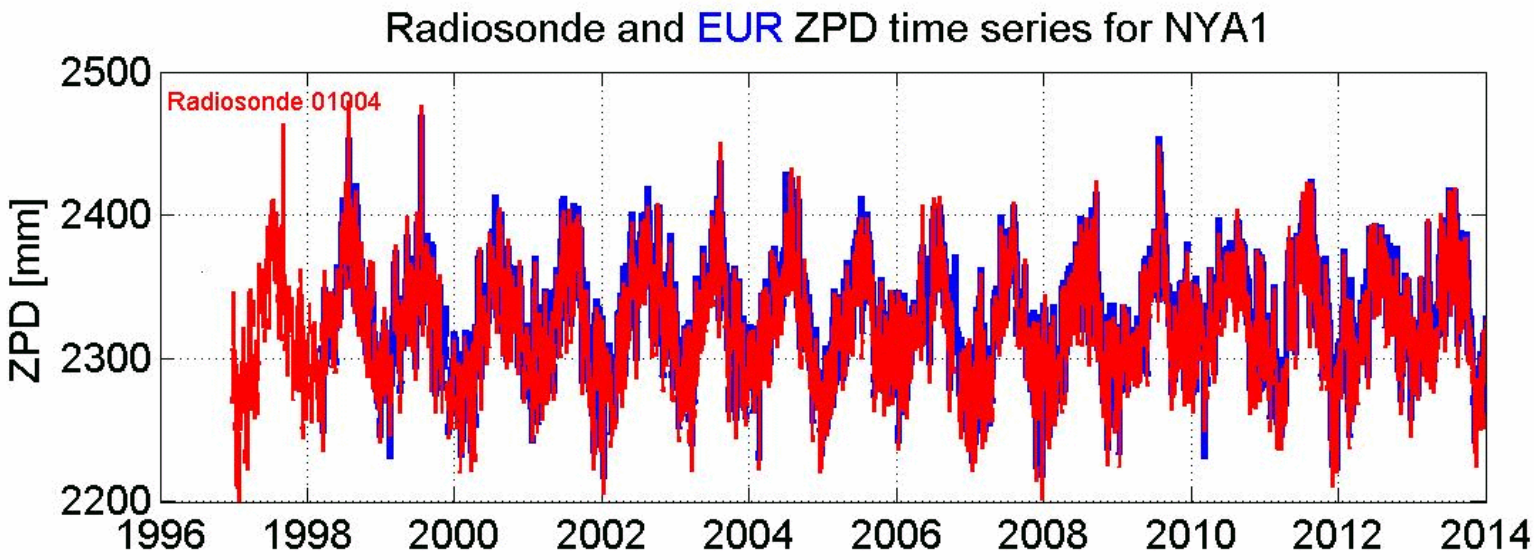
SODA EUR vs radiosonde

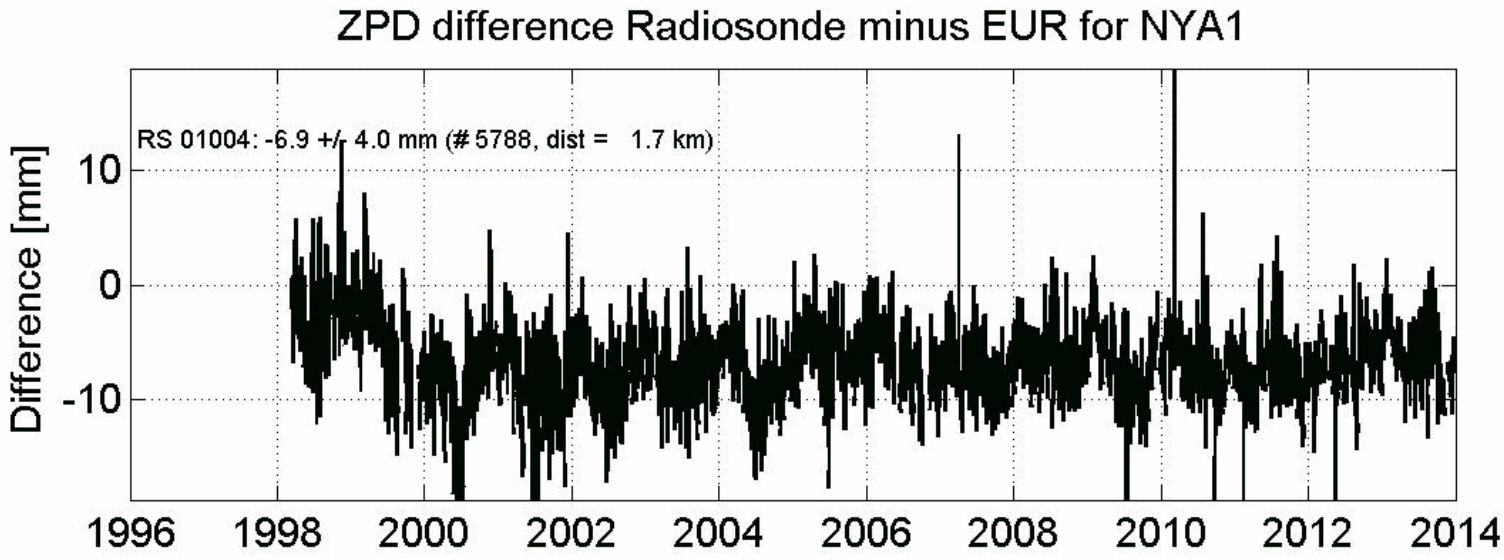




http://www.epncb.oma.be/_networkdata/radiosonde_zpd_biases.php?station=SODA_10513M001

NYA1 EUR vs radiosonde

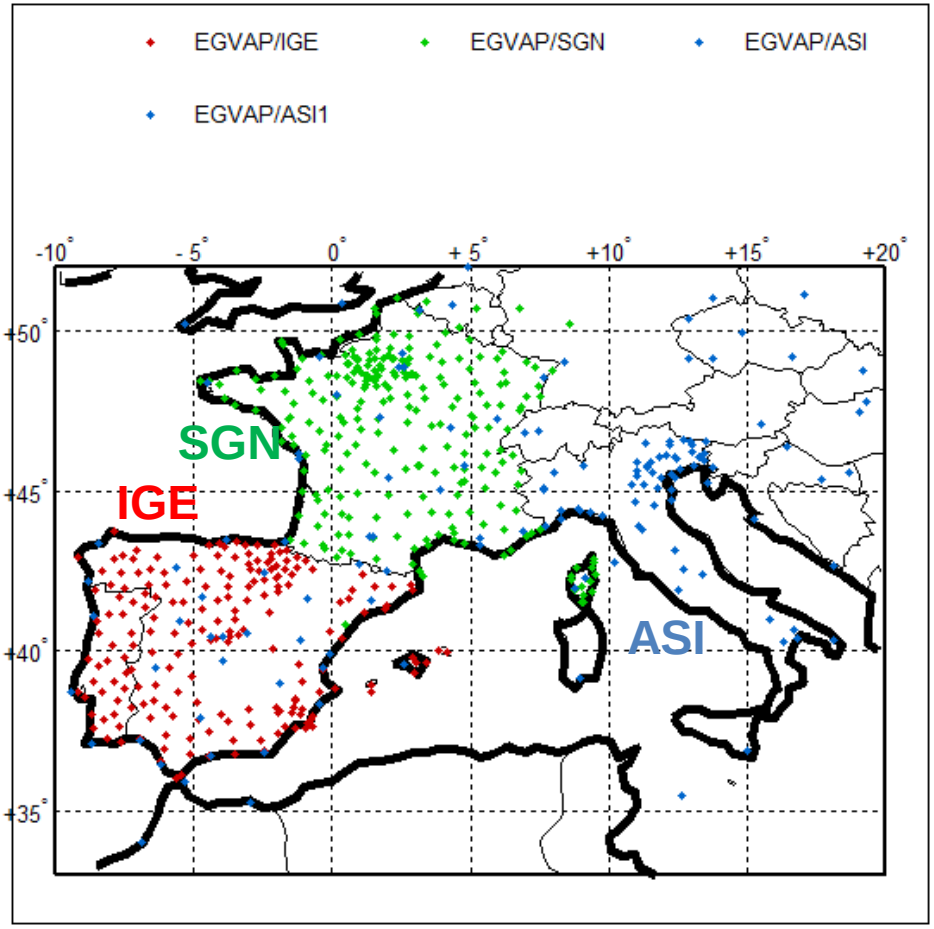




http://www.epncb.oma.be/_networkdata/radiosonde_zpd_biases.php?station=NYA1_10317M003

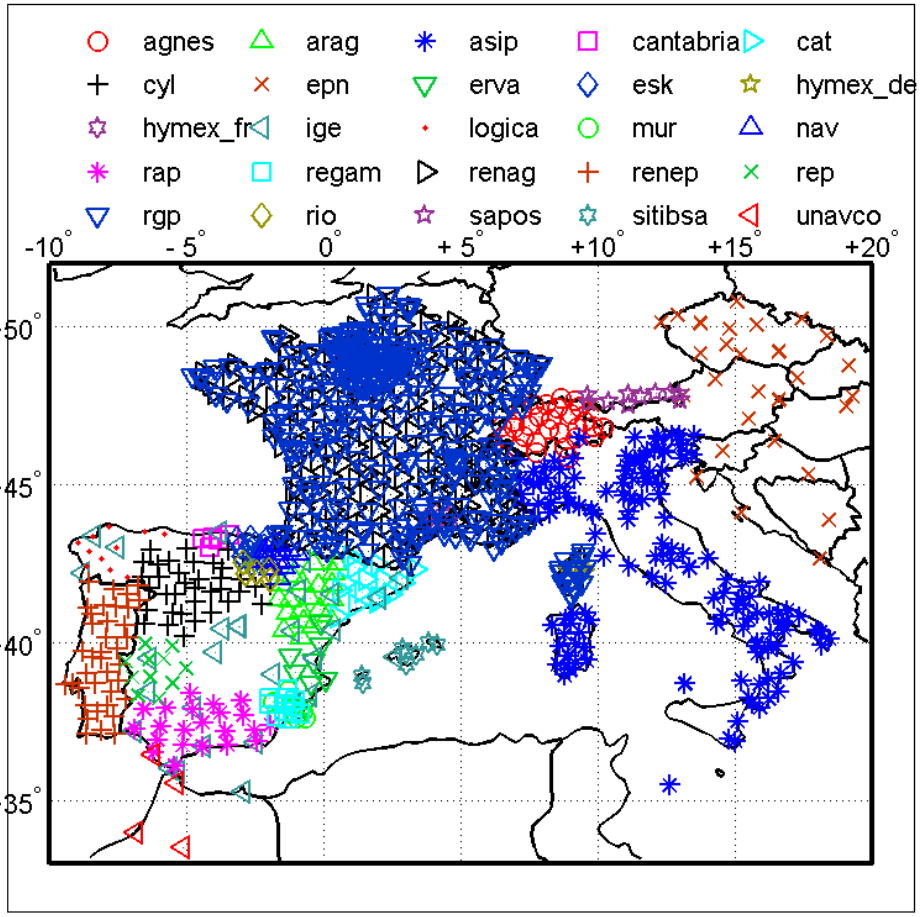
HyMEX SOP1

EGVAP



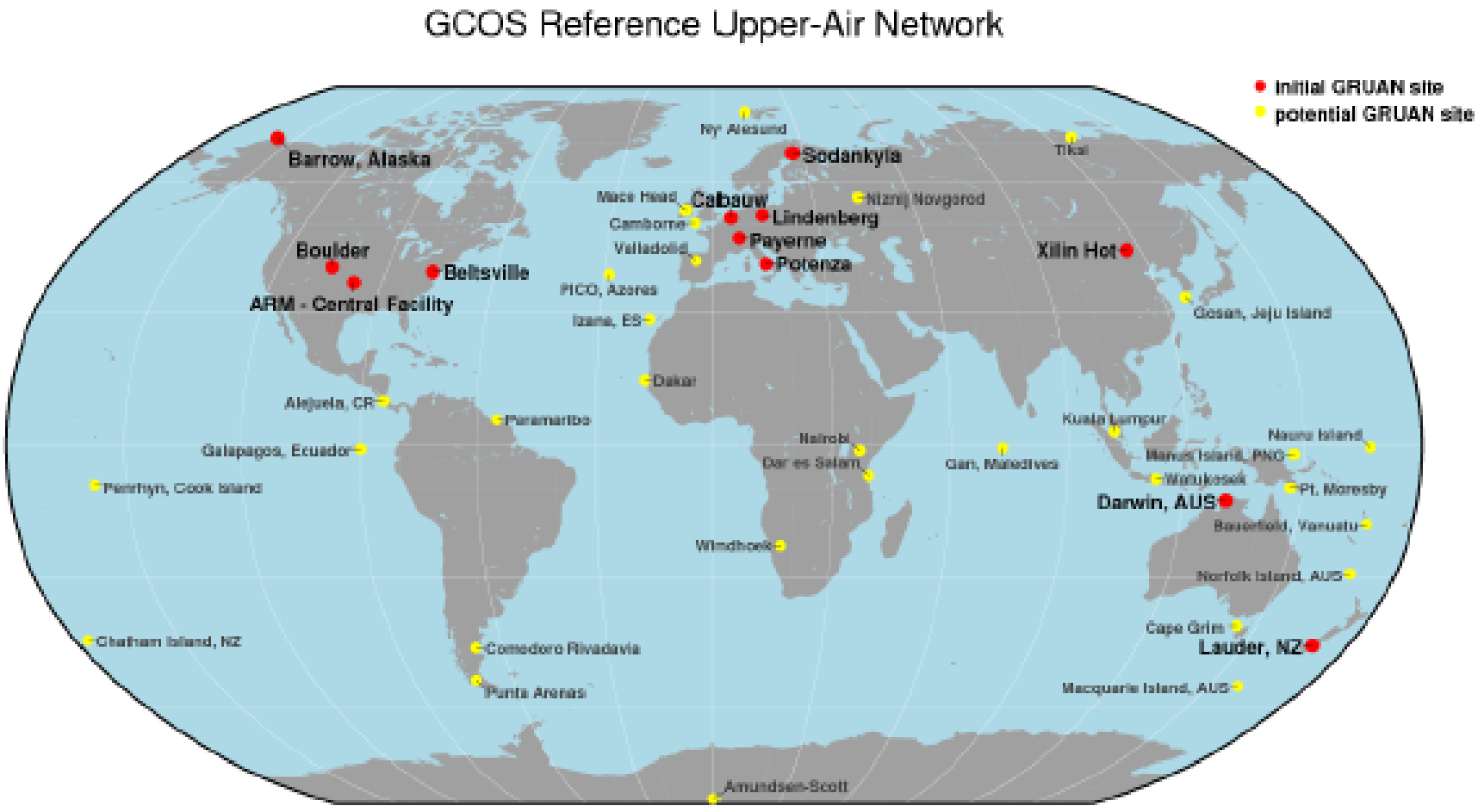
773 stations
(3 Analysis Centres)

HOMOGENEUS REPRO



1046 stations (25 networks)
GIPSY s/w LAREG & ASI proc.
Period 1 Sep 2012 – 31 Mar 2013
Thanks to: IGN-E, GFZ, Swisstopo...

GRUAN sites in ASI / CGS processing



CABW-LDB2-PAYE-TITO: ASI_ solution (E-GVAP Processing)

CABW-LDB2-PAYE-SODA-NYA1: ASIC solution (E-GVAP Processing)

NYA1-SODA: EUR & Repro2 solution (EUREF Processing)

Thank you for your attention