Near Real Time ZTD validation at E-GVAP Super Sites

Francesco Vespe, ASI/CGS Matera

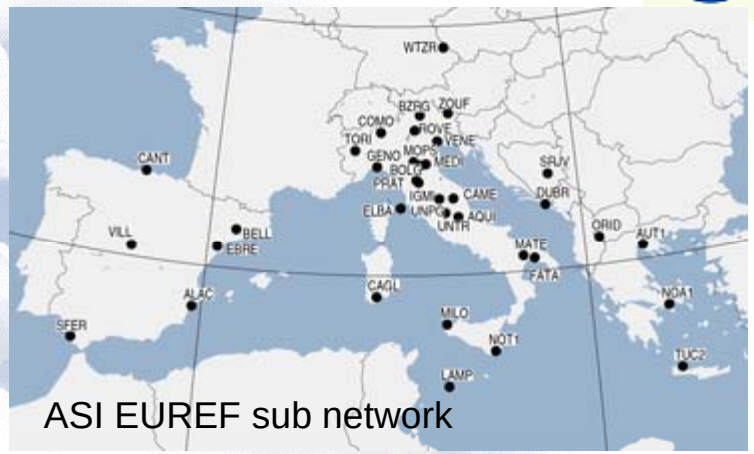
Rosa Pacione, e-GEOS/CGS Matera

Brigida Pace, Sistematica/CGS Matera

History

ASI/CGS has been involved in GPS data analysis of regional permanent network since September 1996 when its solutions were incorporated in EUREF.

ASI/CGS provides to EUREF final, rapid and hourly sinex files.



ASI EUREF sub network

GPS-Meteo Projects

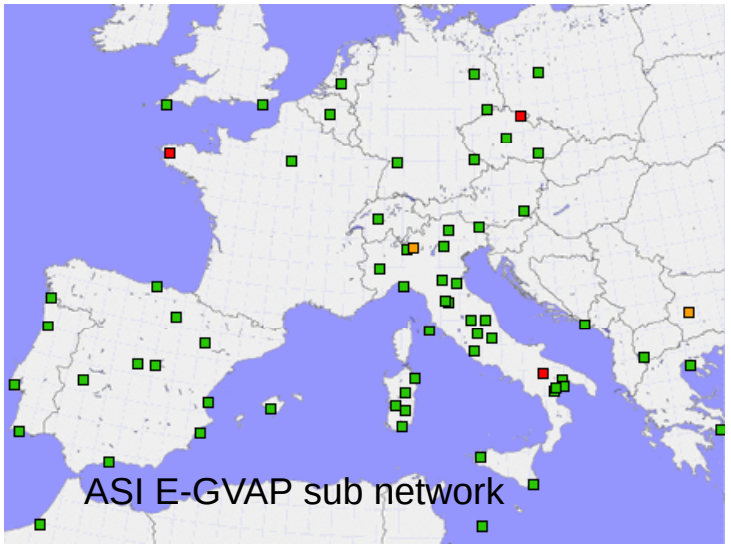
1999 MAGIC *develop and test the capacity for meteo organizations to benefit from GPS as new data source*

2001 COST-716 *NRT demonstration campaign*

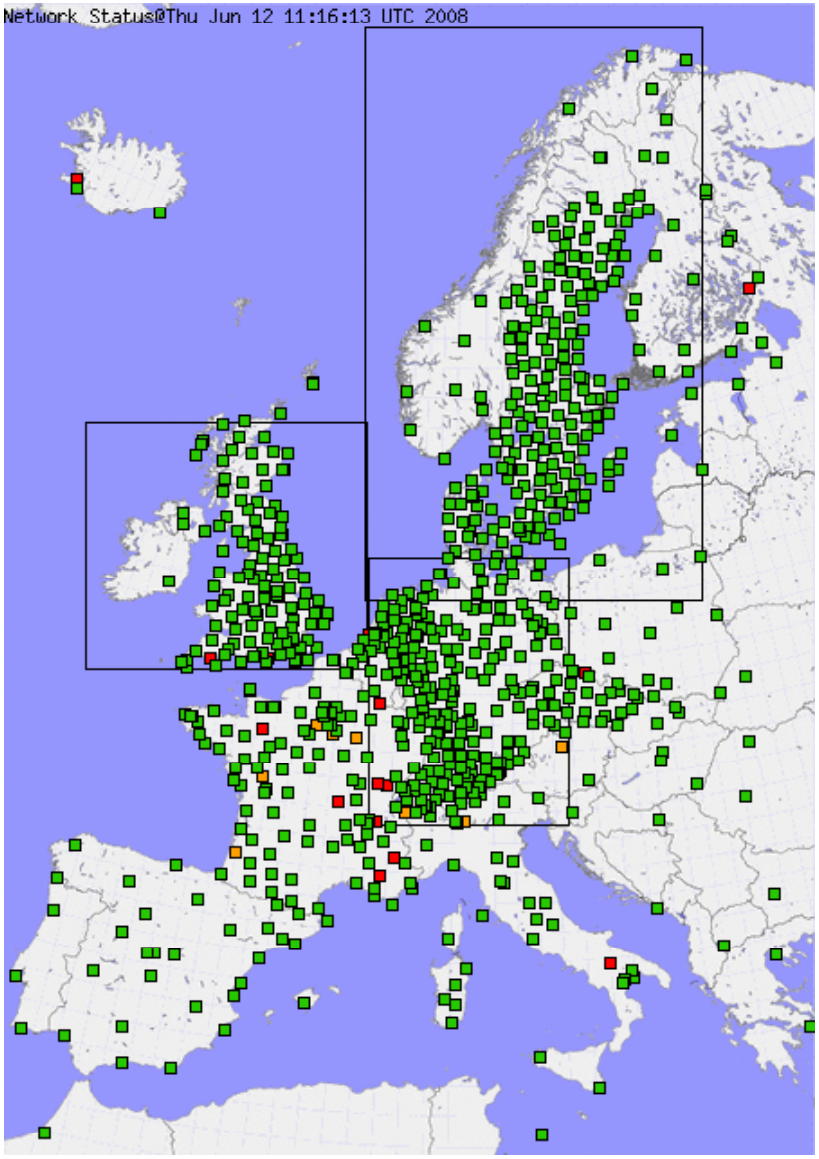
2003 TOUGH *Targeting Optimal Use of GPS Humidity Measurements in Meteorology*

2006 E-GVAP *towards operational use and establishing a GPS delay observing system*

EUMETNET
The Network of European Meteorological Services


ASI E-GVAP sub network

Operational E-GVAP Network



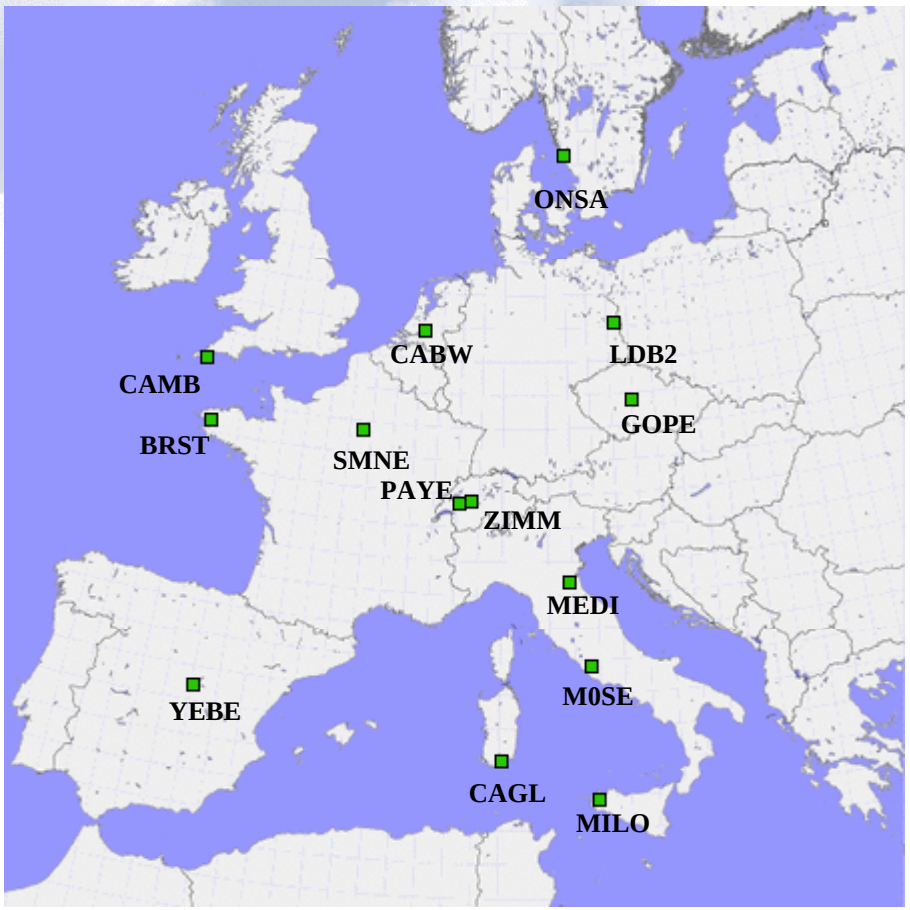
- 13 Institutions
- 10 ACs
- > 800 GPS sites
- ~ 200 analyzed at least by 2 ACs
- ~ 100 analyzed at least by 3 ACs

E-GVAP Super Sites

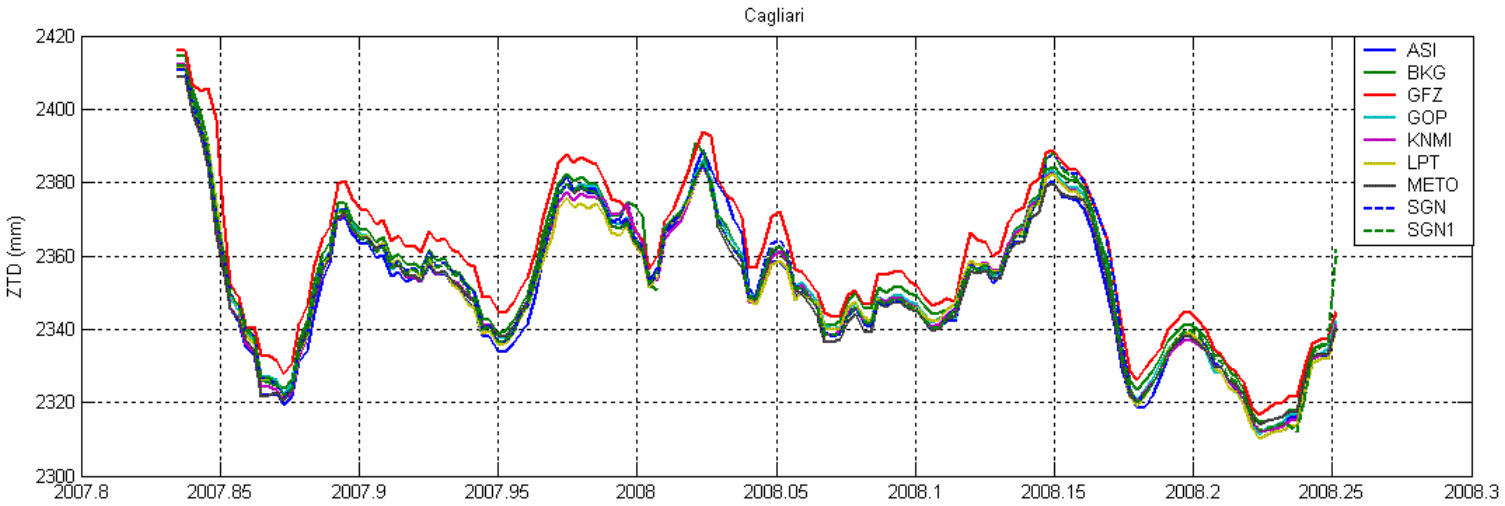
Based on a recommendation from the E-GVAP expert team on data processing a set of **Super Sites** has been introduced**.**

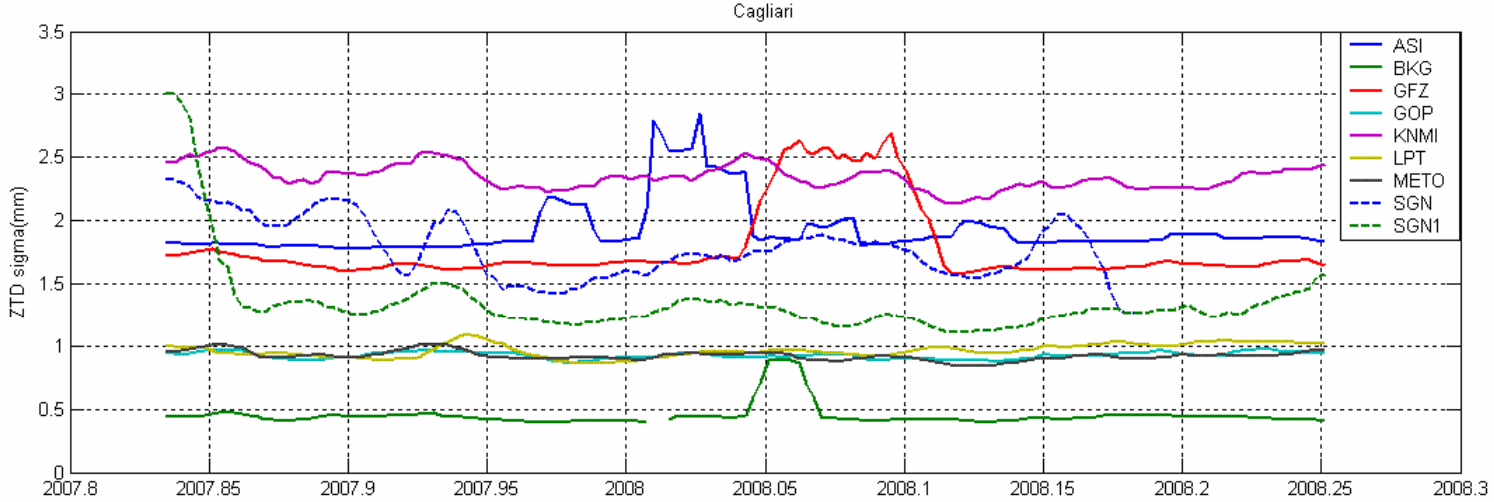
The Super Sites are co-located with meteorological equipment (radiosonde and/or water vapour radiometer).

Comparisons are made between AC solutions and validation performed against independent meteorological observations as well as against numerical weather prediction model data.



Cagliari Super Sites: Time Series November 2007- March 2008





Super Sites Coordinate Repeatability

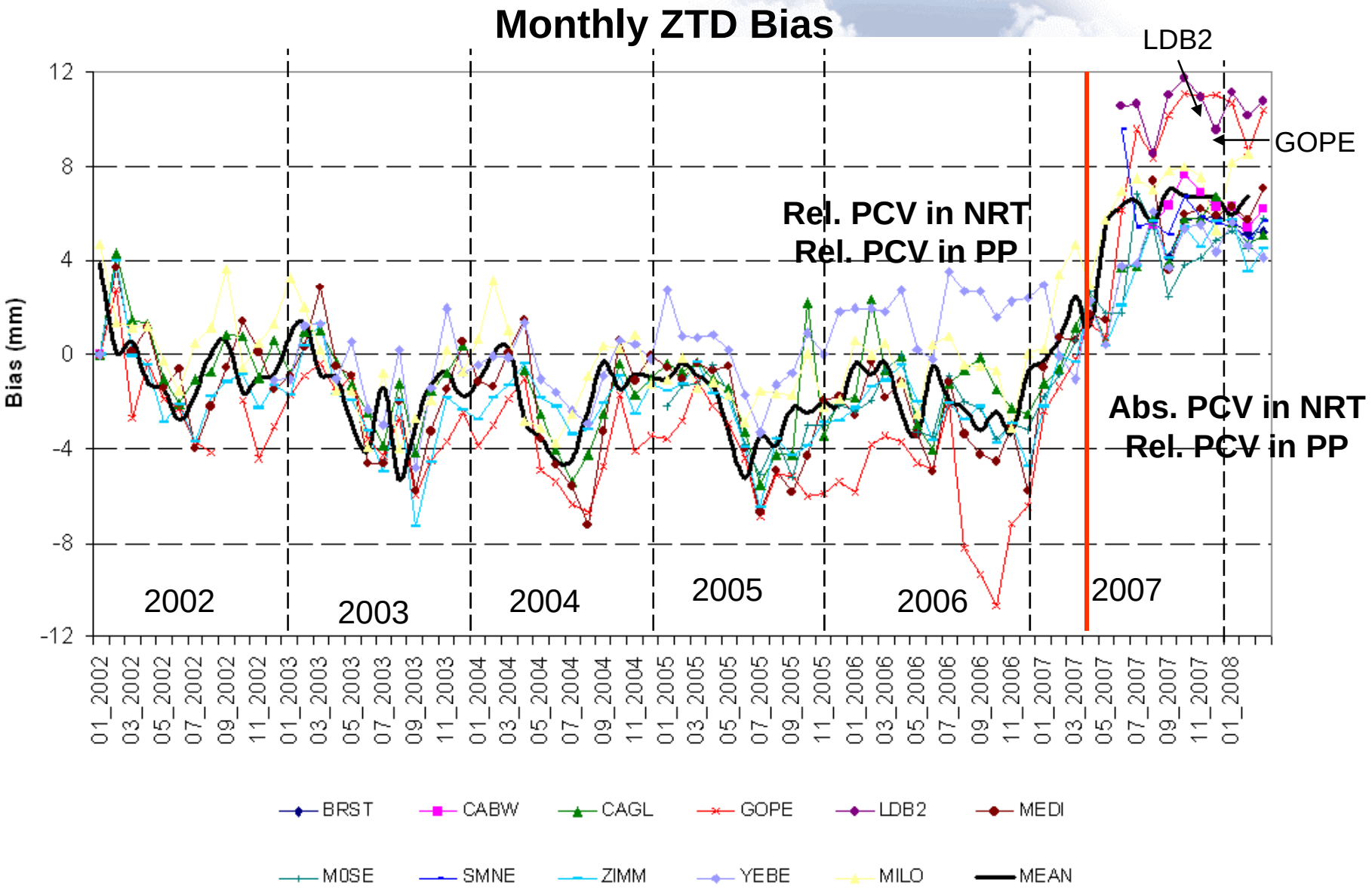
Each site is analyzed in NRT and Post-Processing which is necessary for site coordinate monitoring.

Height coordinate repeatability is a ZTD quality indicator.

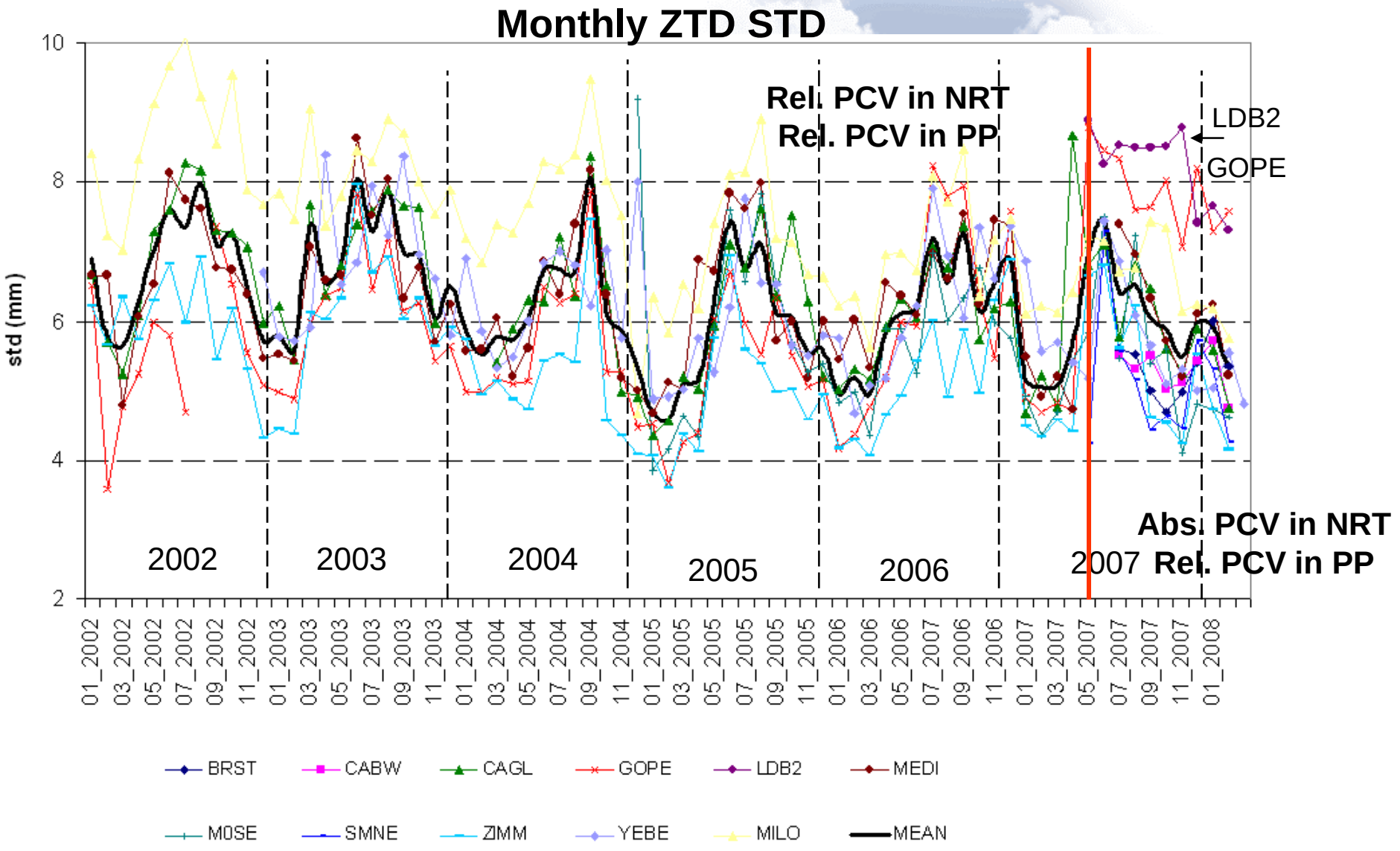
To get 0.45 mm IWV we need 3 mm ZTD that is 9 mm H.

				PP Daily Coordinate Repeatability			
Site	**Riceiver**	**Antenna & Radome**	**h (m)**	**East (mm)**	**North (mm)**	**Up (mm)**	**Analysed since..**
BRST	LEICA GRX1200PRO	LEIAT504 NONE	2,043	5,0	3,8	6,7	May 2007
CABW	TRIMBLE 5700	TRM41249.00 NONE	0,053	2,4	1,8	5,4	June 2007
CAGL	TRIMBLE 4700	TRM29659.00 NONE	0,045	4,3	2,7	7,5	January 1999
CAMB	ASHTECH UZ-12	ASH700936D_M SNOW	1,800	2,9	1,7	6,5	July 2007
GOPE	ASHTECH Z-18	TPSCR3_GGD CONE	0,111	2,6	2,0	6,0	January 2002
LDB2	JPS LEGACY	TPSCR3_GGD CONE	0,047	3,8	1,8	5,9	A pril 2007
MILO	TRIMBLE 4000SSI	TRM29659.00 NONE	0,000	3,8	3,0	8,3	October 2001
M0SE	LEICA GRX1200GGPRO	LEIAT504GG LEIS	0,000	2,7	2,6	6,4	October 2004
MEDI	TRIMBLE 4000SSI	TRM29659.00 NONE	0,000	5,4	4,0	7,5	January 1999
ONSA	JPS E_GGD	AOAD/M_B OSOD	0,691	NA	NA	NA	March 2008
PAYE	TRIMBLE NETR5	TRM55971.00 NONE	0,000	NA	NA	NA	NA
SMNE	LEICA CRS1000	LEIAT504 NONE	0,139	3,0	1,6	5,5	A pril 2007
YEBE	TRIMBLE NETRS	TRM29659.00 DOME	0,000	3,1	2,1	6,0	August 2003
ZIMM	TRIMBLE NETRS	TRM29659.00 NONE	0,000	3,3	2,8	6,5	January 1999
		Mean over all Super Sites		3,51	2,49	6,51	

Super Sites: PP and NRT (1/2)



Super Sites: PP and NRT (2/2)



Super Sites GPS Internal Validation (Nov 2007– Mar 2008) (1/2)

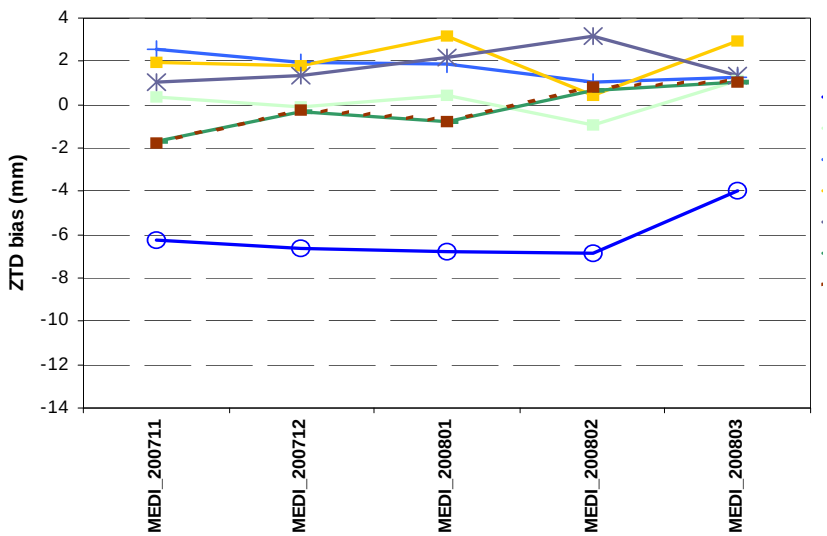
Pair wise comparison of individual NRT solutions over the whole period is done considering the ASI solution as the reference.

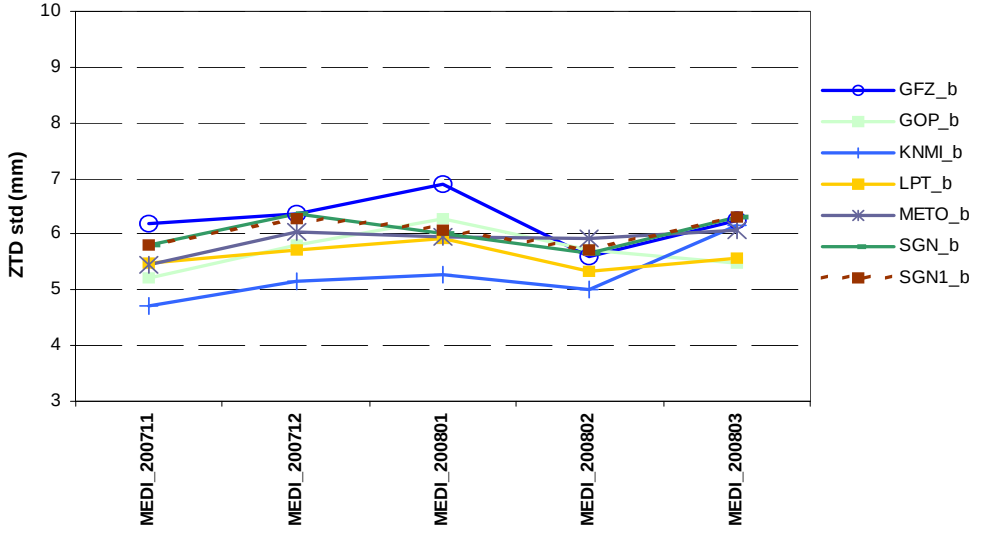
Examples are shown for MEDI, BRST and CAGL Super Sites

- the standard deviation ranges from 4 mm to 8 mm
- the bias ranges from -8 mm to 4 mm.

The larger bias (-10 mm/-12 mm) w.r.t GFZ is is because GFZ is still applying relative PCVs

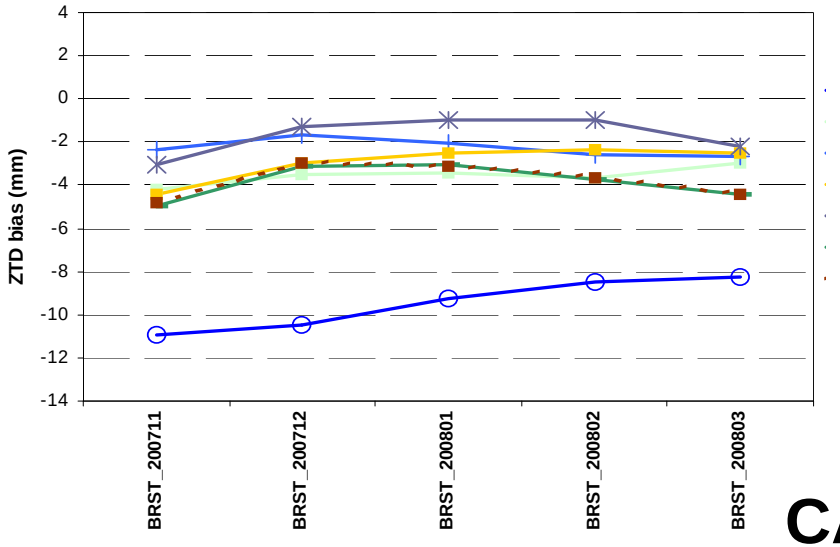
MEDI

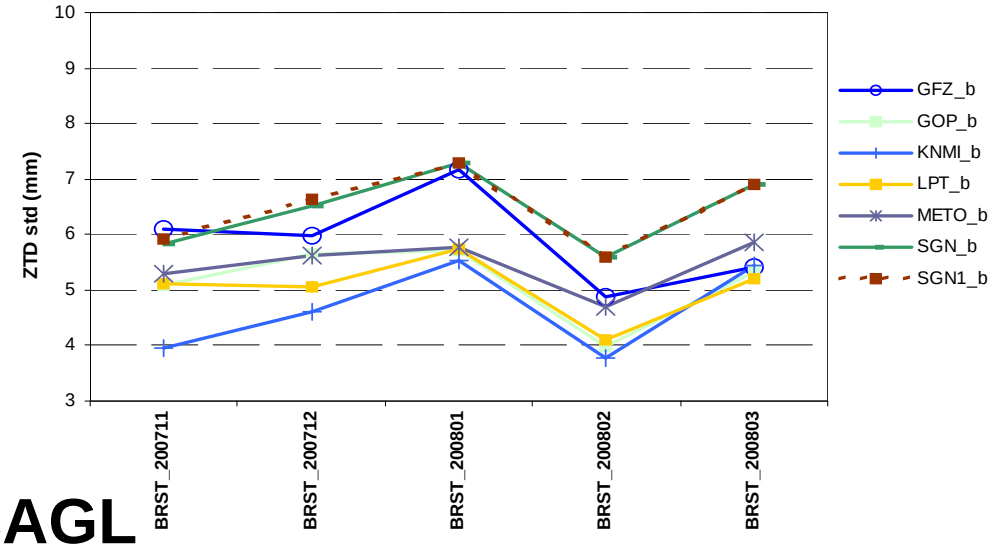




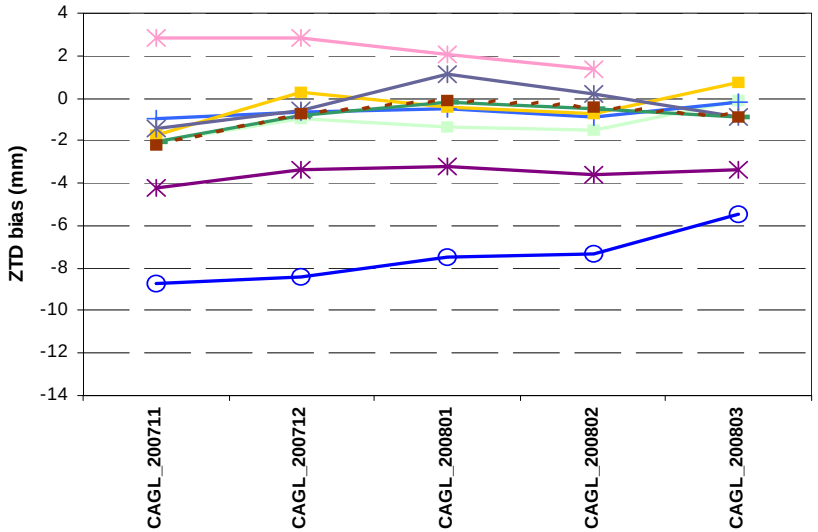
Super Sites GPS Internal Validation (Nov 2007– Mar 2008) (2/2)

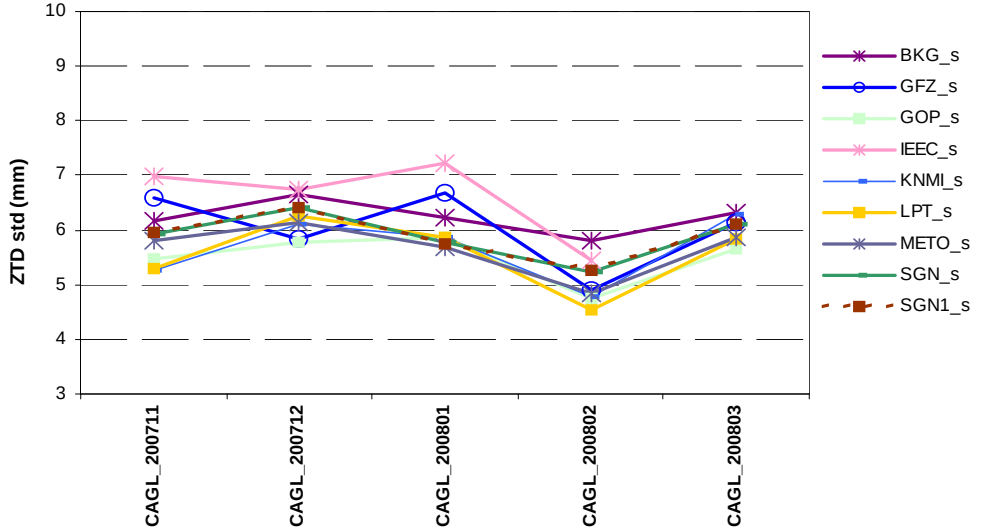
BRST



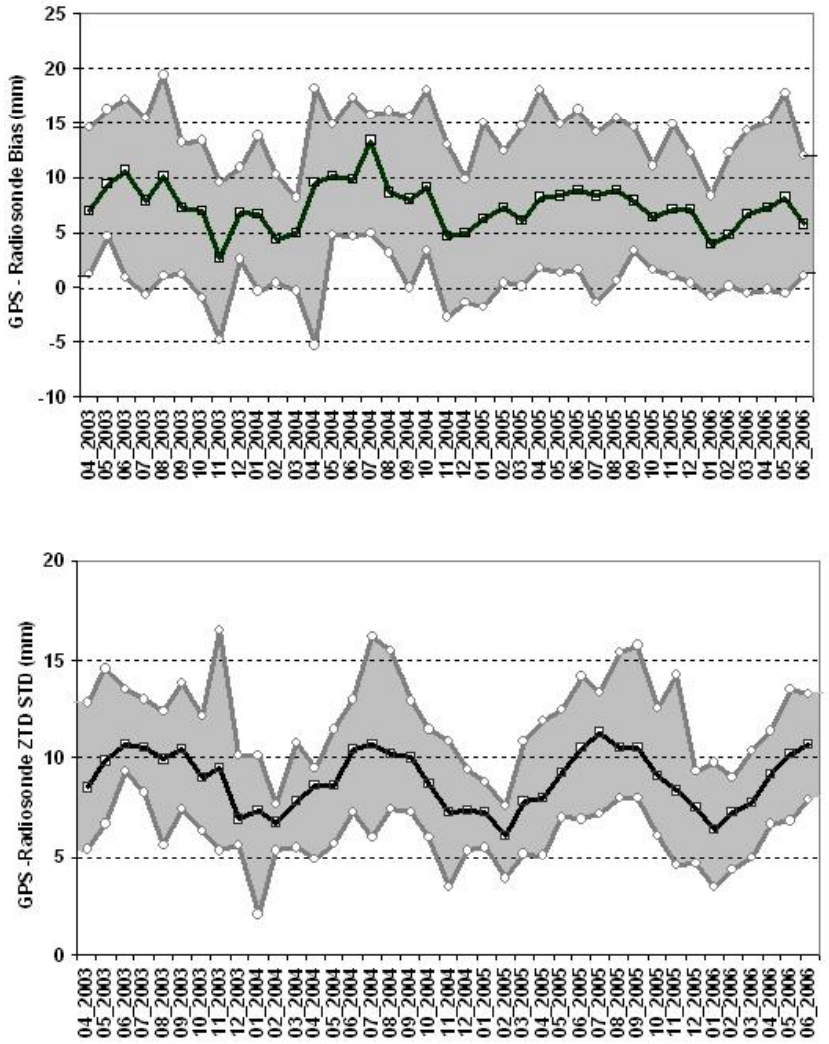


CAGL





Super Sites and Radiosonde (1/4)



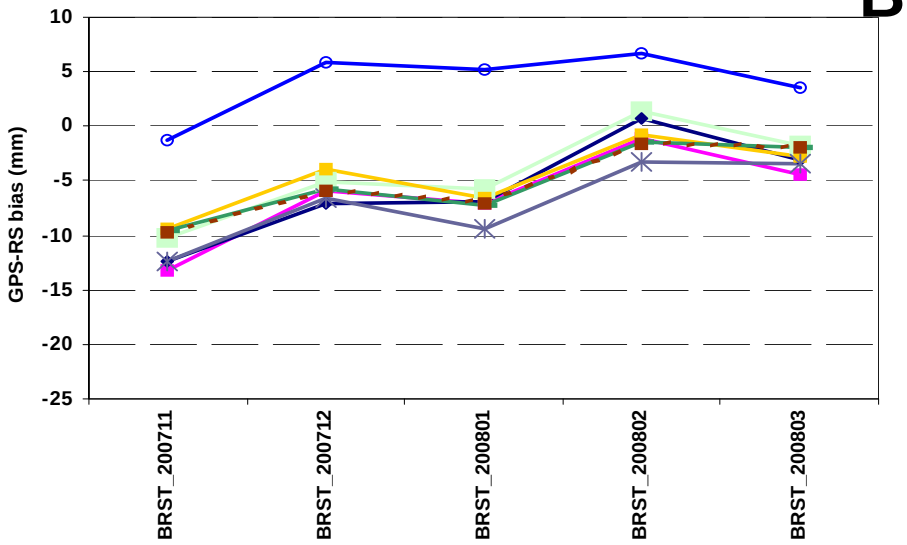
$$GPS - RS > 0$$

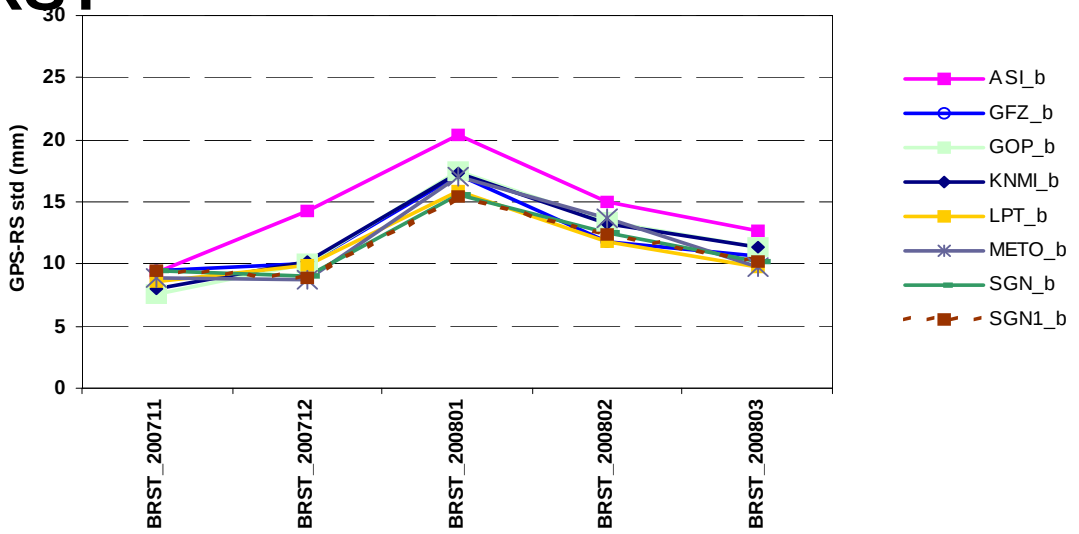
Monthly variation in ZTD bias (top) and std (bottom) of GPS versus radiosonde for 13 stations (black line) using 'ASI TOUGH' ZTD estimates.
The gray area lies between the minimum and maximum values (*Pacione and Vespe, 2008, JTECHA, Vol. 25, No. 5, pages 701–714*).

$$5mm < std < 15mm$$

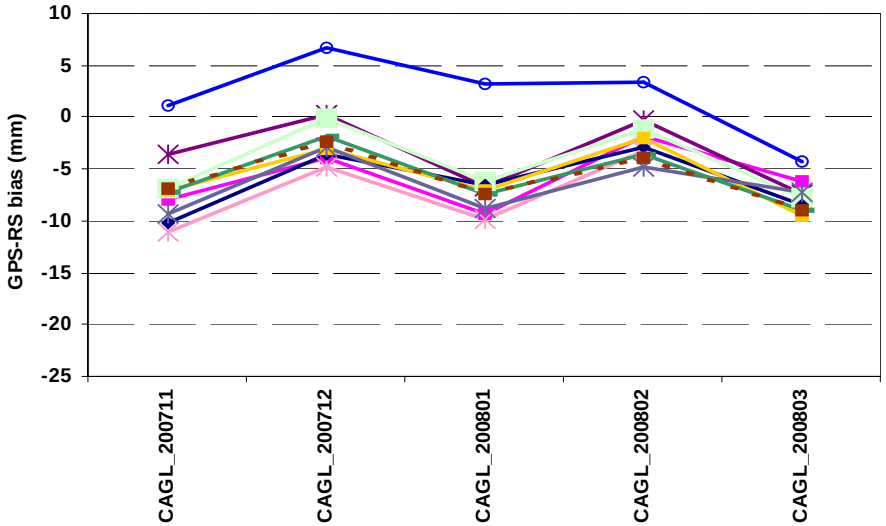
Super Sites and Radiosonde (2/4)

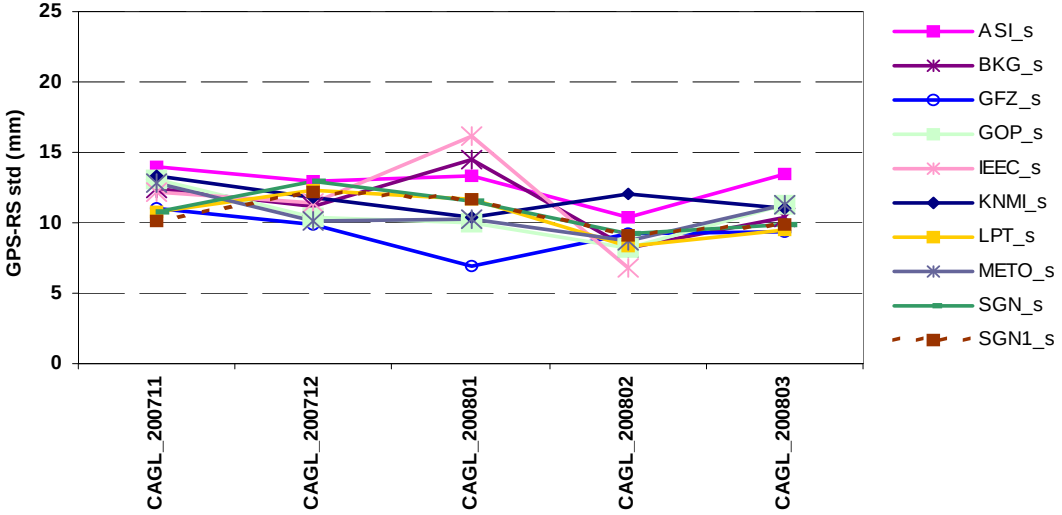
BRST





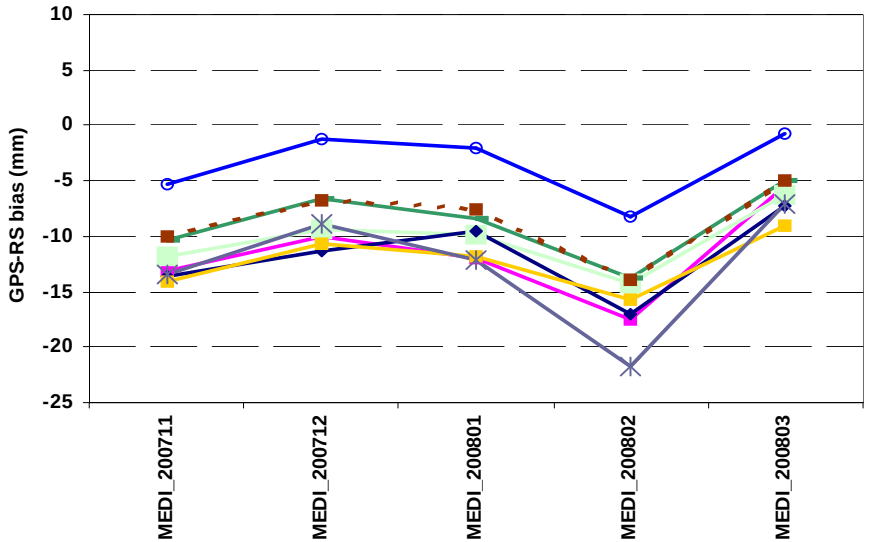
CAGL

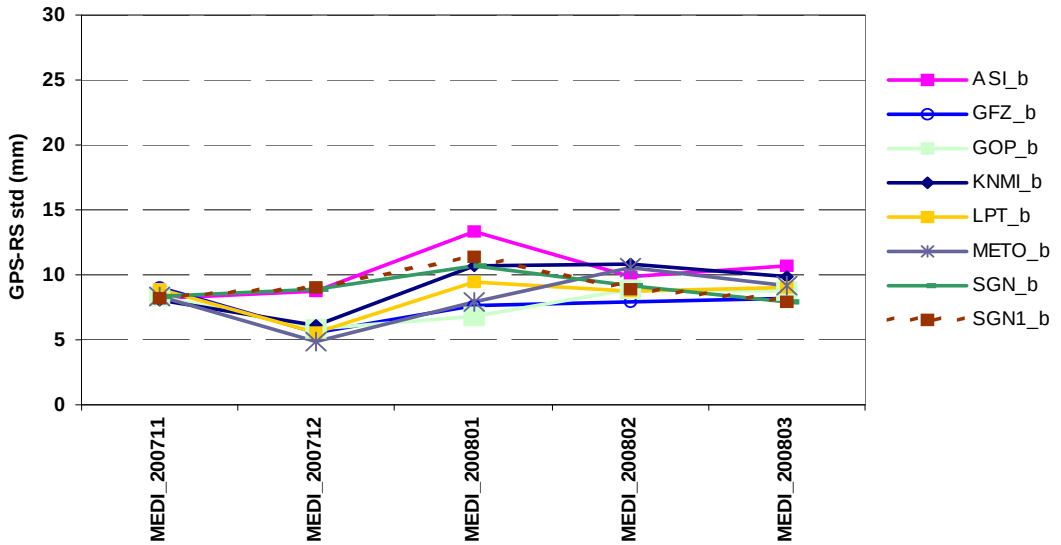




Super Sites and Radiosonde (3/4)

MEDI

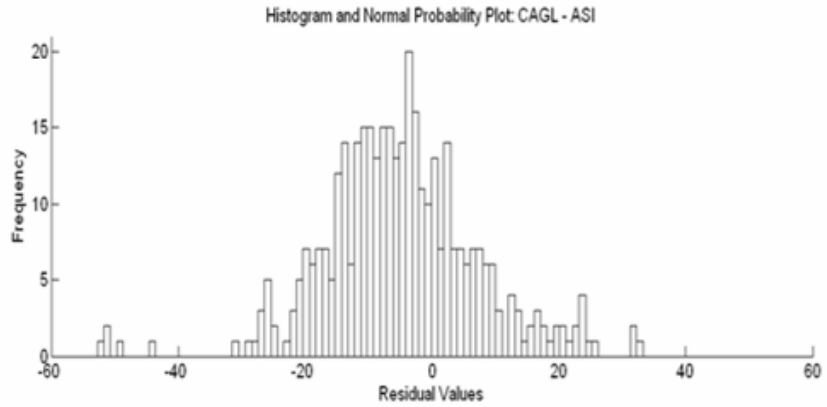


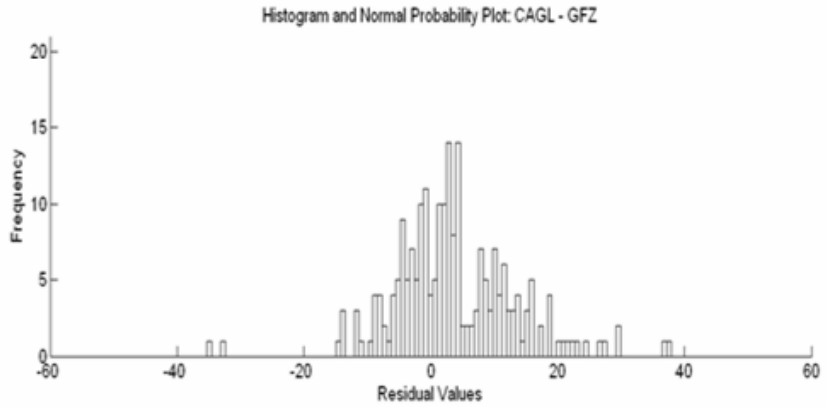


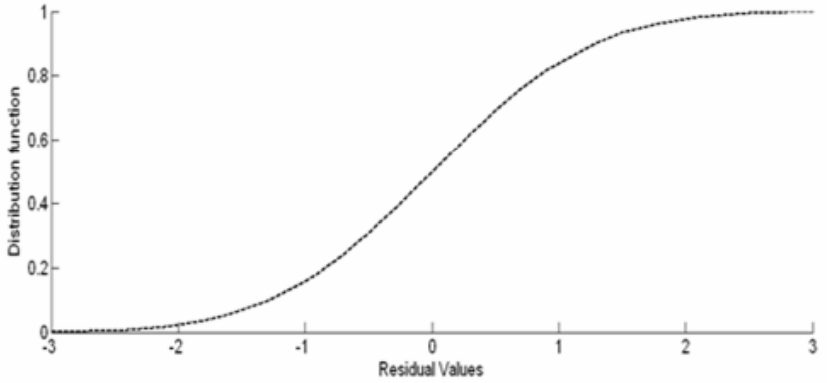
- The Sdt is in the expected range
- The Bias is now GPS – RS < 0, except for GFZ which is still using relative PCVs

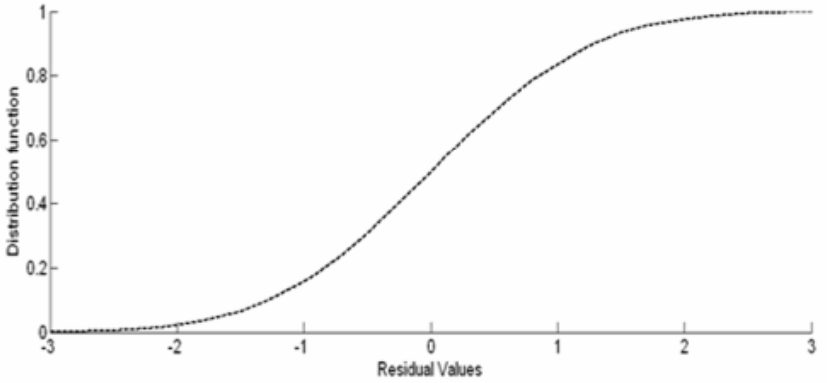
Super Sites and Radiosonde (4/4)

For each Super Sites and AC a residual analysis has been performed. The obtained histograms are gaussian within a confidence level of 0.9, All the considered GPS estimates behave equally well w.r.t. the radiosonde 'truth'.









NRT ZTD Combination: a new ASI product

Combining different solutions of the atmospheric signal is a good way to detect problems in a single ACs and to provide a quality indicator (QI) for each solution. Meteorologists before indeed deemed the formal errors of the single AC solution a good QI. In ***Pacione and Vespe, 2008, JTECHA, Vol. 25, No. 5, pages 701–714*** . We have widely demonstrated such QI is not reliable

For a single site ZTD is modeled as:

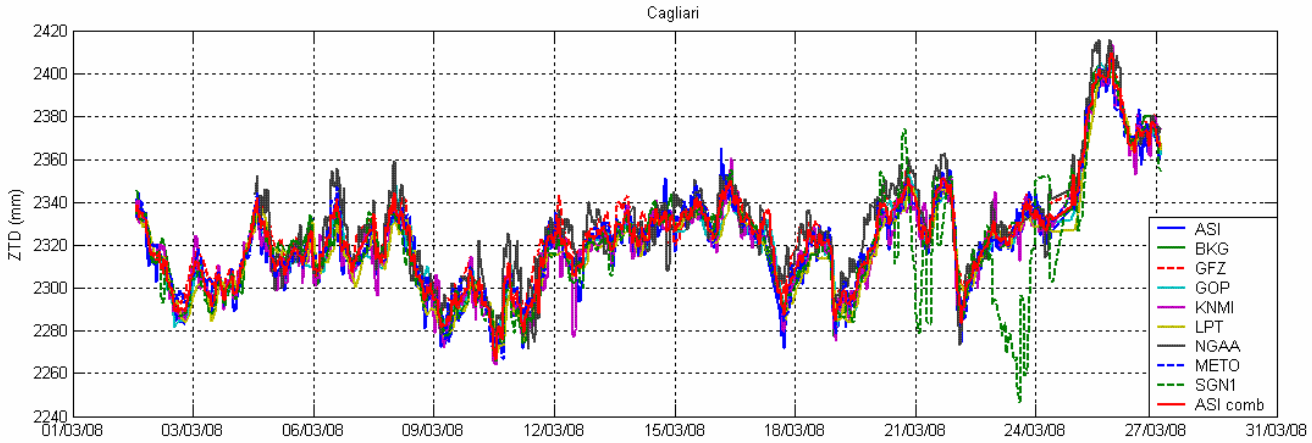
$$y_n^k = Y_n + b^k + e_n^k \qquad n = 1,\ldots, N \quad \text{time epochs}$$

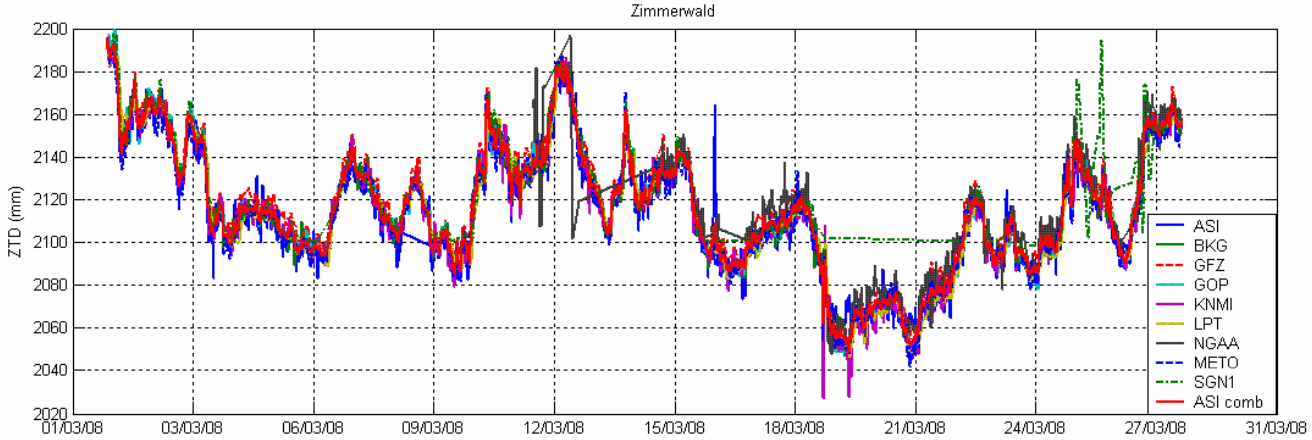
$$k = 1,\ldots, K \quad \text{analysis centers}$$

where ***Yn*** is the 'true' ZTD at epoch t_n, b^k is the analysis center bias and e^k_n is the observation error. The equations can be solved for each epoch. Thus we have a rank deficiency which can be solved by adding the following constrain equation

$$\sum_k b^k = 0$$

ASI NRT ZTD Combination an example for CAGL and ZIMM March 2008

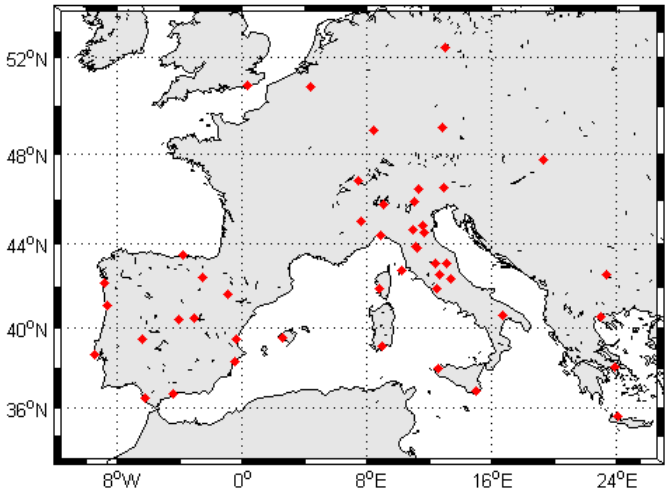


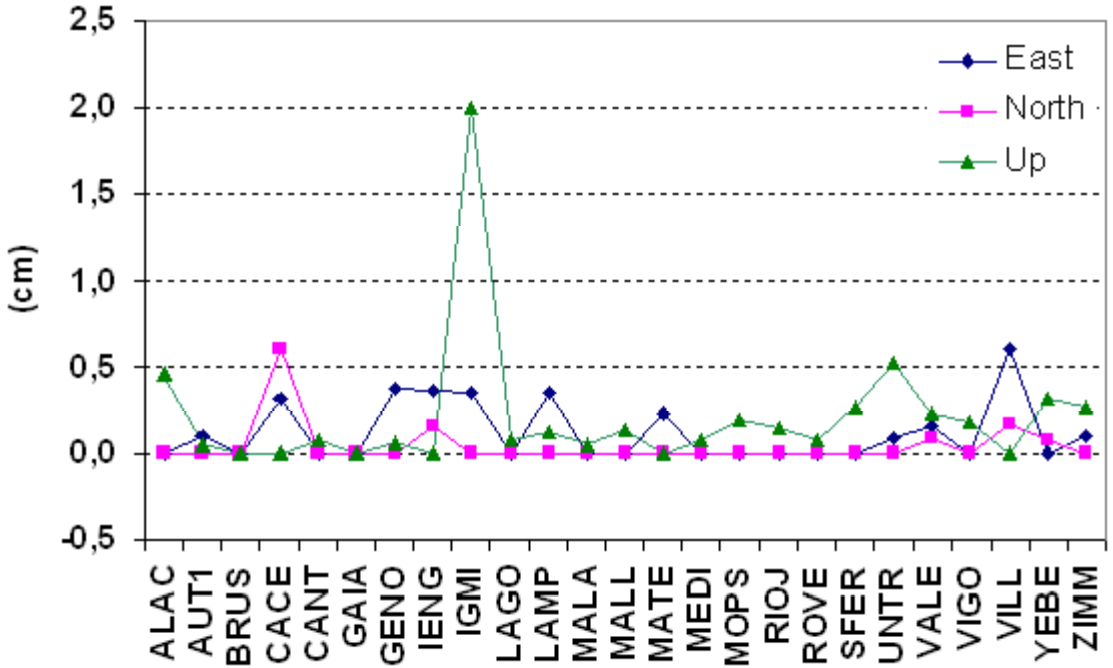


This product will be soon delivered to E-GVAP database

ASI NRT Site Coordinates Monitoring NEW!!

ASI delivers, together with BKG and LPT, site coordinates of ~40 sites to **EUREF** on hourly basis with the aim to establish a near-real time processing for a quick monitoring of the EPN stations.
Site performance is monitored with a delay of less than 2 hours.





Example of hourly residuals w.r.t EUREF (eurwwwmr.snx) weekly rapid solution. Site having 'large' residuals are detected and flagged. If the site belongs to ASI network an alert is send to the station manager.

We found this a good tool for site monitoring.

Summary

- GPS derived ZTDs are used operationally in Europe
- They have been extensively validated at ASI/CGS
- NRT ZTD combined products will be soon delivered to E-GVAP
- We plan to demonstrate the more robust reliability of the combined solution for assimilation purposes
- A Near Real Time Site Coordinates Monitoring system has been set-up and used as a tool for monitoring the site performance.