An Overview of the Italian Space Agency Activities Based on GPS Permanent Network

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An Overview of the Italian Space Agency Activities Based on GPS Permanent Network

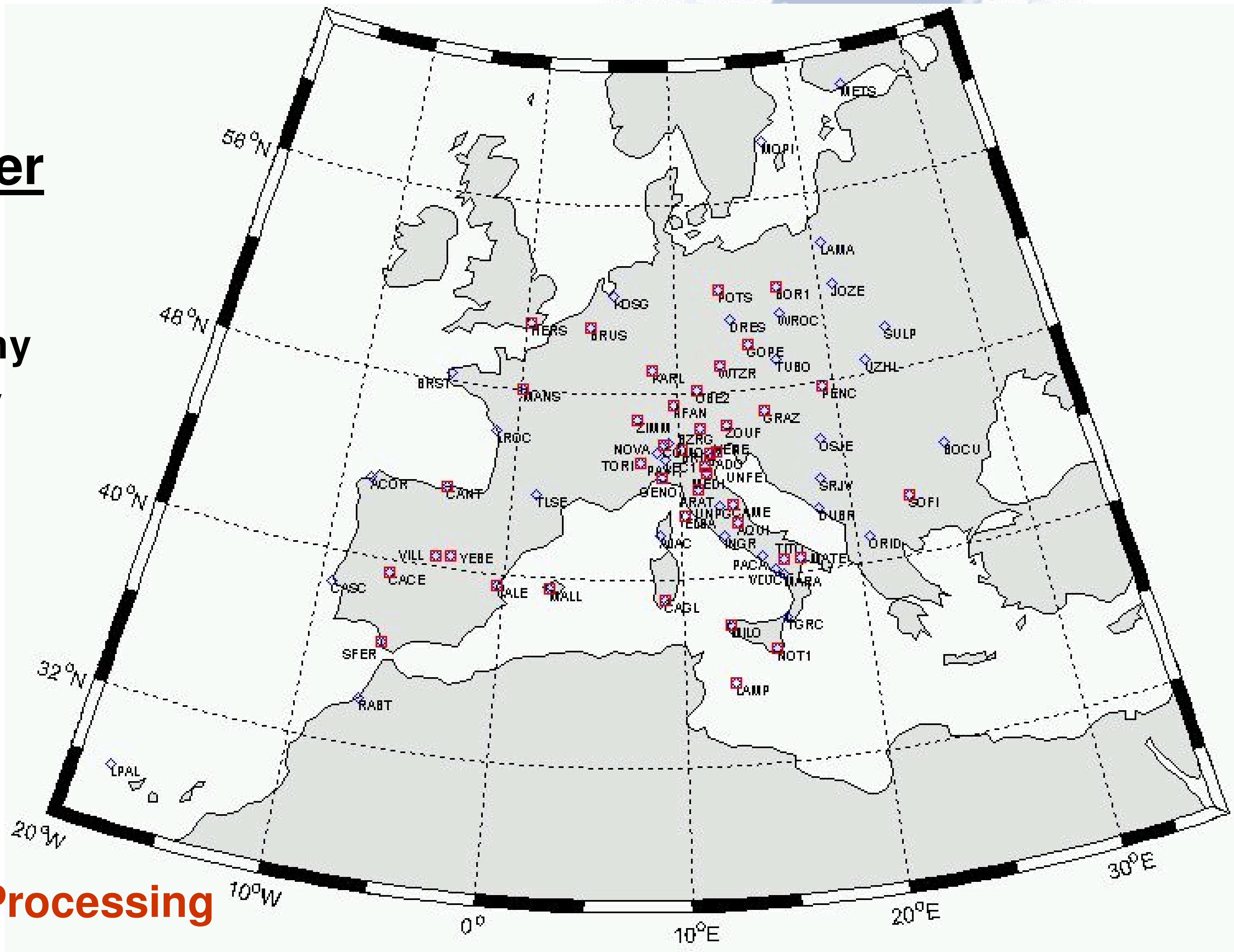
- Weekly Solutions of the coordinates of a subset of EUREF Stations (Poster)
- Strain Rates in The Central Mediterranean Area (Poster)

- ***ZTD estimates (Current Talk)!!***

Ground-Based GPS Network

GPS Data Provider

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



95 stations in Post-Processing

46 stations in NRT

GPS Processing Technology

GPS RNX files

daily → **Post-Processing**
Daily PPP solution
•ZTD
•Site Position

GPS Orbits
ERP
GPS sat. clocks

2-weeks latency

hourly → **Near-Real Time**
Network solution, SLW
•ZTD

IGU Orbits
IGU ERP
Site Position
(1month average of daily PPP)

1h45min latency

GPS Met Products

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

USERS
•NWP
•ENVISAT Sensor CAL/VAL

January 1999

MAGIC

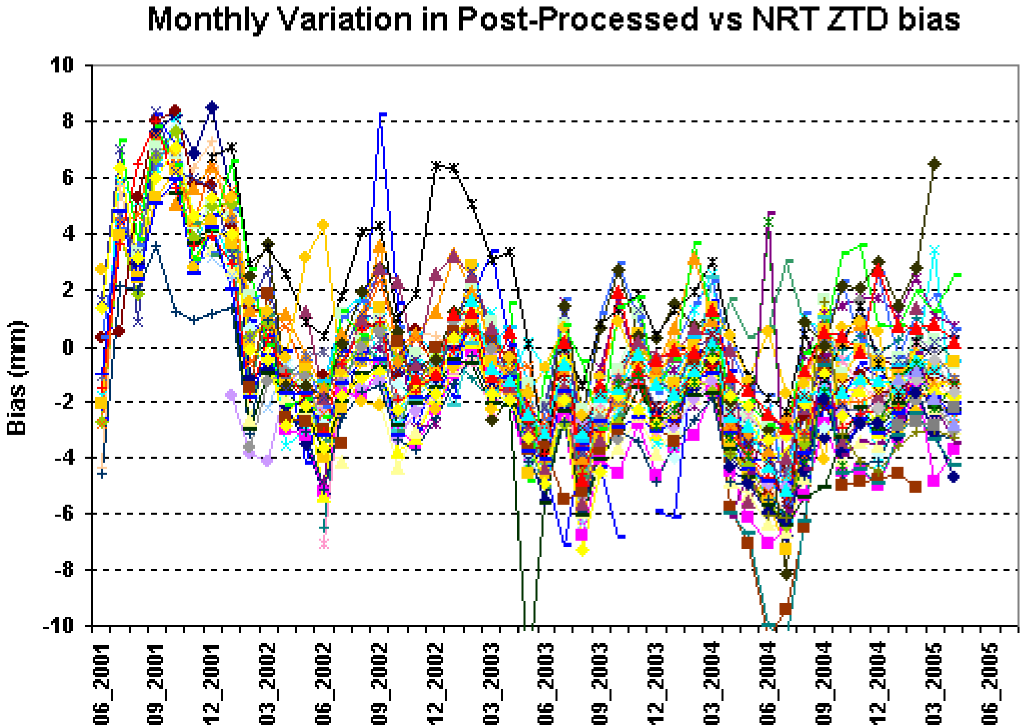
June 2001

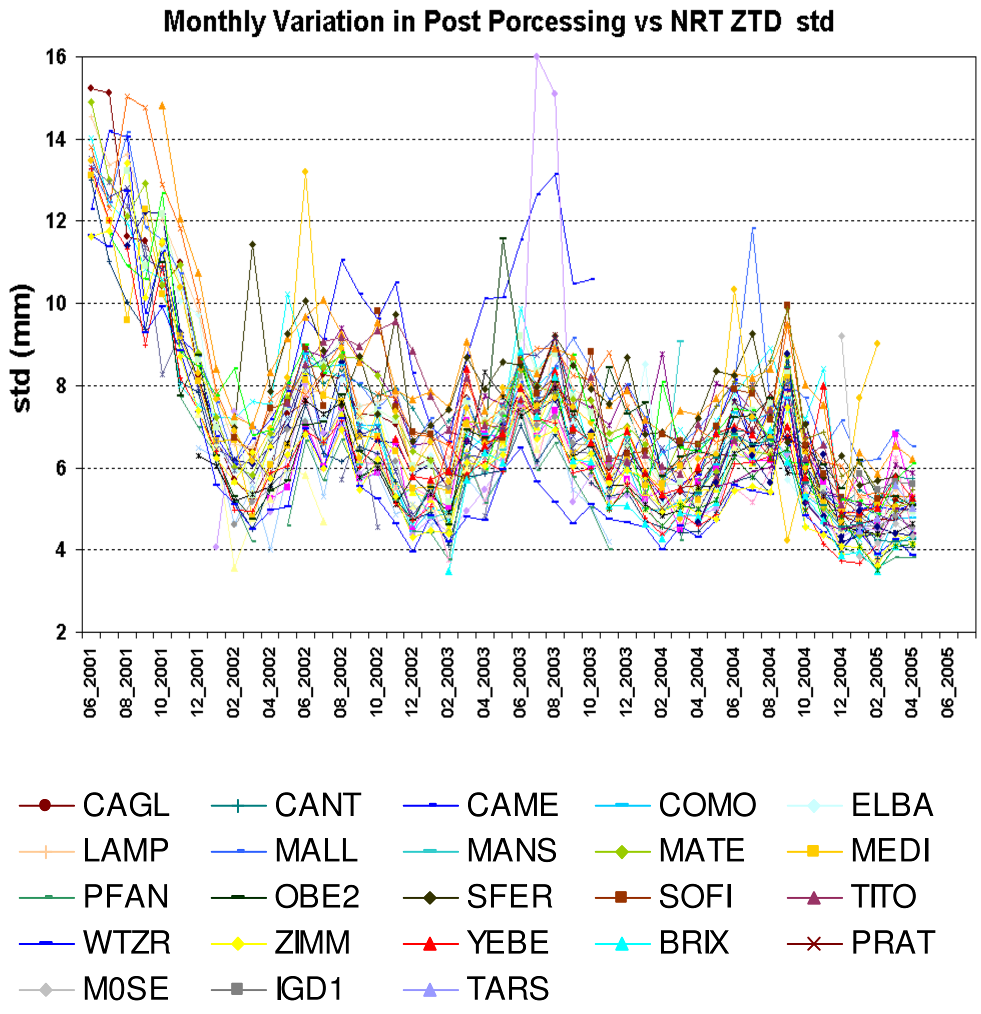
COST 716

February 2003

TOUGH

Internal Consistency of GPS results: Post minus NRT *(jun01-apr05)*

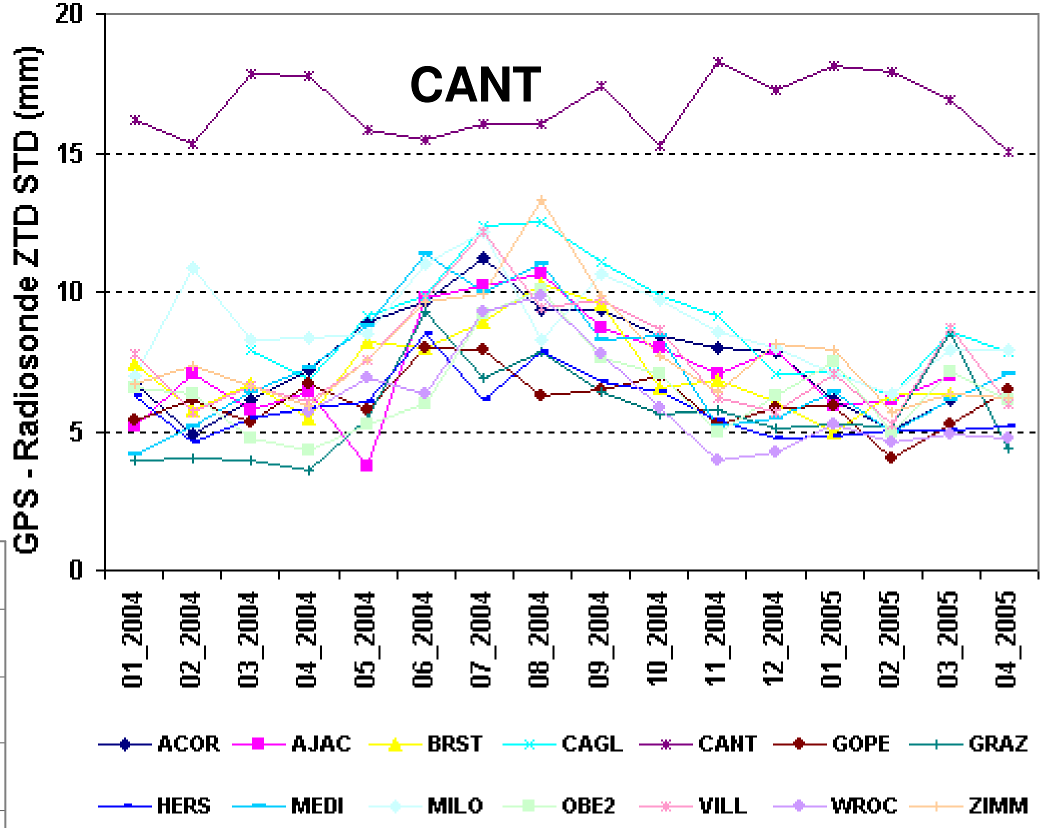


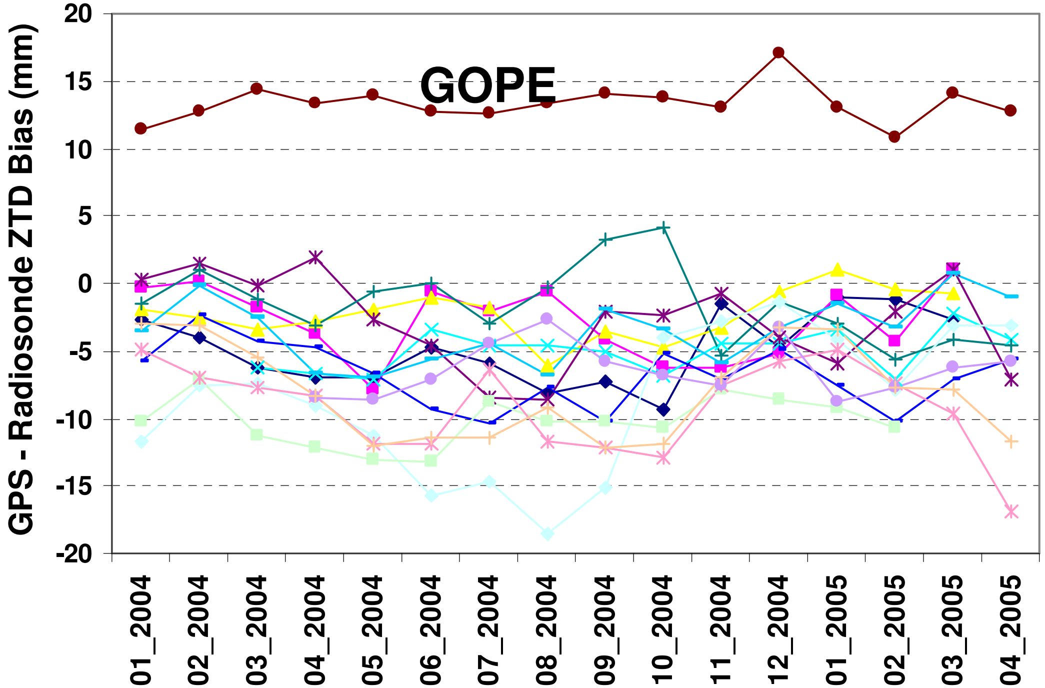


[6mm ZTD ≈ 1mm IPWV]

GPS derived ZTD against Radiosonde *(jan04-apr05)*

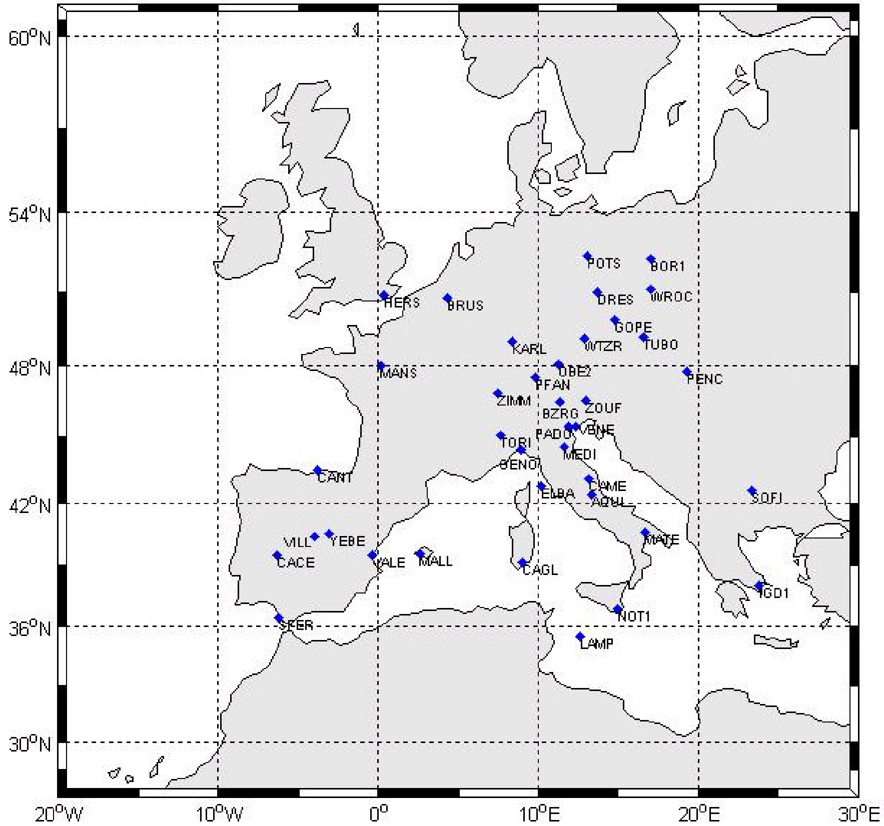
ZTD comparison between GPS and Radiosonde at 14 sites where Radiosonde profiles are available nearby





Inter Comparison of TOUGH results (1/2)

http://geodaf.mt.asi.it/html/GPSAtmo/WP9300/TOUGH_WP9300.html

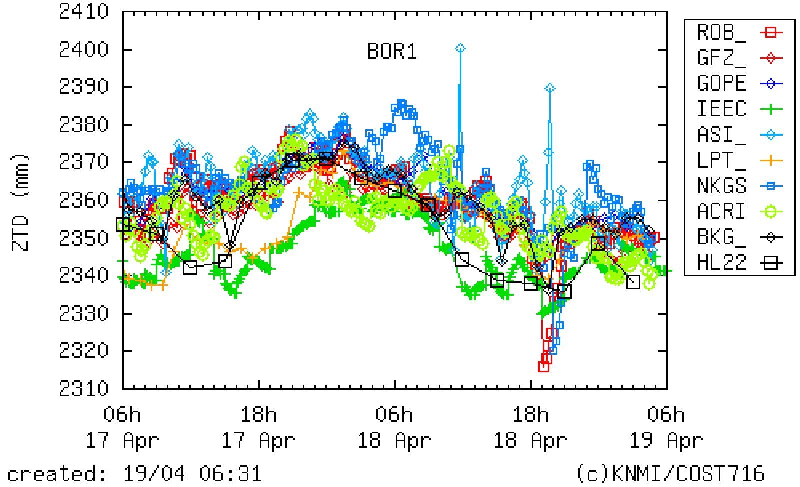


On a subset of IGS/EUREF stations a daily monitoring of the site coordinates reported in the header section of the COST files is done as well of the ZTD bias and std between ASI and the other ACs. Solutions coming from BKG, GFZ and SGN are evaluated as well even if these ACs are not in the TOUGH project and are processing the data voluntarily.

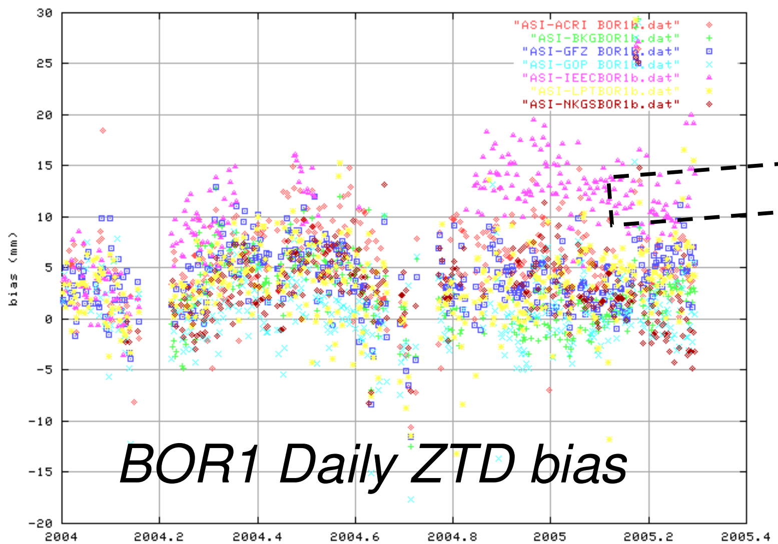
IGS/EUREF stations used for daily monitoring

Inter Comparison of TOUGH results (2/2)

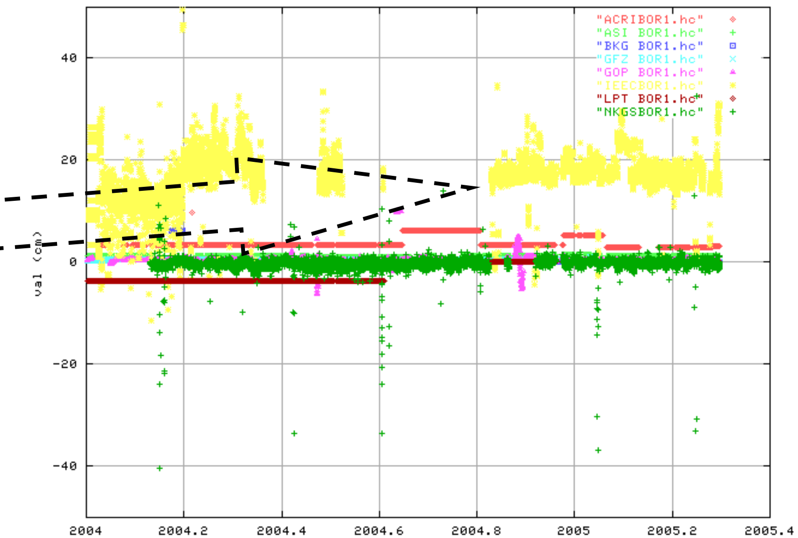
http://geodaf.mt.asi.it/html/GPSAtmo/WP9300/TOUGH_WP9300.html



BOR1 ZTD NRT estimates



BOR1 Daily ZTD bias



BOR1 H (124.425m) time series

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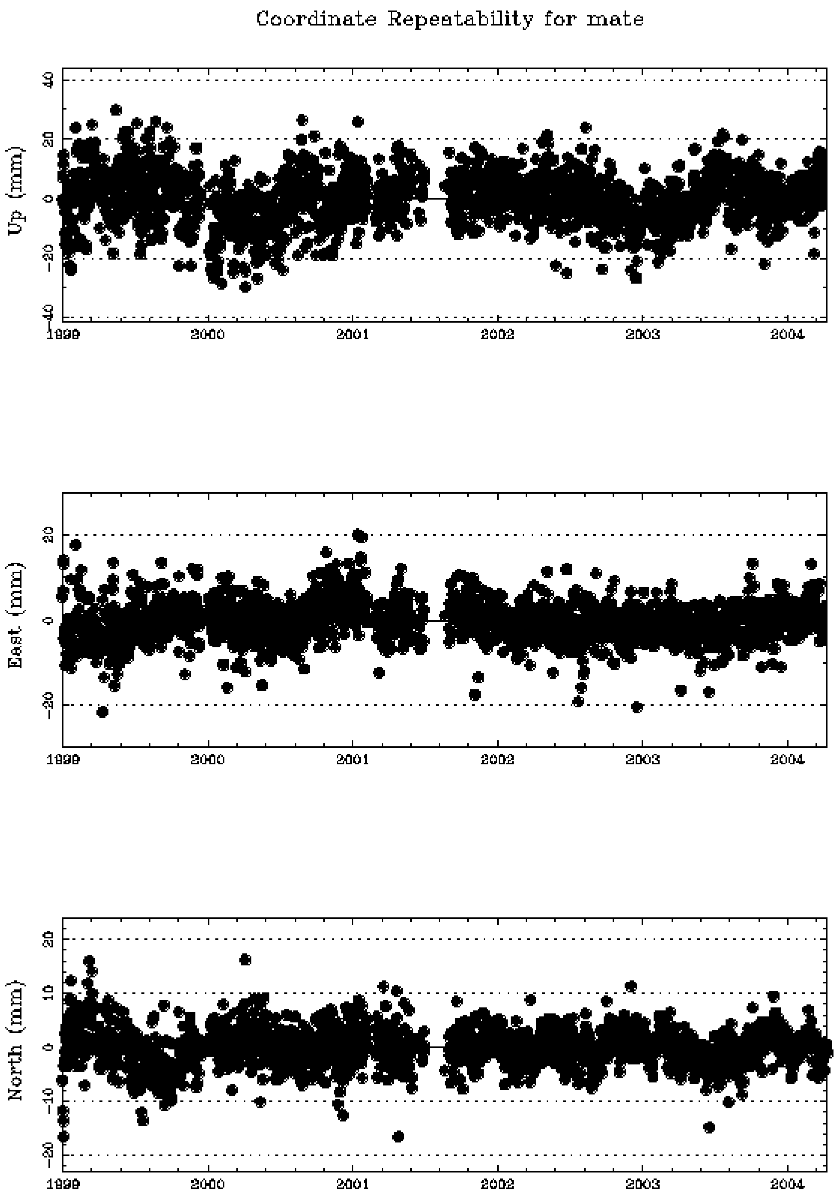
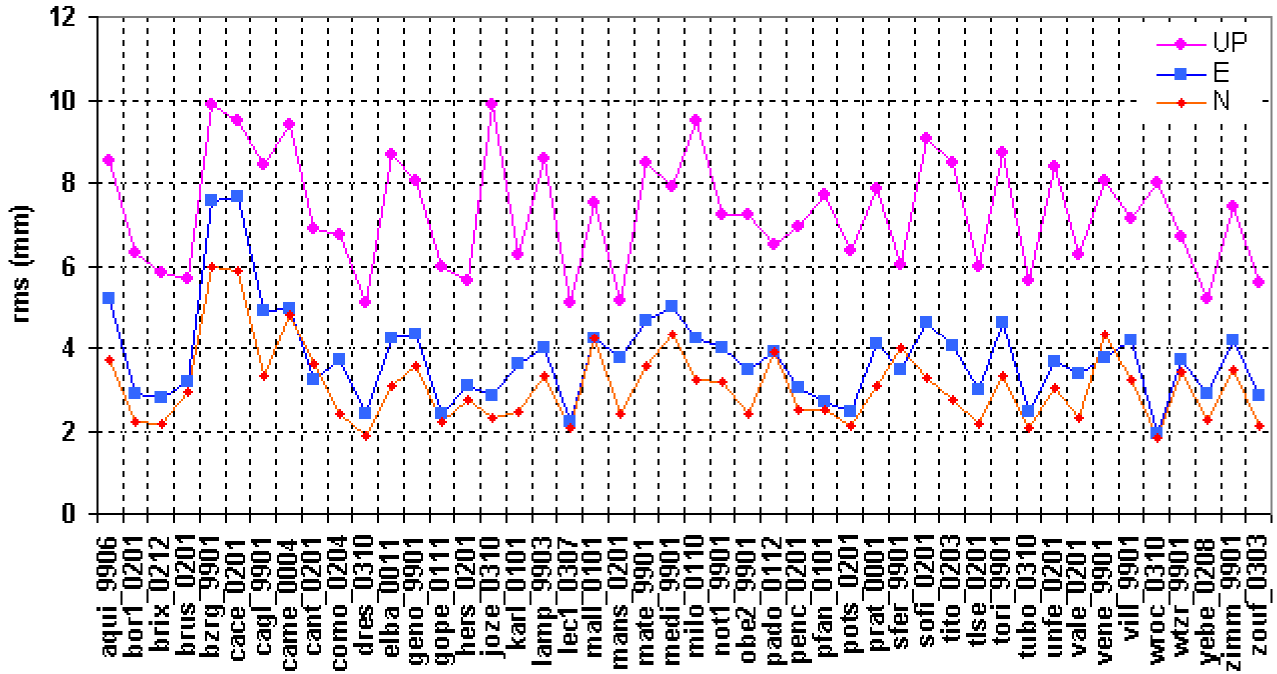
Station coordinate repeatability





Heights coordinate repeatability as indicator for ZTD quality

9mm H ⟶ 3mm ZTD ⟶ 0.45mm PW

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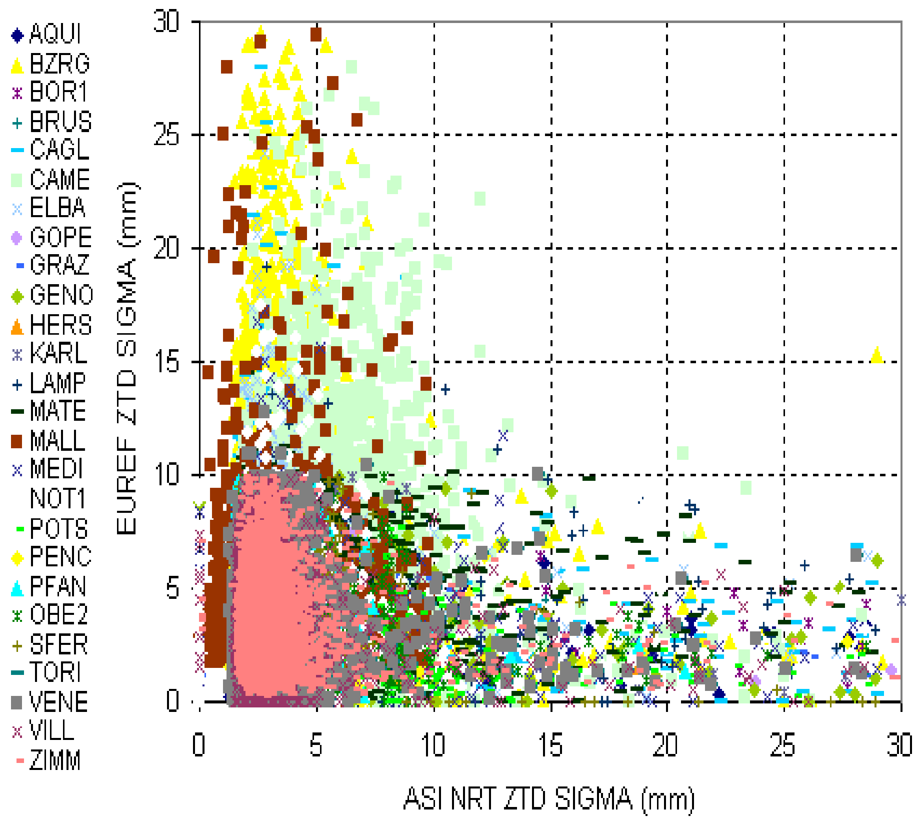
Assessment of the uncertainties of NRT estimates (1/8)



Comparing ZTD solutions coming from different ACs, a poor correlation between the related sigma is seen. This means that we need to define in a proper way a method to assess the real quality of the ZTD, obtained by the GPS processing.

A statistical method to assess the degree of reliability of the NRT ZTD and their real uncertainties is proposed

The results, achieved applying it to the ZTD estimates provided by different ACs, are discussed hereafter.

Assessment of the uncertainties of NRT estimates (2/8)

If we have have different data sets x_i and y_i, measurements of the same observable in time and space, it is possible to assess the real uncertainties of that intrinsically less precise. If y_i is more precise than x_i, we can define the a-dimensional data set z_i as:

$$\boxed{z_i = \frac{(x_i - y_i)}{\sqrt{\sigma_{x_i}^2 + \sigma_{y_i}^2}}}$$

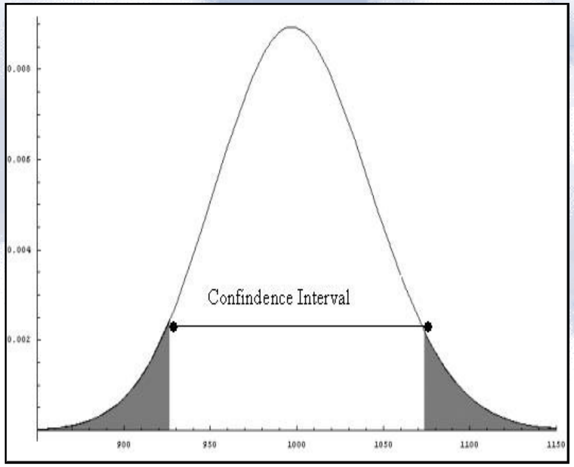
If x_i and y_i were unbiased and if their internal (formal) error was not mis-estimated, z_i behaves like a Gaussian with

μ=0 and σ=1.

μ behaves according to the Normal distribution with:

$$\sigma_\mu = \frac{\sigma_z}{\sqrt{n-1}}$$

Assessment of the uncertainties of NRT estimates (3/8)



The variance σ^2

behaves according the χ^2 function with n-1 degree of freedom

To assess the real values of the uncertainties we should test if σ^2_z is equal to 1 within its confidence interval. The new parameter to study is

$$V = \frac{\tilde{D}(n-1)}{D_{\exp}}$$

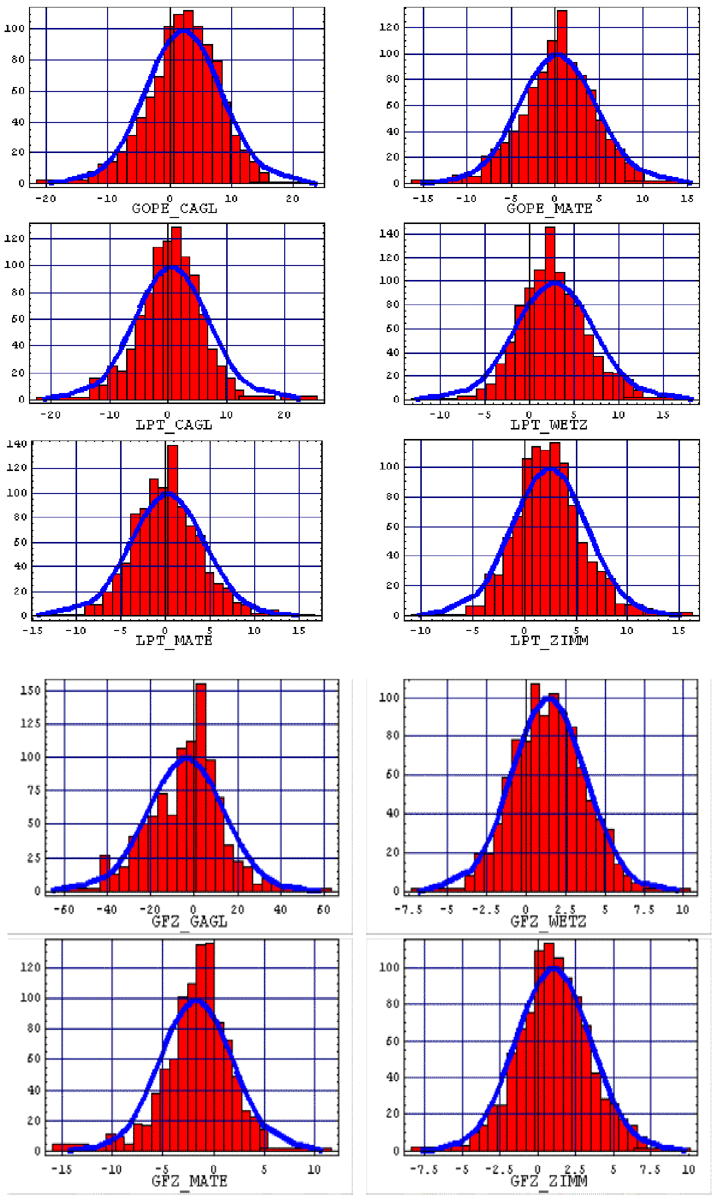
where D_{exp} is the expected variance (=1); while $\tilde{D}$ is the "*z*" estimated variance.

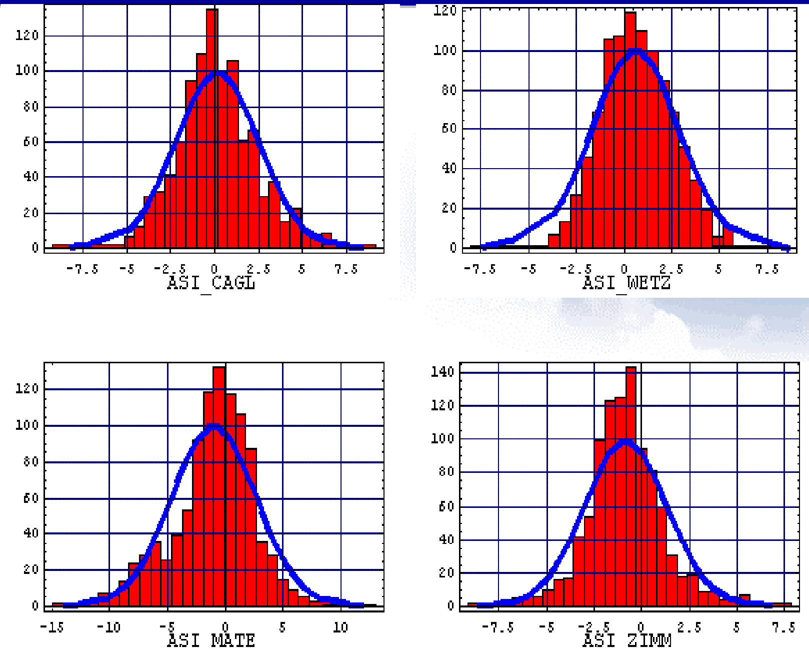
Assessment of the uncertainties of NRT estimates (4/8)

- The ***x*** datasets are ASI, GFZ, GOPE and LPT NRT solutions for the stations of MATE, CAGL, WETZ and ZIMM in the period 2001-2004.

- The ***y*** datasets are the ZTD solutions for CAGL, MATE, WTZR and ZIMM obtained in post processing mode (PP) for the same period; ASI solutions and EUREF combinations

Assessment of the uncertainties of NRT estimates (5/8)





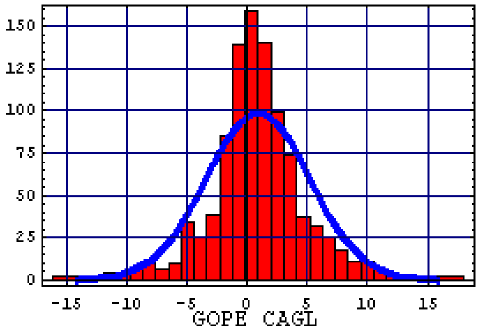
Histograms of the "z" datasets compared with the Gaussian distribution having the same μ and σ of the series. The χ^2 test is applied between the histograms and the Gaussian distribution. The *y* datasets adopted are the ZTD solutions for CAGL, MATE, WTZR and ZIMM obtained in post processing mode (PP); while the *x* datasets are ASI, GFZ, GOPE and LPT NRT solutions.

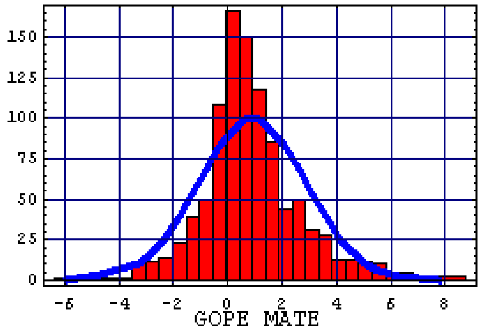
Assessment of the uncertainties of NRT estimates (6/7)

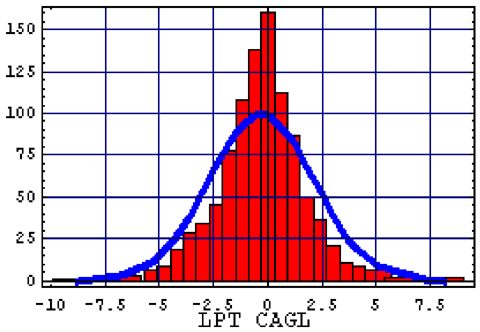
The χ^2 test failed for most of the dataset due to the presence of "coloured" noise in the ZTD time series. The analysis outlines that all the formal errors are underestimated of a factor ranging from 2 to 17 and that the scaled errors are up to 1 cm level

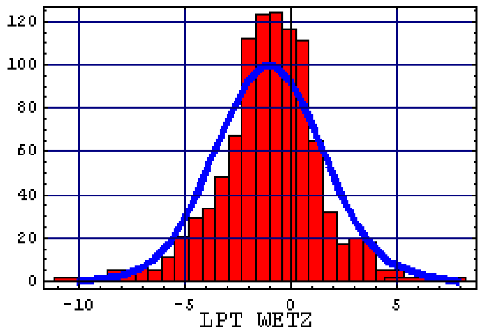
AC_staz	μ	$\bar{x}_{min}$	$\bar{x}_{max}$	Bias	$\bar{\sigma}_{int}$ mm	σ_Z	σ-CI		σ-Bias	Scaled σ_x mm	χ^2 CI		χ^2	χ^2 Test
ASI_CAGL	0,14	-0,07	0,35	no	3,40	2,36	2,22	2,52	yes	8,02	10,12	30,14	62,48	fail
GFZ_GAGL	-3,66	-5,21	-2,10	yes	0,85	17,50	16,46	18,67	yes	14,94	9,39	28,87	138,69	fail
GOP_CAGL	2,20	1,66	2,74	yes	0,92	6,13	5,77	6,54	yes	5,62	9,39	28,87	51,08	fail
LPT_CAGL	0,62	0,07	1,17	yes	1,00	6,21	5,84	6,62	yes	6,23	8,67	27,59	140,32	fail
ASI_MATE	-0,99	-1,31	-0,66	yes	3,38	3,66	3,44	3,90	yes	12,36	10,12	30,14	101,74	fail
GFZ_MATE	-1,71	-2,03	-1,40	yes	0,99	3,55	3,34	3,79	yes	3,52	9,39	28,87	342,00	fail
GOP_MATE	0,25	-0,14	0,64	no	0,96	4,34	4,09	4,63	yes	4,17	9,39	28,87	63,07	fail
LPT_MATE	0,26	-0,10	0,63	no	1,08	4,15	3,90	4,43	yes	4,47	10,12	30,14	100,46	fail
ASI_WTZR	0,62	0,42	0,82	yes	2,45	2,27	2,14	2,42	yes	5,56	7,96	26,30	91,89	fail
GFZ_WTZR	1,44	1,23	1,65	yes	0,88	2,35	2,21	2,51	yes	2,08	9,39	28,87	20,78	OK
LPT_WETZ	2,83	2,44	3,22	yes	0,85	4,38	4,12	4,68	yes	3,75	8,67	27,59	88,72	fail
ASI_ZIMM	-0,85	-1,04	-0,66	no	3,54	2,17	2,04	2,31	yes	7,67	11,59	32,67	131,90	fail
GFZ_ZIMM	1,05	0,83	1,27	yes	0,91	2,47	2,32	2,63	yes	2,24	10,12	30,14	29,18	OK
LPT_ZIMM	2,47	2,15	2,79	yes	0,85	3,62	3,40	3,86	yes	3,06	8,67	27,59	70,66	fail

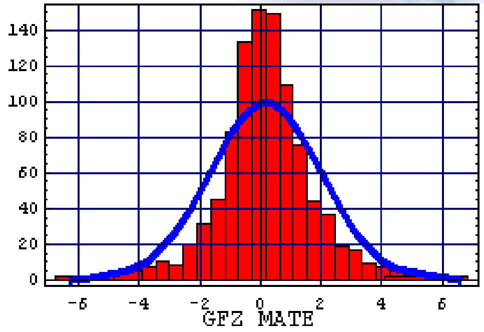
The *y* datasets adopted are the EUREF ZTD solutions for CAGL, MATE, WTZR and ZIMM obtained in post processing mode (PP);

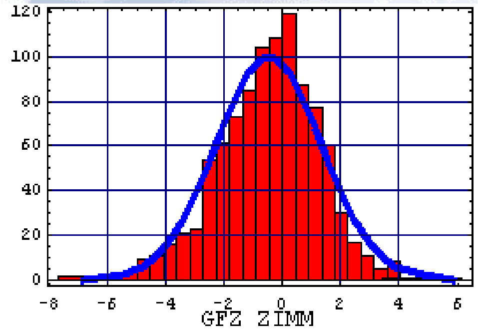


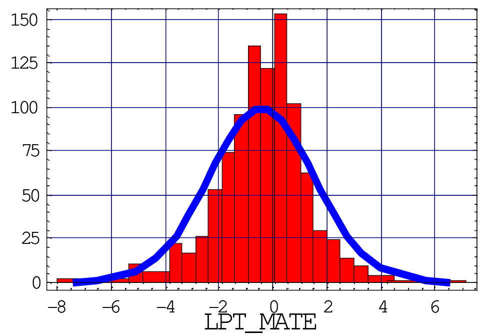


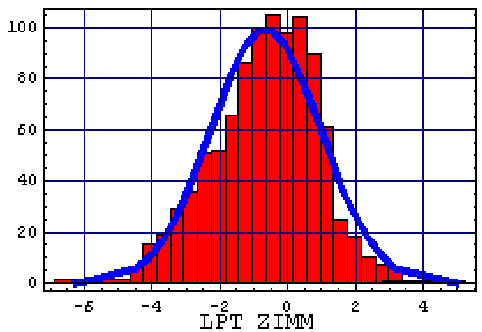


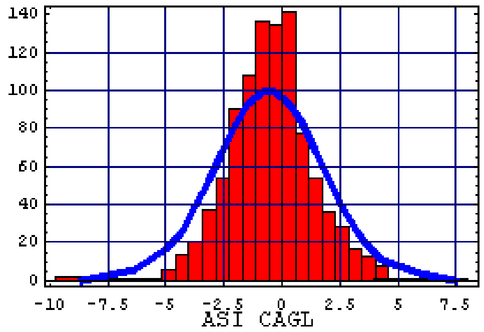


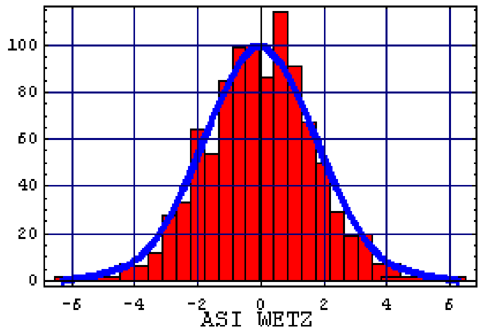


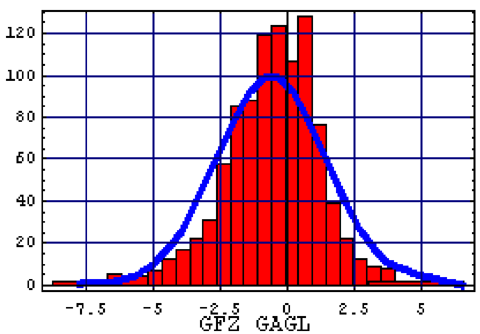


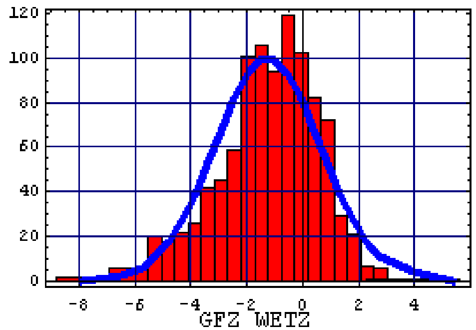


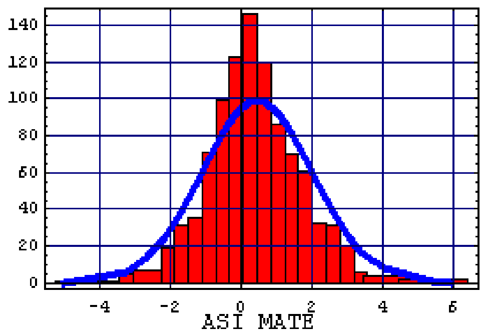


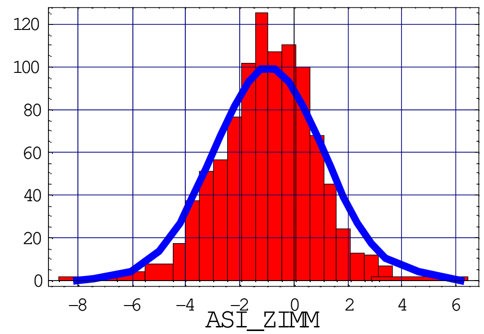












Assessment of the uncertainties of NRT estimates (8/8)

The χ^2 test failed for most of the dataset also for the EUREF dataset Also in this case all the formal errors seem to be underestimated of a factor ranging from 1.6 to 4.2 and the scaled errors are up to 8 mm level

AC_STATION	μ	$\overline{x}_{min}$	$\overline{x}_{max}$	Bias	$\overline{\sigma}_{int}$ (mm)	σ_z	$\sigma - CI$		σ-Bias	Scaled σ_z mm	χ^2 C -I		χ^2	χ^2 Test
ASI_CAGL	-0,5617	-0,7656	-0,3577	yes	3,4008	2,2975	2,1612	2,4506	yes	7,8136	8,6718	27,5871	151,7546	Fail
GFZ_GAGL	-0,5953	-0,7755	-0,4151	yes	0,8538	2,0298	1,9093	2,1650	yes	1,7331	10,1170	30,1435	151,6955	Fail
GOPE_CAGL	0,9254	0,5476	1,3032	yes	0,9166	4,2561	4,0034	4,5396	yes	3,9012	11,5913	32,6706	224,2260	Fail
LPT_CAGL	-0,2880	-0,5011	-0,0749	yes	1,0033	2,4006	2,2581	2,5605	yes	2,4086	9,3905	28,8693	133,1523	Fail
ASI_MATE	0,4523	0,3143	0,5904	yes	3,3771	1,5552	1,4629	1,6588	yes	5,2520	8,6718	27,5871	99,5617	Fail
GFZ_MATE	0,1767	0,0155	0,3379	yes	0,9917	1,8161	1,7083	1,9371	yes	1,8011	10,1170	30,1435	153,1895	Fail
GOPE_MATE	0,9085	0,7347	1,0824	yes	0,9599	1,9585	1,8423	2,0890	yes	1,8801	10,1170	30,1435	205,2952	Fail
LPT_MATE	-0,4362	-0,6100	-0,2625	yes	1,0776	1,9574	1,8413	2,0878	yes	2,1094	8,6718	27,5871	135,2436	Fail
ASI_WETZ	-0,0297	-0,1877	0,1283	no	2,4498	1,7800	1,6743	1,8985	yes	4,3605	10,1170	30,1435	27,7277	OK
GFZ_WETZ	-1,2458	-1,4141	-1,0775	yes	0,8824	1,8961	1,7835	2,0224	yes	1,6730	10,1170	30,1435	117,3274	Fail
LPT_WETZ	-1,0209	-1,2453	-0,7965	yes	0,8544	2,5280	2,3779	2,6964	yes	2,1599	10,1170	30,1435	123,2262	Fail
ASI_ZIMM	-0,9442	-1,1248	-0,7636	yes	3,5379	2,0342	1,9134	2,1697	yes	7,1966	8,6718	27,5871	56,6513	Fail
GFZ_ZIMM	-0,4649	-0,6256	-0,3043	yes	0,9070	1,8101	1,7027	1,9307	yes	1,6418	10,8508	31,4104	63,4362	Fail
LPT_ZIMM	-0,6470	-0,7899	-0,5042	yes	0,8458	1,6094	1,5139	1,7166	yes	1,3612	10,1170	30,1435	42,7551	Fail