

Combination at observation level

ZTD Study - CONT08

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Combination method

1 - CNES Software GINS :

To obtain observation equations per technique



GPS data

GINs



GPS Observation
equations



DORIS data

GINs



DORIS Observation
equations



VLBI data

GINs



VLBI Observation
equations



SLR data

GINs



SLR Observation
equations

Combination method

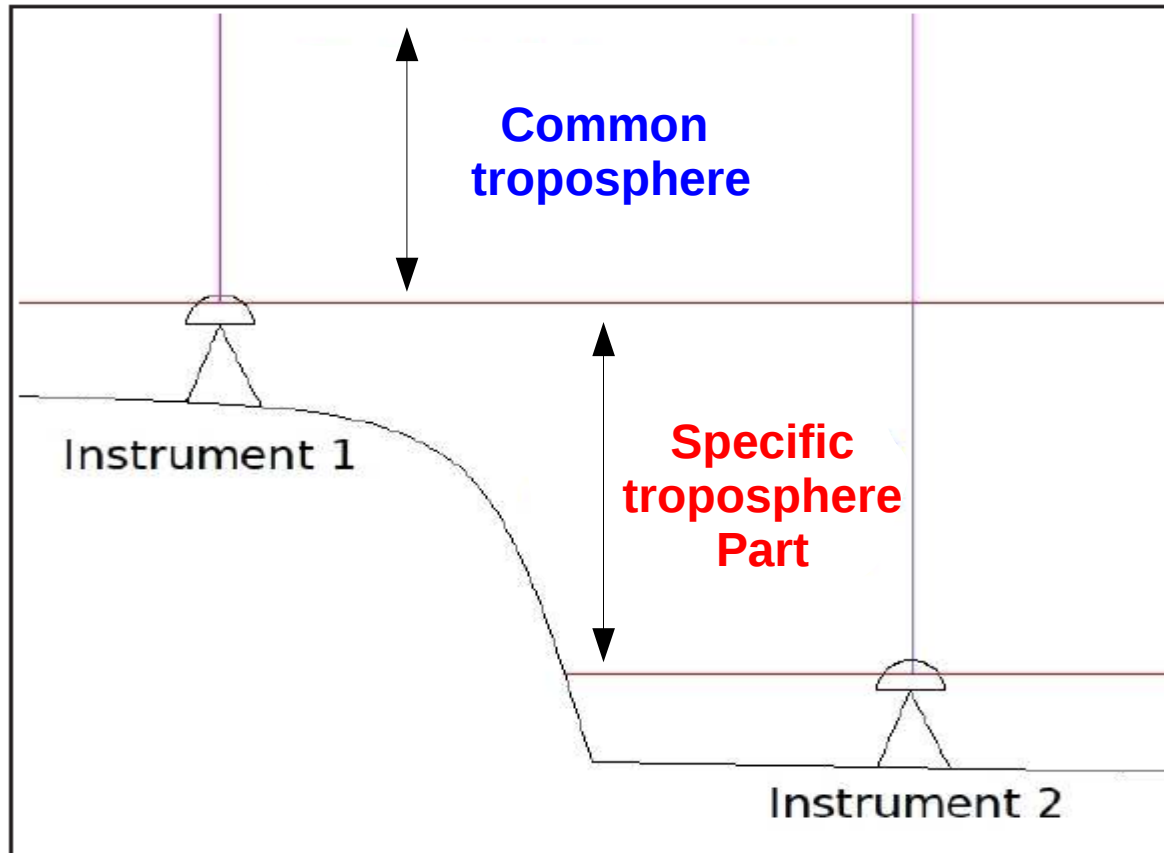
2 – To modify observation equations :

A – ZTD parameters estimated on co-location sites :

Re-sampling and A priori correction for radio technique equations

=> Same sampling and A priori for tropospheric parameters

Height differences taken into account via model



$$\text{ZTD2} = \text{ZTD1} + \Delta\text{ZTD}$$

Model correction for ΔZTD

Common ZWD parameters
estimated on co-location sites

Combination method

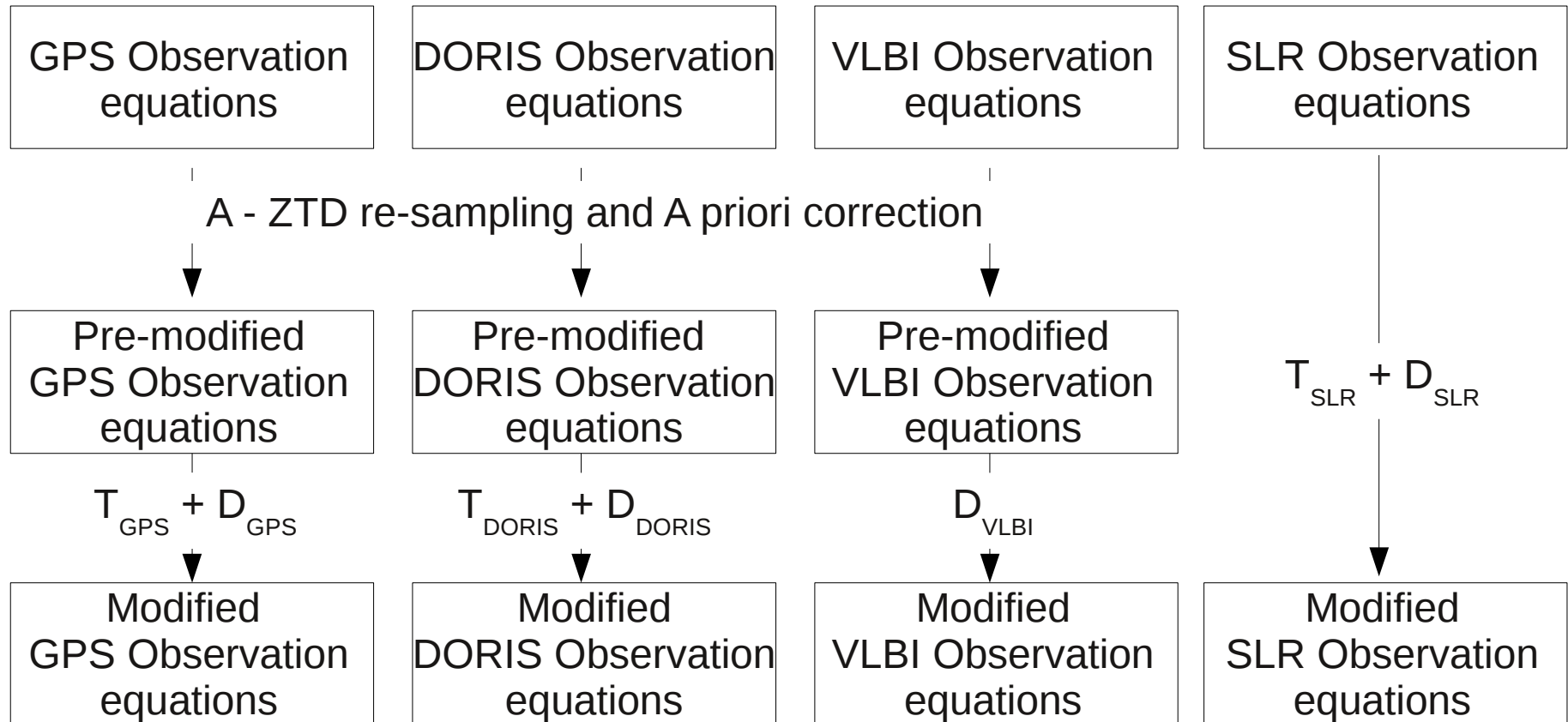
2 – To modify observation equations :

B – Helmert parameters introduction
to take into account technique inconsistencies :

$$\text{Satellite technique : } \delta X_{\text{Tech}} = \delta X_c + T_{\text{Tech} \rightarrow c} + D_{\text{Tech} \rightarrow c} X_0$$

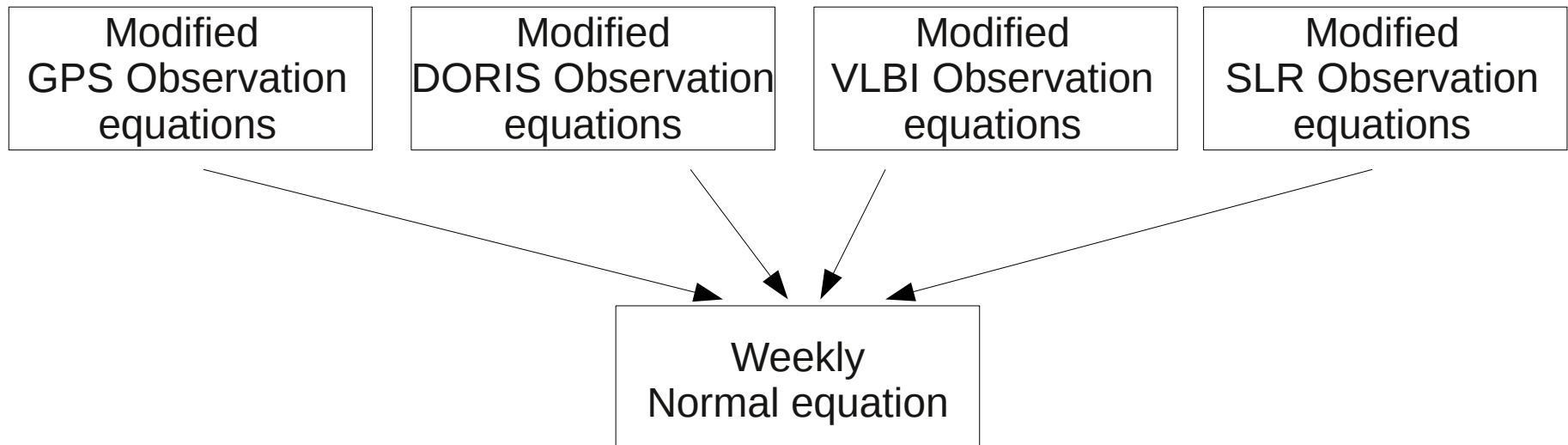
$$\text{VLBI : } \delta X_{\text{VLBI}} = \delta X_c + T_{\text{VLBI} \rightarrow c} + D_{\text{VLBI} \rightarrow c} X_0$$

Combination method



Combination method

3 – To create normal equation :

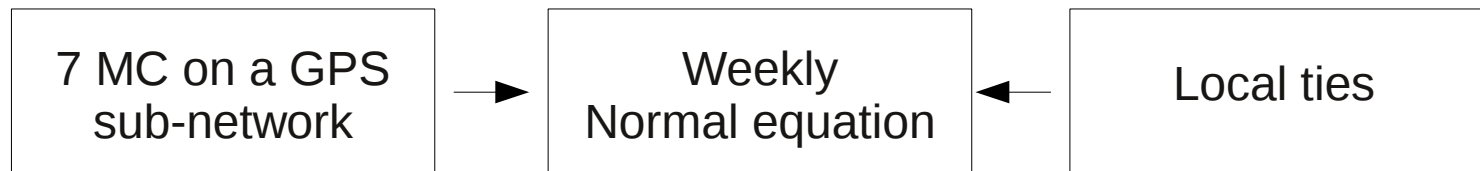


Combination method

4 – Use of Local ties and minimum constraints

Local ties : Re-evaluation of local ties via ITRF 2008
(cf. IAG proceeding [Pollet & al., 2012])

Minimum constraints (MC) : 7 MC to define the combined frame.



Combination method

5 – Estimation

Estimated parameters :

- Daily EOP at 12h00 (Polar motion, UT, Nutation parameters)
- Weekly station positions
- ZWD per 2h (Common ZWD on co-location site
only for site with station height differences < 100 m)
- All other needed parameters as Orbital parameters, Time Bias for VLBI,
frequency bias for DORIS ...

Combined frame definition

All stations / ITRF2008 : $T_x, T_y, T_z, D = 0.0 \pm 0.0 \text{ mm}$; $R_x, R_y, R_z = 0 \pm 0 \text{ } \mu\text{s}$

GPS stations / ITRF2008 : $T_x, T_y, T_z, D = 0.0 \pm 0.0 \text{ mm}$; $R_x, R_y, R_z = 0 \pm 0 \text{ } \mu\text{s}$

VLBI stations / ITRF2008

DORIS stations / ITRF2008

SLR stations / ITRF2008

$T_x = -0.7 \pm 0.4 \text{ mm}$

$T_y = 1.5 \pm 0.4 \text{ mm}$

$T_z = 0.0 \pm 0.2 \text{ mm}$

$D = 0.0 \pm 0.1 \text{ mm}$

$R_x = 69 \pm 12 \text{ } \mu\text{s}$

$R_y = 32 \pm 18 \text{ } \mu\text{s}$

$R_z = 0 \pm 4 \text{ } \mu\text{s}$

$T_x = 0.3 \pm 0.1 \text{ mm}$

$T_y = -0.5 \pm 0.1 \text{ mm}$

$T_z = 0.0 \pm 0.1 \text{ mm}$

$D = -0.1 \pm 0.1 \text{ mm}$

$R_x = -7 \pm 9 \text{ } \mu\text{s}$

$R_y = -5 \pm 3 \text{ } \mu\text{s}$

$R_z = 0 \pm 1 \text{ } \mu\text{s}$

$T_x = 0.8 \pm 1.1 \text{ mm}$

$T_y = -1.1 \pm 0.8 \text{ mm}$

$T_z = -0.5 \pm 1.3 \text{ mm}$

$D = -0.1 \pm 0.3 \text{ mm}$

$R_x = 33 \pm 9 \text{ } \mu\text{s}$

$R_y = -16 \pm 53 \text{ } \mu\text{s}$

$R_z = 40 \pm 38 \text{ } \mu\text{s}$

HOMOGENEOUS COMBINED FRAME

Daily EOP estimations

SLR

PX	PY
-190 +/- 187 μ as	-170 +/- 156 μ as

DORIS

PX	PY
-266 +/- 311 μ as	-32 +/- 316 μ as

GPS

PX	PY
-13 +/- 18 μ as	13 +/- 22 μ as

VLBI

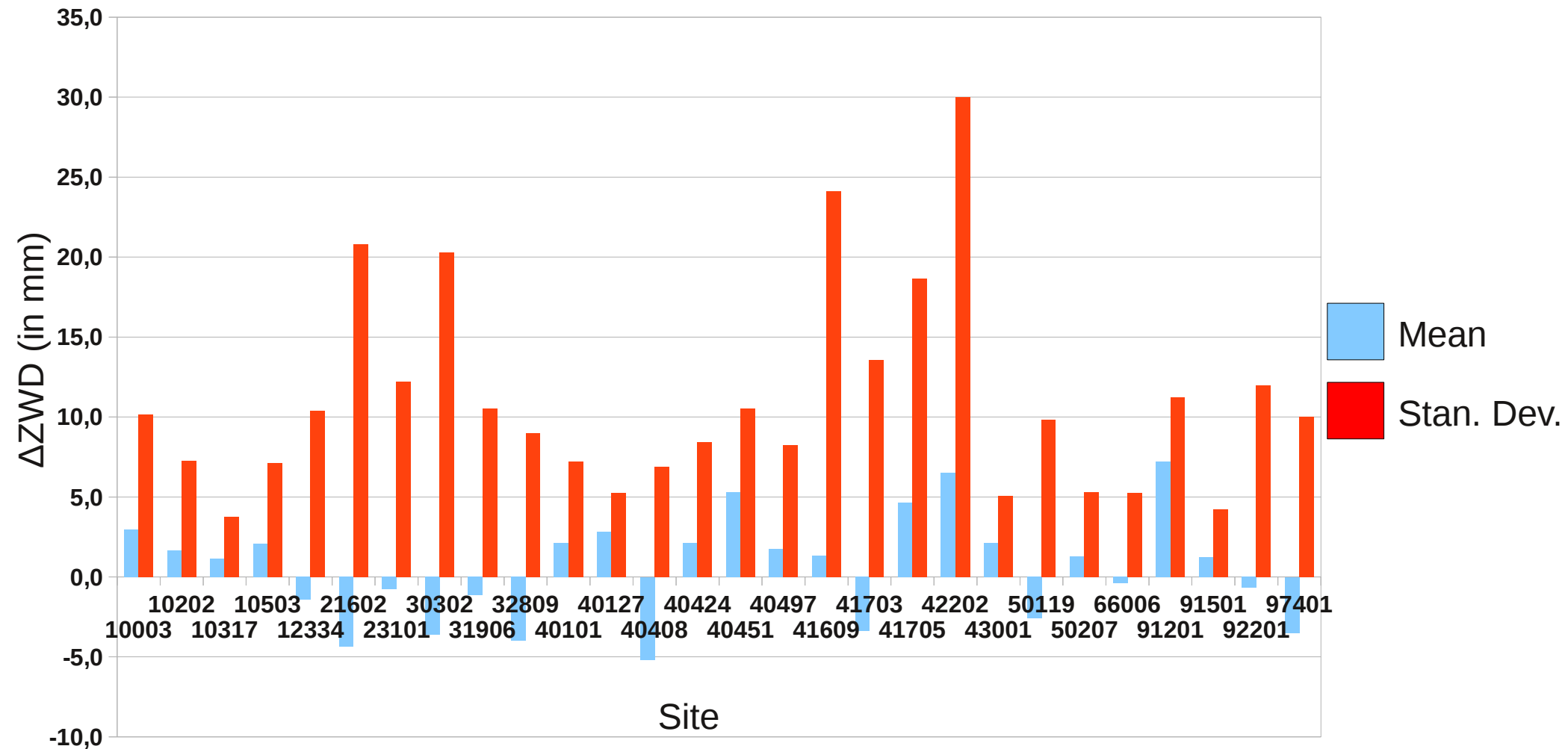
PX	PY	UT	d ϵ	d Ψ
27 +/- 96 μ as	-24 +/- 70 μ as	2 +/- 17 μ s	-4 +/- 75 μ as	-36 +/- 54 μ as

COMBINATION

PX	PY	UT	d ϵ	d Ψ
-5 +/- 11 μ as	1 +/- 11 μ as	4 +/- 17 μ s	23 +/- 124 μ as	-16 +/- 79 μ as

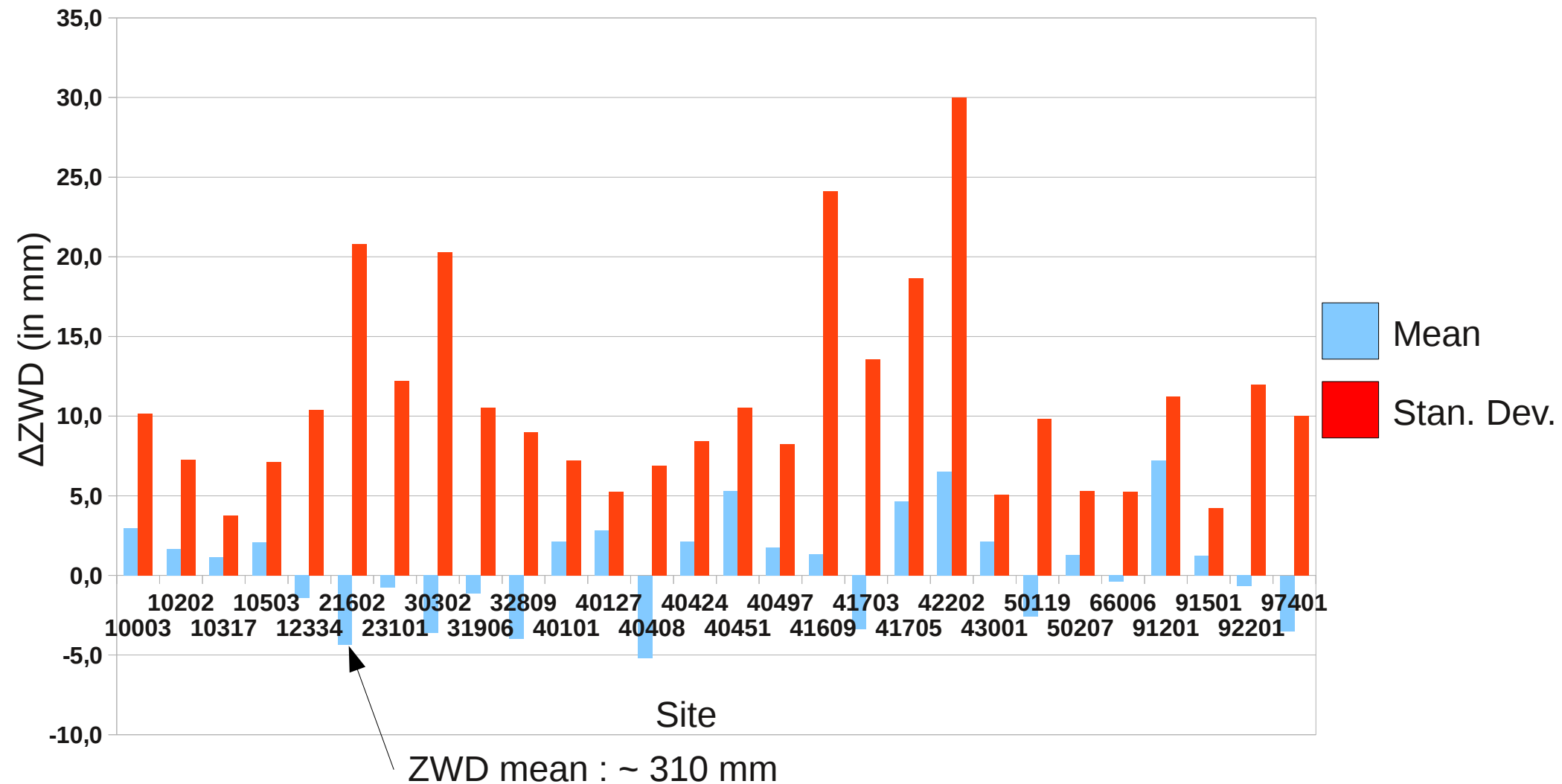
ZWD comparison

GPS - DORIS



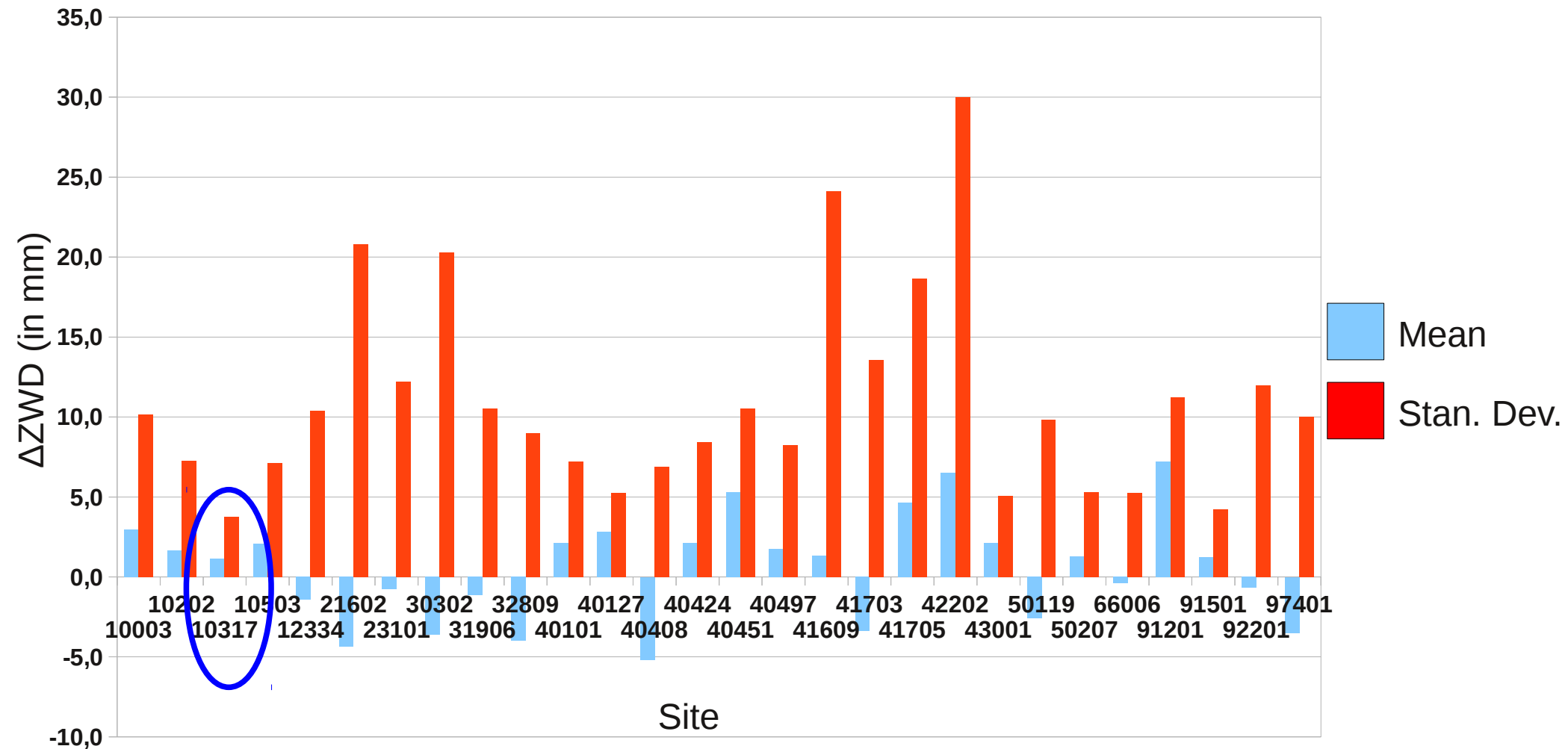
ZWD comparison

GPS - DORIS



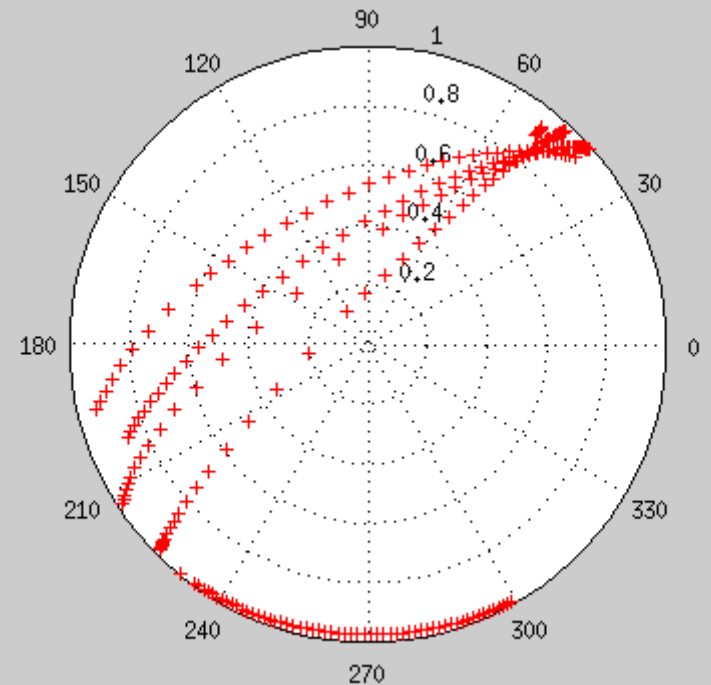
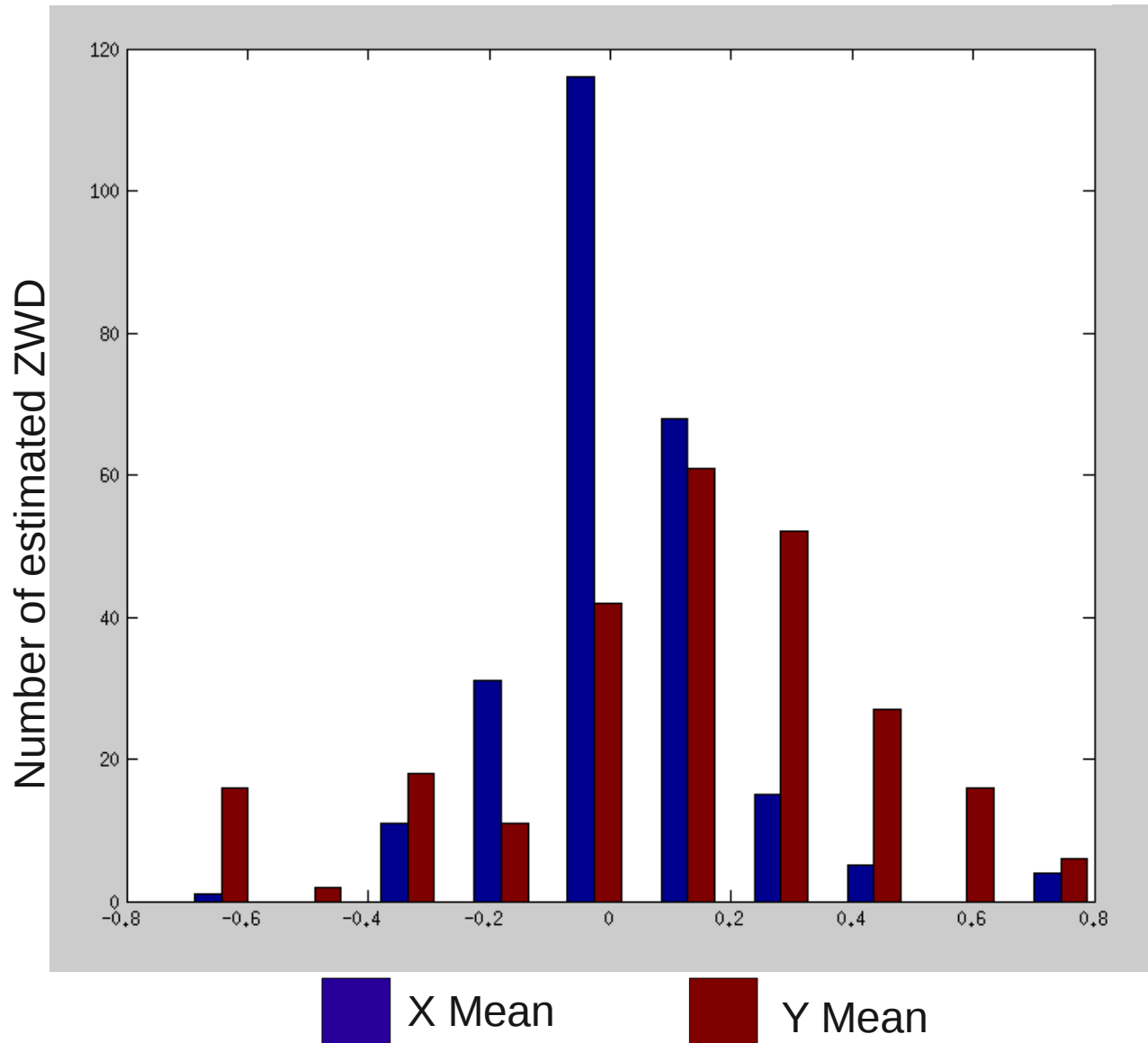
ZWD comparison

GPS - DORIS



10317 – DORIS

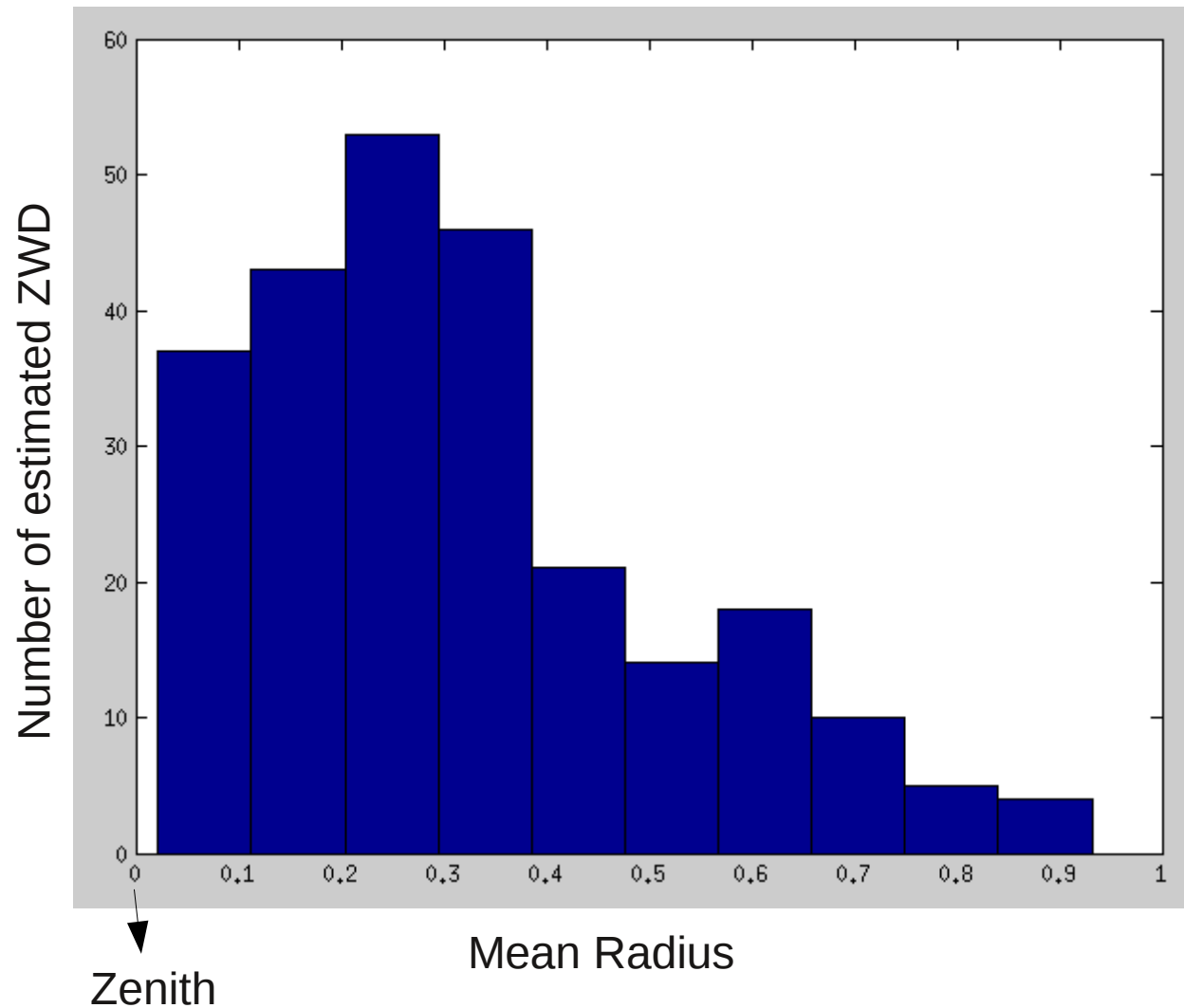
Measurement distribution



Example of Skymplot
Station 10317
Measurements providing
information for estimation of 1 ZWD

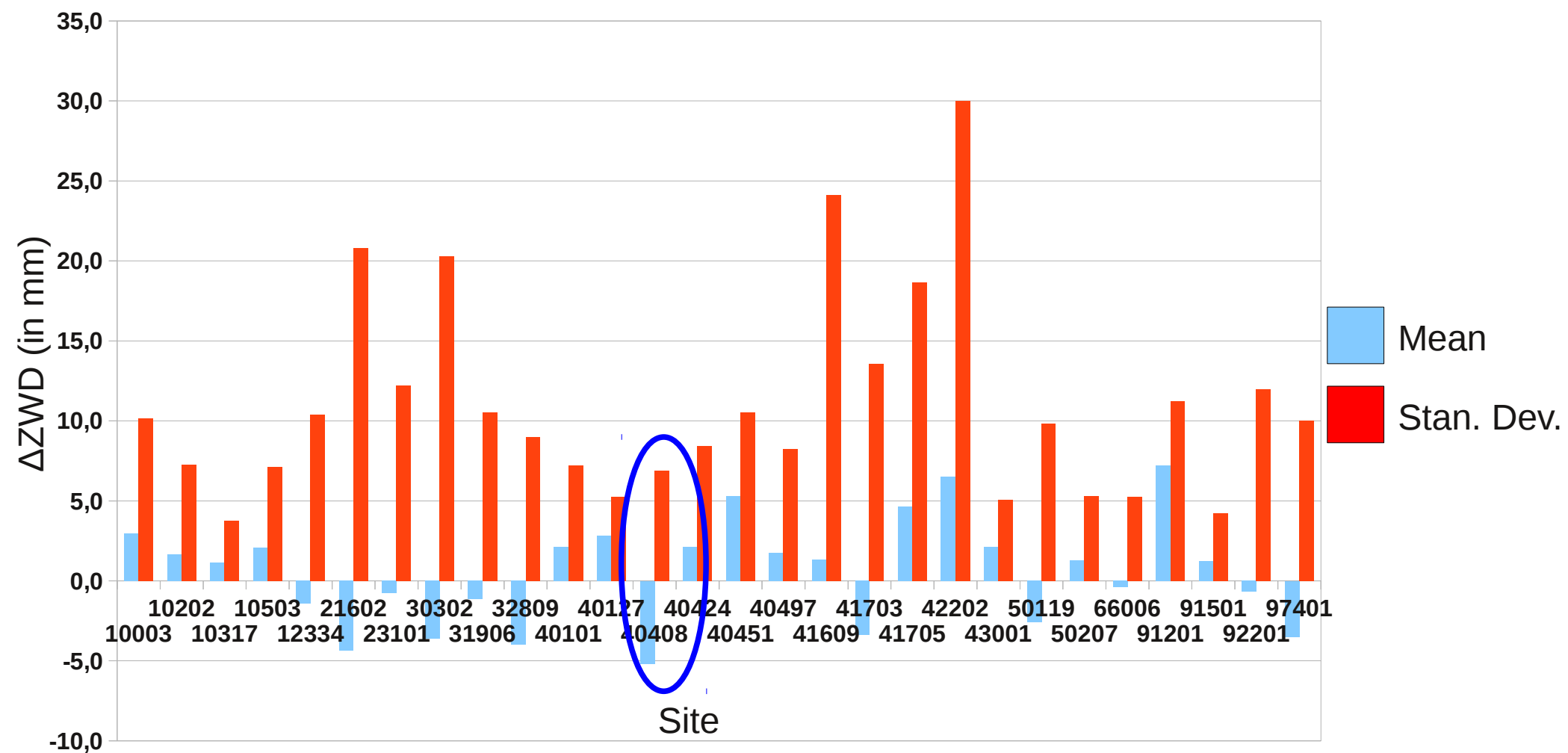
10317 – DORIS

Measurement distribution



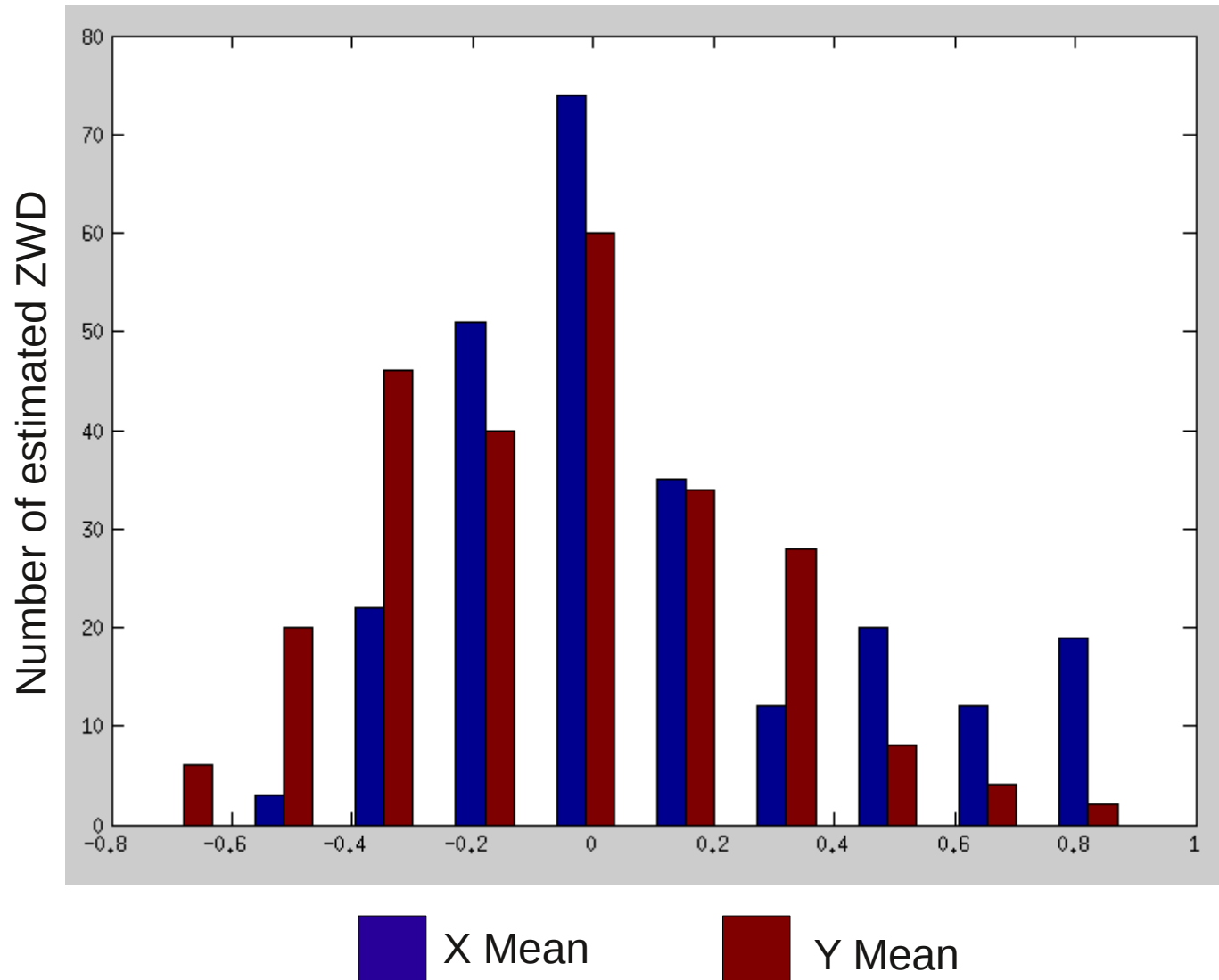
ZWD comparison

GPS - DORIS



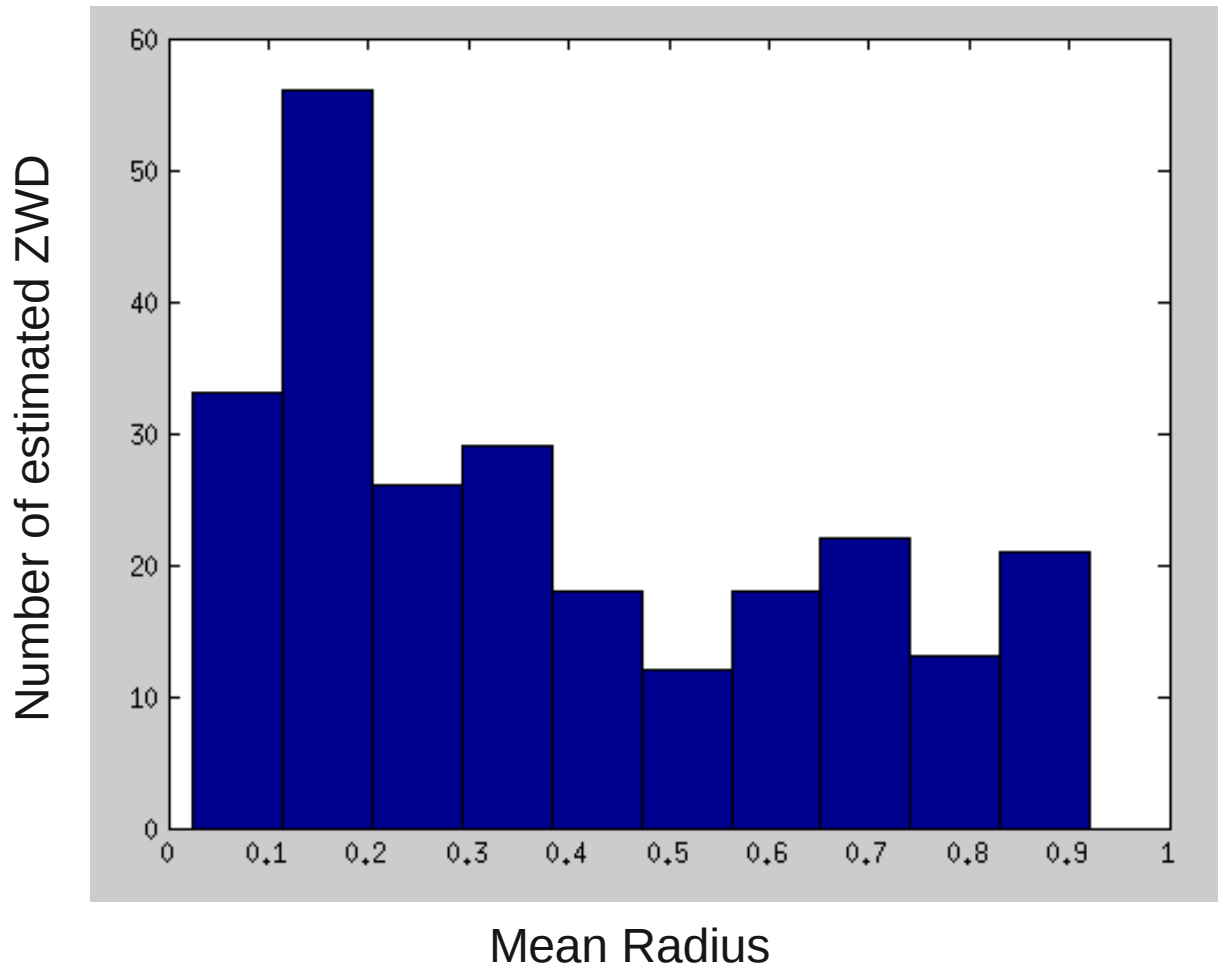
40408 – DORIS

Measurement distribution



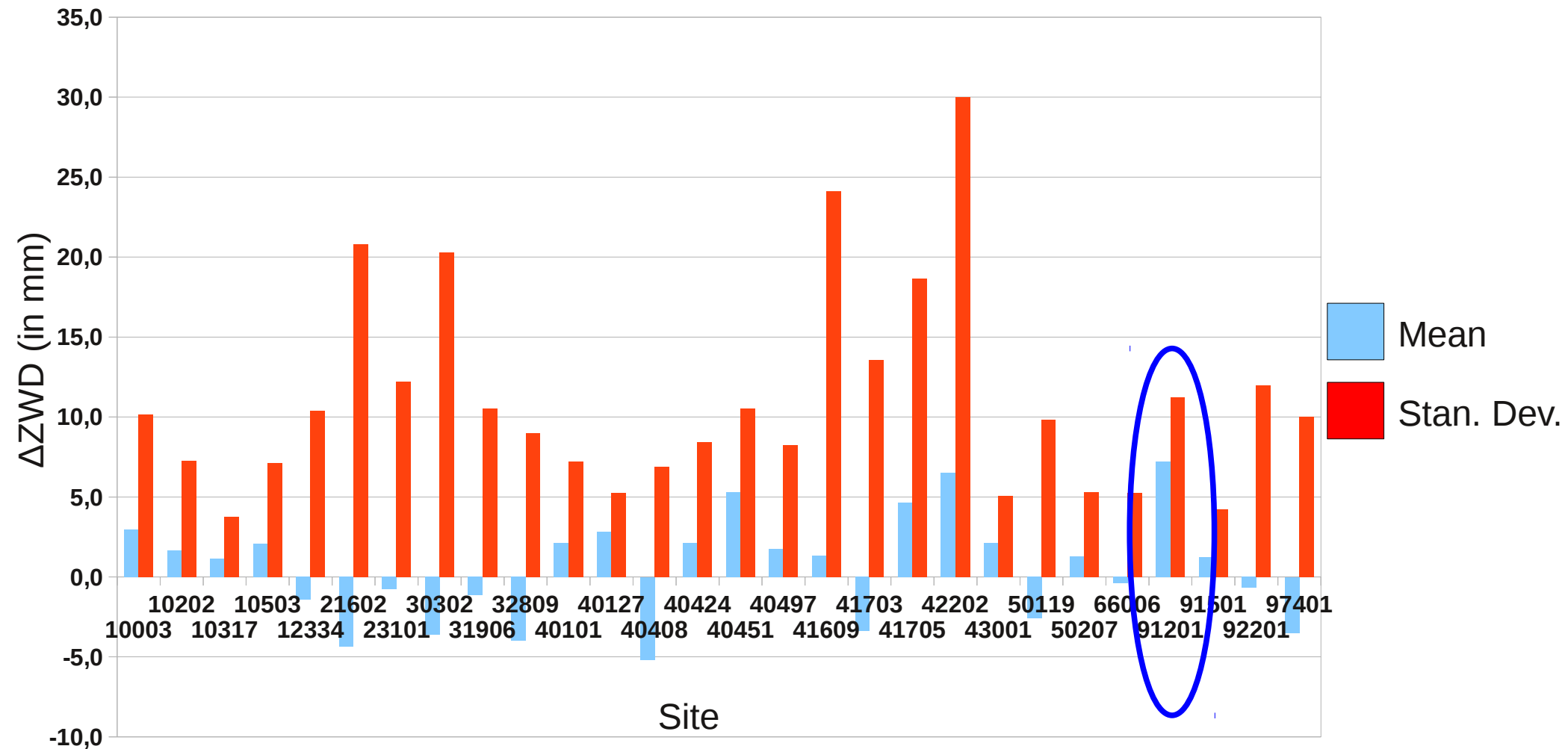
40408 – DORIS

Measurement distribution



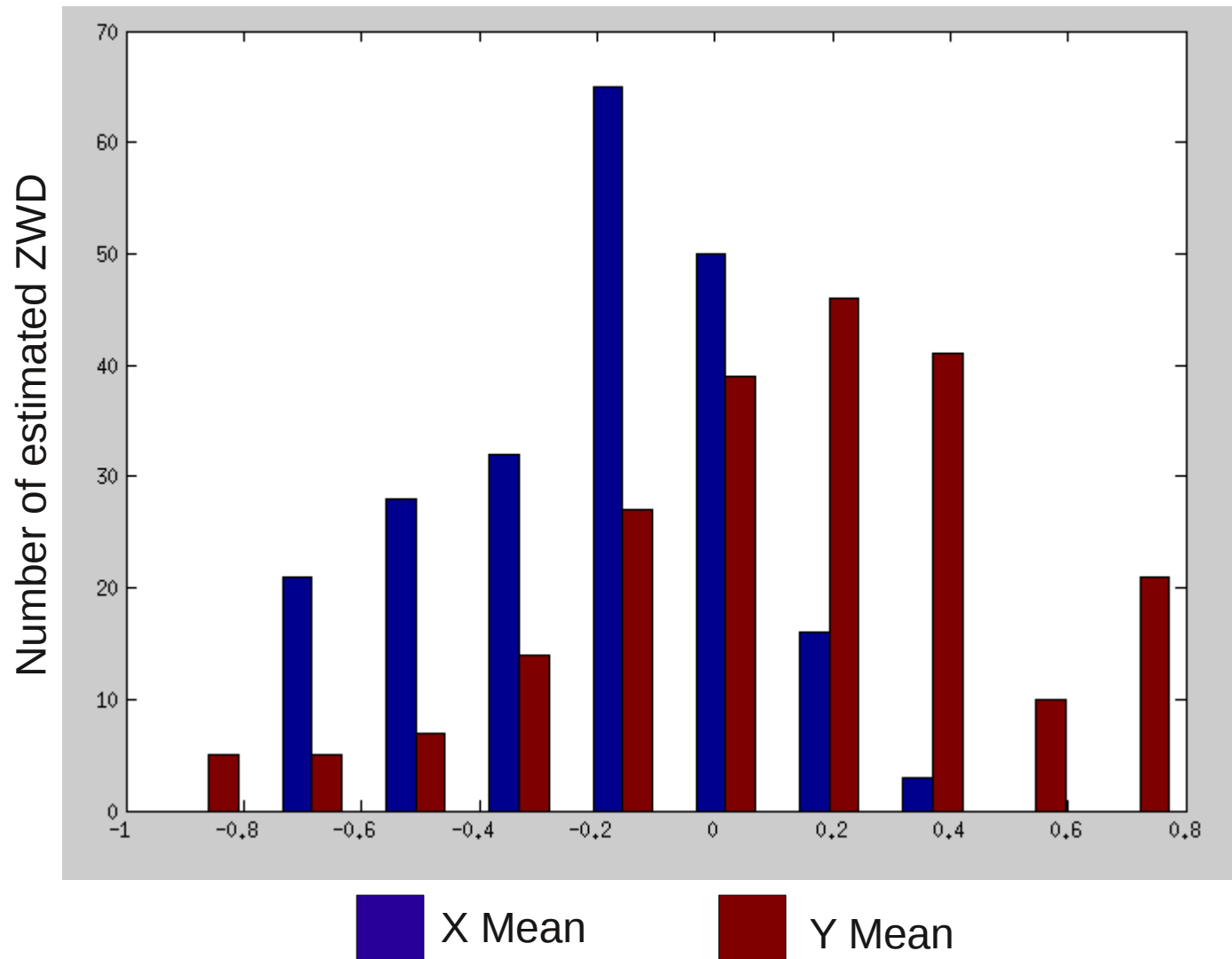
ZWD comparison

GPS - DORIS



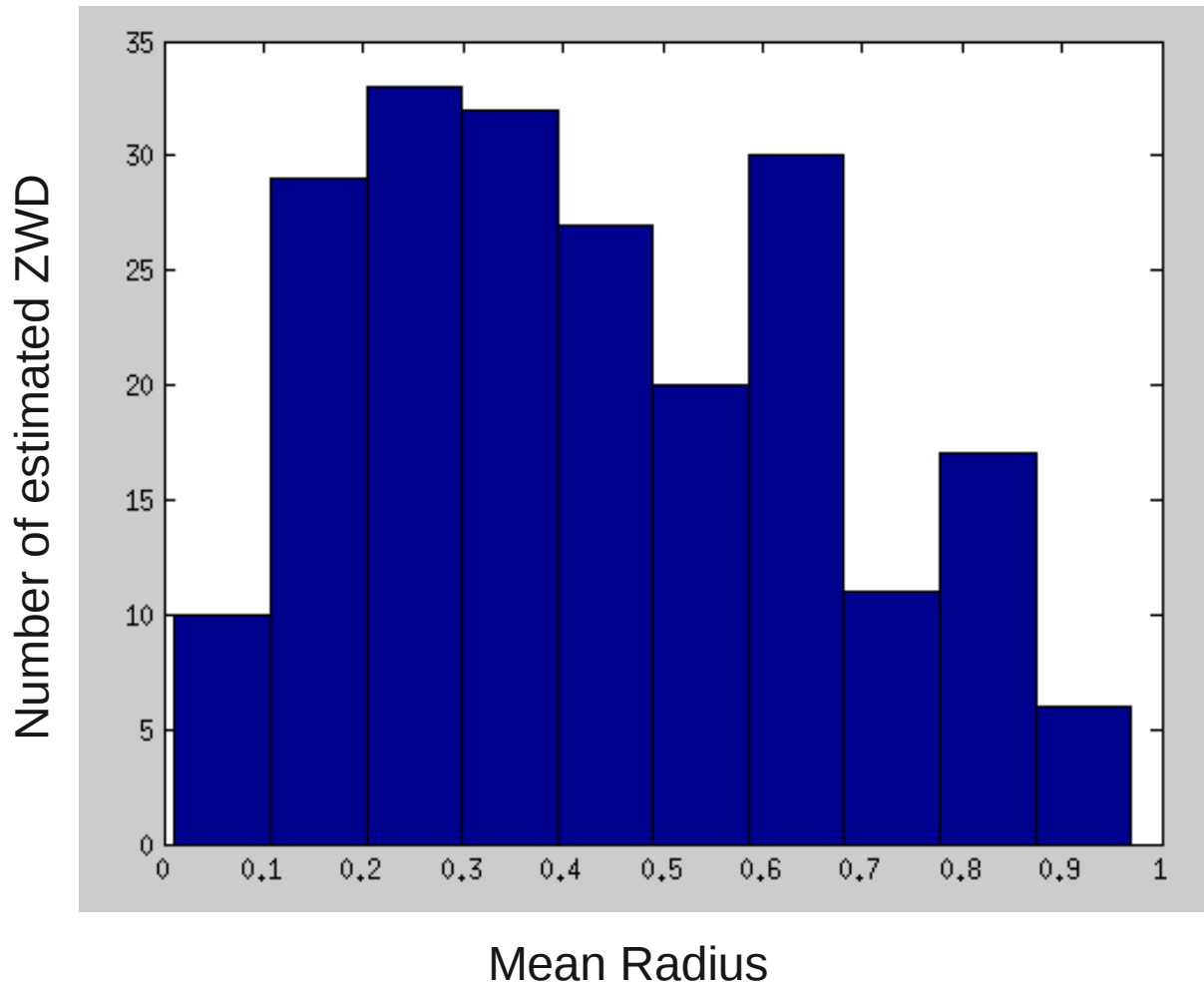
91201 – DORIS

Measurement distribution



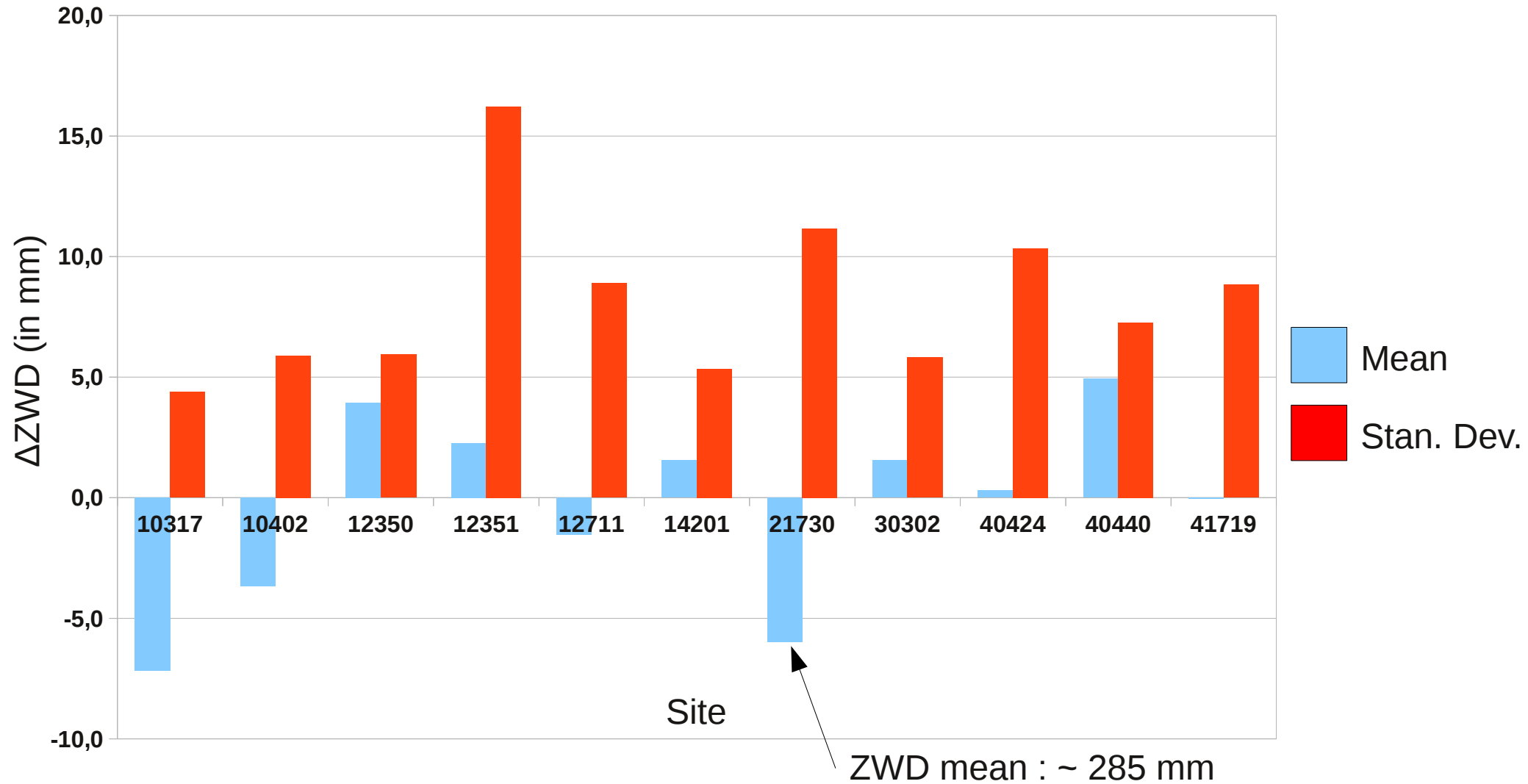
91201 – DORIS

Measurement distribution



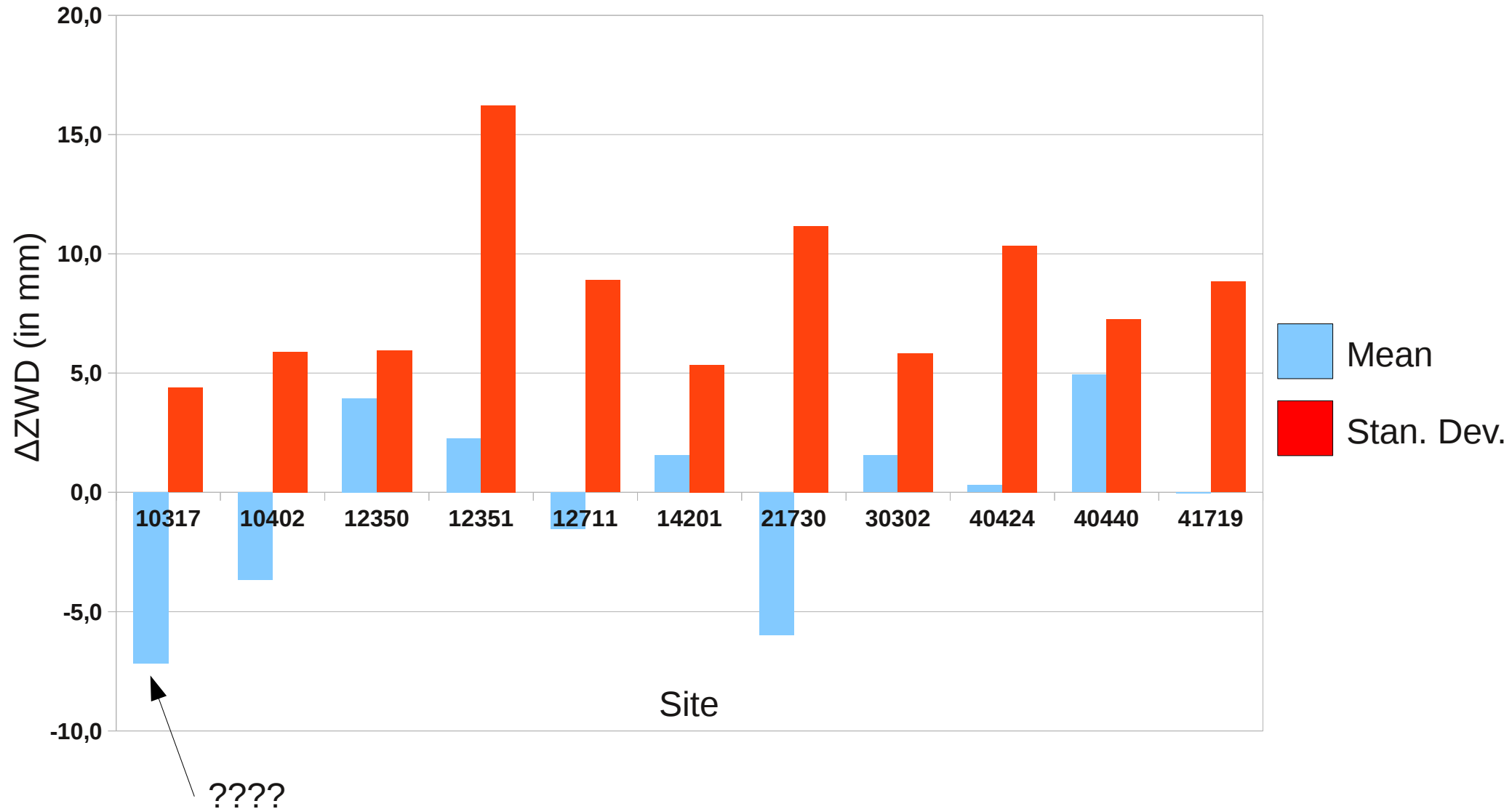
ZWD comparison

GPS - VLBI



ZWD comparison

GPS - VLBI



ZWD Comparison

