



PPP STATIC PERFORMANCES vs OBSERVATION TIME-SPAN

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Performances in GNSS positioning

DIFFERENCED APPROACH

Precision depends by the **baseline length** (d) and the **observation time** (t)

$$\varepsilon \propto (d/t)$$

For short baseline lengths (< 15-20 Km) the precisions are **within 1 cm**, even for **few hours** of observation time...

PPP APPROACH

The “**absolute**” **positioning** of a **single receiver** is calculated in the same **reference system of the orbits**.

The PPP performance are nowadays the same of the differenced approach...at least while processing **24 hours RINEX** files!

WHICH PRECISION CAN WE EXPECT FOR SHORTER OBSERVATION TIMES?



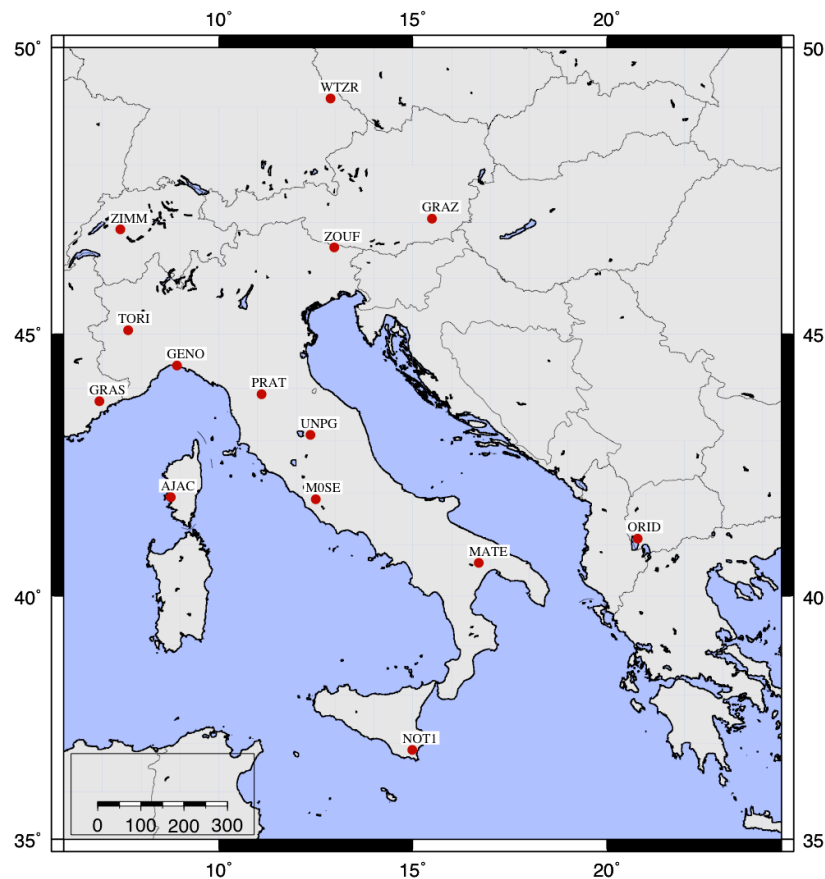
The test - dataset

We splitted a 24 hour RINEX file in several sub-files of shorter time span...

1	24 Hours RINEX file (30 seconds sampling rate)																							
2	12 hours RINEX file												12 hours RINEX file											
4	6 hours RINEX file						6 hours RINEX file						6 hours RINEX file						6 hours RINEX file					
8	3 h RINEX			3 h RINEX			3 h RINEX			3 h RINEX			3 h RINEX			3 h RINEX			3 h RINEX			3 h RINEX		
24	1 h	1 h	1 h	1 h	1 h	1 h	1 h	1 h	1 h	1 h	1 h	1 h	1 h	1 h	1 h	1 h	1 h	1 h	1 h	1 h	1 h	1 h	1 h	1 h
48	½ hour RINEX files																							

The test - dataset

We split a 24 hour RINEX file in several sub-files of shorter time span...



- 1 year of daily data
- 14 EPN class A stations

For each station...	
RINEX time span	n. of RINEX files
24 hours	365
12 hours	730
6 hours	1460
3 hours	2920
1 hour	8760
½ hour	17520



Software package and data processing parameters

The whole dataset (about **445.000** RINEX files) was calculated with the **PPP** approach by using the **GIPSY-OASIS II** software package...

- Orbits and clocks products: **non-fiducial precise FlinnR orbits from JPL**
- Phase ambiguity resolution: **WLPB** (produced by JPL and consistent with JPL orbits)
- Alignment to IGB08: **JPL X-files**
- Antenna phase center calibration: **IGS absolute (igs08.atx)**
- Cut-off Angle for observations: **7°**
- Tropospheric model: **VMF-1**
- International Reference Ionosphere Model: **2° order ionospheric model**



The test – analysis method

In order to evaluate the repeatability of the solutions a **reference** was needed...a regression line does not allow to consider seasonal movements.

Based on the **time series** of the solutions from the **24h** files, a **model** of the time series was computed for each of the 14 sites:

$$mod(t) = q + t * m + \sum_{i=1}^5 [A_i \sin(2\pi f_i * t) + B_i \cos(2\pi f_i * t)]$$

- f_i calculated by mean of the Lomb-Scargle periodogram
- q , m , A_i and B_i estimated with a least square approach

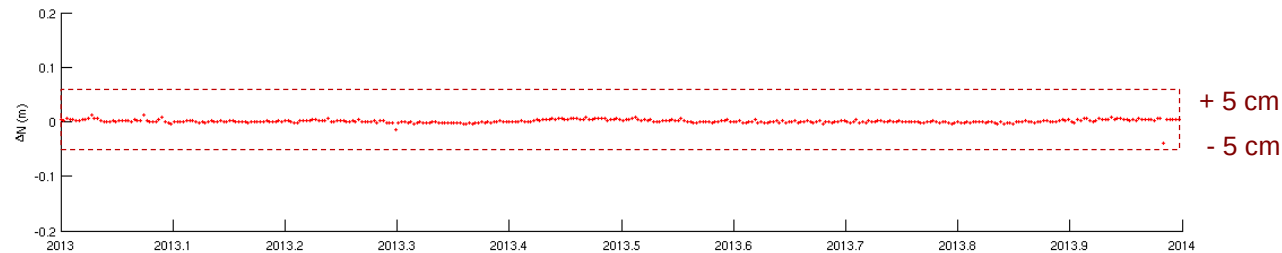
This ***mod(t)*** was calculated separately for the 3 geodetic components North, East and Up...

...then it was **removed from the raw time series** of the PPP solutions.



The test – analysis method

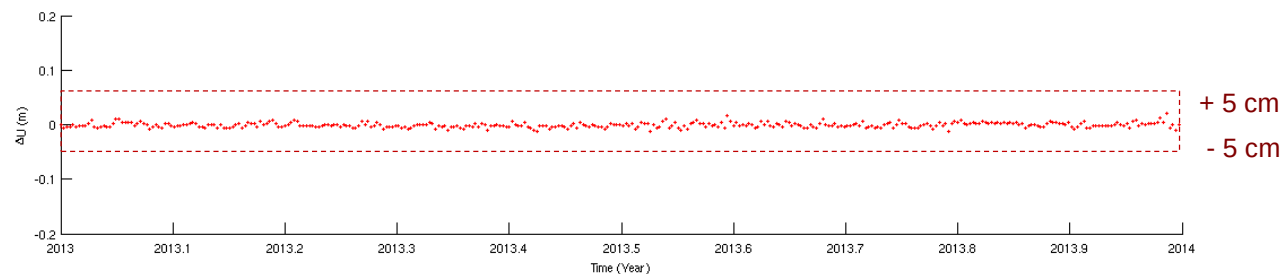
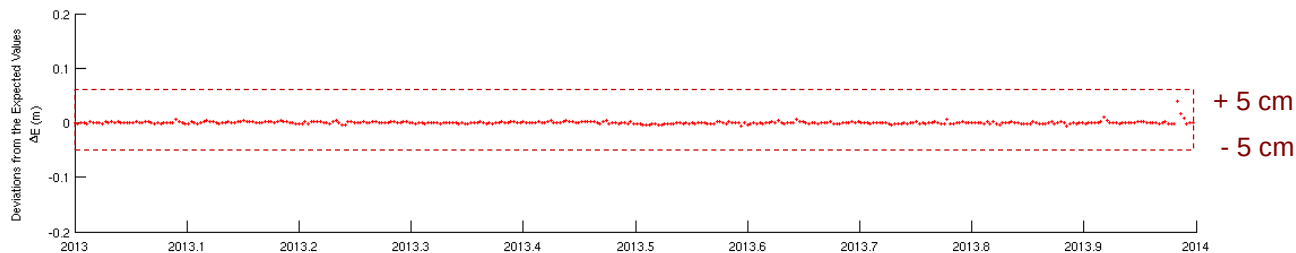
We obtained the time series of the **residuals** of the **solutions with respect to the models...**



Residuals for the solutions with observation time of:

24 hours

WTZR station

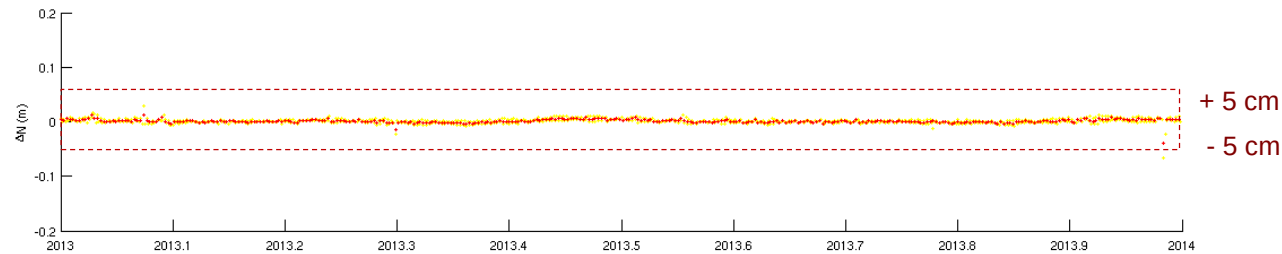


Associated formal error are not reported in these pictures



The test – analysis method

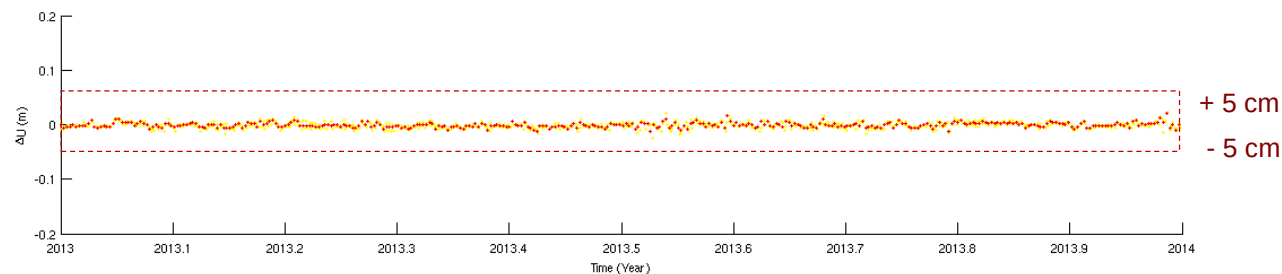
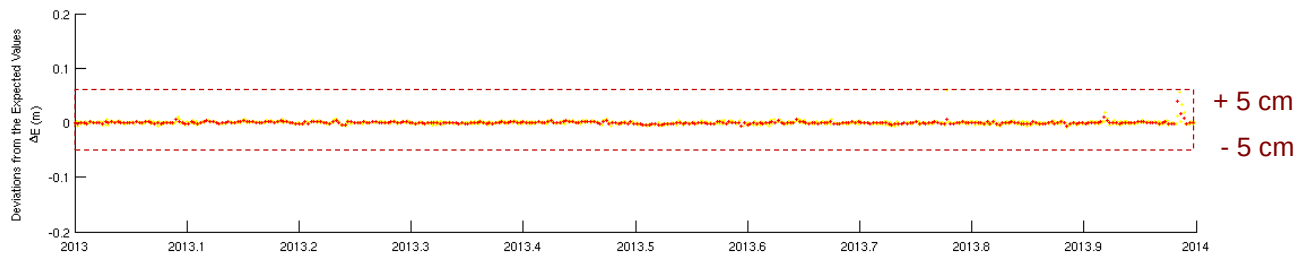
We obtained the time series of the **residuals** of the **solutions with respect to the models...**



Residuals for the solutions with observation time of:

**24 hours
+
12 hours**

WTZR station

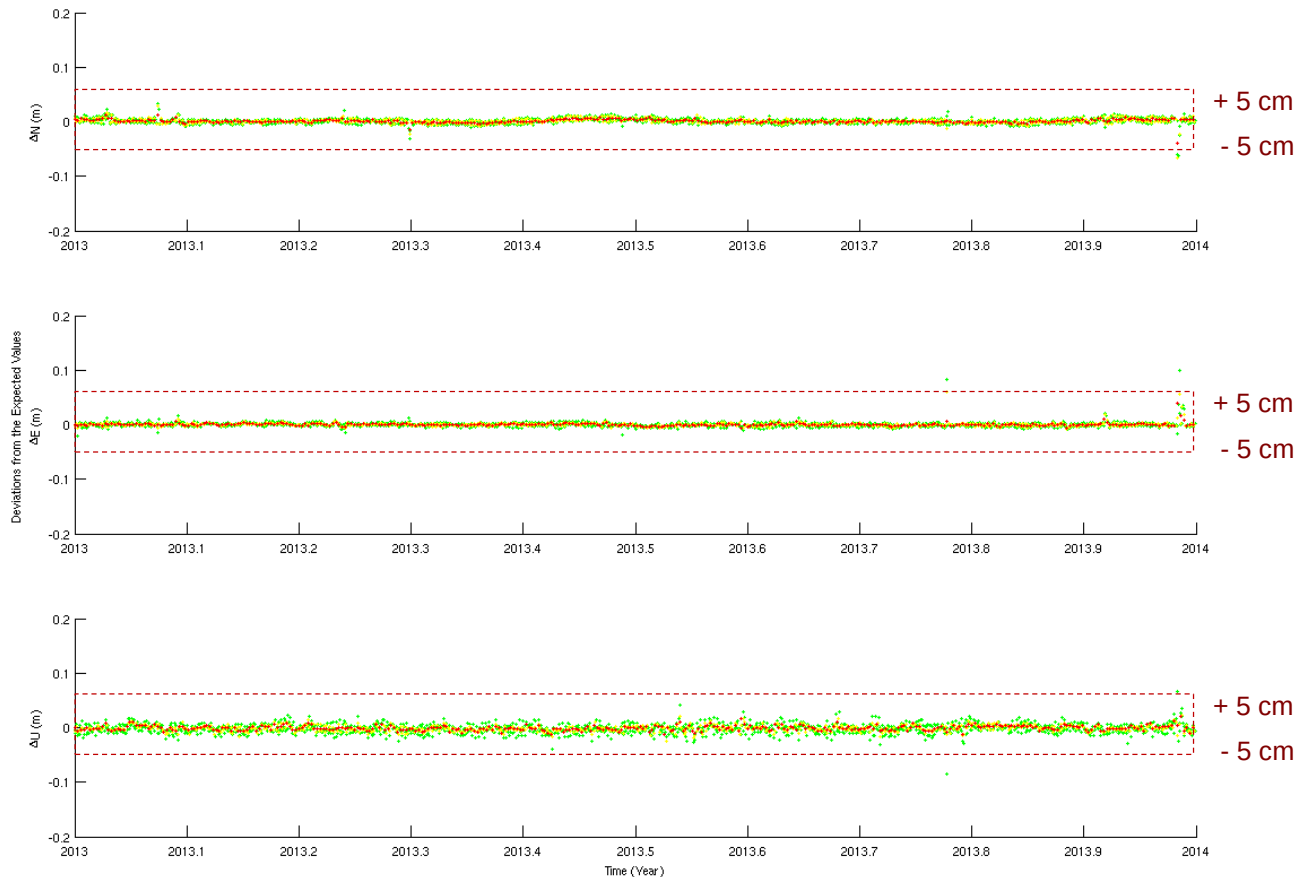


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The test – analysis method

We obtained the time series of the **residuals** of the **solutions with respect to the models...**



Residuals for the solutions with observation time of:

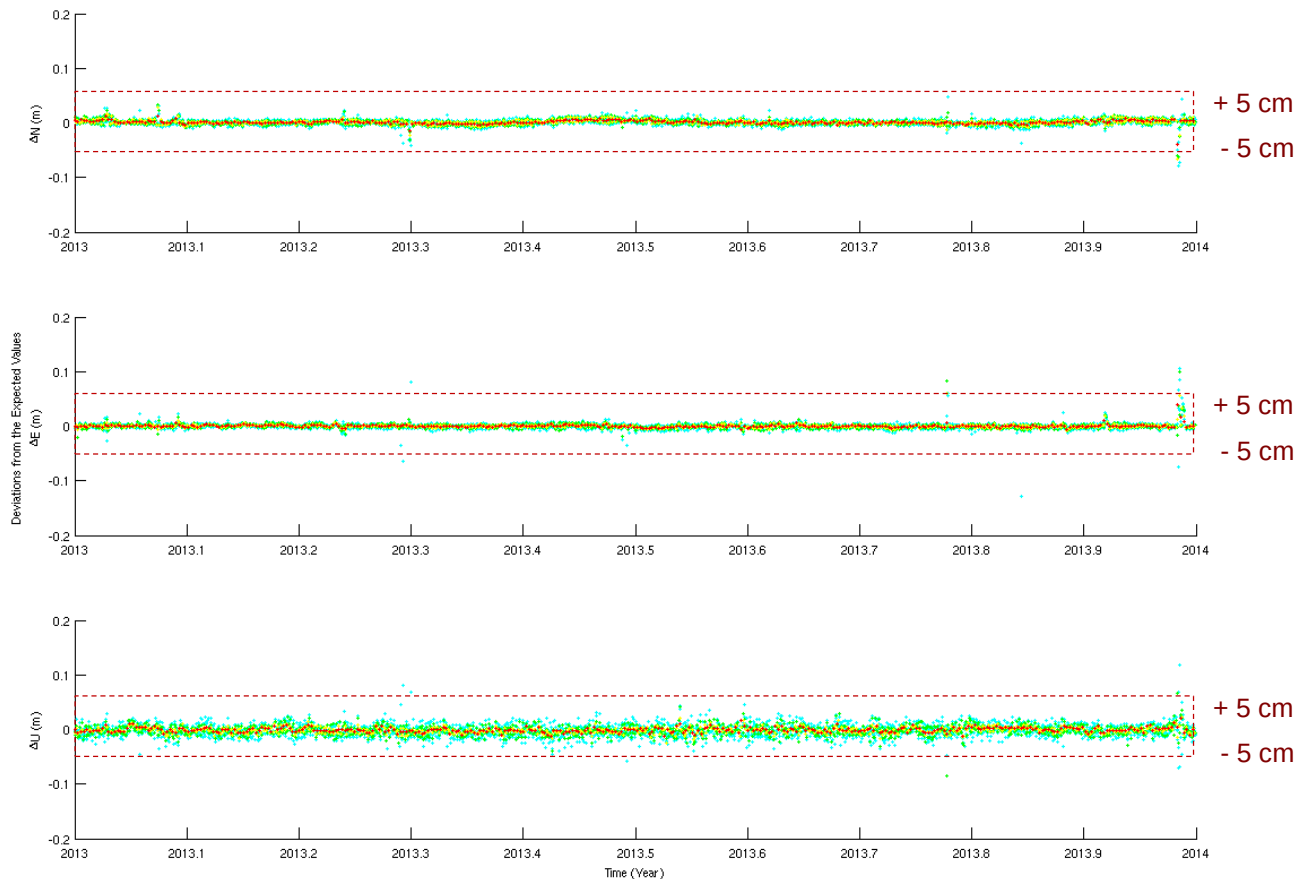
24 hours
+
12 hours
+
6 hours

Associated formal error are not reported in these pictures



The test – analysis method

We obtained the time series of the **residuals** of the **solutions with respect to the models...**



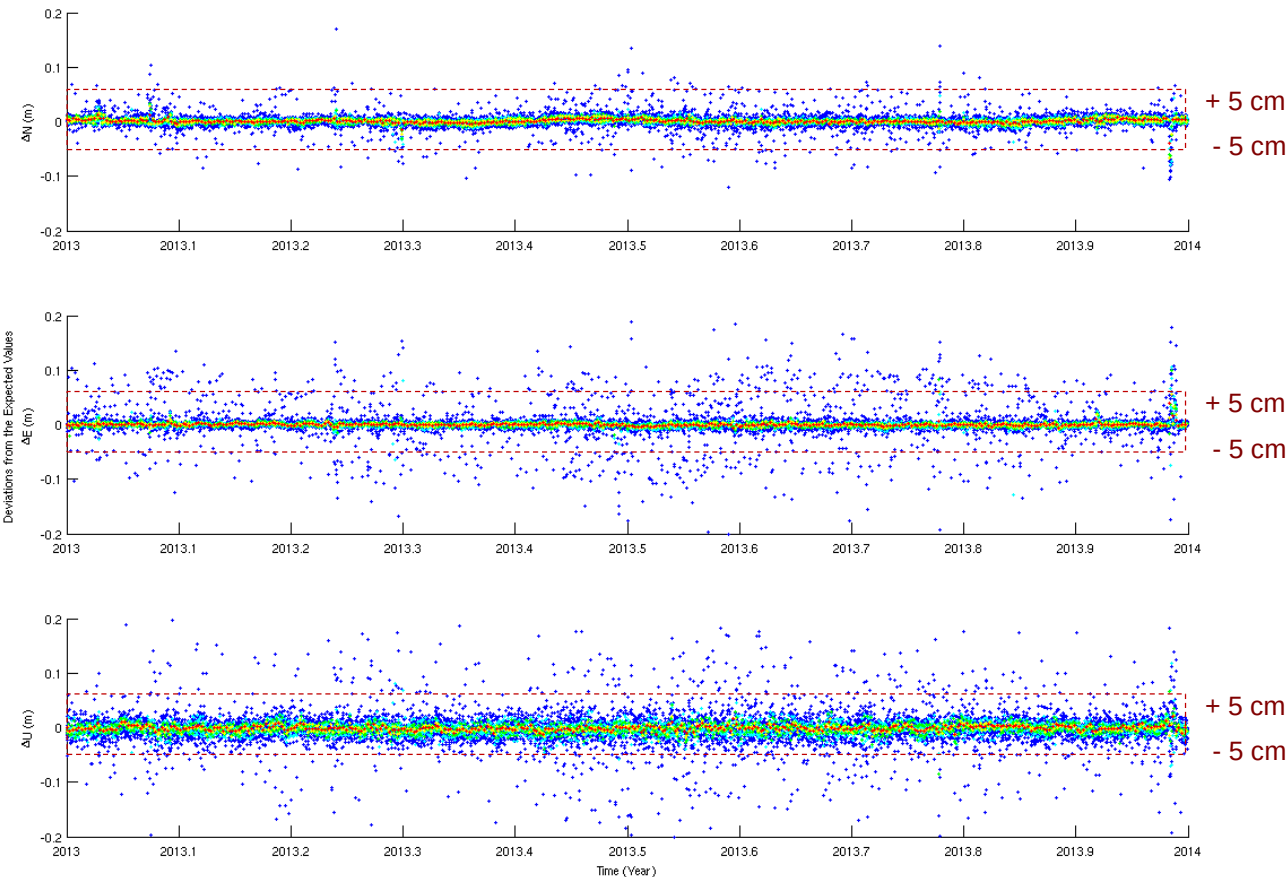
Residuals for the
solutions with
observation time
of:

24 hours
+
12 hours
+
6 hours
+
3 hours

Associated formal error are not reported in these pictures

The test – analysis method

We obtained the time series of the **residuals** of the **solutions with respect to the models...**



Residuals for the solutions with observation time of:

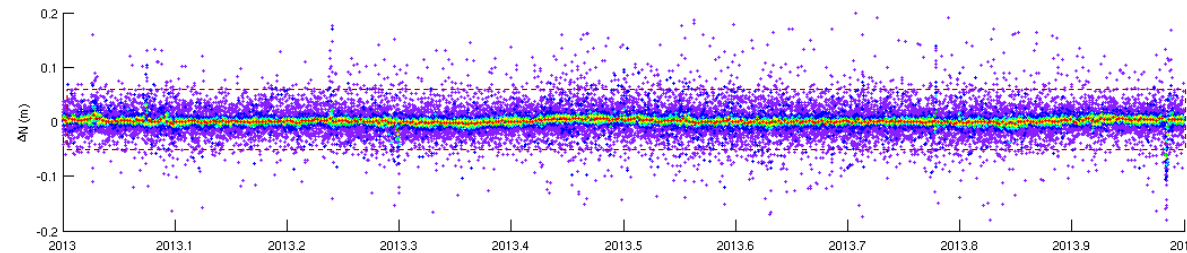
24 hours
+
12 hours
+
6 hours
+
3 hours
+
1 hour

Associated formal error are not reported in these pictures



The test – analysis method

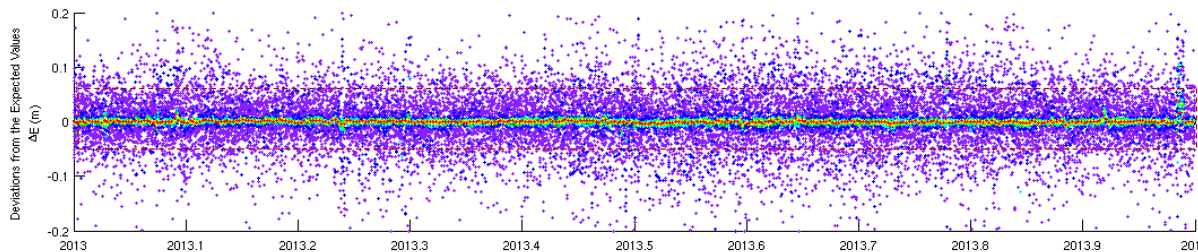
We obtained the time series of the **residuals** of the **solutions with respect to the models...**



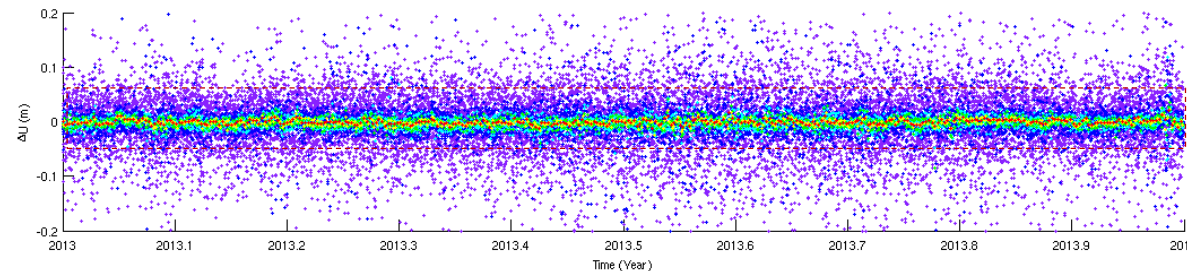
Residuals for the solutions with observation time of:

24 hours
+
12 hours
+
6 hours
+
3 hours
+
1 hour
+
½ hour

WTZR station



+ 5 cm
- 5 cm



+ 5 cm
- 5 cm

Associated formal error are not reported in these pictures



The test – main questions

We assumed as not suitable for any technical application a solution with an error of more then **1 meter**.

...then we wondered:

- If we look at the formal error given by GIPSY, how many “wrong” solution can we recognize, depending by the observation time?
- How many solutions are not “wrong” if we look at the formal error, but still have a residual of more then 1 meter?
- Having removed both these kind of outliers, what is the repeatability of the solutions depending on the observation time?
- Can we trust the formal error as a reliable estimation of the quality of the solutions?



The test – outlier solutions

Solutions with formal error > 33 cm

Observation time	24 h	12 h	6 h	3 h	1 h	1/2 h
AJAC	0,0%	0,1%	0,1%	0,9%	0,8%	0,5%
GENO	0,0%	0,0%	0,2%	1,2%	0,6%	2,9%
GRAS	0,0%	0,7%	1,2%	2,6%	1,3%	1,2%
GRAZ	0,0%	0,1%	0,3%	0,8%	0,5%	0,5%
M0SE	0,3%	0,1%	0,5%	1,2%	1,2%	1,0%
MATE	0,0%	0,1%	0,3%	1,2%	1,3%	1,6%
NOT1	0,3%	1,4%	1,9%	2,9%	3,5%	9,2%
ORID	0,0%	0,1%	0,4%	1,4%	1,3%	0,9%
PRAT	0,0%	0,0%	0,1%	0,9%	0,5%	0,6%
TORI	0,0%	0,1%	0,1%	0,8%	0,8%	1,5%
UNPG	0,0%	0,3%	0,2%	0,9%	0,7%	0,7%
WTZR	0,0%	0,1%	0,1%	0,5%	0,2%	0,1%
ZIMM	0,5%	1,1%	0,8%	1,1%	1,7%	0,7%
ZOUF	0,0%	0,0%	0,4%	1,6%	0,5%	0,6%
SUMMARY	0,1%	0,3%	0,5%	1,3%	1,1%	1,6%

33 cm of formal error means that the solution may lie over **1 meter** distant from the real position.

Whenever the low quality of the solution is evidenced by the formal error is possible to reject the solution and **repeat the measure** without encountering mistakes!



The test – outlier solutions

Solutions with formal error < 33 cm but residual with respect to the reference > 1 mt

Observation time	24 h	12 h	6 h	3 h	1 h	1/2 h
AJAC	0,0%	0,0%	0,0%	0,0%	0,0%	0,1%
GENO	0,0%	0,0%	0,0%	0,0%	0,0%	0,3%
GRAS	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
GRAZ	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
MOSE	0,0%	0,0%	0,0%	0,0%	0,0%	0,1%
MATE	0,0%	0,0%	0,0%	0,0%	0,0%	0,1%
NOT1	0,0%	0,0%	0,0%	0,0%	0,2%	1,7%
ORID	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
PRAT	0,0%	0,0%	0,0%	0,0%	0,0%	0,1%
TORI	0,0%	0,0%	0,0%	0,0%	0,0%	0,1%
UNPG	0,0%	0,0%	0,0%	0,0%	0,0%	0,1%
WTZR	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
ZIMM	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
ZOUF	0,0%	0,0%	0,0%	0,0%	0,0%	0,1%
SUMMARY	0,0%	0,0%	0,0%	0,0%	0,0%	0,2%

These solutions can be a real problem!

There is no way to detect this kind of outlier if we have just the single RINEX file...

...some of these points lie several meters far from the true position!

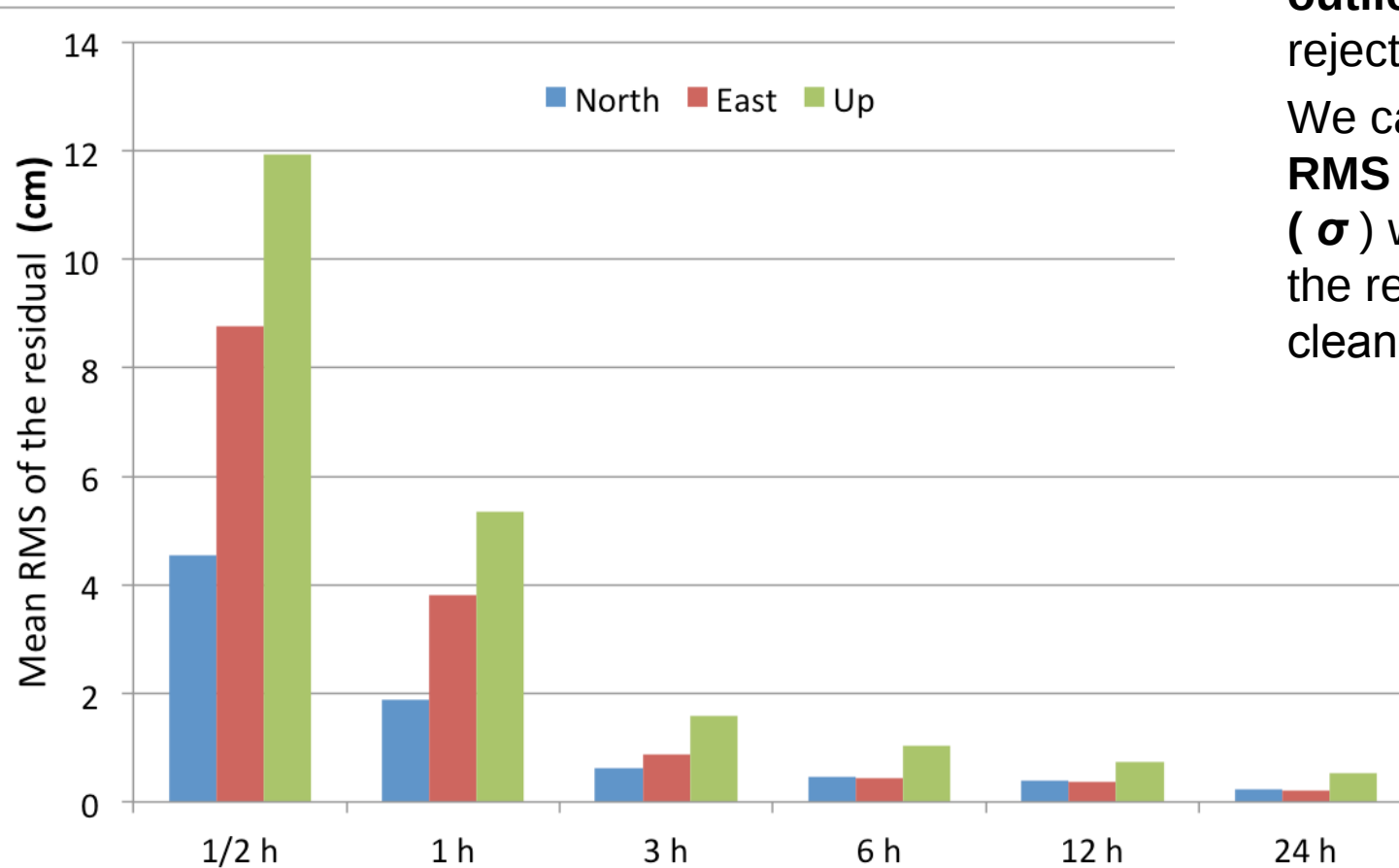
Fortunately this kind of error is very rare!



Precisions vs observation time

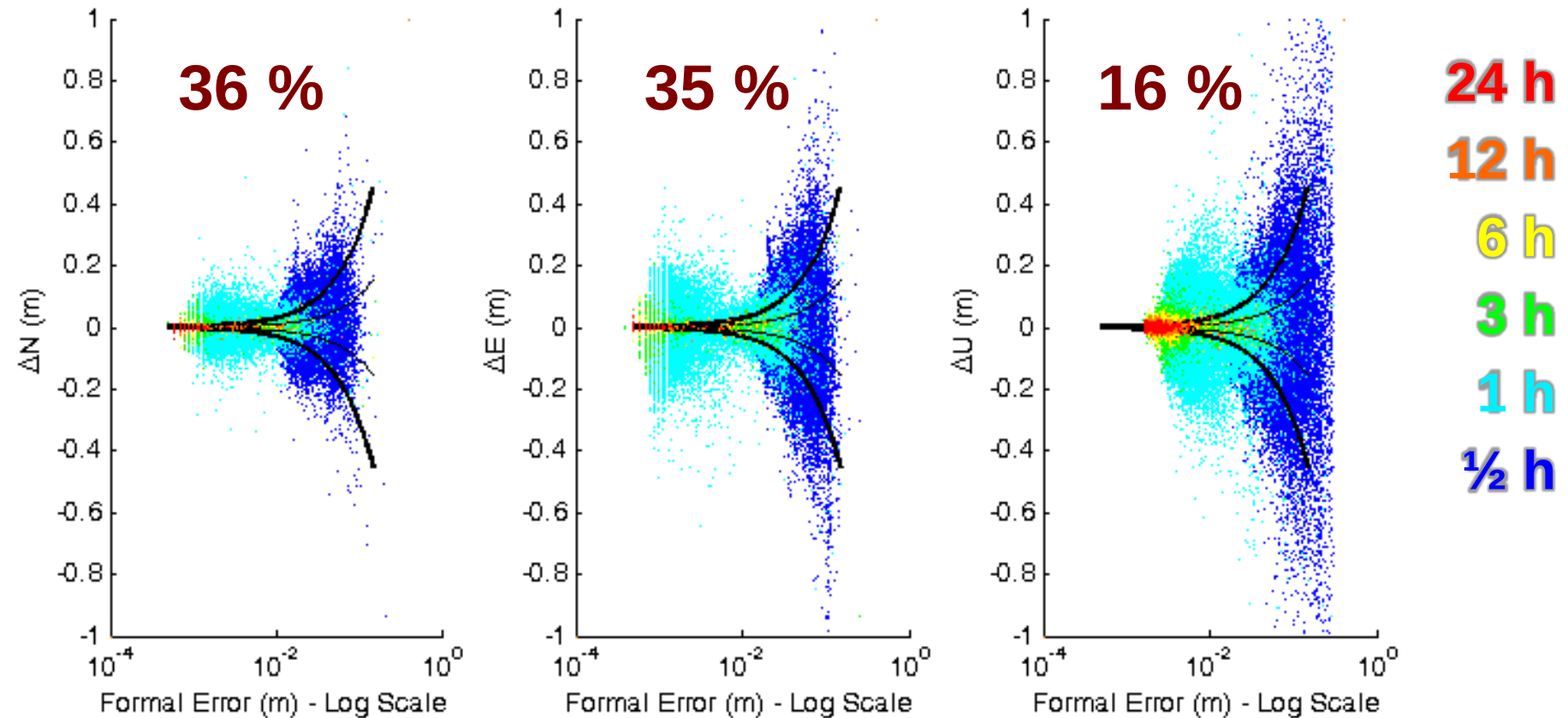
All of these solutions were considered as **outliers** and then rejected.

We calculated the **RMS of the residuals** (σ) with respect to the reference for the cleaned time series...



Precisions vs formal error

After a single survey with few hours of observation time the **formal error** is the only parameter available to judge the quality of our solution...**how much is it reliable?**





Conclusions

- Starting from **1 year** of **24h RINEX** files of **14 EPN class A permanent stations** around Italy a test concerning the **precision of the PPP** approach for different observation times has been performed.
- The main results are:
 - The % of **bad solution** that we can **recognize by the formal error** vary from 0.1% (24h) to 1.6% (1/2h)
 - The % of **bad solution** that have a formal error < 33cm is zero for all the observation times, until solutions of ½ h thus that present a 0.2%.
 - The **RMS of the time series of the residuals is less than 1 cm** for observation times of more than 6 hours. This RMS increase for the shorter observation times but **remain about the 10 cm even for the ½ hour solutions**.
 - The **formal error given** by GIPSY is underestimating the sigma value for the 35% of the solutions.



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Thank you for your attention!

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