Final results of the Italian "Rete Dinamica Nazionale" (RDN)

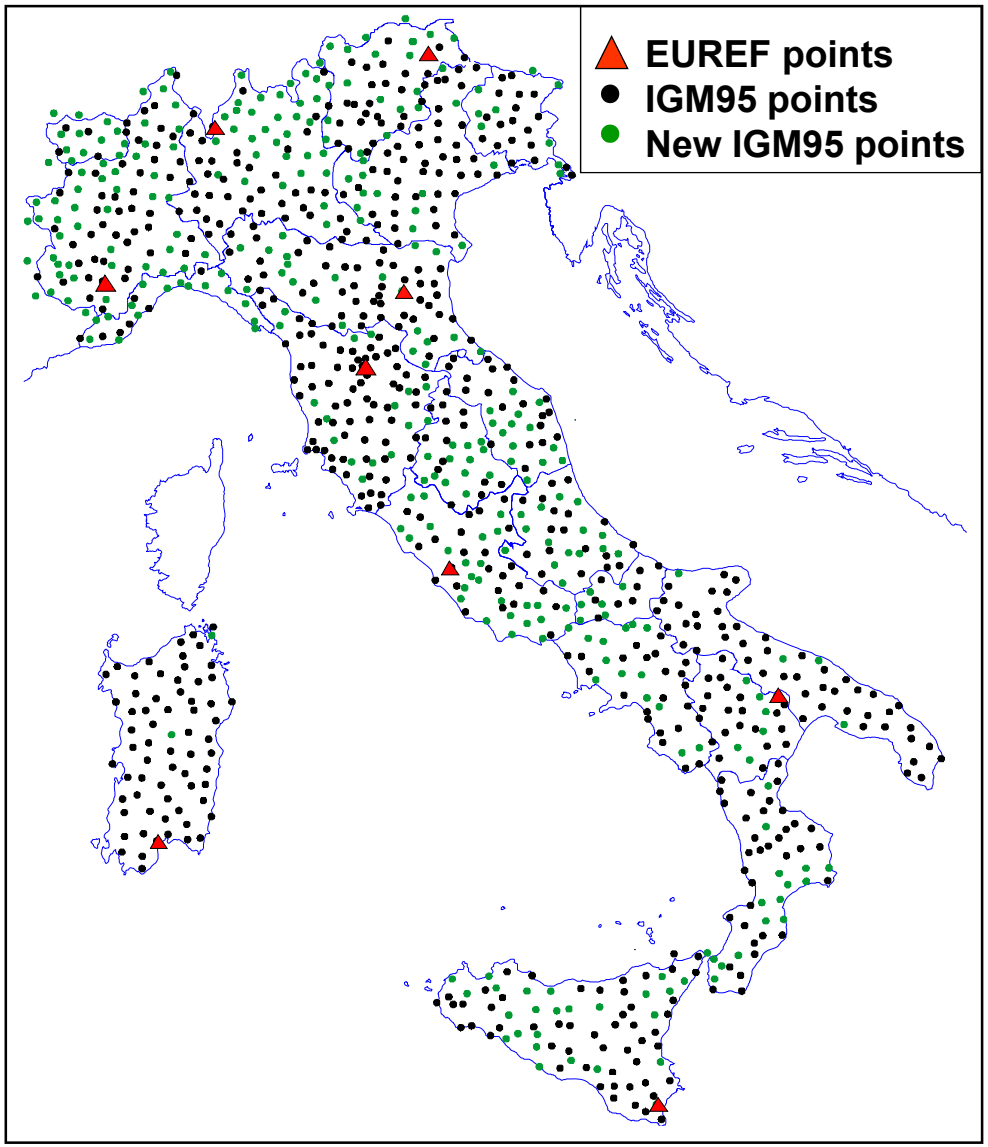
L. Baroni, F. Cauli, G. Farolfi, R. Maseroli

Symposium EUREF 2009 **Firenze,** 27th - 29th May

Outlook

- Comparison between old IGM95 and new reference system RDN
- Data and network features
- Processing
  - Strategy
  - Errors and repeatibility of the 28 daily solutions
  - Alignment to ITRF2005 and Transformation to ETRF2000
- Comparison of results by independent Analysis Centres

IGM95



- Italian reference frame since 1996
- Realization of ETRS89
- 9 EUREF points,
  (4 permanent sites)
- Densification campaign from 1990 to 1995 (1230 points)
- Precision $\sigma_{95\%}$:
  - ~ 25 mm planimetry
  - ~ 40 mm altimetry

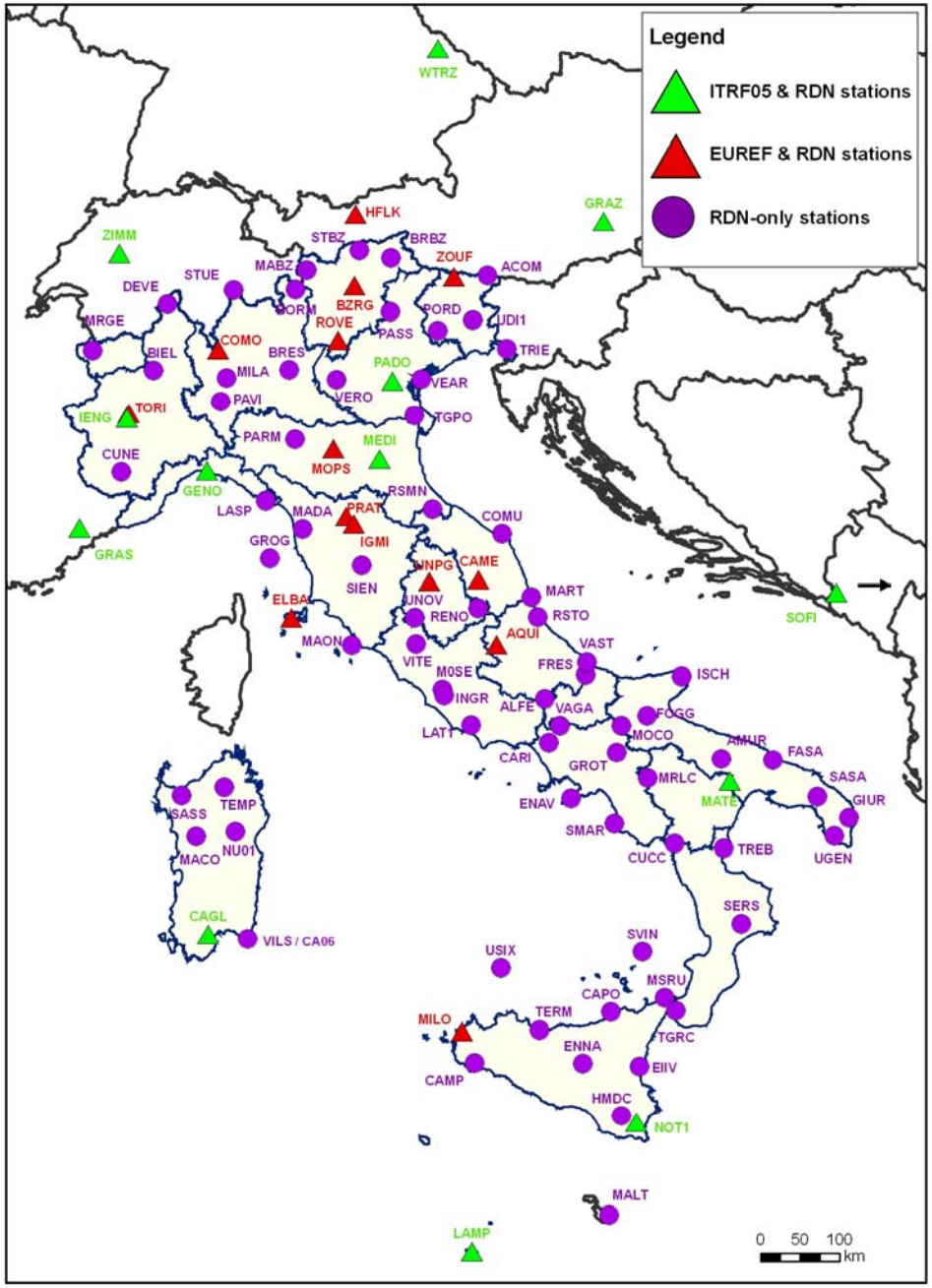
Rete Dinamica Nazionale

- 100 permanent stations:

  13 IGS (ITRF2005)
  28 EPN

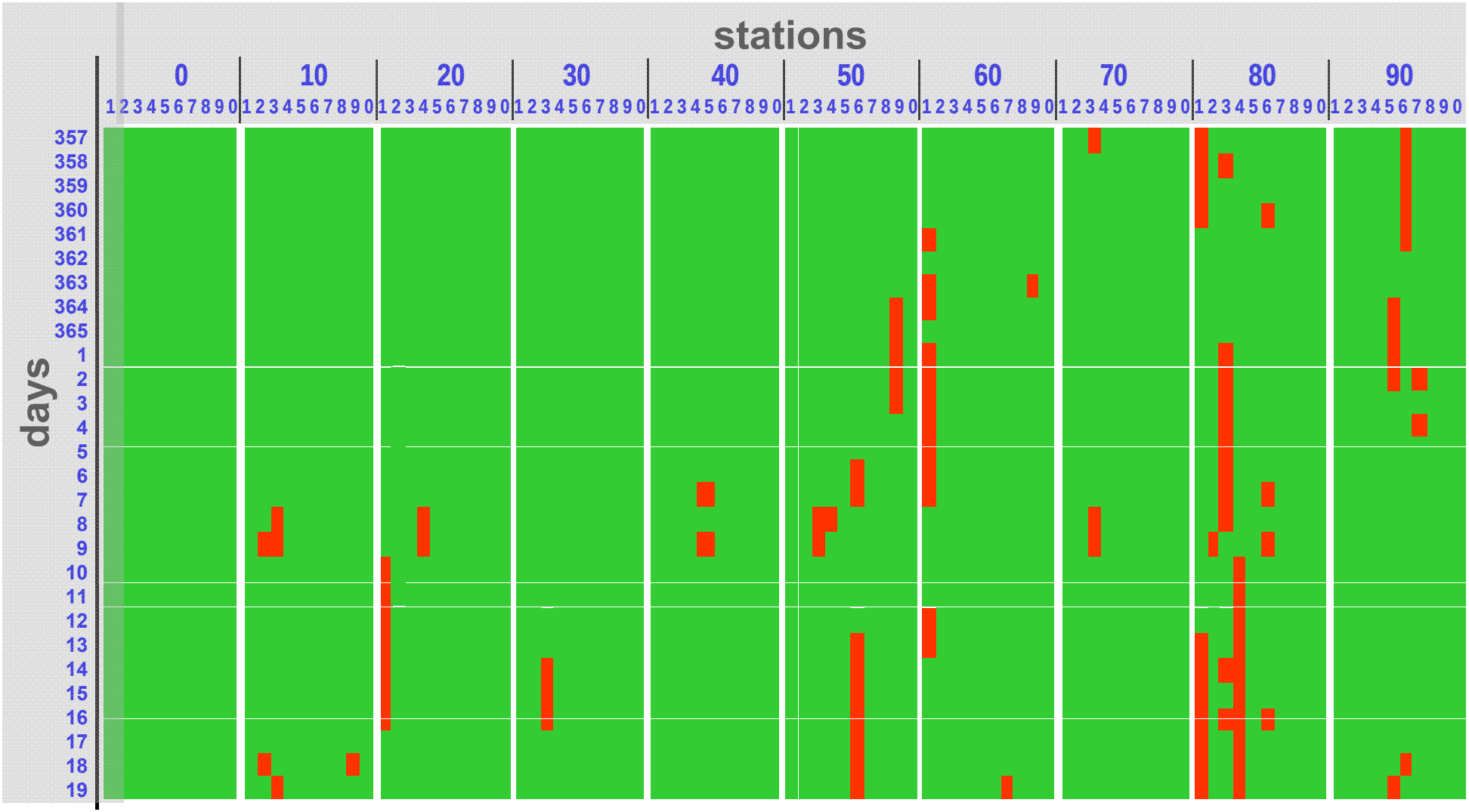
Features of the network:

- Homogeneous distribution
- Good monumentation
- Mean interdistance 100÷150 km
- Stations owned by public institutions (broadcast RTK signal)
- Redundancy; temporal continuity



Data availability

28 Daily RINEX of 100 stations
Observation window: 23 dec 2007 – 19 jan 2008



Processing at Geodetic Service of IGM

Input data:

- Daily Rinex (sample rate 30 s)
- IGS05 Orbits and Earth Rotation Parameters
- Absolute Antenna Phase Center Model (IGS05.atx)
- Ocean Tide Loading corrections with model GOT00.2 (Goddard)
- Rigorous control of match Rinex header / logsheet

Strategy:

- EUREF guidelines

Main processing parameters:

- Software Bernese 5.0
- Cut off ≤ 3°
- Baselines built up with OBS MAX strategy (max length of 200 km)
- Troposphere delays estimated every 1 hour with Neill Mapping function

Result:

- 28 Daily Normal Equations

Alignment to Datum

28 Daily Normal Equations were combined applying a minimal constraint condition on 13 fiducial stations ITRF2005,
using a 3 parameters Helmert translation. Epoch of reference 2008.0

Transformation to ETRF2000

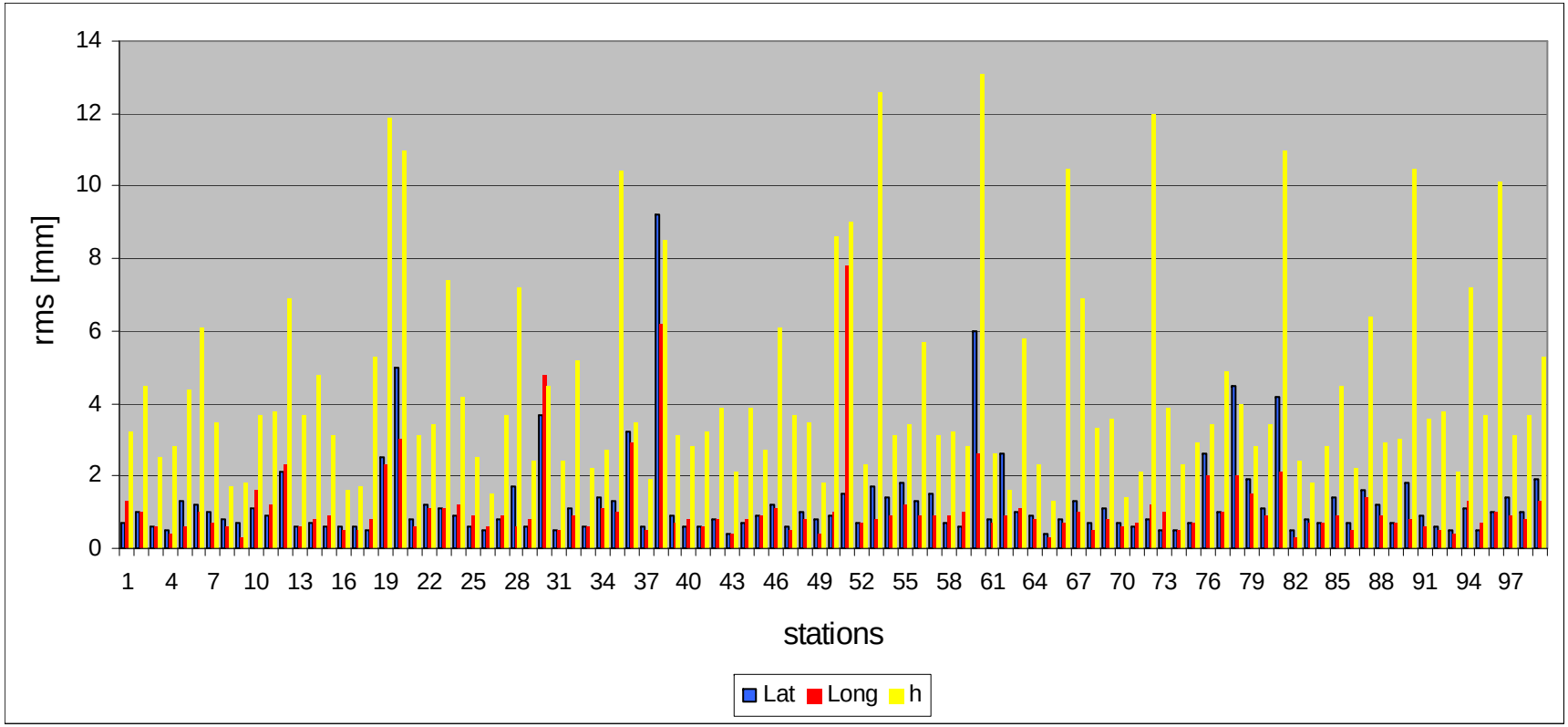
$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{ETRF2000(2008.0)} = (1+K_{(2008.0)}) \cdot \begin{bmatrix} 1 & -Rz & Ry \\ Rz & 1 & -Rx \\ -Ry & Rx & 1 \end{bmatrix} \cdot \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{ITRF2005(2008.0)} + \begin{bmatrix} Tx \\ Ty \\ Tz \end{bmatrix}_{(2008.0)}$$

Tx	*Ty*	*Tz*	*K*	*Rx*	*Ry*	*Rz*	*epoca*
[mm]	[mm]	[mm]	*[10^{-9}]*	[mas]	[mas]	[mas]	
52.5	51.0	-68.2	1.04	1.539	9.310	-15.048	2008:001

Boucher, Altamimi: memo V7 2 October 2008

Estimation of Errors

Repeatability of the 28 daily solutions for each station



	N	E	h
mean rms. [mm]	1.3	1.1	4.5

max planimetric rms < 10 mm

max altimetric rms < 13 mm

Coordinate changes on fiducial stations

Differences between a priori and computed coordinates:

Most cases not significant (about 5 mm in almost all the 3 components)

This confirms the coherence of RDN as a densification network

	ΔE	ΔN	Δh	Module
STAT.	[mm]	[mm]	[mm]	[mm]
CAGL	-0.7	0.5	-1.3	1.6
GENO	0.2	1.9	3.5	4.0
GRAS	-0.1	-2.3	1.5	2.8
GRAZ	0.9	1.4	-1.0	2.0
IENG	-0.1	-2.8	-9.6	9.9
LAMP	-0.9	2.5	9.7	10.0
MATE	-0.7	2.4	-1.6	2.9
MEDI	-0.8	-7.3	10.6	12.9
NOT1	0.4	1.1	2.9	3.2
PADO	1.4	3.0	4.9	5.9
SOFI	0.4	-0.9	-5.3	5.4
WTZR	-0.3	-1.6	-6.7	6.9
ZIMM	2.5	1.5	-7.1	7.7

mean	0.2	0.0	0.0	5.8
rms	0.7	1.7	3.4	3.5

Comparison among Analysis Centers

Computations was also performed independently by:

- **University of Padova (prof. Caporali, EPN LAC)**
- **G3 group in Milano (prof. Sansò)**

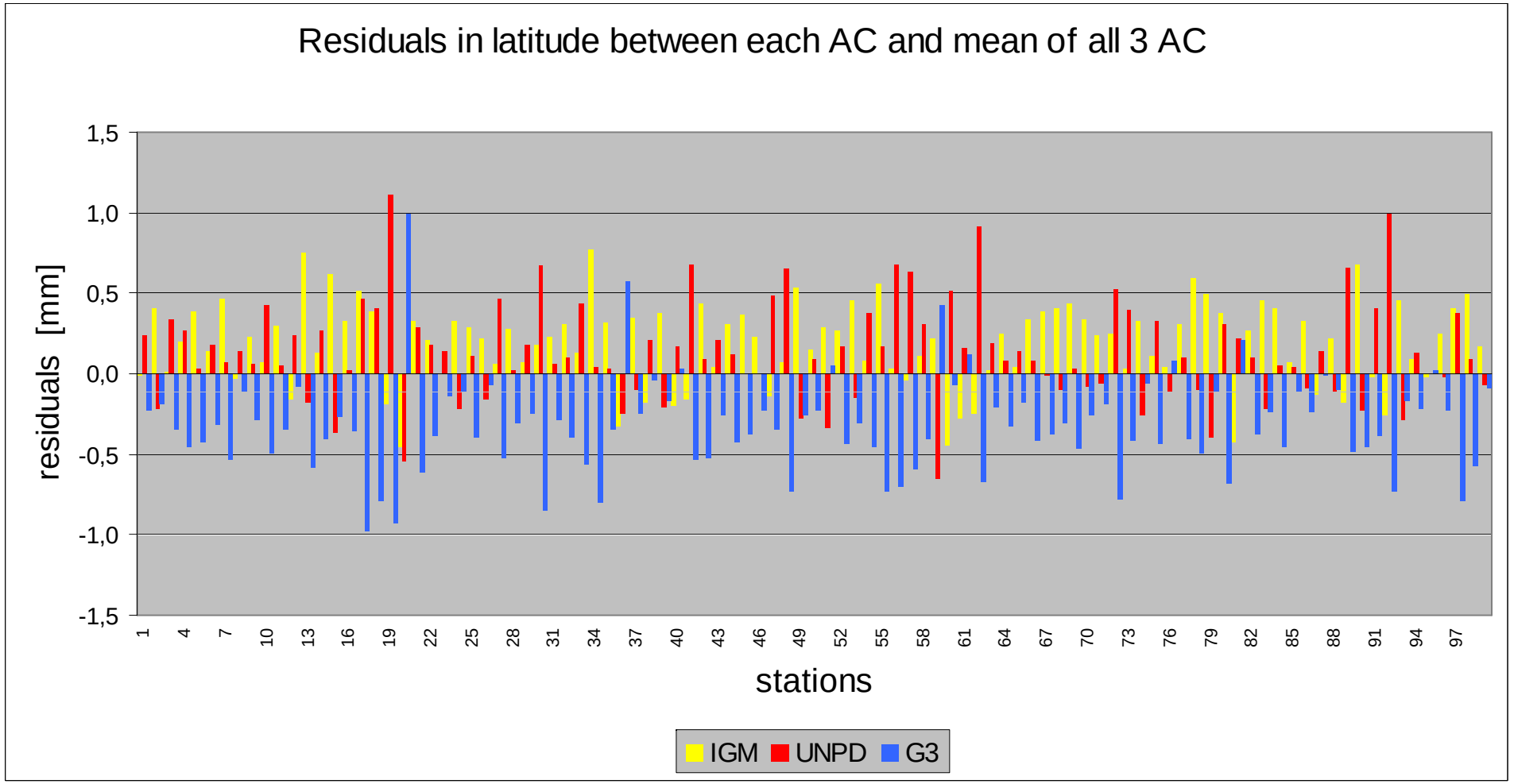
Common procedures:

- **Input data**
- **Reference system (ETRF2000 epoch 2008.0)**

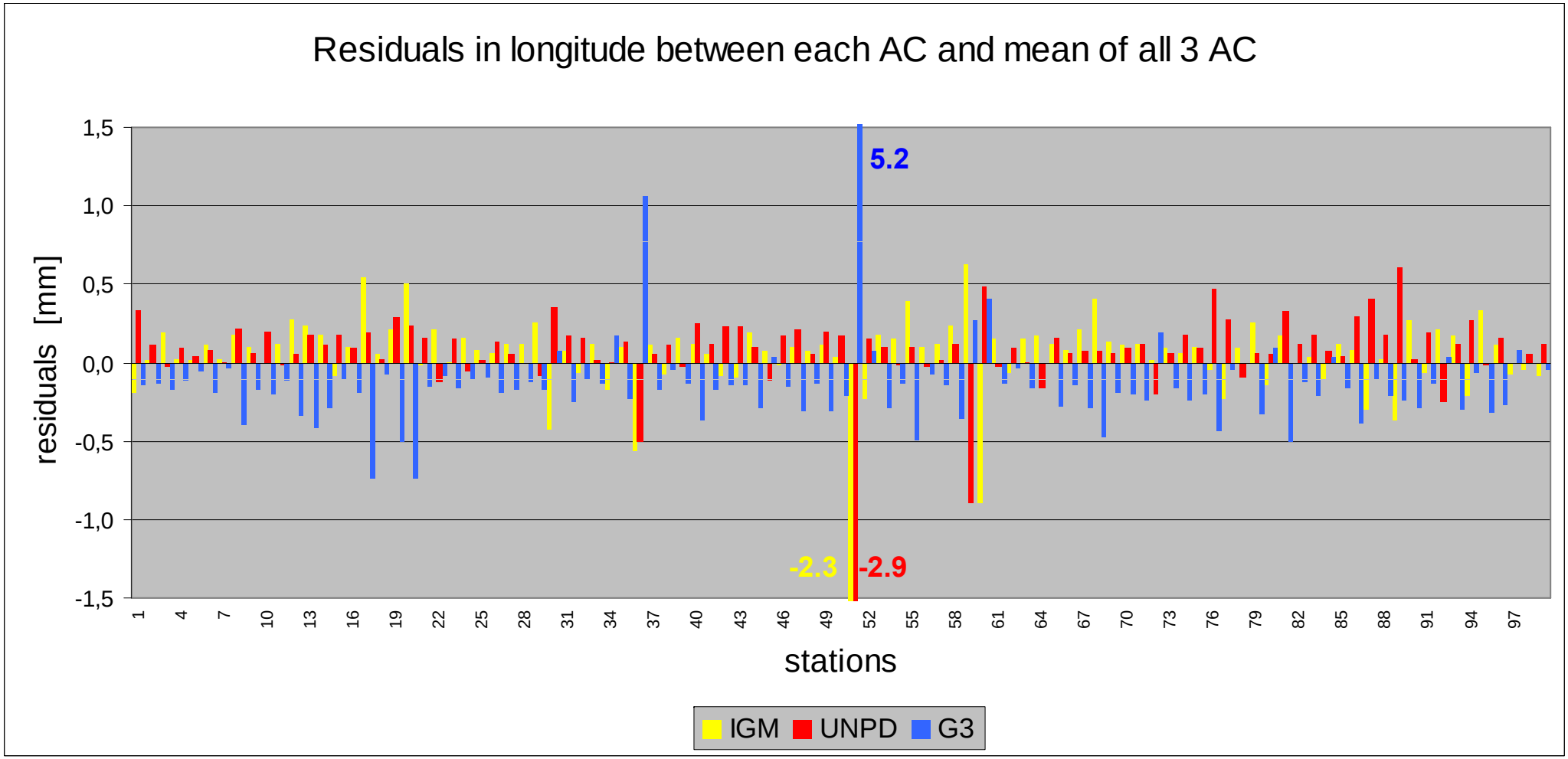
Different procedures:

- **Processing Strategy**
- **Data cleaning**
- **Datum alignment**

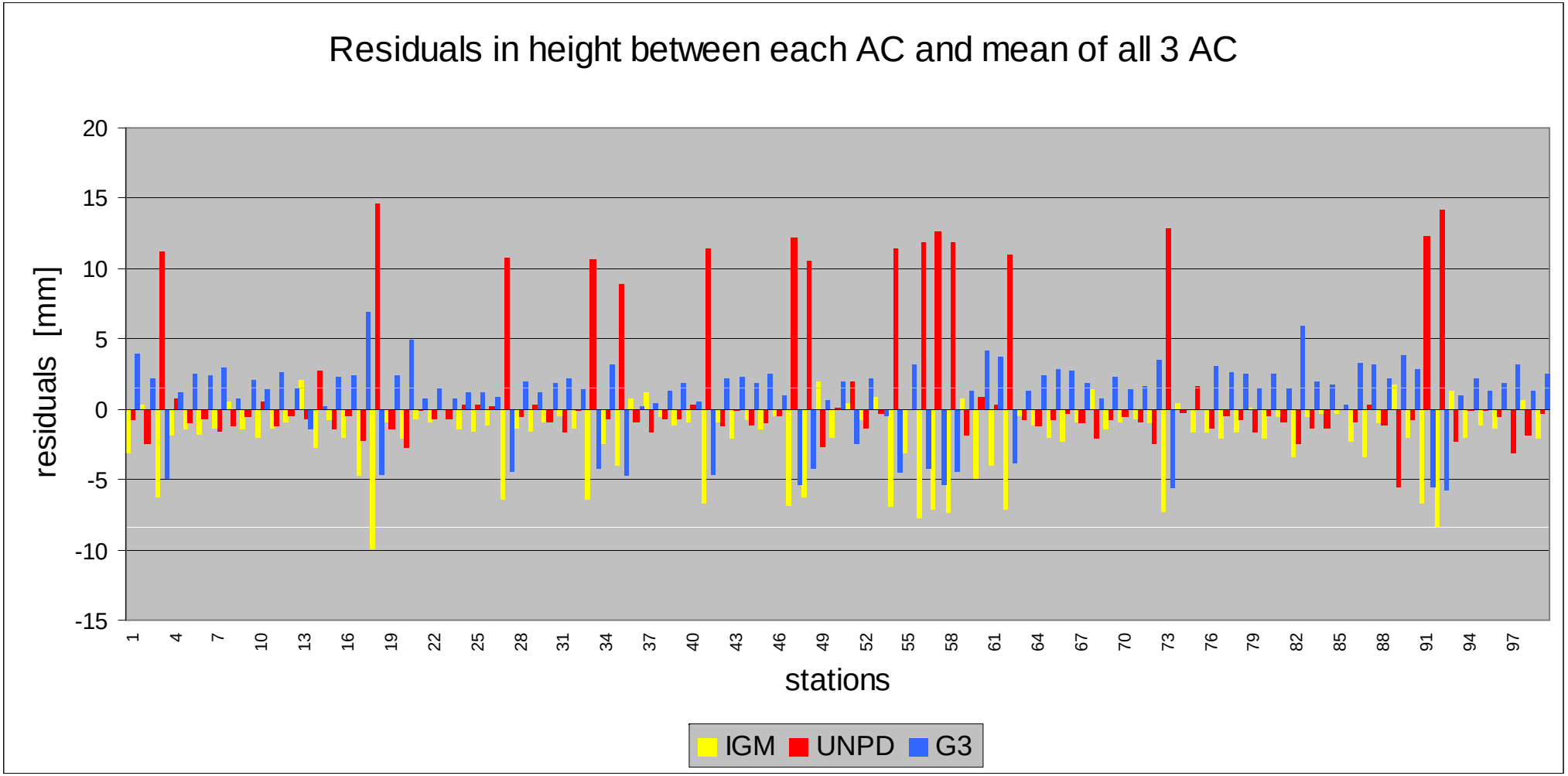
Comparison among 3 Analysis Centers



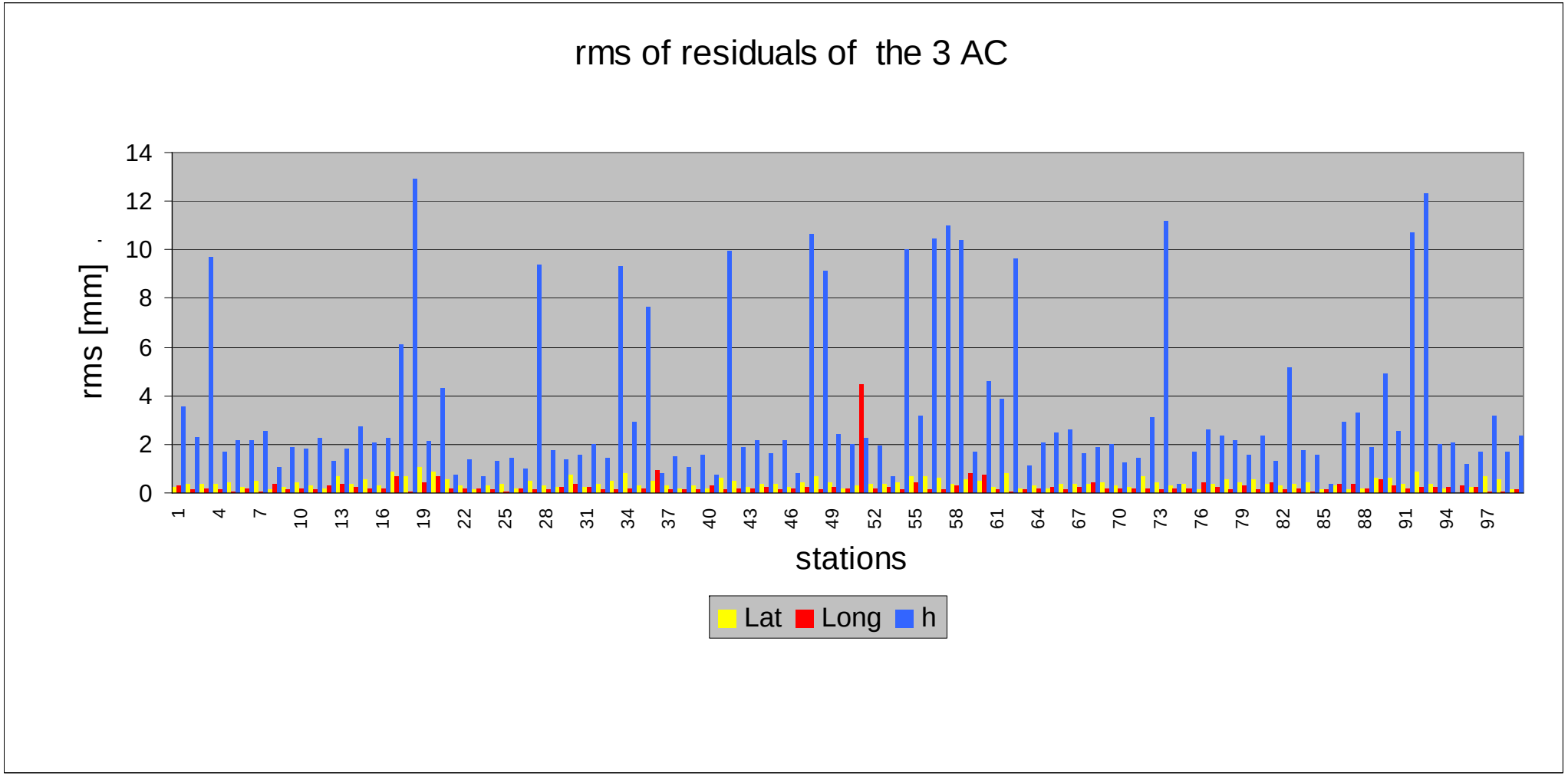
Comparison among 3 Analysis Centers



Comparison among 3 Analysis Centers



Comparison among 3 Analysis Centers



Further comparison with another AC

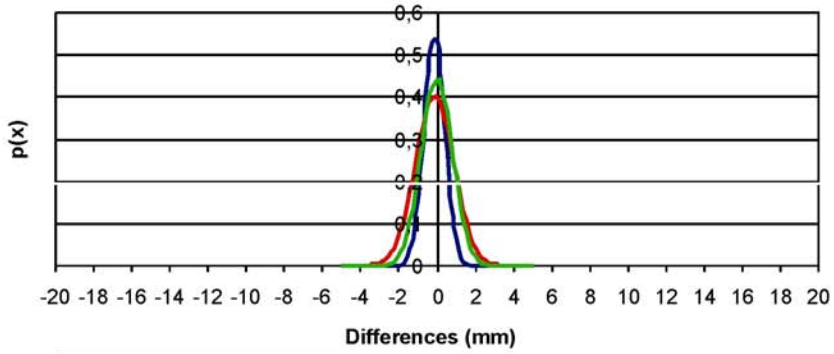
University of Bologna (prof. Barbarella) performed 3 computations following:

- **Different strategies**
- **Different softwares:**

  Bernese
  GIPSY
  Gamit

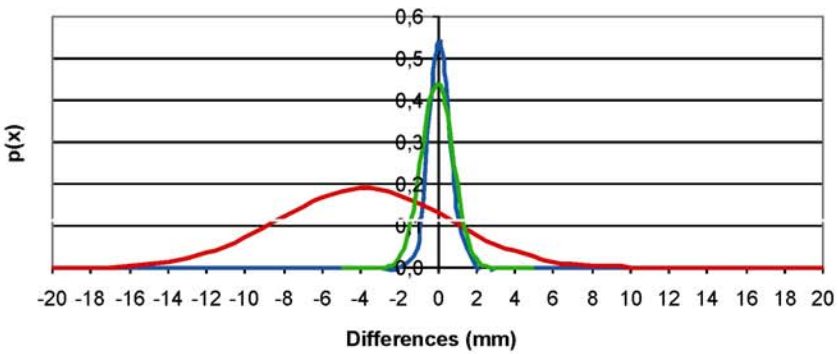
Distribution of the differences between IGM and each single solution of Bologna

NORTH



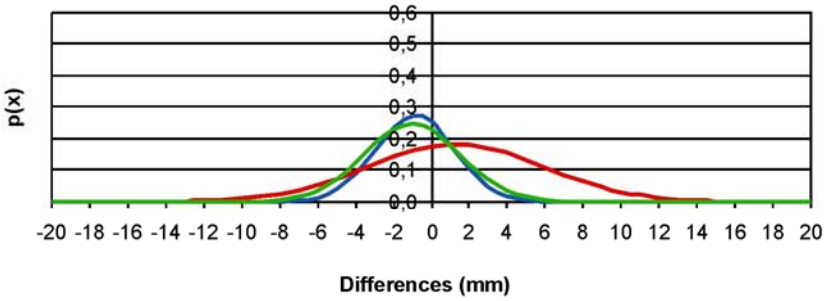
	IGM-Bernese BO	IGM-Gipsy BO	IGM-Gamit BO
μ	-0,1	-0,1	0,0
σ	0,5	1,0	0,8

EST



	IGM-Bernese BO	IGM-Gipsy BO	IGM-Gamit BO
μ	0,1	-3,9	0,3
σ	0,5	4,4	0,7

HEIGHT



	IGM-Bernese BO	IGM-Gipsy BO	IGM-Gamit BO
μ	-0,9	1,3	-1,0
σ	2,1	4,7	2,6

IGM-Bernese BO
IGM-Gipsy BO
IGM-Gamit BO

Probabily density function

$$p(x) = \frac{1}{\sqrt{2\pi\sigma^2}} \times e^{\frac{-(x-\mu)^2}{2\sigma^2}}$$

Conclusions

- **RDN computed according to the EUREF specifications for regional frame densification**
- **EUREF Guidelines for GNSS data processing**
- **Results independently checked**
- **mm repeatibility**
- **RDN was adopted officially at the begining of 2009.0 , in time with expected INSPIRE implementing rule**
- **Request EUREF certification**