EPN Local Analysis Centres Workshop
Brussels - May 15-16, 2013

Activities at the LAC UPA: status and perspectives

Università degli Studi di Padova

DIPARTIMENTO DI GEOSCIENZE

A. Caporali
M. Bertocco
J. Zurutuza

Outline:

1.- Introduction: UPA LAC's background
2.- ETRS89 (ETRF2000) densification in Italy
3.- BSW 5.0 vs BSW 5.2: upgrading, tests and results
4.- Perspectives

UPA LAC's background:

- The LAC center at the University of Padova **operates since 1999** in support of the EPN weekly computations.
- Based on the **knowledge and experience gained**, a growing network of **Italian stations is processed in parallel to the EPN** sub network.
- At this time **some 400 Italian permanent** stations are computed in **10 regional clusters**, and the corresponding normal equations are stacked on a daily and weekly basis to generate one minimally constrained normal equation for the entire network.
- **The parallelism between the EPN and the National networks is crucial** to synchronize the processing standards (e.g. antenna files, solution numbers of EPN class A sites included in the processing). Time series of the national network are created by normal equation stacking.

UPA LAC's background:

- A detailed **spectral analysis** is carried out to **characterize the noise** and **estimate the true uncertainty of the velocity**. This work is useful in two ways:
    - One is the **densification and maintenance of the INSPIRE** standard ETRS89 at the national level, which is requested by Governmental Agencies (Cadastre, Regional MCA's, the Italian NMCA IGMI)
    - The other is the **monitoring of the horizontal gradients** of the velocities, i.e. the **strain rate tensor**, and **its relationship to seismic provinces**, in collaboration with the Civil Protection and the National Institute of Geophysics and Volcanology.
- **In the event of earthquakes** (e.g. 2012 Emilia sequence), the **UPA LAC proved the capability of rapid computation** (24 hr lag) of the **coseismic displacements** using rapid/ultrarapid IGS products.
- **Similar objectives are pursued within the activities of the CEGRN**: Coordinates, Velocities and strain rates for a relatively dense network in Central Europe are computed following the guidelines for EPN densification.

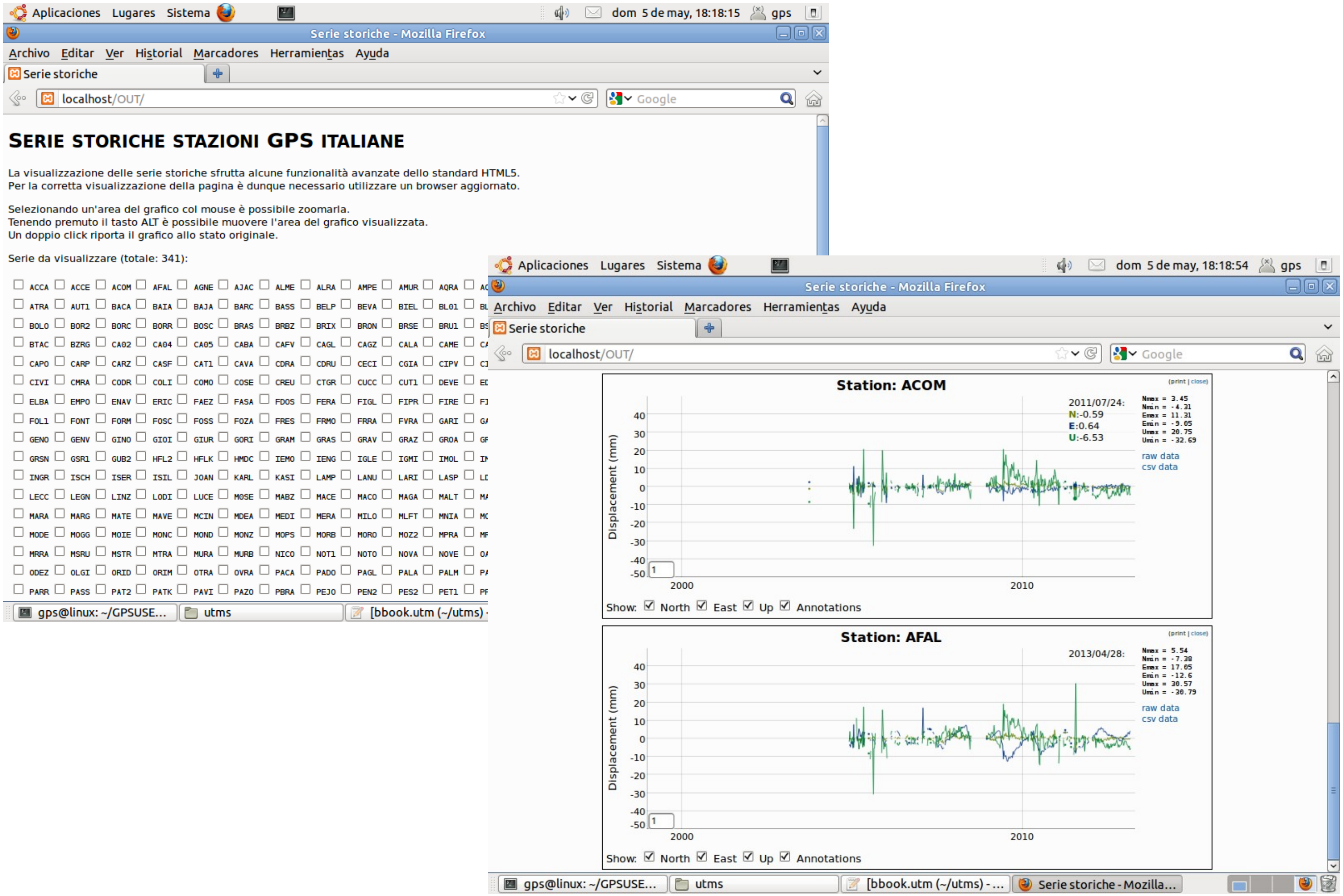
ETRS89 Densification:

- Weekly, 400+ Italian stations are processed.
- Data include:
  - ✓ **EPN** sites
  - ✓ **RDN** sites (presented in the EUREF 2009 symp., Florence)
  - ✓ **RTK** broadcasting sites
- Adjustment strategy:
  - ✓ **Minimum constraints of EPN class A sites** mapped to session's epoch using velocity to be **fully consistent** with the ephemeris frame
- Derived products (ellipsoid GRS80 used) in a weekly Bulletin with:
  - ✓ **ETRS89** (ETRF) geodetic and cartesian coordinates,
  - ✓ **UTM** coordinates, including X, Y, convergence, scale factor,
  - ✓ **EGG08** model used to compute geoid undulations and deflections of the vertical.

NEQs Stacking:

- **STA file** is being permanently updated by:
  - ✓ Add new set-ups of sites (**TYPE 001**),
  - ✓ Add antenna/receiver changes (**TYPE 002**),
  - ✓ Set problems in sites (**TYPE 003**),
  - ✓ Set relative constraints between sites (different/new set-ups), **TYPE 004**.
- **TYPE 001** maps the EUREF's sites to the session numbering in the EPN solution's numbers.
- Once the **stacking is finished**, **detailed velocities' fields** are mapped for the different study areas.
- **3D velocities**: **not as accurate as 2D**, since most stations have **not many observations' years**.

ETRS89 Densification: some of the outputs.



ETRS89 Densification: some of the outputs.

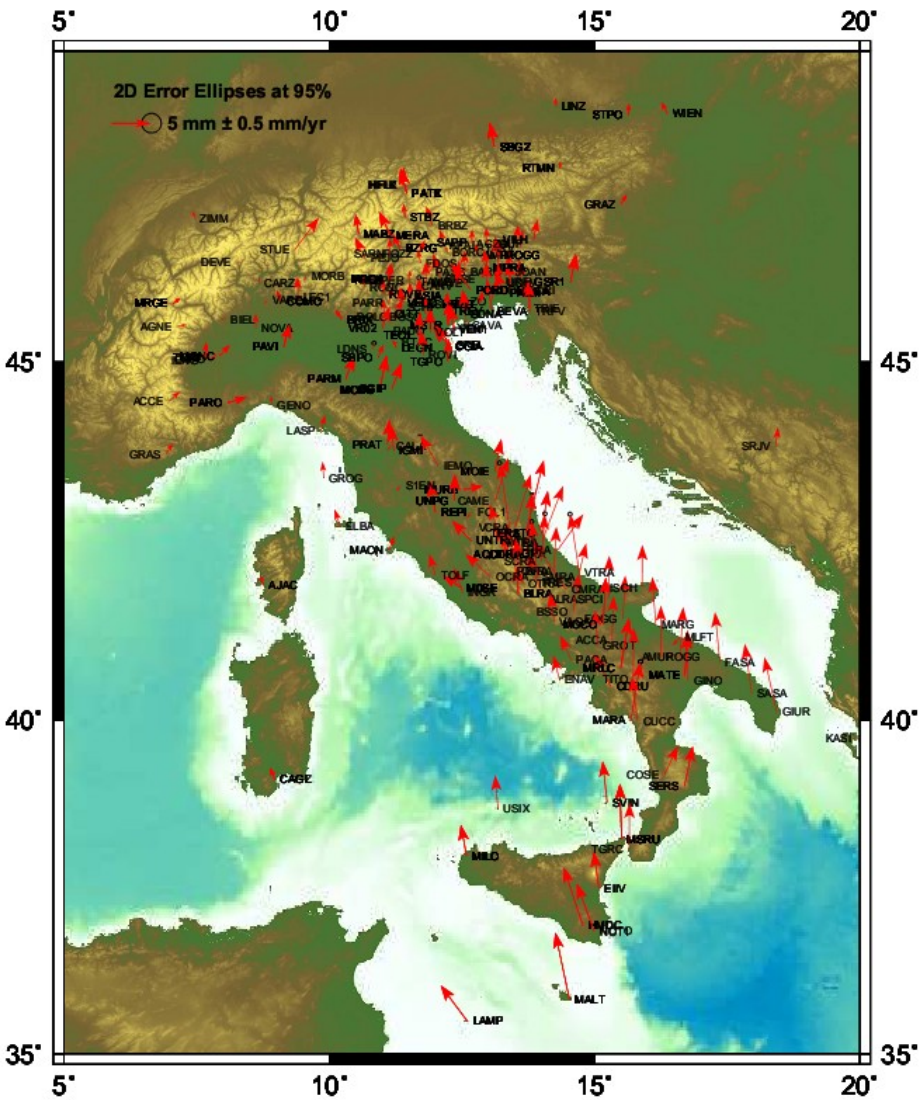
1

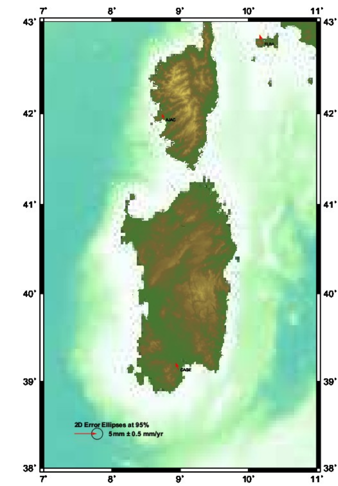
Lista delle Coordinate finali
per GPS-1234

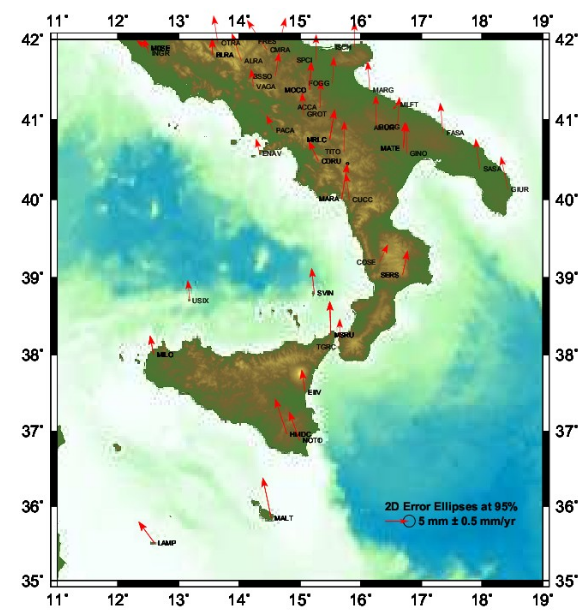
Universita di Padova
Programma GP TO UTMs del NGS-USA VERSIONE 2.1
Ellissoide GRS80/WGS84

Nome Stazione		Latitudine	Longitudine	UTM NORD(Y) METRI	UTM EST (X) METRI	ZONA	CONVERGENZA G M S	SCALA FATTORE	ELEV (M)	EllGEOIDEica h(M)
AQUI	12757M001	42 22 5.65200N	013 21 0.88048E	4691980.538	364159.972	33	-1 6 42.94	0.99982704		
BZRG	12751M001	46 29 56.47636N	011 20 12.45470E	5152147.609	679307.217	32	1 41 43.70	0.99999521		
CAGL	12725M003	39 8 9.27309N	008 58 21.89610E	4331859.102	497644.802	32	-0 1 1.92	0.99960007		
CAGZ	12725M004	39 8 9.19401N	008 58 21.91712E	4331856.664	497645.306	32	-0 1 1.91	0.99960007		
COMO	12761M001	45 48 7.77809N	009 05 44.22688E	5072071.003	507430.311	32	0 4 6.79	0.99960068		
ELBA	12721M002	42 45 10.43193N	010 12 39.93569E	4734086.222	599109.455	32	0 49 19.93	0.99972084		
GENO	12712M002	44 25 9.78564N	008 55 16.10197E	4918457.738	493722.130	32	-0 3 18.70	0.99960048		
GRAZ	11001M002	47 4 1.65844N	015 29 36.51432E	5212741.913	537469.766	33	0 21 40.69	0.99961725		
IENG	12724S001	45 0 54.46678N	007 38 21.84472E	4985531.534	392792.226	32	-0 57 44.76	0.99974133		
IGMI	12701M003	43 47 44.32675N	011 12 49.66354E	4851558.011	678099.072	32	1 31 57.16	0.99999015		
LAMP	12706M002	35 29 59.17817N	012 36 20.34964E	3931104.097	282827.850	33	-1 23 27.39	1.00018124		
LINZ	11033S001	48 18 35.20681N	014 16 59.00457E	5350980.252	446840.378	33	-0 32 7.41	0.99963472		
M0SE	12772M001	41 53 35.19942N	012 29 35.71642E	4640947.266	292042.938	33	-1 40 28.06	1.00013218		
MATE	12734M008	40 38 56.86567N	016 42 16.03966E	4501204.826	644108.043	33	1 6 37.86	0.99985562		
MOPS	12791M001	44 37 45.66317N	010 56 57.08466E	4943625.279	654613.668	32	1 22 10.60	0.99989398		
NOT1	12717M004	36 52 33.03158N	014 59 23.21972E	4081099.325	499089.478	33	-0 0 22.07	0.99960001		
PADO	12750S001	45 24 40.14376N	011 53 45.80920E	5032706.146	726614.078	32	2 3 48.02	1.00023145		
PRAT	12760M001	43 53 8.01611N	011 05 56.84377E	4861304.106	668620.015	32	1 27 19.79	0.99994972		
ROVE	12774M001	45 53 36.60964N	011 02 31.55224E	5084242.683	658426.453	32	1 27 59.86	0.99990856		
SBG2	11031M002	47 48 12.30519N	013 06 37.53357E	5296180.068	358514.098	33	-1 24 0.40	0.99984599		
TORI	12724M002	45 3 48.11332N	007 39 40.59956E	4990861.161	394604.569	32	-0 56 51.91	0.99973659		
UNPG	12752M001	43 7 9.79991N	012 21 20.51732E	4777467.171	284880.043	33	-1 48 29.25	1.00016931		
UNTR	12785M001	42 33 31.23544N	012 40 25.62525E	4714431.101	309038.147	33	-1 34 25.67	1.00004868		
VEN1	19513M001	45 25 50.04318N	012 21 14.66616E	5034188.554	293029.349	33	-1 53 8.25	1.00012671		
WTZR	14201M010	49 8 39.10476N	012 52 44.06098E	5445651.680	345311.226	33	-1 36 16.64	0.99989395		
ZIMM	14001M004	46 52 37.54129N	007 27 54.98323E	5192649.567	383055.111	32	-1 7 13.10	0.99976809		
ZOUF	12763M001	46 33 25.98367N	012 58 24.77266E	5157956.019	344671.416	33	-1 28 17.84	0.99989657		
ACCA	ACCA	41 9 30.93312N	015 19 52.21527E	4556415.429	527785.134	33	0 13 4.66	0.99960950		
ACCE	ACCE	44 28 34.24758N	006 59 17.54254E	4926731.718	340001.169	32	-1 24 35.23	0.99991483		
ACOM	12767M001	46 32 52.55466N	013 30 53.62219E	5156000.700	386145.942	33	-1 4 41.62	0.99975933		
AFAL	12766M001	46 31 37.70613N	012 10 28.24235E	5156498.093	283307.435	33	-2 3 4.51	1.00017721		
AGNE	AGNE	45 28 4.57813N	007 08 22.61545E	5036617.922	354572.015	32	-1 19 35.12	0.99986003		
ALRA	00000M000	41 44 2.12539N	014 02 3.76112E	4620685.241	419696.770	33	-0 38 34.16	0.99967935		
AMUR	00000M000	40 54 26.13144N	016 36 14.52426E	4529700.464	635093.220	33	1 3 1.94	0.99982463		

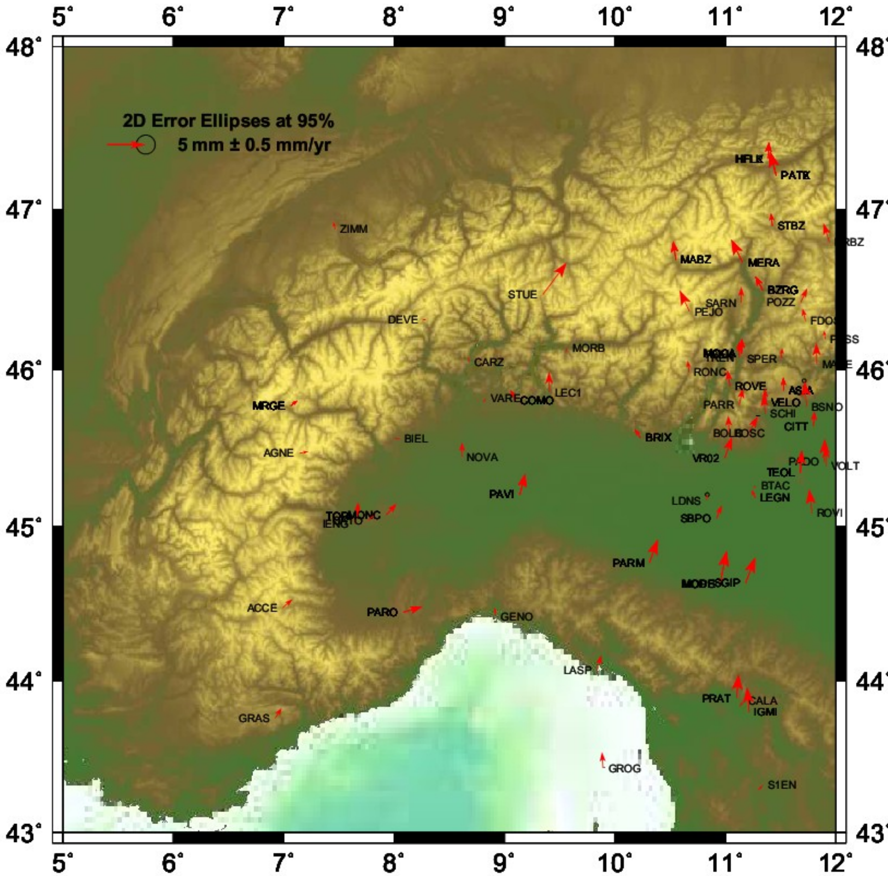
ETRS89 Densification: some of the outputs.

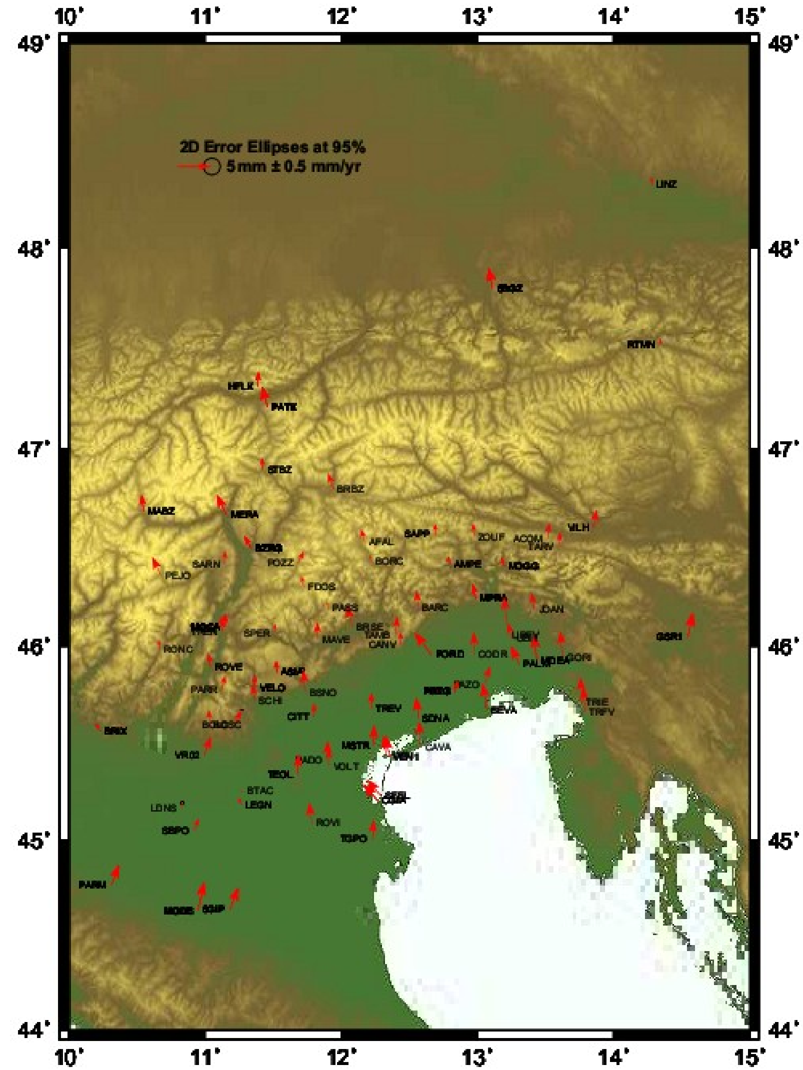






ETRS89 Densification: some of the outputs.





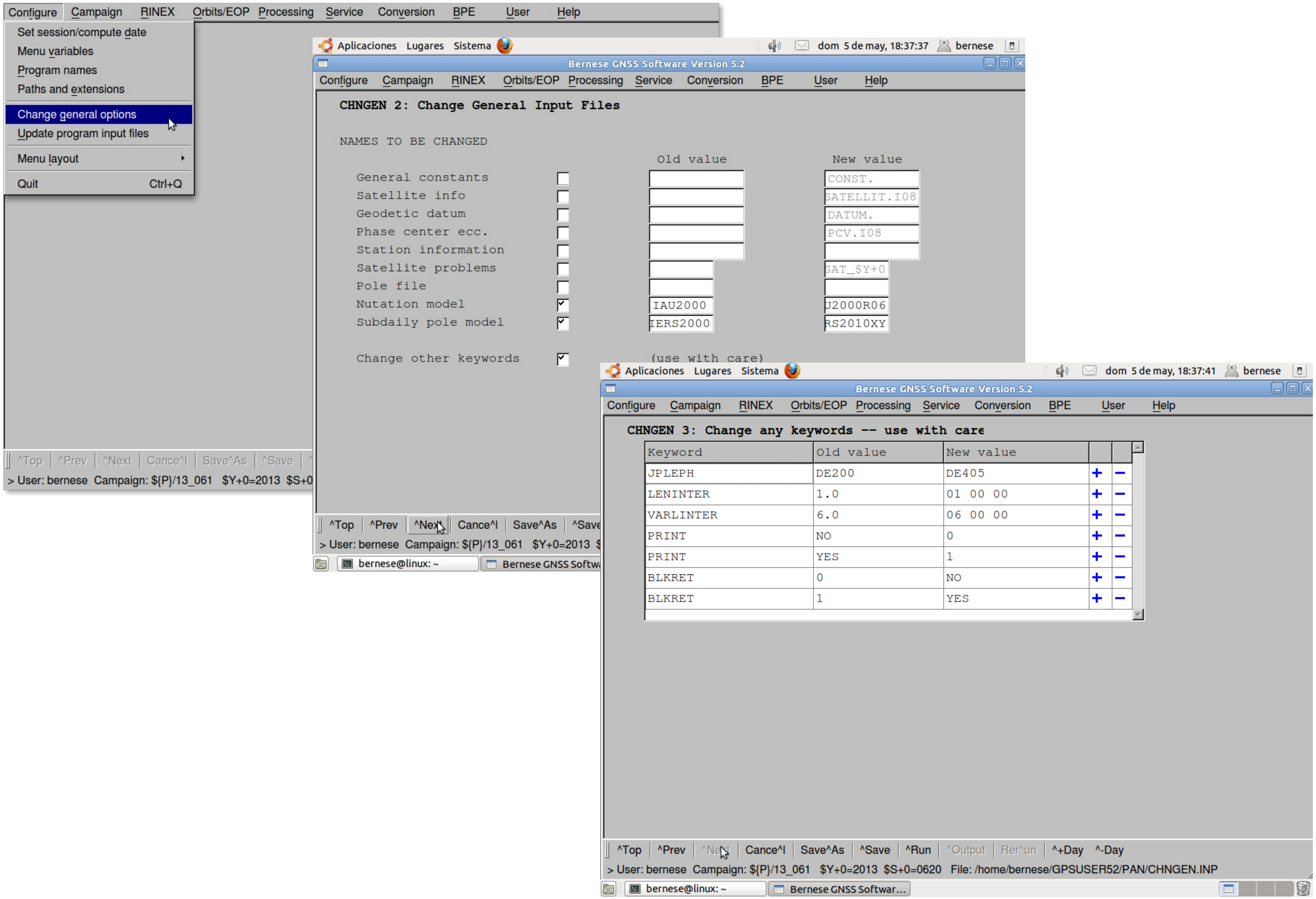
BSW 5.2 installation:

- Linux machine (ubuntu 10.10), with cpp 4.4.5 and gfortran 4.4
- Installation scripts: straightforward (same for QT4).
- Only one problem, sorted out by following the advised setting in `D_PHAECC.F90 (SR search_off, lines 1772 and 1966):`

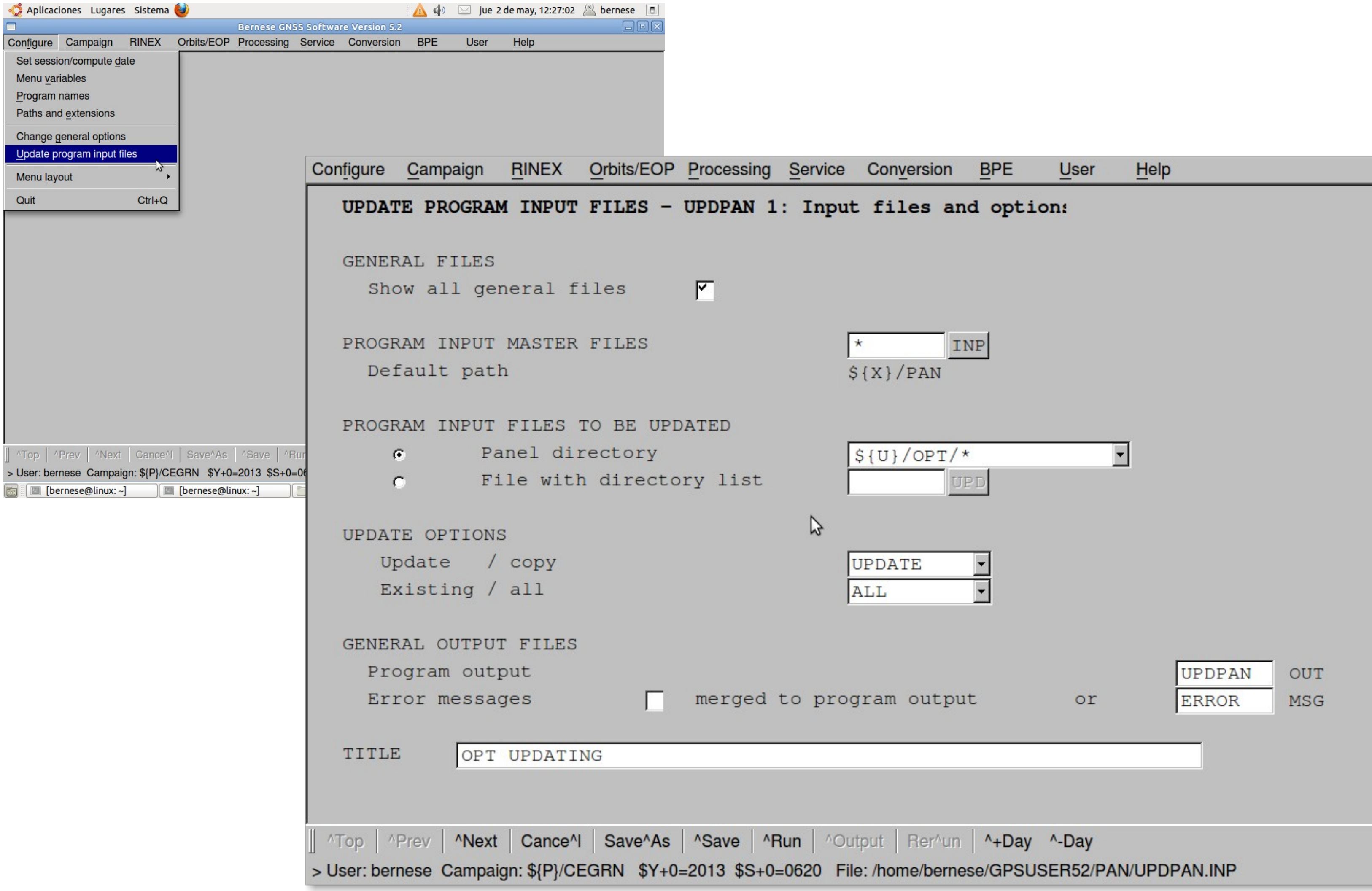
```
                   isys  = INT(prn/100)
                   isPrn = (prn/=isys*100)
  ! Values for satellite antennas are buffered in isys=0
      IF (antnam(1:3) == 'MW ' .OR. antnam(1:5) == 'SLR
                        R') isys = 0
      ! Take always GPS offsets for receiver antennas
         isys = 0 ! decomment this line if necessary
```

- Running the examples: without problems
- Additional tasks (addressed in the V50_TO_V52.TXT file):
  - ✓ Import the previous INP files
  - ✓ Modify some of the variables

BSW 5.2 installation:



BSW 5.2 installation:



BSW 5.0 scripts in BSW 5.2:

- Most of the input files/panels are **easily imported**.
- **Changes in** “General Options”, also fine.
- New options are not, however, implemented: peer review is needed.
- **In our case**, the new DATAPOOL/SAVEDISK structure is not really needed and won’t be used: our scripts include a well-defined data retrieval/storage strategy.
- Running the **examples**: without problems

BSW 5.0 vs BSW 5.2:

- Data for GW1725 to GW1731 have been processed using both packages.
- Options and input data have been “the same” in both processings.
- Some files cannot be the same due to the updates in BSW52 (Satellite info file and constant and datum files)
- To check the quality, a Helmert 3D was computed for each weekly solution:

Week 1725

- Biases in the 7 parameters (rotations, very small)

BSW 5.0 vs BSW 5.2: weekly NEQ-ing. CHI2 and statistics…

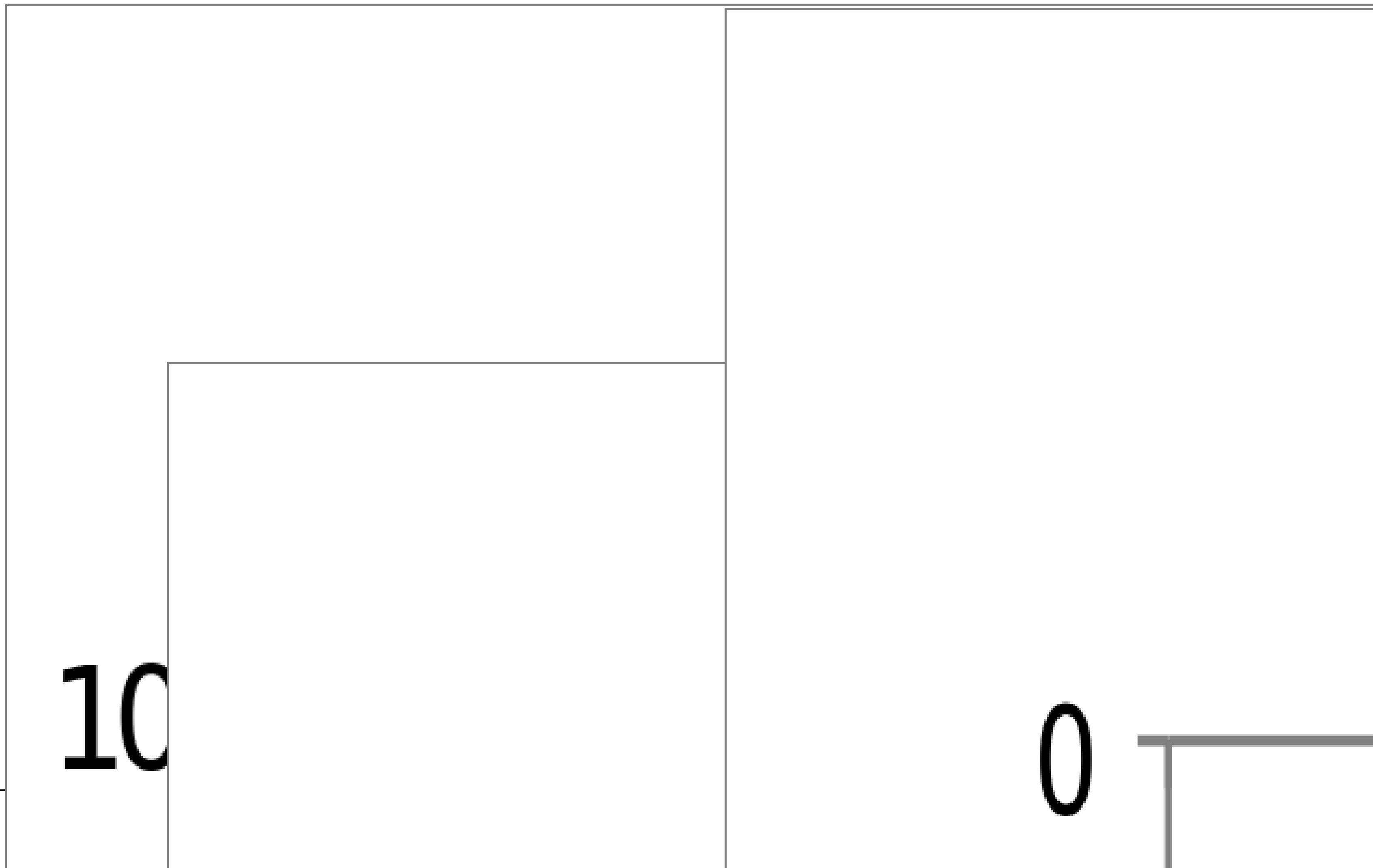
BSW52: Wk1725

Total number of authentic observations	1060166
Total number of pseudo-observations	3
Total number of explicit parameters	126
Total number of implicit parameters	15381
Total number of observations	1060169
Total number of adjusted parameters	15507
Degree of freedom (DOF)	1044662
A posteriori RMS of unit weight	0.00124 m
Chi**2/DOF	1.53
Total number of observation files	286
Total number of stations	42
Total number of satellites	0

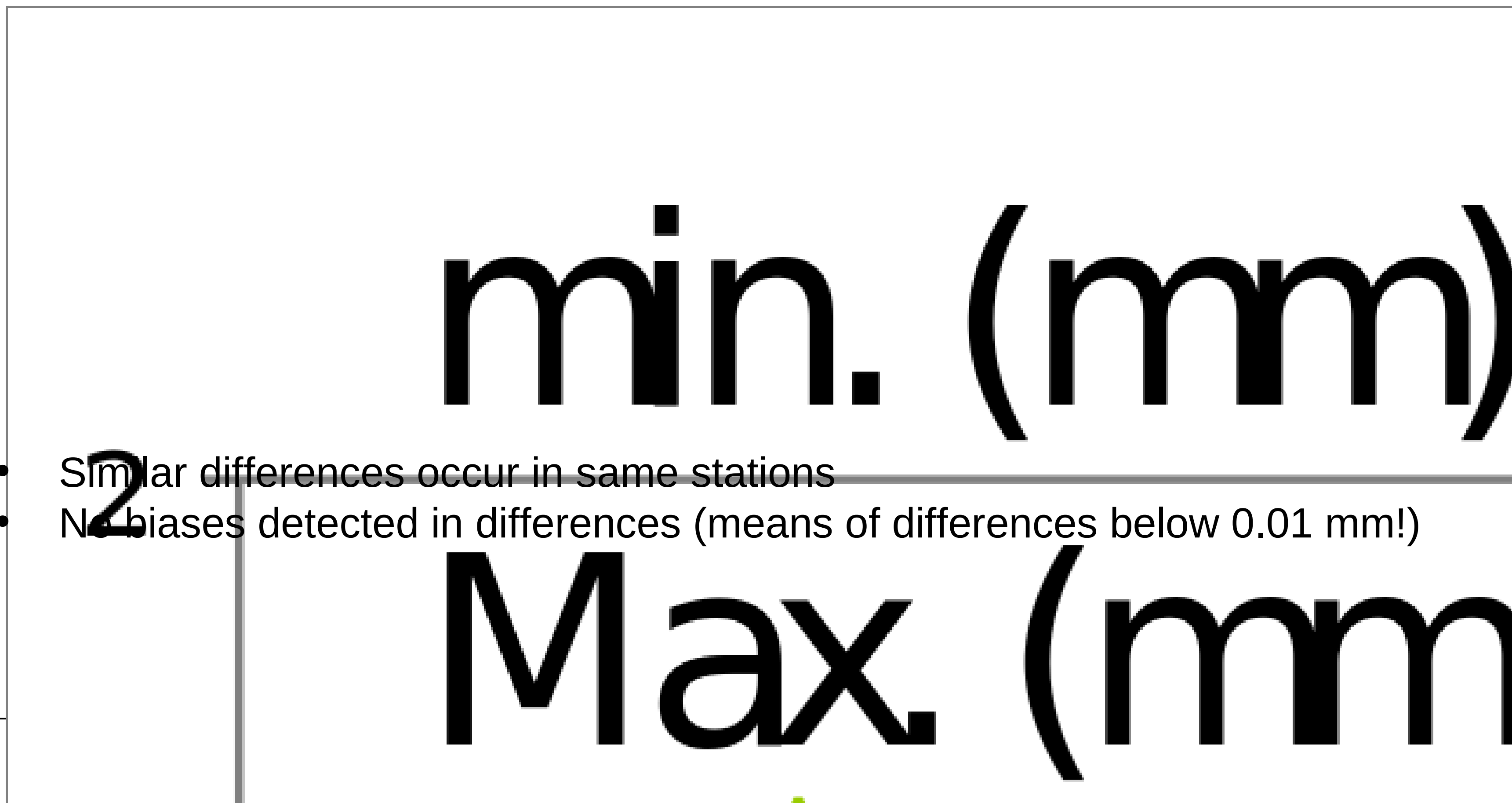
BSW50: Wk1725

Total number of authentic observations	1060166
Total number of pseudo-observations	3
Total number of explicit parameters	126
Total number of implicit parameters	12734
Total number of adjusted parameters	12860
Total number of observations	1065959
Degree of freedom (DOF)	1053099
A posteriori RMS of unit weight	0.00125 m
Chi**2/DOF	1.57
Total number of observation files	286
Total number of stations	42
Total number of satellites	0

BSW 5.0 vs BSW 5.2: weekly solutions.



BSW 5.0 vs BSW 5.2: station by station solutions



- Similar differences occur in same stations
- No biases detected in differences (means of differences below 0.01 mm!)

UNIVERSITÀ DEGLI STUDI DI PADOVA

Perspectives

The activities carried out lead to some proposal on how the **UPA LAC can provide an additional contribution to the EPN**, besides the weekly computation of the assigned sub network.

For example, the following activities could be foreseen, on account of the ongoing EPN work on ETRS89 maintenance and monitoring, and on the densification of the velocity field in Europe:

- **Combination of the EPN long term solution with national network** solutions
- **Rigorous spectral analysis** of time series of each station, and cross correlation of time series of different stations as a function of their relative distance, to detect common mode systematics, in the NEU directions
- **Rigorous computation of the uncertainty in the station velocities** taking into account the noise profile and non white noise component of the time series
- **Computation of the spatial gradient of the velocity**, to highlight the local deformation in the coordinate grid (and hence departures from nominal coordinates).

Università degli Studi di Padova

Thank you for your attention