Densification of IGS/EPN by local permanent networks: results sensitivity with respect to the adjustment choices

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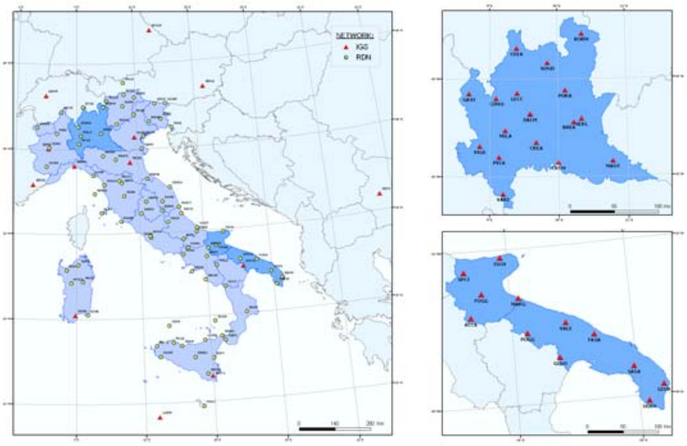
Abstract:

Local GNSS permanent networks materialize, through their stations coordinates estimation and distribution, the global reference frame; the estimates are provided by the classical network adjustment process, including near reference IGS or EPN permanent stations used as constraints. GNSS data modeling is still a research field: IERS conventions as well as IGS and EPN guidelines are periodically updated in order to reflect the state of the art. The purpose of this work is to evaluate the differences in the adjustment results and quality indexes provided by the adoption of different network adjustment approaches. The results of different elaboration approaches have been compared on two Italian local GNSS permanent network: the first is in Lombardia Region, in the northern, pre alpine Italy, the second is in Puglia Region, in the southern, mediterranean, Italy; for Lombardia network, one year of data has been analyzed; for Puglia network, six months of data are available and have been considered. From a technical point of view, the use of IGS and EPN stations as constraining references could degrade results accuracy in zones where they are too sparse, like for example central-southern Italy: a possible solution is to adopt a national zero order permanent network, adjusted in IGS, to constrain the adjustment of local networks. A test zero order network has been established by IGM (Istituto Geografico Militare, the Italian Cartographic Institute), that is called RDN (Dynamic National Network). At the present, only one month of results is available and has been analyzed.

The Networks:



Network	# PSs	Average distance between PSs	Web
RDN	83	70 km	http://www.igmi.org
LOMBARDIA	17	50 km	http://www.gpslombardia.it
PUGLIA	12	60 km	http://gps.sit.puglia.it

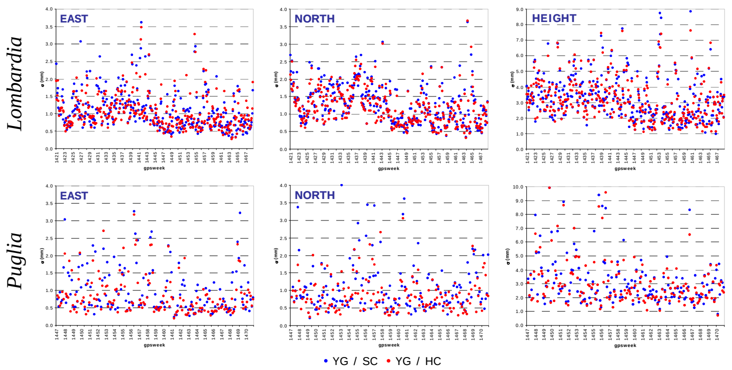
Methodological Comparisons:

All elaborations performed with BSW5.0, by stochastically constraining IGS PSs to their IGS05 published coordinates.

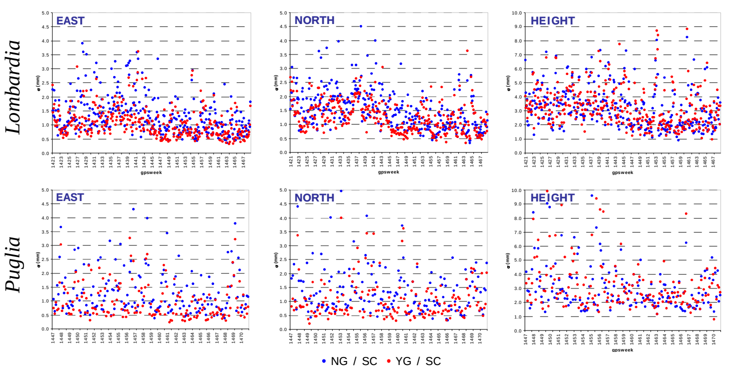
- Soft Constraints (SC): IGS PSs constraints standard deviations of 2 mm and 4 mm in planimetry and height.
- Hard Constraints (HC): IGS PSs constraints std of 0.2 mm and 0.4 mm in planimetry and height.
- No Gradients (NG): hourly ZTD estimates for each PS, no horizontal gradients estimation.
- Yes Gradients (YG): daily horizontal gradients estimates for each PS.
- Ocean loading (OL): use of GOT00.2 ocean loading tide correction model.

	LOMBARDIA PSs												PUGLIA PSs											
	dEAST (mm)				dNORTH (mm)				dHEIGHT (mm)				dEAST (mm)				dNORTH (mm)				dHEIGHT (mm)			
	E	σ	m	M	E	σ	m	M	E	σ	m	M	E	σ	m	M	E	σ	m	M	E	σ	m	M
NG / SC	0.0	1.5	-10.4	7.0	0.0	1.7	-8.7	10.7	0.0	3.5	-23.3	17.2	0.0	1.5	-7.9	6.1	0.0	1.6	-9.4	6.3	0.0	3.4	-14.2	16.3
NG / HC	0.0	1.4	-10.4	7.0	0.0	1.6	-8.2	8.7	0.0	3.4	-23.6	19.2	0.0	1.2	-6.8	4.4	0.0	1.3	-9.6	7.4	0.0	3.1	-14.3	17.6
YG / SC	0.0	1.2	-7.2	9.3	0.0	1.4	-7.5	8.7	0.0	3.5	-23.9	15.6	0.0	1.2	-5.7	4.4	0.0	1.3	-7.3	5.6	0.0	3.5	-16.3	17.6
YG / HC	0.0	1.1	-6.7	9.4	0.0	1.3	-7.2	8.9	0.0	3.4	-24.6	15.3	0.0	1.0	-4.7	4.6	0.0	1.1	-7.3	6.1	0.0	3.4	-15.8	19.2
YG / SC /OL	0.0	1.2	-7.2	9.4	0.0	1.4	-7.4	8.9	0.0	3.5	-24.0	15.5	0.0	1.2	-5.7	4.5	0.0	1.3	-7.3	5.7	0.0	3.6	-16.5	18.5

Hard Constraints vs Soft Constraints



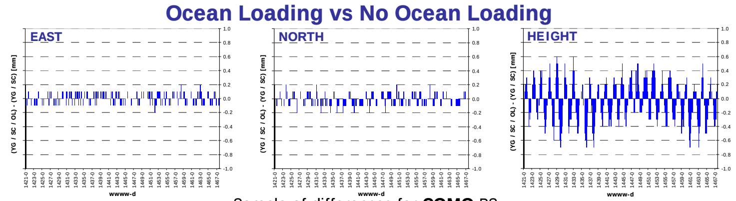
Yes Gradients vs No Gradients



In the graphs: for each day, for each component j (East, North, Height): $\sigma(d)=\sqrt{\frac{1}{N_S}\sum_{i=1}^{N_S}\left(j(d)-\hat{j}(d)\right)^2}$ where $\hat{j}(d)$ is the predicted j from a linear interpolation on all the solutions.

In the tables: statistics on all the residuals.

Ocean Loading vs No Ocean Loading



\- Sample of differences for **COMO** PS -

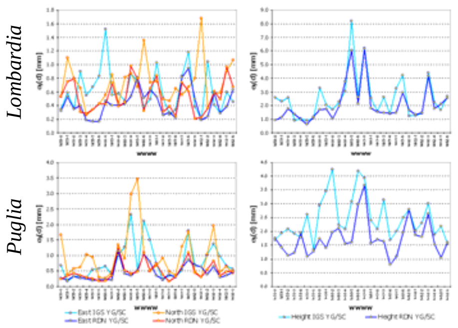
A significant statistic improvement is provided by the NG->YG transition: it wasn't completely expected, because of the local nature of the networks. The SC->HC doesn't really change the results, contrary to the idea that a stronger weight to constrained stations might improve the repeatability of the adjusted stations. Best quality indicators (final multibase RMS's, here not shown) are provided by SC/YG solution: however, differences are never significant. Comparison of the interpolated coordinates and velocities are still under progress, but first analyses don't show significant differences. OL tide model don't entails significant variations. More detailed analyses and further comparisons will be described in the final paper.

Reference Comparisons:

To compare the adjustment of local networks in IGS versus the adoption of a zero order national network (RDN) the following approach has been tested:

1. direct adjustment of local PNs in IGS;
2. adjustment of RDN in IGS by the same approach;
3. adjustment of local PNs in RDN without constrain others IGS PSs;
4. comparison of 3. and 1.

	LOMBARDIA PSs												PUGLIA PSs											
	dEAST (mm)				dNORTH (mm)				dHEIGHT (mm)				dEAST (mm)				dNORTH (mm)				dHEIGHT (mm)			
	E	σ	m	M	E	σ	m	M	E	σ	m	M	E	σ	m	M	E	σ	m	M	E	σ	m	M
YG / SC IGS	0.0	0.7	-2.8	2.2	0.0	0.8	-2.4	2.7	0.0	3.1	-15.6	6.7	0.0	1.0	-4.1	2.9	0.0	1.3	-4.1	4.7	0.0	2.6	-10.3	7.2
YG / SC / RDN	0.0	0.5	-2.5	1.7	0.0	0.6	-2.1	2.6	0.0	2.5	-15.4	7.5	0.0	0.5	-3.6	2.1	0.0	0.6	-2.6	3.9	0.0	1.9	-10.9	4.7



By introducing RDN network, repeatabilities of local networks improve; "final" (BSW5.0 COMPARE) coordinates estimates change of few millimeters, but considering that at present only a month of results is available, these differences cannot be considered significant: more data are needed.

Conclusions:

The first tests have been performed and discussed. In future, further analyses will be made on the IGS05 versus ITRF05 choice in constraining IGS PSs and on the application of Ocean Loading tables in RDN; moreover, the use of RDN will be tested with a greater data set.

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(Poster available at http://geomatica.como.polimi.it/prin/2006/index.php)