From GPS to tomography for SAR images correction

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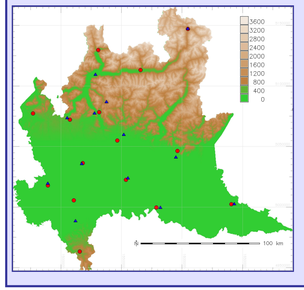
ABSTRACT

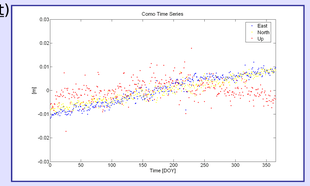
Water vapor is one fundamental component in the atmosphere and it is the main driver of meteorological processes. Both GPS and SAR signals are delayed by the presence of water vapor in the lowest atmospheric layer, the troposphere. However the GPS technique allows the estimation of water vapour; particularly GPS permanent networks can provide tropospheric “products” at two different levels: ZTD hourly estimates for each permanent station and tropospheric tomography that allows the determination of the refractivity index for a 3D grid. Both the types of products can be used to correct the atmospheric effects present in SAR interferograms. The first aim of this work is the evaluation of GPS potential in water vapor estimation by analyzing the external consistency with other meteorological data, similarly to what is find in literature. Particularly, we have analyzed hourly ZTD’s produced from daily adjustment of GPS Lombardia permanent network. Using meteorological data (pressure, temperature and humidity) observed from meteorological stations, ZTD’s have been inferred and compared with GPS ZTD's. Moreover a ZTD’s spatial interpolation by kriging has been tested by using as check data the same observed values.
Moreover a project to integrate GPS and SAR at a local level is under development, with the following objectives:
1. to estimate both absolute movements and deformations;
2. to perform tropospheric tomography.
A specific test to cover different spatial scales in order to derive data suitable to correct SAR measurements has been set up: it foresees the use of Lombardia permanent network and the installation of a six GPS receivers local network in Como town: three receivers at 100-300 meters and three 1-2 kilometer far: the receivers will acquire data for at least 6 months in order to cover several passages of a SAR satellite. The idea is to compare the estimated water vapor density at different resolutions with those produced by the permanent scatterers analysis in the area.

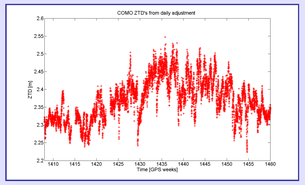
LOMBARDIA PERMANENT NETWORK

(www.gpslombardia.it)



Lombardia Positioning Service: 15 PS’s.
Mean reciprocal distance: 50 km
Red: GPS PN’s
Blue: meteo stations





Network adjustment by Bernese 5.0 SW: Daily adjustment in IGS Permanent Network from January 2006
1. IGS PS’s constrained to their official IGS05 coordinates
2. Adoption of IGS final products: EPH, EOP, PCV
3. EPN/IGS standard strategy in raw data elaboration
4. Output estimates: daily coordinates (left example) and hourly ZTD’s (right example) for Lombardia PS’s

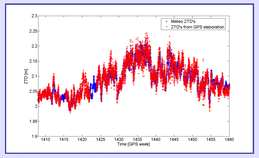
ZTD’s are estimated by applying Niell model for the hydrostatic part and estimating the wet part.

FIRST ANALYSIS

From meteorological stations: ground pressure, temperature and humidity; from ground atmospheric parameters, by applying Saastamoinen model: “meteorological estimated” ZTD’s; comparison between meteo and GPS ZTD’s. Two case studies. Bormio site: very near GPS and meteo stations; Como site: 3 km of distance and 50 m of elevation difference.

BORMIO SITE

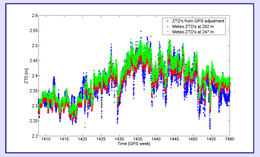
Bormio [cm]	Diff. Meteo - GPS
Mean	-1.8
Dev. St.	1.5
Max	5.5
Min	-4.8



Same behavior, no bias, reasonable statistics

COMO SITE

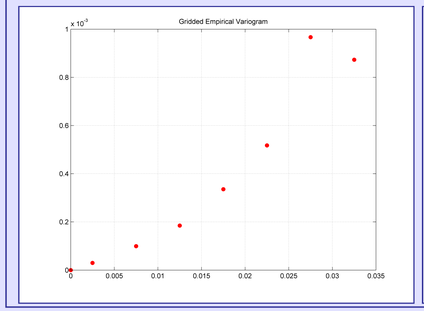
Como [cm]	Diff. Meteo – GPS Original	Diff. Meteo - GPS Elev. Red.
Mean	3.2	1.5
Dev. St.	2.6	2.6
Max	13.0	11.3
Min	-6.3	-8.4

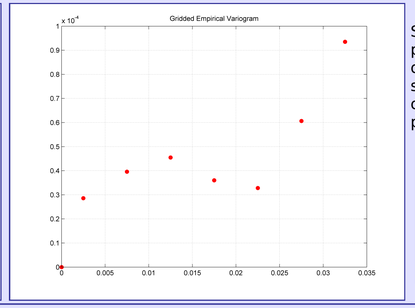


Same behavior with a bias due to elevation difference. Meteo data reduced for elevation difference: the bias reduces but the statistic are not very satisfactory.

KRIGING PREDICTION OF ZWD

In order to assess the feasibility of kriging in ZTD/ZWD spatial prediction a numerical experiment has been done. ZWD is considered a 2D homogeneus and hysotropic random field, for which ordinary kriging prediction has been implemented and applied in MatLab. Input observations are the hourly ZWD's estimated by BSW5.0 in the GPS stations of Lombardia permanent network; at first, the ZWD's are reduced to the same height of the prediction point, by using Saastamoinen model; then, the empirical variogram of reduced ZWD is computed and interpolated by a proper model. Finally, ZWD is predicted. The process has been applied to two case studies : GPS stations of Como and Crema. In both the cases, one year (2007) has been considered, one day every ten, for two hours (1 am and 13 am) of the day. ZWD's from the other stations have been interpolated by the above procedure and compared with the local GPS ZWD's (obviously not used in the interpolation). Almost always, the empirical variogram has a clear pattern (left), but some exceptions exist (right). Prediction statistics are typically accurate, but many outliers are present (statistics in table); particularly, Crema shows a clear, not yet explained, bias.





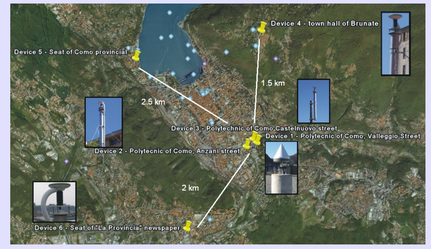
Some present approximations will be corrected in the immediate future: particularly, more complex model variograms will be tried for anomalous data; moreover, at present ZWD height reduction is done by using standard pressure, temperature and humidity: after EGU, the use of observed ground parameters will be implemented and tested. In the final paper, a more definitive accuracy assessment will be provided.

[cm]	COMO	CREMA
Mean	0.1	-0.6
Dev. St.	0.8	0.7
Max	2.3	0.9
Min	-3.0	-2.5

MIST PROJECT

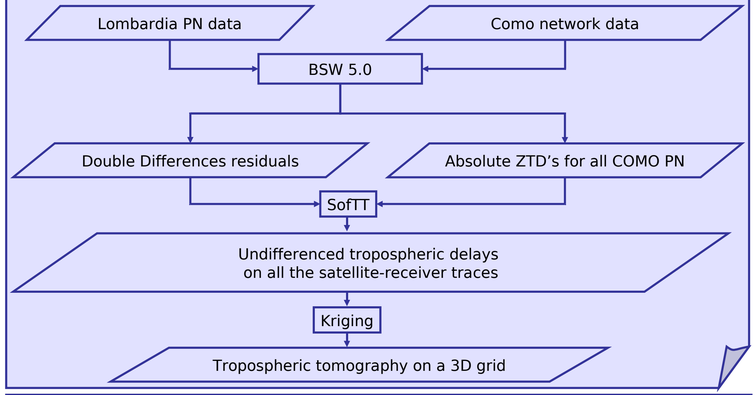
Id site	Receiver	Antenna	GPS week installation	Download data
CAST	GRX1200	ATX1202	1470	Ethernet
ANZA	GRX1200	ATX1202	1470	Ethernet
COMO	TopCon Odyssey	TPSCR3_GGD	1356	Ethernet
BRUN	GX1200	ATX1202	1471	GSM modem
LAPR	GX1200	ATX1202	1471	GSM modem
PRCO	GX1200	ATX1202	After EGU08	GSM modem

Id mission	Date
Envisat	4 April
Envisat	20 April
Envisat	9 May
Envisat	25 May
Envisat	13 June
Envisat	29 June
Envisat	18 July
Envisat	3 August
Envisat	22 August
Envisat	7 September
Envisat	26 September
Envisat	12 October



The receivers will acquire data for about 7 months (from April 2008 to October 2008) in connection with some passages of SAR satellite.

DATA ANALYSIS FLOW



CONCLUSION AND ACKNOWLEDGEMENTS

Comparisons between meteo and GPS not really satisfactory: more analysis needed; a kriging procedure implemented and under test for 2D ZWD prediction; MIST experiment set up and data acquisition started.

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