Relating the Italian Height System to EVRF2007: final results

R. Maseroli[1)], F. Cauli[1)] and A. Caporali[2)]

1) Istituto Geografico Militare Italiano, Firenze
2) Universita di Padova

51. TWG, Padova, 13 October 2009

Outlook

- Rationale: National height system is internally consistent but has unkown relation to a mean European Height System
- Context: INSPIRE homogeneization requirements + EUVN – DA project
- Data: Need a well selected set of points of known ETRF2000 coordinates (3D), gravity and orthometric height
- Method: Use EGG08 gravimetric geoid and GPS sites with ETRF2000 coordinates to connect and homogeneize the national vertical frame within EVRS
- Product: Estimate conversion formulas from national to EVRF2007

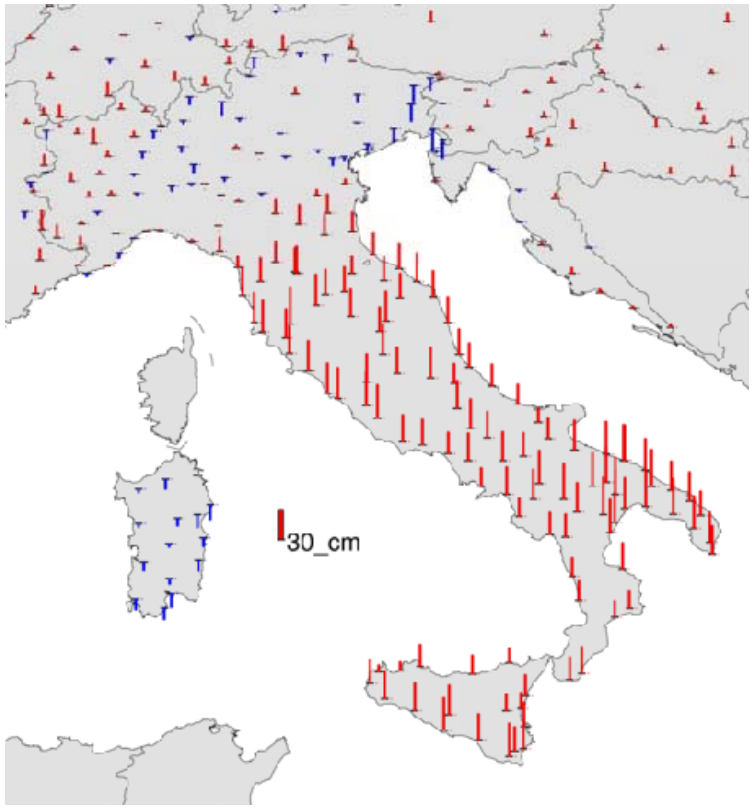
Early submission

- **Country: Italy Last update: 07-Aug-06 Data provider: IGM Contact person: M. Pierozzi Number of points: 15+195**
- **GPS data details: Campaign date: 1992-96**
- **Elevation cut-off [deg]: 15**
- **Source http://crs.bkg.bund.de/evrs/euvn_da/EUVN_DAcompstat.php**

European Vertical Reference System (EVRS)

EUVN_DA / EGG comparison statistics

		RMS [cm]			max-min range [cm]		
	#	EGG97	EGG03	EGG06	EGG97	EGG03	EGG06
Austria	17	11	6	5	33	19	17
Belgium	8	7	5	4	24	16	11
Bulgaria	26	10	11	-	40	44	-
Croatia	20	20	15	7	80	56	29
Czech R.	8	5	3	3	15	8	9
Denmark	-						
Estonia	26	9	7	7	40	35	19
Finland	50	11	4		51	18	
France	168	12	8	8	70	42	48
Germany	85	10	4	4	46	15	15
Great Britain	182	19	13	12	74	56	56
Hungary	22	9	4	5	40	20	19
Italy	195	23	19	19	116	81	74
Latvia	20	13	9	11	39	27	31
Lithuania	9	6	3	-	16	10	
Netherlands	15	6	4	2	20	11	7

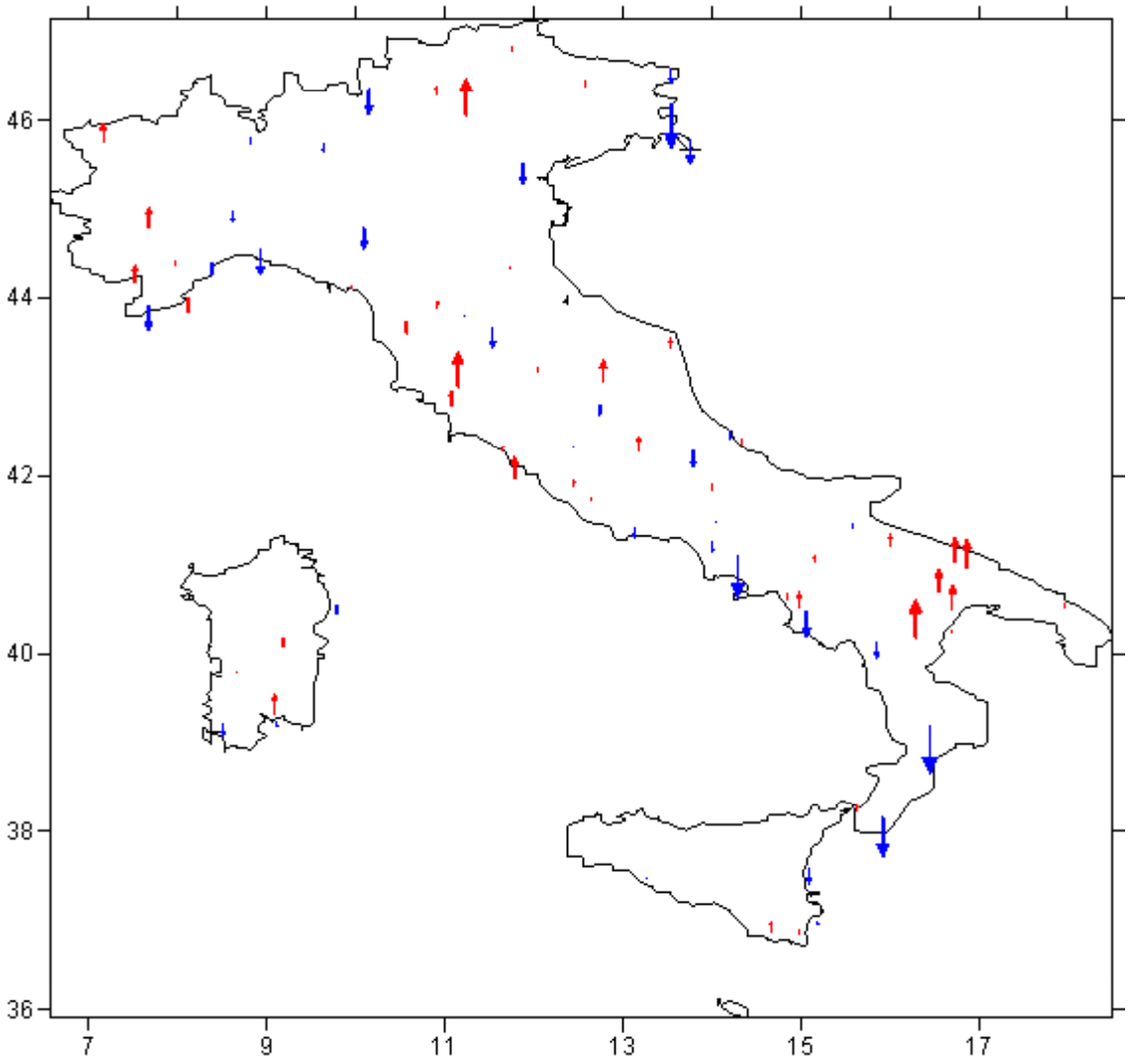


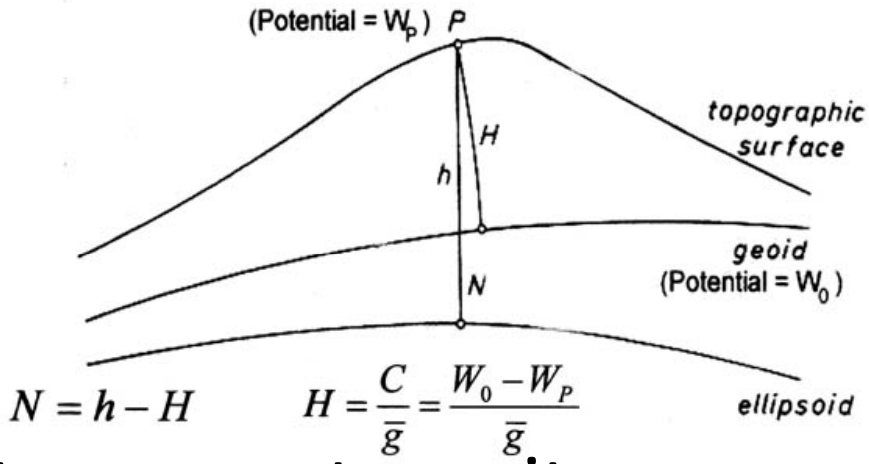
Data Points

- Backbone for 3D ellipsoidal coordinates is the new RDN (99 points) compliant with ETRF2000
- Previous network IGM95 (ETRF89) has been readjusted and aligned to RDN → several points are available in ETRF2000, among them GEOTRAV points which are also leveled points
- Select a subset with the criteria:
  - Geographic distribution
  - Gravity is measured at the point
  - Validation with national geoid
- Remark: points in the continent (63), Sicily (7) and Sardinia (7) need to be treated separately, due to different origin.

Results

- Validation of raw heights (no gravity)
- 63 + 7 + 7 points selected for continent and islands
- N_{EGG08} computed at each point, as well as h(ETRF2000)-H(National height system)
- Model the differences h-H-N_{EGG08} with a regression plane





Taking into account gravity:

•To compute the mean gravity we have to correct for free air and Bouguer.
•Plate correction may be unsuited for high mountain areas (see below)
• This latter correction needs an assumption about the mean density of the crust. We can take ρ = 2670 kg m^{-3}

$$H = \frac{C}{g + (0.5 * \frac{2\gamma}{r} - 2\pi G\rho)H}$$

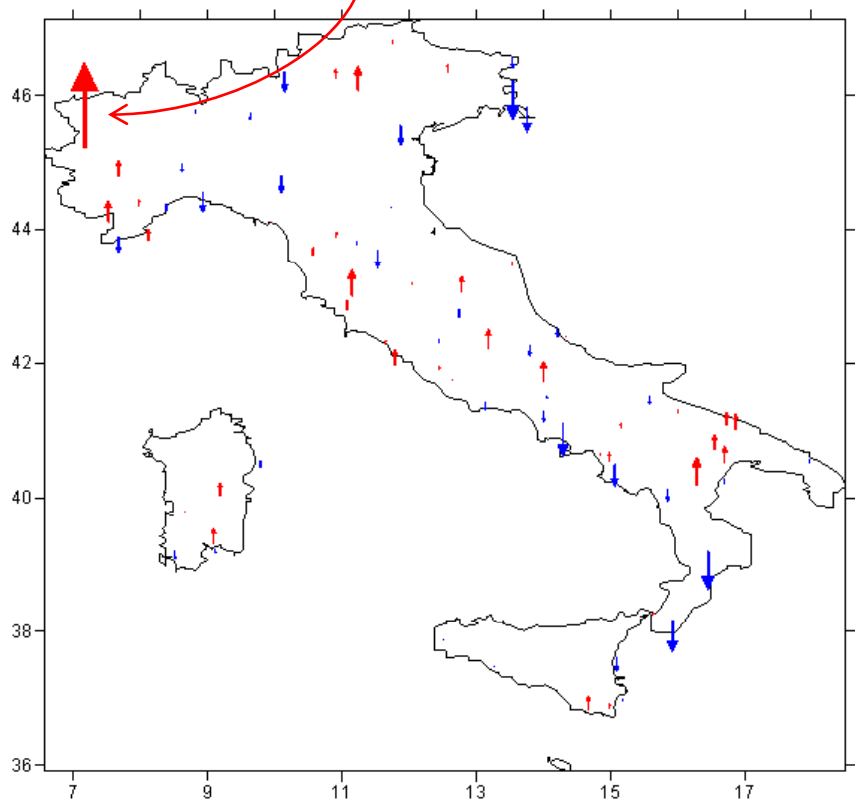
Statistics and transformation formulas:

$$(h-H)-N_{EGG08}=a_0+\xi(Nord-Nord_0)+\eta(East-East_0)+\varepsilon$$

N pts=64	regression plane CONTINENT	
Origin(*)	ϕ (dd.ddd)	λ(dd.ddd)
	42.9228	12.5866
a_0 (m)	ξ(")	η (")
-0.106	-0.044	0.057
N pts = 6	regression plane SICILY	
origin(*)	ϕ (dd.ddd)	λ(dd.ddd)
	37.4131	14.4826
a_0 (m)	ξ(")	η (")
-0.558	-0.128	0.012
N pts = 6	regression plane SARDINIA	
Origin(*)	ϕ (dd.ddd)	λ(dd.ddd)
	39.8735	9.0906
a_0 (m)	ξ(")	η (")
-0.467	0.075	-0.163

(*) mean of coordinates

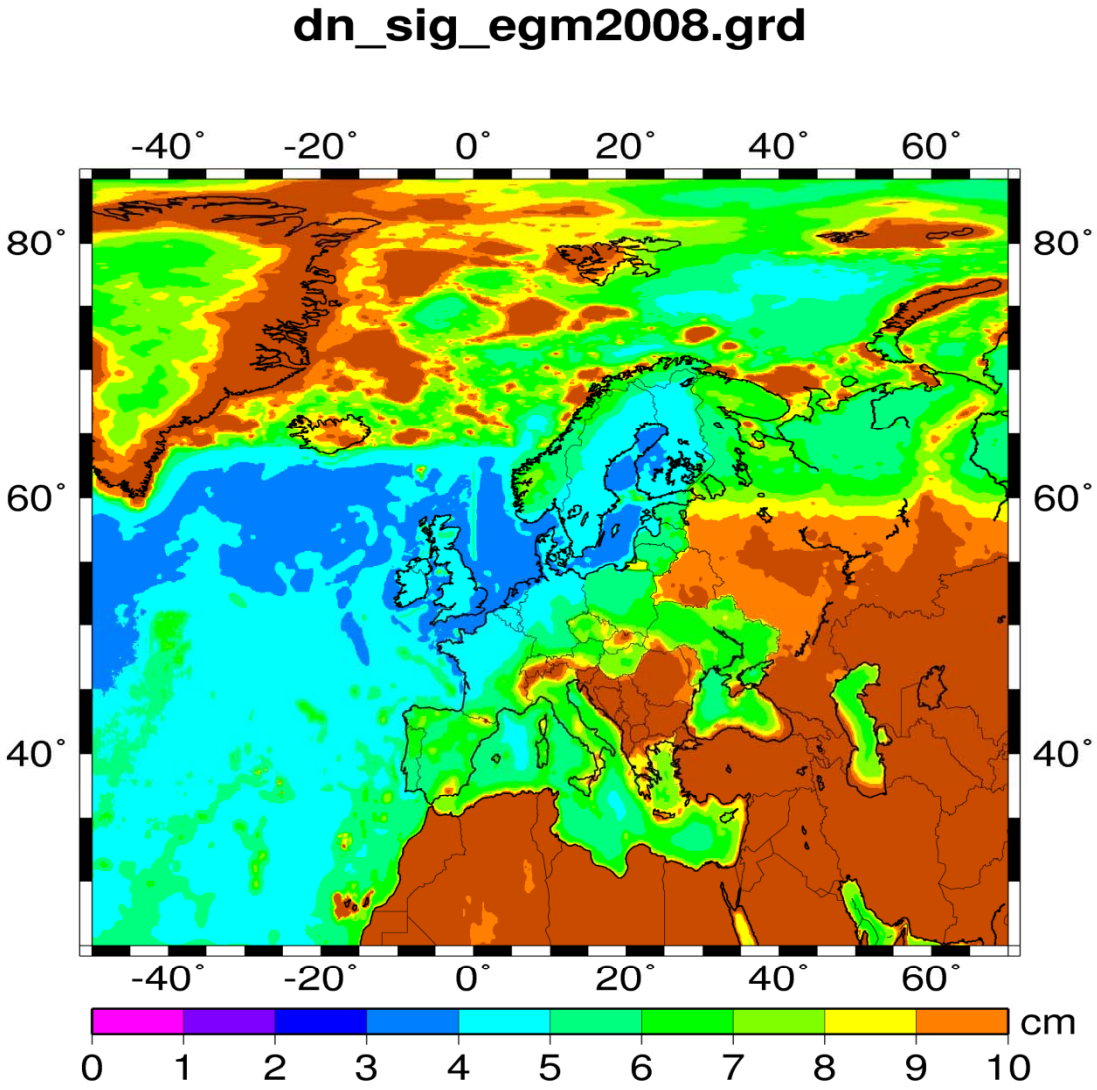
	Mean (m)	Stdev (m)	Max (m)	Min (m)
Continent	0.00	0.07	0..33	-0.14
Sicily	0.00	0.03	0.03	-0.05
Sardinia	0.00	0.04	0.06	-0.03



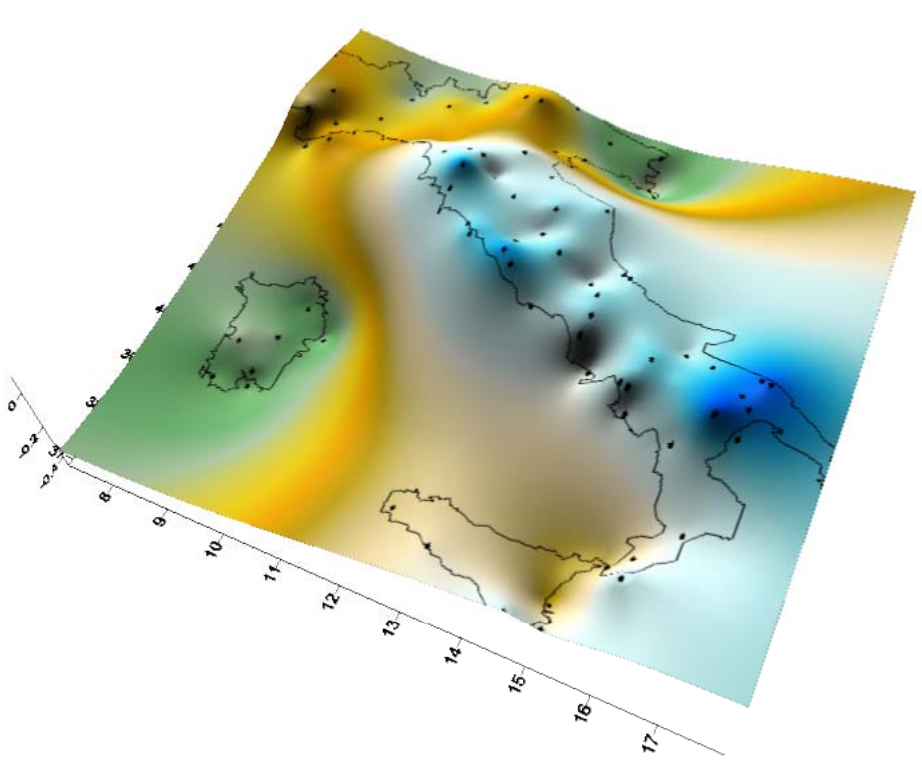
Error estimates for EGG08

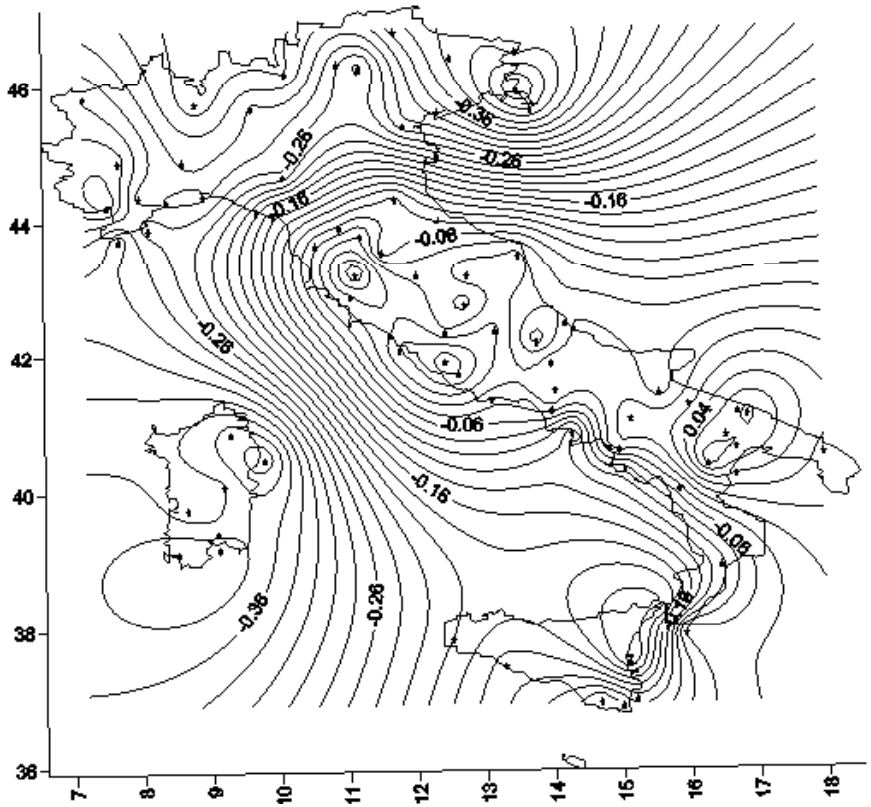
- Preliminary error map
- Uncertainty range for Italy:

  6 – 10 cm



ITALGEO05-EGG08





ITALGEO05 seems to embody the regression planes, so that h-H fits ITALGEO05 without the addition of regression planes

The origin of ITALGEO95 is shifted and the purely gravimetric model is complemented by GPS/leveling observations

Conclusions (Oct09)

- Comparison h/H/N based on leveled heights for validation and on orthometric heights for final results
- Bias of -11,-56 and -47 cm in the national height system(s) relative to a common frame materialized by the gravimetric geoid and the ETRF2000 ellipsoidal heights
- Regression planes have also different inclinations, max 0.16” (ca. 8 mm/10 km)
- RMS of fit is max 7.3 cm ->within the estimated uncertainty of the geoid model
- Disagreement between EGG08 and ITALGEO2005 seems to match the geometry of the three regression planes