

The first absolute gravity and height reference network in Sicily

ABSTRACT

In this poster we present the realization and the surveys performed to establish a new reference gravity and elevation network in Sicily with the aim to provide new reference systems useful for all the scientific and technological activities related to the gravity field and to the proper definition of a modern height system in this region. This network belongs to the under construction new Italian Reference Gravity Network (G0) that is part of the INGV Project Pianeta Dinamico, Task S2, during the period 2019-2022.

The Sicilian network encloses 5 stations (Catania, Centuripe, Milazzo, Noto, and Palermo), evenly distributed forming a large mesh network which roughly covers the entire Sicily (Fig.1). All absolute stations are hosted inside structures that guarantee protection for the instrumentation during the measurements and the necessary power supply. In addition to the absolute gravity value, at each station, the vertical gravity gradient and the gravity difference (Δg) between the indoor absolute gravity and an outdoor satellite station were also measured. Gravity measurements were carried out between the end of 2021 and the 2022 with the Microg LaCoste FG5#238 and the Scintrex CG-6 gravimeters for absolute and relative measurements, respectively. Gravity data have been corrected for known effects ensuring the reliability and accuracy at the μGal level. The coordinates and the orthometric heights were at the same time measured with mixed terrestrial and satellite local networks at each site. The precise coordinates obtained after the adjustments were useful to post-process the absolute gravity data and to refer all the gravity measurements presented in this work to the equipotential surface of the gravity field. Since three of the five selected stations were measured in the past, it was also possible to evaluate the long-term stability of the gravity values at these stations.

THE NETWORK

We selected 5 stations in Sicily, considering the sites of previous absolute measurements, in order to control any potential changes of the gravity values or to confirm the long-term stability: Palermo (UNIPA) and Milazzo (MLZ) in the north west and north east, respectively), Centuripe (CNT) in the center, Catania (CTA) and Noto (NTO) in the eastern and south-eastern part of Sicily.

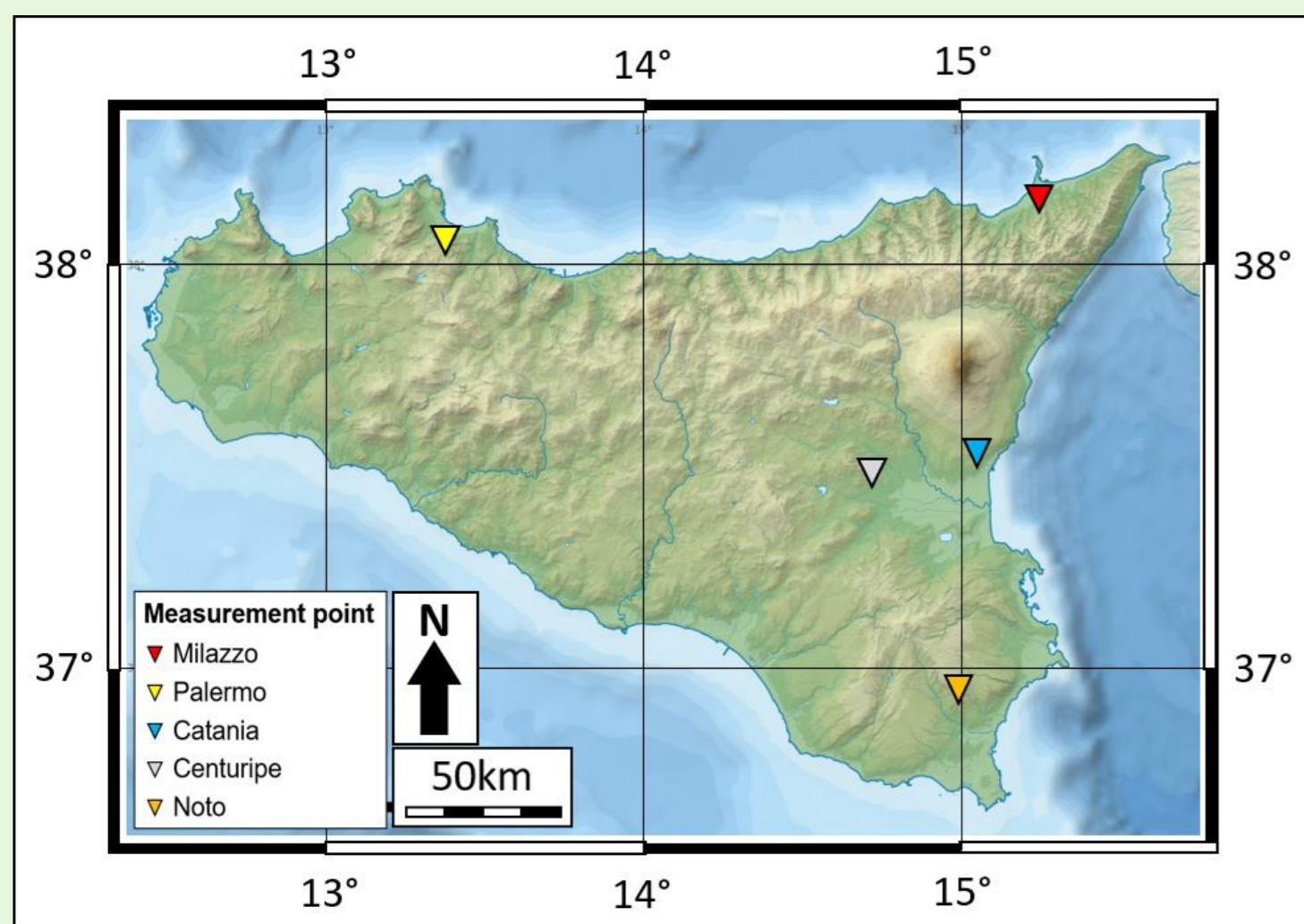


Fig. 1 Stations of absolute gravimetric and GNSS measurements in Sicily.

Of these, 3 stations (Centuripe, Milazzo and Noto) were already measured in the 1990s; 1 station (Palermo) is new and 1 station (Catania - CTA) is located in the gravity laboratory of the Osservatorio Etno (INGV), where since 2007 absolute gravity measurements are carried out to check the performances of the Microg LaCoste FG5#238 absolute gravimeter.

ABSOLUTE GRAVIMETER

Microg LaCoste FG5#238

Requires sessions of 10 to 15 hours; the value of g refers to a variable height (~ 1.3 m), depending on the installation set up.

Instrumental characteristics:

Accuracy 2 μGal

Precision 1 μGal in ~ 4 min, 0.1 μGal in 6.25 h; **Repeatability** within 2-3 μGal

It has been compared several times with the Italian Primary Standard gravimeter (IMGC-02)



Fig. 2 Measurements with FG5#238 at CNT absolute station.

RELATIVE GRAVIMETER

Scintrex CG-6

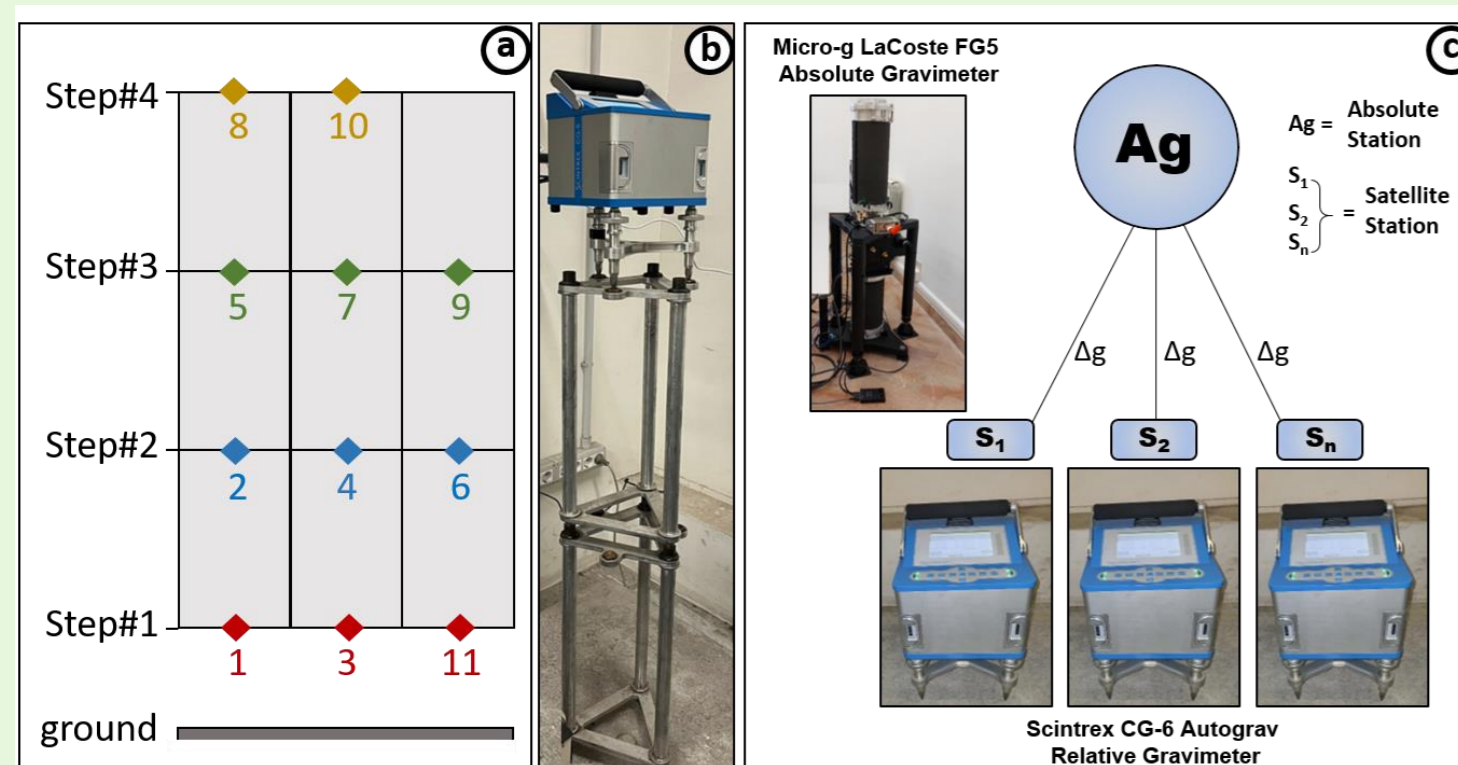


Fig. 3 Gravity gradient measurements with Scintrex CG-6 at different heights from the ground.

The procedure for the measurement of the vertical gravity gradient (VGG) requires CG-6 measurements at four different heights from the ground, roughly the following: step#1 = 15 cm; step#2 = 45 cm; step#3 = 70 cm; step#4 = 125 cm (Fig. 3a,b). The values also include the height of the tripod (about 15 cm) used for leveling the instrument, plus a fixed height of 2.591 cm which is the location of the CG-6 sensor with respect to the bottom of the instrument.

We also used this relative gravimeter to connect the indoor absolute gravity site to the outdoor sites, with the aim to provide the value of g outside (Fig. 3c).

MEASUREMENTS

The 5 absolute stations that constitute the network were measured between the end of 2021 and 2022. The tables report the date and the instruments used during measurements.

ABSOLUTE GRAVITY & POSITIONING MEASUREMENTS								
SITES	1990			1994			2022	
	Jun	Sep	Oct	Mar	Apr	May	Jun	Sep
CTA							POS	FG5
CNT		IMGC02				FG5	FG5&POS	
MLZ	IMGC02					FG5&POS		
NTO			IMGC02	FG5		POS		
UNIPA					FG5			

GRAVITY GRADIENT & SATELLITE MEASUREMENTS						
SITES	1990		1991		2022	
	Jun	Oct	Jun	Dec	May	Sep
CTA						CG-6
CNT		LCR	LCR	CG-6		
MLZ	LCR				CG-6	
NTO				CG-6		
UNIPA				CG-6		

POSITIONING RESULTS

The coordinates of the indoor reference sites have been estimated after a mixed terrestrial and GNSS survey by surveying two outdoor points with GNSS measurements carried out with Leica GX1230 receiver and LEICA AX1202 antenna at high sampling rate. The raw data were processed in Precise Point Positioning modality by the software GAPS (<http://gaps.gge.unb.ca>). The GNSS sites were then connected to the indoor G0 sites through a classical topographic surveys using a total station Stonex. All the observations were jointly adjusted in one solution by least squares method. The obtained accuracies are well within the requested International Standards.



HO network - SICILY						
GO sites	Meas. epoch	Ellipsoidal coordinates ITRF14			GEIOD ITALGEO	Orthometric heights
		yr	h (m)	LAT	LONG	N(m)
CATANIA	2022.419	71.32	37.5137922	15.0819436	41.11	30.21
CENTURIPE	2022.413	713.21	37.6271528	14.7378358	42.09	671.12
MILAZZO	2022.411	44.74	38.2208923	15.2420093	42.75	1.99
NOTO	2022.416	124.78	36.8760409	14.9890523	41.36	83.42
PALERMO		80	38.1054	13.3483	43.52	36.48

ABSOLUTE GRAVITY RESULTS

The tables show the g absolute values at the 5 stations in Sicily. The measured g values refer to the measured heights and were also transferred to the ground using the locally measured Vertical Gravity Gradients. Thanks to the availability of previous g and VGG measurements in some stations, measured during '90, it was also possible to compare the old and new measured g values at the same heights from the ground.

Absolute gravity measurements at CATANIA station (CTA)					
Date	Meter and measured height	Number of sets/drops per set/total drops	g at measured height (μGal)	g at ground (μGal)	
Time UTC (from:to)	(m)				
P (hPa)					
29-30/09/2022	FG5#238	18/100/1800	980031286.1 \pm 3.4	980031649.5 \pm 3.7	
10:47:04-00	1.2917				
1009.63					
30/09/2022 - Vertical gravity gradient dg/dh = -281.4 \pm 1.2 $\mu\text{Gal}/\text{m}$					

CONCLUSIONS

In this poster we presented the realization and the surveys performed to establish a new reference gravity and elevation network in Sicily with the aim to provide new reference systems useful for all the scientific and technological activities related to the gravity field and to the proper definition of a modern height system in this region.

The Sicilian network is composed by 5 stations for which we measured the absolute gravity, the VGG and the coordinates both ellipsoidal and orthometric heights referred to the epoch of the surveys. We also "transport" the absolute g values outside and close to the buildings hosting the absolute gravity stations, establishing outdoor satellite gravimetric sites, useful to perform rapid links during any relative gravimetric field survey that need to be linked to the absolute gravity value.

Moreover, the comparison with the previous measurements carried out in '90 have been done in order to estimate the long-term stability of gravity stations which is a fundamental requisite of station belonging to a reference network.

Remarks:

- The realization of the absolute gravity and height reference networks in the Sicilian region will allow improvement in the estimation and interpretation of the gravity field and will contribute to the already designed modern gravity and height system in Italy (Pianeta Dinamico and PRIN2020 projects).
- By comparing the ground g values acquired in 2022 with previous values, we found slight variations of the order of μGal demonstrating the long-term (about 30 years) stability of the selected stations considering the geodynamic scenario where Sicily is located.
- The indoor coordinates of the absolute reference sites, measured with mixed terrestrial and GNSS surveys, are estimated at sub-centimetric and centimetric accuracy for the planar and height components respectively.

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