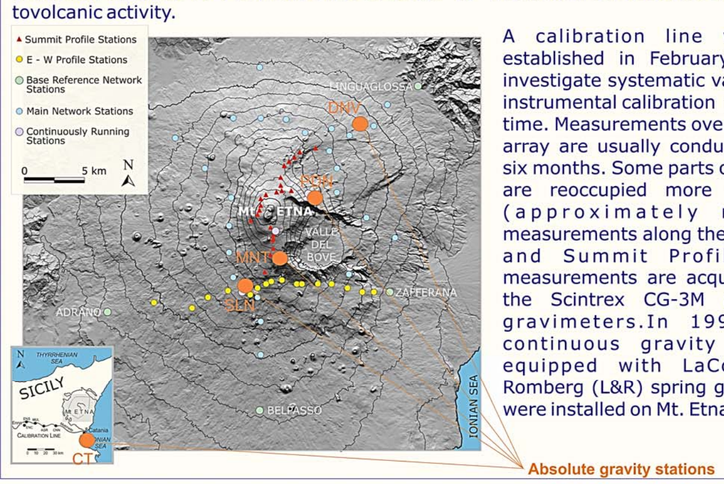
Absolute gravity stations in Africa

Etna's microgravity network

The Etna's gravity network is composed of 71 stations and consists of four integrated subarrays: the Main Network; the Summit Profile; the Est-West Profile and a Base Reference Network of 4 stations each of which is considered to be stable with respect tovolcanic activity.



A calibration line was also established in February 1995 to investigate systematic variations in instrumental calibration factor with time. Measurements over the whole array are usually conducted every six months. Some parts of the array are reoccupied more frequently (approximately monthly measurements along the East-West and Summit Profiles). All measurements are acquired using the Scintrex CG-3M and CG-5 gravimeters.In 1998 three continuous gravity stations equipped with LaCoste and Romberg (L&R) spring gravimeters were installed on Mt. Etna.

Absolute and relative gravity observations spanning the 2008 Etna eruption

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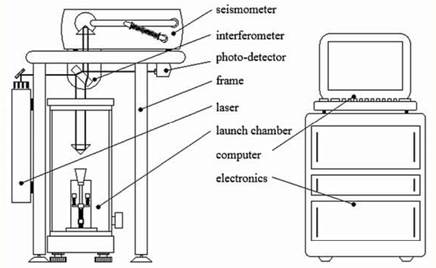
We analyzed both absolute and relative gravity measurements collected at Mt Etna during a 1-yr time interval spanning the onset of the 2008 eruption. Two significant gravity changes were detected in different sectors of the volcano. In the north-eastern flank, a gravity decrease was observed during the June 2007 July 2008 period. The computed negative mass variation of about -4.20 x 10^{10} kg could reflect opening of new voids beneath the NE-Rift, which is affected by a strong extensional tectonics. In the southern flank, a gravity increase was observed in September 2007 along an EW trending profile, where quasi-monthly measurements are carried out. The calculated positive mass change of about 1.05 x 10^{11} kg was interpreted as due to shallow and localized magma intrusion just beneath the southern sector of the volcano.

IMGC-02 transportable absolute gravimeter

Picture of the new absolute gravimeter IMGC-02



Schematic layout of the IMGC-02 absolute gravimeter

Results od absolute measurements

Four absolute gravity stations were settled in 2007, while a fifth station was installed in 2008. Four of them were located very close to the active craters at: (i) Serra la Nave (SLN, 1740 m a.s.l.); (ii) Montagnola (MNT, 2500 m a.s.l.); (iii) Pizzi Deneri (PDN, 2810 m a.s.l.); and the newest (iv) the Caserma Donnavita (DNV, 1250 m a.s.l.). One absolute station was installed out of the volcanic area, inside the gravity laboratory of INGV - Catania (CT, 50 m a.s.l.), to be adopted as reference.

Station	Acronym	2007			2008				2008 - 2007	
		g	*Ug*	*h*	*g*	*Ug*	*h*	*γ*	*Δg*	*UΔg*
		μGal	μGal	mm	μGal	μGal	mm	μGal/m	μGal	μGal
Catania INGV	INGV-CT	980031500.8	12.4	499 9	980031537.4	10.6	517 7			
Serra La Nave	SLN	979641610.2	6.2	492.2	979641609.3	7.4	514.2	-358.2	-8.8	10
Montagnola	MNT	979468483.7	15.5	487.1	979468458.5	20.4	515.6	-281.4	-33.2	26
Pizzi Deneri	PDN	979379856.3	20.1	480.4	979379797.8	29.2	515.3	-347.7	-70.6	35
Caserma Donnavita	DNV				979741042.9	10.2	514 2	-365.7		
Catania INGV	INGV-CT				980031537.8	16.1	518 9	-299.2		

The table reports the experimental results of absolute measurements of the free-fall acceleration g carried out at Mt. Etna and Catania in 2007 and 2008.

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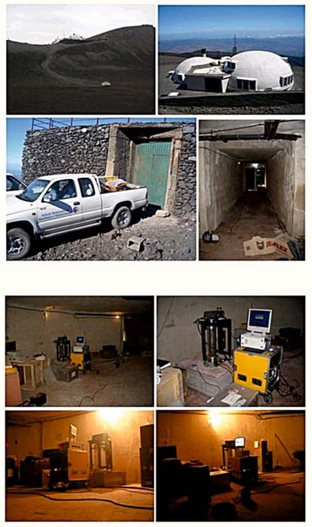
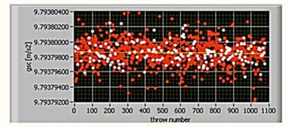
ISTITUTO NAZIONALE DI RICERCA METROLOGICA

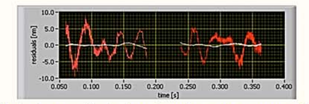
Recently, with the aim of compare relative microgravity measurements routinely acquired on Etna volcano using spring gravimeters with absolute gravity observations, we performed two surveys in June 2007 and July 2008 by using the new IMGC-02 transportable absolute gravimeter. The experiment was carried out in co-operation between the INGV-CT and the INRiM Torino.
The IMGC-02 transportable instrument adopts the absolute ballistic method, which has been recognized at international level (Comité International des Poids et Mesures - CIPM) as primary method of measurement of the acceleration due to gravity. To assure the measurement compatibility the IMGC-02 participates regularly to the International Comparisons of Absolute Gravimeters (ICAGs) organized by the Bureau International des Poids et Mesures (BIPM).
The present features of the instrument, including the complete automation and the better transportability, make it a useful tool for geophysicists and metrologists.

Absolute gravity measure in Pizzi Deneri (PDN; 2820 m a.s.l.)

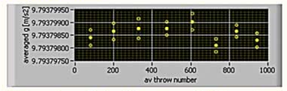




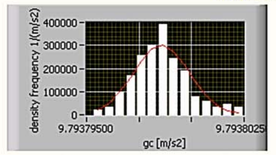
Time series (rejected red; accepted white)



Trajectory residuals (one launche red; average white)



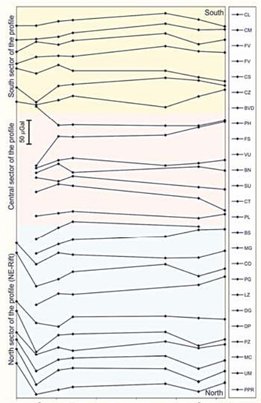
Data sets collected (average of 50 launches)



Density frequency graph

Gravity changes along the NE-Rift

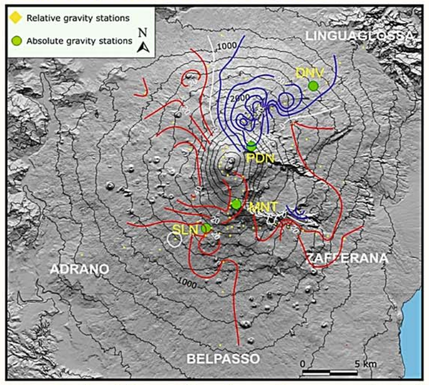
We use the most frequently data acquired along the Summit Profile (almost 1 survey/month during the summer time) to deliver a detailed description and evolution as for both spatial and timing of some gravity anomalies observed during the 2007 - 2008 period. Measures revealed that a gravity decrease up to -80 μGal occurred between June and July 2007 in the stations along the NE-Rift. No remarkable gravity change took place during the following months.



Considering the geodynamical context within which the 2007-2008 gravity changes took place, we hypothesize that, rather than being directly associated to the migration of the magma, the gravity anomaly we found image phase of higher tensile stress on the upper northeastern sector of the volcano. What's more, the gravity decrease could be due to increase in the rate of micro-fracturing along the NE-Rift fracture zone, implying the development of a local density (gravity) decrease. It is not clear from the present analysis the relationship between the gravity variation observed and the eruption began some months later. It is reasonably to assume that this gravity deficiency has been generated by a phenomenon that caused a structural instability within the volcano edifice which could have favored the eruption setting off few months after its start.

June 2007 - July 2008 gravity change

Contour map (June 2007 - June 2008) of gravity changes from the entire Etna network. The gravity field is mainly characterized by a negative anomaly involving the North-East sector of the volcano, with wavelength of about 5 km (centred on stations along the NE-Rift) and a maximum amplitude of about -50 μGal.

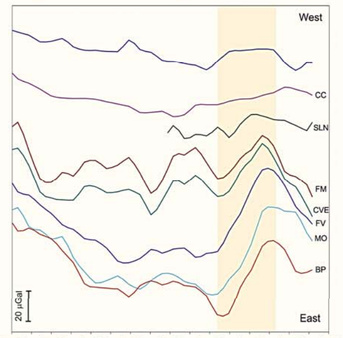


Although the data we present here comes from two discrete gravity (relative/absolute) surveys spanning a 1-yr period, we use the most frequently acquired data along the East West and Summit Profiles (almost 1 survey/month; the latter only during the summer time) to deliver a detailed description of some gravity anomalies observed during the 2007 - 2008 period at the scale of the volcano.

The map lacks information from the summit stations, owing to extensive snow cover in June 2007. The map shows also an absence of major gravity variations elsewhere at the scale of the volcano.

Gravity changes along the East - West Profile

Almost monthly surveys are carried out along the East-West Profile which runs from Zafferana to Adrano. This profile is crucial to evidence the subsurface mass movement in the upper southeastern sector of the volcano, since it is located where local structural systems connected by regional lineaments play a key role in the dynamic processes of the volcano. After about five years during which no significant gravity variations occurred (2001-2006), a progressive gravity increase started in 2006 and reached a maximum amplitude of approximately 70 μGal in late 2007. A maximum positive mass per unity length of 2.1 x 10^{7} kg/m was computed.



If we consider an average prism length of 5 km, which is a reasonable approximation of the sources in the investigated area, positive mass changes of 1.05 x 10^{11} kg is estimated. So, after two major episodes (mid-1995 to mid-1998 and late-1999 to late-2001) of magma intrusion occurred beneath the southern sector of the volcano inferred through gravity observations along the East-West Profile, another mass accumulation in the shallow plumbing system of the volcano started in late 2006 and reached the maximum value in September 2007. This mass increase is likely to be due to a magma uprise from the deep source to shallower portions of the Etna plumbing system. Some of the magma could have supplied the 2008-09 eruption.