ITALIAN MAGNETIC NETWORK AND GEOMAGNETIC FIELD MAPS OF ITALY AT YEAR 2010.0

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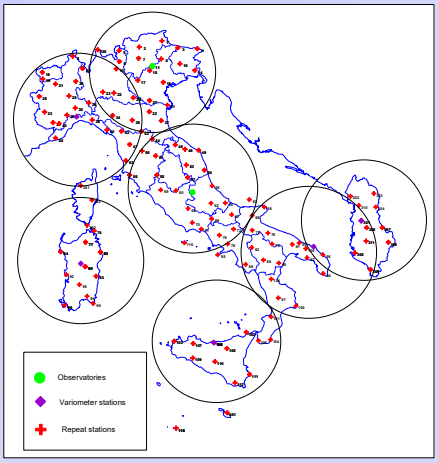
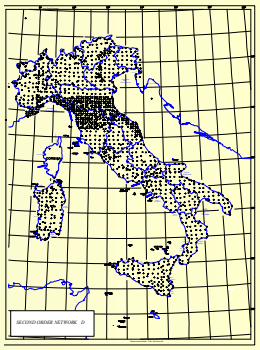


***2010 Repeat station network**. Red crosses indicate repeat stations, filled circles indicate Observatories and diamonds indicate variometer stations; large circles indicate coverage areas for rapid time variations as recorder at Observatories and variometer stations.*

The 2010 survey started in September 2009 and was concluded in November 2010. In this period of time Istituto Nazionale di Geofisica e Vulcanologia (INGV) has made measurements on the national repeat station network and also repeated some measurements outside Italy. This was the case for 11 repeat stations in Albania, in collaboration with the National academy of the Sciences of Albania and with the university of Tirana, and on 3 repeat stations in Corsica, thanks to the information furnished by the Institute de Physique du globe de Paris (IPGP). Moreover INGV made 1 new measurement in the island of Malta.

The magnetic characteristics of the Italian territory to a detail that allowed the compilation of an appropriate scale cartography for the identification of the crustal magnetic contribution, were the object of an effort that dates back to the end of the 70s of nineteen hundred. Within the Finalized Project Geodinamica (PFG-CNR), the measurement of horizontal H, vertical Z and total field F, on 2552 stations distributed in homogeneous way, was completed. These stations, constituting the so-called second order network, has been since then, the basis of the national magnetic cartography. For what concerns magnetic declination D, the second order network was born earlier than the PFG-CNR started. 1529 points of measurement were in fact determined in the 30s of nineteen hundred by the Military Geographical Institute (IGM). For military demands, in fact, a network was established for declination; information on this can be found in Talamo, 1975, in which the latest survey completely realized by the IGM is reported. In this poster the repeat stations survey undertaken at 2010.0 that led to on update of the national cartography is described.

***Italian II order network** undertaken by CNR-PFG for elements **F**,**H** and **Z**: the measurements have been made in years 1977-1981*



***Italian II order network** undertaken by IGM for element **D**: the measurements have been made in years 1932-1938*

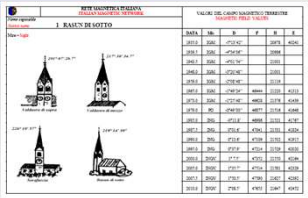
MAGNETIC MEASUREMENTS

Also in this 2010.0 survey a **DIM (Declination Inclination Magnetometer)**, a portable theodolite fitted with a fluxgate magnetometer, was used for the angular measurements of the Earth's magnetic field (therefore the declination D and the inclination I) and a nuclear precession magnetometer (in second plane in the photo) for the measurement of the field intensity F. All other elements can be derived.

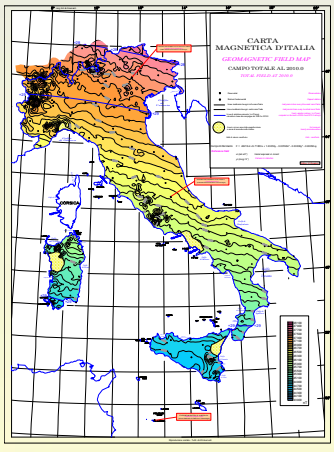
GEODETIC MEASUREMENTS

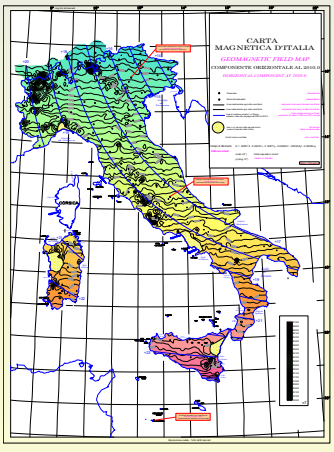
For the azimuth determination in newly constituted stations, as well as on those in which the visibility of the old azimuth marks is limited or absent, a **gyroscopic theodolite** was used. This instrument was preferred to Global Positioning System (GPS) instruments, since it can also be used for measurements in galleries or roof covered places, or even where, in presence of bushes of tall stem, the GPS could show problems for the satellites limited visibility. Moreover the two instruments show, on the overall, comparable precisions of tenth of minutes.

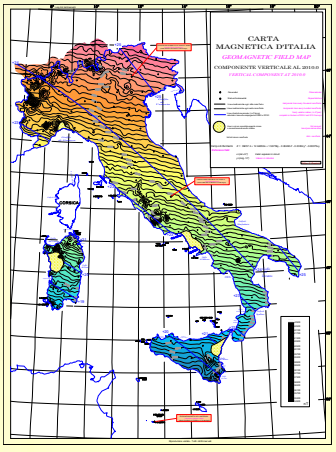
MONOGRAPH

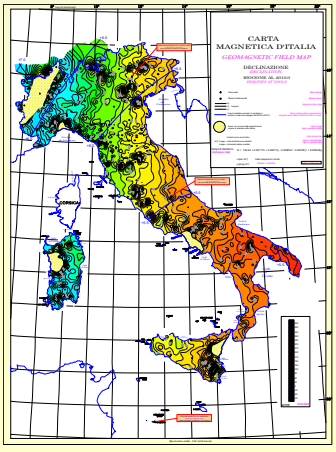


For every repeat station a monograph is realized. In the monograph the site is described, instructions are given to easily reach it, what land marks are useful for the approach, what azimuths are visible and all those information that could be useful for identification









REDUCTION PROCEDURES

Magnetic elements observed at the repeat stations are reduced firstly to 02 UT for the diurnal variation correction, with reference to digital data from L'Aquila or Castello Tesino Observatory, or to the portable variometric station when the station was installed. The value of element E (i.e., D,I or F) at station s, reduced i.e., at 02_{UT} was calculated following the:

$E_s(02_{UT})_d = E_{var}(02_{UT})_d + [E_s(t) - E_{var}(t)_d]$

Where:

$E_s(02_{UT})_d$= Value of E at station s reduced at time 02_{UT} of day of measure d

$E_{var}(02_{UT})_d$= Value of E at variometer station at time 02_{UT} of day of measure d

$E_s(t)_d$ = Value of element E observed at station s at time t at that day d

$E_{var}(t)_d$= Value of element E at variometer station at time t at that day d

Secondly data are reduced to Castello Tesino Obs. for the fixed epoch, i.e. 2010.0 following the:

$E_s(2010.0) = E_{Obs}(2010.0) + [E_s(02_{UT})_d - E_{Obs}(02_{UT})_d]$

Where:

$E_s(2010.0)$= Value of element E at station s reduced to epoch 2010.0

$E_{Obs}(2010.0)$= Mean value of element E at the Observatory for epoch 2010.0

$E_{Obs}(02_{UT})_d$ = Value of element E measured at the Observatory at the time 02_{UT} of the day of measure d

NORMAL FIELD

A 'normal' geomagnetic (reference) field expresses, generally in the form of a second degree polynomial in latitude and longitude, the value of the field at a certain location as if the field was only due to the Earth's core sources (Haines, 1990, Barton, 1996). In fact this is the only time dependent part that undergoes the well known secular variation and then its knowledge is necessary in maps updating procedures. The normal field was computed independently for each element and results, for a generic element E, from the expression (Bullard, 1967):

$$E = a_0 + a_1\varphi + a_2\lambda + a_3\varphi^2 + a_4\lambda^2 + a_5\lambda\varphi$$

φ and λ are latitude and longitude respectively and a_i are the coefficients. The coefficients a_i were determined by means of a least squares fit over the observational values. An empirical rule given by Bullard (the so-called Bullard's rule; Bullard, 1967) relates the number of coefficients of a global Spherical Harmonic model with that of a regional model, and, in turn, the details represented by the regional model itself. To avoid contamination from stations located in anomalous areas, when the coefficients were determined, the Chauvenet rejection criterion was used

COEFFICIENTS OF THE NORMAL GEOMAGNETIC FIELD IN ITALY FOR 2010.0

$$D\ (') = 124.42 + 0.02717\,\varphi + 0.20077\,\lambda - 0.00005\,\varphi^2 - 0.00007\,\lambda^2 + 0.00004\,\lambda\varphi$$
$$F\ (nT) = 46216.4 + 5.71653\,\varphi + 1.23053\,\lambda - 0.00198\,\varphi^2 - 0.00006\,\lambda^2 - 0.00050\,\lambda\varphi$$
$$H\ (nT) = 24381.5 - 9.45241\,\varphi - 0.19877\,\lambda - 0.00002\,\varphi^2 - 0.00002\,\lambda^2 - 0.00030\,\lambda\varphi$$
$$Z\ (nT) = 39257.2 + 12.64859\,\varphi + 1.56759\,\lambda - 0.00490\,\varphi^2 - 0.00004\,\lambda^2 - 0.00075\,\lambda\varphi$$
$$I\ (') = 3489.39 + 1.10003\,\varphi + 0.07616\,\lambda - 0.00033\,\varphi^2 - 0.00001\,\lambda^2 - 0.00005\,\lambda\varphi$$

φ = (Lat. – 42°) *in minutes*
λ = (Long. – 12°) *in minutes*
D, I in minutes
F, H, Z in nT

FUTURE WORKING HYPOTHESIS

In this figure we show a 'selection' of Italian Network Stations. The average spacing is around 100 Km. This repeat stations selection is based on their distribution and low values of anomaly with respect the normal field. The measurements will be made in the summer of 2012 and so the measures will be reduced to the epoch 2012.5

ESSENTIAL REFERENCES:

-Bullard, E.C., The removal of trend from magnetic surveys, *Earth Planet. Sci. Lett.*, 2, 293-300, 1967.

-Dominici G., A. Meloni, M.Miconi, M. Pierozzi, M. Sperti, La Rete Magnetica Italiana e la Carta Magnetica d'Italia al 2005.0, Italian Magnetic Network and Geomagnetic Field Maps of Italy at year 2005.0, *Bollettino di Geodesia e scienze Affini*, 1, 1-47, 2007

-Haines, G.V., Regional magnetic field modelling: a review, *J. Geomag. Geoel.*,42, 1001-1018, 1990.

-Meloni, A., Battelli, O., De Santis, A. and Dominici, G., The 1990.0 magnetic repeat station survey and normal reference fields for Italy, *Annali di Geofisica*, Vol. XXXVII, N. 5, 949-967, 1994.

-Molina F., E. Armando, R. Balia., O. Battelli, E. Bozzo, G. Budetta, G. Caneva, M. Ciminale, N. De Florentiis, A. De Santis, G. Dominici, M. Donnaloia, A. Elena, V. Iliceto, R. Lanza, M. Loddo, A. Meloni, E. Pinna, G. Santarato, R. Zambrano, Geomagnetic Survey of Italy. Repeat Stations Network and Magnetic Maps: a Short Report. *Annales Geophysicae*, 3, 3, 365-368, 1985.

-Newitt, L.R., Barton C.E. and J. Bitterly, Guide for magnetic repeat station surveys, *IAGA Working Group*,

-Talamo R, Le carte magnetiche d'Italia delle isodinamiche della H e delle isogone dell'Istituto Militare e loro aggiornamento al 1973.0, *Bollettino di Geodesia e Scienze Affini*, Vol. XXXIV, n.1,p.34