

Italian geodetic researches in Antarctica and International collaborations

A. Capra

DISTART, University of Bologna. ITALY

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Abstracts

The paper wants to furnish a view of principal research activities in geodesy carried out by Geodesy Unity within the National Research Program in Antarctica (PNRA) operating since 1985.

The activities carried out during the scientific Italian expeditions in Antarctica involved different targets and fields of application. We can distinguish two fundamental branches: monumentation and surveying of a geodetic GPS network as reference frame and for geodynamics purposes; measurements and studies for glacier movements monitoring. Various collaboration within international projects were also executed.

The scientific results were presented at various National and International Congress and were published on reviews and Congress Proceedings. A description of activities is presented and the references are added for every application and study for a more detailed evaluation of scientific contribution.

1. Italian Geodetic Network for geodynamics purposes

An Italian geodetic network was monumented and surveyed through GPS satellite technique different time since 1988-89 expedition. The main object was the design, the monumentation and the survey of a geodetic network in the area of Terra Nova Bay Station. The network was established in order to supply a reference system for several studies: crustal deformations in the Mount Melbourne area, global geodynamics, glacier movements monitoring, geophysical surveys positioning, cartographic application, etc.

The network consists of 20 stations over a 2000 km² area and could be divided in a general network of 12 stations with baselines of some tens of km and in a detail network of 8 stations with baselines few km length, located inside the general net on the volcanic cone of M. Melbourne (Gubellini et al., 88, 91, Capra et al., 95). The network was monumented during

the 1988-89 and 1989-90 campaigns (Gubellini and Postpischl, 1988, 1991).

The network was planned for the use of GPS receivers, because the use of classical instruments in Antarctica is possible under restrictive conditions. A particular benchmark was designed for this network: it allows an easy and precise tridimensional set up of GPS antennas, which are very stable even under strong winds.

The general net was completely surveyed two times in 1990-91 and 1993-94 campaigns and the net for deformation control was surveyed three times in 90-91, 93-94 and 95-96 campaigns. The results of net adjustment did not showed appreciable co-ordinate variations in comparison with the GPS method accuracy (Gubellini A. et al., 94, Capra A. et al., 94, Al Bayari O. et al., 96).

The network reference station (0100) co-ordinates were determined with high precision in WGS 84-ITRF system through the data processing made by NOAA, when the reference station was included in a network of reference

GPS stations during a co-operative aerophotogrammetric GPS assisted test.

In 1996-97 Antarctica expedition some stations of general net was repeated to study the possible effects of GPS reference system variation, using two different set of co-ordinates for the emanation point: the network reference station (0100) co-ordinates used till today were determined with high precision in WGS84 – ITRF system through the data processing made by NOAA and the co-ordinates obtained through satellite Doris system in absolute positioning in 1995-96 campaign (Capra, 97).

The use of precise ephemeris furnishes generally better results rather than broadcast ephemeris, overall by the point of view of deformations control analysis. Unfortunately the distribution of permanent GPS tracking stations has been rare and disomogeneous in Antarctica till today, so the actual accuracy improvement through the use of precise ephemeris was not sure. For this reason tests on the use of precise computed ephemeris instead of broadcast were made. A new determination of emanation station co-ordinates will be available through SCAR GPS Epoch 95-96 campaign and a new comparison will be available at that time.

This study is particularly interesting to establish the reference system for the network frame and for geodynamics purposes, the works are in progress and the results will be presented at next 1997 IAG Symposium, overall considering that the emanation station will be a permanent GPS tracking station in 1998.

The project of GPS permanent tracking station on point 0100 was started. The station will be included in SCAR GPS permanent stations network in Antarctica for geodynamics studies and will be included in IGS network for precise ephemeris determination and for global geodynamics studies.

In 1996-97 expedition operations started with cohobented box for GPS receiver installation and with the furnishing of the station power support, serial connections for remote station control and data discharging (Capra, 97). In 1997-98 expedition the installation will be concluded and the station will be functioned in February 1998.

The availability of GPS permanent station acquisitions in real time and, therefore, the effective inclusion in IGS network will depend, obviously, on the possibility of a satellite

connection through a dedicated line from Italian base in Antarctica. The channel activation is in progress and we hope it will be available during 1998.

Moreover the reference benchmark for tidal gauge height was connected to 0100 geodetic network station to refer the ellipsoidal height to geoidal (Capra,97).

The GPS data acquired indifferent time and under different environmental conditions permitted to carry out interesting studies and researches on GPS data elaboration. The attention was pointed out on the effects generated on measurements results by environmental conditions, overall ionosphere disturb, and by the different GPS software utilised (Capra et al., 95, Al Bayari O. et al., 96).

1.1 International Projects and Collaborations

Different activities were made within the SCAR (Scientific Committee for Antarctica Research) constituted by all the countries that are carrying out researches in Antarctica.

During the meeting of the SCAR Working Group on Geodesy and Geographic Information (SCAR WGGGI) held in Hobart in August 1988, it was agreed to undertake a co-operative GPS survey in Antarctica to determine the rates of relative motion within the Antarctic tectonic plate, and between this plate and adjoining tectonic plates.

In order to confirm the feasibility of using GPS techniques for the above mentioned themes, our group collected data within an international SCAR project with the aim to verify the GPS measurements for long base lines determination. The project concerned a quadrilateral constituted by the following stations: Terra Nova Bay, Scott Base, Wellington and Hobart, surveyed during the 1989-90 campaign. In 1990-91 and 1991-92 were carried out two more campaigns (Gubellini et al., 94).

Within SCAR geodetic activities the Italian geodesists participated in the GPS Pilot Project in 1990-91.

The network reference station (0100) was included also in a network of reference GPS stations during a co-operative aerophotogrammetric GPS assisted test. The data processing made by NOAA of the network allowed us to determine a reliable value of

reference station co-ordinates in WGS 84-ITRF system.

The Italian geodesists are also participating to the SCAR Epoch 95-96 GPS campaign, sub-program of GIANT (Geodetic Infrastructure for Antarctica) 94-96 program. The program objectives are: the link of Antarctica with the Global Terrestrial Reference Frame ITRF with highest accuracy; measurement of the relative rates and directions of separation of the Antarctic plate from adjoining plates and microplates; determination of relative motion of crustal blocks within the Antarctic plate; unification of the vertical datum, determination of height of mean sea level at tide gauge stations; determination of the vertical motion of the Antarctic lithosphere due to changing ice and ocean loading.

The measurements results will present to Special Session in 1997 IAG Symposium, Rio, Brazil.

In 1996 was activated a collaboration with Dr. Larry Hothem and Dr. Ian Whillians of U.S.A. Antarctic Research Group within the 1996 Transantarctic Mountain Deformation Survey. The TransAntarctic chain is parallel to the coast and developed for a thousand of km. Our contribute regarded the exchanging data from some stations of geodetic net. Contemporary we will receive data from U.S.A. stations located near McMurdo Bas, at about 300 km from Italian base.

2. Glaciers Monitoring

In the framework of the PNRA Project: *Glaciologia e Paleoclima*, GPS measurements were experimented in Antarctica since 1990 in order to individuate new survey methodologies for the study of the dynamics of glaciers, ice streams, ice shelves etc.

GPS technique is particularly indicated for the survey in remote sites. After an initial phase for the identification of the most suitable benchmark monumentation to use on the ice, different GPS techniques of survey were tested in Antarctica: GPS static measurements were adopted when the accuracy requirement of the experiments needed for this approach, or in presence of long distances, and during the geodetic connection of the fixed stations to the reference frame. Rapid static was used on short distances (within 15

Km) during the survey of control points for geometrical calibration of satellite images, photogrammetric plotting, ice cores positioning etc. Continuous GPS kinematic was employed for a detailed survey of the tridimensional path followed by moving objects (glacial bodies or aerial and terrestrial vehicles). Continuous kinematic can be efficiently adopted for a variety of applications such as geophysical survey positioning, GPS assisted aerophotogrammetry, measure of ice surfaces variation and ocean tidal flexure of floating ice tongue, oversnow antarctic traverse, etc (Capra A., Vittuari L., 96).

The principal glaciers monitored, with series of up to 6 repetition measurements, are: David-Drygalski, Priestley, Nansen, Reeves, Strand Line, Tarn Flat, Hells Gate (Frezzotti et al., 94, Frezzotti et al., 97).

Among the glaciers monitoring activities it is remarkable the study and the control of ice shelf platforms oscillation under the effects of sea tidal undulation, applied on the Drygalski Ice Tongue and Hells Gate Ice Shelf (Frezzotti et al., 94, Bondesan et al., 95, Capra et al., 96).

About 300 meteorite specimens have been collected by two European expeditions (1984-85 GANOVEX and 1990-91 EUROMET/PNRA) on blue-ice field at Frontier Mountain (73 S, 160 E) near the Italian Antarctic base Terra Nova Bay- Victoria Land. However, the meteorite concentration process active at Frontier Mountain seems to be atypical and not completely understood. In an attempt to provide a quantitative measure of the ice flow and ablation a rapid-static GPS network was established in 1993/94 on the meteorite blue-ice field at Frontier Mountain. The network consists of 18 points monumented in the ice by flagged stakes and 4 reference points located on the rock. Both horizontal movements and ablation/accumulation measurements were performed annually. These complex measurements will help to understand the accumulation mechanism at Frontier Mountain and will be useful to discover other ice field where large concentrations of meteorites have accumulated (Capra et al., 96).

During the 1993-94 expedition the USGS in a co-operative project with the Dept. of Survey and Land Information (New Zealand) conducted a first application of GPS controlled

aerophotogrammetry in Antarctica. Eleven independent missions were performed with GPS data collection at one second with a multiple antenna receiver equipment configuration, using two tracking units on the aircraft and from two to five reference stations on ground. On day 326 the survey focused on different projects coordinated by the TNB Station, with the photo scale ranging from 1:20 000 to 1:50 000 for mapping purposes and 1:3 000 for biological aims (Vittuari L., 94).

Another activity that involved GPS measurements was the geometric calibration of satellite images and the survey of control points in aerial photogrammetry for map production.

A project in this framework was carried out on Northern Foothills area with the aim to produce a topographic base for a morphological map at the scale 1:50 000. After a aerotriangulation procedure, a DTM was realised through photogrammetric plotting and the elevation description was over-imposed on a geometrical corrected satellite image.

A contribution was offered to production of Antarctic Geomorphological and Glaciological 1:250 000 Map Series, Mt.Melbourne Quadrangle (Victoria Land), MURST-PNRA, edited by Museo Nazionale dell'Antartide, Dip.Sienze della Terra, Siena, Italy.

2.1 International Projects and Collaborations

A GPS network was designed at Dome C within an international project (EPICA) with the aim of the deformation control of the Dome.

A deep ice drilling is the most important scientific project at the future Concordia Station, a French-Italian Co-operative Project. The main purpose for drilling in this part of Antarctica (about 75 S, 124 E) is to obtain a climatic record covering a very long period, about 400,000 years, because accumulation rate is very low (3 g per cm per year) and the thickness is large (over 3000 m). The paleoclimatic reconstruction will follow the vertical stratigraphy and will be seriously dependent on the large ice sheets stability and on a controlled superficial ice flow. For the determination of surface deformation (ice flow, height variation), the expected surface deformation ranges from 0 to 5 cm per year, a 3-D GPS strain network was planned and

designed. The net consist of 37 stations, symmetrically arranged, covering a 50 km diameter area and monumented by suitable aluminium stakes. The first measurements was carried out during the summer Antarctic season 1995-96 (Gandolfi S., Vittuari L., 96).

International project ITASE (International Trans Antarctic Scientific Expedition) regards a terrestrial scientific traverse. During the 1993-94 season two oversnow traverses were performed in the framework of the international projects EPICA (European Programme on Ice Coring in Antarctica) and ITASE (International Trans Antarctic Scientific Expedition). The French Antarctic Program undertook the first complete oversnow traverse from Dumont d'Urville to Dome C, while the Italian Antarctic Research Program carried out the first leg of the Terra Nova Bay - Dome C traverse, in order to verify the accessibility to the plateau from Terra Nova Bay Station by heavy vehicles.

During the whole journey a continuous kinematic survey was carried out. One of the main objectives of the traverse project is the development of a high resolution interpretation of the last 100-200 years conditions of the climate, atmosphere and surface over the Dome C drainage area.

Within the collaboration with the ICAIR (NZ) centre, GPS measurements for ground control points determination at Edmonson Point were made in 1994-95 campaign. The aim was the production of digital ortophotos of the area, to be used in environmental protection project.

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