AALBORG UNIVERSITY

MONITORING PERMANENT GPS STATIONS IN UMBRIA, ITALY

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Contents

PREFACE

It is a fact that the earth's crust is in continuous movement and it can be divided into global and local displacements. There are a lot of natural events like earthquakes, volcanic eruption and subsidence that cause these crustal movements. Also in Europe these effects take place caused by the African plate which is moving into the European plate. It is possible to monitor these movements using GPS technology and in particular using networks of permanent GPS (GNSS) stations.
A permanent station is a physical point which is equipped with GNSS (Global Navigation Satellite System) receiver and it’s a structure for acquisition, storage and processing of data and code phase from satellite constellations such as GPS and GLONASS, 24 hours per day, for 365 days per year, providing position services in various forms and for various applications. Actually there exist‘s a lot of networks of permanent stations on different scale and for different purposes like international network of IGS (International GPS Service for Geodynamics) which is an international network used for scientific purposes and of general interest; it defines a global datum called ITRS (International Terrestrial Reference System) and it is used to determine the GPS orbits (precise ephemerides), clock corrections, earth rotation parameter and in geodynamics to follow the movement of the continental plates.
In Europe we have a network called EPN-EUREF realized for scientific purposes which define a European Global Datum called ETRS (European Terrestrial Reference System) and that permits to study the local deformations of the European plate and to frame the national networks. EUREF is responsible for the reference frame realization in Europe and the primary goal of many EUREF activities is to provide homogeneous coordinates all over Europe. EUREF creates an important basis by introducing the European Terrestrial Reference System ETRS89 which was aligned to the international reference system ITRS at epoch 1989. European stations show movements of several centimeters within one year measured in a fixed ITRS, ETRS89 of the stable part of Europe.

Most European countries support this idea and generate in the years since 1989 reference frame realizations (ETRFs) mainly based on GPS campaigns. Many countries defined their new reference frames directly in ETRS89. (Monitoring of official national ETRF coordinates on the EPN web Project of the EUREF TWG, E.

BROCKMANN). The latest realizations of the IGS and EUREF are IGS05 and ETRS00. The aim of this work is precisely to frame the Umbrian Regional Network (Italy) within IGS05 and ETRF00 using GAMIT/GLOBK software to process GPS data.

The Umbrian Regional Network is formed by 11 permanent stations with an average spacing of 40 Km. The stations are furnished with “GPS+GLONASS Topcon Odyssey RS and Legacy-GGD receivers” and geodetic antennas “choke-ring Topcon CR-3”. In this work we would obtain two solutions of this Regional Network, the first with the old GPS data and the second one with a recent set of data. By analyzing the results it is our hope that we will be able to say if there have been displacement of the network during the time consequentially of natural event, like the "L'Aquila earthquake" and the crustal movement, understanding the extent.

Chapter 1

Introduction to GNSS

1.1 Existing satellite constellations

The acronym GNSS - Global Navigation Satellite System is used to indicate all navigation satellite systems used to provide a position to the users on the Earth. The first satellite system was developed starting 1970 for American military application and it is called GPS - Global Positioning System. Actually there are several other existing and planned GNSS systems in other countries:

- Russian - GLONASS (GlobalnayaNavigatsionnayaSputnikovaya Sistema)
- European – Galileo
- Indian IRNSS and SBAS
- China – Compass
- Japan – QZSS

Today the navigation satellite systems is used also for more civilian purposes because now these are the best technologies to find position anywhere on the earth and in the fastest way.

1.2 GPS

The GPS consists of 24 operation satellites, non-geostationary, in orbit around the world which transmits one-way signals and allow to give the current GPS satellite position and time to the users. These satellites are distributed on six approximately circular orbits with radii of 26560 kilometers, inclined at an angle of 55° relative to the equator, with 4 or more satellites. The orbital period is about 12 hours.
The GPS navigation system consists of 3 segments:

1) Space
2) Control
3) Users

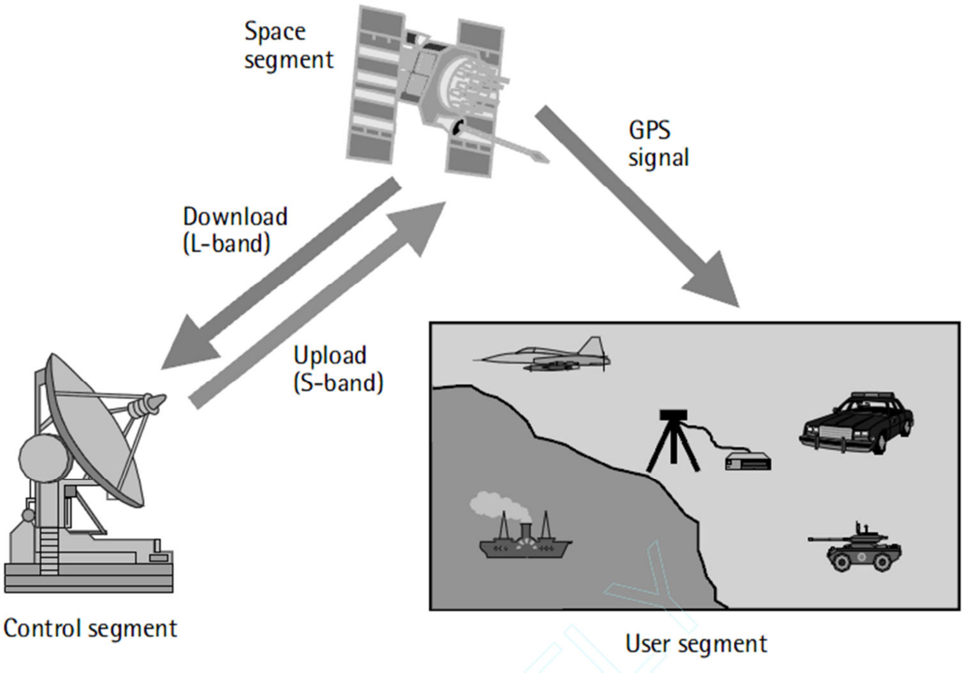

Figure 1.1: Space, User, Control segments.

The space segment consisted of 24 satellites with an average life of about 7 years end with orbital period of 11 hours and 56 minutes. The orbital planes are six, spaced of 60° from each other and the inclination to the equator is almost 55°. With this good geometry it is possible to see four or more GPS satellites from almost each point on the earth starting by elevation of 15° above the horizon.

The control segment of GPS system is located in Colorado Springs, USA, and it contains one Master Control Station (MCS) and other five monitor stations located around the world that track and collect the GPS data continuously on time. The control segment is responsible for controlling the functioning of space segments (satellite solar arrays, battery power levels and properlant levels) and it also estimates and uploads all ephemerid and clock data.
This elaborated correct information about time and positions of each satellite is transferred to appropriate ground antenna and are uploaded to each satellite, stored in their system and transmitted with the signal to the end user. This procedure repeats every hour because without this service it is impossible to find a precise position for any GPS application.

The *user segment* is represented by all civilian and military users that can find their position on the Earth receiving the GPS signal connecting GNSS receivers to a GNSS antenna. All users can use GPS system worldwide, without charge and with good result.

1.2.1 GPS signal

To obtain precise GPS measurement, the GPS satellites is furnished with precise cesium and/or rubidium atomic clocks to transmit good information of time. The GPS signals are transmitted on wide spectrum and are composed of two carrier frequencies:

- L1= 154*f_0= 1,575.42 Mhz (λ=19cm)
- L2= 120*f_0= 1,227.60 Mhz (λ= 24.4 cm)

where f_0=10.23 Mhz is a fundamental GPS frequency.

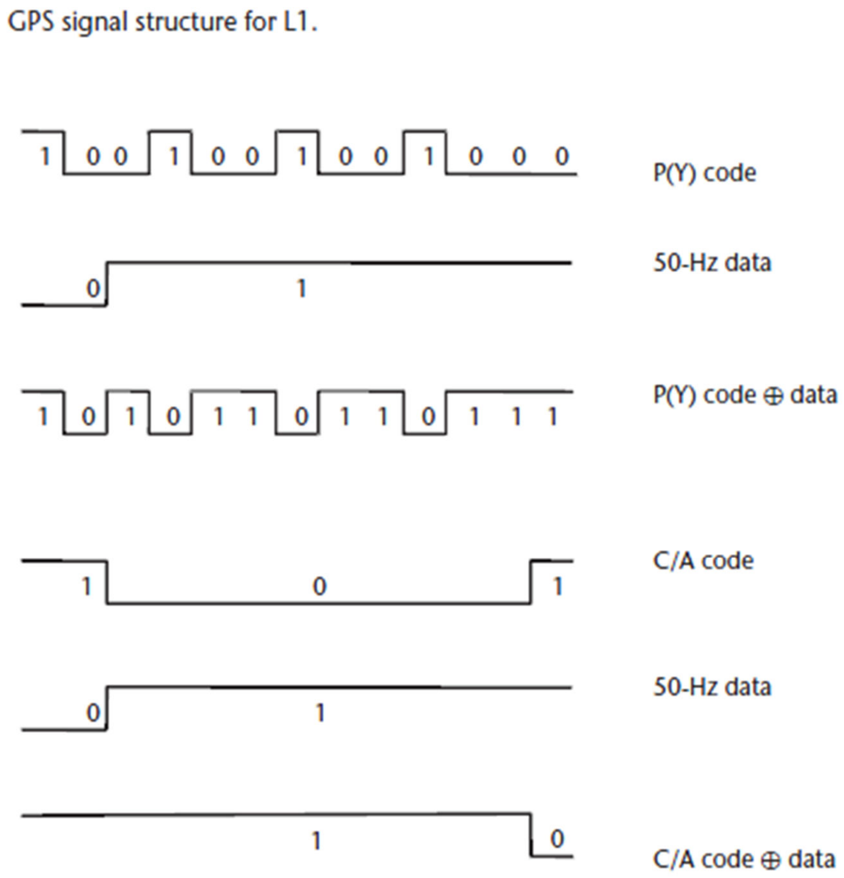

Figure 1.2: GPS signal structure for L1.

The use of two different frequencies allows of corrects the relevant GPS errors, known as ionospheric delay and limits the interferences on signal propagation. It would be possible to compute this ionospheric delay because the delay varies approximately as the inverse square of signal frequency (f^{-2}) and using two different frequencies is possible to compensate the delay in each carrier. All of this is possible also if they transmit at the same frequencies L1/L2 because the modulation is different for each satellite since this is made using different pseudorandom noise codes (PRN) that are not correlated between various satellites. They transmit two different PRN codes called coarse acquisition (C/A) and precision (P) codes and they consist of a stream of binary digits, zeros and ones, known as bits. These codes are created with a precise mathematical algorithm, where the C/A-code is modulated onto the L1 carrier only, and the P-code is modulated using L1 and the L2 carriers. Using the P-code is thus possible to obtain more accuracy on positioning if compared with position obtained with C/A code only and this is because the P-code is 10 times

faster then C/A code. The P-code is encrypted only for military application. This code with a code called antispoofing AS and it becomes possible to obtain the Y-code that has the same chipping rate of P-code.
The message transmitted by GPS to receivers, is on both L1 and L2 carriers as a binary biphase low rate modulation of 50 Kbps is a data stream. This data stream is composed of 25 frames with 1,500 bits each that are transmitted every 12.5 minutes. The message transmitted contains mainly, ephemeris, satellite clock correction, satellite almanac (time in which it is visible in the sky), atmospheric data and health status.

1.2.2 GPS modernization

The block I satellites were lunched in the early 1970s. Over the years, satellites are replaced because their lifetime is limited. The block II and IIA were lunched between 1989s and 1997s and today few of these satellites are still in orbit like PRN 32. Last generation of satellites were lunched till 2004 and they are called - block IIR and IIR-M that contain the MASER clock with stability of 10^{-14} - 10^{-15}. The block IIR-M satellites transmit one new civilian code on L2 frequency and there is no selective availability (SA). Modernization started in 2010 with the launch of new satellites (block IIF) and these satellites transmits new civilian signal L5 at 1,176.45 MHz and this signal provides higher accuracy in all condition. The newest modernization plan is to launch new satellite family through 2030 called block III. This block will be able to transmit the fourth civilian code with higher power signal and will be also provided the integrity check on the GPS signals.

1.3 GLONASS

GLONASS constellation is the Russian navigation system and is formed by 24 satellites divided into 3 orbital planes, approximately circular, positioned at the altitude of 19,100 km and with an orbital period of 11 hours and 15 minutes and an inclination of 64.8°. This structure guarantees a visibility of 5 satellites at the same time on 99 percent of Earth surface. As the GPS constellation, also the GLONASS has a control segment positioned on Russian territory where users segment the compute the ephemeris and distribute then to the satellites.

The GLONASS signal is different for each satellite because it uses a frequency-division multiplexing of independent satellite signals (two carrier signals corresponding to L1 and L2 have frequencies f1 = (1.602 + 9k/16) GHz and f2 = (1.246 + 7k/16) GHz, where k = 0, 1, 2, … 24 are the satellite numbers, frequencies lie in two bands at 1.597–1.617 GHz (L1) and 1240–1260 GHz (L2). GPS and GLONASS methods for receiving and analyzing signals are similar.

With the implementation of new frequency (f3) will be guaranteed the interoperability with GPS signal (L1) and Galileo signal(E5) but one of the problems with GLONASS is the position of Control segment that is not homogenously distributed around the world and the satellite clock which is less accurate compared with other navigation systems.

1.4 Galileo

The Galileo system is a navigation system being developed by the European Union. Galileo provides a highly accurate global positioning service under civilian control. This system will be completely inter-operable with GPS and GLONASS.

The complete constellation of Galileo system consists of 30 satellites: 27 operational and 3 spares, located in three circular Medium Earth Orbit planes. These orbits are located at the nominal altitude of about 29.000 km and having an inclination of the orbital planes of 56 to the equatorial plane.

The Galileo signal is similar to the GPS signal and is based on a fundamental frequency 10.23 Mhz (like GPS). Multiplying by different integer values Galileo includes three signals called E1, E5 and E6.

The Galileo program was started with two test satellites, GIOVE-A and GIOVE–B. Thus were launched in 2005 and 2008 respectively, reserving radio frequencies only for Galileo by the International Telecommunications Union and have been used for testing key Galileo technologies. On the 21 October 2011 the first two satellites were lunched to validate the Galileo concept. When the setting of In-Orbit Validation (IOV) is completed, additional satellites will be launched in the next years to arrive at Initial Operational Capability (IOC).

The Galileo system is different compared with other navigation systems, since it furnishes five different services:

- Open Service (OS): free signal, free access code, point positioning within 4 meters with 95 percent of probability.
- Safety of Life Service (SoL): Better results compared with OS, with alarm transmitted to users when the obtained accuracy position is less then specific (Integrity).
- Commercial Service (CS): access to signal E6b/c with the accuracy of PP to 1 m with 95 percent of probability and also with integrity.
- Public Regulated Service (PRS): access to signal E6a and E1a that are encrypted and reserved to all users that require the determination of their position continuously and with controlled access.
- Search and Rescue Service (SAR): specific service reserved for the users of rescue and civil protection agencies around the world with the possibility to transmit the alarm signal on the specific and dedicated frequency.

1.5 Position determination

The basic idea for computing a point position on the surface of the Earth using GPS is to know distance from 3 different satellites to the user receiver and apply the technique of resection as showed in the figure below (insert figure). The distance between satellites and receivers are calculated from received the GPS signal over the time, using built-in software. The partial result of receiver processing is the distance between satellite and receiver which is the pseudorange and the satellite position (ephemerides) using navigation message.

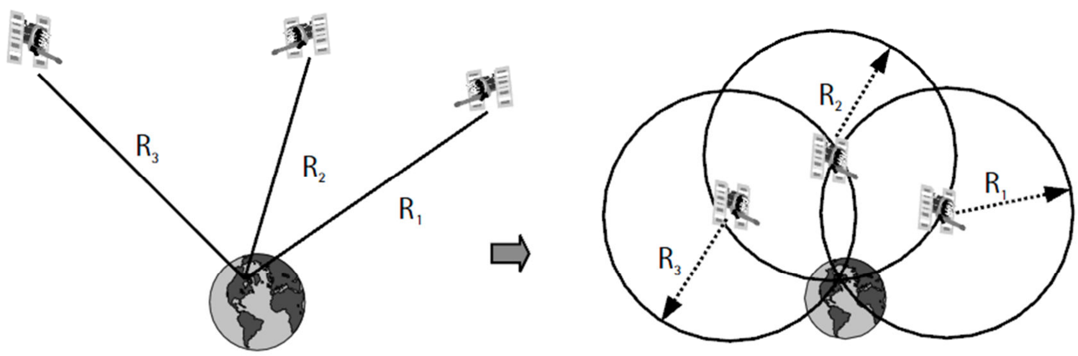

Figure 1.3: Positioning determination

Chapter 2

Technique of surveying using GPS

2.1 Pseudorange measurements

To get position we need the ranges from the receiver to the satellites. The pseudorange is the distance between the GPS receiver‘s antenna and the GPS satellite‘s antenna. To measure pseudorange we can be use C/A – code or P – code.

Pseudoranging determination – Let us say that the sattellite clock has perfect synchronization with the receiver clock. When satellite transmits the PRN code then receiver starts generate an exact replica of the code, after some time the transmitted code is received by the receiver. The receiver compares the transmitted code and with a replica, in that way we can compute signal travel time. The travel time times the speed of light (the speed of light = 299792458 m/s) gives the range between receiver and satellite. The problem is that satellite and receiver clocks is not perfectly aligned and this means that our measurement is affected by errors and biases. That is why this quantity is referred to as the pseudorange and not the range.

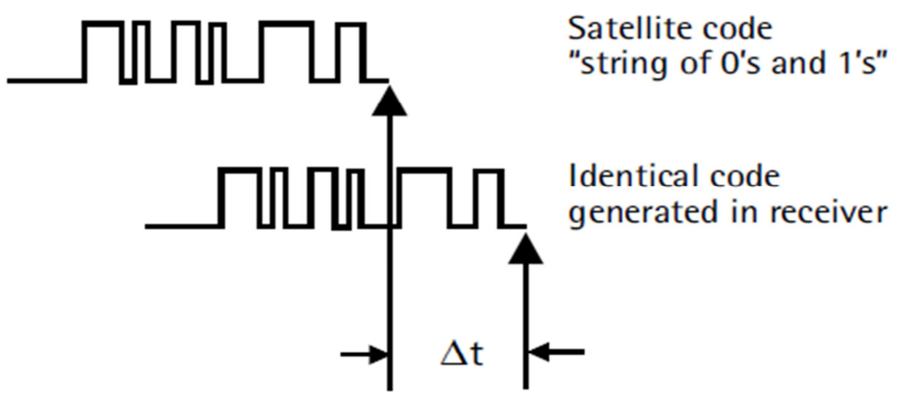

Figure 2.1: Pseudorange measurement.

2.2 Carrier-phase measurements

Simply put, the carrier phase measurement is a measure of the range between a satellite and receiver expressed in units of cycles of the carrier frequency. This measurement can be made with very high precision (of the order of millimeters), but the whole number of cycles between satellite and receiver is not known.

A good analogy to this is to imagine a measuring tape extending from the satellite to the receiver that has numbered markers every one millimeter. Unfortunately, however, the numbering scheme returns to zero with every wavelength (approximately 20 centimeters for GPS L1). This allows us to measure the range very precisely, but with an ambiguity in the number of whole carrier cycles.

A number of subtleties must be considered when generating these measurements in a receiver. To fully appreciate these requires a more detailed look at what we mean precisely when discussing the carrier phase.

All current GPS satellites transmit radio frequency (RF) signals in the L-band. These signals consist of, at the very least, an RF carrier modulated by a pseudorandom noise (PRN) code. When discussing the phase of a signal it is important to realize that phase is fundamentally a property of sinusoids. Every sinusoid has an amplitude and a phase and can be written in complex notation as $A^{j(\omega t + \theta)}$, where A is the amplitude, ω is the radial frequency, and θ is the phase in radians at $t = 0$.

When the RF carrier is modulated by a PRN code, the resulting signal is no longer a pure sinusoid but can, by Fourier's Theorem, be expressed as a linear combination of sinusoids. The concept of the phase of a combination of sinusoids is less clear than that for a single sinusoid (e.g., how do we define the phase of the sum to two sinusoids?).

For GNSS signal processing we define the signal phase to be the phase of the carrier signal. In other words, this is the phase of the pure sinusoid that would result if the PRN code and any other modulations are "wiped off." In the following discussion, when we mention the signal phase, this is what we shall be referring to." (*Cillian O'Driscoll 2010, Inside GNSS*)

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2.3 Point positioning with GPS

GPS point positioning (standalone or autonomous positioning) works with one receiver that measures pseudoranges. A receiver tracks a minimum of four or more satellites simultaneously to determine the GPS receiver position at any time. Satellite ephemerides are delivered through the navigation message and the ranges through the C/A - code (civilian) or P (Y) – code (military) depending on the type of receiver used either civilian or military. The measured pseudoranges are contaminated by the satellite and the receiver clock errors. "Correcting the satellite clock errors may be done by applying the satellite clock correction in the navigation message; the receiver clock error is treated as an additional unknown parameter in the estimation process. This brings the total number of unknown parameters to four: three for the receiver coordinates and one for the receiver clock error. This is the reason why at least four satellites are needed. It should be pointed out that if more than four satellites are tracked, a least-squares estimation or Kalman filtering technique is applied " (El-Rabbany, 2002) .

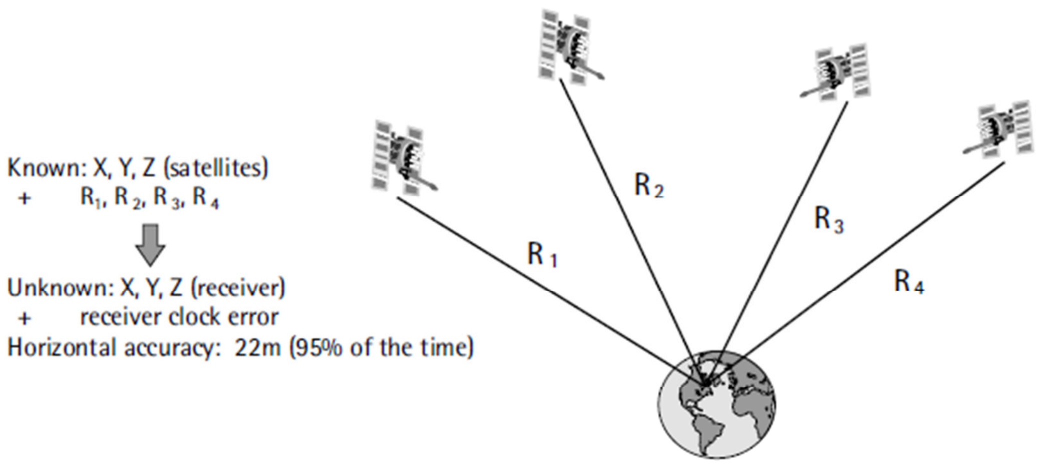

Figure 2.2: Point positioning

2.4 Differential GPS positioning

GPS differential positioning works with two GPS receivers, which track the same satellites to get their relative coordinates. The first receiver is a reference (base) which remains stationary at a site with precisely known coordinates. The second receiver (remote or rover receiver) may or may not be stationary, depending on the type of GPS operation, and its coordinates are unknown. GPS relative positioning has much better accuracy than the stand alone positioning from millimeter to a sub-meter, depending on whether the carrier-phase or the pseudorange measurement is used. This accuracy level can be achieved due to the fact that the measurements of two or more receivers tracking one particular satellite contain similar the same errors and biases.

2.5 Real Time Kinematic surveying

Real Time Kinematic surveying method is the same as a simple kinematic surveying, but optional GPS receiver which is in the known point using radio waves, GSM or Internet sends corrections adopted by the moving receiver, and it can immediately calculate the unknown position of points and their accuracy. RTK surveying method works when we have a large number of unknown points located closer then 10 – 15 km from a known point and the unknown point coordinates are required in real time. Both GPS receivers must simultaneously track the same and not less than 4 satellites. Corrections can be transmitted by the pseudorange or phase differences. In the first case, the accuracy is lower and is 1-2 meters. In the second case can be obtained at 1-2 centimetre accuracy. Ellipsoid height determined approximately 1.5 times less.

Real Time Kinematic surveying method most important advantage is point position you can find in the real time. Points can be measured with only 5-10 seconds. The main Real Time Kinematic method disadvantage is the short wave radio radius of action, because of various obstacles, it works only within few kilometres. From a surveyor's point of view this is no real limitation as he most often operates within few kilometres.

2.6 Static GPS surveying

Static survey – first method which was developed for GPS surveying and this method is used for measuring long baselines (~20 km), tectonic, geodetic networks etc. Static GPS surveying works with two or more static receivers tracking the same satellites, has good accuracy for long distance but works slowly. One receiver is placed on a point which coordinates are known (Reference Receiver), other receiver (Rover) is placed on the other end of the baseline and in both receivers data recorded simultaneously also data must be recorded at the same rate (rate could be set 15, 30, 60 seconds). Usually static surveys are post processed, it means that the GPS observations are stored in the receiver and the coordinates of the points are computed after survey using rinex data and appropriate software (e.g GAMIT/GLOBK).

To summarize, our project is about tectonics, and we need the very best accuracy obtainable from GPS. That is we use static receivers which observe both P-code and carrier phases. We place the receiver at site with minimum multipath and we use the best available antennas and receivers. Use of scientific software for post processing is recommended.

If we use all described precautions we expect to obtain an accuracy of (X, Y, Z) coordinates of each site of the order of few millimeter.

Whit this accuracy we expect to obtain accuracy in the drift of coordinates of 2-3 cm/years for each coordinate.

Chapter 3

Crustal movement

3.1 Introduction

Until the early 900s geologists were convinced that continent and ocean basins were stable and immobile forms of the Earth surface. In the last decades, thanks to the lot of information and data that came from new observations and surveys, they changed completely idea about the activity of the Earth and consequent phenomena as earthquake and volcanic eruption.

Now we interpret the crustal Earth not as a rigid plate but rather divided into 20 clods, also called plates and the six largest are showed in figure 3.1 below.

Figure 3.1*:* The six largest continental plates.

Observing the picture is possible to see that the biggest plates are the Eurasian, Pacific, North American, South American, Antartic and African plates.

The latter is pushing against European plate causing the continuous crustal displacement over time which has been observed throughout this plate.

This occurs because the plates rest on mantle which is not a rigid substrate and thus allow their movement.

3.2 Continental drift theory

The idea of *continental drift* dates back to 1915 when the meteorologist *Alfred Wegener* presented the scientific report accompanied with a lot of proofs and observations. His idea was that 200 million years ago there was only one super-continent called *PANGEA* that started to move at that time.

As support of this theory *Wegener* brought many proofs:

- Good matching between continental boundaries.
- Paleontological evidence that showed the presence of the fossil from the same animal species in South America and Africa.
- Lithological prove demonstrating the presence of the same lithotype to South American and African coasts.

This theory was challenged around of 1950s as the forces that *Wegener* had indicated as responsible of drift were really insufficient. He claimed that the only forces liable for the phenomenon were the centrifugal force caused by rotation of the Earth that pushed the continents toward the equator and others forces as Coriolis and solar and lunar attraction caused east and west drift.

Wegener was with A. *Holmes* in 1931 when it was assumed that the main forces of drift are coming from the center of the Earth. Effectively he hypothesized the presence of convection currents within the mantle due to radioactive decay that would be the real perpetrators of drift, as showed in fig. x.x.

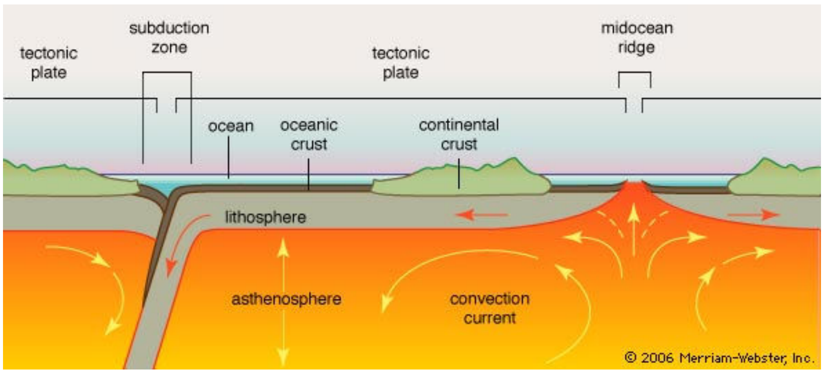

Figure 3.2: Convection current in Continental drift.

Now we will describe how these forces act on the plates and results in movements of enormous masses for thousands of miles.

These forces are convective current generated by thermal imbalances present inside the Earth and the mantle is particularly affected by these phenomena.

These forces are divided in two different ways:

a) In the classical conception only the mantle is affected by these forces and the plates passively are traveling on that.
b) According to another point of view, the plates should be included on the current convection because they would be directly responsible of thermal gradient between mantle and plates generating themselves the convective as the plates sink into the mantle because these elements are in the different temperatures.

In reality the convection current may not follow any of the two theories and then there is a need to understand how they really work.

Returning to the crustal movement we saw that the crustal Earth is formed by 20 plates in relative movements. The effects of these movements are more visible at the contact points between the plates. The contact points are called margins and they can be of different types:

- Divergent margins (fig. 3.3)
- Converged margins (fig. 3.4)
- Transform margins (fig. 3.5)

On the next page it is possible to observe the difference between these various margins.

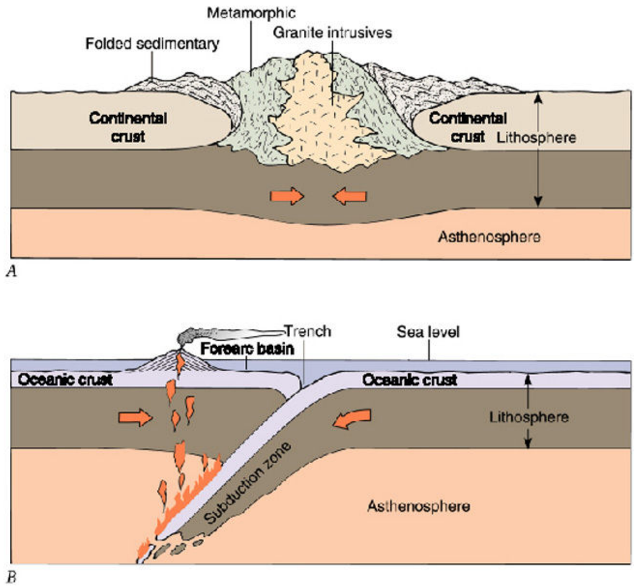

Figure 3.3: Convergent margin.

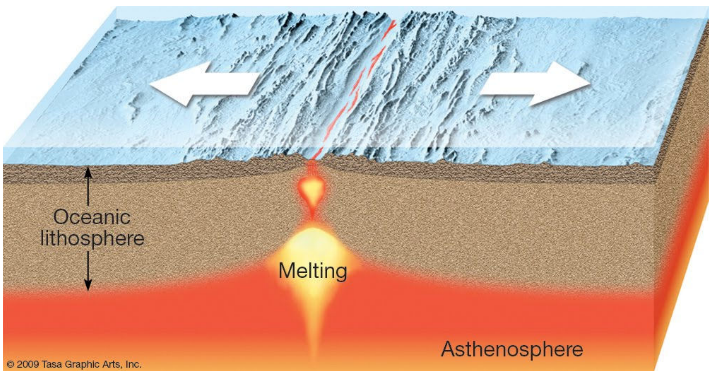

Figure 3.4: Divergent margin.

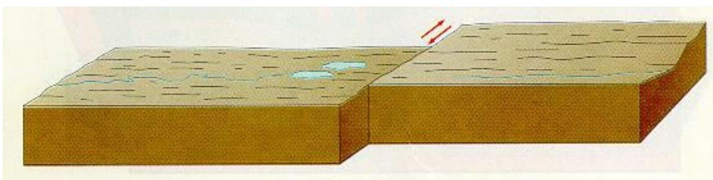

Figure3.5*:* Transform margin.

3.2.1 Convergent margin

In the convergent margin case there are the margins which precisely converge, namely collide. When this happens, one of them begins to slide below the other one, penetrating in the asthenosphere where it starts to disappear within the mantle. Is assumed which this happens around of 700 kilometers of depth because below it the earthquake is registered. Some geophysicists emphasize which the hypocenters of earthquakes, in this kind of margins, are distributed along the incline of 45° on the horizontal that plunges from the grave till under the continent. This area is called *Benioff plane.*

After this discovered is came the conviction which the oceanic crust descends into the mantle fading gradually following the Benioff plane.

The morphological results are different because they depend on the types of margins that collide as continental or oceanic.

In case of ocean plates slides for continental plates thus form what is called *subduction zone* which usually form an *accretion prism*, *magmatic arc* and *tranches*.

A *prism accretion* is a series of “flakes”, or prism in fact, which consists of terrigenous material sedimented on the oceanic plate and which cannot penetrate beneath the plate and built up against the continental margin during the subduction. This should be the genesis of the *Apennine Mountains* in Italy, almost the north part.

A *volcanic arc* is formed by erupting activity, in proximity of subduction zone, caused by thermal gradient between mantle and oceanic crust that is reached by water and that melts partially at certain depth.

Tranches is the line which defines effectively the boundaries between the plates on which the mutual slipping start.

On average they reach a depth of 7-9 km (“Mariana Tranches” reach 10900 meters) and they cover is about 3% of the Earth’s surface.

On the contrary when the collision occurs between two continental that usually have the same density, is not possible for them to slide one under each other; the result is the formation of mountain ranges or big corrugations of the Earth’s surface.

3.2.2 Divergent margins

The divergent margins are represented by two plates which are moving away from each other and are leaving empty space that is filled by mantle magma. This happens along the oceanic ridges where new oceanic crust is created continuously at a speed of about 3-10 cm/years.

Not all divergent margins are on the ocean floors in fact it is assumed that the Red Sea is a newly formed one that involves the African plates and which cause formation of rifts.

3.2.3 Transform margins

Transform margins is represented by shift between two plates side by side without which there is any creation or destruction of crust. There are many seismological researches which demonstrate that the majority of earthquakes happened around the world are usually caused by transform margins displacement. Some typical characteristics recognizable using aerial photographs are the presence of big scarps on the areas of contact and the presence of unique rift usually linear for many kilometers.

3.3 Monitoring crustal movement

In the last 25 years plate tectonic prediction has made use of three types of data also called *conventional* plate motion data:

- The first type is obtained estimating the distance between the magnetic anomalies measured on mid-ocean ridges. This is possible because the history of geomagnetic reverse is well known and measuring the distance between these anomalies makes it possible to compute the drift velocity.

  The problem with this kind of data is that it is not possible to measure the crustal expansion rate shorter than the time lapse between two geomagnetic reversals that is among tens of thousands to tens of millions of years.

- Another type of data is obtained from the azimuth of a submarine transform fault estimated from bathymetric survey. The measured azimuths are used to compute the direction of the motions plates. The precision with which the azimuth of transforms can be computed depends on the quality of bathymetric data used and sometimes is really difficult to obtain accuracy values.
- The last “conventional” data type is the sliding direction computed from focal mechanisms deducted studying the directions of seismic waves from earthquakes due to long transform faults or at trenches. These types of data are the less accurate between the conventional data list and therefore we will not focus on them.

Today, with the advent of space geodesy, it’s possible to measure the continental drift with more precision and with much smaller time intervals using the GNSS system. In fact, GPS measurements are precise enough to allow a determination of tectonic motion within few years.

This can be made using a network of permanent station, dynamically defined, using inertial reference frame that moves with the geocenter. Comparing the position of these points over time, it’s possible to compute the velocity and direction of the plate motion.

The goal of this work is precisely to describe the hypothetical tectonic motion registered in the center of Italy using a network of GPS permanent station located approximately in the center of Italy.

Chapter 4

Problem formulation

4.1 Reference system for GPS measurements

To express unequivocally and mathematically the position of one point on the Earth surface using GPS technology it is important to specify the reference system used in our computation. In geodesy this reference system is called a datum and it may be defined in different ways. Conventionally each way refers on the Earth surface to the position of some points with fixed coordinates.

This means that when the reference system changes, the coordinates of the point changes too.

For many applications, including topographic applications, reference systems are used sympathetic to the Earth.

The datum definition is a 3-D definition and satellite geodesy is based on global geodetic datum. Therefore it is valid in any point on the Earth.

This global definition is based on a set of three geocentric axes OXYZ, and then with the origin located to the mass center of the Earth where:

- Z is parallel to the rotation axis of the Earth
- X-Y located in the equatorial plane
- X directed along Greenwich meridian and Y which completes a right-handed system.

This system is fixed with the Earth and is therefore called ECEF (Earth-Centered-Earth-Fixed).

Thanks to this reference system it is possible to define a global ellipsoid valid for the entire world and which allows to express the coordinates of the selected points using GPS technology. The deviation from the vertical change zone by zone and it depends on geoid undulation and is minimum where the gradient of this undulation is little.

The global datum uses a 3-D datum where the height is refers to the ellipsoid. The ellipsoidal height is reduced to orthometric using a vertical datum.

Actually the GPS measurement is based on different reference system, the international one called ITRS and the European one called ETRS.

In our project we use ITRS.

With the advent of GPS the reference systems have developed using a network of GPS permanent stations. Also the network of GPS permanent station is divided in International (IGS), European (e.g. EUREF) national (e.g. Italian RDN) and regional (e.g. GPSUMBRIA).

4.1.1 IGS (International GNSS service for geodynamic)

The IGS network of permanent stations is a worldwide network designed for scientific purposes and is of general interest since it allows to:

- Define a Global Datum (e.g. ITRS)
- Compute the GPS orbits (precise ephemerides), correction of clock offset and defines the EOP (Earth orientation parameters)
- Monitoring of continental crustal movements

The network has been realized with uses of GPS permanent station, VLBI stations etc. by many national and institutional agencies.

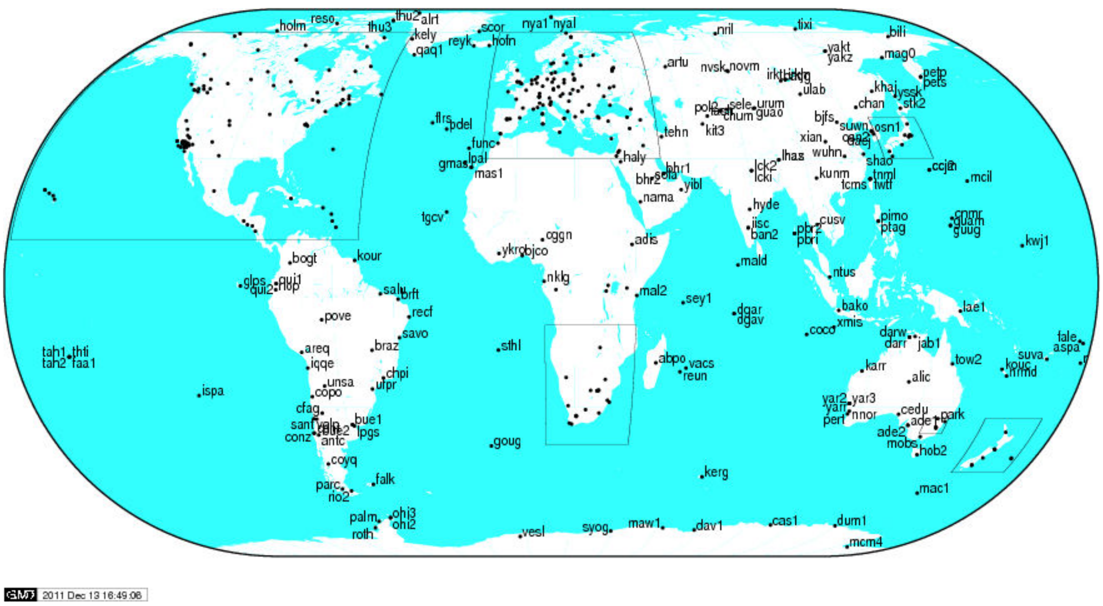

Figure 4.1: IGS Network

<u>4.1.2 EPN-EUREF (European permanent network)</u>

The EPN-EUREF is a European network realized as IGS for scientific purpose and allow to:

- define global European datum (ETRS)
- monitors local deformation of the European plate
- determine precise ephemerides and clock offset correction etc.
- frame national networks.

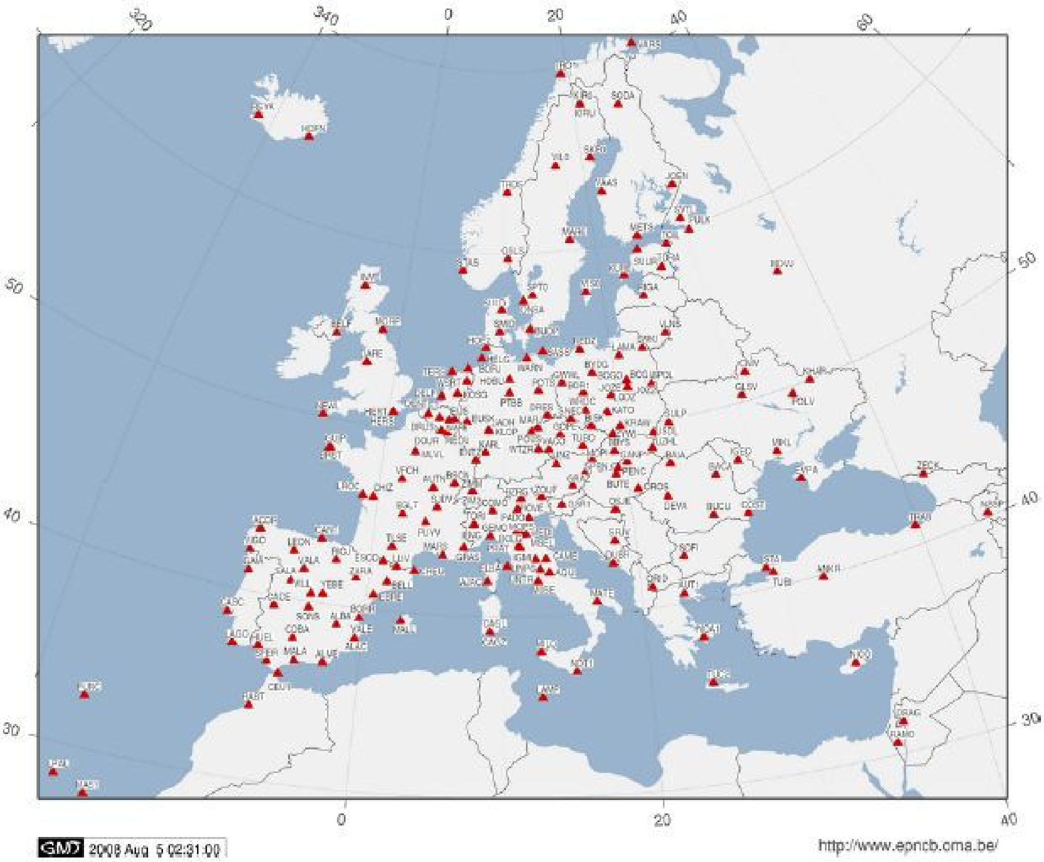

Figure 4.2: EPN-EUREF network

4.1.3 RDN (Italian National Dynamic Network)

The objective of National Dynamic Network is to organize, in the entire Italy, a fixed network of GPS permanent station which observe continuously the GNSS signals and transmit it to a control center. This kind of network allows the IGM (Military Geographical Institute) to materialize and monitor with high precision, in the entire country, a global reference system.

The network is composed of 99 GPS permanent stations homogeneously distributed and it has been adopted to ITRF05 and ETRF00 at epoch 2008.0.

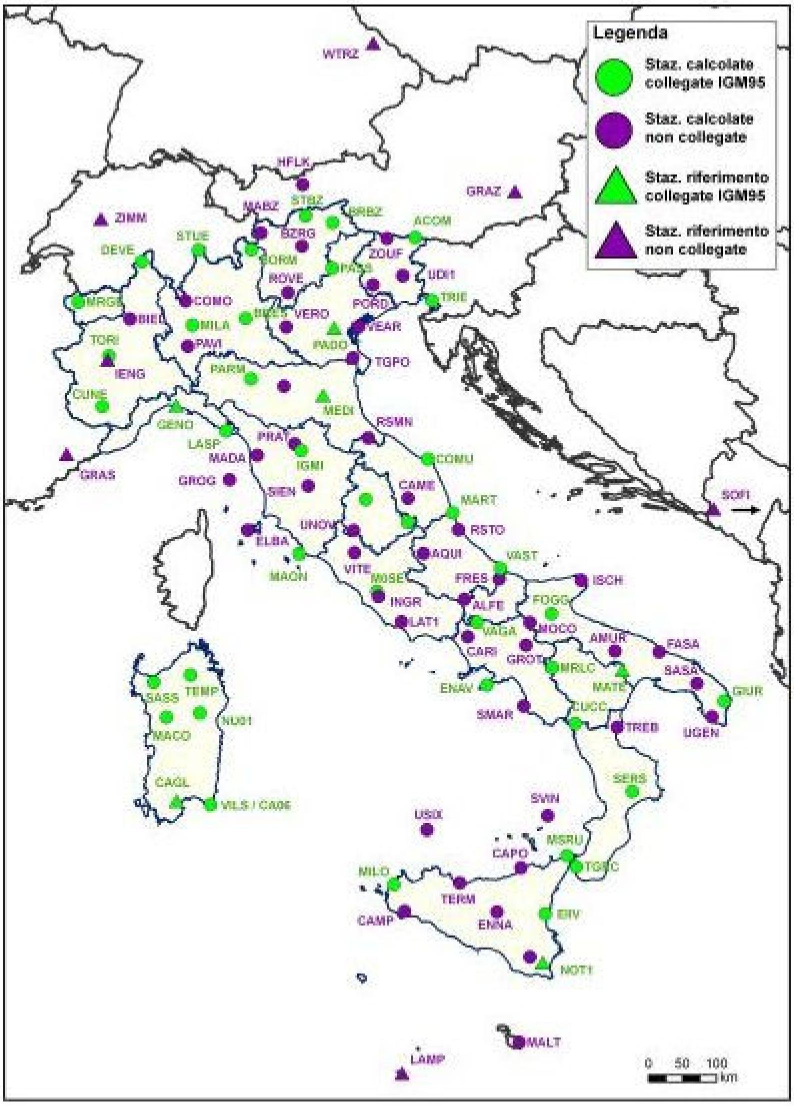

Figure 4.3: RDN network

4.1.4 GPSUMBRIA (Umbria GPS network)

GPSUMBRIA is a regional GPS/GNSS network of permanent stations born in a context of collaboration between Umbria Region and Perugia University. This network is one of the first ones developed in Italy and it has been designed to promote the use of GPS and satellite positioning.

The network has been designed and realized by Civil and Environmental Engineering Department- Topography Laboratory of Perugia University.

The equipment and installation of the network was assigned to GEOTOP s.r.l. (Ancona), which realized seven new permanent stations with GPS/GLONASS Topcon Odyssey-RS receiver in addition of five existing ones, for a total of twelve stations with an average spacing of 40 km.

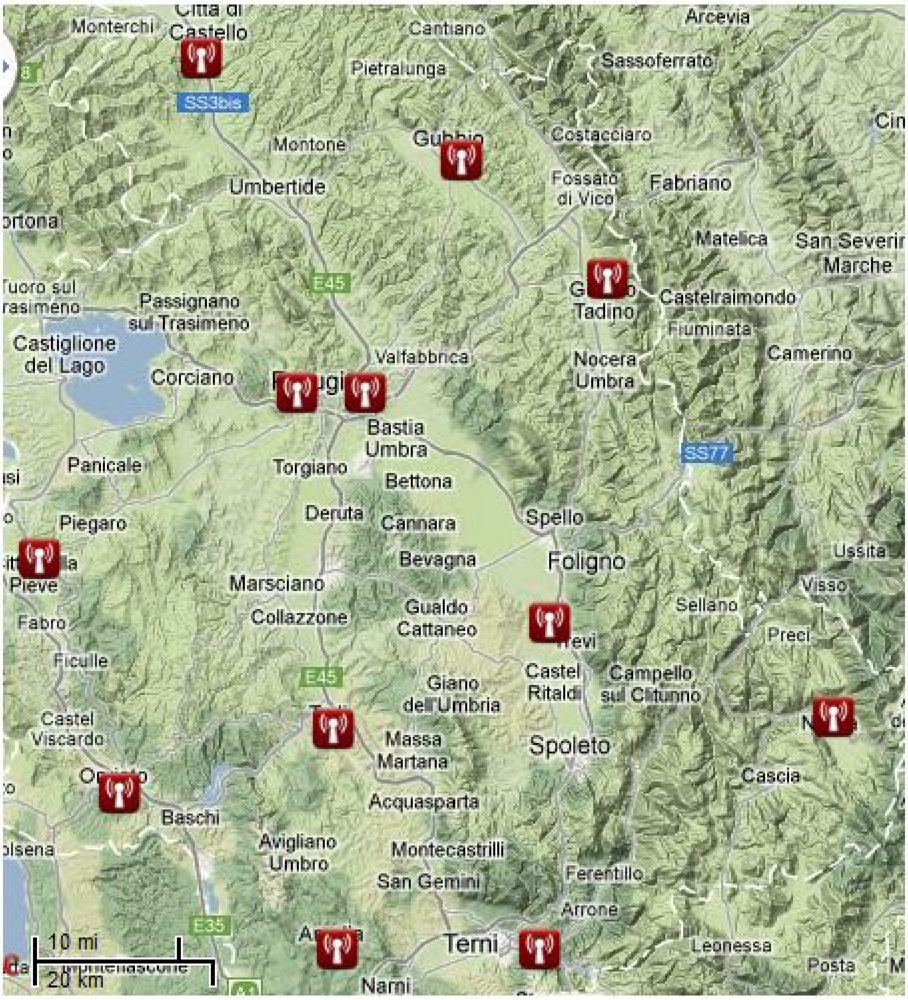

Figure 4.4: GPSUMBRIA network

4.2. Monitoring GPS network

To achieve a good result on this monitoring work, using GPS, is really important to have a good geometry of the network to obtain a small magnitude of uncertainties on coordinate values and homogeneously distributed on it. The purpose is to analyze the displacement in the center of Italy with the focus on six GPSUMBRIA stations listed below:

- ITGT (Gualdo Tadino)
- REFO (Foligno)
- RENO (Città di Castello)
- REPI (Città della Pieve)
- RETO (Todi)
- UNTR (Terni)

All these stations have been coordinated in ITRF05 and using many IGS/EPN/RDN permanent stations distributed in a wide area to obtain a good coverage of the network.
We list all the stations used for this purpose divided by home network:

- **IGS** stations:

  -CAGL (Cagliari)

  -MEDI (Bologna)

- **IGS/EPN** stations:

  -BZRG (Bolzano)

  -GENO (Genova)

  -GRAS (Caussols (FR))

  -IENG (Torino)

  -MATE (Matera)

  -PADO (Padova)

-NOT1 (Noto)

- **EPN/RDN/GPSUMBRIA**

  -UNPG (Perugia)

- **EPN/RDN**

  -AQUI (Aquila)

  -IGMI (Firenze)

- **RDN/GPSUMBRIA**

  -RENO (Norcia)

  -UNOV (Orvieto)

- **RDN**:
  -INGR (Roma)
  -MAON (Grosseto, Monte Argentario)
  -MART (Martinsicuro)
  -RSMN (Repubblica di San Marino)
  -SIEN (Siena)
  -VITE (Viterbo)

The monitor network consists of 26 permanent stations and is held fixed during the processing of data from 2008 and 2011, respectively. This make it easier to compare the changes between the two epochs.

4.4 Project formulation

In Chapter 3 was mentioned the objective of this work which describes crustal movement in the center of Italy using GPS technology.

The European plate moves with the rate of ~ 2cm/year in direction of north/east. This is caused (as described in Chapter 3) by the African plate because the African plate moves into the European one. This global trend of movement can change locally (earthquakes, tsunamis, volcanic eruption etc.).

The amount of the movements which we aspect to obtain in one year is bigger compared with the precision which is actually possible to obtain with GPS measurements. That's why this computation will be done using a really wide GPS network formed by many permanent stations of IGS (International GNSS service), "*RDN*" (National Dynamic Network) and some stations of the "Umbria Regional Network", all framed in the realization of datum ITRF05. A permanent station is a physical point which is equipped with GPS or GNSS (Global Navigation Satellite System) receiver and it's a structure for acquisition, storage and processing of data and code phase from satellite constellations such as GPS and GLONASS, 24 hours per day, for 365 days per year.

The computation of displacements will be done using one month of GPS data from 2008 and one month from 2011. The idea is to obtain daily solution for each month computing the coordinate of all points in GPS network. We expect that in each month all points will have the same coordinates because the movement is really slow.

Computing the average of coordinates for each month we expect a time lapse of three years will make it possible to observe a significant displacement between the coordinate means.

The network computation will be done using the software GAMIT/GLOBK developed by Massachusetts Institute of Technology (MIT). This software can be used for estimating station coordinates and velocities, functional representations of post-seismic deformation, satellite orbits, atmospheric delays and Earth orientation parameters.

Chapter 5

Network Computation with GAMIT/GLOBK

5.1 Introduction on GAMIT/GLOBK

GAMIT/GLOBK is a complete scientific software developed by MIT (Massachusetts Institute of Technology) for GPS analysis and processing. GAMIT is collection of programs to process phase data to estimate three-dimensional relative positions of ground stations and satellite orbits, atmospheric zenith delays, and earth orientation parameters. The software is designed to run under any UNIX operating system. GLOBK is a Kalman filter whose primary purpose is to combine various geodetic solutions such as GPS, VLBI, and SLR experiments. It accepts as data, or "quasi-observations" the estimates and covariance matrix for station coordinates, earth-orientation parameters, orbital parameters, and source positions generated from the analysis of the primary observations. The input solutions are generally performed with loose a priori uncertainties assigned to all global parameters, so that constraints can be uniformly applied in the combined solution. With this work is possible to run each module separately or in batch processing, where this last solution is preferred because more efficient and is possible save the time on computation. In this chapter will be described all step for obtain a solution using GAMIT/GLOBK.

5.2 Data collection for GAMIT computation

Whit GAMIT/GLOBK really important step for obtain a good result when is working in batch processing is to collect all data in the right way.
For these purpose, the first thing to do is to create a working directory which will contain all files necessary for the computation.
Since the objective of this work is to analyze 2 months of data, respectively in 2008 and 2011, it has been created 2 different working directories:

-2008

-2011

Each working directories contain the follow subdirectories:

-rinex

-igs

-gfiles

-brdc

-tables

5.2.1 Input files

As mentioned in the chapter 4, in this work has been used 26 stations. All rinex which come from stations which are not IGS has been collected by server of Umbria Region and put into rinex directory while regarding IGS stations, is possible to download it directly using the GAMIT shell within rinex directory.
As an example is shown the shell command for the rinex subdirectory of 2008:

- *sh_get_rinex –yr* 2007 *–doy* 357 *–ndays* 9 *–sites* bzrg geno gras ieng mate medi not1 pado
- *sh_get_rinex –yr* 2008 *–doy* 001 *–ndays* 19 *–sites* bzrg geno gras ieng mate medi not1 pado

Now all rinex data are available. Usually, as in this case, the rinex file are collected in hatanaka format (e.g aqui3570.07d) and since that GAMIT cannot read this format it has been necessary to decompress it in rinex format (e.g. aqui3570.07o) running the modules "crx2rnx" for each rinex data directly within the rinex directory (e.g. *crx2rnx* aqui3570.07d).
Concerning the "*igs*" subdirectory it must contain the "igs precise ephemerides" (e.g. igswwwwd.sp3) which is possible to download from SOPAC archive running the follow script within "igs" subdirectory:

- "*sh_get_orbits -yr* 2007 *-doy* 357 *–ndays* 9 *–makeg* no"

- *"sh_get_orbits -yr* 2008 *–doy* 001 *–ndays* 19 *–makeg* no"

The use of precise ephemerides is necessary to obtain good final results.
The use of "*makeg* no" is necessary because the *g-files* have been downloaded by hand directly from SOPAC archive and copied into "*gfiles*" and "*igs*" subdirectories (e.g gigsf7.357).
The G-files contain the initial condition of satellite positions which are used by "arc" modules for create a tabular ephemerides (T-files) whit the position of all satellites expressed every 15 minute throughout the observation span.
Regarding the "*brdc*" subdirectory, it must contain the navigation transmitted files, which can be downloaded directly within "*brdc"* with the script:

- *sh_get_nav -yr* 2007 *-doy* 357 *–ndays 9*
- *sh_get_nav -yr* 2008 *-doy* 019 *–ndays 19*

5.2.2 Control files

The GAMIT module is based on six important control files which are within "tables" directory and where "*tables*" directory is copied from GAMIT software installation (e.g. gg/tables) and put on working directory (e.g. "*2008"*).
These control file are listed below:

- autcln.cmd
- process.defaults
- sestbl
- sittbl
- sites.defaults
- station.info

Some of these control files must be edited in accord whit the purpose of the work. The "*autcln.cmd"* contains the Command file for AUTCLN to be used for global and regional data.
The "*process.defaults"* is one of the most important control file because contain the structure of directories and the GAMIT command file.

The *"Sestbl"* is the input control file for fixdrv, specifying the type of analysis and the a priori measurement errors and satellite constraints.

The "sittbl" is the input control file for fixdrv, specifying for each site the a priori coordinate constraints and optionally the clock and atmospheric models.

The "*site.defaults"* must be edited appropriately listing the stations which must be used on processing.

This file is shown below:

```
# File to control the use of stations in the processing
#
# Format: site expt keyword1 keyword2 ....
#
#  where the first token is the 4- or 8-character site name (GAMIT
uses only
#  4 characters, GLOBK allows only 4 unless there are earthquakes or
renames),
#  the second token is the 4-character experiment name, and the
remaining
#  tokens, read free-format, indicate how the site is to be used in
the processing.
#  All sites for which there are RINEX files in the local directory
will be used
#  automatically and do not need to be listed.
#
# GAMIT:
#  ftprnx = sites to ftp from rinex data archives.
#  ftpraw = sites to ftp from raw data archives.
#  localrx = sites names used to search for rinex files on your
local system.
#           (required in conjunction with rnxfnd path variable set
in process.defaults).
#  xstinfo = sites to exclude from automatic station.info updating.
#  xsite   = sites to exclude from processing, all days or specified
days
# GLOBK:
#  glrepu = sites used in the GLRED repeatability solution (default
is to use all)
#  glreps = sites used for reference frame definition
(stabilization) in
#            GLORG for the GLRED repeatabilitiy solution (default
is IGS list)
#  glts   = sites to plot as time series from GLRED repeatability
solution (default is all)
#
# Replace 'expt' with your experiment name and edit the following to
list sites needed from external archive
 all_sites 2008
 aqui_gps 2008 ftprnx
 bzrg_gps 2008 ftprnx
 cagl_gps 2008 ftprnx
 geno_gps 2008 ftprnx
 gras_gps 2008 ftprnx
 ieng_gps 2008 ftprnx
 igmi_gps 2008 ftprnx
 ingr_gps 2008 ftprnx
 itgt_gps 2008 ftprnx
 maon_gps 2008 ftprnx
```

```
 mart_gps 2008 ftprnx
 mate_gps 2008 ftprnx
 medi_gps 2008 ftprnx
 not1_gps 2008 ftprnx
 pado_gps 2008 ftprnx
 refo_gps 2008 ftprnx
 remo_gps 2008 ftprnx
 reno_gps 2008 ftprnx
 repi_gps 2008 ftprnx
 reto_gps 2008 ftprnx
 rsmn_gps 2008 ftprnx
 sien_gps 2008 ftprnx
 unpg_gps 2008 ftprnx
 unov_gps 2008 ftprnx
 untr_gps 2008 ftprnx
 vite_gps 2008 ftprnx
.
 all_sites 2008 xstinfo
# templates for removing sites
 ttth_gps  2008 xsite:1999_256-1999_278 glreps xsite:1999_300-
1999_365
 thht_gps  2008 xsite glreps
```

where 2008 is the name of working directory and the stations are listed with the extension "*gps*".

The line "`all_sites 2008 xstinfo`" is really important for GAMIT run because allow to avoid the creations of station.info file using the old one, previously set by hand as described below.

The last control file is the "*station.info*" which as the name suggests contains all information about the GPS station and can be edited automatically by GAMIT reading the rinex header using the follow script on "*tables*" directory:

- *sh_upd_stnfo -l* sd

With this script has been created the new file called "*station.info.new*" which must replace the old one already present within "*tables*" directory:

- *mv* station.info.new station.info

Now all rinex headers must be scanned to read all data and edit that file with the command:

- *sh_upd_stnfo –files* ../rinex/*.07o
- *sh_upd_stnfo –files* ../rinex/*.08o

An extract of obtained file (Aquila GNSS station) is shown below:

```
# Station.info written by MSTINF user vmassi11        on 2012-01-09  22:04
* Refrence file : station.info
*
*
*SITE  Station Name      Session Start      Session Stop       Ant Ht   HtCod  Ant N    Ant E    Receiver Type  Antenna Type     Dome
 AQUI  AQUI              2007 357  0  0  0  2007 357 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui3577.070
 AQUI  AQUI              2007 358  0  0  0  2007 358 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui3580.07o
 AQUI  AQUI              2007 359  0  0  0  2007 359 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui3590.07o
 AQUI  AQUI              2007 360  0  0  0  2007 360 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui3600.07o
 AQUI  AQUI              2007 361  0  0  0  2007 361 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui3610.07o
 AQUI  AQUI              2007 362  0  0  0  2007 362 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui3620.07o
 AQUI  AQUI              2007 363  0  0  0  2007 363 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui3630.07o
 AQUI  AQUI              2007 364  0  0  0  2007 364 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui3640.07o
 AQUI  AQUI              2007 365  0  0  0  2007 365 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui3650.07o
 AQUI  AQUI              2008   1  0  0  0  2008   1 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui0010.08o
 AQUI  AQUI              2008   2  0  0  0  2008   2 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui0020.08o
 AQUI  AQUI              2008   3  0  0  0  2008   3 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui0030.08o
 AQUI  AQUI              2008   4  0  0  0  2008   4 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui0040.08o
 AQUI  AQUI              2008   5  0  0  0  2008   5 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui0050.08o
 AQUI  AQUI              2008   6  0  0  0  2008   6 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui0060.08o
 AQUI  AQUI              2008   7  0  0  0  2008   7 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui0070.08o
 AQUI  AQUI              2008   8  0  0  0  2008   8 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui0080.08o
 AQUI  AQUI              2008   9  0  0  0  2008   9 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui0090.08o
 AQUI  AQUI              2008  10  0  0  0  2008  10 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui0100.08o
 AQUI  AQUI              2008  11  0  0  0  2008  11 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui0110.08o
 AQUI  AQUI              2008  12  0  0  0  2008  12 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui0120.08o
 AQUI  AQUI              2008  13  0  0  0  2008  13 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui0130.08o
 AQUI  AQUI              2008  14  0  0  0  2008  14 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui0140.08o
 AQUI  AQUI              2008  15  0  0  0  2008  15 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui0150.08o
 AQUI  AQUI              2008  16  0  0  0  2008  16 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui0160.08o
 AQUI  AQUI              2008  17  0  0  0  2008  17 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui0170.08o
 AQUI  AQUI              2008  18  0  0  0  2008  18 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui0180.08o
 AQUI  AQUI              2008  19  0  0  0  2008  19 23 59 30  0.0000  DHARP  0.0000   0.0000   TRIMBLE 4700   TRM29659.00      NONE  aqui0190.08o
```

<u>5.2.3 Global files</u>

The GAMIT software is based also on a series of different global files with different content, already present within "*tables*" directory or when are not presents downloadable from SOPAC archive. These are listed below for completeness:

- *ftp_info* : Table of addresses and protocols for downloading files from external archives.

Input to : *sh_get_hfiles, sh_get_nav, sh_get_orbits, sh_get_rinex, sh_get_stinfo, sh_update_eop.*

- *rcvant.dat* : Table of correspondences between GAMIT 6-character codes and the full (20-character) names of receivers and antennas used in RINEX and SINEX files.

Input to : *model, sh_upd_stnfo/mstinf*2.

- *guess_rcvant.dat* : Used optionally by sh_gamit to determine the GAMIT code from nonexact 20-character names of receivers and antennas in the RINEX header.

Input to : sh_upd_stnfo/mstinf2.

- *antmod.dat* : Table of antenna phase center offsets and, optionally, variations as a function of elevation and azimuth.

Input to : *model.*

- *svnav.dat* : Table giving NAVSTAR numbers, block number (I or II), spacecraft mass, and yaw parameters for each GPS satellite (listed by PRN number).

Input to : makex, arc, model.

- *svs_exclude.dat*: Table giving dates during which a satellite should be excluded from processing.

Input to : *sh_sp3fit / orbfit*

- *gdetic.dat*: Table of parameters of geodetic datums

Input to : *tform, model.*

- *ut1.* : UT1 table - contains TAI-UT1 values in tabular form.

Input to : *arc, model, sh_sp3fit/orbfit, ngstot, bctot, ttongs.*

- *pole.* : Pole table - contains polar motion values in tabular form for interpolation in model and arc, and bctot.

Input to : *arc, model, sh_sp3fit/orbfit, ngstot, bctot, ttongs*

- *leap.sec* : Table of jumps (leap seconds) in TAI-UTC since 1 January 1982.

Input to : *fixdrv, model, arc, bctot, ngstot, ttongs.*

- *nutabl.* : Nutation table - contains nutation parameters in tabular form for transforming between an inertial and an Earth-fixed system.

Input to : *arc, model, sh_sp3fit/orbfit, ngstot, bctot, ttongs.*

- *luntab.* : Lunar tabular ephemeris.

Input to : *arc, model.*

- *soltab.* : Solar tabular ephemeris.

Input to : arc,model.

- *otl.grid, otl.list*: Ocean tide components from a global grid or station list.

Input to : *grdtab.*

- *atl.grid, atl.list:* Atmospheric tide components from a global grid or station list.

Input to : *grdtab.*

- *atml.grid, atml.list:* Non-tidal atmospheric loading components from a global grid or station list.

Input to : *grdtab.*

- *map.grid, map.list* : Atmospheric mapping function coefficients and hydrostatic zenith delays based on a numerical weather model; currently provided only for VMF1.

Input to : *grdtab.*

5.3 GAMIT batch processing running

When all data and files listed in the previous paragraphs are correctly edited the biggest part of work is made it and is possible to run all modules of GAMIT with automatic batch processing command shown below:

- *sh_gamit -s* 2007 357 365 *–expt* 2008 –noftp
- *sh_gamit -s* 2008 001 019 *–expt* 2008 –noftp

Whit these two commands all modules run automatically for all monthly GPS data from 2008 (28 Julian days) obtaining a daily solutions located within each respectively folder.

5.3.1 GAMIT batch processing results

The most important output files of GAMIT run are:

- GAMIT.status
- sh_gamit_ddd.summary (d= Julian doy)
- qexpta.ddd (y= year)

Here show some extract of these files for Julian doy 357 of 2007 and for brevity only for L'Aquila GPS station.

- GAMIT.status:

```
STATUS :120113:1632:33.0 MAKEXP/makexp: Started  MAXEXP Ver. 9.80 2010/9/8 21:00:00
(Linux)  Library Ver. 10.89 of 2012/1/04 09:00:00 (Linux)
STATUS :120113:1632:33.0 MAKEXP/makexp: Normal end in Program MAKEXP
STATUS :120113:1632:33.0 MAKEJ/makej: Started MAKEJ 10.03 2011/9/30 09:24:00 (Linux)
Library ver. 10.89 of 2012/1/04 09:00:00 (Linux)
STATUS :120113:1632:33.0 MAKEJ/makej: Opened J-file: (Name jbrdc7.357)
STATUS :120113:1632:33.0 MAKEJ/j_from_e: Opened navigation file: (Name brdc3570.07n)
STATUS :120113:1632:33.0 MAKEJ/j_from_e: J-File written for 31 satellites Start: 2007
356  23 59 Stop : 2007   357  23 59
```

```
STATUS :120113:1632:33.0 MAKEJ/makej: Jfile: jbrdc7.357 contains PRNs 01 02 03 04 05
06 07 08 09 10 11 12 13 14 15 17 18 19 20 21 22 23 24 25 27 28 30 31 32 16 26
STATUS :120113:1632:33.0 MAKEJ/makej: Normal end in MAKEJ
STATUS :120113:1632:33.0 MAKEX/makex: Started Makex 10.03 2011/9/30 09:24:00 (Linux)
Library ver. 10.89 of 2012/1/04 09:00:00 (Linux)
STATUS :120113:1632:33.0 MAKEX/openf: Opened: 2008.makex.infor
STATUS :120113:1632:33.0 MAKEX/openf: Opened: 2008.makex.batch
STATUS :120113:1632:33.0 MAKEX/makex: **Begin processing: AQUI 2007 357  1
STATUS :120113:1632:33.0 MAKEX/openf: Opened: session.info
STATUS :120113:1632:33.0 MAKEX/openf: Opened: l20087.357
STATUS :120113:1632:33.0 MAKEX/openf: Opened: station.info
STATUS :120113:1632:33.0 MAKEX/openf: Opened: ./jbrdc7.357
STATUS :120113:1632:33.0 MAKEX/openf: Opened: kaqui7.357
STATUS :120113:1632:33.0 MAKEX/openf: Opened: ./brdc3570.07n
STATUS :120113:1632:33.0 MAKEX/openf: Opened: hi.dat
STATUS :120113:1632:34.0 MAKEX/makex: Epochs 2880  X-file interval  30  Length of
session (hrs) 24.0
STATUS :120113:1632:34.0 MAKEX/get_rxfiles: Searching for data in ./aqui3570.07o
STATUS :120113:1632:34.0 MAKEX/get_rxfiles: Found data in ./aqui3570.07o
STATUS :120113:1632:34.0 MAKEX/openf: Opened: xaqui7.357
STATUS :120113:1632:34.0 MAKEX/openf: Opened: ./aqui3570.07o
STATUS :120113:1632:34.0 MAKEX/makex: TRM  0.00: accept data within +-0.300s of
nominal epochs
STATUS :120113:1632:35.0 MAKEX/makex: Wrote all the epochs requested.
STATUS :120113:1632:35.0 MAKEX/makex:   25089 observations written to xfile   204
observations rejected as unreasonable
STATUS :120113:1632:35.0 MAKEX/makex: End processing: AQUI 2007 357  1
STATUS :120113:1633: 0.0 MAKEX/makex: LEI  0.00: accept data within +-1.000s of
nominal epochs
STATUS :120113:1633: 1.0 MAKEX/makex: Wrote all the epochs requested.
STATUS :120113:1633: 1.0 MAKEX/makex:   20671 observations written to xfile     0
observations rejected as unreasonable
STATUS :120113:1633: 1.0 MAKEX/makex: End processing: VITE 2007 357  1
STATUS :120113:1633: 1.0 MAKEX/rbatch: End of batch file reached
STATUS :120113:1633: 1.0 MAKEX/makex: Normal End of MAKEX
STATUS :120113:1633: 2.0 FIXDRV/fixdrv: Started v.10.35 of 2011/12/28 13:30:00
(Linux)
STATUS :120113:1633: 2.0 FIXDRV/fixdrv: New Clock-polynomial (I-) file being written-
-see fixdrv.out
STATUS :120113:1633: 3.0 FIXDRV/bmake: Setting numzen =  13 from zenint =  2.0 hr
STATUS :120113:1633: 4.0 FIXDRV/bmake: Created GAMIT batch file b20087.bat
STATUS :120113:1633: 4.0 FIXDRV/fixdrv: Normal end
STATUS :120113:1633: 4.0 ARC/aversn: Started ARC, Version 9.69 of 2011/5/23 16:00:00
(Linux)      Library ver. 10.89 of 2012/1/04 09:00:00 (Linux)
STATUS :120113:1633: 4.0 ARC/arc:   Integrating satellite  1  PRN  1
STATUS :120113:1633: 4.0 ARC/arc:   Integrating satellite  2  PRN  2
STATUS :120113:1633: 4.0 ARC/arc:   Integrating satellite  3  PRN  3
STATUS :120113:1633: 4.0 ARC/arc:   Integrating satellite  4  PRN  4
STATUS :120113:1633: 4.0 ARC/arc:   Integrating satellite  5  PRN  5
STATUS :120113:1633: 4.0 ARC/arc:   Integrating satellite  6  PRN  6
STATUS :120113:1633: 4.0 ARC/arc:   Integrating satellite  7  PRN  8
STATUS :120113:1633: 4.0 ARC/arc:   Integrating satellite  8  PRN  9
STATUS :120113:1633: 4.0 ARC/arc:   Integrating satellite  9  PRN 10
STATUS :120113:1633: 4.0 ARC/arc:   Integrating satellite 10  PRN 11
STATUS :120113:1633: 4.0 ARC/arc:   Integrating satellite 11  PRN 12
STATUS :120113:1633: 4.0 ARC/arc:   Integrating satellite 12  PRN 13
STATUS :120113:1633: 4.0 ARC/arc:   Integrating satellite 13  PRN 14
STATUS :120113:1633: 4.0 ARC/arc:   Integrating satellite 14  PRN 15
STATUS :120113:1633: 4.0 ARC/arc:   Integrating satellite 15  PRN 16
STATUS :120113:1633: 4.0 ARC/arc:   Integrating satellite 16  PRN 17
STATUS :120113:1633: 4.0 ARC/arc:   Integrating satellite 17  PRN 18
STATUS :120113:1633: 4.0 ARC/arc:   Integrating satellite 18  PRN 19
STATUS :120113:1633: 5.0 ARC/arc:   Integrating satellite 19  PRN 20
STATUS :120113:1633: 5.0 ARC/arc:   Integrating satellite 20  PRN 21
STATUS :120113:1633: 5.0 ARC/arc:   Integrating satellite 21  PRN 22
STATUS :120113:1633: 5.0 ARC/arc:   Integrating satellite 22  PRN 23
STATUS :120113:1633: 5.0 ARC/arc:   Integrating satellite 23  PRN 24
STATUS :120113:1633: 5.0 ARC/arc:   Integrating satellite 24  PRN 25
STATUS :120113:1633: 5.0 ARC/arc:   Integrating satellite 25  PRN 26
STATUS :120113:1633: 5.0 ARC/arc:   Integrating satellite 26  PRN 27
STATUS :120113:1633: 5.0 ARC/arc:   Integrating satellite 27  PRN 28
STATUS :120113:1633: 5.0 ARC/arc:   Integrating satellite 28  PRN 30
STATUS :120113:1633: 5.0 ARC/arc:   Integrating satellite 29  PRN 31
STATUS :120113:1633: 6.0 ARC/arc: Normal stop in ARC (Name tigsf7.357)
STATUS :120113:1633: 6.0 YAWTAB/orbits/yawtab: Program YAWTAB Version ver. 9.91
2011/4/16 09:00:00 (Linux)     Library ver. 10.89 of 2012/1/04 09:00:00 (Linux)
STATUS :120113:1633: 6.0 YAWTAB/orbits/yawtab:  YAWTAB Run on 2012/  1/ 13  16:33: 6
by vmassi11
```

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STATUS :120113:1633: 6.0 YAWTAB/orbits/yawtab:  Yaw Table interval       :   30
seconds
STATUS :120113:1633: 6.0 YAWTAB/orbits/yawtab:  Yaw calculation interval :   30
seconds
STATUS :120113:1633: 6.0 YAWTAB/orbits/yawtab:  Ephemeris (T-) File      : tigsf7.357
STATUS :120113:1633: 6.0 YAWTAB/orbits/yawtab: PRN nos. in channels selected:   1  2
3  4  5  6  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 30 31
STATUS :120113:1633: 6.0 YAWTAB/orbits/get_ecl_pos: Blk IIA PRN  25 is eclipsing
(Type E) 2007   12   22   21   41. Beta angle  13.00
STATUS :120113:1633: 6.0 YAWTAB/orbits/get_ecl_pos: Blk IIA PRN  27 is eclipsing
(Type E) 2007   12   22   22    8. Beta angle  11.90
STATUS :120113:1633: 6.0 YAWTAB/orbits/get_ecl_pos: Blk IIA PRN   8 is eclipsing
(Type E) 2007   12   22   22   52. Beta angle   8.30
STATUS :120113:1633: 6.0 YAWTAB/orbits/get_ecl_pos: Blk IIA PRN  10 is eclipsing
(Type E) 2007   12   23    0   33. Beta angle   9.00
STATUS :120113:1633: 6.0 YAWTAB/orbits/get_ecl_pos: Blk IIR PRN  18 is eclipsing.
Dusk time  2007   12   23    0   59. Beta angle   8.94
STATUS :120113:1633: 6.0 YAWTAB/orbits/get_ecl_pos: Blk IIR PRN  22 is eclipsing.
Dusk time  2007   12   23    2    7. Beta angle   9.08
STATUS :120113:1633: 6.0 YAWTAB/orbits/get_ecl_pos: Blk IIA PRN   9 is eclipsing
(Type E) 2007   12   23    2   30. Beta angle  10.90
STATUS :120113:1633: 6.0 YAWTAB/orbits/get_ecl_pos: Blk IIR PRN  31 is eclipsing.
Dusk time  2007   12   23    3   11. Beta angle   9.55
STATUS :120113:1633: 6.0 YAWTAB/orbits/get_ecl_pos: Blk IIR PRN  20 is eclipsing.
Dusk time  2007   12   23    5   45. Beta angle   6.77
STATUS :120113:1633: 6.0 YAWTAB/orbits/get_ecl_pos: Blk IIR PRN  20 is eclipsing.
Dusk time  2007   12   23    6   10. Beta angle   6.76
STATUS :120113:1633: 6.0 YAWTAB/orbits/get_ecl_pos: Blk IIA PRN  25 is eclipsing
(Type E) 2007   12   23    9   42. Beta angle  12.60
STATUS :120113:1633: 6.0 YAWTAB/orbits/get_ecl_pos: Blk IIA PRN  27 is eclipsing
(Type E) 2007   12   23   10    7. Beta angle  11.60
STATUS :120113:1633: 6.0 YAWTAB/orbits/get_ecl_pos: Blk IIA PRN   8 is eclipsing
(Type E) 2007   12   23   10   51. Beta angle   7.90
STATUS :120113:1633: 6.0 YAWTAB/orbits/get_ecl_pos: Blk IIA PRN  10 is eclipsing
(Type E) 2007   12   23   12   32. Beta angle   8.60
STATUS :120113:1633: 6.0 YAWTAB/orbits/get_ecl_pos: Blk IIR PRN  18 is eclipsing.
Dusk time  2007   12   23   12   57. Beta angle   8.57
STATUS :120113:1633: 6.0 YAWTAB/orbits/get_ecl_pos: Blk IIR PRN  22 is eclipsing.
Dusk time  2007   12   23   14    6. Beta angle   8.71
STATUS :120113:1633: 6.0 YAWTAB/orbits/get_ecl_pos: Blk IIA PRN   9 is eclipsing
(Type E) 2007   12   23   14   32. Beta angle  11.30
STATUS :120113:1633: 6.0 YAWTAB/orbits/get_ecl_pos: Blk IIR PRN  31 is eclipsing.
Dusk time  2007   12   23   15    9. Beta angle   9.93
STATUS :120113:1633: 6.0 YAWTAB/orbits/get_ecl_pos: Blk IIR PRN  20 is eclipsing.
Dusk time  2007   12   23   17   44. Beta angle   6.39
STATUS :120113:1633: 6.0 YAWTAB/orbits/get_ecl_pos: Blk IIA PRN  25 is eclipsing
(Type E) 2007   12   23   21   43. Beta angle  13.30
STATUS :120113:1633: 6.0 YAWTAB/orbits/get_ecl_pos: Blk IIA PRN  27 is eclipsing
(Type E) 2007   12   23   22   10. Beta angle  12.30
STATUS :120113:1633: 6.0 YAWTAB/orbits/get_ecl_pos: Blk IIA PRN   8 is eclipsing
(Type E) 2007   12   23   22   51. Beta angle   8.70
STATUS :120113:1633: 6.0 YAWTAB/orbits/get_ecl_pos: Blk IIA PRN  10 is eclipsing
(Type E) 2007   12   24    0   31. Beta angle   8.30
STATUS :120113:1633: 6.0 YAWTAB/orbits/yawtab: Epoch  500
STATUS :120113:1633: 6.0 YAWTAB/orbits/yawtab: Epoch 1000
STATUS :120113:1633: 6.0 YAWTAB/orbits/yawtab: Epoch 1500
STATUS :120113:1633: 6.0 YAWTAB/orbits/yawtab: Epoch 2000
STATUS :120113:1633: 6.0 YAWTAB/orbits/yawtab: Epoch 2500
STATUS :120113:1633: 6.0 YAWTAB/orbits/yawtab: Epoch 3000
STATUS :120113:1633: 6.0 YAWTAB/orbits/yawtab:  Created file: yigsft.357
STATUS :120113:1633: 6.0 YAWTAB/orbits/yawtab:  Normal stop in YAWTAB
STATUS :120113:1633: 6.0 GRDTAB/grdtab: Program GRDTAB Version 1.11 of 2010/10/14
10:20:00 (Linux)
STATUS :120113:1633: 6.0 GRDTAB/grdtab: GRDTAB Run on 2012/  1/ 13  16:33: 6 by
vmassi11
STATUS :120113:1633: 6.0 GRDTAB/grdtab:  Opened D-file: (Name d20087.357)
STATUS :120113:1633: 6.0 GRDTAB/grdtab: Opened coordinate file: (Name l20087.357)
STATUS :120113:1633: 6.0 GRDTAB/rd_otl_list:  Opened station ocean tide table (Name
otl.list)
STATUS :120113:1633: 6.0 GRDTAB/rd_otl_grid:  Opened ocean-loading grid file (Name
otl.grid)
STATUS :120113:1633: 6.0 GRDTAB/grdtab: Normal stop in GRDTAB - created u20087.357
STATUS :120113:1633: 6.0 MODEL/open: Site AQUI: Started MODEL version 10.40 2012/1/4
09:00:00 (Linux)
STATUS :120113:1633: 6.0 MODEL/open:  Site rename File         : eq_rename
STATUS :120113:1633: 6.0 MODEL/open:  Input Observation File   : xaqui7.357
STATUS :120113:1633: 6.0 MODEL/open:  Output C-file            :
/tmp/caqui7.357.1942645599
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STATUS :120113:1633: 6.0 MODEL/open:  Ephemeris (T-) File      : tigsf7.357
STATUS :120113:1633: 6.0 MODEL/open:  Loading/Met (U-) File : u20087.357
STATUS :120113:1633: 7.0 MODEL/setup: Yaw modelling is implemented
STATUS :120113:1633: 7.0 MODEL/model: Begin processing
STATUS :120113:1633: 9.0 MODEL/model: 25089 valid observations
STATUS :120113:1633: 9.0 MODEL/model:  PRN   8 is seen eclipsing from 2007 12 23
22:51  to  2007 12 23  23:36
STATUS :120113:1633: 9.0 MODEL/model:  PRN   9 is seen eclipsing from 2007 12 23
2:32  to  2007 12 23   3:08
STATUS :120113:1633: 9.0 MODEL/model:  PRN  10 is seen eclipsing from 2007 12 23
0:34  to  2007 12 23   1:18
STATUS :120113:1633: 9.0 MODEL/model:  PRN  18 is seen eclipsing from 2007 12 23
3:38  to  2007 12 23   4:22
STATUS :120113:1633: 9.0 MODEL/model:  PRN  20 is seen eclipsing from 2007 12 23
20:18  to  2007 12 23  21:08
STATUS :120113:1633: 9.0 MODEL/model:  PRN  22 is seen eclipsing from 2007 12 23
4:47  to  2007 12 23   5:30
STATUS :120113:1633: 9.0 MODEL/model:  PRN  25 is seen eclipsing from 2007 12 23
21:43  to  2007 12 23  22:02
STATUS :120113:1633: 9.0 MODEL/model:  PRN  27 is seen eclipsing from 2007 12 23
22:10  to  2007 12 23  22:37
STATUS :120113:1633: 9.0 MODEL/model:  PRN  31 is seen eclipsing from 2007 12 23
17:48  to  2007 12 23  18:28
STATUS :120113:1633: 9.0 MODEL/model: Site AQUI Normal stop in MODEL after  2880
epochs
STATUS :120113:1634: 3.0 AUTCLN/ctog_mem: Allocating    61.38 Mbytes for run
STATUS :120113:1634: 3.0 AUTCLN/main: Start: Reading cfiles
STATUS :120113:1634: 5.0 AUTCLN/main: Estimating clocks from range data. Pass  1
STATUS :120113:1634: 8.0 AUTCLN/main: Estimating clocks from phase data. Pass  1
STATUS :120113:1634:10.0 AUTCLN/main: Scanning Double difference for slips. Pass  1
STATUS :120113:1634:11.0 AUTCLN/main: Estimating clocks from range data. Pass  2
STATUS :120113:1634:12.0 AUTCLN/main: Prealligning phase data. Pass  2
STATUS :120113:1634:12.0 AUTCLN/main: Estimating clocks from phase data. Pass  2
STATUS :120113:1634:14.0 AUTCLN/main: Scanning Double difference for slips. Pass  2
STATUS :120113:1634:22.0 AUTCLN/main: Estimating clocks from range data. Pass  3
STATUS :120113:1634:24.0 AUTCLN/main: Prealligning phase data. Pass  3
STATUS :120113:1634:24.0 AUTCLN/main: Estimating clocks from phase data. Pass  3
STATUS :120113:1634:26.0 AUTCLN/main: Scanning Double difference for slips. Pass  3
STATUS :120113:1634:34.0 AUTCLN/main: Estimating clocks from range data. Pass  4
STATUS :120113:1634:36.0 AUTCLN/main: Prealligning phase data. Pass  4
STATUS :120113:1634:36.0 AUTCLN/main: Estimating clocks from phase data. Pass  4
STATUS :120113:1634:38.0 AUTCLN/main: Scanning Double difference for slips. Pass  4
STATUS :120113:1634:46.0 AUTCLN/main: Estimating clocks from range data. Pass  5
STATUS :120113:1634:48.0 AUTCLN/main: Prealligning phase data. Pass  5
STATUS :120113:1634:48.0 AUTCLN/main: Estimating clocks from phase data. Pass  5
STATUS :120113:1634:50.0 AUTCLN/main: Scanning Double difference for slips. Pass  5
STATUS :120113:1634:58.0 AUTCLN/main: Cleaning data. First pass
STATUS :120113:1634:58.0 AUTCLN/main: Cleaning data. Iteration  2
STATUS :120113:1634:59.0 AUTCLN/main: Cleaning data. Iteration  3
STATUS :120113:1635: 0.0 AUTCLN/main: Start Flat DD
STATUS :120113:1635: 4.0 AUTCLN/main: Final Phase clock fit
STATUS :120113:1635: 4.0 AUTCLN/main: +Phase clock and bias estimation pass   2
STATUS :120113:1635: 6.0 AUTCLN/main: Outputing clean c-files
STATUS :120113:1635:19.0 AUTCLN/main: Finished
STATUS :120113:1635:19.0 CFMRG/cversn: Started CFMRG ver. 9.54 of 2010/8/27 13:15
(Linux)          Library ver. 10.89 of 2012/1/04 09:00:00 (Linux)
STATUS :120113:1635:19.0 CFMRG/cfmrg: Parameter summary written to file cfmrg.out
STATUS :120113:1635:19.0 CFMRG/cfmrg: Normal stop in CFMRG
STATUS :120113:1635:19.0 SOLVE/sversn: Started SOLVE ver. 10.42 2010/11/04 13:00
(Linux)           Library ver. 10.89 of 2012/1/04 09:00:00 (Linux)
STATUS :120113:1635:19.0 SOLVE/lsquar: Reading C-file headers
STATUS :120113:1635:19.0 SOLVE/normd: Reading data and forming normal equations
STATUS :120113:1635:20.0 SOLVE/normd:  Epoch < 200 >     1:39:30.000
STATUS :120113:1635:20.0 SOLVE/normd:  Epoch < 400 >     3:19:30.000
STATUS :120113:1635:21.0 SOLVE/normd:  Epoch < 600 >     4:59:30.000
STATUS :120113:1635:22.0 SOLVE/normd:  Epoch < 800 >     6:39:30.000
STATUS :120113:1635:23.0 SOLVE/normd:  Epoch <1000 >     8:19:30.000
STATUS :120113:1635:23.0 SOLVE/normd:  Epoch <1200 >     9:59:30.000
STATUS :120113:1635:25.0 SOLVE/normd:  Epoch <1400 >    11:39:30.000
STATUS :120113:1635:25.0 SOLVE/normd:  Epoch <1600 >    13:19:30.000
STATUS :120113:1635:26.0 SOLVE/normd:  Epoch <1800 >    14:59:30.000
STATUS :120113:1635:27.0 SOLVE/normd:  Epoch <2000 >    16:39:30.000
STATUS :120113:1635:28.0 SOLVE/normd:  Epoch <2200 >    18:19:30.000
STATUS :120113:1635:29.0 SOLVE/normd:  Epoch <2400 >    19:59:30.000
STATUS :120113:1635:31.0 SOLVE/normd:  Epoch <2600 >    21:39:30.000
STATUS :120113:1635:32.0 SOLVE/normd:  Epoch <2800 >    23:19:30.000
STATUS :120113:1635:32.0 SOLVE/lsquar: Setting up mapping operator for bias
parameters
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STATUS :120113:1635:32.0 SOLVE/lsquar: Calculating new normal equation submatrices
STATUS :120113:1635:44.0 SOLVE/lsquar: Finding and removing dependent biases
STATUS :120113:1635:51.0 SOLVE/fnddbi: Bias matrix ill conditioned - bias removed
with rcond: 0.909495E-12 ratio:    0.799E+12
STATUS :120113:1635:51.0 SOLVE/lsquar: Applying a priori 1000.0 cyc sigma on biases
STATUS :120113:1635:51.0 SOLVE/lsquar: Solving initial normal equations
STATUS :120113:1635:52.0 SOLVE/lsquar: Finished solving initial normal equations
STATUS :120113:1635:52.0 SOLVE/lsqerr: Constrained bias-free nrms =  0.127D+00
STATUS :120113:1635:52.0 SOLVE/lcloos: Performing LC biases-free loose solution
STATUS :120113:1635:52.0 SOLVE/lcnorm: Solving normal equations in LC mode
STATUS :120113:1635:53.0 SOLVE/lsqerr: Loose bias-free nrms =       0.127D+00
STATUS :120113:1635:53.0 SOLVE/solve: Normal stop
STATUS :120113:1635:53.0 MODEL/open: Site AQUI: Started MODEL version 10.40 2012/1/4
09:00:00 (Linux)
STATUS :120113:1635:53.0 MODEL/open:  Site rename File         : eq_rename
STATUS :120113:1635:53.0 MODEL/open:  Input Observation File   : xaqui7.357
STATUS :120113:1635:53.0 MODEL/open:  Output C-file            :
/tmp/caquib.357.3019145599
STATUS :120113:1635:53.0 MODEL/open:  Ephemeris (T-) File      : tigsf7.357
STATUS :120113:1635:53.0 MODEL/open:  Loading/Met (U-) File : u20087.357
STATUS :120113:1635:54.0 MODEL/setup: Yaw modelling is implemented
STATUS :120113:1635:54.0 MODEL/model: Begin processing
STATUS :120113:1635:56.0 MODEL/model: 25089 valid observations
STATUS :120113:1635:56.0 MODEL/model:  PRN   8 is seen eclipsing from 2007 12 23
22:51  to  2007 12 23  23:36
STATUS :120113:1635:56.0 MODEL/model:  PRN   9 is seen eclipsing from 2007 12 23
2:32  to  2007 12 23   3:08
STATUS :120113:1635:56.0 MODEL/model:  PRN  10 is seen eclipsing from 2007 12 23
0:34  to  2007 12 23   1:18
STATUS :120113:1635:56.0 MODEL/model:  PRN  18 is seen eclipsing from 2007 12 23
3:38  to  2007 12 23   4:22
STATUS :120113:1635:56.0 MODEL/model:  PRN  20 is seen eclipsing from 2007 12 23
20:18  to  2007 12 23  21:08
STATUS :120113:1635:56.0 MODEL/model:  PRN  22 is seen eclipsing from 2007 12 23
4:47  to  2007 12 23   5:30
STATUS :120113:1635:56.0 MODEL/model:  PRN  25 is seen eclipsing from 2007 12 23
21:43  to  2007 12 23  22:02
STATUS :120113:1635:56.0 MODEL/model:  PRN  27 is seen eclipsing from 2007 12 23
22:10  to  2007 12 23  22:37
STATUS :120113:1635:56.0 MODEL/model:  PRN  31 is seen eclipsing from 2007 12 23
17:48  to  2007 12 23  18:28
STATUS :120113:1635:56.0 MODEL/model: Site AQUI Normal stop in MODEL after  2880
epochs
STATUS :120113:1636:51.0 AUTCLN/main: Start: Reading cfiles
STATUS :120113:1636:53.0 AUTCLN/main: Estimating clocks from range data. Pass  1
STATUS :120113:1636:56.0 AUTCLN/main: Estimating clocks from phase data. Pass  1
STATUS :120113:1636:58.0 AUTCLN/main: Scanning Double difference for slips. Pass  1
STATUS :120113:1636:58.0 AUTCLN/main: Estimating clocks from range data. Pass  2
STATUS :120113:1637: 0.0 AUTCLN/main: Prealligning phase data. Pass  2
STATUS :120113:1637: 0.0 AUTCLN/main: Estimating clocks from phase data. Pass  2
STATUS :120113:1637: 2.0 AUTCLN/main: Scanning Double difference for slips. Pass  2
STATUS :120113:1637: 9.0 AUTCLN/main: Estimating clocks from range data. Pass  3
STATUS :120113:1637:12.0 AUTCLN/main: Prealligning phase data. Pass  3
STATUS :120113:1637:12.0 AUTCLN/main: Estimating clocks from phase data. Pass  3
STATUS :120113:1637:14.0 AUTCLN/main: Scanning Double difference for slips. Pass  3
STATUS :120113:1637:23.0 AUTCLN/main: Estimating clocks from range data. Pass  4
STATUS :120113:1637:25.0 AUTCLN/main: Prealligning phase data. Pass  4
STATUS :120113:1637:26.0 AUTCLN/main: Estimating clocks from phase data. Pass  4
STATUS :120113:1637:27.0 AUTCLN/main: Scanning Double difference for slips. Pass  4
STATUS :120113:1637:35.0 AUTCLN/main: Estimating clocks from range data. Pass  5
STATUS :120113:1637:38.0 AUTCLN/main: Prealligning phase data. Pass  5
STATUS :120113:1637:38.0 AUTCLN/main: Estimating clocks from phase data. Pass  5
STATUS :120113:1637:40.0 AUTCLN/main: Scanning Double difference for slips. Pass  5
STATUS :120113:1637:48.0 AUTCLN/main: Cleaning data. First pass
STATUS :120113:1637:49.0 AUTCLN/main: Cleaning data. Iteration  2
STATUS :120113:1637:50.0 AUTCLN/main: Cleaning data. Iteration  3
STATUS :120113:1637:50.0 AUTCLN/main: Start Flat DD
STATUS :120113:1637:55.0 AUTCLN/main: Final Phase clock fit
STATUS :120113:1637:55.0 AUTCLN/main: +Phase clock and bias estimation pass   2
STATUS :120113:1637:56.0 AUTCLN/main: +Phase clock and bias estimation pass   3
STATUS :120113:1637:58.0 AUTCLN/main: +Phase clock and bias estimation pass   4
STATUS :120113:1637:59.0 AUTCLN/main: +Phase clock and bias estimation pass   5
STATUS :120113:1638: 1.0 AUTCLN/main: +Phase clock and bias estimation pass   6
STATUS :120113:1638: 2.0 AUTCLN/main: +Phase clock and bias estimation pass   7
STATUS :120113:1638: 3.0 AUTCLN/main: +Phase clock and bias estimation pass   8
STATUS :120113:1638: 5.0 AUTCLN/main: +Phase clock and bias estimation pass   9
STATUS :120113:1638: 6.0 AUTCLN/main: +Phase clock and bias estimation pass  10
STATUS :120113:1638: 8.0 AUTCLN/main: +Phase clock and bias estimation pass  11
```

```
STATUS :120113:1638: 9.0 AUTCLN/main: +Phase clock and bias estimation pass  12
STATUS :120113:1638:10.0 AUTCLN/main: +Phase clock and bias estimation pass  13
STATUS :120113:1638:11.0 AUTCLN/main: +Phase clock and bias estimation pass  14
STATUS :120113:1638:13.0 AUTCLN/main: +Phase clock and bias estimation pass  15
STATUS :120113:1638:15.0 AUTCLN/main: +Phase clock and bias estimation pass  16
STATUS :120113:1638:42.0 AUTCLN/main: One-way bias flag removal
STATUS :120113:1638:42.0 AUTCLN/scan_nodd: Starting scan
STATUS :120113:1638:43.0 AUTCLN/scan_nodd: Finishing scan
STATUS :120113:1638:43.0 AUTCLN/est_dd_wl: WL DD Reference site UNOV PRN_12 BF  746
Duration  804 Epochs
STATUS :120113:1638:43.0 AUTCLN/est_comb: Start LC
STATUS :120113:1638:54.0 AUTCLN/est_comb: Start EXWL
STATUS :120113:1639: 7.0 AUTCLN/est_comb: Start MWWL
STATUS :120113:1639:20.0 AUTCLN/main: Outputing clean c-files
STATUS :120113:1639:32.0 AUTCLN/main: Finished
STATUS :120113:1639:32.0 CFMRG/cversn: Started CFMRG ver. 9.54 of 2010/8/27 13:15
(Linux)          Library ver. 10.89 of 2012/1/04 09:00:00 (Linux)
STATUS :120113:1639:32.0 CFMRG/cfmrg: Parameter summary written to file cfmrg.out
STATUS :120113:1639:33.0 CFMRG/cfmrg: Normal stop in CFMRG
STATUS :120113:1639:33.0 SOLVE/sversn: Started SOLVE ver. 10.42 2010/11/04 13:00
(Linux)           Library ver. 10.89 of 2012/1/04 09:00:00 (Linux)
STATUS :120113:1639:33.0 SOLVE/lsquar: Reading C-file headers
STATUS :120113:1639:33.0 SOLVE/normd: Reading data and forming normal equations
STATUS :120113:1639:34.0 SOLVE/normd:  Epoch < 200 >     1:39:30.000
STATUS :120113:1639:35.0 SOLVE/normd:  Epoch < 400 >     3:19:30.000
STATUS :120113:1639:36.0 SOLVE/normd:  Epoch < 600 >     4:59:30.000
STATUS :120113:1639:38.0 SOLVE/normd:  Epoch < 800 >     6:39:30.000
STATUS :120113:1639:40.0 SOLVE/normd:  Epoch <1000 >     8:19:30.000
STATUS :120113:1639:43.0 SOLVE/normd:  Epoch <1200 >     9:59:30.000
STATUS :120113:1639:45.0 SOLVE/normd:  Epoch <1400 >    11:39:30.000
STATUS :120113:1639:46.0 SOLVE/normd:  Epoch <1600 >    13:19:30.000
STATUS :120113:1639:48.0 SOLVE/normd:  Epoch <1800 >    14:59:30.000
STATUS :120113:1639:49.0 SOLVE/normd:  Epoch <2000 >    16:39:30.000
STATUS :120113:1639:52.0 SOLVE/normd:  Epoch <2200 >    18:19:30.000
STATUS :120113:1639:54.0 SOLVE/normd:  Epoch <2400 >    19:59:30.000
STATUS :120113:1639:57.0 SOLVE/normd:  Epoch <2600 >    21:39:30.000
STATUS :120113:1639:58.0 SOLVE/normd:  Epoch <2800 >    23:19:30.000
STATUS :120113:1639:59.0 SOLVE/lsquar: Setting up mapping operator for bias
parameters
STATUS :120113:1639:59.0 SOLVE/lsquar: Calculating new normal equation submatrices
STATUS :120113:1640:19.0 SOLVE/lsquar: Finding and removing dependent biases
STATUS :120113:1640:19.0 SOLVE/fnddbi: Bias matrix ill conditioned - bias removed
with rcond: 0.407454E-09 ratio:    0.847E+13
STATUS :120113:1640:20.0 SOLVE/fnddbi: Bias matrix ill conditioned - bias removed
with rcond: 0.232831E-09 ratio:    0.647E+13
STATUS :120113:1640:25.0 SOLVE/lsquar: Applying a priori 1000.0 cyc sigma on biases
STATUS :120113:1640:25.0 SOLVE/lsquar: Solving initial normal equations
STATUS :120113:1640:28.0 SOLVE/lsquar: Finished solving initial normal equations
STATUS :120113:1640:28.0 SOLVE/lc_solution: Solving LC normal equations after L1/L2
separate
STATUS :120113:1640:28.0 SOLVE/lcnorm: Solving normal equations in LC mode
STATUS :120113:1640:29.0 SOLVE/lc_solution: LC solution complete
STATUS :120113:1640:29.0 SOLVE/get_widelane: Fixing wide-lane ambiguities from AUTCLN
N-file
STATUS :120113:1640:36.0 SOLVE/lsqerr: Constrained bias-free nrms =  0.175D+00
STATUS :120113:1640:36.0 SOLVE/get_narrowlane: Resolving narrow-lane ambiguities
STATUS :120113:1640:38.0 SOLVE/lsqerr: Constrained bias-fixed nrms = 0.189D+00
STATUS :120113:1640:38.0 SOLVE/lcloos: Performing LC biases-free loose solution
STATUS :120113:1640:38.0 SOLVE/lcnorm: Solving normal equations in LC mode
STATUS :120113:1640:38.0 SOLVE/lsqerr: Loose bias-free nrms =       0.175D+00
STATUS :120113:1640:38.0 SOLVE/lcloos: Performing biases-fixed loose solution
STATUS :120113:1640:41.0 SOLVE/lsqerr: Loose bias-fixed nrms =      0.188D+00
STATUS :120113:1640:41.0 SOLVE/solve: Normal stop
```

Within this entire file are listed all modules run with GAMIT for each station and is possible to check if there is some problem with the computation.

There are two first-order criteria for determining if a solution is acceptable:

1) Are there adequate data to perform a reasonable estimate?

2) Do the data fit the model to their noise level?

The primary indicator that the first criterion has been met is the magnitude of the uncertainties of the baseline components that are included within q-files. For the second criterion, the primary indicator is the "normalized rms" (nrms) of the solution. In practice with the default weighting scheme, a good solution usually produces a nrms of about 0.2.

If the final solution of a batch sequence meets these two criteria, there is usually no need to look carefully at any other output. This last criterion is included within sh_gamit_ddd.summary file shown below, for best and worst two sites of network.

- Sh_gamit_357.summary:

```
Sites excluded by xsite command thht

Postfit RMS rms, total and by satellite
RMS  IT Site   All   01   02   03   04   05   06   08   09   10   11   12   13   14   15   16   17   18   19   20   21   22   23   24   25   26   27   28   30   31
RMS  16 ALL    6.4  70  71  54  80  55  56  59  58  74  59  57  56  73  57  60  69  75  55  58  61  69  57  73  60  54  58  71  57  75
Best and Worst two sites:
RMS  16 REPI   3.7    4    4    3    5    3    4    3    3    5    3    3    4    4    3    3    4    4    3    4    3    3    3    4    3    3    3    4    3    5
RMS  16 REMO   4.5    4    5    4    6    5    4    3    5    6    4    5    4    5    4    4    5    5    4    4    4    4    4    6    3    3    4    6    4    5
RMS  16 CAGL   8.3    9   11    6   10    7    7    8    9    8    9    8    7   10    8    6    8   11    6    7    6    9    6   11    7    8    6    9    7    9
RMS  16 MEDI   8.3   10    8    7   10    7    6    9    7   11    7    7    6    8    8    7    8   10    7    6    8   12    7    9    7    6    7   11    8    9

Double difference statistics
 Prefit nrms:  0.55121E+00    Postfit nrms: 0.17543E+00
 Prefit nrms:  0.54960E+00    Postfit nrms: 0.18864E+00
 Prefit nrms:  0.55121E+00    Postfit nrms: 0.17532E+00
 Prefit nrms:  0.54960E+00    Postfit nrms: 0.18828E+00
 Number of double differences:  89041

 Phase ambiguities (Total  WL-fixed   NL-fixed): 527 527 517  AUTCLN (Total Expected)  527 527
 Phase ambiguities WL fixed 100.0% NL fixed  98.1%

Processing 2007 357 GPS week 1459 0 Using node: js2 Finished at: 12_01_13_16:40:41
```

Is possible notes which the values are less than 0.2 suggesting so a good quality of computation results.

In addition, looking into the results shown in Appendix A, is possible to see which the mean of uncertainties on Z and X components are 5 mm and approximately 2-3 mm on Y and L components.

We omitted for brevity the results with GAMIT of all others Julian day of 2007/2008 and 2011 also because the results show almost the same magnitude of uncertainties.

The alignment of these values on ITRF05 is made with GLOBK, which allows the obtaining of final values of coordinates of sites expressed on ITRF05 datum. Without this alignment it would be impossible derive any conclusion about the displacement.

This step will be the argument of next chapter.

Chapter 6

GLOBK network computation and results

6.1 Introduction on GLOBK processing

GLOBK is a module composed by "*glred*" which use h-files as input to a Kalman filter to produce a daily solution and by "*glorg*" which applies generalized constraints to the combined solution to align the solution obtained with GAMIT in a specific reference frame.

The starting point of processing is an ensemble of quasi-observation files which it has been obtained by GAMIT processing and its represents the input files. The first step is to convert the ASCII quasi-observation files into binary h-files that can be read by GLOBK. This is made using the program "*htoglb"*.

For GPS processing the second step is usually to run *glred* for all binary h-files from a survey or period of continuous observations to obtain a time series of station coordinates.

The script "*sh_glred*", combines these initial steps, invoking in sequence *htoglb*, *glred*, and plotting of time series.

The GLOBK estimates are usually obtained with loose constraints and "*glorg"* is run to impose reference frame constraints.

6.2 Directory structure

GLOBK does not require any particular directory structure, but the one used by "*sh_gamit"* and "*sh_glred"* works well, with the following directories at the same level as the day directories created by GAMIT run:

- *"glbf"* contains the binary h-files;
- *"gsoln"* for running solutions and it contains the command files, lists of binary hfiles, experiment list files and globk output files;

- “tables” for files of a priori station coordinates.

6.3 GLOBK input files

There are three classes of input to the software:

1) *Quasi-observations,* or *solution files*, which are contained in binary h- or global files which must be created from the output of GAMIT processing. These are produced by program *htoglb* and put into *“glbf”* directory.
2) *A priori values* for station coordinates, *satellite initial conditions* and *parameters*, and *Earth orientation values* are given in the “*tables”*.
3) *Command file* which specifies controls the type of solution, parameters estimated, and constraints applied and which must be edited appropriately.

We list the command files located within “*gsoln*” directory and appropriately edited. The first command file is “*globk_comb.cmd*” and the command file for “*glred”:*

```
* Globk command file to combine two or more daily h-file and/or daily h-files
* into longer spans (e.g weekly or monthly) (no velocities)
*    --works also for daily repeatabilities

* << column 1 must be blank if not comment >>

# renames and earthquakes for global IGS analysis--add local earthquakes and renames
 eq_file ../tables/eq_rename


 make_svs @.svs
 com_file @.com
 srt_file @.srt

### FOR ITRF2008 ### Use
# eq_file ../tables/itrf2008.eq
# apr_file  ../tables/itrf2008.apr

 apr_file ../tables/itrf05.apr
. apr_file ../tables/regional.apr

 sol_file @.sol

 max_chii 13 3
# increase chii and rotation tolerance to include all files for diagnostics
# or to account for natrually large rotations when you have only short baselines
x  max_chi  100  5.0 20000


 in_pmu ../tables/pmu.usno

 crt_opt NOPR
# rwk 080916: add MIDP option when combining files of more than one day
 prt_opt NOPR GDLF CMDS MIDP
 org_opt PSUM CMDS GDLF PBOP
 org_cmd glorg_comb.cmd
*  org_out globk_comb.org     ! Normally org file name is generated from print
*                             ! file name and is not given in command file.
```

```
* Apply the pole tide whenever not applied in GAMIT
 app_ptid all

* Stations loose for glorg
 apr_neu  all  10 10 10  0 0 0

* Satellites loose for combination w/ global h-files
x apr_svs  all  10 10 10 1 1 1 1R
#  tight if not combining with global data (may omit if GAMIT in BASELINE mode)
# Do not use Z option on make_svs command above
  apr_svs all   0.05 0.05 0.05   0.005 0.005 0.005  0.01 0.01 0.00 0.01 FR


* If using old SIO h-files, unlink radiation-pressure for satellites with the wrong
block number
#  PN22/SV22  1993-2003
x apr_svs  prn_22 100 100 100 10 10 10 0R
#  PN16/SV56  2003 2 7 - 2003 3 31
x apr_svs  prn_16 100 100 100 10 10 10 0R
#  PN21/SV45  2003 4 1 - 2003 4 30
x apr_svs  prn_21 100 100 100 10 10 10 0R
#  PN22/SV47  2006 12 1 - 2007 2 28
x apr_svs  prn_22 100 100 100 10 10 10 0R
#  PN12/SV58  2006 11 17 - 2007 2 28
x apr_svs  prn_12 100 100 100 10 10 10 0R
#  PN25/SV62  possibly mismatched radition-pressure models in some MIT or SOPAC h-
files
x apr_svs  prn_25 100 100 100 10 10 10 0R
#  Unlink rad parms for some days that have chi2 > 0.3
x  apr_svs  all  100 100 100 10 10 10 0R


*  apply constraints before 1994
x  apr_svs  all  .1 .1 .1 .01 .01 .01 F F F F F F F F F

# EOP loose if estimating rotation in glorg
 apr_wob  10 10  10 10
 apr_ut1   F 10

# EOP tight if translation-only stabilization in glorg
x  apr_wob .25 .25 .1 .1
x  apr ut1 .25 .1

# Comment out this line if not saving a combined H-file
 out_glb  H------_comb.GLX

# Optionally put a long uselist and/or sig_neu and mar_neu reweight in a source file
x  source ../tables/uselist
x  source ../tables/daily_reweights
# Remove the command below if you want to glorg separately on the combination
# solution.
  del_scra yes
```

The command file for *glorg* is *glorg_comb.cmd* and is shown below:

```
* Glorg command file for daily- to monthly solutions (no velocities)
*    --works also for daily repeatabilities

* << column 1 must be blank if not comment >>

 apr_file ../tables/itrf05.apr
# Substitute a regional solution for spatial filtering:
x apr_file ../tables/vel_070425c.apr

# Position and rotation (moderate to large spatial scale, at least 6 well-distributed
stations)
 pos_org xtran ytran ztran xrot yrot zrot
# Position only (small network, EOP constrained in globk)
x pos_org xtran ytran ztran

# Natural downweight of heights is 10 in variance (3 in sigma)
 cnd_hgtv  10  10 3. 3.
# Downweight heights 20-1000 if necessary (but need more stations for redundancy)
x cnd_hgtv  100 100 3. 3.
```

```
# Set n-sigma for keeping station between 2.5 and 4.0
 stab_it 4 0.5  2.5

# List of stations for stabilization (default is 'all')
 stab_site clear
 source ../tables/stab_site.global
#  substitute or augment a regional list for spatial filtering
. source ../tables/stab_site.regional
```

As already mentioned, for a frame solution, "*glorg*" uses the "generalized constraint" method in which up to seven Helmut parameters (3 translations, 3 rotations, and 1 scale) are estimated such that adjustments to a priori values of the coordinates of a group of stations are minimized.

For global- or continental-scale networks we usually estimate only translation and rotation and include as reference ("stabilization") sites a distributed set of stations for which you have both good a priori values and good data.

The reference frame for your solution is realized by data you have for the sites specified in the "*stab_site.global"* mentioned within "*glorg*" command file and which contain the list of sites used to frame the network in ITRF05 applying the generalized constraint on the solution obtained with *glred.*

Below is shown just that file:

```
* Global stabilization list for ITRF05
*  last changed by rwk 080409

 stab_site clear

* Eurasia-stab
 stab_site cagl bzrg geno gras ieng
 stab_site mate medi not1 pado
```

In this project we used the 9 IGS stabilization sites listed in the file above.

At this point all files are edited and it is possible to run GLOBK modules to computes the final coordinates.

6.4 Running glred and glorg

With GLOBK it is possible to run in sequence *glred* and *glorg* for all month of data using only one command. Below is shown this command for 2 different years:

- *sh_glred -s* 2007 357 2008 019 *–expt* 2008 *–noftp –opt* H G E;
- *sh_glred -s* 2011 163 190 *–expt* 2011 *–noftp –opt* H G E;

where *glred* uses the hfiles as input to a Kalman filter to produce a combined solution and *glorg* applies generalized constraints to the combined solution.
The option H establish which h-files within "*glbf*" directory must be used. G is used for save *glred* command line to file called "*sh_glred.cmd*" while the E is used for plot the results.

6.5 GLOBK output

There are two types of output produced in running *glred*. The first is the "log" file, which contains the effect on the solution (usually loosely constrained), as each new h-file is added. The second is the "print" file, generated also by *glorg*, which contains the estimated parameter values.
We have used *glorg* to define the reference frame, then we have obtained two versions of the solution file, one from the *glred* solution (the .prt file in the globk command-line arguments) and one from the *glorg* solution (the .org file in the globk command file).
Since the *glred* output is loosely constrained, only the height and baseline length components have sufficient small uncertainties to be useful for careful evaluation.
Examining the *glred* output it is useful if the *glorg* output indicates a problem with the solution and you want to determine if the source is in the data or the constraints.
For this reason we only show the *glorg* output file (*e.g. globk_2008_07357.org*) which contains the final coordinates of station sites expressed in ellipsoidal coordinates.

For brevity is showed only the output of computation from Julian doy 357 2007:

```
Globk Analysis

 +++++++++++++++++++++++++++++++++++++
 + GLORG                Version 5.16 +
 +++++++++++++++++++++++++++++++++++++


 Stabilization with  50.0% constant,  50.0% site dependent weighting.
 Delete sites with   2.5-sigma condition.
 Height variance factor      10.00 Position,     10.00 Velocity
 For Position: Min dH sigma 0.0050 m;    Min RMS 0.0030 m,    Min dNE sigma 0.00050 m
 For Velocity: Min dH sigma 0.0050 m/yr; Min RMS 0.0030 m/yr, Min dNE sigma 0.00010
m/yr
 Sigma Ratio to allow use: Position   3.00 Velocity   3.00

=====================================================================================
===============
 Starting Position stabilization iteration   1 L0712241200_2008.glx
 For    9 sites in origin, min/max height sigma     130.60    131.66 mm; Median
131.01 mm, Tol      15.00 mm L0712241200_2008.glx

 Position system stabilization results
 ----------------------------------------
 X Rotation  (mas)     9.15416 +-    3.92984 Iter  1 L0712241200_2008.glx
 Y Rotation  (mas)     1.82342 +-    2.96791 Iter  1 L0712241200_2008.glx
 Z Rotation  (mas)     3.62113 +-    3.65557 Iter  1 L0712241200_2008.glx
 X Translation (m)     0.27636 +-    0.09240 Iter  1 L0712241200_2008.glx
 Y Translation (m)    -0.09908 +-    0.13913 Iter  1 L0712241200_2008.glx
 Z Translation (m)    -0.37679 +-    0.08352 Iter  1 L0712241200_2008.glx
 Condition Sigmas used     0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
Sites and relative sigmas used in stabilization
MATE_4PS   1.00  NOT1_GPS   1.00  PADO_GPS   1.00  MEDI_2PS   1.00  BZRG_GPS   1.00
CAGL_2PS   1.00
GENO_GPS   1.00  IENG_GPS   1.00  GRAS_3PS   1.00
 For   27 Position Iter  1 Pre RMS    0.0881 m; Post RMS   0.00515 m
L0712241200_2008.glx
 For    9 sites in origin, min/max NE sigma       1.77      2.71 mm; Median
1.98 mm, Tol       1.50 mm L0712241200_2008.glx
Deleting MATE_4PS Position error   0.0196 m, relative variance     0.96 Nsigma
3.89
Deleting BZRG_GPS Position error   0.0214 m, relative variance     0.94 Nsigma
4.28

=====================================================================================
===============
 Starting Position stabilization iteration   2 L0712241200_2008.glx
 For    7 sites in origin, min/max height sigma     130.85    131.66 mm; Median
131.04 mm, Tol      15.00 mm L0712241200_2008.glx

 Position system stabilization results
 ----------------------------------------
 X Rotation  (mas)     4.09675 +-    1.14190 Iter  2 L0712241200_2008.glx
 Y Rotation  (mas)     0.41294 +-    0.96958 Iter  2 L0712241200_2008.glx
 Z Rotation  (mas)    -0.75334 +-    1.21781 Iter  2 L0712241200_2008.glx
 X Translation (m)     0.15677 +-    0.02718 Iter  2 L0712241200_2008.glx
 Y Translation (m)     0.02774 +-    0.04642 Iter  2 L0712241200_2008.glx
 Z Translation (m)    -0.26743 +-    0.02396 Iter  2 L0712241200_2008.glx
 Condition Sigmas used     0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
Sites and relative sigmas used in stabilization
NOT1_GPS   1.00  PADO_GPS   1.00  MEDI_2PS   1.09  CAGL_2PS   0.99  GENO_GPS   1.01
IENG_GPS   0.98
GRAS_3PS   0.97
 For   21 Position Iter  2 Pre RMS    0.0878 m; Post RMS   0.00125 m
L0712241200_2008.glx
 For    7 sites in origin, min/max NE sigma       1.73      2.69 mm; Median
1.95 mm, Tol       1.50 mm L0712241200_2008.glx

=====================================================================================
===============
 Starting Position stabilization iteration   3 L0712241200_2008.glx
 For    7 sites in origin, min/max height sigma     130.85    131.66 mm; Median
131.04 mm, Tol      15.00 mm L0712241200_2008.glx

 Position system stabilization results
```

```
 ---------------------------------------
 X Rotation  (mas)     4.08795 +-    1.14183 Iter  3 L0712241200_2008.glx
 Y Rotation  (mas)     0.42486 +-    0.96631 Iter  3 L0712241200_2008.glx
 Z Rotation  (mas)    -0.74639 +-    1.21627 Iter  3 L0712241200_2008.glx
 X Translation (m)     0.15661 +-    0.02720 Iter  3 L0712241200_2008.glx
 Y Translation (m)     0.02733 +-    0.04632 Iter  3 L0712241200_2008.glx
 Z Translation (m)    -0.26719 +-    0.02394 Iter  3 L0712241200_2008.glx
 Condition Sigmas used     0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
Sites and relative sigmas used in stabilization
NOT1_GPS   0.98  PADO_GPS   0.99  MEDI_2PS   1.09  CAGL_2PS   0.99  GENO_GPS   1.01
IENG_GPS   0.98
GRAS_3PS   0.96
 For   21 Position Iter  3 Pre RMS    0.0885 m; Post RMS   0.00126 m
L0712241200_2008.glx
 For    7 sites in origin, min/max NE sigma       1.73      2.69 mm; Median
1.95 mm, Tol       1.50 mm L0712241200_2008.glx

=====================================================================================
===============
 Starting Position stabilization iteration   4 L0712241200_2008.glx
 For    7 sites in origin, min/max height sigma     130.85    131.66 mm; Median
131.04 mm, Tol      15.00 mm L0712241200_2008.glx

 Position system stabilization results
 ---------------------------------------
 X Rotation  (mas)     4.08629 +-    1.14198 Iter  4 L0712241200_2008.glx
 Y Rotation  (mas)     0.42630 +-    0.96587 Iter  4 L0712241200_2008.glx
 Z Rotation  (mas)    -0.74592 +-    1.21613 Iter  4 L0712241200_2008.glx
 X Translation (m)     0.15658 +-    0.02720 Iter  4 L0712241200_2008.glx
 Y Translation (m)     0.02729 +-    0.04631 Iter  4 L0712241200_2008.glx
 Z Translation (m)    -0.26715 +-    0.02394 Iter  4 L0712241200_2008.glx
 Condition Sigmas used     0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
Sites and relative sigmas used in stabilization
NOT1_GPS   0.98  PADO_GPS   0.99  MEDI_2PS   1.09  CAGL_2PS   0.99  GENO_GPS   1.01
IENG_GPS   0.98
GRAS_3PS   0.96
 For   21 Position Iter  4 Pre RMS    0.0885 m; Post RMS   0.00126 m
L0712241200_2008.glx
 For    7 sites in origin, min/max NE sigma       1.73      2.69 mm; Median
1.95 mm, Tol       1.50 mm L0712241200_2008.glx
Rotating into local coordinates for equates
 Checking covariance matrix after equate and force
Globk Analysis


---------------------------------------------------------
 GLOBK Ver 5.19, Global solution
---------------------------------------------------------

 Solution commenced with: 2007/12/24  0: 0    (2007.9781)
 Solution ended with    : 2007/12/24 23:59    (2007.9808)
 Solution refers to     : 2007/12/24 11:59    (2007.9795) [Seconds tag  45.000]
 Satellite IC epoch     : 2007/12/24 12: 0  0.00
 GPS System Information : Time GPST Frame J2000 Precession IAU76 Radiation model
BERNE Nutation IAU00 Gravity EGM08
 MODELS Used in Analysis: SD-WOB  SD-UT1  UNKNOWN E-Tide  K1-Tide PoleTideOC-Load
MeanPTD
 Reference Frame        : itrf05
 Run time               : 2012/ 1/14  5:14 58.00

 There were         1 exps from          1 global files in the solution
 There were       110597 data used,       0 data not used and       110597 data total
 There were           78 global parameters estimated
 There were   29 stations,    0 radio sources, and   29 satellites

 The  prefit chi**2 for      72 input parameters is     0.000

 LIST file      : L0712241200_2008.glx
 COMMON file    : L0712241200_2008.com
 GLOBK CMD file : globk_comb.cmd
 GLORG CMD file : glorg_comb.cmd
 APRIORI file   : ../tables/itrf05.apr
 APRIORI file   : ../tables/itrf05.apr (glorg)
 NUTATION file  :
 PLANETARY file :
 SD ORIENT file :
 PMU file       : ../tables/pmu.usno
```

```
 BACK SOLN file :
 OUTGLOBAL file : H071224_comb.GLX
 SVS EPHEM file : L0712241200_2008.svs_A
 SVS MARKOV file:
 EARTHQUAKE file: ../tables/eq_rename


 SUMMARY POSITION ESTIMATES FROM GLOBK Ver 5.19
  Long.       Lat.      dE adj. dN adj. dE +-  dN +- RHO    dH adj.   dH +-  SITE
(deg)       (deg)      (mm)     (mm)   (mm)     (mm)        (mm)      (mm)

16.70446   40.64913    9.13  -5.89   1.54   1.81  0.056  6.61     5.99 MATE_4PS
14.98979   36.87584   -2.07   1.22   1.13   1.51 -0.456 -4.96     2.48 NOT1_GPS*
13.91596   42.88532   13.40   5.65   1.44   1.68  0.020  4.15     5.57 MART_GPS
13.35025   42.36824   14.21   6.07   1.44   1.66  0.046  5.28     5.56 AQUI_GPS
13.09309   42.79283   16.70   6.22   1.28   1.43  0.020  9.08     4.71 RENO_GPS
12.78205   43.23366    9.97   6.18   1.19   1.36  0.052  6.55     4.61 ITGT_GPS
12.51480   41.82808   11.07   3.74   1.33   1.49  0.039  5.50     5.09 INGR_GPS
12.45074   43.93346    4.65   4.26   1.42   1.63  0.002  2.44     5.58 RSMN_GPS
12.40694   42.78229   15.36   5.84   1.63   1.84  0.036  7.83     6.09 RETO_GPS
12.35570   43.11939    8.31   5.34   1.28   1.47  0.019  4.14     4.92 UNPG_3PS
12.22557   43.45247   14.35   6.68   1.10   1.27  0.015  3.40     4.16 REMO_GPS
12.11947   42.41760   14.61   5.60   1.65   1.84  0.022 -0.02     6.06 VITE_GPS
12.11313   42.71586   11.65   6.63   1.26   1.43  0.033  5.36     4.75 UNOV_GPS
12.00243   42.95212   14.30   7.10   0.93   1.07  0.025  1.85     3.56 REPI_GPS
11.89606   45.41115    1.14   0.94   1.27   1.54  0.046  6.44     4.22 PADO_GPS*
11.64682   44.51996   -2.24  -1.18   1.75   2.05  0.044 -0.49     6.04 MEDI_2PS*
11.33680   46.49902  -13.60  17.34   1.43   1.61 -0.066 -42.22    5.67 BZRG_GPS
11.31299   43.34159    6.98   3.38   1.32   1.51  0.016  0.78     5.12 SIEN_GPS
11.21380   43.79565   14.19   5.93   1.38   1.55 -0.045  2.88     5.41 IGMI_GPS
11.13069   42.42818    7.80   3.73   1.03   1.16  0.027  5.31     3.91 MAON_GPS
 8.97275   39.13591    2.35  -0.98   1.29   1.47  0.075  4.92     3.67 CAGL_2PS*
 8.92114   44.41939    1.50  -1.22   1.39   1.60 -0.034  1.43     5.51 GENO_GPS*
 7.63941   45.01513   -1.23  -0.43   1.21   1.40 -0.061 -10.30    4.39 IENG_GPS*
 6.92057   43.75474    0.31   1.46   1.16   1.28 -0.027  1.48     3.91 GRAS_3PS*
```

Above is shown the *glorg* print file for the same run. It begins with a report of application of generalized constraints to establish the reference frame ("stabilization").

Recall that glorg is minimizing, in an iterative scheme, the departure from a priori values of the coordinates of a selected set of stations while estimating a rotation and translation of the frame. In our case the solution has been obtained after 4 iterations.

The first four lines echo the parameters used to decide whether a station is retained at each iteration of the stabilization scheme. The first line indicates that only 50% of the weight for a station may be changed in each iteration, thus preventing the ratio of weights from becoming too high.

Concerning the results it is possible to appreciate the small magnitude of uncertainties, expressed in mm, valuated with a mean of about 2 mm in plane components and approximately 5 mm in height.

This value has been obtained for almost all Julian days considered in this computation network.

At this point, to accomplish the object of this work, we need to compute the displacement of sites between 2008 and 2011 and this will be the contents of the next chapter.

Chapter 7

Displacement computation

7.1 Strategy of computes

The idea of computing the displacements at each site during the time span 2008 and 2011, consists in using the mean values of each coordinate components computed by *glorg* and making the difference between them.
Following this approach it should be possible to establish the magnitude and direction of displacement.
The mean value at each site, computed using all data at disposal for each period of survey, is stored by *glorg* within the file called "*VAL.expt"* and put into "*gsoln"* directory.
To facilitate the reading of results it has been created the summary table with all mean values of coordinate components which contain also the difference between them.
These differences have been plotted on different graphs, one for each coordinate, separating the resulting plane displacements from height displacements. To Distinguish the two types of movements is necessary because the standard deviations on planimetric components of coordinates is smaller than the standard deviation on vertical components of coordinates due to atmospheric delay that affect more that component of coordinate.

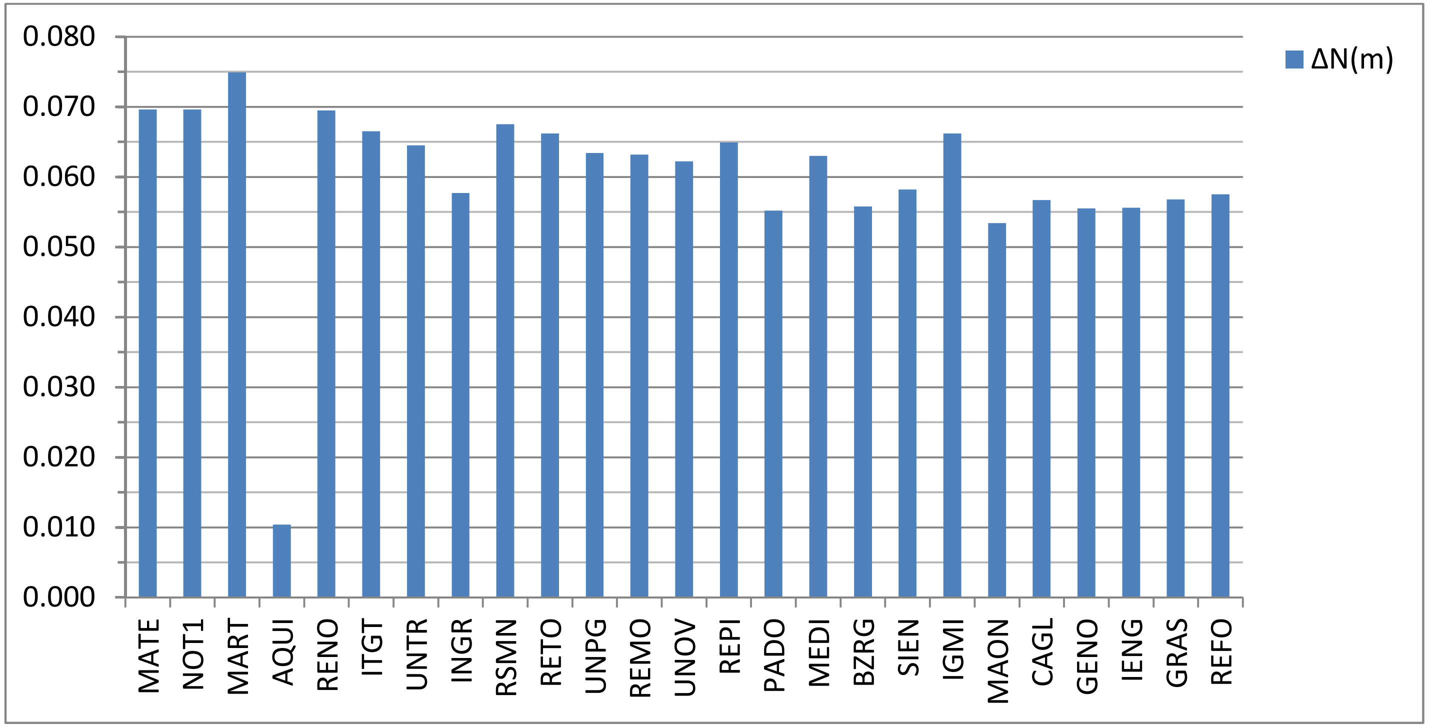
7.2 Analysis results

The table below lists the mean values of coordinate components for both periods 2008 and 2011 and the differences between them which represent the displacements. Is must be noted that "*VITE*" site has been reallocated during the time span and so it can't be considered as significant on displacement computation.

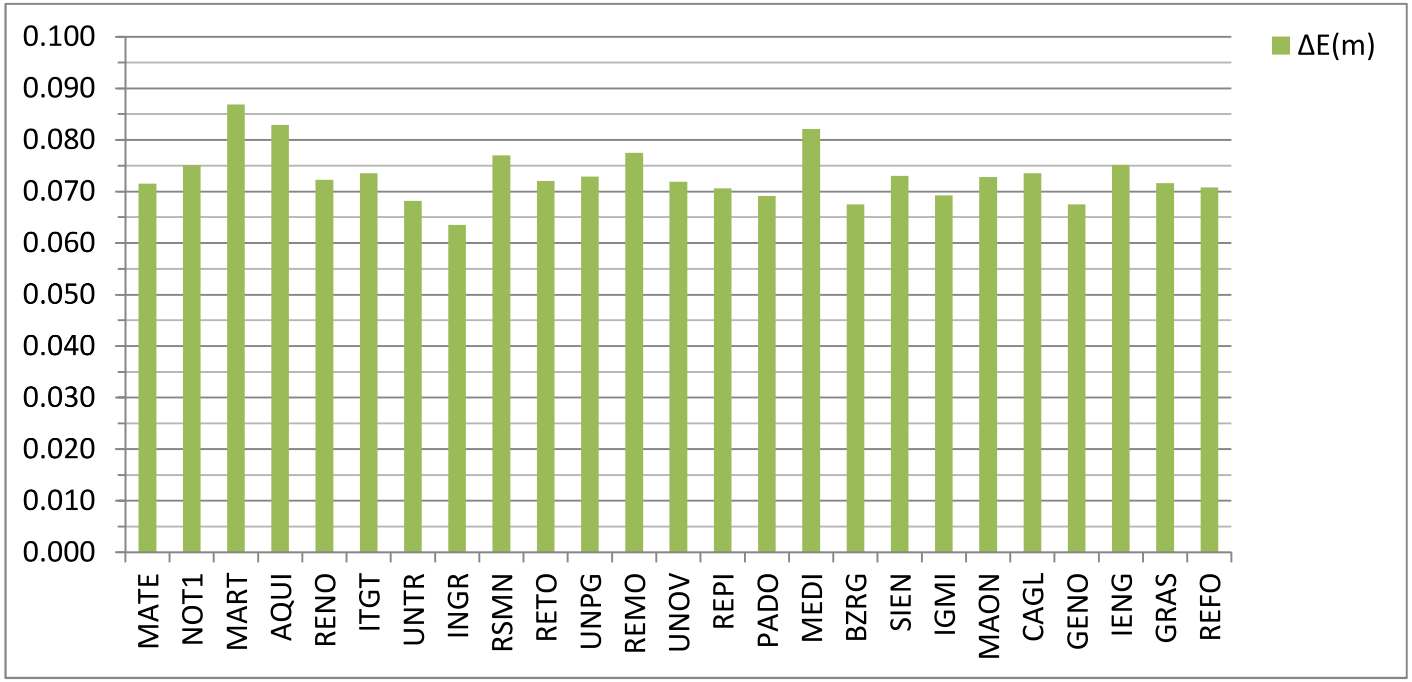
Also the “*RSMN*” station looks like replaced and seems changed the height position, so this station will be considered only for horizontal displacement. All these differences are resumed with graphs subsequently shown.

	2008			2011			Δ(2008/2011)			
	N(m)	E(m)	UP(m)	N(m)	E(m)	UP(m)	ΔN(m)	ΔE(m)	ΔUP(m)	ΔPLAN(m)
MATE	4525040.695	1410869.081	535.654	4525040.765	1410869.153	535.650	0.070	0.072	-0.004	0.100
NOT1	4105000.282	1334829.113	126.338	4105000.352	1334829.188	126.335	0.070	0.075	-0.004	0.102
MART	4773971.898	1135058.657	61.886	4773971.973	1135058.743	61.873	0.075	0.087	-0.013	0.115
AQUI	4716410.922	1098024.500	713.075	4716410.933	1098024.583	712.981	0.010	0.083	-0.094	0.084
RENO	4763675.750	1069526.699	669.114	4763675.820	1069526.772	669.114	0.069	0.072	0.000	0.100
ITGT	4812748.993	1036693.381	572.316	4812749.060	1036693.455	572.316	0.066	0.074	0.000	0.099
UNTR	4737610.527	1039196.580	219.258	4737610.592	1039196.649	219.260	0.065	0.068	0.001	0.094
INGR	4656281.070	1038090.139	104.449	4656281.128	1038090.202	104.437	0.058	0.063	-0.012	0.086
RSMN	4890650.705	998117.697	767.437	4890650.773	998117.774	767.727	0.067	0.077	0.289	0.102
RETO	4762503.046	1013665.223	466.374	4762503.112	1013665.295	466.372	0.066	0.072	-0.002	0.098
UNPG	4800028.749	1003949.738	351.093	4800028.812	1003949.811	351.084	0.063	0.073	-0.009	0.097
REMO	4837106.530	987963.594	476.591	4837106.593	987963.672	476.592	0.063	0.078	0.001	0.100
UNOV	4755107.406	990712.991	379.578	4755107.469	990713.063	379.579	0.062	0.072	0.001	0.095
VITE	4721905.178	995977.035	453.880	4721020.819	995309.056	419.153	-884.359	-667.978	-34.726	1108.281
REPI	4781408.441	977934.414	575.755	4781408.506	977934.484	575.751	0.065	0.071	-0.004	0.096
PADO	5055146.551	929631.280	64.699	5055146.606	929631.349	64.693	0.055	0.069	-0.006	0.088
MEDI	4955939.024	924446.533	50.020	4955939.087	924446.615	50.009	0.063	0.082	-0.011	0.103
BZRG	5176247.707	868737.055	329.125	5176247.763	868737.122	329.135	0.056	0.068	0.010	0.088
SIEN	4824763.977	915903.831	417.661	4824764.036	915903.904	417.663	0.058	0.073	0.002	0.093
IGMI	4875309.376	901033.779	95.067	4875309.442	901033.848	95.065	0.066	0.069	-0.001	0.096
MAON	4723083.358	914594.426	228.393	4723083.411	914594.499	228.384	0.053	0.073	-0.010	0.090
CAGL	4356589.831	774755.654	238.364	4356589.888	774755.728	238.369	0.057	0.074	0.005	0.093
GENO	4944743.657	709318.338	155.530	4944743.712	709318.406	155.530	0.055	0.068	0.000	0.087
IENG	5011061.662	601184.784	316.625	5011061.717	601184.859	316.628	0.056	0.075	0.003	0.094
GRAS	4870755.179	556470.907	1319.316	4870755.236	556470.978	1319.313	0.057	0.072	-0.002	0.091
REFO	4781802.542	1035009.734	306.628	4781802.599	1035009.805	306.642	0.058	0.071	0.014	0.091

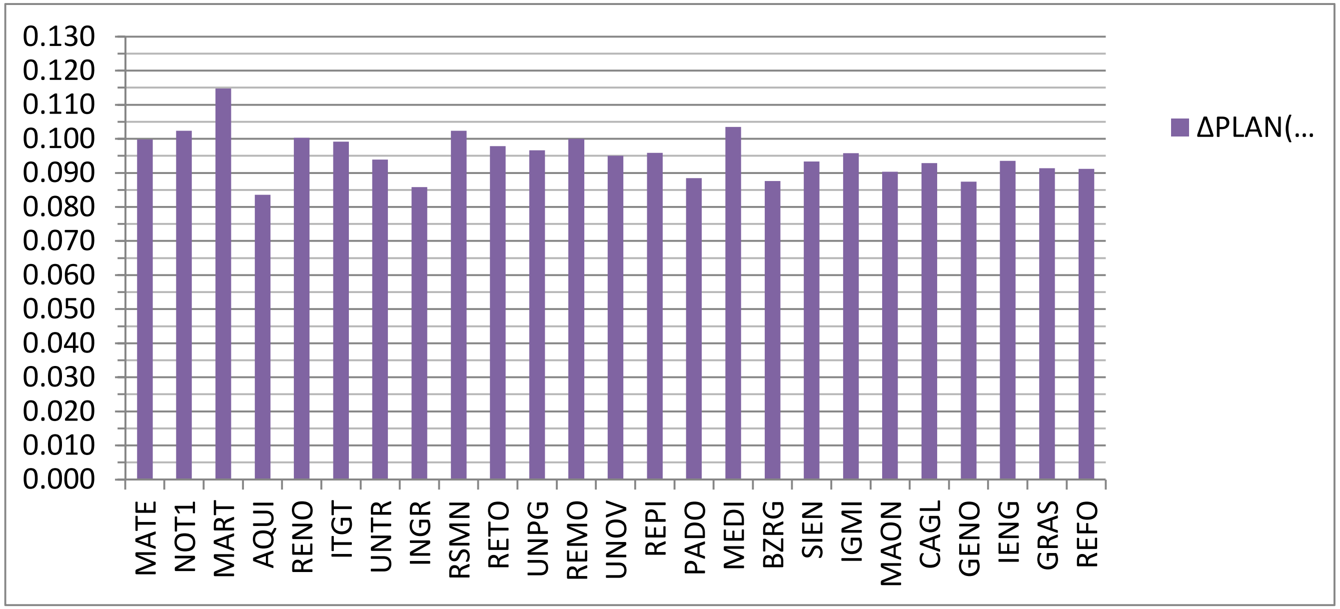
The follow graph shows the displacement during the examined time span in north coordinate:



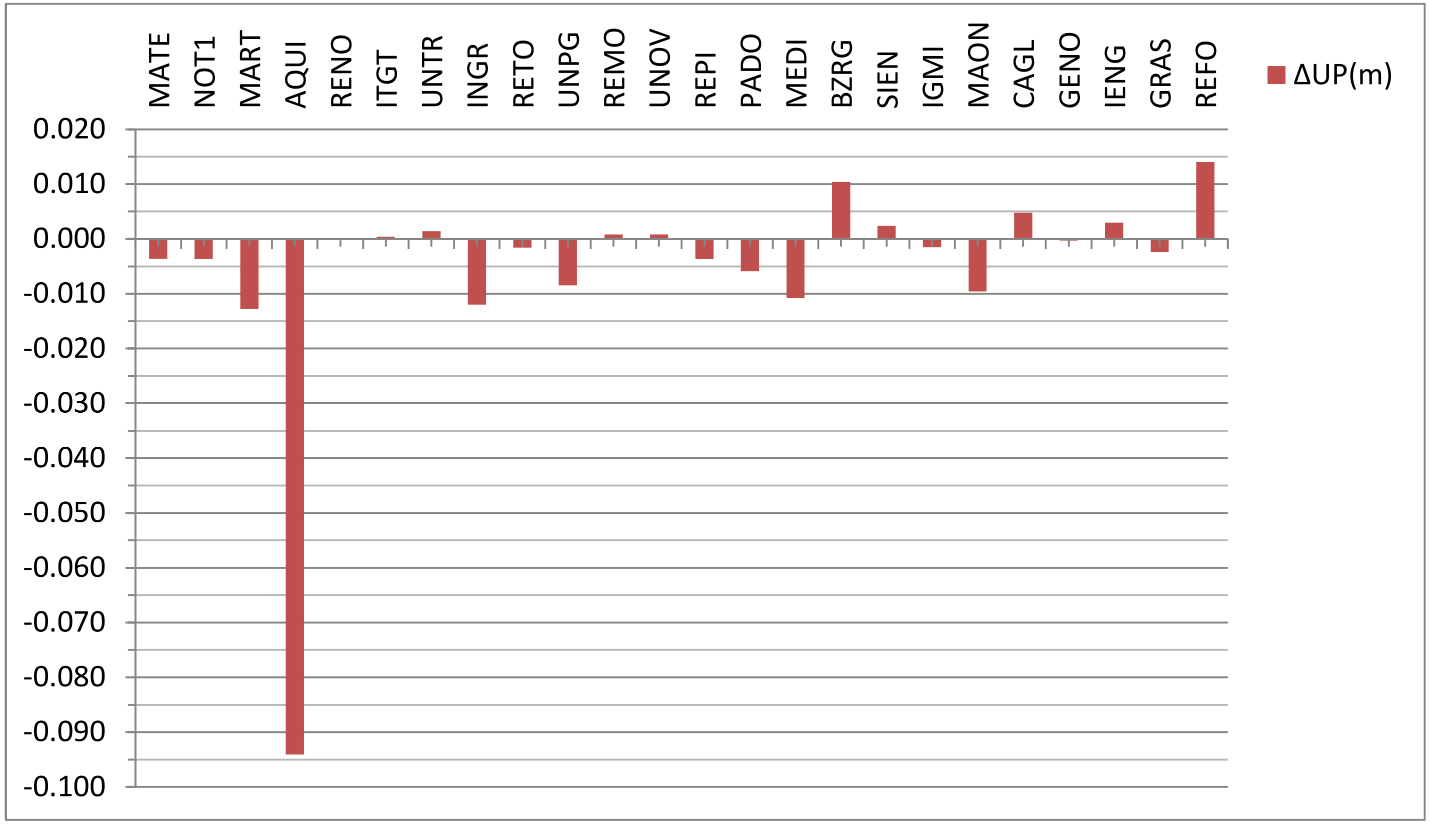
In this page is shown the graph of computed displacement on east component:



The plane displacement has been computed with the follow relation which ties ΔN to ΔH: **$\Delta PLAN = (\Delta N^{2}+\Delta E^{2})^{(1/2)}$**. The result obtained is plotted on the graph shown below:



The last graph shows the displacement registered on up coordinate:



From the results is possible to observe that the values of displacements on north and east components respectively vary between 6 and 8 cm for almost all stations. Considering the direction of plane displacements, since the north and east components have almost the same magnitude and the increments are all positive, the displacements are all in the north-west direction.
Concerning the displacement in altitude it is not possible to do significant observation because the values are all within 1 cm which is almost the accuracy of our measurements and it is non-sense to try to draw any conclusion.
There is an exception on this last consideration regarding L'Aquila station which shows a decrease of height value of about 9.5 cm caused by a strong earthquake that occurred on 6 April of 2009. A lot of studies on that earthquake have confirmed that value and so this obtained value can be considered as a positive indicator concerning the quality of results.

7.3 Conclusions

This work confirmed the good accuracy which can be achieved with GPS survey, which is particularly high when we use the technique of data post processing whereby we obtained a precision of about 1 cm. For this kind of work the use of scientific software like GAMIT/GLOBK has proved very beneficial thanks to possibility to choose and follow carefully each step of computation.
Another important factor which contributed to achieve good results is the good geometry of the network, really wide and quite homogenously distributed.
Thanks to all of these positive factors the obtained solution matches the values initially postulated. To further improve the quality of analysis we should think to include in computation data collected annually from 2008 till 2011 to get a yearly overview of displacements.
This kind of survey and monitoring of networks of permanent stations is really important for countries to develop these kinds of infrastructure which can be used for many applications, static and kinematics. The GPSUMBRIA network is a good example of this kind of infrastructure.
Improving this kind of monitoring and the relative precision one might think of for the future to use this method of survey to determine the stress on soils starting from the measurement of surface displacements.

Appendix A

Analysis of GPS data with GAMIT/GLOBK

Below is shown some extracts of the q-file obtained for Julian day 357 of 2007 where is possible to appreciate the small magnitude of uncertainties on baselines components.

- Q2008a.357:

```
Program SOLVE Version 10.42 2010/11/04 13:00 (Linux)


 SOLVE Run on 2012/ 1/13  16:39:33
 OWNER: MIT  OPERATOR: vmassi11

 Solution refers to     : 2007/12/23 12: 0    (2007.9767)

 Epoch interval:     1  -  2880

 Decimation interval:   4
  LC solution with AUTCLN bias-fixing
 --Bias constraints =  1000. cycles


 Double-difference observations:  89041
 Epoch numbers    1 to 2880  Interval:    30 s   decimation:   4
 Start time: 2007  12  23   0    0    0.000

 Total parameters:  1494   live parameters:   427
 Prefit nrms:  0.54960E+00    Postfit nrms: 0.18864E+00
 -- Uncertainties not scaled by nrms




Channels used:      1     2     3     4     5     6     7     8     9    10    11    12    13    14
15    16    17    18    19    20    21    22    23    24    25    26    27    28    29
                  4310  4197  3515  4193  3781  3599  3532  3424  3931  3530  3807  3822  4318
3209  3187  4415  4328  3407  3885  3427  3789  3559  3737  3425  3001  3539  3368  3740  4466


       Label (units)          a priori     Adjust (m)     Formal  Fract     Postfit
    1*AQUI GEOC LAT  dms    N42:10:36.15150    -0.0991     0.0386  -2.6  N42:10:36.14830
    2*AQUI GEOC LONG dms   E013:21:00.89653    -0.0054     0.0381  -0.1 E013:21:00.89629
    3*AQUI RADIUS    km     6369.1830935152    -0.0053     0.0475  -0.1    6369.18308823
    4*BZRG GEOC LAT  dms    N46:18:24.62570    -0.0868     0.0390  -2.2  N46:18:24.62289
    5*BZRG GEOC LONG dms   E011:20:12.47163    -0.0286     0.0380  -0.8 E011:20:12.47029
    6*BZRG RADIUS    km     6367.2593672132    -0.0617     0.0474  -1.3    6367.25930549
    7*CAGL GEOC LAT  dms    N38:56:51.51074    -0.1032     0.0385  -2.7  N38:56:51.50740
    8*CAGL GEOC LONG dms   E008:58:21.91191    -0.0160     0.0380  -0.4 E008:58:21.91125
    9*CAGL RADIUS    km     6369.8994337119    -0.0044     0.0478  -0.1    6369.89942927
   10*GENO GEOC LAT  dms    N44:13:37.27967    -0.1046     0.0389  -2.7  N44:13:37.27628
   11*GENO GEOC LONG dms   E008:55:16.11807    -0.0115     0.0380  -0.3 E008:55:16.11755
   12*GENO RADIUS    km     6367.8617360520    -0.0137     0.0477  -0.3    6367.86172239
   13*GRAS GEOC LAT  dms    N43:33:45.23259    -0.1013     0.0388  -2.6  N43:33:45.22932
   14*GRAS GEOC LONG dms   E006:55:14.06621    -0.0117     0.0379  -0.3 E006:55:14.06569
   15*GRAS RADIUS    km     6369.2733817679    -0.0115     0.0475  -0.2    6369.27337028
   16*IENG GEOC LAT  dms    N44:49:21.78783    -0.1029     0.0389  -2.6  N44:49:21.78451
   17*IENG GEOC LONG dms   E007:38:21.86030    -0.0134     0.0379  -0.4 E007:38:21.85969
   18*IENG RADIUS    km     6367.8005239634    -0.0278     0.0475  -0.6    6367.80049620
   19*IGMI GEOC LAT  dms    N43:36:12.33367    -0.0981     0.0388  -2.5  N43:36:12.33050
   20*IGMI GEOC LONG dms   E011:12:49.67950    -0.0021     0.0380  -0.1 E011:12:49.67941
```

```
   21*IGMI RADIUS    km     6368.0338924499    -0.0143     0.0475  -0.3    6368.03387814
   22*ITGT GEOC LAT  dms    N43:02:29.97295    -0.0986     0.0387  -2.5  N43:02:29.96976
   23*ITGT GEOC LONG dms   E012:46:55.37394    -0.0083     0.0381  -0.2 E012:46:55.37357
   24*ITGT RADIUS    km     6368.7205109269    -0.0101     0.0475  -0.2    6368.72050087
   25*MATE GEOC LAT  dms    N40:27:32.53146    -0.1112     0.0384  -2.9  N40:27:32.52786
   26*MATE GEOC LONG dms   E016:42:16.05620    -0.0041     0.0383  -0.1 E016:42:16.05603
   27*MATE RADIUS    km     6369.6417891686    -0.0060     0.0469  -0.1    6369.64178317
   28*MEDI GEOC LAT  dms    N44:19:39.26590    -0.1065     0.0389  -2.7  N44:19:39.26246
   29*MEDI GEOC LONG dms   E011:38:48.53646    -0.0221     0.0381  -0.6 E011:38:48.53547
   30*MEDI RADIUS    km     6367.7187047662    -0.0177     0.0478  -0.4    6367.71868709
   31*NOT1 GEOC LAT  dms    N36:41:28.62418    -0.1039     0.0384  -2.7  N36:41:28.62082
   32*NOT1 GEOC LONG dms   E014:59:23.23668    -0.0272     0.0383  -0.7 E014:59:23.23558
   33*NOT1 RADIUS    km     6370.6040440986     0.0004     0.0475   0.0    6370.60404450
   34*PADO GEOC LAT  dms    N45:13:07.47615    -0.1020     0.0389  -2.6  N45:13:07.47285
   35*PADO GEOC LONG dms   E011:53:45.82601    -0.0150     0.0380  -0.4 E011:53:45.82532
   36*PADO RADIUS    km     6367.4007812621    -0.0115     0.0476  -0.2    6367.40076976
   37*REMO GEOC LAT  dms    N43:15:37.34600    -0.0979     0.0387  -2.5  N43:15:37.34284
   38*REMO GEOC LONG dms   E012:13:32.04691    -0.0028     0.0381  -0.1 E012:13:32.04678
   39*REMO RADIUS    km     6368.5432991367    -0.0105     0.0474  -0.2    6368.54328863
   40*RENO GEOC LAT  dms    N42:36:03.76068    -0.0987     0.0386  -2.6  N42:36:03.75748
   41*RENO GEOC LONG dms   E013:05:35.12446    -0.0020     0.0381  -0.1 E013:05:35.12437
   42*RENO RADIUS    km     6368.9813435755    -0.0068     0.0474  -0.1    6368.98133673
   43*REPI GEOC LAT  dms    N42:45:36.91564    -0.0982     0.0387  -2.5  N42:45:36.91247
   44*REPI GEOC LONG dms   E012:00:08.73215    -0.0034     0.0380  -0.1 E012:00:08.73201
   45*REPI RADIUS    km     6368.8287355745    -0.0087     0.0474  -0.2    6368.82872692
   46*RETO GEOC LAT  dms    N42:35:25.83471    -0.0989     0.0387  -2.6  N42:35:25.83151
   47*RETO GEOC LONG dms   E012:24:24.98325    -0.0033     0.0381  -0.1 E012:24:24.98311
   48*RETO RADIUS    km     6368.7825222340    -0.0052     0.0477  -0.1    6368.78251701
   49*UNOV GEOC LAT  dms    N42:31:26.78651    -0.0983     0.0386  -2.5  N42:31:26.78333
   50*UNOV GEOC LONG dms   E012:06:47.26185    -0.0058     0.0381  -0.2 E012:06:47.26160
   51*UNOV RADIUS    km     6368.7204306810    -0.0067     0.0475  -0.1    6368.72042395
   52*UNPG GEOC LAT  dms    N42:55:38.76946    -0.0991     0.0387  -2.6  N42:55:38.76625
   53*UNPG GEOC LONG dms   E012:21:20.53350    -0.0098     0.0381  -0.3 E012:21:20.53307
   54*UNPG RADIUS    km     6368.5418265097    -0.0096     0.0475  -0.2    6368.54181687
   55*UNTR GEOC LAT  dms    N42:22:01.25720    -0.0998     0.0386  -2.6  N42:22:01.25397
   56*UNTR GEOC LONG dms   E012:40:25.64152    -0.0028     0.0381  -0.1 E012:40:25.64140
   57*UNTR RADIUS    km     6368.6185277042     0.0010     0.0474   0.0    6368.61852868
   58*VITE GEOC LAT  dms    N42:13:33.69174    -0.0988     0.0386  -2.6  N42:13:33.68855
   59*VITE GEOC LONG dms   E012:07:10.07721    -0.0039     0.0381  -0.1 E012:07:10.07704
   60*VITE RADIUS    km     6368.9055746272    -0.0103     0.0477  -0.2    6368.90556428


Baseline vector (m ): AQUI        (Site 1) to BZRG        (Site 2)
 X  -279850.08389 Y(E)  -225241.71534 Z   327451.43789  L   486080.59409
      +-  0.00523         +-  0.00210      +-  0.00491       +-  0.00223  (meters)
03821

 Baseline vector (m ): AQUI        (Site 1) to CAGL        (Site 3)
 X   300871.25999 Y(E)  -317226.57635 Z  -272210.83441  L   515029.08092
      +-  0.00661         +-  0.00252      +-  0.00548       +-  0.00250  (meters)


 Baseline vector (m ): AQUI        (Site 1) to GENO        (Site 4)
 X   -84615.24442 Y(E)  -382254.88123 Z   165210.51005  L   424938.87378
      +-  0.00613         +-  0.00242      +-  0.00544       +-  0.00219  (meters)

 Baseline vector (m ): AQUI        (Site 1) to GRAS        (Site 5)
 X   -10816.66065 Y(E)  -533761.53051 Z   112967.79441  L   545692.30723
      +-  0.00552         +-  0.00226      +-  0.00489       +-  0.00206  (meters)

 Baseline vector (m ): AQUI        (Site 1) to IENG        (Site 6)
 X  -115970.15415 Y(E)  -489444.93553 Z   212368.32661  L   545990.59307
      +-  0.00543         +-  0.00223      +-  0.00492       +-  0.00211  (meters)



Baseline vector (m ): AQUI        (Site 1) to IGMI        (Site 7)
 X   -69256.30016 Y(E)  -193116.33965 Z   115403.33677  L   235389.64695
      +-  0.00521         +-  0.00211      +-  0.00459       +-  0.00188  (meters)

 Baseline vector (m ): AQUI        (Site 1) to ITGT        (Site 8)
 X   -53227.15368 Y(E)   -60072.74695 Z    70449.39349  L   106794.10966
      +-  0.00491         +-  0.00190      +-  0.00427       +-  0.00177  (meters)

 Baseline vector (m ): AQUI        (Site 1) to MATE        (Site 9)
 X    49441.98156 Y(E)   303169.06640 Z  -143105.52672  L   338873.40430
      +-  0.00562         +-  0.00249      +-  0.00475       +-  0.00205  (meters)
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 Baseline vector (m ): AQUI        (Site 1) to MEDI        (Site10)
 X  -131106.83395 Y(E)  -170282.78936 Z   173111.75841  L   275958.16922
      +-  0.00659         +-  0.00265      +-  0.00607       +-  0.00254  (meters)

 Baseline vector (m ): AQUI        (Site 1) to NOT1        (Site11)
 X   342038.65831 Y(E)   231388.63527 Z  -469936.86851  L   625597.15847
      +-  0.00647         +-  0.00271      +-  0.00534       +-  0.00252  (meters)

 Baseline vector (m ): AQUI        (Site 1) to PADO        (Site12)
 X  -203625.54538 Y(E)  -165308.90254 Z   243195.73594  L   357679.41228
      +-  0.00596         +-  0.00240      +-  0.00557       +-  0.00239  (meters)

 Baseline vector (m ): AQUI        (Site 1) to REMO        (Site13)
 X   -59815.63034 Y(E)  -107756.22920 Z    88064.30994  L   151474.87333
      +-  0.00455         +-  0.00188      +-  0.00404       +-  0.00170  (meters)

 Baseline vector (m ): AQUI        (Site 1) to RENO        (Site14)
 X   -26272.92798 Y(E)   -27860.81971 Z    34702.87007  L    51679.60150
      +-  0.00464         +-  0.00187      +-  0.00408       +-  0.00172  (meters)

 Baseline vector (m ): AQUI        (Site 1) to REPI        (Site15)
 X   -18730.02059 Y(E)  -117487.60636 Z    47609.60767  L   128143.77106
      +-  0.00422         +-  0.00171      +-  0.00371       +-  0.00147  (meters)

 Baseline vector (m ): AQUI        (Site 1) to RETO        (Site16)
 X   -13251.26629 Y(E)   -82480.14233 Z    33706.24098  L    90081.52207
      +-  0.00596         +-  0.00237      +-  0.00524       +-  0.00204  (meters)

Baseline vector (m ): AQUI        (Site 1) to UNOV        (Site17)
 X    -3309.49065 Y(E)  -104937.68390 Z    28227.39969  L   108718.24283
      +-  0.00486         +-  0.00196      +-  0.00427       +-  0.00168  (meters)

 Baseline vector (m ): AQUI        (Site 1) to UNPG        (Site18)
 X   -37361.82840 Y(E)   -92053.94144 Z    61039.73425  L   116600.52965
      +-  0.00492         +-  0.00198      +-  0.00436       +-  0.00177  (meters)

 Baseline vector (m ): AQUI        (Site 1) to UNTR        (Site19)
 X    -1743.03929 Y(E)   -57509.48057 Z    15273.54824  L    59528.64703
      +-  0.00459         +-  0.00185      +-  0.00402       +-  0.00158  (meters)

 Baseline vector (m ): AQUI        (Site 1) to VITE        (Site20)
 X    18549.06754 Y(E)   -99712.83005 Z     3874.64426  L   101497.43470
      +-  0.00574         +-  0.00233      +-  0.00502       +-  0.00200  (meters)

 Baseline vector (m ): BZRG        (Site 2) to CAGL        (Site 3)
 X   580721.34387 Y(E)   -91984.86101 Z  -599662.27229  L   839817.44129
      +-  0.00661         +-  0.00240      +-  0.00583       +-  0.00292  (meters)

 Baseline vector (m ): BZRG        (Site 2) to GENO        (Site 4)
 X   195234.83946 Y(E)  -157013.16590 Z  -162240.92783  L   298482.65522
      +-  0.00599         +-  0.00226      +-  0.00551       +-  0.00222  (meters)

 Baseline vector (m ): BZRG        (Site 2) to GRAS        (Site 5)
 X   269033.42324 Y(E)  -308519.81517 Z  -214483.64348  L   462132.76501
      +-  0.00535         +-  0.00203      +-  0.00496       +-  0.00207  (meters)

 Baseline vector (m ): BZRG        (Site 2) to IENG        (Site 6)
 X   163879.92973 Y(E)  -264203.22020 Z  -115083.11128  L   331517.86593
      +-  0.00521         +-  0.00201      +-  0.00492       +-  0.00191  (meters)

 Baseline vector (m ): BZRG        (Site 2) to IGMI        (Site 7)
 X   210593.78373 Y(E)    32125.37568 Z  -212048.10111  L   300576.41074
      +-  0.00509         +-  0.00200      +-  0.00477       +-  0.00207  (meters)


Baseline vector (m ): BZRG        (Site 2) to ITGT        (Site 8)
 X   226622.93020 Y(E)   165168.96838 Z  -257002.04440  L   380379.79893
      +-  0.00485         +-  0.00186      +-  0.00454       +-  0.00199  (meters)

 Baseline vector (m ): BZRG        (Site 2) to MATE        (Site 9)
 X   329292.06545 Y(E)   528410.78174 Z  -470556.96460  L   780432.62077
      +-  0.00568         +-  0.00261      +-  0.00509       +-  0.00264  (meters)

 Baseline vector (m ): BZRG        (Site 2) to MEDI        (Site10)
 X   148743.24994 Y(E)    54958.92597 Z  -154339.67948  L   221282.11542
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     +-  0.00647         +-  0.00258      +-  0.00616       +-  0.00264  (meters)

Baseline vector (m ): BZRG        (Site 2) to NOT1        (Site11)
X   621888.74219 Y(E)   456630.35061 Z  -797388.30639  L  1109542.69676
     +-  0.00661         +-  0.00280      +-  0.00584       +-  0.00317  (meters)

Baseline vector (m ): BZRG        (Site 2) to PADO        (Site12)
X    76224.53850 Y(E)    59932.81280 Z   -84255.70195  L   128456.78507
     +-  0.00576         +-  0.00231      +-  0.00559       +-  0.00234  (meters)

Baseline vector (m ): BZRG        (Site 2) to REMO        (Site13)
X   220034.45354 Y(E)   117485.48614 Z  -239387.12794  L   345722.71725
     +-  0.00444         +-  0.00180      +-  0.00429       +-  0.00191  (meters)

Baseline vector (m ): BZRG        (Site 2) to RENO        (Site14)
X   253577.15590 Y(E)   197380.89562 Z  -292748.56782  L   434697.95941
     +-  0.00459         +-  0.00184      +-  0.00439       +-  0.00199  (meters)

Baseline vector (m ): BZRG        (Site 2) to REPI        (Site15)
X   261120.06329 Y(E)   107754.10898 Z  -279841.83021  L   397625.55928
     +-  0.00413         +-  0.00162      +-  0.00402       +-  0.00181  (meters)

Baseline vector (m ): BZRG        (Site 2) to RETO        (Site16)
X   266598.81760 Y(E)   142761.57301 Z  -293745.19691  L   421594.63585
     +-  0.00592         +-  0.00233      +-  0.00549       +-  0.00247  (meters)

Baseline vector (m ): BZRG        (Site 2) to UNOV        (Site17)
X   276540.59324 Y(E)   120304.03143 Z  -299224.03820  L   424832.65496
     +-  0.00479         +-  0.00190      +-  0.00456       +-  0.00207  (meters)

Baseline vector (m ): BZRG        (Site 2) to UNPG        (Site18)
X   242488.25548 Y(E)   133187.77389 Z  -266411.70364  L   384076.46764
     +-  0.00484         +-  0.00192      +-  0.00462       +-  0.00206  (meters)

Baseline vector (m ): BZRG        (Site 2) to UNTR        (Site19)
X   278107.04460 Y(E)   167732.23476 Z  -312177.88965  L   450480.48306
     +-  0.00454         +-  0.00181      +-  0.00436       +-  0.00199  (meters)

Baseline vector (m ): BZRG        (Site 2) to VITE        (Site20)
X   298399.15143 Y(E)   125528.88529 Z  -323576.79363  L   457713.33385
     +-  0.00569         +-  0.00228      +-  0.00530       +-  0.00242  (meters)

Baseline vector (m ): CAGL        (Site 3) to GENO        (Site 4)
X  -385486.50441 Y(E)   -65028.30489 Z   437421.34446  L   586656.59300
     +-  0.00717         +-  0.00261      +-  0.00614       +-  0.00281  (meters)

Baseline vector (m ): CAGL        (Site 3) to GRAS        (Site 5)
X  -311687.92064 Y(E)  -216534.95416 Z   385178.62881  L   540739.60678
     +-  0.00648         +-  0.00238      +-  0.00552       +-  0.00257  (meters)

Baseline vector (m ): CAGL        (Site 3) to IENG        (Site 6)
X  -416841.41414 Y(E)  -172218.35918 Z   484579.16101  L   661991.60952
     +-  0.00649         +-  0.00239      +-  0.00563       +-  0.00272  (meters)

Baseline vector (m ): CAGL        (Site 3) to IGMI        (Site 7)
X  -370127.56015 Y(E)   124110.23670 Z   387614.17118  L   550129.53686
     +-  0.00651         +-  0.00242      +-  0.00545       +-  0.00255  (meters)

Baseline vector (m ): CAGL        (Site 3) to ITGT        (Site 8)
X  -354098.41367 Y(E)   257153.82940 Z   342660.22789  L   555814.54670
     +-  0.00633         +-  0.00231      +-  0.00522       +-  0.00246  (meters)

Baseline vector (m ): CAGL        (Site 3) to MATE        (Site 9)
X  -251429.27842 Y(E)   620395.64275 Z   129105.30769  L   681744.53871
     +-  0.00693         +-  0.00299      +-  0.00561       +-  0.00262  (meters)

Baseline vector (m ): CAGL        (Site 3) to MEDI        (Site10)
X  -431978.09394 Y(E)   146943.78699 Z   445322.59282  L   637581.18060
     +-  0.00770         +-  0.00292      +-  0.00678       +-  0.00311  (meters)

Baseline vector (m ): CAGL        (Site 3) to NOT1        (Site11)
X    41167.39832 Y(E)   548615.21162 Z  -197726.03410  L   584610.11766
     +-  0.00735         +-  0.00311      +-  0.00577       +-  0.00268  (meters)

Baseline vector (m ): CAGL        (Site 3) to PADO        (Site12)
X  -504496.80537 Y(E)   151917.67381 Z   515406.57035  L   737048.12530
     +-  0.00719         +-  0.00269      +-  0.00636       +-  0.00299  (meters)
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Baseline vector (m ): CAGL        (Site 3) to REMO        (Site13)
X  -360686.89033 Y(E)   209470.34715 Z   360275.14435  L   551154.27861
     +-  0.00605         +-  0.00226      +-  0.00502       +-  0.00240  (meters)

Baseline vector (m ): CAGL        (Site 3) to RENO        (Site14)
X  -327144.18797 Y(E)   289365.75664 Z   306913.70447  L   533808.84484
     +-  0.00613         +-  0.00229      +-  0.00505       +-  0.00238  (meters)

Baseline vector (m ): CAGL        (Site 3) to REPI        (Site15)
X  -319601.28058 Y(E)   199738.96999 Z   319820.44208  L   494293.18208
     +-  0.00577         +-  0.00212      +-  0.00473       +-  0.00225  (meters)

Baseline vector (m ): CAGL        (Site 3) to RETO        (Site16)
X  -314122.52628 Y(E)   234746.43402 Z   305917.07539  L   497357.12201
     +-  0.00716         +-  0.00270      +-  0.00601       +-  0.00276  (meters)

Baseline vector (m ): CAGL        (Site 3) to UNOV        (Site17)
X  -304180.75064 Y(E)   212288.89244 Z   300438.23409  L   477342.26234
     +-  0.00625         +-  0.00233      +-  0.00517       +-  0.00241  (meters)

Baseline vector (m ): CAGL        (Site 3) to UNPG        (Site18)
X  -338233.08839 Y(E)   225172.63491 Z   333250.56866  L   525509.54235
     +-  0.00632         +-  0.00236      +-  0.00528       +-  0.00247  (meters)

Baseline vector (m ): CAGL        (Site 3) to UNTR        (Site19)
X  -302614.29928 Y(E)   259717.09578 Z   287484.38265  L   491605.18125
     +-  0.00606         +-  0.00227      +-  0.00499       +-  0.00233  (meters)

Baseline vector (m ): CAGL        (Site 3) to VITE        (Site20)
X  -282322.19245 Y(E)   217513.74630 Z   276085.47867  L   450822.84958
     +-  0.00694         +-  0.00265      +-  0.00579       +-  0.00265  (meters)

Baseline vector (m ): GENO        (Site 4) to GRAS        (Site 5)
X    73798.58377 Y(E)  -151506.64928 Z   -52242.71564  L   176436.38253
     +-  0.00603         +-  0.00221      +-  0.00540       +-  0.00205  (meters)

Baseline vector (m ): GENO        (Site 4) to IENG        (Site 6)
X   -31354.90973 Y(E)  -107190.05430 Z    47157.81656  L   121229.93758
     +-  0.00596         +-  0.00221      +-  0.00541       +-  0.00208  (meters)

Baseline vector (m ): GENO        (Site 4) to IGMI        (Site 7)
X    15358.94427 Y(E)   189138.54158 Z   -49807.17328  L   196188.78559
     +-  0.00598         +-  0.00228      +-  0.00531       +-  0.00201  (meters)

Baseline vector (m ): GENO        (Site 4) to ITGT        (Site 8)
X    31388.09074 Y(E)   322182.13428 Z   -94761.11657  L   337292.46820
     +-  0.00578         +-  0.00219      +-  0.00511       +-  0.00196  (meters)

Baseline vector (m ): GENO        (Site 4) to MATE        (Site 9)
X   134057.22599 Y(E)   685423.94764 Z  -308316.03677  L   763437.03497
     +-  0.00657         +-  0.00295      +-  0.00566       +-  0.00265  (meters)

Baseline vector (m ): GENO        (Site 4) to MEDI        (Site10)
X   -46491.58953 Y(E)   211972.09187 Z     7901.24836  L   217154.47349
     +-  0.00721         +-  0.00281      +-  0.00662       +-  0.00245  (meters)

Baseline vector (m ): GENO        (Site 4) to NOT1        (Site11)
X   426653.90273 Y(E)   613643.51651 Z  -635147.37856  L   980818.08230
     +-  0.00727         +-  0.00309      +-  0.00621       +-  0.00307  (meters)


Baseline vector (m ): GENO        (Site 4) to PADO        (Site12)
X  -119010.30096 Y(E)   216945.97870 Z    77985.22589  L   259443.06671
     +-  0.00663         +-  0.00256      +-  0.00613       +-  0.00224  (meters)


Baseline vector (m ): GENO        (Site 4) to REMO        (Site13)
X    24799.61408 Y(E)   274498.65204 Z   -77146.20011  L   286209.83040
     +-  0.00546         +-  0.00213      +-  0.00490       +-  0.00190  (meters)

Baseline vector (m ): GENO        (Site 4) to RENO        (Site14)
X    58342.31644 Y(E)   354394.06152 Z  -130507.63999  L   382140.31562
     +-  0.00559         +-  0.00218      +-  0.00498       +-  0.00197  (meters)
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 Baseline vector (m ): GENO        (Site 4) to REPI        (Site15)
 X    65885.22383 Y(E)   264767.27488 Z  -117600.90238  L   297106.95853
      +-  0.00518         +-  0.00197      +-  0.00463       +-  0.00181  (meters)

 Baseline vector (m ): GENO        (Site 4) to RETO        (Site16)
 X    71363.97814 Y(E)   299774.73891 Z  -131504.26907  L   335038.92945
      +-  0.00670         +-  0.00259      +-  0.00596       +-  0.00234  (meters)

 Baseline vector (m ): GENO        (Site 4) to UNOV        (Site17)
 X    81305.75378 Y(E)   277317.19733 Z  -136983.11037  L   319812.17309
      +-  0.00572         +-  0.00221      +-  0.00511       +-  0.00203  (meters)

 Baseline vector (m ): GENO        (Site 4) to UNPG        (Site18)
 X    47253.41602 Y(E)   290200.93979 Z  -104170.77580  L   311931.11630
      +-  0.00578         +-  0.00224      +-  0.00518       +-  0.00201  (meters)

 Baseline vector (m ): GENO        (Site 4) to UNTR        (Site19)
 X    82872.20514 Y(E)   324745.40066 Z  -149936.96181  L   367162.72980
      +-  0.00553         +-  0.00215      +-  0.00494       +-  0.00197  (meters)

 Baseline vector (m ): GENO        (Site 4) to VITE        (Site20)
 X   103164.31197 Y(E)   282542.05118 Z  -161335.86579  L   341324.10923
      +-  0.00649         +-  0.00255      +-  0.00577       +-  0.00237  (meters)

 Baseline vector (m ): GRAS        (Site 5) to IENG        (Site 6)
 X  -105153.49350 Y(E)    44316.59498 Z    99400.53220  L   151333.02213
      +-  0.00508         +-  0.00186      +-  0.00469       +-  0.00203  (meters)

 Baseline vector (m ): GRAS        (Site 5) to IGMI        (Site 7)
 X   -58439.63951 Y(E)   340645.19086 Z     2435.54236  L   345630.24953
      +-  0.00531         +-  0.00206      +-  0.00472       +-  0.00184  (meters)

 Baseline vector (m ): GRAS        (Site 5) to ITGT        (Site 8)
 X   -42410.49303 Y(E)   473688.78356 Z   -42518.40092  L   477480.39541
      +-  0.00513         +-  0.00200      +-  0.00451       +-  0.00185  (meters)

 Baseline vector (m ): GRAS        (Site 5) to MATE        (Site 9)
 X    60258.64221 Y(E)   836930.59691 Z  -256073.32112  L   877301.24461
      +-  0.00604         +-  0.00289      +-  0.00516       +-  0.00260  (meters)
 Correlations (X-Y,X-Z,Y-Z) =     0.49943   0.85458   0.40342
 N  -296074.44632 E      823572.07370 U   -61044.53664  L   877301.24461
      +-  0.00224         +-  0.00259      +-  0.00773       +-  0.00260  (meters)

 Baseline vector (m ): GRAS        (Site 5) to MEDI        (Site10)
 X  -120290.17330 Y(E)   363478.74115 Z    60143.96400  L   387561.37251
      +-  0.00668         +-  0.00264      +-  0.00616       +-  0.00239  (meters)

 Baseline vector (m ): GRAS        (Site 5) to NOT1        (Site11)
 X   352855.31896 Y(E)   765150.16578 Z  -582904.66291  L  1024567.95693
      +-  0.00669         +-  0.00302      +-  0.00566       +-  0.00296  (meters)

 Baseline vector (m ): GRAS        (Site 5) to PADO        (Site12)
 X  -192808.88474 Y(E)   368452.62797 Z   130227.94153  L   435765.90257
      +-  0.00605         +-  0.00237      +-  0.00564       +-  0.00217  (meters)

 Baseline vector (m ): GRAS        (Site 5) to REMO        (Site13)
 X   -48998.96969 Y(E)   426005.30131 Z   -24903.48447  L   429536.49358
      +-  0.00475         +-  0.00192      +-  0.00426       +-  0.00176  (meters)

 Baseline vector (m ): GRAS        (Site 5) to RENO        (Site14)
 X   -15456.26733 Y(E)   505900.71080 Z   -78264.92434  L   512152.14904
      +-  0.00491         +-  0.00199      +-  0.00437       +-  0.00184  (meters)


Baseline vector (m ): GRAS        (Site 5) to REPI        (Site15)
 X    -7913.35994 Y(E)   416273.92415 Z   -65358.18673  L   421447.85415
      +-  0.00441         +-  0.00174      +-  0.00395       +-  0.00162  (meters)

 Baseline vector (m ): GRAS        (Site 5) to RETO        (Site16)
 X    -2434.60564 Y(E)   451281.38818 Z   -79261.55343  L   458195.60504
      +-  0.00614         +-  0.00243      +-  0.00545       +-  0.00219  (meters)
 Baseline vector (m ): GRAS        (Site 5) to UNOV        (Site17)
 X     7507.17000 Y(E)   428823.84661 Z   -84740.39472  L   437180.95054
      +-  0.00504         +-  0.00201      +-  0.00449       +-  0.00185  (meters)

 Baseline vector (m ): GRAS        (Site 5) to UNPG        (Site18)
 X   -26545.16775 Y(E)   441707.58907 Z   -51928.06016  L   445540.97859
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     +-  0.00512         +-  0.00204      +-  0.00458       +-  0.00186  (meters)

Baseline vector (m ): GRAS        (Site 5) to UNTR        (Site19)
X     9073.62136 Y(E)   476252.04994 Z   -97694.24617  L   486253.54642
     +-  0.00483         +-  0.00195      +-  0.00431       +-  0.00181  (meters)

Baseline vector (m ): GRAS        (Site 5) to VITE        (Site20)
X    29365.72819 Y(E)   434048.70046 Z  -109093.15015  L   448510.79783
     +-  0.00589         +-  0.00238      +-  0.00522       +-  0.00218  (meters)

Baseline vector (m ): IENG        (Site 6) to IGMI        (Site 7)
X    46713.85400 Y(E)   296328.59588 Z   -96964.98984  L   315269.77360
     +-  0.00521         +-  0.00205      +-  0.00473       +-  0.00188  (meters)

Baseline vector (m ): IENG        (Site 6) to ITGT        (Site 8)
X    62743.00047 Y(E)   429372.18858 Z  -141918.93312  L   456550.26450
     +-  0.00502         +-  0.00197      +-  0.00453       +-  0.00185  (meters)

Baseline vector (m ): IENG        (Site 6) to MATE        (Site 9)
X   165412.13572 Y(E)   792614.00193 Z  -355473.85332  L   884284.90380
     +-  0.00595         +-  0.00285      +-  0.00518       +-  0.00265  (meters)

Baseline vector (m ): IENG        (Site 6) to MEDI        (Site10)
X   -15136.67980 Y(E)   319162.14617 Z   -39256.56820  L   321923.39581
     +-  0.00659         +-  0.00262      +-  0.00615       +-  0.00235  (meters)

Baseline vector (m ): IENG        (Site 6) to NOT1        (Site11)
X   458008.81246 Y(E)   720833.57080 Z  -682305.19511  L  1093120.98524
     +-  0.00668         +-  0.00299      +-  0.00577       +-  0.00308  (meters)

Baseline vector (m ): IENG        (Site 6) to PADO        (Site12)
X   -87655.39123 Y(E)   324136.03299 Z    30827.40933  L   337191.28794
     +-  0.00594         +-  0.00236      +-  0.00562       +-  0.00205  (meters)

Baseline vector (m ): IENG        (Site 6) to REMO        (Site13)
X    56154.52381 Y(E)   381688.70633 Z  -124304.01667  L   405328.37015
     +-  0.00463         +-  0.00189      +-  0.00428       +-  0.00177  (meters)

Baseline vector (m ): IENG        (Site 6) to RENO        (Site14)
X    89697.22617 Y(E)   461584.11582 Z  -177665.45654  L   502663.40906
     +-  0.00480         +-  0.00197      +-  0.00440       +-  0.00187  (meters)

Baseline vector (m ): IENG        (Site 6) to REPI        (Site15)
X    97240.13356 Y(E)   371957.32917 Z  -164758.71893  L   418274.23273
     +-  0.00429         +-  0.00172      +-  0.00398       +-  0.00167  (meters)

Baseline vector (m ): IENG        (Site 6) to RETO        (Site16)
X   102718.88787 Y(E)   406964.79320 Z  -178662.08563  L   456170.64096
     +-  0.00605         +-  0.00241      +-  0.00547       +-  0.00225  (meters)

Baseline vector (m ): IENG        (Site 6) to UNOV        (Site17)
X   112660.66350 Y(E)   384507.25163 Z  -184140.92692  L   440960.46605
     +-  0.00493         +-  0.00198      +-  0.00453       +-  0.00191  (meters)

Baseline vector (m ): IENG        (Site 6) to UNPG        (Site18)
X    78608.32575 Y(E)   397390.99409 Z  -151328.59236  L   432434.05731
     +-  0.00501         +-  0.00202      +-  0.00460       +-  0.00190  (meters)

Baseline vector (m ): IENG        (Site 6) to UNTR        (Site19)
X   114227.11486 Y(E)   431935.45496 Z  -197094.77837  L   488326.14376
     +-  0.00472         +-  0.00193      +-  0.00434       +-  0.00186  (meters)

Baseline vector (m ): IENG        (Site 6) to VITE        (Site20)
X   134519.22170 Y(E)   389732.10548 Z  -208493.68235  L   462013.14984
     +-  0.00581         +-  0.00236      +-  0.00526       +-  0.00226  (meters)
Baseline vector (m ): IGMI        (Site 7) to ITGT        (Site 8)
X    16029.14647 Y(E)   133043.59270 Z   -44953.94329  L   141344.92602
     +-  0.00483         +-  0.00187      +-  0.00422       +-  0.00162  (meters)

Baseline vector (m ): IGMI        (Site 7) to MATE        (Site 9)
X   118698.28172 Y(E)   496285.40605 Z  -258508.86349  L   572027.37596
     +-  0.00565         +-  0.00257      +-  0.00479       +-  0.00222  (meters)

Baseline vector (m ): IGMI        (Site 7) to MEDI        (Site10)
X   -61850.53379 Y(E)    22833.55029 Z    57708.42164  L    87619.18441
     +-  0.00649         +-  0.00260      +-  0.00599       +-  0.00248  (meters)
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Baseline vector (m ): IGMI        (Site 7) to NOT1        (Site11)
X   411294.95846 Y(E)   424504.97493 Z  -585340.20528  L   831860.06787
     +-  0.00651         +-  0.00277      +-  0.00543       +-  0.00270  (meters)

Baseline vector (m ): IGMI        (Site 7) to PADO        (Site12)
X  -134369.24523 Y(E)    27807.43711 Z   127792.39917  L   187507.98625
     +-  0.00585         +-  0.00233      +-  0.00547       +-  0.00224  (meters)

Baseline vector (m ): IGMI        (Site 7) to REMO        (Site13)
X     9440.66981 Y(E)    85360.11045 Z   -27339.02683  L    90127.11629
     +-  0.00444         +-  0.00182      +-  0.00397       +-  0.00157  (meters)

Baseline vector (m ): IGMI        (Site 7) to RENO        (Site14)
X    42983.37217 Y(E)   165255.51994 Z   -80700.46671  L   188863.76699
     +-  0.00457         +-  0.00184      +-  0.00405       +-  0.00163  (meters)

Baseline vector (m ): IGMI        (Site 7) to REPI        (Site15)
X    50526.27956 Y(E)    75628.73329 Z   -67793.72910  L   113439.85160
     +-  0.00410         +-  0.00164      +-  0.00364       +-  0.00151  (meters)

Baseline vector (m ): IGMI        (Site 7) to RETO        (Site16)
X    56005.03387 Y(E)   110636.19732 Z   -81697.09579  L   148496.96104
     +-  0.00590         +-  0.00231      +-  0.00521       +-  0.00211  (meters)

Baseline vector (m ): IGMI        (Site 7) to UNOV        (Site17)
X    65946.80951 Y(E)    88178.65575 Z   -87175.93709  L   140442.51856
     +-  0.00476         +-  0.00191      +-  0.00422       +-  0.00178  (meters)

Baseline vector (m ): IGMI        (Site 7) to UNPG        (Site18)
X    31894.47176 Y(E)   101062.39821 Z   -54363.60252  L   119106.11630
     +-  0.00483         +-  0.00193      +-  0.00430       +-  0.00172  (meters)

Baseline vector (m ): IGMI        (Site 7) to UNTR        (Site19)
X    67513.26087 Y(E)   135606.85908 Z  -100129.78853  L   181585.33854
     +-  0.00451         +-  0.00182      +-  0.00399       +-  0.00165  (meters)

Baseline vector (m ): IGMI        (Site 7) to VITE        (Site20)
X    87805.36770 Y(E)    93403.50960 Z  -111528.69251  L   169919.53230
     +-  0.00566         +-  0.00229      +-  0.00499       +-  0.00216  (meters)

Baseline vector (m ): ITGT        (Site 8) to MATE        (Site 9)
X   102669.13525 Y(E)   363241.81335 Z  -213554.92020  L   433694.90456
     +-  0.00535         +-  0.00236      +-  0.00447       +-  0.00203  (meters)

Baseline vector (m ): ITGT        (Site 8) to MEDI        (Site10)
X   -77879.68027 Y(E)  -110210.04241 Z   102662.36492  L   169561.37301
     +-  0.00629         +-  0.00247      +-  0.00579       +-  0.00236  (meters)

Baseline vector (m ): ITGT        (Site 8) to NOT1        (Site11)
X   395265.81199 Y(E)   291461.38223 Z  -540386.26199  L   730206.89644
     +-  0.00625         +-  0.00258      +-  0.00513       +-  0.00251  (meters)

Baseline vector (m ): ITGT        (Site 8) to PADO        (Site12)
X  -150398.39170 Y(E)  -105236.15559 Z   172746.34245  L   252062.73723
     +-  0.00562         +-  0.00219      +-  0.00525       +-  0.00221  (meters)

Baseline vector (m ): ITGT        (Site 8) to REMO        (Site13)
X    -6588.47666 Y(E)   -47683.48225 Z    17614.91646  L    51258.24602
     +-  0.00412         +-  0.00161      +-  0.00363       +-  0.00142  (meters)

Baseline vector (m ): ITGT        (Site 8) to RENO        (Site14)
X    26954.22570 Y(E)    32211.92724 Z   -35746.52342  L    55153.89811
     +-  0.00423         +-  0.00162      +-  0.00369       +-  0.00152  (meters)


Baseline vector (m ): ITGT        (Site 8) to REPI        (Site15)
X    34497.13309 Y(E)   -57414.85941 Z   -22839.78581  L    70768.45405
     +-  0.00375         +-  0.00141      +-  0.00326       +-  0.00132  (meters)


Baseline vector (m ): ITGT        (Site 8) to RETO        (Site16)
X    39975.88740 Y(E)   -22407.39538 Z   -36743.15251  L    58738.59206
     +-  0.00565         +-  0.00217      +-  0.00495       +-  0.00215  (meters)

Baseline vector (m ): ITGT        (Site 8) to UNOV        (Site17)
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 X    49917.66303 Y(E)   -44864.93695 Z   -42221.99380  L    79292.70087
      +-  0.00446         +-  0.00171      +-  0.00389       +-  0.00165  (meters)

 Baseline vector (m ): ITGT        (Site 8) to UNPG        (Site18)
 X    15865.32528 Y(E)   -31981.19449 Z    -9409.65924  L    36919.46687
      +-  0.00453         +-  0.00174      +-  0.00399       +-  0.00158  (meters)

 Baseline vector (m ): ITGT        (Site 8) to UNTR        (Site19)
 X    51484.11439 Y(E)     2563.26638 Z   -55175.84525  L    75508.66353
      +-  0.00418         +-  0.00160      +-  0.00364       +-  0.00157  (meters)

 Baseline vector (m ): ITGT        (Site 8) to VITE        (Site20)
 X    71776.22123 Y(E)   -39640.08310 Z   -66574.74923  L   105618.93465
      +-  0.00541         +-  0.00213      +-  0.00472       +-  0.00206  (meters)

 Baseline vector (m ): MATE        (Site 9) to MEDI        (Site10)
 X  -180548.81551 Y(E)  -473451.85576 Z   316217.28513  L   597283.77336
      +-  0.00694         +-  0.00305      +-  0.00622       +-  0.00279  (meters)

 Baseline vector (m ): MATE        (Site 9) to NOT1        (Site11)
 X   292596.67674 Y(E)   -71780.43113 Z  -326831.34179  L   444504.18615
      +-  0.00654         +-  0.00284      +-  0.00525       +-  0.00238  (meters)

 Baseline vector (m ): MATE        (Site 9) to PADO        (Site12)
 X  -253067.52695 Y(E)  -468477.96894 Z   386301.26266  L   657832.38451
      +-  0.00634         +-  0.00282      +-  0.00573       +-  0.00269  (meters)

 Baseline vector (m ): MATE        (Site 9) to REMO        (Site13)
 X  -109257.61191 Y(E)  -410925.29560 Z   231169.83666  L   483979.66662
      +-  0.00502         +-  0.00236      +-  0.00426       +-  0.00203  (meters)

 Baseline vector (m ): MATE        (Site 9) to RENO        (Site14)
 X   -75714.90955 Y(E)  -331029.88611 Z   177808.39678  L   383313.65615
      +-  0.00507         +-  0.00231      +-  0.00426       +-  0.00194  (meters)

 Baseline vector (m ): MATE        (Site 9) to REPI        (Site15)
 X   -68172.00216 Y(E)  -420656.67276 Z   190715.13439  L   466874.41641
      +-  0.00473         +-  0.00224      +-  0.00394       +-  0.00187  (meters)

 Baseline vector (m ): MATE        (Site 9) to RETO        (Site16)
 X   -62693.24785 Y(E)  -385649.20873 Z   176811.76770  L   428856.80211
      +-  0.00632         +-  0.00274      +-  0.00540       +-  0.00231  (meters)

 Baseline vector (m ): MATE        (Site 9) to UNOV        (Site17)
 X   -52751.47221 Y(E)  -408106.75031 Z   171332.92640  L   445745.22895
      +-  0.00530         +-  0.00243      +-  0.00447       +-  0.00203  (meters)

 Baseline vector (m ): MATE        (Site 9) to UNPG        (Site18)
 X   -86803.80997 Y(E)  -395223.00784 Z   204145.26097  L   453223.36097
      +-  0.00535         +-  0.00244      +-  0.00456       +-  0.00208  (meters)

 Baseline vector (m ): MATE        (Site 9) to UNTR        (Site19)
 X   -51185.02085 Y(E)  -360678.54697 Z   158379.07496  L   397231.48414
      +-  0.00503         +-  0.00231      +-  0.00422       +-  0.00191  (meters)

 Baseline vector (m ): MATE        (Site 9) to VITE        (Site20)
 X   -30892.91402 Y(E)  -402881.89645 Z   146980.17098  L   429966.70253
      +-  0.00611         +-  0.00274      +-  0.00519       +-  0.00230  (meters)

 Baseline vector (m ): MEDI        (Site10) to NOT1        (Site11)
 X   473145.49226 Y(E)   401671.42464 Z  -643048.62692  L   893710.31481
      +-  0.00768         +-  0.00322      +-  0.00677       +-  0.00325  (meters)

 Baseline vector (m ): MEDI        (Site10) to PADO        (Site12)
 X   -72518.71143 Y(E)     4973.88682 Z    70083.97753  L   100972.60502
      +-  0.00708         +-  0.00284      +-  0.00672       +-  0.00280  (meters)

 Baseline vector (m ): MEDI        (Site10) to REMO        (Site13)
 X    71291.20361 Y(E)    62526.56016 Z   -85047.44847  L   127377.68615
      +-  0.00599         +-  0.00243      +-  0.00560       +-  0.00236  (meters)

Baseline vector (m ): MEDI        (Site10) to RENO        (Site14)
 X   104833.90597 Y(E)   142421.96965 Z  -138408.88834  L   224568.88843
      +-  0.00609         +-  0.00245      +-  0.00567       +-  0.00235  (meters)

 Baseline vector (m ): MEDI        (Site10) to REPI        (Site15)
 X   112376.81336 Y(E)    52795.18300 Z  -125502.15074  L   176540.84334
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     +-  0.00575         +-  0.00230      +-  0.00538       +-  0.00229  (meters)

 Baseline vector (m ): MEDI        (Site10) to RETO        (Site16)
 X   117855.56766 Y(E)    87802.64703 Z  -139405.51743  L   202566.37911
     +-  0.00714         +-  0.00284      +-  0.00655       +-  0.00279  (meters)

 Baseline vector (m ): MEDI        (Site10) to UNOV        (Site17)
 X   127797.34330 Y(E)    65345.10546 Z  -144884.35872  L   203945.14254
     +-  0.00624         +-  0.00250      +-  0.00579       +-  0.00248  (meters)

 Baseline vector (m ): MEDI        (Site10) to UNPG        (Site18)
 X    93745.00555 Y(E)    78228.84792 Z  -112072.02416  L   165734.78003
     +-  0.00629         +-  0.00252      +-  0.00585       +-  0.00246  (meters)

 Baseline vector (m ): MEDI        (Site10) to UNTR        (Site19)
 X   129363.79466 Y(E)   112773.30879 Z  -157838.21017  L   233164.55806
     +-  0.00605         +-  0.00243      +-  0.00563       +-  0.00238  (meters)

 Baseline vector (m ): MEDI        (Site10) to VITE        (Site20)
 X   149655.90149 Y(E)    70569.95931 Z  -169237.11415  L   236681.66134
     +-  0.00695         +-  0.00281      +-  0.00638       +-  0.00277  (meters)

 Baseline vector (m ): NOT1        (Site11) to PADO        (Site12)
 X  -545664.20369 Y(E)  -396697.53781 Z   713132.60445  L   981670.24566
     +-  0.00717         +-  0.00301      +-  0.00636       +-  0.00318  (meters)

 Baseline vector (m ): NOT1        (Site11) to REMO        (Site13)
 X  -401854.28865 Y(E)  -339144.86447 Z   558001.17845  L   766727.73757
     +-  0.00599         +-  0.00259      +-  0.00496       +-  0.00251  (meters)

 Baseline vector (m ): NOT1        (Site11) to RENO        (Site14)
 X  -368311.58629 Y(E)  -259249.45499 Z   504639.73857  L   676405.92121
     +-  0.00602         +-  0.00254      +-  0.00493       +-  0.00242  (meters)

 Baseline vector (m ): NOT1        (Site11) to REPI        (Site15)
 X  -360768.67890 Y(E)  -348876.24163 Z   517546.47618  L   720918.18305
     +-  0.00571         +-  0.00246      +-  0.00466       +-  0.00235  (meters)

 Baseline vector (m ): NOT1        (Site11) to RETO        (Site16)
 X  -355289.92460 Y(E)  -313868.77760 Z   503643.10949  L   691665.32500
     +-  0.00709         +-  0.00294      +-  0.00594       +-  0.00279  (meters)

 Baseline vector (m ): NOT1        (Site11) to UNOV        (Site17)
 X  -345348.14896 Y(E)  -336326.31918 Z   498164.26819  L   693215.96567
     +-  0.00619         +-  0.00264      +-  0.00509       +-  0.00249  (meters)

 Baseline vector (m ): NOT1        (Site11) to UNPG        (Site18)
 X  -379400.48671 Y(E)  -323442.57672 Z   530976.60276  L   728351.55140
     +-  0.00626         +-  0.00265      +-  0.00520       +-  0.00255  (meters)

 Baseline vector (m ): NOT1        (Site11) to UNTR        (Site19)
 X  -343781.69760 Y(E)  -288898.11585 Z   485210.41675  L   661118.08738
     +-  0.00597         +-  0.00254      +-  0.00488       +-  0.00238  (meters)

 Baseline vector (m ): NOT1        (Site11) to VITE        (Site20)
 X  -323489.59076 Y(E)  -331101.46532 Z   473811.51277  L   662397.95086
     +-  0.00688         +-  0.00292      +-  0.00572       +-  0.00271  (meters)

 Baseline vector (m ): PADO        (Site12) to REMO        (Site13)
 X   143809.91504 Y(E)    57552.67334 Z  -155131.42600  L   219224.45394
     +-  0.00527         +-  0.00214      +-  0.00503       +-  0.00214  (meters)

 Baseline vector (m ): PADO        (Site12) to RENO        (Site14)
 X   177352.61740 Y(E)   137448.08283 Z  -208492.86587  L   306292.67293
     +-  0.00540         +-  0.00217      +-  0.00512       +-  0.00219  (meters)


Baseline vector (m ): PADO        (Site12) to REPI        (Site15)
 X   184895.52479 Y(E)    47821.29618 Z  -195586.12827  L   273362.69867
     +-  0.00502         +-  0.00200      +-  0.00481       +-  0.00205  (meters)

Baseline vector (m ): PADO        (Site12) to RETO        (Site16)
 X   190374.27910 Y(E)    82828.76021 Z  -209489.49496  L   294938.66847
     +-  0.00657         +-  0.00260      +-  0.00609       +-  0.00264  (meters)

 Baseline vector (m ): PADO        (Site12) to UNOV        (Site17)
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 X   200316.05474 Y(E)    60371.21863 Z  -214968.33625  L   299970.98429
      +-  0.00557         +-  0.00223      +-  0.00527       +-  0.00227  (meters)

 Baseline vector (m ): PADO        (Site12) to UNPG        (Site18)
 X   166263.71698 Y(E)    73254.96110 Z  -182156.00169  L   257275.57572
      +-  0.00562         +-  0.00225      +-  0.00532       +-  0.00227  (meters)

 Baseline vector (m ): PADO        (Site12) to UNTR        (Site19)
 X   201882.50610 Y(E)   107799.42197 Z  -227922.18770  L   322995.02363
      +-  0.00535         +-  0.00215      +-  0.00509       +-  0.00219  (meters)

 Baseline vector (m ): PADO        (Site12) to VITE        (Site20)
 X   222174.61293 Y(E)    65596.07249 Z  -239321.09168  L   333075.04902
      +-  0.00636         +-  0.00256      +-  0.00591       +-  0.00259  (meters)

 Baseline vector (m ): REMO        (Site13) to RENO        (Site14)
 X    33542.70236 Y(E)    79895.40949 Z   -53361.43988  L   101763.61140
      +-  0.00380         +-  0.00158      +-  0.00342       +-  0.00143  (meters)

 Baseline vector (m ): REMO        (Site13) to REPI        (Site15)
 X    41085.60975 Y(E)    -9731.37716 Z   -40454.70227  L    58474.86610
      +-  0.00324         +-  0.00135      +-  0.00294       +-  0.00127  (meters)

 Baseline vector (m ): REMO        (Site13) to RETO        (Site16)
 X    46564.36406 Y(E)    25276.08687 Z   -54358.06896  L    75907.31341
      +-  0.00533         +-  0.00214      +-  0.00474       +-  0.00207  (meters)

 Baseline vector (m ): REMO        (Site13) to UNOV        (Site17)
 X    56506.13969 Y(E)     2818.54529 Z   -59836.91026  L    82348.91529
      +-  0.00404         +-  0.00167      +-  0.00363       +-  0.00160  (meters)

 Baseline vector (m ): REMO        (Site13) to UNPG        (Site18)
 X    22453.80194 Y(E)    15702.28776 Z   -27024.57569  L    38484.57813
      +-  0.00412         +-  0.00170      +-  0.00373       +-  0.00160  (meters)

 Baseline vector (m ): REMO        (Site13) to UNTR        (Site19)
 X    58072.59105 Y(E)    50246.74863 Z   -72790.76170  L   105809.52967
      +-  0.00373         +-  0.00156      +-  0.00336       +-  0.00146  (meters)

 Baseline vector (m ): REMO        (Site13) to VITE        (Site20)
 X    78364.69789 Y(E)     8043.39915 Z   -84189.66568  L   115297.97029
      +-  0.00507         +-  0.00210      +-  0.00450       +-  0.00200  (meters)

 Baseline vector (m ): RENO        (Site14) to REPI        (Site15)
 X     7542.90739 Y(E)   -89626.78665 Z    12906.73761  L    90864.95591
      +-  0.00340         +-  0.00137      +-  0.00302       +-  0.00118  (meters)

 Baseline vector (m ): RENO        (Site14) to RETO        (Site16)
 X    13021.66170 Y(E)   -54619.32262 Z     -996.62909  L    56158.94716
      +-  0.00542         +-  0.00215      +-  0.00478       +-  0.00184  (meters)

 Baseline vector (m ): RENO        (Site14) to UNOV        (Site17)
 X    22963.43733 Y(E)   -77076.86419 Z    -6475.47038  L    80685.15455
      +-  0.00417         +-  0.00168      +-  0.00369       +-  0.00146  (meters)

 Baseline vector (m ): RENO        (Site14) to UNPG        (Site18)
 X   -11088.90042 Y(E)   -64193.12173 Z    26336.86419  L    70266.28640
      +-  0.00424         +-  0.00171      +-  0.00379       +-  0.00150  (meters)

 Baseline vector (m ): RENO        (Site14) to UNTR        (Site19)
 X    24529.88869 Y(E)   -29648.66086 Z   -19429.32183  L    43107.50604
      +-  0.00385         +-  0.00156      +-  0.00341       +-  0.00142  (meters)

 Baseline vector (m ): RENO        (Site14) to VITE        (Site20)
 X    44821.99553 Y(E)   -71852.01034 Z   -30828.22581  L    90122.70623
      +-  0.00517         +-  0.00210      +-  0.00454       +-  0.00189  (meters)


Baseline vector (m ): REPI        (Site15) to RETO        (Site16)
 X     5478.75430 Y(E)    35007.46403 Z   -13903.36669  L    38063.66892
      +-  0.00505         +-  0.00199      +-  0.00446       +-  0.00173  (meters)

 Baseline vector (m ): REPI        (Site15) to UNOV        (Site17)
 X    15420.52994 Y(E)    12549.92245 Z   -19382.20799  L    27766.22560
      +-  0.00366         +-  0.00147      +-  0.00325       +-  0.00140  (meters)
```

```
 Baseline vector (m ): REPI        (Site15) to UNPG       (Site18)
 X   -18631.80781 Y(E)    25433.66492 Z    13430.12658  L    34269.28469
      +-  0.00375         +-  0.00150      +-  0.00337       +-  0.00136  (meters)

 Baseline vector (m ): REPI        (Site15) to UNTR       (Site19)
 X    16986.98130 Y(E)    59978.12579 Z   -32336.05943  L    70225.02294
      +-  0.00332         +-  0.00134      +-  0.00295       +-  0.00119  (meters)

 Baseline vector (m ): REPI        (Site15) to VITE       (Site20)
 X    37279.08814 Y(E)    17774.77631 Z   -43734.96341  L    60153.30506
      +-  0.00477         +-  0.00194      +-  0.00420       +-  0.00186  (meters)

 Baseline vector (m ): RETO        (Site16) to UNOV       (Site17)
 X     9941.77564 Y(E)   -22457.54158 Z    -5478.84129  L    25163.42144
      +-  0.00559         +-  0.00222      +-  0.00494       +-  0.00196  (meters)

 Baseline vector (m ): RETO        (Site16) to UNPG       (Site18)
 X   -24110.56211 Y(E)    -9573.79911 Z    27333.49327  L    37684.17027
      +-  0.00565         +-  0.00224      +-  0.00502       +-  0.00219  (meters)

 Baseline vector (m ): RETO        (Site16) to UNTR       (Site19)
 X    11508.22700 Y(E)    24970.66176 Z   -18432.69274  L    33101.92440
      +-  0.00537         +-  0.00213      +-  0.00474       +-  0.00192  (meters)

 Baseline vector (m ): RETO        (Site16) to VITE       (Site20)
 X    31800.33383 Y(E)   -17232.68772 Z   -29831.59672  L    46884.44220
      +-  0.00637         +-  0.00256      +-  0.00561       +-  0.00245  (meters)

 Baseline vector (m ): UNOV        (Site17) to UNPG       (Site18)
 X   -34052.33775 Y(E)    12883.74246 Z    32812.33457  L    49012.26199
      +-  0.00446         +-  0.00179      +-  0.00399       +-  0.00172  (meters)

 Baseline vector (m ): UNOV        (Site17) to UNTR       (Site19)
 X     1566.45136 Y(E)    47428.20333 Z   -12953.85145  L    49190.34975
      +-  0.00410         +-  0.00166      +-  0.00363       +-  0.00143  (meters)

 Baseline vector (m ): UNOV        (Site17) to VITE       (Site20)
 X    21858.55819 Y(E)     5224.85385 Z   -24352.75543  L    33138.38199
      +-  0.00534         +-  0.00217      +-  0.00470       +-  0.00209  (meters)

 Baseline vector (m ): UNPG        (Site18) to UNTR       (Site19)
 X    35618.78911 Y(E)    34544.46087 Z   -45766.18601  L    67502.30882
      +-  0.00418         +-  0.00168      +-  0.00374       +-  0.00158  (meters)

 Baseline vector (m ): UNPG        (Site18) to VITE       (Site20)
 X    55910.89594 Y(E)    -7658.88861 Z   -57165.08999  L    80327.66879
      +-  0.00541         +-  0.00220      +-  0.00479       +-  0.00211  (meters)

 Baseline vector (m ): UNTR        (Site19) to VITE       (Site20)
 X    20292.10683 Y(E)   -42203.34948 Z   -11398.90398  L    48195.71889
      +-  0.00511         +-  0.00209      +-  0.00449       +-  0.00184  (meters)


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    **** Summary of biases-fixed solution ****
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 Total parameters:  1494   live parameters:   427
 Prefit nrms:  0.54960E+00    Postfit nrms: 0.18828E+00


End of loose solution with LC   observable and ambiguities fixd
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Normal stop in SOLVE
```

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