National Report of France, 2004

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1. The GPS network RBF

The RBF network was observed in 1994-1996. 1019 points were observed by GPS, in France and Corsica. Since this time the condition of each marker is verified every two years and in case of destruction built and observed again, the next year.

The first determination in ETRS89 was performed with the Ashtech software GPPS and the Geolab software in 1997. This is the realisation of EUREF French component named RGF93. Every stations of the GPS permanent network (RGP) were connected to the nearest (2-3) RBF points. By comparison with the weekly solutions of the RGP the accuracy of about 2-3 cm in position can be confirmed for RBF.

In 2003, all the RBF observations were computed again using the Bernese software. Otherwise the baselines between RGP and RBF were observed during the operations of linkage of RGP and levelling aided by GPS. The aim is to combine all the determinations, and to fit to a EUREF solution of the RGP which will provide users with an access to the national reference with an accuracy better than 5 mm.

2. The GPS permanent Network RGP

The RGP network is composed today of 43 permanent GPS stations installed by IGN and several partners (universities, research laboratories, district services,…). The partnership is now with public institutes but is becoming with private organisations, which are installing real time networks. The real time will be a service with an admission charge, but the observations will be transferred to the RGP for deferred and free of charge applications.

- 31 stations (15 IGN, 16 partners) deliver observations files every hour, with a one second sampling rate.
- 12 stations (2 IGN, 10 partners) deliver observations files every 24 hours, with a thirty seconds sampling rate
- 10 stations are also EPN stations
- 7 stations are also IGS

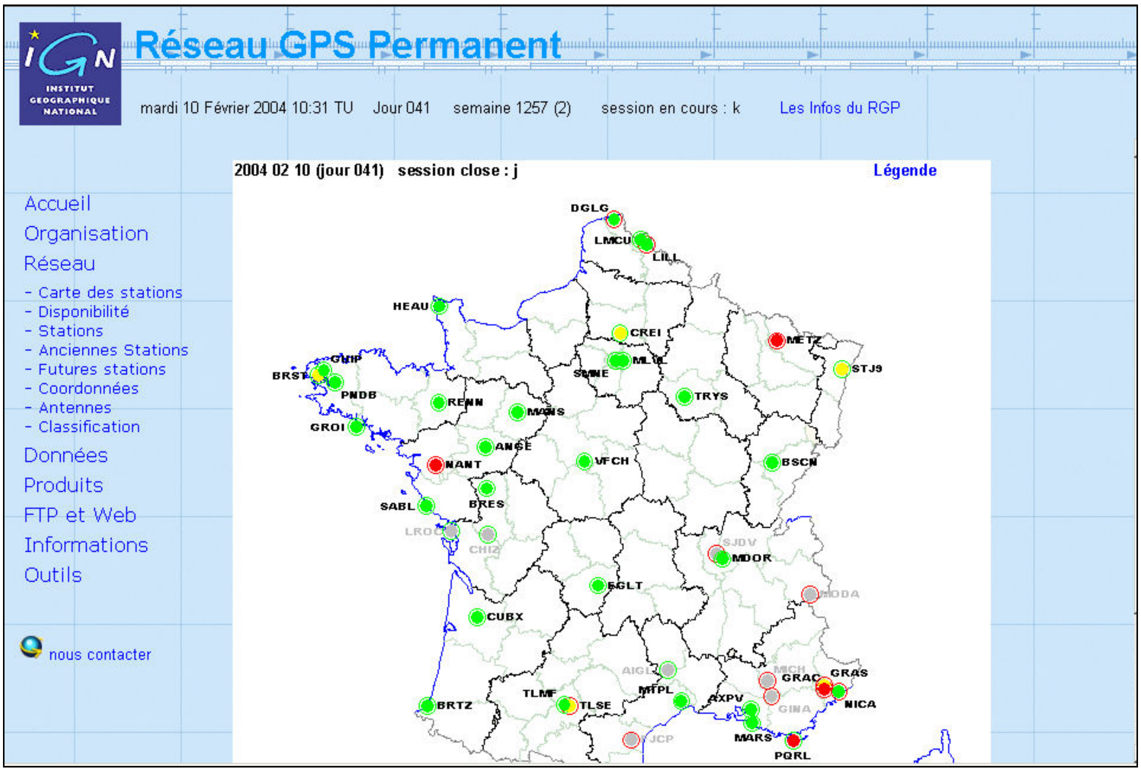

Fig. 1: RGP website (http://geodesie.ign.fr/RGP/index.htm)

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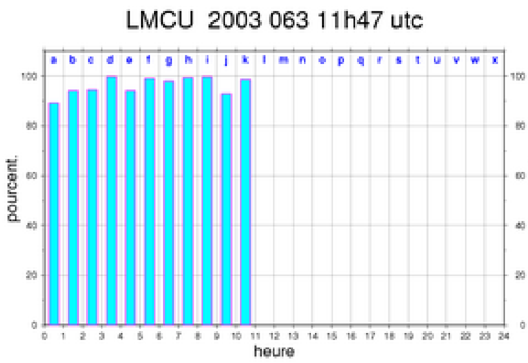

Fig. 2: Lack of data

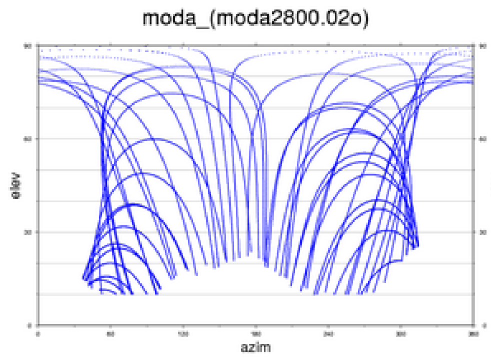

Fig. 3: Mountain mask

Two operational centres, one in Marne-La-Vallée, the other in Saint Mandé:

- collect data
- data quality check (Fig. 2 and 3)
- deliver data on Internet
- process hourly, daily and weekly solution
- deliver products on Internet

Data are public (free of charge).

The website (Fig. 1) is the interface with users. In real time a map shows if the data are arrived or not. Every station is described and diagrams give a view of the data quality. The users can obtain data directly through the web.

Data processing

Depending on the data flow, successive processes are carried out.

Along with the 1-hour data associated with IGS predicted orbits (IGU), hourly solutions are performed in 3-hour moving computation. Expected results are i) an immediate data quality control, ii) providing near real time sub-products as atmospheric behavior parameters (Fig. 5).

Through the availability of rapid orbits IGS products (i.e. after 28 hours), a daily solution is processed. The involved products are intended to refine a reference control assessment and provide more accurate atmospheric models.

Finally, weekly solutions from precise IGS orbits and up to date EOP are made available. The IGN EUREF contribution is included in these activities.

Regarding the maintenance of French national reference, several combinations are routinely performed.

- A daily 7-day moving combination is an efficient tool to recover large errors and to deal with any "instantaneous stability defect" of RGP stations.
- Weekly precise solution is itself a combination.
- In turn, all solutions (combinations) are re-combined in pluri-annual one, in order to provide users with the more accurate coordinate product. In this way, the 4-year 2000-2004 ETRS89 solution is proposed as RGF93 realization usable up to 5-millimeter accuracy requirements.

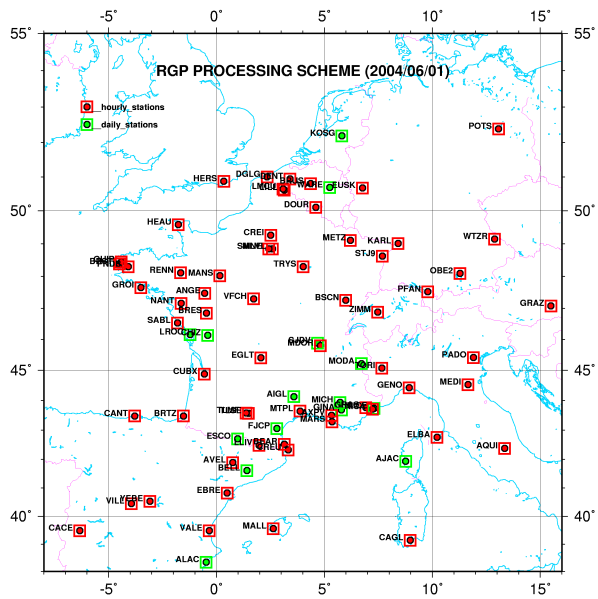

Fig. 4: RGP data processing scheme

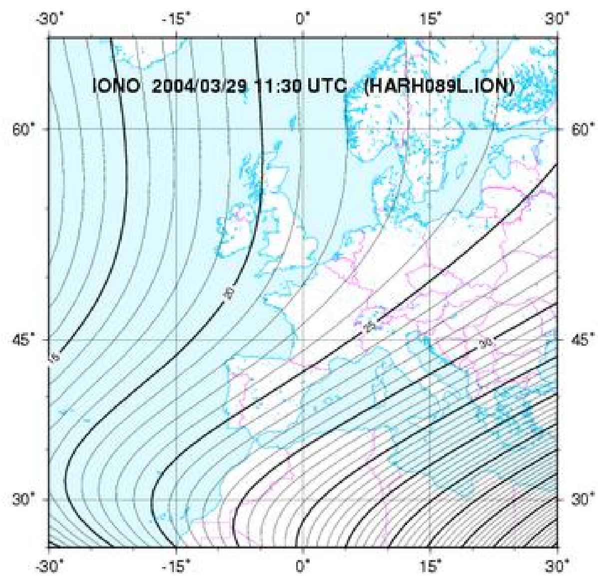

Fig. 5 : Ionospheric model issued from 3 hours of data

3. Scientific levelling

Since four years IGN has started to measure levelling line with a great accuracy using the motorized levelling method (Fig. 6) and ZEISS NI002 level (Fig. 7). The levelling lines are linked to the first order network of Great-Britain (by the Chanel Tunnel), Belgium, Germany and Spain (Fig. 8).

Some statistics on the Strasbourg-Brest line are given bellow:

- length : 1088 km
- number of observations : 17436
- difference between forward an backward : 23,5 mm
- standard deviation: $0{,}5\ \text{mm}/\sqrt{\text{km}}$.

In 2003 855 km and 15000 observations were performed.

4. Levelling aided by GPS (NIVAG)

The maintenance of the French National Levelling Network is performed with levelling aided by GPS. The aim is to equip every town of more than 200 inhabitants with at least three levelling benchmarks. The distance beetween bench marks is less than one kilometre, and

Fig. 6: Motorized levelling

Fig. 7: Surveyor operating a Zeiss NI002 level

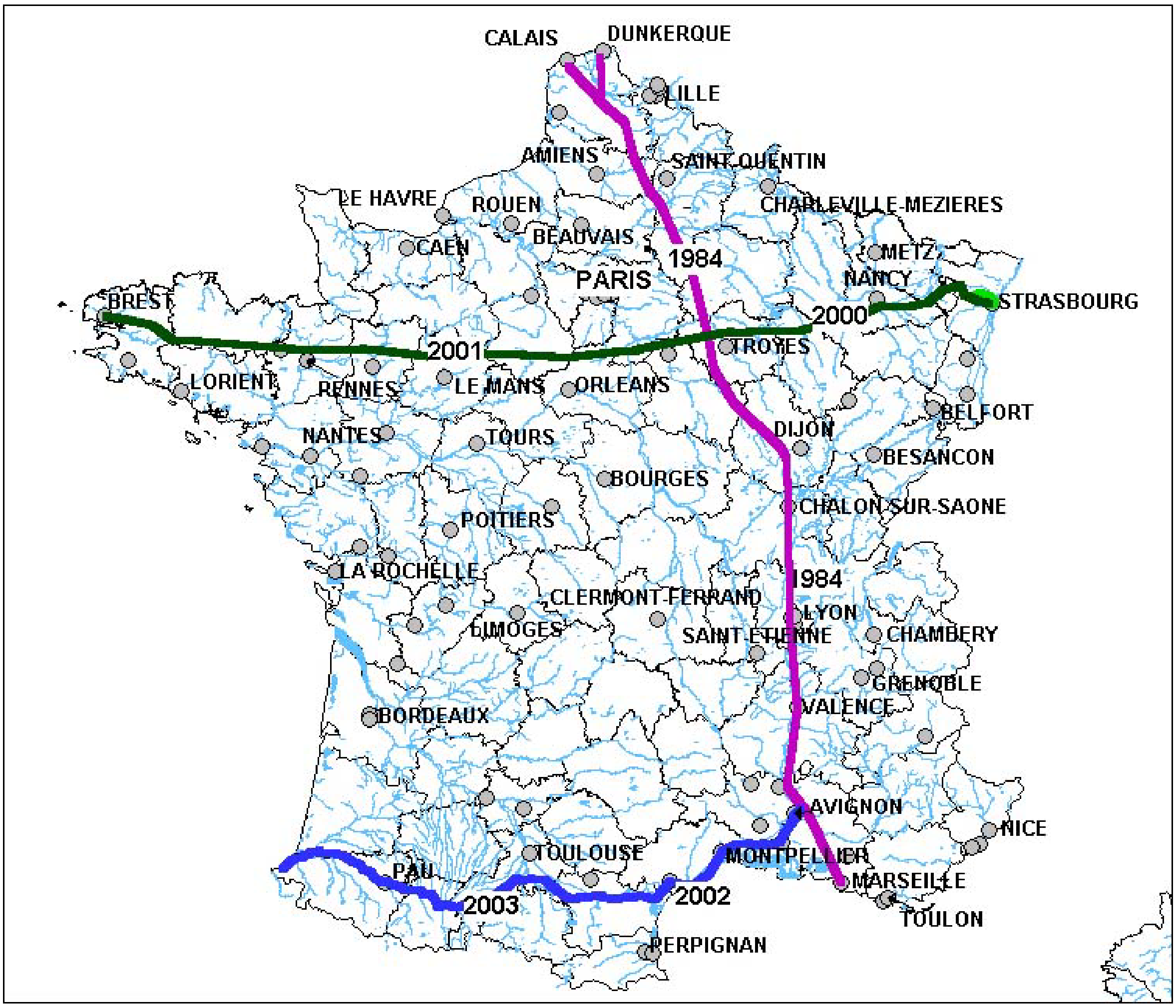

Fig. 8: Scientific levelling lines

less than five kilometres beetween two sets of three benchmarks,. A pivot is observed with GPS, and linked to the RBFand RGP networks and with levelling observations to NGF levelling network (Fig. 9). The pivot is used for GPS determination of village points, for 3 or 4 villages and linked in height by precise levelling to benchmark. The 3 benchmarks are also linked with each other by precise levelling.

The normal height is computed with GPS and RAF98 grid, and if one old benchmark exists it is compared with the normal height from precise levelling.

In 2002-2003, 672 villages were equiped. France will be entirely equiped in 2007.

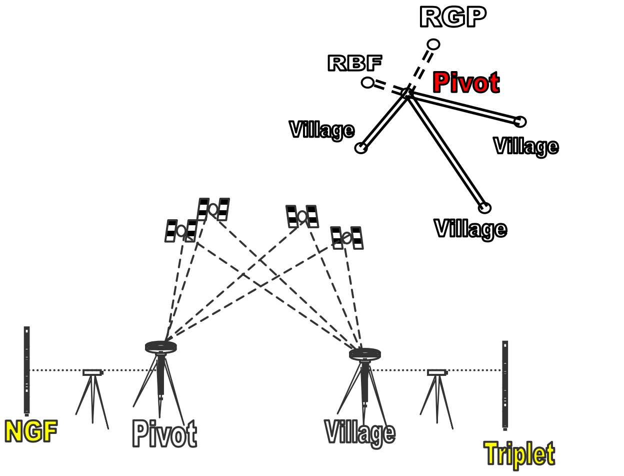

Fig. 9: Observation scheme of levelling aided by GPS

5. Gravimetry

Since 2000 IGN has been establishing a new gravimetric network [Gattacceca T., 2000, 2001, 2002, 2003], the purpose of which is to replace the old RGF83. The latter included 6 absolute stations, 53 first order stations and 280 second order stations. About 30% of these stations are destroyed. The new network will permit to check the dense gravity coverage and to put it in a modern reference. The first order network will comprise about twenty absolute stations, set up mainly near permanent GPS stations. Twelve have been yet measured with a FG5 gravimeter by the Ecole et Observatoire des Sciences de la Terre, others will be observed from 2005 with a A10. It is planned to include by relative measurements the majority of the 1019 geodetic points of the French Base Network (RBF), the main stations of the RGF83 gravimetric network and the first order nodes of the levelling network. At present 389 points have been observed (Fig. 10) using two spring gravimeters Scintrex CG-3M owned by the Institut National des Sciences de l'Univers. Each campaign consists of the following operations:

- calibration of the gravimeters on the absolute base Montpellier–Mont Aigoual ($\Delta h \approx 1500\,\text{m}$, $\Delta g \approx$, $3000\,\mu\text{ms}^{-2}$);
- measurement of a primary loop network of about 15 points 100 km away from one another, with at least two re-occupations;
- measurement of secondary networks between primary points.

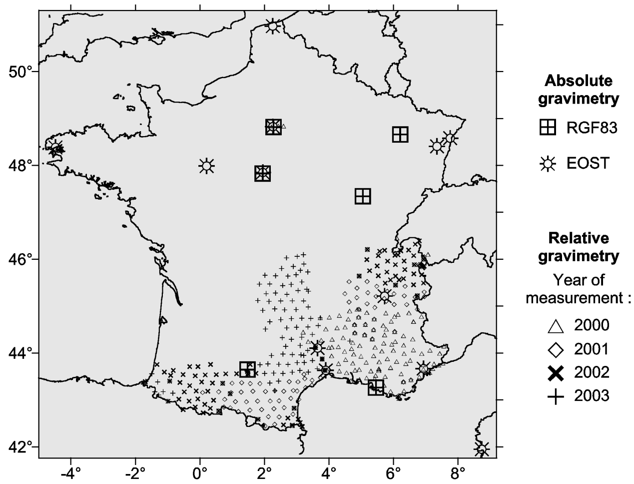

Fig. 10 : The new French gravimetric network

After measurements are corrected for drift and tide effects, they are adjusted using the GEOLAB software. Presently two points are held fixed (Montpellier and Sèvres), the adjustment is therefore quasi-free. The standard deviation of a measurement is $0.26\,\mu\text{ms}^{-2}$, the average half amplitude of the confidence interval at a probability level of 95% is $0.54\,\mu\text{ms}^{-2}$.

6. Geoid and height reference

The last French quasigeoid model has been computed in 1998 [Duquenne H., 1998]. It presented a considerable mistakes along the French Riviera (error up to 0.60 m) and in Corsica (error larger than 1 m) due to blunders in marine gravity data. In 2001 an airborne gravity survey (Fig. 11 and [Duquenne H. et al., 2003]) was carried out by KMS (Denmark), the University of Bergen (Norway), the Ecole Supérieure des Géomètres et Topographes, the Institut National des Sciences de l'Univers and the Institut Géographique National. Gravity data were corrected in the Mediterranean sea and a geoid model covering Corsica and Provence has been computed. Its error remains below 0.20 m in Corsica (Fig. 12).

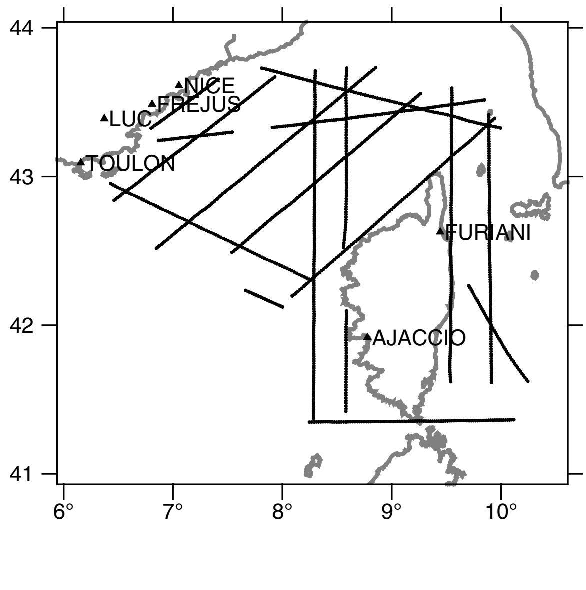

Fig. 11: Valid lines of flight of the aerial survey in Corsica and French Riviera

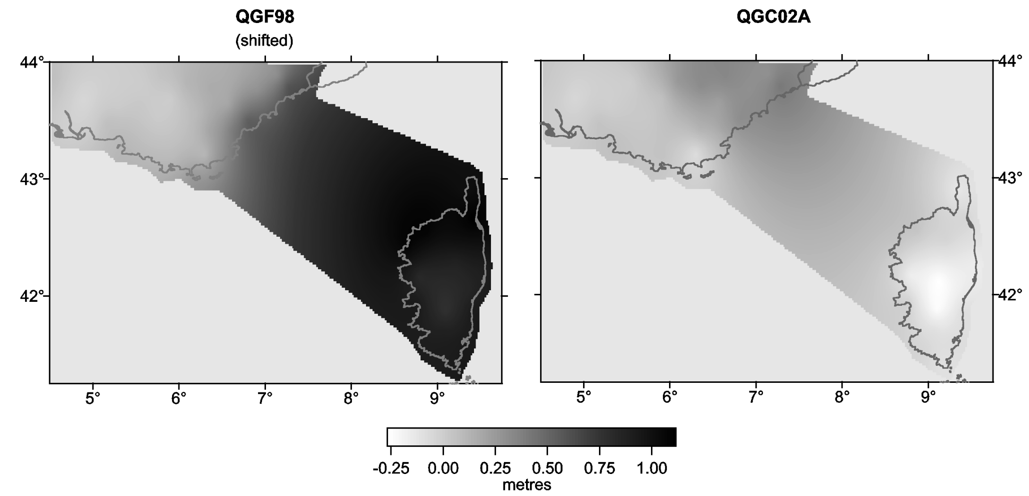

Fig. 12 Comparison of the differences between the quasigeoid models (QGF98 and QGC02A) and the levelled GPS points of the RBF

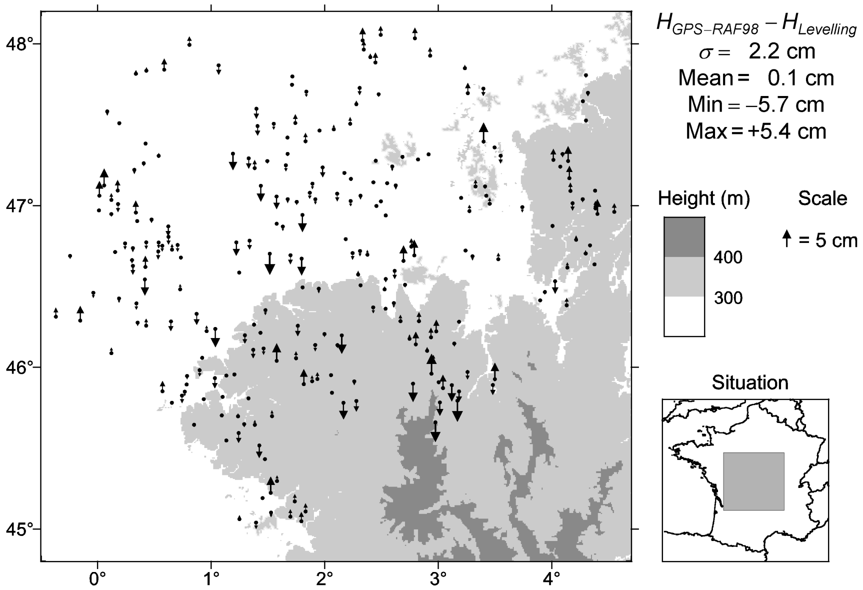

Fig.13: Evaluation of the RAF98 grid by mean of 258 "NIVAG" control points

With a view to use the geoid for levelling by GPS, it has been fitted to 984 levelled GPS points of the geodetic network RBF, leading to the RAF98 grid. RAF98 allows to transform ellipsoidal heights referred to RGF93 into normal heights referred to NGF-IGN69. Independent evaluations of RAF98 were carried out at first in 2000 [Nocquet J.M. et al., 2000], then in 2002 and 2003 using the levelled GPS points "NIVAG" measured to maintain the levelling network by GPS (see above and Fig. 13). From a set of 258 control points it is possible to conclude that levelling by GPS is feasible throughout continental France with a precision of 2 to 3 cm.

7. Contribution to international networks

Doris Network

In collaboration with CNES (the French Spatial Agency), IGN is in charge of the building and maintenance of the DORIS network. In 2003 two new stations were installed in China (Jiufeng) and Crozet Islands. In the context of the IDS service, three new stations were installed in Germany (Wettzel), Greece (Gavdos), and Antarctica (Sorsdal, Fig. 15). At last five stations were restored in the Philippines (Manila), Ascension Island (south Atantlic), Norway (Ny-Alesund), Australia (Yaragadee), Saint Helena Island (south Atlantic).

The IDS (International Doris Service) is now operational: http://lareg.ensg.ign.fr/DORIS/

ITRF :

In 2003 IGN has determined precise geodetic links between spatial instruments (VLBI, Satellite Laser, GPS, DORIS, Fig. 16 to 18) in three ITRF sites: In south Africa (Hartebeesthoek) , China (Shangai, Shesha).

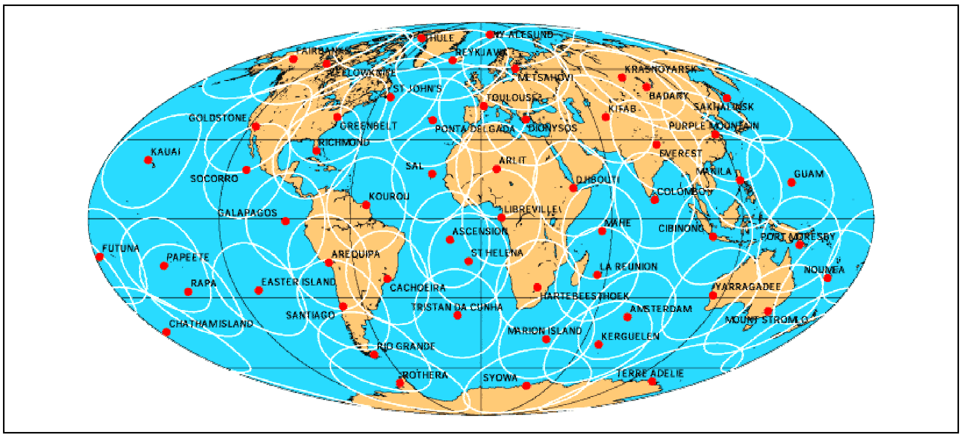

Fig. 14: DORIS network: 54 stations, 30 countries

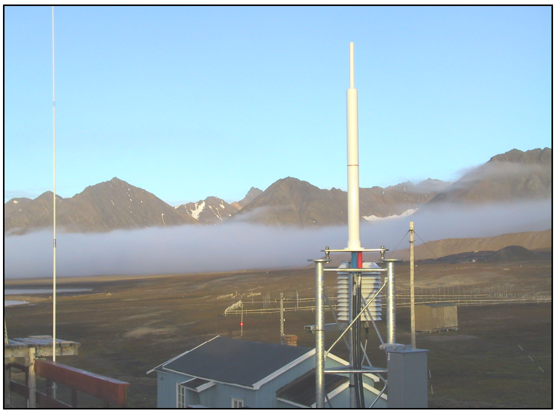

Fig 15: Sorsdal Doris station

Fig. 16: Laser and VLBI linking

Fig. 18: Precise centring

Fig. 17: Laser axis determination

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