An inventory of collocated and nearly-collocated CGPS stations and tide gauges

Progress report on the survey
- (July 25, 2007) -
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Note : The dynamic tables below are continuously updated. Please, don't hesitate to complete the form given here or to sent an E-mail to Guy Wöppelmann (gwoppelm@univ-lr.fr) to help us to keep this survey up-to-date.

- CGPS@TG table .
- DORIS@TG table .

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0. Background

Vertical land movements are an important signal in long sea level records. Over the past few years, considerable developments have taken place with the Global Positioning System (GPS) and DORIS for monitoring rates of vertical land movements at tide gauges, with the aim of eventually removing the land movement signals from the sea-level records. These developments have taken place through a number of "GPS at Tide Gauges (CGPS@TG)" Working Groups over the last 15 years. For a summary of this work, please see http://www.pol.ac.uk/psmsl/landmove.html

Considerable developments have taken place with the GPS technique in particular, and with the organisation of centres to analyse such data. In 2001, the International GNSS Service (IGS) established a pilot project called TIGA to analyse GPS data from stations at or near tide gauges on a continuous basis (TIGA stands for "GPS Tide Gauge Benchmark Monitoring"). The objectives of the TIGA pilot project are twofold: both technical and scientific. Technical issues aim at setting up the required research infrastructure: observing stations, data centres, and dedicated analysis centres. For the purpose of using tide gauges to derive true long term sea level changes, an important research issue is the implementation of an appropriate GPS processing strategy to estimate vertical velocities at each station with an accuracy better than 1 mm/yr, and hopefully much better than this within a decade or so. However, the use of GPS to monitor vertical land motions at tide gauges has proven to be not as straightforward as some supposed 15 years ago. Determining rates of vertical land motion with an accuracy better than 1 mm/yr is still a very challenging problem in Geodesy today. Many issues are to be taken into account: we are aiming at a level of performance where serious consideration of the reference frame and its long term stability need to be addressed.

In this context this report presents the status on the availability of permanent GPS receivers near tide gauges. It is our hope that this report will encourage more GPS and DORIS operators to join and contribute their GPS data to the GLOSS and TIGA community.

1. Introduction

In order to get a better idea about the status and opportunities on continuous GPS positioning of tide gauges, a survey is carried out within various geosciences communities since October 1999. The survey aims at ***identifying the existing permanent GPS stations which are close to tide gauges*** (up to approximately 10 km). Four progress reports have been released so far :

- December 1999 report.
- April 2001 report.
- September 2002 report.
- December 2003 report.
- February 2005 report.

The 2001 progress report was presented to the GLOSS group of experts during its 7th meeting held in Hawaii, April 2001. An action item was agreed on there : ***to update the list of GPS receivers at tide gauge sites at regular intervals***. Actually the list and tables are continuously updated. However, a new formal report is released after a GLOSS GE meeting.

Considering the involvement of DORIS teams in the monitoring of vertical land motions, with the aim of removing the land motion signal from the tide gauge sea level records, the present survey is extended to DORIS ground stations that fulfil the vicinity criteria. The survey might further be extended to other advanced geodetic techniques.

2. Survey results

2.1. Main dynamic tables

The results of the survey are stored in a database which content can be browsed and searched through a web interface. Go to the following URLs to get a view of the survey tables :

- http://www.sonel.org/phpgen/projects/survey.cgps.php3 [NOT WORKING... IN MAINTENANCE]
- http://www.sonel.org/phpgen/projects/survey.doris.php3 [NOT WORKING... IN MAINTENANCE]

The main views are ordered by station name. The 'Search' link presents a form that can be filled up with criteria. A subset of the data matching these criteria will then be displayed. The 'List all' link scrolls the view to the entire list of stations.

A brief explanation of the table columns follows: Columns 2,3,4 are the name, longitude and latitude of the GPS (DORIS) station. The first column is an internal database index and the other ones are :

5. IGS (DORIS) code of the GPS/DORIS station (PPPP means this is a planned station) ;
6. GPS (DORIS) starting date of continuous operation ;
7. Approximate distance between antenna and tide gauge in meters (**'-1' means *no information***) ;
8. GLOSS code ;
9. PSMSL code ;
10. Country name.

The codes represent an official commitment to a specific network. Therefore, they may give an idea of the quality, interest and data availability.

2.2. Standard thematic tables

The following tables are simple text tables produced for the report in order to outline certain characteristics. (You just have to click on the links to access them).

General information :

- Table ordered by country and GPS station name (304 in total)
- Planned GPS stations (17 in total)

GLOSS related information :

- Permanent GPS at GLOSS stations (131 in total)
- Permanent GPS at GCOS stations (80 in total), following the requirements as given by Harrison (2005)

Sorted by distance to the tide gauge :

- Up to 1000 meters (146 in total)
- Between 1001 and 3000 meters (16 in total)
- Between 3001 and 10000 meters (41 in total)
- Over 10000 meters (14 in total)
- No distance information (87 in total)

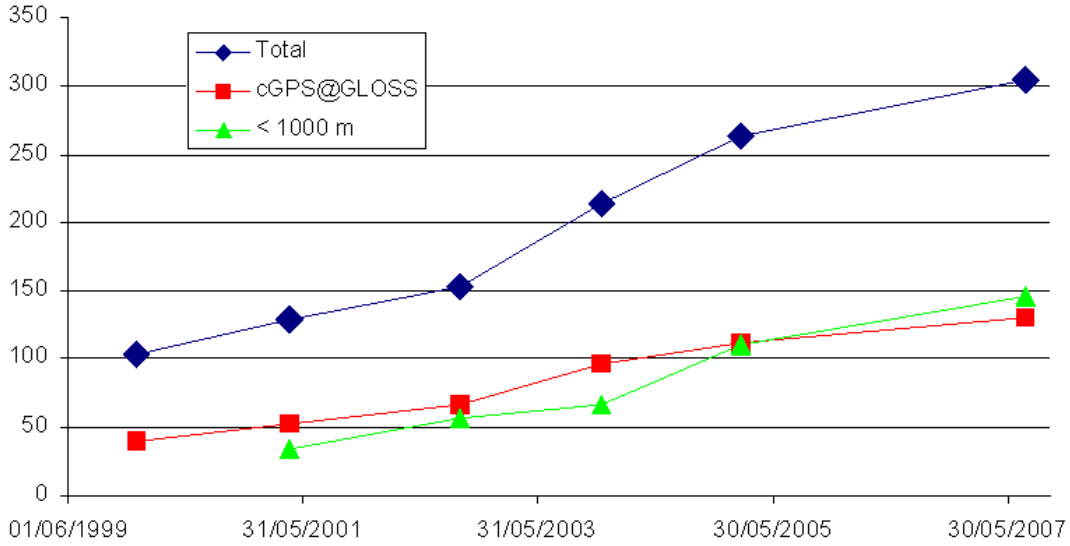
Data availability and IGS pilot project TIGA :

- Identified stations for which data is made available (226 in total)
- TIGA Operational Stations (106 in total)

2.3. Global view

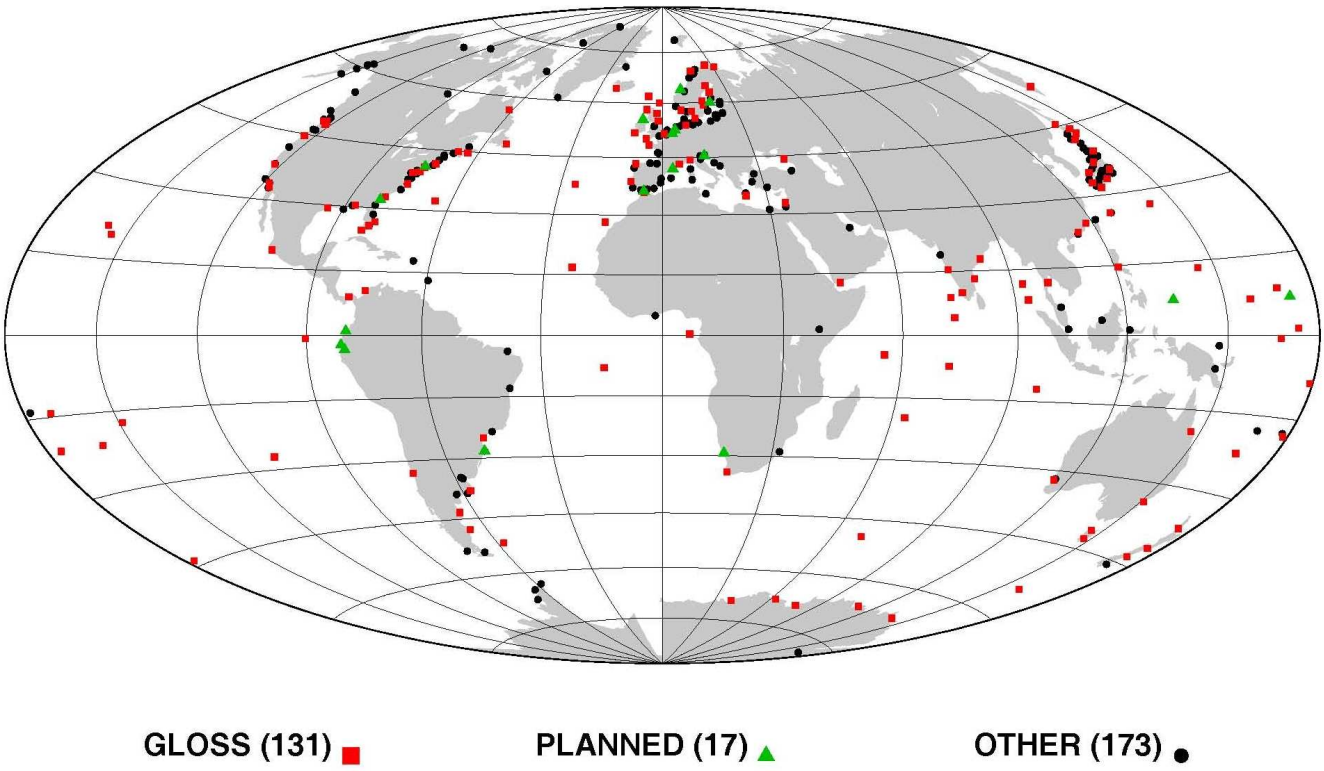
The amount of operational permanent GPS stations less than about 10 km away from a tide gauge has increased from 264 to **304** since the last progress report. Figure 1 illustrates this evolution since the survey was first undertaken in 1999.

Figure 1
Evolution of the # of CGPS@TG stations



There are **17** planned stations meeting the vicinity criterion. Overall, the stations are distributed worldwide (see figure 2), though not evenly. It is worth to note that **131** out of the 304 tide gauge / GPS sites are stations committed to GLOSS.

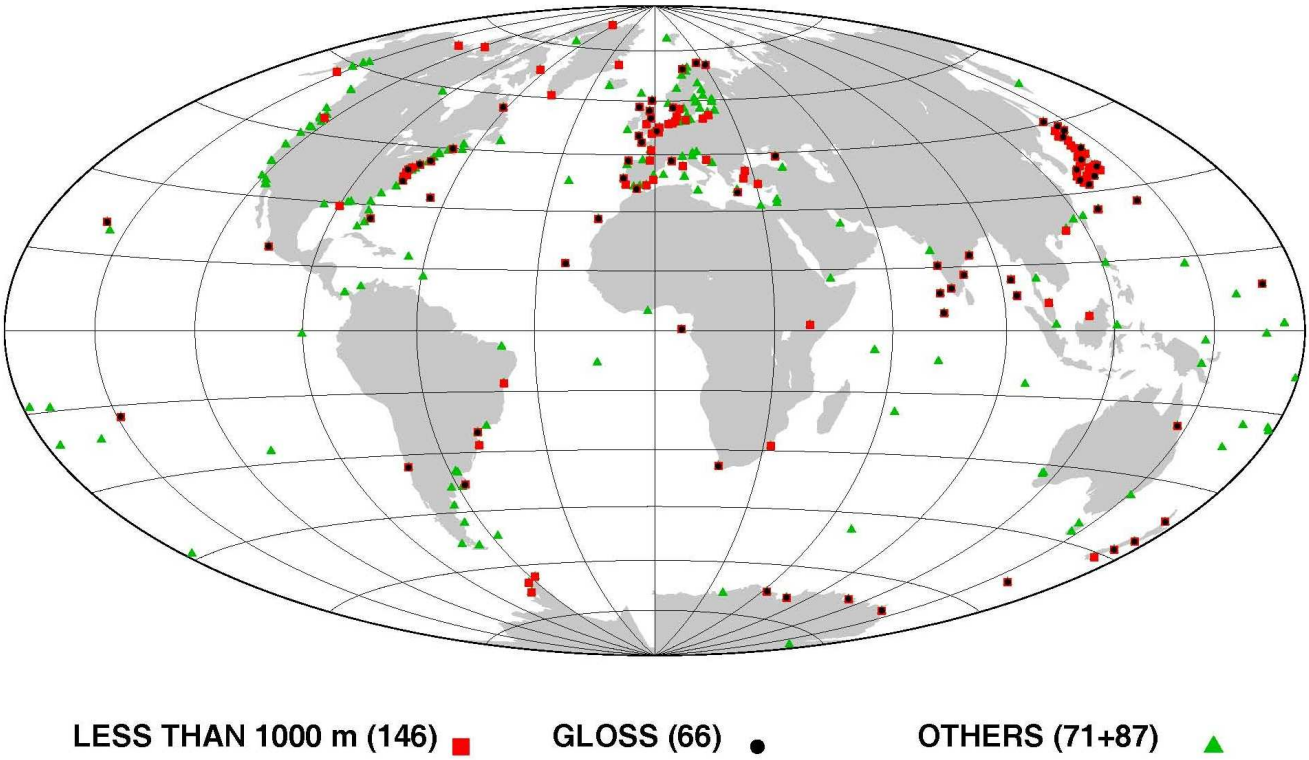
Figure 2
Worldwide distribution of CGPS@TG stations



It is quite interesting to have a look at the distance between the GPS antenna and the tide gauge. The survey shows that 146 GPS stations are less than 1000 meters away from the tide gauge (66 out of the 146 are linked to GLOSS tide gauges, see map below), 16 stations are between 1 and 3 km and 41 are between 3 and 10 km. Distance information is still missing for 87 stations. This information is critical for some applications like GLOSS-LTT : ***In no circumstances can it be assumed that even relatively close sites are not moving differentially at the mm/year level*** **(IOC, 2000)**.

Therefore, frequent levelling (at least annually) is required over a long period of time (10-20 years). Experience shows that these regular levelling surveys are often neglected over time, in particular if the distance involved is more than a few hundred metres. Where the distance is more than 1 km, it is unlikely anyone will perform a levelling tie on a regular basis. Moreover, the levelling error can become a significant part of the total error budget. So, stations more than 1 km away cannot be considered 'nearly collocated' in the practical sense, though they may still be of interest for certain applications. Nevertheless, some GPS stations are considered here even if they are more than 10 km away from the tide gauge. This is acceptable if there is evidence of local stability and if a rigorous and frequent surveying program is undertaken within CGPS@TG project.

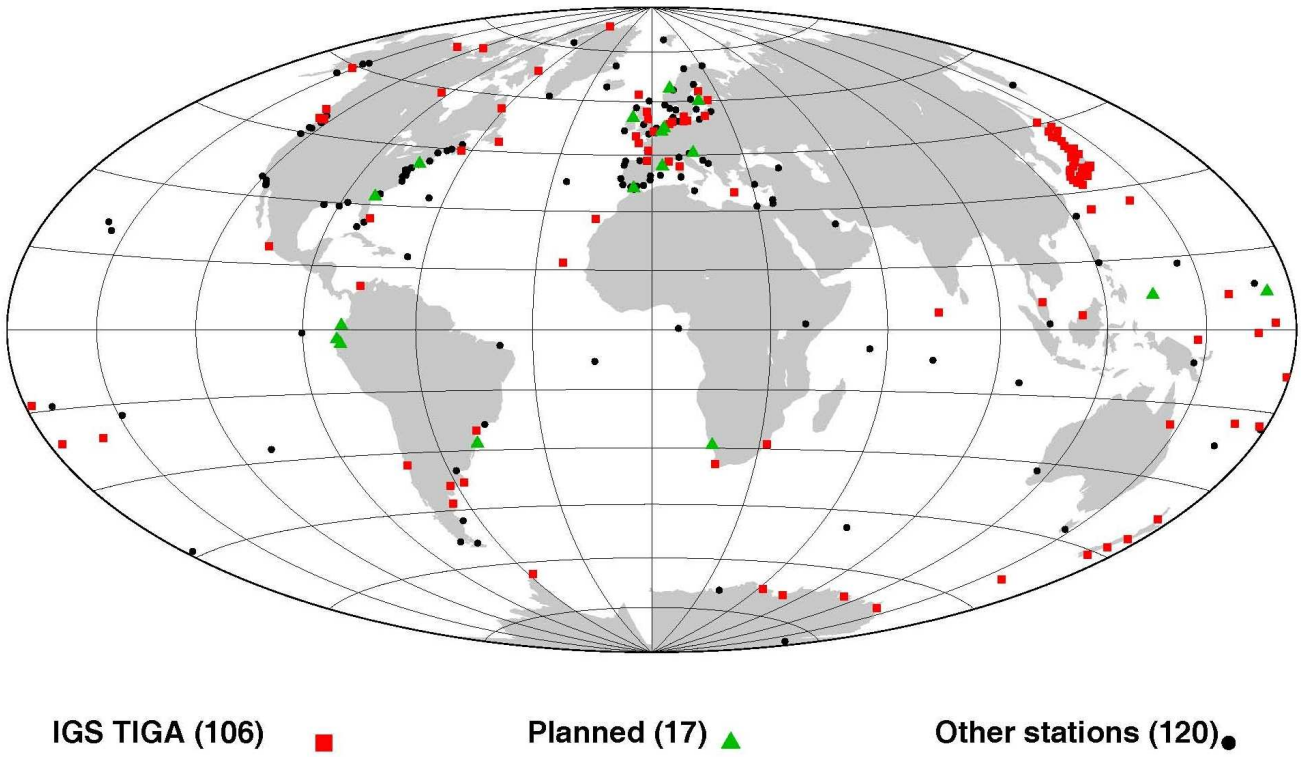
Figure 3
Continuously GPS stations operating less than 1000 meters from a tide gauge



2.4. Data access and GLOSS

Figure 4 shows the stations for which the access to the GPS observations was identified. Data from 74% of the CGPS@TG stations reported here are freely accessible on Internet, following the IGS philosophy of sharing the data for mutual benefits (precise orbits, clocks...). A few stations are be available for scientific use under certain conditions. Figure 4 outlines those stations that have been committed to TIGA.

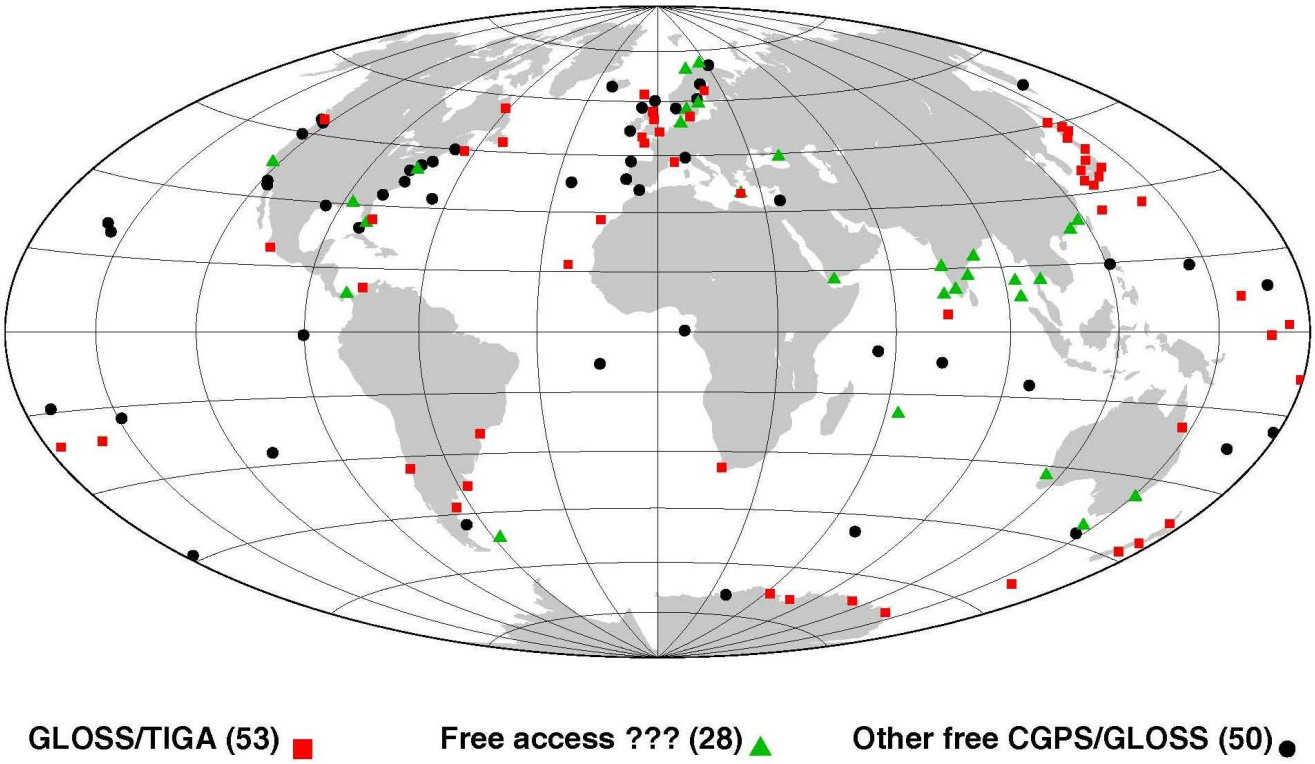
Figure 4
Permanent GPS stations for which access to the data could be identified



A dedicated data centre was set up in 2001 at the University of La Rochelle to gather, archive and make available as much GPS data from permanent stations as possible to support the scientific community interested by the CGPS@TG synergy. In particular, this data centre supports the IGS TIGA Pilot Project. Its anonymous FTP server address is: ftp.sonel.org.

Today, 106 stations have committed to TIGA. Among them 53 are GLOSS out of the potential of 131 CGPS@GLOSS stations. The access to their data for scientific purposes is therefore ensured by this international commitment to IGS. Moreover, the survey has located free access to GPS data files of 50 additional CGPS@GLOSS stations.

Figure 5
CGPS@GLOSS stations for which data is freely accessible



3. Outlook and Requests

The survey highlights that GPS data of 26% of the stations is not available to the GLOSS or IGS scientific community yet (78 out of 304). Of course, all the stations may not be useful for scientific applications. But for sure GLOSS stations are useful for scientists ! Actions should therefore be undertaken to : (i) make the CGPS@GLOSS data files freely available as are the tide gauge data files, (ii) ensure that this GPS data will be processed by as many groups as possible. Determining rates of vertical crustal motions in a well-defined global reference frame with an accuracy better than 1 mm/yr is a very challenging problem in Geodesy today. The IGS TIGA pilot project aim to address these issues, but this requires an active participation and commitment to the project. In particular, the GPS sitelog and the TIGA Observing Station form should be kept up-to-date whenever a change occurs at the station. The local contacts are requested to ensure that the updated forms are properly delivered to all the members of the project through the TIGA mailing lists : tiga_tac@gfz-potsdam.de and tiga_all@gfz-potsdam.de

More information is also needed to provide better use of CGPS@TG site collocations. The following information should be included on the stations forms :

- Distance between GPS antenna and tide gauge,
- Height difference (levelling or geodetic tie) between GPS and tide gauge benchmarks (accompanied with its accuracy and date of measurements)
- Tide gauge zero definition with respect to the TGBM
- GPS data collection (accessibility, delivery, commitment to IGS TIGA pilot project)
- Operational contacts for both GPS and tide gauge.

4. Related useful documents on the web

IGS-PSMSL [1997] : Proceedings of the workshop on methods for monitoring sea level, March 17-18, 1997, Pasadena (California), 202 pp.

M. Bevis [1998] : "Continuous GPS positioning of tide gauges : some preliminary considerations". Report to the IGS. GLOSS Bulletin Nr. 6.

M. Bevis, W. Scherer and M. Merrifield [2002] : Technical issues and recommendations related to the installation of continuous GPS stations at tide gauges. Marine Geodesy, 25, pp. 87-99.

CGPS@TG Working Group : CGPS@TG Website - A technical forum on continuous GPS monitoring of tide gauges.

Harrison D.E. [2005] : Tide gauge measurements of sea level: requirements for climate monitoring and research. Report of the OOPC chair. 28 January 2005.

IOC [2000] : Manual on sea level measurement and interpretation. IOC Manuals and Guides n°14. Volume III: Reappraisals and Recommendations as of the year 2000.

TIGA Website : GPS Tide Gauge Benchmark Monitoring - Pilot Project of the International GPS Service.

ESEAS Website : European Sea Level Service.

DORIS Stations Handbook on the Web at IGN France.
