

National Report of France to the XIIIth GLOSS Group of Experts Meeting, held at PSMSL, Liverpool, 28th October-1st November 2013

prepared by

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1. Background & New context

Today, 15 French tide gauges are contributing to the GLOSS core network (Table 1). This contribution relies mainly on the willingness of France to maintain instruments on its overseas Departments and collectivities that provide reliable and valuable data on sea level around the globe.

Since 2010, the French hydrographic service SHOM has been designated as the official national coordinator for French in situ sea level observations (SGMer 2010; Pouvreau 2012a) and has developed a new webportal (refmar.shom.fr) to access French high frequency sea level data. In parallel, the SONEL data center (www.sonel.org) has been acknowledged as “Service d’observation” by the INSU (CNRS) in 2011, and similarly by AllEnvi (www.allenvi.fr), highlighting its utility for research on environmental issues.

During XIIth GLOSS Group of Experts meeting in November 2011, SONEL has been designated as data assembly centre for GLOSS concerning observations from GNSS stations co-located with tide gauges whose servers are hosted at the University of La Rochelle, France.

2. Overview of French Stations committed to GLOSS

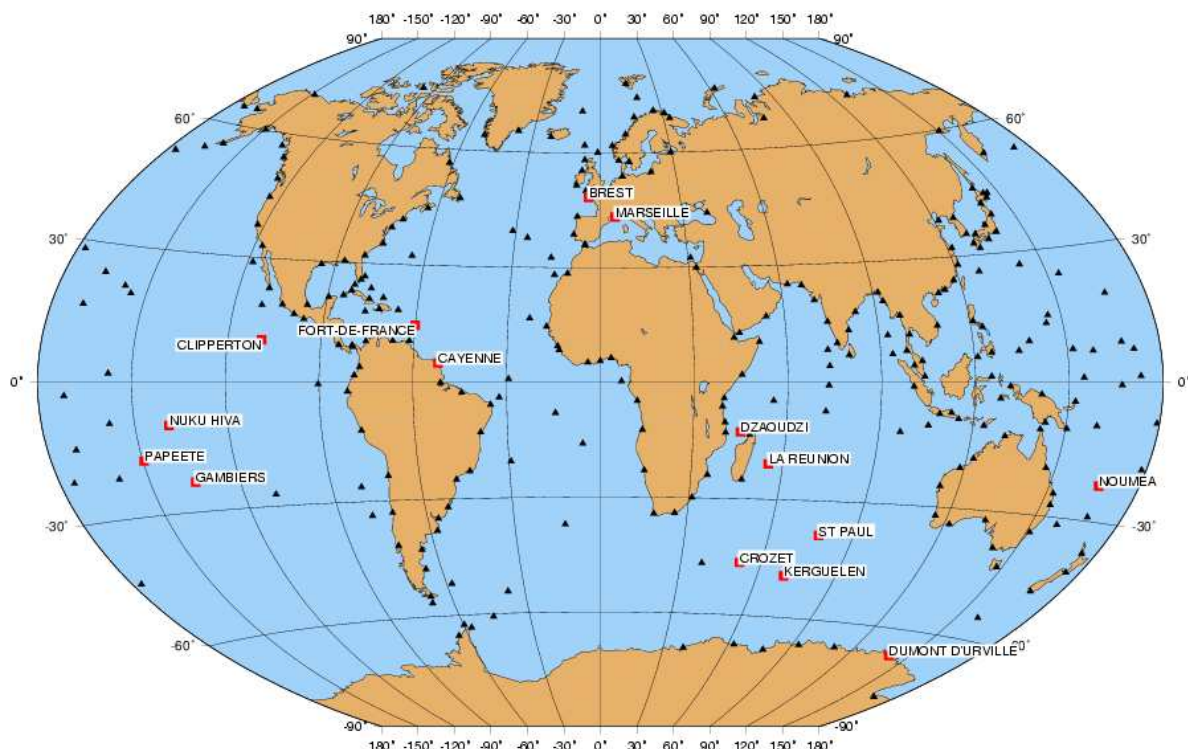


Figure 1: Geographical distribution of the French stations committed to GLOSS (black crosses represent the other GLOSS stations from the core network)

Figure 1 highlights the geographical distribution of these stations around the world. We also report on an additional GLOSS station which is operated in collaboration with French organisms (Sao Tomé). The stations are namely:

GLOSS Id.	Station Name	Operator	Network
017	Pointe des Galets (La Réunion)	SHOM / DMS-OC / MF	RONIM
021	Crozet	LEGOS / INSU	ROSAME
023	Kerguelen	LEGOS / INSU	ROSAME
024	Amsterdam St Paul	LEGOS / INSU	ROSAME
096	Dzaoudzi	SHOM/DMSOI/CG976/MF	RONIM
123	Nouméa	SHOM / GNC / IRD	RONIM
131	Dumont D'Urville	LEGOS / INSU	ROSAME
138	Rikitea	UHSLC	
140	Papeete Fare Ute (Tahiti)	UHSLC	
142	Nuku Hiva	UHSLC	
165	Clipperton	SHOM	Not permanent
202	Ile Royale (Cayenne)	SHOM / DM-Guyane	RONIM
204	Fort-de-France	SHOM / MF / MN	RONIM
205	Marseille	SHOM / IGN	RONIM
242	Brest	SHOM	RONIM
260	Sao Tomé	LEGOS / IRD	

Table 1: GLOSS stations under French responsibility

Given its isolated location, the new permanent tide gauge installed in Leava on the Futuna Island (Pacific Ocean) is suggested as new GLOSS station (Cf. Section 3.3.1).

3. Status of French sea level stations committed to GLOSS

3.1. Atlantic Ocean & Mediterranean Sea

GLOSS 205: MARSEILLE

- Operated by IGN and SHOM (RONIM TG Network).
- Contributing to the North-East Atlantic and Mediterranean Tsunami Warning System (IOC- ICG/NEAMTWS)
- **Sensor:** Although the original floating gauge is still operating in Marseille since February 1885, an acoustic tide gauge was installed in June 1998. It was replaced in April 2009 with a new tide gauge using a Khrona radar sensor. Yearly, IGN in cooperation with SHOM and LIENSs is performing controls and maintenance operations of the geodetic and sea-level infrastructure (Coulomb 2013). The results show a locally stable site at the millimetre level. Van de Castele tests are regularly carried out. Absolute gravimetric observations have been carried out on some reference points and relative gravimetric observations close to the GNSS permanent station.
- **Data transmission:** Real-time data are available for this gauge through both the IOC and the REFMAR websites thanks to an Internet connexion (<http://refmar.shom.fr/MARSEILLE>).
- **GNSS:** The permanent GPS station is operational since July 1998 and is committed to the IGS/TIGA permanent service (GPS Tide gauge benchmark monitoring).
- **Data:** Historical hourly data from IGN and dating back to 1885, will be available after quality controls are finalized.

GLOSS 242: BREST

- **Operated by SHOM (RONIM TG Network)**
- **Contributing to the North-East Atlantic and Mediterranean Tsunami Warning System (IOC – ICG/NEAMTWS)**
- **Sensor:** In April 2013, the radar sensor Krohne BM100 was replaced by a new KHRONE OPTIFLEX 1300C guided wave radar sensor.
- **Data transmission:** Real-time data are available for this gauge through both the IOC and the REFMAR websites thanks to an Internet connexion (<http://refmar.shom.fr/BREST>).
- **GNSS:** A GPS station is operating continuously since October 1998 and is committed to IGS TIGA pilot project. The distance between the GPS and the tide gauge is about 350 metres. Six levelling operations were carried out between 1999, 2004, 2006, 2009, 2010 and 2013 so that the station is tightly linked to the GPS permanent station. The levelling results show that the whole site is stable at the millimetre level. This ensures that the GPS is actually monitoring the vertical motion that affects the tide gauge.
- **Data:** Hourly data and associated mean sea levels from 1846 are available (UHSLC, PSMSL). Mean sea levels from 1711 have been calculated from daylight high water observations (Woodworth et al., 2010).

GLOSS 204: FORT-DE-FRANCE, MARTINIQUE

- **Operated by SHOM, Météo France, marine nationale (RONIM TG Network)**
- **Contributing to the Caribbean Tsunami Warning System (IOC – ICG/CARIBE-EWS)**
- **Sensor:** A radar tide gauge was installed by SHOM in October 2005. In December 2011, the existing radar sensor Khrono BM70A has been replaced by a new Khrono Optiwave radar sensor. Levelling operations carried out in 2006, 2010 and 2011 show a good stability of the benchmarks.
- **Data transmission:** In December 2011, SHOM has installed a Meteosat satellite transmitter for GTS and an Internet connexion in collaboration with Météo France in order to meet the needs of the Caribbean tsunami warning system. Real-time data will be available through both the IOC and the REFMAR websites (<http://refmar.shom.fr/FORT-DE-FRANCE>).
- **GNSS:** In December 2011, under SONEL program, the University of La Rochelle (LIENSs) and SHOM have installed a permanent GPS station on the same site as the tide gauge. Thanks to this installation, Fort-de-France station is committed to the IGS/TIGA.

GLOSS 202: CAYENNE-ILE ROYALE-ILES DU SALUT, GUYANE FRANCAISE

- **Operated by SHOM and DM Guyane (RONIM TG Network)**
- **Contributing to the Caribbean Tsunami Warning System (IOC – ICG/CARIBE-EWS)**
- There is no tide gauge in Cayenne anymore, so we suggest replacing it with the nearby “Îles du Salut” tide gauge, which is operating since 2006, and subsequently becoming the GLOSS station Nr. 202 in replacement of Cayenne. The Oldest data measured at this island are dating back to 1896.
- **Sensor:** Last levelling operations were carried out in 2002 and 2013 and show a good stability of the benchmarks. In December 2012, the existing Khrono OPTIFLEX radar sensor has been replaced by a new one.
- **Data transmission:** In December 2012, SHOM has installed a Meteosat satellite transmitter for GTS and an Internet connexion in collaboration with DM Guyane. Thanks to these installations, real-time data is now available through both the IOC and the REFMAR websites (http://refmar.shom.fr/ILE_ROYALE). However, the quality of the real time GPRS transmission to the continent is poor.
- **GNSS:** In December 2012, under SONEL and REGINA programs, IGN and SHOM have installed a permanent GNSS station on the same site as the tide gauge. The antenna has been

moved to its final position in October 2013 by IGN. A precise levelling survey between the tide gauge local markers and the local levelling network was performed. Some local geodetic points have also been tied by GPS observations. Thanks to this installation, Île Royale station should be submitted to the IGS/TIGA permanent service (GPS Tide gauge benchmark monitoring).

GLOSS 260: SAO TOME

- **Operated by LEGOS, IRD and MARAPA (PIRATA Network)**
- **Sensor:** Sao Tomé was installed in 1989 by IRD and is part of the global observing network in the Tropical Atlantic and part of the PIRATA network since 1997. The tide gauge maintenance is performed under the technical responsibility of IRD with the help on-site of the non-governmental organization “MARAPA”. The station is not operational since August 2010 and will be replaced in October 2013.
- **Data transmission:** Data are transmitted in real-time via the Argos system and processed by the LEGOS. The data are available on the Hawaii Sea Level center, on the IOC website and on the ROSAME ftp site.
- **GNSS:** Temporary GNSS operations and associated levelling are carried out regularly.

3.2. Indian Ocean & Antarctica

GLOSS 017: POINTE DES GALETS, LA REUNION

- **Operated by SHOM, DEAL La Réunion, Météo France (RONIM TG Network)**
- **Contributing to the Indian Ocean Tsunami Warning System (IOC – ICG/IOTWS)**
- **Sensor:** A Khrono OPTIFLEX radar tide gauge was installed in October 2007 by SHOM. Levelling operations carried out in 2007 and 2010 show a good local stability of the benchmarks.
- **Data transmission:** The real-time data are available on both the IOC and REFMAR websites thanks to an Internet connexion and a Meteosat satellite transmitter (http://refmar.shom.fr/POINTE_DES_GALETS).
- **GNSS:** Under SONEL program, a GNSS antenna may be installed in the near future depending on the resolution of onsite technical difficulties and masks.

GLOSS 096: DZAOUDZI, MAYOTTE

- **Operated by SHOM, CG976, DMSOI, Météo France (RONIM TG Network)**
- **Contributing to the Indian Ocean Tsunami Warning System (IOC – ICG/IOTWS)**
- **Sensor:** A radar tide gauge was installed in November 2008 by SHOM. Levelling operations carried out in 2006, 2008 and 2010 show a good stability of the benchmarks.
- **Data transmission:** The data are transmitted in real-time both through an Internet connexion and a Meteosat satellite transmitter. They are thus available on both the IOC and REFMAR websites (<http://refmar.shom.fr/DZAOUDZI>).
- **GNSS:** Under SONEL and REGINA programs, in cooperation with the local authorities (the DREAL and the General Council of Mayotte), a GNSS permanent station installation is scheduled during the second half of November 2013 and will be tied with precise leveling to all the local markers and leveling network benchmarks.

GLOSS 021, 023, 024, 131, 260

The four stations of the South Indian Ocean are part of the ROSAME network operated by LEGOS, INSU Technical Division and IGN.

- **Sensor:** They are basically equipped with pressure and radar sensor.

- **Data transmission:** All the stations transmit their data in real time through ARGOS. The raw data are processed at LEGOS and then, after validation, are collected by National and International Institutions and Data Centers (REFMAR, GLOSS...).

<http://refmar.shom.fr/KERGUELEN>

http://refmar.shom.fr/ILE_POSESSION_CROZET

http://refmar.shom.fr/ILE_SAINTE-PAUL

http://refmar.shom.fr/DUMONT_D_URVILLE

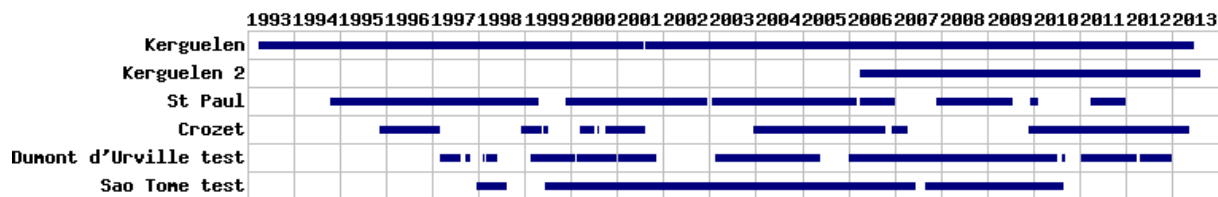


Fig. 2: Timeline of the available data for the ROSAME tide gauge network.

GLOSS-023: KERGUELEN

- **Operated by LEGOS (ROSAME TG Network)**

- **Contributing to the Indian Ocean Tsunami Warning System (IOC – ICG/IOTWS)**

- **Sensor:** The station is operational since April 1993, with only a short gap of a few days in January 2000 (Figure 2). Monthly tide gauge calibrations were performed until 2003 in order to monitor the sensor drift (Martin Miguez *et al.*, 2012). A new station was installed in 2006 in the frame of the Indian Ocean Tsunami Warning System (IOTWS). This new station is equipped with radar and pressure gauges.

- **Data transmission:** Real time 1-minute data are available on IOC website through GTS message.

- **GNSS:** The TGBMs were connected in December 2003 using precise levelling and differential GPS to the IGS permanent station (KERG). This IGS station is located at a distance of about 3 km. It is operational since November 1994, close to a DORIS station, which is operational since January 1998. In April 2012, during a GNSS station installation close to the DORIS and existing IGS station, as part of the REGINA program, some local tide gauge markers have been tied by GPS to the permanent GNSS stations. GPS buoy sessions are made few times a year in order to tie the instrumental references of all sensors. Thanks to these installations, the station should be submitted to the IGS/TIGA.

GLOSS-021: CROZET

- **Operated by LEGOS (ROSAME TG Network)**

- **Sensor:** The station was installed in December 1994. Then, it was destroyed at the end of July 2001. A new infrastructure was built in December 2003. It was destroyed again in February 2007. A new installation was installed in late 2009 and was operational until April 2013 when a station breakdown stopped data acquisition. The station will be fixed during the next maintenance rotation scheduled in April 2014. This site is particularly difficult to maintain.

GLOSS-024: SAINT-PAUL

- Operated by LEGOS (ROSAME TG Network)

- Sensor: The station is operational since October 1994, with a gap from April to June 1999. The station was rebuilt in 2007 and operated with radar and pressure gauges since November 2008. This station faced strong software and hardware difficulties in 2009 and later on. A new station will be installed in April 2014.

- GNSS: In December 2011, a permanent GPS station was installed but is facing power supply issues. A new station will be installed during the next maintenance rotation scheduled in April 2014 that may allow the GLOSS station to be submitted to the IGS/TIGA.

- Data: A data archaeological exercise allowed estimating the sea level change at Saint-Paul for the last 135 years (Testut *et al.* 2010).

GLOSS-131 : DUMONT D'URVILLE

- Operated by LEGOS (ROSAME TG Network)

- Sensor: Dumont d'Urville station was installed in February 1997. It has been operational from February 1997 to August 1997, from February 1998 to May 1998, and since February 1999, with a short gap in January and February 2000. It was reinstalled in January 2006 with high data acquisition sampling (2 minutes) but the data link was broken beginning of 2007 by an iceberg. The station was reinstalled completely in January 2008. In 2010 the cable was damaged. The station was fully reinstalled in January 2012 including new sensors (Oxygen, PAR and Fluo), but a new cable problem stop the data acquisition. Station will be fixed during next maintenance rotation in January 2014.

- GNSS : Close to a DORIS station, the tide gauge is committed to the IGS/TIGA

3.3. Pacific Ocean

GLOSS 165: CLIPPERTON

- Non permanent station. It is not easy to install and maintain a permanent real time station at Clipperton, partly for technical reasons (large shore and breaking waves) and partly because of security problems.

- January to March 2005: LEGOS moored two pressure gauges at Clipperton : one in the open sea and the other in the lagoon (Testut *et al.* 2008).

- November 2006 to May 2008: The French Navy moored a SHOM pressure tide gauge at Clipperton.

- In August 2011, the French Navy ship Arago has moored a SHOM pressure gauge (OT660). Dipping, GPS and levelling measurements were carried out. The tide gauge was only recovered in May 2013 by the French Navy. After more than one year of data acquisition the tide gauge stopped out of memory in November 2012. Post-Processing is still ongoing at SHOM and the data will be made available as soon as possible.

3.3.1. New Caledonia and Wallis & Futuna Islands

GLOSS 123: NOUMEA-NUMBO

- **Operated by SHOM (RONIM TG Network)**
- **Contributing to the Pacific Tsunami Warning System (IOC – ICG/PTWS)**
- **Sensor:** A modern radar tide gauge was installed at Numbo by SHOM in January 2005 to replace the floating and the acoustic gauges in Nouméa (Chaleix) that were getting older. The Numbo station is about 6 km away from the older one. The old and new tide gauges were operated simultaneously for 5 months and comparisons showed little difference between the two records (<4cm). Levelling operations carried out in 2006, 2007, 2008 and 2010 show a good local stability of the benchmarks
- **Data transmission:** The data are transmitted in real-time both through an Internet connexion and GTS. They are thus available at both the IOC and REFMAR websites (http://refmar.shom.fr/numbo_noumea).
- **GNSS:** The IGS station is about 10 km distance, and it is set up on a different ground. However, temporary GNSS stations on a fixed mast are carried out regularly.

PROPOSAL: LEAVA, FUTUNA ISLAND

- **Operated by SHOM, UPF (French Pacific TG Network)**
- **Contributing to the Pacific Tsunami Warning System (IOC – ICG/PTWS)**
- **Sensor:** Since October 2011, a KELLER PR-36XW pressure gauge has been installed at Leava on Futuna Island. It transmits real time data through GTS MTSAT-1 of the Japan Meteorological Agency (JMA). First, the pressure sensor showed an important drift and, moreover, the cable was destroyed by a great storm at the end of 2011. In April 2013, the pressure sensor was replaced and a radar sensor QHR 104-1 has been installed.
- **Data transmission:** Real time data are sent to the PTWC through GTS and are available on the IOC and REFMAR websites (<http://refmar.shom.fr/LEAVA>).
- **GNSS:** A permanent GPS station is installed on the roof of the gauge, providing accurate sea level monitoring and intending to commit to the IGS/TIGA. At 4 km from the tide gauge, IGN has installed, in May 2012, a REGINA GNSS station co-located with the DORIS antenna.
- **Data:** The Oldest data date back 1986.

Its isolated location (800km from GLOSS stations of Fidji and Tonga) makes it interesting for GLOSS objectives. We therefore suggest it to be included to the GLOSS core network.

3.3.2. French Polynesia

The University of Hawaii maintains these three stations: Rikitea, Papeete Fare Ute, Nuku Hiva.

GLOSS 138: RIKITEA

- **Operated by UHSLC**
- **Contributing to the Pacific Tsunami Warning System (IOC – ICG/PTWS)**
- **Sensor:** UHSLC station has been maintained by UHSLC in September 2013. In May 2012, the Geodesy observatory of Tahiti of the University of French Polynesia and SHOM have installed a radar (Vegapulse) and a pressure tide gauge close to the UHSLC installation. The new tide gauge will be dedicated to tsunami and storm surge warning. Indeed, it appears that UHSLC tide gauge is located near a fish-tank that could possibly disturb the measurements. In the future, the SHOM/UPF station may replace the UHSLC.

- **Data transmission:** The two stations provide real time data to PTWC and IOC website through GTS. Hourly heights are collected in delayed mode on REFMAR website (<http://refmar.shom.fr/RIKITEA>).

- **GNSS:** As part of the REGINA program and in cooperation with Meteo France, a GNSS permanent station was installed in June 2011, very close to the DORIS station and using the former GSI reference point and monument (GAMB). Marker of the tide gauge run by the University of Hawaii Sea Level Center was tied by GPS observations with the DORIS and GNSS reference point by IGN in 2007 and 2009 using GNSS observations.

In May 2012, a permanent GNSS antenna has been installed by SHOM on the roof of the tide SHOM/UPF gauge station. The GLOSS station should be submitted to the IGS/TIGA.

GLOSS 140: PAPEETE FARE UTE

- **Operated by UHSLC**

- **Contributing to the Pacific Tsunami Warning System (IOC – ICG/PTWS)**

- **Sensor:** UHSLC station has been maintained by UHSLC in September 2013. Levelling operations carried out in 2006, 2007, 2008 and 2010 show a good stability of the benchmarks.

- **Data transmission:** Real time data are provided to PTWC, IOC and REFMAR websites through GTS (<http://refmar.shom.fr/PAPEETE>).

- **GNSS:** A CNES permanent GPS station is installed on the top of the tide gauge. It is operating since August 2003 and is intended to be committed to the IGS/TIGA. A DORIS station is also operating about 7 km from the tide gauge since July 1995, alongside with an IGS station.

GLOSS 142: NUKU HIVA

- **Operated by UHSLC**

- **Contributing to Pacific Tsunami Warning System (IOC – ICG/PTWS)**

- **Sensor:** The station operates a Druck pressure sensor and a Vegapuls radar sensor for measuring water level. Levelling operations carried out in 2007 and 2009 show a good stability of the benchmarks.

- **Data transmission:** Real-time data are transmitted to PTWC, IOC and REFMAR websites through GOES satellite transmitter (http://refmar.shom.fr/NUKU_HIVA).

- **GNSS:** In June 2011, the University of French Polynesia and SHOM have installed a new tide pole and a permanent GPS station that would participate to the IGS/TIGA.

4. GLOSS requirements & the French stations

The table below provides a synthetic overview of the station status regarding the GLOSS requirements (IOC 2006, pp. 52).

Station	Type	Digital	Precision	Control	Meteo	Last Levelling	CGPS	Real-time
La Réunion	Radar	Yes	1cm	Semestrial	Pressure	2010	No	ADSL + GTS
Crozet	Pressure	Yes	1cm	<Annual	Pressure	2010	No	ARGOS
Kerguelen	Pressure Radar	Yes	<1cm	Monthly	Pressure	Yes	Yes	ARGOS ADSL GTS
Amsterdam St Paul	Pressure Radar	Yes	<1cm	Annual	Pressure	Yes	Yes	ARGOS
Dzaoudzi	Radar	Yes	1cm	Semestrial	Pressure	2008	2013	GPRS + GTS
Nouméa - Numbo	Radar	Yes	1cm	Semestrial	Pressure	2008	No	ADSL
Dumont D'Urville	Pressure	Yes	1cm	Annual	Pressure	2008	Yes	ARGOS ADSL
Rikitea	Radar Pressure Float	Yes	1cm	UHSLC		1997?	Yes	GTS
Papeete	Radar Pressure	Yes	1cm	UHSLC		2010	Yes	GTS
Nuku Hiva	Radar	Yes	1cm	UHSLC		2009	Yes	GTS
Clipperton	Pressure 2005, 2006- 2008, 2011- 2012	Yes	5cm	Annual	model	2006	No	No
Ile Royale	Radar	Yes	1cm	Semestrial	Pressure	2006	Yes	GPRS + GTS
Fort-de- France	Radar	Yes	1cm	Semestrial	Pressure	2011	Yes	ADSL + GTS
Marseille	Radar Float	Yes	1cm	Semestrial	Pressure	2009	Yes	ADSL
Brest	Radar	Yes	1cm	Semestrial	Pressure	2013	Yes	ADSL
Sao Tomé	Pressure	Yes	1cm	<Annual	Pressure	2010	No	ARGOS
Leava, Futuna Island	Pressure Radar	Yes	1cm	Annual	Pressure	2011	Yes	GTS

5. Sea level data distribution

5.1. Access to data

Since 2010, SHOM has been charged by a French Prime Ministerial instruction to gather and coordinate tide gauge observations in French territories (SGMer 2010). The REFMAR website (refmar.shom.fr), hosted at SHOM, provides a portal that would take inventory and distribute tide gauge high frequency data from the various French producers.

Depending on the quality controls, raw data or validated data are available on the portal. Real time data will be also available every 2 hours or less thanks to the web collecting system.

For GLOSS applications, hourly sea level data from the French stations committed to GLOSS are provided directly to the University of Hawaii Sea Level Centre (UHSLC) which acts as GLOSS data centre.

Mean sea levels and GPS data at the tide gauges are available at SONEL (www.sonel.org) which also acts as IGS/TIGA data centre and as GLOSS data assembly centre for GNSS at

tide gauges. Through SONEL webportal, mean sea levels are also provided to the PSMSL (www.psmsl.org).

In parallel, SHOM, UHSLC and LEGOS real-time sea level data are available on the IOC sea level monitoring facility (www.ioc-sealevelmonitoring.org/)

5.1. REFMAR coordination of French sea level observations

Since 2010, REFMAR has begun contacting French sea level data producers to draw an inventory of all the French sea level stations that could be operated by Port Authorities, Research institutes, universities, flood warning systems, local authorities, and so on. REFMAR pays particular attention to general data access and data policy conditions. The origin of each data set will be acknowledged, so that REFMAR will ensure the visibility of the producers and trace the applications of the tide gauge observations in research and commercial fields.

Through REFMAR website and meetings, SHOM also aims at providing advice and recommendations to producers and will promote state-of-the-art measurement practices: For example, REFMAR has created teaching sheets to describe how to install a tide staff, what is a sea level observatory, etc...

<http://refmar.shom.fr/documentation/recommandations/fiches-techniques>

In June 2013, SHOM organized the first meeting “Journées REFMAR” in Paris. The event was divided in two parts:

- 2 days for scientific and research presentations dedicated to REFMAR users.
- 1.5 days for technical trainings on “How to make good sea level measurements” dedicated to sea level data producers.

134 participants were registered, 37 oral presentations were presented and 29 posters displayed. The event was also attended by foreign countries in particular French speaking community with 9 foreign countries registered: Algeria, Guinea, Ivory Coast, Monaco, Portugal, UK, Romania, Spain, and Tunisia.

Presentations and posters are available on REFMAR website:

<http://refmar.shom.fr/fr/journees-refmar-2013/communications>



Fig. 3: Participants at “Journées REFMAR” held in Paris in June 2013.

6. French cooperation on foreign GLOSS stations

As part of the DORIS (Doppler Orbitography and Radiopositioning Integrated by Satellite) and REGINA (Réseau GNSS pour l'IGS et la navigation) programs in partnership with CNES, IGN is mainly in charge of the installation and maintenance of the geodetic infrastructures (DORIS and GNSS stations). In this framework, provided tide gauges locations are close to the geodetic stations, they are considered as collocated instruments and, as far as possible, are integrated in the survey process. In any case, GNSS data of REGINA stations are freely and publicly available at the IGS data centers, and when it offers an interesting collocation, provided to the SONEL GNSS at tide gauges data center.

In most of the cases, reports including the field operation, markers descriptions and the results (three dimensional as well as height differences) are available upon request.

In particular, the inner and outer geodetic connections are archived in the SONEL database.

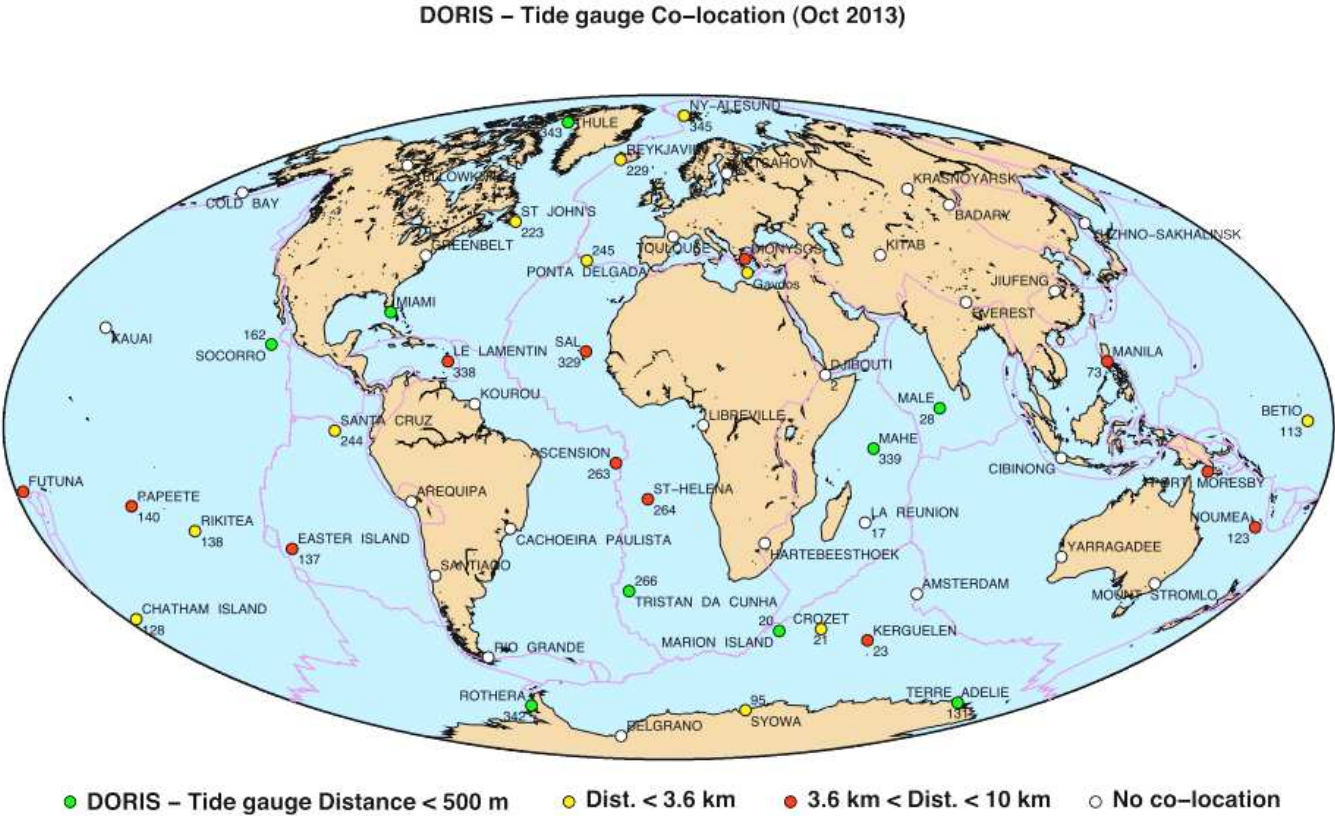


Fig. 4: Map of DORIS collocation with Tide Gauges (source : JC. Poyard, IGN).

GLOSS 266: Tristan Da Cunha, United Kingdom

In 1986, the first station of the DORIS network is installed on behalf of CNES at Tristan da Cunha by Bob Spencer from National Oceanography Centre (NOC).

As part of a station renovation in June 2012, the GNSS station belonging to NOC in the immediate vicinity of the DORIS station was included in the tie operation. A precise leveling survey was carried out between all the markers, including the tide gauge reference benchmark.

GLOSS 253: Dakar, Senegal

In the frame of a local project, IGN performed in the first half of October 2011 a precise levelling between the markers close to the tide gauge, the local levelling network and the new IGS DAKR station. A new point, very close to the tide gauge has also been included in the survey and tied using GPS observations to the IGS station. During this work, the technical possibility for a future GNSS permanent station at very close proximity of the tide gauge was also explored (Poyard J-C. 2011).

GLOSS 339: Pointe la Rue, Seychelles

As part of the REGINA program and in cooperation with the Seychelles national meteorological services, a GNSS permanent station was installed in June 2012, about 300m from the tide gauge and close to the DORIS station. Markers around the tide gauge have been visited and tied using GPS. For logistics reasons, no precise leveling has been performed.

GLOSS 002: Djibouti.

By the end of the year 2013, during a joint REGINA station installation in cooperation with the CERD, conditions in terms of long term maintenance, GNSS observations and data communications, will be explored for a GNSS station installation at the immediate vicinity of the tide gauge.

7. SONEL data center : GNSS data co-located to TG

All mean sea levels and GNSS data from the above-mentioned French stations are made available on SONEL website (www.sonel.org).

Since 2011, SONEL has been designated to act as the data assembly centre for GLOSS concerning observations from GNSS stations co-located with tide gauges. This GNSS activity is described in a dedicated report to the GLOSS Group of Experts.

8. Data rescue / Data archeology / Inventory

- In December 2011, under the auspices of the IOC/GLOSS and supported by IHO has launched an update of the inventory of all historic data remaining in paper form that could be rescued.

After his first work published in his thesis published in 2008 (Pouvreau, 2008), M. Nicolas Pouvreau has consolidated his inventory of French historic sea level data in non-electronic form and has made it available on REFMAR website :

<http://refmar.shom.fr/mesures-maregraphiques/french-historic-tide-gauges-data-in-non-digital-form>

The webpage gives information on the period of measurement, the owner of the data, the place where it is archived, the form of the data (charts, tables,...) and even the time step of the acquisition.

Around 2 200 years of non-electronic sea level data have already been identified. Nevertheless, this inventory is obviously not exhaustive and further searching needs to be funded and carried out.

- At La Rochelle University (LIENSs), M. Thomas Gouriou published in 2012 a thesis on the digitalization and reconstruction of the tide observations in La Rochelle and its vicinity. He managed to rescue chart data dating back to 1824, and referenced them on both vertical and time scales to rebuild a whole series of sea level observations. During this work, the mean sea level trend on this region has been estimated to $+1.38 \pm 0.08$ mm/year, from 1860 to 2010. This result is consistent with Liverpool's trend ($+1.2 \pm 0.1$ mm/year from 1858 to 1997 Woodworth, 1999a) and also with recent results suggesting that sea level rise along the European Atlantic coasts is slower than the global sea level rise ($+1.7 \pm 0.2$ mm/year between 1901 and 2010 [IPCC fifth Assessment Report, 2013]).

http://refmar.shom.fr/documents/10227/29933/These_TGouriou_2012_VolumeI_Manuscrit.pdf

- In September 2013, M. Yann Ferret has just begun a 2-year study at SHOM on the digitalization and reconstruction of the tide observations in St-Nazaire. Chart data at SHOM and Nantes Port authorities have been recovered and could allow to rebuild a series of observations dating back to 1868.

<http://refmar.shom.fr/documents/10227/137393/05Po+Reconstruction+maregraphique+Saint+Nazaire.pdf>

- In the same time, at IRD, M. Jérôme Aucan has begun to work on the reconstruction of the tide observations in Nouméa (New Caledonia). Paper data dating back to the beginning of the XXth century are being scanned by SHOM and will be made available to IRD in 2014 to begin the study.

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