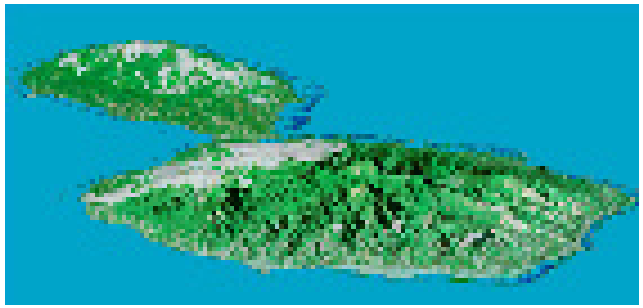
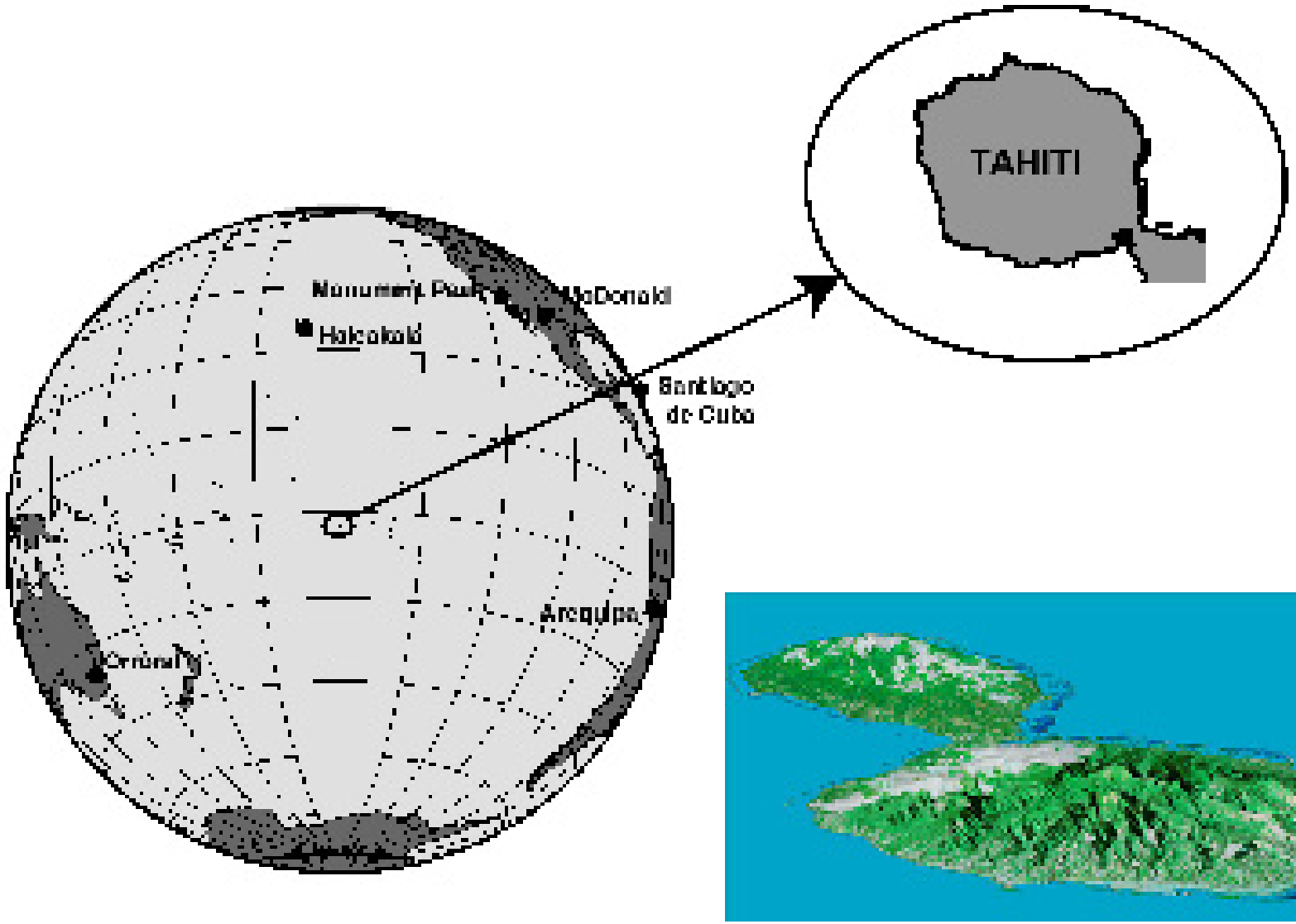
UNIVERSITÉ DE LA
POLYNÉSIE FRANÇAISE

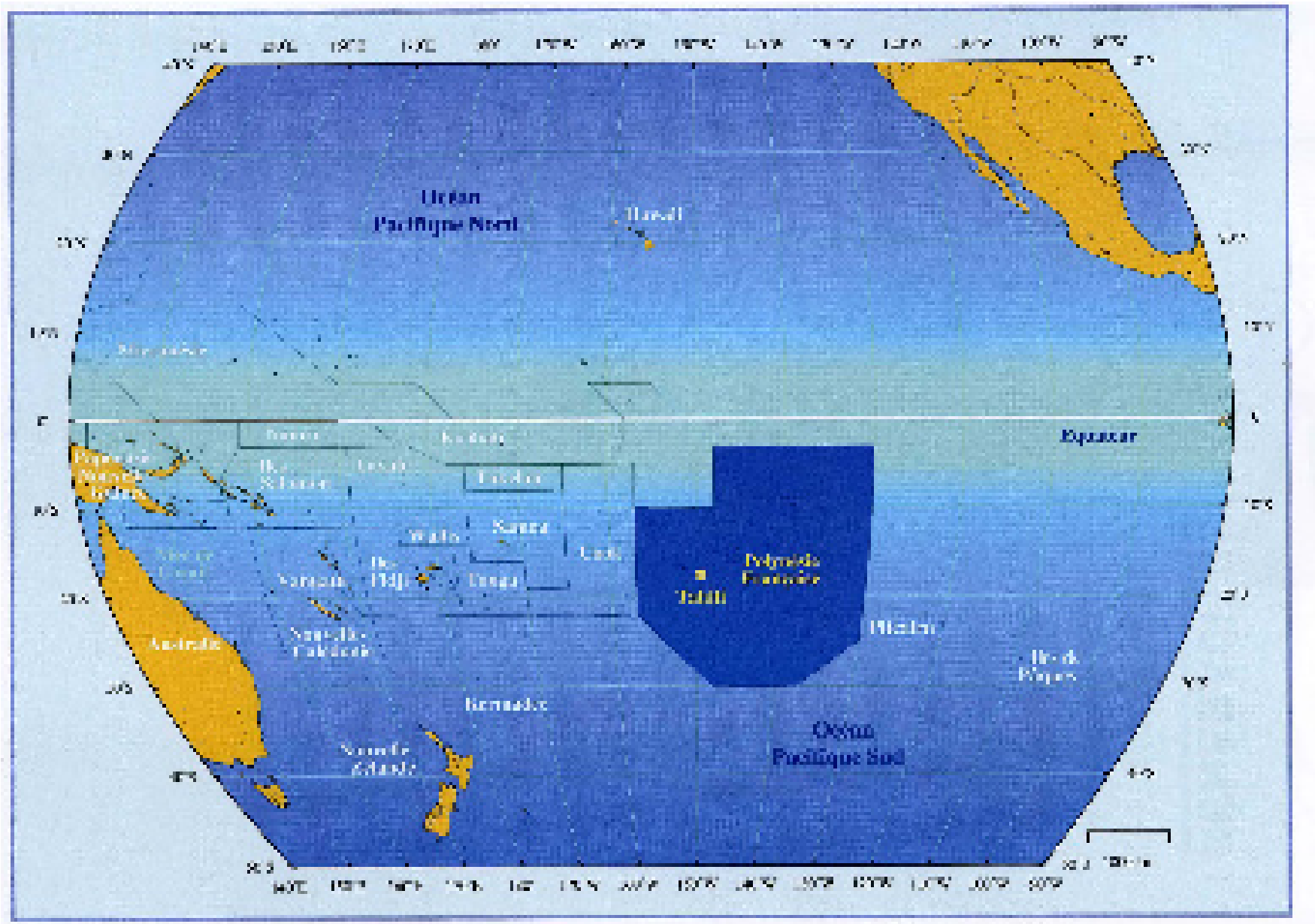


The Geodesy Observatory of Tahiti

JP Barriot, L. Sichoix, A. Fadil, F. Ye,
Y. Vota, L. Mercier, Y. Verschelle

Where is the Geodesy Observatory of Tahiti ?





2/3 of USA surface, 120 islands, half-Corsica in total km2

OGT : structure UPF-CNES-NASA

- Station laser : propriété NASA, staff UPF+CNES, fonctionnement CNES+UPF,
- GPS : CNES, NGA, Trimble
- Stations marégraphiques : UPF
- budget annuel OGT : 150 000 euros / an (hors salaires, géré par l'UPF), budget consolidé total ~ 400 000 euros / an)
- Recherche associée à l'OGT (dont ANR, CNES et INSU : 80 000 euros / an

OGT : insertion internationale

UNESCO ->

ICSU (Int. Council of Scientific Union) ->

IUGG (Int. Union of Geodesy and Geophysics) ->

IAG (Int. Association of Geodesy) ->

GGOS (Global Geodetic Observing System)

L'OGT héberge l'ICET (International Center for Earth Tides), service de l'IAG et World Data Center (ICSU + IUGG + IAU)

Existing techniques in French Polynesia

- **Tahiti Geodetic**
- **Observatory (OGT)**

✓ **MOBLAS-SLR station**
(co-funded by NASA, CNES and UPF in 1997)

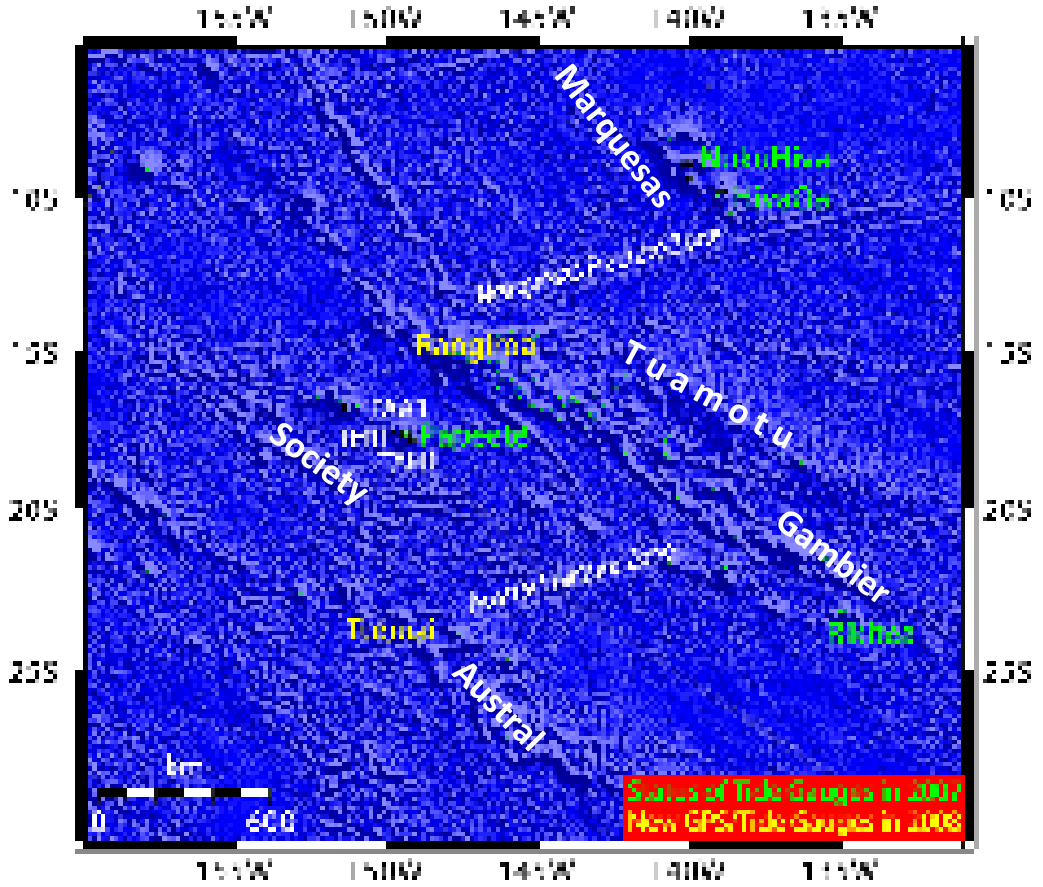
✓ **3 GPS THTI & TAH1 stations (1998, 2000, 2009)**

✓ **DORIS (1999)**

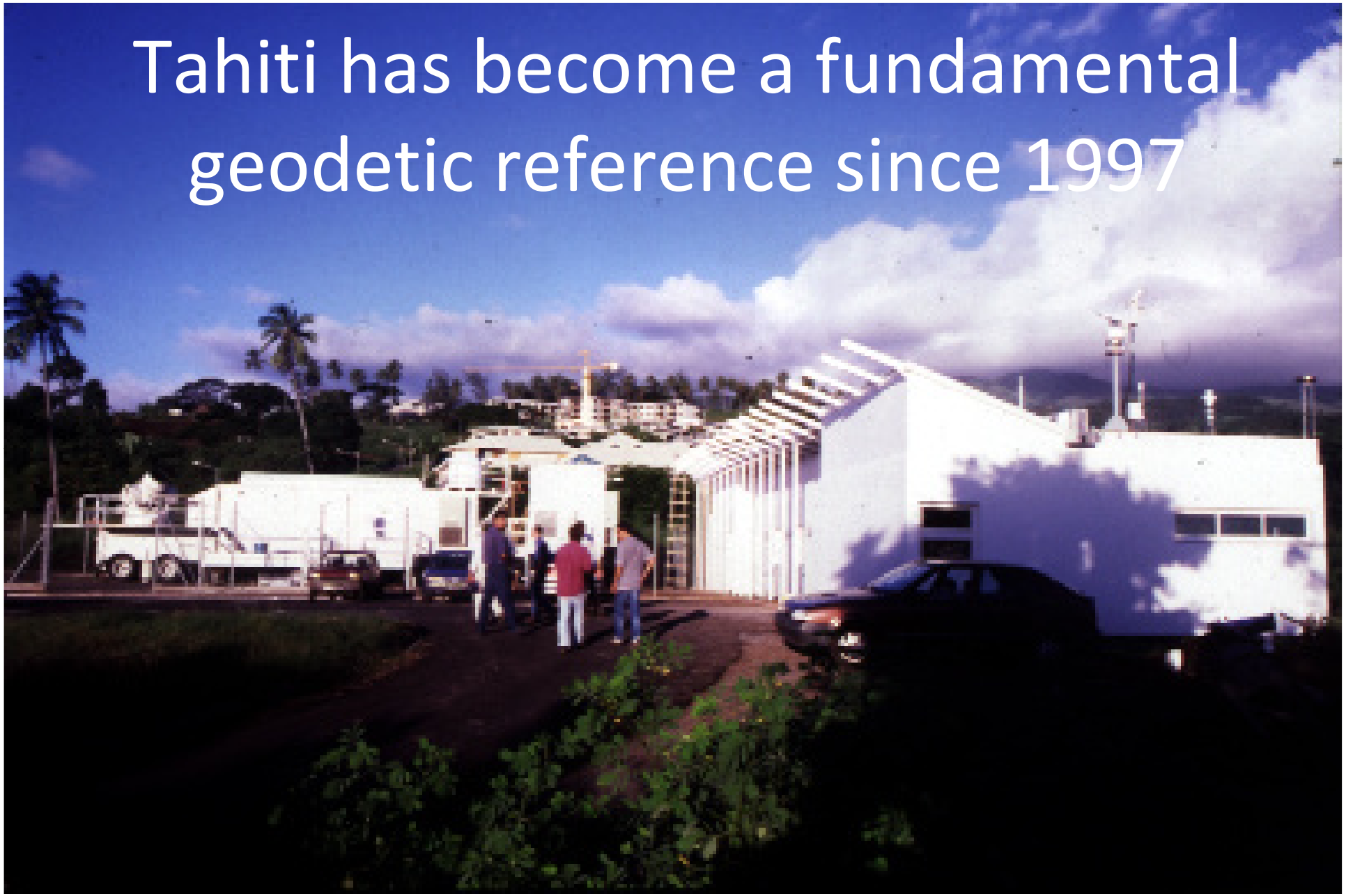
➢ **Previous network tide gauges**

➢ **2008 : 2 GPS/tide gauges deployed in Tubuai Island & Rangiroa Atoll by UPF**

➢ **2009 : gPhone gravimeter**



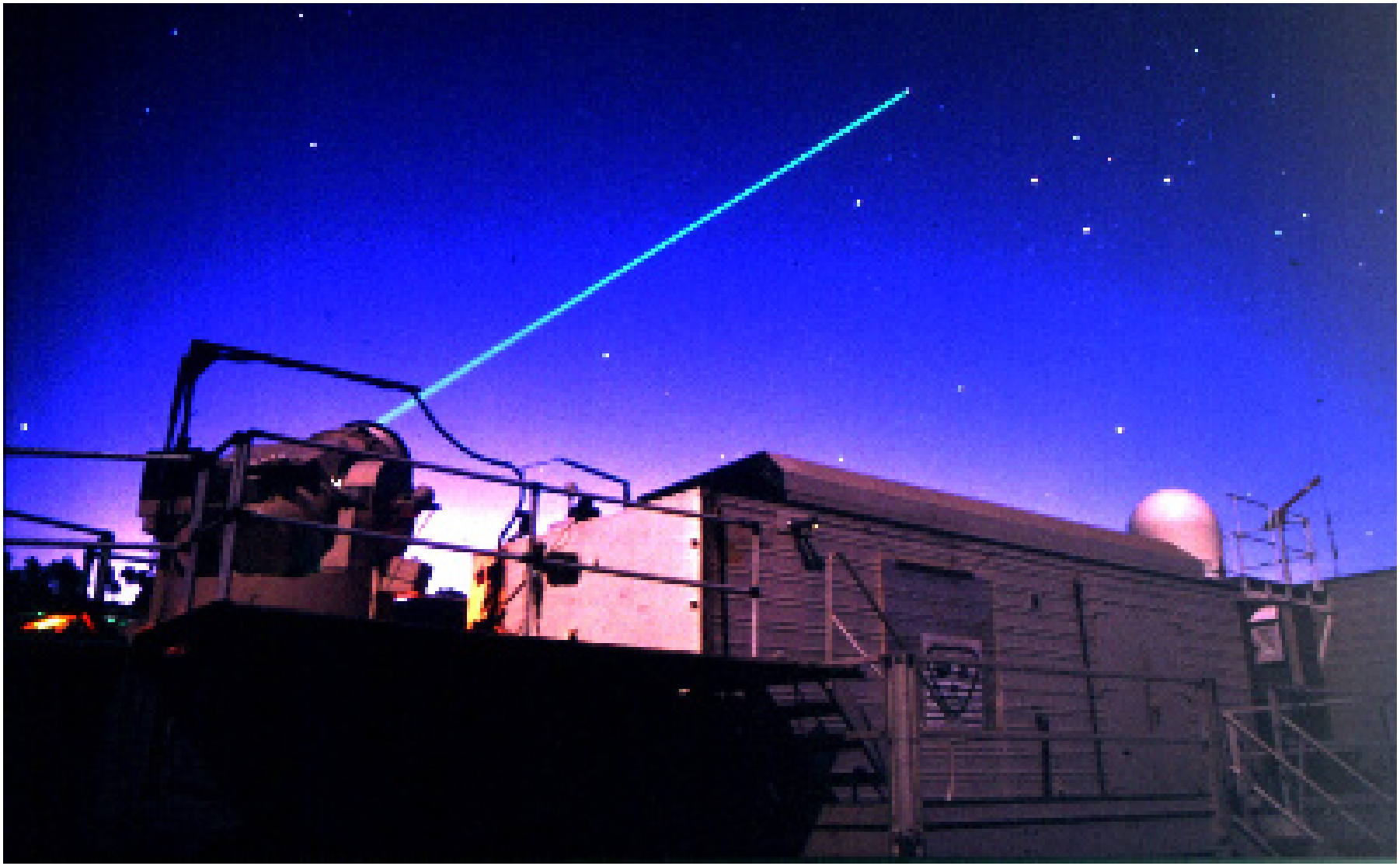
Tahiti has become a fundamental geodetic reference since 1997

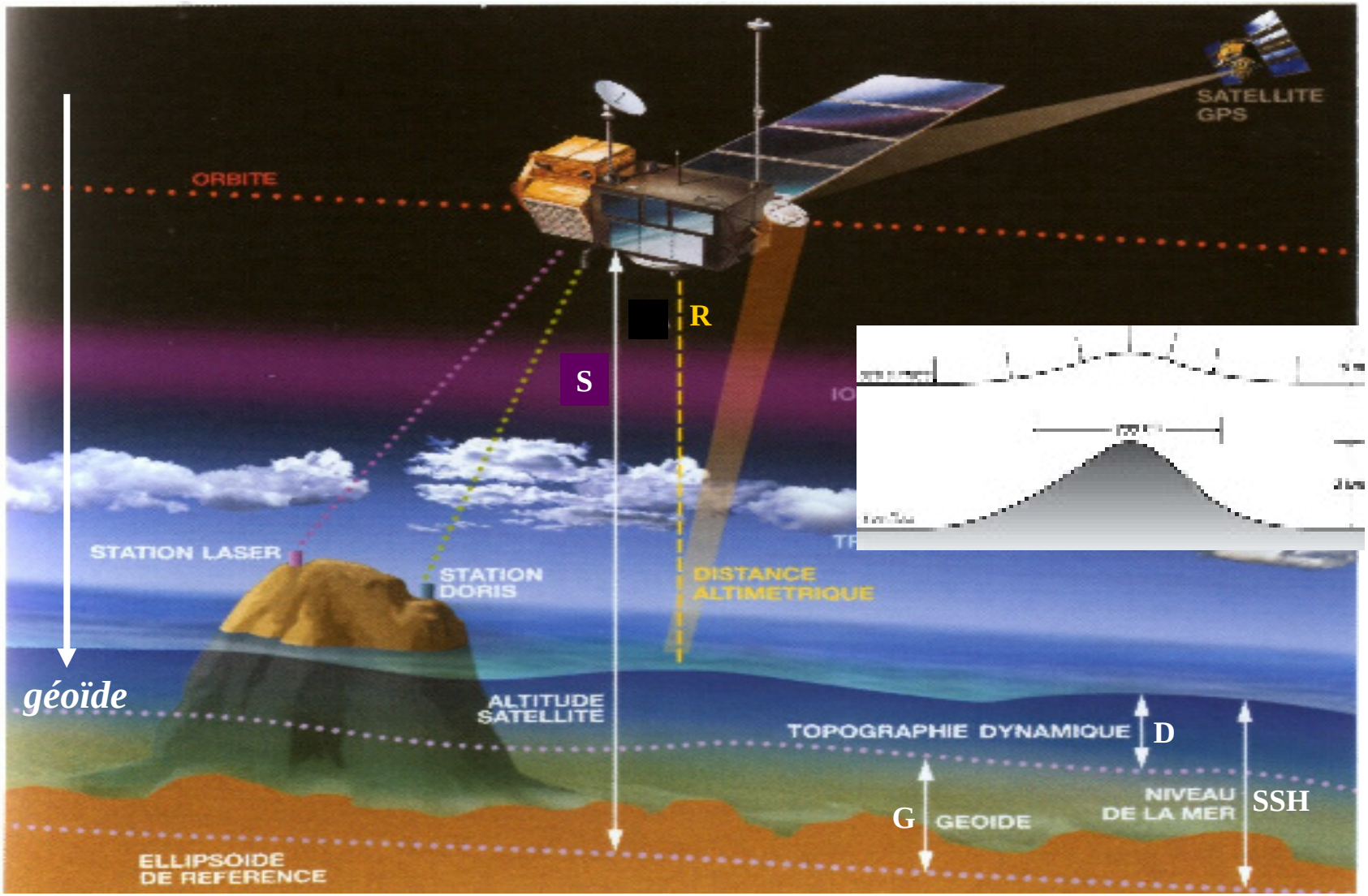


Objectives of the laser station:

- To track satellite between 300 to 30 000 km WITH A PRECISION OF 1 CM (OR LESS !)
- Applications:
  - To improve the gravity field and reference frames
  - To study the rotation of the Earth
  - To determine the sea surface topography
  - To determine mean sea level variations
  - To improve tectonic models

Laser tracking of satellites





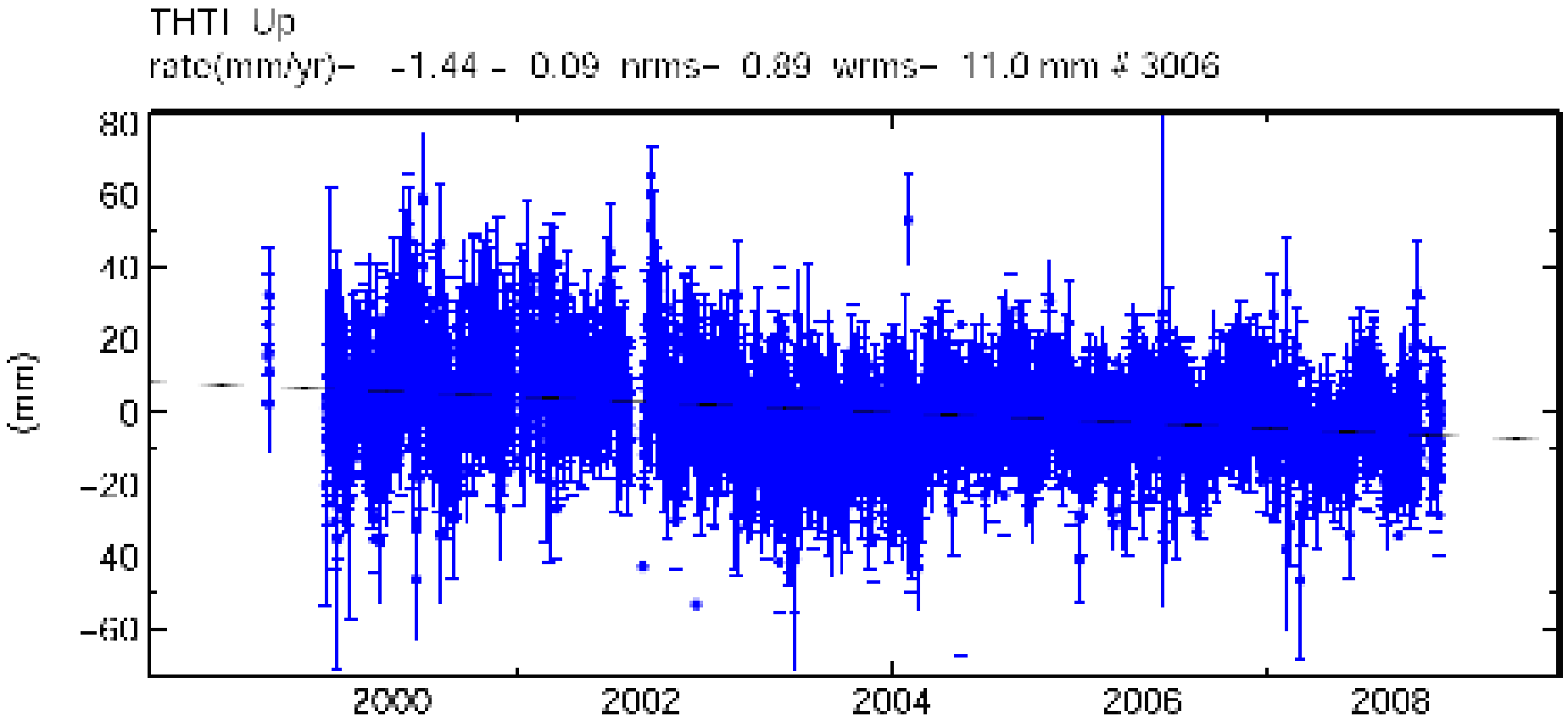
L'altimétrie des océans par satellite. Celui-ci mesure par radar sa distance (R) à la surface de la mer. Le suivi de sa trajectoire (par exemple par des balises Doris exploitant l 'effet Doppler) permet un positionnement par rapport à un référentiel lié au centre de la Terre, donc de connaître son altitude (S) par rapport à un ellipsoïde. On en déduit (de R et S) la hauteur de la surface océanique (SSH). En fait, cette surface dépend des courants marins dont la dynamique, dictée par les vents, les différences de température et de salinité, est fonction de la forme du géoïde, c 'est-à-dire de la quantité G et de D en grande partie variable dans le temps (donc corrigeable)

Other system: GPS

Other system: DORIS

Erasing Tahiti: the viscoelastic subsidence

Talk by Abdel



Determination of the subsidence rate of Tahiti from 8 years of GPS measurements: # 1.5 mm/y

Sea level measurements:
S and collocated tide gauge

The new OGT tide gauge station in Tubuai (Australs archipelago)

With SHOM and Protection Civile

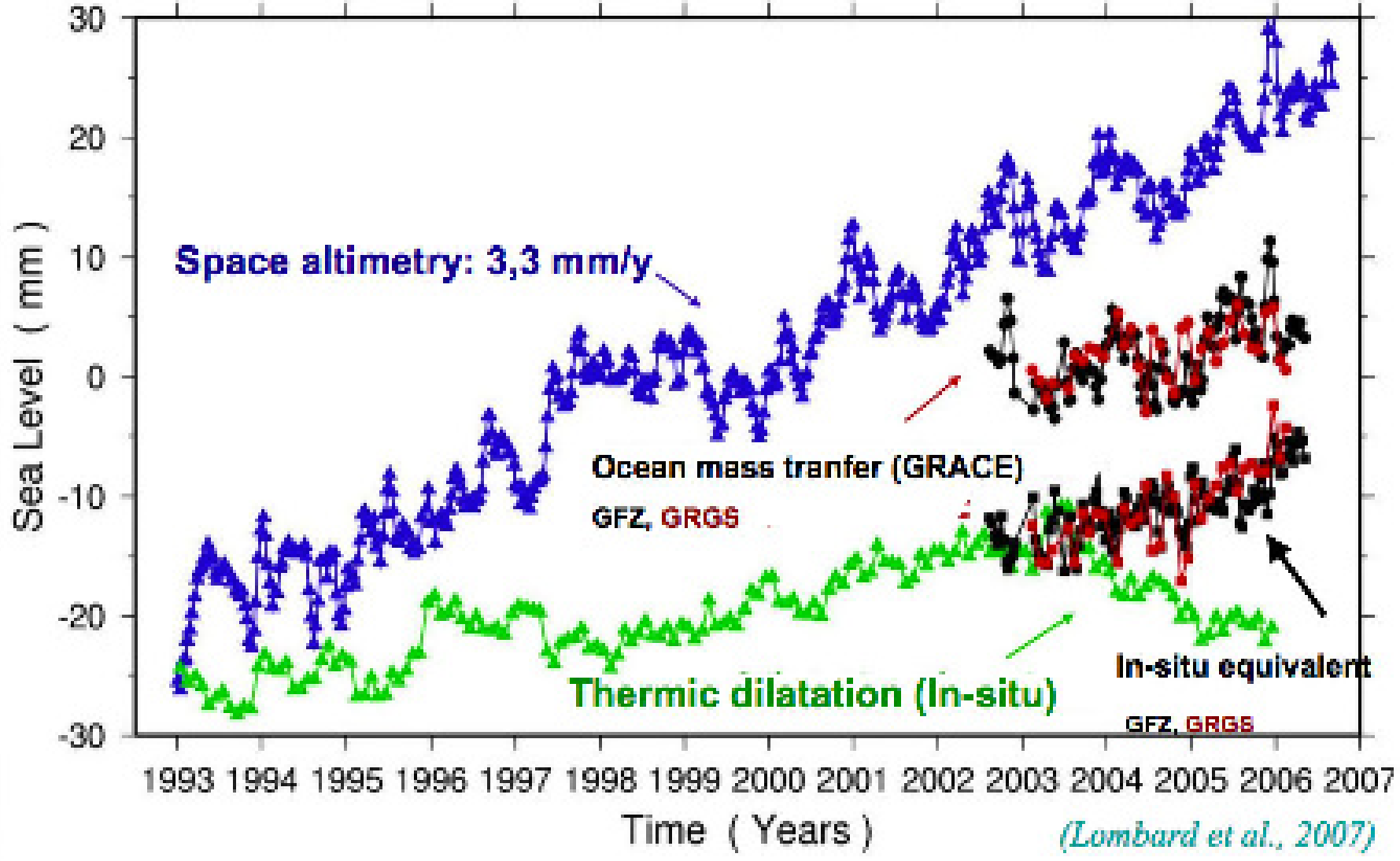
Nuku-Hiva (Marquesas) Tide Gauge Station

Mangareva Tide gauges (U. of Hawaii)

Station update planned in 2010

Global Sea Level Variations:

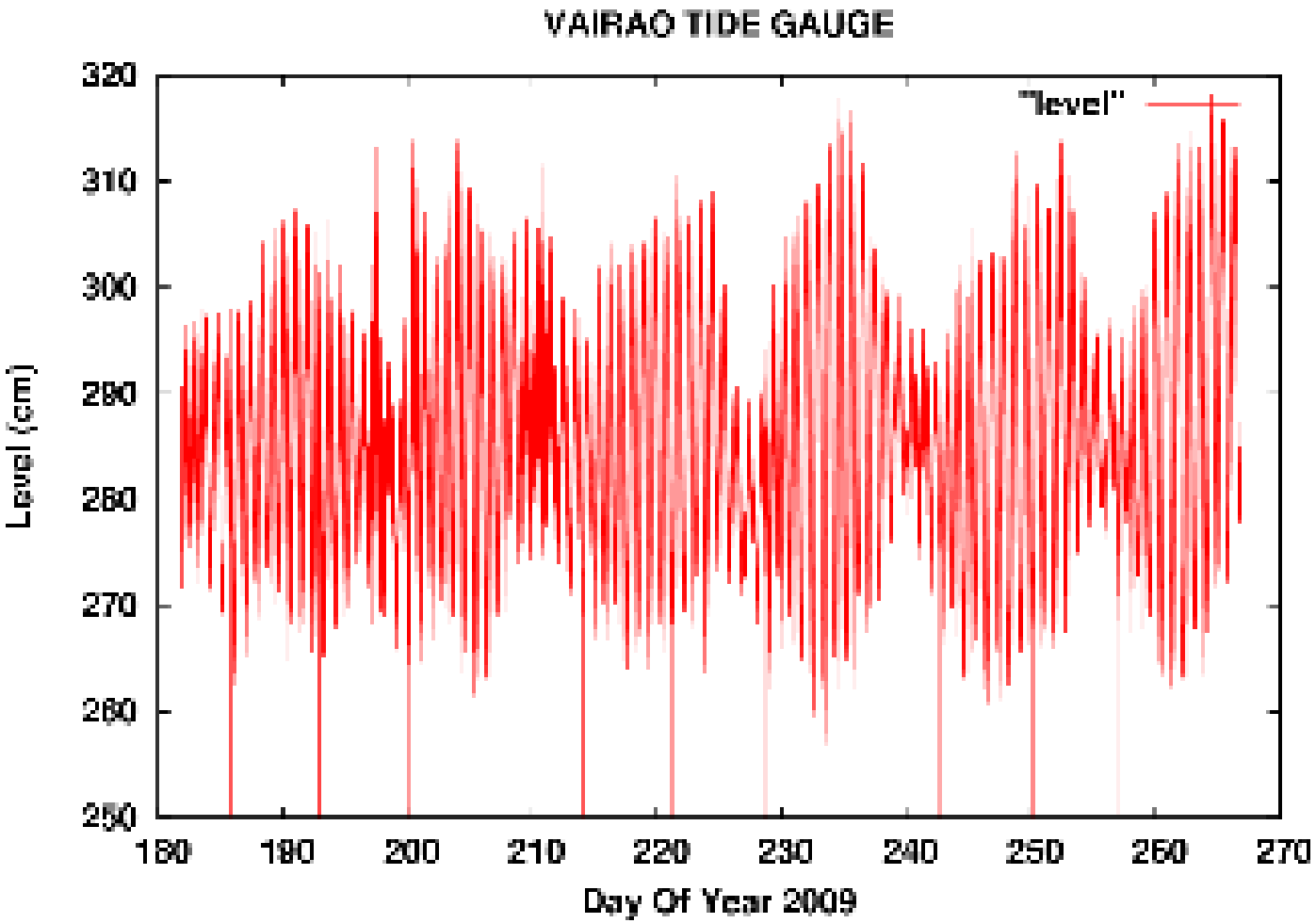
Sea level variation = tide gauge variation – GPS height variation



Marégraphe expérimental de Vairao (presqu'île)

Instrument development by Laurent

Enregistrement –type du marégraphe de Vairao à Tahiti-Iti (IFREMER)



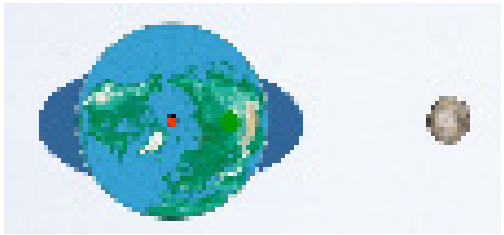
gPHONE

gravity meter (PET)

Collaborations: Obs. Geo. Lanzarote et de Membach, EOST

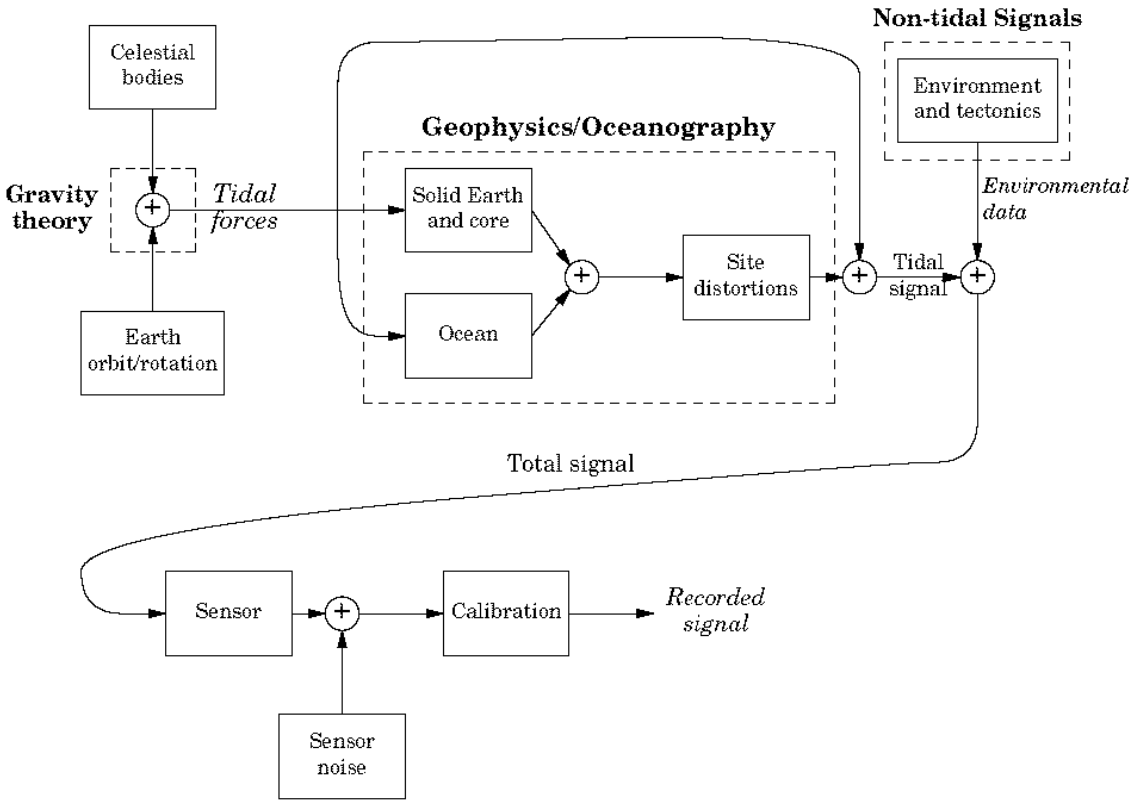
Spring gravimeter, top and PET (gPhone) :

Les marées terrestres



Que permet le PET ?

Figure 1.1: An Earth-Tide Flow-Chart



- **Réponse élastique et non-élastique de la Terre (nombres de Love) au forçage des marées terrestres et marines en fonction des fréquences astronomiques de forçage.**
- **Quelles ont les effets des hétérogénéités latérales dans la croûte et le manteau sur cette réponse, au échelles globales et régionales ?**
- **Quels sont les effets des non-linéarités ?**
- **La réponse est elle liée localement à des effets intersismiques ou hydrologiques ?**

The PET gravimeter is collocated with GEOSCOPE instruments in Tahiti-Pamatai

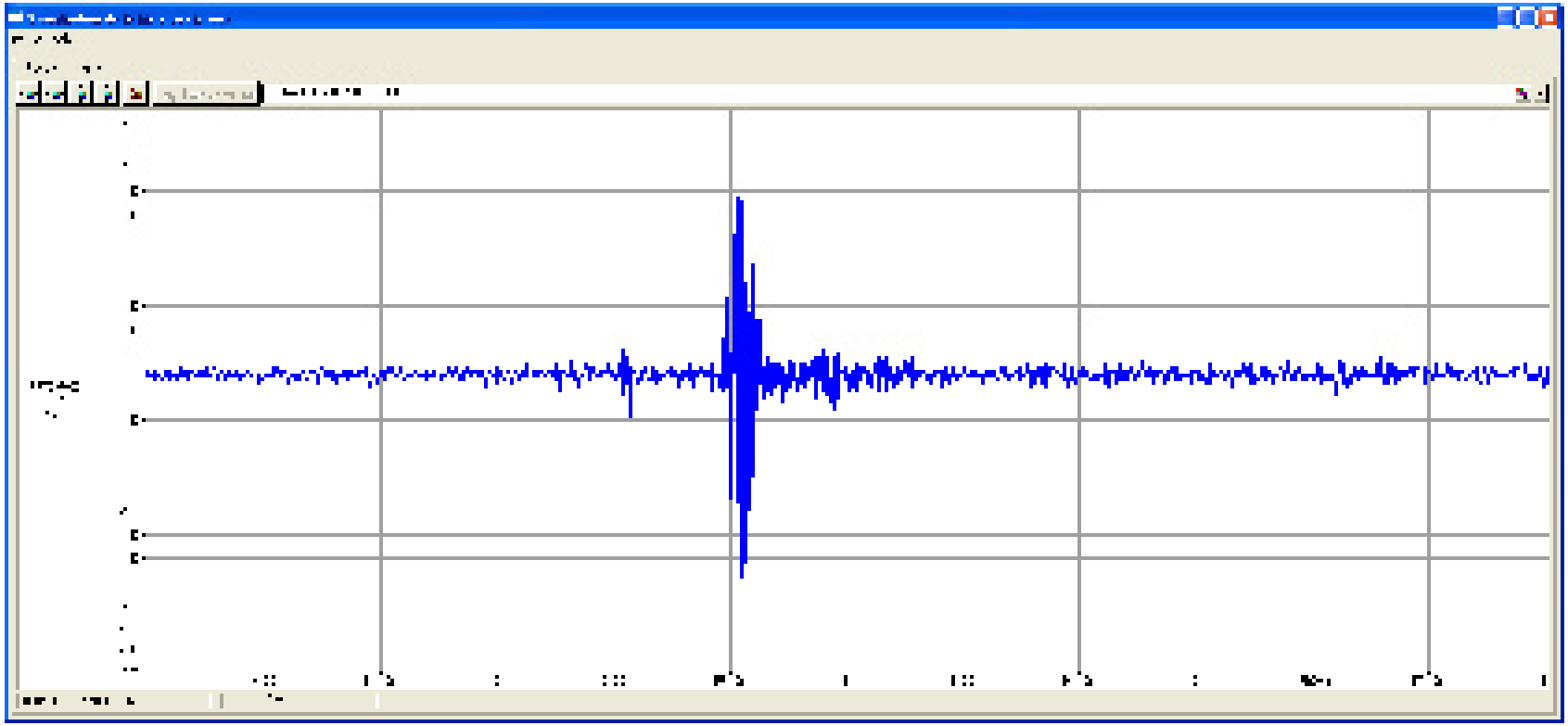
Tahiti Gphone #59 with Geoscope broadband seismometers

Detection of the Sandwich Island Earthquake by Tahiti gPhone

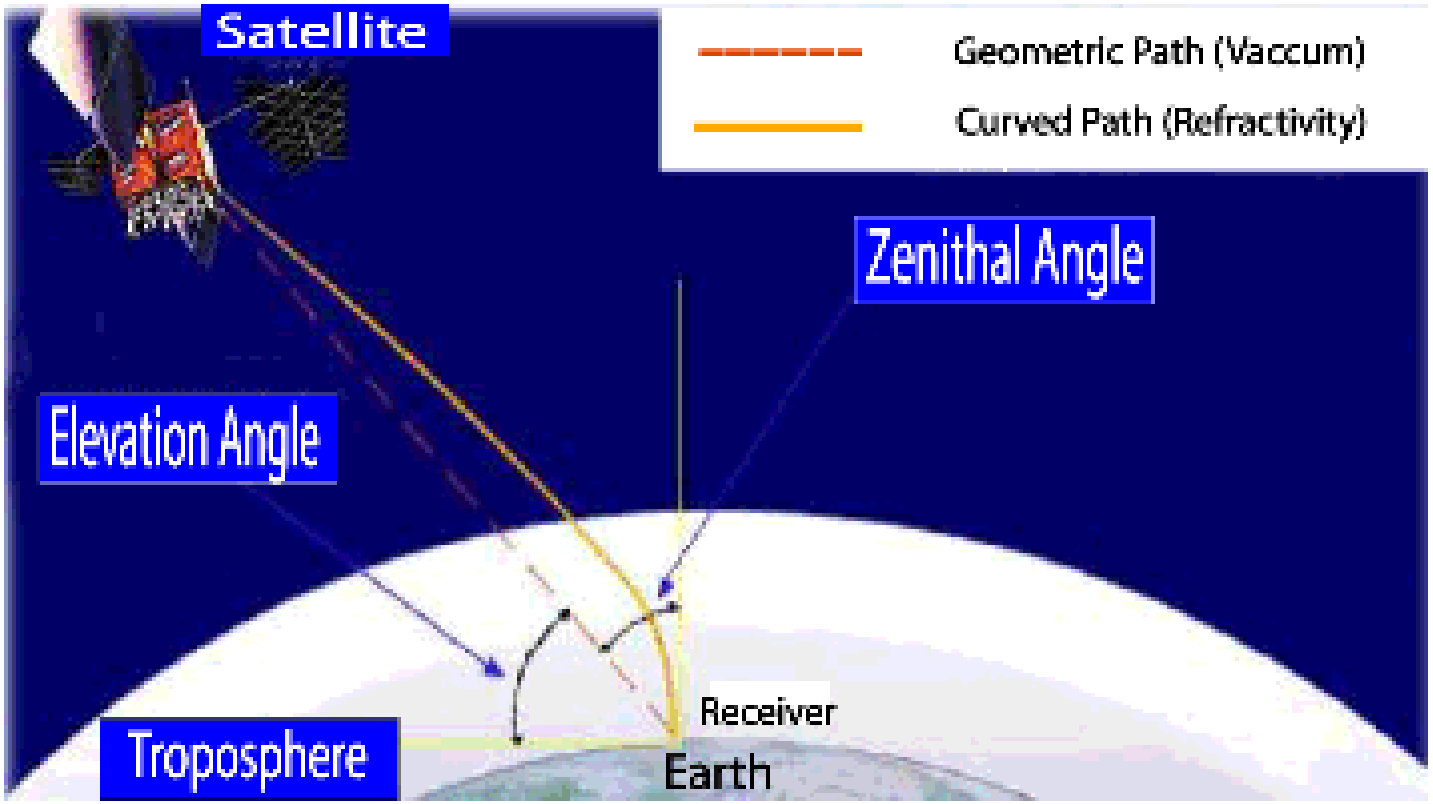
Sandwich Isl,

6.6 2009/04/16 14:57:05 -60.215 -26.797 10.0 **SOUTH SANDWICH ISLANDS REGION**

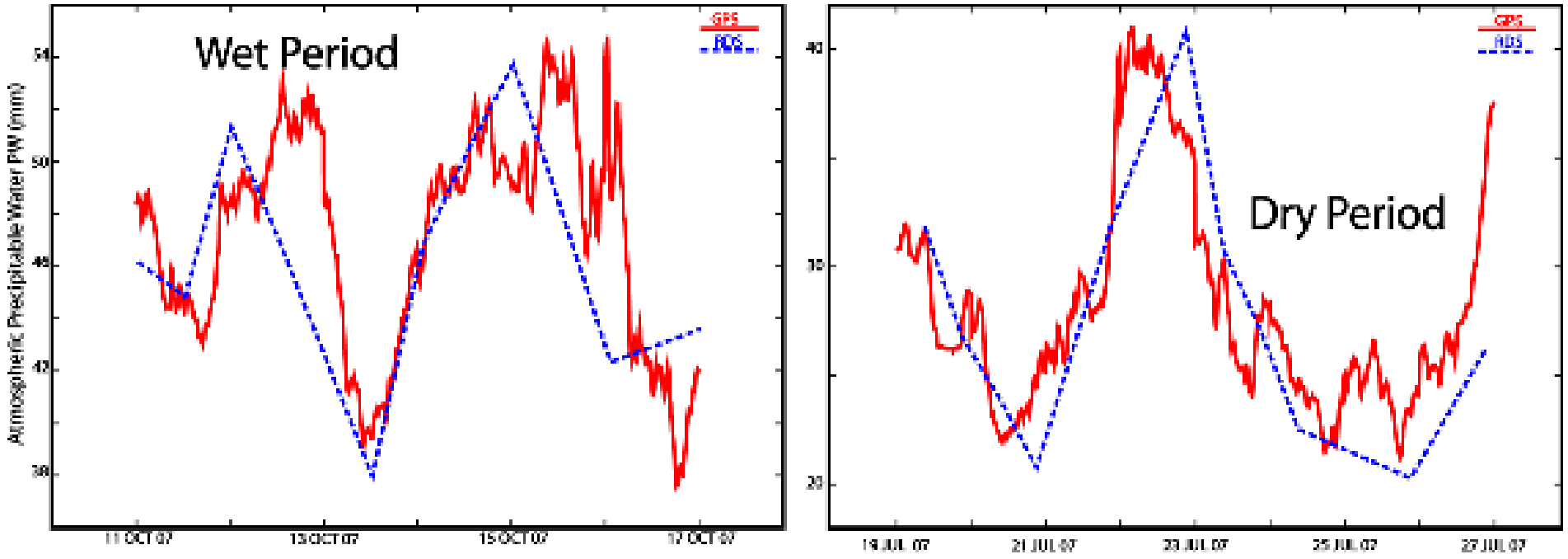
Filtered Gravity (20 to 100 seconds)

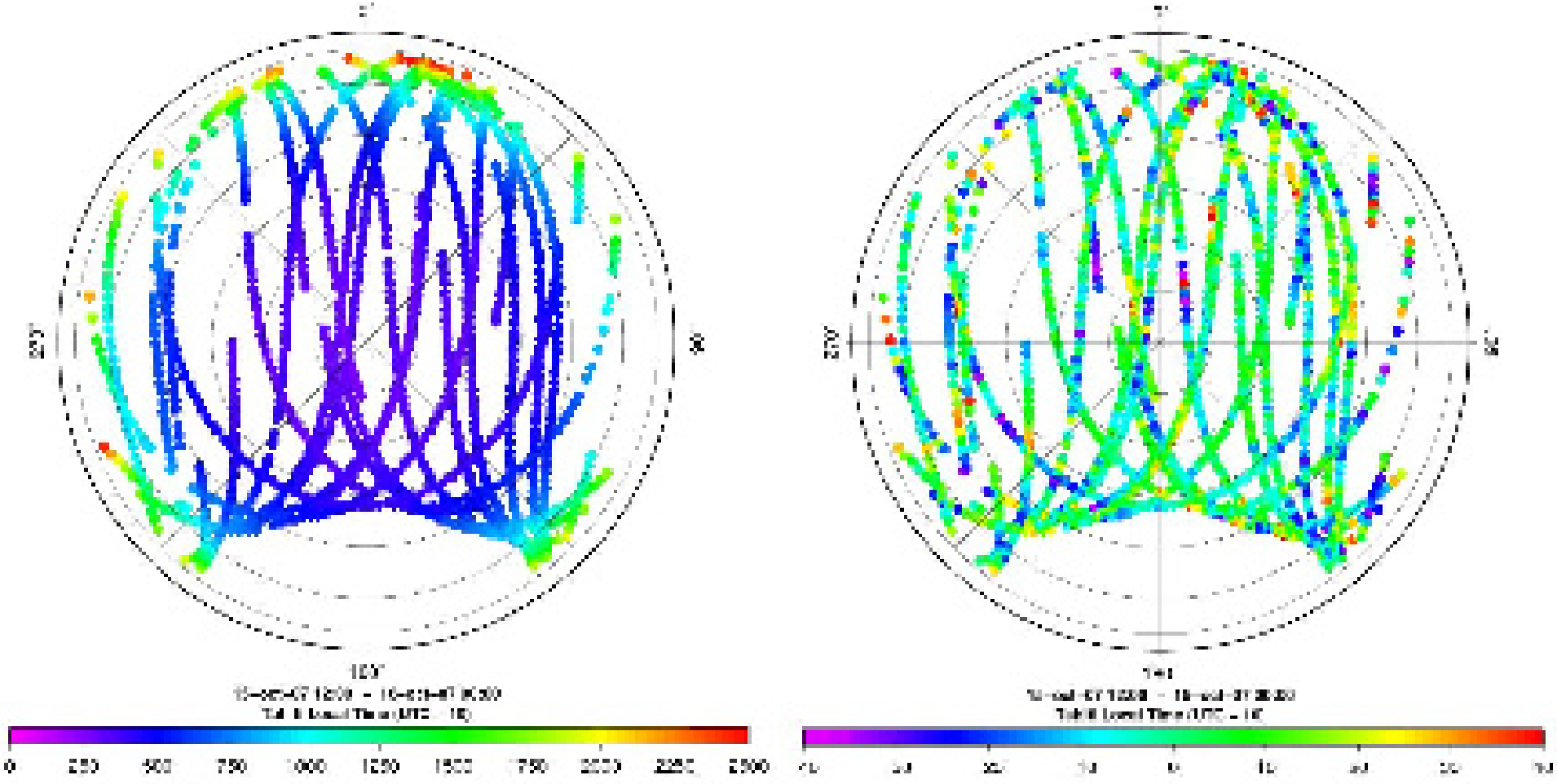


Studies of GPS propagation at the Geodetic Observatory of Tahiti



Comparisons of water vapor contents (IPW) of the atmosphere from GPS modeling (red) and radiosoundings (blue)





LEFT: skyview of the slant wet delays (mm) relative to the GPS station of the OGT (half-day)
RIGHT: residuals of the processing (multipath, antenna center of phase, unmodelled water vapor). **See poster Fadil et al, PSI2009)**

Modeling of water vapor contents: One-stationTroposphere Tomography

GPS Observable: slant wed delay SWD (and SIPW)

➢ **Our study : one GPS station with slant geometry**

❖ **Radon transform**

Refractivity mapped along Zernike functions

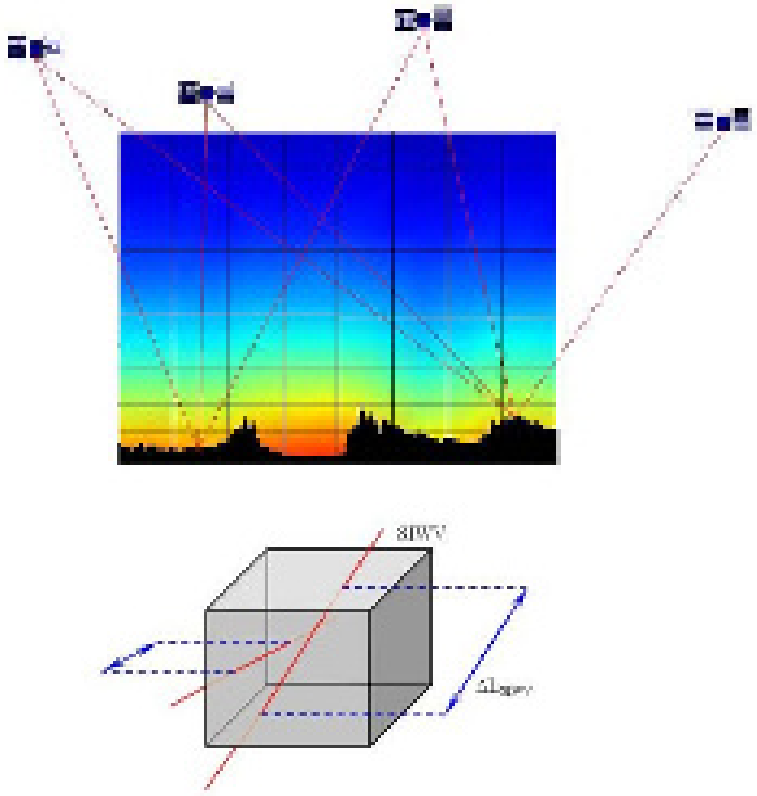
$$SWD \;\alpha\; \int_{Trop.} \mathrm{N_W(s)}\, ds =$$

$$\int_{Trop.} \sum \mathrm{E}_{nklm} R_k^{(l)}(\vec{r}(s))\, Y_l^{(m)}(\varphi,\varepsilon) e^{-i2\pi nt}\, ds$$

❖ **➔A X = B**

$$\Rightarrow \quad X^* = (A^T C_B^{-1} A + \alpha^2 C_X^{-1})\, A^T C_B^{-1} B$$

Talk by Lydie




Studies of the
erosive processes
in Tahiti

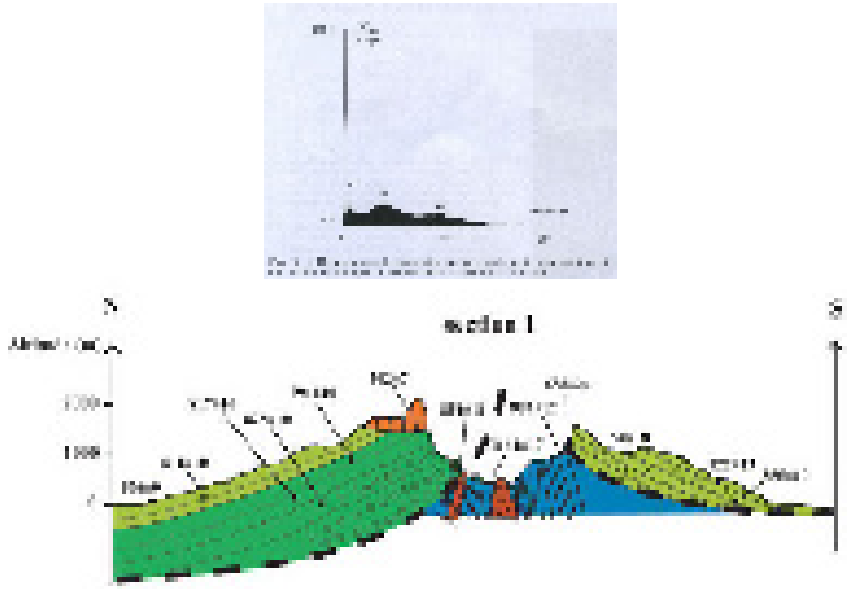
Erasing Tahiti: the subsidence…and the rain !

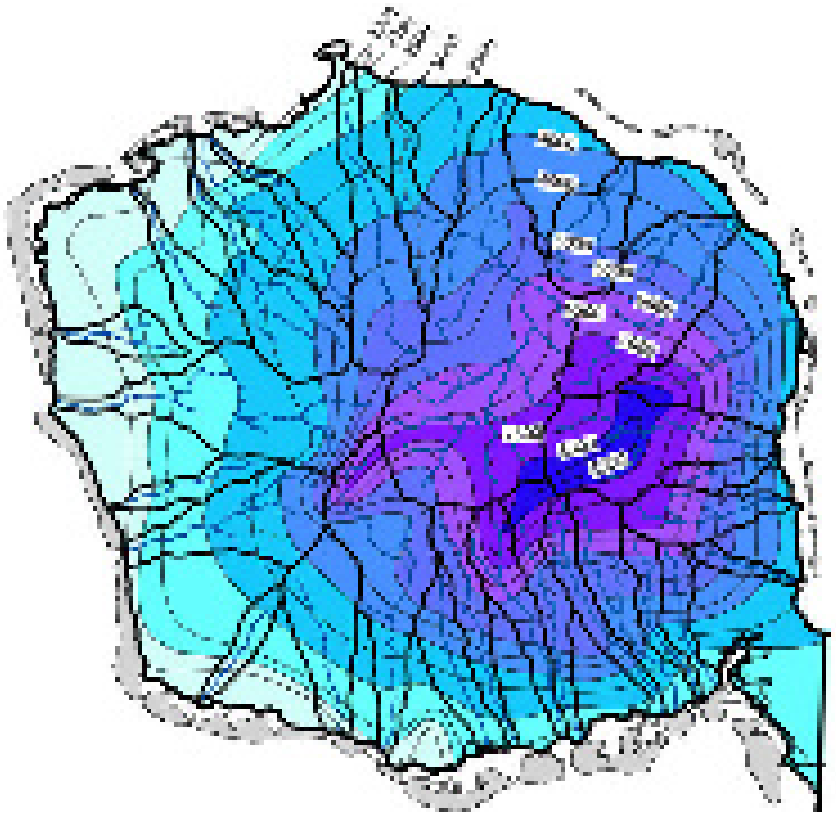
Isohyets of Tahiti Nui

3 types of slopes:

seashore 2 %, volcano 17 %, valleys : 42 %

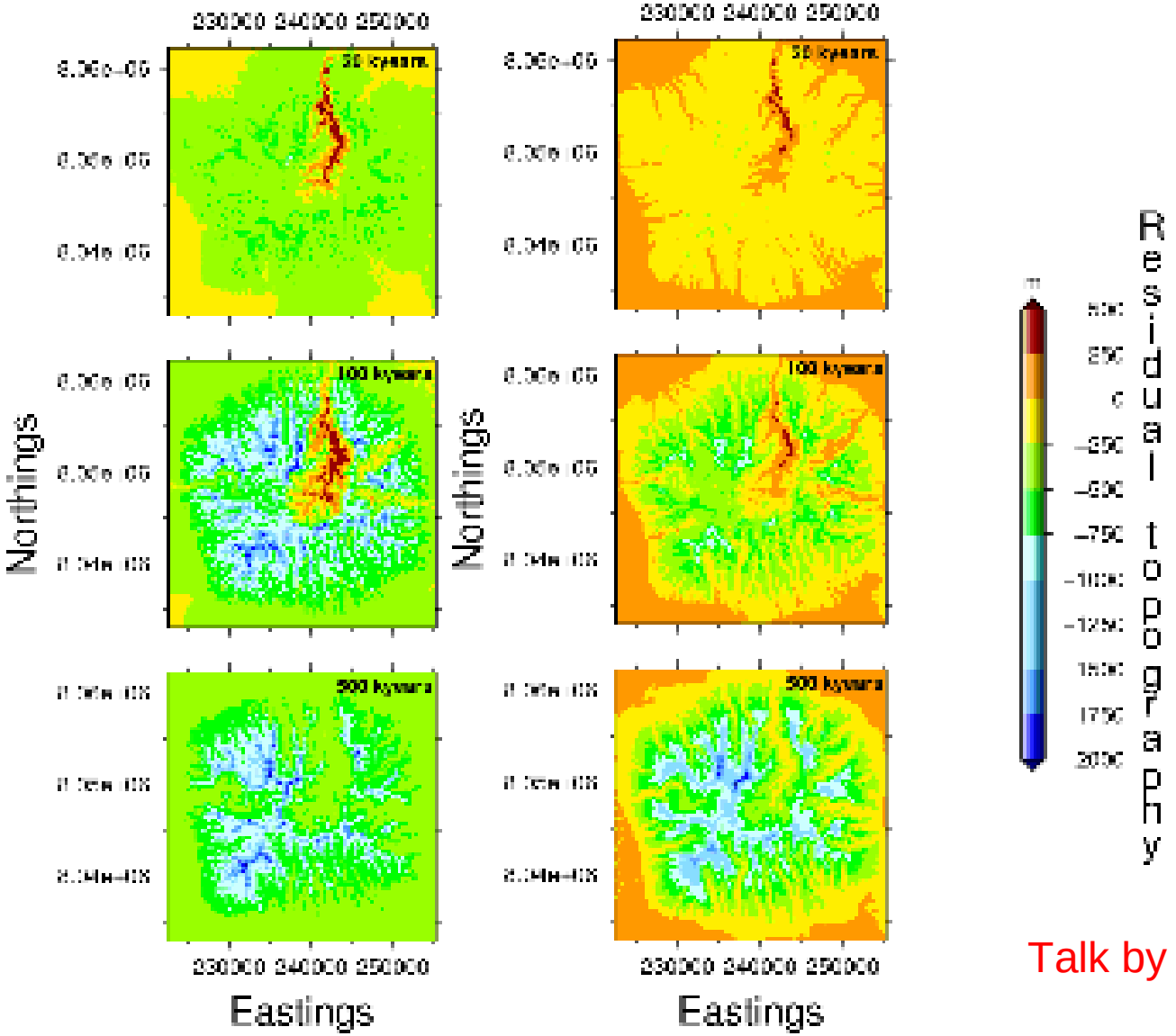
+ heavy rains ==> intense erosion





See Guillande et al., Hildenbrand et al.

Modelling Erosive processes



LEFT: **evolution of the altitude field of Tahiti under a mean rain of 3 m / year**

RIGHT: **differences between the evolution of the same model with a rain of 3m /year and 1 m / year**

See poster PSI 2009: Sichoix et al., and booklet «Doctoriales 09 »: Ye et al.,

Talk by Fengyin

ICET activities:

- **International Centre for Earth Tides (ICET)**
-
- http://www.upf.pf/ICET/
-
- *Director: Jean-Pierre Barriot (France, French Polynesia)*
-
- **Overview**
-
- The period from mid-2007 to mid-2009 was essentially devoted to the translation of ICET from Brussels to Papeete. This includes three main points: web site, the “Bulletin des Marées Terrestres, BIM”, and GGP data stream validation.
-

ICET activities (2)

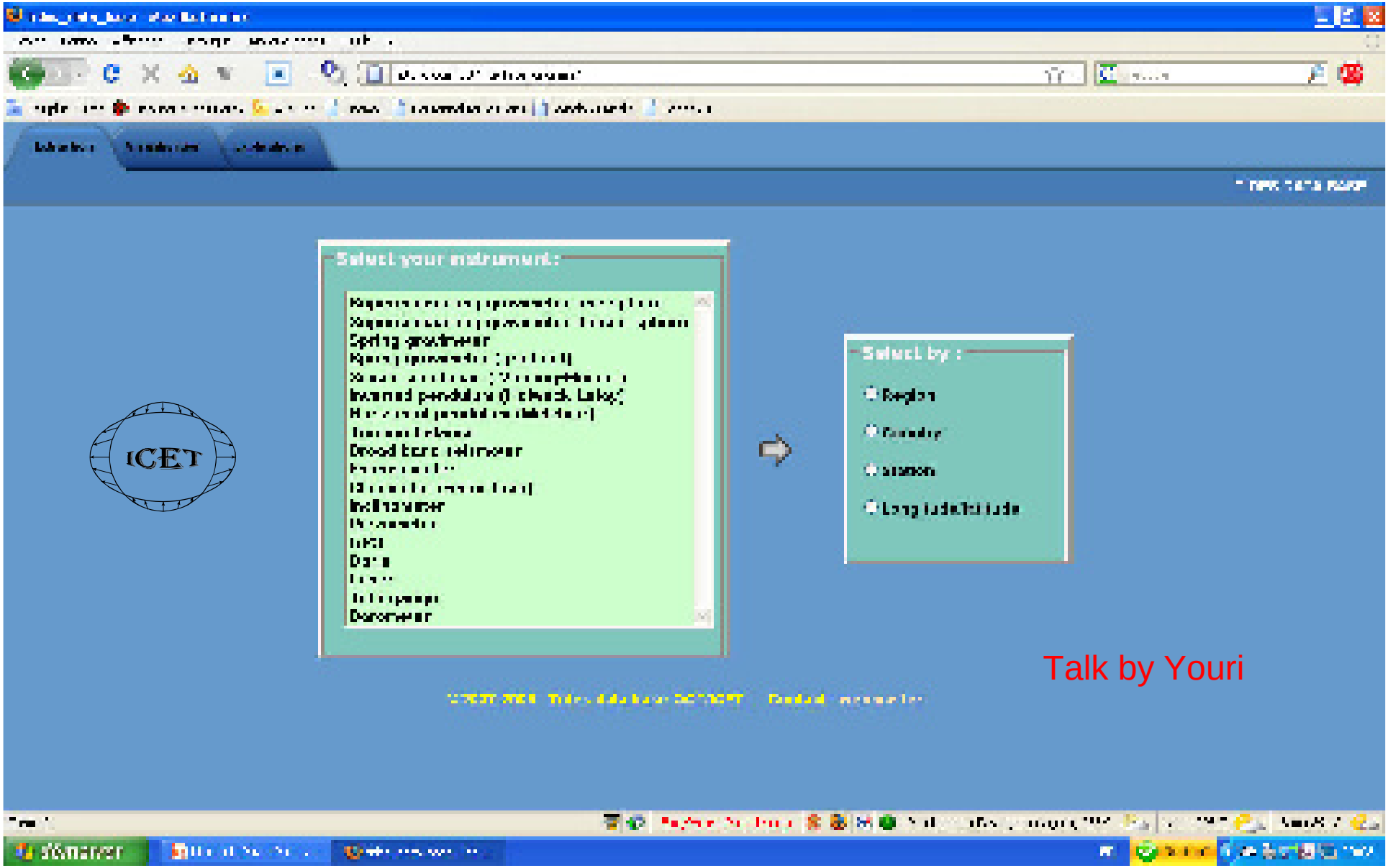
-
- 1/ The web site of ICET was entirely migrated from the Royal Observatory of Belgium to the University of French Polynesia.
-
- 2/ A prototype of the new ICET database has been tested and presented at the ETS2008 meeting in Vienna and IAG2009 in BuenosAires. The database is able to store any kind of data related to Earth Tides, and not only cryogenic gravimeter data (development by Youri Verschelle)
-
- 3/ The server that will host the new ICET database as been bought (6 500 euros) by the University Central Bureau on Information technologies and Networks (RENATER). The ICET database is online on a trial basis.

ICET activities (3)

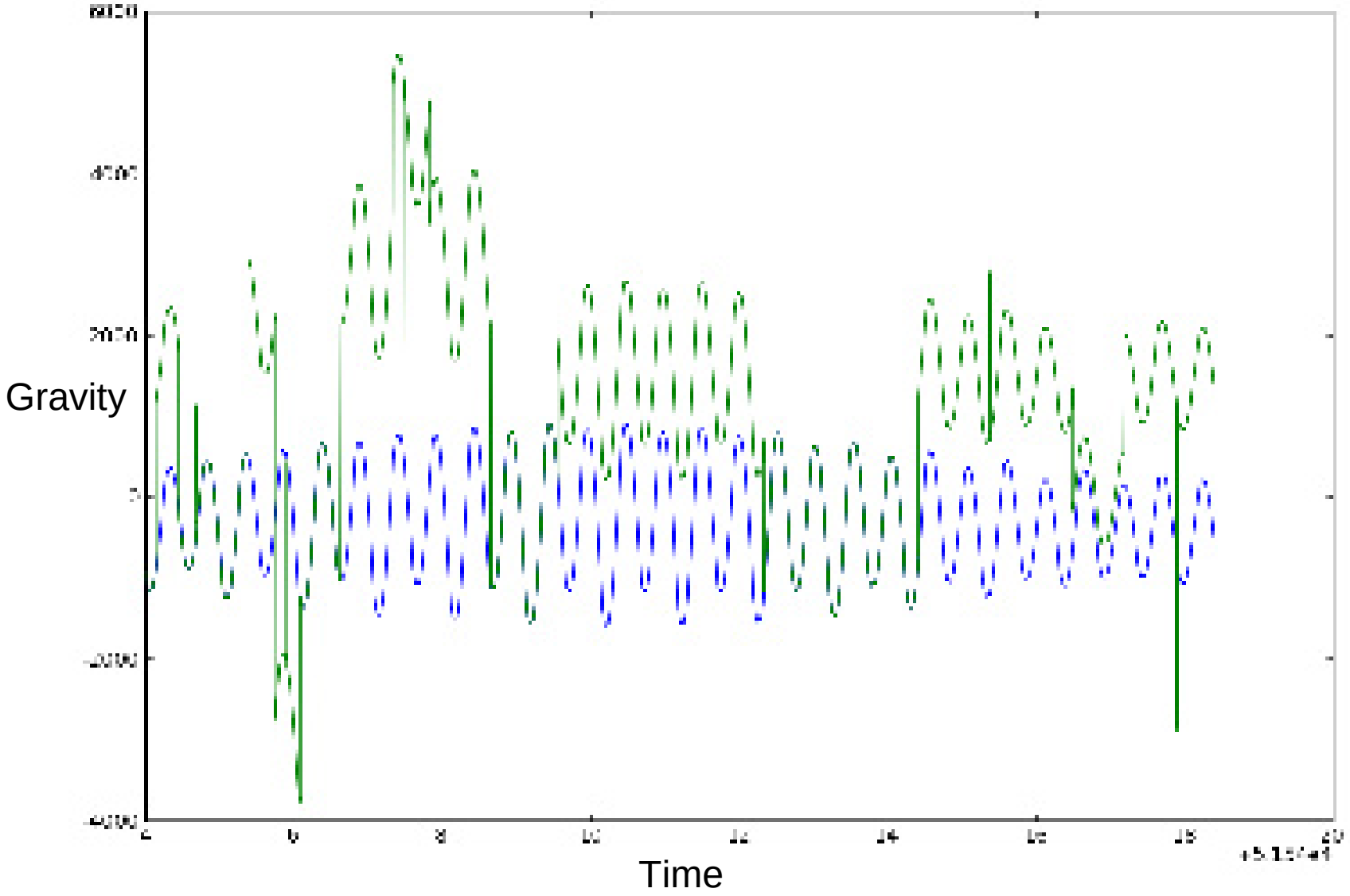
- 4/ A new validation software to treat the GGP data has been written. The purpose of this software is to discard jumps and spikes in the raw data on an automated, or nearly automated basis. Based on Wiener-Kolmogorov filtering techniques, it responds to the critics raised during the ETS2008 meeting in Iena, by re-adding the "noise" to the GGP filtered data. We hope to start routine operations on GGP data by January 2010.
-
- 5/ A GGP “header” script is also under completion. The purpose of this script, written in Python, is to enforce a strict standardization of GGP file headers, in order to completely automate their validation and archiving.
-
- 6/ The BIM 144 has been completed and is on line on the ICET website. BIMs 145 and 146 will be on line soon (BIM 145: end september 09). All together, they will gather more than 25 papers presented at the ETS2008.

ICET activities (4)

- 7/ The new gPhone gravimeter of the ICET center has been received late December and is now in operation in Tahiti-Pamatai. We observed on April 16, 2008 a 6.6 Earthquake in the South Sandwich Islands.
-
- 8/ ICET is also participating in the deployment in Fench Polynesia of a network of Tide-Gauge / GPS stations (POGENET, POLynesian GEodetic NETwork), as a contribution to the GGOS effort.
-
- 9/ Hiring on Sept. 1 of a new Assistant Professor (Ms Lydie Sichoix) for the Geodesy Observatory. She will take care of some of ICET activities (GGP validation software).
-



Querying the new ICET Earth Tides Database



Validation and correction of GGP data at ICET-Tahiti through a generalized collocation procedure (green: raw data, blue: corrected data)

Summary of instruments in French Polynesia:

-- SLR station (ILRS) at OGT

-- 3 permanent GPS colocated with SLR at OGT

-- 1 semi-permanent GPS at Arue

-- 1 DORIS colocated with SLR at OGT

-- 1 gPhone Earth Tides gravimeter at Pamatai

-- 7 tide gauges+GPS stations (all actives 2010):

(2 Tahiti, 1 Huahine (Society), 1 Nuku-Hiva (Marquesas), 1 Rangiroa (Tuamotu), 1 Tubuaï (Australs), 1 Mangareva (Gambiers)

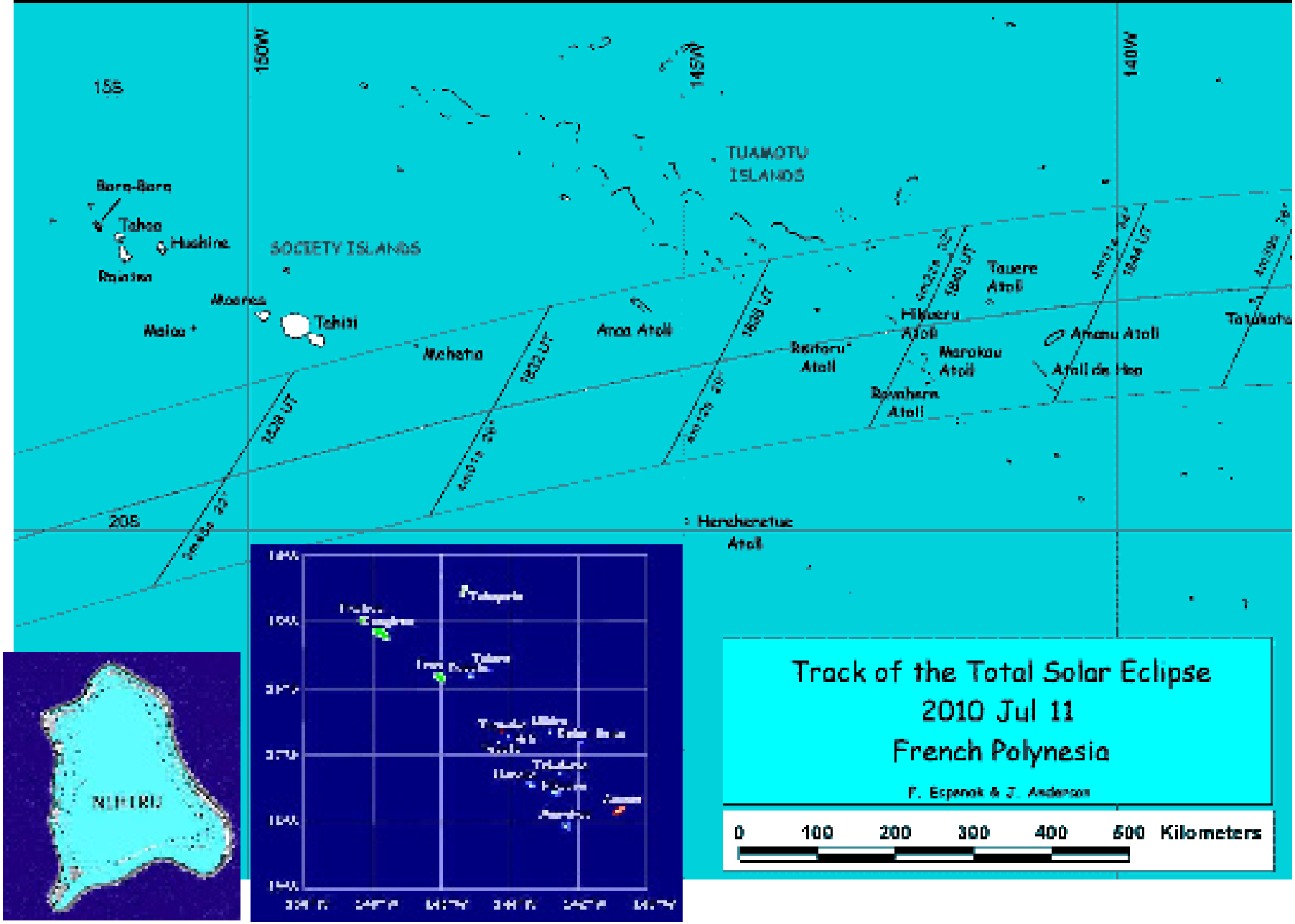
Planned: cryogenic gravimeter, VLBI, altimetry calibration, robotic telescope

2010 plans:

- Ultra-mobile laser station campaign (November 2010)
- Solar eclipse (measurement of the diameter of the Sun) in July 2010 (Tuamotu)
- Recovery of Japanese Boobs (ocean floor seismometers, April 2010)

Station laser ultra-mobile GRGS à Tahiti fin 2010

Total Solar Eclipse of 2010 Jul 11



Seismic japanese boobs (Jamstec)
(Mirai oceanographic vessel, recovery april 2010)

Future plans (> 2011):

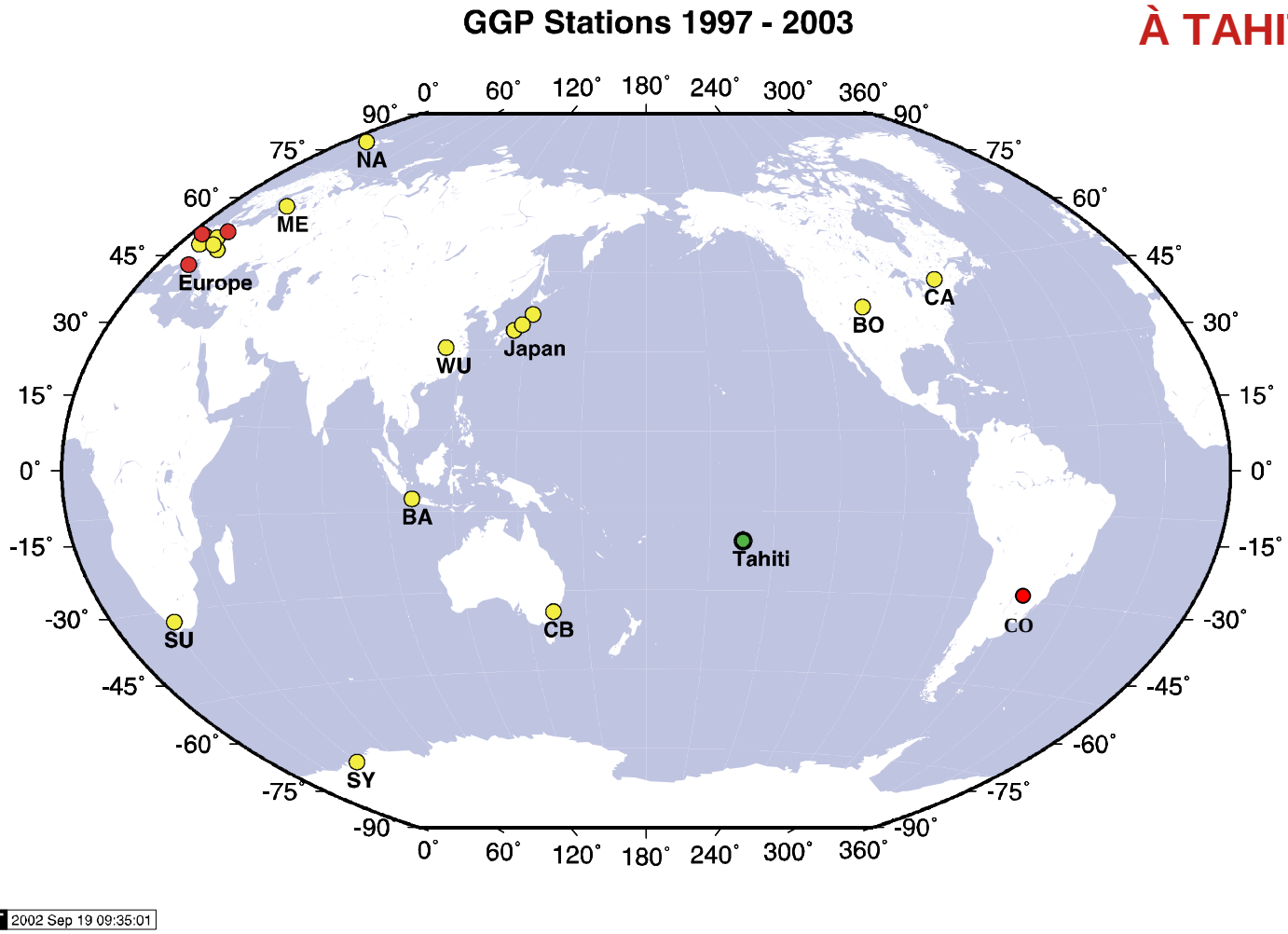
- Cryogenic gravimeter (2012 ?)
- New laser station (2014 +)
- VLBI station (2014 +)
- All these three colocated at Taravao

- + Robotic telescope at Maiao (2011 ?)
- + Altimetry calibration line (2012 ?)

Un gravimètre cryogénique pour Tahiti ?

Gravimètre à supraconductivité de la nouvelle génération

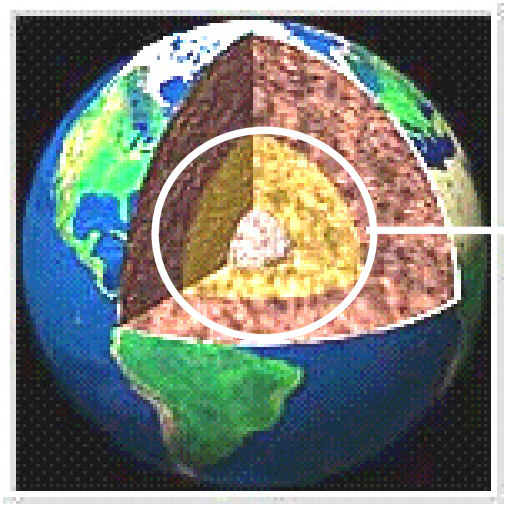
Où installer un nouveau gravimètre cryogénique ?

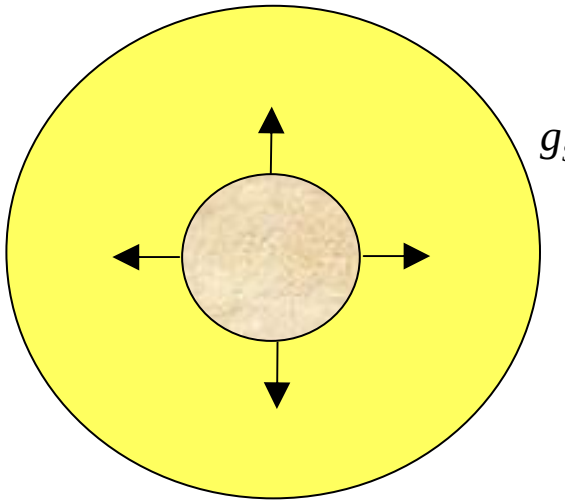


- la plus forte anomalie gravimétrique non expliquée au niveau des océans est dans le Pacifique Sud-Central près de Tahiti d'après les résultats les plus récents de GRACE (Wahr et al. 2004)

Le Triplet de Slichter : le graal du gravimétricien

Translation de la graine dans le noyau externe liquide
(périodes entre 3 h et 7 h)





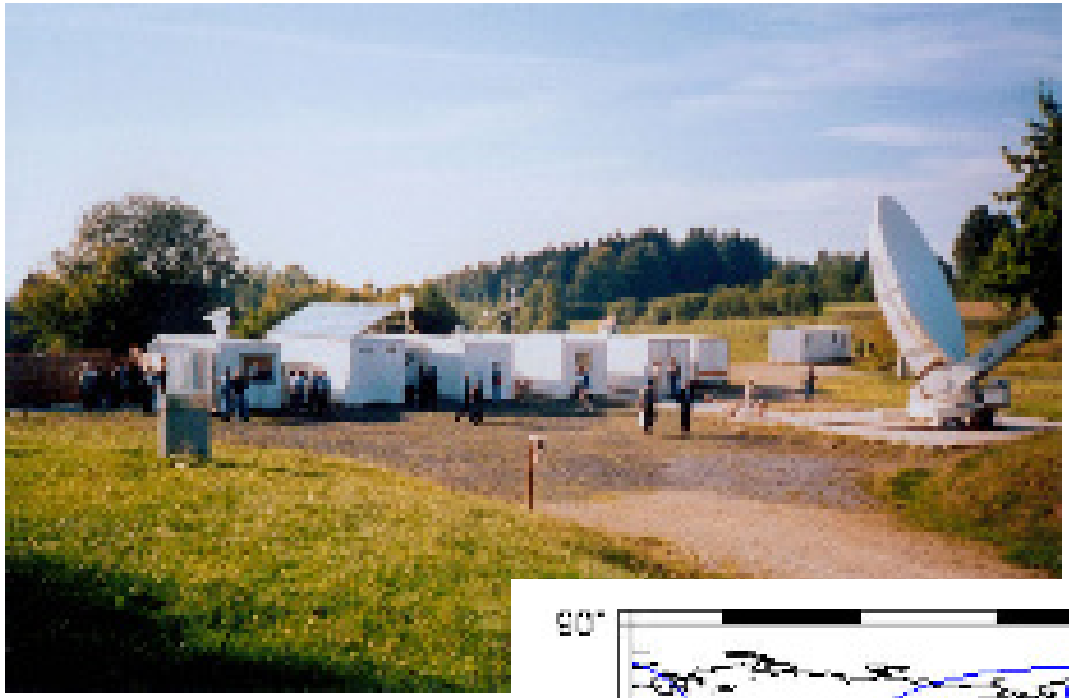
$$g_S(t) = \begin{aligned} & a_r \cos\varphi_S \sin(w_r t + \lambda_S + \phi_r) \\ & + a_a \sin\varphi_S \sin(w_r t + \phi_S) \\ & + a_p \cos\varphi_S \sin(w_r t - \lambda_S + \phi_p) \end{aligned}$$

φ_S *latitude observatoire*

λ_S *longitude observatoire*

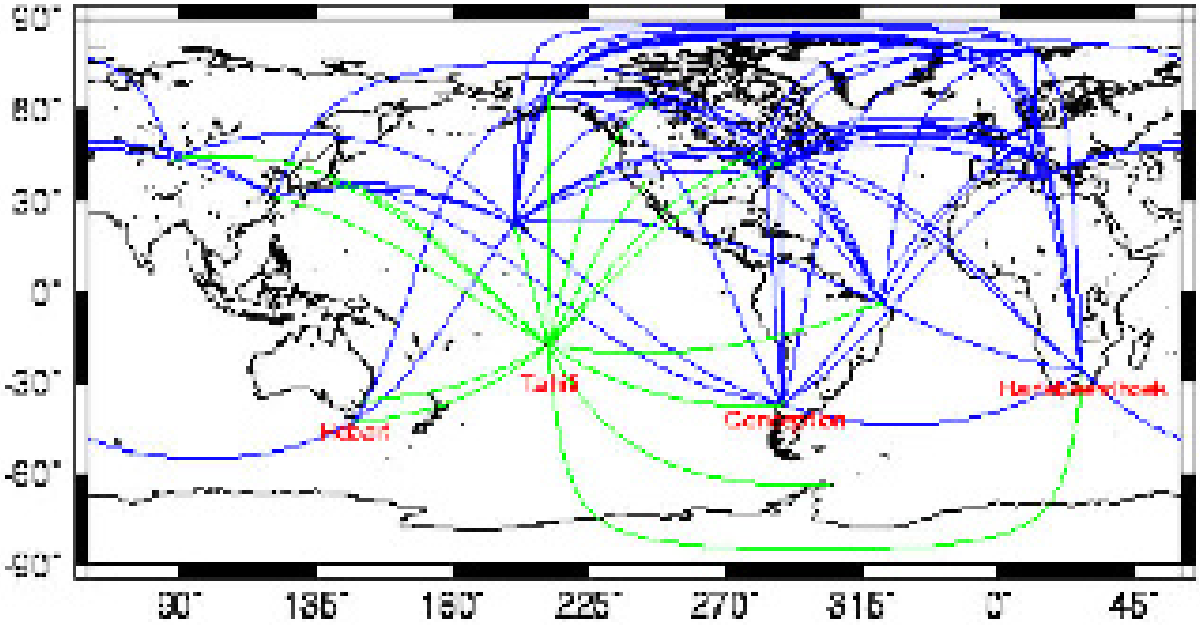
Information sur la viscosité et le saut de densité à l'ICB

•théorie et observations (Smylie, 1992 ; Smylie et al., 1993 ; Courtier et al., 2000) très controversées

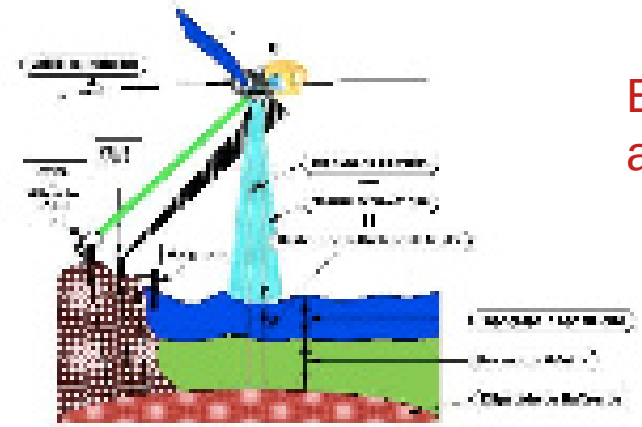


Etablissement d’une mini-antenne VLBI à Tahiti-Iti

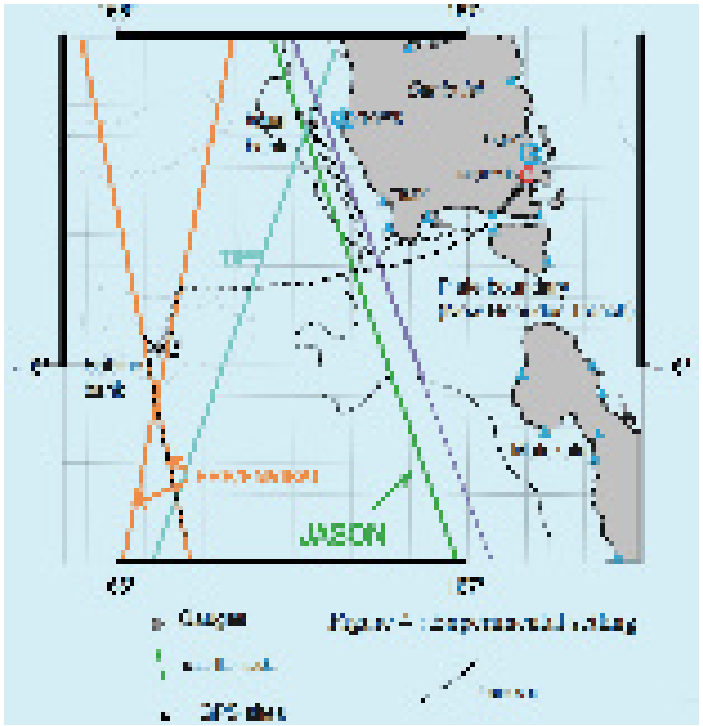
Observatoire TIGO (Conception, Chile)

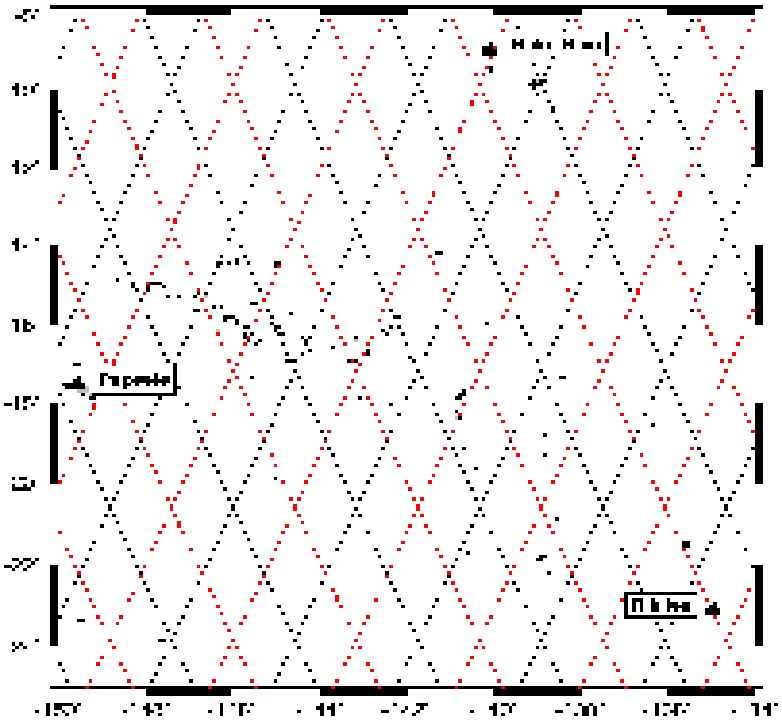


Etablissement d'une ligne de calibration altimétrique à Tahiti



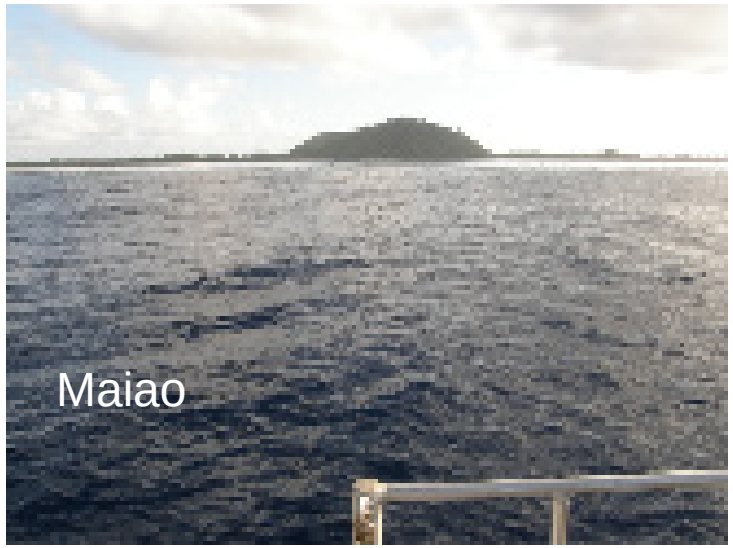
Ligne de calibration ENVISAT aux Vanuatu (Calmant et al.)





Lignes possibles de calibration aux îles de la Société (point amphidromique)

Projet de télescope robotique à Maiao (astrométrie)



Telescope robotique TAROT


And still so many things to do …
And so little time …