Analysis of the GPS time series from the 2004 Ocean Loading Campaign in Brittany

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Introduction

Brittany, in the west part of Europe, is particularly suited for studying ocean loading effects because it is the region where the phenomenon has a very high amplitude, and particularly on the vertical component.

In 1998 and 1999, the ESGT research laboratory has been involved with several French institutes in a first campaign to study the effects of ocean loading in this region. Several geodetic techniques were used, mainly GPS and gravimetry, but only on short periods (only 3 days for the GPS experiment).

In order to confirm the interesting results showed by this first campaign and to go further in the study of the ocean loading effects in Brittany, a new national multi-technique campaign took place in 2004, from March to October. For this 2004 campaign, more geodetic techniques (GPS, gravimetry, inclinometry, tide gauges, laser ranging, barometry …) were used on more sites and during a longer period. Several French institutes were involved in this 2004 campaign (CNES, CNRS, IPGP, EOST, LAREG/IGN, SGN/IGN, LDL, OCA/GEMINI, ESGT …) which is performed in the framework of the GDR-G2 (Groupement de Recherche Géodésie-Géophysique). The main objectives of this 2004 campaign are :

- To validate recent ocean loading models (FES2004, MOG2D) by comparison with real data,
- To study in particular the ocean loading effects due to non linear waves which have high energy in the area of the Mont Saint Michel,
- To refine ocean loading models by including these non linear effects.

Description of the 2004 campaign

The main advantage of multi-technique campaigns is to understand the error sources and to fully exploit the potential of each single technique. For the 2004 ocean loading campaign in Brittany several techniques have been used.

Gravimetry: several gravimeters were in operation during the campaign

- two relative gravimeters (Scintrex) were set up in Cherbourg (IPGP) and Brest (SHOM) from March to October 2004,
- an FG5 absolute gravimeter (EOST) was in operation in May (12-18) at Cherbourg.

Inclinometry: two BLUM-ESNOULT (IPGP) inclinometers were in operation during the whole campaign at Cherbourg.

GPS: two experiments took place from March to October 2004

- First experiment: from March to June 2004, 12 GPS receivers from INSU were temporarily installed in Brittany and in Cotentin.
- Second experiment: from September to October, 6 GPS receivers were re-installed in Brittany only.

Barometry: two experiments took place from March to October

- First experiment: from March to June 2004, 7 barometers (EOST) were temporarily installed in Brittany (3) and in Cotentin (4), close to the GPS receivers.
- Second experiment: from September to October, 7 GPS receivers were installed in Brittany only, close to the GPS receivers.

Satellite Laser Ranging: from September to October 2004, the French Transportable Laser Ranging System (FTLRS) from OCA/GEMINI was installed at Brest.

GPS positioning time series

During the first experiment from March to June, a set of 12 GPS receivers were temporarily installed in Brittany and in Cotentin. In these regions, data of permanent GPS stations from the French GPS permanent array (called RGP) are also available.

We thus computed GPS positioning time series using the 12 temporarily installed GPS receivers and 3 permanent GPS stations from the RGP, as shown in red in Figure 1.

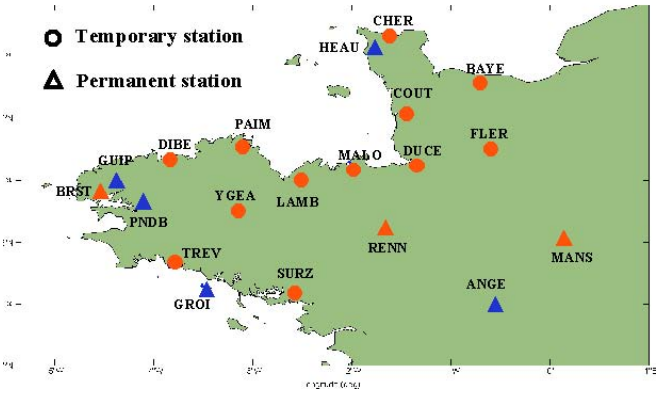

Figure 1. Temporarily installed GPS receivers (dots) and permanent RGP GPS stations (triangles). In red, the GPS receivers used to compute the GPS positioning time series.

For the computation of these GPS positioning time series, we used the Bernese GPS software version 4.2 with the following strategy:

- All stations computed simultaneously,
- One 3D position computed per hour for each station, each position independent from the others,
- Free Network Condition as implemented in the Bernese software,
- One Zenithal Tropospheric Delay estimated every 20 min for each station,
- Integer ambiguity resolution using 24h sessions,
- Cut-off angle of 10°,
- Use of IGS final orbits and ERP weekly solutions.

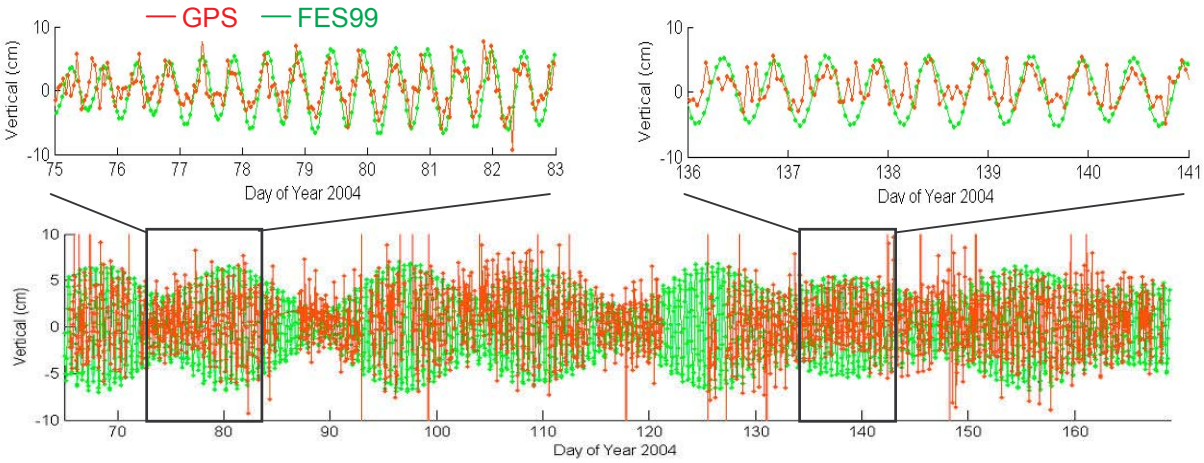

Figure 2. Vertical displacement (in cm) for Brest station, from March to June 2004. In green the theoretical displacement computed from the FES99 ocean loading model. In red, the GPS positioning time series for the vertical component.

The GPS positioning time series are converted into local displacements into North, East and vertical components and compared with the FES99 Ocean Loading model (provided by M. Llubes, LEGOS). Figure 2 illustrates the kind of GPS positioning time series obtained for Brest, for the vertical component. The theoretical displacement for the vertical component computed from the FES99 ocean loading model is plotted in green and the displacement observed by GPS is plotted in red. For this station, there's a good agreement between the model and the GPS positioning time series, both in amplitude (14 cm peak to peak for Brest) and in phase.

Conclusion

In this presentation, we have shown recent GPS results obtained from the 2004 ocean loading campaign in Brittany. Using a set of 12 GPS receivers installed from March to June in a large area surrounding the Mont Saint Michel, we computed GPS positioning time series and compared them with the theoretical displacements computed from the FES99 ocean loading model.

In most of the cases, the GPS positioning time series are coherent with the global FES99 model in terms of amplitude and main period. But it exists some discrepancies which need further investigation. These discrepancies could be due to:

- Limit of GPS positioning accuracy for 1-hour session, with respect to the signal amplitude,
- The strategy used to compute the time series,
- Real local effects not taken into account in the FES99 model.

The next steps of this work are :

- To compare the GPS positioning time series with more refined model (FES2004 for instance),
- To confirm the GPS results by using different strategies and different processing softwares (GAMIT, GOA II),
- To analyze the data of the second GPS experiment (during the autumn equinoctial tides),
- to compare and to combine these GPS results with the other techniques (laser, gravimetry, …).

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