Geodesy and Disasters

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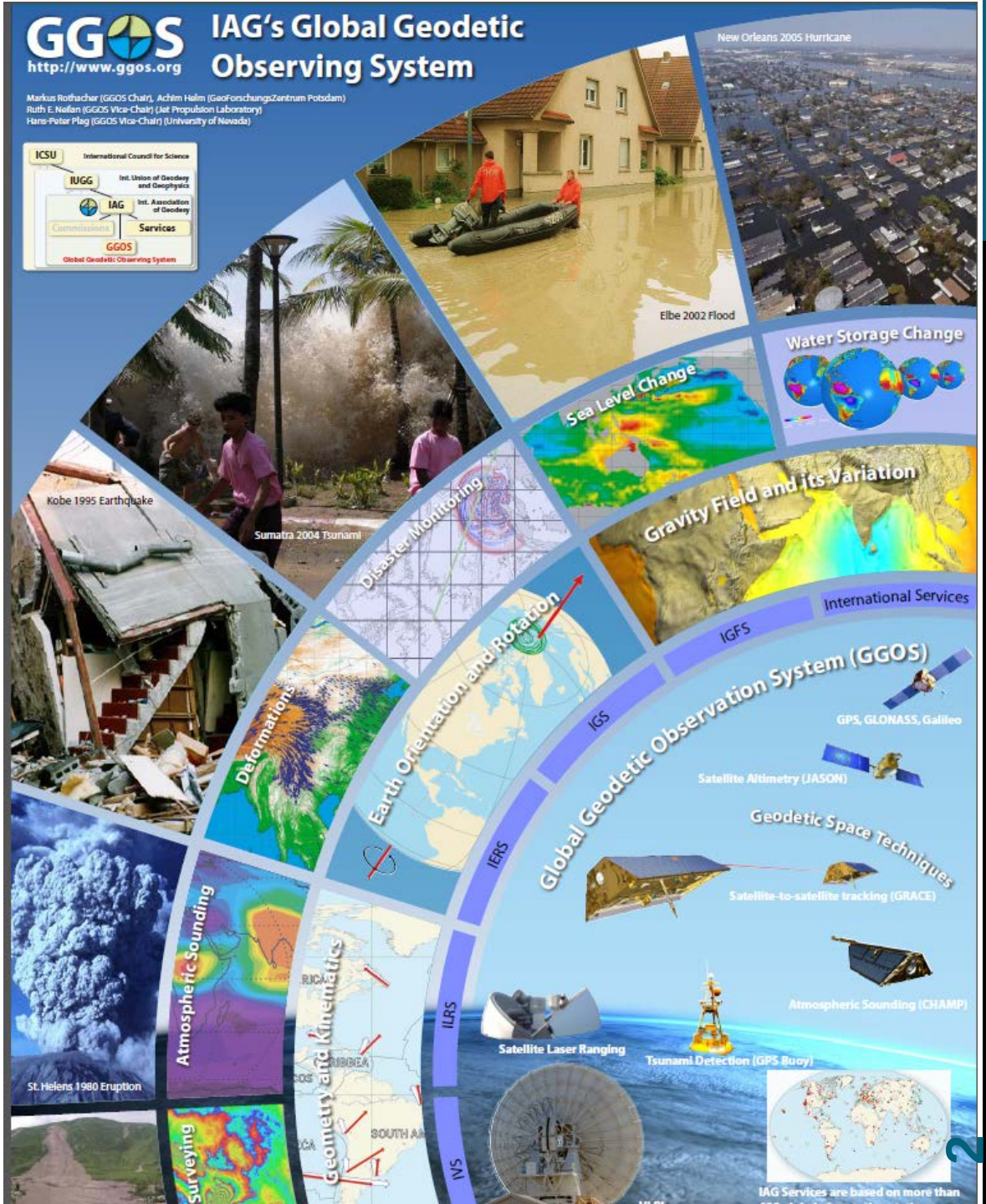
- Geodetic techniques and space missions are useful for risk management
- Galileo is not only a navigation tool but also contributes to the Global Geodetic Observing System



GPS
Galileo
GLONASS

DORIS

GRACE
GRACE-FO

VLBI

SLR
LLR

Altimetry

- **Historical Geodesy Software (+50 ans)**
- **Training – Distribution**
- http://grgs.obs-mip.fr/recherche/logiciels/gins/

- Precise orbits
- **Models of mean and variable gravity fields**
- Pole motion, Length of day
- **Precise Station Coordinates**
- Tropospheric delays…

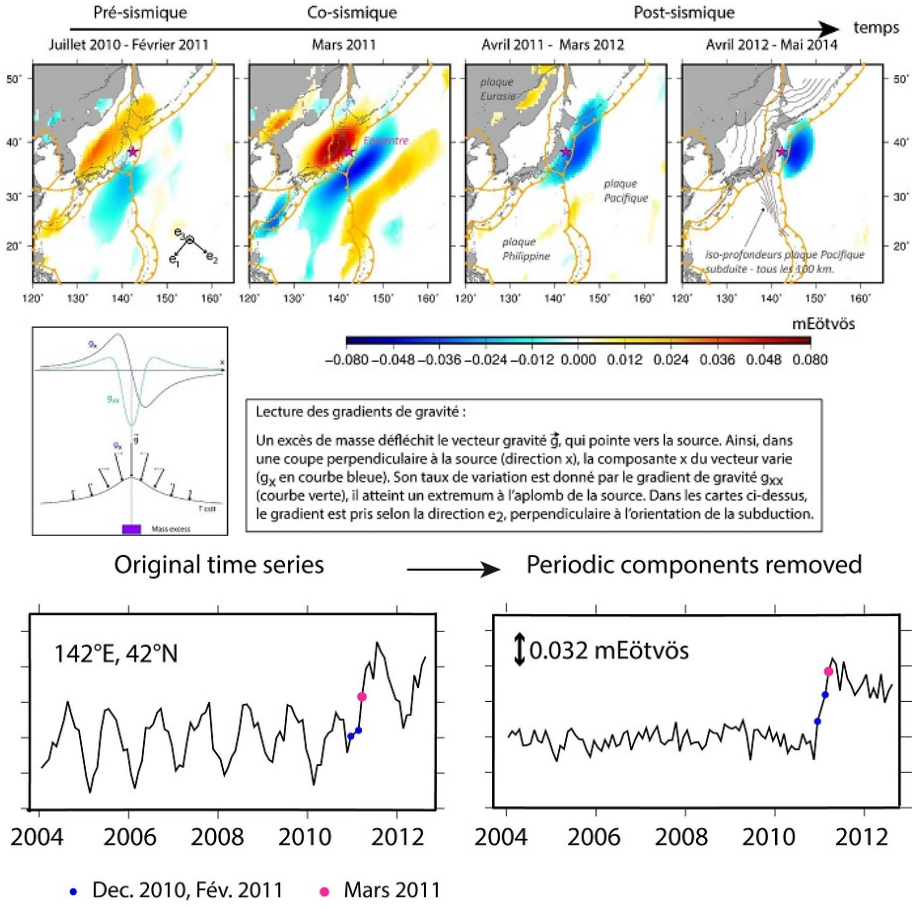
Other Users

Services for IAG
International Association of Geodesy

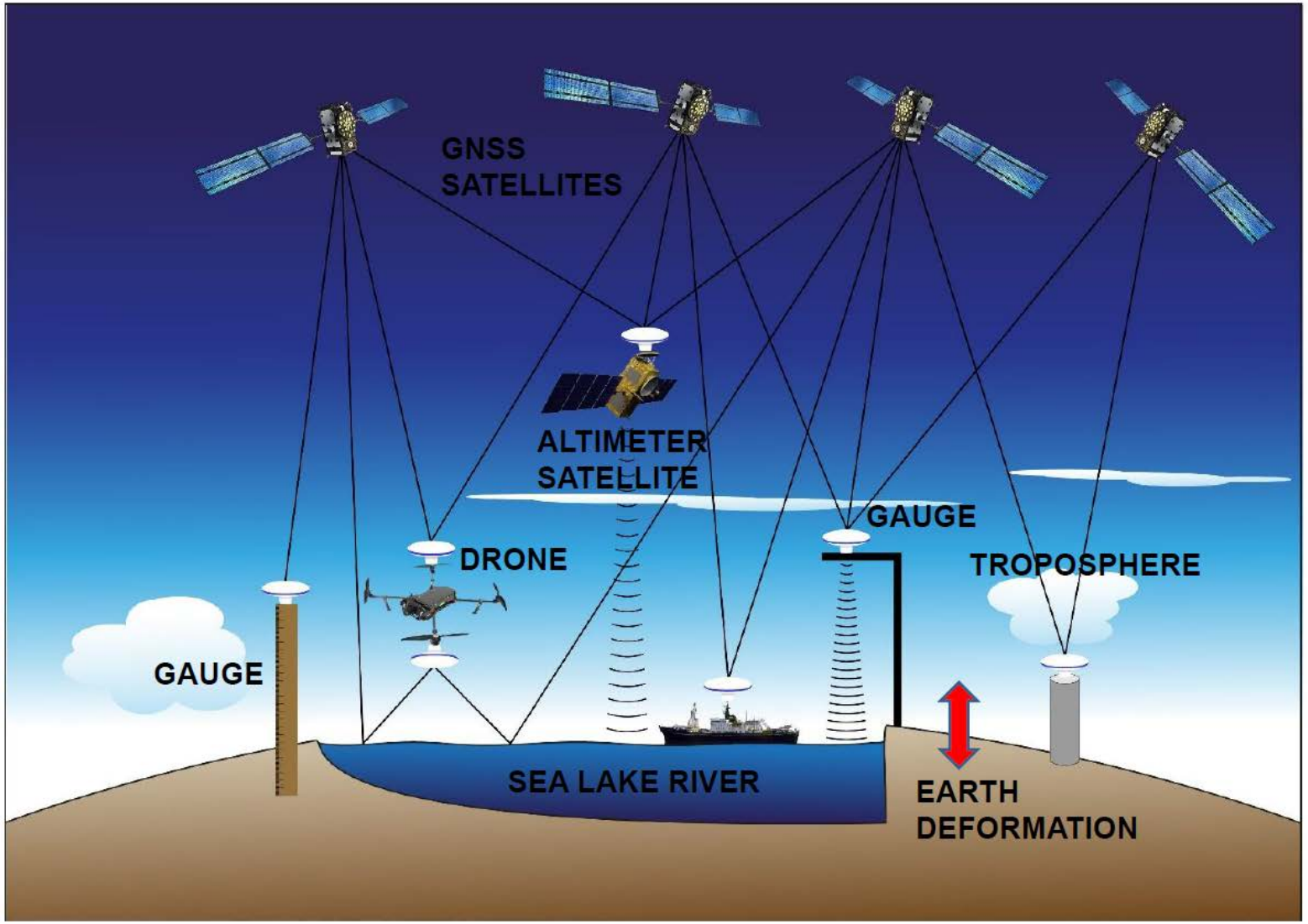
GRAVITY : GRACE AND GRACE-FO

- Major Earthquakes
- Gravity field variation

Migrating pattern of deformation prior to the Tohoku-Oki earthquake revealed by GRACE data
I. Panet et al. *Nature Geoscience (2018)*



Potential monitoring service from 10-days products which might detect anomalies. Almost operational at CNES.



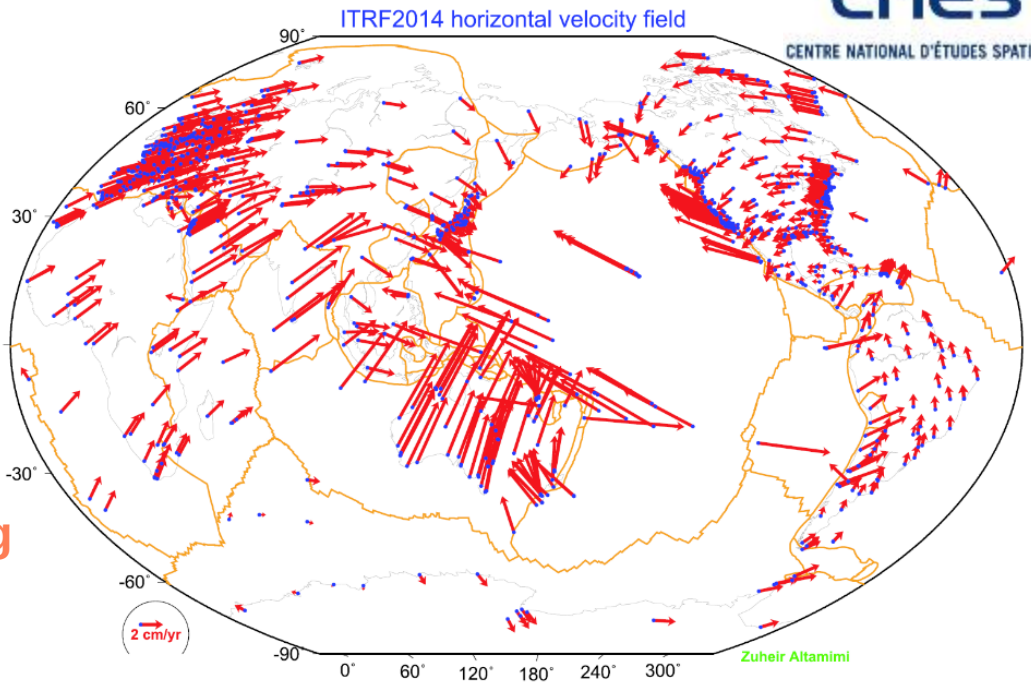
CNES computes the position of Glonass, GPS et GNSS satellites and delivers to the international community via IGS.

Very precise positioning of ground stations is then derived using GINS software.

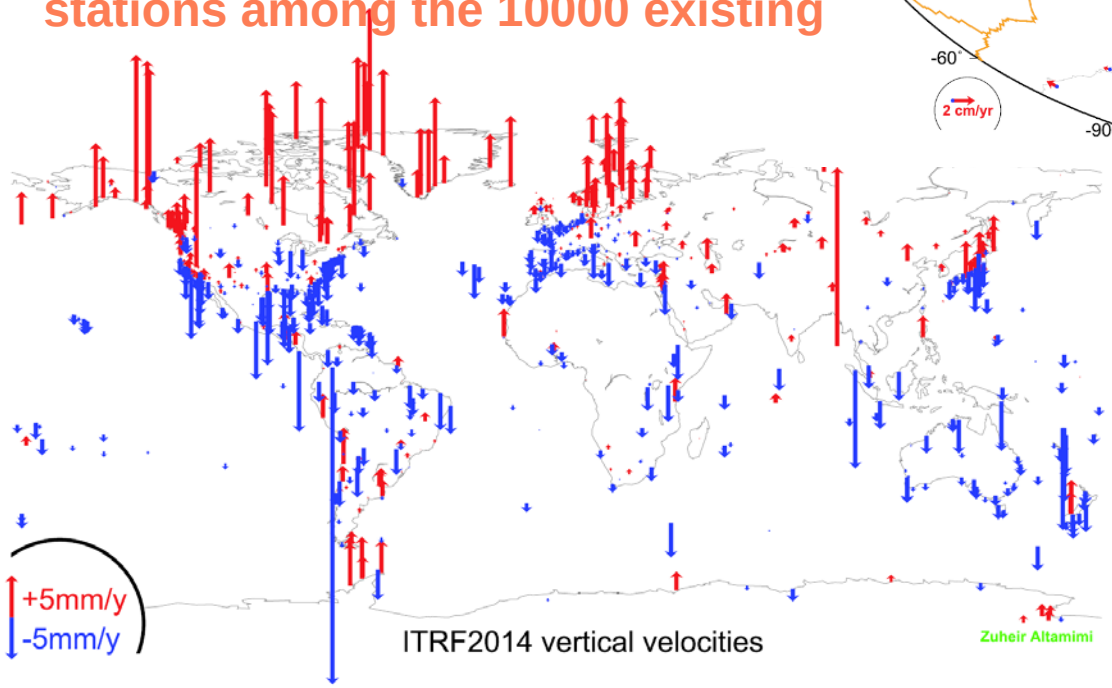
LINEAR DISPLACEMENT OF STATIONS MEASURING TECTONIC VELOCITIES

Computation of 1 daily position of GNSS stations during ~20 years (precision is a few millimeters)

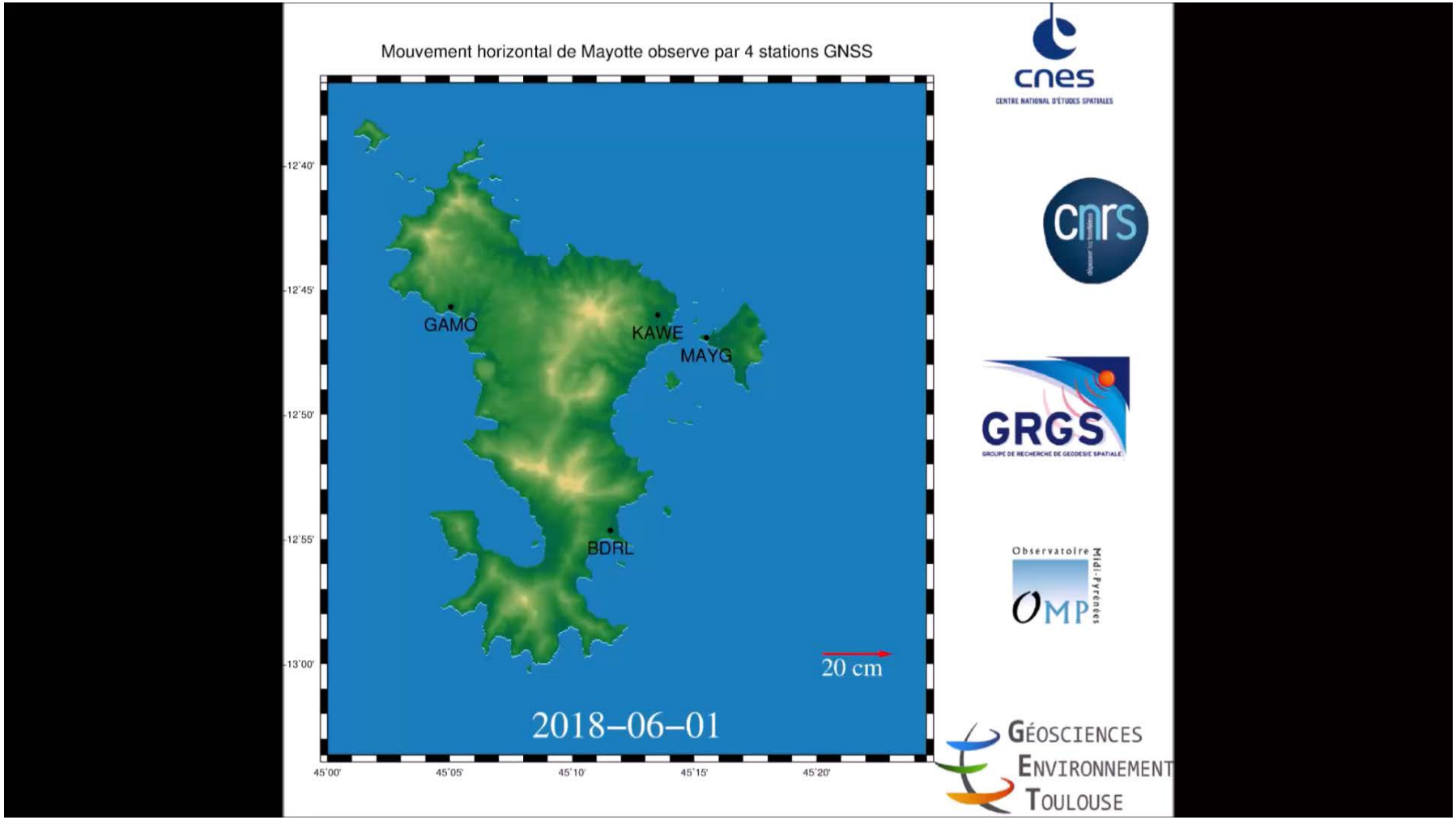
Done everyday by CNES on some of these stations.
Could be run on more targeted stations among the 10000 existing



Altamimi et al. 2016

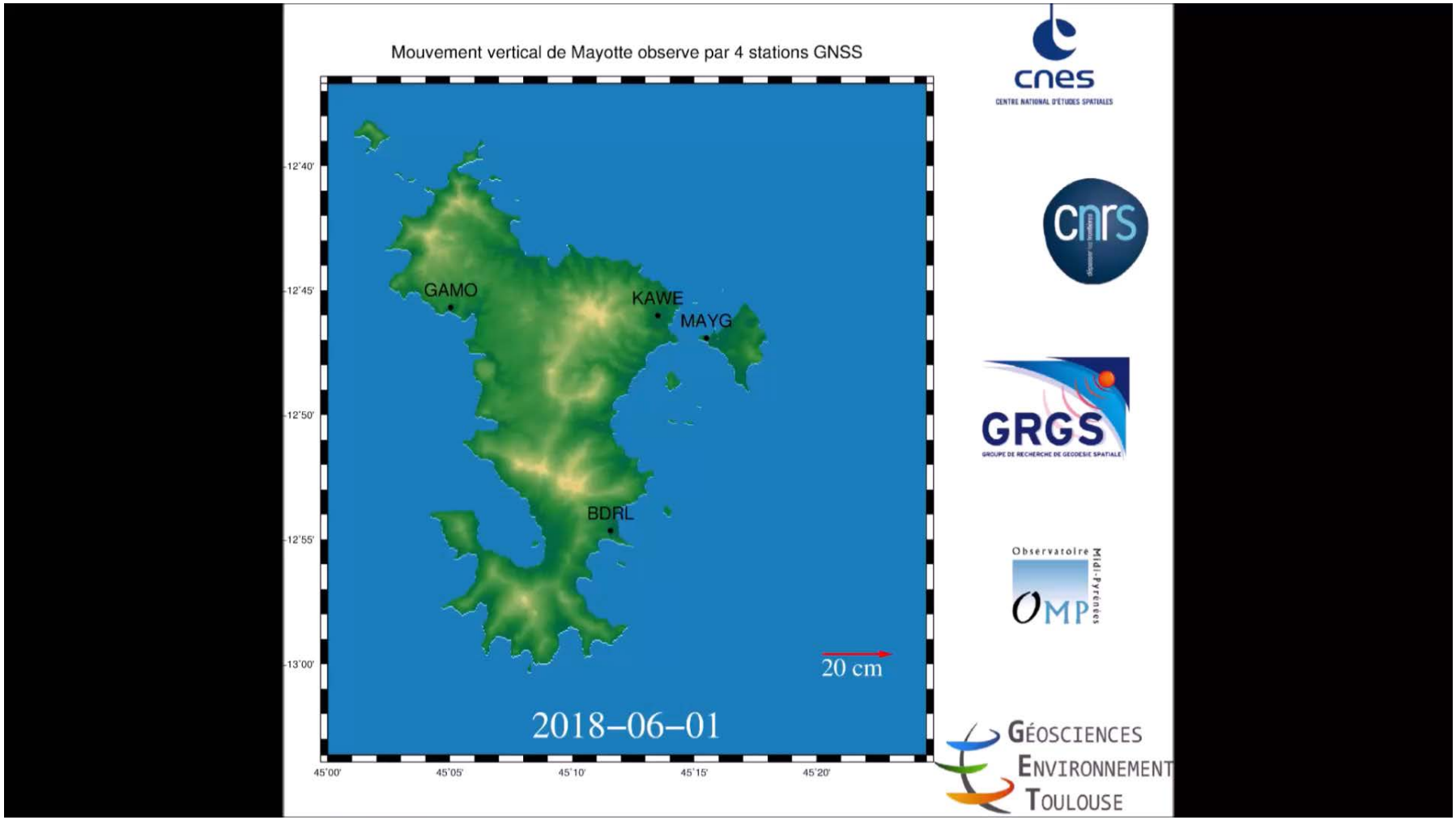


Computation of 1 daily position during 15 months – MAYG: GPS+Galileo - Mayotte island Horizontal Displacement Video



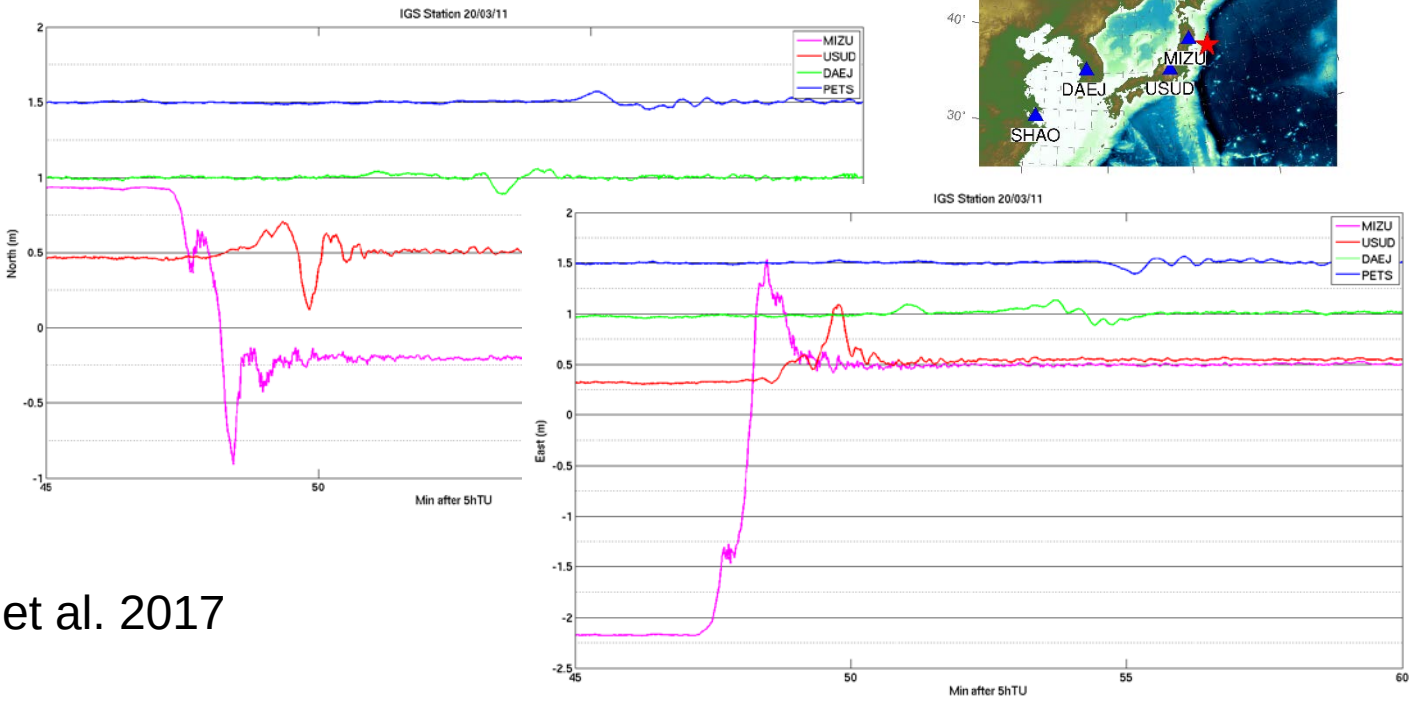
Mayotte island Vertical Displacement video

Daily measurement. Zoom on a risky area for slow movement or landslides
Alert service not yet available.



Measurement of co et post-seismic deformation

- Example of Sendaï in Japan (11/03/11)
- Computation of 1 position per second



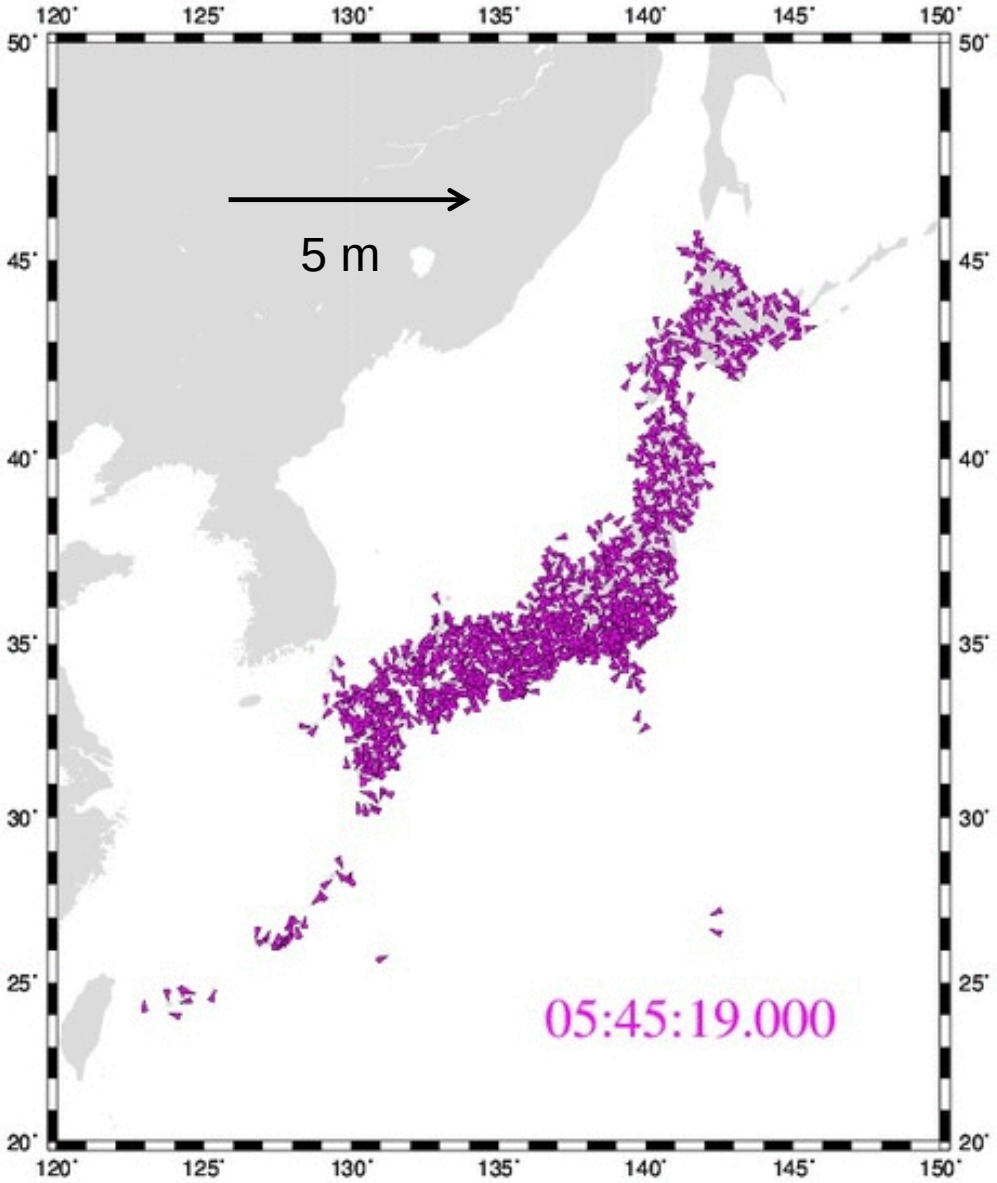
Barbu et al. 2017

Real time displacement during seism enables to characterize its type

TOHOKU/FUKUSHIMA 2011
MARS 2011

- In Japan there is a real-time analysis system

- GEONET network
- 1300 stations
- 1 Hz
- IPPP Solution
- GINS software
- GRG products



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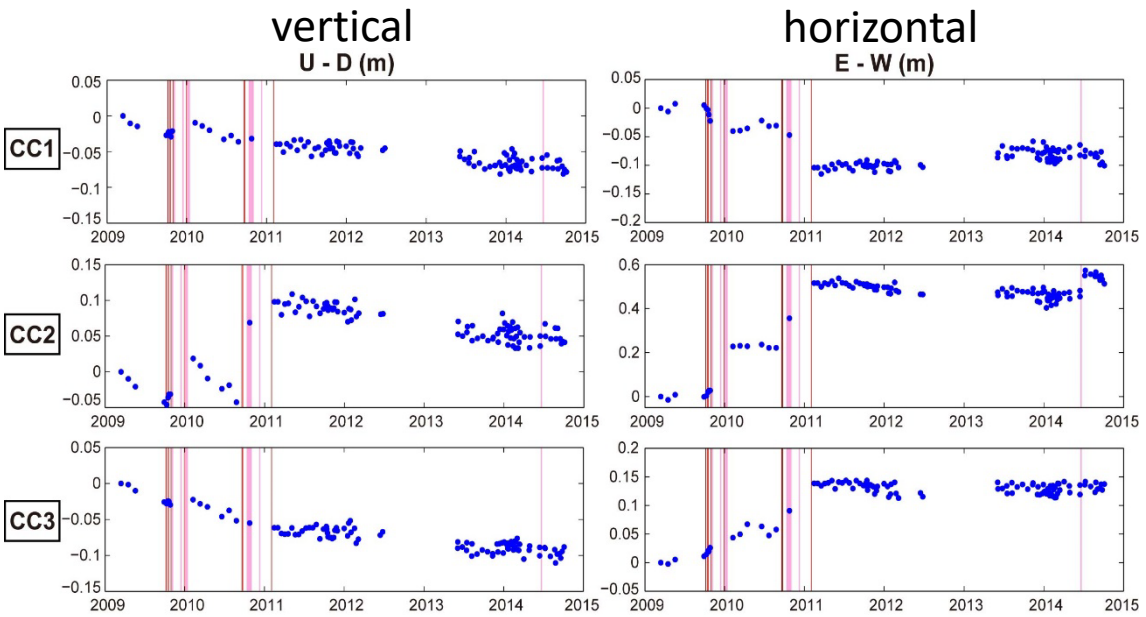
Piton de la Fournaise volcano ground displacement observations. 3 GPS stations for monitoring after 2007 eruption

GNSS observations are usefull:

- **to calibrate In-SAR results**
- **to model the volcano deformation**

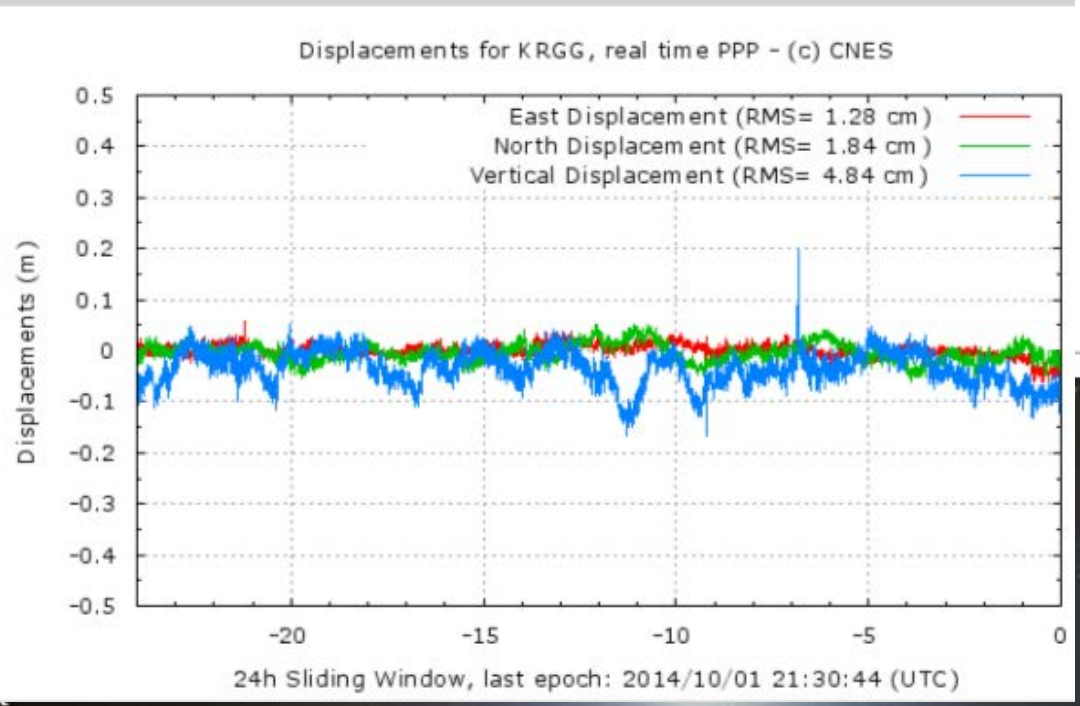


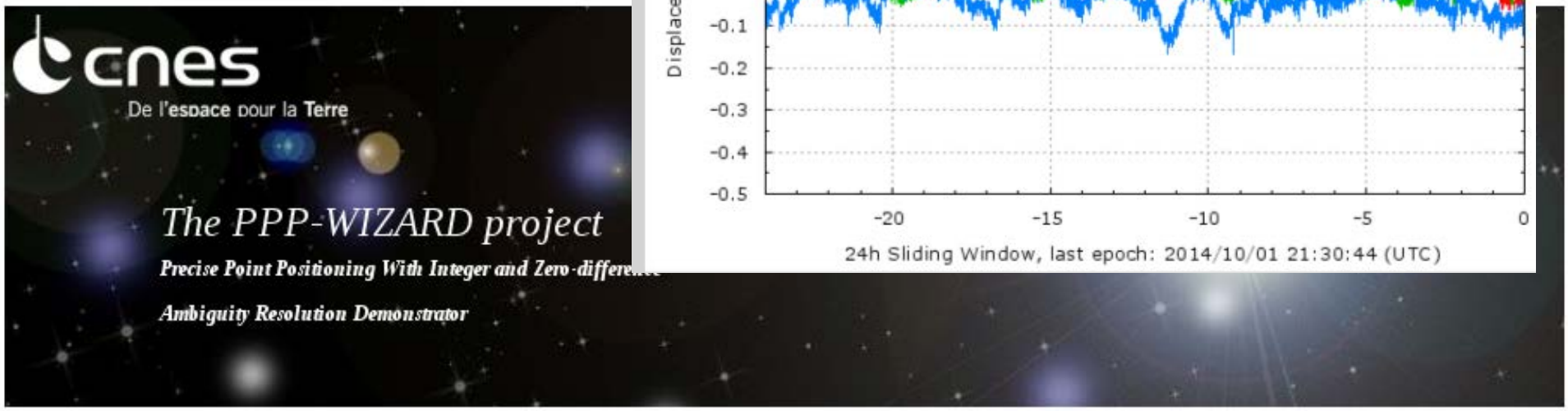
Y. Chen et al. (2017), Long term displacement triggered by the historical eruption in April 2007 at Piton de la Fournaise, La Reunion Island, *Remote Sensing Environment*, 194, 230-247.

CNES DEVELOPED A DEMONSTRATOR FOR REAL-TIME PRECISE POINT POSITIONING

Could be used for CEOS sites

http://www.ppp-wizard.net/





PPP-Wizard Project	SSR Computation	CNES Caster	Network/PPP Monitoring	Links Contacts

PPP-Wizard: Precise Point Positioning With Integer and Zero-difference Ambiguity Resolution Demonstrator

The PPP-WIZARD demonstrator is a 'proof of concept' of the zero-difference ambiguity resolution method developped in the orbit determination service at CNES.
One can find all the details on this method in the publications available in the links page.

PERSPECTIVES

- **Grace-FO will provides gravity field solutions every ten days and we could show examples of monitoring on some CEOS-GSNL sites**

- **Networks of geodetic GNSS receivers get more and more dense and can be used for scientific purposes :**
  - . GNSS can monitor on a long term basis every day **(e.g. Mayotte)**
  - . GNSS can provide high frequency measurements during an event

- **Delivery of very precise computations from ground GNSS stations measurements might improve research or alerts for**
  - **. Swelling of volcanoes**
  - **. Monitoring of seismic zones**
  - **. Load deformation ...**

- **The CEOS Disasters WG might discuss possibility to Integrate these results in the pilots, demonstrators and GSNL on a case by case basis or propose the GINS software to scientific teams**