

Geodesy and Disasters

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GGOS IAG's Global Geodetic Observing System

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ICSU International Council for Science
 IUGG Int. Union of Geodesy and Geophysics
 IAG Int. Association of Geodesy
 GGOS Global Geodetic Observing System

New Orleans 2005 Hurricane
 Elbe 2002 Flood
 Kobe 1995 Earthquake
 Sumatra 2004 Tsunami

Water Storage Change
 Sea Level Change
 Gravity Field and its Variation
 Deformations
 Earth Orientation and Rotation
 Atmospheric Sounding
 Surveying
 Geometry and Kinematics
 Disaster Monitoring
 International Services
 IGFS
 ICS
 IERS
 ILRS
 IVS

Global Geodetic Observing System (GGOS)
 GPS, GLONASS, Galileo
 Satellite Altimetry (JASON)
 Geodetic Space Techniques
 Satellite-to-satellite tracking (GRACE)
 Atmospheric Sounding (CHAMP)
 Satellite Laser Ranging
 Tsunami Detection (GPS Buoy)

IAG Services are based on more than

- 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



Products

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

Other Users



Services for IAG
International Association of
Geodesy

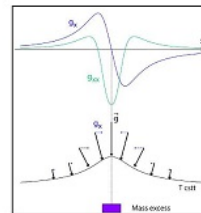
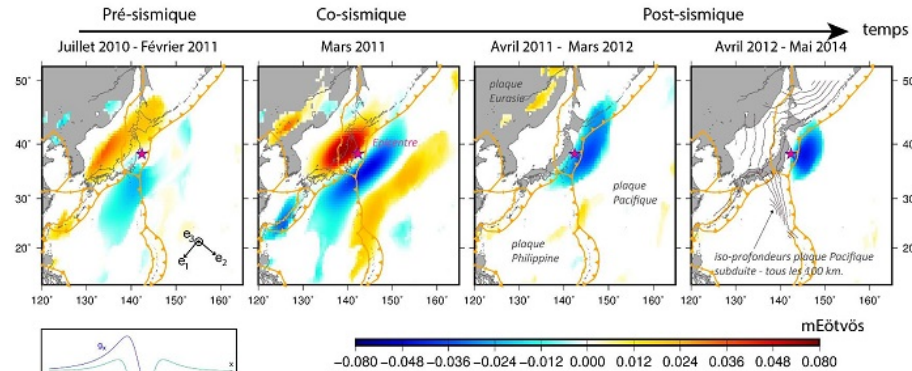
- Precise orbits
- **Models of mean and variable gravity fields**
- Pole motion, Length of day
- **Precise Station Coordinates**
- Tropospheric delays...

GRAVITY : GRACE AND GRACE-FO

- Major Earthquakes
- Gravity field variation

Migrating pattern of deformation prior to the Tohoku-Oki earthquake revealed by GRACE data

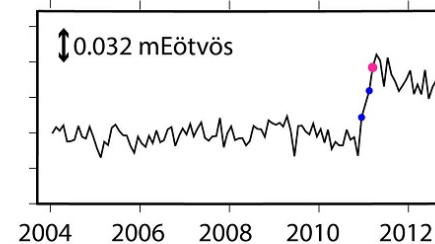
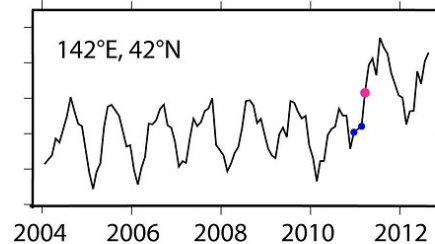
I. Panet et al. *Nature Geoscience* (2018)



Lecture des gradients de gravité :
 Un excès de masse défléchit le vecteur gravité \vec{g} , qui pointe vers la source. Ainsi, dans une coupe perpendiculaire à la source (direction x), la composante x du vecteur varie (g_x en courbe bleue). Son taux de variation est donné par le gradient de gravité g_{xx} (courbe verte), il atteint un extremum à l'aplomb de la source. Dans les cartes ci-dessus, le gradient est pris selon la direction e_2 , perpendiculaire à l'orientation de la subduction.

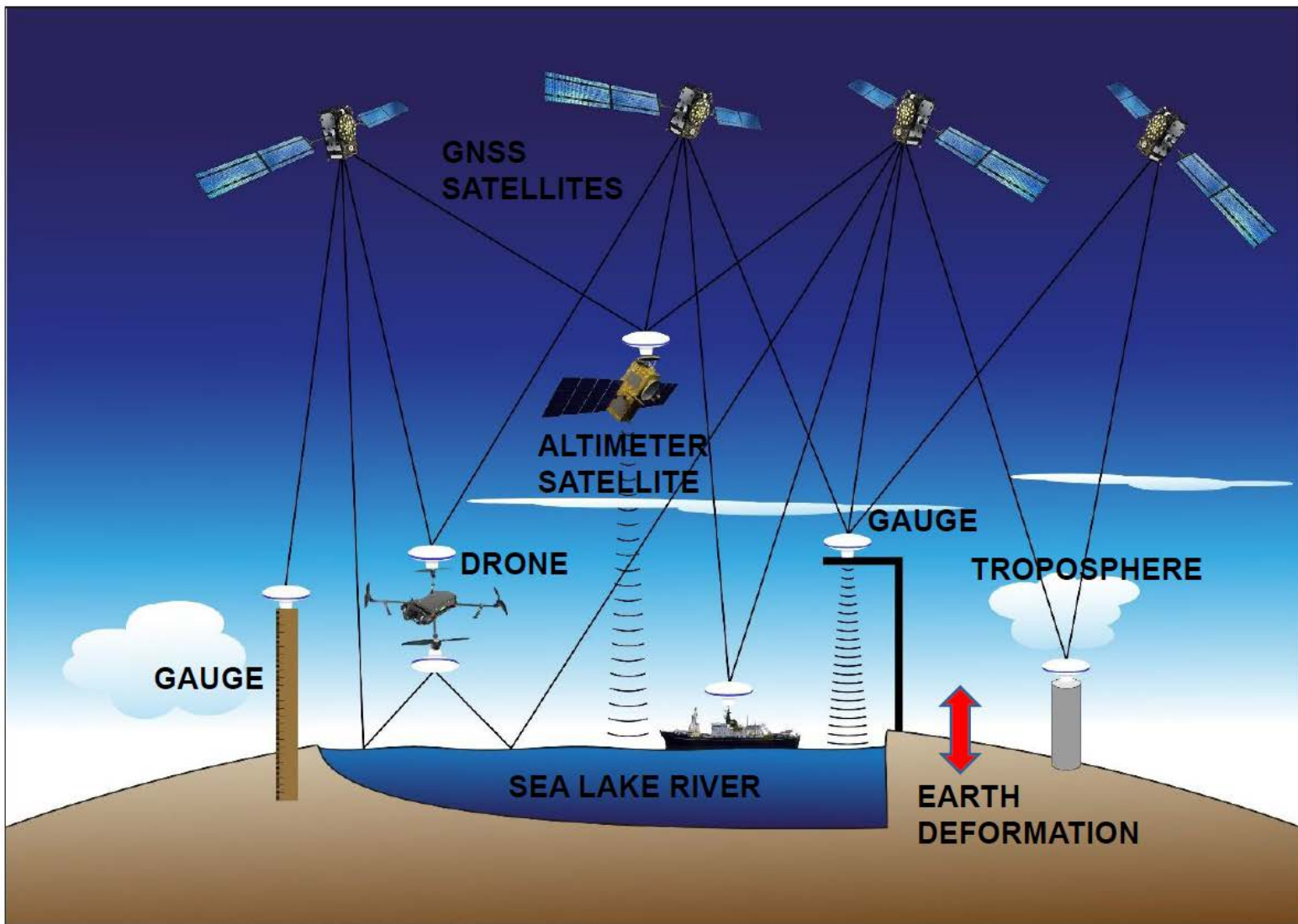
Original time series

Periodic components removed



• Dec. 2010, Fév. 2011 • Mars 2011

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



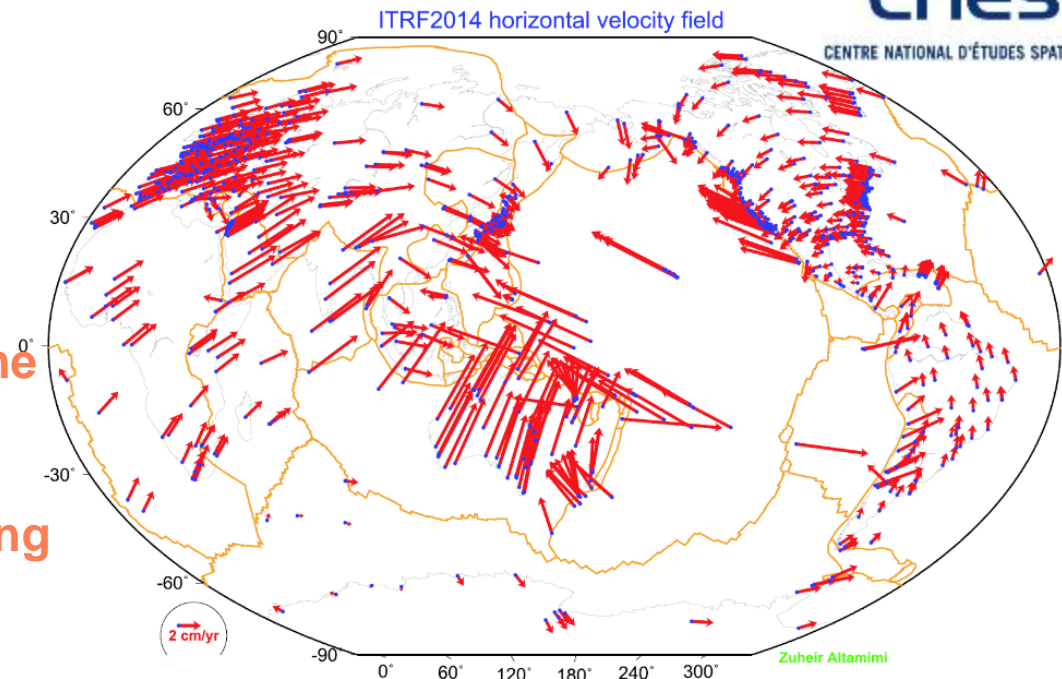
CNES computes the position of Glonass, GPS et GNSS satellites and delivers to the international community via IGS.

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

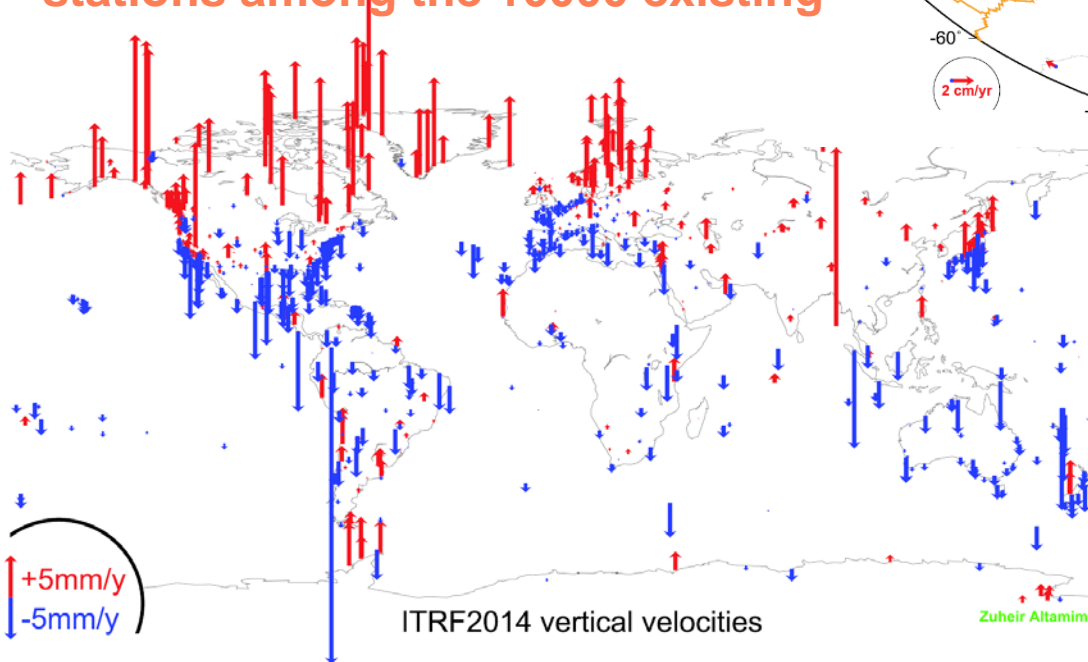
LINEAR DISPLACEMENT OF STATIONS MEASURING TECTONIC VELOCITIES

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

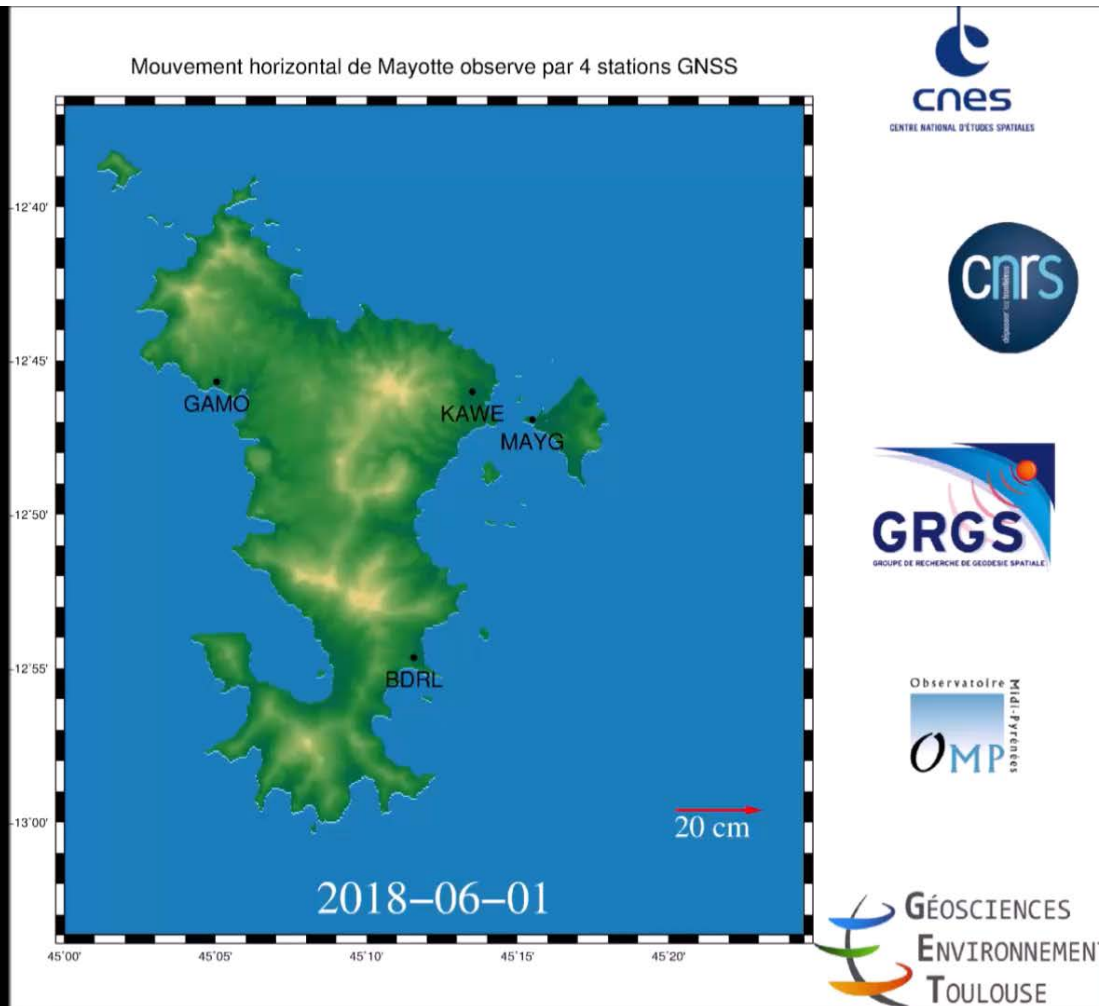
**Done everyday by CNES on some
of these stations.
Could be run on more targeted
stations among the 10000 existing**



Altamimi et al. 2016

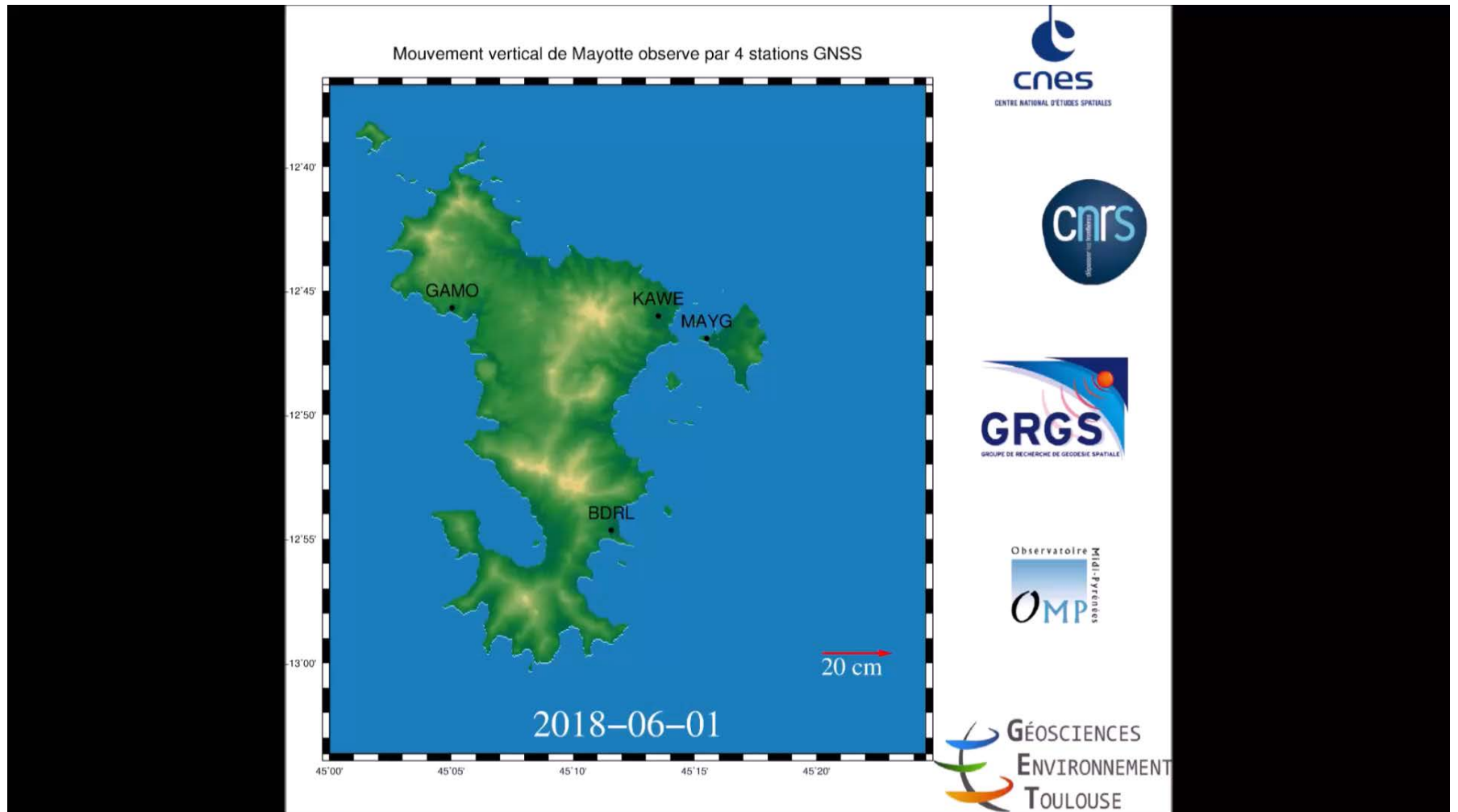


Computation of 1 daily position during 15 months – MAYG: GPS+Galileo - Mayotte island Horizontal Displacement Video



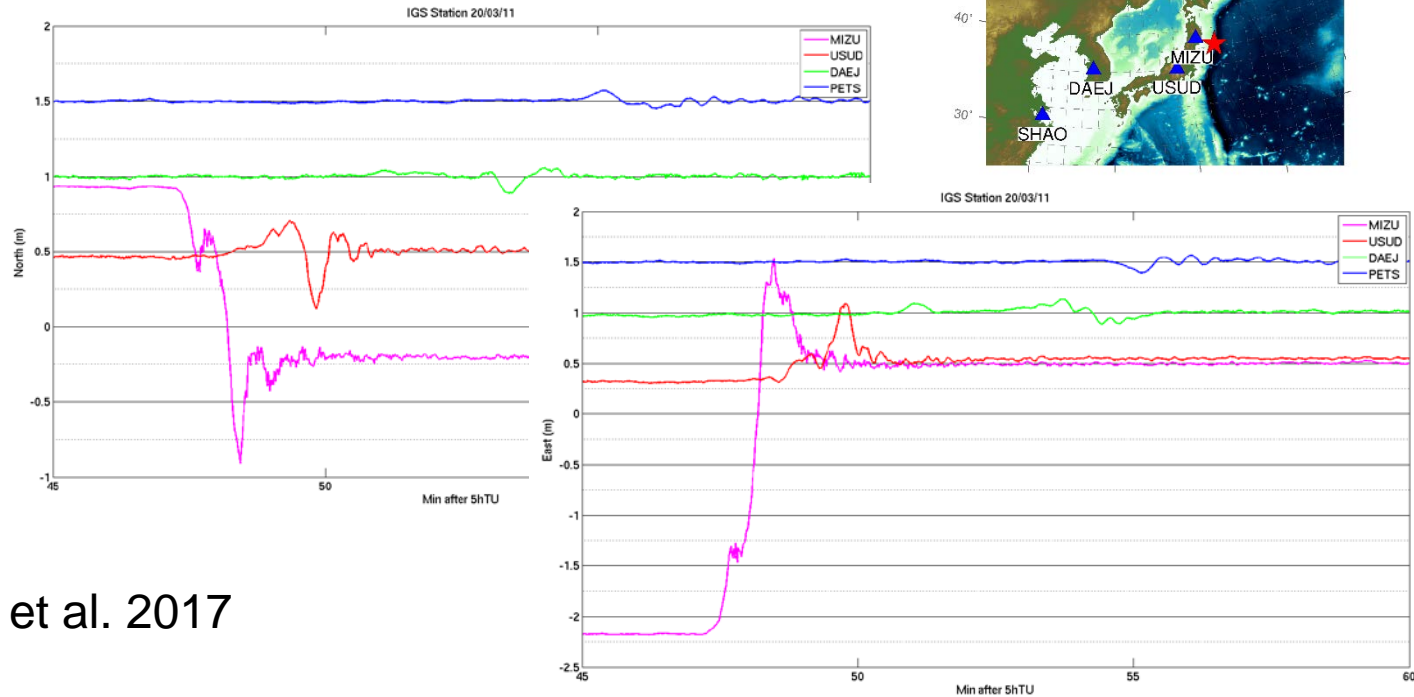
Mayotte island Vertical Displacement video

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



Barbu et al. 2017

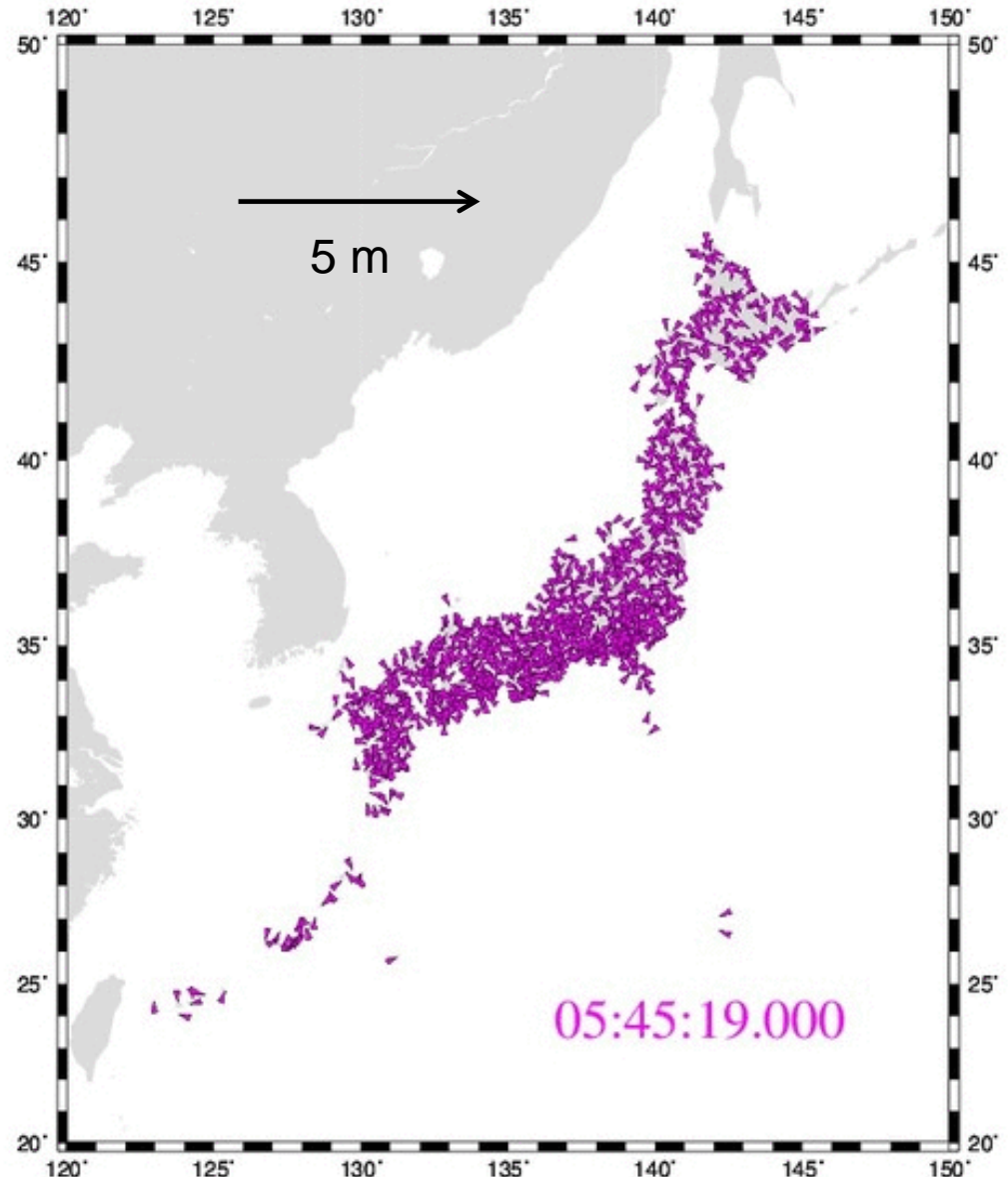
Real time displacement during seism enables to characterize its type

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



CENTRE NATIONAL D'ÉTUDES SPATIALES

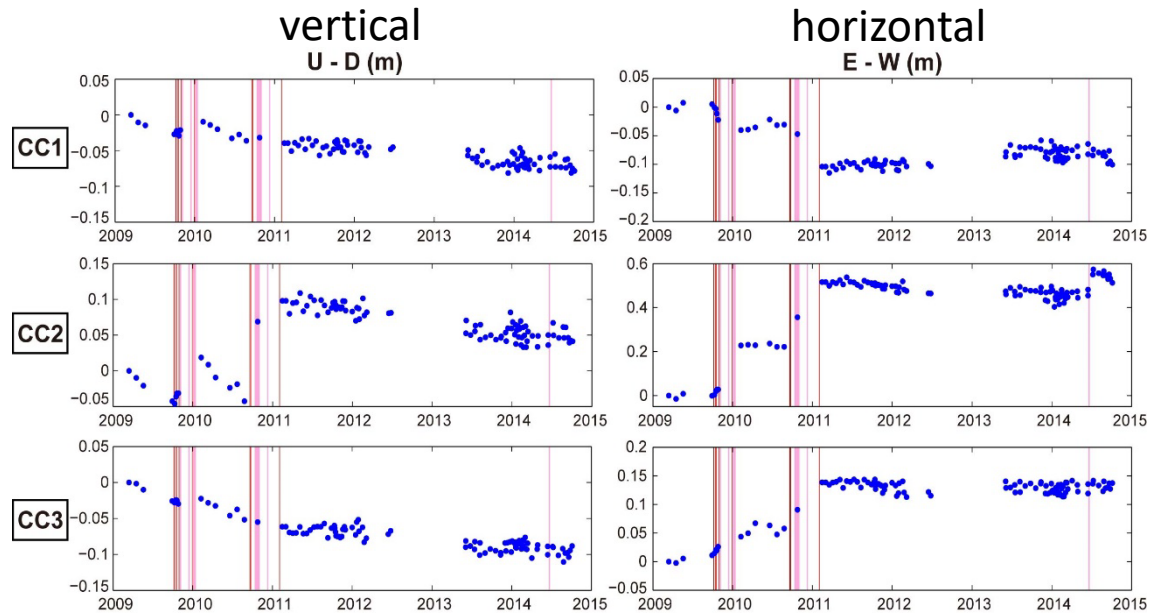


Piton de la Fournaise volcano ground displacement observations. 3 GPS stations for monitoring after 2007 eruption



GNSS observations are useful:

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

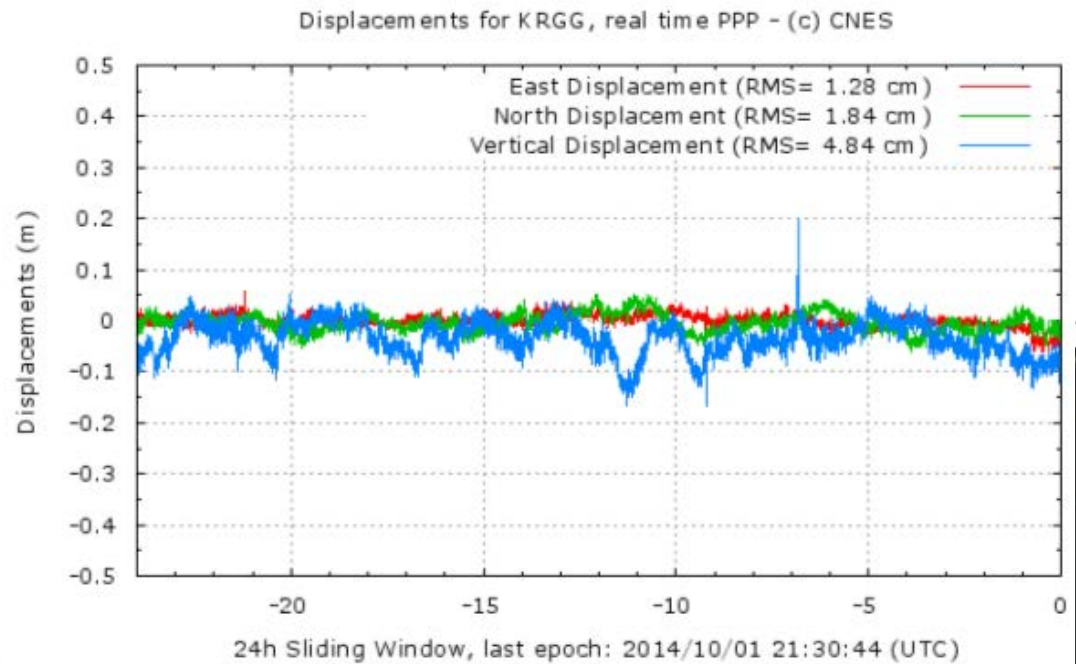


Y. Chen et al. (2017), Long term displacement triggered by the historical eruption in April 2007 at Piton de la Fournaise, La Reunion Island, *Remote Sensing Environment*, 194, 230-247.

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 developed in the orbit determination service at [CNES](http://www.cnes.fr).

One can find all the details on this method in the publications available in the [links](#) page.

- **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**