Processing a combined network of single- and dual-frequency GPS data with GAMIT/GLOBK at Soufrière Hills Volcano, Montserrat (West Indies)

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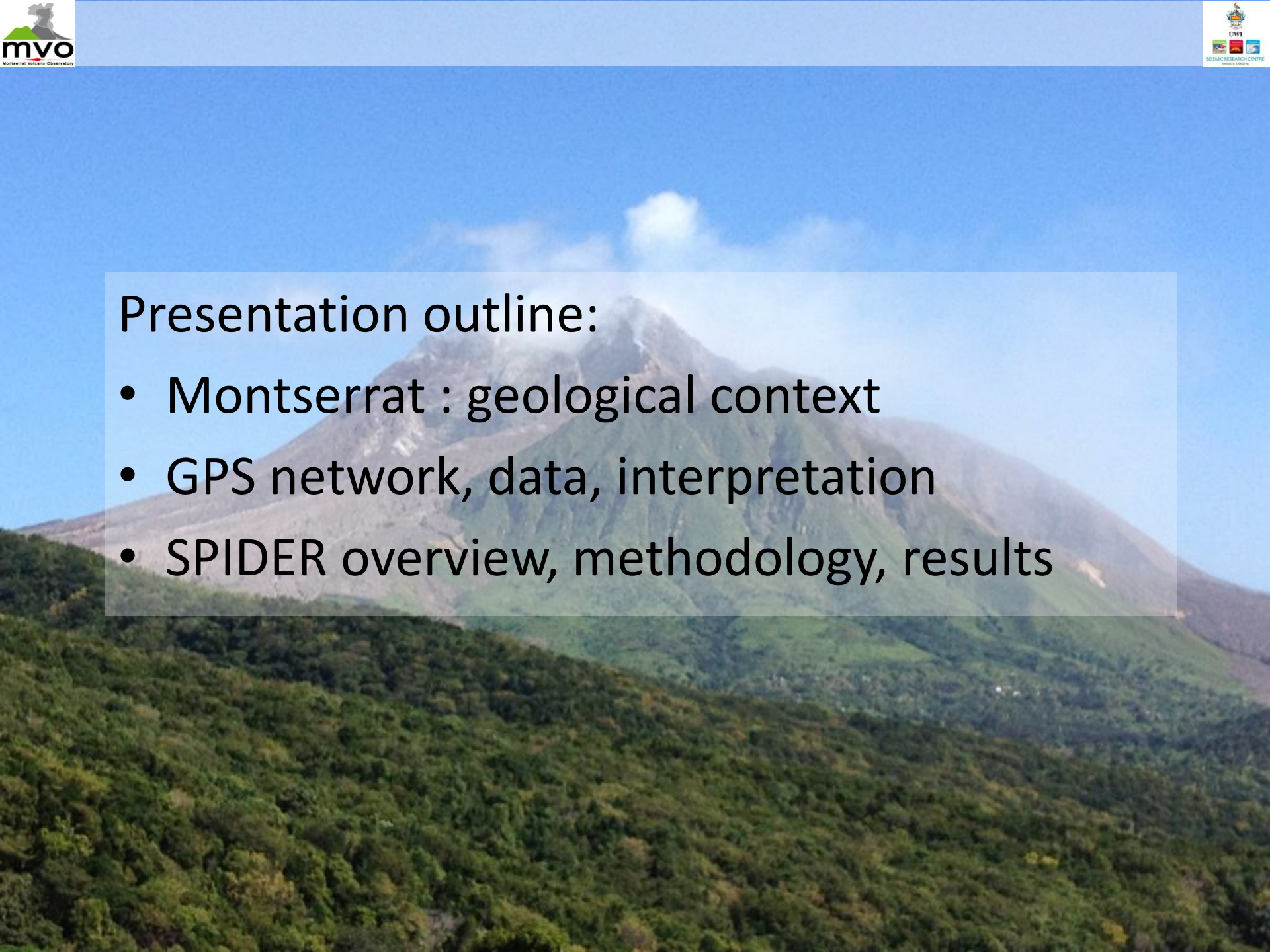
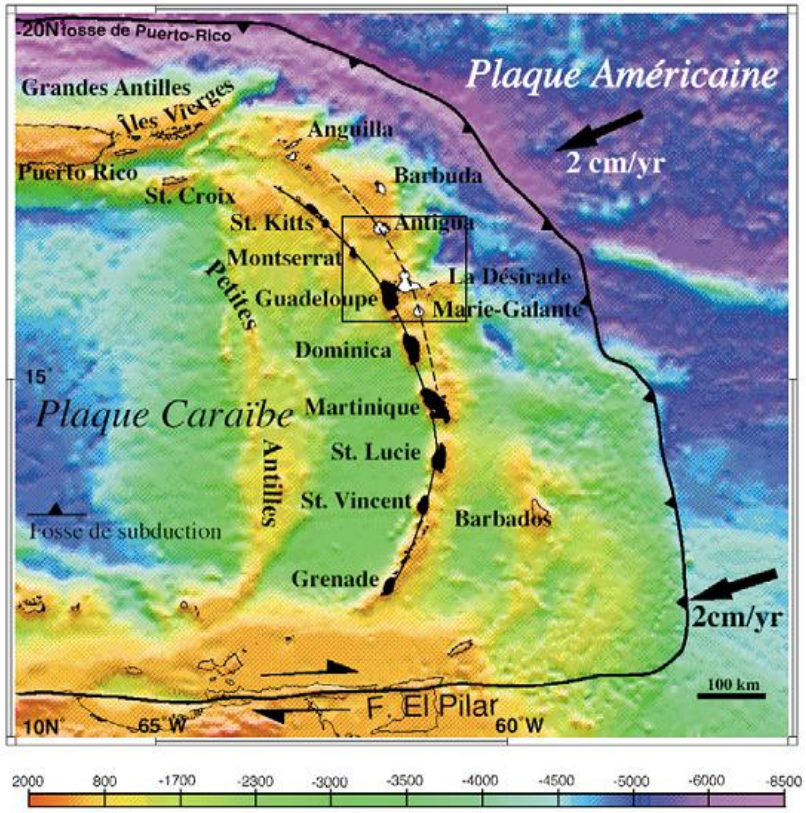


Presentation outline:

- Montserrat : geological context
- GPS network, data, interpretation
- SPIDER overview, methodology, results

Geological context



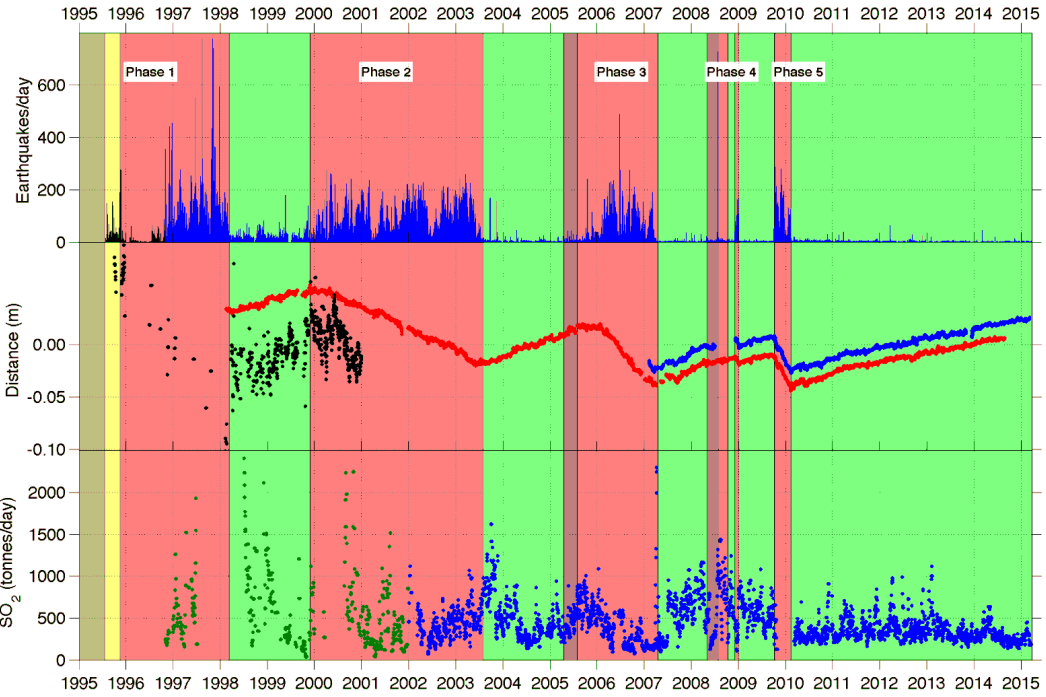
Feuillet et al., 2001

4 Volcanic centers :
-Silver Hills (2.6-1.2 Ma)
-Centre Hills (1- 0.5 Ma)
- Soufrière Hills volcano (170 ka –pres.)
- South Soufrière Hills volcano (~130 ka).

All are andesitic with the exception of South Soufrière Hills volcano (mafic).

Montserrat is part of a volcanic arc, ~150 km west of the subduction zone of the american plate beneath the caribbean plate

Geological context



- 1992-1995: precursory volcano-seismic activity

- 14th Nov 1995: First sight of dome growth.

-Since November 1995, 5 phases of dome growth separated by pauses in effusive activity (ie at the moment we are in « Pause 5 »)

- Phase 1 = Nov. 1995 -> Mar. 1998
- Phase 2= Nov. 1999 -> Jul. 2003
- Phase 3= Aug. 2005 -> Apr. 2007
- Phase 4= Jul. 2008 -> Jan. 2009
- Phase 5= Oct. 2009 -> Feb. 2010

The present eruption

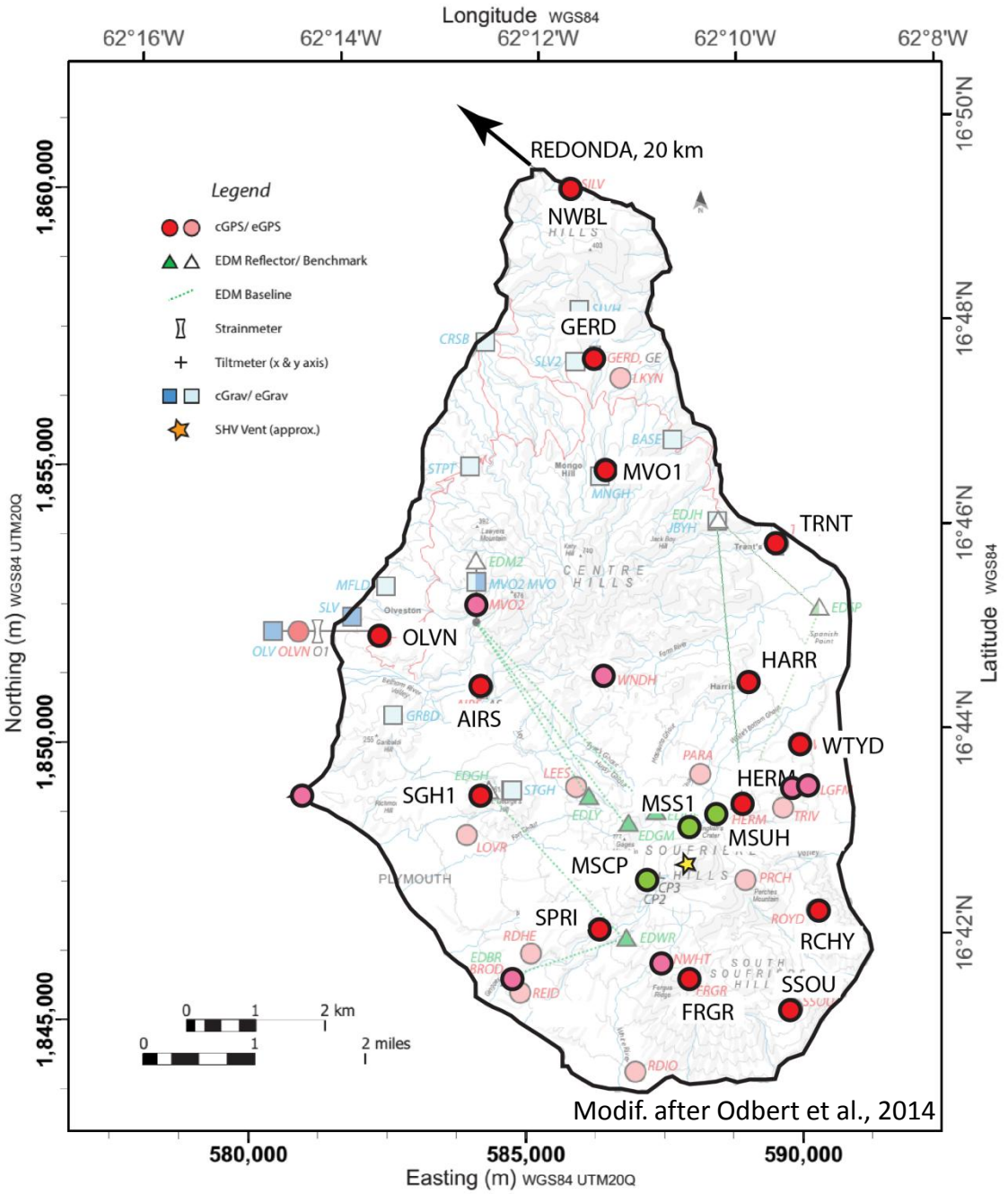
Geological context

11th Feb 2010: Last big event. Dome collapse towards the North (50 Mm3)

-> removal of 20% of lava dome
(1135m->1083m)

-> several Pyroclastic flows which destroyed some villages (pre-evacuation). The island gained ~600m on the sea

MVO deformation network



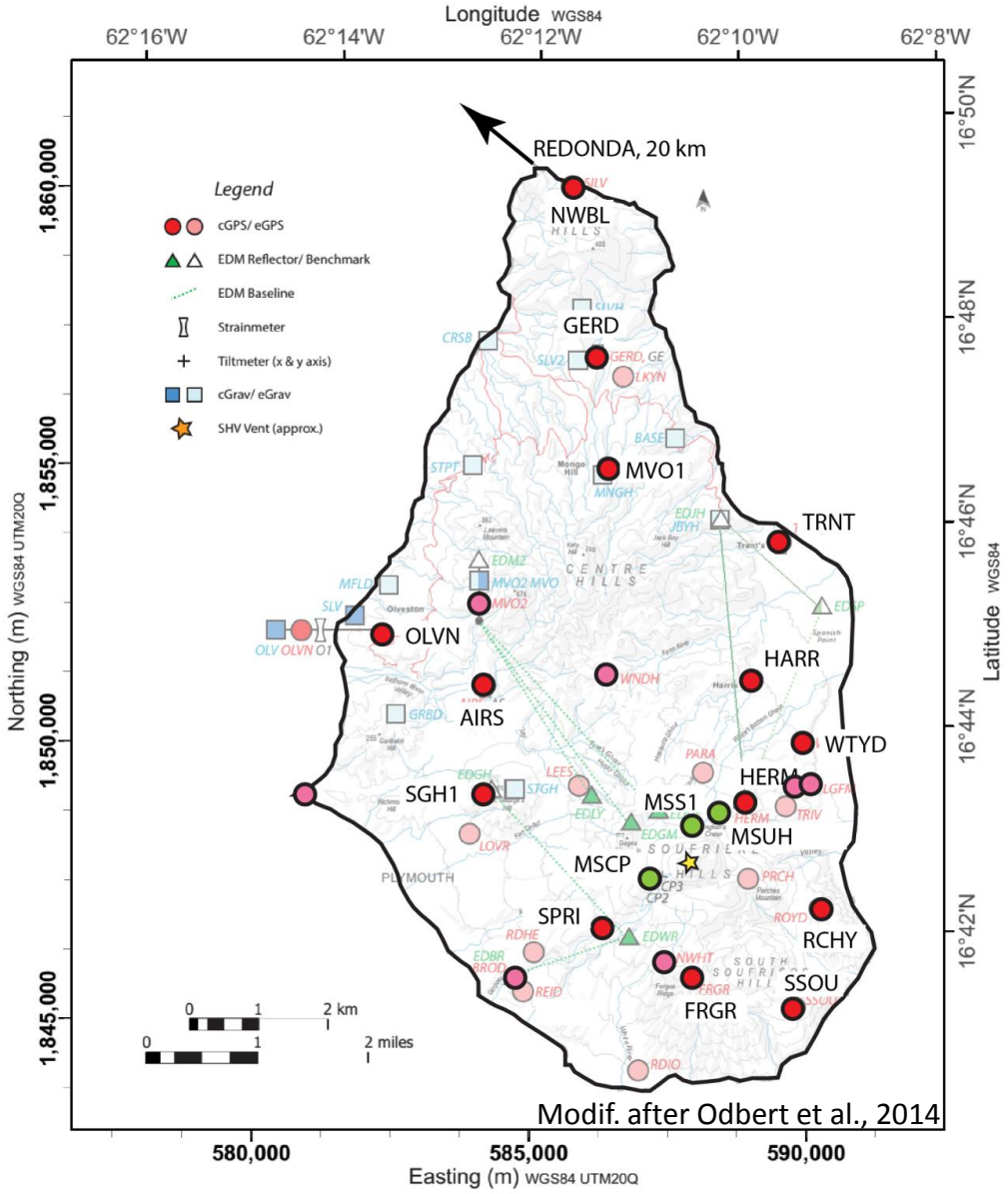
Modif. after Odbert et al., 2014

Campaign / Continuous GPS network

- 15 continuous GPS

+ 7 campaign sites complementing cGPS network, occupied for a week approximately every 2nd month

MVO deformation network



Modif. after Odbert et al., 2014

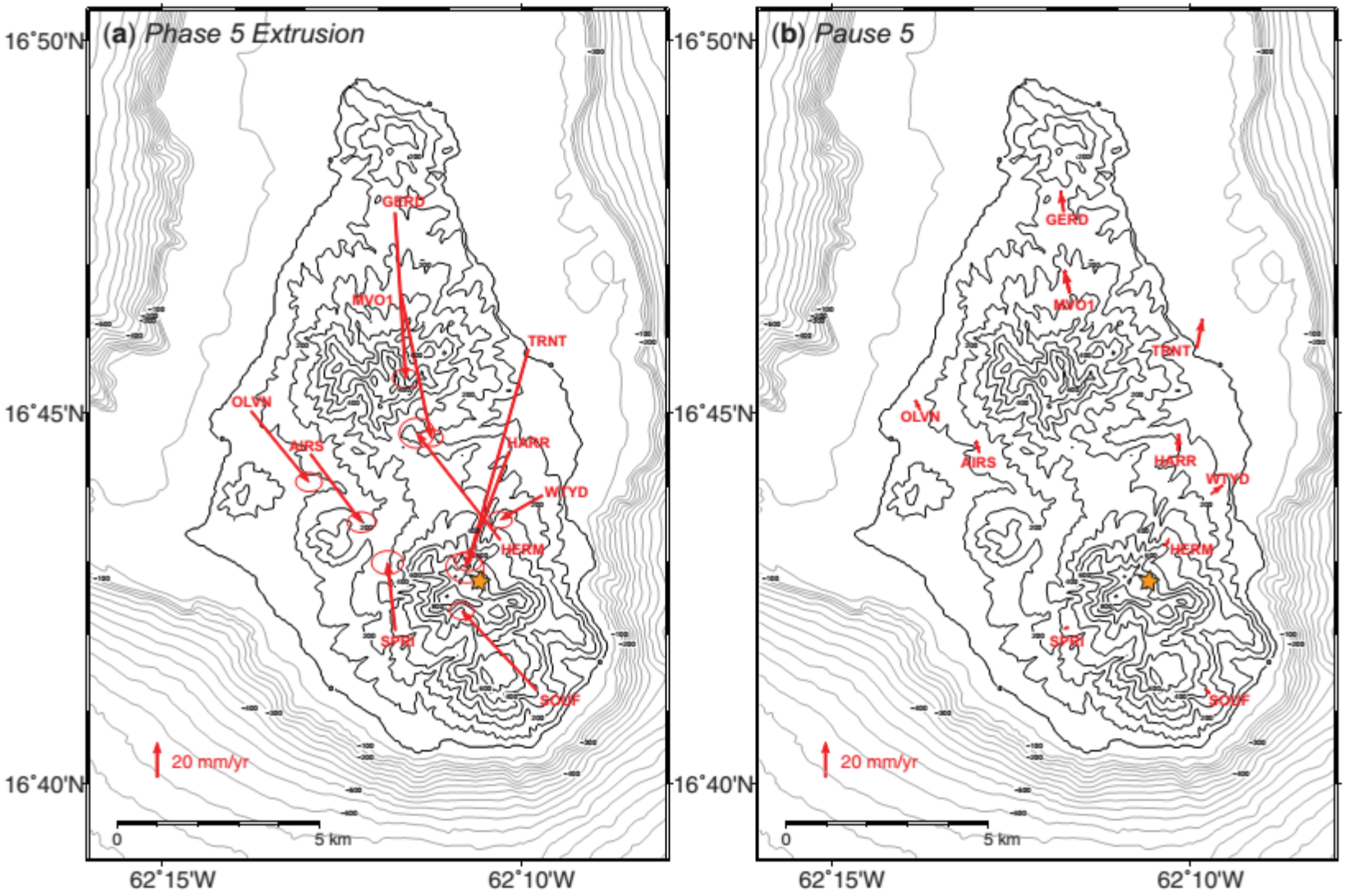
Daily GPS processing

A set of scripts insure that:

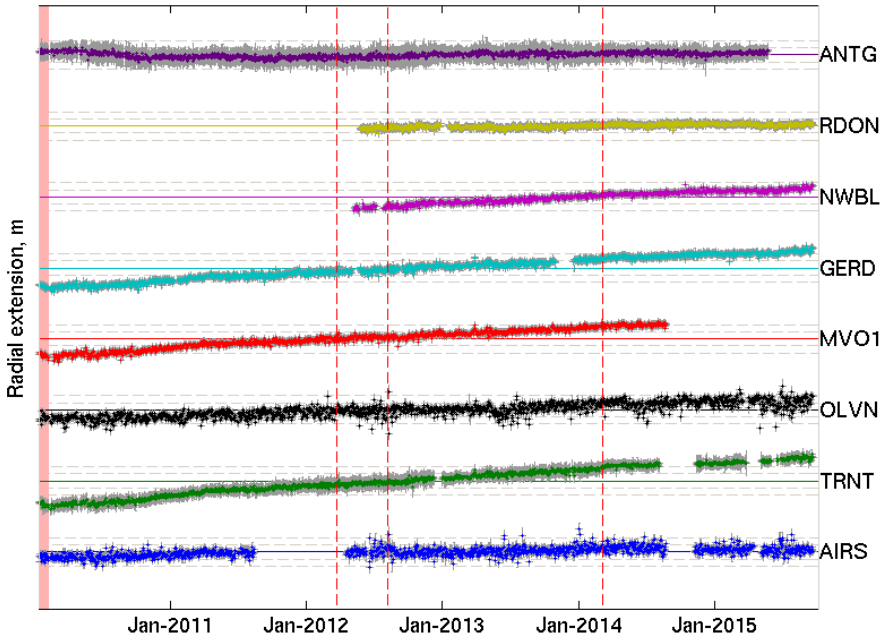
- data are downloaded, converted to RINEX format
- data are processed using GAMIT/GLOBK (Herring et al, 2010; MIT) Freeware, provide support, allow to calculate 3D location of station, no need for a reference station, allow automatization.
- Solution are converted into local coordinate system centered on the dome, to be able to visualize inflation/deflation of volcano

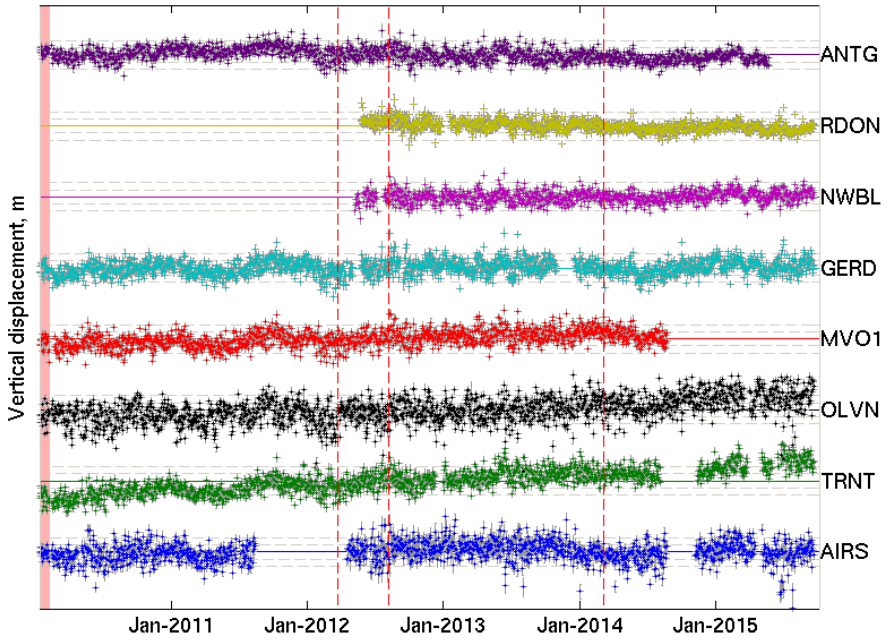
MVO deformation network : velocities

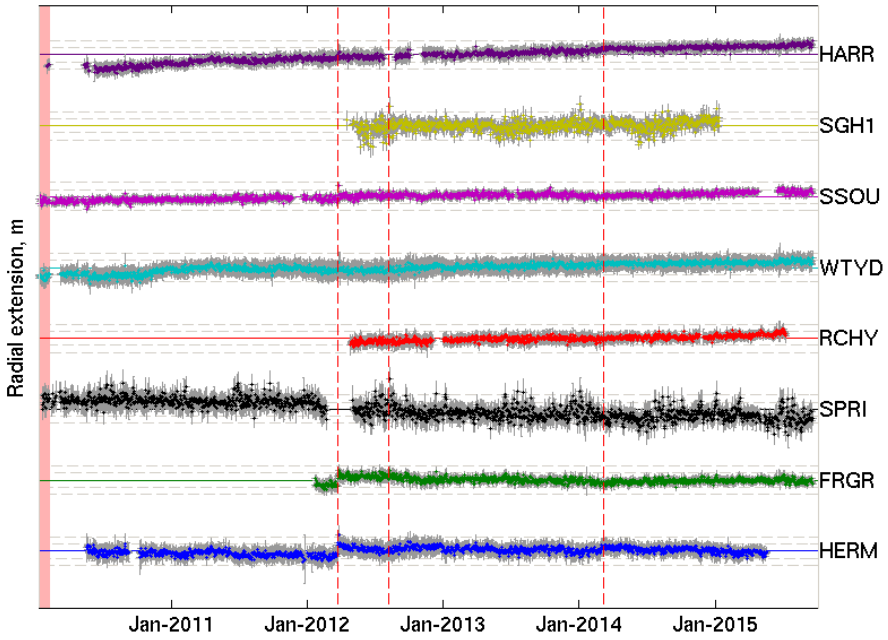
Velocity plots: inflation/deflation cycles
(Caribbean plate movement removed)

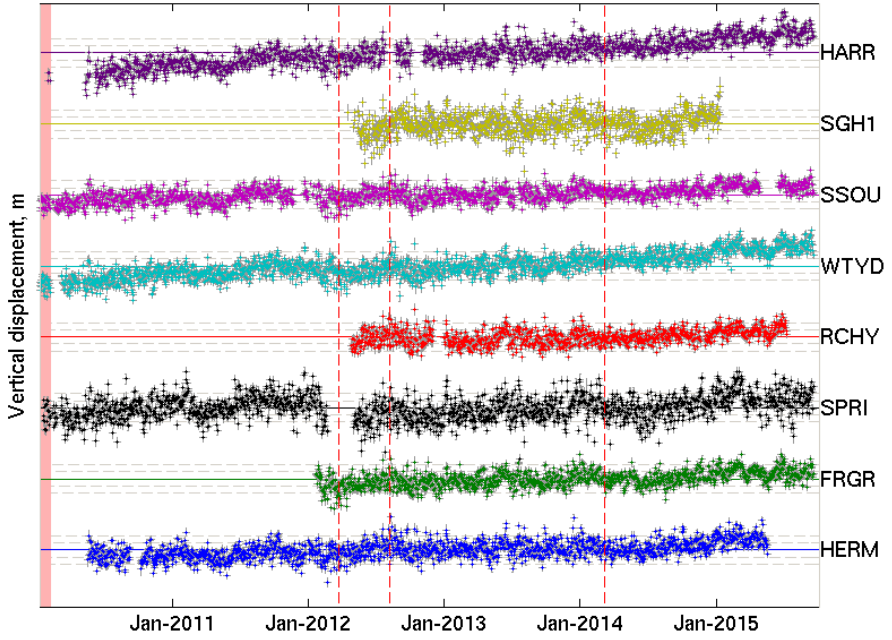


MVO deformation network : timeseries



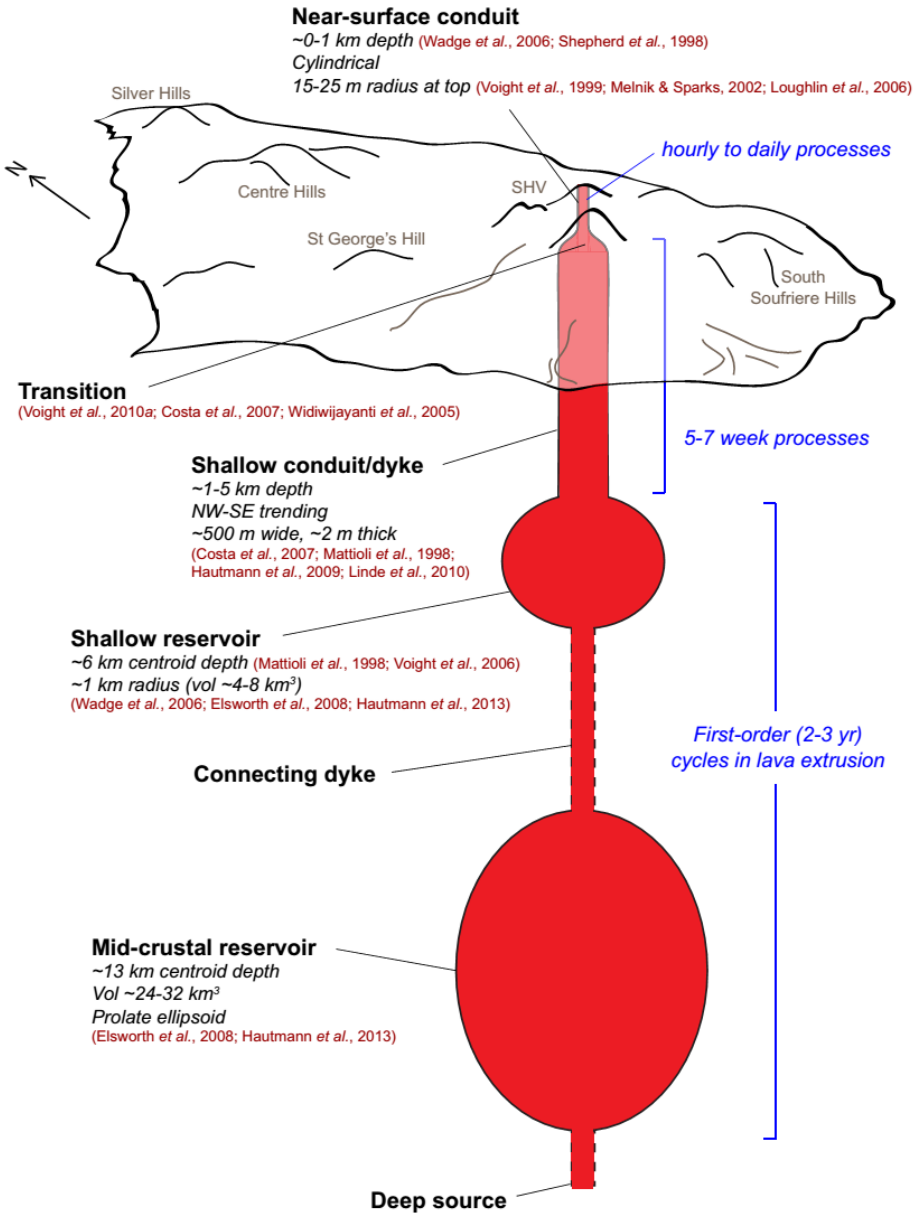






MVO deformation data: towards a model of SHV

Geometry of SHV magmatic system inferred from:



- Early EDM data (<1 km away from dome)
- Tilt data (1997)
- InSAR measurements
- Size of spines

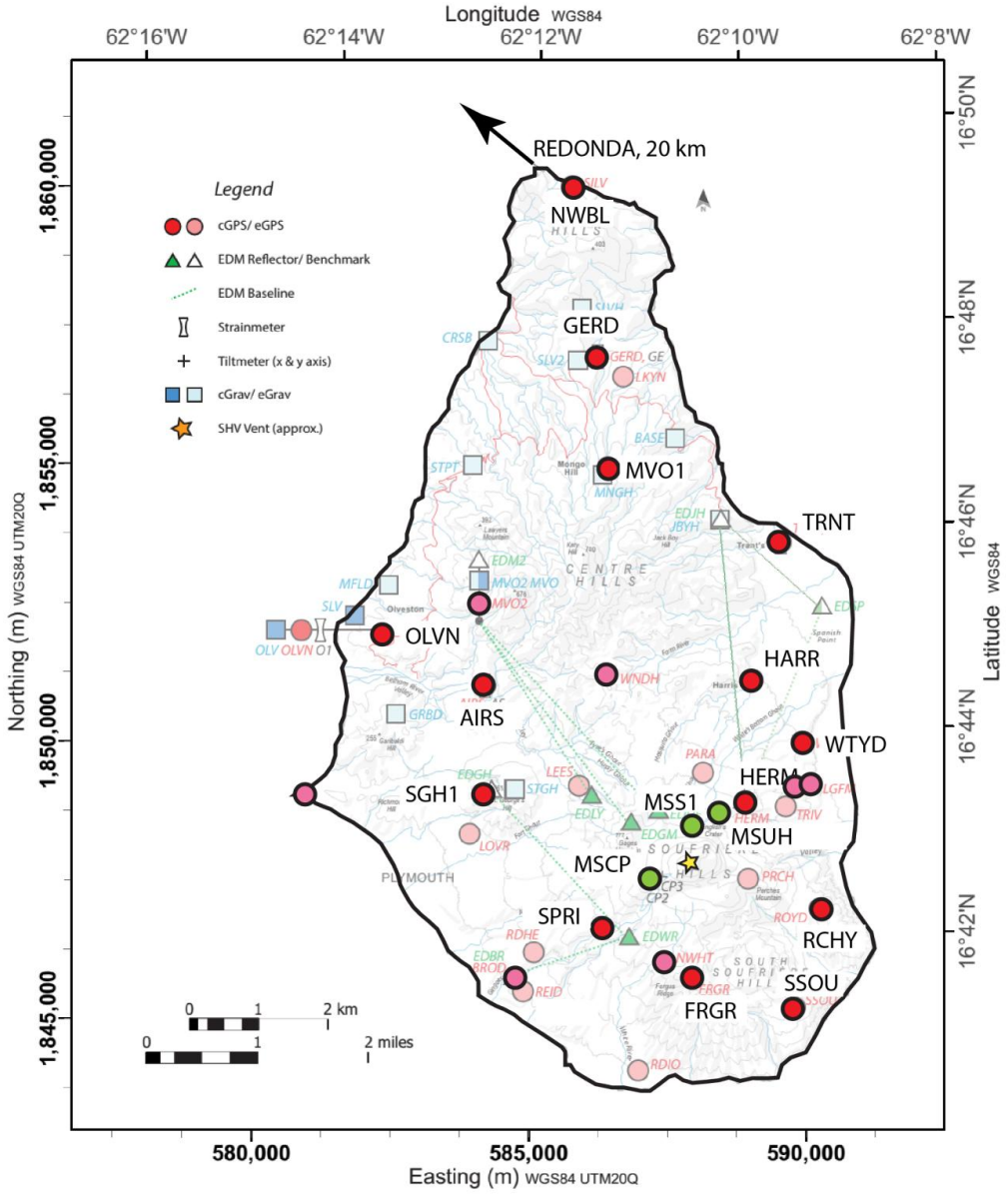
- conduit flow models

- cGPS (97)
- tilt (sub-daily cycles signals)
- strain data (during Vulcanian explosions of March 2004)

- petrological/seismic data
- conduit flow models
- GPS, strain, InSAR data

- cGPS
- strain

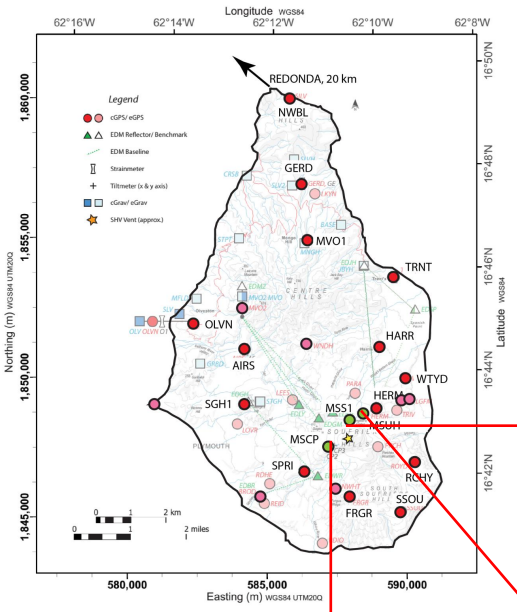
SPIDER stations : introduction



-Collaboration MVO - CALIPSO,NSF (Barry Voight, Penn State, USA)
- 'SPIDER' technology developed by R.Lahusen (Cascade Volcano Observatory)
- Characteristics:
  - low-cost
  - easily deployed / recovered
  - Combine GPS, geophone, tiltmeter, etc

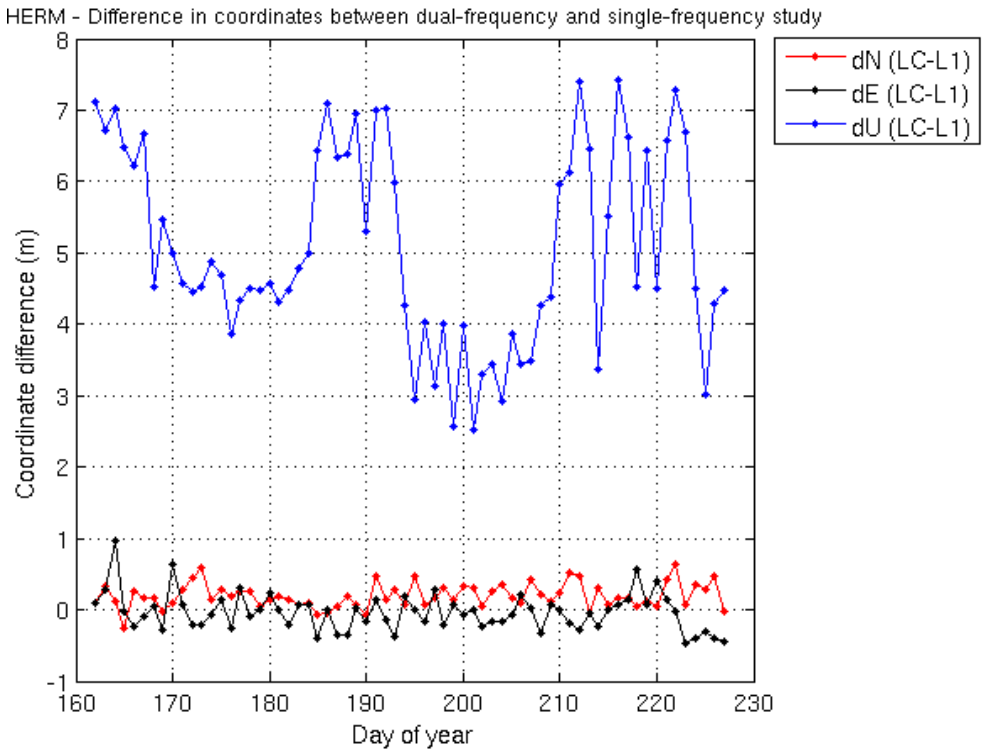
GPS Receiver: Ublox Lea-6T = **L1-only**
GPS Antenna: Trimble bullet

SPIDER stations : deployment (Jun. & Dec. 2014)



SPIDER stations : introduction

Limitation of L1-only data:
(ionospheric error not-removed)



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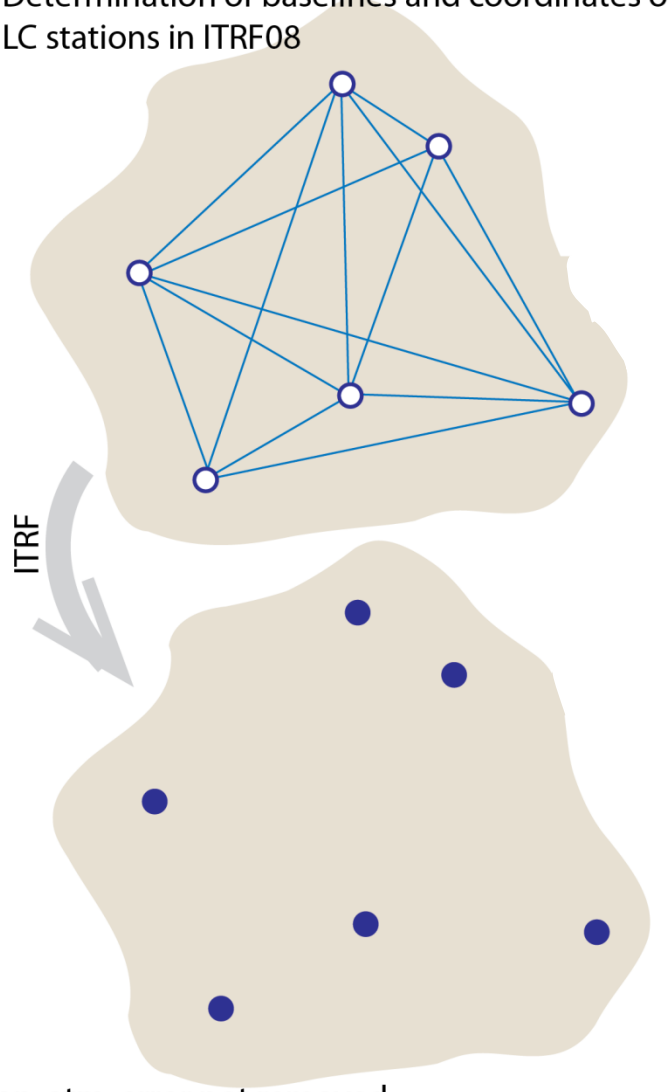
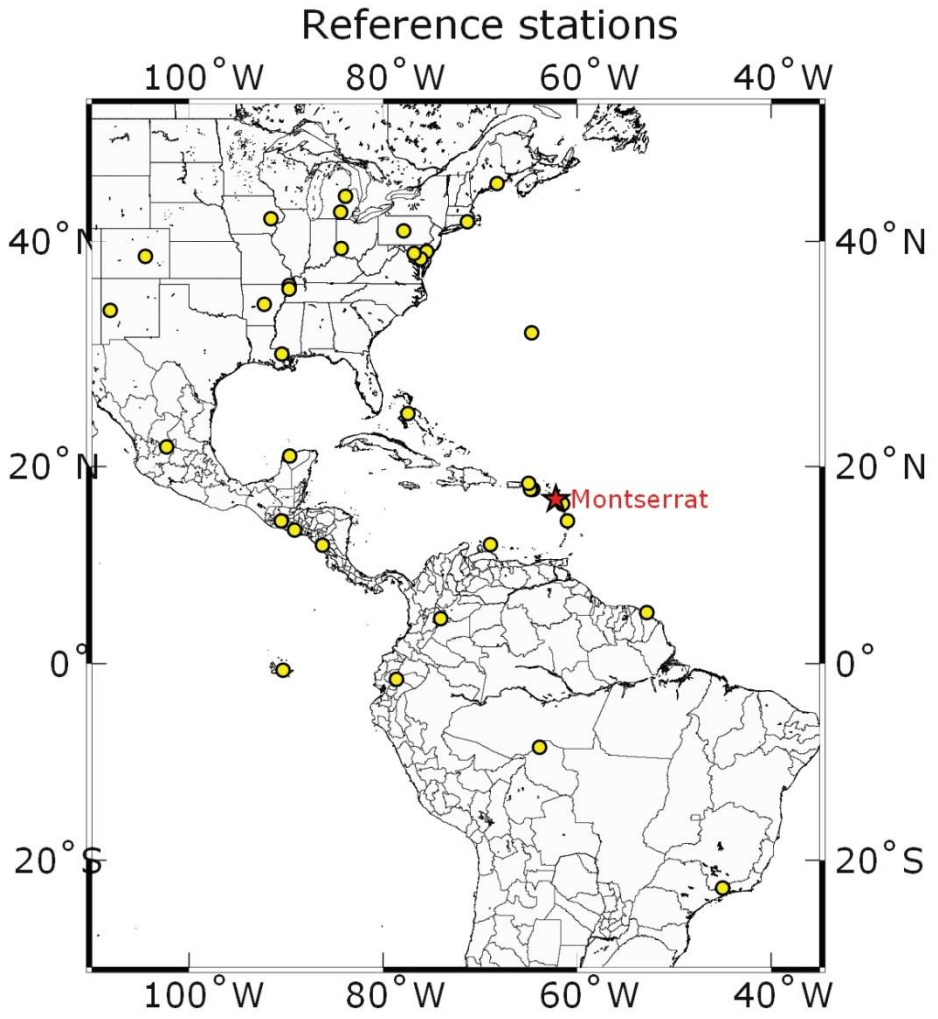
SPIDER stations : processing methodology

STEP 1:
Determination of baselines and coordinates of LC stations in ITRF08



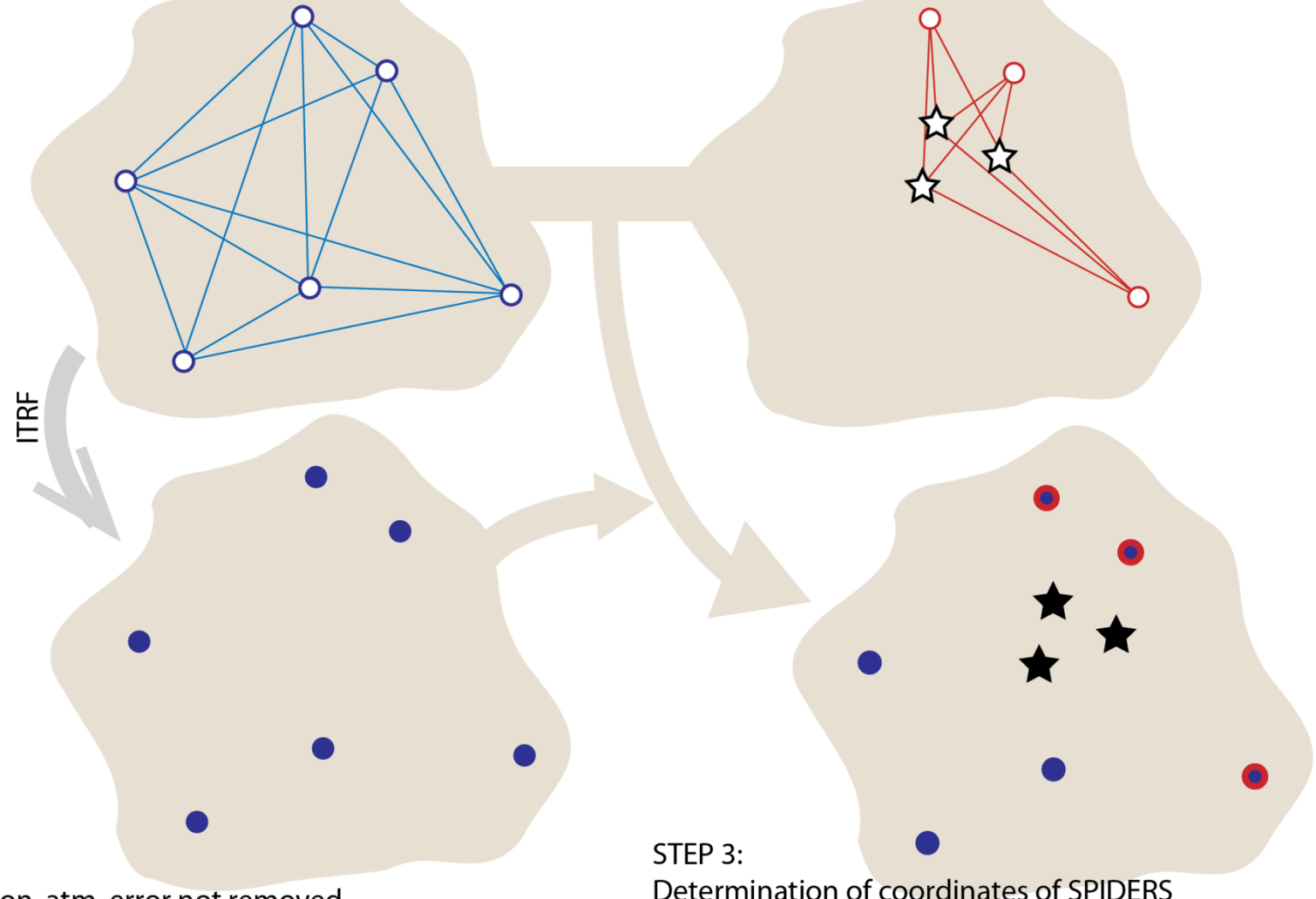


○ LC station, atm. error not removed
☆ SPIDER (L1), atm. error not removed
● LC station, atm. error removed
★ SPIDER (L1), atm. error removed

SPIDER stations : processing methodology

STEP 1:
Determination of baselines and coordinates of LC stations in ITRF08

STEP 2:
Determination of baselines between some LC stations and SPIDERS (L1) stations, using L1 only



STEP 3:
Determination of coordinates of SPIDERS combining baselines calculated in (1) & (2) and using LC stations as reference frame.

- ○ LC station, atm. error not removed
- ☆ SPIDER (L1), atm. error not removed
- ● LC station, atm. error removed
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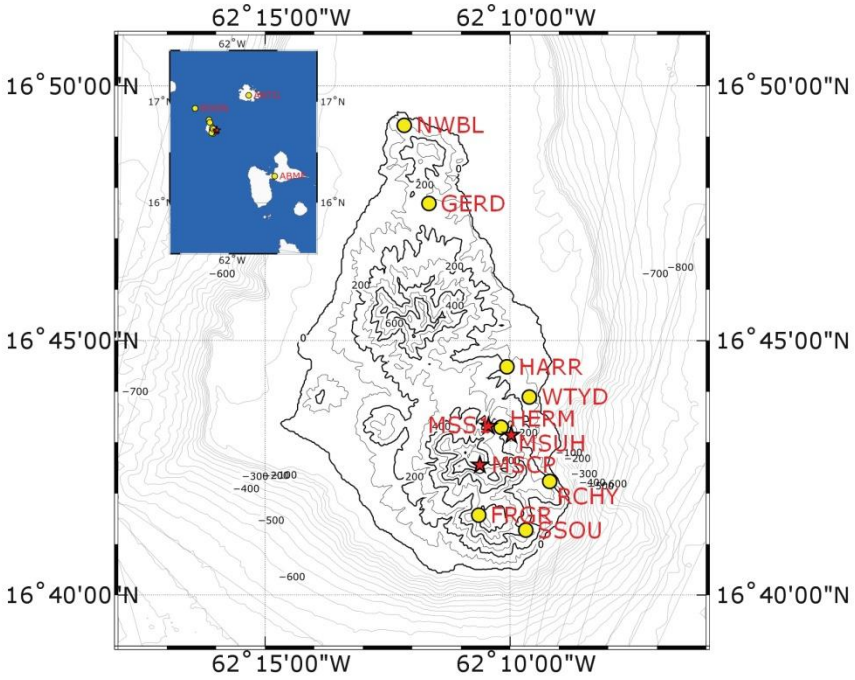
SPIDER stations : processing methodology



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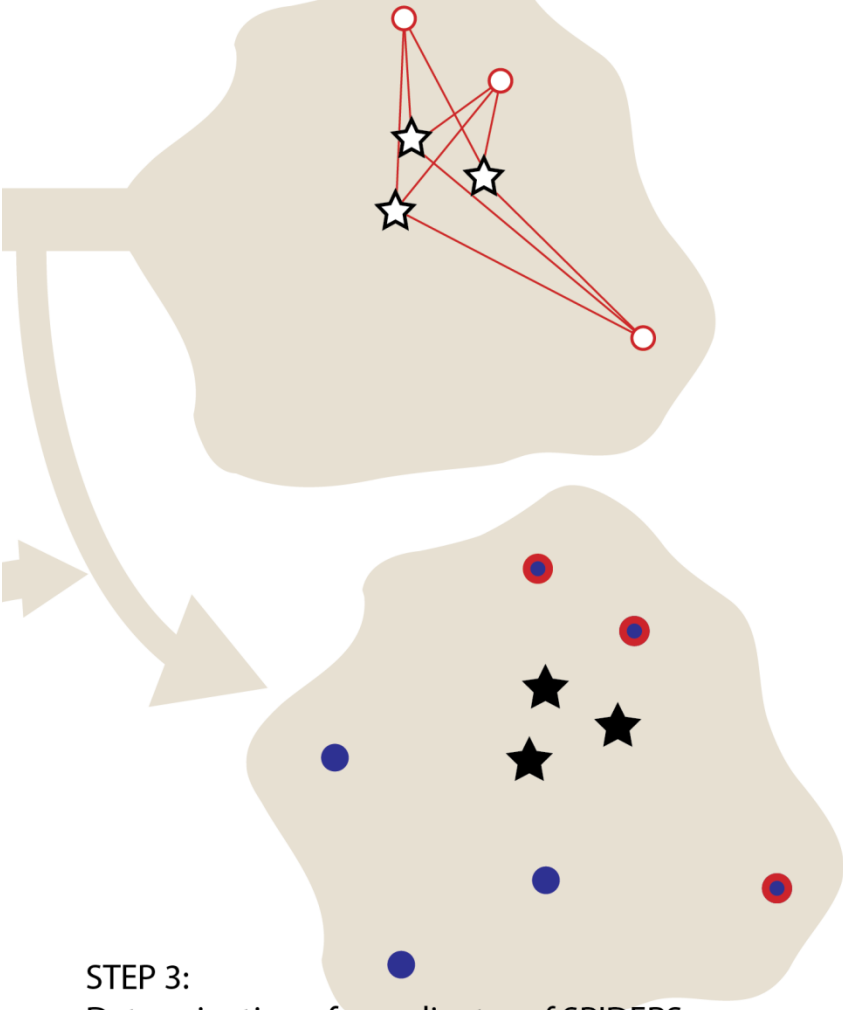

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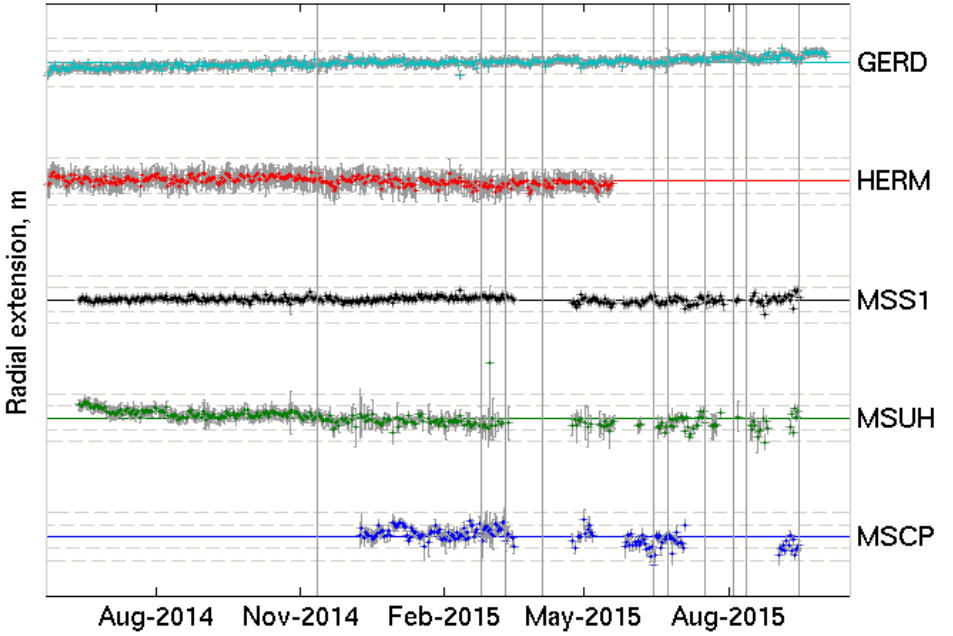
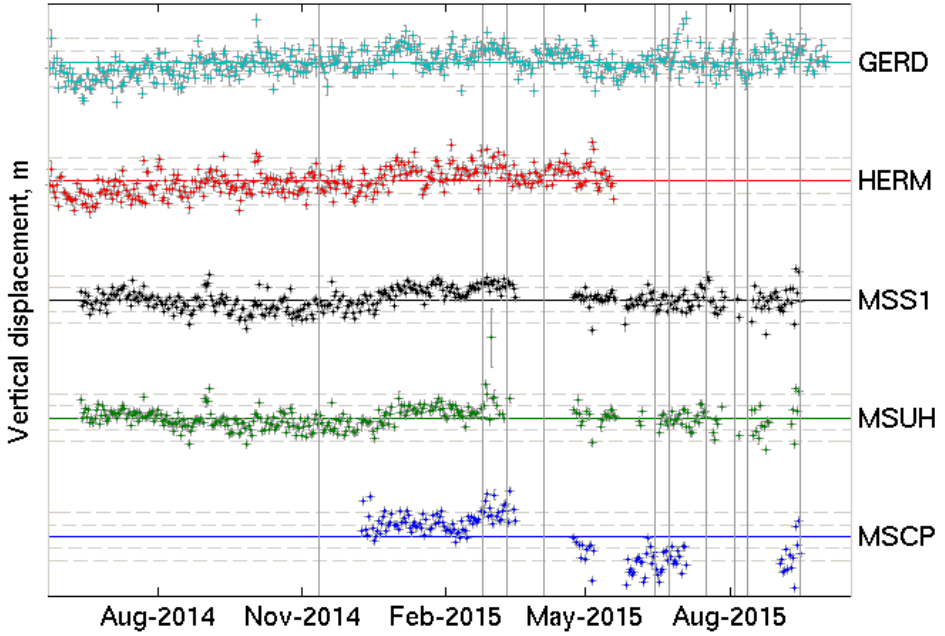
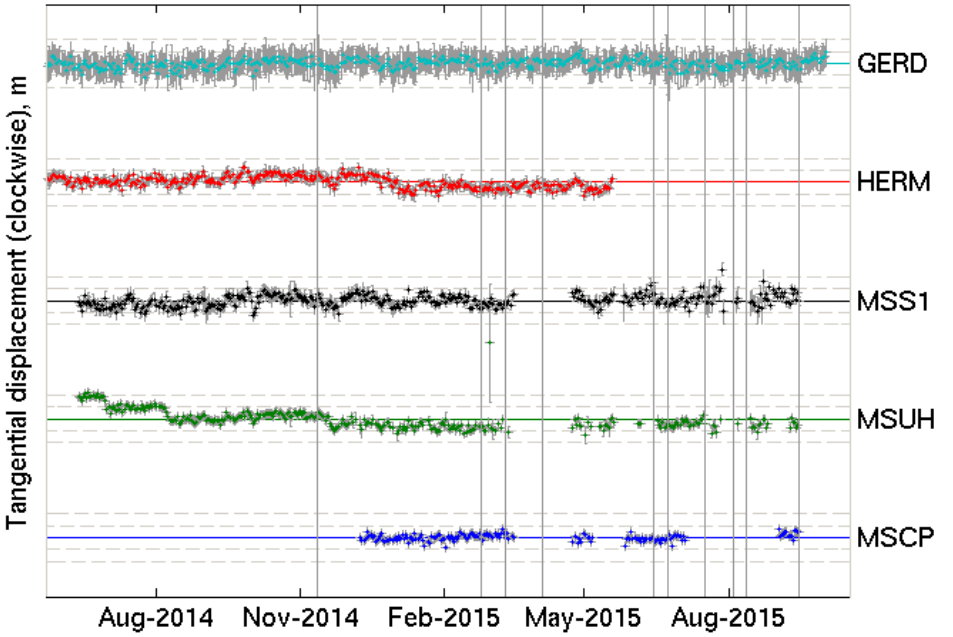
SPIDER stations: results







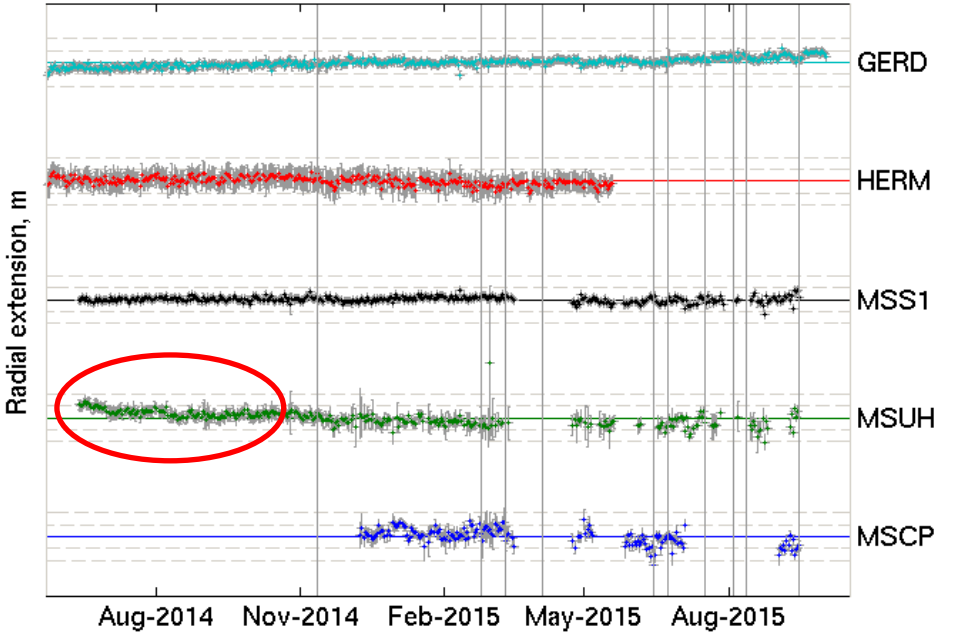
1. **Success !!** Ionospheric error is removed

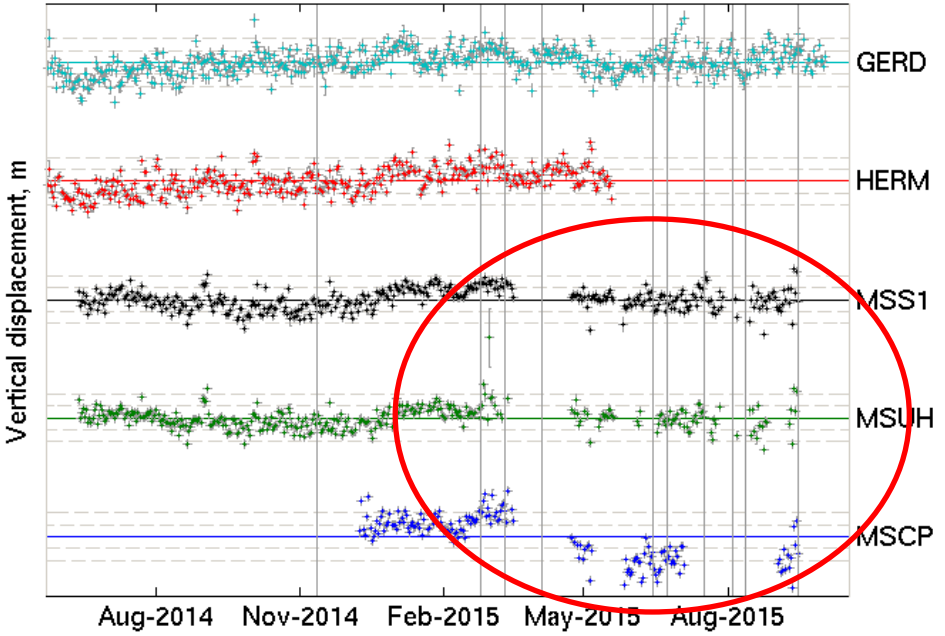
2. **BUT problem** with solutions from May 2015, possibly related to
   - a lot of gap in data themselves
   - HERM down

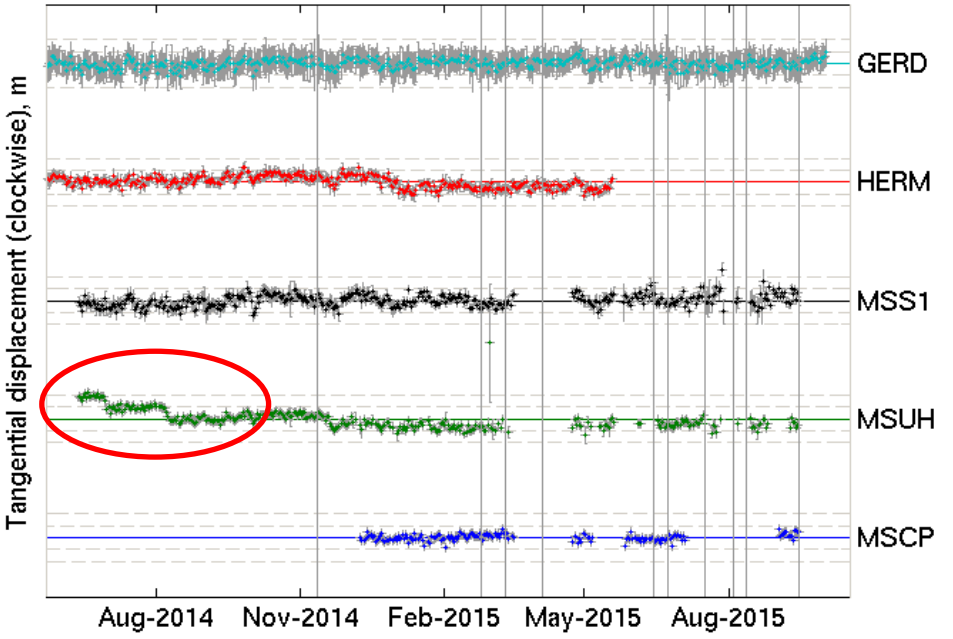
3. **No significant volcano-deformation**

4. **MSUH :** Station is shown settling

SPIDER stations: results







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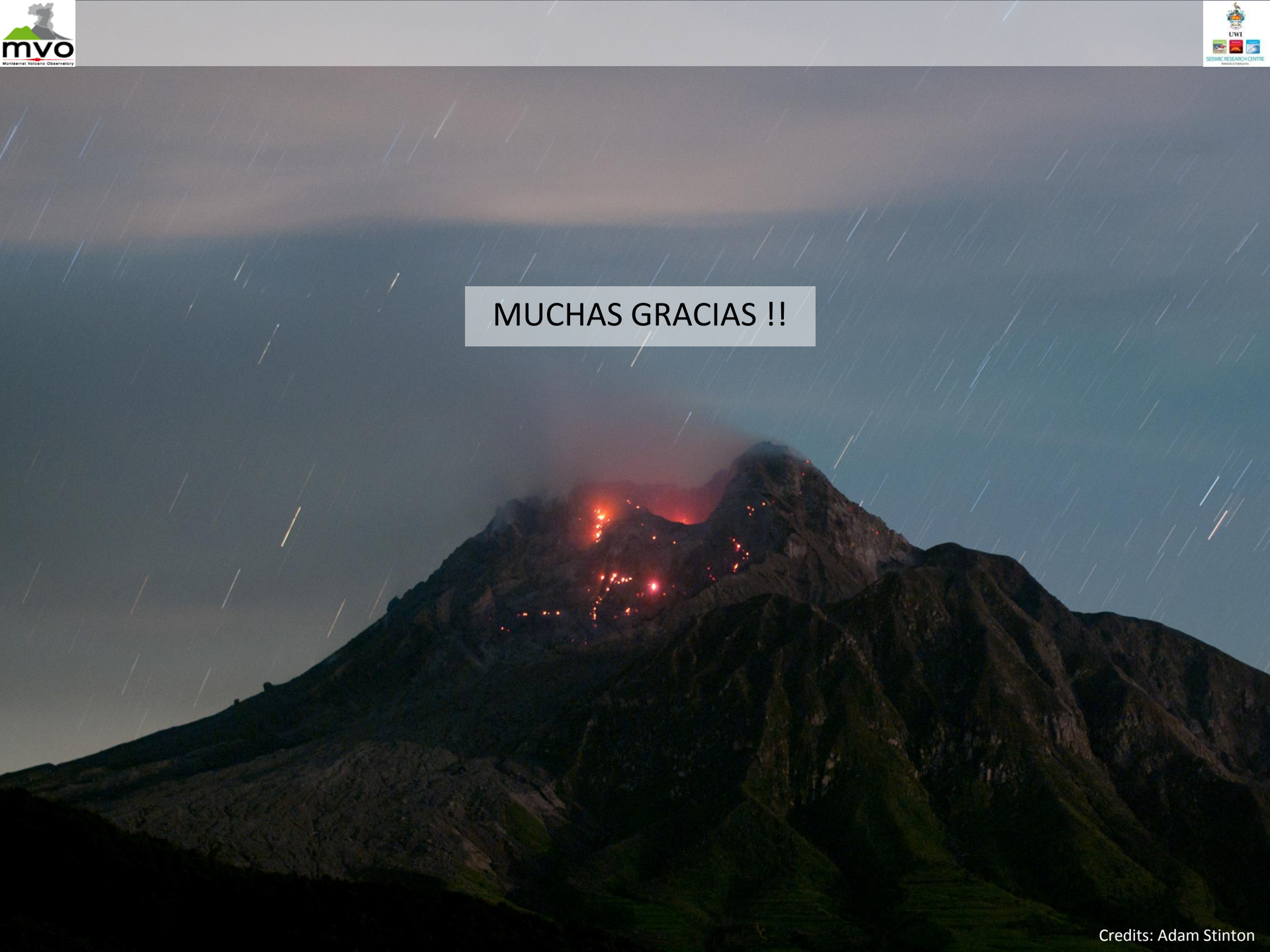
SUMMARY

- Various geophysical methods (eg: deformation, seismics, gas, gravimetry) gave valuable insights in the magmatic system geometry of Soufrière Hills Volcano

- Because they can be installed close to the dome, SPIDER stations could help with:
  - Understanding geometry of uppert part of magmatic system
  - Study of the hydrothermal system
  - Monitoring / eruption forecasting

- This work presents a method to integrate CHEAP (L1-only) receivers within a dual-frequency network, and gives encouraging results: the ionospheric error is removed

- However the processing still need to be refined, particularly improving the reference network, eg. to avoid relying heavily on one station.


MUCHAS GRACIAS !!
Credits: Adam Stinton