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

Montserrat is part of a volcanic arc, ~150 km west of the subduction zone of the American plate beneath the Caribbean plate.

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).
- **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 5= Oct. 2009 -> Feb. 2010
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

Campaign / Continuous GPS network

- 15 continuous GPS

+ 7 campaign sites complementing cGPS network, occupied for a week approximately every 2\textsuperscript{nd} month
Daily GPS processing

A set of scripts ensure 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

Radial extension, m

- ANTG
- RDON
- NWBL
- GERD
- MVO1
- OLVN
- TRNT
- AIRS

Vertical displacement, m

- HARR
- SGH1
- SSOU
- WTYD
- RCHY
- SPRI
- FRGR
- HERM

Jan-2011 Jan-2012 Jan-2013 Jan-2014 Jan-2015
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
- Collaboration MVO - CALIPSO, NSF (Barry Voight, Penn State, USA)
- ‘SPIDER’ technology developed by R.Lahuze (Cascade Volcano Observatory)
- Characteristics:
  - low-cost
  - easily deployed / recovered
  - Combine GPS, geophone, tiltmeter, etc

**GPS Receiver:** Ublox Lea-6T = \textit{L1-only}

**GPS Antenna:** Trimble bullet
SPIDER stations: deployment (Jun. & Dec. 2014)

Credits: Rod. Stewart

Credits: Adam Stinton
SPIDER stations: introduction

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

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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
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.

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SPIDER stations: processing methodology

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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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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 upper 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 !!