Analysis of unrest episodes in the last decade at Mauna Loa volcano through the use of multitemporal and multi-platform InSAR data

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Summary

1. Brief geodynamic notes on the Hawaii Island

2. Satellite data & processing

   ENVISAT and COSMO-SkyMed sensors

   Multi swath and multi orbit data set

3. Multi sensor inverse modelling of 2003-2014 Mauna Loa ground deformation
Youngest of the islands in the Hawaiian archipelago, the Island of Hawaii encompasses five major shield volcanoes. A sixth volcano, Māhukona, lies flooded offshore north of Kailua–Kona.

- **Hawaiian volcano stage** shield-forming stage
- **Most recent eruption** March 24-April 15, 1984
- **Number of historical eruptions** 33
- **Oldest dated rocks** between 100,000-200,000 years ago
- **Estimated age of subaerial eruptions** 400,000 years ago
Structures
GPS Measurements

http://supersites.earthobservations.org/
DATA archive

ENVISAT
183 img.

COSMO SkyMED
118 img.
Track 365_desc I2: mean deformation velocity countour map

LOS velocity [cm/yr]

LOS displacement [cm]

Time [years]

-15  -10  -5  0   5   10  15   20  25   30  35  40

2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Track 136_asc I3: mean deformation velocity contour map

G-POD automatic procedure
CSK_asc: mean deformation velocity countour map
CSK_desc: mean deformation velocity countour map

EAST [m]

LOS velocity [cm/yr]

Displacement [cm]

Time [years]
Nested Inverse Approach

Extensive search over simple source models and their combinations (Mogi, Fialko, Yang, Okada)

Non-linear optimization of source geometries (simplex Nelder-Mead)

Linear inversion of time varying source amplitudes (Truncated SVD)
Preliminary source model

Summit caldera

Rift zones

Subvertical dike
6 km long
Top at 1.5 km below surface

7.5 km b.s. deep
Sill-like shape
Radius ≈6 km
Fit with data

Example: ENVISAT track 200 ASCENDING orbit
Conclusions

The multi-sensor and multi-swath interferometry analysis revealed the presence of an LOS uplift which affected the flanks of Mauna Loa between 2003 and 2014.

The retrieved deformation time series emphasize the existence of two different velocity trends. The first one acts between the 2003 to the 2006 is characterized by high rate, while the second at low rate governed the deformation processes between the 2007 to 2014.

The geometry of the Mauna Loa ground deformation is similar to a butterfly shape and could reflect the presence of complex geodetic sources.

The Nested Inverse Approach on the Track 200_desc I2, Frame 365_desc I2 and COSMO-Sky Med images allowed us to discriminate the type, geometry and physical parameters of the geodetic sources. In particular, the combination of a deeper sill like shape and a superficial sub vertical dike is a preliminary best-fit solution to minimize the detected ground deformation.
Conclusions

Pressure variation in the deep sill-like reservoir

Volume variation in the rift dike system

ENVISAT

COSMO-SkyMED