Source models for the March 5-9, 2011 Kamoamoa fissure eruption, Kilauea Volcano, Hawaii, constrained by InSAR and in-situ observations

P. Lundgren1, M. Poland2, A. Miklius2, S.-H. Yun1, E. Fielding1, Z. Liu1, A. Tanaka3, and W. Szeliga1

1Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA
2Hawaiian Volcano Observatory, U.S. Geological Survey, Hawaiian Volcanoes Nat’l Park, HI, USA
3Geological Survey of Japan, AIST, Tsukuba, Ibaraki, Japan
Kilauea, Hawaii

Montgomery-Brown et al., JGR, 2008

Hawaii InSAR tracks and Kilauea/E Rift context
Kilauea InSAR time series

- Descending Envisat
- Ascending ALOS PALSAR
- TerraSAR-X
- COSMO-SkyMed
- Cdesc
- Casc

Graph showing time series data with labels for Envisat, ALOS, TSX, and CSK.
Future Activity (from Feb 2011 talk)

Late 2010-2011 Kilauea Caldera: accelerated uplift and increased seismicity suggest new eruption in near future

Continued TerraSAR-X and COSMO-SkyMed data should lead to unprecedented temporal resolution of future eruption
Near-real time COSMO-SkyMed data

1st interferogram on March 7, ~12 hrs after acquisition
2nd CSK interferogram (DESC) on March 10, w/ repeat ASC on 11th, all with rapid delivery from ASI (Luigi Dini) and eGEOS
Eruption started late afternoon March 5 (HST) with Pu`u `O`o tilt (deflation) starting 30 min prior to Kilauea tilt (deflation)
ALOS Interferogram ending March 6

ALOS t598 2011/01/19-2011/03/06

12 cm/cycle ALOS
ALOS Interferogram ending March 6

ALOS I598 2011/01/19-2011/03/06

12 cm/cycle ALOS
Comparison X- vs L-band

1.5 cm/cycle TSX

12 cm/cycle ALOS
Interferograms ending March 6-11

Unwrapped interferograms displayed at their natural wrap rates:
12 cm/cycle ALOS
1.5 cm/cycle TSX and CSK
UAVSAR interferograms, 1.4 years spanning the March 5-9, 2011 Kamoamoa eruption
MCMC solution for dike dip angle (74° to SE)
Distributed slip dike modeling after MCMC

Laplacian smoothing vs wrms and roughness

Dike plane geometry from MCMC solution

Dike tensile opening for ALOS t297 March 9 data
Dike is not enough when fitting GPS

ALOS descending track data show a splay fault that increases in displacement

March 6 ALOS t598

March 11 ALOS 601
InSAR sensitivity: dike only

Poor fit to both InSAR and GPS

ALOS t287 asc.

Poor fit to shape

GPS weighting: 1

Data

Synthetic
dike + splay fault

Improved fit to both InSAR and some GPS

data

synthetic

GPS weighting: 1
Dike model: March 6

ALOS LOS + azimuth offsets
GPS 3 components

model shifted 1 km to ~surface in plot

Dike volume = 9.5 x 10^6 m³
Dike model: March 7

CSK ASC ascending

Differences in asc. vs desc. InSAR models
Dike model: March 11

Dike volume = $11 \times 10^6$ m$^3$

Dike shows ~ 1 m additional opening + lesser splay increase
Dike model: March 9-11 all InSAR + GPS

Five InSAR LOS data (TSX, CSK, ALOS) + GPS
Dike model: March 9-11 all InSAR LOS+GPS

Dike model reflects a compromise between ASC and DESC models; Model shifted up by 1 km in plot (seismicity not shifted!)
Dike model: March 6 vs March 11

Most seismicity in 1st day

ALOS +GPS models

Seismicity March 7-11
InSAR time series for one year (late July 2010 – August 2011) of COSMO-SkyMed data. (A) Ascending track mean velocity (5 cm/yr color cycle). Arrows indicate approximate locations of time series shown in (C) and (D). (B) Descending track mean velocity. (C) Point time series for Kilauea caldera and (D) for points near the Kamoamoa dike eruption. The March 2011 fissure eruption shows sharp deflation at Kilauea until mid-2011, whereas (D) shows post-dike transient. Plus (+) signs are unsmoothed time series, circles are time series with a temporal triangular filter width of 3 weeks. Ascending data time series are shifted relative to the descending data. A and B in (C) and (D) refer to series from (A) and (B).

Future work will model Kilauea sources and move toward kinematic models.
Summary

- CSK data provided low-latency (<12 hrs) InSAR of the Kamoamoa eruption
- L-band data identified splay fault which helps explain some GPS data
- Dike models suggest feeding from both Pu`u O`o and Kilauea in accordance with tilt time series
- Opening increased in accordance with field observations
- Future work to use CSK time series and UAVSAR data to constrain post-diking processes
Thank You

SAR data courtesy:

COSMO-SkyMed – ASI
TerraSAR-X – DLR, Hawaii Supersite
ALOS – JAXA, through PIXEL