InSAR Applications

Introduction

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InSAR Short Course
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many slides borrowed from
Matt Pritchard
Cornell University
Magma chamber inflation discovered in Cascades

South Sister, Oregon

InSAR inflation started in 2001

From: Wicks et al., 2001

Confirmed by subsequent GPS ground observations

From: Dzurisin et al., 2006

Major Volcanoes of the Cascade Range

- Mount Baker
- Glacier Peak
- Mount Rainier
- Mount St. Helens
- Mount Adams
- Mount Hood
- Mount Jefferson
- Three Sisters
- Newberry Caldera
- Crater Lake
- Mount McLoughlin
- Medicine Lake
- Mount Shasta
- Lassen Peak
Deformation of Aleutian Volcanoes by Zhong Lu et al.

Major eruption within last:
- 200 years
- 10,000 years
- 2,500,000 years

Lu et al. 2000a, 2003c, 2005a
Mann et al. 2002
Patrick et al., 2003

Lu et al. 2002a
Masterlark & Lu, 2004

Lu et al. 2000b, 2003b, 2004
Lu et al. 2002a
Masterlark et al. 2006

Lu et al. 2002c
Lu et al. 2000c, 2005b

Lu et al. 2003a
Augustine (1990)

Lu et al. 2003a
Shishaldin

Augustine

Lu et al. 2003a
Moran et al. 2006

Westdahl

Peulik

Lu et al. 2002a

Okmok

Lu et al. 2002a

Kiska

Lu et al. 2002b

Seguam

Lu et al. 2003a
Masterlark & Lu, 2004

Makushin

Lu et al. 2002c

Aniakchak

Lu et al. 2000c

Korovin

Lu et al. 2003a

Tanaga

Lu et al. 2002b

Augustine

Lu et al. 2000c, 2005b

Makushin

Kwoun et al. 2006

Aniakchak

Deformation of Aleutian Volcanoes by Zhong Lu et al.
Volcanoes of the central Andes

-1000 of the 1113 volcanoes < 20 Ma
All 53 of the 53 “potentially active”

Hualca Hualca, Peru - (related to Sabancaya?)

Ticsani region, Peru -
1 month(?) deflation 2005

Uturuncu, Bolivia - inflating since 1992
(Pritchard & Simons, 2002, 2004; Sparks et al., 2008)

Lascar, Chile - pyroclastic flow & intracrater
defformation (Pavez et al., 2006; Whelley et al., 2008)

Cerro Overo, Chile - hydrothermal system?

Lazufre, Chile - inflating since 1998
(Pritchard & Simons, 2002, 2004; Froger et al., 2007; Ruch et al., 2008)

Lastarria, Chile
inflating hydrothermal system (Froger et al., 2007)

Cerro Blanco, Argentina -
Asal Rift Dike Injection

6 May – 28 Oct 2005; from Tim Wright, U. Leeds
Hawaii InSAR tracks (A) and (B) Kilauea/E Rift focus area around Kamoamoa eruption (fissures in red, courtesy T. Orr, HVO, GPS sites green dots), (C) Lava flows and fissure opening profile (green dots), fissures (yellow lines).
Co-eruptive satellite InSAR data used in dike modeling
Three different viewing directions improve model resolution compared to satellite InSAR data

Some of InSAR’s Greatest Hits

TheUps and downs of Las Vegas
(From Groundwater Pumping)

From: Amelung et al., 2000

Antarctica ice stream velocities from InSAR/feature tracking

From: Bamber et al., 2000

Enhanced oil recovery detected in the San Jorge Basin, Argentina

Envisat interferogram spans 2004-2006

From: Amelung et al., 2000
Mexico City

Rapid subsidence due to groundwater withdrawal

M. Pritchard, unpublished

B-perp 1.5 km
Creep on the San Andreas Fault

Stack of 12 ERS interferograms spanning May 1992-Jan 2001

Figures from Isabelle Ryder
UC Berkeley
Line of sight velocities from stacked InSAR data

35 interferograms


Fialko, Nature 2006
InSAR phase related to subsurface slip

- ascending and descending tracks
- deformation combination of horizontal and vertical
- main fault near vertical strike-slip
- second fault required to match the “extra” uplift

Gareth Funning et al., 2005
Interferogram coherence or correlation

Second field visit

No clear rupture on a wall
From here to north land is covered by debris
Gravel quarry
Rail station

H.offset 5 cm
H.offset 8 cm
H.offset 13 cm
H.offset 5 cm
H.offset 2 cm

H.offset 6 cm
H.offset 10 cm
H.offset 20 cm
H.offset 8 cm
H.offset 2 cm

No clear rupture
H.offset 15 cm
H.offset 5 cm
Postseismic shallow compaction

- narrow zone of postseismic subsidence along main coseismic rupture
- green circles are field mapping of rupture
- primarily subsidence, but some motion inward
- not limited to left-step of main fault—so not just poroelastic rebound

2008 M7.9 Wenchuan EQ

- six paths cover rupture, plus two at ends
- about 150 PALSAR frames
- ROI_pac processing & SNAPHU unwrapping
- coherence lost in steep slopes with longer baselines, and where displacements large
- ionospheric waves cause up to 1 m of range change variations

2015M7.8 Gorkha Earthquake in Nepal

- ALOS-2 ScanSAR interferogram
- Descending line-of-sight (LOS) perpendicular to horizontal
- InSAR phase only sees vertical component
- High Himalayas dropped down as much as 1.2 m

GPS data from Galetzka, J., et al. (2015), Slip pulse and resonance of the Kathmandu basin during the 2015 Gorkha earthquake, Nepal, Science, 349(6252), 1091-1095
Multiple fault slip triggered above the 2016 Mw 6.4 MeiNong earthquake in Taiwan, "Geophysical Research Letters."