Measuring topographic changes at active volcanoes by double differential TanDEM-X InSAR
Motivation

- The repeat pass intervals of current radar satellite missions are long

- Changing backscattering conditions lead to **low coherence**
  - problematic in summit areas, near lava domes, and above lava flows

  - Monitoring of ground displacements difficult
  - DEM generation difficult!!!

- **General Aim:** Development and test of a method to quantify **discontinuous deformation, volume changes, and material transport** in non-coherent areas
Solution: TanDEM-X

Two radar images recorded simultaneously

Good coherence

Enables DEM generation

Repeat interval 11 days

Growing phase
Magmatic effusion rate, volume of collapsible material

Merapi and Volcán de Colima

Differential DEM analysis

Collapse
Topographic changes, redistribution of material along the edifice, fractions of juvenile and non-juvenile material

Tolbachik

Lava flows (and debris mobilisation)
**Merapi – Indonesia**

**2010 Eruption**
- Explosive eruption on 26 Oct. 2010 destroyed the 2006 lava dome
- A phase of rapid dome growth followed
- New dome was destroyed again on 4th-5th Nov.
- New dome was built on 6th Nov.

**Geological setting**
- Stratovolcano
- One of the most active volcanoes in Indonesia
- ~2968 m a.s.l.
- Dome-building volcano

**Data overview**
- 04. Nov. 2011
Merapi – Summit topography

a) Before 2010 eruption

b) After 2010 eruption

New Crater
Gendol gorge
Merapi – Backscatter magnitude

15. Oct. 2010


(a)  

(b)  

(c)  

(d)  

Lava dome  
Shadow  
Gendol gorge  
Layover
Merapi – DEM results

15. Oct. 2010


04. Nov. 2011

Volumetric change in the summit area
~19 Mio. m³

Pallister et al., 2013, JVGR
~14 Mio. m³

Volcán de Colima – Mexico

Geological setting
- Stratovolcano located on the Trans-Mexican Volcanic Belt
- 3850 m a.s.l.
- Dome-building volcano

Volcán de Colima – Data

TanDEM-X DEM
Descending orbit

08. Jun. 2011
Volcán de Colima – Results & Validation

TanDEM-X

Mean pre-exp. – mean post-exp.


Volume change TanDEM-X
~ 200 000 m³

Photogrammetric DEMs

Volume change Photogram. DEMs
~ 190 000 m³

(James & Varley, 2012)
Tolbachik – Kamchatka

Geological setting

- Located at the southern end of the Kliuchevskaya volcano group
- Tolbachik massif is composed of two overlapping, but morphologically dissimilar volcanoes
Eruption in 2012/13

- ~ 9 month from Nov. 2012 till Aug. 2013
- Very fluid lava flows up to 20 km to the South
- Development of new cinder cones
### Tolbachik – Data

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Tolbachik – Results

Backscatter magnitude

15 Nov. 2012

09 Feb. 2014

Phase & Backscatter magnitude
Total lava flow volume: 0.56 km³
Conclusion

- TanDEM-X enables to calculate topographic/volumetric changes due to volcanic activity

- Studies at different testsites proved that TanDEM-X enables to assess topographic changes on a 10 to 100 m level

- Good additional method to repeat-pass deformation analyses

- Great potential of TanDEM-X in volcano research
Thank you!

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