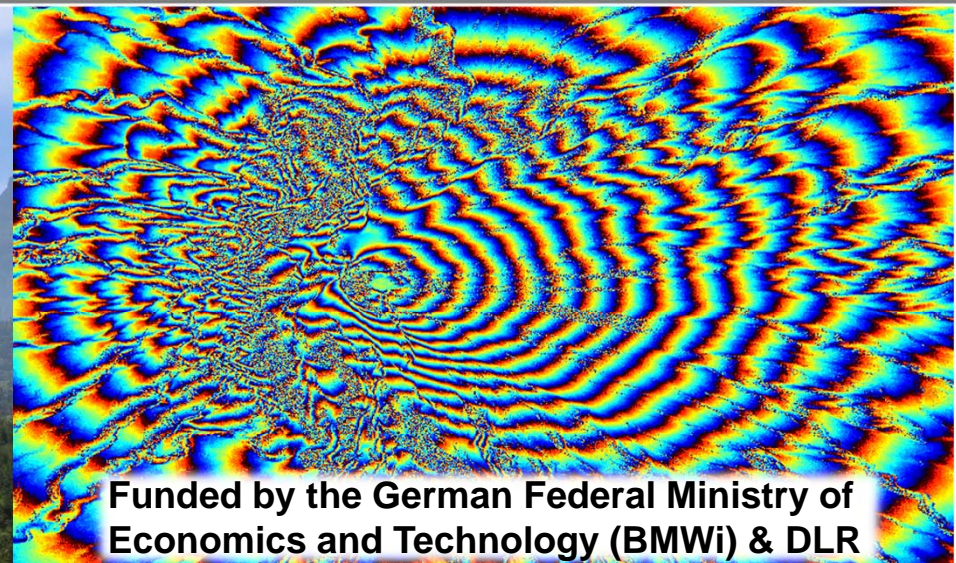


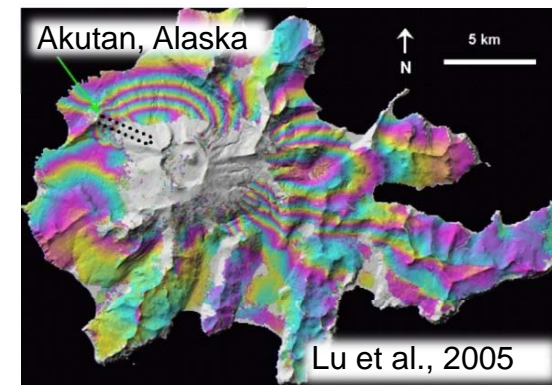
Application of TanDEM-X interferometry in volcano monitoring using Merapi, Indonesia and Volcán de Colima, Mexico as test sites

Geodetic Institute, Department of Civil Engineering, Geo and Environmental Sciences

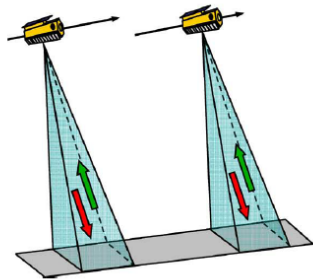


Scope of the study

- **Motivation:** The repeat pass intervals of current radar satellite missions are between 11 and 35 days
 - **low coherence** in summit areas, near lava domes and above lava flows
- **General aim:** Analysis of the capacity of the TanDEM-X mission to monitor topographic changes of dome building volcanoes
 - **topography** is an important parameter in volcano research
 - allows to estimate **volume growth rates, volume changes** and **mass loss suffered** during an eruption



Monostatic vs. bistatic InSAR

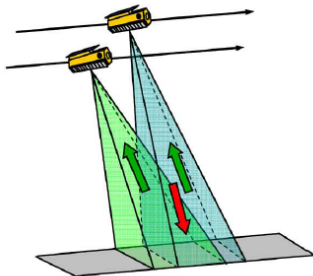


$\Delta t \geq 11$ days

Repeat-pass missions (monostatic)

$$\phi_{\text{insar}} = \phi_{\text{topo}} + \phi_{\text{def}} + \phi_{\text{atm}} + \phi_{\text{orbit}} + \phi_{\text{scat}} + \phi_{\text{noise}}$$

Often problematic along volcanoes



$\Delta t = 0$ days

TanDEM-X (bistatic)

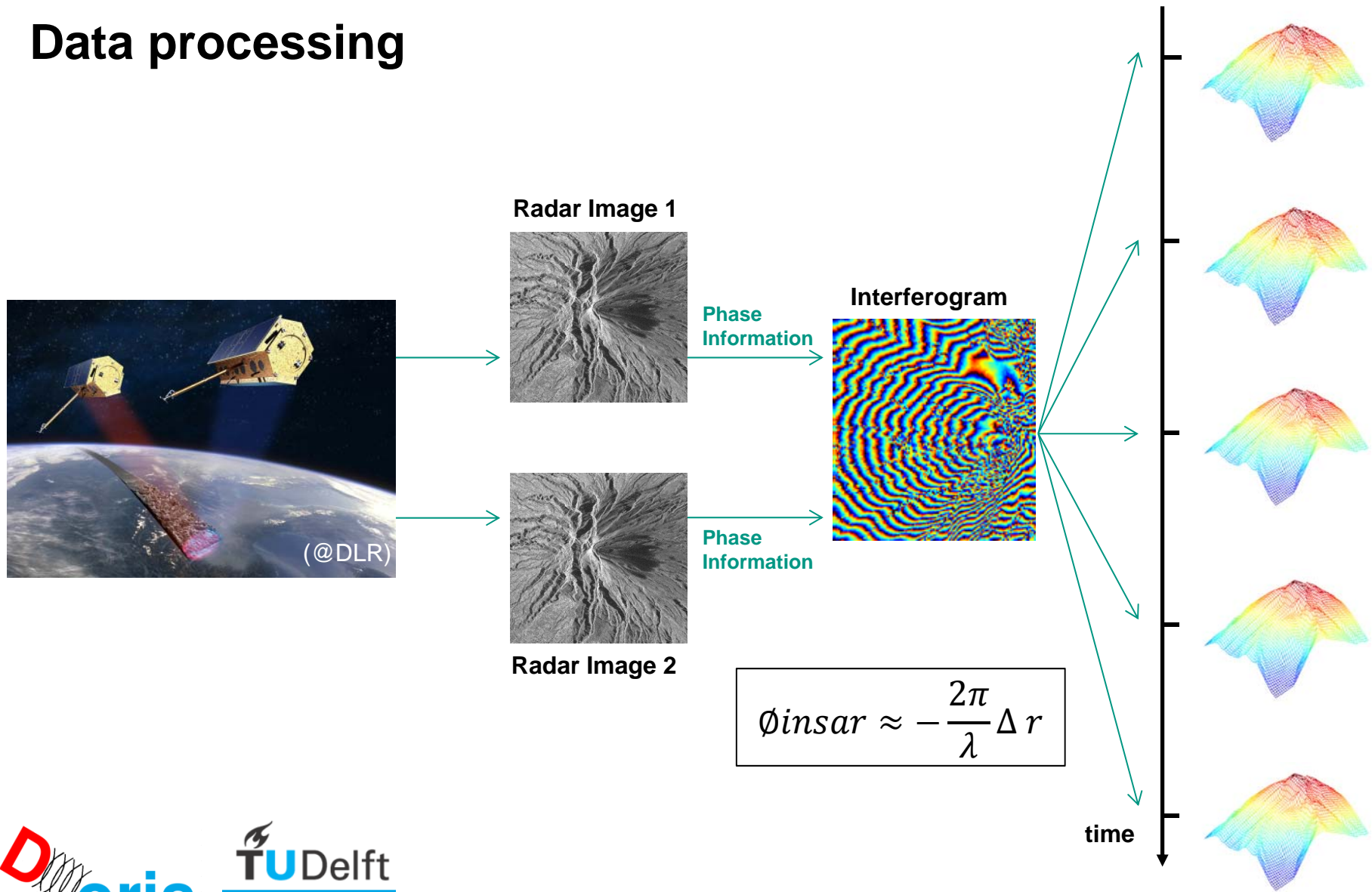
$$\phi_{\text{insar}} = \phi_{\text{topo}} + \phi_{\text{def}} + \phi_{\text{atm}} + \phi_{\text{orbit}} + \phi_{\text{scat}} + \phi_{\text{noise}}$$

No problem any longer

Krieger et al. 2007

■ Enables to quantify volumetric mass movements

Data processing



Merapi, Java, Indonesia



<http://www.wdrep.com/~m1kha3l/images/2012/01/Indonesia-tectonic-plate-interfaces.jpg>



<http://img.docstoccdn.com/thumb/orig/129498024.png>

Merapi 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.

Data overview

10/15/2010

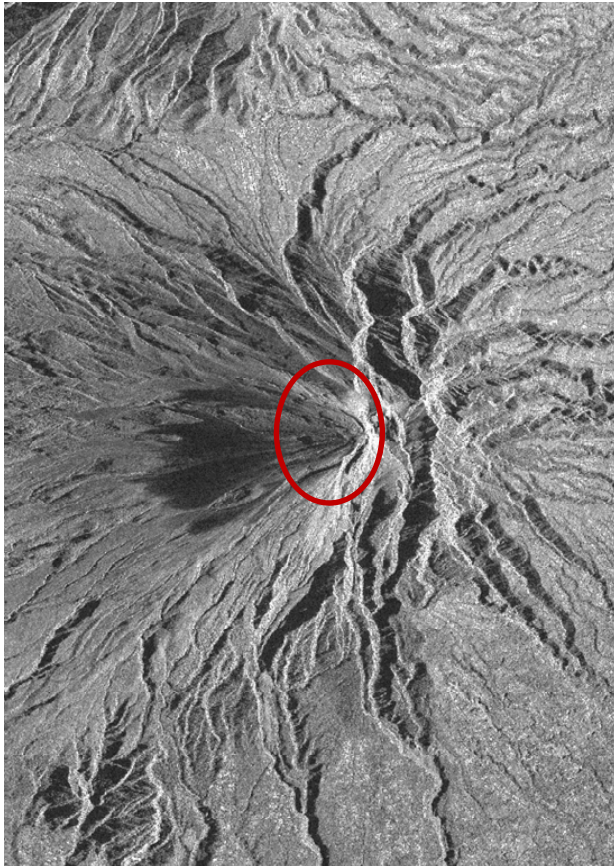
10/24/2011

11/14/2011

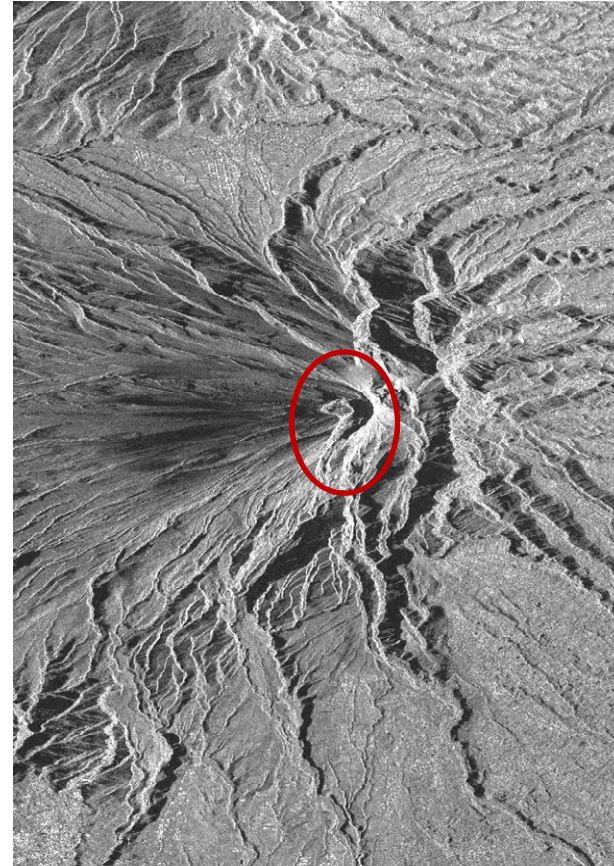
01/09/2012

decending

Intensity images

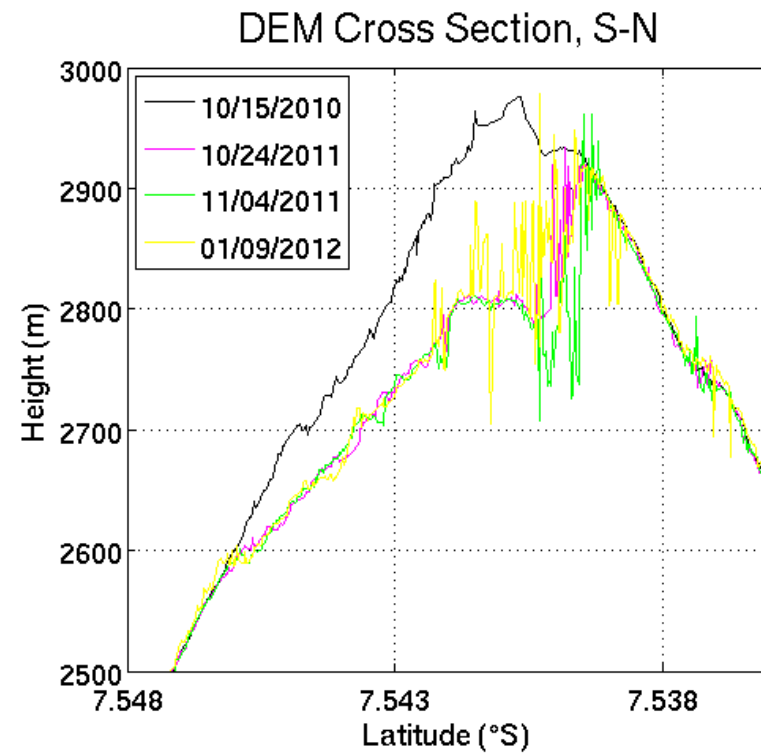
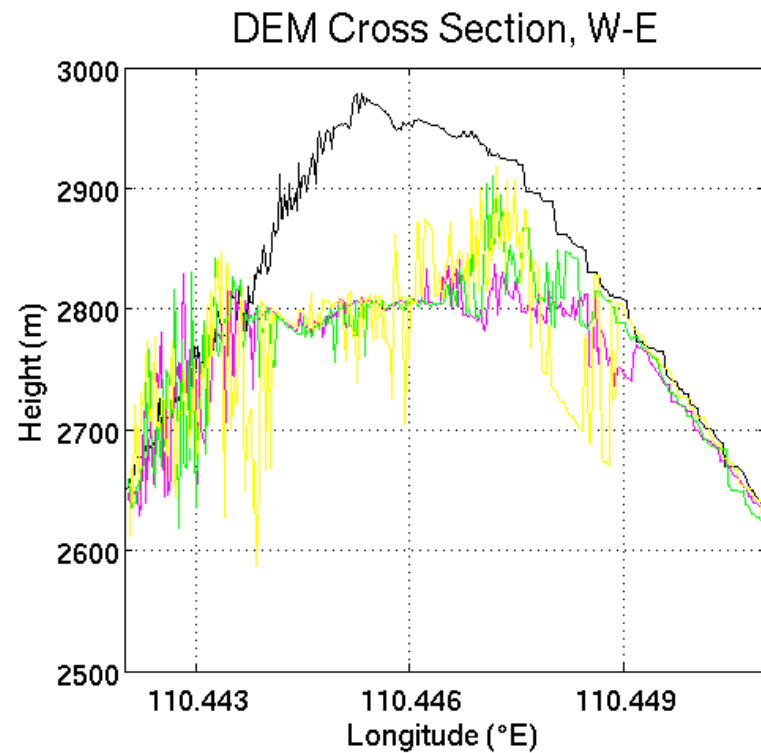


15.Oct.2010

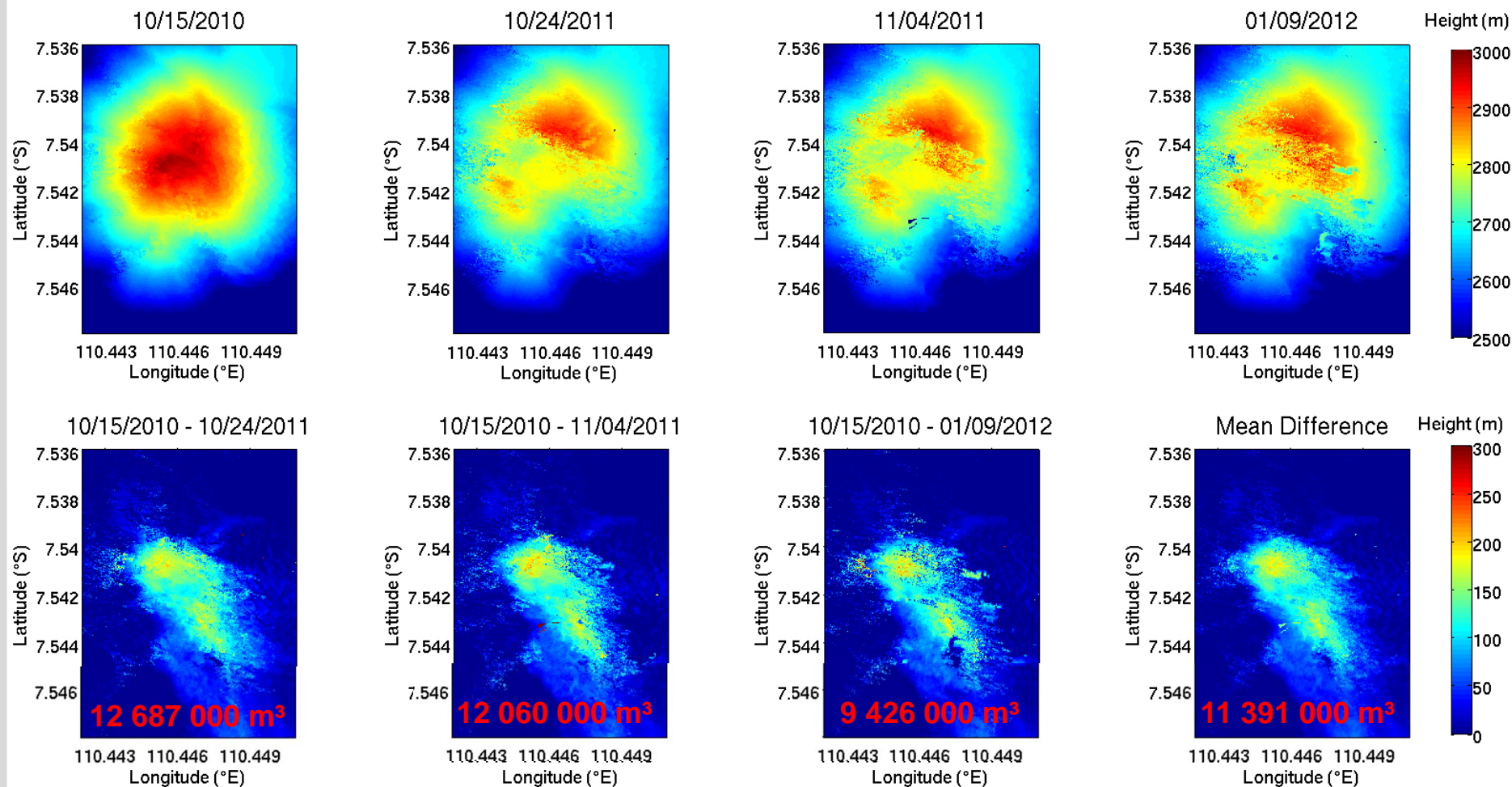


24.Oct.2011

Analysis of Merapi DEM cross sections

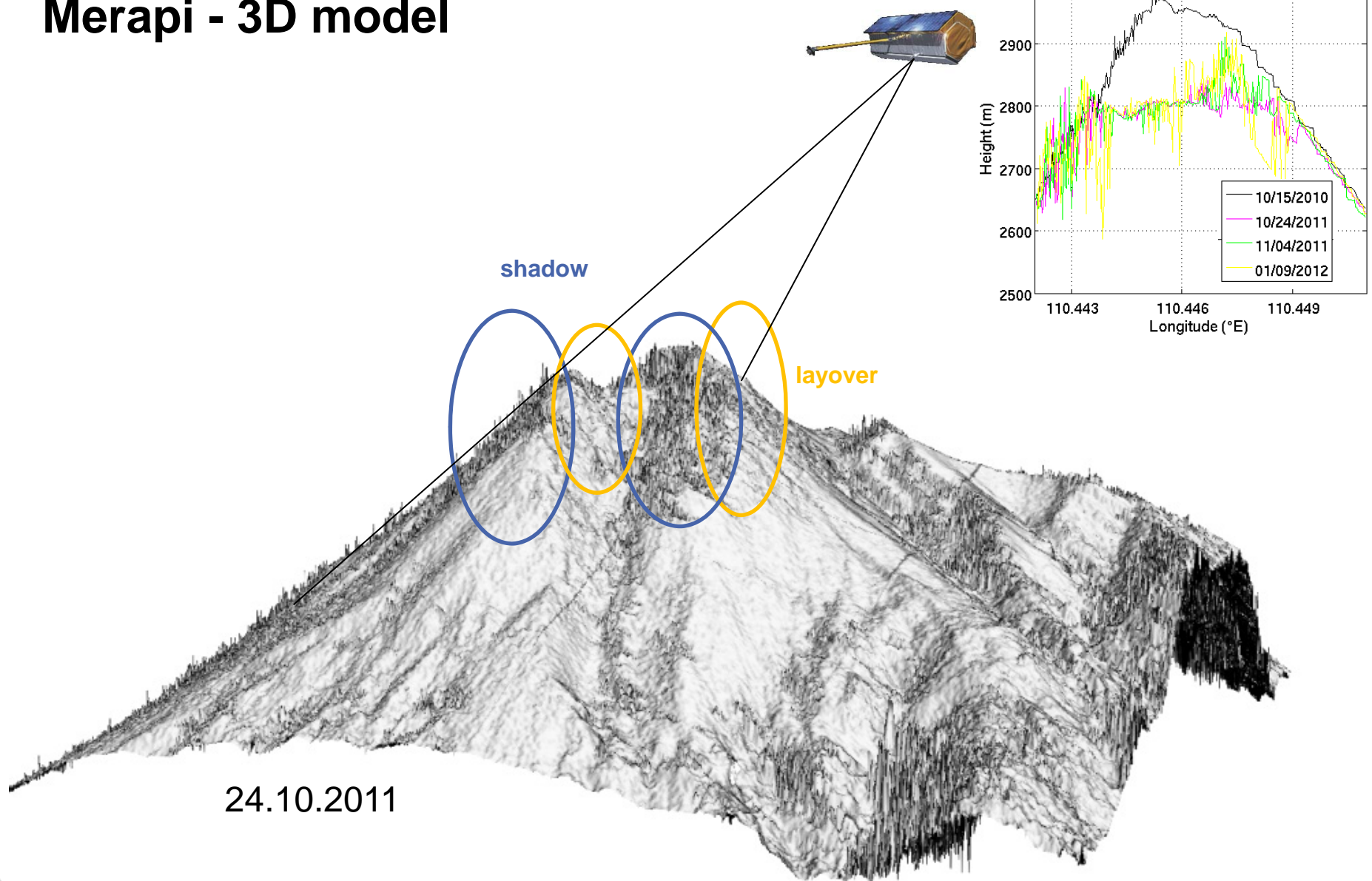


Height change

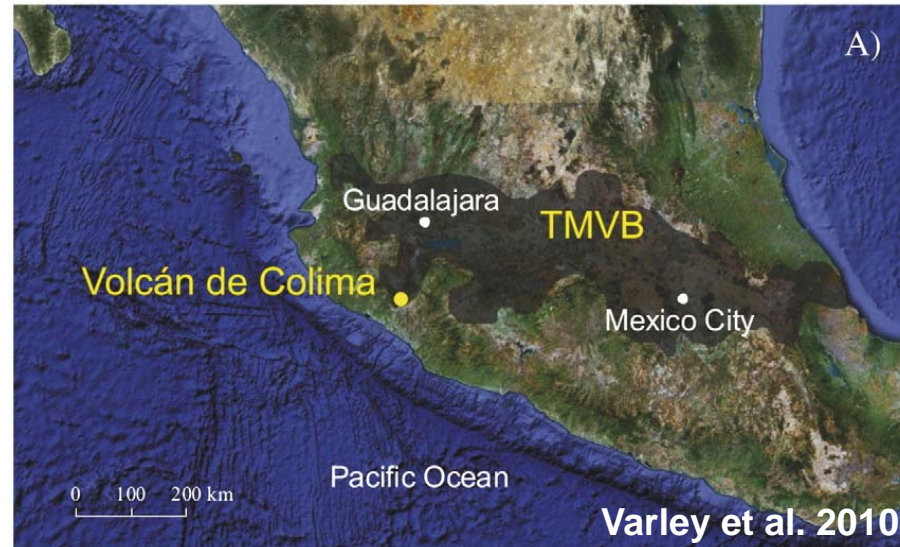


Pallister et al. 2012: ~14 500 000 m³

Merapi - 3D model



Volcán de Colima, Mexico



- Stratocone volcano located on the Trans-Mexican Volcanic Belt
- 100-year cycles dominated by dome growth and intermittent eruptions, culminating in complete dome destructions

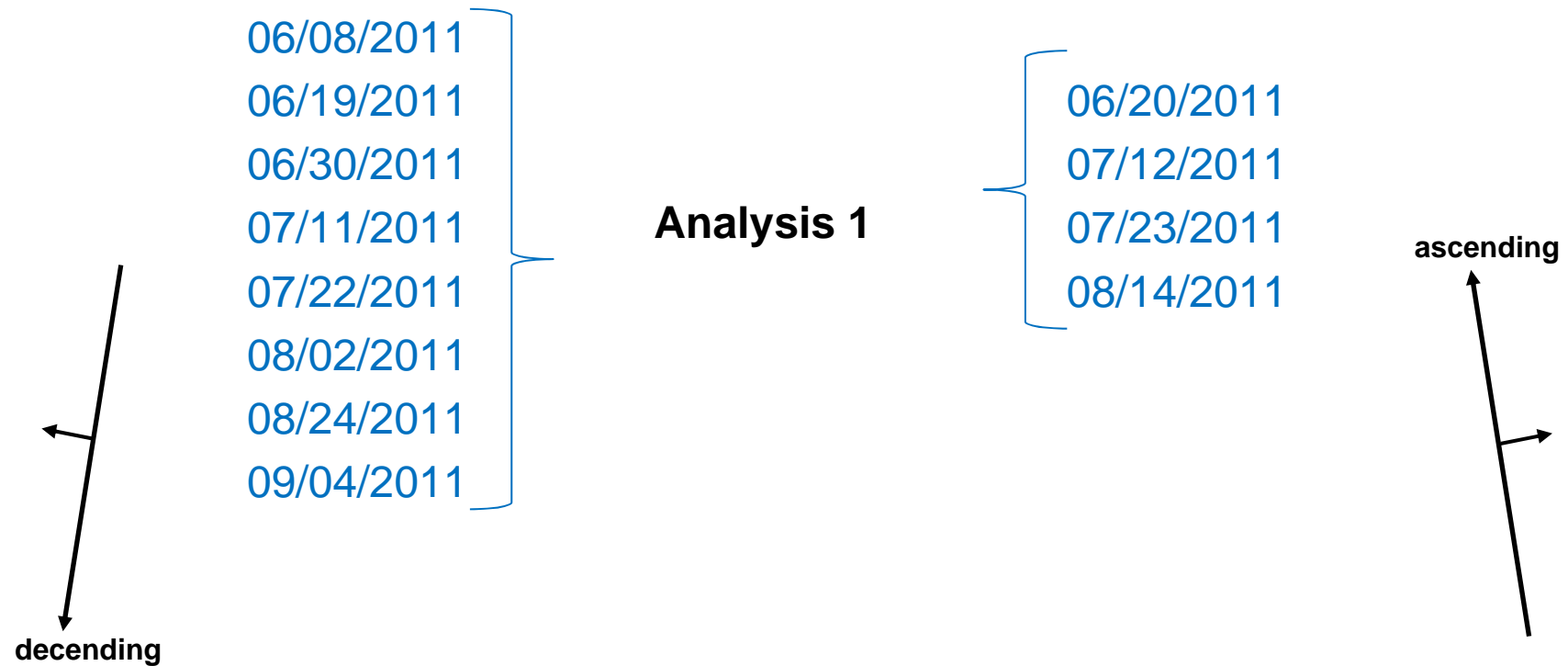
Recent eruptive activity

4 episodes of dome growth

- 1998-1999
- 2001-2003
- 2004
- 2007-2011
- New activity since January 2013

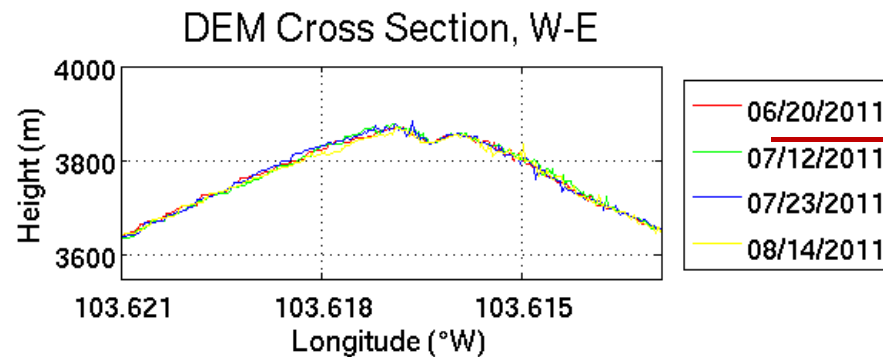


Data overview



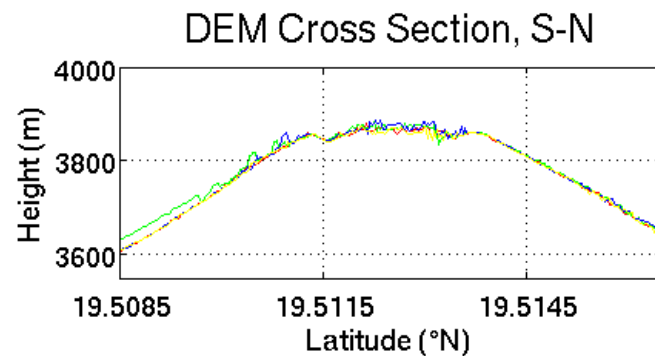
DEM Cross Sections June – August 2011

ASCENDING



June 21, 2011

A small explosion signalled the end of ascending magma.

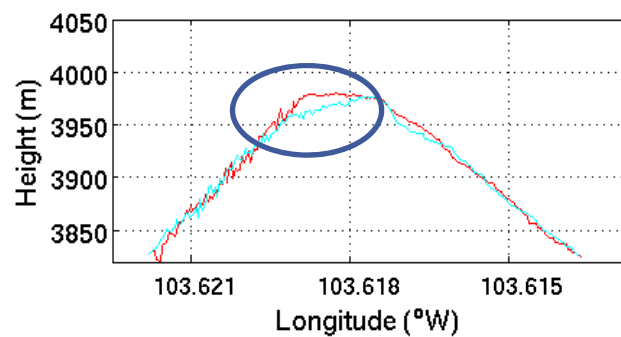
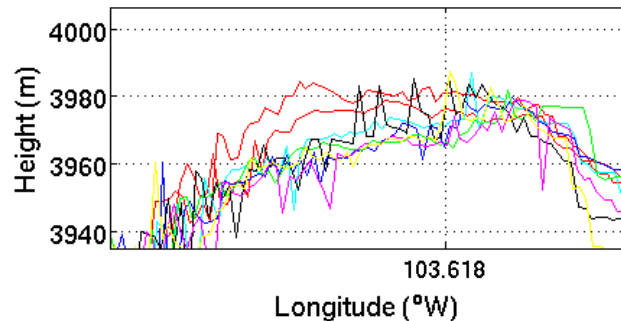
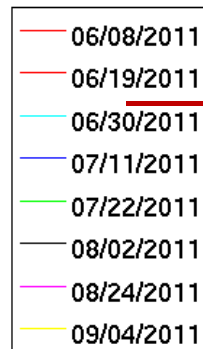
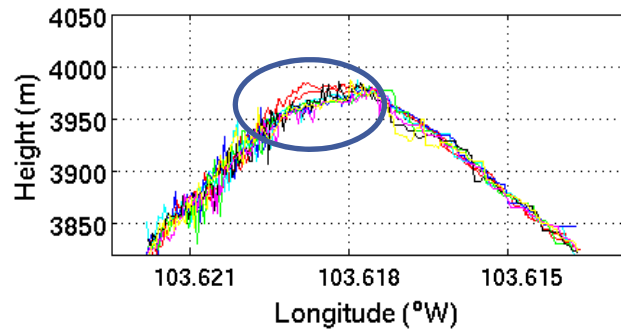


Height change too small to be observed with TanDEM-X?

DEM Cross Sections, W-E

June – September 2011

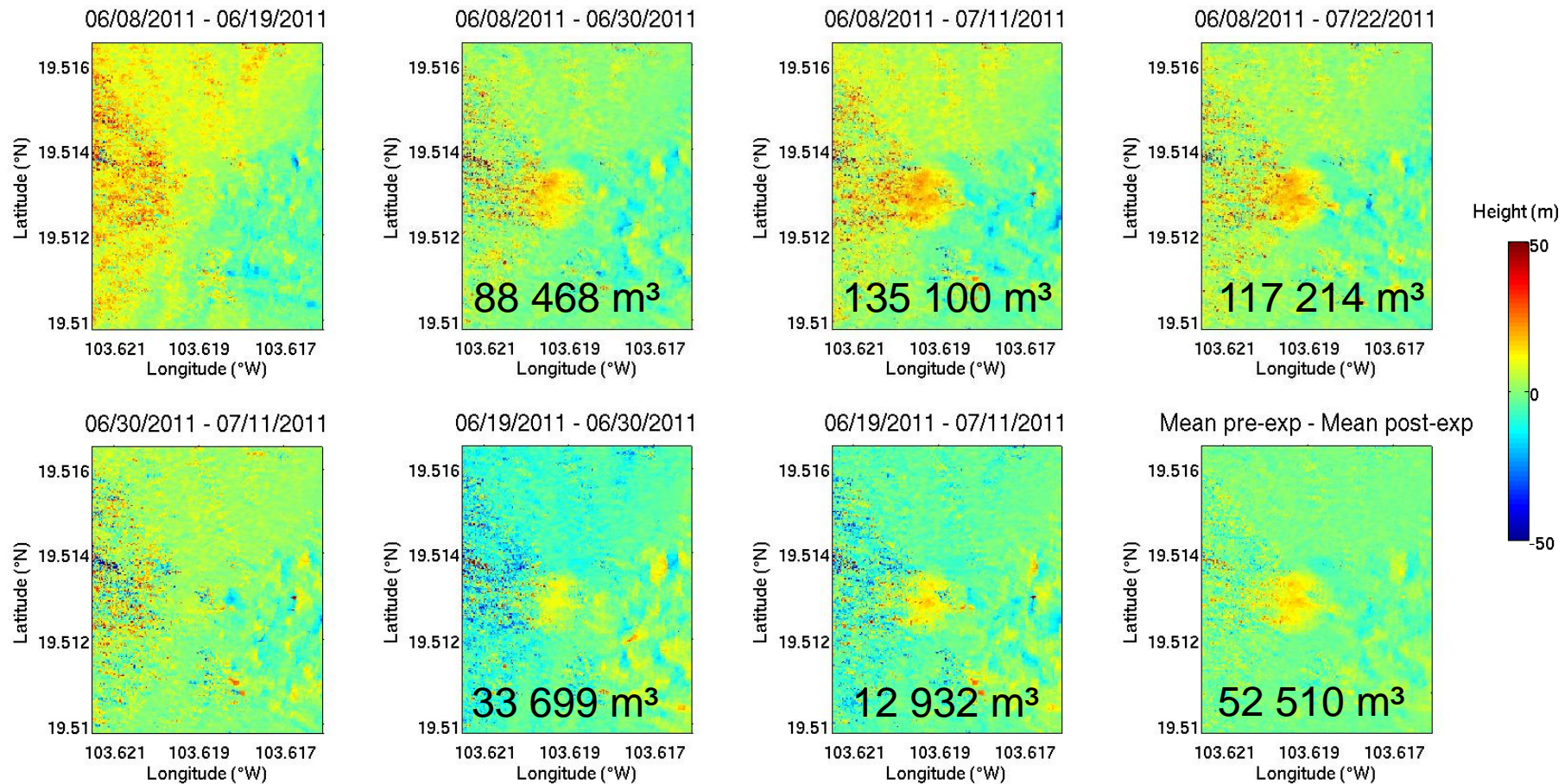
DESCENDING



**Height change is visible with
TanDEM-X!!!**

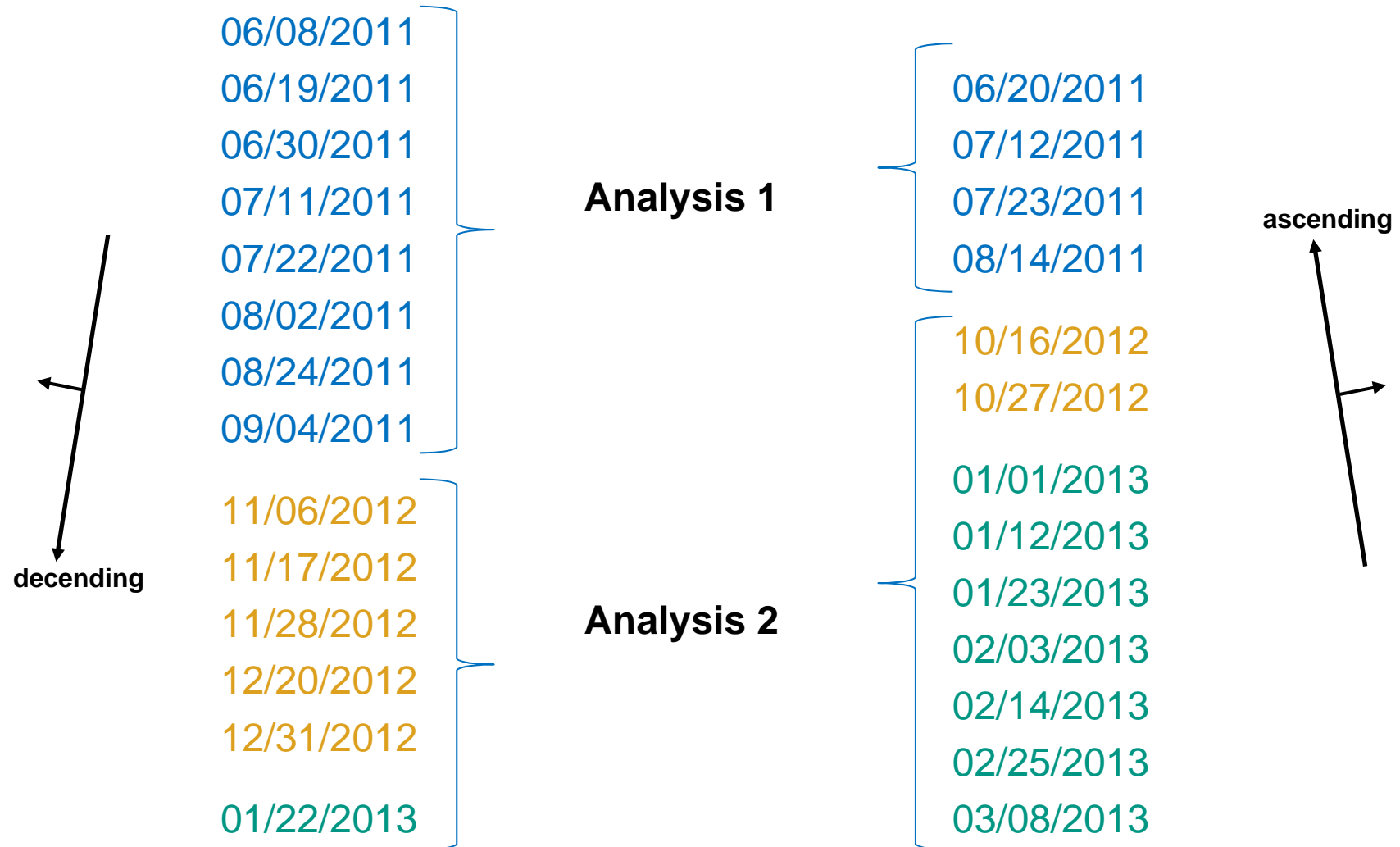
Height change June 2011

DESCENDING



Nick Varley: 190 000 m³

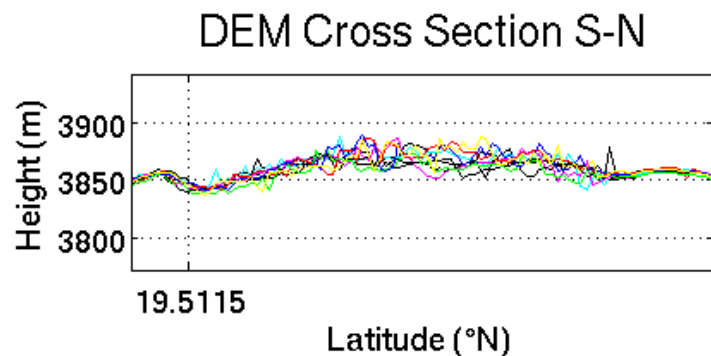
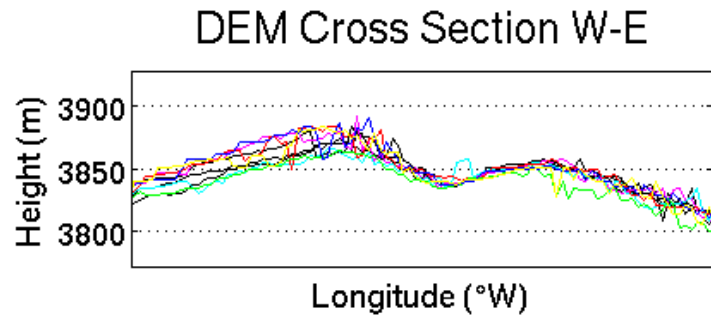
Data overview



DEM cross sections, W-E

November 2012 – January 3013

ASCENDING



January 06, 2013

- Phreatic eruption?

January 29, 2013

- Ash plume

...

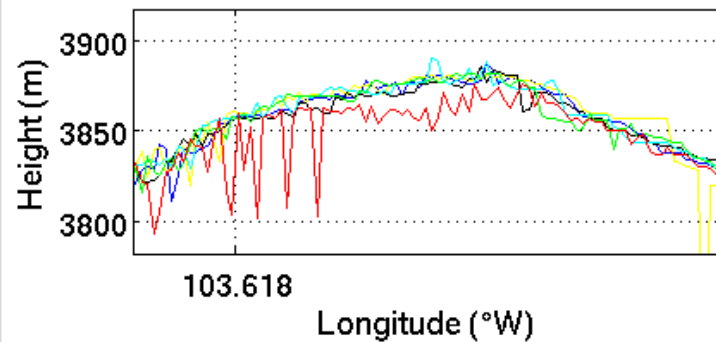
— 10/16/2012
— 10/27/2012
— 01/01/2013
— 01/12/2013
— 01/23/2013
— 02/03/2013
— 02/14/2013
— 02/25/2013
— 03/08/2013

DEM cross sections, W-E

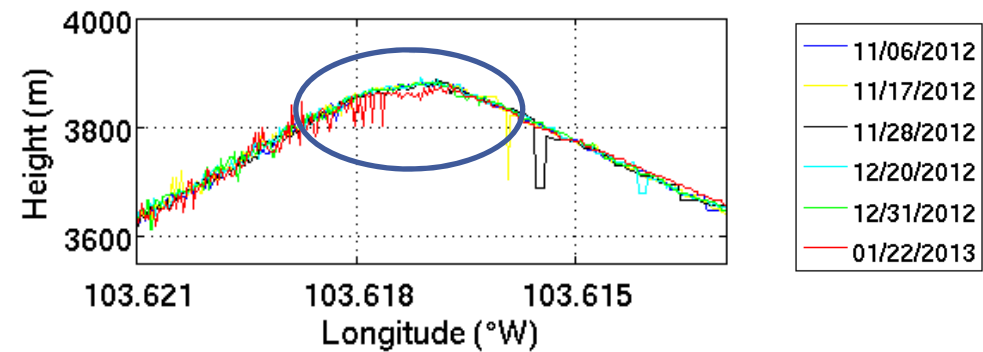
November 2012 – January 2013

DESCENDING

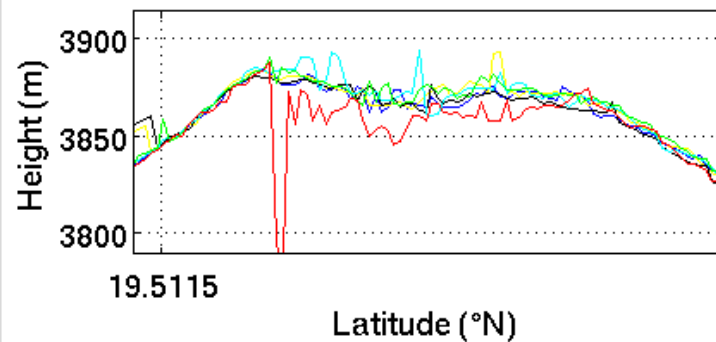
DEM Cross section, W-E



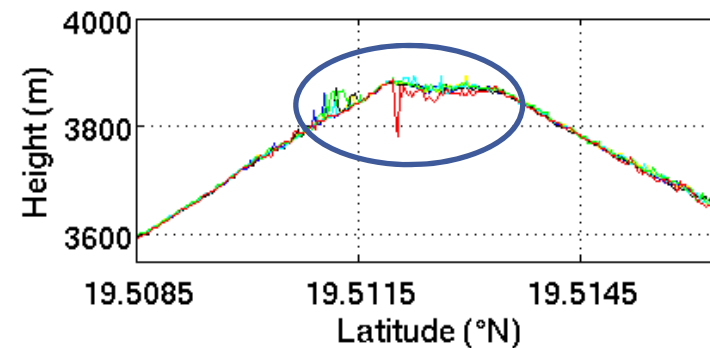
DEM Cross section, W-E



DEM Cross section, S-N



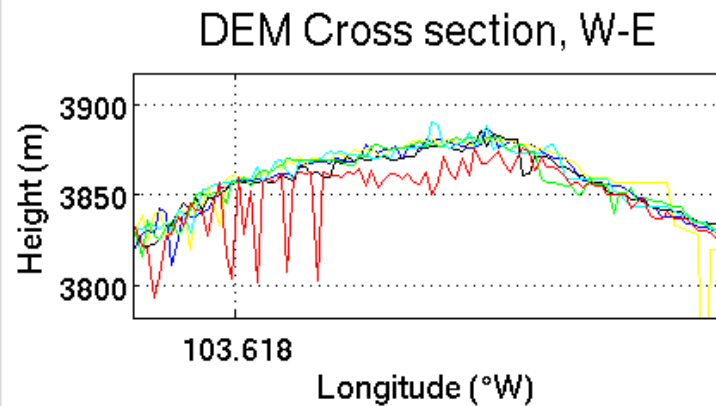
DEM Cross section, S-N



DEM cross sections, W-E

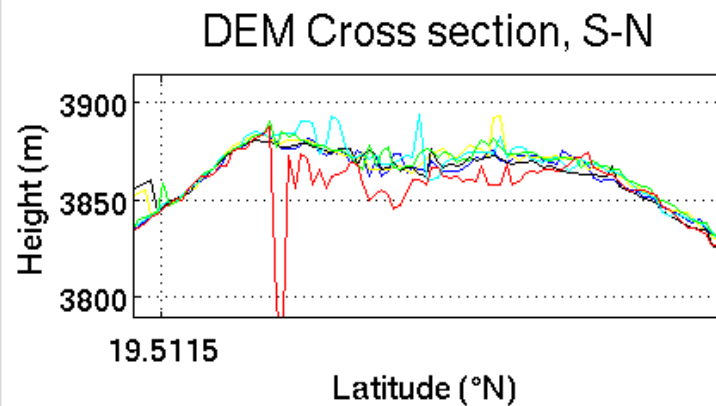
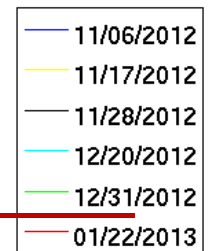
November 2012 – January 2013

DESCENDING



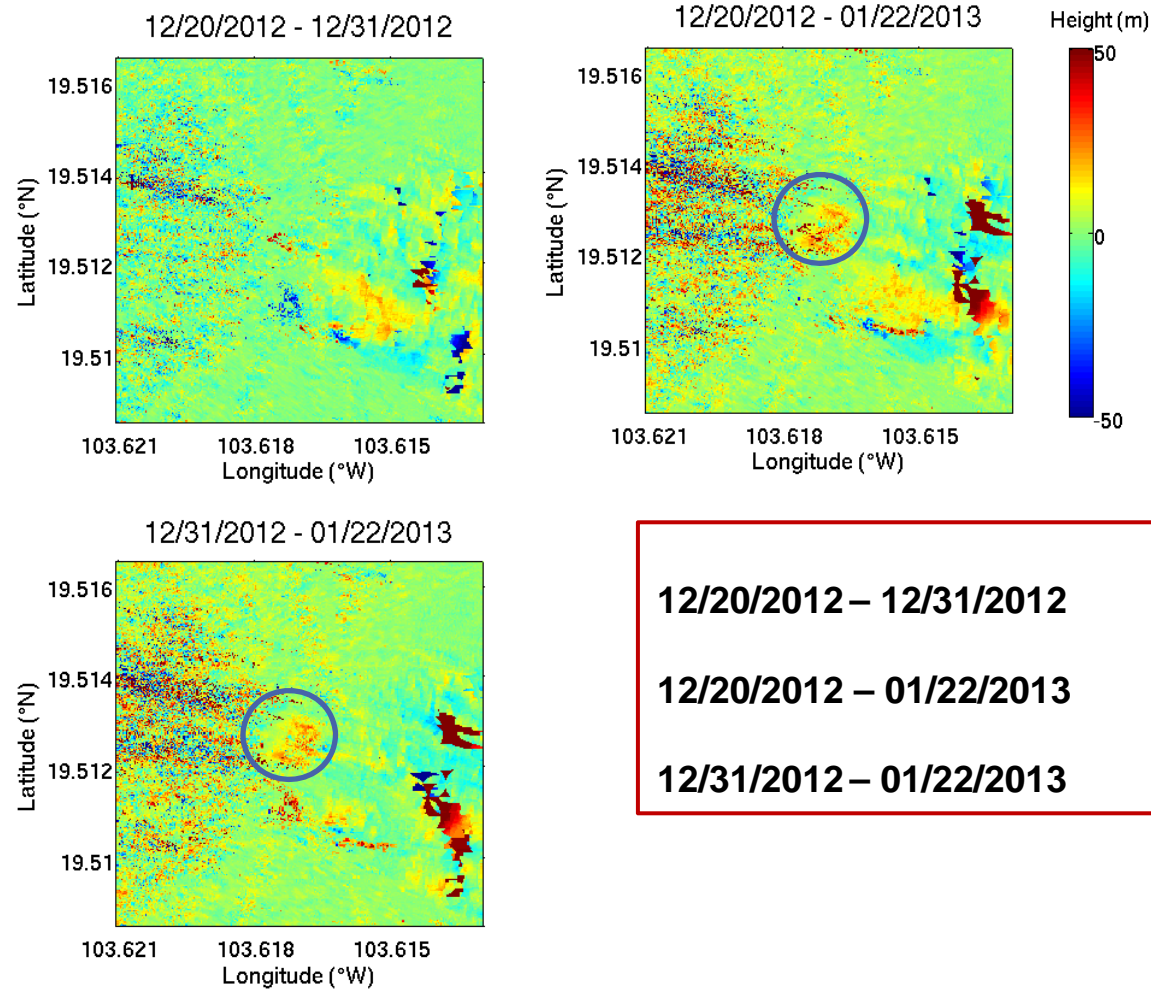
January 06, 2013

Phreatic eruption!



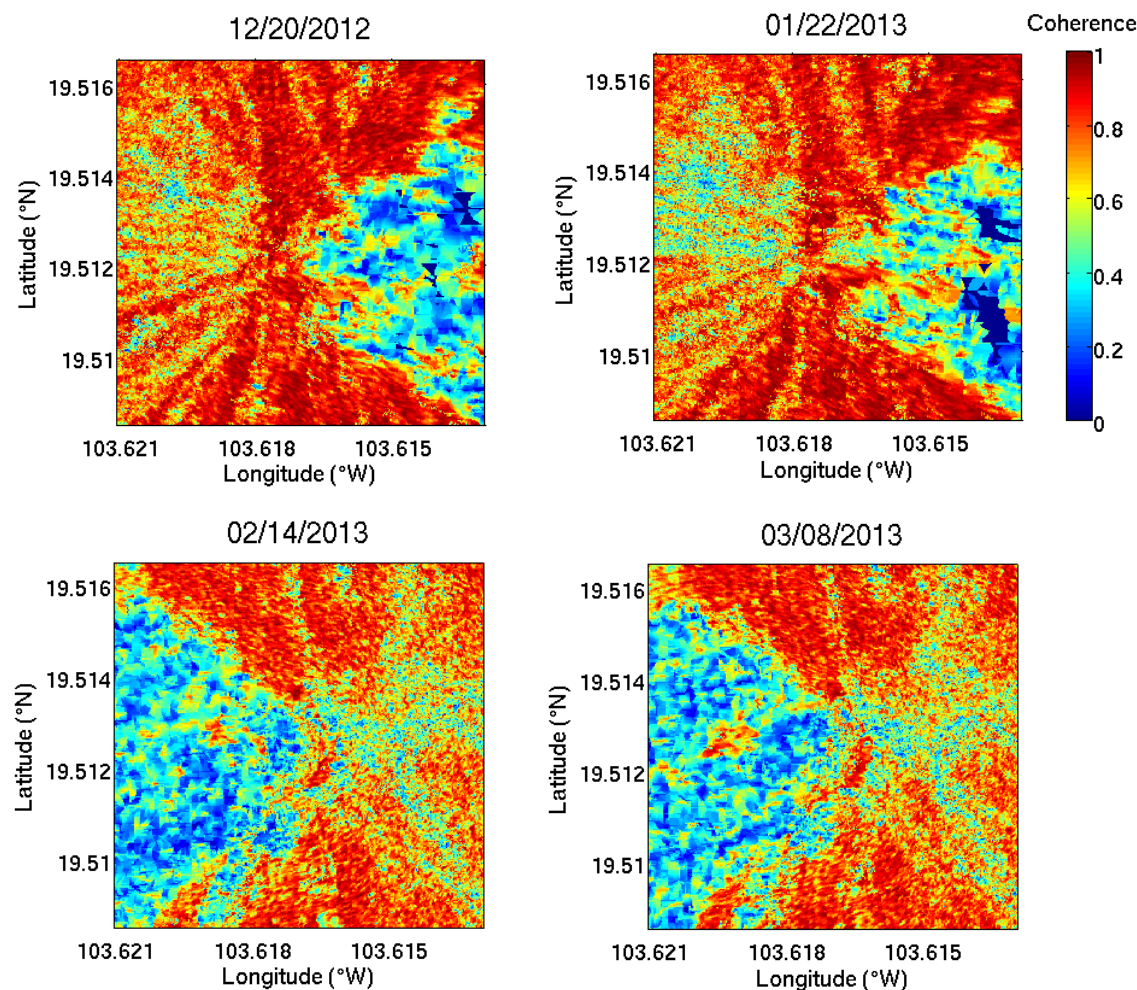
Height change 2012 - 2013

DESCENDING



	mean	stdev
12/20/2012 – 12/31/2012	-0.19	10.38
12/20/2012 – 01/22/2013	3.95	15.26
12/31/2012 – 01/22/2013	4.14	15.40

Coherence 2012 - 2013



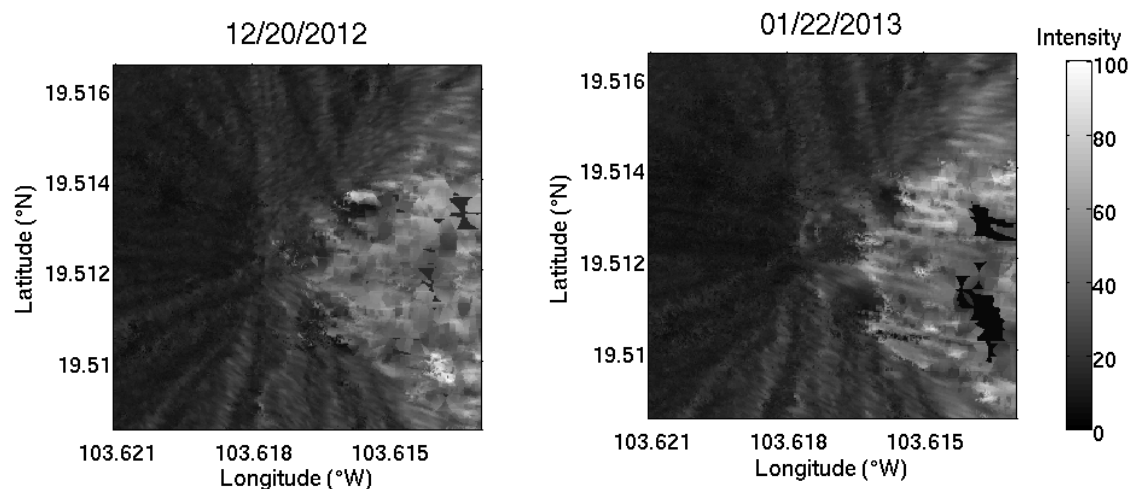
DESCENDING

	mean	stdev
12/20/2012	0.65	0.56
01/22/2013	0.38	2.42

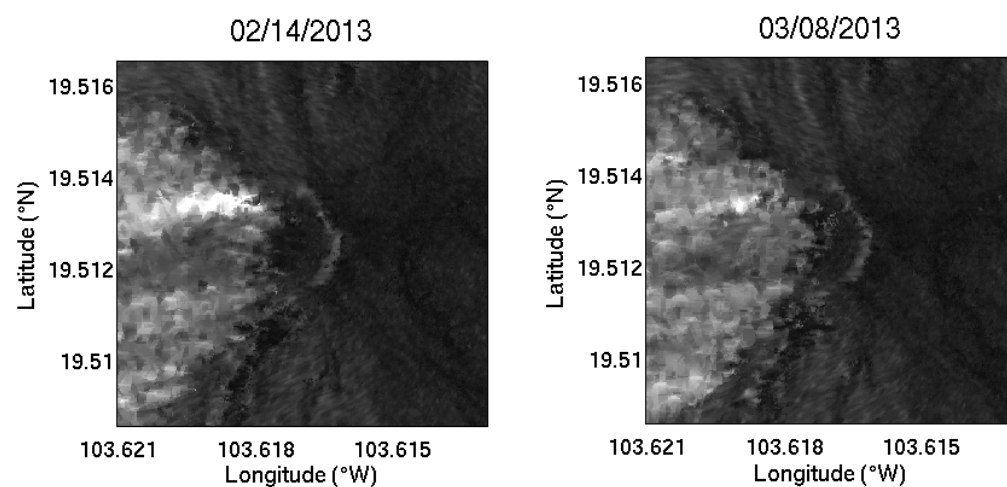
ASCENDING

	mean	stdev
02/14/2013	0.60	0.22
03/08/2013	0.61	0.22

Intensity 2012 - 2013



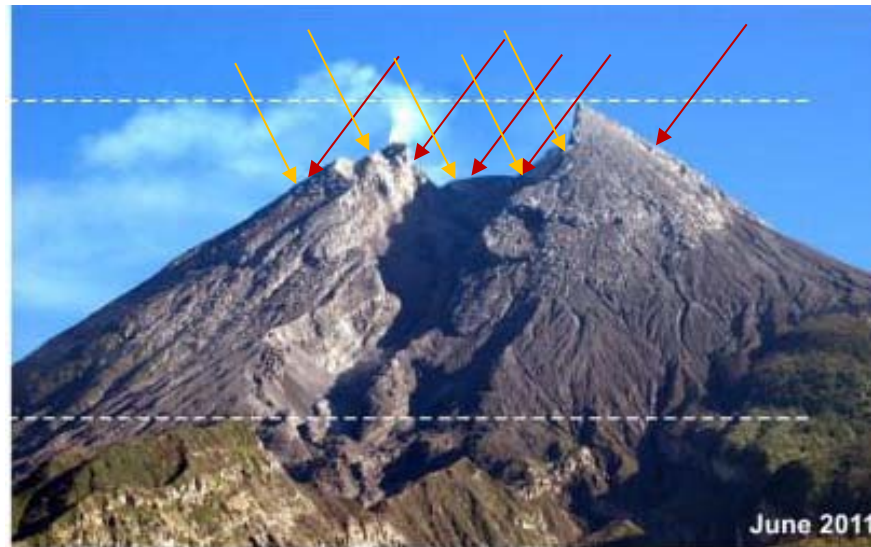
DESCENDING



ASCENDING

Further research

- Fusion of DEMs from the ascending and descending orbit to improve the accuracy of the volume estimates

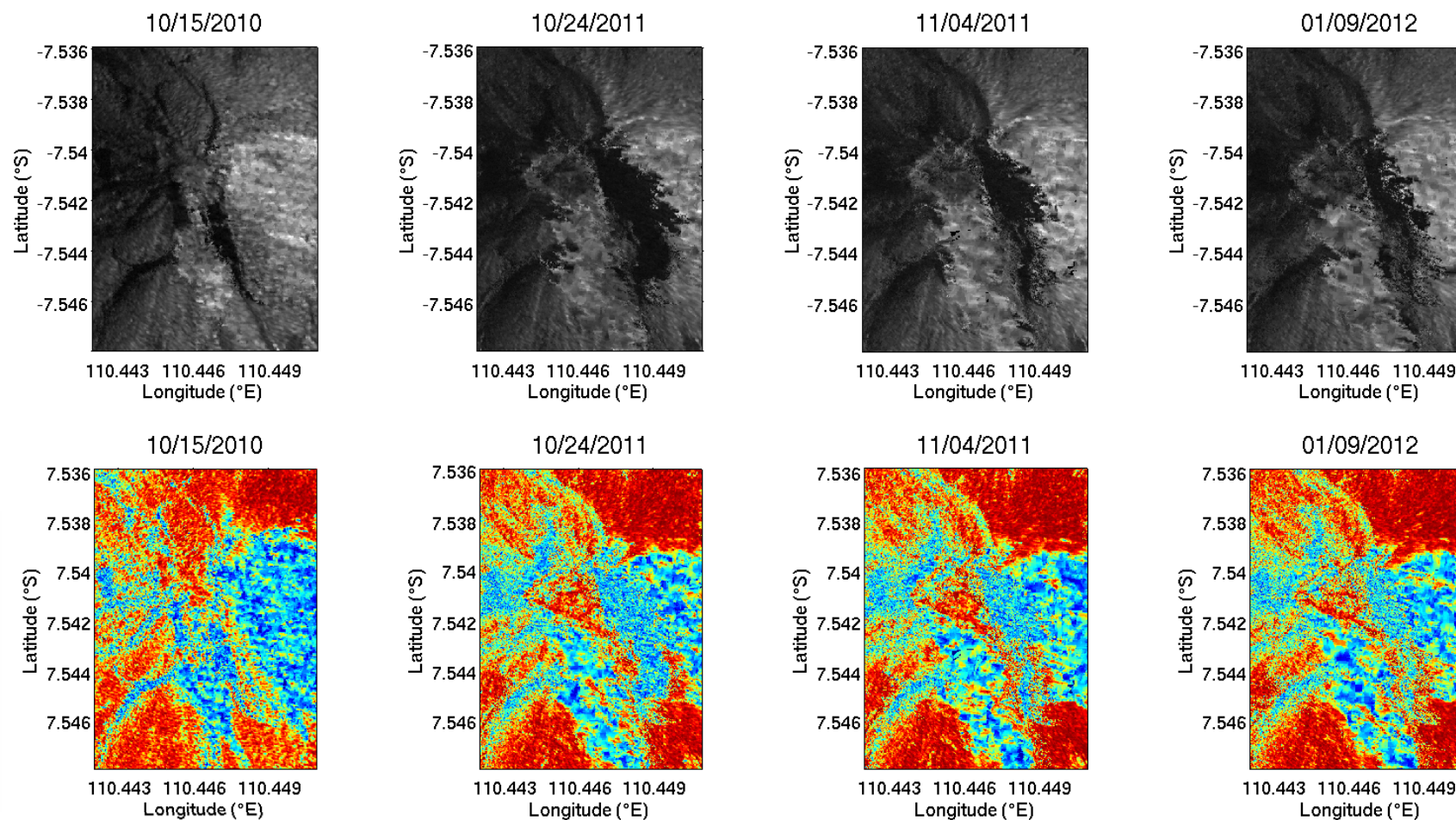


descending
ascending

Surono et al. 2012

- Validation with ground-truth data in collaboration with the local volcano observatory in Indonesia & UGM and other research groups
- Accuracy evaluation of the Digital Elevation Models
- Estimation of magma ascent rates and material fluxes

Volume change



Coherence

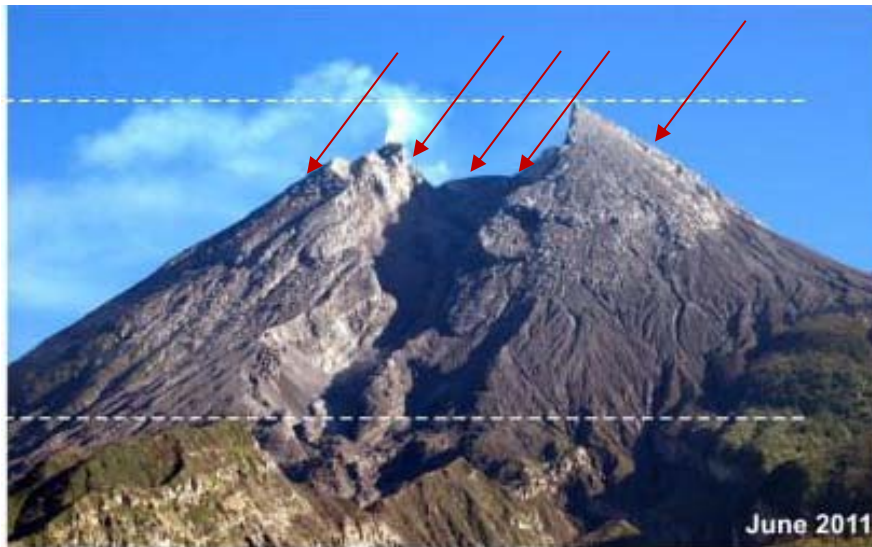
0.59

0.61

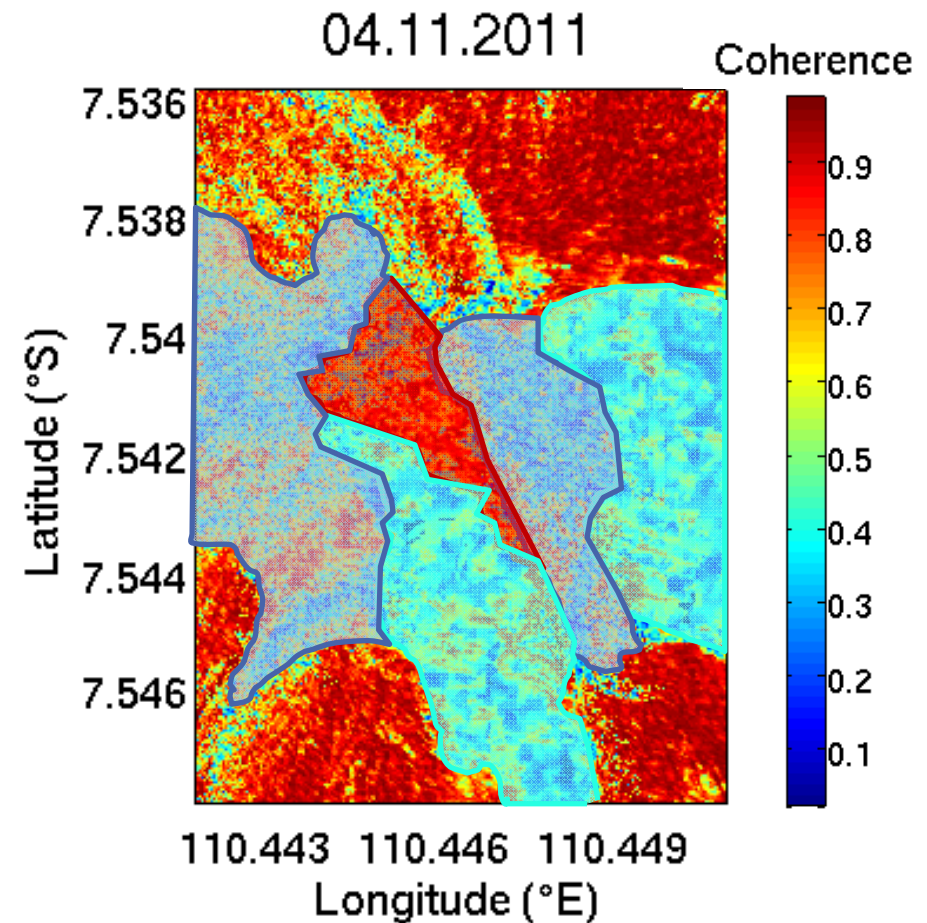
0.62

0.63

Aufnahmegeometrie und Kohärenz

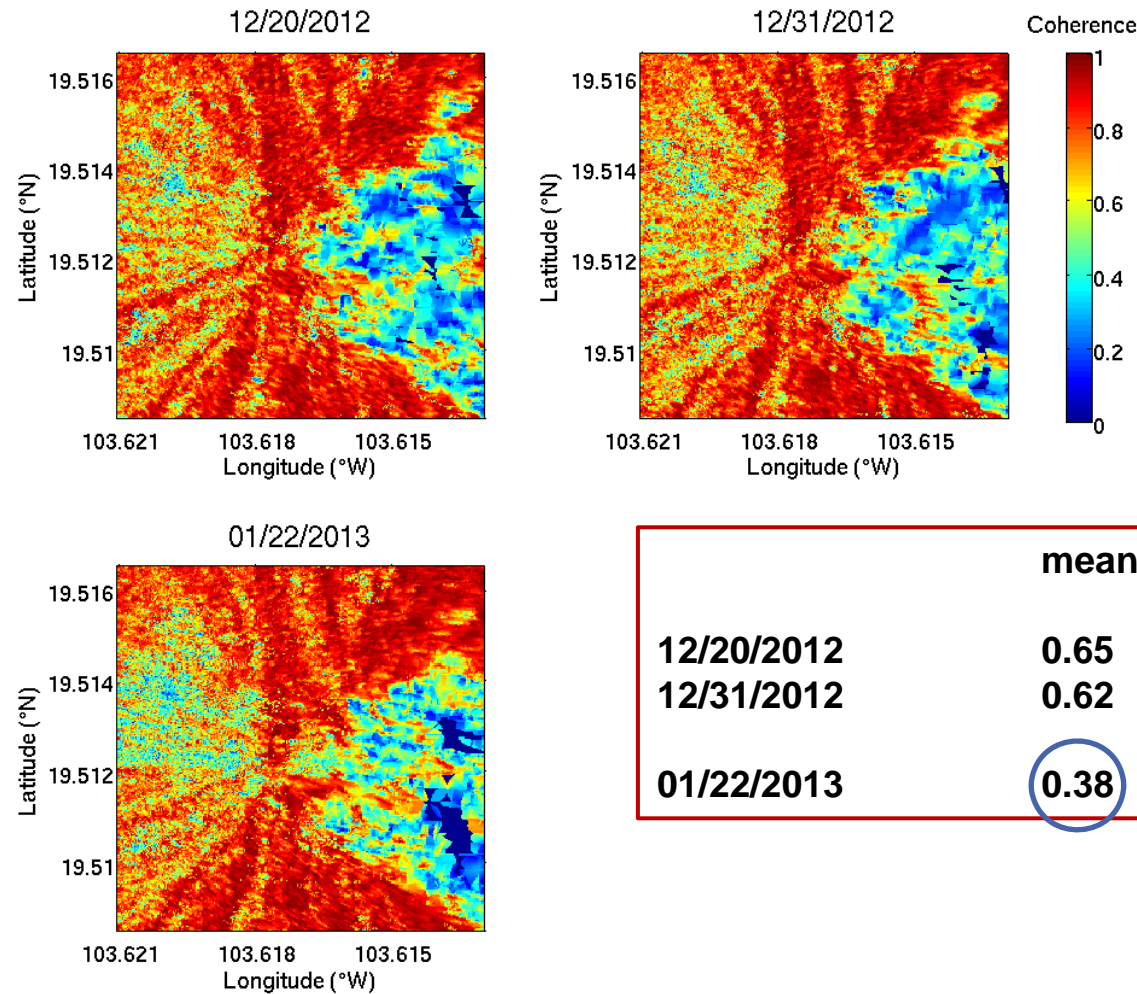


Surono et al. 2012



Coherence 2012 - 2013

DESCENDING



	mean	stdev	Bperp
12/20/2012	0.65	0.56	
12/31/2012	0.62	0.82	
01/22/2013	0.38	2.42	