

Application of TanDEM-X data to volcanic flow hazard assessment: example from Merapi Volcano, Central Java, Indonesia



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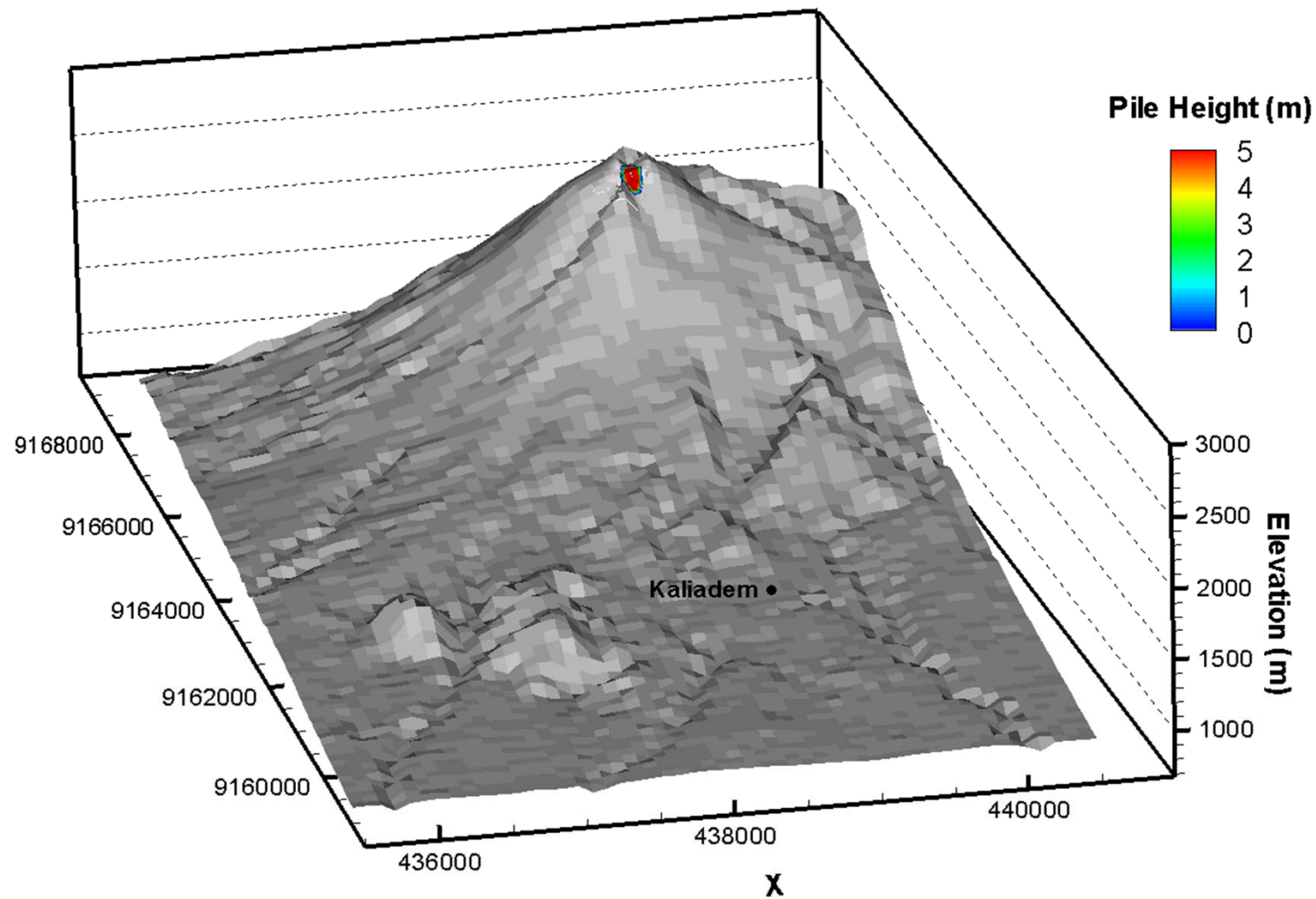
Motivations

➡ TanDEM-X data can generate accurate numerical topography and/or capture rapid topographic changes associated with the emplacement/removal of volcanic deposits over short periods.

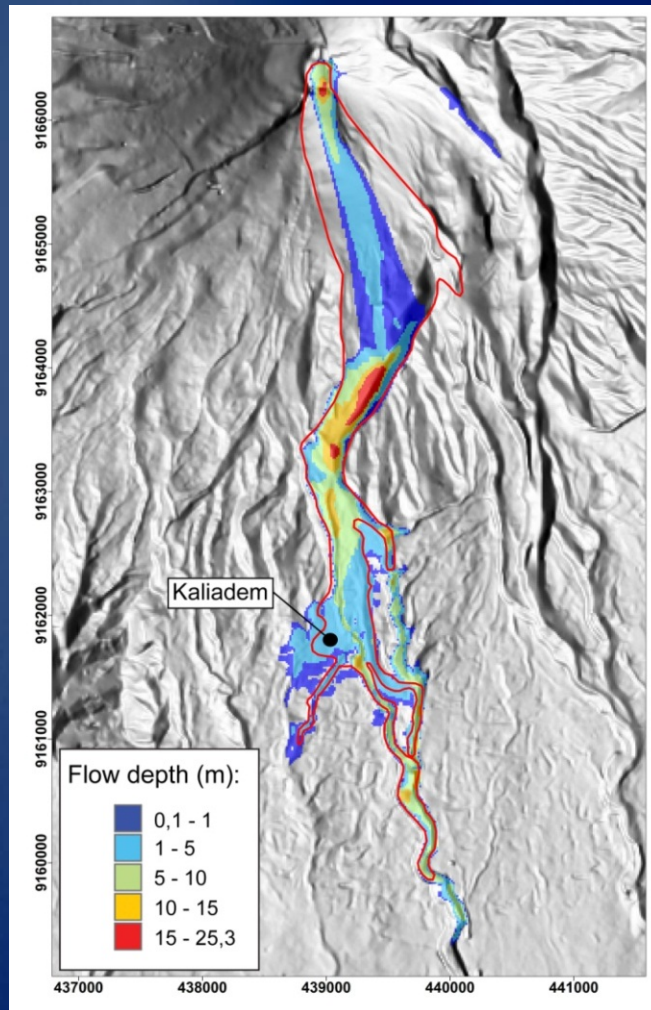
➡ tremendous potential to help us better understand the dynamics of hazardous volcanic flows...
+ define hazard zonations for key areas at risk from future volcanic activity!



Flow simulation at Merapi volcano

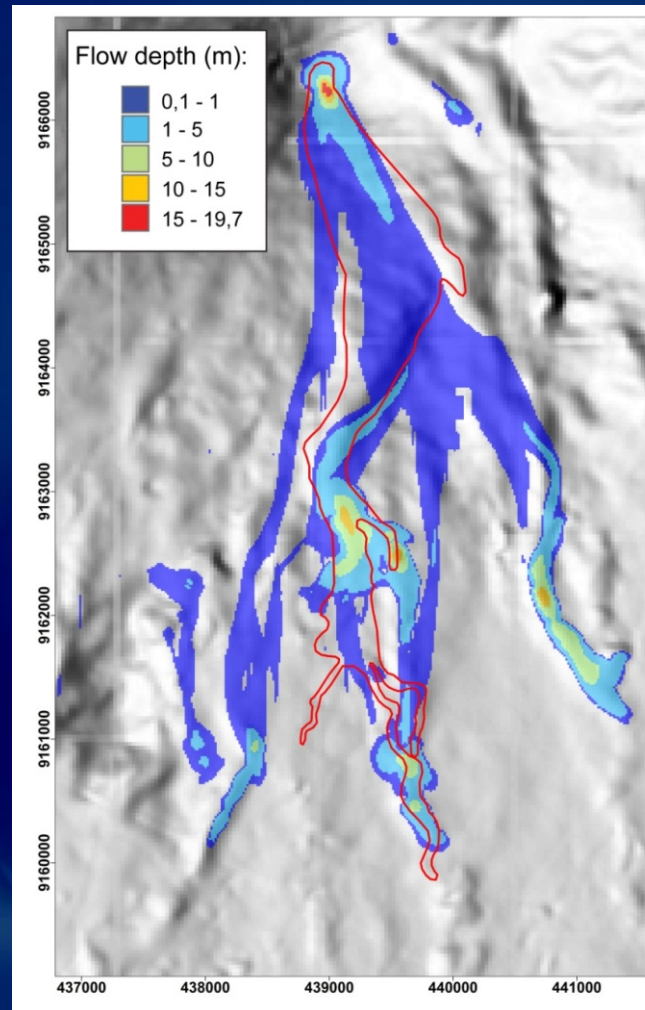


Effects of DEM quality on numerical models



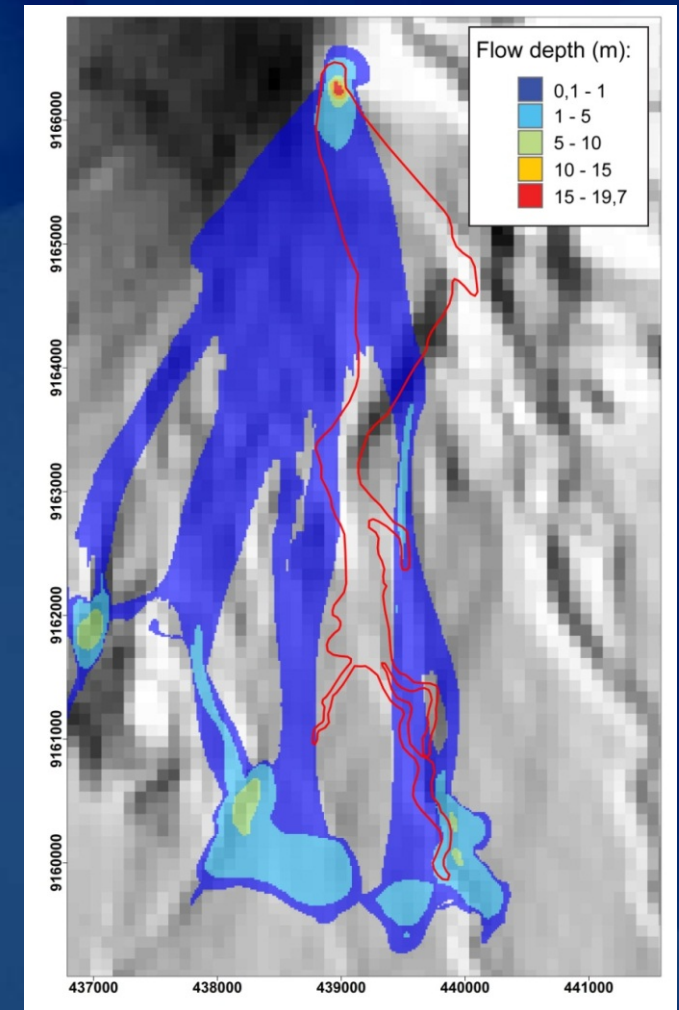
Local DEM

15 m spatial resolution
 ± 9 m vertical accuracy



ASTER GDEM

~30 m spatial resolution
 ± 11 m vertical accuracy



SRTM WRS-2

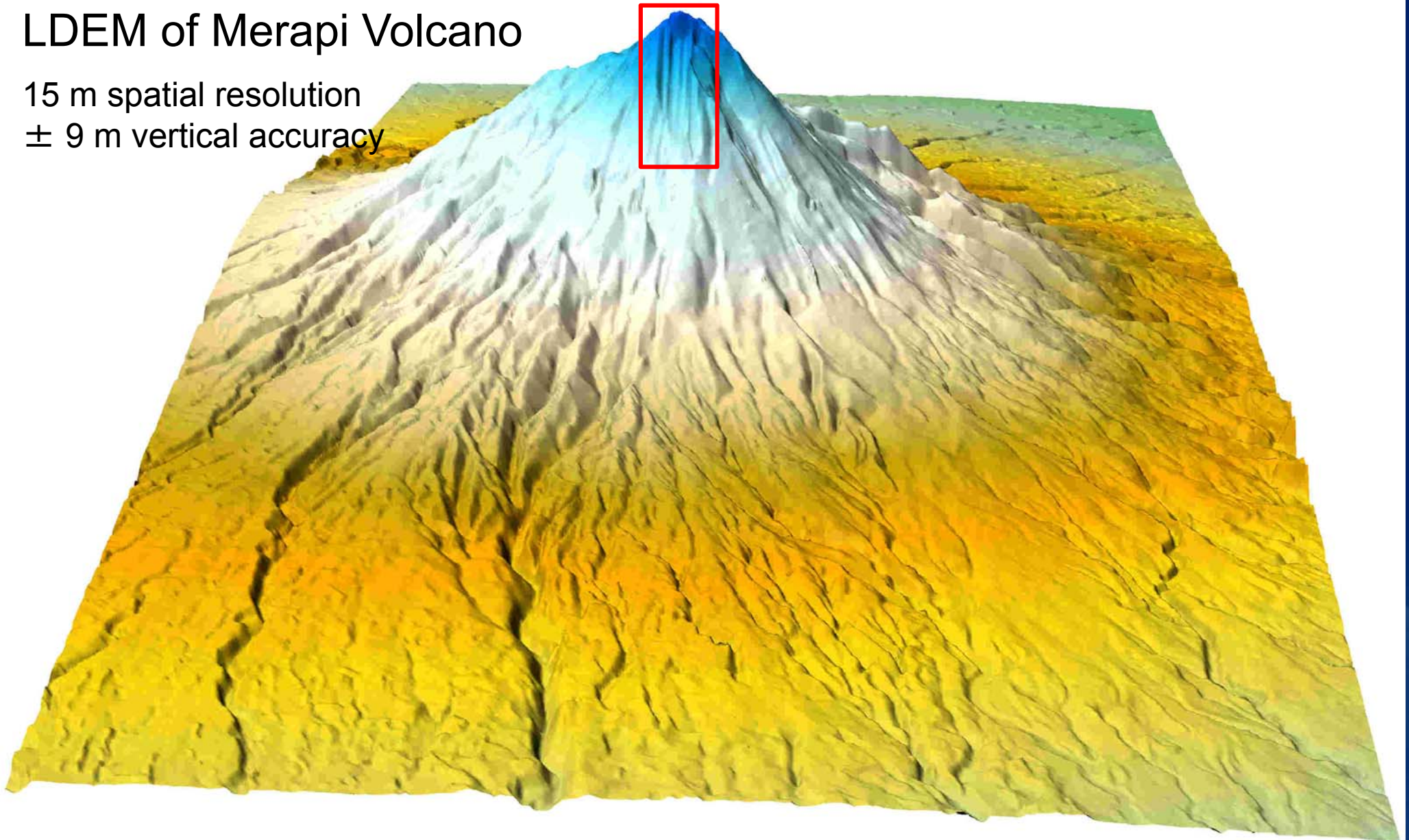
90 m spatial resolution
 ± 10 m vertical accuracy

Flow coverage match: **72.3%** Flow coverage match: **25.6%** Flow coverage match: **7%**

Current DEM errors and anomalies

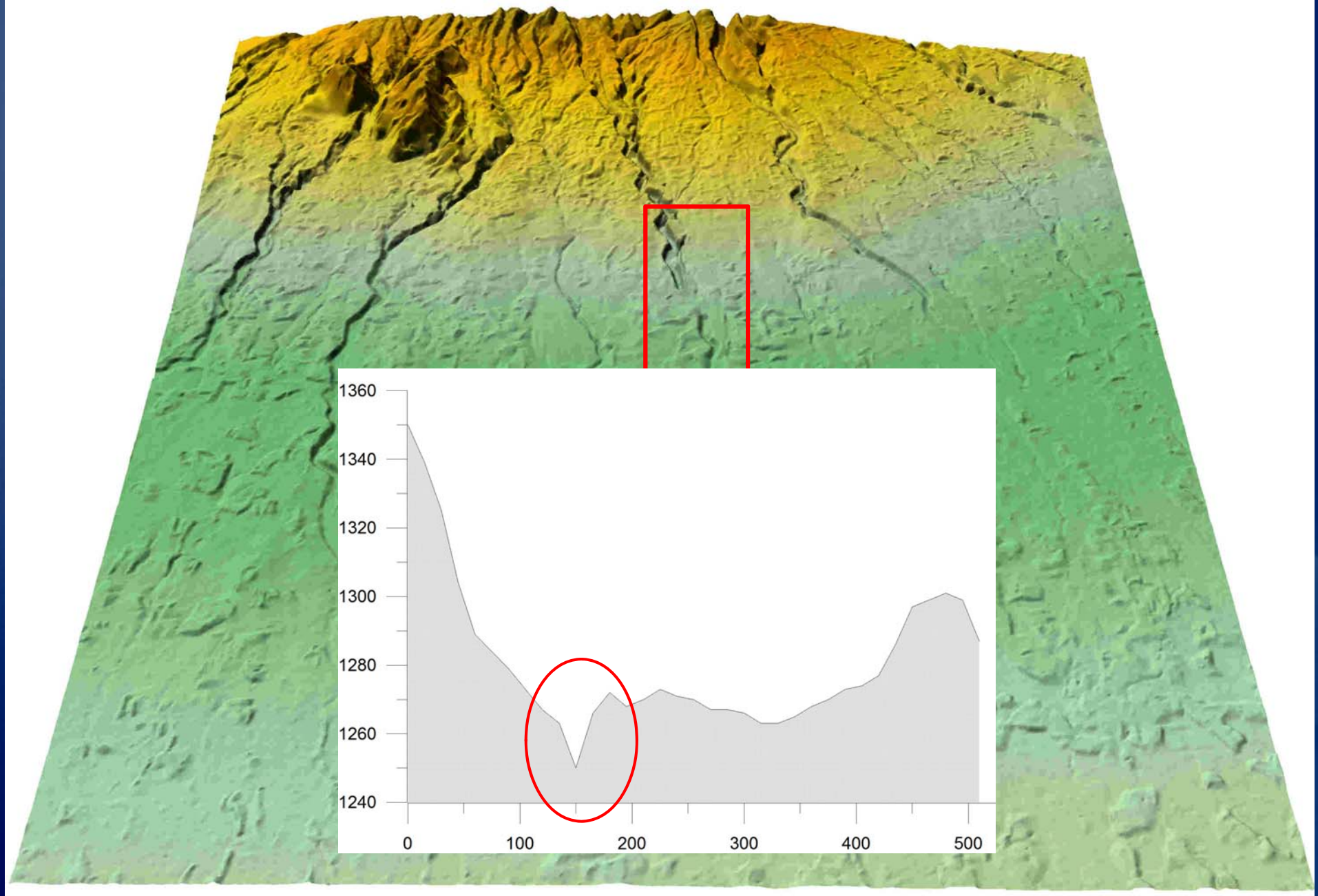
LDEM of Merapi Volcano

15 m spatial resolution
 ± 9 m vertical accuracy

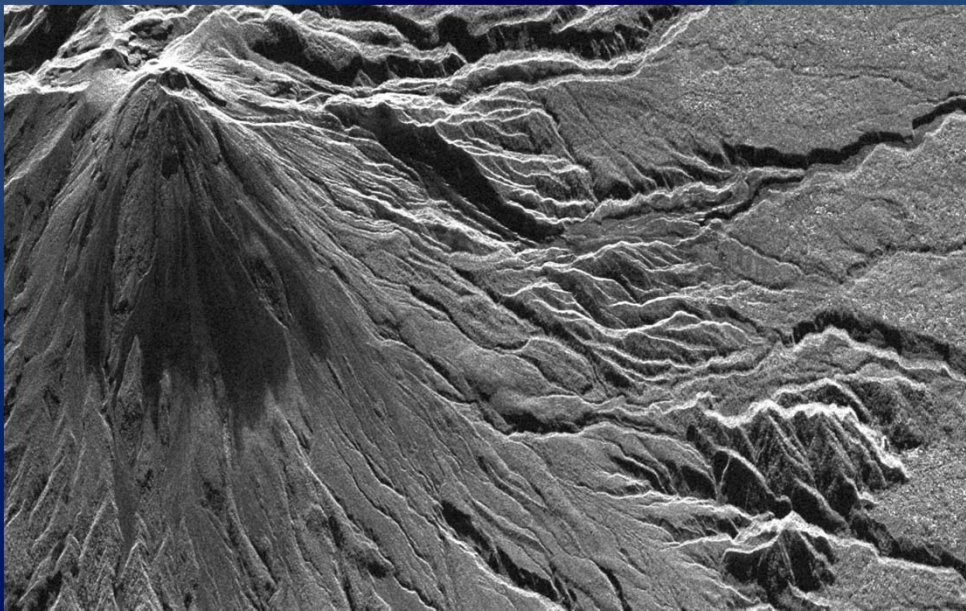


Current DEM errors and anomalies

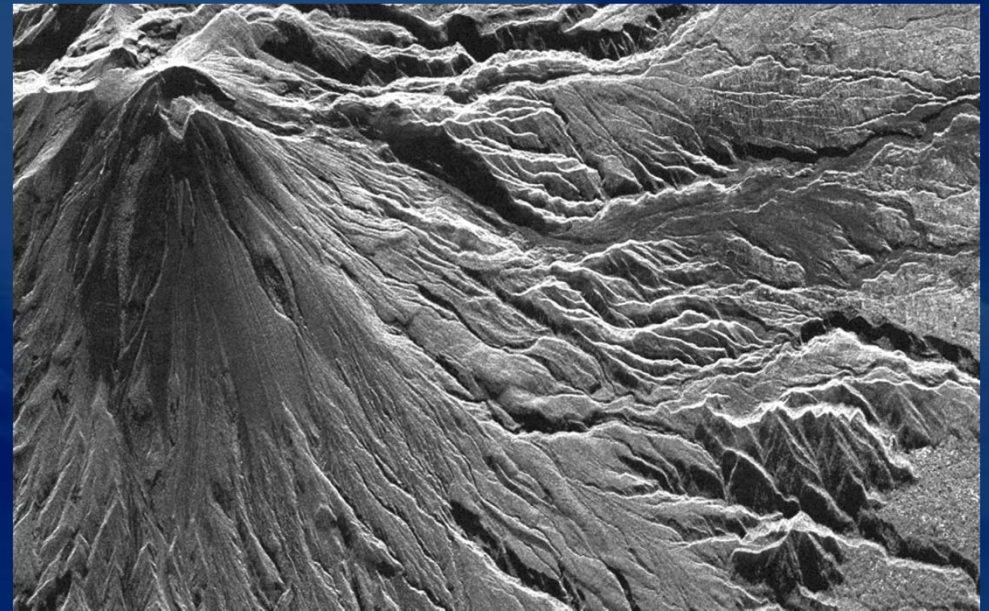
Southern flank of Merapi



Merapi Volcano (Indonesia)

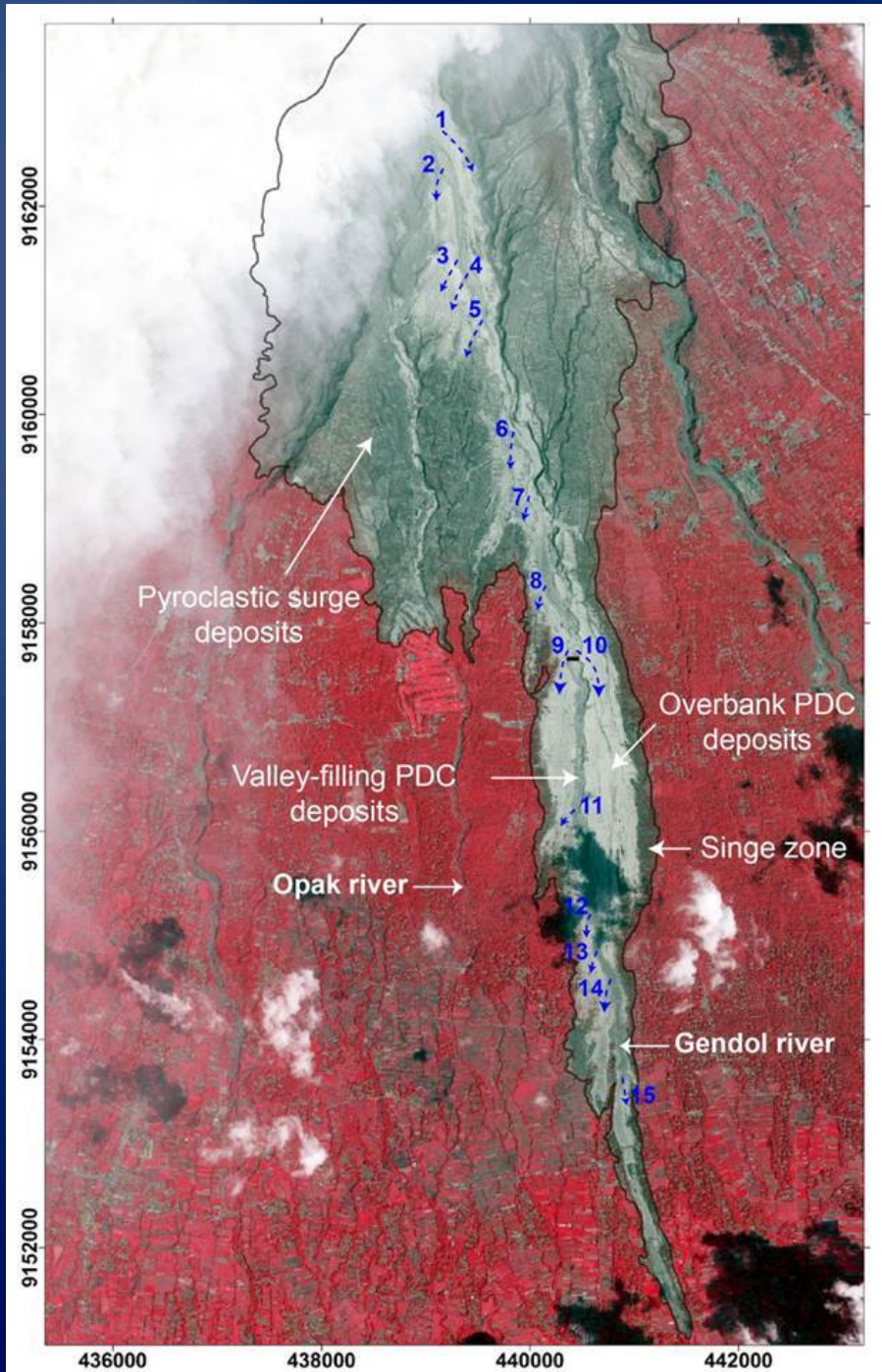


26 Oct. 2010



6 Nov. 2010

Areas and Volumes of the 2010 PDCs



Eruptive phase	Flow type	Area (m ²)	Volume (m ³)	$A/V^{2/3}$	A/L^2
Phase 1	Channeled Gendol	486200	3889600	19.7	0.0085
	Overbank, PDC overspill	388700	1554900	29.0	0.1
	Surges	5 922 600	592 250	839.8	0.191
Phase 2	Channeled & overbank	600 900	4 206 300	23.1	0.0065
Phase 3	Channeled Opak	226 200	678 600	29.3	0.003
	Channeled Gendol	1 307 000	8 873 500	30.5	0.005
	Surges	16 016 300	3 203 300	737.0	0.21
	Overbank 1, re-channeled	693 400	2 773 550	35.1	0.12
	Overbank 2, re-channeled	671 700	2 149 550	40.3	0.18
	Overbank 3, PDC-overspill	143 000	143 000	52.3	-
	Overbank 4, re-channeled	33 100	99 400	15.4	0.03
	Overbank 5, re-channeled	83 600	250 800	21.0	0.045
	Overbank 6, re-channeled	303 300	909 900	32.3	0.077
	Overbank 7, PDC-overspill	340 400	680 800	43.9	-
	Overbank 8, re-channeled	80 850	242 600	20.8	0.083
	Overbank 9, PDC-overspill	382 000	1 222 400	33.4	-
	Overbank 10, PDC-overspill	990 800	1 981 550	62.8	-
	Overbank 11, re-channeled	91 550	247 650	21.7	0.272
	Overbank 12, re-channeled	209 700	629 100	28.6	0.14
	Overbank 13, re-channeled	117 400	352 200	23.5	0.226
	Overbank 14, re-channeled	159 300	796 610	18.5	0.096
	Overbank 15, PDC-overspill	92 000	184 000	28.4	-
Phase 4	Channeled	336 500	336 500	69.5	0.0095
Total channeled		1 533 300	18 233 200		
Total overbank		4 780 900	14 245 000		
Total surges		16 016 300	3 795 500		
Total		22 330 500	36 273 700		

Objectives

Generation of up to date high-resolution DEMs of Merapi :

- existing TanDEM-X acquisitions taken during the 1st global coverage before and after the 2010 eruption
- ➡ testing and validation of the benchmark TanDEM-X + sensitivity of standard volcanic flow models to various qualities of numerical topographies
- ➡ calculation of the volumes + progressive erosion of the 2010 deposits and geometry of the drainage system on the southern flank
→ potential for lahar generation (coll. SEDIMER project)
- └➡ demonstrate the utility of TanDEM-X data products for volcanic flow hazard assessment

Selected Acquisitions

	15/10/2010	03/09/2011	24/10/2011
Mode	Stripmap	Stripmap	Stripmap
Orbit	Descending	Ascending	Descending
Eff. Baseline	162.5 m	115.1 m	76.1 m
Height of Ambiguity	36.4 m	37.8 m	79.1 m
Incidence Angle	37.1°	28.8°	37.3°
Polarization	HH/HH	HH/HH	HH/HH
Average coherence	0.68	0.69	0.79

Methodology

- Data processing using open-source ADORE-DORIS package

The screenshot displays the ADORE-doris project website and its graphical user interface (GUI). The website header includes the project name 'ADORE-doris' and a description: 'Automated DORIS Environment (adore) is a set of bash scripts to ease use of TU-Delft's DORIS software.' Navigation links for 'Project Home', 'Downloads', 'Wiki', 'Issues', and 'Source' are provided. The 'Summary' section contains project information, including a recommendation to follow the project on Google+, a code license of 'GNU GPL v2', and labels such as 'DORIS', 'University of Miami', 'TU Delft', 'Interferometry', 'InSAR', and 'Synthetic Aperture Radar'. It also lists members and featured downloads. The 'Links' section includes external links to TU-Delft DORIS, the project's GitHub page, and a mailing list. The 'Main Goals' and 'Current Features' sections are also visible. The GUI interface, titled 'AGOOEY Settings Editor', shows a list of settings for the 'adore' project, including 'general', 'm_readfiles', 'm_porbits', 'm_crop', 'm_simamp', 'm_timing', 'm_ovs', 's_readfiles', 's_porbits', 's_crop', 's_ovs', 'coarscorr', 'cc_method', 'cc_pos', 'cc_wln', 'cc_wlnsize', 'cc_acc', 'cc_initoff', 'm_filtazi', 'fine', 'reftiming', 'demassist', and 'coregpm'. The 'AGOOEY Process Selector' window is also shown, displaying a grid of process options like 'm_readfiles', 's_readfiles', 'coarscorr', 'demassist', 'subtrfrefpha', 'dlnoi', 'm_porbits', 's_porbits', 'coarscorr', 'coregpm', 'comprefdem', 'slant2h', 'm_crop', 's_crop', 'm_filtazi', 'resample', 'subtrfrefdem', 'geocode', 'm_simamp', 's_filtazi', 'fltrange', 'coherence', 'fine', 'interfero', 'fltphase', 'm_ovs', 's_ovs', 'reftiming', 'comprefpha', and 'unwrap'.

✓ Main Goals:

- Generate high-quality interferograms with ease
- Generate single-master-stack or short-baselines stack interferograms with ease
- Streamline (speed-up) setting-up DORIS input parameters

✓ Current Features:

- Automatic generation of DORIS input files with default parameters
- Interactive mode to quickly generate interferograms
- A method to save/load/edit to easily modify project settings
- Interface for cpxfiddle (to generate raster images)
- Interface to check project status
- Interface to generate SRTM DEM
- Interface to load ArcGIS stitched DEM
- Export DORIS results to Envi, ArcGIS
- Script to load DORIS results into Python environment...

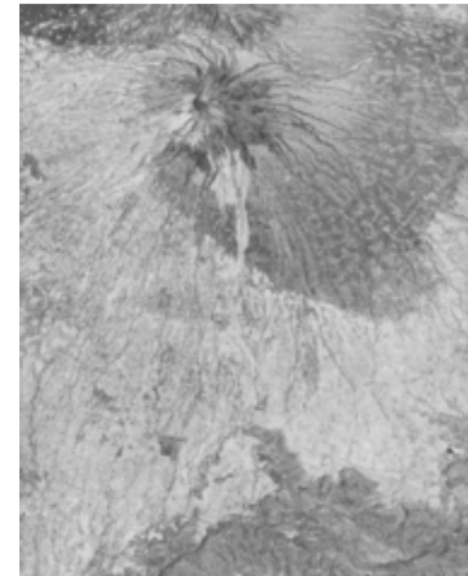
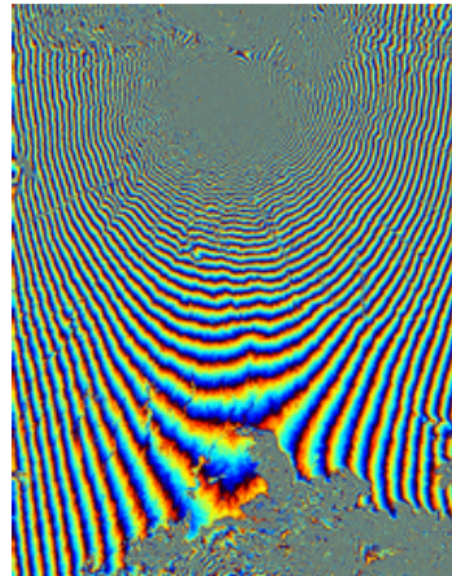
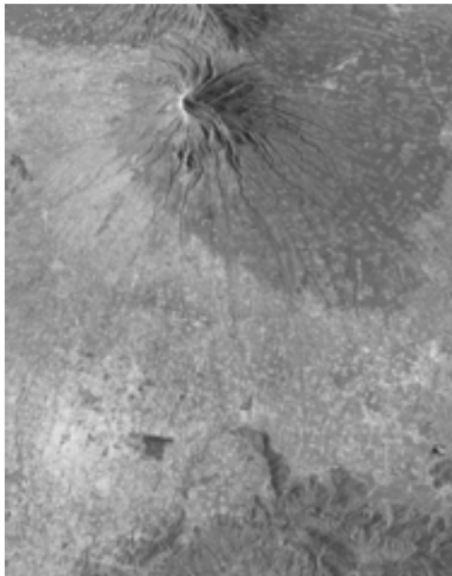
Results

Amplitude

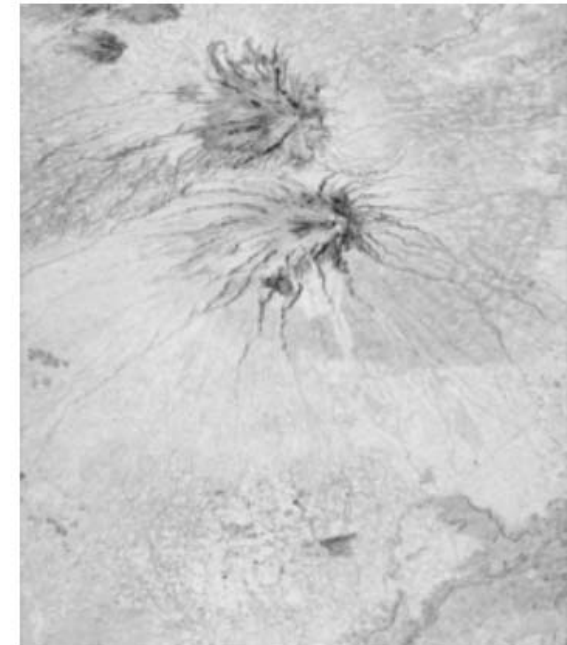
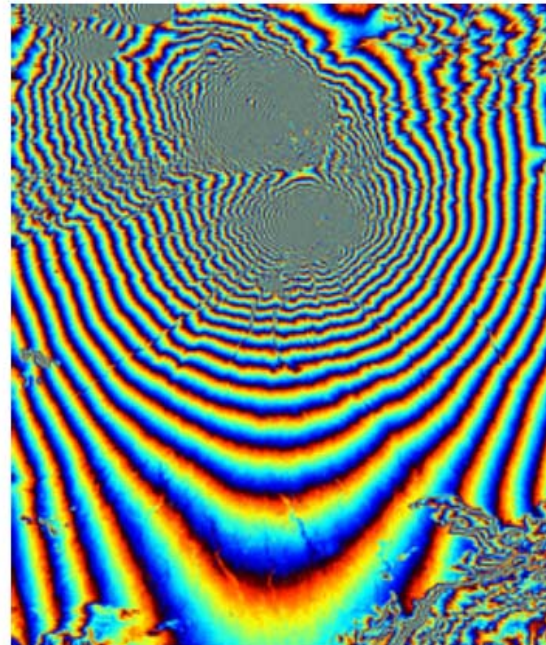
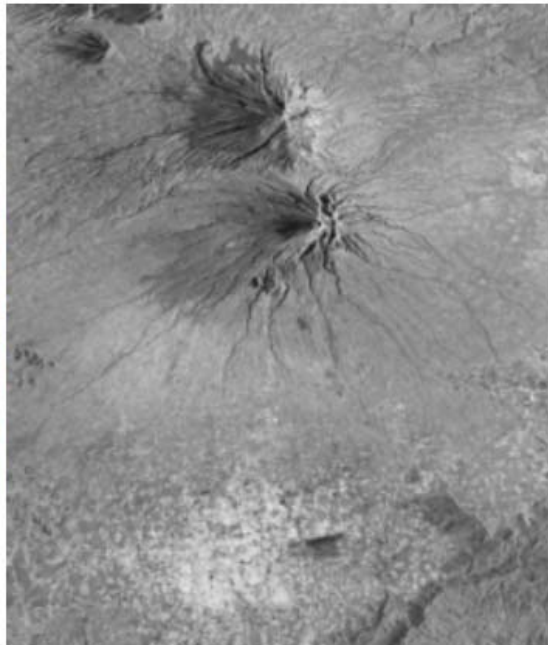
Interferogram

Coherence

Ascending
20110903

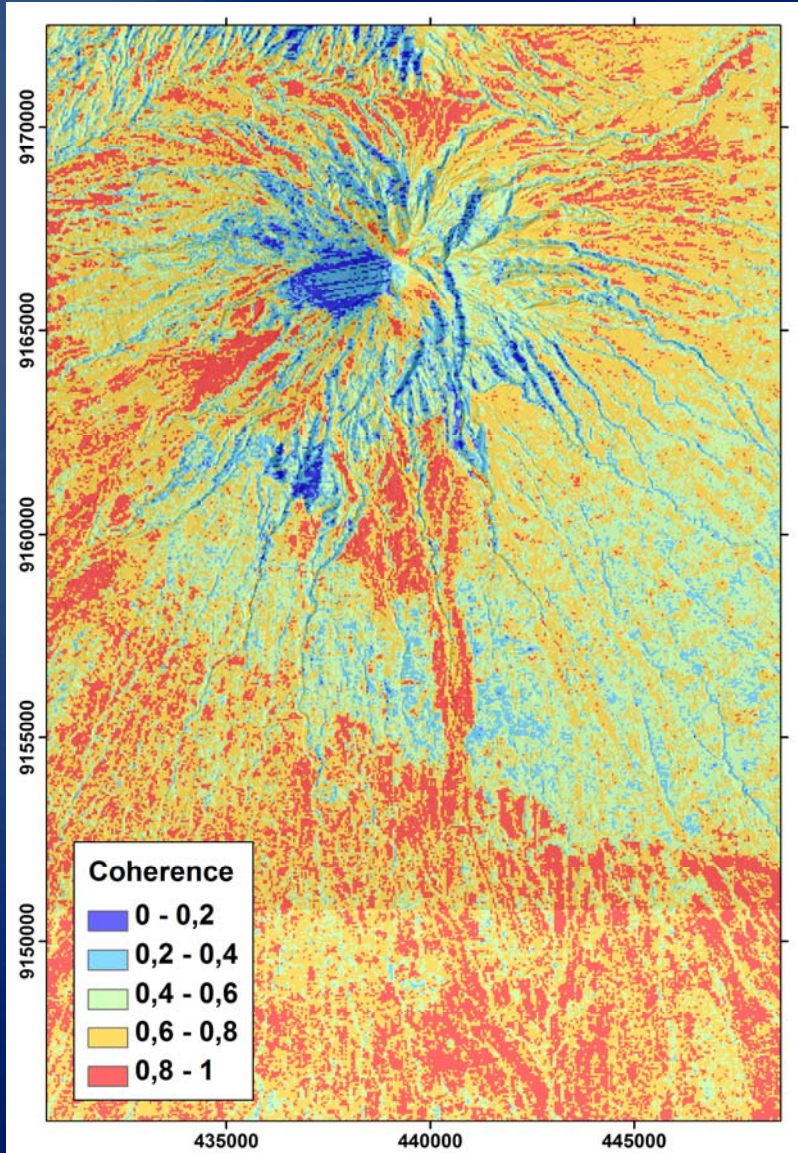


Descending
20111024

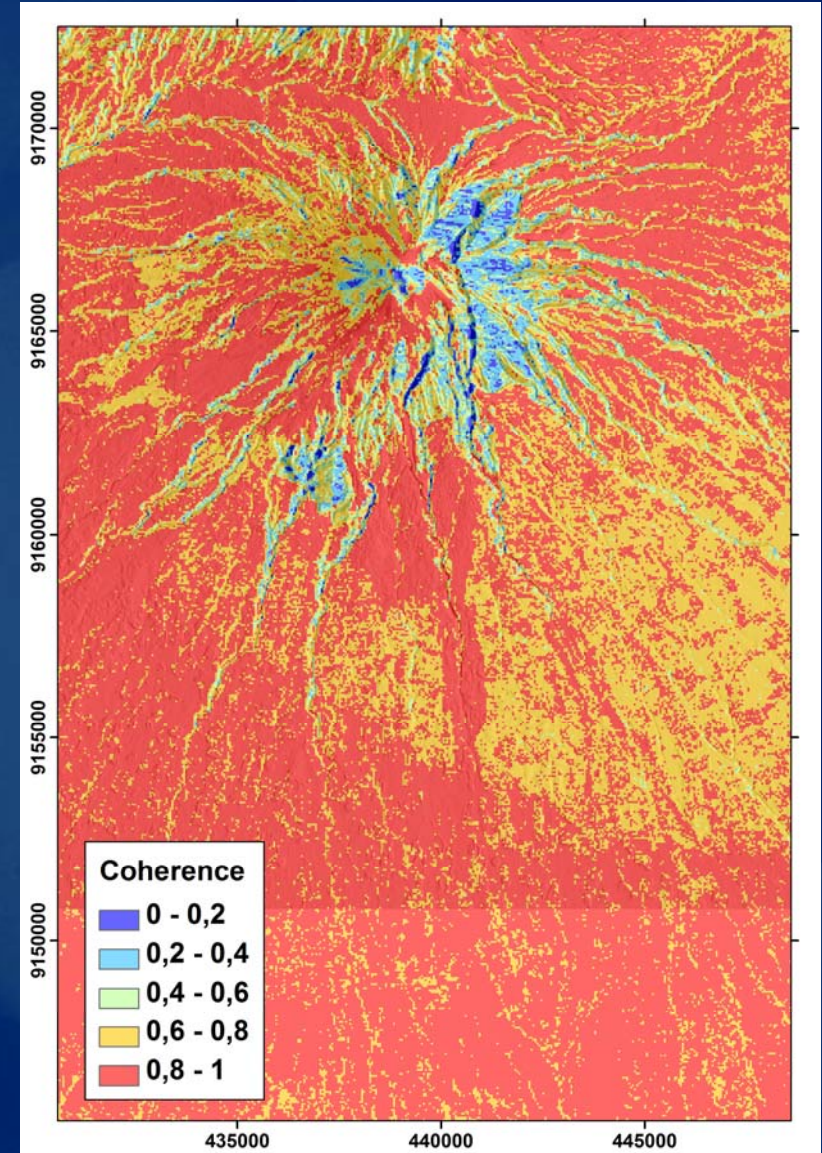


Results: Coherence

Ascending 03/09/2011

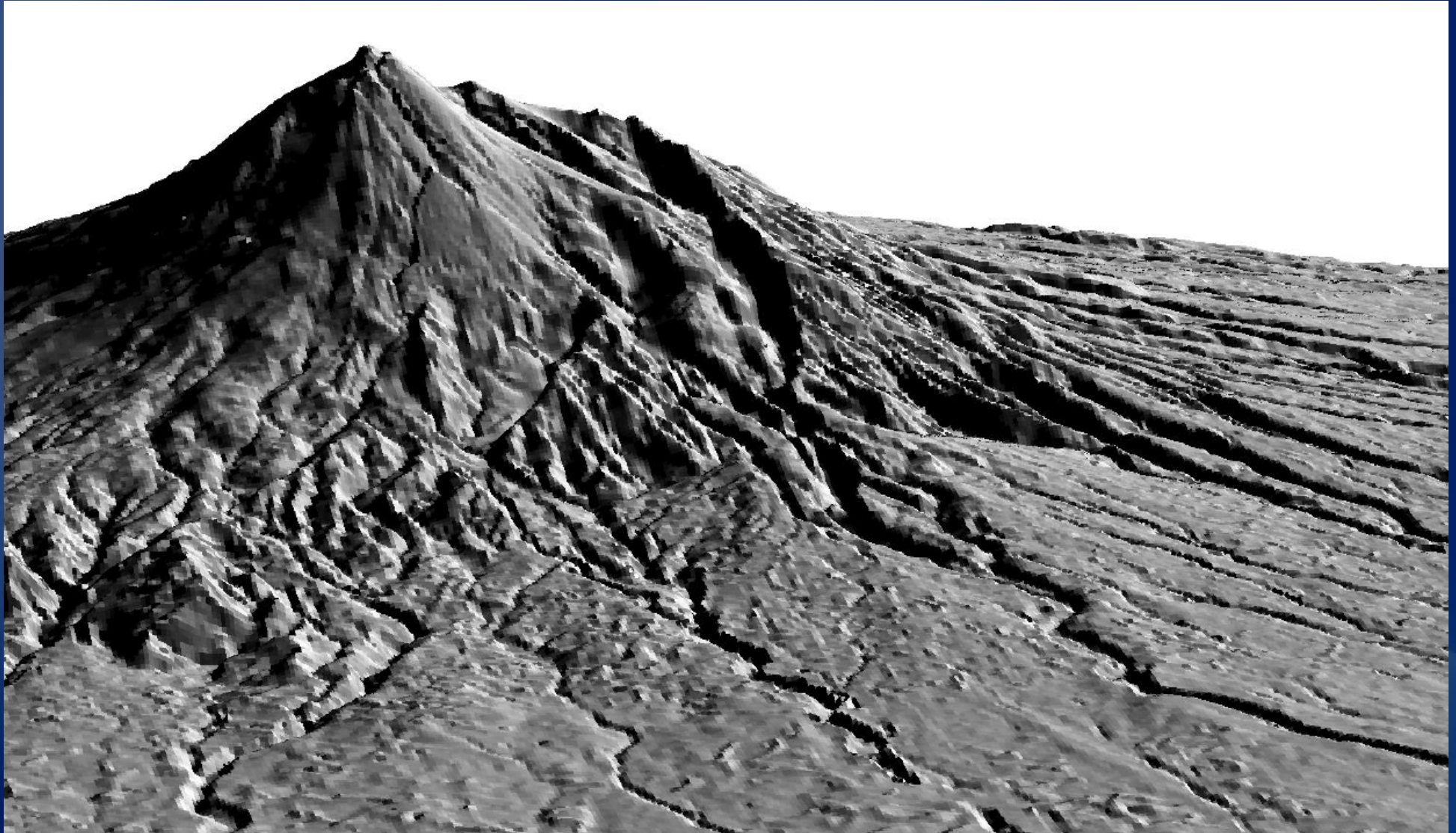


Descending 10/24/2011



- Descending data more coherent than ascending data...
- Loss of coherence in steep and highly vegetated terrains → layover and shadow areas in interferograms → phase unwrapping errors

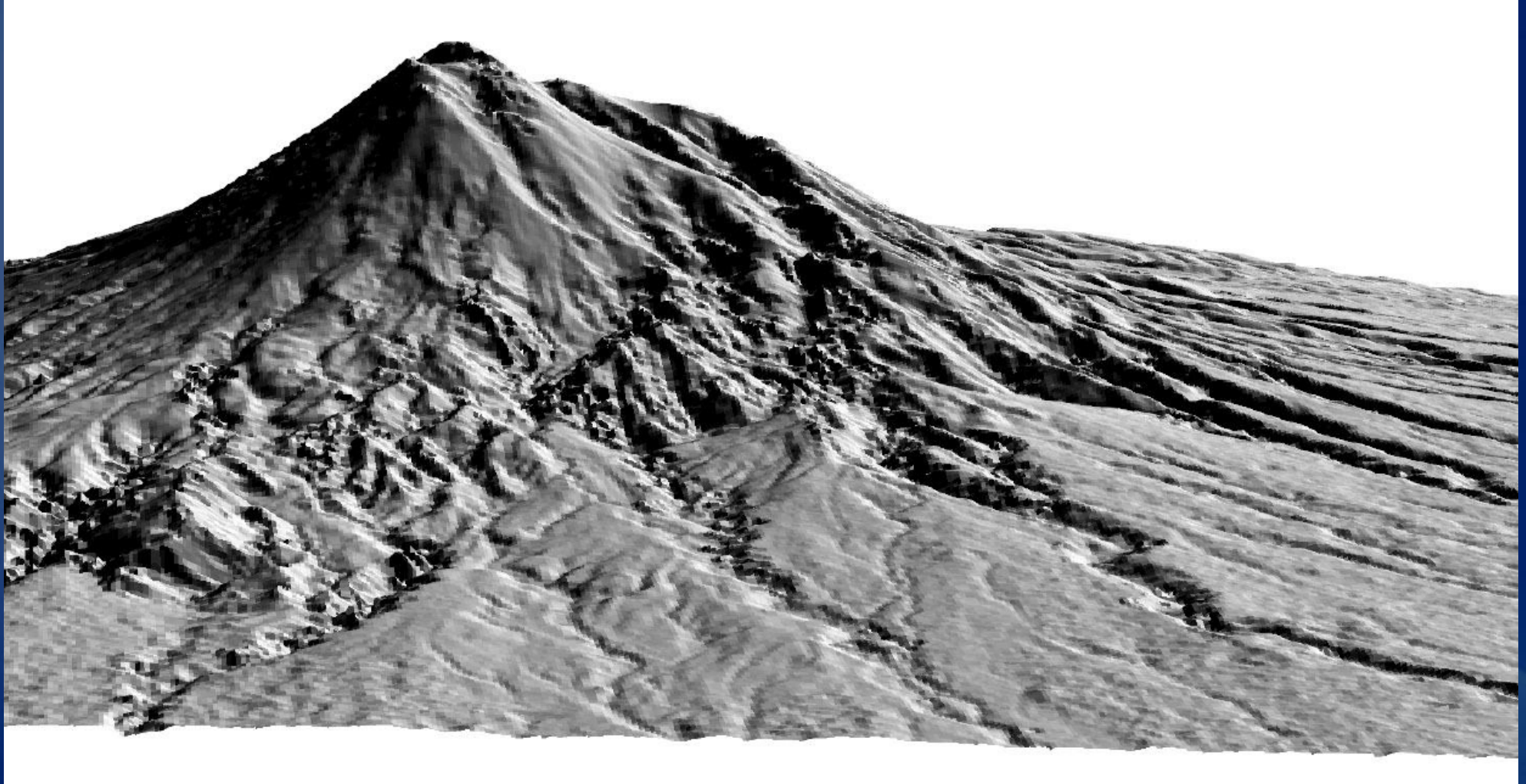
Results: Pre-eruption DEM (reference)



Photogrammetry DEM (1982) 15 m spatial resolution

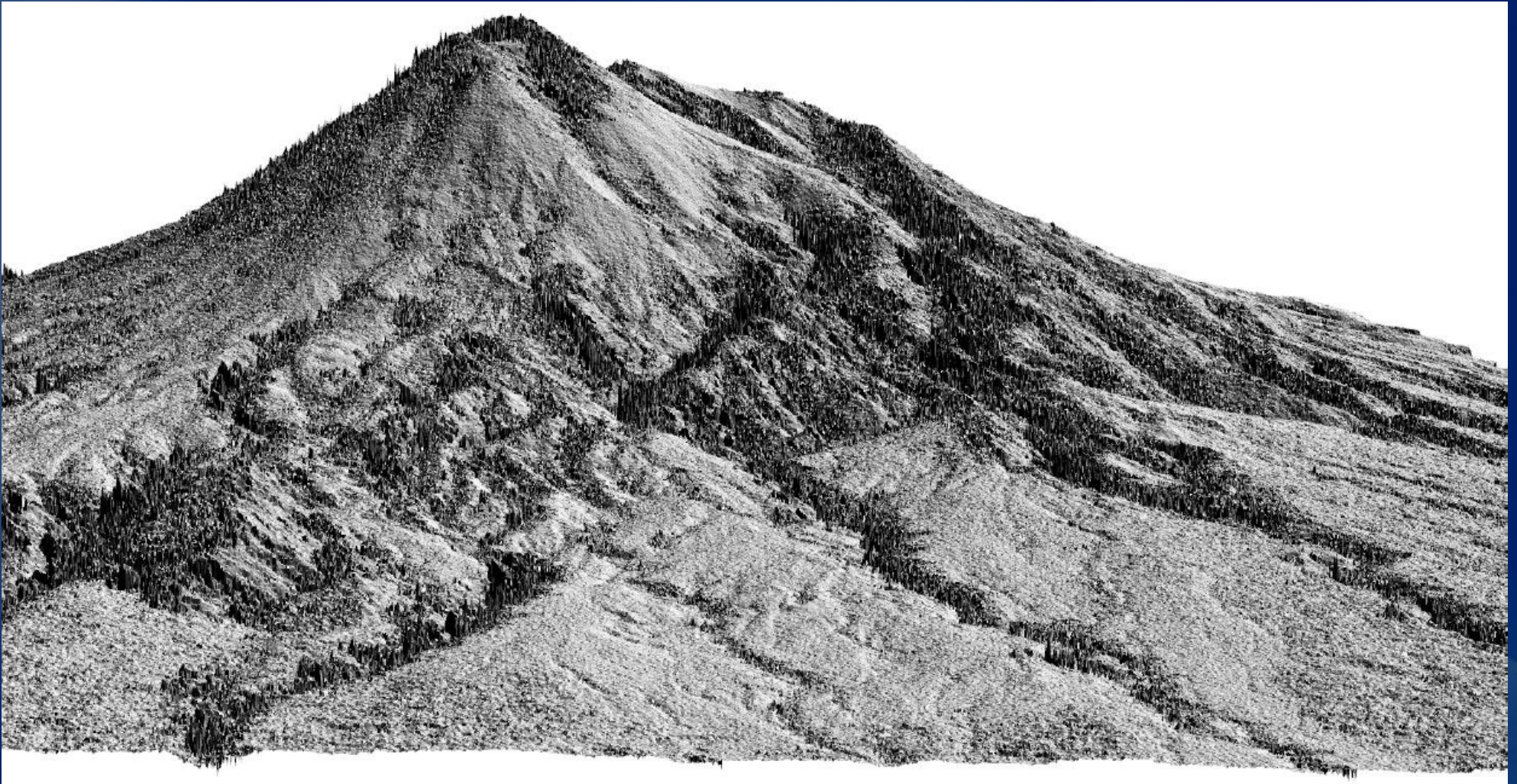
Gerstenecker et al., NHESS, 2005

Results: Post-eruption multi-looked TanDEM



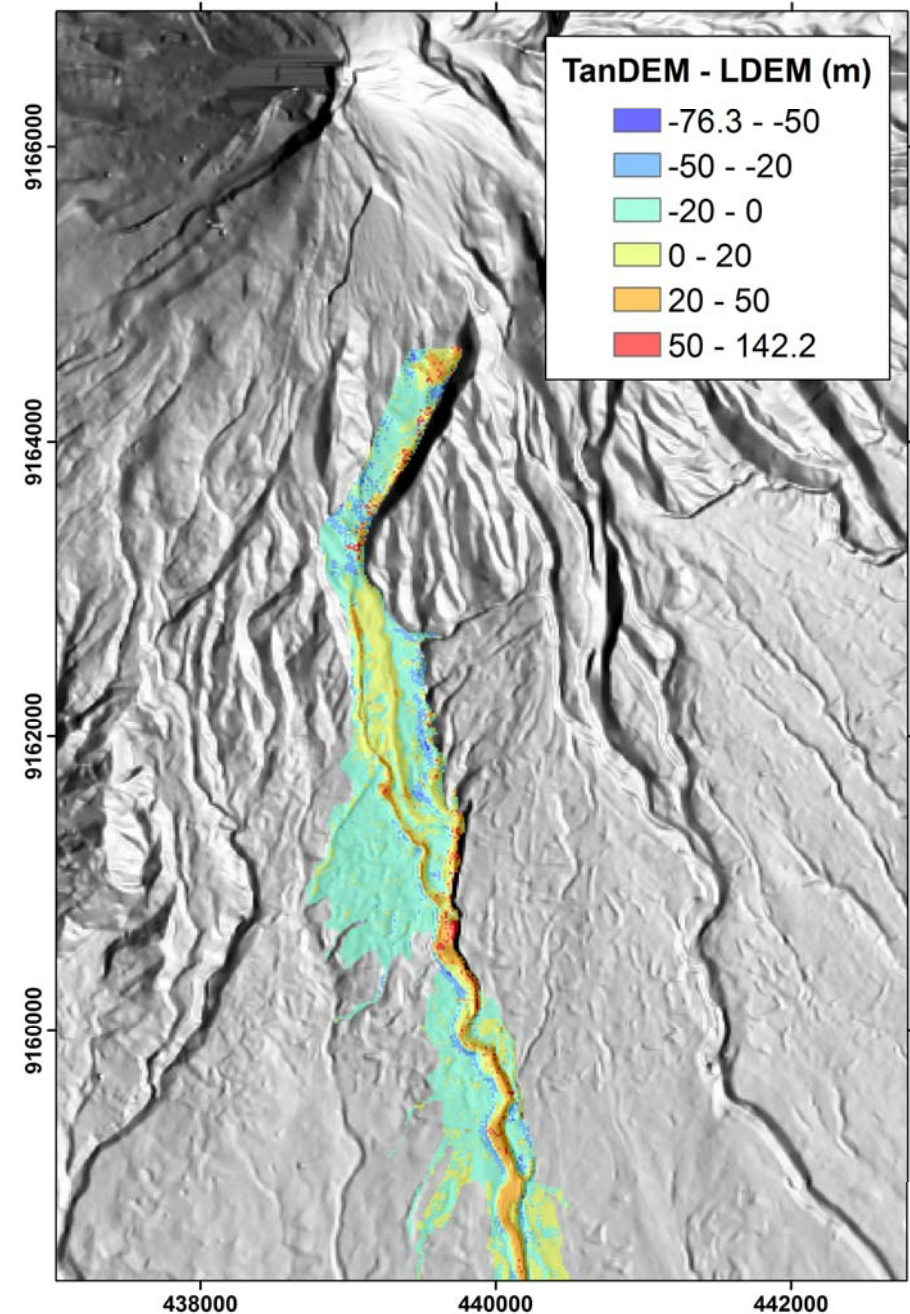
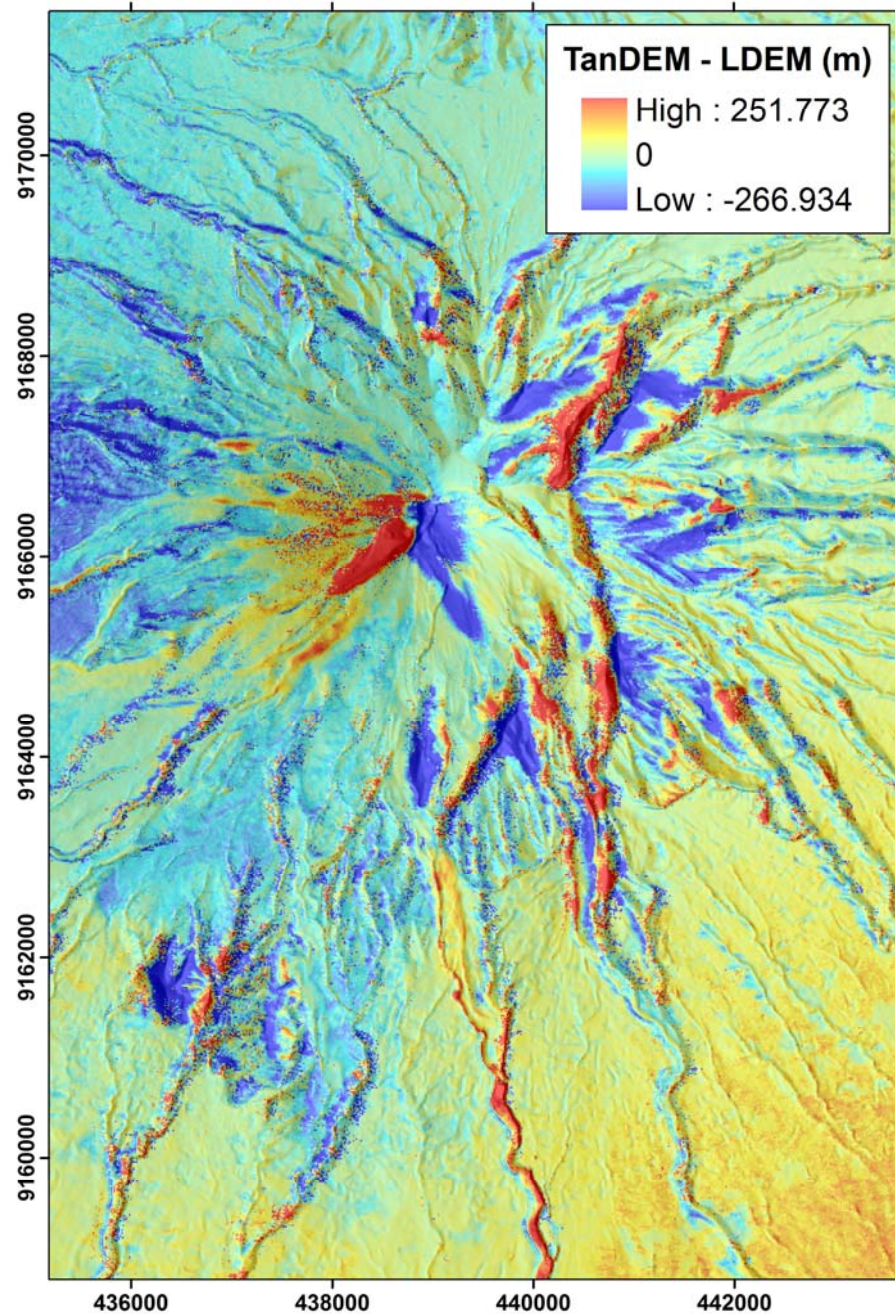
TanDEM-X DEM 20 m spatial resolution
(descending 24/10/2011)

Results: Post-eruption native TanDEM



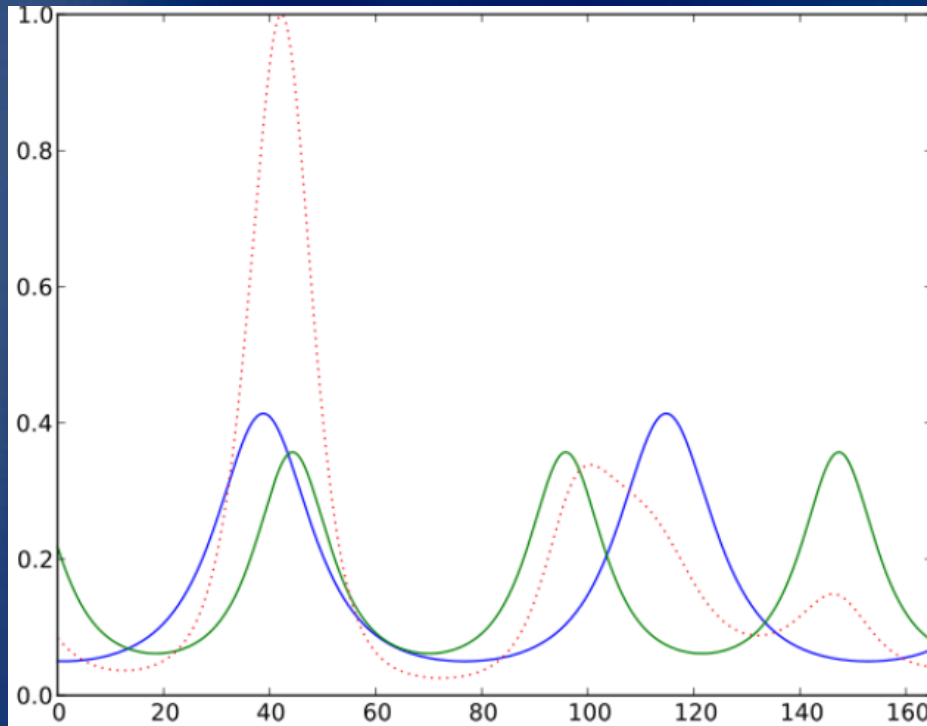
TanDEM-X DEM 3 m spatial resolution
(descending 24/10/2011)

Results: TanDEM - LDEM

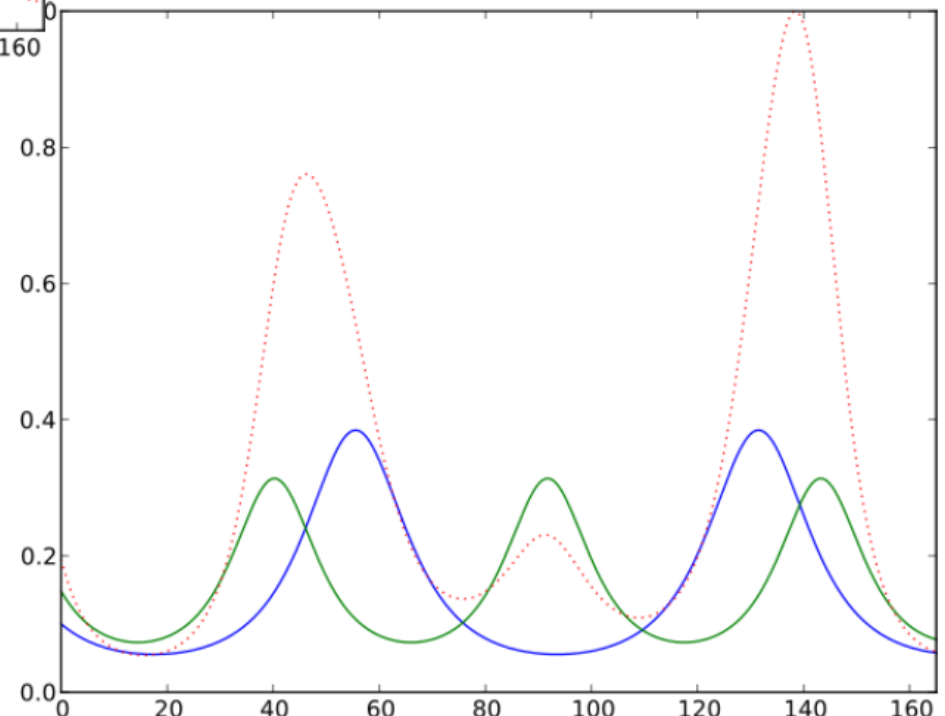


Towards a combined TanDEM...

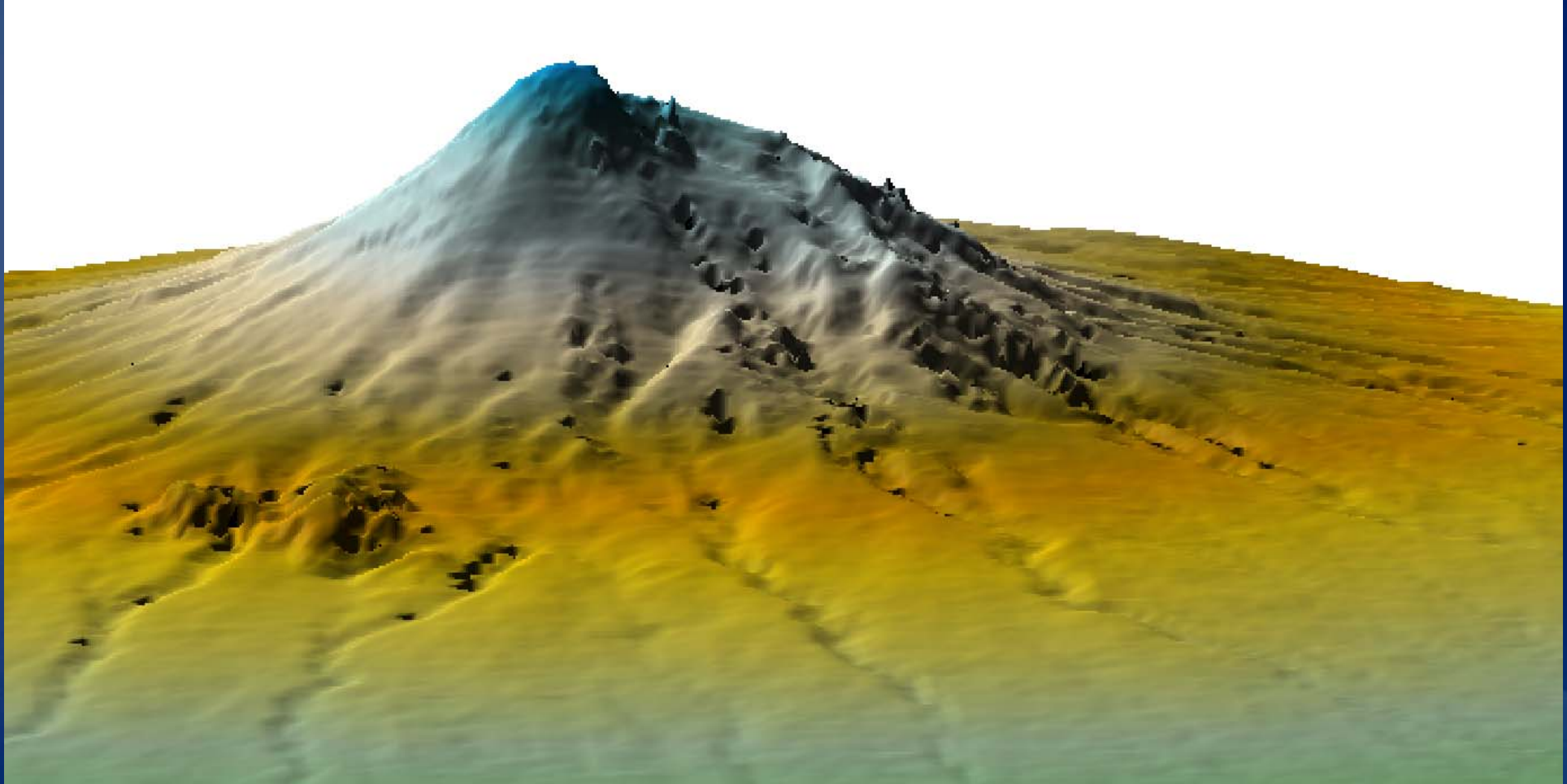
Maximum Likelihood
Estimator



— Ambiguity 100m
— Ambiguity 150m
- - - Joint Ambiguity



Towards a combined TanDEM...





Combined MLE TanDEM at 50 m spatial resolution:

- Better estimation of the topography in low valley gradients... but unwrapping errors are still present in steep slopes!

Preliminary conclusions

Application of TanDEM-X data for volcanic flow hazard assessment is possible but challenging:

- Bistatic and CoSSC data format and processing issues... but now we can (almost) deal with it!
- Phase unwrapping at volcanoes are problematic due to: high fringe rate, large radar shadows at the summit (on steep terrains) and inside valleys
- Combining ascending and descending interferograms to improve coverage becomes difficult due to unwrapping errors...

- 
- Use different radar geometries with larger baselines?
- 
- Use radargrammetry and dual baseline PU correction?

Questions?

