

TanDEM-X data for early mapping and volume estimation of lava flows:

October 2010 Lava flow of Piton de la Fournaise case study

MG Bato

JL Froger, AJL Harris, N Villanueva, T Souriot

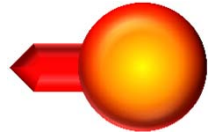
Photo credits: J. Balleydier

5th TerraSAR-X / 4th Tandem-X Science Meeting

10-14 June 2013

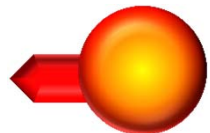
DLR, Germany





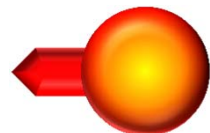
Imaging the Piton de la Fournaise Eruption Through InSAR

- ... The Piton de la Fournaise
- ... InSAR Volcano Monitoring in Piton de la Fournaise
- ... The October 2010 Eruption with TerraSAR-X



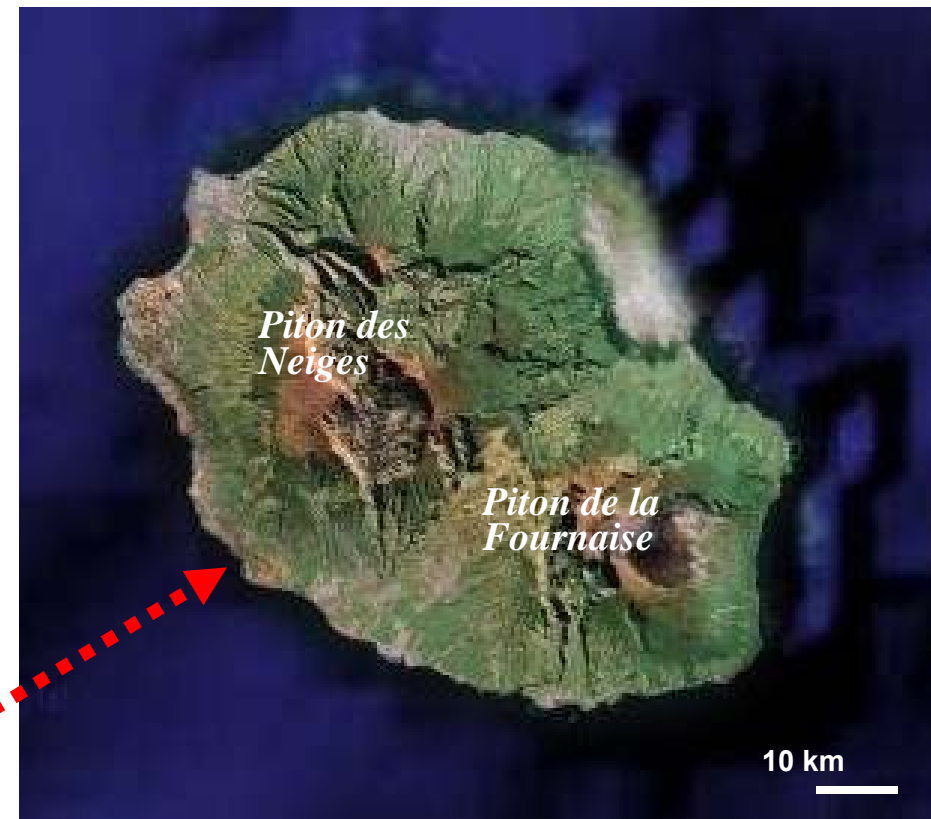
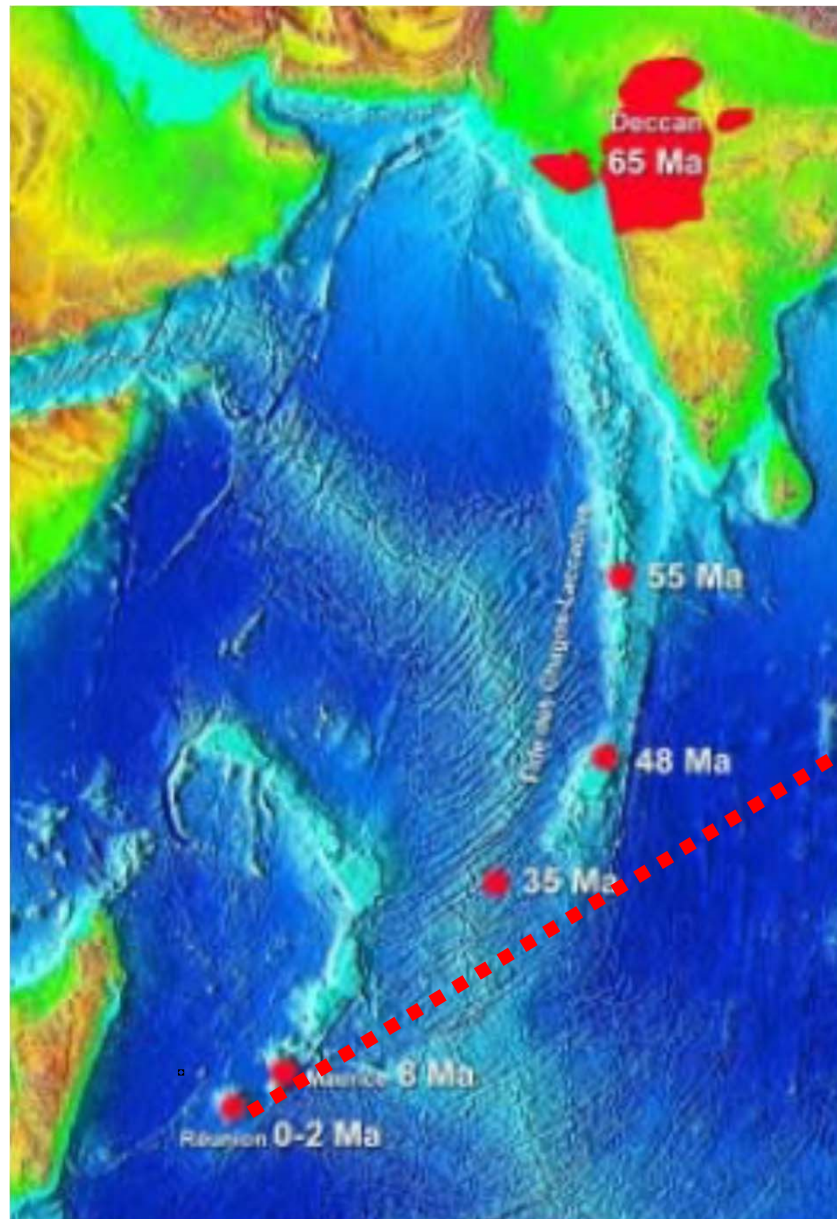
Characterizing the October 2010 Lava Flow using **Cosmo-SkyMed** Data

- ... Image Extraction
- ... Phase Unwrapping
- ... Detrending
- ... The Inversion Model
- ... Conclusion



Characterizing the October 2010 Lava Flow using **Tandem-X** Data

- ... Results
- ... Conclusion

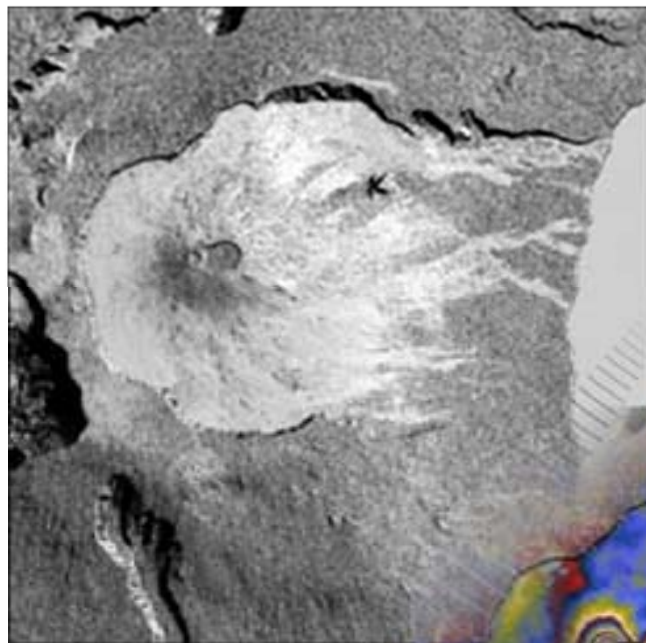
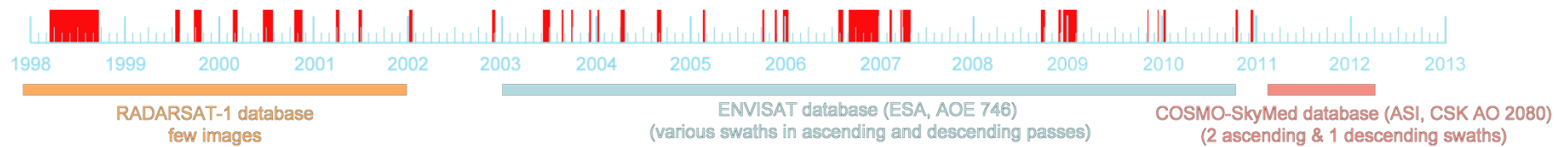


Reunion Island

700 – 800 km east of Madagascar

Deep mantle and constructive plate volcanism

Two basaltic shield volcanoes

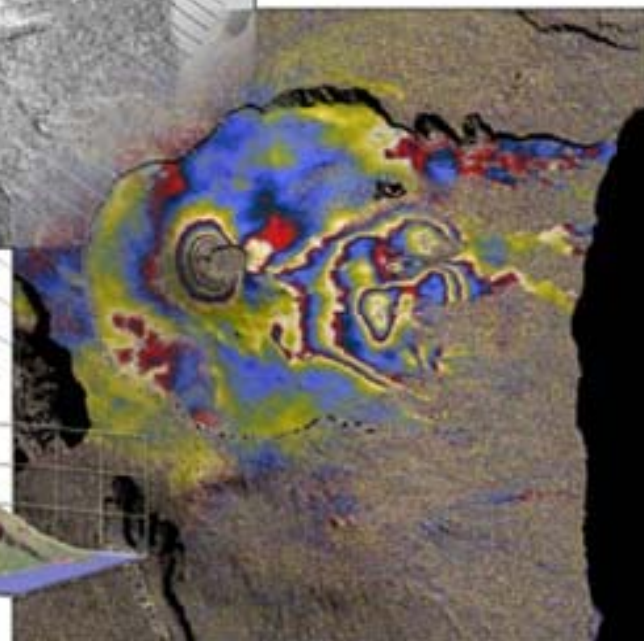
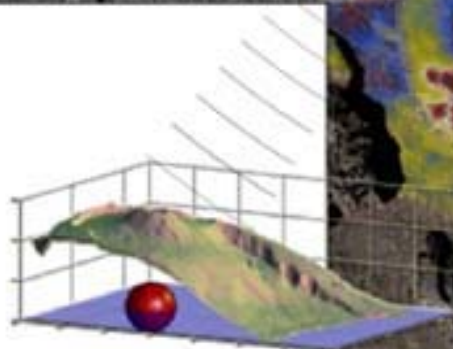


PALSAR database (ESA-JAXA, ALOS ADEN 3622)
(3 swaths in ascending passes)

TerraSAR-X database (CNES-KALIDEOS, DLR LAN 0237)
(1 ascending & 1 descending swaths)

RADARSAT-2 database (CSA-MDA, SOAR 2314)
(2 ascending & 1 descending swaths)

TanDEM-X database



CASOAR

LMV: CASOAR : LIST SELE

← → ↻ https://www.obs.univ-bpclermont.fr/casoar/index_liste.php 🔍 ⭐ ☰

LIST SELECTOR Observatoire de Physique
du Globe de Clermont-Ferrand
Laboratoire Magmas et Volcans

[LOGOUT] [LIST SELECTION] [MAP SELECTION] [TABLE SELECTION] [DEBILITABLES] [PERSON INFO] [HELP] [CONTACT]

User: Bato / OI2
Last connection : 2010-06-28 23:24:23

Folder Selection [RESET]

Projects

- OI2 (Reunion Island)
- ENVISAT_A SAR_ILC
- ENVISAT_A SAR_INTERF
- ENVISAT_MERSI
- ALOS_PAL SAR_ILC
- ALOS_PAL SAR_INTERF
- RADARSAT_ILC
- RADARSAT_INTERF
- TERRA_SAR_X_ILC
- TERRA_SAR_X_INTERF
- OSMO-SKYMED_ILC
- OSMO-SKYMED_INTERF
- Information

General Selection [RESET]

TerraSAR X

Select All Select None Beam All

Mode Ass Desc Droit

Polar: ☒ Single ☒ Dual ☒ Quad ☒ Triplex From 0 To 99999

Order by: Date Normal

And by: Orbit Normal

[Update] [Import] [Export]

TerraSAR X : OI2 - 70 input(s)

	Project	Target	Acquiring Date	Receiving Date	Pass	Mission	Product	PoliMode	Beam	Orbit
	OI2	reunion	2005-12-15	2005-01-21	Des.	TAXI	IM	SINGLE	strip_010	8304
	OI2	reunion	2005-12-24	2005-01-21	Des.	TAXI	IM	SINGLE	strip_010	8471
	OI2	reunion	2005-01-16	2005-02-02	Des.	TAXI	IM	SINGLE	strip_010	8386
	OI2	reunion	2005-02-17	2005-02-02	Des.	TAXI	IM	SINGLE	strip_010	8308
	OI2	reunion	2005-02-07	2005-06-10	Ass.	TAXI	IM	SINGLE	strip_005	8687
	OI2	reunion	2005-02-22	2005-06-10	Des.	TAXI	IM	SINGLE	strip_010	8387
	OI2	reunion	2005-04-09	2005-06-10	Ass.	TAXI	IM	SINGLE	strip_005	10003
	OI2	reunion	2005-04-24	2005-06-10	Des.	TAXI	IM	SINGLE	strip_010	10305
	OI2	reunion	2005-05-12	2005-06-10	Ass.	TAXI	IM	SINGLE	strip_005	10009
	OI2	reunion	2005-06-27	2005-06-10	Des.	TAXI	IM	SINGLE	strip_010	10309
	OI2	reunion	2005-06-29	2005-11-12	Des.	TAXI	IM	SINGLE	strip_010	11210
	OI2	reunion	2005-02-01	2005-11-12	Des.	TAXI	IM	SINGLE	strip_010	11211
	OI2	reunion	2005-09-05	2005-11-12	Des.	TAXI	IM	SINGLE	strip_010	12212
	OI2	reunion	2005-09-21	2005-11-12	Ass.	TAXI	IM	SINGLE	strip_005	12501
	OI2	reunion	2005-10-06	2005-11-12	Des.	TAXI	IM	SINGLE	strip_010	12213
	OI2	reunion	2005-10-15	2005-11-12	Ass.	TAXI	IM	SINGLE	strip_005	12927
	OI2	reunion	2005-10-17	2005-11-12	Des.	TAXI	IM	SINGLE	strip_010	12906
	OI2	reunion	2005-10-24	2010-06-10	Ass.	TAXI	IM	SINGLE	strip_005	15094
	OI2	reunion	2005-10-23	2005-11-18	Des.	TAXI	IM	SINGLE	strip_010	15147
	OI2	reunion	2005-11-03	2010-06-10	Des.	TAXI	IM	SINGLE	strip_010	15214
	OI2	reunion	2005-11-29	2010-06-10	Ass.	TAXI	IM	SINGLE	strip_005	15696
	OI2	reunion	2005-12-11	2010-06-10	Des.	TAXI	IM	SINGLE	strip_010	15216
	OI2	reunion	2005-12-29	2010-06-11	Ass.	TAXI	IM	SINGLE	strip_005	14096
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	OI2	reunion	2010-01-21	2010-06-11	Ass.	TAXI	IM	SINGLE	strip_005	14687
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	OI2	reunion	2010-04-22	2010-06-11	Des.	TAXI	IM	SINGLE	strip_010	15218
	OI2	reunion	2010-05-10	2010-06-11	Ass.	TAXI	IM	SINGLE	strip_005	18100

Data provided by CNES/DLR

reunion 3 D 3010 8304

reunion 3 D 3010 8471

reunion 3 D 3010 8386

reunion 3 D 3010 8308

reunion 3 D 3010 8687

reunion 3 D 3010 8387

reunion 3 D 3010 10003

reunion 3 D 3010 10305

reunion 3 D 3010 10009

reunion 3 D 3010 10309

reunion 3 D 3010 11210

reunion 3 D 3010 11211

reunion 3 D 3010 12212

reunion 3 D 3010 12501

reunion 3 D 3010 12213

reunion 3 D 3010 12927

reunion 3 D 3010 12906

reunion 3 D 3010 15094

reunion 3 D 3010 15147

reunion 3 D 3010 15214

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reunion 3 D 3010 14316

reunion 3 D 3010 14687

reunion 3 D 3010 14817

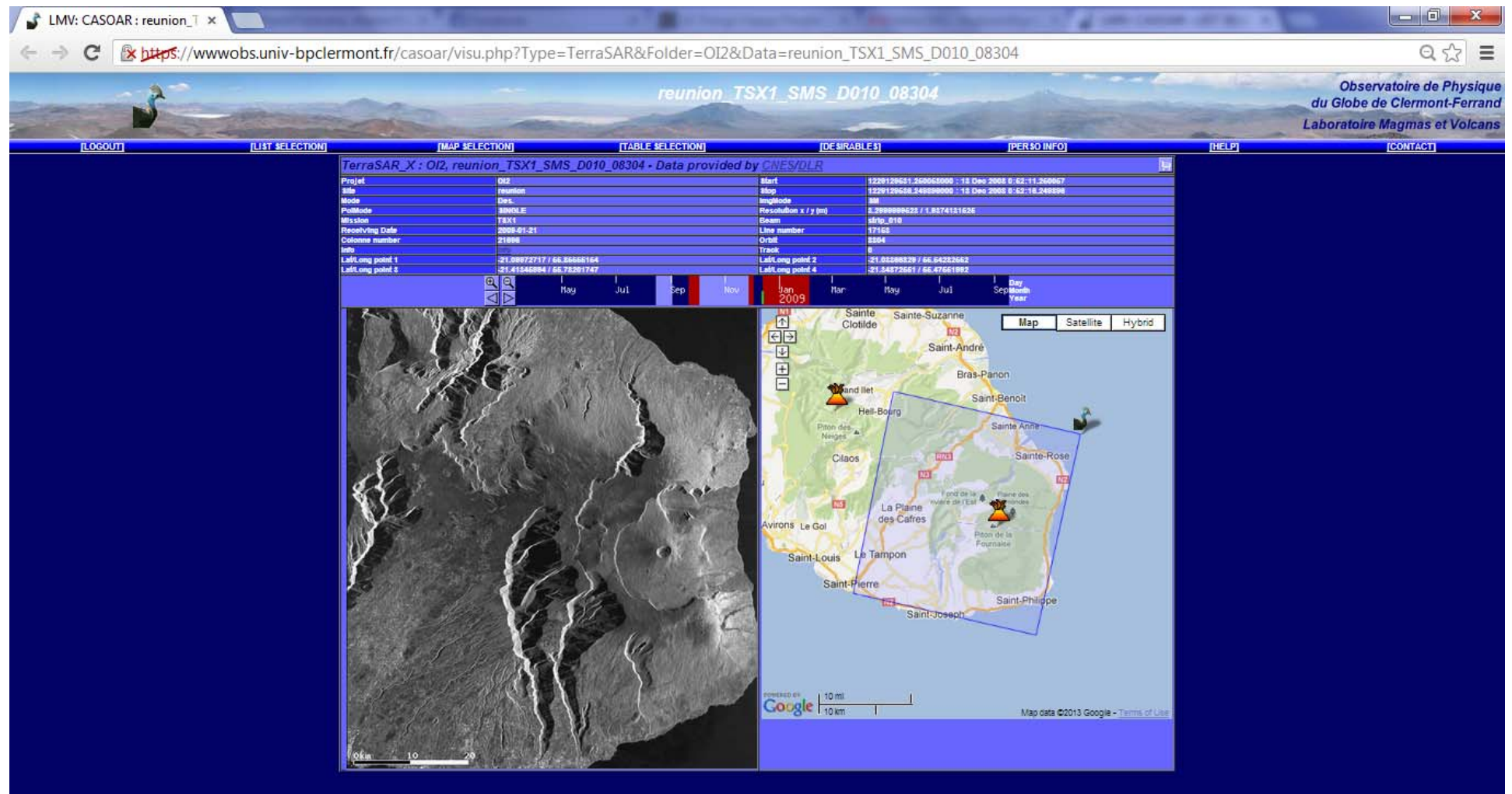
reunion 3 D 3010 16091

reunion 3 D 3010 15215

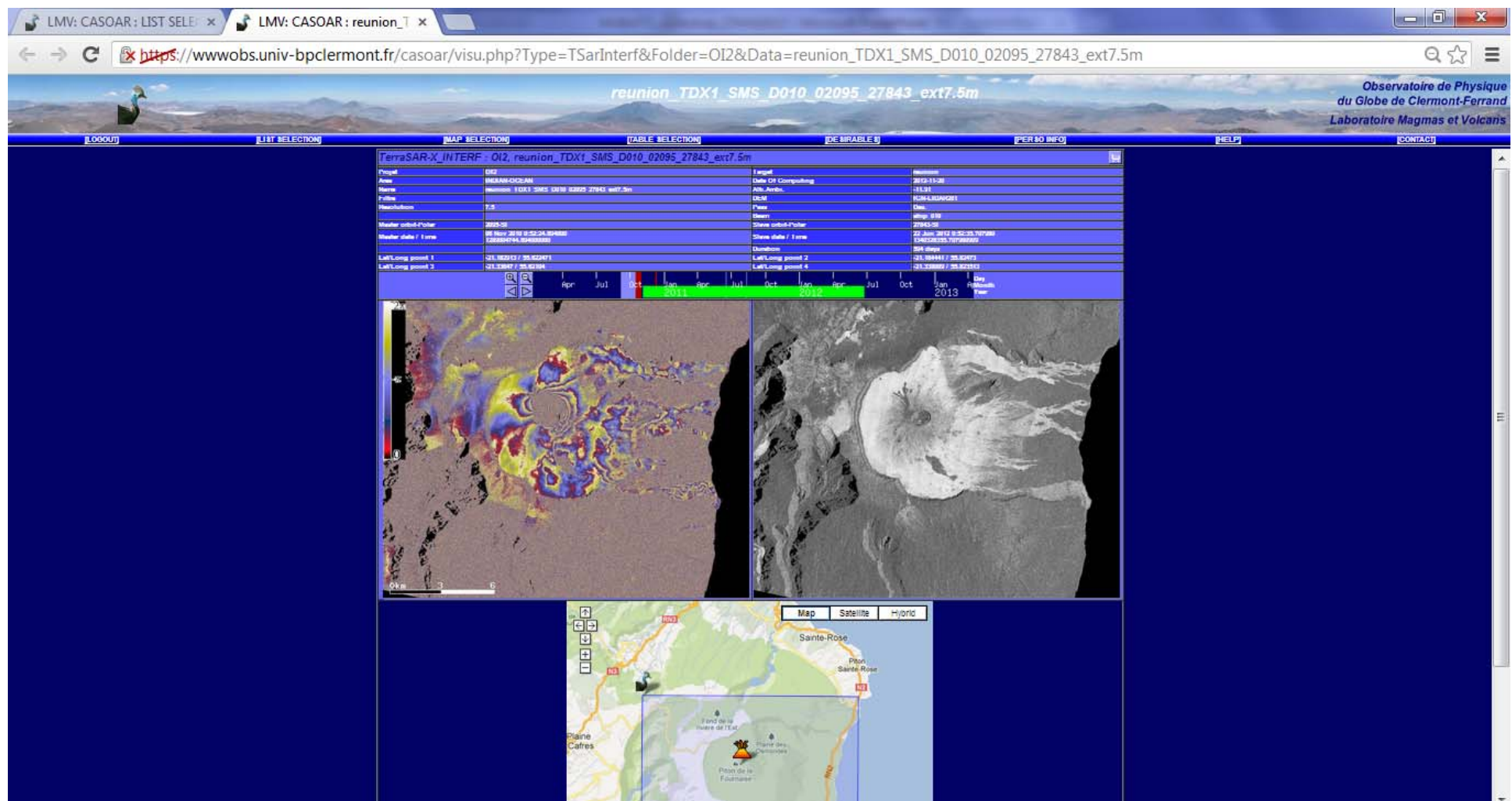
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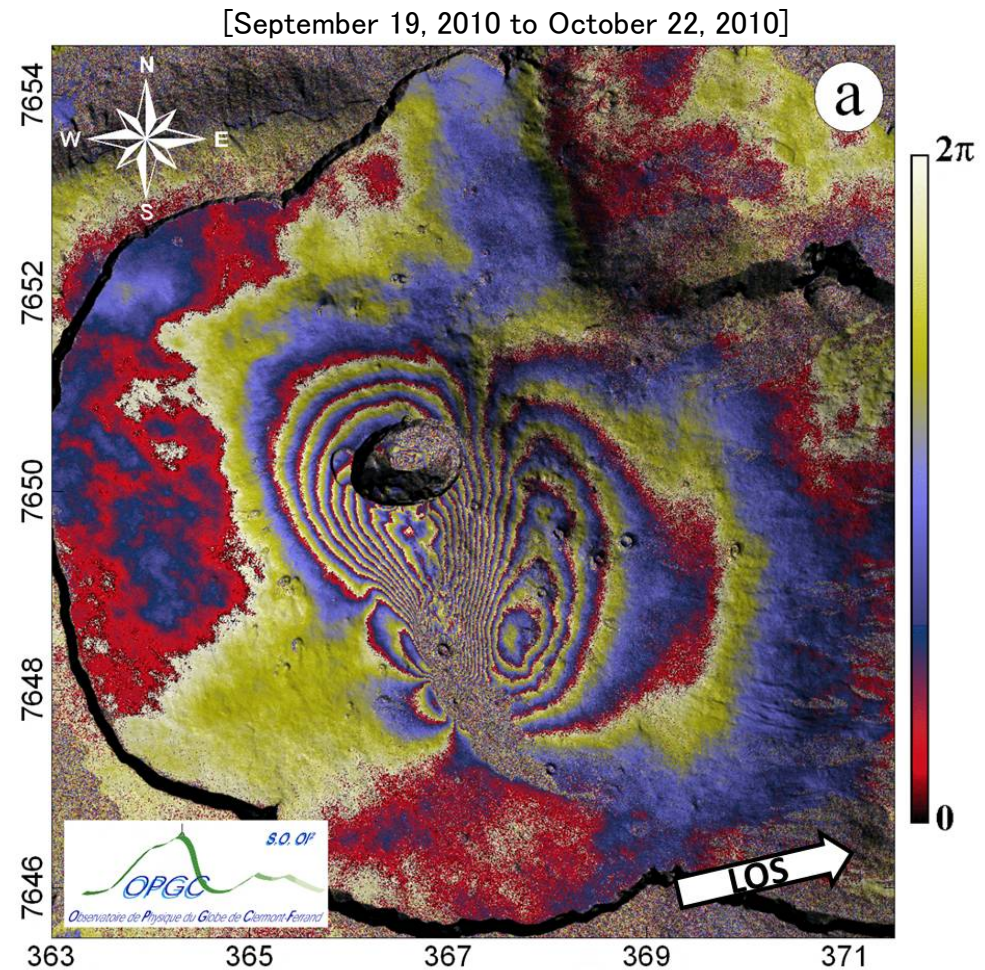
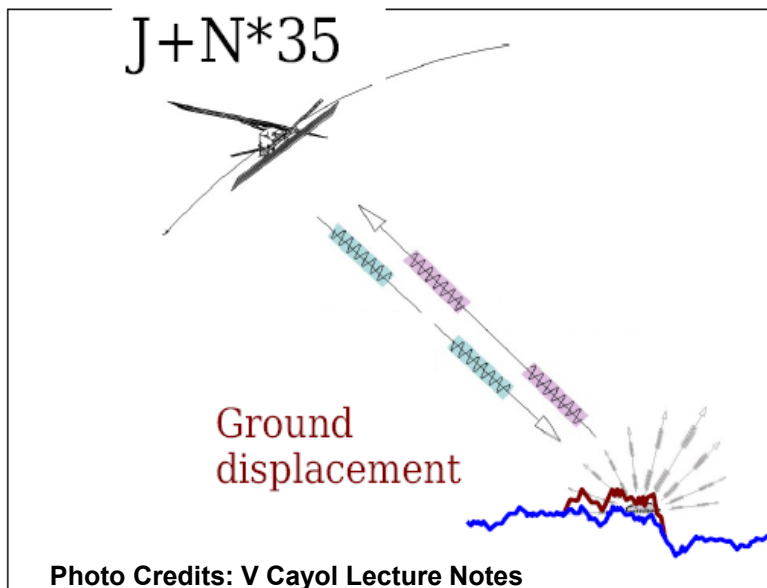
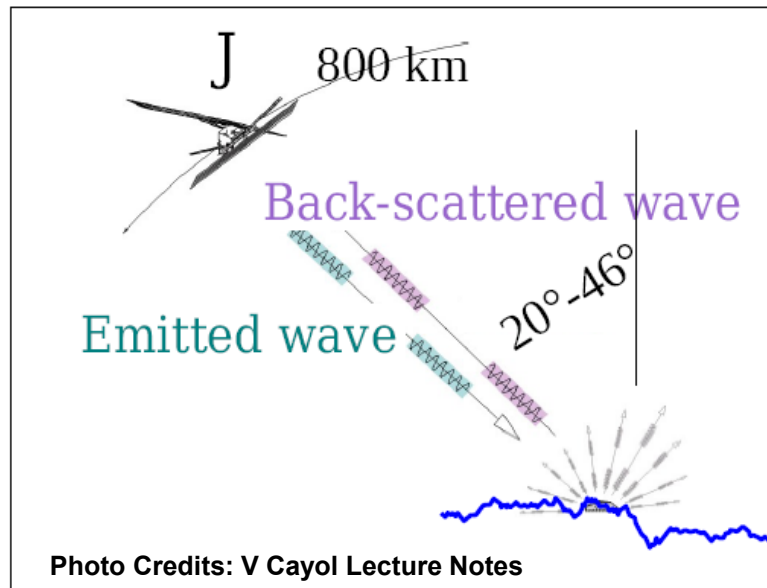
reunion 3 D 3010 15218

reunion 3 D 3010 18100



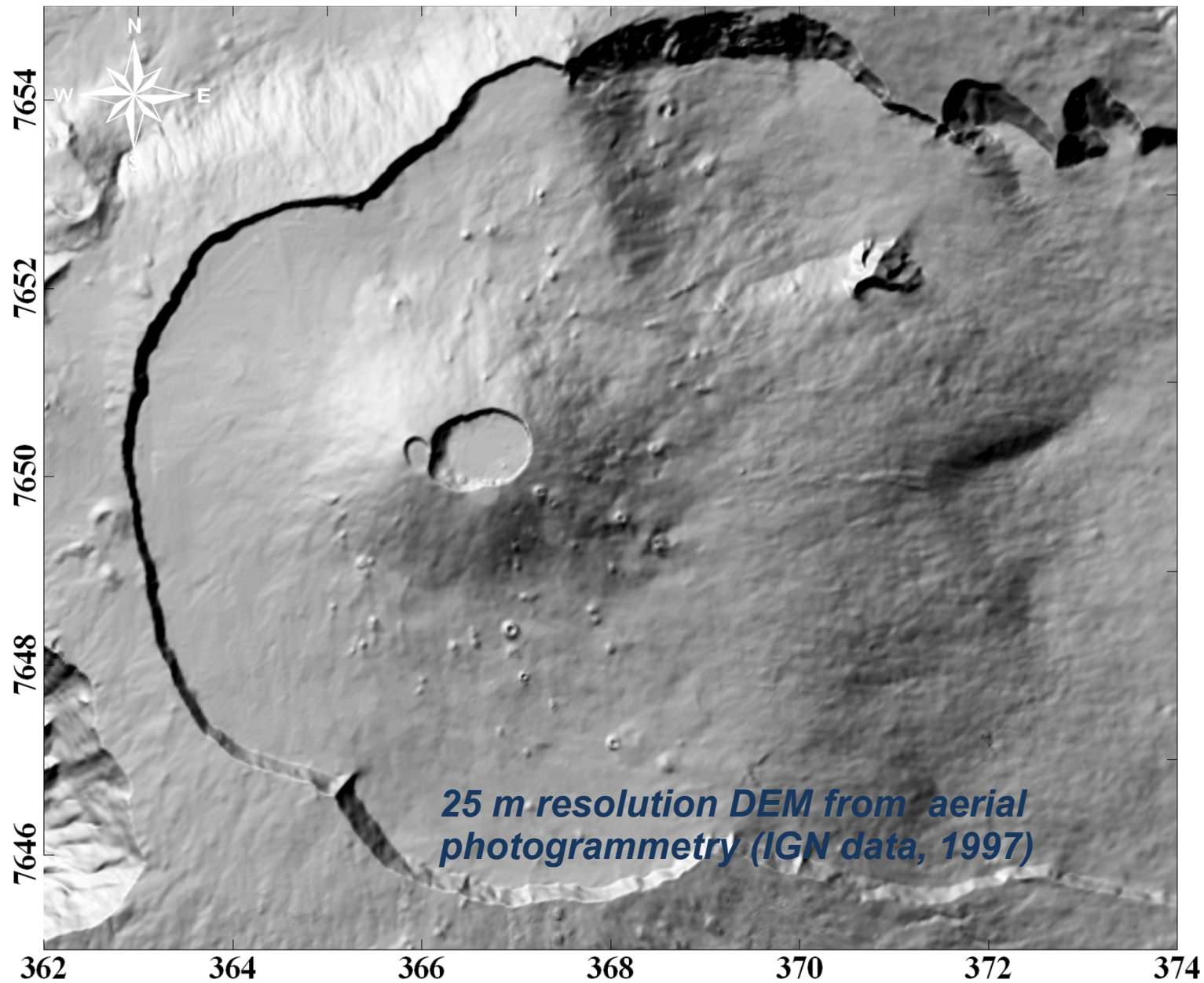
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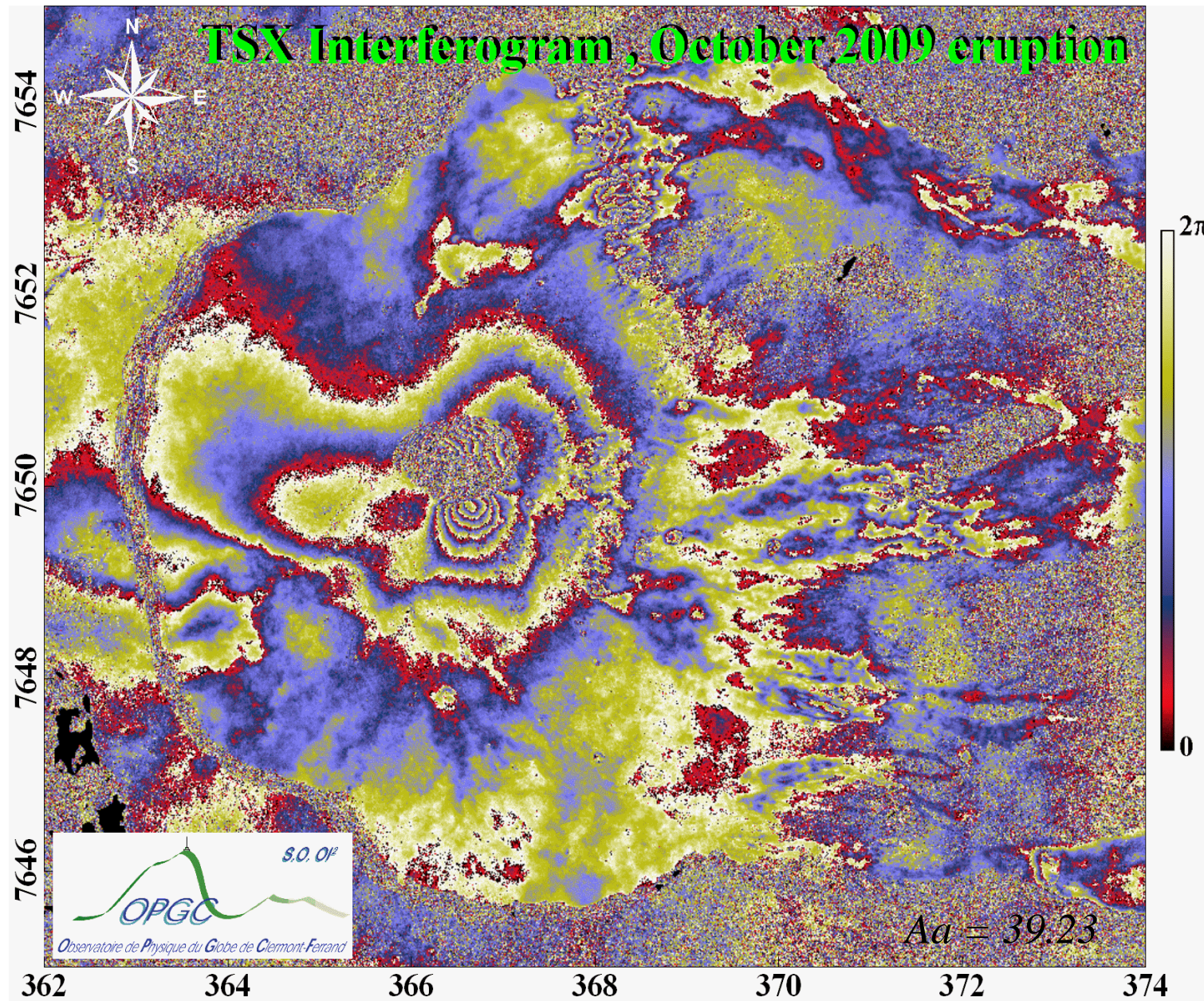


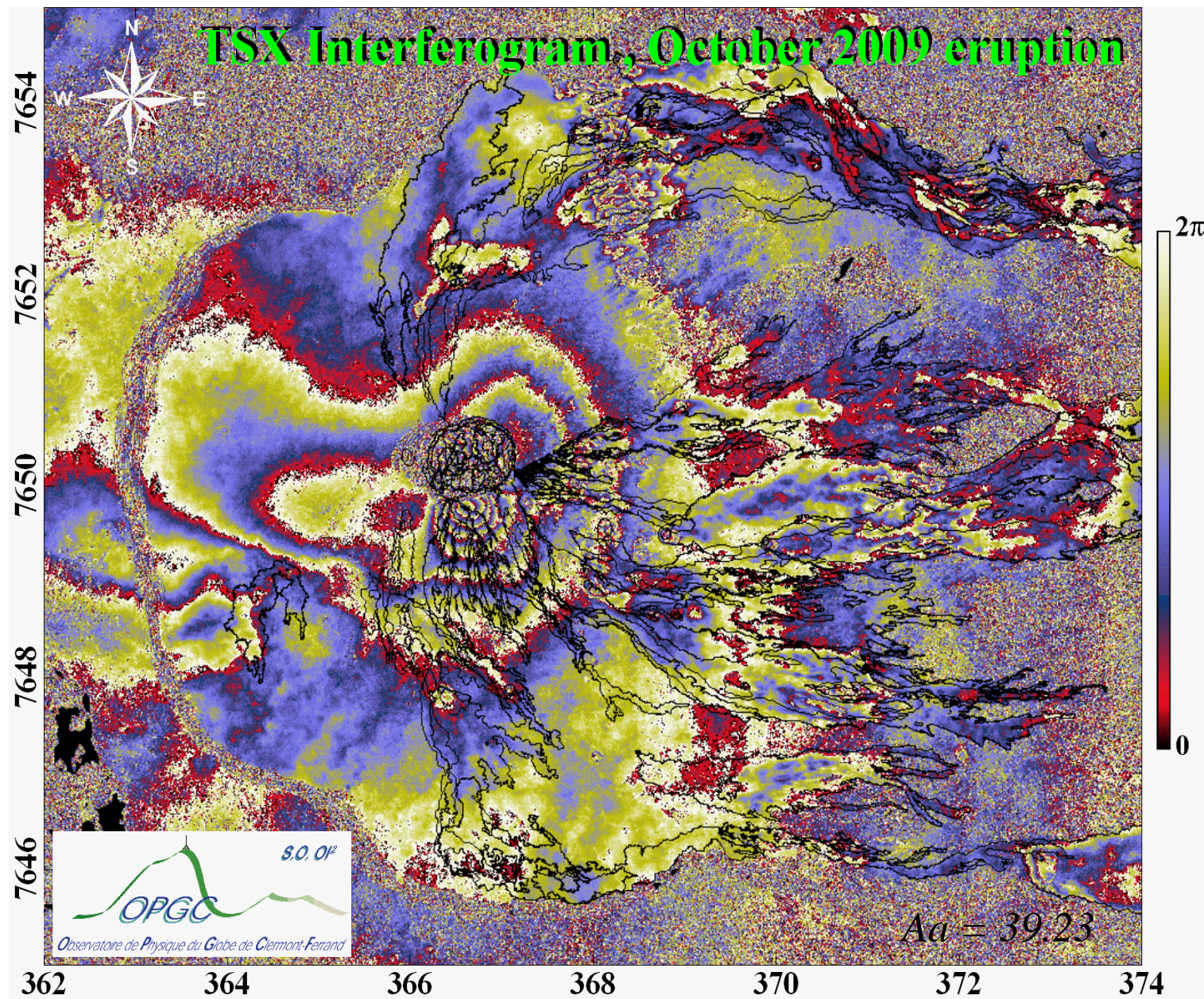


$$1 \text{ fringe} = \lambda / 2 \quad (\lambda_{\text{TSX}} \approx 3 \text{ cm})$$

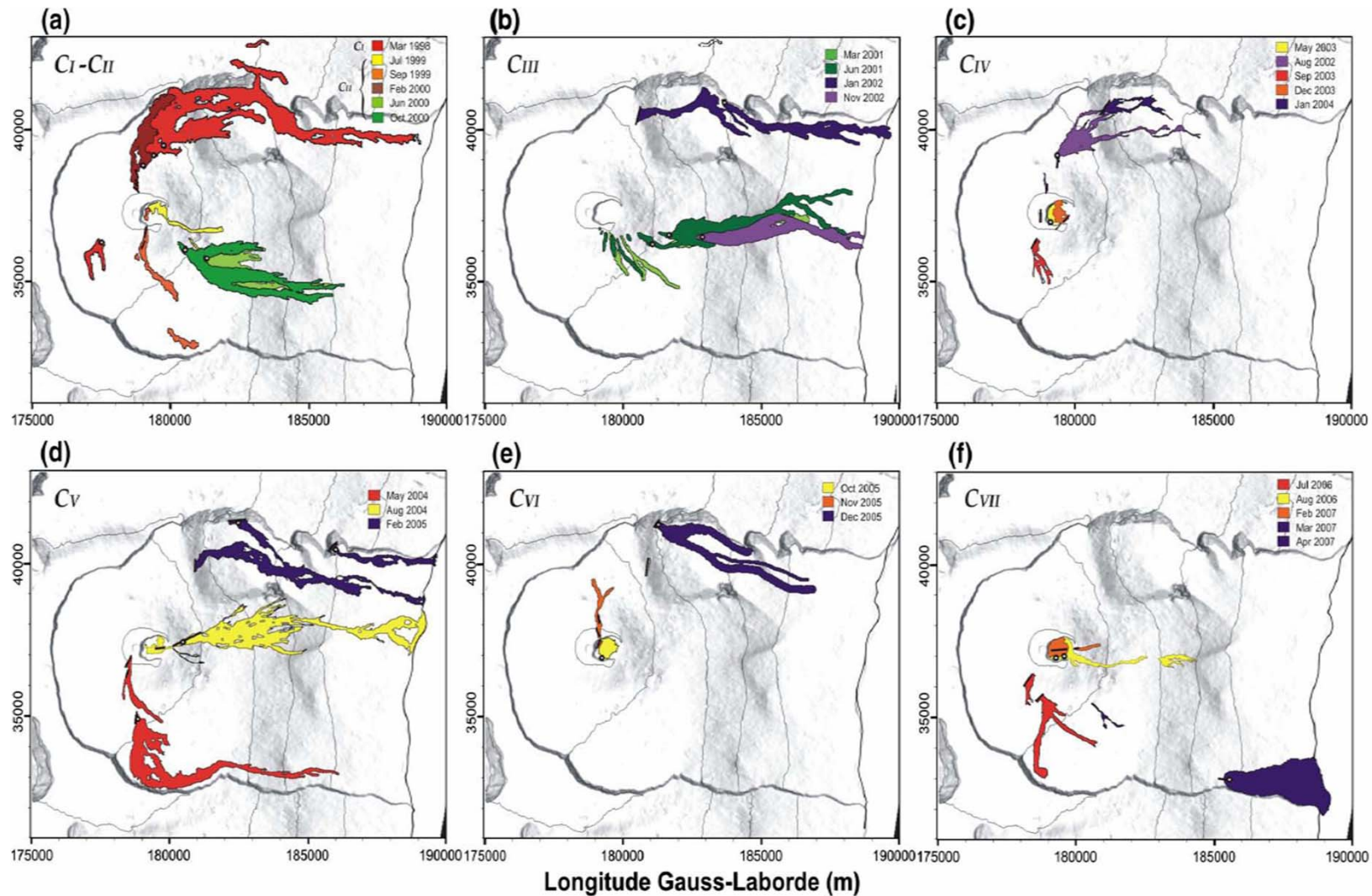
$$\Delta\phi = \phi_{\text{topo}} + \phi_{\text{orb}} + \phi_{\text{disp}} + \phi_{\text{atm}} + \phi_{\text{noise}}$$

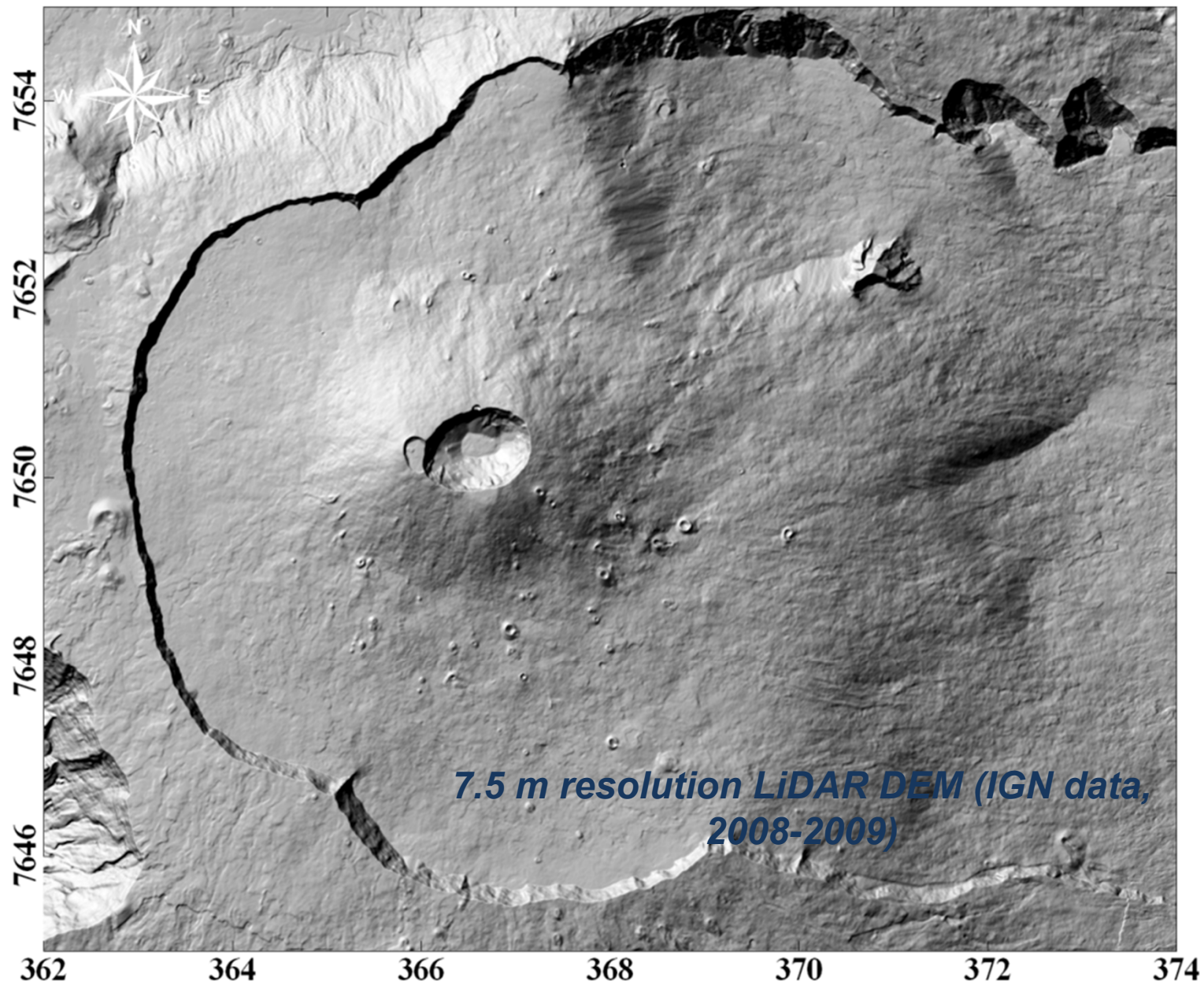


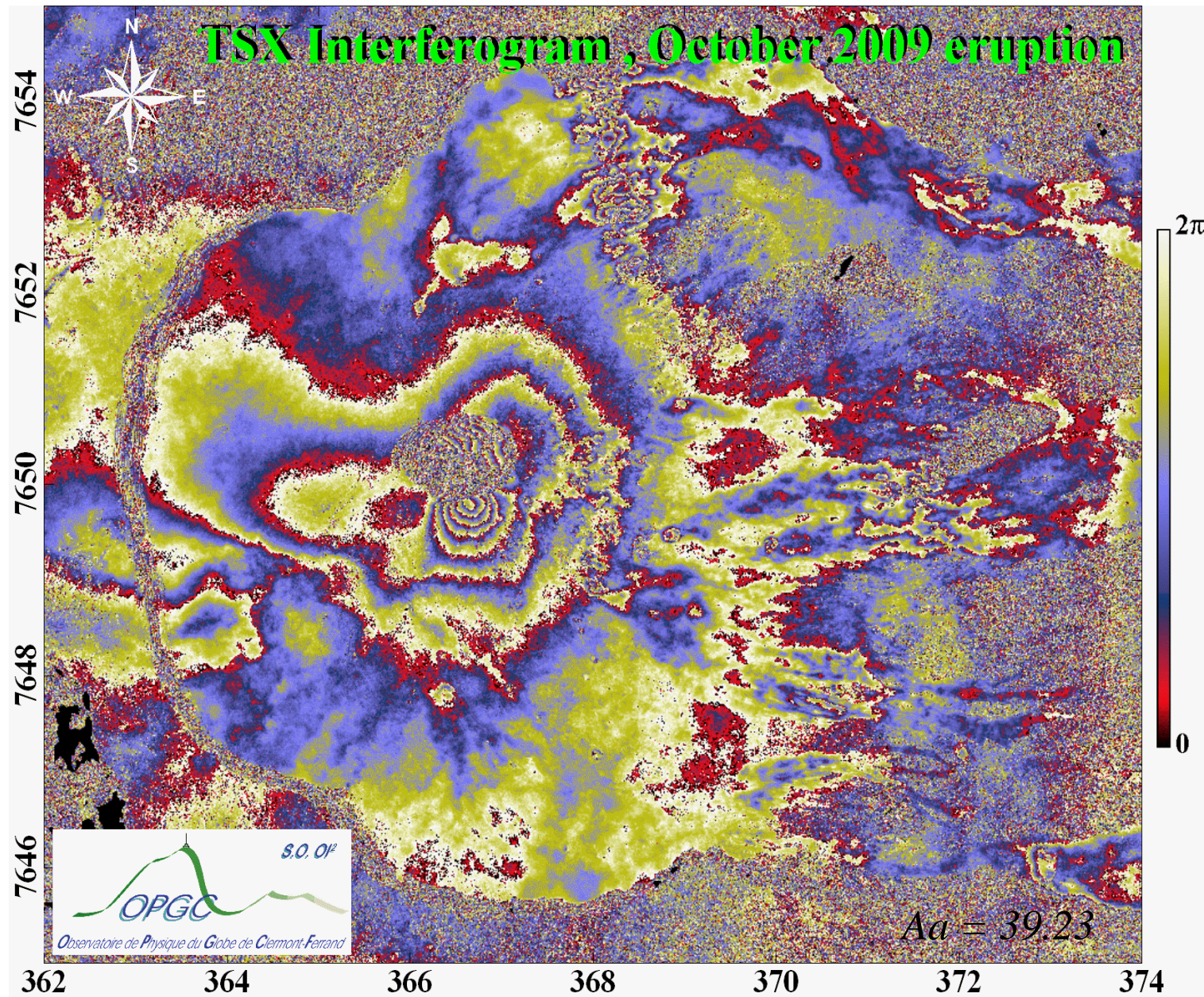


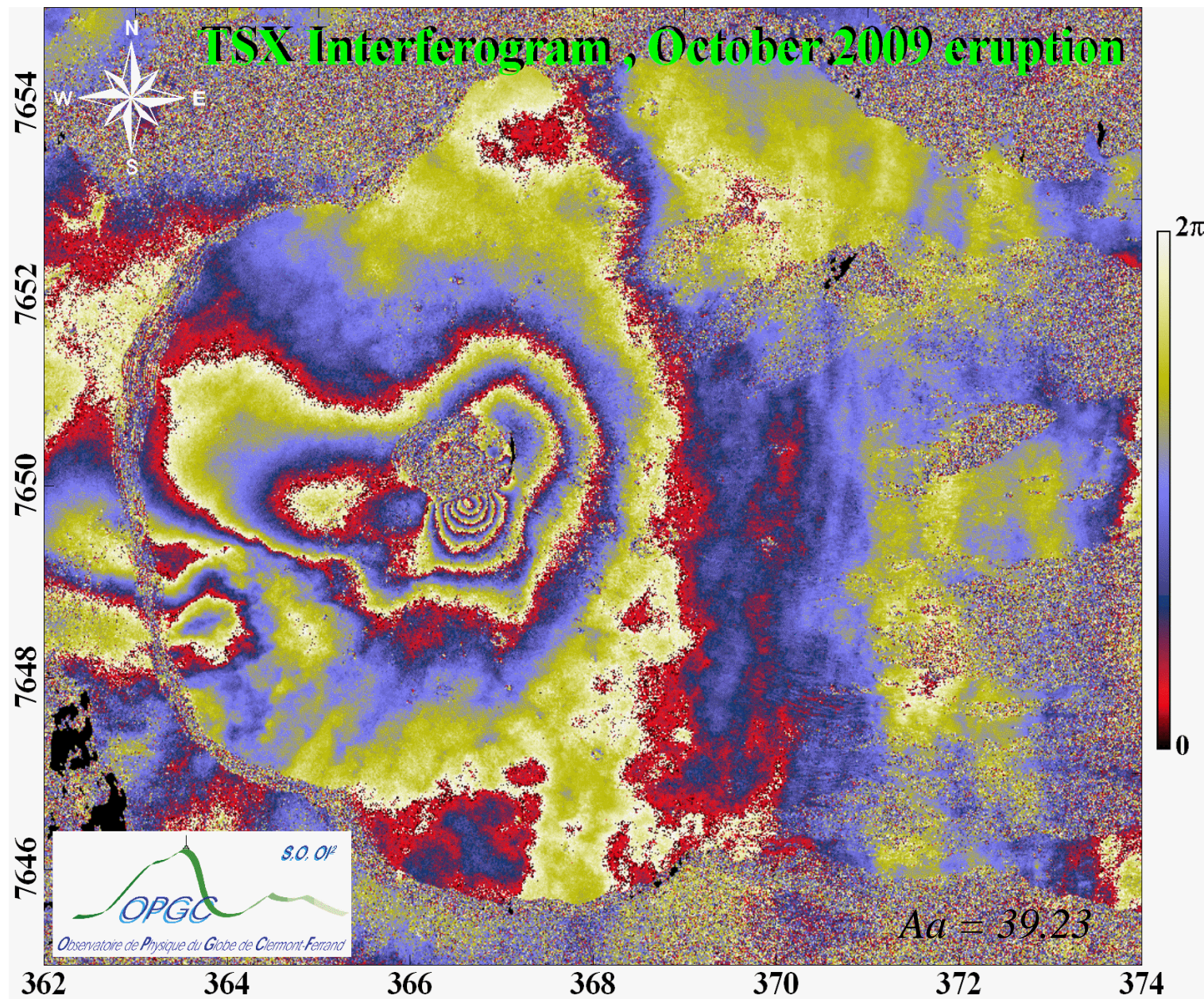


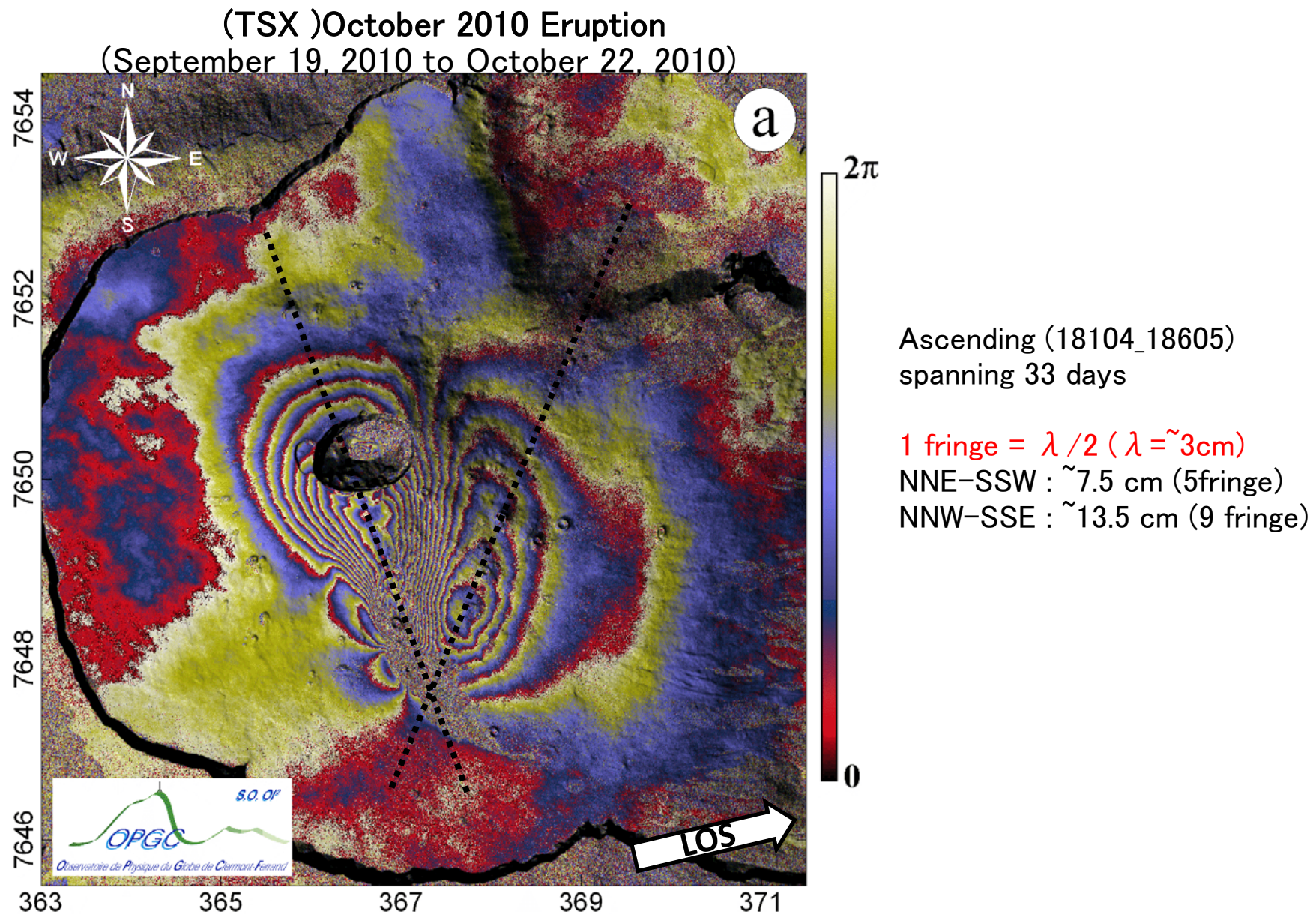
Since 1998, the Piton de la Fournaise topography has changed significantly due to lava flows emplacement (34 eruptions).



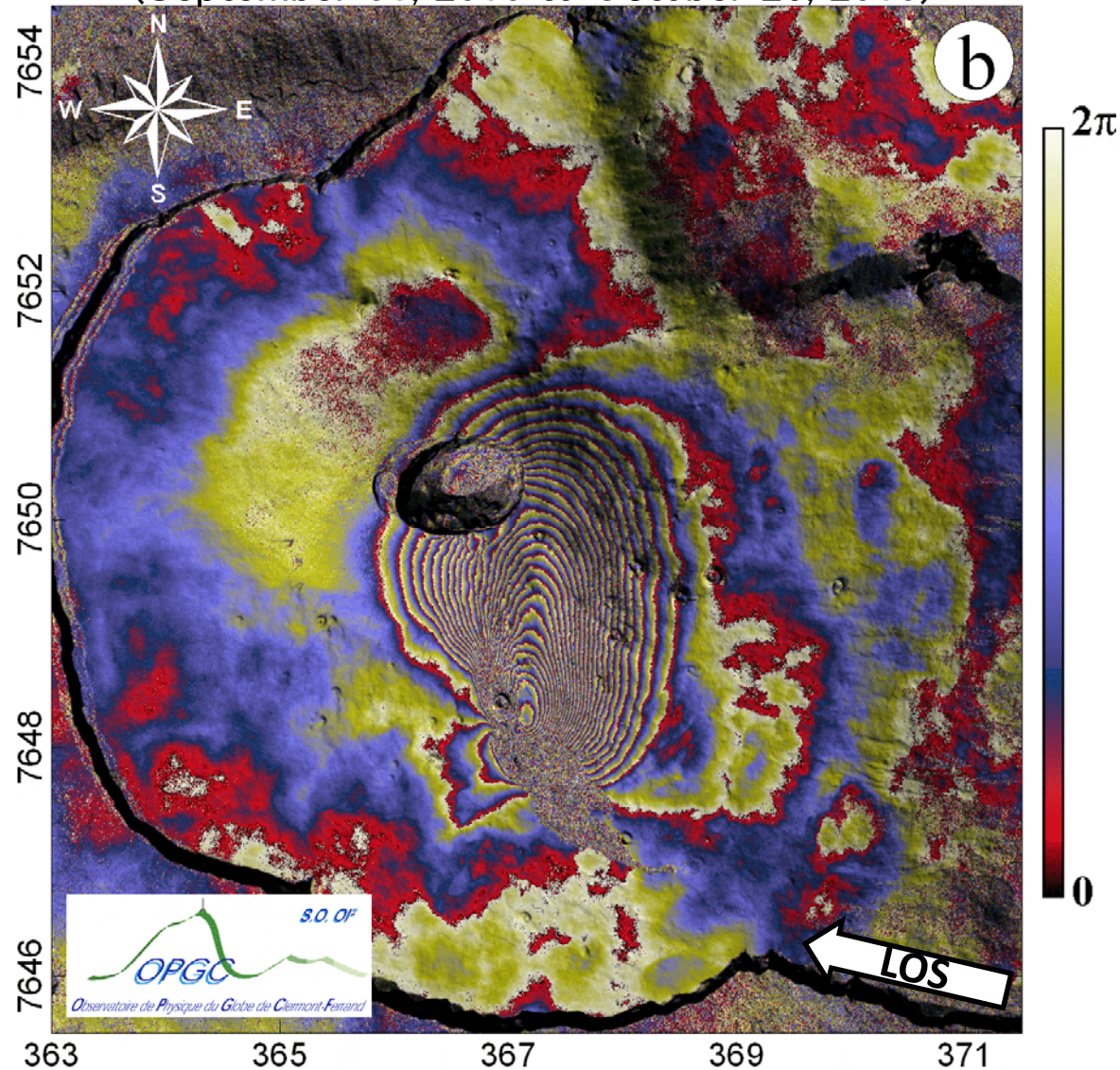






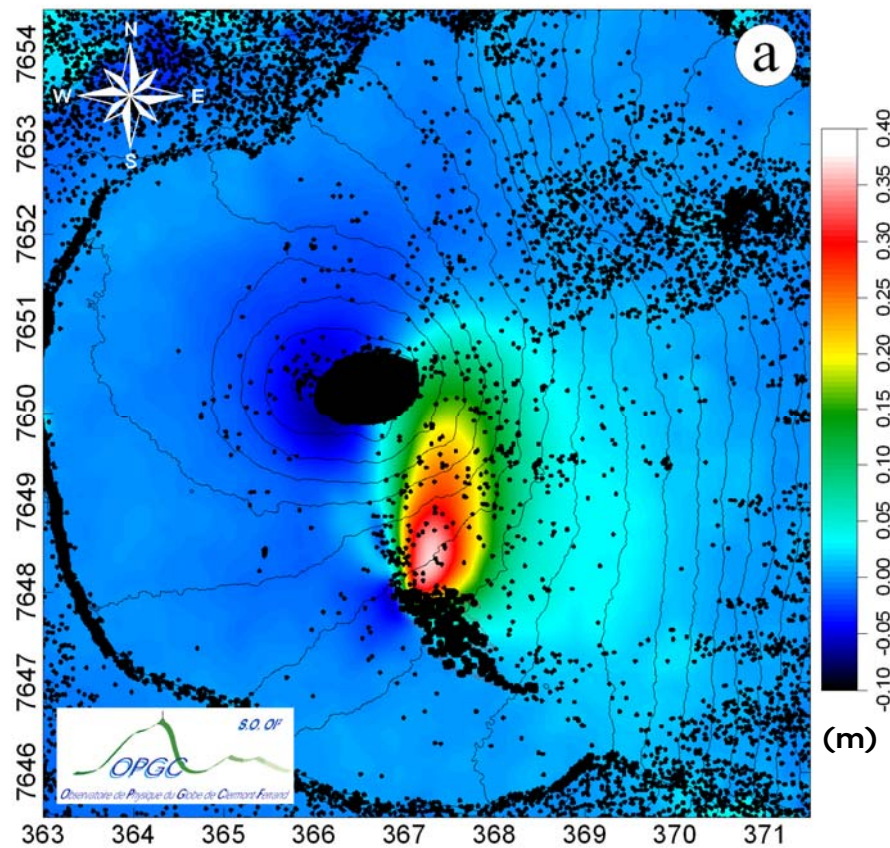


(TSX)October 2010 Eruption
(September 01, 2010 to October 26, 2010)

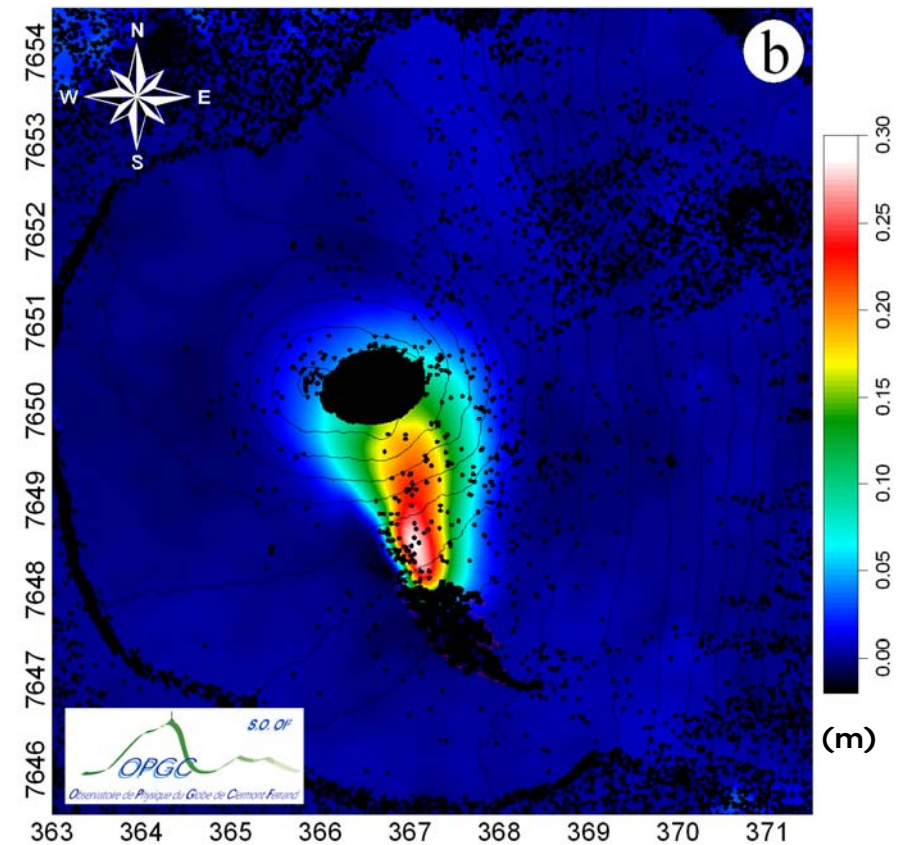


Descending (18104_18605)
spanning 55 days

1 fringe = $\lambda / 2$ ($\lambda \approx 3\text{cm}$)
NS : $\sim 42\text{ cm}$ (27–28 fringes)
Y–B–R

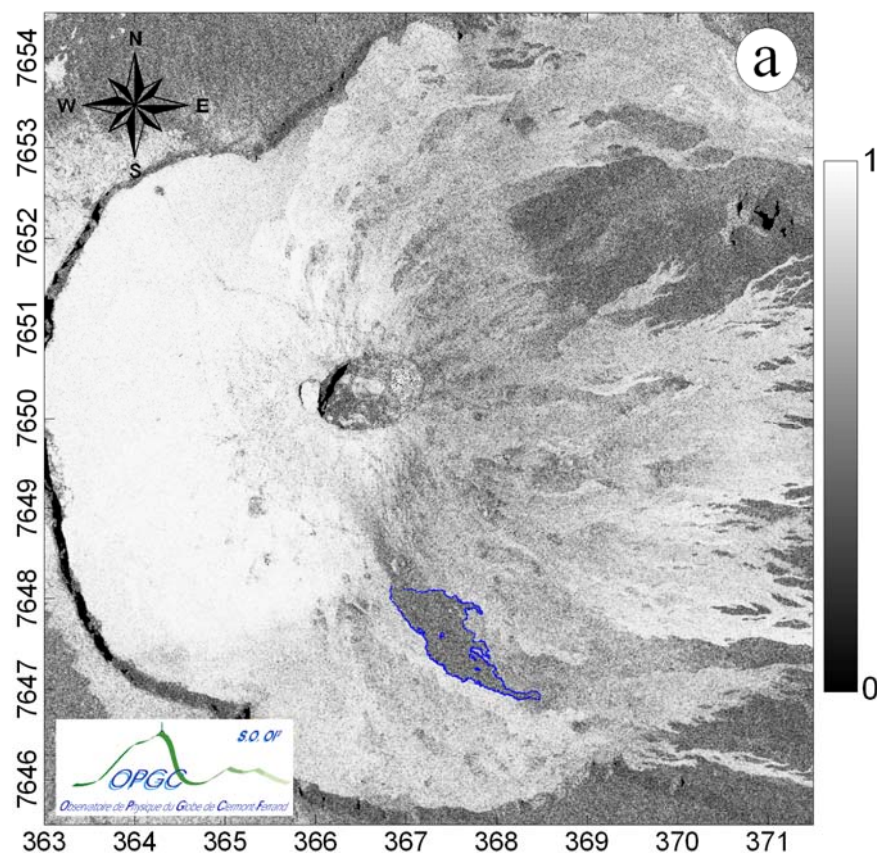


Maximum EW (Horizontal)
displacement: 40 cm



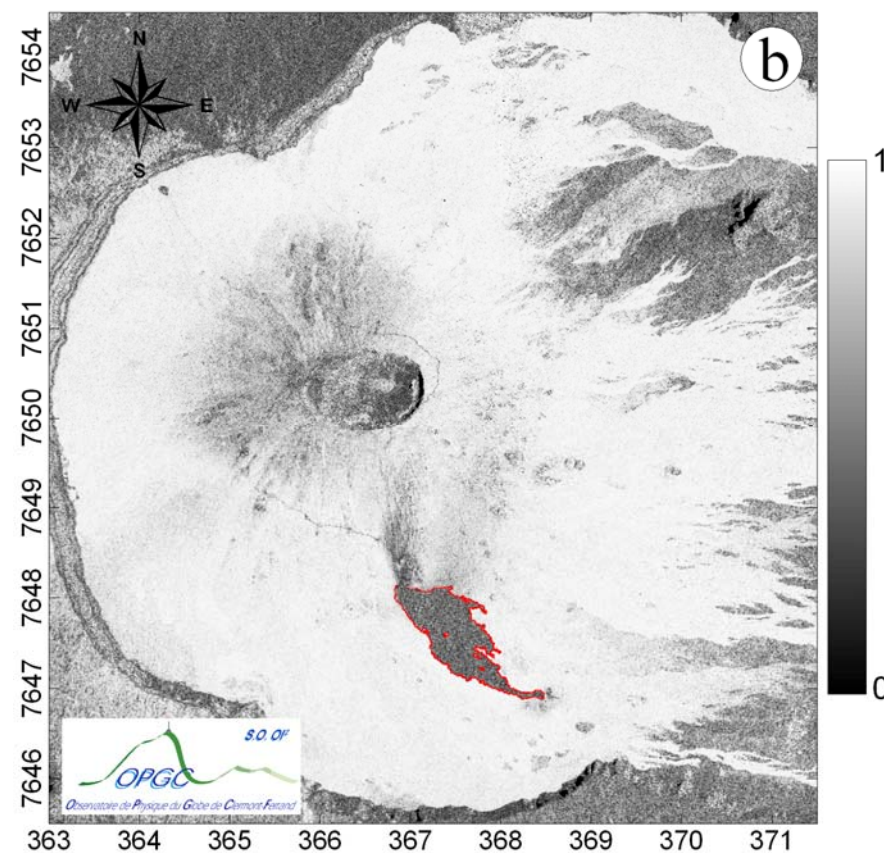
Maximum UD (Vertical)
displacement: 30 cm

Propagation of a dike through the surface!!



Ascending (18104_18605), 33days
(September 19, 2010 to October 22, 2010)

Area: 0.71 km²

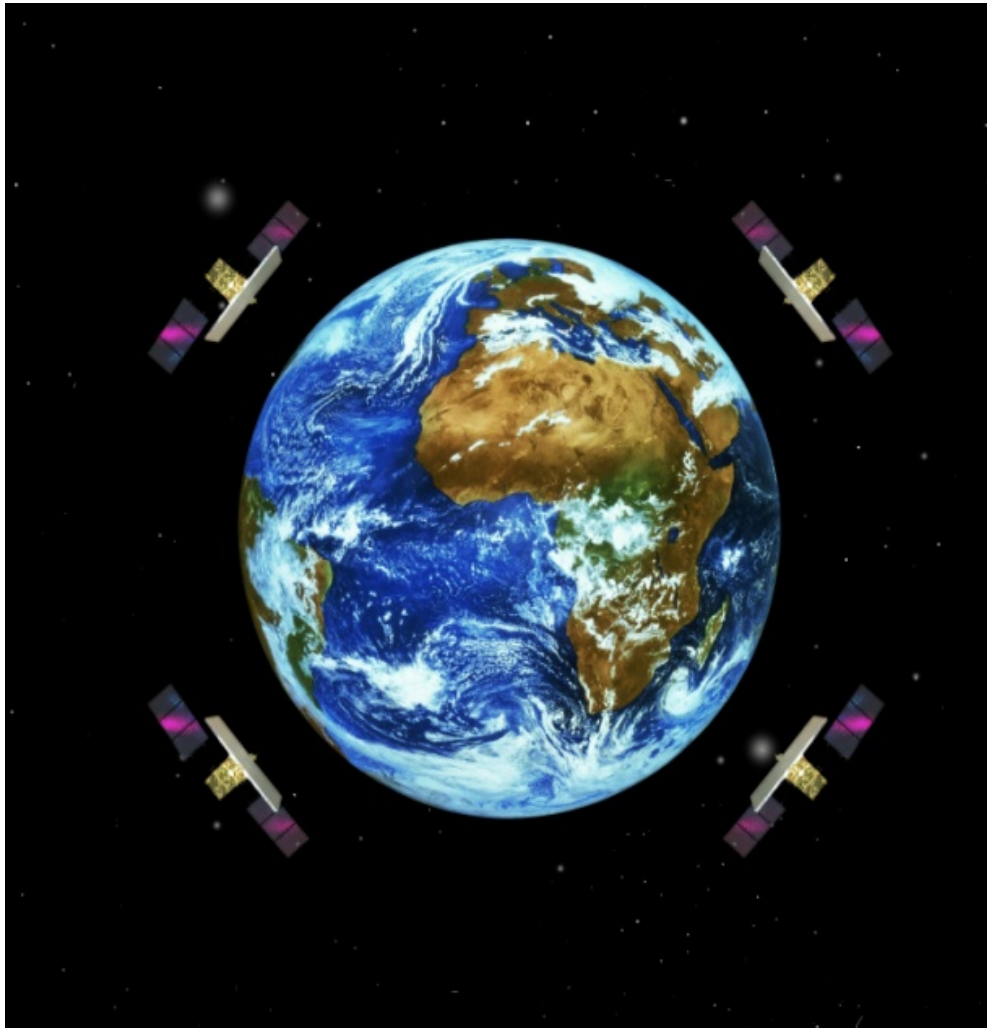


Descending (18104_18605), 55 days
(September 01, 2010 to October 26, 2010)

Area: 0.75 km²

The coherence quantifies the degree of correlation or the stability of the phases between the 2 acquisitions.

What about the post emplacement behavior?

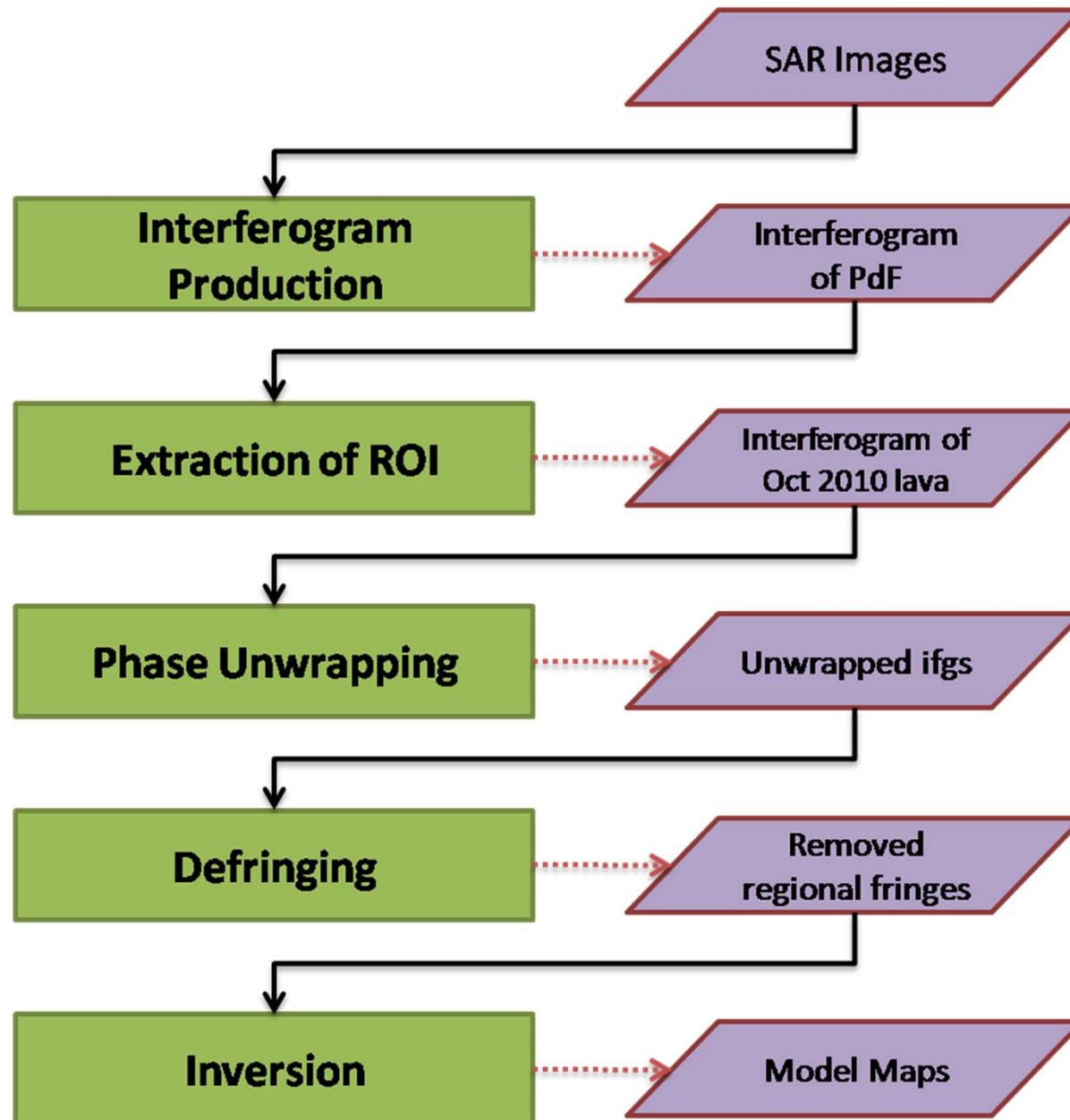


**Cosmo SkyMed Satellite System
(CSK) $\lambda = \sim 3\text{cm}$**

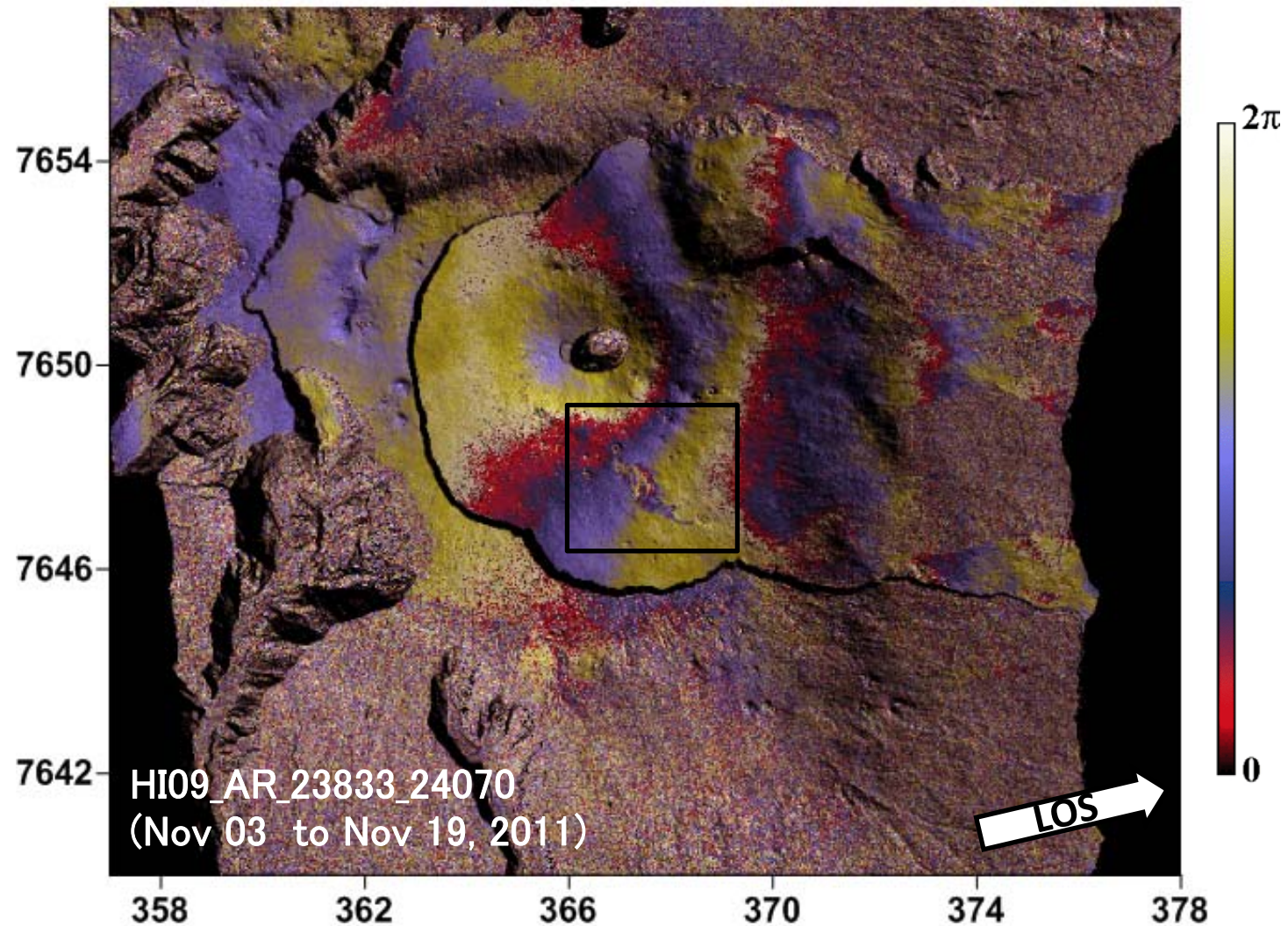
54 SAR Images from CSK
(April 09, 2011 to January 01, 2012)

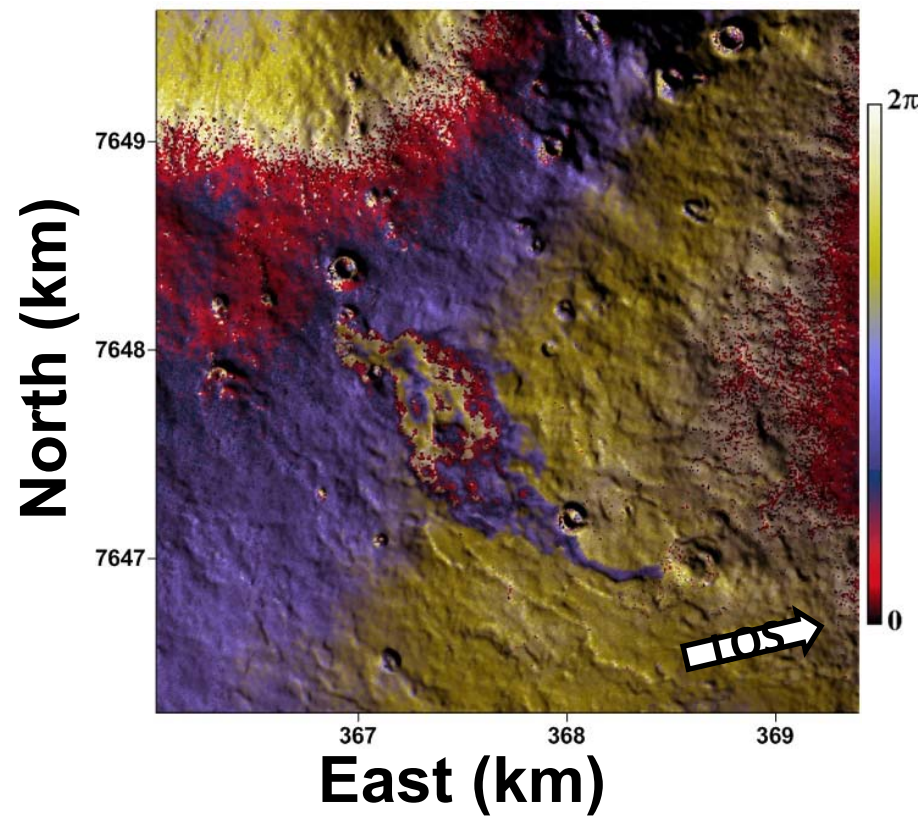
Orbits the Earth every 16 days, covering
237 revolutions per cycle.

435 Interferograms are calculated.



Extracting Region of Interest (ROI)



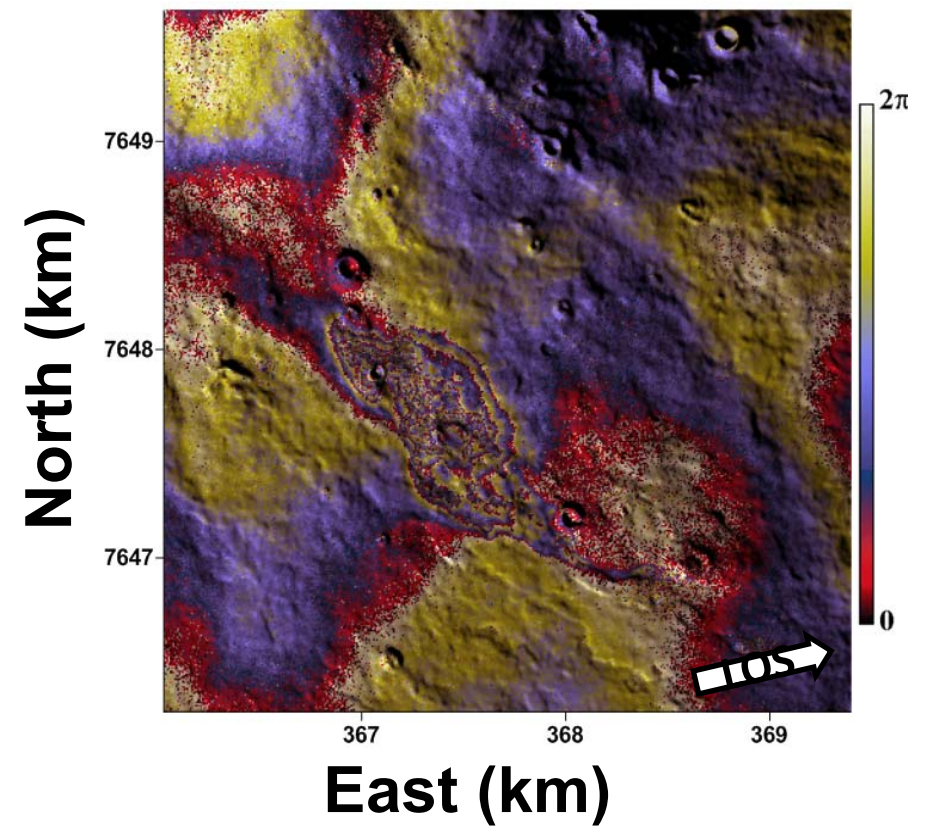


HI09_AR_23833_24070

(November 03 to November 19, 2011)

Duration: 16 days

|AA |: 10.64



HI15_AR_20204_23522

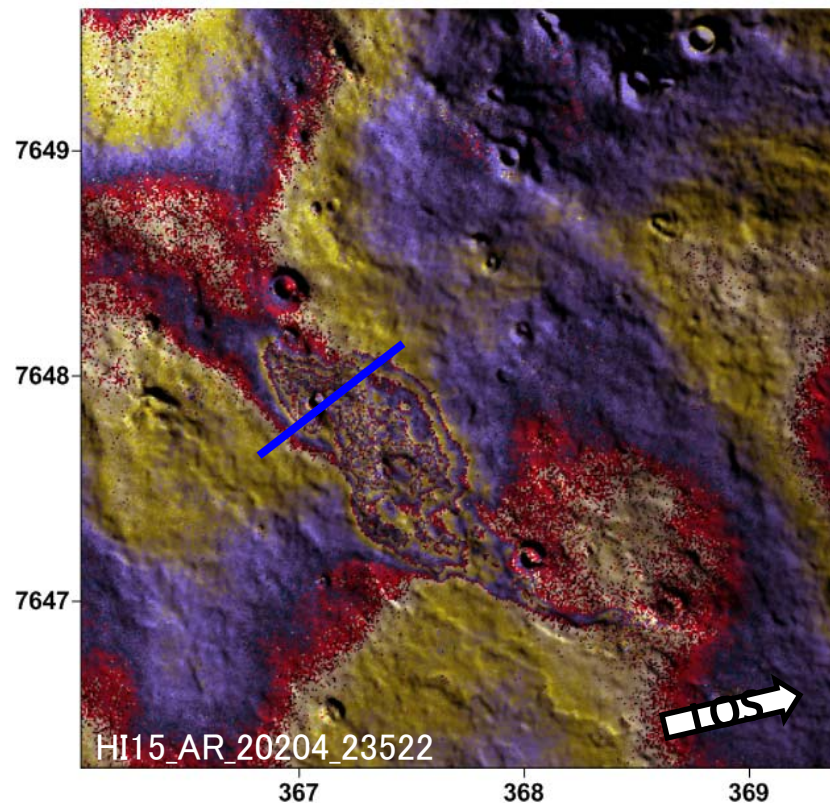
(March 03 to October 13, 2011)

Duration: 224 days

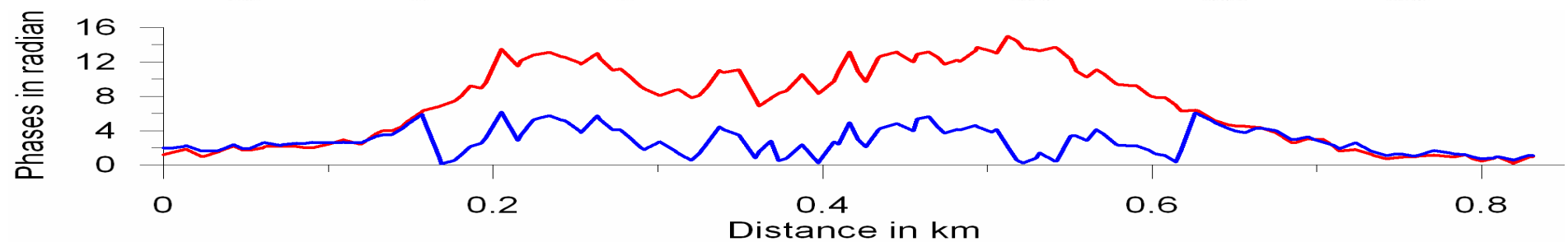
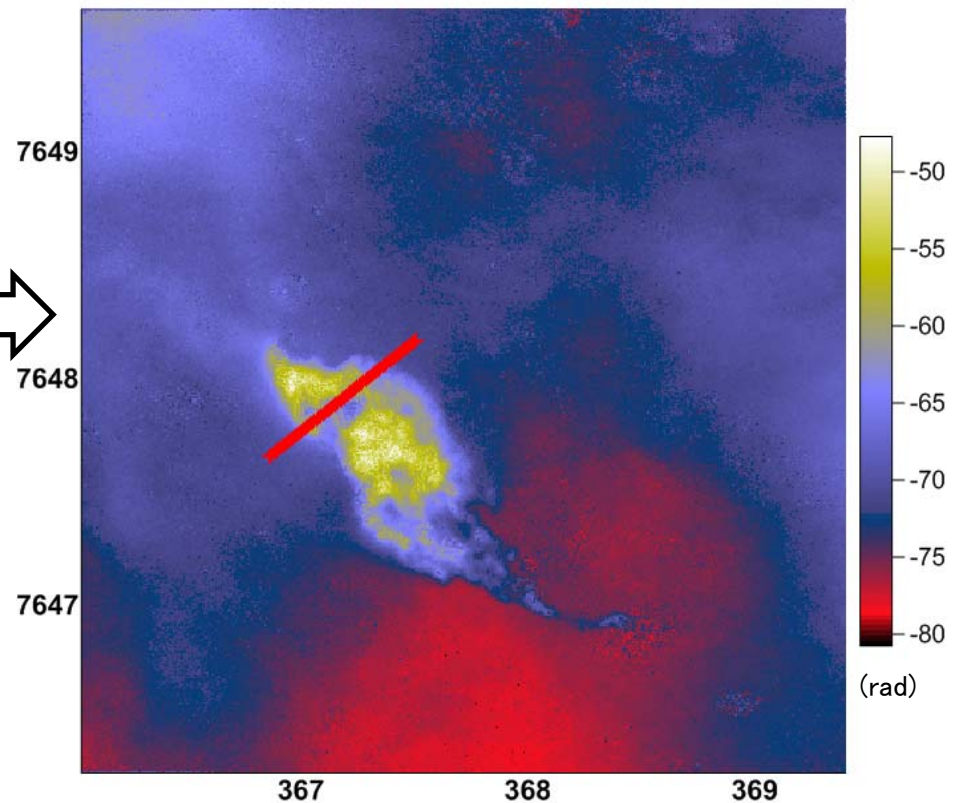
|AA |: 223.59

Phase Unwrapping

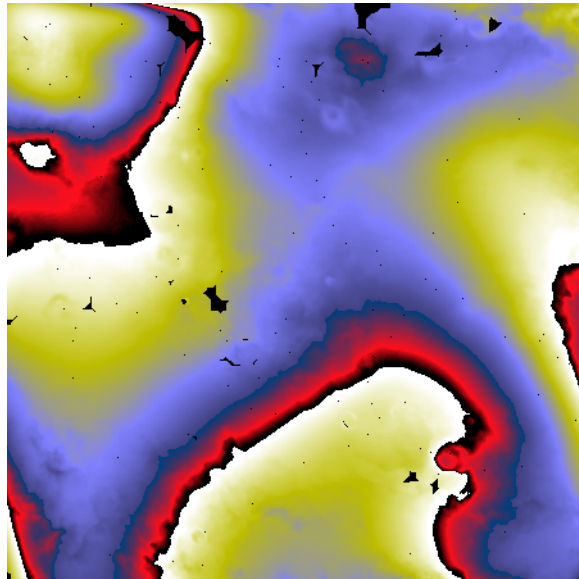
Wrapped Phase



Unwrapped Phase

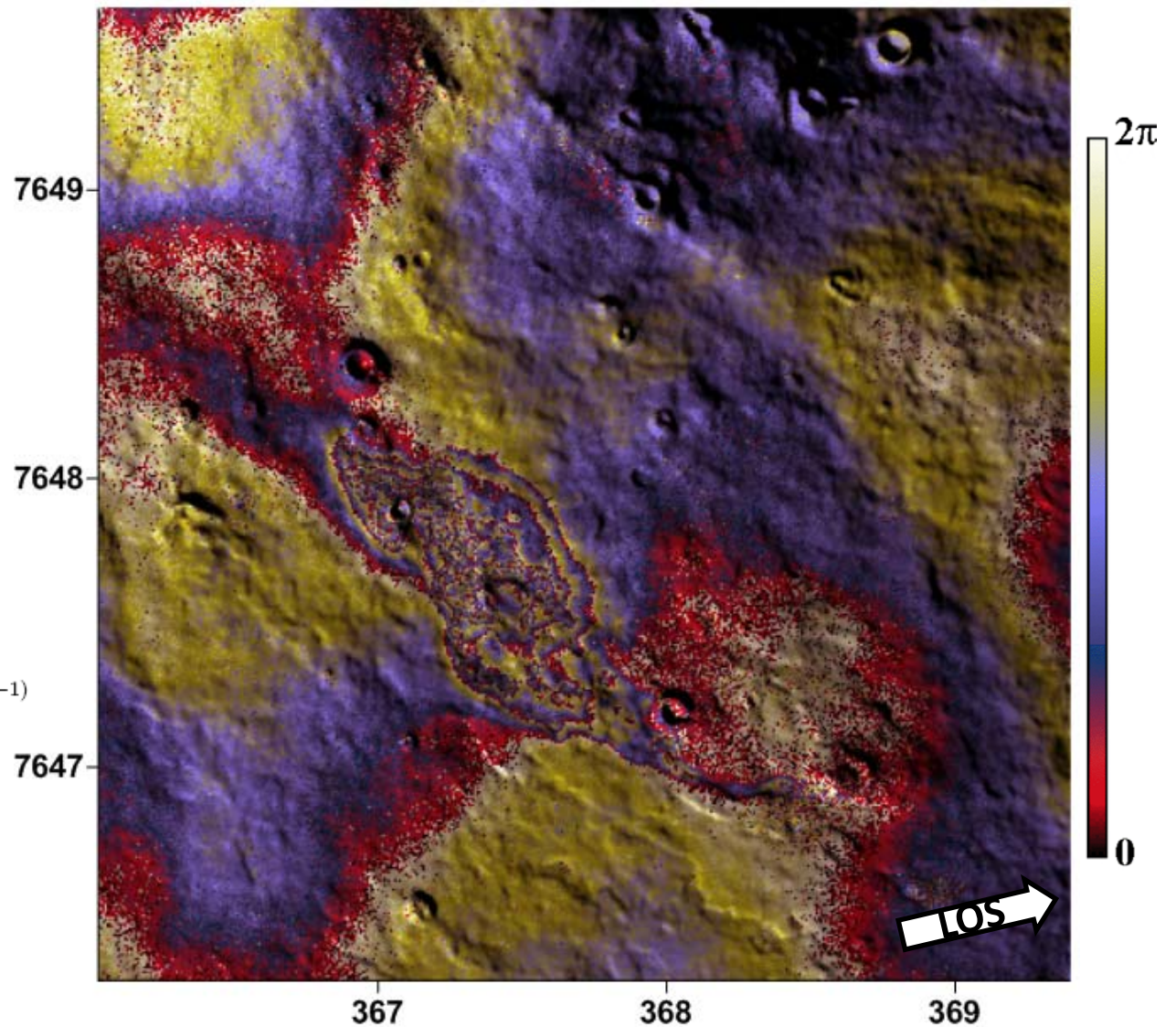


Detrending



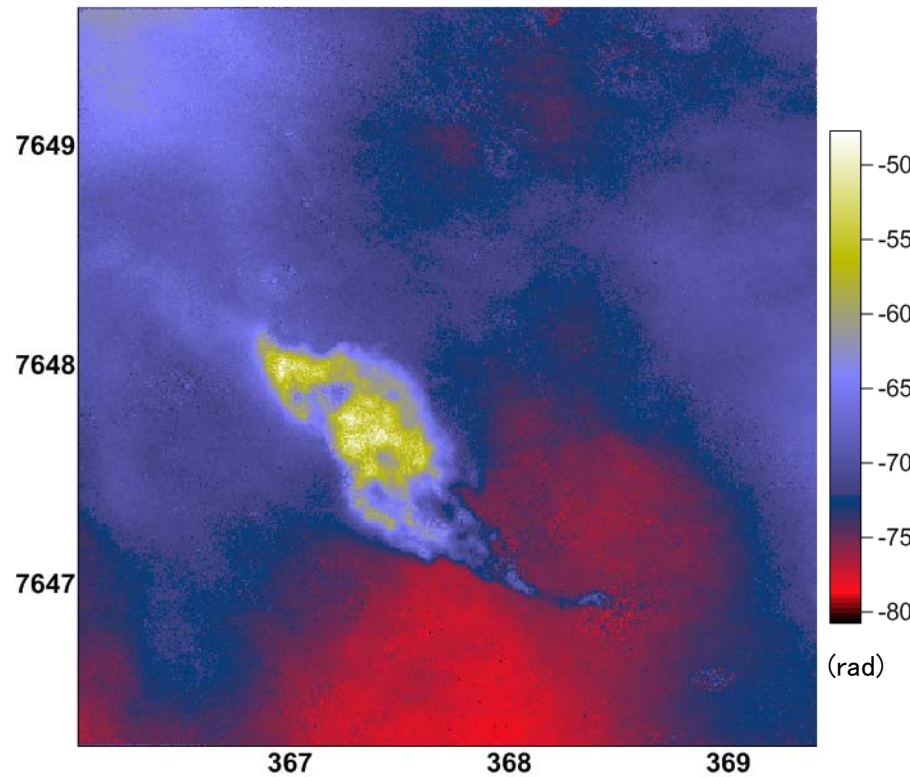
6 degree surface polynomial
(HI15_AR_20204_23522)

$$\phi(X, Y, Z) = \sum_{i=1}^q \sum_{j=1}^p \sum_{k=1}^r P_{ijk} X^{(i-1)} Y^{(j-1)} Z^{(k-1)}$$



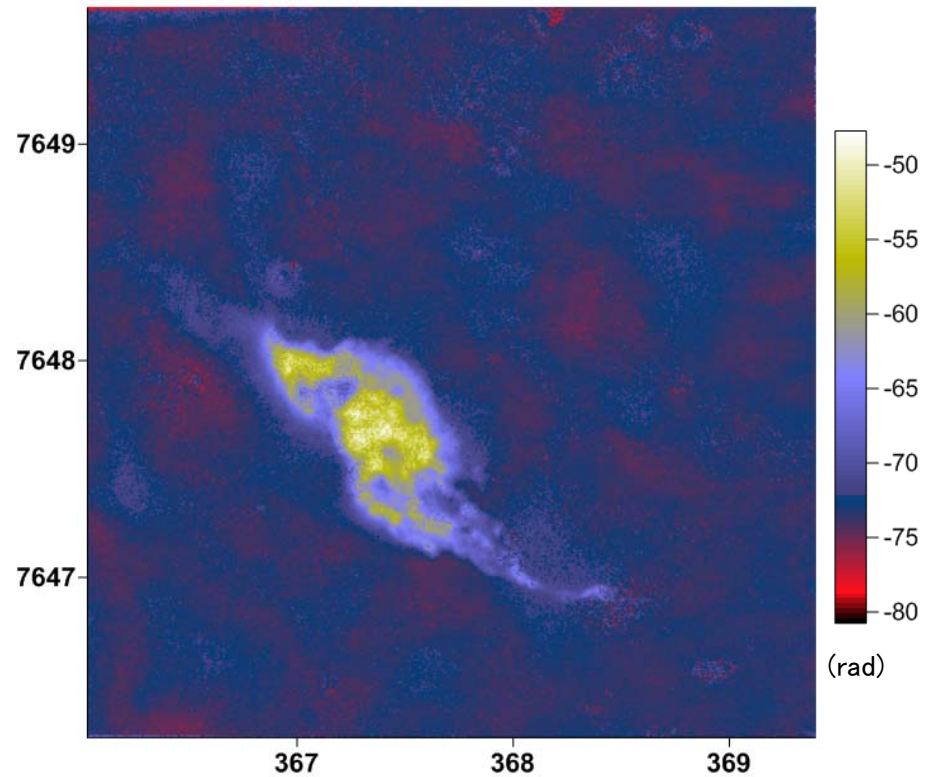
Detrending

Unwrapped Phase



HI15_AR_20204_23522
Duration: 224 days

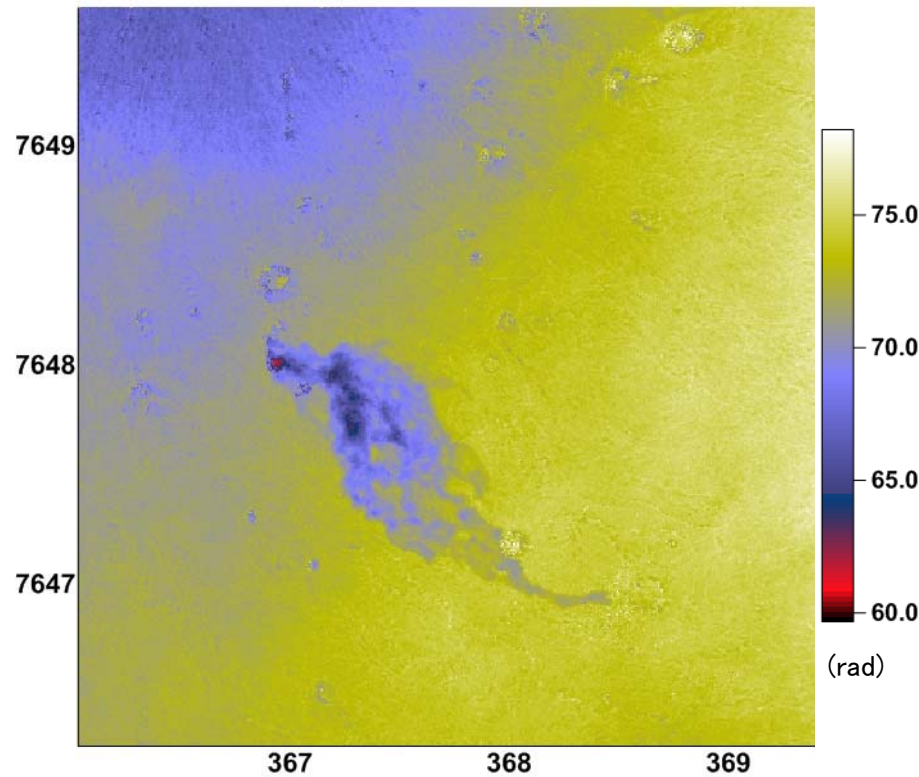
Detrended Unwrapped Phase



(March 03, 2011 to October 13, 2011)
|AA |: 223.59

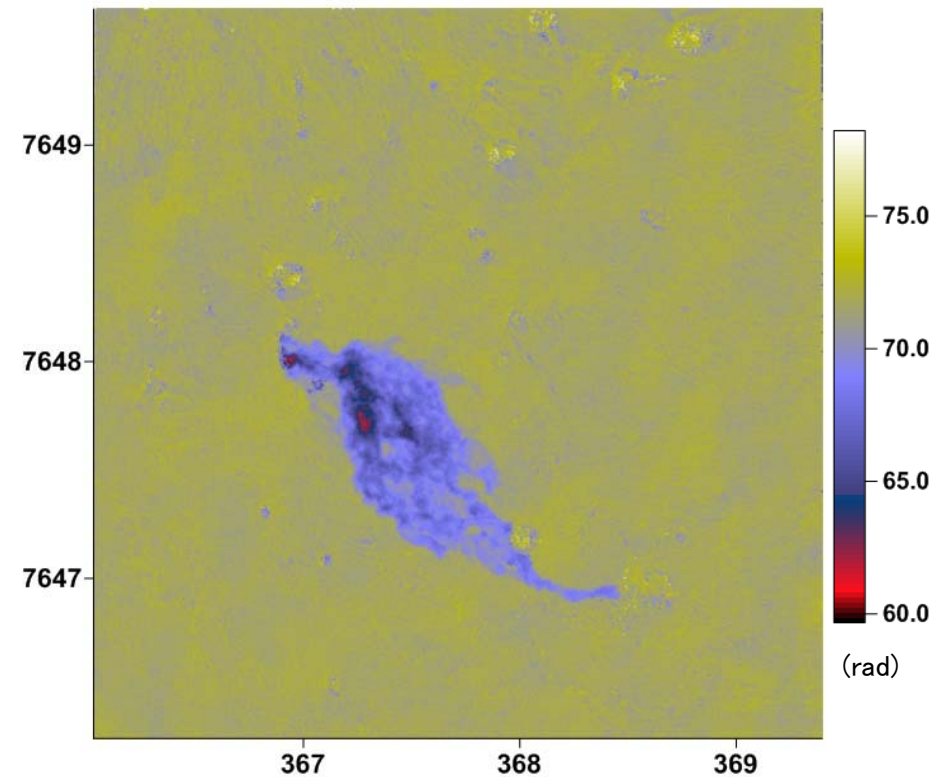
Detrending

Unwrapped Phase



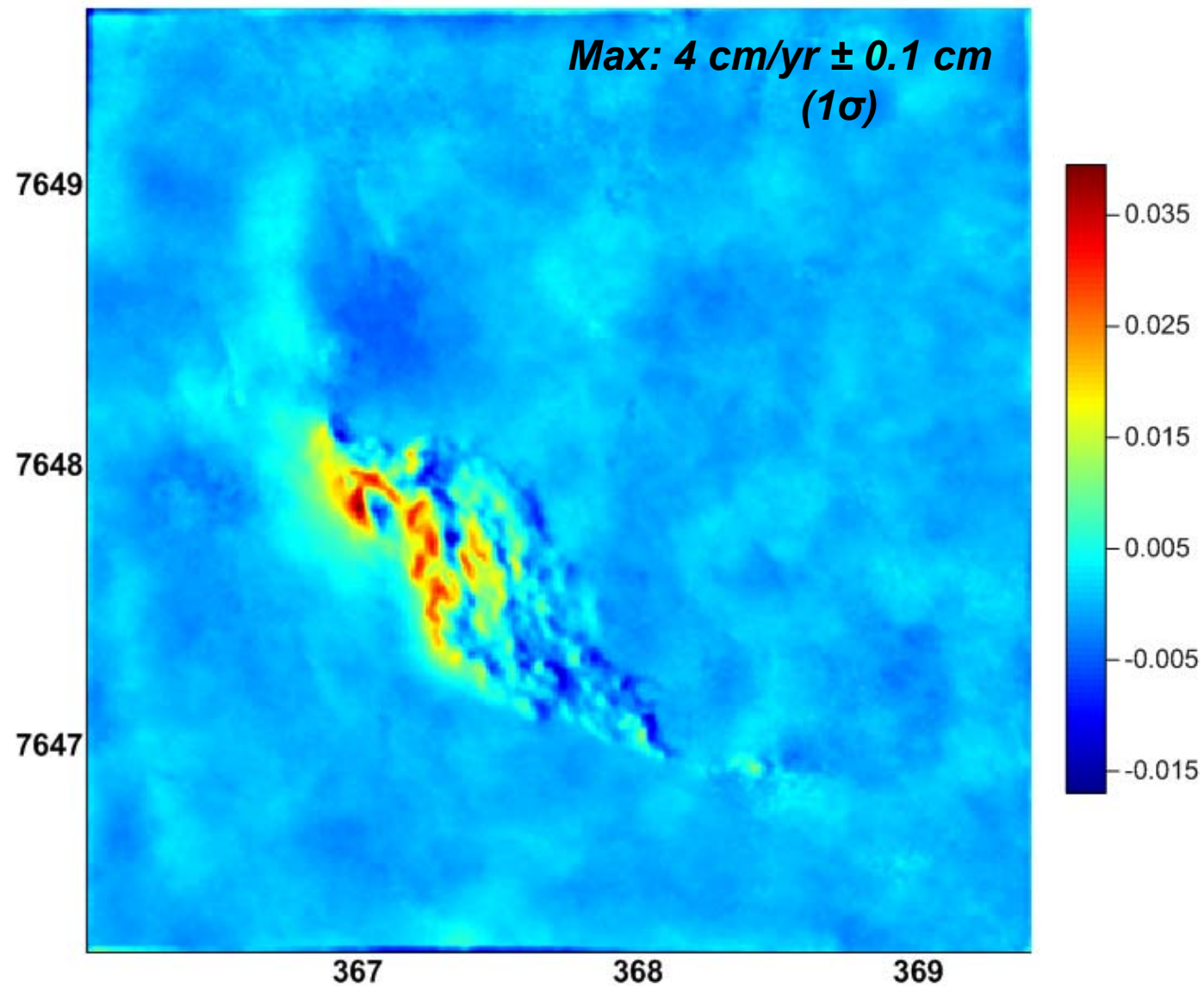
HI09_AR_23833_24070
Duration: 16 days

Detrended Unwrapped Phase

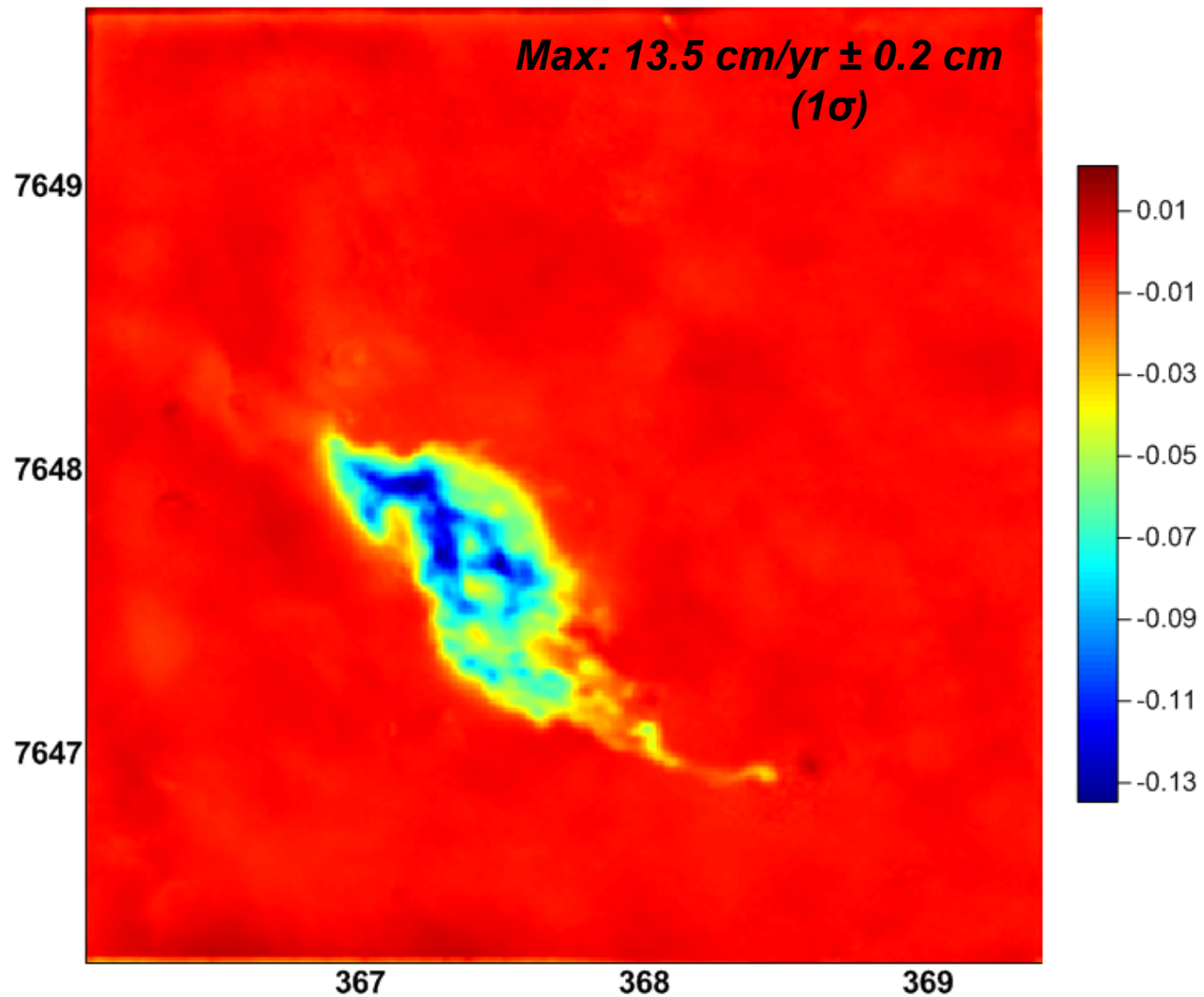


(Nov 03, 2011 to Nov 19, 2011)
|AA |: 10.64

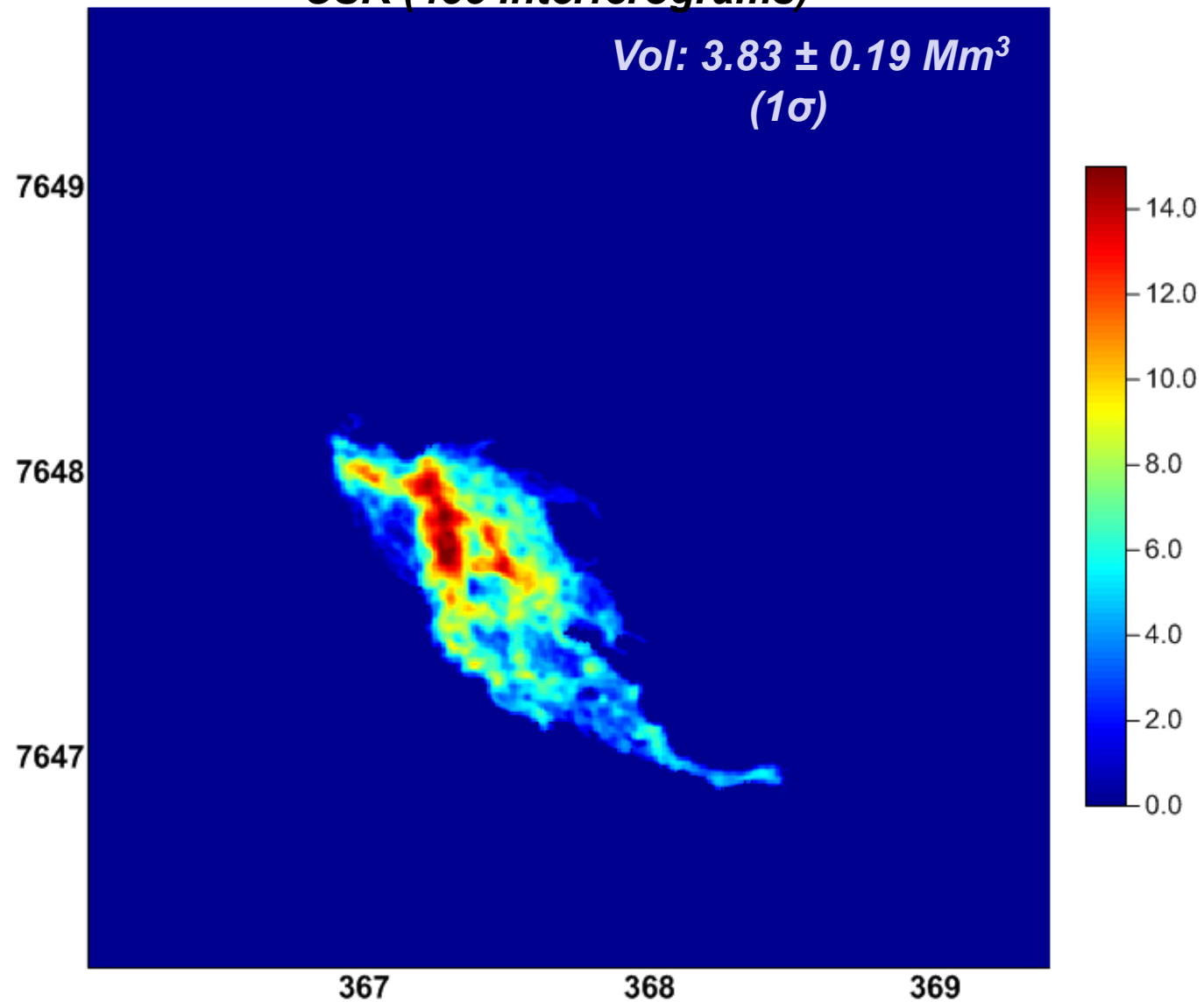
EW Displacement Rate



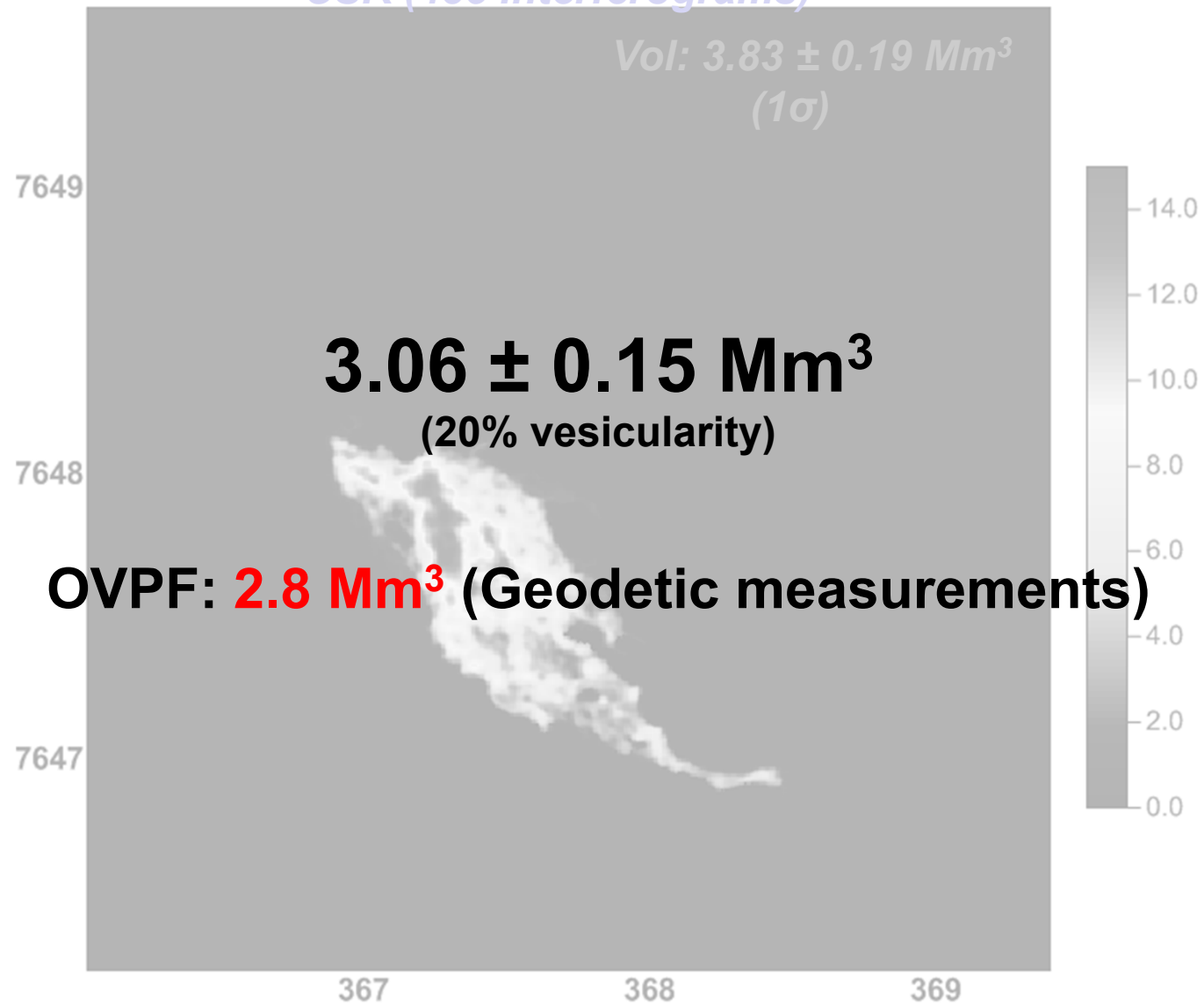
UD Displacement Rate



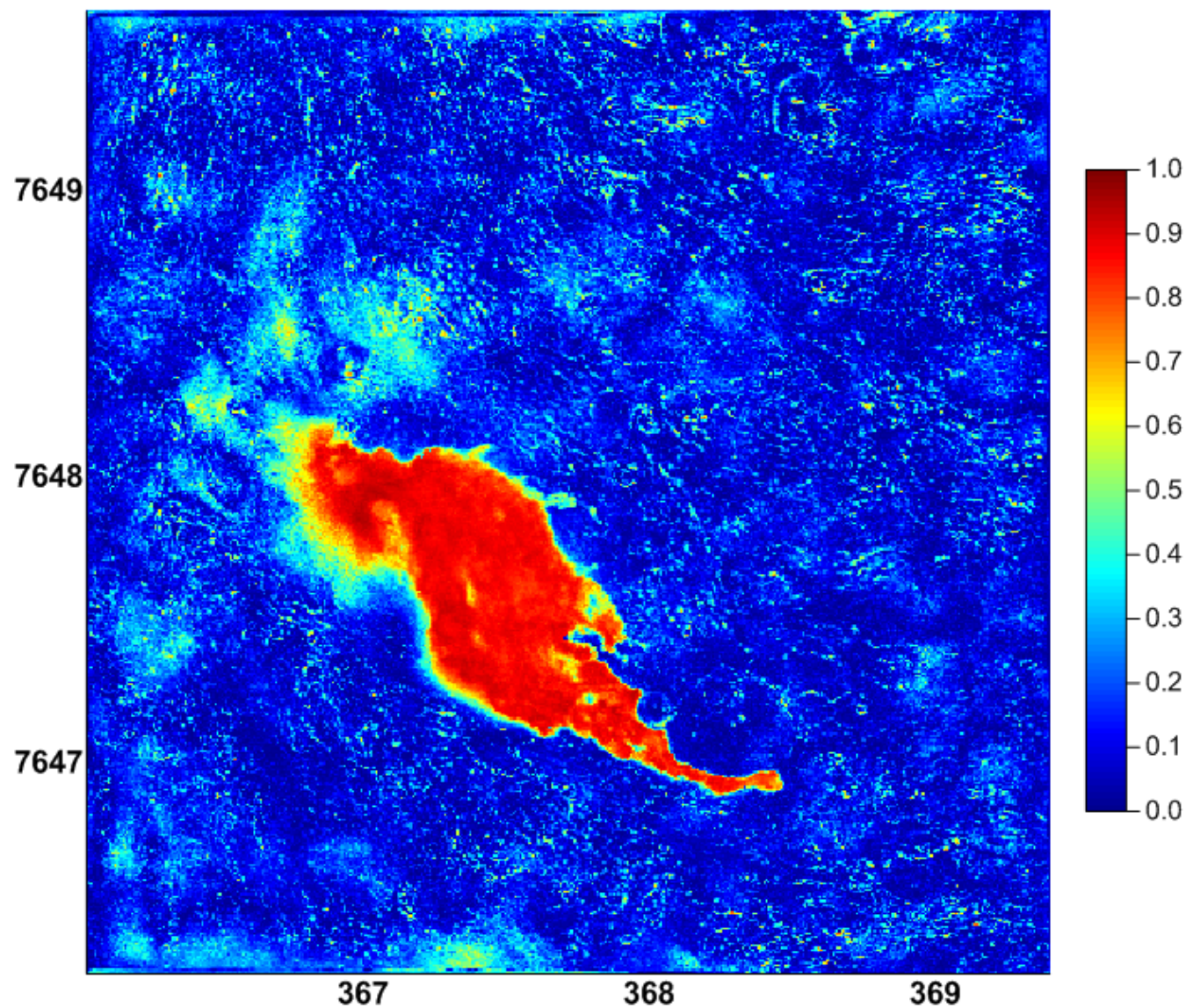
Derived Thickness Map CSK (435 Interferograms)



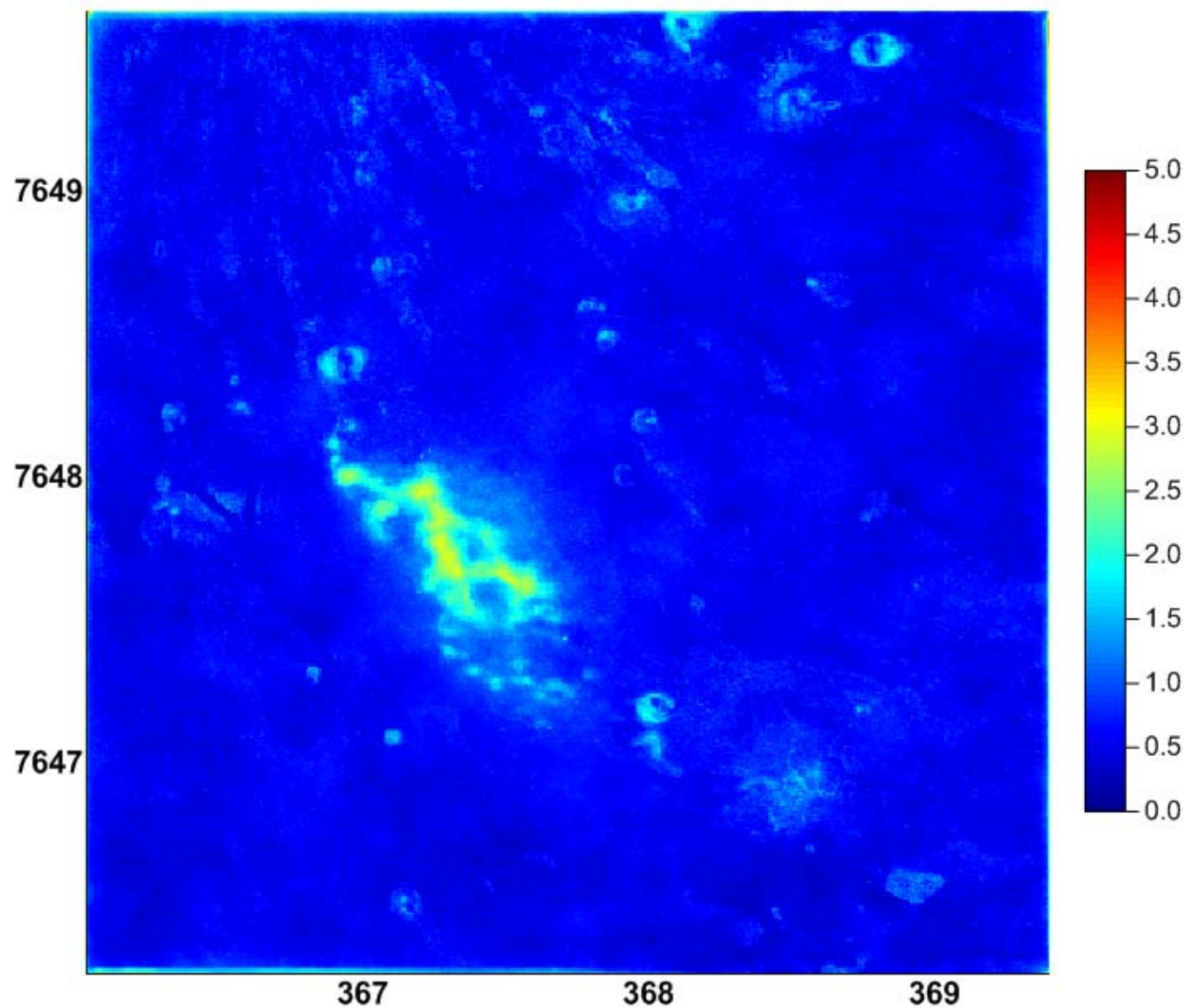
Derived Thickness Map
CSK (435 Interferograms)

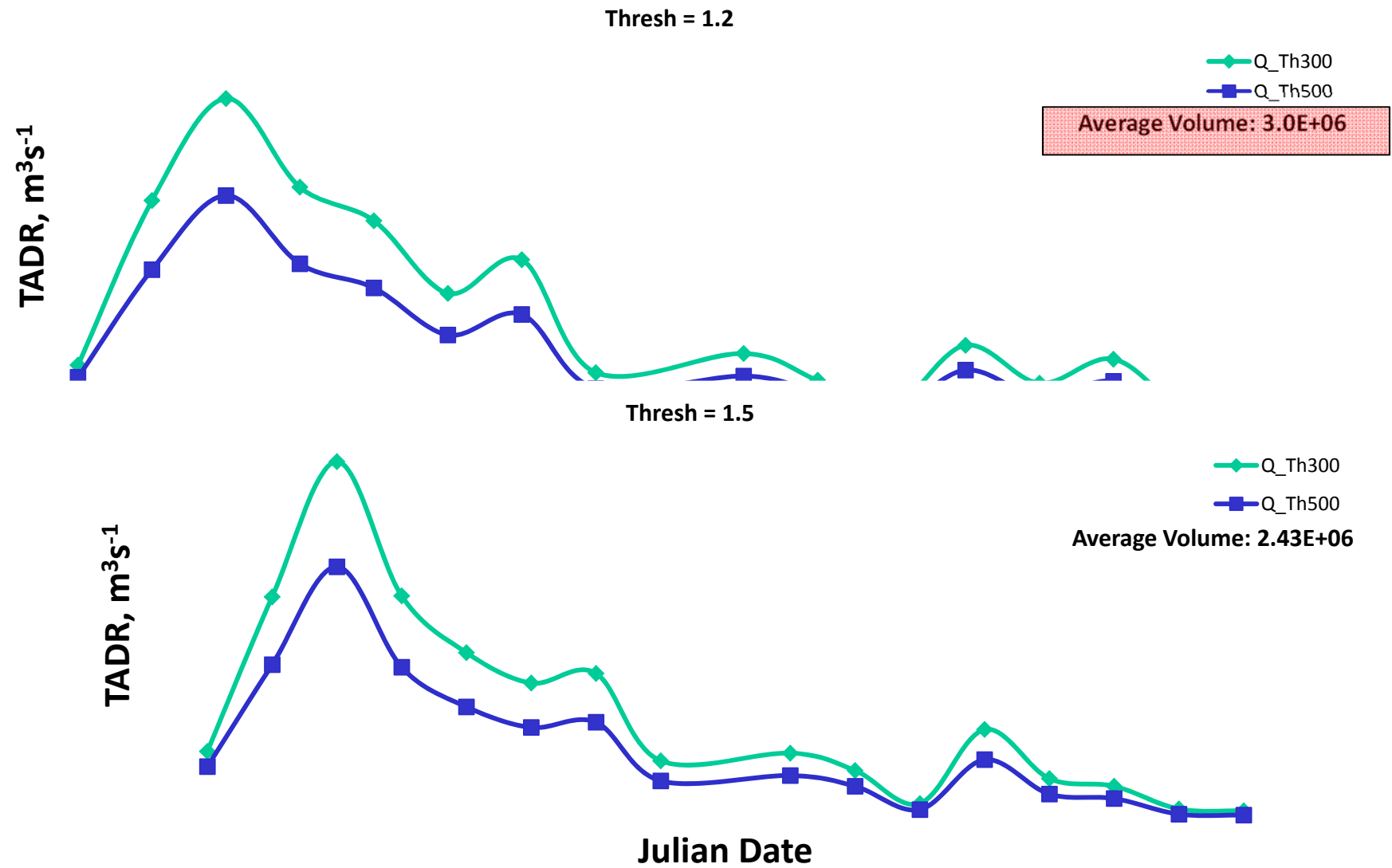


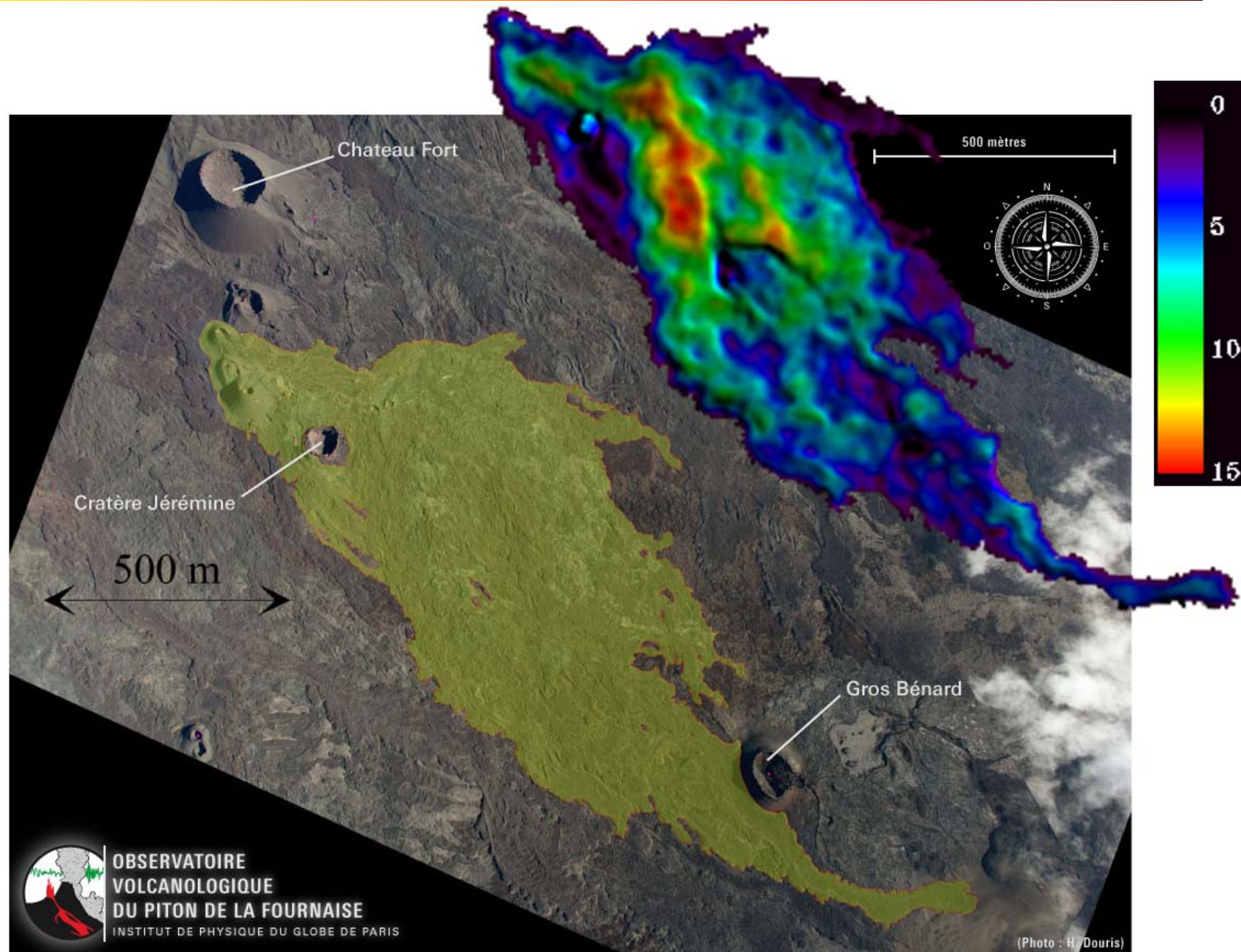
R²Map (Cosmo Skymed, 435 Interferos)

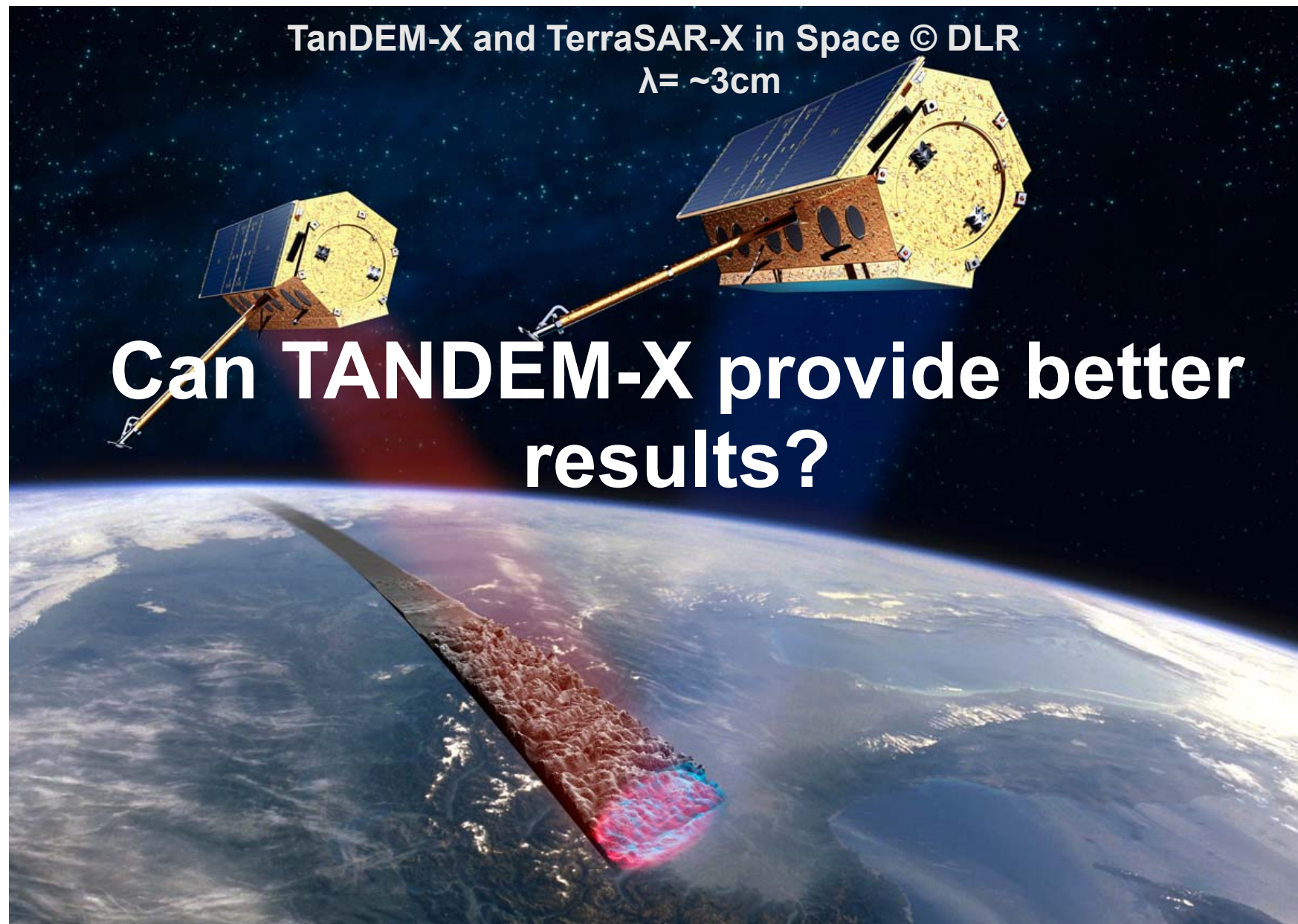


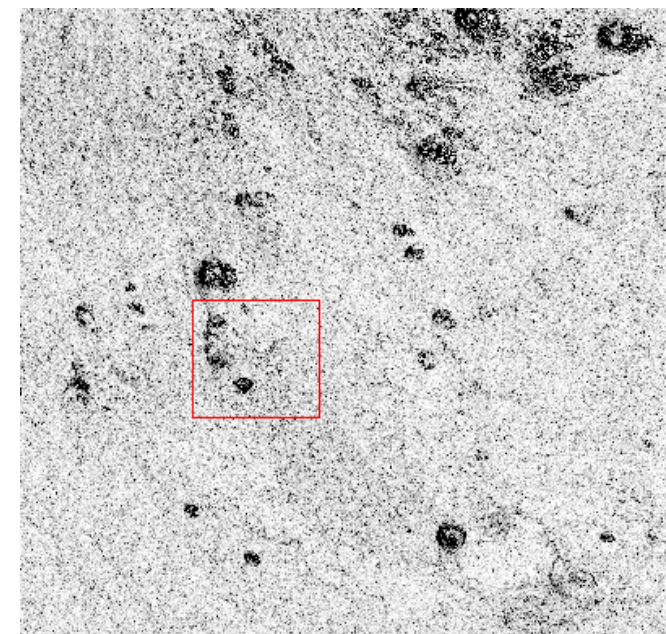
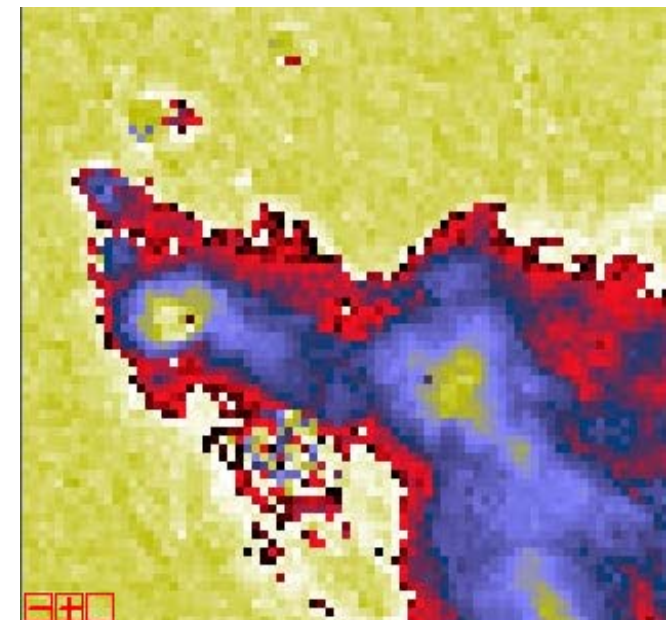
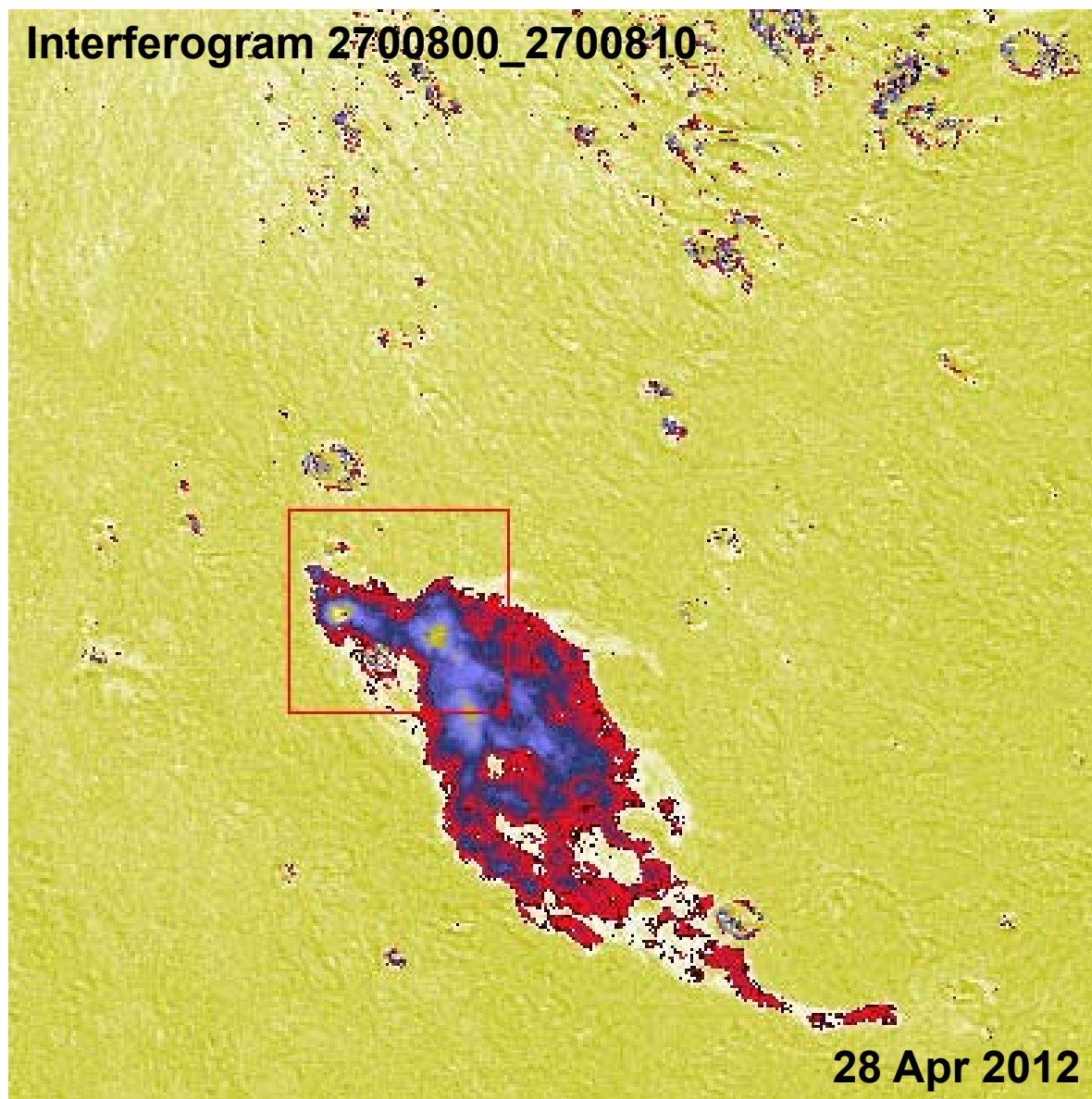
Misfit Map (Cosmo Skymed, 435 Interferos)

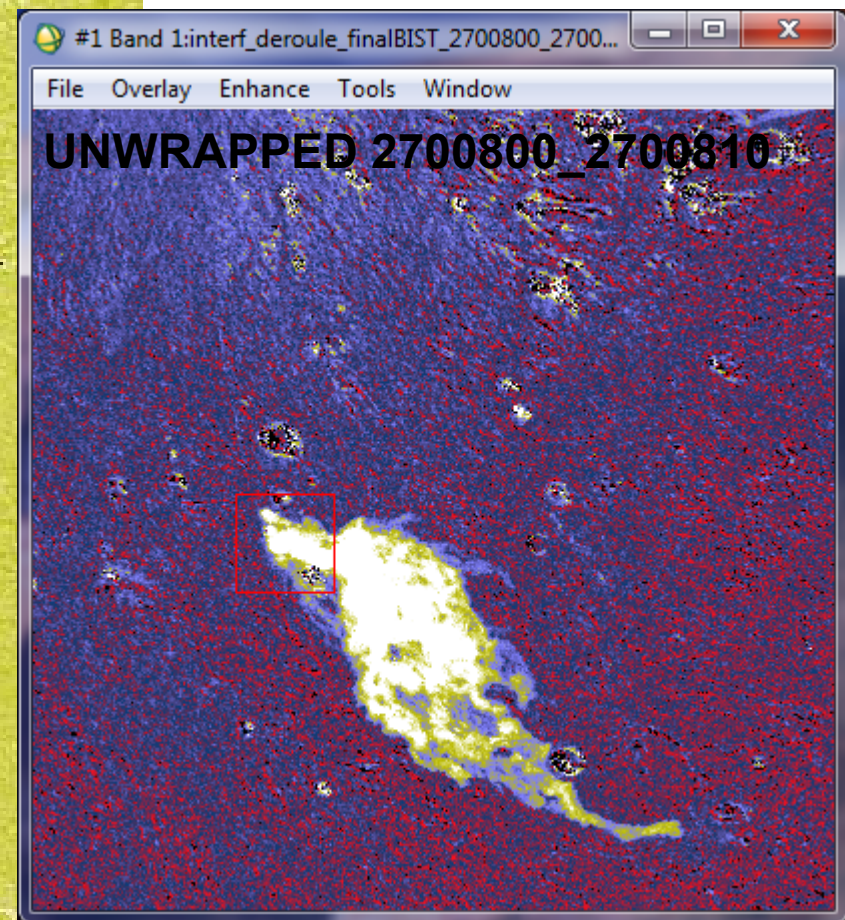
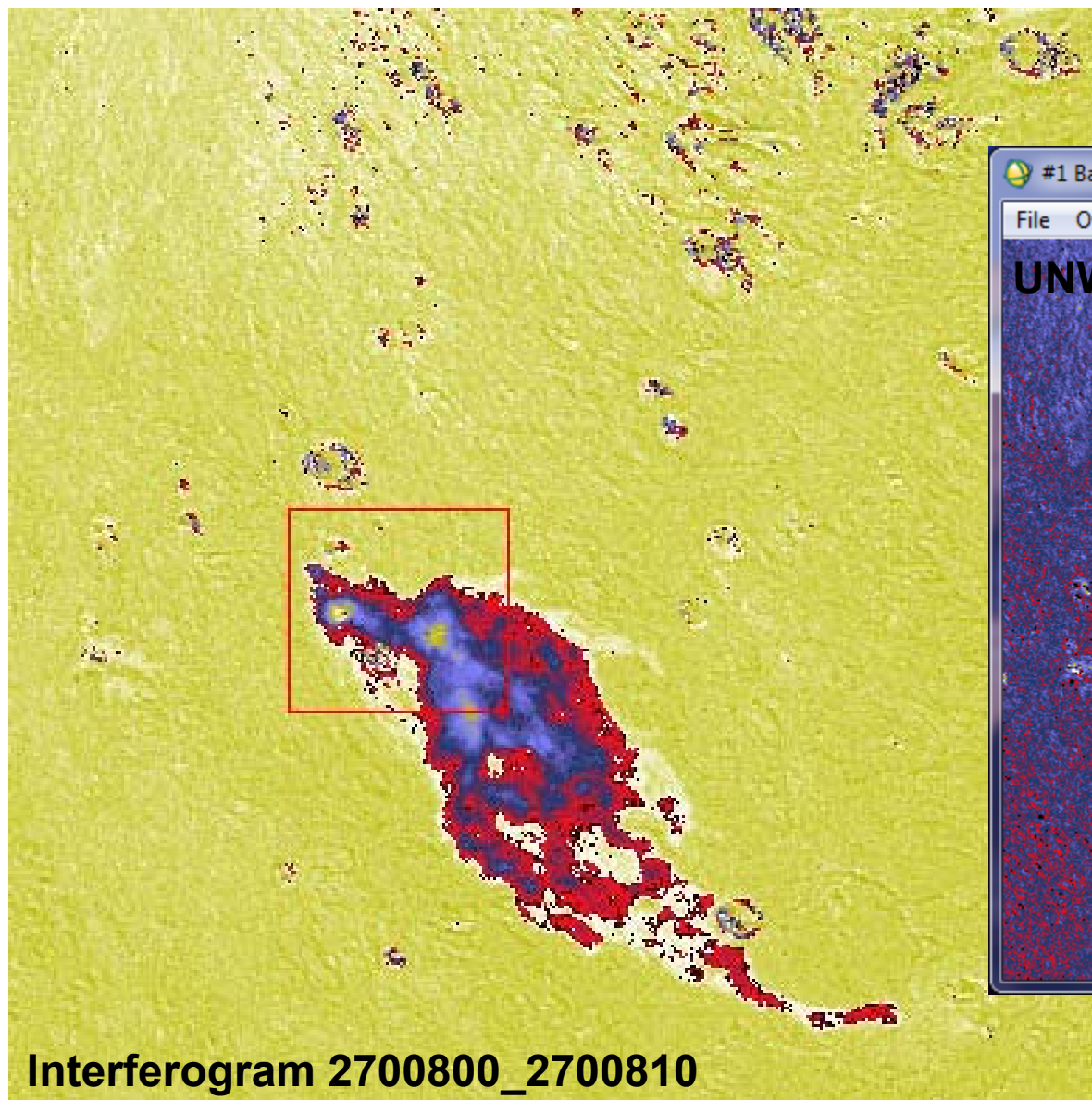


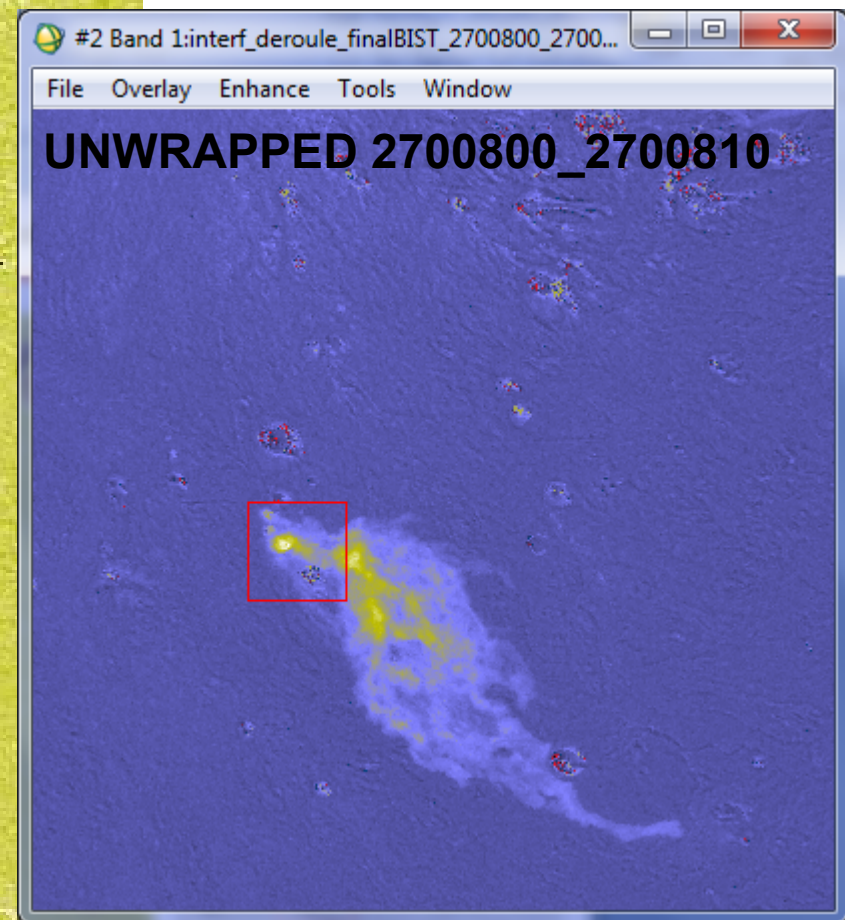
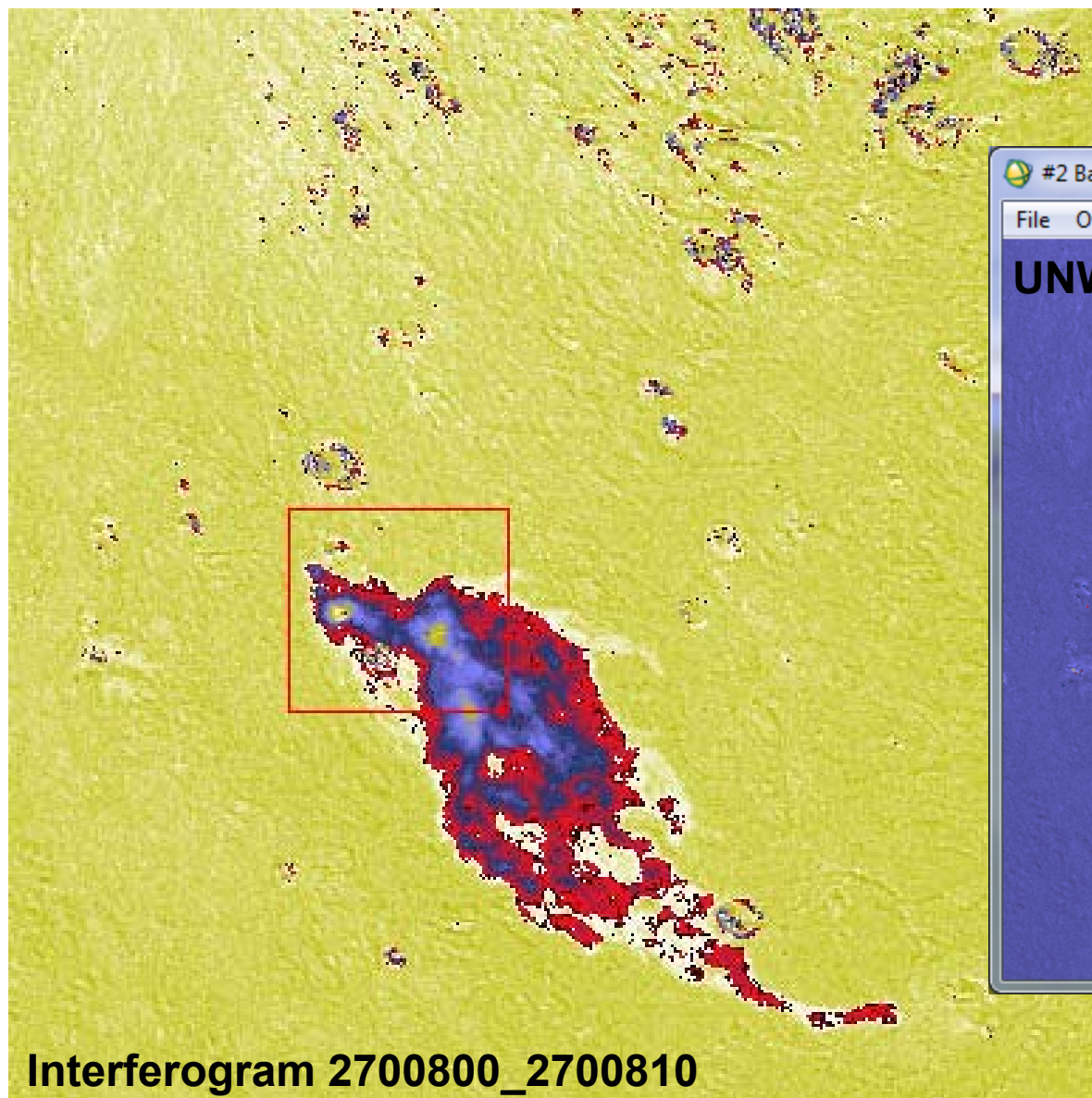


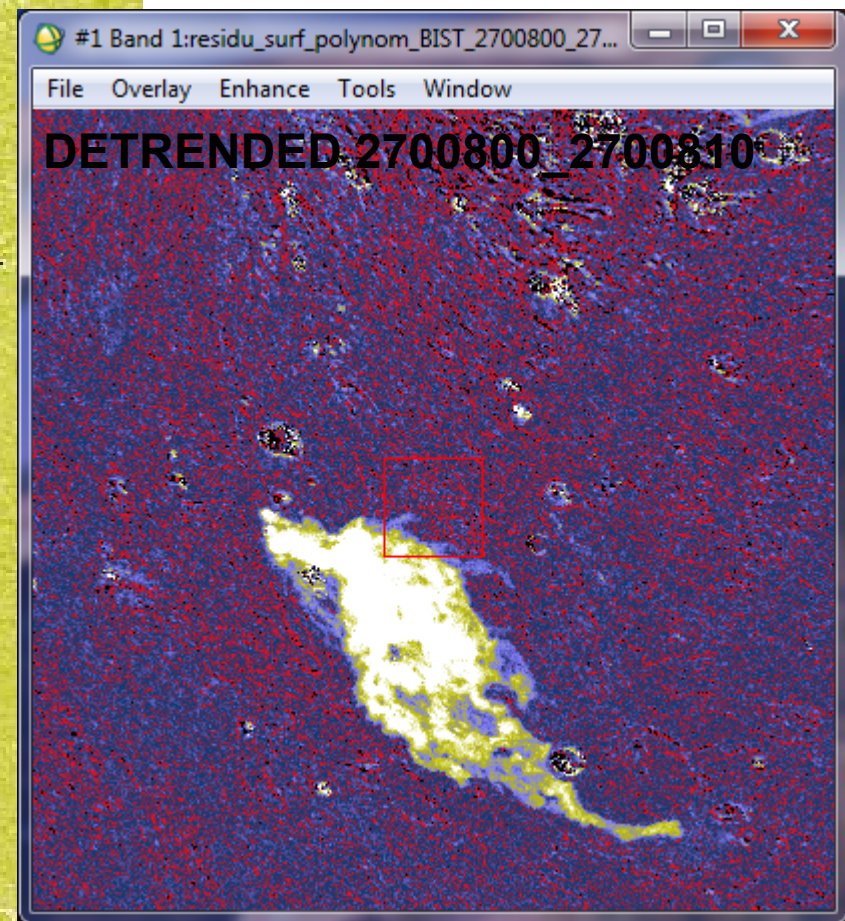
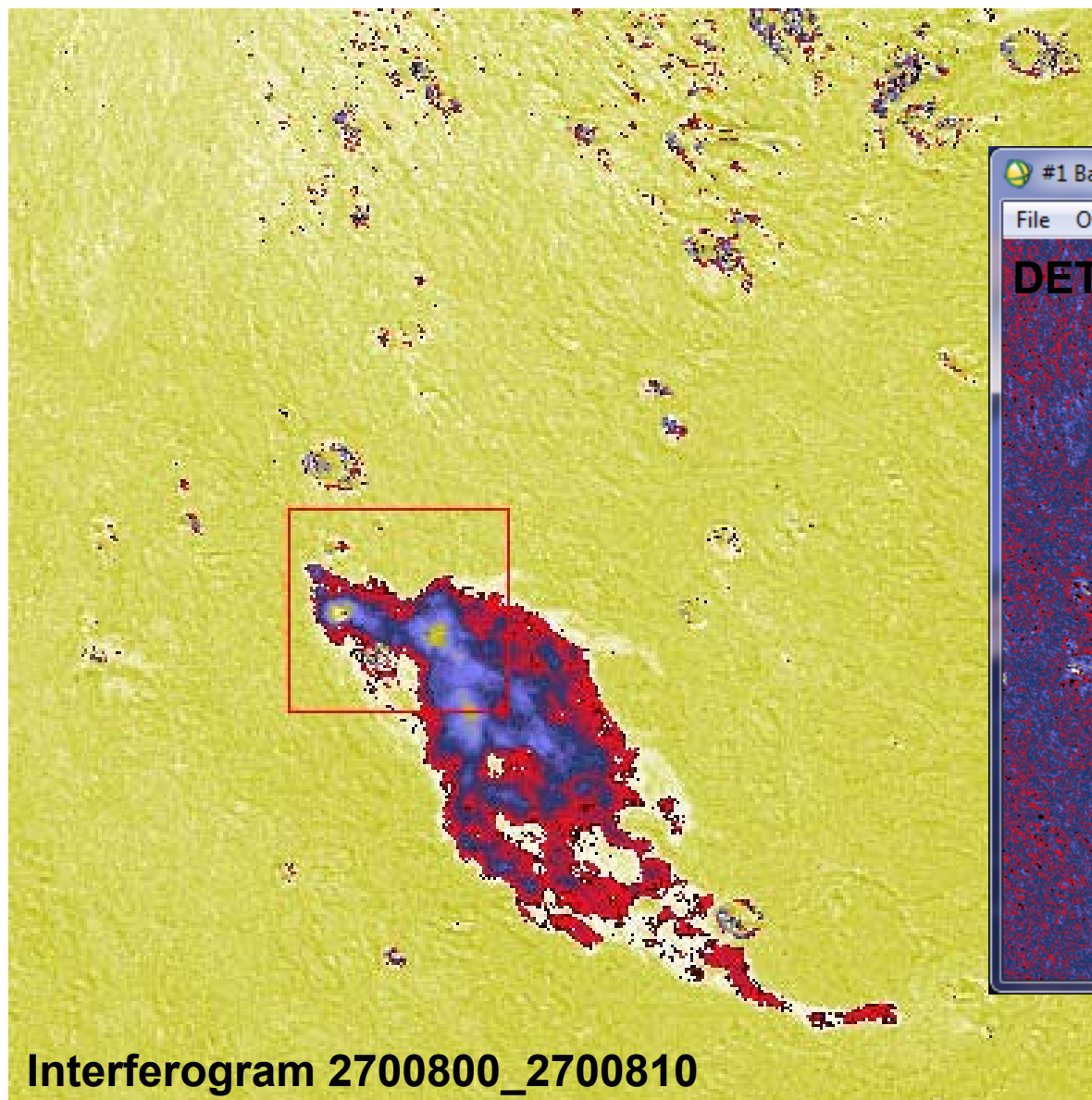


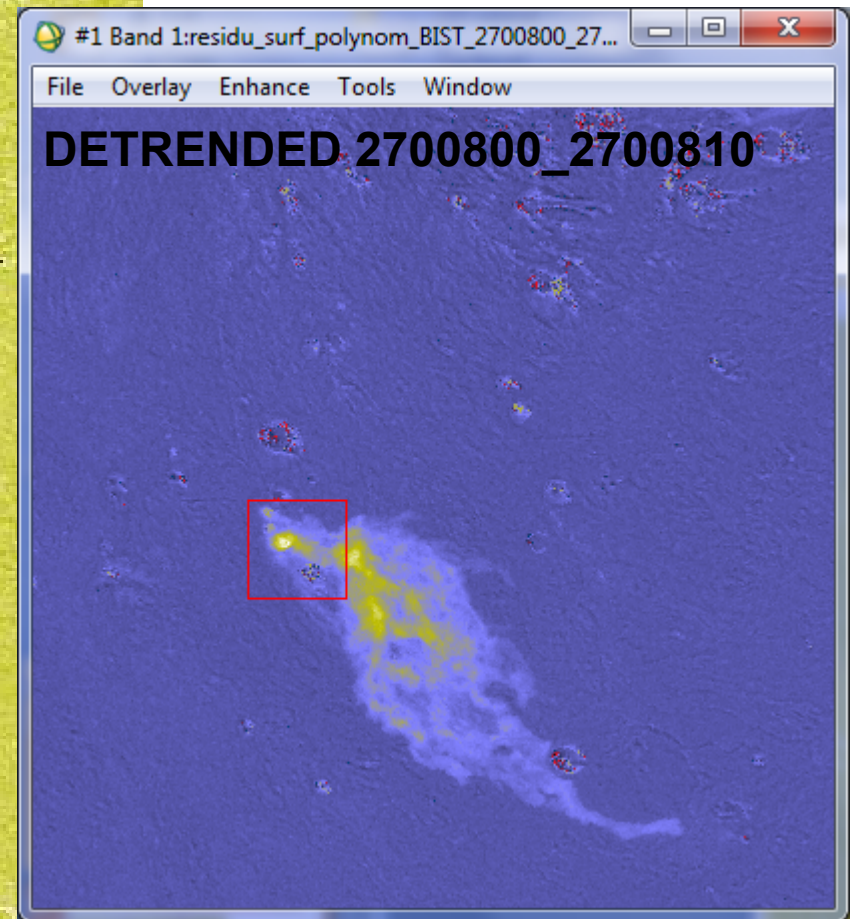
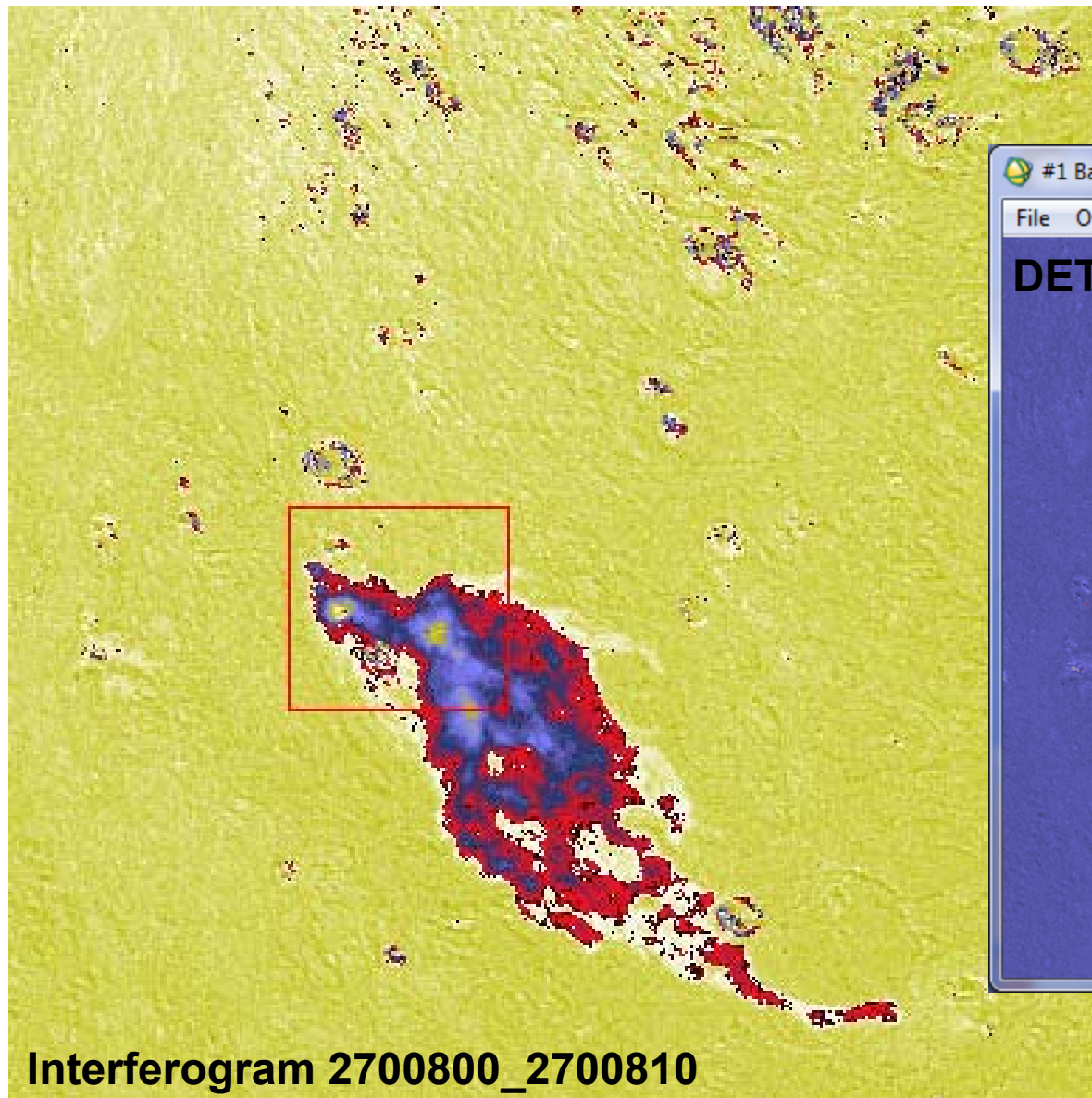






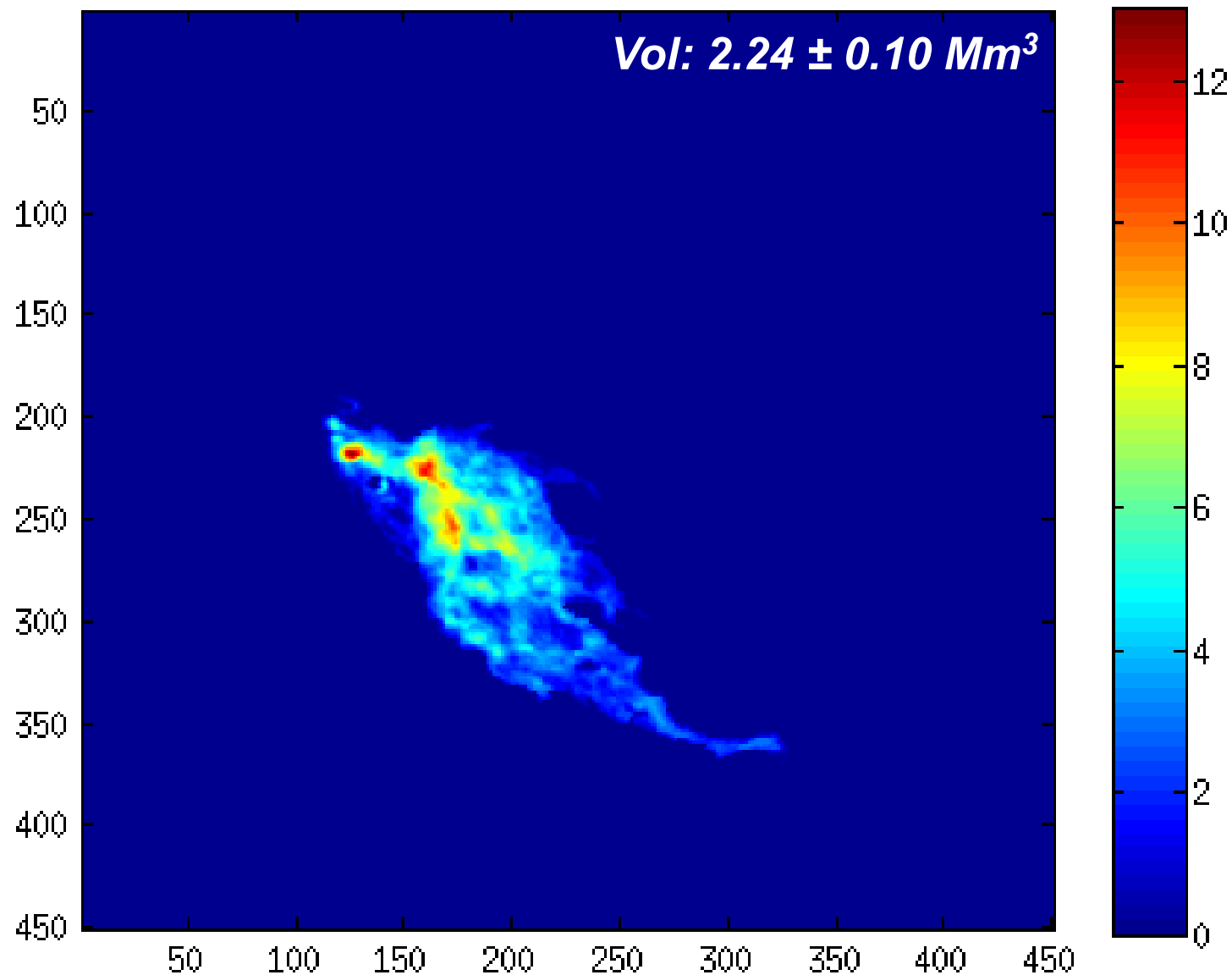






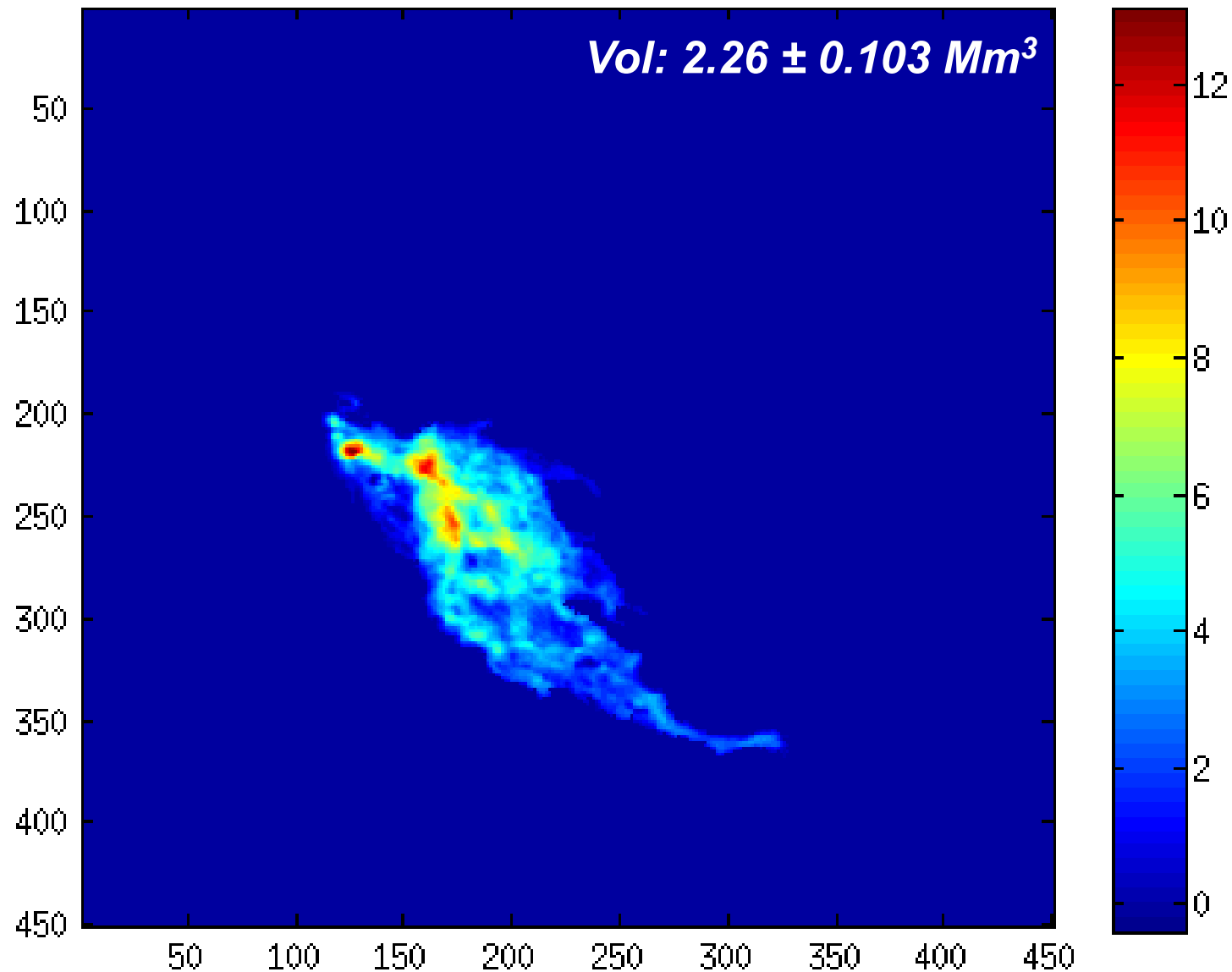
Derived Thickness Map:

TanDEM-X (41 interfero)



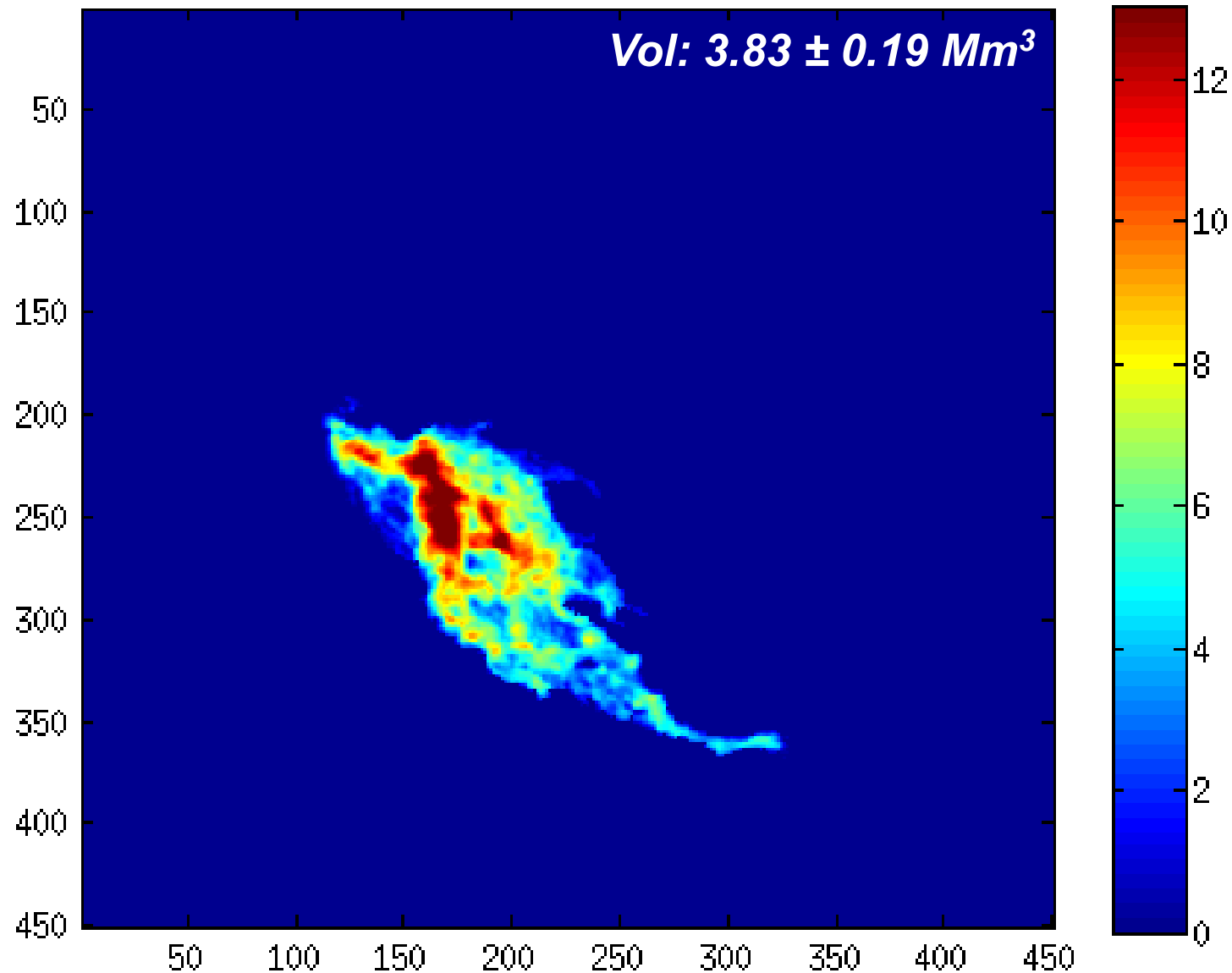
Derived Thickness Map:

TanDEM-X (AA and SNR filtered, 27 interfero)



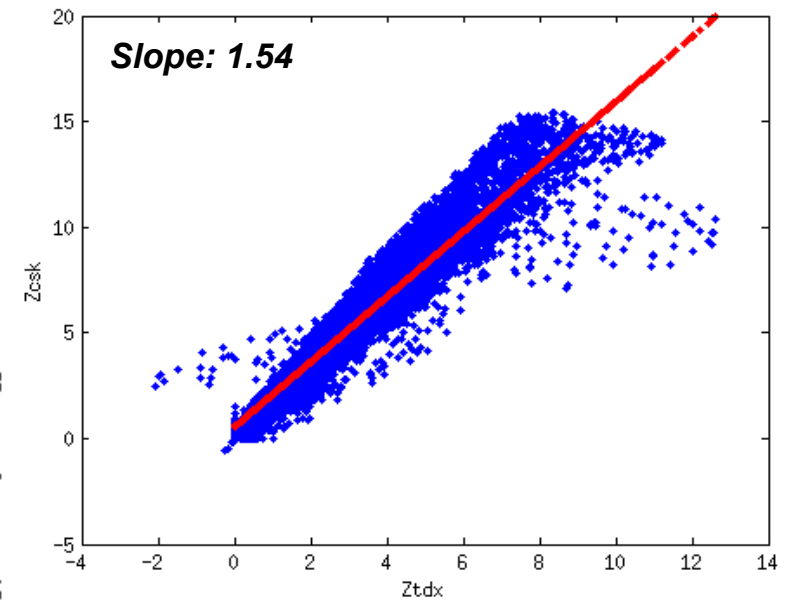
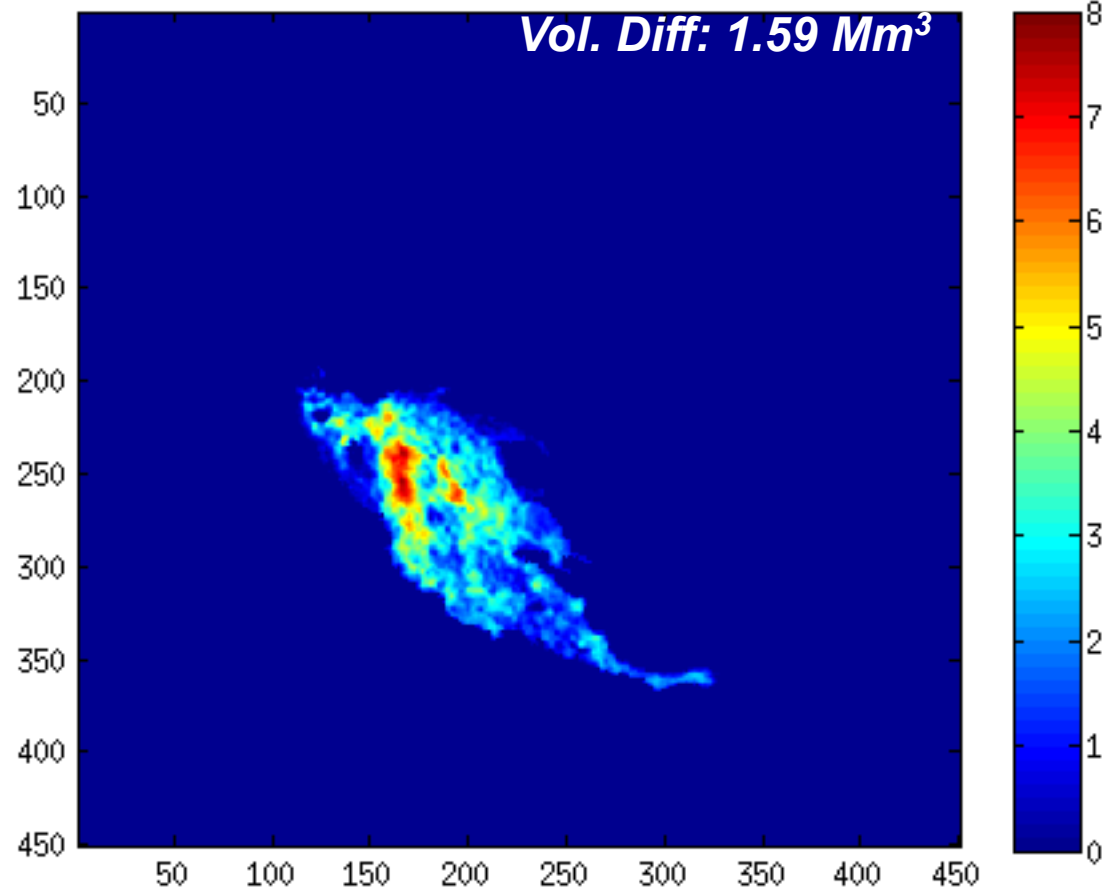
Derived Thickness Map:

Cosmo-SkyMed (435 interfero)



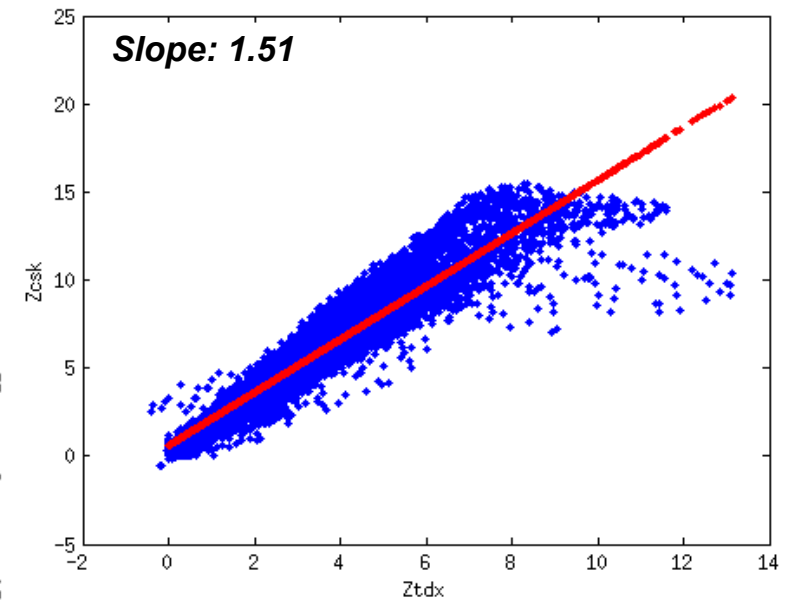
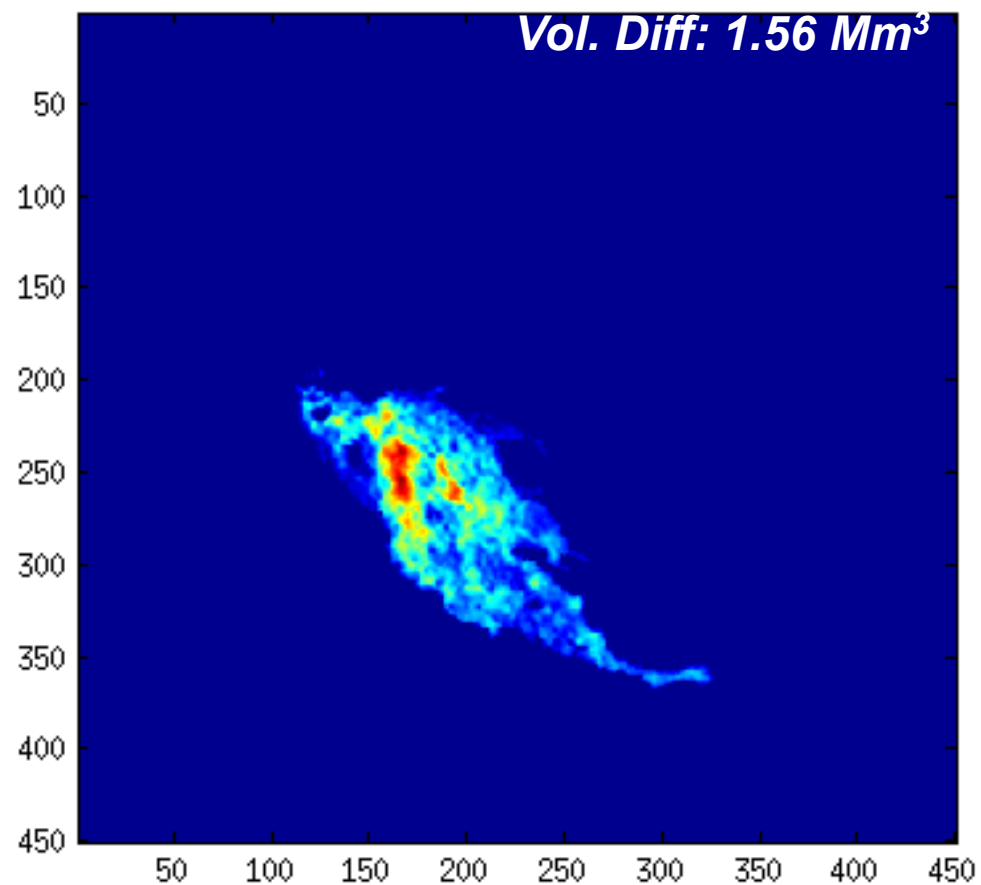
Difference in Thickness

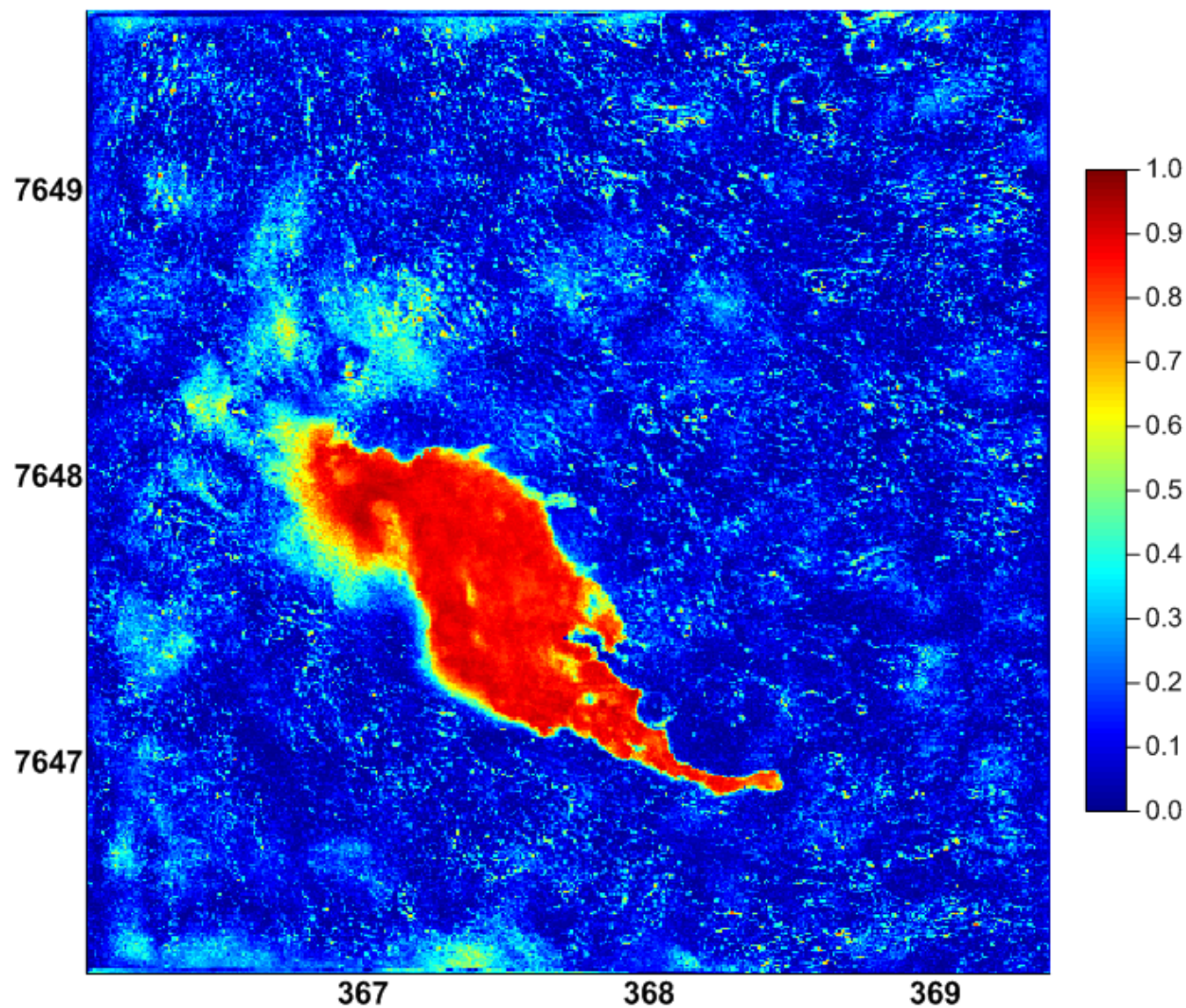
CSK (435 images) vs. TDX (41 images)



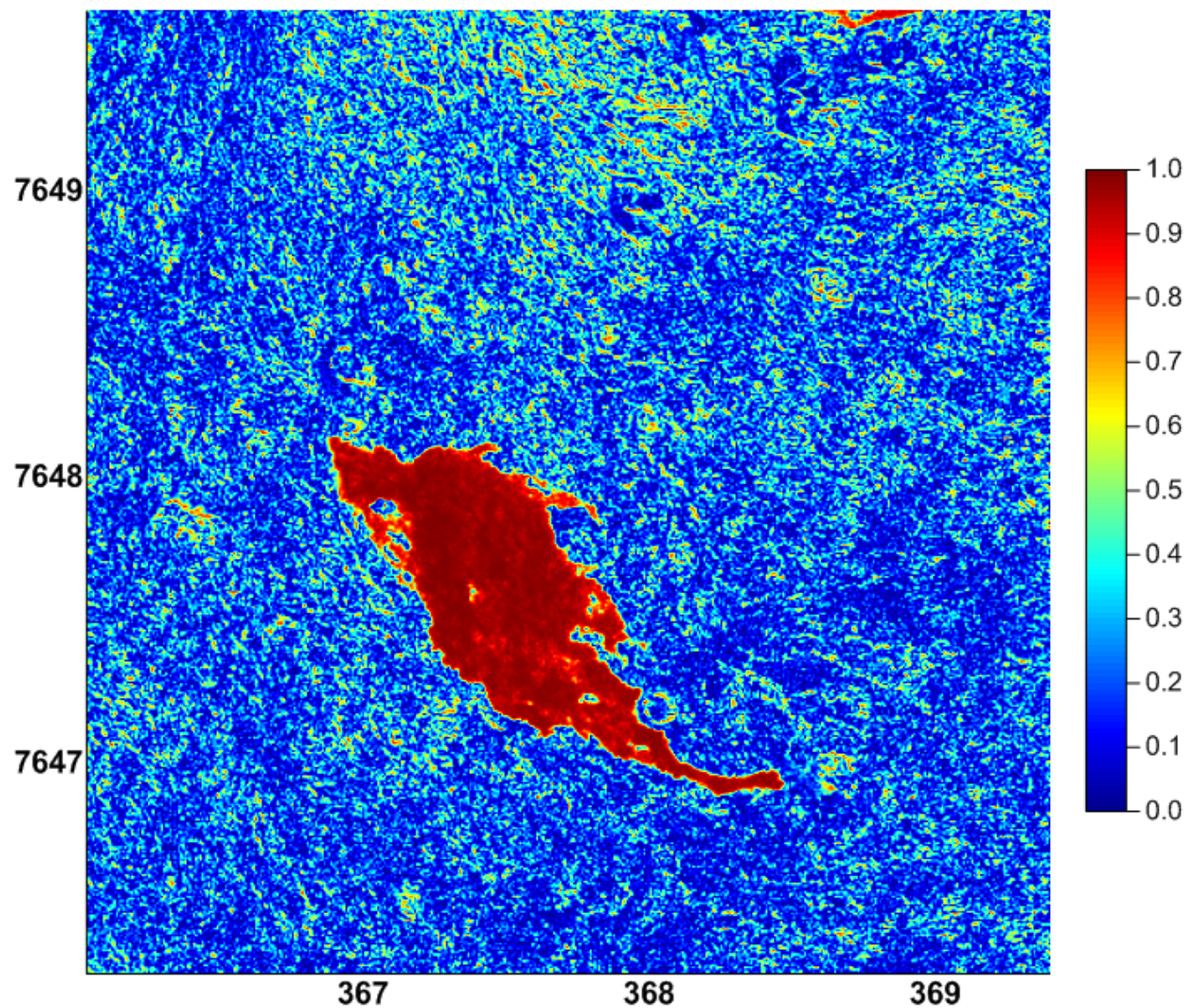
Difference in Thickness

CSK (435 images) vs. TDX (27 images)

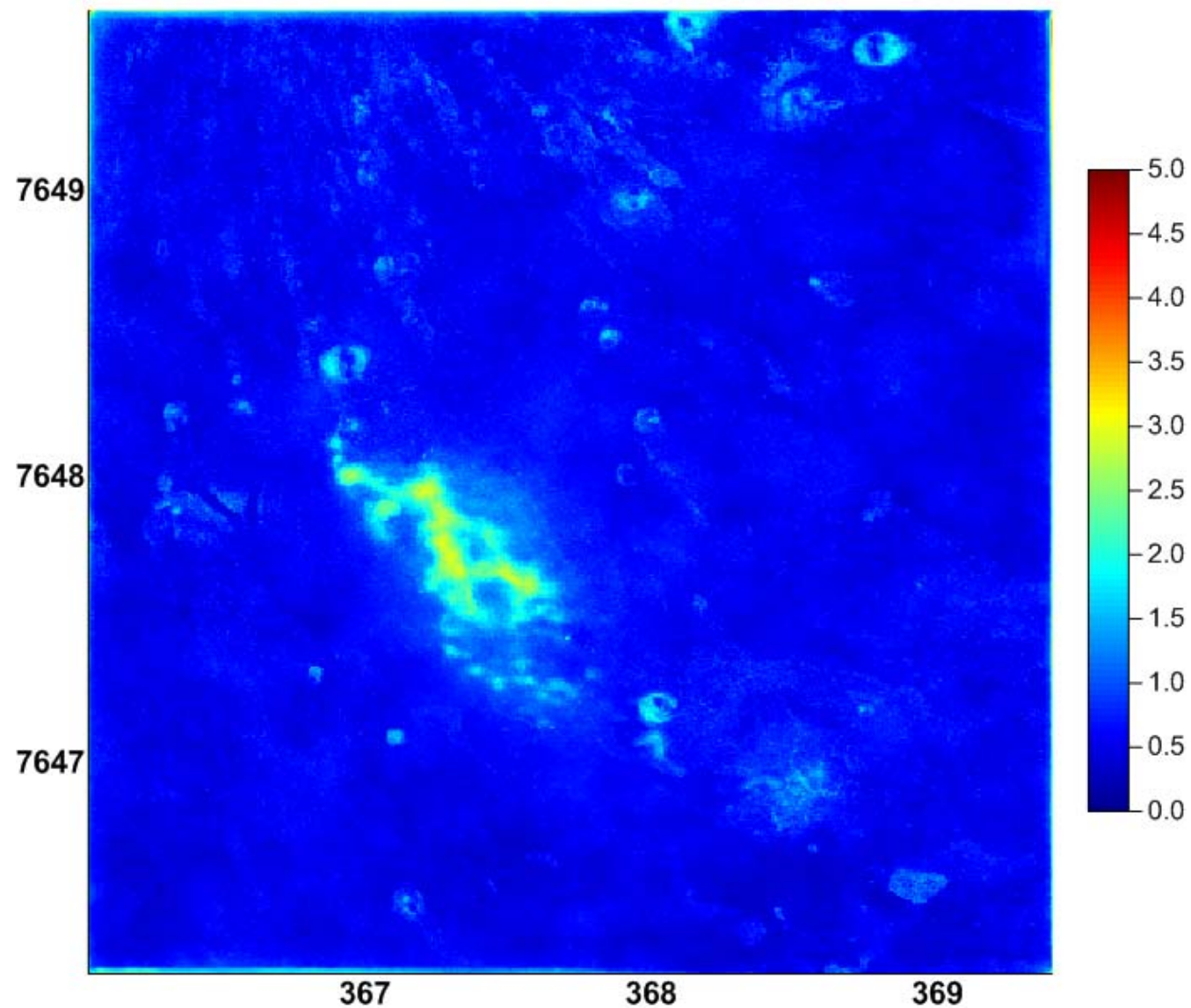


R²Map (Cosmo Skymed, 435 Interferos)

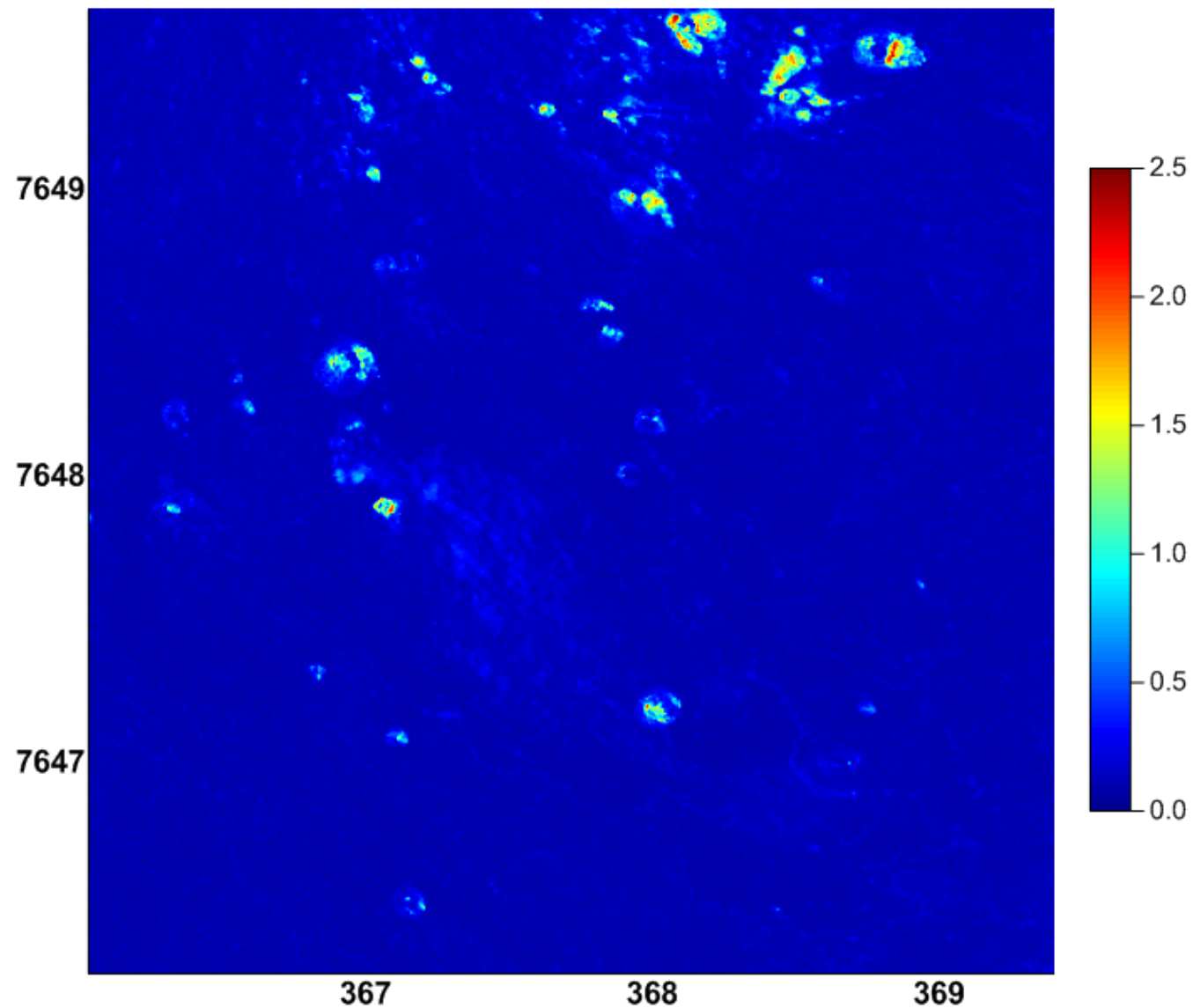
R^2 Map (Tandem-X, 27 Interferos)

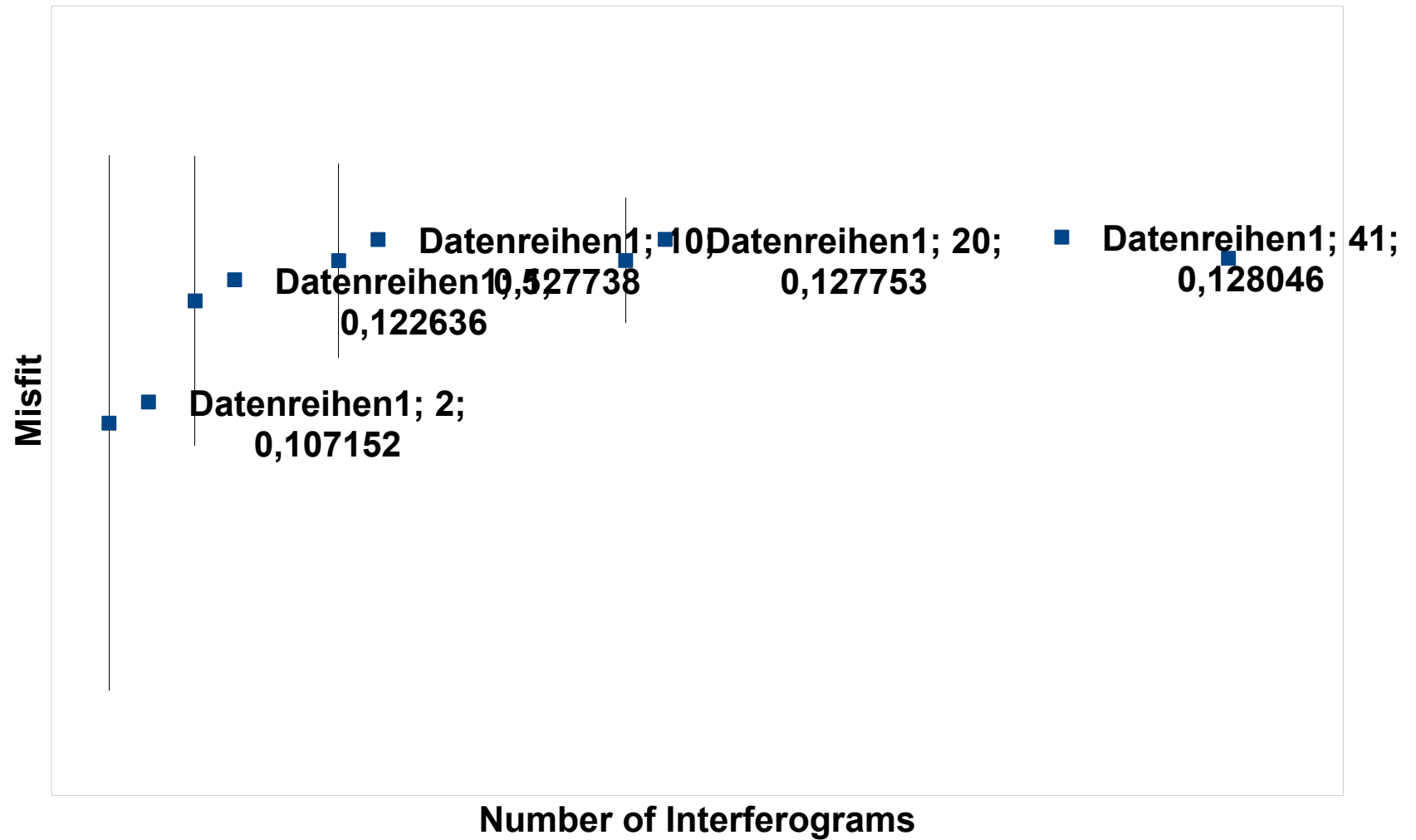


Misfit Map (Cosmo Skymed, 435 Interferos)



Misfit Map (Tandem-X, 27 Interferos)















Thank you ! ☺

