

Search for...

Opacity:



Reset

About



Towards global InSAR deformation monitoring of volcanoes

insarmaps.miami.edu

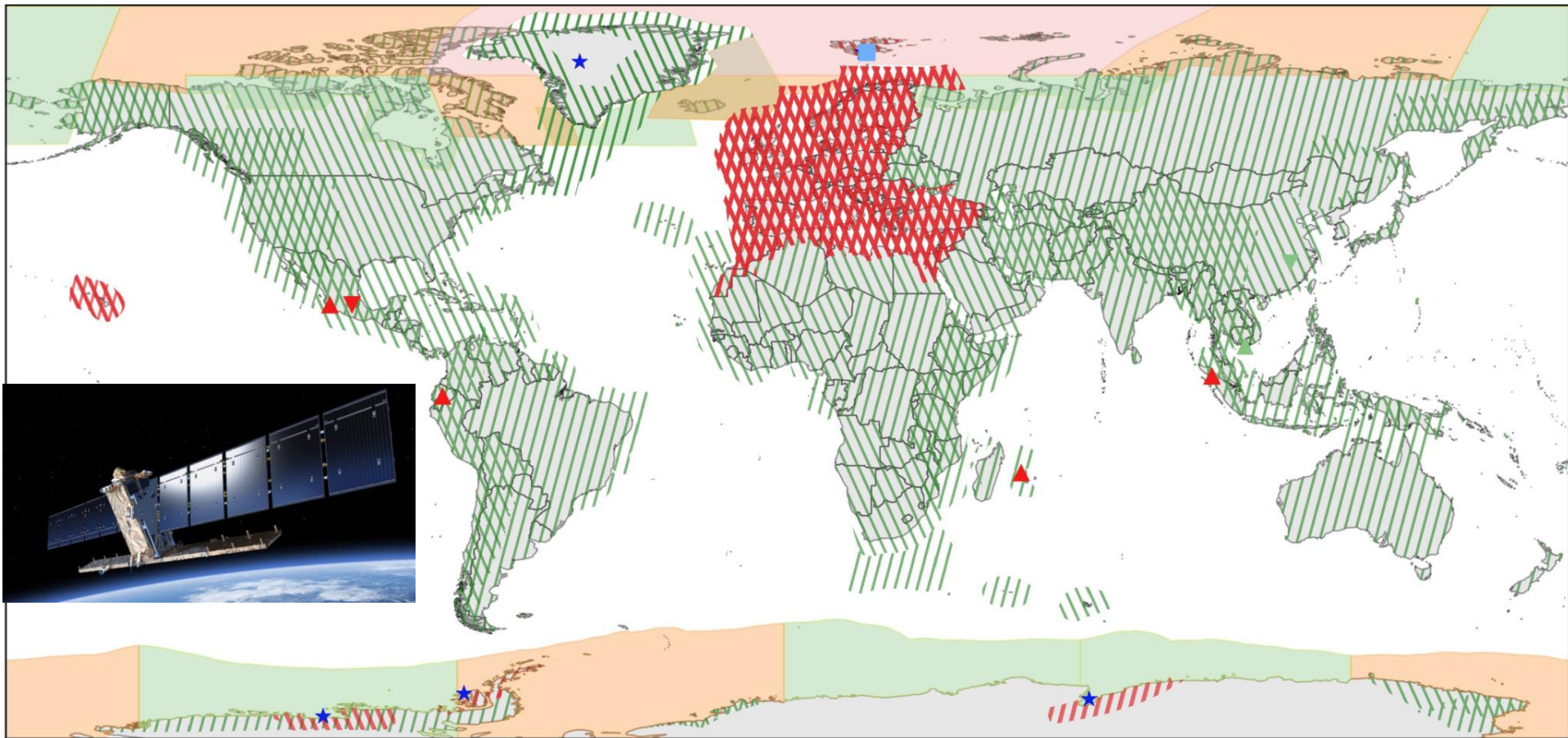
Falk Amelung, Yunjun Zhang, Bhuvan Varugu,
Alfredo Terrero, Joshua Zahner, Sara Mirzaee
University of Miami

• Outline

- Sentinel-1, NISAR
- Examples from Ecuador, Indonesia
- Mauna Loa 2014-2017

Satellite	Rel Orbit	First Frame	Mode	Flight Dir.
Alos	74	2960	SM	D
Alos	423	620	SM	A
Alos	425	640	SM	A
Alos	72	2950	SM	D
Alos	72	2970	SM	D
ALOS	424	610	SM	A ▼
ALOS	422	7010	SM	A ▼
ALOS	422	650	SM	A

Global SAR coverage with Sentinel-1

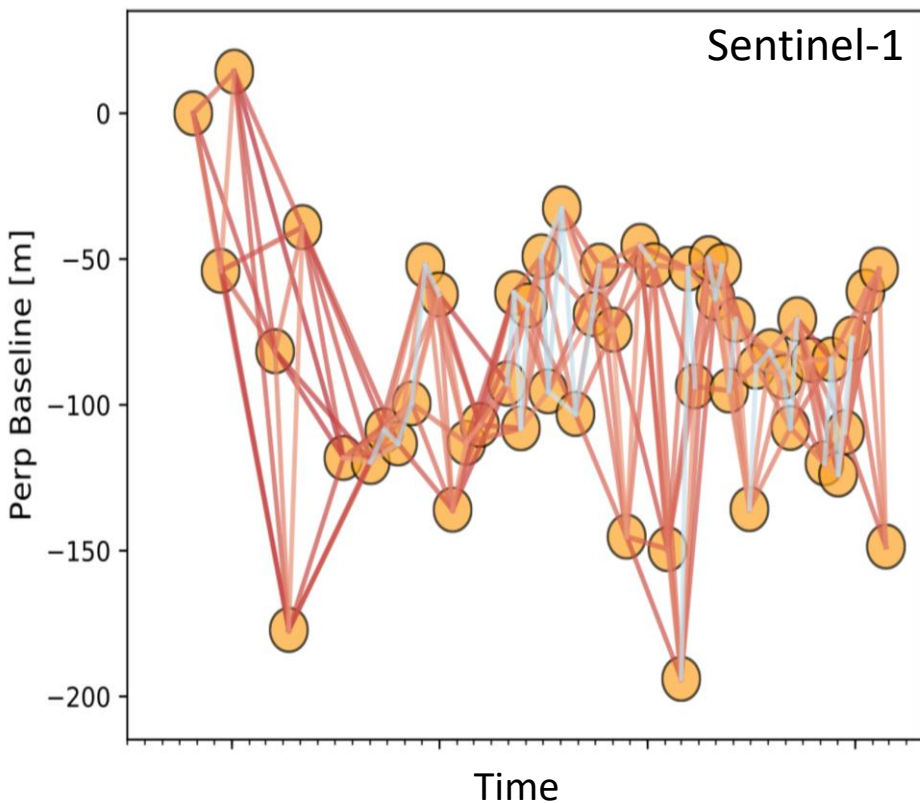


PASS	REVISIT	FREQUENCY *	COVERAGE	FREQUENCY **	REFERENCE DATA SITES (6d repeat)
ASCENDING DESCENDING	6 days 3 days 2 days	12 days 6 days 3 days	1 days 1-3 days 2-4 days	Highly active volcanism Fast subsidence Short growth cycle, intensive agriculture Fast changing wetlands Fast moving outlet glaciers Permafrost & glaciers	

* coverage ensured from same, repetitive relative orbits
 ** coverage not considering repetitiveness of relative orbits

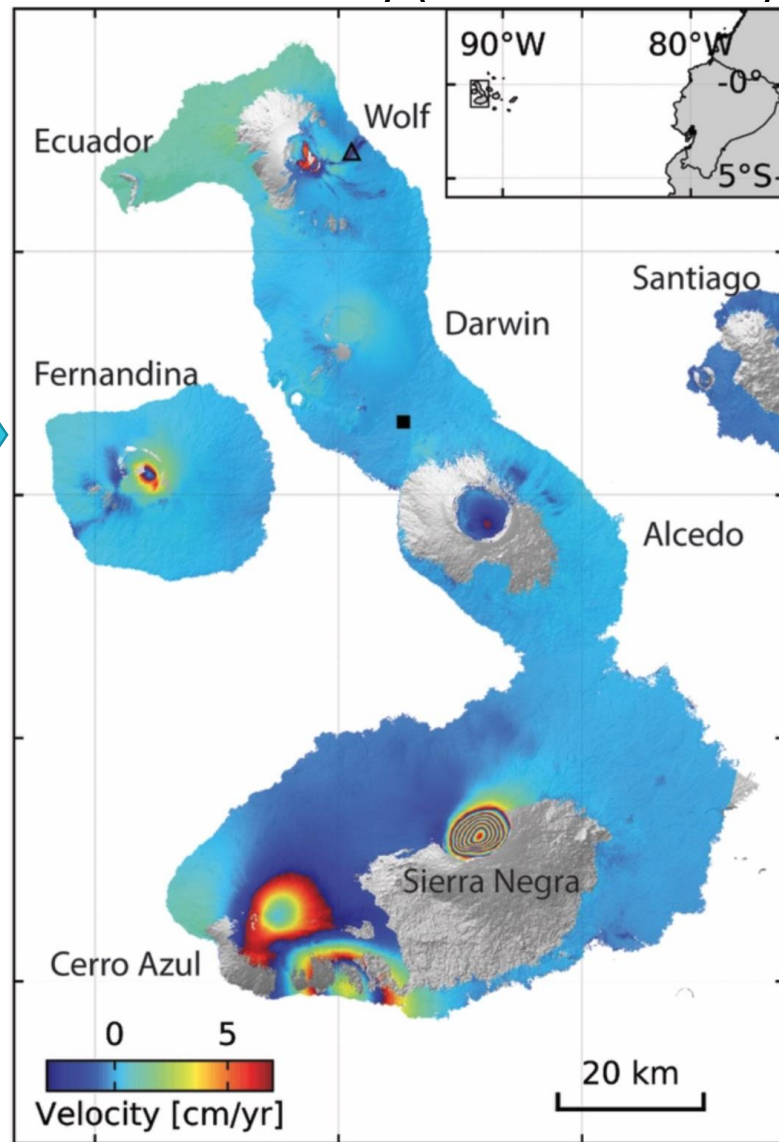
InSAR time series analysis

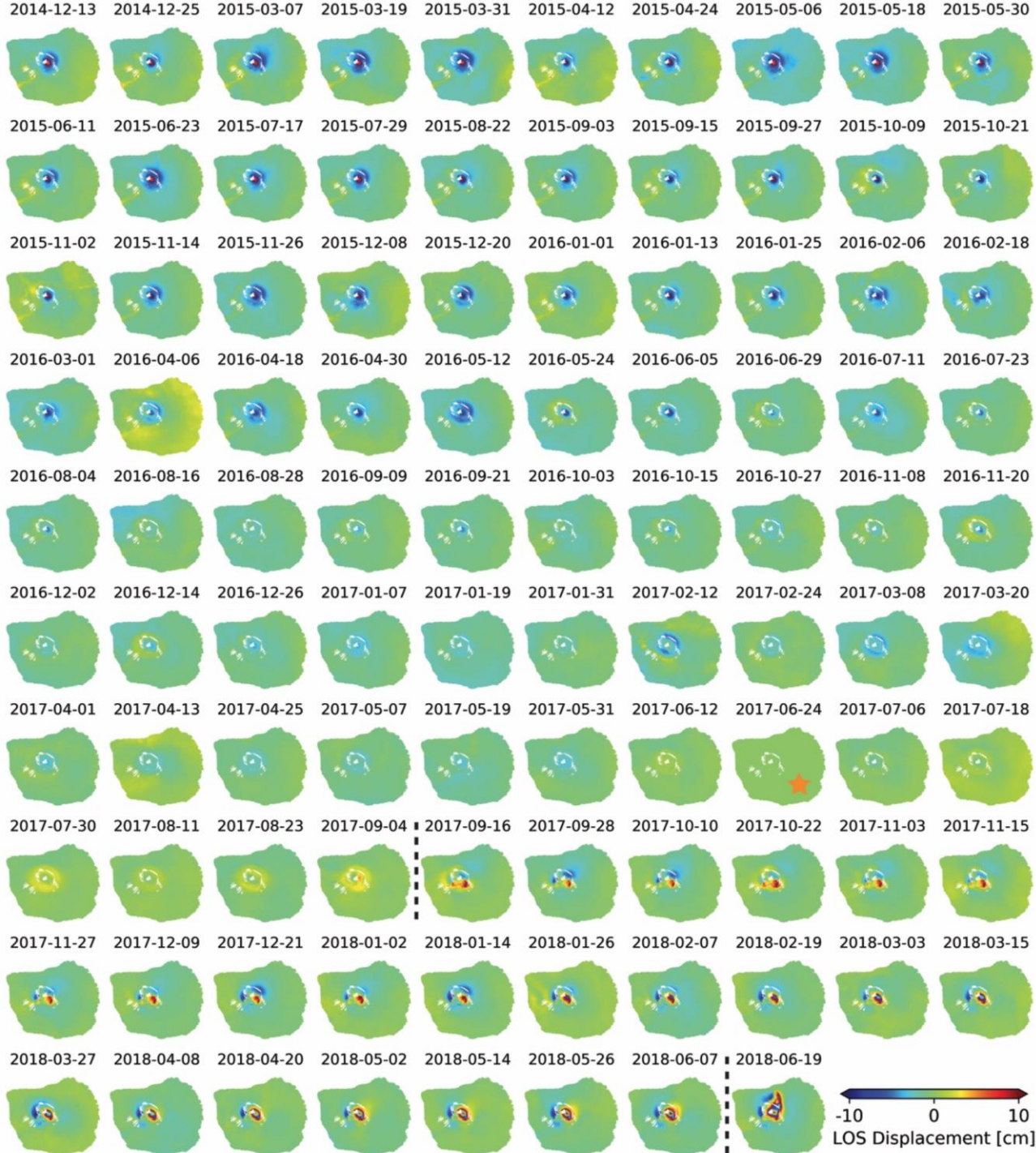
Network of SAR acquisitions



Distributed Scatterer Method

LOS velocity (and time series)



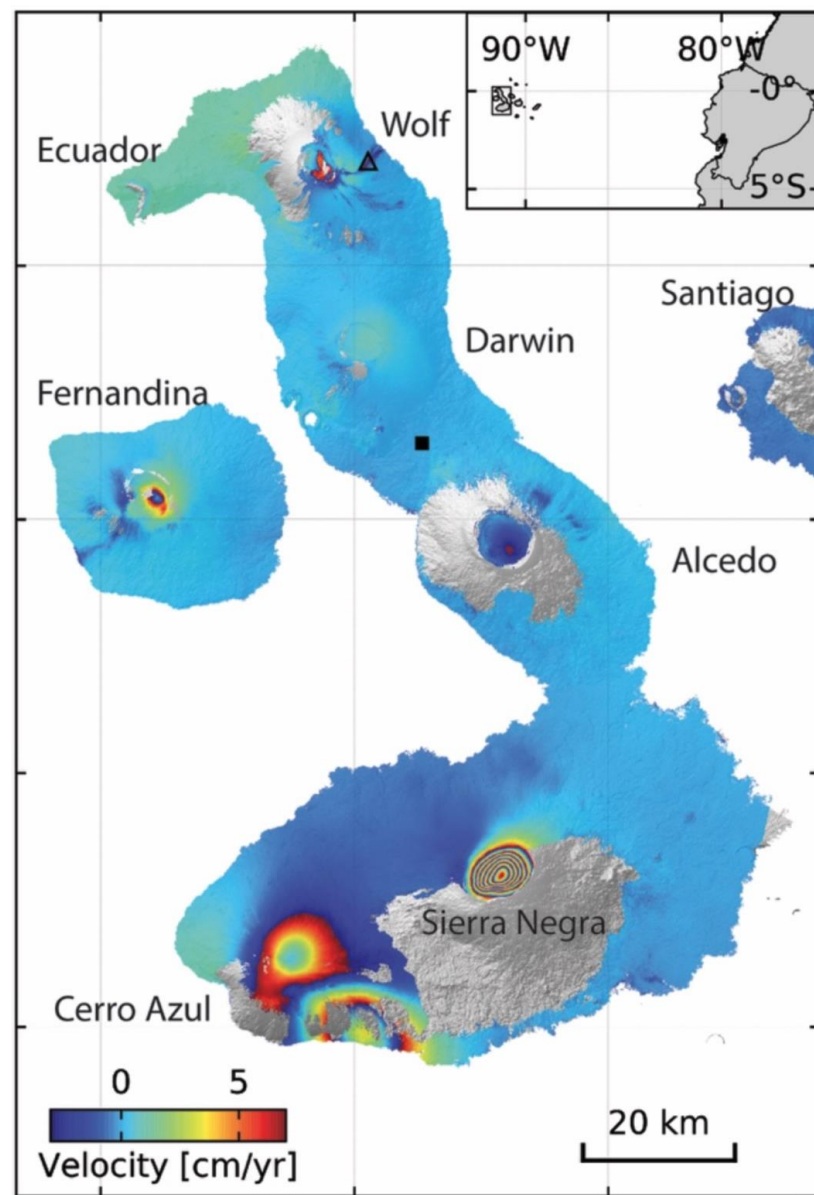
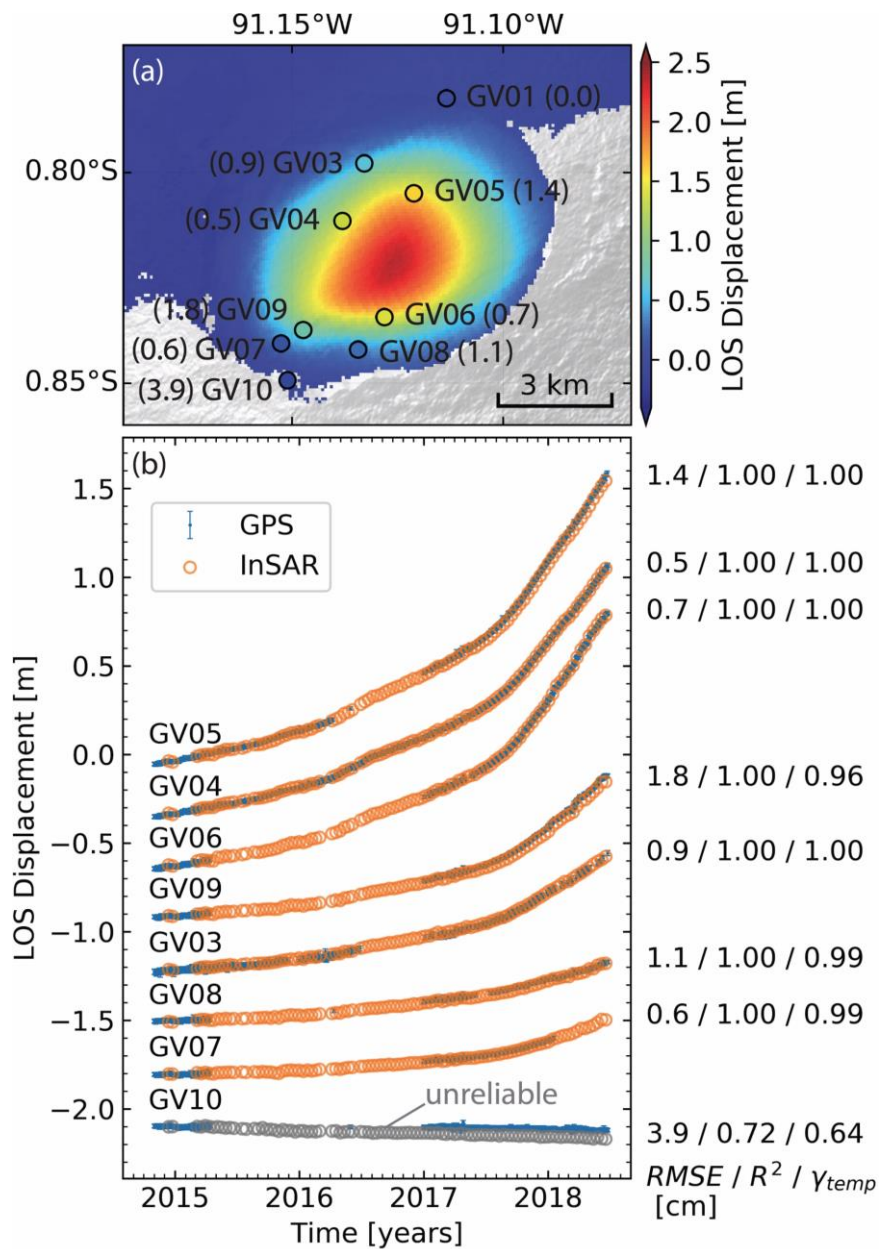


One measurement
every
6-12 days

Continuous
InSAR
Timeseries
(C-InSAR)

200 acquisitions
acquired for Europe
(ascending plus
descending)

InSAR time series analysis





THE NASA-ISRO SAR (NISAR) DUAL-BAND MISSION

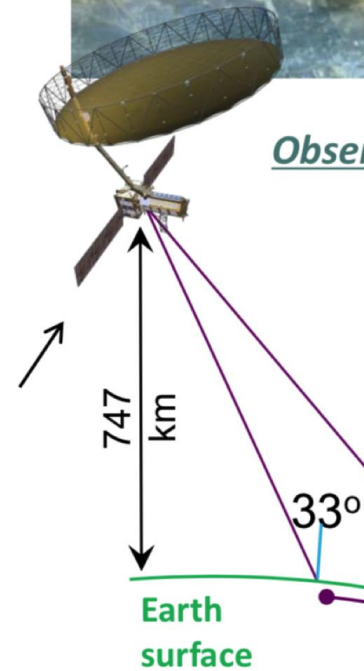
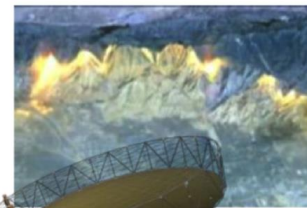
© 2019 California Institute of Technology. Government sponsorship acknowledged.



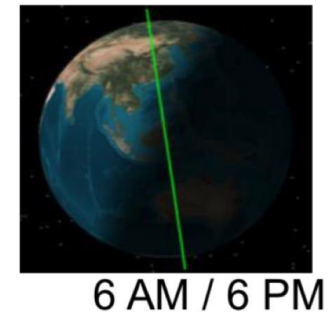
NISAR Science Observations Overview

NISAR Characteristic:	Enables:
L-band (23 cm wavelength)	Low temporal decorrelation and foliage penetration
S-band (9 cm wavelength)	Sensitivity to light vegetation
SweepSAR technique with Imaging Swath > 240 km	Global data collection
Polarimetry (Single/Dual/Quad)	Surface characterization and biomass estimation
12-day exact repeat	Rapid Sampling
3 – 10 meters mode-dependent SAR resolution	Small-scale observations
3 yrs (NASA) / 5 yrs (ISRO) science operations	Time-series analysis
Pointing control < 273 arcseconds	Deformation interferometry
Orbit control < 500 meters	Deformation interferometry
> 10% (S) / 50% (L) observation duty cycle	Complete land/ice coverage
Left-only pointing (Left/Right capability)	Uninterrupted time-series Rely on Sentinel-1 for Arctic

NISAR Will Uniquely Capture the Earth in Motion



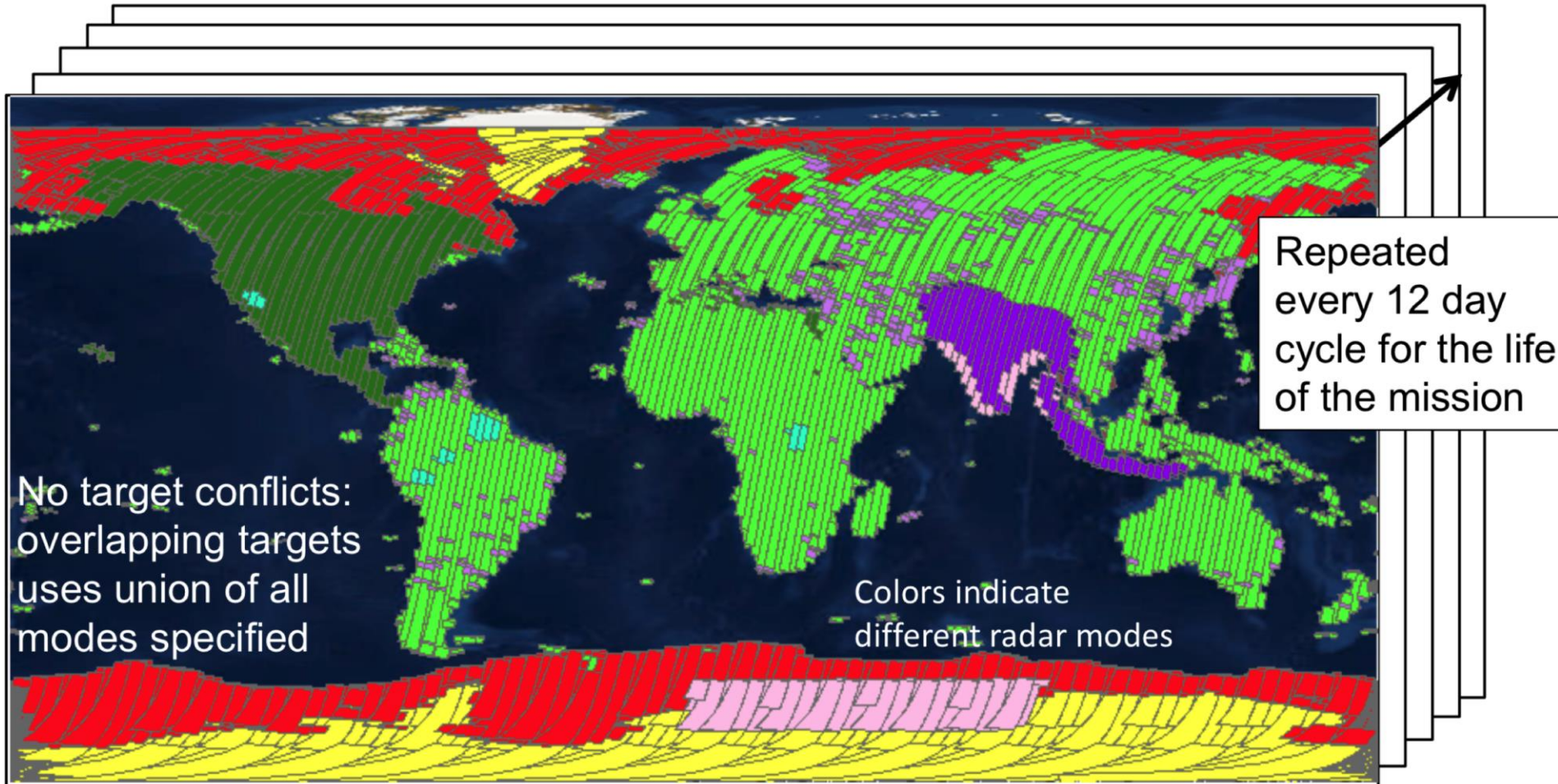
Observation Geometry





NISAR Systematic Observations

L-band globally – S-band over selected areas



Persistent updated measurements of Earth
41 Tbits / day total L+S band science data downlink
120 Tbytes / day total L+S band L0-L2 data products

J. Doubleday
P. Sharma, JPL

NISAR Data Products: Available from the Cloud

- L0, L1, L2 data products: SLCs, terrain-corrected SLCs, interferograms (unwrapped).
- Open and Free. From the Cloud (distributed by the ASF).

New for NiSAR:

- Geocoded SLCs and interferograms.
- **On-demand processing on the Cloud:** allows users to satisfy their needs
- (Custom-on-demand capability)

Relevance of GPS

- Cal-Val of geod. measurements
- Tropospheric correction (Ionospheric correction?)

The screenshot displays the ARIA Facet Search web interface. The browser address bar shows the URL: <https://aria-search.jpl.nasa.gov/search/?source=%7B%22query%22%3A%7B%22bool%22%3A%7B%22must%22%3A%7B%22t...>. The page title is "ARIA Facet Search BETA". The navigation menu includes "Home", "Facet Search", "My Jobs", "Terms of Use", and "Support". The user is logged in as "fielding".

The search results are displayed in a list of facets:

- dataset**: 20 count, OR, range. S1-IFG-STITCHED (13)
- platform**: 10 count, OR, range. Sentinel-1A (11), Sentinel-1B (10)
- sensor**: 10 count, OR, range. SAR-C Sentinel1 (13)
- dataset version**: 10 count, OR, range. v1.1.3 (7), v1.2.1 (3), v1.1.4 (2), v1.2 (1)
- user tags**: 10 count, OR, range. coseismic (13)

The main map area shows a geographical view of Mexico with several SAR data overlays. The overlays are color-coded, likely representing different data products or processing stages. The map includes labels for various cities and regions, such as Ciudad de México, Veracruz, and Acapulco. A "within" button is visible in the top right corner of the map area.

NISAR Science User's Handbook



Describes:

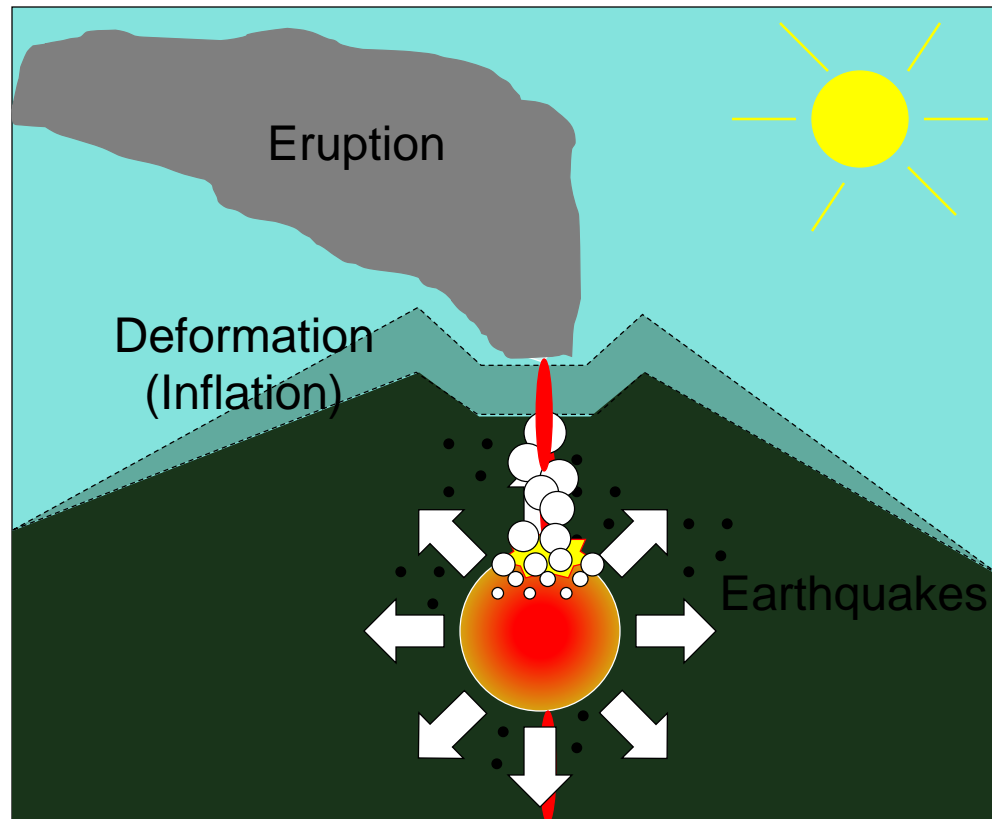
- Science and Applications
- Mission Science Requirements
- Mission Design and CONOPS
- Flight System Characteristics
- Radar and Measurement Principles
- Data Products
- Will be revised prior to launch or as necessary

Other major documents:

- Cal/Val Plan
- Utilization Plan
- Application Workshop Reports
- 21 science and applications white papers

What happens before an eruption?

- Deformation can be one of the first signs of impending eruptions, along with earthquakes and degassing



Ecuador's Cotopaxi volcano may threaten 325,000 people

18 August 2015 | [Latin America & Caribbean](#)

August 2015
Eruption

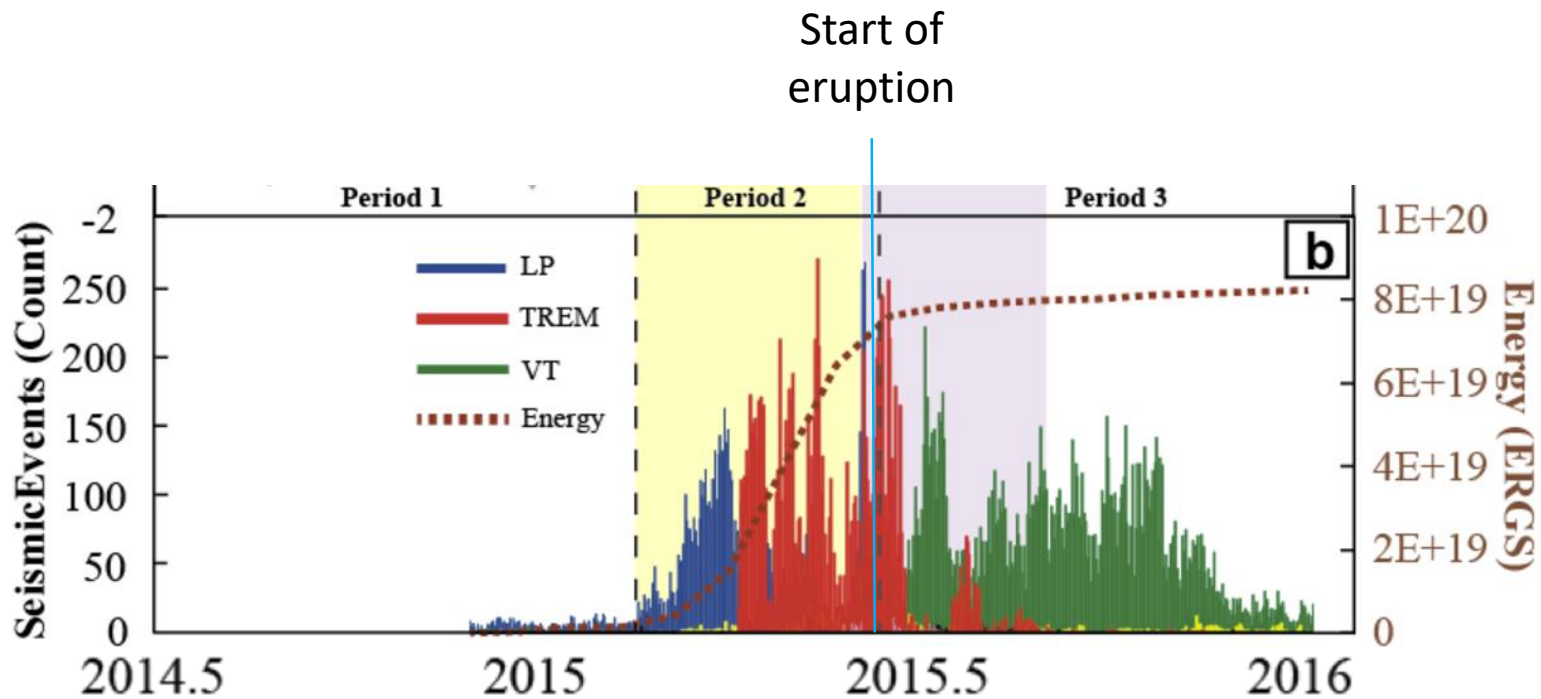


The 2015 crisis of Cotopaxi volcano,

Concerns:

- many fatalities from 1877 eruption
- lahars (can go to the coast)

Seismicity

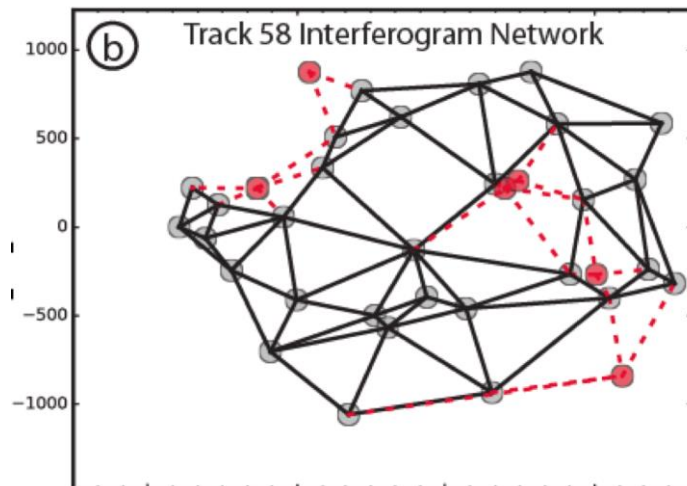
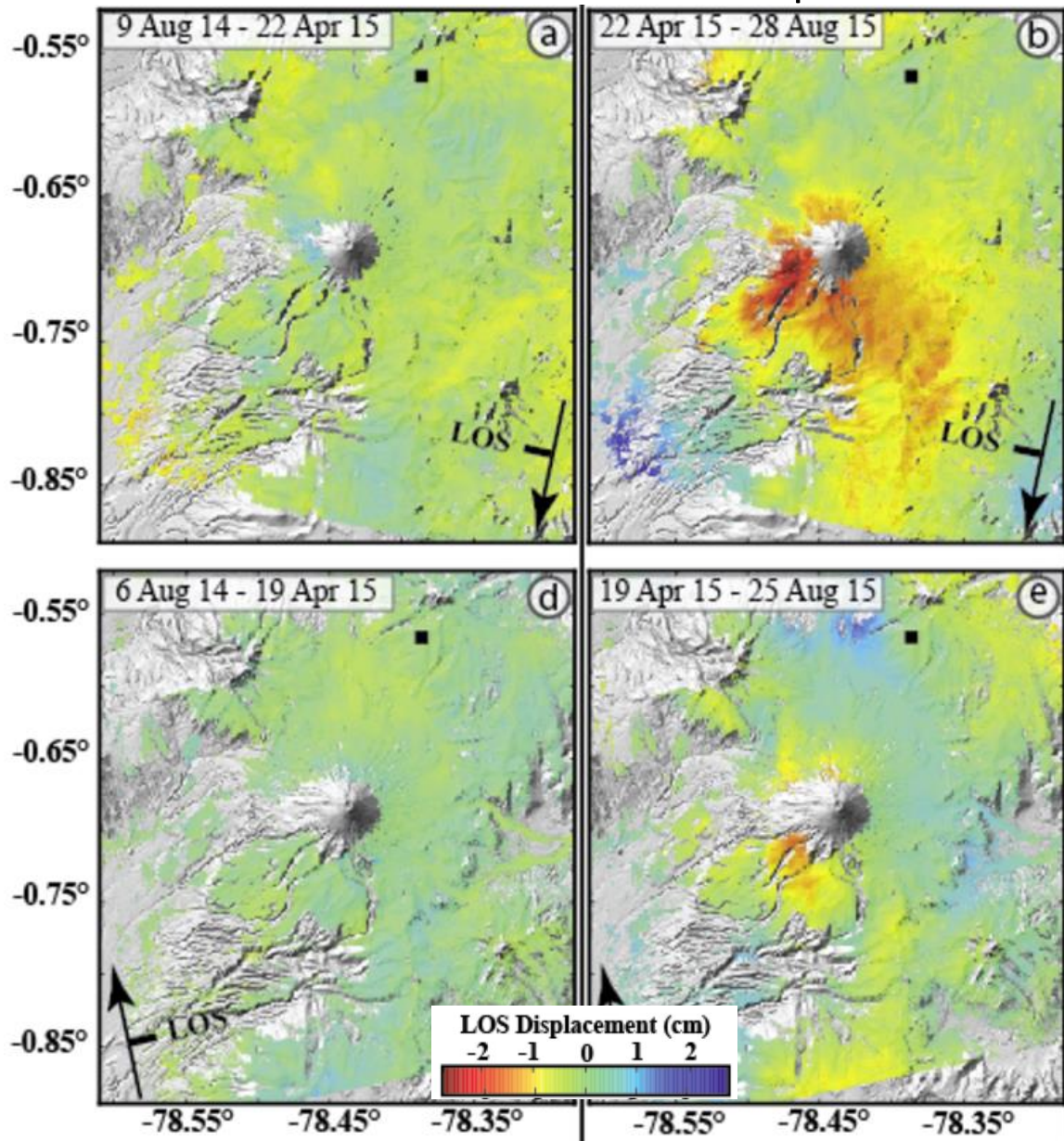


Concurrent seismicity increase and inflation at station MORU (InSAR and GPS)

Precursory inflation from InSAR time-series

before unrest

unrest period



Data used: 70 Cosmo-SkyMed SAR images from Geohazard Supersites initiative



Key findings:

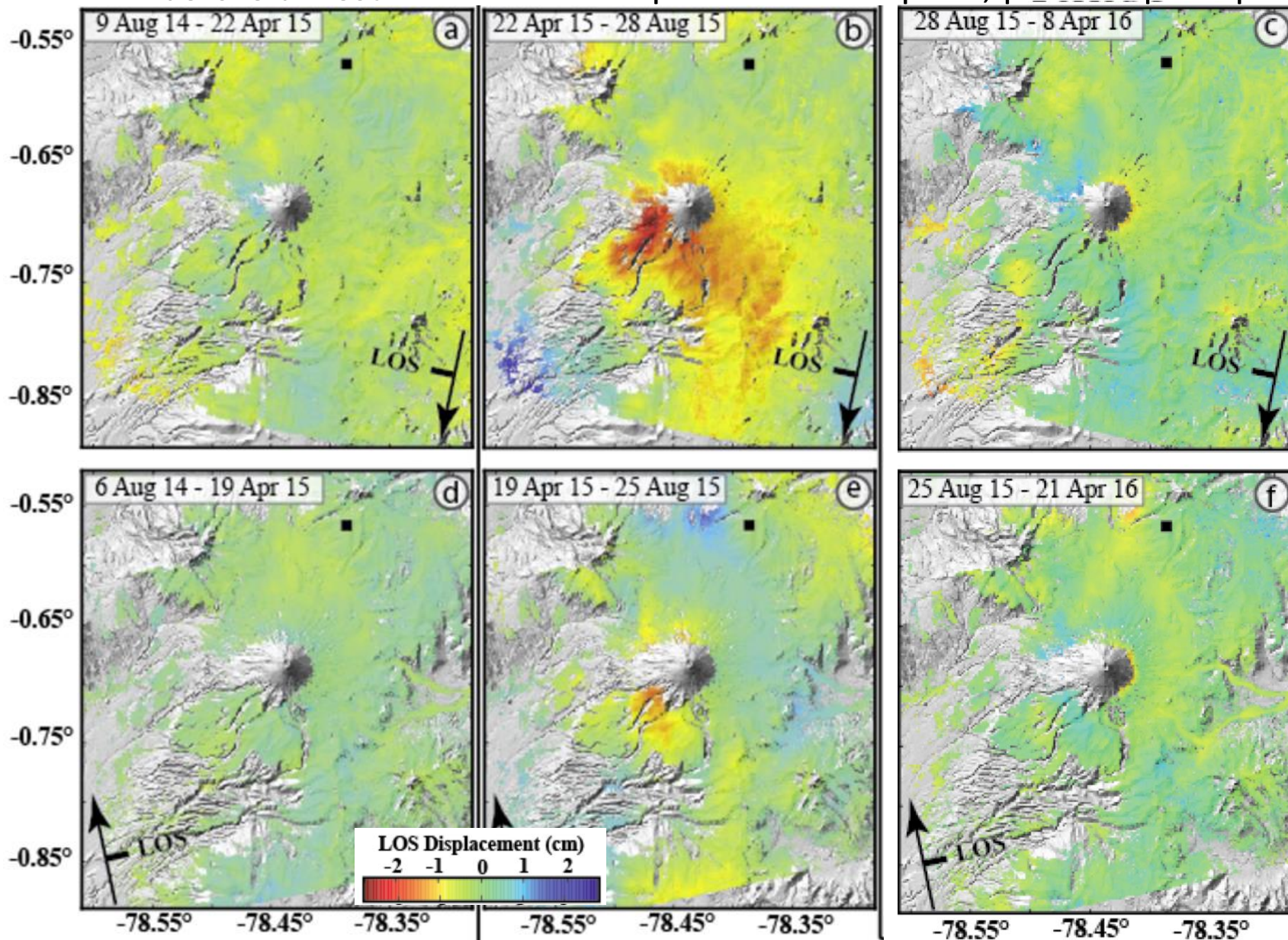
- InSAR detects 3 cm inflation on SW flank **before** eruption.

Precursory inflation from InSAR time-series

before unrest

unrest period

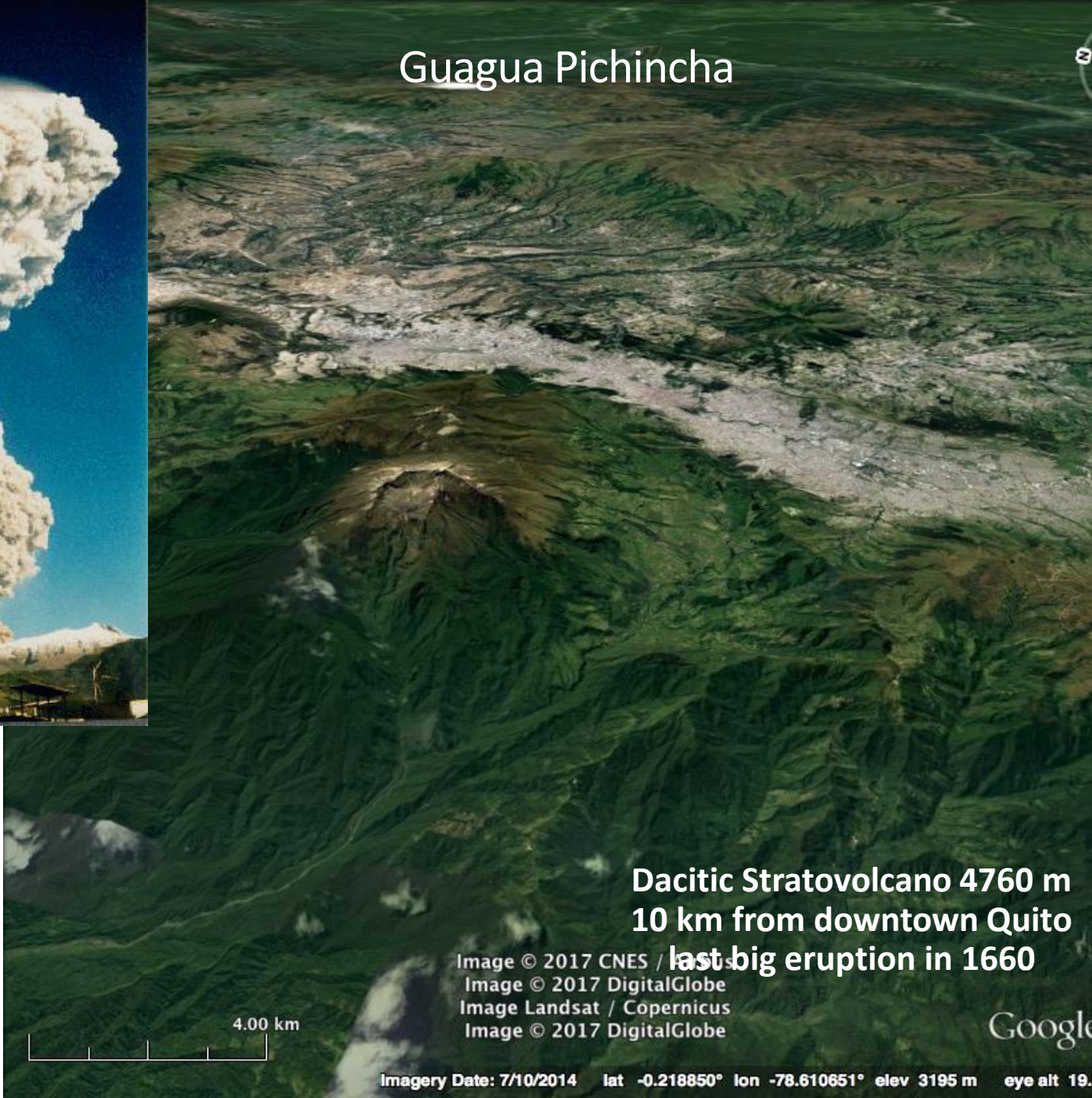
eruptive, post-eruptive period



Guagua Pichincha



**October 7
1999**



**Dacitic Stratovolcano 4760 m
10 km from downtown Quito
last big eruption in 1660**

Image © 2017 CNES / Airbus
Image © 2017 DigitalGlobe
Image Landsat / Copernicus
Image © 2017 DigitalGlobe

4.00 km

Imagery Date: 7/10/2014 lat -0.218850° lon -78.610651° elev 3195 m eye alt 19.00 m

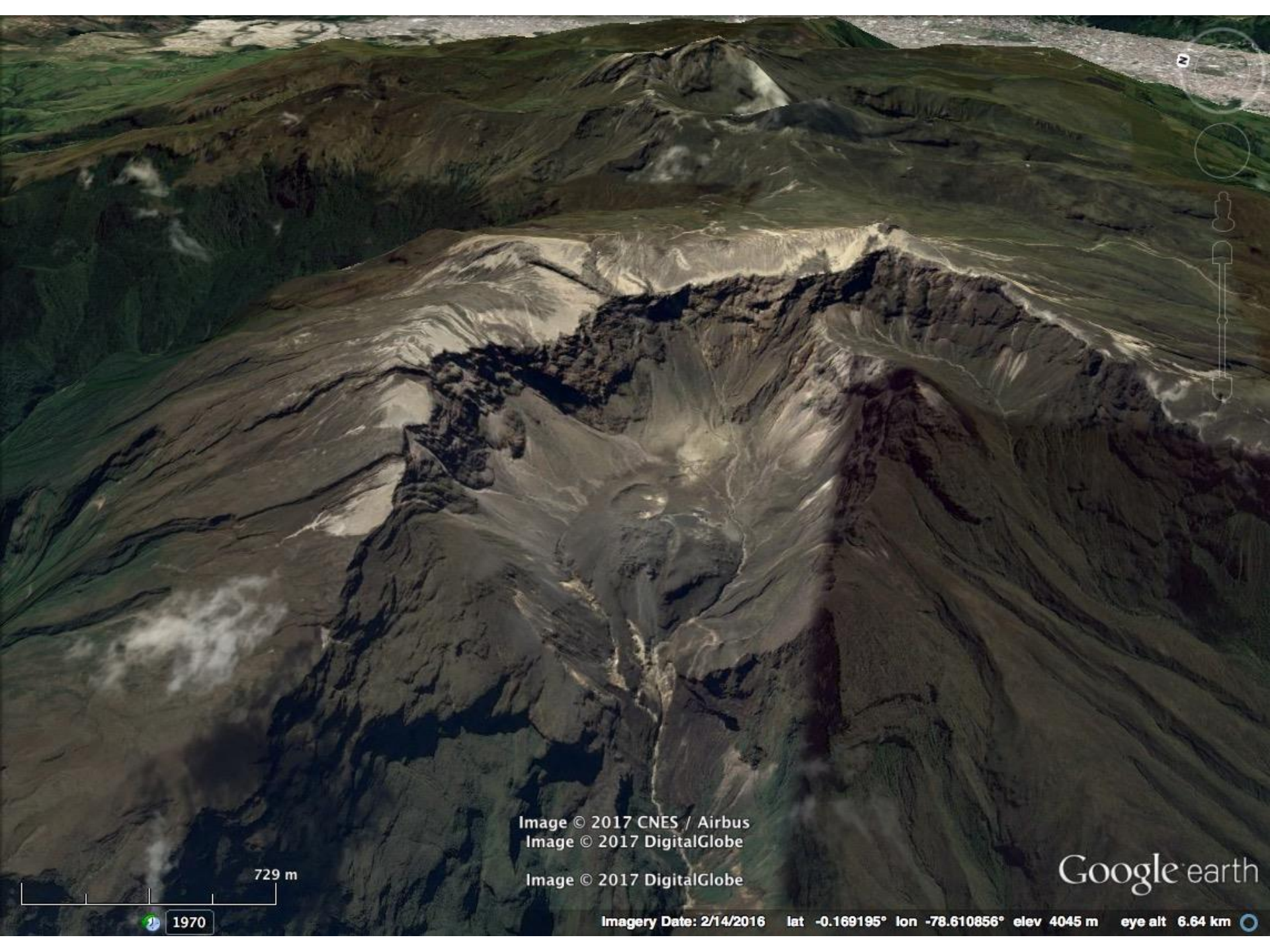


Image © 2017 CNES / Airbus
Image © 2017 DigitalGlobe
Image © 2017 DigitalGlobe

Google earth

729 m

1970

Imagery Date: 2/14/2016 lat -0.169195° lon -78.610856° elev 4045 m eye alt 6.64 km

2014 - 2015

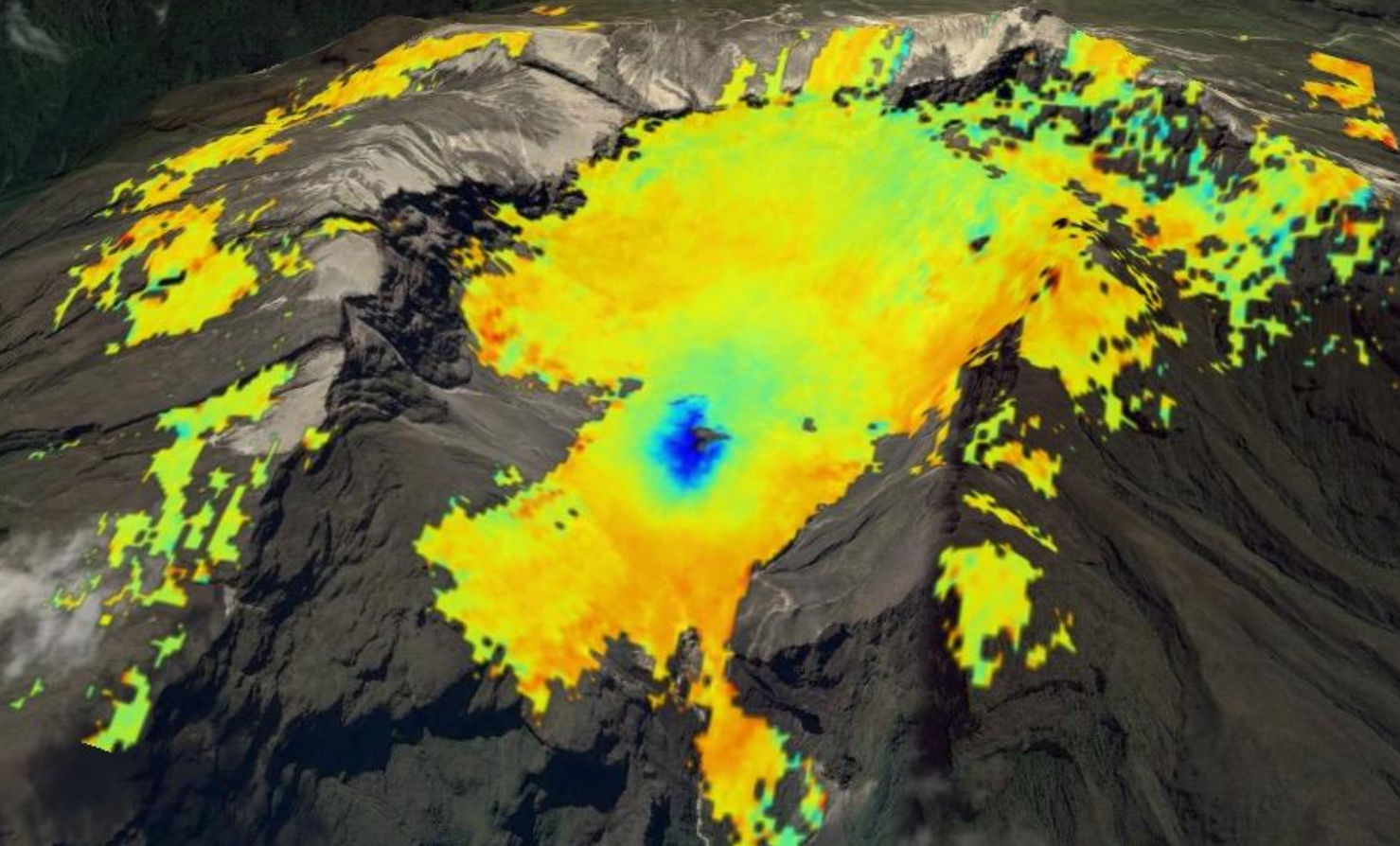


Image © 2017 CNES / Airbus
Image © 2017 DigitalGlobe
Image © 2017 DigitalGlobe

Google earth

729 m
1970

Imagery Date: 2/14/2016 lat -0.169195° lon -78.610856° elev 4045 m eye alt 6.64 km



125 m

Image © 2017 CNES / Airbus

Google earth



1970

Imagery Date: 7/10/2014 lat -0.170721° lon -78.615276° elev 3978 m eye alt 4.56 km

2014 - 2015

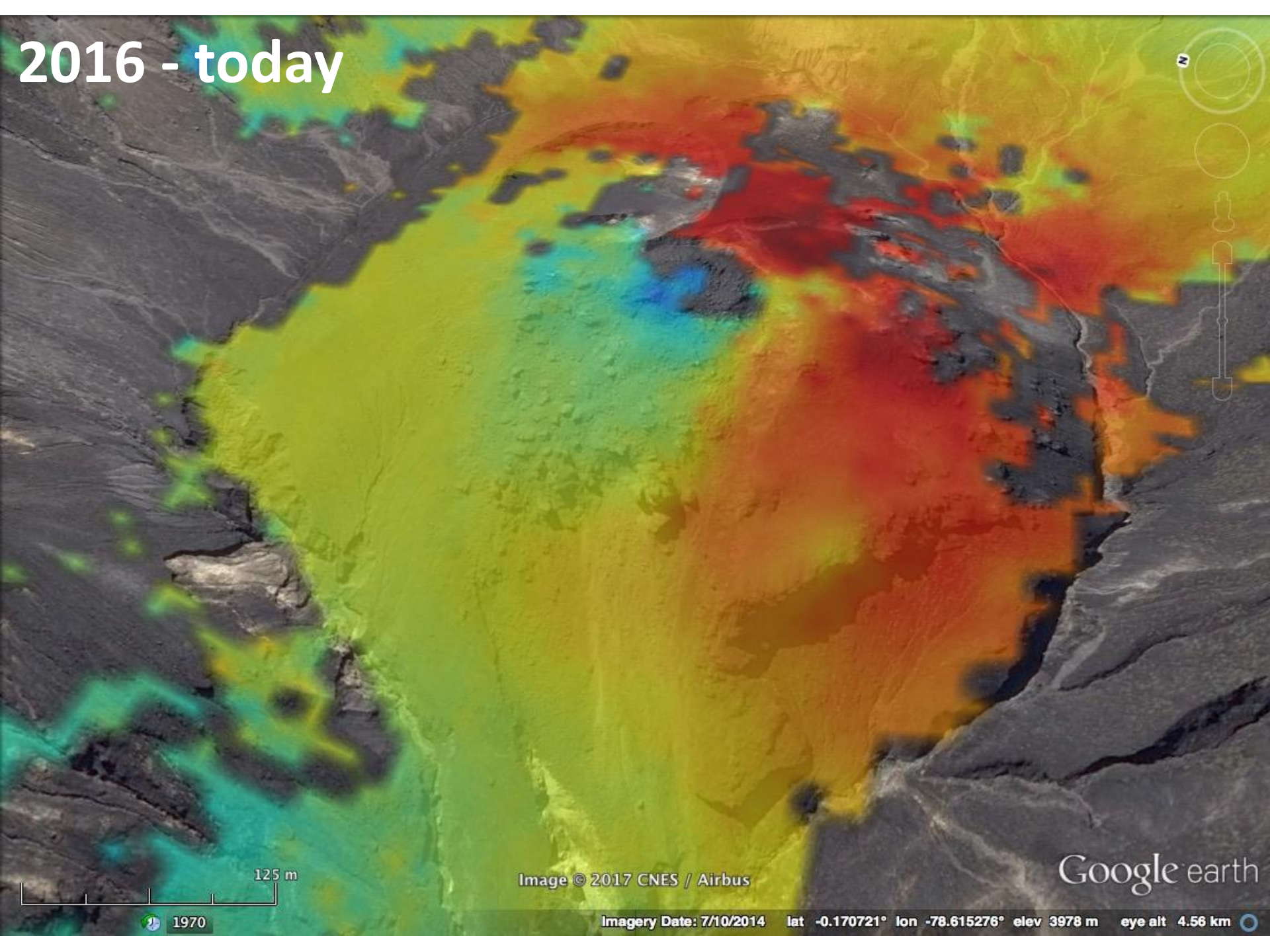


Image © 2017 CNES / Airbus

Google earth

Imagery Date: 7/10/2014 lat -0.170721° lon -78.615276° elev 3978 m eye alt 4.56 km

2016 - today



125 m

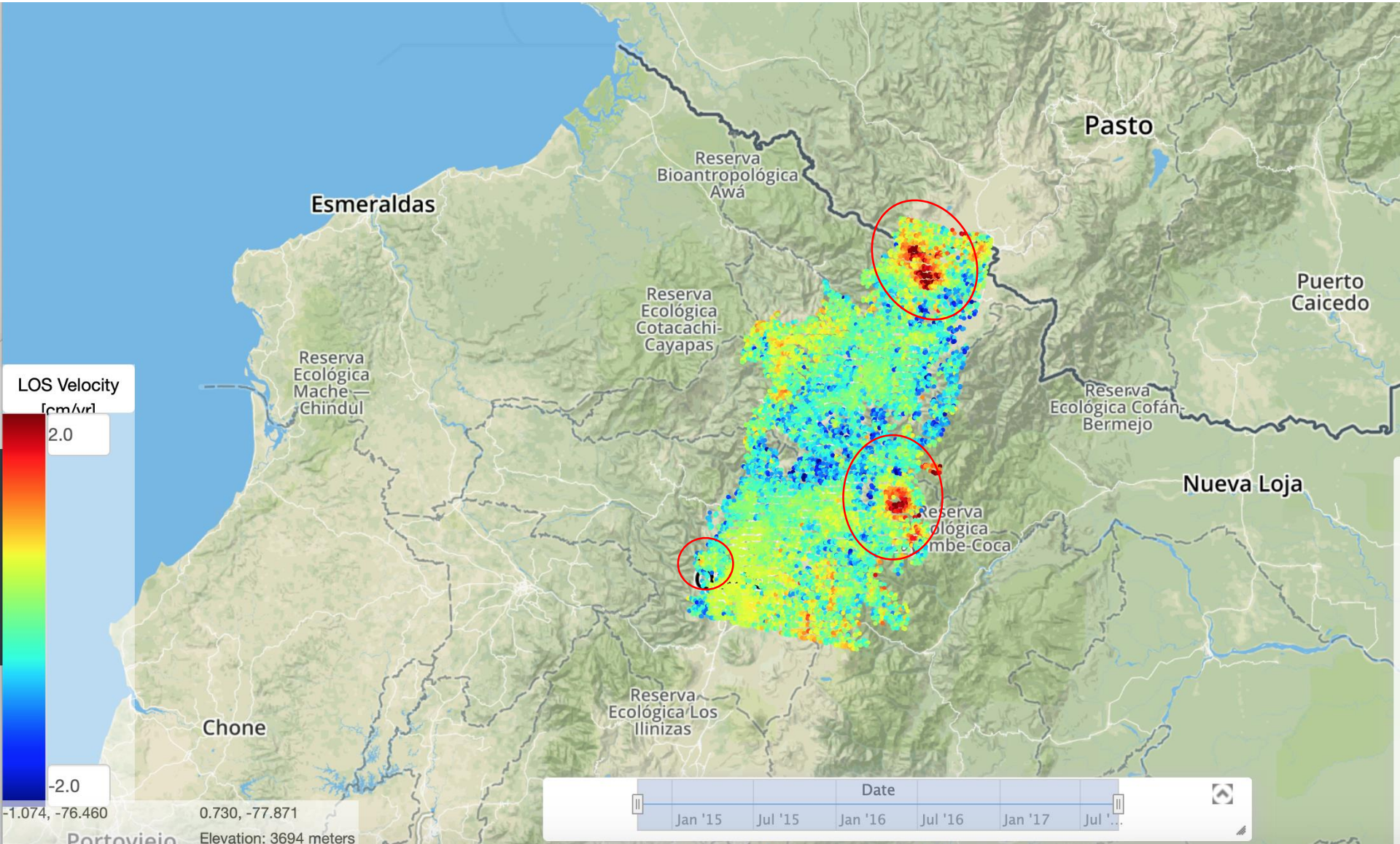
Image © 2017 CNES / Airbus

Google earth

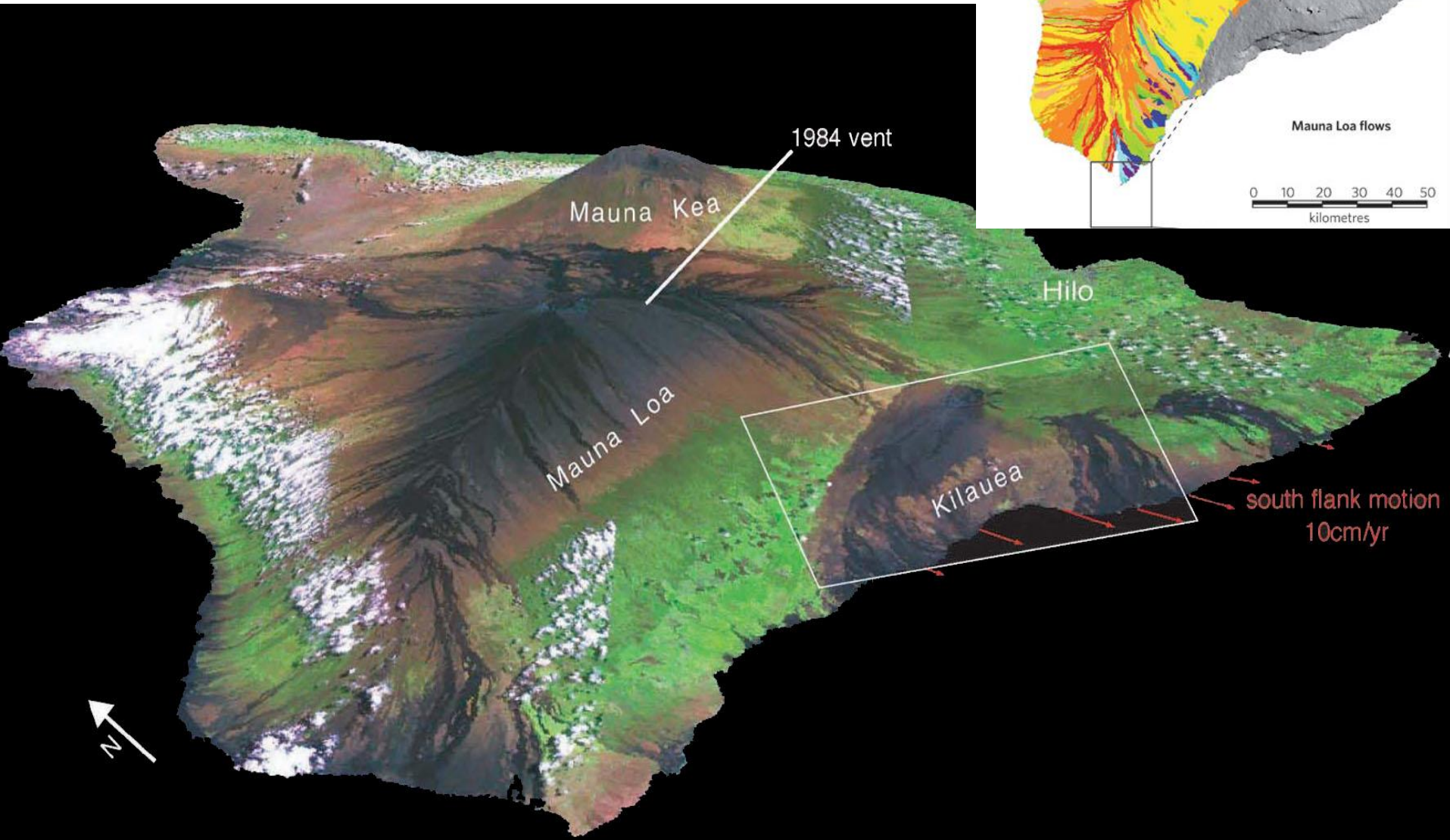
1970

Imagery Date: 7/10/2014 lat -0.170721° lon -78.615276° elev 3978 m eye alt 4.56 km

Inter-Andean Valley, Ecuador, Sentinel, 2015-2019



Eruptions of Mauna Loa and Kilauea volcanoes commonly occur from the rift zones



Lava flow hazards of Mauna Loa eruptions

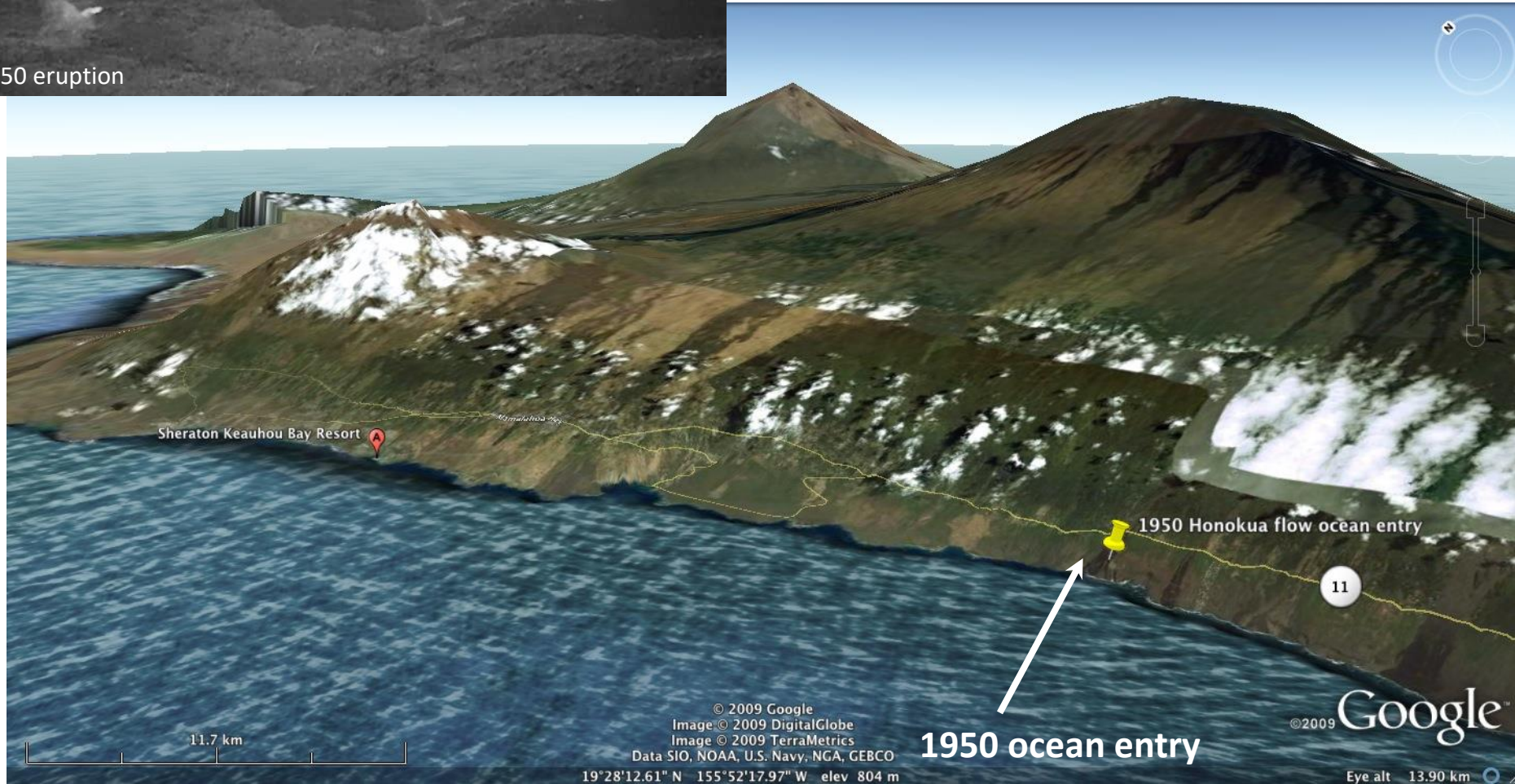
Fissure eruptions from dikes intruded into rift zone (1950, 1975, 1984).



Hilo Hawai'i, 1984

Lava flow hazards of Mauna Loa eruptions

Fissure eruptions from dikes intruded into rift zone (1950, 1975, 1984).





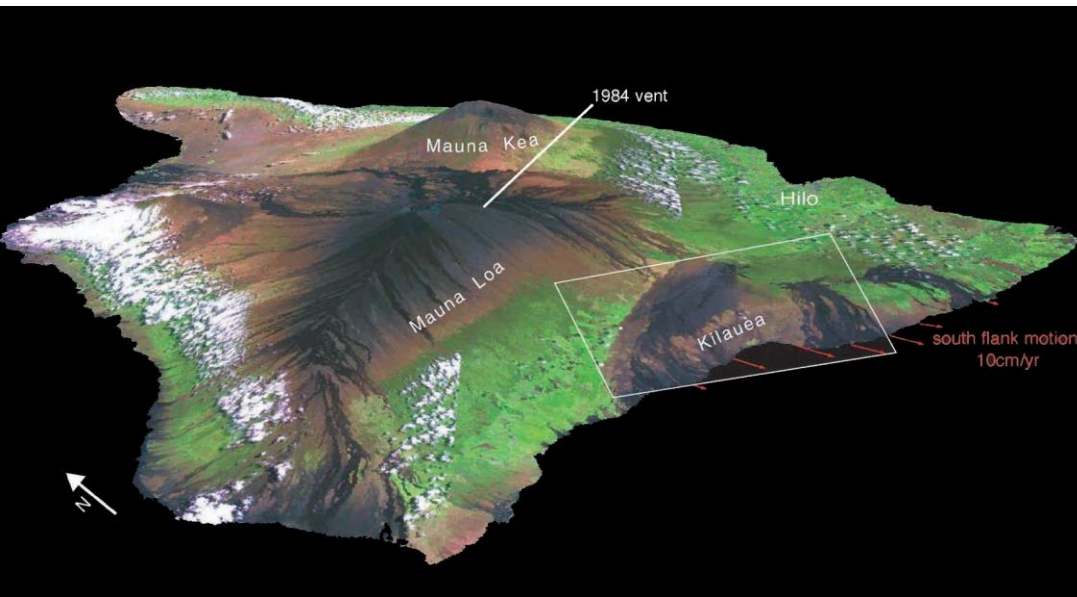
Lava flows from Mauna Loa threaten developments along the coast

The 1950 flow took only 3 hours from eruption initiation to ocean entry. A repeat could lead to disaster.

The eruption was preceded 2 days by a M6.5 quake

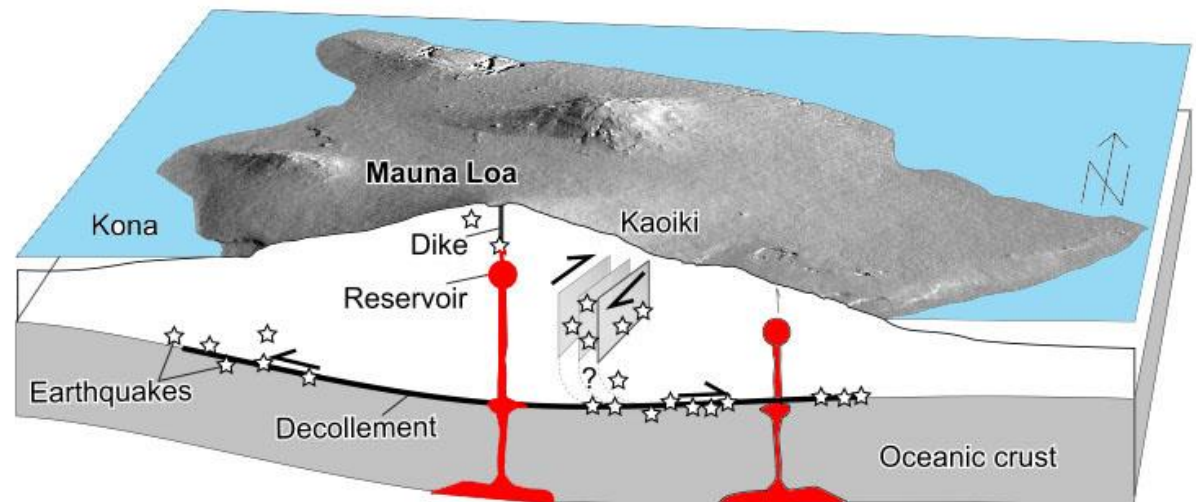


The Hawaiian Volcanoes: Rift intrusion and decollement motion



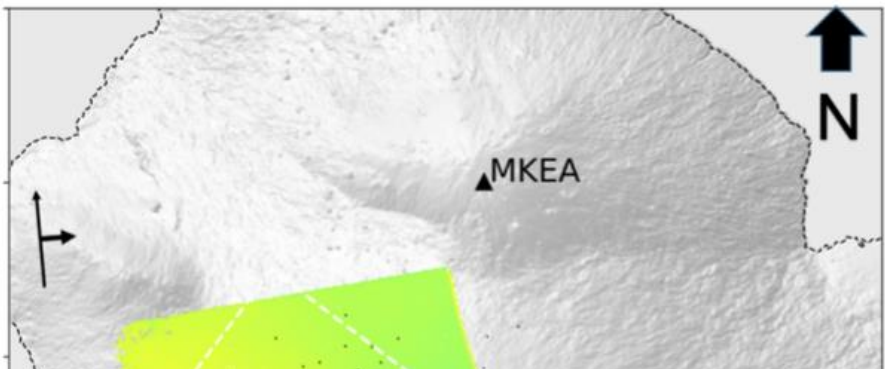
The modes of deformation:

- rift intrusion
- seismic/aseismic decollement slip
- flank motion
- magma chamber inflation/deflation



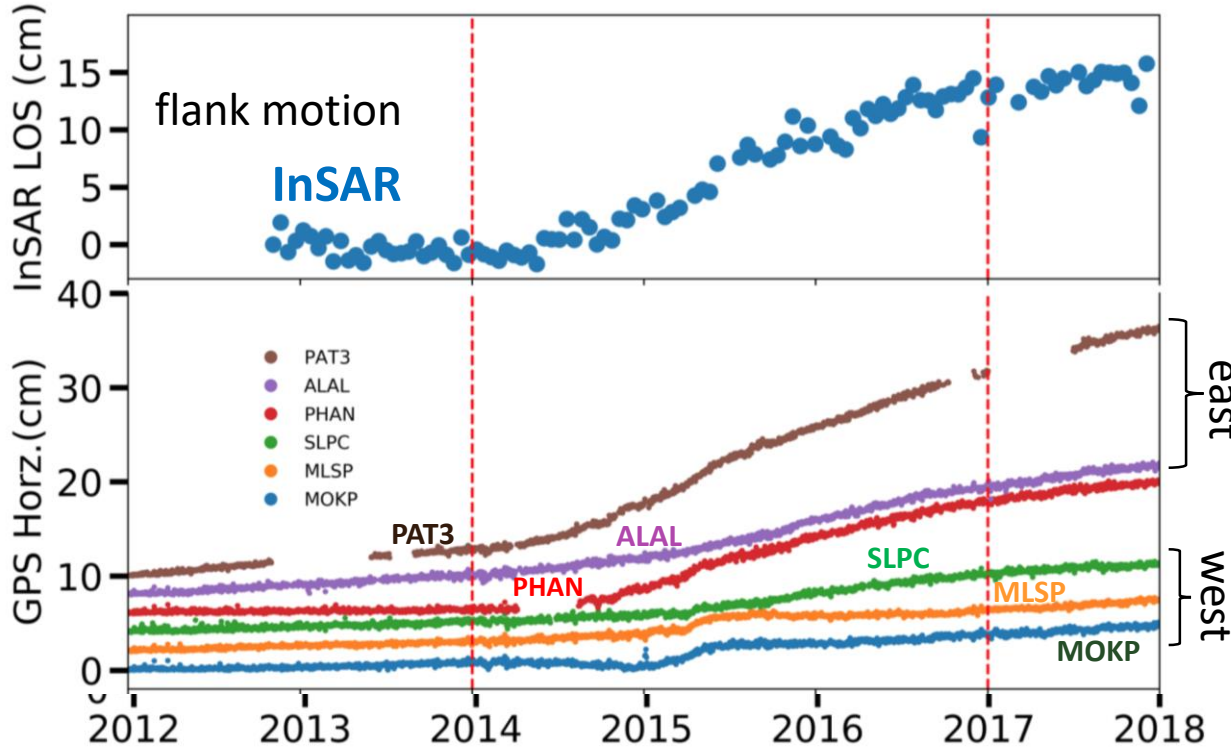
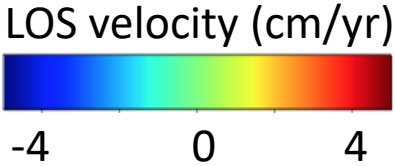
Mauna Loa, Hawaii, 2014-2017 unrest period

LOS displacement from 110 Cosmo-Skymed images



Ground deformation during 2013-2017 unrest period:

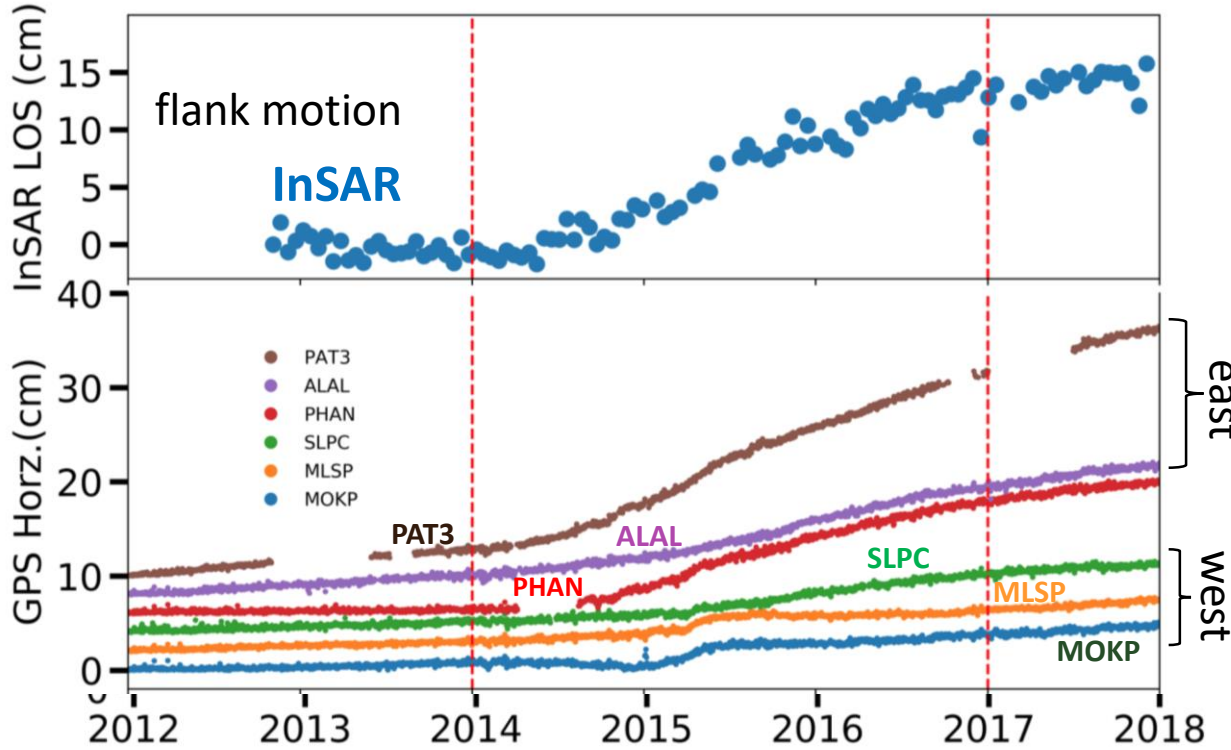
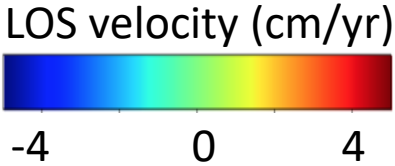
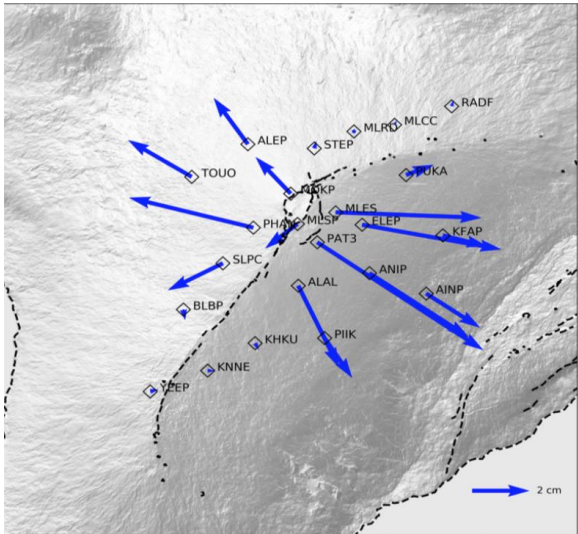
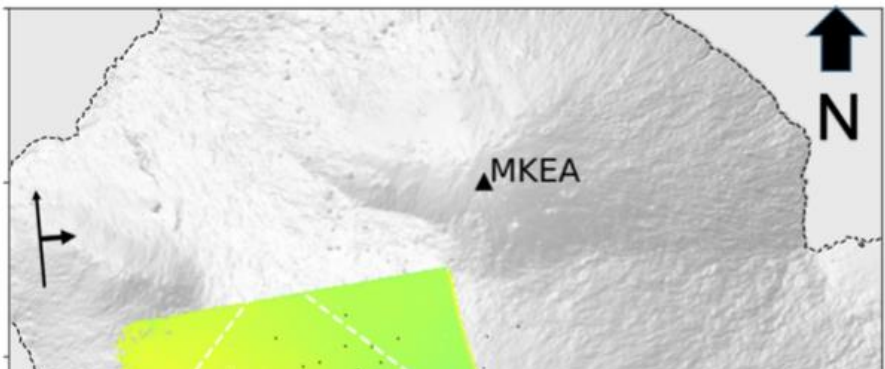
- 15 cm LOS decrease (uplift)
- 20 cm flank motion



unrest period started with east flank motion

Mauna Loa, Hawaii

LOS displacement from 110 Cosmo-Skymed images

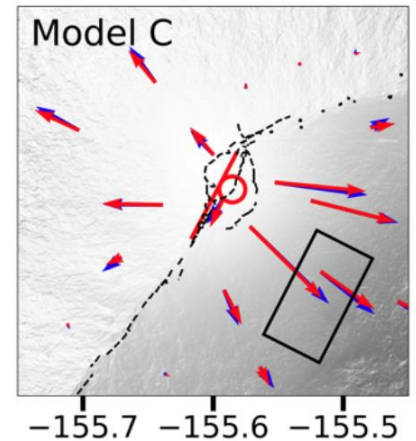
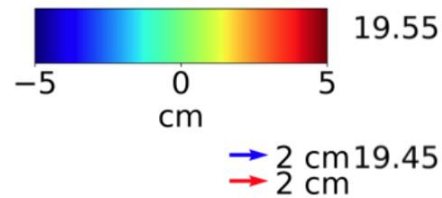
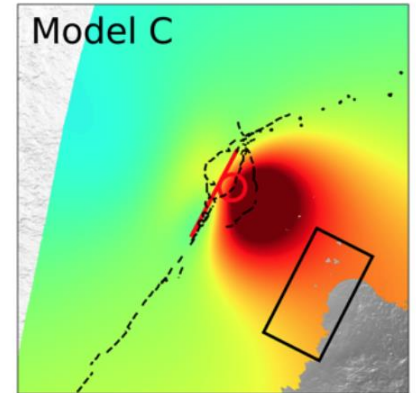
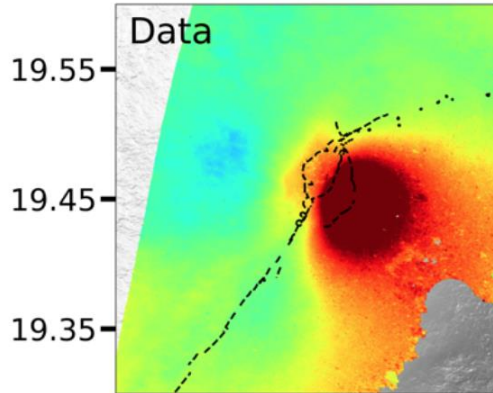
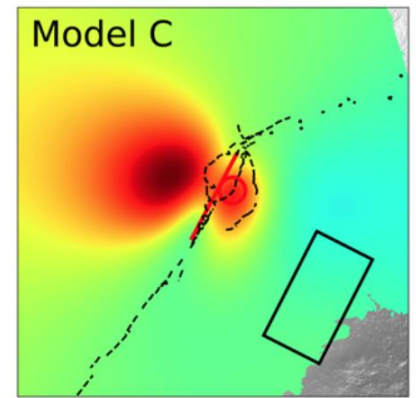
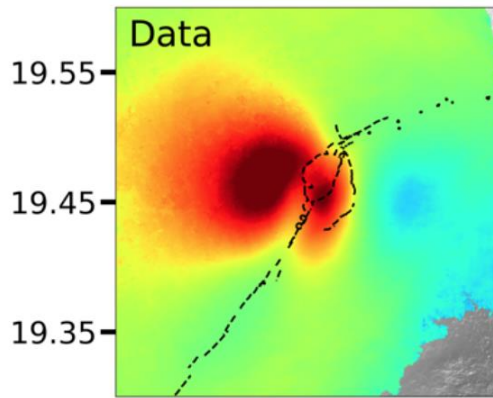


unrest period started with east flank motion

Mauna Loa Source Model

- Dike-like magma body
- Mogi source
- Slip along eastern decollement

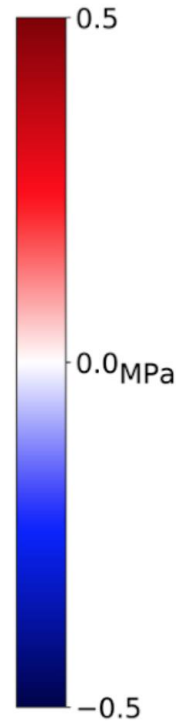
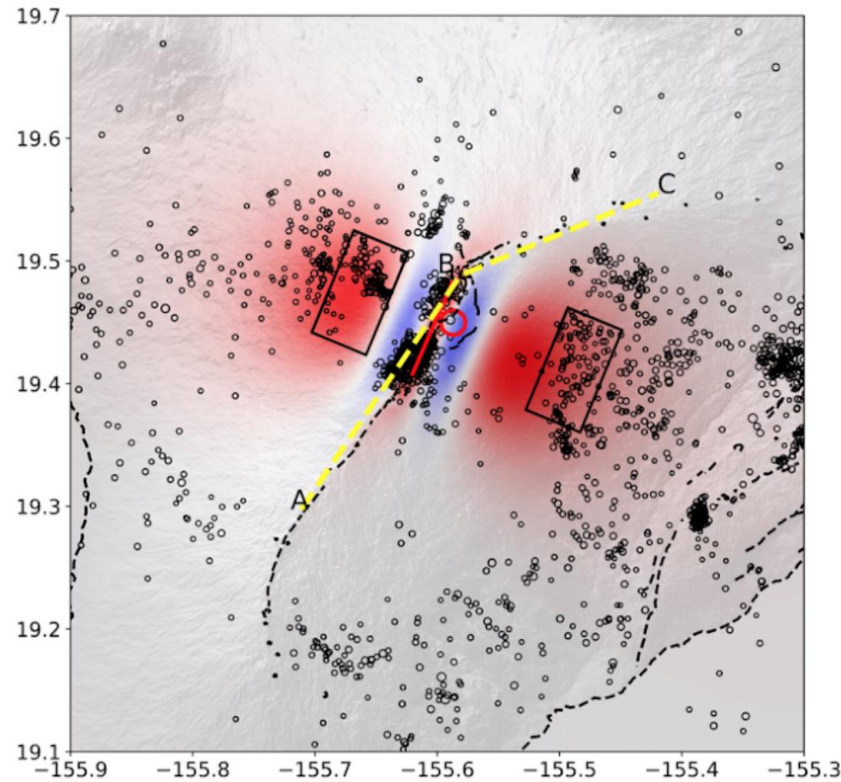
No slip
along
western
decollement!



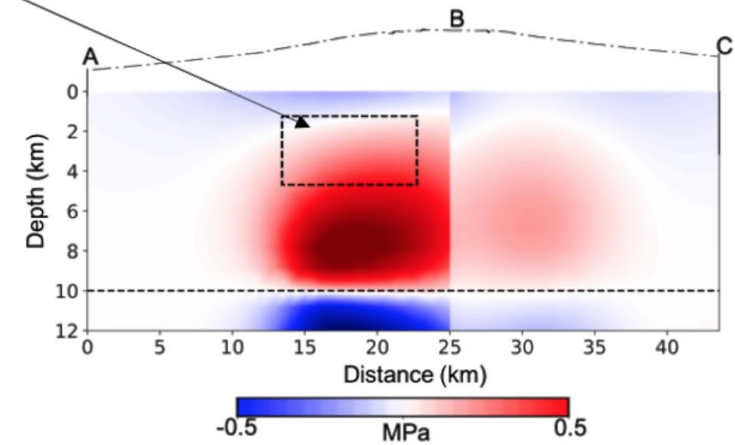
Coulomb stress changes

Along decollement due to magma source

Along rift due to decollement slip



Modelled Dike

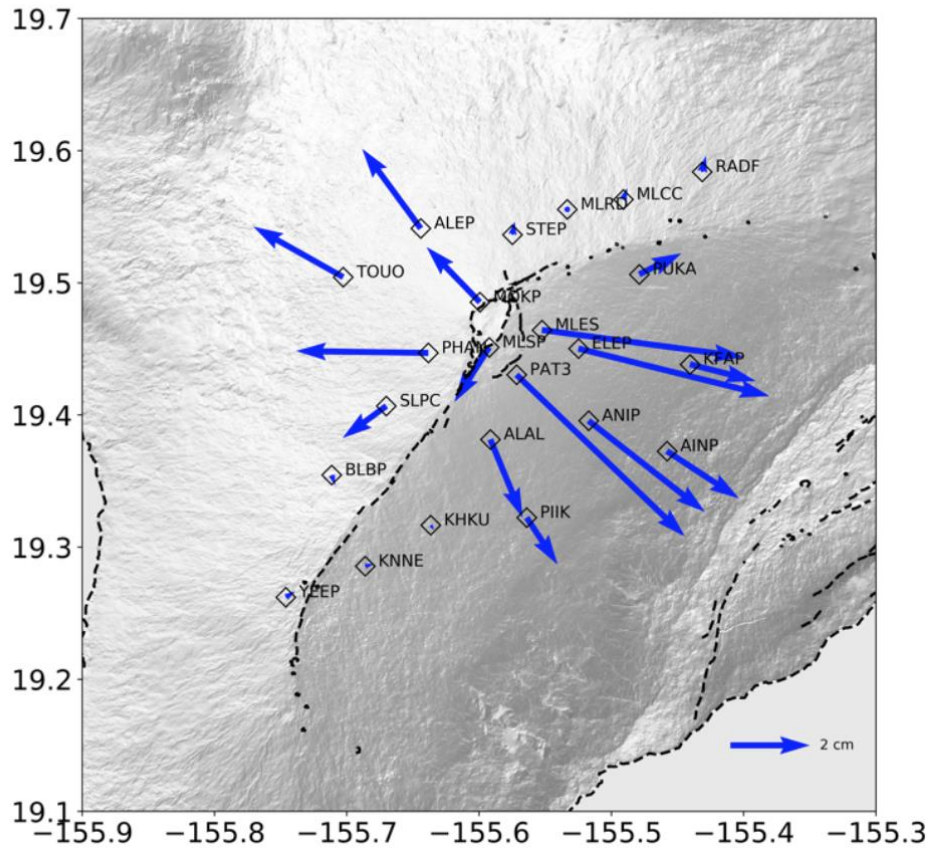


Feedback between dike inflation and decollement slip:

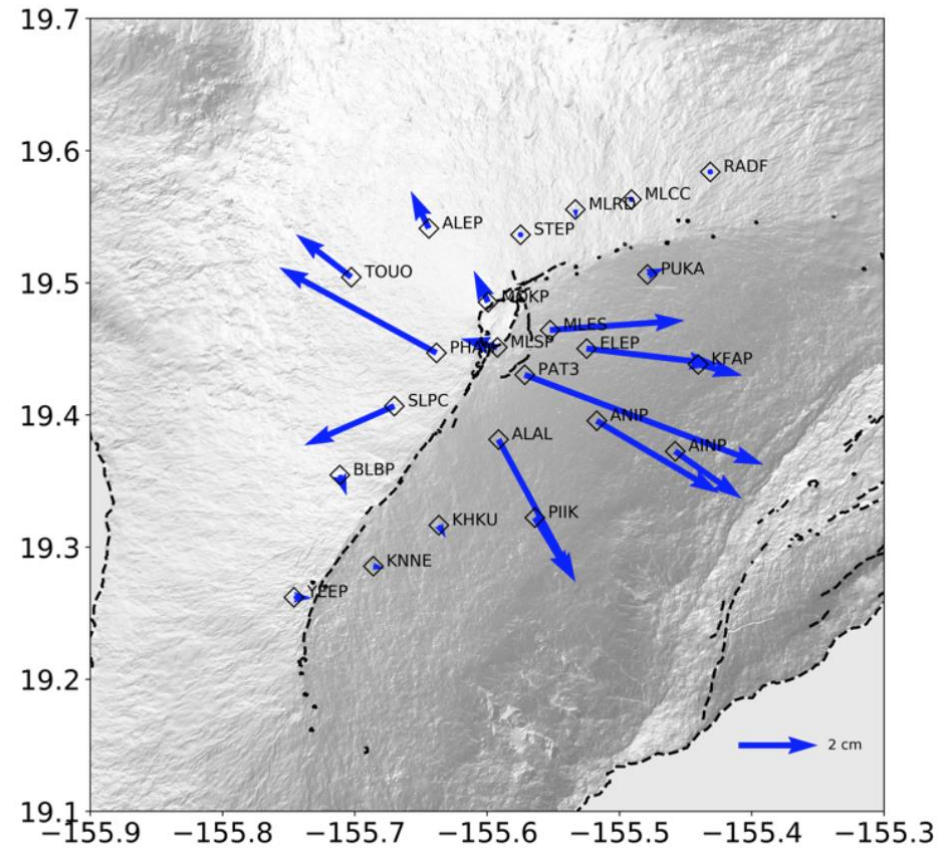
- dike inflation encourages decollement slip
- decollement slip encourages dike inflation

Temporal Variation

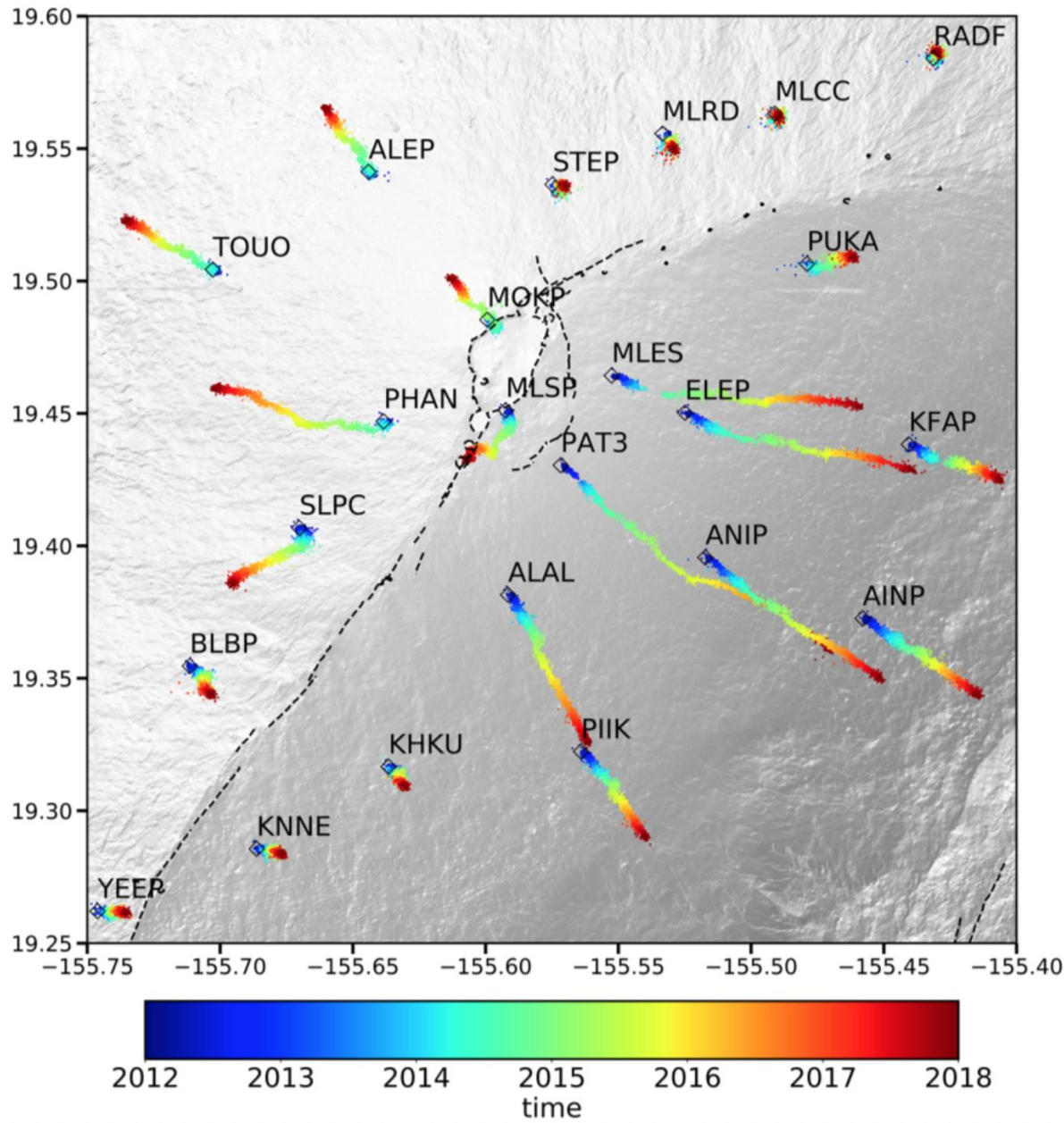
2014 Feb. – 2015 Sep.



2015 Sep. – 2017 Jan.



Is dike inflation variable with time?



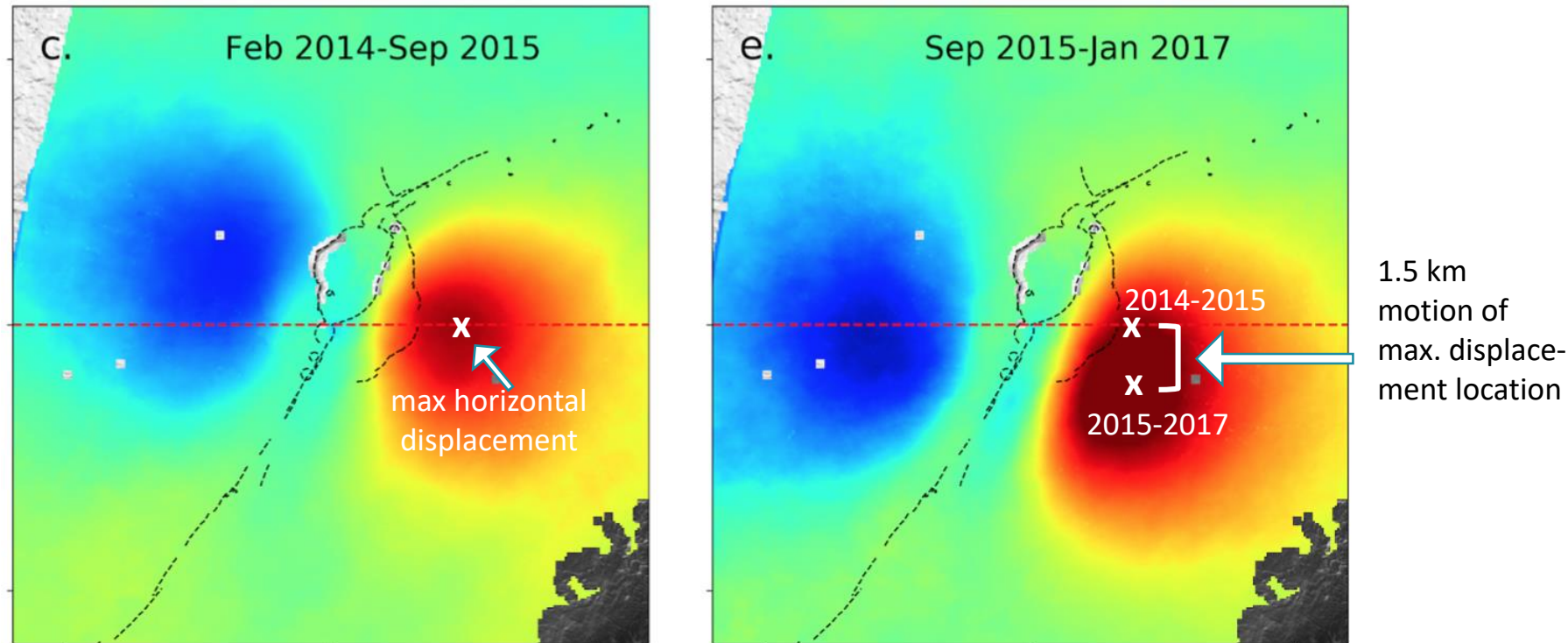
GPS positions as
as a function of time

- Little motion in West

- Change in Aug-Sep 2016

Southward propagation of dike in Sep 2015

East-west displacement from combining ascending and descending imagery



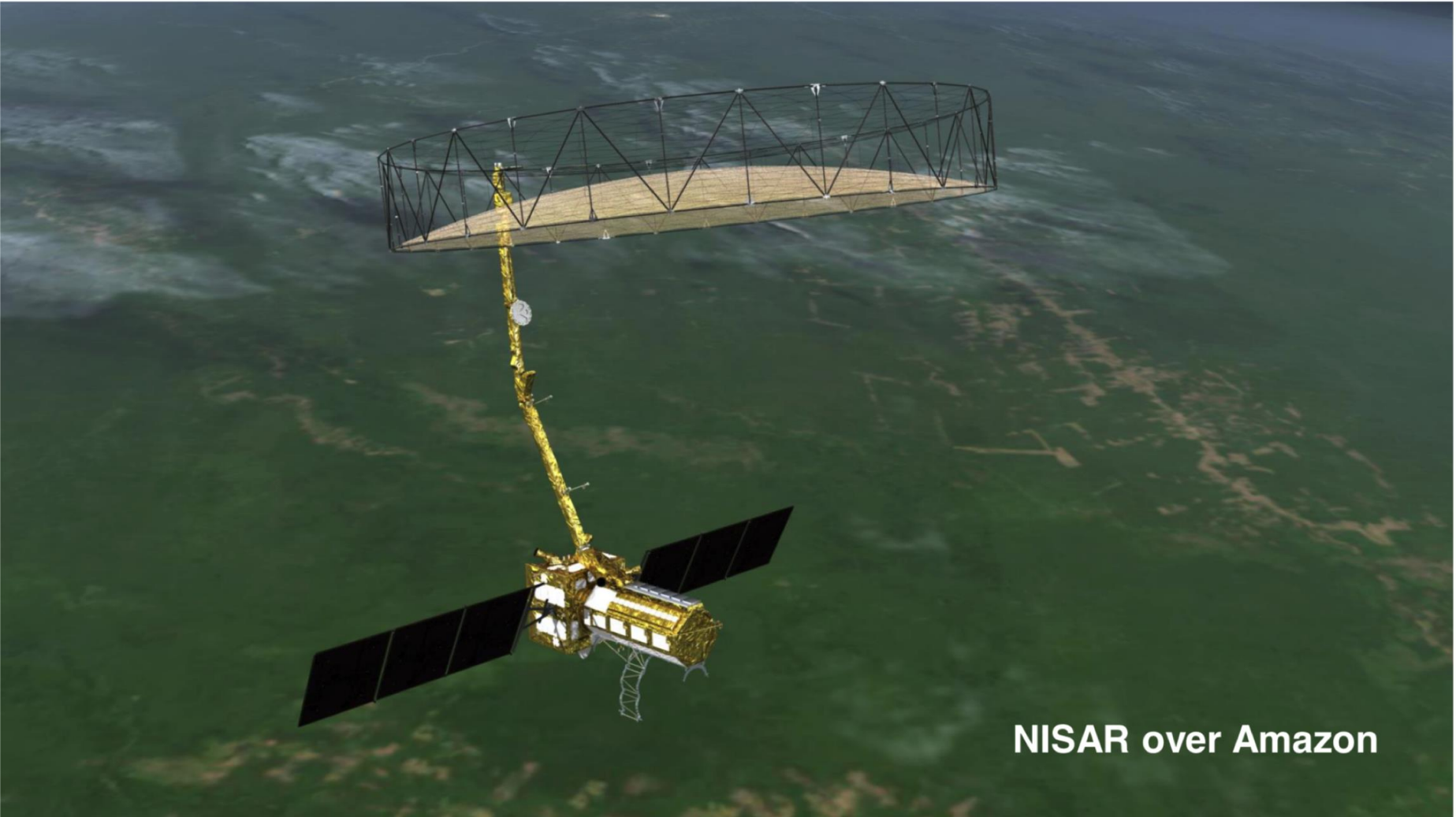
- Inflating dike is located 1.5 km further south during later time period
- southward motion is predicted by stress change models

Forecast:

There will be additional southward motion of the dike-like magma body and eventually it will erupt from the southflank



Questions?



NISAR over Amazon