
Mount Agung, November 2017 Eruption

Volcano-tectonic signal separation reveals pre-eruptive deformation at Mount Agung six months before the November 2017 eruption

Denny Chee

PhD Student

Asian School of the Environment, Nanyang Technological University

CH0003NY@e.ntu.edu.sg

Christina Widiwijayanti, Adriano Gualandi, Benoit Taisne, and Sang-Ho Yun

@Jagiellonian University

Aula Duza 1, June 17th, 2026

127 active volcanoes

Can we use satellite radar to detect which ones are quietly preparing to erupt – months before anyone notices?

10 eruptions

Significance

Tectonic and magmatic deformation signals overlap spatially – standard InSAR cannot separate them

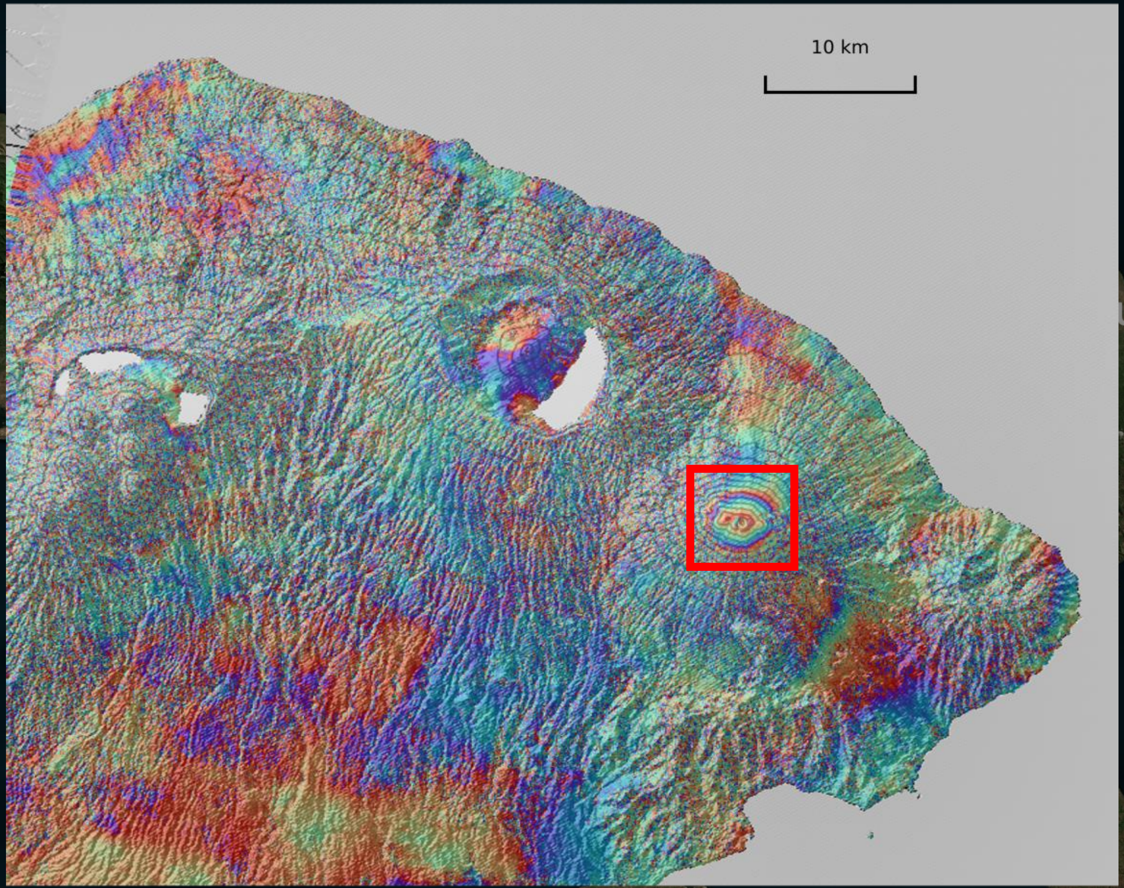
48 active volcanoes along the Sumatran arc — 22 within 10km of the Great Sumatran Fault (Acocella et al, 2018)

Tectonic and magmatic deformation signals overlap spatially – standard InSAR cannot separate them

Lesser Sunda Islands volcanoes sit above both the Flores Thrust and Sunda Megathrust

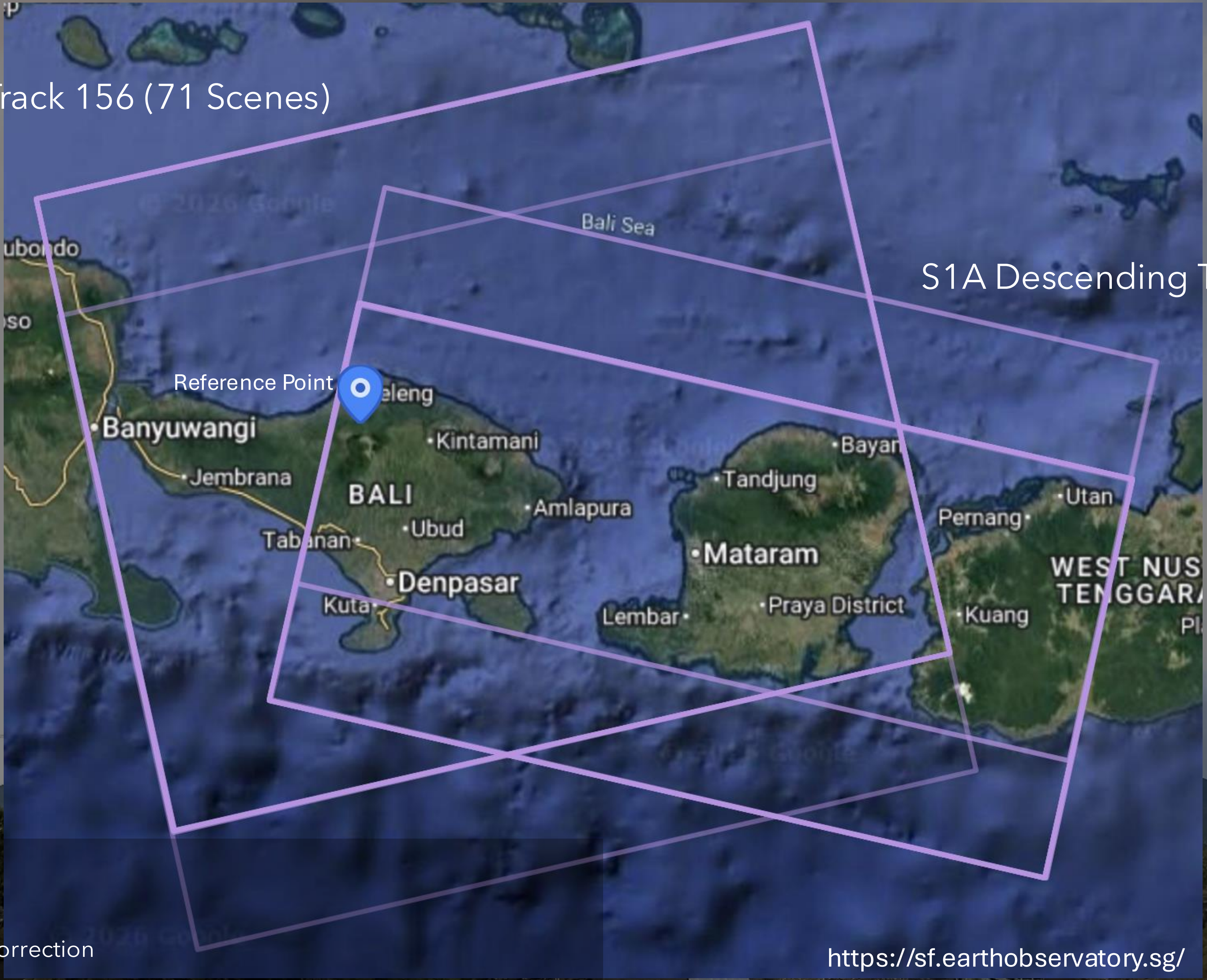
Significance

Tropospheric noise mimics volcanic deformation – a persistent challenge at SEA volcanoes



Tropospheric noise above Mount Agung (2016)

Mount Agung 2017



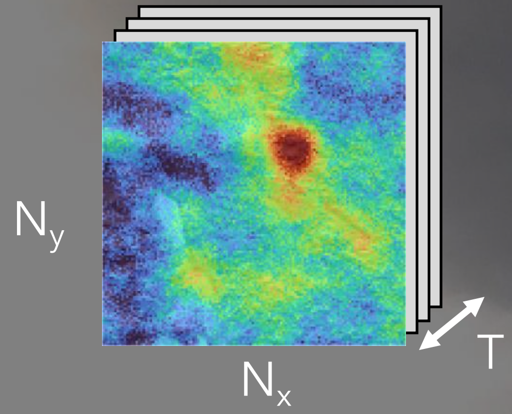
S1A Ascending Track 156 (71 Scenes)

S1A Descending Track 32 (70 Scenes)

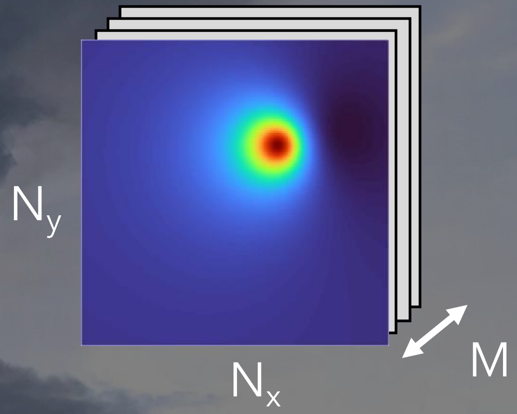
- Data Range: 2016-2018
- StackSentinel and MintPy
- ERA5 tropospheric delay correction
- 19range, 7 azimuth multilook

https://sf.earthobservatory.sg/

Variational Bayesian ICA (vbICA): separating independent source signals in InSAR time series

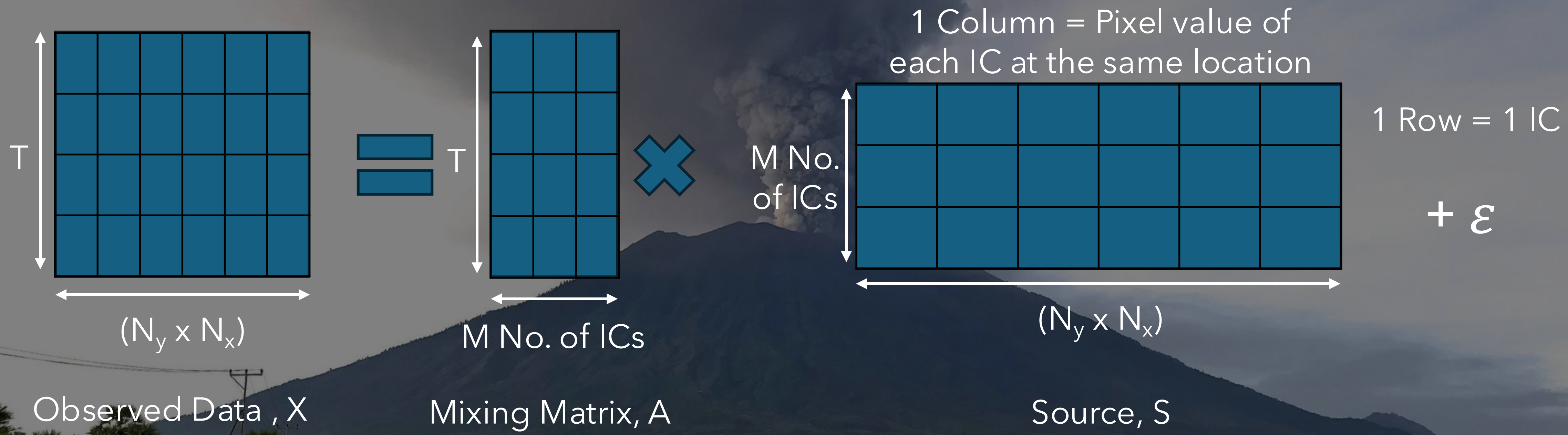


Observed Data , X

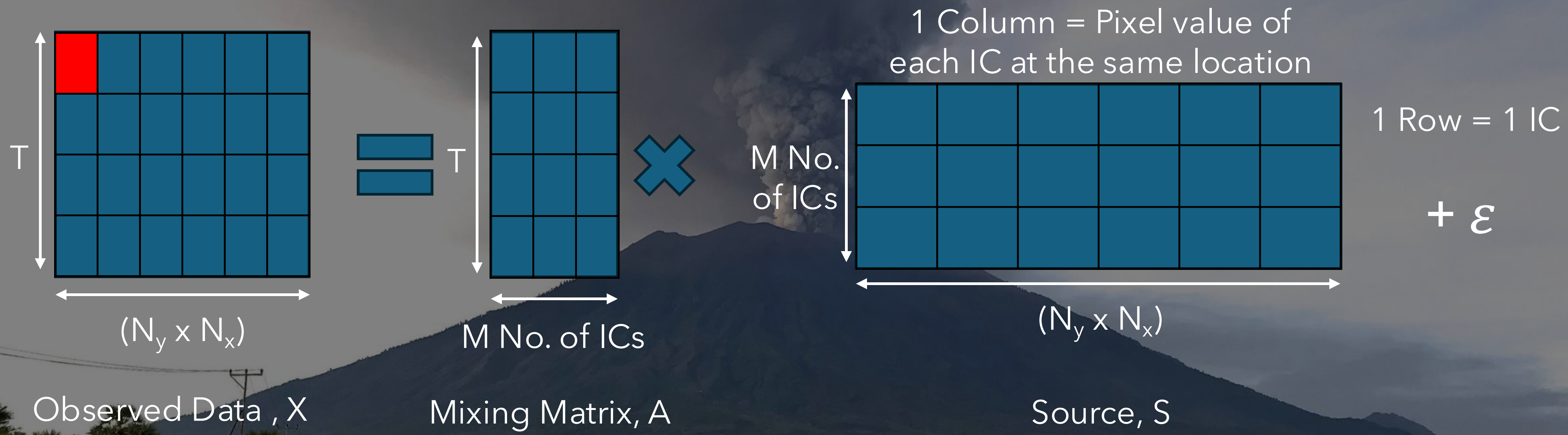


M number of Sources, S

vbICA reconstructs temporal and spatial components using matrix decomposition



Each element in X is computed as the sum of products between corresponding elements of A and S



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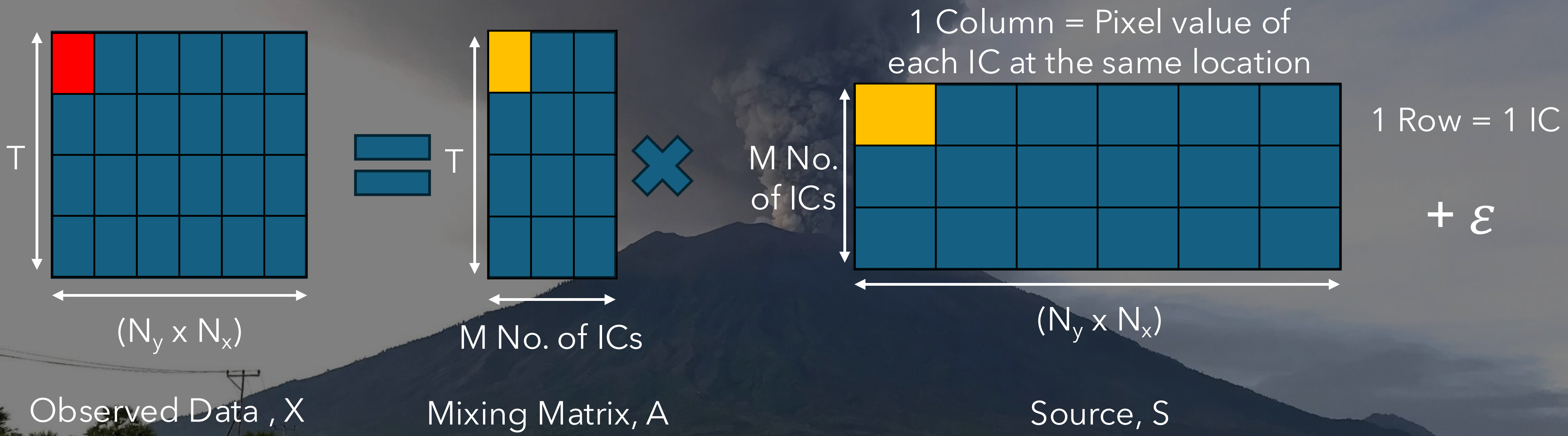

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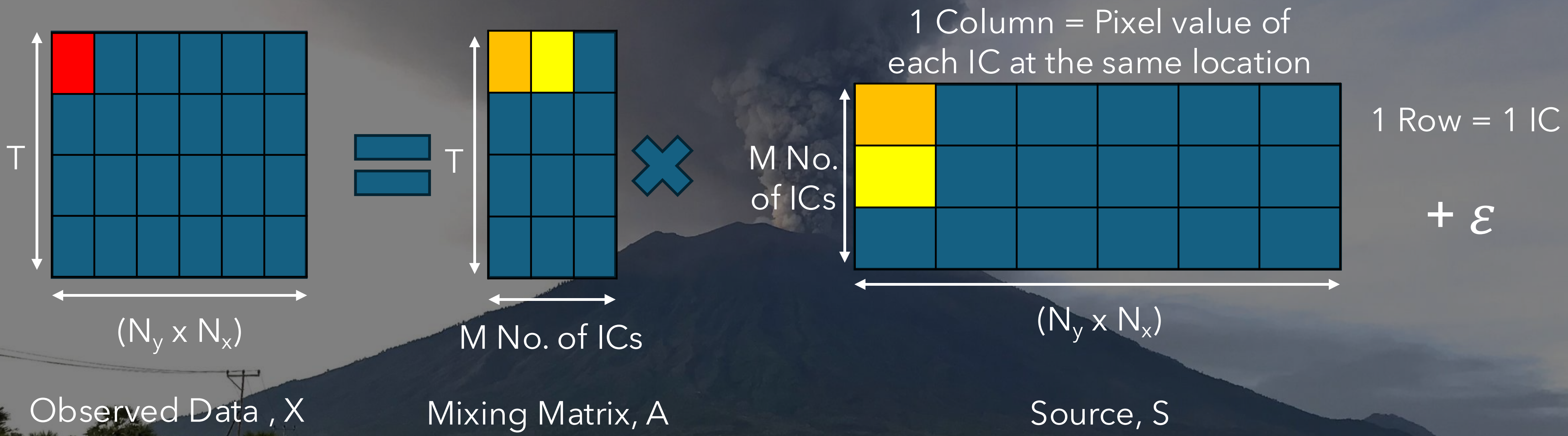

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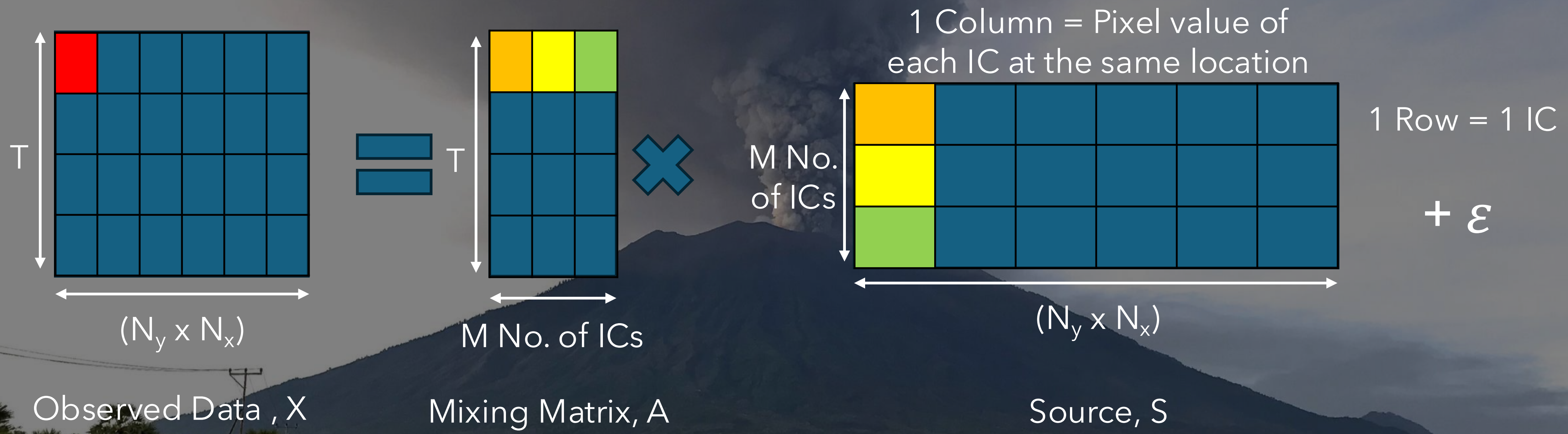

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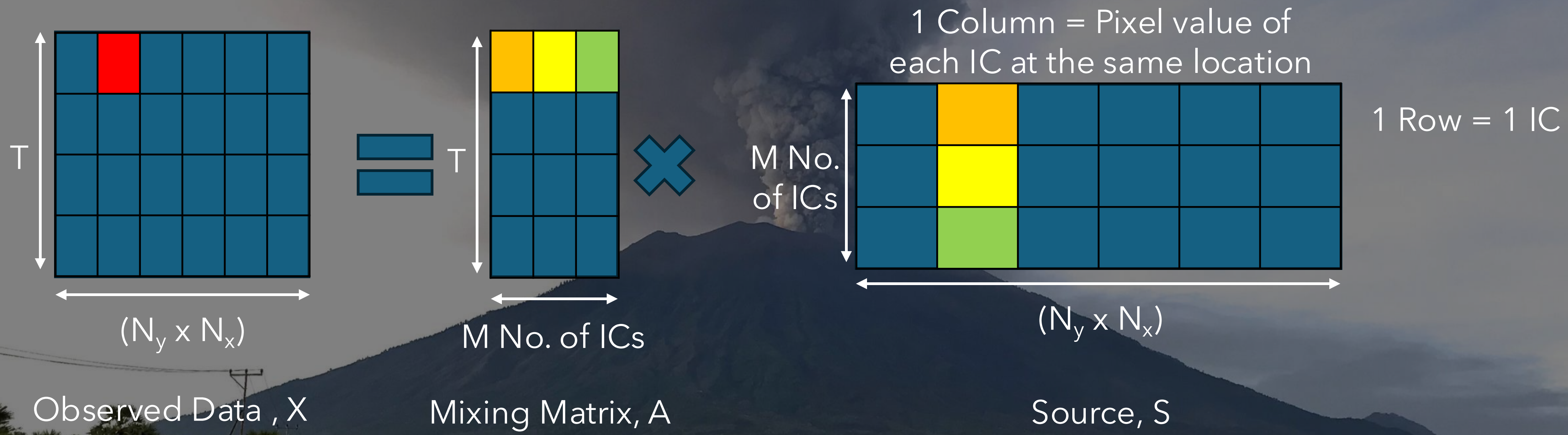

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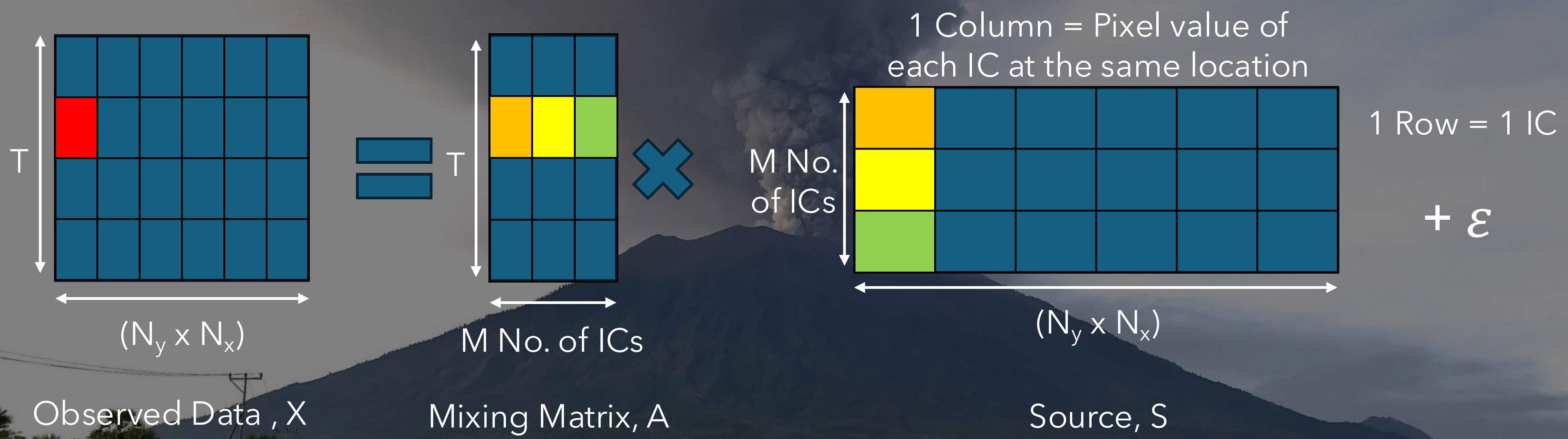

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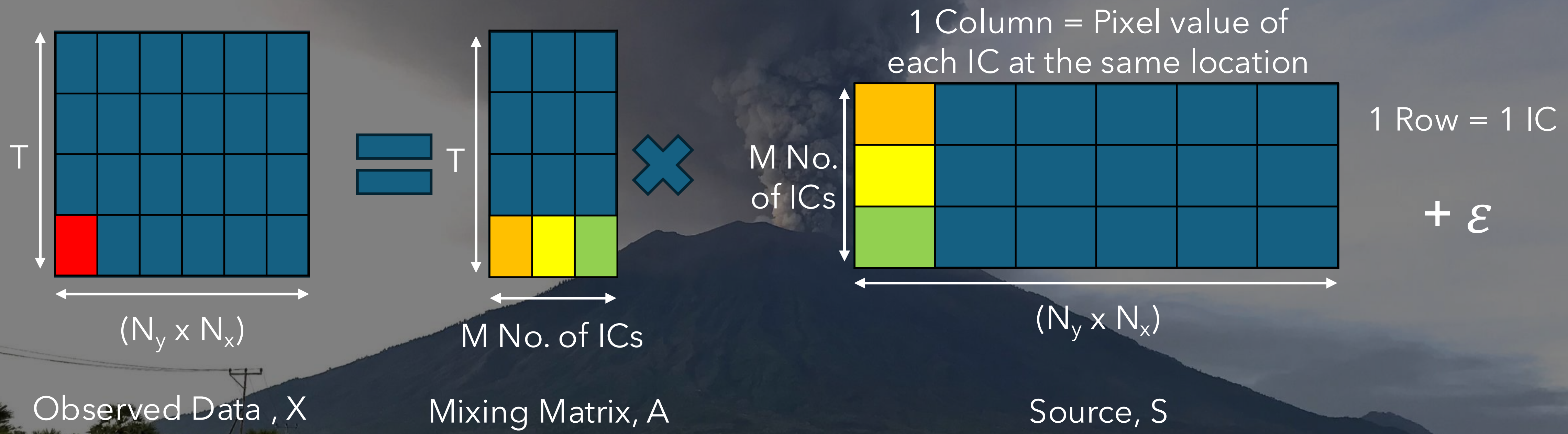
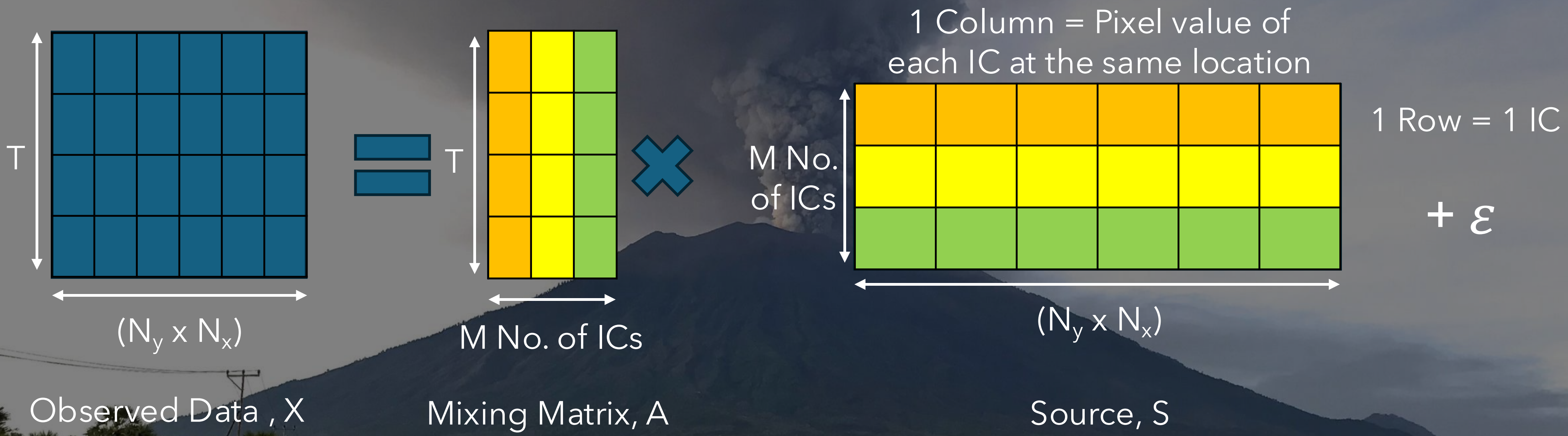
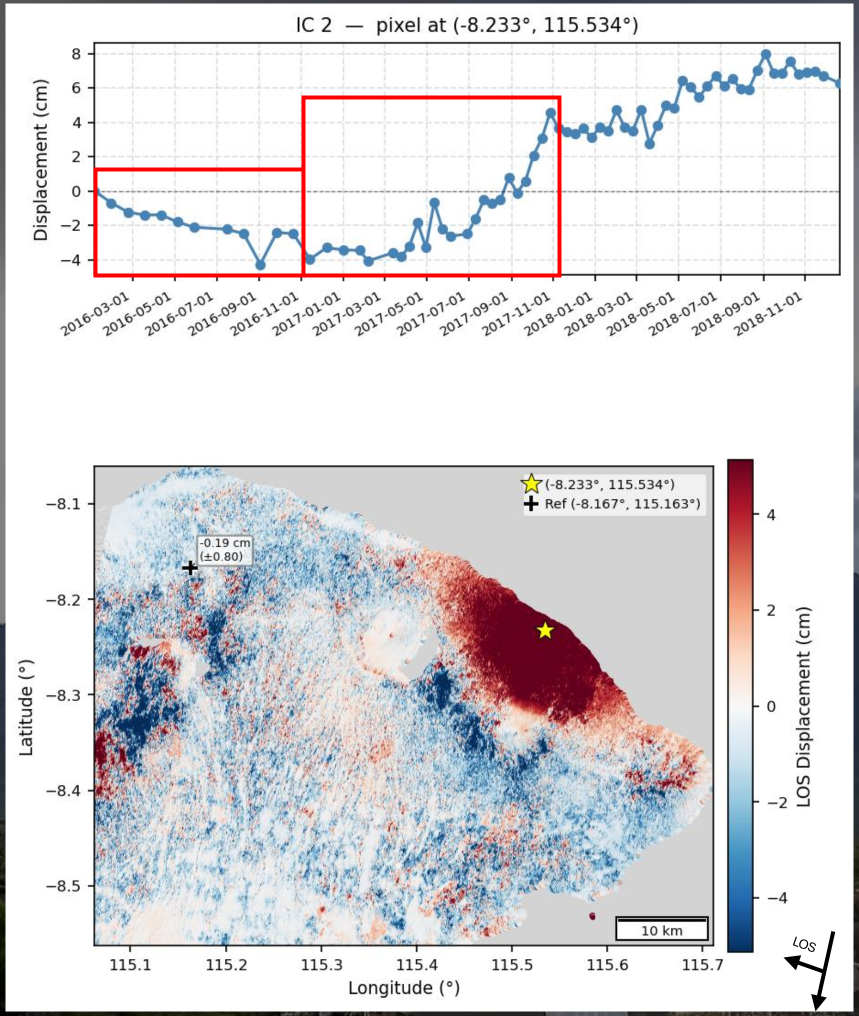


Each column of the mixing matrix corresponds to the temporal evolution of one independent component



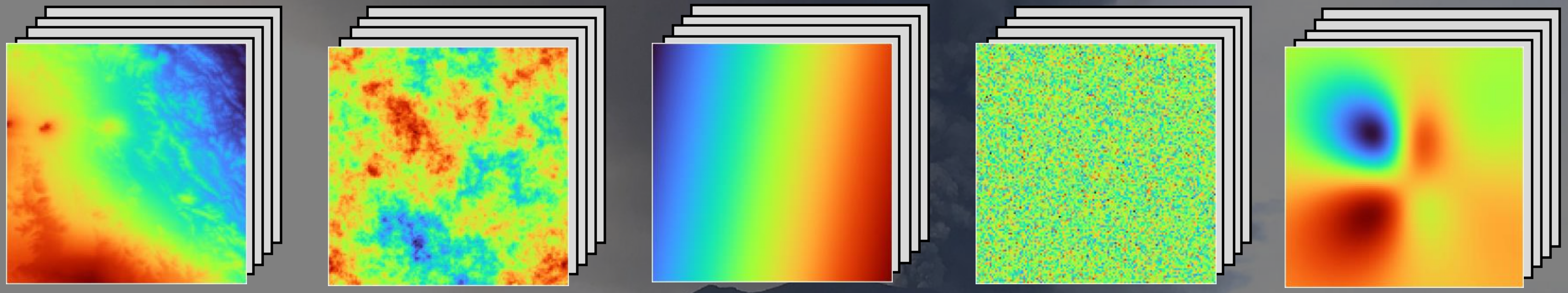
Full timeseries ICA conflates tectonic and magmatic signals



Methods

2016

ICA trained on 2016 data



Tropospheric Noise (Topography)

Tropospheric Noise (Turbulent)

Satellite Orbital Error

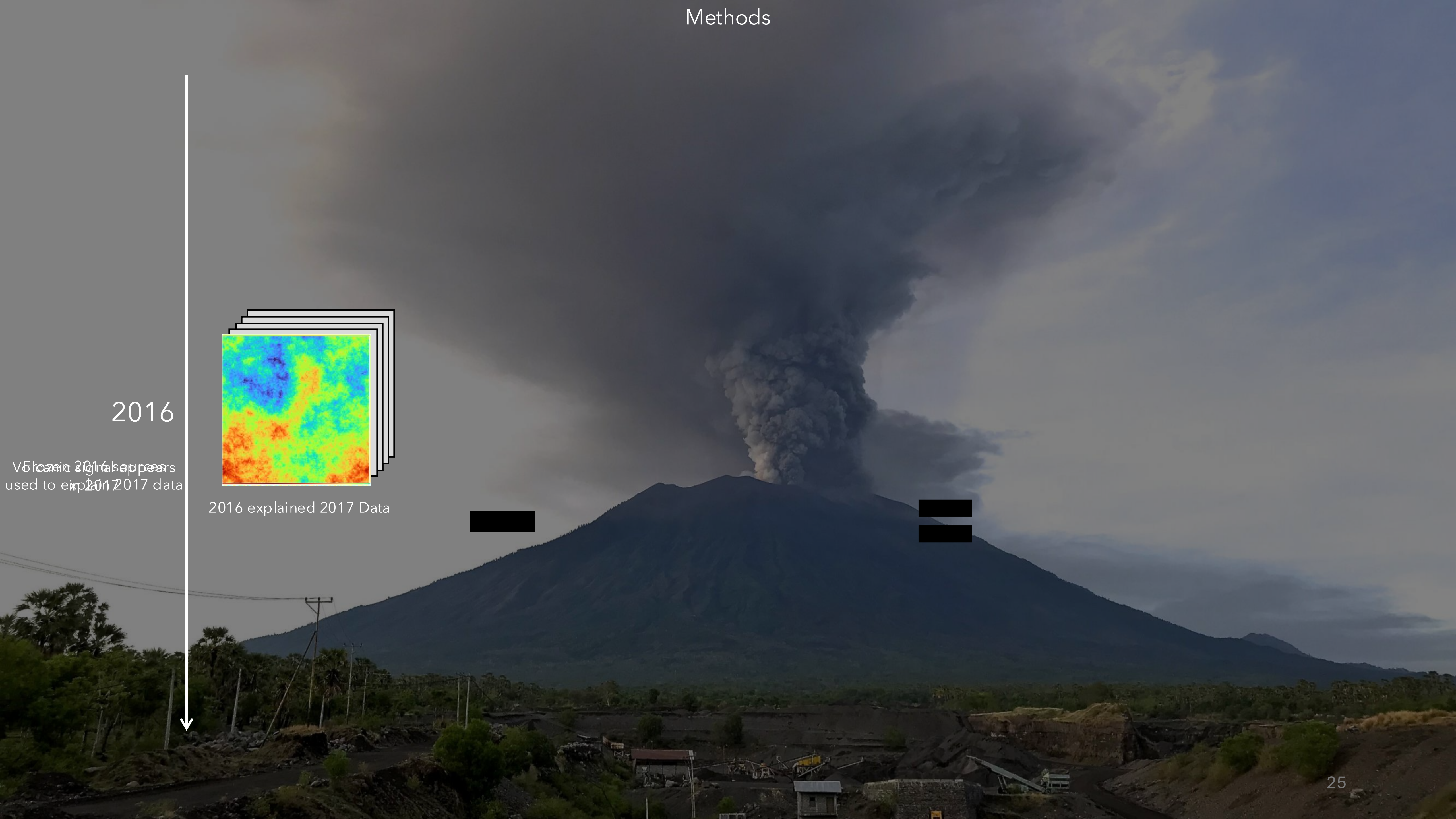
Instrument Noise

Non Volcanic Deformation

Key Assumption:
No volcanic signal

2016

Methods



2016

Volcanic signal appears
in 2017

From 2016 sources
used to explain 2017 data

2016 explained 2017 Data

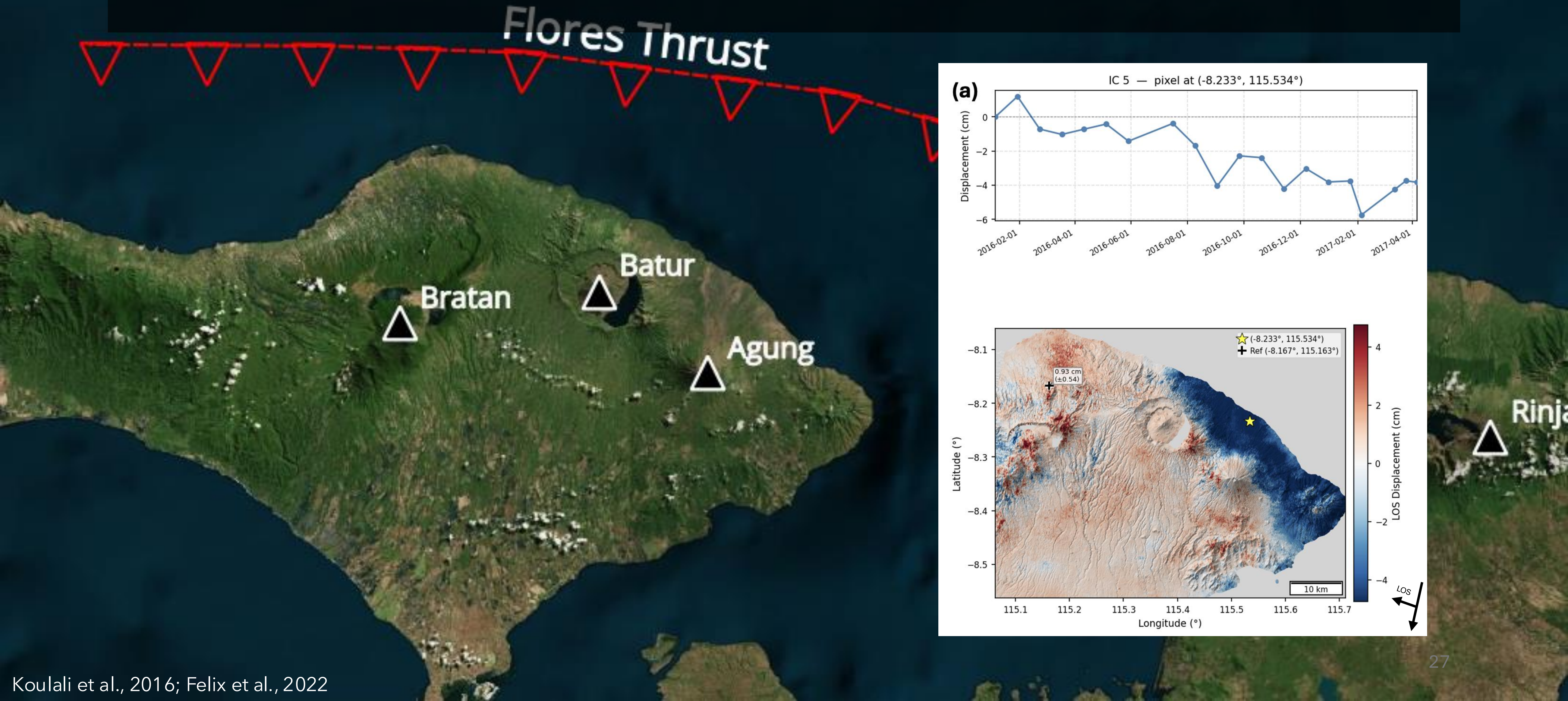
Project 2016 spatial patterns into the 2017 data→ residuals reveal new signal

Project: $A_{new} = X_{2017}\, s_{2016}^{T}\, (s_{2016}^{T}\, s_{2016})^{-1}$

Reconstruct: $x_{explained} = A_{new}\, s_{2016}$

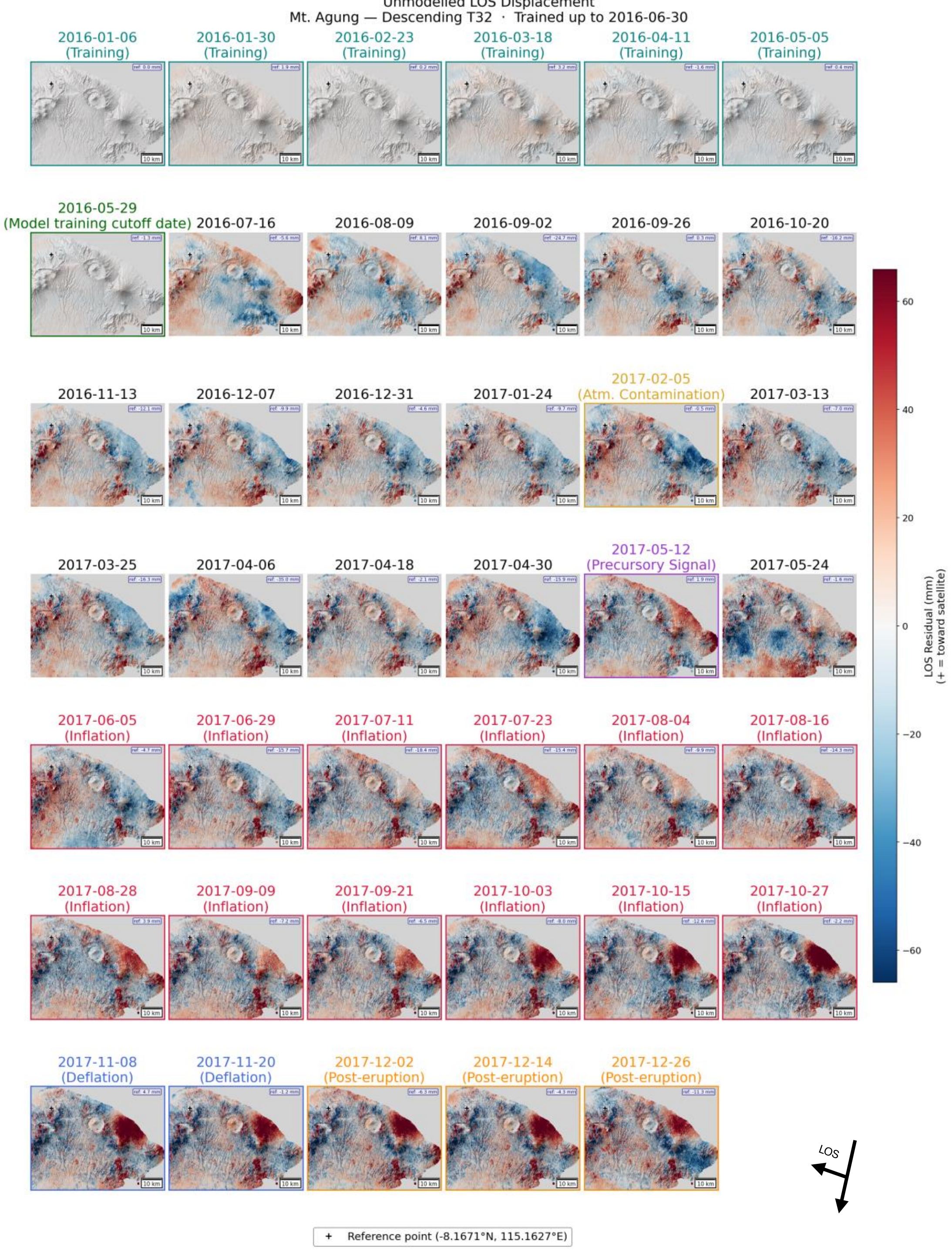
Residuals: $X_{2017} - X_{explained}$ = signal the 2016 model cannot explain

Tectonic subsidence from the Flores Thrust hanging wall dominates the northern Bali deformation field?

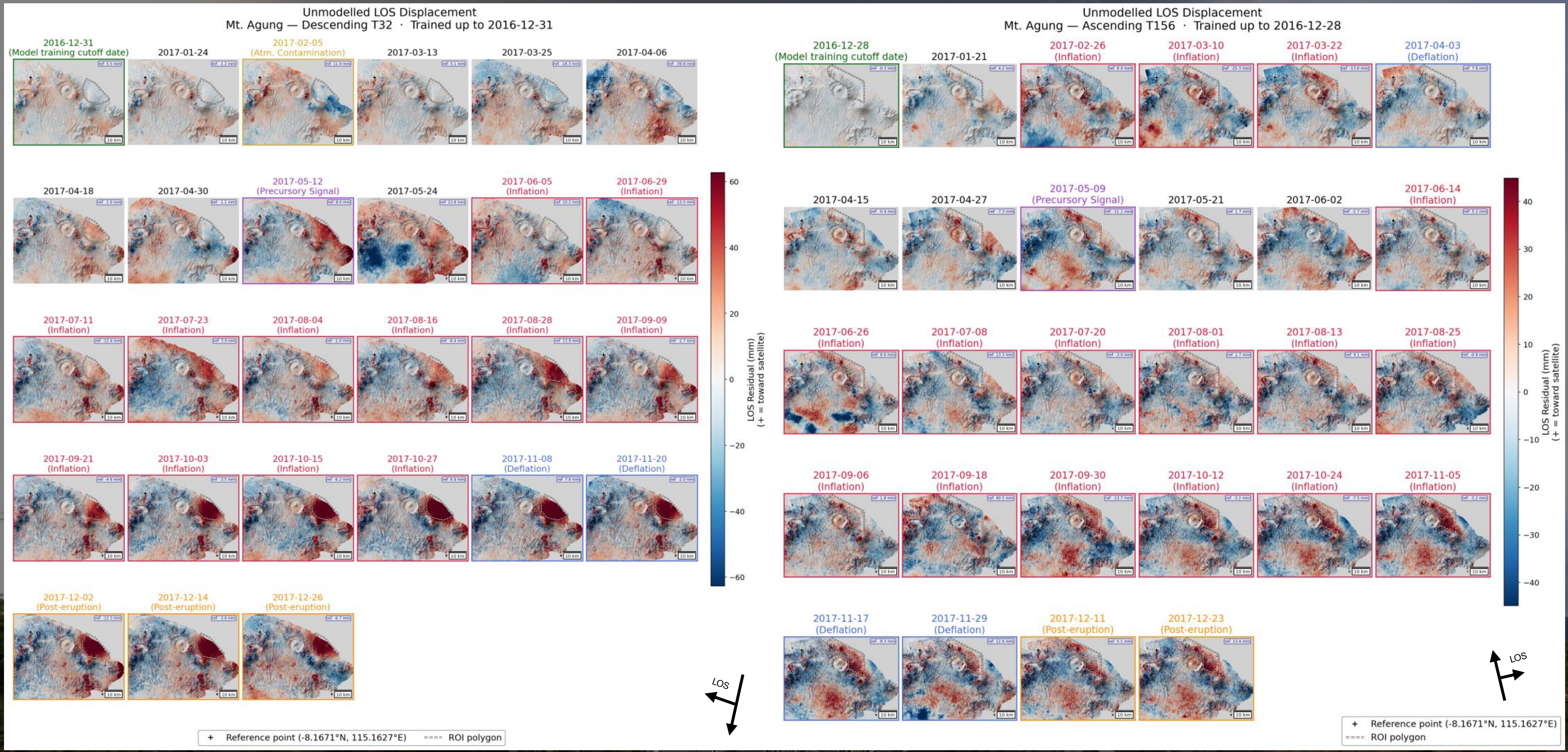


Koulali et al., 2016; Felix et al., 2022

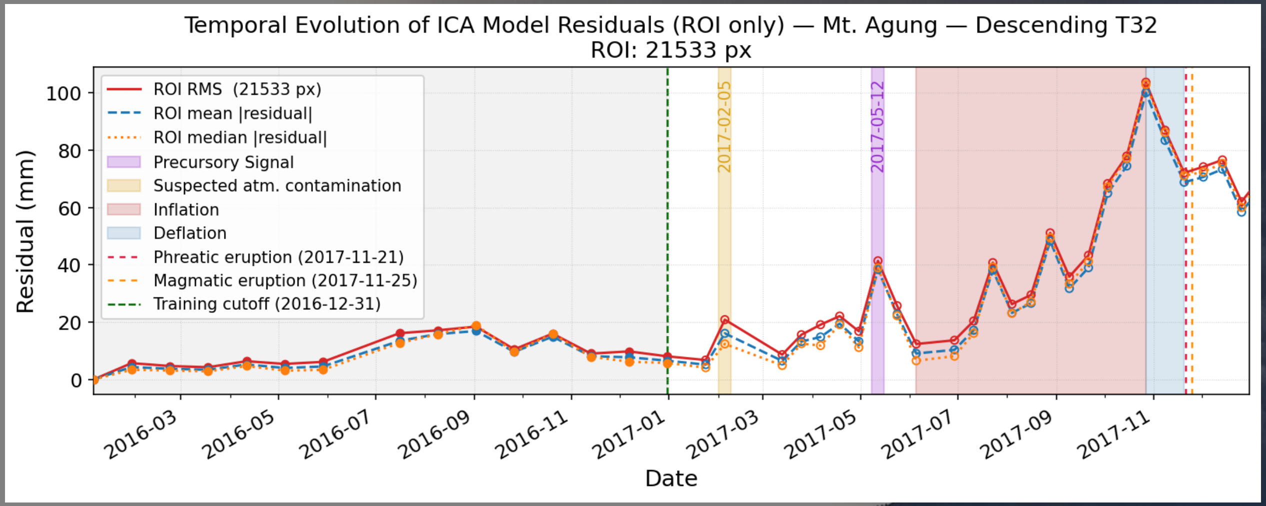
2016 baseline is stable across all training cutoffs

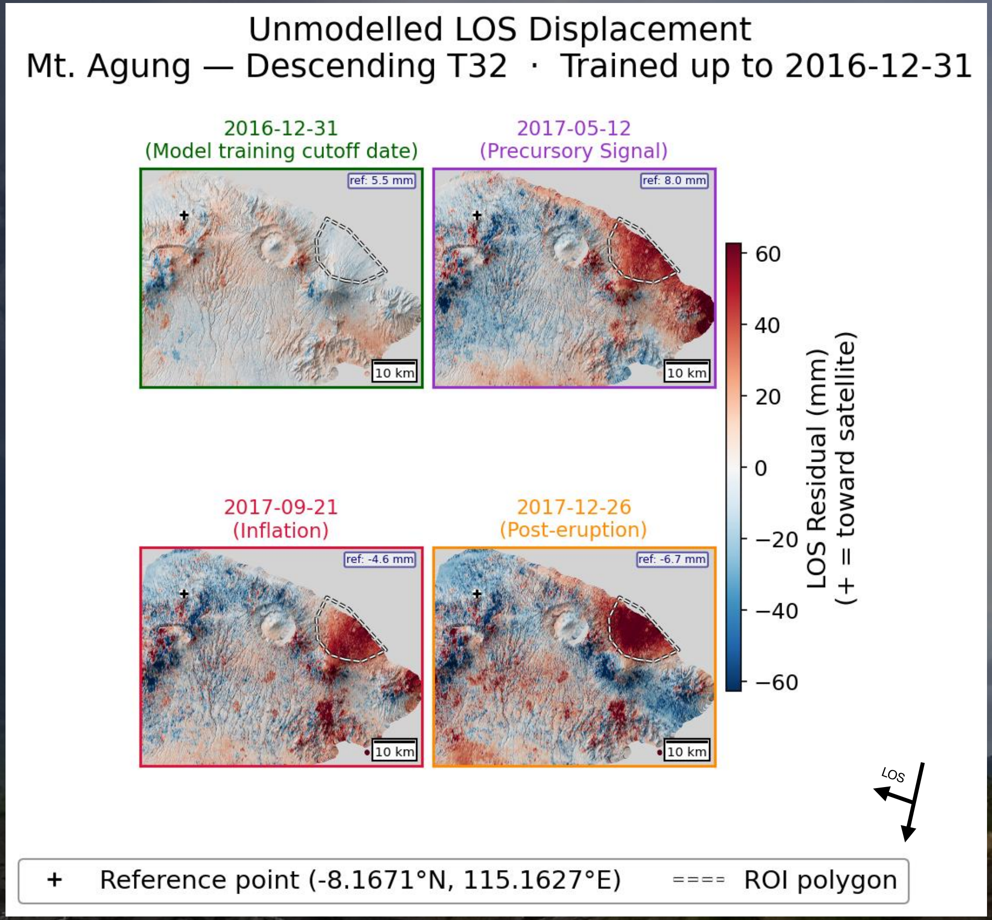


Residual time series capture the 2017 unrest sequence in both tracks

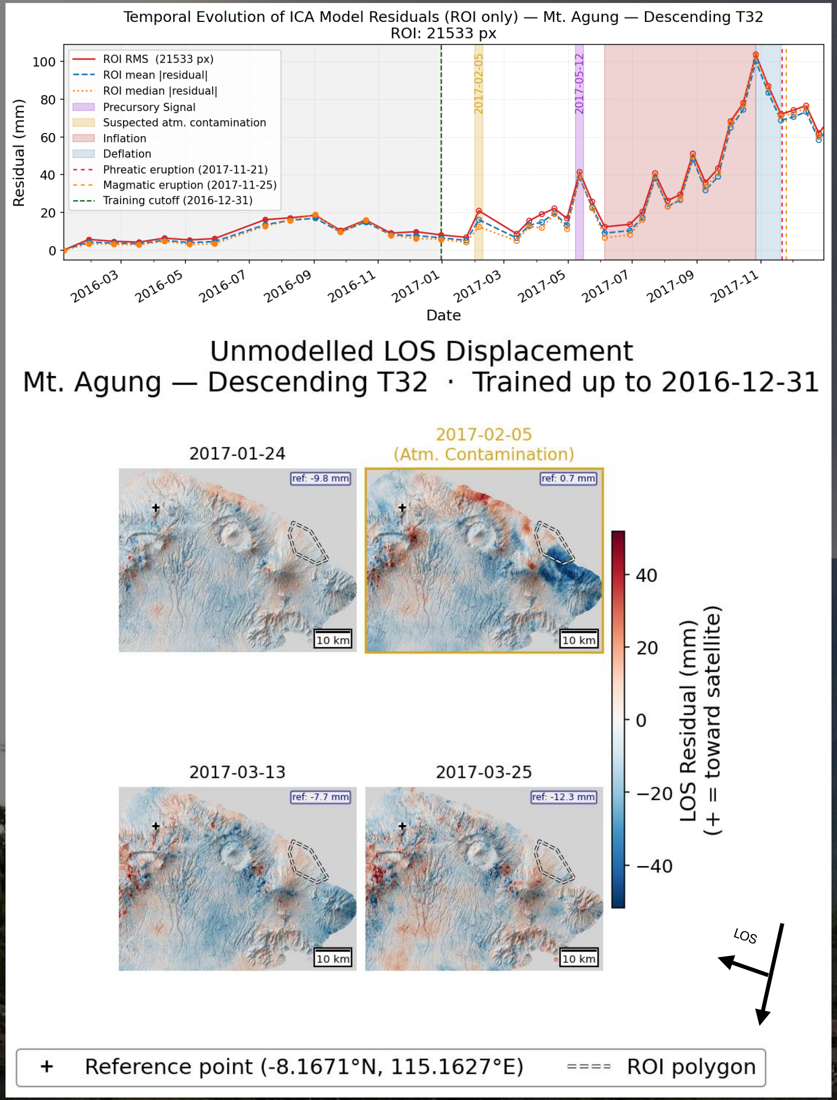


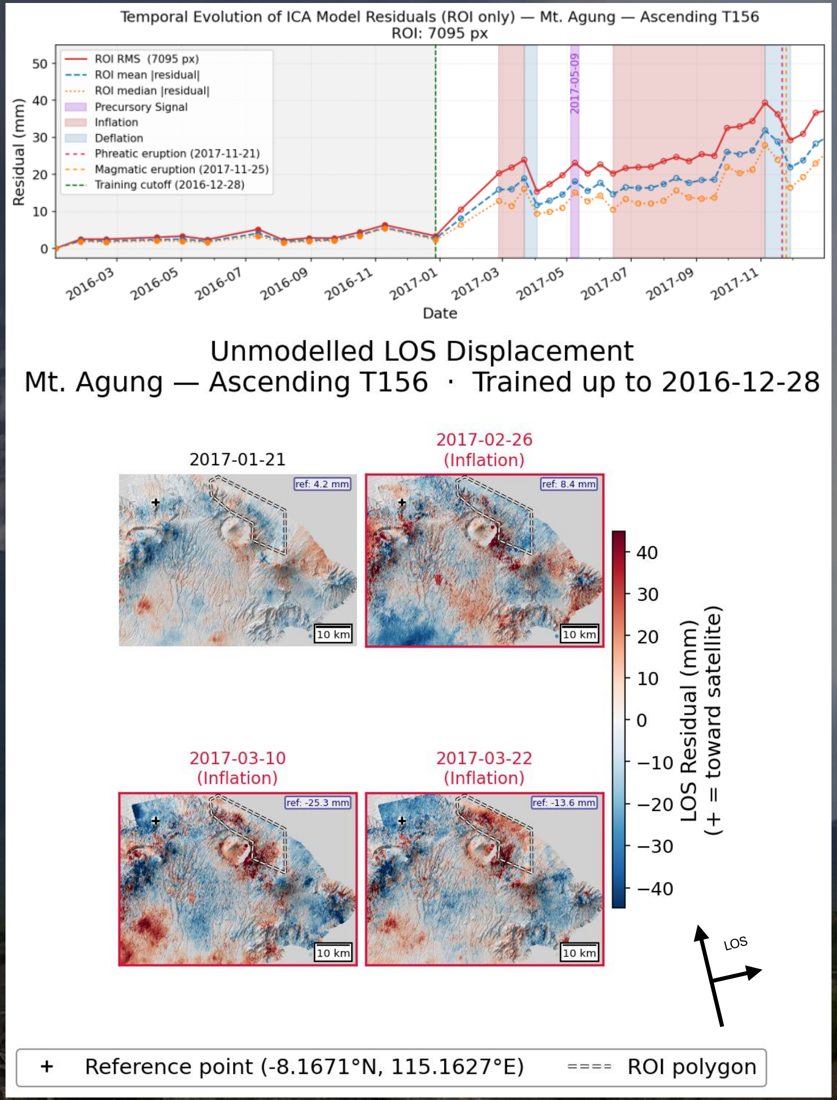
Magmatic inflation anomaly emerges six months before eruption



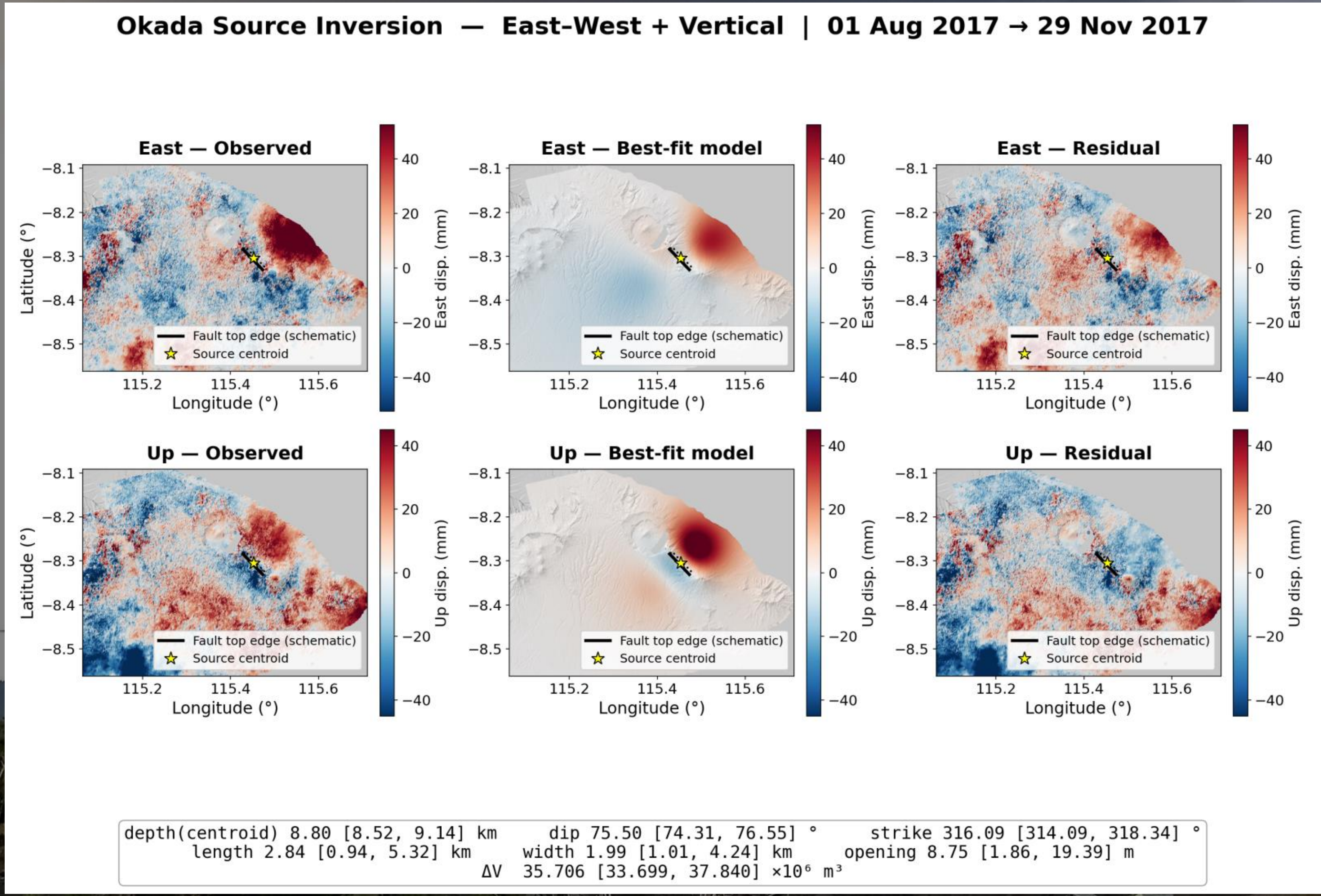


February–March inflation in T156: evidence for earlier onset?





Okada inversion constrains source depth at ~9 km



consistent with the interpretation proposed by Albino et al. (2019).


Marapi
Dempo
Dieng Volcanic Complex
Merapi
Raung
Semeru
Lewotobi
Lewotolo
Ibu
Dukono

Conclusion

- vbICA projection residual analysis is effective for separating overlapping deformation signals in complex volcanic settings.
- At Agung, broad subsidence likely related to the Flores back-arc thrust is distinguished from localised pre-eruptive magmatic inflation.
- This is particularly important for Indonesia, where many active volcanoes are in subduction-zone settings and are strongly influenced by tectonic deformation.
- Advanced InSAR time-series analysis can improve the detection of subtle early magmatic signals that may be masked in standard InSAR products.
- The workflow has potential for semi-real-time monitoring during evolving unrest–eruption sequences when integrated with independent observations such as seismicity, gas emissions, and ground-based deformation.
- The approach provides a simple, robust, and transferable workflow for Indonesian volcanoes and other tectonically active volcanic regions.
- The next step is to implement and test this workflow at other volcanoes in Indonesia.

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Thank you!