Optimally Balancing InSAR Observations for the Damaging November 2022 Mw 5.6 earthquake in West Java, Indonesia

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EARTH
OBSERVATORY
OF SINGAPORE

NANYANG
TECHNOLOGICAL
UNIVERSITY
SINGAPORE

Who we are

Nicholas Lim

Aug 2023

Aug 2021

"The EOS-RS lab is starting with four female and one male founding members, and will exercise and promote diversity and inclusion," said Assoc Prof Yun.

Members of the EOS-RS team, from left to right: Associate Professor Sang-Ho Yun, Ms Cheryl Tay, Ms Way Lin, Ms Shi Tong Chin (Source: Phuong Nguyen/Earth Observatory of Singapore)

EOS Blog

The team from NTU's EOS-Remote Sensing Lab. (Back row, from left) PhD student Bryan Marfito, research assistant Jay Wong, student assistant Ricky Winarko, research fellows Eleanor Ainscoe, Rino Salman and Noel Ivan Ulloa (inset). (Front row, from left) PhD student Cheryl Tay, EOS-RS director Yun Sang-Ho, research associate Shi Tong Chin and research assistant Lin Way. PHOTO: NTU'S EARTH OBSERVATORY OF SINGAPORE

Straits Times

6 Singaporeans, 2 Indonesians, 1 Filipino,
1 British, 1 Nicaraguan, and 1 Korean American

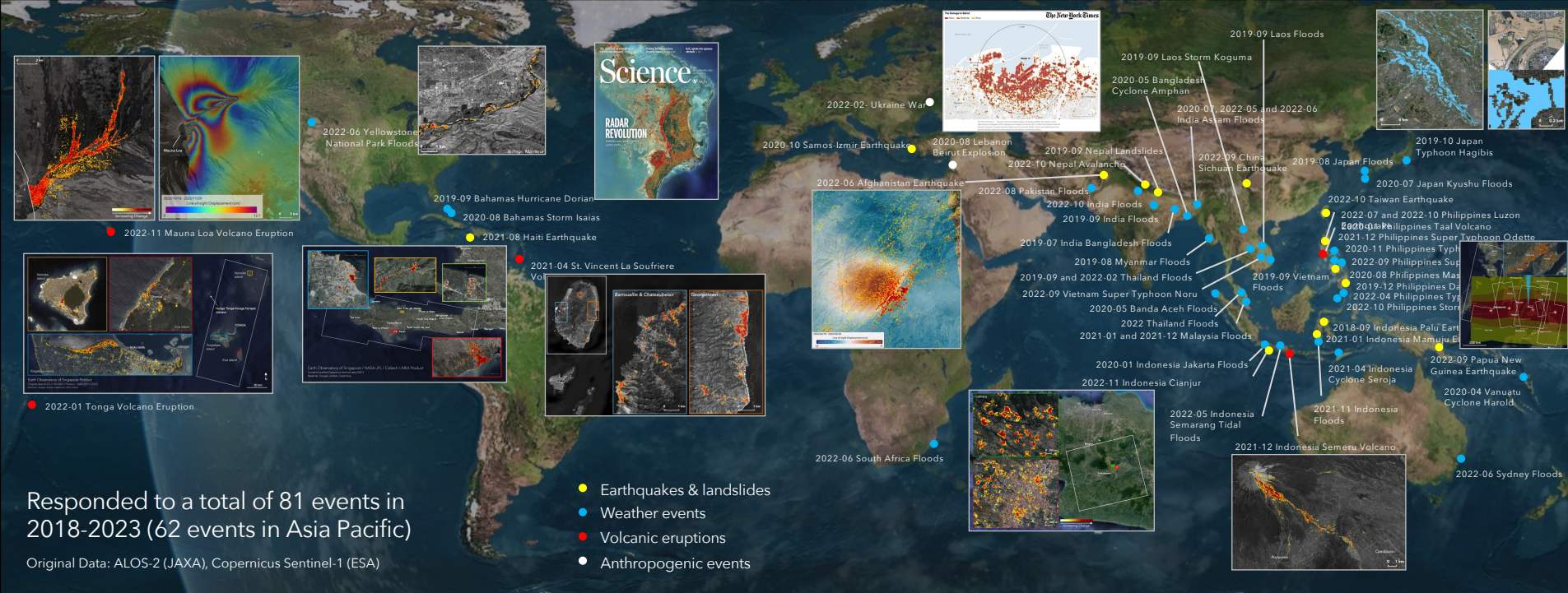# What we do

- Use satellite radar remote sensing for humanitarian assistance and disaster response

- Innovate algorithms (and AI) for automated satellite data processing towards improved disaster response and societal impact

Impact to date

Responded to a total of 81 events in 2018-2023 (62 events in Asia Pacific)

Original Data: ALOS-2 (JAXA), Copernicus Sentinel-1 (ESA)

Legend:
- 🟡 Earthquakes & landslides
- 🔵 Weather events
- 🔴 Volcanic eruptions
- ⚪ Anthropogenic events

Map event labels:

- 2022-11 Mauna Loa Volcano Eruption
- 2022-01 Tonga Volcano Eruption
- 2022-06 Yellowstone National Park Floods
- 2019-09 Bahamas Hurricane Dorian
- 2020-08 Bahamas Storm Isaias
- 2021-08 Haiti Earthquake
- 2021-04 St. Vincent La Soufriere Volcano
- 2022-02- Ukraine War
- 2020-10 Samos-Izmir Earthquake
- 2020-08 Lebanon Beirut Explosion
- 2022-06 Afghanistan Earthquake
- 2022-08 Pakistan Floods
- 2019-07 India Bangladesh Floods
- 2019-08 Myanmar Floods
- 2019-09 and 2022-02 Thailand Floods
- 2022-09 Vietnam Super Typhoon Noru
- 2020-05 Banda Aceh Floods
- 2022 Thailand Floods
- 2021-01 and 2021-12 Malaysia Floods
- 2022-10 India Floods
- 2019-09 India Floods
- 2019-09 Nepal Landslides
- 2022-10 Nepal Avalanche
- 2020-05 Bangladesh Cyclone Amphan
- 2020-07, 2022-05 and 2022-06 India Assam Floods
- 2019-09 Laos Storm Koguma
- 2019-09 Laos Floods
- 2022-09 China Sichuan Earthquake
- 2019-08 Japan Floods
- 2020-07 Japan Kyushu Floods
- 2019-10 Japan Typhoon Hagibis
- 2022-10 Taiwan Earthquake
- 2022-07 and 2022-10 Philippines Luzon 2020-04 Philippines Taal Volcano
- 2020-01 Earthquake
- 2021-12 Philippines Super Typhoon Odette
- 2020-11 Philippines Typh
- 2022-09 Philippines Sup
- 2020-08 Philippines Mas
- 2019-12 Philippines Da
- 2022-04 Philippines Typ
- 2022-10 Philippines Stor
- 2019-09 Vietnam Floods
- 2018-09 Indonesia Palu Eart
- 2021-01 Indonesia Mamuju E
- 2020-01 Indonesia Jakarta Floods
- 2022-11 Indonesia Cianjur
- 2022-05 Indonesia Semarang Tidal Floods
- 2021-04 Indonesia Cyclone Seroja
- 2021-11 Indonesia Floods
- 2021-12 Indonesia Semeru Volcano
- 2022-09 Papua New Guinea Earthquake
- 2020-04 Vanuatu Cyclone Harold
- 2022-06 South Africa Floods
- 2022-06 Sydney Floods

Maps X

Some Turning Points of our Disaster Response Support

"Thank you so much for all of the data and assistance. It helped us to be able to sketch out areas to focus on for our ground survey efforts. There were several significant areas of damage that we would not have located without your assist. Thank you!"

FBI Explosives Unit
August 25, 2020

"For the historical center of Norcia, the damage zones from ARIA imaging (DPMs) compared well with damage maps obtained from on-ground surveys."

Sextos et al. (**Geotechnical Engineers**), Earthquake Spectra 2018
Outstanding Paper Award (National Earthquake Conference 2020)

"After the tragic August earthquake in Amatrice, Italy, NASA's JPL produced maps of the greatest damage. These sophisticated maps will be used in the rebuilding efforts."

Barack Obama, Former President of the US
At the White House with Mateo Renzi on Oct 28, 2016

Sang-Ho Yun made invited presentations on satellite radar remote sensing for disaster response at the White House Conference Center in Washington, D.C. three times in 2016 and 2017.

Map featured on the cover page of Science (Feb 2021)
Contains modified Copernicus Sentinel data (2019)

M7.8 Türkiye Earthquake Response Support
204,000 km² (280 times SG) covered within 10 days

Turkey

Cyprus   Syria

200 km

Kahramanmaras

1 km

N
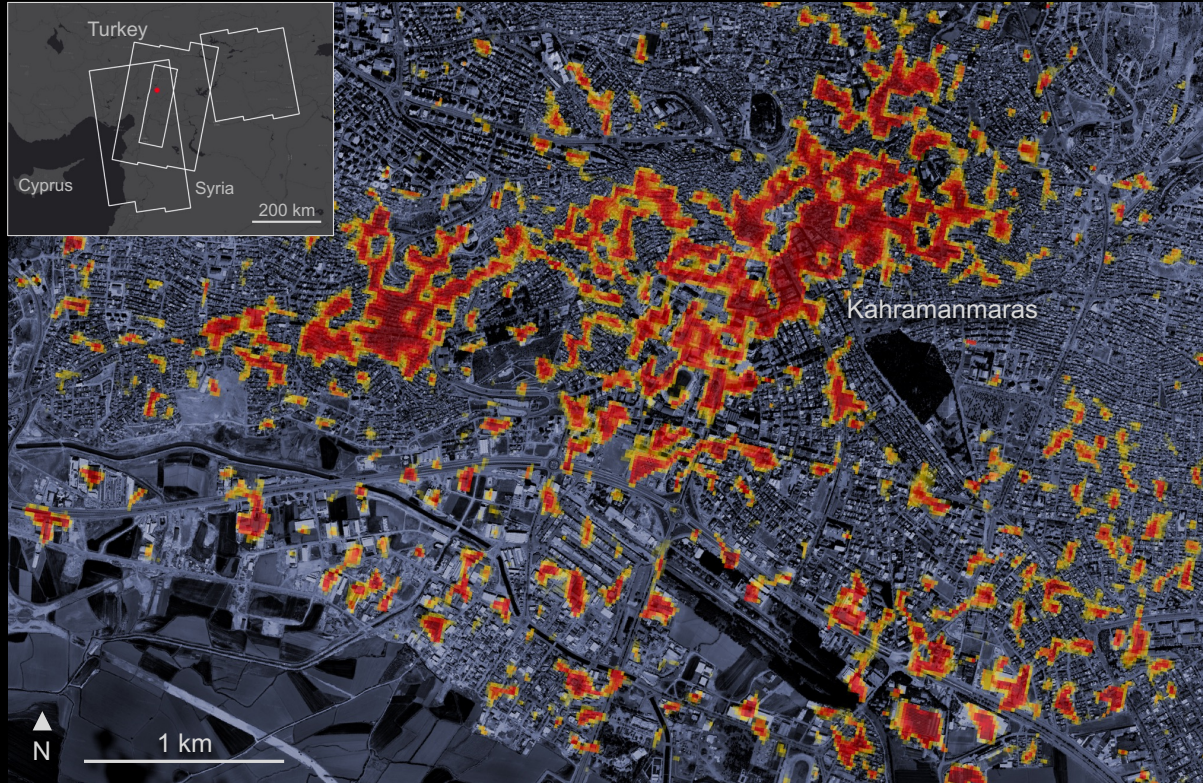
Contains modified Copernicus Sentinel data (2023)

"We have dispatched 10 teams (59 people) to the field for ground observations after downloading your maps on their mobile devices."

Emergency Management Center in Ankara, Türkiye

"Your maps produced an estimate of the number of affected people that is the closest to the ground observation-based Turkish government's number, compared to any other remote sensing-based products."

Geospatial Support Unit at the UN World Food Programme

50M People Live in West Java

166,927 people displaced
Shelter Candidates
Which one is the fault plane?

Candidate 2

Candidate 3

Candidate 1

10 km

Contains modified Copernicus
Sentinel data (2022)

Earth Observatory of Singapore Product
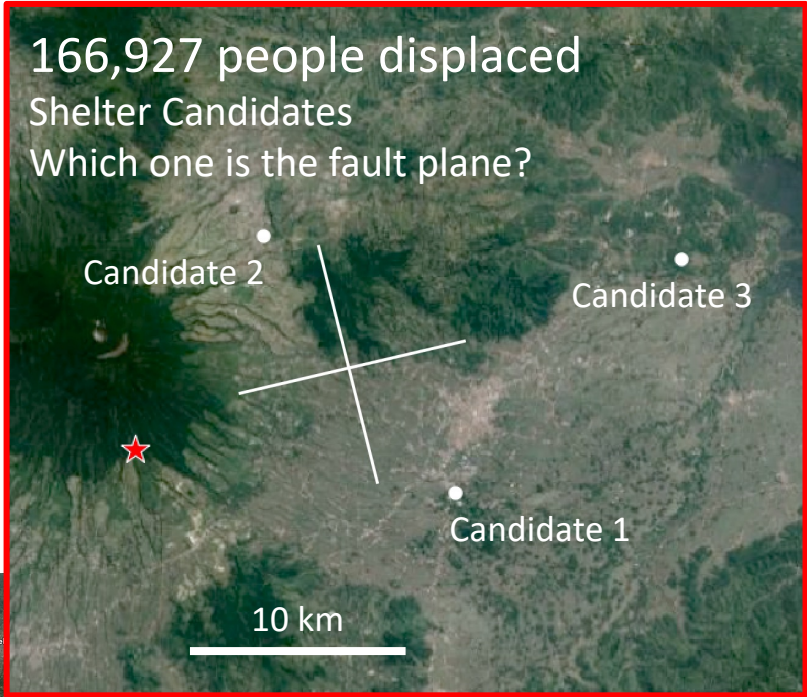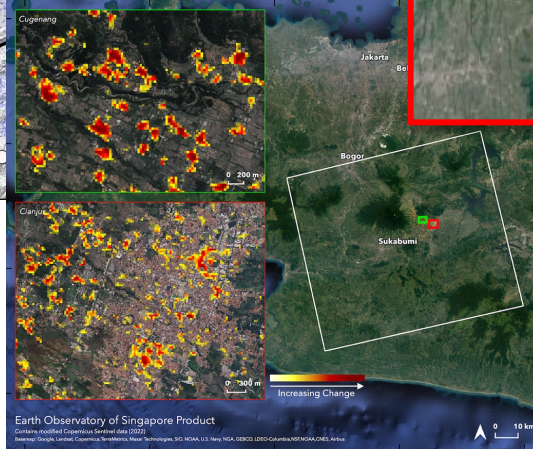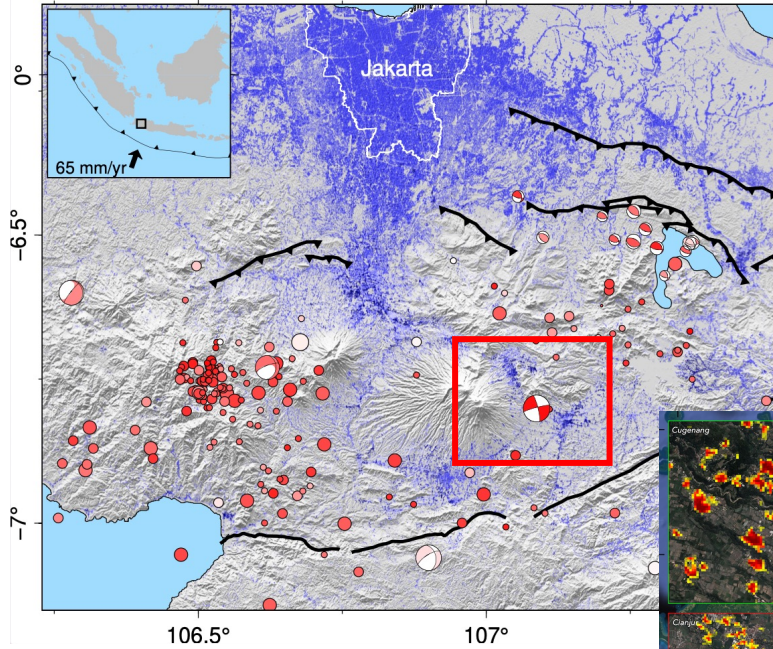
Two Coseismic Interferograms
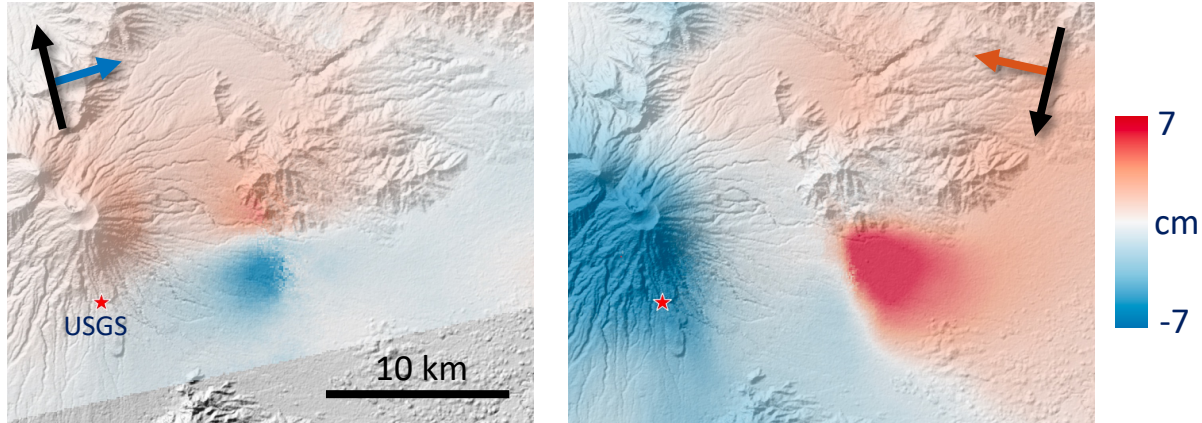
Weight: 0.5   0.5

Derived from ALOS-2

Three Coseismic Interferograms

USGS

10 km

0.33 ?

0.33 ?

0.33 ?

7

cm

-7
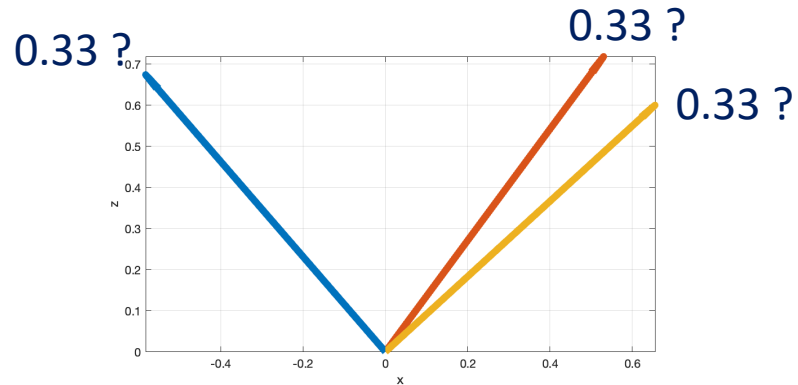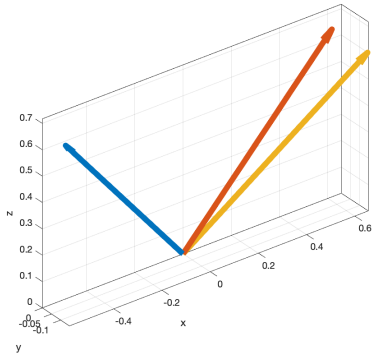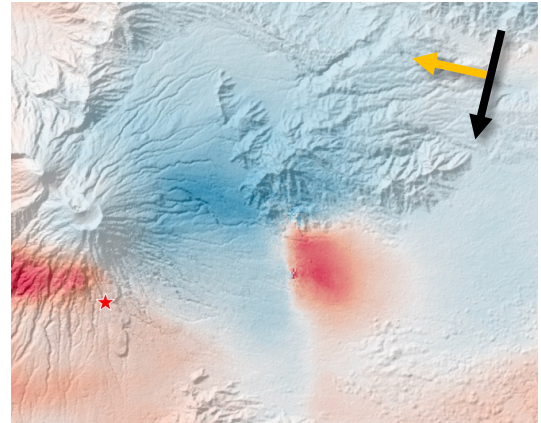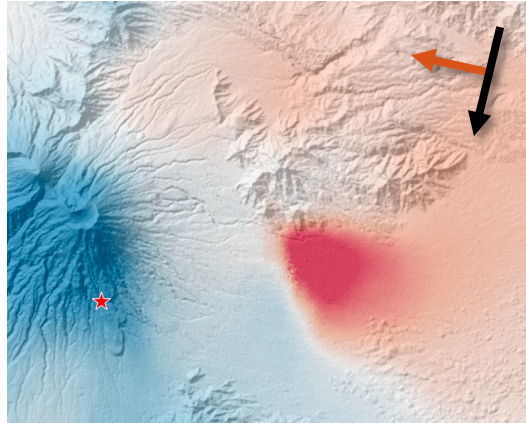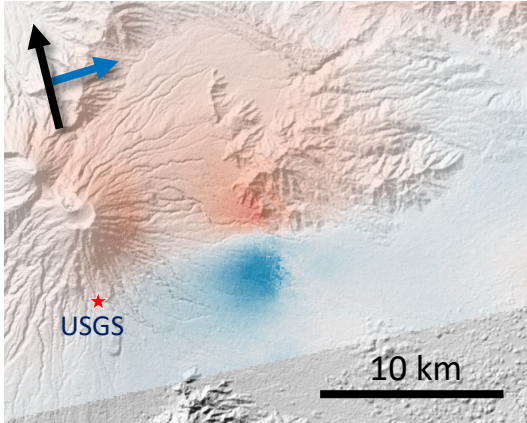
Derived from ALOS-2

Two Coseismic Interferograms

USGS

10 km

0.33

0.66

7

cm

-7
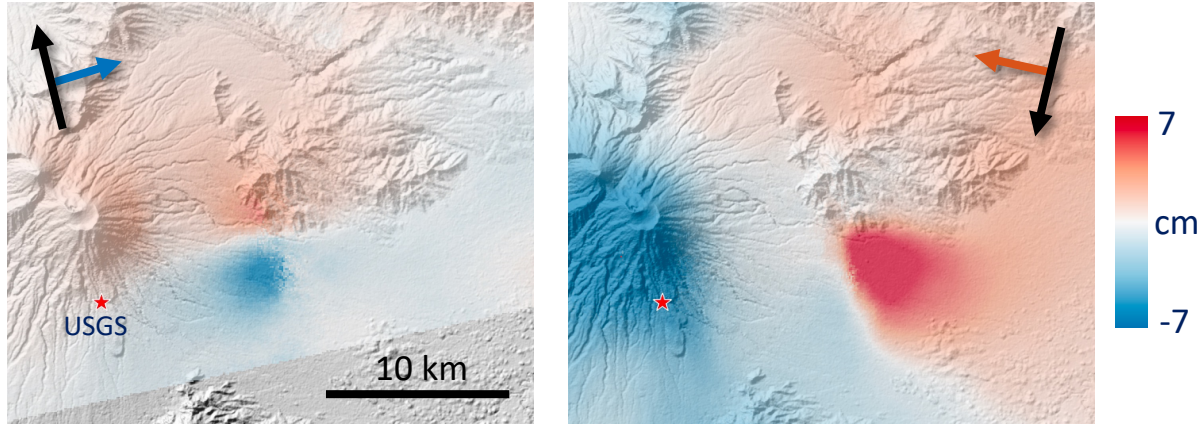
Derived from ALOS-2

How do we balance (weight) the interferograms?
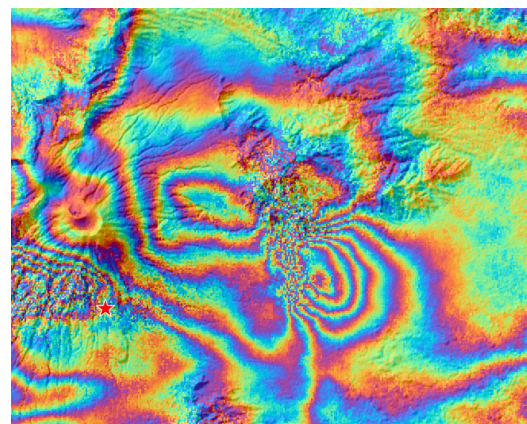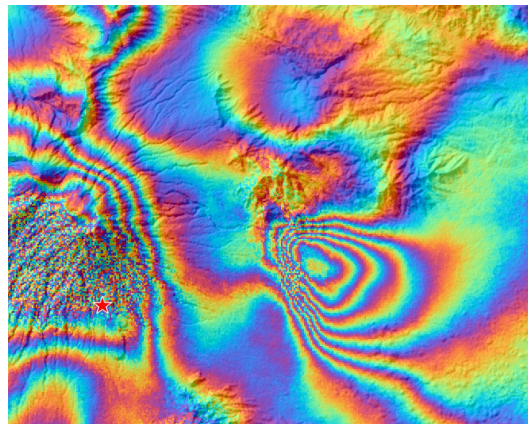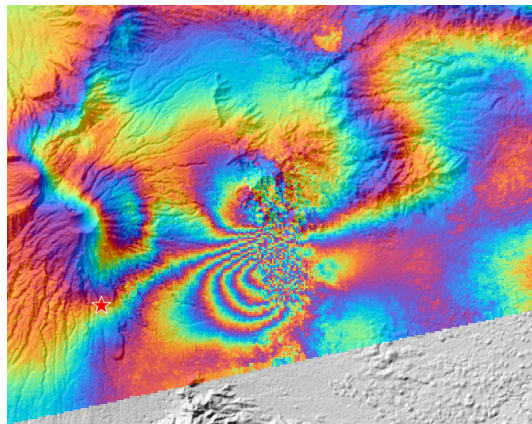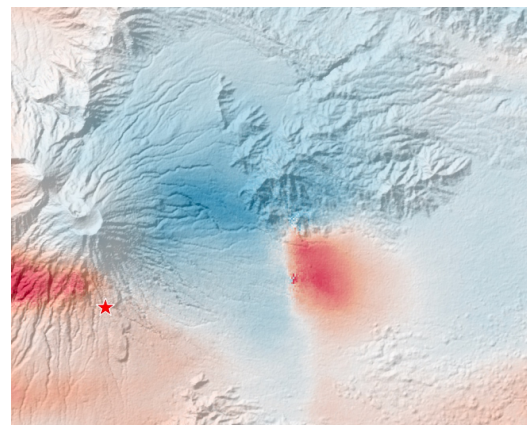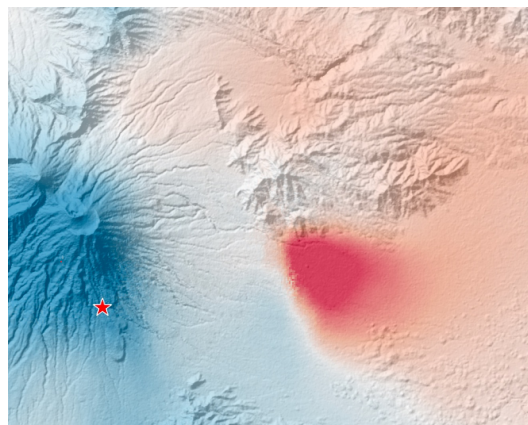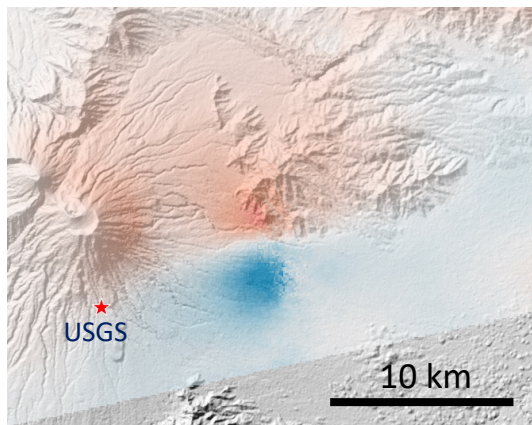
Variance Covariance Matrices (Data Noise)
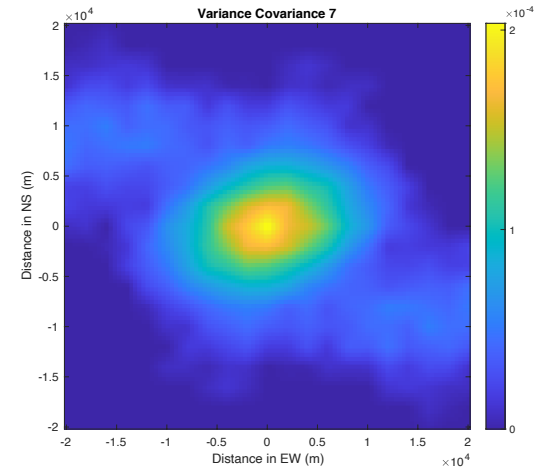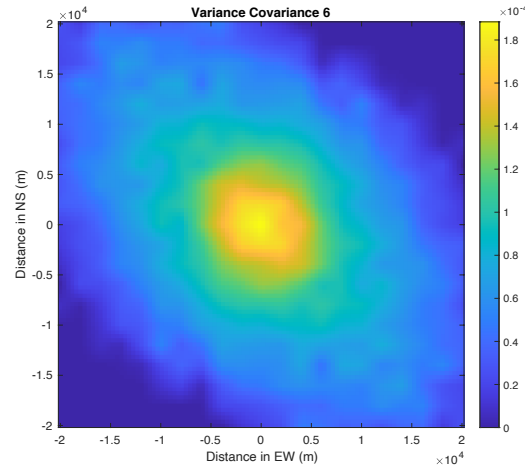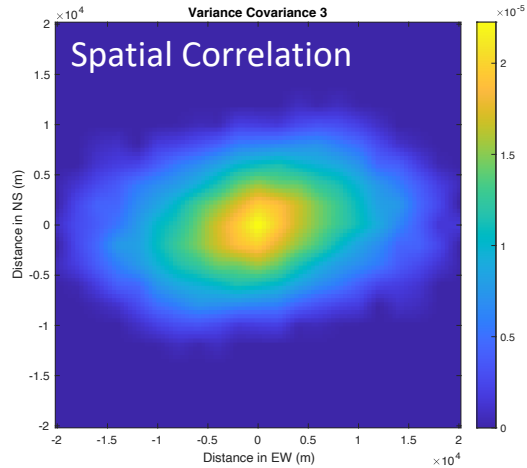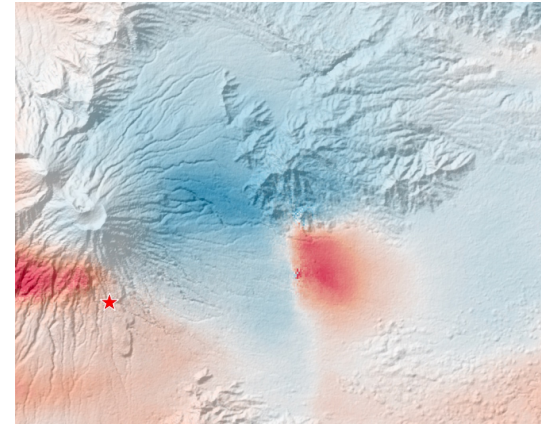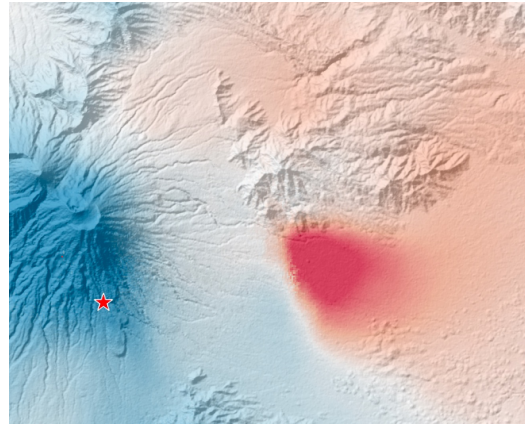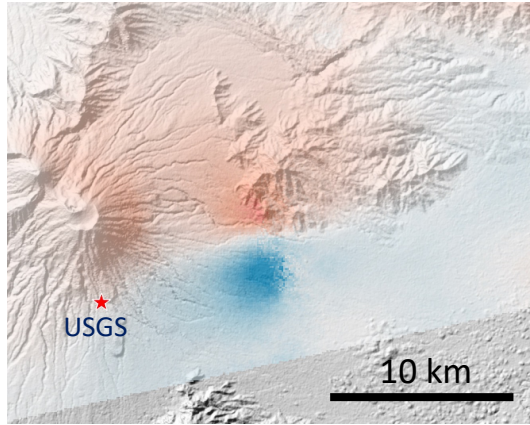
Data Importance

$$d^{pre} = Gm^{est} = G[G^{-g}d^{obs}] = [GG^{-g}]d^{obs} = Nd^{obs}$$

Data Resolution: $N = GG^{-g}$

Data Importance: $n = diag(N)$

(Menke, 1989, Minster et al., 1974)

Balancing Pixels

np=825

np=835

np=834

np=942

LOS Deformation (cm)

Input Slip Model

R-Based, np=825

Simons et al., 2002, np=835

Jonsson et al., 2002, np=834

Uniform, np=942

Slip (cm)
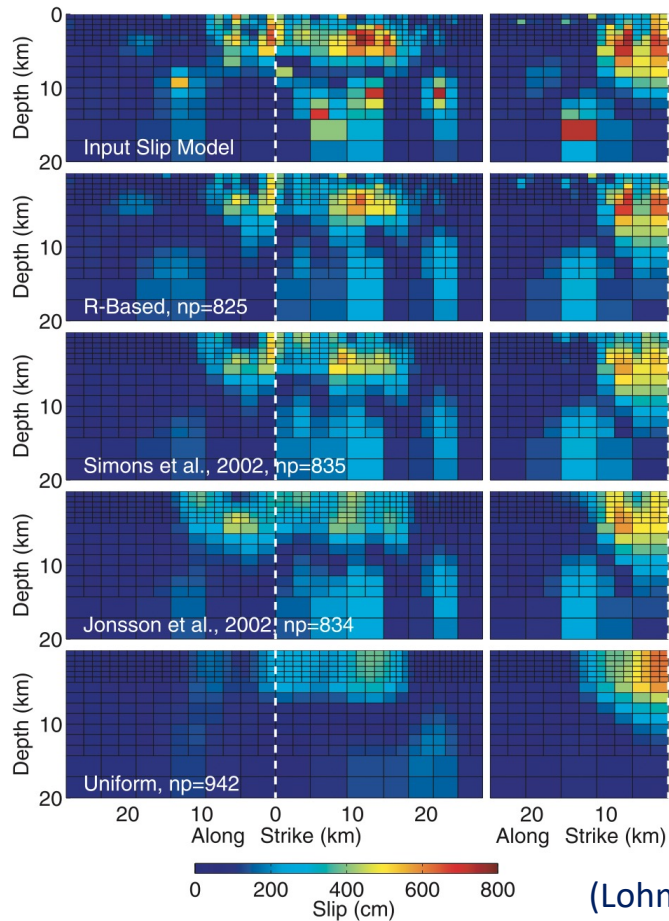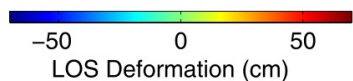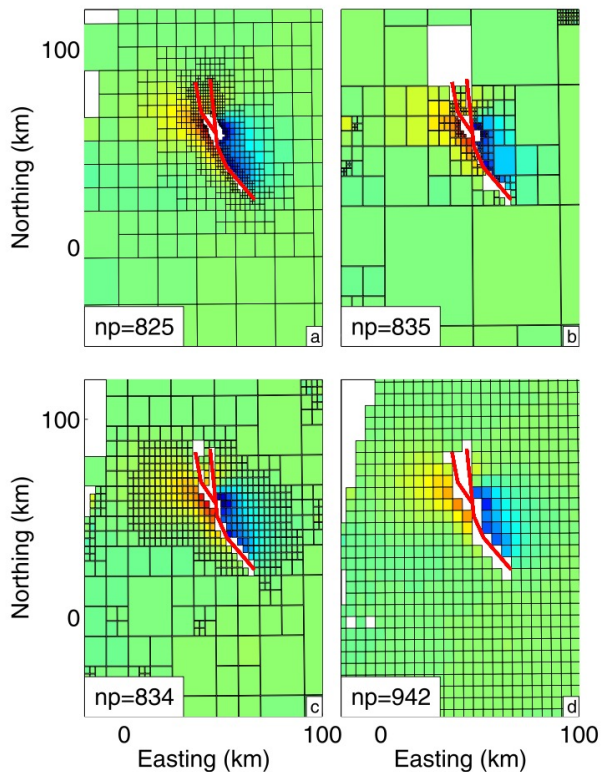
(Lohman & Simons, 2005)

Data Importance-based Subsampling

166,927 people displaced
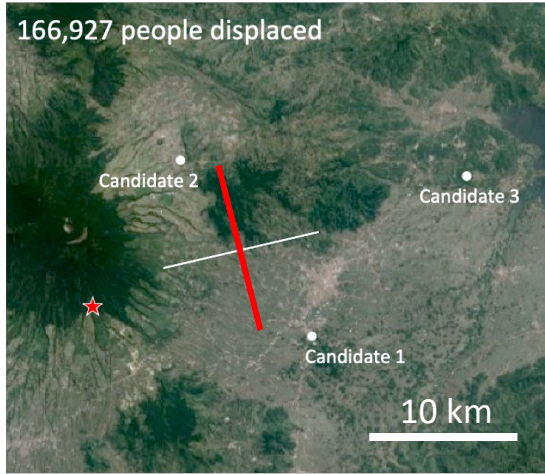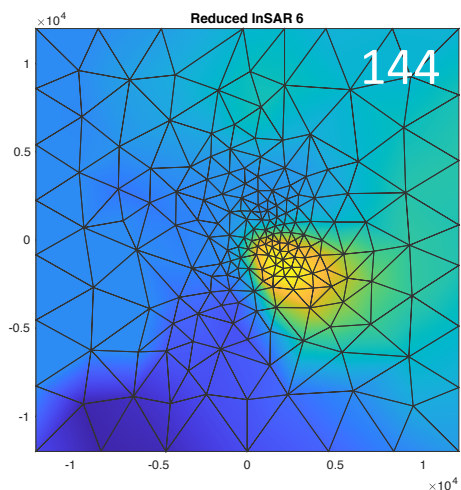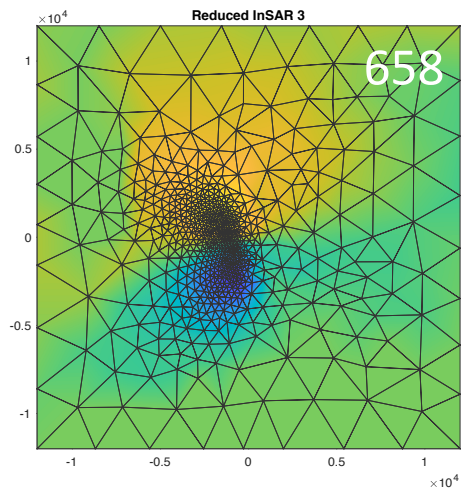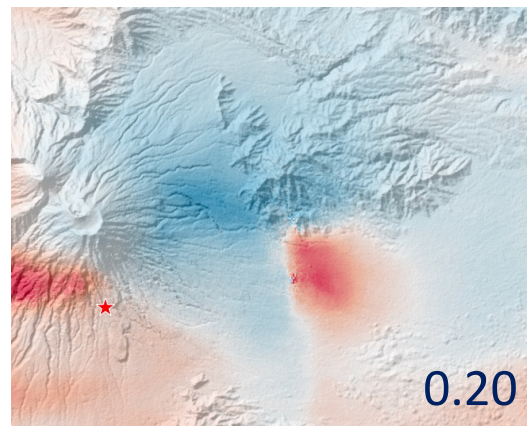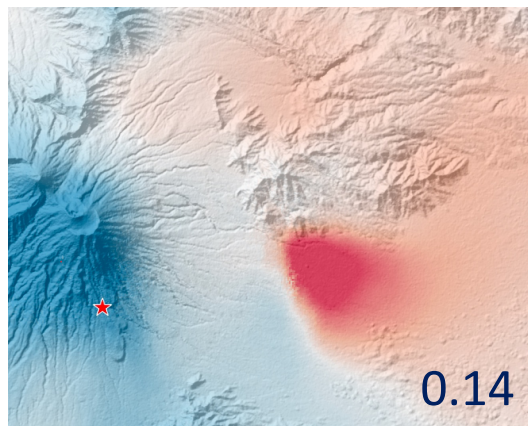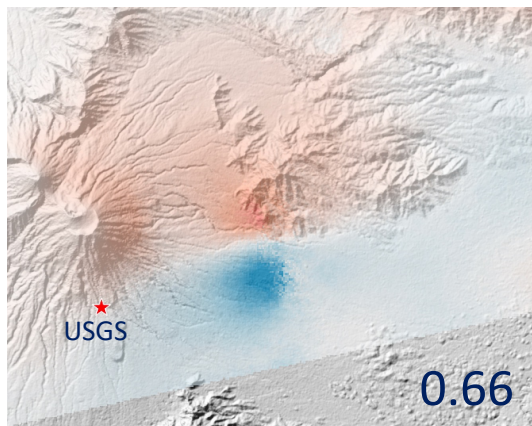
Strike: N13.7°W
Dip: 81°SW
Length: 3 km
Width: 3 km
Top depth: 1 km

Data Importance-based Subsampling

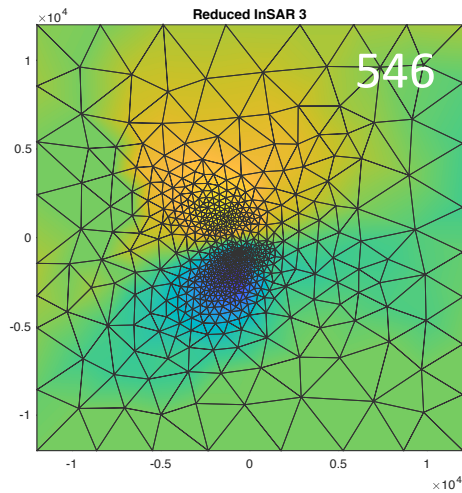166,927 people displaced
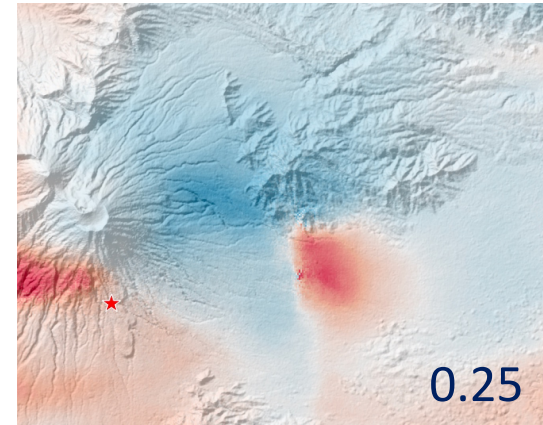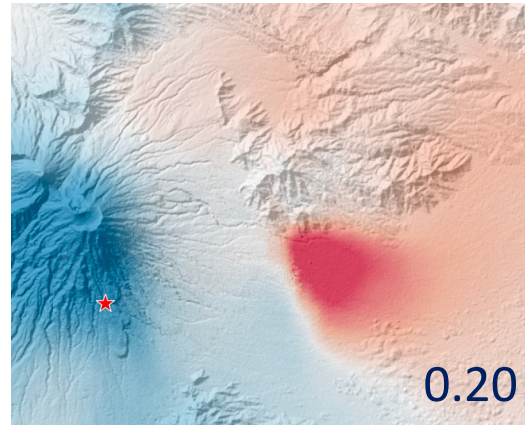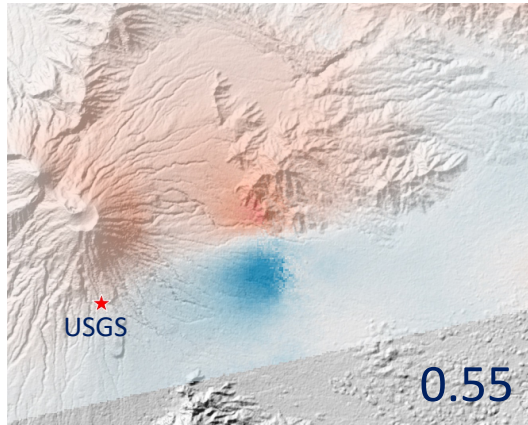
Candidate 2
Candidate 3
Candidate 1

10 km
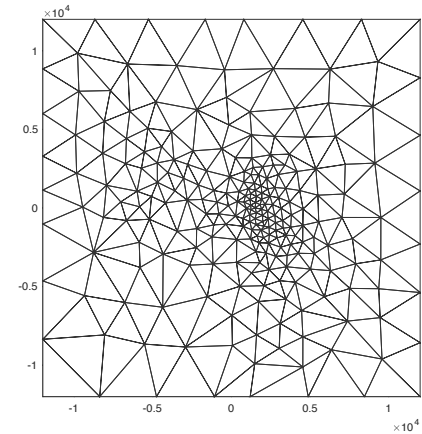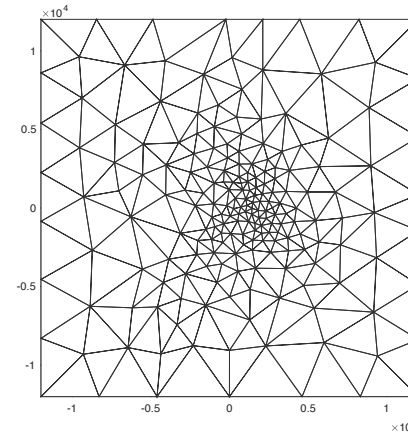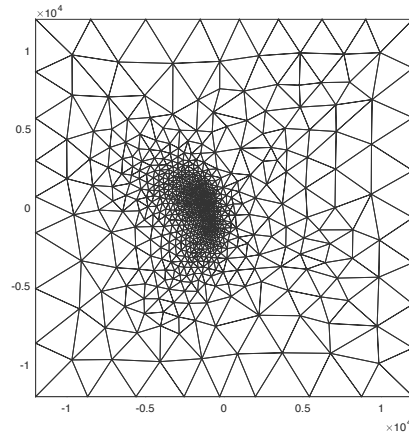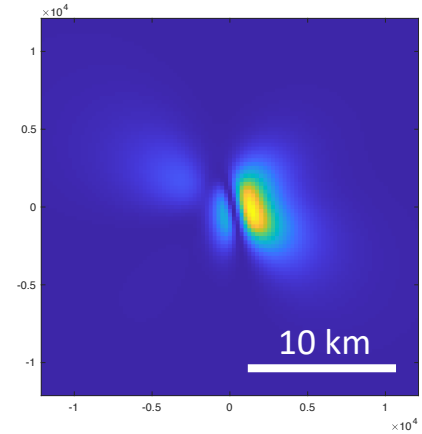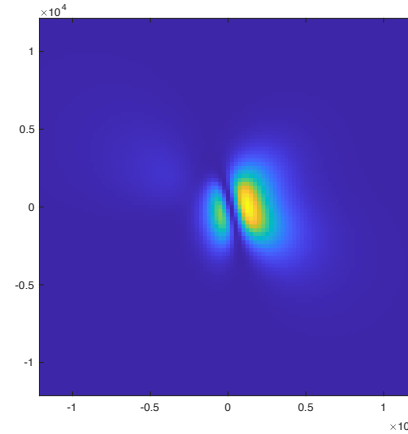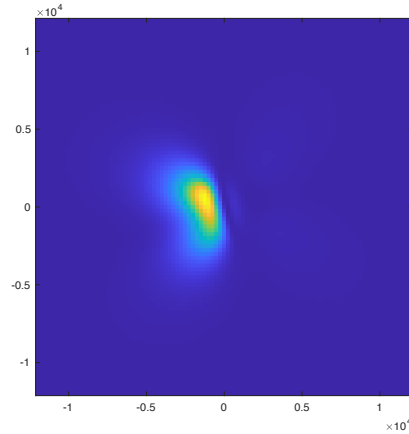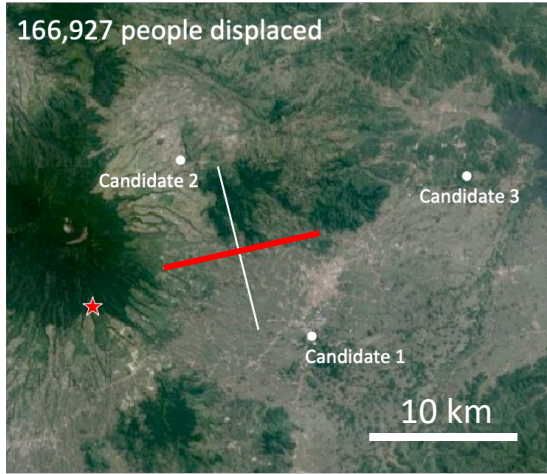
Strike: N76.3°E
Dip: 83°SE
Length: 3 km
Width: 3 km
Top depth: 1 km

10 km
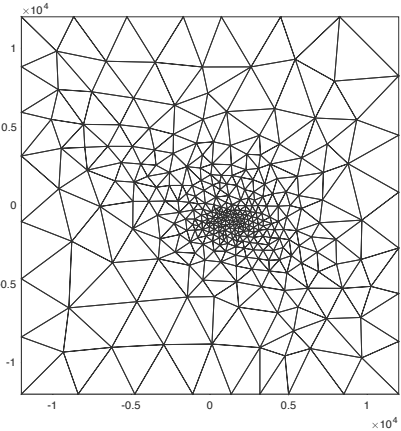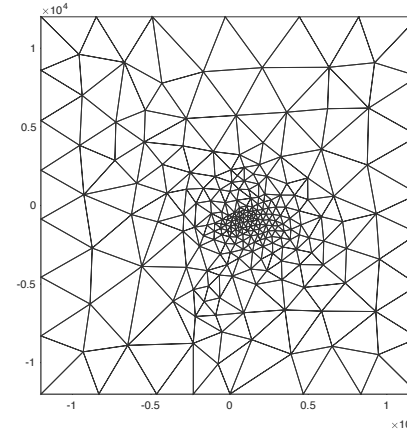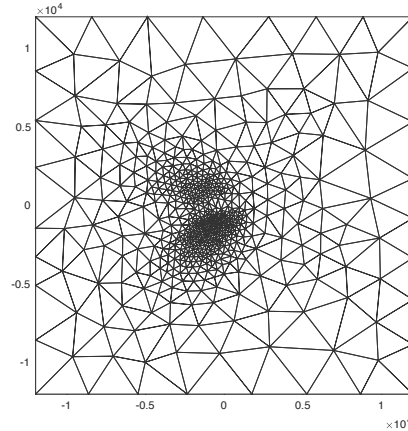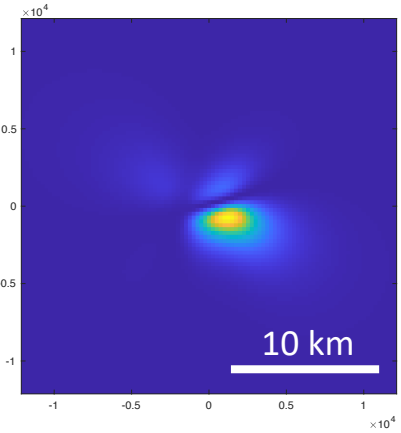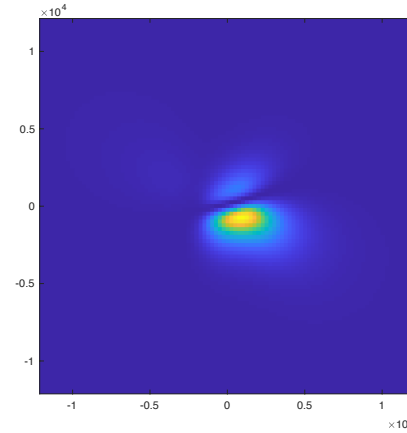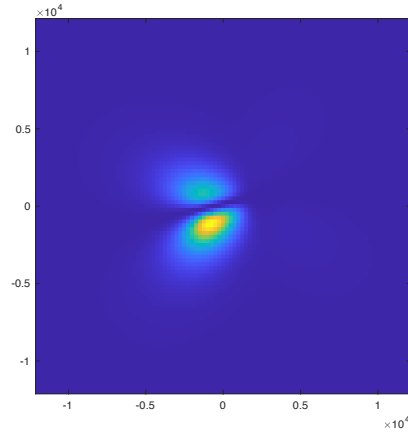
Balancing Interferograms (NS)
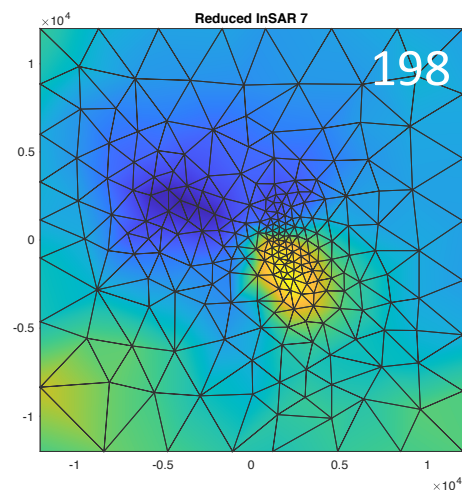
Balancing Interferograms (EW)
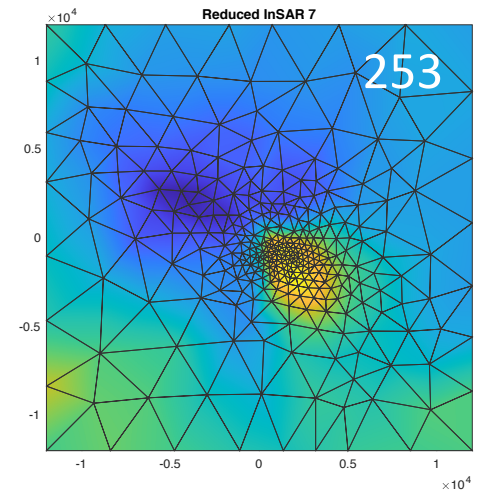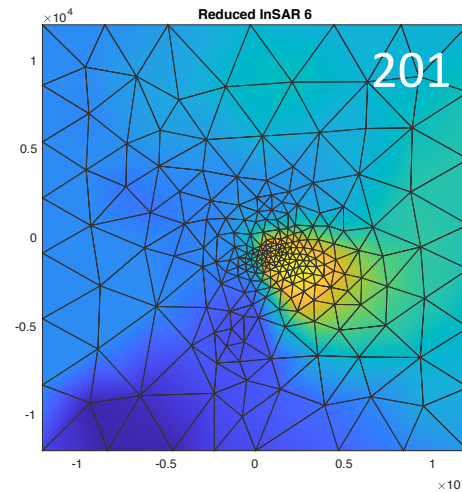
Summary

- Satellite SAR observations has become one of the main-stream information at the forefront of disaster response, validated by response agencies, geotechnical engineers, and FBI.

- November 2022 M5.6 West Java earthquake in Indonesia highlighted the need for rigorous balancing of multiple coseismic interferograms

- Data importance-based balancing shows a promise of moving forward (Yun et al., in prep)

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EARTH OBSERVATORY OF SINGAPORE

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE