Satellite damage detection and field reconnaissance of Kermanshah Earthquake M 7.3

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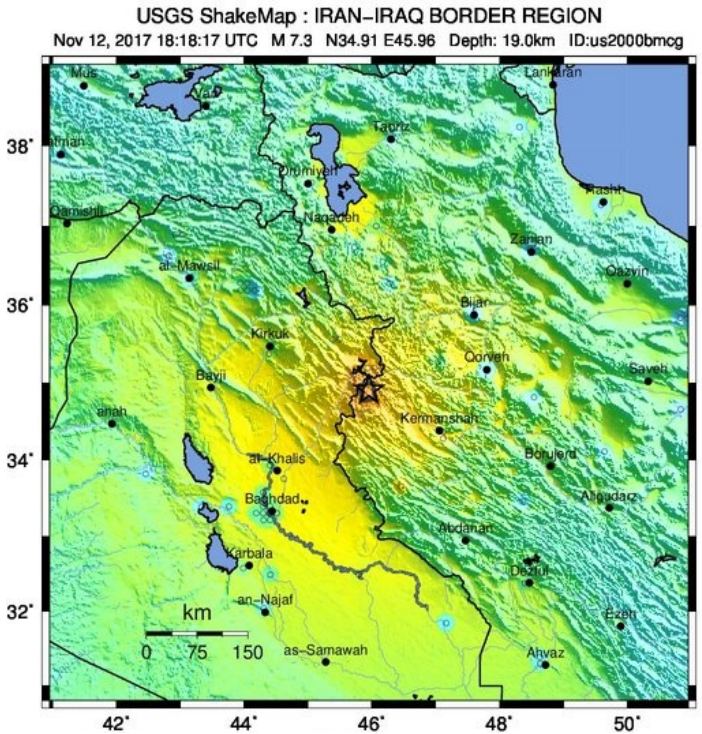
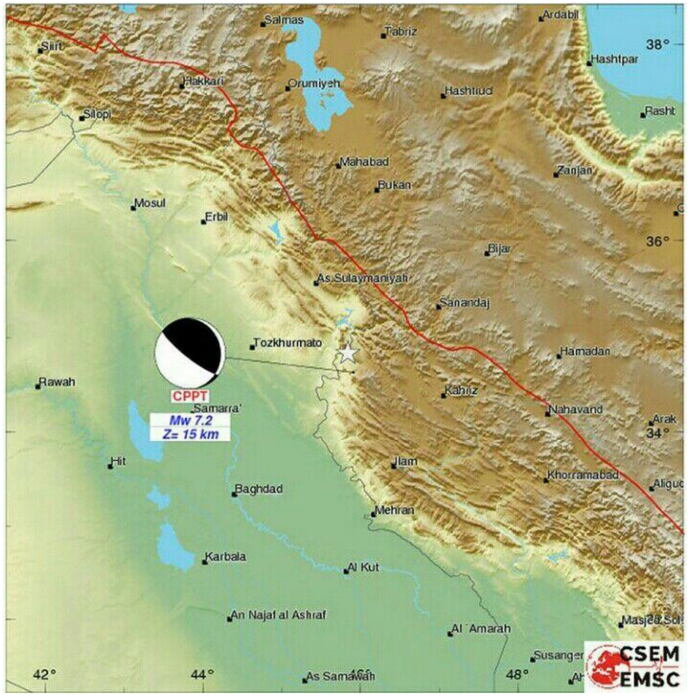
Introduction

- The powerful shallow earthquake (M 7.3) in west of Iran in Kermanshah province, near Iraqi border on November 12, 2017 at 9:18 pm local time.
- Depth was 10 km at first, but most of the agencies revised it after a few hours.
- The earthquake happened on an unknown fault, but it is on a large Zargros thrust belt.





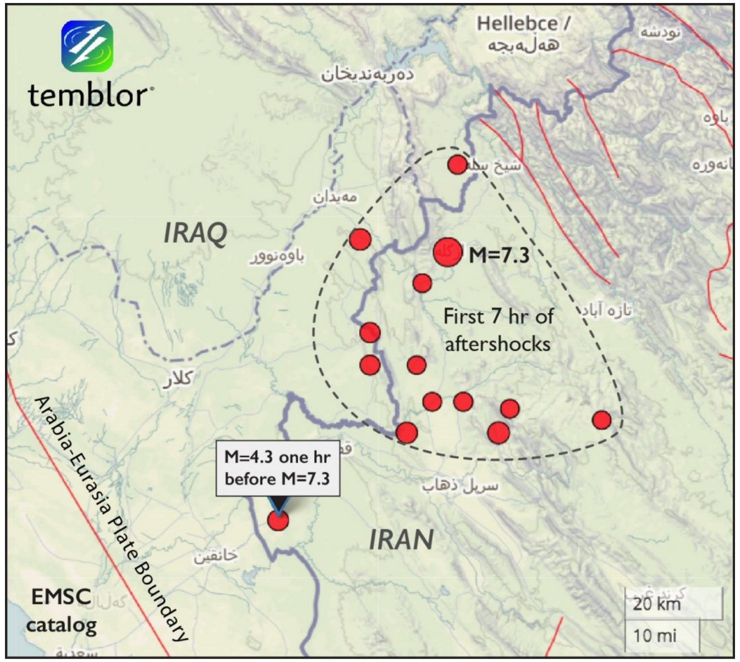
Selected Cities Exposed

MMI	City	Pop.
VIII	Derbendixan	<1 k
VIII	Tazehabad	<1 k
VII	Halabjah	57 k
VII	Seyid Sadiq	<1 k
VII	Qasr-e Shirin	<1 k
VII	Halabjah al Jadidah	<1 k
V	Erbil	933 k
V	Baghdad	7,216 k
V	Tabriz	1,425 k
IV	Mosul	1,740 k
III	Qom	900 k

From GeoNames Database of Cities with 1,000 or more residents (k = x1,000)

General concepts of the quake

- The last number of casualties, injured people and homeless people are, <u>620</u>, <u>7000 </u>and <u>70000</u>
- The foreshock struck rather far from the mainshock.
- The highest causalities of the Iran-Iraq earthquake on the Iranian side appear to be from Sarpole-Zahab city (~ 400), with a population of 35,000 (50 km south of the epicenter).



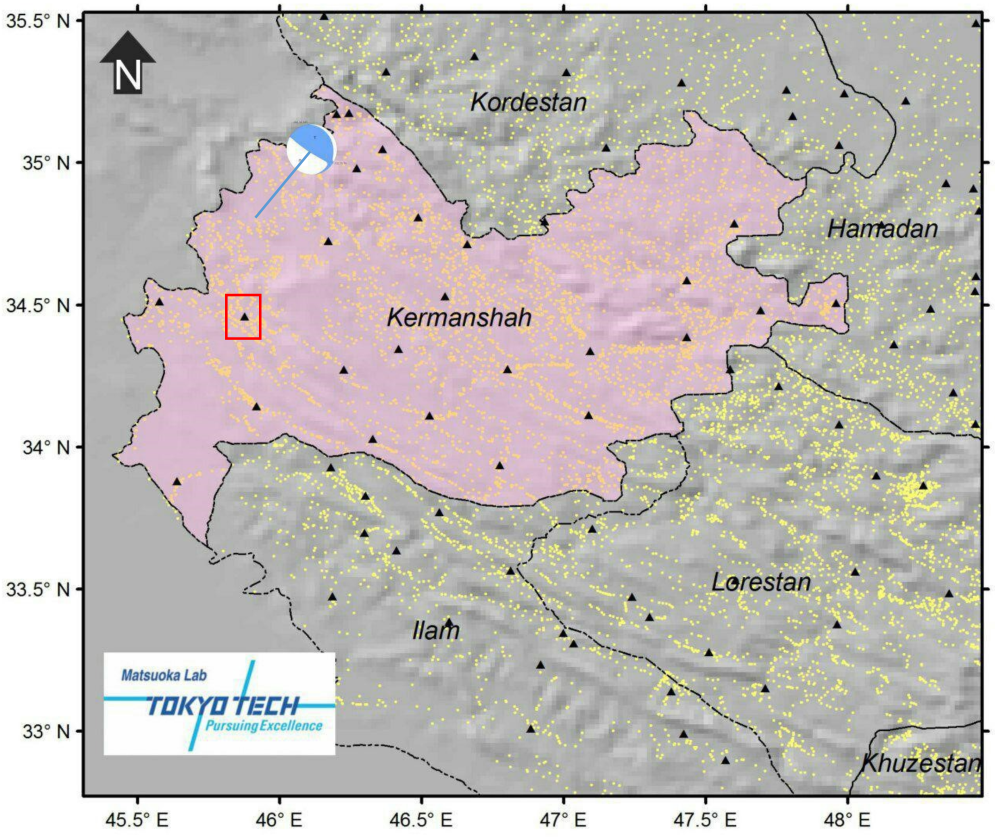
From temblor

General concepts of the quake

- According to the historical earthquake catalogue of Iran gathered by Ambraseys and Melville, the region had been experienced at least two earthquakes in 958 and 1150 AD.
- In addition, one major event in this region is Farsinaj earthquake of 13 December 1957, Ms7.1.
- This earthquake caused heavy damages within an area of 2800 square kilometers in which 1119 people were killed and 900 injured and 15000 left homeless.
- The Farsinaj earthquake ruined more than 5000 house (abode materials) units out of 9000 existed house in the Kermanshah region.

About the damaged villages

- Damage in rural areas is still unknown, but more than 2000 villages in Kermanshah are affected by this earthquake.



Yellow dots are villages and black triangles are cities in west of Iran

Performance of buildings

- All Buildings in nearby villages are affected, but there is no accurate evaluation so far.
- Around 2000 residential units (mainly in Sarpole-Zahab) were totally collapsed in urban areas.
- Moment-resistant reinforced concrete frame construction, with unreinforced masonry walls, is common.

Performance of buildings

- The only hospital of Sarpole-Zahab was patially damaged and treatment was continued in open yards.

Disaster response

- Immediately after the earthquake, 100 professional search teams were dispatched to the affected area.
- Temporary settlements, blood products and necessary foods and drink were provided by I.R. Iran Army, Red Crescent and volunteer people.
- Debris removing operation is continuing with maximum efforts.

About the Iraqi side

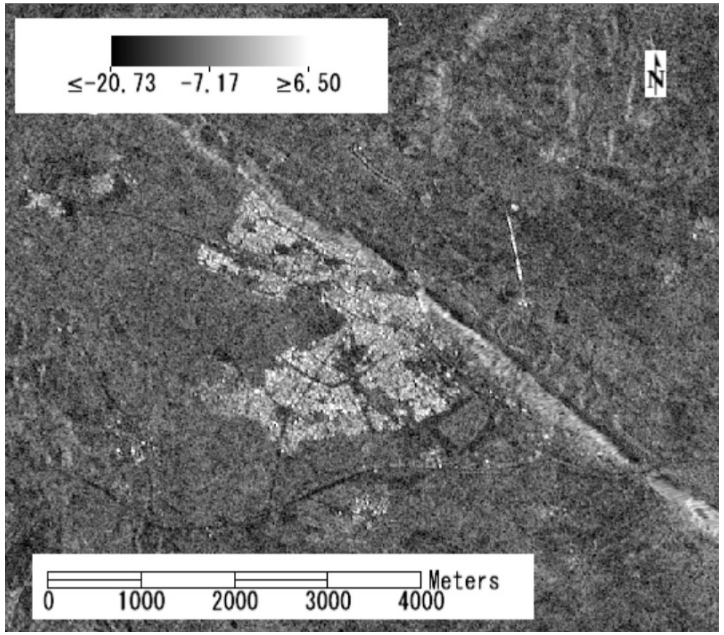
- No information from the Iraqi side, but according to local people, the city of Darbandikhan totally devastated.
- Probably the major dam near the city of Darbandikhan is damaged but its real condition is unknown. The dam was built in the late 1950‘s and repaired in the late 1990‘s after extensive leakage of the spillway gates.

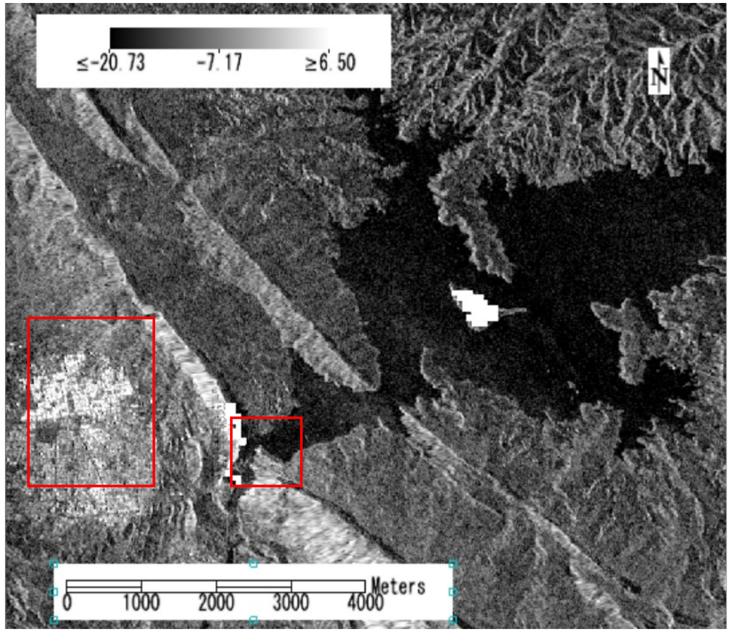
Collateral hazards

- Collateral hazards such as rockfall almost smashed this village after the quake.

Satellite imagery

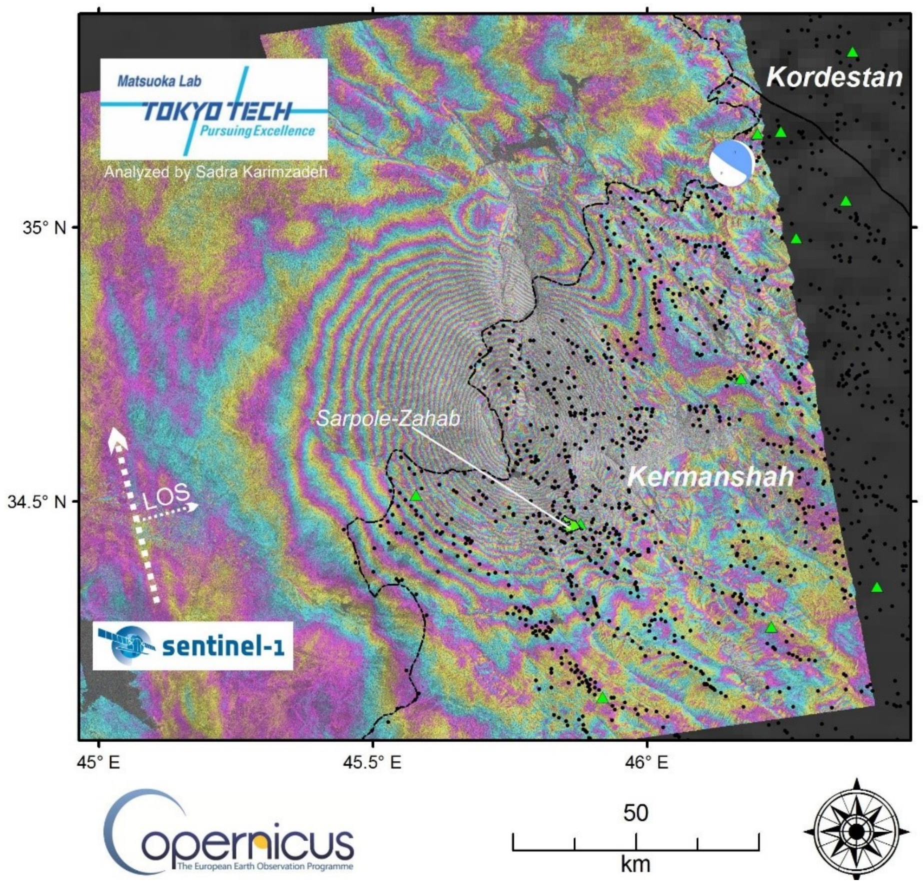
- We used pre- and post-event synthetic aperture radar (SAR) images to detect displacements and building damages.
- SAR can be used in night and day, can be used in all weather conditions.
- Left: SAR intensity image Sarpole-Zahab city in Iran (unit is dB)   Right: Darbandikhan dam in Iraq



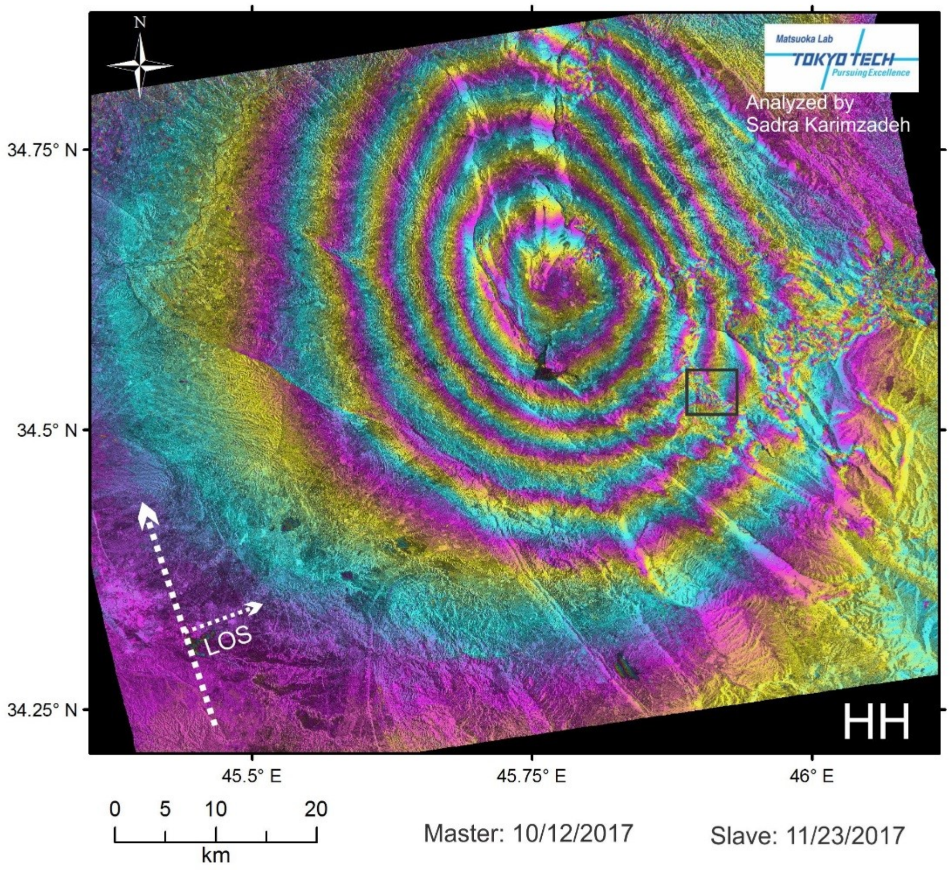


Displacement map

- Soon after the Kermanshah earthquake, ground displacement maps were generated using Sentinel-1 and ALOS-2 SAR data. Total displacement using InSAR technique was about 85cm in the line of site of satellite.



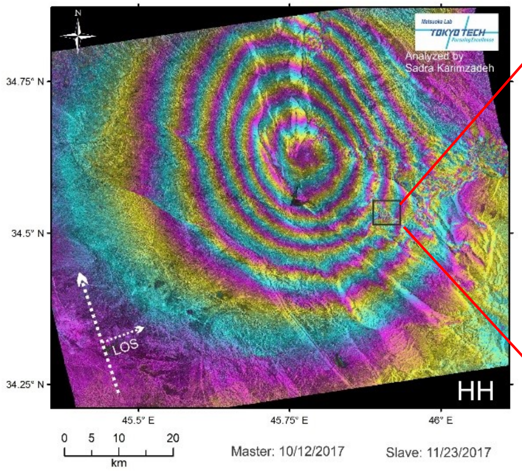
InSAR coseimic map deduced from pre- and post-event Sentinel-1 data

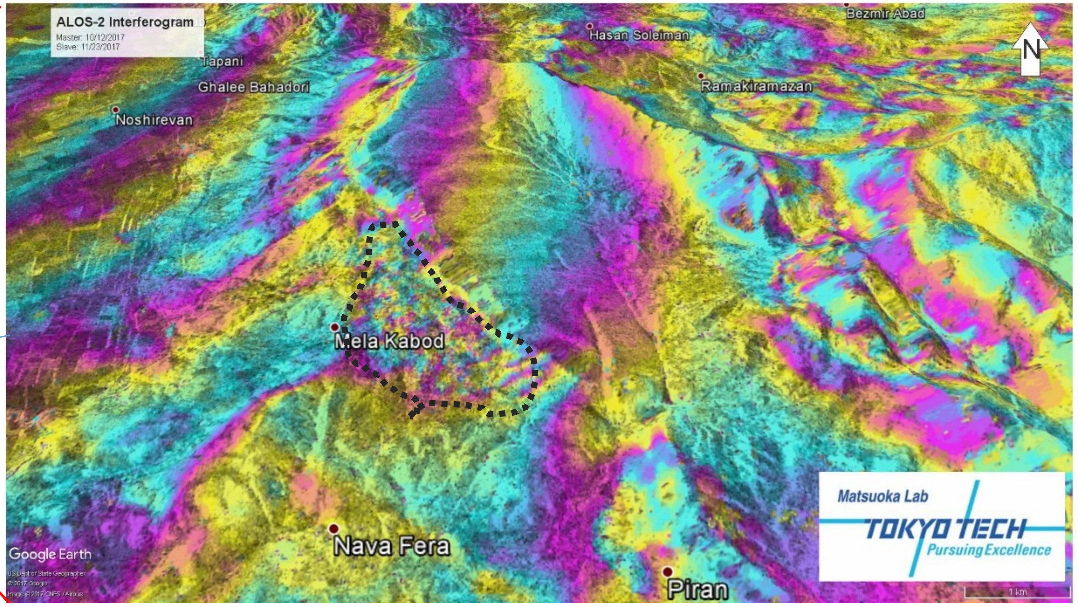


InSAR coseimic map deduced from pre- and post-event ALOS-2 data

Displacement map

- 7 m of slip related to Mela Kabod landslide triggered by 12th November 2017.
- Areas without clear fringe patterns represent incoherent areas.
- When there is a rugged surface within the pixel or the surface changes by land formation, landslides, two SAR signals cannot interfere with each other and looks like “sprayed sands”.

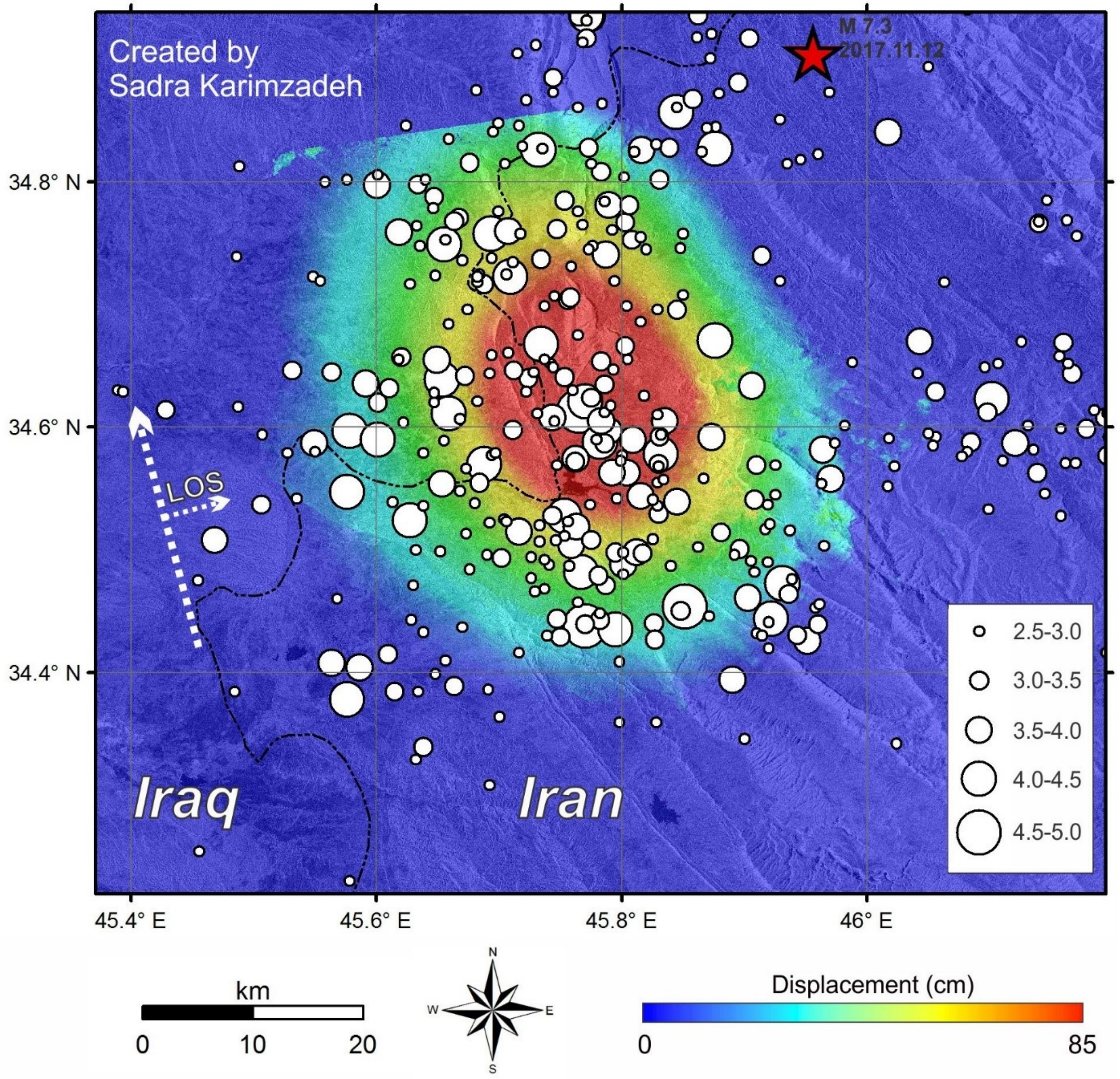




Vajedian, Twitter

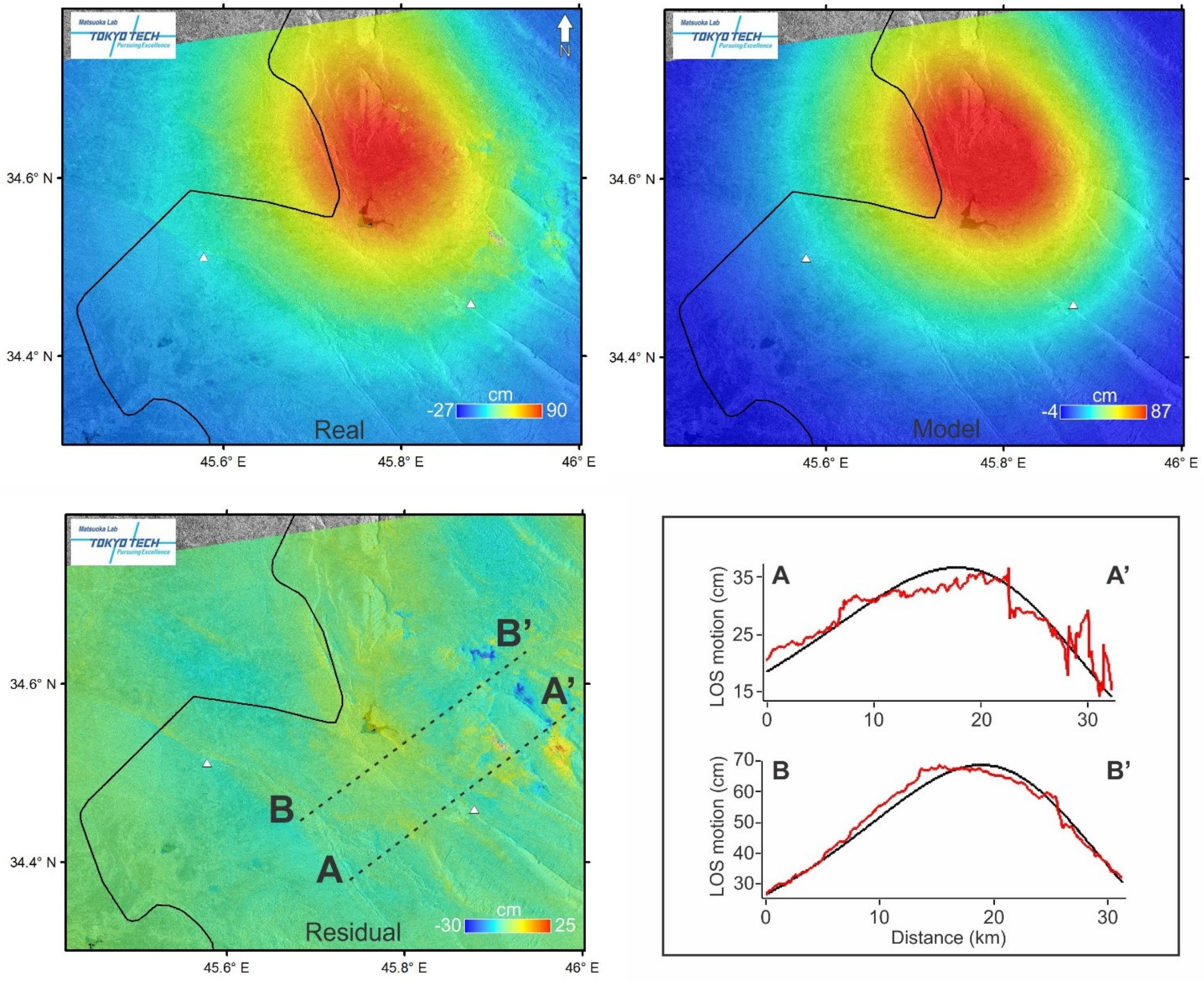
Displacement map

- We calculated ground displacement map of the earthquake using Interferometric Synthetic Aperture Radar (InSAR) method and two ALOS-2 images (2017/10/12 and 2017/11/23).
- Displacement map of Kermanshah Earthquake from high-resolution ALOS-2 data indicating maximum 85 cm displacement in the line-of-sigh of the satellite.

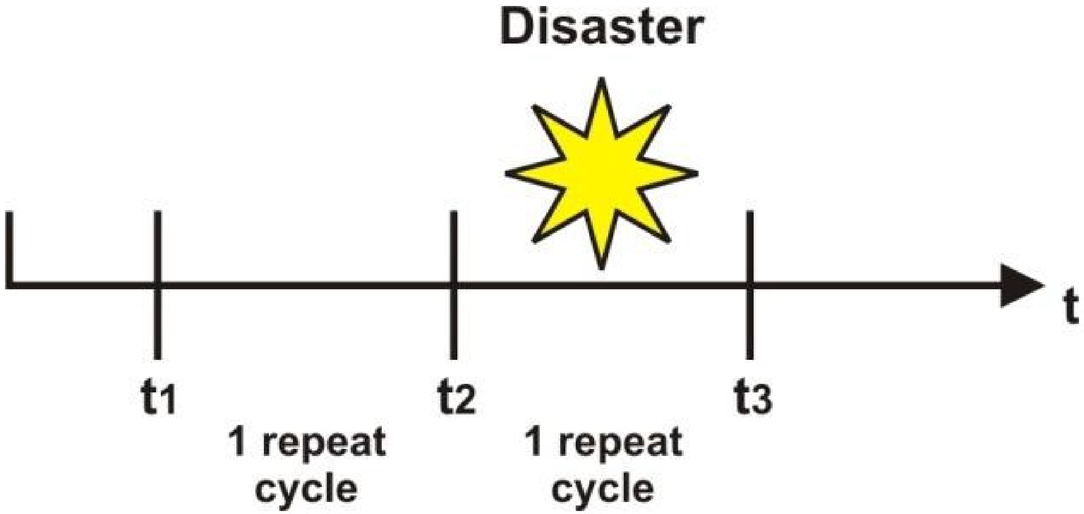


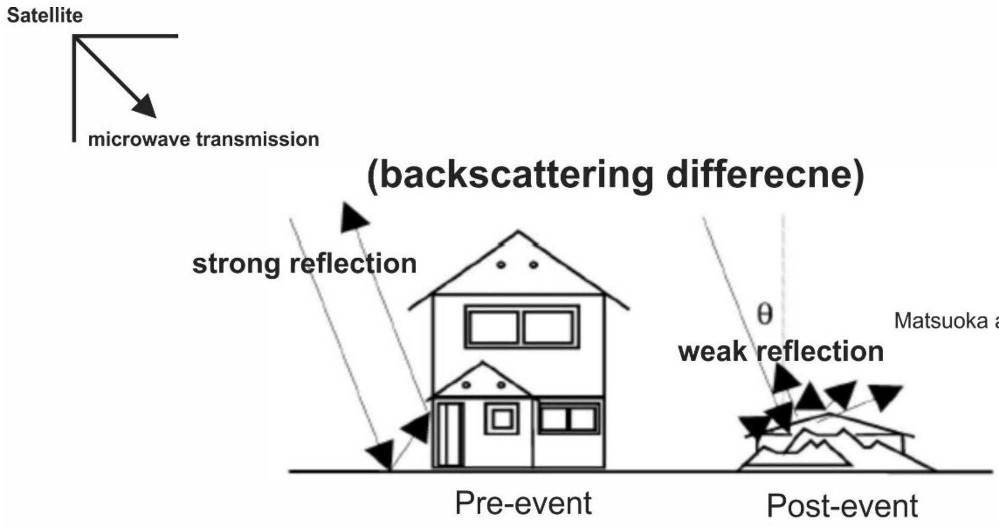
Modeled displacement maps

- Real and modeled displacements of Kermanshah earthquake from high-resolution PALSAR-2 data.
- We used depth parameter between 19-23 km to reach optimum results based on CMT catalogue
- CMT Fault plane: strike=351 dip=10 slip=143

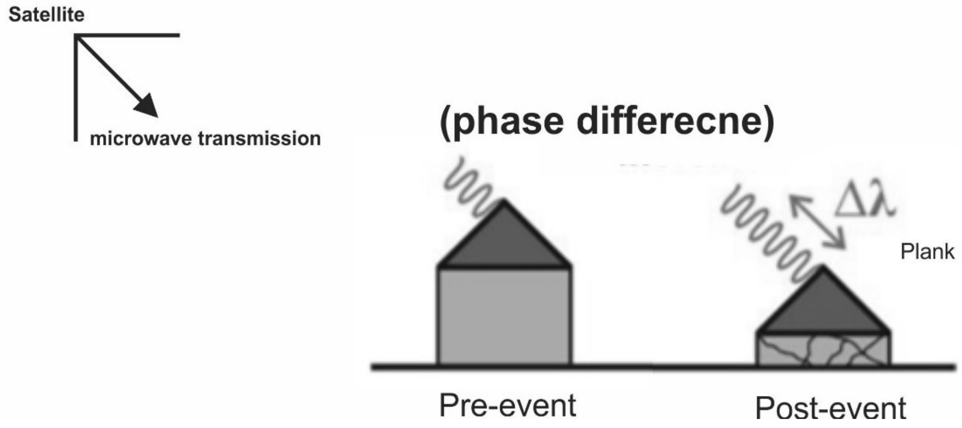


Concepts of SAR for damage detection





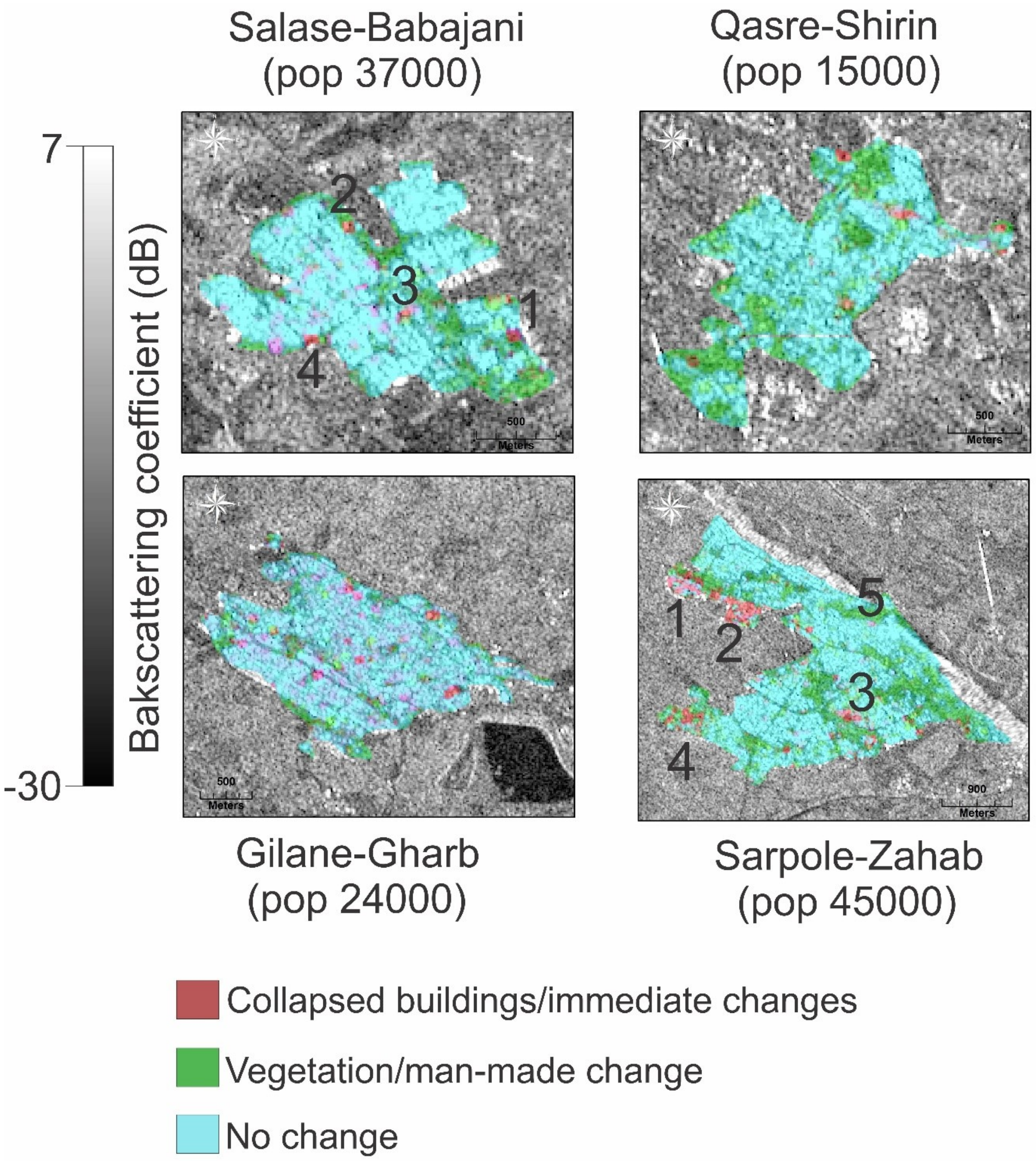
Matsuoka and Yamazaki (2004)



Plank (2014)

Damage maps at four cities

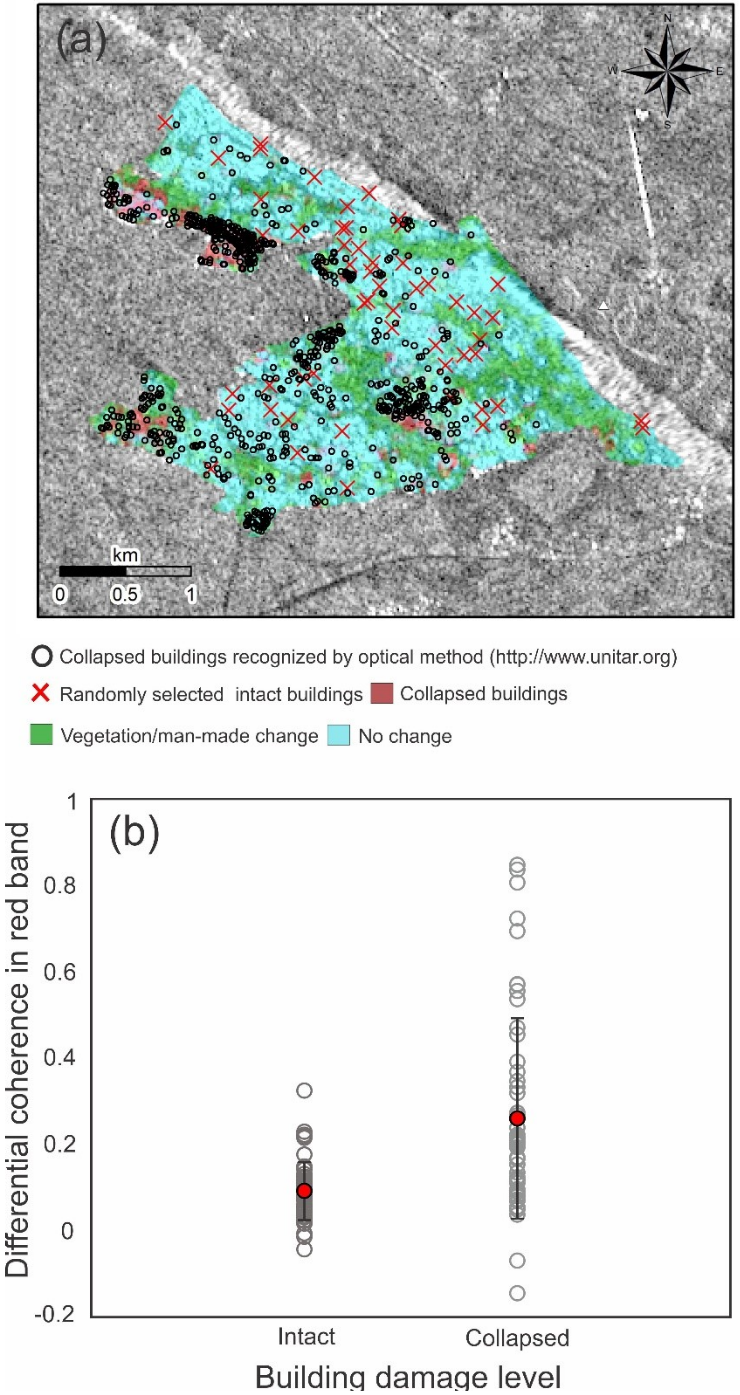
- For a proper disaster response, soon after the event damage proxy maps were generated for 5 cities of Kermanshah Province.
- We visited Sarpole-Zahab and Salase-Babajani in 2017/12/25 and 2017/12/26, respectively
- The most collapsed buildings are observed in Sarpole-Zahab.
- In Salase-Babajani most of the red pixels (red-to-pink) were not exclusively collapsed buildings, but also related with immediate establishment of temporary settlements by local people and authorities.



Ground survey of suspicious sites

Damage validation

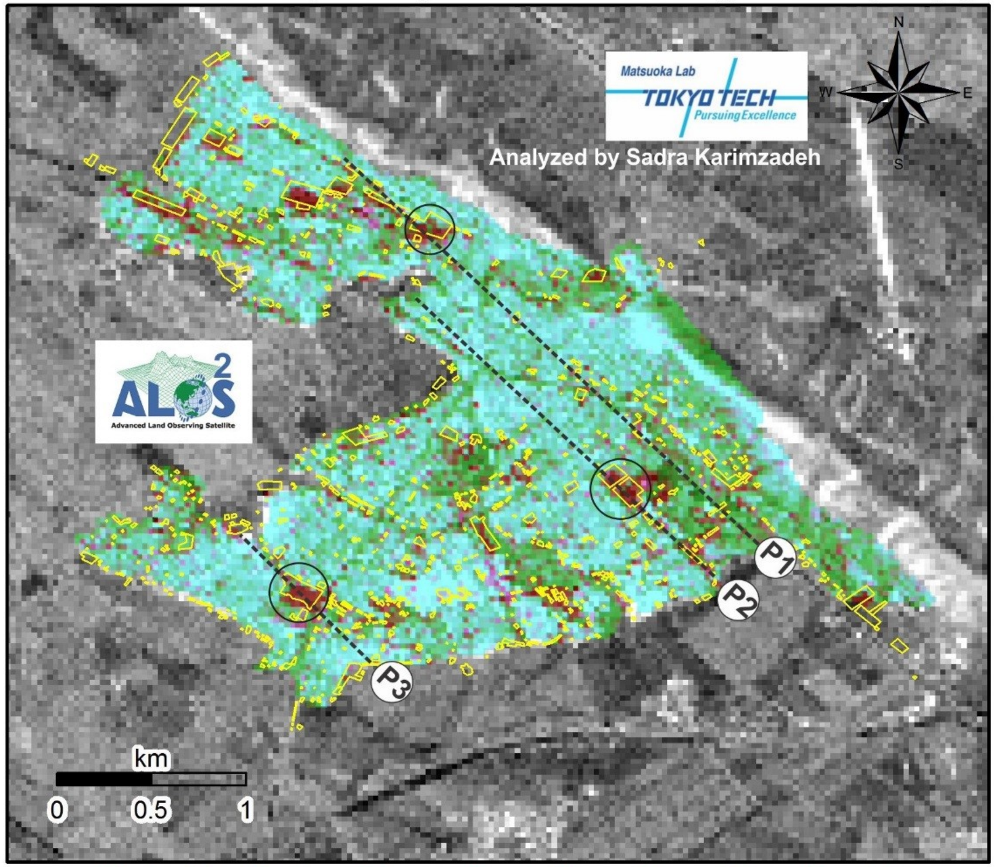
- Based on optical images in UNITAR (United Nations Institute for Training and Research), more than 600 individual buildings (black circles) are damaged in the city.
- We compare coherence value of collapsed and intact buildings.
- We randomly select 50 buildings for each category.



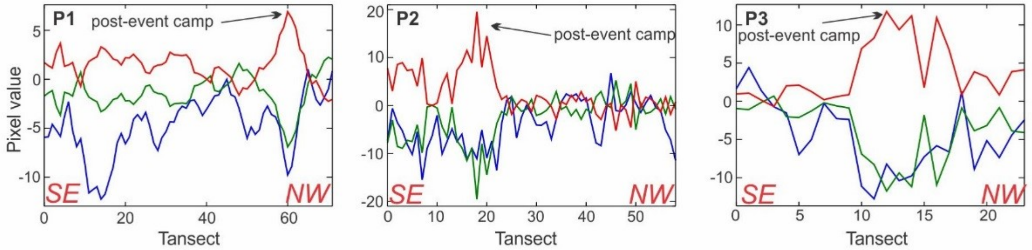
Man-made change validation

- We applied RGB color composition on backscattering values of ALOS-2 data
- Yellow polygons are temporary shelters and camps
- Red band shows higher pixels values in major three camps in three locations in north, south and center of the Sarpole-Zahab city.

RGB color composite of differential backscattering coefficient together with location of temporary settlements (yellow polygons).



Red= Pre-Post Green=Post-Pre Blue=(Pre+Post)/2



Thank you for your attention.

Laleh hotel (carvansaray)