

# Seismic Hazard under Cities Pleiades Stereo Data

John Elliott, Ruth Amey & Scott Watson



Natural Environment Research Council

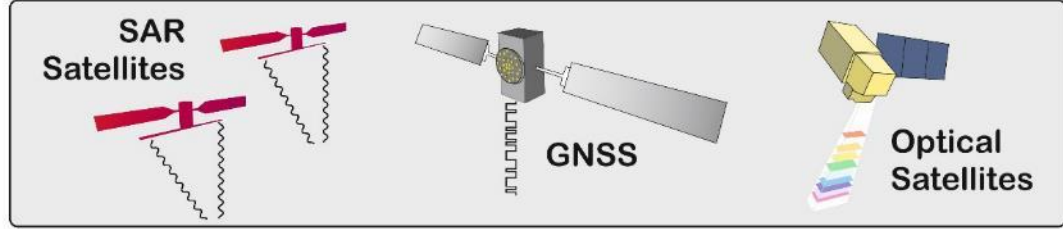


CENTRE FOR OBSERVATION & MODELLING OF EARTHQUAKES, VOLCANOES & TECTONICS



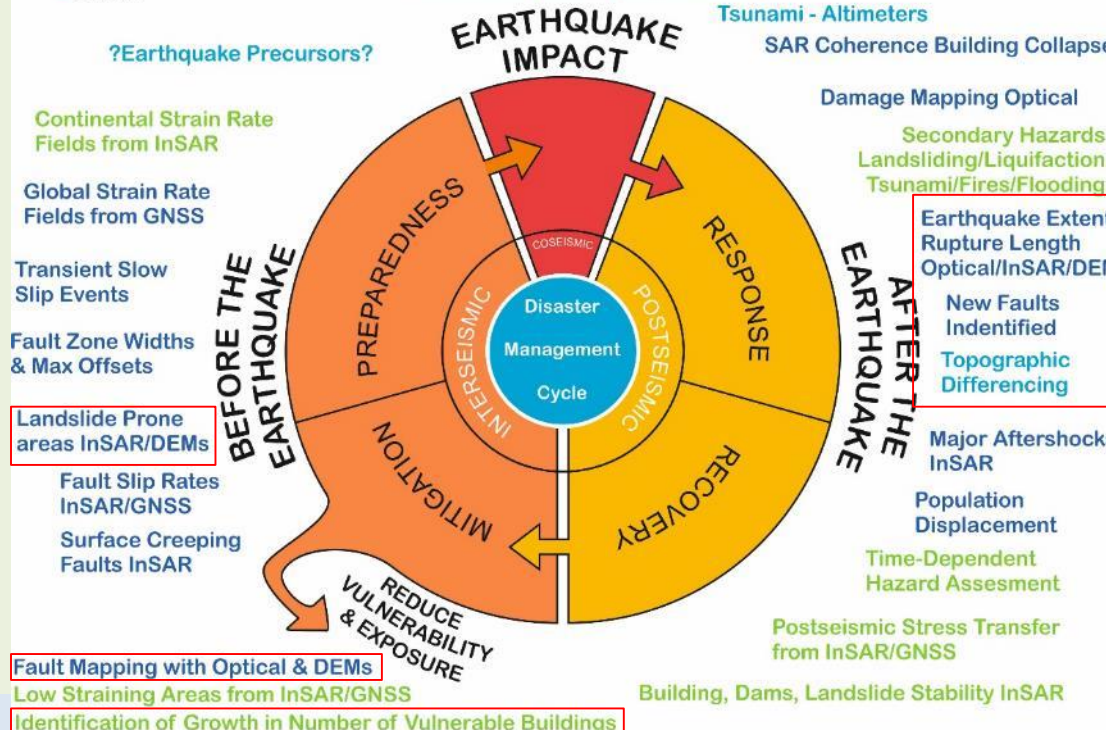


- EO in Disaster Risk Management for earthquakes
- Potential for assessing seismic hazard and improving identification of earthquake risk.

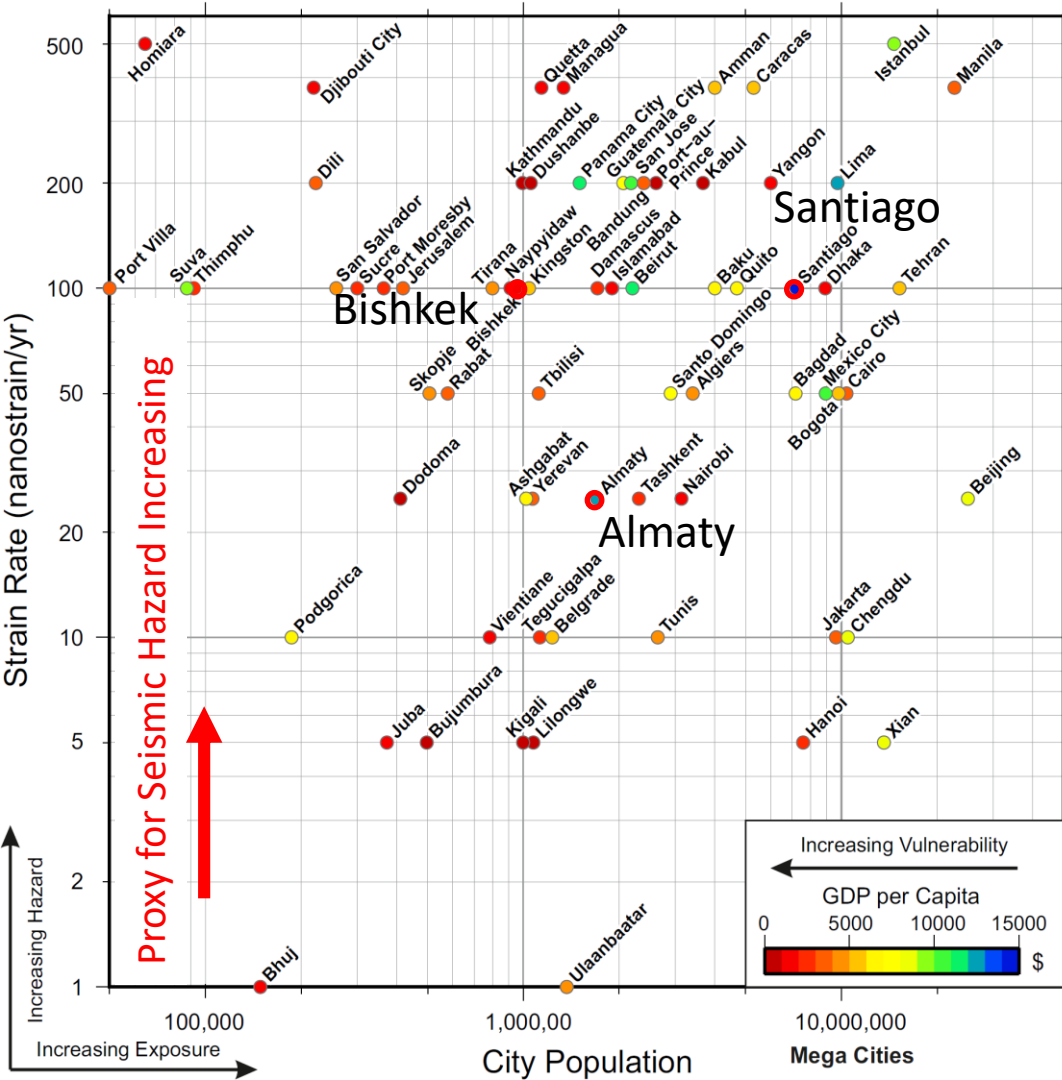


EO Capability  
 ■ Current  
 ■ Emerging  
 ■ Future

High Rate GNSS    Seafloor Geodesy  
 Real-time Optical Imagery/Video  
 Continuously Staring Geostationary SAR



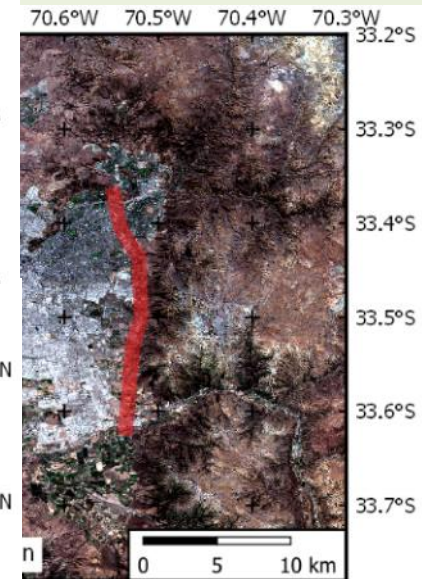
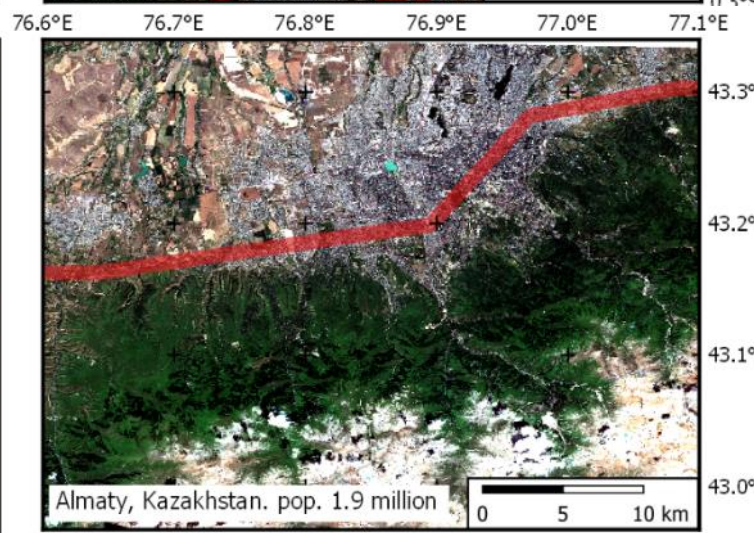
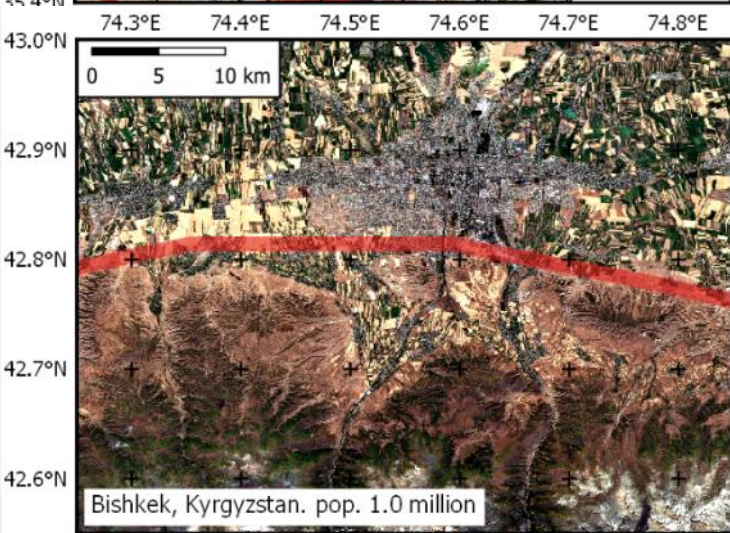
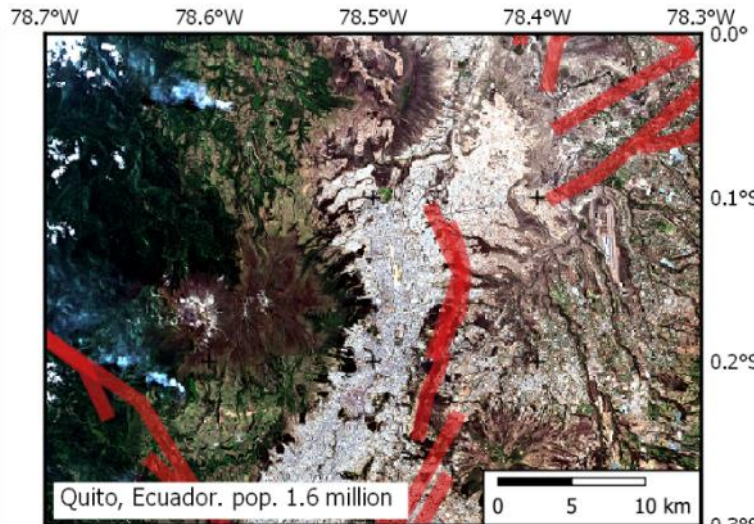
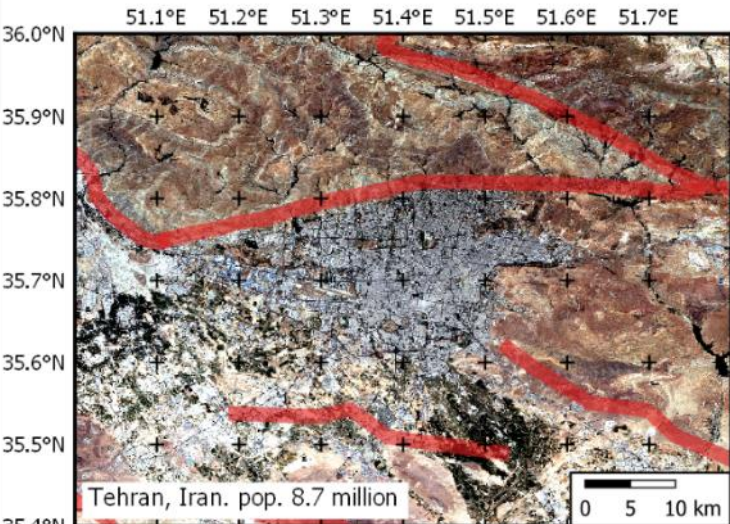
# Exposed Major Cities



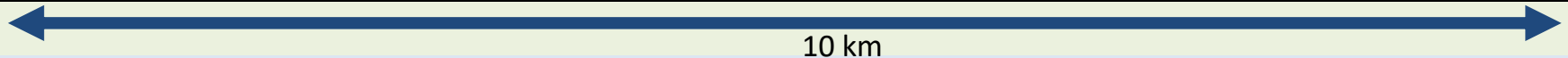
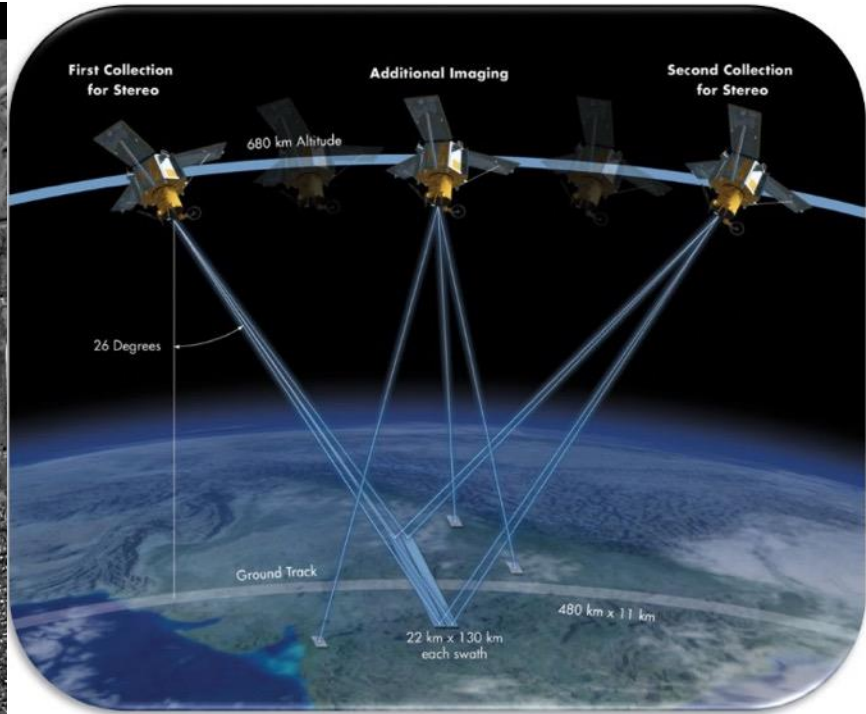
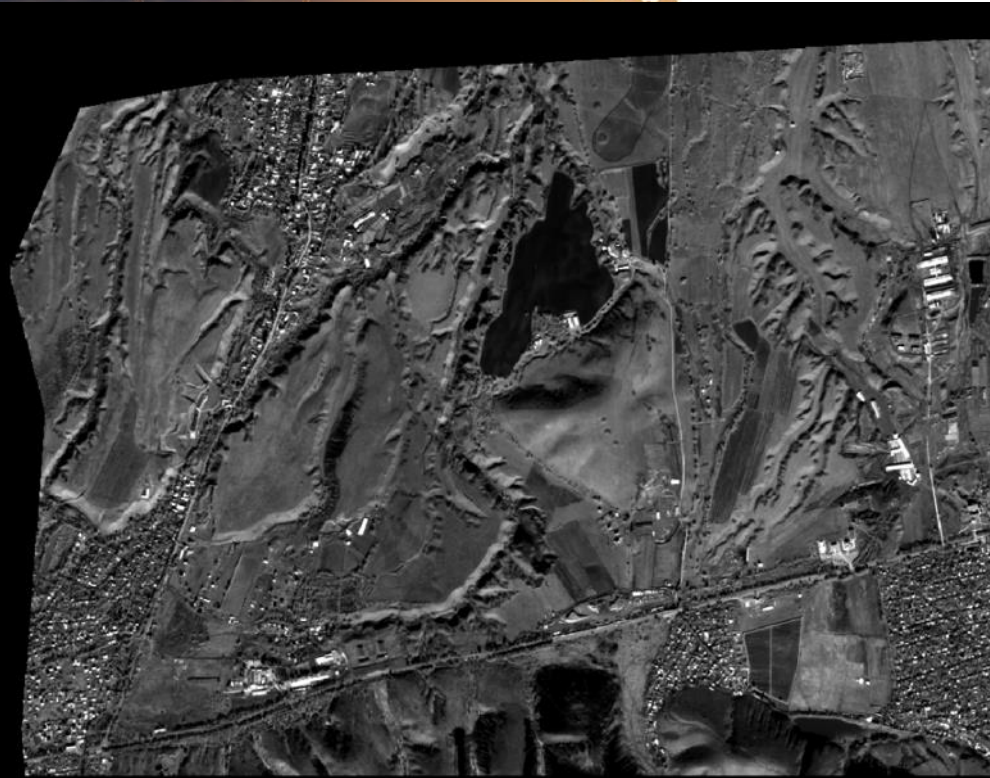
- Over 50 capitals of the least developed countries are located on or near a major fault and are at increasing risk from earthquakes.

Santiago: <https://nhess.copernicus.org/articles/20/1533/2020/>

# neath Cities

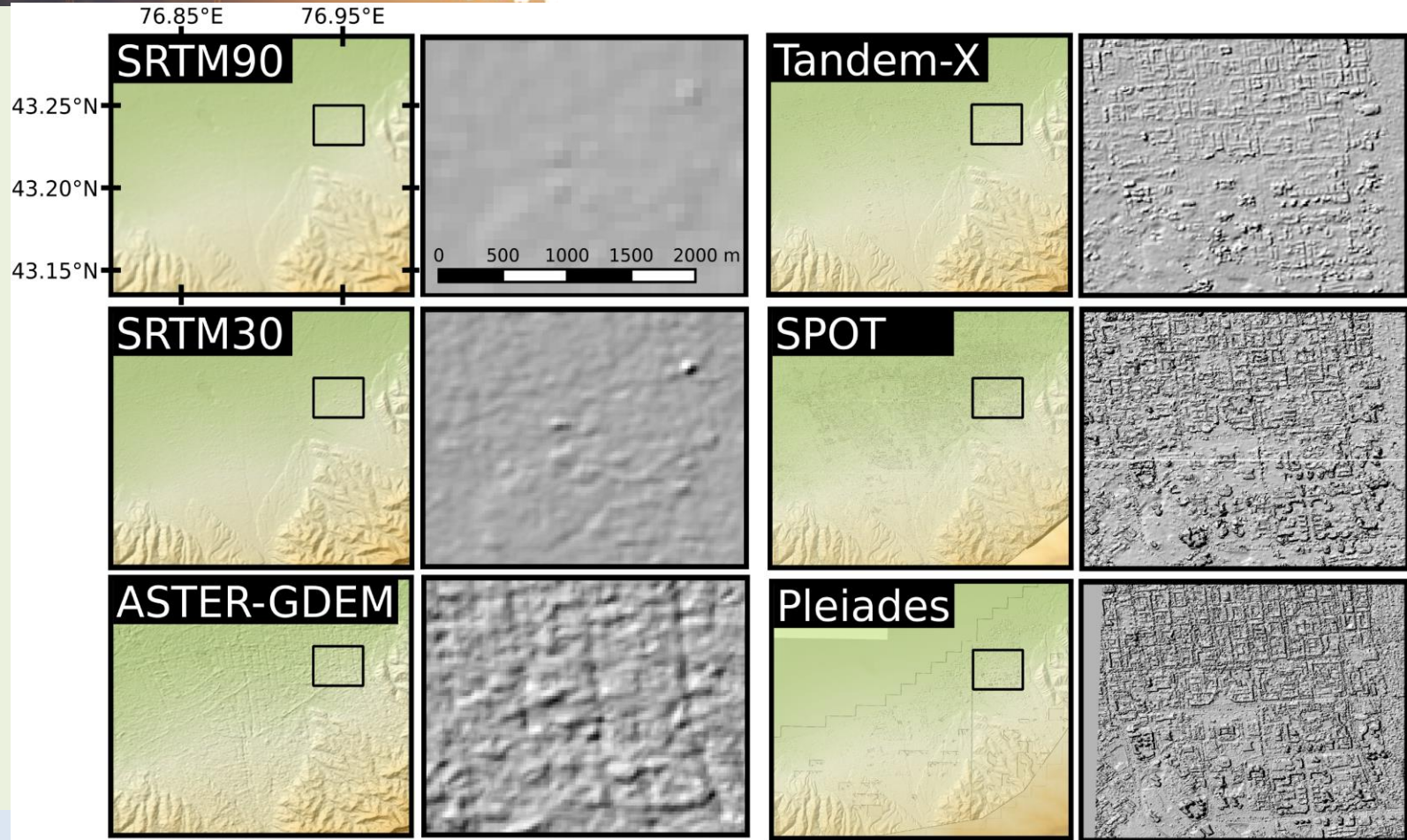


# Pleiades Stereo



10 km

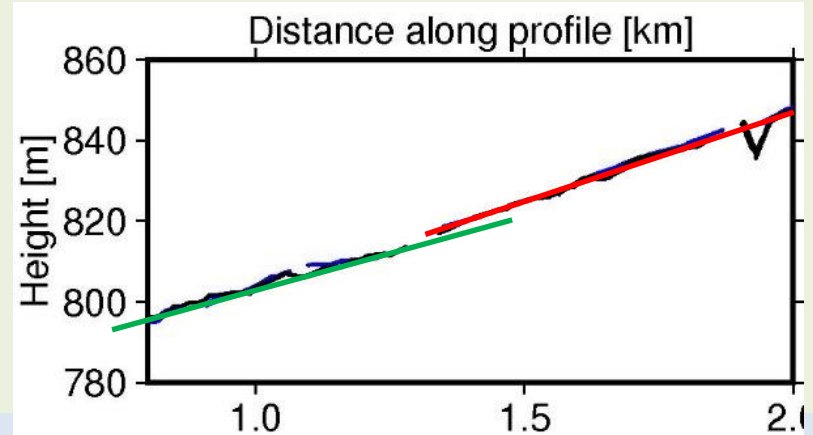
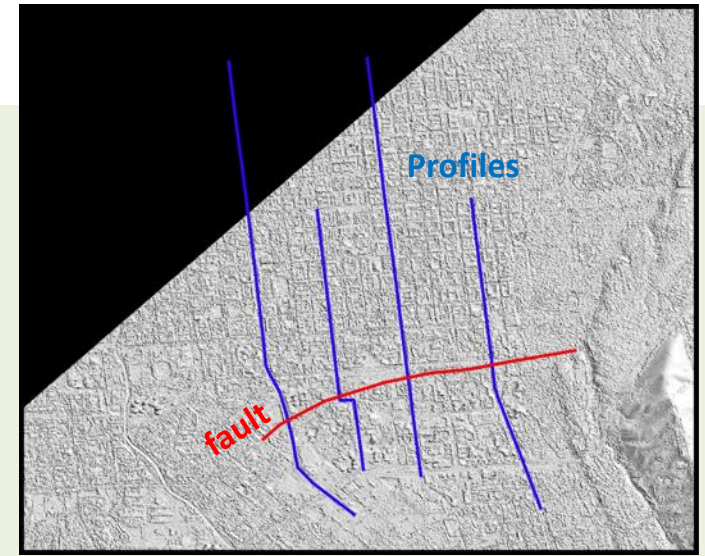
# DEM Comparison



Amey et al.  
(in prep)

# Fault Splays

- Hidden faults in cities present seismic hazard
- High resolution Pleiades-derived DEMs can identify them



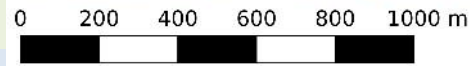


Building information must be recorded and updated

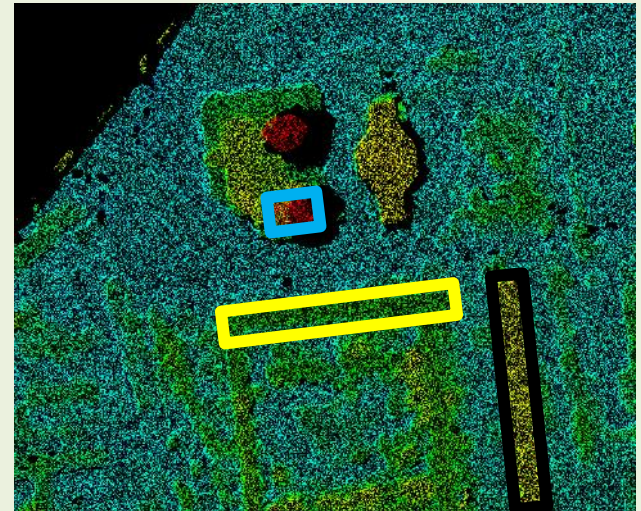
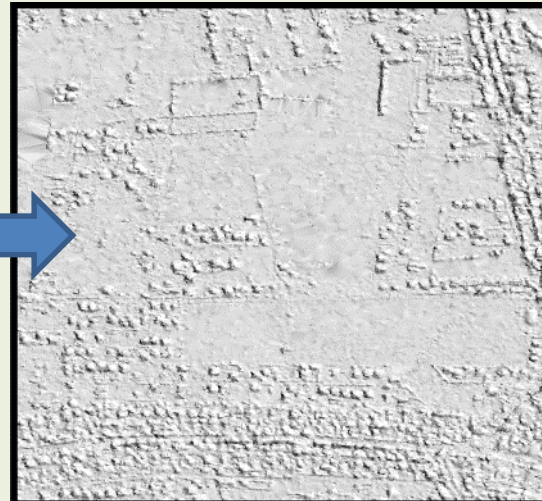
- Calculating building heights
  - Potential to calculate on city-wide basis with satellite data
  - Potential to update as the city expands
  - Better exposure model to use in earthquake modelling



Stereo Optical Images



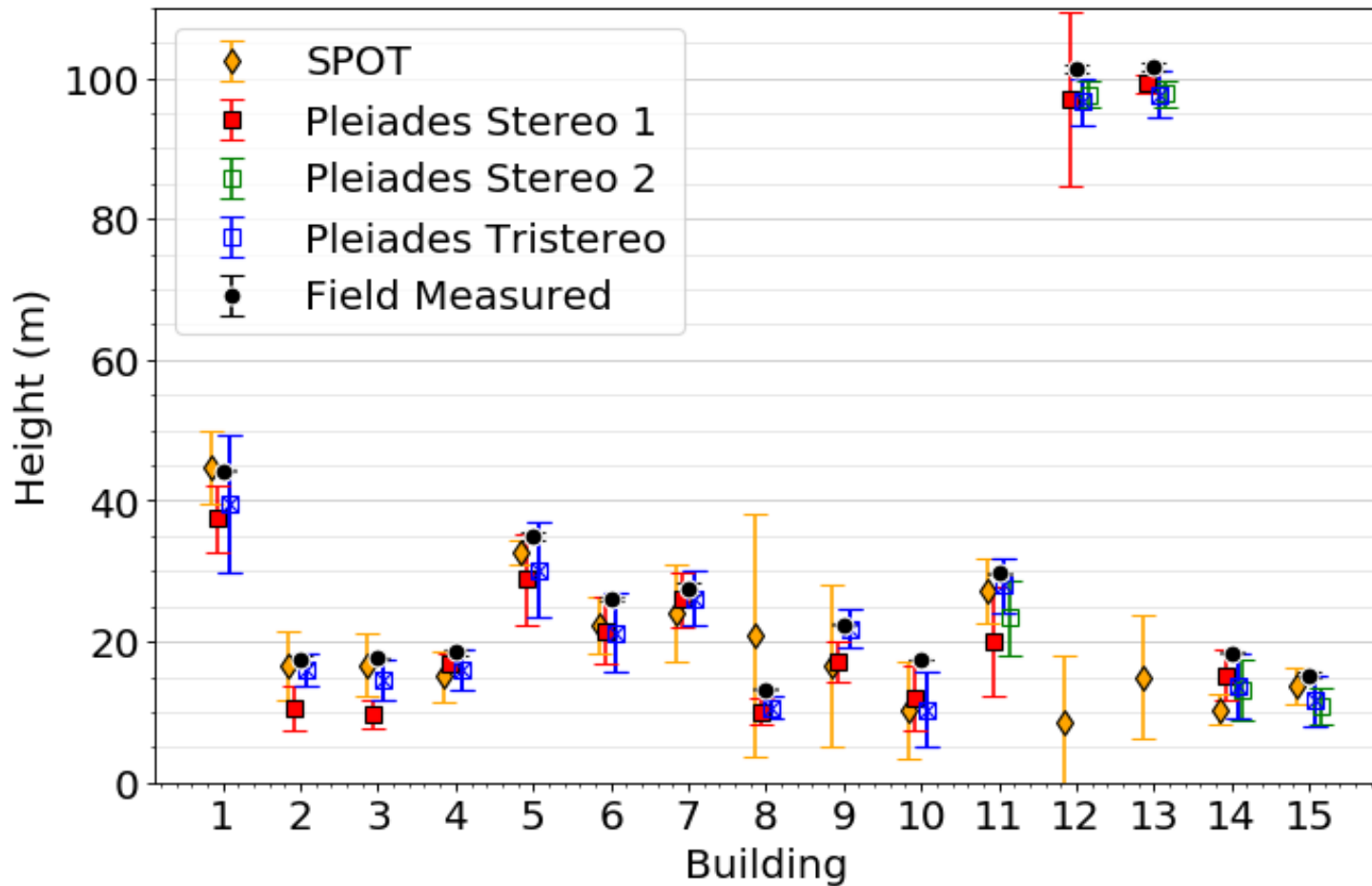
Digital elevation model (DEM)

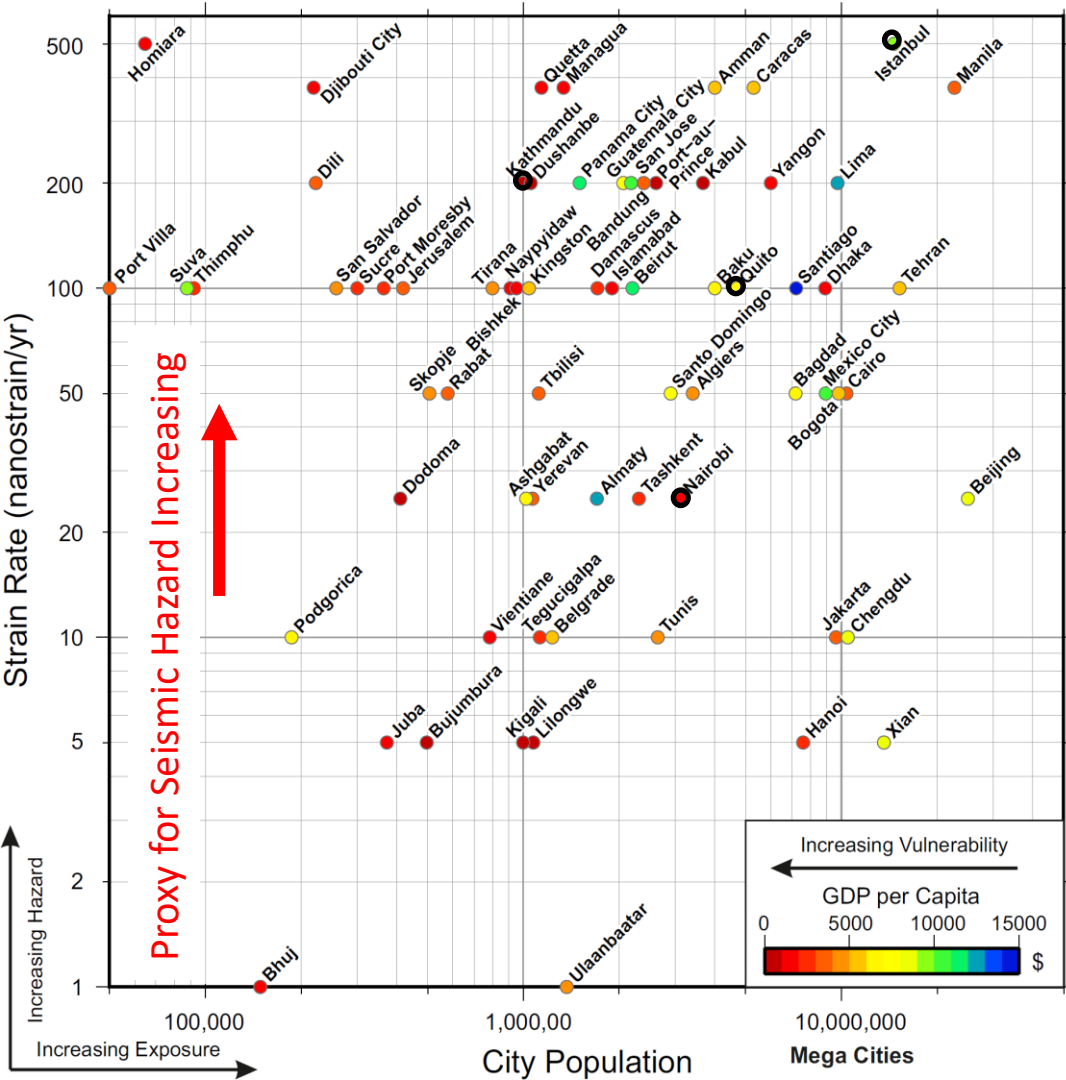


Amey et al.  
(in prep)



# Building Heights





- GCRF Hub - Urban Multi-hazards
  - Kathmandu (Nepal)
  - Quito (Ecuador)
  - Istanbul (Turkey)
  - Nairobi (Kenya)

<https://www.tomorrowcities.org/>

# Tomorrow's Cities



Focus cities Updates & events Resources Vision Research approach About us



Yarının İstanbul'u (Tomorrow's İstanbul)



Focus cities Updates & events Resources Vision Research approach About us



Quito del mañana (Tomorrow's Quito)



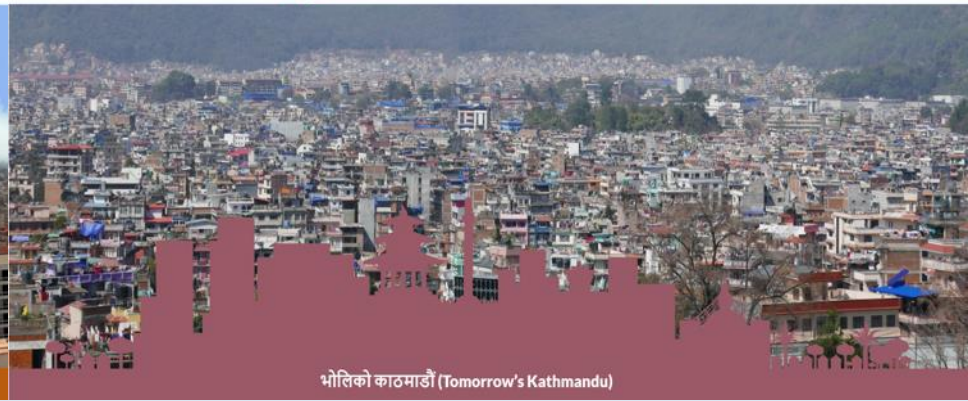
Focus cities Updates & events Resources Vision Research approach About us



Nairobi ya kesho (Tomorrow's Nairobi)



Focus cities Updates & events Resources Vision Research approach About us



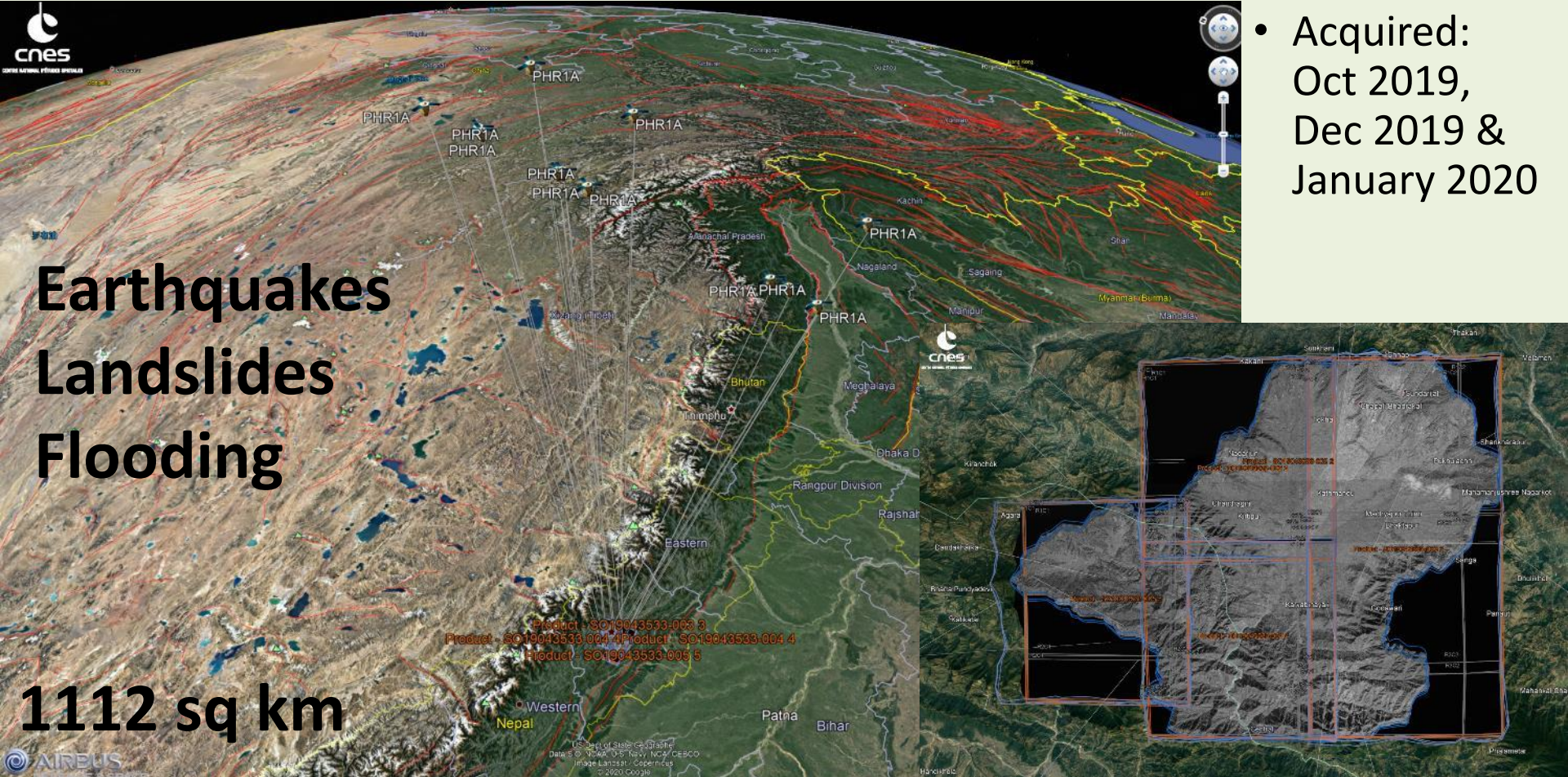
भोलिको काठमाडौं (Tomorrow's Kathmandu)

# Kathmandu, Nepal

- Acquired: Oct 2019, Dec 2019 & January 2020

Earthquakes  
Landslides  
Flooding

1112 sq km



US Dept of State Geo-Intelligence  
Data S.O. 2024, OS Navy, ICSW, CEBCO  
Image Landsat, Copernicus  
© 2020 Google



**John Elliott**



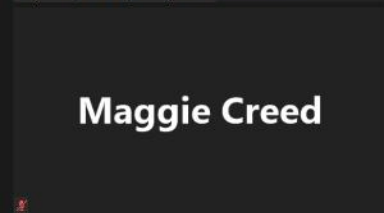
**Dharam Uprety**



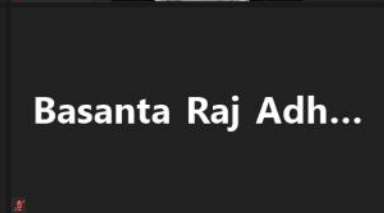
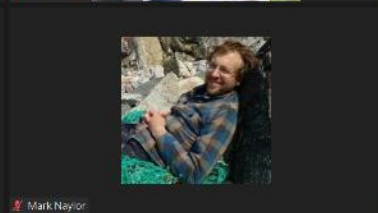
**Arun Thapa**



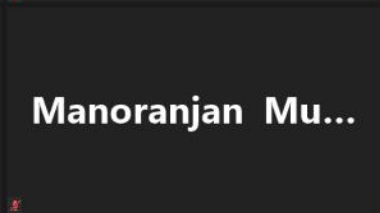
**Narendra Shakya**



**Maggie Creed**



**Basanta Raj Adh...**

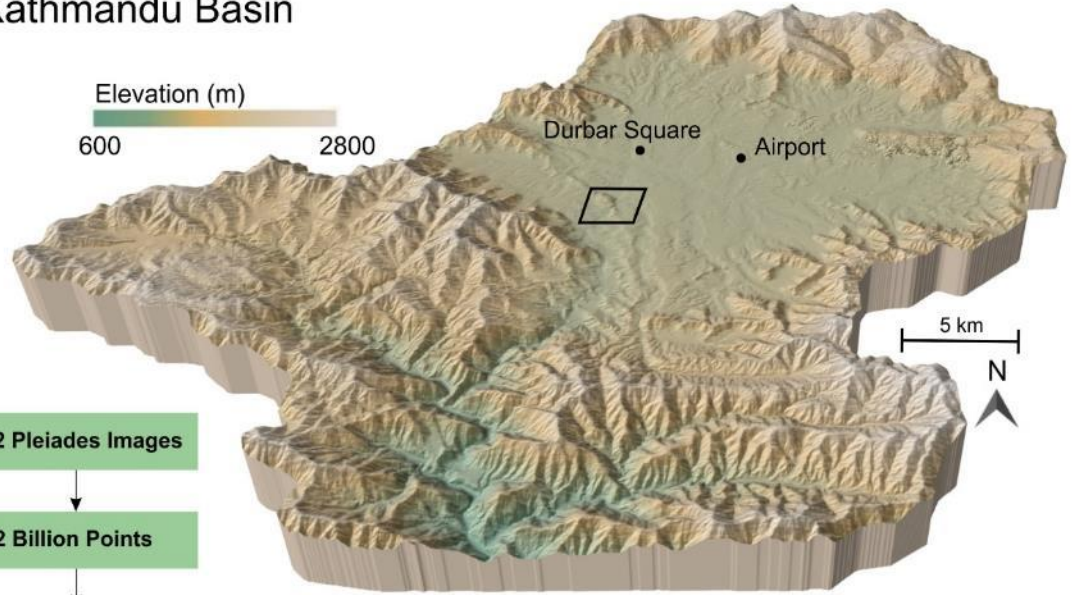


**Manoranjan Mu...**





# Kathmandu Basin

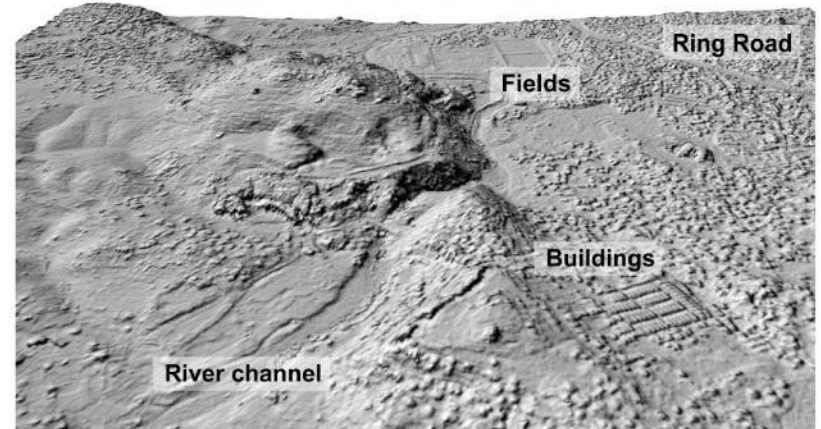


12 Pleiades Images

>2 Billion Points

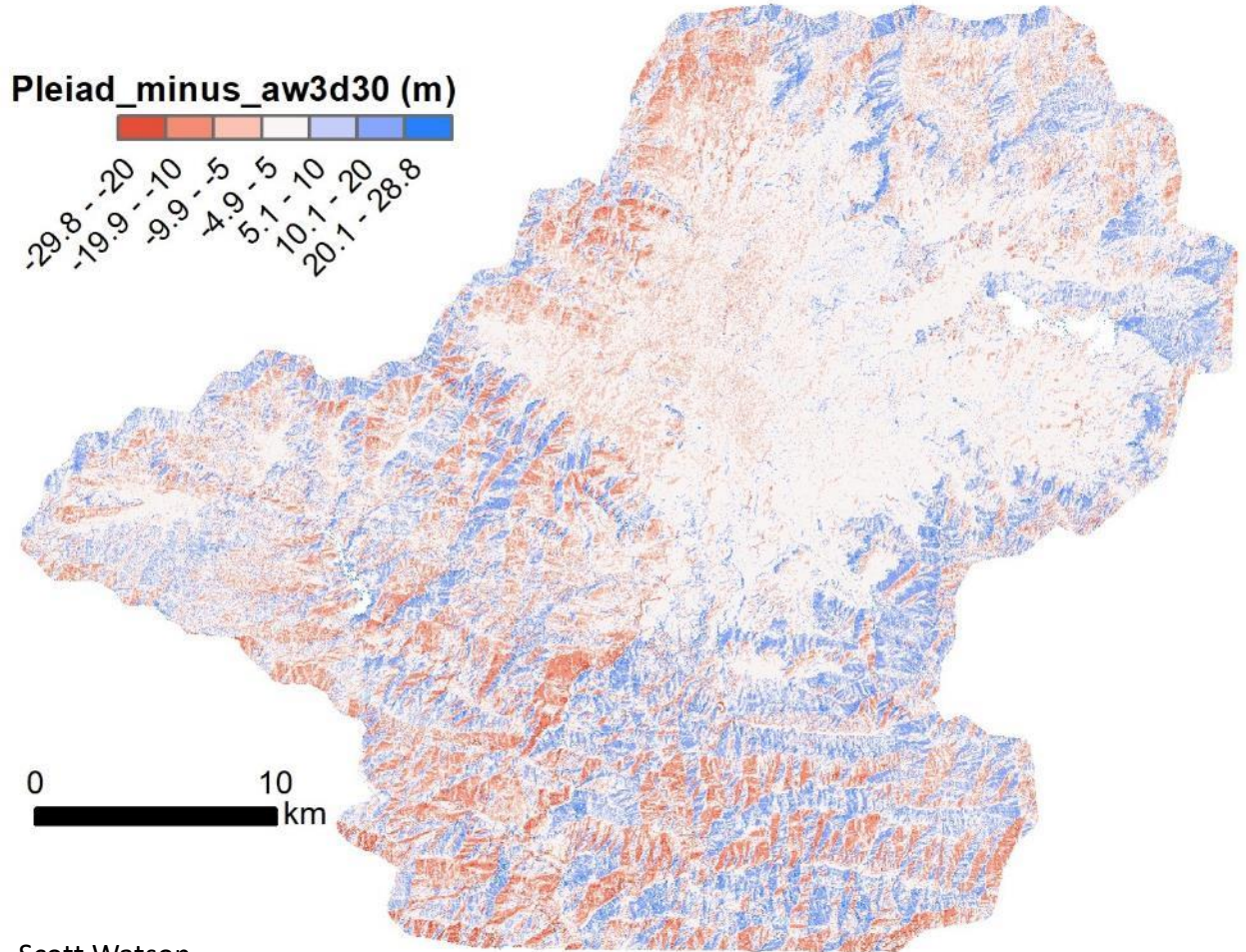
2 m DEM  
0.5 m Orthoimage

Earthquakes  
Landslides  
Flooding  
Urban environment



Scott Watson

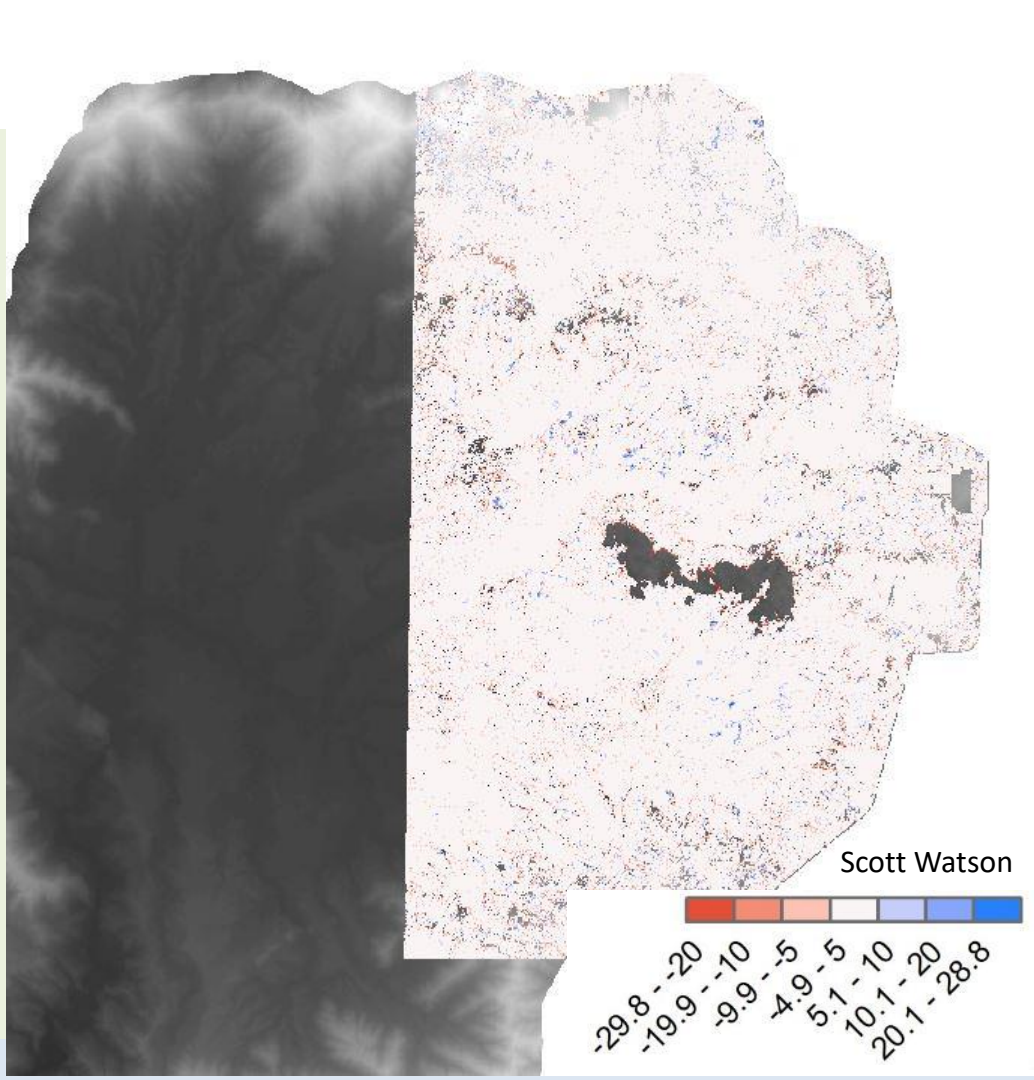
Pleiades minus  
AW3D30 after  
coregistration.  
Standard deviation  
of difference  $\sim 8$  m  
but looks to be an  
apparent offset,  
due to earthquake  
topography  
change?



Scott Watson



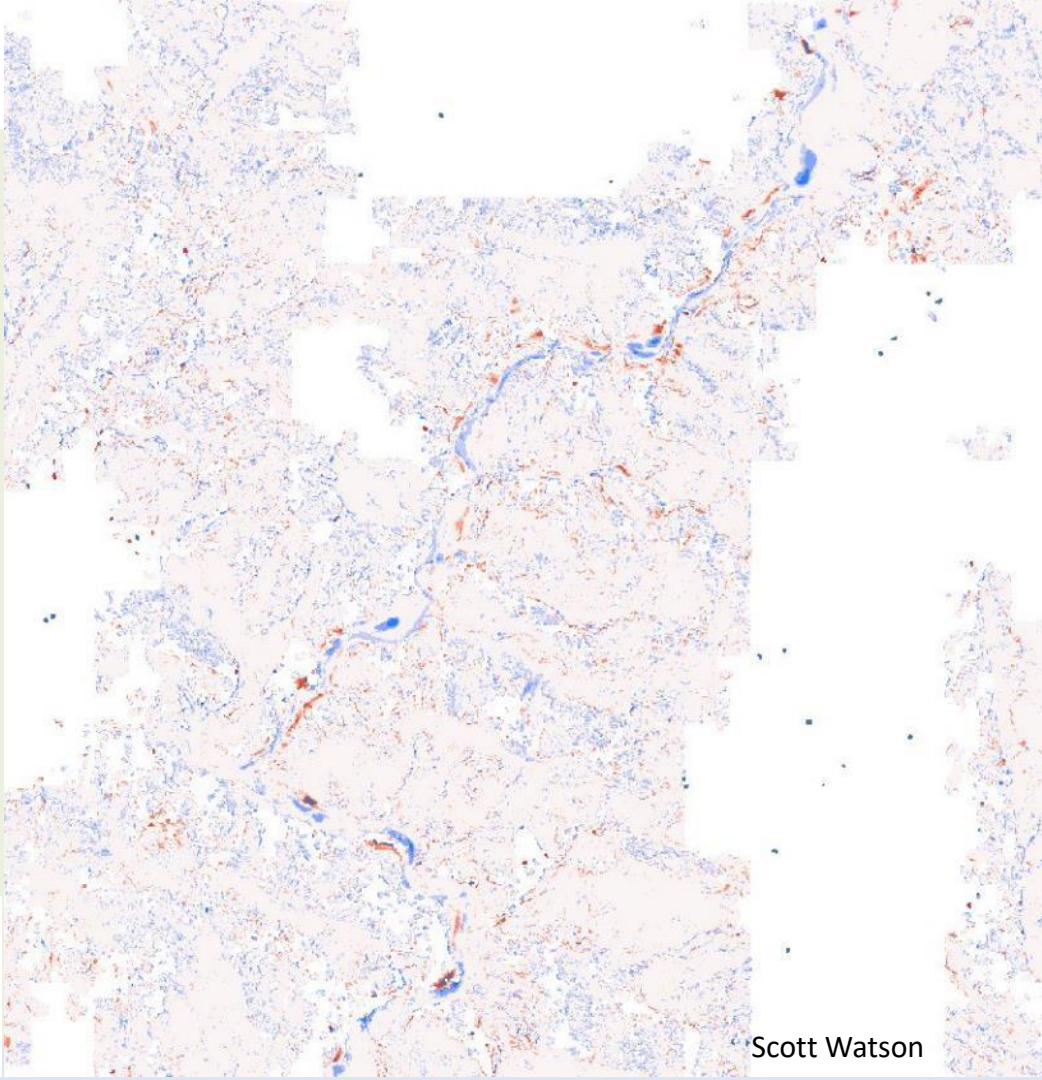
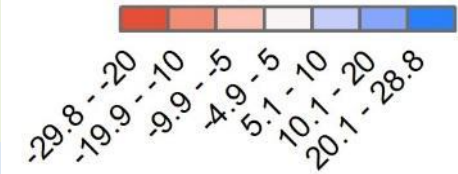
Pleiades minus High Mountain Asia DEM (12/12/2015) after coregistration. Standard deviation of difference  $\sim 3$  m. Much improved compared to AW3D30 comparison.



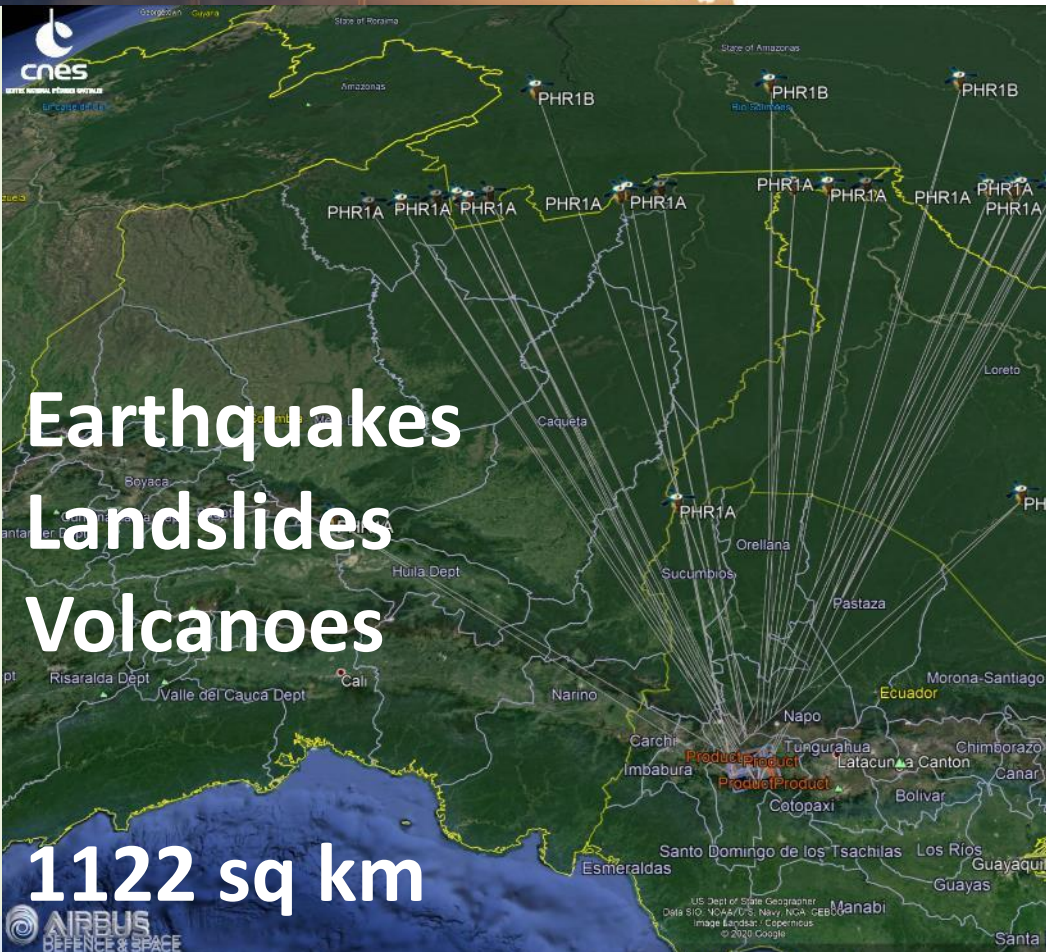




Pleiades minus **High Mountain Asia DEM**  
Shows elevation change associated with  
a river channel (2016 to 2020). Monsoon  
flooding is key element of KTM team  
analysis for Tomorrow's cities.



# Quito, Ecuador



Earthquakes  
Landslides  
Volcanoes

1122 sq km

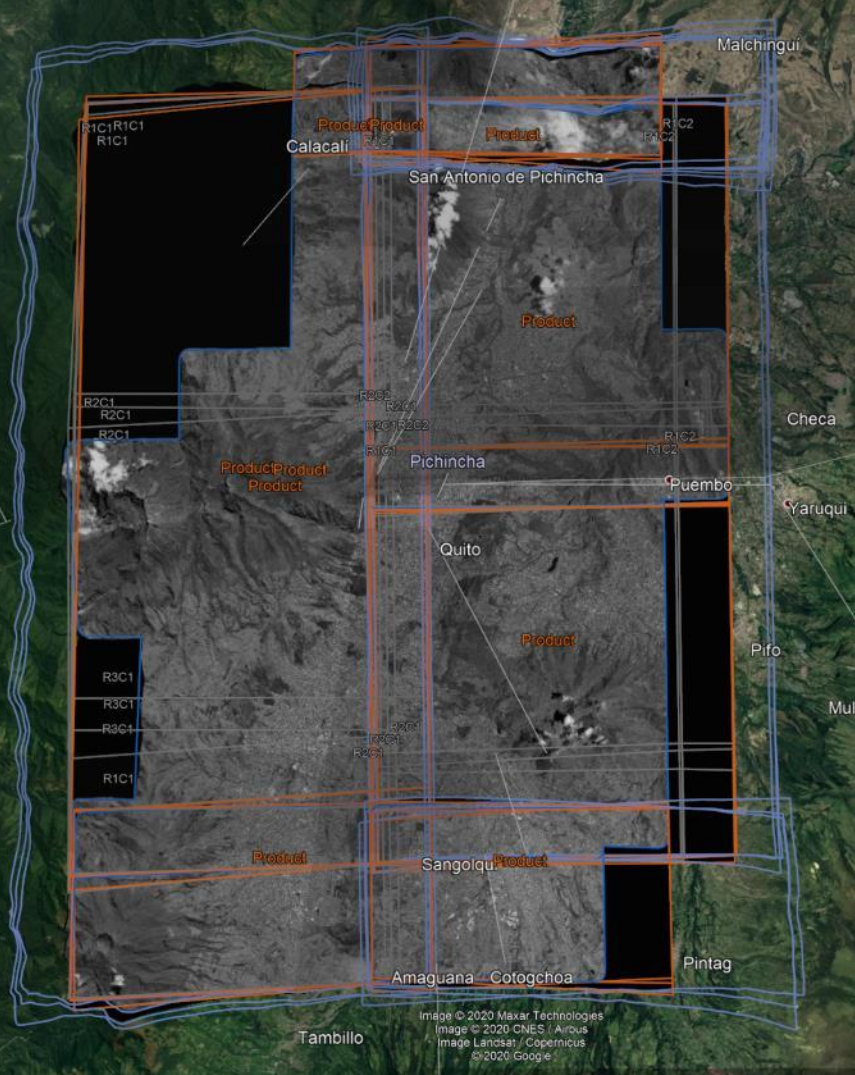


Image © 2020 Maxar Technologies  
Image © 2020 CNES / Airbus  
Image Landsat / Copernicus  
© 2020 Google

# Nairobi, Kenya



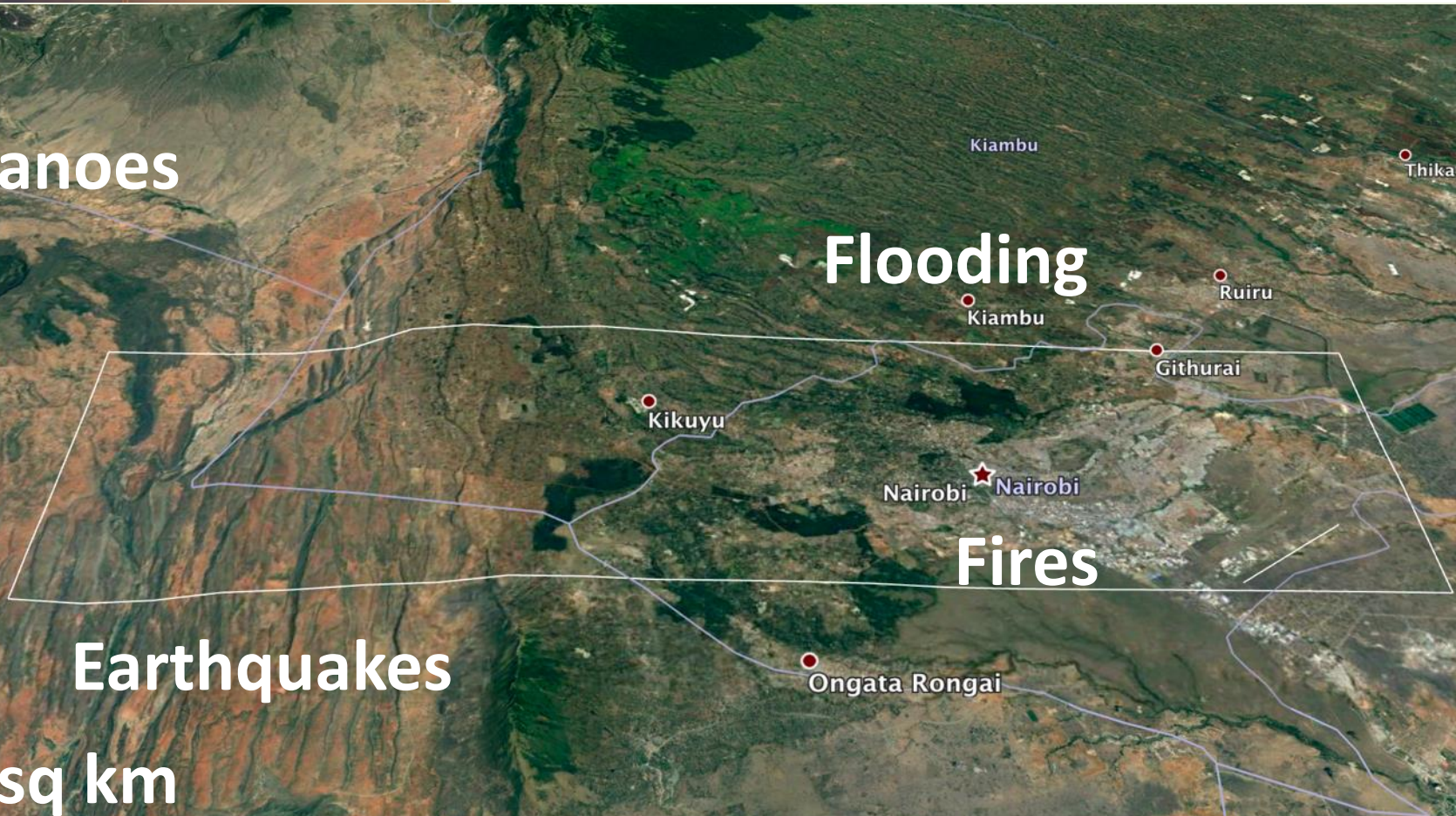
**Volcanoes**

**Flooding**

**Fires**

**Earthquakes**

**1053 sq km**

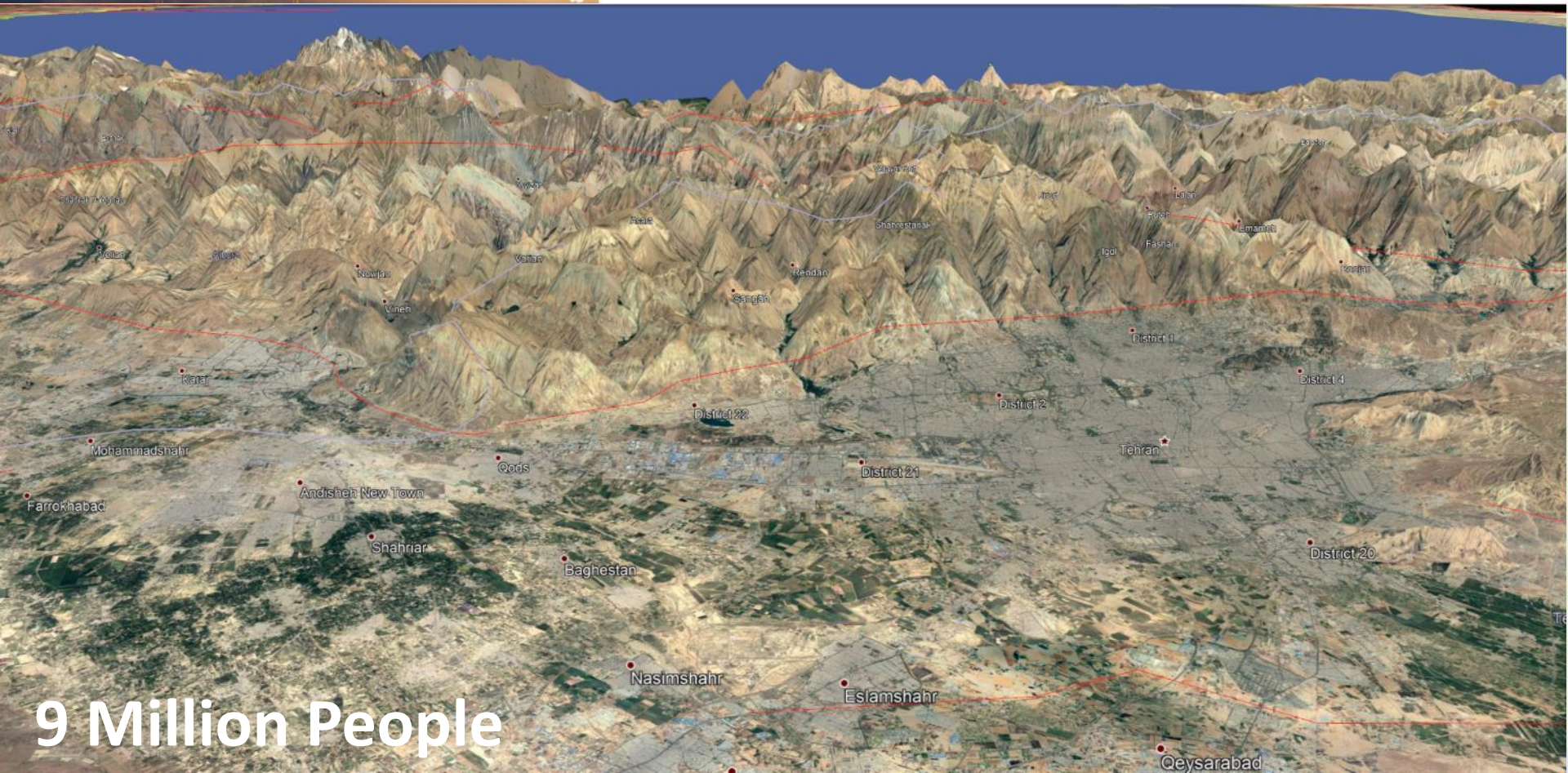


# Istanbul, Turkey



Earthquakes  
Fire

# Next City - Tehran



9 Million People

# Archive Data

ZOOM TO LOCATION

Search

FILTERS

Products Criteria

DEFINE AOI

Draw Modify Upload

Active polygon Polygon 6

Polygon 6 : 632 km<sup>2</sup> Polygon 7 : 631 km<sup>2</sup>

Optical Results

Optical Results 1 - 2

Sort By: Default (by cover and date)

Target Mode

Pleiades 0.5-m - TRI-STEREO - Nov 10, 2014 Res: 0.50m   Inc Ang: 17.6°   Cloud: 0.0%	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Pleiades 0.5-m - TRI-STEREO - Nov 9, 2014 Res: 0.50m   Inc Ang: 18.6°   Cloud: 0.0%	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Coordinates: 51.48, 35.55

# Turkey Earthquake

24<sup>th</sup> January 2020  
Magnitude 6.7  
earthquake  
Eastern Turkey

Request for  
Pleiades taking  
over Fault Rupture  
Zone and also over  
city of Elazig

No acquisitions  
have yet been  
made in the  
intervening 7  
months.





## Earth Observation for the Assessment of Earthquake Hazard, Risk and Disaster Management

J. R. Elliott<sup>1</sup>

Received: 6 December 2019 / Accepted: 23 July 2020  
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### Abstract

Earthquakes pose a significant hazard, and due to the growth of vulnerable, exposed populations, global levels of seismic risk are increasing. In the past three decades, a dramatic improvement in the volume, quality and consistency of satellite observations of solid earth processes has occurred. I review the current Earth Observing (EO) systems commonly used for measuring earthquake and crustal deformation that can help constrain the potential sources of seismic hazard. I examine the various current contributions and future potential for EO data to feed into aspects of the earthquake disaster management cycle. I discuss the implications that systematic assimilation of Earth Observation data has for the future assessment of seismic hazard and secondary hazards, and the contributions it will make to earthquake disaster risk reduction. I focus on the recent applications of Global Navigation Satellite System (GNSS) and increasingly the use of Interferometric Synthetic Aperture Radar (InSAR) for the derivation of crustal deformation and these data's contribution to estimates of hazard. I finish by examining the outlook for EO in geohazards in both science and decision-making, as well as offering some recommendations for an enhanced acquisition strategy for SAR data.

**Keywords** Earth Observation · Earthquakes · Seismic hazard · Disaster risk reduction · InSAR · Crustal strain

### Abbreviations

ASI	Agenzia Spaziale Italiana
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
ALOS-PALSAR	Advanced Land Observing Satellite Phased Array type L-band Synthetic Aperture Radar
AW3D	Advance World 3-Dimensional
BIROS	Bi-spectral InfraRed Optical System
CNES	Centre National d'Études Spatiales
COMET	Centre for the Observation and Modelling of Earthquakes, Volcanoes and Tectonics
CONAE	Comisión Nacional de Actividades Espaciales

✉ J. R. Elliott  
j.elliott@leeds.ac.uk

<sup>1</sup> COMET, School of Earth & Environment, University of Leeds, Leeds LS2 9JT, UK



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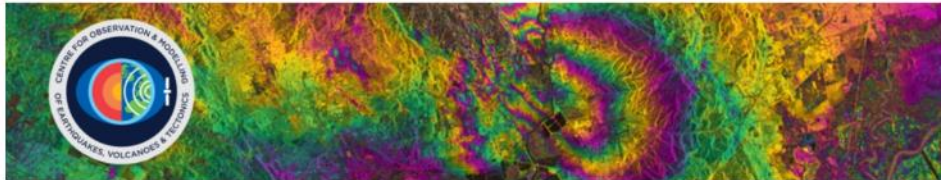
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## COMET-LiCS Sentinel-1 InSAR portal



- Home
- Product details
- Velocities
- Earthquakes

Give user feedback

### Earthquake Event Data Provider

Direct interferogram data download: LiCSAR data

<https://comet.nerc.ac.uk/comet-lics-portal-earthquake-event/>

#### Interactive map:

Please wait for the map to refresh. Filter the earthquake responses by date and click the markers to download LiCSAR InSAR data.

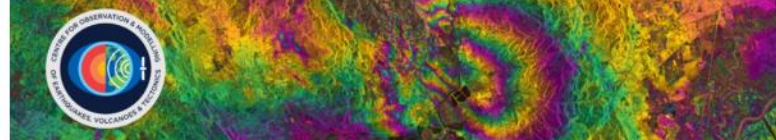


Select date range (default to the last year):

2019-09-03 to 2020-09-02

There were 60 earthquake responses by LiCSAR from 2019-09-03 to 2020-09-02.

Location	Date.Time.UTC	Magnitude	Depth.km	USGS.ID	Latitude	Longitude	LiCSAR.Data
1 95 km NW of Vallena, Chile	2020-09-01 21:09:17	6.5	14	us7000bg4v	-27.93	-71.39	<a href="#">Link</a>
2 80 km NW of Vallena, Chile	2020-09-01 04:30:02	6.3	17	us7000bfjx	-28.04	-71.31	<a href="#">Link</a>
3 75 km NW of Vallena, Chile	2020-09-01 04:09:30	7	35	us7000bfjr	-28.01	-71.2	<a href="#">Link</a>
4 104 km NW of Vallena, Chile	2020-09-01 04:09:24	6.8	10	at00qfyojo	-27.9	-71.5	<a href="#">Link</a>
5 69 km SW of Palana, Russia	2020-09-01 00:51:17	5.6	10	us7000bfjtj	58.73	168.97	<a href="#">Link</a>
6 15 km S of Liuli, Tanzania	2020-08-24 07:03:49	5	10	us6000bjm1	-11.22	-34.64	<a href="#">Link</a>



## Earthquake Event

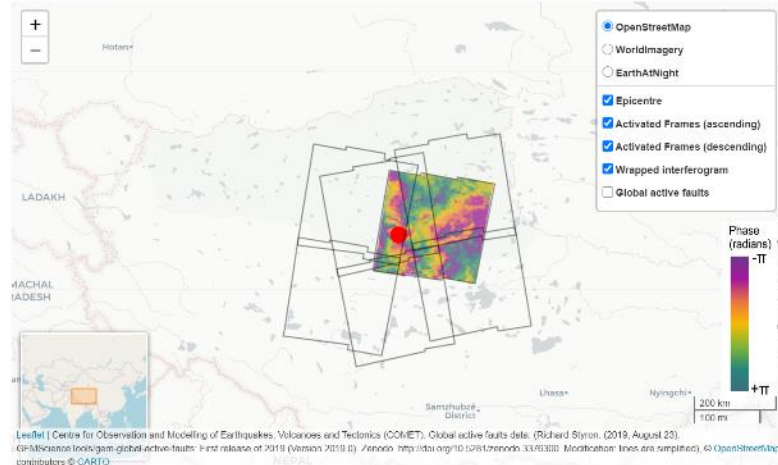
Last compiled on 2020-09-02 03:08:06 UTC

Give user feedback

#### USGS Information:

Location	Date.Time.UTC	Magnitude	Depth.km	USGS.ID	Latitude	Longitude
western Xizang	2020-07-22 20:07:19	6.3	10	us6000b26j	33.13	86.84

#### Location Map:



### Activated Frames:

Links to past data and metadata (look components)

Ascending	Descending
012A_05842_131313	019D_05619_131313
114A_05790_131313	121D_05668_131313
114A_05591_131313	019D_05818_131313
012A_05841_131313	

LiCSAR Data: