Characterising Iran's rapidly subsiding regions using Earth Observation data

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Andrew Watson[1], Scott Watson[1], Mark Thomas[1], Kate Donovan[2], Yasser Maghsoudi[1], Milan Lazecky[1], Richard Rigby[1], John Elliott[1]

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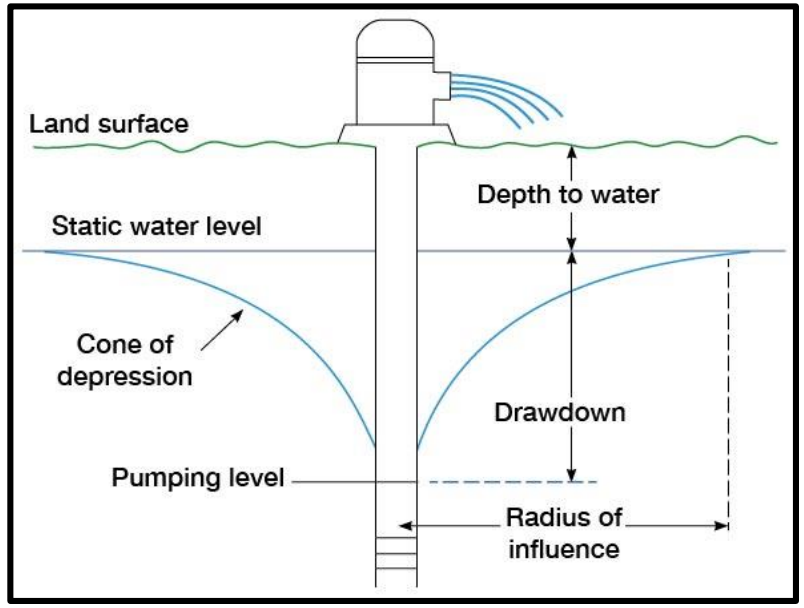
OSPA QR Code

1. Groundwater extraction and subsidence



EFFECTIVE STRESS CONCEPT

$$\sigma = \sigma' + u$$

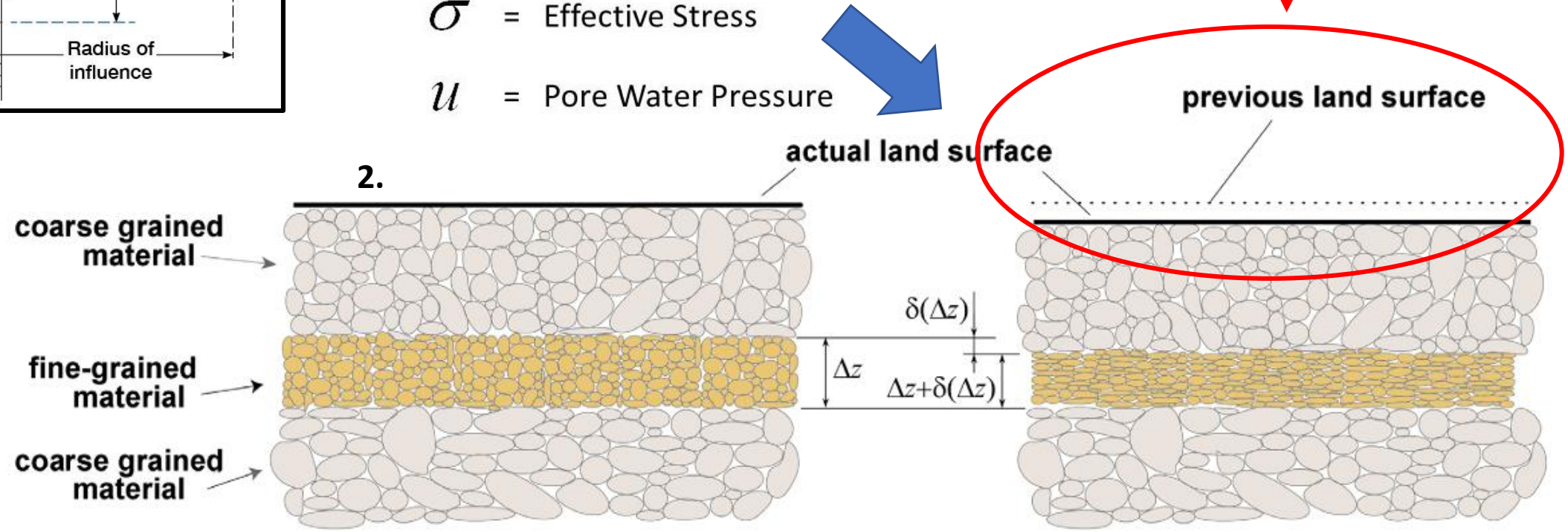
where...

σ = Total Vertical Stress

σ' = Effective Stress

u = Pore Water Pressure

Deformation due to groundwater extraction

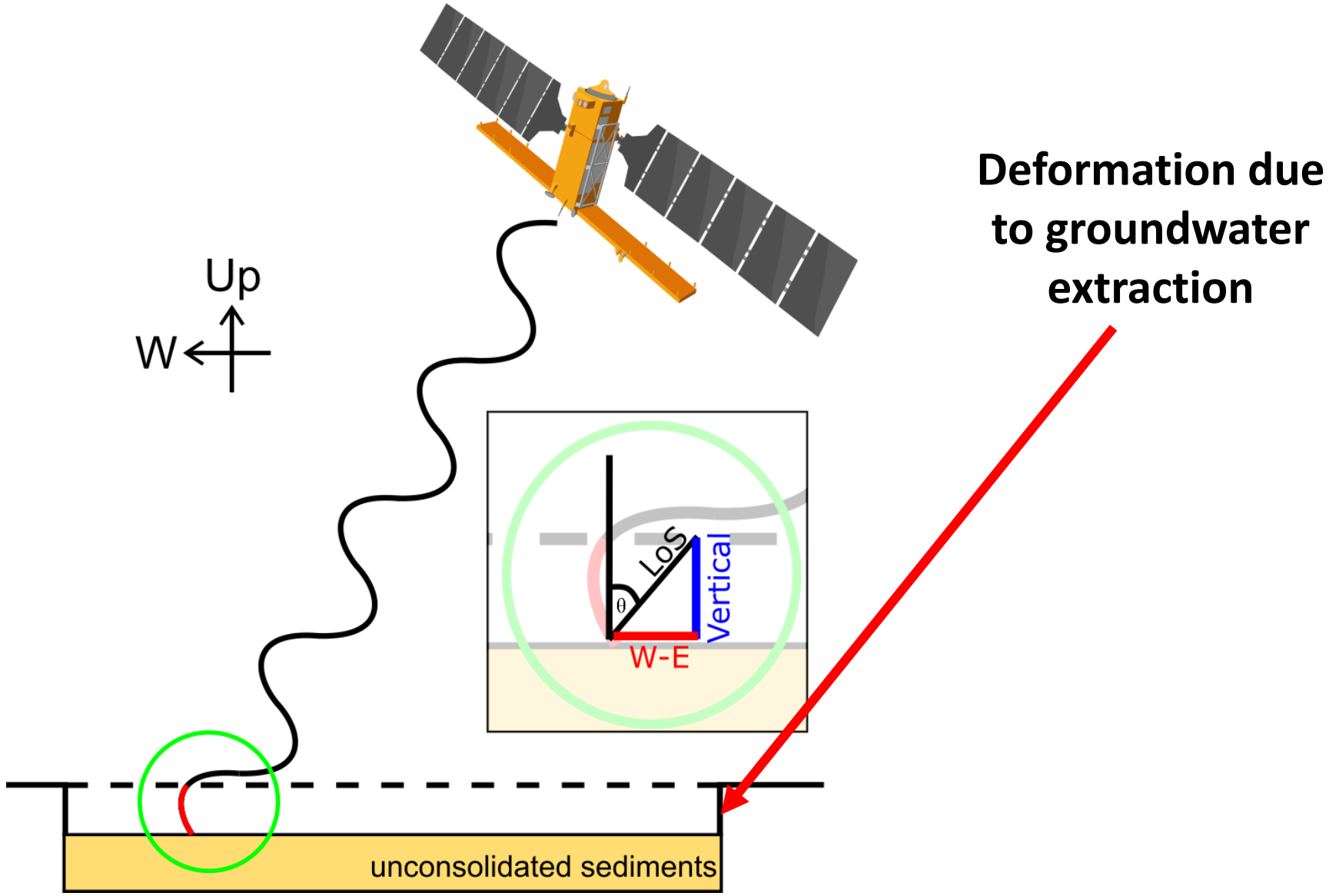


Gambolati & Teatini (2015)

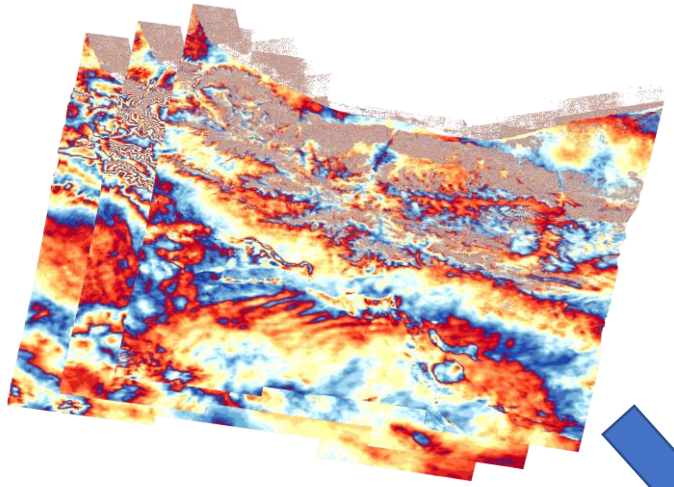
1. Groundwater extraction and subsidence

Sentinel-1:

- **Oct 2014-present**
- **6 or 12** day repeat time
- **100 m pixel** width
- **Global** coverage



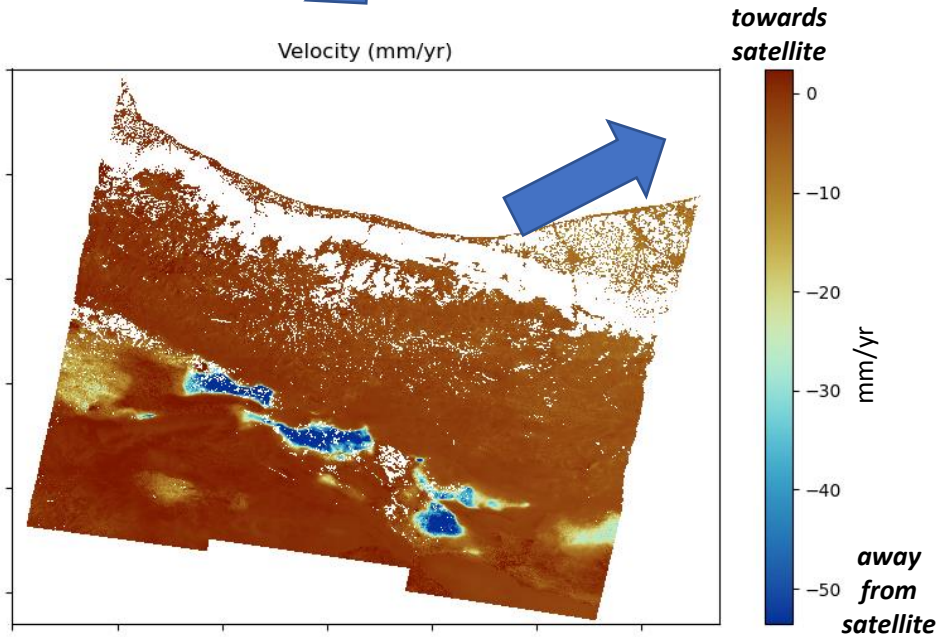
2. Calculate vertical InSAR velocities

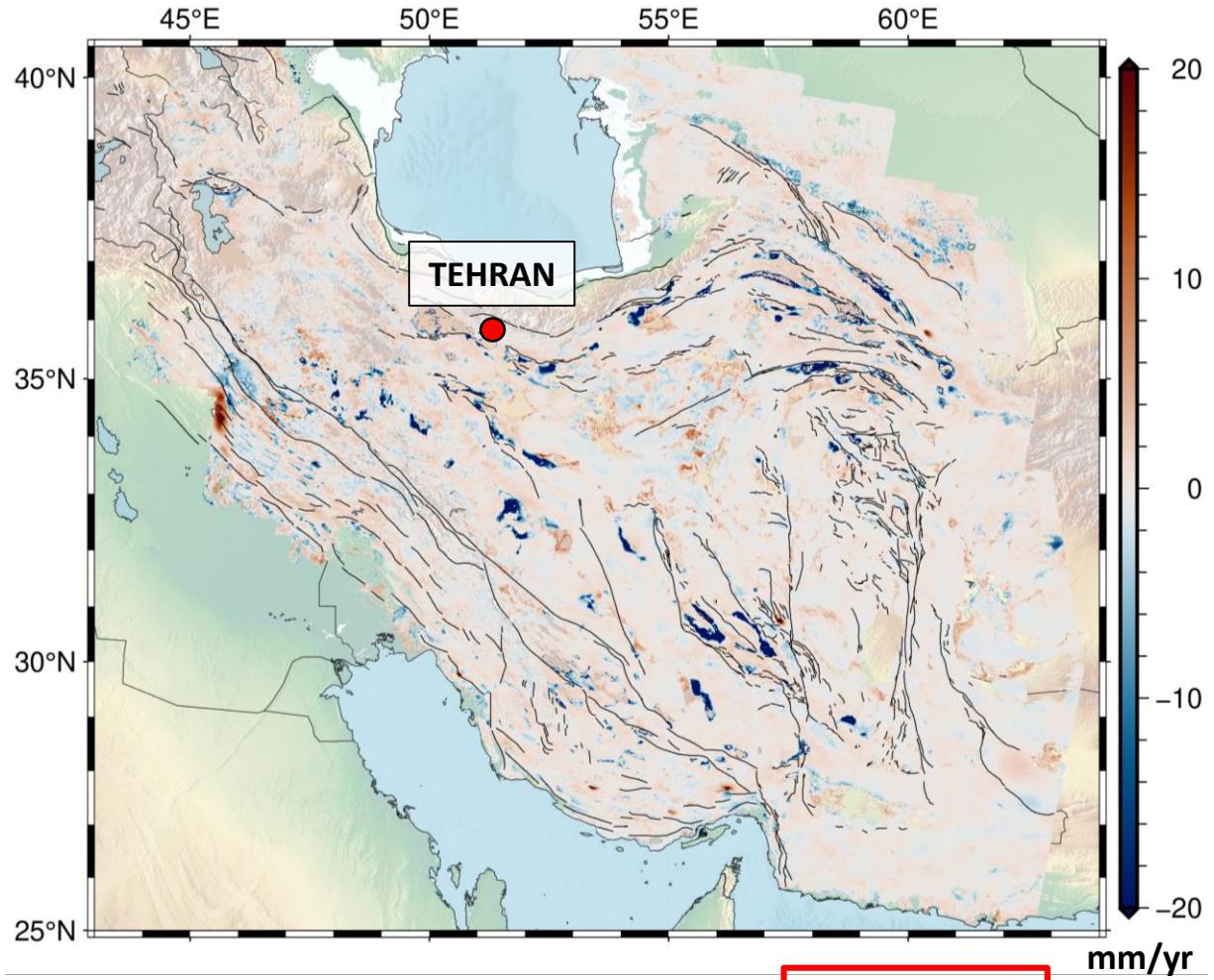


Sentinel-1 interferograms
LiCSAR
Lazecky *et al*. (2020)

LiCS
LOOKING INSIDE THE CONTINENTS FROM SPACE

LoS time-series analysis
LiCSBAS
Morishita *et al*., (2020)

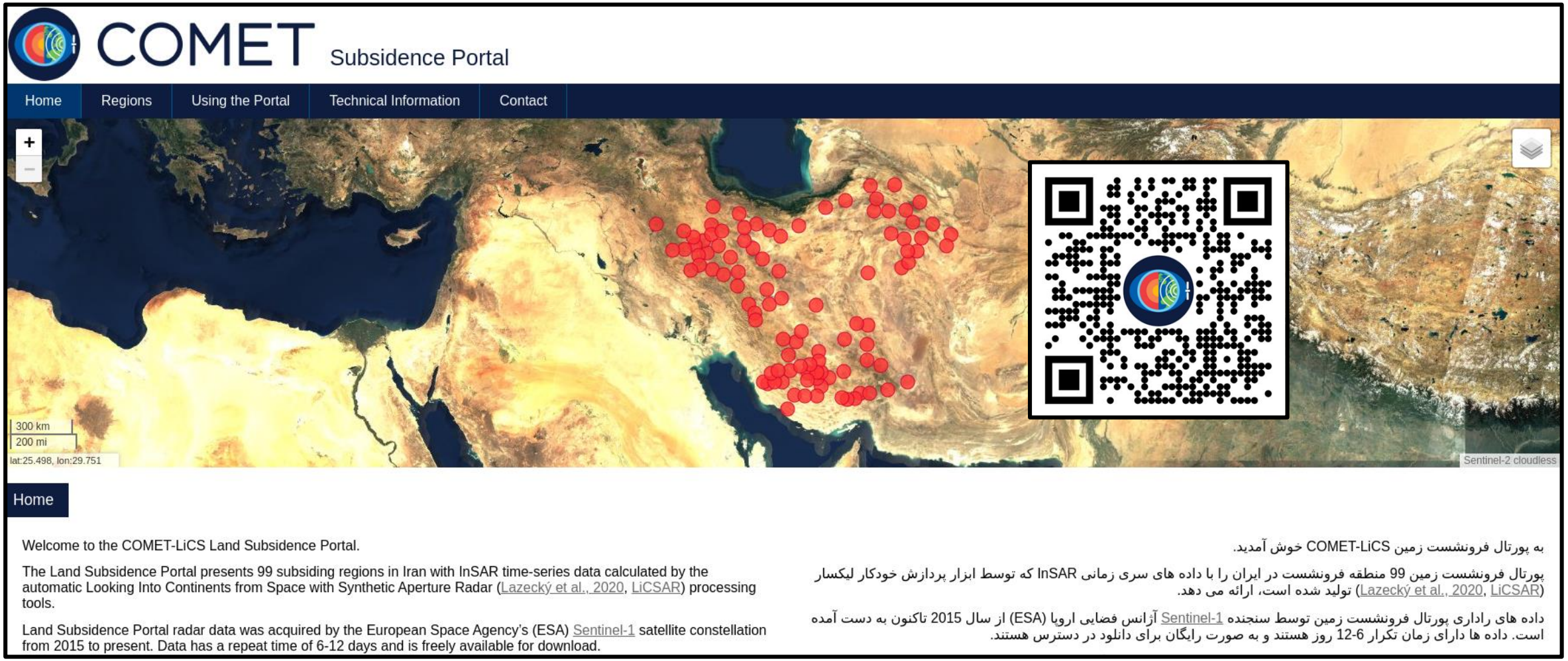




Velocity decomposition + velocity field construction
Watson *et al*., (2022)

G34A-06
Wed 14th
Poster

2: Calculate InSAR velocities



https://comet-subsidencedb.org/

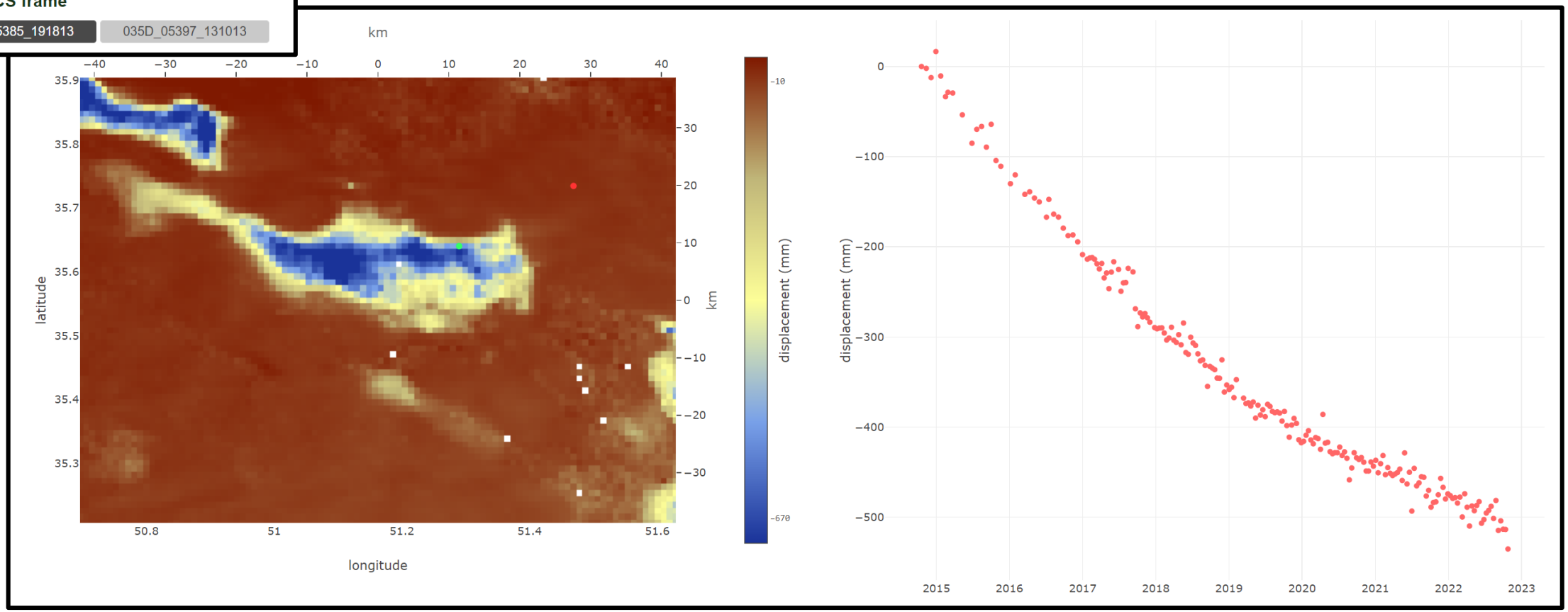
2: Calculate InSAR velocities

Western Tehran Plain

دشت غرب تهران

Sentinel-1 LiCS frame

028A_05385_191813 | 035D_05397_131013



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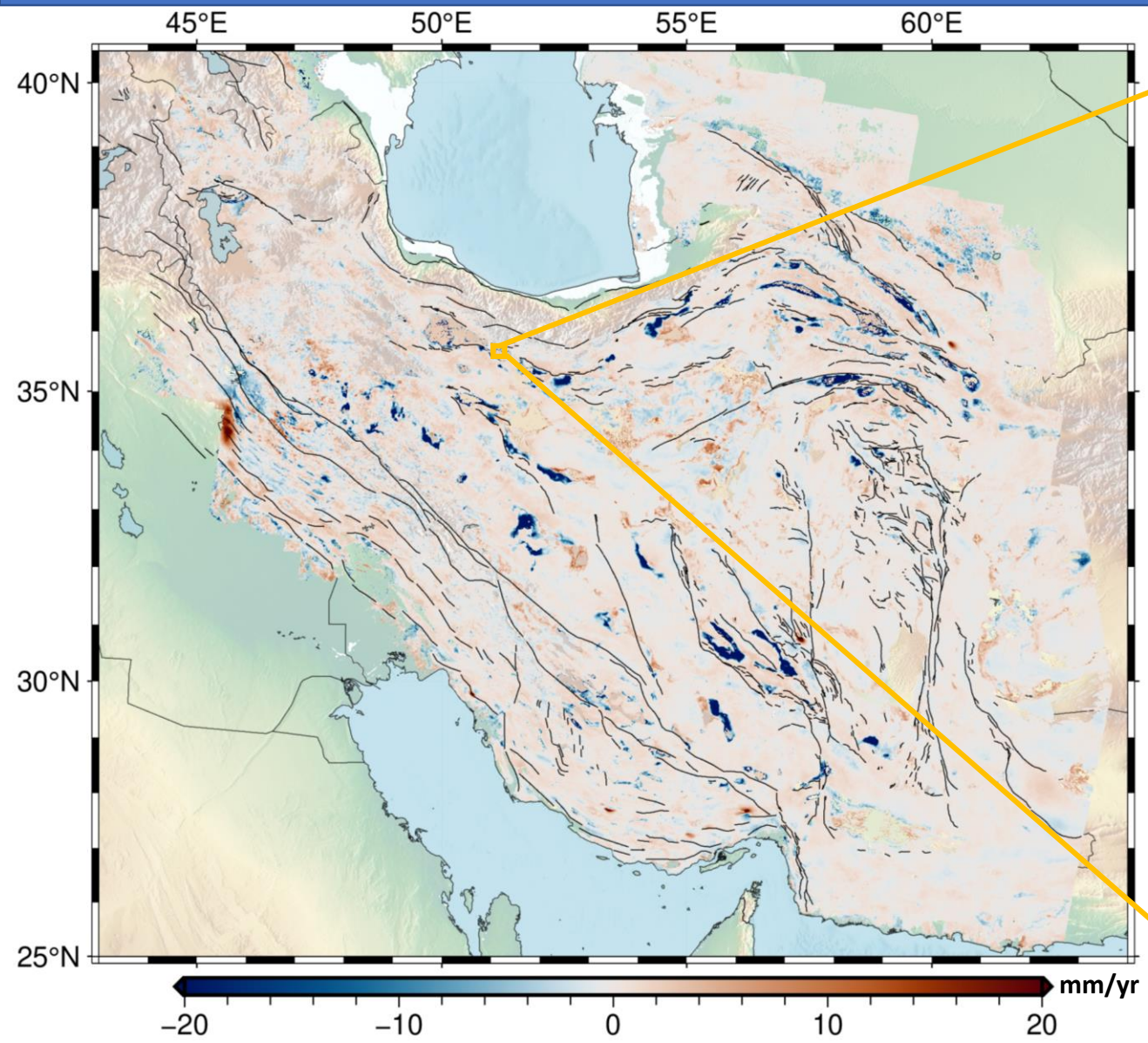

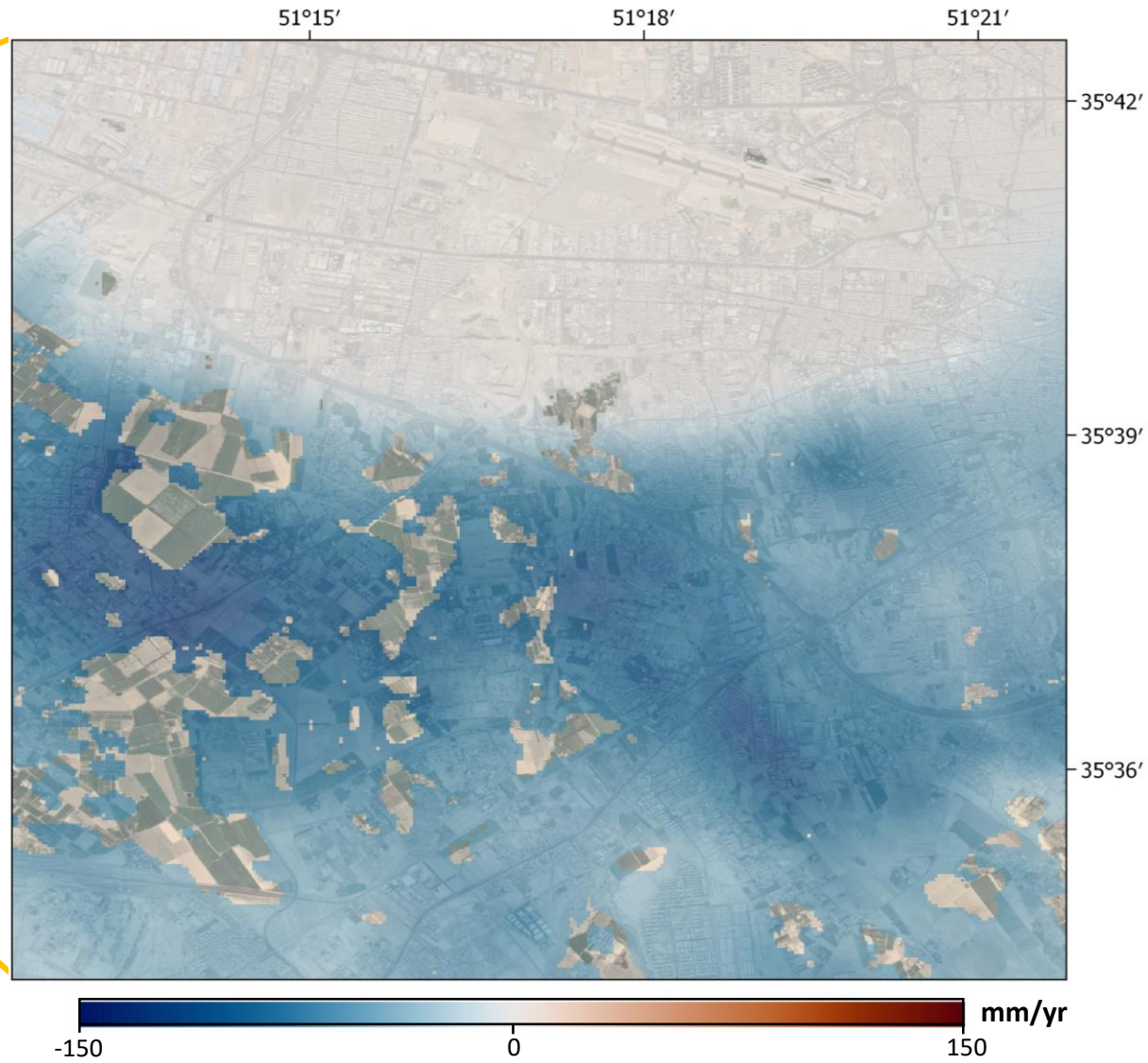

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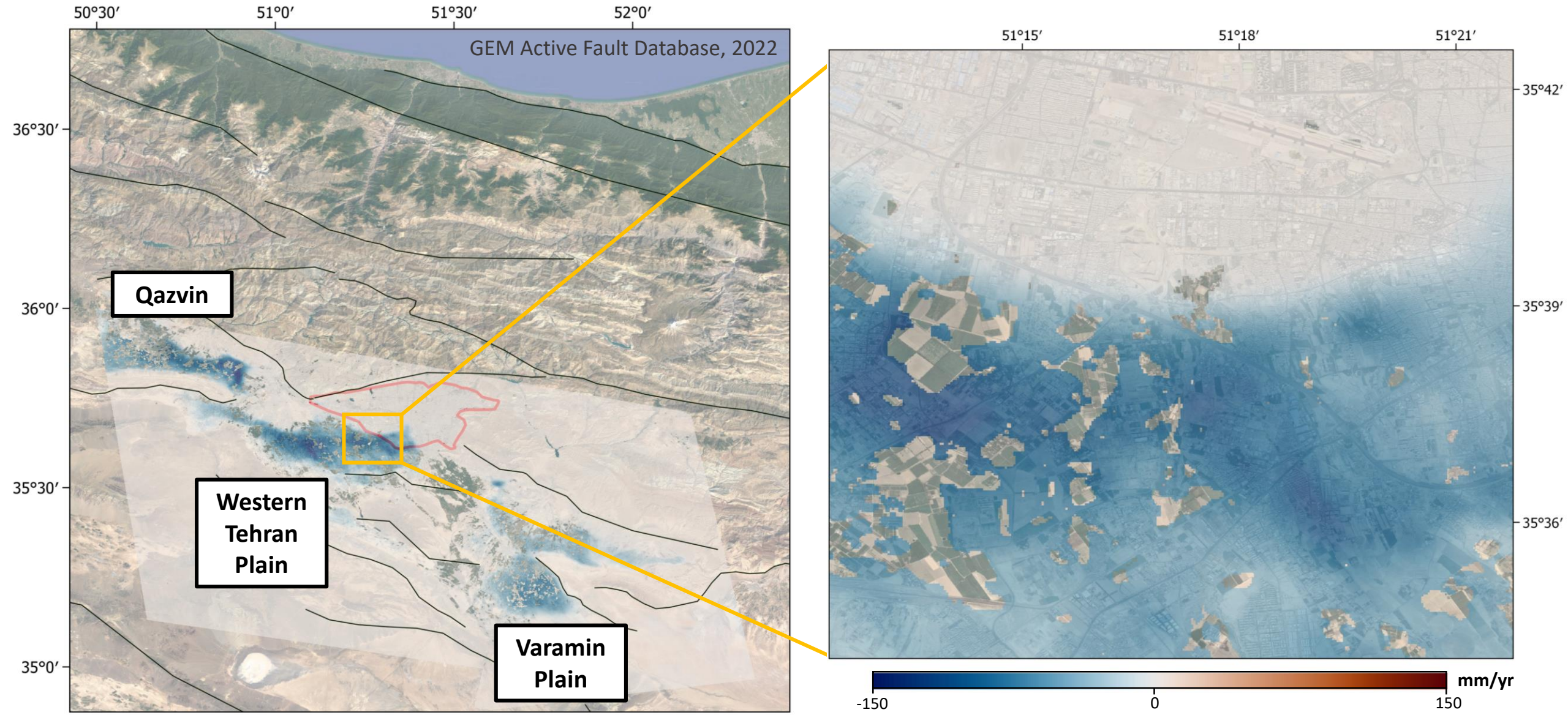

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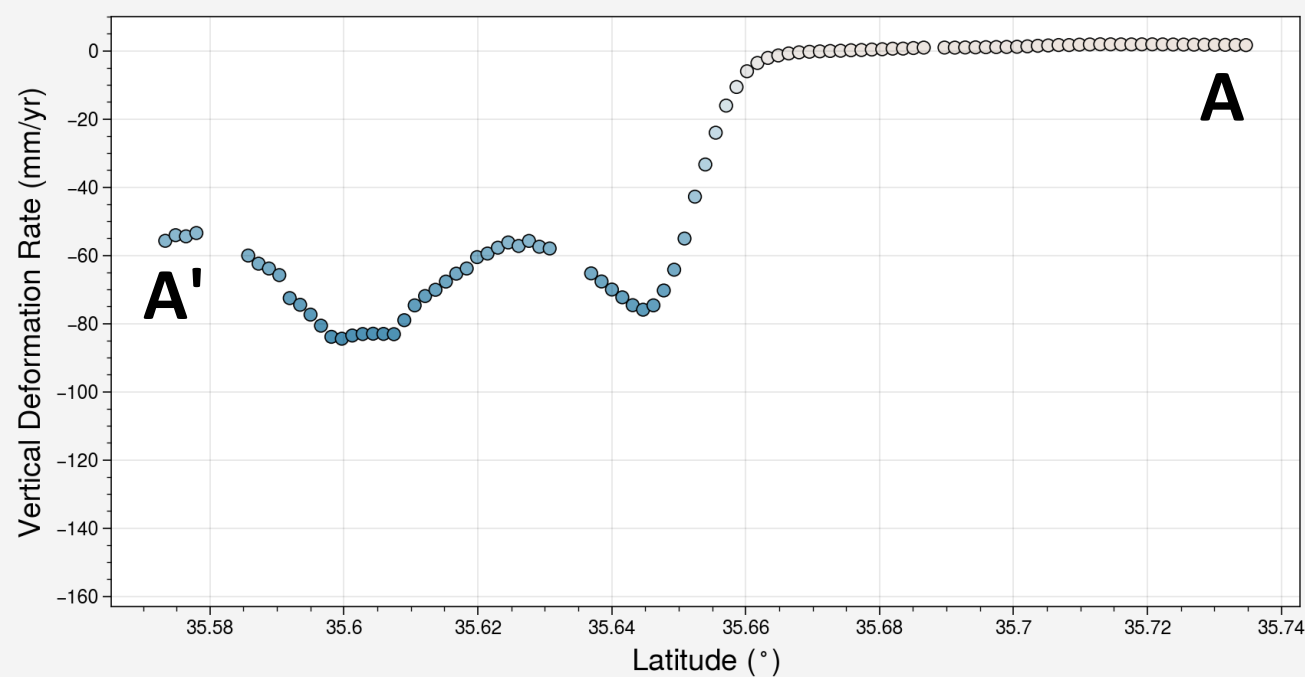
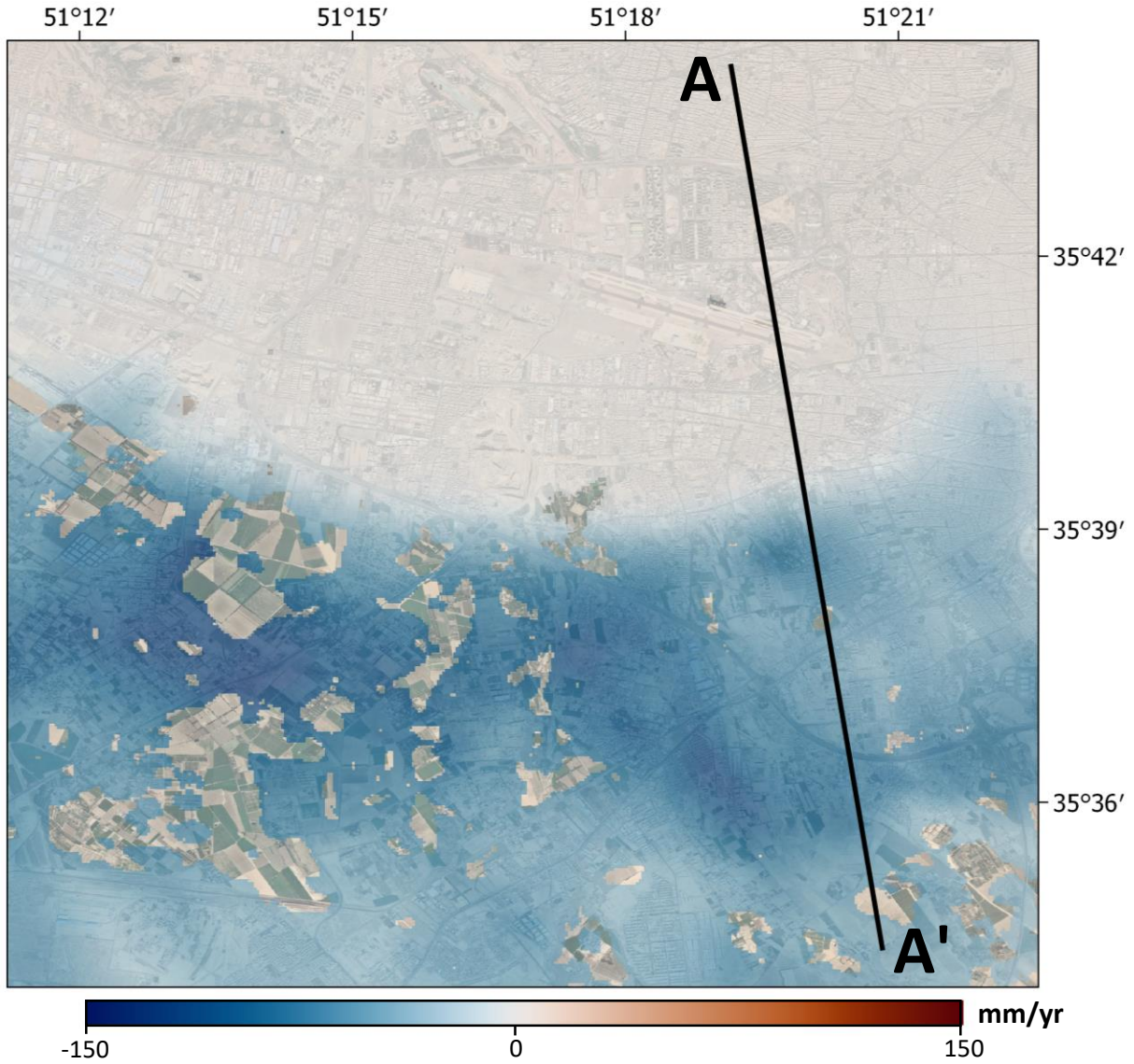
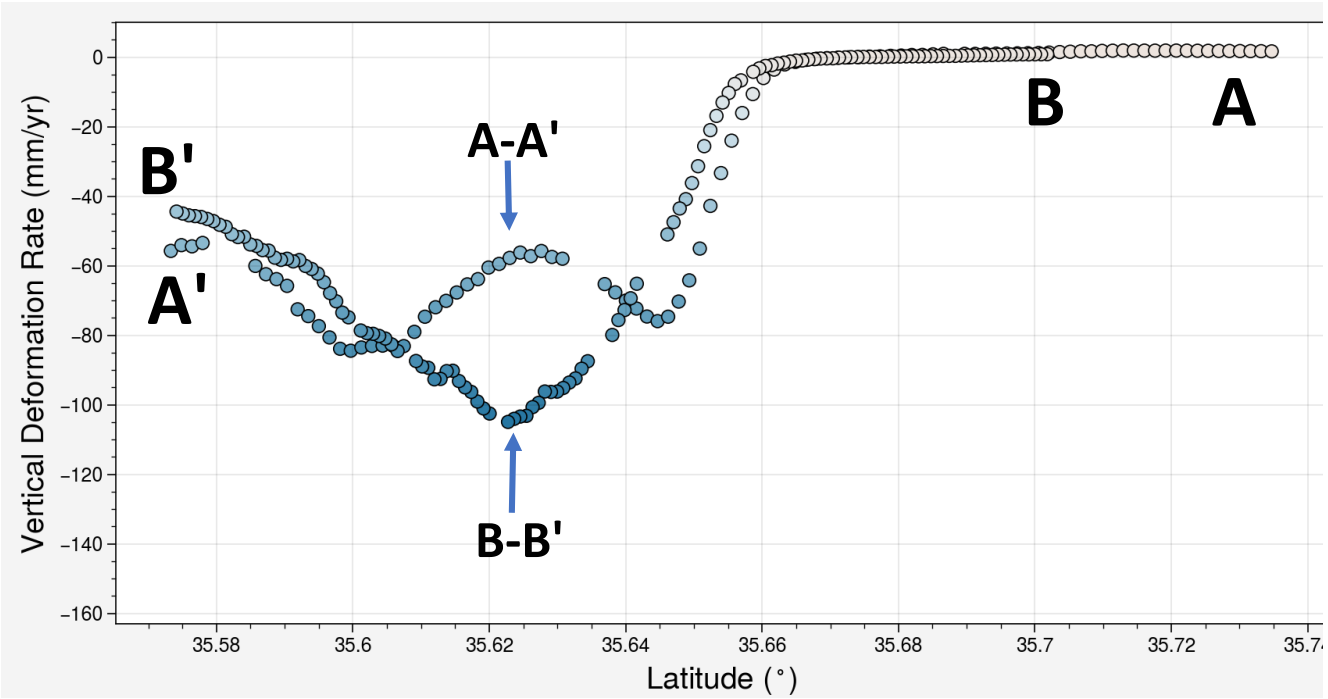
Western Tehran Plain

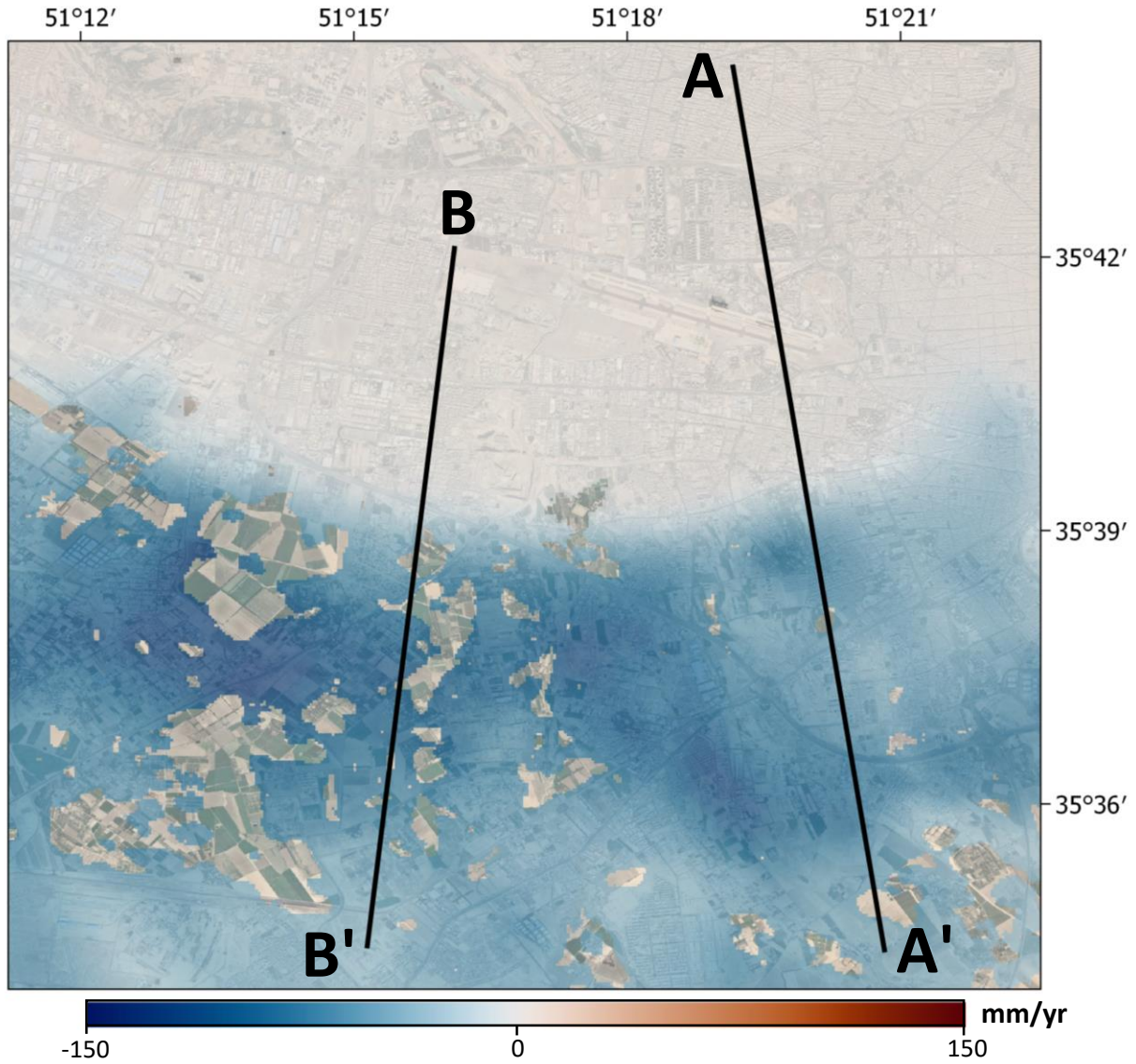




2: Calculate InSAR velocities

Western Tehran Plain



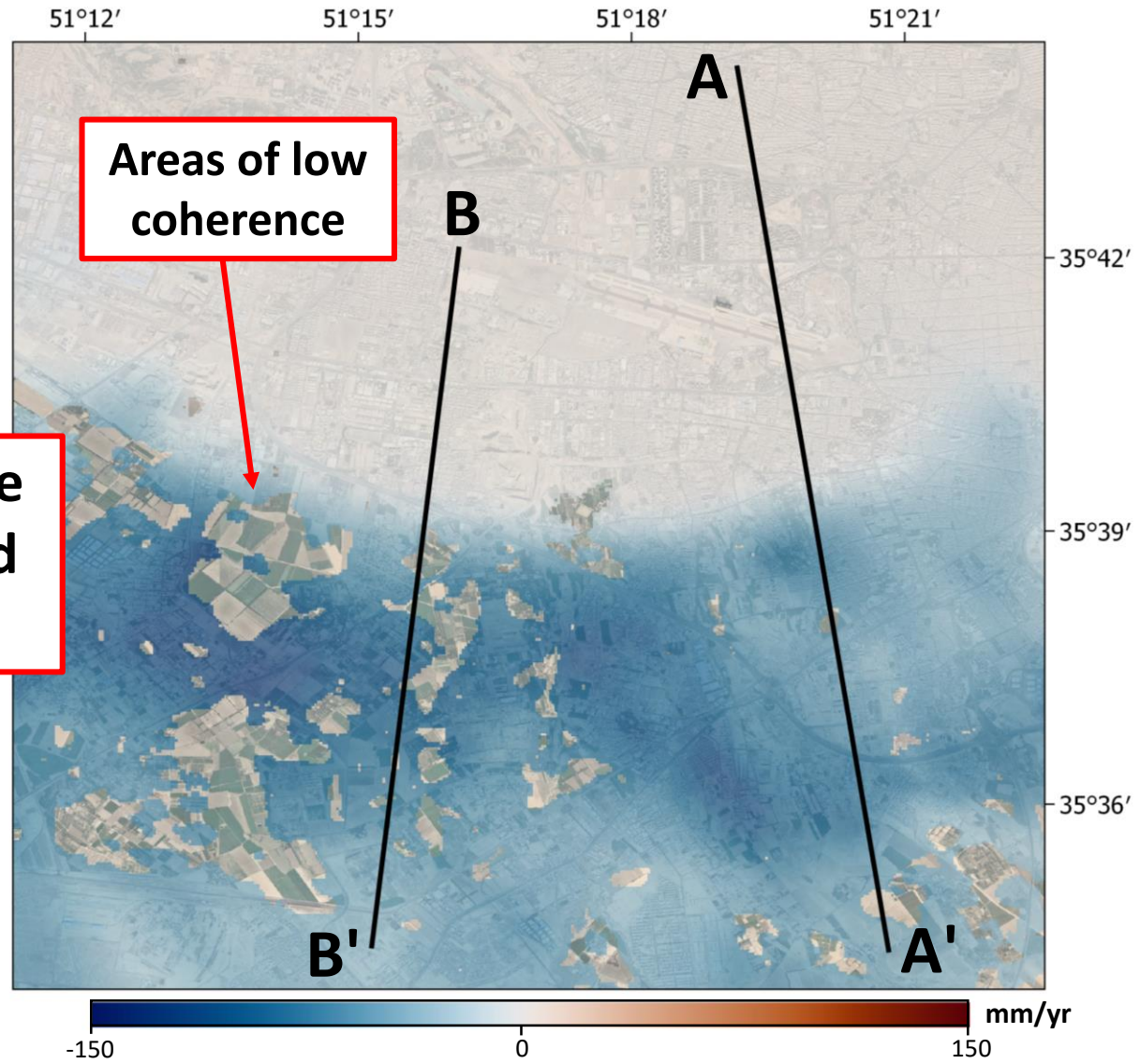


2: Calculate InSAR velocities

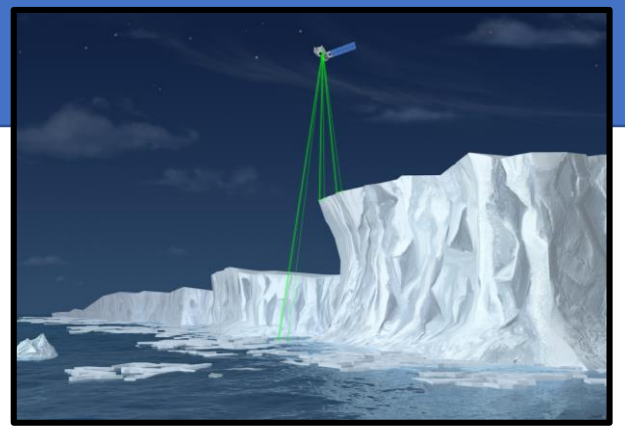
Western Tehran Plain

	Maxiumum subsidence rate (mm/yr)	Instrument	Acquisition period
Motagh *et al.* (2008)	30	Envisat	Jun-Oct 2004
Foroughnia *et al.* (2019)	~150	Envisat, Sentinel-	
Dehghani *et al.* (2013)	~200	Envisat	
Haghshenas Haghighi & Motagh (2019)	250	Envisat, ALOS, TerraSAR-X, Sentinel-1	2003-2017
This study	**150**	**Sentinel-1**	**2014-2022**

Can we validate these rates and magnitudes?



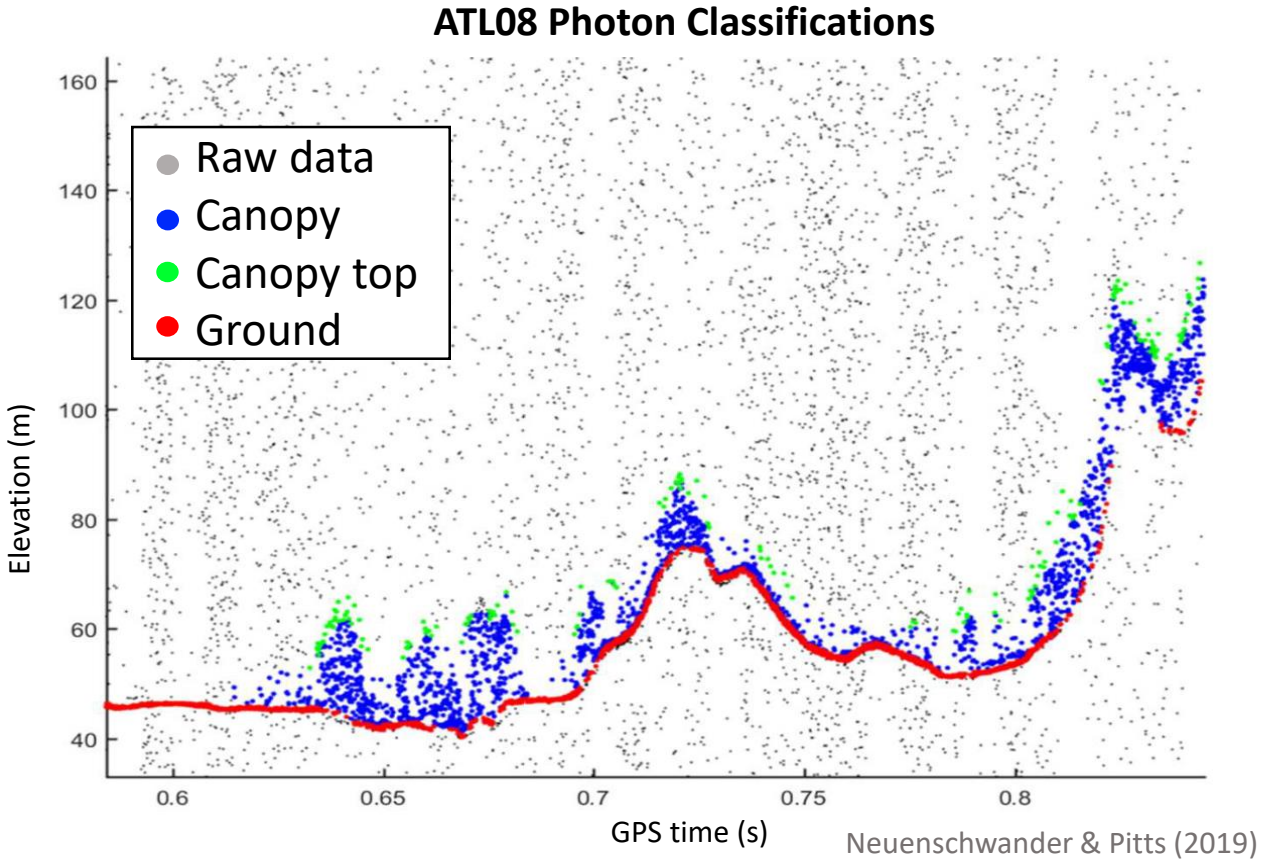
3. Validating InSAR: ICESat-2 laser altimetry



1. ICESat-2 laser altimetry data (repeat time ~3 months)

- ATL03 product = Geolocated Photon Data
- ATL08 product = Land and Vegetation Height
- Difference the ground returns

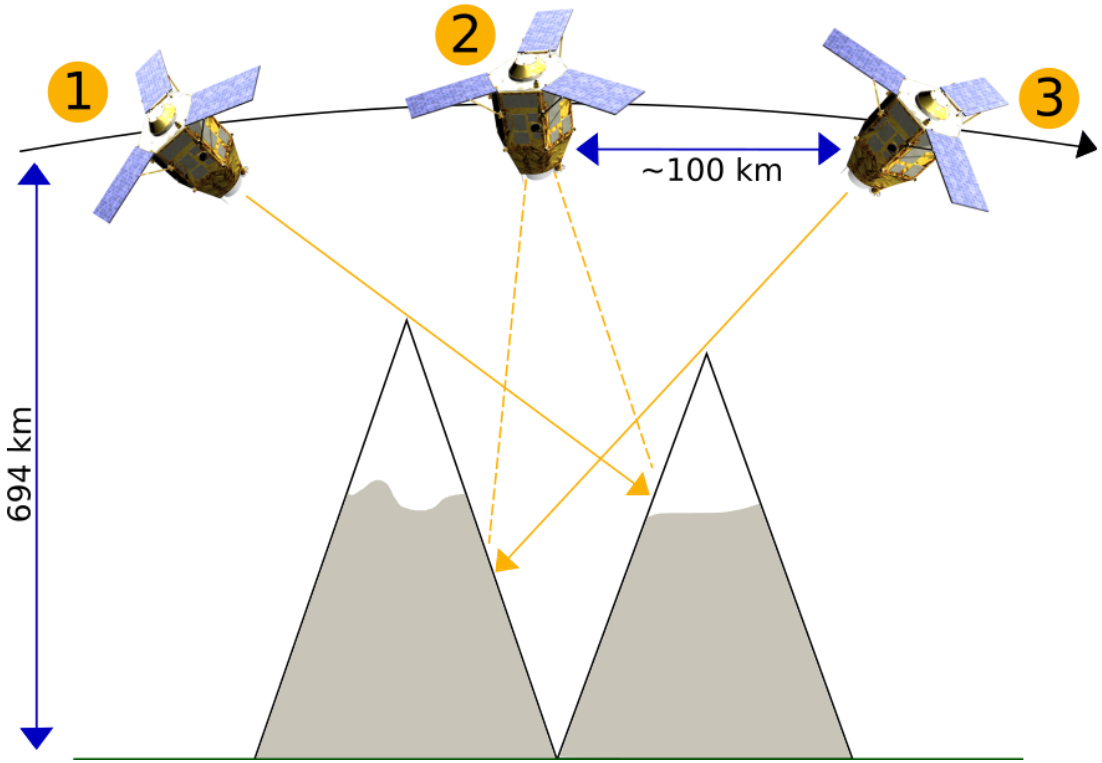
-> subsidence rate



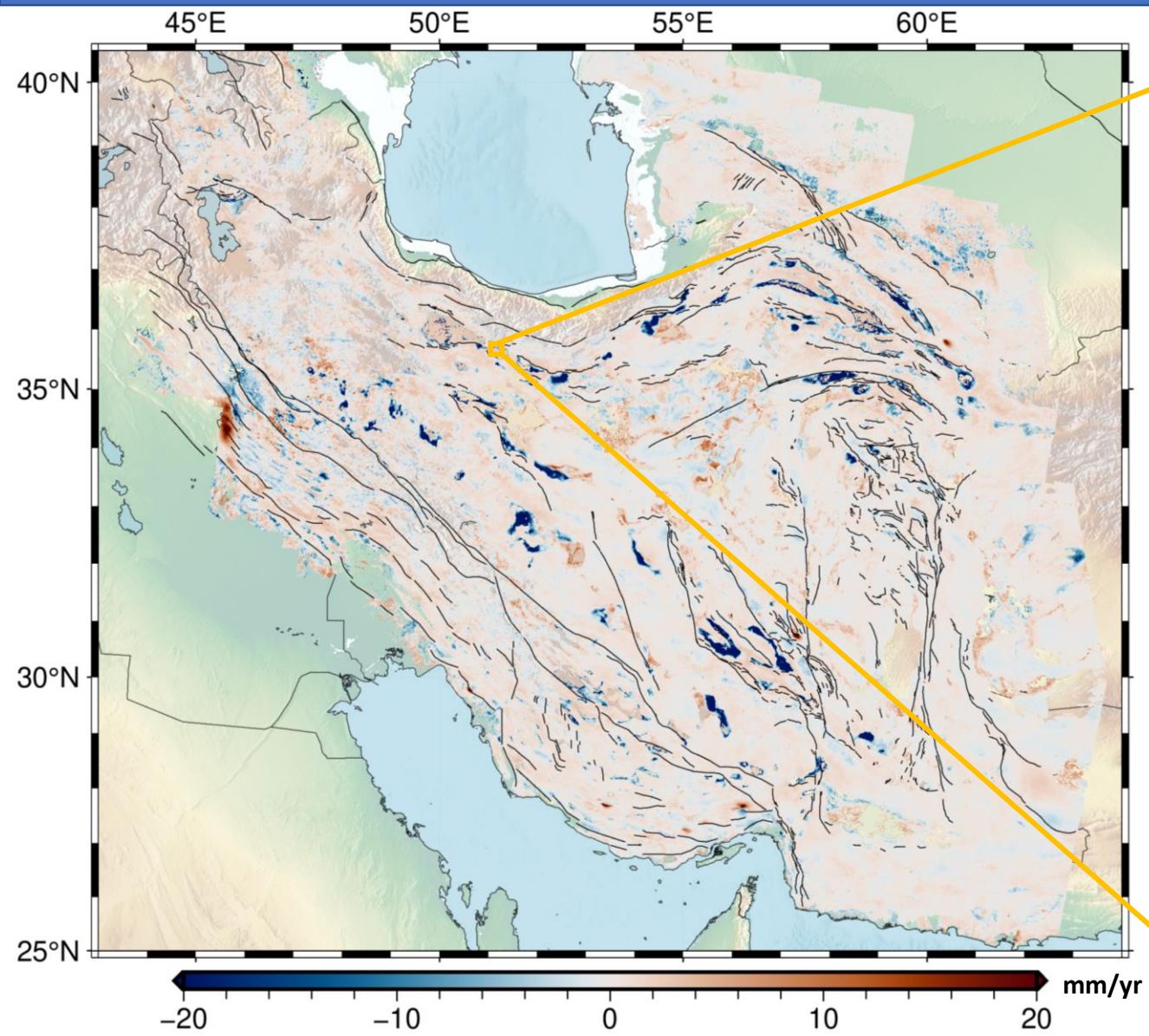
Neuenschwander & Pitts (2019)

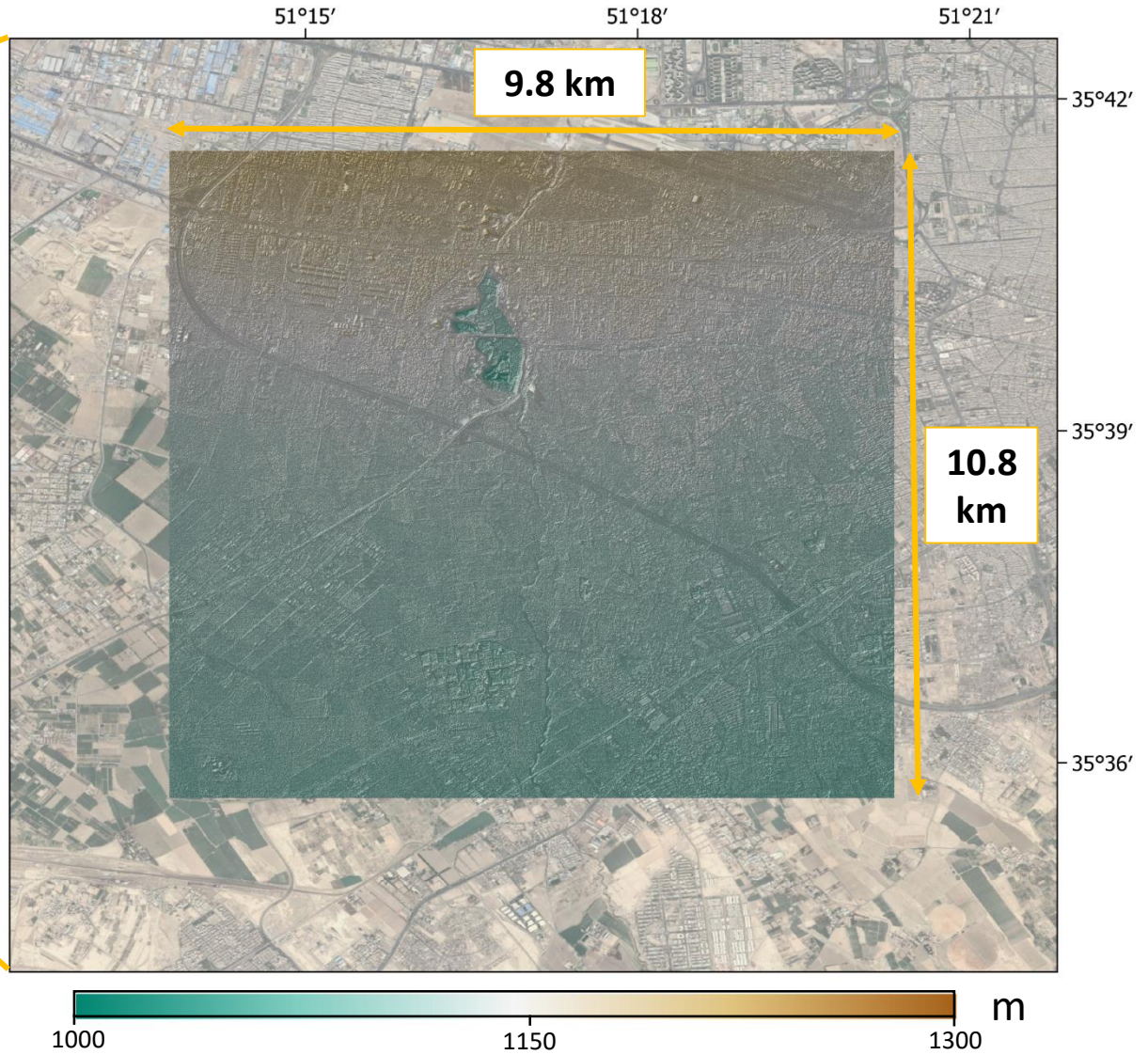
3. Validating InSAR: VHR DEMs

1. **Pléiades 50 cm/Pléiades Neo 30 cm stereoscopic** imagery
2. Construct dense point cloud and **1.5m DEM** from each stereoscopic set
3. **Reproject** secondary DEM to reference DEM grid
4. **Remove static offset** between DEM pairs
5. **Difference DEMs** to calculate vertical change



3. Validating InSAR: DEMs





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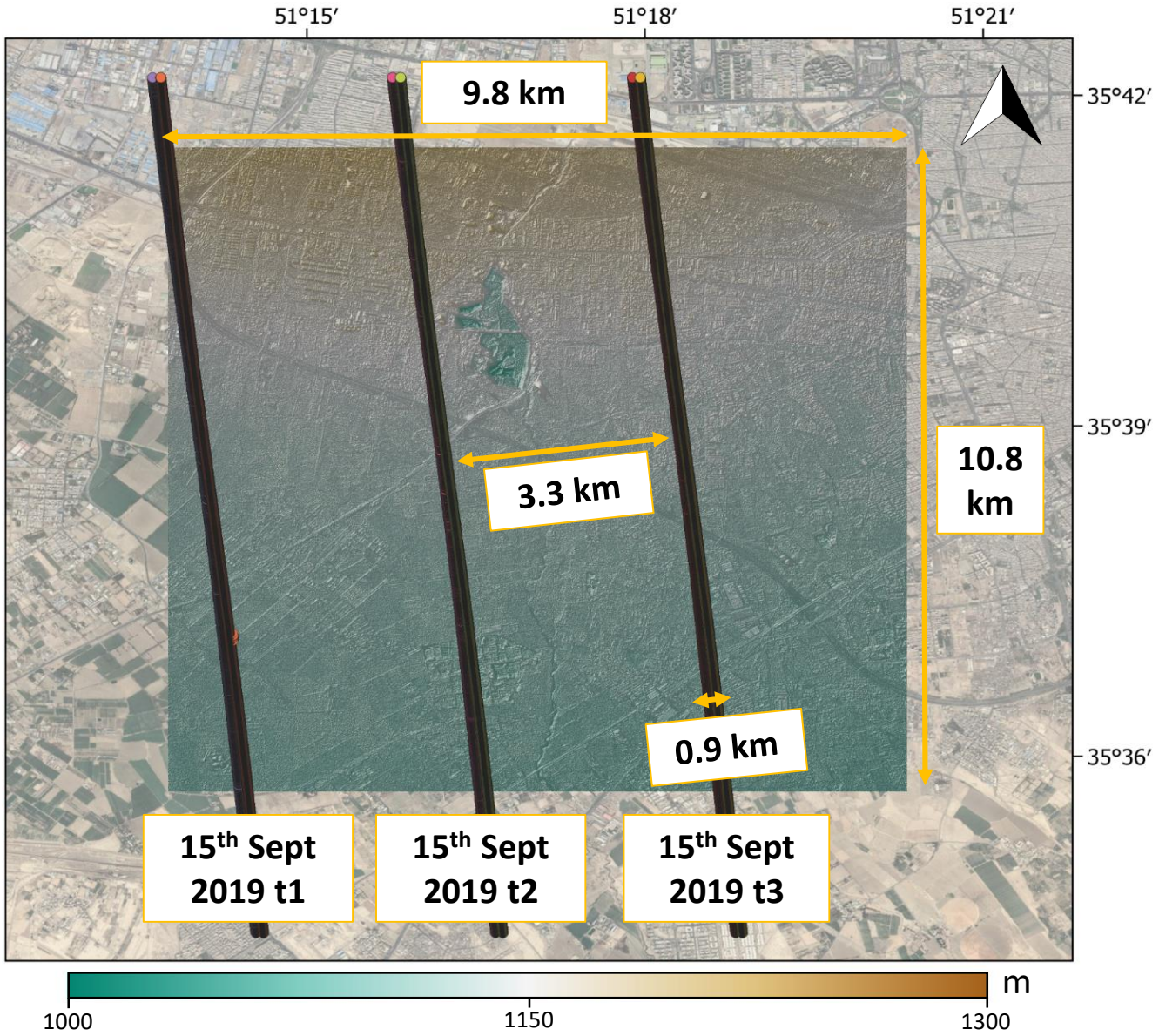

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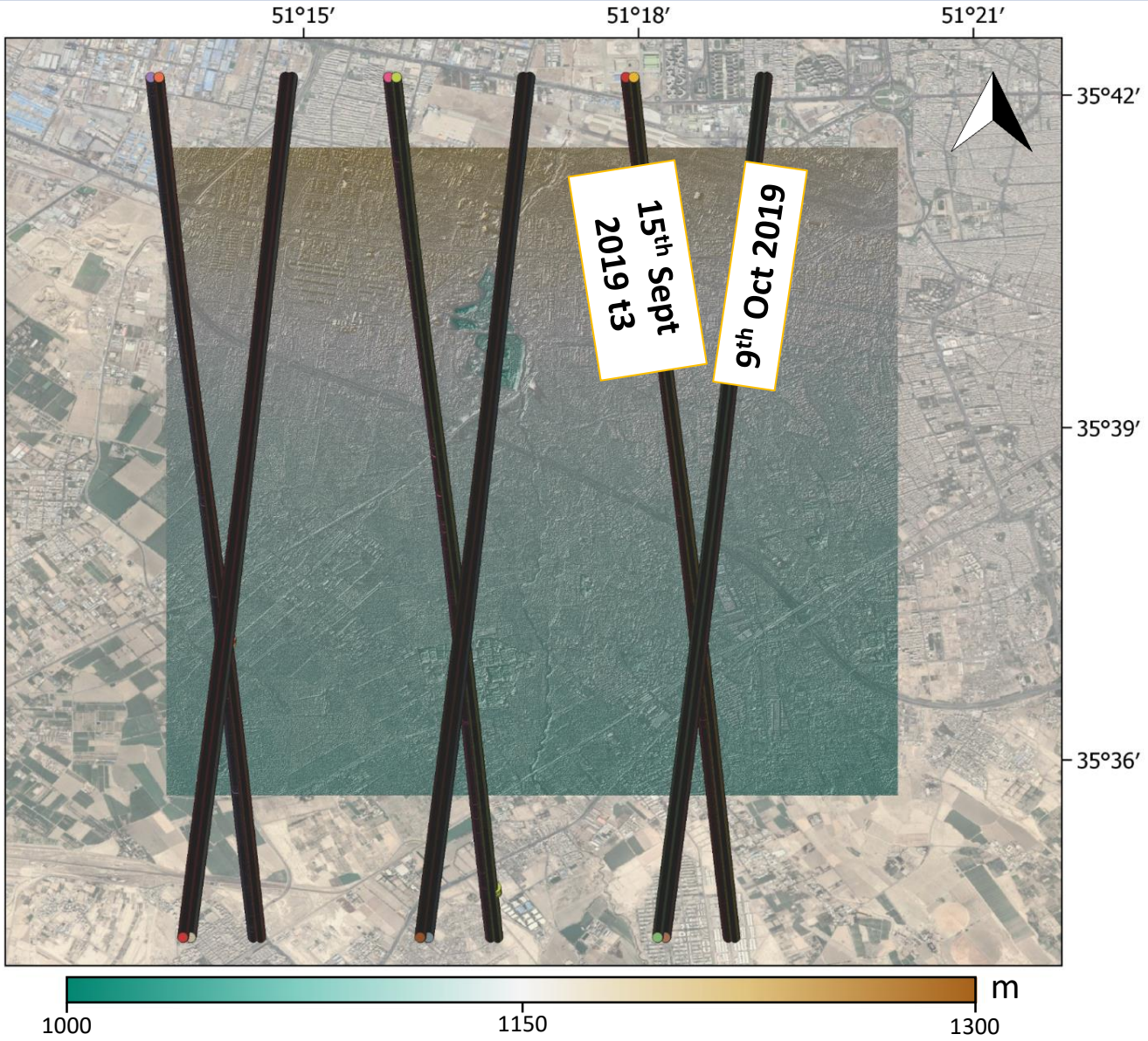

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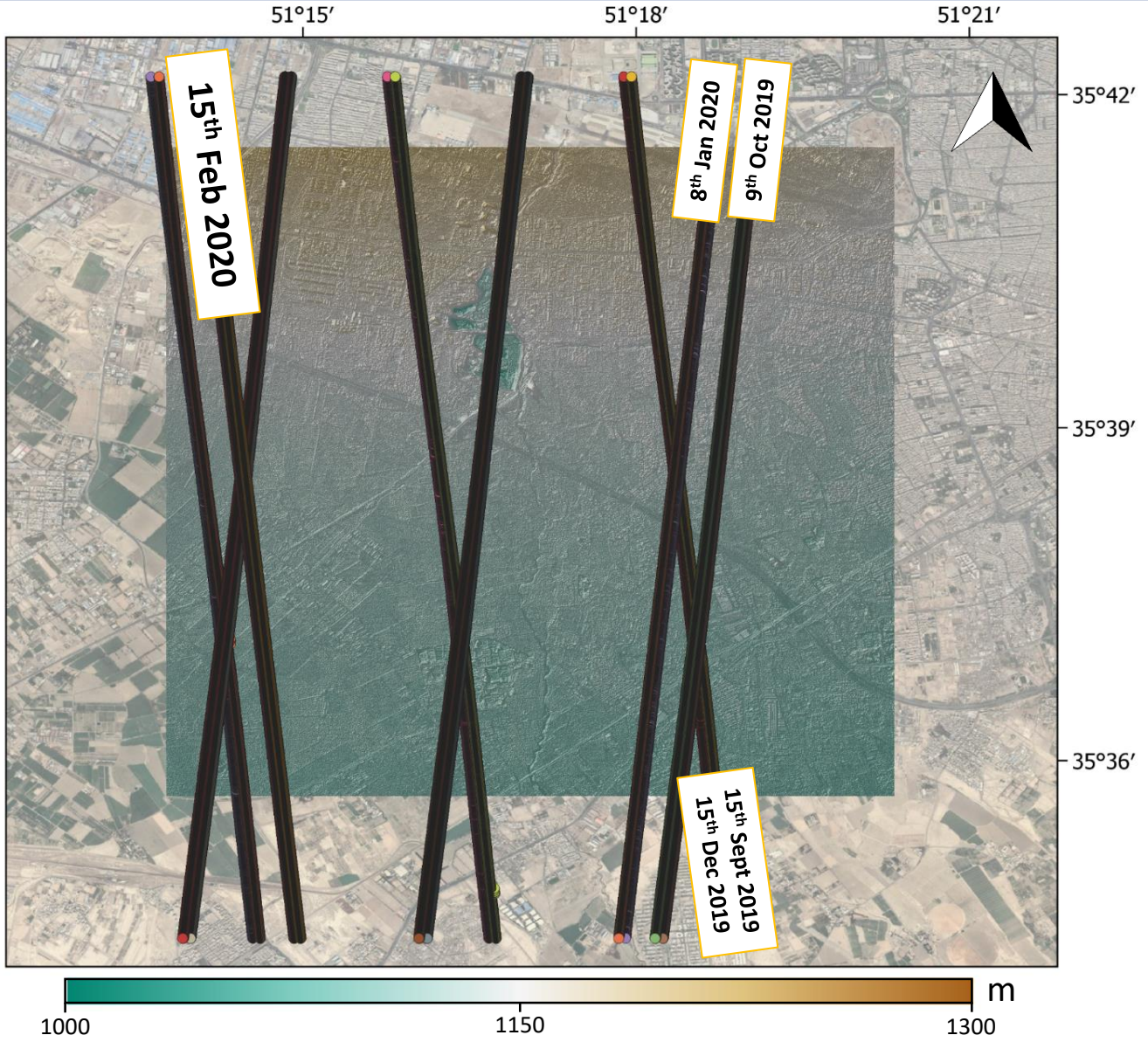
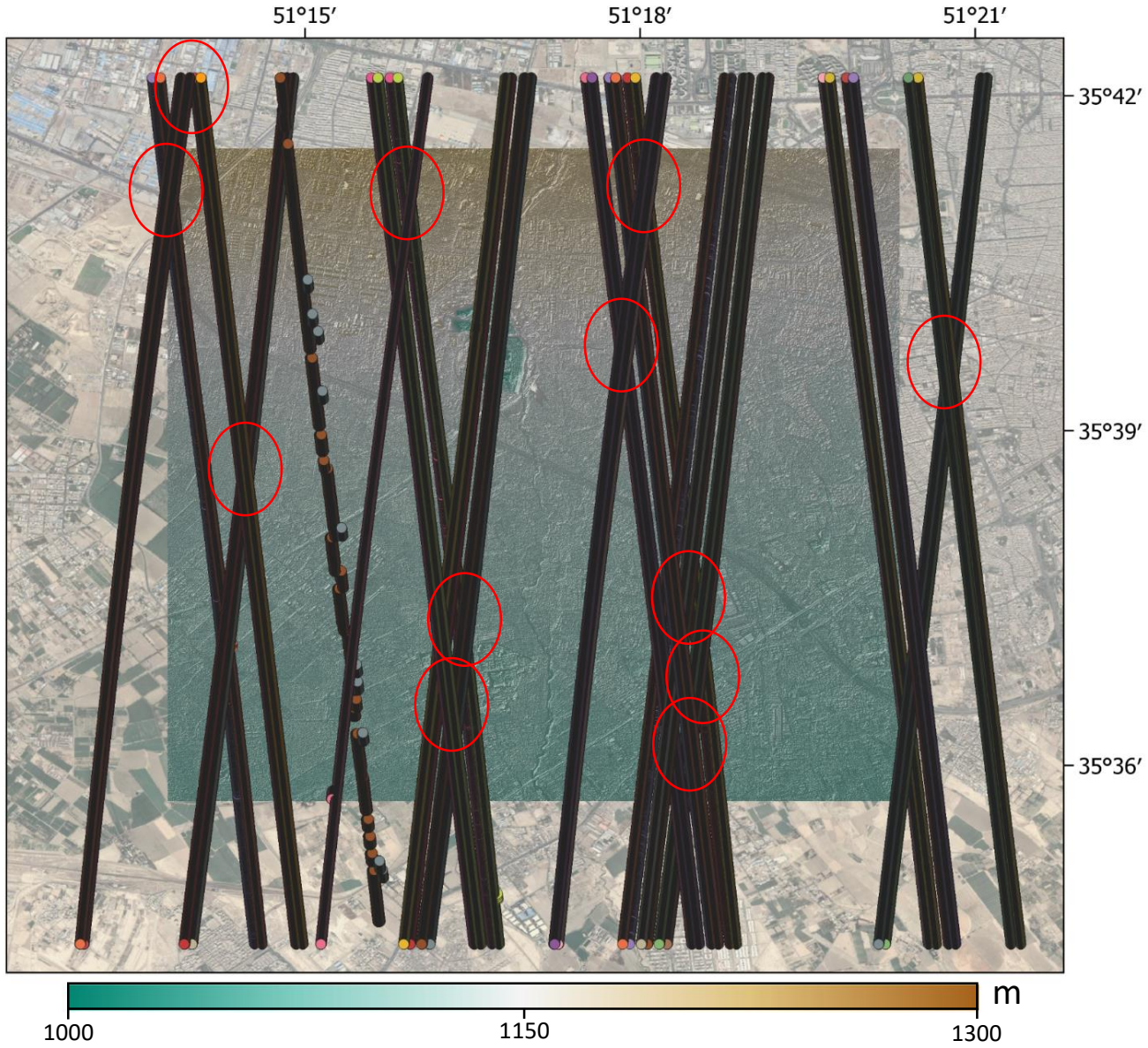


3. Validating InSAR: ICESat-2 laser altimetry

ICESat-2 tracks: Oct 2019 – Oct 2022

Intersections >2 years



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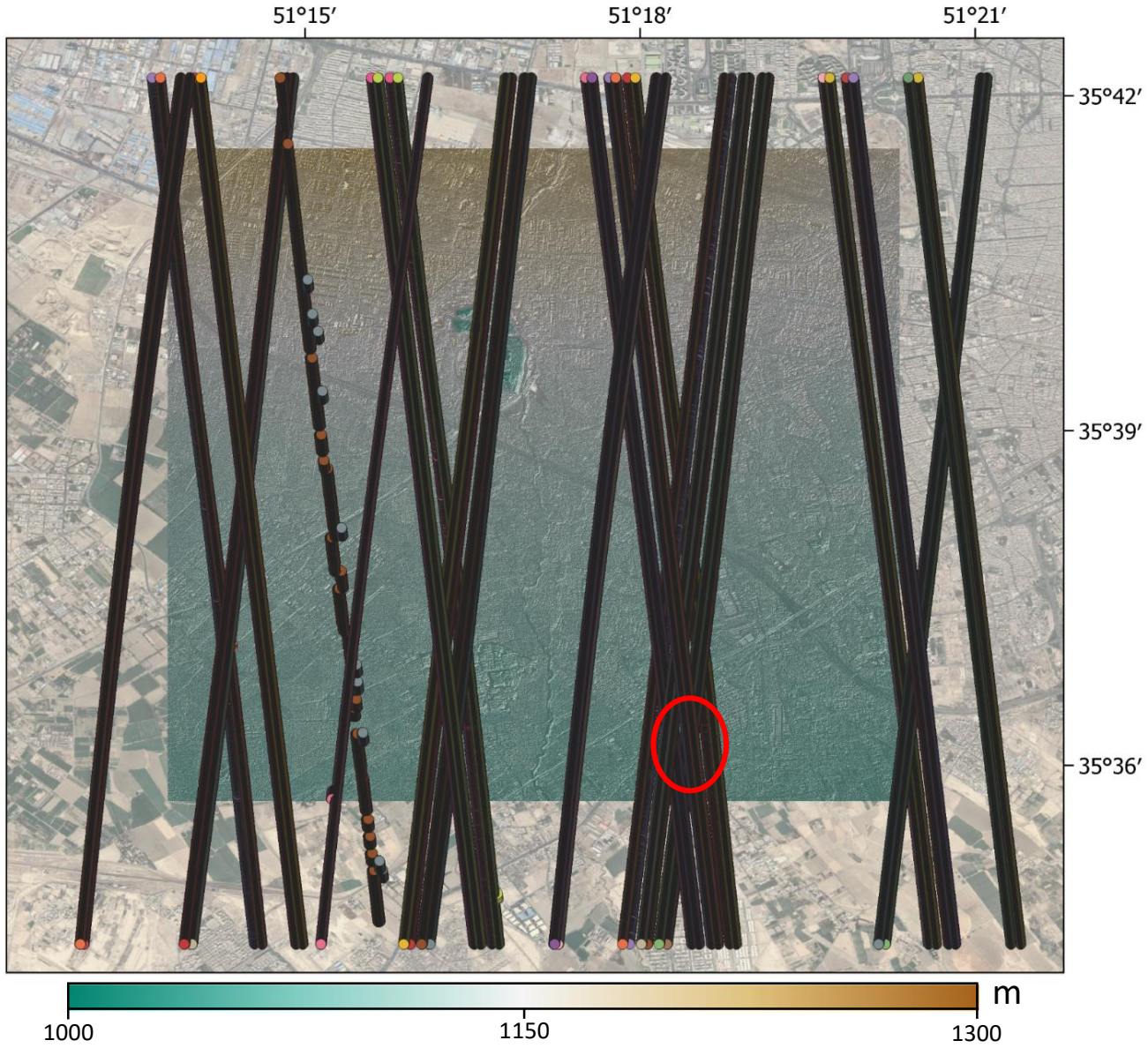

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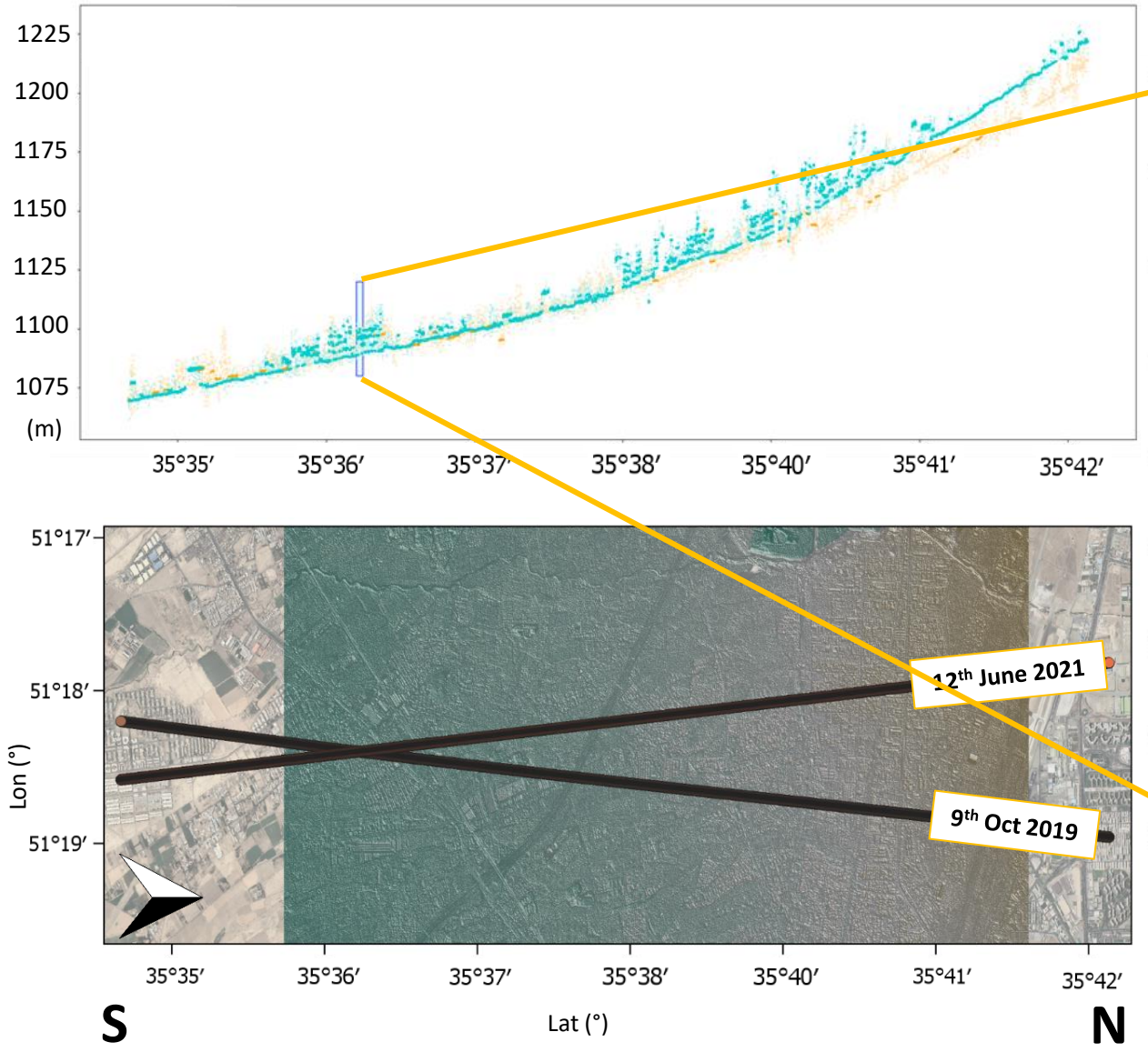
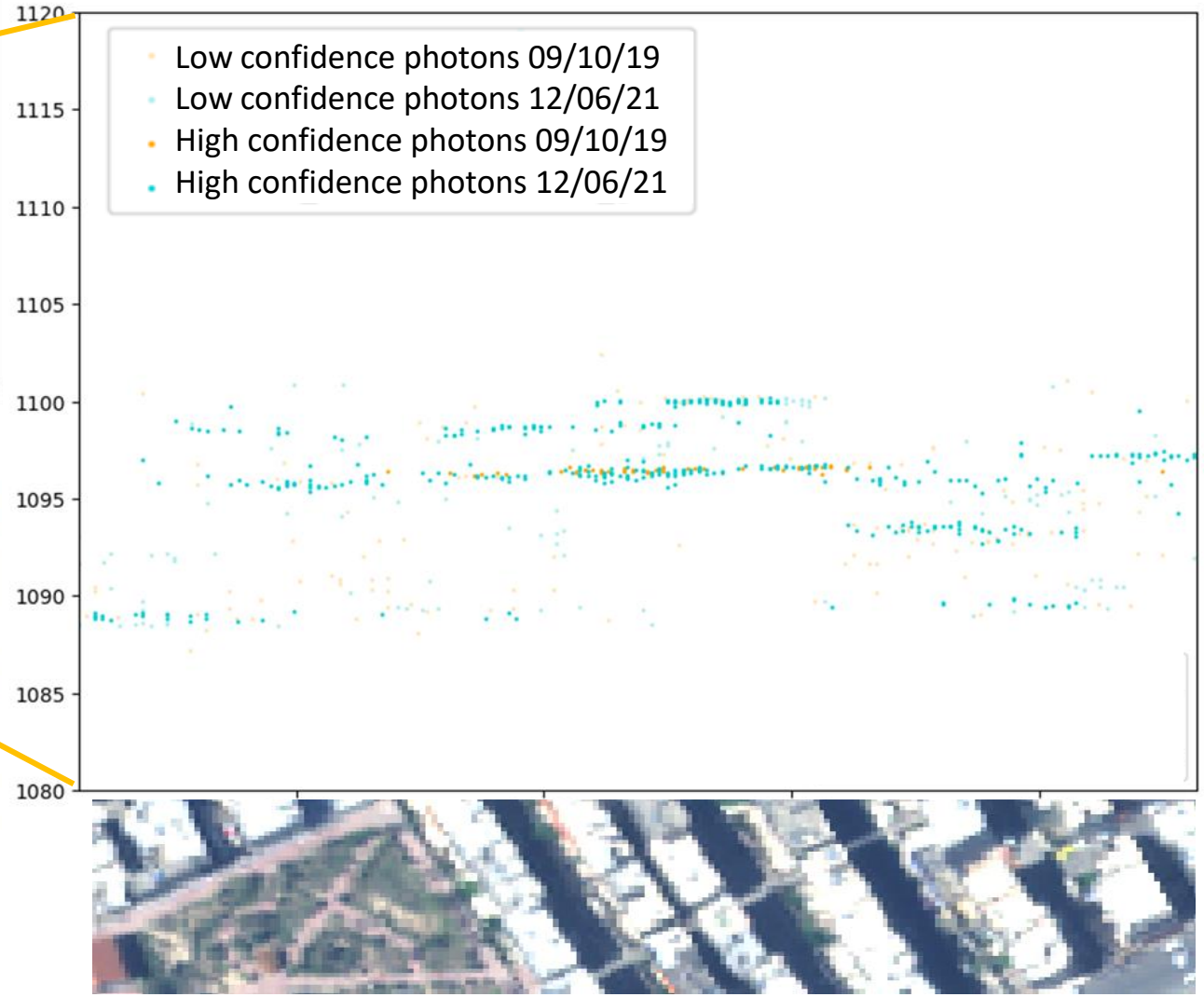
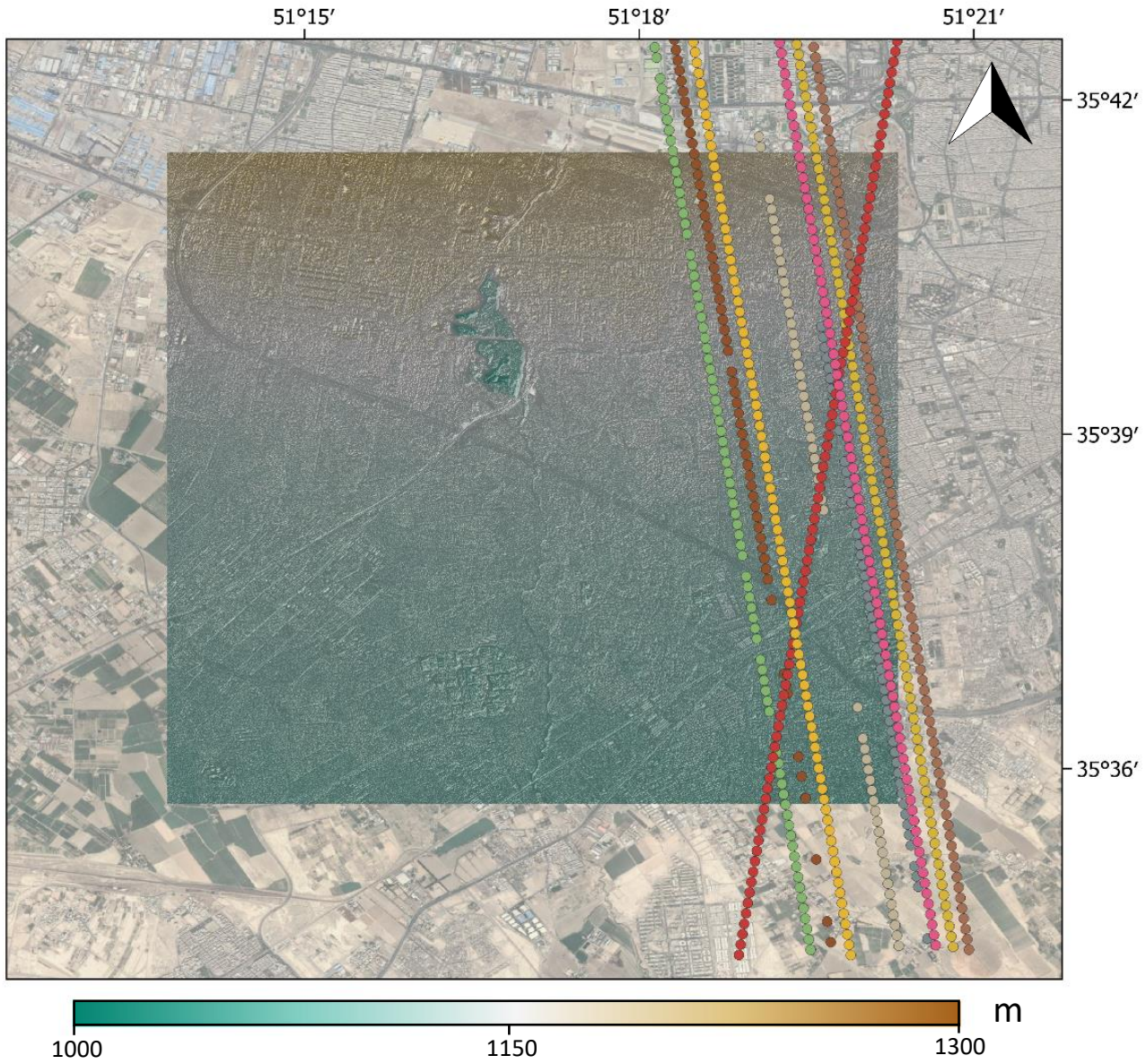


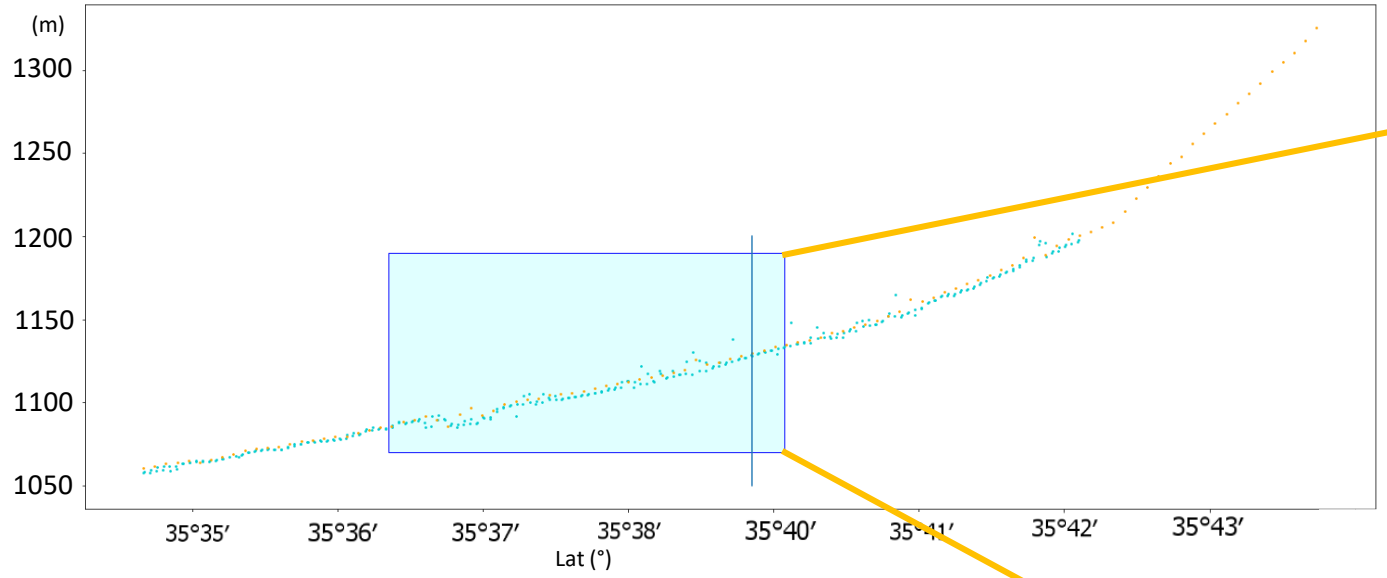


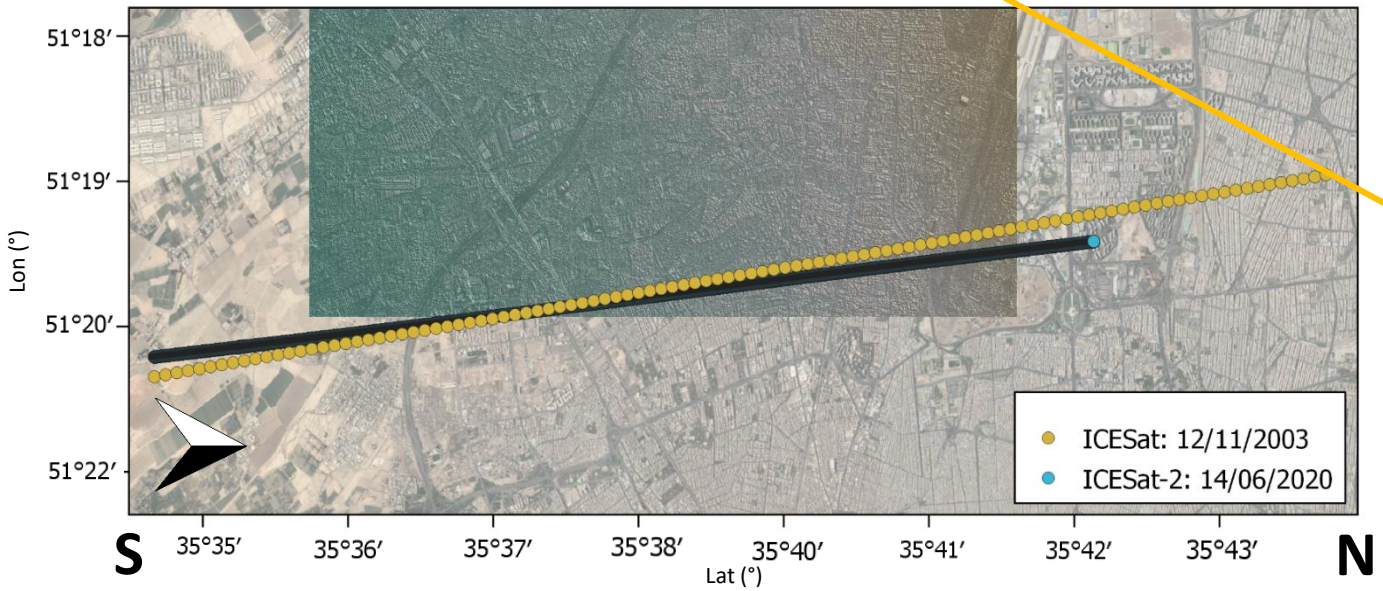
3. Validating InSAR: **ICESat** Laser altimetry

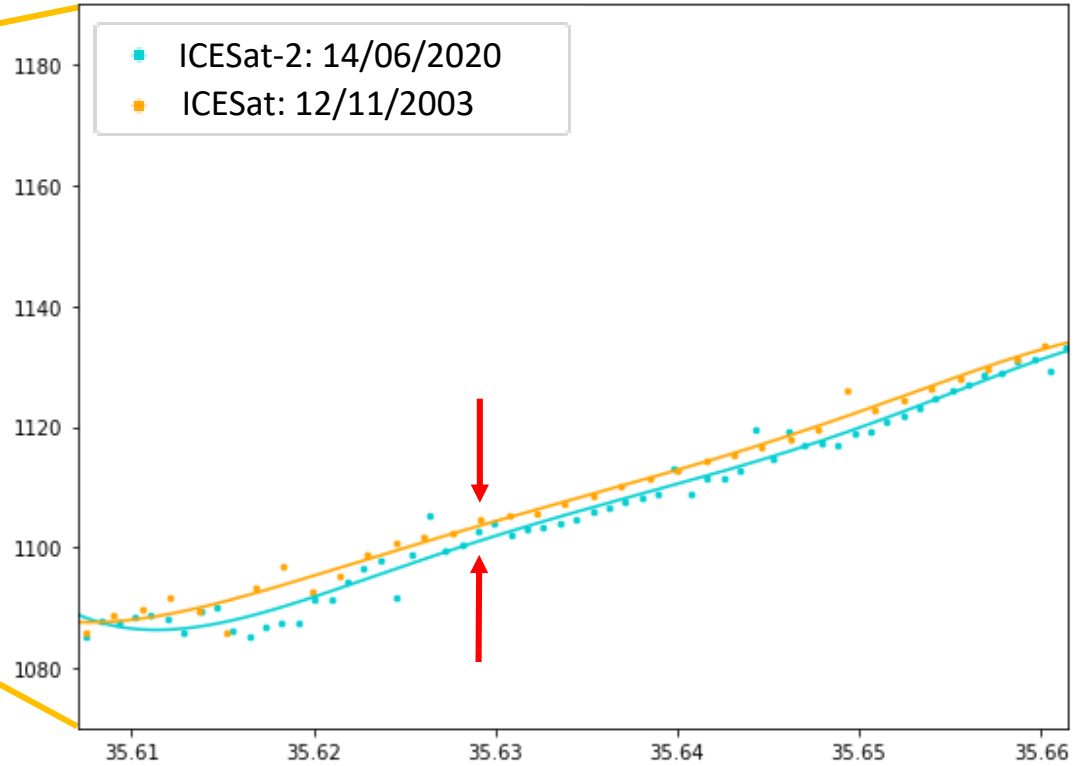


Track	Laser	Date
1241	Laser 2A	14/10/2003
326	Laser 2A	12/11/2003
326	Laser 2C	14/06/2004
326	Laser 3A	31/10/2004
326	Laser 3B	17/03/2005
326	Laser 3C	16/06/2005
326	Laser 3D	17/11/2005
326	Laser 3E	21/03/2006
326	Laser 3F	20/06/2006
326	Laser 3G	21/11/2006
326	Laser 3I	29/10/2007
326	Laser 2D	12/11/2008

3. Validating InSAR: Laser altimetry







1.5-2.5 m subsidence in 16.5 years

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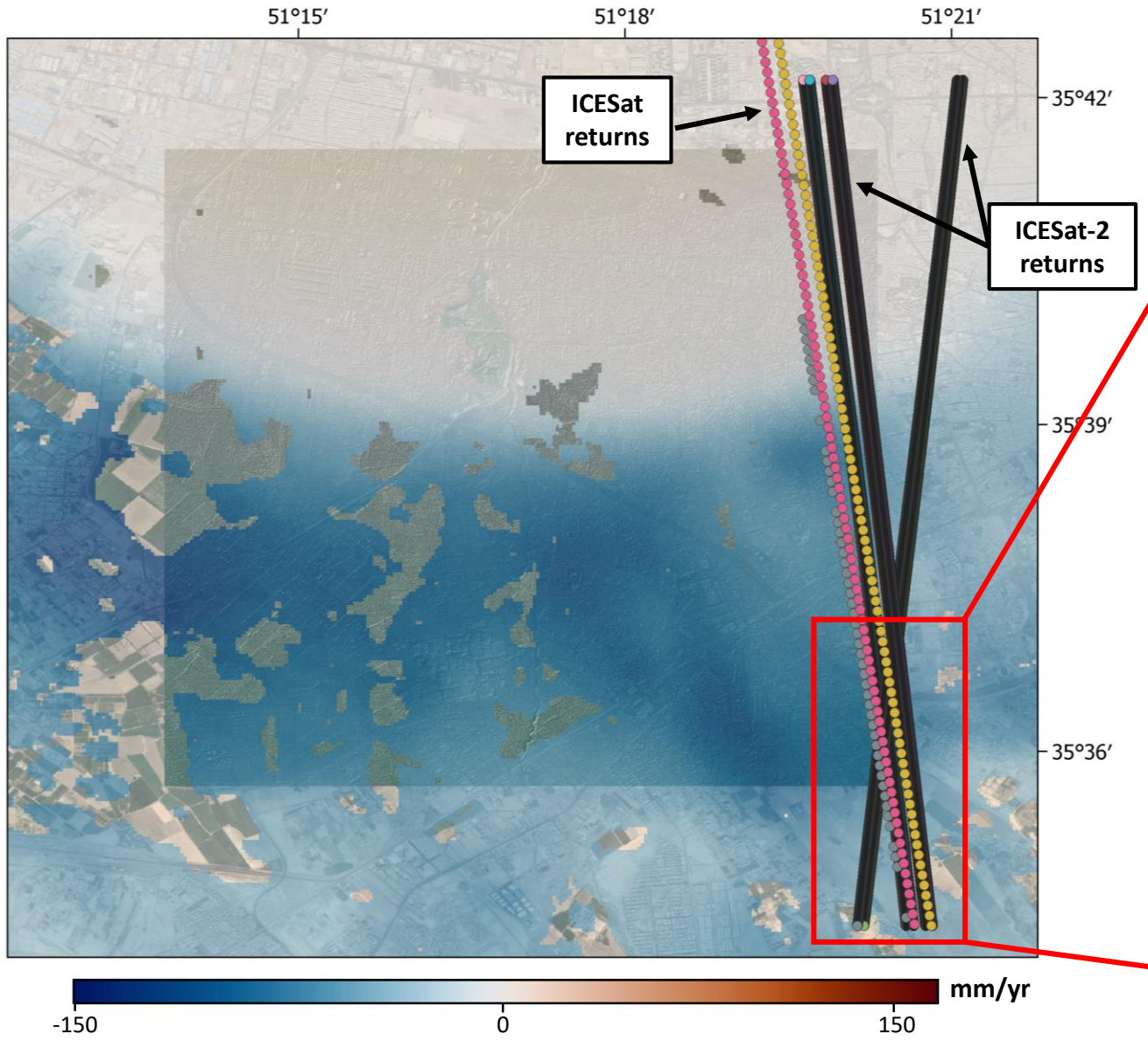

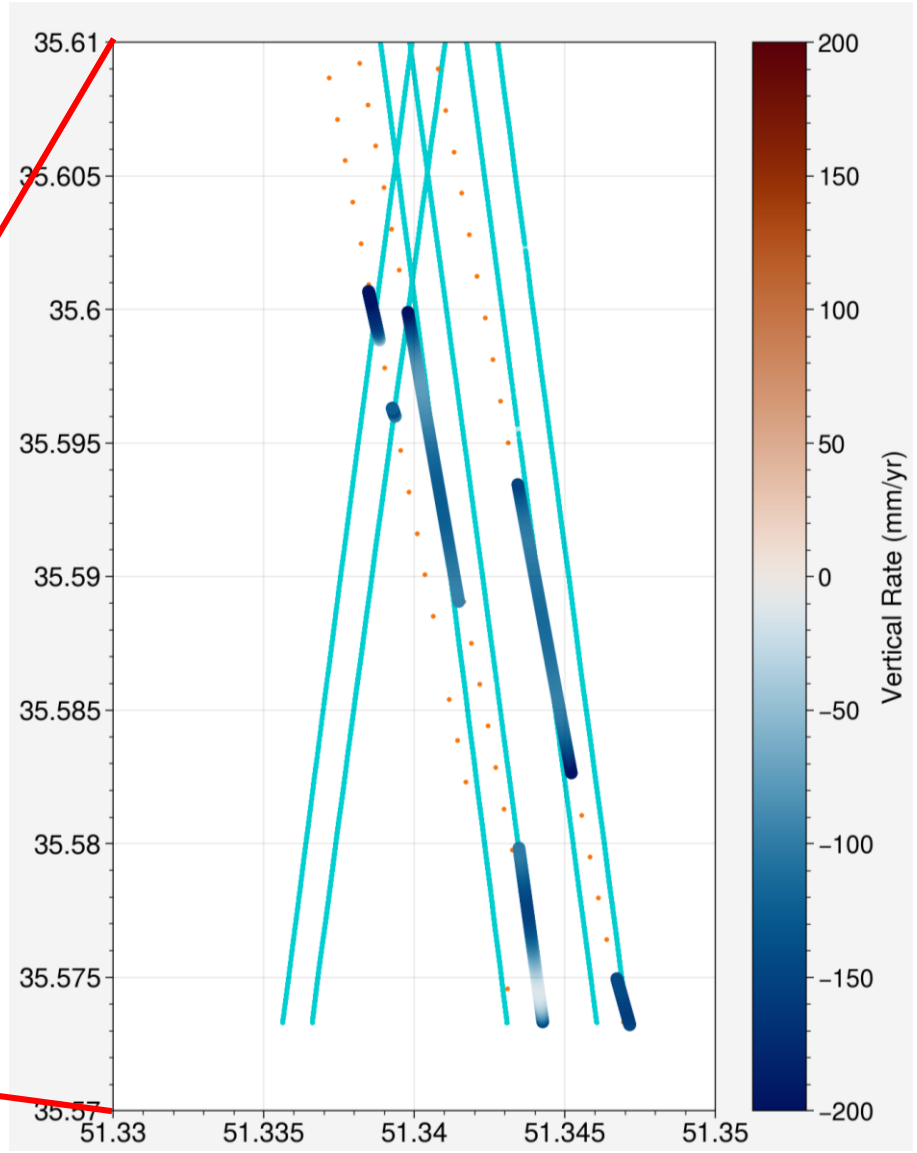

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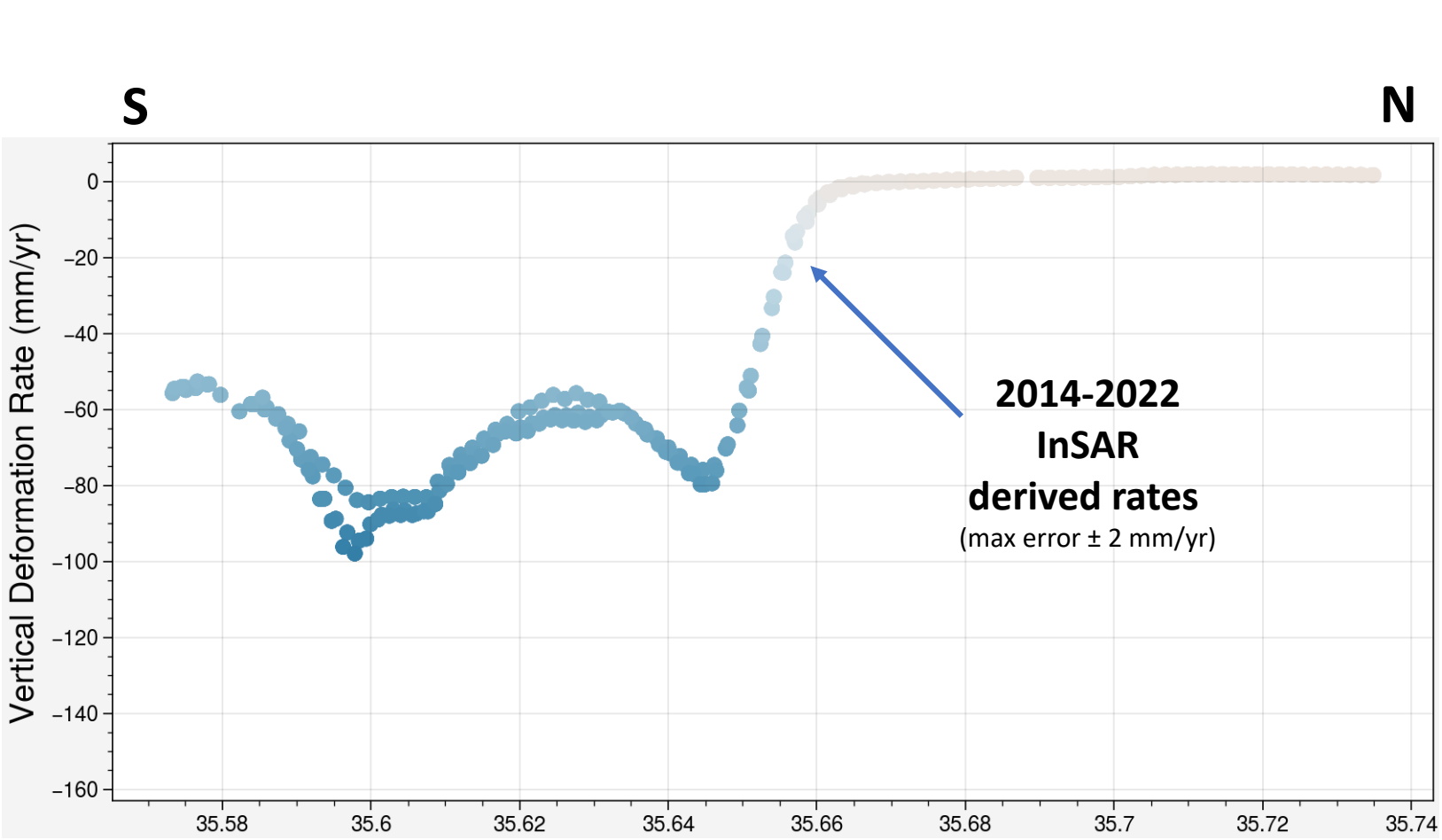

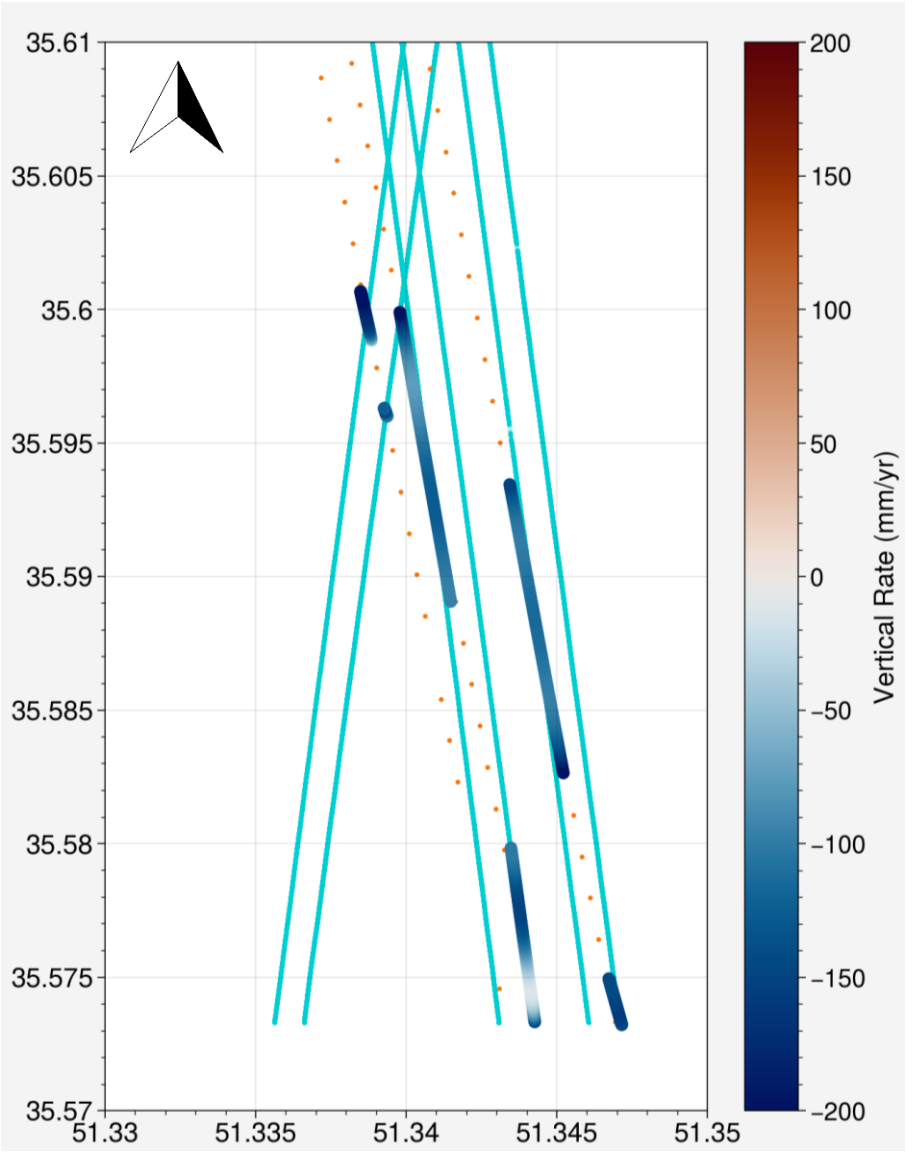

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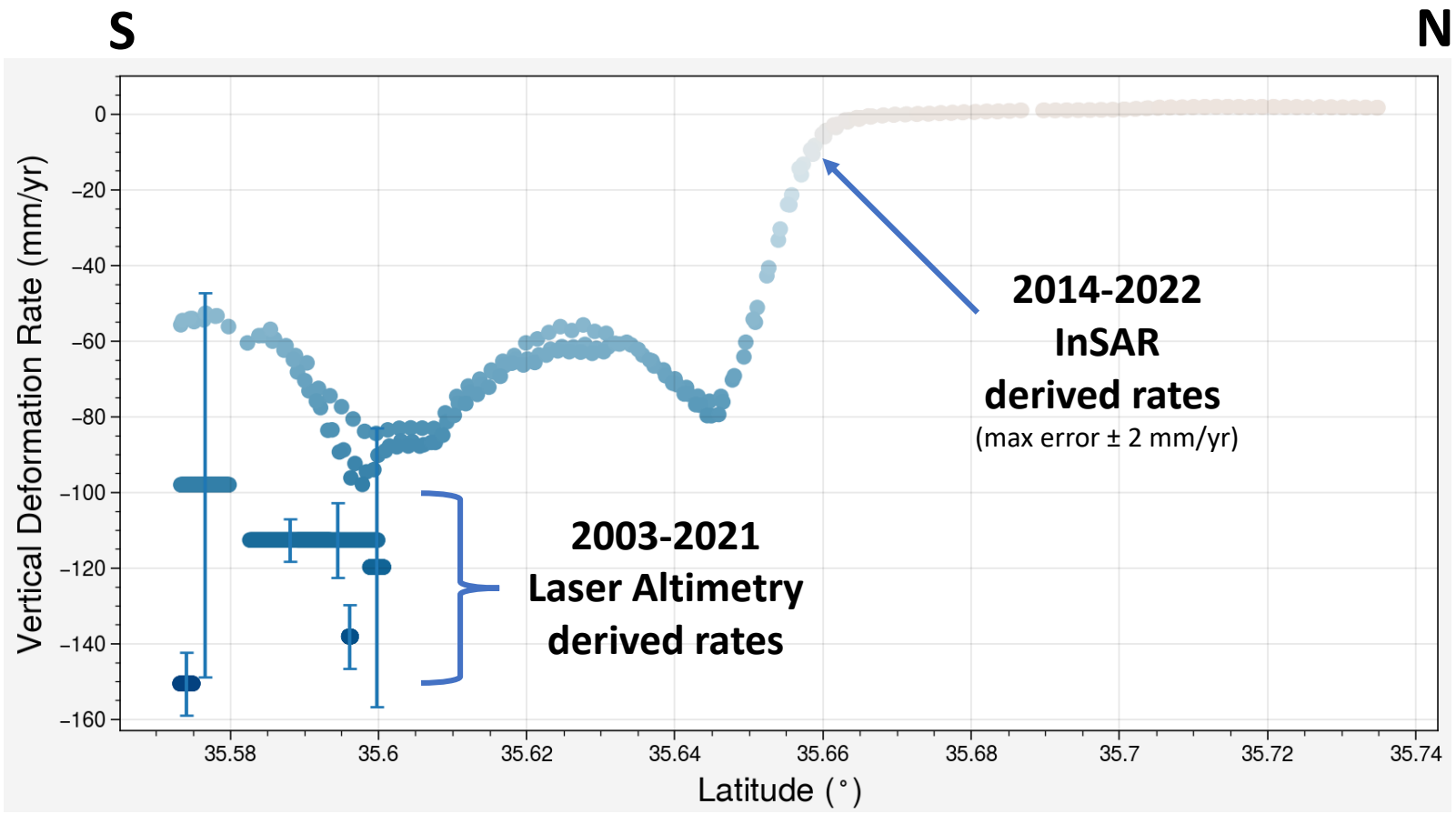

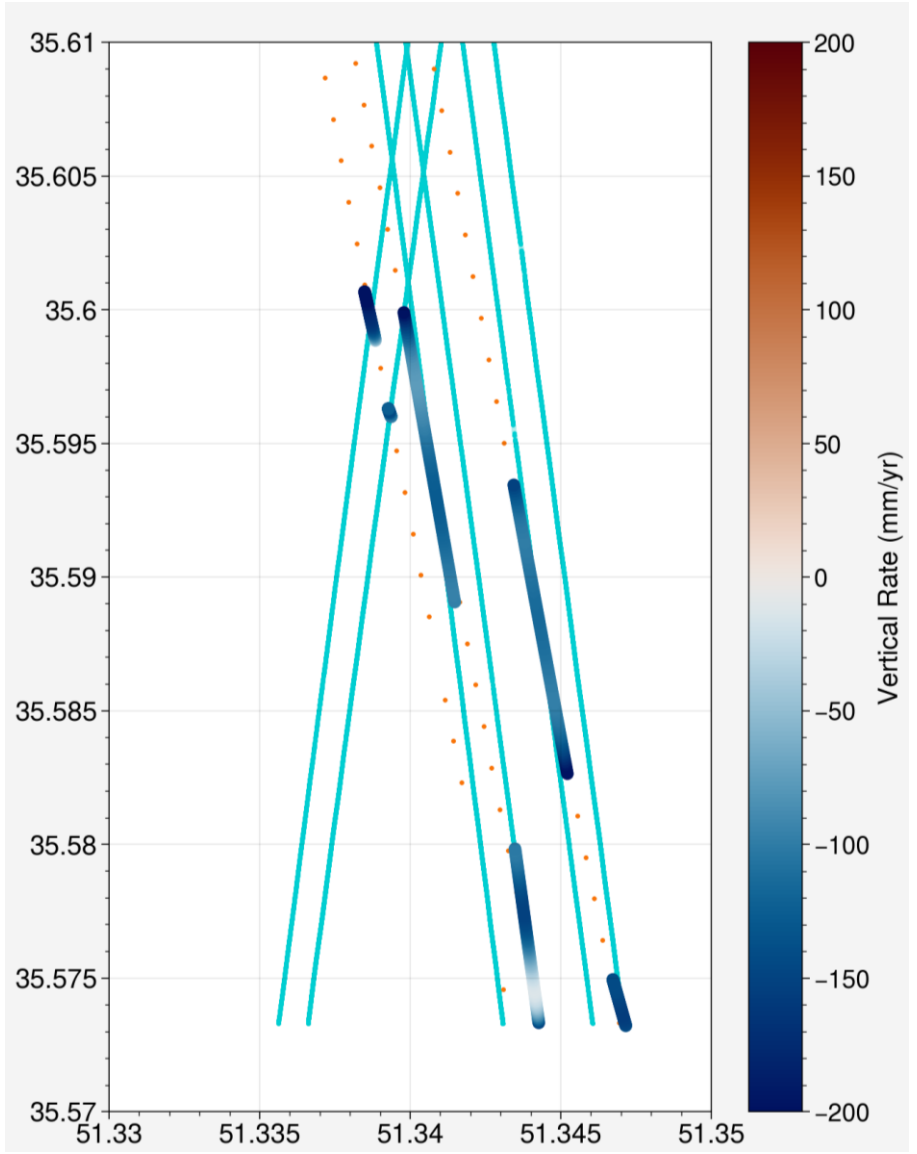

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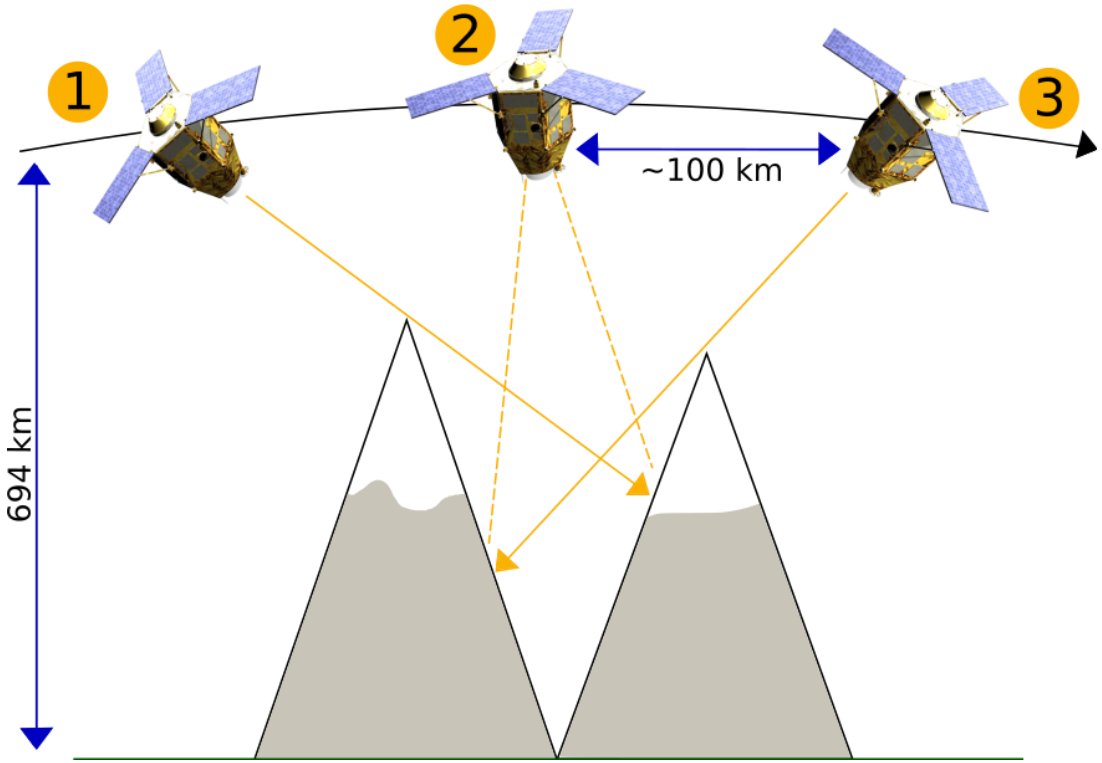

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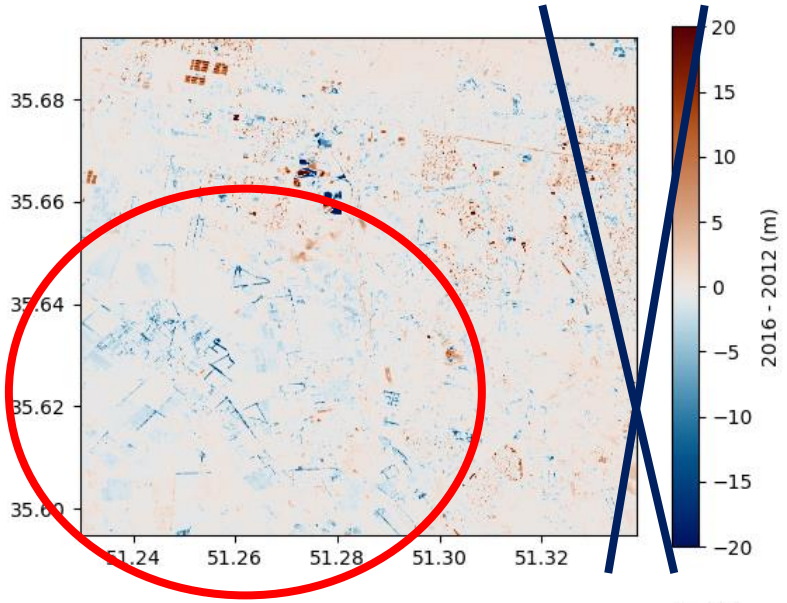

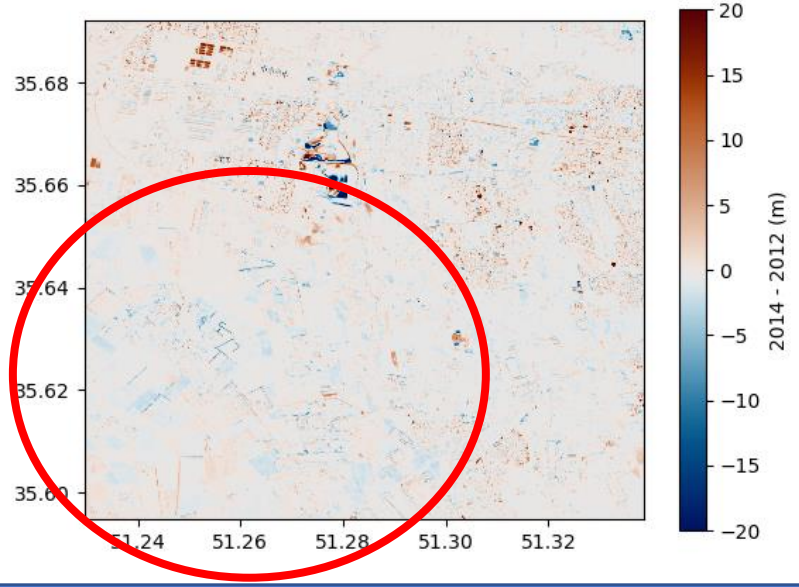

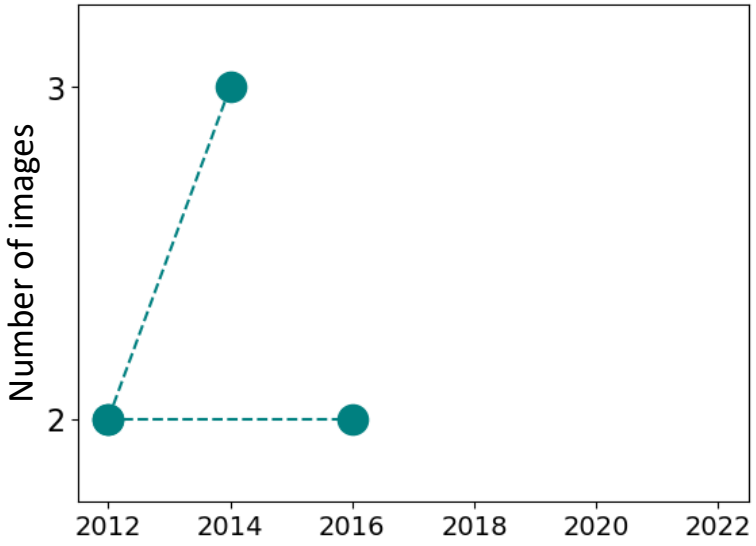

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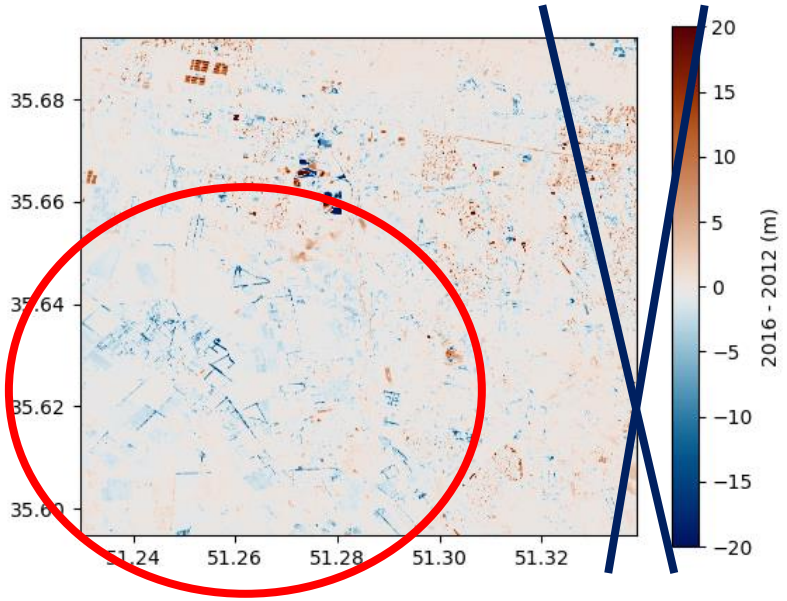
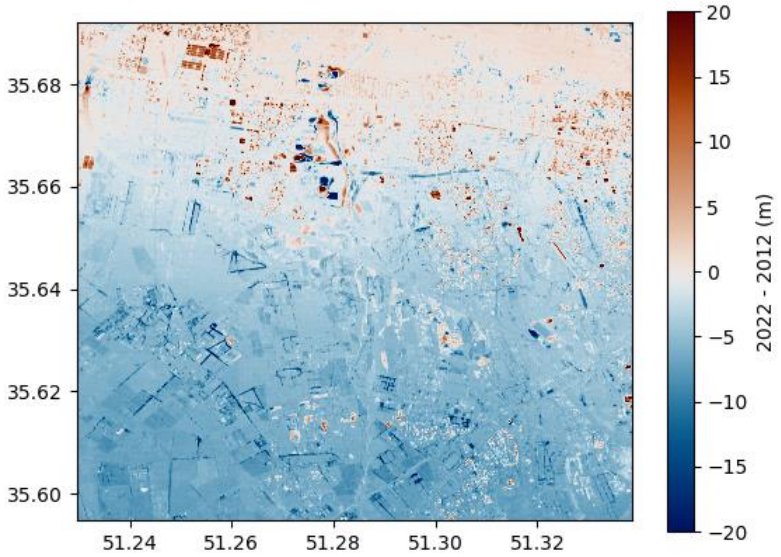
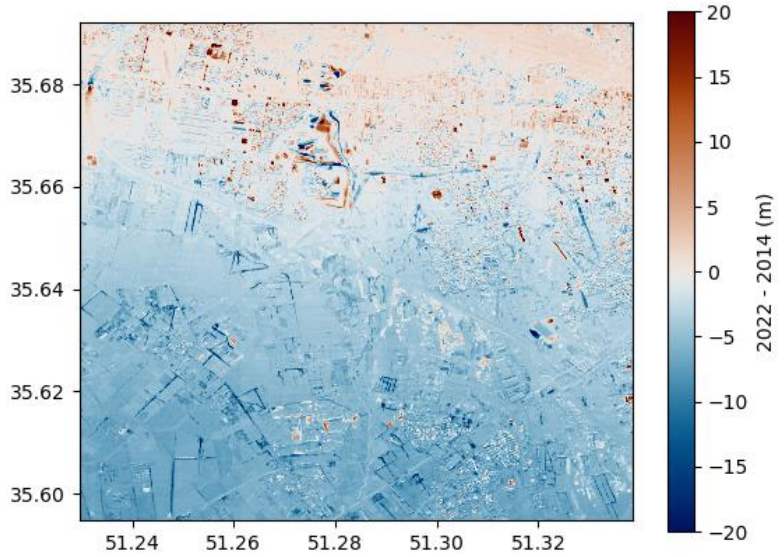
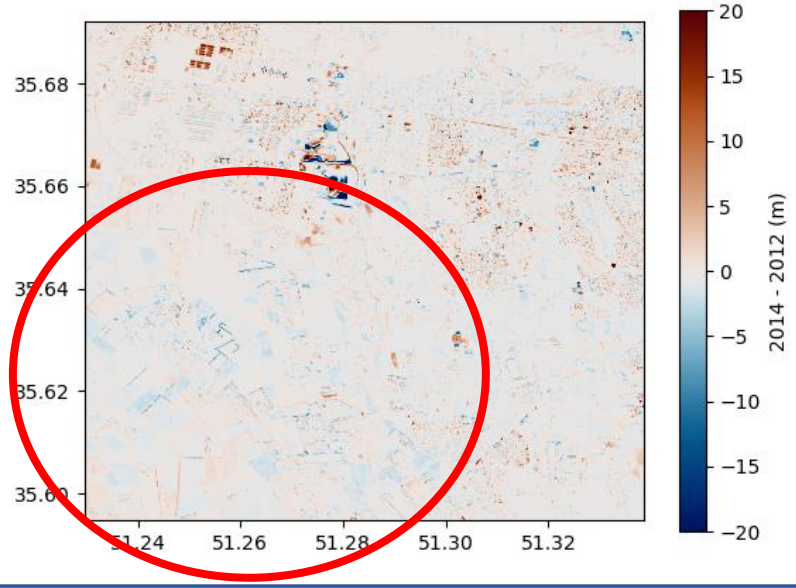
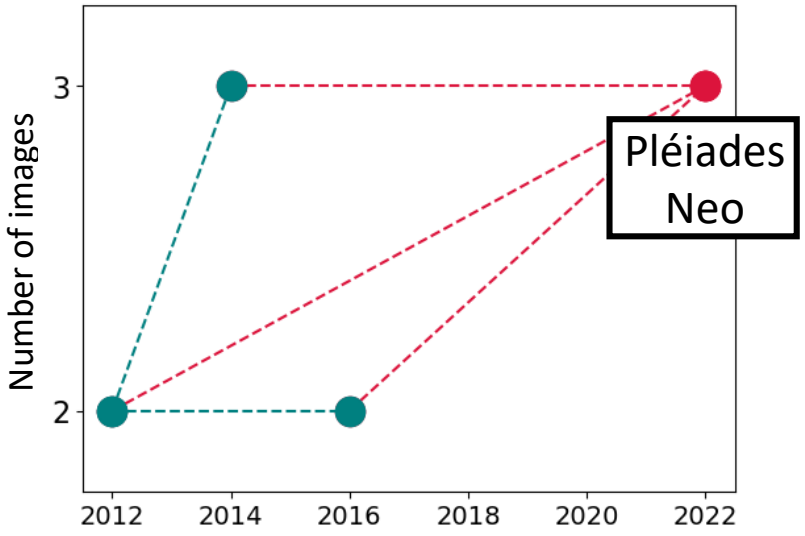
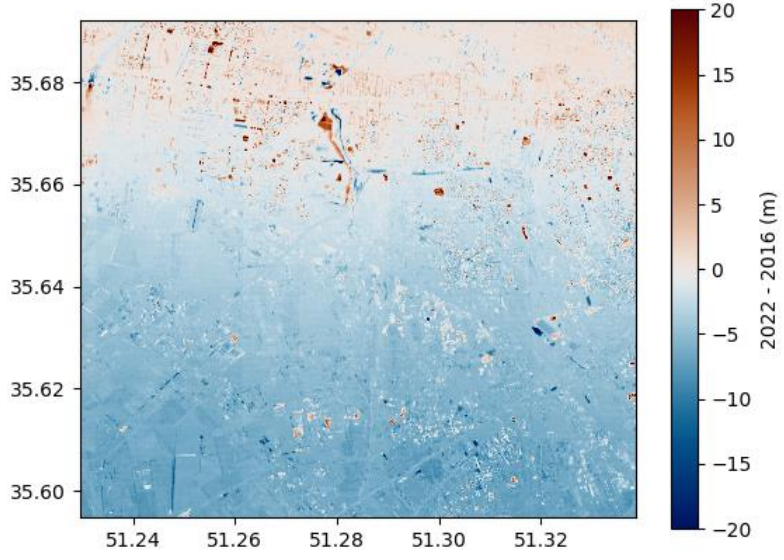










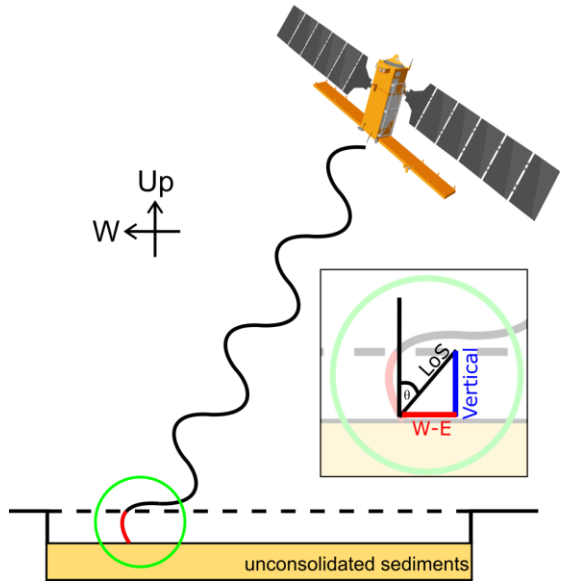


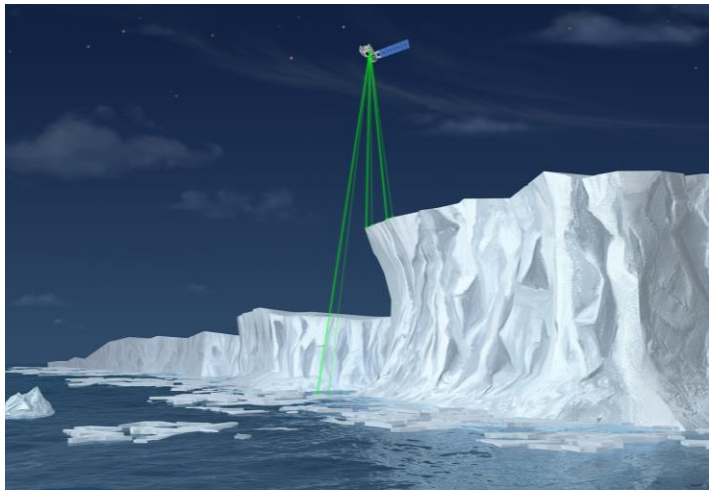
Conclusions

1. **Sentinel-1 InSAR** analysis **successfully maps subsidence** in medium resolution in low coherence areas

2. It is **challenging to systematically validate InSAR** results using laser altimetry and/or VHR DEMs

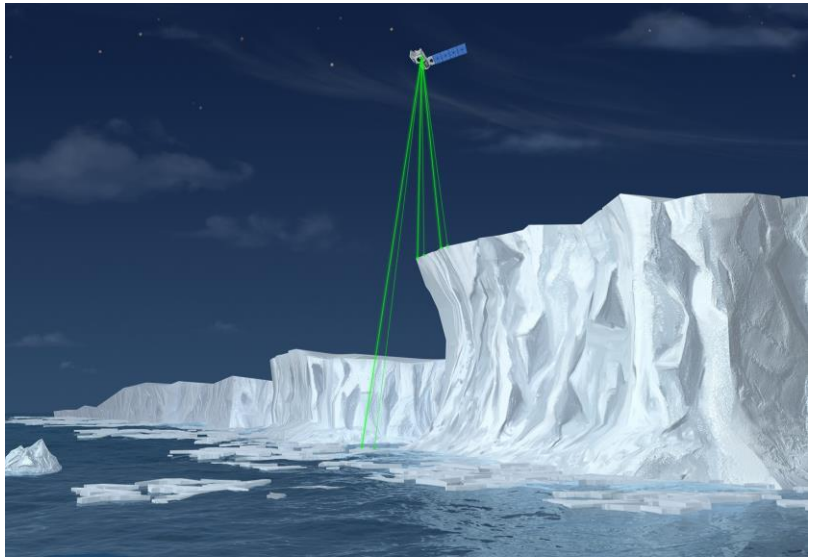
3. **Laser altimetry** only captures subsidence where **rates are fast and time-series long**

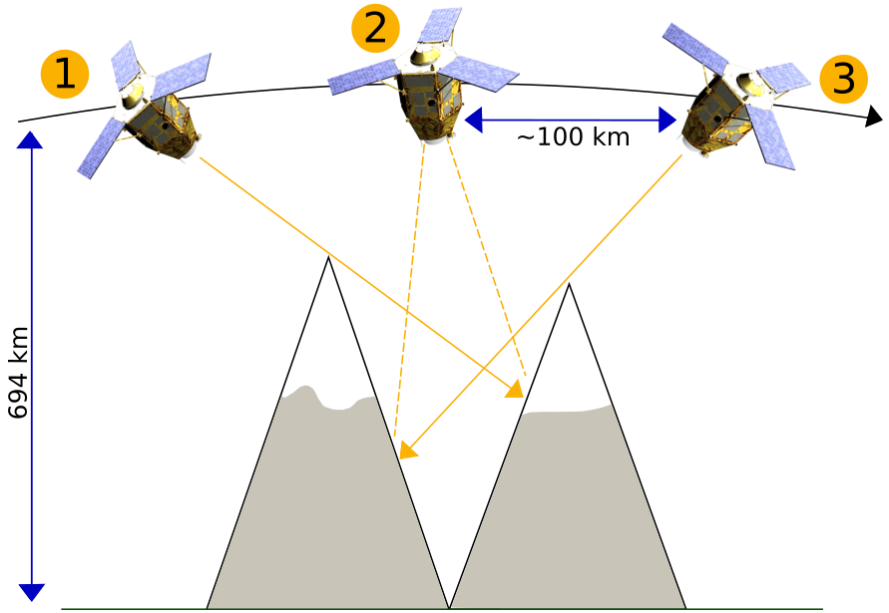




Future Work

1. Compare **DEM rates** with InSAR and laser altimetry rates
2. Check for **internal consistency of InSAR** data itself





Thank you for listening

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OSPA QR Code

Characterising Iran's rapidly subsiding regions using Earth Observation data

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