

Characterising Iran's rapidly subsiding regions using Earth Observation data

Jess Payne^{1*}

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Yasser Maghsoudi¹, Milan Lazecky¹, Richard Rigby¹, John Elliott¹



OSPA QR Code

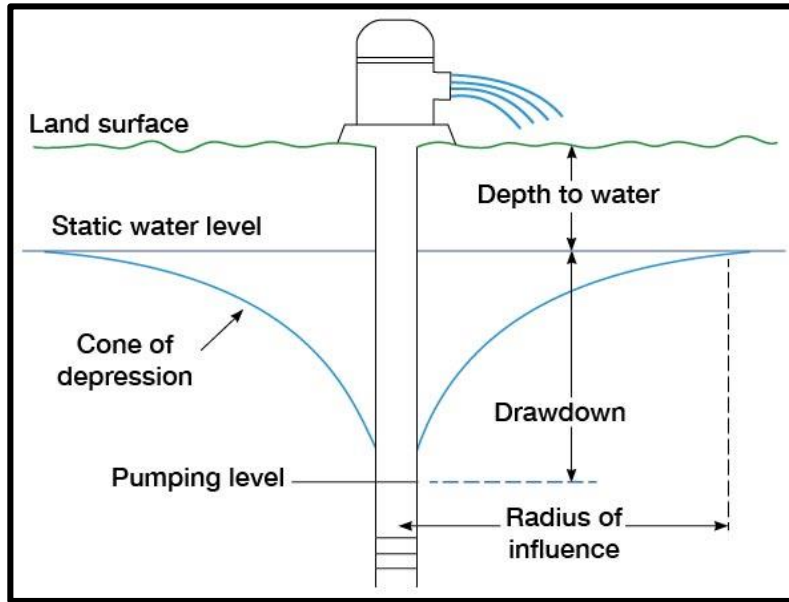
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1. Groundwater extraction and subsidence



EFFECTIVE STRESS CONCEPT

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

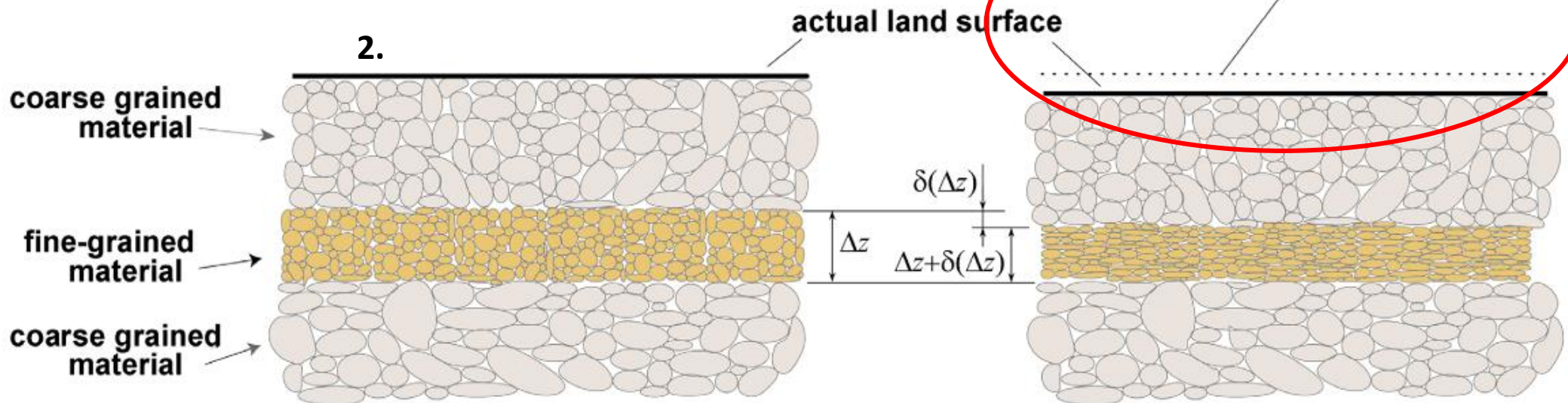
where...

σ = Total Vertical Stress

σ' = Effective Stress

u = Pore Water Pressure

Deformation due to groundwater extraction

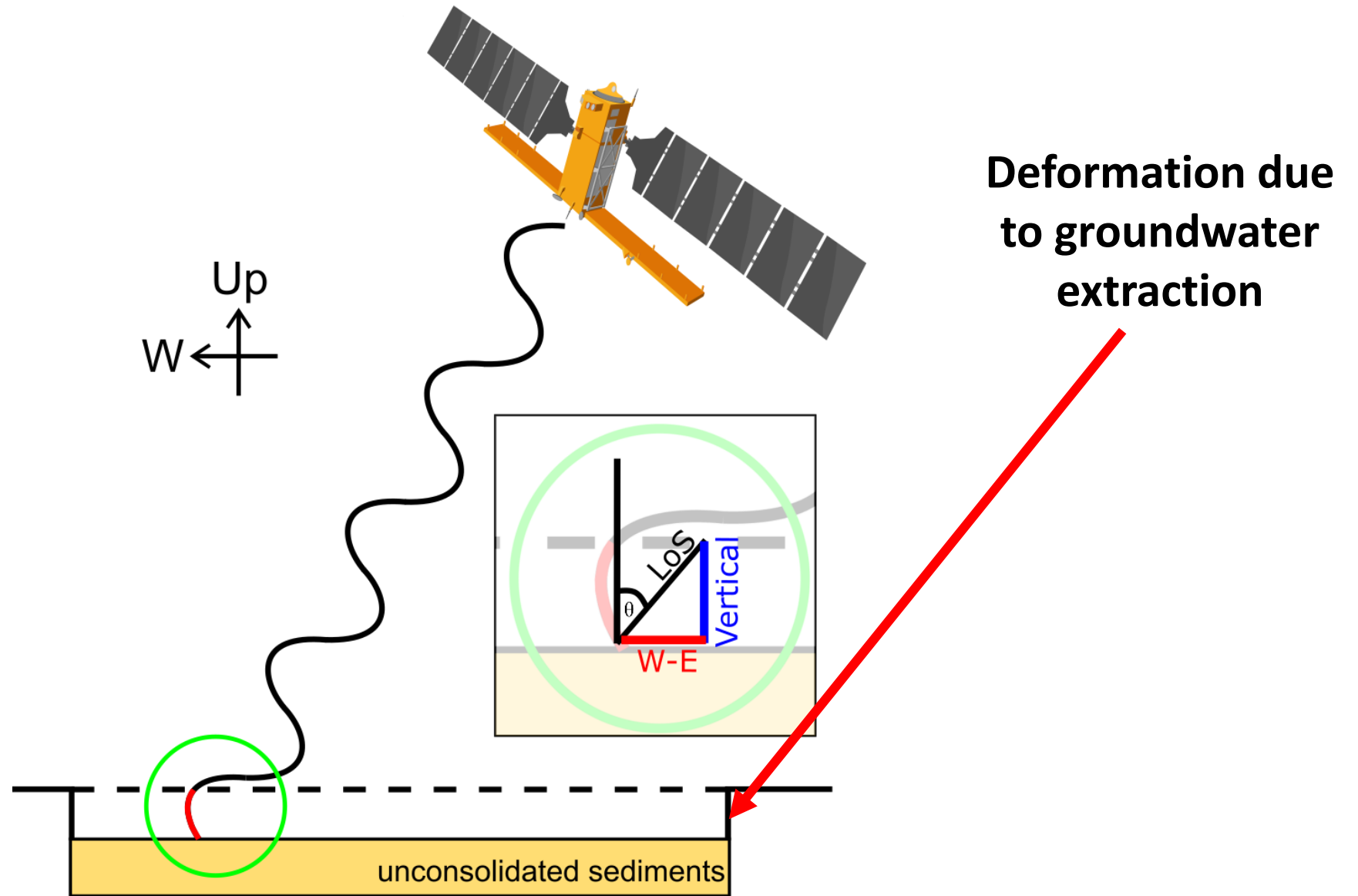


Gambolati & Teatini (2015)

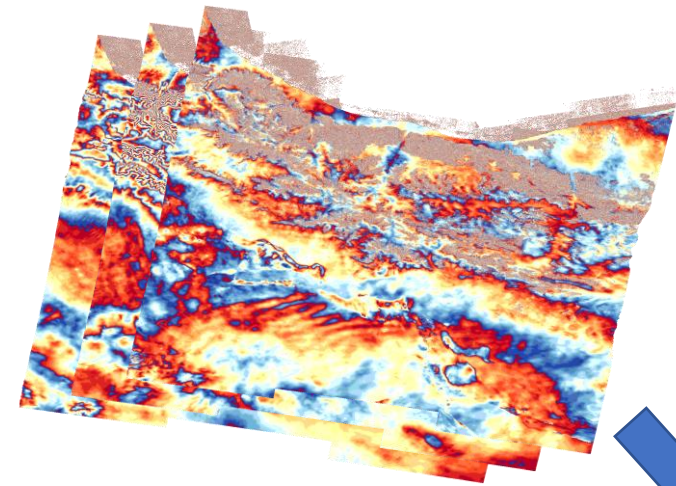
1. Groundwater extraction and subsidence

Sentinel-1:

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



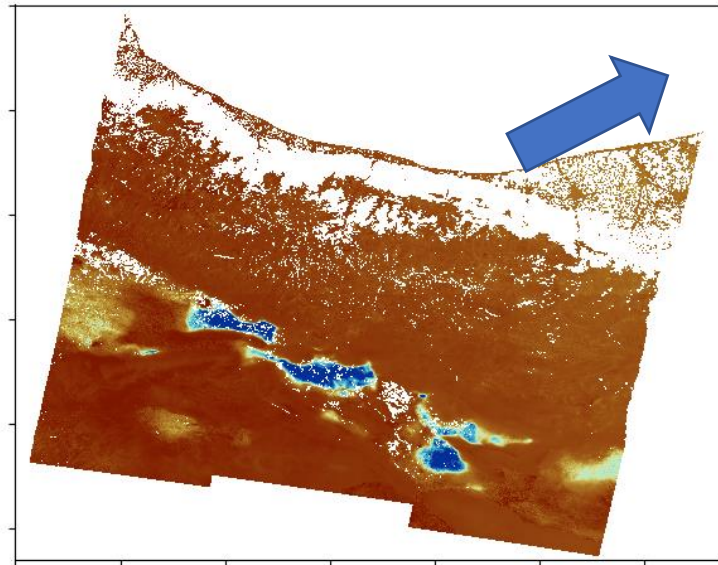
2. Calculate vertical InSAR velocities



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



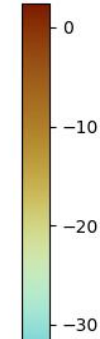
Velocity (mm/yr)



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

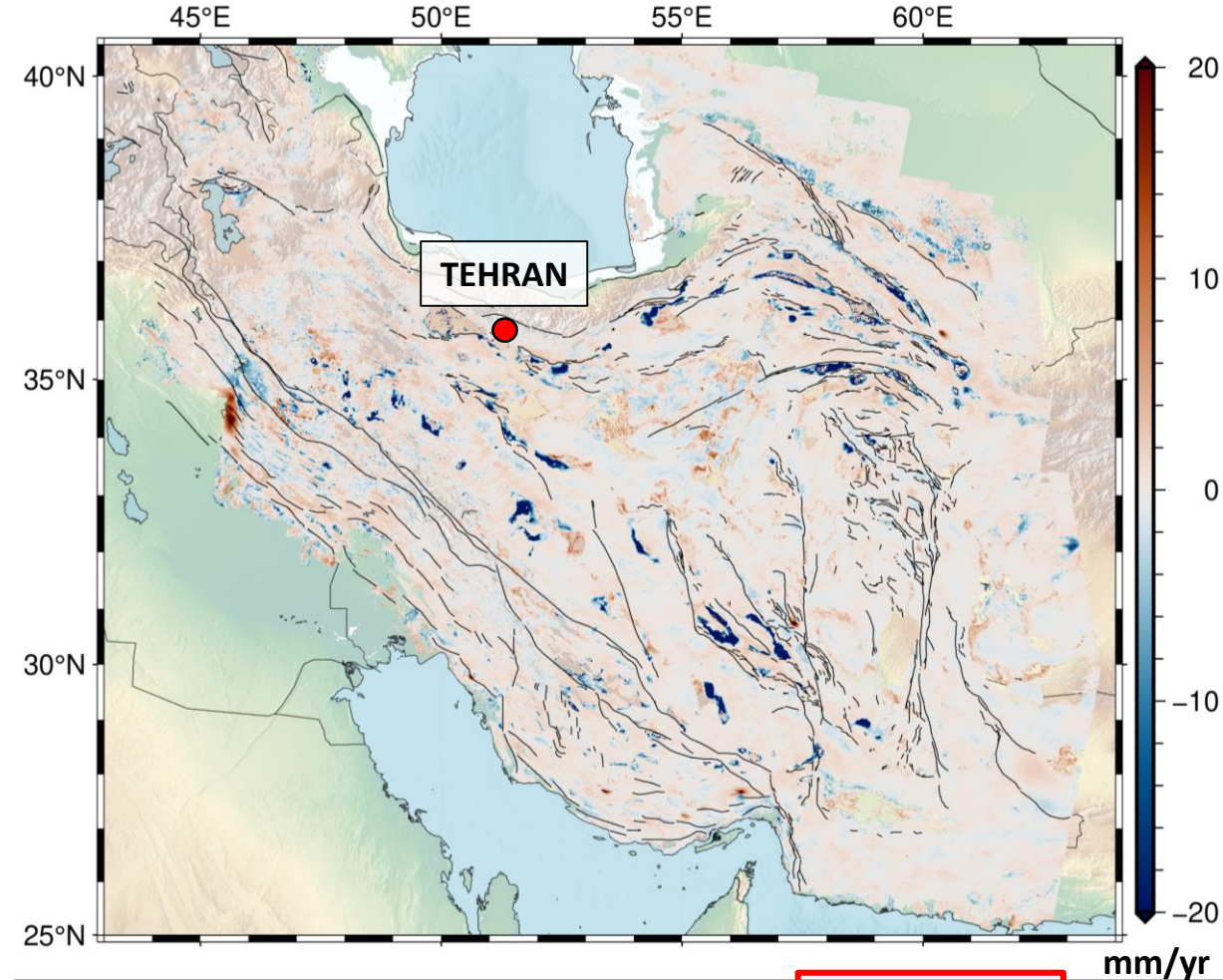


towards
satellite



mm/yr


away
from
satellite



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

G34A-06
Wed 14th
Poster

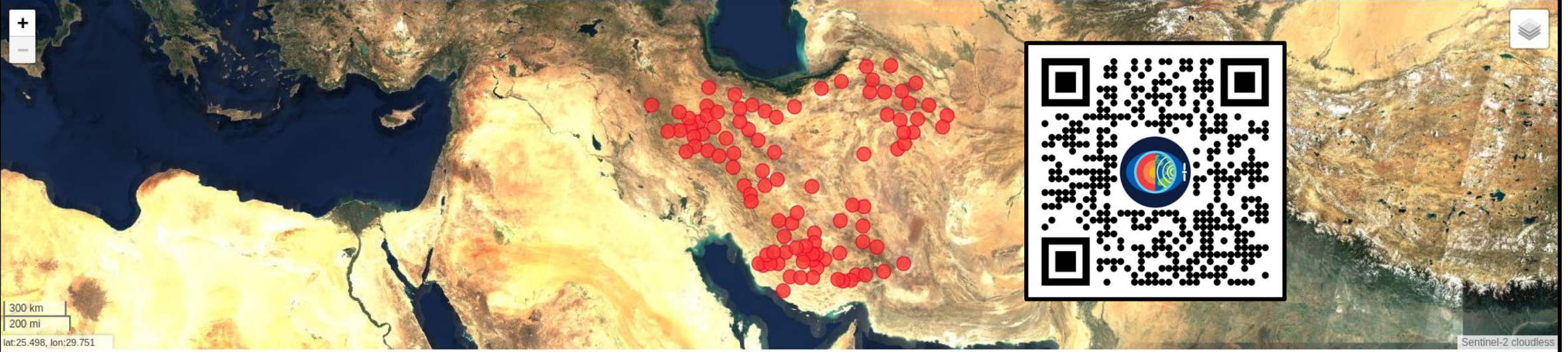
2: Calculate InSAR velocities



COMET

Subsidence Portal

Home Regions Using the Portal Technical Information Contact



Home

Welcome to the COMET-LICS Land Subsidence Portal.

The Land Subsidence Portal presents 99 subsiding regions in Iran with InSAR time-series data calculated by the automatic Looking Into Continents from Space with Synthetic Aperture Radar (Lazecký et al., 2020, LiCSAR) processing tools.

Land Subsidence Portal radar data was acquired by the European Space Agency's (ESA) [Sentinel-1](#) satellite constellation from 2015 to present. Data has a repeat time of 6-12 days and is freely available for download.

به پورتال فرونشست زمین COMET-LICS خوش آمدید.

پورتال فرونشست زمین 99 منطقه فرونشست در ایران را با داده های سری زمانی InSAR که توسط ابزار پردازش خودکار لیکسار (Lazecký et al., 2020, LiCSAR) تولید شده است، ارائه می دهد.

داده های راداری پورتال فرونشست زمین توسط سنجنده [Sentinel-1](#) آژانس فضایی اروپا (ESA) از سال 2015 تاکنون به دست آمده است. داده ها دارای زمان تکرار 6-12 روز هستند و به صورت رایگان برای دانلود در دسترس هستند.

<https://comet-subsidencedb.org/>

2: Calculate InSAR velocities

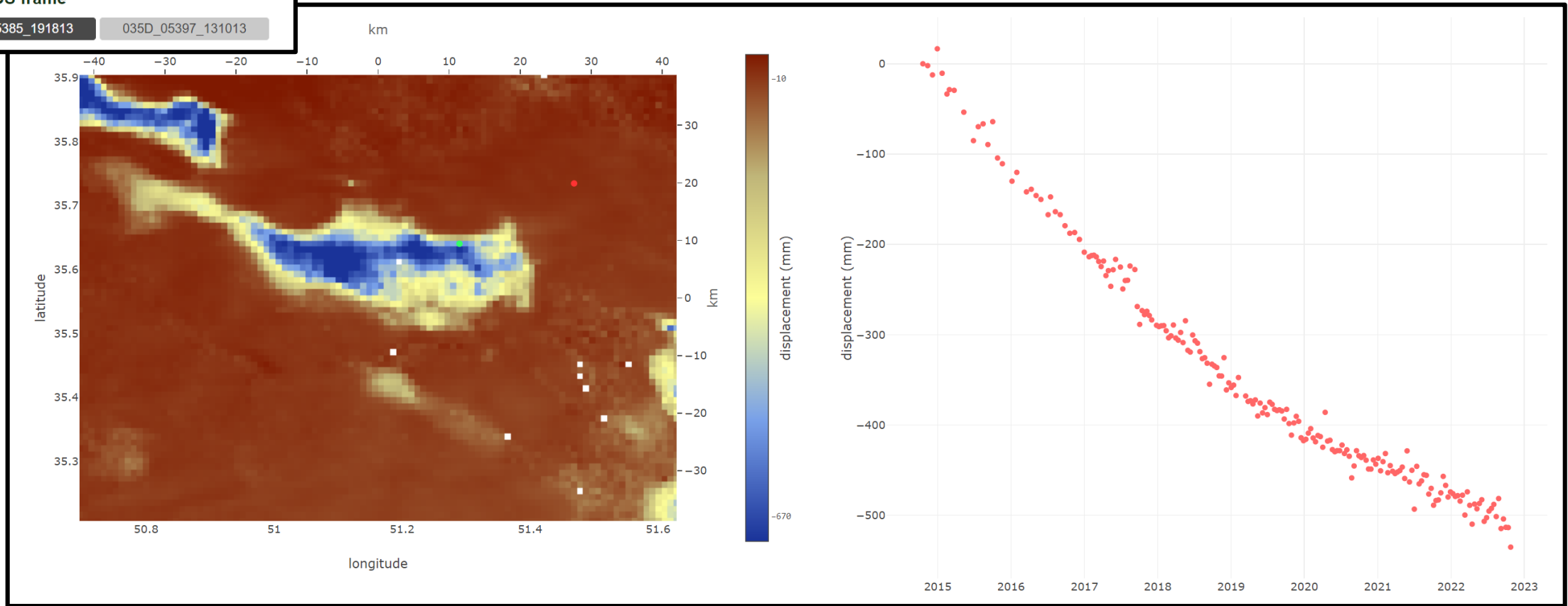
Western Tehran Plain

دشت غرب تهران

Sentinel-1 LiCS frame

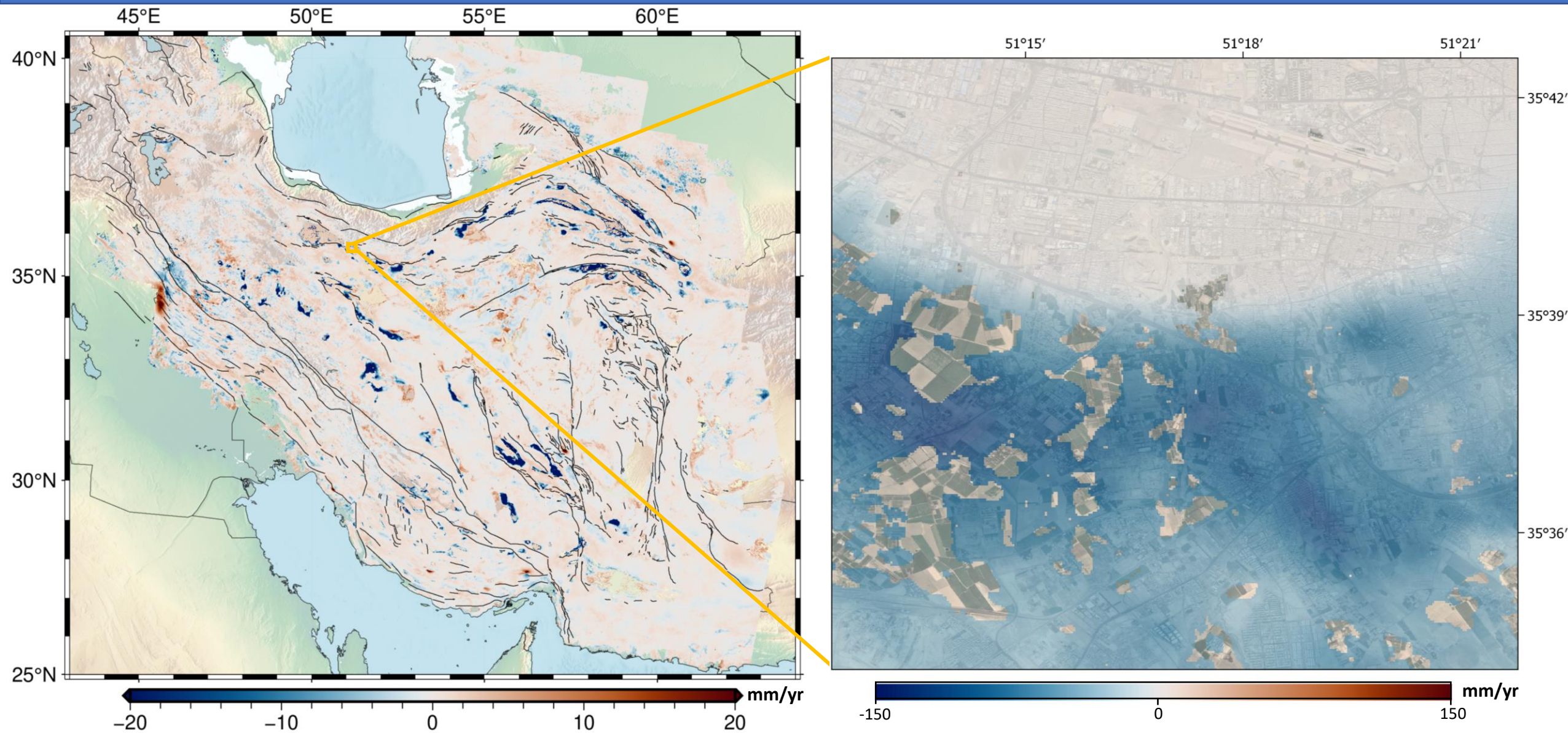
028A_05385_191813

035D_05397_131013

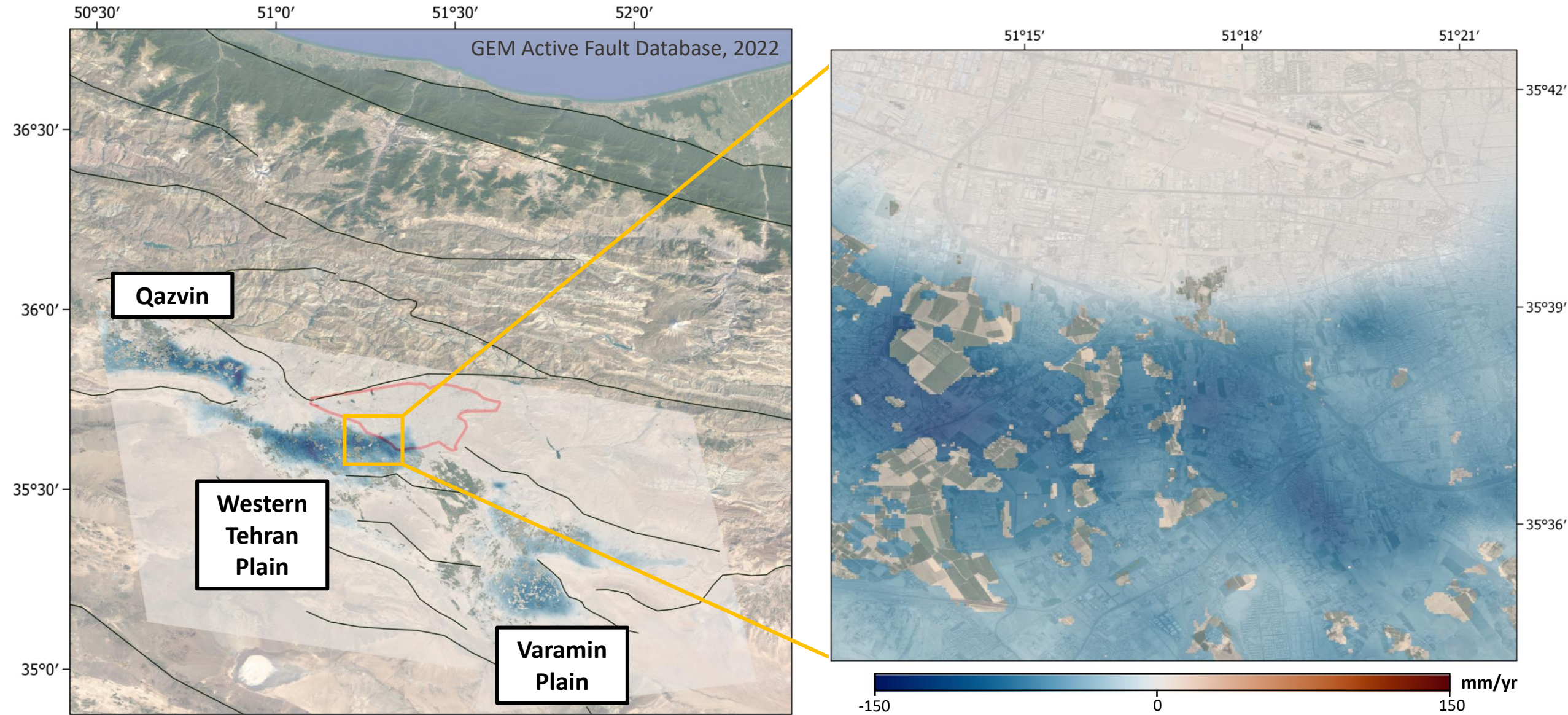


<https://comet-subsidencedb.org/>

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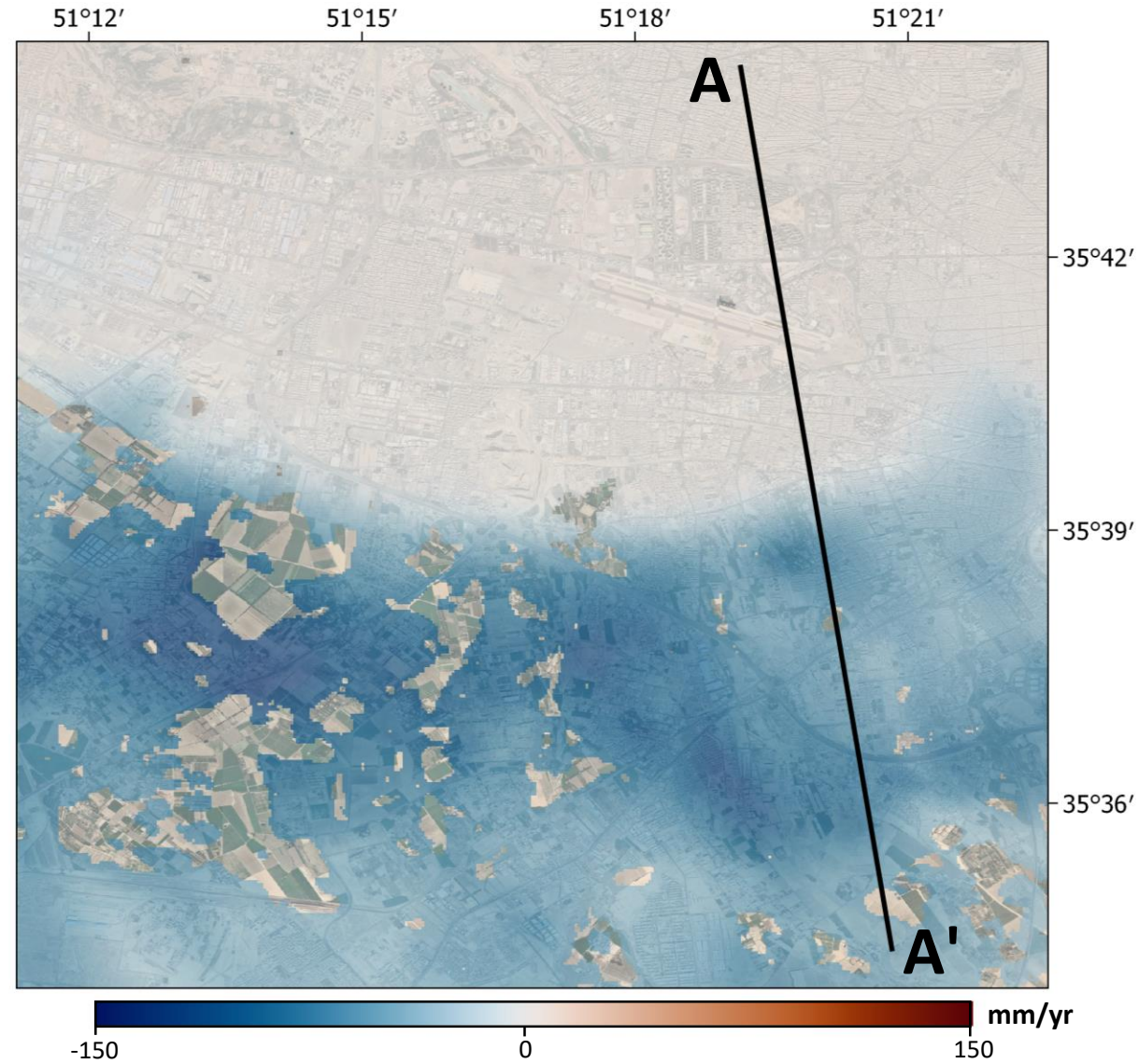
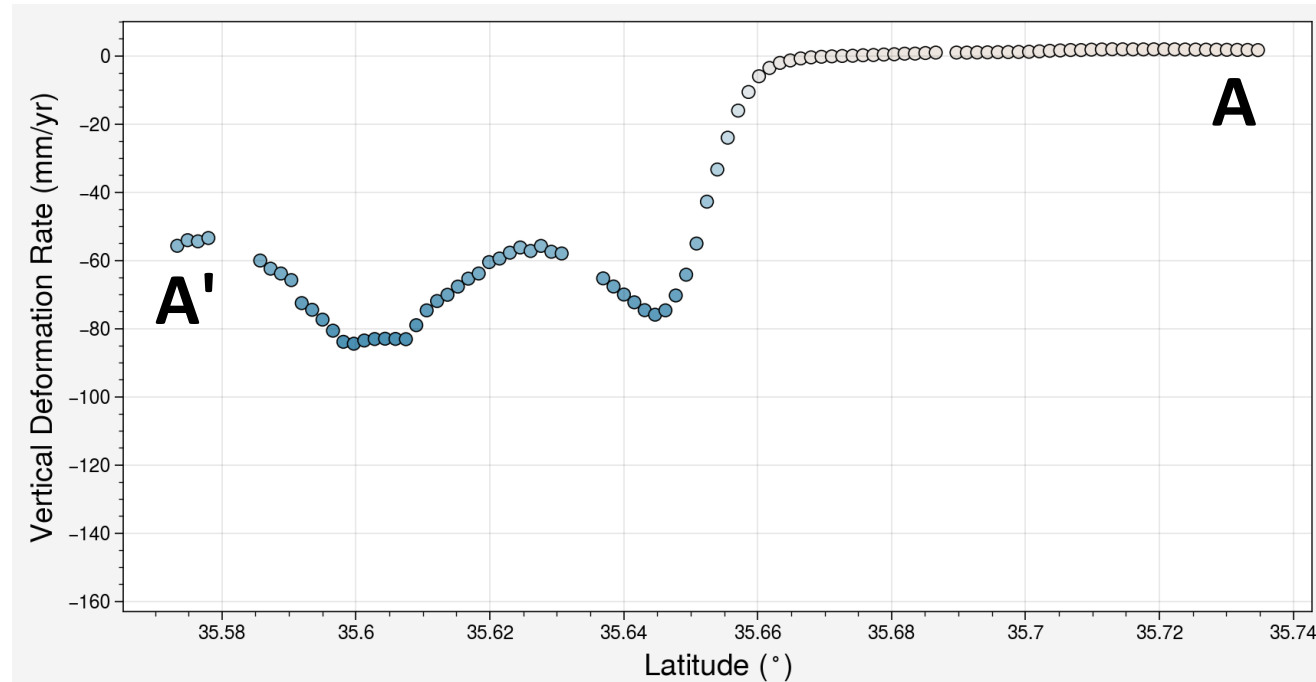


2: Calculate InSAR velocities



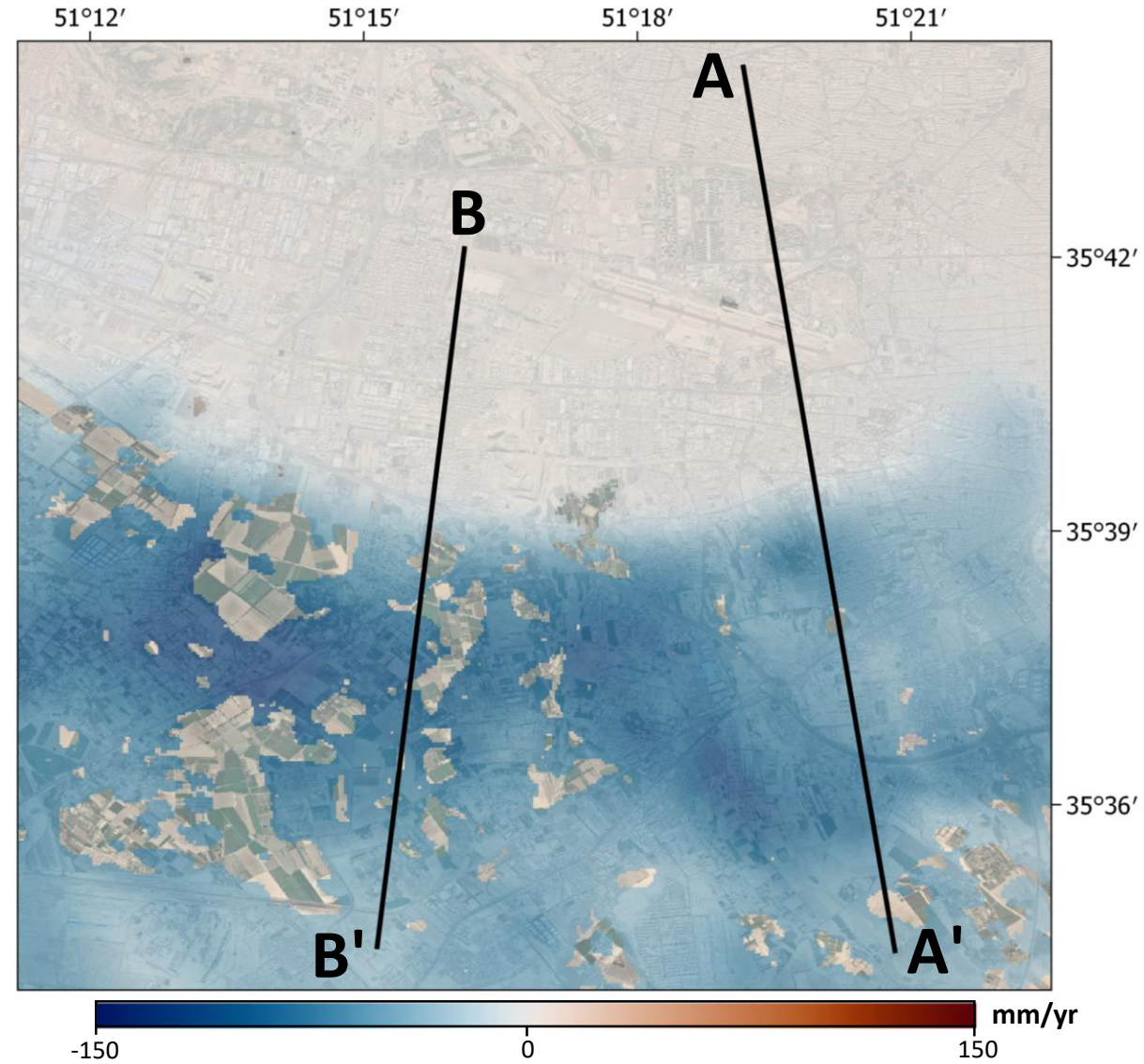
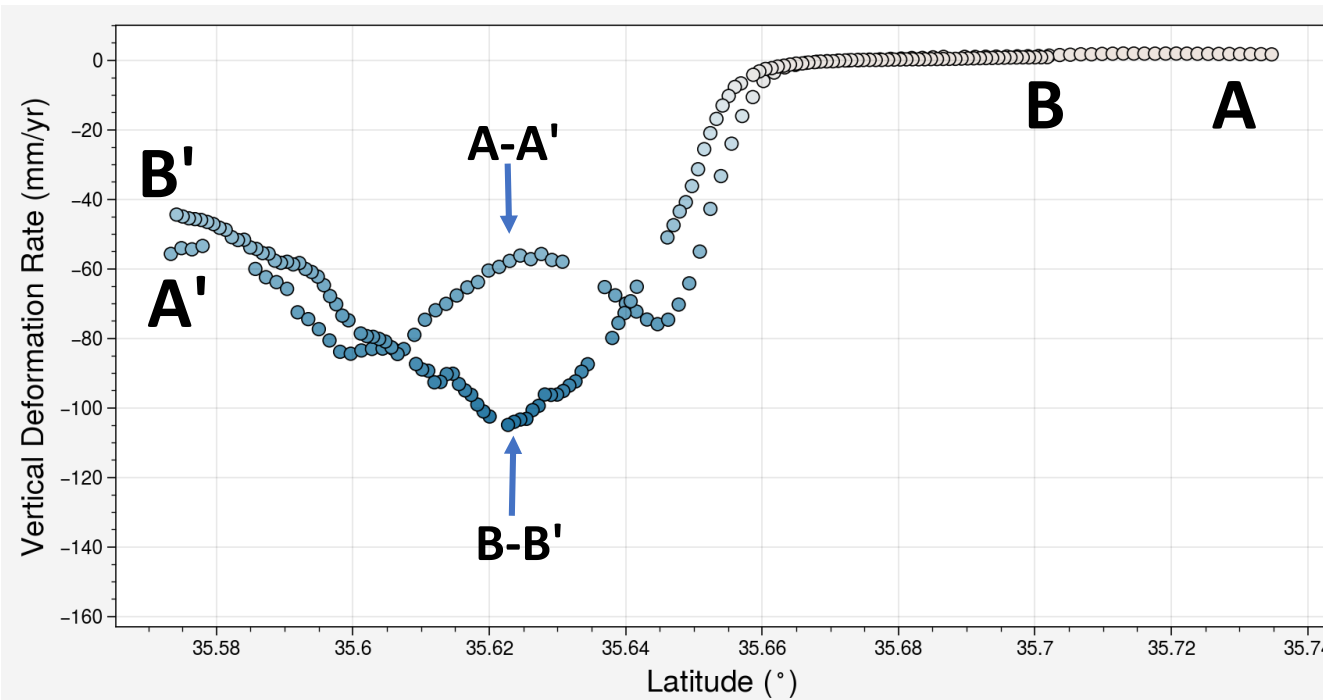
2: Calculate InSAR velocities

Western
Tehran
Plain



2: Calculate InSAR velocities

Western
Tehran
Plain

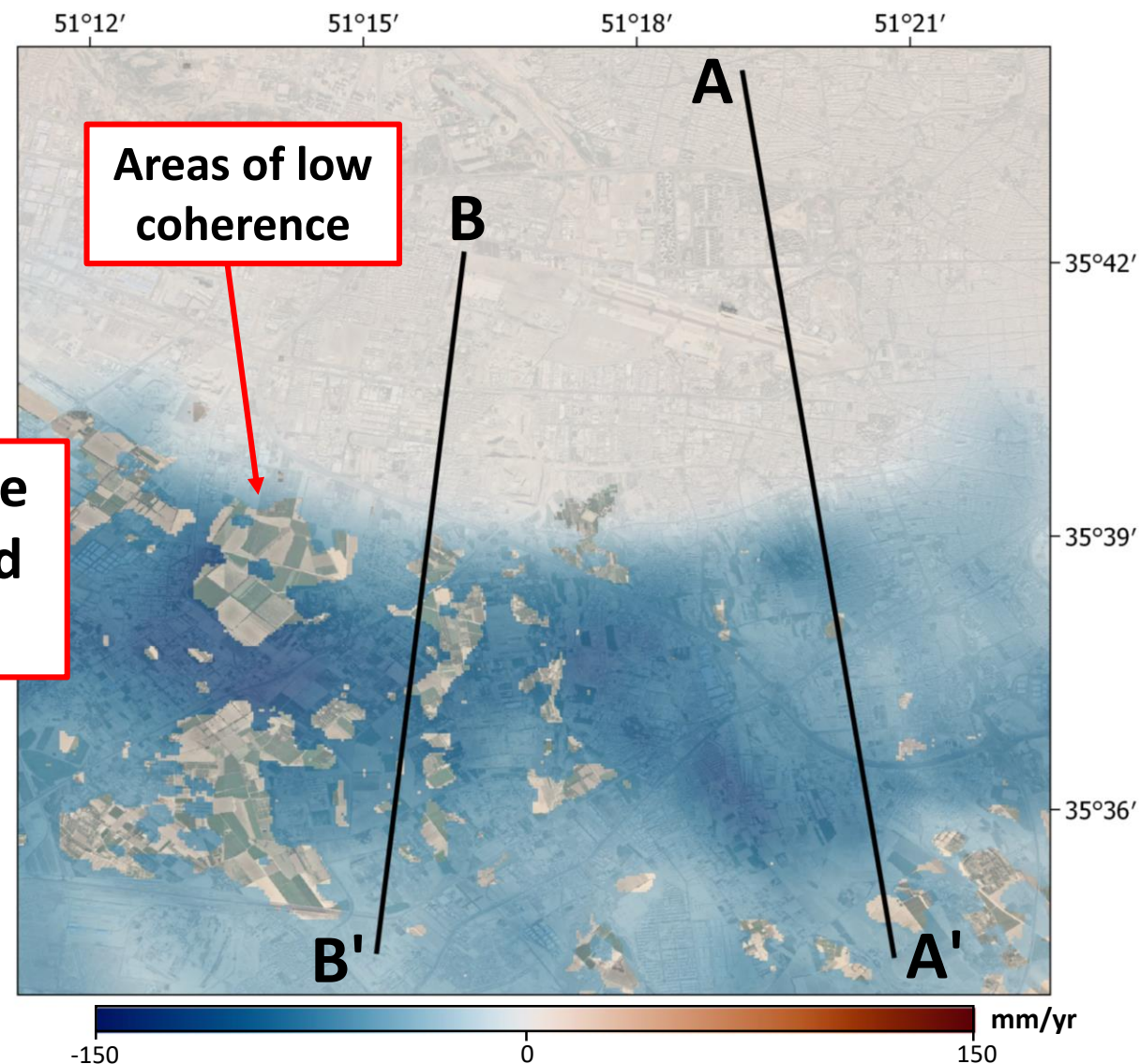


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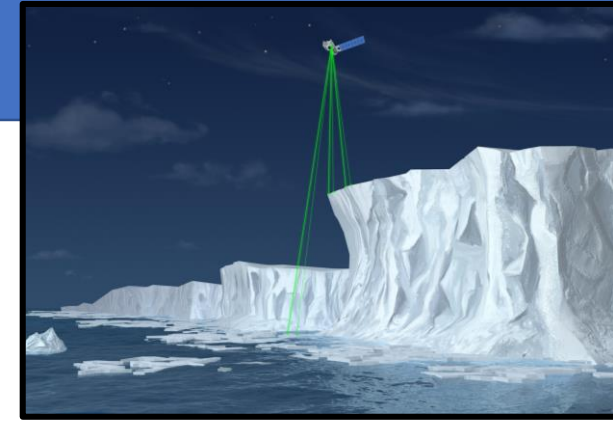
Western Tehran Plain

	Maximum subsidence rate (mm/yr)	Instrument	Acquisition period
Motagh <i>et al.</i> (2008)	30	Envisat	Jun-Oct 2004
Foroughnia <i>et al.</i> (2019)	~150	Envisat, Sentinel-1	
Dehghani <i>et al.</i> (2013)	~200	Envisat	
Haghshenas Haghghi & 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?

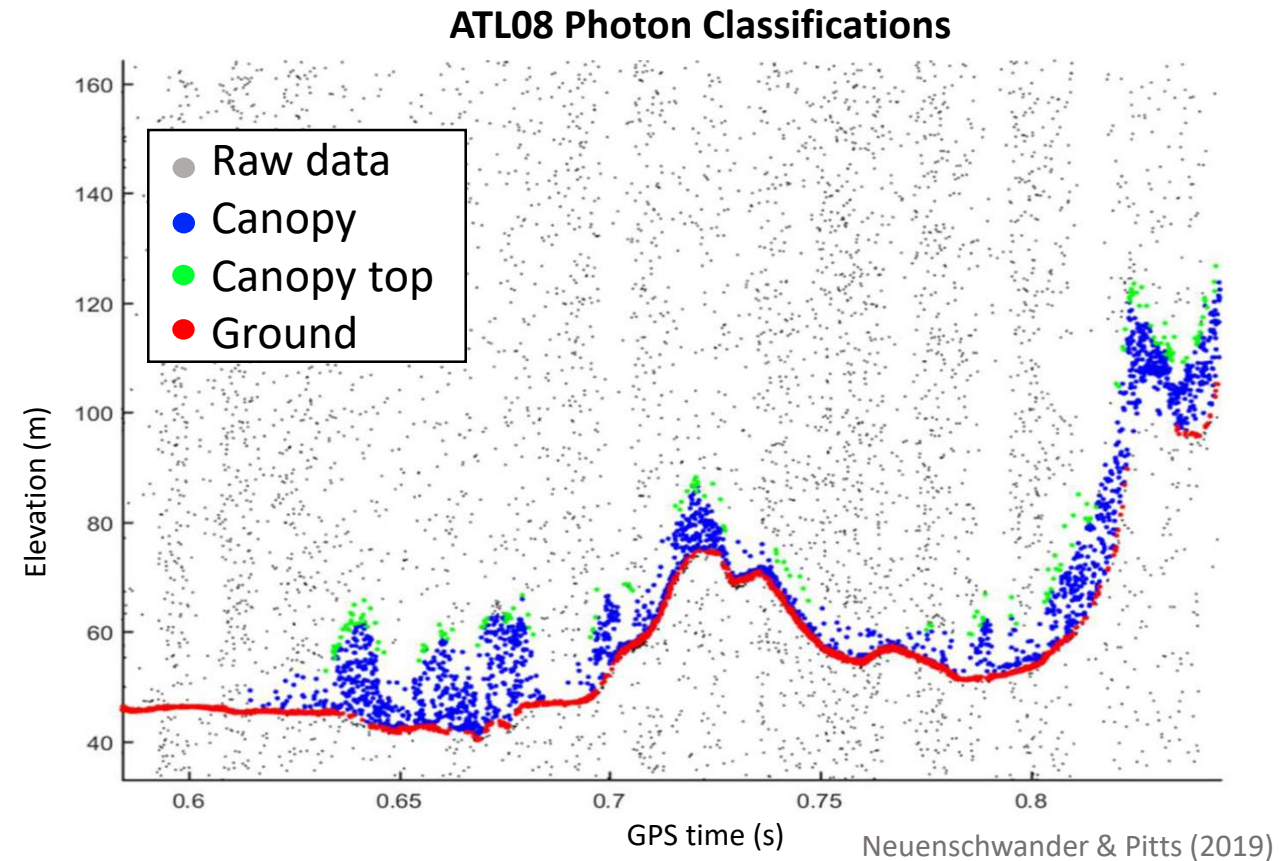


3. Validating InSAR: ICESat-2 laser altimetry



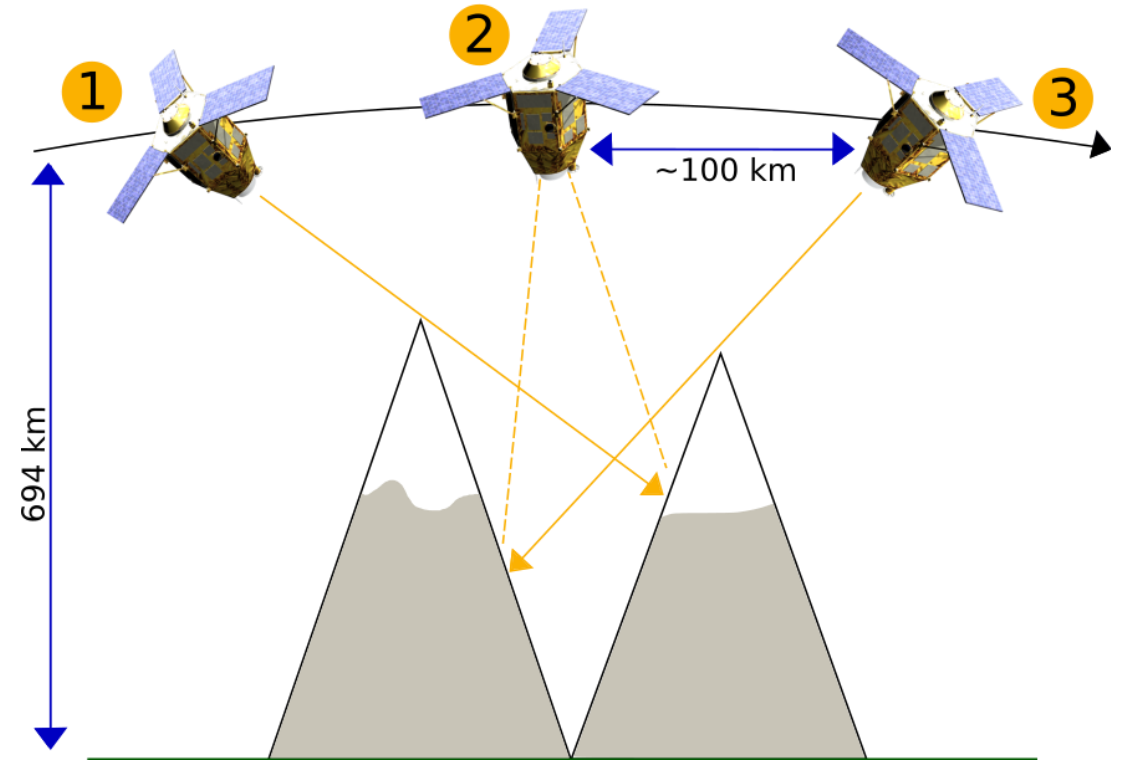
1. ICESat-2 laser altimetry data (repeat time ~3 months)

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

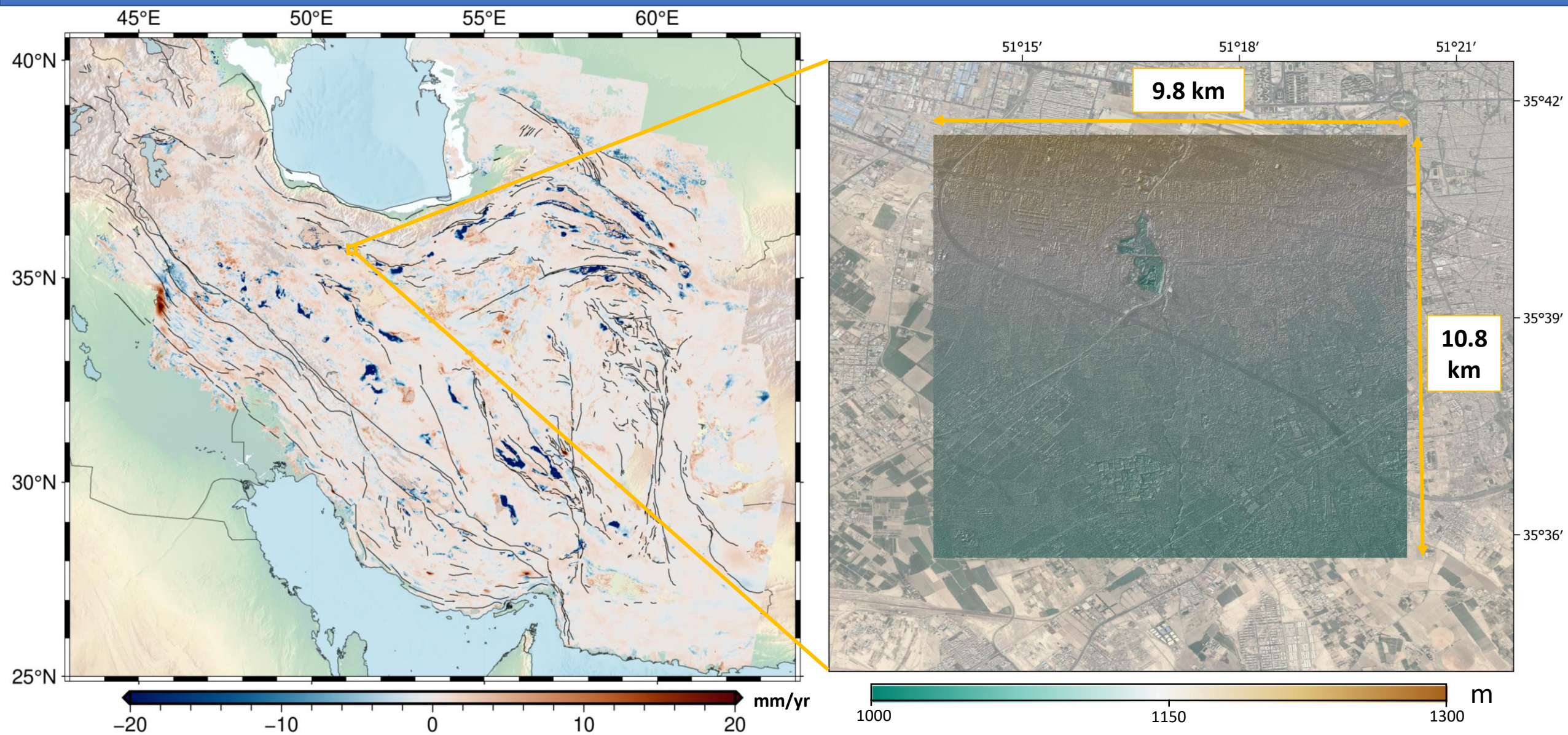


3. Validating InSAR: VHR DEMs

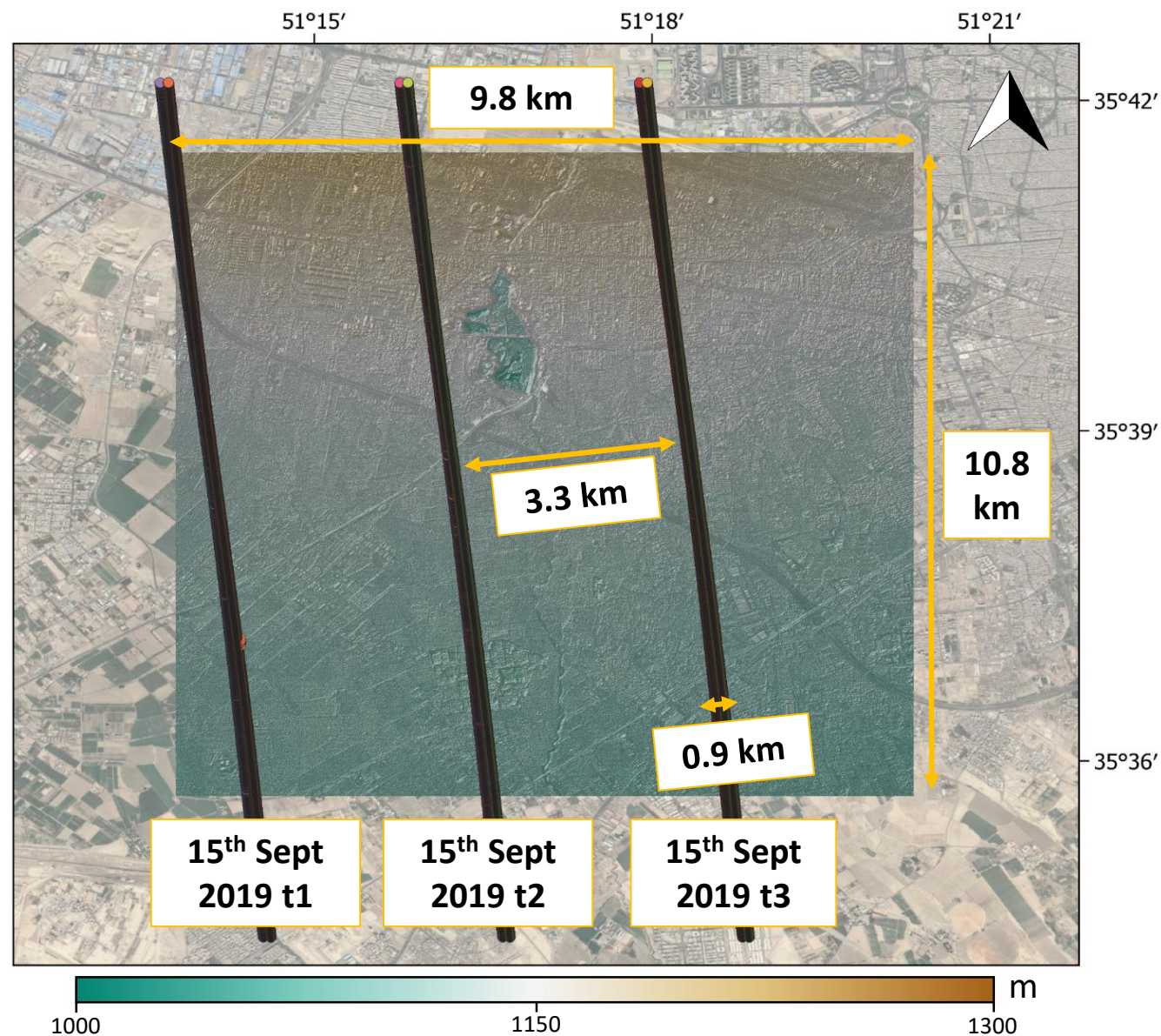
1. **Pléiades 50 cm/Pléiades Neo 30 cm stereoscopic** imagery
2. Construct dense point cloud and **1.5m DEM** from each stereoscopic set
3. **Reproject** secondary DEM to reference DEM grid
4. **Remove static offset** between DEM pairs
5. **Difference DEMs** to calculate vertical change



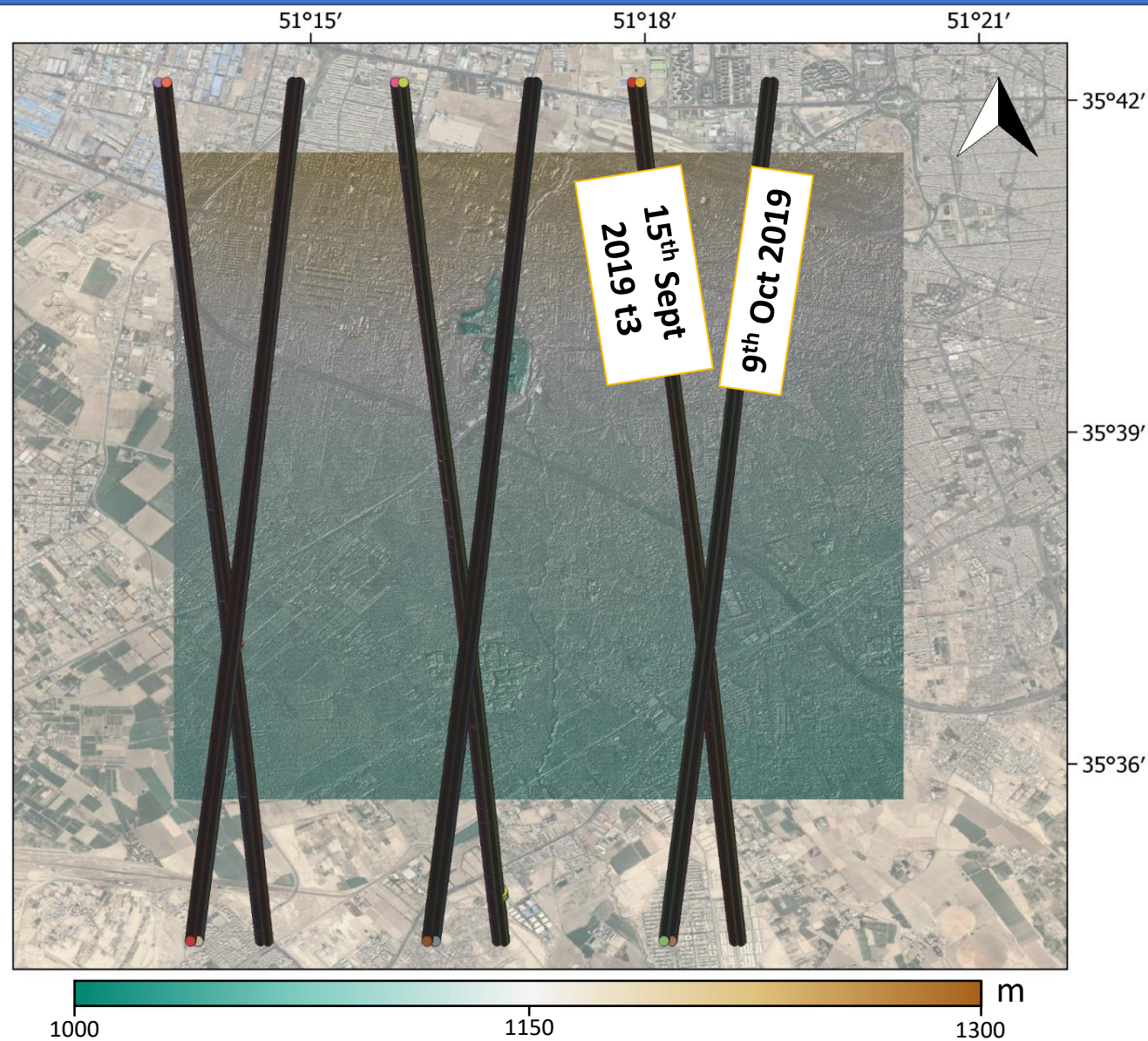
3. Validating InSAR: DEMs



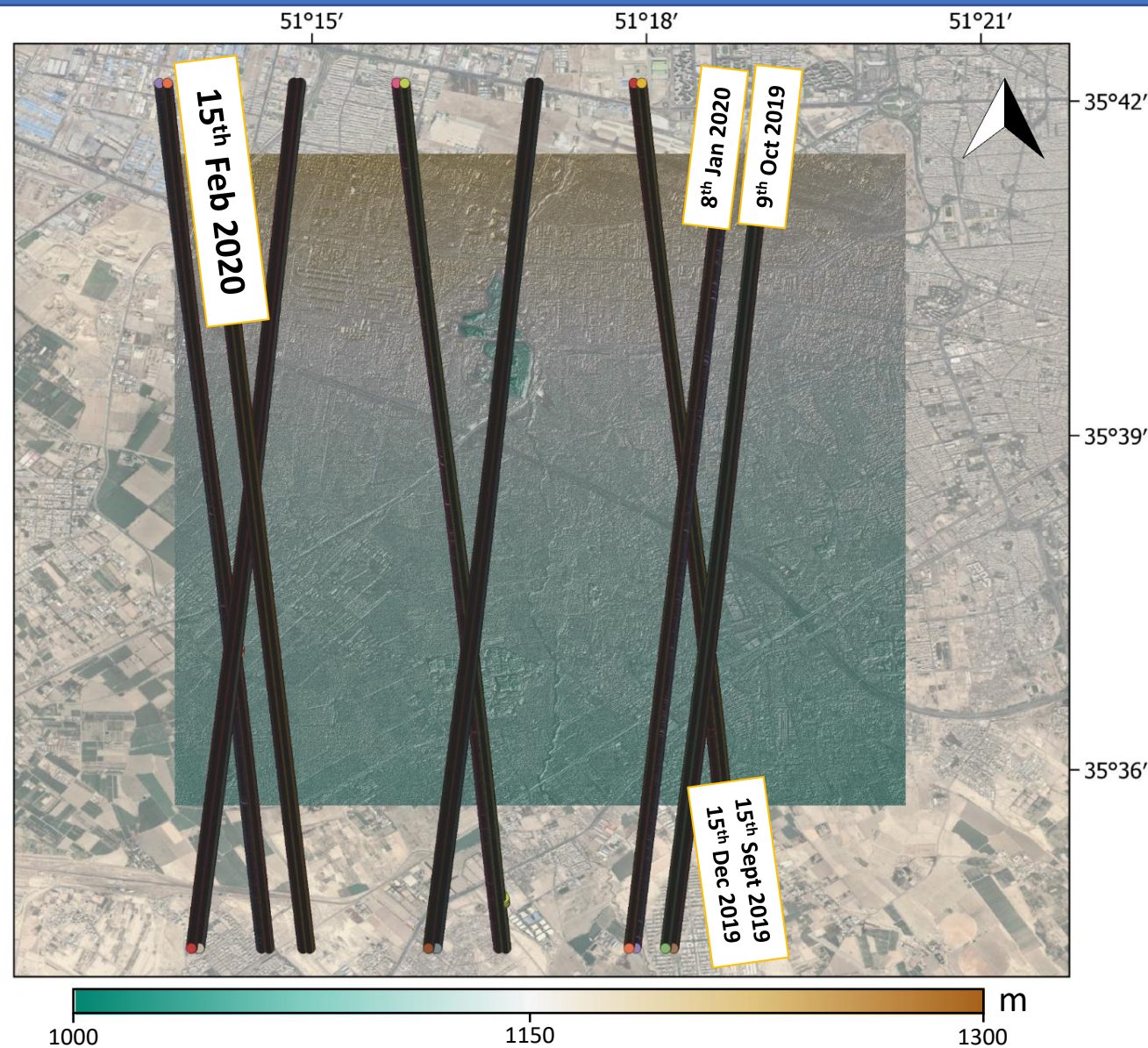
3. Validating InSAR: ICESat-2 laser altimetry



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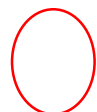


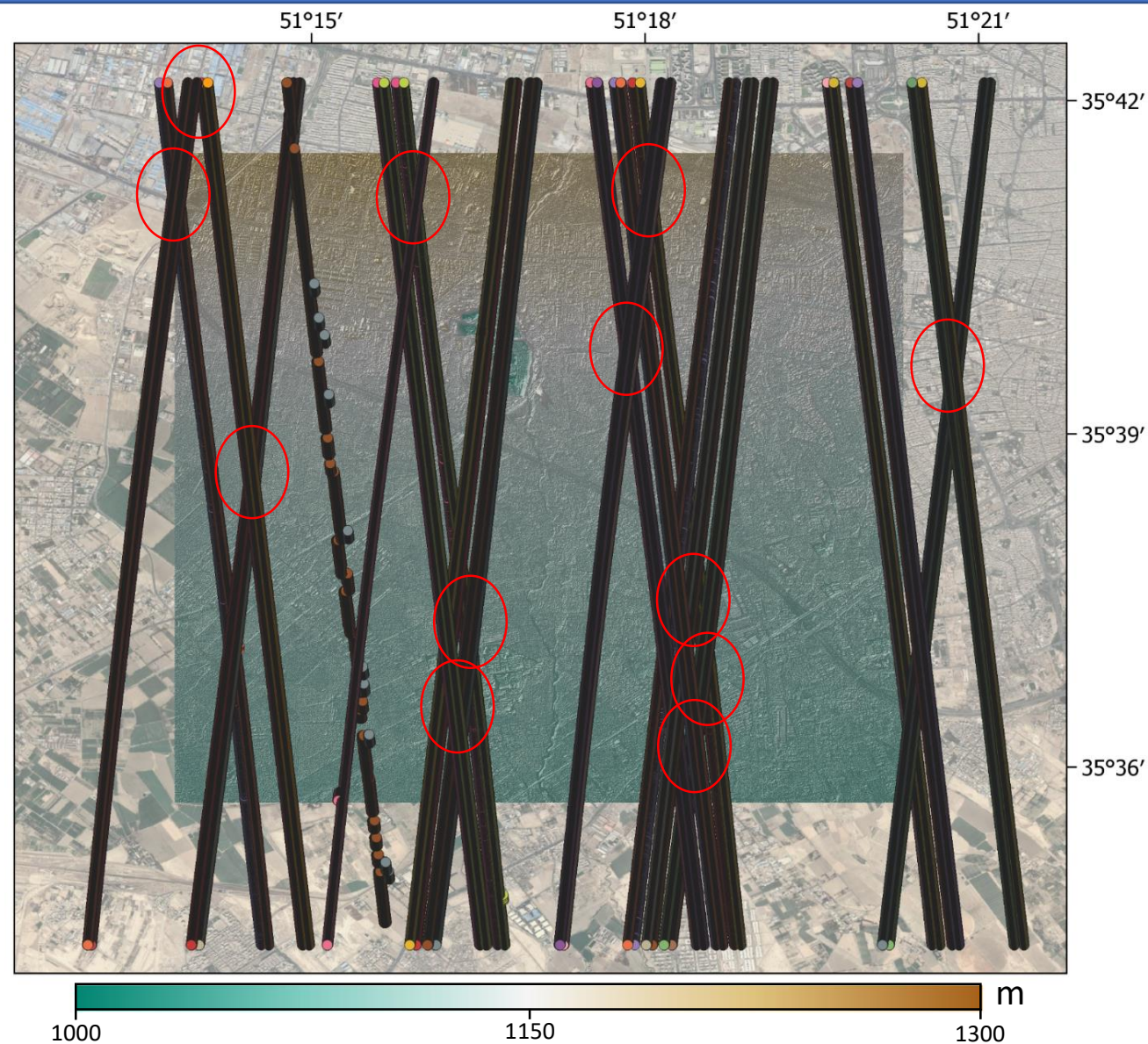
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**ICESat-2
tracks:
Oct 2019 –
Oct 2022**

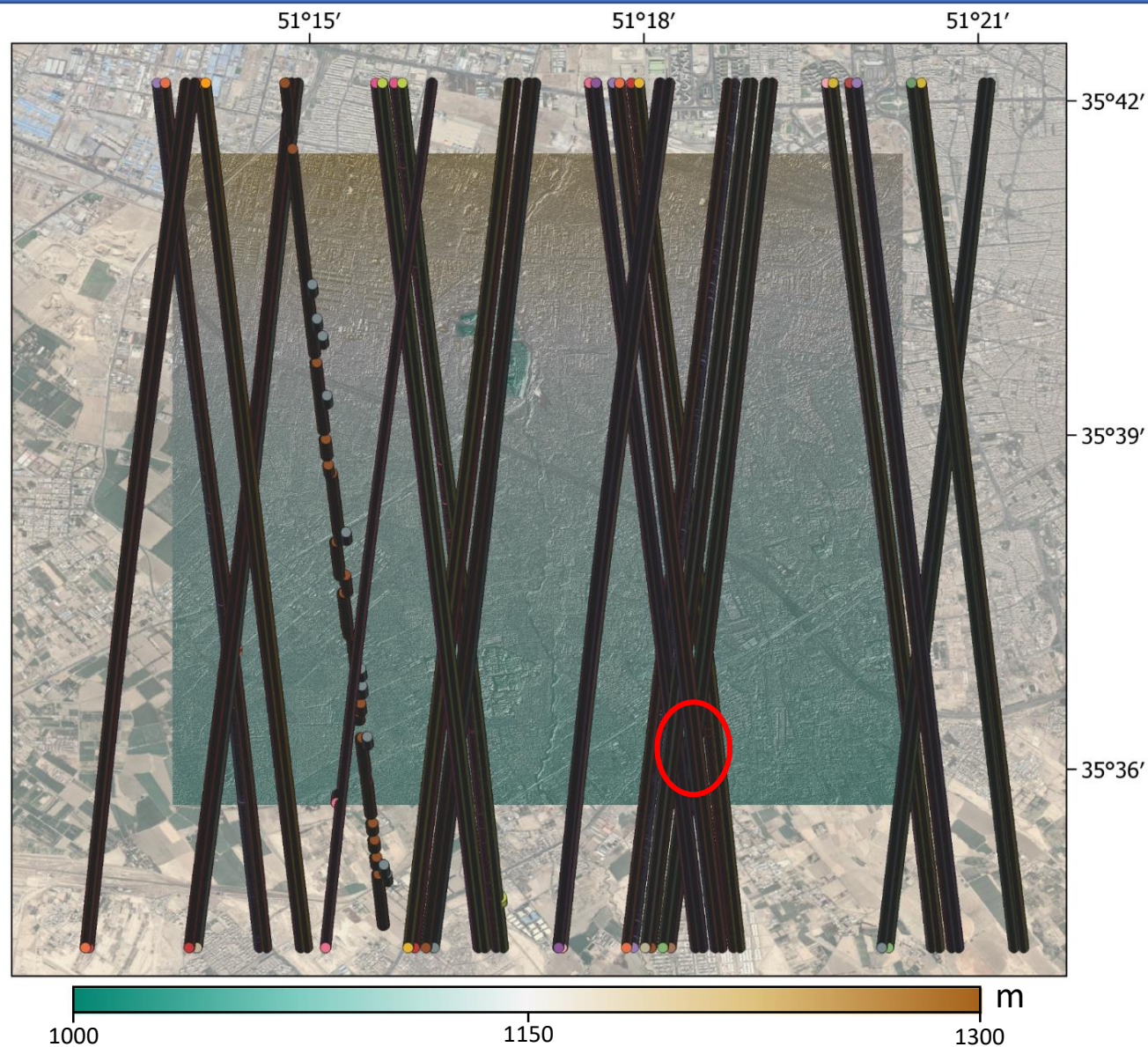
 Intersections
>2 years



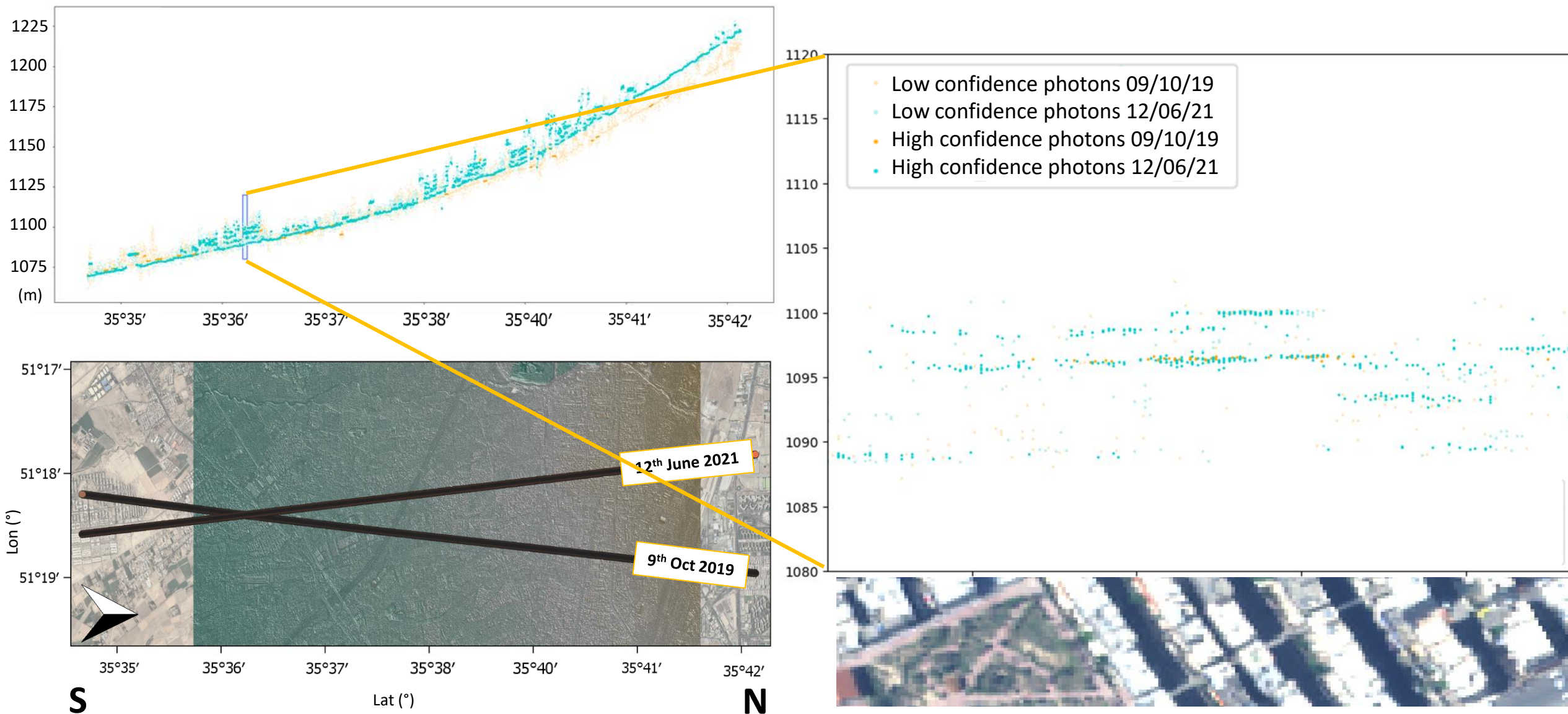
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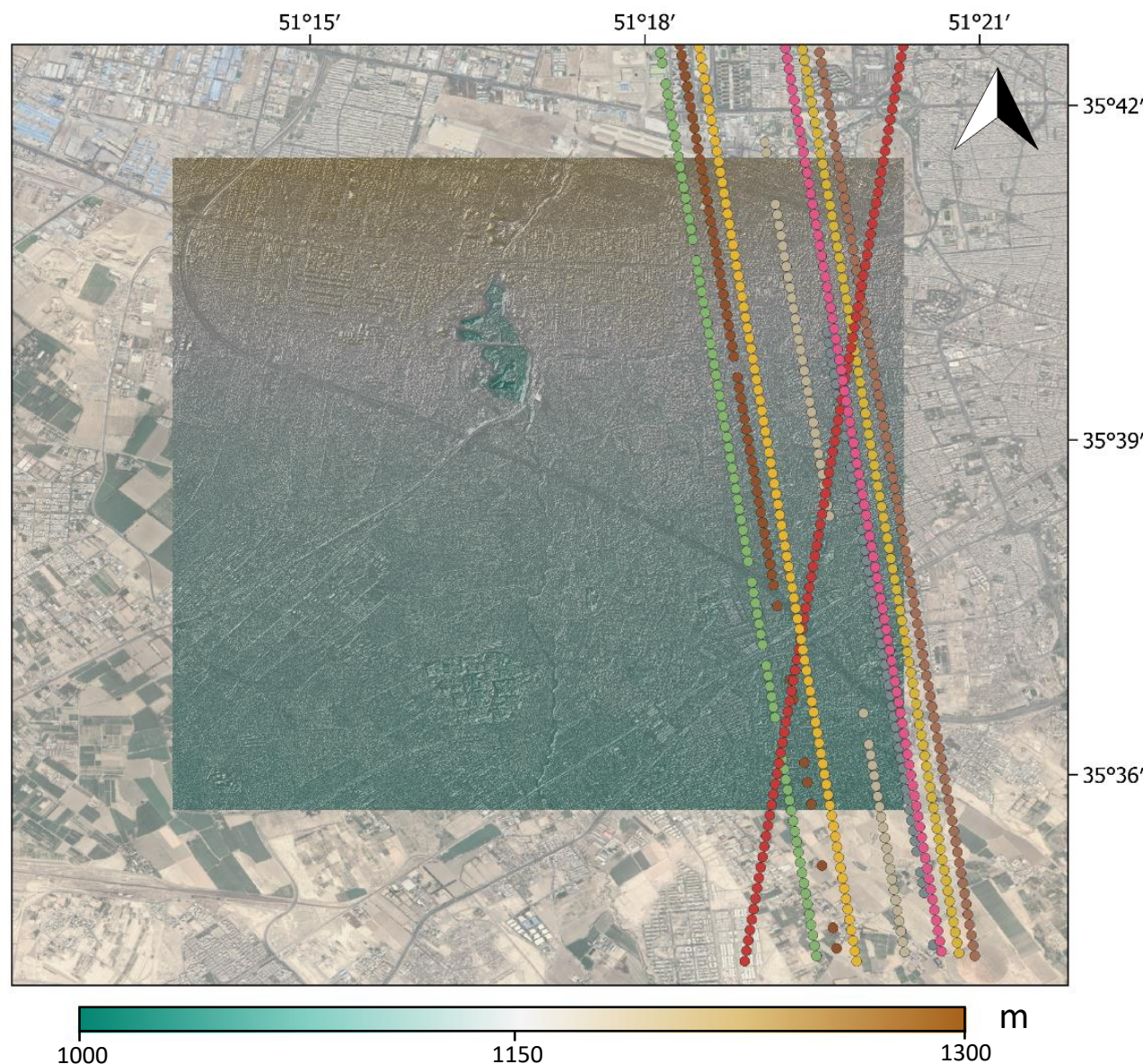
○ Intersections
>2 years



3. Validating InSAR: ICESat-2 laser altimetry

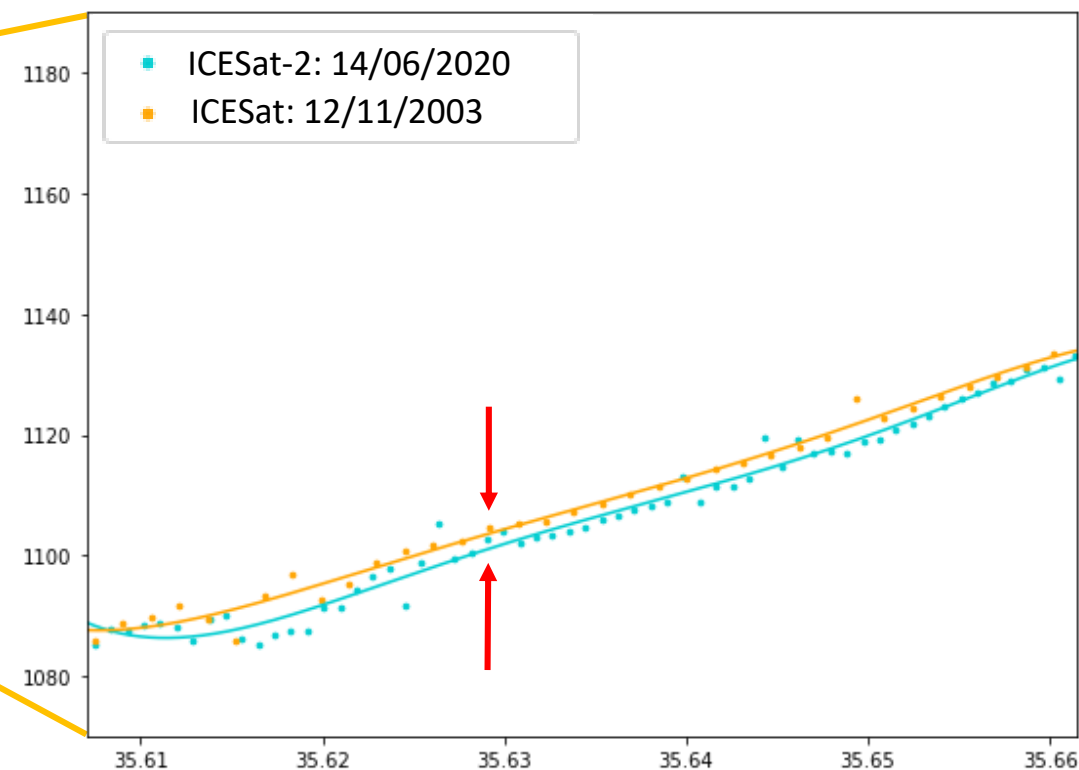
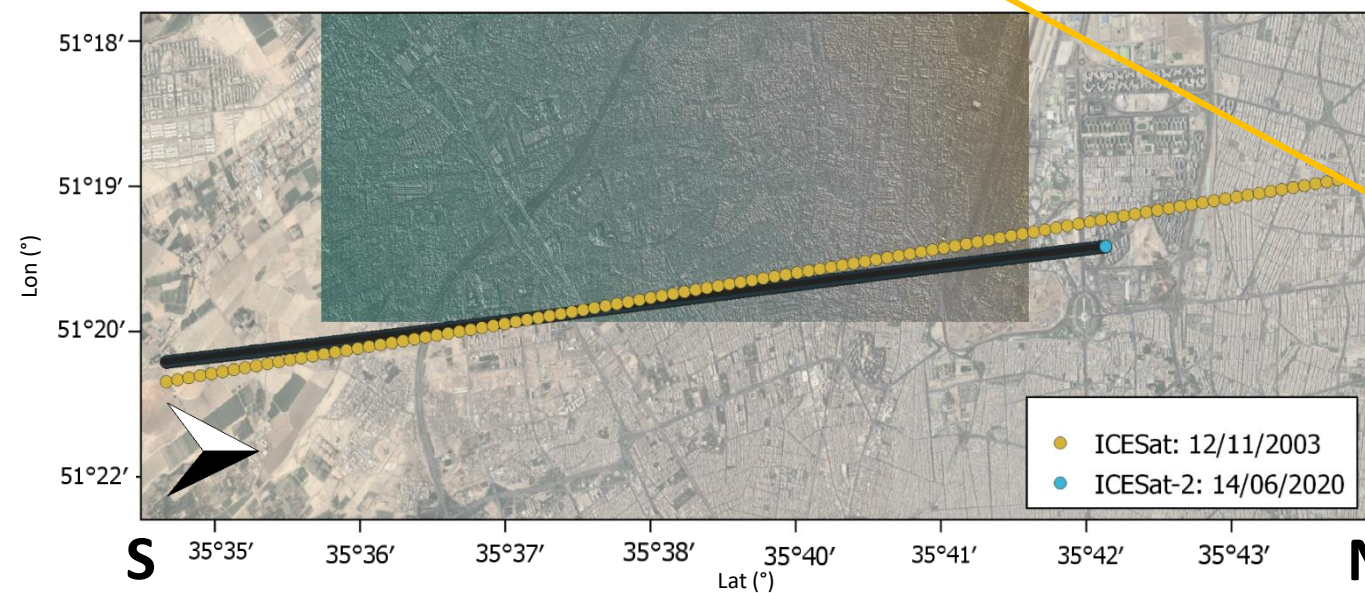
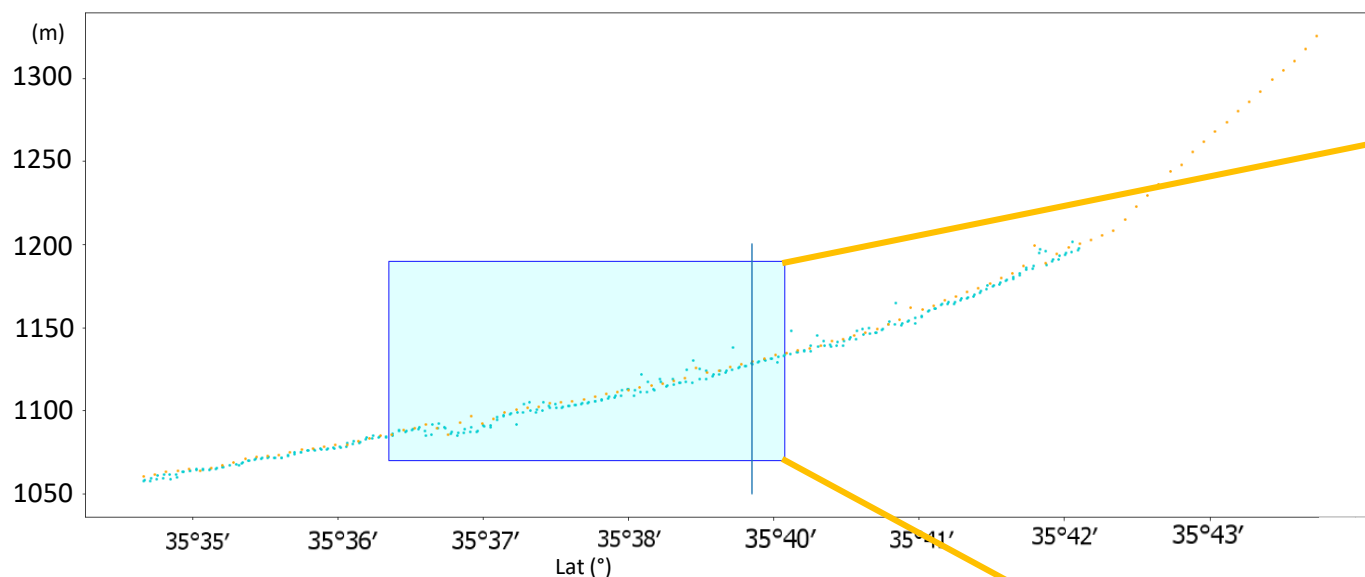


3. Validating InSAR: ICESat Laser altimetry



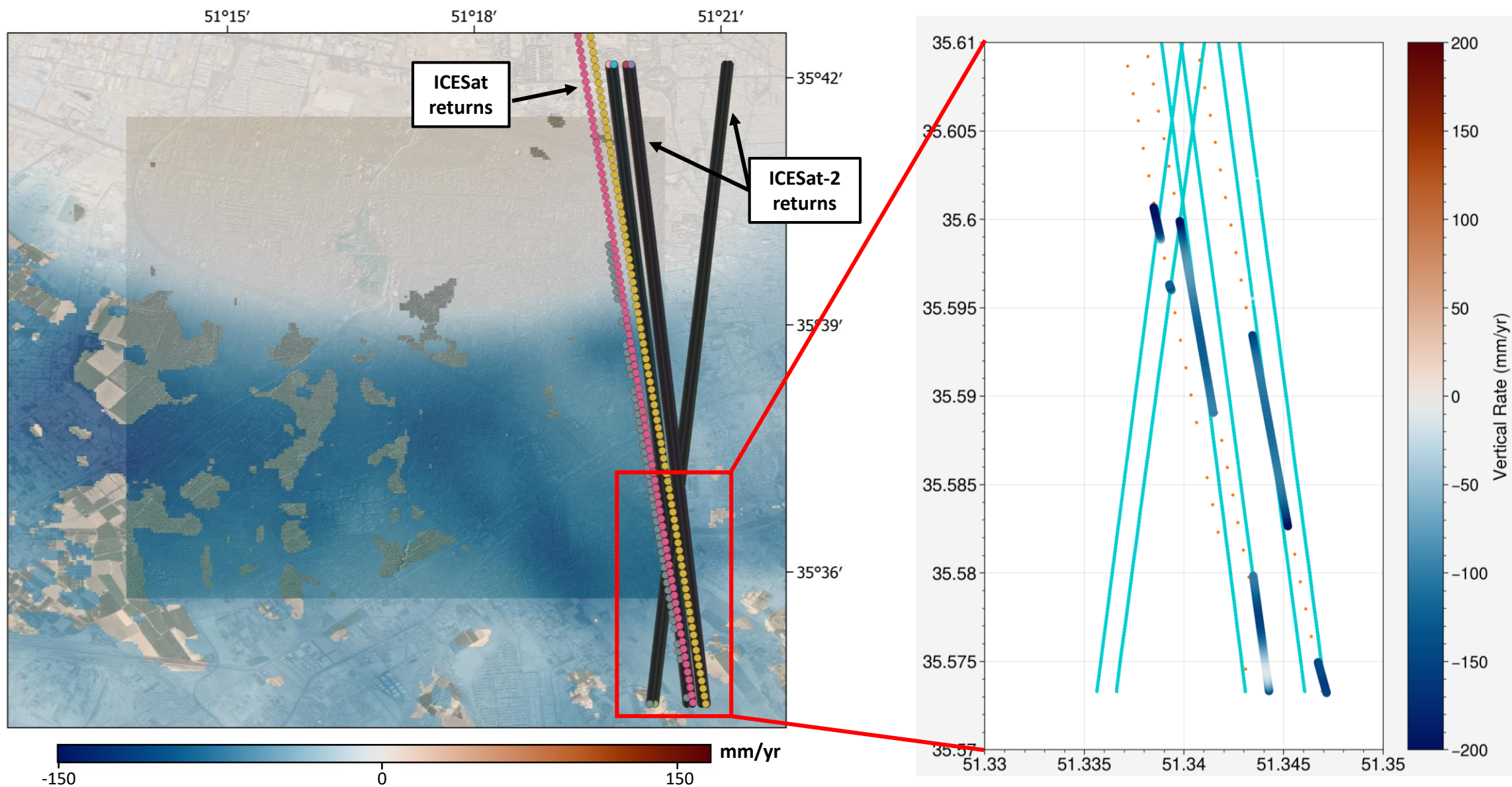
Track	Laser	Date
1241	Laser 2A	14/10/2003
326	Laser 2A	12/11/2003
326	Laser 2C	14/06/2004
326	Laser 3A	31/10/2004
326	Laser 3B	17/03/2005
326	Laser 3C	16/06/2005
326	Laser 3D	17/11/2005
326	Laser 3E	21/03/2006
326	Laser 3F	20/06/2006
326	Laser 3G	21/11/2006
326	Laser 3I	29/10/2007
326	Laser 2D	12/11/2008

3. Validating InSAR: Laser altimetry

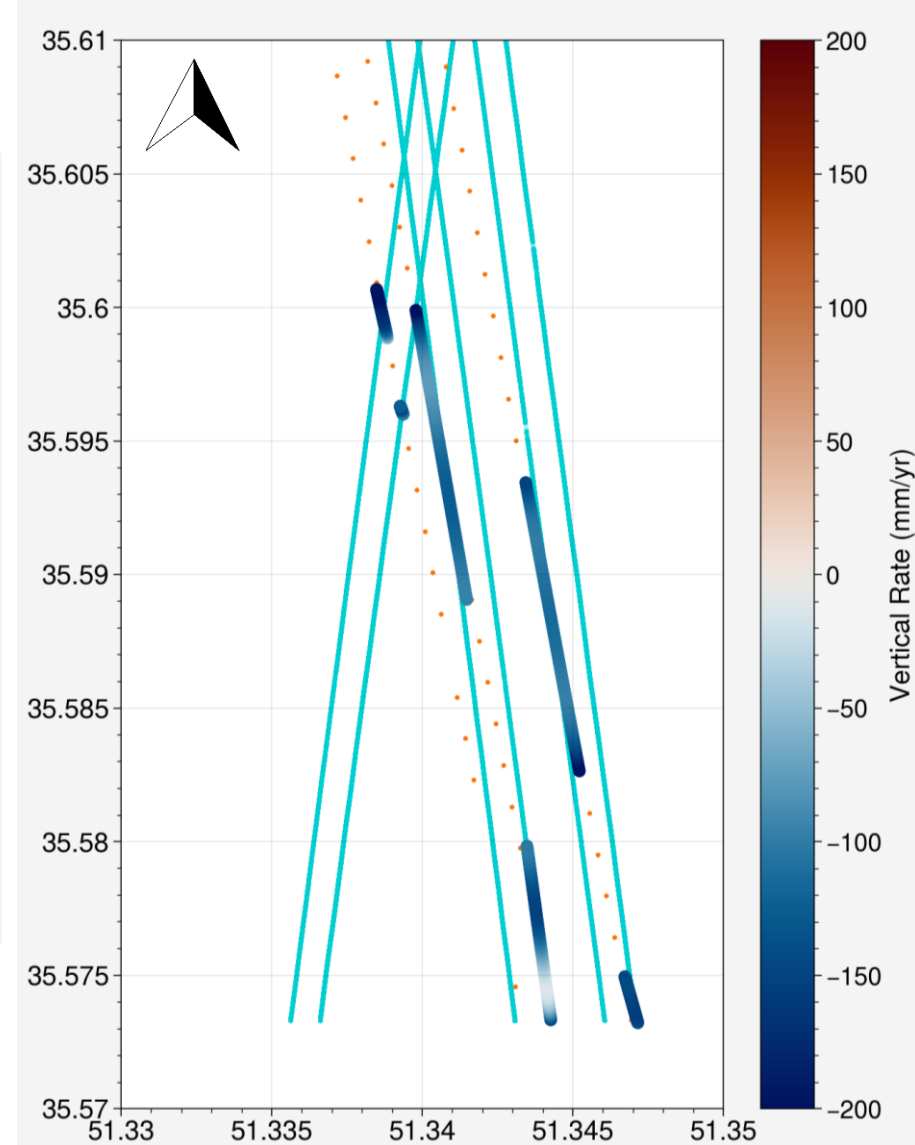
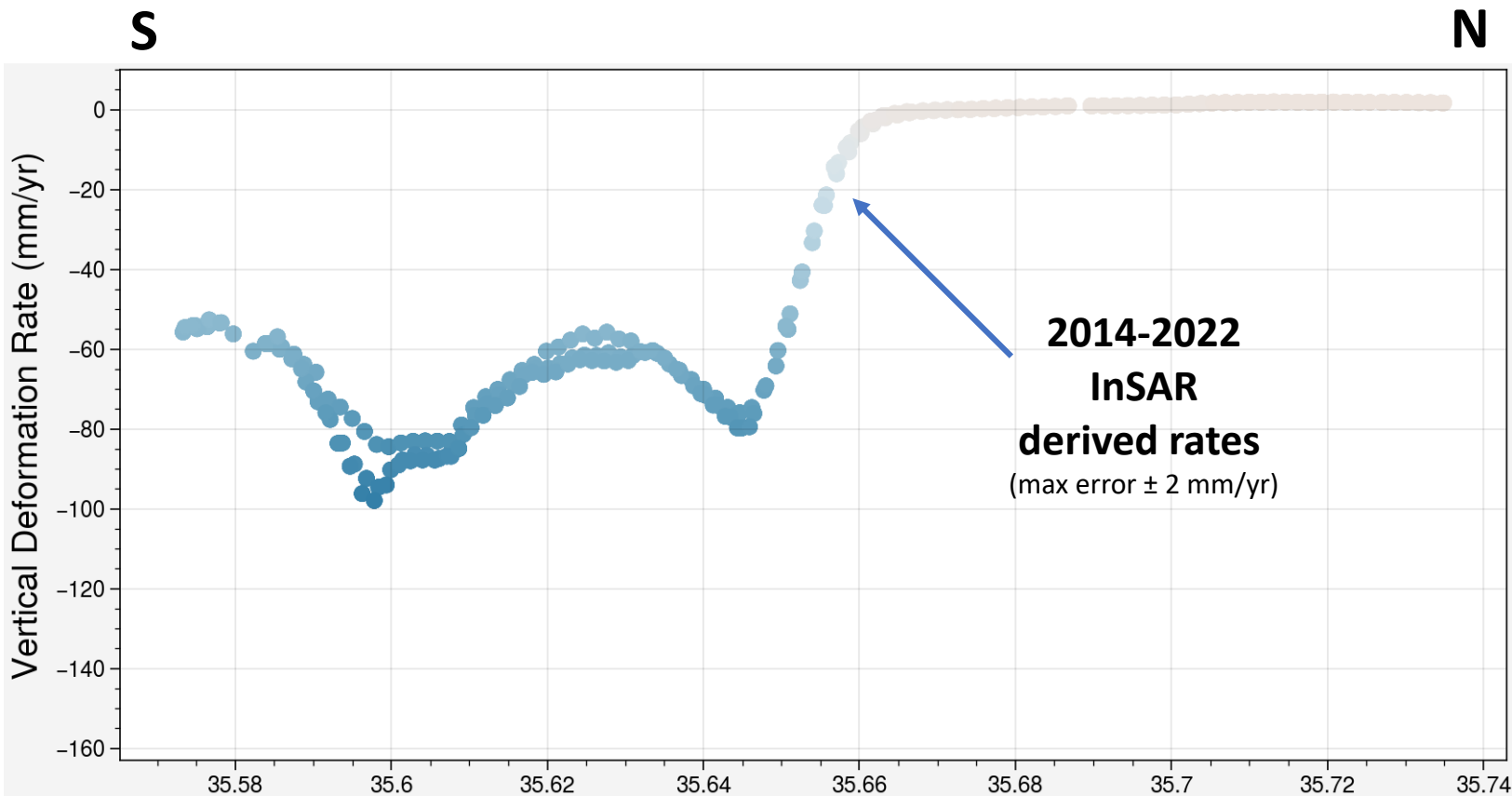


**1.5-2.5 m subsidence
in 16.5 years**

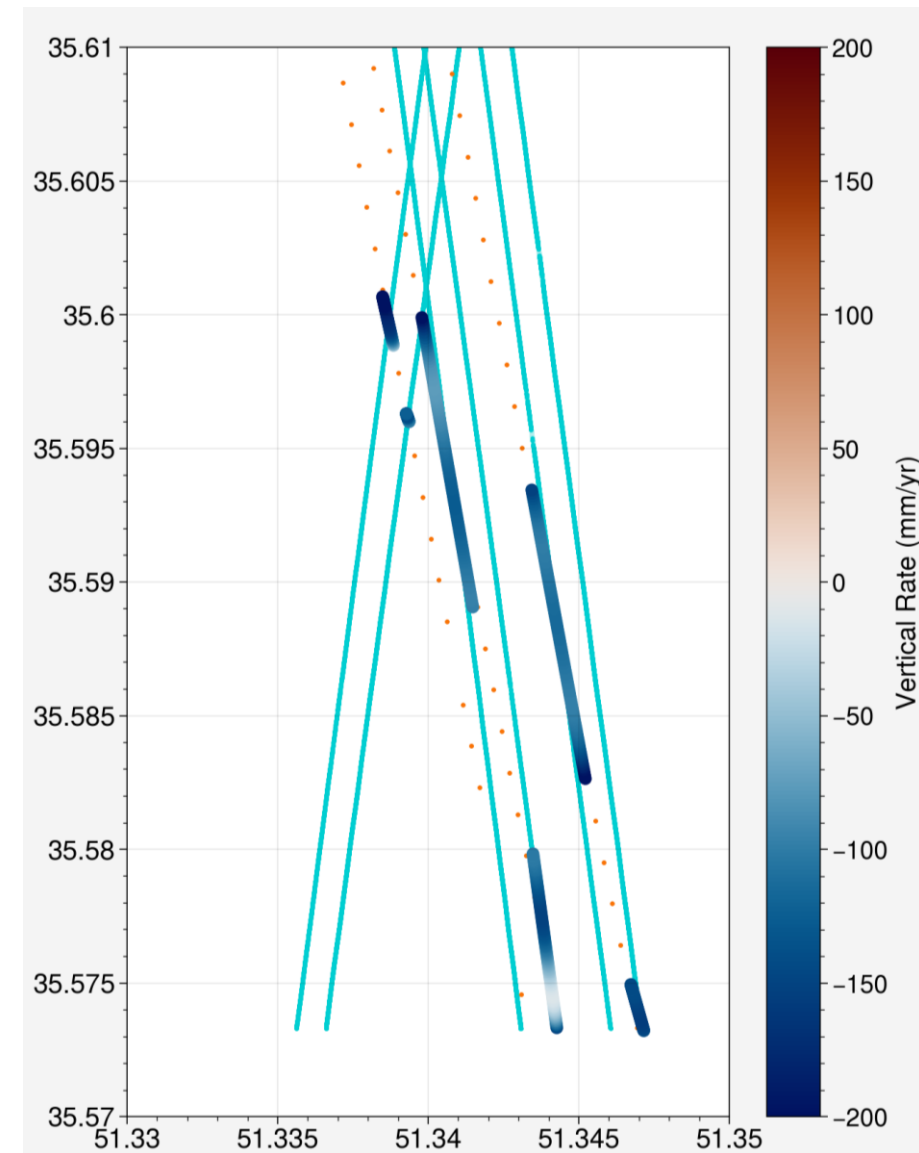
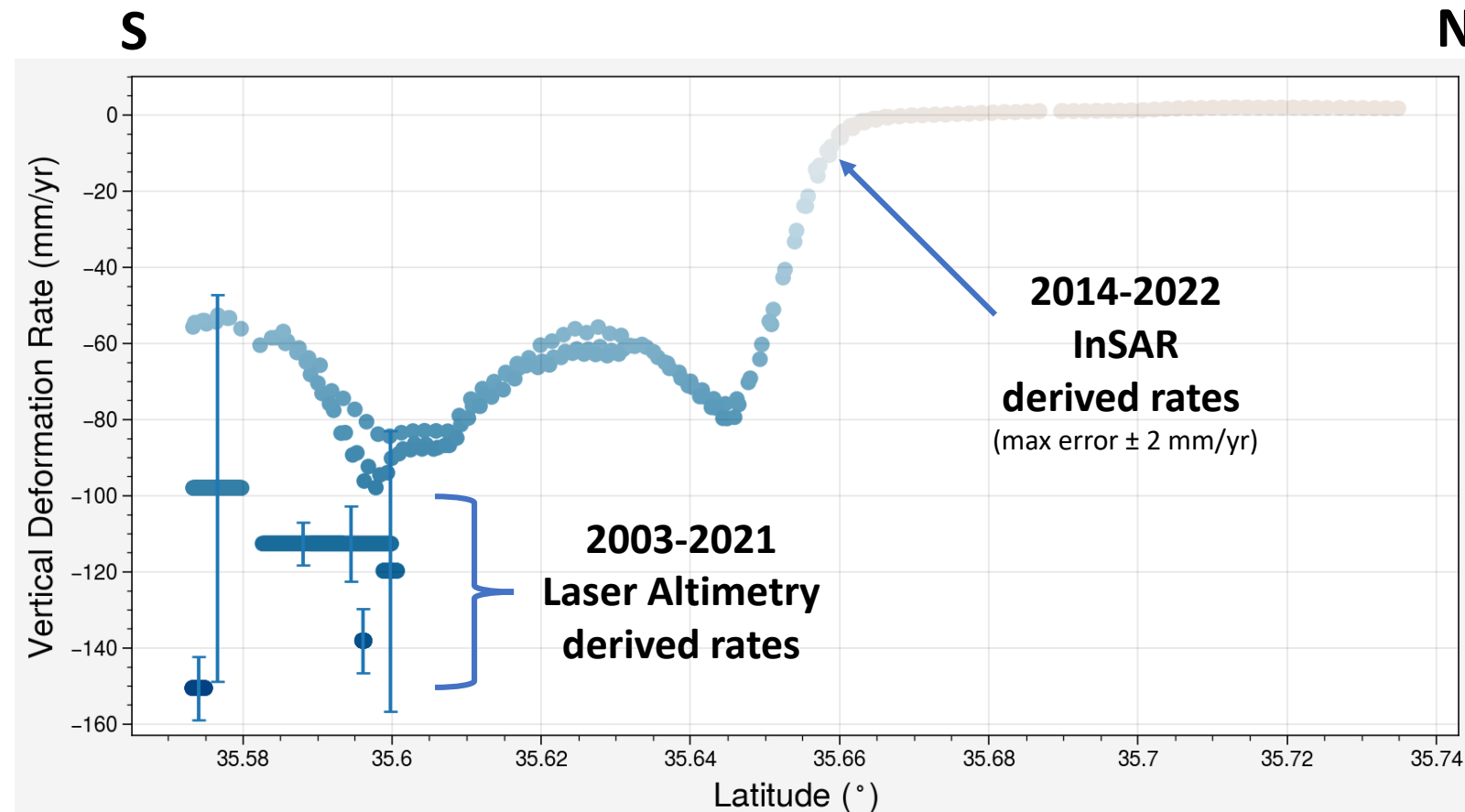
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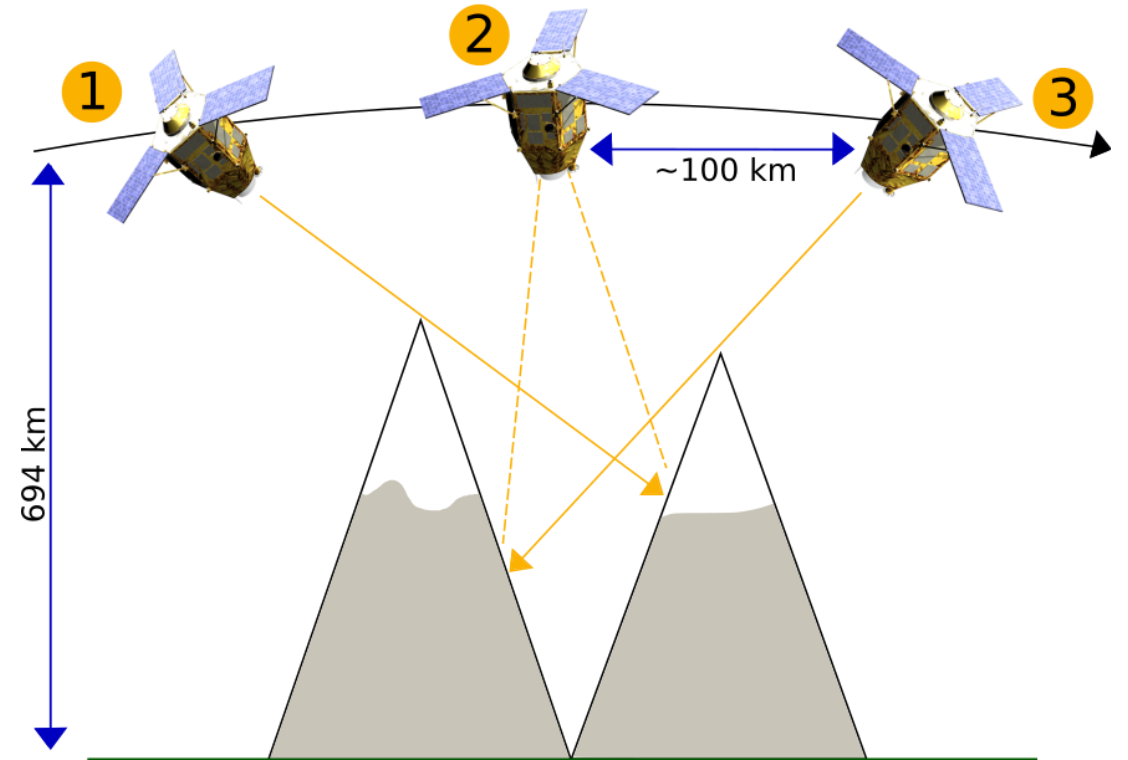


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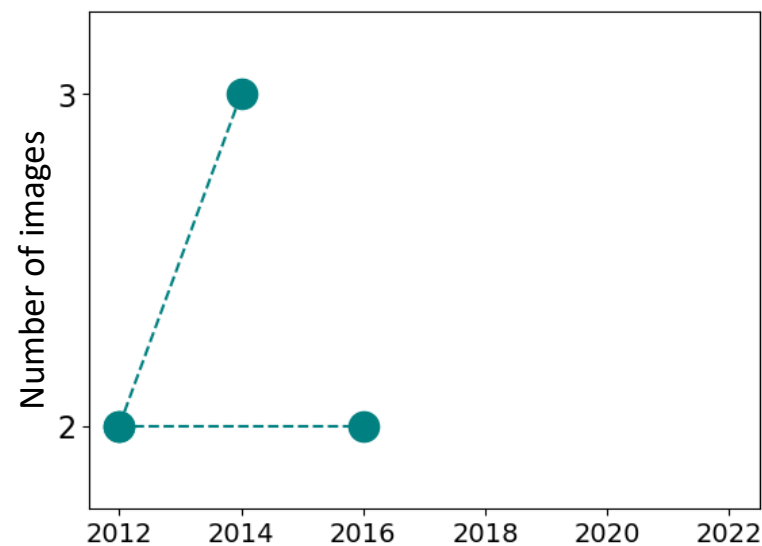
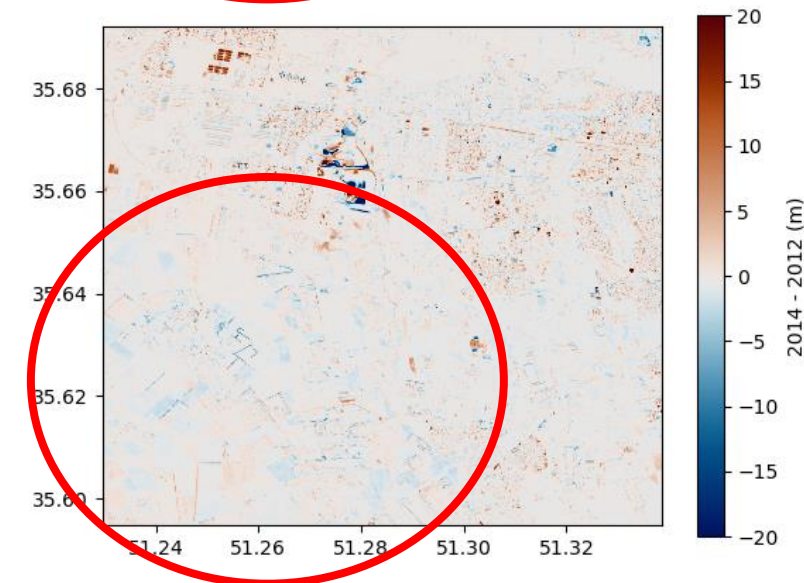
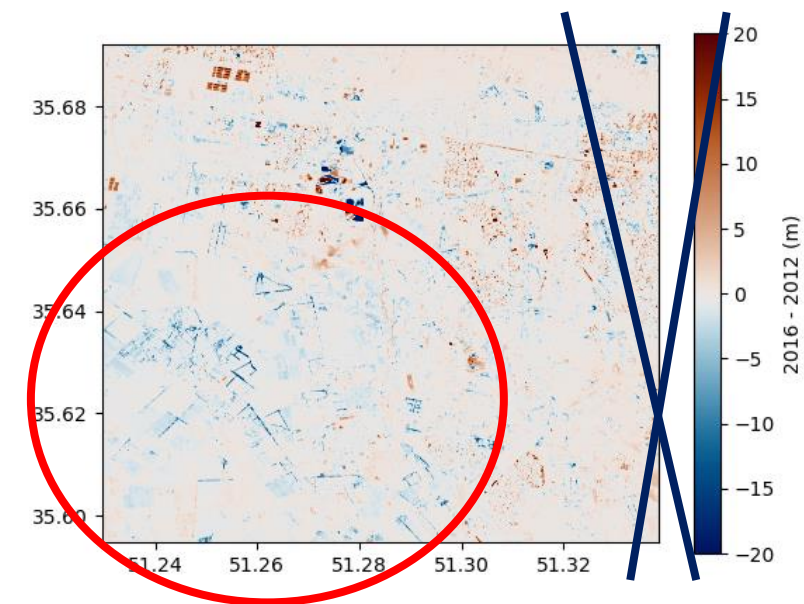


3. Validating InSAR: VHR DEMs

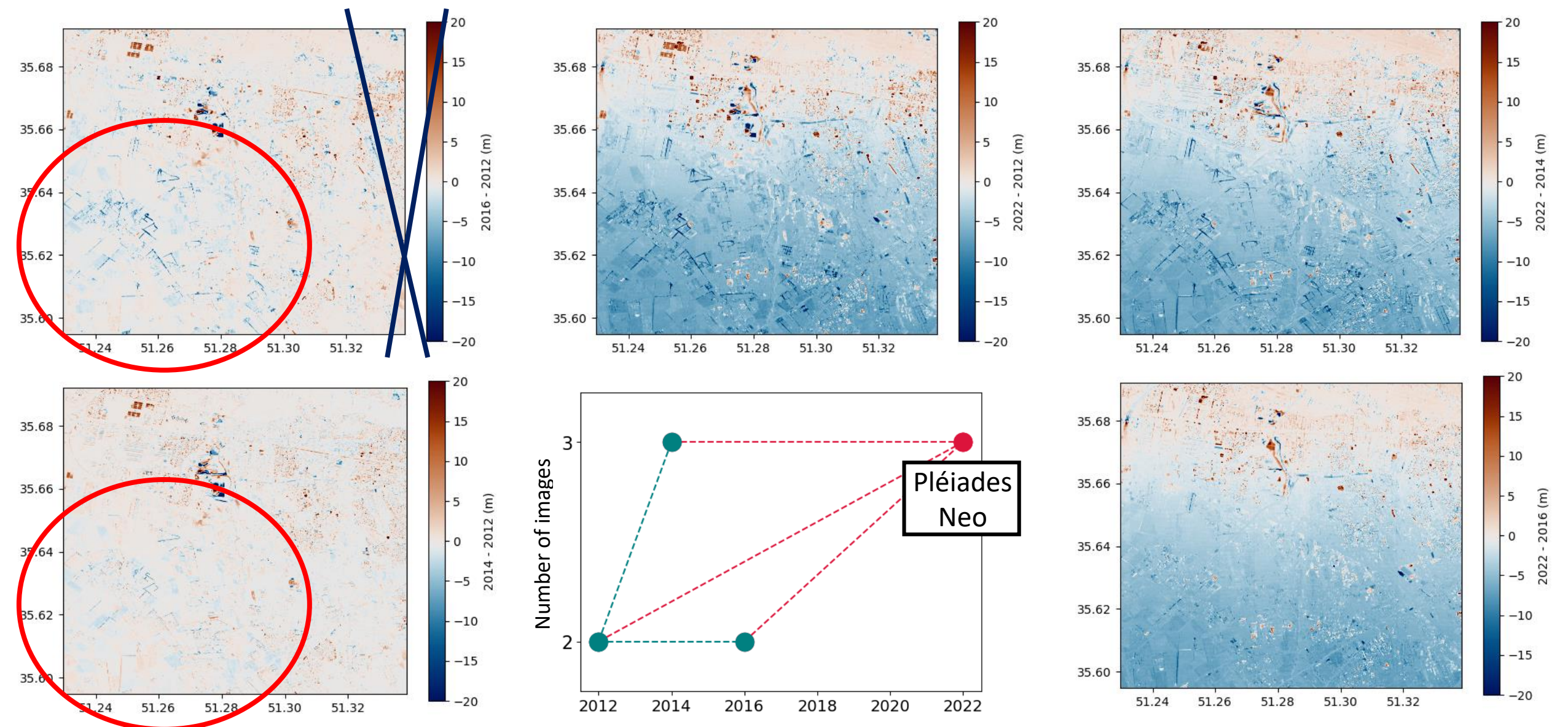
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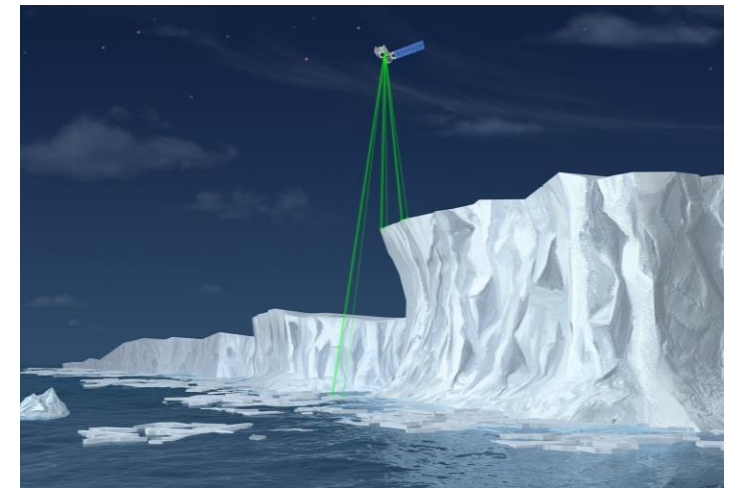
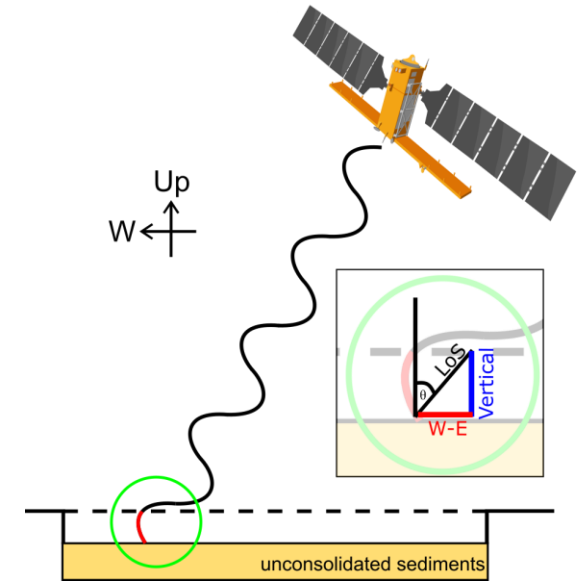


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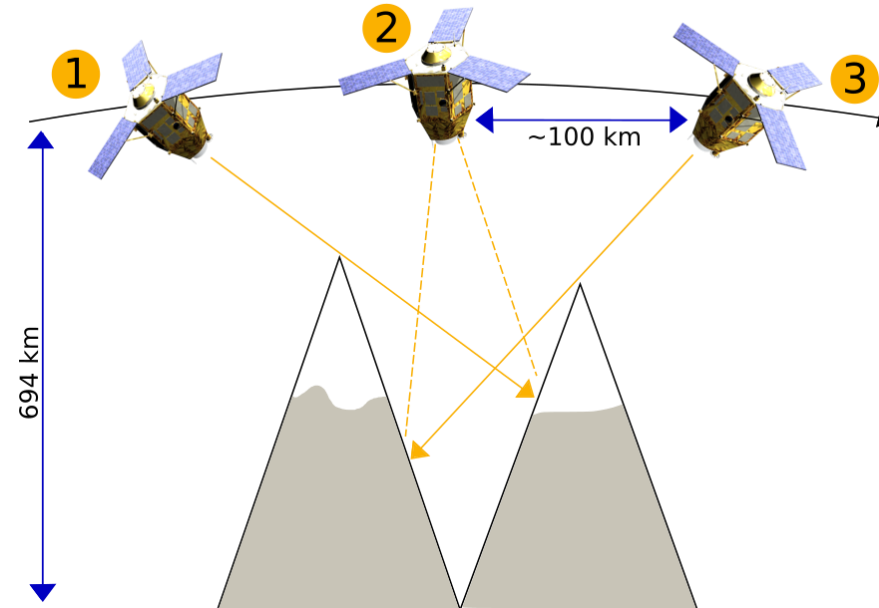
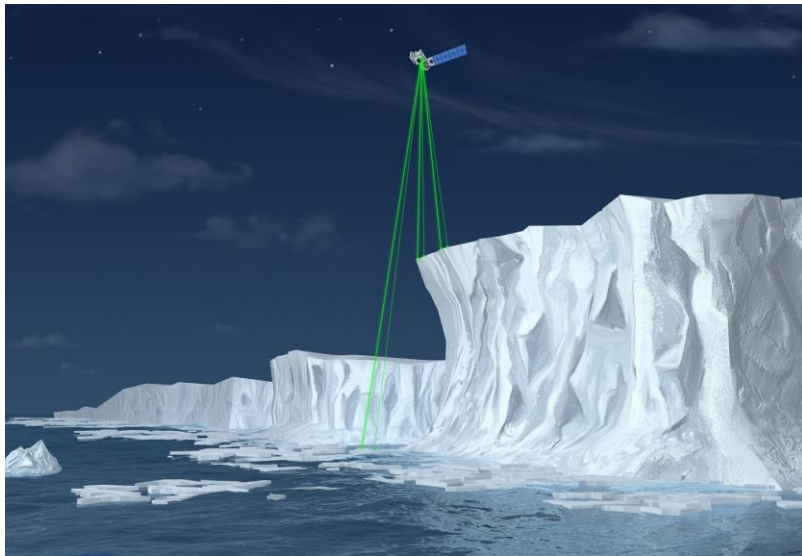
Conclusions

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





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