Direct Observation of Dutch Peatlands in a Mixed Scatterer Interferometry Framework

Enabling Sentinel-1 DS InSAR of the Netherlands

Philip Conroy, Simon van Diepen, Freek van Leijen and Ramon Hanssen

LOSS Living on Soft Soils Subsidence & Society

NWO

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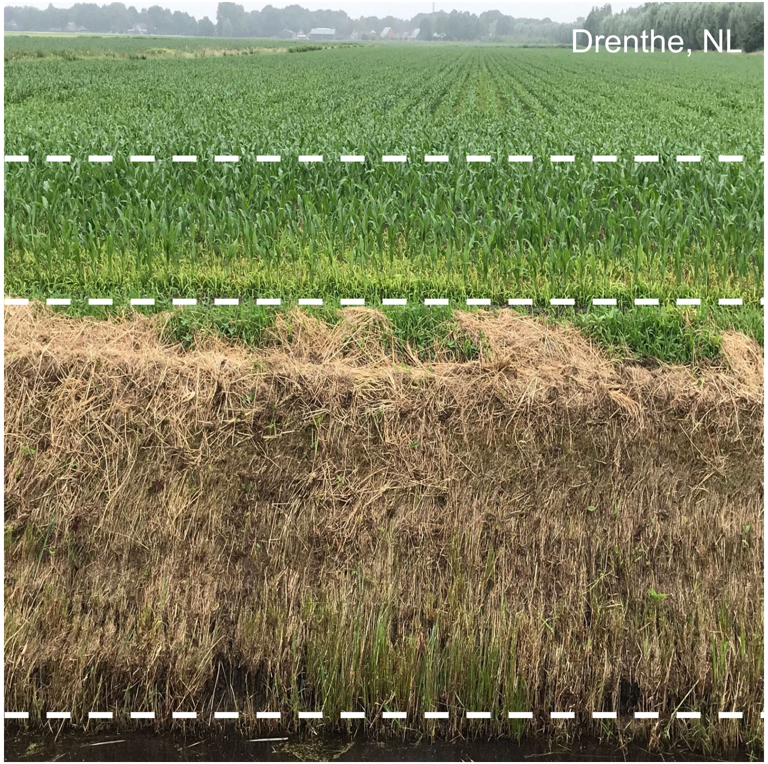
Challenges of Monitoring Subsidence in the Dutch Peatlands



Land cover

“Dry” soft soils

Ground water

Challenges of Monitoring Subsidence in the Dutch Peatlands

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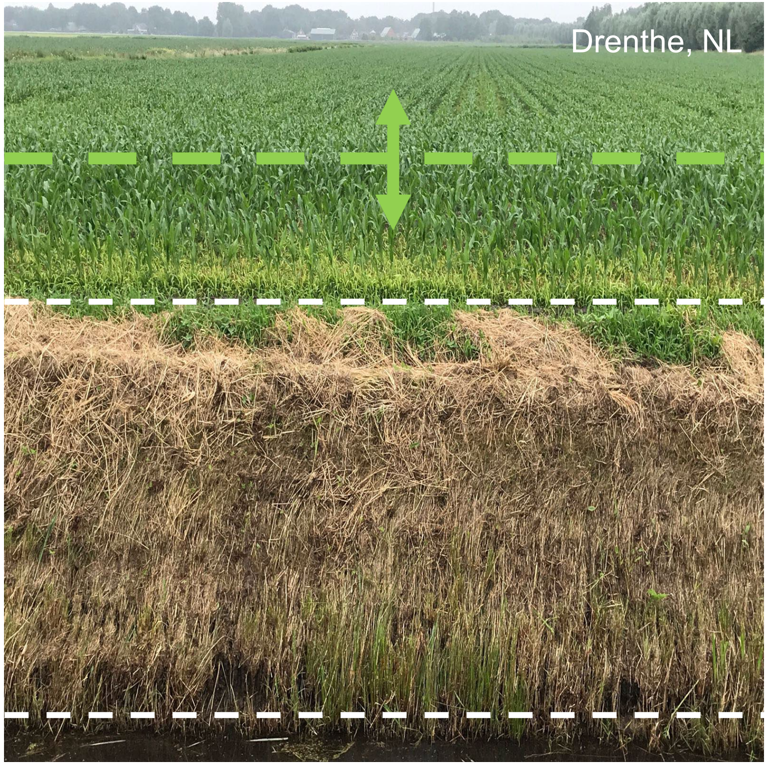

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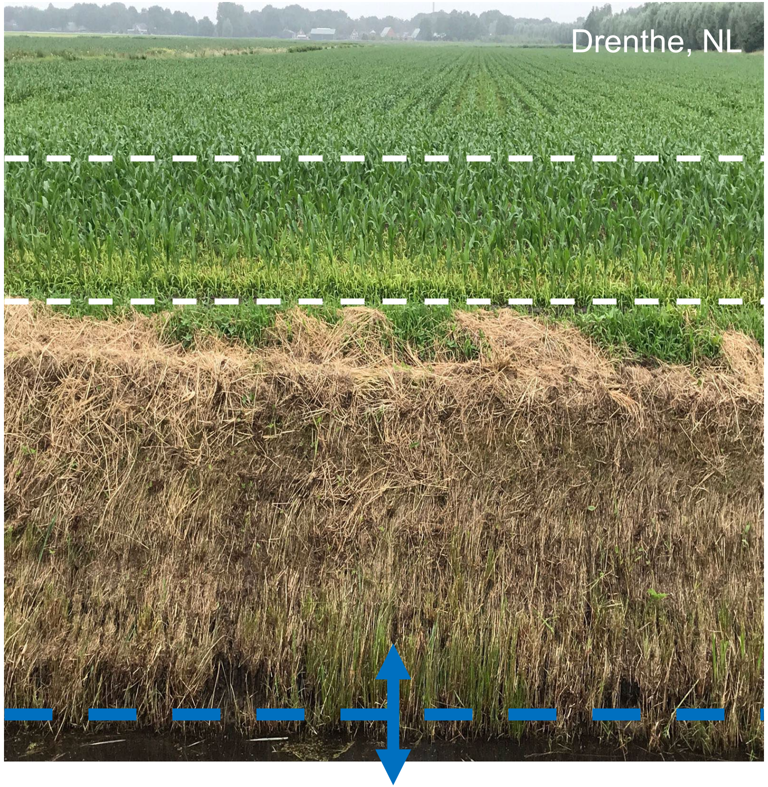
- Large fluctuations in the land cover
- Large fluctuations in the water table, both natural and artificial



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Challenges of Monitoring Subsidence in the Dutch Peatlands

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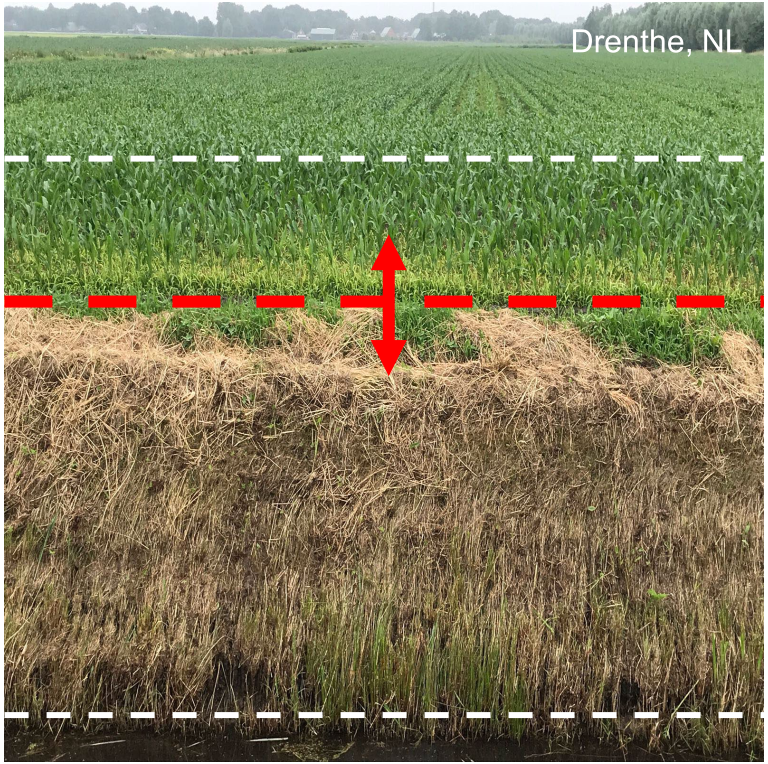
➢ Very rapid surface movement
➢ Non-stationary coherence
➢ Phase unwrapping errors



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Ground Truth Measurements

- Extensometer measurement

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- Extreme deformation rates

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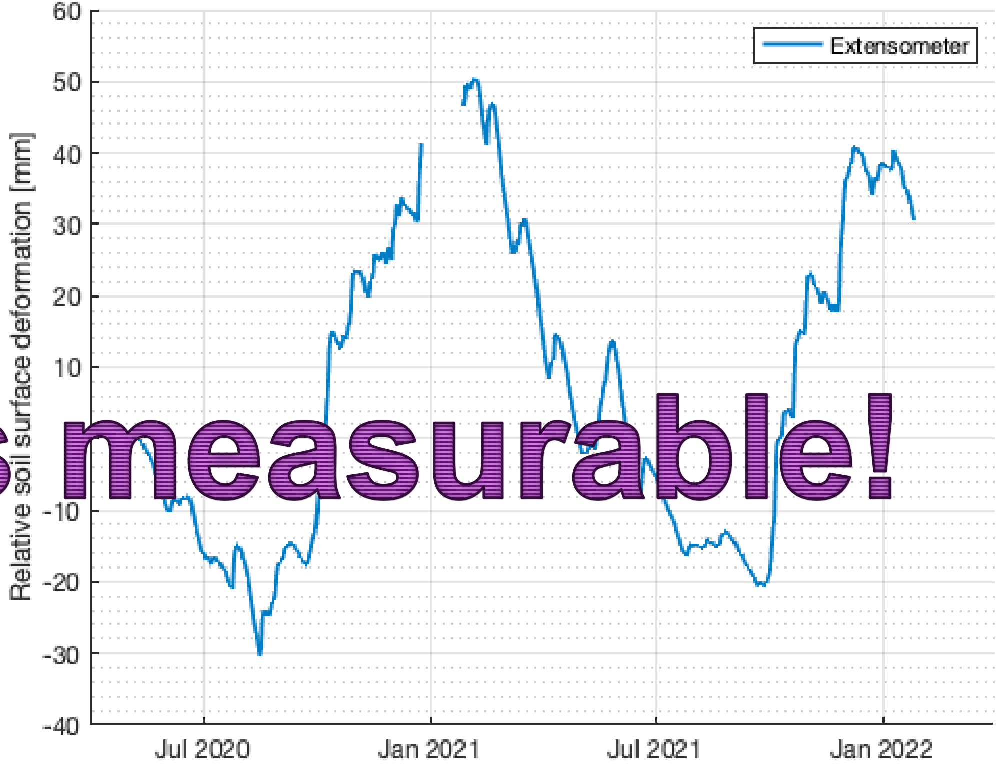

This is measurable!

Multilooking & Contextual Data Integration

zegveld_parcel_attributes_full [4]	
objectid	1646282
(Derived)	
(Actions)	
objectid	1646282
gewascateg	Grasland
gewas	Grasland, blijvend
gewascode	265
length	766.330184259988982
area	20757.373033329498867
objectid_2	NULL
aanid	27336
versiebron	luchtfoto
type	BTR-landbouw
soil_unit_	hVb
ahn_05_dsm	-2.428999901000000
ghg_mbgl	NULL
glg_mbgl	0.8 - 1.0
EERSTE_BOD	hVb
EERSTE_GWT	II

Parcels form a natural multilooking "unit"

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Multilooking & Contextual Data Integration

Key parameters:

- Land cover
- Soil type
- Water management zone ("Peilgebied")

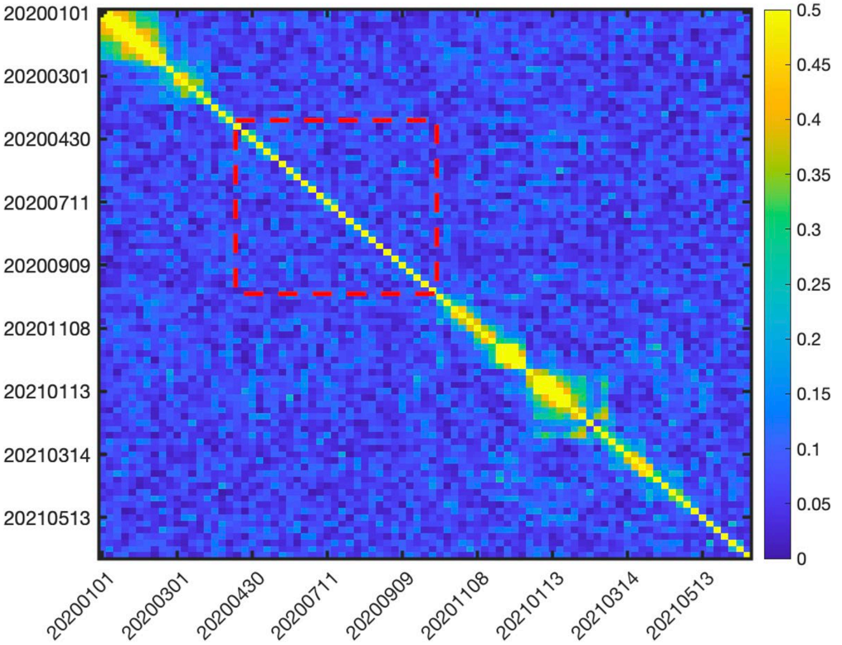
Ergodicity and representativity vs. noise suppression

Loss of Lock in Spring/Summer

- InSAR observations of Dutch grasslands commonly show a complete loss of coherence in the spring and summer

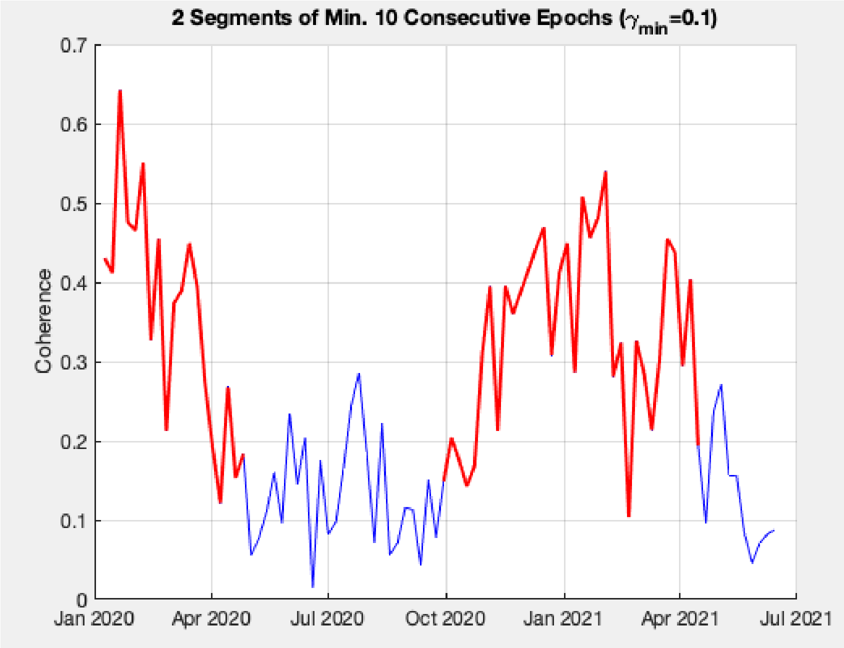
- Practically speaking, this sustained long-term loss of coherence results in a cutting of the time series into disconnected segments

Typical Parcel Coherence Matrix (Sentinel-1)



Segmentation by Coherence

- We identify coherent time series segments where we are confident in the data quality
- Each segment is treated as an independent time series
- We can unwrap the time series with an acceptable level of error within the segment[1]
  - ~90% success rate at $\gamma = 0.1$
  - ~98% success rate at $\gamma = 0.2$



[1] *Probabilistic Estimation of InSAR Displacement Phase Guided by Contextual Information and Artificial Intelligence*, IEEE Transactions on Geoscience and Remote Sensing. 2022 (In Review).

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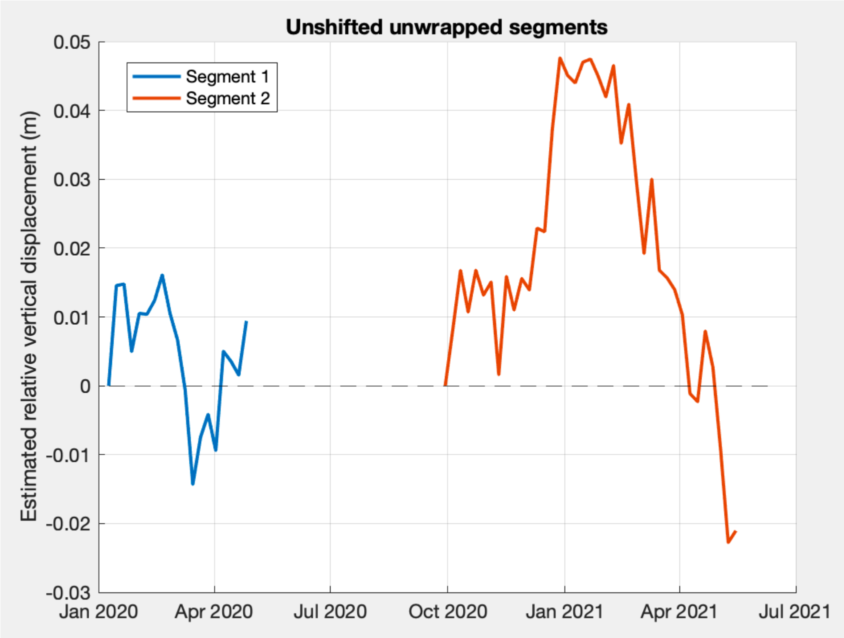
Partial Time Series Reconstruction

- We obtain an unwrapped time series for each segment
- Displacement is referenced to the first epoch
- How to reconnect the segments?



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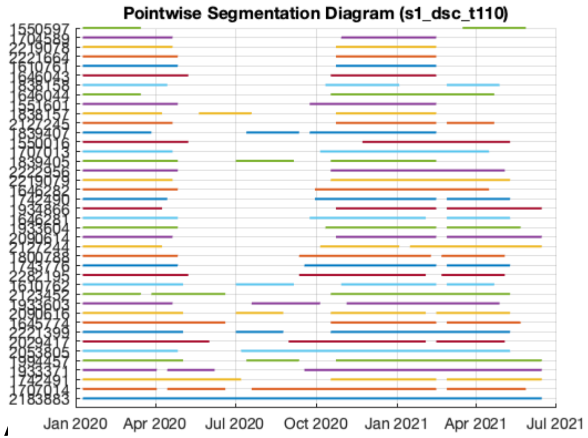
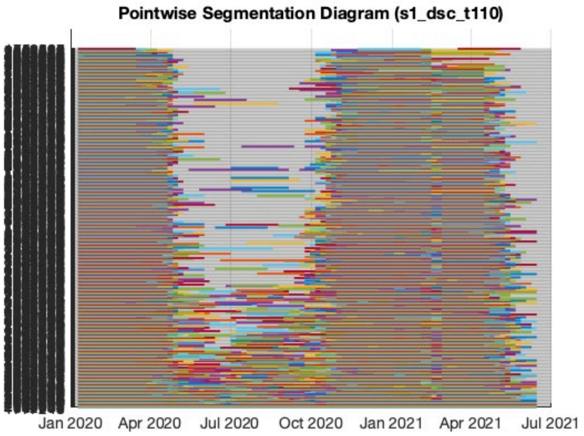
Multi-Parcel Estimation

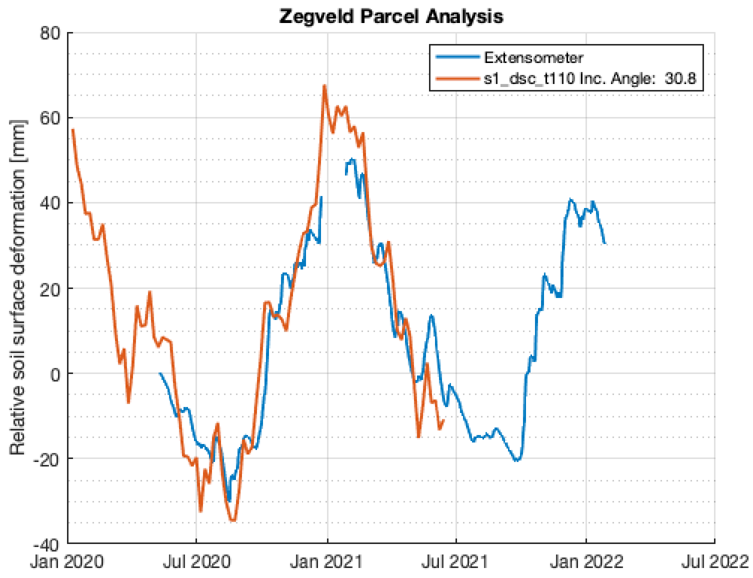
- We can average multiple parcels together to retain coherence over time
- Enough similar parcels will remain coherent during the spring/summer period
- Similarity assessed on contextual data

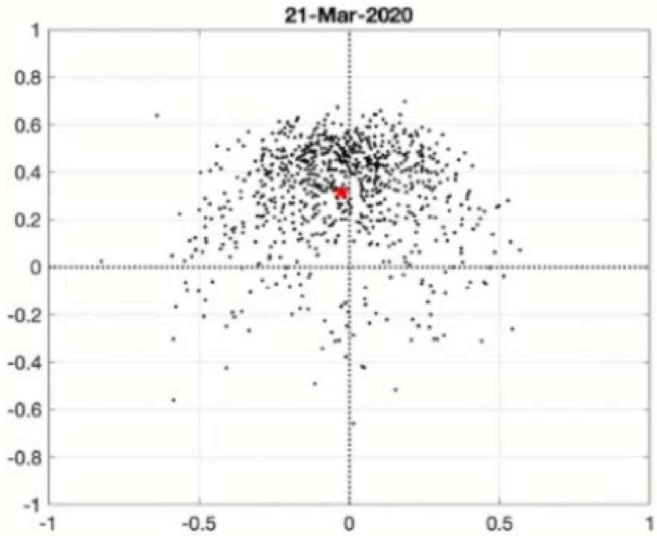


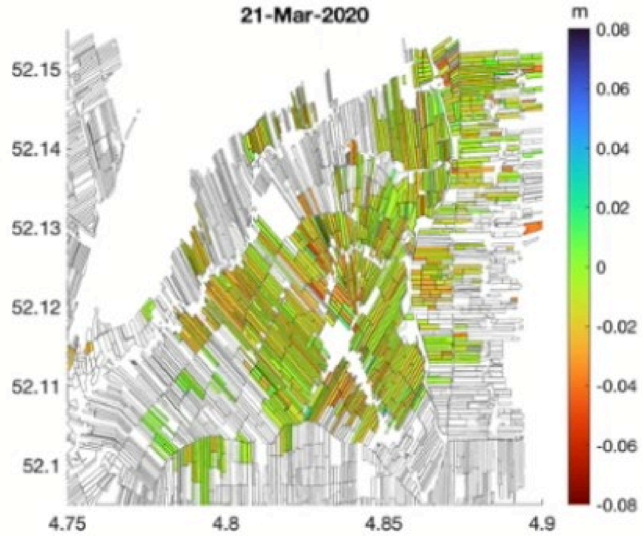


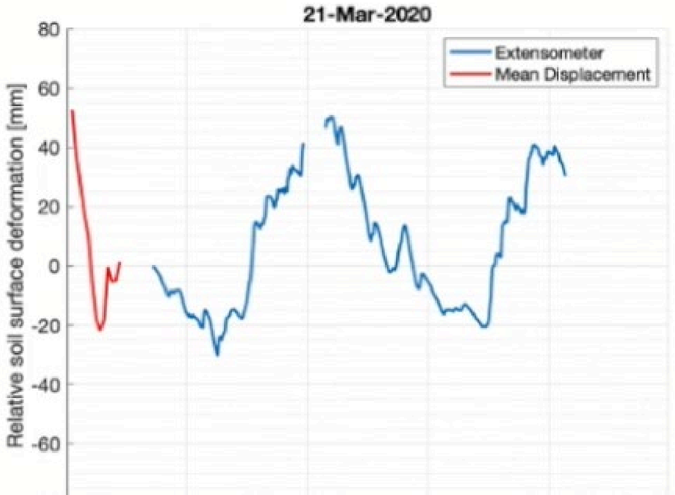
Multi-Parcel Estimation

- We (re-)multilook the parcels to obtain an average time series for the full group (right)
- Shift the individual segments according to the obtained mean displacement
- Two outputs:
  - Mean displacement time series of entire group
  - Per parcel time series reconstruction









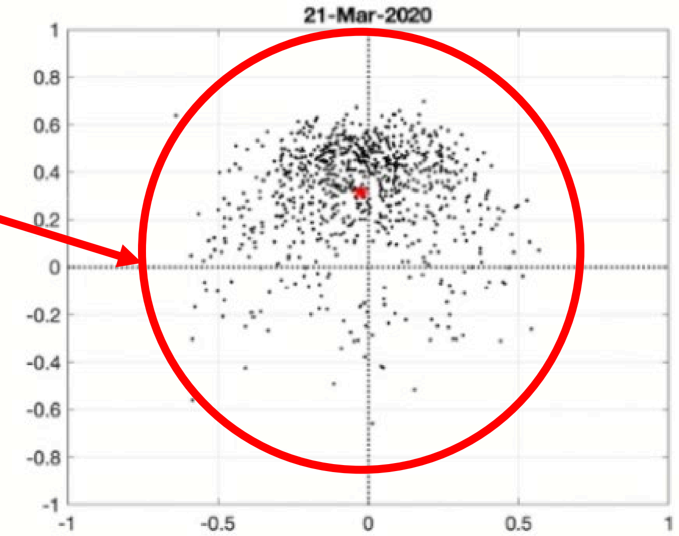
* Coherent Mean

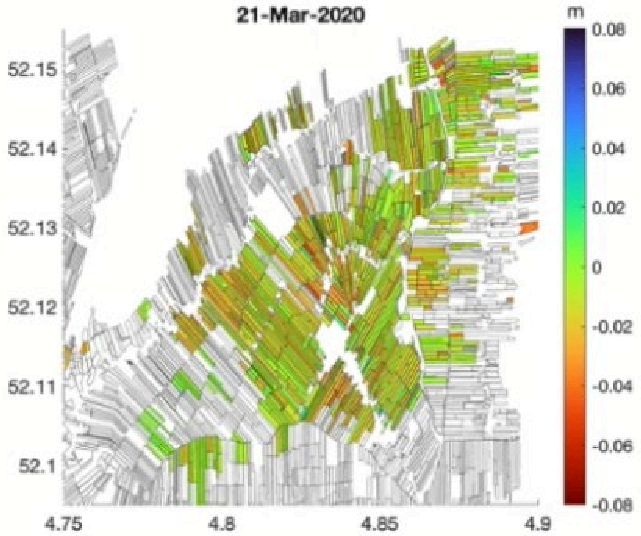
Parcel Loss-of-Lock

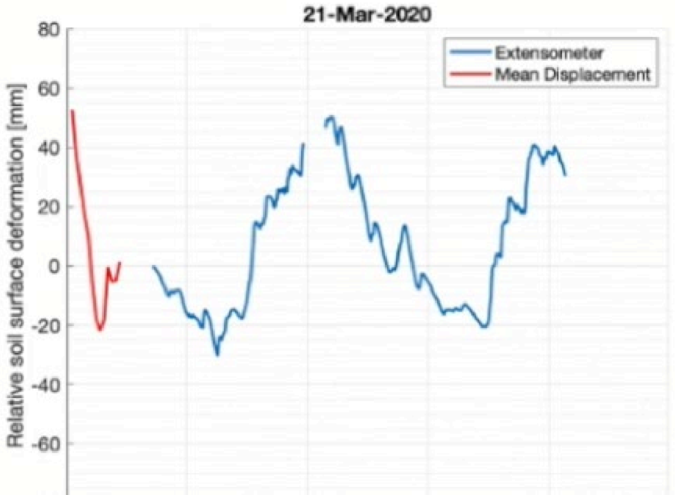
Soil code: ‘PvB’
Grassland cover
AHN -1.5m – -2.1m

Sentinel-1
Descending Track 110

Parcel averaging







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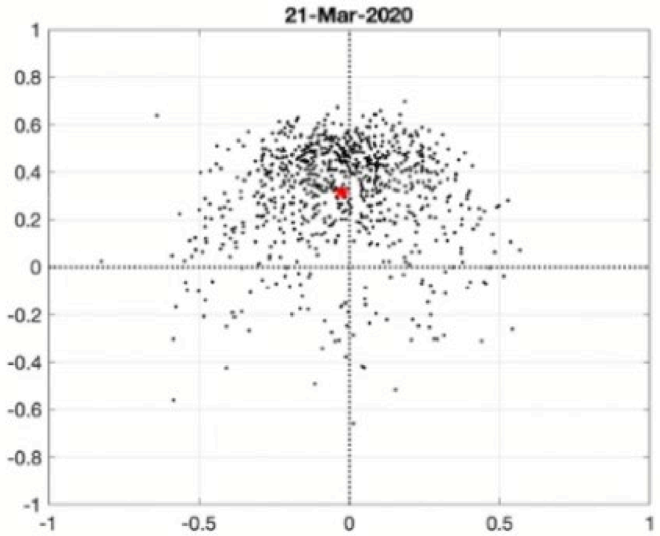
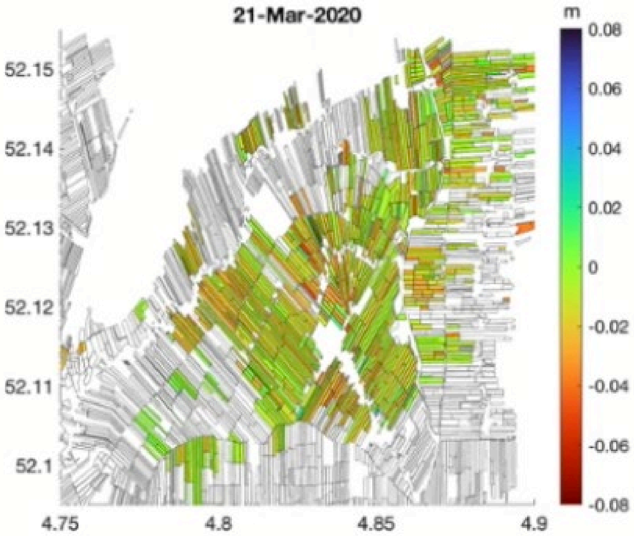
Unwrapped mean





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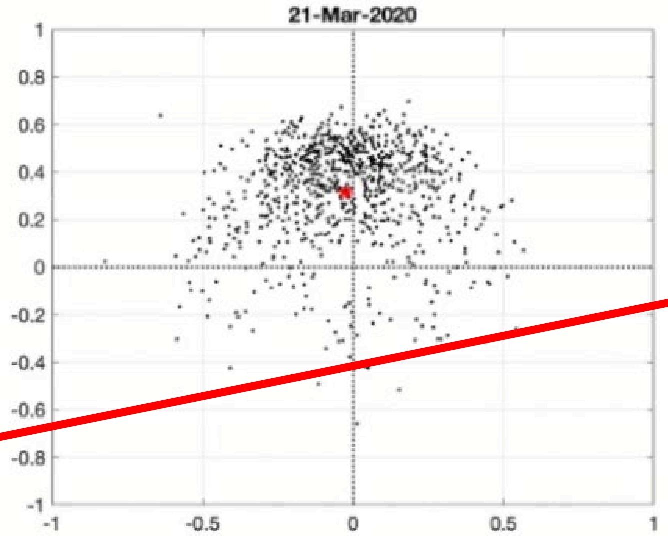
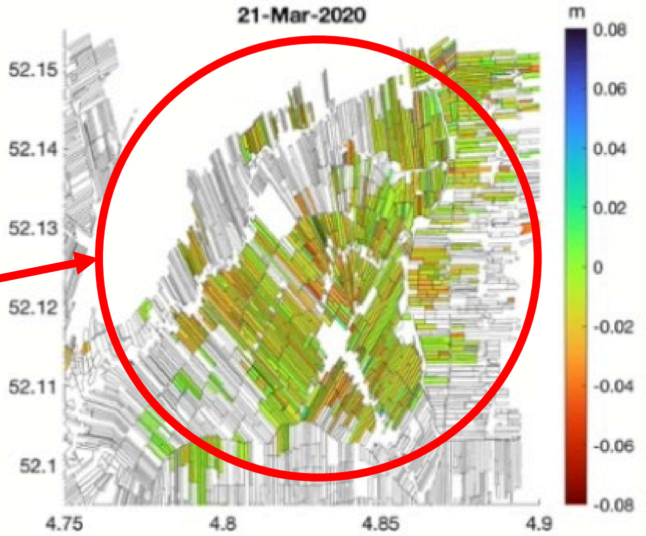
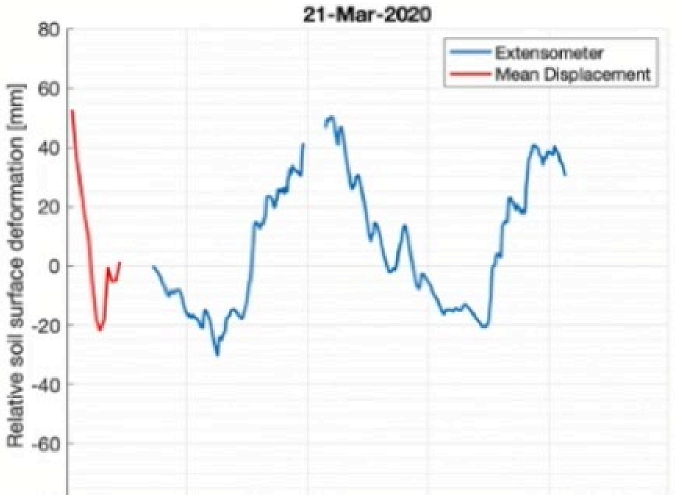
Deformation per parcel







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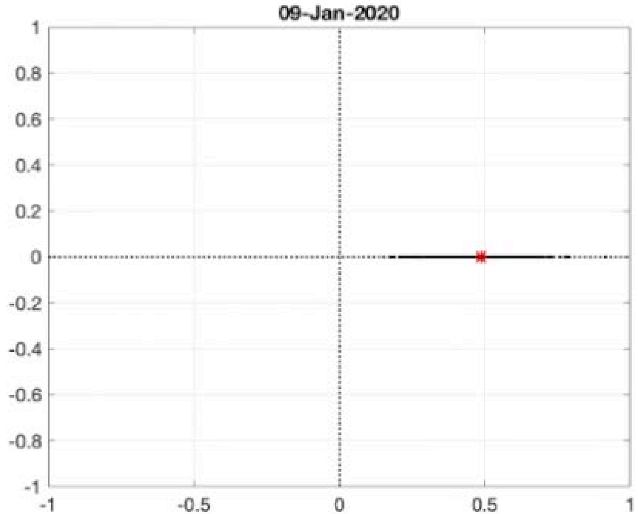

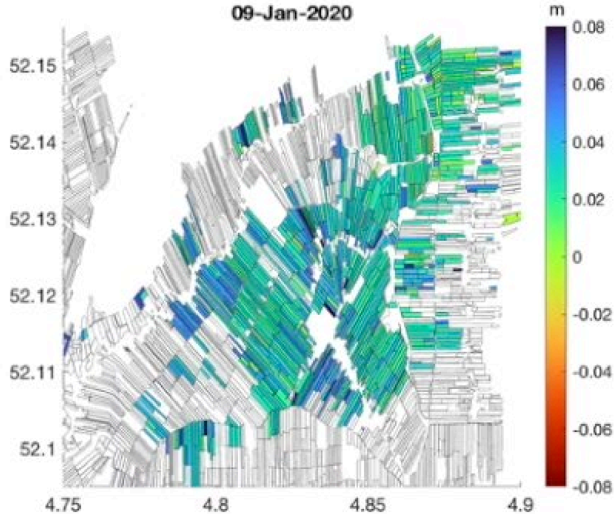

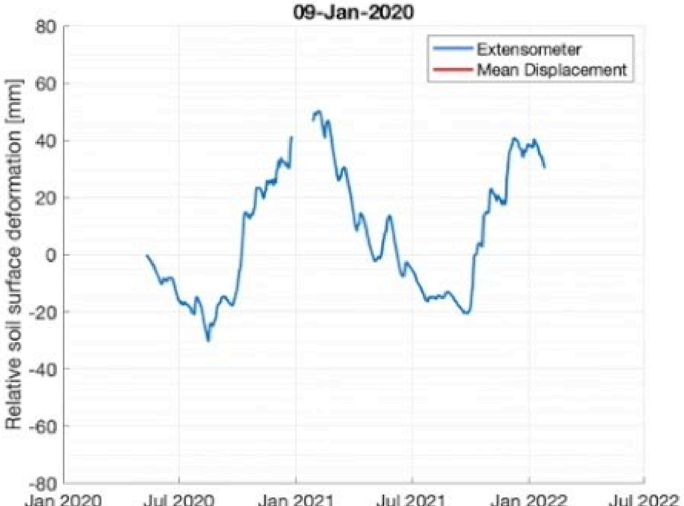

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Conclusions

- Loss-of-lock cuts the InSAR time series into disconnected segments
- We detect these segments using the daisy-chain coherence
- Neighbouring points are used to fill in the gaps in the incoherent segments
- *First accurate time series of surface motion of the Dutch peatlands!*

Future Work

- SHP tests within parcels
- Additional contextual data: parcel shape to estimate water infiltration
- Weighted parcel averaging by number of pixels
- Additional spatial constraints
- Process longer time series

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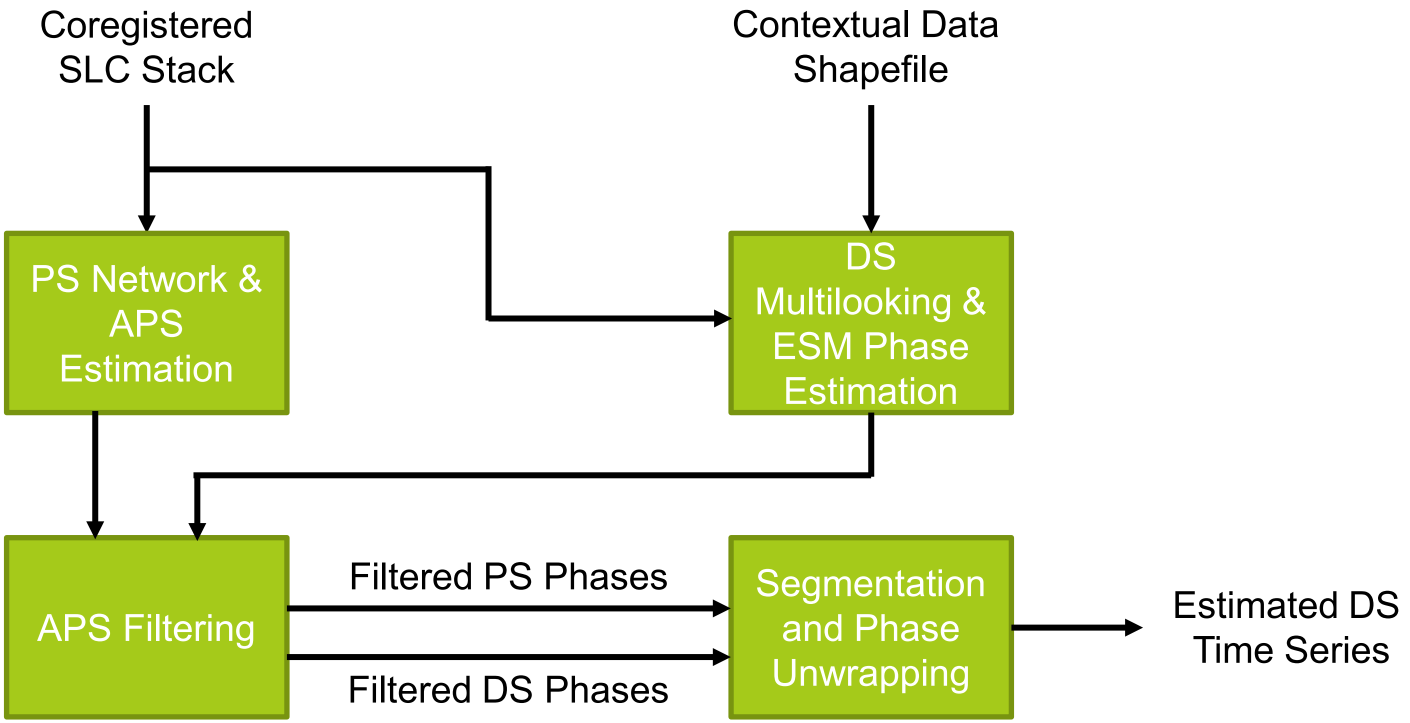
Extra Slides

Mixed PS/DS Processing Flow Diagram



Equivalent Number of Looks