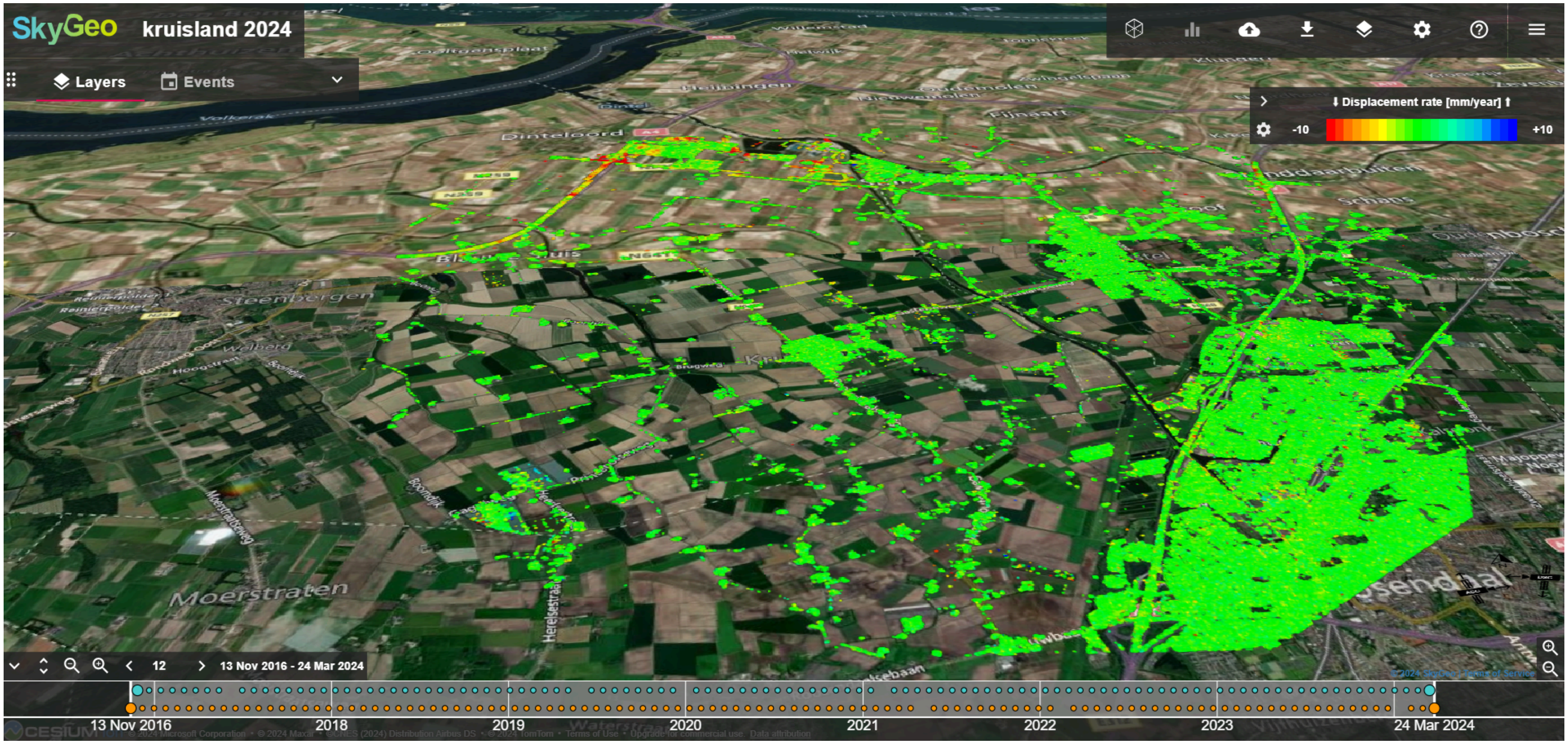

Memo - Baseline Displacement / Brabantwater - Kruisland

Brabantwater - Jacob Oosterwijk / jacob.oosterwijk@brabantwater.nl
SkyGeo - Marjan de Vries / marjan.devries@skygeo.com
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Executive summary

This report concerns a baseline analysis of the ongoing long term displacement processes in the area, in preparation for proposed water extraction in Kruisland. The displacement information is based on InSAR data covering the potential Kruisland extraction area. Brabant Water wants to carefully monitor the possible effects of extraction on displacement in the area, and will also monitor it with InSAR in the future.

The deformation is analyzed for the period 13 November 2016 to 24 March 2024.

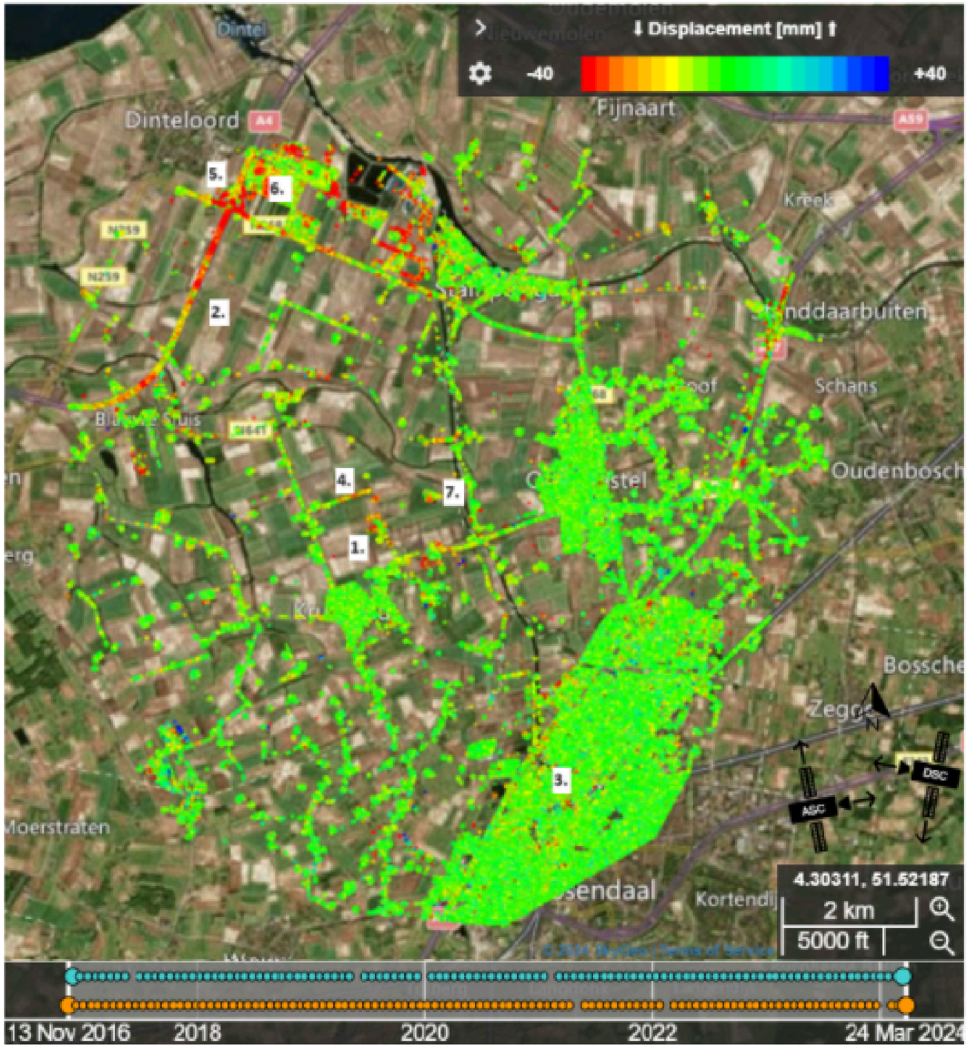
Dataset	Satellite	Period	Images	Median time interval
RSAT-XF asc	RADARSAT-2	13-11-2016 - 24-03-2024	110	24
RSAT-XF dsc	RADARSAT-2	27-11-2016 - 14-03-2024	108	24

Presentation of findings are represented in two parts:
- Four different types of displacement mechanisms
- Three areas with higher displacement rates

This non-exhaustive list of locations was selected as an example to illustrate the different deformation mechanisms that might be present in the area of Kruisland, as well as representable examples of areas with high cumulative displacements over 7.5 years of analysis. They will give a good idea of current ongoing displacements and will serve as a reference or baseline for further monitoring.

For this historical baseline, there are no signs of subsidence due to deep subsurface phenomena. Current observed displacement is related to surficial mechanisms such as thermal effects, site maintenance, and compaction due to shallow foundations. This displacement rate remains up to ~ -15 mm/year.

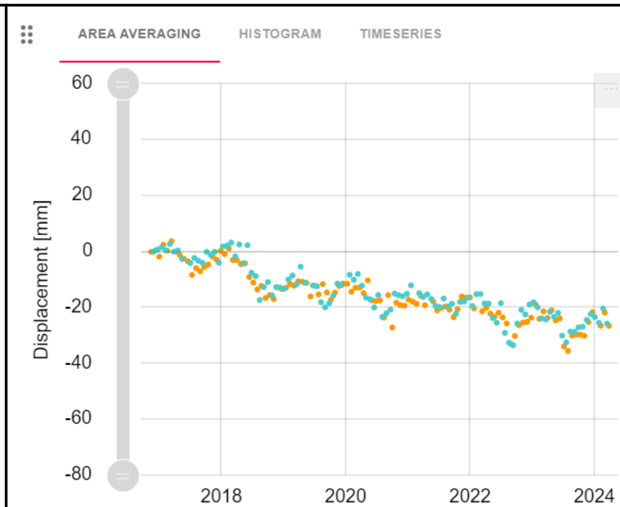
Kruisland area of interest



Location	Address
1	Engelseweg 6, Kruisland
2	A4 next to Potmarkreek
3	Brug Zuid Hollandweg over Nieuwe Roosendaalsche vliet
4	Tweede Boutweg, Kruisland
5	Intersection A4 and Noordlangeweg
6	Noordzeedijk 120, Dinteloord
7	Kleine Bolspolder 3, Kruisland

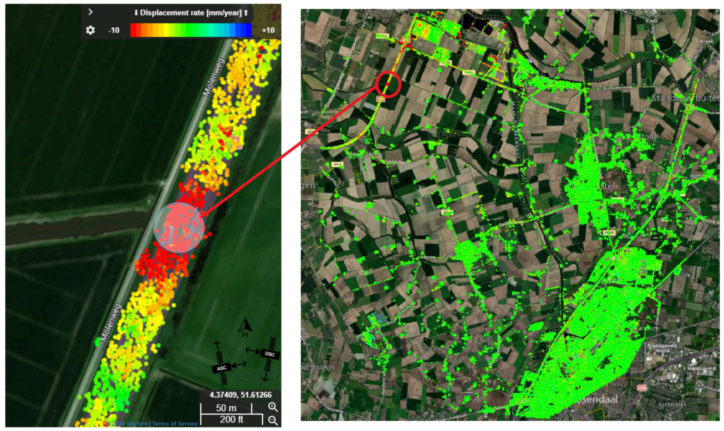
Different types of displacement mechanisms

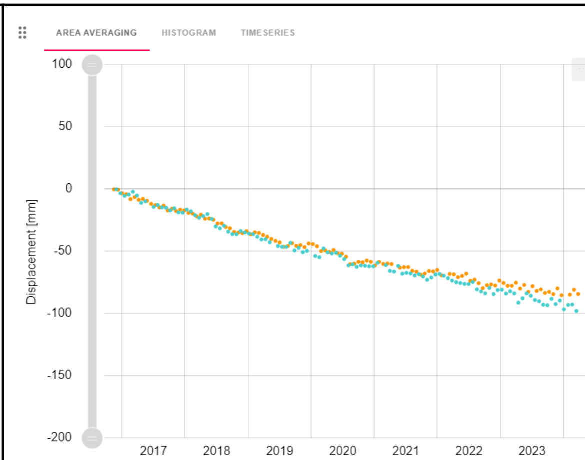
<table>
<tr><th>Type of displacement and location</th><th colspan="2">Examples</th></tr>
<tr><td>1. Subsidence on shallow foundation (Engelseweg 6, Kruisland)</td><td>


</td><td>
</td></tr>
<tr><td colspan="3">The average displacement rate in this location is around -4.0 mm/year, and a total displacement of around -30 mm in 7.5 years of analysis. The buildings across the street are newer, most likely founded on piles, with a displacement 3 times less than the building in Engelseweg 6, which is around -10 mm in 7.5 years of analysis.

Description: This mechanism is found on buildings constructed with most likely shallow foundations, rather than pile foundations. Over time, the soil beneath these foundations may compress and settle due to the building load, resulting in gradual subsidence. This is a common issue in areas with soft or unconsolidated soils. The displacement is characterized by localized displacement on the building, meaning that another building with a pile foundation next to it might show significantly different long-term rates. Additionally, we observe a seasonal trend in subsidence, likely associated with changes in soil moisture that are more pronounced near the surface where shallow foundations are located. This seasonal subsidence is not visible in buildings with pile foundations likely due to its anchorage in deeper, more stable soil layers that are unaffected by these surface-level moisture variations.</td></tr>
</table>

2. **Shallow compaction over filled-in creek(roads) (A4 next to Potmarkreek)**

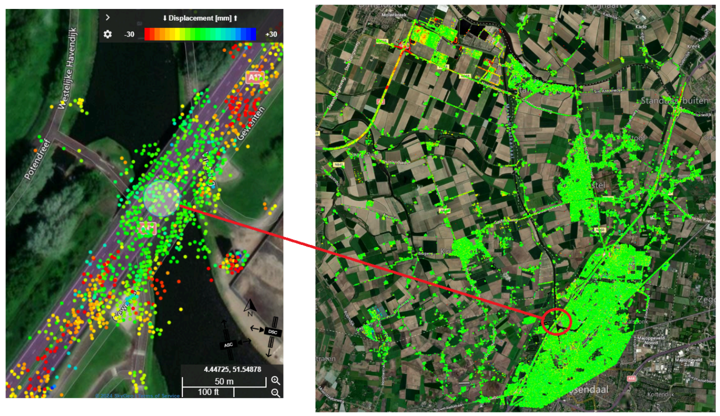


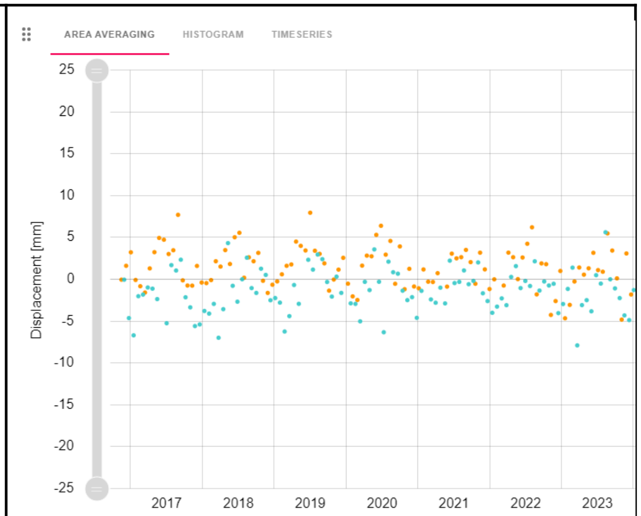


The displacement rate on this road section is higher than neighboring areas, reaching up to velocities of ~ -12.5 mm/y, as compared to the rest of the road, which is around -3.7 mm/y.

Description: On this road, a localized higher subsidence velocity is observed. This correlates with the location of a former Creek that has been filled-in. The disturbed soil layers tend to compact over time. Initially, this compaction can be rapid but typically decelerates as the soil reaches a new equilibrium. Soil settling is a natural consequence of the re-compaction process after being disturbed.

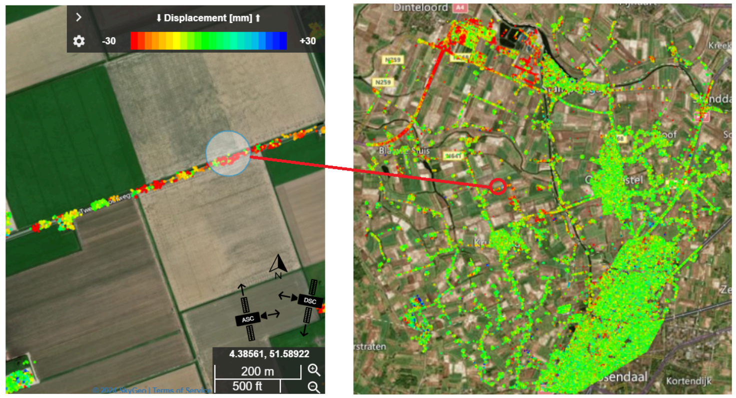
3. Seasonality due to thermal expansion (Brug Zuid Hollandweg over Nieuwe Roosendaalsche vliet)





Seasonal variations are around 5 - 7 mm, which is not the case for the surrounding areas, with mainly linear displacements.

Description: Seasonality is observed where temperature is expected to play a role. Thermal expansion and contraction of materials (such as asphalt in roads, steel in bridges, and some building materials) lead to cyclic displacements. These movements are usually periodic, corresponding to seasonal temperature variations. In this case, subsidence and uplift correspond to winter and summer periods.

<table>
<tr>
<td>4. Generic long-term shallow compaction (Tweede Boutweg, Kruisland)</td>
<td>
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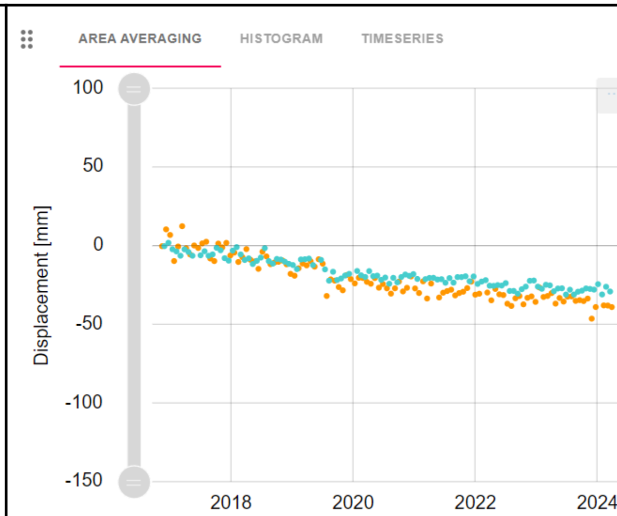
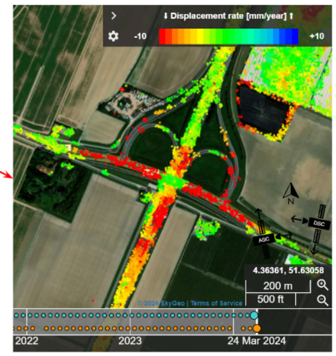
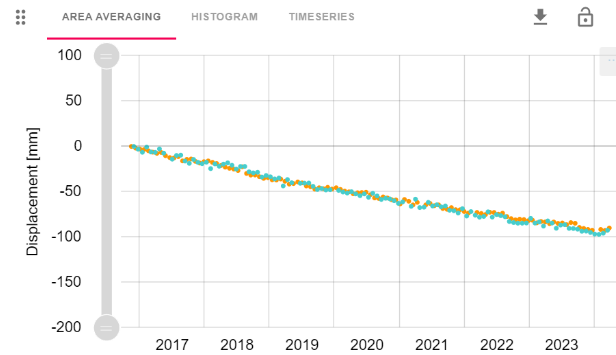
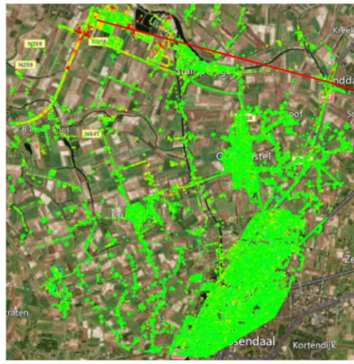
<td>
</td>
</tr>
<tr>
<td colspan="3">The displacement can be very localized and can correlate with local soil type. The displacement rates can be between ~ -2.5 and -6 mm/y

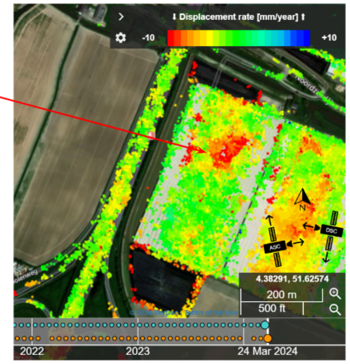
Description: Overall, we observe gradual and continuous subsidence due to natural soil compaction processes. Factors contributing include soil consolidation under the weight of overburden and ongoing sedimentary processes, common in The Netherlands.</td>
</tr>
</table>

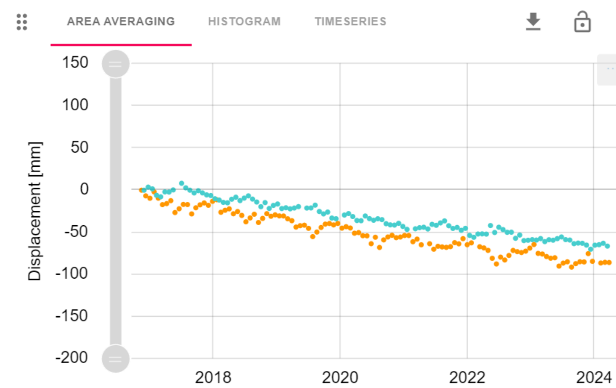
Areas with higher displacement rates.

<table>
<tr><th>Type of displacement and location</th><th colspan="2">Examples</th></tr>
<tr><td>5. Road A4. (Intersection A4 and Noordlangeweg).</td><td> 
</td><td>
</td></tr>
<tr><td colspan="3">Description: On the intersection, the displacement rate is higher than neighboring areas, reaching velocities of up to ~ -15 mm/y. This increased displacement may be related to residual soil compaction of the viaduct-ramps after construction of the viaduct around 2014. Note that the viaduct in the center is stable, most likely due to the presence of a pile foundation.</td></tr>
</table>

6. Greenhouses. (Noordzeedijk 120, Dinteloord).



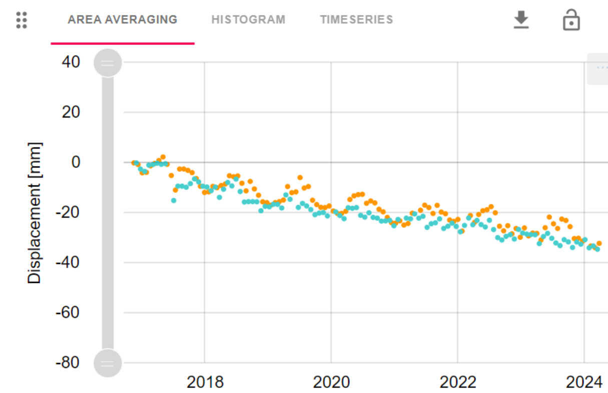




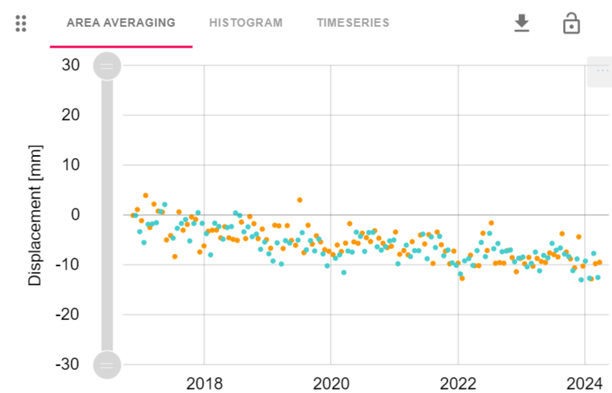
Description: On the roof of the greenhouses, the displacement rate reaches up to velocities of ~ -12 mm/y. This displacement indicates that the structure most likely does not have a deeper foundation. The spatial difference most likely indicates spatial variations in the soil properties and the corresponding bearing capacity and/or compaction. In the time series also a seasonal effect can be seen which corresponds to the thermal expansion of the metal structure of the greenhouse and shows opposite signals for the different satellite-tracks due to the different look-direction.

7. Displacement Magnitude Differences in Urban Areas: Impact of Foundation Types (Kleine Bolspolder 3, Kruisland)

1.



2.



Description: We observe different displacement magnitudes within the same location. Time series show that the barn (1), exhibits more than twice as much displacement (up to ~5 mm/yr) as the terrain next to it (up to ~2 mm/yr). The reason for this can be local variations in soil properties and compaction occurring due to the additional load of the barn.