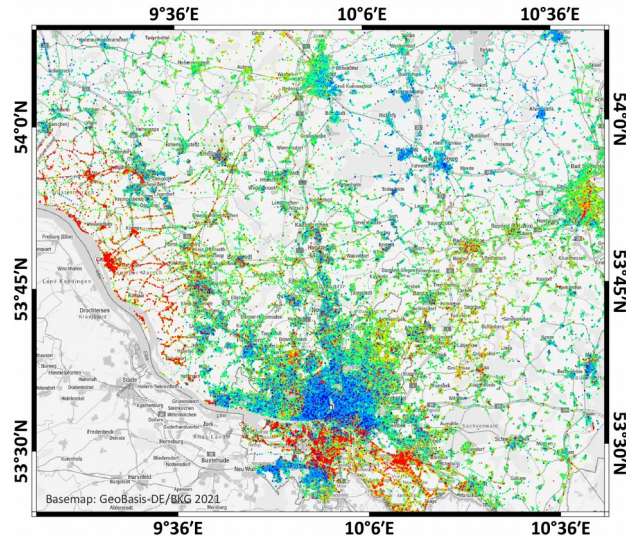


Detecting (very slow) ground motion in Schleswig-Holstein from radar satellite data

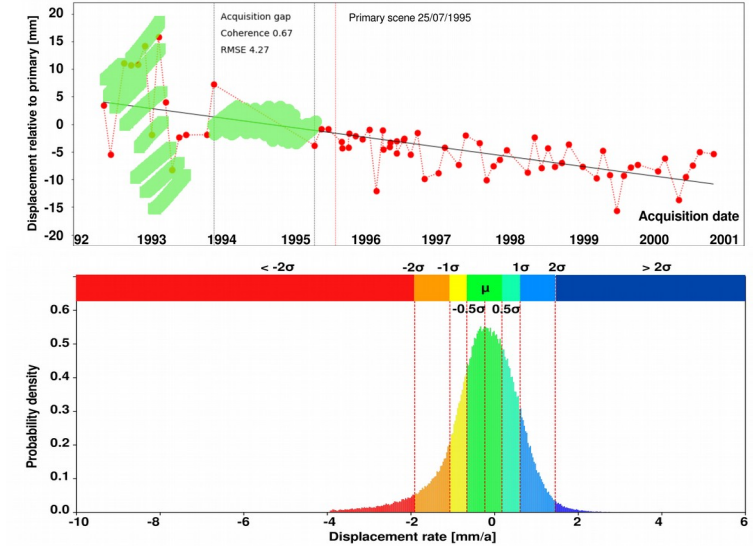
Dieter Hoogstraat¹, Dr. Henriette Sudhaus¹, Andreas Omlin² ¹Kiel University CAU, ²Geological Survey of Schleswig-Holstein



EGU21-13454



We show, how we combine statistical methods to select persistent scatterer (PS) from different datasets and finally visualize the annual ground motion rates derived from these scatterers in a way that allows us to separate signals representing very slow ground motion processes, from a noisy background.

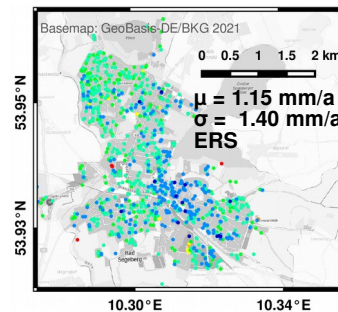
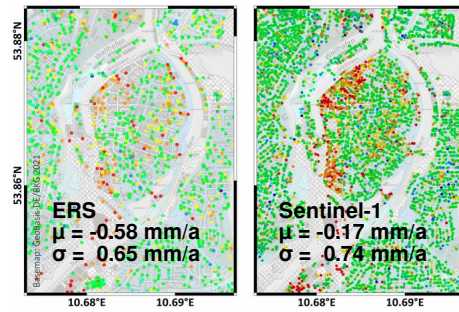
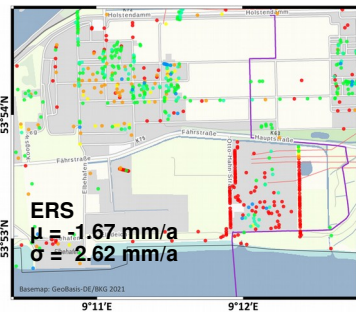
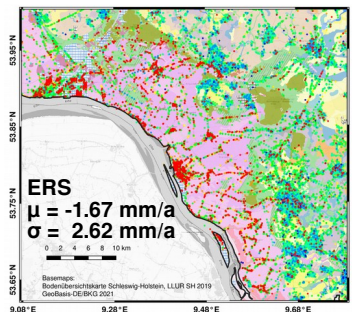


Elbe marshlands

Brunsbüttel
(Nuclear power plant)

Lübeck's historic city
(UNESCO World Heritage)

Anhydrite swelling



All ERS data was provided by Nico Adam through the German Aerospace Center (DLR). The Sentinel-1 data is part of the Bodenbewegungsdienst, BGR 2021

Detailed information on the initial approach can be found in: Hoogstraat, D. H. (2019): Auswertung von Zeitreihen stabiler Streupunkte..., Bsc-Thesis, Kiel University (DE), Inst. f. Geosciences

Detecting (very slow) ground motion in Schleswig-Holstein from radar satellite data

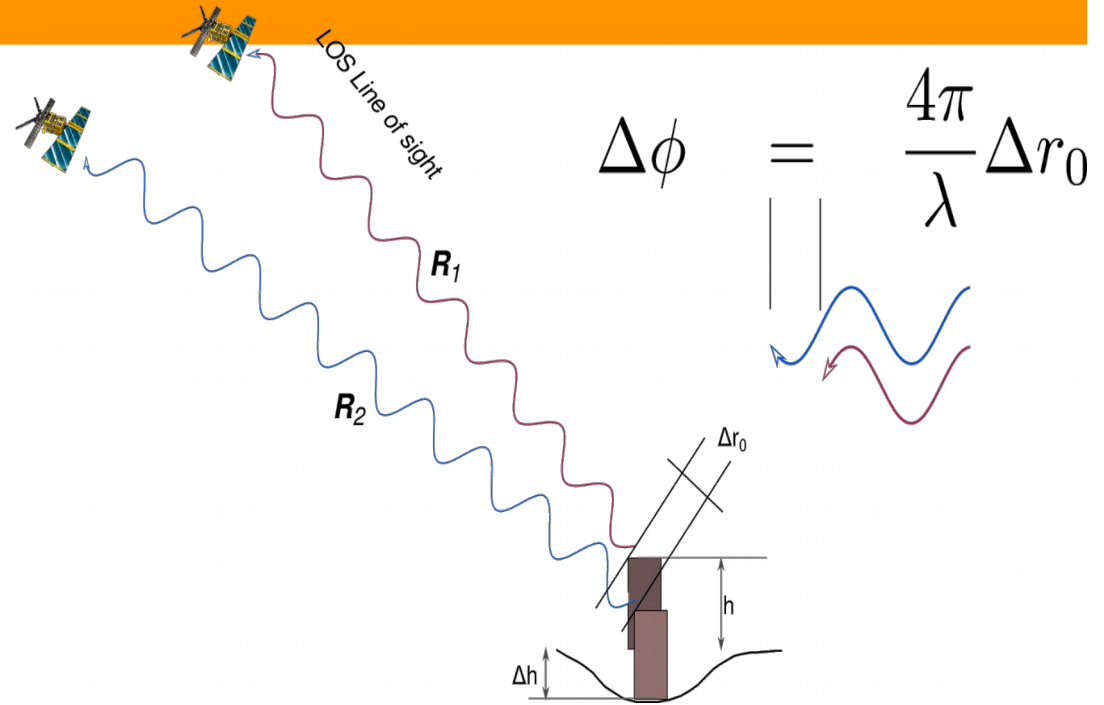
Dieter Hoogestraat, Kiel University CAU

Dr. Henriette Sudhaus, Kiel University CAU

Andreas Omlin, Geological Survey of Schleswig-Holstein

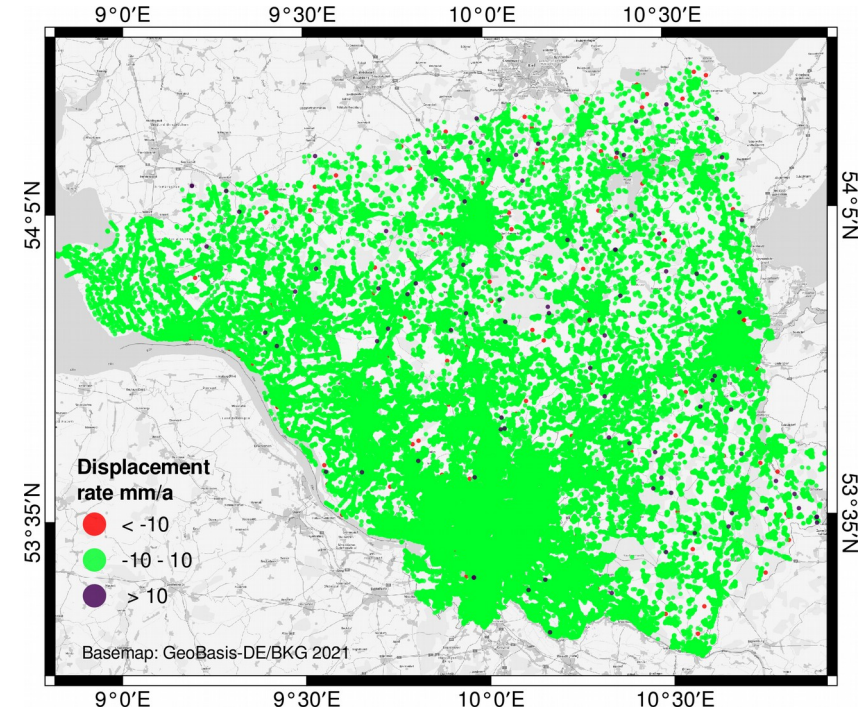
PS-InSAR

- Distances are measured as a difference in phase.
- Ground motion is measured as a difference in distances.
- Some backscattering objects occur in almost every scene. They are called Persistent Scatterer (PS.)
- Observing those PS leads to time series indicating long term ground motion trends.



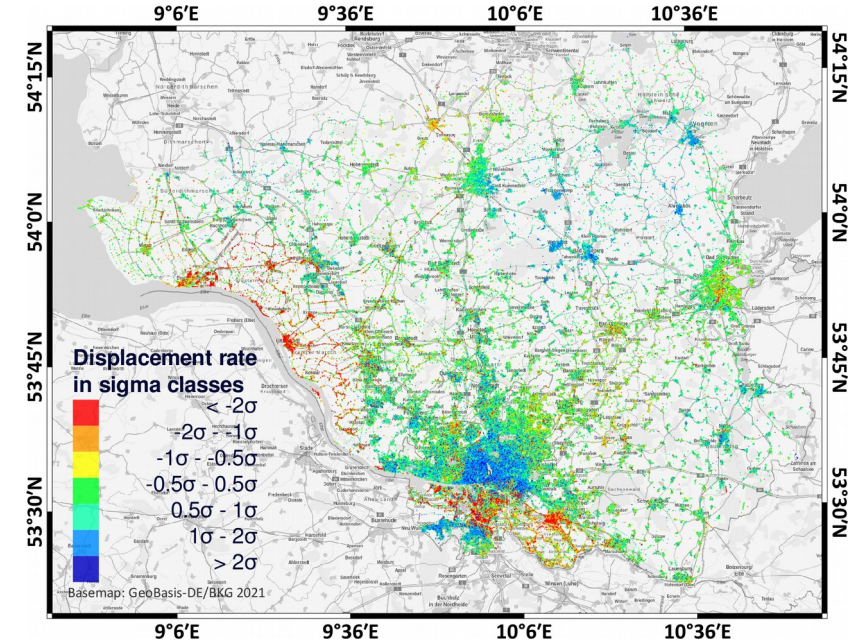
Challenges

- Often, older data is not stationary in a statistical sense.
- There is no ground truth.
- Ground motion trends differ by satellite and by track.
- Most of all: for an tectonically almost stable area like Schleswig-Holstein ground motion in many cases is a fact below all detection limits.



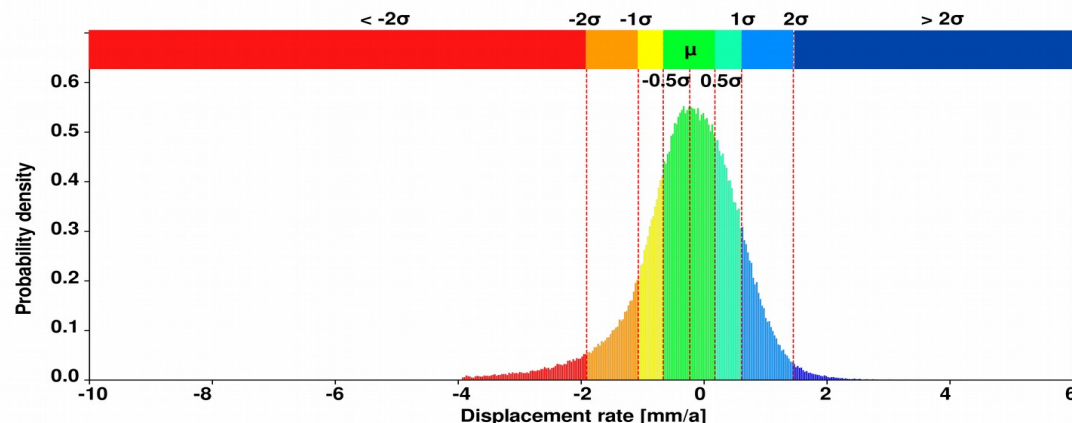
Our suggestions

- We found a way to visualize the effects of very slow ground motion.
- Our tools allow us to relate data from different tracks to each other without calculation deramping functions or offsets.
- Using sigma-classes allows to connect ERS data to Sentinel-1 data.
- We began to use PS at transmission towers to obtain a simple, but spatially good defined ground truth.



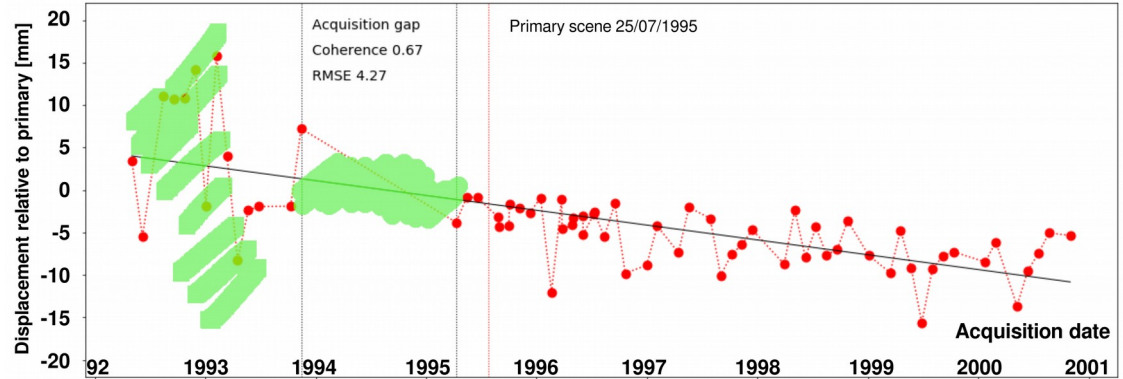
Sigma-classes (the main tool!)

- Cut the data to $\mu \pm 3\sigma$.
- Calculate a categorized color scale with 7 classes: $\mu \pm 0.5\sigma$, $\mu \pm 1\sigma$, $\mu \pm 2\sigma$, all the rest $\pm$.
- Use these classes to color all the PS by defo_mm/ye (ERS) or Mean_Velo (Sentinel 1).
- Where applicable, find a reference point to be used as $\emptyset$ -line. Usually, in a region like Schleswig-Holstein **transmission towers** are good starting point to compensate for near-surface processes or to quantify those.



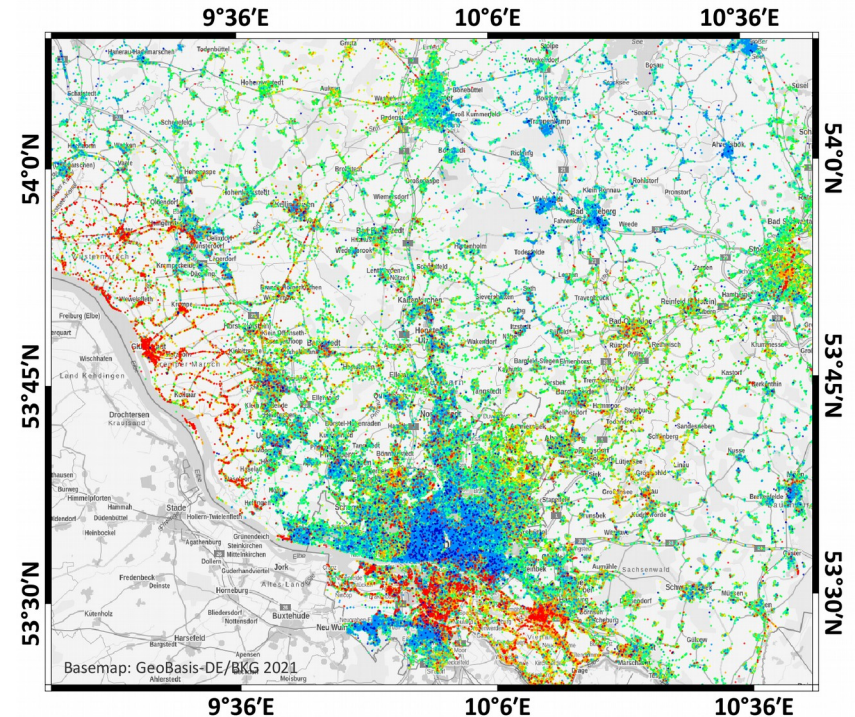
Data preparation

- “Older data” (ERS) is often less stationary than more recent data.
- Furthermore, for PS data over Schleswig-Holstein there is an acquisition gap of more or less one year, depending on the track.
- We use only PS with a strong stationarity.
- Sentinel 1 data needs to be demosaicked before it can be used for very slow ground motion analysis.



Elbe marshlands

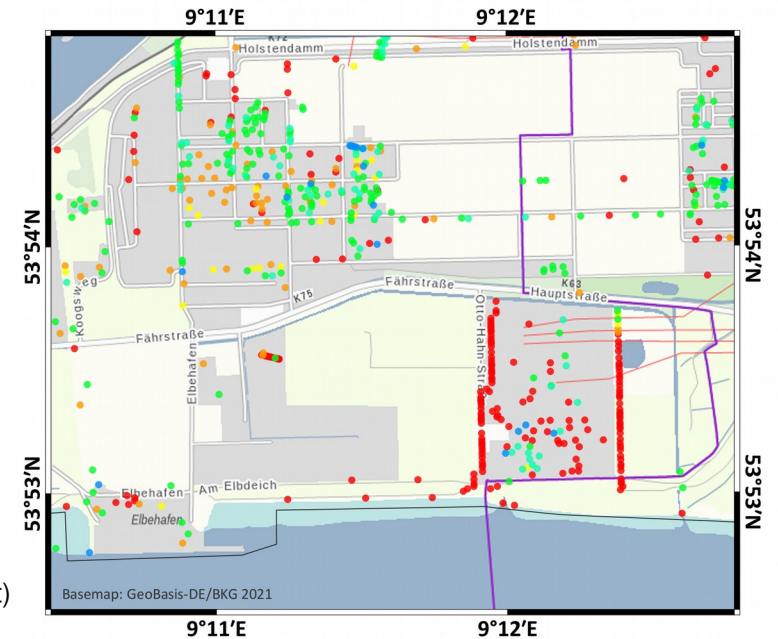
- One of the most obvious processes is the subsidence of the marshes along the Elbe river.
- Subsidence rates are up to 15 mm/a.
- The reasons for this are compacting processes due to dewatering and biological processes.
- Even though subsidence processes can be detected easily, there's a general uplift trend over urban areas that we cannot explain at the moment.



Infrastructure

- Infrastructure often is clearly identifiable due to the fact that they often show construction features that are good corner reflectors.
- PS derived from those infrastructure installations are almost always stable.

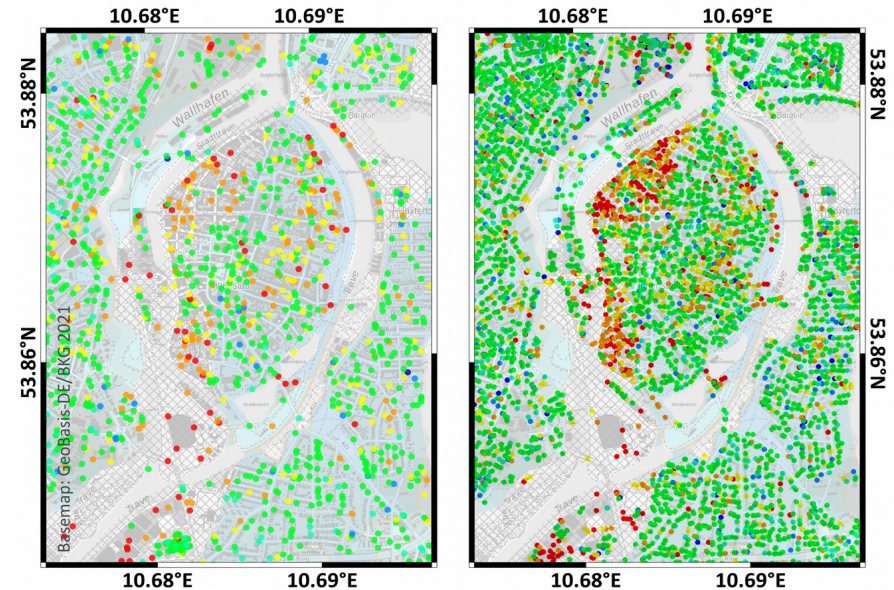
Brunsbüttel (Nuclear power plant)



Lübeck's UNESCO World Heritage

- A region of strong subsidence along the western rim of Lübeck's historic town depicts an area with anthropogenic fills over peat.

Lübeck's historic city (UNESCO World Heritage)



Conclusion

- A statistics based approach can be used to identify and structually qualify even very slow ground motion processes.
- To do this, analytic classes should be calculated based on the statistically most significant range between – und + 3 standard deviations.
- Stationarity is a better quality mark than outliers, because it's outliers we are looking for.
- Hydrogeological effects play a major role for the structure of surface measurable ground motion processes.
- Anthropogenic installations with well known behaviour like transmission towers, seem to be a good approach for the definition of a spatially well defined ground truth.

Thank you very much for your attention.

And if there's something left:
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