Using InSAR Velocity Measurements at Transmission Towers to Calibrate Ground Motion Data

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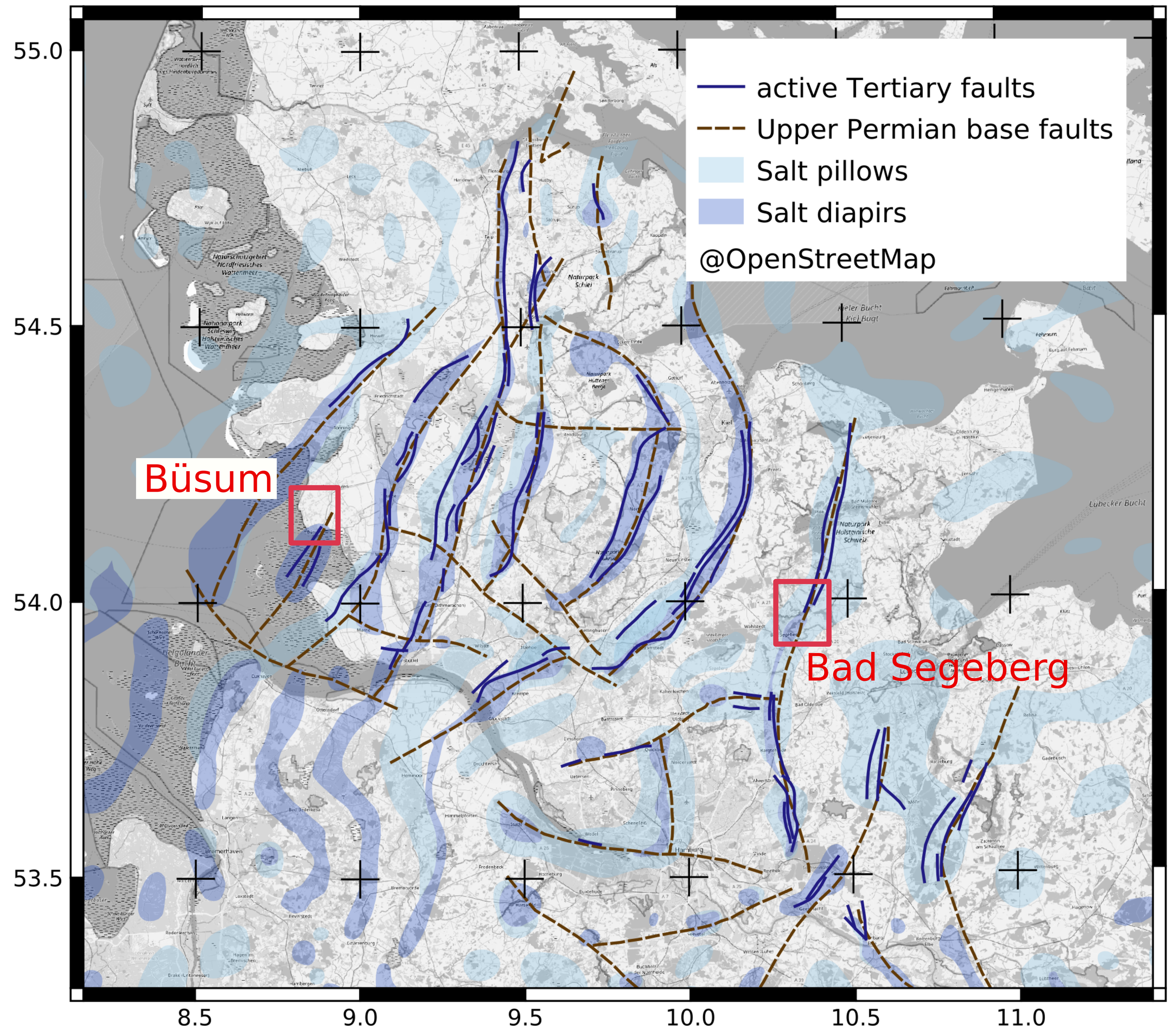


Fig. 1: Tectonics and salt diapirism in Schleswig-Holstein.

Introduction

The near-surface geology of Schleswig-Holstein is characterized by glacial deposits, deformed by rising Permian and Upper Triassic salt structures (Fig. 1). Ground motions potentially associated with these processes are very slow and superimposed by signals of e.g. hydrological and anthropogenic sources.

To measure ground motion, we use radar interferometric time series data provided by the German Aerospace Center and the Federal Institute for Geosciences and Natural Resources' Ground motion service. These data are based on Synthetic Aperture Radar images acquired by ESA's Sentinel-1 satellites. Time-series analyses are possible for temporally stable backscattering objects (persistent scatterers) on the ground. Here we present analyses of ground motion detected in Schleswig-Holstein (Fig. 2). The presented analyses include seeking motion at known faults and dykes.

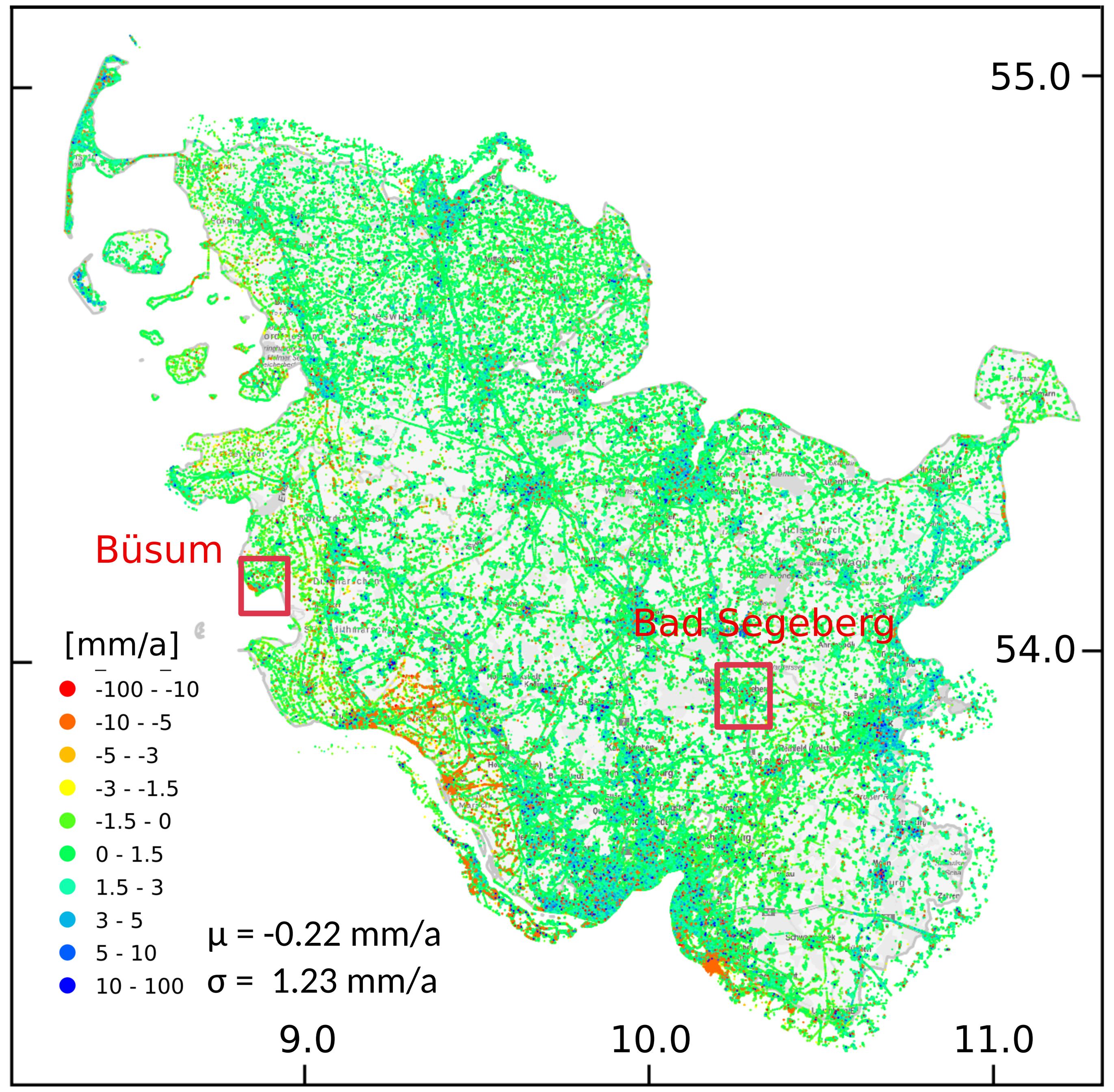


Fig. 2: Ground motion rates (desc. tracks) in Schleswig-Holstein.

Methods

InSAR time series provide relative motion measurements, which require referencing to points of known motion, e.g. absolute motions based on GNSS. Lacking those, as in many places in Schleswig-Holstein, we are testing alternatives. Here we use scatterers from the bases of well-funded high-voltage AC transmission towers for relative calibration. Further, we visualize motion values based on sigma-classes of the motion value distribution within the wider region of interest: In this way we can highlight significance of motion (Fig. 3).

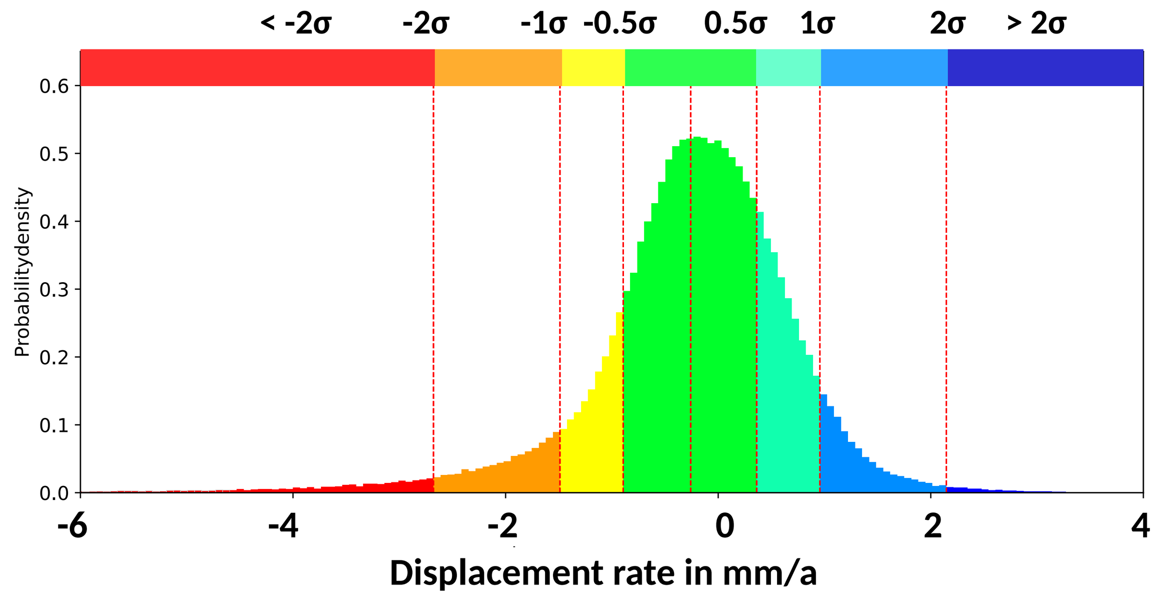
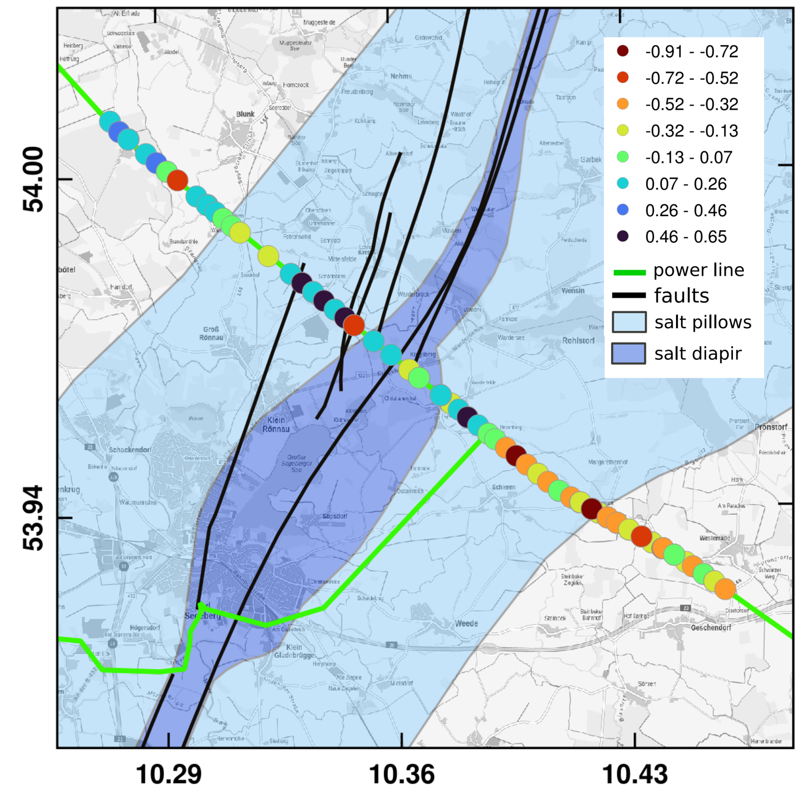


Fig. 3: Scale of sigma-classes over the hydrological region Neustadt-Lübecker Becken.

Tectonics and Salt Tectonics

A surfacing salt diapir is located in the town of Bad Segeberg. We detect upward motion associated with the rising salt (Fig. 2). As often in this region the salt moved up along a major tectonic fault (Fig. 1).



We detect small systematic motion variation (~1.5mm/yr) along a power line that crosses a fault north of Bad Segeberg (Fig. 4). A change from negative (away from the satellite) to positive motion from east to west could be associated to salt motion at the fault.

Fig. 4: Motion at a fault-crossing power line north of Bad Segeberg.

Marsh Land Subsidence and Dykes

Wide marsh lands at the western coast of Schleswig-Holstein are subject to significant subsidence (Fig. 1). To secure land from storm surges dykes are being reinforced by widening and adding on top. We can quantifiy the sagging of reinforced dykes e.g. at the coast of Büsum, where these reinforcmernts took plase in 2013 to 2014.

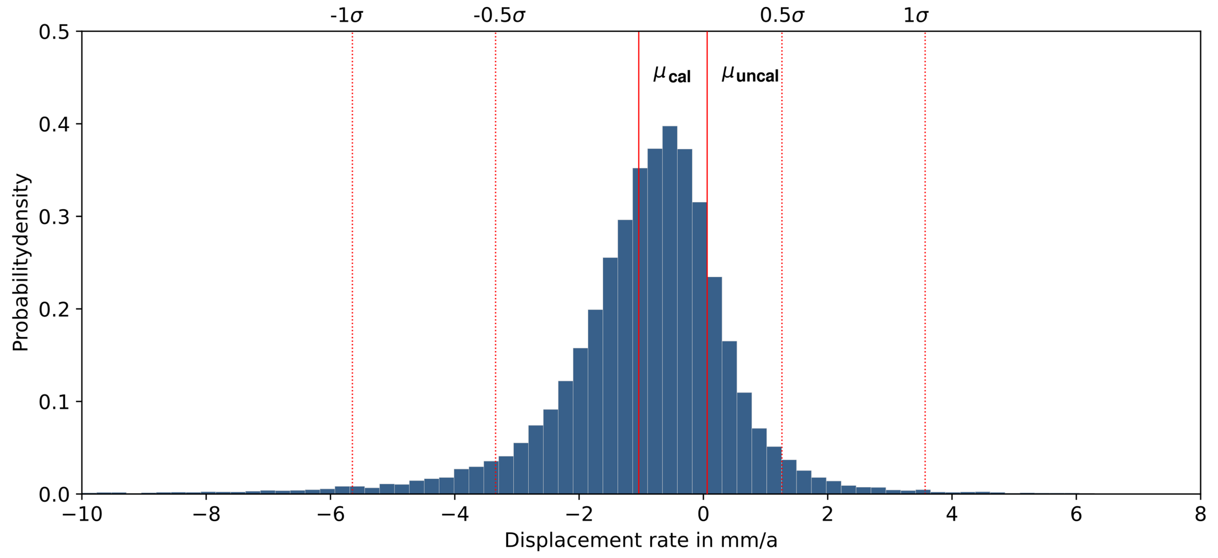


Fig. 5: Distribution of motion shows predominant subsidence.

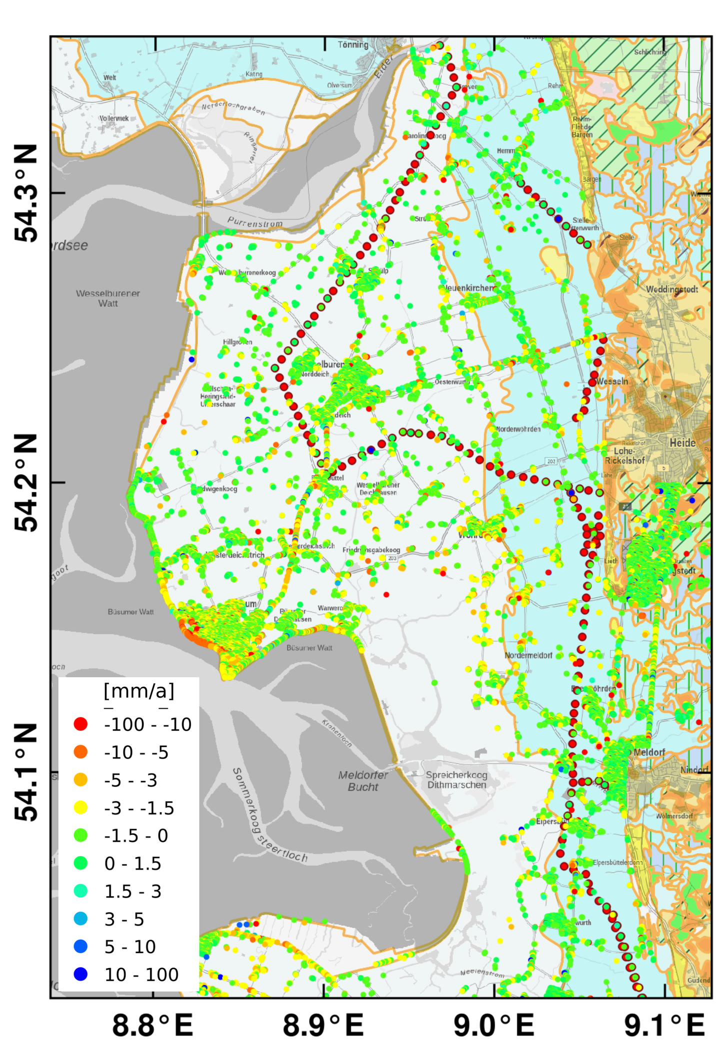


Fig. 6: Ground motion at scatterers at high-voltage transmission towers.

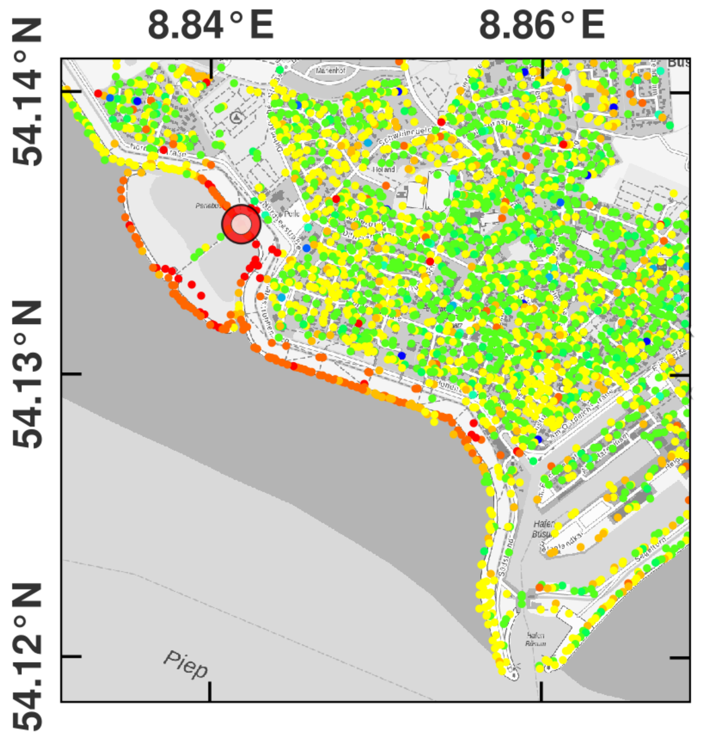


Fig. 7: Ground Motion at Scatterers in Büsum highlighting the sagging at newly reinforced dykes (2013 to 2014). Large red circle marks the position of the scatterer of times series in Figure 8.

With the calibration based on motion at transmission tower bases, we show a predominating subsidence in Büsum. Furthermore we see an increased subsidence at reinforced dykes that slows with time. Mean subsidence rate are larger at dykes with more recent reconstructions.

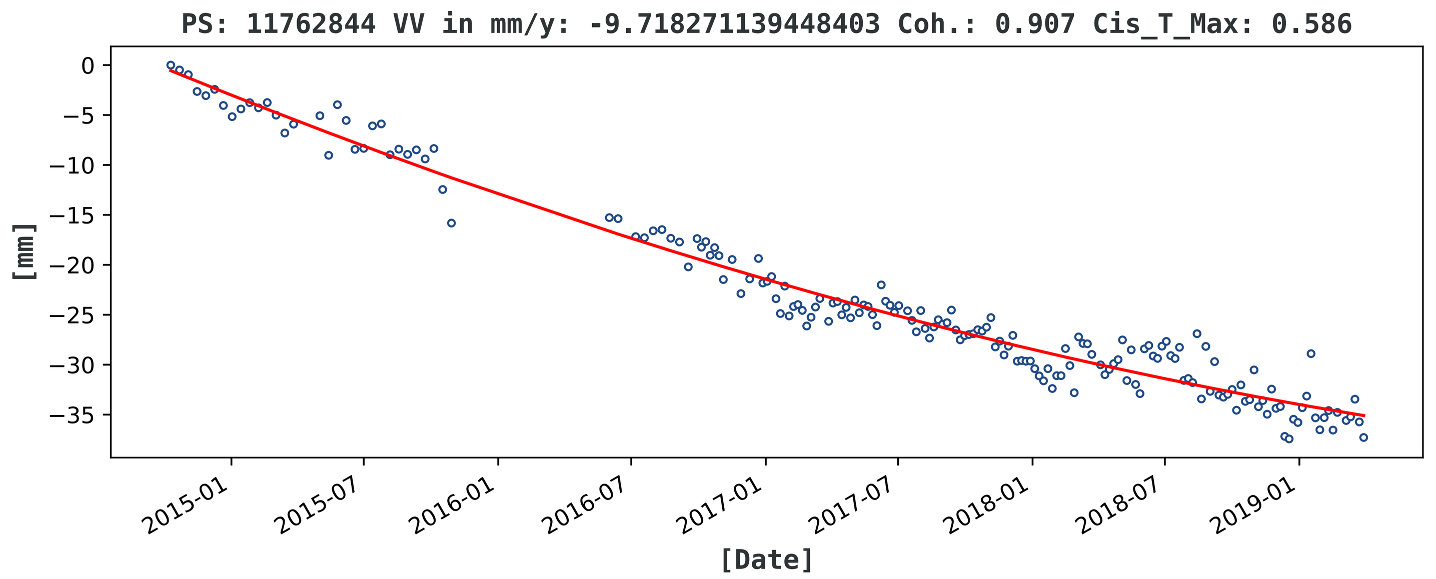


Fig. 8: Motion time series of a scatterer at a dyke reinforced in 2014 showing slight exponential decelleration of subsidence with time.