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Bundesministerium für Bildung und Forschung

ptJ Projektträger Jülich Forschungszentrum Jülich

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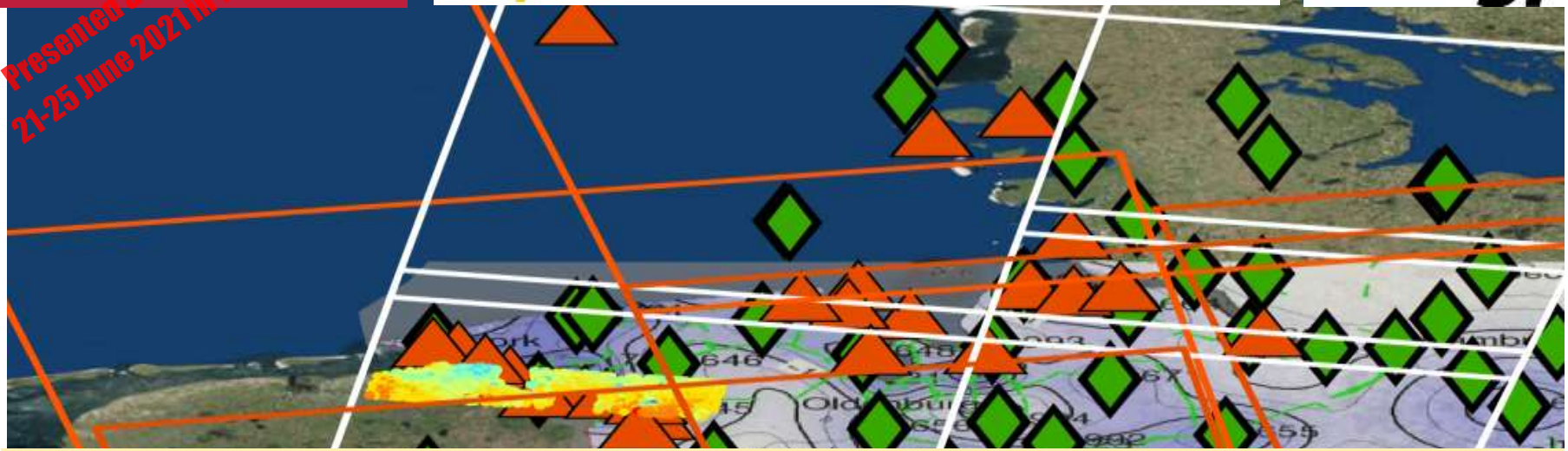
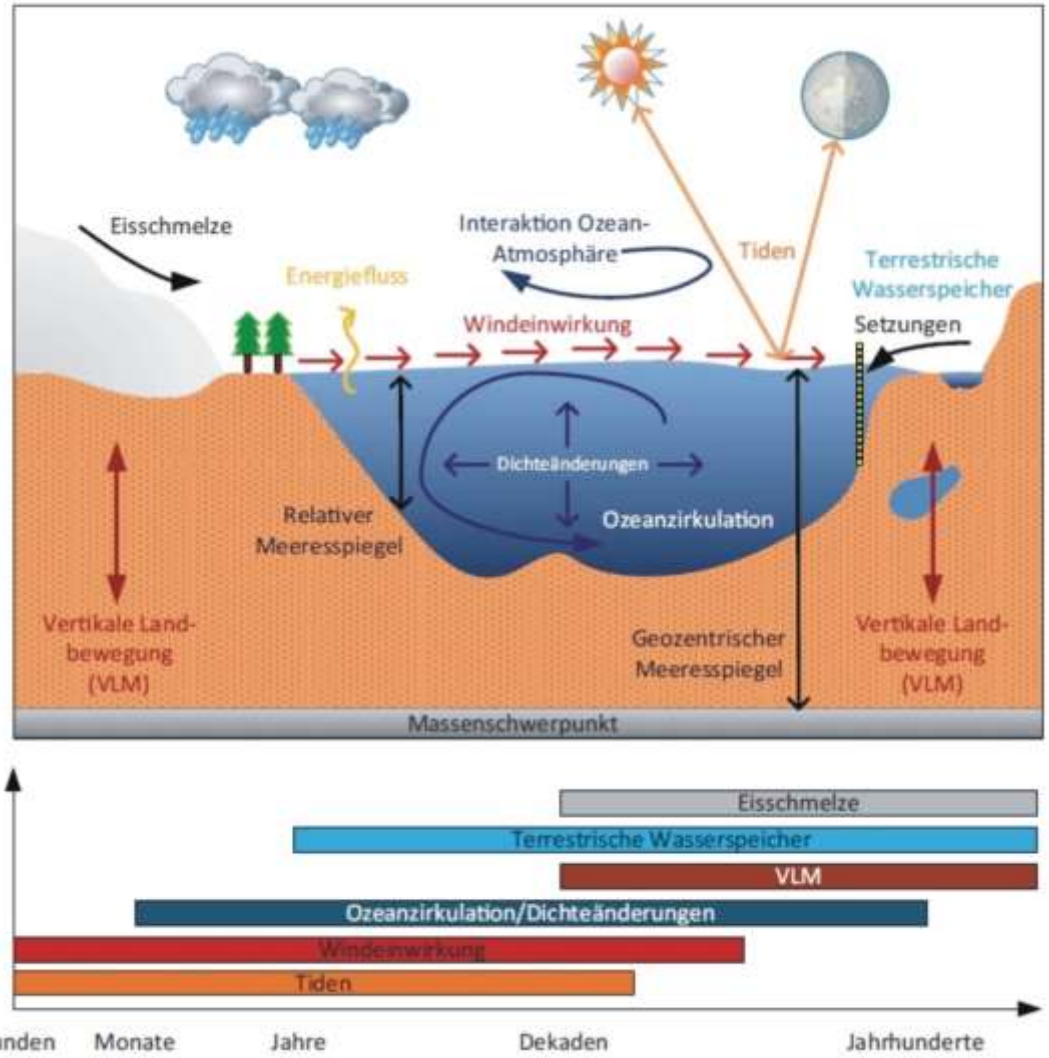


Vertical Land Movements in Coastal Areas around Northern and Baltic Sea within German

Wolfgang Niemeier, Anika Riedel, Dieter Tengen, Björn Riedel and Markus Gerke

FIG WW 2021, paper 11139, Session 6.1, June 21, 2021

Mean-Sea-Level (MSL) Variations and its influencing processes

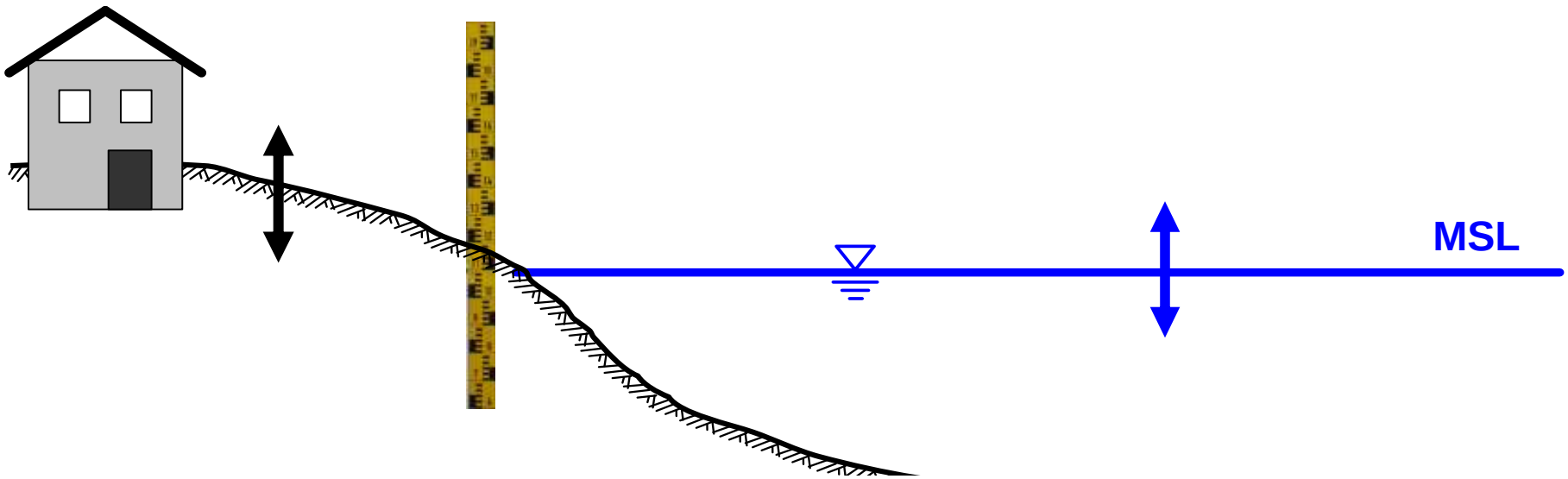


JENSEN, J. ET AL.: Meeresspiegeländerungen in der Nordsee: Entwicklungen und Herausforderungen, HyWa, 2014

Surrounding of Tidegauges: Intersection between Land and Sea

Relative MSL: Important parameter for standard tasks in coastal engineering

Absolute MSL: Important parameter for verification of climate models and comparison with data from altimetry



- **Knowledge on vertical movement of land in coastal areas**
- **Knowledge on stability of tidegauge and its surrounding**

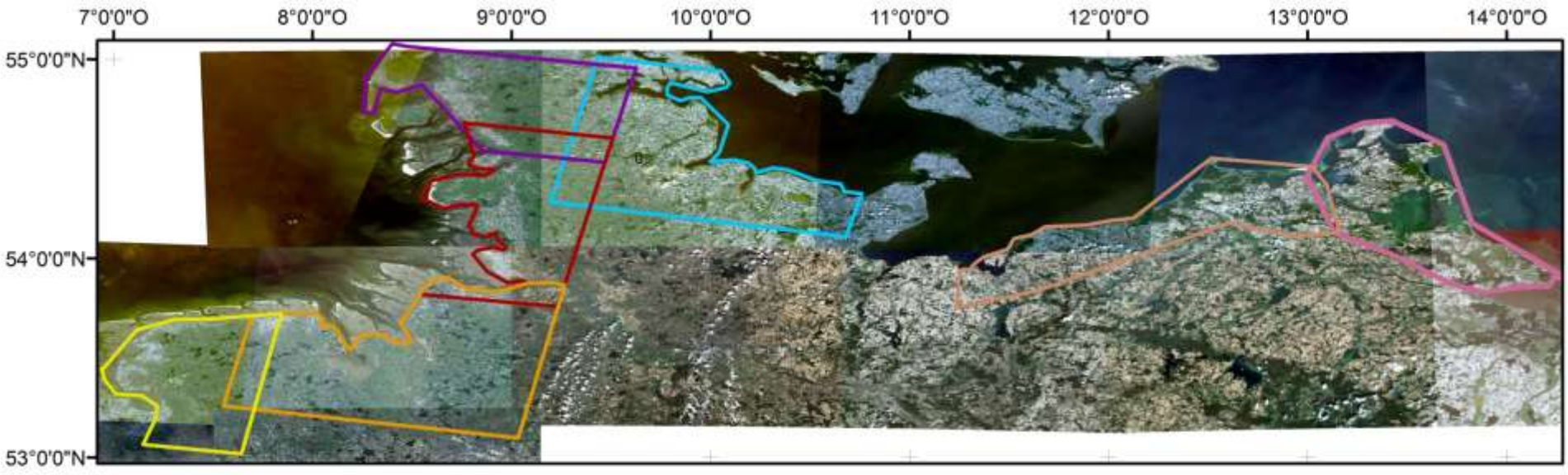
Processing of Radar Data

Available Radar Data: Sentinel-1 Scenes

Processed up to now for German North Sea area and western part of Baltic Sea

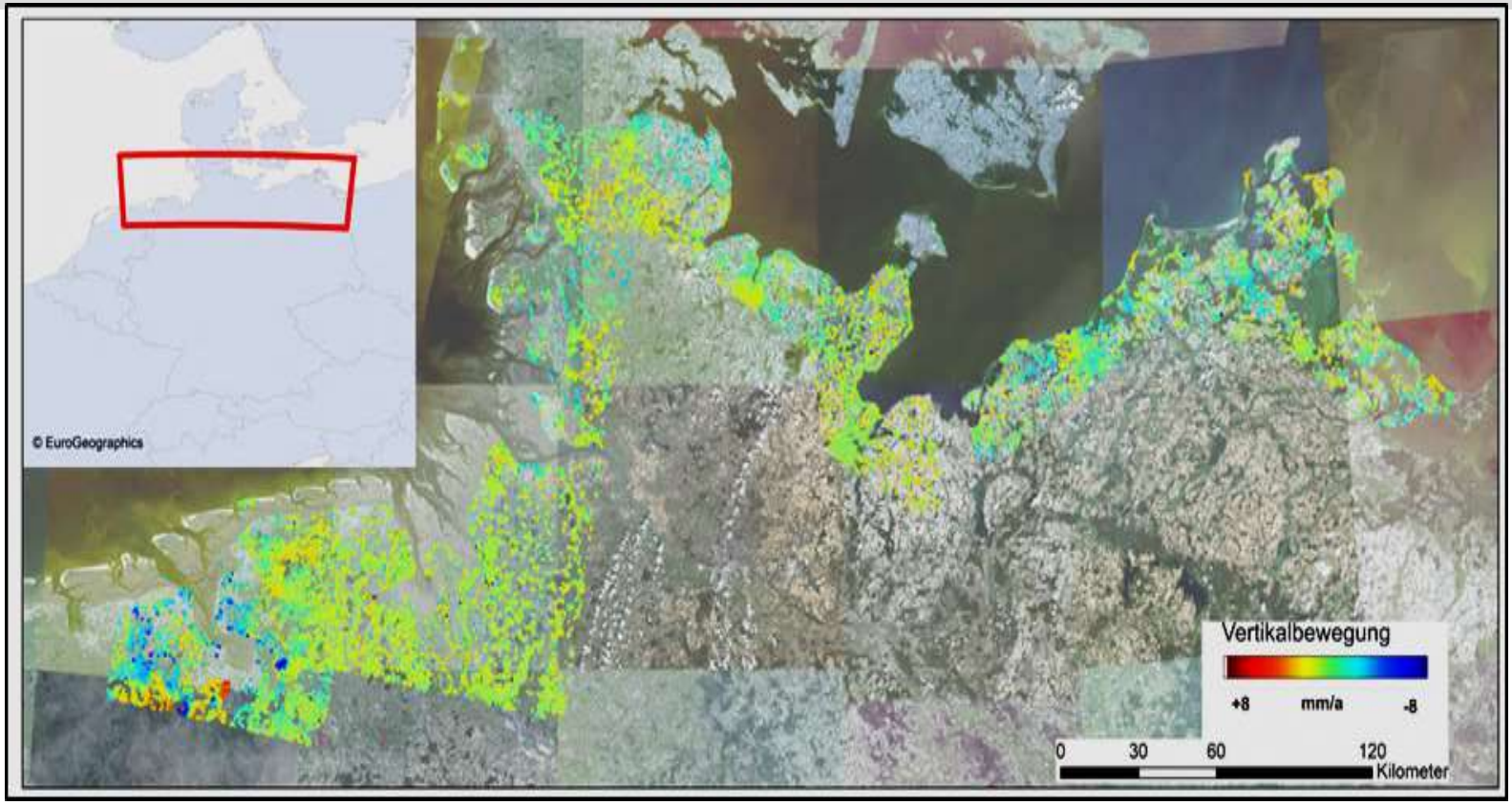
- 133 scenes of track 139 in descending orbit form Oct. 2014 to March 2018
  130 Scenes of track 146 in ascending orbit from Oct. 2014 to Sept. 2018
- Processing with multitemporal PSI method of Feretti et al. (2001)

Details to Data Processing of Sentinel-1 Radar Scenes



Name	Extension	Area (km^2)	Processing time (days)	File size (TB)	Computer
Patch1	Groningen-Papenburg	14135	14	2	Work station
Patch2	Wilhemshaven-Bremen	18848	22	2	Work station
Patch3	Cuxhaven-Bredtstedt	10965	6	1,2	High power
Patch4	Bredtstedt-Sylt	10748	6	1,1	High power
Patch5	Flensburg-Lütjenburg	13000	7	1,3	High power
Baltic Sea-west	Wismar-Stralsund	11100	8	2	High power
Baltic Sea–east	Stralsund- Świnoujście	11500	5	2	High power

Summarized Solution for German Coast

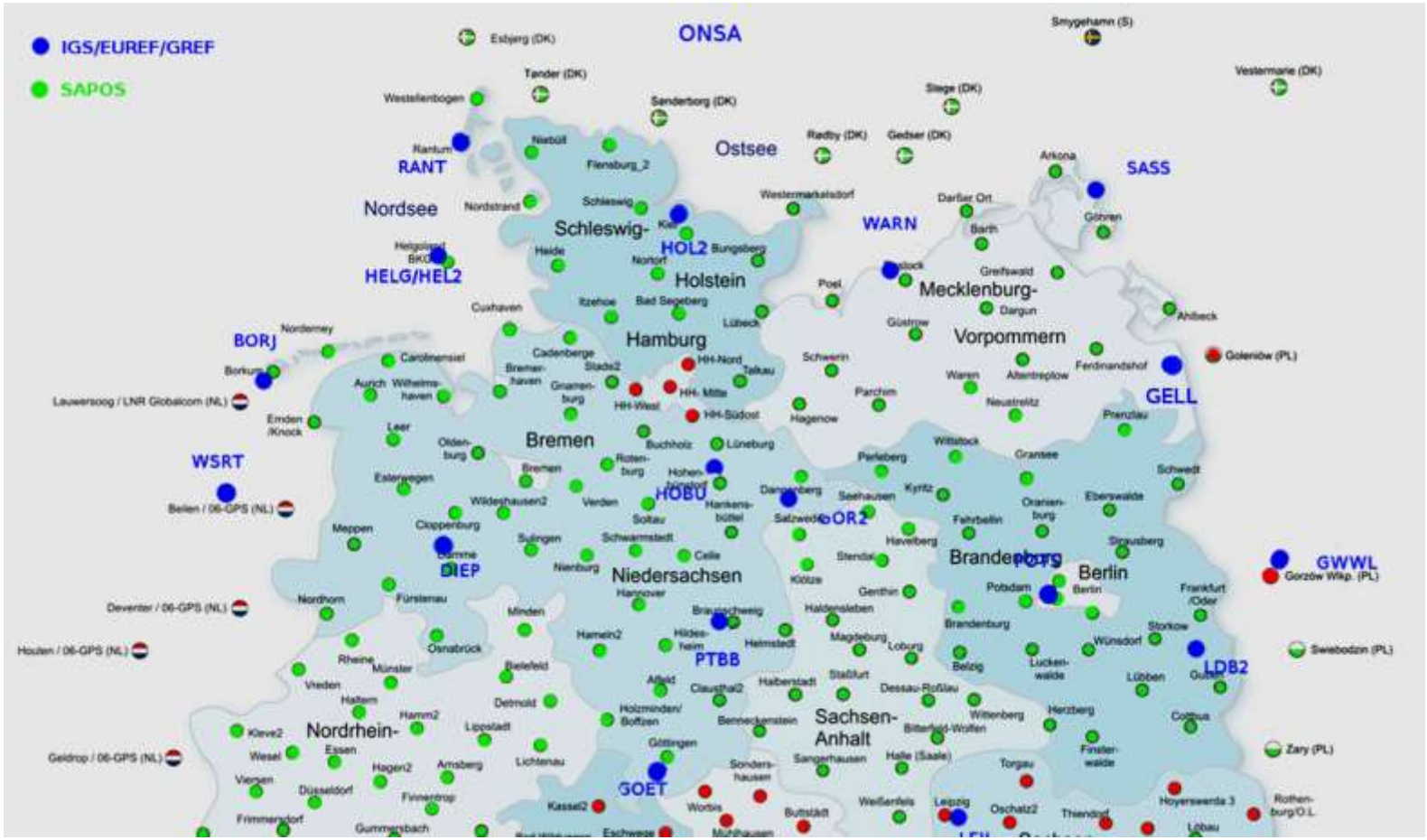


Special effects:

- Around Emden: Subsidence associated with **long-lasting gas extraction** in Groningen Gasfield
- In Wilhelmshaven and Etzel: Subsidence due to **storage caverns** in the underground
- In Rostock: Sudsidence due to **construction activities**

GNSS Permanent stations: SAPOS/IGS/EUREF/DREF

140 SAPOS, 21 IGS/EUREF/GREF stations in Northern Germany



GNSS Processing and Analysis

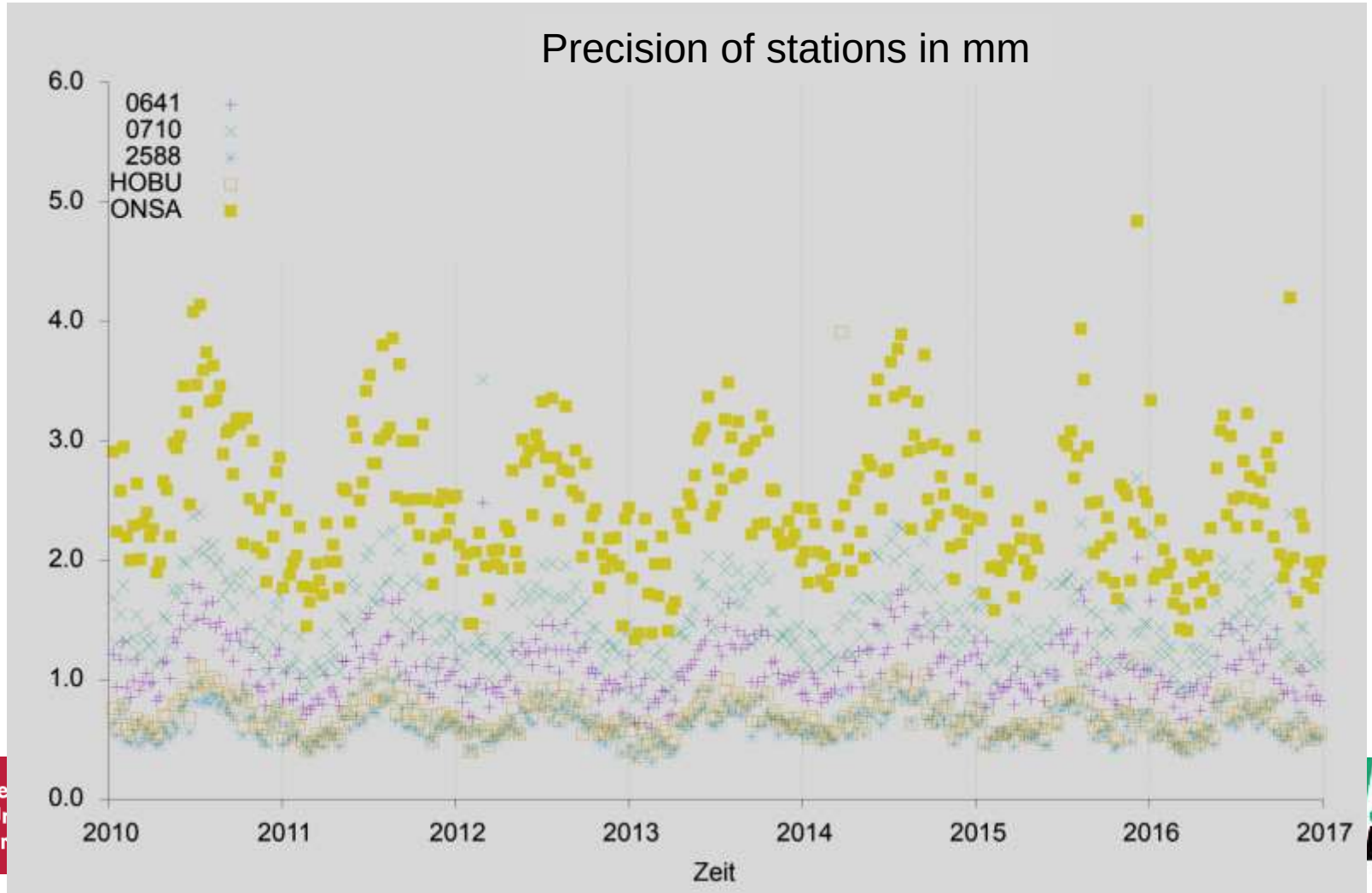
Problem: Absolute variations have to be determined in relation to stable areas.
„Stable Area“ can be expected to be **low mountain range** in the South!

geologically stable ?

Source: Bundeszentrale für Politische Bildung

GNSS: Precision after combination of partial networks

- Major axis of error ellipse for selected stations:
  (Datum is defined by all stations in the low mountain range in the South)



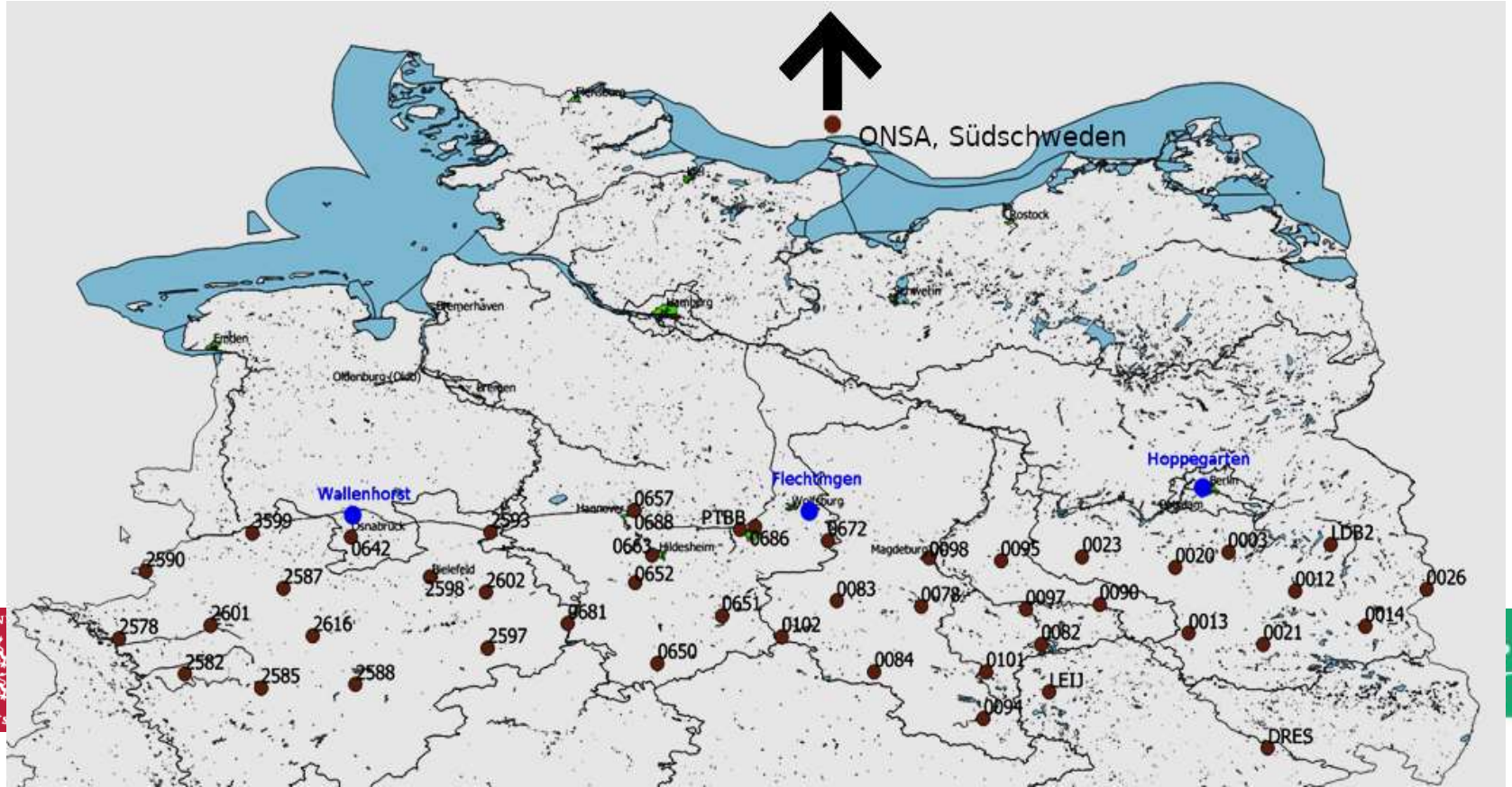
north

south

GNSS: Transformation on „stable“ reference stations

Idea: Transformation of stations of each epoch (weekly solution) on ‚stable‘ reference stations in low mountain range (with max. 46 stations)

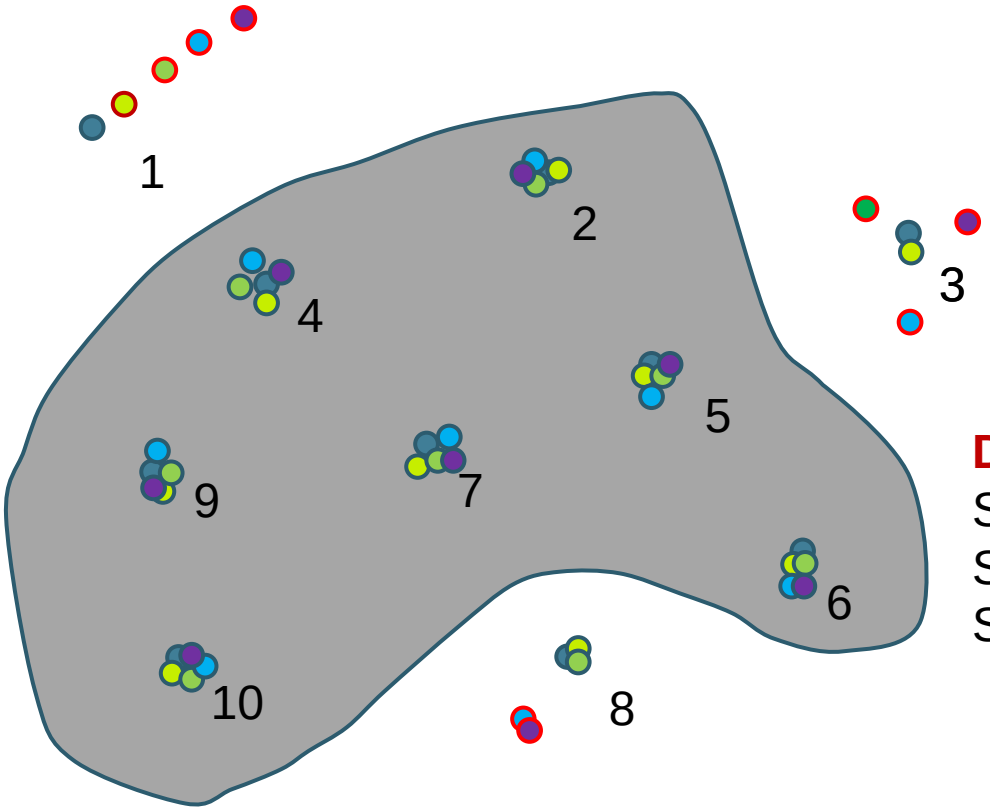
Why:
- Uniform reference for all epochs.
- No dependancy on realisation of global reference frame.
- Similar reference as for new levelling network in Germany (Wallenhorst, Flechtingen, Hoppegarten).



To explain this extension of classical congruency test: (Data based modelling)

Location of epochs: 2010, 2011, 2012, 2013, 2014

Stations with significant displcements: 1, 3, 8



2010
2011
2012
2013
2014

Data driven modelling:

Station 1: linear movement

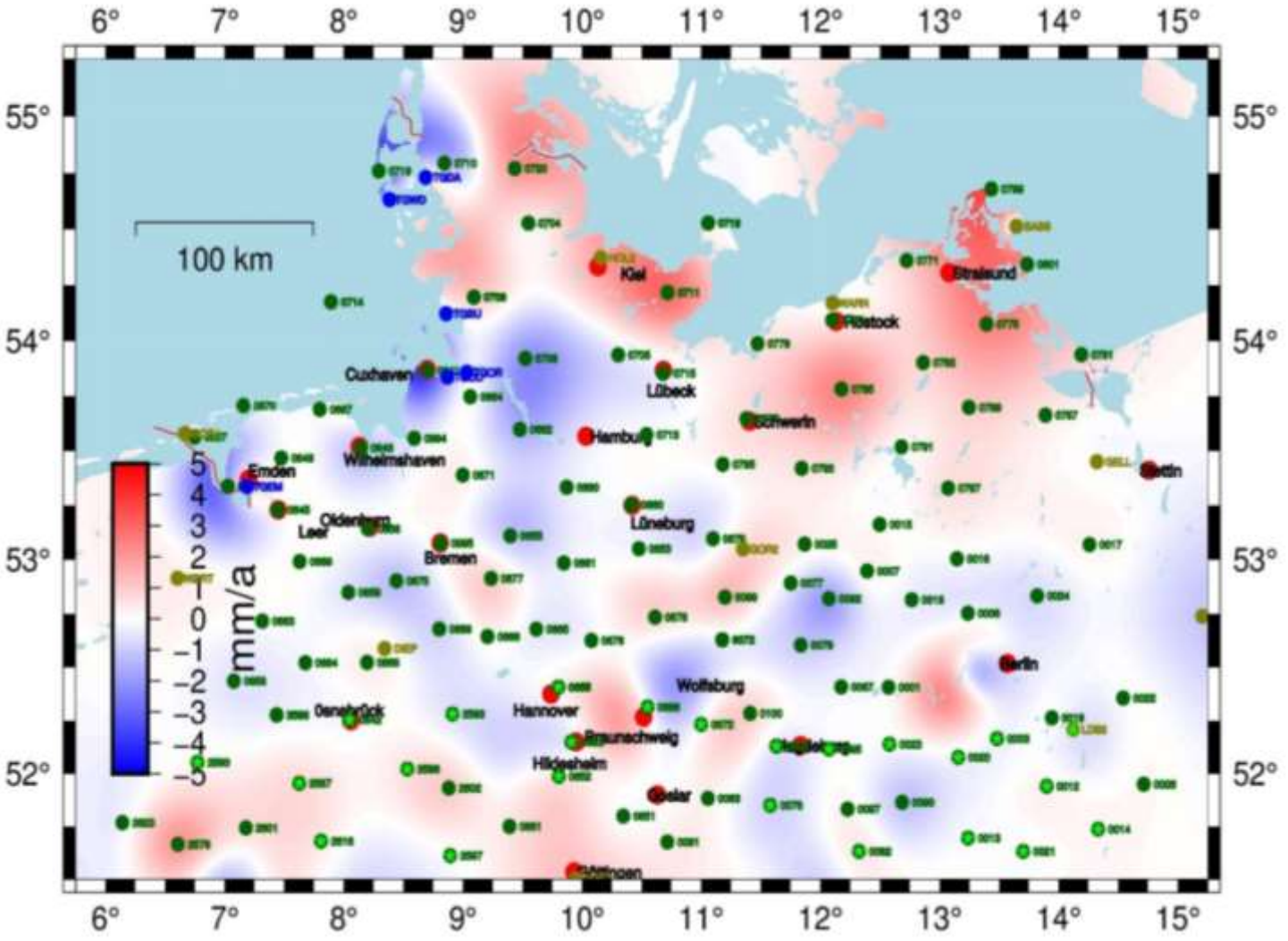
Station 3: arbitrary

Station 8: offset

Stable stations

Modelling of vertical movements
1. Just GNSS data

Principle: Approximation of velocity field by radial basic-functions (RBF)



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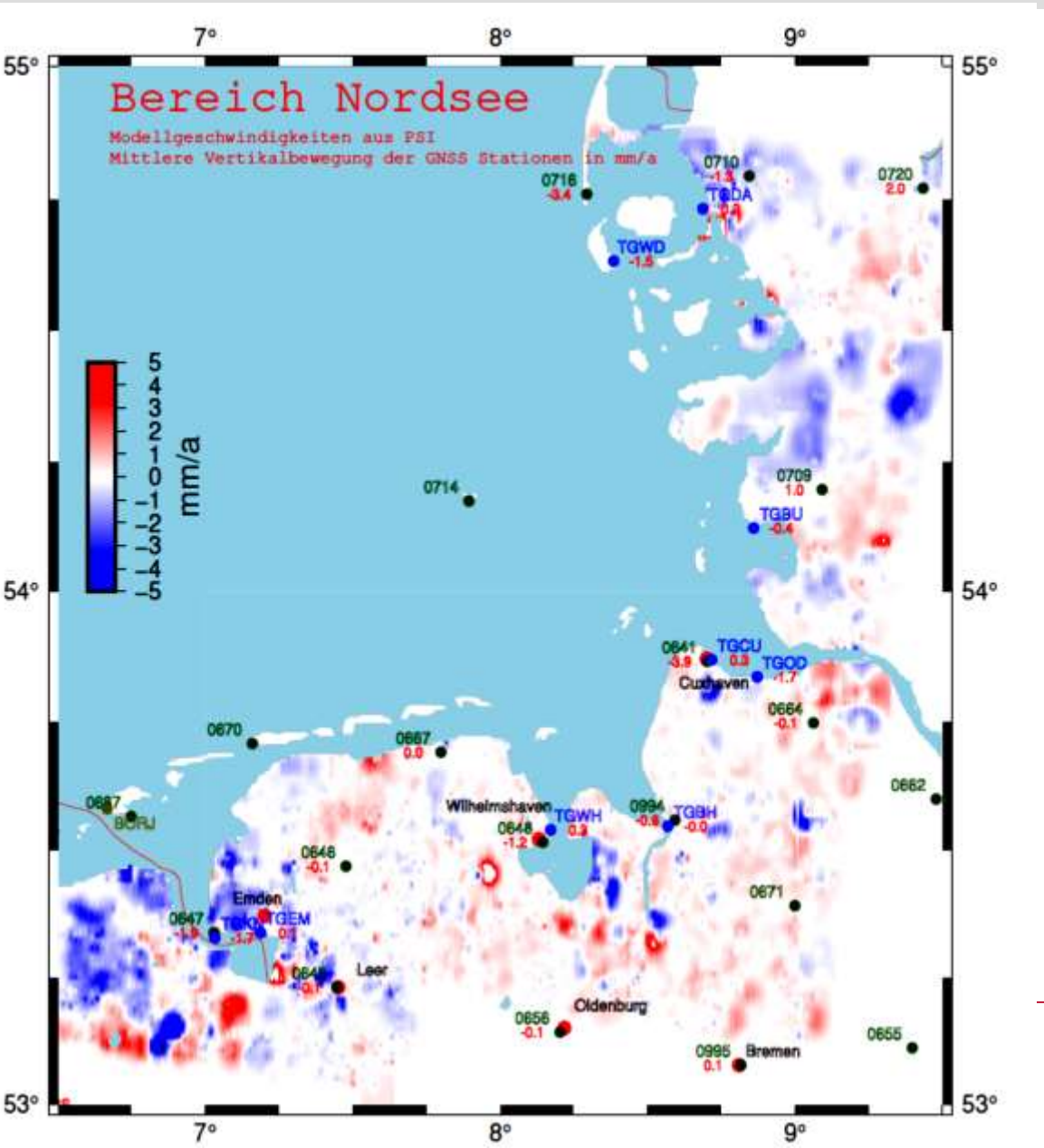
Modelling of verticla movements
2. With PSI-results out of Sentinel-1 data (Oct.2014 – Febr. 2019)



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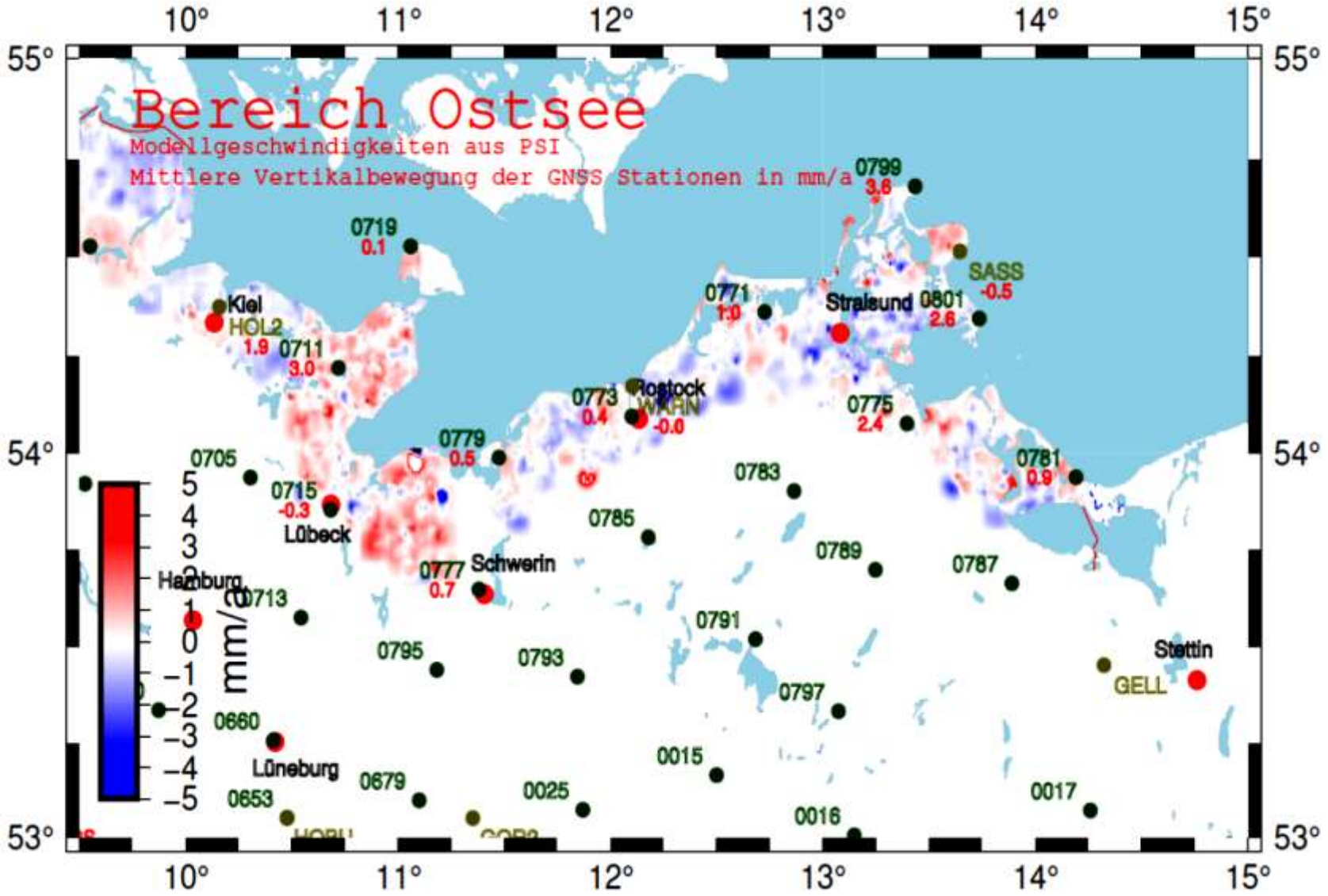

Summary

- One of the emerging problems for our profession:
  Study behaviour of variations of earth surface

- Due to modern sensors, we are able to get continuous data, covering larger areas:
  - **GNSS: continuous in time, restricted to stations**
  - **PSI: continuous in time, restricted to good scatteres**

- **Sophisticated processing and analysis methods** are necessary

- **Our profession can contribute to study effects of climate change with precise and reliable results!**