

# Draft for a new German chart-datum-surface

Andreas Boesch, BSH

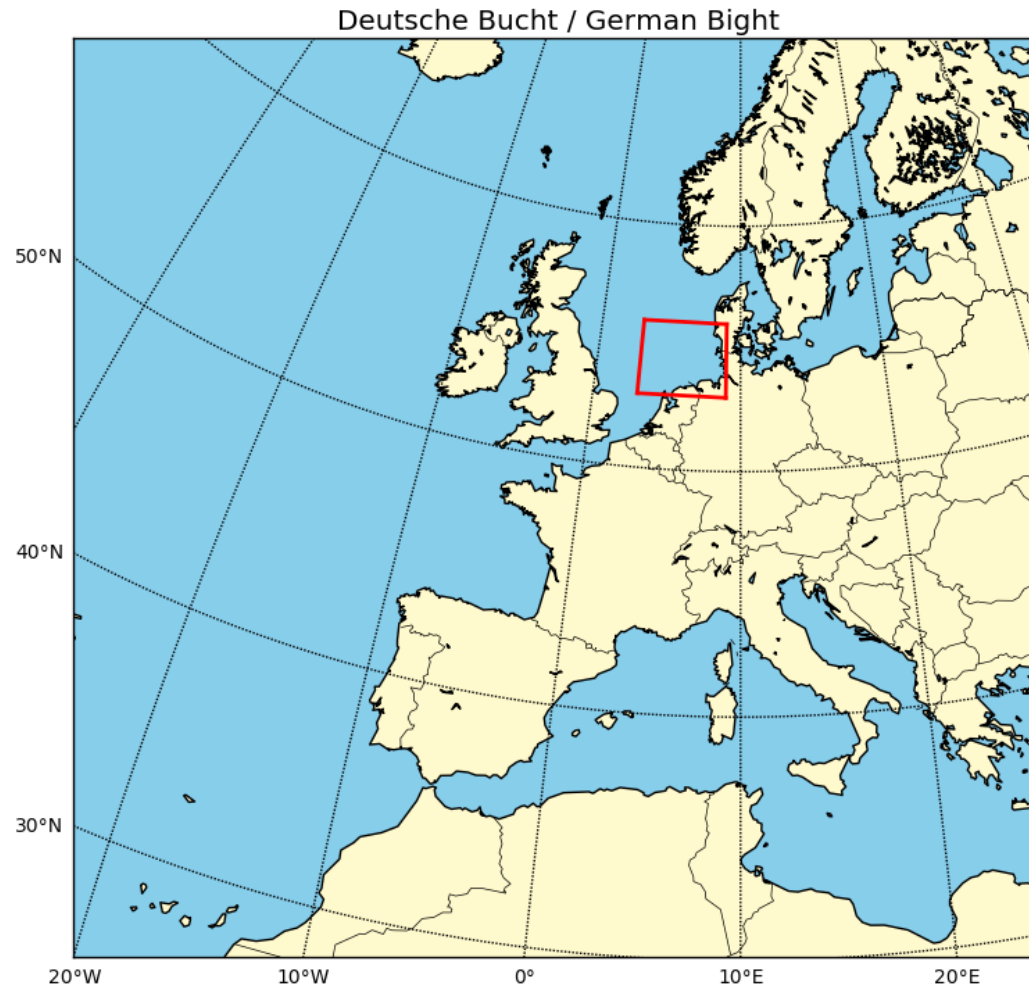


# Area of interest

German Bight

53°N - 56°N  
8°E - 9.5°E

Tides are complicated  
because of shallow  
waters and long rivers

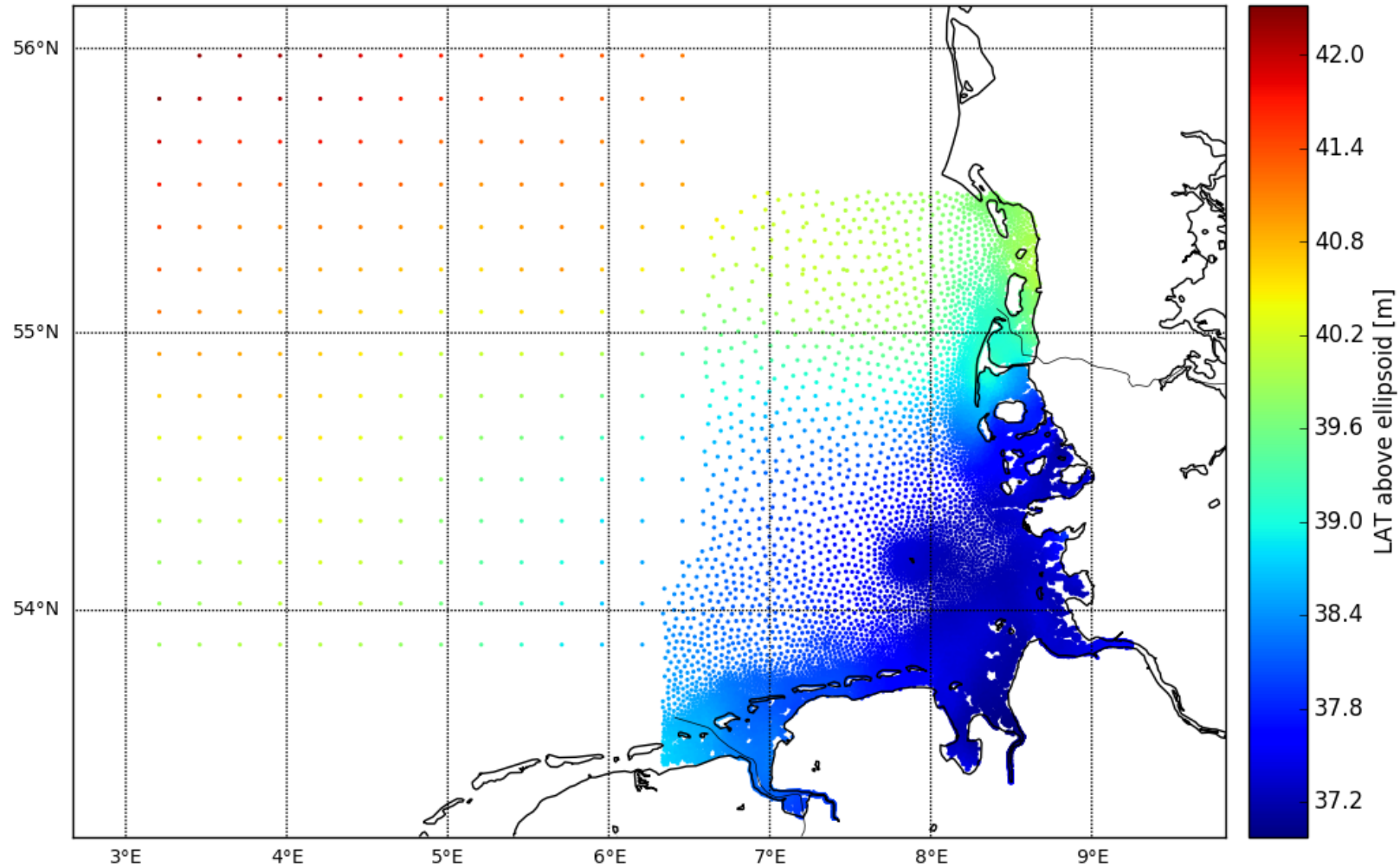


# Current chart-datum-surface



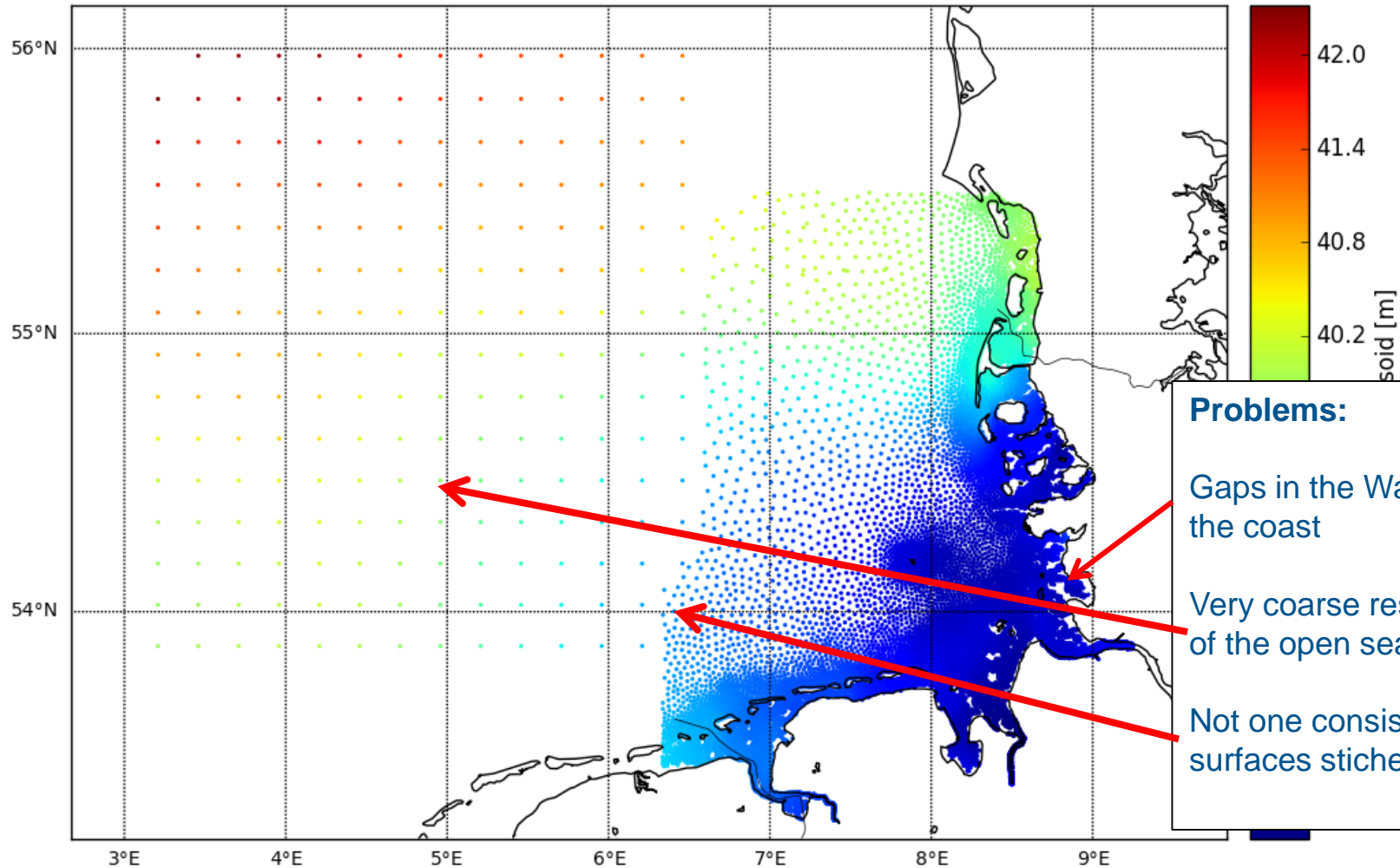
BUNDESAMT FÜR  
SEESCHIFFFAHRT  
UND  
HYDROGRAPHIE

Last update: 2016



# Current chart-datum-surface

Last update: 2016



## Problems:

Gaps in the Wadden Sea and close to the coast

Very coarse resolution in large parts of the open sea

Not one consistent surface, but four surfaces stiched together

# Considerations for new surface & LAT calculation

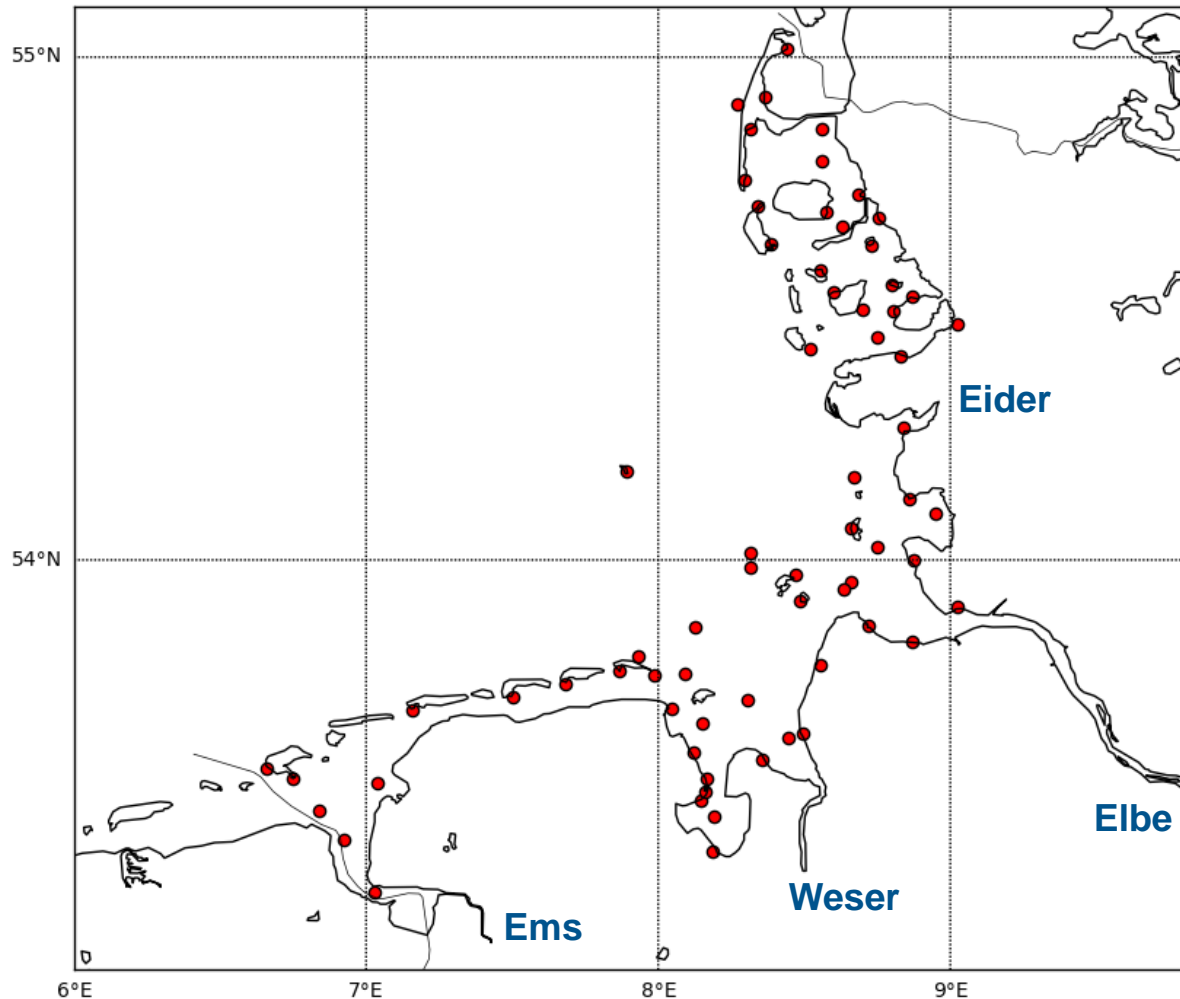
- **One consistent surface with appropriate spatial resolution and no gaps**
- Tides are difficult to simulate close the coast with numerical models
- LAT-values based on tide gauge observation are preferred  
-> basis for chart datum (CD) at location of tide gauge
- **LAT calculation:**  
Tidal analysis with method „harmonic representation of inequalities“ using 19 years of observational data. LAT is lowest low-water of tidal synthesis.

Boesch, A. & Müller-Navarra, S. (2019). *Ocean Sci.*, 15, 1363-1379.

Müller-Navarra, S. (2013). *Berichte des BSH*, 50.

Horn, W. (1960). *Intern. Hydr. Rev.*, 37, 65-84.

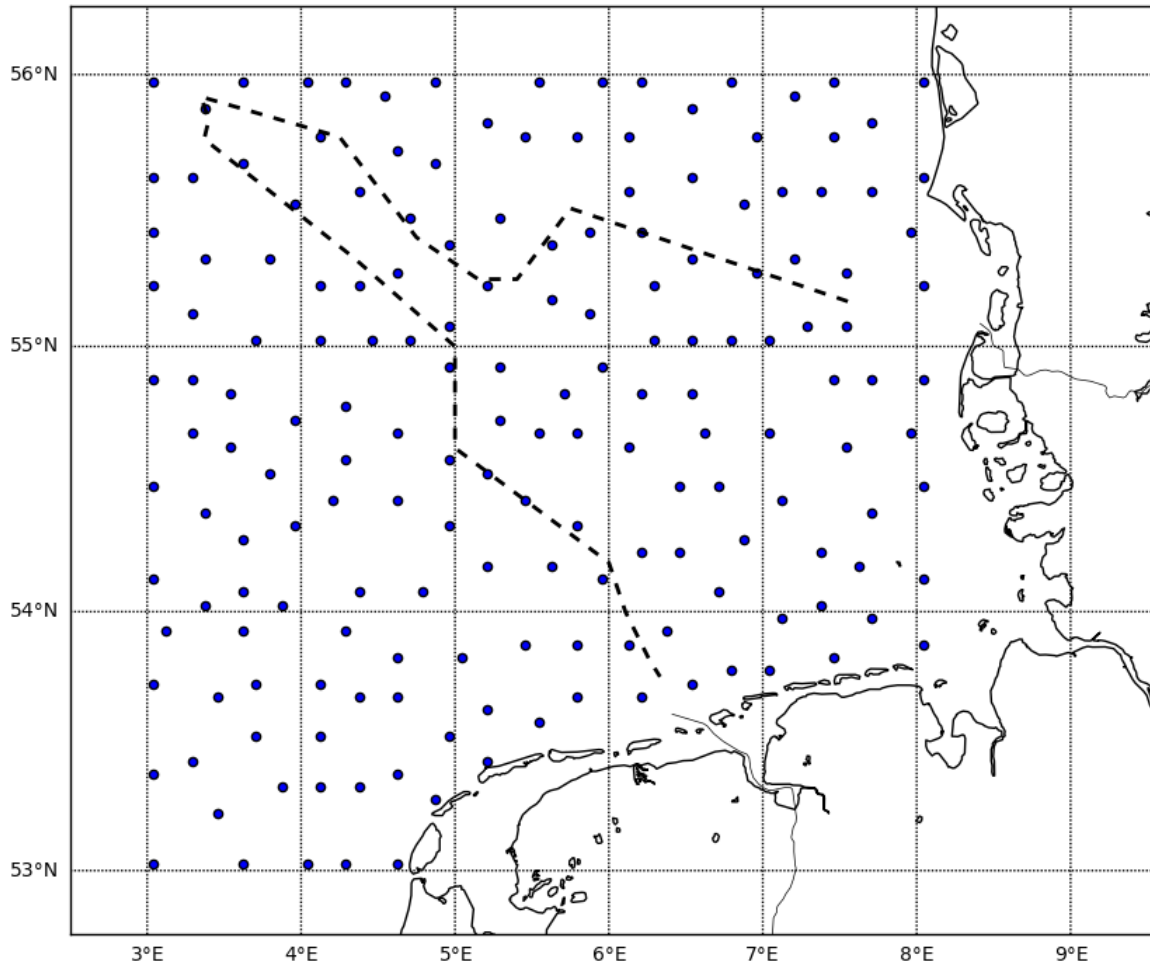
# Boundary conditions: tide gauges and estuaries



- North Sea CD is based on LAT
- Rivers Ems, Weser, Elbe and Eider have separate CD definitions
- CD at mouth of rivers and at tide gauges are boundary conditions for surface creation
- Tide gauges belong to either State agencies or the Federal Waterways and Shipping Authority (WSV)
- CD at tide gauges are set by different agencies



# LAT from hydrodynamic model data

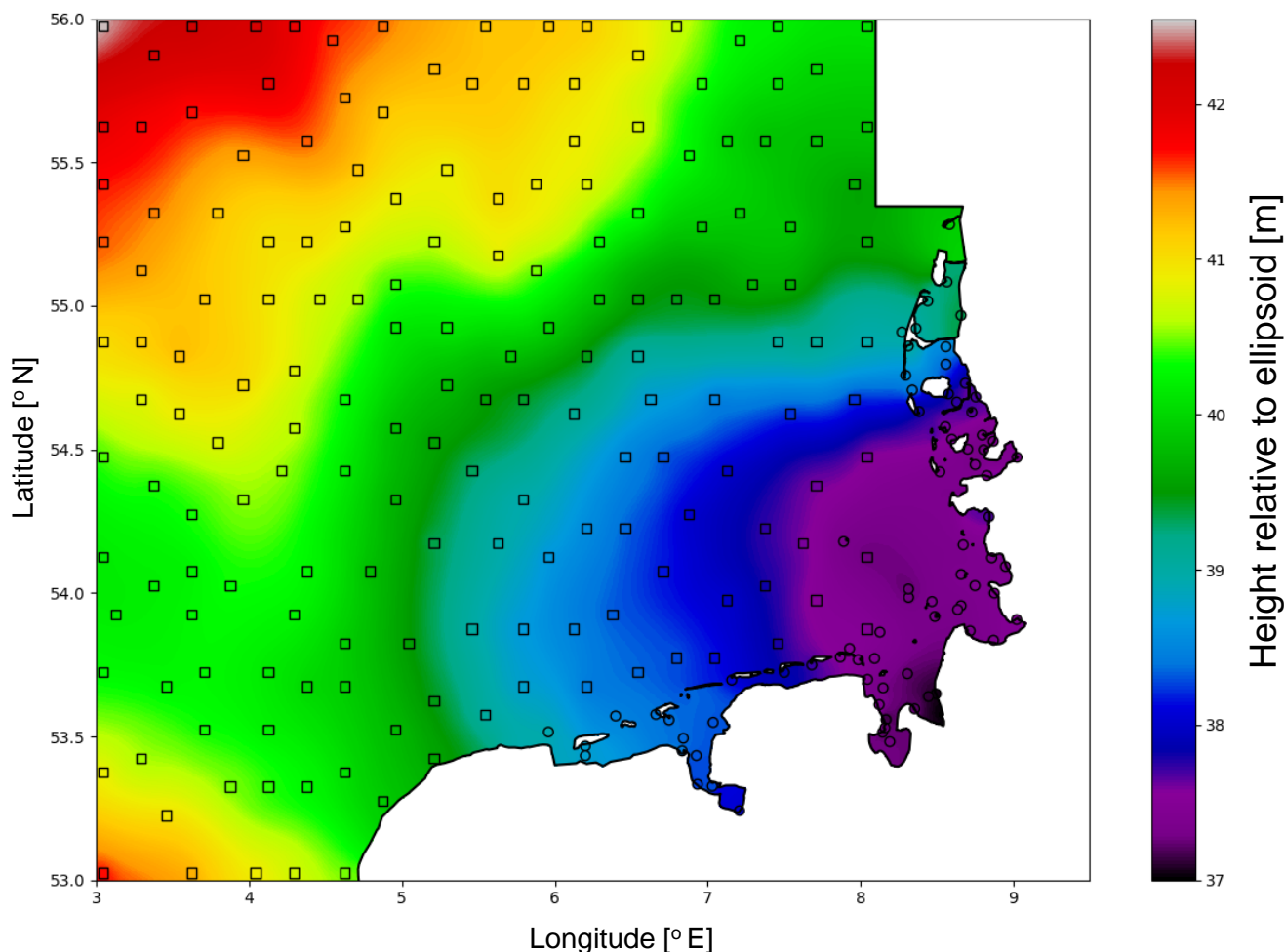


- BSH circulation model (cmod)
- 175 grid points used
- 19 years of simulated water levels at each point (1999-2017)
- Heights of time series corrected to be centered around MSL ( $\approx$  NHN)
- Reduction to ellipsoidal heights (ETRS89) using the geoid-model EGG2008

# Draft for a new chart-datum-surface complete area



BUNDESAMT FÜR  
SEESCHIFFFAHRT  
UND  
HYDROGRAPHIE



**Spatial resolution:** ~ 400 m

## Input data:

- CD at 66 German tide gauges
- CD datum at 3 Danish tide gauges
- CD at 7 Dutch tide gauges
- LAT at 175 model points

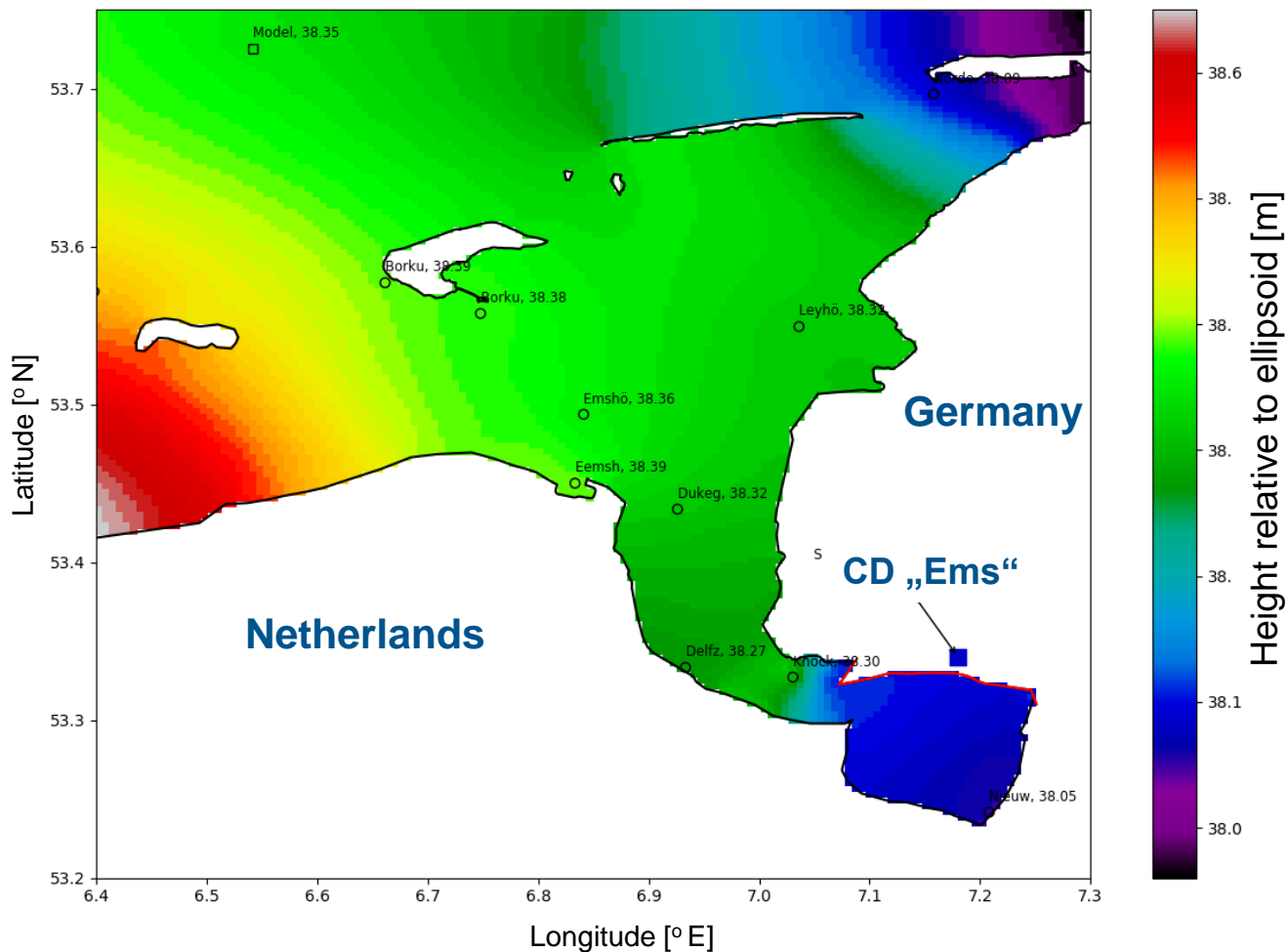
## Surface construction method:

- Interpolation with minimal curvature taking into account boundaries (coast line, islands, ...)
- Method adopted from computer vision

Briggs, I.C. (1974), *Geophysics*, 39(1), 39-48  
Terzopoulos, D. (1988). *IEEE Trans. Pattern Anal. Mach. Intell.*, 10(4), 417-438  
Zoraster, S. (2003). *Computer & Geosciences*, 29, 1175-1182.



# Draft for a new chart-datum-surface Mouth of Ems river

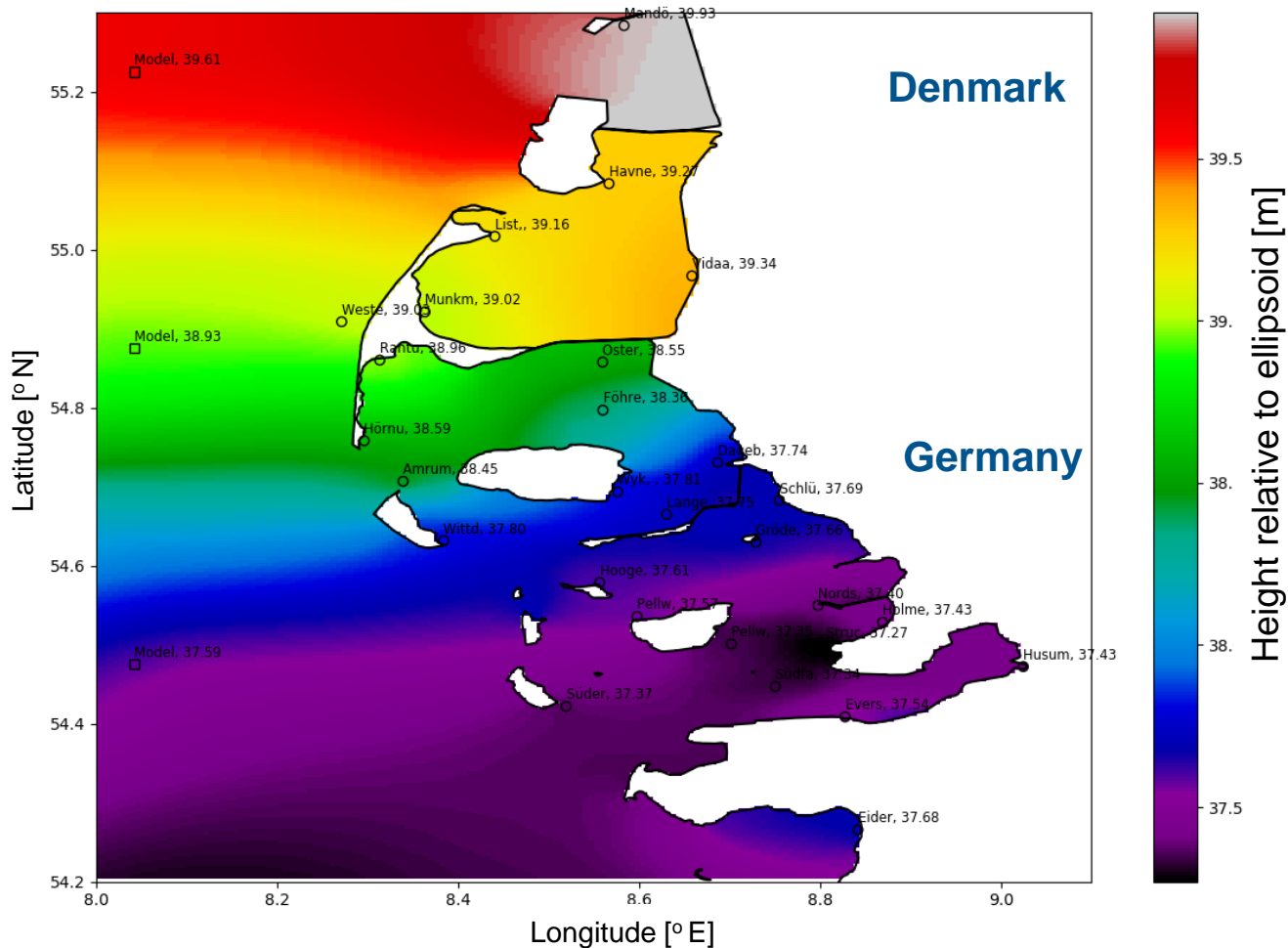


CD/LAT from 7 Dutch tide  
gauges as published in Dutch  
tide tables:

Nieuwe Statenzijl  
Delfzijl  
Eemshaven  
Huibertgat  
Wierumergronden  
Schiermonnikog  
Lauwersoog

Surface matches separate chart  
datum of Ems river

# Draft for a new chart-datum-surface North Frisian coast



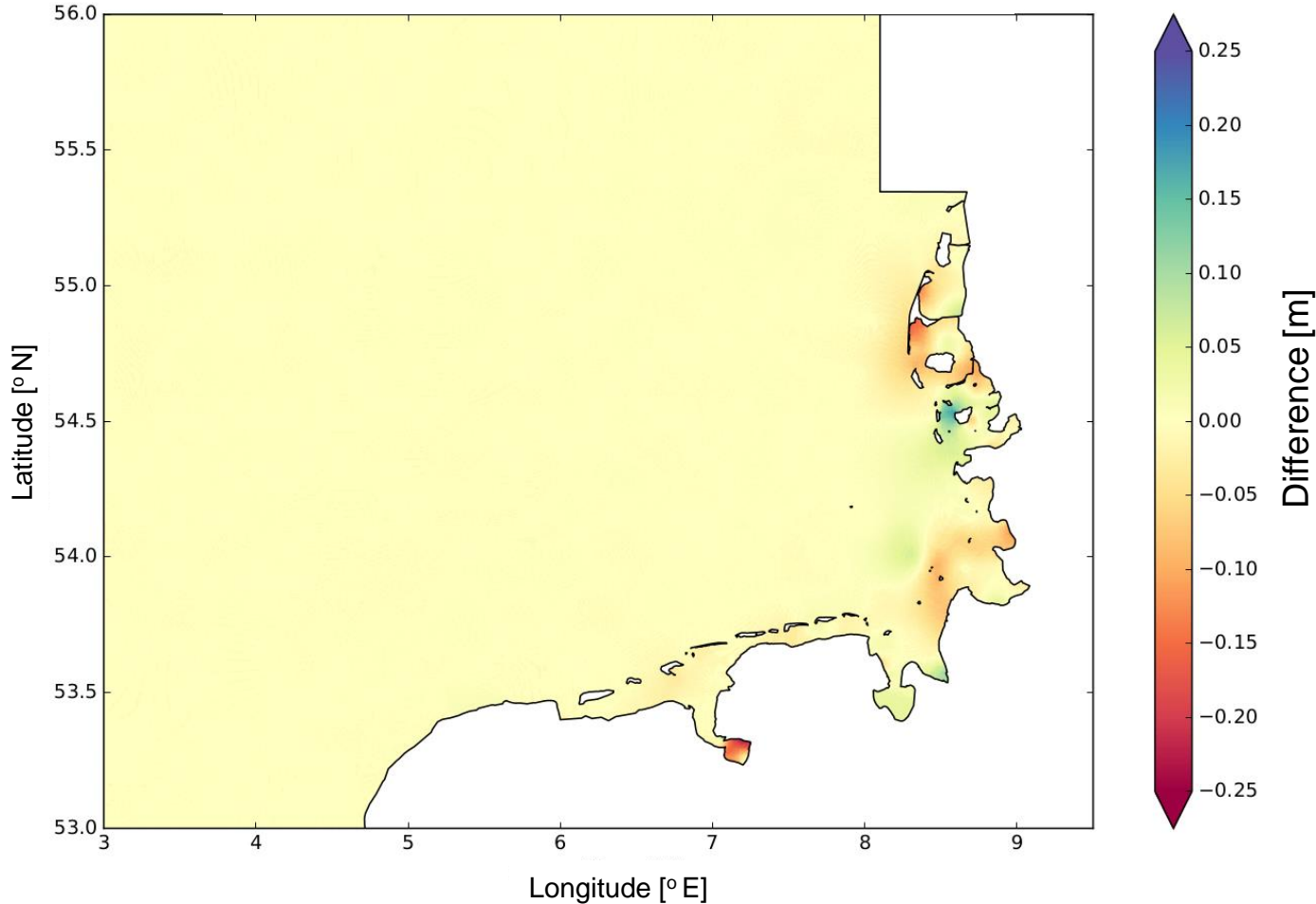
CD/LAT from 3 Danish tide gauges as published in Danish tide tables:

Havneby  
Mandø  
Vidaa / Hoyer

Surface takes into account dam between mainland and island Sylt

# Chart datum vs. „pure“ LAT

LAT – CD

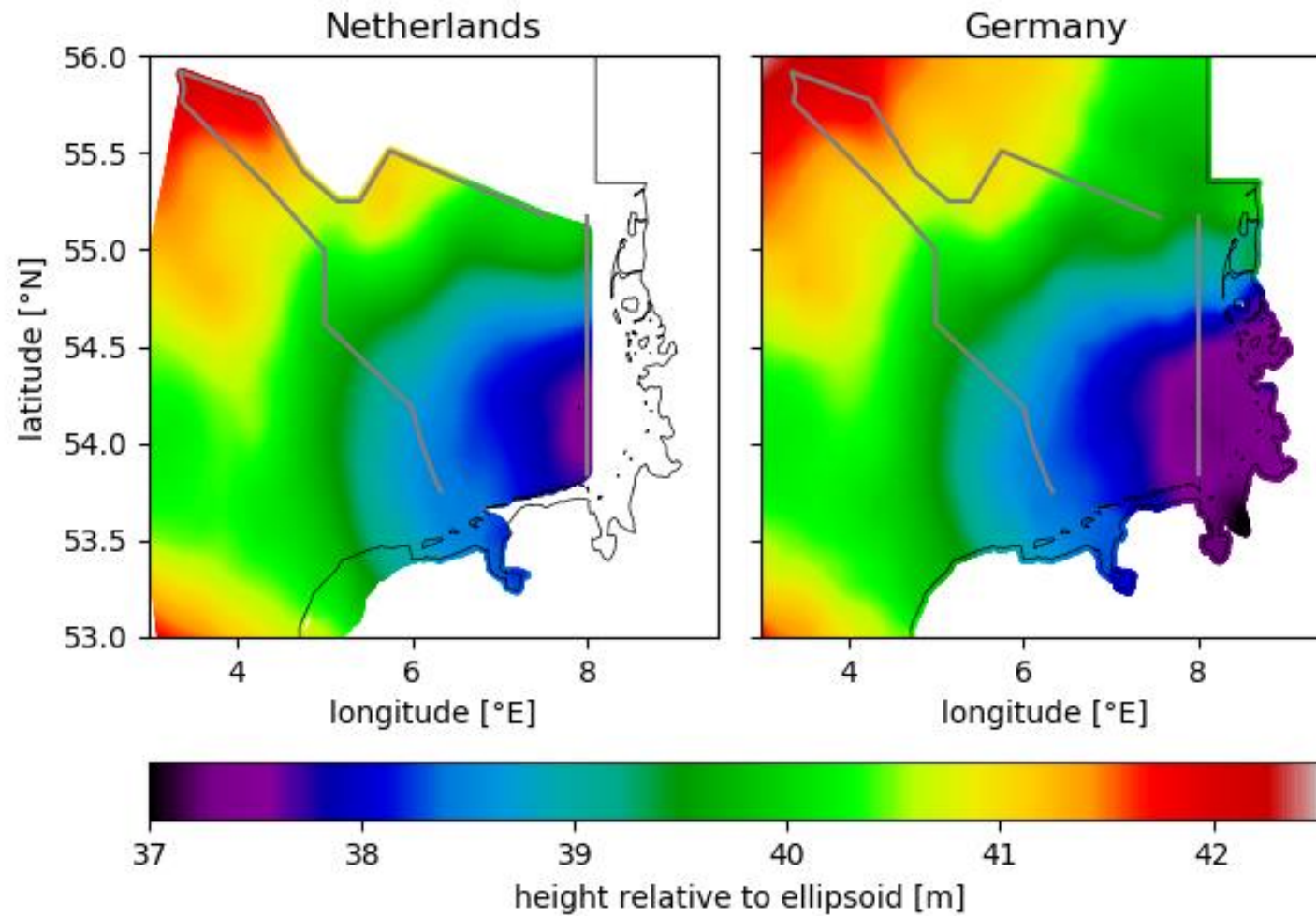


Differences along the coast where chart datum is set manually.

## Difference surface:

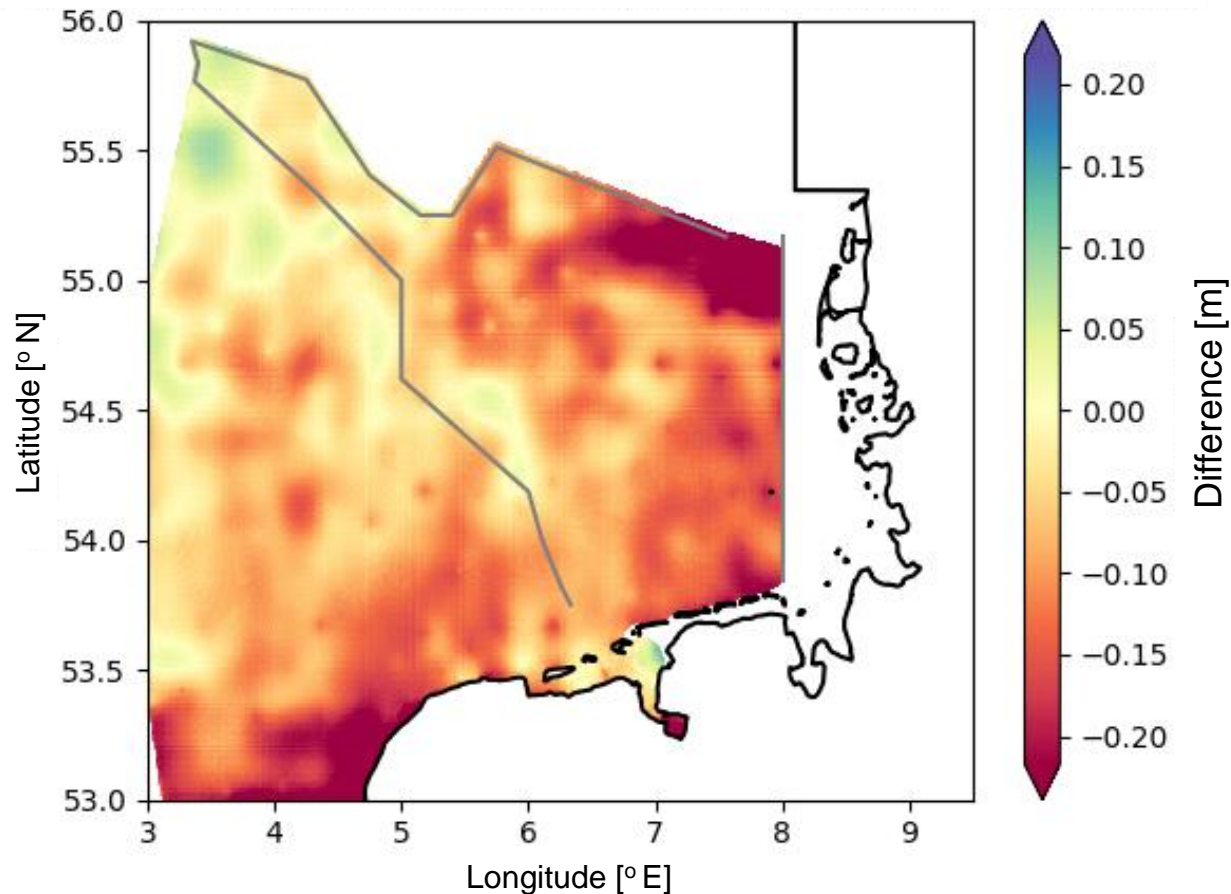
mean = 0.00 m  
stand. dev. = 0.01 m  
minimum = -0.24 m  
maximum = 0.20 m

# Dutch and German surfaces



# Dutch and German surfaces: differences

## Germany – Netherlands (next grid point)



### Difference surface:

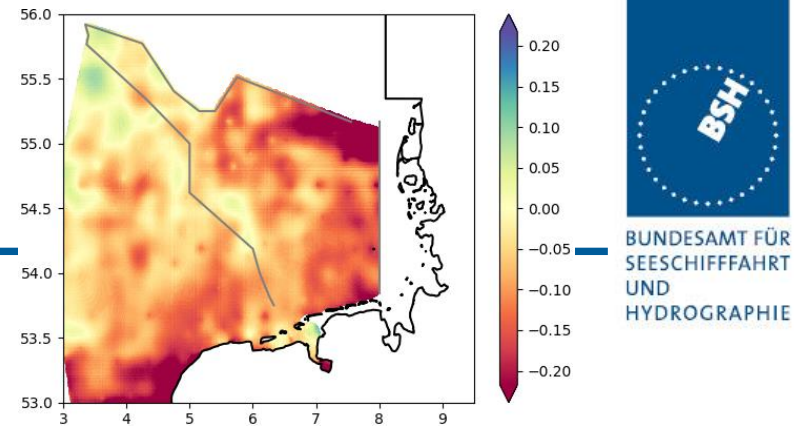
median = -0.09 m  
mean = -0.08 m  
stand. dev. = 0.07 m  
minimum = -0.55 m  
maximum = 0.12 m

### Examples of larger differences:

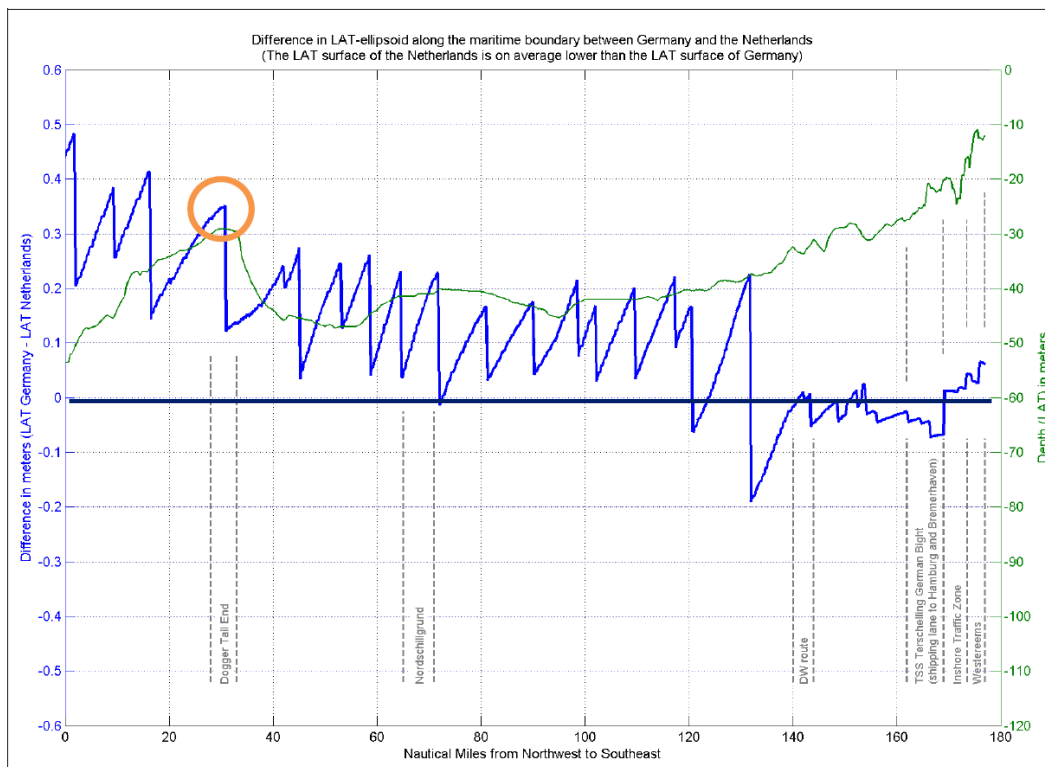
- Along Dutch coast
- Dollart / Ems estuary
- Danish-German border near island Sylt

# Dutch and German surfaces: differences along maritime border

From: Document regarding „1 Percent Norm“  
R. Kuilman, 11-10-2017



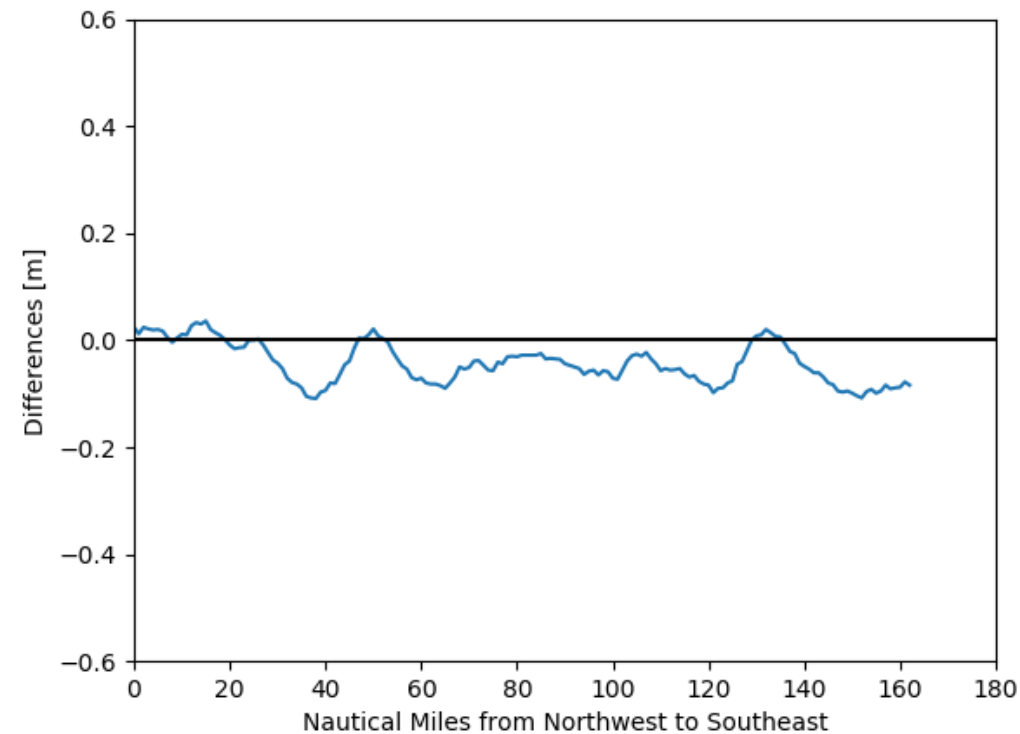
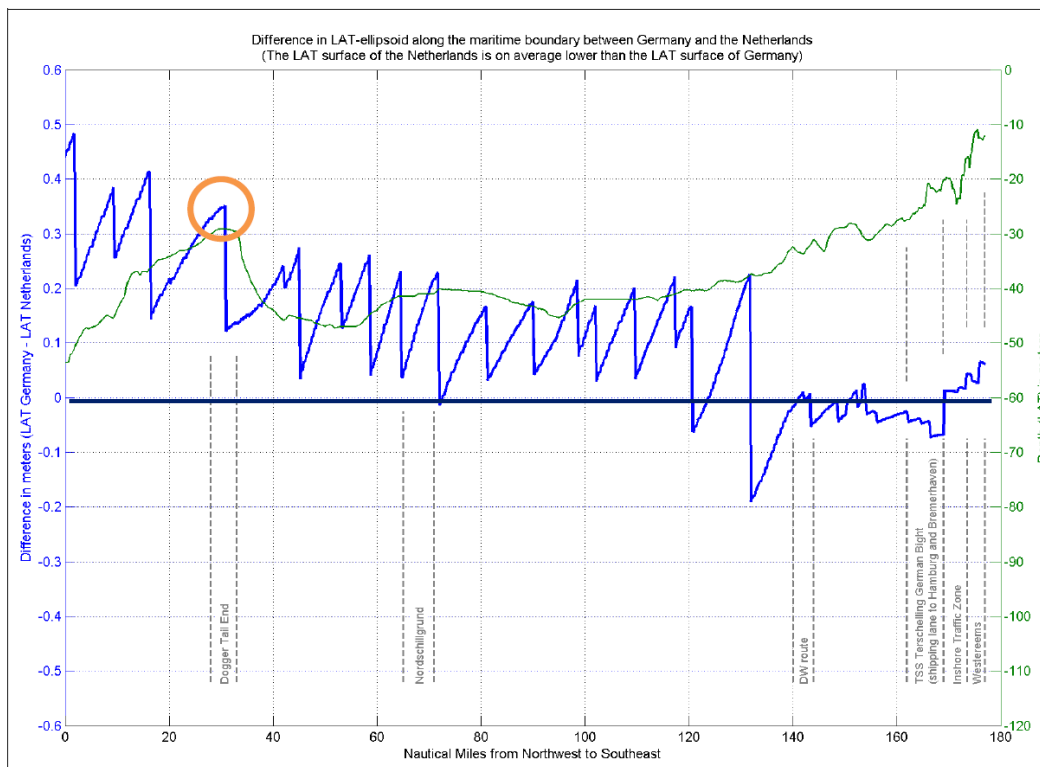
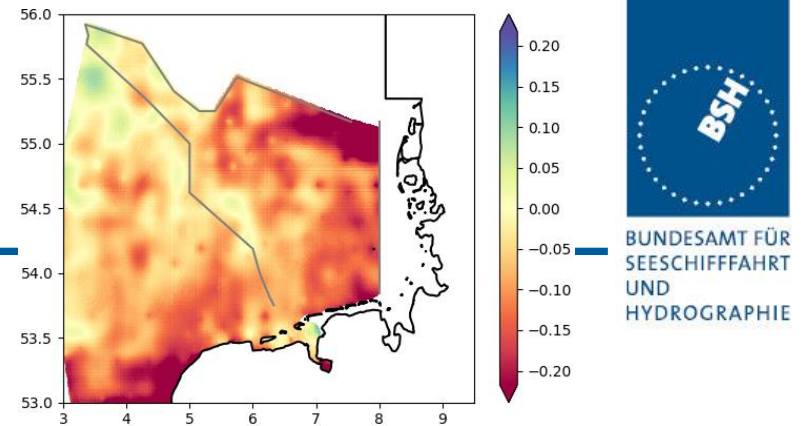
BSH  
BUNDESAMT FÜR  
SEESCHIFFFAHRT  
UND  
HYDROGRAPHIE





# Dutch and German surfaces: differences along maritime border

From: Document regarding „1 Percent Norm“  
R. Kuilman, 11-10-2017



# Take-home-message

New version of chart-datum  
surface has been developed

Uses observations from tide  
gauges and results from  
numerical simulations

Differences along Dutch-  
German border will be  
smaller

