



How do we Develop a New Realization of an Existing National Height Reference?

A few slides on DVR90 and how it is made public available

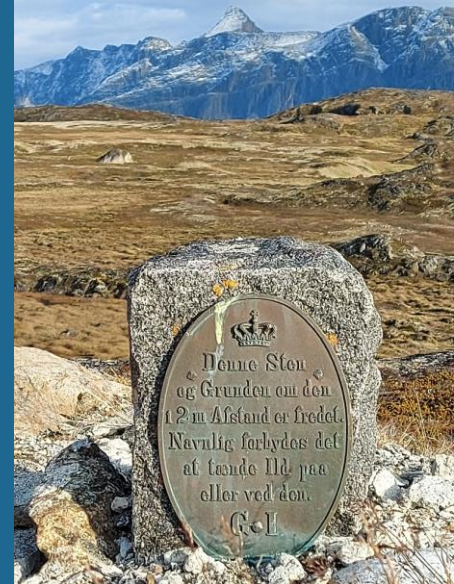
And some questions for You to answer...

A personal view by Kristian Keller, krkel@kds.dk

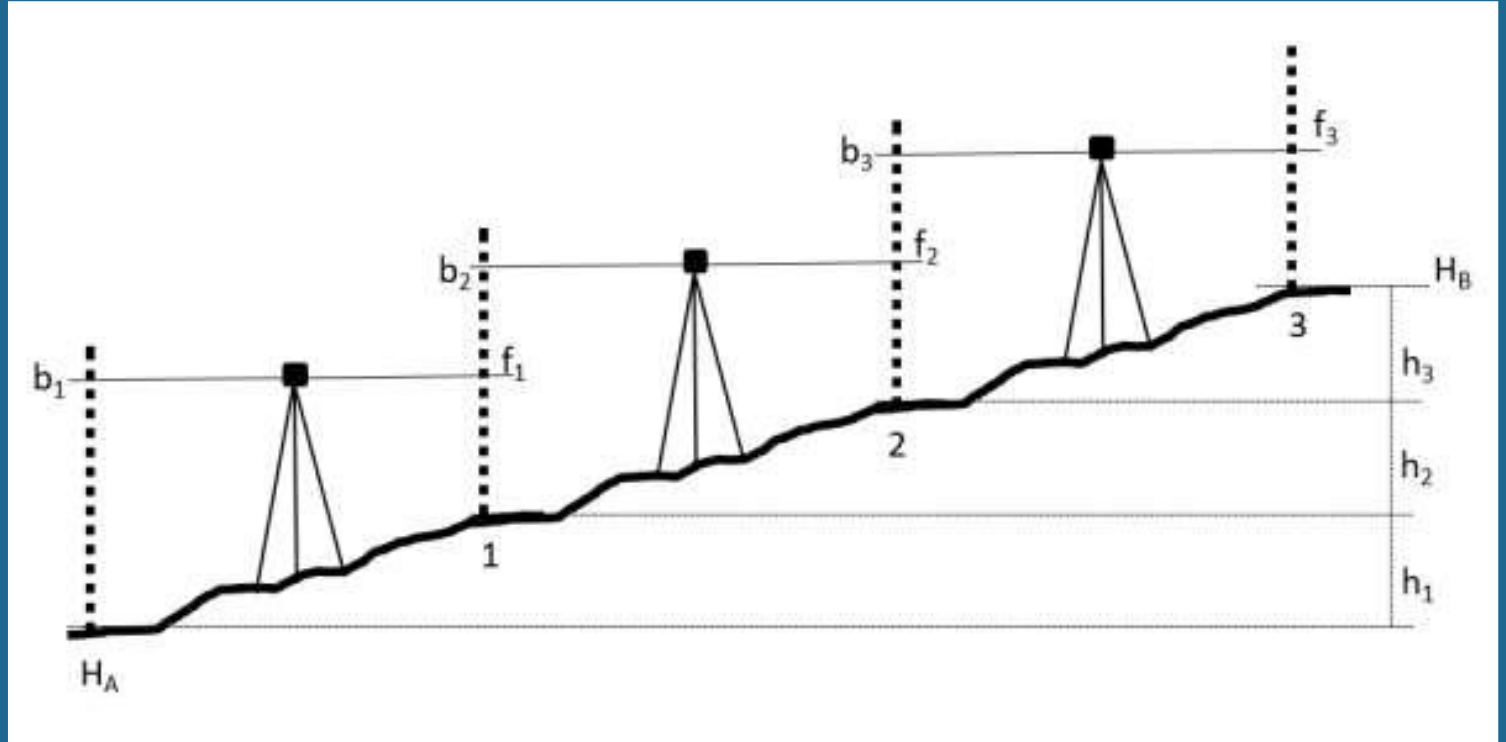


Agency for Climate Data

Our task: Public access to a reliable height!
Solution: Bench marks (mm), GNSS + geoid (cm)



DVR90 Levelling - observe height differences at sub mm level

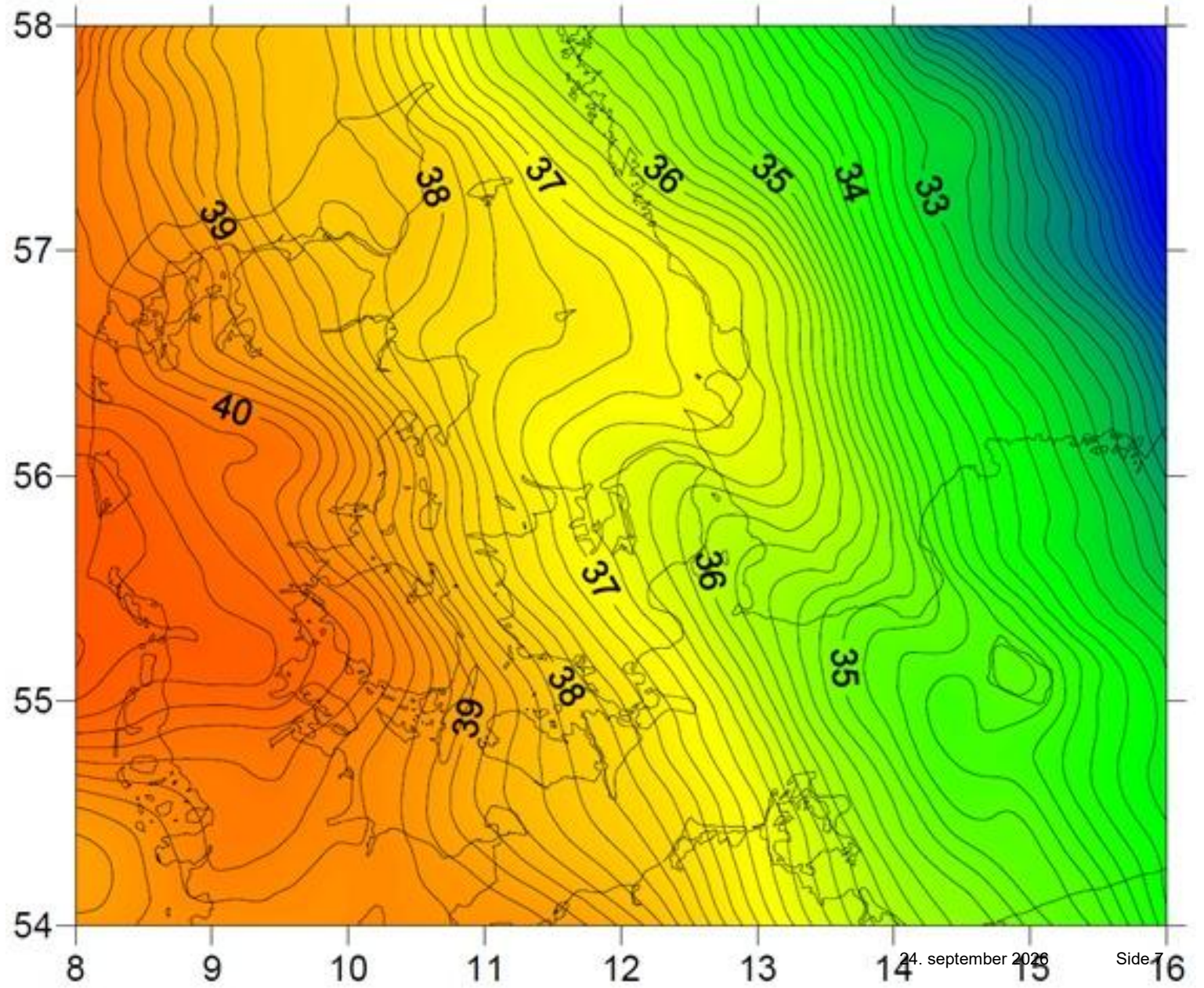
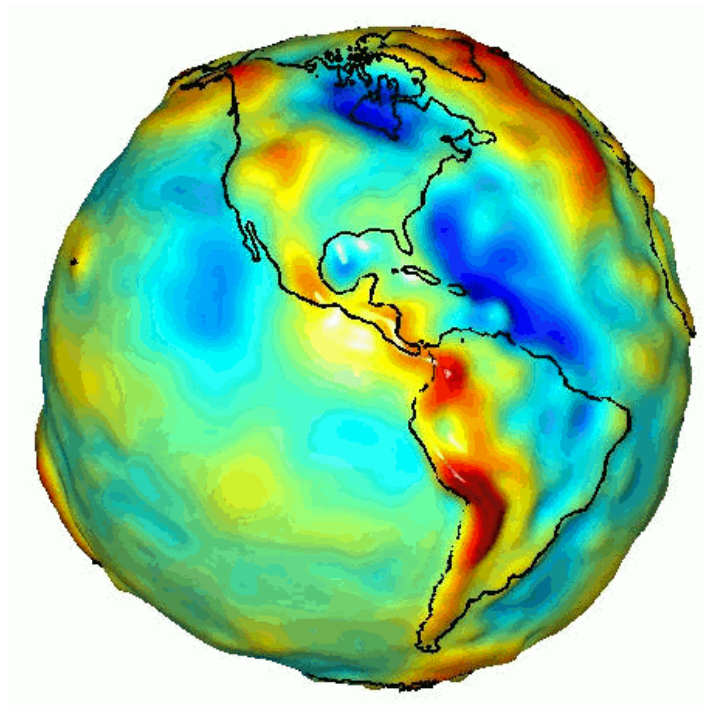


Densification of DVR90



The Danish geoid
makes DVR90 heights
available using GNSS.

We fit it to DVR90 and
make it less accurate...



Then we are
all fine 😊

What is the
problem?

<https://geodesy.science/cartoon/>

Geodesy Tracks the Rising Sea

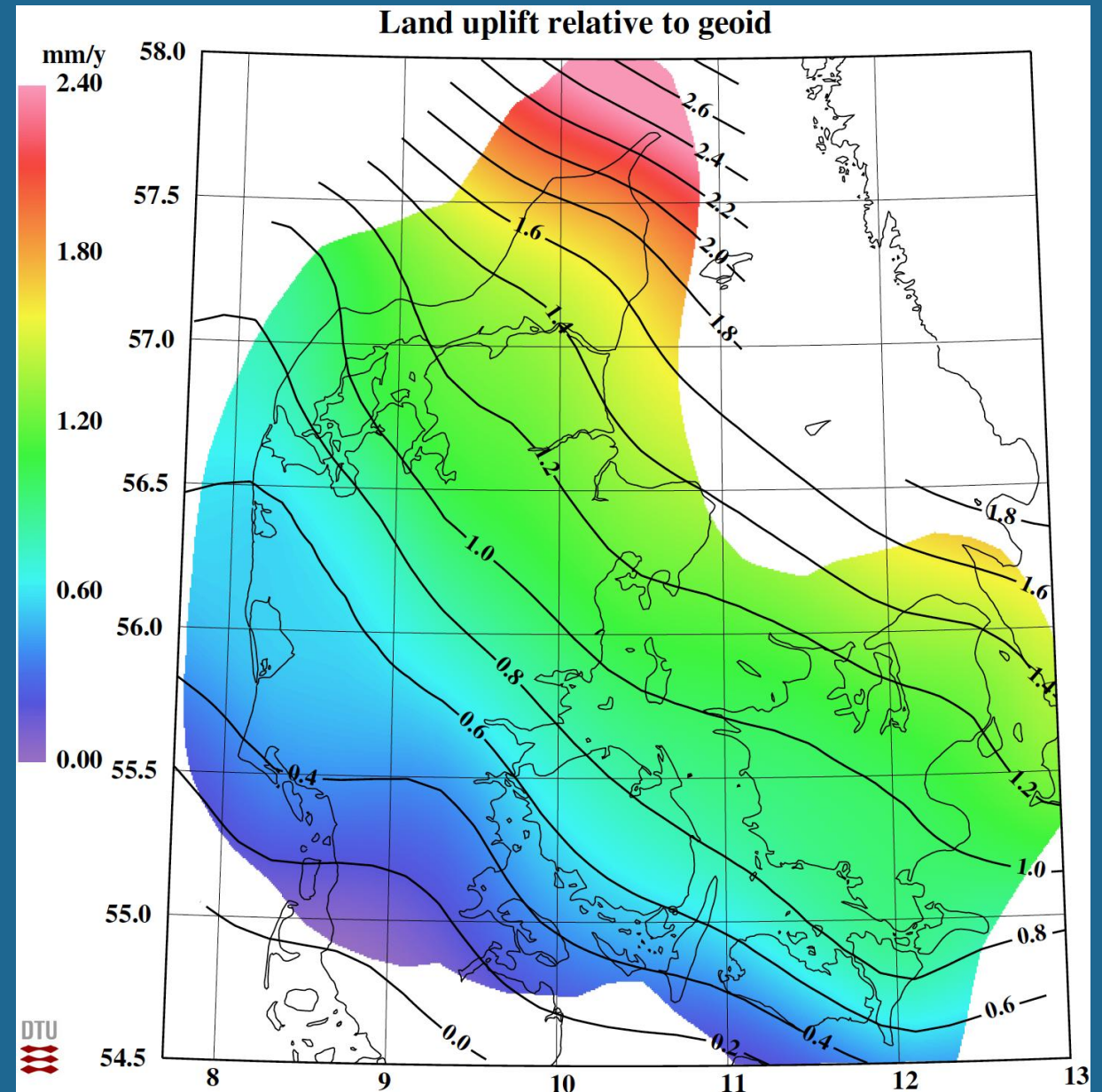
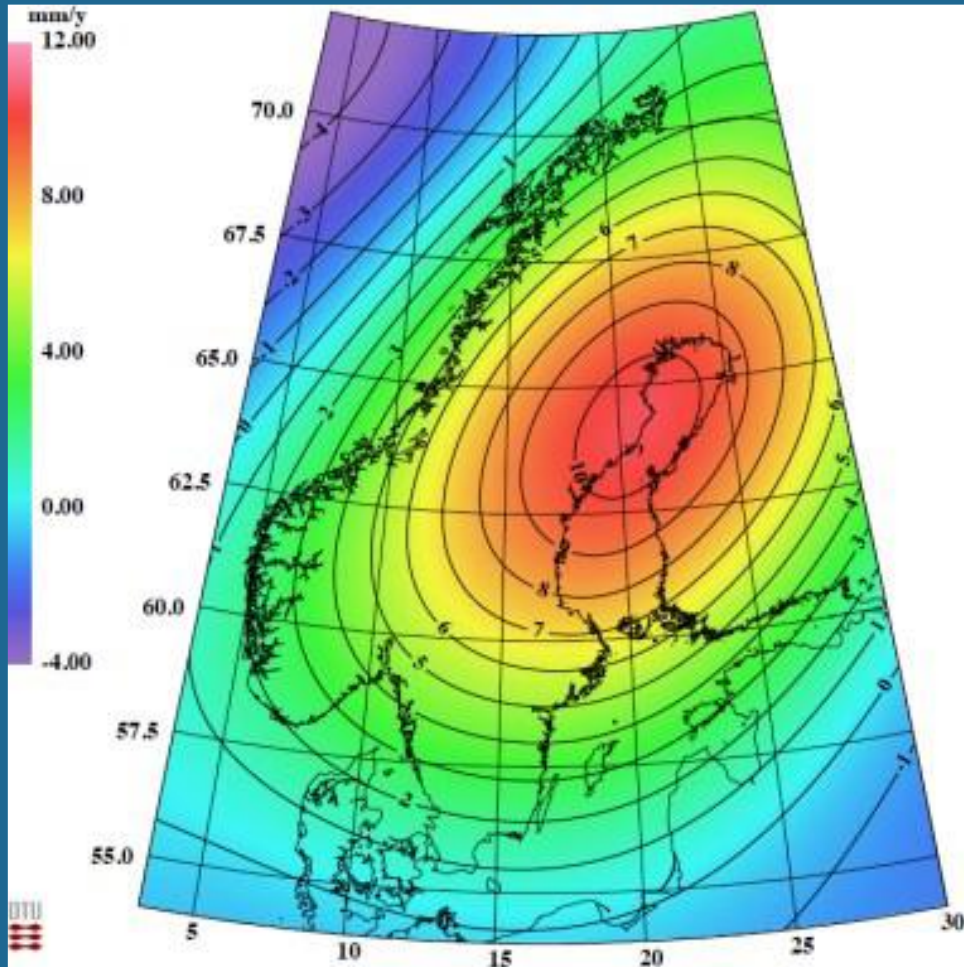


While islands slowly disappear, geodesy tracks every millimeter of sea-level rise with satellites and coastal gauges.



Atmaja Septa
Miyosa
cartoonist **Septa**

Sea level rise is NOT
stopped by uplift!



Uplift model mm/year by Per Knudsen et al, 2024

MSL in DVR90 heights...ups!

	MSL 1990 (start-1993) [m]	MSL 2020 (start-2017) [m]
Hirtshals	-0,087	-0,085
Frederikshavn	-0,053	-0,058
Hanstholm	-0,029	0,031
Århus	-0,008	0,026
Fredericia	-0,009	0,032
Esbjerg	0,046	0,094
Fynshav	0,010	0,066
Slipshavn	0,005	0,046
Korsør	0,030	0,062
Hornbæk	-0,002	0,029
København	0,052	0,086
Rødbyhavn	0,047	0,088
Gedser	0,056	0,099
Tejn	-0,026	0,049

We MUST focus on
THE SEA LEVEL

- Accelerating
sea level rise!
Present 4mm/year

When is the
difference too large?
- at 10 cm?
- at 20 cm?

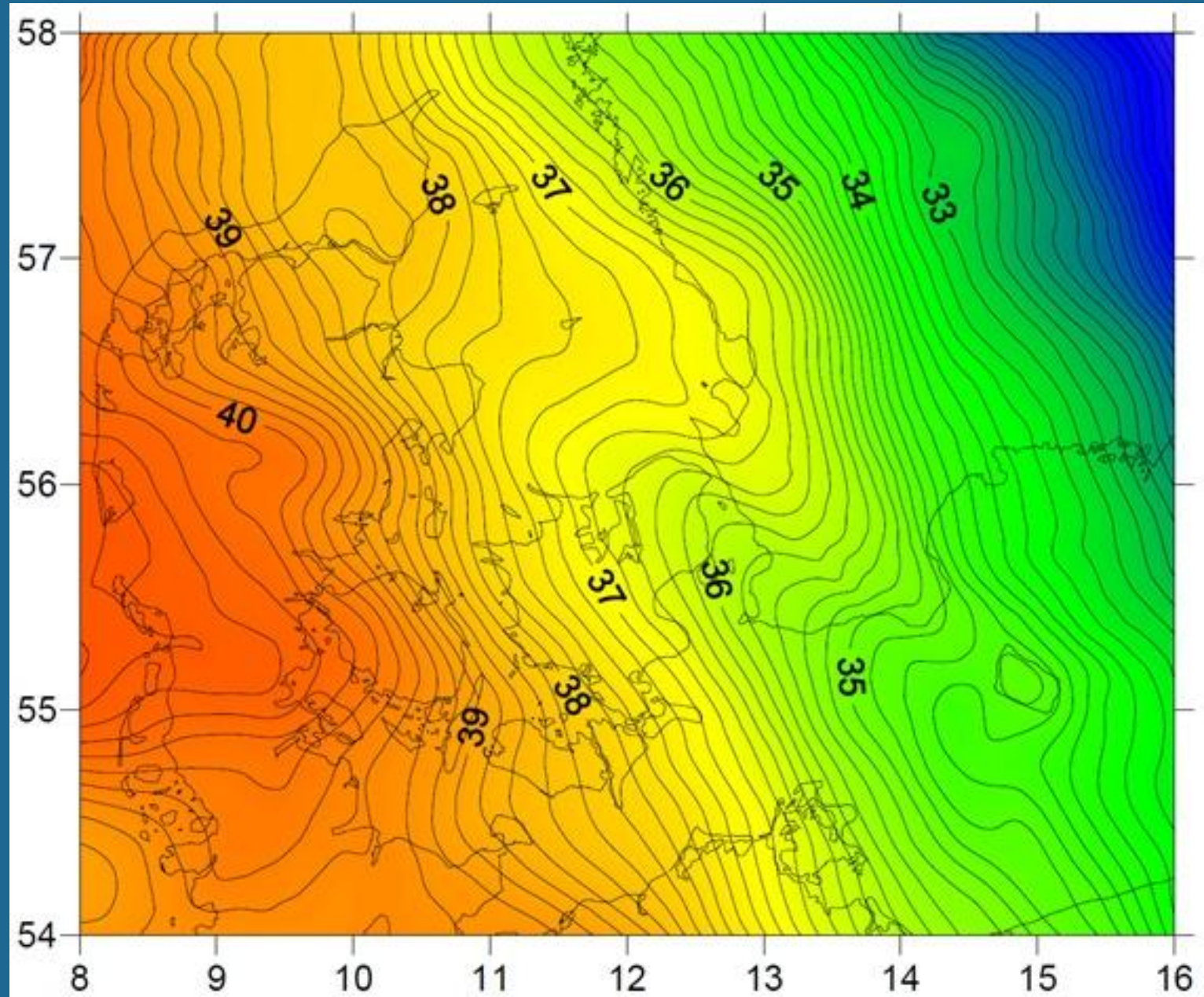
We need to be serious about the sea level rise and find a way to make a reliable height reference available for all - ASAP!

- What do You suggest?
- ...
- ...
- ...
- ...
- ...
- ...
- ...

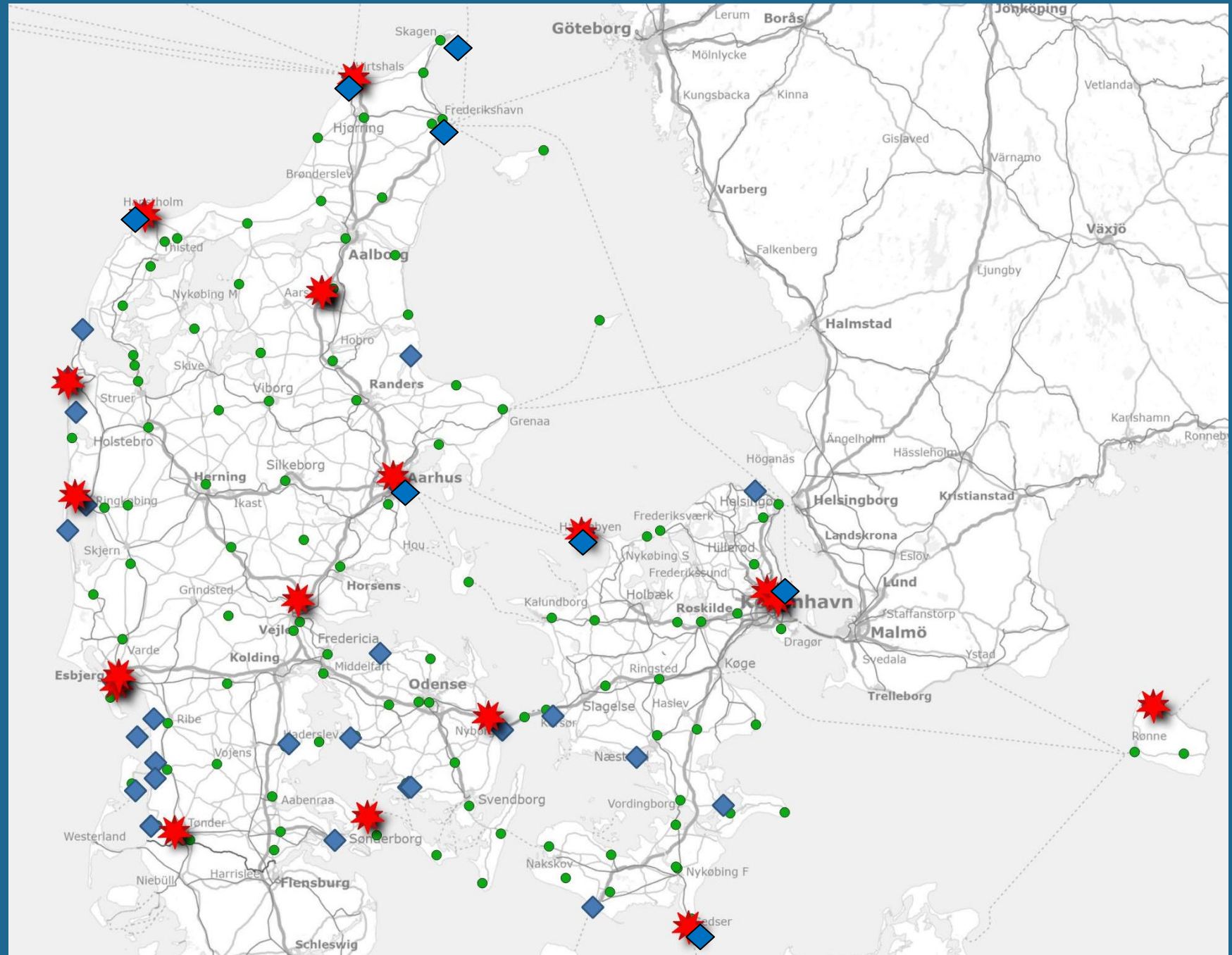
Let's make the geoid
define a new
reference!

Well – we can fit the
geoid to something
new...

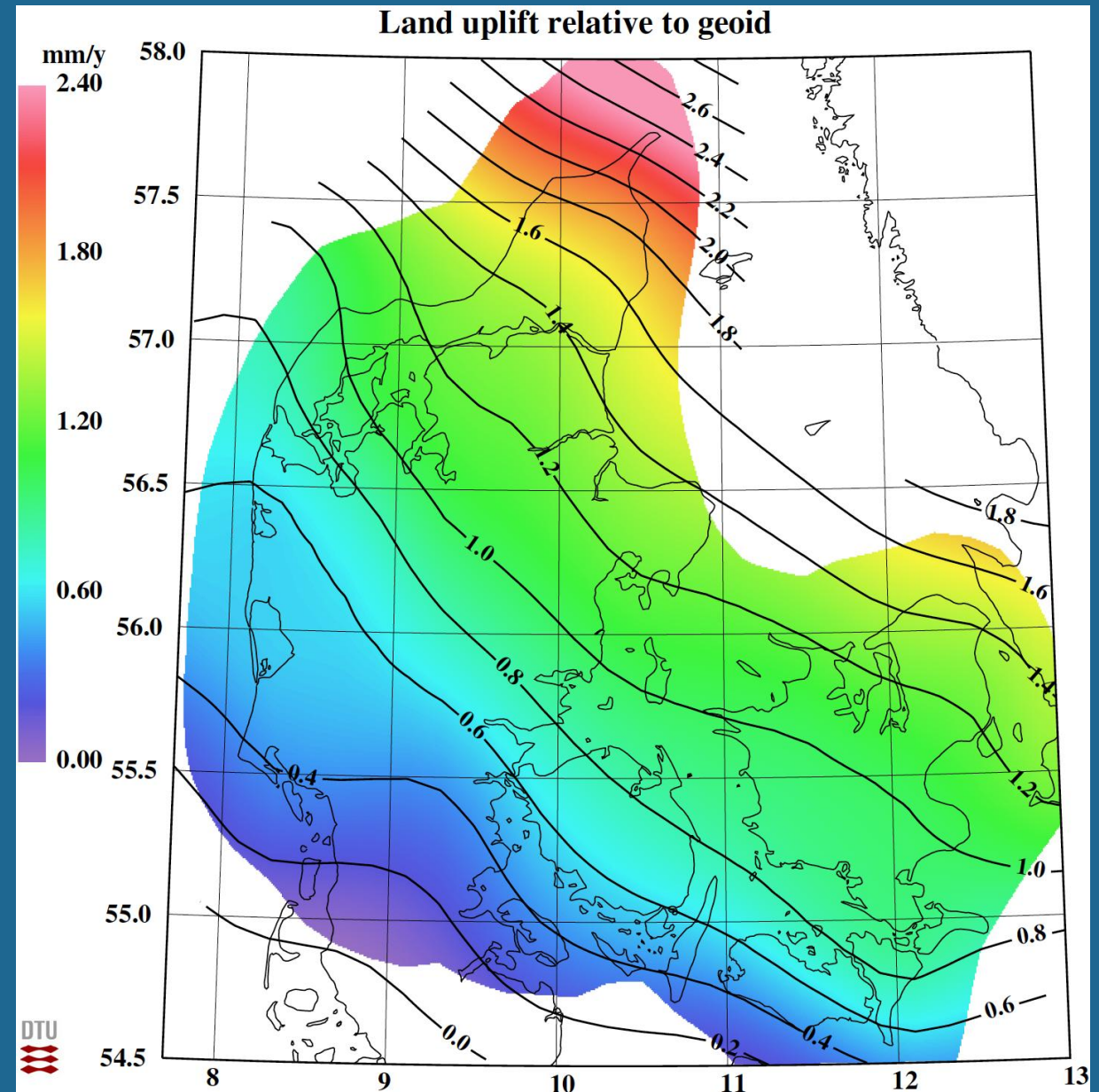
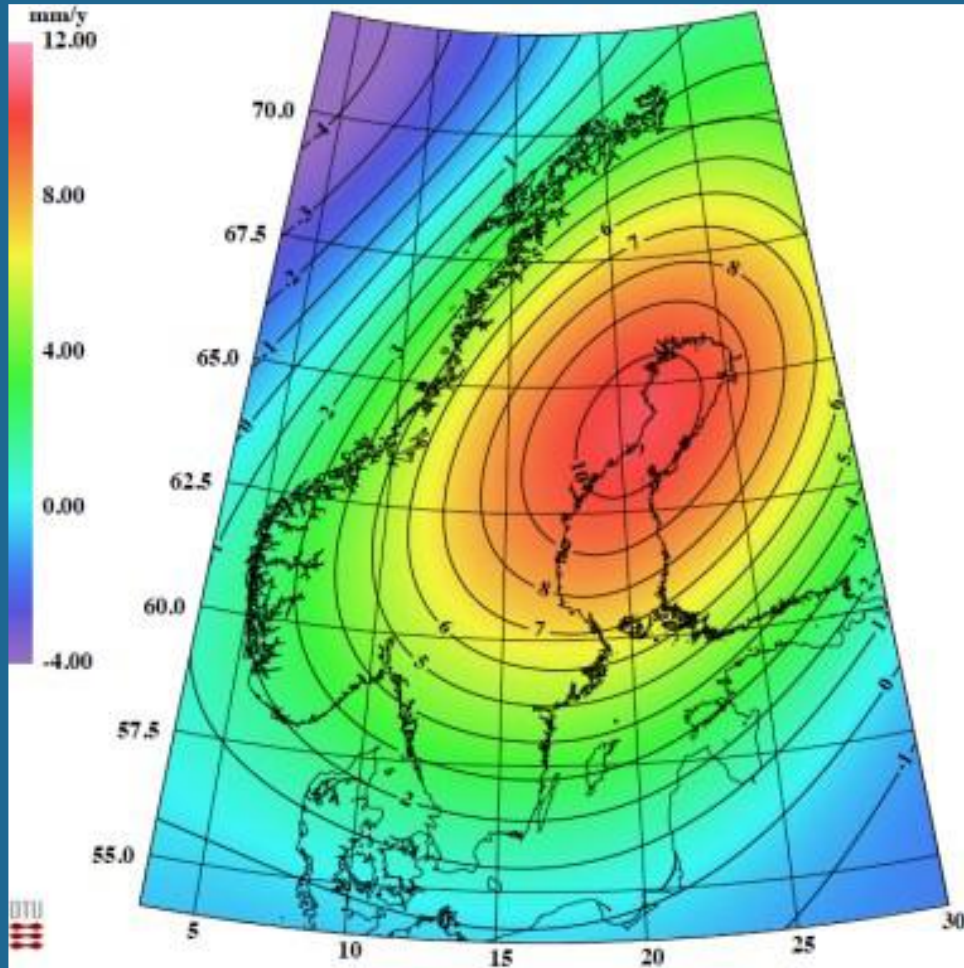
Aarhus GM 902
TG ~ “sea level”
CORS
5D using predicted
heights...?



- Green dot ~125:
- 5D GNSS (lev.)
- Blue Square ~16+
- Tide Gauge (lev.)
- Red Star: ~16
- CORS GNSS (lev)
- BUT levelling is based on DVR90, defined on observation from 1980's...



The uplift model might predict the present height from an 'old' height...



Uplift model mm/year by Per Knudsen et al, 2024

InSAR !

will help you update the heights of
your bench marks every
month/year - a dynamic reference?



Present: 9 reflectors at CORS
Future: at all 5D bench marks?



Hydrodynamic Leveling

(by Tim E. Jensen, DTU Space)

Tide gauge observations:

Mean Sea Level above DVR90

MSL = Geoid + SST

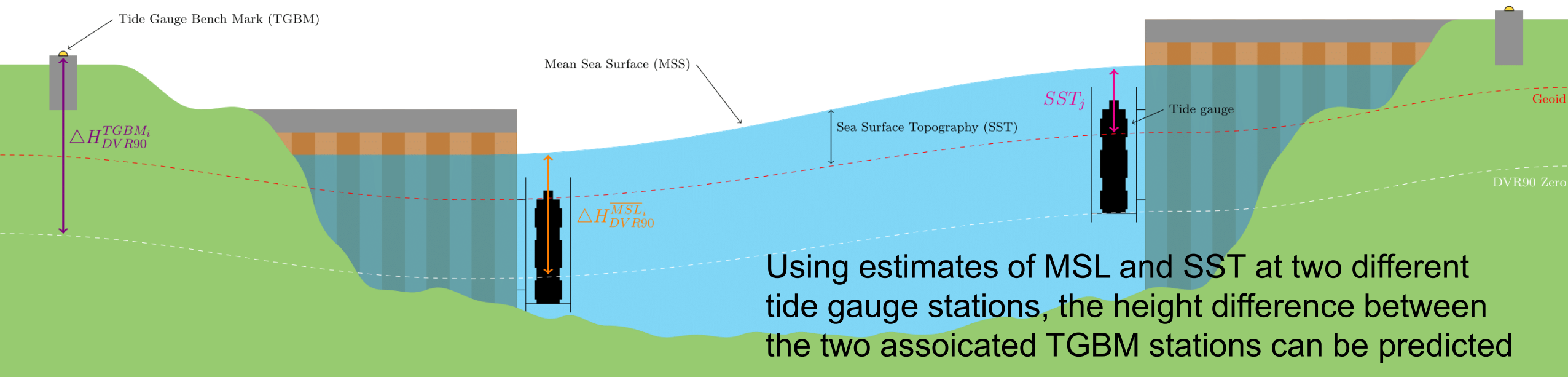
$$\begin{aligned}\Delta H_{DVR90}^{\overline{MSL}_i} &= \Delta H_{DVR90}^{Geoid} + \Delta H_{Geoid}^{\overline{MSL}_i} \\ &= \Delta H_{DVR90}^{Geoid} + SST_i\end{aligned}$$

MSL w.r.t. nearby TGBM station:

$$\begin{aligned}\Delta H_{TGBM_i}^{\overline{MSL}_i} &= \Delta H_{DVR90}^{\overline{MSL}_i} - \Delta H_{DVR90}^{TGBM_i} \\ &= \Delta H_{TGBM_i}^{Geoid} + SST_i \\ \Rightarrow \Delta H_{Geoid}^{TGBM_i} &= SST_i - \Delta H_{TGBM_i}^{\overline{MSL}_i}\end{aligned}$$

Sea Surface Topography:

$$SST_j$$



PROBLEM:

René:

“...and we (KDS...) have a problem at the island of Bornholm as there is a bias of 13,5 cm compared to the mainland of Denmark...”
said in 2013 and on going...

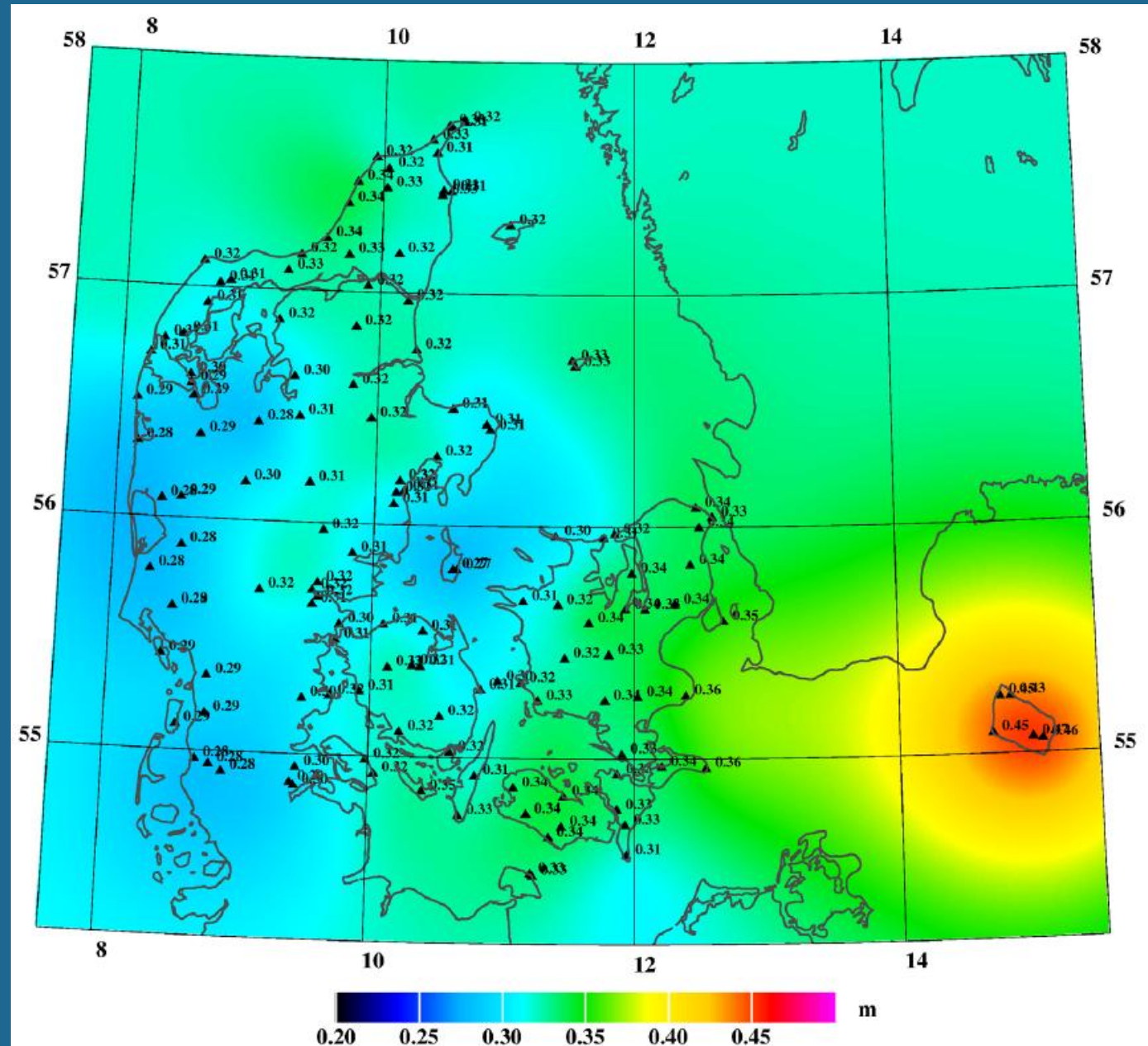
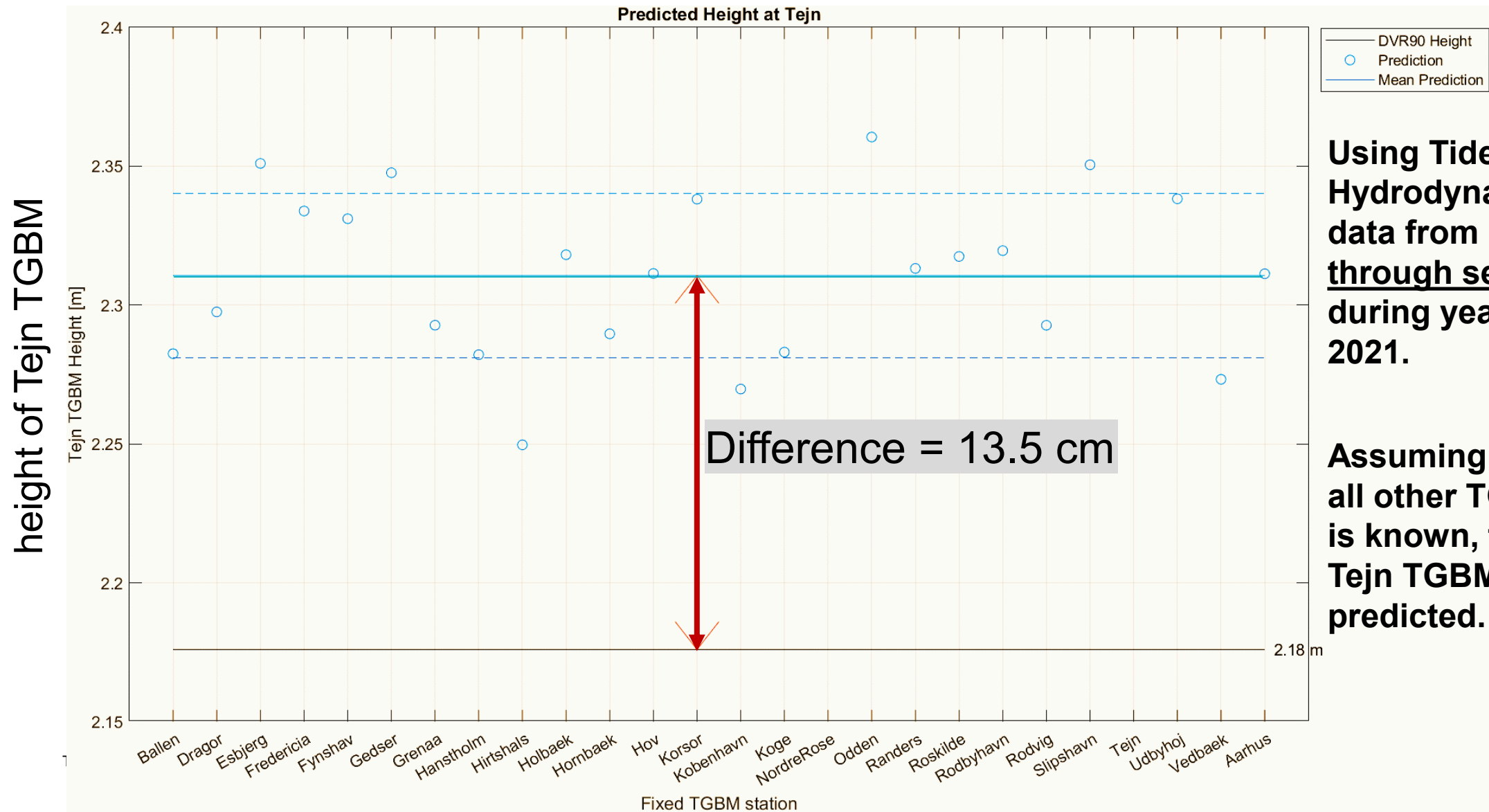


Fig. 2. Forskel mellem DVR90 og den gravimetriske geoide. Enhed meter.

Predicted Heights at Tejn using hydrodynamic leveling



Using Tide Gauge and Hydrodynamic Model data from months may through september during years 2019 to 2021.

Assuming the height of all other TGBM stations is known, the height of Tejn TGBM can be predicted.

I am sure
that we will
find the
perfect
solution for
Denmark!

Thank You

<https://geodesy.science/cartoon/>

The Geodetic Tailor



Geodesists stitch together observations of Earth's surface, gravity, rotation, and their changes to tailor the most precise model of our dynamic planet.