



Euroopa Liidu  
struktuuritoetus



Eesti tuleviku heaks



1918

**TALLINNA TEHNIKAÜLIKOOL**  
TALLINN UNIVERSITY OF TECHNOLOGY

**MAA-AMET**  
Estonian Land Board



# Determining Sea Surface Topography by GNSS Surveys on Ice

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# Topics

- Calm sea surface
- Definitions
- Principles of SST determination
  
- SST in the Baltic Sea
- Determination of SST at the Väinameri Basin
- Evaluation of the SST model obtained

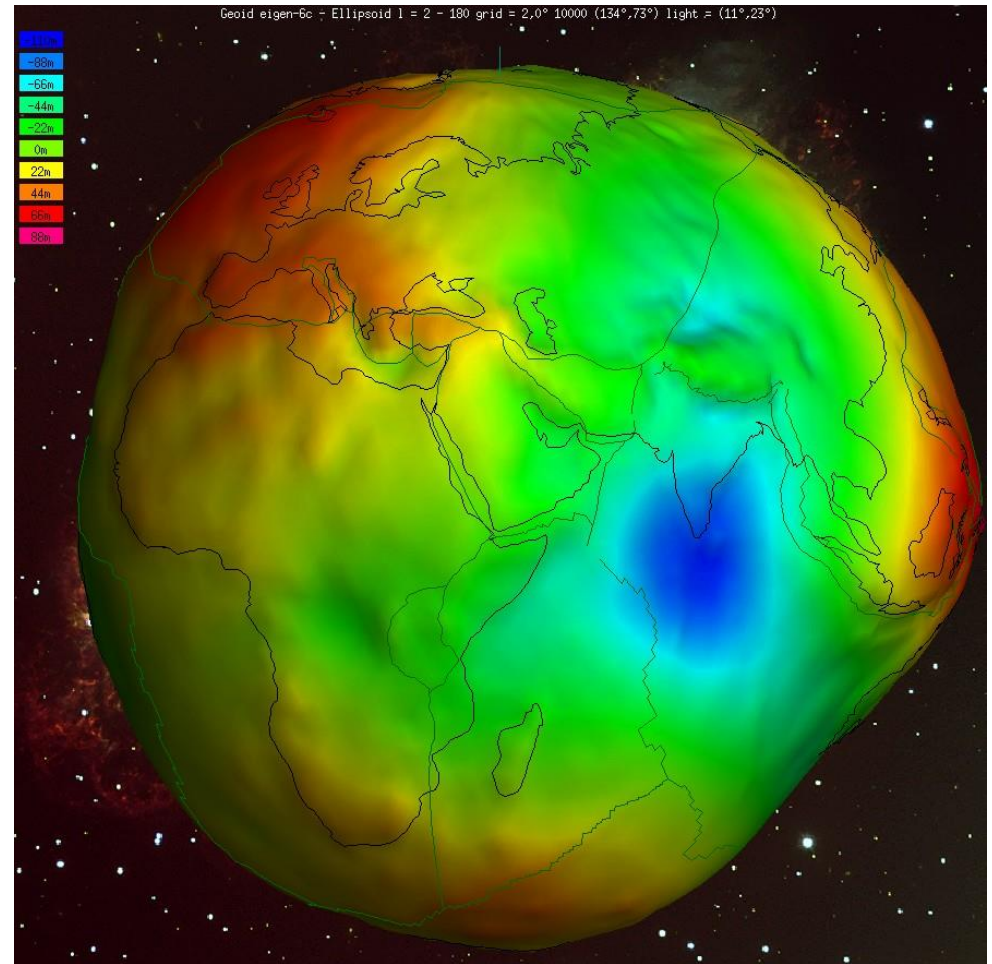


# Background & calculation process

# Calm sea surface = GEOID

WITHOUT

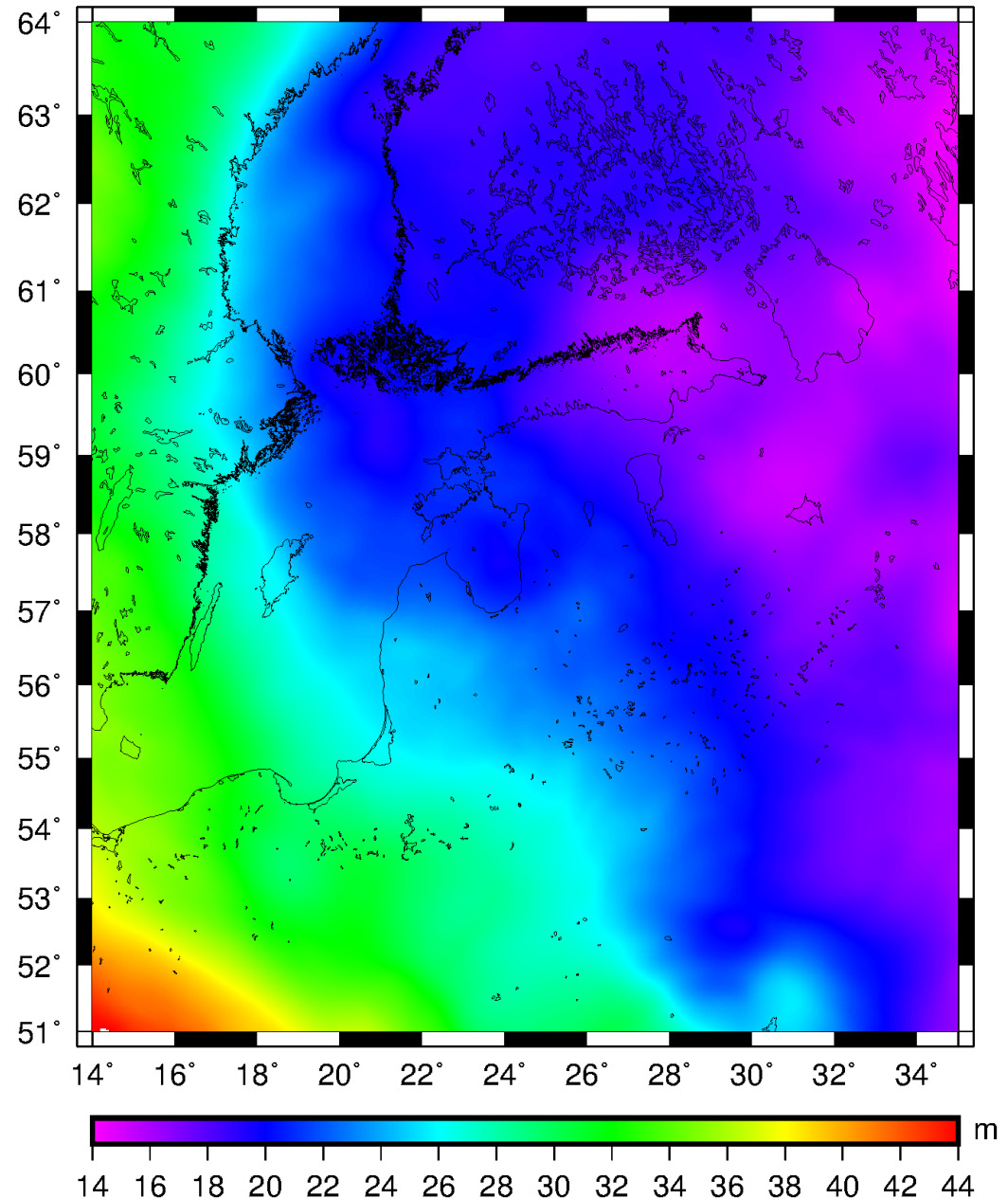
- wind
- waves
- tides
- currents
- ...



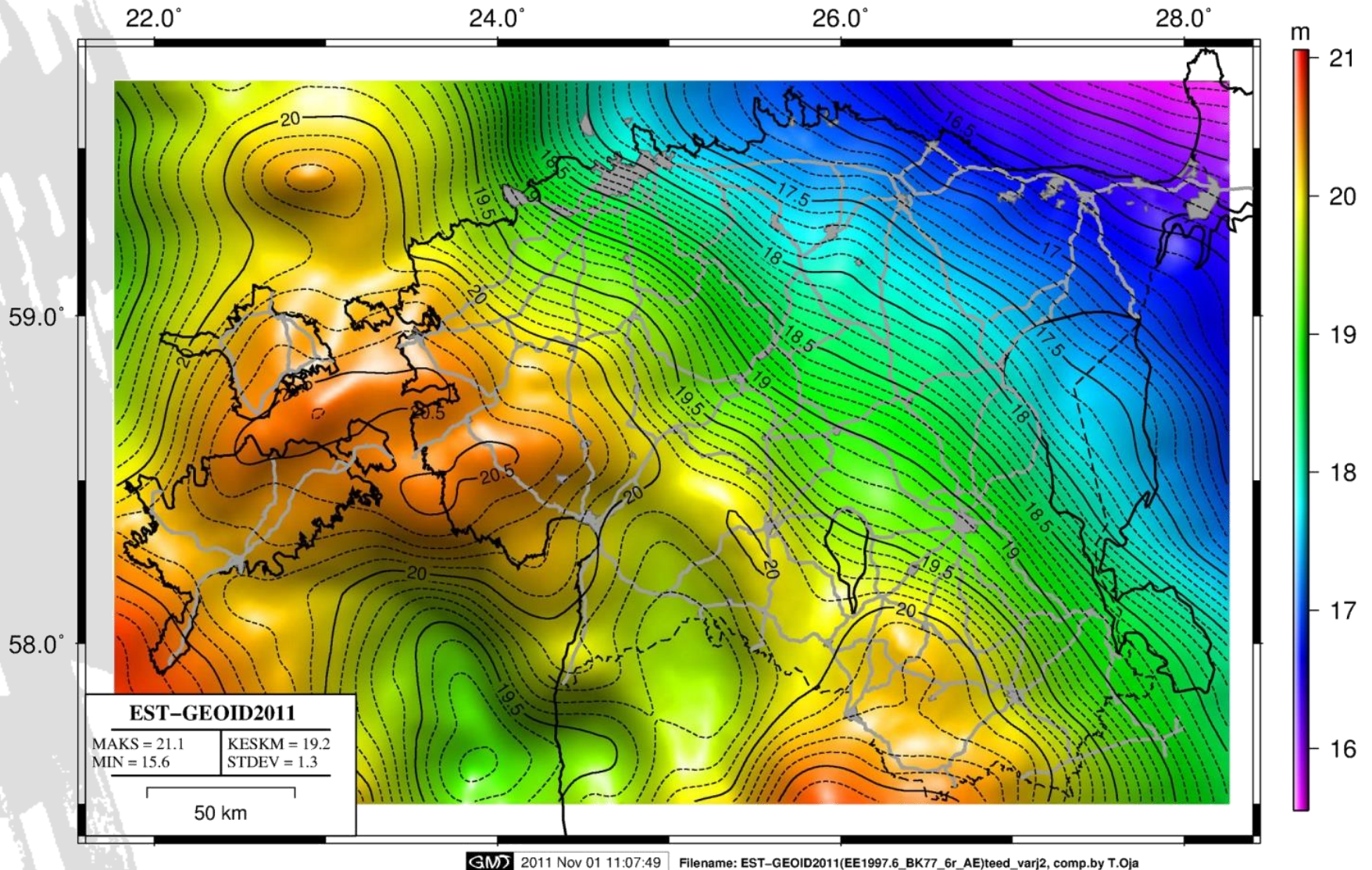
[icgem.gfz-potsdam.de/](http://icgem.gfz-potsdam.de/)

# Baltic Sea area

Long wavelength  
geoid signal in the  
Baltic Sea area

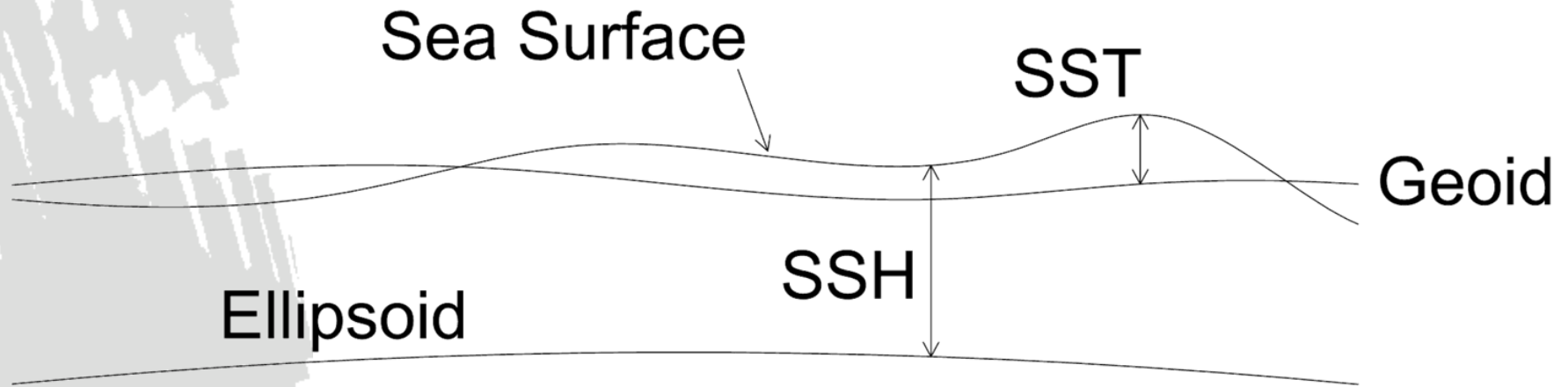


# Detailed geoid signal



# Sea Surface Height (SSH)

## Sea Surface Topography (SST)

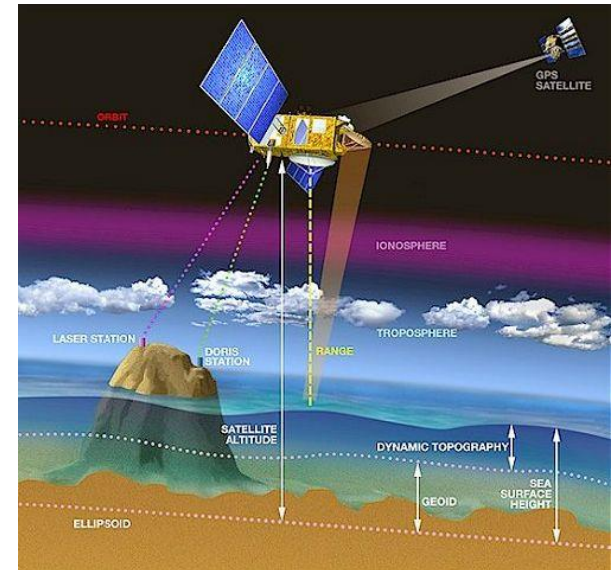
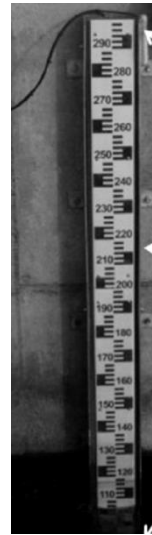


Mean Dynamic Topography (MDT)

- SST averaged over a time period

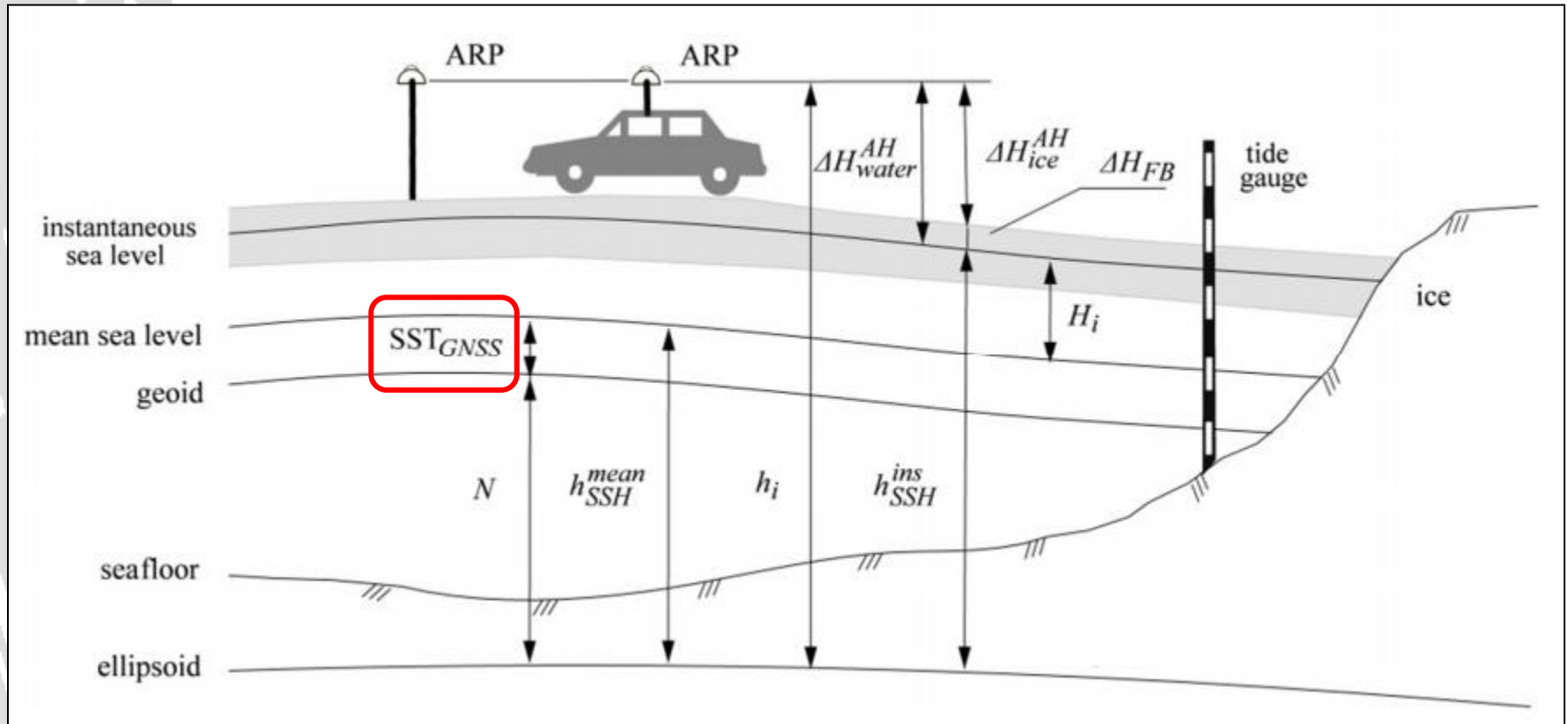
# Measuring SSH

- Tide gauges
- Satellite altimetry
- GNSS (GPS)



*earth.eo.esa.int*

# SST determination by GNSS on ice



$$SST_{GNSS} = h_i - \Delta H_{ice}^{AH} - \Delta H_{FB} - H_i - N + \varepsilon$$

$\varepsilon$  – errors

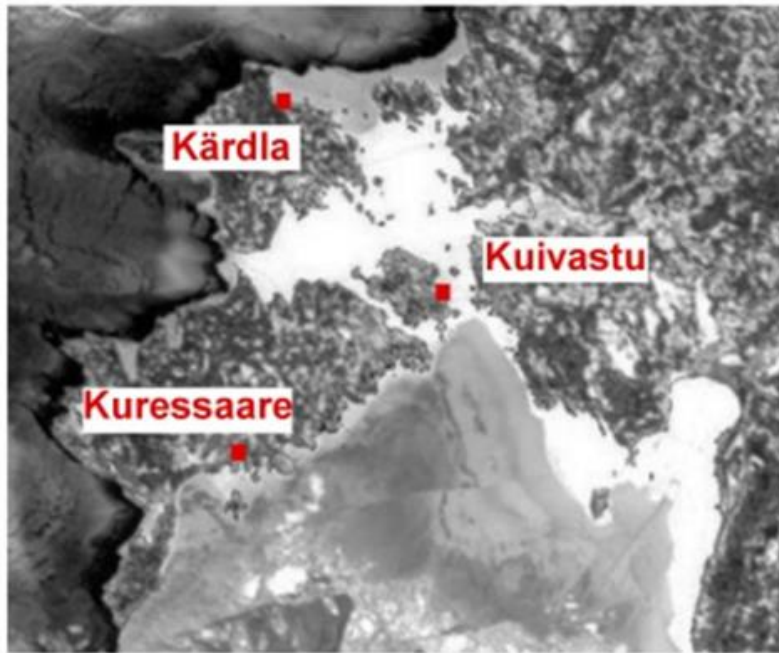


# **Case study**

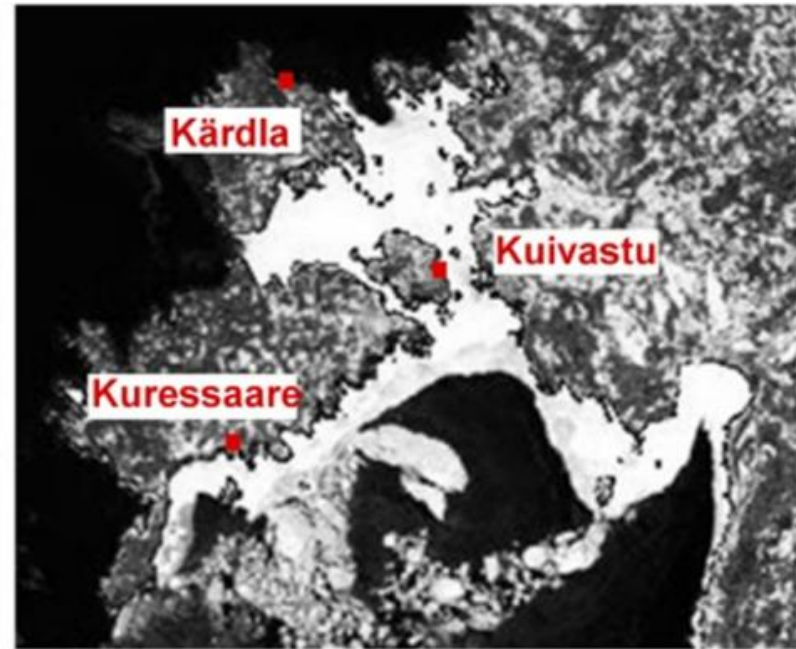
**at the Väinameri Basin  
in the Baltic Sea**

# Väinameri Basin

- 2200 km<sup>2</sup>
- 6 automatic tide gauges (for  $H_i$ )
- Covered by GRAV-GEOID2011



A



B

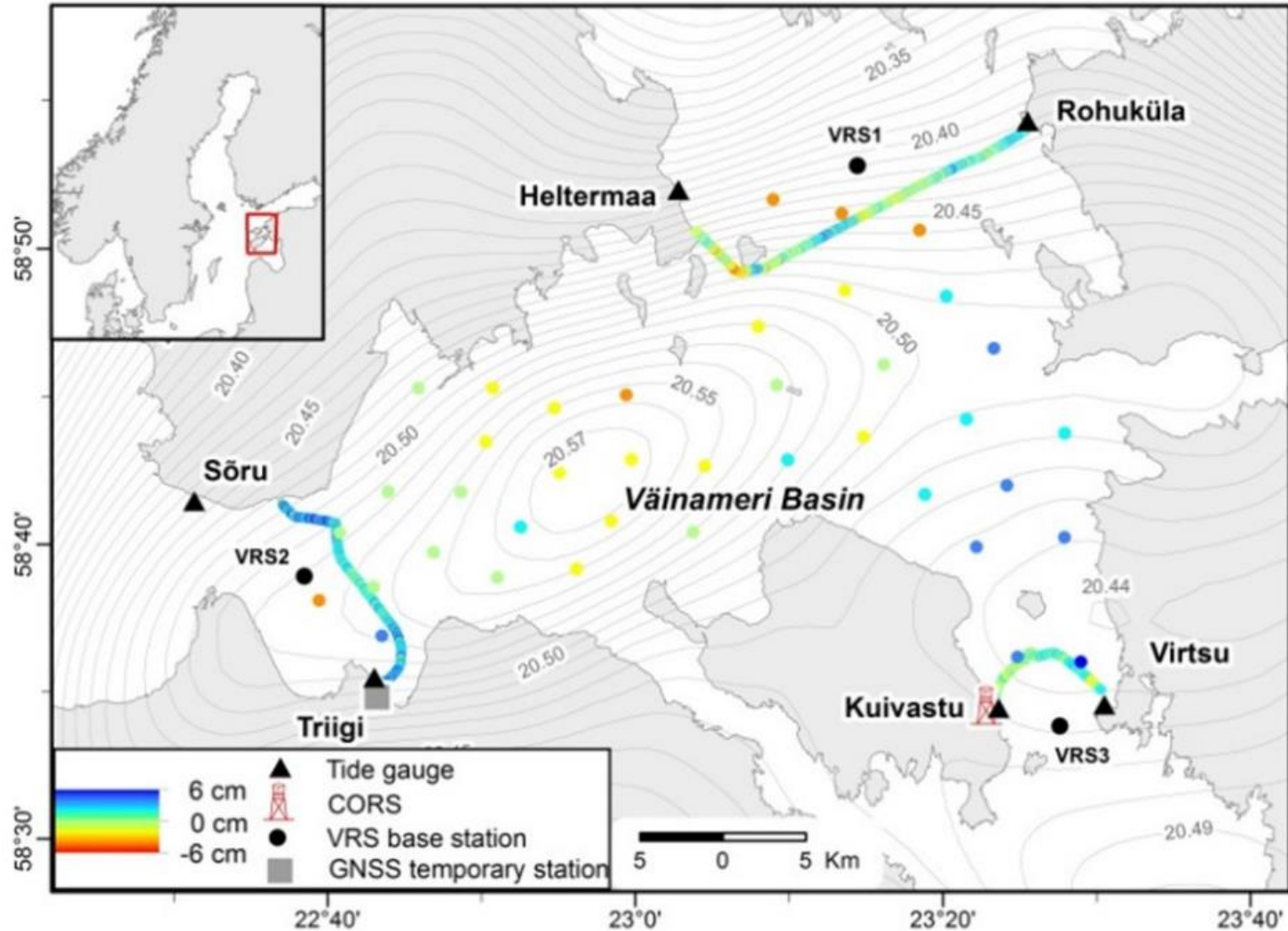
# Field work (2011)



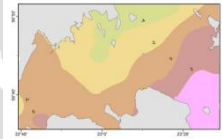
# Field work (2013)



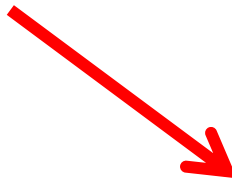
# GNSS surveys



SST surface  
(2013)



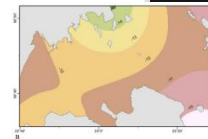
SST profiles  
(2011)



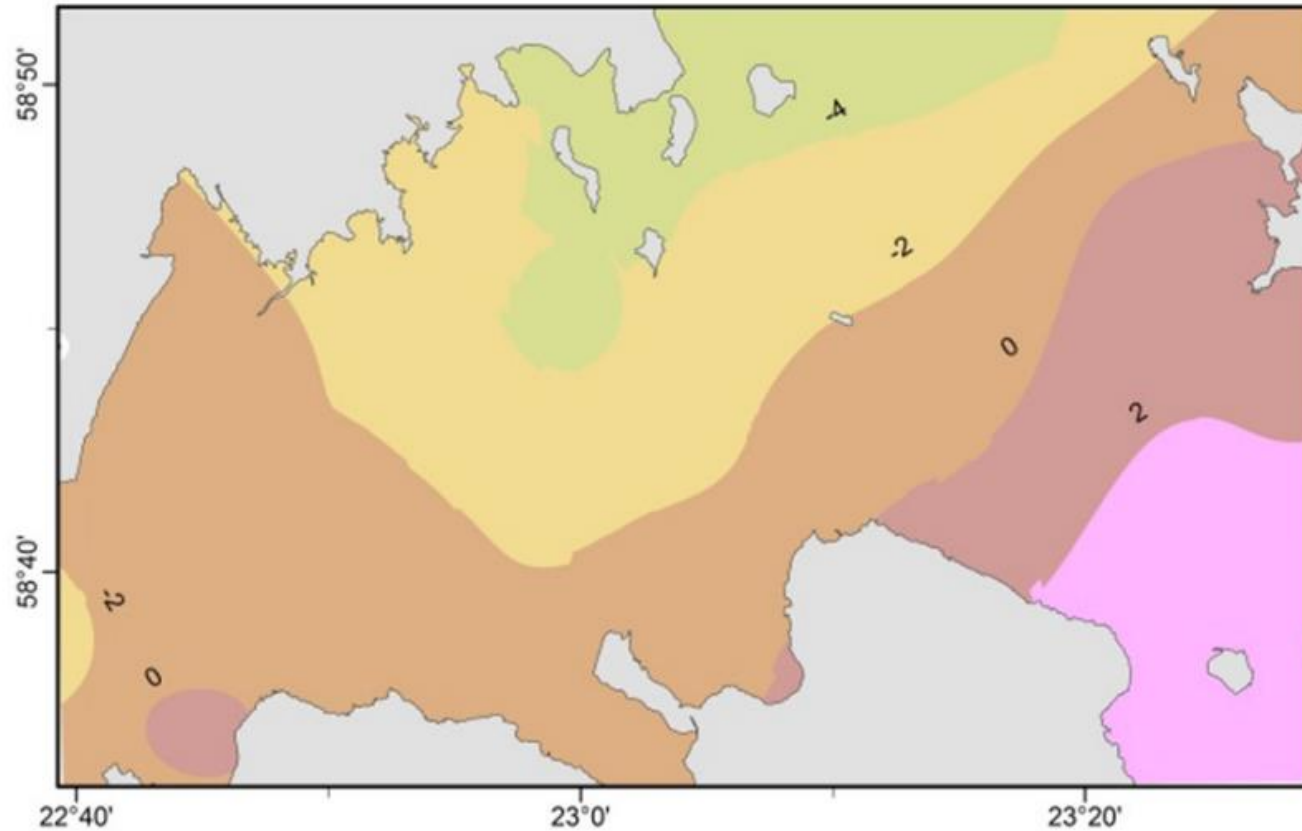
DTU10MDT  
(1993-2009)



Regional  
annual model  
(2010)

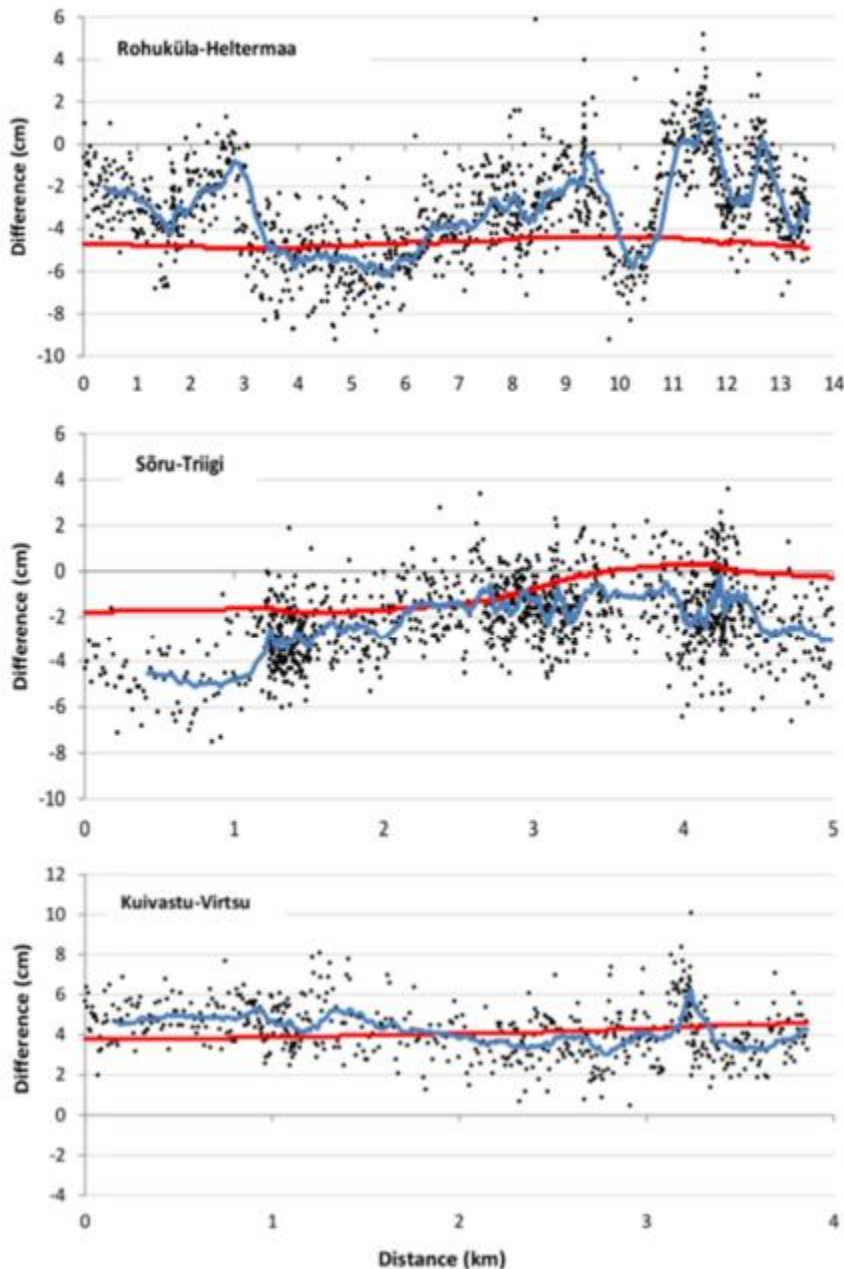


# GNSS derived SST surface\*



*\*Created using the point-wise survey from 2013 only*

# 2011 profiles vs. 2013 SST surface



Red – SST surface  
Blue – profile  
Black – discrepancy  
(surface minus profile)

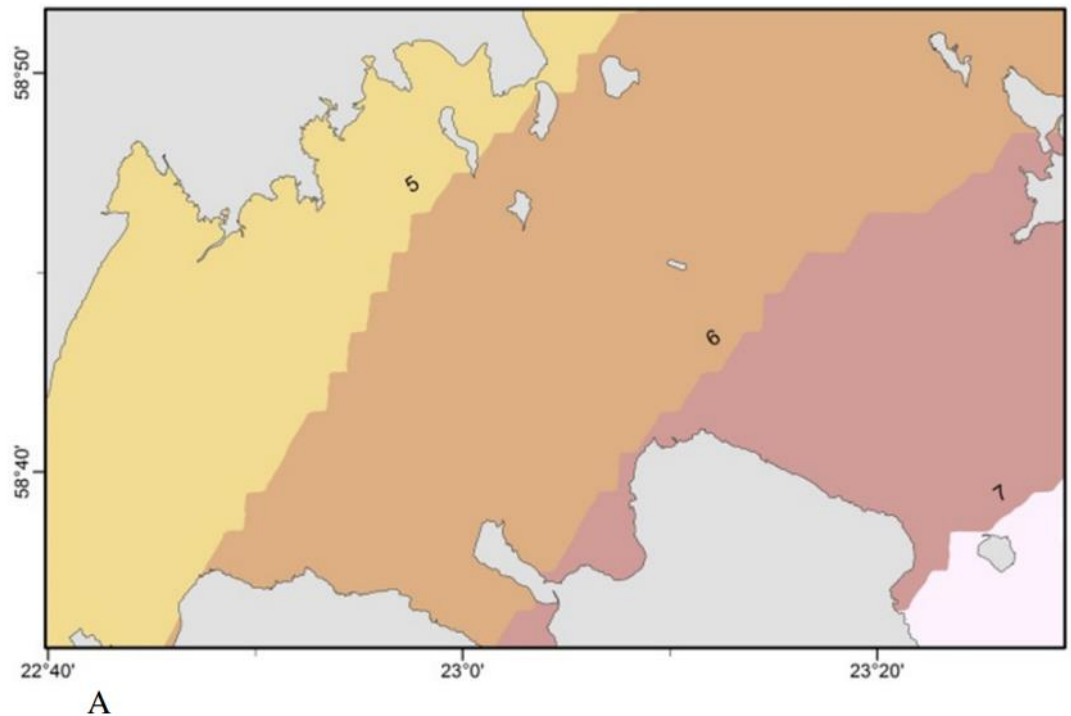
Av. discrep  $\pm 4.3$  cm  
STDEV  $\pm 2.3$  cm

# Global model: DTU10MDT

17 years of  
satellite altimetry

1 arc-minute  
~1.8 x 0.9 km

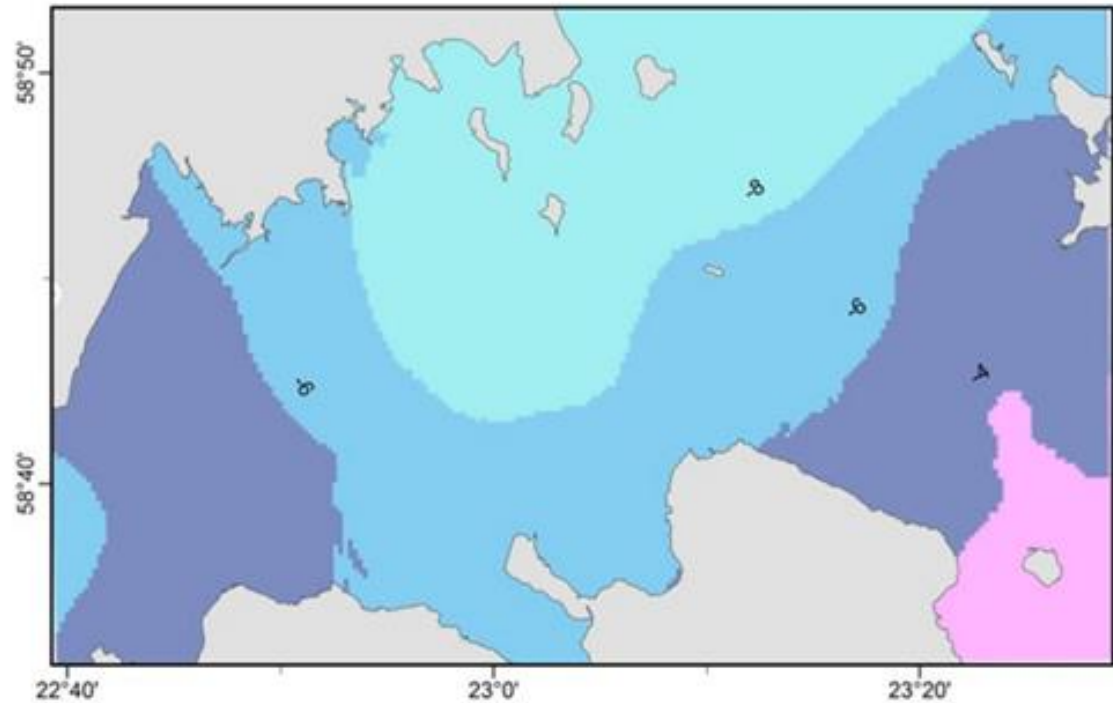
Accuracy ~10 cm



# SST surface vs. DTU10MDT

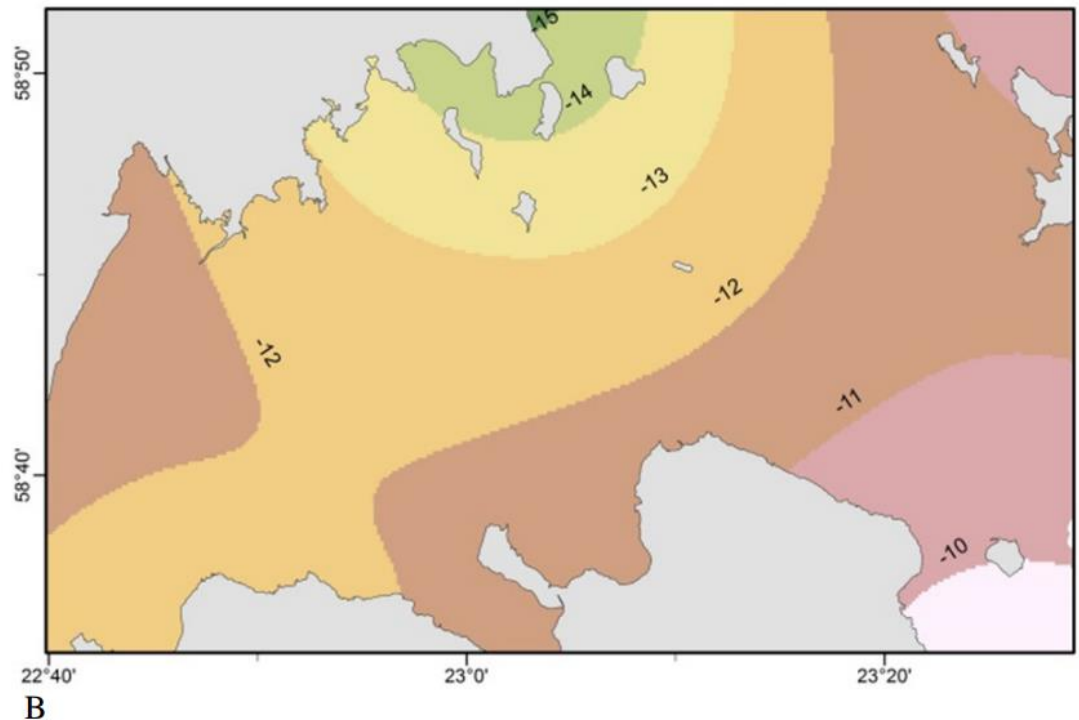
Offset removed

Relative differences  
4...5 cm in SE-NW



# Regional annual (2010) model\*

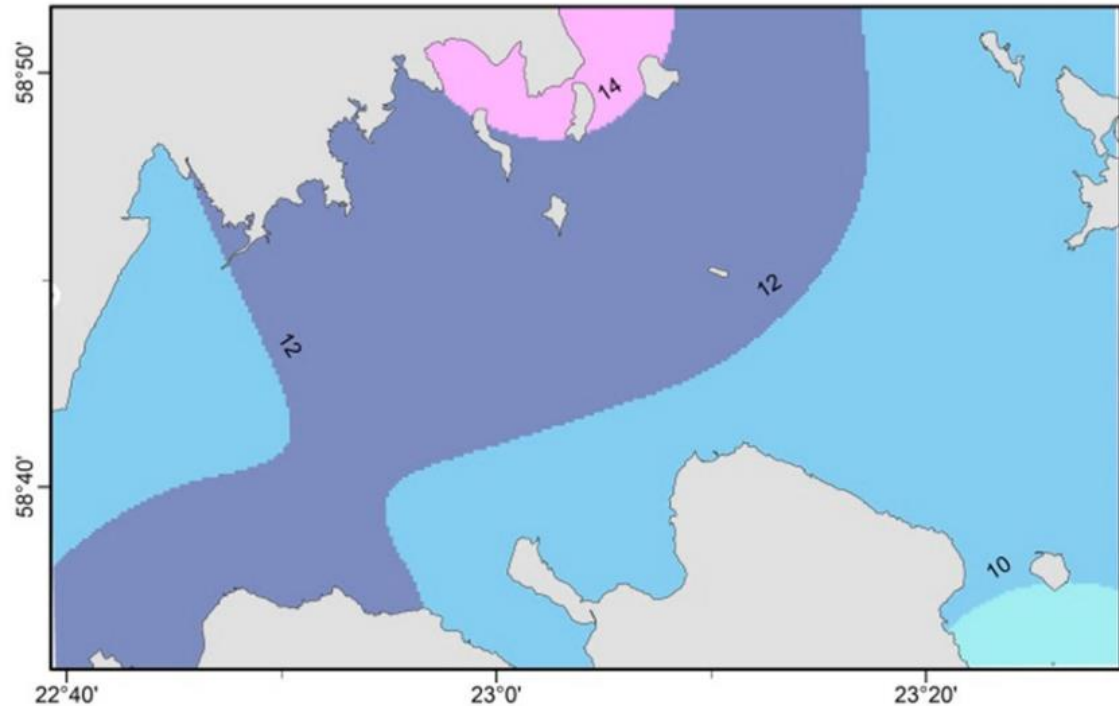
Six surrounding  
tide gauges



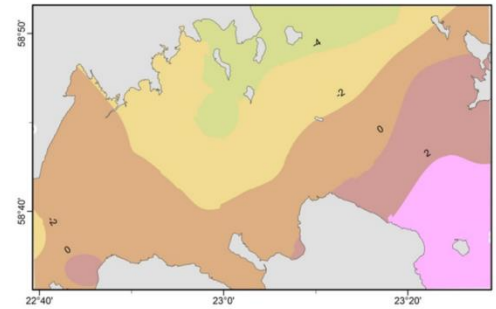
\*A. Liibus. „Precise hydrodynamic levelling using pressure gauges with application to improvement of the Estonian National Levelling Network”. Academic dissertation. Tartu. 2013

# SST surface vs. regional annual model

Relative differences  
4...5 cm in SE-NW



# Conclusions



- Possible to obtain high resolution SST models
- GNSS survey offered an instantaneous model
  - Could be extended to a number of models
- Comparisons to long-term models revealed relative discrepancies of 4...5 cm
  - Within the expected accuracy of the long-term models

# Support

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