TALLINN UNIVERSITY OF TECHNOLOGY

Sea level and sea state observation and forecast network in Estonia

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*** Marine Systems Institute ** Estonian Land Board**

BOOS AM
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MOTIVATION

Sustainable *in situ* operational sea level and wave measurement technologies for the Baltic Sea (ice presence), being low cost in operation.

OUTLINE

- **Pressure based sea level and wave measurements**
- **Wave data derived from navigation buoys movement**
- **Wave fields from marine radars**
- **Data management and presentation**

EU FP5

PAPA

2002-2005

EfficienSea

Efficient, Safe and Sustainable Traffic at Sea

2009-2012

2016-2019)

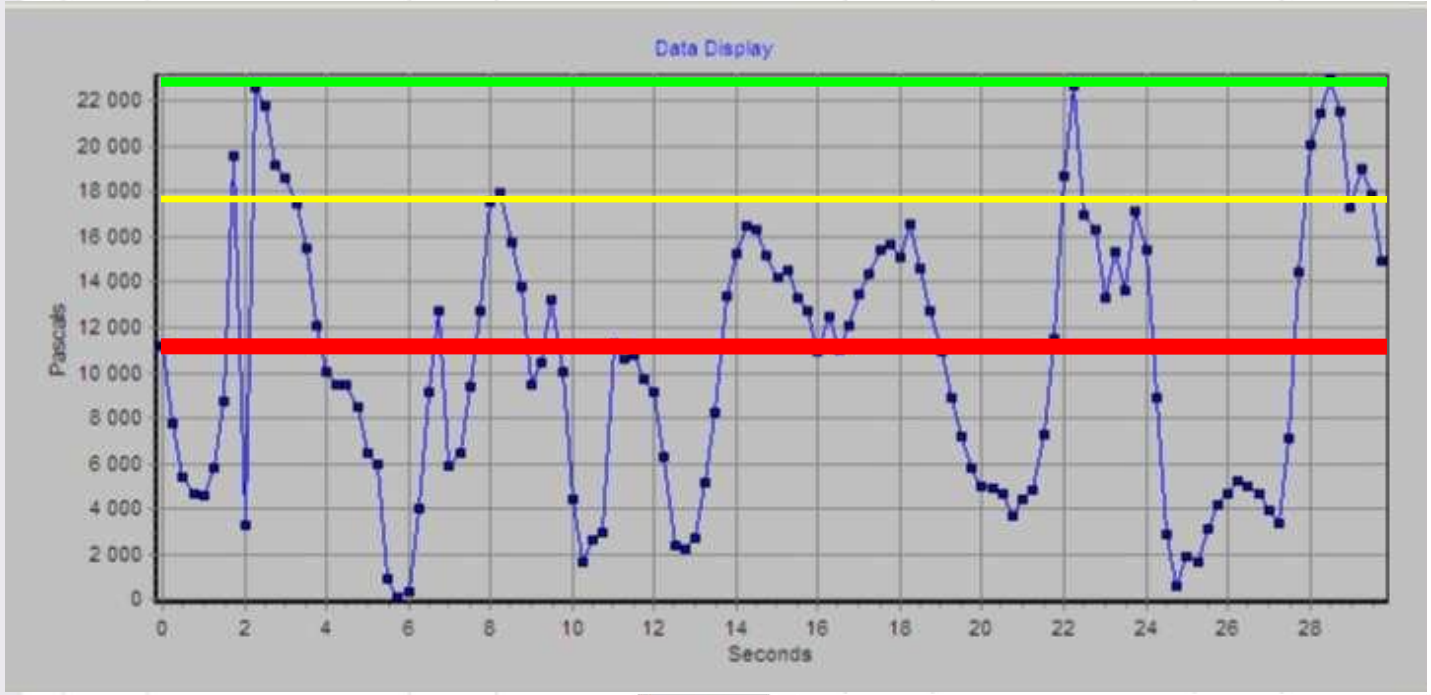
BONUS

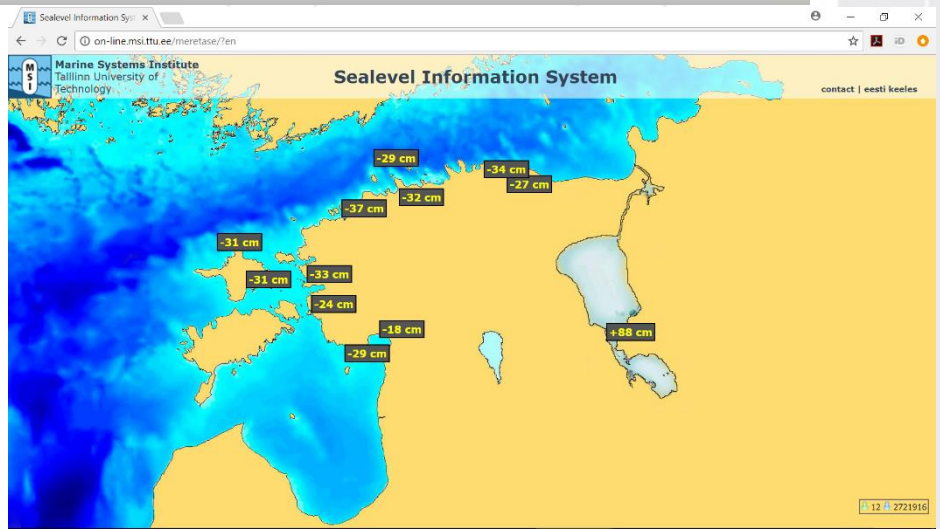
Science for a better future of the Baltic Sea region

HARDCORE

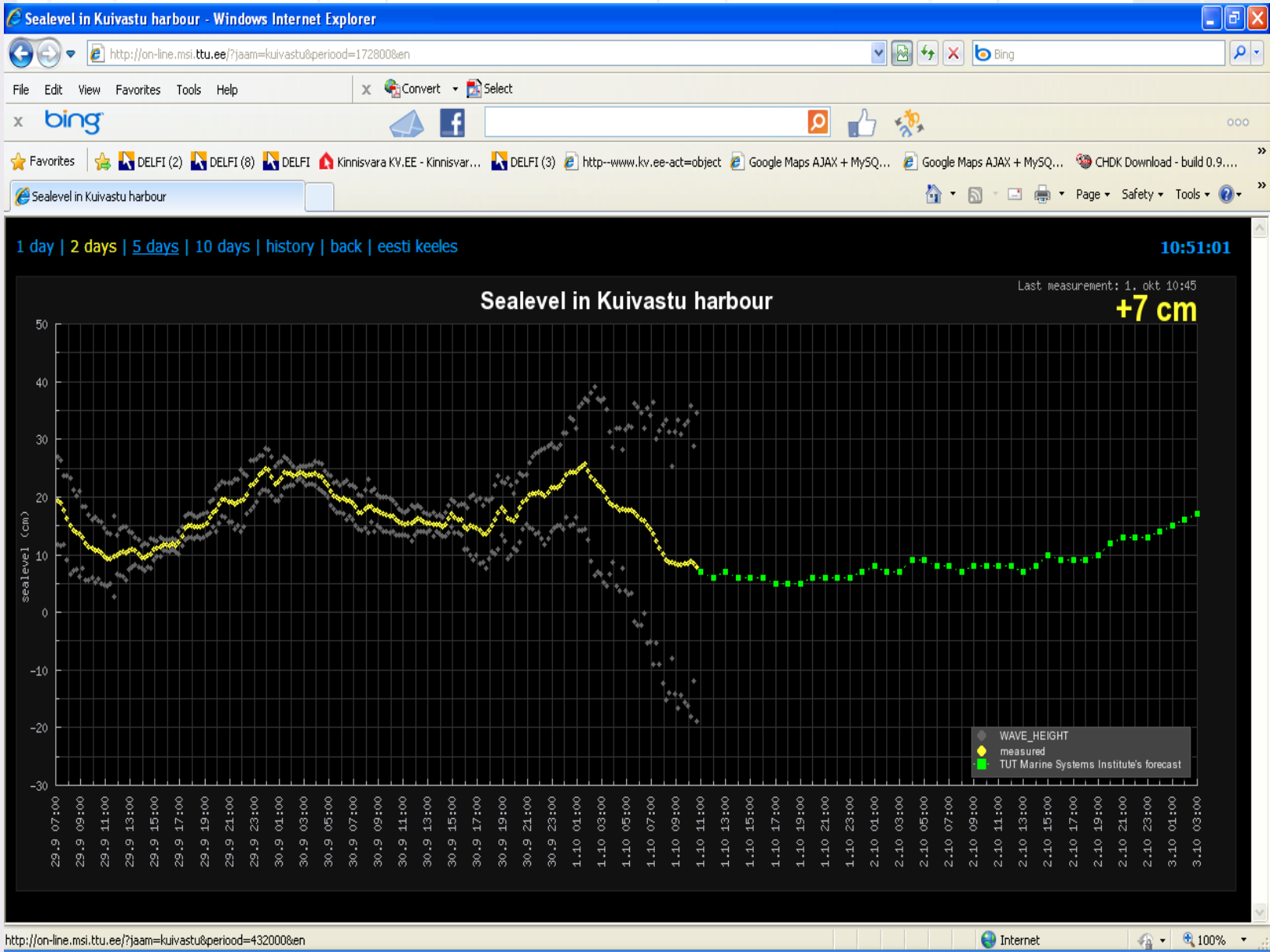
2014-2017

Pressure based sea level measurement + wave calculation





On-line sea level together with local wave properties



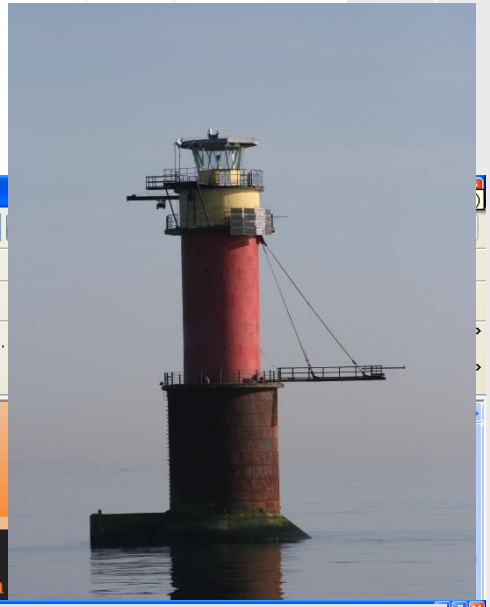
Harbour marine weather systems (since 2004)

on-line.msi.ttu.ee/munalaid

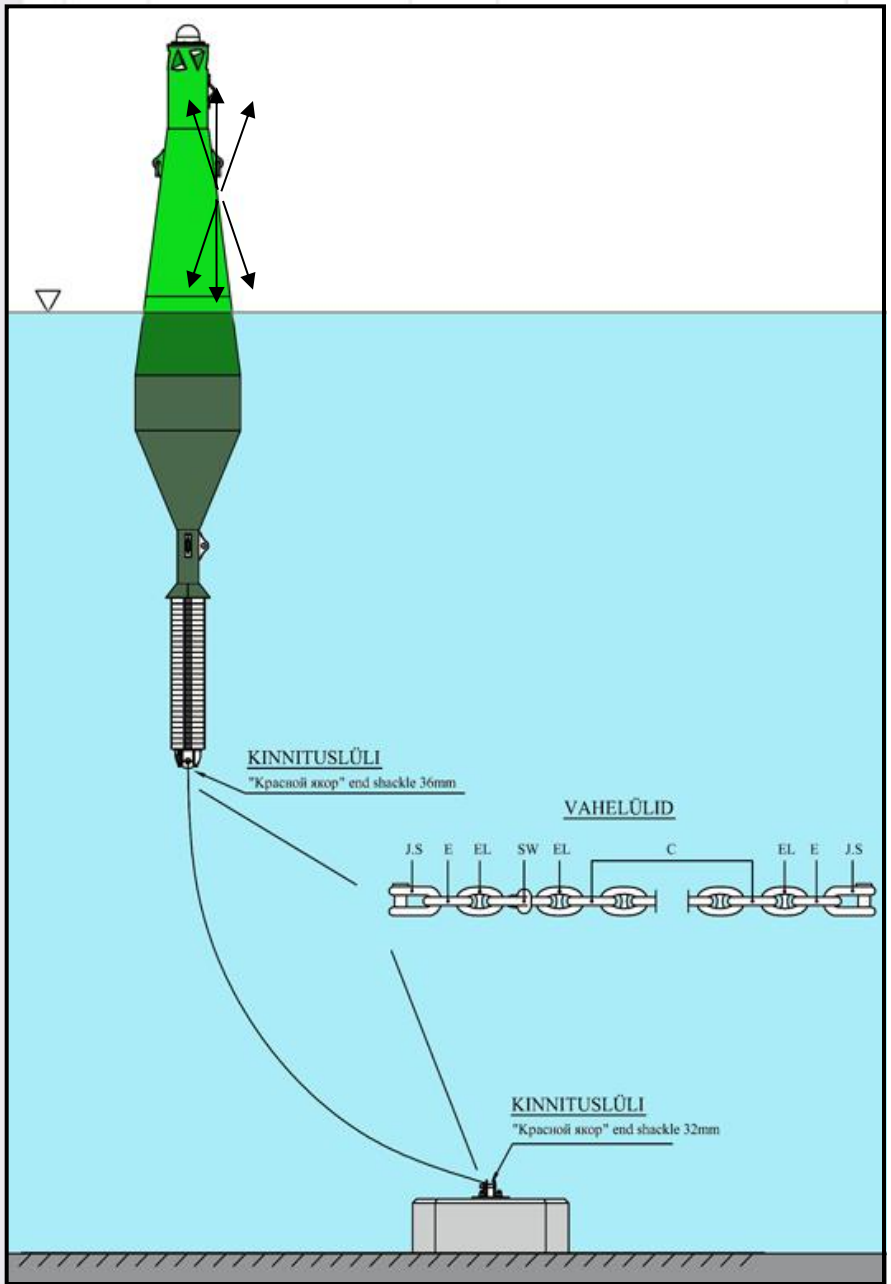
Lighthouse based autonomous marine weather system

Tallinnamadal (since 2007)

on-line.msi.ttu.ee/tallinnamadal



Use of buoy motion data for wave height estimate



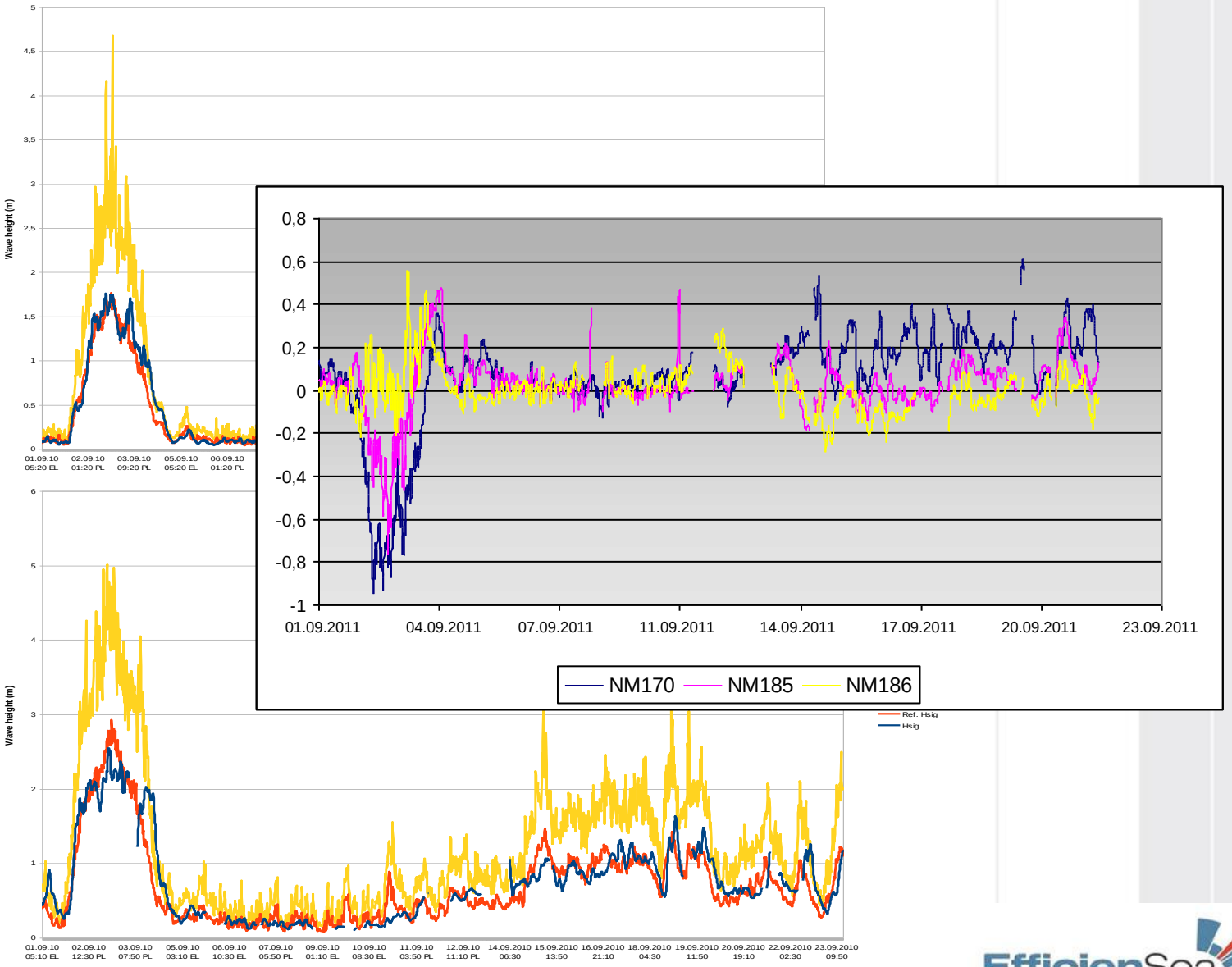
3D motion data acquisition:
5 samples in 1 second (3x2B binary)
150 second registration time
15 minute/ 4 times in hour – interval
Continuous registration

Motion data transmission:
TCP/IP over GPRS, AtoN monitoring
15 min interval (3kB binary, 12kB/hour)
Continuous – 72kB/hour

Motion data analysis:
Timely filtering
Mathematical analysis
Calibration with reference data

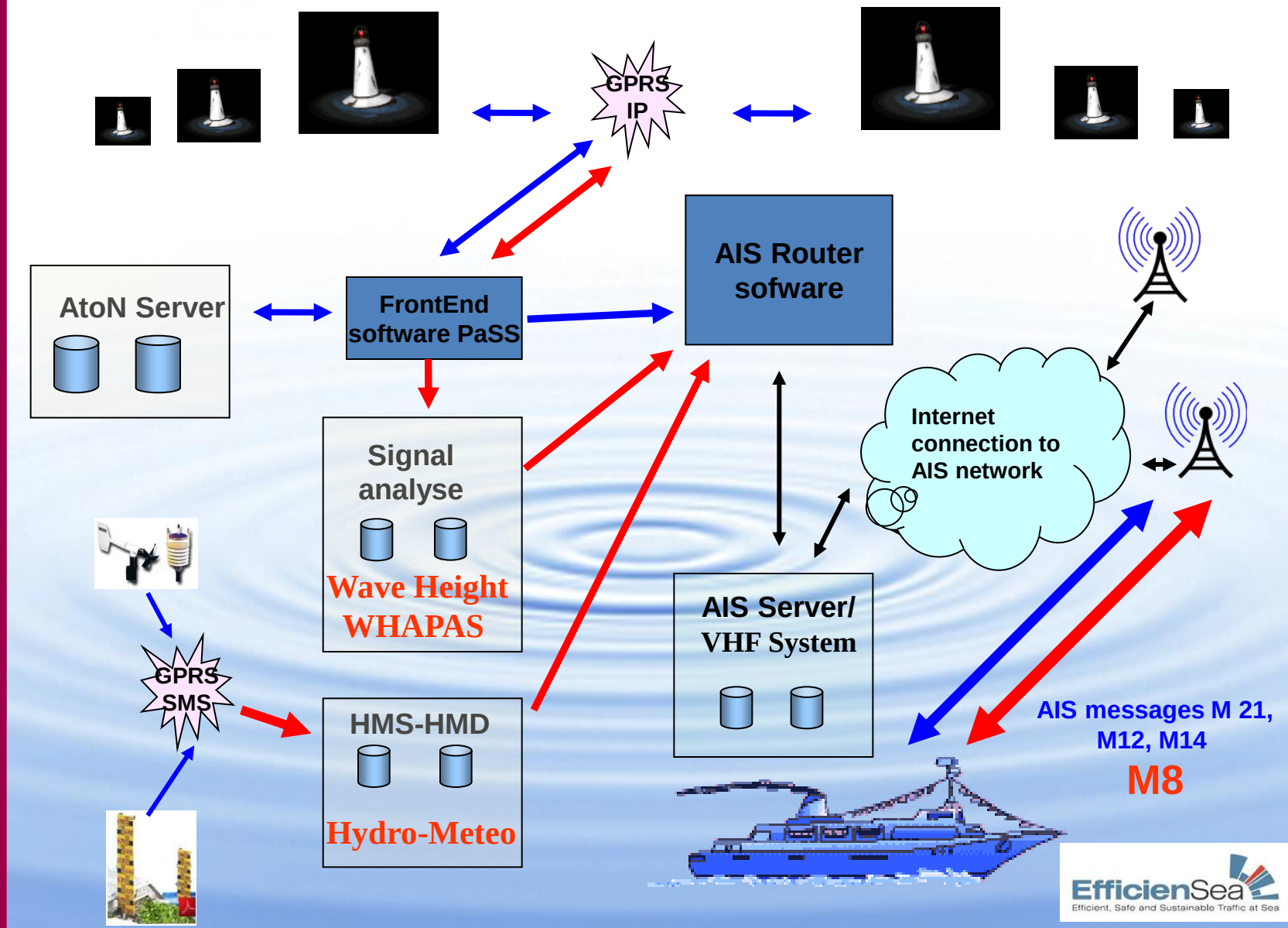
Wave data output:
Record to data base
Save special text file
Broadcast via AIS Router

Validation of wave data obtained from navigational buoys

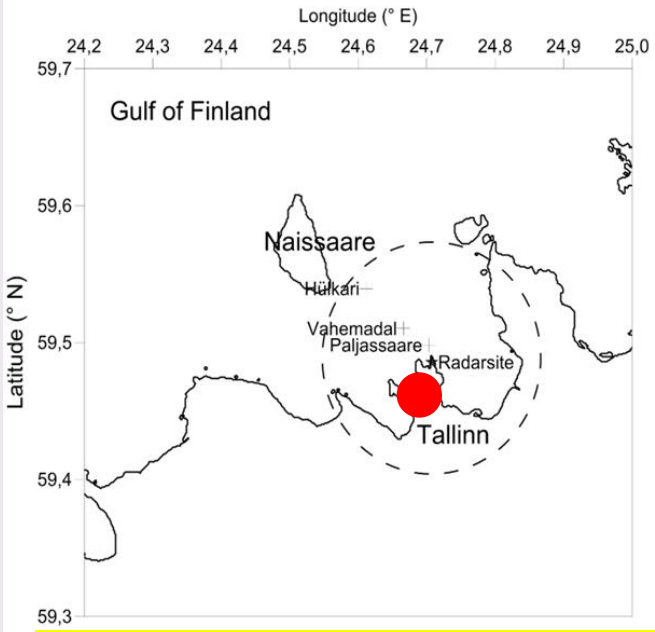


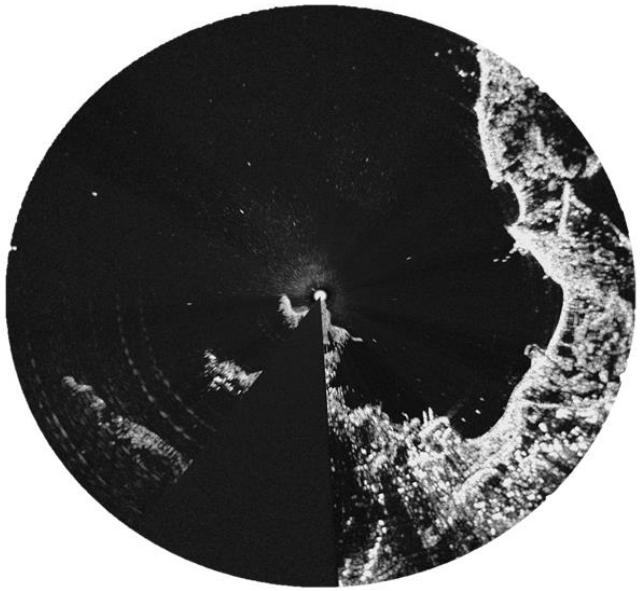
EfficienSea
Efficient, Safe and Sustainable Traffic at Sea

Integration of marine metoc data into AIS system + additional wave data



Sea state from coastal radar in the Tallinn Bay



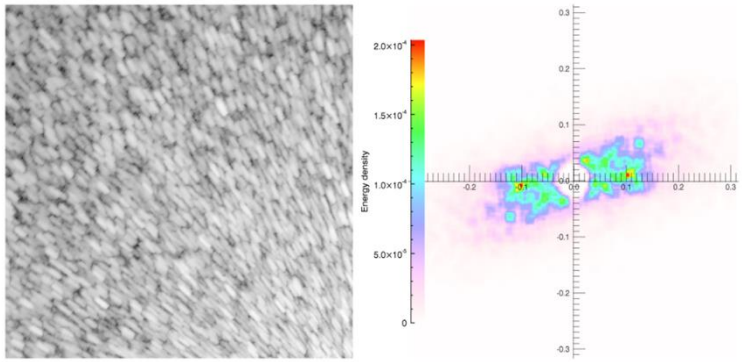


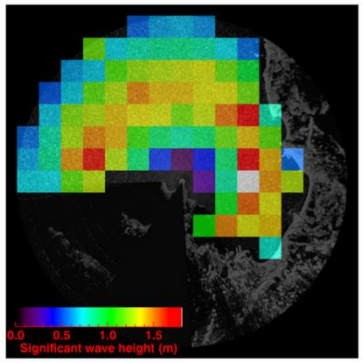
GLCM (Grey Level Co-occurance Matrix) method based on radar image spectra

$$Hs = a_1\sqrt{B_1 E_{IS}\,\tan(\theta)} + a_2 B_2 + a_3 B_3$$

$$B_1 = f(d,\theta) \quad B_2 = f(d,\theta,\bar{x}) \quad B_3 = f(d,\theta,\sigma^2)$$

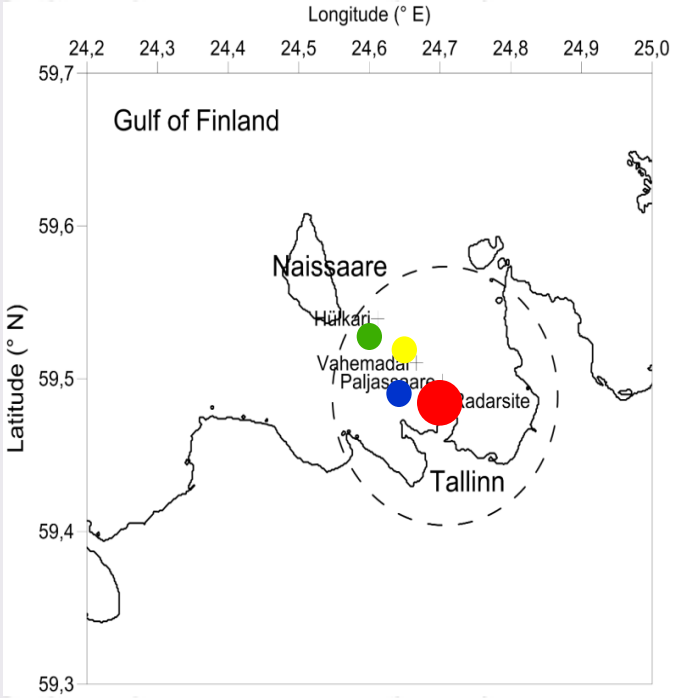
d – distance between radar tower and subscene
Θ – incidence angle
x – GLCM mean
σ² – GLCM variance

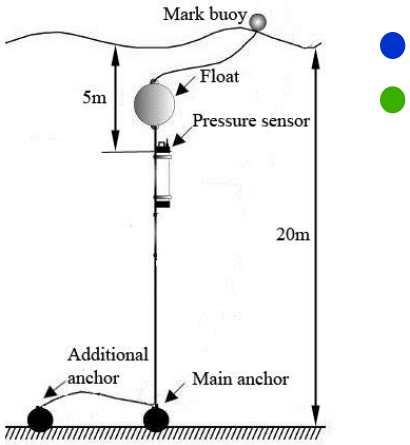


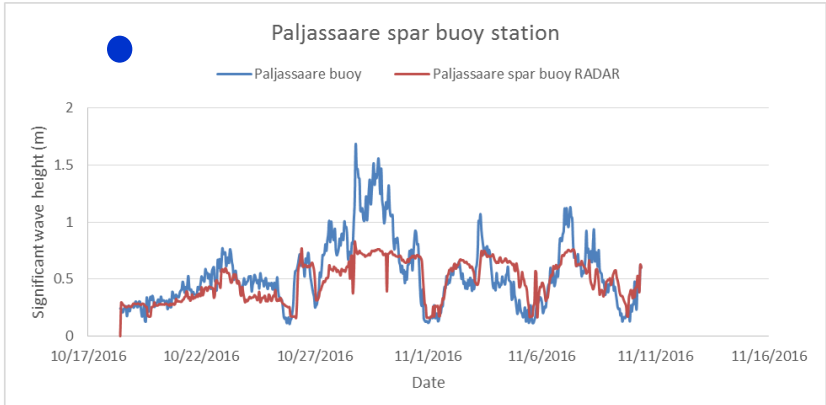


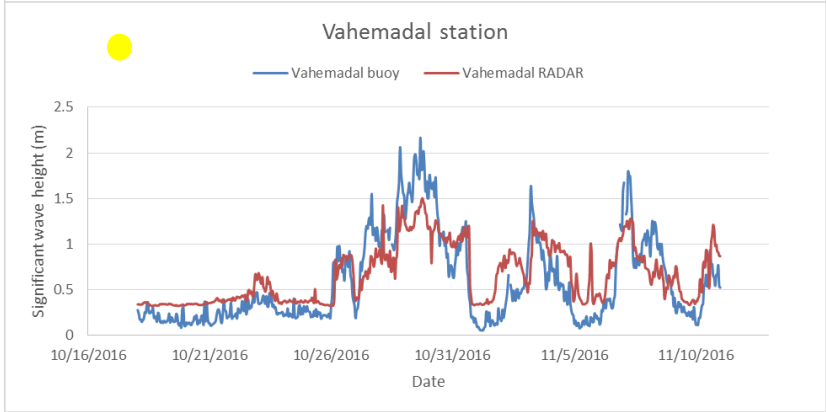
BONUS
SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION

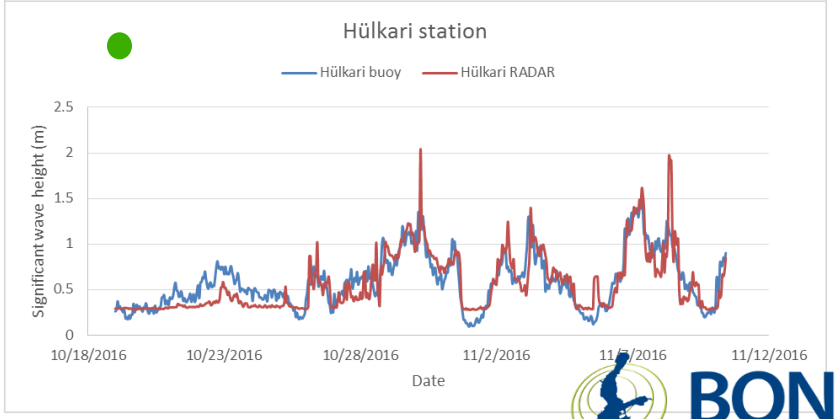
Tuning the method with best-fit (r) polynomial function





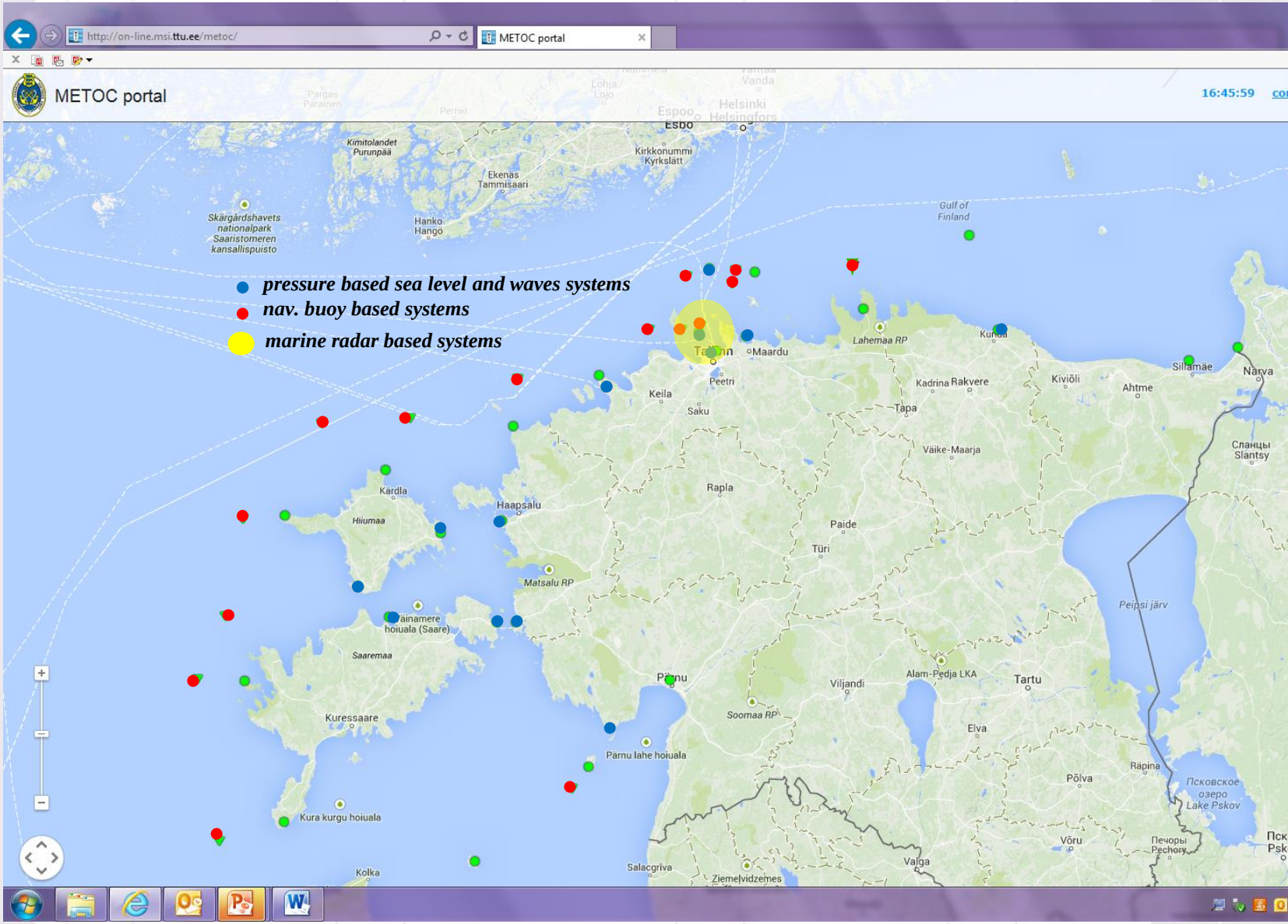






Outline of in-situ operational wave gauges in Estonian coastal sea, NE Baltic Sea

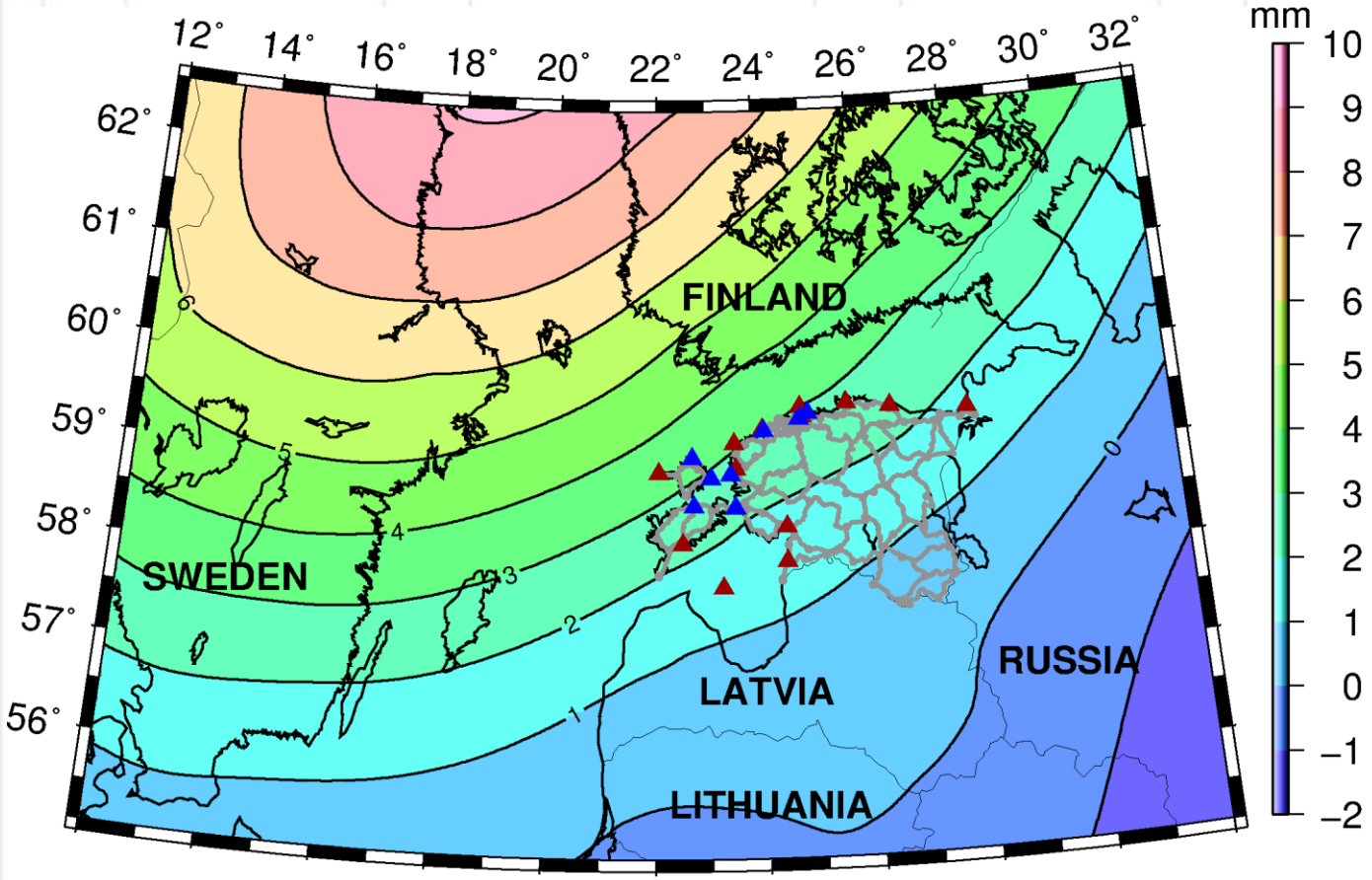
http://on-line.msi.ttu.ee/metoc/



Updated tide gauge records for specifying mean sea level estimates along the Estonian coast

- The reconstruction of Estonian high-precision levelling network in 2003 – 2016
- Adoption of the EVRS referred normal heights in Estonia from January 1, 2018
- Datum change caused change in the previous height values about 14-25 cm along the Estonian coast

Area of interest, land uplift



Motivation

- to revise and recalculate TG data
- to obtain the coherent time series for all the tide gauges along the Estonian coastline
- to specify sea level records (and corresponding mean sea level estimates) with respect to the NAP
- The reconstruction extended the height network to the existing TG
  - Distance between new benchmark and the TG station would not exceed 300 metres
  - Gives the possibility to refer tide gauges rigorously to the national height system and check the TG readings

Level staff: benchmarks

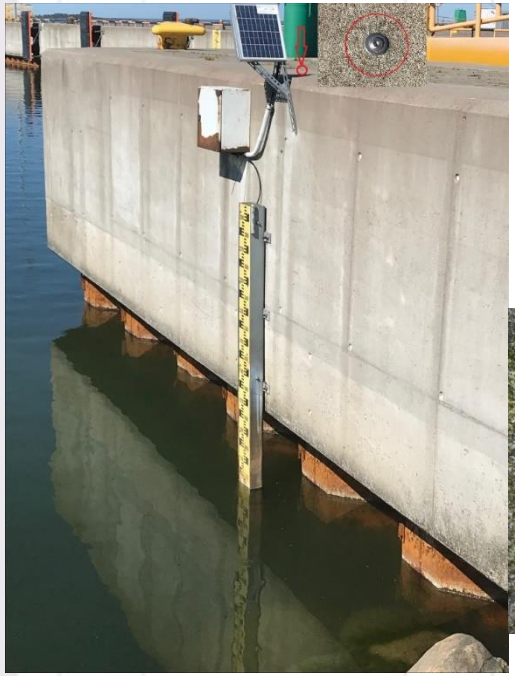


Photo 1. TG with level staff and local benchmark, sealevel sensor on back side

Photo 2.
Wall benchmark

Photo 3.
Ground benchmark

Average mean sea level computations

- ESTONIA: average mean sea level in EH2000
  - yearly averages and standard deviation from automatic data were calculated
  - correction from obsolete Baltic Height System 1977 to the EH2000 was applied
  - height connections from TGBM computed
- FINLAND: average mean sea level in EVRS
  - yearly average data acquired
  - computed to N2000 and EVRS

Computations results

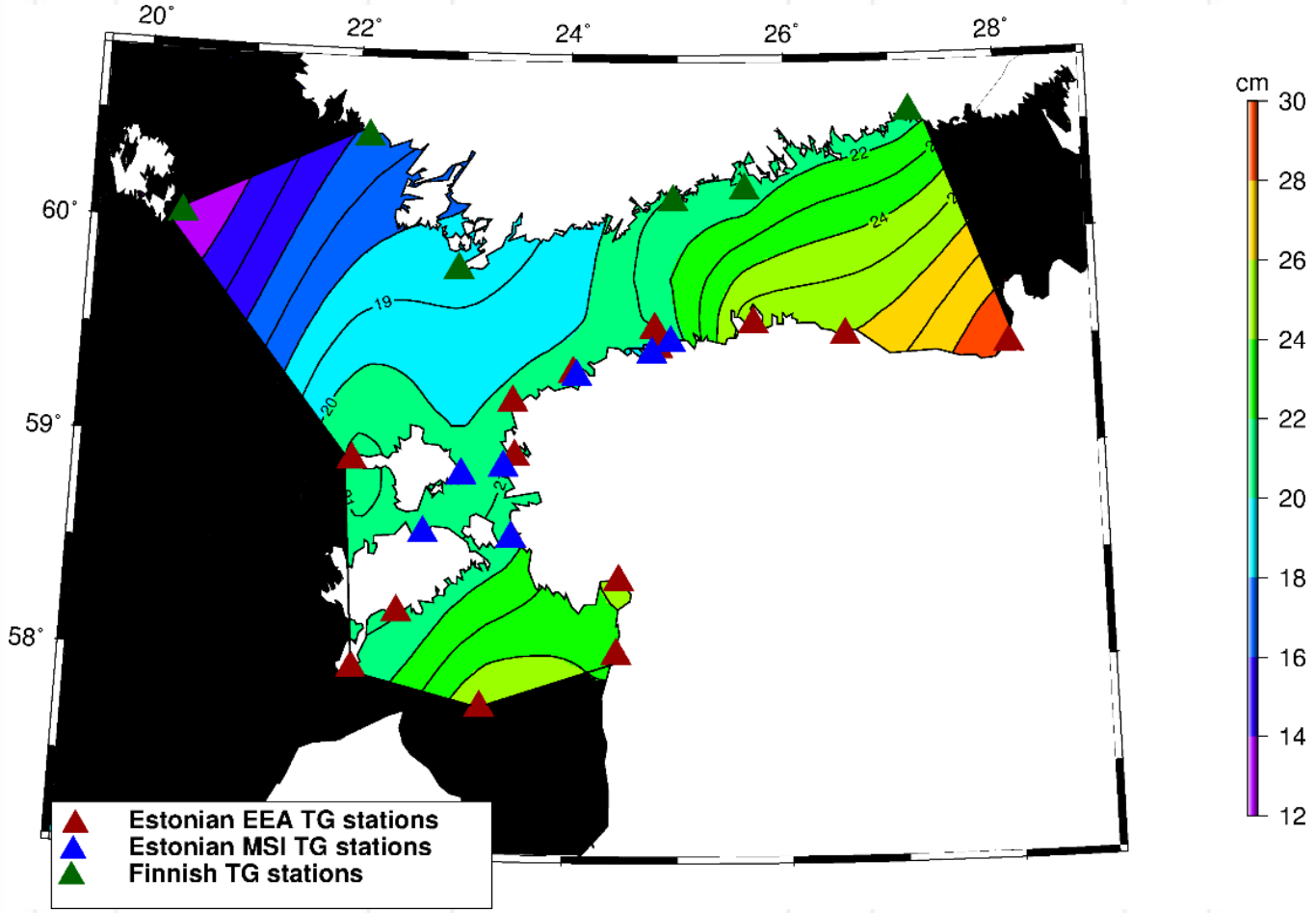
TG network	STD in EH2000/EVRS (cm)	STD in BK77 (cm)
Estonia (all)	3.1	4.6
Estonia (EEA)	*2.7*	*4.9*
Estonia (MSI)	*3.6*	*3.8*
Finland	3.1	-

From MSI network Lehtma TG data not used in the computations

Summary of Height systems transfer: BHS77 → EH2000

- Standard deviation has decreased from 5.2 cm (BK77) to the 3.5 cm (EH2000) for all TGs at the Estonian coast
- Decrease in SD shows:
  - new height system is more consistent
  - takes into account vertical land movement in the Estonian coast caused mainly by postglacial isostatic adjustment

SST based on 2014-2017 sea level data



Summary

- *Pressure based wave measurement systems provide temporary very high resolution (5 minutes) wave data in coastal zone*
- *Wave data from navigation buoys improve situational awareness on fairways*
- *GLCM method implemented on images of conventional marine radars giving spacially high resolution wave fields, in areas of intensive ship traffic*
- *To serve e-Navigation needs the integration of data systems into expert and decision support frameworks is essential, like AIS*
- *Transfer of height systems BHS77 → EH2000 improve data quality of sea level records.*


Thank's for your attention!