Sea level and sea state observation and forecast network in Estonia

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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

**EfficientSea**
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 database
Save special text file
Broadcast via AIS Router
Validation of wave data obtained from navigational buoys
Integration of marine metoc data into AIS system + additional wave data
Sea state from coastal radar in the Tallinn Bay

\[ H_s = a_1 \sqrt{B_1 E_{IS}} \tan(\theta) + a_2 B_2 + a_3 B_3 \]

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

\( d \) – distance between radar tower and subscene
\( \theta \) – incidence angle
\( x \) – GLCM mean
\( \sigma^2 \) – GLCM variance

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

<table>
<thead>
<tr>
<th>TG network</th>
<th>STD in EH2000/EV RS (cm)</th>
<th>STD in BK77 (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estonia (all)</td>
<td>3.1</td>
<td>4.6</td>
</tr>
<tr>
<td><em>Estonia (EEA)</em></td>
<td>2.7</td>
<td>4.9</td>
</tr>
<tr>
<td><em>Estonia (MSI)</em></td>
<td>3.6</td>
<td>3.8</td>
</tr>
<tr>
<td>Finland</td>
<td>3.1</td>
<td>-</td>
</tr>
</tbody>
</table>

*From MSI network Lehtma TG data not used in the computations*
Summary of Height systems transfer: BHS77 $\rightarrow$ 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!