Sea Level Rise on the Coast of the Baltic Sea

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Introduction

- Sea level rise (SLR) is an important indicator of global climate change. Sea level rises in the Baltic Sea (BS) as well but it is largely compensated by postglacial land uplift (LU) in this area.
- However, the LU in the BS region is quite different. The official LU model NKG2016LU of the Nordic Commission of Geodesy (NKG) for northern Europe shows a maximum absolute LU about 10 mm/yr in northern part of Gulf of Botnia and a zero-line follows the shores in southern part of the BS (Fig. 1).

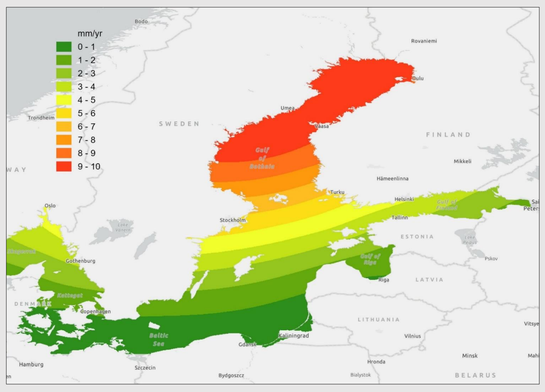

Fig 1. Postglacial land uplift in the Baltic Sea according to the Nordic Geodetic Commission (NKG) GIA model NKG2016LU

- The aim of the study was to check the absolute SLR values at the coast of the BS using SLR models. To find out the relative sea level rise (RSLR) in the coastal areas of the BS, the rates from LU models were compared with to SLR models.

Data and methods

- Two different absolute LU models, the model NKG2016LU and EST2020VEL were used in this study.
- The NKG and EST models cover the entire BS and the Estonian area, respectively.
- Different absolute SLR models, from the ESA's BalticSEAL and IPCC AR5 project were used in this study.
- The ESA's BalticSEAL project absolute sea level trend model from 1995 to 2019 has been calculated using Jason, Envisat, CryoSat and Sentinel-3 satellite altimetry data (Fig. 2).

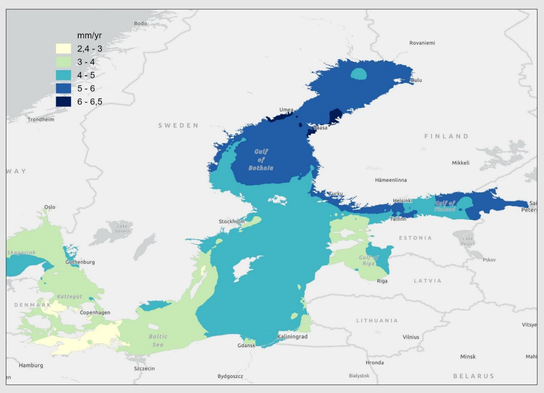

Fig 2. Absolute sea level rise in the Baltic Sea according to ESA's BalticSEAL data

- The IPCC AR5 project models are the sea level projections over the 21st century according to different climate scenarios:
  - RCP2.6 – CO_2 emissions peak around 2020 and then decline to zero by 2100 (global warming below 2 °C);
  - RCP4.5 – CO_2 emissions peak around 2040, then decline (global warming between 2 °C and 3 °C);
  - RCP8.5 – CO_2 emissions continue to rise throughout the 21st century (global warming below 5 °C).
- The RSLR was calculated from formula:

$$RSLR = SLR - LU,$$

where *SLR* represents the absolute sea level rise (mm/yr) and *LU* represents the absoulte land uplift (mm/yr).

- ArcGIS Pro was used to calculate, analyse and vizualize the models.

Results

The Baltic Sea

- The absolute SLR from 1995 to 2019 was 2.4 to 6.5 mm/yr in the BS (Fig. 2).
- The RSLR was **-5 to 4.5 mm/yr** based on NKG2016LU model and ESA's data (Fig. 3).
- The southern areas of the BS are the most affected by the RSLR, e.g. 0 to 3 mm/yr at the coastal areas of Latvia and Lithuania, 3 to 4.5 mm/yr at Poland and Russia, 1 to 3 mm/yr at Denmark and Germany where the coasts are shallow as well.

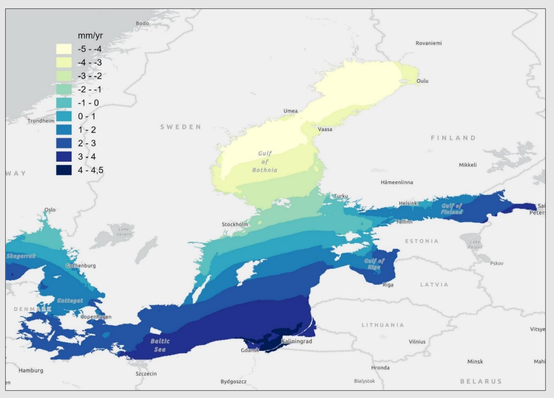

Fig 3. Relative sea level rise (mm/yr) in the Baltic Sea based on NKG2016LU and ESA model

Coastal Areas of Estonia

- The RSLR in the coastal area of Estonia was **-1.1 to 3.1 mm/yr** based on NKG2016LU model (Fig. 3) and **-0.3 to 3.4 mm/yr** based on EST2020VEL model (Fig. 4).
- The difference of RSLR between two LU models (Fig. 5) is **-0.9 to 0.1 mm/yr** and the mean difference is **-0.4 mm/yr.**
- In the coastal areas of Estonia, the RSLR is variable (Fig. 3, Fig. 4). The southwest and northeast parts of Estonia are most affected by RSLR where it is 2 to 3 mm/yr. In other parts, RSLR is lower. RSLR is 1 to 2 mm/yr in the west, 0 to 2 mm/yr in the northwest and north.

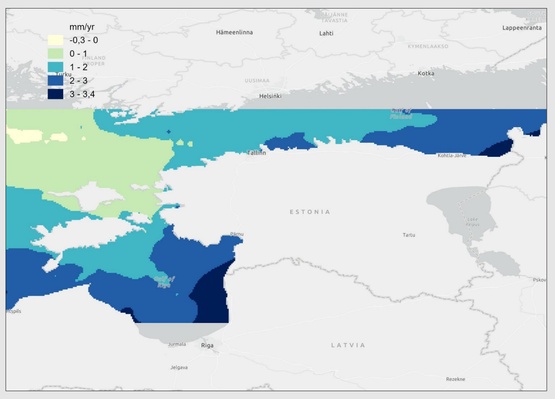

Fig 4. Relative sea level rise in the coastal areas of Estonia based on EST2020VEL and ESA model

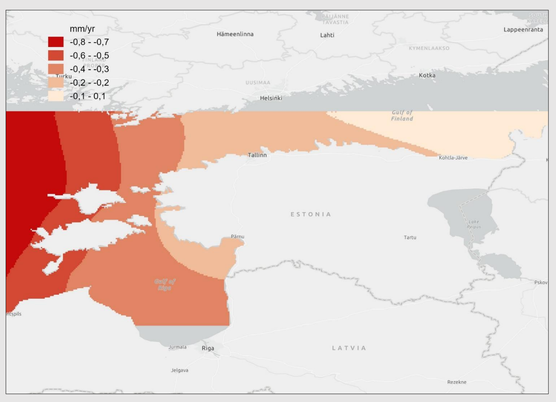

Fig 5. Difference in relative sea level rise between NKG2016LU and EST2020VEL LU models

Projections for the year 2100

- The projected RSLR (Table 1) was calculated using the NKG2016LU LU model and IPCC AR5 data.

Table. 1. The relative sea level rise (meters) durning the 21st century according to the IPCC AR5

Projection	Sea level rise in the Baltic Sea by 2100
RCP2.6	-1.4 to 0.3
RCP4.5	-1.3 to 0.4
RCP8.5	-1.1 to 0.7

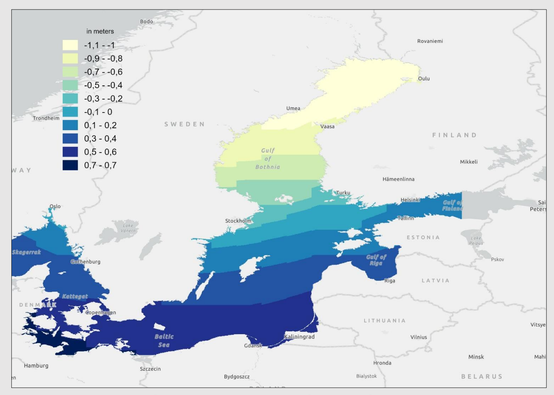

Fig 6. Relative sea level projection by 2100 according to RCP8.5 projection

- Based on IPCC AR5 sea level projections, southern coastal areas are the most at risk by 2100. Consistently, all projections predict RSLR of between 0.3 and 0.7 meters at most. The north areas are not threatened by RSLR, there it is between -1.4 to -1.1 meters.

Summary

The SLR along the coast of the BS is influenced by LU. The RSLR in the period 1995-2019 was -5 to 4.5 mm/yr (NKG2016LU) in the BS. Southern areas are more affected by RSLR then northern parts. In the coastal areas of Estonia, the RSLR in the period 1995-2019 was -1.1 to 3.1 mm/yr (NKG2016LU) and -0.3 to 3.4 mm/yr (EST2020VEL), the difference between the models is -0.9 to 0.1 mm/yr. As coastal areas in the southern part of the BS are mostly flat, the sea may reach people's properties by the end of the century. Also, IPCC AR5 sea level projections predict the RSLR by 2100 maximum 0.3 to 0.7 meters.

Acknowledgment

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