WAVE ENGINEERING

TALLINN UNIVERSITY OF TECHNOLOGY

Interannual coastal processes in Estonia, Peraküla beach monitored by laser scanning technology

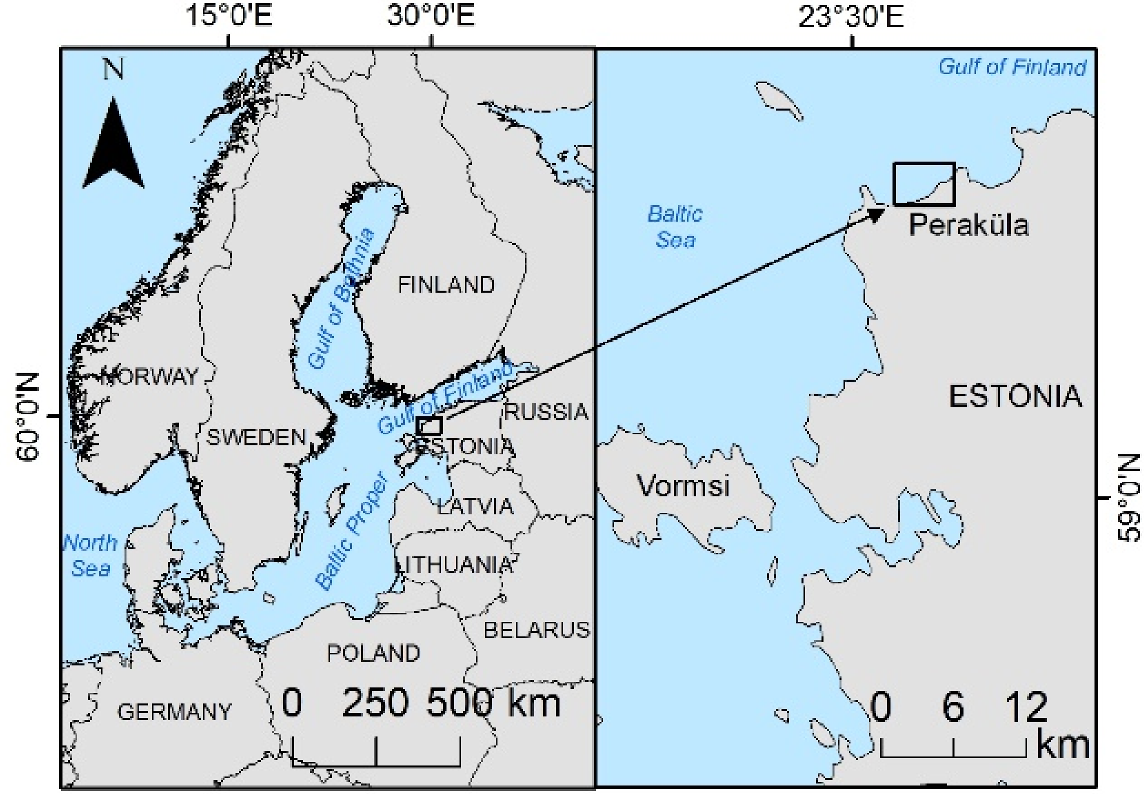
M.Eelsalu, **K.Pindsoo**, T.Soomere and K.Julge
Department of Cybernetics at Tallinn University of Technology
Katri.Pindsoo@ioc.ee

2nd Baltic Earth Conference, Helsingør, 11–15 June 2018

Introduction

- Driving force of evolution of sandy beaches: highly intermittent wave regime
- Beaches of the southern Gulf of Finland: sheltered from predominant south-westerly winds

Step-like evolution: rapid reaction to high waves from unusual directions



Severe erosion in the sedimentary beaches of the Baltic Sea:

- High waves approaching from extraordinary directions are sometimes combined with (relatively) high water level


Photo: A.Kask


Photo: K.Rooväli

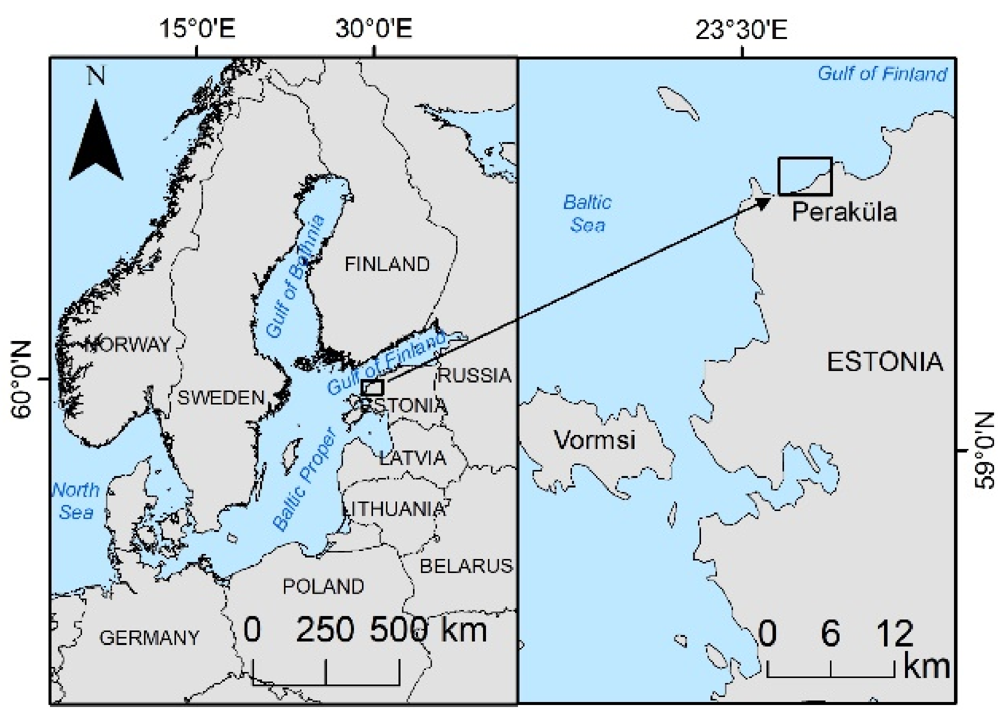
TALLINN UNIVERSITY OF TECHNOLOGY

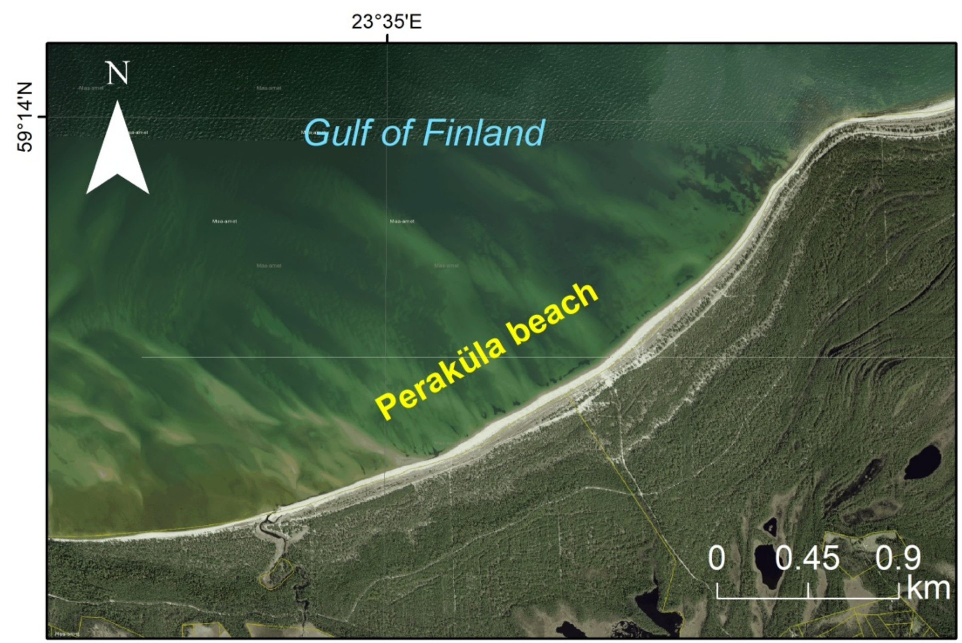
The challenge:

- Quantification of the slow phase of evolution
- Needs reasonable analyses and technologies of measurements

Study area

- Peraküla beach: north-western Estonia
- Area monitored for 2008–2017
- Test area:
  - Length: ~ 1 km
  - Width: ~ 13 m
- Sheltered against majority of wave storms – open to northern directions
- Modest intensity of coastal processes

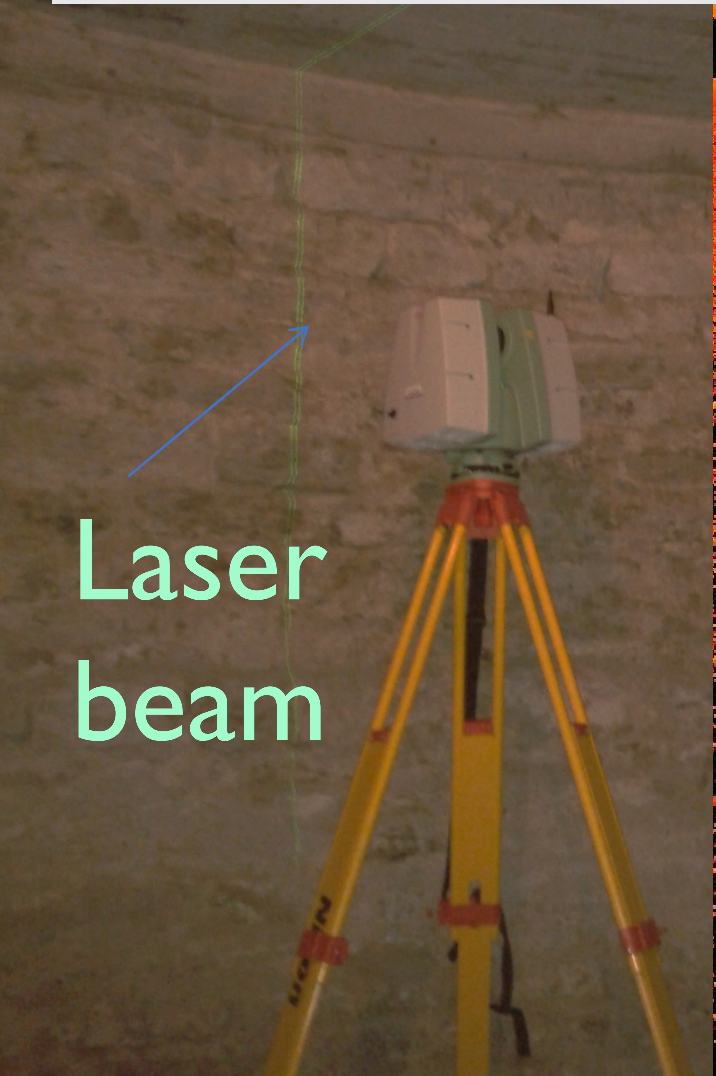


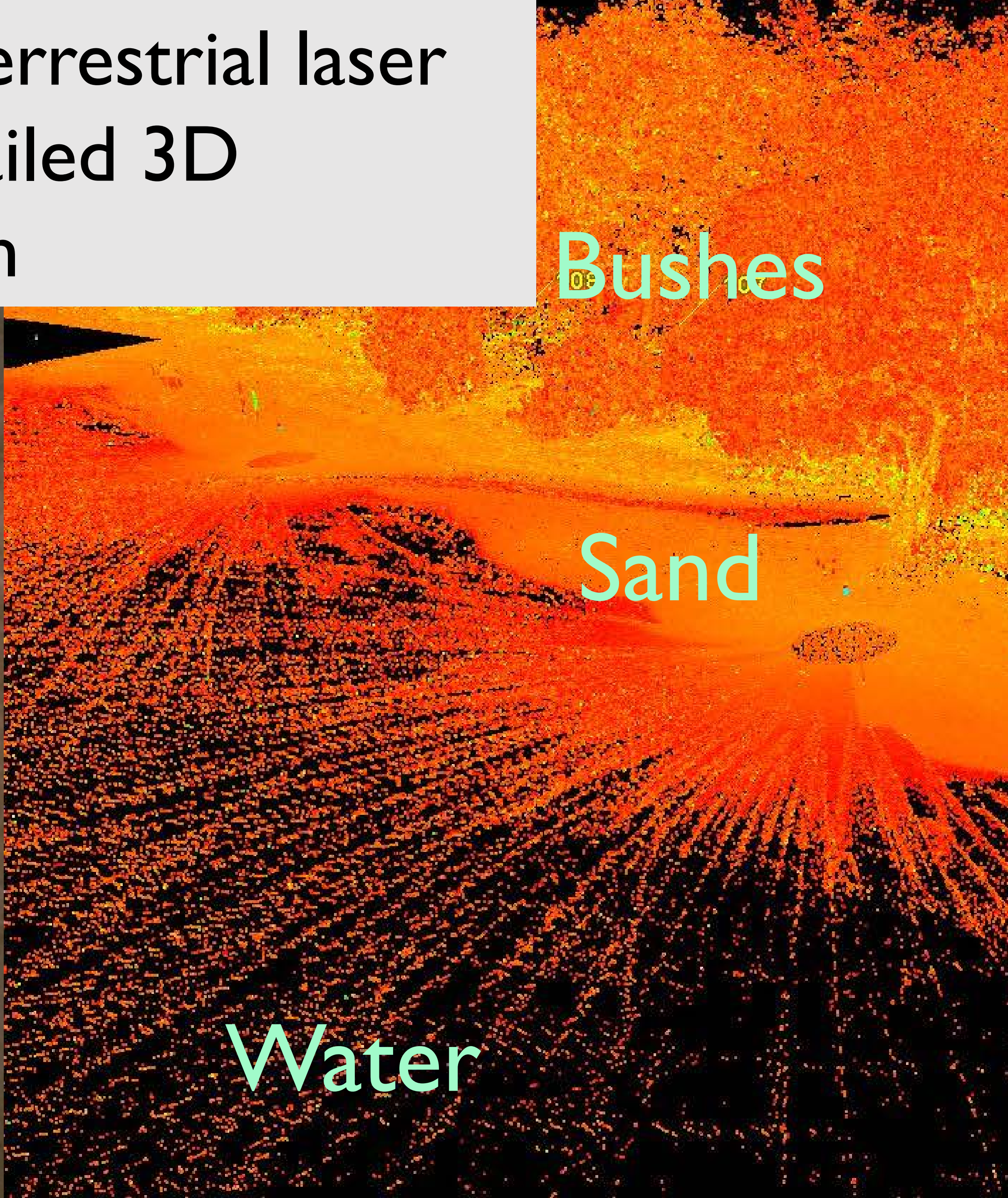


Storm in the study area (Nov 2017):

- Strong wave storm on the background of average water level (+0.2 m)
- Remarkable erosion: sharp scarp was developed
- Local media reported of the erosion scarp of 2 m

Beach view by terrestrial laser scanning → detailed 3D elevation pattern





To evaluate the changes: high-resolution information

- Methods of remote sensing:
  - terrestrial (TLS) and
  - airborne (ALS) laser scanning
- Laser pulses to measure the distance to objects

- **TLS** provides data: resolution up to ~1 cm
- **TLS** spatial coverage: until 300 m

- **ALS** density: varies 0.1-20 points/m2
- **ALS** points density: depends on altitude up to 6000 m

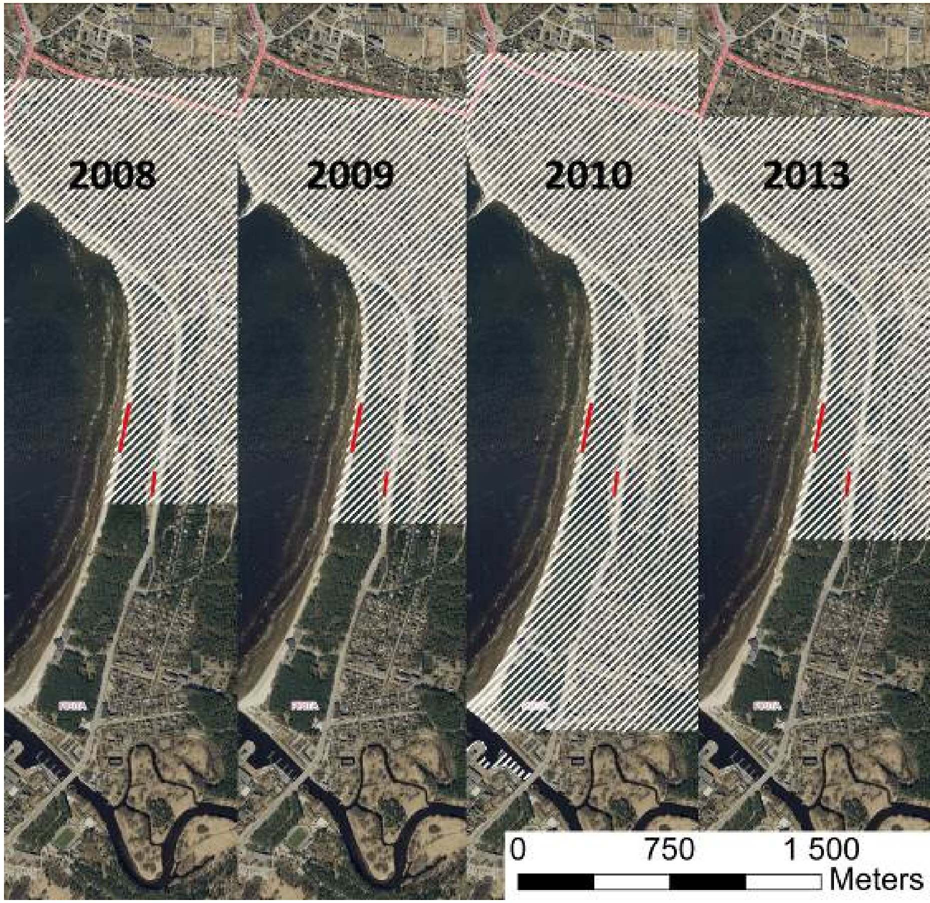
Terrestial laser scanning (TLS)

- TLS device: Leica ScanStation C10
- Heights of the reference points: determined by levelling benchmark nearby

- **TLS survey**:
- May 2015 and December 2017
- Spatial resolution ~2*2 cm
- 9 scanning stations

Airborne laser scanning (ALS)

- Estonian Land Board 2008–2012
  - Leica ALS50-II
  - ground filtering and classification of points
- In this study: only points classified as “ground” applied
- Study area: within a single flight corridor
  - Flight line matching errors excluded



TALLINN UNIVERSITY OF TECHNOLOGY

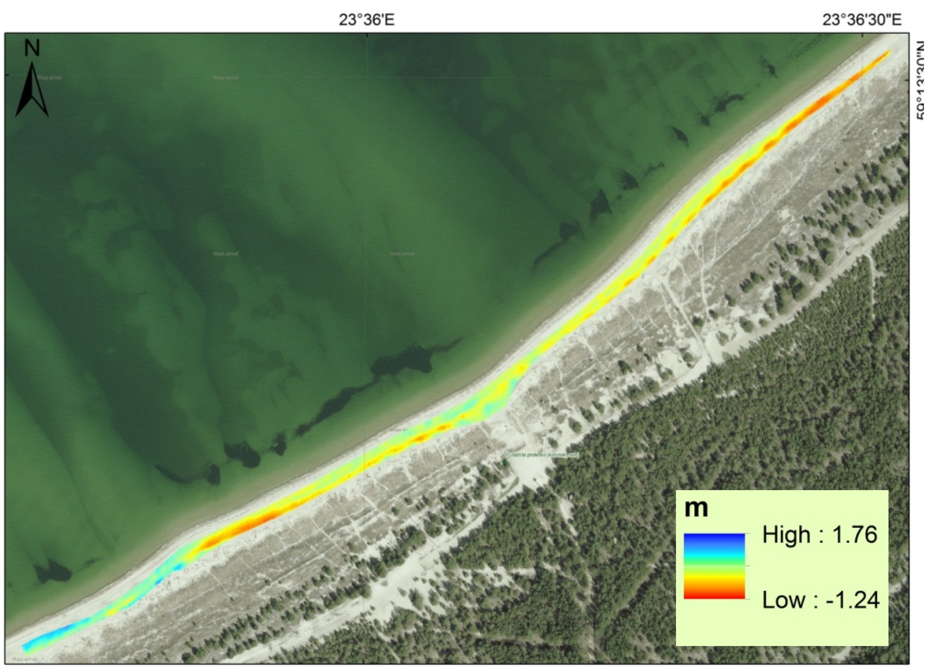
Combining ALS and TLS

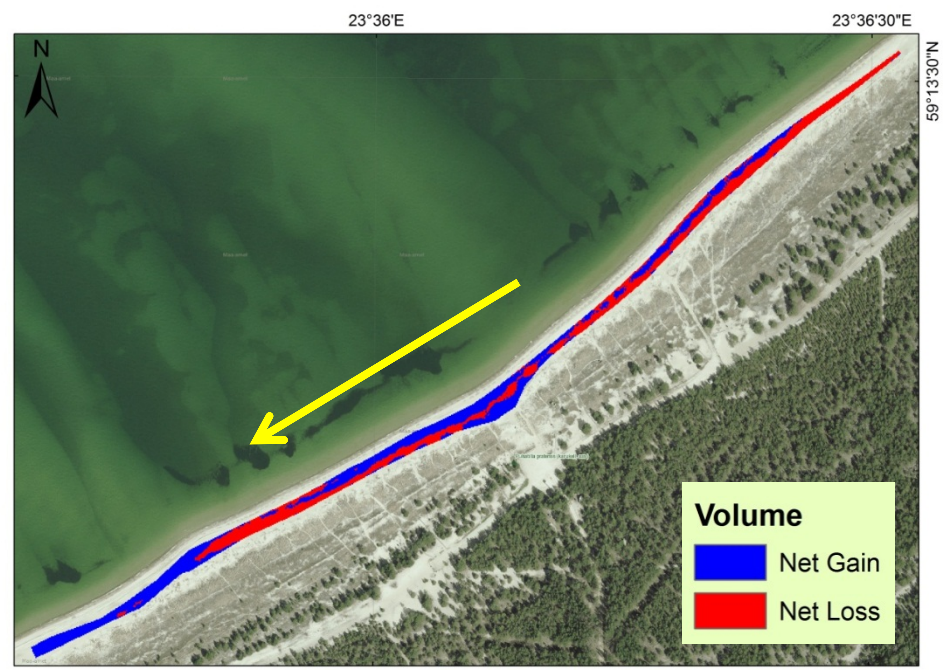
- Differences in spatial resolution
- Elimination of systematic erros: applying elevation differences from a steady horizontal surface (Julge et al., 2014)
- Data sets linked by parking lot

- **Result:** 3D Digital Elevation Models of the study area
- **Possible to identify:** changes to the volume of each part of the beach and in the spatial structure

Interannual variability (2008-2012) based on ALS

- Variable spatial pattern:
  - half of study area experienced erosion (-1820 m^3)
  - half of area accumulation (+1805 m^3)
- Sand volume of the area in almost perfect equlibrium
- Storms meanwhile caused sediment flow from NE to SW

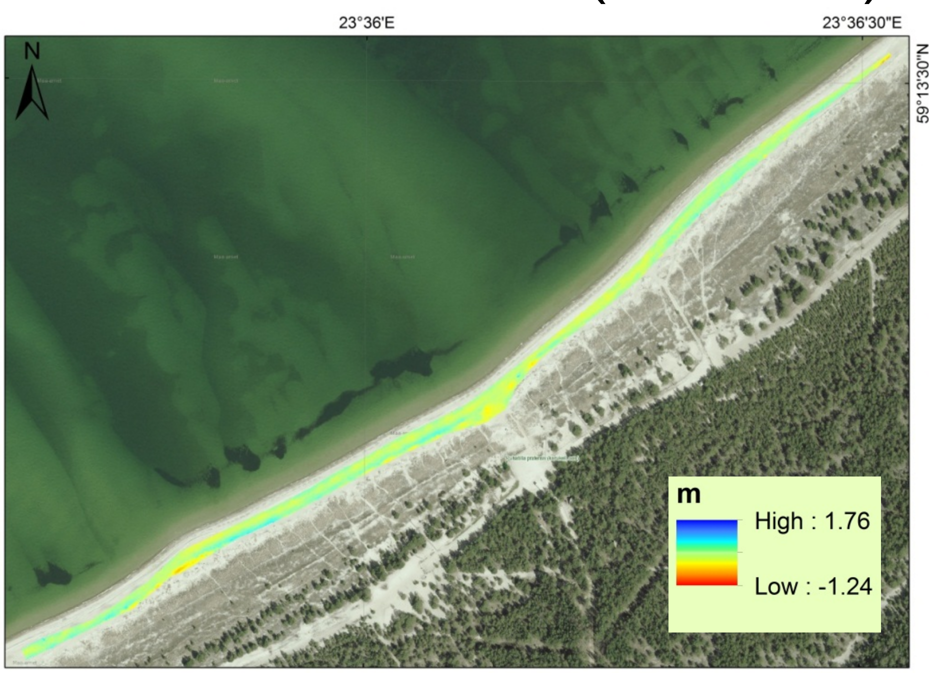


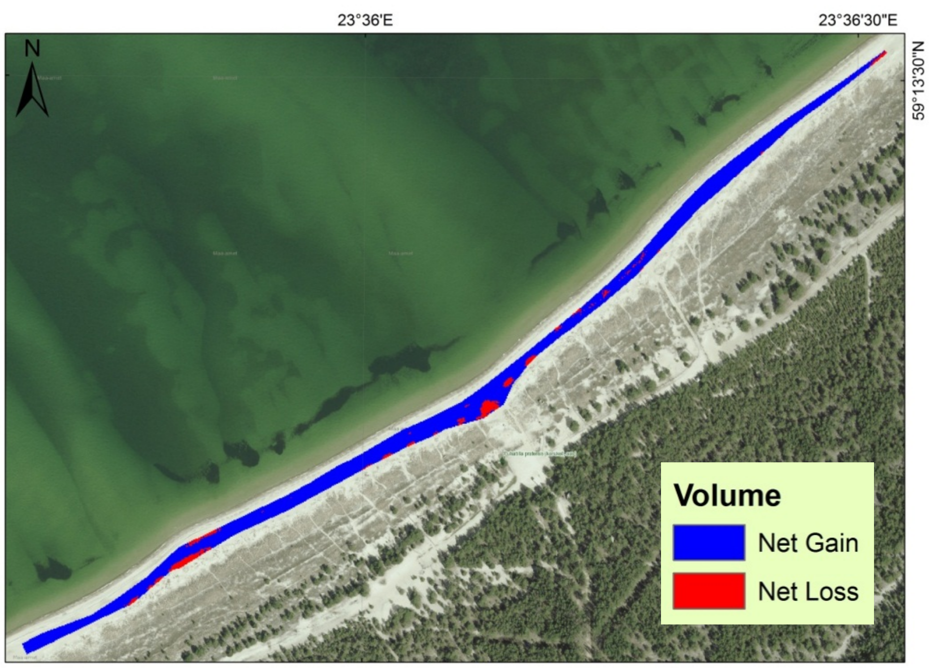


WAVE ENGINEERING TALLINN UNIVERSITY OF TECHNOLOGY

Interannual variability (2012-2015) ALS + TLS

- Area gained (+2998 m^3) sediment
- Excess sand was distributed evenly
  - Growth of beach sections 0.2-0.5 m
- Small erosion (-110 m^3) in the central part

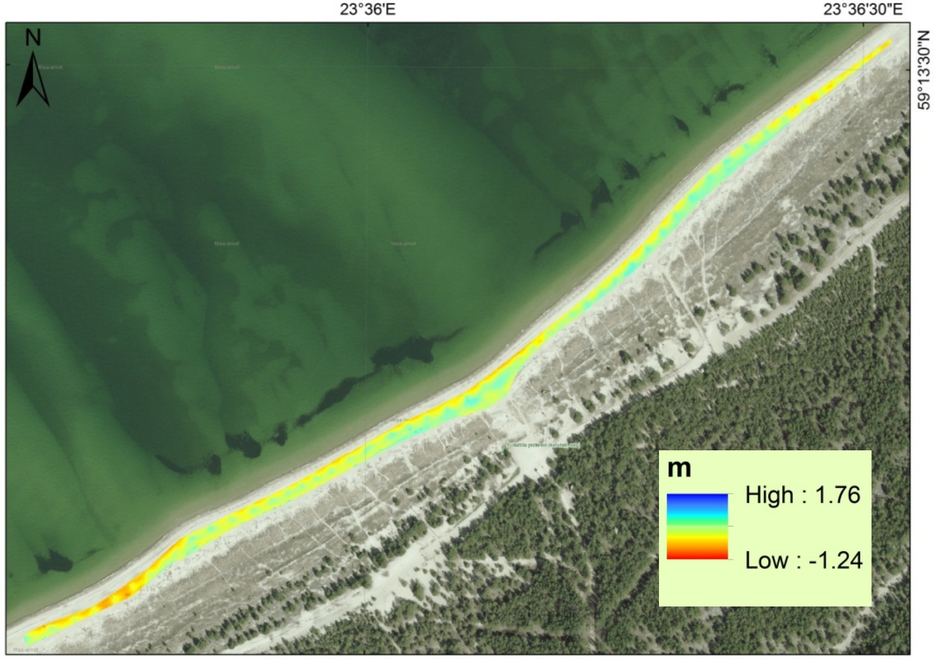


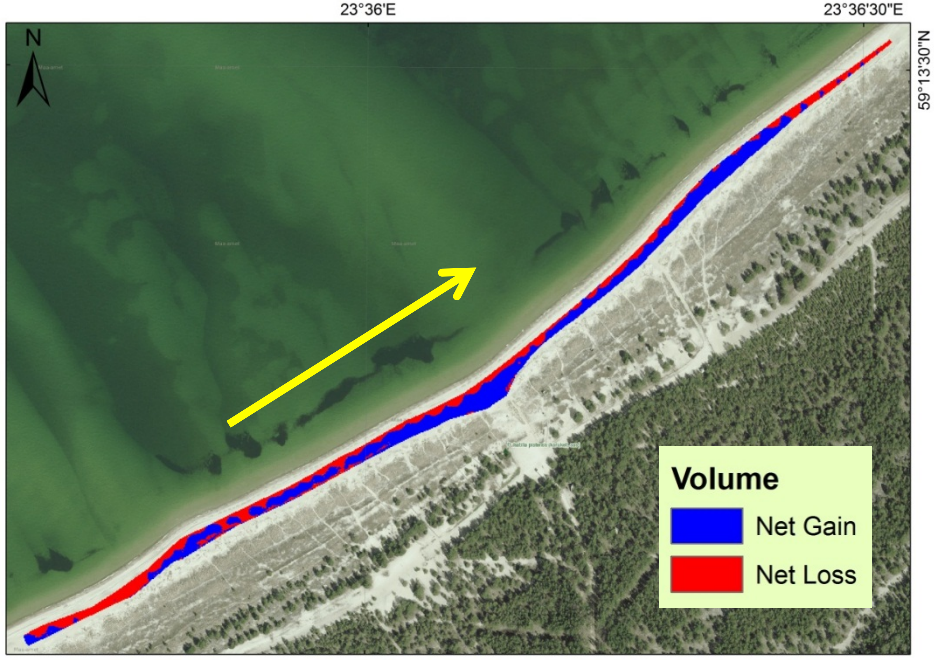



After storm in November 2017
K.Pindsoo, dets 2017

Interannual variability (2015-2017) After the storm

- Predominant process accumulation (+1860 m^3)
  - Rate comparable to years 2012–2015
- Spatial pattern of processes different
- Erosion in few locations (-1125 m^3)
- Sediment flow from SW to NE – SE part restored the shape & height it had on 2008

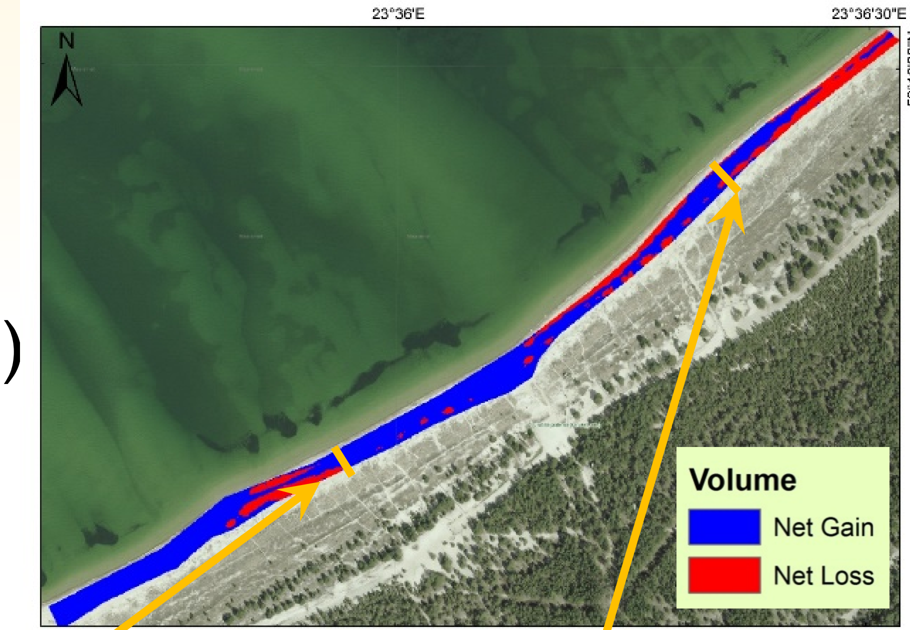


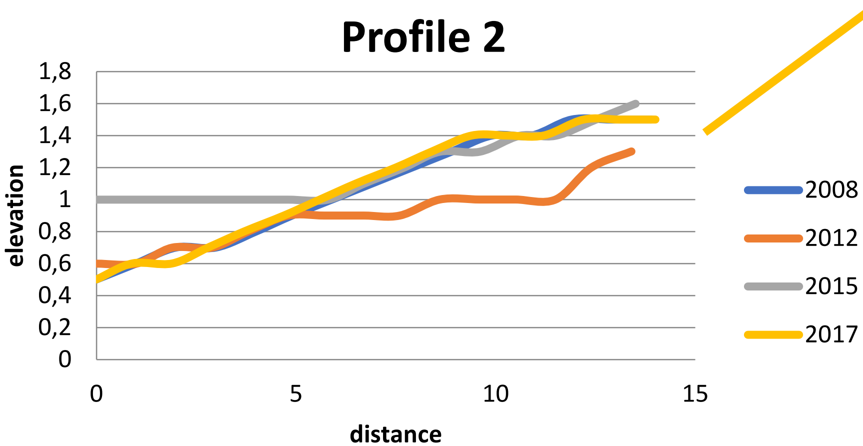


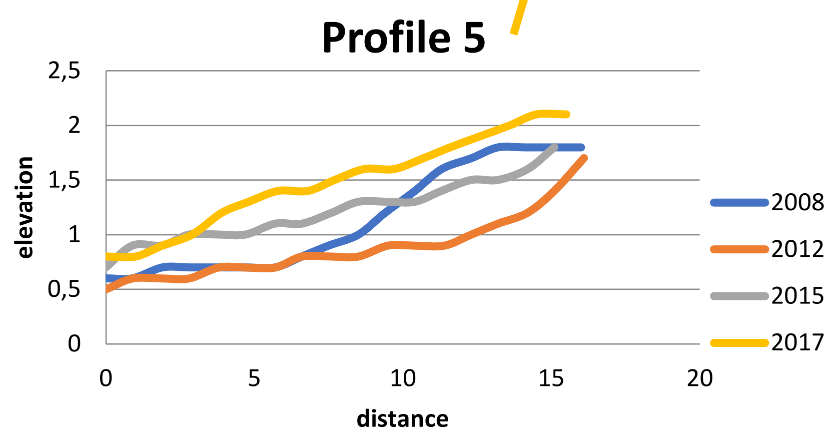
Interannual variability (2008-2017)

Sand has been in active motion:

- Accumulation (3570 m^3)
  - +3.6 m^3/m of shoreline
- Erosion in few locations (600m^3)
- Storms approaching from different direction move material back and forth – net loss of sand minor







Conclusions

- Combination or ALS and TLS offers high-quality temporal and spatial data:
  - Gives insight to internal structure of beach processes
- At Peraküla beach sand is distributed alongshore direction with non-stationary patterns
- Peraküla beach is generally healthy and its predominant process is accumulation
  - The storm-eroded material remains in the system

Lessons to take home:

- The appearance of the beaches after a single storm: often deceptive
- The classic process of cross-shore transport (cut-and-fill) not necessarily active in the Baltic Sea
- Relocation of sand back and forth along the shore often occurs


WAVE ENGINEERING
TALLINN UNIVERSITY OF
TECHNOLOGY
Thank you for your attention!