Geophysical Research Abstracts
Vol. 18, EGU2016-9925, 2016
EGU General Assembly 2016

Past storminess recorded in the internal architecture of coastal formations of Estonia in the NE Baltic Sea region

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Over the past 50 years, storminess has increased in northern Europe because of the changes in cyclonic activity. The cyclone season in the Baltic Sea area has shifted from autumn to winter; this has led to intensification of shore processes (erosion, sediment transport and accumulation) and has increased pressure to the economy (land use, coastal protection measures) of the coastal regions in the Baltic states. Therefore, studing the effects of such changes on shore processes in the past is critical for prediction of the future changes along the Baltic coasts.

Beach ridge plains are found worldwide, where cyclones and storm surges affect accumulation forms. These sandy shores are highly susceptible to erosion. Due to the isostatic uplift on the NE coast of the Baltic Sea, the signs of major past events are well-preserved in the internal architecture of old coastal formations (dune ridge-swale complexes). Wave-eroded scarps in beach deposits are visible in subsurface ground-penetrating radar (GPR) records, indicating the past high-energy events.

Several study areas and transects were selected on the NW coast of Estonia, using high-resolution topographic maps (LiDAR). Shore-normal subsurface surveys have been conducted with a digital GSSI SIR-3000 georadar with a 270 MHz antenna at each transect. Interpretation of GPR facies was based on hand auger and window sampler coring, which provided accurate depths of key stratigraphic boundaries and bounding surfaces. Several samples for luminescence and 14C dating were collected to determine the approximate chronology of the coastal formations along the Estonian coast.

We have found that changes in storminess, including the periods of high and low intensity of storms in late Holocene, are clearly reflected in the internal patterns of ancient coastal formations. The sections with small ridges with short seaward-dipped layers (interface between wave-built and aeolian deposits) in deeper horizons are probably formed during relatively calm periods. Such short seaward-dipped layers refer to low sea levels during their formation. More extensive layers reflect stronger storm events with higher water levels. Large amounts of sand in nearshore zone contribute to the formation of larger ridges. We have found at least three periods with high cyclonic activity and two relatively calm periods punctuated by few intense storms along the Estonian coast. In addition, a comparative study of the erosional palaeo-surfaces and recent storm monitoring data is currently underway for a better understanding, and thus a reliable reconstruction of the past storm parameters.

Further studies are required for a better chronology of coastal events to clarify the periodicity of storminess in this part of the Baltic Sea region. The findings of the current study will contribute to the forecast of future scenarios in regional storm risk assessment of the coastal areas.

ACKNOWLEDGMENTS:
This work has been funded by the Estonian Ministry of Education and Research and by the Estonian Science Foundation grants No. 7564, 8549, 9191, 9011, IUT18-9, PUT456, the BONUS project BaltCoast and Doctoral School of Earth Sciences and Ecology (EU Structural Support).