Mo(o)re balance

Sorgekoog Project

– About losses of high elevation and water table dynamics in a water pumped catchment area

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Introduction

Losses of high elevation based on artificial drainage systems provide big challenges particularly for coastal lowlands especially in view of climate change and its consequences such as a rise in temperatures and rising sea levels. One third of the land area of the federal state Schleswig-Holstein, Germany is nowadays below 2.5 mNHN and mostly used as agricultural land on vulnerable (minero-) organic soils. The area under investigation called *Sorgekoog*, predominantly an agricultural area has been characterised by an artificial drainage system for centuries.

The aim of the **Sorgekoog Project** is to develop a water management concept for the future of water management in the entire catchment area of the *Sorgekoog*, taking into account the objectives of the EC Water Framework Directive (EC-WFD). For this purpose, extensive investigations on the ecological conditions of present soil and water bodies, an analysis of shrinking-sensitive soils as well as an analysis of agrarian-structural aspects are elicited.

pick up!
about the *Sorgekoog*:
- catchment area: 11.750 ha
- lowland area (<2.5 mNHN): 8.293 ha
- lowest position: -2.7 mNHN
- annual precipitation: Ø 878 mm
- landscape characterization:
  - agricultural land
  - nature reserve
  - Special Areas of Conservation (SAC)
  - Special Protected Areas (SPA)
  - meadow bird conservation area
- 3 pumping stations
- river body density (including ditches): 197 m/ha ≙ 1.635 km

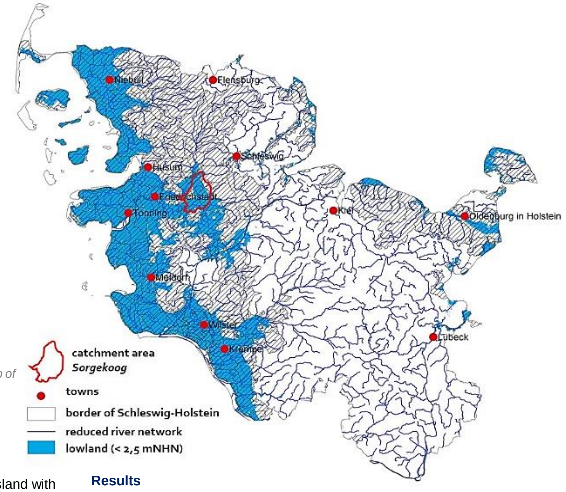

Fig. 1: Map of Schleswig-Holstein, Germany

Methodology

field work:
- 15 groundwater measuring stations were implemented on grassland with
1. different types of land use (pasture vs. cutting grassland vs. mixed type of both)
2. different organic soil types (fen, bog, clay, marsh soils, mud soils) and with
3. different settings of the position of the groundwater measuring stations (near the ditch, centered in the grassland)
- Pedological analysis of these 15 agriculturally used areas by boreholes.
- Measuring ditch water levels of 8 monitoring plots; measuring of water levels close to pumping stations.
- Measuring hydraulic conductivities on 16 monitoring plots (0-0.2 m bgl; 0.2-0.4 m bgl).

ArcGIS® –work:
- 13.160 digitalized leveling points from the years 1966 were taken to make a differentiation in a 2006 generated digital elevation model for the catchment area; screen width 1 meter (DEM1).
- DEM1 of the years 2006 and 2020 were evaluated in order to determine the changes in elevation during the 14-year time lapse.
- Changes in elevation were combined (*ArcGIS*® tool: *intersect*) with digitalized soil maps, including texture (soil map 1:50.000; established in 1966 and simultaneous generated with take of the leveling points from 1966 s.a.), soil type (soil map 1:50.000) and thickness of clay cover (peatland map of Schleswig-Holstein 1998) information as well as information about the holocene thickness (map of Holocene thickness 1:25.000; established in 1966 and simultaneous generated with the leveling points from 1966 s.a.).
- Statistical analysis of the data done by use of *Microsoft* Excel® 2019 and R 3.6.2.

Results

- Data basis of digitalized relief height difference points show a normal distribution (Q-Q plot analysis).
- Significant correlations for the vulnerability of losses of height of organic soils and the holocene thickness were identified (p <0,001).
- Several organic soil types show significant differences in their vulnerability to terrain height loss (p <0,001).
- Marine clay covered organic soils indicate significant higher losses of terrain height than soils without a marine clay cover (p <0,001). Whereby the thickness of the marine clay clover (0.2 m and 0.5 m) has no significant influence on the terrain height losses.
- Even areas used under nature conservation aspects suffered very high terrain height losses (Ø up to 1,5 cm/year) despite long (more than 30 years) ditch blocking and stowage as well as (saisonal) temporary flooding.
- In addition to the natural and anthropogenic generated drainage depth and intensity as well as the type of land use, the place of location in the relief is one main factor for the vulnerability of terrain height loss.
- The substantial monitoring results do not show any relationship between ditch water levels and ground water level, neither in winter nor during stowage events in summer periods → principal causes: strongly degraded, compacted (top) soils with generally low hydraulic conductivities (Ø 0,0864 cm/day) as well as vertically and horizontally consolidated layers in the top- and subsoils.
- Within the summer half-year, only precipitation events lead to (temporary) increase of ditch and ground water tables. Preferential water flow through shrinking cracks, subsurface wateroutflow of macropores and surface run-off will be the main reasons.

Fig. 2: Groundwater level measuring station (established in 1989) which indicates a loss of height of 1.45 cm/a despite 30 years of ditch blocking and flooding in a nature protection area.

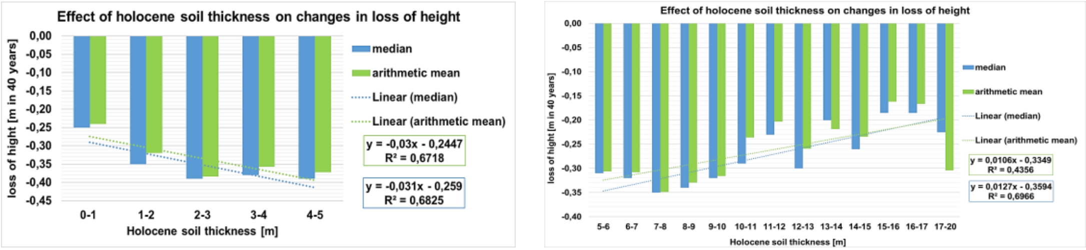

Fig. 3a) and 3b): Losses of height of organic soils strongly correlated with the holocene soil depth.

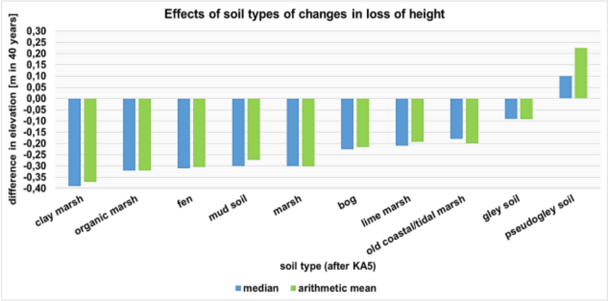

Fig. 4: Several organic soil types show significant differences in their vulnerability to terrain hight loss.

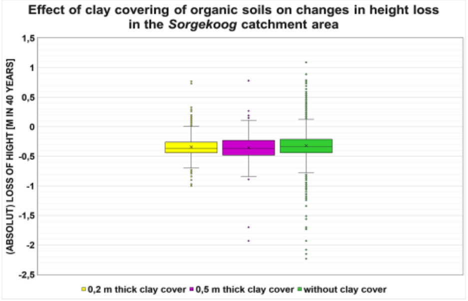

Fig. 5: Organic soils with marine clay cover are significantly more vulnerable for terrain height losses than soils without marine clay cover.

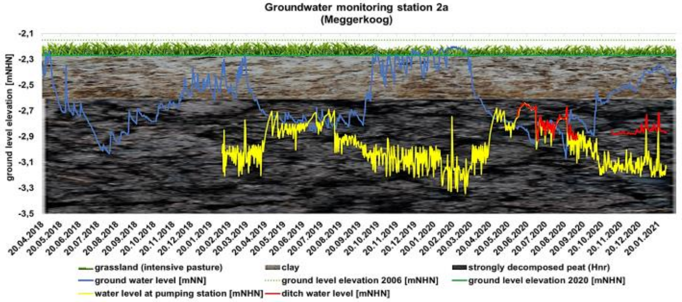

Fig. 6: High ditch water levels do not show effects on ground water levels.The seasonally dependent strong fluctuations in groundwater levels are natural.

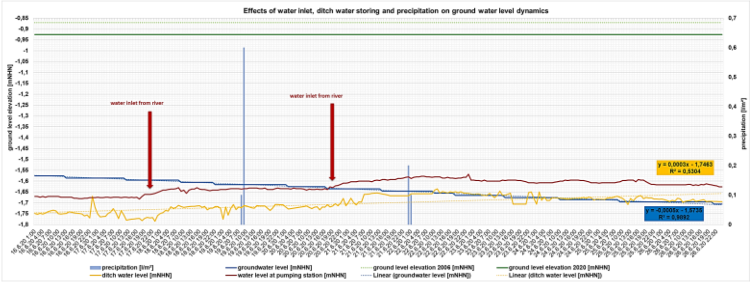

Fig. 7: Water inlet from a river Eider and blocking of ditches did not raise the ground water levels in the area.

Conclusion

The results indicate that in lowland areas which have been drained over long time periods, soil properties can engage a significant importance with regard to changes in altitude and missing interactions between ditch water levels, soil water and ground water tables. In addition, the high evapotranspiration rates in the windy peatland area will be one main of other factors. Nevertheless, especially in spring, summer and autumn high ditch water levels in the catchment area should be adjusted to prevent further artificial drainage. Appropriate water management adapted to high water levels is essential due to progressive terrain elevation losses, especially in soils covered with marine clay. In view of the outdated water management infrastructure and the expected high investment requirements, there is also an urgent need for action to ensure high ditch water levels and, where it is possible, to harmonize the fluctuations in the ground/soil water levels and reduce further losses in elevation. In addition, further measures that could possibly reduce the high evapotranspiration rates (windbreak planting or fallow, establishment of a closed and dense grass sod) would be beneficial. The establishment of a closed grass sod would also promote the build-up of humus and thus also serve to enrich and store carbon in the soils.

Eider-Treene-Association

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