Assessing water table dynamics of peatland areas using Landsat TIR imagery

Carolina Carrión Klier [1], *Tobias Schuetz* [1], Johanna Untenecker [2], Michel Bechtold [2]

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Introduction

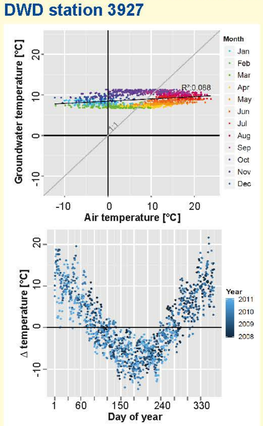
Water saturation conditions in peatlands are a driving factor for the emission of greenhouse gases. Thus, the identification of long-term saturation dynamics in peatland areas is a first step towards the quantification of emissions from these ecosystems. Unfortunately, information on groundwater levels is not always available on the necessary spatial or temporal resolution.
Publicly available databases of remotely sensed satellite data offer ways to close this lack of information. In this study the Landsat-archives are used to reconstruct spatial and temporal water saturation conditions in two peatland areas in Germany:

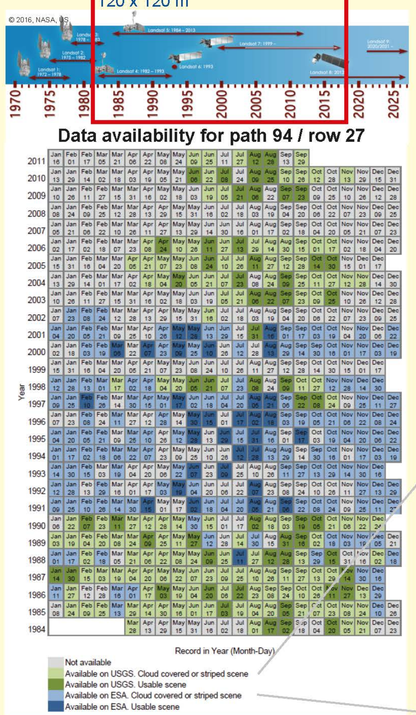
- Study I: Temporal water table dynamics in the Pfrungener Ried in Baden-Wuerttemberg
- Study II: Spatial patterns of water table depth in the Drömling fen in Sachsen-Anhalt

Methods

Previous studies have shown the potential of the thermal signature of the soil surface monitored by thermal infrared imagery to derive information about subsurface hydrology. It is also known that shallow-groundwater systems as wet peatlands are less susceptible to seasonal temperature fluctuations than drained peatlands and soils with deeper groundwater. Hence, wetter peatlands will be characterized by a smoother seasonal surface temperature curve, being cooler in the summer and warmer in the winter.

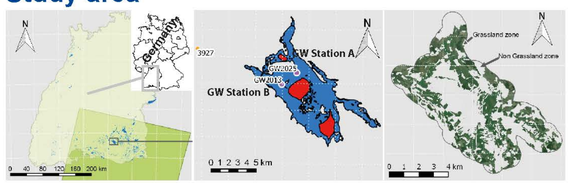
Relation between GW temperature and air temperature at GW station A and DWD station 3927





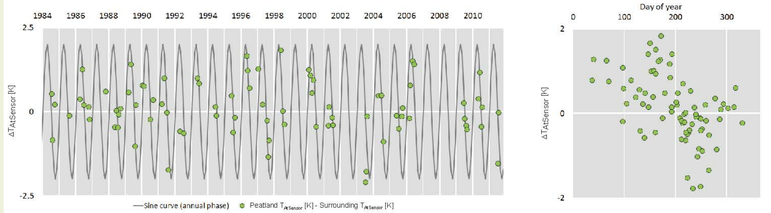
Study I: Temporal water table dynamics

Study area

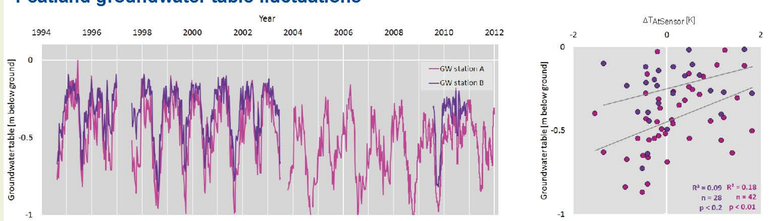


Results

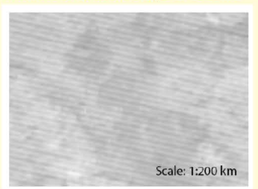
Peatland temperature anomaly (spatial means)



Peatland groundwater table fluctuations



Example for common errors in Landsat data: striped scene



Data analysis: setting

Due to the strong influence of the vegetation cover on thermal infrared radiative transfer, we here analyze temperature dynamics as relative differences between comparable vegetation cover in the same region. We restricted our analysis on grassland vegetation because of its predominance in the study area and its relative low vegetation height.

Data analysis: data transformation (Thermal Values -> K)

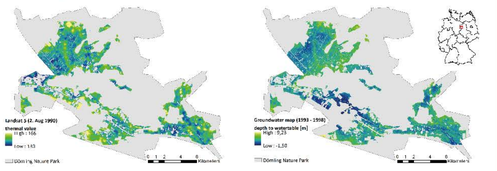
$T_{AtSensor}\,[K] = c_1 / \ln(c_2 / T_{VAl}\,[W / m^2\ sr\ \mu m] + 1)$

T_{VAl} Corr.Thermal Value
$c_{1/2}$ Calibration constants

After: Markham & Barker, 1986.

Study II: Spatial patterns of water table depth

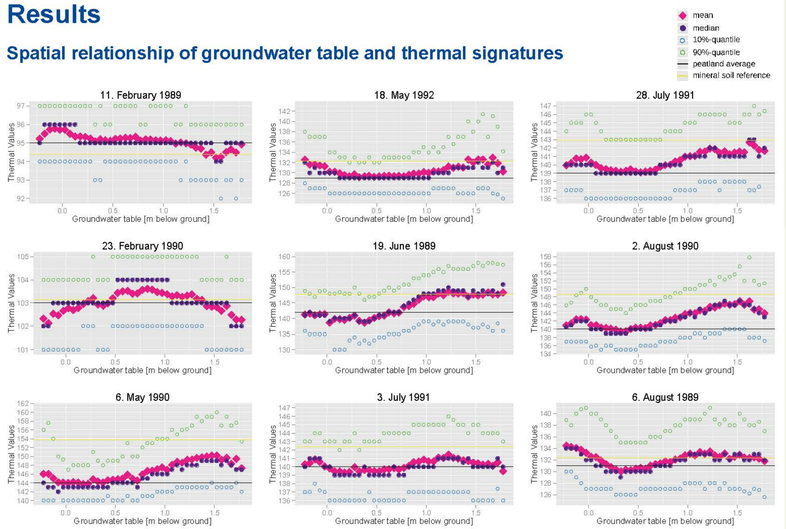
Study area



The nature park Drömling is a fen peatland area and is rich in long-term water level data. The area presents a broad variety of hydrological states. It was used as study area to compare spatial patterns of thermal values and spatially interpolated water table depths.

Results

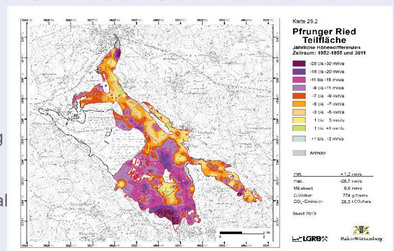
Spatial relationship of groundwater table and thermal signatures



Conclusions

Preliminary results for selected peatlands are i) peatland characteristic annual patterns of TIR temperature differences, and i) intra-annual variability over the years of available Landsat imagery within these patterns. iii) consistent relationship between maps of thermal value and water table depth during summer months. Dry peatland and surrounding mineral soil are considerably warmer than wet peatland. Ambiguity in the wet range may indicate partial ponding water and needs further information from other spectral bands.

Outlook: spatial analysis of peatland subsidence 1952 - 2011



(1) Chair of Hydrology, Albert-Ludwigs-University of Freiburg, Freiburg, Germany
tobias.schuetz@hydrology.uni-freiburg.de www.hydro.uni-freiburg.de
(2) Thünen Institute of Climate-Smart Agriculture, Braunschweig, Germany
michel.bechtold@thuenen.de www.thuenen.de

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