Remote sensing of drained thermokarst lake basin successions

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Thermokarst lakes are important factors for permafrost landscape dynamics and carbon cycling. Thermokarst lake cover is particularly high in Arctic lowlands with ice-rich permafrost. In many of these vast lowland regions, drained thermokarst lake basins of different age have been identified that overlap each other in space, suggesting intense dynamics of repeated lake formation and loss with complex carbon cycle histories during the Holocene [Grosse et al., 2013]. Observing the permafrost and ecosystem succession patterns following thermokarst lake drainage will help to better determining the landscape and regional scale impacts of lake loss on northern hydrology, permafrost aggradation, vegetation succession, carbon cycling, as well as spectral land surface property changes. Previous remote sensing approaches to study drained thermokarst lake basins used a combination of Landsat, high resolution satellite and aerial, and field data to quantify carbon stocks accumulated in post-drainage peat in drained thermokarst lake basins (DTLBs) for the northern Seward Peninsula in Northwest Alaska [Jones et al., 2012]. We here expand on this method by using different remote sensing products in combination with dating of lake drainage events. These events are identified based on the historical remote sensing record and accelerated mass spectrometry radiocarbon dating. The joint us of remote sensing and geochronological field data allows to assess the specific succession patterns of various DTLB types and their impacts on land surface properties in different Arctic permafrost regions (North Alaska, Northwest Alaska, North Siberia).

The datasets used in this analysis include a range of remote sensing and topographic data, such as aerial photography, historic topographic maps, high resolution satellite images (Corona, Spot, Ikonos, Quickbird, Worldview, GeoEye), and imagery from the full Landsat archive as well as from the Moderate Resolution Imaging Spectrometer (MODIS) sensors. We report temporal trends of spectral properties based on Landsat multispectral indices for individual DTLBs of different ages, but also employ landscape-scale chronosequences allowing the analysis succession trajectories of DTLBs that drained well before the start of the remote sensing record. Here we are particularly focusing on the long-term impacts of lake drainage on changes in normalized difference vegetation index (NDVI), normalized difference moisture index (NDMI), normalized difference water index (NDWI), Tasseled Cap index (brightness, greenness, wetness), land surface temperatures, and albedo. We further conducted field studies including reconnaissance flights targeting historically drained lakes and cored DTLBs to sample for radiocarbon-dating of terrestrial peat layers indicative of the drainage event.

Results of this ongoing study suggest a strong impact exerted by thermokarst lake drainage on land surface reflectance characteristics in thermokarst lowland regions. The information may be useful for parameterizing surface properties in land surface models of thermokarst-affected regions, particularly where increased lake drainage is projected to take place.

References

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