Geophysical Research Abstracts
Vol. 20, EGU2018-15439, 2018
EGU General Assembly 2018

Mapping Indonesian peatlands by DSM techniques for the volumetric estimation of their carbon stock

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Indonesian peatlands play an important role in the global carbon cycle because they store a large amount of carbon in the terrestrial ecosystem. However, they were always endangered by human landscape transformation (e.g. deforestation, industrial plant cultivation), and its negative effects (e.g. organic matter decomposition, CO_2 emission, extensive soil fires). Hence, it is an urgent challenge to elaborate a fast, cheap, and efficient methodology for mapping these peatland areas as it was proposed by the 'Indonesian Peat Prize'.
As an applicant of the Prize, our team elaborated a time and cost-effective methodology based on up-to-date digital soil mapping (DSM) techniques which can be used to optimize sampling strategy, map Indonesian peatlands, and estimate their carbon stock as well. The methodology consists of coherent steps to ensure consistency, and all of them leans on the theory of regionalized variables. Regression kriging (RK) – which is one of the most commonly applied DSM techniques nowadays – stays at the heart of the methodology because it is able to take the available environmental covariates (e.g. digital terrain model, satellite images, land use map) into consideration which makes the spatial prediction more precise. Furthermore, its prediction-error variance reflects the position of unsampled locations in both geographical and feature space, which can be exploited in sampling optimization. Moreover, its prediction-error variance is independent from the observed data, i.e. it can be computed before the actual sampling takes place which makes it time and cost-effective pre-survey quality measure. The elaborated methodology was presented and tested on the Bengkalis Island (approx. 500 km2) in Riau Province, Indonesia. Altogether 117 peat thickness observations were available from the Bengkalis Island. In addition, we visited 22 new sampling locations to measure peat thickness, bulk density, and carbon content as well. The location of the new observations was optimized according to the elaborated methodology. We modelled the spatial variability of peatland areas by RK based sequential simulation, where the resulting stochastic realizations were used to construct the spatial uncertainty model of peat thickness and volume. We applied the peat volume estimation to predict the carbon stock at the Bengkalis Island.
We present the workflow of the elaborated methodology, as well as the main results from the Bengkalis Island:
(1) the optimized sampling design,
(2) the compiled peat thickness map and its uncertainty,
(3) the estimated peat volume and its uncertainty, as well as
(4) the predicted carbon stock and its uncertainty.