Soil organic carbon changes 2000–2015

Spatiotemporal modelling of global soil organic carbon changes as a function of land cover change

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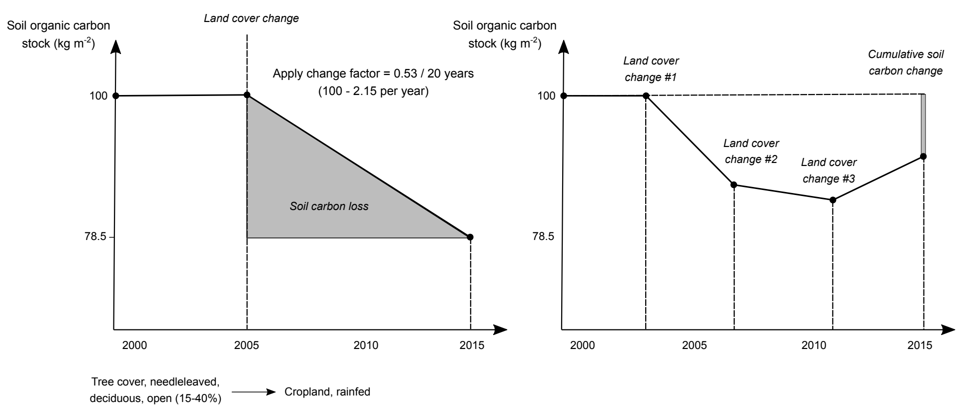
Trends in soil organic carbon is one of three indicators used to determine degraded lands by the UNCCD **Land Degradation Neutrality (LDN) Target Setting Progamme**. We have estimated soil carbon gains/losses for land cover changes between 2000–2015.

A need for an improved global soil carbon assessment: Trends in soil organic carbon stocks, eventually along with above-ground carbon stocks, make up one of the three main indicators for the UNCCD Land Degradation Neutrality (LDN) initiative. Differences in the estimates of the total soil organic carbon stocks however, have been significant (Jackson et al., 2017). Uncertainty about how much organic carbon there is in the soil is especially high for the northern latitudes. The 2017 SoilGrids250m (Hengl et al., 2017) estimate of the soil carbon stock has been shown to contain biased estimates — about 2× higher than the actual (Tifafi et al., 2018). This indicates that we are in danger of not actually knowing how much soil carbon there is, nor how much has been lost in the last 20+ years due to changing land use, degradation and/or changes in management/inputs.

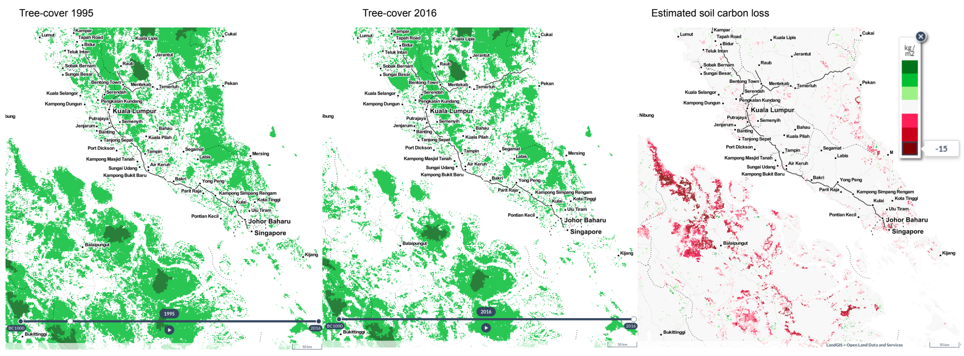
In this paper we provide a data-driven estimate of the total soil organic carbon stock for standard depth 0–30 cm. We further use the produced baseline estimate within an expert-based system to derive an estimate of the global soil carbon loss due to land cover change (2000–2015). For this we use the ESA Climate Change Initiative time series of land cover maps at 300 m resolution produced for the period 1992–2015, which are available via `https://www.esa-landcover-cci.org`.



Schematic example of derivation of soil organic carbon loss as a function of land cover change. Change factor after the IPCC methodology (UNCCD-LDN, 2018).

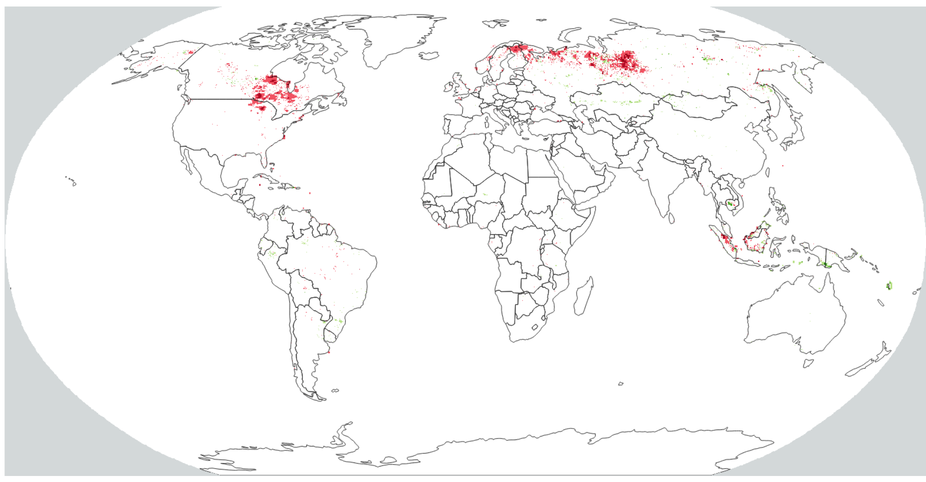
Methods: For mapping soil carbon we use a compilation of published point data coming from the main national and international soil point data providers (USDA National Cooperative Soil Characterization Database, Africa Soil Profiles Database, LUCAS Soil, SISLAC and others). Additional points, if not available through these databases, have been imported from ISRIC's WoSIS Soil Profile Database (Batjes et al., 2017). Soil organic carbon content, bulk density and coarse fragments were modelled separately, then used to derive global soil organic carbon stock. For spatial prediction we use an ensemble machine learning framework building up on the xgboost and ranger R packages. We first derive a long-term estimate of soil organic carbon stock (in kg m^{-2}), then use a temporal function to predict soil carbon changes due to changes in land cover (see scheme above).

Maps described in this paper can be accessed via the LandGIS app at `https://landgis.opengeohub.org`.



Estimated soil organic carbon losses with a zoom in on Malesia / Indonesia.

Results: Our results indicate that the most distinct areas of soil organic carbon loss in the last 15 years lay in the northern hemisphere, followed parts of Indonesia, Brazil and central Africa, were large areas of natural forests have been converted to croplands. This is however, an estimate purely based on the expert based change functions based on IPCC Tier I methodology and needs to be further validated using national monitoring efforts (UNCCD-LDN, 2018). We also recognize that there is a need for a new statistical and spatiotemporal framework to measure model and monitor soil organic carbon dynamics. This framework ought to be science- and data-driven.



World map of estimated soil carbon loss (0–30 cm) based on the land cover changes 2000–2015. Red color indicates soil organic carbon loss; green color indicates potential soil organic carbon gains.

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