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Spatiotemporal models of global soil organic carbon stock to support land degradation assessments at regional and global scales: limitations, challenges and opportunities

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There is an increasing interest in fitting and applying spatiotemporal models that can be used to assess and monitor soil organic carbon stocks (SOCS), for example, in support of the '4 pourmille' initiative aiming at soil carbon sequestration towards climate change adaptation and mitigation and UN's Land Degradation Neutrality indicators and similar degradation assessment projects at regional and global scales. The land cover mapping community has already produced several spatiotemporal data sets with global coverage and at relatively fine resolution e.g. USGS MODIS land cover annual maps for period 2000–2014; European Space Agency land cover maps at 300 m resolution for the year 2000, 2005 and 2010; Chinese GlobeLand30 dataset available for years 2000 and 2010; Columbia University's WRI GlobalForestWatch with deforestation maps at 30 m resolution for the period 2000–2016 (Hansen et al. 2013). These data sets can be used for land degradation assessment and scenario testing at global and regional scales (Wei et al 2014). Currently, however, no compatible global spatiotemporal data sets exist on status of soil quality and/or soil health (Powlson et al. 2013). This paper describes an initial effort to devise and evaluate a procedure for mapping spatio-temporal changes in SOC stocks using a complete stack of soil forming factors (climate, relief, land cover, land use, lithology and living organisms) represented mainly through remote sensing based time series of Earth images. For model building we used some 75,000 geo-referenced soil profiles and a stacks space-time covariates (land cover, land use, biomass, climate) at two standard resolutions: (1) 10 km resolution with data available for period 1920–2014 and (2) 1000 m resolution with data available for period 2000–2014. The initial results show that, although it is technically feasible to produce space time estimates of SOCS that demonstrate the procedure, the estimates are relatively uncertain ($<$45% of variation explained) and lead to obvious artifacts, especially in areas that have not be represented in time-dimension (temporal extrapolation). For some regions that possess somewhat adequate amounts of point data in space and time (e.g. USA) relatively credible space time estimates can be produced. By adding more training data (both legacy and newly collected points) these models can be gradually improved until they can become operational for decision making and scenario testing.