Global trends of soil organic carbon (SOC) based on soil moisture and ensemble learning

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Motivation

- The response of SOC spatial variability to different soil moisture conditions has not been explored at the global scale in part due to the lack of continuous information of these variables across large areas of the world.
- Analyzing this relationship could be useful to reduce the current uncertainty around SOC distribution and change.
- Large scale models and SOC mapping efforts contrast with country specific SOC maps, and large uncertainties on SOC magnitudes and patterns remain across large areas of the world.

Objectives

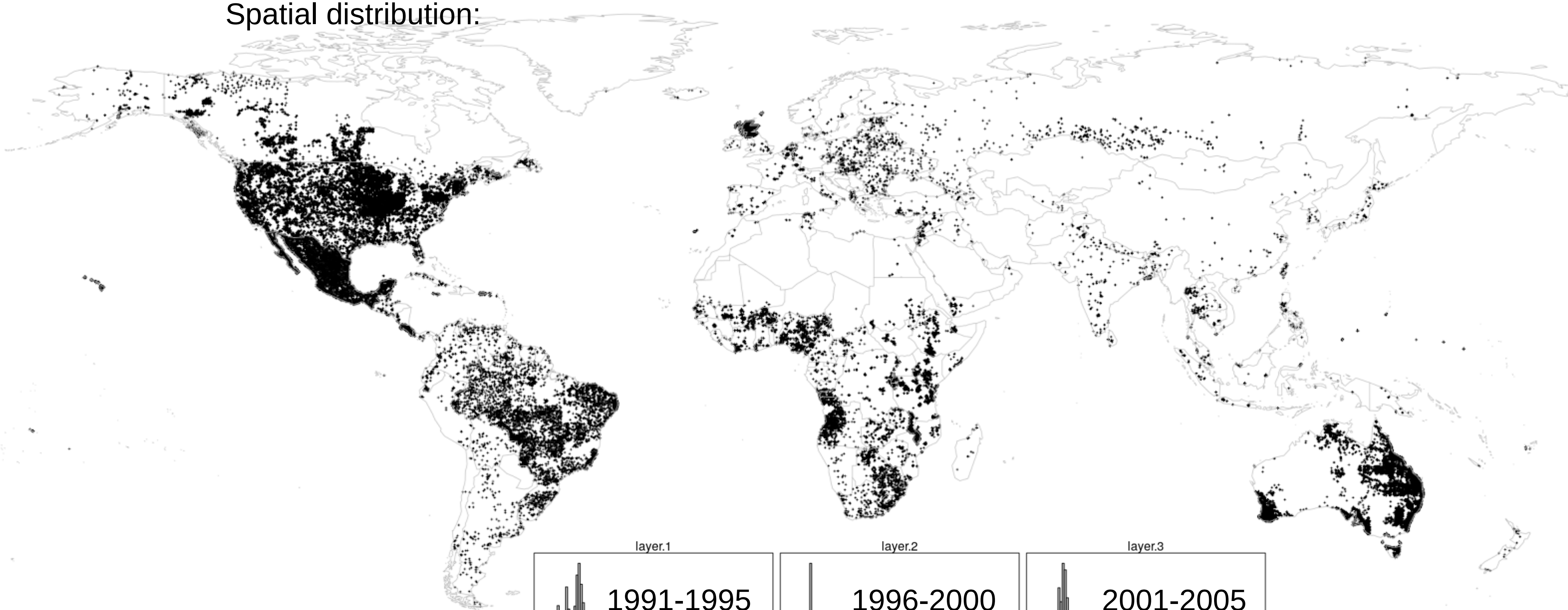
- To identify the main effects of soil moisture grids on SOC profile data.
- To generate multi-temporal digital SOC maps using SOC profile data for training and multi-temporal soil moisture grids as covariates
- To detect SOC trends using multi-temporal digital SOC maps

Data and methods

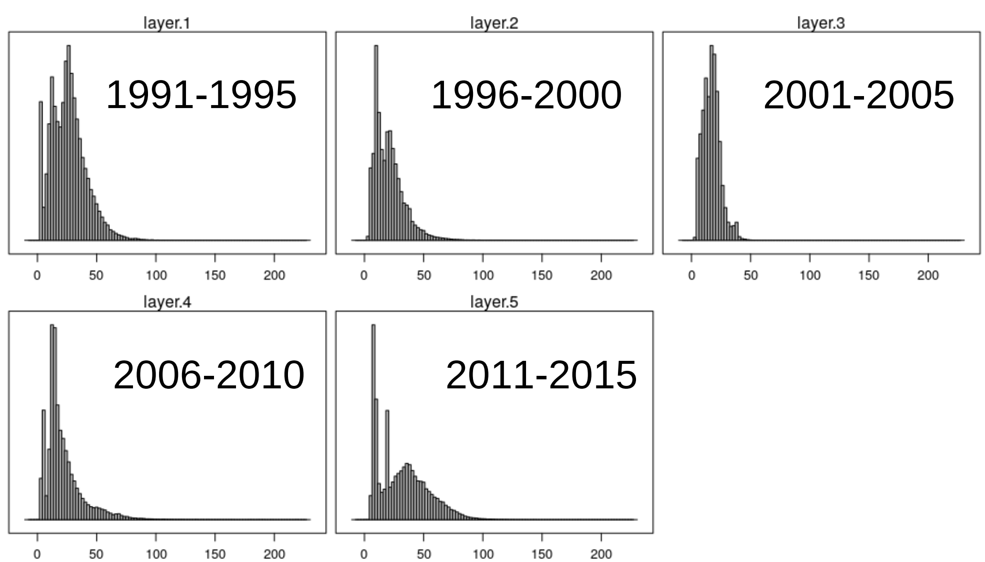
- *SOC profile data (WoSIS, n=87002, 1991-2015, https://doi.org/10.5194/essd-12-299-2020)*
- *Soil moisture 15km grids (1991-2015, https://doi.org/10.5194/essd-2019-191)*
- Bayesian analysis (R-stan) of main effects: (SOC ~ soil moisture)
- Ensemble learning (Superlearner) for prediction
- Trend detection (1991-2015, doi:10.3390/rs5052113)

Distribution of SOC data

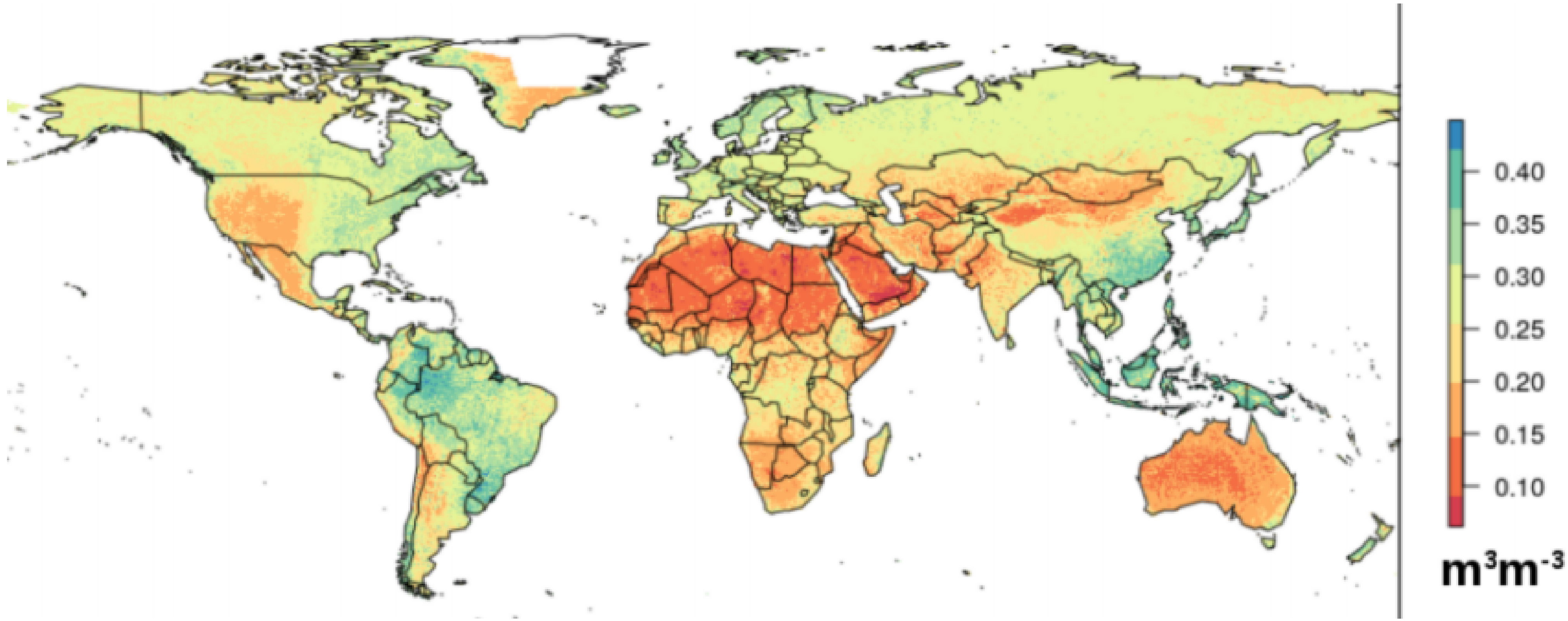
Spatial distribution:



Statistical distribution:



Mean soil moisture (1991-2015)



Submitted as: data description paper

05 Nov 2019

Gap-Free Global Annual Soil Moisture: 15km Grids for 1991–2016

Review status

A revised version of this preprint is currently under review for the journal ESSD.

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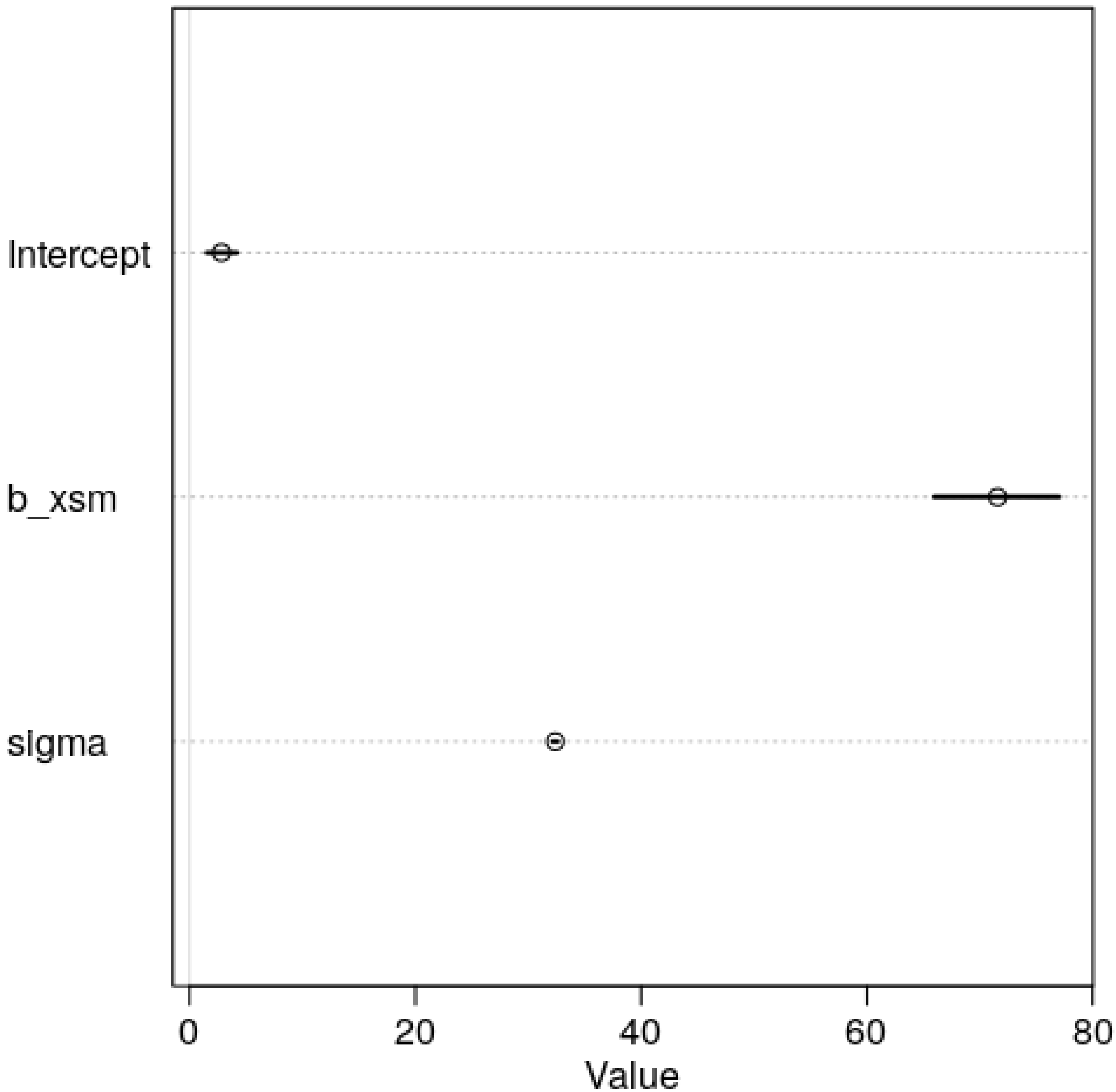
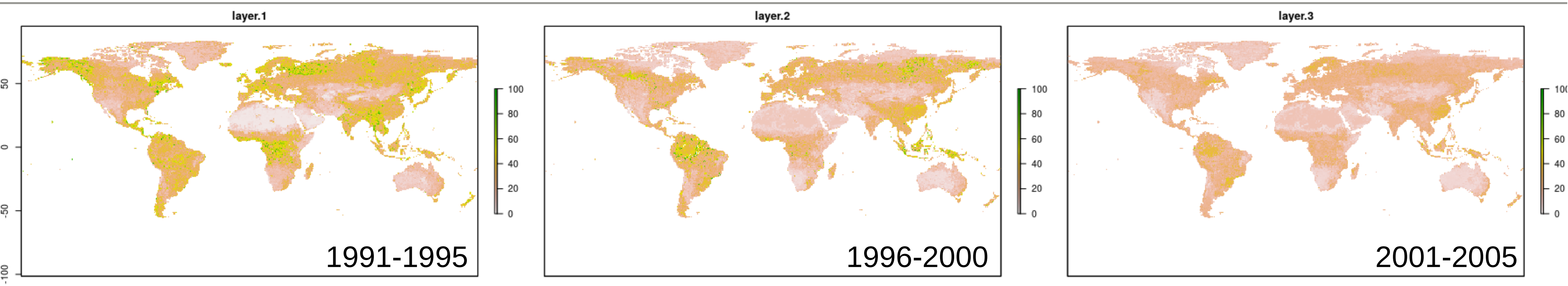
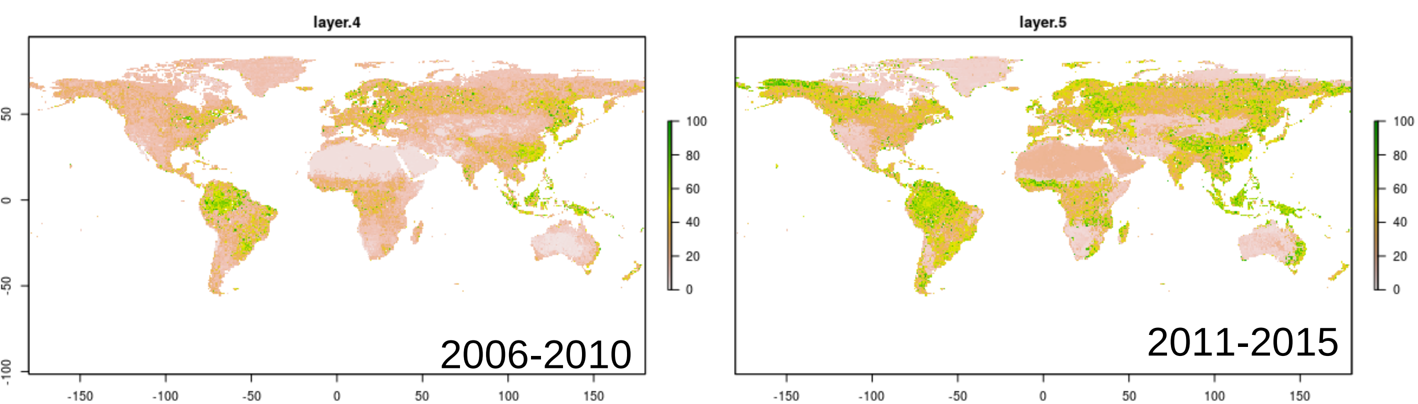
Positive effect of soil moisture (b_xsm) on SOC



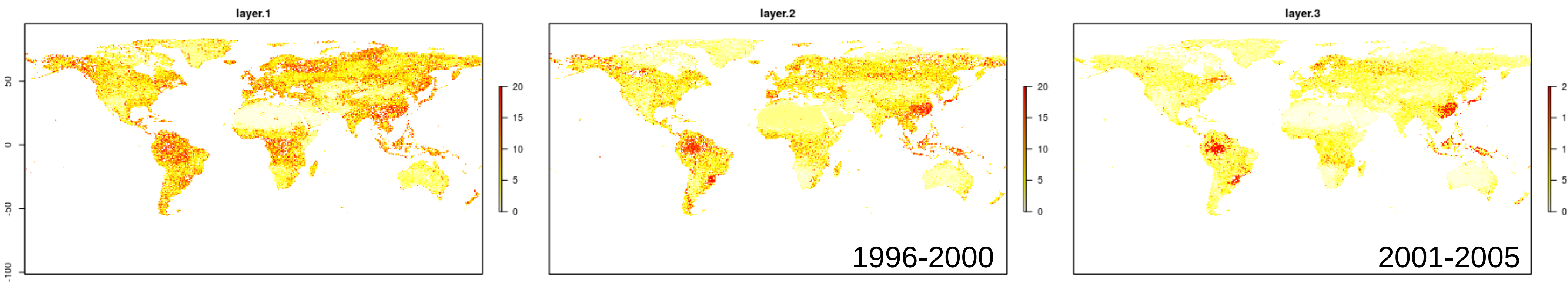
SOC predictions (0-30 cm depth)

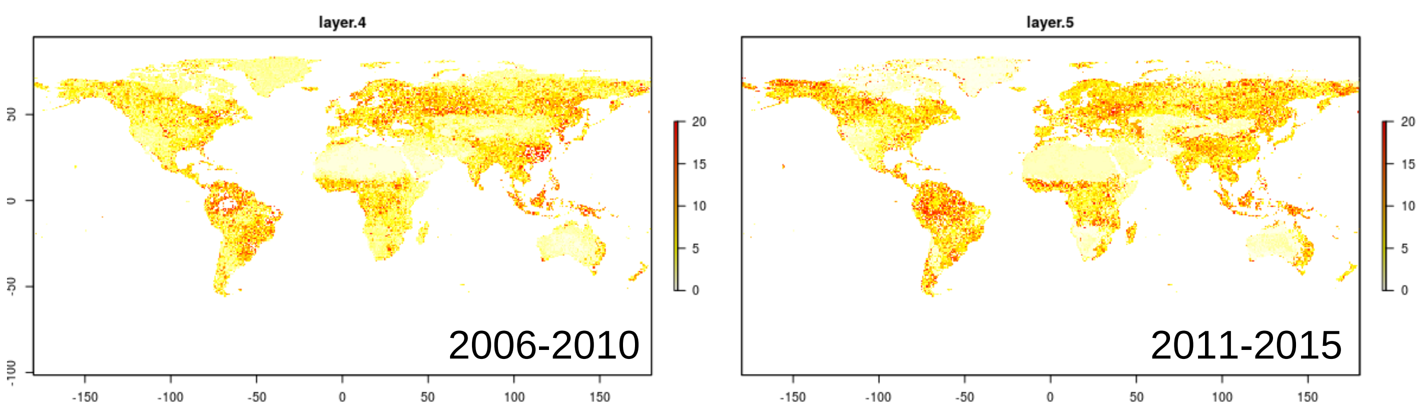




- Ensemble learning (stack of models) via R-Superlearner r=0.45 to r=0.55 RMSE (16 to 33 gr/kg)

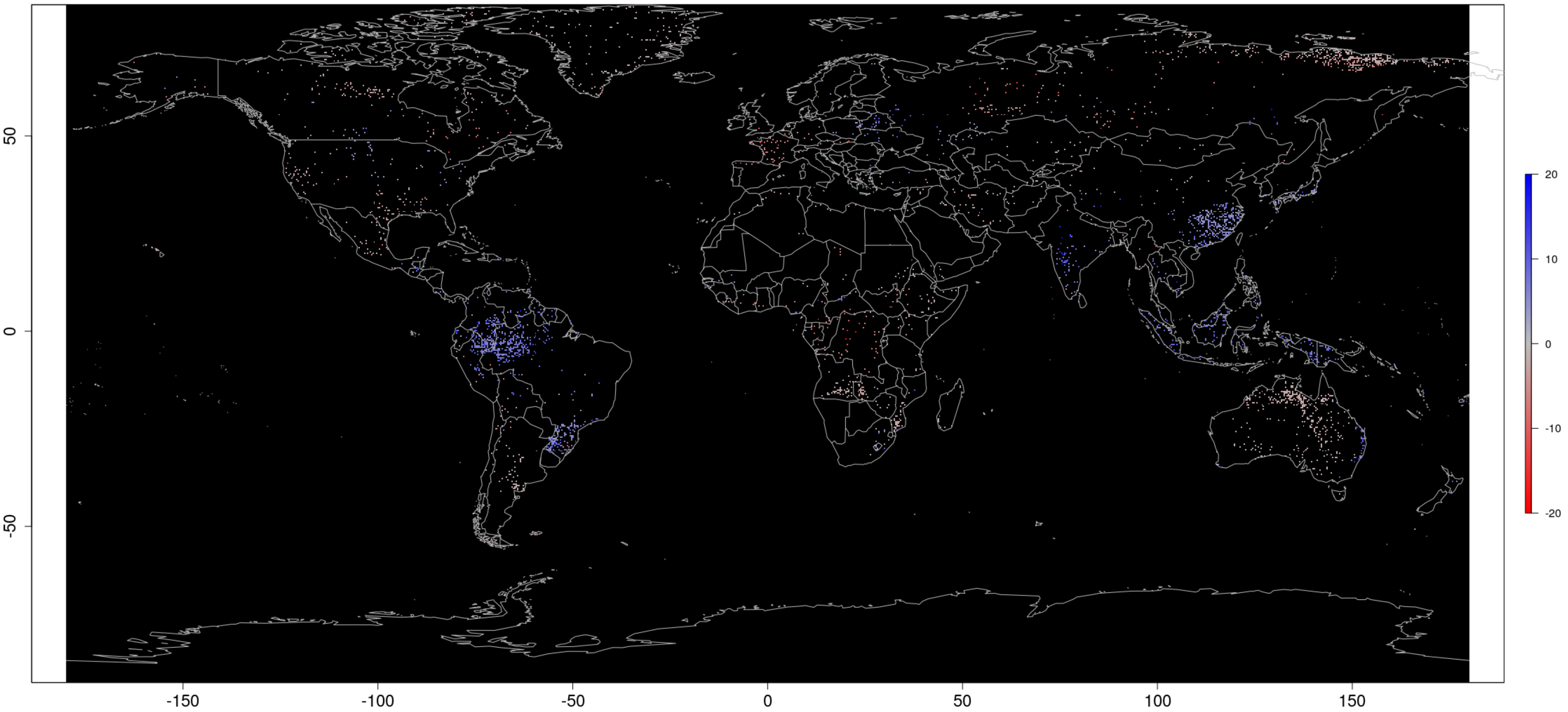
Uncertainty of SOC predictions (%)





Bootstrapping the spatial ensemble for each period (n=1000)

Trend detection of SOC (1991-2015)



Main conclusions

- Trend detection reveal areas showing significant (p-value < 0.05) positive trends across ~2.7 million km2 at the global scale ranging from 0.3 to 29 g/kg.
- Significant negative trends of SOC were found across ~3.6 million km2 at the global scale ranging from -22.2 to -0.3 g/kg.
- Main SOC losses were found across North America, Europe, central Africa, and Siberia.
- Our results quantifying the response of soils to changing soil moisture conditions contribute with new insights that are useful for the development of soil carbon monitoring systems.