Human societies began to play a significant role in global sediment transfer 4,000 years ago

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Reply to Li et al.: Human societies began to play a significant role in global sediment transfer 4,000 years ago

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In a recent study (1), we conducted a global synthesis of long term records of reconstructed sediment accumulation rates (SAR) in lakes to diagnose that a dominant anthropogenic imprint on soil erosion rates started ~4,000 years ago. Our approach was based on the assumption that lake SARs are watershed integrators of terrestrial biogeochemical responses to atmospheric (climate) and land surface dynamics spanning several millennia (2–4). Our statistical analysis was based on SAR reconstructions for the last 12,000 years (1), global pollen records spanning the same period to infer past vegetation changes (5), and model-based climate reconstructions from transient Holocene simulation with MPI-ESM1.2-LR developed at the Max Planck Institute for Meteorology (6), which has been previously used for analysis of coupled climate-carbon-vegetation dynamics (7).

Li et al. (8) suggest that complex 'human-vegetation-climate' interactions in the Late Holocene may have biased pollen inferred climate reconstructions. Hence, these pollen records may not be appropriate in our study to reconstruct climate variations in addition to land cover changes. Climate can be reconstructed from pollen records (see e.g., 9), but we have chosen not applying those data because they were already used in our study for land cover reconstruction. Yet, to avoid circularity and standardize our approach, climate time series for the past 8,000 years (i.e., average, minimum and maximum of annual precipitation, surface air temperature, and wind) were instead collected for all sites from model simulation with the MPI-ESM1.2-LR, which does not include or assimilate the pollen records.

Li et al. (8) are questioning the climate model selection in our study Forcing (greenhouse gas vs orbital) is minor, consequently climate changes are also minor in all models. Other model reconstructions can be investigated, but regardless of which climate reconstructions are used, the climate changes over the last 4,000 years are minor. Thus, the anthropogenic factor (i.e., significant tree cover reduction synchronous to the increases in SAR trends) emerges as the dominant driver of SARs.

In our study we show that pollen records from European and North American lakes have been affected by human activities during the Holocene, hence recording a combination of a climate and a human signal. Li et al. suggest that pollen records from European and North American sites are less appropriate for climate reconstructions compared with records from remote areas. This discussion goes beyond the conclusions of our paper, but our subset of sites is including lake systems only, hence representing only a small fraction of all pollen archives stored in the pollen database, e.g. not including bogs, ponds, swamps, soils, estuaries or alluvial systems. Hence, our subset of pollen records is not representative of the total pollen records available and seems not appropriate to discuss the climate reconstruction methodologies. Other papers discuss climate reconstruction methodologies from pollen records (9), but this was not the scope of our paper.

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