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# High resolution simulations of climate and vegetation in Europe at the Last Glacial Maximum

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This work presents a new gridded dataset of surface conditions in Europe during the Last Glacial Maximum (LGM, 21 kya) including climate, vegetation cover, and soil temperature. To obtain the new dataset, we carried out a 30-years simulation for LGM conditions performed by an iterative asynchronous coupling between the Weather Research and Forecasting (WRF) model and the Lund-Potsdam-Jena Dynamic Global Vegetation Model version LMfire (LPJ-LMfire). The domain encompasses Europe at 18 km spatial resolution. The iterative asynchronous coupling design consists of four parts: (i) the fully coupled Community Climate System Model version 4 (CCSM4) provides global atmospheric variables for the LGM conditions to generate the first approximation of land cover with LPJ-LMfire on a coarse grid (ca. 100 km), (ii) WRF is driven by CCSM4 and uses the surface variables obtained in step (i) to generate the first downscaled atmospheric variables for the LGM at 18 km grid size, (iii) LPJ is run with the downscaled atmospheric variables (of step ii) to produce the land cover at 18 km, (iv) same as in (ii) but WRF uses surface parameters at 18 km resolution. Parts (iii) and (iv) were carried out asynchronously over 8 iterations to achieve a stable equilibrium between land cover and climate. Focusing on vegetation and land use, the results show that vegetation cover is reduced progressively in each step of the iteration. The vegetation fraction decrease strongly from 60 to approximately 20 % from the present to the LGM conditions. The MODIS land use category of bare/sparsely vegetated land is mostly observed over Europe in the LGM compared to cropland in the present. Our results compare favourably with pollen-based land cover reconstructions for LGM Europe, and show that asynchronous coupling is still a valuable method for preparing high-resolution reconstructions of past land cover and climate. Thus, the new LGM surface cover at 18 km grid spacing enables us to have insights of the regional vegetation pattern, which together with reconstructed datasets can improve the characterisation of the LGM climate. The resulting dataset can not only be used by atmospheric models as an input to make the representation of the surface fluxes more realistic, but it will also be valuable for a range of studies that consider the environmental history of Europe including climate, ecology and biodiversity, and anthropology.