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Climate engineering of vegetated land for hot extremes mitigation: an ESM sensitivity study

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Mitigation efforts to reduce anthropogenic climate forcing have thus far proven inadequate, as evident from accelerating greenhouse gas emissions. Many subtropical and mid-latitude regions are expected to experience longer and more frequent heat waves and droughts within the next century. This increased occurrence of weather extremes has important implications for human health, mortality and for socio-economic factors including forest fires, water availability and agricultural production. Various solar radiation management (SRM) schemes that attempt to homogeneously counter the anthropogenic forcing have been examined with different Earth System Models (ESM). Land climate engineering schemes have also been investigated which reduces the amount of solar radiation that is absorbed at the surface. However, few studies have investigated their effects on extremes but rather on mean climate response. Here we present the results of a series of climate engineering sensitivity experiments performed with the Community Earth System Model (CESM) version 1.0.2 at 2°-resolution. This configuration entails 5 fully coupled model components responsible for simulating the Earth's atmosphere, land, land-ice, ocean and sea-ice that interact through a central coupler. Historical and RCP8.5 scenarios were performed with transient land-cover changes and prognostic terrestrial Carbon/Nitrogen cycles. Four sets of experiments are performed in which surface albedo over snow-free vegetated grid points is increased by 0.5, 0.10, 0.15 and 0.20. The simulations show a strong preferential cooling of hot extremes throughout the Northern mid-latitudes during boreal summer. A strong linear scaling between the cooling of extremes and additional surface albedo applied to the land model is observed. The strongest preferential cooling is found in southeastern Europe and the central United States, where increases of soil moisture and evaporative fraction are the largest relative to the control simulation. This preferential cooling is found to intensify in the future scenario. Cloud cover strongly limits the efficacy of a given surface albedo increase to reflect incoming solar radiation back into space. As anthropogenic forcing increases, cloud cover decreases over much of the northern mid-latitudes in CESM.