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The impact of CO_2 fertilization and historical land use/land cover change on regional climate extremes

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Recent research highlights the role of land surface processes in heat waves, droughts, and other extreme events. Here we use an earth system model (ESM) from the Geophysical Fluid Dynamics Laboratory (GFDL) to investigate the regional impacts of historical anthropogenic land use/land cover change (LULCC) and the vegetative response to changes in atmospheric CO_2 on combined extremes of temperature and humidity. A bivariate assessment allows us to consider aridity and moist enthalpy extremes, quantities central to human experience of near-surface climate conditions.

We show that according to this model, conversion of forests to cropland has contributed to much of the upper central US and central Europe experiencing extreme hot, dry summers every 2-3 years instead of every 10 years. In the tropics, historical patterns of wood harvesting, shifting cultivation and regrowth of secondary vegetation have enhanced near surface moist enthalpy, leading to extensive increases in the occurrence of humid conditions throughout the tropics year round. These critical land use processes and practices are not included in many current generation land models, yet these results identify them as critical factors in the energy and water cycles of the midlatitudes and tropics.

Current work is targeted at understanding how CO_2 fertilization of plant growth impacts water use efficiency and surface flux partitioning, and how these changes influence temperature and humidity extremes. We use this modeling work to explore how remote sensing can be used to determine how different forest ecosystems in different climatological regimes are responding to enhanced CO_2 and a warming world.