Title:	Cropland trees need to be included for accurate model simulations of land-atmosphere heat fluxes, temperature, boundary layer height, and ozone
Authors:	Mishra, A.K. (/jspui/browse?type=author&value=Mishra%2C+A.K.) Hakkim, H. (/jspui/browse?type=author&value=Hakkim%2C+H.) Kumar, V. (/jspui/browse?type=author&value=Kumar%2C+V.) Kumar, A (/jspui/browse?type=author&value=Kumar%2C+A) Datta, S. (/jspui/browse?type=author&value=Datta%2C+S.) Sinha, V. (/jspui/browse?type=author&value=Sinha%2C+V.)
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Abstract:	Trees significantly impact land-atmosphere feedbacks through evapotranspiration, photosynthesis and isoprene emissions. These processes influence the local microclimate, air quality and can mitigate temperature extremes and sequester carbon dioxide. Despite such importance, currently only 5 out of 15 atmospheric chemistry climate models even partially account for the presence of cropland trees. We first show that the tree cover over intensely farmed regions in Asia, Australia and South America is significantly underestimated (e.g. only 1–3% tree cover over north-India) in the Model of Emissions of Gases and Aerosol from Nature (MEGAN) and absent in Noah land-surface module of the Weather Research and Forecasting (WRF-Chem) Model. By including the actual tree cover (~10%) over the north-west Indo Gangetic Plain in the Noah land-surface module of the WRF-Chem and the MEGAN module, during the rice growing monsoon season in August, we find that the latent heat flux alone increases by 100%–300% while sensible heat flux reduces by 50%–100%, leading to a reduction in daytime boundary layer height by 200–400 m. This greatly improves agreement between the modelled and measured temperature, boundary layer height and surface ozone, which were earlier overestimated and isoprene and its oxidation products which were earlier underestimated. Mitigating peak daytime temperatures and ozone improves rice production by 10 to 20%. Our findings from north west Indo-Gangetic Plain establish that such plantations mitigate heat stress, and have beneficial effects on crop yields while also sequestering carbon. Expanding agroforestry practices to 50% of the cropland area could result in up to 40% yield gain regionally. Implementing such strategies globally could increase crop production and sequester 0.3–30 GtC per year, and therefore future climate mitigation and food security efforts should consider stakeholder participation for increased cropland agroforestry in view of its beneficial effects.
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