Role of land use changes in regional climate studies over East Asia

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Long-term simulations with regional climate models (RCMs) show biases over East Asia that result partly from fix-in-time land use data (EX2001). Using four satellite-based land use images (EX8901) from the past 30 years instead of default values, 34-year integrations were performed to make comparisons (EX8901 minus EX2001) over East Asian land areas. The decreased albedo (−0.019) resulted in weakened upward short-wave flux, contributing to positive surface radiative forcing (2.89 W m^{-2}), which then induced enhanced sensible heat fluxes. The near-surface wind speed was weakened (−0.15 m s^{-1}) in relation to the increased roughness length (0.042 m) and weakened pressure gradient, and induced a decreased precipitation bias of 0.0095 mm day^{-1}. The increased ground temperature and enhanced soil water content promoted strengthened sensible and latent heat fluxes, which induced a decreased surface air temperature bias (−0.24 °C). Results show that by including land use changes, model simulations can be improved. The impact of land use changes between the 1980s and 2010s on the monsoon-related circulation and precipitation over East Asia was further explored using the Weather Research and Forecasting regional climate model with the mosaic approach, which could consider subgrid-scale land use characteristics and the corresponding changes. Simulated results using the satellite-based land use data show that the monsoon-related precipitation and rain belt movement could be well reproduced, whereas the precipitation was generally overestimated. In terms of the general effect of land use changes between the 1980s and 2010s, the precipitation decreased in the north and increased in the south. Significant subregional characteristics are apparent in China, especially with respect to East Asian summer monsoon (EASM)-related precipitation. The increased roughness induced weakened near-surface wind speeds in the southern part of the EASM region, while the decreased roughness resulted in intensified values in the northern part. Meanwhile, the impacted EASM-related circulation and moisture flux, which could be well explained by the land use changes induced, influenced the pressure gradient and temperature gradient at low to middle latitudes, resulting in a weakened moisture flux from the southwest and the southeast, whereas it intensified from the South China Sea and at middle to high latitudes. In general, with weakened moisture flux at low to high latitudes, the EASM-related rain belt's northward movement was restrained. Although the enhanced westerly currents contributed to the increased moisture flux at middle to high latitudes, the precipitation there decreased due to the stronger weakened northward moisture flux.

Key words: land use changes, albedo, roughness, surface air temperature, East Asia summer monsoon