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Land use radiative impact on temperature and precipitation response in the Eurasian regions

Alexey V. Eliseev and Igor I. Mokhov

A.M.Obukhov Institute of Atmospheric Physics RAS, Laboratory of the Climate Theory, Moscow, Russian Federation (eliseev@ifaran.ru, +7 (495) 9531652)

Simulations with the climate model of intermediate complexity IAP RAS CM (A.M. Obukhov Institute of Atmospheric Physics RAS, Moscow) are performed for the 16th–21st centuries forced by the historical reconstructions and future projections of anthropogenic and natural forcings including long–lived greenhouse gases, tropospheric and stratospheric sulphates, total solar irradiance, and land use. Future projections of the external anthropogenic forcings are based on the SRES emission scenarios except the land use forcing which is prescribed in accordance to the scenarios developed in the framework of the Land Use Harmonization (LUH) project.

Land use exerts negative radiative forcing in most agricultural regions, in particular, in the Eurasian extratropics. At the top of the atmosphere, this forcing is stronger in summer than in winter reaching $\approx -6\ W\,m^{-2}$ in the central Eurasia in the late 20th century. However, in the regions with semi–desert natural vegetation, weak positive radiative forcing develops (e.g., about $1\ W\,m^{-2}$ in the Middle East). On a global mean basis, the top–of–the atmosphere radiative forcing in the IAP RAS CM attains $-0.11\ W\,m^{-2}$ in the late 20th century. Additional radiative forcing developing in the 21st century is small and its magnitude does not exceed $1\ W\,m^{-2}$ everywhere.

Land use radiative forcing causes a decrease of globally and annually averaged surface air temperature by $\approx 0.07\ K$ and precipitation by 7% during the 20th century. In turn, other anthropogenic and natural forcings cause warming amounting $0.7\ K$ and precipitation increase attaining 4% during the same period. Combined forcing (land use+other forcings), results in temperature and precipitation increase in the 20th century which are about $0.6\ K$ and $\approx 3\%$, correspondingly, and agree with observations.

While warming dominates in Eurasia during the 20th century under combined forcing, regional cooling in the regions of strong negative radiative forcing is exhibited. In addition land use retards warming in the northernmost Eurasia by several tenths of kelvin. Land use radiative forcing modifies seasonal features of surface air temperature response in the extratropical Eurasia. Namely, other anthropogenic forcings, accounted in these simulations, lead to general decrease of annual temperature range under annual mean warming, land use imposes similar decrease of annual temperature range, but under annual mean cooling. In addition, surface cooling suppresses precipitation, especially in summer. Spatial patterns of temperature and precipitation trend in the 20th century reasonably agrees with observations.

In the 21st century, land use radiative impact on surface air temperature and precipitation for the LUH scenarios is small as a whole. In this century, IAP RAS CM simulates strong annual mean warming in the Eurasian interior reaching $2-4\ K$, $4-6\ K$, and $4-7\ K$ for the SRES scenarios B1, A1B, and A2 respectively. In line with the results obtained for the 20th century, the warming is strongest during the cold part of the year. Annual precipitation increases by $5-25\%$ depending on region and anthropogenic scenario.