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Climate Impacts of Large-scale Wind Farms as Parameterized in a Global Climate Model

Anna Fitch (1,2)

(1) Swedish Meteorological and Hydrological Institute, Norrköping, Sweden, (2) National Center for Atmospheric Research, Boulder, USA

The local, regional and global climate impacts of a large-scale global deployment of wind power in regionally high densities over land is investigated for a 60 year period. Wind farms are represented as elevated momentum sinks, as well as enhanced turbulence to represent turbine blade mixing in a global climate model, the Community Atmosphere Model version 5 (CAM5). For a total installed capacity of 2.5 TW, to provide 16% of the world's projected electricity demand in 2050, minimal impacts are found, both regionally and globally, on temperature, sensible and latent heat fluxes, cloud and precipitation. A mean near-surface warming of 0.12+/-0.07 K is seen within the wind farms. Impacts on wind speed and turbulence are more pronounced, but largely confined to within the wind farm areas. Increasing the wind farm areas to provide an installed capacity of 10 TW, or 65% of the 2050 electricity demand, causes further impacts, however, they remain slight overall. Maximum temperature changes are less than 0.5 K in the wind farm areas. Impacts, both within the wind farms and beyond, become more pronounced with a doubling in turbine density, to provide 20 TW of installed capacity, or 130% of the 2050 electricity demand. However, maximum temperature changes remain less than 0.7 K. Representing wind farms instead as an increase in surface roughness generally produces similar mean results, however, maximum changes increase and influences on wind and turbulence are exaggerated. Overall, wind farm impacts are much weaker than those expected from greenhouse gas emissions, with global mean climate impacts very slight.