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Spatially distributed modeling of renewable energy production on a regional scale

Veronika Hofer, Monika Prasch, and Wolfram Mauser

Ludwig-Maximilians-University Munich, Faculty of Geosciences, Department of Geography, Germany
(v.hofer@iggf.geo.uni-muenchen.de)

The region Oberland adjacent to the Bavarian Alps in Germany has set itself the goal to become independent of fossil fuels by 2035. In order to demonstrate different scenarios of a possible energy mix for electricity and heat, a process-based model approach for simulating renewable energy technologies (i.e. production technologies such as photovoltaic and solar thermics, wind energy, near-surface and deep geothermal energy as well as storage technologies such as batteries, buffer storage, power to heat, and power to gas) is developed and integrated into the physically-based spatial land surface process model PROMET. Therein, each energy form is calculated separately with consideration of specific locations of households, energy plants, and storages. The tool takes into account climatic (air temperature, wind speed, direct and diffuse solar irradiation) and natural conditions (soil substrate and soil temperatures) as well as technical parameters (efficiencies and rated output). The validation of the wind power and solar power production submodules is presented. Hourly wind speed and monthly wind power yield measurements of a 600 kW wind turbine located in the region are compared to simulated values for the years 2004 – 2015. The model accuracy reaches high values of R^2 = 0.71 and NSE = 0.66 (Nash-Sutcliffe Efficiency) for wind speed simulation and of R^2 = 0.80 and NSE = 0.73 for wind power yield. The solar power production module is validated by means of hourly power yield measurements taken from 13 different photovoltaic plants located within the entire range of the region and hourly solar irradiation measurements from one climate monitoring station near the center of the region for different periods within the years 2009 - 2016. Reached model validity is also high concerning incoming global radiation with R^2 = 0.81 and NSE = 0.81. The performance of the photovoltaic devices can be reproduced with an accuracy of R^2 = 0.70 and NSE = 0.68. In the next steps, daily and seasonal periods of energy deficit and surplus are compared to the demand on different scales. Further, the need of additional production plants and storage facilities will be quantified, which eventually shall be implemented into the model environment.