Geophysical Research Abstracts
Vol. 21, EGU2019-13091-1, 2019
EGU General Assembly 2019

Analyzing spatiotemporal covariance and climatic driven fluctuations in runoff to assess regulatory needs in hydropower production

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A key problem for adapting an electricity system dominated by renewable energy is to optimize the locations of wind- and hydropower stations over large regions with different conditions for power production combined with a significant climate-driven variation in renewable energy supply. A significant challenge is the substantial covariation in the supply of renewable energy, which exists on long periods, over large geographical areas and between different renewables. As a consequence, this covariation may significantly increase or decrease the requirements for storage capacity and/or backup power. Especially, negative correlation will contribute to decreasing storage need. In Sweden, hydropower plays a crucial role for the electricity production accounting for around 40% of the total generated electricity and 20% of hydropower storage in Europe (Russia and Turkey excluded). This important energy balancing resource will increase even more in importance in a future energy system, as the share of renewable intermittent energy sources increases.

Here, we performed a detailed analysis of the spatiotemporal variability in runoff and wind energy covering the entire Sweden. The analyses were based on historical hydrological data simulated using a hydrological model with a high spatial resolution, with the aim to spectrally decompose the water availability in both time and space and identify key periodicities and spatial patterns affecting the covariance in hydrological parameters. The assessment comprised a study of the importance of the spatial extent of the investigated areas (i.e. the level of aggregation of sub-watersheds) and how the covariance decays with separation distance between the investigated areas, opening for spatial coordination over larger geographical regions. The results highlights how information of climatic variations in e.g. water availability as a basis for forecasts of hydro power production, can serve as a tool to improve the planning of electricity generation and investments in power systems.