EGU24-1227, updated on 15 Aug 2024
https://doi.org/10.5194/egusphere-egu24-1227
EGU General Assembly 2024

Increases in extreme power shortage events of wind-solar supply systems worldwide

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Extreme power shortage events, especially occurred in wind-solar hybrid supply systems, are longstanding serious threats to safeguard energy security and socioeconomic stabilization. Here, 43 years of hourly reanalysis climatological data are leveraged to examine historical trends in defined extreme long-duration and low-reliability events in wind-solar systems worldwide. We find interannual and decadal uptrends in the two types of defined extreme power shortage events regardless of their frequency, duration, and intensity since 1980. For instance, duration of extreme low-reliability events worldwide has increased by 5.39 hours (0.113 hours y^{-1} on average) between 1980–2000 and 2001–2022. However, such ascending trends are unevenly distributed worldwide, with a higher variability in low- and middle-latitude developing countries but a smaller change in high-latitude developed countries. This observed uptrends in extreme power shortage events are primarily driven by increases in extremely low wind speeds instead of solar radiation. However, the changes in power shortage events and extremely low wind speeds are strongly disproportionated. Only 8.80% change in extremely low wind speed gives rise to over 30% variability in extreme power shortage events, despite a mere 1.26% change in average wind speed. Our findings underline that wind-solar hybrid supply systems will probably suffer from weakened power security if such upwards trends persist in a warmer coming future.