Impact of solar eclipses on weather variables for the energy sector

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Objective & Background

Energy consumption and production heavily depend on weather conditions, in particular temperature and wind speed, solar radiation and cloud cover. Grid and renewable power plant operators strongly rely on the quality of weather forecasts to ensure the security of the energy supply and the overall supply-demand balance.

Solar eclipses reduce incident ground solar radiation during a couple of hours in a proportion that depends on the location on Earth and the configuration of the eclipse. The change in radiation is relatively abrupt and intense on a wide area and could lead, in clear sky conditions, to a sudden massive decrease in solar power production followed by a similar increase. An eclipse can thus be seen as a sort of massive ramping event, possibly threatening the safety of the grid and energy supply if not anticipated.

This work aims to implement solar eclipses effects in Météo-France's NWP models and assess the impacts on the main weather variables relevant for the energy sector on recent cases of eclipses over Europe. The advantage of including solar eclipses within the NWP model lies in the fact that effects on other variables than radiation -for instance temperature - are fully accounted for.

Method

Solar eclipses have been integrated in AROME and ARPEGE thanks to a collaboration with Institut de Mécanique Céleste et de Calcul des Ephémérides [IMCCE]. The implementation was validated on a simulation of the eclipse of the June 10th 2021. Impacts on incident ground solar radiation, 2-meter air temperature, cloud cover and 10-meter wind speed were assessed on the case study of the eclipse of March 20th 2015 and October 25th 2022.

In addition the effect of the eclipse on the power production has been assessed by coupling the NWP output under consideration of the eclipse to a regional PV model. The effect of the eclipse on the national photovoltaic poser production of the different european countries has thus been evaluated and analysed to anticipate its impacts.

Principal Findings

Impacts are rather limited in cloudy conditions but sizeable under clear skies, where the reduction in solar radiation approximately equals the obscuration.

A decrease of the 2-meter air temperature electricity consumption-related weighted mean over France of approximately 2°C for the 2015 eclipse and a decrease of approximately 1°C near Lazu, Romania, for the 2022 eclipse were attributed to the occurrence of the eclipses by the simulations.

A slight diminution of the wind speed (-0.3 m/s) was noticed during the 2022 eclipse in Lazu, followed by the establishment of a horizontal compensatory circulation between the shaded areas and the surrounding warmer regions, very lightly increasing the wind speed.

The conclusions made for the solar radiation can be generalized to the solar power generation: the reduction can be approximated as first order as proportional to the obscuration.

The magnitude of the impacts of the eclipse on both the weather and the photovoltaic power production seems to substantially depend on the initial weather conditions (not only cloud cover).