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Impact of aerosols on solar energy production – Scenarios from the Sahel Zone

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Solar energy is one option to serve the rising global energy demand with low environmental impact. Building an energy system with a considerable share of solar power requires long-term investment and a careful investigation of potential sites. Therefore, understanding the impacts from varying regionally and locally determined meteorological conditions on solar energy production will influence energy yield projections. Aerosols reduce global solar radiation due to absorption and scattering and therewith solar energy yields. Depending on aerosol size distribution they reduce the direct component of the solar radiation and modify the direction of the diffuse component compared to standard atmospheric conditions without aerosols. The aerosol size distribution and composition in the atmosphere is highly variable due to meteorological and land surface conditions. A quantitative assessment of aerosol effects on solar power yields and its relation to land use change is of particular interest for developing countries countries when analyzing the potential of local power production.

This study aims to identify the effect of atmospheric aerosols in three different land use regimes, namely desert, urban/polluted and maritime on the tilted plane of photovoltaic energy modules. Here we focus on the Sahel zone, i.e. Niamey, Niger (13.5 N;2.1 E), located at the edge of the Sahara where also detailed measurements of the atmospheric state are available over the year 2006. Guided by observations a model chain is used to determine power yields. The atmospheric aerosol composition will be defined by using the Optical Properties of Aerosols and Clouds (OPAC) library. Direct and diffuse radiation (up- and downward component) are then calculated by the radiative transfer model libRadtran which allows to calculate the diffuse component of the radiance from different azimuth and zenith angles. Then the diffuse radiance will be analytically transformed to an east, south and west facing module with different tilting angles (between 0° and 45°) from each direction and compared to the tilted diffuse radiation derived by the Perez-model (Loutzenhiser et al. 2007) which is widely used in the photovoltaic community. This will allow an assessment how well standard approaches work in tropical region under various aerosol conditions including strong dust outbreaks from the Sahara.

This presentation will introduce the modeling chain to assess solar power yields for different photovoltaic modules in the Sahel zone and address their relative dependence on aerosol conditions.