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Quantification of Solar Surface Radiation in the Alps

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Solar radiation is the driver of the Earth's weather and has been a key parameter in Meteorology ever since. Due to the rapid development in photovoltaics in the last decade, solar surface radiation has also become a central quantity for electrical engineers dealing with photovoltaics (PV). In many cases photovoltaic plants are already economically viable. For the design of PV-plants and for local and regional energy planning, high precision solar surface radiation estimations are indispensable.
Within the Interreg IV project "Solar Tirol" we combined state of the art meteorological methods and common tools in Geographical Information Systems to derive monthly and annual solar surface climatology data. Project base data are derived from a Lidar field campaign and cover the main valleys of South Tirol (1500 km^2 with a spatial resolution of 0.5 m). Far shading from the surrounding mountains and near shading from nearby obstacles like houses and trees are taken into account. Aerosols and water vapor input data are taken from MACC (Monitoring atmospheric composition & climate) service, whereas the surface albedo is retrieved from satellite data. The clear-sky radiation is modelled using cloud index provided by Meteoswiss (data from 2004 to 2013). To validate our data, we use several ground station measurements of global irradiance (pyranometer). At Bolzano Airport data from two pyranometer model CMP11 (one measuring global irradiance and the other one diffuse irradiance) and a pyrheliometer model CHP1 measuring direct irradiance are available for our study. Furthermore we study small scale effects by validating radiation at 7 microclimatic stations (pyranometer, Apogee Instruments) in an Alpine catchment.
A comprehensive validation of solar surface radiation, using ground station measurements in South Tirol will be presented. We performed a validation for different time scales (daily, monthly, annually) with a focus on the needs of the PV community. Mean absolute bias (MAB) is in the order of 10 W/m^2 for monthly and annually and 20 W/m^2 for daily values. Although only measurements with horizontal irradiance are available an attempt is made to estimate the accuracy of our radiation calculation on tilted surfaces (roofs). Our results show, that shadowing by mountains has a surprisingly low impact on monthly and annual irradiation. In contrast the impact of clouds is very high and difficult to properly account for in complex terrain. Especially in summer time a high resolution cloud detection could improve the accuracy of our calculations significantly.