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Simulating 15 years of surface solar radiation at Lampedusa island using MODIS satellite and local cloud optical thickness data

Konstantinos Tsioumitas (1), Nikolaos Hatzianastassiou (1), Nikolaos Benas (2), Daniela Meloni (3), Giandomenico Pace (3), Alcide di Sarra (3), Christos Matsoukas (4), and Ilias Vardavas (5)

(1) Laboratory of Meteorology, Department of Physics, University of Ioannina, 45110, Ioannina, Greece , (2) R & D Satellite Observations Department, Royal Netherlands Meteorological Institute (KNMI), Netherlands , (3) , Laboratory for Observations and Analyses of Earth and Climate, Via Anguillarese 301, 00123 Rome, Italy, (4) Department of Environment, University of the Aegean, 81100 Mytilene, Greece, (5) Department of Physics, University of Crete, 71110 Heraklion, Crete, Greece

Surface solar radiation (SSR) is a key component of the surface energy budget, which is a major driver of the Earth's climate, while it plays a crucial role in many physical processes and applications like evaporation, photosynthesis or renewable energy. Therefore, accurately determining SSR at scales ranging from local to global is of primary importance. Clouds are a major modulator of SSR playing a significant role for weather and climate. In particular, their effect on SSR strongly depends on cloud optical thickness (COT). Both SSR and COT are characterized by a strong geographical variability. Thus, it is important to develop tools and methods for estimating both of them for specific world locations. In the present study, such an effort is made using a radiative transfer model (RTM) along with satellite and surface measurements to compute a climatology of SSR and COT for the island of Lampedusa, in the central Mediterranean (35.5°N, 12.6°E) between Sicily and the Tunisian coasts.

The FORTH deterministic spectral RTM is used to estimate SSR at Lampedusa. The model is initialized with daily instantaneous (satellite overpass time) Level-2 Terra Moderate Resolution Imaging Spectroradiometer (MODIS) satellite data for aerosol, cloud and other atmospheric and surface parameters, at resolutions of 10 km x 10 km and 5 km x 5 km. Missing data of surface albedo are replaced by high-resolution (1-km) MODIS MCD43B3 data. The daily SSR fluxes are computed with the RTM and MODIS satellite data for the period 2001-2015. These fluxes are compared to available corresponding SSR measured by Eppley PSP and Kipp&Zonen CMP21 pyranometers installed at the ENEA (National Agency for New Technologies, Energy, and Sustainable Economic Development of Italy) Station for Climate Observations in Lampedusa. The calibration of the pyranometers is updated approximately every year; corrections are made for instrumental cosine response, temperature, and thermal offset.

A comparison among COT data retrieved from MODIS-Terra and estimated by applying an empirical algorithm to the SSR observations is carried out. The local surface-based COT data are subsequently introduced in the RTM to compute new SSR fluxes, which are compared with the corresponding pure satellite-based SSR fluxes. This comparison allows us to determine the effect of using surface-based local COT data instead of satellite ones on computed SSR fluxes. The comparison between the two sets of model computed SSR fluxes against corresponding pyranometers' measurements leads us to conclude whether surface- or satellite-derived COT data perform better.