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The effect of clouds on shortwave radiation over the Mediterranean basin based on recent satellite data

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Clouds are an important element of the climate system as they have a big impact on the Earth's energy balance. More specifically, they affect both shortwave and longwave radiation producing the "albedo" and the "greenhouse" effects, respectively, thus cooling and warming the Earth, while they modify the radiative cooling and heating profiles in the atmosphere. The role of clouds for the climate system can be described using the concept of radiative forcing, which is appropriately estimated with models.

In the present study, the cloud radiative effect (CRE) on shortwave (SW) radiation is investigated over the broader Mediterranean basin that is one of the most climatically sensitive regions of our planet. More specifically, the temporal and spatial variability of CRE is examined on a gridded 2.5ºx2.5º equal angle latitude-longitude and mean monthly basis, for the 7-year period (March 2000 - February 2007), by using a deterministic spectral radiation transfer model and quality cloud data taken from the ISCCP and MODIS satellite databases. The model input data for various surface and atmospheric parameters, are mainly taken from the MODerate resolution Imaging Spectroradiometer (MODIS) of NASA (National Aeronautics and Space Administration), the National Centers for Environmental Prediction – National Center for Atmospheric Research (NCEP/NCAR) Global Reanalysis project, and the International Satellite Cloud Climatology Project (ISCCP-D2). The CRE computations are performed in the spectral range 0.2–10 μm. The model computes the cloud effect on the SW radiation budget of the Earth-atmosphere system, namely at the top of atmosphere (TOA reflected solar radiation, CRE_{TOA}), within the atmosphere (absorbed solar radiation, CRE_{atmab}), and at the surface (downwelling and absorbed solar radiation, CRE_{surf} and $\mathrm{CRE}_{surfnet}$).

The ISCCP-D2 cloud data include: cloud amount, cloud-top pressure, cloud-top temperature, liquid water path, and optical depth for total clouds. ISCCP provides cloud amount and cloud-top temperature separately for low-, mid-, and high-level clouds, as well as cloud amount, cloud-top temperature, cloud optical depth, and cloud albedo separately for ice and liquid water phase clouds. Given the criticism received recently by ISCCP cloud products, specifically cloud amount (A_c), in this work qualitative similar data that were made available from MODIS are also used. A detailed inter-comparison has been performed between A_c from the two databases emphasizing on assessing spatio-temporal patterns in the area indicated by them. The computed relative difference between MODIS and ISCCP annual mean Ac for the broader Mediterranean basin equals 1.05%, and the correlation coefficient is equal to 0.93. Also, both data sets indicate an increase in the regional mean Ac over the period 2000-2007, equal to 8.8% based on MODIS and 6.9% based on ISCCP.

According to the model results, the annual regional mean CRE_{TOA} equals -35.3±1.4 Wm^{-2}, (with local values ranging from -56 to -17 Wm^{-2}) indicating thus a "planetary" cooling of the study region caused by clouds. Clouds also increase the atmospheric absorption of SW radiation (CRE_{atmab}) by 10.8±0.4 Wm^{-2} (values up to 21 Wm^{-2}) inducing thus a significant warming of the region's atmosphere. As a result, clouds are found to decrease the downwelling and absorbed SW radiation at surface (CRE_{surf} and $\mathrm{CRE}_{surfnet}$) by -54.2±2.1 and -46.1±1.8 Wm^{-2}, respectively (with local values as large as -83 and -75 Wm^{-2}, respectively), inducing thus an important surface radiative cooling. The regional mean cloud SW radiative effect at surface is found to have increased during the first 7 years of this century, having thus produced a cloud dimming

CREs are maximum over areas with larger clouds amounts, namely the northern parts of the study region. Therefore the existence of clouds in the region, actually strengthens the north-to-south gradient of surface solar radiation and hence temperature.