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Solar absorption in the atmosphere – estimates from collocated surface and satellite observations over Europe

Maria Zyta Hakuba (1), Doris Folini (1), Martin Wild (1), and Gabriela Schaepmann-Strub (2)

(1) ETH Zurich, Institute for Atmospheric and Climate Science, Zurich, Switzerland (maria.hakuba@env.ethz.ch), (2) Institute of Evolutionary Biology and Environmental Studies, University of Zurich, Switzerland (gabriela.schaepman@ieu.uzh.ch)

Solar radiation is the primary source of energy for the Earth's climate system. While the incoming and outgoing solar fluxes at the top-of-atmosphere can be quantified with high accuracy, large uncertainties still exist in the partitioning of solar absorption between surface and atmosphere. To compute best estimates of absorbed solar radiation at the surface and within the atmosphere representative for Europe during 2000-2010, we combine ground-based observations of surface downwelling solar radiation (GEBA, BSRN) with collocated satellite-retrieved surface albedo (MODIS) and top-of-atmosphere net irradiance (CERES EBAF, 1° resolution). The combination of these datasets over European land yields best estimates of annual mean surface and atmospheric absorption of 117 $\pm$6 Wm^{-2} (42 $\pm$2 % of TOA incident irradiance) and 65 $\pm$3 Wm^{-2} (23 $\pm$1 %). The fractional atmospheric absorption of 23% represents a robust estimate largely unaffected by variations in latitude and season, thus, making it a potentially useful quantity for first order validation of regional climate models.

These estimates are based on quality assessed surface data. First of all, we examine the temporal homogeneity of the monthly GEBA time series beyond 2000 and find the vast majority to be suitable for our purposes. The spatial representativeness of the GEBA and BSRN sites for their collocated 1° CERES EBAF grid cells we assess by using a satellite-derived surface solar radiation product (CM SAF) at 0.03° spatial resolution. We find representation errors of on average 3 Wm^{-2} or 2% (normalized by point values).

Care is taken to identify and quantify uncertainties, which arise mostly from the measurements themselves, in particular surface albedo and ground-based solar radiation data. Other sources of uncertainty, like the spatial coverage by surface sites, the multiplicative combination of spatially averaged surface solar radiation and surface albedo, and the spatial representativeness of the point observations, are either negligibly small or can be corrected for.