EMS Annual Meeting Abstracts
Vol. 20, EMS2023-564, 2023, updated on 20 May 2024
https://doi.org/10.5194/ems2023-564
EMS Annual Meeting 2023

Estimation of atmospheric parameters and solar irradiance based on a sky imaging system

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The presentation refers to DeepSky, a project aiming to develop an innovative and flexible on-site measurement system to fully address the needs of end-users of the meteorological, atmospheric and solar communities. DeepSky is based on the analysis of information retrieved by two head camera (an all-sky imager (ASI) and a thermal camera), radiative transfer in solar / thermal spectral bands and methods of computational optics and deep learning. The proposed system is able to reliably assess a range of geophysical variables (solar radiation, cloud cover percentage and type, aerosol optical properties, etc.).

For this scope, a bouquet of methodologies has been developed. Aerosol Optical Depth (AOD) is retrieved by the ratio of red to blue (RBR) color intensities, which are relevant to radiances at wavelengths 440 nm and 675 nm. A cloud type identification methodology is presented by exploiting the sky condition information: the proposed methodology uses a k-Nearest-Neighbor algorithm, considering as inputs specific information derived from the ASI such as color intensity, the cloud coverage, the saturated area around the Sun, the raindrop appearances and solar zenith angle. A methodology to retrieve precipitable water under cloud-free conditions using images from a thermal-infrared camera is also presented, by examining the relationship between PW and zenith-sky temperature.

Finally, this work is focused on modeling the global and diffuse horizontal irradiances (GHI and DHI) using deep learning techniques and ASI-derived information. The preliminary estimations underestimate GHI and DHI observations with systematic biases of –1.8 W m^{-2} and –0.5 W m^{-2}, while the dispersion errors are 82.7 W m^{-2} and 39.8 W m^{-2}, respectively. The correlation coefficient is high, approaching 0.95 and 0.85 for GHI and DHI.

Overall, a new on-site monitoring system is presented covering multiple needs in the areas of atmospheric physics and solar energy and providing parameters for which separate instruments would be needed.