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Quantifying the Clear-sky Bias of Satellite Land Surface Temperature Climate Data Records using Microwave-based Estimates

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The Land surface temperature (LST) is one of the most relevant parameters when addressing the physical processes that take place at the surface of the Earth. Satellite data are particularly appropriate for measuring LST over large areas with high temporal resolution. The estimation of LST from space-borne sensors has been systematically performed at a global scale for over three decades and LST climate data records (CDRs) are available e.g. from the International Satellite Cloud Climatology Project and the Pathfinder Atmospheres-Extended dataset, opening new perspectives for climate monitoring.

Most available long-term databases of Land Surface Temperature (LST) derived from space-borne sensors rely on infrared (IR) observations. Although there is a large number of IR sensors on-board geostationary satellites and polar orbiters providing LST retrievals with different temporal and spatial resolutions, the use of IR observations limits LST estimates to clear-sky conditions. The use of IR LST datasets may therefore result in analyses that are "biased" towards clear-sky conditions and not representative of all-weather conditions. Such "clear-sky bias" of IR-based LST (defined here as the difference between average clear-sky and average all-weather LSTs) has never been quantified. Hence, the true impact of relying only on clear-sky data is still uncertain. On the other hand, an "all-weather" global LST database may be obtained from passive microwave (MW) measurements, which are much less affected by clouds. Using the subset of clear-sky MW LST as a surrogate for IR LST, global maps of "LST clear-sky bias" can therefore be generated that will allow making a first assessment of the spatial and temporal characteristics of the deviations.

A 3-year record of all-weather MW LST is used here to provide a first quantification of the clear-sky bias of IR LST at the global scale. The LST dataset used for this purpose relies on MW observations provided by the Advanced Microwave Scanning Radiometer–Earth Observing System (AMSR-E) onboard NASA's Aqua satellite and is publicly available through the ESA DUE GlobTemperature project.

The amplitude of the bias is closely related to the fraction of clear-sky days and, therefore, arid regions are associated to very low values of bias whereas mid-latitudes present the highest values. During daytime, the input of solar radiation for clear-sky situations leads to higher LST values and therefore the bias is generally positive (e.g, 2-8 K over the mid-latitudes) whereas, during nighttime, the bias is generally negative although with lower amplitude (around -2 K), because of the increased radiative cooling for clear-sky situations. The clear, cloudy and all-sky LSTs are also compared with near-surface air temperature. Although LST is generally higher than air temperature, the contrast between the two may be strongly influenced by local weather conditions. Both the clear-sky bias and differences between LST and air temperature are also analyzed at the local scale taking into account the predominant cloud regime.