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Multi-year in situ validation of major satellite land surface temperature data sets over multiple stations

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This contribution presents the results of a systematic validation of several state-of-the-art satellite data sets of land surface temperature (LST) against in situ data. LST can be obtained with satellite remote sensing and is a useful quantity for various applications within climate research. Information on the quality of satellite derived LST data is usually gained by validating it against in situ data, which is generally based on investigating the absolute differences between the two data sets.
In the work presented here, LST data sets from several polar-orbiting and geostationary satellites, namely AATSR, GOES, MODIS and SEVIRI, are compared over two sets of in situ stations, operated by Karlsruhe Institute of Technology (KIT) and by the National Oceanic and Atmospheric Administration (NOAA) (Surface Radiation Budget Network - SURFRAD stations). The stations are located throughout the world and cover different land surface types, climates, biomes and topographies. Three years of satellite LST data are validated over all stations and, thanks to longer data availability, ten years over the SURFRAD sites.
All satellite, in situ and matched data sets were produced in a harmonized format developed in the framework of ESA's GlobTemperature (GT) project. The obtained results are directly comparable to each other, as all validations follow a standardized approach.
The results of the validations show that the differences between satellite and in situ LST are strongly influenced by spatial homogeneity, land cover class and orography. For the years 2010 – 12, overall differences between satellite and in situ LST are often within 2 K, with generally better results during night. During day, when shadows are present and the influence of heterogeneous land covers is higher, the observed differences increase. AATSR and MODIS LST tend to exceed the corresponding in situ LST values, whereas SEVIRI and GOES LST tend to be lower than the in situ LST.
Time series of LST differences were also investigated at each station separately. A seasonal cycle was observed for most data sets, but its magnitude varied significantly with station and satellite data set. It was strongest for a station located in a heterogeneous landscape and for a station exposed to rainy seasons. At another station located in a valley, a considerable influence from topography was found. At two stations, directional effects from bushes or trees were clearly visible in the analyses.
The results show that it is important to investigate the differences between the area-integrated satellite measurements and the in situ point measurement for each site separately in order to be able to interpret the many factors influencing the results at each station.
In situ validation of LST is a well-established and reliable method to gain information on the quality of satellite LST data sets and the large GT data base makes it feasible to perform standardised validations and inter-comparisons. The results presented here provide a baseline for further validation work and for constructing a larger and more comprehensive data base within ESA's Climate Change Initiative (CCI) LST project.