Geophysical Research Abstracts
Vol. 20, EGU2018-16003, 2018
EGU General Assembly 2018

All-weather land surface temperature estimates from microwave satellite observations, over several decades and real time: methodology and comparison with infrared estimates

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The land surface temperature can be estimated from satellite passive microwave observations, with limited contamination from the clouds as compared to the infrared satellite retrievals. With ∼60% cloud cover in average over the globe, there is a need for "all weather," long record, and real-time estimates of land surface temperature (LST) from microwaves. A simple yet accurate methodology is developed to derive the land surface temperature from microwave conical scanner observations, with the help of pre-calculated land surface microwave emissivities. The method is applied to the Special Sensor Microwave/Imagers (SSM/I) and the Earth observation satellite (EOS) Advanced Microwave Scanning Radiometer (AMSR-E) observations, regardless of the cloud cover.

The SSM/I results are compared to infrared estimates from International Satellite Cloud Climatology Project (ISCCP) and from Advanced Along Track Scanning Radiometer (AATSR), under clear-sky conditions. Limited biases are observed (∼0.5 K for both comparisons) with a root-mean-square difference (RMSD) of ∼5 K, to be compared to the RMSE of ∼3.5 K between ISCCP et AATSR. AMSR-E results are compared with the Moderate Resolution Imaging Spectroradiometer (MODIS) clear-sky estimates. As AMSR-E and MODIS are on board the same satellite, this reduces the uncertainty associated to the observations match-up, resulting in a lower RMSD of ∼ 4K. AMSR-E is also compared with the Spinning Enhanced Visible and Infrared Imager (SEVIRI), the Geostationary Operational Environmental Satellite (GOES) Imager, and the Japanese Meteorological Imager (MTSAT). When comparing with all infrared sensors, the STD of the differences between microwave and infrared LST is generally higher than between IR retrievals. However, the biases between microwave and infrared LST are, in some cases, of the same order as the ones observed between infrared products.

The microwave LSTs are also compared to in situ LST time series from a collection of ground stations over a large range of environments. For 22 stations available in the 2003-2004 period, SSM/I LSTs agree very well for stations in vegetated environments (down to RMSD of ∼2.5 K for several stations), but the retrieval methodology encounters difficulties under cold conditions due to the large variability of snow and ice surface emissivities. For 10 stations in the year 2010, AMSR-E presents an all-station mean RMSD of ∼4.0 K with respect tom the ground LSTs. Over the same stations, MODIS agrees better (RMSD of 2.4 K), but AMSR-E provides a larger number of LSTs estimates by being able to measure under cloudy conditions, with an approximated ratio of 3 to 1 over the analysed stations. At many stations the RMSD of the AMSR-E clear and cloudy-sky are comparable, highlighting the ability of the microwave inversions to provide LSTs under most atmospheric and surface conditions.