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All-weather estimates of the land surface skin temperatures from a combined analysis of microwave and infrared satellite observations

Jimenez Carlos (1), Aires Filipe (2), Catherinot Julie (3), Catherine Prigent (1), and Rossow Bill (3)

(1) Observatoire de Paris, LERMA, Paris, France (carlos.jimenez@obspm.fr), (2) CNRS/IPSL/LMD, University Paris VI, Paris, France, (3) NOAA CREST, City College of New York, New York, USA

The surface skin temperature (Ts) is a key parameter at the land-atmosphere interface. Upwelling longwave radiation directly depends upon Ts. Energy exchanges at the land-surface boundary are largely controlled by the difference between Ts and the surface air temperature, the air and the surface reacting with different time and space scales to external forcing while still being complexly interconnected. The partition of net radiation at the land surface into latent and sensible heat fluxes, which can be parameterized in terms of the skin - air temperature differences, is a crucial problem spanning all spatial and temporal scales.

Global datasets of Ts are estimated from satellite infrared radiance observations. The main limitation of satellite infrared measurements of Ts is their inability to penetrate clouds, limiting them to clear conditions. Microwave wavelengths, being much less affected by clouds than the infrared, are an attractive alternative in cloudy regions as they can be used to derive an all-sky skin Ts product.

A neural network inversion scheme has been developed to retrieve surface Ts along with Ts also atmospheric water vapor, cloud liquid water, and surface emissivities over land from a combined analysis of Special Sensor Microwave /Imager (SSM/I) and International Satellite Cloud Climatology Project (ISCCP) data [1]. The retrieval scheme uses first guess information to better constrain the inversion problem, and provides along with the retrieved parameters an estimate of the retrieval error by judging the closeness between observed SSM/I radiances and the simulated radiances corresponding to the retrieved atmospheric state.

In the absence of routine in situ Ts measurements, retrieved Ts values are evaluated globally by comparison to the surface air temperature (Tair) measured by the meteorological station network [2]. This evaluation is now extended locally at a few sites by using the Ts in-situ measurements from several stations archived at the CEOP (Coordinated Enhanced Observing Period) data center.

The Ts-Tair difference from the global comparisons showed all the expected variations with solar flux, soil characteristics, and cloudiness. During daytime the Ts-Tair difference is driven by the solar insulation, with positive differences that increase with increasing solar flux. With decreasing soil and vegetation moisture, the evaporation rate decreases, increasing the sensible heat flux, thus requiring larger Ts-Tair differences. Nighttime Ts-Tair differences are governed by the longwave radiation balance, with Ts usually closer or lower than Tair. The presence of clouds dampens all the difference.

The evaluation with in-situ Ts from the the CEOP Earth Observing Period 4 is conducted at 20 stations representing different biomes. The ISCCP infrared Ts estimates, the derived microwave Ts, and a different microwave Ts estimate obtained by a linear regression with the 37 GHz measured radiances [3], are compared for selected months in 2003. The differences between the Ts estimates are analyzed for both cloudy and clear-sky conditions, using the ISCCP cloud flag. Large differences can be observed at some stations, which seems to depend on factors such as vegetation cover, cloudiness, temperature range, and homogeneity of the terrain around the station. To put the microwave-infrared Ts difference in perspective, clear-sky estimates from other infrared instruments, such as the Atmospheric Infrared Sounder (AIRS), and the Moderate Resolution Imaging Spectroradiometer (MODIS)) are also added to the comparison.

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