Combined passive microwave and infrared estimates of land surface skin temperature: application to the prediction of land surface turbulent fluxes

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INTRODUCTION — land surface skin temperature (Ts)

Despite their recognized importance in many applications, accurate measurements of Ts are not yet available for the whole globe, for clear and cloudy skies, with a time sampling adequate to resolve the diurnal cycle and to analyze synoptic, seasonal, and inter-annual variability. Ts is not conventionally observed by the meteorological weather station network. Satellite IR observations provide only clear air estimates of Ts.

PRODUCT — all-weather Ts from a combined analysis of MW and IR satellite observations

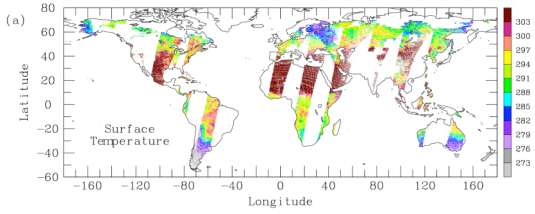

Fig. 1. Example of retrieved Ts in K from SSM/I observations on June 11, 93.

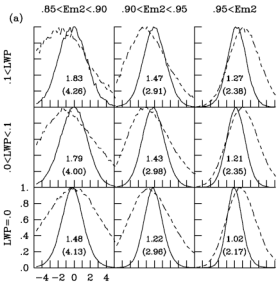

Fig. 2. Normalized histograms of the Ts theoretical retrieval error (retrieved Ts minus true Ts) in K. Results are presented for 3 ranges of liquid water path (LWP) (3 cloud conditions) and 3 ranges of emissivities at 19 GHz horizontal polarization (Em2). Solid lines indicates the errors with first guess and dashed lines without. The r.m.s errors are given with first guess and without first guess (in brackets).

A neural inversion scheme has been developed to retrieve simultaneously Ts, the atmospheric water vapor, the cloud liquid water and the surface emissivities over land from SSM/I observations [1]. The neural network is trained with a database of synthetic radiances generated from a global collection of coincident surface and atmospheric parameters extracted from the NCEP/NCAR reanalysis and ISCCP data. First guess information has been included in the inversion scheme using pre-calculated monthly-mean emissivities, ISCCP cloud and surface parameters and the meteorological analysis from NCEP/NCAR. The inversion scheme provides for each SSM/I observation Ts over land with a theoretical RMS error of 1.3 K in clear-sky and 1.6 K in cloudy scenes.

In the absence of in situ routine measurements of Ts, the retrieved Ts were evaluated by comparison to the surface air temperature (Tair) measured by the meteorological station network [2]. After suppression of the variability associated to the diurnal solar flux variations, the Ts and Tair data sets show very good agreement in their synoptic variations, even for cloudy cases, with no bias and a global RMS difference of 2.9 K. This is an upper limit of the retrieval error as includes the errors in the in situ data as well as the matching errors associated to imperfect time and space collocations

APPLICATION — using all-weather Ts to predict land surface sensible (Qh) and latent (Qle) fluxes

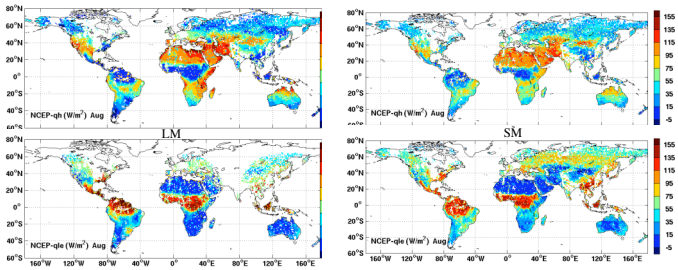

Fig. 3. Example of original LM (left panels) and predicted SM (right panels) monthly mean sensible (top panels) and latent (bottom panels) fluxes for August 93.

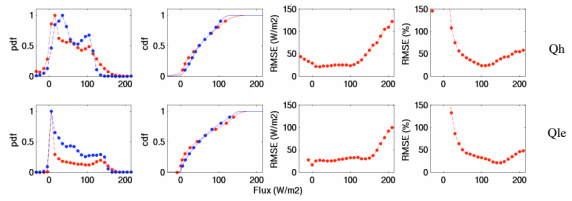

Fig. 4. Left to right, normalized pdf of the 93 LM original fluxes (red) and SM predicted fluxes (blue), the cdf, and the distribution of the RMS errors (absolute and relative).

Land heat fluxes are essential components of the water and energy cycles. Despite a large body of work, a robust land surface scheme to estimate a global, multi-decadal surface flux product does still not exist. As a step in that direction, we propose a statistical model (SM) based on neural networks that learns the global relationship between a suite of global satellite observations and the fluxes estimated by a given land model (LM) [3] . We used the SM to study first the satellite observations sensitivity to the fluxes, and then to produce a dataset of predicted land fluxes from the satellite data. The predicted fluxes cannot be considered as a pure satellite data inversion (as they are linked to the given LM), but they can be regarded as a tuning of the LM fluxes that is consistent with the satellite data (similar in nature to an assimilation process) and be used to identify potential problems in the LMs when the predicted fluxes deviate largely from the original LM fluxes.

An example of all-weather monthly mean fluxes predicted by such a scheme is presented. The SM links a suite of satellite data (AVHRR reflectances, ERS backscatter, SSM/I emissivities, and the previous MW Ts) with the land heat fluxes from the NCEP-NCAR reanalysis. The predicted fluxes have realistic spatial and seasonal patterns, with global correlations of 0.78 (Qh) and 0.87 (Qle) with the original LM fluxes, and global RMS errors of around 25 W/m^2.

NEXT — diurnal cycle of Ts (ΔTs)

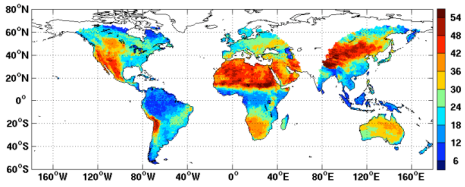

Fig. 5. Example of Ts diurnal cycle monthly means for May 93 estimated following the statistical technique detailed in [4] from ISCPP IR Ts.

Having ΔTs would help estimate the land surface fluxes. A new temporal interpolation algorithm designed to work when only a few Ts measurements are available has been developed and applied to reconstruct the ΔTs from ISCPP IR Ts [4]. The algorithm uses PCA techniques and does not require ancillary data or model constraints to estimate ΔTs. It can also be applied to reconstruct an all-weather ΔTs from the MW Ts, but this remains challenging due to the limited temporal sampling of the MW Ts.

REFERENCES

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