Geophysical Research Abstracts
Vol. 16, EGU2014-7023, 2014
EGU General Assembly 2014

Correcting atmospheric effects in thermal ground observations for hyperspectral emissivity estimation

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Knowledge of Land surface temperature is of crucial importance in energy balance studies and environmental modeling. Accurate retrieval of land surface temperature (LST) demands detailed knowledge of the land surface emissivity. Measured radiation by remote sensing sensors to land surface temperature can only be performed using a-priori knowledge of the emissivity. Uncertainties in the retrieval of this emissivity can cause huge errors in LST estimations.

The retrieval of emissivity (and LST) is per definition an underdetermined inversion, as only one observation is made while two variables are to be estimated. Several researches have therefore been performed on measuring emissivity, such as the normalized emissivity method, the temperature-emissivity separation (TES) using the minimum and maximum difference of emissivity and the use of vegetation indices. In each of these approaches atmospherically corrected radiance measurements by remote sensing sensors are correlated to ground measurements. Usually these ground measurements are performed with the ground equivalent of the remote sensing sensors; the CIMEL 312-2 has the same spectral bands as ASTER. This way parameterizations acquired this way are only usable for specific sensors and need to be redone for newer sensors.

Recently hyperspectral thermal radiometers, such as the MIDAC, have been developed that can solve this problem. By using hyperspectral observations of emissivity, together with sensor simulators, ground measurements of different satellite sensor can be simulated. This facilitates the production of validation data for the different TES algorithms. However before such measurements can be performed extra steps of processing need to be performed.

Atmospheric correction becomes more important in hyperspectral observations than for broadband observations, as energy levels measured per band is lower. As such the atmosphere has a relative larger contribution if bandwidths become smaller.

The goal of this research was to enhance current methods for estimation of hyperspectral emissivity from field measurements. In particular the research focused on the atmospheric correction of the hyperspectral data, and the estimation of emissivity and temperature. For this, radiation measurements over different vegetation types were performed using the MIDAC thermal hyperspectral radiometer.

The measurements of thermal radiation were performed in 2012 during ESA‘s REFLEX fieldcampaign and each consisted of rapid acquisition of 4 targets: a hot and cold black-body (with predefined temperature), a gold plate and the vegetation-component of interest (vegetation/soil). The high spectral resolution of the measurement (at 0.5 cm-1 resolution) enables the characterization of individual gaseous absorption features and consequently allows for the atmospheric correction.

Atmospheric correction of the 4 measurements was performed by creating a simple atmospheric correction model on basis of MODTRAN simulations. These MODTRAN outputs were converted to band resolutions using the spectral sensitivity of the MIDAC instrument. This approach enabled the estimation of different gas concentrations, such as C02 and H20, and at the same time atmospherically correct the raw measurements. Afterwards the data of the vegetation-component and gold plate (Infragold standard) were calibrated against the measurements of the hot/cold black bodies. Using the measurement of the gold plate the measured radiation from the vegetation-component was corrected for incoming radiation. Afterwards the temperature and emissivity of the vegetation-component was determined by fitting the atmospherically corrected data against the Planck curve.

The success of the methodology was tested against measurements performed simultaneously with the MIDAC acquisitions. The atmospheric correction approach was tested by comparing the retrieved gaseous concentrations with LICOR 7500 measurements of these constituents. The TES estimations were evaluated by comparing the retrieved temperature with measurements of the vegetation-component skin temperature. Preliminary results show that the atmospheric is able to retrieve similar gaseous concentrations as measured from the flux towers. Unfortunately the atmospheric correction of the radiances is troubled by a mismatch of sensor sensitivity of the actual MIDAC instrument and the one used in the sensor simulator. This causes that specific absorption features are not fully corrected for. As a consequence the temperature retrieved using the TES step of the approach provides higher uncertainties in comparison with the skin temperature measurements. At present we investigate the improvement of the sensor sensitivity in the simulator and will present the findings in the presentation.