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An End-to-End simulator for the development of atmospheric corrections and temperature – emissivity separation algorithms in the TIR spectral domain

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The development and optimization of image processing algorithms requires the availability of datasets depicting every step from earth surface to the sensor's detector. The lack of ground truth data obliges to develop algorithms on simulated data. The simulation of hyperspectral remote sensing data is a useful tool for a variety of tasks such as the design of systems, the understanding of the image formation process, and the development and validation of data processing algorithms.
An end-to-end simulator has been set up consisting of a forward simulator, a backward simulator and a validation module. The forward simulator derives radiance datasets based on laboratory sample spectra, applies atmospheric contributions using radiative transfer equations, and simulates the instrument response using configurable sensor models. This is followed by the backward simulation branch, consisting of an atmospheric correction (AC), a temperature and emissivity separation (TES) or a hybrid AC and TES algorithm. An independent validation module allows the comparison between input and output dataset and the benchmarking of different processing algorithms.
In this study, hyperspectral thermal infrared scenes of a variety of surfaces have been simulated to analyze existing AC and TES algorithms. The ARTEMISS algorithm was optimized and benchmarked against the original implementations. The errors in TES were found to be related to incorrect water vapor retrieval. The atmospheric characterization could be optimized resulting in increasing accuracies in temperature and emissivity retrieval.
Airborne datasets of different spectral resolutions were simulated from terrestrial HyperCam-LW measurements. The simulated airborne radiance spectra were subjected to atmospheric correction and TES and further used for a plant species classification study analyzing effects related to noise and mixed pixels.