Sub-Pixel Fractional Area of Wildfires from MODIS Observations:
Retrieval, Validation, and Potential Applications

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I. Introduction and Motivation

Using satellite, unmanned aircraft, and meteorological data, this study develops and validates a method to retrieve sub-pixel fire area fractions from pixels, detected at 1 km nominal spatial resolution, by the Moderate Resolution Imaging Spectroradiometer (MODIS). A two-component model (Dozier method) for retrieving sub-pixel area fraction and temperature has been available since 1981. However, in the current investigation, modifications are made to the retrieval to account for atmospheric effects by implementing output from a radiative transfer model at 3.95 and 11 μm (MODIS fire detection channels). In addition, two clustering techniques are implemented to remove potential sources of error that may exist when using individual pixels. The sub-pixel retrieval will not only provide a valuable step for improving the precision of wildfire size estimates, but also has potential for improving our understanding of the meteorological effects on fire radiative power (FRP). This may prove crucial for fire weather and air quality forecasters.

II. Data & Study Region

- MODIS geolocation, level1B radiances, and level 2, collection 5 fire product data (1 km resolution)
- Autonomous Modular Sensor (AMS)

AMS scans do NOT overlap
- T (MODIS/AMS) ± 15 min

Δ AMS data: Aug.-Oct. 2007

V. AMS & MODIS Comparisons

Pixel Level (Fig. 6)
- The retrieval shows some skill for a fire area greater than 0.001 km² (1000 m²), which corresponds to a fire area fraction of 0.001 in a 1 km MODIS pixel. Several MODIS pixel fire fractions are within 15% of the AMS fire fraction while others deviate by more than 75% (Fig. 7). These results are expected based on potential congestion issues and other random processes (e.g., Gage and Justice, 2003).

AMS Level (Fig. 8)
- The sum method produces the highest correlation (R²) suggesting that the random variation can be reduced by averaging when looking at a fire event as a whole.

Cluster Level (Fig. 9)

III. MODIS Hot Spot Retrieval

The original “Dozier” method (1981) uses the spectral contrast between a sub-pixel hot target and the surrounding (grey-valued) surroundings of the pixel for the 3.95 μm middle infrared (S1) and 11 μm thermal infrared (TIR) channels. This provides two equations that can be solved for the fire temperature (Tf) and the fractional area of the pixel covered by the fire (P). Unfortunately, the original Dozier method makes several unrealistic assumptions (Gage and Justice, 2001). Most significantly, all atmospheric corrections are neglected and the larger 1 km and background emissions are used here. A modification of the original method and accounts for atmospheric effects by incorporating a radiative transfer model.

IV. AMS Hot Spot Detection

Fiery AMS data can be used to validate MODIS retrievals, a method for AMS fire hot spot detection must be developed. In our approach, the process is a Viterbi algorithm for each MODS pixel under scrutiny, which greatly reduces the overall complexity of the validation process. The threshold is based on the one used in the Global Assessment of Fire (GAF) algorithm, which provides a fractional area of 0.001 in a 1 km MODIS pixel. These pixels have equal FRP?

Examples of AMS Fire Detection

 AMS Scan

Detection Procedure (Fig. 5)
- Based on the scatter plots and histograms at 6 and 11 μm, the retrieval shows some skill for a fire area fraction of 0.001 in a 1 km MODIS pixel. Several MODIS pixel fire fractions are within 15% of the AMS fire fraction while others deviate by more than 75% (Fig. 7). These results are expected based on potential congestion issues and other random processes (e.g., Gage and Justice, 2003).

References


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