GOES-R ABI Active Fire Algorithm Validation

Wilfrid Schroeder
Earth System Science Interdisciplinary Center, University of Maryland, College Park – USA
wilfrid.schroeder@noaa.gov
Co-Investigators: Ivan Csiszar (NOAA/NESDIS), Christopher Schmidt (Univ Wisconsin)

Introduction&Background

The GOES-R/ABI Active Fire algorithm will provide high frequency fire detection and characterization data for the Western Hemisphere at a nominal spatial resolution of 2km. The validation strategy for the fire algorithm builds on the use of near-coincident high spatial resolution airborne and spaceborne reference data sets to quantify sub-pixel fire activity imaged by ABI. Candidate airborne reference data sets include multispectral linescanners and/or focal plane array instruments operating at wavelengths in the VNIR-SWIR and/or MIR-LWIR spectrum, and at saturation temperatures above 600K. The spatial resolution of these instruments varies typically between 10-45m depending on the aircraft's height above ground. Candidate spaceborne reference data sets may be divided into two groups: Landsat-class and moderate spatial resolution data covering the mid-infrared spectrum. Both airborne and spaceborne reference data sets will provide a fire classification product (binary mask identifying fire-affected pixels) to validate fire detections, whereas complementary fire retrievals (e.g., fire radiative power estimates) may only be derived from a small data subset of those data due to saturation issues and other sensor limitations. Here we present these alternatives and describe the proposed science algorithms to be used to generate the corresponding fire reference data and to support the scaling-up analyses for the validation of the ABI fire product using NASA AMS and MASTER airborne data acquired over Western U.S. wildfires.

Fire Detection Data

The GOES-R ABI active fire detection *deep-dive* data validation method has been developed and tested using approximately 20 airborne reference scenes acquired over the Western U.S. Scene-independent fire detection and retrievals algorithms were developed for NASA AMS and MASTER airborne sensor data and used to quantify sub-pixel fire activity observed near-coincidently by GOES Imager data as a proxy for GOES-R ABI. Summary fire statistics are derived on a per-pixel basis and used to estimate fire size, temperature and fire radiative power (FRP).

Fire Characterization Data

The active fire characterization data retrieval methods are based primarily on two techniques that use mid- (4 μm) and thermal-infrared (11 μm) data to derive fire size and temperature, and fire radiative power (FRP).
The Dozier [1981] fire size and temperature retriveal is a bi-spectral method and has the following format:

$$L_4 = pB(\lambda_4, T_f) + (1-p)B(\lambda_4, T_b) + (1-\varepsilon_4)\tau_4 L_{4Solar}$$
$$L_{11} = pB(\lambda_{11}, T_f) + (1-p)B(\lambda_{11}, T_b)$$

Where L_4 and L_{11} are the top-of-atmosphere radiance in the 4 and 11 μm channels, p is the pixel fraction occupied by fire, and B is the planck function in channel i, T is the instanteneous temperature for the fire (f) and background (b) components, ε_4 and τ_4 are the 4 μm emissivity and transmittance values, respectively, and L_{4Solar} is the reflected solar radiance.

The fire radiative power is based on the radiance method of Wooster *et al.* [2003&2005] retrieval as has the form:

$$FRP = C \times (L_{MIR} - L_{MIRb}) \times A$$

Where L_{MIR} and L_{MIRb} are the mid-infrared radiances for the fire pixel and the background, C is a constant dependent on the 4 μm channel spectral response, and A is the pixel area.

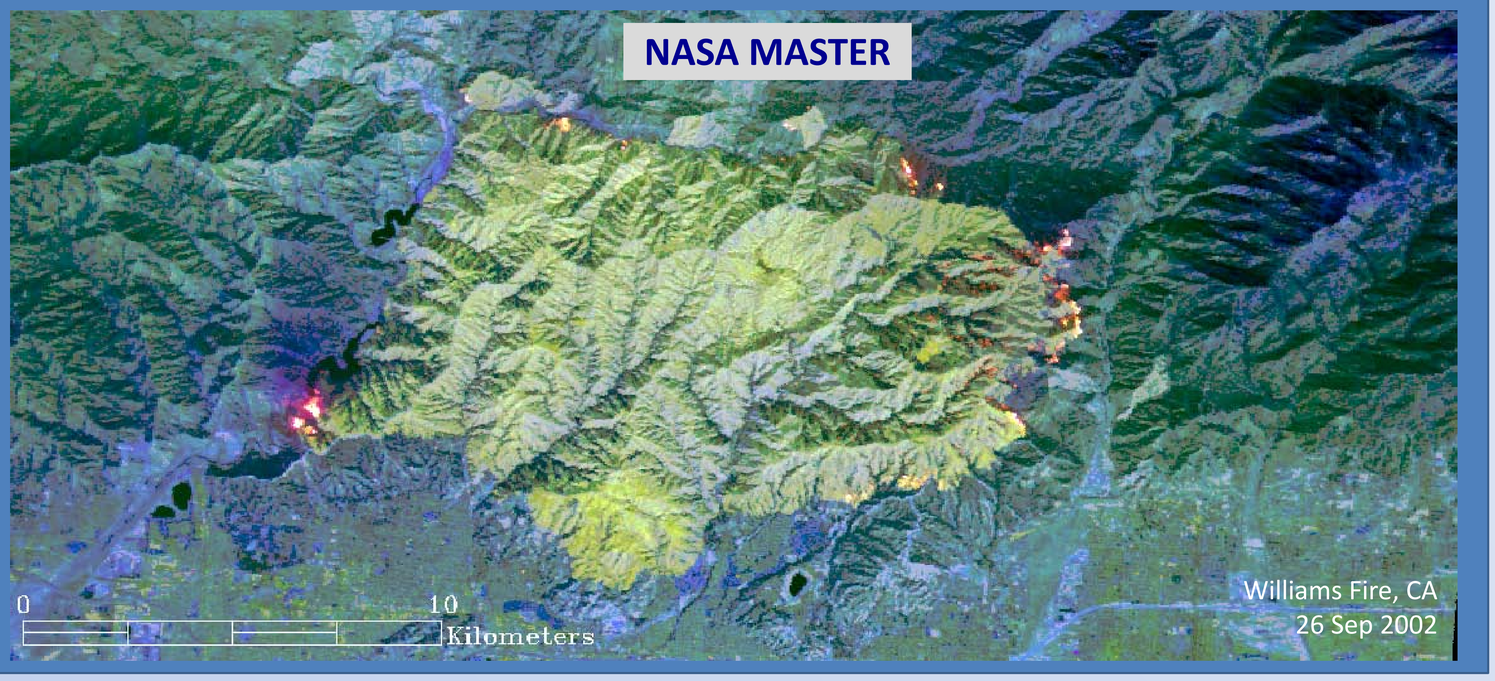
Fire Reference Data

The fire characterization reference data are derived using the retrieval methods above applied to fine-resolution fire-dedicated airborne and/or spaceborne data. For development and testing purposes, the reference data described here were derived from the NASA/Ames Airborne Modular Sensor-Wildfire (AMS) and MODIS/ASTER airborne simulator (MASTER). These instruments have fire-dedicated bands with high saturation temperatures providing a wide dynamic range for imaging of both small and large fire events. The data used had a nominal spatial resolution ranging between 10-45m and were acquired near coincidently with GOES Imager East/West.

Future Activities

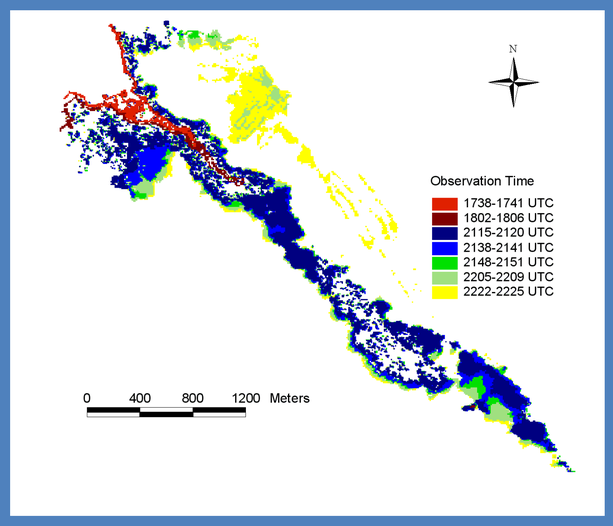
We will continue to work with the available airborne data to develop and further refine the GOES-R ABI *deep-dive* fire characterization validation tool. The tool is being made generic to allow assimilation of a wide range of candidate future reference data sets.

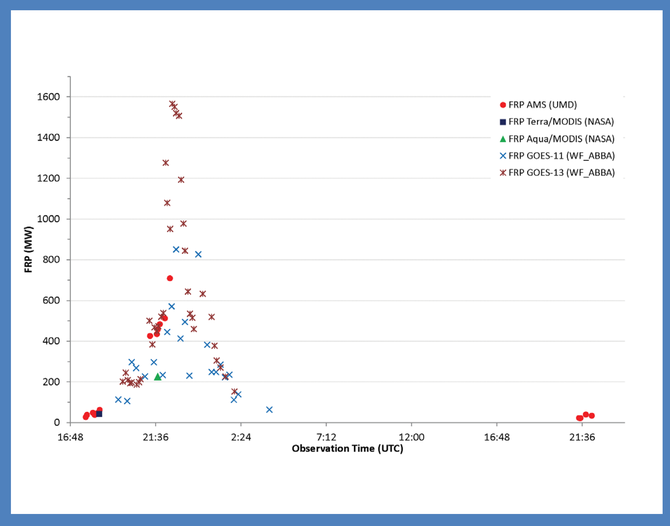
Airborne Active Fire Test Data Sets



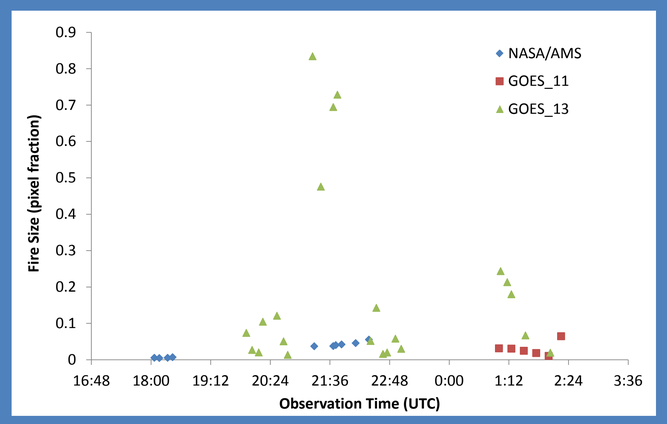
Preliminary Results

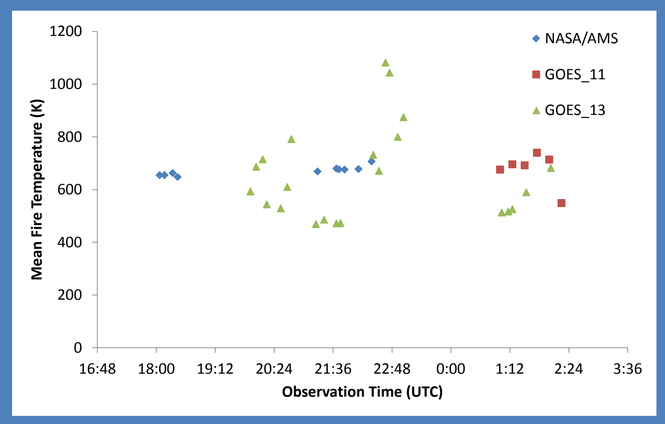
Rx Fire (Henry Coe State Park) – FRP, Fire Size & Temp Retrievals





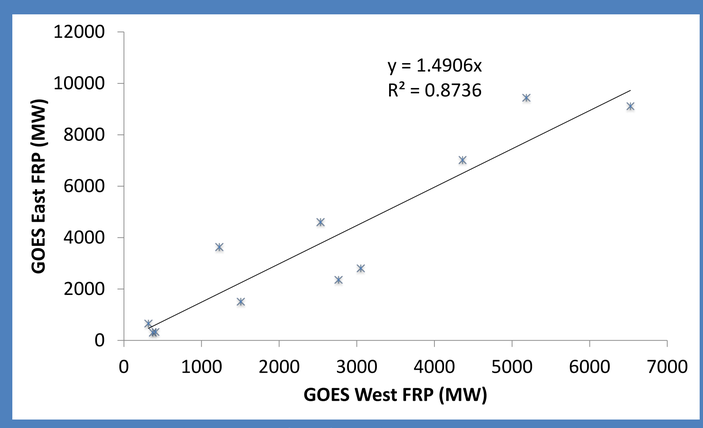
Fire area (left) and fire radiative power (FRP) progression over time as measured by AMS airborne instrument during the Henry Coe Rx fire in CA, 18 October 2011. Fire area depicts the accumulated active fire (flamming and smoldering) as fire progressed over terrain and in response to ground/aerial ignition. Satellite FRP retrievals correspond to the total output and may include one or more fire pixels for each observation hour.

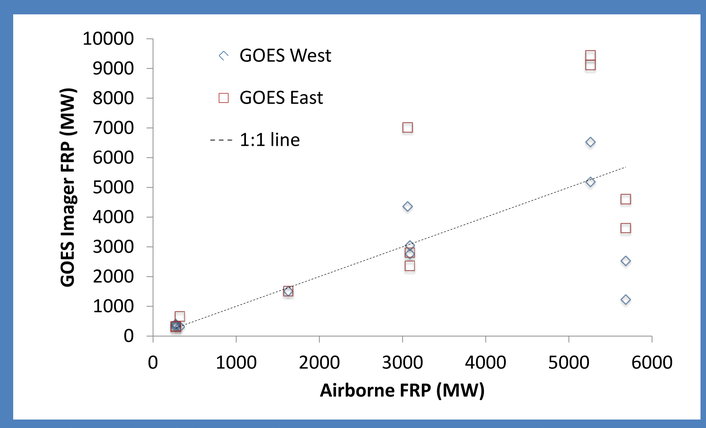




Fire size (left) and temperature (right) progression over time as measured by AMS airborne instrument and GOES Imagers (11 & 13) during the Henry Coe Rx fire in CA, 18 October 2011. Fire size is depicted as GOES pixel fraction occupied by fire. GOES Imager retrievals availability are limited by detection performance and frequent fire pixel saturation.

Western U.S. Wildfires – FRP Retrievals





Fire Radiative Power (FRP) retrievals using near-coincident GOES Imager (West/East) & NASA/MASTER ~40m airborne reference data