Towards multi-platform validation of active fire products from moderate resolution sensors in the Amazon

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BACKGROUND

One of the goals of the LBA-ECO Phase III study LC-35 (Analysis of long-term fire dynamics and impacts in the Amazon using integrated multi-source fire observations) is to evaluate fire detections from multiple moderate and coarse resolution sensors (i.e. MODIS, AVHRR, GOES Imager) as part of the generation of a fused multi-sensor active fire product in the Amazon. This pilot study evaluates the potential for product validation using higher resolution sensors that are flown on separate platforms and therefore provide fire observations with a non-negligible time difference. The problem is analyzed by comparing validation results for the single-platform Terra MODIS and ASTER configuration with those for Terra and Landsat/ETM+.

VALIDATION OF ACTIVE FIRE PRODUCTS

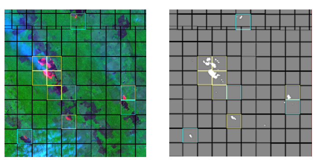
Active fire product accuracy is a function of observing conditions (i.e. satellite view angle); environmental conditions (non-fire background); sensor conditions (i.e. degradation of sensitivity).

Validation is defined as the process of assessing by independent means the quality of the data products derived from system outputs.

For proper validation of the active fire products, simultaneous mapping of thermal conditions within the satellite pixel is required. The most viable option for a statistically robust analysis is the use of higher resolution satellite observations (Csiszar et al., 2006).

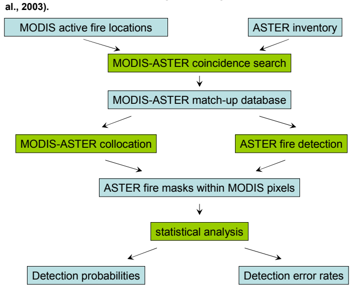
THE MODIS ACTIVE FIRE VALIDATION PROCESS: SINGLE-PLATFORM CONFIGURATION

Active fires from 1km Terra MODIS are validated using 30m fire masks from ASTER flown on the same satellite platform.



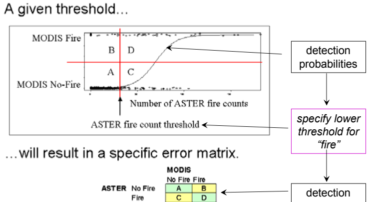
ASTER RGB image (left) and derived fire mask (right) with the grid of 1km MODIS pixels. Blue and yellow gridcells indicate low and nominal detection confidence from the version 4 algorithm (Giglio et al., 2003).

Acre (Brazil) 29 August 2003 14:55 UTC



Reference ASTER scenes are selected using automated coincidence search. ASTER fire masks are derived with a contextual algorithm and quality controlled by visual inspection. Validation results are derived by the analysis of summary statistics of ASTER fire pixels within MODIS pixels (Morisette et al., 2005).

A given threshold…



…will result in a specific error matrix.

Logistic regression

$$\pi(x_i) = \frac{e^{\beta_0 + \sum_{j=1}^{p} \beta_j x_{ij}}}{1 + e^{\beta_0 + \sum_{j=1}^{p} \beta_j x_{ij}}}$$

$\sum_{j=1}^{p} \beta_j x_{ij}$: linear combination of p ASTER summary statistics within MODIS pixel i

$\pi(x_i)$: the probability that MODIS pixel i will be equal to 1 (i.e. labeled as "fire") given the values of x_i

β_0, β_j : parameters estimated from the data

GENERALIZATION OF THE MODIS APPROACH: MULTI-PLATFORM CONFIGURATION

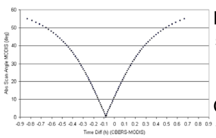
The Terra MODIS-ASTER single-platform configuration is rather unique. For off-nadir view angles of Terra/MODIS, or for any view angles of Aqua/MODIS, AVHRR, GOES Imager or future VIIRS, high resolution reference data need to be collected from independent platforms.

Satellite Sensor	Terra ASTER	Landsat7 ETM+	BIRD HSRS	CBERS IRMSS	IRS AWiFS
Altitude	705 km	705 km	572 km	778 km	817 km
Repeat Cycle[1]	16 days	16 days	11 days	26 days	5-24 days
Equator Crossing Time	10:30	10:05	10:30 (drifting)	10:30	10:30
Swath width[1]	60 km	180 km	148 km	120 km	740 km
Resolution[2]	30 m	30 m	290 m	80 m	56-70 m

Comparison of several major higher resolution sensors near the 10:30 Terra orbit

[1]Some systems have limited off-nadir capabilities, which allow the sampling within a wider angular range, but always over a fixed swath width at a time. This also impacts potential revisit time.

[2]The resolution listed refers to bands with potential active fire signal. (Note: the spectral sampling of most sensors is suboptimal for fire detection.)



MODIS scan angles observed by CBERS as a function of the difference between the CBERS and MODIS overpasses.

For example, CBERS IRMSS provides a fuller sampling of the Terra/MODIS angular range, but at the expense of temporal coincidence.

QUESTIONS:

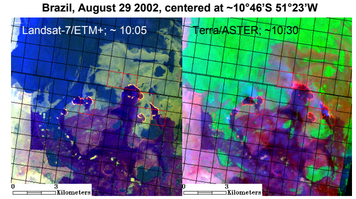
1.How do summary fire characteristics from higher resolution sensors change over time?

2.How do these changes impact validation?

MODIS VALIDATION USING LANDSAT-7/ETM+

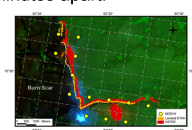
The orbits of Landsat-7 and Terra enable the collection of ETM+ and ASTER imagery from the same day, but ~30 minutes apart.

Brazil, August 29 2002, centered at ~10°46'S 51°23'W



RGB: 7 (2.09-2.35µm) - 5 (1.55-1.75 µm) - 2 (0.525-0.605 µm).

RGB: 8 (2.235 - 2.285 µm) - 3 (0.76 - 0.86 µm) - 1 (0.52 - 0.60 µm).

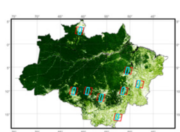


Above: propagation of a fire front as observed by ETM+ and ASTER.

Left: Imagery of a fire complex from ETM+ and ASTER.

Overlain on both figures is the 1km MODIS grid. Red gridcells denote pixels flagges as "fire".

DATA



Pairs of same-day ASTER/ETM+ imagery from over ETM+ scenes in 2001, 2002 and 2003 were selected along the Arc of Deforestation (including Roraima) in the Brazilian Amazon.

Landsat/ETM+	ASTER
L71_229_067_00020010813	AST_L1B_00308132001142735_20060804225441_13755.hdf AST_L1B_00308132001142743_20060804225441_13757.hdf AST_L1B_00308132001142752_20060804225341_13387.hdf
L71_224_064_00020020829	AST_L1B_00308292002134916_20060804223640_8171.hdf AST_L1B_00308292002134925_20060804223550_7776.hdf AST_L1B_00308292002134934_20060804223550_7778.hdf
L71_224_067_00020020829	AST_L1B_00308292002135027_20060804224551_11620.hdf AST_L1B_00308292002135036_20060804224450_10982.hdf AST_L1B_00308292002135045_20060804224340_10168.hdf
L71_224_071_00020020829	AST_L1B_00308292002135155_20060804224450_10988.hdf AST_L1B_00308292002135204_20060804224450_10995.hdf AST_L1B_00308292002135213_20060804224450_10993.hdf
L71_222_066_00020020831	AST_L1B_00308312002133736_20060804223740_8558.hdf AST_L1B_00308312002133745_20060804223640_8178.hdf AST_L1B_00308312002133754_20060804223640_8176.hdf
L71_227_068_00020021005	AST_L1B_00310052002140852_20060804224551_11608.hdf AST_L1B_00310052002140901_20060804224551_11603.hdf AST_L1B_00310052002140910_20060804224551_11613.hdf AST_L1B_00310052002140919_20060804224551_11618.hdf
L71_231_067_00020021017	AST_L1B_00310172002143318_20060804225541_14203.hdf AST_L1B_00310172002143327_20060804225541_14205.hdf AST_L1B_00310172002143336_20060804225641_14542.hdf
L71_232_058_00020030128	AST_L1B_003_01282003143550_06052003112632.hdf AST_L1B_003_01282003143559_06052003113023.hdf AST_L1B_003_01282003143608_06052003164616.hdf AST_L1B_003_01282003143617_06052003165422.hdf

APPROACH

Pre-processing

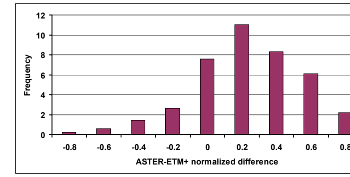
- co-register ASTER and ETM+ imagery
- derive fire masks from ASTER and ETM+ with contextual algorithm
- inspect and correct ASTER and ETM+ fire masks
- map fire masks into MODIS pixels

Analysis

- compare summary statistics from ASTER and ETM+
- compare detection probabilities from ASTER and ETM+

RESULTS

Summary statistics



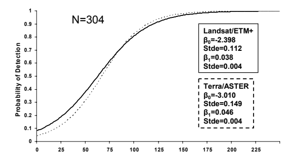
Histogram of normalized differences between the total number of fire pixels derived from ASTER and ETM+ within the same MODIS pixels.

There is a bias towards higher fire counts from ASTER than from ETM+. Possible explanations:

1.Impact of the diurnal cycle of fire activity

2.Residual differences in ASTER and ETM+ fire detections

Detection probabilities

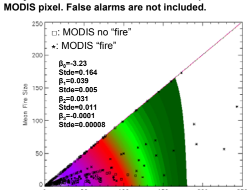


Detection probabilities from the logistic regression analysis of the total number of 30m fire pixels within the MODIS pixel. False alarms are not included.

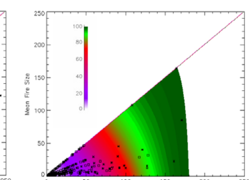
Overall, the logistic regression curves for detection probabilities derived from ETM+ and ASTER are similar.

For small, more variable fires ETM+ provides spuriously high detection probabilities as fires are more likely to grow further.

For large, more persistent fires detection probabilities are close.



Detection probabilities from the logistic regression analysis of fire counts, the mean cluster size and their product from ASTER.



Detection probability contours derived from ASTER with summary statistics from ETM+.

An implication of the lower ETM+-derived fire counts is that, for example, the same MODIS sensor on a platform with a 10:05 overpass time would produce lower detection rates. This effect will be studied using fire detections from various local times from the GOES Imager.

CONCLUSIONS

- Statistical analysis of summary statistics from fire masks derived from ETM+ as reference data for MODIS active fire validation, acquired ~25 minutes before the MODIS overpass, provides comparable validation results with those obtained from simultaneous ASTER measurements.
- Summary fire counts are higher from ASTER, suggesting diurnal cycle effects and possible differences in fire detections from ASTER and ETM+.

FUTURE PLANS

- Similar analysis is underway for the use of ASTER and ETM+ for the validation of the active fire product from the GOES Imager.
- The fire detection algorithms for ASTER and ETM+ will be refined to account for the anomalous sensor behavior at saturation (i.e. blooming, spikes, near-zero digital output).
- Further sensors will be included in collaboration with international partners within GOFC-GOLD Fire and CEOS WGCV Land Product Validation Subgroup.

ACKNOWLEDGMENT

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