# GOES Active Fire Product Validation Using High Resolution Data

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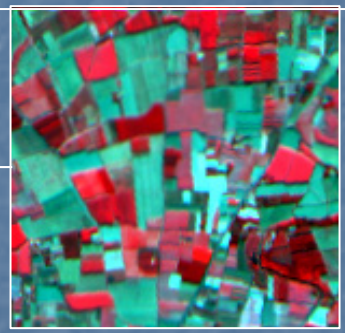
# Background: Validation of Remote Sensing Active Fire Products

- Possible ways to address the problem:
  - Ground based observations
    - time consuming process
    - limited spatial coverage and sampling capacity
  - Airborne imaging
    - costs tend to be prohibitive
    - sampling can be poor if campaings are not well coordinated (multimission campaigns make it even more difficult)
  - High resolution orbital sensors
    - sampling will be restricted to morning hours (~10am local)
    - Sensor limitation may prevent extraction of physical parameters relevant to fire studies (e.g.: fire energy)

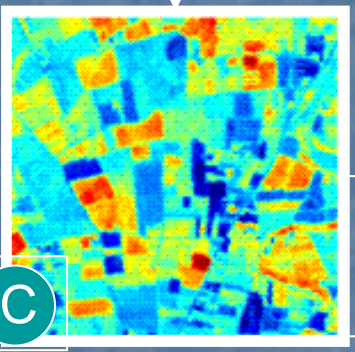
# Current Validation Framework

Field data

High resolution imagery



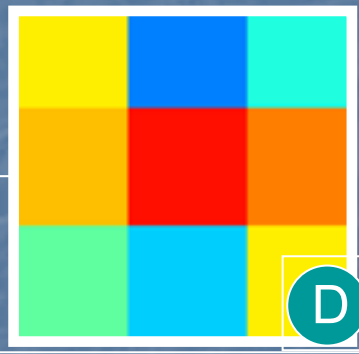
Transfer function



C

High resolution "Product"

Aggregate & Relate



D

Moderate resolution "Product"

Accuracy Assessment

for one product, at one site, at one point in time

(Jeff Morisette)

# Use of ASTER to Validate MODIS Active Fire Product

- Same orbital platform (EOS/Terra) providing exact coincident observation
- 30m resolution based binary detection ("yes" / "no")
  - Contextual algorithm applied to bands 3 (0.8 μm) and 8 (2.3μm) [Louis Giglio].
- 60 x 60km nicely navigated images (no pre-processing needed)
- Performance of detection evaluated based on logistic regression analysis and on error matrices (for deriving fire omission curves) using summary ASTER active fire statistics per MODIS pixel area

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

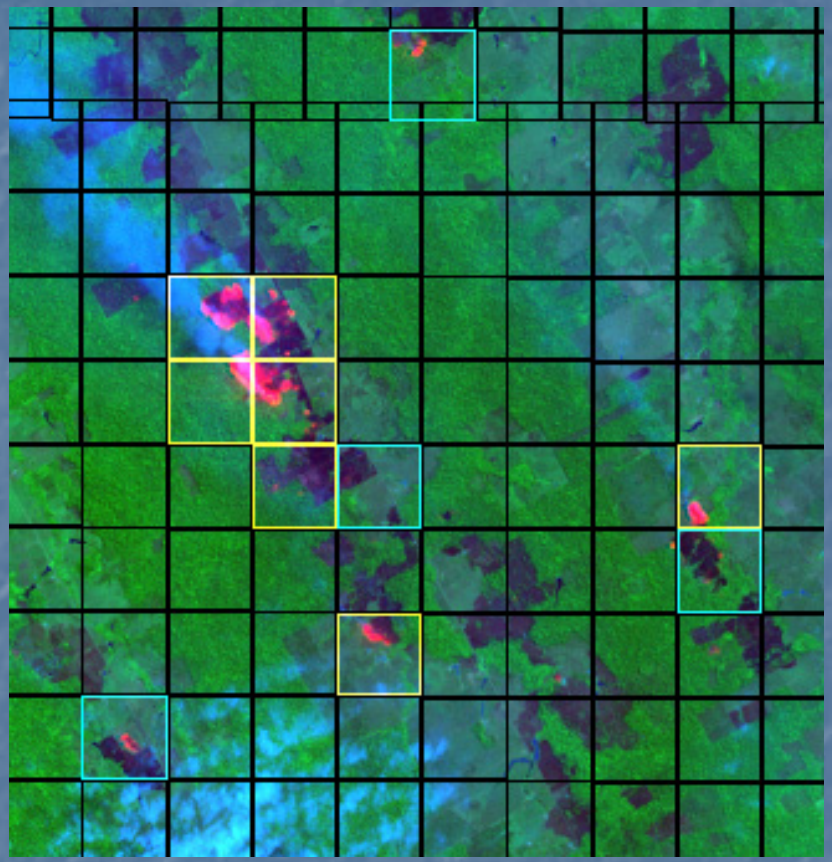
$\sum_{j=1}^{p} \beta_j x_{ij}$ : **linear combination of *p* ASTER summary statistics within MODIS pixel *i***

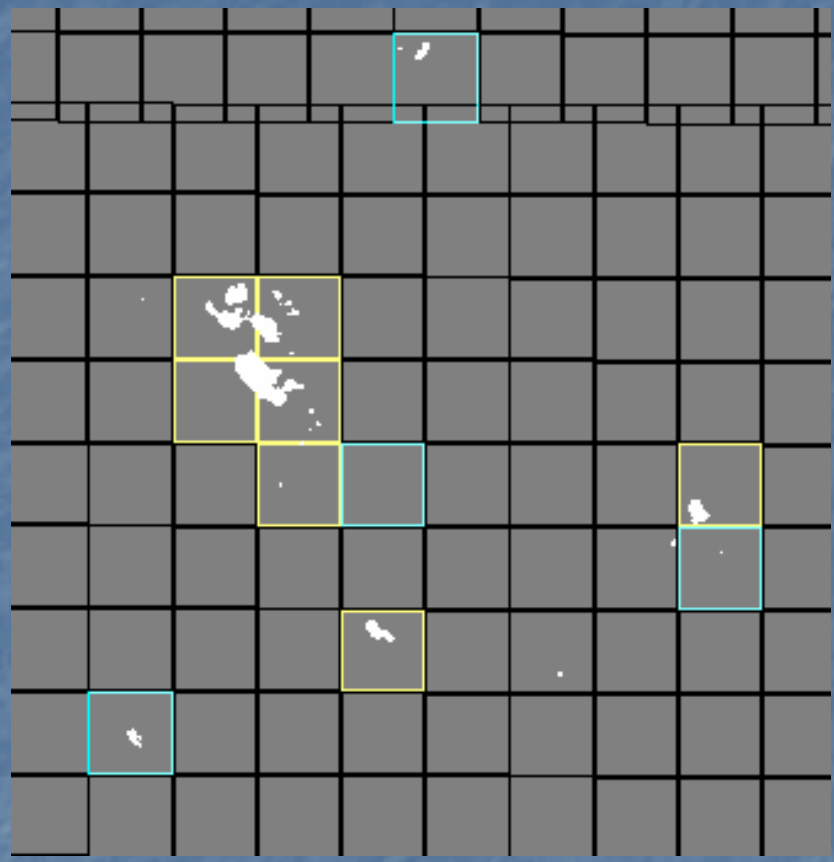
**$\pi(x_i)$: the probability that MODIS pixel *i* will be equal to 1 (i.e. labeled as "fire") given the values of $x_i$**

**$\beta_0$, $\beta_j$ : parameters estimated from the data**

- Published material for 3 different study regions:
  - South Africa: Morisette et al. (2005) *Int. J. Remote Sens.*
  - Brazilian Amazon: Morisette et al. (2005) *Earth Interactions*
  - Northern Eurasia: Csiszar et al. (2006) *IEEE Trans. Geosci. Remote Sens.*

# MODIS validation with ASTER





**Acre (Brazil) 29 August 2003 14:55 UTC**

**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).**

# Using ASTER Data to Validate GOES Active Fire Product

- Same implementation process as used with MODIS
  - Find near coincident acquisitions from both instruments
  - Co-locate ASTER binary fire masks and GOES active fire detections
    - Navigation issues with GOES requires either pre-processing of the data or that special considerations are made during processing and analysis
  - Limited area coverage of ASTER scene requires that a large number of images be processed (for sampling reasons)

# Using ASTER Data to Validate GOES Active Fire Product

- Will work with the full resolution ABBA fire data to avoid considerations involving routine resampling
- Pixel footprint considered will be 1× X and Y (as opposed to 2×X and 1×Y with MODIS to account for PSF)
- Nearest neighbour approach used for compensating for GOES navigation problems
  - While useful for most cases, outliers may still influence the statistics

** consider results preliminary **

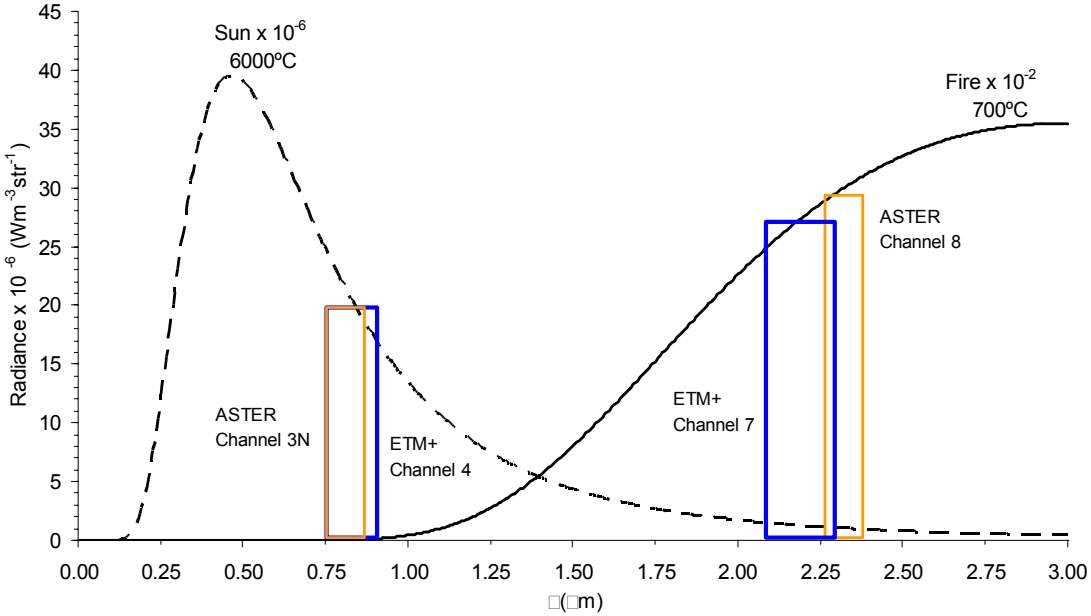
# Extending the Methodology to Include ETM+ Data

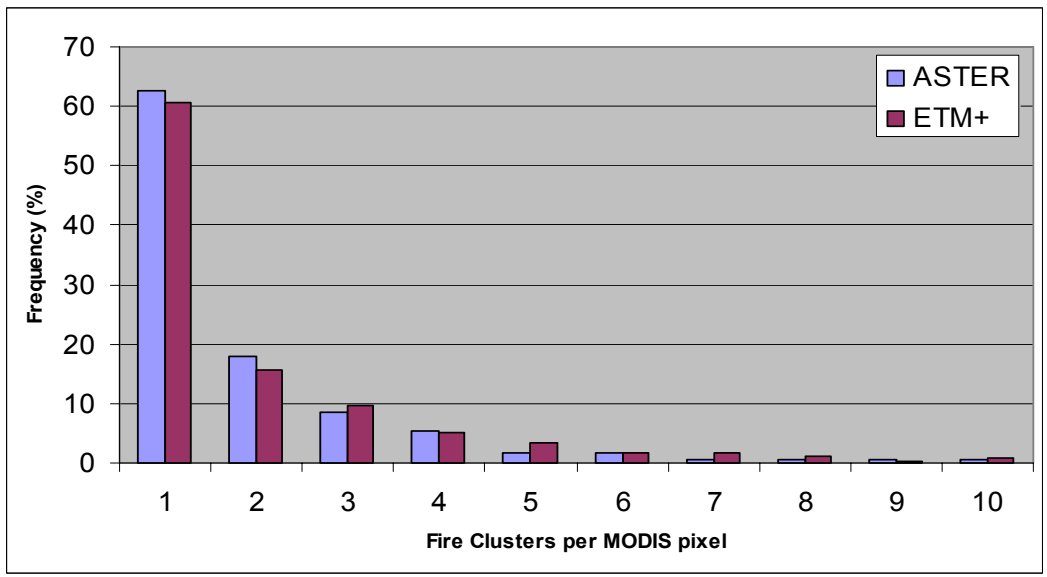
- Same algorithm architecture used for ASTER is applied to ETM+ bands 4 (0.85 μm) and 7 (2.2μm)
  - Different thresholds to accomodate spectral differences between corresponding bands
- Improved performance with reduced sensor artifacts (e.g.: blooming)
- Larger spatial coverage (9x ASTER area) allowing for improved sampling capacity
- Data access has its own limitations
  - ($$)
  - Sensor malfunctioning since May 2003

# ASTER-ETM+ Active Fire Masks

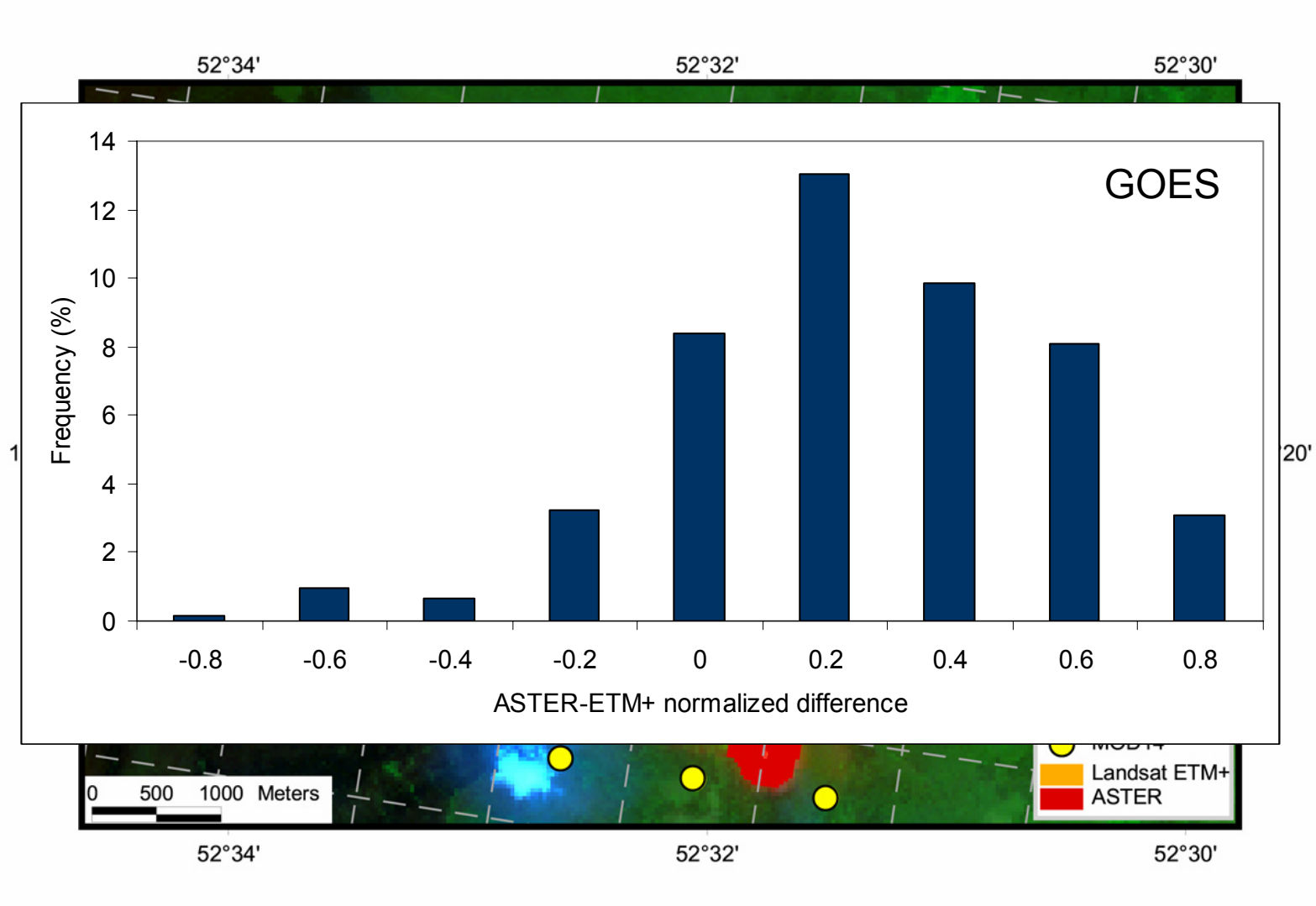


ASTER bands 3 and 8 and ETM+ bands 4 and 7

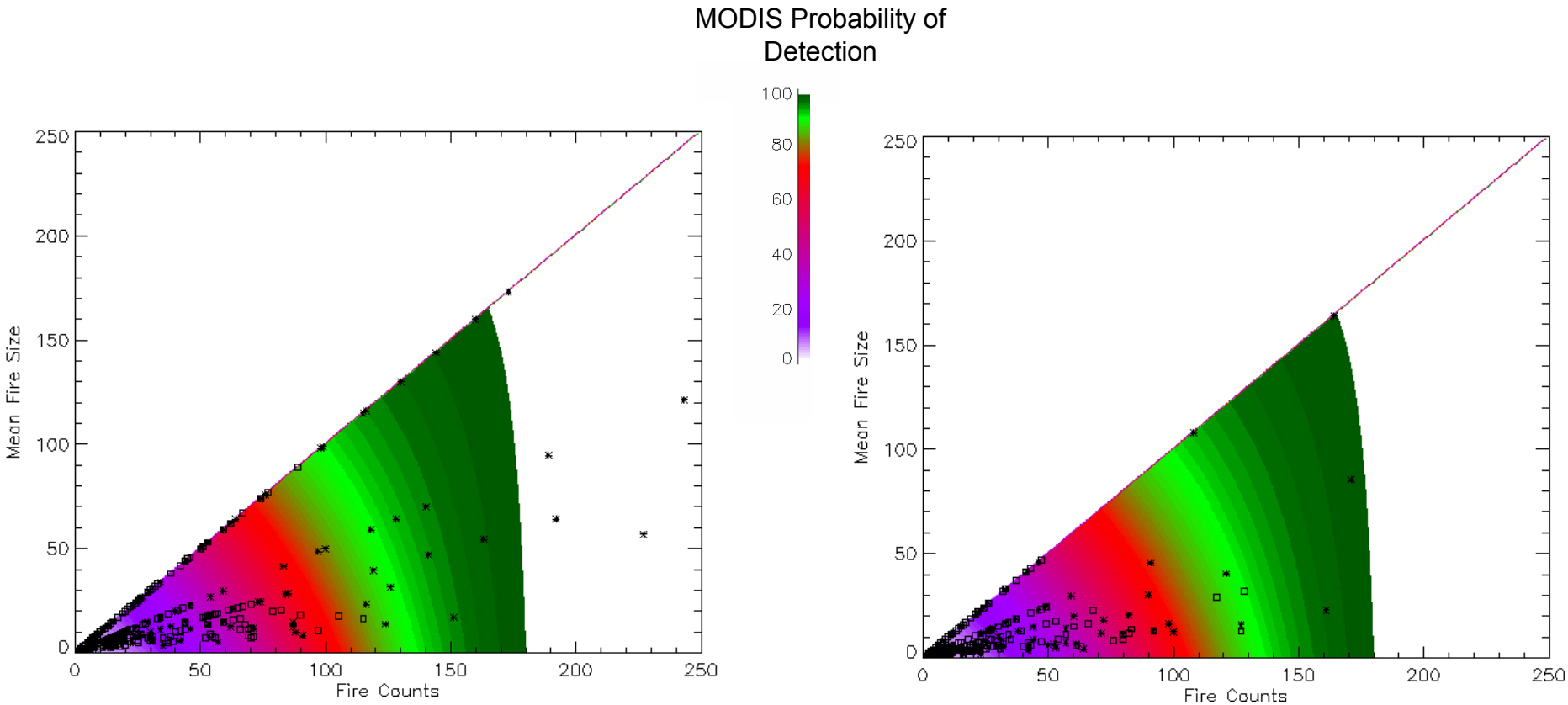


# Quantifying Differences in Fire Size from ASTER&ETM+ Observations – Implications to Detection Performance



# Changes in Fire Size Influencing the Chance of Detection

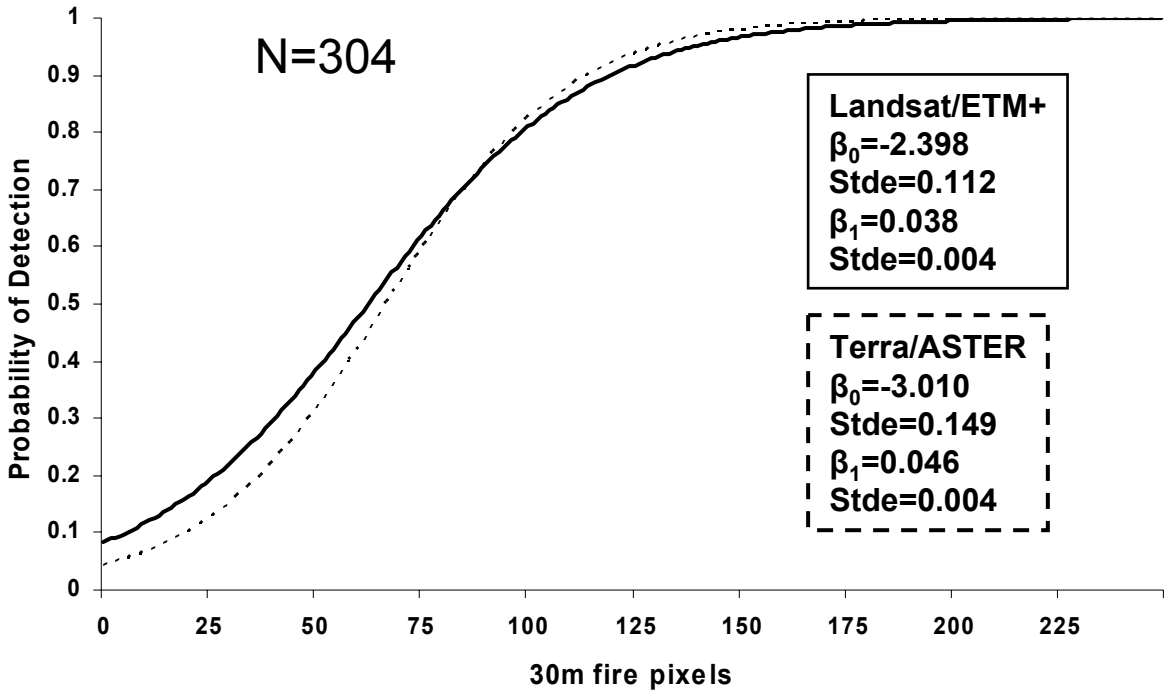



ASTER (10:30am) Fire Size Characteristics

ETM+ (10:00am) Fire Size Characteristics

Smaller fires at 10 am – fewer fires detected

# Detection probabilities



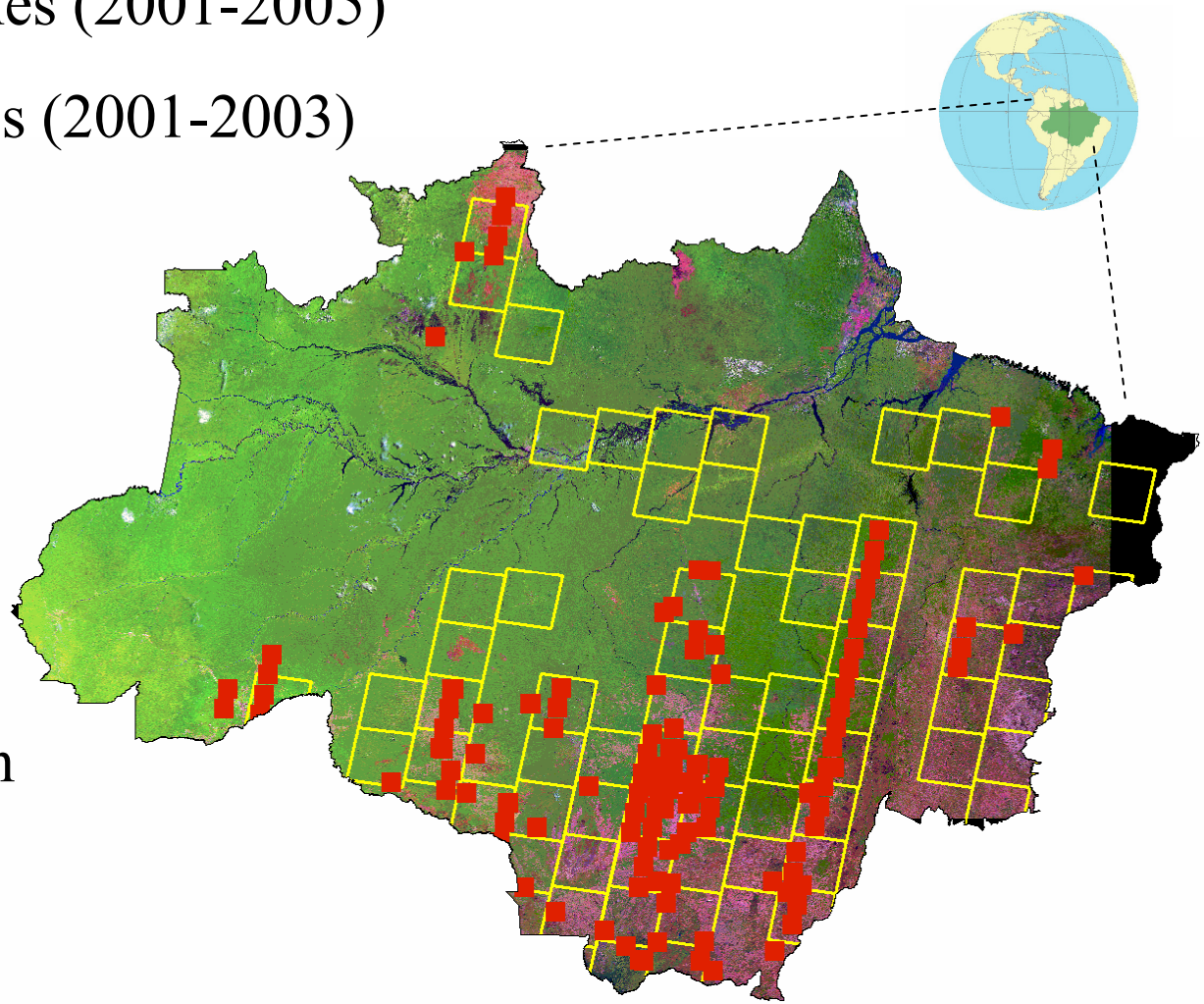

**Detection probabilities from the logistic regression analysis of the total number of 30m fire pixels within the MODIS pixel. False alarms are not included.**

higher apparent detection probabilities from ETM+ for small fires (smaller fires than the true fires at 10:30)

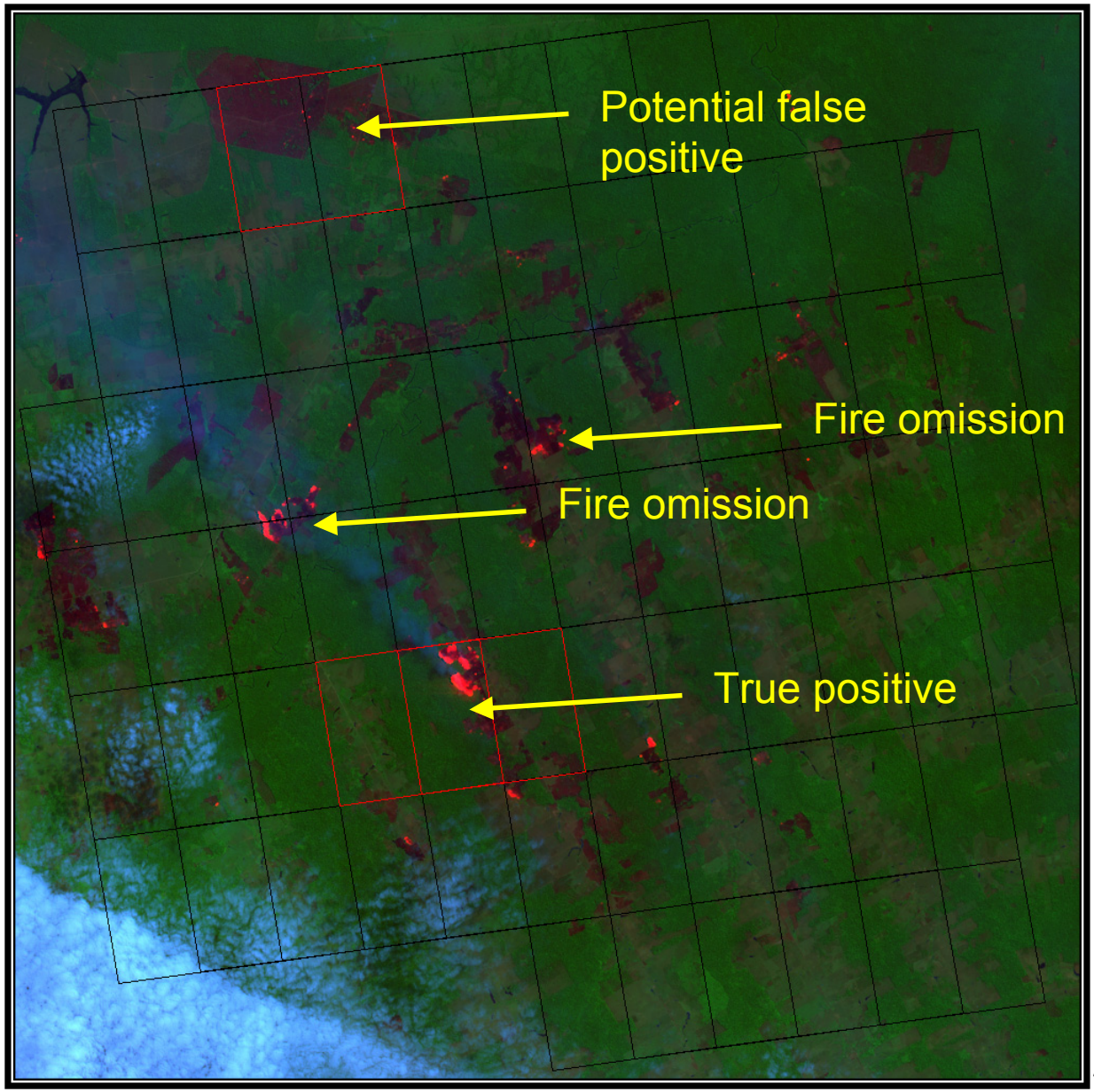
# Brazilian Amazon Basin Study Region

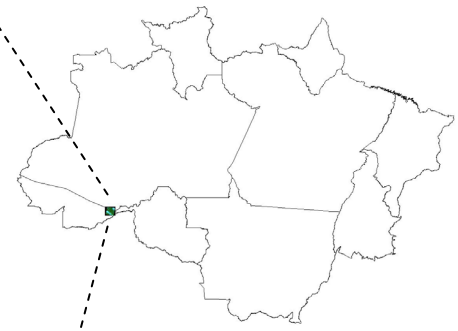
- Use of large number of ASTER and ETM+ data covering the majority of the fire prone areas in the Brazilian Amazon Basin
  - 160+ ASTER scenes (2001-2005)
  - 120+ ETM+ scenes (2001-2003)

- Characterize the detection envelopes of MODIS and GOES based on vegetation cover type and on geometry of observation



# Validating GOES Active Fire Data

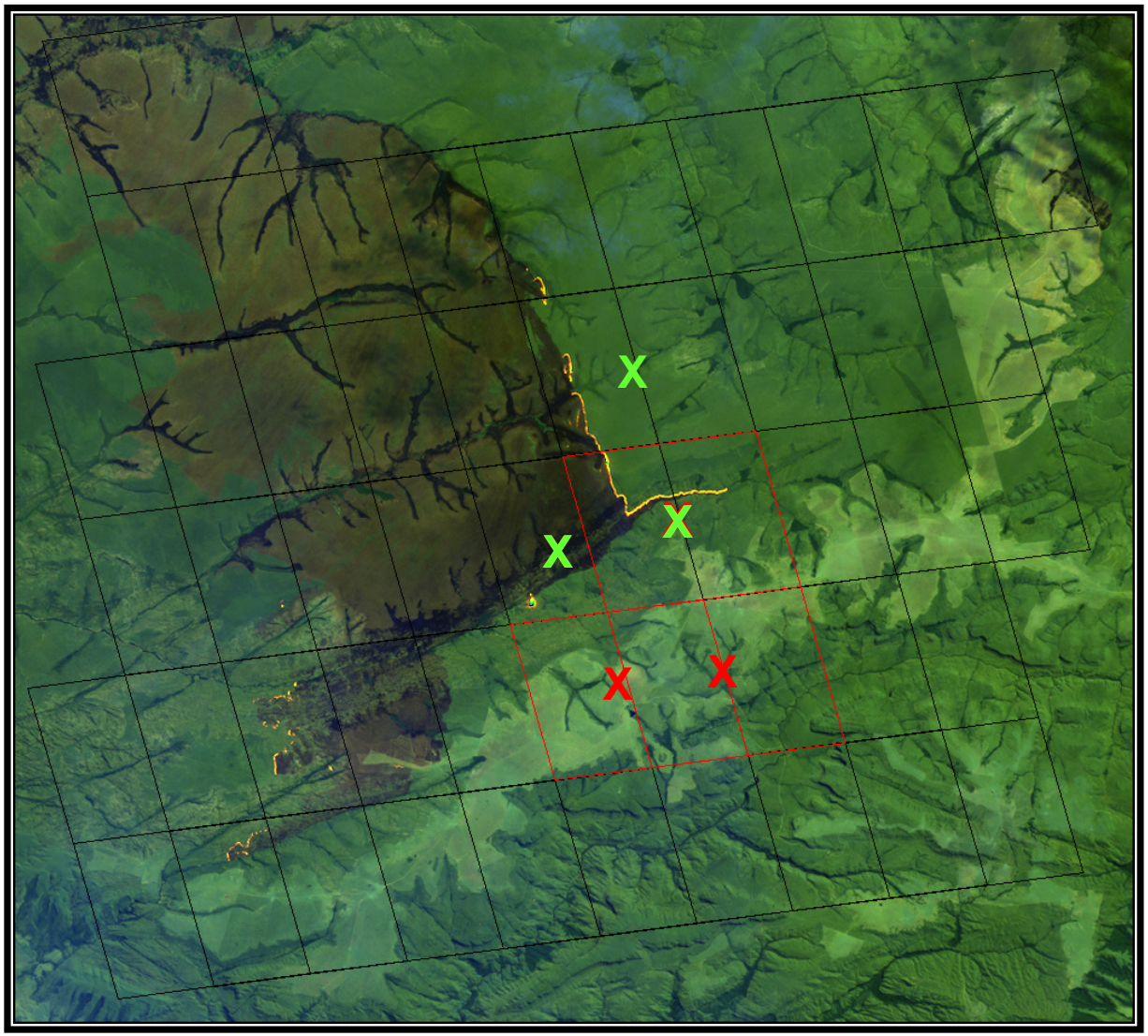


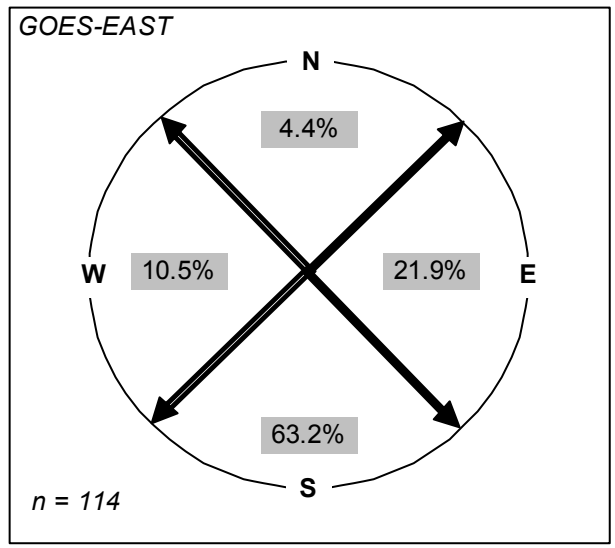
ASTER scene 29 Aug 2003 @ 1456UTC centered in eastern Acre state – Western Amazon basin

# Validating GOES Active Fire Data

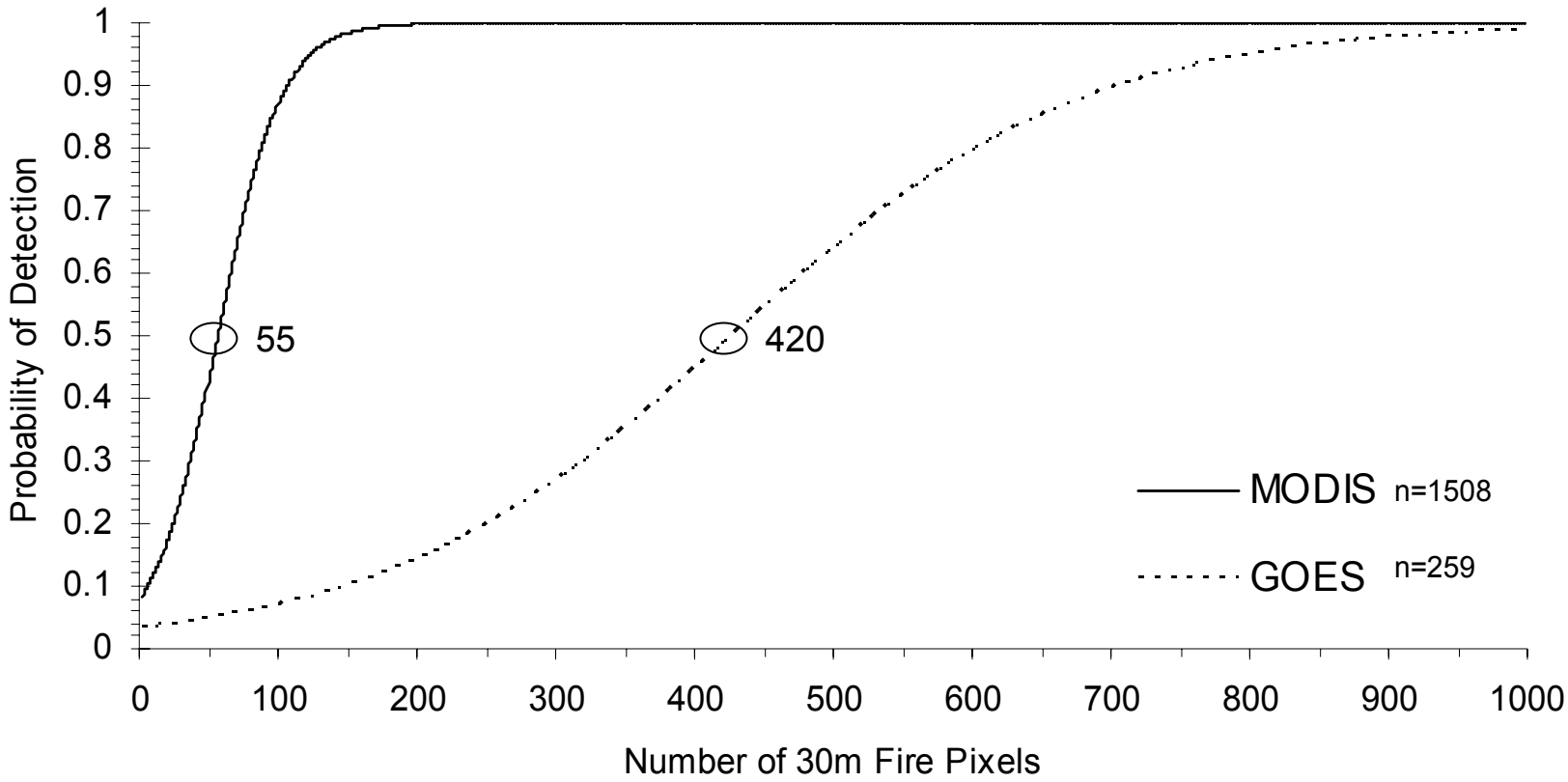
Use of nearest neighbour approach does not always resolve the navigation problems affecting the GOES data




Navigation drift:



# Validating GOES Active Fire Data

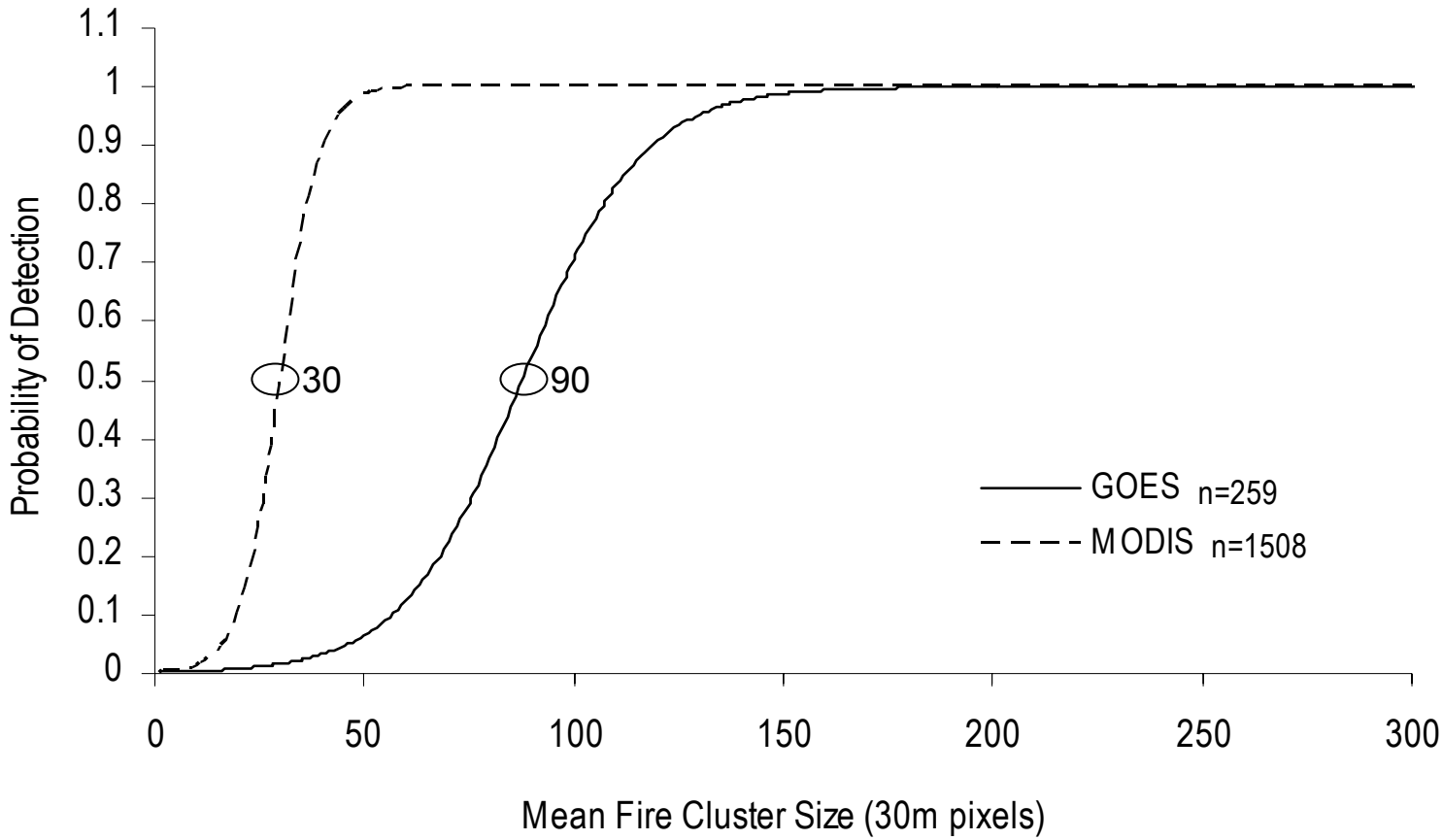



** Preliminary results from 162 ASTER scenes and 65 ETM+ scenes (58 additional ETM+ images to be processed which will potentially double sampling number of GOES detections)

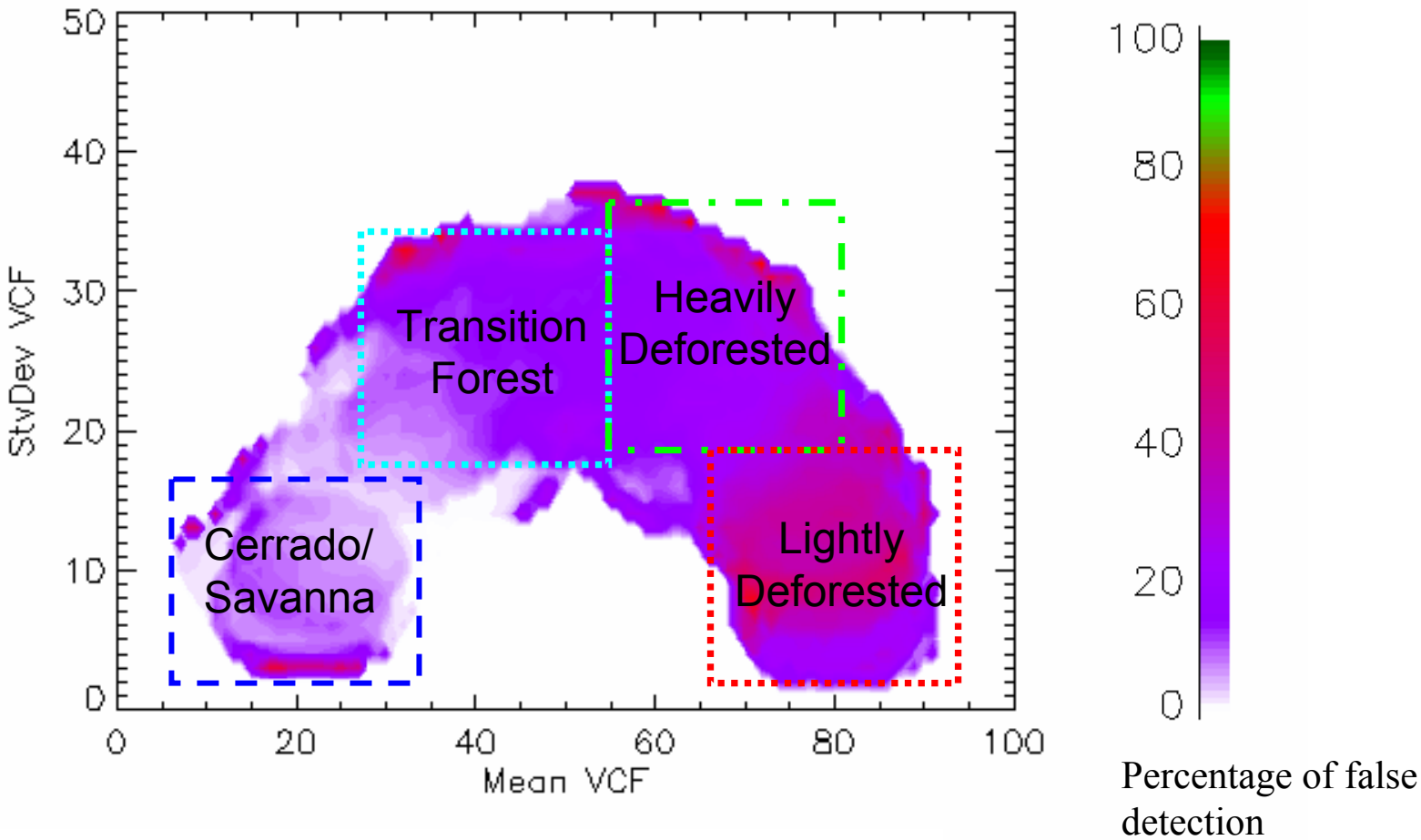
**Registration of GOES will be done using automated processing (i.e.: feature matching algorithm using MODIS data for reference)

# Validating GOES Active Fire Data

The presence of contiguous fire lines increases the probability of detection compared to more spatially stratified fires

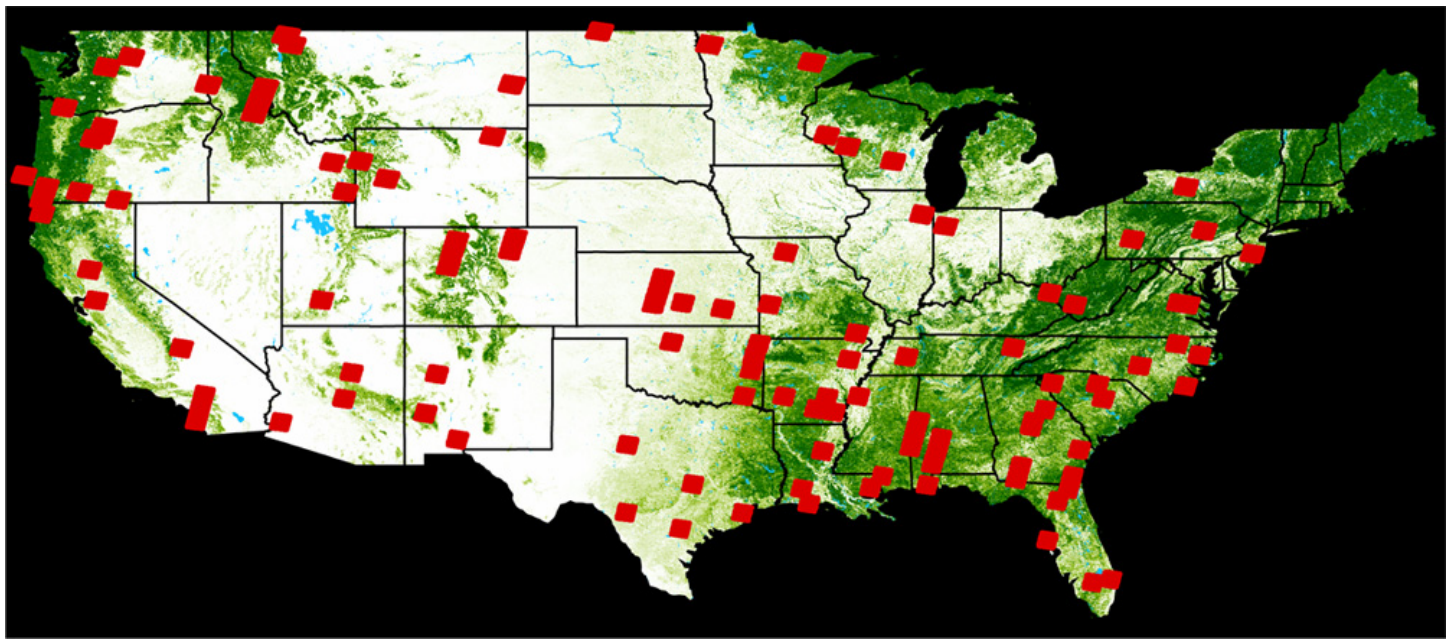


# Stratifying Detection Performance by Vegetation Conditions



# Validating GOES Active Fire Data

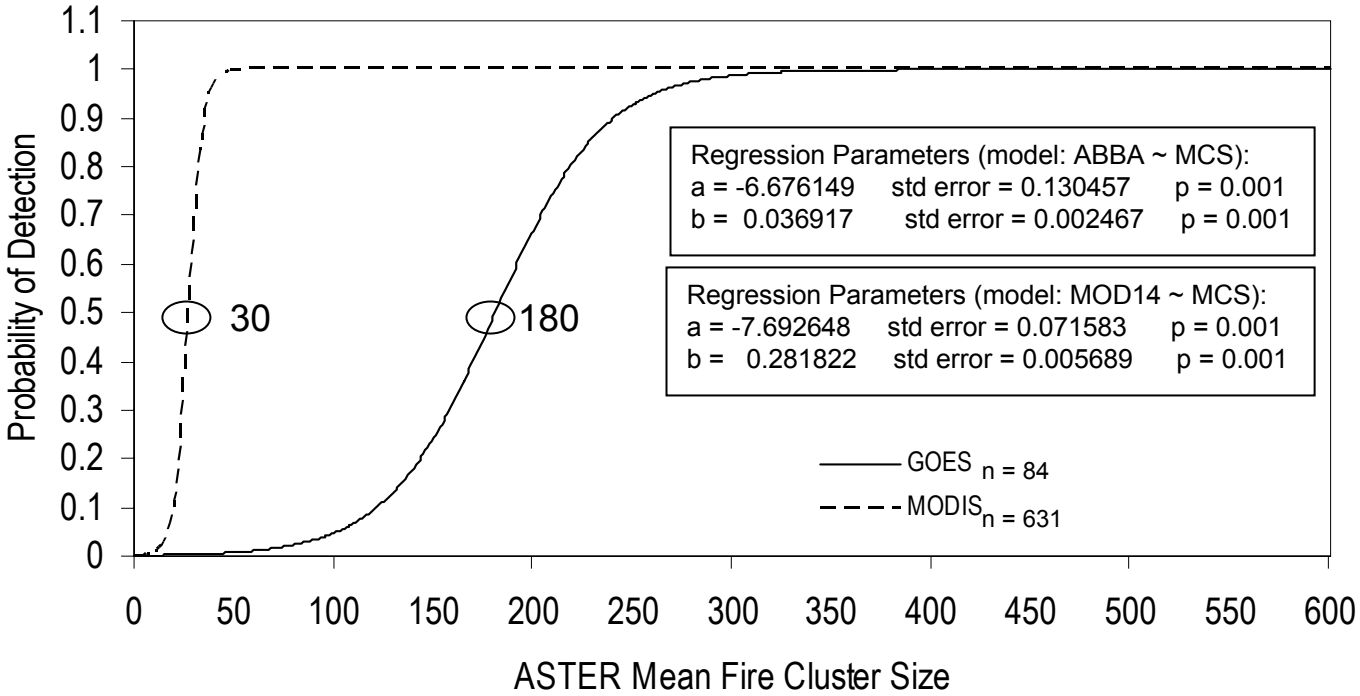
- 115 ASTER scenes selected over the conterminous U.S.
  - Study funded by NOAA to assess the performance of the Hazard Mapping System (HMS)



# Validating GOES Active Fire Data

Statistical detection envelopes for MOD14 and ABBA active fire detection products based on ASTER's Mean Cluster Size were derived

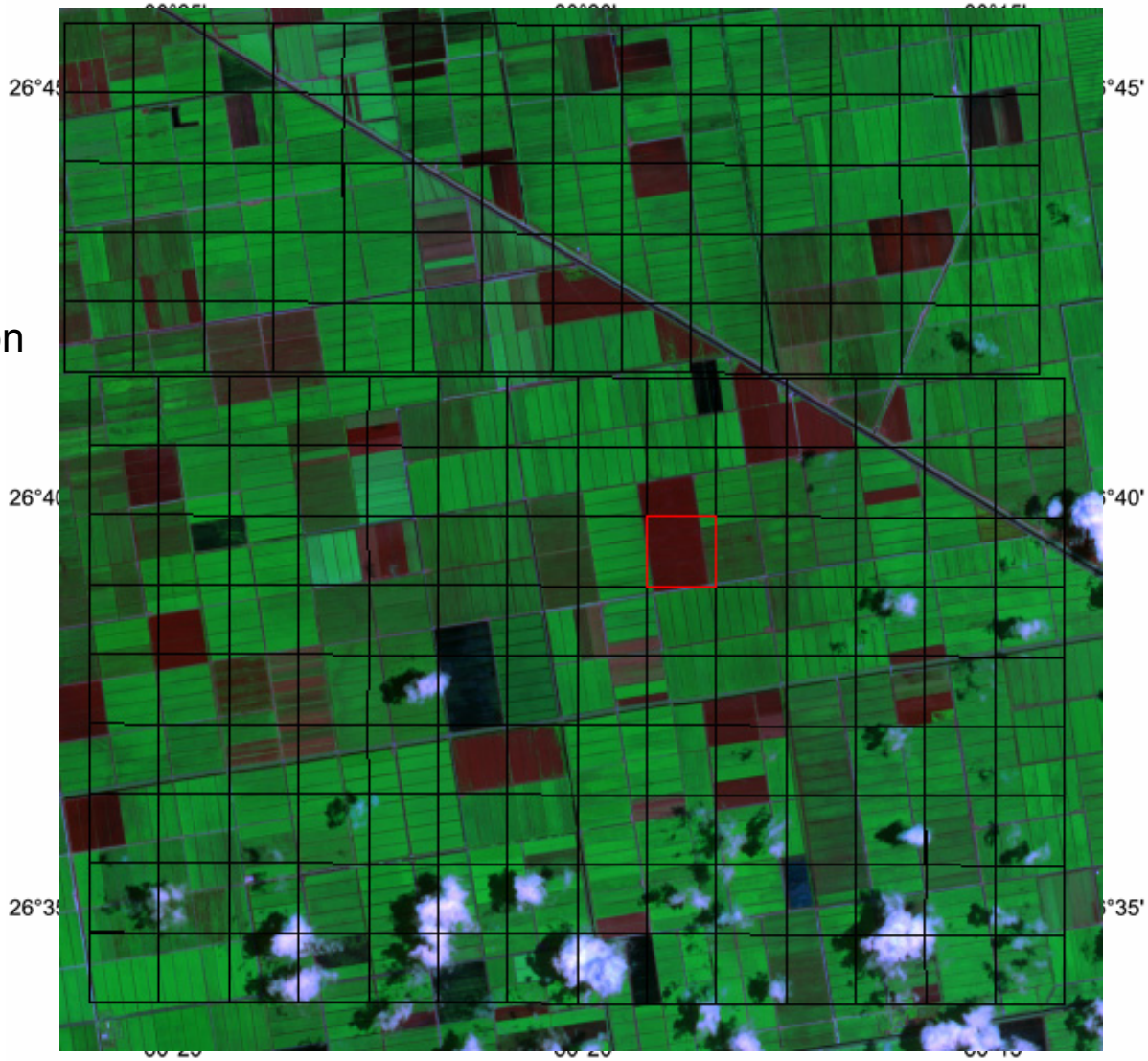
Navigation issues were mostly resolved (results were visually inspected) – sampling size was considered small though



# False Detections Delineated for MODIS and GOES Using ASTER RGB (8-3-1) as Background

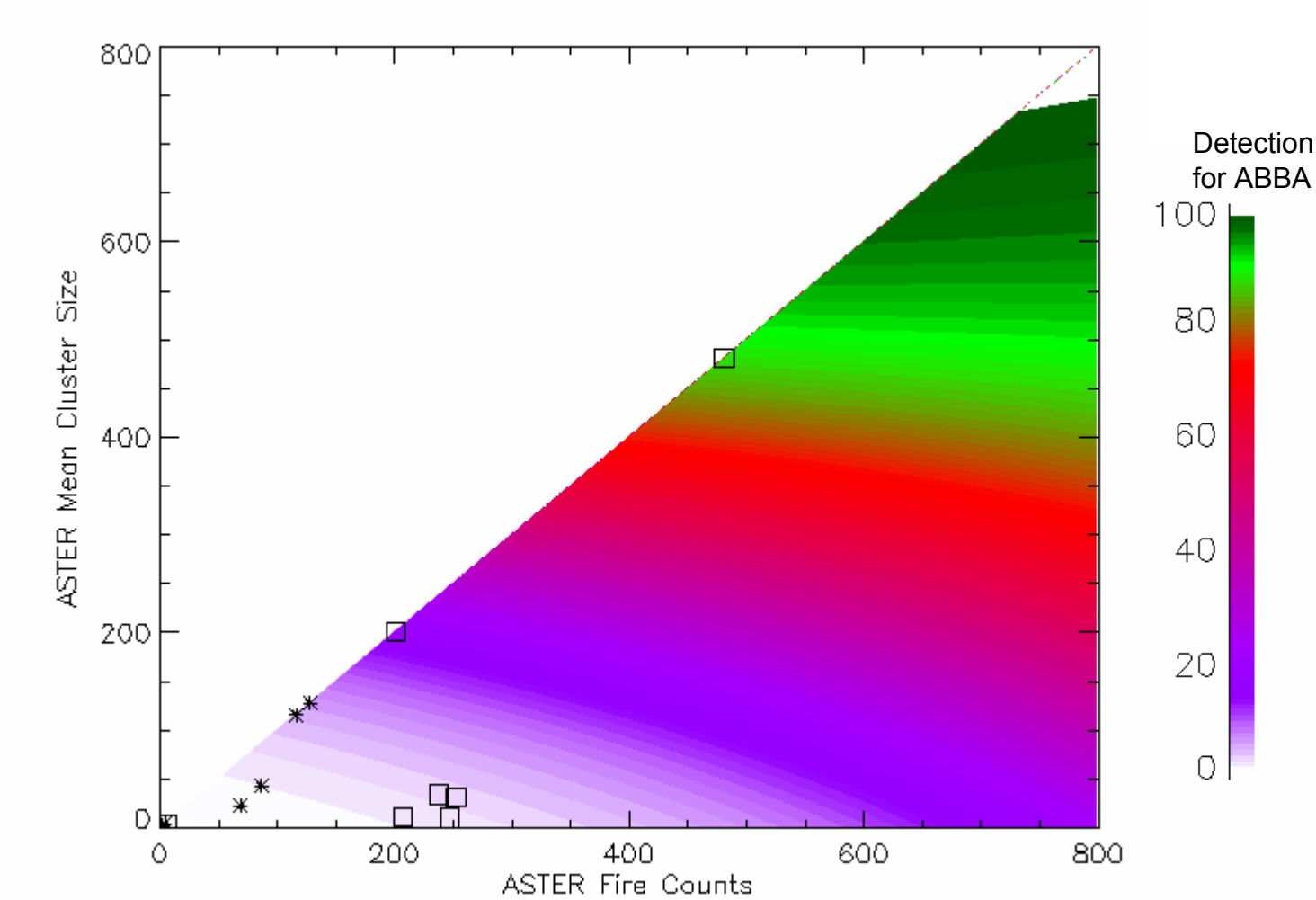
GOES ABBA False Detection

MOD14 False Detection



# Validating GOES Active Fire Data

Relating ABBA probability of detection with inputs from HMS analysts




* added  □ removed

# Final Remarks

- As a binary fire product, ASTER and ETM+ still can't specify fire size and temperature associated with GOES and MODIS detections
- Mid-morning fire characteristics (specially in relation to background conditions such as temperature and humidity) may/may not explain mid-afternoon conditions
- Performance of the GOES data over north and south America should be compared to other geostationary sensors, algorithms and regions before results are extrapolated
  - ASTER and ETM+ data are globally available making this methodology applicable to other geostationary data sets

# Future Implemenation

- Automated registration of the GOES data using MODIS data as reference and conclusion of the statistical analysis for the Brazilian Amazon region – present-Jan2007
- Compare the results from ASTER, ETM+, MODIS/Terra, GOES analyses to MODIS/Aqua – Jan2007-August2007
- Use FRP to complement the analysis involving MODIS and GOES – Feb2007-August2007
- Transfer results to biomass burning emission transport modelling – present until late 2008

The end

# MOD14 Fire Omission Probability Curve

Apply error matrix analysis using ASTER 30m fire pixels for deriving empirically based omission estimates