Sampling of fire regimes with satellite active fire data: scan pattern, land cover data, and diurnal cycle effects

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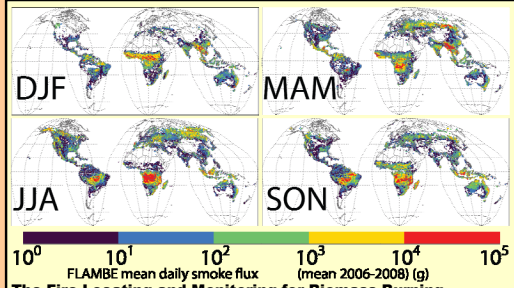
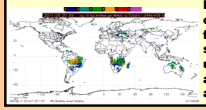
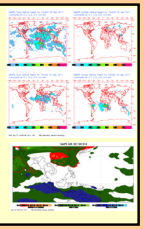
FLAMBÉ and NAAPS: Global forecasting of aerosol in real time



The Fire Locating and Monitoring for Biomass-Burning Emissions (FLAMBÉ) system uses active fire detection from GOES WF_ABBA and MODIS (through Rapid Response) to detect biomass burning activity in near real time. A simple model of emissions uses land cover data to assign fires to classes whose properties are taken from field measurements.

FLAMBE generates hourly smoke flux estimates that are used by the Navy Aerosol Analysis and Prediction System (NAAPS) to produce 120-hour forecasts of aerosol distribution, optical depth, and visibility every six hours. NAAPS also includes aerosols from sea salt, sulfate, and dust. Observations and analyses are at http://www.nrlmry.navy.mil/aerosol/





NAAPS forecasts are used operationally by the Navy for visibility and aviation safety. NAAPS is also useful for air quality and atmospheric research applications.

Relevant Papers and Resources

NRL Aerosol webpage: http://www.nrlmry.navy.mil/aerosol_web

7SEAS Data Portal: http://www.nrlmry.navy.mil/flambe/7seas/7seas.html

References Related to FLAMBÉ and NAAPS:

J.S. Reid *et al.*, Global Monitoring and Forecasting of Biomass-Burning Smoke: Description of and Lessons from the Fire Locating and Modeling of Burning Emissions (FLAMBE) Program, *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* 2, pp. 144-162, 2009.

J. Zhang, J. S. Reid, D. L. Westphal, N. Baker, and E. J. Hyer, A system for operational aerosol optical depth data assimilation over global oceans, *J. Geophys. Res.*, vol. 113, D10208, doi:10.1029/2007JD009065, 2008.

Hyer, E.J. et al. Patterns of fire activity over Indonesia and Malaysia from polar and geostationary satellite observations, *Atmospheric Research, in review, 2011.*

Recent Publications Using FLAMBÉ:

Parrington, M. et al. The influence of boreal biomass burning emissions on the distribution of tropospheric ozone over North America and the North Atlantic during 2010, *Atmospheric Chemistry and Physics, in review, 2011.*

French, N.H.F. et al. Model comparisons for estimating carbon emissions from North American wildland fire, *Journal of Geophysical Research- Biogeosciences 166*, G00K05, doi://10.1029/2010JG001469, 2011.

Fisher, J. A. et al. Source attribution and interannual variability of Arctic pollution in spring constrained by aircraft (ARCTAS, ARCPAC) and satellite (AIRS) observations of carbon monoxide, *Atmospheric Chemistry and Physics 10*, pp. 977–996, 2010.

Hyer, E.J and B.N. Chew, Aerosol transport model evaluation of an extreme smoke episode in Southeast Asia, *Atmospheric Environment 44(11)*, pp. 1422-1427, DOI:10.1016/j.atmosenv.2010.01.043, 2010.

Hyer, E.J. and J.S. Reid, Baseline uncertainties in biomass burning emission models resulting from spatial error in satellite active fire location data, *Geophys. Res. Lett.* 36, doi:10.1029/2008GL037145, 2009.

FLAMBÉ and NAAPS are developed by NRL with support from NASA and the Office of Naval Research.

Rationale: Land cover and available fuel

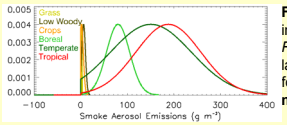


Figure 1. This graphic shows the release of aerosols from burning in different vegetation types, based on data from the review by *Reid et al. (ACP, 2005)*. In terms of estimating emissions based on land cover, the priority is 1) forest vs. non-forest; 2) variability within forests; 3) everything else. **Forest vs non-forest is the single most important determinant of smoke release per area burned.**

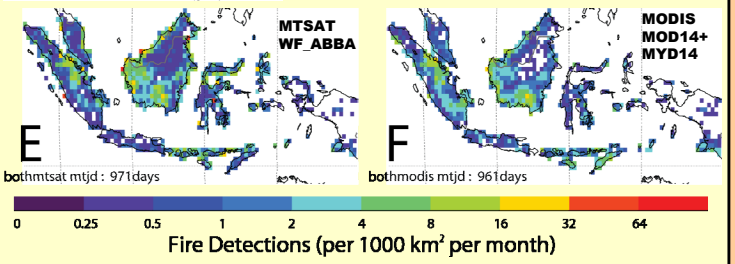
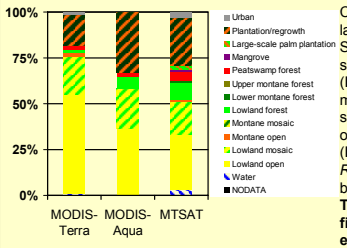
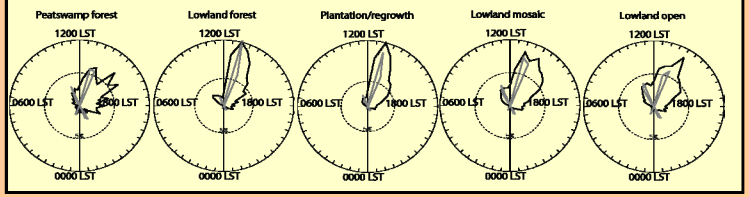


Figure 2, above. Fire detection density from two sensors, the MTSAT geostationary imager (left) and MODIS (right), over a period of nearly 3 years from 2009-2011. The overall patterns of burning seen by the two sensors are similar, but the geostationary imager captures more burning in interior areas of the Malay Peninsula and Borneo. Areas with relatively more geostationary detections correspond broadly to areas of intact forest. **The implication is that the two sensors have different sensitivities to burning in different land cover types.**

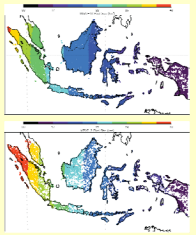
Diurnal cycle effects on sampling of fire regimes

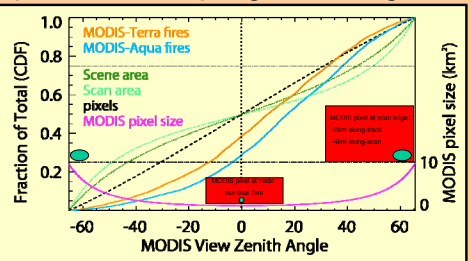


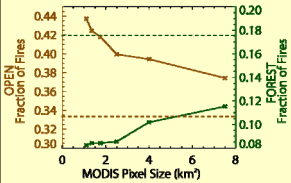
Comparison of the fire locations to a new map of SE Asia land cover produced at the National University of Singapore (*Miettinen et al., Remote Sensing Letters 2011)* shows important differences between the different sensors (**Figure 3, left**). Terra and Aqua MODIS sample relatively more burning in open areas, while MTSAT observations show relatively more fire in forested areas. Diurnal cycles of fires in each land cover type based on MTSAT data (**Figure 4, below**) agree generally with earlier work (*Giglio, RSE 2007; Mu et al. JGR in review)* showing forest burning, especially peat swamp, occurring later in the day. **These diurnal effects are consistent with the observed fire distributions, but diurnal cycles alone cannot explain all differences.**



Pixel ground footprint and sampling of fire regimes



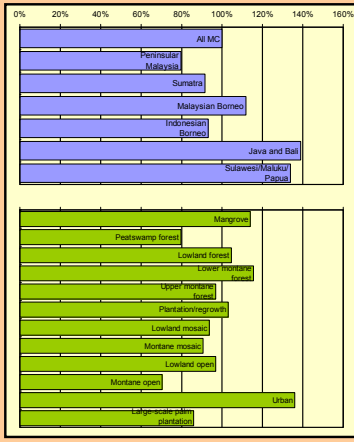




Both geostationary and MODIS sensors have variable pixel geometry across the scan. For MTSAT, pixel size is a function of distance from the subsatellite point, which is fixed (Figure 5, above left). For MODIS, pixel size varies across the scan (Figure 6, above). Because pixel size and geography covary for MTSAT, we cannot directly test the effect of varying pixel size, but we can for MODIS. Figure 8 (left) shows fraction of detected fires in forest and open areas as a function of MODIS pixel size. MTSAT fractions are shown as dotted lines.

The relative efficiency of detection of fires in different land cover types is strongly affected by the pixel ground footprint size. Detection of fires in forest vs. open land cover by MTSAT (16-40 km² pixel size) is qualitatively consistent with the trend vs. MODIS pixel size (1-10 km²).

Using MTSAT diurnal cycle to diagnose MODIS sampling of fire regimes and regions



MTSAT has demonstrated different sensitivity to fire regimes from MODIS, but we can use the MTSAT diurnal information to estimate the magnitude of biases in estimated distributions of fire based on MODIS data. For regional fire distributions (above left, Figure 9), we can do this by comparing the fire activity during the period sampled by MODIS with the overall fire activity, and then normalizing to the regional totals. For this regional comparison, we can use a metric of "fires detected per usable (cloud-free + cloudy) look." For vegetation types (Figure 10, below left) we cannot accurately estimate the number of looks, so the results are less accurate, because they are based on total fire counts only. **We can see that regional estimates of fire activity based solely on MODIS MOD14 may overestimate fires in southern Indonesia while underestimating activity in Malaysia. We can also see that fires in peat swamp forest will be under-estimated in MOD14-based inventories, relative to fires in non-forest areas.**