THE SPATIAL DYNAMICS OF FIRE IN THE AMAZON BASIN AND SATELLITE NEEDS FOR CHARACTERIZING THESE DYNAMICS IN THE CONGO BASIN

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1. Introduction

The Amazon is rapidly being transformed by fire. Satellites typically detect thermal signatures from 40,000 to 50,000 separate fires each year. Amazonian forests are being rapidly cleared, and the remaining forest fragments appear unusually vulnerable to fire. This occurs because forest remnants have dry, fire-prone edges, are juxtaposed with frequently burned pastures, and are often degraded by selective logging, which increases forest desiccation and fuel loading. To date, fires have generally been spatially co-located with road networks and associated human land use because almost all fires in this region are anthropogenic in origin.

Detection of active fires beneath forest canopies has not been possible due to the low intensity of initial fires but may be possible in recurrent burns and logged forests due to the more intense fires resulting from higher fuel loads. The canopy damage caused by fires, even low intensity fires, is detectable through sub pixel linear mixture modeling techniques but rapid canopy closure necessitates mapping every one to two years for accurate assessment of fire dynamics. Forest fires create positive feedbacks in future fire susceptibility, fuel loading and fire intensity. Unless current land-use and fire-use practices are changed, fire has the potential to transform large areas of tropical forest into scrub-savanna. In portions of the eastern Amazon, accidental fires have impacted nearly 50% of remaining forests and caused more deforestation than intentional clearing in some years. Fires are operating as a large-scale edge effect in the sense that most fires originate outside fragments and penetrate considerable distances into forest interiors. Multi-temporal analyses of satellite imagery reveal that fire frequency is substantially elevated within 2400 m of forest margins, although most burned forest occurred within 500 m of forest edges. The obvious synergism between forest fragmentation and fire poses serious risks to tropical ecosystems and has important implications for land management. Models suggest that by the year 2020, from 40-56% of the Brazilian Amazon could be deforested or heavily degraded, with pristine forests confined to far western areas of the region. However, more recently, Brazil has committed to the creation of 50 million hectares of new national forests by 2010, an area the size of Spain, which could blunt the fire threat to Amazonian forests. All of this presumes that the spatial dynamics of Amazonian fires remain unchanged. Climate change, if severe enough, could alter this situation, potentially changing the fire regime to one of increased fire frequency and severity for vast portions of the Amazon forest, even far from deforested edges.

2. What about the Congo?

The African humid tropics have experienced the least amount of forest clearing within the humid tropical biome over the last two decades. Central Africa currently lacks the large-scale, agro-industrial activities that contribute to the relatively high rates of forest clearing in the Amazon and SE Asia. Much of the forest clearing is due to the expansion of small landholder, subsistence agriculture or artisanal uses that are difficult to detect with anything but high spatial resolution satellite sensors. The expansion of subsistence agriculture includes the use of slash and burn techniques, similar to the other tropical regions. MODIS active fire detections are rare within the forested region of Central Africa. When they do occur, they are closely associated with areas of human land use as indicated by satellite imagery. However, little is known about the dynamics of these fires. Do they spread into the forest and if so, how far? Do the characteristics of leaf-litter and duff within the Congo forests allow fire to spread once started or is fire spread virtually impossible once under the canopy? With so much known about the spatial dynamics of fire in the Amazon, why is so little is known about the current fire dynamic in Central Africa?

Perhaps the most telling difference is the availability of satellite imagery of sufficient spatial, temporal and spectral resolutions. The major areas of tropical forest all experience frequent cloud cover, some subregions more than others. The northern Amazon, the western Congo, and insular Indochina (Indonesia, Malaysia, Papua New Guinea) are the most difficult regions to acquire cloud free satellite observations. The US Landsat Data Collection, the largest and most complete collection of global Landsat data, only has roughly a 50% chance of including any acquisitions in these areas with less than 10% cloud cover over a five year period. These holdings are based on an acquisition plan that collects observations according to the probability of low cloud cover which is not optimal for these regions. However, the availability of Landsat observations in the Amazon is augmented with data collection by the Brazilian space agency's (INPE) receiving station in Cuíaba, Brazil and availability in SE Asia by stations in Bangkok, Thailand and Alice Springs, Australia. While the addition of these regional stations does not guarantee full, cloud-free coverage – the chances of annual observations are greatly increased compared to the African Congo. The Malindi receiving station in Kenya nominally covers the region but has been of limited value with few if any acquisitions between 1990 and 2000. Malindi is reported to have made recent (2008) acquisitions and stations for other instruments of similar capacity may soon be implemented in Gabon, providing hope for future capacity to conduct detailed analyses of land cover change and the associated fire dynamics in Central Africa.