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MODIS Data Used to Study 2002 Fires in Kalimantan, Indonesia

PAGES 189, 192

Smoke and haze blanketed western Indonesia during August and September 2002, signaling the arrival of another El Niño event in Southeast Asia. Although not as severe as the 1997–1998 El Niño event, the 2002 El Niño produced drought conditions in western Indonesia that favored extensive biomass burning in lowland areas of Borneo, Sumatra, and Sulawesi, three of the largest islands that form part of the vast Indonesian archipelago. Data derived from the Moderate Resolution Imaging Spectrometer (MODIS) on board the NASA Terra satellite showed that most of the burning during 2002 occurred in central and western Kalimantan (Indonesian Borneo), where forests are being cleared to make way for industrial oil palm and pulp plantations.

Comparison of fire data from several different satellite sensors also reveals that fires detected in Kalimantan during 1997 appeared more numerous (Figure 1) and burned over a longer period (Figure 2) than fires that burned in late 2002 (see discussion below). This result is consistent with recent El Niño observations that characterize the current event as moderate relative to the 1997–1998 event (see http://www.cpc.ncep.noaa.gov/ products/analysis_monitoring/enso_advisory/).

The El Niño-related fires in Indonesia have had a significant impact on regional air quality, as well as the global carbon cycle. A recent study on the 1997 fires in Kalimantan suggests that burning in these areas, which contain significant amounts of peat, may produce an extraordinarily large biogenic pulse of carbon—up to 40% of the mean annual global carbon emissions from fossil fuels [*Page et al.*, 2002]. Smoke from the fires also poses significant hazards to health and transportation, and the fires themselves consume a considerable amount of forest biomass [*Siegert et al.*, 2001] in one of the world's most important areas of tropical biodiversity [*Myers et al.*, 2000].

Satellite sensors on board polar-orbiting satellites have played a major role in identification of fire outbreaks and spread in Indonesia. Until MODIS data became freely available to the user community through the U.S. Geological Survey (see http://edcdaac.usgs.gov/dataproducts.html), most operational fire mapping was conducted using thermal imagery provided by the NOAA Advanced Very High Resolution Radiometer (AVHRR). Use of MODIS fire products presents several distinct advantages over the AVHRR, including improved geolocation, use of consistent processing methods, and rapid delivery over the Internet. Moreover, algorithms applied to AVHRR data typically produced a large number of false positives due to saturation in AVHRR channel 3 (3.55 – 3.93 μm) in which surface temperatures greater than 325 K received a maximum value in the output range of the sensor [*Kaufman et al.*, 1990]. Although Sun-glint and high surface temperatures during the day may still produce false positives in MODIS imagery [*Justice et al.*, 2002], MODIS thermal channels saturate at much higher temperatures, and therefore should provide a more accurate source of information on the timing and distribution of fire events than the AVHRR. Further, fewer false positives in MODIS products are likely, since more bands are available to help reject false positives (36 for MODIS versus five for AVHRR), and the placement of the MODIS mid-infrared channel (centered at 4 μm for MODIS versus 3.8 μm for AVHRR) reduces the proportion of radiance received from surface reflection.

The 2002 Fires in Perspective

Because MODIS fire data are relatively recent (the instrument was launched in December 1999), data from the AVHRR or Optical Line Scan (OLS), on board the Defense Meteorological Satellite Program satellites (DMSP), may be used to put the 2002 fires in historical perspective.

Figure 1 shows the distribution of 2002 fires from MODIS and the 1997 fires derived from daytime passes (approximately 14.30 local time) of the AVHRR on board the NOAA 14 satellite. These data were obtained from local receiving stations in Kalimantan and Java during the peak of the burning from August-September (Figure 2). The MODIS data represent those thermal anomalies that were classified as

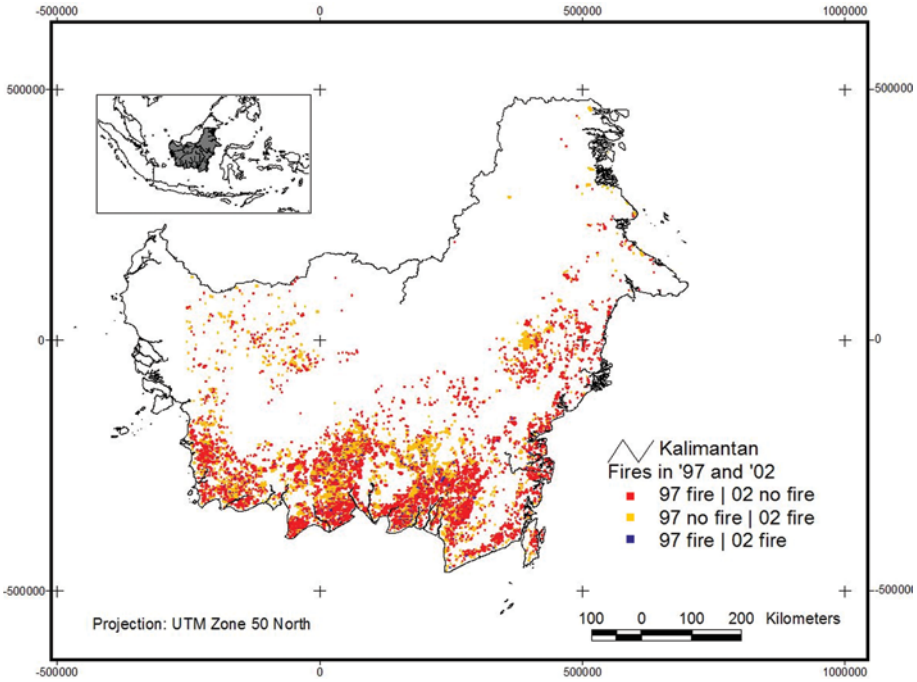

Fig. 1. Overlay of 1997 fires from AVHRR with 2002 fires from MODIS covering Kalimantan, Indonesia.

BY DOUGLAS O. FULLER

nominal or high-confidence fires (see http://edcdaac.usgs.gov/modis/dataprod.html for further information); whereas the AVHRR fires represent a set of fires validated using DMSP-OLS observations [*Fuller and Fulk*, 2000]. This Figure reveals a similar spatial pattern, but very little overlap between the two events. Of the fire pixels identified in 1997, fewer than 10% of the 2002 fires fell on the pixels that experienced fire in 1997. While some of the differences between fires mapped with AVHRR and MODIS may be due to the different methods employed to identify active fires, as well as diurnal fire effects (Terra overpass time is approximately 10.30 local versus 14.30 for NOAA 14), overall, the MODIS fire products indicate fewer fire pixels during the 2002 burning event in Kalimantan.

In addition, comparison of the two sources indicates displacement of 2002 fires away from areas that burned previously. This result is consistent with the pattern of land clearing observed during 1997–1998, in which fires tended to penetrate increasingly toward the forested interior of Borneo as more land was cleared for plantations. Fortunately, the 2002 fires appear to have ended by December (Figure 2), a pattern that is similar to that observed in 1997 using DMSP-OLS data. Because of their coarse spatial resolution (2.7 km versus 1 km for both AVHRR and MODIS), DMSP-OLS fire data are not directly comparable to AVHRR or MODIS. However, DMSP-OLS data do provide useful information on the timing of the different fire events as shown in Figure 2, which indicates that the 1997 event possessed a moderately longer duration than the 2002 event.

This research underscores the importance of satellite data continuity as well as the value of MODIS as a successor to the NOAA-AVHRR. Future sensor systems comparable to the AVHRR and MODIS are essential to support continued terrestrial monitoring of fires and land-cover change. Planning is underway to develop a new series of comparable sensors on board the National Polar Operational Environmental Satellite System (NPOESS) for launch in 2009 [*Townshend and Justice*, 2002].

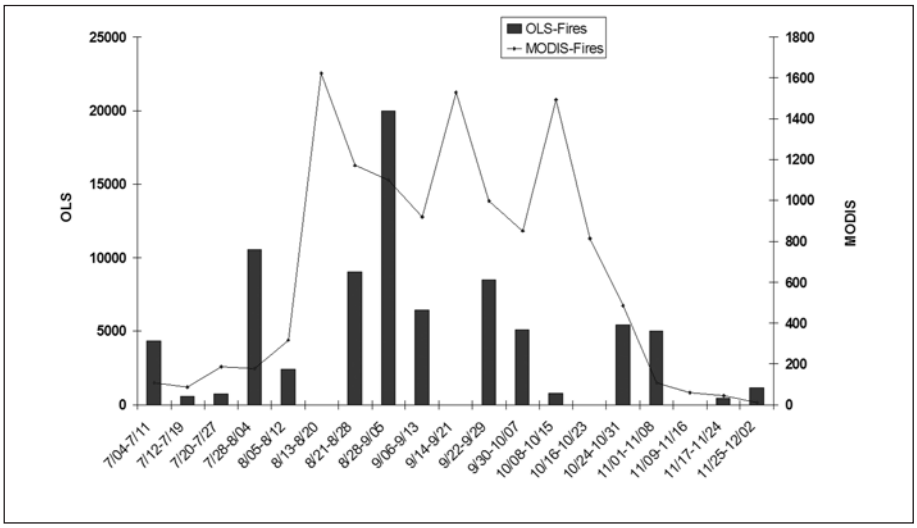

Fig. 2. Timing of the 1997 fire event from DMSP-OLS observations versus the 2002 event observed from MODIS. The Y axes show the number of fire cells detected for each data type. The DMSP-OLS observations cover a larger area of western Indonesia relative to the MODIS data shown in Figure 1.

In addition, the 2002 launch of another MODIS instrument on the Aqua platform gives fire researchers the potential to obtain four fire observations each day, thus leading to improved understanding of diurnal fire effects and duration of individual fires.

Acknowledgments

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References

Fuller, D. O. and M. Fulk, Comparison of NOAA-AVHRR and DMSP-OLS for operational fire monitoring in Kalimantan, Indonesia, *International Journal of Remote Sensing, 21*, 181–187, 2000.

Justice, C. O. et al., The MODIS fire products, *Remote Sensing of Environment, 83*, 244–262, 2002.

Kaufman, Y. J., A. W. Setzer, C. O. Justice, C. J. Tucker, M. C. Pereira, and I. Fung, Remote sensing of biomass burning in the tropics, *Fire in the Tropical Biota: Ecosystem Processes and Global Challenges*, edited by J. G. Goldammer, pp. 371–399, Springer-Verlag, Berlin, 1990.

Myers, N., R. A. Mittermeier, C. G. Mittermeier, G. A. B. da Fonseca, and J. Kent, Biodiversity hotspots for conservation priorities, *Nature, 403*, 853–858, 2000.

Page, S. E, F. Siegert, J. O. Rieley, H.-D. V. Boehm, A. Jaya, and S. Limin, The amount of carbon released from peat and forest fires in Indonesia during 1997, *Nature, 420*, 61–65, 2002.

Siegert, F., G. Ruecker, A. Hinrichs, and A. A. Hoffmann, Increased damage from fires in logged forests during droughts caused by El Niño, *Nature, 414*, 437–440, 2001.

Townshend, J. R. G. and C. O. Justice, Towards operational monitoring of terrestrial systems by moderate-resolution remote sensing, *Remote Sensing of Environment, 83*, 351–359, 2002.

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Key Senators Issue Call for 'Meaningful' Climate Legislation

PAGE 190

With the U.S. Senate currently considering national energy legislation, Senators John McCain (R-Arizona) and Joseph Lieberman (D-Connecticut) plan to offer a modified version of their bipartisan, proposed Climate Stewardship Act of 2003 (S. 139) as an amendment.

The amendment would establish a market-driven system of greenhouse gas tradeable allowances to reduce emission. It would also provide for a program of scientific research on abrupt climate change in order to identify and understand past instances of abrupt change; and would establish a national greenhouse gas data base.

At a 7 May hearing of the Senate Commerce, Science and Transportation, committee chair McCain said, "I do not believe any energy legislation can be truly meaningful unless it seeks to address climate change."

McCain admitted that the amendment would face stiff opposition, but said he hoped it would be the beginning of "a long Congressional battle" to bring about climate change policy legislation.

At the hearing, McCain tried to get witnesses to help him make the case for the need for significant climate legislation. He said that although he understood the need for scientists often to express concerns and findings in terms of uncertainty, more definitiveness would help his cause. "It makes it a little more difficult for me to make my case and ask colleagues to vote on cap and trade initiatives when they say that scientists aren't sure yet."

Richard Alley, professor of geosciences at Pennsylvania State University, told the committee, "I am never going to tell you I am certain." However, Alley, who chaired a recent National Academy of Science committee that issued the 25 February report, "Abrupt Climate Change: Inevitable Surprises," added that the wealth of evidence presented in Academy reports and international documents indicates that climate change is highly likely, is occurring, and highly likely occurring because of human influence.

"I make many decisions that I personally have less confidence in than the science behind climate change," Alley said. He later told *Eos*, "Even though there is uncertainty, the history is that if we react as if science is true, we are generally successful."

Andrew Solow, director of the Marine Policy Center at the Woods Hole Oceanographic Institution, testified about melting glaciers, among other issues. "I would be willing to bet that human activity has changed the climate, and these activities will continue to change the climate," he noted.

—RANDY SHOWSTACK, Staff Writer