Geophysical Research Abstracts,
Vol. 10, EGU2008-A-06196, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-06196
EGU General Assembly 2008

Characterizing the diurnal cycle of fire activity across Africa in 2004 using frequency-magnitude analyses

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A frequency-magnitude analysis of fire radiative power (FRP) on a per pixel basis was performed to examine the spatial and temporal differences in diurnal cycles of fire activity. Fire pixels across Africa in 2004 were subset from imagery collected with the Spinning Enhanced Visible and Infrared Imager (SEVIRI) onboard the geostationary Meteosat satellite, and also with the Moderate Resolution Imaging Spectroradiometer (MODIS) onboard the polar orbiting Aqua and Terra satellites. Frequency-magnitude distributions (i.e., the counts of fire pixels within a discrete range of FRP values) were analyzed in two fashions. First, as a means of eliciting a diurnal response at 15-minute temporal resolution, 96 power-laws per day were fit to only the SEVIRI-derived FRP data. Results demonstrate that the slopes (β) and intercepts (α) of the best-fit power law were synchronized and oscillated in daily cycles. Minimum nighttime slopes had a mean (μ) of 0.84 and a standard deviation (σ) of 0.25, whereas maximum daytime slopes had values of 2.98 ± 0.34 ($\mu \pm 1\sigma$) indicating that throughout the day the rate of increase and decrease in the number of less energetic fire pixels is quicker than that for the most energetic fire pixels. Supporting analyses further revealed that the fraction of persistent fire pixels (i.e. those that are detected in the same geographic location over consecutive SEVIRI imaging timeslots) also exhibited a diurnal cycle, and that more energetic fire pixels are more likely to be detected during prolonged periods of persistence. Second, as a means of cross-calibrating the two sensors, frequency-magnitude distributions of concurrent ($\pm$ 6 minutes) and collocated fire pixels detected by SE-

VIRI and MODIS were paired under the assumption that an individual thermal distribution measured by SEVIRI has a unique counterpart measured by MODIS. Results of this strategy revealed that ratios of SEVIRI to MODIS fire pixel counts, χ_{count}, and FRP, χ_{FRP}, tracked in general with the diurnal profile of FRP thereby indicating that the MODIS instrument and detection algorithm, in combination, are relatively more sensitive than SEVIRI during the night compared to the day. Over the course of a full 24 hr diurnal cycle, SEVIRI measured 38.1 $\pm$ 6.3% ($\mu \pm 1\sigma$) of the fire radiative energy (FRE) that MODIS would have measured if it had the same spatial coverage and temporal resolution as SEVIRI. It is also shown that this daily-integrated ratio fluctuated over a range of 30% throughout the year due to the migration of fire activity. Both strategies reinforce the notion that spatially and temporally integrated statistics are strongly influenced by the locations and times of greatest fire activity. The implications of this work can be extended to biomass burning emissions inventories if the relationships between FRP, FRE, and trace gas and particulate matter production are also considered.