Comment on "Seasonal, intraseasonal, and interannual variability of global land fires and their effects on atmospheric aerosol distribution" by Y. Ji and E. Stocker

Louis Giglio and Jorge Pinzon
Science Systems and Applications, Inc., Lanham, Maryland, USA

Prasad Kasibhatla
Nicholas School of the Environment and Earth Sciences, Duke University, Durham, North Carolina, USA

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1. Introduction

[1] On the basis of an analysis of active-fire time series from the Tropical Rainfall Measuring Mission (TRMM) Visible and Infrared Scanner (VIRS) for the 1998–2001 time period, *Ji and Stocker* [2002] (hereinafter referred to as JS2002) have suggested that biomass-burning fires in the tropics and subtropics exhibit significant intraseasonal oscillations. Specifically, the analysis of JS2002 shows 15- and 25–60-day oscillations superimposed on seasonal and interannual cycles of fire activity. JS2002 have also found that variability of the VIRS fire data is consistent ($r \approx 0.55$) with the TOMS aerosol index (AI) during the same period.

[2] Here, we show that these reported intraseasonal oscillations are most likely artifacts caused by the methodology used by JS2002 to composite the raw fire counts from VIRS. We also comment on the potential impact of the nonuniform latitudinal sampling frequency of VIRS with respect to the analysis of JS2002. Finally, we point out potential problems related to the use of the TOMS AI data set past the middle of 2000 in the JS2002 analysis.

2. The 15- and 25–60-Day Intraseasonal Oscillations

[3] The orbit of TRMM was deliberately chosen such that the local overpass time drifts significantly each day. Over time, this permits complete sampling of the diurnal rainfall cycle. Consequently, TRMM may also be used to study the prominent diurnal cycle of fire activity [*Giglio et al.*, 2000]. The existence of this cycle has been established through both ground-based observations and, more recently, satellite data [e.g., *Prins and Menzel*, 1992; *Langaas*, 1993; *Prins et al.*, 1998; *Eva and Lambin*, 1998; *Pack et al.*, 2000; *Justice et al.*, 2002]. A typical pattern of diurnal fire activity is shown in Figure 1.

[4] In their analysis, JS2002 employed a 288-pentad time series, with each pentad produced from 5-day composites of VIRS fire observations. During each 5-day interval, however, the local overpass time of TRMM drifts by several hours. Figure 2 illustrates this for three different latitudes. Clearly, a VIRS time series of any phenomenon characterized by diurnal variation will contain sampling-induced periodicities. An appropriate, latitude-dependent, averaging interval of 25–50 days, however, can be used to "average out" the effect of such periodicities. This issue has been discussed in the context of diurnal precipitation cycles by *Lin et al.* [2002].

[5] To examine whether or not the specific orbital characteristics of TRMM can lead to an incorrect diagnosis of intraseasonal oscillations in the fire time series, it is worth considering the following relevant question: Given a constant number of fires burned each day, what time series would the VIRS observe? Assuming 100 fires per day distributed over the diurnal cycle of Figure 1, the time series that would be observed at each of the three latitudes is shown in the left panels of Figure 3. (The arbitrary choice of 100 fires per day is simply a convenient scale factor; any physically meaningful value will yield the same results.) It is readily apparent that the use of daily VIRS data can introduce severe biases in apparent fire activity unless a correction is made for the differences in diurnal sampling.

[6] Following the procedure used by JS2002, we now average the daily time series in Figure 3 over pentads, with the resulting time series shown in the middle panels of Figure 3. Clearly, the 5-day averaging interval is 5–10 times too short to average out the signature of the diurnal burning cycle. The result is that highly periodic artifacts remain even in the pentad time series. To quantitatively

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demonstrate this, we show the amplitude of the discrete Fourier transform of each pentad time series in the right panels of Figure 3. Very strong components at frequencies of 0.021, 0.042, 0.066, and 0.084 d^{-1} are evident; these correspond to periods of 48, 24, 15, and 11 days, respectively, entirely consistent with the intraseasonal oscillations reported by JS2002. (Note that the absence of the 48-day oscillation at the equator is expected given the spacing of the observations shown in Figure 2c). We suggest, therefore, that the intraseasonal oscillations in fire activity reported by JS2002 are most likely artifacts caused by aliasing of the 24-hour diurnal burning cycle. This is not to say that intraseasonal oscillations in fire activity do not exist, but simply that a VIRS pentad time series cannot be used to reliably observe such oscillations.

3. Nonuniform Latitudinal Sampling Frequency of VIRS

[7] The number of VIRS overpasses is considerably greater at higher latitudes (Figure 4), an issue that has been addressed by *Giglio et al.* [2003] in the context of the production of an independent VIRS active fire data set. JS2002 have, in effect, multiplied the distribution of active fire activity by a highly nonlinear weighting function. This contaminates the subsequent empirical orthogonal function analysis by introducing a nonlinear bias in the correlation between the individual 10° × 10° regions over which the analysis was performed. Consequently, the overall correlation coefficients reported by *Ji and Stocker* [2002] are affected by this bias.

4. TOMS Aerosol Index Time Series

[8] On a separate issue, we question the use of the Earth Probe TOMS aerosol index (AI) time series through 2001

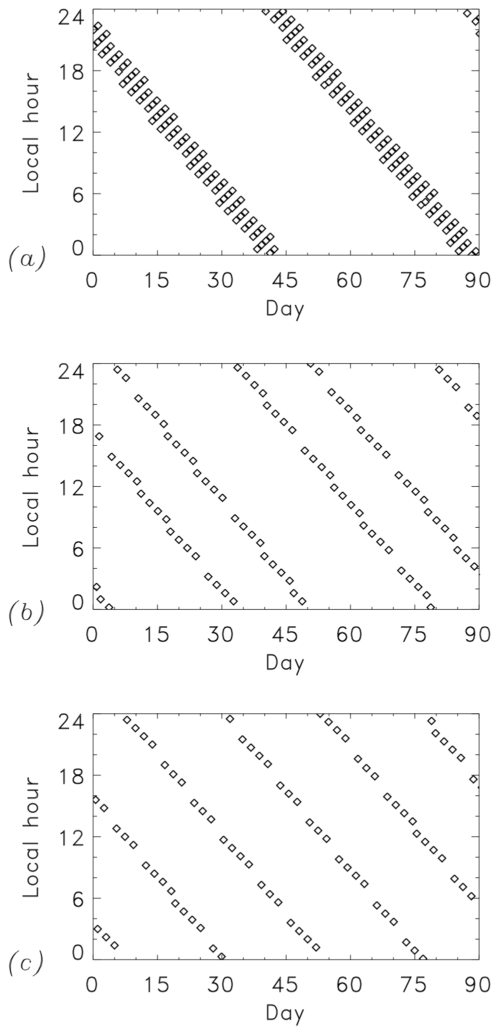

Figure 2. Local time of VIRS overpass during a three-month period (February–April 1999) at three different sites: (a) United States (36°N, 86°W), (b) Southeast Asia (15°N, 105°E), and (c) equatorial Africa (0°N, 25°E).

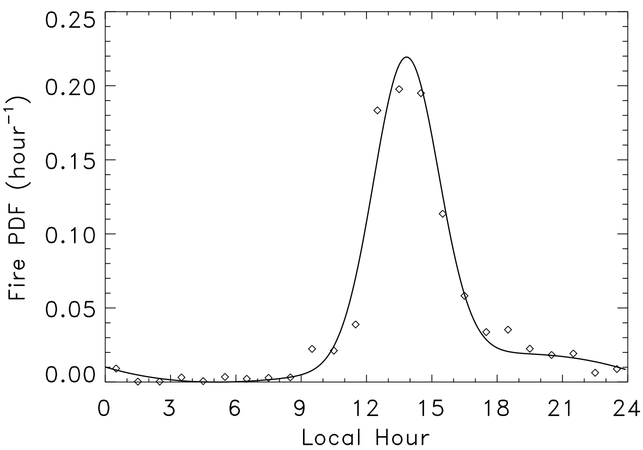

Figure 1. Typical diurnal burning cycle expressed as a probability density function (PDF). These data were derived for the 1999–2001 burning season in Borneo using TRMM VIRS observations, but are representative of the diurnal burning cycle in most regions. The solid curve is a fitted Gaussian + cubic polynomial.

in the JS2002 analysis. This instrument has undergone nontrivial degradation since mid-2000, rendering subsequent TOMS data unsuitable for time series analysis. Indeed, the Goddard Distributed Active Archive Center (DAAC) does not distribute TOMS data acquired after June 2000 for this reason. The TOMS web site does offer subsequent TOMS data, but explicitly warns against using it beyond mid-2000 for time series analysis. Consequently, the last 30% of *Ji and Stocker*'s [2002] AI time series is composed of observations that are both biased and very noisy. An example of this for Southeast Asia, one of the two regions that Ji and Stocker considered as part of their singular spectrum analysis, is shown in Figure 5. Other regions exhibit the same sort of behavior. The effect of this degradation is to produce spurious oscillations in the AI principal components and artifacts in the corresponding eigenvectors. The numerical values of the reported correlations between fire counts and AI are therefore questionable.

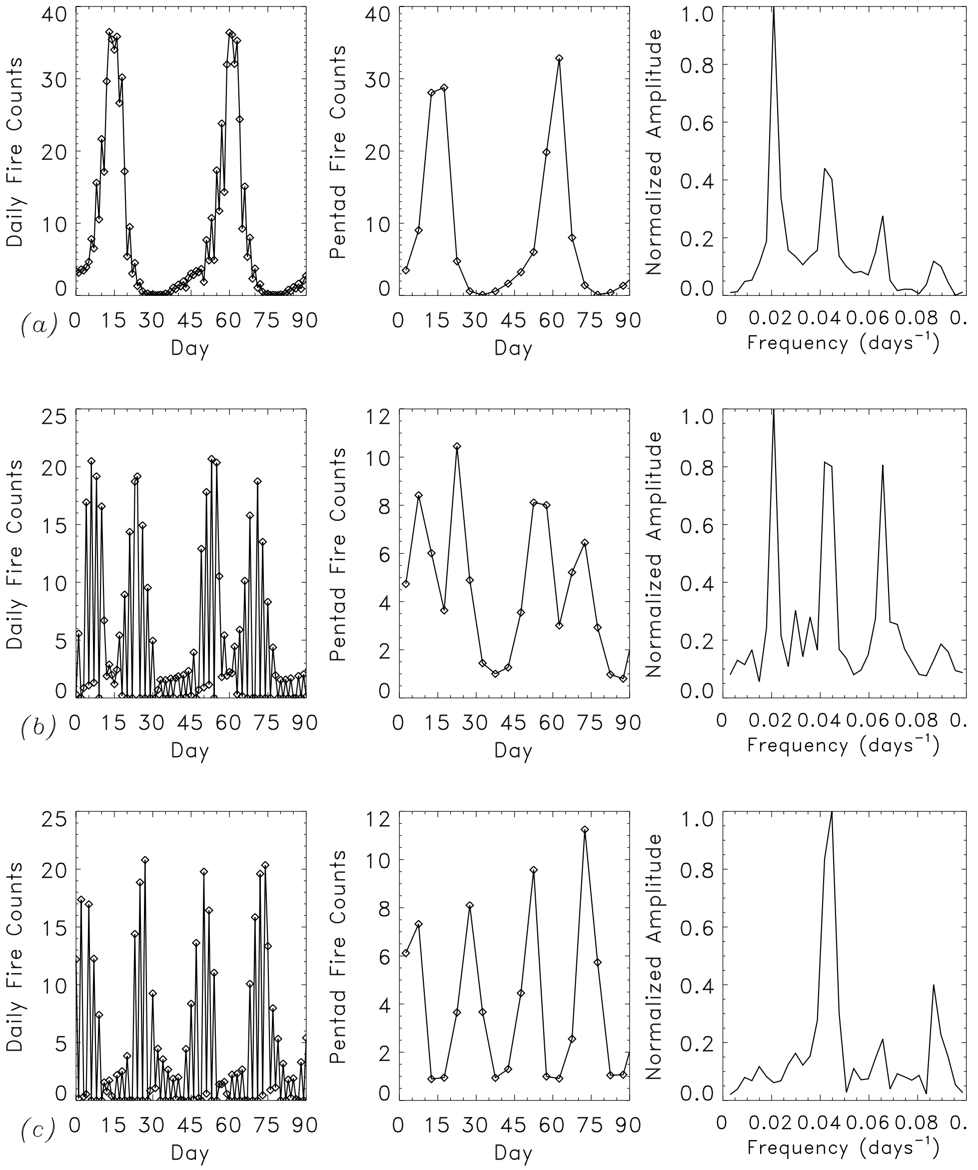

Figure 3. Daily (left column) and pentad (center column) time series of active fire activity as observed by the TRMM VIRS instrument, given a constant number of fires each day and the diurnal burning cycle of Figure 1, for (a) United States, (b) Southeast Asia, and (c) equatorial Africa. Unbiased time series of fire activity would lie perfectly flat. Right column: corresponding amplitude of the discrete Fourier transform of each pentad time series.

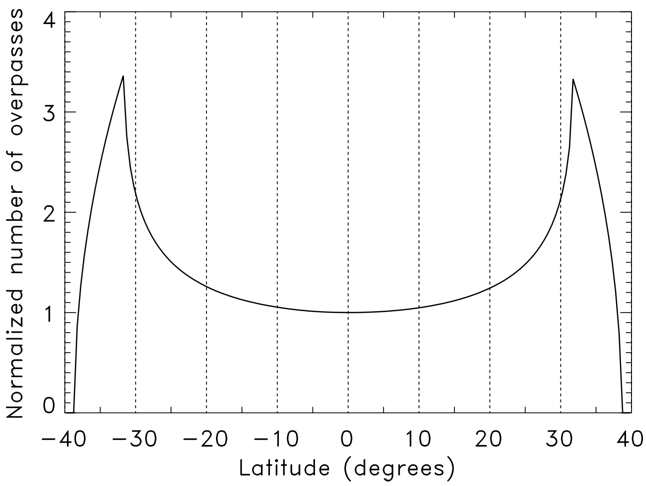

Figure 4. Average number of VIRS overpasses (or "looks") as a function of latitude. Grid cells at 32°N and 32°S are seen more than 3 times as often as those along the equator.

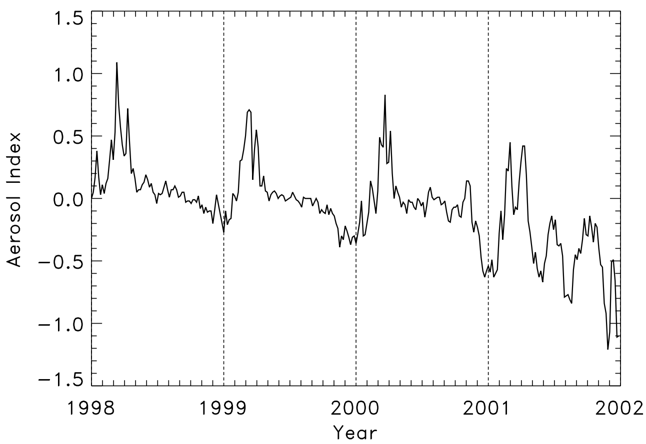

Figure 5. Aerosol index pentad time series within 10° × 10° region located in Southeast Asia. Series degradation becomes very apparent in late 2000.

[9] **Acknowledgments.** This work was supported by NASA grants NAS 531365 and NAG 5-9605.

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L. Giglio and J. Pinzon, NASA/GSFC, Code 923, Greenbelt, MD 20771, USA. (giglio@hades.gsfc.nasa.gov; pinzon@negev.gsfc.nasa.gov)

P. Kasibhatla, Nicholas School of the Environment, Duke University, Room A355, Levine Science Research Center, Box 90328, Durham, NC 27708, USA. (psk9@duke.edu)