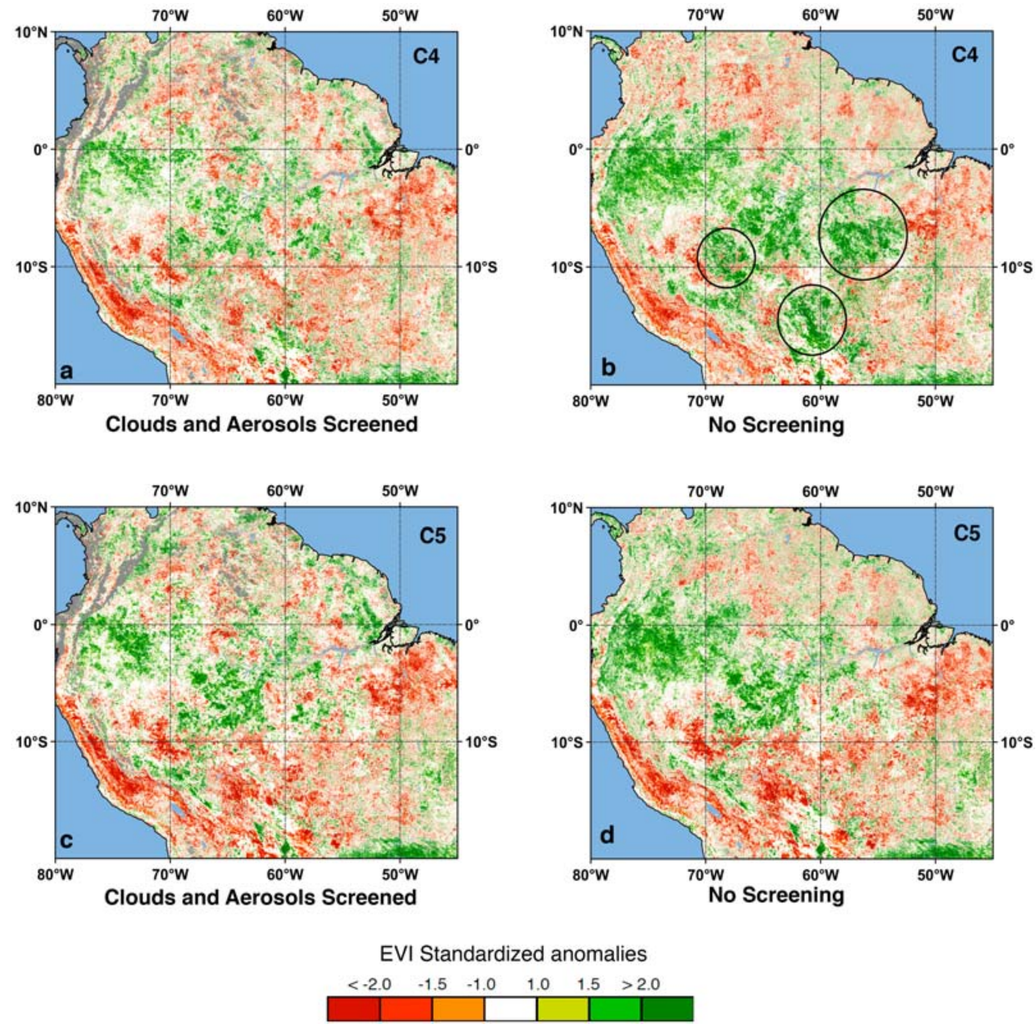

Figure 1. Spatial patterns of July to September (JAS) 2005 standardized anomalies of Enhanced Vegetation Index (EVI) at 1×1 km^2 spatial resolution. (a) Collection 4 (C4) EVI data filtered for clouds (adjacent cloud, mixed clouds and possible shadow) and aerosols (high and climatology aerosols); and anomalies calculated as by SDHR07. (b) C4 EVI with no data-quality filtering (same as Figure 1B of SDHR07). (c) Collection 5 (C5) EVI data filtered for clouds (adjacent cloud, mixed clouds and possible shadows) and aerosols (high and climatology aerosols); and anomalies calculated as by SDHR07. (d) C5 EVI with no data-quality filtering. For consistency between C4 and C5 EVI, anomalies are calculated relative to the base period 2000–2004.

refer to intact (i.e., undisturbed) Amazon forests, south of the Equator, affected with drought during the dry season (July–August–September) of 2005 (Figure S1).

3. Results and Discussion

[5] SDHR07 claim to have filtered out cloud, shadow and aerosol contaminated data from their analysis. However, their published patterns cannot be reproduced when such data are filtered out (Figure 1a compared to Figure 1B of SDHR07) and the spatial extent of greening decreased by 35% (Table S1). SDHR07's patterns can be reproduced only if no data are screened from analysis (Figure 1b). SDHR07's patterns also cannot be reproduced with the newer C5 EVI data, irrespective of whether atmosphere-corrupted data are filtered or not (Figures 1c and 1d). These current EVI data show 28–35% less greening than SDHR07 (Table S1). Three prominent patches of greening in SDHR07 (encircled in Figure 1b), the largest one being approximately 300,000 km^2 in extent, are missing (Figures 1a, 1c, and 1d), and these are located in regions of atmosphere contamination of EVI (Figures S2b and S2c). Exclusion of atmosphere-corrupted data generates somewhat similar patterns with both versions of the EVI data (Figures 1a and 1c and Table S1). Thus, we conclude that the results of SDHR07 cannot be reproduced either with C4 or C5 EVI data owing to inclusion of atmosphere-corrupted data in their analysis.

[6] The quality flags accompanying the EVI data indicate aerosols as the dominant source of atmosphere corruption of EVI data during the dry season in the Amazon region (Figure S2 of the auxiliary material) - large quantities of aerosols emanate from biomass burning during this time [e.g., *Eck et al.*, 1998; *Schafer et al.*, 2002]. Aerosol con-

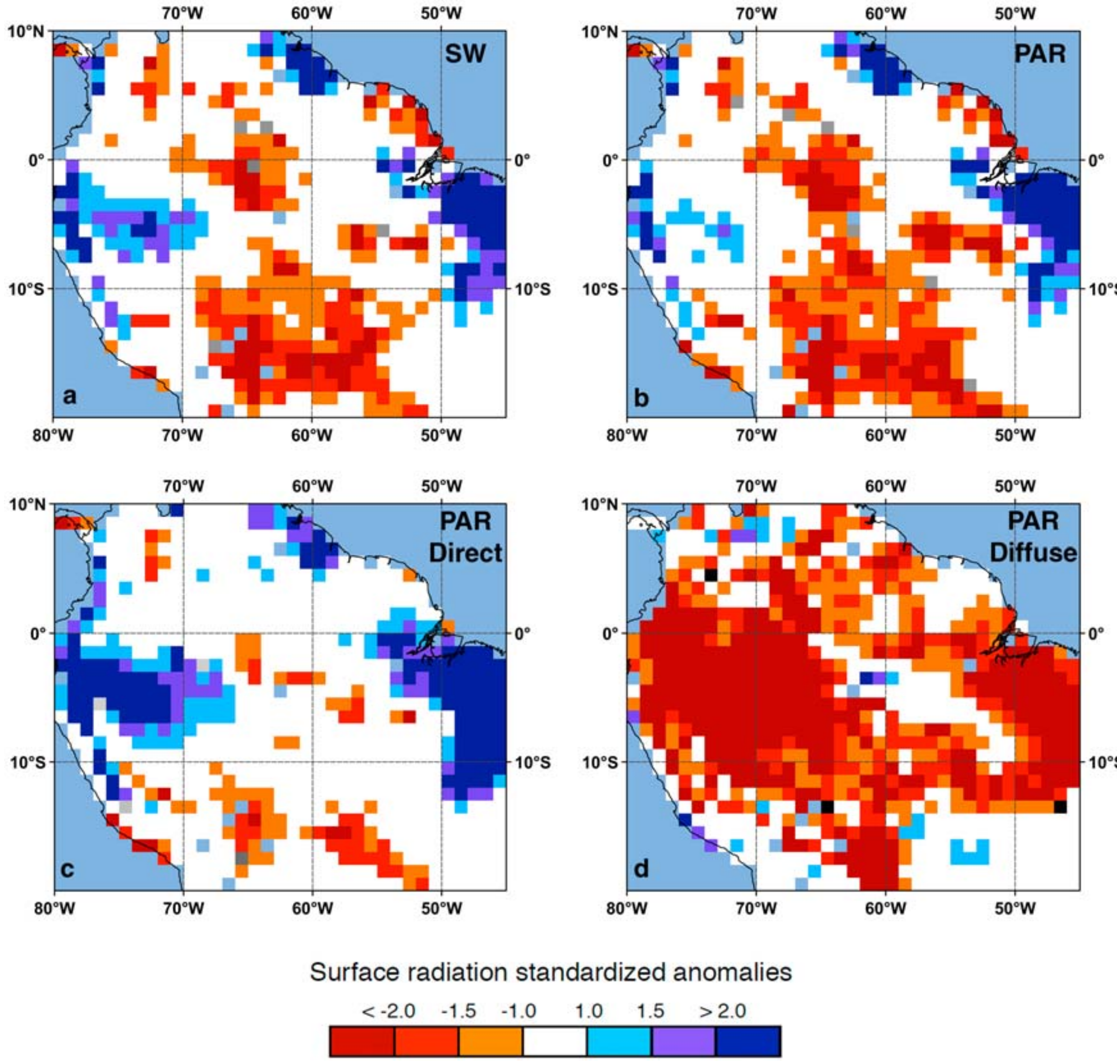

Figure 2. Spatial patterns of July to September (JAS) standardized anomalies of all sky (total sky) surface radiation at 1° × 1° spatial resolution for 2005. (a) Shortwave (SW) radiation. (b) Photosynthetically active radiation (PAR, 400–700 nm). (c) Direct PAR. (d) Diffuse PAR. The reference period for anomaly calculation is 2000–2004.

tamination, as indicated by the "high" and "climatology" quality flags, was higher during the dry season of 2005 compared to non-drought years (Figures S2b and S2c) - consistent with several other reports of anomalous aerosol loads during the 2005 dry season [e.g., *Koren et al.*, 2007; *Bevan et al.*, 2009]. Such corrupted EVI data must be excluded from analysis [e.g., *Didan and Huete*, 2006] (cf. auxiliary material). This will reduce the length of EVI data record, i.e., there may not be valid EVI data for one or two months in the third (July–September) quarter of a year. Consequently, the quarterly mean EVI calculated from the remaining valid EVI data will be incorrect because EVI increases monotonically through the dry season [e.g., *Huete et al.*, 2006]. Similarly, the lack of valid quarterly mean EVI from one or more years will bias the climatological mean and standard deviation in view of the short record length (2000–2006, excluding 2005) and, the 2005 dry season EVI anomalies, as well. The correct estimate of greening, after accounting for these issues (cf. auxiliary material), is about 11–12% (Figure S1). Another 28–29% of these forests show no-changes or browning (Figure S1). The remaining 60% of EVI data are invalid, being atmosphere-corrupted. Including data from more recent years (2007 and 2008) does not change these estimates (Table S3). Thus, we conclude that there is no evidence of large-scale greening of Amazon forests during the 2005 drought in regions for which valid EVI data are available.

[7] SDHR07 speculate that increased levels of sunlight, from lower cloudiness during the drought, might have somehow caused the forests to green-up, drawing on the light-limited nature of Amazon rainforests [*Nemani et al.*, 2003]. The expectation of increased sunlight on the forest canopy due to lower cloud cover may be true for dry seasons, in general, and for the drought of 2005, in particular, which coincided with the dry season of 2005 [*Marengo et al.*, 2008]. However, as mentioned earlier, dry seasons in the Amazon are also associated with significant aerosol loads in the atmosphere from biomass burning [e.g., *Eck et al.*, 1998; *Schafer et al.*, 2002]. This was especially the case in 2005 (Figure S3) [e.g., *Koren et al.*, 2007; *Aragao et al.*, 2007; *Bevan et al.*, 2009]. High levels of aerosol optical depth may reduce photosynthetically active radiation (PAR;

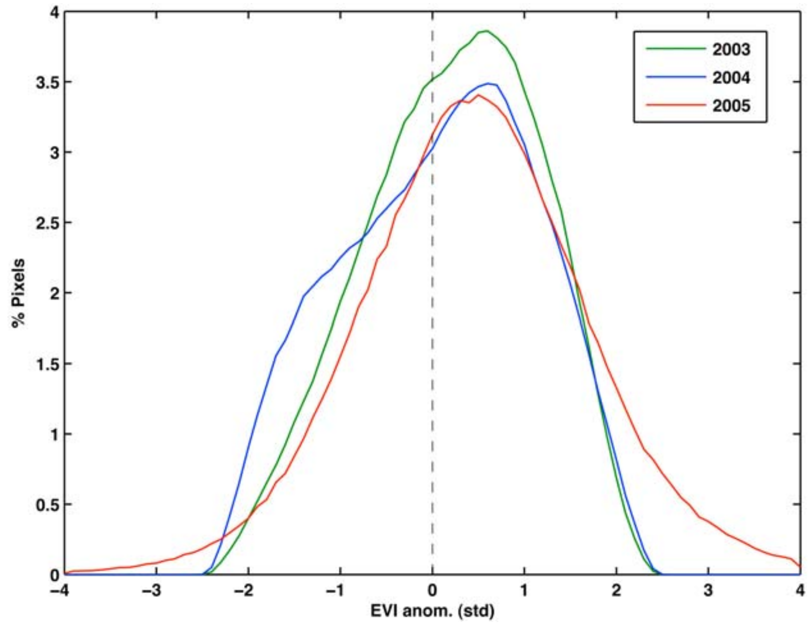

Figure 3. Frequency distribution (%) of July to September EVI standardized anomalies in intact forests within the 2005 drought region, south of the Equator. Shown here are distributions from two non-drought years - 2003 and 2004; and drought year 2005. The reference period used for anomaly calculation is 2000–2008, but excluding 2005.

400–700 nm) by 20%–45%, under cloudless skies [e.g., *Eck et al.*, 1998; *Schafer et al.*, 2002]. We find that surface shortwave radiation declined over 35% of the Amazon forests during the dry season of 2005 (Figure 2a) and PAR declined over an even larger region (47.5%) (Figure 2b). Thus, we conclude that there is no evidence of enhanced surface sunlight levels during the drought of 2005.

[8] Aerosol scattering of solar radiation may increase the diffuse fraction of sunlight incident on the forest canopy, which may enhance photosynthetic rates [e.g., *Gu et al.*, 2003; *Niyogi et al.*, 2004; *Mercado et al.*, 2009; *Oliveira et al.*, 2007]. However, reductions in diffuse PAR were observed over 78.5% of Amazon forests (Figure 2d) and these regions overlap with areas of greening (Figure S1). The extent of decline in direct PAR (14%) was much smaller (Figure 2c). Thus, the observed changes in total and direct-to-diffuse fractions of surface solar radiation are contrary to the expectation of enhanced surface sunlight levels during the drought of 2005. Therefore, we conclude that the speculation of light driven greening of Amazon forests during the drought of 2005 is without basis.

[9] If the greening of Amazon forests in 2005 was induced by the drought, then the magnitude and spatial extent of greening should be expected to vary systematically with the severity of drought. We find that 11%–14% of Amazon forests show greening, while, 24%–30% display browning or no change, irrespective of how the precipitation deficit, a measure of drought severity, is varied (increased or decreased) (Table S2). Besides, the magnitudes of greening and browning also do not change with drought severity (Table S2). Thus, we conclude that there was no co-variation between the severity of drought and the spatial extent and magnitude of greenness changes of Amazon forests in 2005.

[10] Finally, how unique are the drought year 2005 greenness changes relative to non-drought years? To assess this, we analyzed the entire nine-year (2000–2008) dry season C5 EVI record. During the non-drought years of 2003 and 2004, approximately 8% of the intact forests show greening compared to 11% in the drought year 2005 (Table S3). The extents of browning or no-change in 2003 (27%) and 2004 (27%) are also similar to that in 2005 (23%) (Table S3). EVI anomalies of these forests display nearly identical negatively skewed (i.e., dominated by positive EVI anomalies) frequency distributions in 2003, 2004 and 2005 (Figure 3). Moreover, the relative extent of greening vis-à-vis browning in non-drought year 2003 (8% vs. 4%, respectively) is also not significantly different from that in the drought year 2005 (11% vs. 4%, respectively) (Table S3). Besides, prominent spatial patterns of greening and browning, unrelated to precipitation anomalies, are found in other non-drought years as well. Thus, we conclude that the spatial patterns of EVI changes seen in drought year 2005 are not unique in comparison to non-drought years.

4. Conclusions

[11] This study attempts to reconcile contradictory reports of increased tree mortality [*Phillips et al.*, 2009] and extensive biomass burning [*Aragao et al.*, 2007] with anomalous greening of Amazon forests (SDHR07) during the 2005 drought. Our analysis here is focused on answering the following five questions.

[12] First, are the results published by SDHR07 reproducible with both the current (C5) and previous (C4) versions of EVI data? The greening patterns published by SDHR07 cannot be reproduced with C4 EVI data when atmosphere-corrupted data are filtered and analyzed following SDHR07. The published patterns also cannot be reproduced with the newer C5 EVI data irrespective of whether corrupted data are filtered or not. Thus, we conclude that the results of SDHR07 are not reproducible.

[13] Second, what fraction of the intact forest area impacted by the drought exhibited anomalous greening in year 2005? About 11–12% of the forests show greening, while 28–29% of the forests show no-changes or browning, and for nearly 60% of the drought impacted area, there are no valid EVI data to make a determination of changes. Thus, we conclude that there is no evidence of large-scale greening of the Amazon forests during the 2005 drought in regions for which valid EVI data exist.

[14] Third, is there evidence of higher than normal amounts of sunlight during the 2005 drought, which may have somehow caused the forests to green-up, as speculated by SDHR07? Our analysis indicates that surface shortwave radiation declined over 35% of the Amazon forests during the dry season of 2005 and PAR declined over an even larger region (47.5%). Similarly, reductions in diffuse PAR were observed over 78.5% of Amazon forests. These reductions are contrary to the expectation of enhanced surface sunlight levels during the drought of 2005. Thus, we conclude that the speculation of light driven greening of Amazon forests during the drought of 2005 by SDHR07 is without basis.

[15] Fourth, if drought caused the forests to green-up, is there a relationship between the severity of drought and the spatial extent or magnitude of greening? We find that 11%–14% of Amazon forests show greening and 24%–30% display browning or no-change, irrespective of how the precipitation deficit, a measure of drought severity, is varied. Thus, we conclude that there was no co-variation between the severity of drought and the spatial extent and magnitude of greenness changes of Amazon forests in 2005.

[16] Fifth, are greenness changes during the 2005 drought unique compared to changes in non-drought years? During the non-drought years of 2003 and 2004, approximately 8% of the intact forests show greening compared to 11% in the drought year 2005. The extents of browning or no-change in 2003 (27%) and 2004 (27%) are also similar to that in 2005 (23%). Thus, we conclude that the spatial patterns of EVI changes seen in drought year 2005 are not unique in comparison to non-drought years. Therefore, our overall conclusion is that the Amazon forests did not green-up during the 2005 drought.

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