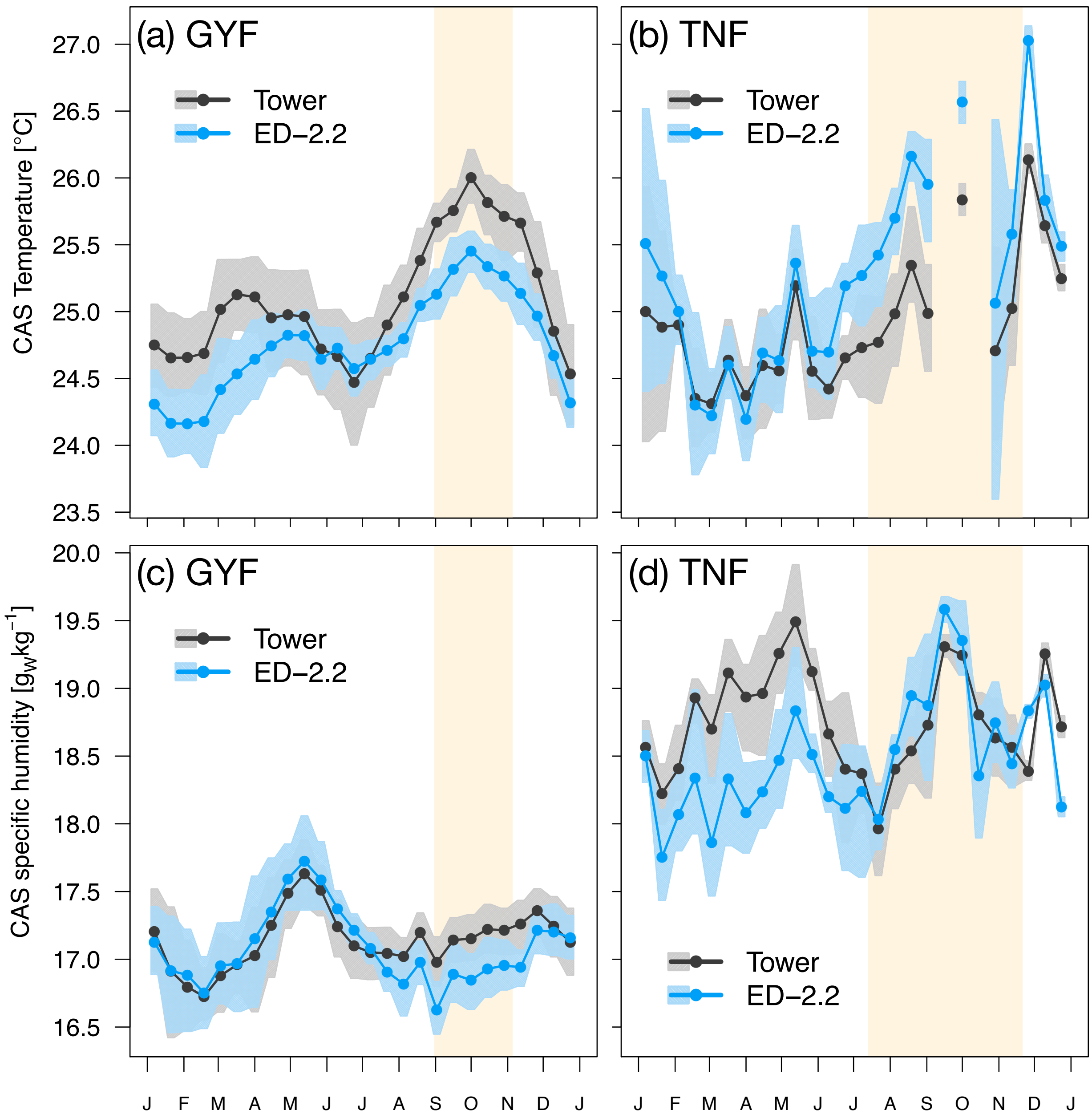

Figure S1: Fortnightly means of the (a,b) mean canopy air space temperature and (c,d) mean canopy air space specific humidity, obtained from the model and from the vertical average of the (a,c) GYF and (b,d) TNF tower measurements. Data for the TNF tower are available between 2002 and 2005 (Hutyra et al., 2008). Bands are the 95% confidence interval of means obtaining from bootstrapping, and rectangles in the background correspond to the site's climatological dry season. The missing periods are due to insufficient data of all times of the day to generate the fortnightly averages.

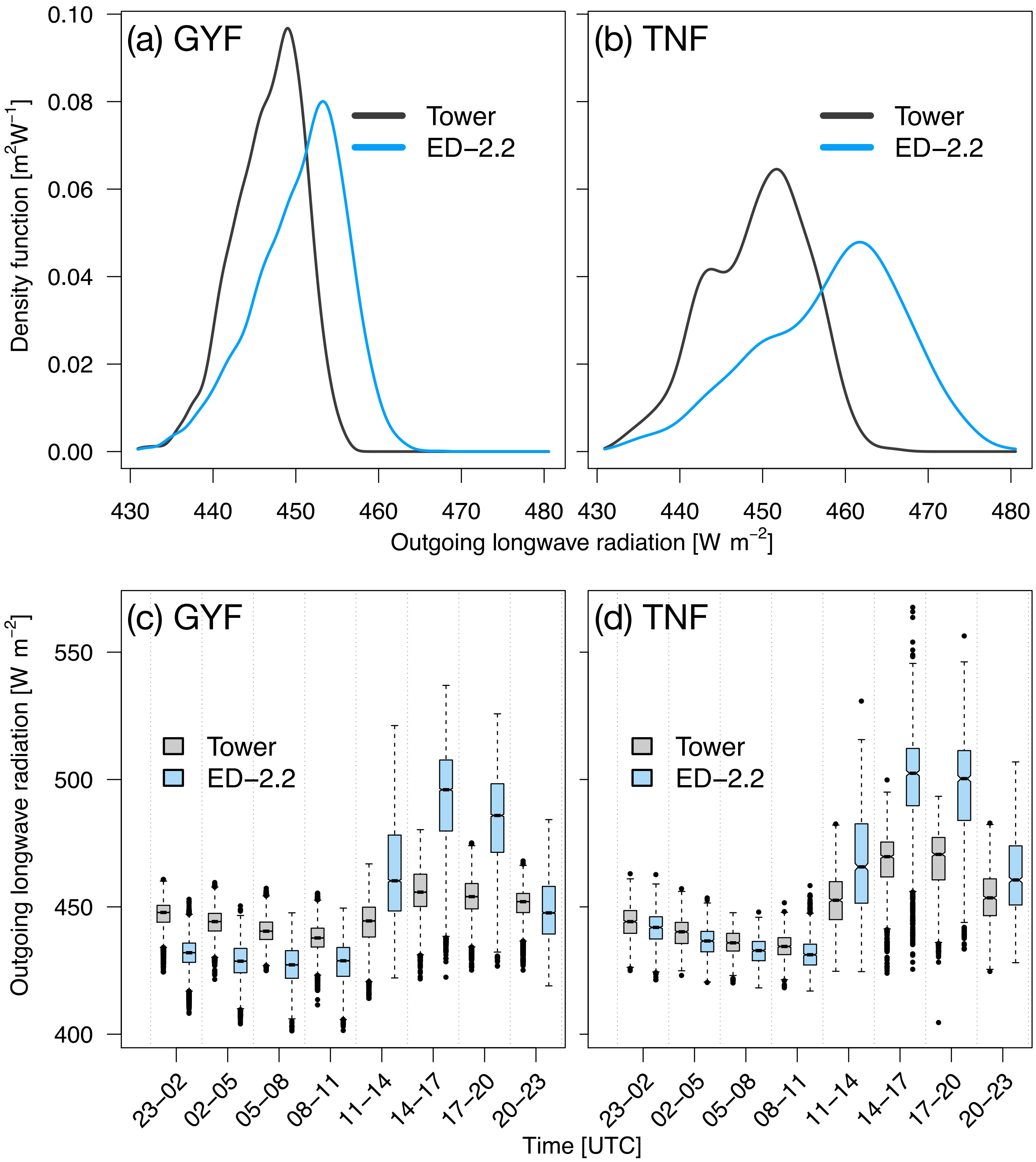

Figure S2: (a-b) Kernel density estimate of daily averages of outgoing thermal infrared (longwave) irradiance predicted by the model and measured at the towers for sites (a) GYF and (b) TNF. Only days with no gaps in observations were used to estimate kernel density for both observations and model. (c-d) Box-and-whisker plot of outgoing thermal infrared irradiance from ED-2.2 and observations, organized by time of day, for sites (c) GYF and (d) TNF. The model distribution includes only the times for which a corresponding observation existed.

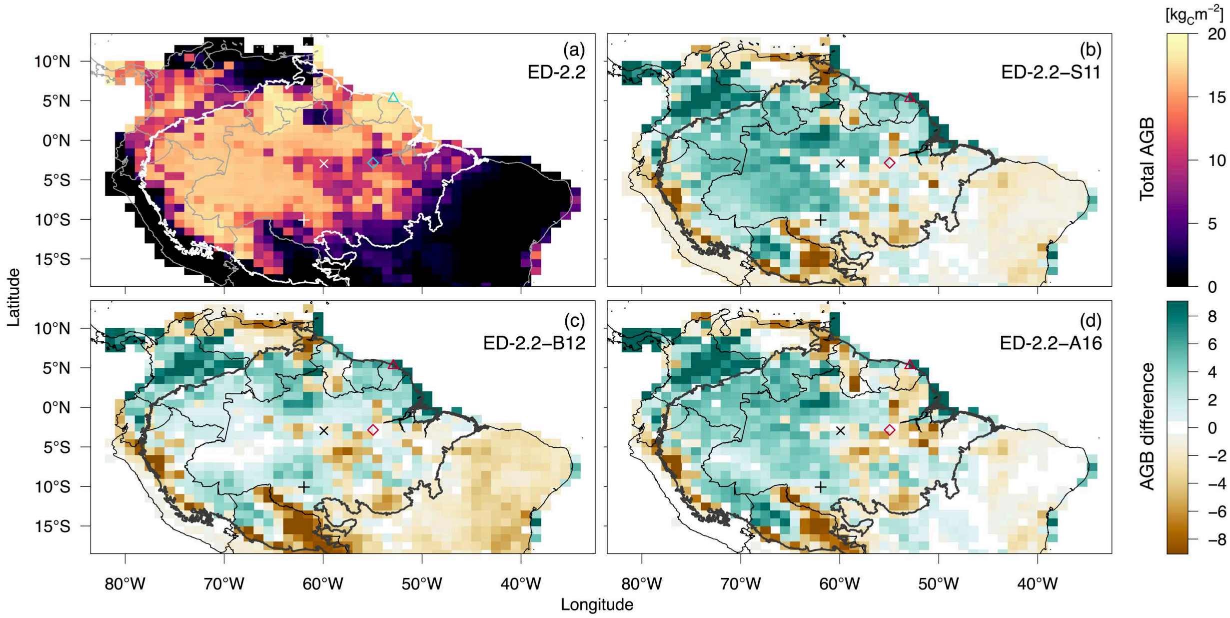

Figure S3: (a) Regional aboveground biomass obtained from ED-2.2, and difference between ED-2.2 and based on remote-sensing estimates from (b) Saatchi et al. (2011), (c) Baccini et al. (2012), and (d) Avitabile et al. (2016). Remote-sensing maps were aggregated to 1° resolution. Positive (negative) values in (b-d) mean that ED-2.2 predicted higher (lower) aboveground biomass than remote sensing estimates. The location of focus sites of Paracou (GYF, triangle) and Tapajós (TNF, lozenge), and the sites used for radiation profile evaluation: Ducke (MDK, $\times$), and Jaru (RJA, $+$) are shown for reference. Thick contour is the domain of the Amazon biome, and thin contours are the political borders.

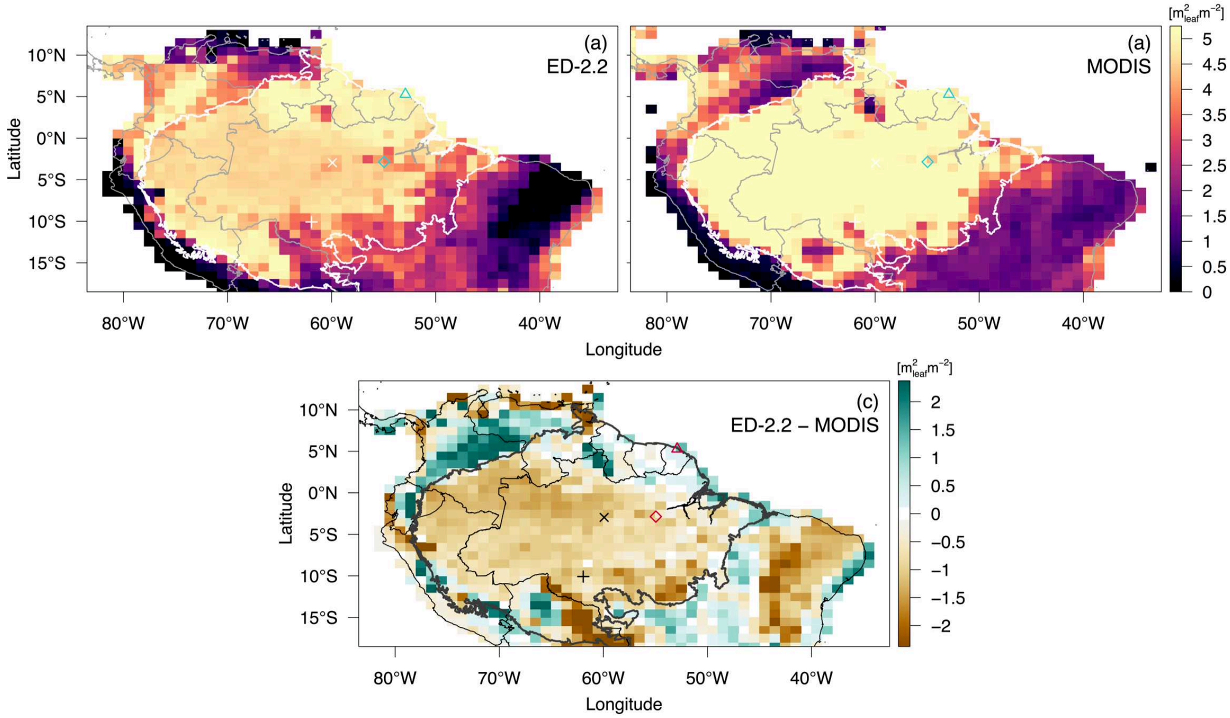

Figure S4: Comparison of leaf area index from (a) ED-2.2, and (b) based on remote-sensing estimates from Moderate Resolution Imaging Spectroradiometer (MODIS), product MCD15A2H, Collection 6 (Yan et al., 2016); (c) Difference between ED-2.2 and the MODIS-MCD15A2H product. Estimates from MODIS-MCD15A2H used all cloud-free, high-quality data available between August 2002 and July 2004. The location of focus sites of Paracou (GYF, triangle) and Tapajós (TNF, lozenge), and the sites used for radiation profile evaluation: Ducke (MDK, $\times$), and Jaru (RJA, $+$) are shown for reference. Thick contour is the domain of the Amazon biome, and thin contours are the political borders.

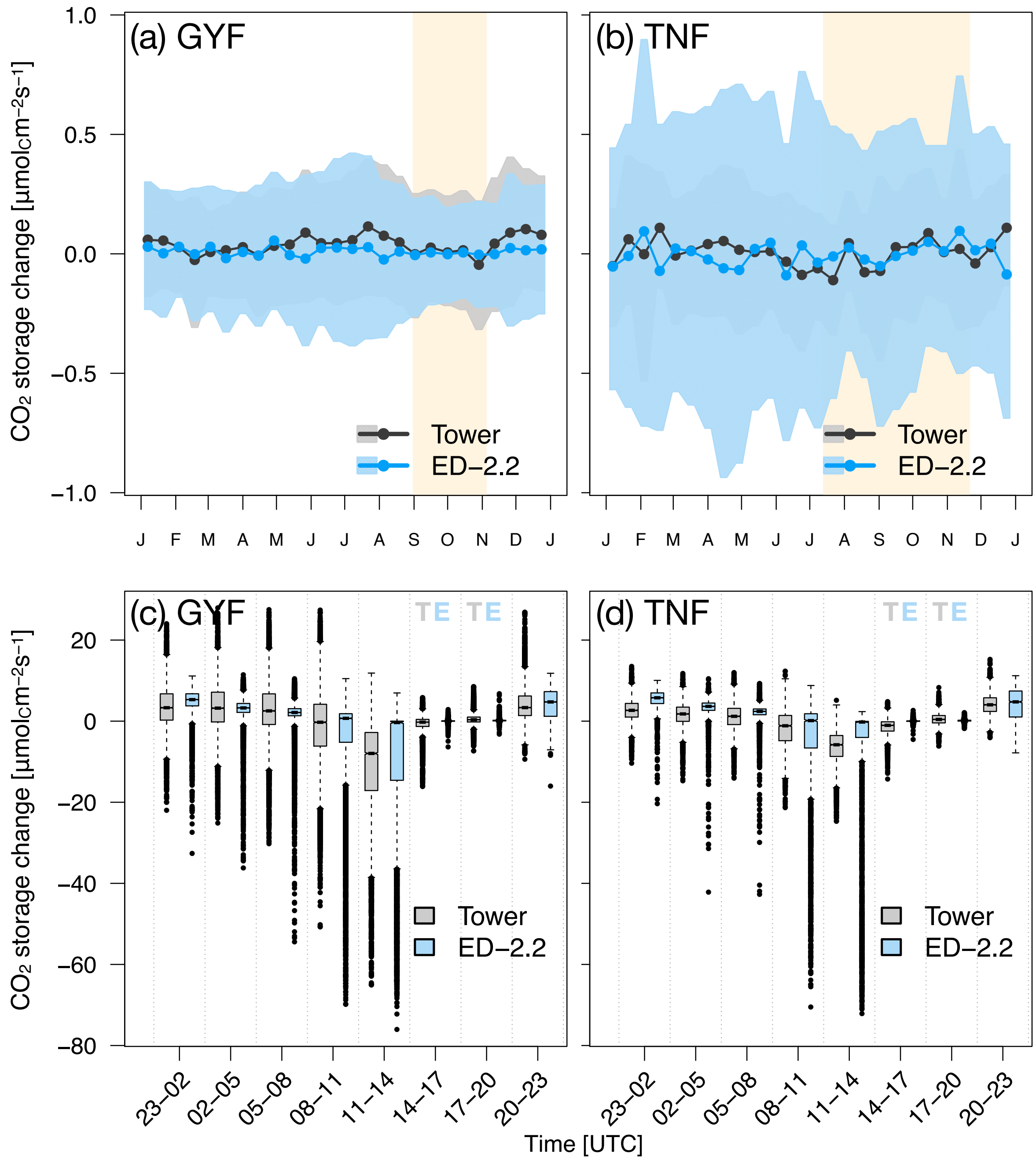

Figure S5: Mean annual cycle from fortnightly means of change in CO_2 storage in the canopy air space for (a) GYF and (b) TNF. Bands are the 95% confidence interval of means, and rectangles in the background correspond to the site's climatological dry season. Box plot of change in CO_2 storage in the canopy air space aggregated by time of day for all hours with available data for (c) GYF and (d) TNF.

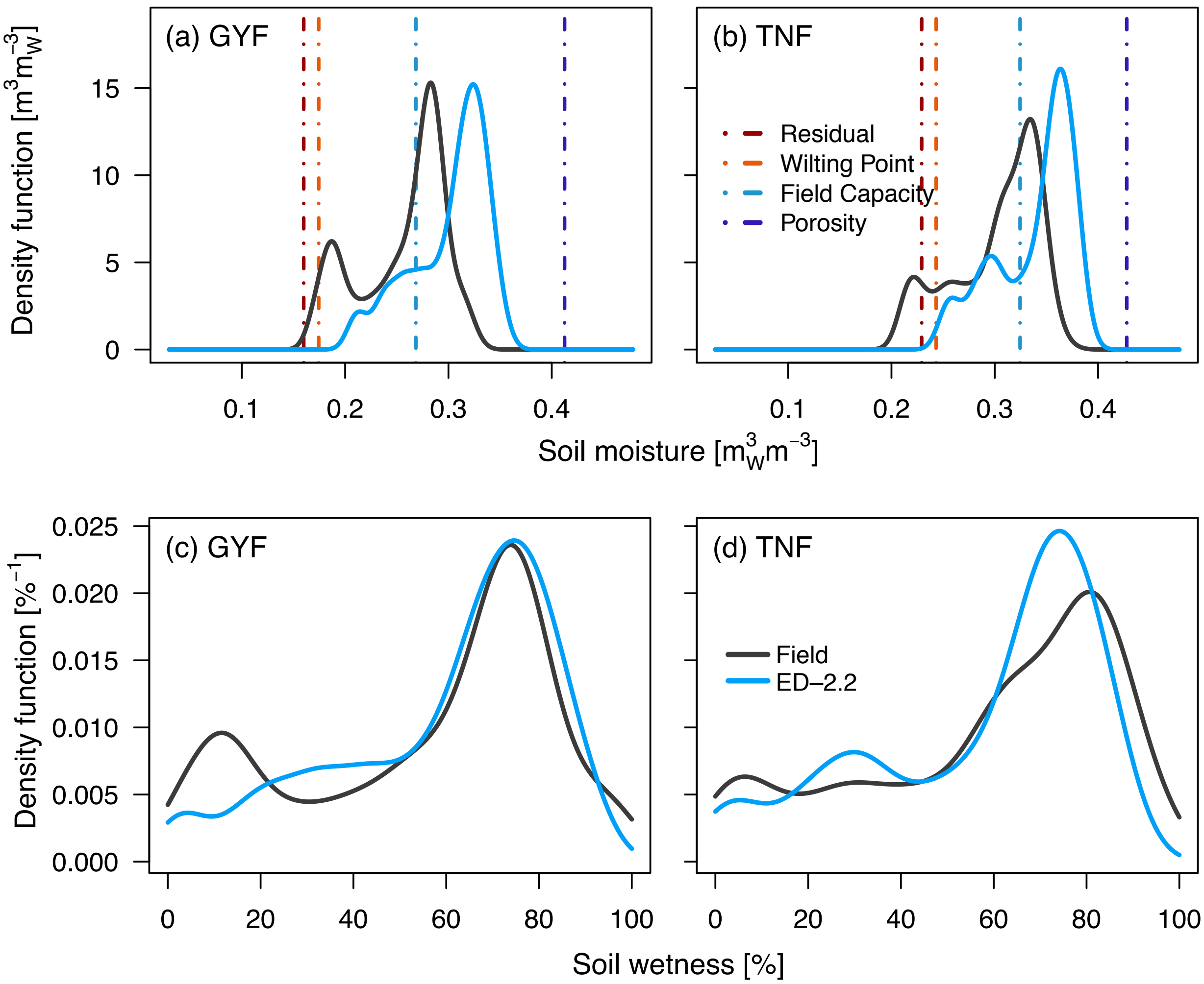

Figure S6: Kernel density estimate of daily averages of (a-b) volumetric soil moisture and (c-d) relative soil moisture at (a,c) GYF (depth 53 cm) and (b,d) TNF (depth 20 cm). Data for GYF were collected at the tower site (2007-2012), and data for TNF were collected at a site located 15 km south of the tower between 2001 and 2003 and available from Miller et al. (2009) and de Gonçalves et al. (2013). Vertical dashed lines in panels (a) and (b) correspond to the residual, permanent wilting point, field capacity and porosity calculated by ED-2.2 using the reference soil texture at each site: (56% sand; 9% silt; 35% clay) for GYF (Bonal et al., 2008), and (39% sand; 2% silt; 59% clay) for TNF .(Nepstad et al., 2002) Soil wetness was defined as the relative water content between residual (0%) and porosity (100%).

S1 Derivation of the respiration estimates at Guyaflux (GYF)

To obtain respiration estimates at Guyaflux (GYF), we follow the same methodology described by Malhi et al. (2009), and used the same approach to obtain the standard error estimates. Whenever possible, we used published estimates of the different terms of the respiration terms.

- *Leaf respiration.* Individual-level leaf respiration was measured and reported by Stahl (2010). Leaf-level measurements were scaled to ecosystem scale using LAI-2000 measurements also by Stahl (2010). Following Malhi et al. (2009) and Lloyd et al. (2010), the value was scaled down by 34% to account for diurnal down-regulation of dark respiration.

- *Stem respiration.* Individual-level stem respiration was measured and reported by Stahl (2010); Stahl et al. (2011). Values from both *terra firme* and seasonably flooded forest were included. Wet season and dry season values were weighted by the season length in 2008, also reported by Stahl et al. (2011). Although Stahl et al. (2011) had scaled to stand level, we recalculated their estimate to be consistent with Malhi et al. (2009), by finding the mean stem area index from the forest inventory, following Chambers et al. (2000, 2004). The stem area index was $1.07 \pm 0.03\ \mathrm{m^2\,m^{-2}}$.

- *Total soil respiration.* Total soil respiration was reported by Epron et al. (2006) and Bréchet et al. (2011). Following Malhi et al. (2009), their estimates were averaged using an weighting factor equivalent to the sampling area times the square root of the duration of the measurments.

- *Coarse woody debris respiration.* Coarse woody debris (CWD) respiration was reported by Rowland et al. (2013). Their estimates of coarse woody debris respiration were scaled by soil water content, and thus these estimates are not entirely observed.

- *Soil Heterotrophic respiration.* This term was estimated by Bréchet (2009), using trenching method.

- *Root respiration.* This term was assumed to be the difference between total soil respiration and soil heterotrophic respiration, following Malhi et al. (2009).

- *Aggregated respiration terms.* Heterotrophic respiration (soil + CWD), autotrophic respiration (leaf + root + stem), and ecosystem respiration (heterotrophic + autotrophic) were defined as the sum of the terms, as defined above. Uncertainties were assumed independent, and propagated similarly to Malhi et al. (2009).

References

Avitabile, V., Herold, M., Heuvelink, G. B. M., Lewis, S. L., Phillips, O. L., Asner, G. P., Armston, J., Ashton, P. S., Banin, L., Bayol, N., Berry, N. J., Boeckx, P., de Jong, B. H. J., DeVries, B., Girardin, C. A. J., Kearsley, E., Lindsell, J. A., Lopez-Gonzalez, G., Lucas, R., Malhi, Y., Morel, A., Mitchard, E. T. A., Nagy, L., Qie, L., Quinones, M. J., Ryan, C. M., Ferry, S. J. W., Sunderland, T., Laurin, G. V., Gatti, R. C., Valentini, R., Verbeeck, H., Wijaya, A., and Willcock, S.: An integrated pan-tropical biomass map using multiple reference datasets, Glob. Change Biol., 22, 1406–1420, doi:10.1111/gcb.13139, 2016.

Baccini, A., Goetz, S. J., Walker, W. S., Laporte, N. T., Sun, M., Sulla-Menashe, D., Hackler, J., Beck, P. S. A., Dubayah, R., Friedl, M. A., Samanta, S., and Houghton, R. A.: Estimated carbon dioxide emissions from tropical deforestation improved by carbon-density maps, Nature Clim. Change, 2, 182–185, doi:10.1038/nclimate1354, 2012.

Bonal, D., Bosc, A., Ponton, S., Goret, J.-Y., Burban, B., Gross, P., Bonnefond, J.-M., Elbers, J., Longdoz, B., Epron, D., Guehl, J.-M., and Granier, A.: Impact of severe dry season on net ecosystem exchange in the Neotropical rainforest of French Guiana, Glob. Change Biol., 14, 1917–1933, doi:10.1111/j.1365-2486.2008.01610.x, 2008.

Bréchet, L.: Contribution à l'étude de la variabilité spatiale des composantes du bilan de carbone d'un sol de forêt tropicale humide (Paracou, Guyane française), Ph.d. thesis, Université Henri Poincaré de Nancy, Nancy, Lorraine, France, URL `http://www.theses.fr/2009NAN10105`, in French, 2009.

Bréchet, L., Ponton, S., Alméras, T., Bonal, D., and Epron, D.: Does spatial distribution of tree size account for spatial variation in soil respiration in a tropical forest?., Plant Soil, 347, 293–303, doi:10.1007/s11104-011-0848-1, 2011.

Chambers, J. Q., Higuchi, N., Schimel, J. P., Ferreira, L. V., and Melack, J. M.: Decomposition and carbon cycling of dead trees in tropical forests of the central Amazon, Oecologia, 122, 380–388, doi:10.1007/s004420050044, 2000.

Chambers, J. Q., Tribuzy, E. S., Toledo, L. C., Crispim, B. F., Higuchi, N., Santos, J. d., Araújo, A. C., Kruijt, B., Nobre, A. D., and Trumbore, S. E.: Respiration from a tropical forest ecosystem: partitioning of sources and low carbon use efficiency, Ecol. Appl., 14, S72–S88, doi:10.1890/01-6012, 2004.

de Gonçalves, L. G. G., Restrepo-Coupe, N., da Rocha, H. R., Saleska, S. R., and Stockli, R.: LBA-ECO CD-32 LBA Model Intercomparison Project (LBA-MIP) Forcing

Data, doi:10.3334/ORNLDAAC/1177, URL http://daac.ornl.gov, oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A., 2013.

Epron, D., Bosc, A., Bonal, D., and Freycon, V.: Spatial variation of soil respiration across a topographic gradient in a tropical rain forest in French Guiana, J. Trop. Ecol., 22, 565–574, doi:10.1017/S0266467406003415, 2006.

Hutyra, L. R., Munger, J. W., Gottlieb, E. W., Daube, B. C., Camargo, P. B., and Wofsy, S. C.: LBA-ECO CD-10 H_2O profiles at km 67 tower site, Tapajós National Forest, doi:10.3334/ORNLDAAC/861, URL http://daac.ornl.gov, Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A., 2008.

Lloyd, J., Patiño, S., Paiva, R. Q., Nardoto, G. B., Quesada, C. A., Santos, A. J. B., Baker, T. R., Brand, W. A., Hilke, I., Gielmann, H., Raessler, M., Luizão, F. J., Martinelli, L. A., and Mercado, L. M.: Optimisation of photosynthetic carbon gain and within-canopy gradients of associated foliar traits for Amazon forest trees, Biogeosciences, 7, 1833–1859, doi:10.5194/bg-7-1833-2010, 2010.

Malhi, Y., Aragão, L. E. O. C., Metcalfe, D. B., Paiva, R., Quesada, C. A., Almeida, S., Anderson, L. O., Brando, P., Chambers, J. Q., da Costa, A. L., Hutyra, L. R., Oliveira, P., Patino, S., Pyle, E. H., Robertson, A. L., and Teixeira, L. M.: Comprehensive assessment of carbon productivity, allocation and storage in three Amazonian forests, Glob. Change Biol., 15, 1255–1274, doi:10.1111/j.1365-2486.2008.01780.x, 2009.

Miller, S. D., Goulden, M., and da Rocha, H. R.: LBA-ECO CD-04 Meteorological and Flux Data, km 83 Tower Site, Tapajos National Forest. Data set., doi:10.3334/ORNLDAAC/946, URL http://daac.ornl.gov, Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A., 2009.

Nepstad, D. C., Moutinho, P., Dias-Filho, M. B., Davidson, E., Cardinot, G., Markewitz, D., Figueiredo, R., Vianna, N., Chambers, J., Ray, D., Guerreiros, J. B., Lefebvre, P., Sternberg, L., Moreira, M., Barros, L., Ishida, F. Y., Tohlver, I., Belk, E., Kalif, K., and Schwalbe, K.: The effects of partial throughfall exclusion on canopy processes, aboveground production, and biogeochemistry of an Amazon forest, J. Geophys. Res.-Atmos., 107, 8085, doi:10.1029/2001JD000360, 2002.

Rowland, L., Stahl, C., Bonal, D., Siebicke, L., Williams, M., and Meir, P.: The Response of Tropical Rainforest Dead Wood Respiration to Seasonal Drought, Ecosystems, 16, 1294–1309, doi:10.1007/s10021-013-9684-x, 2013.

Saatchi, S. S., Harris, N. L., Brown, S., Lefsky, M., Mitchard, E. T. A., Salas, W., Zutta, B. R., Buermann, W., Lewis, S. L., Hagen, S., Petrova, S., White, L., Silman, M., and Morel, A.: Benchmark map of forest carbon stocks in tropical regions across three continents, Proc. Natl. Acad. Sci. U. S. A., 108, 9899–9904, doi:10.1073/pnas.1019576108, 2011.

Stahl, C.: Variations saisonnières des flux de CO_2 et H_2O au niveau des feuilles et des troncs des arbres de la canopée en forêt tropicale humide guyanaise, Ph.d. thesis, Université Henri Poincaré de Nancy, Nancy, Lorraine, France, URL `http://www.theses.fr/2010NAN10049`, in French, 2010.

Stahl, C., Burban, B., Goret, J.-Y., and Bonal, D.: Seasonal variations in stem CO_2 efflux in the Neotropical rainforest of French Guiana, Ann. For. Sci., 68, 771–782, doi:10.1007/s13595-011-0074-2, 2011.

Yan, K., Park, T., Yan, G., Chen, C., Yang, B., Liu, Z., Nemani, R. R., Knyazikhin, Y., and Myneni, R. B.: Evaluation of MODIS LAI/FPAR product Collection 6. Part I: consistency and improvements, Remote Sens., 8, 359, doi:10.3390/rs8050359, 2016.