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Supporting Information for

Global satellite data highlights the diurnal asymmetry of the surface temperature response to deforestation

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Introduction

In this supplement, we provide additional information on our methods and supplementary figures and data to support the conclusions in the main text. The method we used to standardize the flux tower nocturnal gradient measurements to 10m above displacement height is discussed in Text S2. The data used to make these corrections to the original gradient measurements are provided in Tables S2-S4. Table S1 shows the land cover classes from the IGBP land cover classification scheme that were used in this analysis to defined "open" and "forested" land. We include two figures (Figures S1-S2) that that illustrate the spatial patterns of the drivers of daytime ΔT_S, as well as ΔK_a and ΔLE, the two terms used to calculate ΔH_P. In addition, the relationships between ΔK_a and ΔLE and ΔT_S are presented here. Figure S3 shows the difference in the nocturnal surface inversion at two site pairs of flux towers, and Figure S4 presents the relationship between R_n and ΔT_S.

Text S1.

The air temperature measurement height at the flux towers varied anywhere from 1.5 to 30.6 m above displacement height, *d*. For direct comparison with the MERRA nocturnal temperature inversion, we standardized the flux tower inversion calculation (Γ) to 10 m above the *d* using:

$$\Gamma = \Gamma_{orig} + \frac{\Delta T}{\Delta z}(z - 10) \quad \text{(S1)}$$

where Γ_{orig} is the original inversion calculation ($T_S - T_a$), $\Delta T/\Delta z$ is the average nocturnal air temperature gradient (0.07 K/m for grasslands and 0.03 K/m for forests) (Table S2), and *z* is the measurement height above *d* (Tables S3-S4).

As most grassland sites reported the average canopy height as < 1m, we made the simplification that the measurement height was equal to the height above *d*. For forest tower sites, we calculated *d* as 2/3 of the canopy height (Table S3). For the grassland tower sites, standardizing to 10 m on average changed the Γ_{orig} values by -0.39 K, ranging from -0.52 to 0.09 K (Table S3). For the forest tower sites, this standardization resulted in an average correction of 0.34 K, ranging from 0.02 to 0.62 K (Table S4).

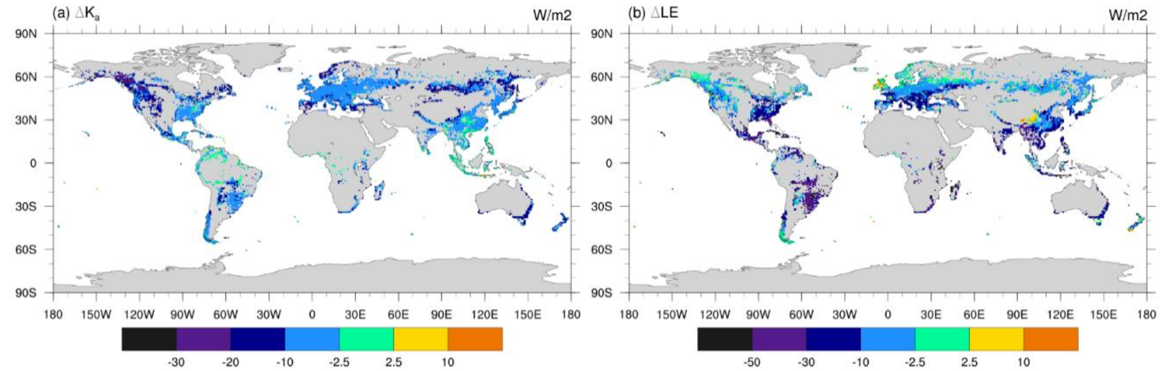

Figure S1. The 11-year annual mean (a) ΔK_a and (b) ΔLE.

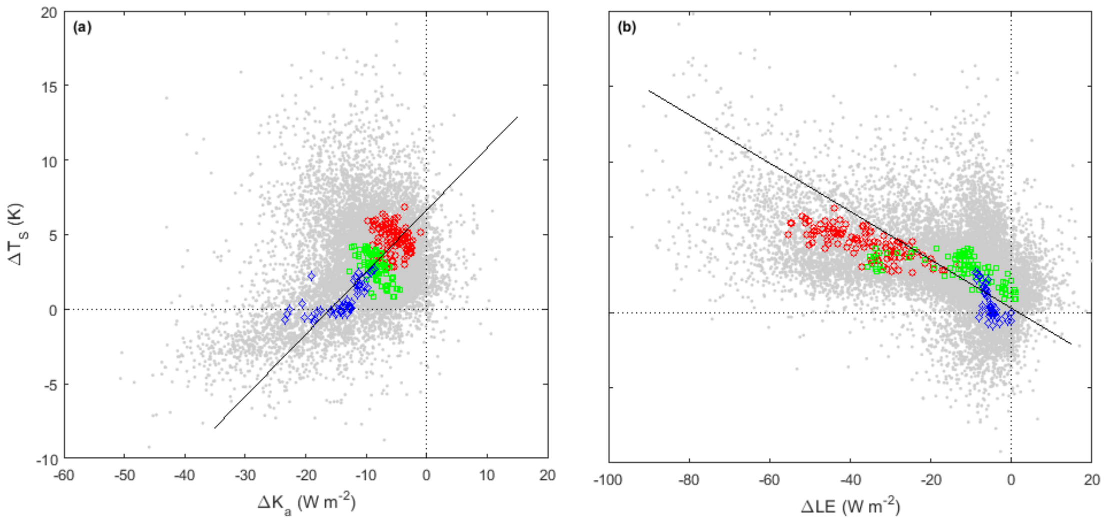

Figure S2. The dominant drivers of ΔT_S are (a) ΔK_a and (a) ΔLE. All sample grids are shown as the gray dots, while the zonal means of each climate zone are shown as the red circles (tropical), green squares (temperate), and blue diamonds (boreal). The black solid lines in (c) $y = 0.417\ (\pm 0.006)\ x + 6.649\ (\pm 0.06)$ ($R^2 = 0.17$, $p < 0.001$) and (d) $y = -0.160\ (\pm 0.002)\ x + 0.272\ (\pm 0.04)$ ($R^2 = 0.22$, $p < 0.001$) indicate the geometric mean regression for all sample grids (gray dots). Parameter bounds in the regressions are for the 95% confidence intervals.

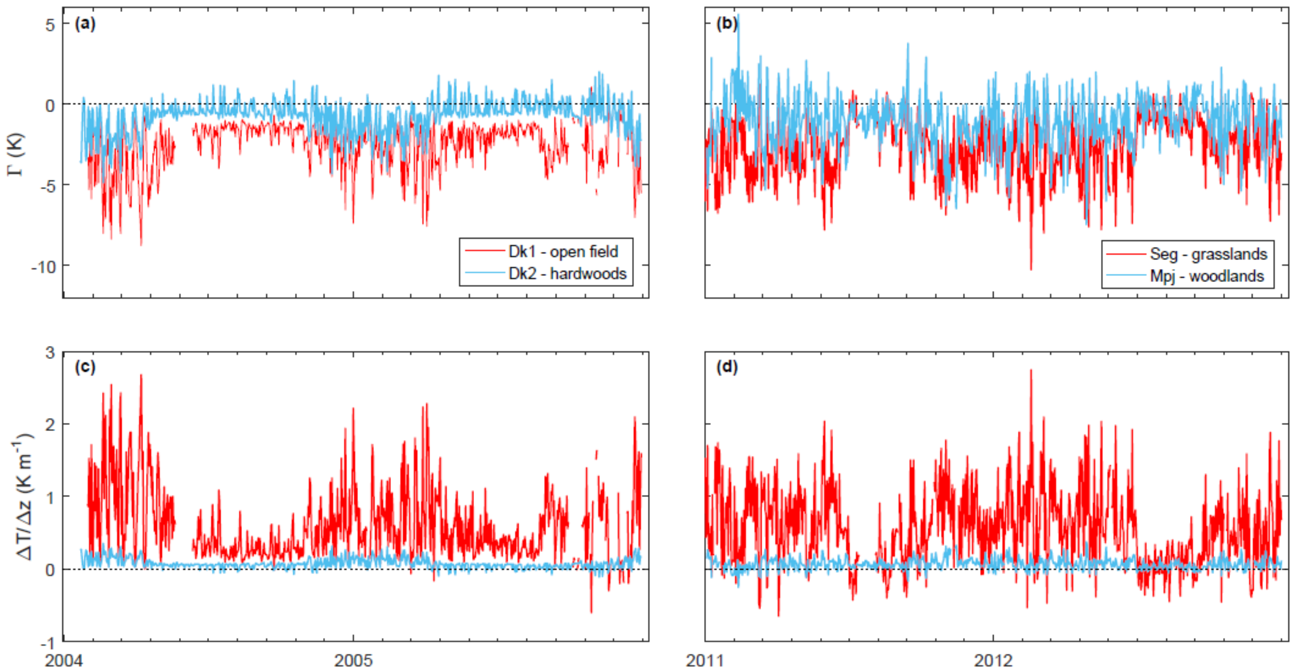

Figure S3. Two site pairs of flux towers used to compare the surface inversion between adjacent forested and open lands. Panels (a) and (c) show the surface inversion $\mathbf{\Gamma}$, standardized to 10 m above the displacement height and the temperature gradient $\boldsymbol{\Delta T}/\boldsymbol{\Delta z}$, calculated as $(T_S - T_a)/z$, where z is measurement height for the site pair in North Carolina. Panels (b) and (d) show the same data for a site pair in New Mexico.

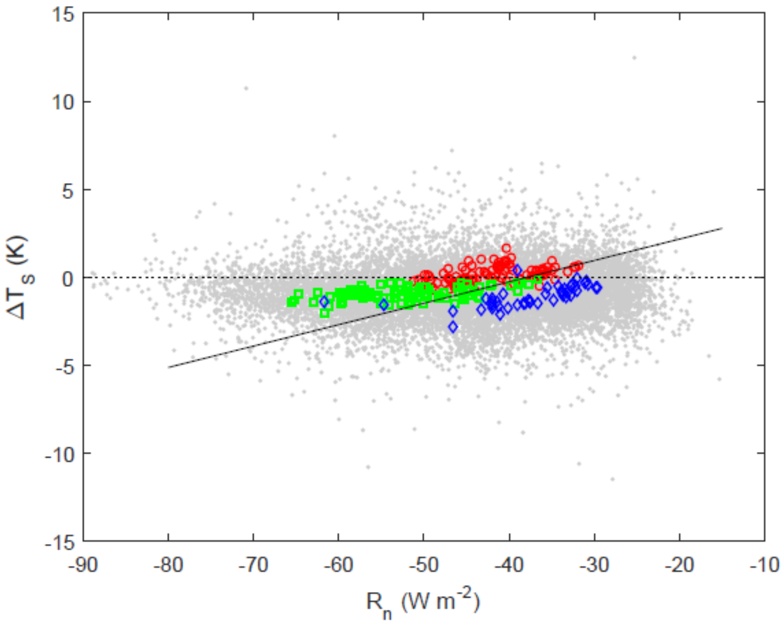

Figure S4. There is a positive relationship between R_n and ΔT_S (geometric mean regression: y = 0.122x (±0.002) + 4.602 (±0.08) (R2 = 0.001, p < 0.001).

Table S1. The land cover classes from the MODIS (MCD12Q1) IGBP land cover classification scheme. We use IGBP classes 1-5 as representative of the "forest" land cover category (shaded green in the above table), and IGBP classes 9, 10, and 14 for the "open" land cover category (shaded orange in the table).

Value	Label
0	Water
1	Evergreen needleleaf forest
2	Evergreen broadleaf forest
3	Deciduous needleleaf forest
4	Deciduous broadleaf forest
5	Mixed forest
6	Closed shrublands
7	Open shrublands
8	Woody savannas
9	Savannas
10	Grasslands
11	Permanent wetlands
12	Croplands
13	Urban and built-up
14	Cropland/natural vegetation mosaic
15	Snow and ice
16	Barren or sparsely vegetated
254	Unclassified
255	Fill Value

Table S2. The average air temperature gradient, as measured from different heights at four sites (one grassland, three forested). These data were used to standardize the flux tower nocturnal inversion (T_S – T_a) measurements to 10 m above the displacement height. A gradient of 0.07 K/m was used for all grassland sites (average of grassland gradients), and a gradient of 0.03 K/m (average of the forest gradients) was used for forest sites.

Site Name	Site ID	Land cover	h (m)	T_a low (m)	T_a high (m)	ΔT_a (K)	$\Delta T/\Delta z$ (K)	Dates	Reference
Grasslands									
ARM Lamont, OK	n/a	GRA	< 1	2	25	-2.36	0.103	2003-2013	*Turner et al.* [2016]
Santarem-Km77-Pasture	BR-Sa2	CRO	< 1	2.2	11.3	-0.325	0.036	2001-2005	*Sakai et al.* [2004]
Forests									
Western Boreal – Mature Aspen	CA-Oas	ENF	18	18	37	-3.86	0.020	1996-2006	*Blanken et al.* [1997]
Great Mountain Forest	US-GMF	MF	18.7	19.1	31.7	-0.165	0.013	1999-2000	*Lee and Hu* [2002]
Santarem-Km67-Primary Forest	BR-Sa1	EBF	40	49.75	61.94	-0.565	0.046	2002-2006	*Hutyra et al.* [2007]

Table S3. The measurement details of each grassland flux tower site. The measurement height (*z*) was used to standardize the surface inversion to 10m above the displacement height. Because the canopy height of most sites was reported as < 1m, we approximated *d* as 0 m. The final Γ here are what are reported in the main text (Table 1).

Site ID	measurement dates	original Γ (K)	gradient (K/m)	measurement height (m)	final Γ (K)
DE-RuR	2013 - 2014	-1.26	0.07	2.6	-1.78
US-FPe	2000 - 2008	-1.34	0.07	3.2	-1.82
US-KUT	2006 - 2007	-2.89	0.07	2	-3.45
US-Bkg	2008 - 2009	-0.91	0.07	3.5	-1.36
US-CaV	2009 - 2009	-1.70	0.07	3.5	-2.16
US-Var	2007 - 2014	-1.39	0.07	1.5	-1.98
US-Dk1	2004 - 2005	-1.80	0.07	3	-2.29
US-Seg	2012 - 2013	-1.97	0.07	3.5	-2.43
US-Goo	2004 - 2006	-2.36	0.07	3.5	-2.81
US-Wkg	2008 - 2015	-2.74	0.07	6.4	-2.99
US-Aud	2009 - 2010	-2.21	0.07	3.5	-2.66
BR-Sa2	2001 - 2005	-0.12	0.07	11.3	-0.11
FSM ranch	1999 - 2002	-0.02	0.07	8.3	-0.14
AU-Stp	2010 - 2011	-0.87	0.07	5	-1.22
AU-Emr	2012 - 2012	-1.36	0.07	5	-1.71

Table S4. The measurement details of each forest flux tower site. The measurement height (z) reported here is the measurement height above the displacement height. This height was used to standardize the original inversion values to 10 m above the displacement height. The final Γ here are what are reported in the main text (Table 1).

Site ID	measurement dates	original Γ (K)	gradient (K/m)	canopy h (m)	d (m)	measurement height (m)	final Γ (K)
CA-Obs	2006 - 2010	-0.45	0.03	10	6.67	18.33	-0.20
CA-Oas	2005 - 2010	-1.14	0.03	21.5	14.33	24.67	-0.70
CA-Qfo	2006 - 2010	-1.51	0.03	13.8	9.20	14.80	-1.37
CA-Gro	2007 - 2011	-1.79	0.03	21.6	14.40	26.60	-1.30
US-Syv	2003 - 2005	-0.22	0.03	22	14.67	21.33	0.12
US-Wcr	2003 - 2005	-0.78	0.03	25	16.67	13.33	-0.68
US-UMB	2007 - 2014	-1.39	0.03	22	14.67	31.33	-0.75
US-Ho1	2008 - 2011	-1.14	0.03	20	13.33	15.67	-0.97
US-Blk	2007 - 2008	-1.34	0.03	21.4	14.27	20.82	-1.00
US-Slt	2005 - 2006	-0.91	0.03	20	13.33	10.67	-0.89
US-MMS	2007 - 2013	-0.36	0.03	26	17.33	28.37	0.19
US-MOz	2011 - 2013	-1.16	0.03	17	11.33	20.67	-0.84
US-Dk2	2004 - 2005	-1.10	0.03	25	16.67	23.13	-0.70
US-WBW	2003 - 2003	-0.76	0.03	17	11.33	18.67	-0.50
US-ChR	2008 - 2010	-1.53	0.03	25	16.67	23.33	-1.13
US-Mpj	2012 - 2013	-1.39	0.03	21.4	14.27	20.82	-1.07
RJ forest	1999 - 2002	-0.04	0.03	35	23.33	31.67	0.61

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