



Supplement of

Global 1 km land surface parameters for kilometer-scale Earth system modeling

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Table S1 MODIS land cover classes and corresponding PFTs and non-vegetation land units.

MODIS LC_Type5	#	PFTs and non-vegetation land units (abbreviations)
Non-Vegetated Lands	0	Bare soil (Bare soil)
Evergreen Needleleaf Trees	1	Needleleaf evergreen tree, temperate (NET-Temperate)
	2	Needleleaf evergreen tree, boreal (NET-Boreal)
Deciduous Needleleaf Trees	3	Needleleaf deciduous tree (NDT)
Evergreen Broadleaf Trees	4	Broadleaf evergreen tree, tropical (BET-Tropical)
	5	Broadleaf evergreen tree, temperate (BET-Temperate)
Deciduous Broadleaf Trees	6	Broadleaf deciduous tree, tropical (BDT-Tropical)
	7	Broadleaf deciduous tree, temperate (BDT-Temperate)
	8	Broadleaf deciduous tree, boreal (BDT-Boreal)
Shrub	9	Broadleaf evergreen shrub, temperate (BES-Temperate)
	10	Broadleaf deciduous shrub, temperate (BDS-Temperate)
	11	Broadleaf deciduous shrub, boreal (BDS-Boreal)
Grass	12	C3 grass, arctic (C3GRS-Arctic)
	13	C3 grass (C3GRS)
	14	C4 grass (C4GRS)
Cereal Croplands	15	Crop (Crop)
Broadleaf Croplands		
Water Bodies	16	Lake (Lake)
	17	Ocean (wetland)
Permanent Snow and Ice	18	Glacier (Glacier)
Urban and Built-up Lands	19	Urban (Urban)

8

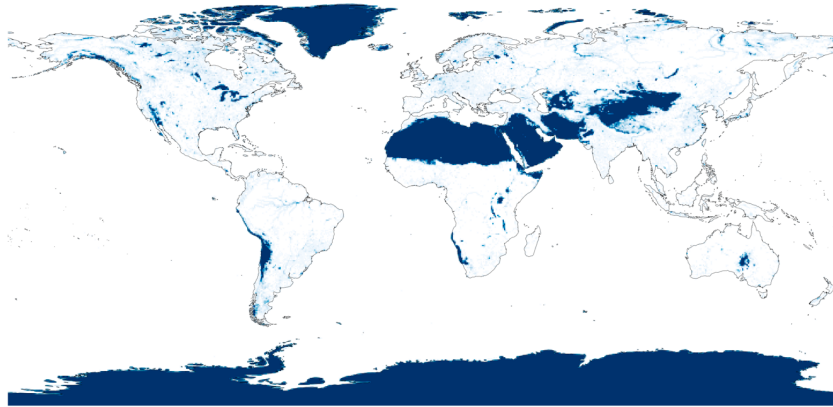
9

10 Table S2. The ratio between canopy height top and bottom in default ELM2/CLM5 and their
 11 example values for each PFT.

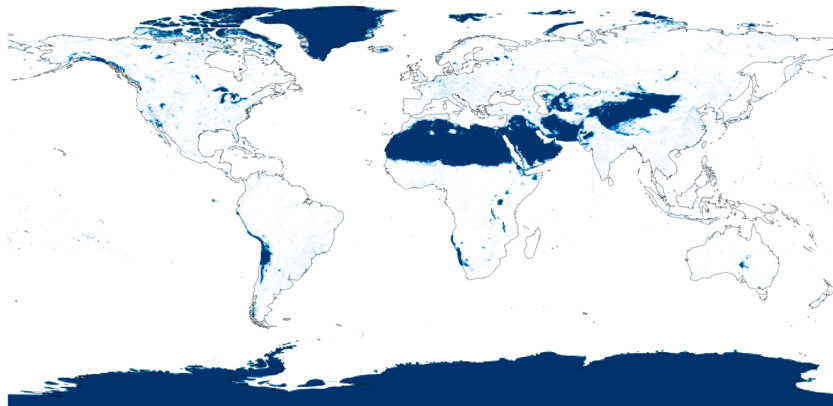
#	PFTs	Ratio	Example height	
			Canopy top height	Canopy bottom height
1	Needleleaf evergreen tree, temperate (NET Temperate)	0.500	17	8.5
2	Needleleaf evergreen tree, boreal (NET Boreal)	0.500	17	8.5
3	Needleleaf deciduous tree, boreal (NDT Boreal)	0.500	14	7
4	Broadleaf evergreen tree, tropical (BET Tropical)	0.029	35	1
5	Broadleaf evergreen tree, temperate (BET Temperate)	0.029	35	1
6	Broadleaf deciduous tree, tropical (BDT Tropical)	0.556	18	10
7	Broadleaf deciduous tree, temperate (BDT Temperate)	0.575	20	11.5
8	Broadleaf deciduous tree, boreal (BDT Boreal)	0.575	20	11.5
9	Broadleaf evergreen shrub, temperate (BES Temperate)	0.200	0.5	0.1
10	Broadleaf deciduous shrub, temperate (BDS Temperate)	0.200	0.5	0.1
11	Broadleaf deciduous shrub, boreal (BDS Boreal)	0.200	0.5	0.1
12	C3 grass, arctic	0.020	0.5	0.01
13	C3 grass	0.020	0.5	0.01
14	C4 grass	0.020	0.5	0.01
15	Crop	0.020	0.5	0.01

12 *Grids with canopy top height less than 0.1 m are assigned 0.1 m.

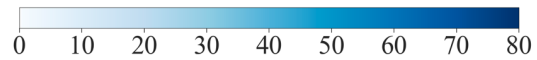
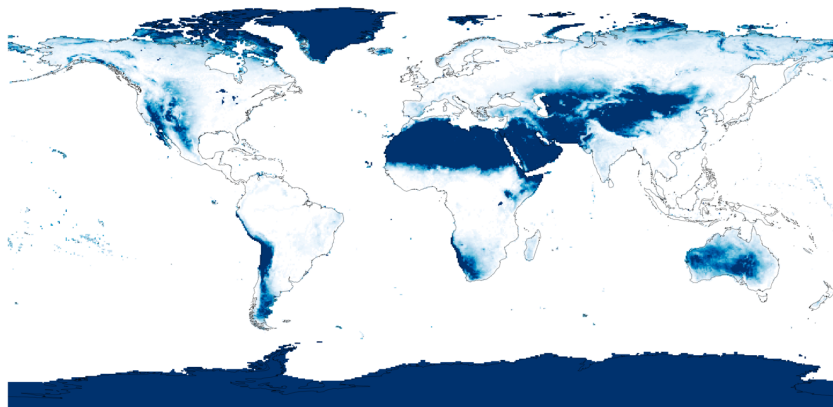
(a) New: Bare soil (25.78%)



(b) K2012: Bare soil (24.42%)



(c) ELM2/CLM5 default: Bare soil (33.43%)



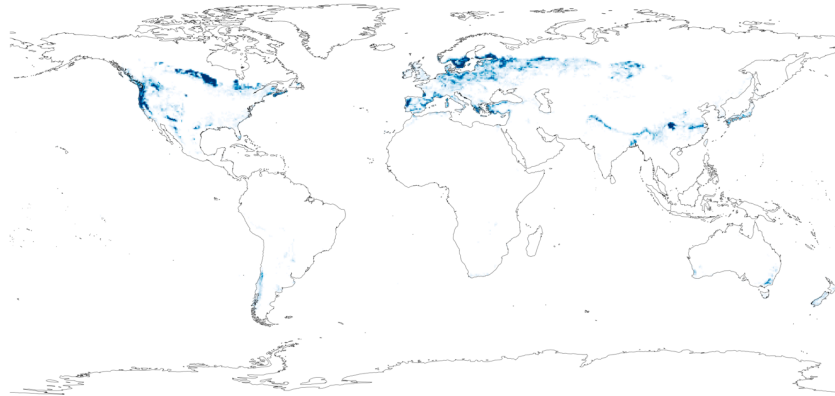
13

14 Figure S1. Global distribution of bare soil for (a) new, (b) K2012 and (c) ELM2/CLM5 default

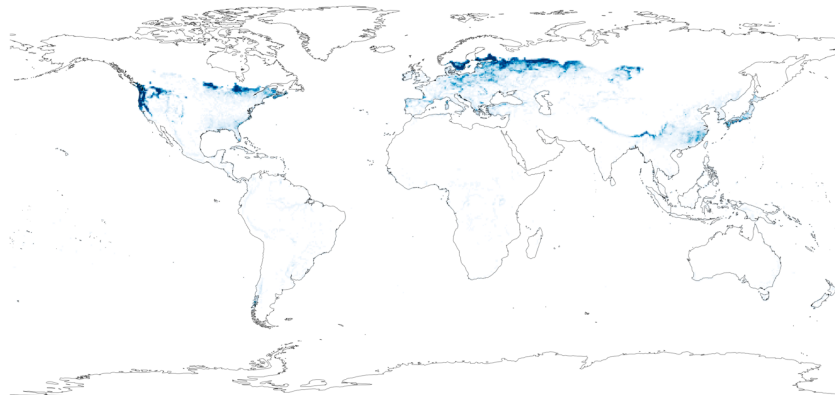
15 PFT parameters. All are at the 0.5-degree resolution. The global average is indicated in the plot

16 title.

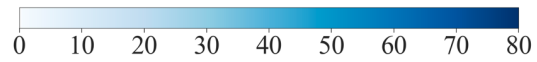
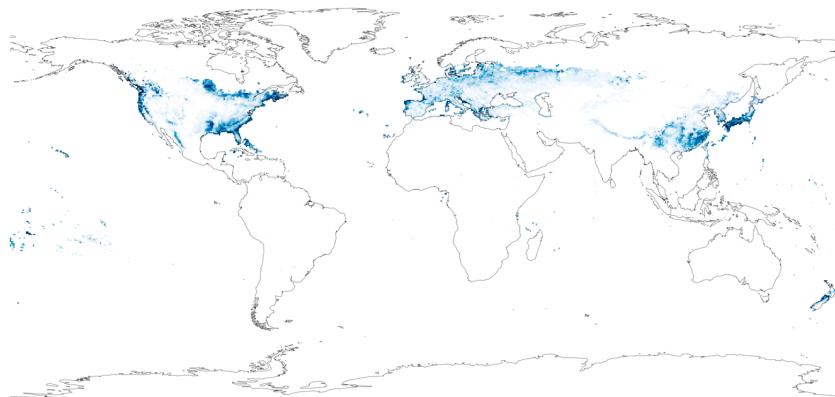
(a) New: NET-Temperate (1.87%)



(b) K2012: NET-Temperate (2.00%)



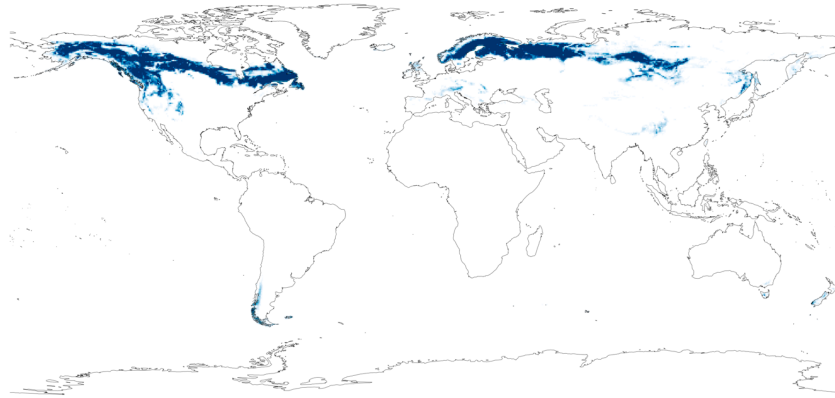
(c) ELM2/CLM5 default: NET-Temperate (2.90%)



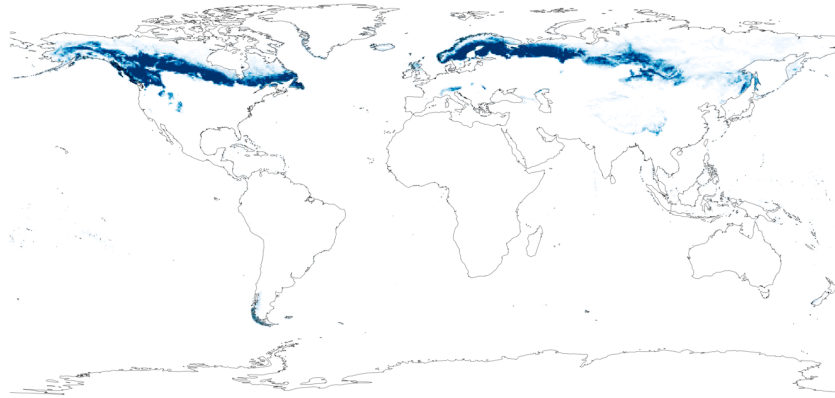
17

18 Figure S2. Same to Figure S1, but for needleleaf evergreen tree, temperate (NET-Temperate).

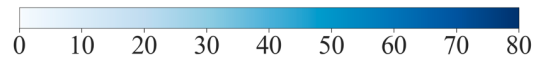
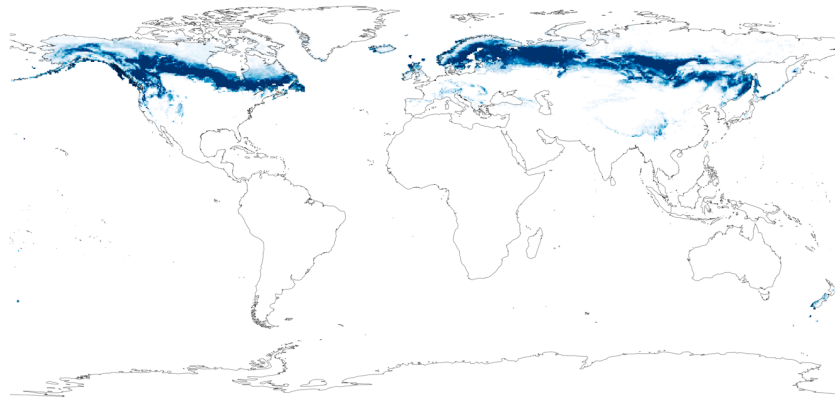
(a) New: NET-Boreal (4.74%)



(b) K2012: NET-Boreal (4.60%)



(c) ELM2/CLM5 default: NET-Boreal (6.32%)

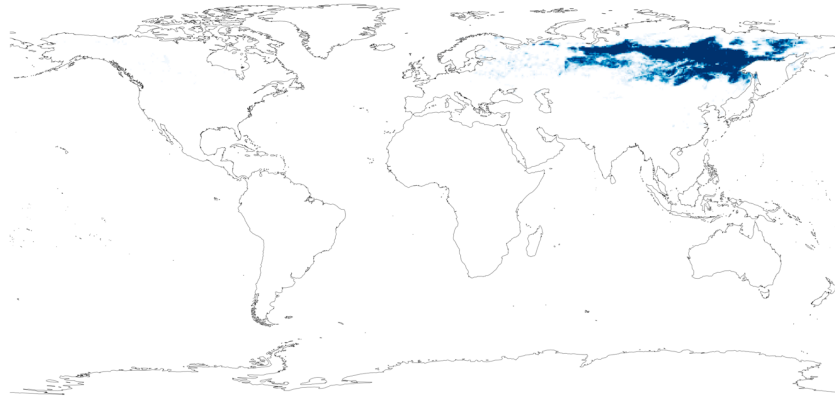


19

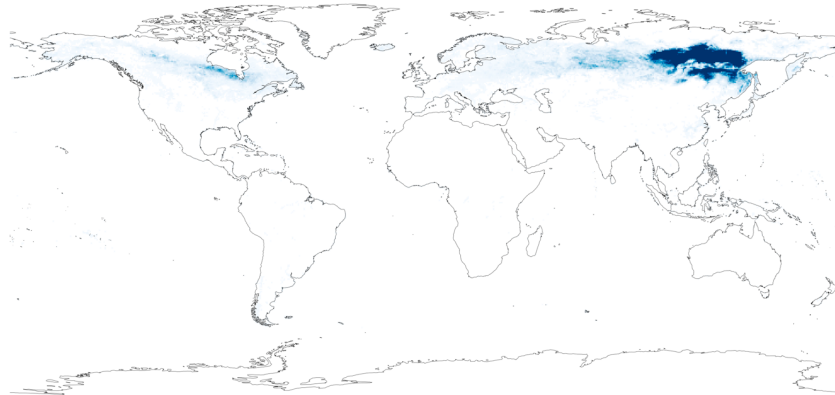
20 Figure S3. Same to Figure S1, but for needleleaf evergreen tree, boreal (NET-Boreal).

21

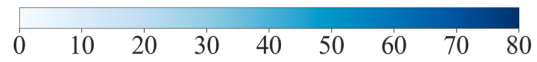
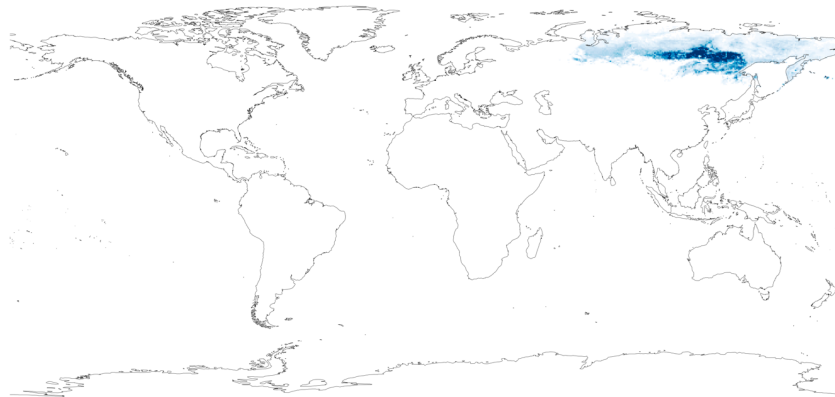
(a) New: NDT-Boreal (3.23%)



(b) K2012: NDT-Boreal (2.28%)



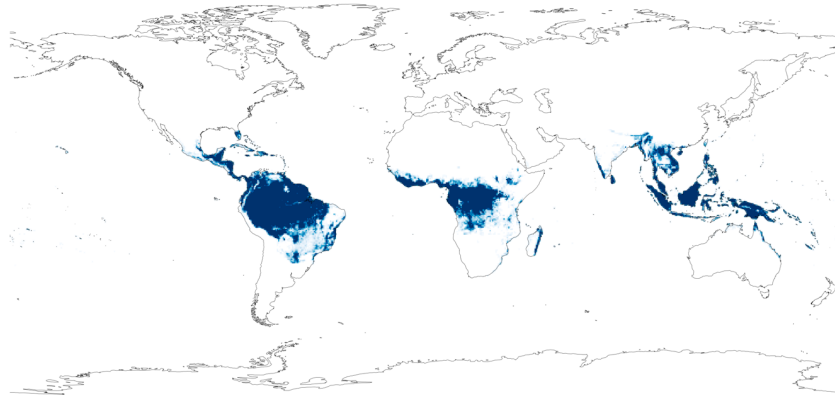
(c) ELM2/CLM5 default: NDT-Boreal (0.92%)



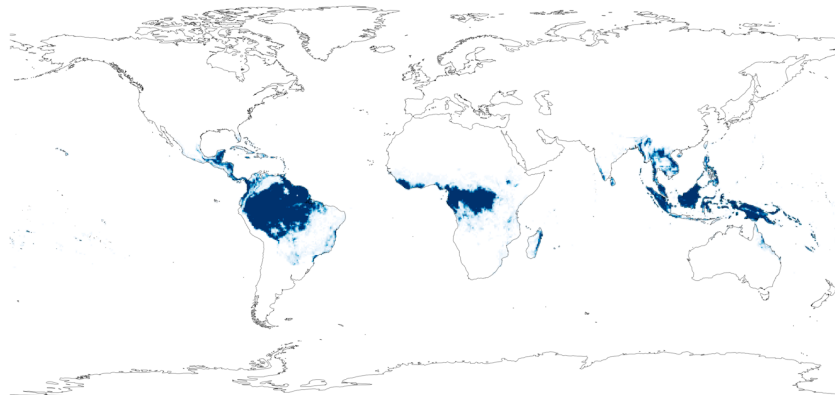
22

23 Figure S4. Same to Figure S1, but for needleleaf deciduous tree, boreal (NDT-Boreal).

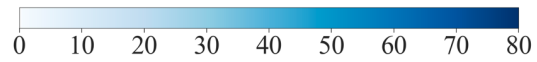
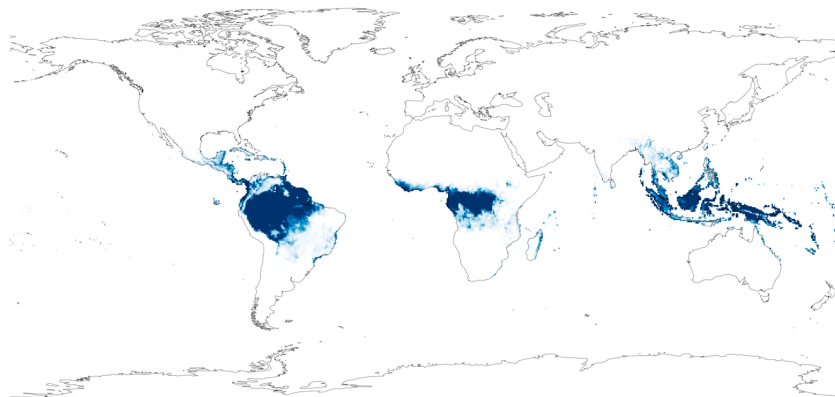
(a) New: BET-Tropical (12.27%)



(b) K2012: BET-Tropical (8.91%)



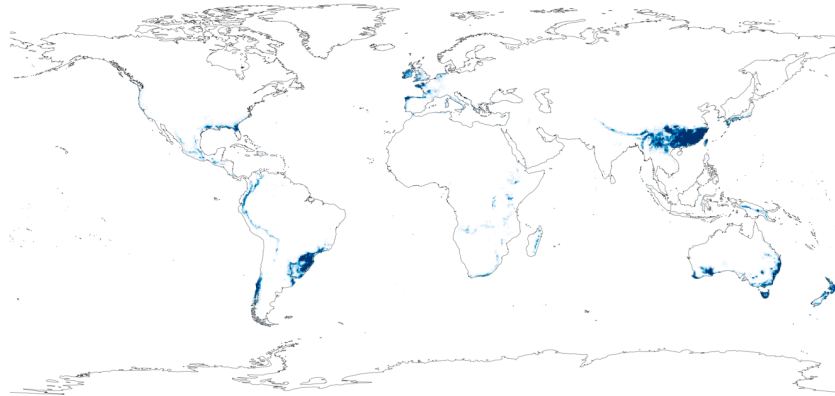
(c) ELM2/CLM5 default: BET-Tropical (8.65%)



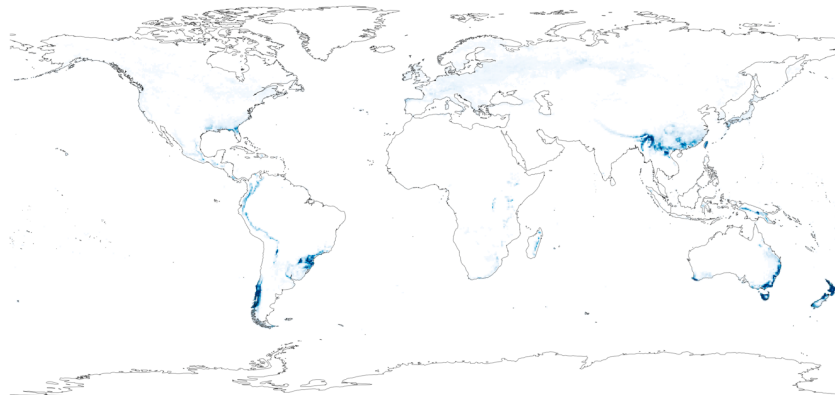
24

25 Figure S5. Same to Figure S1, but for broadleaf evergreen tree, tropical (BET-Tropical).

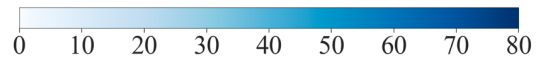
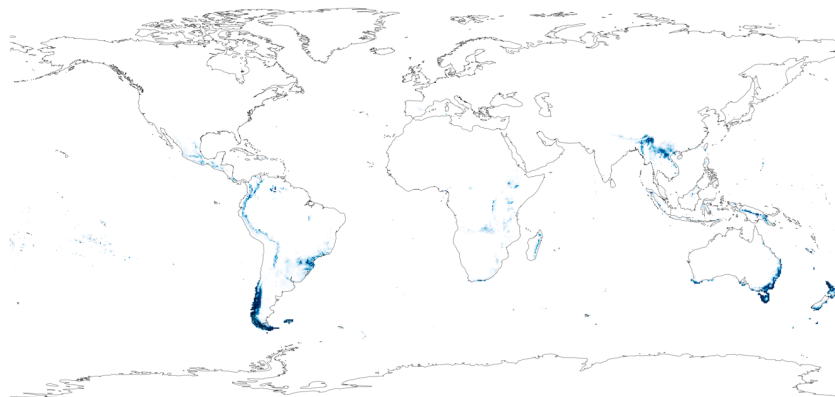
(a) New: BET-Temperate (2.62%)



(b) K2012: BET-Temperate (1.43%)



(c) ELM2/CLM5 default: BET-Temperate (1.36%)

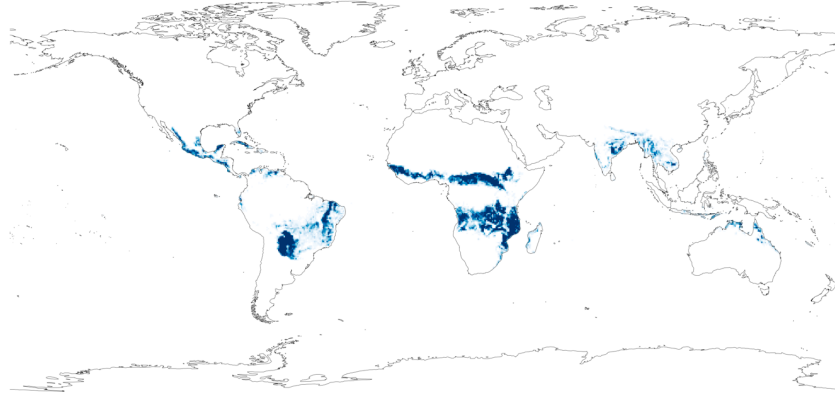


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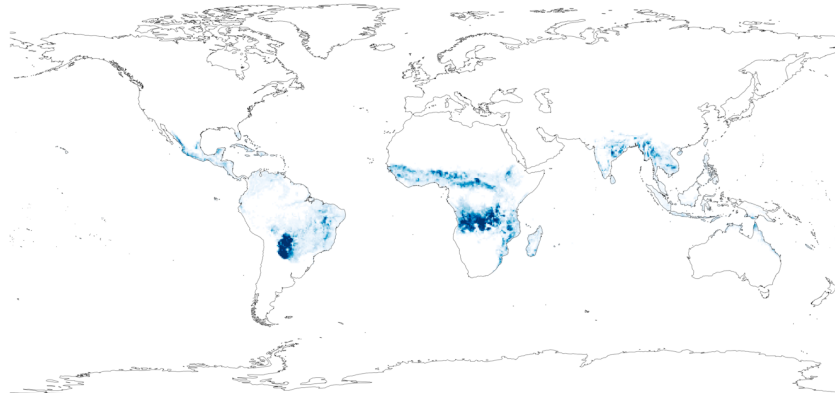
27 Figure S6. Same to Figure S1, but for broadleaf evergreen tree, temperate (BET-Temperate).

28

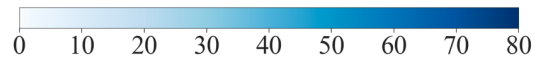
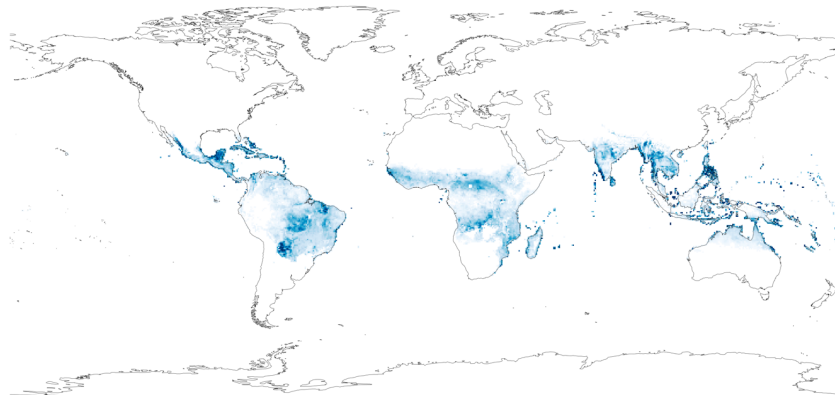
(a) New: BDT-Tropical (4.38%)



(b) K2012: BDT-Tropical (2.94%)



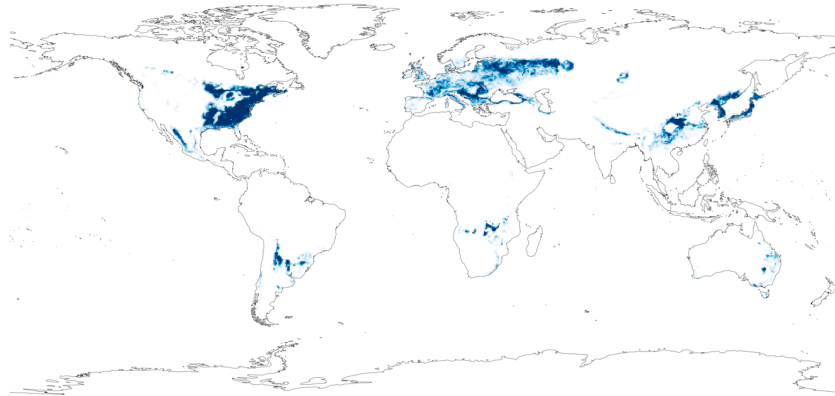
(c) ELM2/CLM5 default: BDT-Tropical (5.12%)



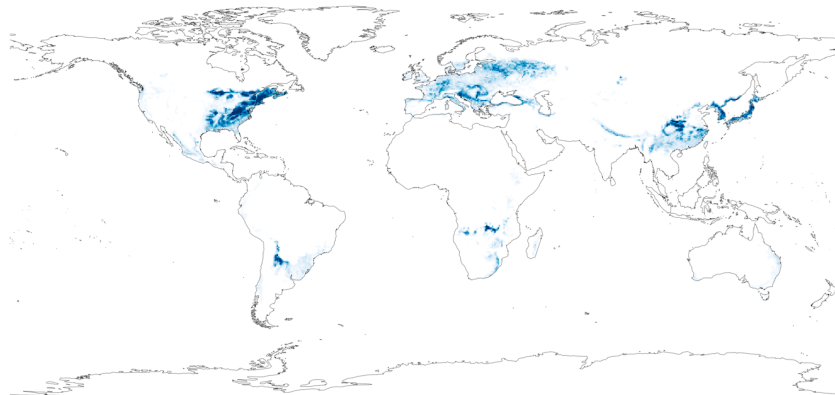
29

30 Figure S7. Same to Figure S1, but for broadleaf deciduous tree, tropical (BDT-Tropical).

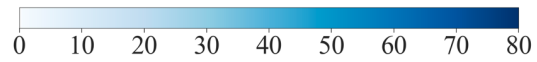
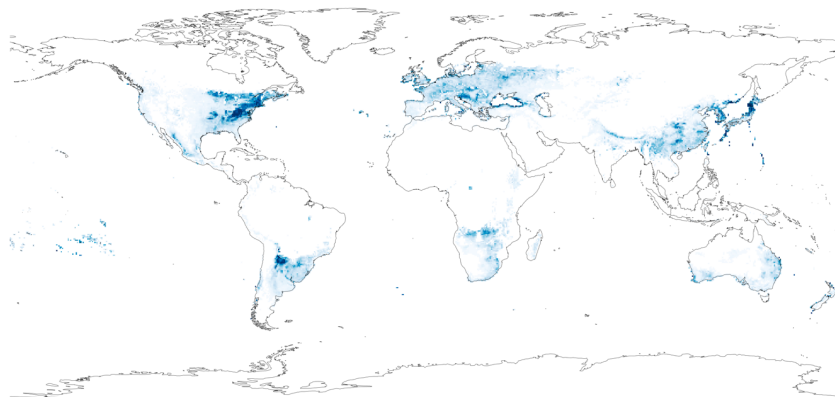
(a) New: BDT-Temperate (4.51%)



(b) K2012: BDT-Temperate (2.66%)



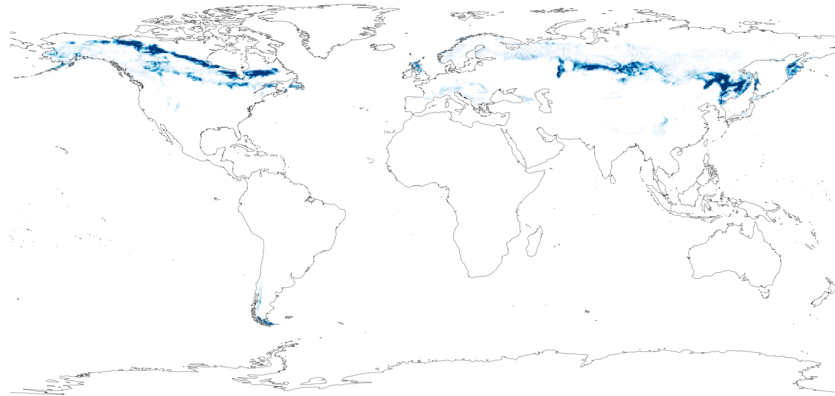
(c) ELM2/CLM5 default: BDT-Temperate (3.33%)



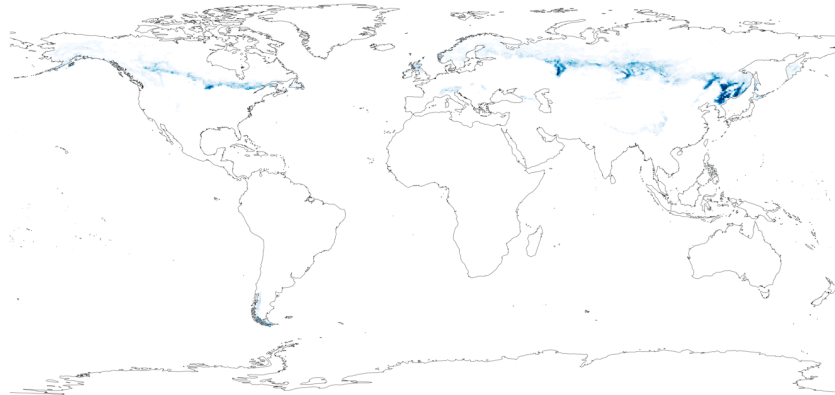
31

32 Figure S8. Same to Figure S1, but for broadleaf deciduous tree, temperate (BDT-Temperate).

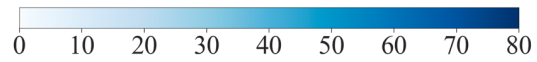
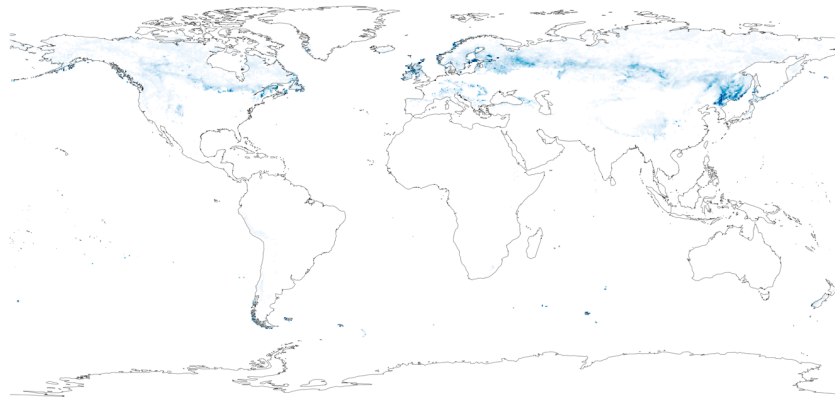
(a) New: BDT-Boreal (2.07%)



(b) K2012: BDT-Boreal (0.87%)



(c) ELM2/CLM5 default: BDT-Boreal (1.22%)



33

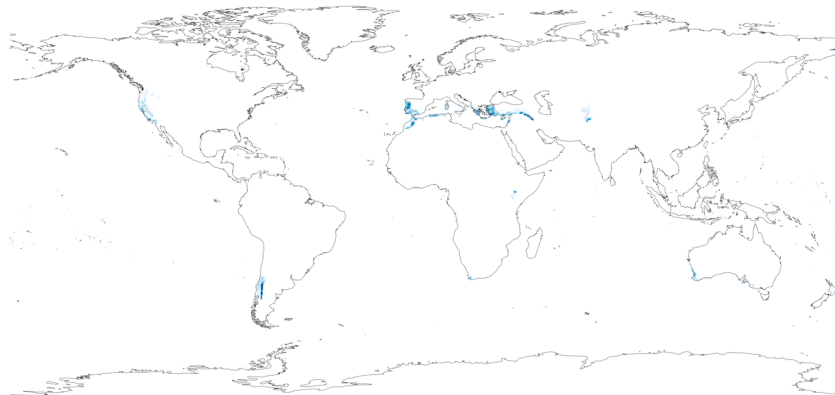
34 Figure S9. Same to Figure S1, but for broadleaf deciduous tree, boreal (BDT-Boreal).

35

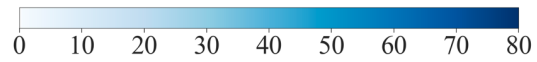
(a) New: BES-Temperate (0.04%)



(b) K2012: BES-Temperate (0.33%)



(c) ELM2/CLM5 default: BES-Temperate (0.13%)

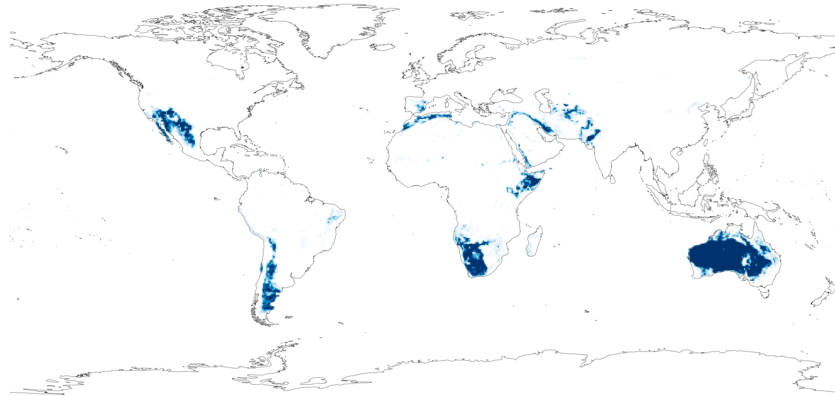


36

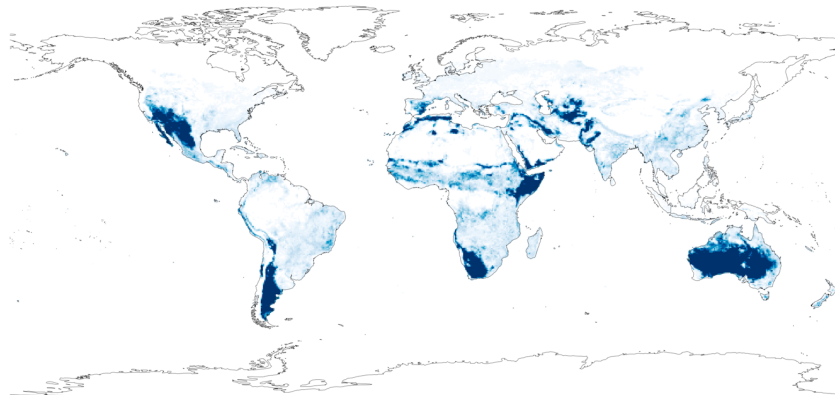
37 Figure S10. Same to Figure S1, but for broadleaf evergreen shrub, temperate (BES-Temperate).

38

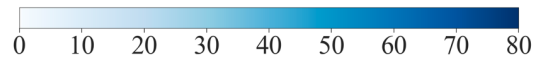
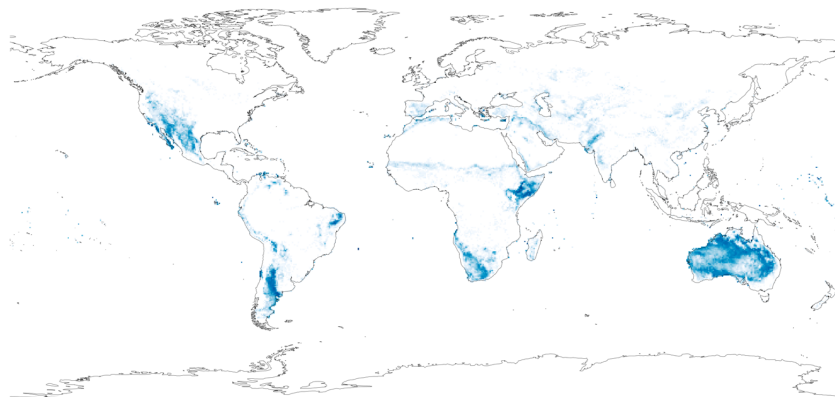
(a) New: BDS-Temperate (5.99%)



(b) K2012: BDS-Temperate (11.73%)



(c) ELM2/CLM5 default: BDS-Temperate (3.79%)

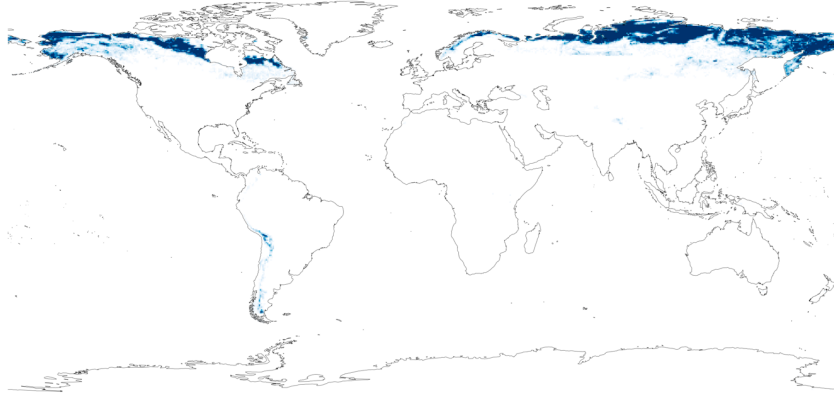


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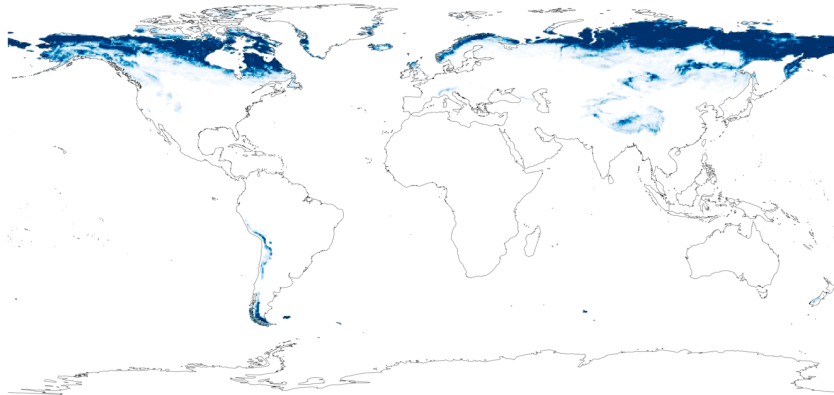
40 Figure S11. Same to Figure S1, but for broadleaf deciduous shrub, temperate (BDS-Temperate).

41

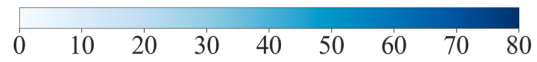
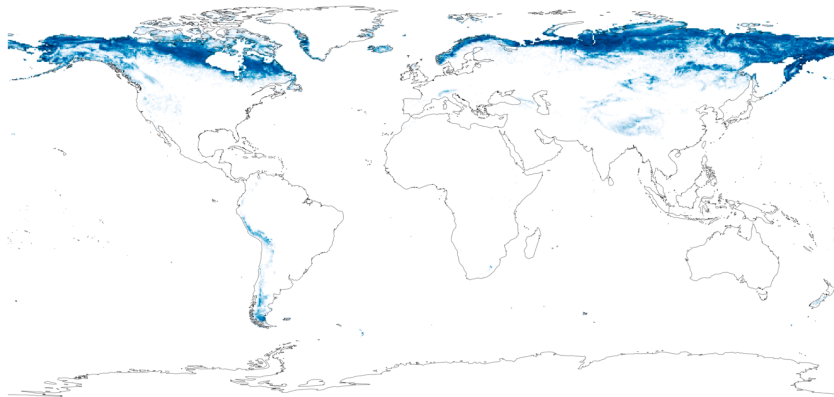
(a) New: BDS-Boreal (3.44%)



(b) K2012: BDS-Boreal (7.17%)



(c) ELM2/CLM5 default: BDS-Boreal (5.42%)

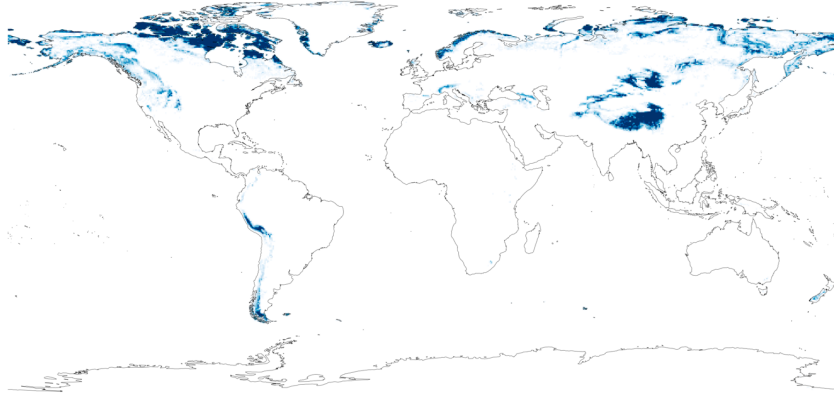


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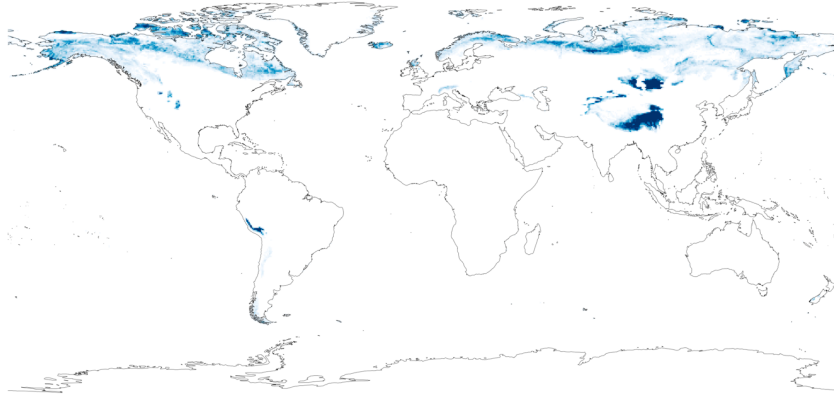
43 Figure S12. Same to Figure S1, but for broadleaf deciduous shrub, boreal (BDS-Boreal).

44

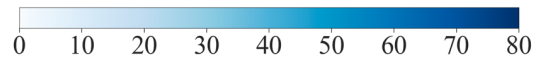
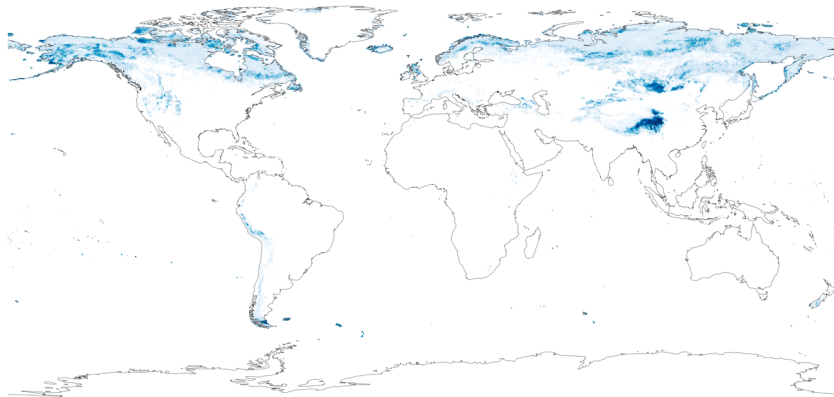
(a) New: C3G-Arctic (4.46%)



(b) K2012: C3G-Arctic (3.06%)



(c) ELM2/CLM5 default: C3G-Arctic (2.85%)

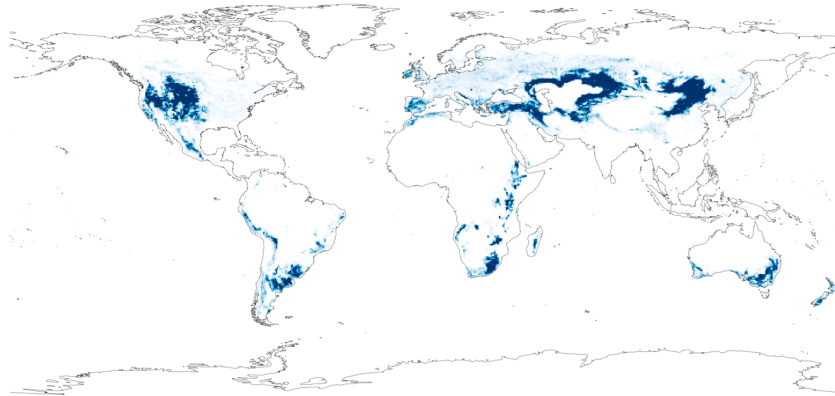


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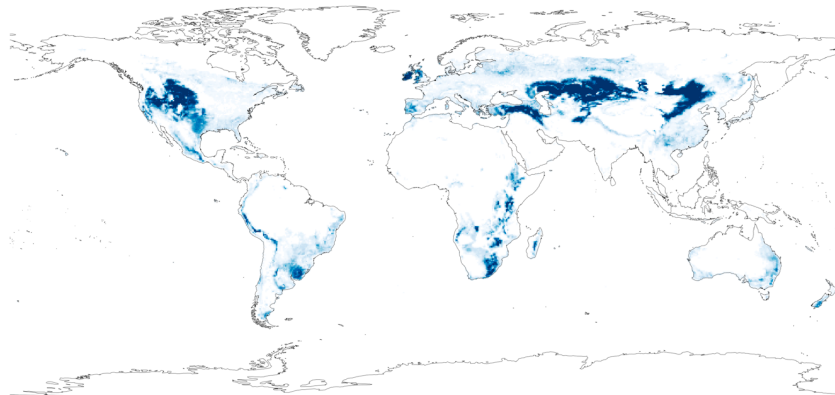
46 Figure S13. Same to Figure S1, but for C3 grass, arctic (C3G-Arctic).

47

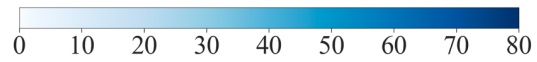
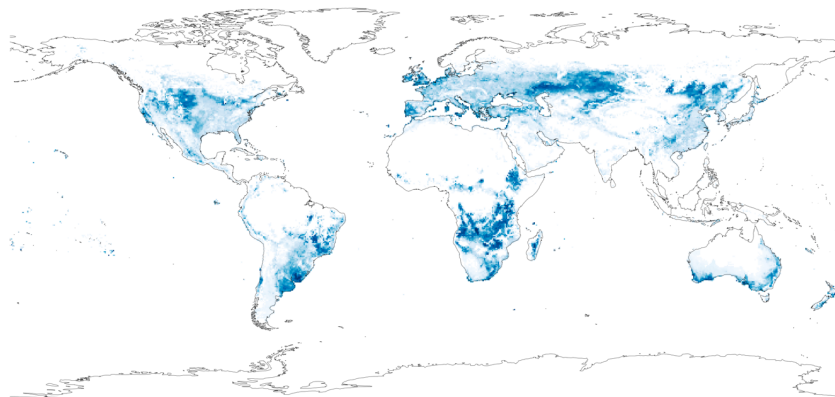
(a) New: C3G (7.64%)



(b) K2012: C3G (7.24%)



(c) ELM2/CLM5 default: C3G (7.96%)

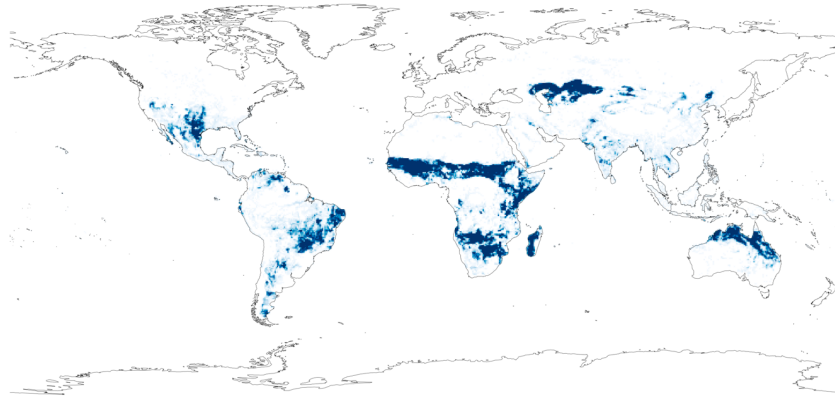


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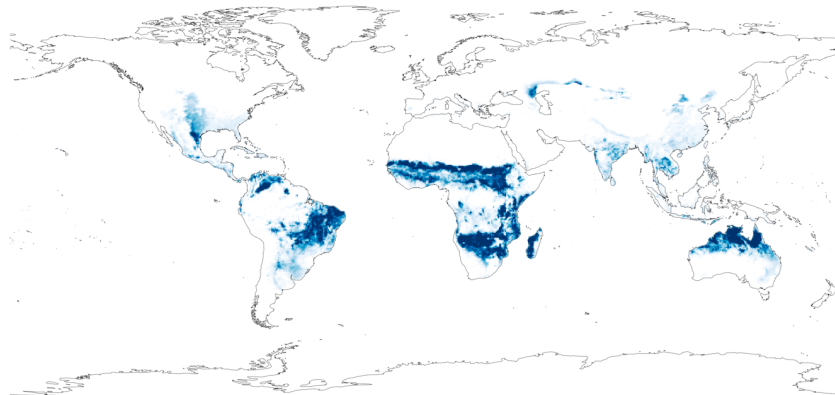
49 Figure S14. Same to Figure S1, but for C3 grass (C3G).

50

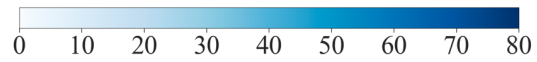
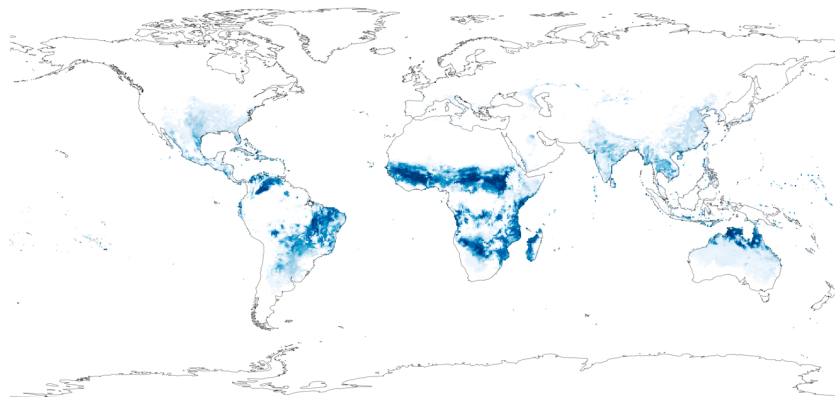
(a) New: C4G (9.05%)



(b) K2012: C4G (9.17%)



(c) ELM2/CLM5 default: C4G (7.25%)

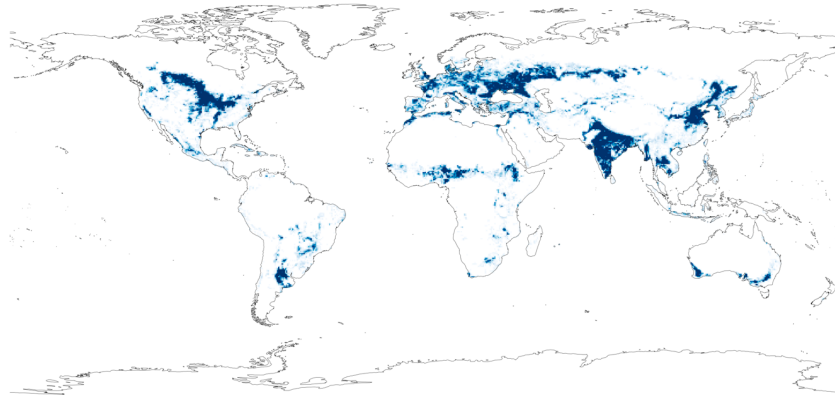


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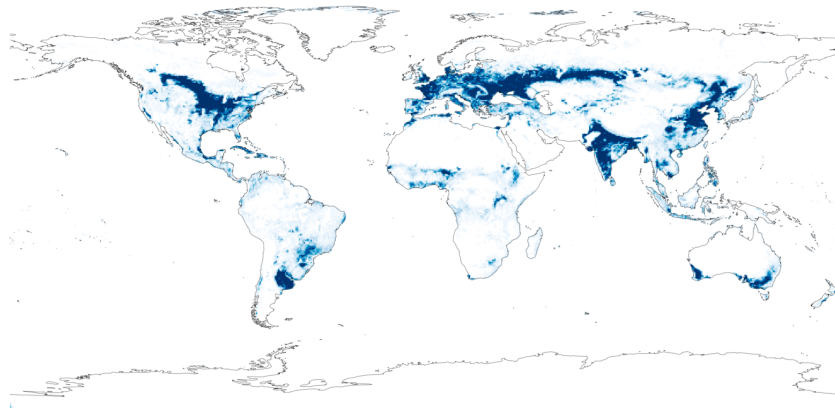
52 Figure S15. Same to Figure S1, but for C4 grass (C4G).

53

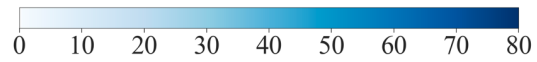
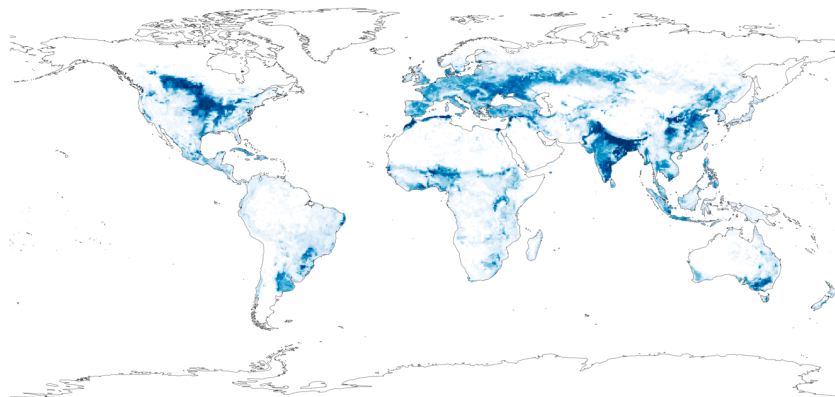
(a) New: Crop (7.90%)



(b) K2012: Crop (11.20%)



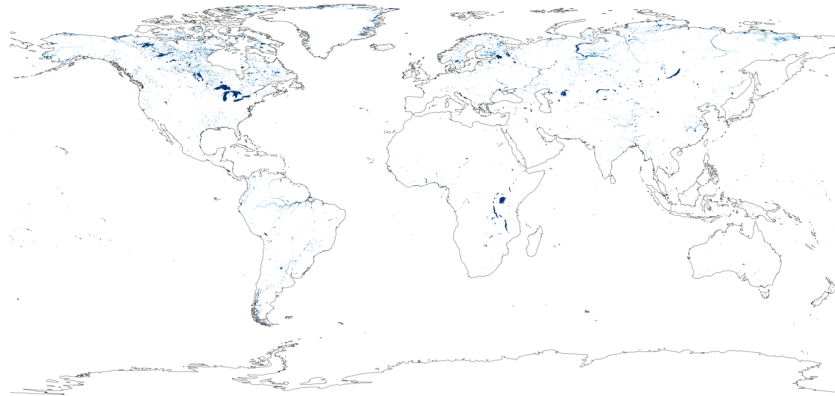
(c) ELM2/CLM5 default: Crop (9.37%)



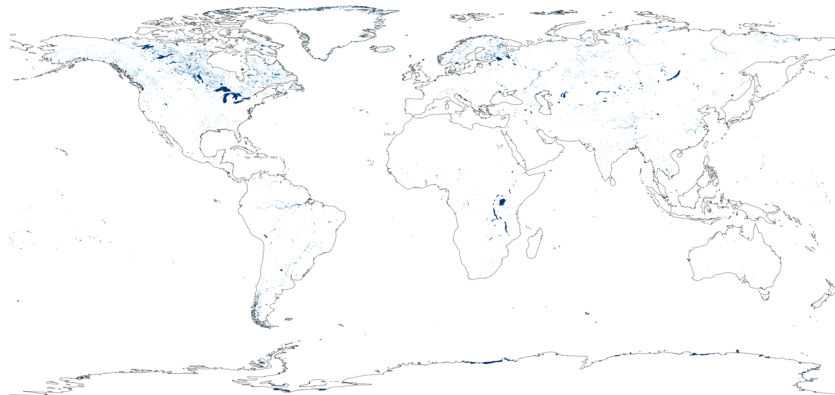
54

55 Figure S16. Same to Figure S1, but for Crops.

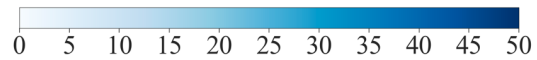
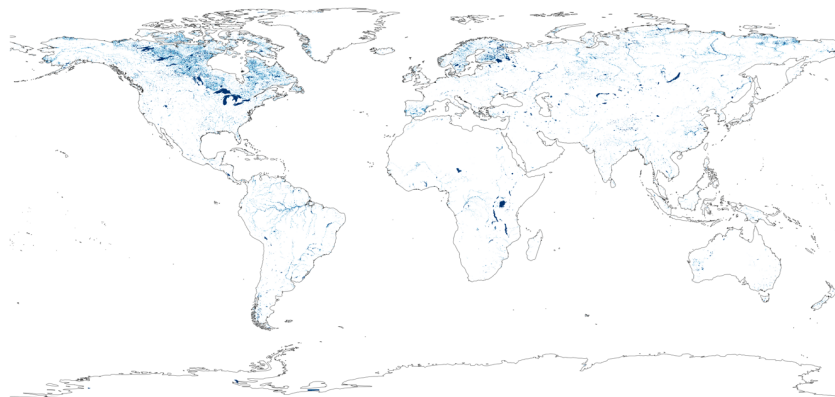
(a) New: Lake (1.25%)



(b) K2012: Lake (1.37%)



(c) ELM2/CLM5 default: Lake (1.68%)



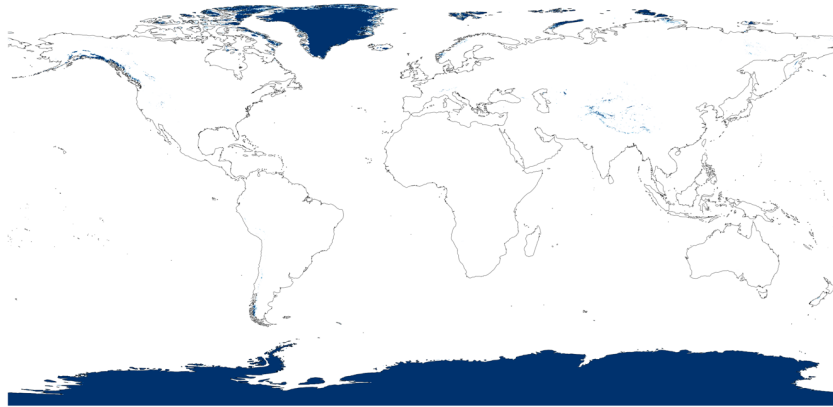
56

57 Figure S17. Global distribution of non-vegetated land cover, lake for (a) new, (b) K2012 and (c)

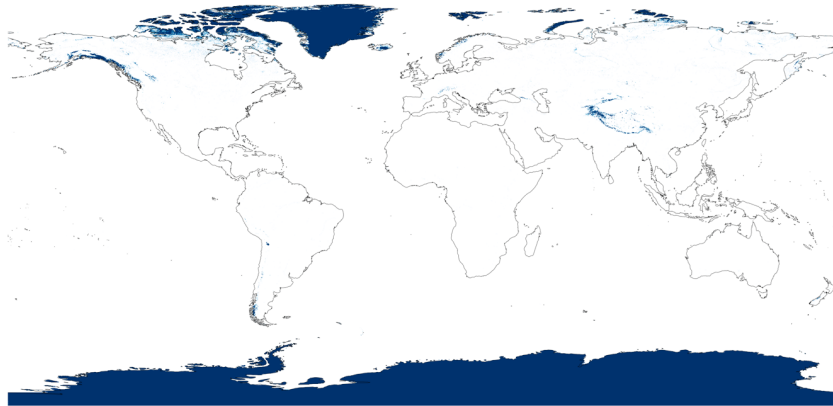
58 ELM2/CLM5 default PFT parameters. All are at the 0.05-degree resolution. The global average

59 is indicated in the plot title.

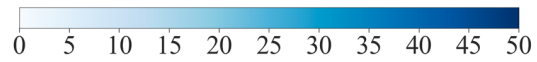
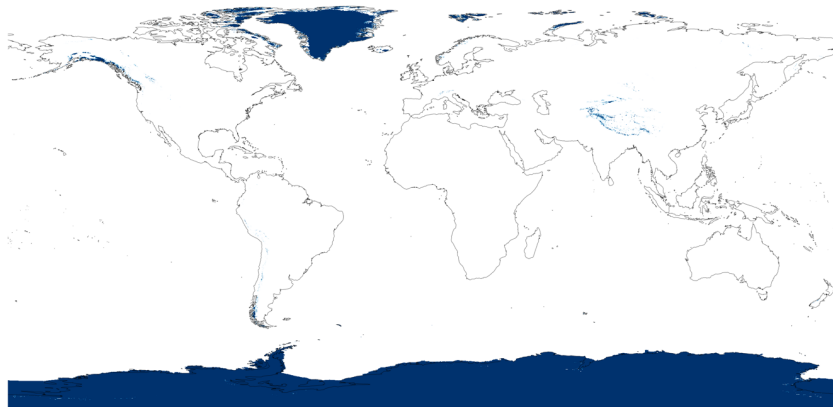
(a) New: Glacier (9.86%)



(b) K2012: Glacier (10.57%)



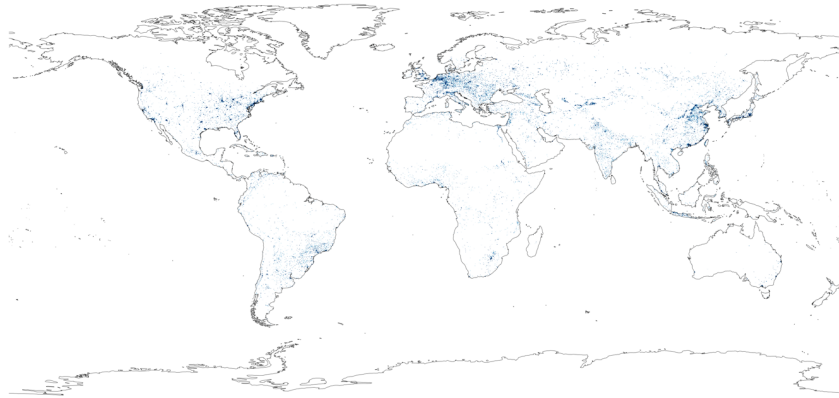
(c) ELM2/CLM5 default: Glacier (10.63%)



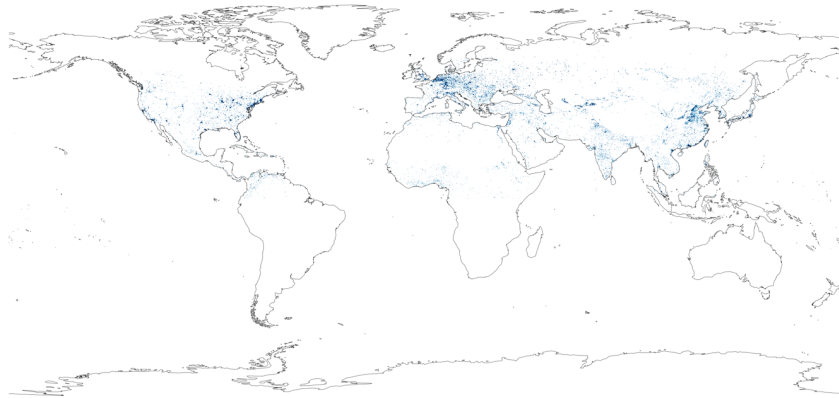
60

61 Figure S18. Same to Figure S17, but for glacier.

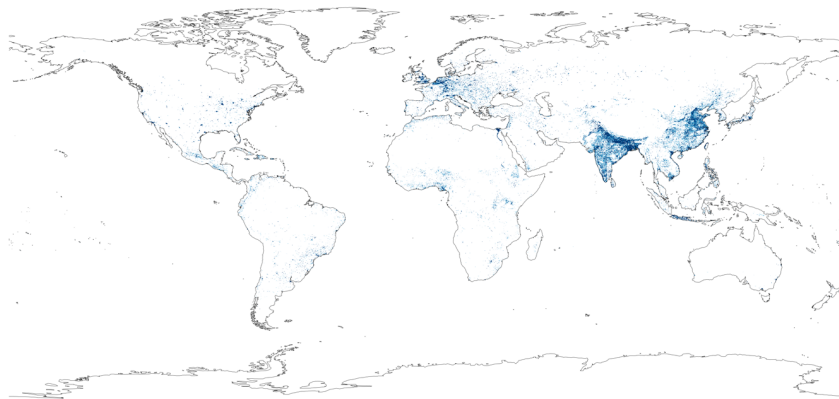
(a) New: Urban (NH, 0.61 %; global, 0.49 %)



(b) K2012: Urban (NH, 0.54 %)



(c) ELM2/CLM5 default: Urban (NH, 0.73 %; global, 0.55 %)



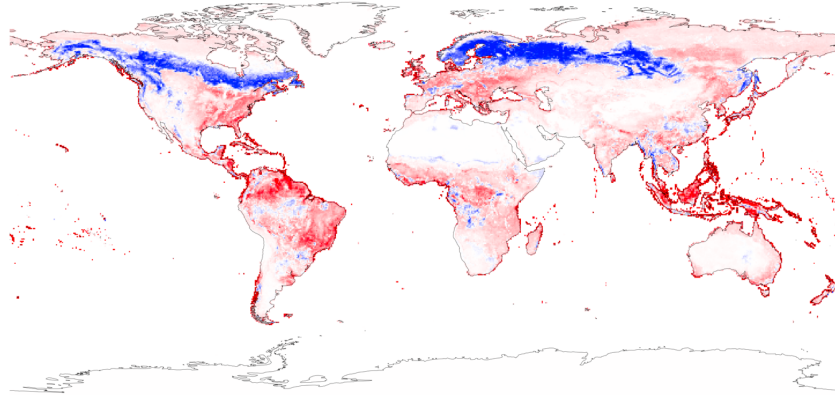
62

63 Figure S19. Same to Figure S17, but for urban. It should be noted that only the northern

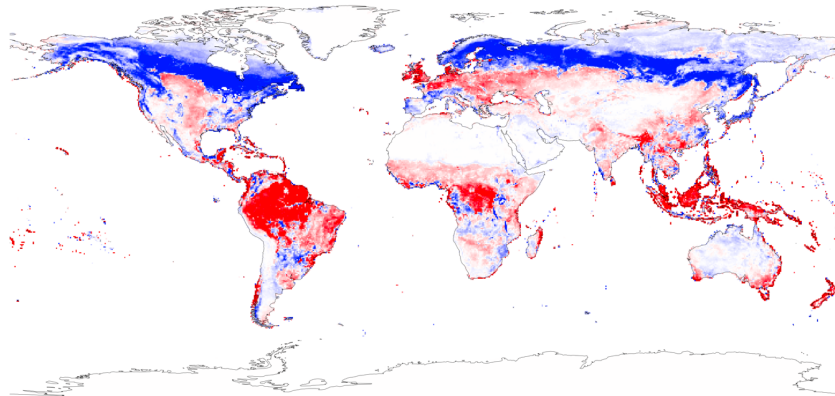
64 hemisphere (NH) urban areas from K2012 are depicted in (b), constrained by its data availability.

65

(a) LAI difference: New – K2012 ($0.15 \text{ m}^2/\text{m}^2$)



(b) LAI difference: New – ELM2/CLM5 default ($0.04 \text{ m}^2/\text{m}^2$)

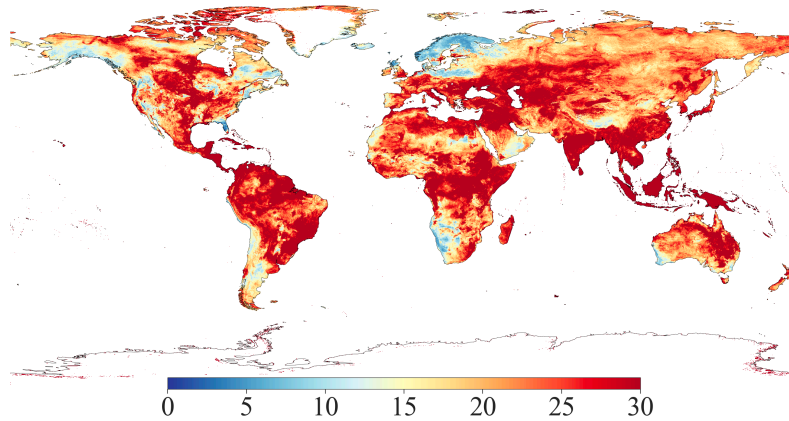


66

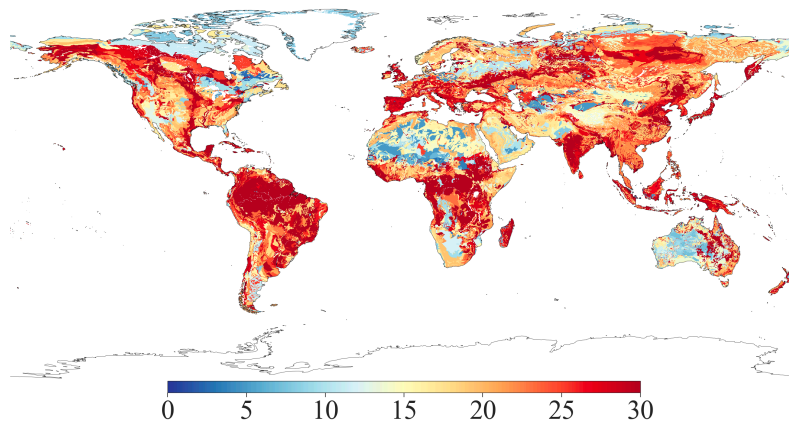
67 Figure S20. The difference of global annual mean LAI between (a) new and K2012 and (b) new
68 and ELM2/CLM5 default.

69

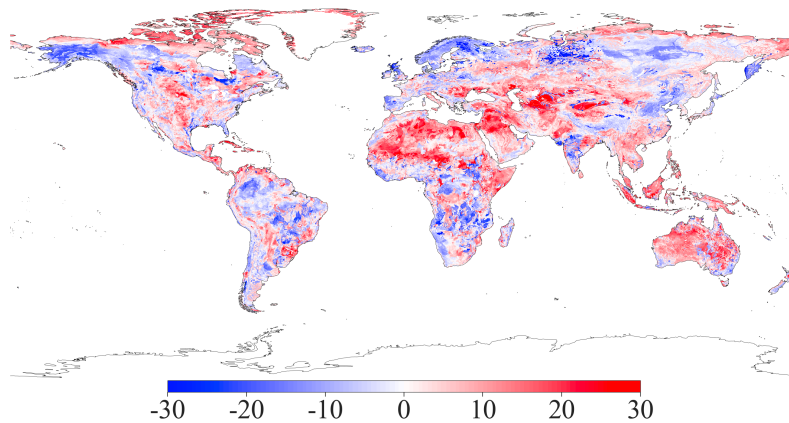
(a) New: Percent clay (24.49 %)



(b) ELM2/CLM5 default: Percent clay (22.26 %)



(c) Difference: Percent clay (8.07 %)



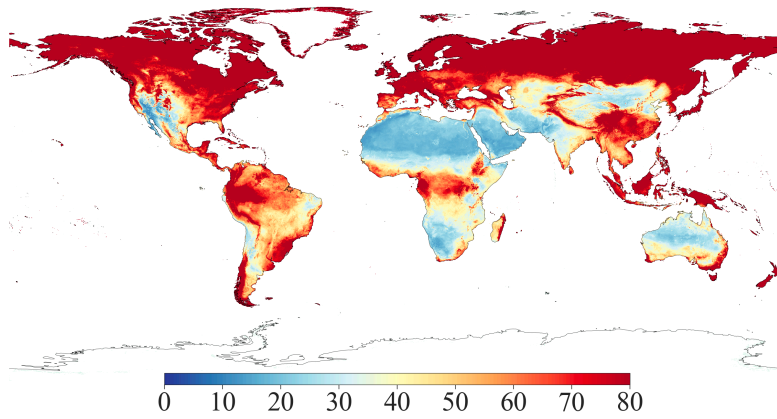
70

71 Figure S21. Global Distribution of Percent clay: (a) New Parameters, (b) ELM2/CLM5 Default

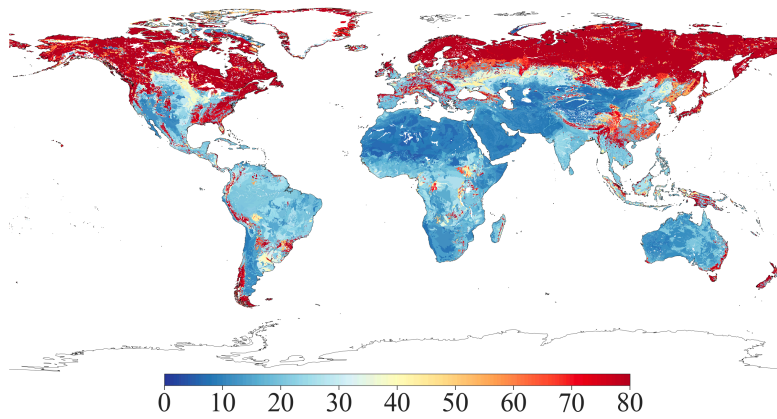
72 PFT Parameters, and (c) Difference (New – ELM2/CLM5 Default). The global average is

73 indicated in the subplot title, with the global average of the absolute difference provided for (c).

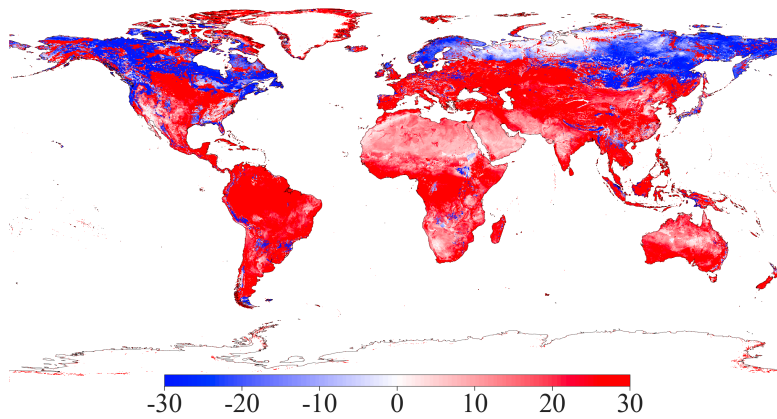
(a) New: Organic matter (61.70 kg/m^3)



(b) ELM2/CLM5 default: Organic matter (42.80 kg/m^3)



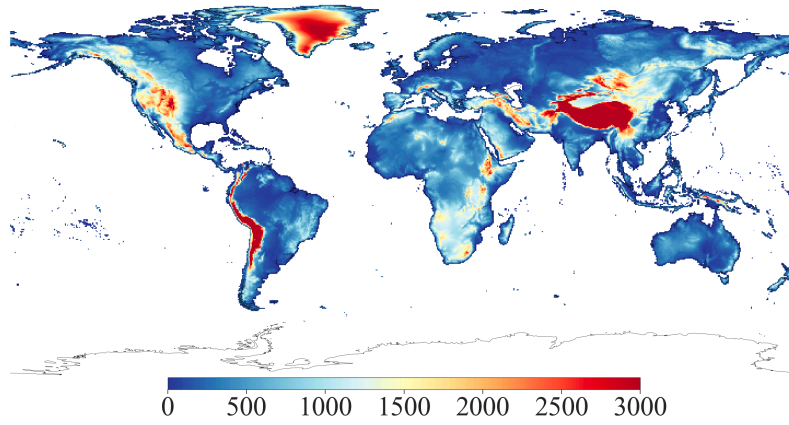
(c) Difference: Organic matter (30.52 kg/m^3)



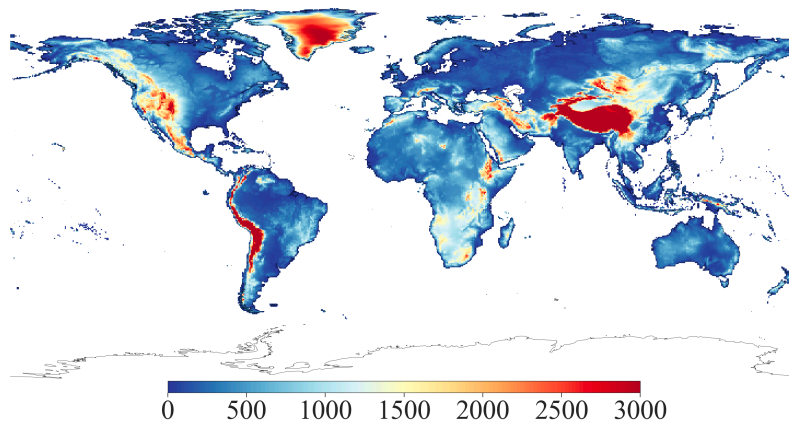
74

75 Figure S22. Same to Figure S21 but for soil organic matter.

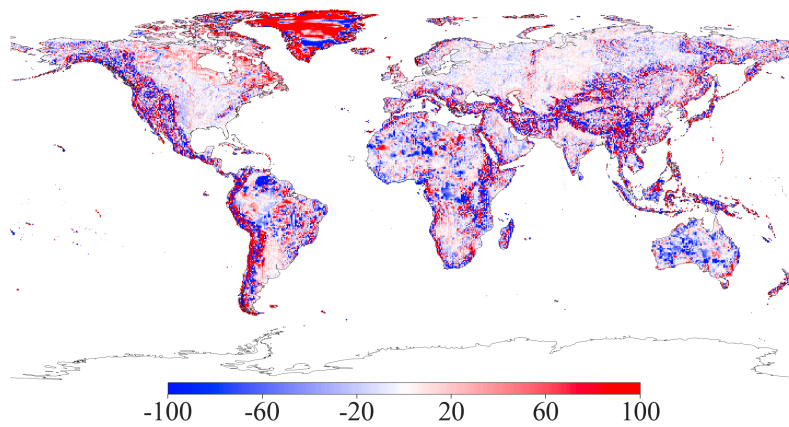
(a) New: Elevation (614.08 m)



(b) ELM2/CLM5 default: Elevation (631.55 m)

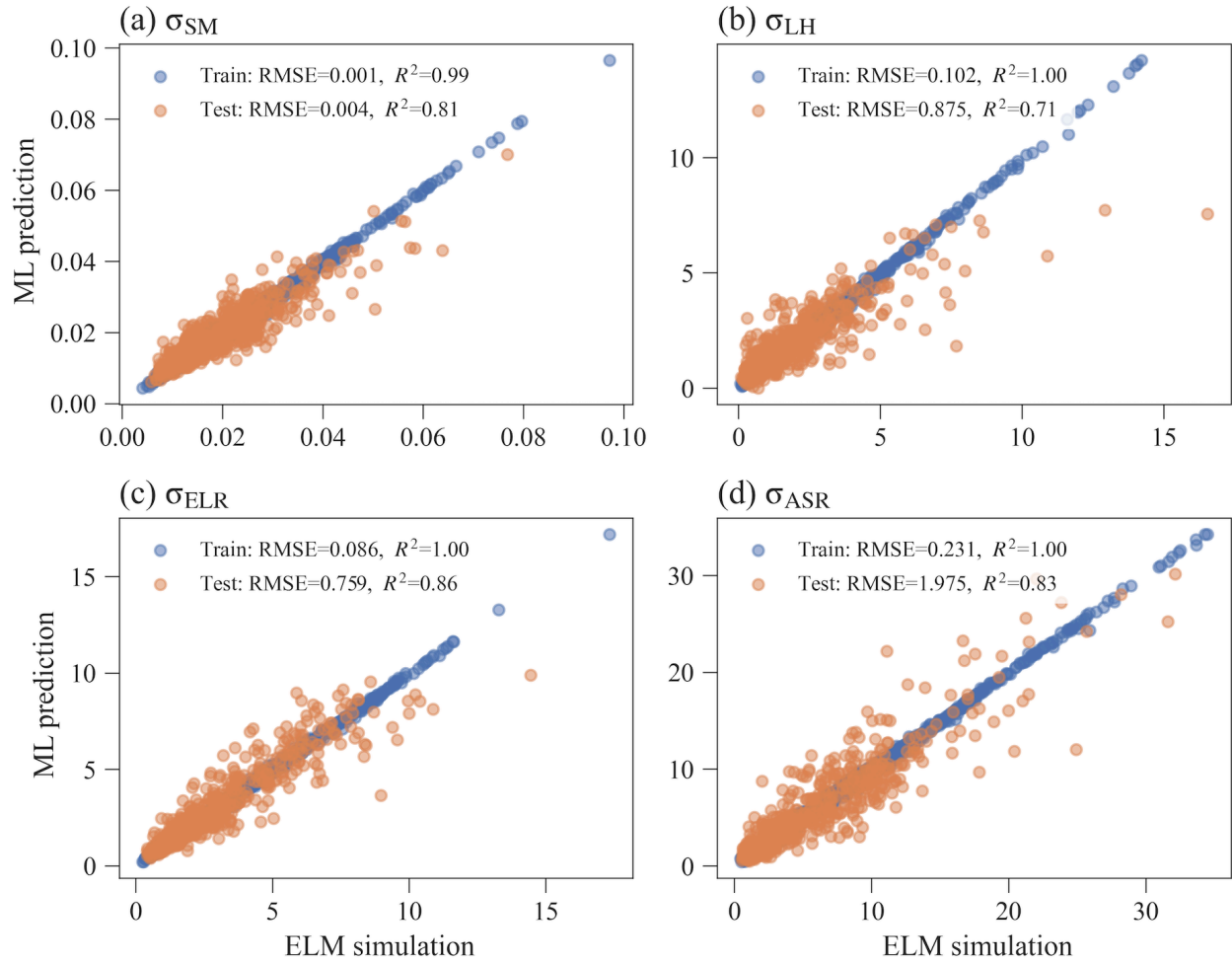


(c) Difference: Elevation (47.98 m)



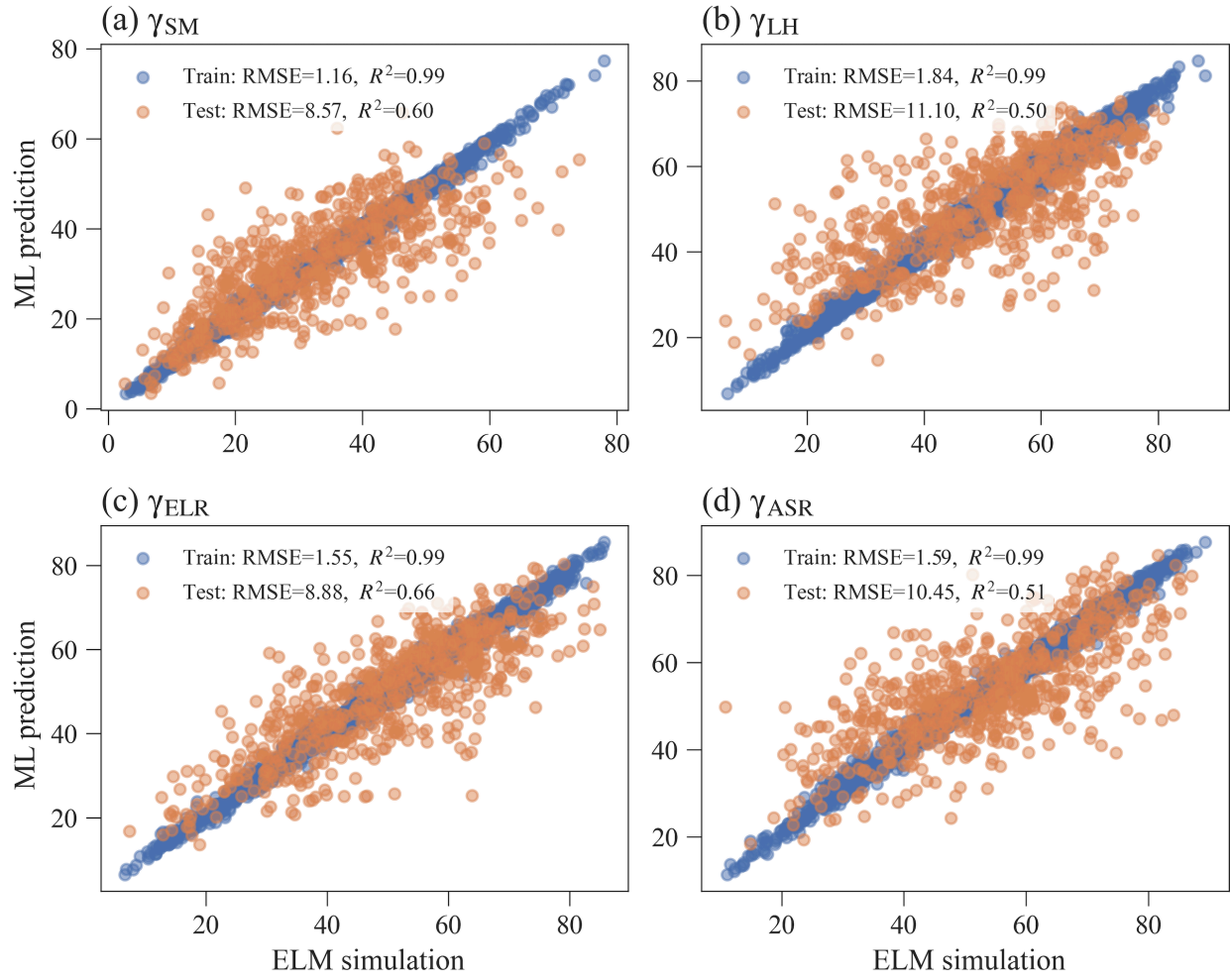
76

77 Figure S23. Same to Figure S21 but for elevation.



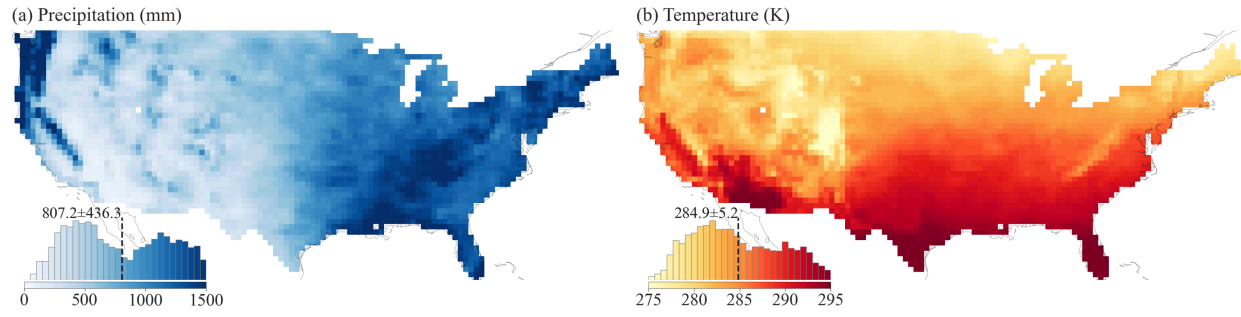
78

79 Figure S24. The performance of ML models during training and testing for predicting the spatial
 80 standard deviation of (a) SM, (b) LH, (c) ELR, and (d) ASR.



81

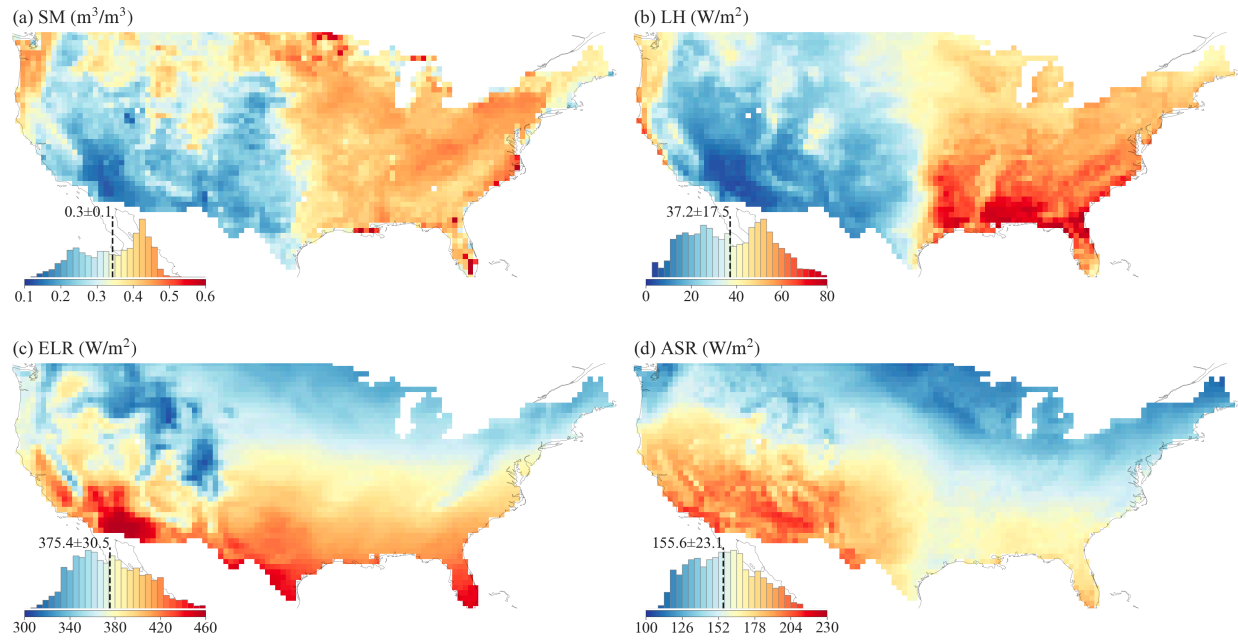
82 Figure S25. The performance of ML models in the training and testing samples for predicting the
 83 spatial information loss of (a) SM, (b) LH, (c) ELR, and (d) ASR.



84

85 Figure S26. Annual mean precipitation and temperature over CONUS at 0.5° resolution.

86



87

88 Figure S27. The annual mean for reference data of (a) GLEAM SM, (b) MODIS LH, (c)
 89 ERA5_Land ELR, and (d) ERA5_Land ASR over CONUS. The inserted histogram plot illustrates
 90 the distribution of grid values.