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A long-term estimation of biogenic volatile organic compound (BVOC) emission in China from 2001–2016: the roles of land cover change and climate variability

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Table S1. Look-up table for mapping the IGBP legend to eight main vegetations categories.

Name	Value	Description	Main Category Percentage
Needleleaf Evergreen Forest	1	Dominated by evergreen conifer trees (canopy >2m).	100% NET
Broadleaf Evergreen Forest	2	Dominated by evergreen broadleaf and palmate trees (canopy >2m).	100% BET
Needleleaf Deciduous Forest	3	Dominated by deciduous needleleaf (larch) trees (canopy >2m).	100% NDT
Broadleaf Deciduous Forest	4	Dominated by deciduous broadleaf trees (canopy >2m).	100% BDT
Mixed Forests	5	Dominated by neither deciduous nor evergreen (40-60% of each) tree type (canopy >2m).	100% Mixed Forests
Closed Shrublands	6	Dominated by woody perennials (1-2m height) >60% cover.	100% Shrub
Open Shrublands	7	Dominated by woody perennials (1-2m height) 10-60% cover.	60% Shrub 40% Grass
Woody Savannas	8	Tree cover 30-60% (canopy >2m).	60% Mixed Forest 20% Shrub 20% Grass
Savannas	9	Tree cover 10-30% (canopy >2m).	30% Mixed Forest 35% Shrub 35% Grass
Grasslands	10	Dominated by herbaceous annuals (<2m).	100% Grass

Permanent Wetlands	11	Permanently inundated lands with 30-60% water cover and >10% vegetated cover.	40% Grass
Croplands	12	At least 60% of area is cultivated cropland.	100% Crop
Urban and Built-up Lands	13	At least 30% impervious surface area including building materials, asphalt, and vehicles.	None
Cropland/Natural Vegetation Mosaics	14	Mosaics of small-scale cultivation 40-60% with natural tree, shrub, or herbaceous vegetation.	60% Crop 20% Shrub 20% Grass
Permanent Snow and Ice	15	At least 60% of area is covered by snow and ice for at least 10 months of the year.	None
Barren	16	At least 60% of area is non-vegetated barren (sand, rock, soil) areas with less than 10% vegetation.	None

Table S2. The climatic criteria for mapping main vegetation categories to CLM PFTs.

Main Category	Mapping Condition	CLM PFT
NET	T_c >-19 °C and GDD > 1200	100% NET Temperate
	T_c≤-19 °C or GDD ≤ 1200	100% NET Boreal
BET	T_c >15.5 °C	100% BET Tropical
	T_c≤15.5 °C	100% BET Temperate
NDT	None	100% NDT
BDT	T_c >15.5 °C	100% BDT Tropical
	-15.5 °C <T_c≤15.5 °C or GDD>1200	100% BDT Temperate
	T_c≤-15.5 °C or GDD ≤ 1200	100% BDT Boreal
Mixed Forest	T_c >15.5 °C	50% BET Tropical

		50% BDT Tropical
	-15.5 °C<T_c≤15.5 °C and GDD>1200	33.33% NET Temperate
		33.33% BET Temperate
		33.33% BDT Temperate
	T_c≤-15.5 °C or GDD ≤ 1200	33.33% NDT
		33.33% NET Boreal
		33.33% BDT Boreal
Shrub	T_c >-19 °C and GDD > 1200	100% BDS Temperate
	T_c≤-19 °C or GDD ≤ 1200	100% BDS Boreal
Grass	GDD<1000	100% C3 Arctic
	GDD>1000 and (Tc ≤ 22°C or Pmon≤25 mm)	100% C3
	GDD>1000 and Tc > 22°C and Pmon >25 mm	100% C4
Crop	None	100% Crop

Table S3. MEGAN2.1 biogenic emission classes and emission factors (ug m-2 h-1) for each of the plant functional types (Guenther et al., 2012). EF_1~EF_{15} represents different PFTs, and they are needle evergreen temperate trees (EF_1), needle evergreen boreal trees (EF_2), needle deciduous boreal trees (EF_3), broadleaf evergreen tropical tree (EF_4), broadleaf evergreen temperate tree (EF_5), broadleaf deciduous tropical tree (EF_6), broadleaf deciduous temperate tree (EF_7), broadleaf deciduous boreal tree (EF_8), broadleaf evergreen temperate shrub (EF_9), broadleaf deciduous

temperate shrub (EF_{10}), broadleaf deciduous boreal shrub (EF_{11}), arctic C3 grass (EF_{12}), cool C3 grass (EF_{13}), warm C4 grass (EF_{14}) and crop (EF_{15}).

Compound Class	EF_1	EF_2	EF_3	EF_4	EF_5	EF_6	EF_7	EF_8	EF_9	EF_{10}	EF_{11}	EF_{12}	EF_{13}	EF_{14}	EF_{15}
Isoprene	600	3000	1	7000	10 000	7000	10 000	11 000	2000	4000	4000	1600	800	200	1
Myrcene	70	70	60	80	30	80	30	30	30	50	30	0.3	0.3	0.3	0.3
Sabinene	70	70	40	80	50	80	50	50	50	70	50	0.7	0.7	0.7	0.7
Limonene	100	100	130	80	80	80	80	80	60	100	60	0.7	0.7	0.7	0.7
3-Carene	160	160	80	40	30	40	30	30	30	100	30	0.3	0.3	0.3	0.3
t-β-Ocimene	70	70	60	150	120	150	120	120	90	150	90	2	2	2	2
β-Pinene	300	300	200	120	130	120	130	130	100	150	100	1.5	1.5	1.5	1.5
α-Pinene	500	500	510	600	400	600	400	400	200	300	200	2	2	2	2
Other Monoterpenes	180	180	170	150	150	150	150	150	110	200	110	5	5	5	5
α-Farnesene	40	40	40	60	40	60	40	40	40	40	40	3	3	3	4
β-Caryophyllene	80	80	80	60	40	60	40	40	50	50	50	1	1	1	4
Other Sesquiterpenes	120	120	120	120	100	120	100	100	100	100	100	2	2	2	2
232-MBO	700	60	0.01	0.01	0.01	0.01	0.01	2	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Methanol	900	900	900	500	900	500	900	900	900	900	900	500	500	500	900
Acetone	240	240	240	240	240	240	240	240	240	240	240	80	80	80	80
CO	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
Bidirectional VOC	500	500	500	500	500	500	500	500	500	500	500	80	80	80	80
Stress VOC	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
Other VOC	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140

Table S4. The physical schemes for the WRF simulation.

Physical mechanism	Scheme
Microphysics	WSM 3-class simple ice scheme
Long-wave radiation	RRTM scheme
Short-wave radiation	Duhbia scheme
Land Surface	Noah Land Surface Model
PBL Sche	YSU scheme
Cumulus parameter	Kain-Fritsch (new Eta) scheme

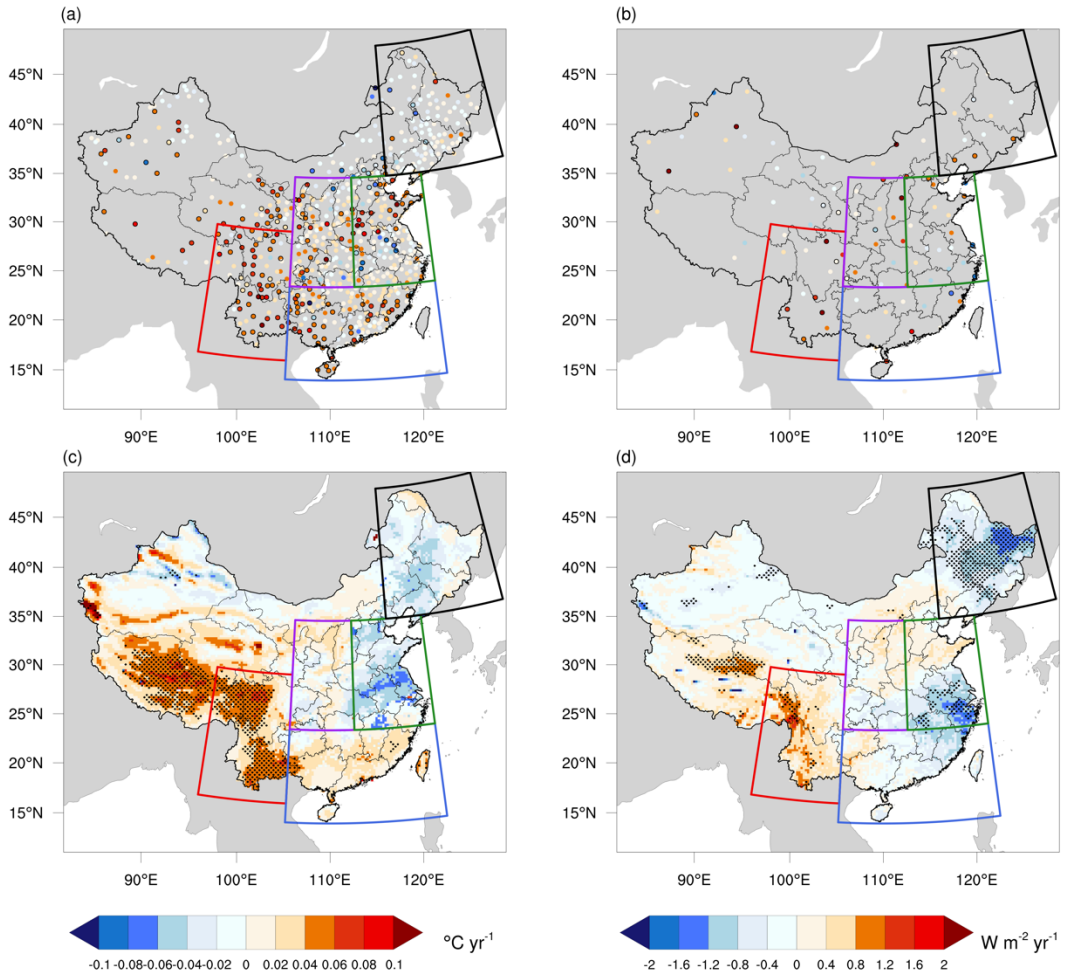

Figure S1. The trend of growing season averaged 2-meter temperature (T2) and downward shortwave radiation (DSW). (a) and (b) are for in-situ T2 and DSW, respectively, and the sites with statistically significant trend are marked by black circles. (c) and (d) are for the WRF simulated T2 and DSW, respectively, and the regions with statistically significant trend are illustrated by shadow. The boxes represent the sub-regions chosen for the regional validation of meteorology, and these regions include Northeastern (black), Central (purple), Eastern (green), Southeastern (red) and Southern (blue) China.

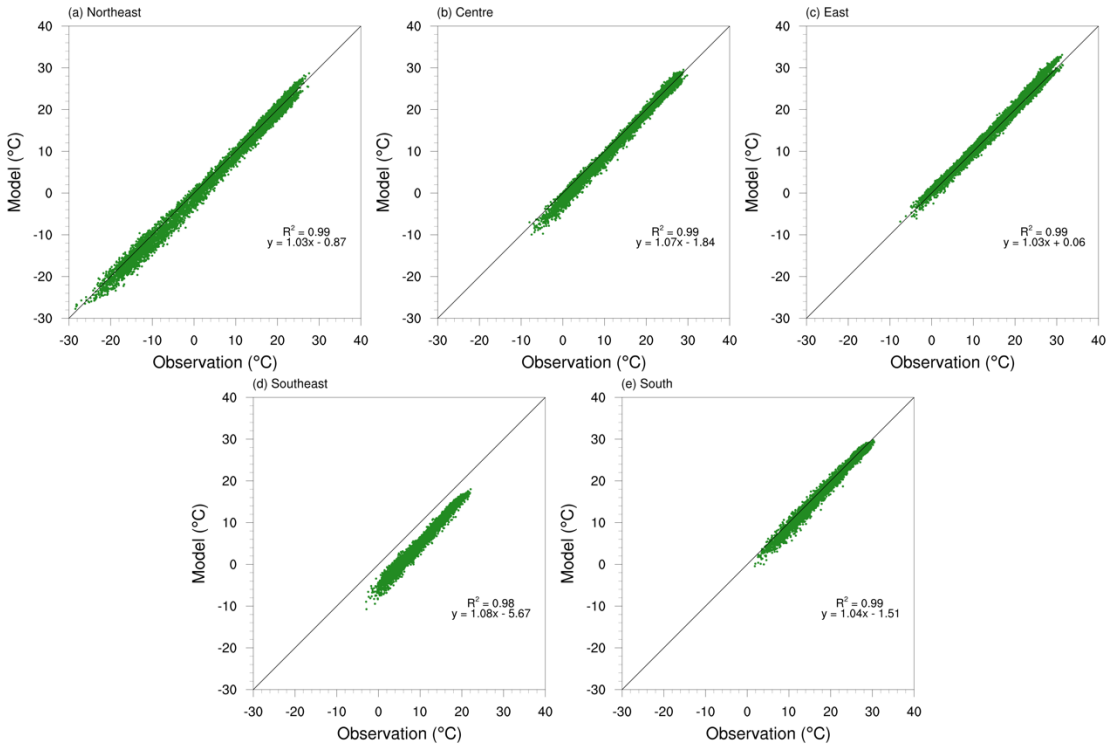

Figure S2. Validations of the daily 2-meter temperature in different regions.

Table S5. The statistic parameters for the validation of the region averaged 2-meter temperature in different regions. MB, ME and RMSE are shorts for mean bias, mean error and root mean square error, respectively.

	R	MB(°C)	ME(°C)	RMSE(°C)
Northeast	0.99	-0.71	1.31	1.60
Centre	0.99	-0.89	1.12	1.42
East	0.99	0.50	0.95	1.13
Southeast	0.99	-4.70	4.70	4.80
South	0.99	-0.71	0.88	1.13

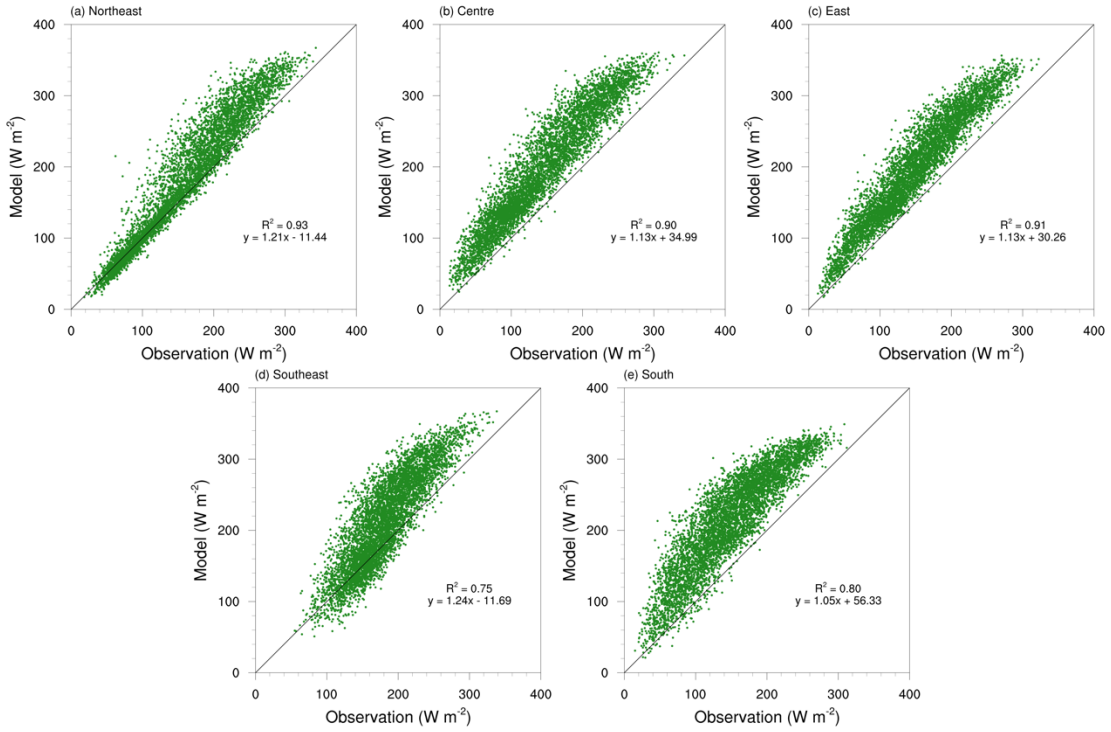

Figure S3. Validations of the daily downward shortwave radiation in different regions.

Table S6. The statistic parameters for the validation of the region averaged downward shortwave radiation in different regions. MB, ME and RMSE are shorts for mean bias, mean error and root mean square error, respectively.

	R	MB (W m^{-2})	ME (W m^{-2})	RMSE (W m^{-2})
Northeast	0.96	21.93	24.94	35.37
Centre	0.95	53.60	53.66	59.66
East	0.95	48.99	49.01	54.34
Southeast	0.87	31.91	37.61	46.38
South	0.90	64.26	64.51	71.13

Reference

Guenther, A. B., Jiang, X., Heald, C. L., Sakulyanontvittaya, T., Duhl, T., Emmons, L. K., and Wang, X.: The Model of Emissions of Gases and Aerosols from Nature version 2.1 (MEGAN2.1): an extended and updated framework for modeling biogenic emissions, Geoscientific Model Development, 5, 1471-1492, 10.5194/gmd-5-1471-2012, 2012.