

1 **Spatial scale-dependent land-atmospheric methane exchanges in the**  
2 **northern high latitudes from 1993 to 2004**

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4 X. Zhu<sup>1</sup>, Q. Zhuang<sup>1,2</sup>, X. Lu<sup>3</sup>, and L. Song<sup>1,4,5</sup>

5 <sup>1</sup>Department of Earth, Atmospheric, and Planetary Sciences, Purdue University, West  
6 Lafayette, IN, 47907, USA

7 <sup>2</sup>Department of Agronomy, Purdue University, West Lafayette, IN 47907, USA

8 <sup>3</sup>The Ecosystems Center, Marine Biological Laboratory, Woods Hole, MA 02543, USA

9 <sup>4</sup>Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of  
10 Sciences, Beijing, 100101, China

11 <sup>5</sup>Graduate University of the Chinese Academy of Sciences, Beijing, 100049, China

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13 **Corresponding author:** X. Zhu, Department of Earth, Atmospheric, and Planetary  
14 Sciences, Purdue University, West Lafayette, IN, 47907, USA. Email:  
15 zhu123@purdue.edu

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## 18 **TOPMODEL parameterization scheme**

19 An illustration of the TOPMODEL-based parameterization scheme was shown in  
20 Fig. S3. Watershed-mean topographic wetness index (TWI) (Fig. S3b) was calculated  
21 from original TWI data (Fig. S3a) according to basin boundaries from watershed  
22 delineation (Fig. S2). Time-varying scaling parameter  $m$  ( $m$  values of July in 1994 were  
23 shown in Fig. S3c) was estimated from Eq. (3) and Eq. (4). The topography-related data,  
24 including TWI, watershed delineation and terrain slope, was acquired from HYDRO1K  
25 database ([http://eros.usgs.gov/#Find\\_Data/Products\\_and\\_Data\\_Available/gtopo30/hydro](http://eros.usgs.gov/#Find_Data/Products_and_Data_Available/gtopo30/hydro)),  
26 which provides global coverage of topographically derived data based on 30-sec USGS-  
27 GTOPO30 DEM data. The original 1-km TWI data was spatially averaged to get 5-km  
28 TWI used in this study. The original five-level watershed delineation basin data was  
29 aggregated into four-level data according to Pfafstetter code  
30 ([http://eros.usgs.gov/#/Find\\_Data/Products\\_and\\_Data\\_Available/gtopo30/hydro/P311](http://eros.usgs.gov/#/Find_Data/Products_and_Data_Available/gtopo30/hydro/P311)),  
31 with average surface area of 6597 km<sup>2</sup> (Fig. S2).

32 The calibrated time-varying  $\alpha$  in Eq. (3) were shown in Fig. S4a, and the  
33 comparison of total inundated area from GIEMS data (Prigent et al., 2007; Papa et al.,  
34 2010) and model simulations were shown in Fig. S4b. The calibrated parameter  $\alpha$  had a  
35 strong temporal variation: larger in warmer months and smaller in colder months. The  
36 monthly parameter  $\alpha$  was spatially constant and larger  $\alpha$  corresponded to larger  
37 parameter  $m$ , and resulted in higher variance of local WTD. It is important to note that, in  
38 our three-step calibration procedure, only the total inundated area over the whole region,  
39 rather than for each grid cell, was confirmed by satellite data. The calibration at each grid  
40 cell was impossible since only inundated area fraction data (for the West Siberian

- 41 Lowlands, ~7% of all grid cells were inundated during the growing season (Fig. 5b))  
42 rather than WTD data was available from satellite observations.

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79 **Table S1** Site information of methane measurements used for the validation.

<b>Site Name</b>	<b>Latitude (°)</b>	<b>Longitude (°)</b>	<b>Reference</b>
Toolik Lake, Alaska, USA	68.63	-149.63	Christensen (1993)
Patuanak, Saskatchewan, Canada	55.85	-107.68	Turetsky et al. (2002)
Yamal Peninsula, Russia	68.13	71.70	Heyer et al. (2002)
Chersky, Russia	68.83	161.67	Nakano et al. (2000)
Lena Delta, Russia	72.37	126.50	Sachs et al. (2010)
Thompson, Manitoba, Canada	55.67	-97.87	Bellisario et al. (1999)
North Point - Kinosheo transect, Hudson Bay lowlands, Canada	51.47	-80.62	Moore et al. (1994)
North Point - Kinosheo transect, Hudson Bay lowlands, Canada	51.55	-81.77	Moore et al. (1994)
Lementa Bog, Fairbanks, Alaska, USA	64.88	-147.50	Moosavi et al. (1996)
Prudhoe Bay, Alaska, USA	70.30	-148.32	Vourlitis et al. (1993)
Barrow, Alaska, USA	71.00	-157.00	Rhew et al. (2007)
Tobolsk, West Siberia, Russia	58.47	68.12	Glagolev et al. (2011)
Surgut, West Siberia, Russia	61.43	73.33	Glagolev et al. (2011)
Pangody, West Siberia, Russia	65.87	74.96	Glagolev et al. (2011)
Plotnikovo, West Siberia, Russia	56.85	82.85	Glagolev et al. (2011)
Noyabrsk-Hills, West Siberia, Russia	63.12	74.49	Glagolev et al. (2011)
Noyabrsk-Palsa, West Siberia, Russia	63.80	75.55	Glagolev et al. (2011)
Vah, West Siberia, Russia	59.74	70.42	Glagolev et al. (2011)
Muhrino, West Siberia, Russia	60.89	68.70	Glagolev et al. (2011)
Tazovsky, West Siberia, Russia	67.18	78.92	Glagolev et al. (2011)
Gyda, West Siberia, Russia	70.89	78.55	Glagolev et al. (2011)
Skala, West Siberia, Russia	55.40	81.78	Glagolev et al. (2011)

81 **Figure captions**

82 **Fig. S1.** The VIC grid cells over the pan-Arctic at a spatial resolution of 100 km.

83 **Fig. S2.** The delineation of the watersheds over the pan-Arctic (average surface area of  
84 6597 km<sup>2</sup>), derived from HYDRO1K dataset.

85 **Fig. S3.** An illustration of TOPMODEL-based parameterization scheme used for  
86 redistributing water table depth. See text for more details.

87 **Fig. S4.** Calibrated monthly parameter  $\alpha$  for TOPMODEL-based parameterization (a)  
88 and the comparison of monthly total inundated area from GIEMS data (Prigent et al.,  
89 2007; Papa et al., 2010) and model simulations (b) from 1993 to 2004.

90 **Fig. S5.** Monthly precipitation and air temperature averaged over the pan-Arctic for the  
91 year 1994 (maximum methane emission year from 1993 to 2004 at a 5-km spatial  
92 resolution). The climate data was derived from NCEP/NCAR Reanalysis dataset.