GOSAT CO2 AND CH4 EMISSIONS FROM THAWING PERMAFROST REGIONS IN CENTRAL ASIA (2009-2018): CASE AREAS IN MONGOLIA, YAKUTSK, AND TIBETAN PLATEAU

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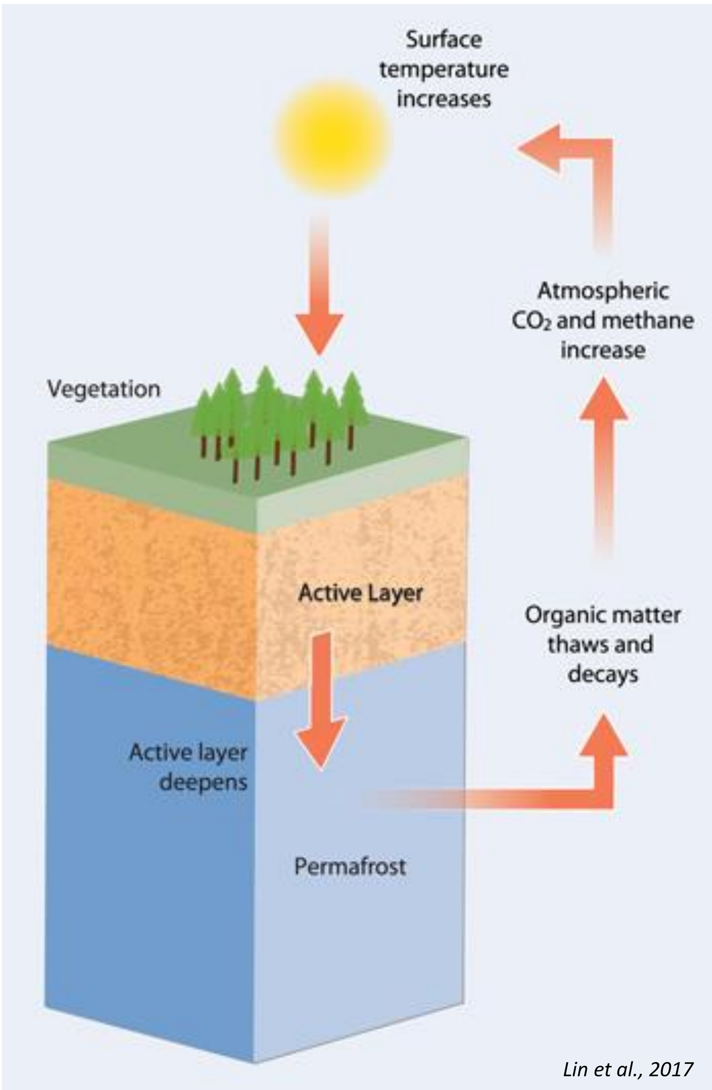
INTRODUCTION

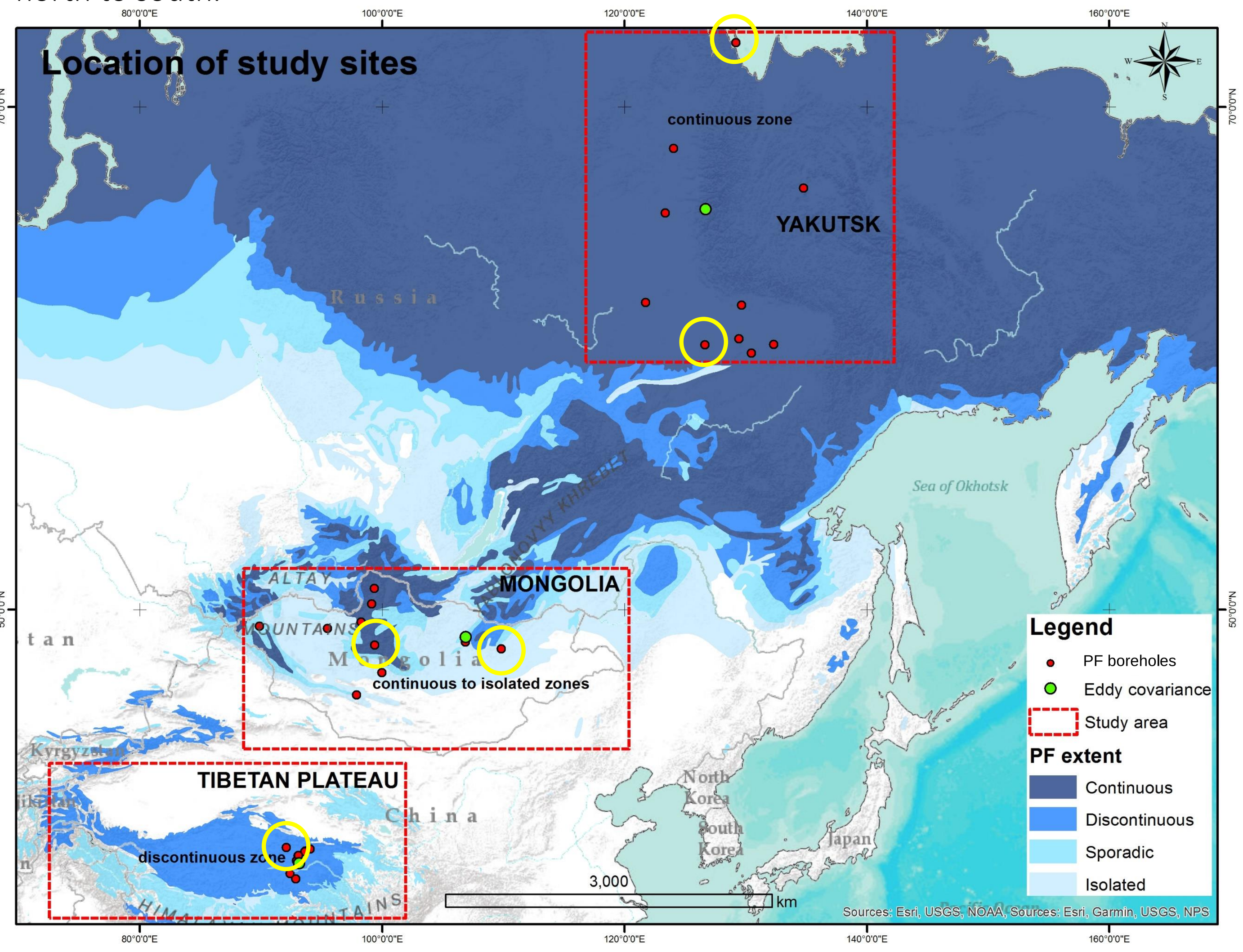


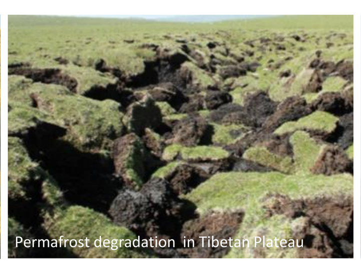
Permafrost of high latitude ecosystems contains an estimated 1700 Gt of carbon dioxide (CO2) and methane (CH4), which is almost twice as much greenhouse gas (GHG) as is currently contained in the atmosphere [IPCC, 2018]. Under climate warming, central Asian permafrost regions should not be neglected and this area is very important components of global permafrost. The magnitude and timing of GHG emissions thawing permafrost regions in central Asia and their impact on climate change remain uncertain. The critical question focus on how much thaw out in the current and when it will be emitted GHG into the atmosphere?

Objective of the research is to estimate the actual magnitude of the CO2 and CH4 emissions from thawing permafrost in central Asia such as Mongolia, Yakutsk in Russia, and Tibetan Plateau in China based on high-resolution remote sensing approaches and observation datasets.

STUDY AREA

The study is selected three different ecosystems and focus to estimate GHG emissions from thawing permafrost due to climate change and human activities in central Asia: lowland permafrost in Yakutsk, mountain permafrost in Mongolia, and plateau permafrost in the Tibetan Plateau. These study areas represent a large gradient from north to south.





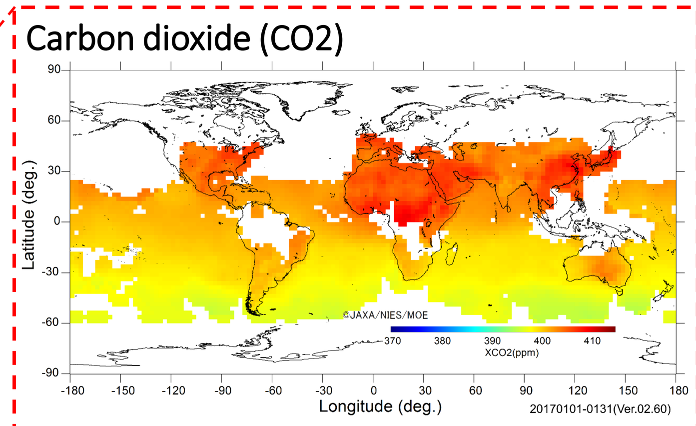
METHOD AND DATASETS

Monthly global distributions of CO2 and CH4 are calculated from the FTS SWIR Level 3 product (2009-2018) using the **Ordinary Kriging Interpolation** method in this study.

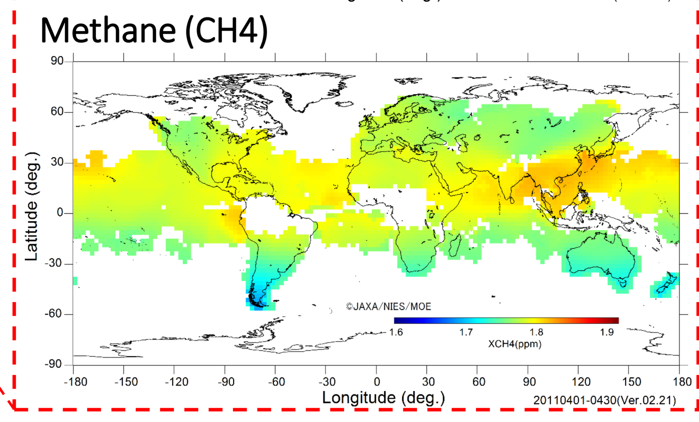
GOSAT satellite data

Sensor / Band		Product Level	Product name	Product category	Product unit	Data format
FTS		L1A	FTS L1A data	Internal	FTS scene	HDF5
			FTS L1A calibration data	Internal	FTS scene	
			FTS L1A lunar calibration data	Internal	FTS scene	
		L1B	FTS L1B data	Standard	FTS scene	
			FTS L1B calibration data	Internal	FTS scene	
			FTS L1B lunar calibration data	Internal	FTS scene	
	SWIR	L2	L2 CO_2 column amount (SWIR)	Standard	Option (on demand)	
			L2 CH_4 column amount (SWIR)	Standard		
			L2 H_2O column amount (SWIR)	Research		
	TIR		L2 CO_2 profile (TIR)	Standard		
			L2 CH_4 profile (TIR)	Standard		
			L2 CO_2 column amount (TIR)	Research		
			L2 CH_4 column amount (TIR)	Research		
			L2 temperature profile (TIR)	Research		
			L2 H_2O profile (TIR)	Research		
			L2 H_2O column amount (TIR)	Research		
	SWIR	L3	L3 global CO_2 distribution (SWIR)	Standard	Globe (monthly average)	
			L3 global CH_4 distribution (SWIR)	Standard		
	TIR		L3 global CO_2 distribution (TIR)	Standard		
			L3 global CH_4 distribution (TIR)	Standard		
CAI		L1A	CAI L1A data	Internal	CAI scene	
			CAI L1A calibration data	Internal	CAI scene	
			CAI L1A lunar calibration data	Internal	CAI scene	
		L1B	CAI L1B data	Standard	CAI frame	
		L1B+	CAI L1B+ data	Standard		
		L2	L2 cloud flag	Standard		
			L2 cloud property	Research		
			L2 aerosol property	Research		
		L3	L3 global radiance distribution	Standard	Globe (every 3 days)	
			L3 global reflectance distribution (clear sky)	Standard		
			L3 global cloud property	Research	Globe (monthly average)	
			L3 global aerosol property	Research		
			L3 global NDVI	Standard	Rectangle (latitude 30° Ч longitude 60°) (every 15 days)	
-		L4A	L4A global CO_2 flux	Standard	Global 64 regions (annually)	Text / Net CDF
			L4A global CH_4 flux	Research		
-		L4B	L4B global CO_2 distribution	Standard	Global 2.5°Ч2.5°mesh (monthly)	Net CDF
			L4B global CH_4 distribution	Research		

Carbon dioxide (CO2)

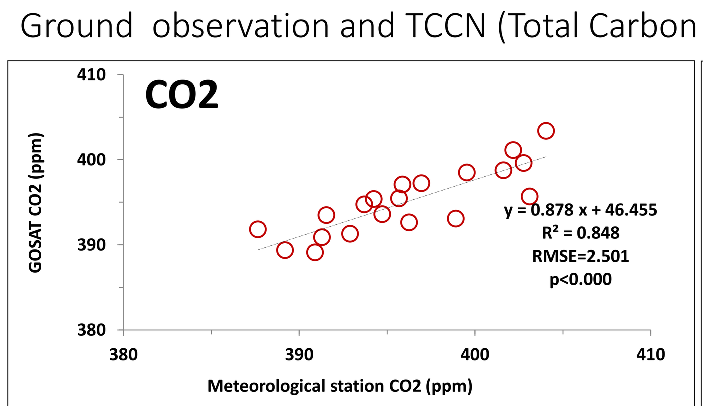


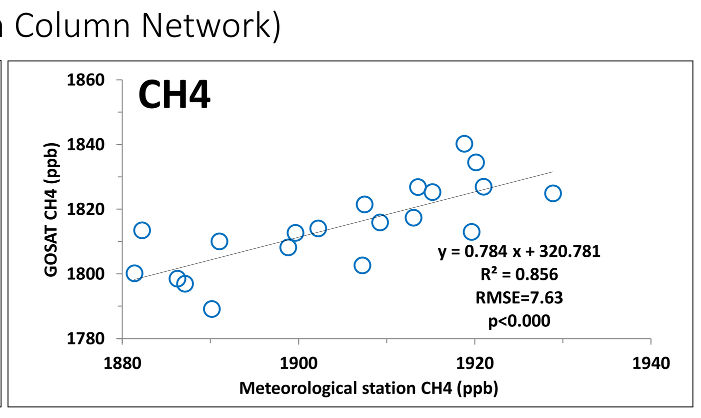
Methane (CH4)



GOSAT data validation of CO2 and CH4

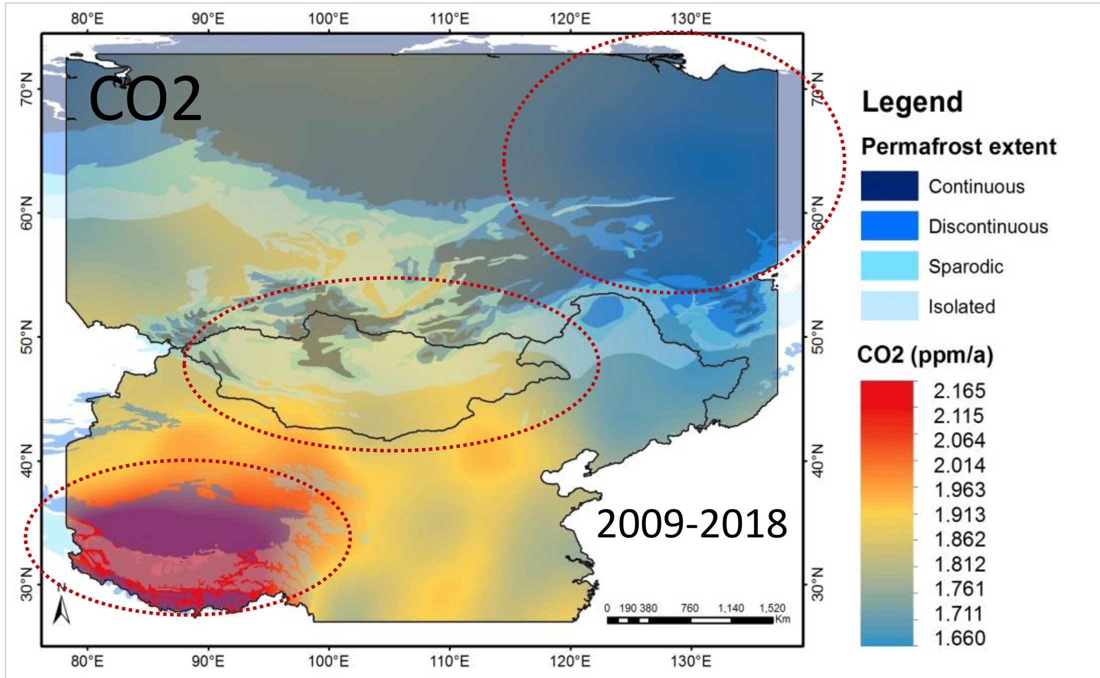
Ground observation and TCCN (Total Carbon Column Network)

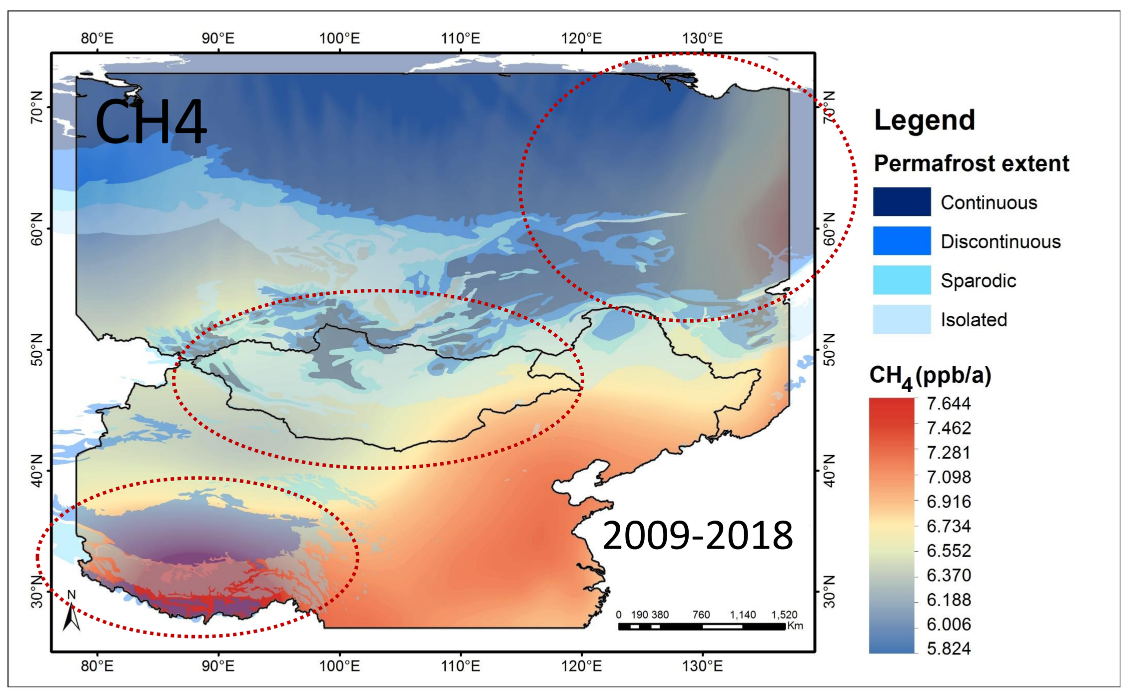




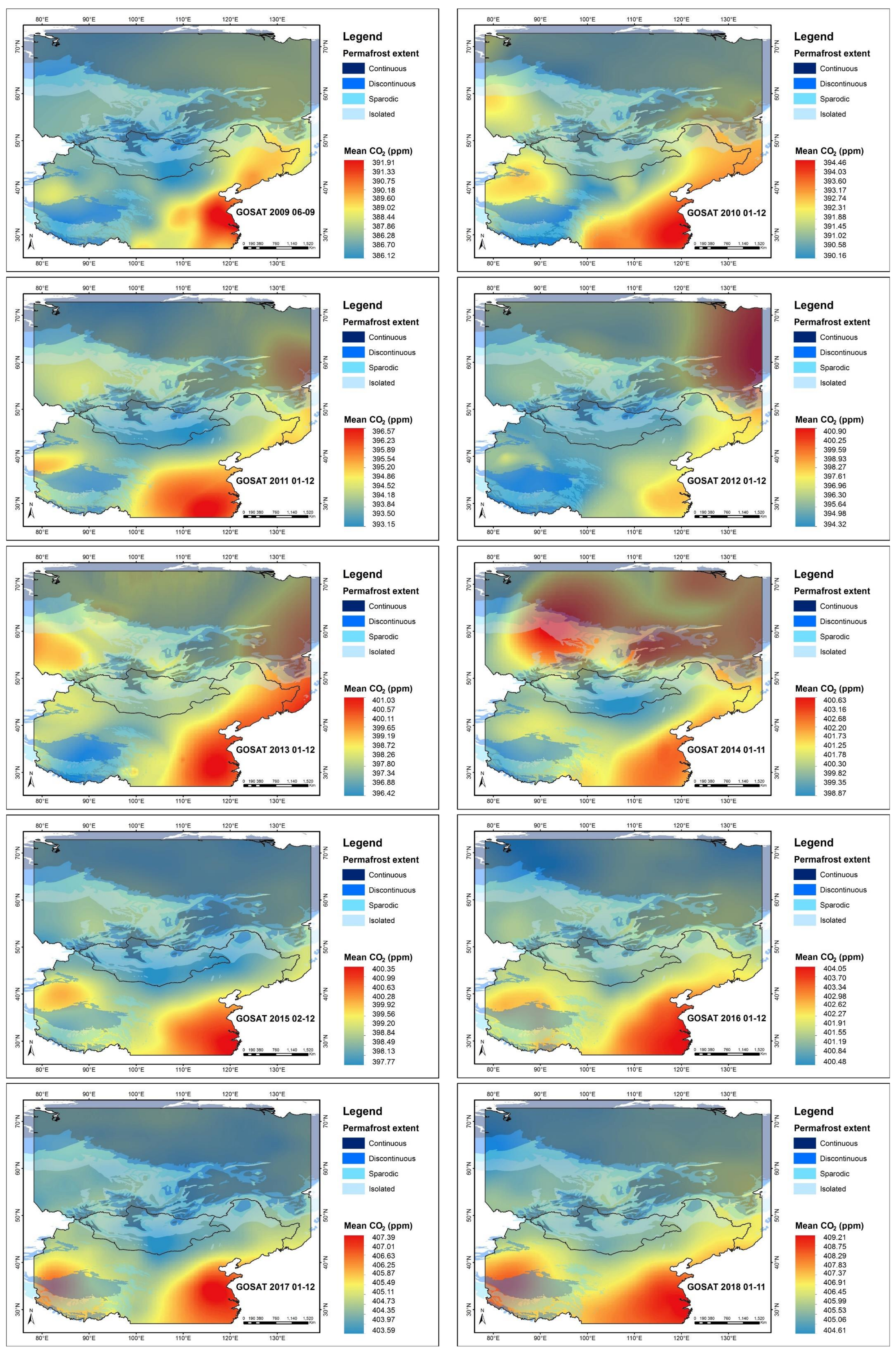
RESULTS AND DISCUSSION

Greenhouse gases emissions from thawing permafrost regions in central Asia

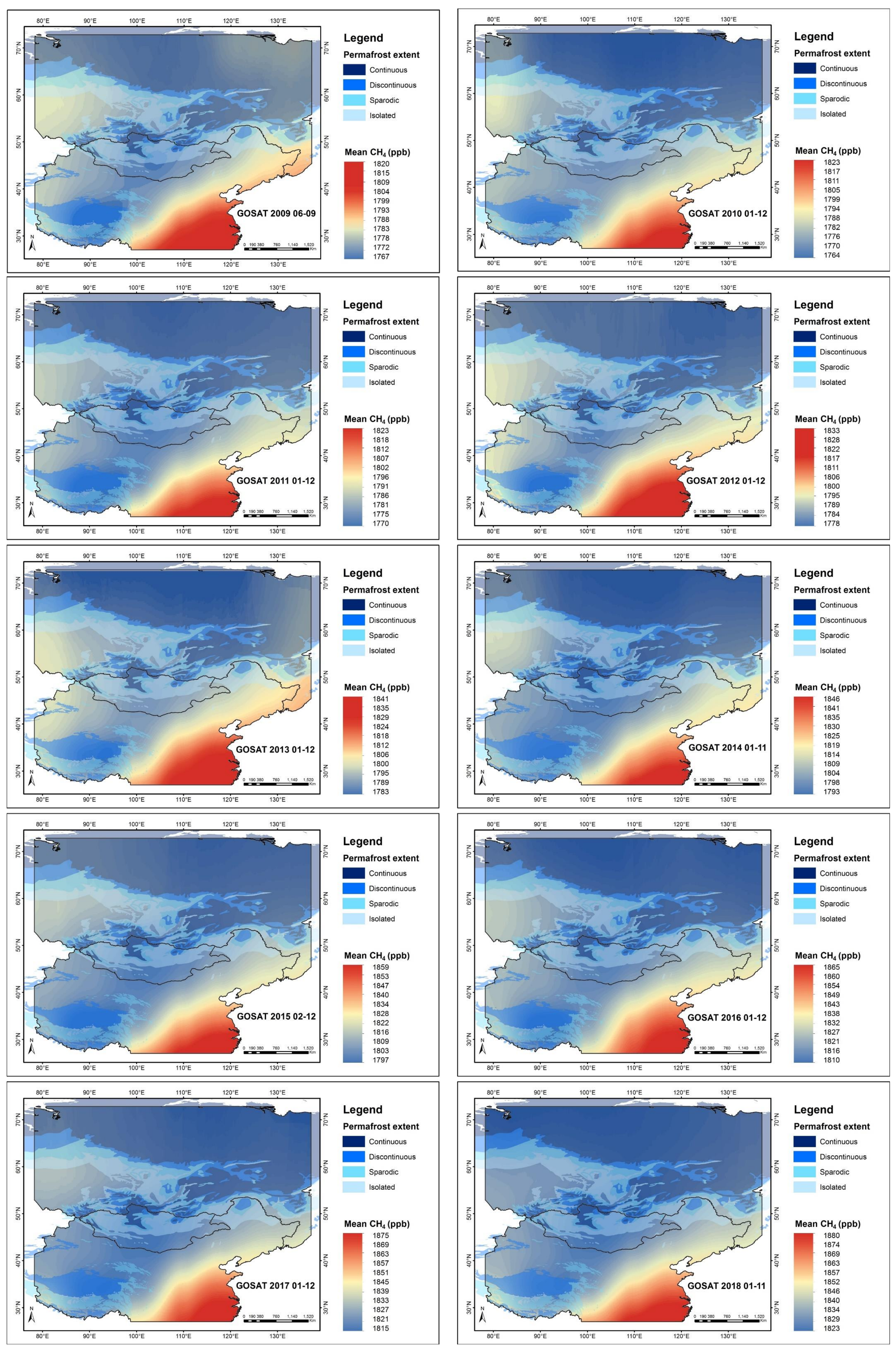




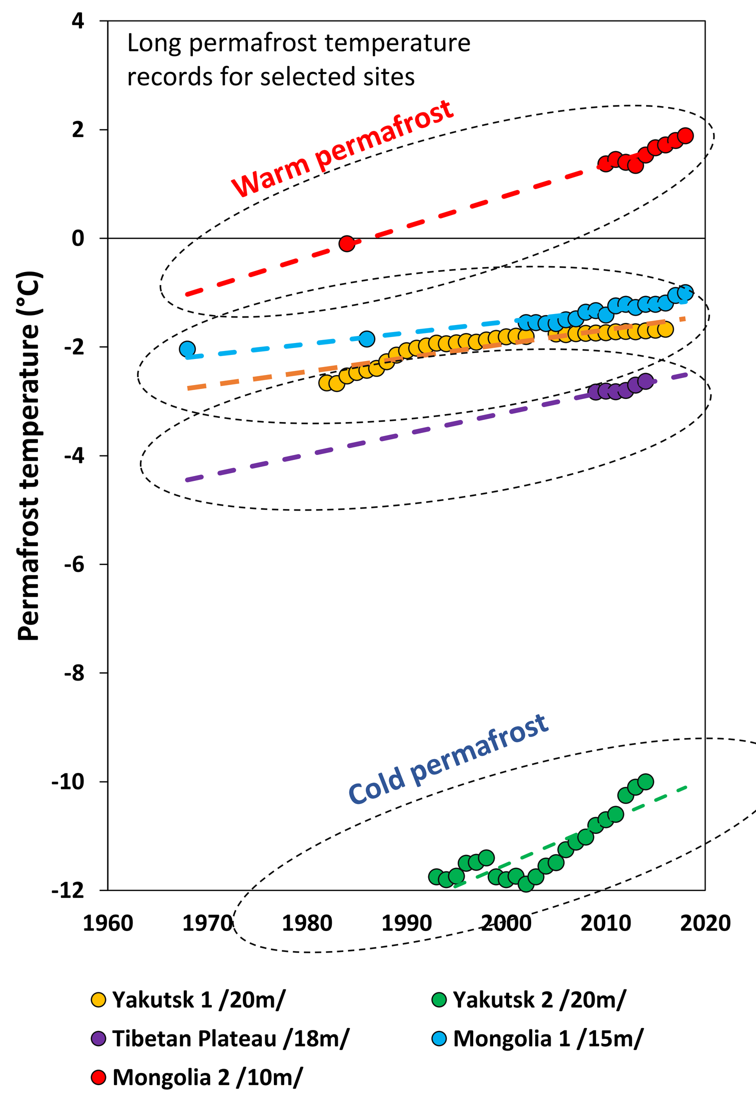
CO2 emissions from 2009 to 2018

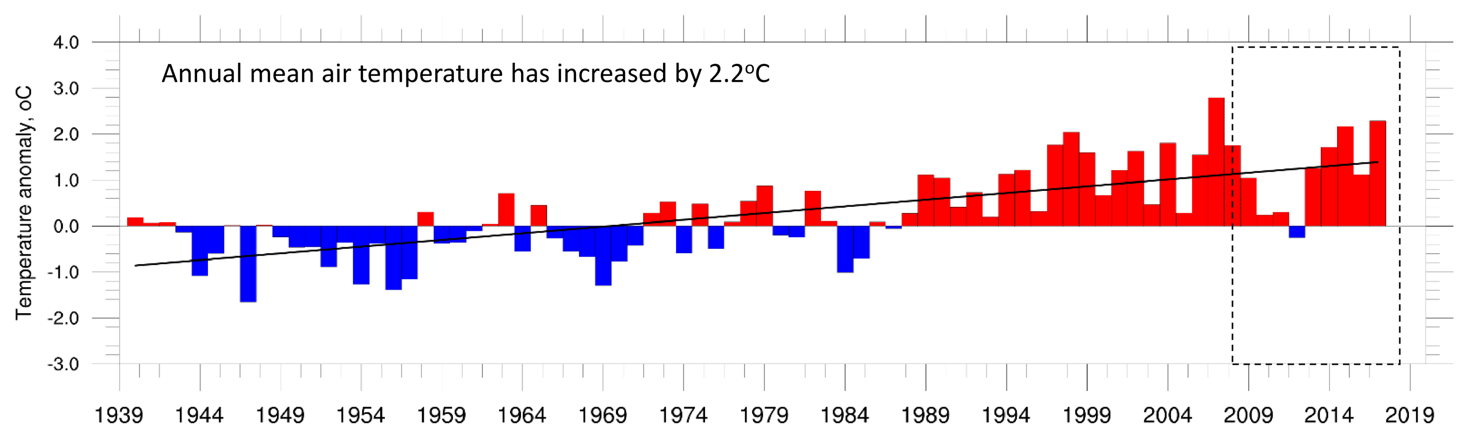


CH4 emissions from 2009 to 2018



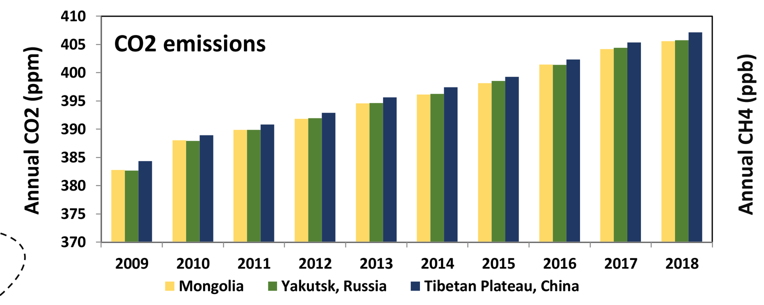
Permafrost & air temperature changes in Mongolia, Yakutsk, and Tibetan Plateau

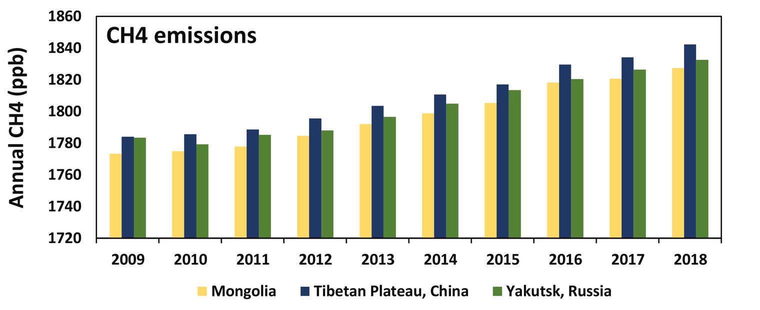




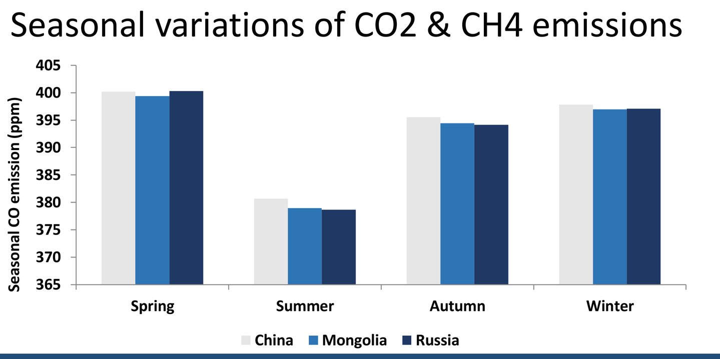
Data sources: Jambaljav 2017, Boris et al., 2018

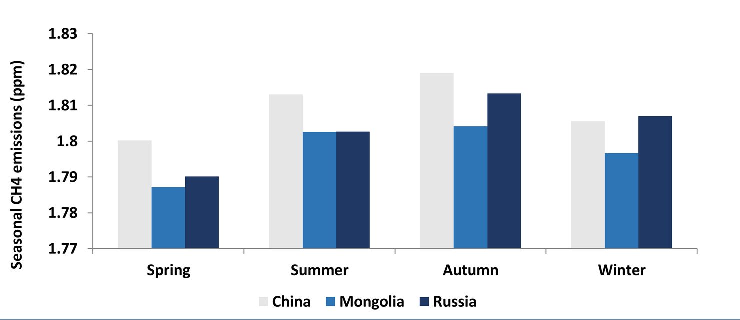
Annual mean CO2 & CH4 emissions from thawing permafrost areas





Seasonal variations of CO2 & CH4 emissions





CONCLUSIONS

In recent decades, permafrost temperature has risen and annual surface thaw depths have increased in central Asia, indicating that the permafrost active layer has begun to thaw. When permafrost thaws, the organic matter is exposed to microbes which can then breakdown carbon based organic matter, thereby releasing the trapped organic CO2 and CH4 into the atmosphere.

- The annual CO2 emissions has increased gradually between 383 ppm and 407 ppm from thawing permafrost regions in central Asia during the last 10 years, with the highest value being in spring and the lowest in summer and autumn. The annual CH4 emissions raised significantly from 1780 ppb to 1834 ppb which are high in Tibetan Platea in China and low in Mongolia between 2009 and 2018, while seasonal variations of CH4 emissions similar results with CO2 trend.
- The CO2 and CH4 emissions from thawing permafrost in central Asia have an annual increasing trend both. The annual mean rate of increase is CO2 (2.417 ppm/a) and CH4 (6.904 ppb/a).
- This research have addressed gap in our understanding of the efforts of GHG emissions from thawing permafrost regions in these key areas, and it is very important to improve datasets for regional and national GHG inventories.