

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

Adiya Saruulzaya*, Dalantai Sainbayar*, Sumiya Erdenesukh**

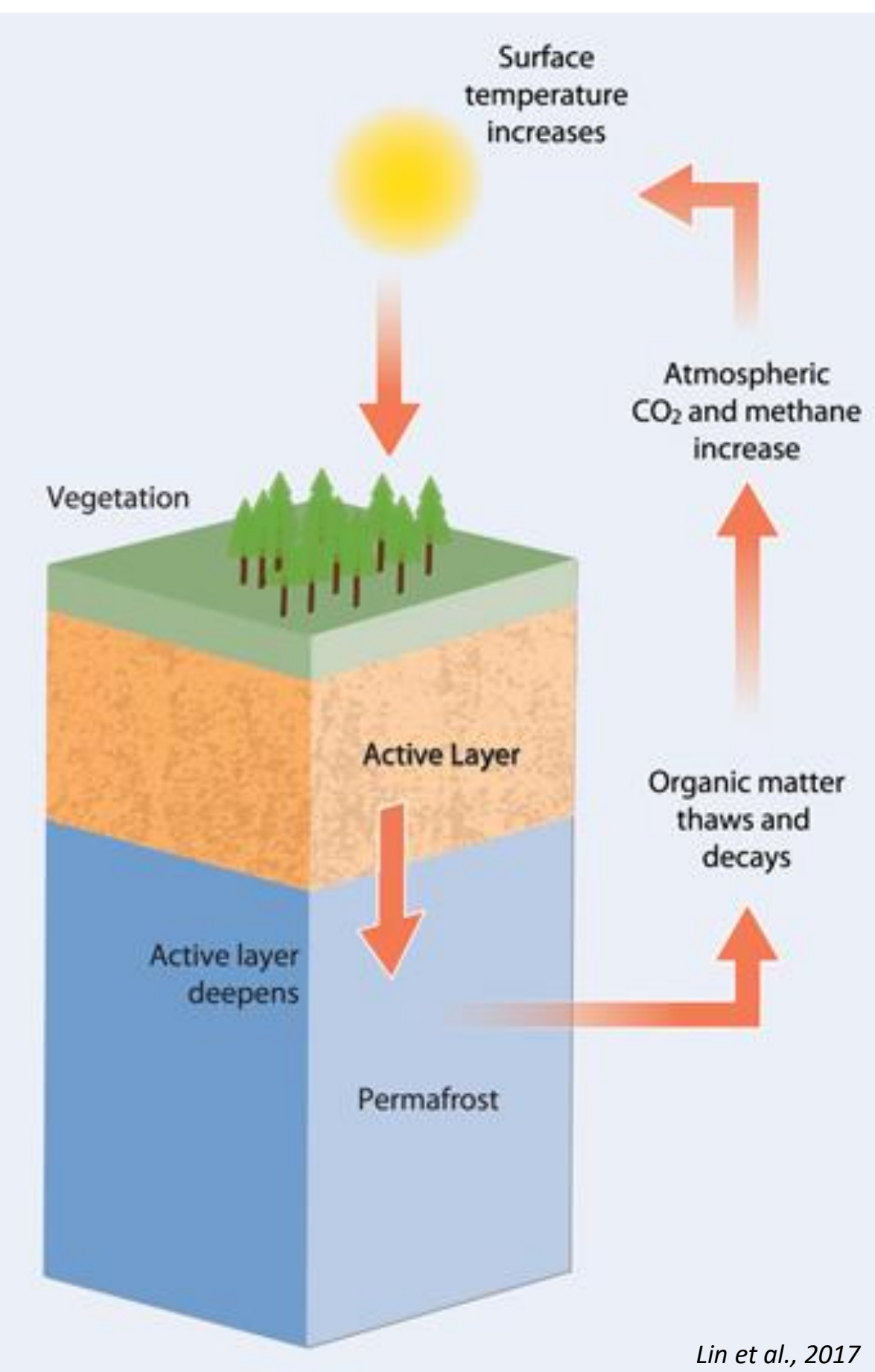
*Institute of Geography and Geoecology, Mongolian Academy of Sciences

**National University of Mongolia

saruulzaya@mas.ac.mn



INTRODUCTION

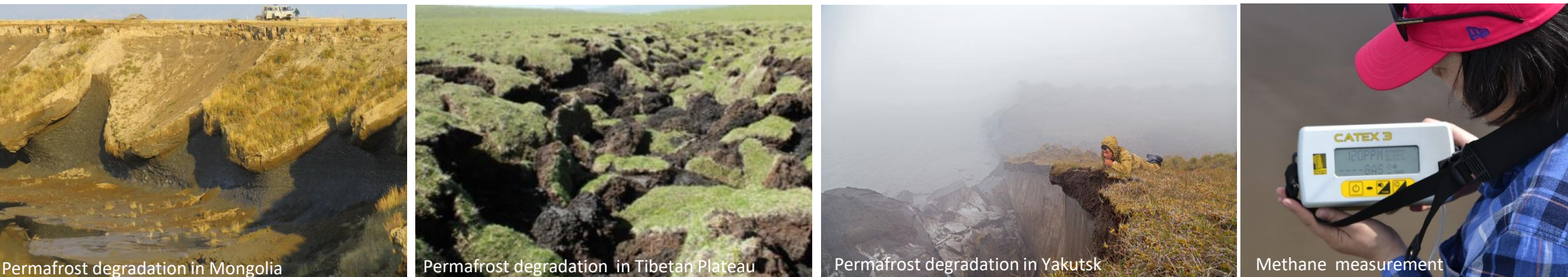
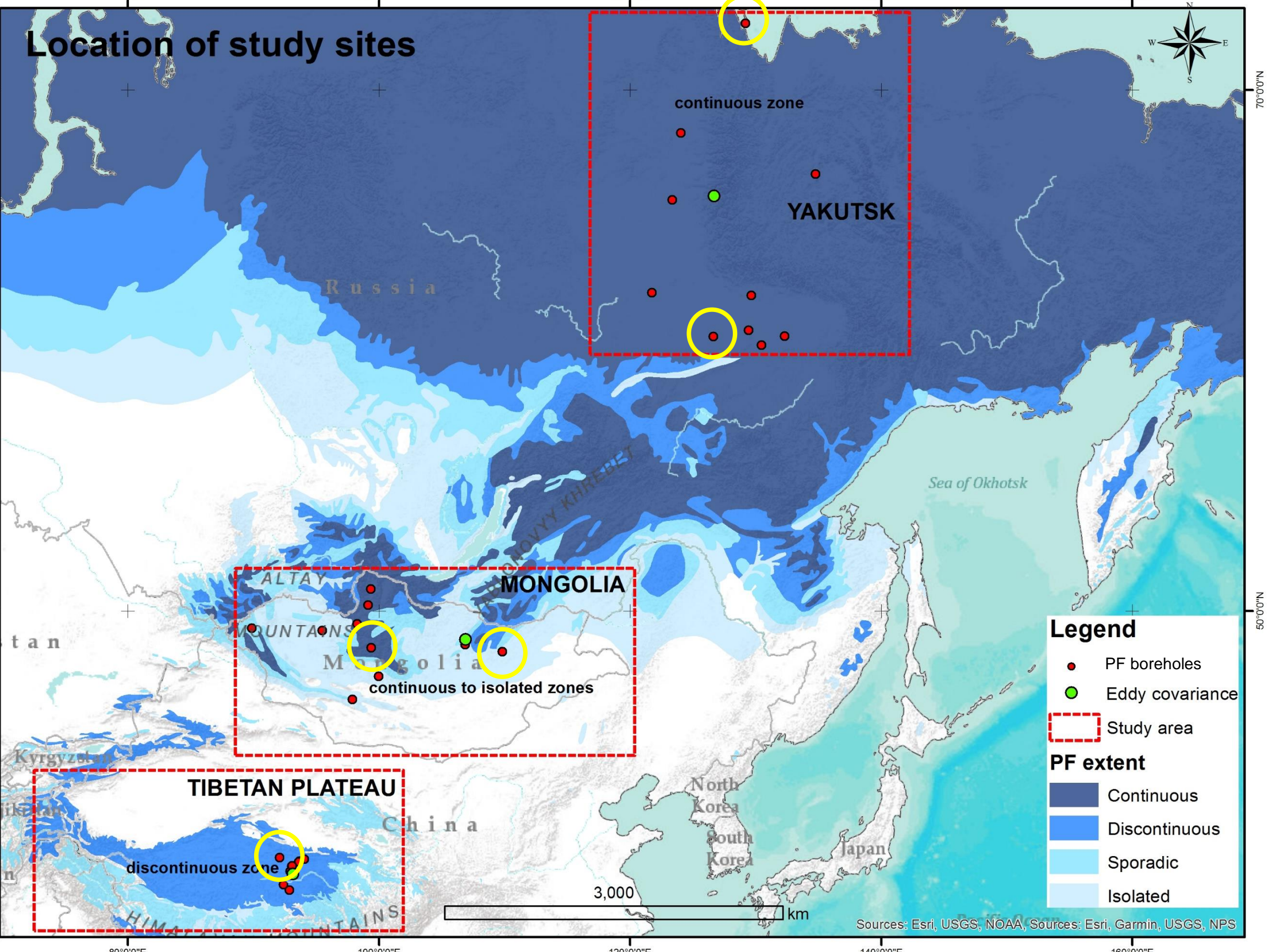


Permafrost of high latitude ecosystems contains an estimated 1700 Gt of carbon dioxide (CO₂) and methane (CH₄), which is almost twice as much greenhouse gas (GHG) as is currently contained in the atmosphere [IPCC, 2018]. Under climate warming, central Asian permafrost regions should not be neglected 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.

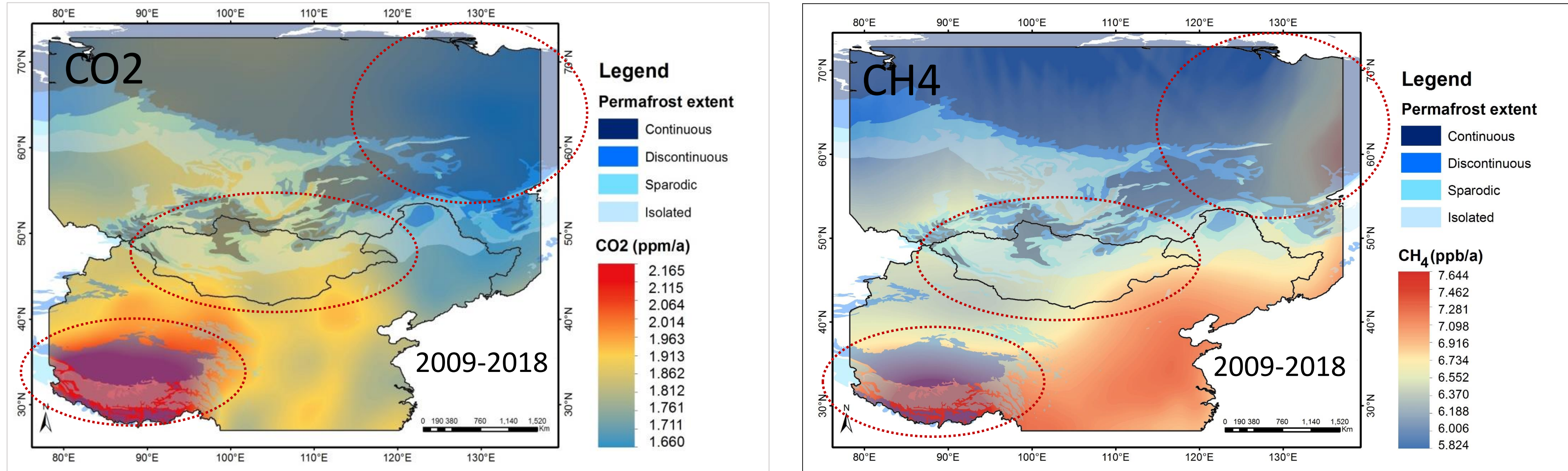
STUDY AREA

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.

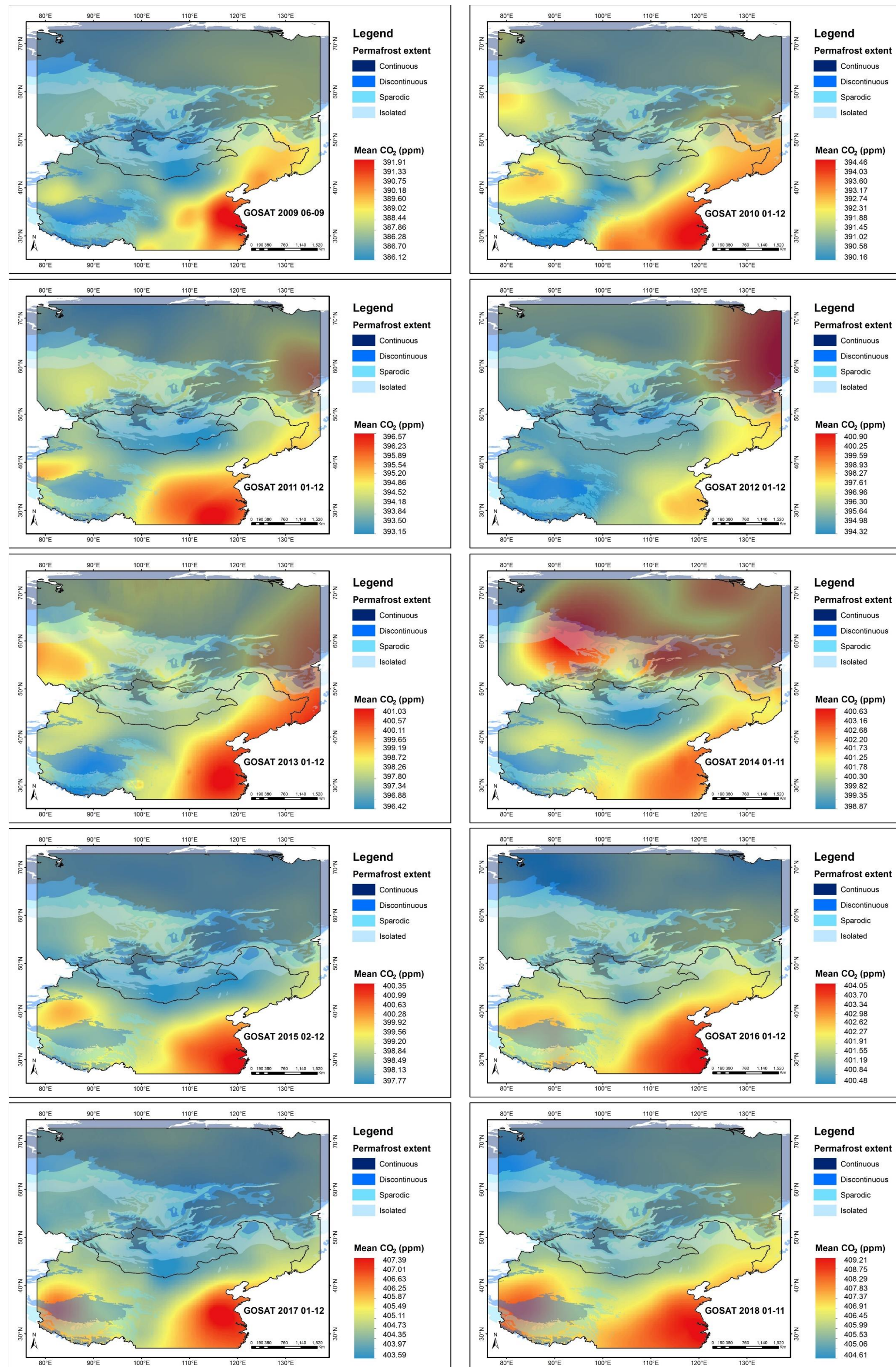


RESULTS AND DISCUSSION

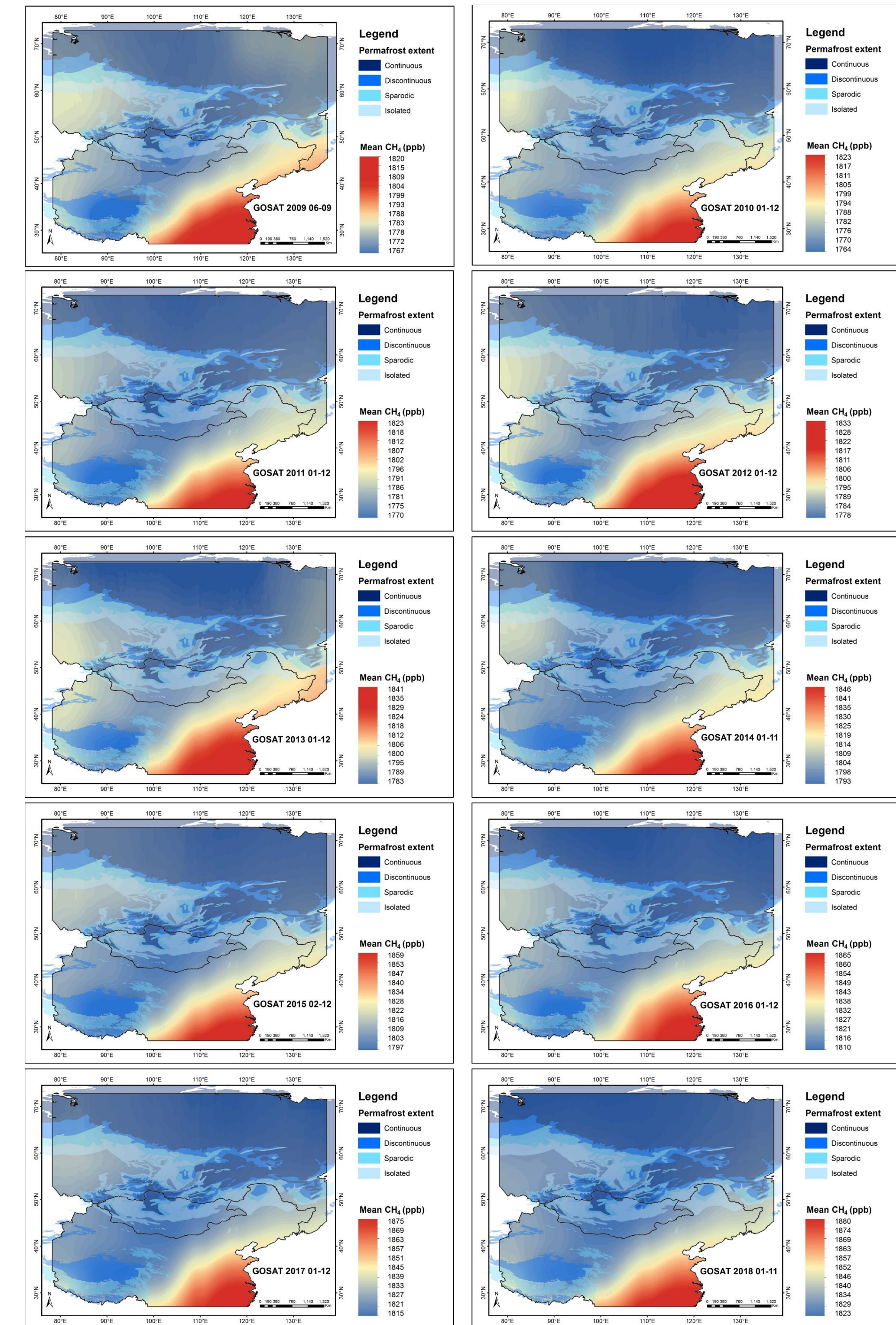
Greenhouse gases emissions from thawing permafrost regions in central Asia



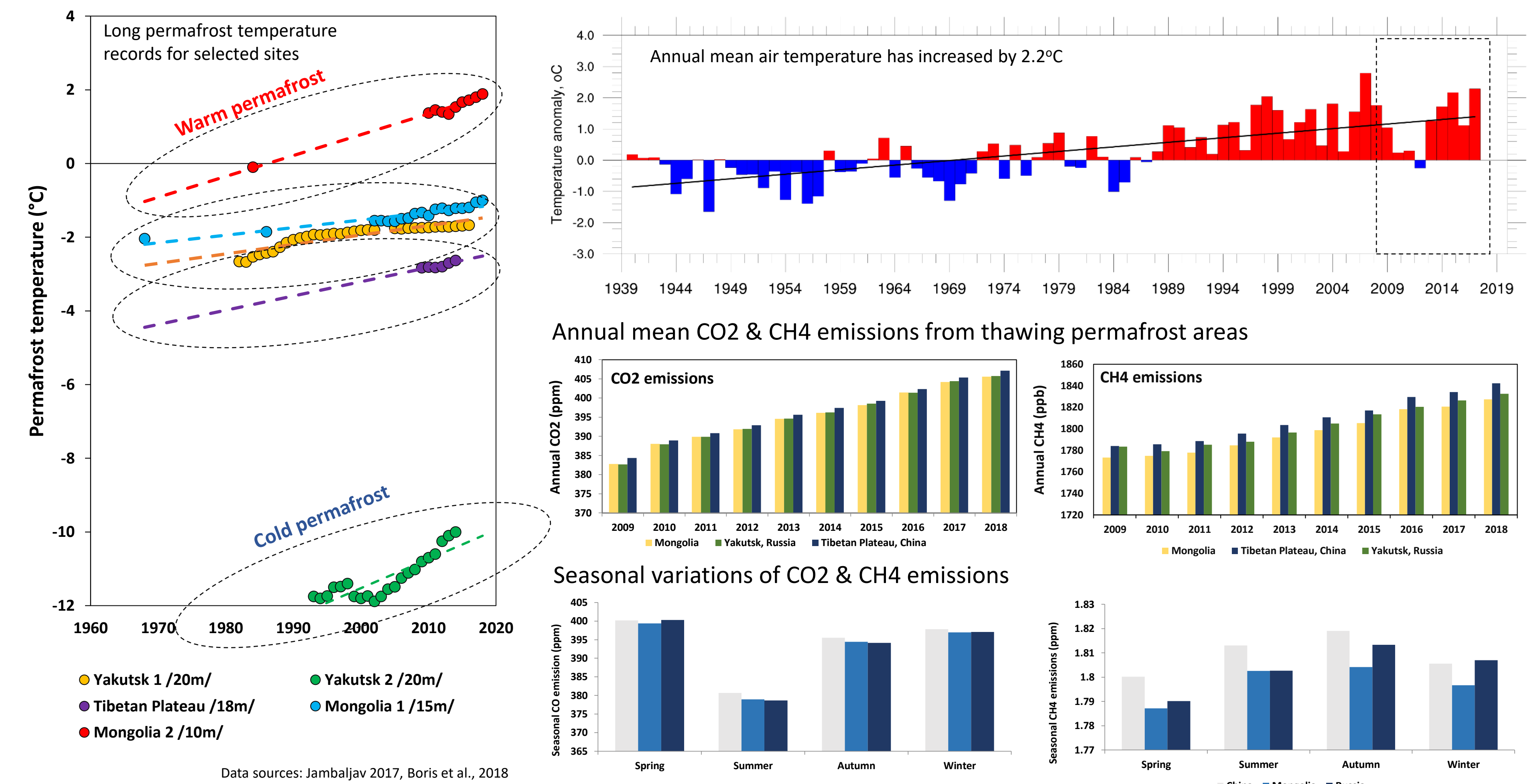
CO2 emissions from 2009 to 2018



CH4 emissions from 2009 to 2018



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



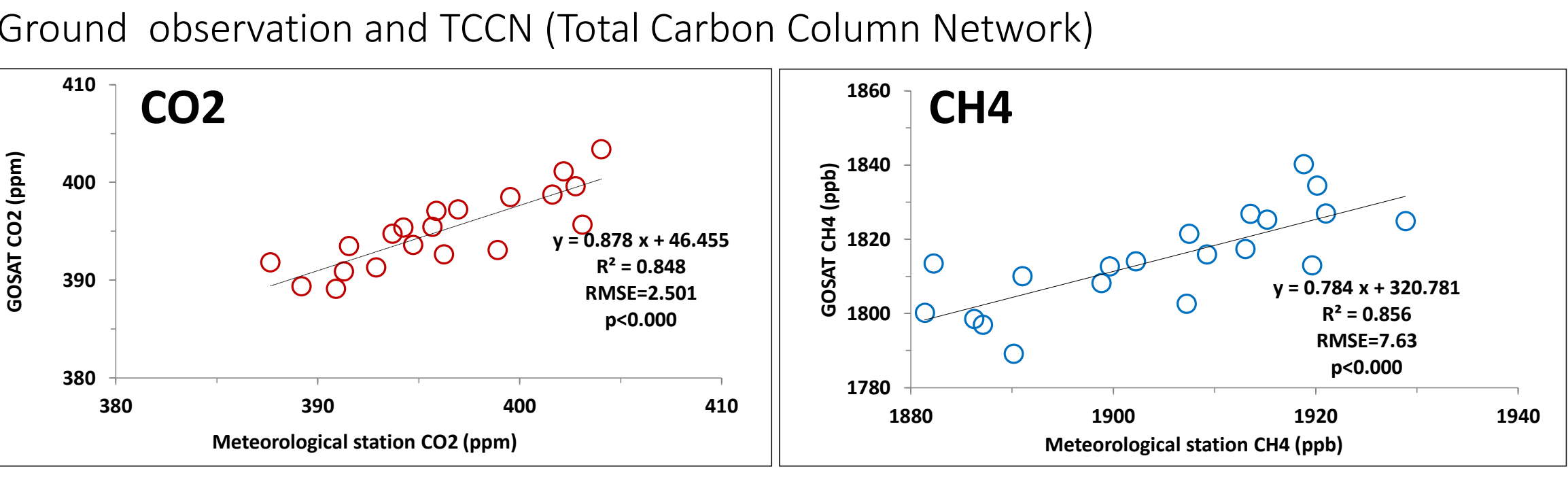
METHOD AND DATASETS

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

Product Band	Product Level	Product name	Product category	Product unit	Data format
FTS	L1A	FTS L1A data	Internal	FTS scene	NetCDF
	L1A	FTS L1A calibration data	Internal	FTS scene	NetCDF
	L1B	FTS L1B calibration data	Internal	FTS scene	NetCDF
	L1B	FTS L1B solar calibration data	Internal	FTS scene	NetCDF
	L1B	FTS L1B solar calibration data	Internal	FTS scene	NetCDF
	L1B	FTS L1B solar calibration data	Internal	FTS scene	NetCDF
	L1B	FTS L1B solar calibration data	Internal	FTS scene	NetCDF
	L1B	FTS L1B solar calibration data	Internal	FTS scene	NetCDF
	L1B	FTS L1B solar calibration data	Internal	FTS scene	NetCDF
	L1B	FTS L1B solar calibration data	Internal	FTS scene	NetCDF
SWIR	L2	L2 CO ₂ column amount (CO ₂)	Standard	CO ₂ column amount (ppm)	NetCDF
	L2	L2 CH ₄ column amount (CH ₄)	Standard	CH ₄ column amount (ppb)	NetCDF
	L2	L2 CO ₂ profile (TR)	Standard	CO ₂ profile (ppm)	NetCDF
	L2	L2 CH ₄ profile (TR)	Standard	CH ₄ profile (ppb)	NetCDF
	L2	L2 CO ₂ column amount (CO ₂)	Standard	CO ₂ column amount (ppm)	NetCDF
	L2	L2 CH ₄ column amount (CH ₄)	Standard	CH ₄ column amount (ppb)	NetCDF
	L2	L2 CO ₂ profile (TR)	Standard	CO ₂ profile (ppm)	NetCDF
	L2	L2 CH ₄ profile (TR)	Standard	CH ₄ profile (ppb)	NetCDF
	L2	L2 CO ₂ column amount (CO ₂)	Standard	CO ₂ column amount (ppm)	NetCDF
	L2	L2 CH ₄ column amount (CH ₄)	Standard	CH ₄ column amount (ppb)	NetCDF
CAI	L1	L1 global CO ₂ distribution (TR)	Standard	CO ₂ distribution (ppm)	NetCDF
	L1	L1 global CH ₄ distribution (TR)	Standard	CH ₄ distribution (ppb)	NetCDF
	L1	L1 global CO ₂ distribution (TR)	Standard	CO ₂ distribution (ppm)	NetCDF
	L1	L1 global CH ₄ distribution (TR)	Standard	CH ₄ distribution (ppb)	NetCDF
	L1	L1 global CO ₂ distribution (TR)	Standard	CO ₂ distribution (ppm)	NetCDF
	L1	L1 global CH ₄ distribution (TR)	Standard	CH ₄ distribution (ppb)	NetCDF
	L1	L1 global CO ₂ distribution (TR)	Standard	CO ₂ distribution (ppm)	NetCDF
	L1	L1 global CH ₄ distribution (TR)	Standard	CH ₄ distribution (ppb)	NetCDF
	L1	L1 global CO ₂ distribution (TR)	Standard	CO ₂ distribution (ppm)	NetCDF
	L1	L1 global CH ₄ distribution (TR)	Standard	CH ₄ distribution (ppb)	NetCDF

GOSAT data validation of CO2 and CH4



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 Plateau 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.