



A Case Study on Estimation of Soil NO_x Emissions in North China Derived from Satellite Observations

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Introduction

Nitrogen oxides (NO_x=NO+NO₂), as short-lived reactive gases, serve as crucial precursors for greenhouse gases - ozone (O₃) and fine particulate matter (PM_{2.5}). In recent years, as the emission reduction strategies of various countries and organizations have been gradually implemented and achieved results, anthropogenic nitrogen oxide emissions have steadily decreased, and the relative contribution of soil NO_x emissions, as one of the natural emission sources, is gradually increasing. Based on the NO_x observation data of the Tropospheric Monitoring Instrument (TROPOMI) of the Sentinel-5P satellite, this study used the inverse algorithm DECSO (Daily Emission estimation Constrained by Satellite Observations) and combined with the gridding method (considering land use type and climate factors) to estimate the spatial distribution and monthly/annual total soil NO_x emissions in North China (2019).

TROPOMI

Soil NO_x Emission

Satellite Retrieval

Purpose

- This study estimates soil NO_x emissions through satellite data to compensate for the shortcomings of traditional empirical models or ground observations.
- Separating soil emissions from total NO_x emissions avoids misattributing natural emissions to human activities, thereby more accurately evaluating the effectiveness of emission reduction policies.
- By separating soil NO_x, fossil fuel-related CO₂ emissions can be more accurately estimated (because NO_x and CO₂ are often released from the same source), which helps carbon accounting and climate policymaking.

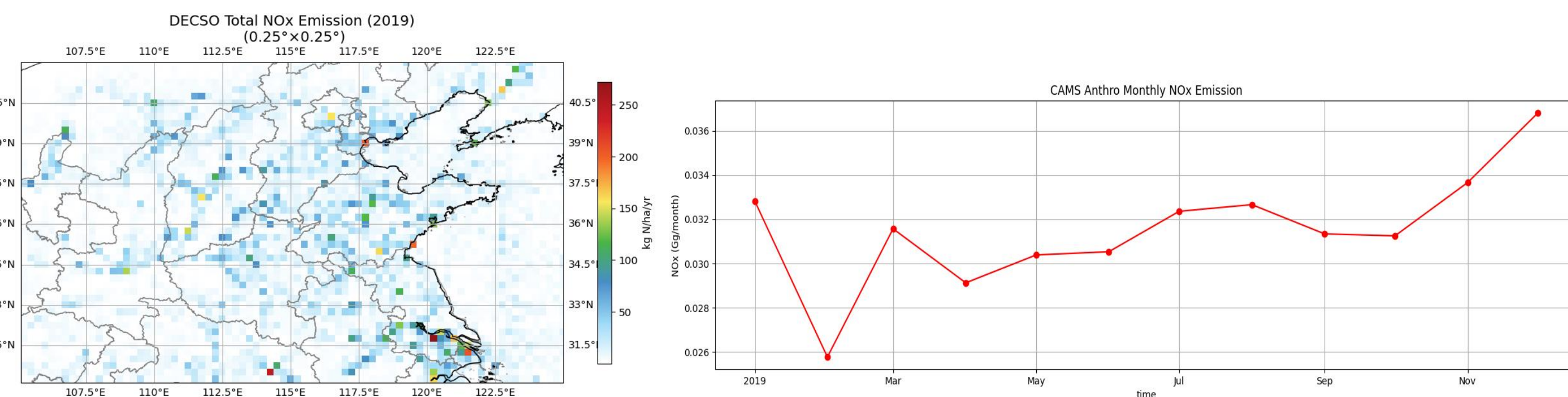
Study Area and Data

● DECSO Total NO_x Emissions Data

In this study, monthly NO_x emissions in 2019 over North China (105 - 125°E, 30 - 42°N) are derived from TROPOMI NO₂ observations using DECSO (Daily Emission Estimation Constrained by Satellite Observations) on a spatial resolution of 0.25° × 0.25°.

● CAMS Anthropogenic NO_x Emissions Data (version 6.2)

CAMS-GLOB-ANT, the inventory provides monthly average global emissions of 36 compounds including NO_x, with a spatial resolution of 0.1°×0.1° in longitude and latitude, covering 17 emission sectors.

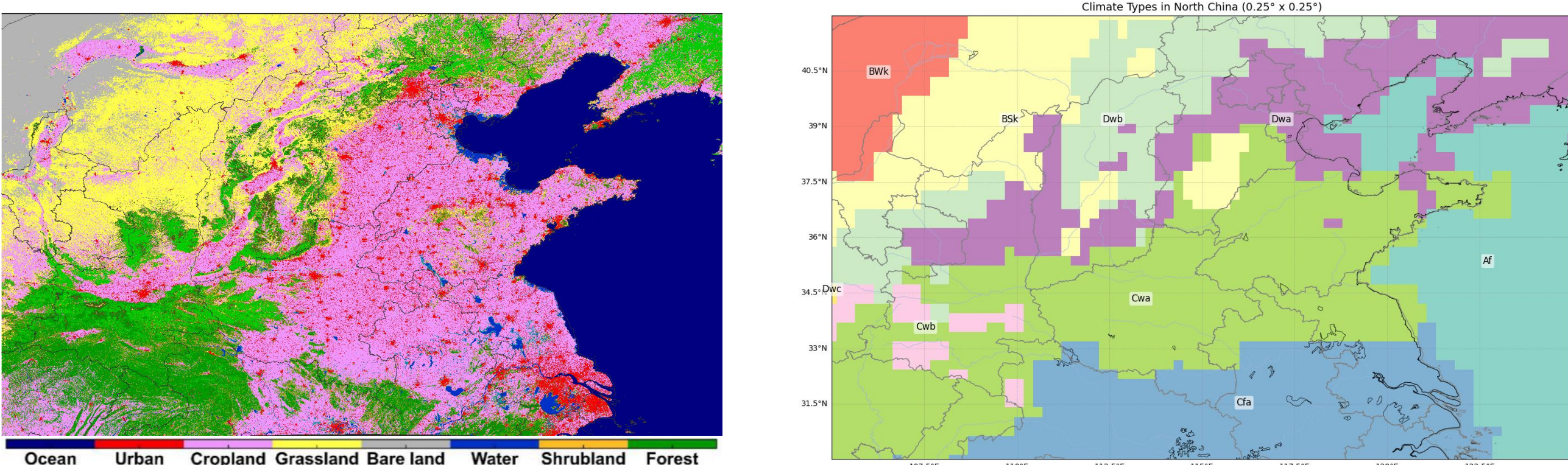


● Land Use/Land Cover (LULC) Data

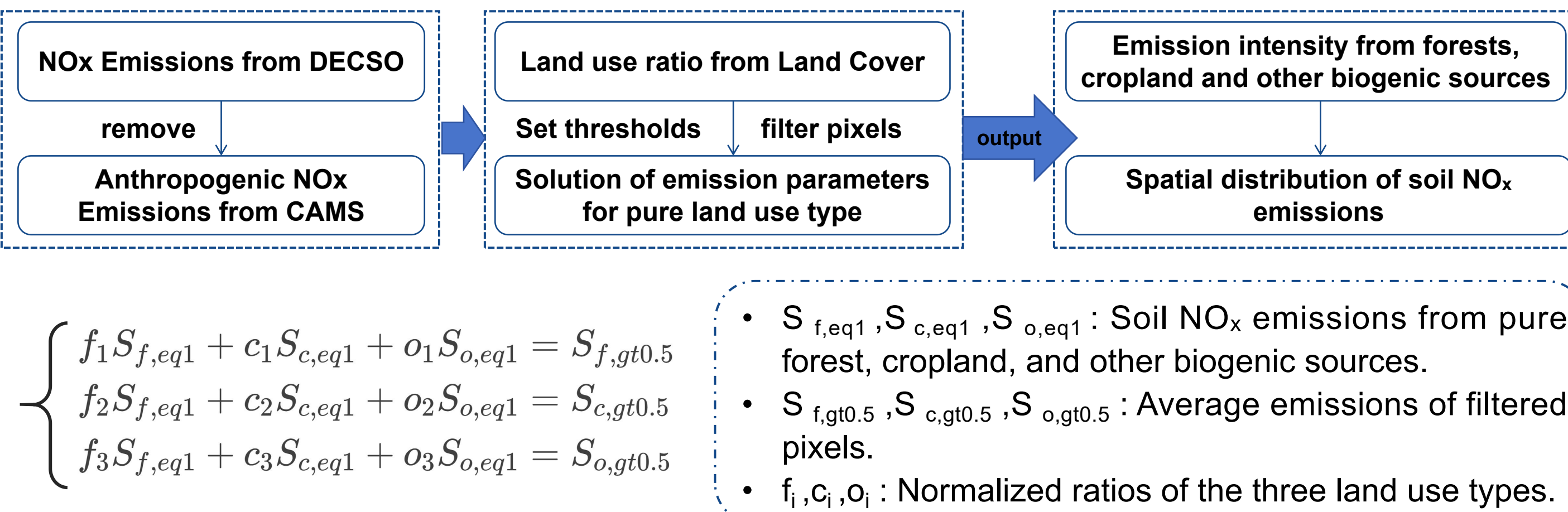
The grid was regridded to 0.25°(original resolution was 100 m) and the land cover fraction was calculated for each grid cell.

● Climate Classification Data

Region 1 is a temperate steppe climate, Region 2 a humid subtropical climate, Region 3 a temperate monsoon climate, and Region 4 a continental climate.



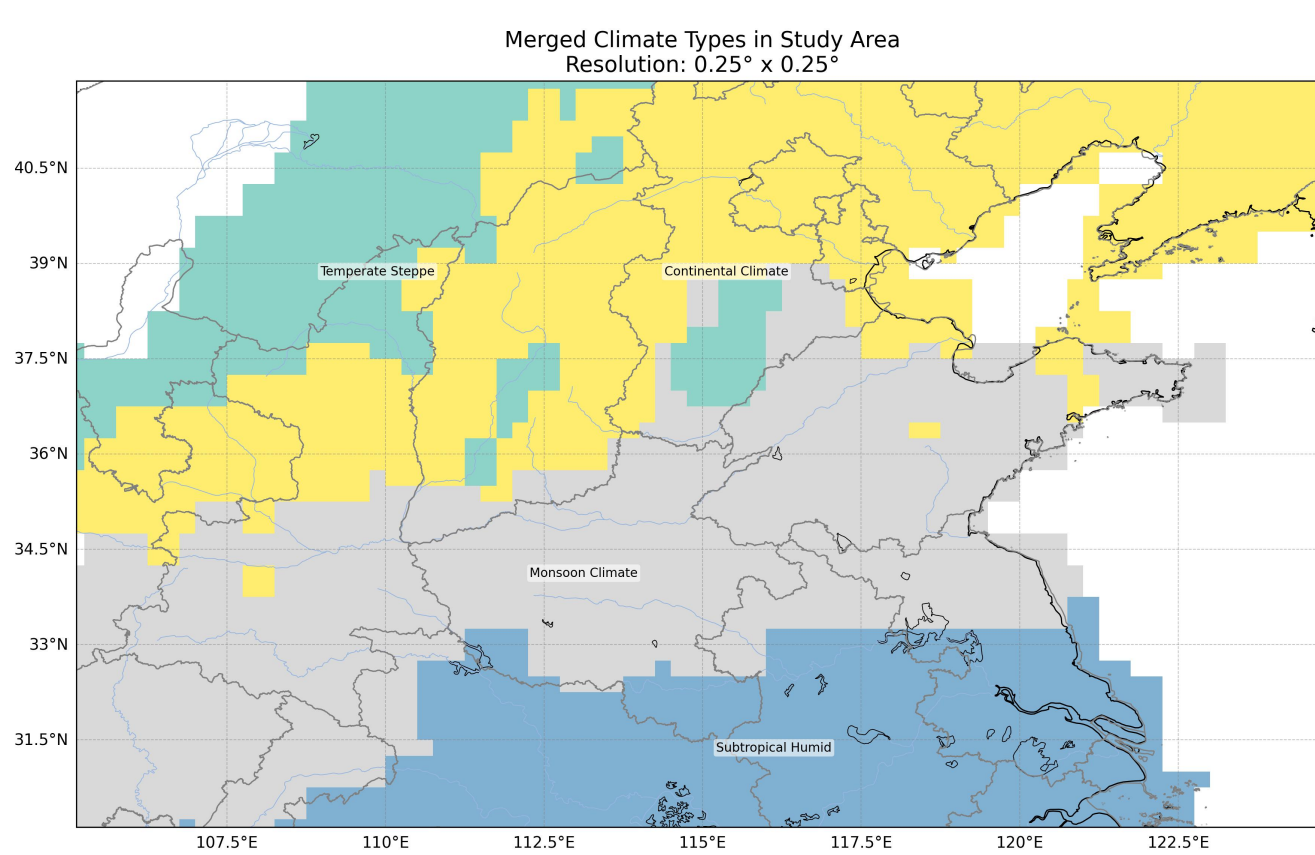
Methods



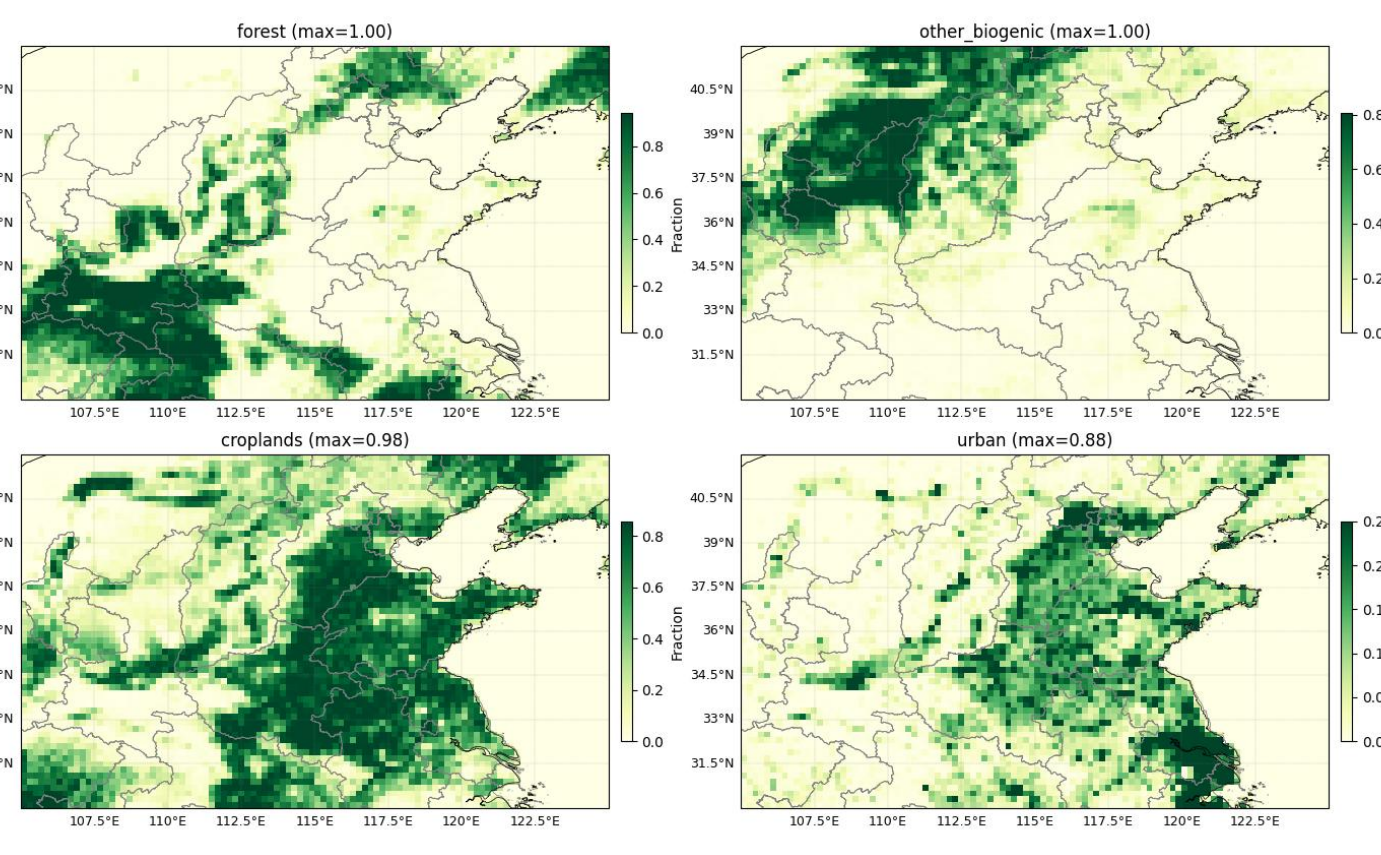
- $S_{f,eq1}, S_{c,eq1}, S_{o,eq1}$: Soil NO_x emissions from pure forest, cropland, and other biogenic sources.
- $S_{f,gt0.5}, S_{c,gt0.5}, S_{o,gt0.5}$: Average emissions of filtered pixels.
- f_i, c_i, o_i : Normalized ratios of the three land use types.

Results

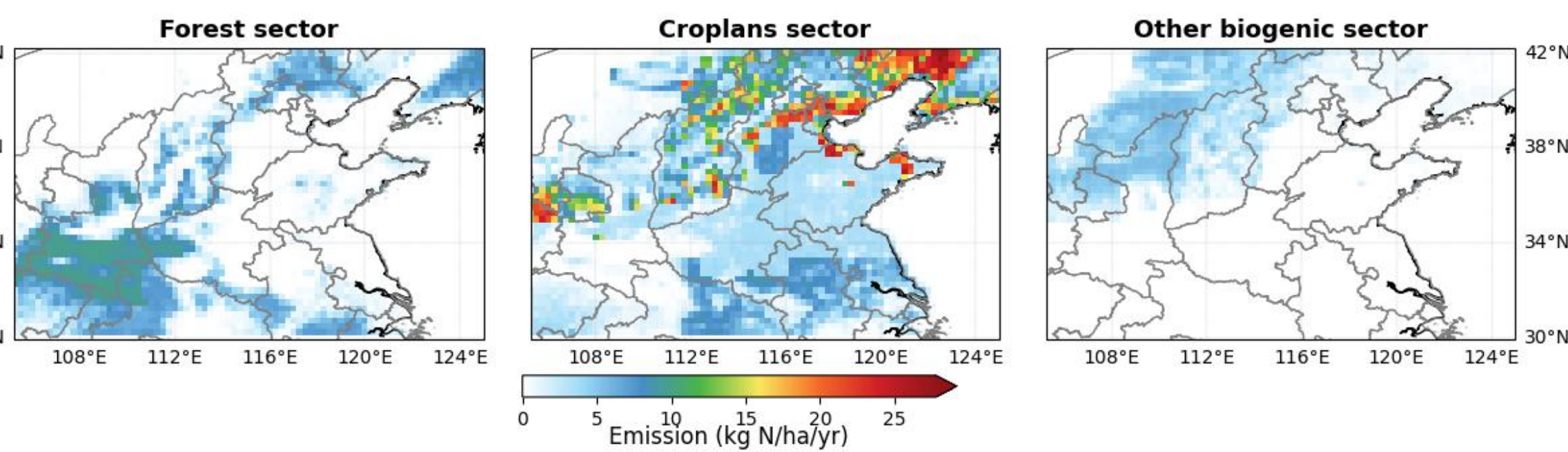
● The result of climate types



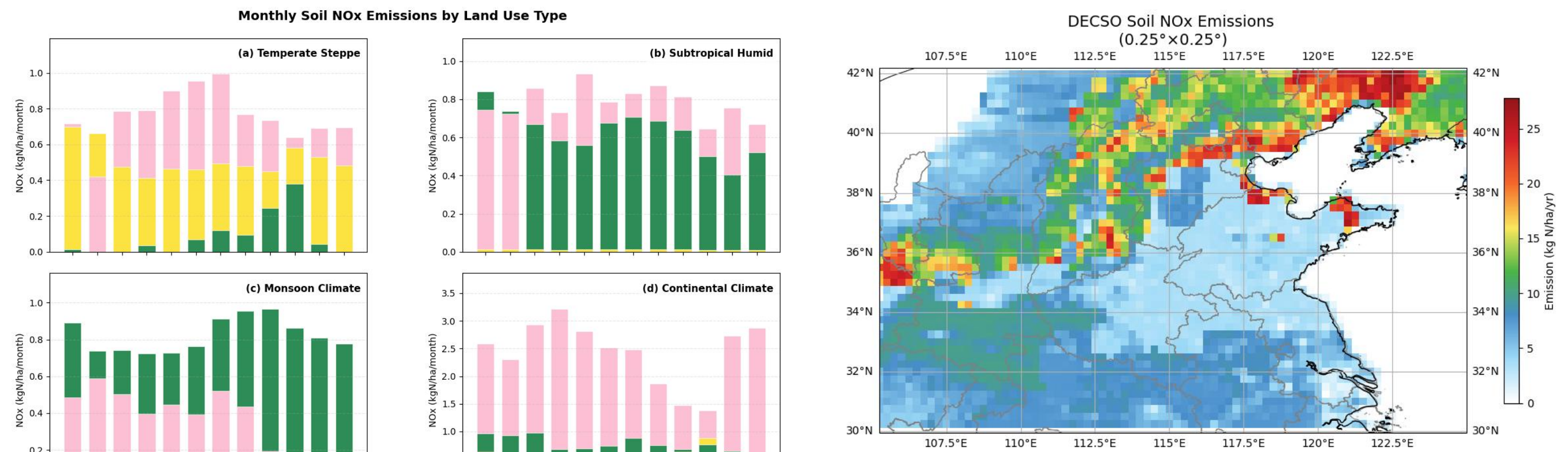
● The result of land use fraction



● The spatial distribution of the derived annual soil NO_x emissions from forest, croplands and other biogenic source



● Monthly soil NO_x emissions for each climate zone based on the land use



● The spatial distribution of annual DECSO - soil NO_x emissions

Conclusions

- The yearly averaged soil NO_x emissions for the entire domain from forests, croplands, and other biogenic sources are 1.02, 0.43, and 0.46 kg N ha⁻¹ yr⁻¹. The total annual soil NO_x emissions are 0.33 TgN yr⁻¹, which is similar to the estimates reported by Zhao et al. (0.3 TgN yr⁻¹ China; 2025).
- The monthly emissions in monsoon and continental climate zones are generally higher than those in temperate steppe and subtropical humid climate zones, which may be related to the seasonal changes in temperature and precipitation.
- The spatial distribution of soil emissions showed that emissions from farmland areas were underestimated. This may result from data resolution limits: threshold screening excludes mixed pixels containing small farmland plots and urban areas.

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