Satellite-based Monitoring of Methane Emissions from China's Rice Hub

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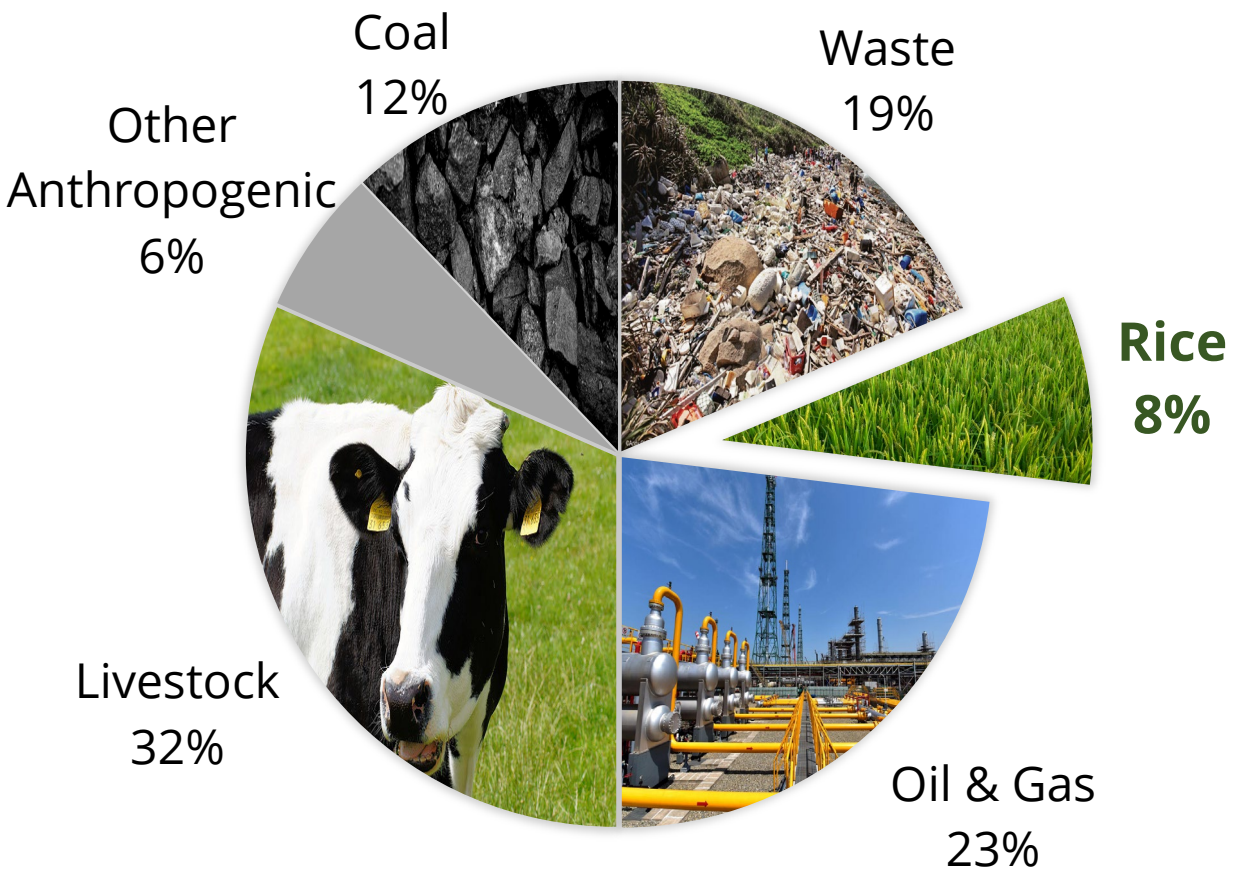
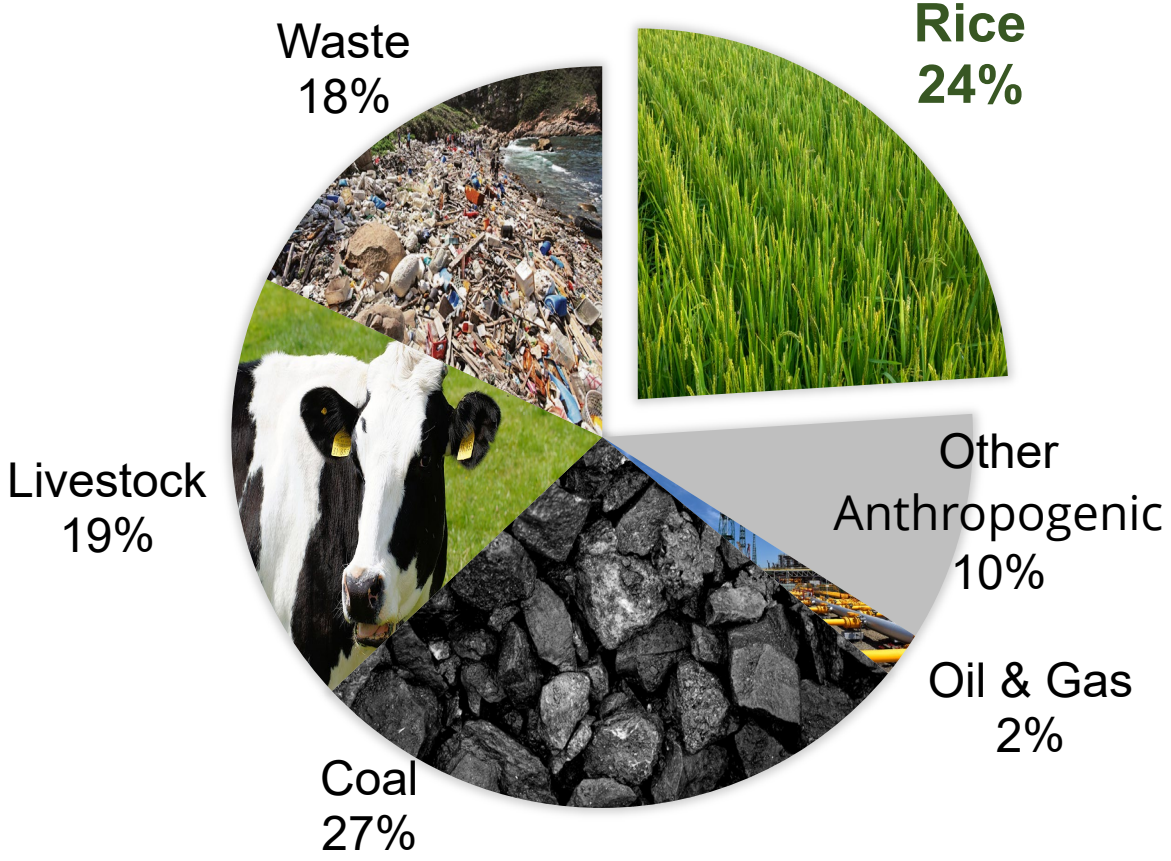
Rice is one of the dominant anthropogenic methane sources

Global

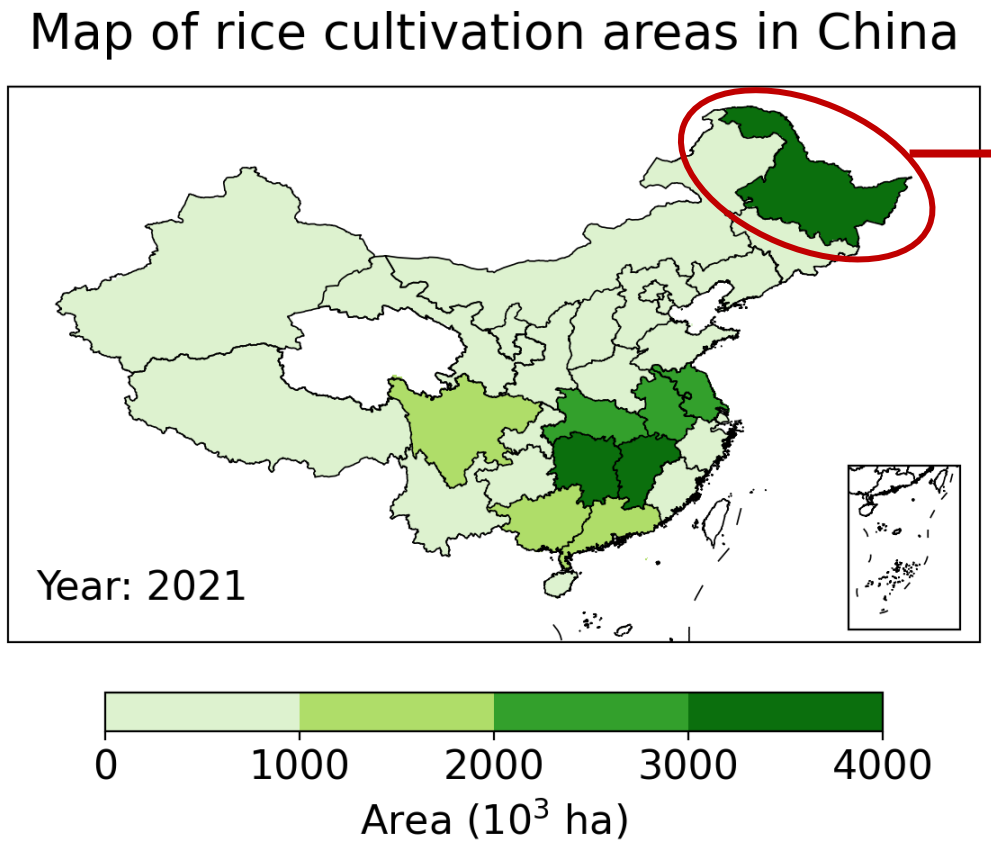


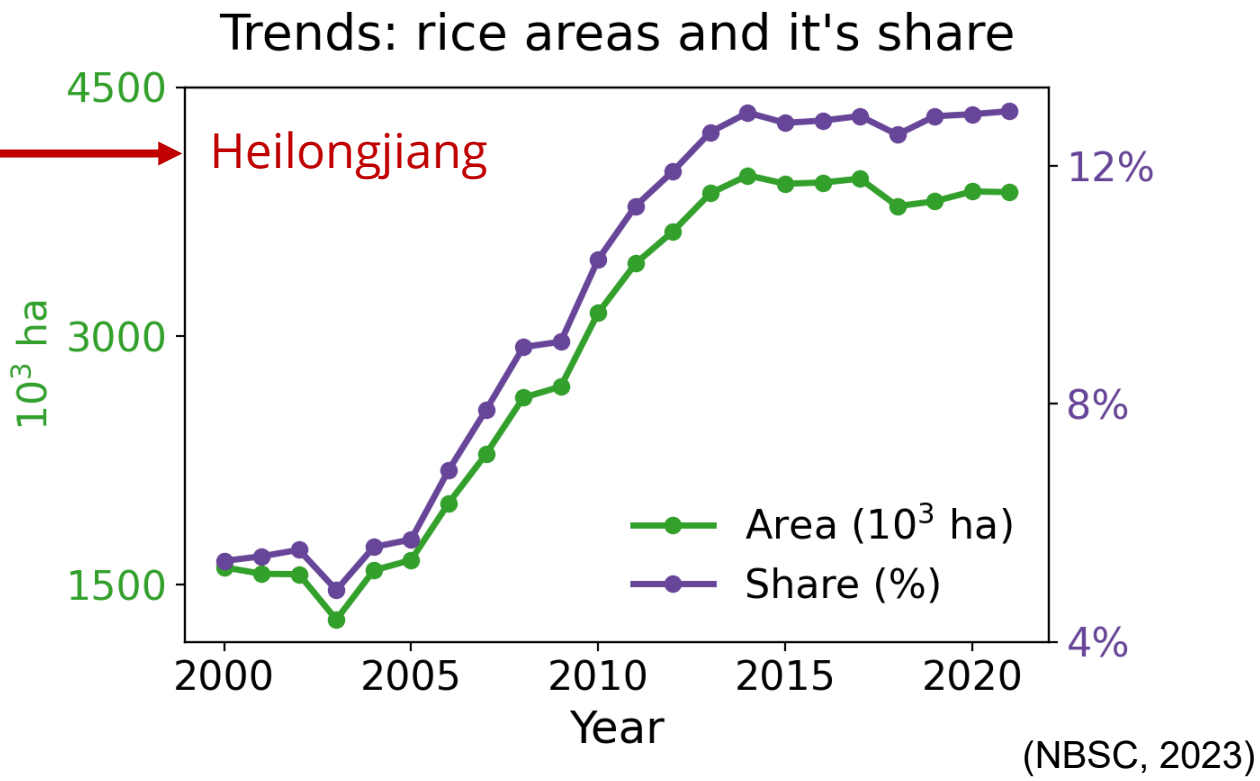
China



(From bottom-up inventory)

Heilongjiang province: the most important rice production base in China

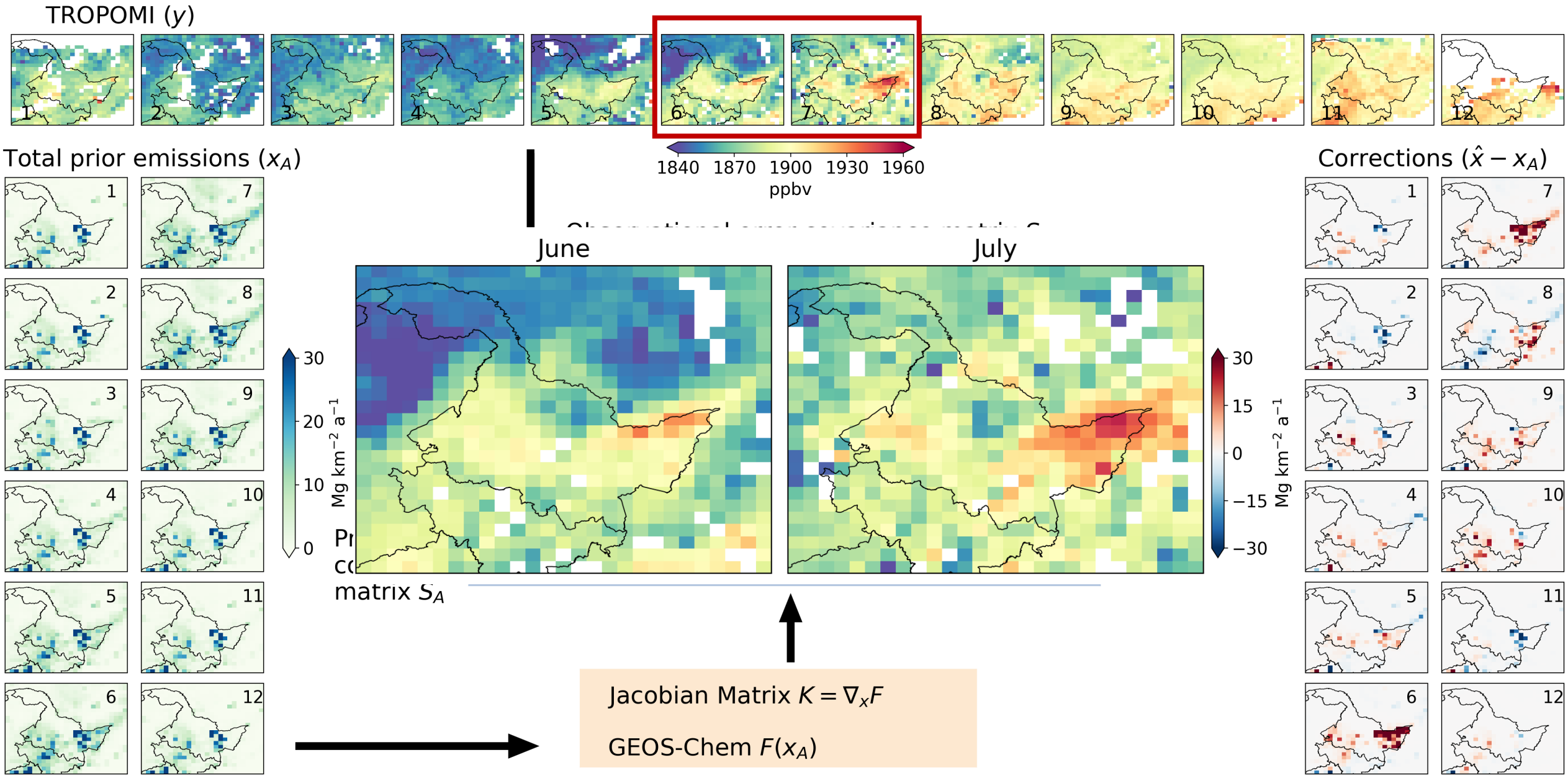




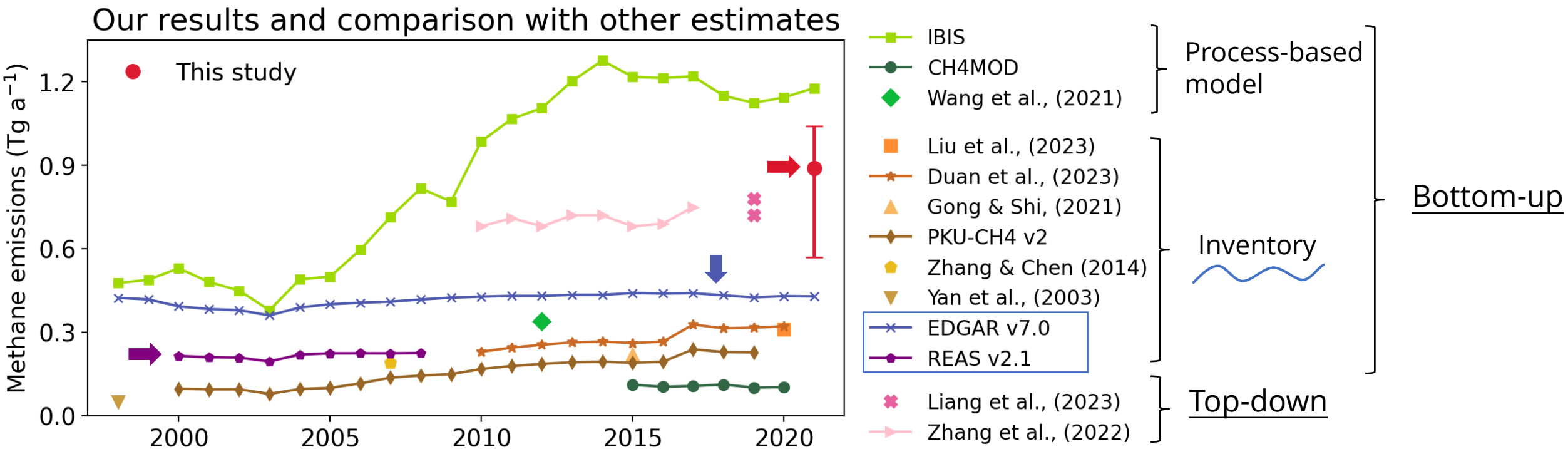
Goals:

- ✓ Use satellite observations of CH4 to characterize the magnitude and seasonality of rice methane emissions from **Heilongjiang province**, China.
- ✓ Compare our results with other rice emission estimates.

Inverse model: use satellite data to correct bottom-up estimates



Annual total rice emissions and comparison

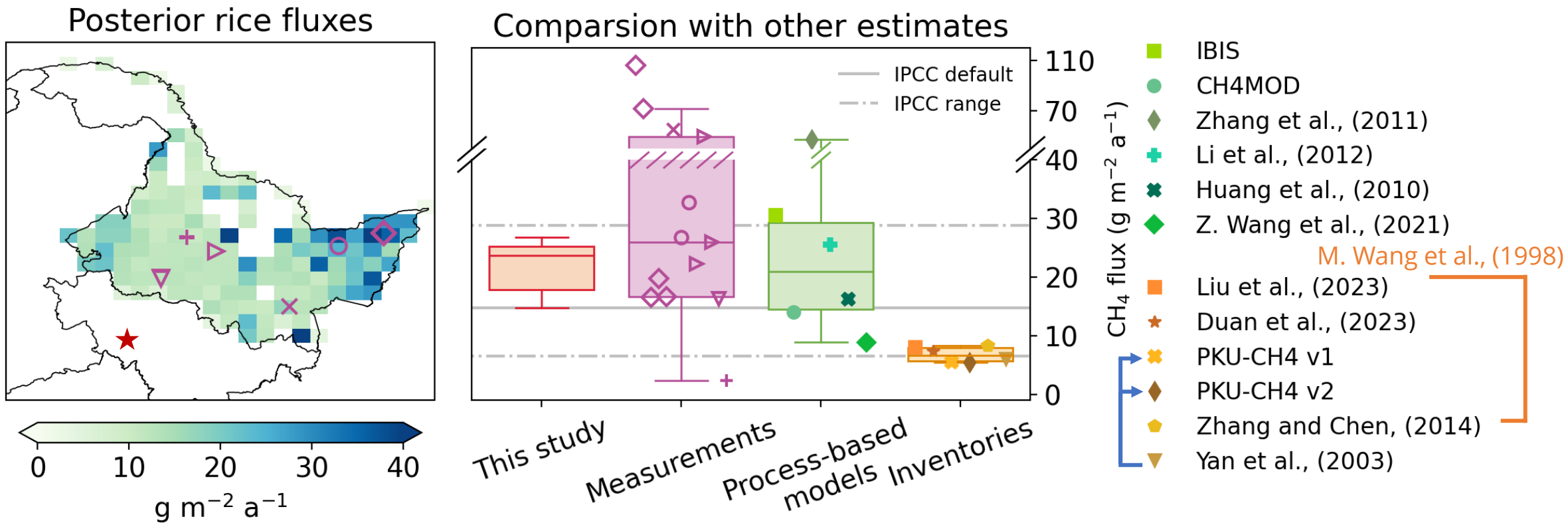


- The annual total emission is estimated to be 0.89 (0.57 – 1.04) Tg a^{-1}, a factor of two or more higher than bottom-up inventories.

$$\text{Bottom-up estimates of rice emission} = \underbrace{\text{Rice methane flux}}_{\text{(EFs)}} \times \underbrace{\text{Rice cultivation area}}_{\text{(Activity data)}}$$

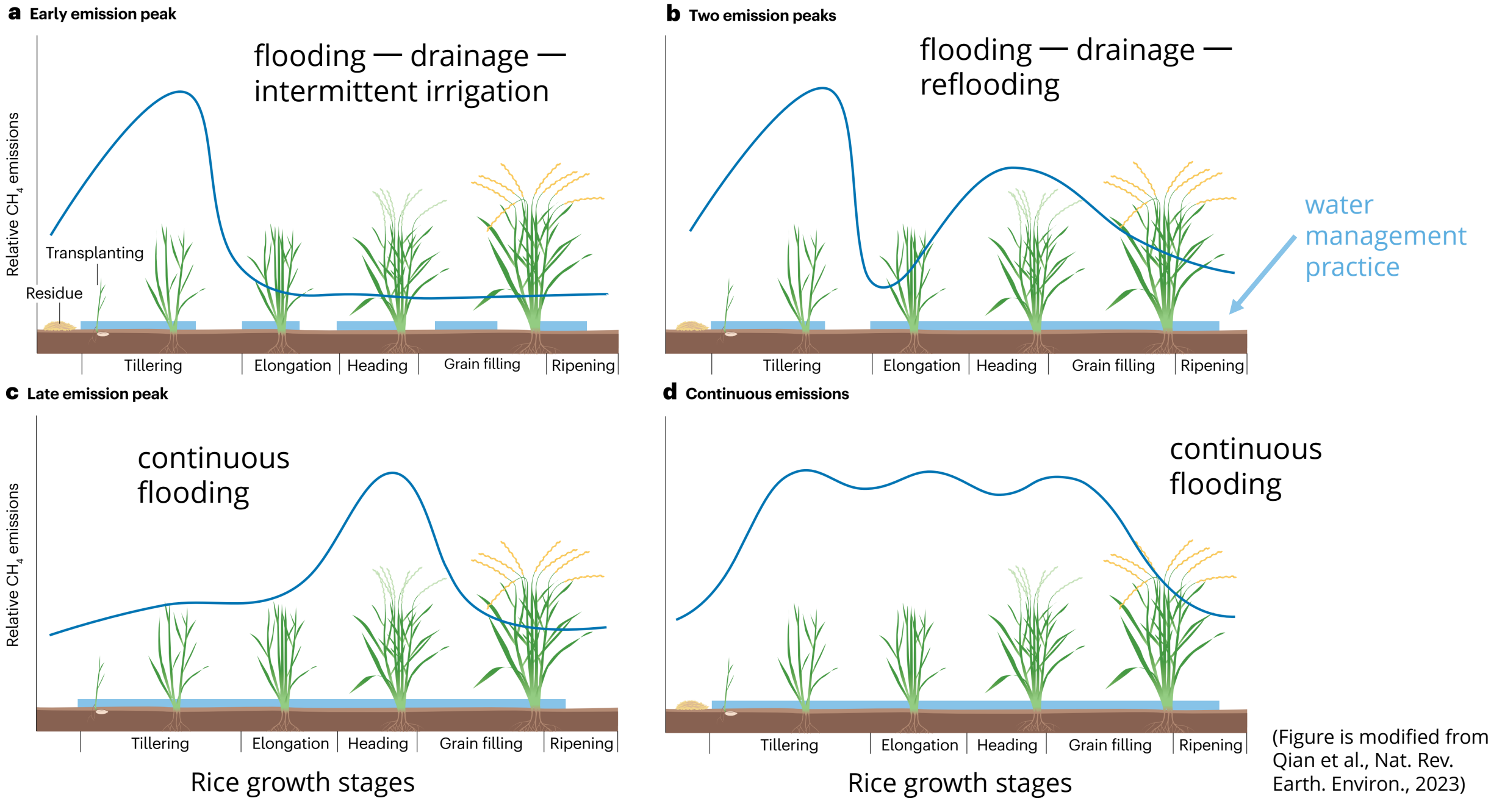
Global and continental inventories could not capture the emissions changes cause by the increase in paddy rice area at provincial-level.

Rice methane flux and validation



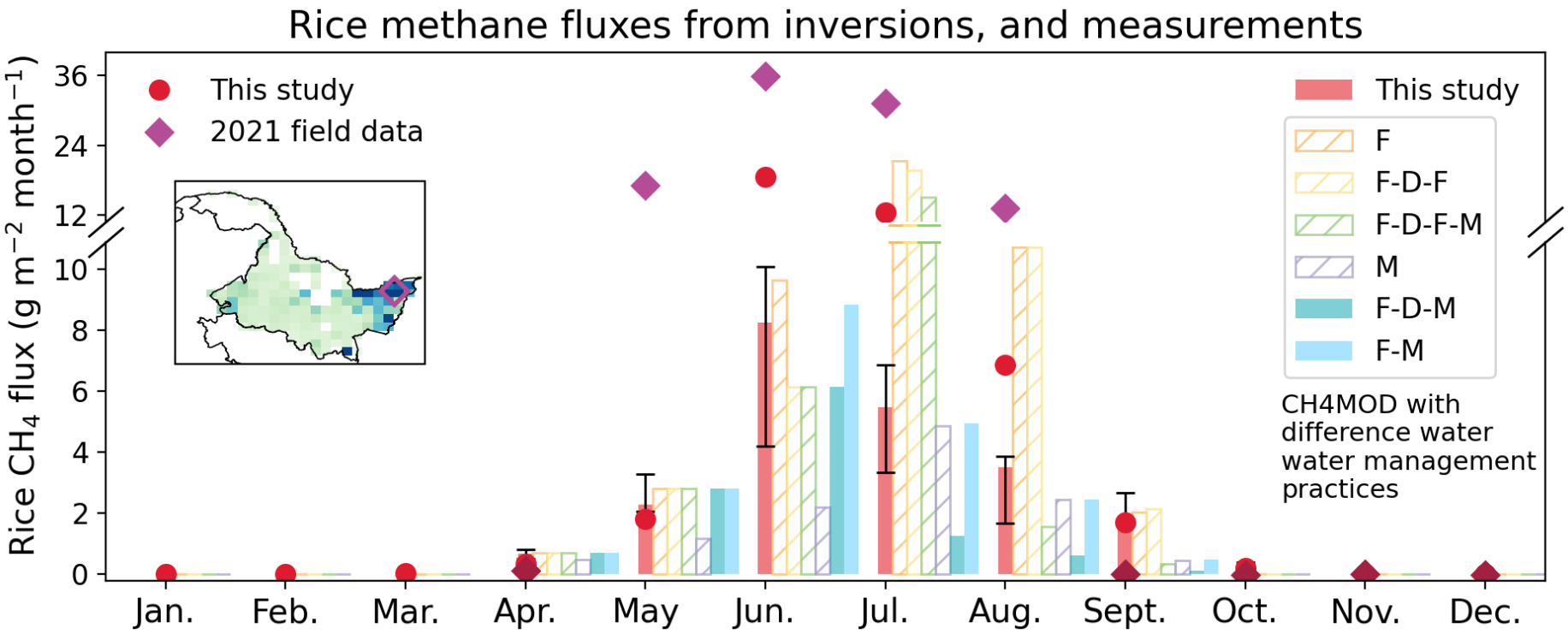
- The annual average rice methane flux is estimated to be 23.0 (14.7 – 26.9) g m^{-2} a^{-1}:
  - compatible with IPCC default values, measurements and process-based models.
  - less uncertainty than those from measurements and process-based models.
- EFs used in various bottom-up inventories are low, from a rice field measurements (★) (Yan et al, 2003) or a preliminary numerical model (M. Wang et al., 1998)

Seasonality is largely affected by water management practices



(Figure is modified from Qian et al., Nat. Rev. Earth. Environ., 2023)

Seasonality: one peak in the tillering stage of rice



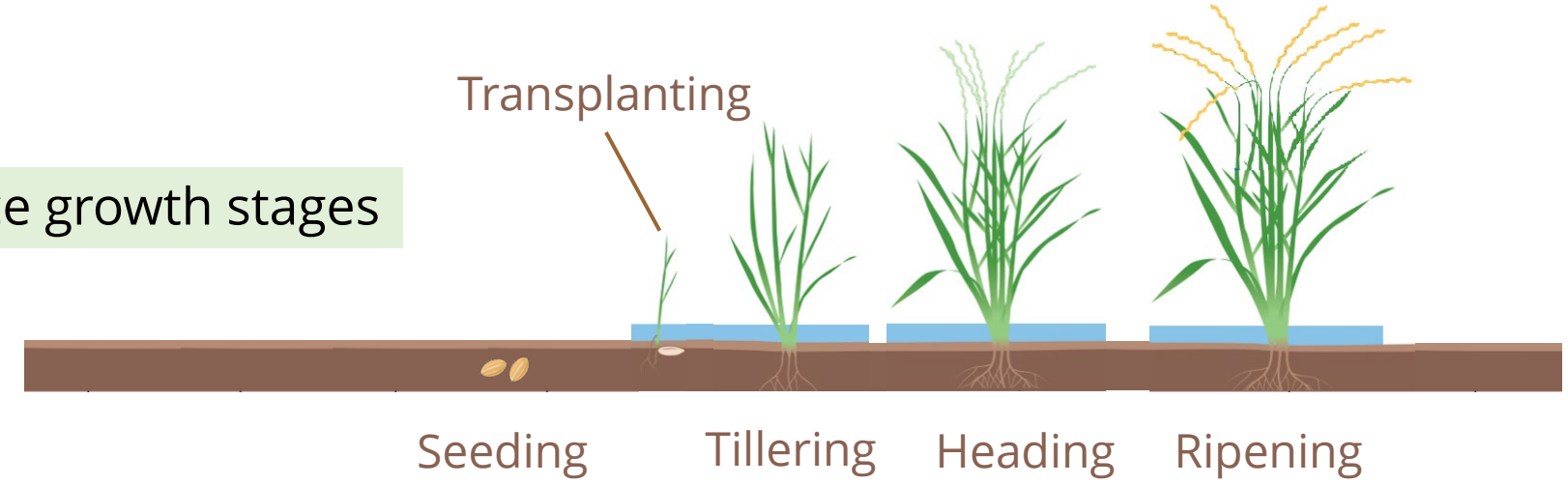
- Our results are consistent with 2021 rice field measurements.

F: flooding

M: intermittent irrigation

D: drainage

Rice growth stages



- Our results are consistent with the CH4MOD model simulations using FM and FMD

Conclusions

We apply TROPOMI CH_4 observations to perform high-resolution (0.625° × 0.5°) inversions to infer rice methane emissions for 2021 from Heilongjiang province, China:

- **Annual total rice emissions**: our results are close to previous top-down estimates but a factor of 2 or more higher than various bottom-up inventories that use:
  - the outdated activity data (paddy rice area) and/or
  - the lower EF (rice methane flux): our estimates of rice methane flux are compatible with IPCC default values, and with most of process-based simulations and rice field measurements.
- **Seasonality**: one peak in the tillering stage of rice, possibly in response to the water management practice.

Satellite-based inversions can be used to reduce uncertainty. The top-down estimates of rice methane flux can be used to calibrate and improve bottom-up estimates.

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