

Supplement

Table S1. The WRF-Chem configurations.

Attribute	WRF option	Model configuration	Reference
Microphysics	2	Purdue Lin scheme	Chen and Sun (2002)
Cumulus	5	Grell 3D ensemble scheme	Grell (1993), Grell and Devenyi (2002)
Shortwave/Longwave radiation	4	RRTMG scheme	Iacono et al. (2008)
Land surface	2	Unified Noah land-surface model	Tewari et al. (2004)
Surface layer	1	Revised MM5 scheme	Fairall et al. (2003), Jimenez et al. (2012)
Planetary boundary layer	1	Yonsei University scheme (YSU)	Hong et al. (2006)
Model top		50 hpa	
Vertical levels		50	
Horizontal resolution		27 km (parent domain), 9 km (nested domain)	

*RRTMG is the Rapid Radiative Transfer Model for General Circulation Models Applications; MM5 is the Mesoscale Meteorological model.

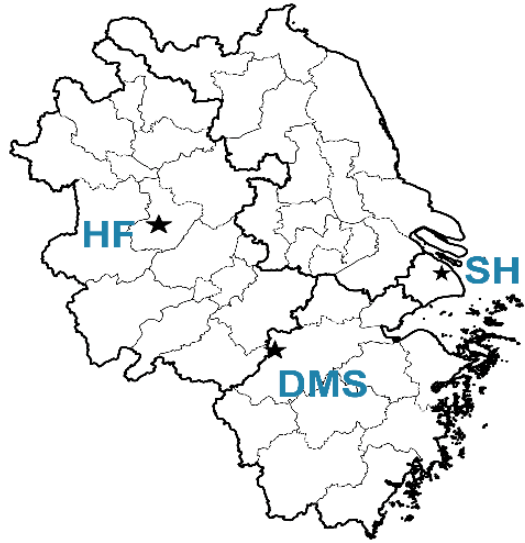


Figure S1. Locations of the three independent validation sites (HF, SH, and DMS) in the Yangtze River Delta (YRD).

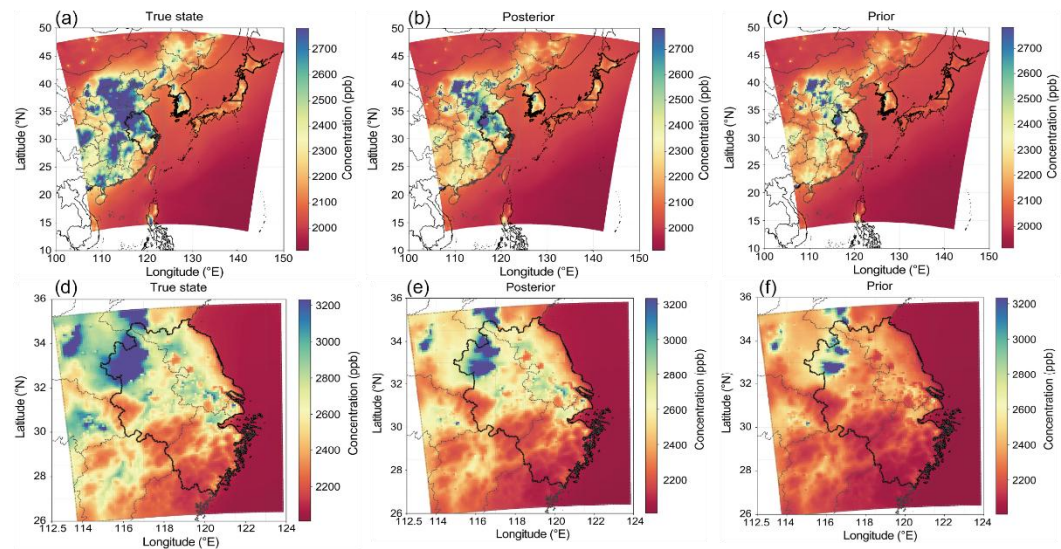


Figure S2. Time-averaged (21 September–30 October 2022) near-surface CH₄ concentration fields for the true state (a), posterior (b), and prior (c), shown over the full parent domain (a–c) and the nested domain (d–f).

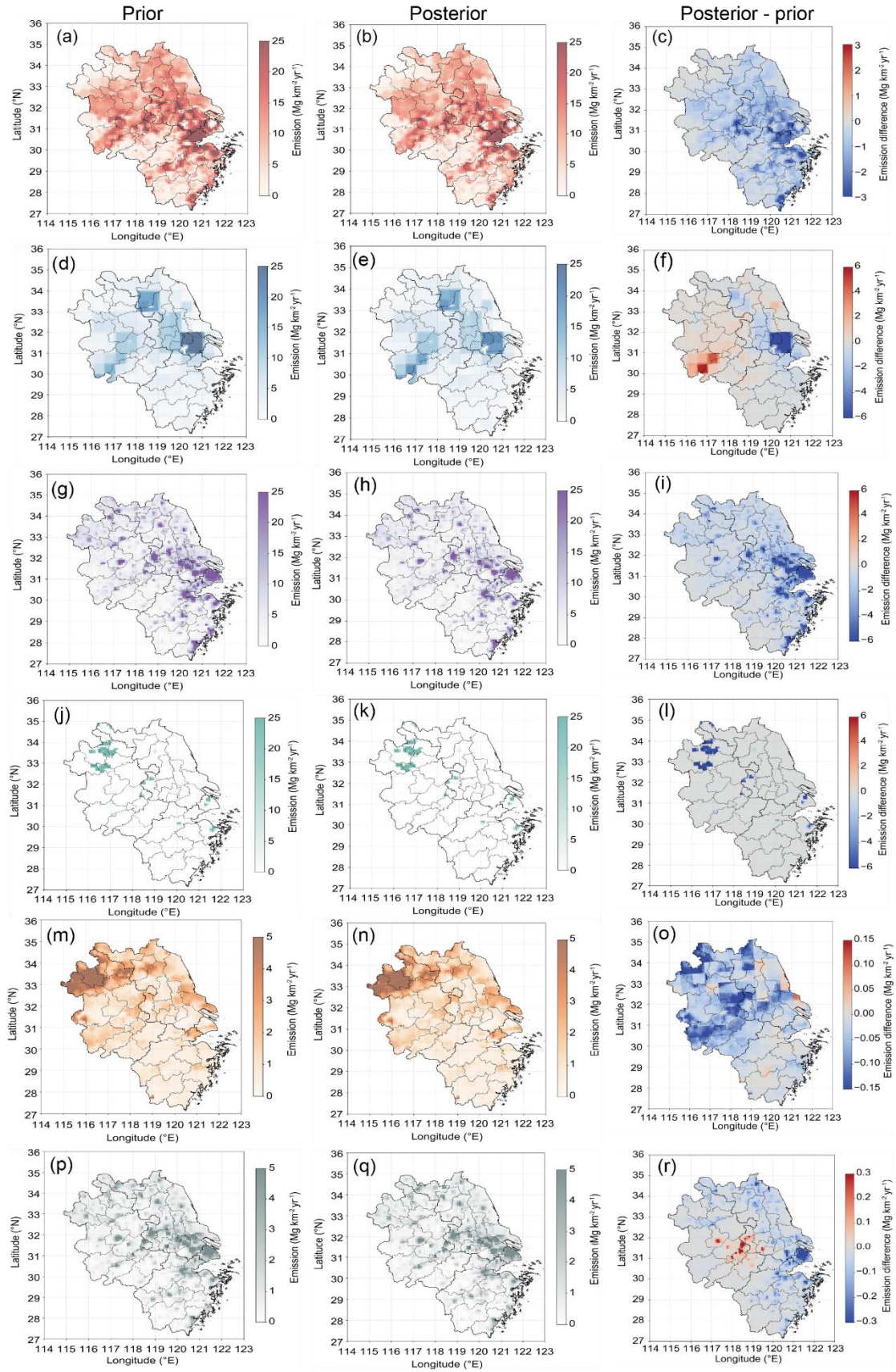


Figure S3. Annual-averaged sectoral CH₄ emissions (1 January–31 December 2022, in Mg km⁻² yr⁻¹) over the Yangtze River Delta (YRD) region for (a, d, g, j, m, p) prior, (b, e, h, k, n, q) posterior, and (c, f, i, l, o, r) difference (posterior minus prior) for the rice cultivation (a–c), natural (d–f), waste (g–i), fuel exploitation

(j–l), livestock (m–o), and other (p–r) sectors.

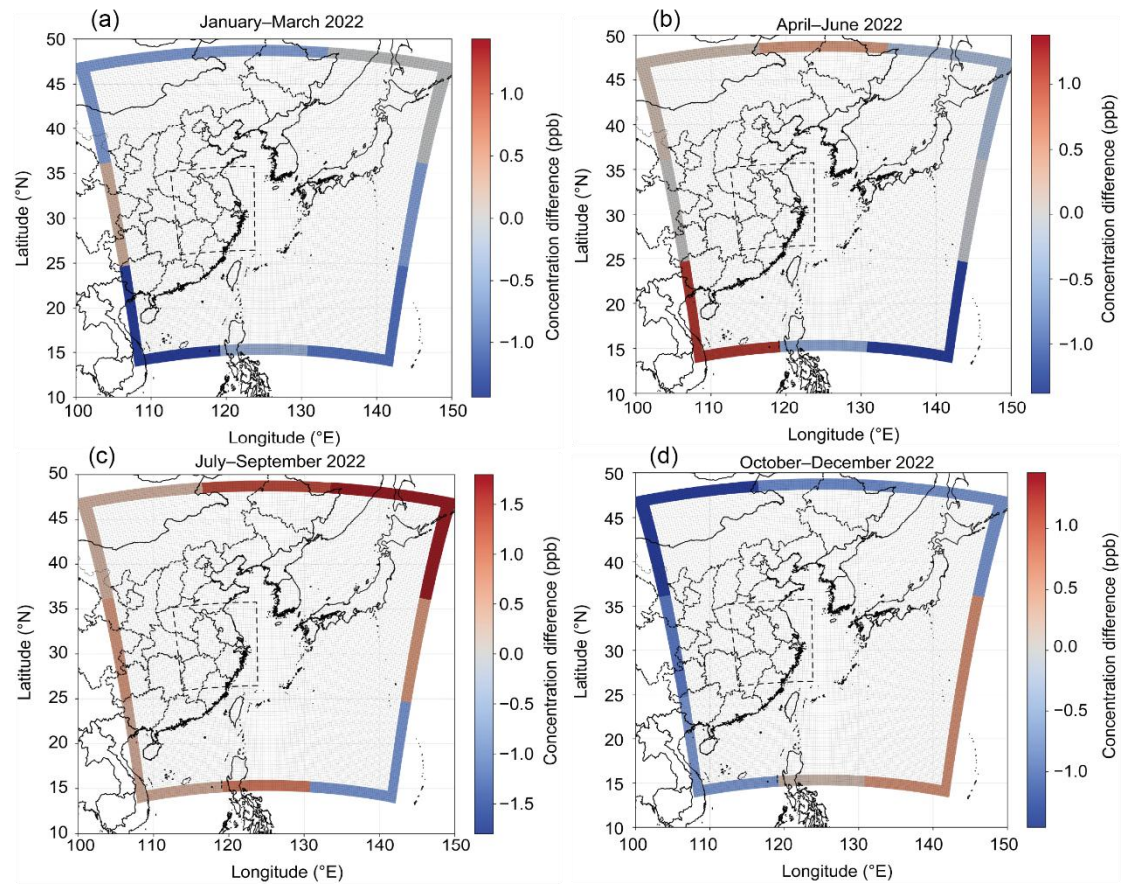


Figure S4. Seasonal-averaged differences (Posterior minus prior) in surface CH₄ boundary concentrations between the posterior and prior cases during 2022: (a) January to March, (b) April to June, (c) July to September, (d) October to December.

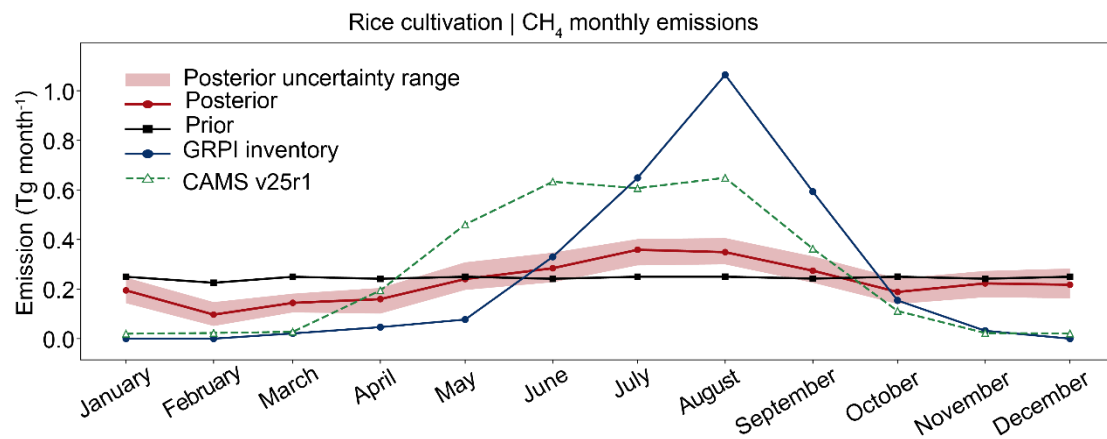


Figure S5. Seasonal cycle of monthly rice-cultivation CH₄ emissions in the YRD in 2022, comparing the prior and posterior estimates with the GRPI bottom-up inventory and CAMS v25r1 inversion-optimized fluxes.

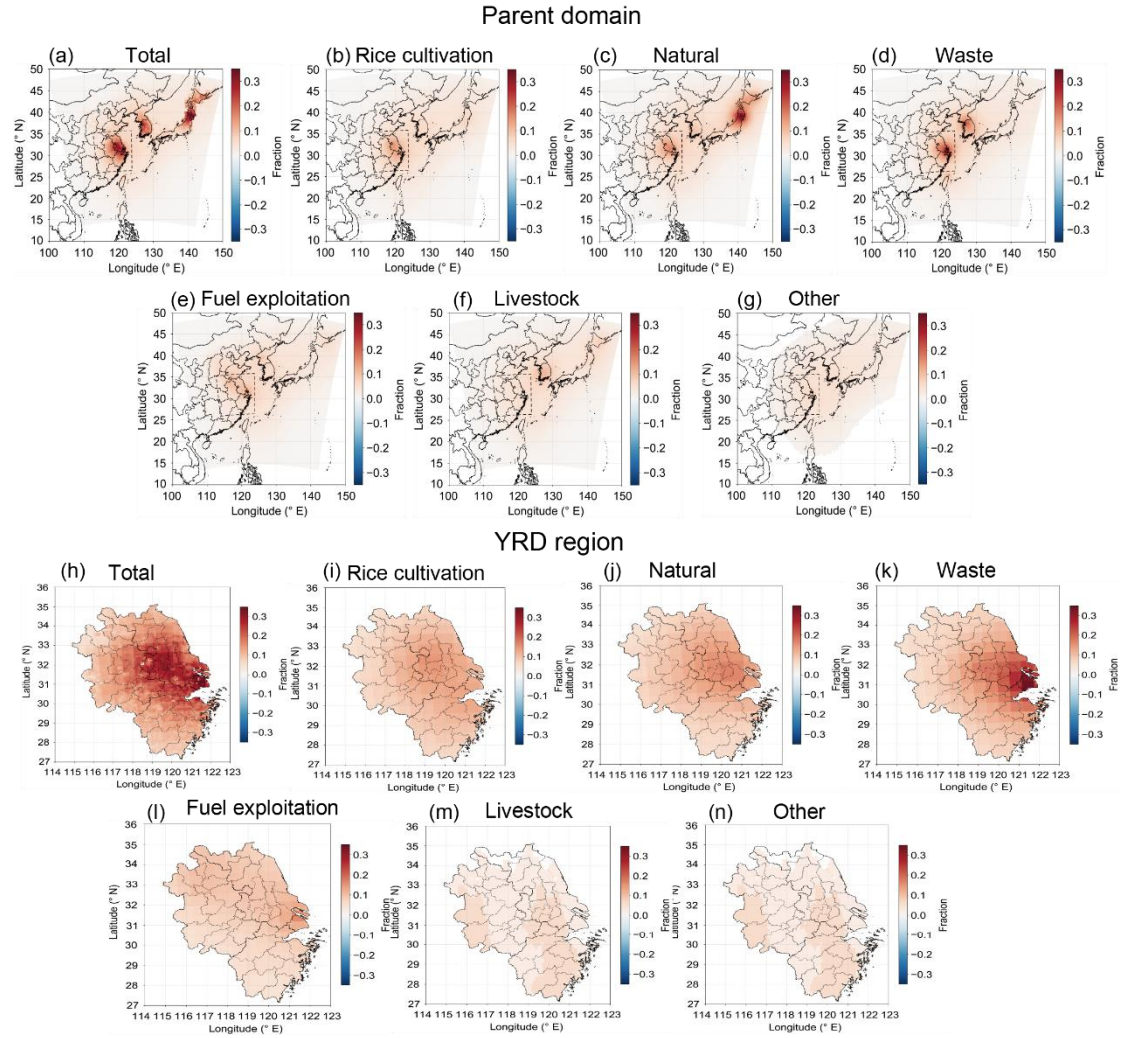


Figure S6. Spatial patterns of posterior flux uncertainty reduction for the total (a, h) and individual sectors (b–g, i–n), shown for the parent domain (a–g) and the Yangtze River Delta (YRD) region (h–n) during 2022.