EGU General Assembly 2020

The distribution and trends in Chinese methane emissions, 2010-2017

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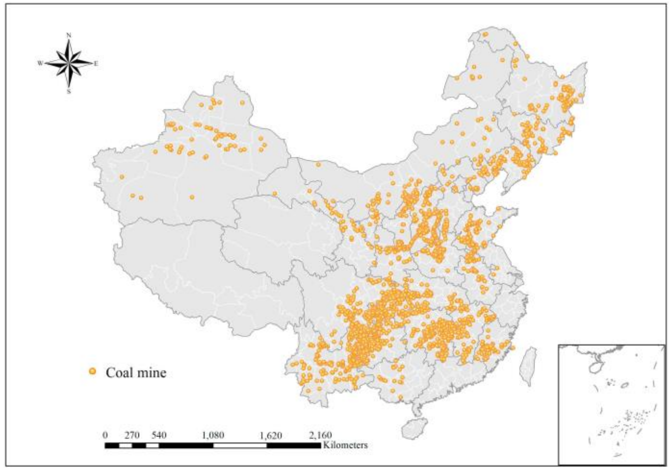
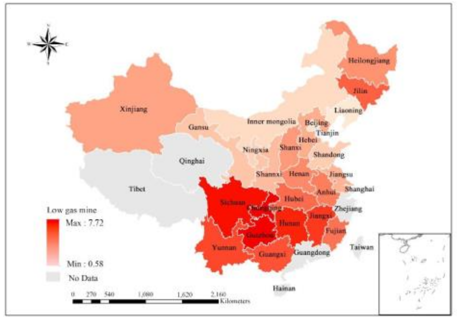
Bottom-up inventories illustrate diversity of CH_4 sources

Coal mine distribution

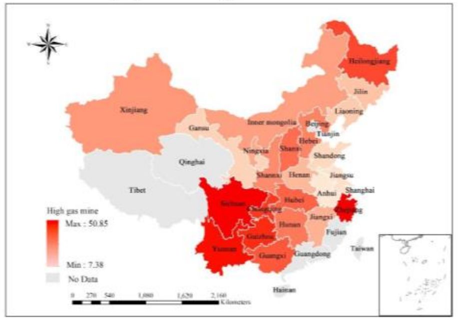


CHRED
(China High Resolution Emission Gridded Database)

(Wang, et al., 2019)

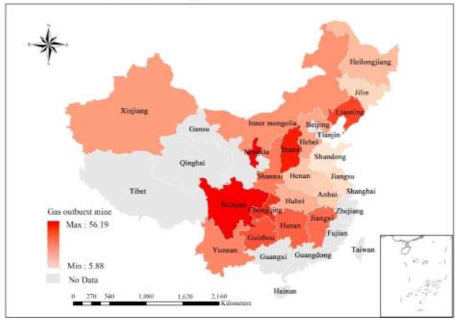


(a) Low gas mine



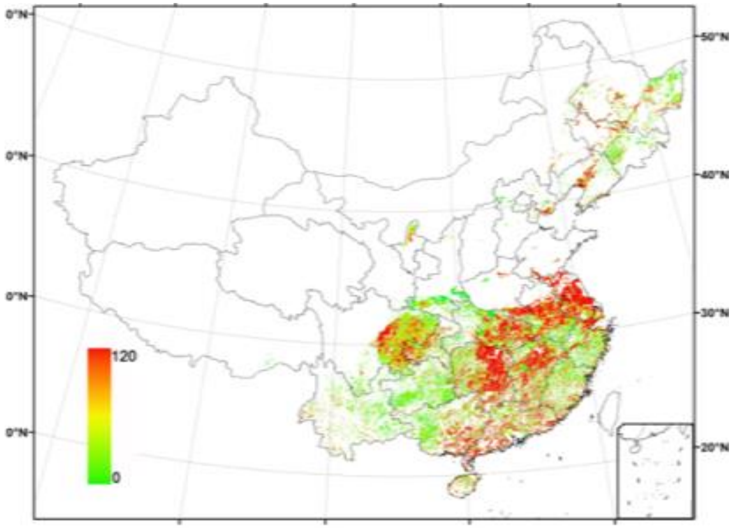
(b) High gas mine

Provincial emission factors →



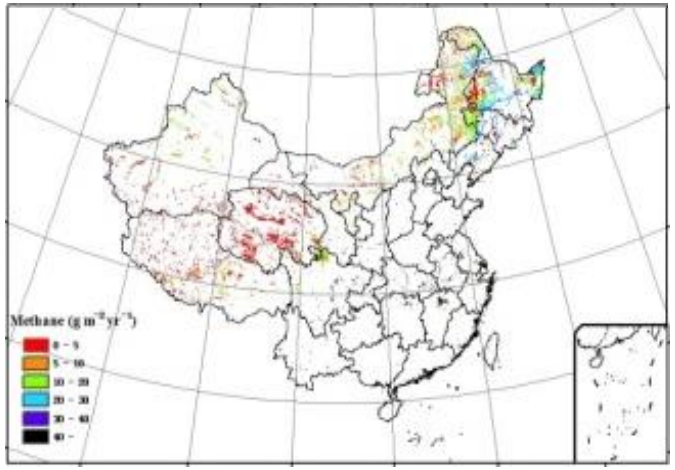
(c) Gas outburst mine

Paddy Methane Emissions



(Zhang et al., 2013)

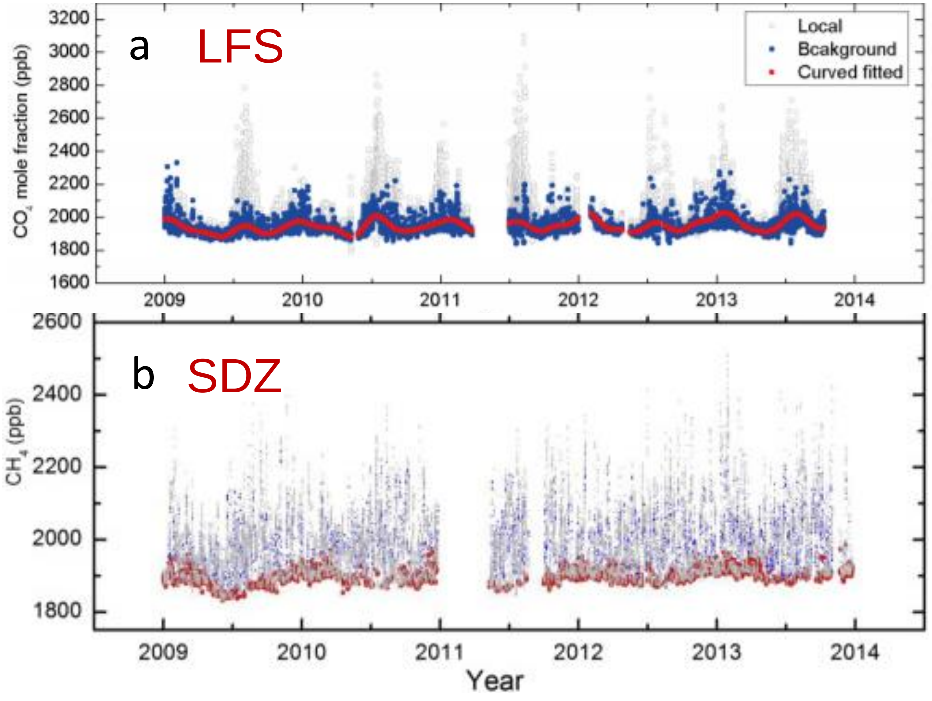
Natural Wetland Emissions



(Li et al., 2015)

Coal combustion linked to large increase in Chinese emissions?

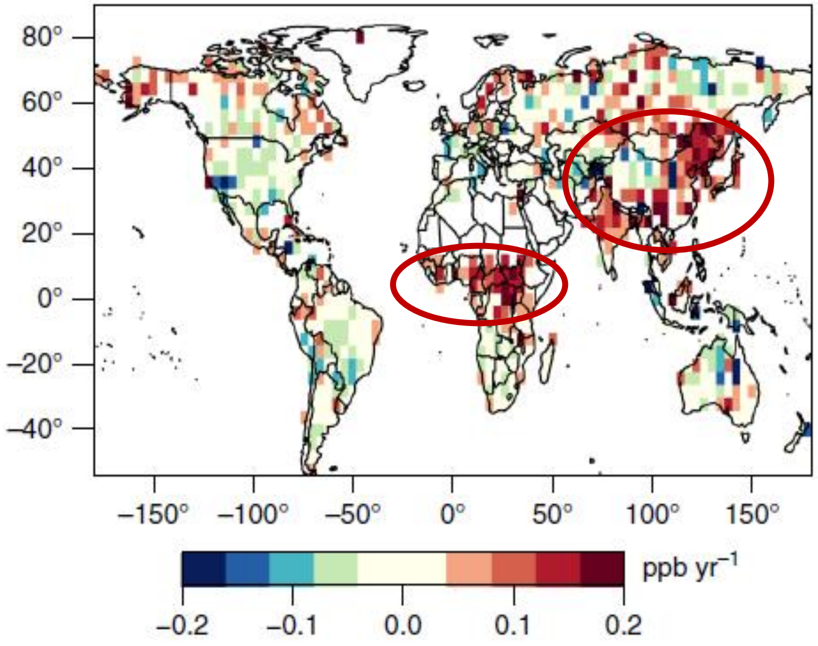
In situ network of mole fraction measurements across China

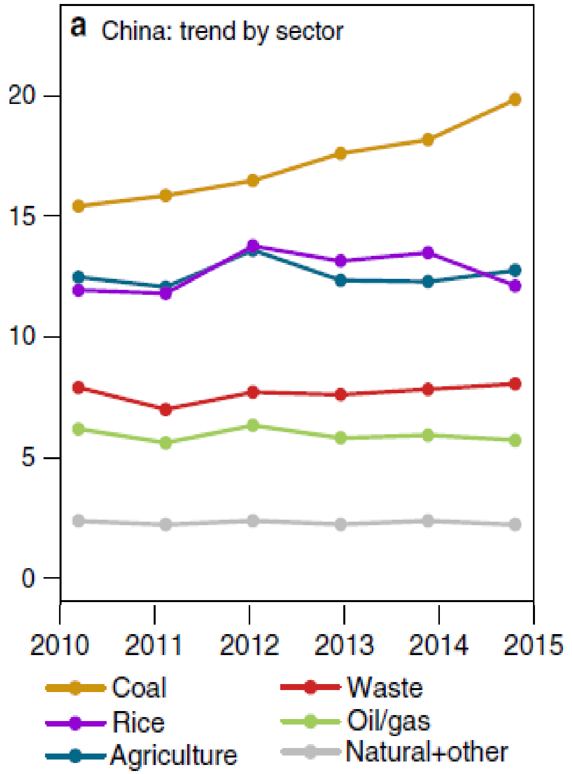


(a) LFS(longfengshan) & (b) SDZ(shangdianz methane observation variation between 2009 ar 2014

(Fang et al. 2016, 2017)

Trend in nadir GOSAT CH4 column observations



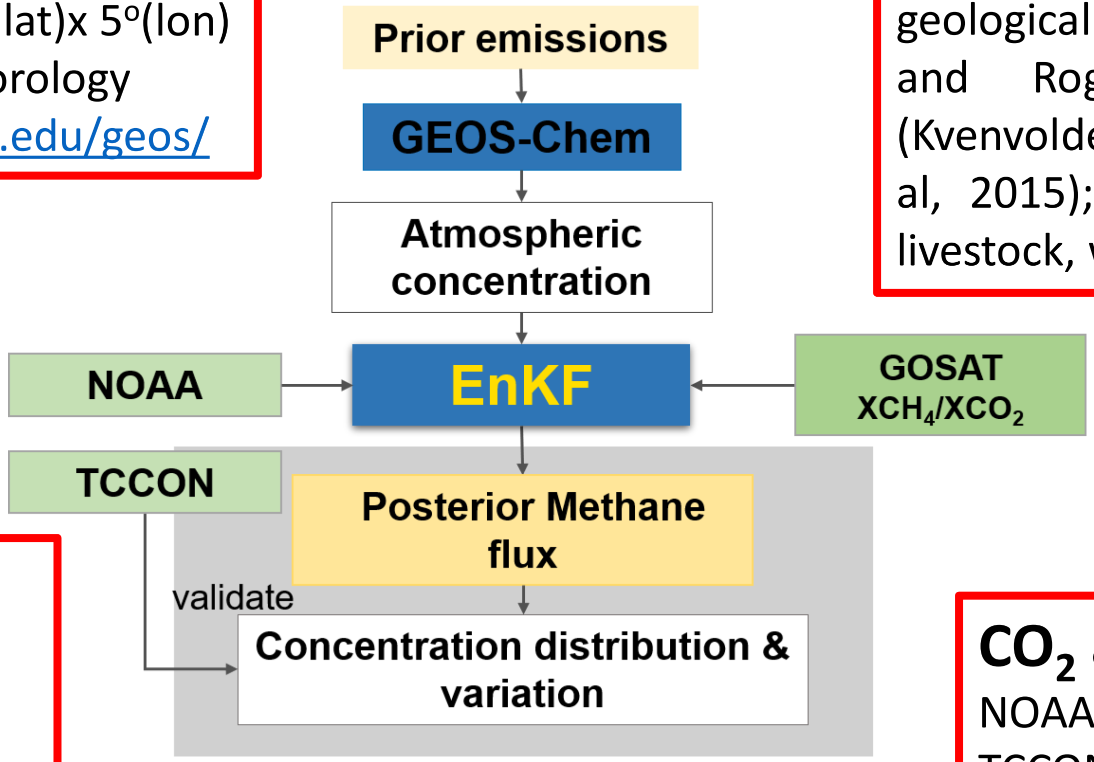


(Miller et al, 2019)

Ensemble Kalman Filter

Forward model:

GEOS-Chem (v12.5.0): 4°(lat)x 5°(lon)
MERRA reanalyzed meteorology
http://acmg.seas.harvard.edu/geos/



Prior emissions:

Wetlands (WetCHARTS); fire (GFED4.0); termites (Fung et al, 1991); geological (Etiope, 2015; Kvenvolden and Rogers, 2005); geothermal (Kvenvolden and Rogers, 2005; Lyon et al, 2015); oil and gas, coal mining, livestock, waste (EDGAR v4.41)

Inverse method:

Ensemble Kalman Filter
4-month lag window
Monthly posteriori fluxes
Feng et al., 2017

CO_2 and CH_4 Data:

NOAA in situ network
TCCON
GOSAT proxy XCH4:XCO2 ratios

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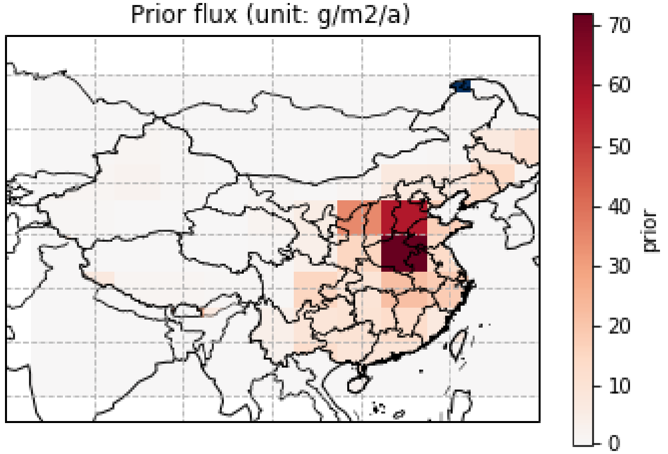
Posterior CH_4 fluxes smaller than prior estimates

Annual mean prior and posterior CH_4 fluxes (2010-2017) and their difference

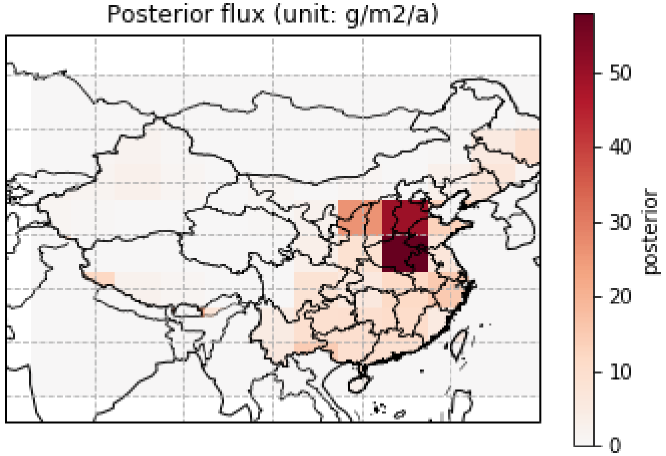
Prior



Mean: 3.46 $g/m^2/a$

Max: 71.26 $g/m^2/a$

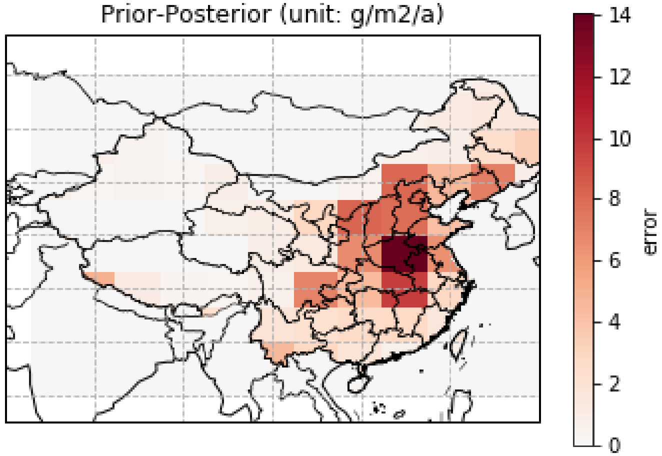
Posterior



Mean: 2.62 $g/m^2/a$

Max: 58.17 $g/m^2/a$

Difference



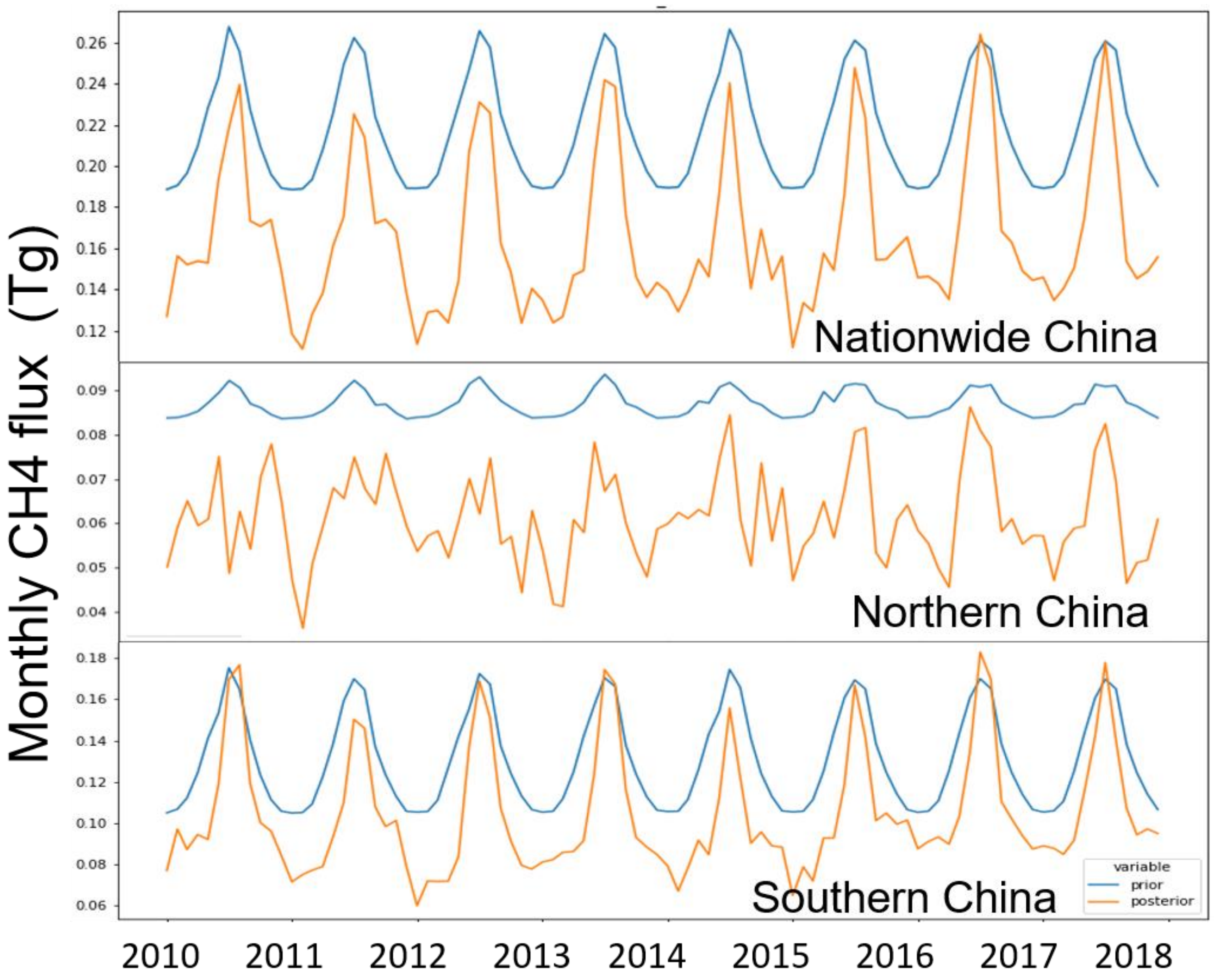
Mean: 0.84 $g/m^2/a$

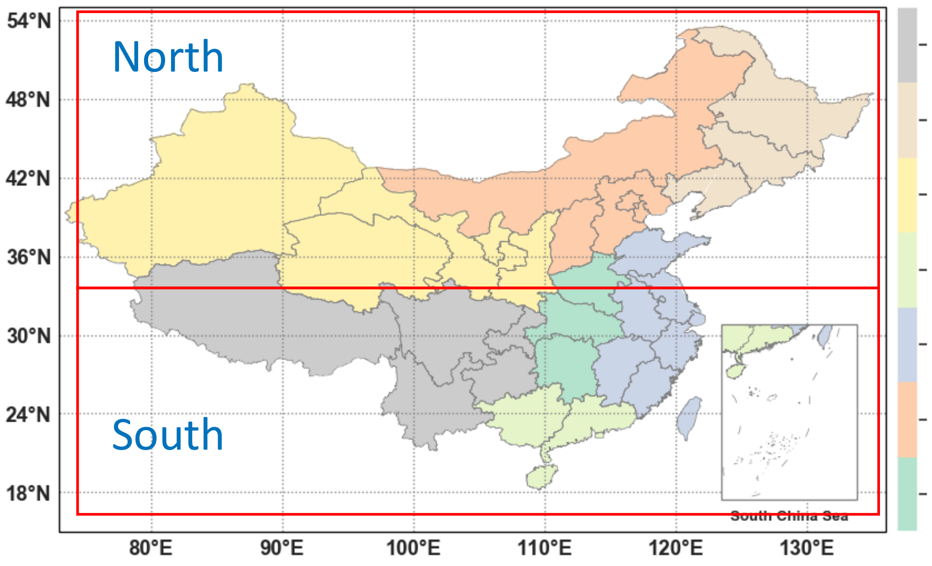
Max: 14.09 $g/m^2/a$

Key messages:

- Chinese CH_4 emissions originate mainly from northern region.
- Posterior CH_4 estimates are smaller than Prior emissions in China, particularly over northern China, the maximum difference is 14.09 $g/m^2/a$

Posterior fluxes show larger seasonal variations

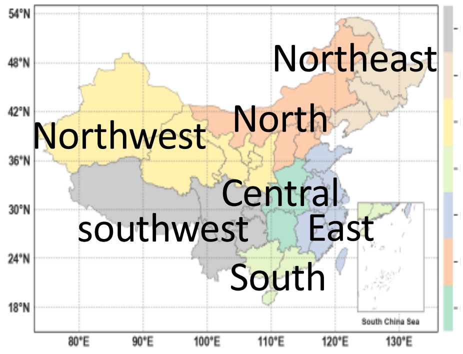




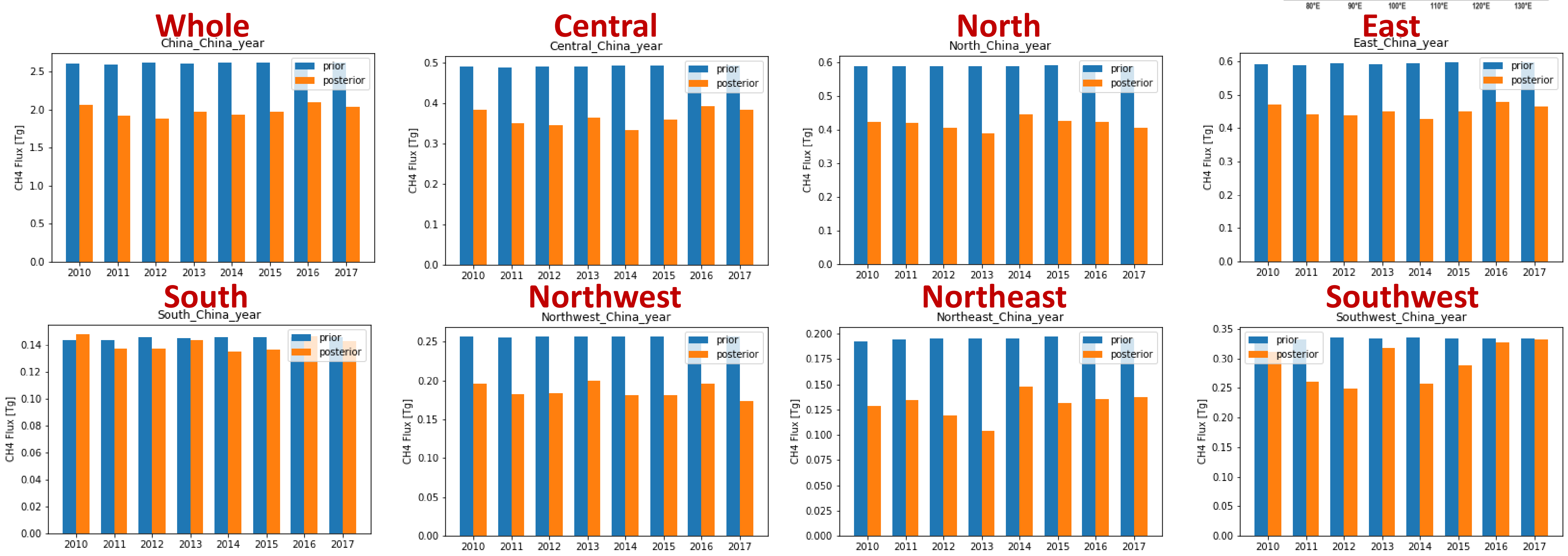
- Posterior estimates show less net nationwide methane emissions than Prior flux
- Systematic deviation exits in northern regions, and the temporal variation of posterior flux is more complicated
- half-peak bandwidths of posterior flux are smaller that those of prior values in Southern regions, which means more emissions concentrate on shorter time period.

Assimilation results

Annual mean changes vary across China



Prior
Posterior

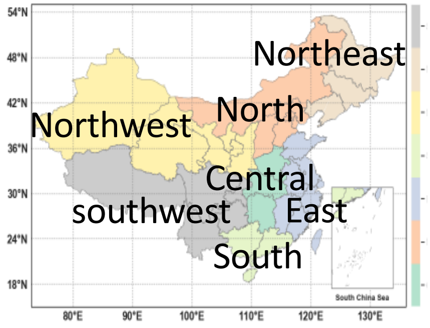


- Obvious differences of posterior flux trend among regions
- Some regions have different trends before and after 2013

East > North > Central > Southwest > Northwest > South ≈ Northeast

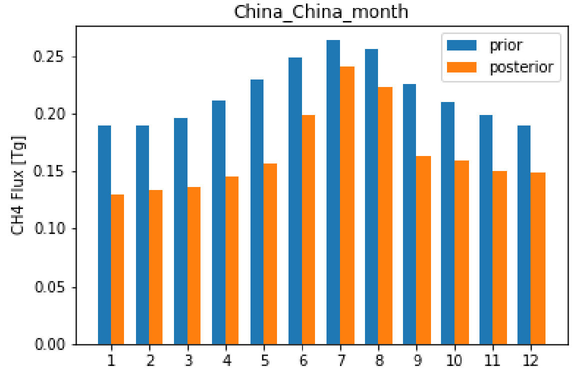
Assimilation results

Monthly mean changes also vary across China

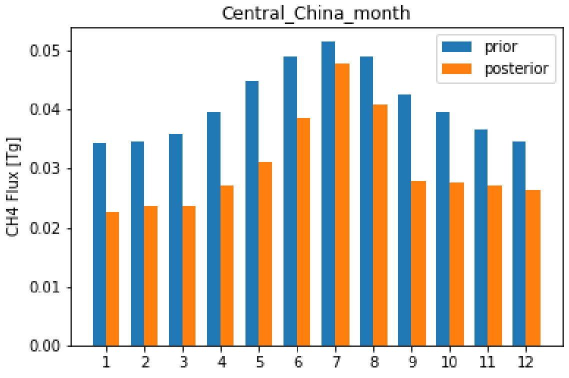


Prior
Posterior

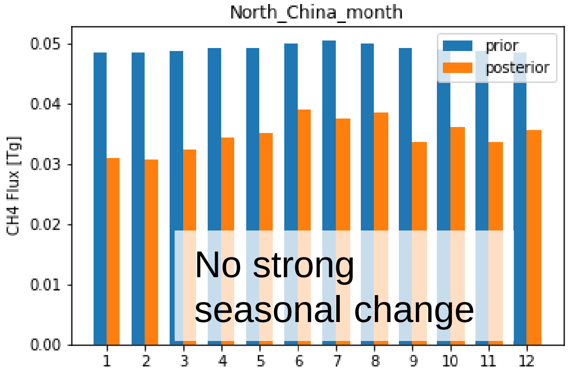
Whole



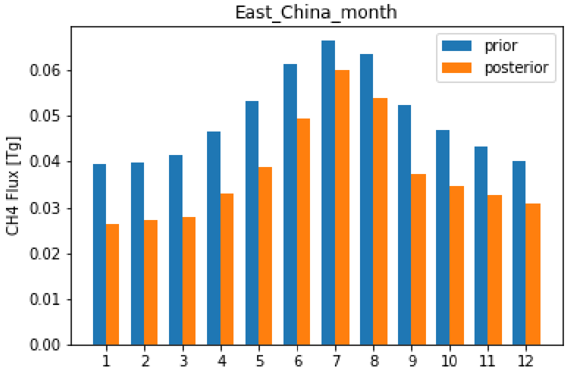
Central



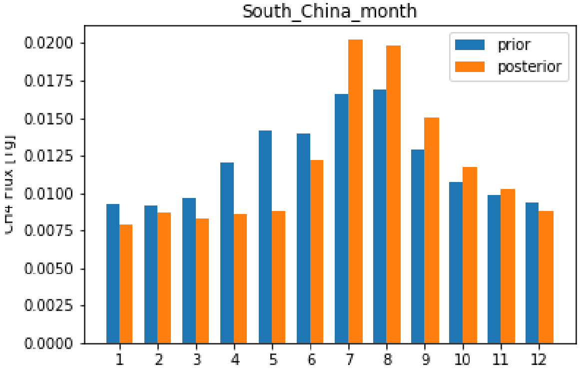
North



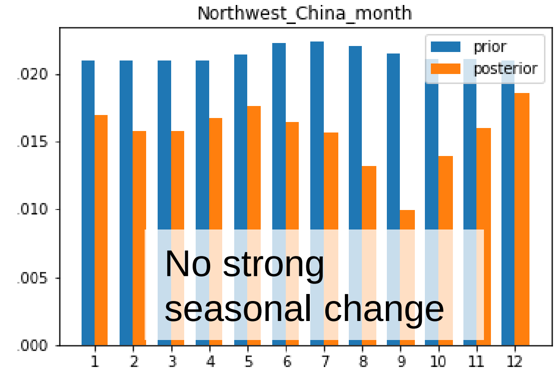
East



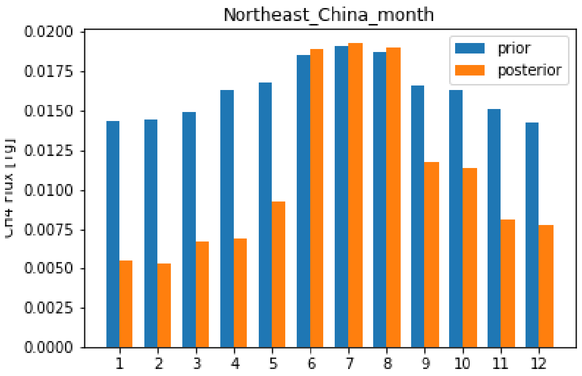
South



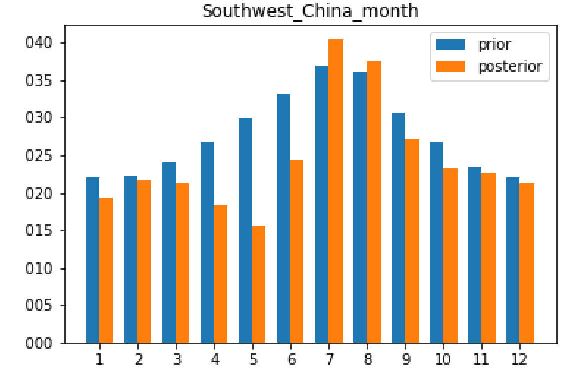
Northwest



Northeast



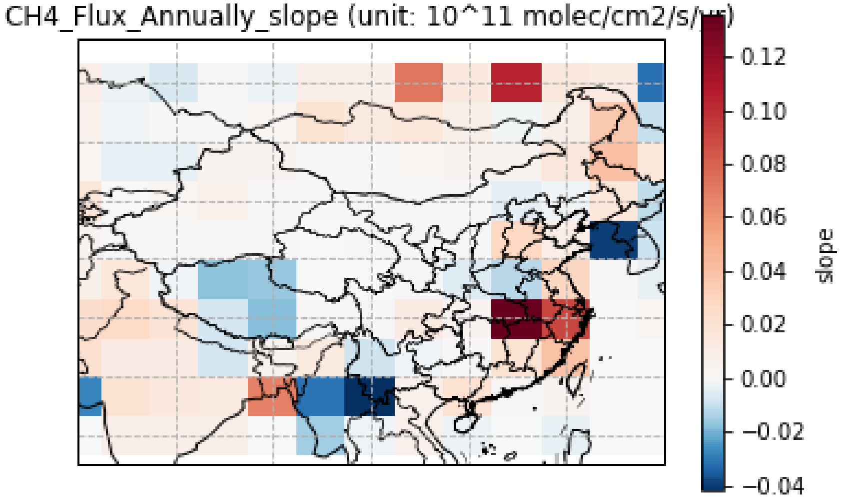
Southwest



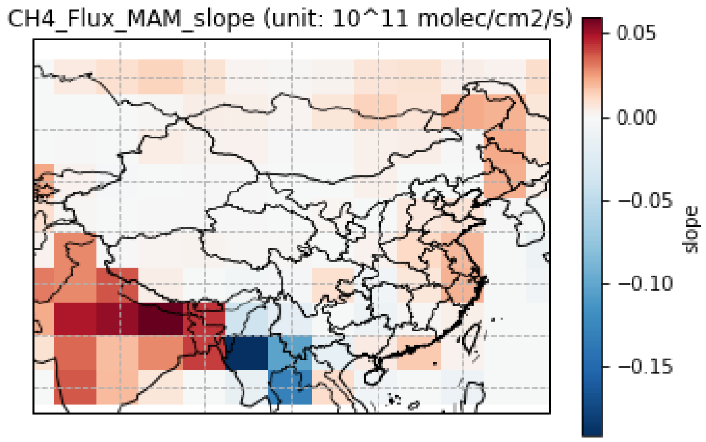
Northern regions: dominated by coal mines emissions→ have no obvious seasonal trend

Southern regions: mainly from paddy field & wetland → have obvious seasonal trend

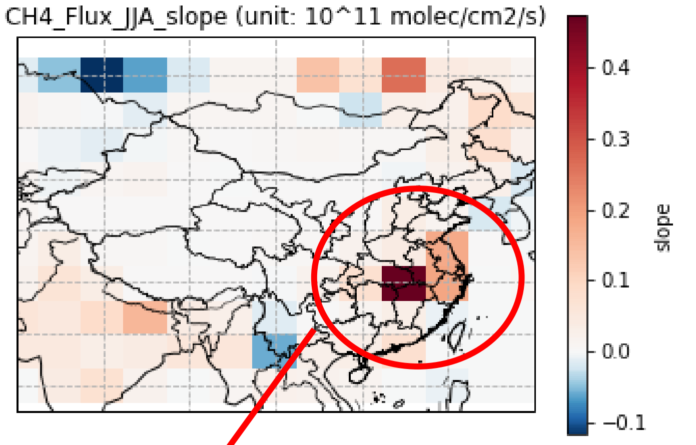
Largest CH_4 trends from central and east China (2010-2017)



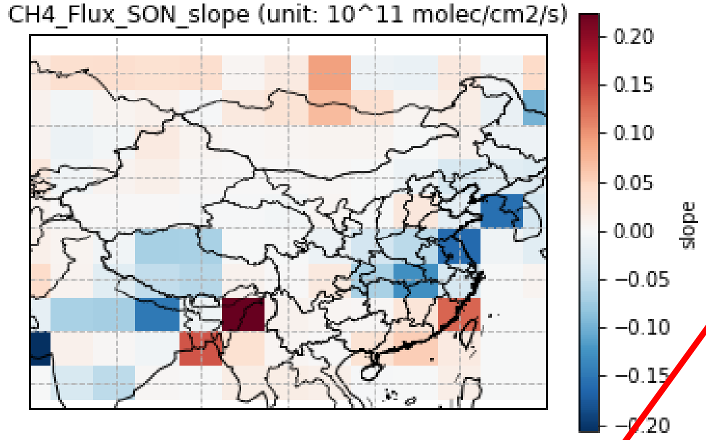
MAM



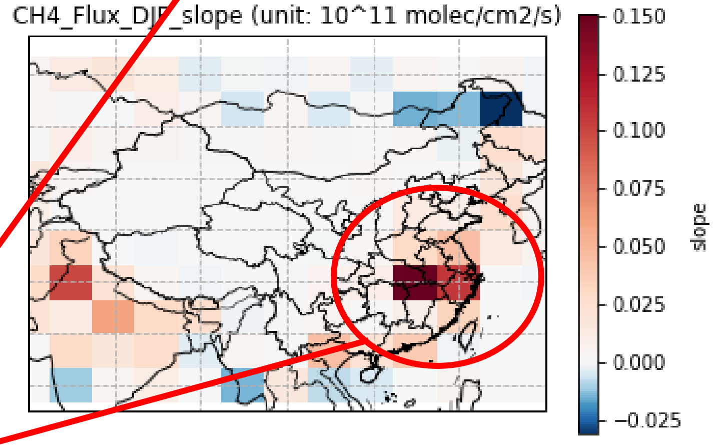
JJA



SON



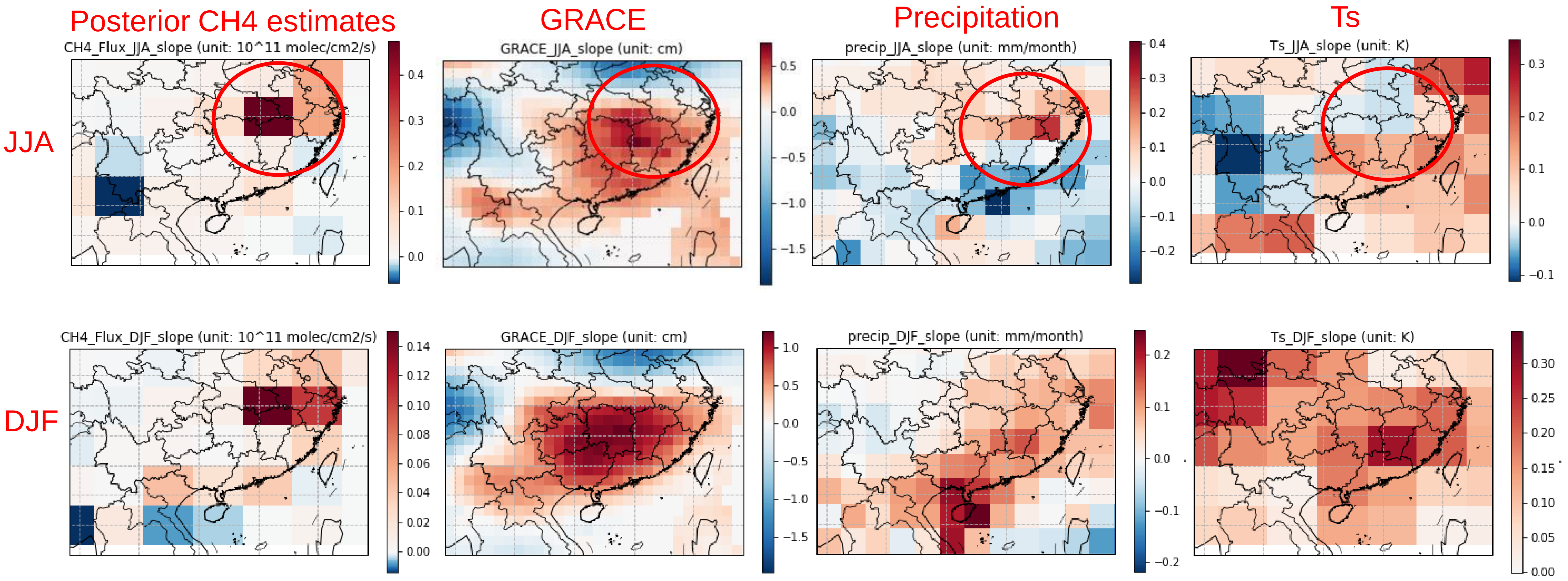
DJF



- Theil-Sen slope used to determine trends, discounting short-lived variations
- Increase of Methane emissions main from:
  - central and east China during summer and winter months

(methane emissions from central and east china are mainly from wetland and rice fields)

Changes in CH_4 emissions associated with hydrology



- More annual increases of CH_4 emissions and grace occurred during summer period
- CH_4 emissions in southern regions (mainly from wetland and paddy fields) are more related with soil water storage (GRACE) than temperature

Conclusion

- Chinese CH_4 emissions originate mainly from northern region. Posterior CH_4 estimates are smaller than Prior emissions in China, particularly over northern China, the maximum difference is 14.09 $g/m^2/a$.

- Systematic deviation exits between posterior and prior flux in northern regions, and the temporal variation of posterior flux is more complicated; more methane emissions in posterior estimates concentrate on shorter time period in southern regions.

- Annual mean Chinese CH_4 emissions (posterior results) decrease from 63 Tg in 2010 to 57 Tg in 2013, but then increased to 64 Tg in 2016. Some regions have different trends before and after 2013.

- Generally, regional CH_4 emissions are smallest during January and peak in July.

- Methane emissions variations across central and east China make most contributions to the nationwide emission increase, and emissions in summer months are more related to hydrological conditions.

Thanks for your attention

Appendix

Regional annual total methane emission（unit: Tg)

	China	Central	North	East	South	Northwest	Northeast	Southwest
2010	62.71	11.69	12.88	14.30	4.50	5.95	3.93	9.46
2011	58.65	10.65	12.82	13.42	4.17	5.53	4.11	7.94
2012	57.36	10.54	12.37	13.41	4.19	5.59	3.66	7.60
2013	59.91	11.09	11.83	13.69	4.37	6.06	3.19	9.68
2014	58.78	10.15	13.59	13.06	4.10	5.52	4.52	7.85
2015	60.12	10.97	12.98	13.71	4.16	5.52	4.01	8.77
2016	64.11	11.97	12.91	14.62	4.47	5.98	4.15	10.00
2017	62.10	11.64	12.37	14.18	4.34	5.29	4.19	10.09

East > North > Central > Southwest > Northwest > South ≈ Northeast