Towards understanding the contrasting CH_4 emission variations over tropical continents

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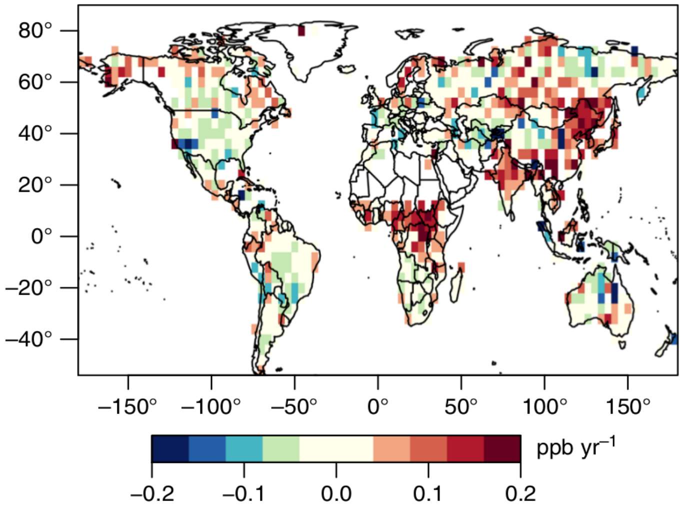
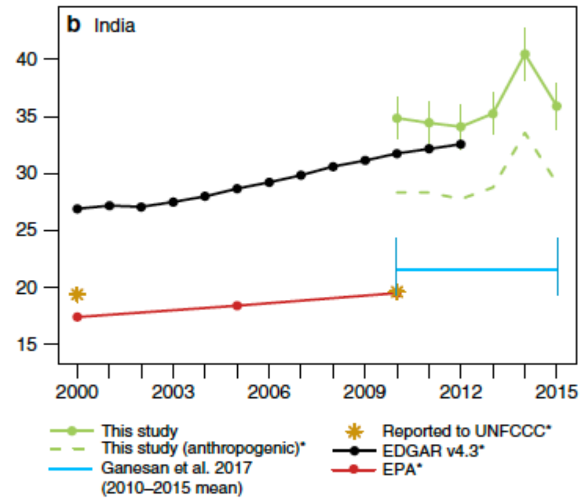
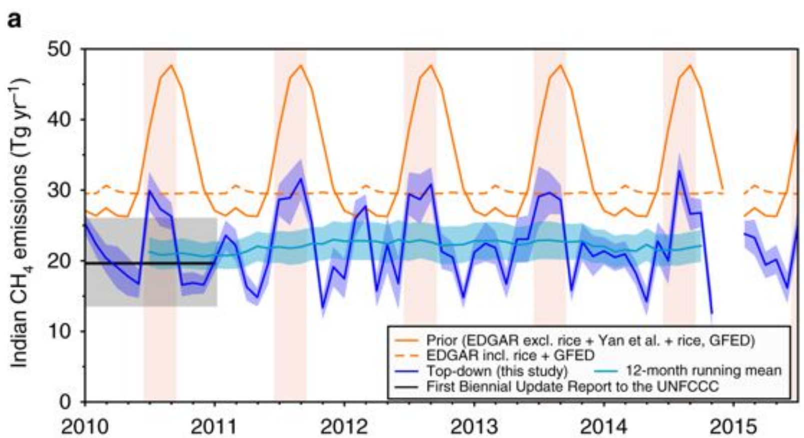
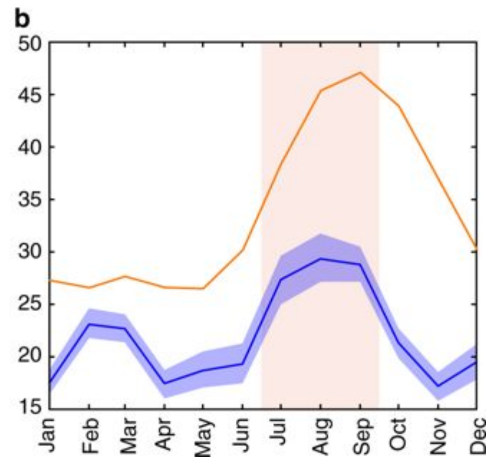
What are the reasons that atmospheric CH_4 has experienced growth rates > 1990s mean value?





Miller et al., 2019



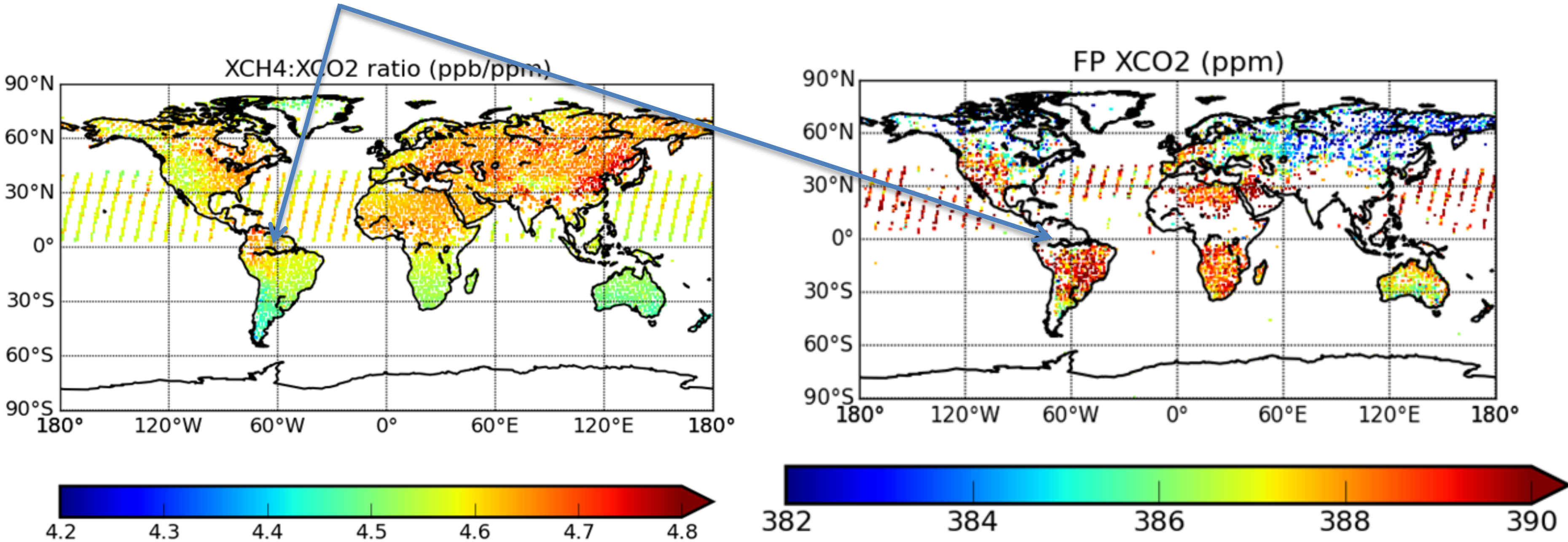


Ganesan et al., 2017

Based on similar GOSAT XCH4 data, two recent papers reach different conclusions about about geographical hotspots for emission growth, e.g. India.

We directly use GOSAT X_{CH_4}:X_{CO_2} ratios (Fraser et al, 2014; Feng et al, 2017)

- ✓ Ratio product less prone to bias, but subject to error from high cirrus clouds; avoids use of model X_{CO_2}
- ✓ Lots more data than the full-physics approach, particularly over key geographical regions



Good XCH4:XCO2 retrievals in 2010.07 | **Good full-physics XCO2 retrievals in 2010.07**

Consistent coverage provided by ratio data is essential for studying spatial temporal inter-annual variations of CH_4.

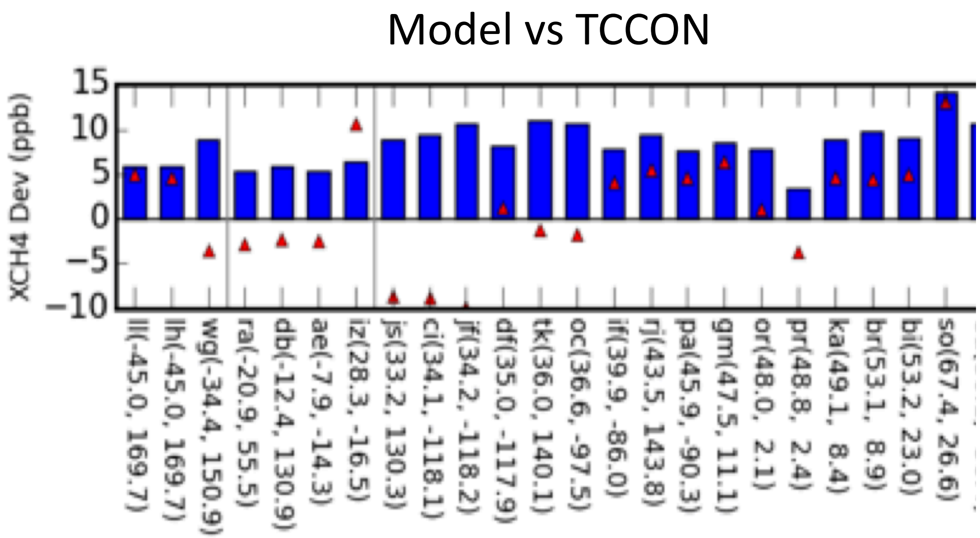
Experiment setup:

- **Prior CO2 Inventories:** Fossil fuel ; Biospheric fluxes: Oceanic surface fluxes; Biomass burning.
- **Prior CH4 Inventories:** Wetland; Rice; Termites; Animal; Biomass burning; Fossil fuel ; Waste; Gas Industry; Coal mine; Ocean; Biomass burning…
- **Prior Uncertainties**:

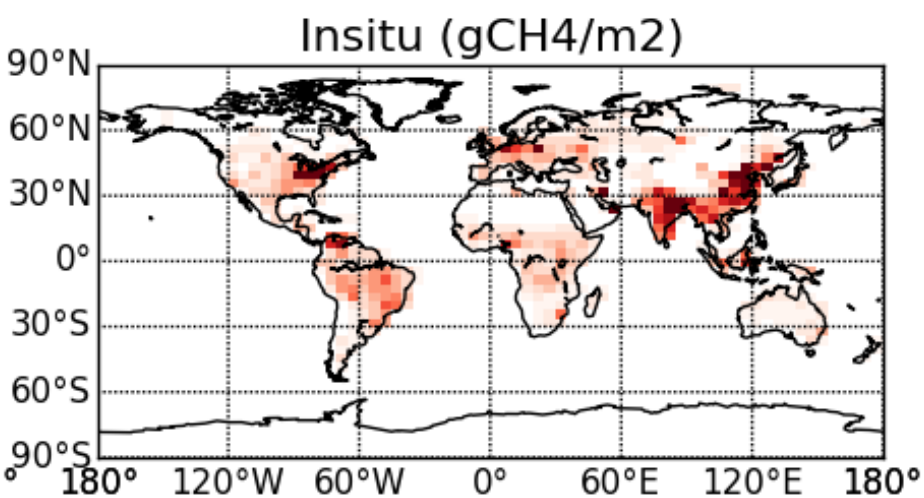
  Land: 50%; Ocean: 50%
- **CTM (Geos-Chem v9.02)**
  - ✓ Vertical Res: 47 levels from surface to 0.1 hPa.
  - ✓ Horizontal Res: 4^o (latitude) × 5^o (latitude)
- **Observations:**
  - ✓ Proxy GOSAT XCH4/XCO2 UoL v7
  - ✓ In-situ CH4 from 52 stations .
  - ✓ In-situ CO2 from q stations .
- **Outputs:**
  - ✓ Monthly CO2 fluxes.
  - ✓ Monthly CH4 fluxes.

(Feng et al., *in prep*)

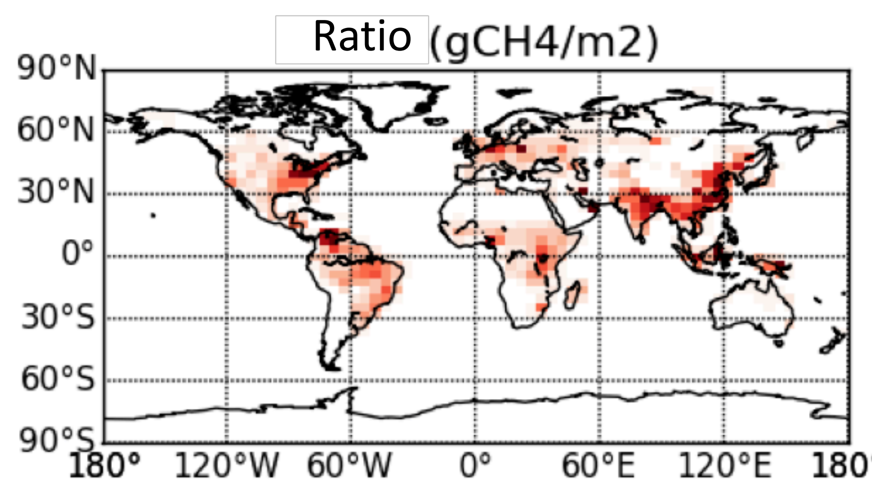
Results

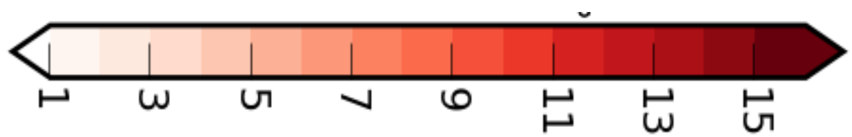


Posteriori fluxes inferred from in situ data



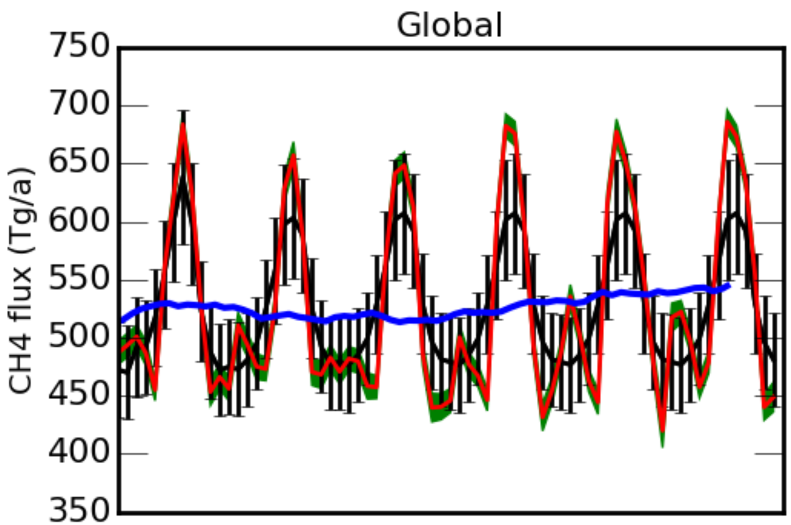
Posteriori fluxes inferred from GOSAT X_{CH4}:X_{CO2}

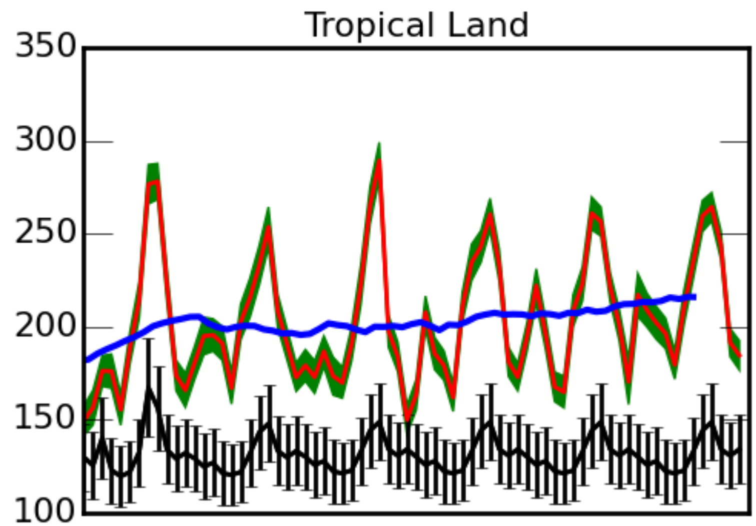


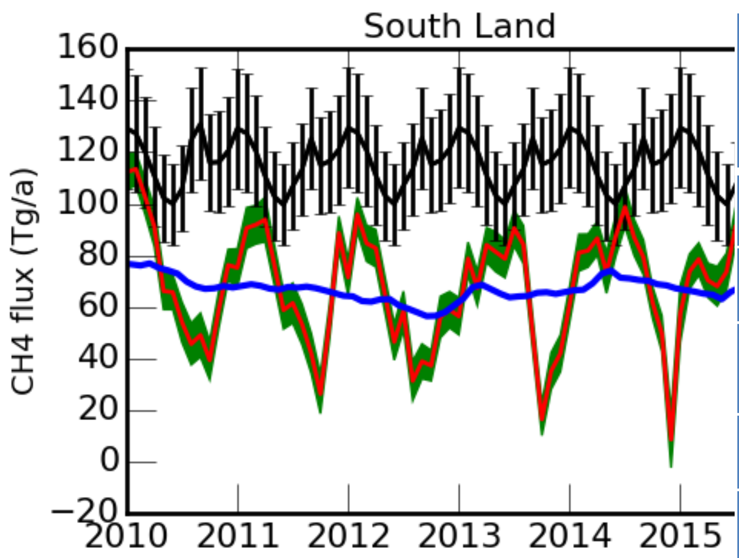


Biggest differences between in situ and GOSAT data are over tropics.

GOSAT: CH_4 flux trends, 2010-2016







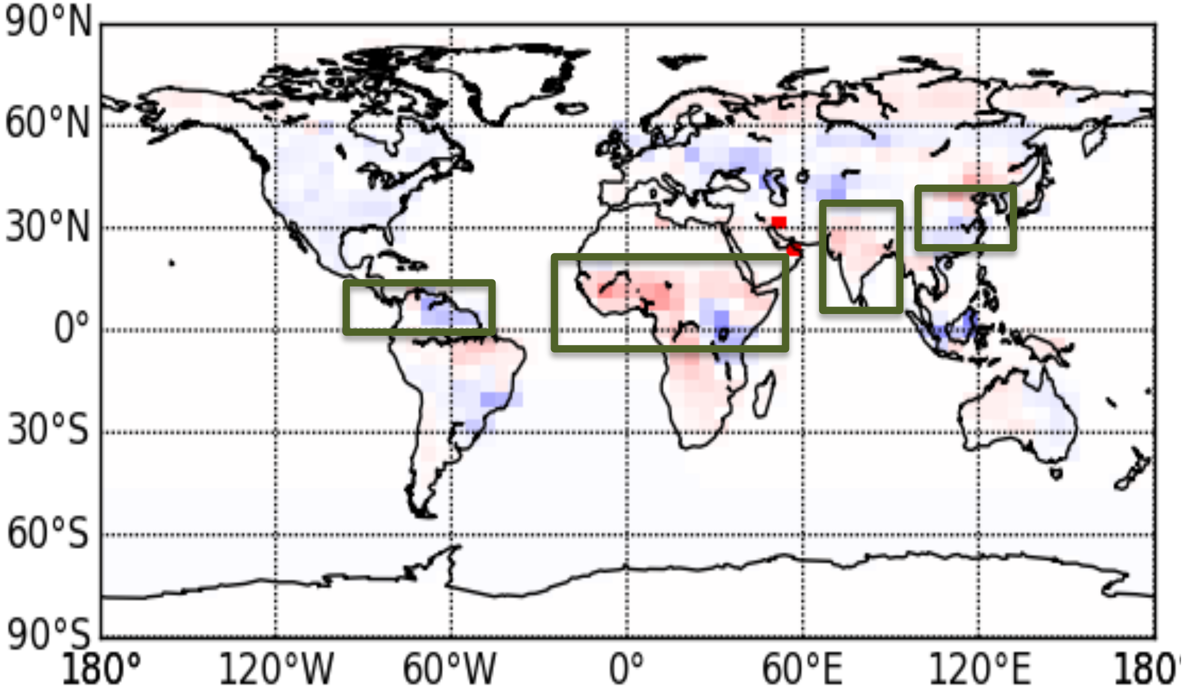
	Global (uncertainty)	Tropical_land (uncertainty)	South_land (uncertainty)	North land (uncertainty)
2010	529.74 (6.86)	194.34 (6.01)	72.91 (4.81)	238.50 (5.06)
2011	519.19 (7.31)	200.38 (6.18)	67.74 (5.04)	227.14 (5.21)
2012	515.54 (7.17)	198.28 (5.99)	60.56 (4.69)	233.53 (5.35)
2013	522.54 (6.83)	202.63 (5.53)	63.69 (4.64)	232.29 (5.19)
2014	536.66 (7.01)	207.12 (5.78)	71.32 (4.90)	233.47 (5.17)
2015	542.39 (6.75)	215.95 (5.70)	65.94 (4.87)	235.23 (4.95)

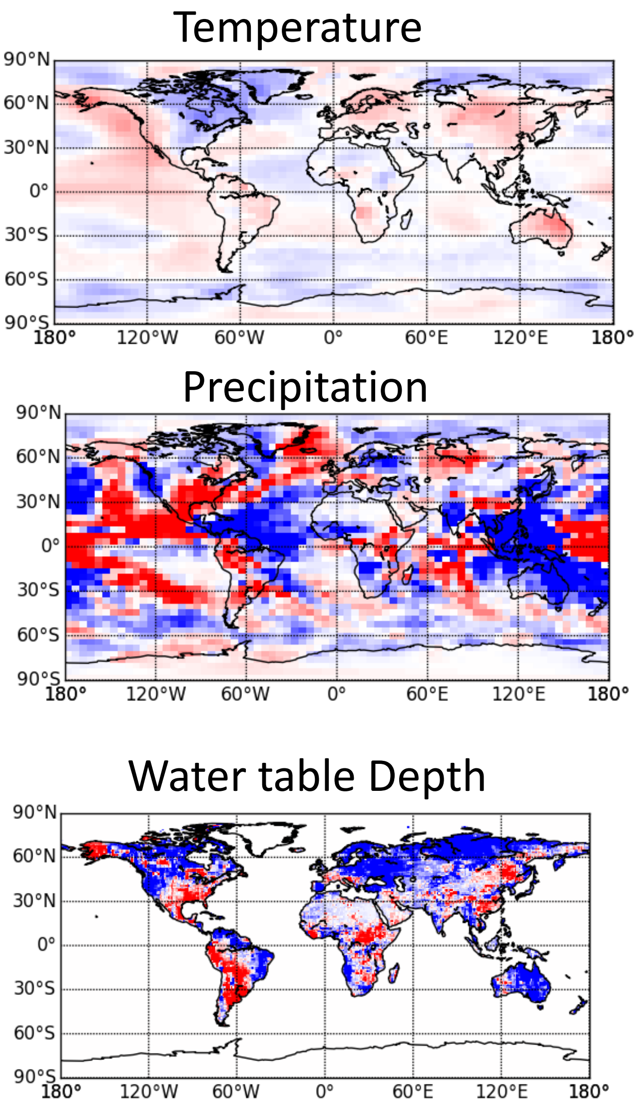
Global emission growth is dominated by tropical lands

Tropical Hot spots:

CH_4 emission Difference:

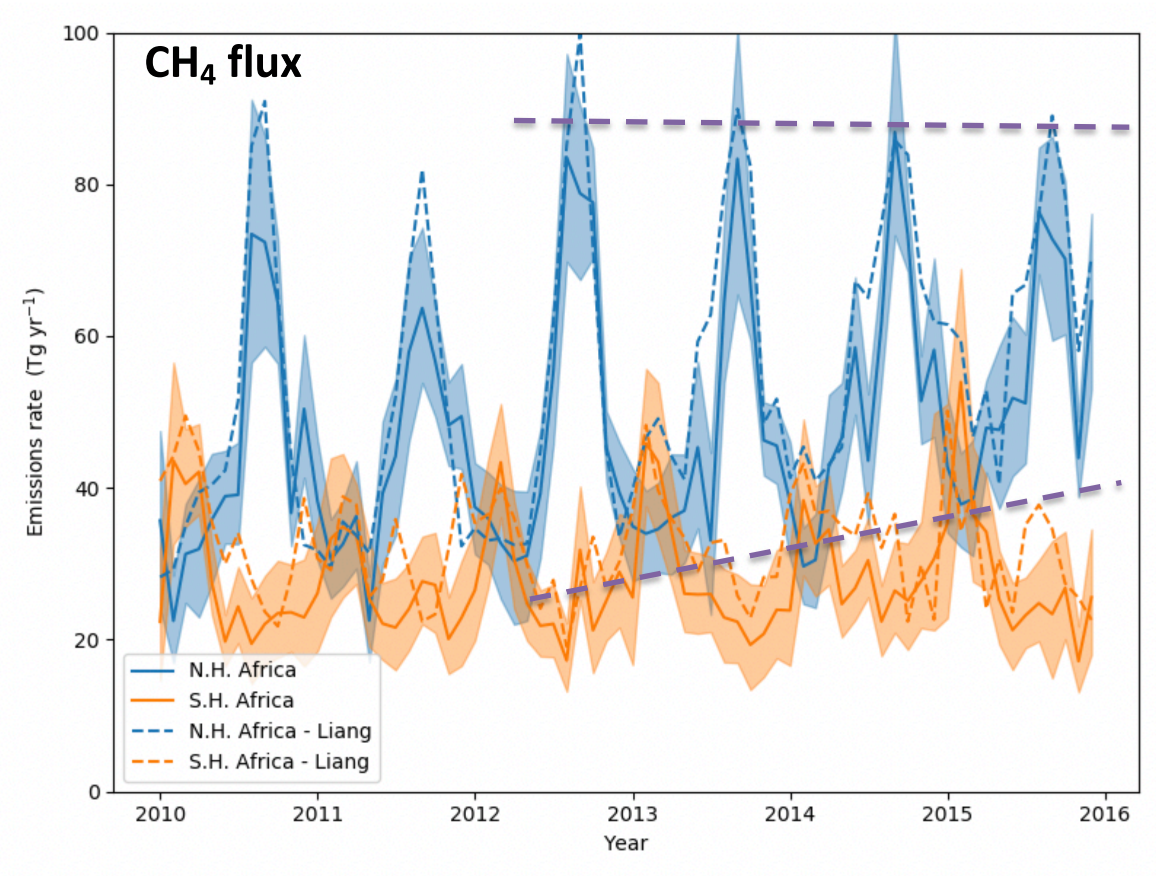
Mean(2013—2015) minus Mean(2010—2012)

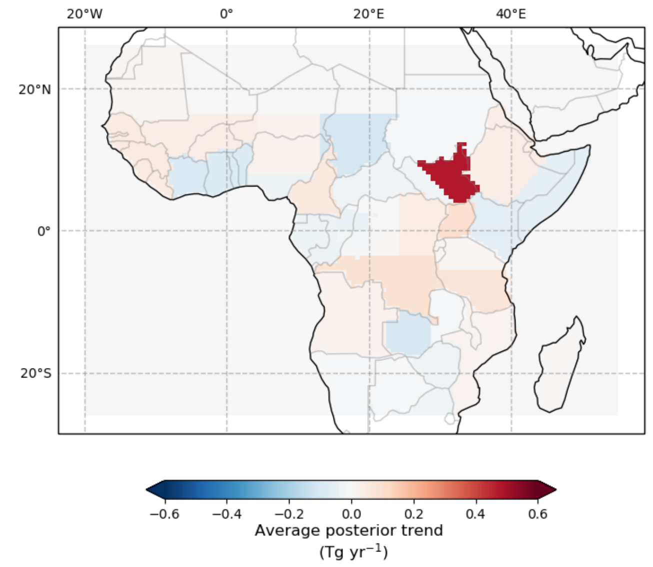




Correlation with environmental changes

➢ Tropical Africa

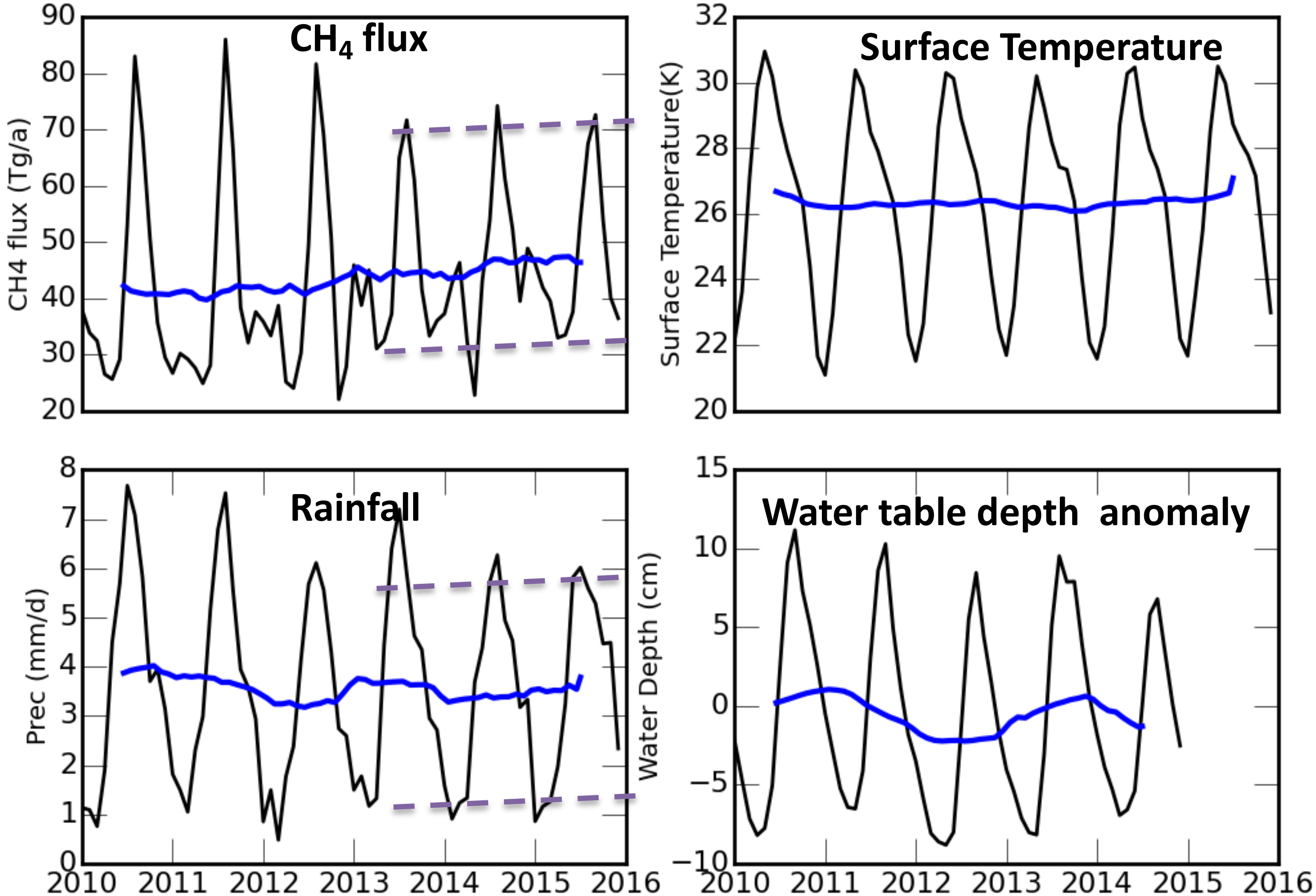




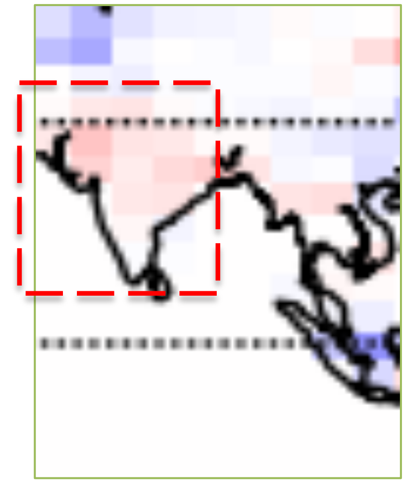
Emission trend:

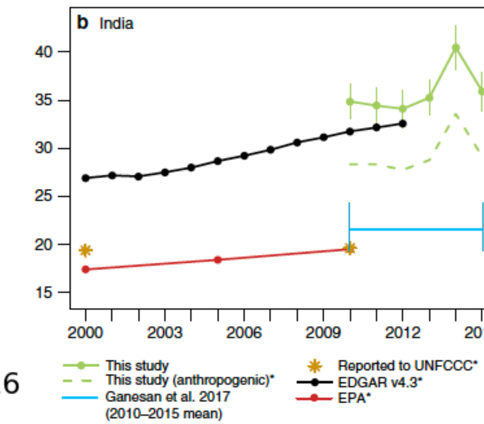
- agrees with nested high-resolution inversion (Lunt et al., 2019).
- mainly caused by expanded Sudd wetland (Lunt et al., 2019).
- temporary increase sufficient explain 25% of global increase in CH_4.

India



Emission change

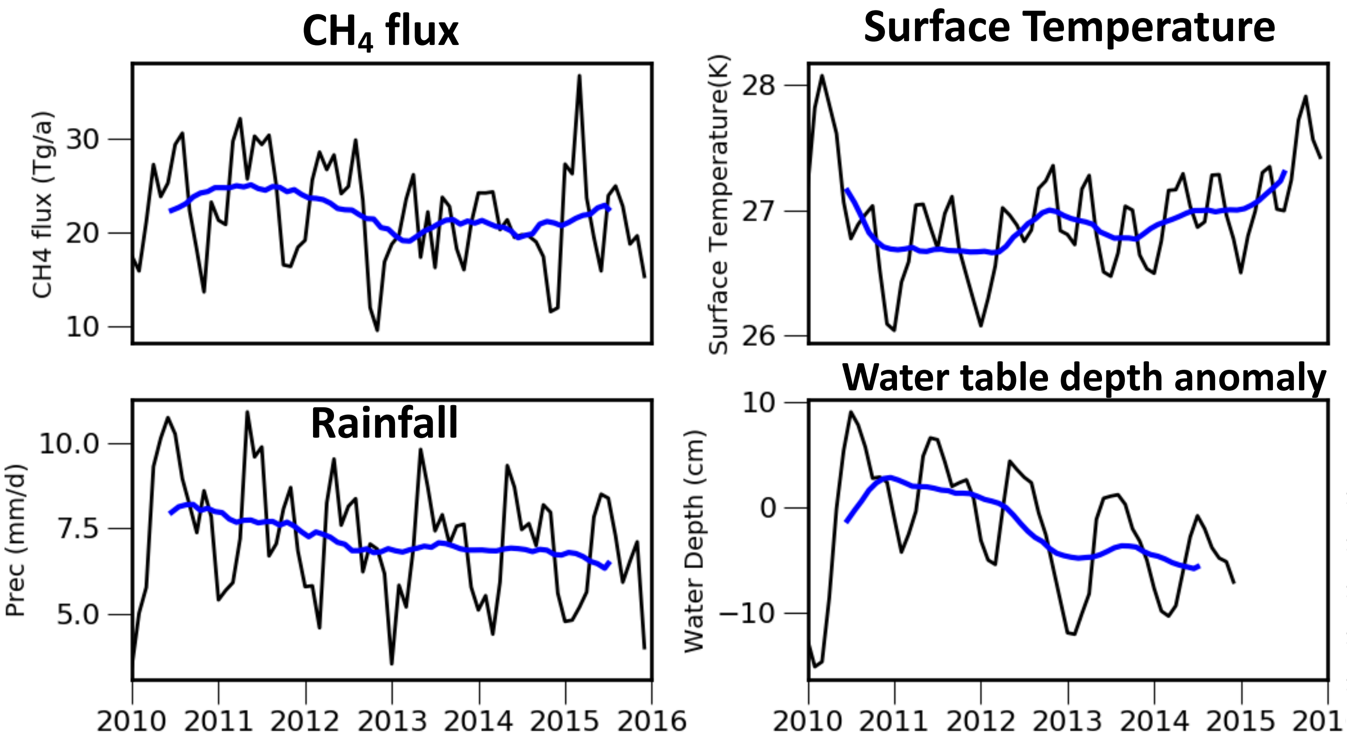




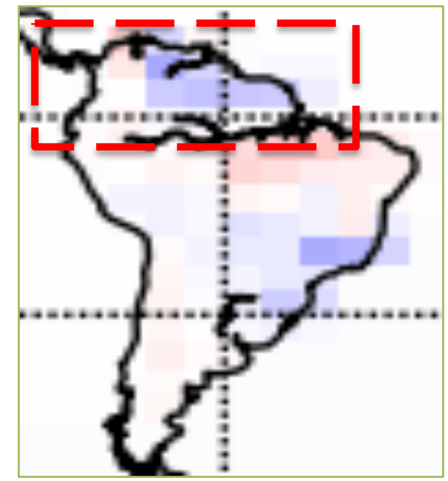
Miller et al., 2019

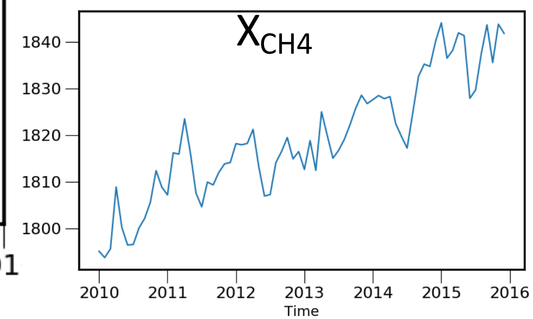
- Small annual increase from 2012, but without spike in 2014 as reported by Miller et al (2019)
- Smaller seasonal cycles (max and min) for both CH_4 fluxes and precipitation in 2013-2015.

West and East Amazon



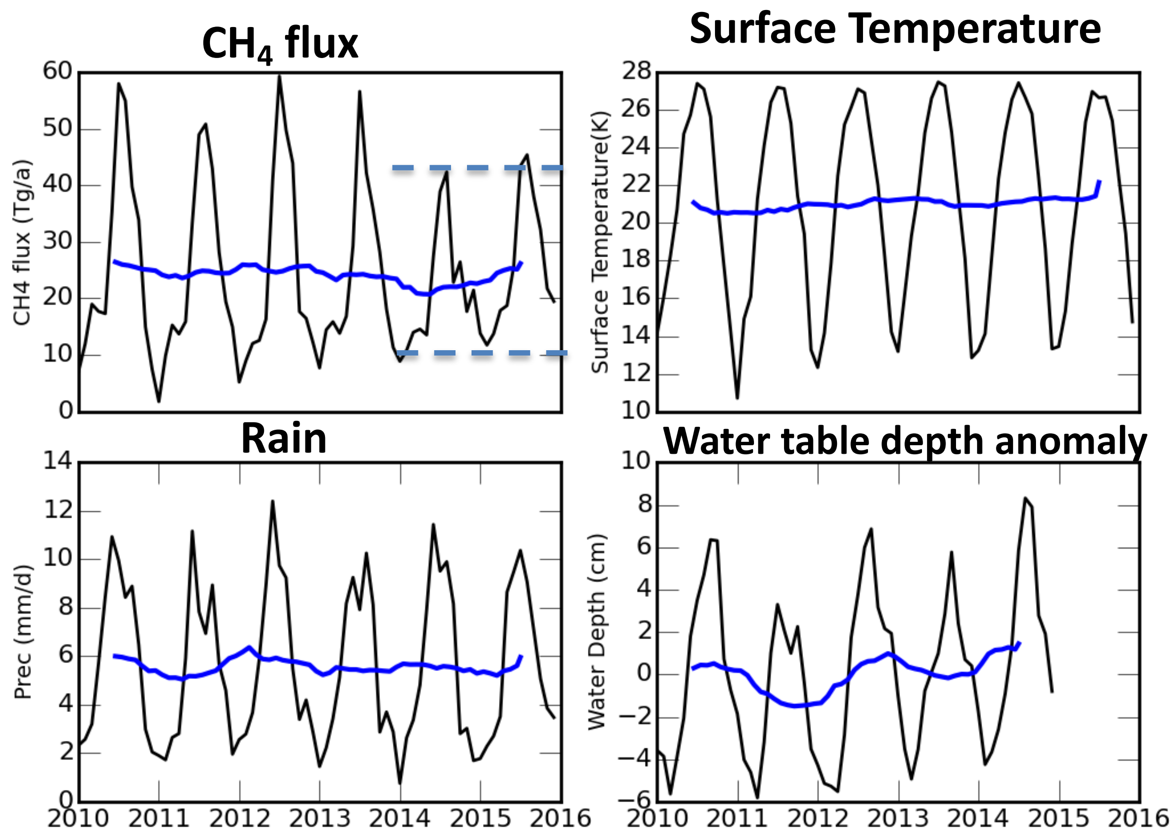
Emission Change



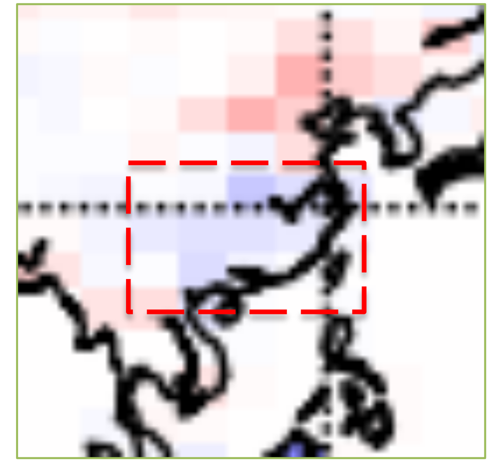


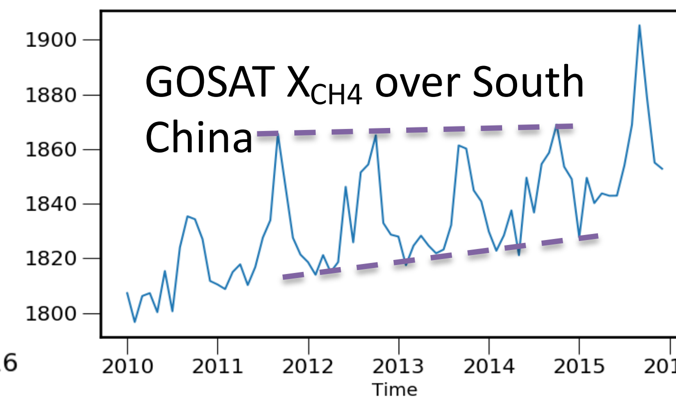
- Highest emission at mid 2011, following 2010 floods (Parker et al.,. 2018).
- Negative trend down till 2013, consistent with precipitation (and water table depth) changes.
- After 2013, emission goes up following the increase of water table depth.
- Spike seen at early 2015 in both GOSAT X_{CH4} and posterior fluxes.

Southern China



Emission Change





1) Emission peak reached its highest at 2010 and 2013 summer following 2010/2013 flooding
2) Emission peak goes down when summer precipitation goes down.
3) Seasonal cycle between for 2014 and 2015, much smaller than previous year.

China flooding causes worst death toll in decade

Closing remarks

- We directly use X_{CH4}:X_{CO2} proxy product to help minimize bias in flux estimates
- Our EnKF approach simultaneously estimates CH_4 and CO_2 regional fluxes.
- Primary results show growing CH_4 emissions from tropical continents, where Africa dominates the pan-tropical signal
- We find variations in tropical continental fluxes are strongly influenced by hydrological conditions.