Regional scale trends in CO_2 and CH_4 fluxes (checks using OCO-2 and GOSAT)

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環境省 Ministry of Environment, Suishin-hi

Talk outline

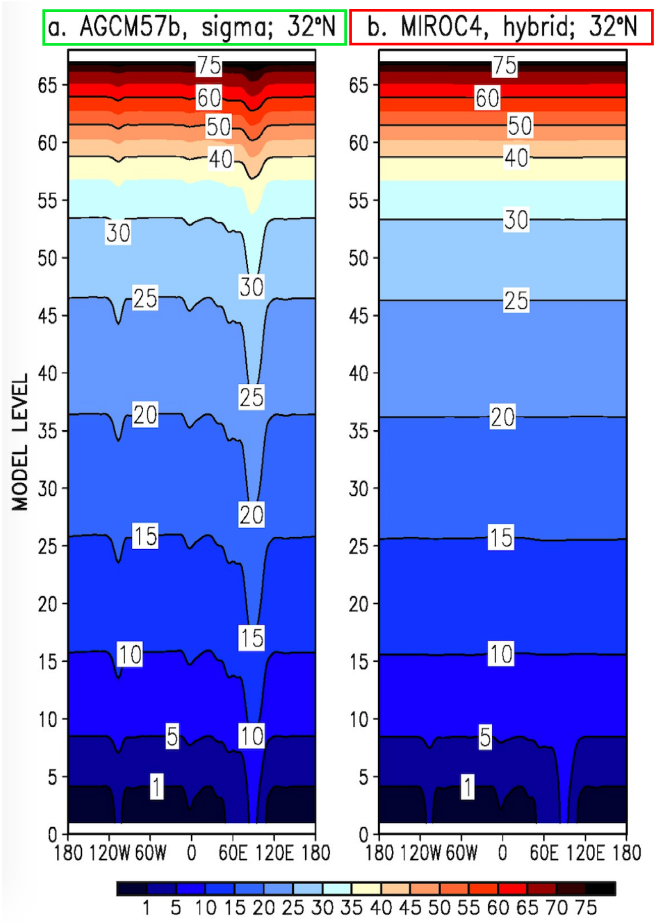
- Development of forward model MIROC4-ACTM (MACTM) for greenhouse gases research

- CO_2 fluxes from in situ data inversion
  - Comparisons of XCO_2 from OCO-2 and GOSAT for spatial gradients and time series

- CH_4 emissions from in situ data inversion
  - Comparisons of XCH_4 from GOSAT for spatial gradients and time evolution

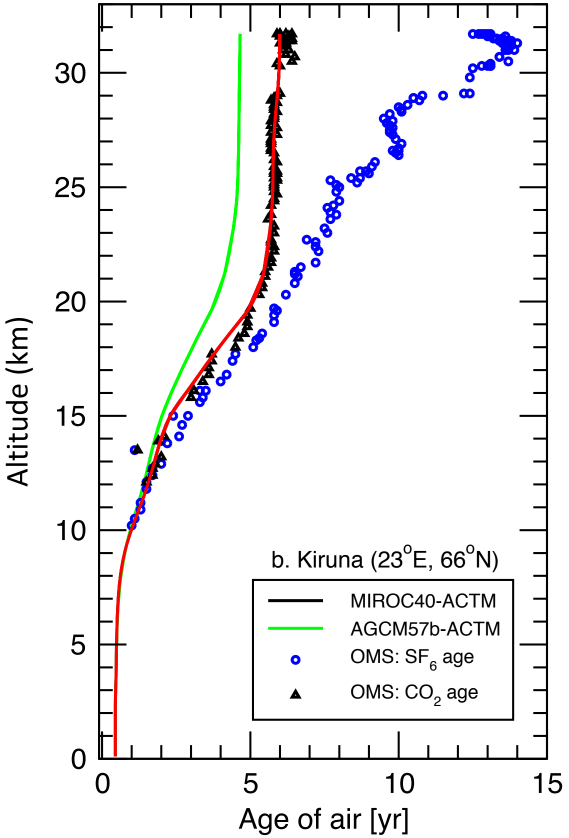
- Conclusions

Development of MIROC4-ACTM@JAMSTEC for better transport and chemistry



Geopotential height (km)

Age of air **for XCO_2**??
(polar stratosphere)



Ray et al., JGR, 2017
Patra et al., SOLA, 2018

The **AGCM5.7b** atmospheric general circulation model (Numaguti et al., 1997; Patra et al., 2009)

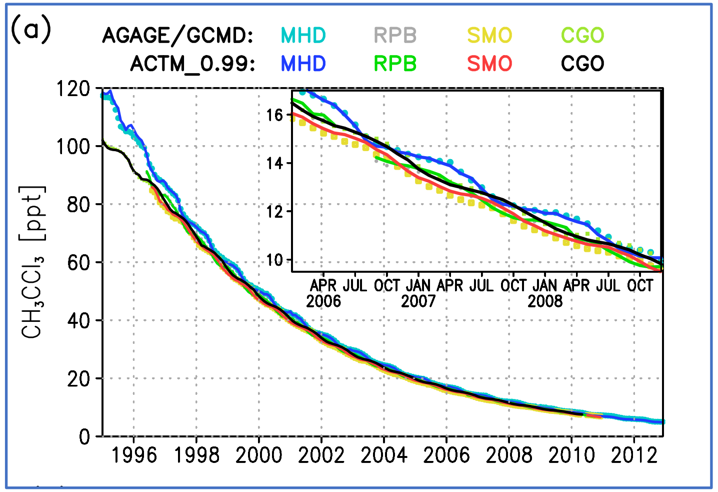
The **MIROC4.0** atmospheric general circulation model (Watanabe et al., 2008; Patra et al., 2018)

Horizontal resolution: T42 (2.8x2.8°) or T106 (1.1x1.1°)

Vertical coordinate : 67 hybrid (p-sigma & pressure)

Meteorology nudged to JMA 55-year Reanalysis (JRA-55; Kobayashi et al., JMSJ, 2015)

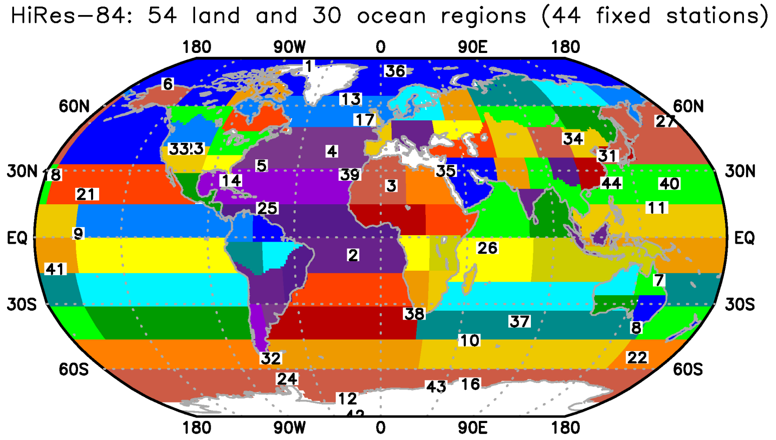
Species simulated: Transport tracers: ^{222}Rn, SF_6
Greenhouse gases: CO_2, CH_4, N_2O
Chemistry (OH) tracer : CH_3CCl_3

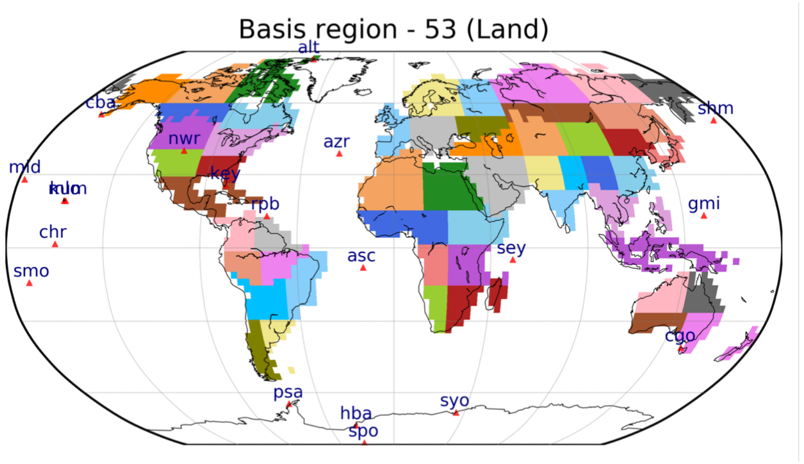


CH_3CCl_3 simulations suggest the validity of global mean OH abundance and NH/SH OH ratio (Patra et al., 2014)
-- for XCH_4

Inversions using MACTM & X-data processing

- CO_2 inversions are done for 54 land and 30 ocean regions (top)
  - Non-fossil fluxes are optimized, fossil fuel emissions assumed known!
  - using data from 42 sites (surface only) from NOAA & JMA
  - data from 67 sites (surface + CONTRAIL Tokyo-sydney flasks)
  - same MIROC_CTL, but using lower FF emission over China
- CH_4 inversions are for 53 land regions (bottom)
  - Total CH4 emissions are optimized, sectorial information from a priori
  - Using data from 35 sites (surface only) from NOAA
- MACTM forward simulations are conducted for the inversion fluxes, and model is sampled at the time (within 30 min) and location (within 1.4^o) of measurements
- All satellite data are gridded in to 2.5 x 2.5^o before plots are made (e.g., Patra et al., Sci. Rep., 2017).

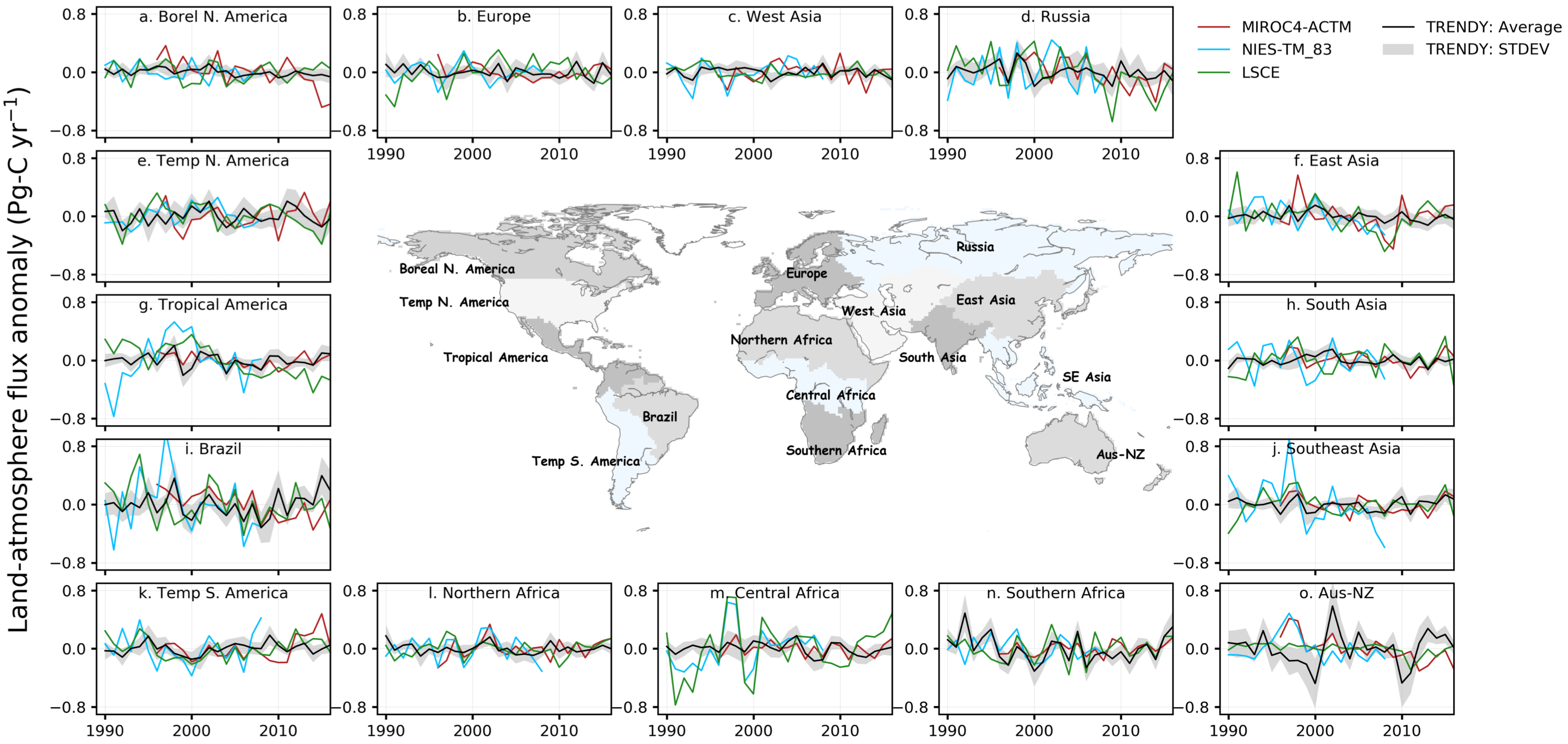




NOAA flask data (Dlugokencky et al.) are mainly used in both the inversions

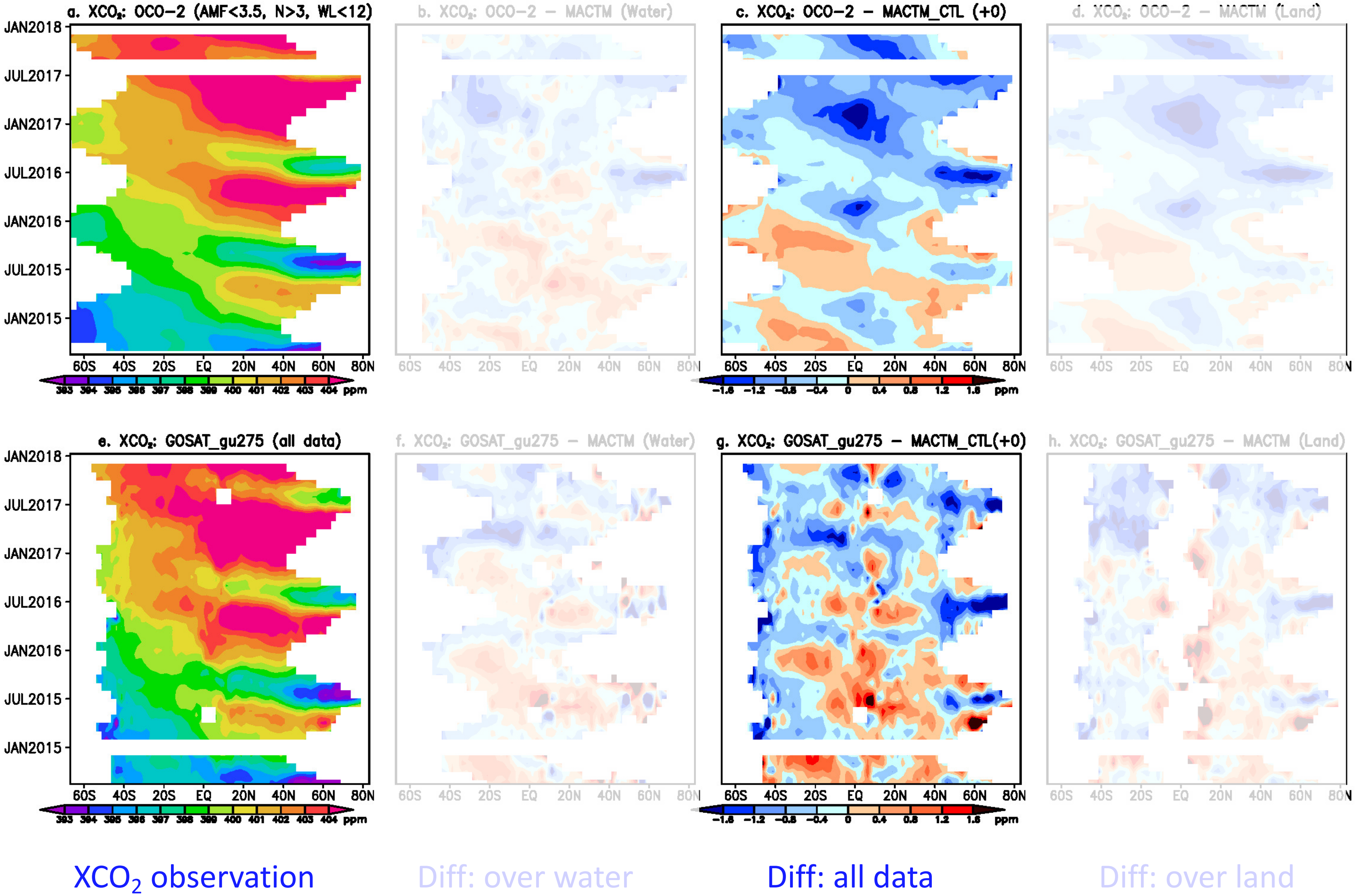
Natural CO_2 fluxes at subcontinental scale

LSCE: Chevallier et al.
TRENDY: Sitch et al.



Analysis in progress (plot courtesy of Naveen Chandra)

Comparisons of MIROC4-ACTM with OCO-2 (top row) and GOSAT_GU (bottom row)



OCO-2 v9r data are processed in close collaboration with OCO-2 science team members

GOSAT GUSub275, bias corrected data (thanks to Morino-san & NIES colleagues)

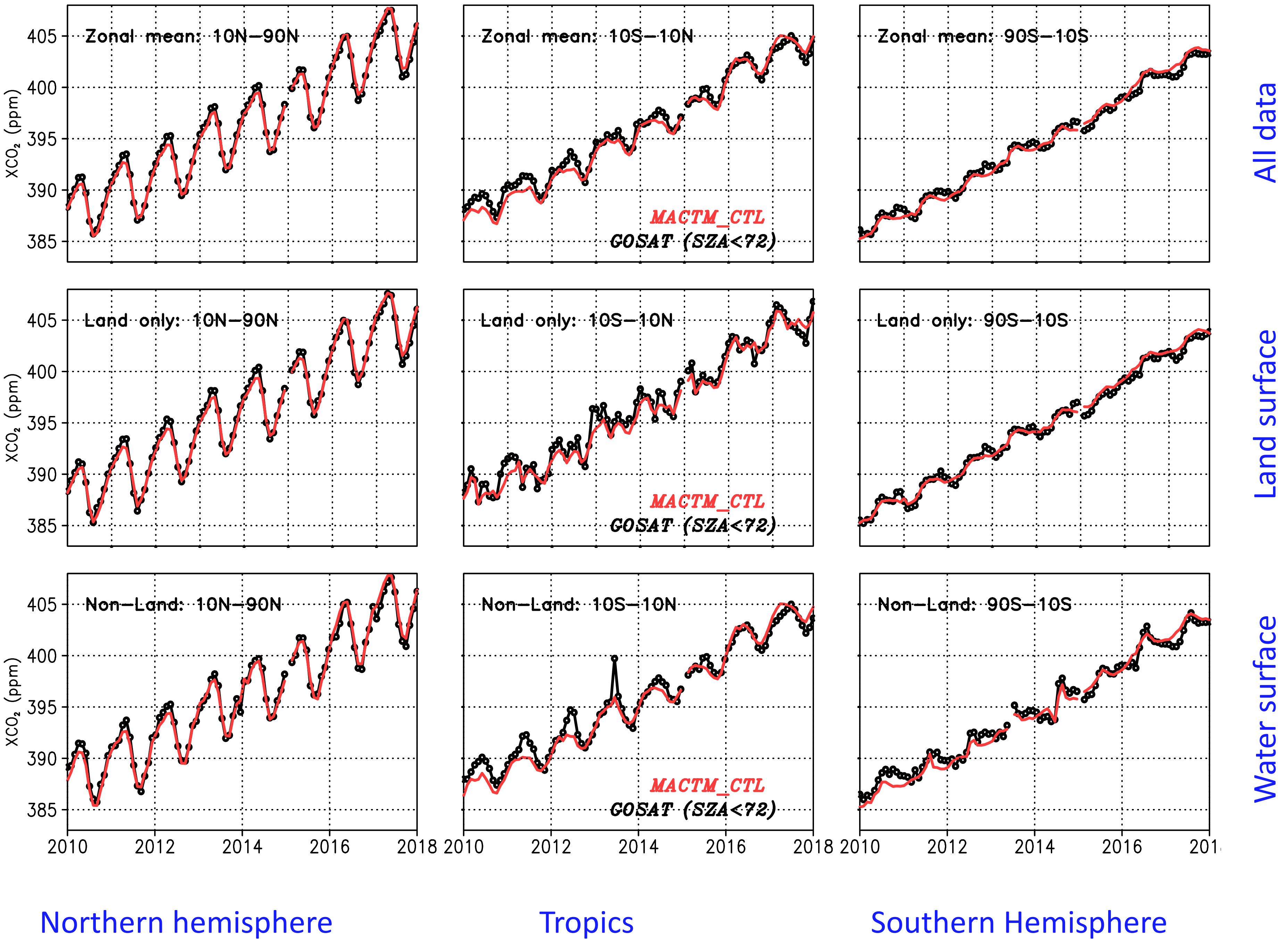
Updated from:
Patra et al., SciRep, 2017

XCO_2 time evolution for MACTM and GOSAT/NIES

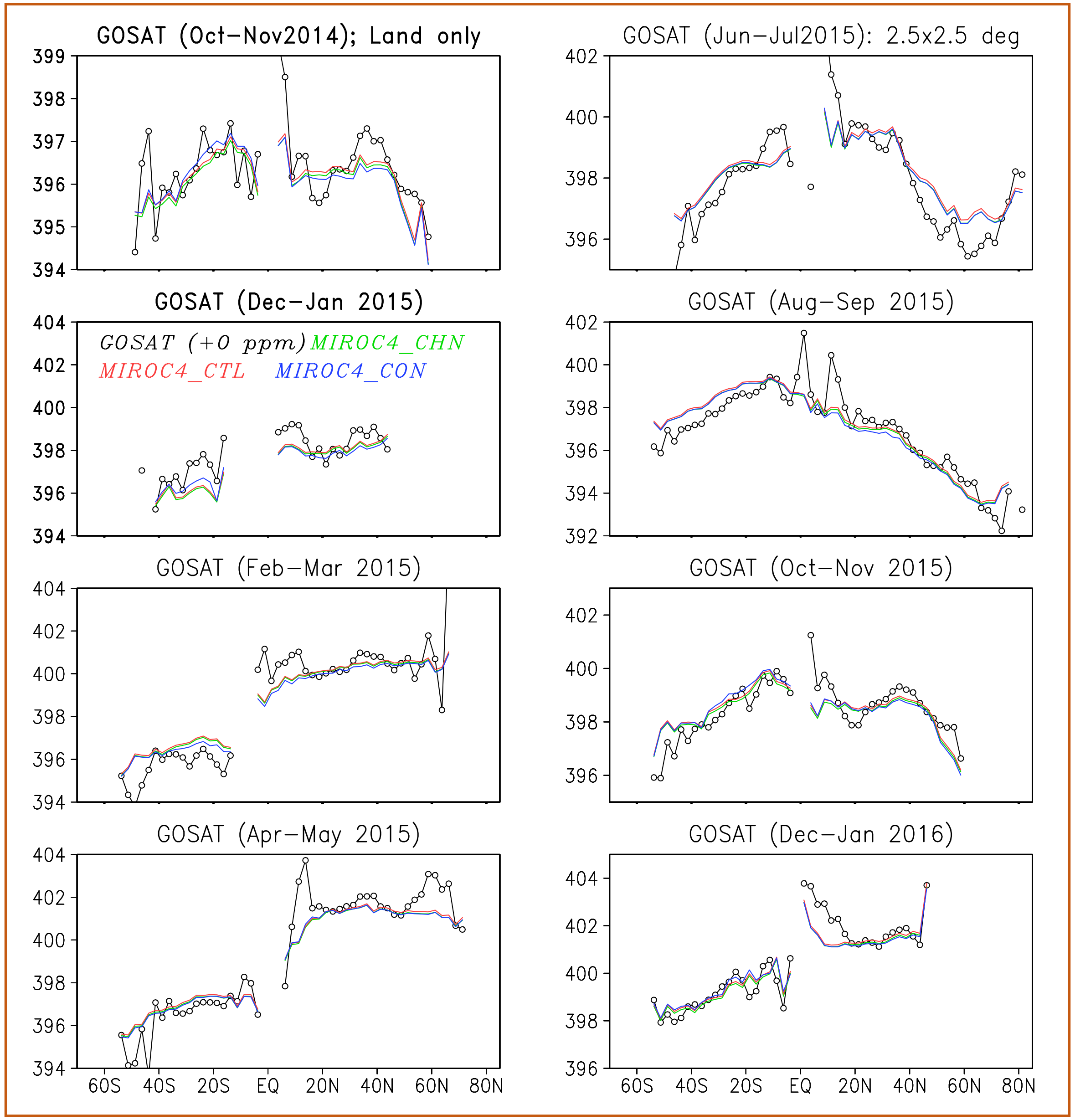
NIES-GUSub, bias corrected data, suggest reasonably good MACTM simulation, particularly for the NH (left)

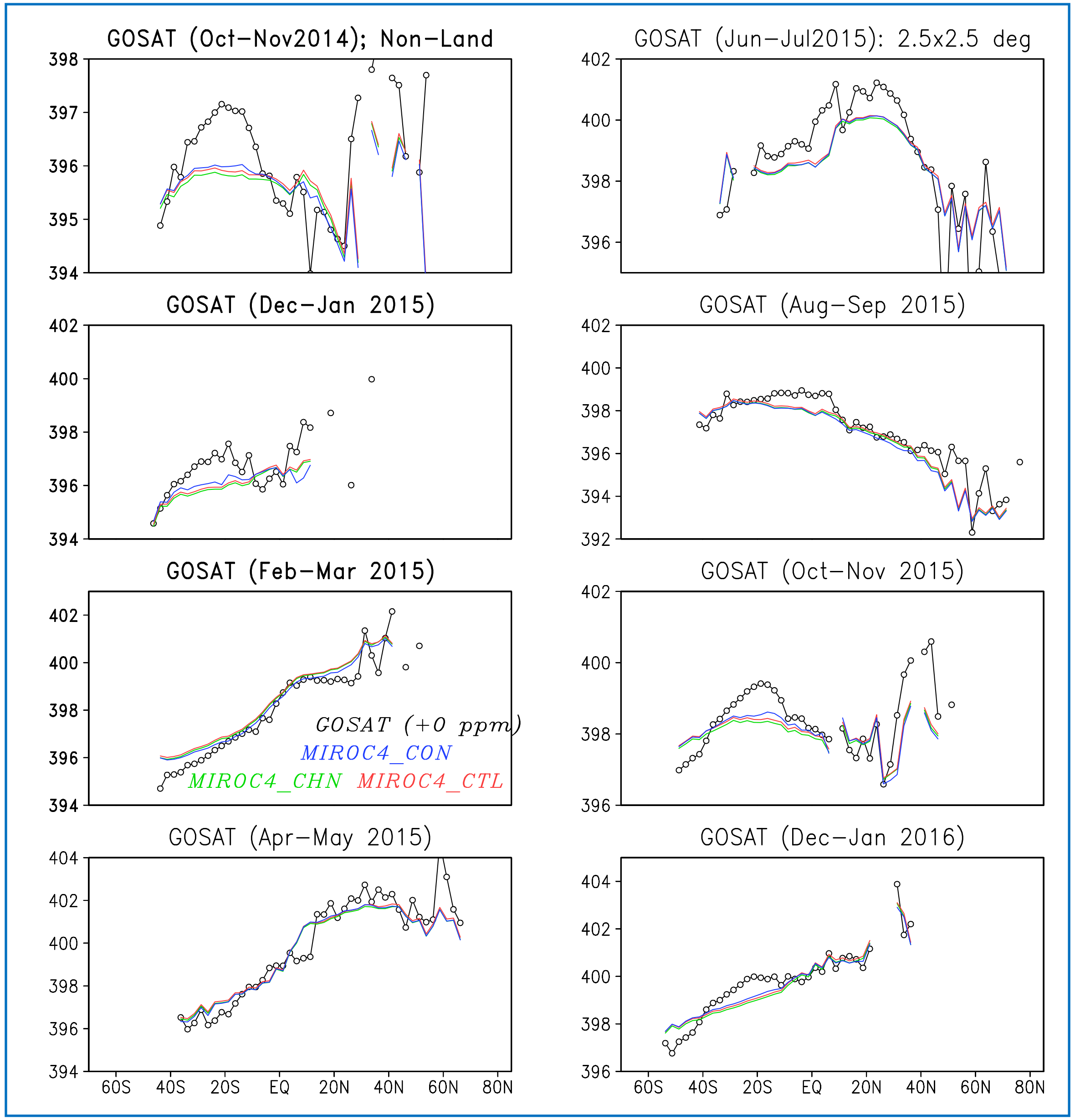
Better MACTM-GOSAT agreement for the later years over the tropics (middle)?

Slightly better MACTM-GOSAT agreement over land than ocean in the SH (right)?

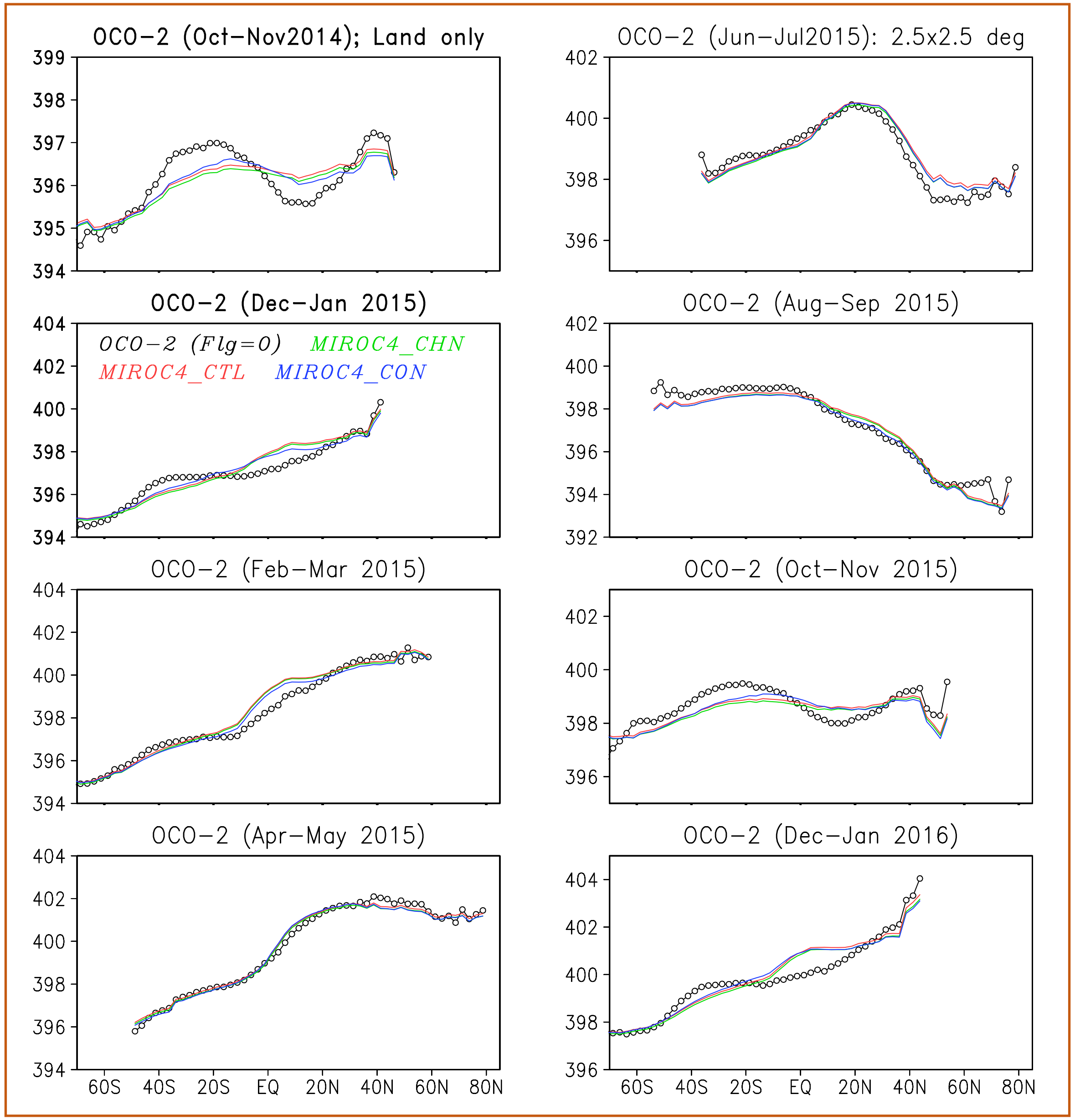


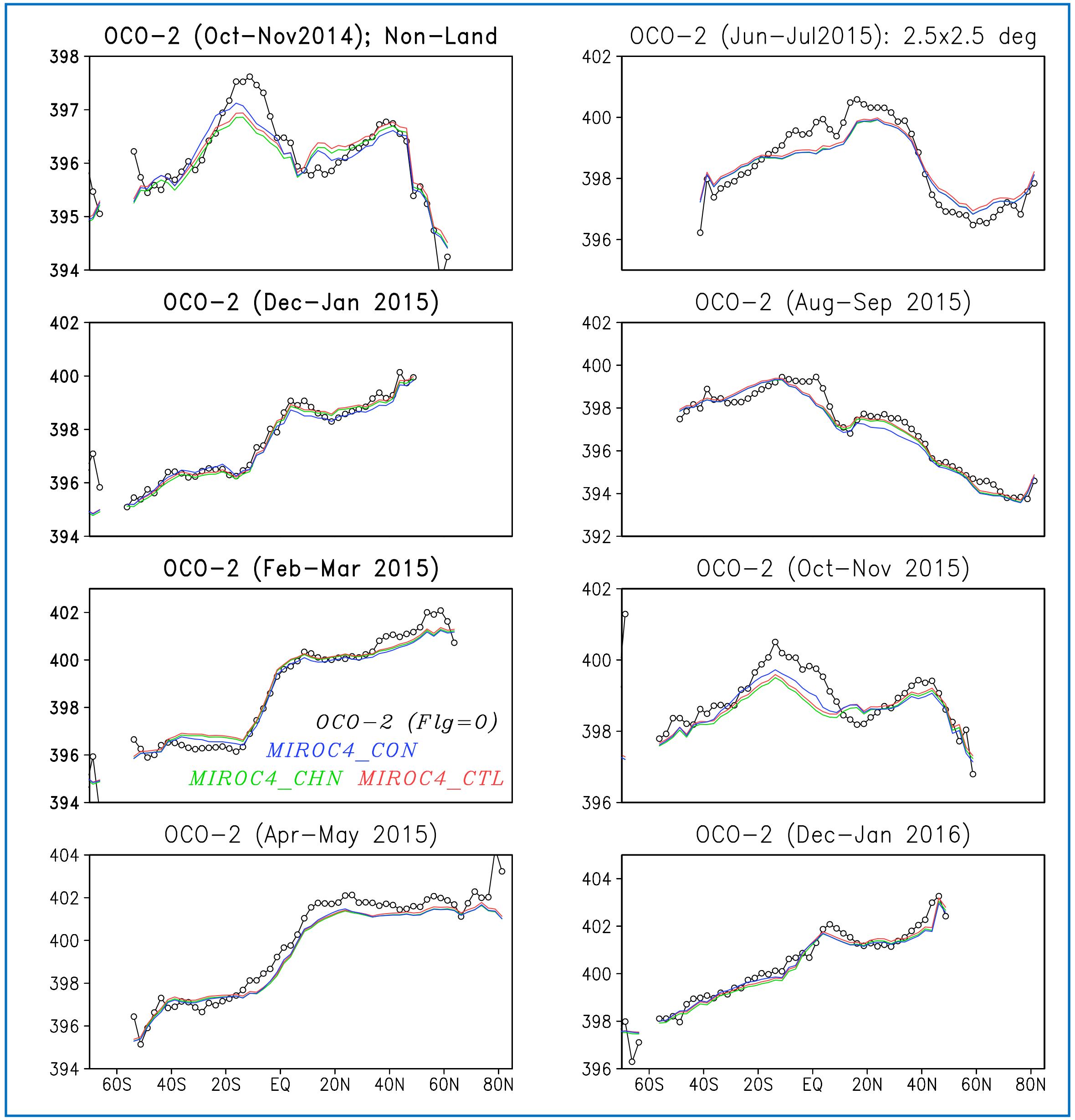
MACTM and GOSAT_GUSub275: Meridional gradients over Land (L) and Water (R) surfaces





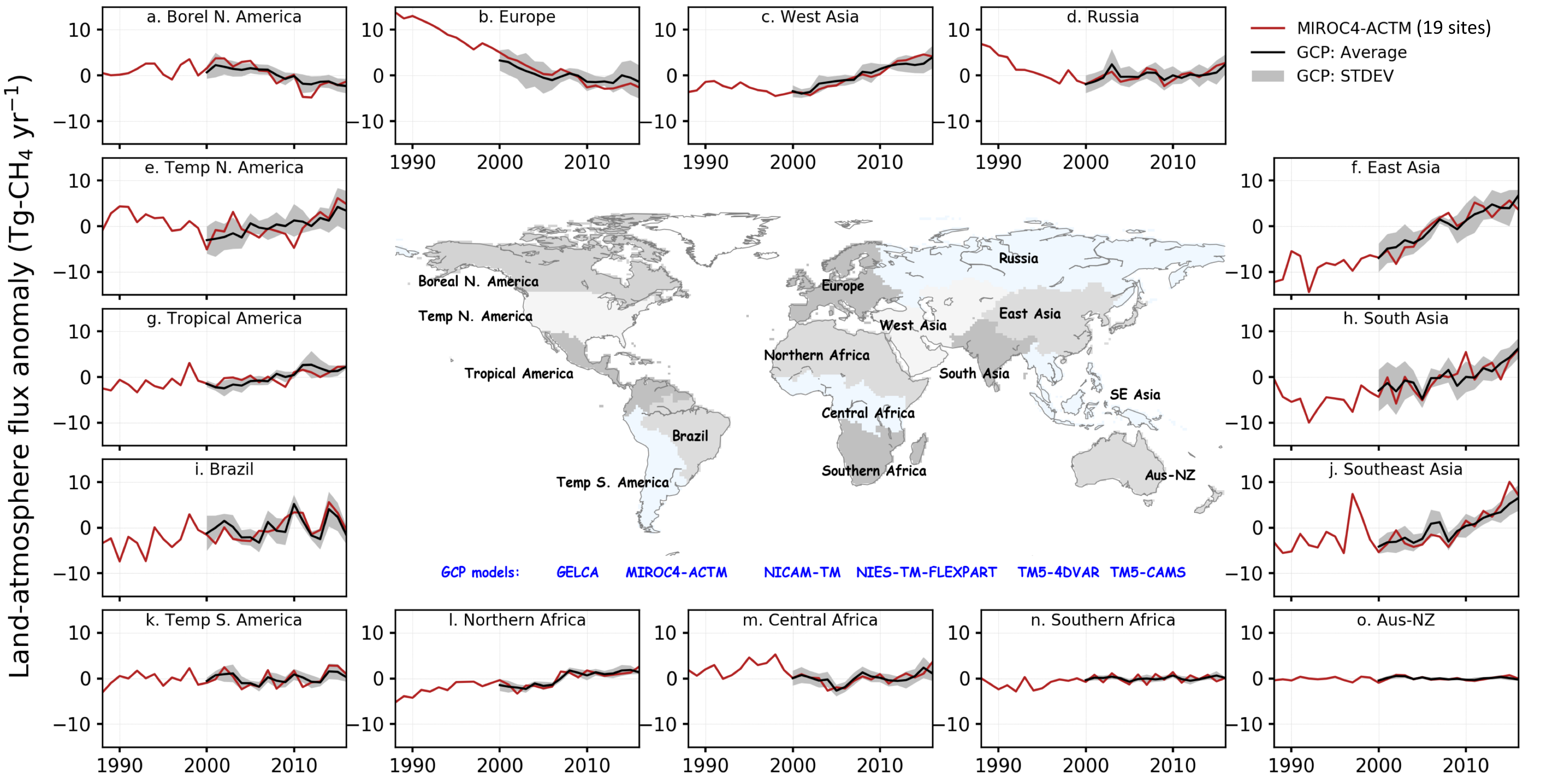
MACTM and OCO-2v9r : Meridional gradients over Land (L) and Water (R) surfaces





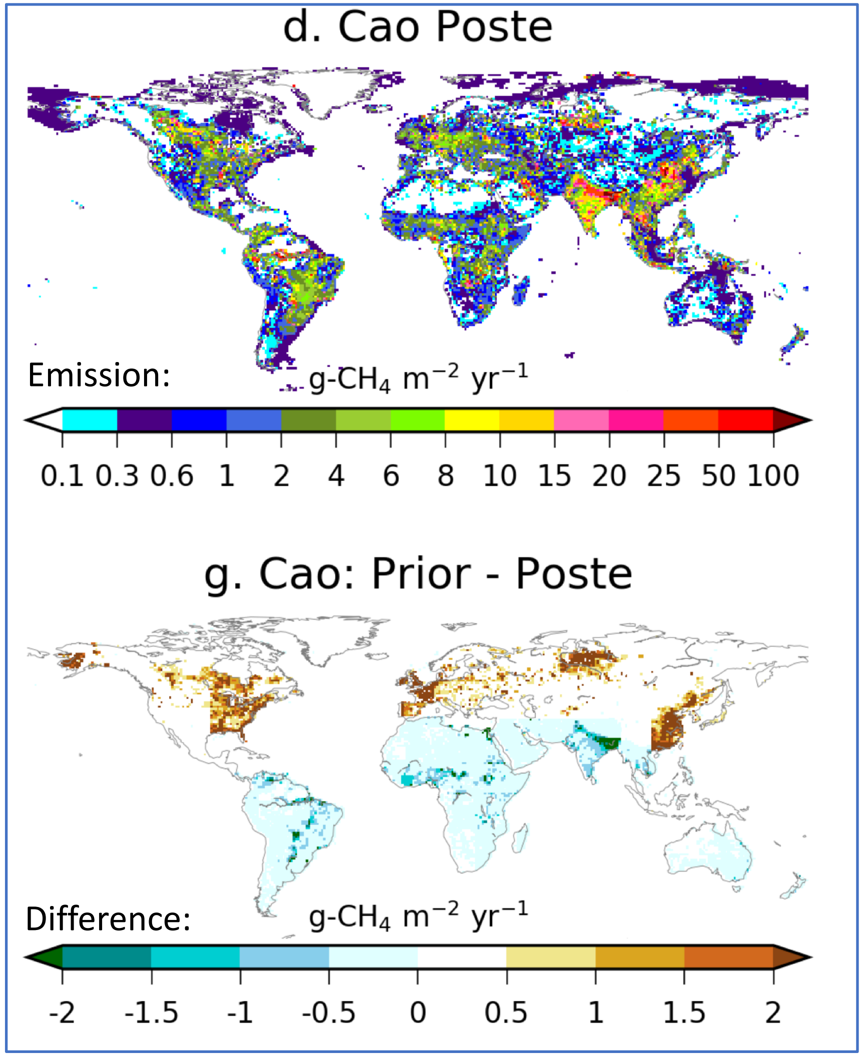
Regional CH_4 emissions and trends

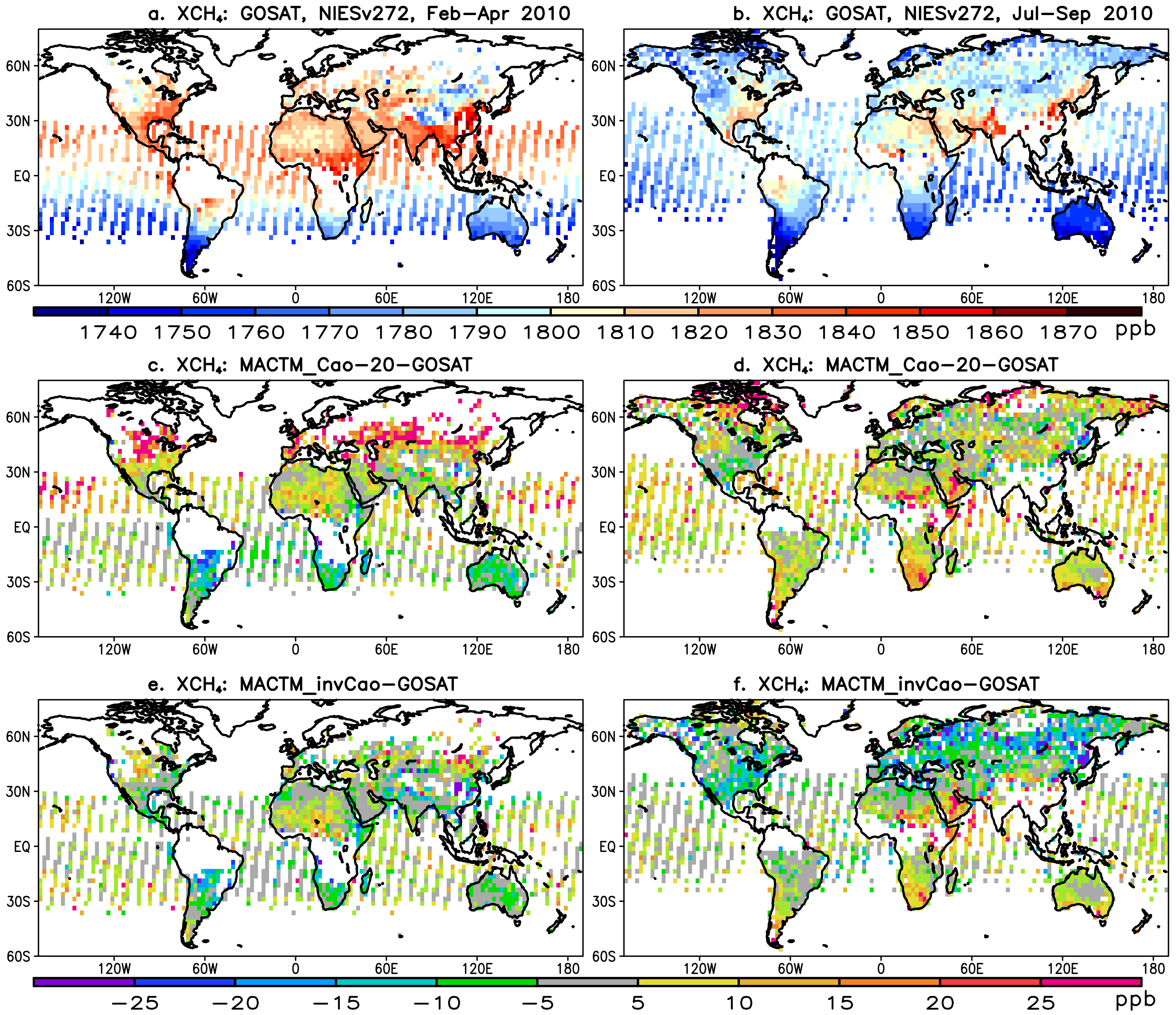
GCP: Saunois et al., in prep.



Analysis in progress (plot courtesy of Naveen Chandra)

MIROC4-ACTM and GOSAT/NIES-v272_RA XCH_4: spatial distributions

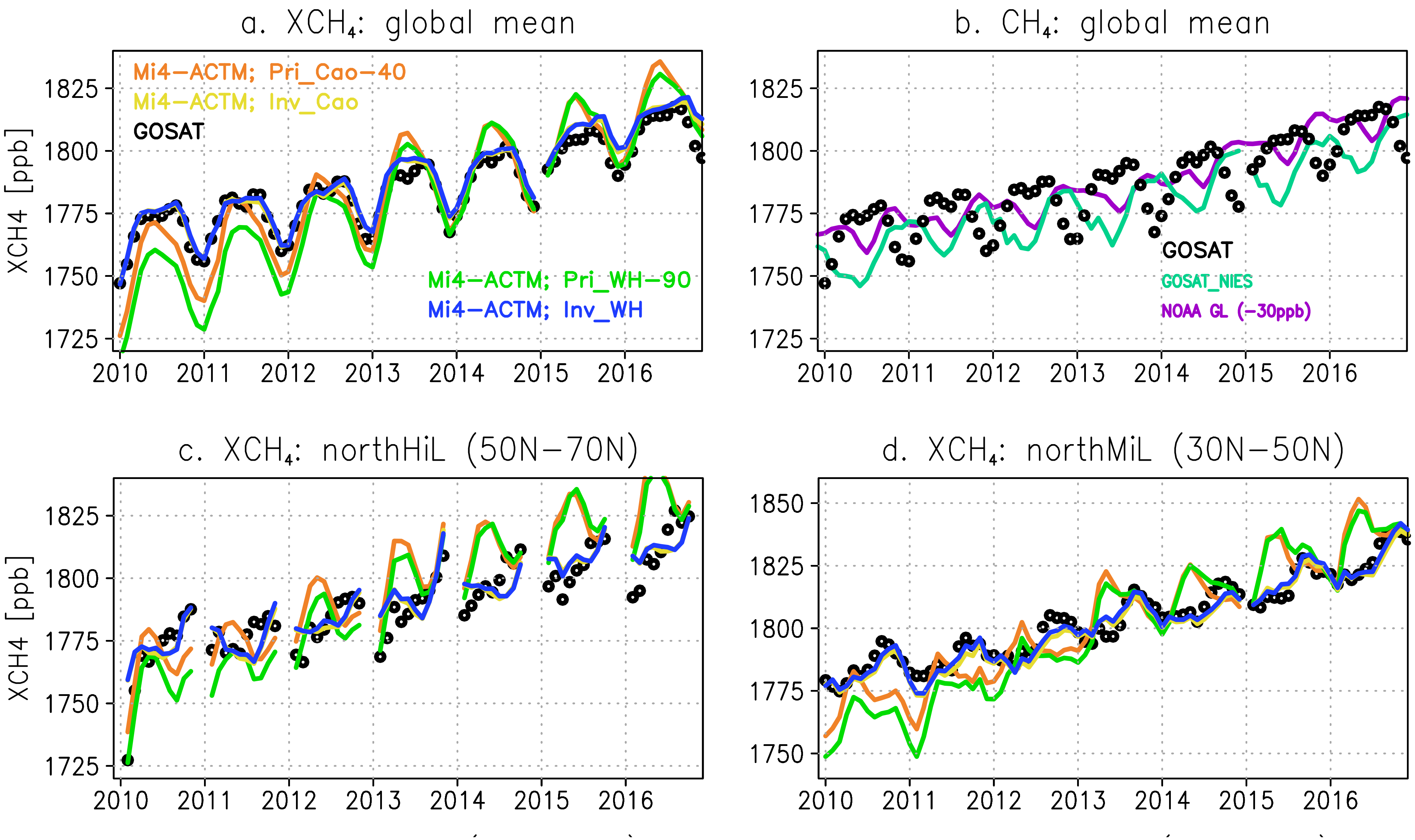




Spring

Summer

MIROC4-ACTM and GOSAT/NIES-v272_RA XCH_4: time evolution – GL/NHE

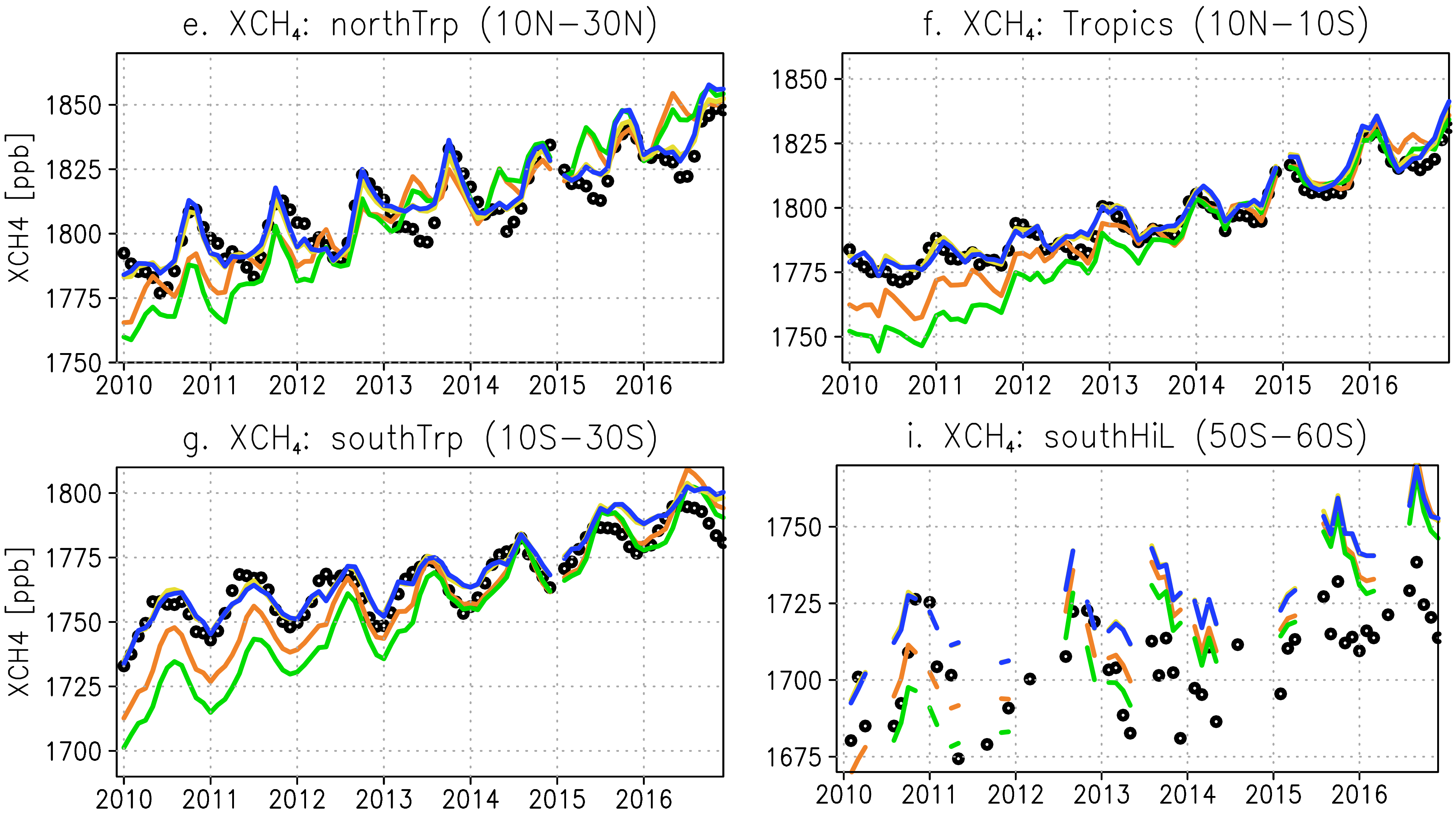


Bigger seasonal cycle in a priori simulation

… that arises from the NH high latitudes and extra-tropics

GOSAT and ACTM-Inv suggest “small” late summer peak

MIRROC4-ACTM and GOSAT/NIES-v272_RA XCH_4: time evolution – TR-SH



Similar seasonal cycles in a priori & poste simulations over the tropics and SH extratropics

The SH high latitude data seems noisy!

I should check the GOSAT-GU bias corrected data

Conclusions

- Global inversion products of CO_2 and CH_4 fluxes are estimated using MIROC4-ACTM, well-validated for transport in troposphere and stratosphere, and OH chemistry parameterisations
- Our inversion results of CO_2 and CH_4 are consistent with OCO2 (GOSAT) XCO_2 and GOSAT XCH_4 retrievals
  - Although there are only about 40 sites used in the inversions, the good model transport and chemistry helps to well simulate the basic features in XCO_2 and XCH_4 distributions and trends at global, hemispheric and regional scales
- Data screening is still an issue for the use of XCO_2/XCH_4 retrievals in “our” inverse modelling
  - The NIES GOSAT bias corrected XCO_2 GU product is quite alright!
  - Need to check XCH_4 GU product in my analysis

remote sensing

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Special Issue

Remote Sensing of Carbon Dioxide and Methane in Earth's Atmosphere

Special Issue **Editor:**

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Carbon dioxide (CO_2) and methane (CH_4) are the two most important greenhouse gases that have led to a significant fraction of the increase in earth's surface temperature in the past 100 years. This Special is dedicated to the past progress and new developments in satellite remote sensing of long-lived greenhouse gases, with a focus on CO and CH_4.

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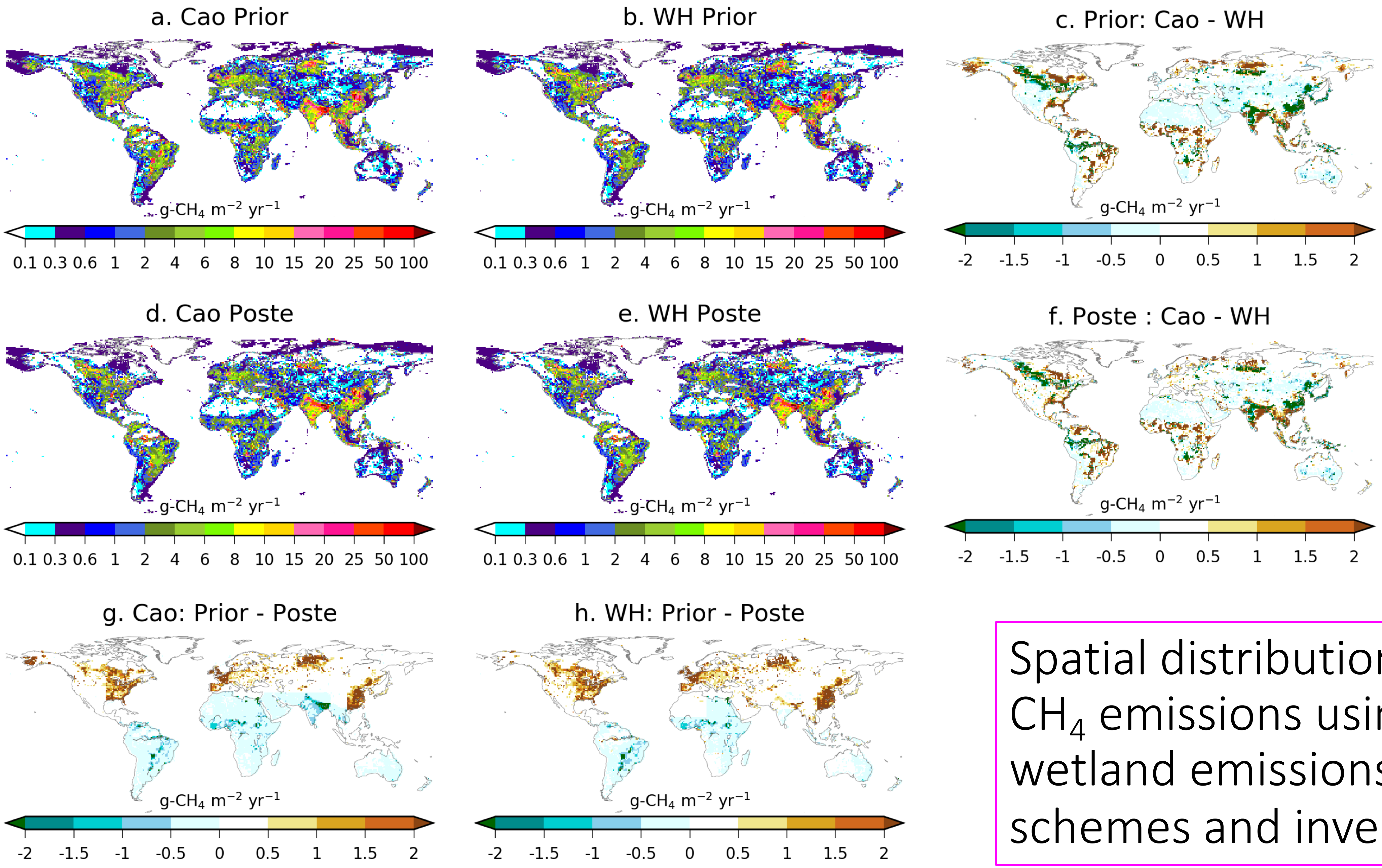
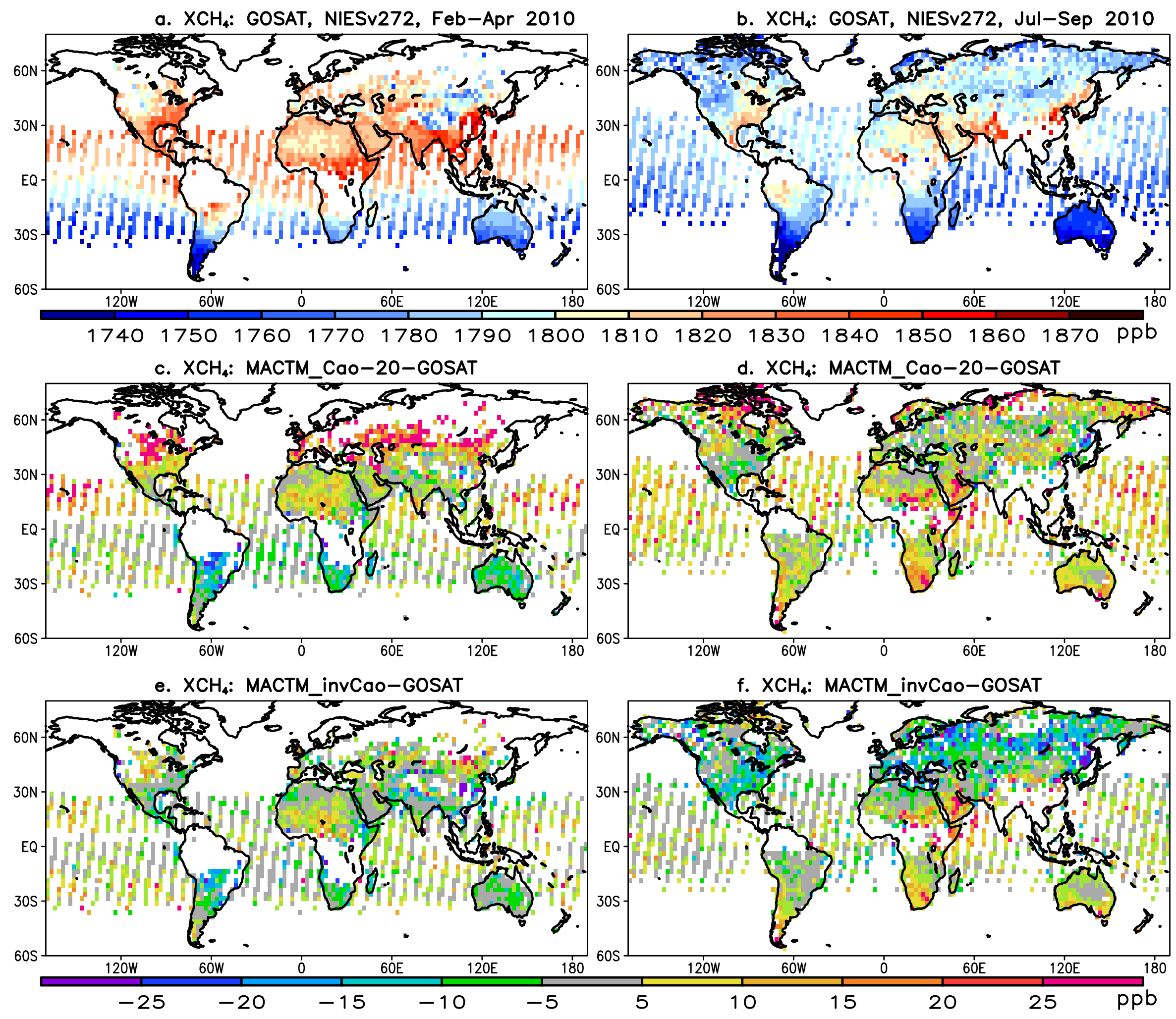
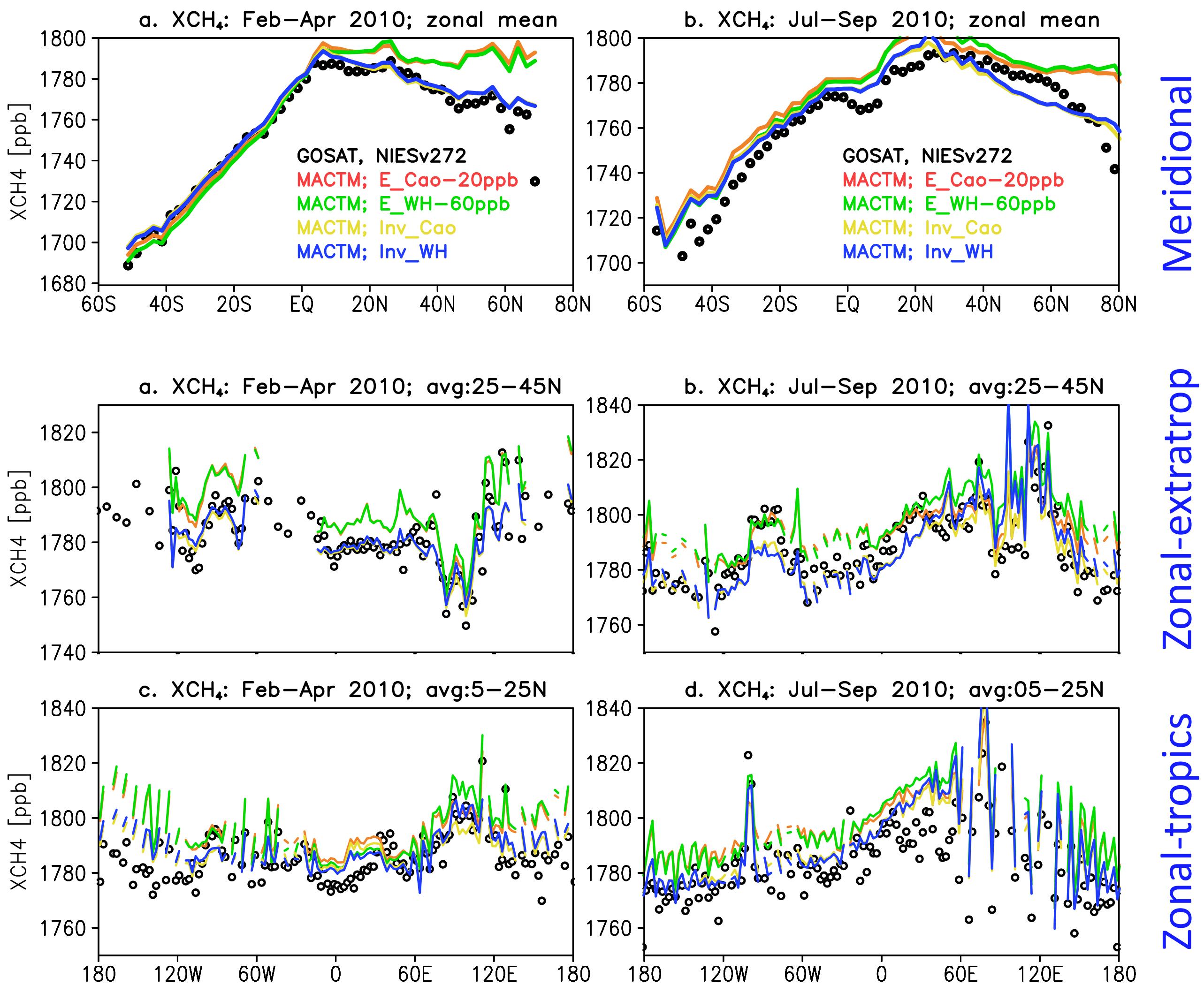


Spatial distributions of CH_4 emissions using two wetland emissions schemes and inversions

MIROC4-ACTM and GOSAT/NIES-v272_RA XCH_4: spatial distributions



Spring Summer



Spring Summer

MACTM and OCO-2v8B: Meridional gradients over Land (L) and Water (R) surfaces