Can O_2/N_2 measurements help to constrain global total fossil fuel emission?

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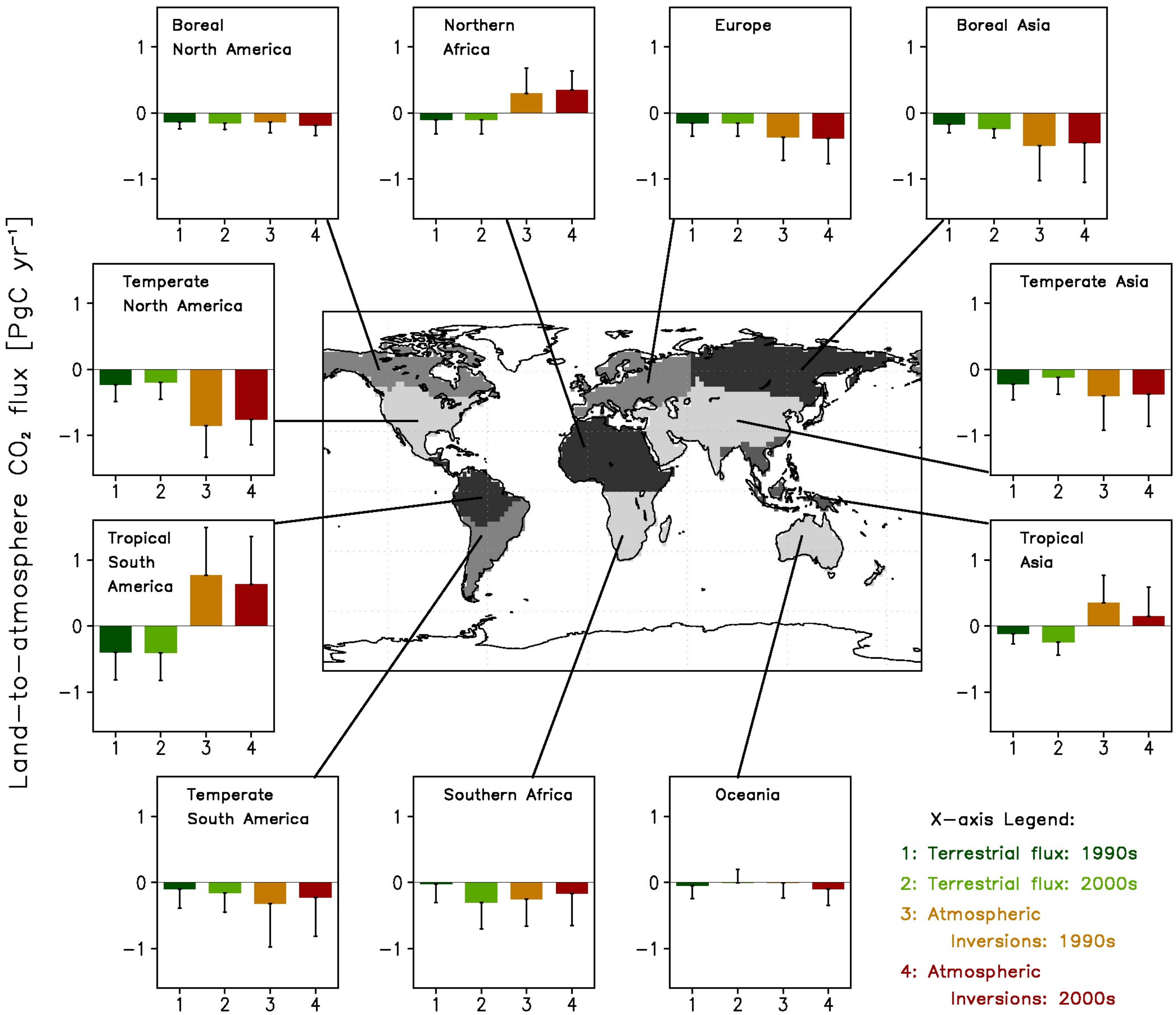
and potential collaborators

2nd Decadal APO meeting
San Diego, 18 Sept 2015

Background: Synthesis of Land fluxes from TDIs and DGVMs

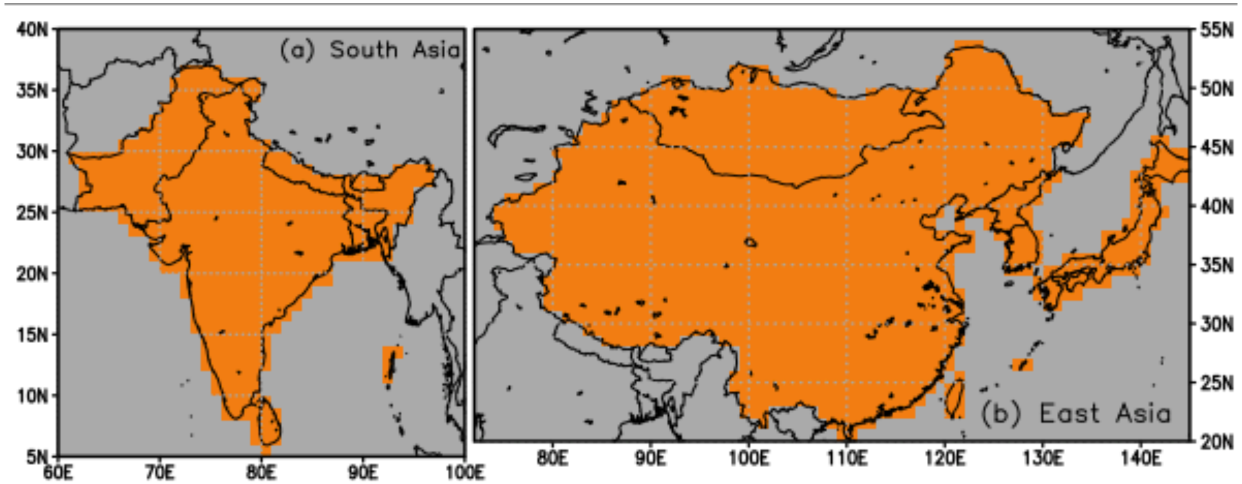


Unfair to compare inversion fluxes (include all CO_2 component) with the DGVMs (dynamic vegetation models)

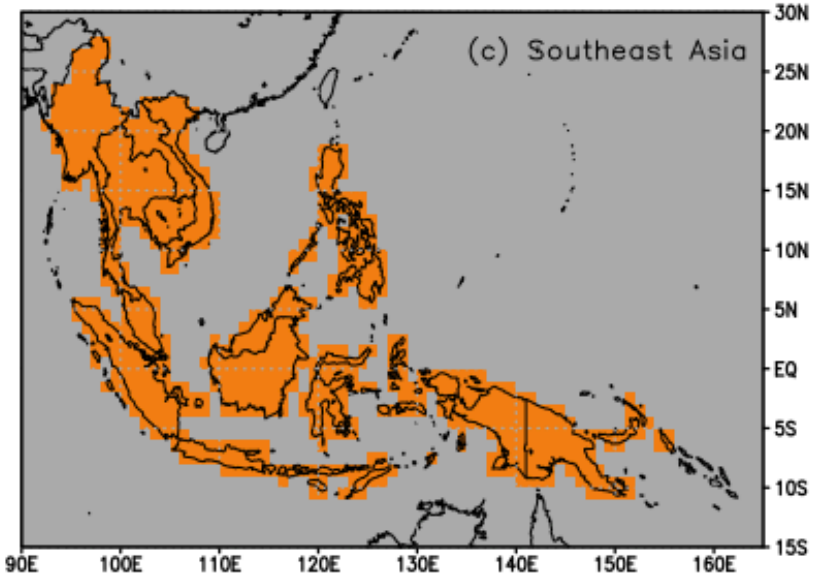
Why is the Asia (temperate and boreal) regions so large?

Figure 6.15, IPCC-AR5-WG1, plot by P. Patra

Asia Pacific Network (APN) project: ARCP2013-01CMY-Patra/Canadell (2011-2014)



Objective: To develop a grand synthesis of the net GHG (CO_2, CH_4, N_2O, black carbon and carbon monoxide) balance of Asia, excluding Siberia, using bottom-up and top-down constraints and estimates covering the 2000-2012 period.



References:

3rd APN workshop at JAMSTEC, Yokohama, 8-10 April 2014
TransCom meeting in Groningen University, 24-26 June 2014
Asian GAW meeting, KRISS, Daejeong, 20-22 October 2014
4th APN/NIES workshop at JAMSTEC, Yokohama, 2-4 March 2015

Top-down constraints – expected models

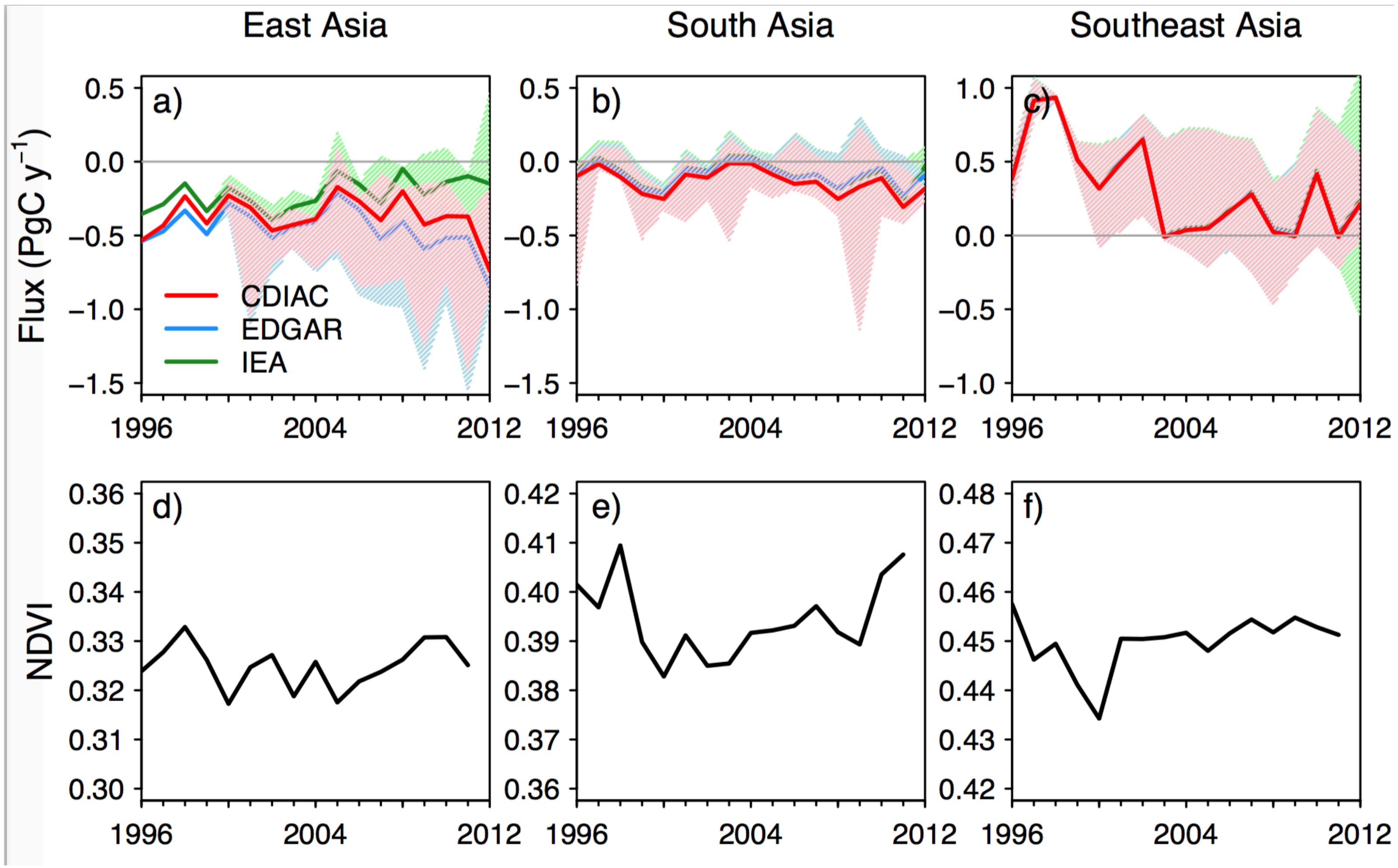
	CO_2
TM5[1]	✔✔
LMDZ-PYVAR[4]	✔✔
ACTM[5]	✔✔
NIES-TM[6]	✔✔

1. WUR, JRC, NOAA
2. MPI-BGC
3. Univ. of Edinburgh
4. LSCE and NILU (N2O)
5. JAMSTEC
6. NIES
7. MRI JMA
8. NILU
9. MRI/U. Toronto
10. JAMSTEC
11. Emory Univ.
12. Univ. Chile

✔: Longterm, 2000-2012

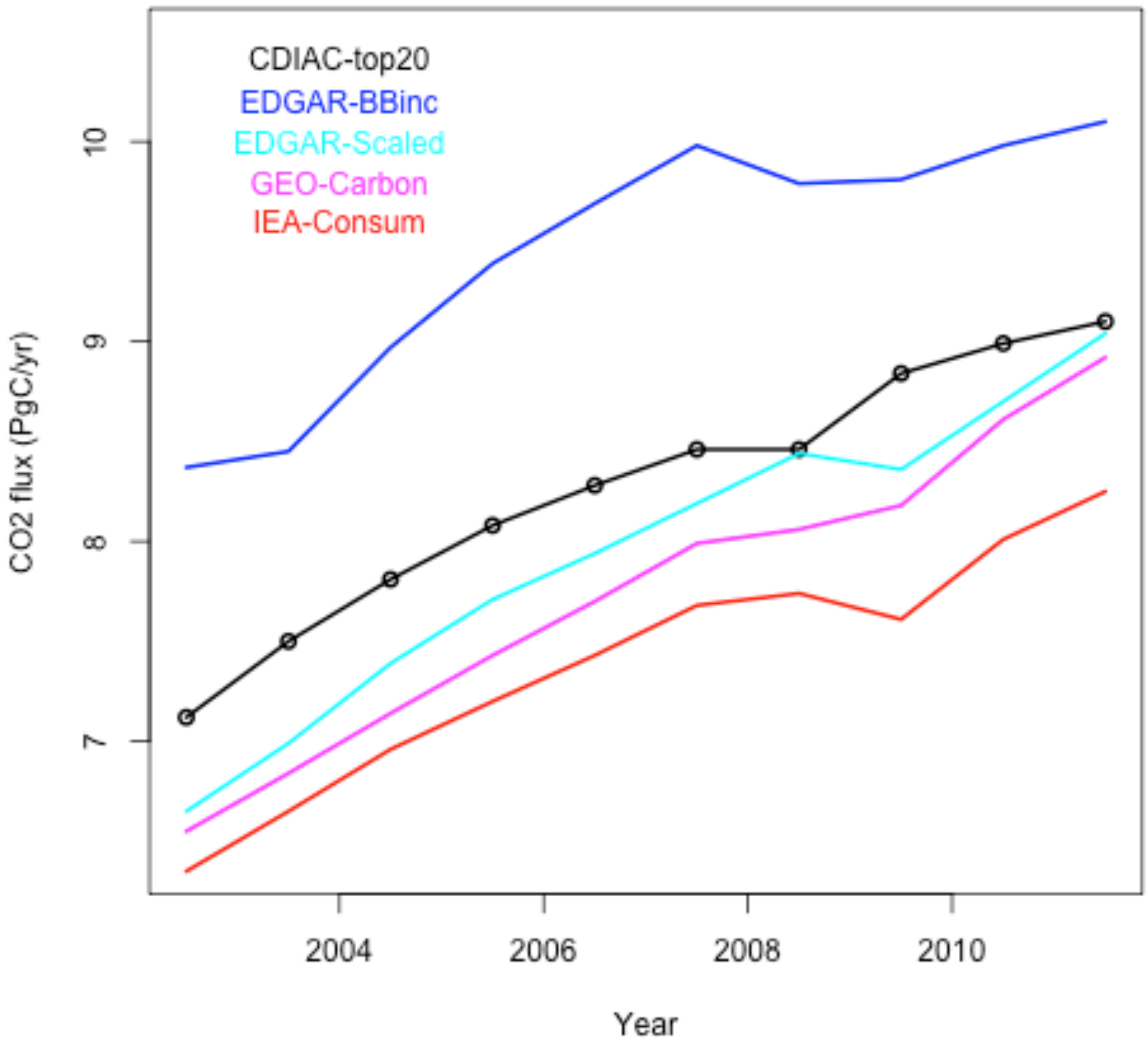
✔: focussed, 2010-2012

Top-down Asian CO_2 budget using 3 different (adjusted a posteriori) fossil fuel inventories



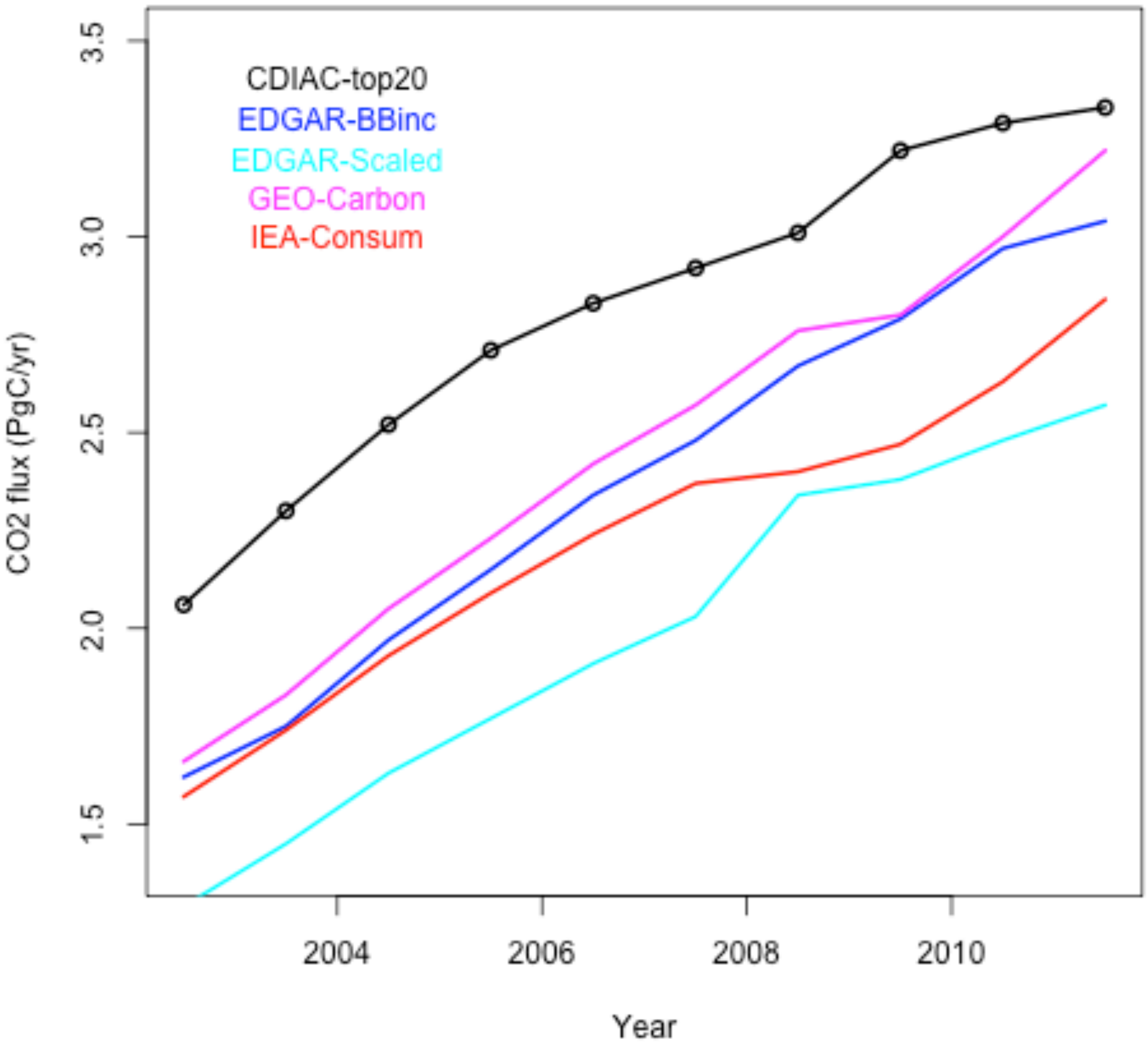
(Thompson et al., in review)

Global total fossil fuel (FF) emissions

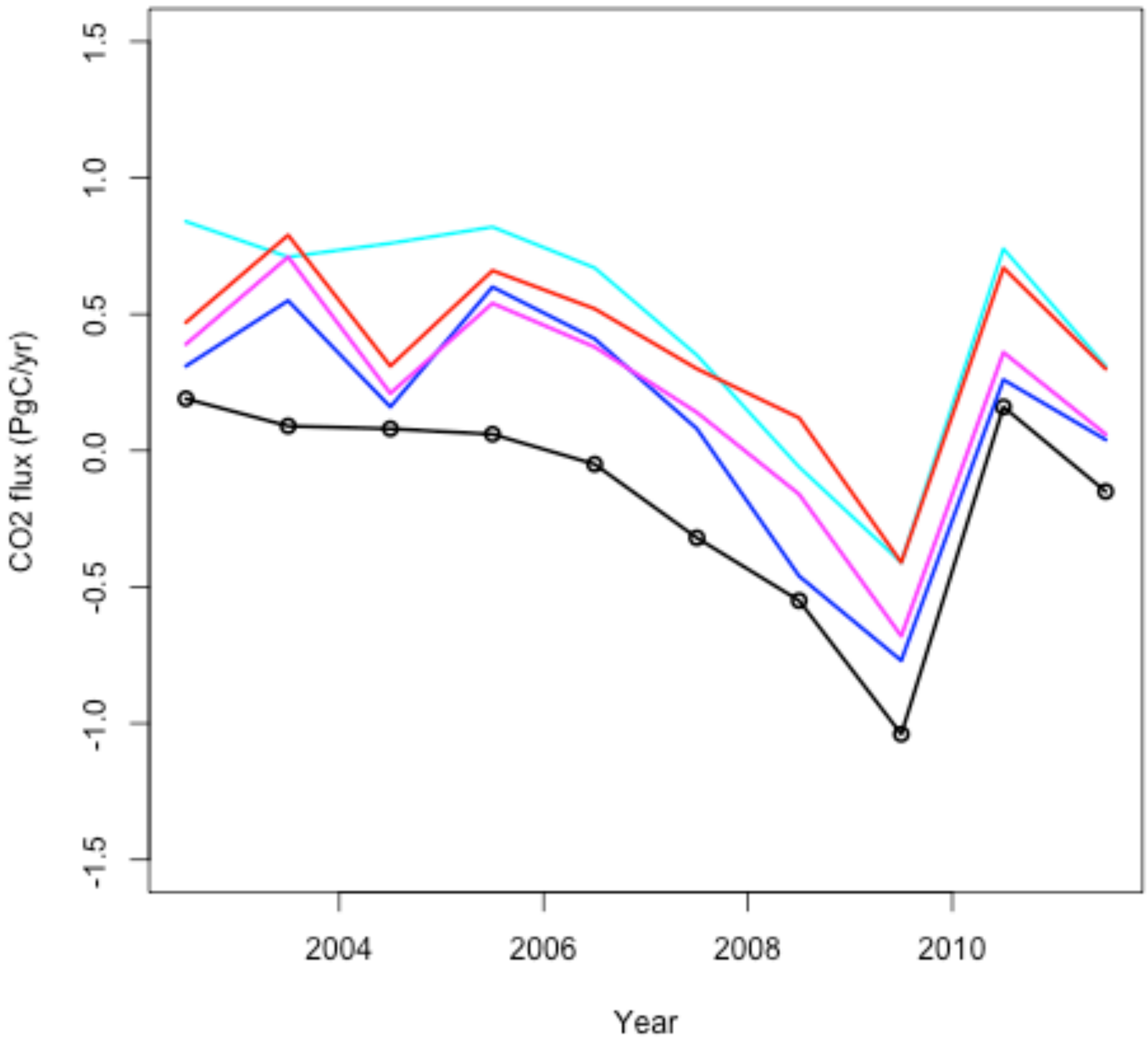


GEO & IEA maps: courtesy of Ingrid van der Laan-Luijkx

East Asian (China, Japan, Korea) FF emissions

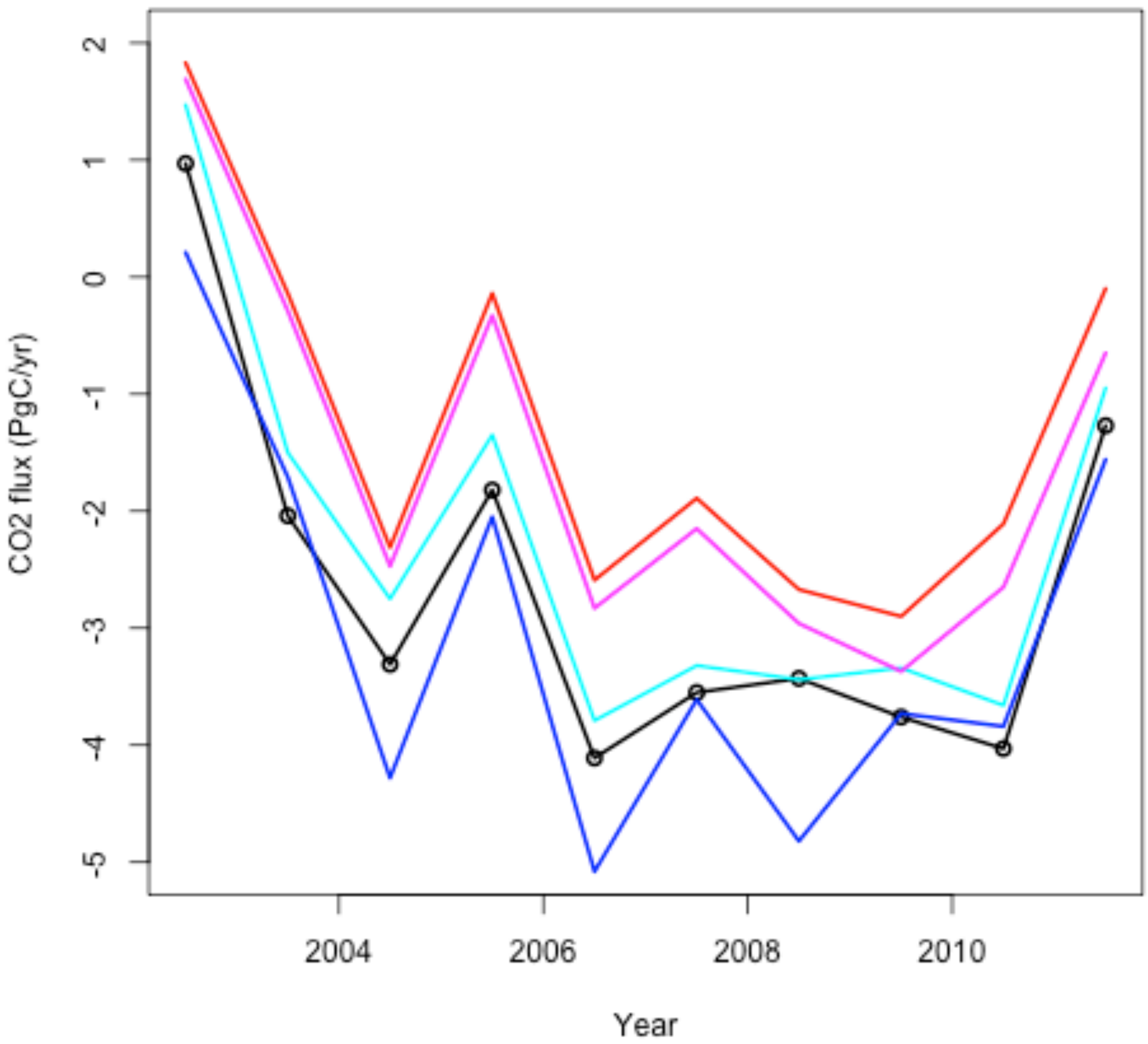


East Asian land flux for different FF emissions

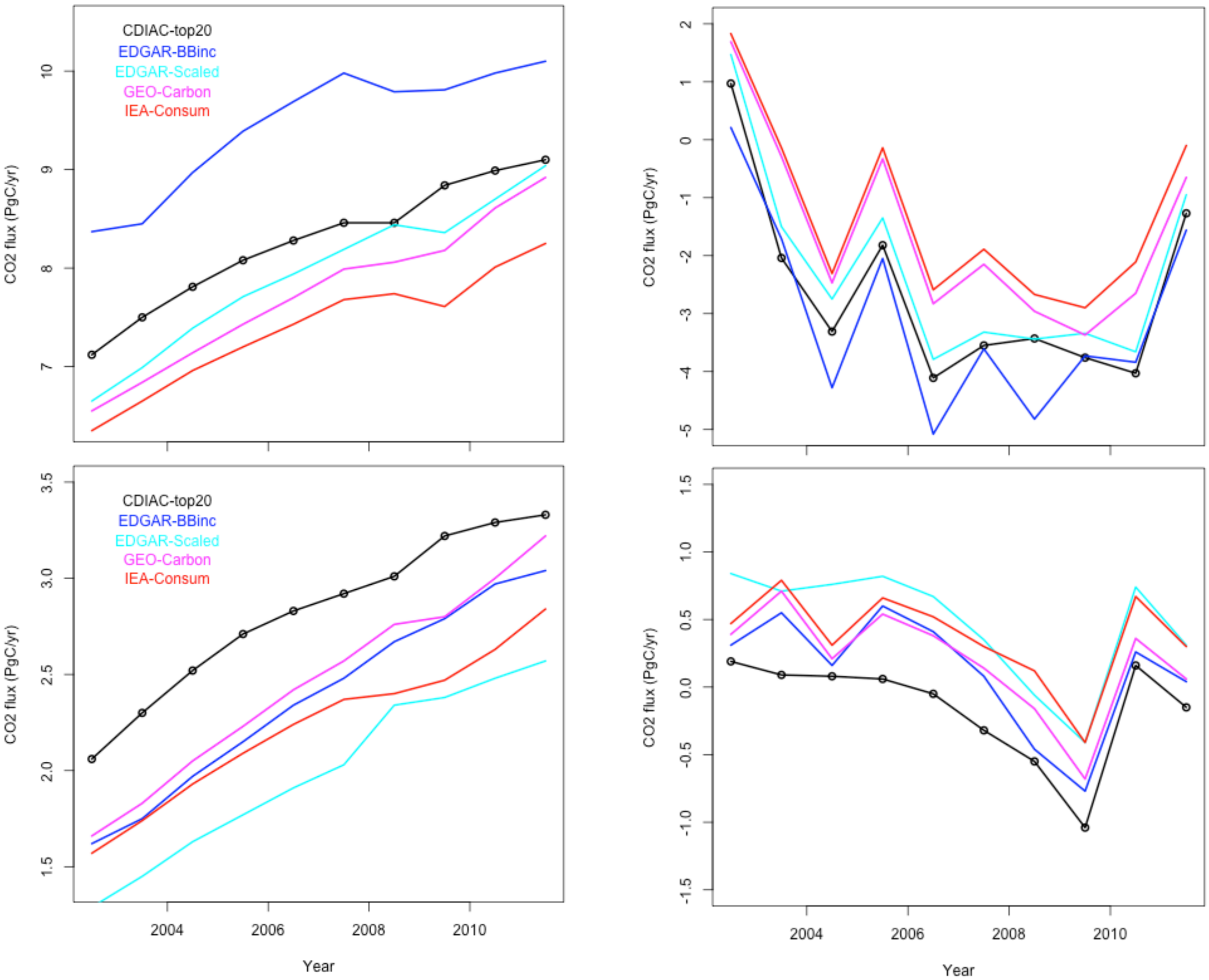


84 region CO_2 inversions using ACTM: courtesy of Tazu Saeki

Global land flux for different FF emissions



FF Emissions   Land Fluxes



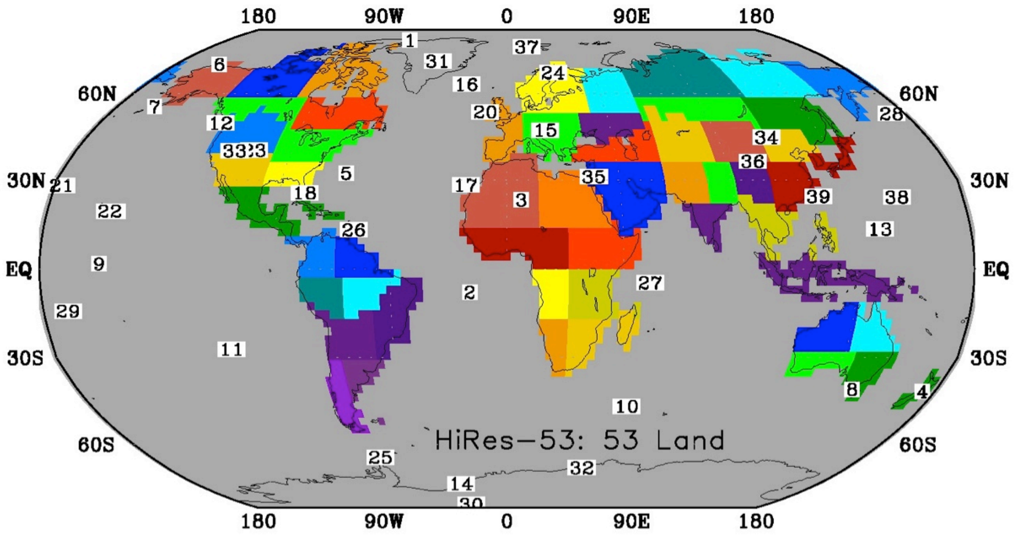
Global

East Asia

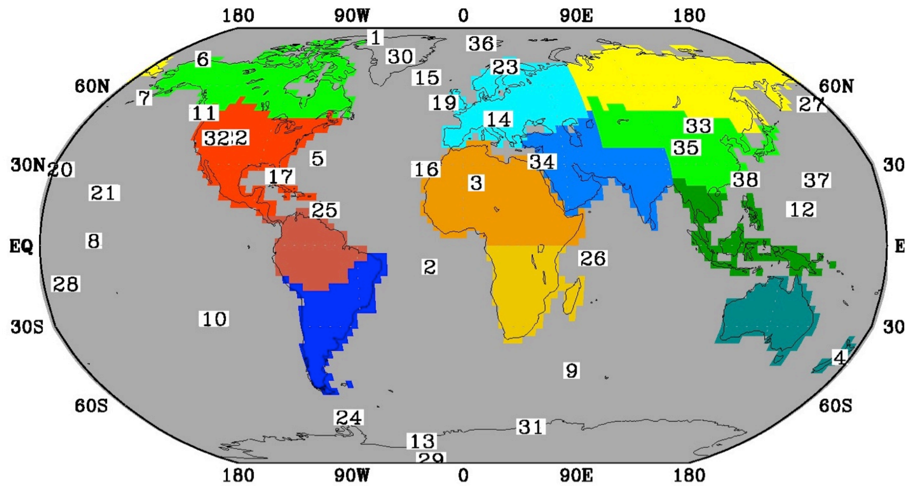
Inversions by T. Saeki

In search of independent evidence

53-Regions (land only) Inverse Model for CH_4 at JAMSTEC



12 aggregated regions for analysis

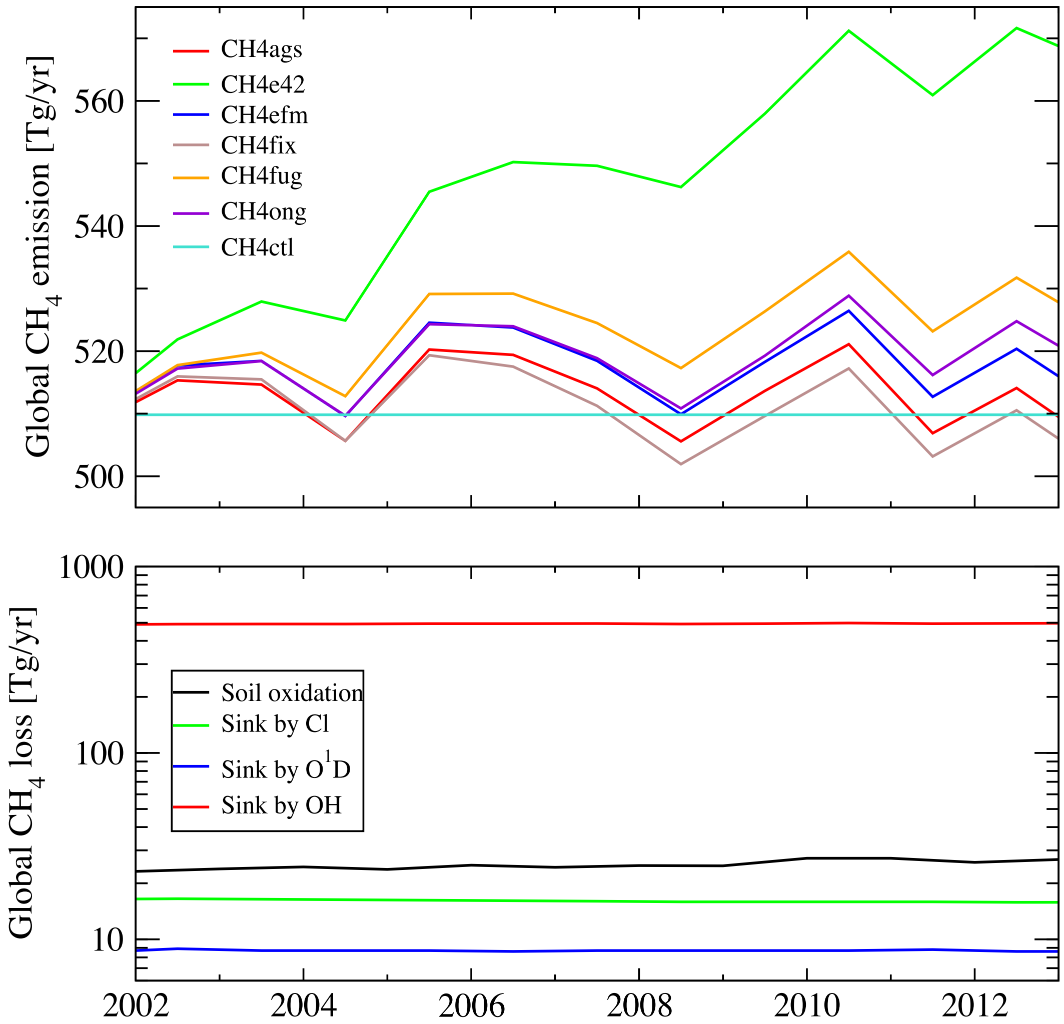


$$C_S = (G^T C_D^{-1} G + C_{S_0}^{-1})^{-1}$$

$$S = S_0 + \left(G^T C_D^{-1} G + C_{S_0}^{-1}\right)^{-1} G^T C_D^{-1} (D - D_{ACTM})$$

S_0 = regional prior sources
C_{S0} = Prior source covariance = 70% of region-total emission for each month
D = atmospheric concentration data
Data covariance ***C_D*** = 5 ppb for measurements + scaled RSD for model uncertainty
D_{ACTM} = ACTM simulation using S_0
G = Green's functions for regional source-receptor relationships

Net CH_4 emissions for 6 a priori cases (top) and modelled loss rates (bottom)



Source types

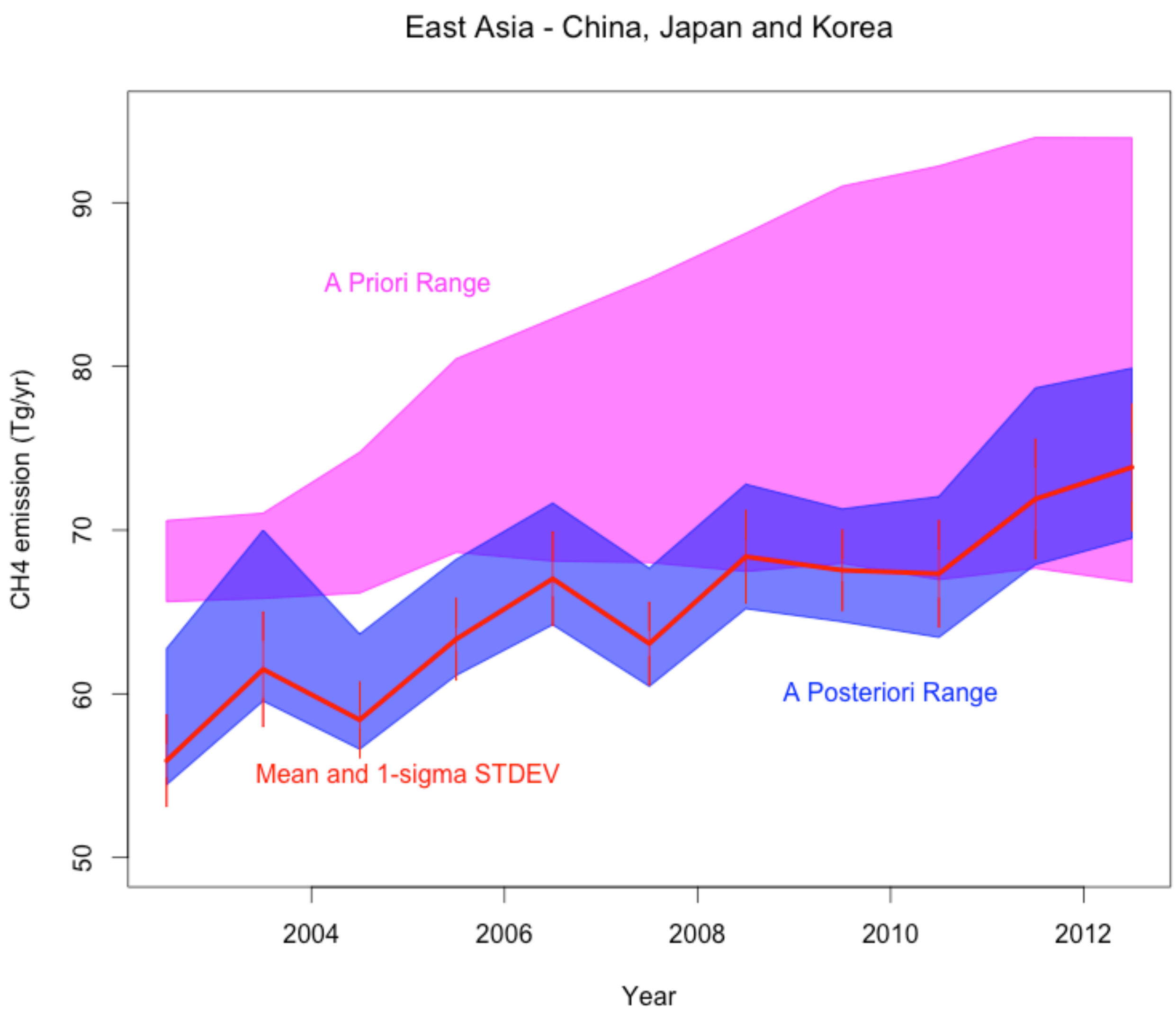
Natural:
VISIT: Wetl & Rice
GISS: Termite
GFED: Bio. Burn
SRON: Ocean
SRON: MudVolcano

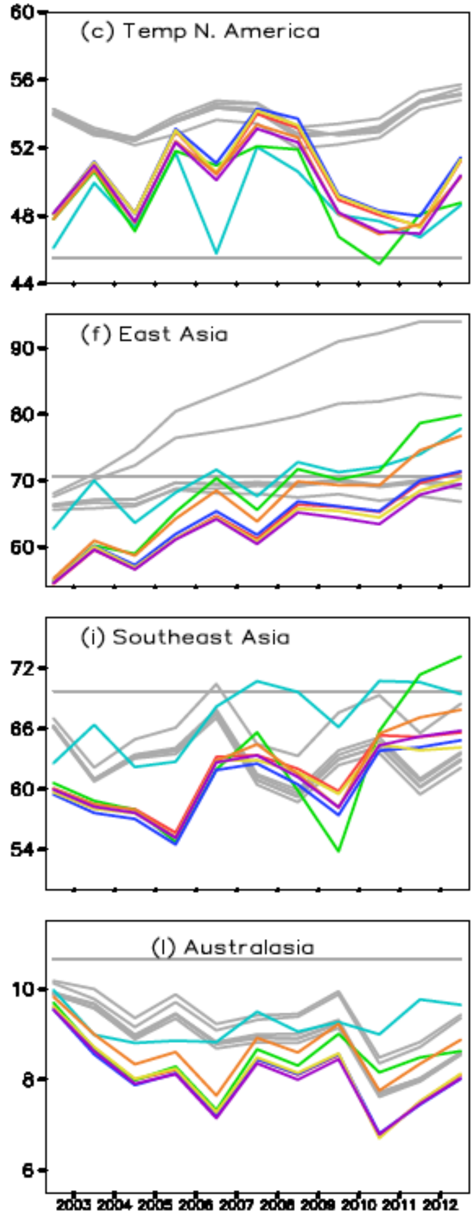
Anthropogenic:
(EDGAR4.2)
IPCC_1A (transport)
IPCC_1B (Fugitive)
IPCC_2 (Industry)
IPCC_4A (Ent. Ferm.)

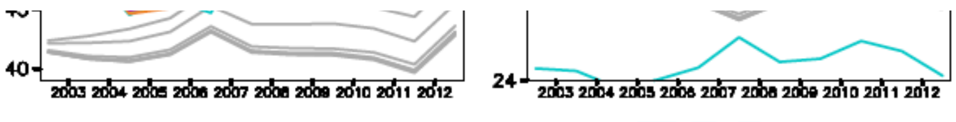
Soil sink: VISIT

For Prior CH_4 emission cases (top panel), only one of emission type has trend, except for E42.

More on CH_4 inversion – trends and interannual variability

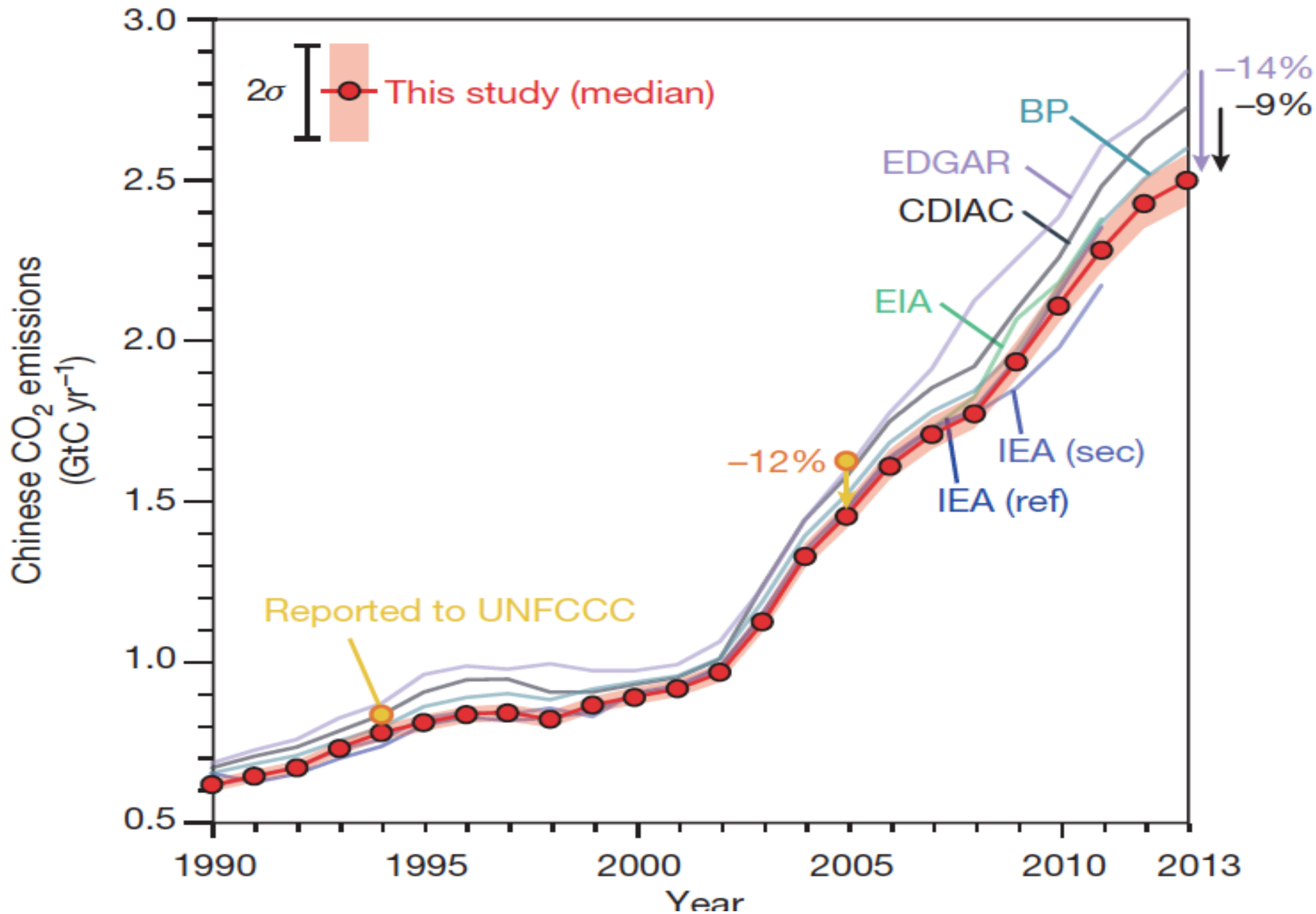






Patra et al., JMSJ,
In review, 2015

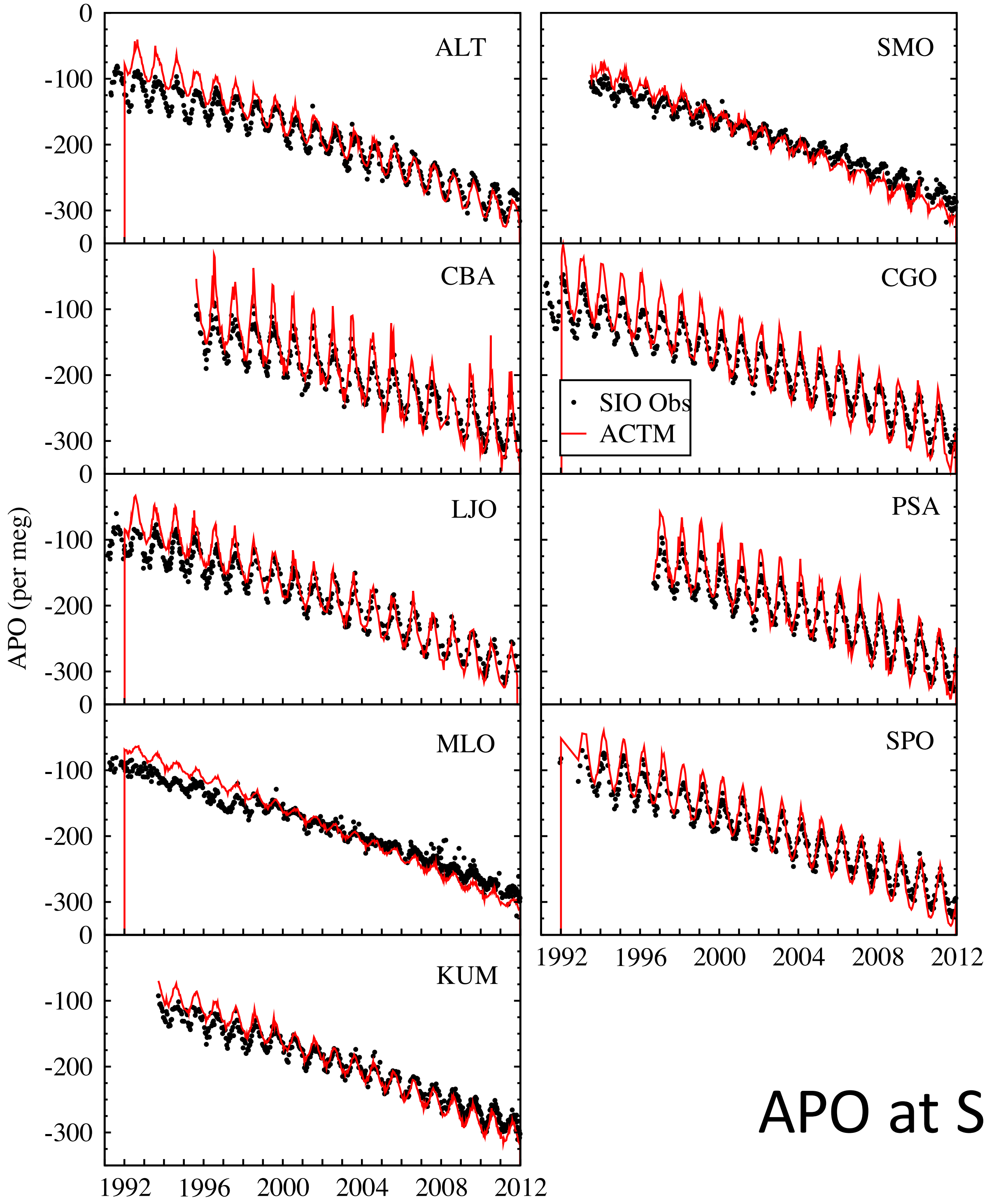
China FF emissions – new inventory



Liu et al., Nature, 20 Aug 2015

Independent constraints for global FF CO_2?

- APO – since oxygen is consumed at certain ratios during FF burning
  - Some of the FF (coal) signal is not distinct
  - Regional flux constraint using continuous measurements downwind
- $\delta^{13}C$: not only dependent on FF emissions
- $\Delta^{14}C$: seems the most independent so far
- Others



Estimation of Fossil Fuel Source Using O_2/N_2 and CO_2 (ver: 20 April 2015)

Assuming:
O_2:CO_2 for fossil fuel
O_2:CO_2 for land exchange
Z(O_2) for ocean outgassing

CDIAC (account for cement separately)

fossil	cement	land	ocean
7.64	0.33	0.84	3.05
6.47	0.23	0.07	2.85
7.56	0.31	0.54	3.13
8.73	0.43	1.85	3.19

IEA (account for cement separately)

fossil	cement	land	ocean
7.39	0.33	0.52	3.11
6.29	0.23	-0.16	2.9
7.34	0.31	0.27	3.18
8.29	0.43	1.3	3.3

APO at SIO surface sites

Summary

- We are trying to estimate CO_2 fluxes from 3 Asia regions, and understand source of uncertainties
  - Transport: using multimodel
  - Prior fossil fuel emissions: using multiple inventory emissions
- Assumption of fossil fuel emissions influence the absolute and trends in inversion fluxes
- CH_4 inversion suggest a much slower increase in emissions from Chinese coal industry (This study, Tohjima et al., Thompson et al.)
- Independent check on global and regional fossil fuel emissions is needed using related chemical tracers
  - Impact on NH-SH APO gradient?