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

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2\textsuperscript{nd} 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?
Objective: To develop a grand synthesis of the net GHG (CO$_2$, CH$_4$, N$_2$O, 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

| Model         | CO₂ |  
|---------------|-----|---
| TM5¹          | ✔✔  | -
| LMDZ-PYVAR⁴   | ✔✔  | -
| ACTM⁵         | ✔✔  | -
| NIES-TM⁶      | ✔✔  | -

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

Inversions by T. Saeki
In search of independent evidence
53-Regions (land only) Inverse Model for CH$_4$ at JAMSTEC

\[ C_S = \left( G^T C_D^{-1} G + C_{S0}^{-1} \right)^{-1} \]

\[ S = S_0 + \left( G^T C_D^{-1} G + C_{S0}^{-1} \right)^{-1} G^T C_D^{-1} (D - D_{ACTM}) \]

- $S_0$ = 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

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 O2/N2 and CO2 (ver: 20 April 2015)

Assuming:
- O2:CO2 for fossil fuel
- O2:CO2 for land exchange
- Z(O2) for ocean outgassing

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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?