Research on carbon fluxes and carbon cycle

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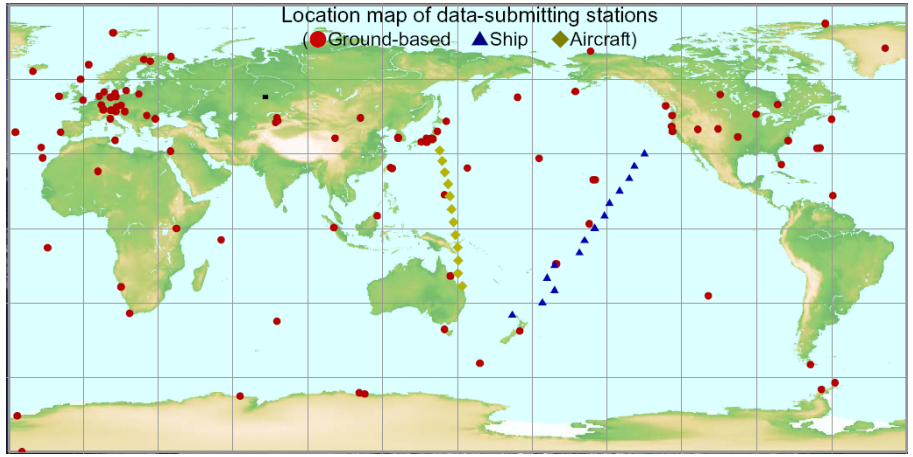
Contents

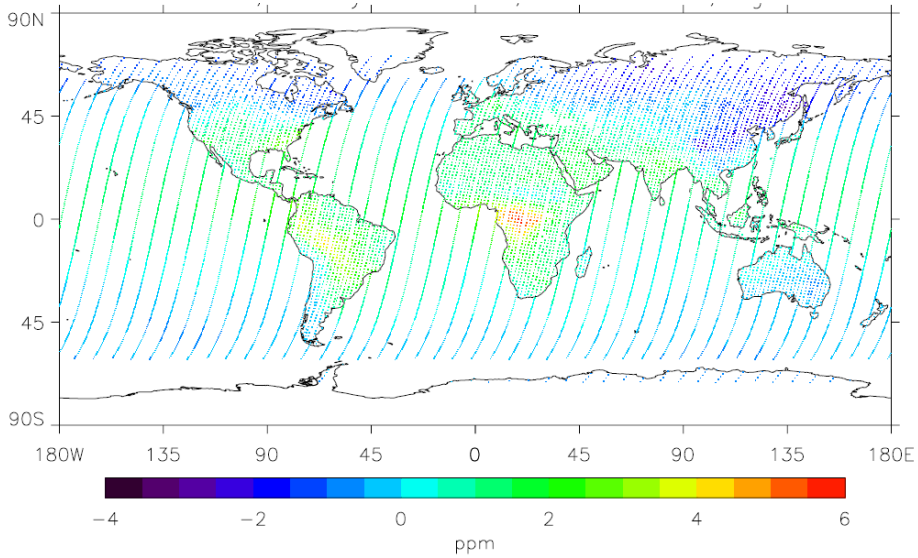
Use of GOSAT data in carbon cycle research and new challenges for research community

- Bottom-up inventories of the carbon dioxide/methane fluxes
- Modeling of the terrestrial biosphere fluxes, including seasonal and diurnal change, forest fire/biomass burning
- Accurate atmospheric transport modeling
- Improvements in inverse modeling and data assimilation
- Applications to understanding relationships between climate change and carbon cycle trends in the Earth system scale.

What will change with GOSAT data made available: observational coverage



Currect ground based observations of CO2:
~40 continuous sites (hourly data)
~100 flask samples per week
~10 aircraft profiles per day
Map by WDCGG at JMA, Tokyo



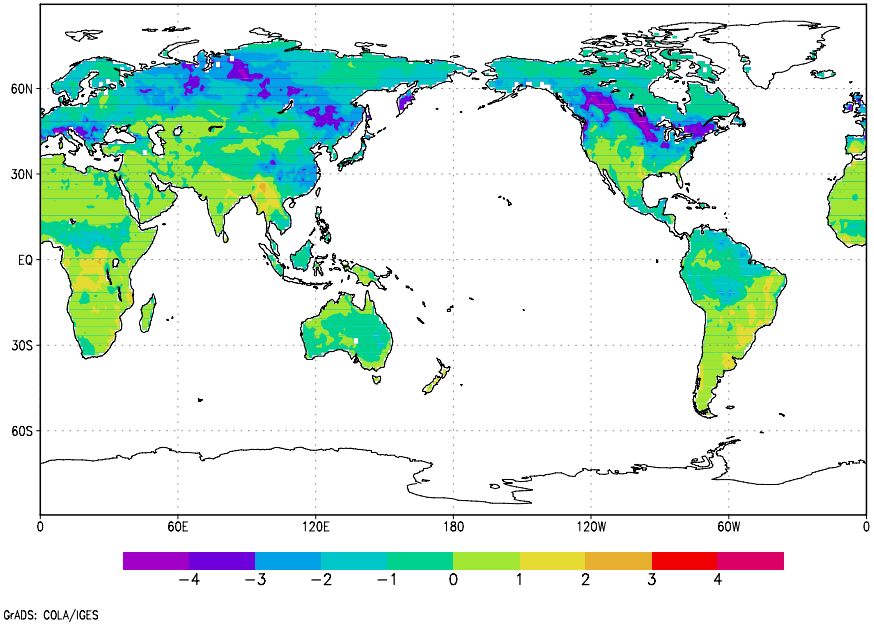
GOSAT orbit and XCO_2 (with global offset subtracted), ~1000 cloud-free observations per day

GOSAT data challenge: 10-20 times increase of the available data, demanding use of new, more accurate models, inverse techniques

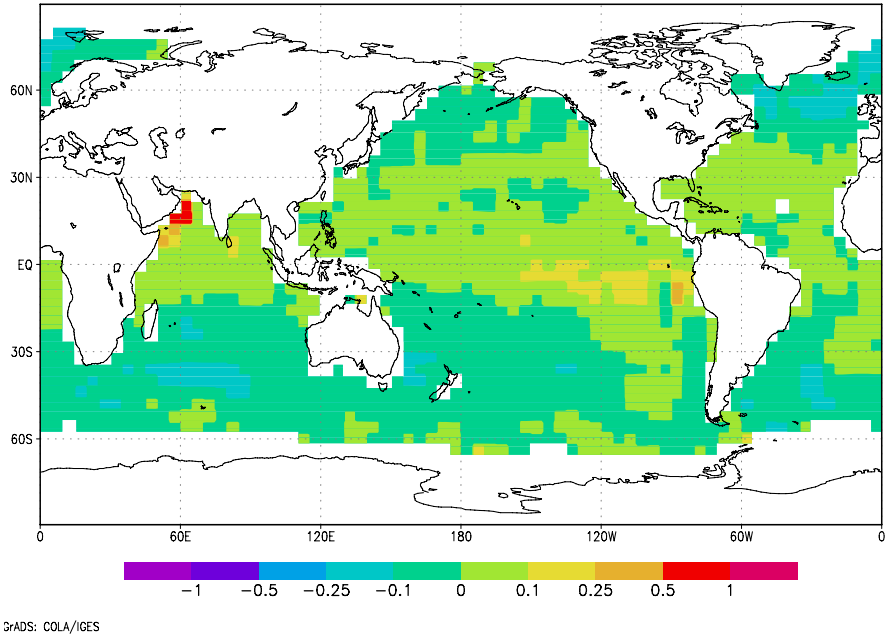
Long standing problems: flux estimation critically depends on emission inventories, surface flux models

Two most successful models of natural CO2 fluxes

Terrestrial biosphere, CASA model



Ocean (Takahashi et all, 2002, 2008)



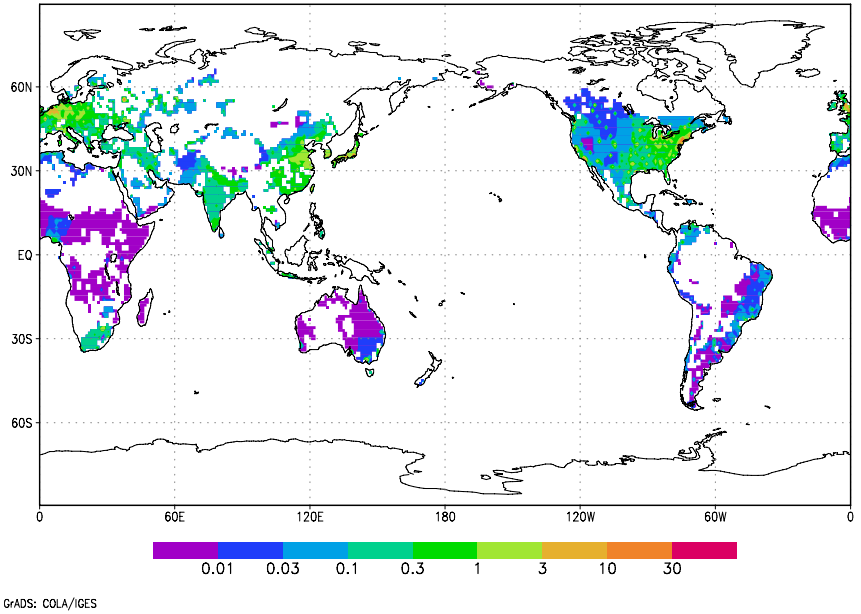
CO2 fluxes in July, gC/m2/day

Goal: to improve seasonal cycle, add daily, diurnal variations.

Goal: to make interannually varying fluxes, improve southern ocean flux seasonality

Anthropogenic fluxes: fossil fuel consumption

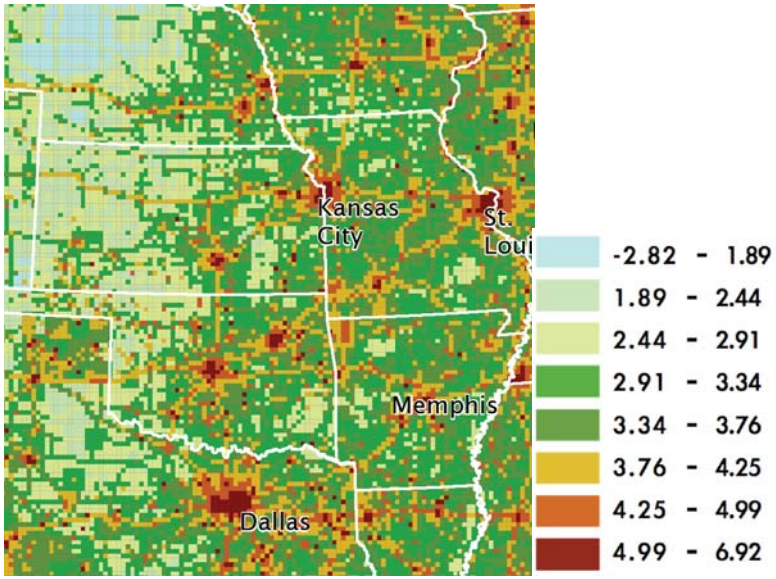
Annual fossil fuel use, Adres, CDIAC



CO2 fluxes in 1998 gC/m2/day, 1x1 deg grid

Goal: make seasonally and diurnally varying global emissions approaching GOSAT pixel resolution (10x10 km)

High resolution emissions, Vulcan project

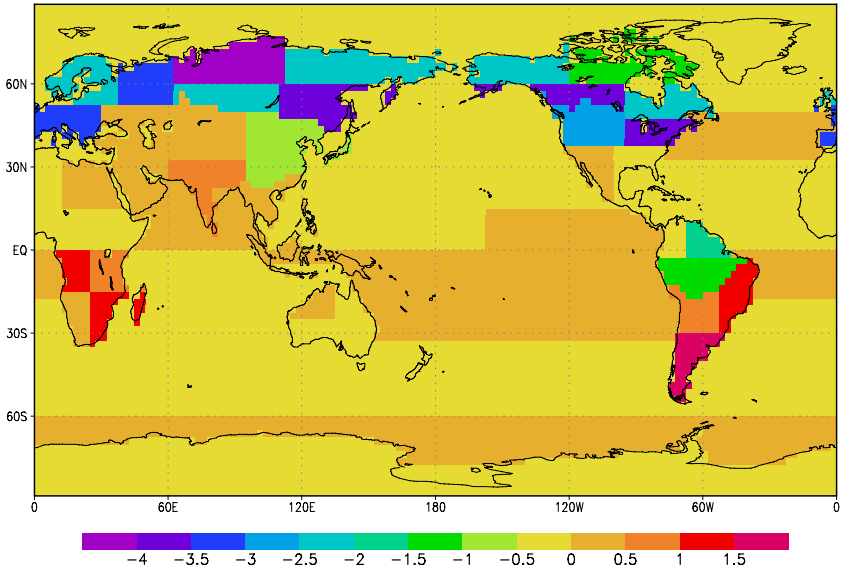


$\log_{10}$CO2 fluxes in 2002,
tC per 10x10 km, annual

Goal: to make interannually varying fluxes, global coverage

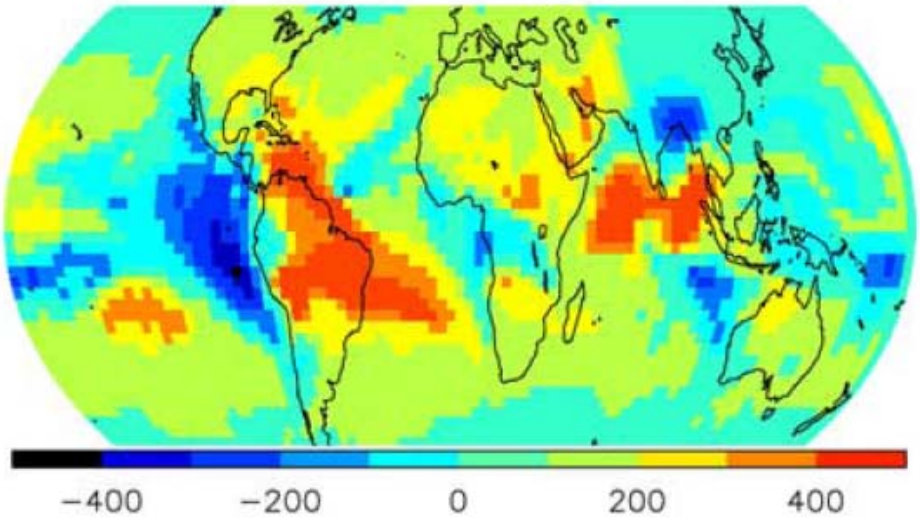
Inverse modeling: from monthly fluxes at regional scale to high resolution grid

Aggregated fluxes with 64 region inversion
Patra et al 2005



CO2 fluxes in July 1996, gC/m2/day

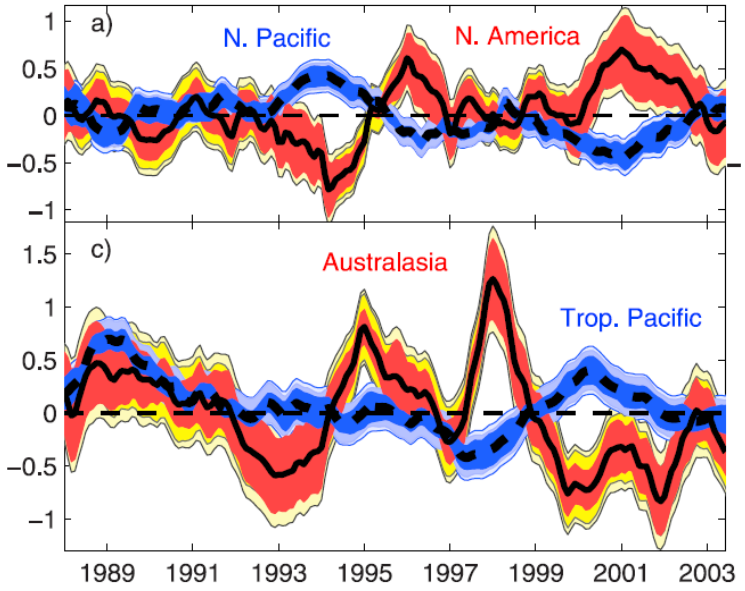
Surface flux corrections (Chevallier et al 2005)



CO2 fluxes in Aug 1990, gC/m2/year

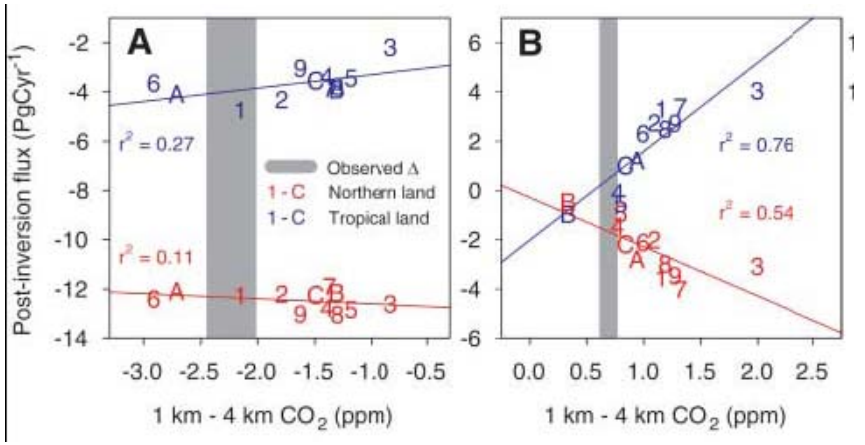
Inverse modeling: Transcom model intercomparison of flux inversions gives better understanding of the model biases and errors

Multimodel fluxes



Mean CO2 fluxes estimated with 13 models of atmospheric transport and inversion, using surface observations,
Transcom project, Baker et al, GBC, 2006
Units Gt/Year

Independent validation with vertical CO2 profiles (Stephens et al, Science, 2007)



Observations (grey) suggest which inverse model is right.

Multi-model estimates of fluxes with several alternative approaches demonstrated to be robust

Summary

Expected advances in carbon cycle research with available GOSAT data

- Improved understanding of carbon cycle and its variability at regional scale, its sensitivity to climate variability and climate change.
- Robust estimates of the regional flux distributions based on multi-model intercomparison results

Expected improvement in flux estimation methods, which contribute to and provide feedback/validation to operational algorithms for CO2 flux estimates.

- Bottom-up flux inventories.
- Modeling of the terrestrial biosphere fluxes
- Accurate atmospheric transport modeling
- Improvements in inverse modeling and data assimilation