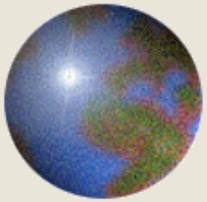
NASA Carbon Flux and State Estimation System



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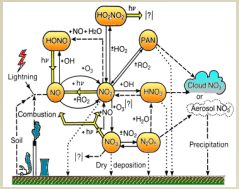
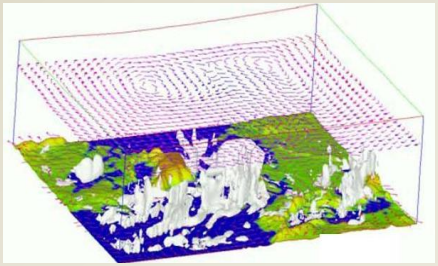
NASA Carbon Flux and State Estimation System

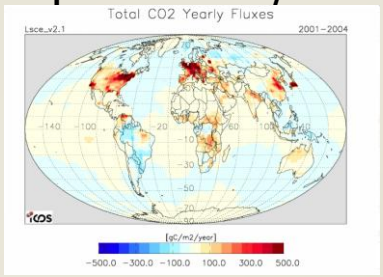
Chemical production



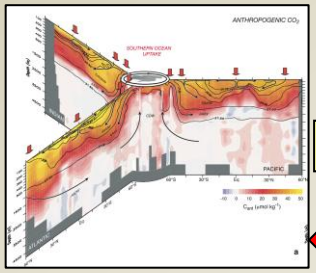
Transport (GEOS-5)



Optimal flux/state

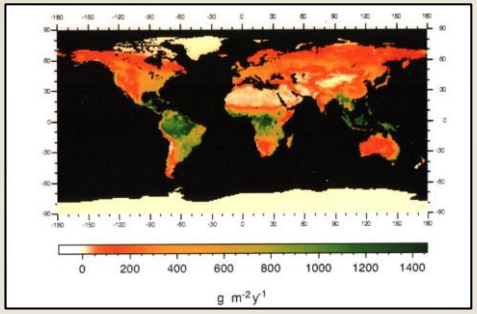


Oceans (NOBM, ECCO2)

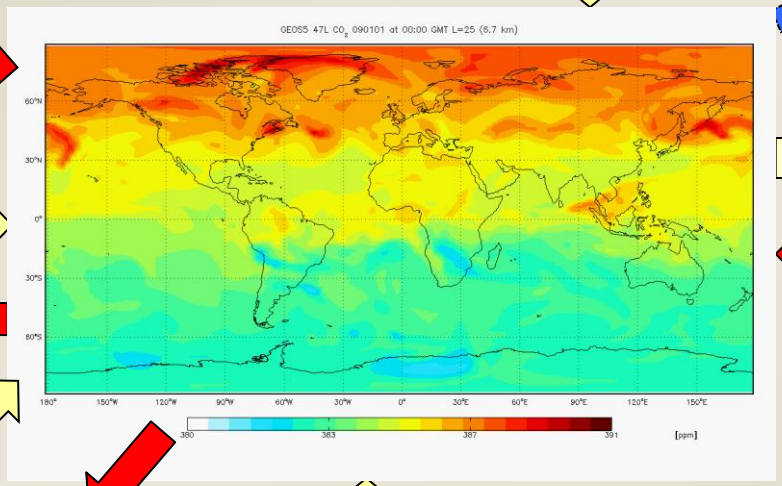


Gruber *et al*, 2009

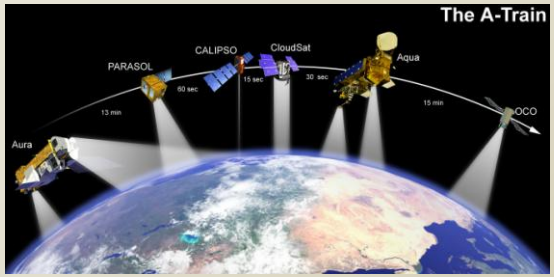
Terrestrial Biosphere (CASA, CASA-GFED3)



Potter *et al,* 1993



Observations



Optimal flux and state estimation

Anthropogenic

$$\min_{\mathbf{x}_0} C(\mathbf{x}) = \left\{ \sum_i (\mathbf{y}_i - \mathbf{F}_i(\mathbf{x}))^\top (\mathbf{S}_n^i)^{-1} (\mathbf{y}_i - \mathbf{F}_i(\mathbf{x})) + (\mathbf{x}_0 - \mathbf{x}_a)^\top \mathbf{S}_a^{-1} (\mathbf{x}_0 - \mathbf{x}_a) \right\}$$

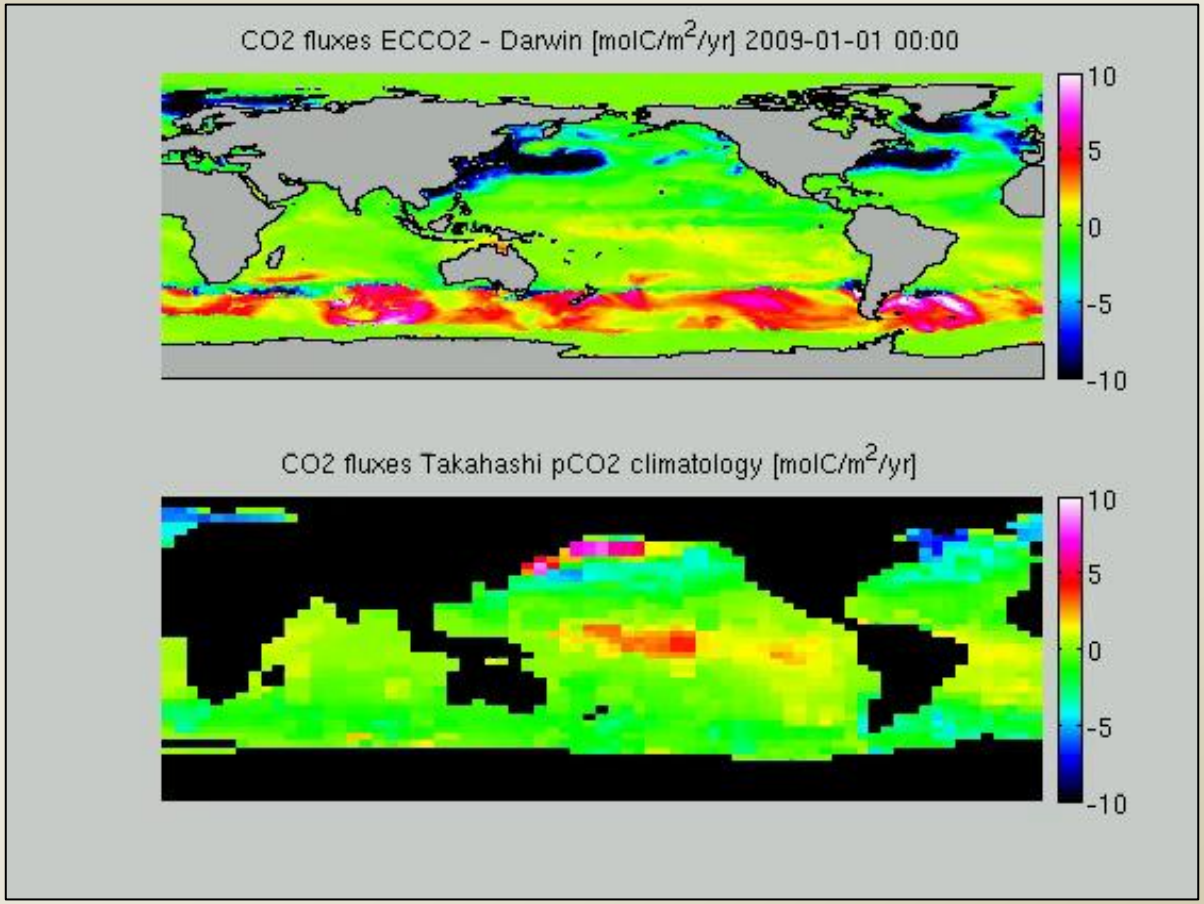
- GEOS-Chem currently runs at 2x2.5, but can extended to native GEOS-5 fields
- Most emissions are gridded on monthly scale

Ocean biogeochemistry

Comparison of predicted synoptic-scale carbon fluxes between JPL-MIT ECCO2 and monthly Takahashi inventories for 2009

ECCO2 includes 4D-var ocean circulation with Darwinian self-organized biological activity

Positive values are flux into atmosphere

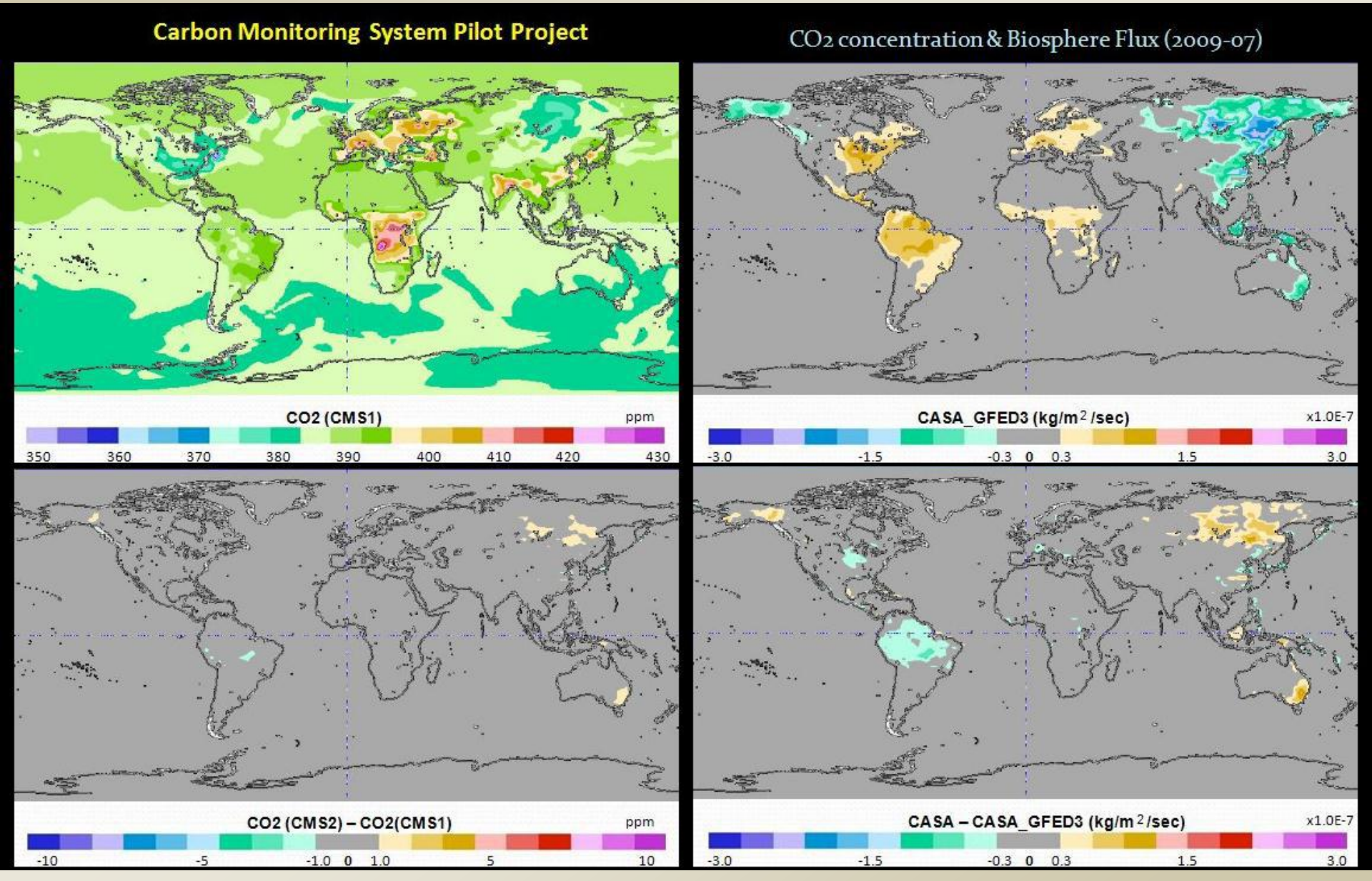


- CO2 flux driven synoptic scale variability and air-sea pCO2 difference
- Available oceanic pCO2 is determined by **temperature** (higher solubility at lower temps), **biological activity** (low in winter due to limited light availability), **ocean circulation** (horizontal and vertical processes, upwelling etc.)

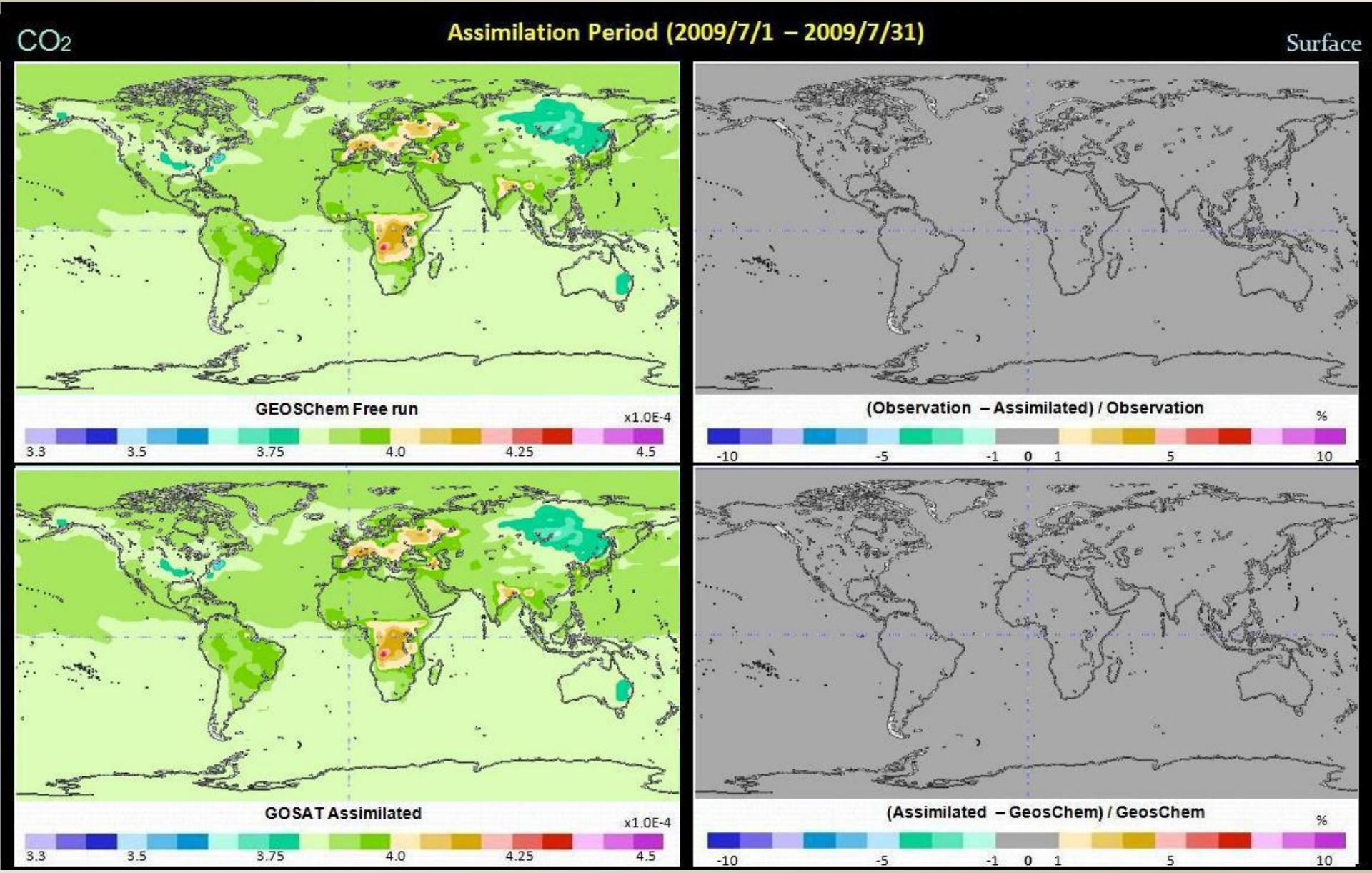
CASA and CASA-GFED3

	Standard	CMS-1	CMS-2
Biosphere	CASA-NEP-DIURNAL Net _terrestrial_exch_2x25_5.29	CASA-GFED3-CMS-NEP (J. Collatz)	CASA-ARC-CMS-NEE (C. Potter)
Biomass burn	GFEDv2-8day (2008)	CASA-GFED3-CMS-FIRE (J. Collatz)	CASA-GFED3-CMS-FIRE (J. Collatz)
Bio fuel	Yevich and Logan (1995)	CASA-GFED3-CMS-FUEL (J. Collatz)	CASA-GFED3-CMS-FUEL (J. Collatz)
Ocean	TAKAHASHI-2009	NOBM (G. Watson)	NOBM (G. Watson)
Fossil fuel	CDIAC (2007) (scaled for 2009 using BP numbers)	CDIAC	CDIAC
Ship	ICOADS (scaled for 2009)	ICOADS	ICOADS
Aviation	Aircraft-1992 (scaled for 2009)	Aircraft-1992	Aircraft-1992
Chemical src.	CO2_prod_rates CH4_source Isoprene-2004 Monterpene-2004	CO2_prod_rates CH4_source Isoprene-2004 Monterpene-2004	CO2_prod_rates CH4_source Isoprene-2004 Monterpene-2004

CASA and CASA-GFED3



3D-var GOSAT assimilation



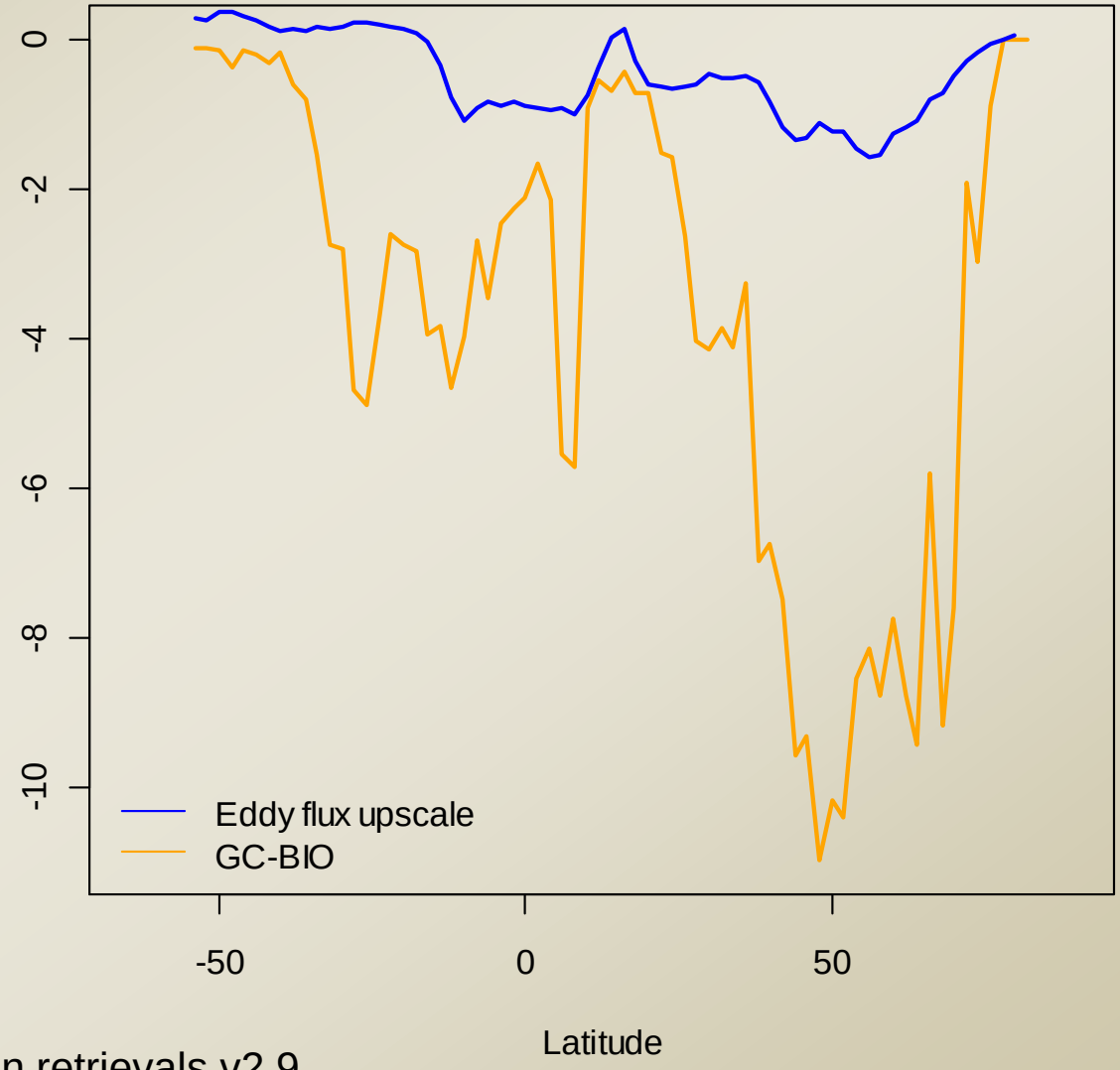
Estimates CO2 Flux from GOSAT

Spatially resolved
CO2 fluxes estimated with 4D-var GEOS-Chem based on standard climatology for July 2009.

Ingested GOSAT CO2 profiles
with known 3-4% low bias

NO bias correction applied

Comparison with FLUX-NET eddy-covariance upscaled to monthly mean



Unphysical results due to low bias
Expected substantial improvements in retrievals v2.9 in the next 6 months
Investigating TES CO2 data

Conclusions and Future Directions

- The NASA Carbon Flux Estimation System incorporates the full suite of NASA observational, modeling, and assimilation capabilities to assess the role NASA satellite remote sensing can play in improving knowledge of the carbon cycle and eventually anthropogenic emissions.
- Both 3D-var CO_2 assimilation and 4D-var CO_2 flux estimation have been developed through collaboration within the GEOS-Chem Adjoint Working Group
- Two diagnostic eco-system model outputs from CASA and CASA-GFED3 have been incorporated into GEOS-Chem as bottom up inventories for 2009-2010.
- The GSFC NOBM ocean model output has been incorporated, JPL-MIT ECCO2 should be incorporated by end of May.
- CO_2 concentrations and fluxes in GEOS-Chem have been constrained by GOSAT and TES CO_2 observations.
- Estimated CO_2 fluxes constrained by GOSAT have been compared against up-scaled eddy-covariance measurements from FLUXNET
- Analysis of GOSAT bias underway
- Development of GOSAT OSSE to assess GOSAT potential to differentiate between eco-system and ocean model predictions
- Extension of flux estimates to full year