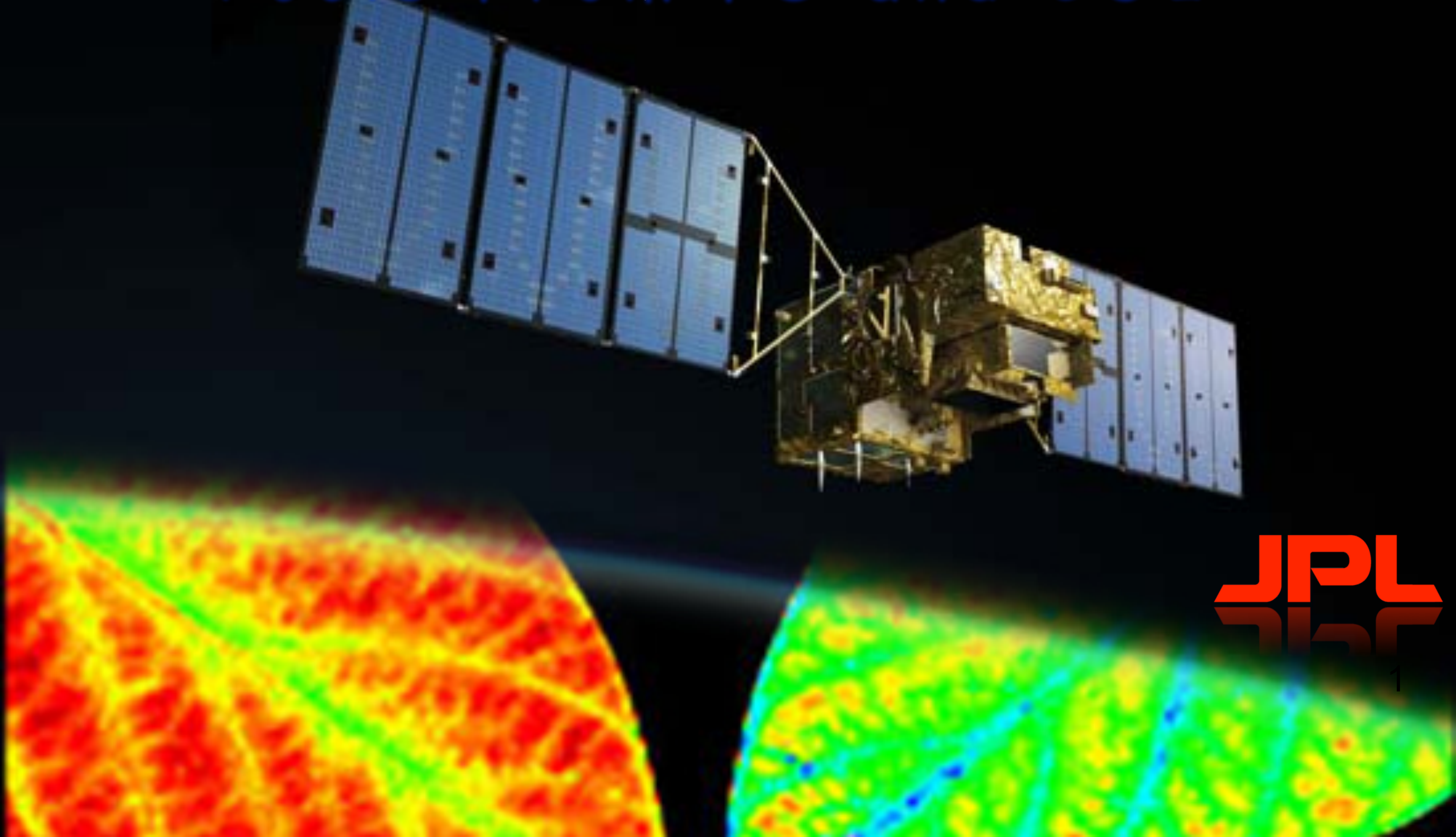
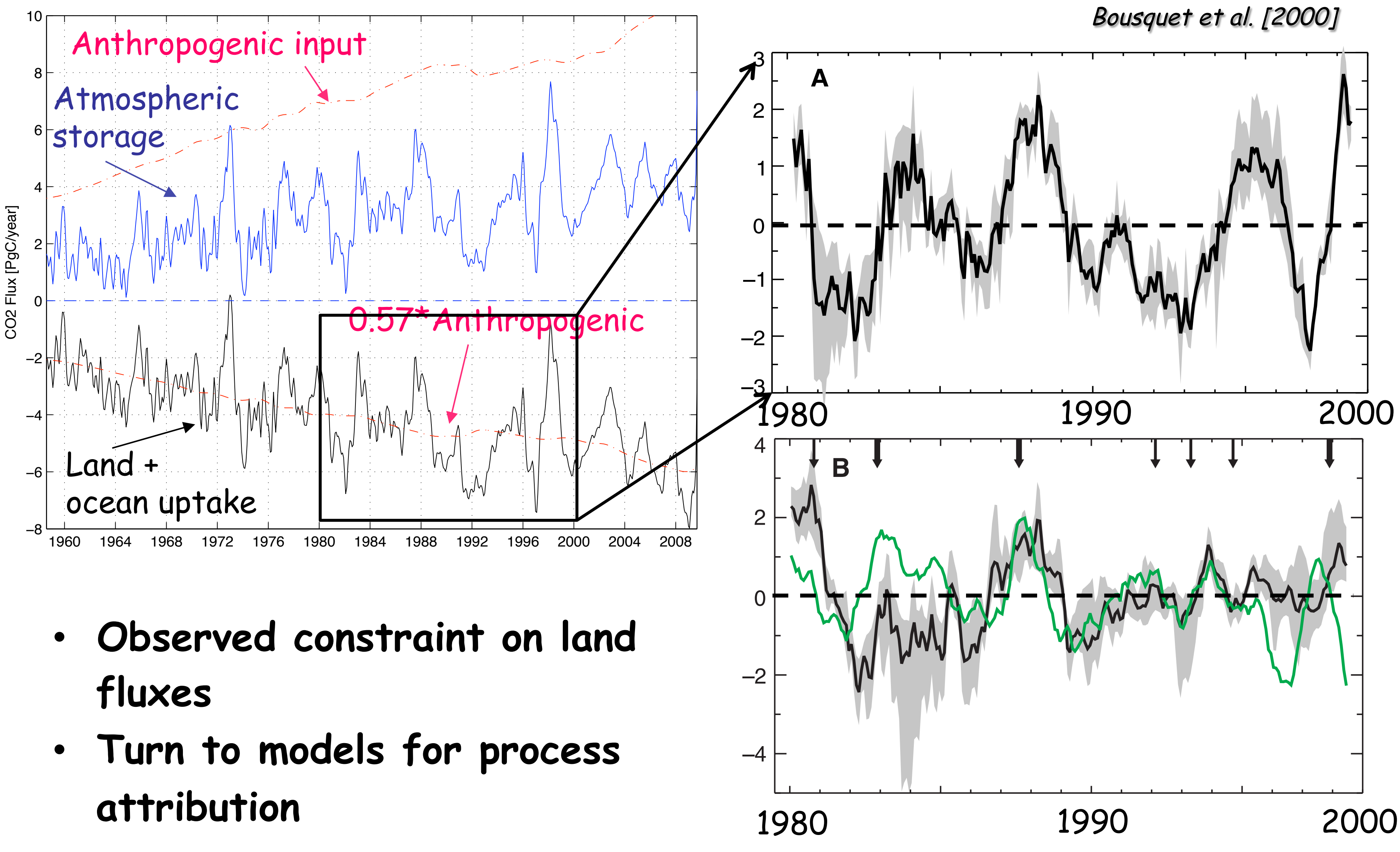
Complementary Estimates of Carbon Pools From FS and CO2



Tropics Dominate Land Sink



- Observed constraint on land fluxes
- Turn to models for process attribution

Sensitivity to Climate Unknown

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Climate–Carbon Cycle Feedback Analysis: Results from the C^4MIP Model Intercomparison

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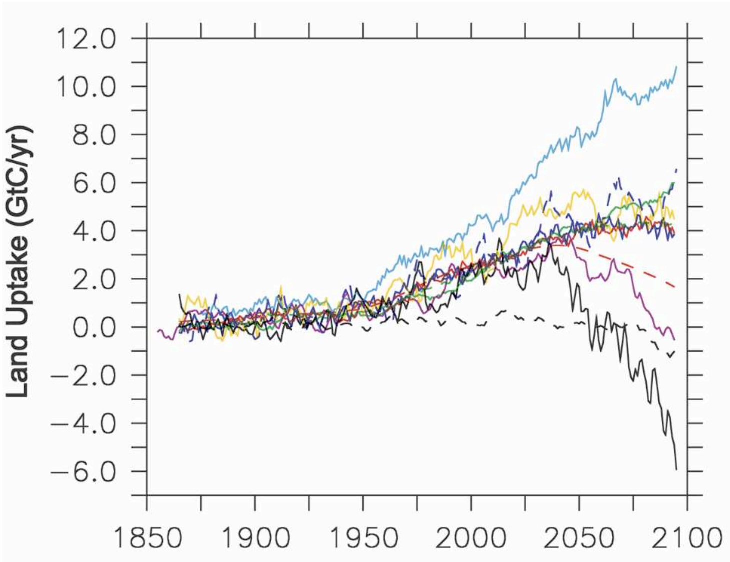
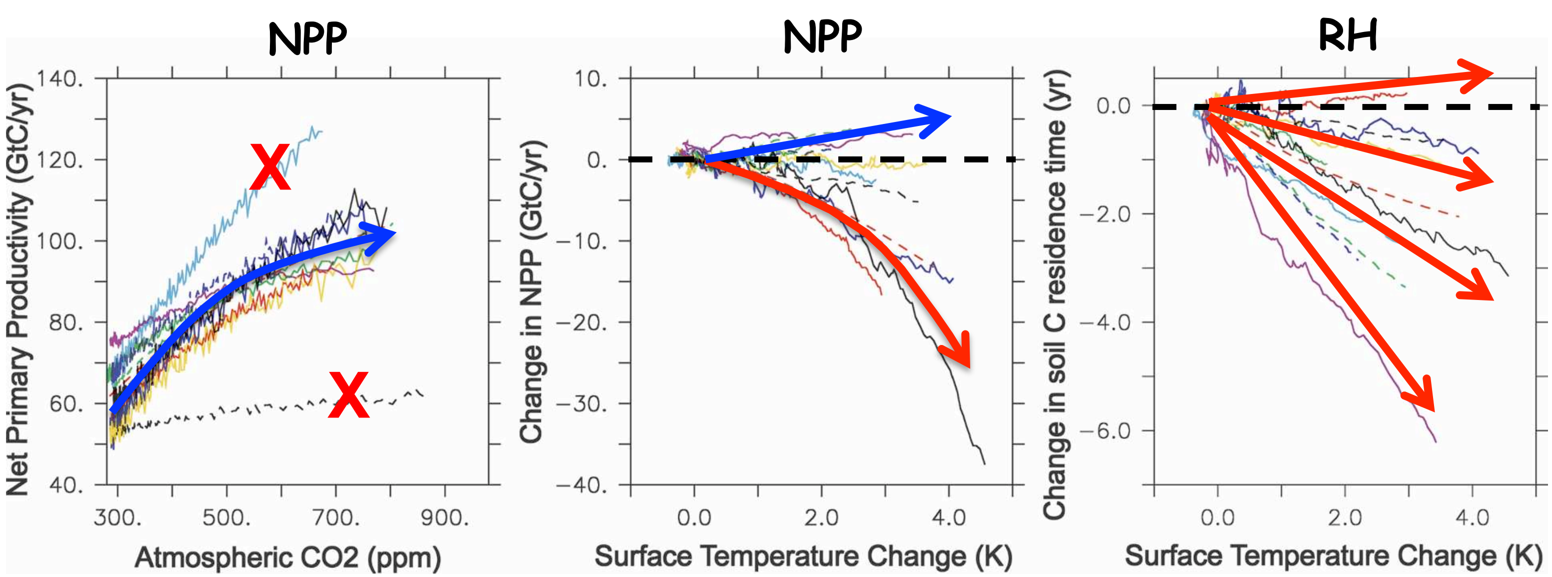
Eleven coupled climate–carbon cycle models used a common protocol to study the coupling between climate change and the carbon cycle. The models were forced by historical emissions and the Intergovernmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (SRES) A2 anthropogenic emissions of CO_2 for the 1850–2100 time period. For each model, two simulations were performed in order to isolate the impact of climate change on the land and ocean carbon cycle, and therefore the climate feedback on the atmospheric CO_2 concentration growth rate. There was unanimous agreement among the models that future climate change will reduce the efficiency of the earth system to absorb the anthropogenic carbon perturbation. A larger fraction of anthropogenic CO_2 will stay airborne if climate change is accounted for. By the end of the twenty-first century, this additional CO_2 varied between 20 and 200 ppm for the two extreme models, the majority of the models lying between 50 and 100 ppm. The higher CO_2 levels led to an additional climate warming ranging between 0.1° and 1.5°C.

All models simulated a negative sensitivity for both the land and the ocean carbon cycle to future climate. However, there was still a large uncertainty on the magnitude of these sensitivities. Eight models attributed most of the changes to the land, while three attributed it to the ocean. Also, a majority of the models located the reduction of land carbon uptake in the Tropics. However, the attribution of the land sensitivity to changes in net primary productivity versus changes in respiration is still subject to debate; no consensus emerged among the models.

Model Partitioning of GPP/RE



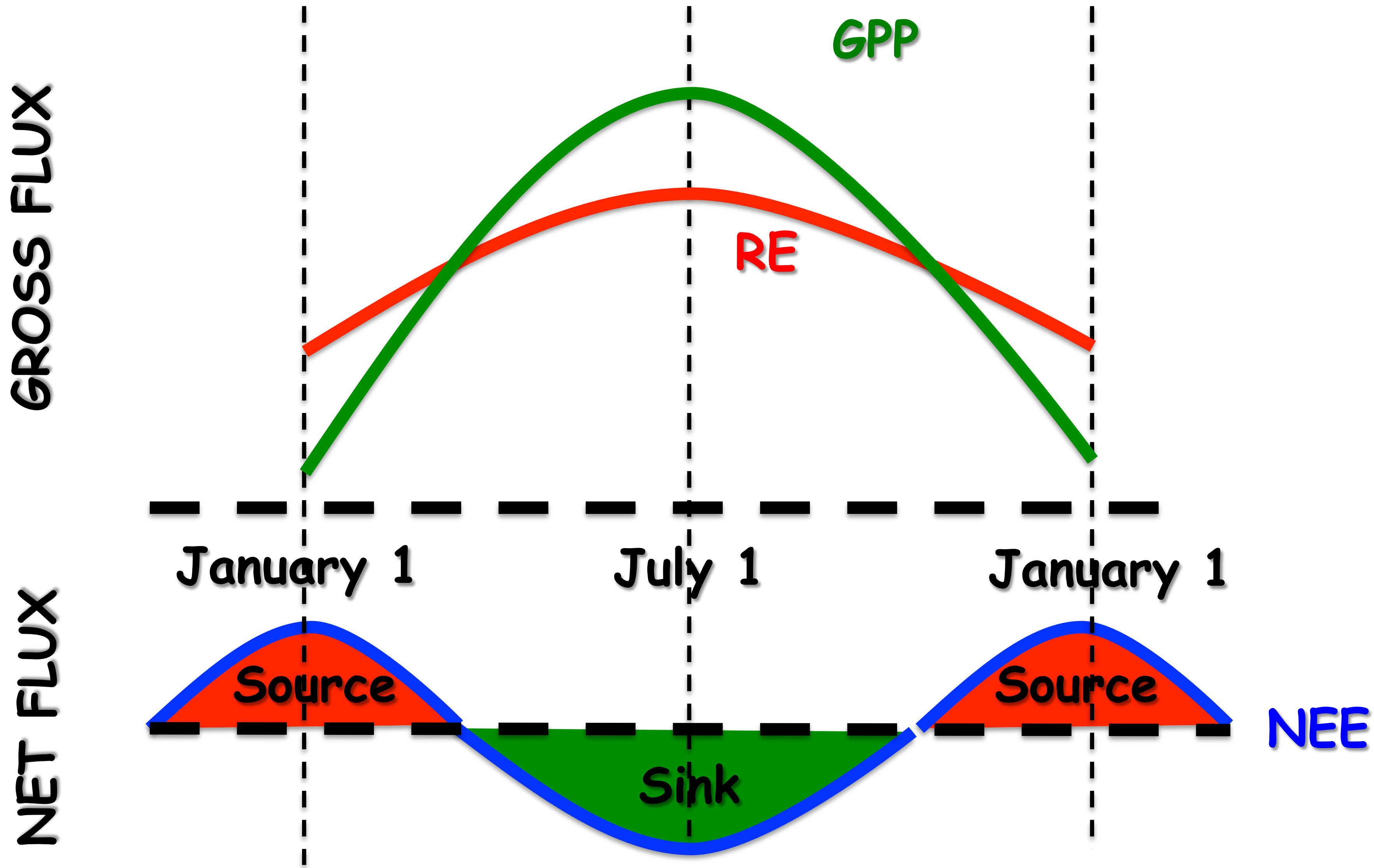
- Agree on CO2 fertilization
- Disagree on NPP response to temperature and moisture
- Disagree on RE, or turnover time from dead plant matter to respired CO2



Source/Sink Controls

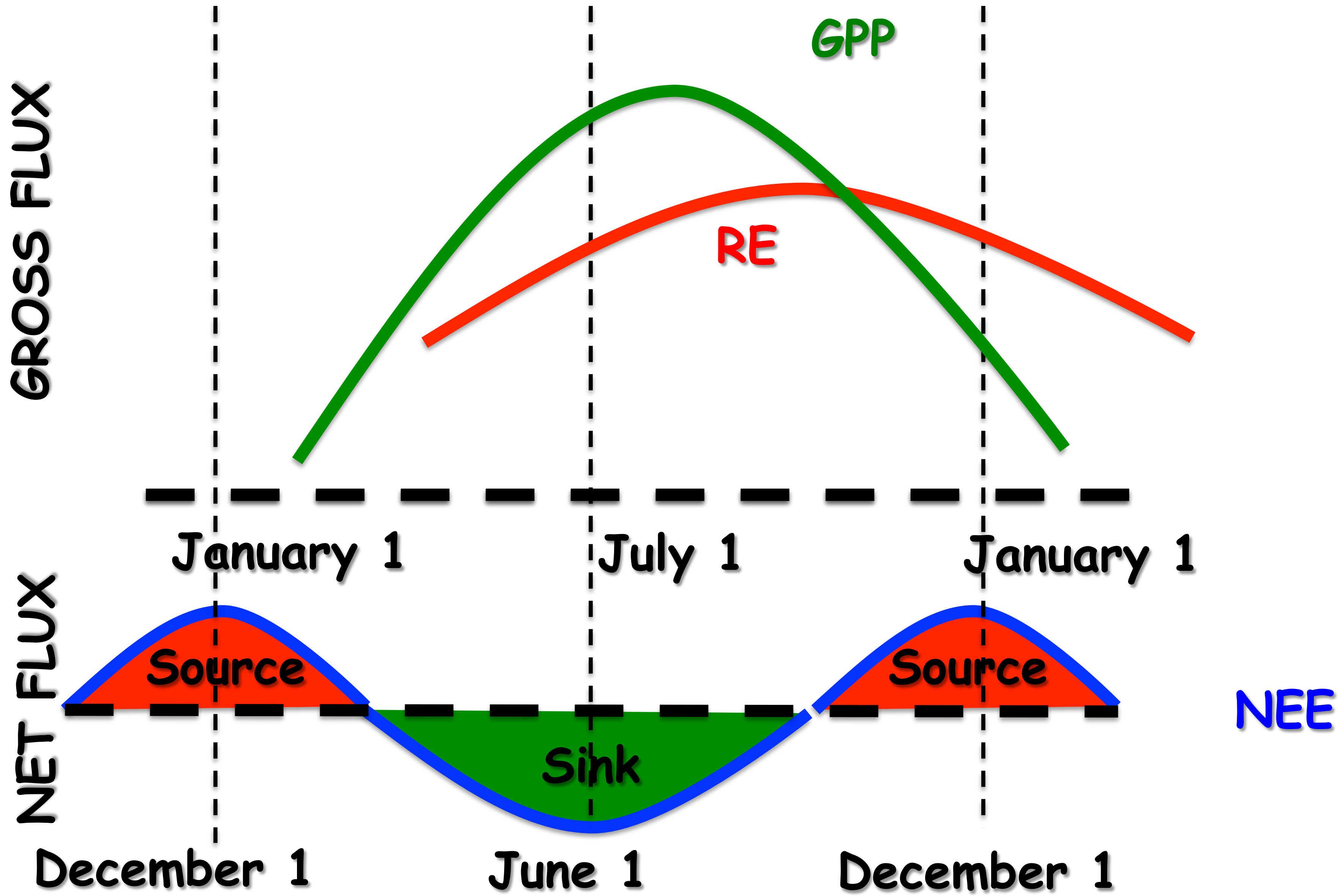
- What is partitioning of land flux into GPP and RE?
- What is response to environment?
  - GPP -> CO2 fertilization, N deposition, Hydrologic Cycle
  - RE -> Temperature, Moisture (Canopy and Soil)
- What is the phase relationship between GPP & RE?

NEE = RE - GPP

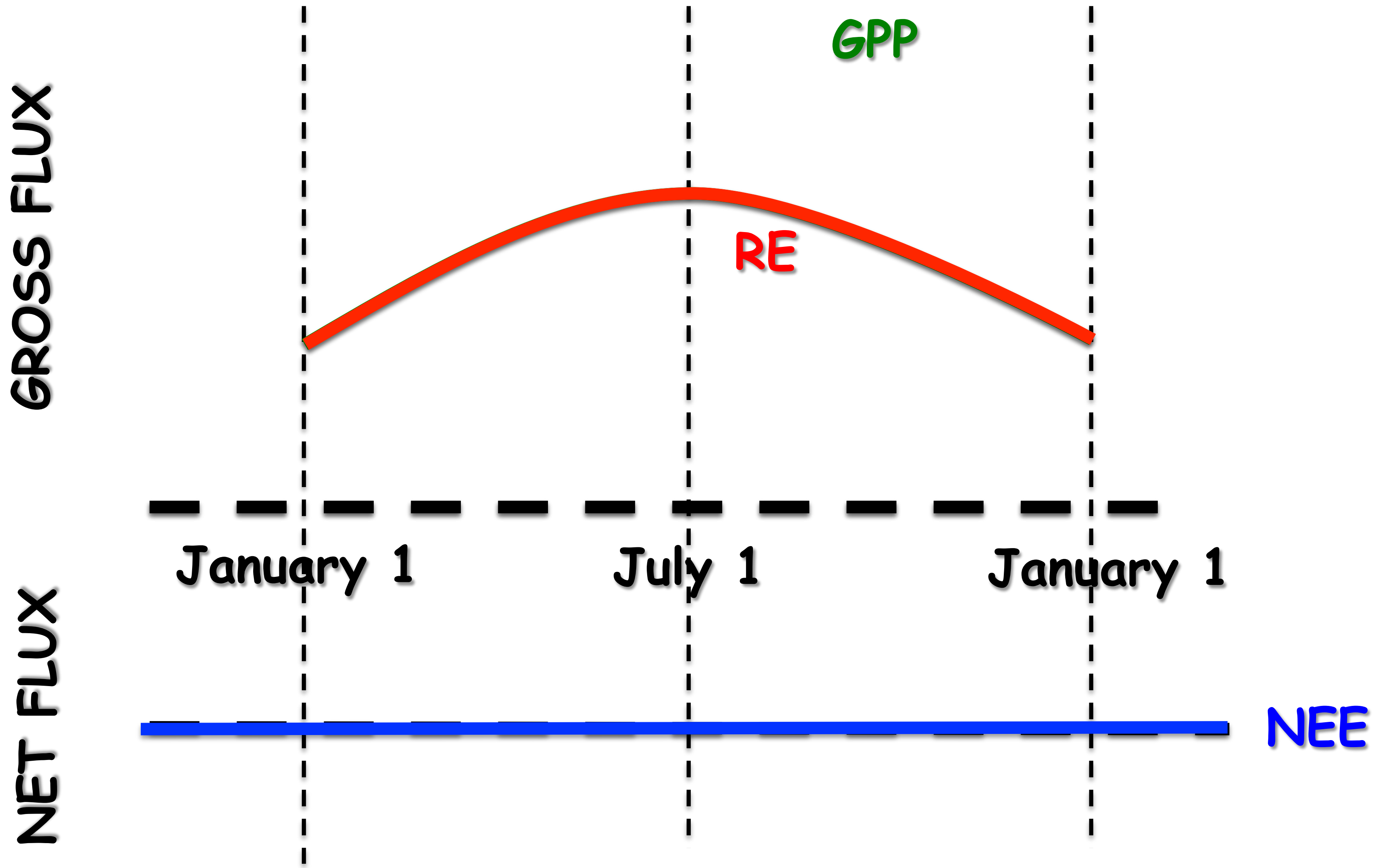


GPP
RE
GROSS FLUX
January 1
July 1
January 1
NET FLUX
Source
Sink
Source
NEE

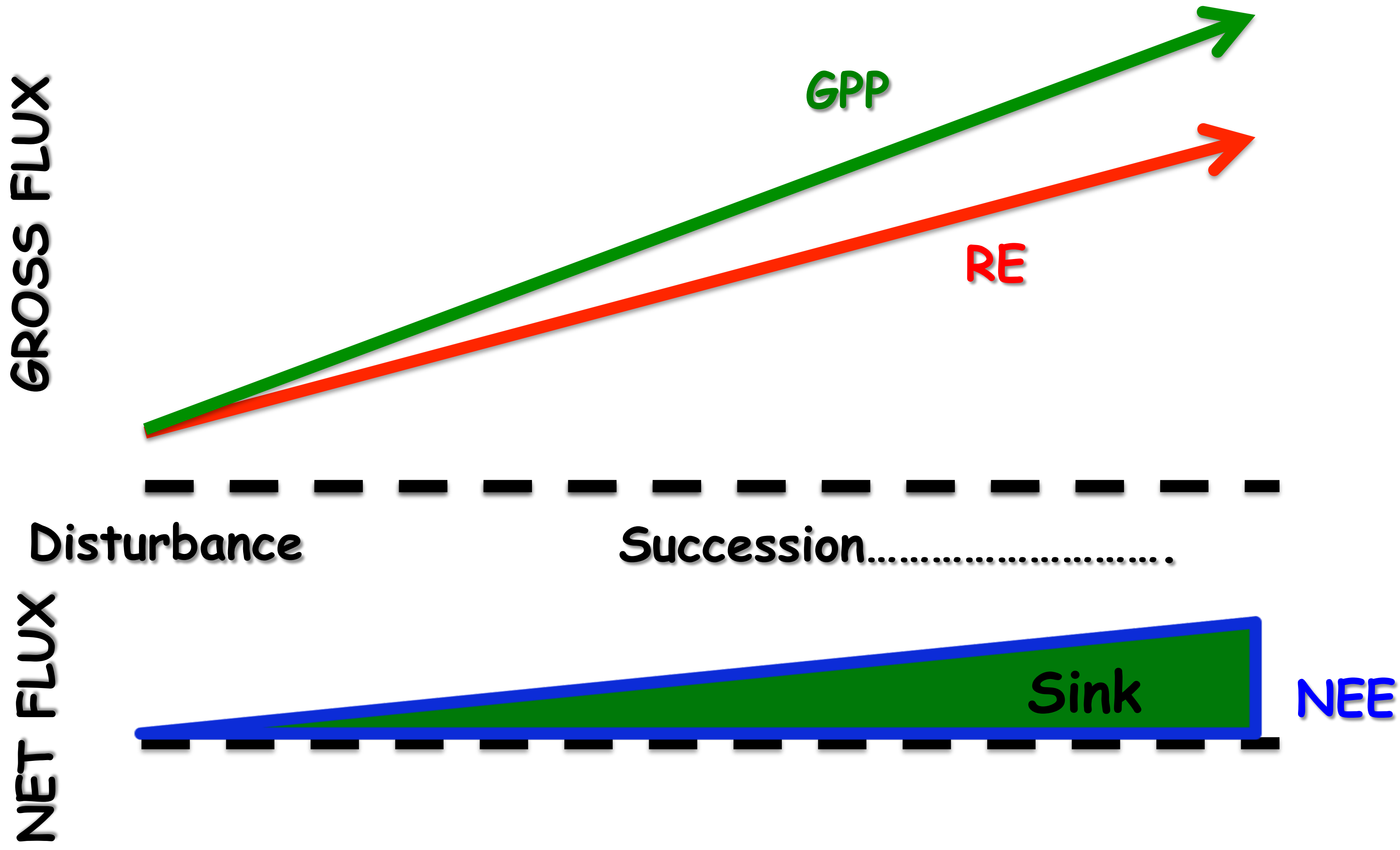
Phase


GPP
RE
GROSS FLUX
January 1
July 1
January 1
NET FLUX
Source
Sink
Source
NEE
December 1
June 1
December 1

Amplitude



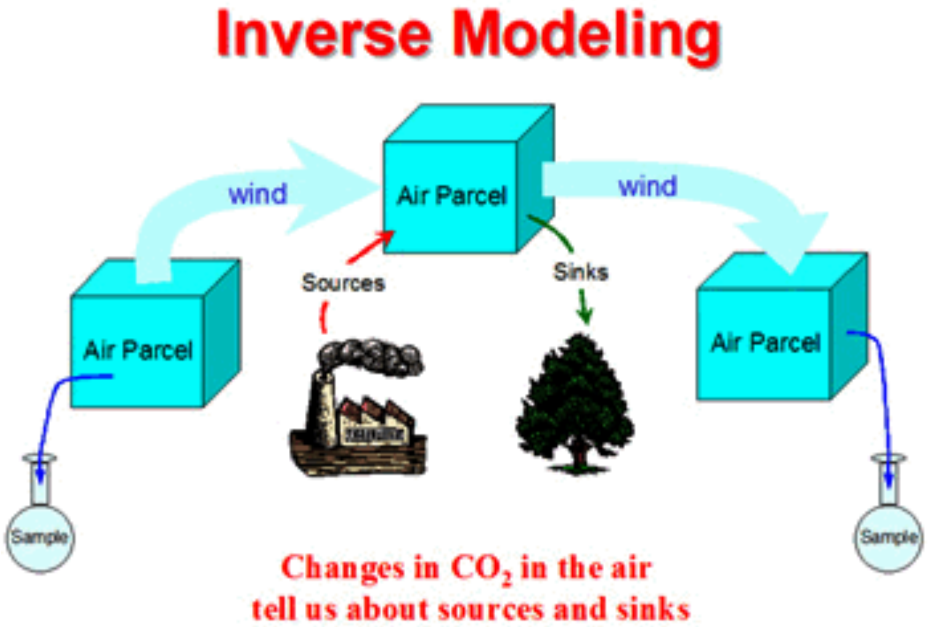
Long Term Carbon Pools

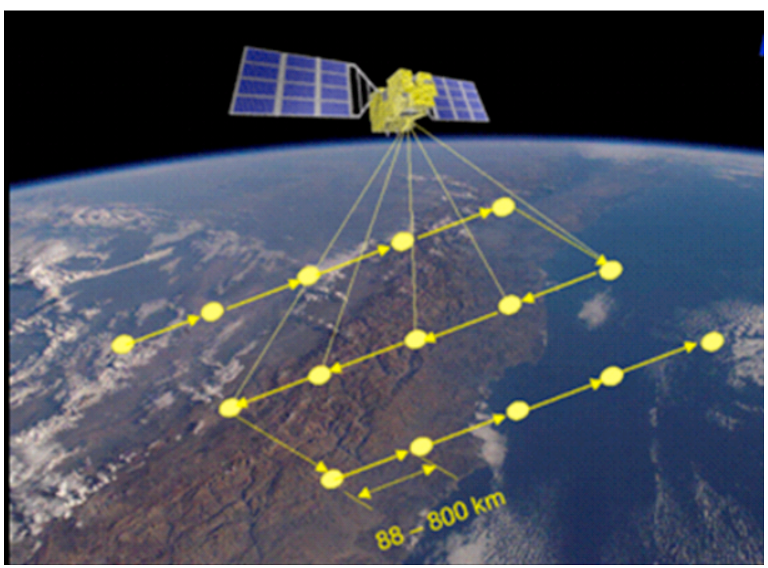


Questions

- What is the spatial distribution of
  - Phase Lag?
  - Amplitude Difference?
- Is the phase shorter in tropics because fast turnover time?
- Is the phase longer in boreal regions because slow turnover time?
- What is the role of stand age vs environment
  - Long term increase in RE due to climate (e.g., rising temp) or increasing carbon input?

CO2 Flux





- *Estimate*: 4x5, monthly, 2010
- *Numerics*: 4DVAR
- *Transport*: GEOS-CHEM
- *Observations*: Column CO2 from GOSAT

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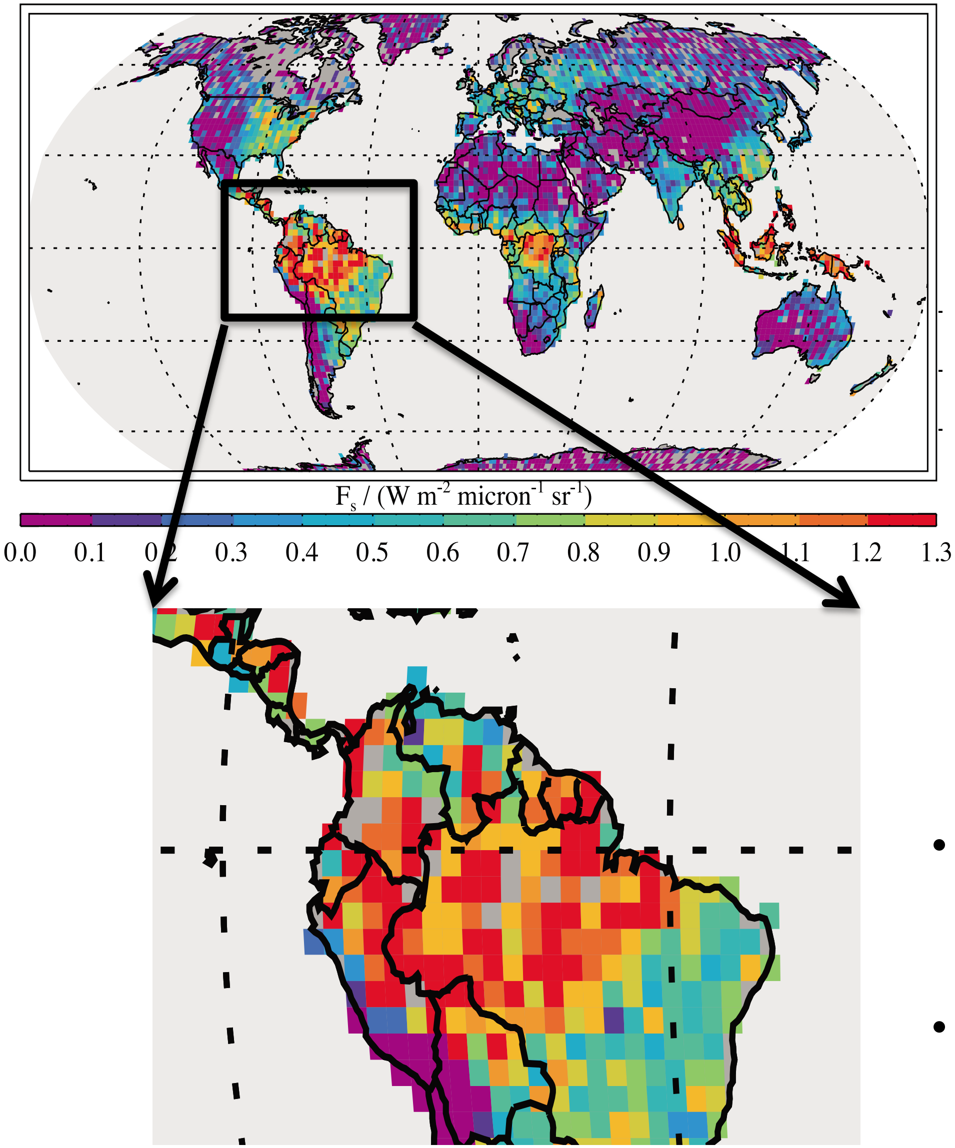
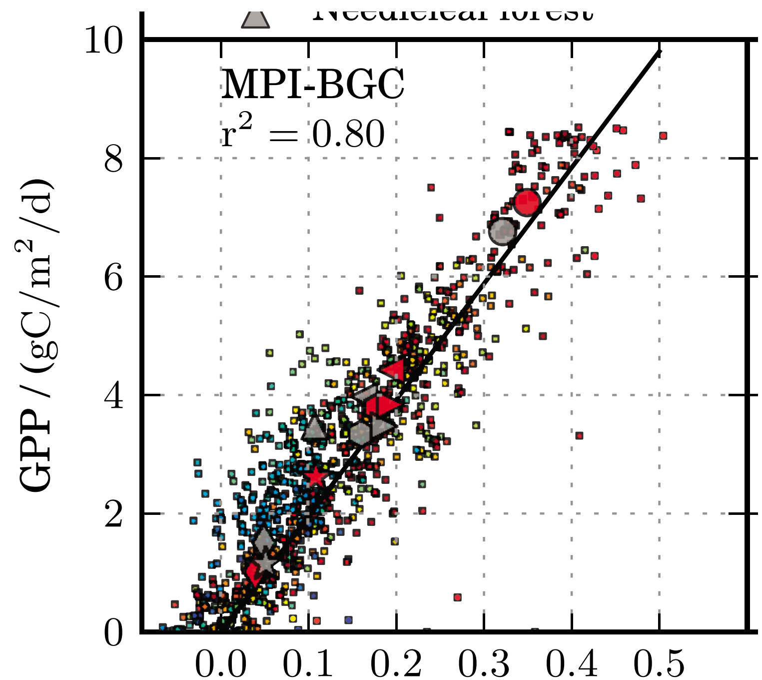
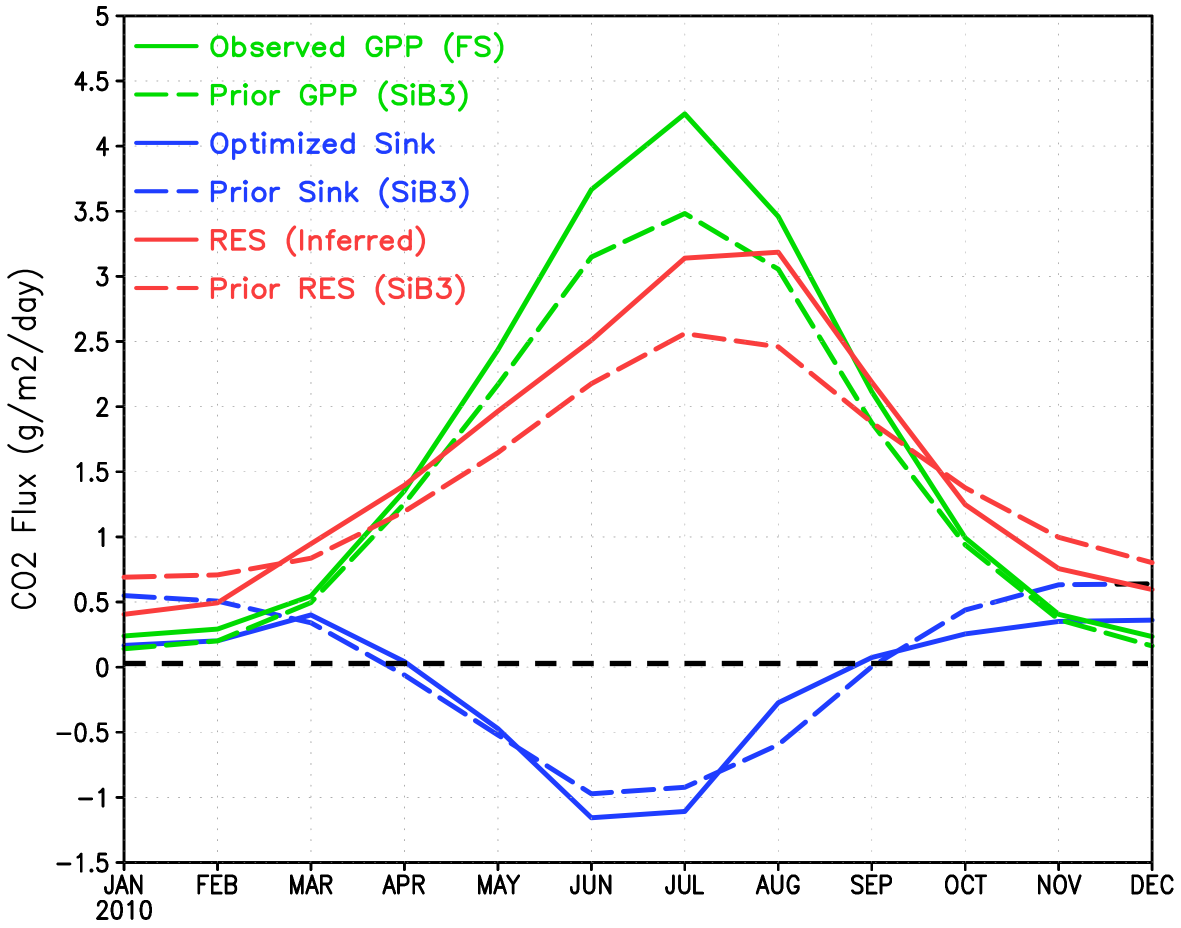
GPP





- Assume Linear Relationship of FS & GPP
- Due to gaps, use weighted average with MPI

Example:
Seasonal CO_2 Flux for N. America

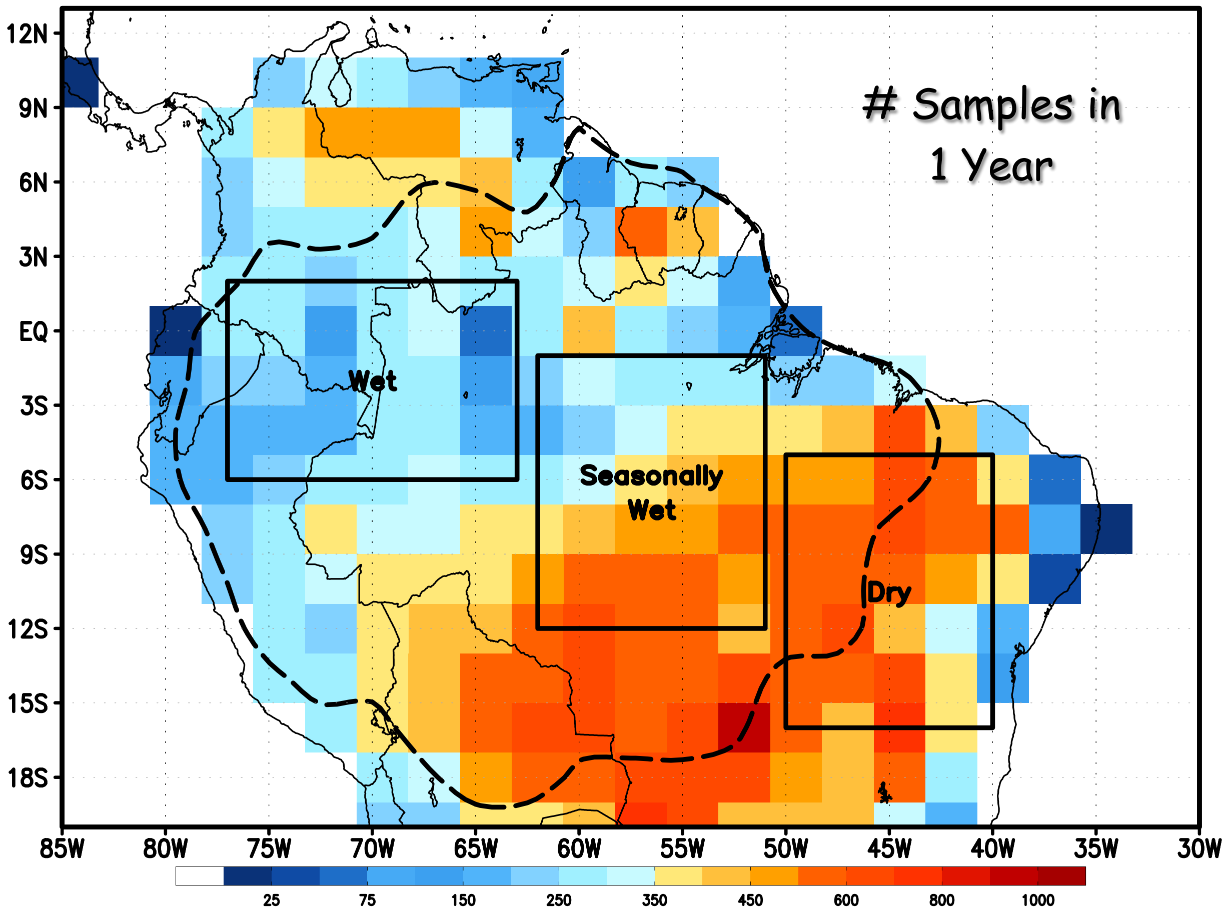


Shift in amplitude/phase of RE, leads to shift in timing of peak CO2 uptake

Using Amazon XCO2 Effectively

Observing The Amazon is Hard

Spatial Coverage



- Sampling coverage biased towards southeast and dry season
- Very few points over lower Amazon Basin during wet season

Observing The Amazon is Hard

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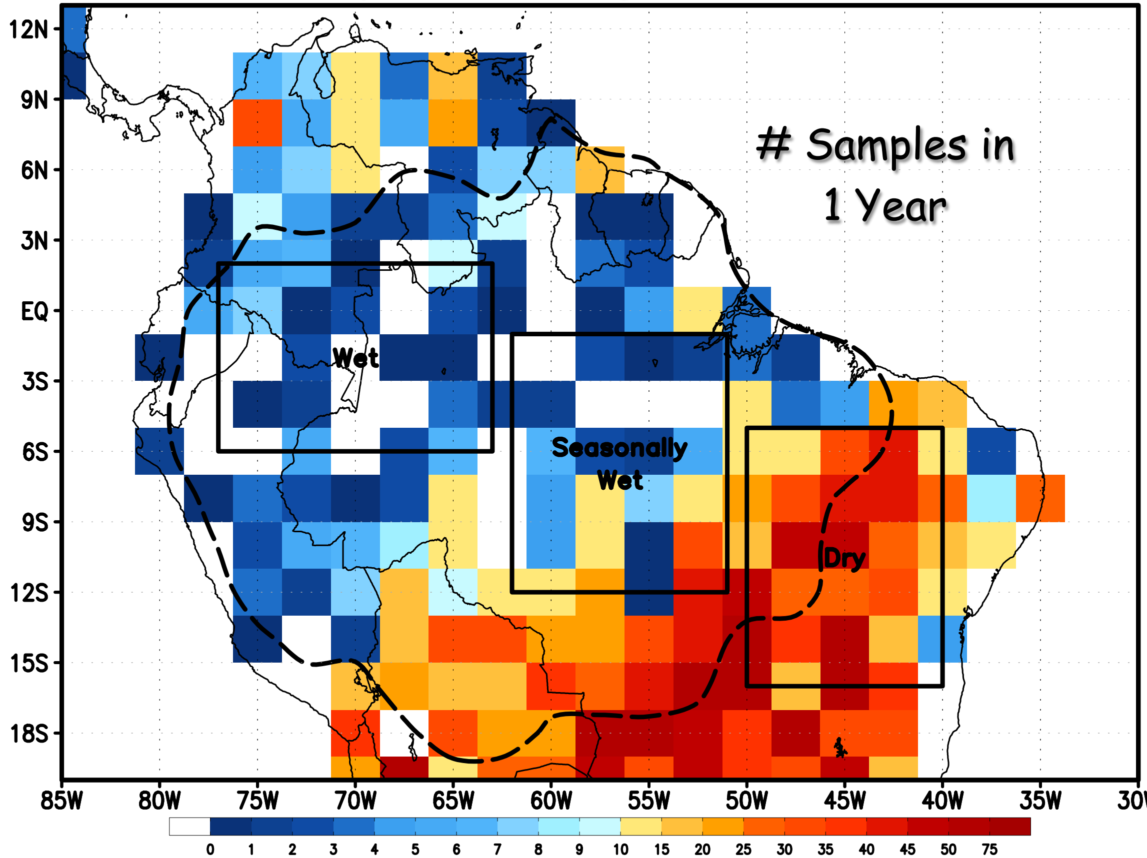
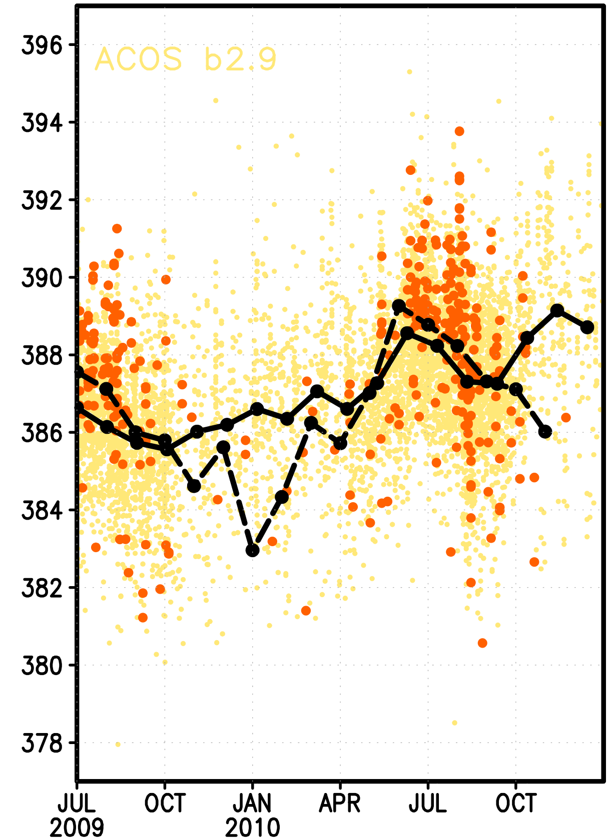
Spatial Coverage of XCO2



Seasonal Coverage



- Sampling coverage biased towards southeast and dry season
- Very few points over lower Amazon Basin during wet season
- How can we resolve low sampling coverage in central Amazon?

Comparison to Independent Data in Amazon

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- XCO2 Retrieval Intercomparison
- BARCA (Balanço Atmosférico Regional de Carbono na Amazônia) Aircraft Campaigns
  - In-situ CO2/CH4 and flask measurements for GHG's/isotopes in Nov 08 (Phase A) and May 09 (Phase B)
- Background CO2 from GLOBALVIEW
  - http://www.esrl.noaa.gov/gmd/ccgg/globalview/co2/co2_intro.html
- Flux tower data from LBA
  - http://daac.ornl.gov/LBA/lba.shtml

Sensitivity Studies

Local or Large-Scale?

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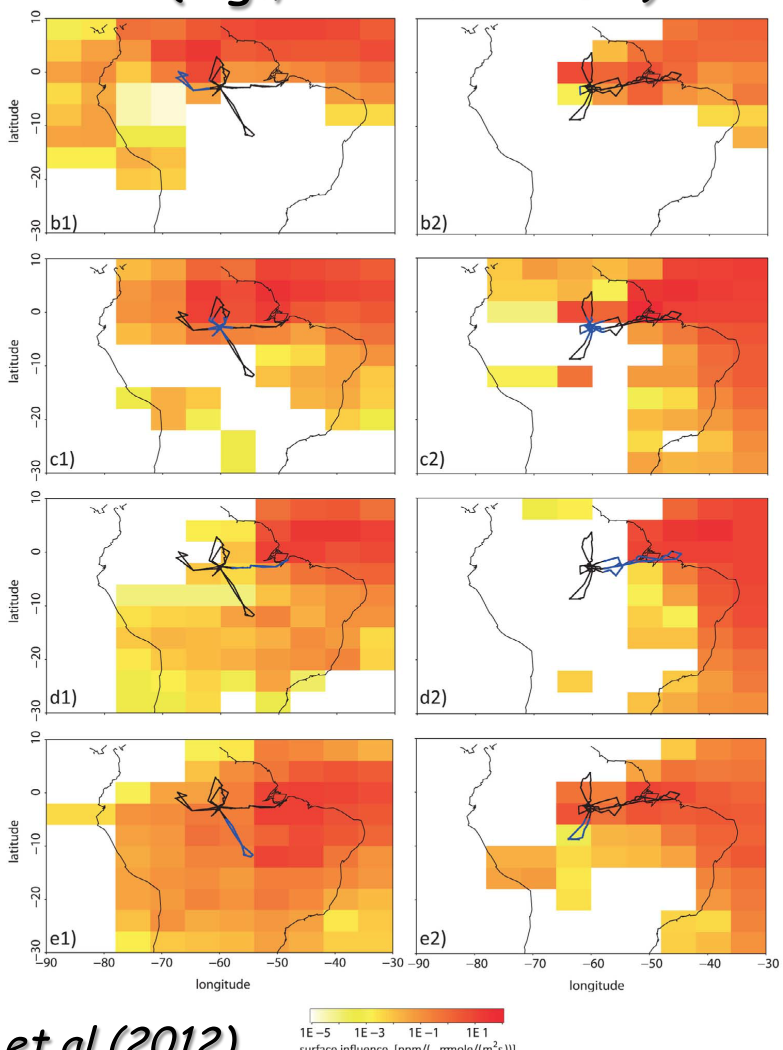
Flux Footprint
(e.g., CH4 & STILT)



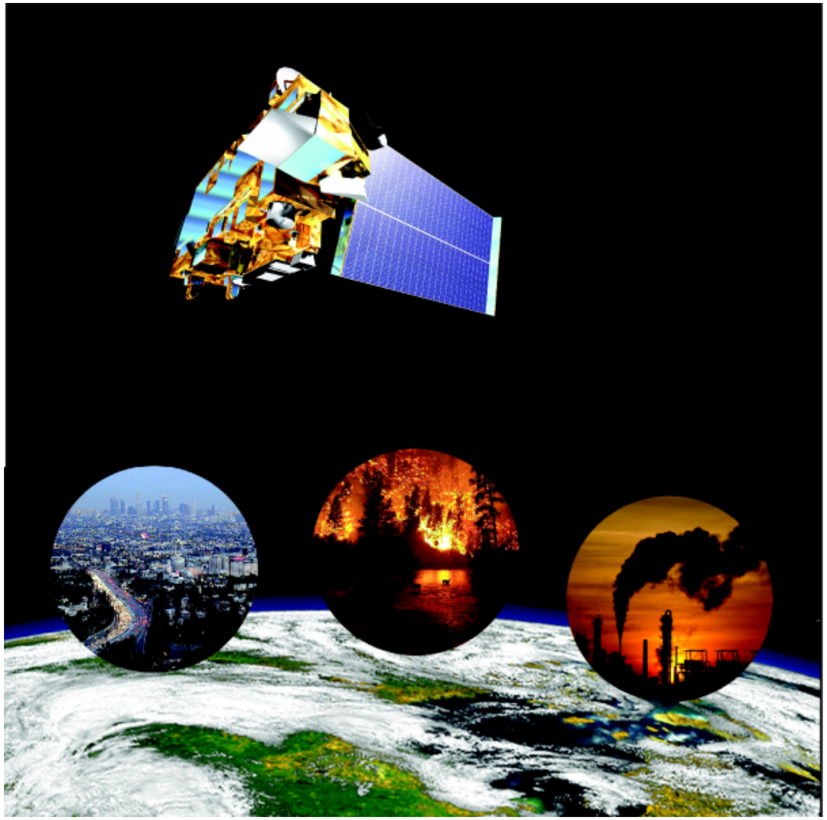
Beck et al (2012)

- STILT-based CH4 footprint shows some seasonal/regional dependence
  - Offshore influence is consistently strong
- Alternatively, perform sensitivity calculations of column CO2 using GEOS-CHEM Adjoint
  - Transport or surface flux?
  - Regional or local?

Test For Amazon Emission Sources

Natural or Biomass Burning?

MOPITT CO



Tracer gases such as Carbon Monoxide can tell us about sources of CO_2 from Biomass Burning

Sub-Monthly Constraints

Assimilate FS into GPP Model

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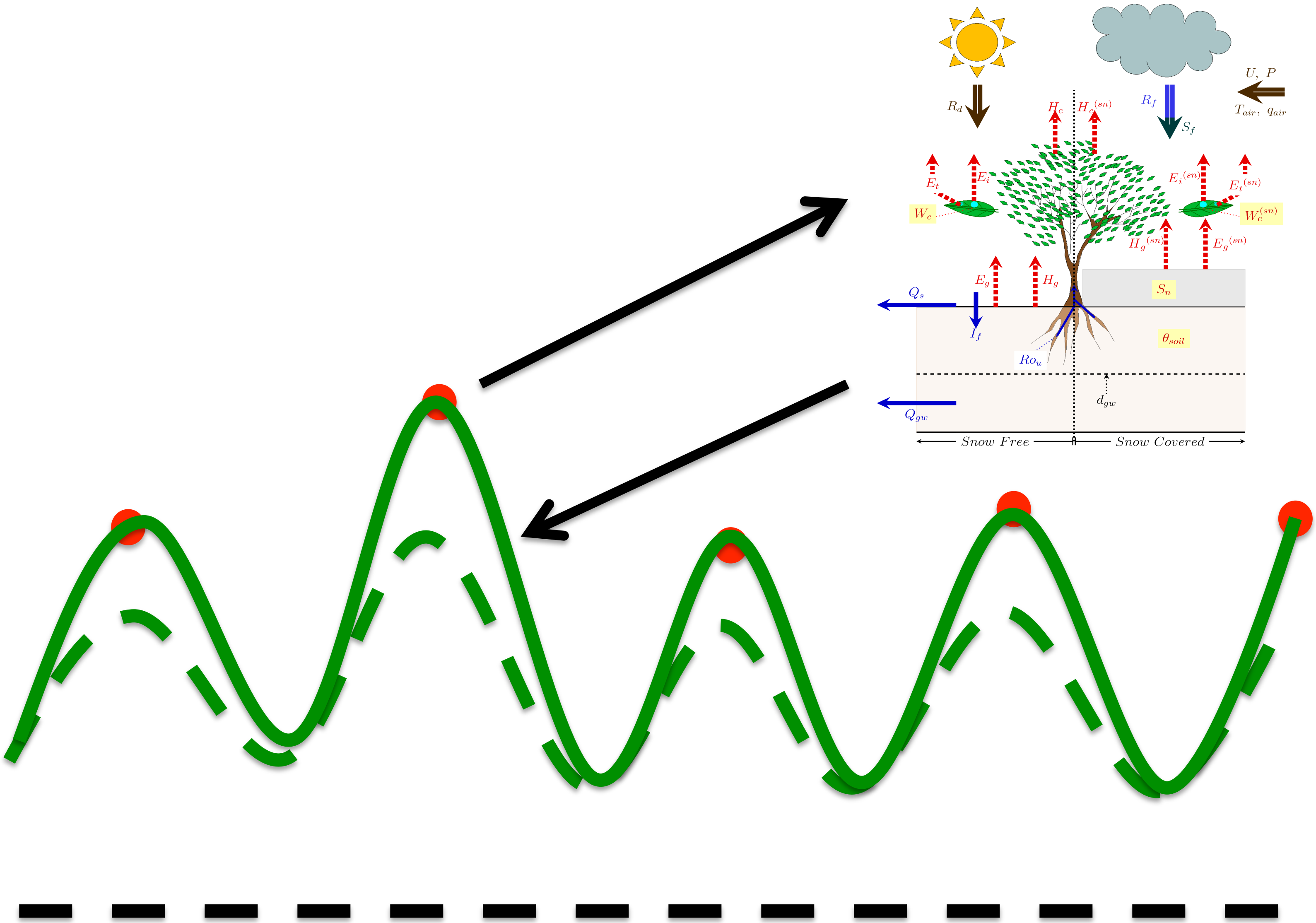

Take Home Points

- Joint retrievals of XCO2 and FS may have strong predictive power for:
  - Predicting short and long term carbon pools
  - Analyzing carbon imbalance in the Amazon
  - Disentangling Carbon Sources (Biomass Burning verse Respiration)
  - Data assimilation in land surface models