Preliminary Results of the NACP Regional Interim Synthesis

AmeriFlux Annual Meeting
Washington, DC, September 22, 2009

Bob Cook, Debbie Huntzinger,
Mac Post, Andy Jacobson, Yaxing Wei, and
NACP Interim Synthesis Participants

Participants: *Dozens of modeling teams and data providers, Canada, USA, Mexico, Europe*

Overall Science Questions:

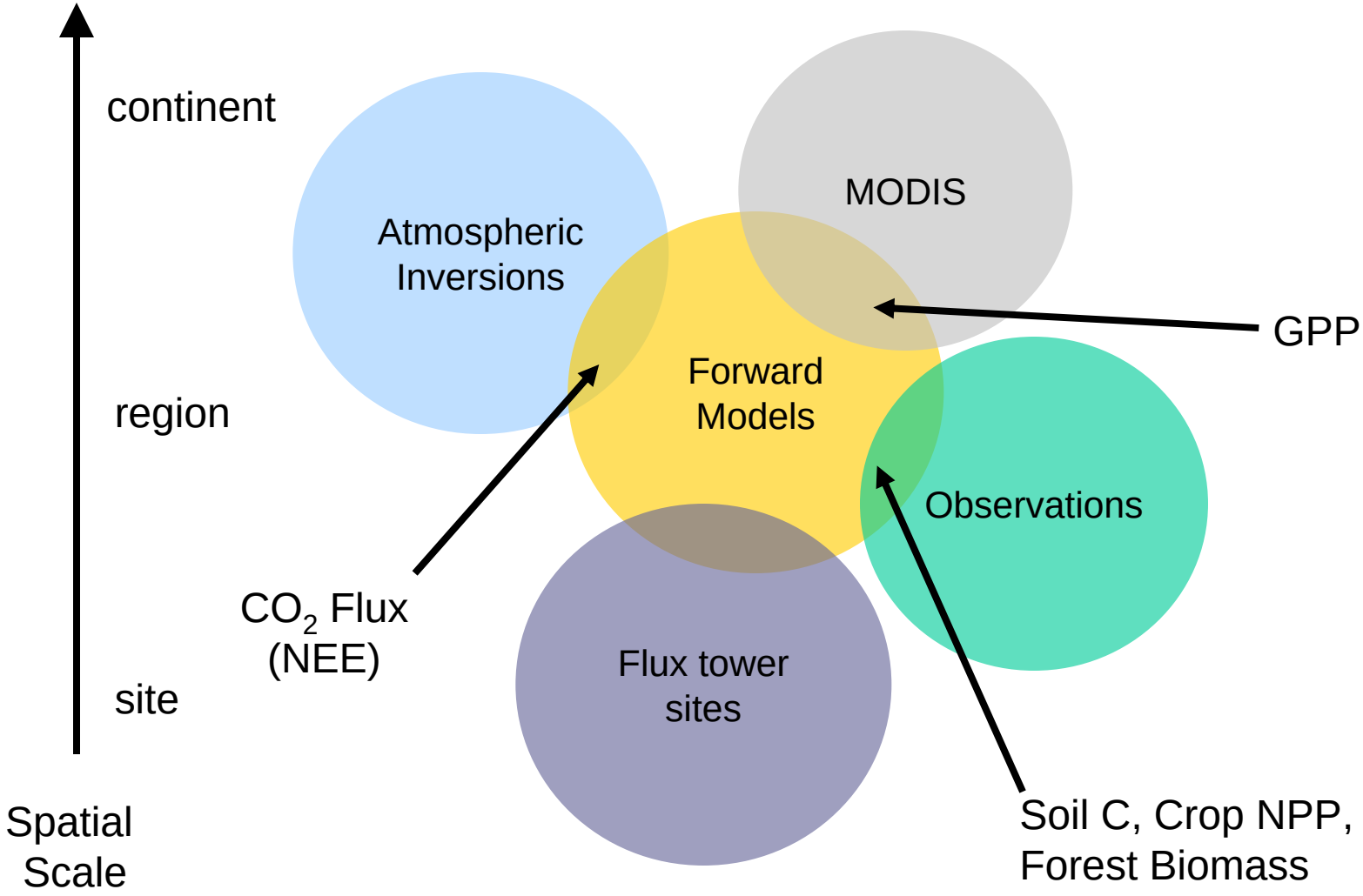
- Identification of Sources/Sinks
  - What are the magnitudes and spatial distribution of carbon sources and sinks, and their uncertainties during 2000-2005?
- Interannual Variation
  - What is the spatial pattern and magnitude of interannual variation in carbon fluxes during 2000-2005?
  - What are the components of carbon fluxes and pools that contribute to this variation?
- 2002 Drought
  - Do model results and observations show consistent spatial patterns in response to the 2002 drought?
  - From measurements and ecosystem models, can we infer what processes were affected by the 2002 drought?

Interim Synthesis: Regional and Continental Models and Observations

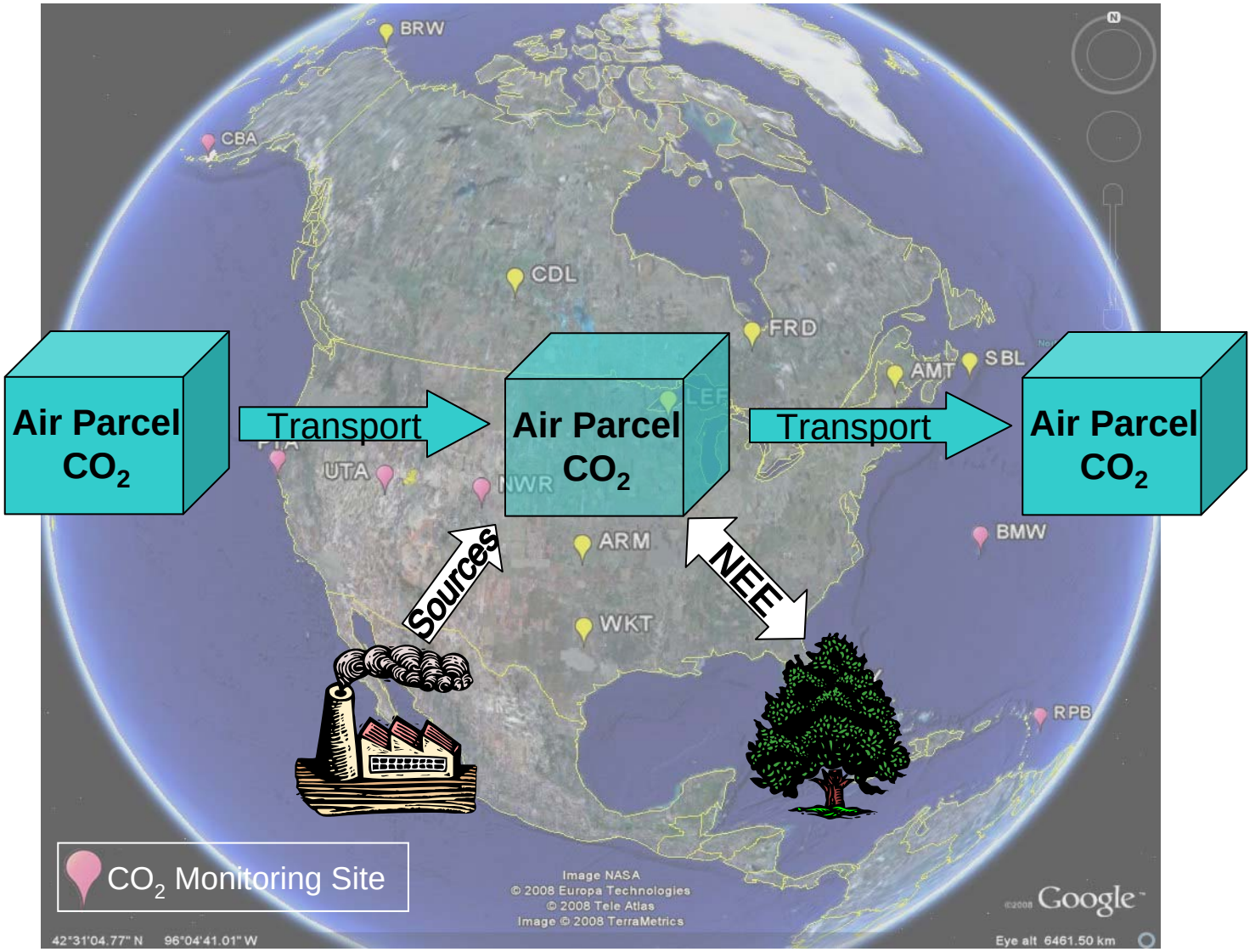
- Initiated by MAST-DC and NACP investigators in 2008
- Model simulations (off-the-shelf)
  - 22 forward/ecosystem models
  - 24 inversion models
- Observations
  - MODIS sensor, crop and forest inventories, soil C
- 2000-2005
- 1-degree spatial resolution
- Monthly temporal resolution
- Data in uniform format (netCDF CF-1)

http://nacp.ornl.gov/int_synth_contreg.shtml

Use of Multiple Sources of Information



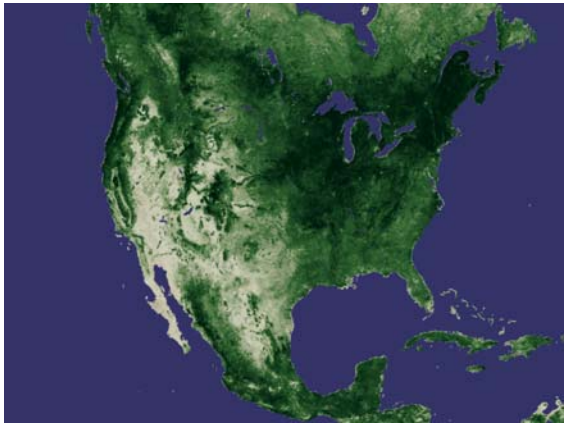
Modeling Approaches: Inversions



Sources: Denning and Michalak

Modeling Approaches: Forward/Ecosystem

- Process understanding and data from site studies (e.g., flux towers)
- Models aggregate fluxes to regional scales
- Multiple fluxes, including Net ecosystem exchange (NEE) and component fluxes (GPP, R, NPP), etc.
- Test hypotheses and make projections
- Boundary conditions
  - Soil properties
  - Vegetation type
  - Land management
- Forcing data
  - Weather
  - Nutrient inputs
  - Disturbances
  - Land-use/land cover changes



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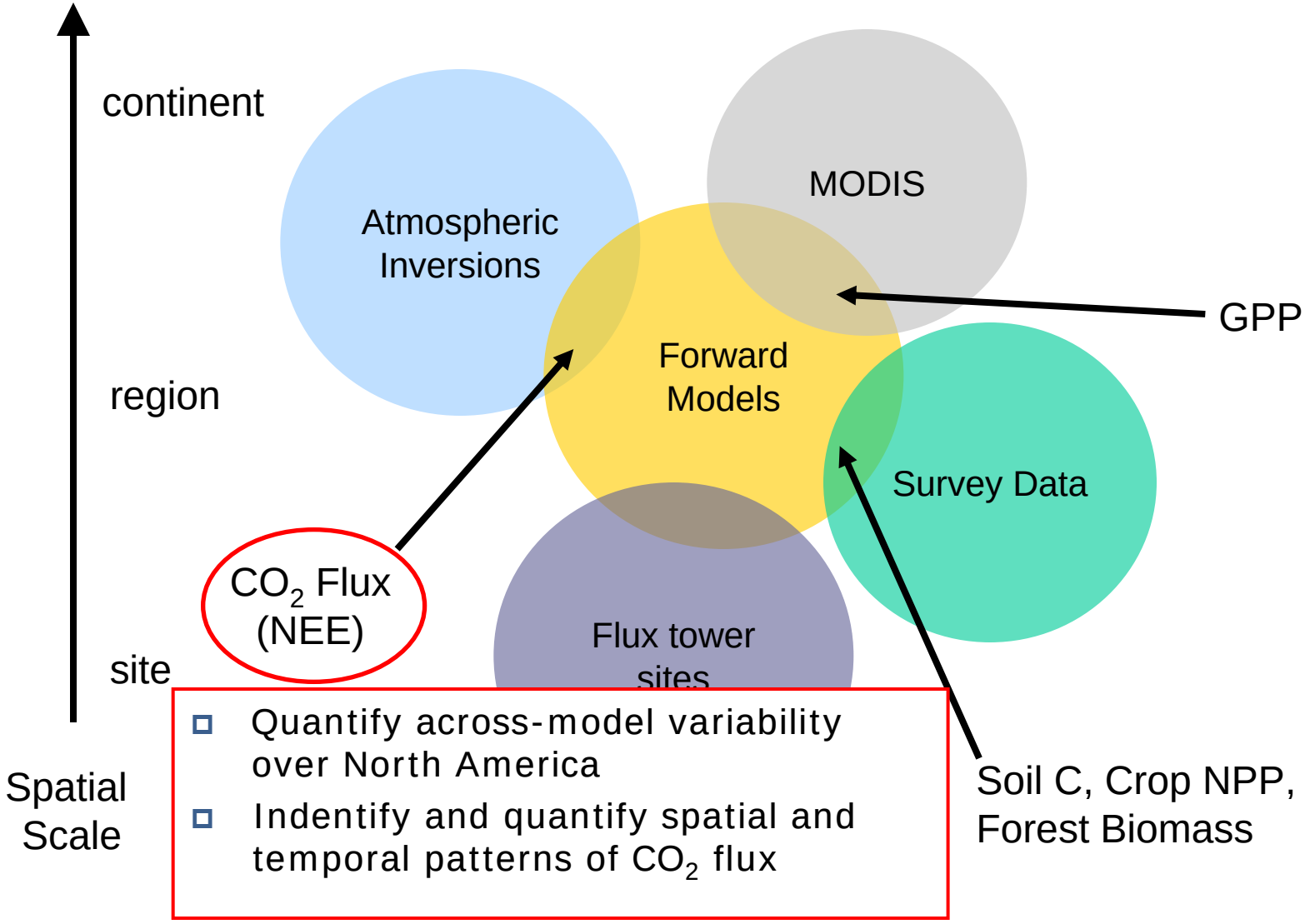


- Quantify across-model variability over North America
- Indentify and quantify spatial and temporal patterns of CO_2 flux

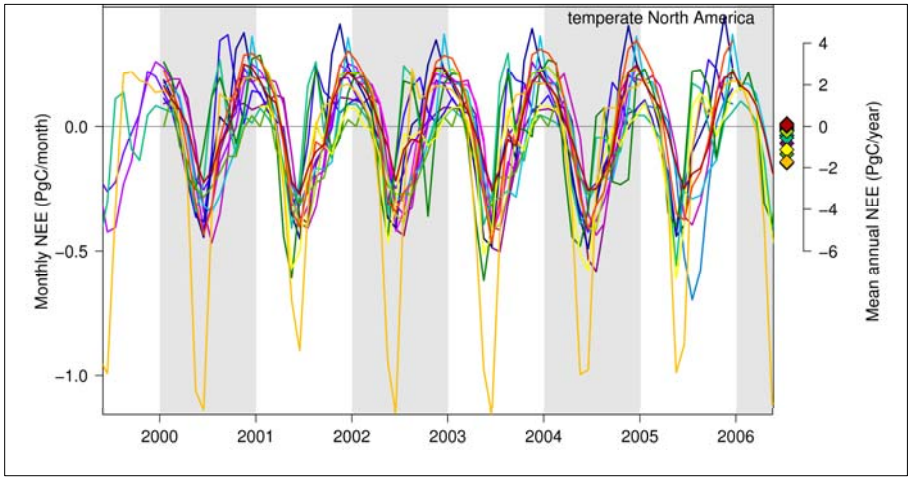
Net Ecosystem Exchange

Significant model-model differences, especially among forward models.

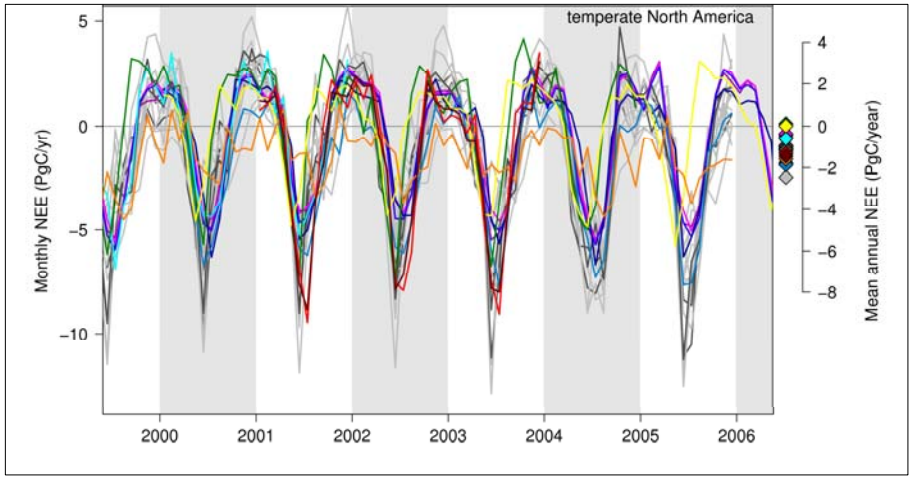
Shapes and depths of seasonal cycle vary considerably among models. Inversions tend to have sharper peak uptake.

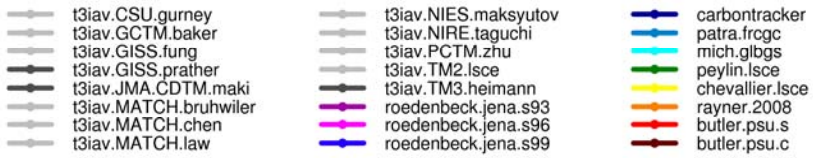
Temperate North America

Forward Models



Inverse Models

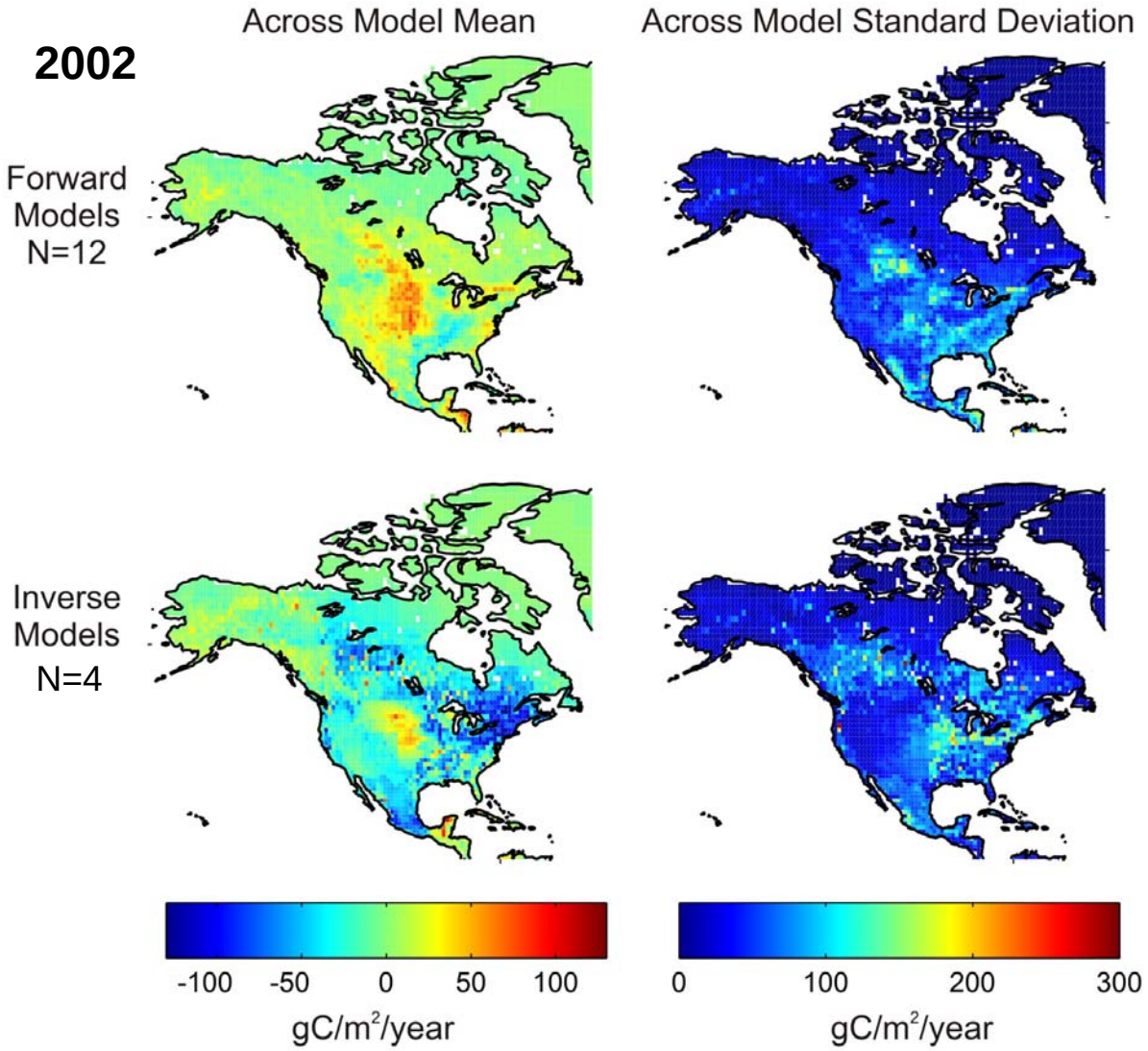




Inter-Model Annual C Flux (NEE)

Inverse and forward average models, while differing in magnitude, show similar spatial patterns

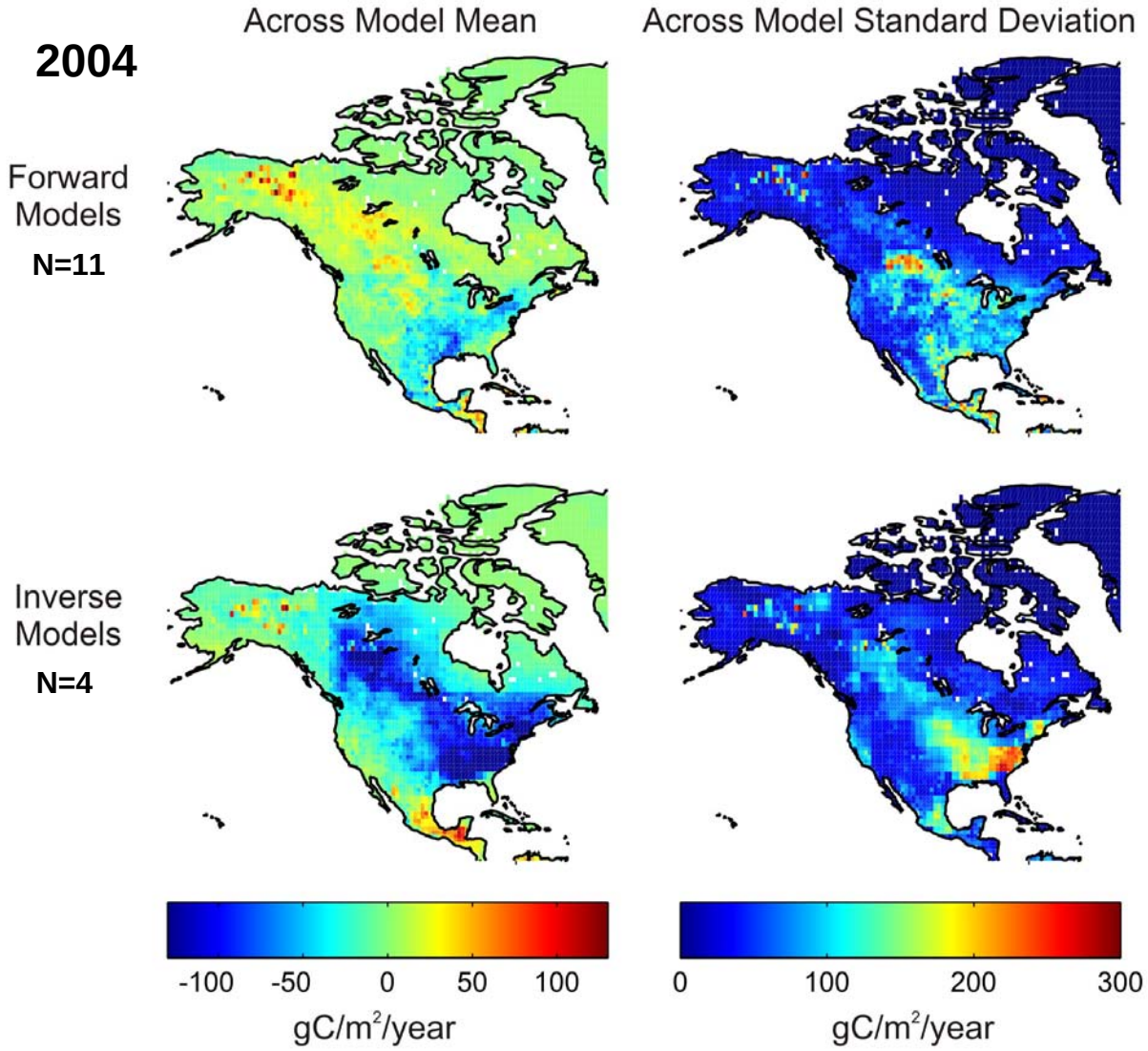
Inverse models localized the 2002 drought to a smaller area than forward models.



Note: Only four inversion models provided 1°x1° fluxes

Inter-Model Annual C Flux (NEE)

Inversion models indicate strong and variable uptake in the U.S. southeast, Agreement among models is weak,
Perhaps due to lack of sampling in SE USA



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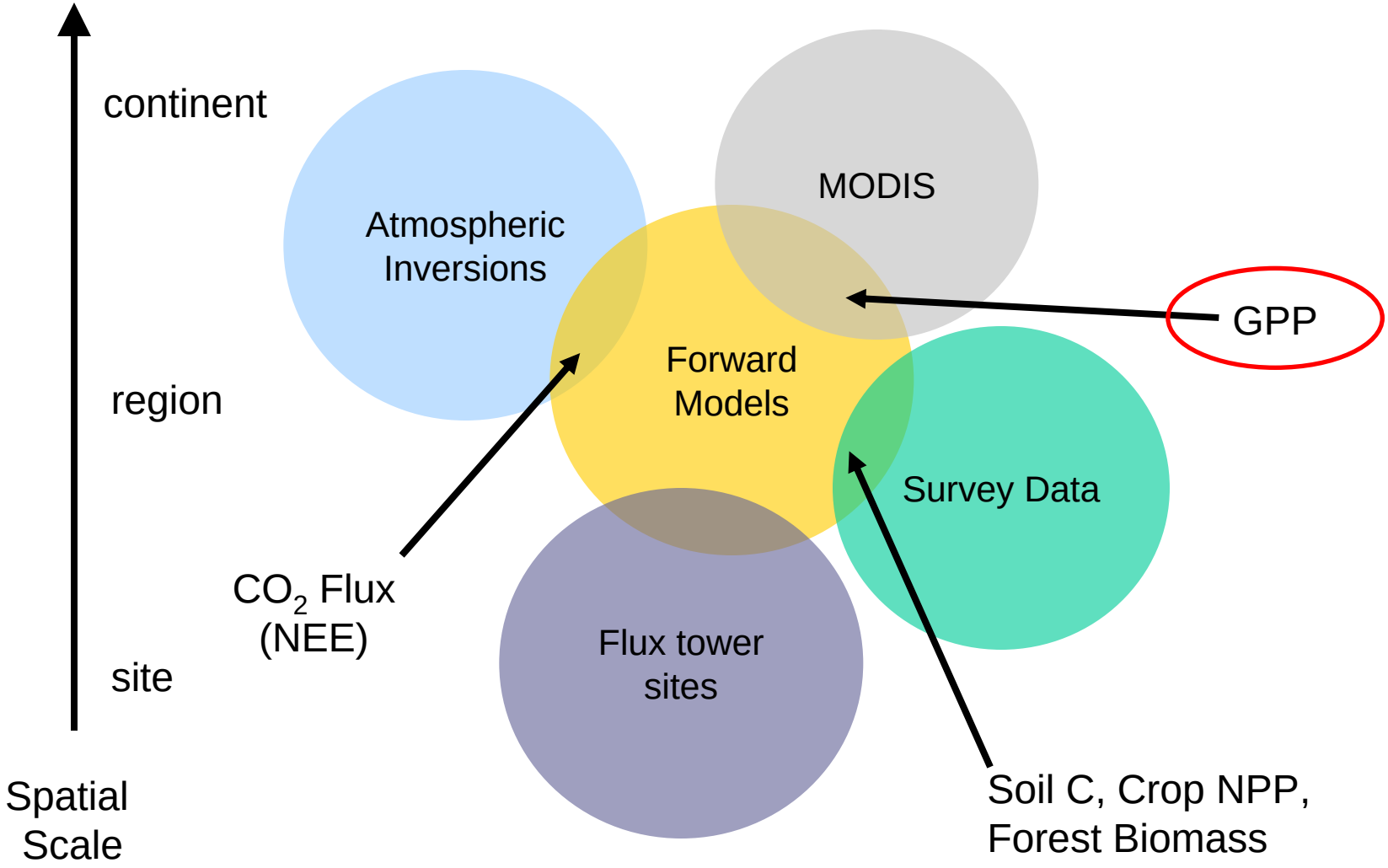
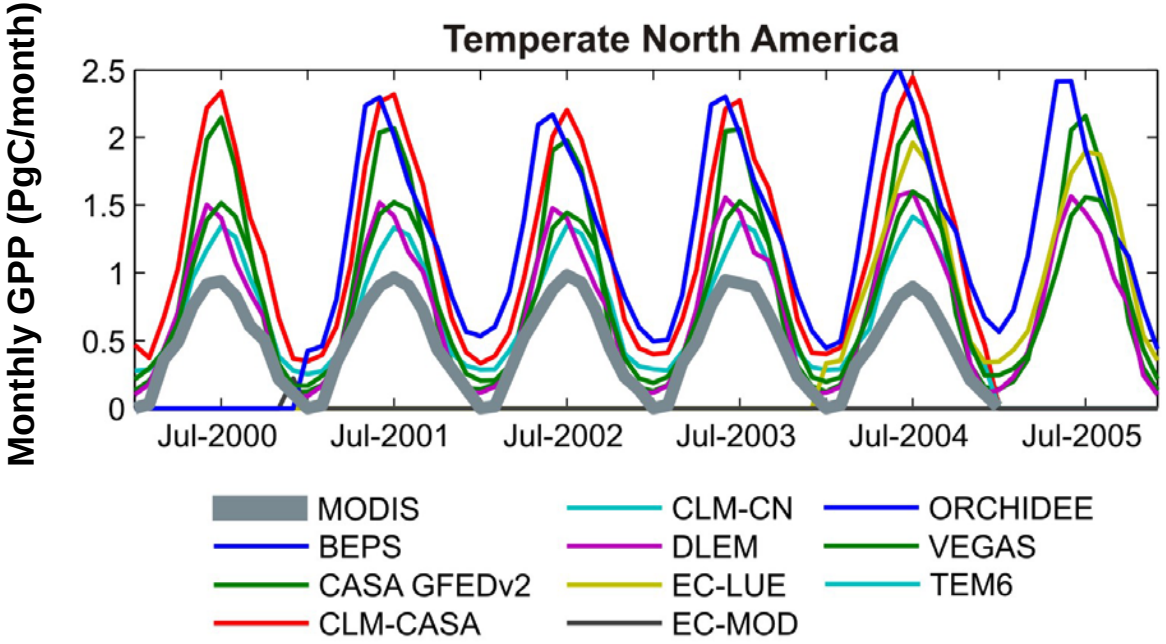


Gross Primary Production

- Forward models predict greater GPP than the MODIS product
- Forward models' estimates of photosynthetic uptake are highly variable
  - Annual mean GPPs vary by a factor of 2



NACP Model – Inventory Comparison

Dave McGuire, Dan Hayes, Mac Post, Werner Kurz, Linda Heath, Tris West, Gretchen Moisen, Ben de Jong, Graham Stinson, Brian McConkey, Yaxing Wei, and Michele Thornton

- Examining the ability of forward and inverse models to identify sources and sinks of C for the North American continent by comparing model estimates with inventory-based estimates of forest C stocks and crop yields

Forest Inventory Estimates

Sub-region	Forest Area	Vegetation C	Delta Vegetation C	NPP	Rh	NEE = -(NPP-Rh-FireEmissions)	Harvest Removals	FireEmissions	Area Burned
Canada	X	X	X	X	X	X	X	X	X
U.S.	X	X	X			X	X	X	?
Mexico	X	X					X		?

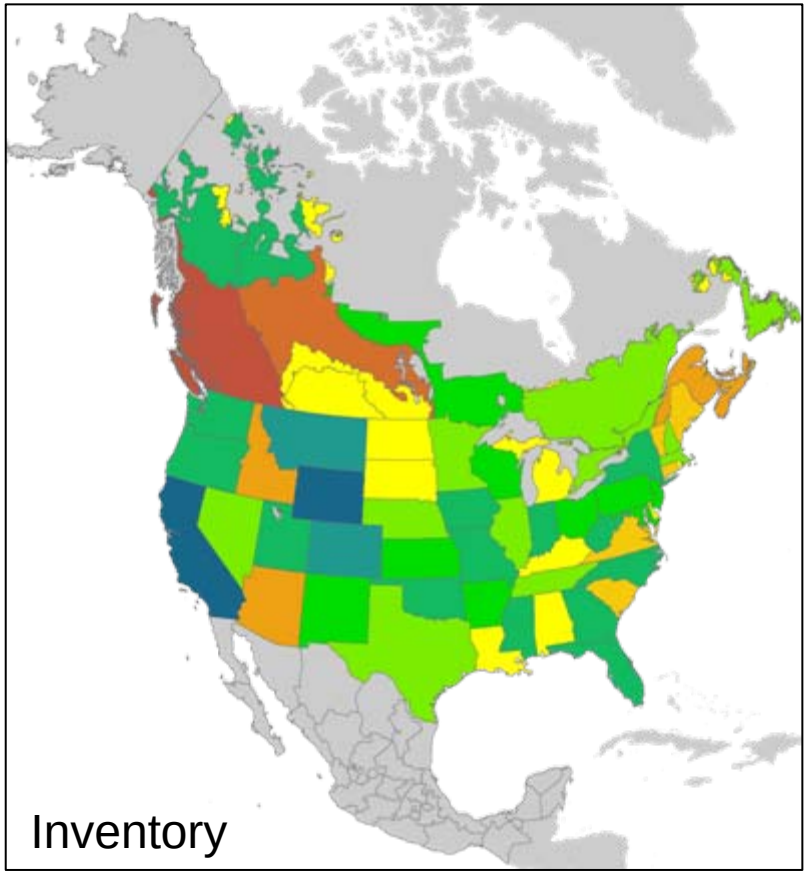
Production Agriculture (Cropland) Inventory Estimates

Sub-region	Cropland Area	Soil C	Delta Soil C	NPP	Rh	NEE	Harvest Removals	FireEmissions	Area Burned
Canada	?	?	?	?		?	?		?
U.S.	X	X	X	X		X	X		
Mexico	X	X		?			X		X

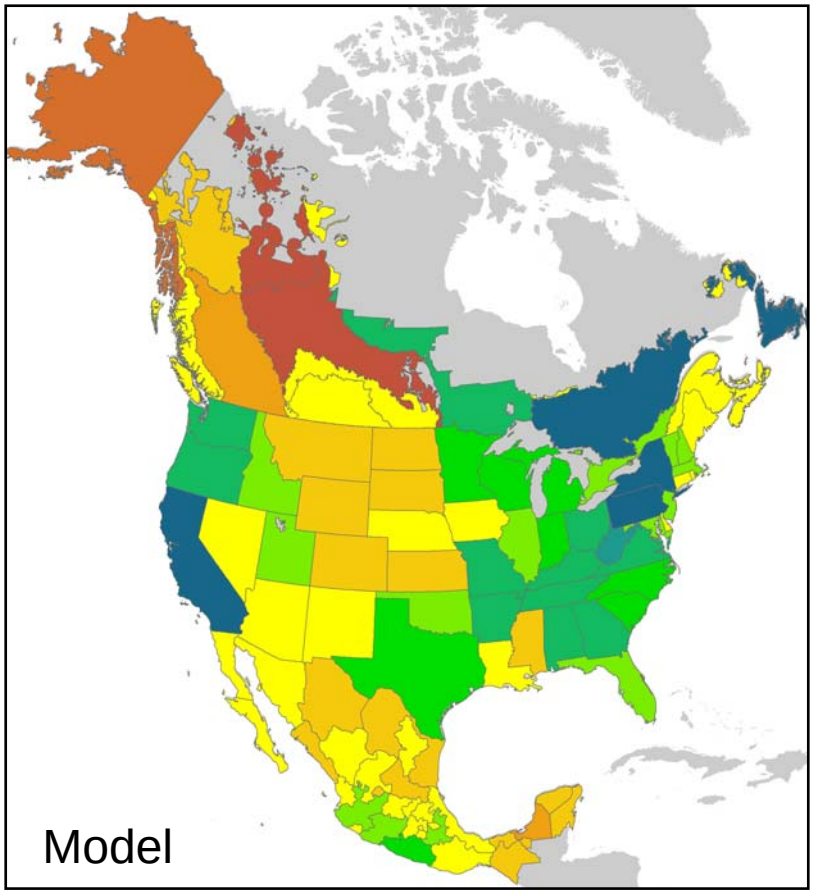
* inventory-based estimates are available by either political state units (U.S. & Mexico) or the Kyoto Protocol reporting units for Canada

NACP Model – Inventory Comparison

Change in Total Forest Sector C Stocks from Inventory-based Estimates



Mean Model Estimates for Forest Sector Net C Exchange (NEE)

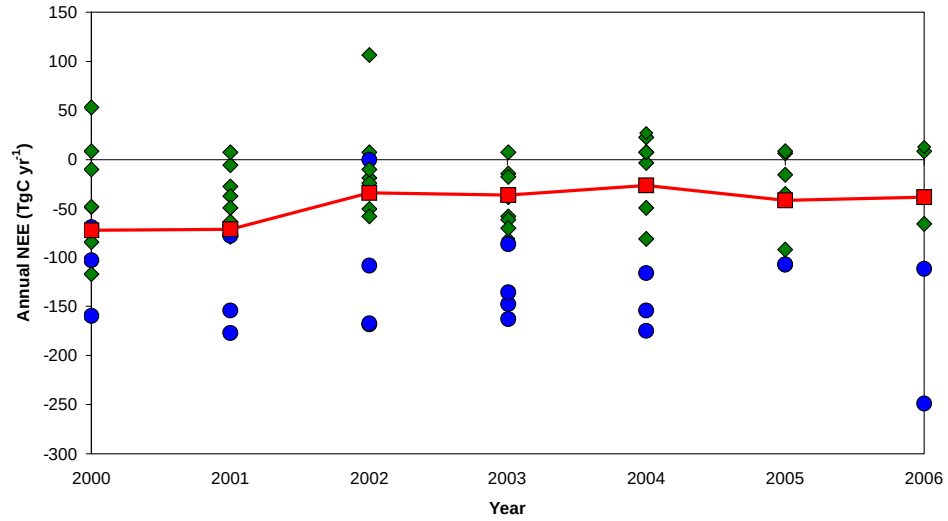


Avg. Annual Flux (TgC yr^{-1}), 2000 - 2006

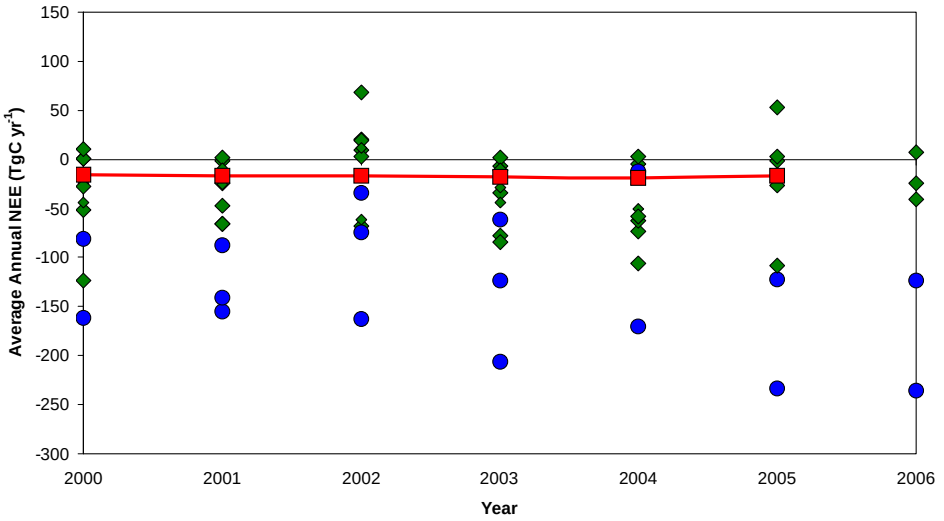
*** negative values represent a land-based C sink**

NACP Model – Inventory Comparison

Forest Sector Canada Annual NEE



Agricultural Sector U.S. Annual NEE



Forward Models **Inverse Models** **Inventory Estimate**

Conclusions from this preliminary work

- Synthesis work provides forum for summarizing status/capabilities of terrestrial carbon modeling (off-the-shelf).
- Inversions predict more seasonality and uptake over N. America than forward models.
- Inversions impacted by low density of sampling sites, prior information/assumptions.
- Spread in forward model predictions due, *in part*, to differences in model purpose, inputs, and model formulation.
- MODIS GPP much smaller (1/2 to 1/3) than that predicted by forward simulations.
- We can make broad statements of agreement among different models/approaches, but cannot identify mechanisms responsible for disagreement

Steps Forward

- Continue analysis:
  - Component fluxes (e.g., NPP, Ra, Rh);
  - Satellite indices (e.g., LAI, FPAR, NDVI, EVI); and
  - Inventory data (e.g., Soil C, Biomass, crop NPP) at monthly or annual times
- Workshop in Oak Ridge (November 9-11, 2009)
- Complete four+ manuscripts
  - Inventory, temporal, spatial, extreme events, others
- Plans for a formal multi-scale synthesis
  - Sites, regions, continent, global
  - Consistent modeling framework (driver data, inputs, etc.)
  - Observations at multiple scales to assess models
- Initiating a “synthesis of synthesis” for NACP
  - Land – rivers – coasts

http://nacp.ornl.gov/int_synth_contreg.shtml

Acknowledgements

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Canada, Europe, Mexico, and USA

Sponsors:

Carbon Cycle IWG