Integration of Observations and Modeling Results in the North American Carbon Program

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*Bob Cook, Mac Post, Debbie Huntzinger,
Andy Jacobson, Dan Hayes,
Ken Davis, Yaxing Wei, Peter Thornton,
Kevin Schaefer, and Dan Ricciuto*

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

Interim Synthesis Questions

- ❑ **Identification of Sources/Sinks**
  - ■ What are the magnitudes and spatial distribution of carbon sources and sinks, and their uncertainties during 2000-2006?

- ❑ **Interannual Variation**
  - ■ What is the spatial pattern and magnitude of interannual variation in carbon fluxes during 2000-2006?
  - ■ What are the components of carbon fluxes and pools that contribute to this variation?
  - ■ Do model results and observations show consistent spatial patterns in response to the 2002 drought?

- ❑ **At intensively studied sites (flux towers)**
  - ■ Are the various observations and modeling estimates of carbon fluxes at individual sites consistent with each other - and if not, why?

Interim Synthesis: Regional and Continental Models and Observations

- Initiated by MAST-DC and NACP investigators in 2007
- Model simulations (off-the-shelf)
  - 22 forward/ecosystem models
  - 24 inversion models
- Observations
  - MODIS remote sensing products, crop and forest inventories, soil C
- Period: 2000 – 2006
- 1-degree spatial resolution
- Monthly temporal resolution

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

Use of Multiple Sources of Information
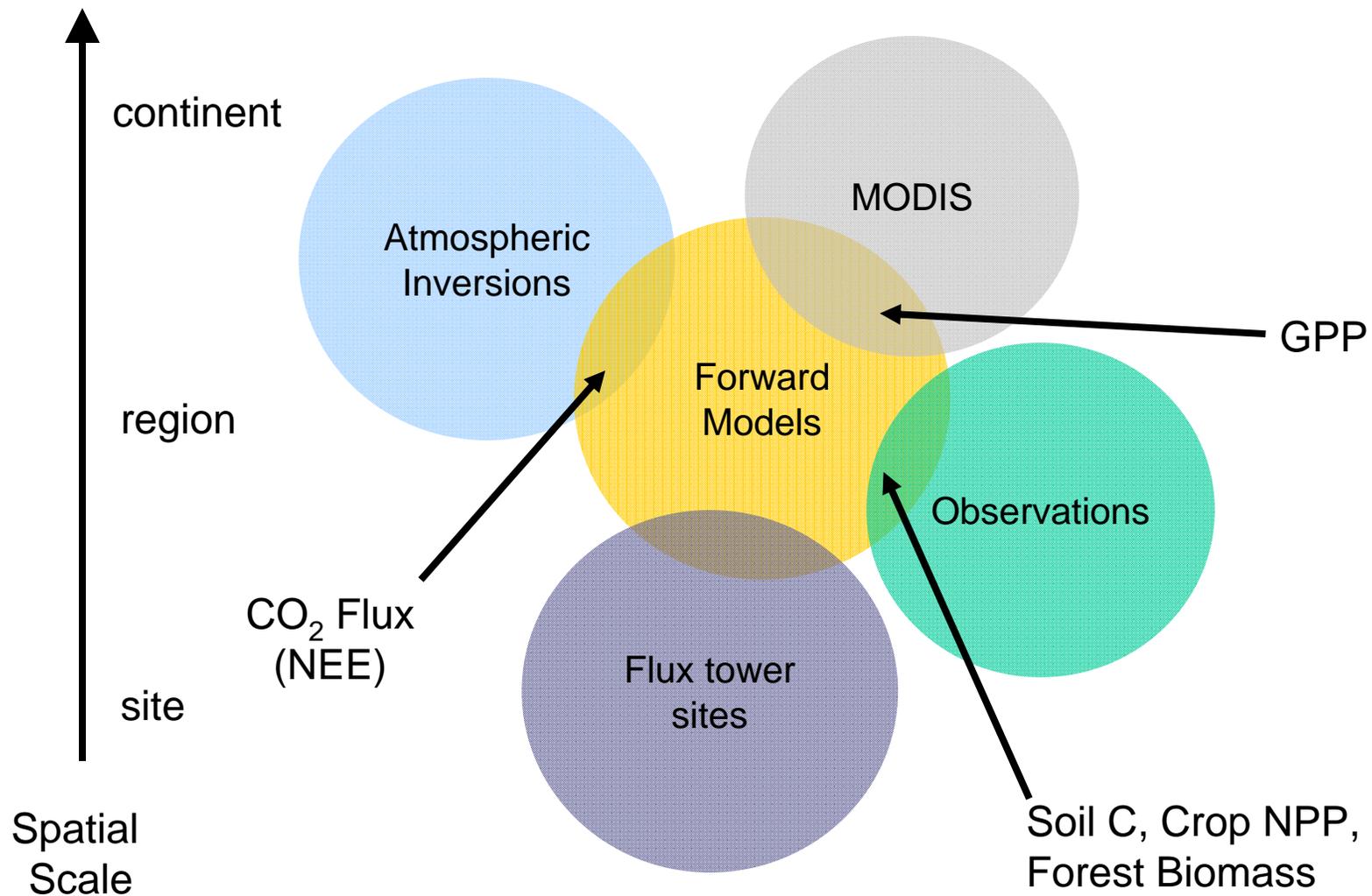
# Modeling Approaches: Inversions

Sources: Denning and Michalak
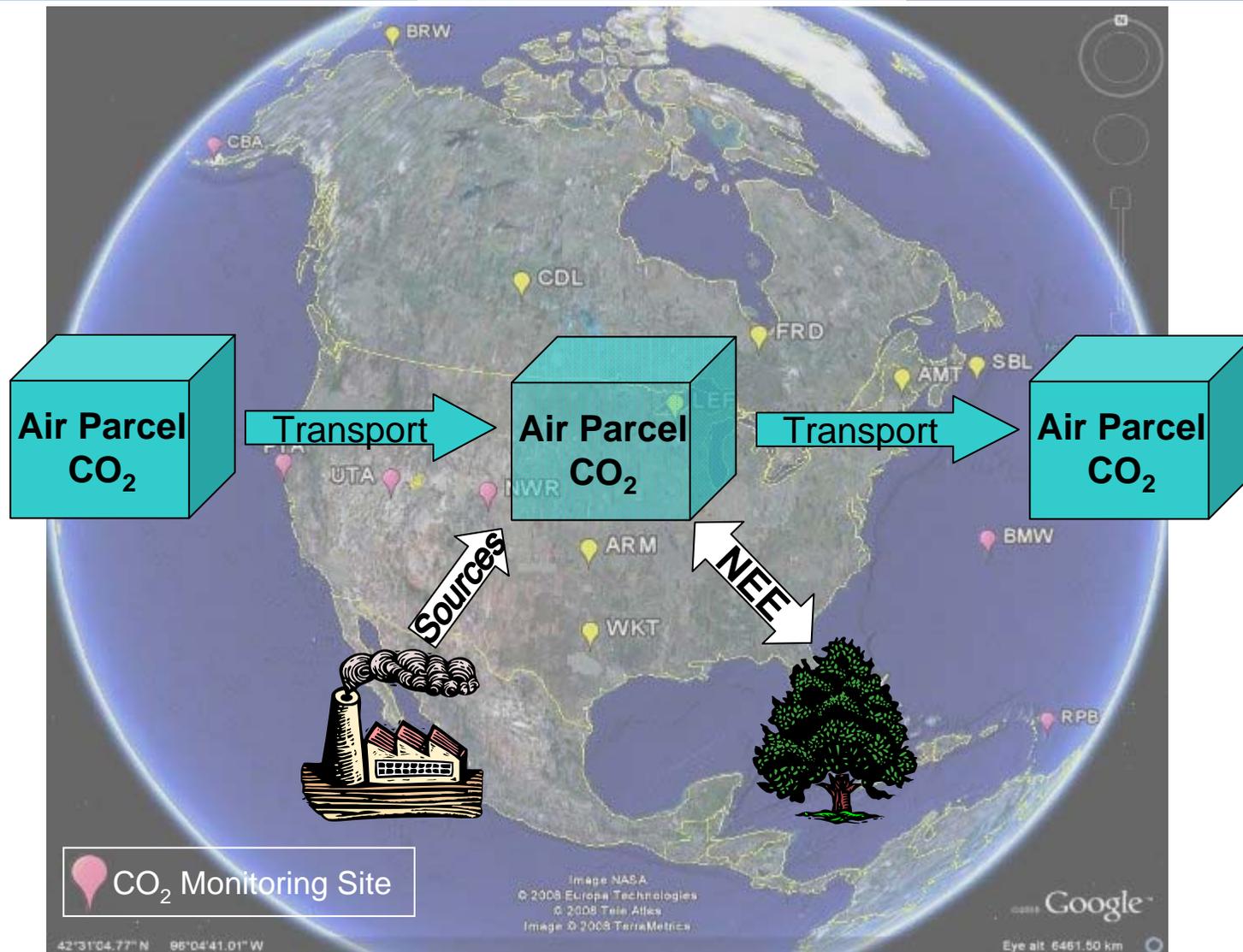
Modeling Approaches: Forward/Ecosystem

- 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

- Models have different formulations
- Boundary conditions differ
  - Soil properties
  - Vegetation type
  - Land management
- Forcing data differ
  - Weather
  - Nutrient inputs
  - Disturbances
  - Land-use/land cover changes

Use of Multiple Sources of Information
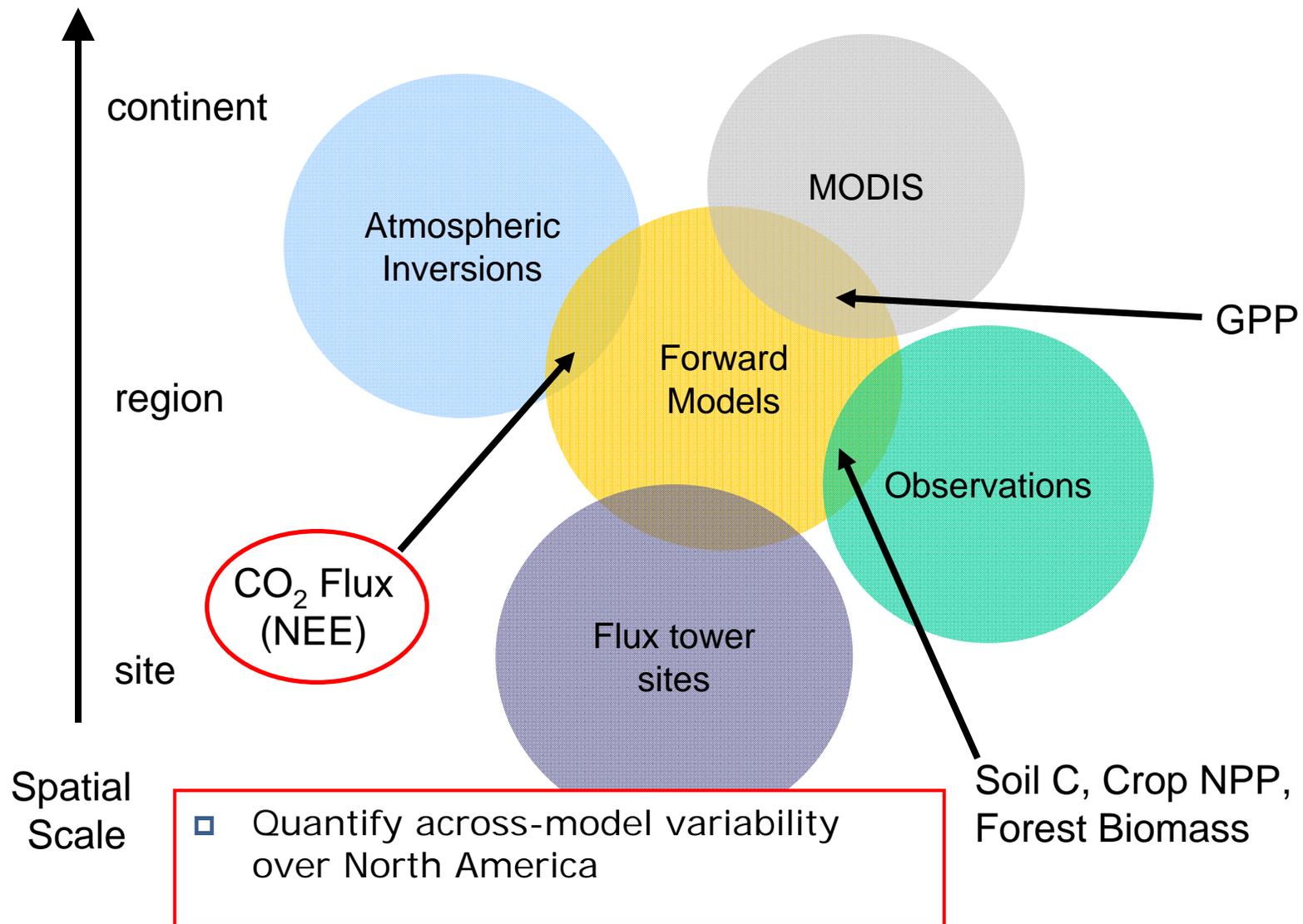
Net Ecosystem Exchange

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

Source: Andy Jacobson

Use of Multiple Sources of Information
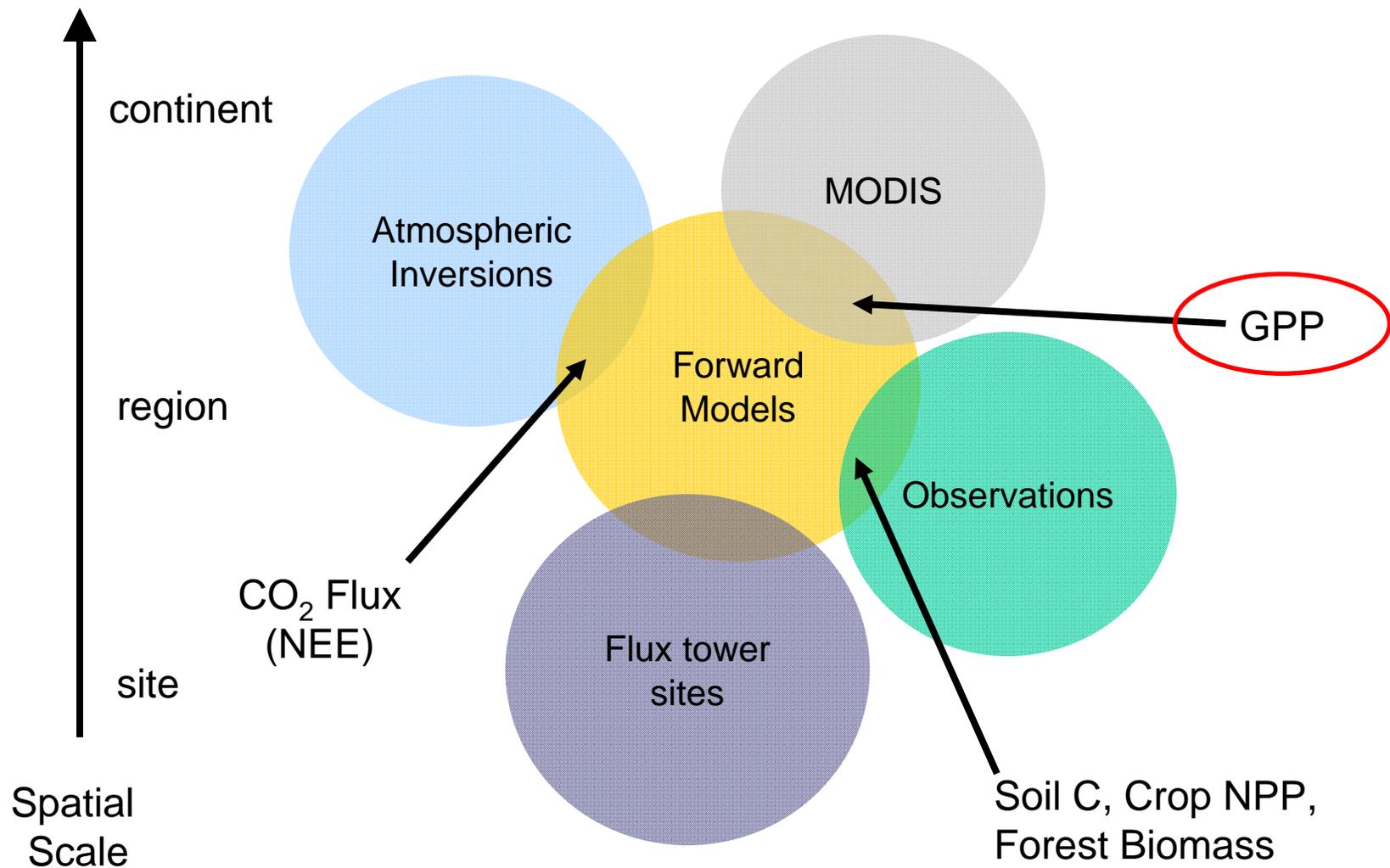
Gross Primary Production

- Forward models predict somewhat greater GPP than the MODIS product
- Forward models' estimates of photosynthetic uptake vary by a factor of 2 to 3

Forward Models and MODIS GPP

Temperate North America

Source: Debbie Huntzinger
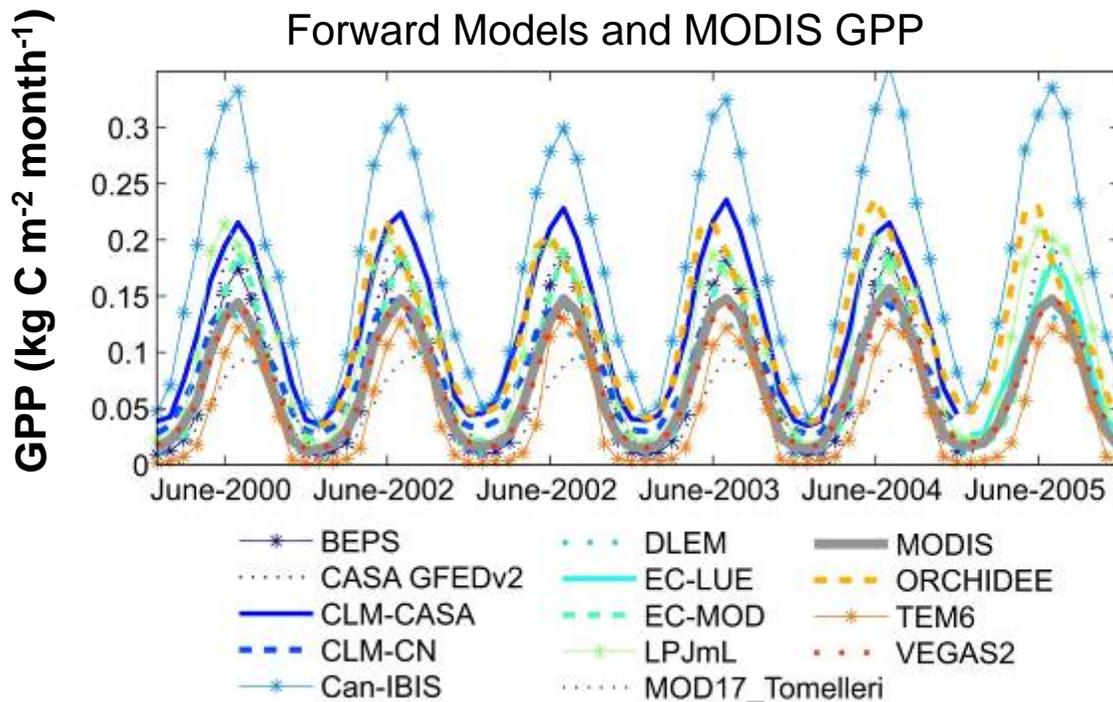
Representation of Photosynthesis in Forward Models

Enzyme Kinetic

- BEPS
- Can-IBIS
- CLM-CASA′
- CLM-CN
- ORCHIDEE
- TEM6

Light Use Efficiency

- CASA-GFEDv2
- CASA
- EC-LUE
- ISAM
- MOD17_Tomelleri
- NASA-CASA
- VEGAS2

MODIS GPP is based on LUE

Seasonal patterns of model GPP:
GPP (EK) > GPP (LUE)

Source: Debbie Huntzinger
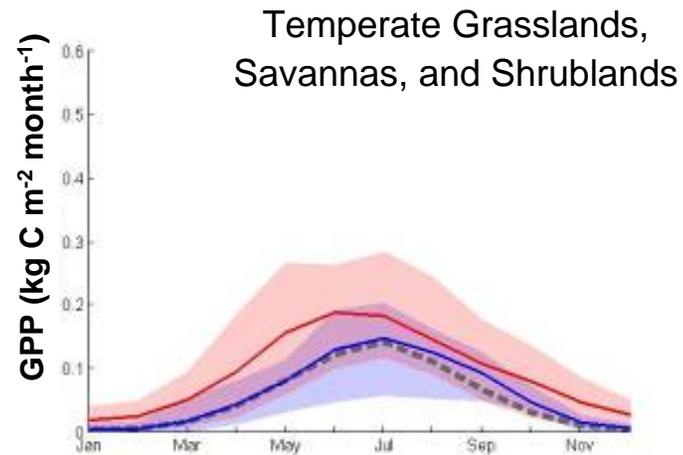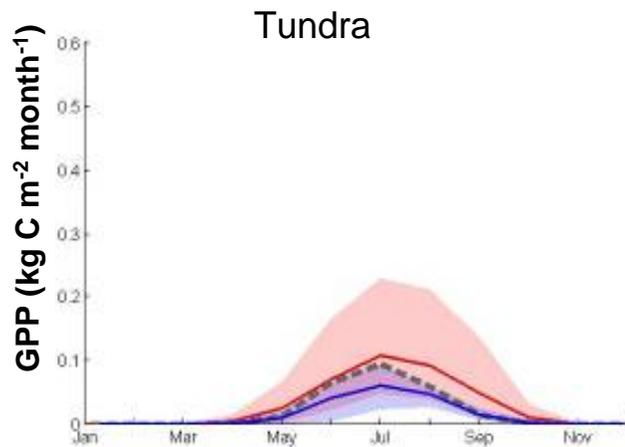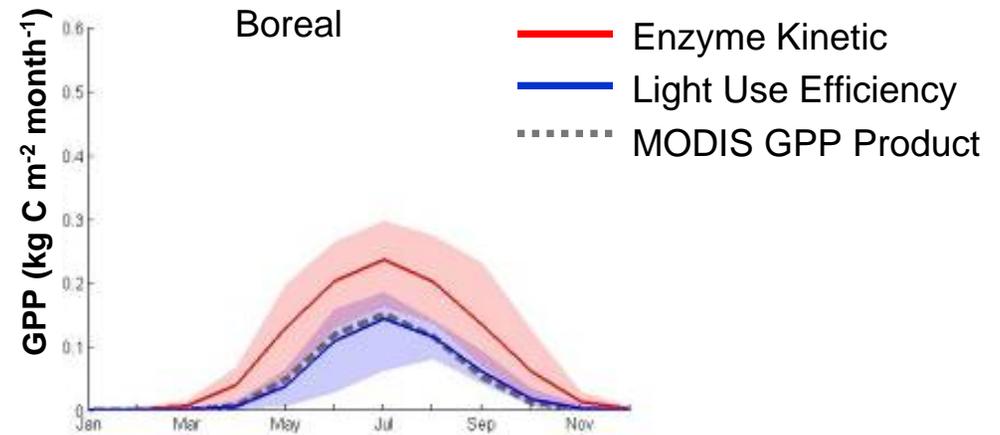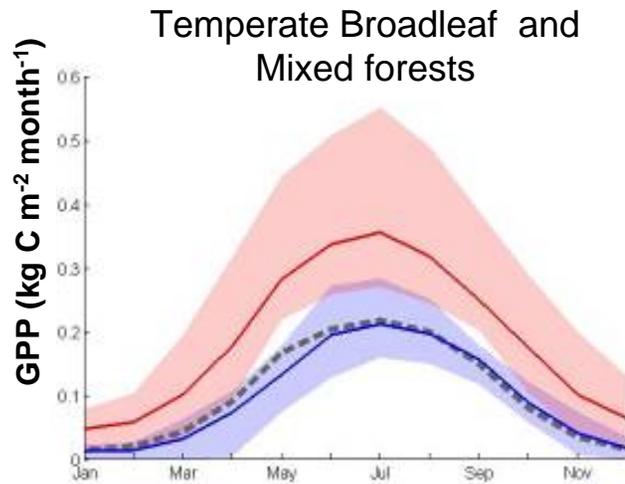
NACP Model – Inventory Comparison: NEE

◻ Use inventory-based estimates of forest C stocks and crop yields to evaluate the inverse and forward models

◻ Inventory estimates are available for political state units (U.S. & Mexico) or for the Kyoto Protocol reporting units Canada

◻ Inventory Group: 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


Kyoto Protocol reporting units for Canada

NACP Model – Inventory Comparison (2000 – 2006)

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

Mean Model Estimates for Forest Sector Net C Exchange (NEE)
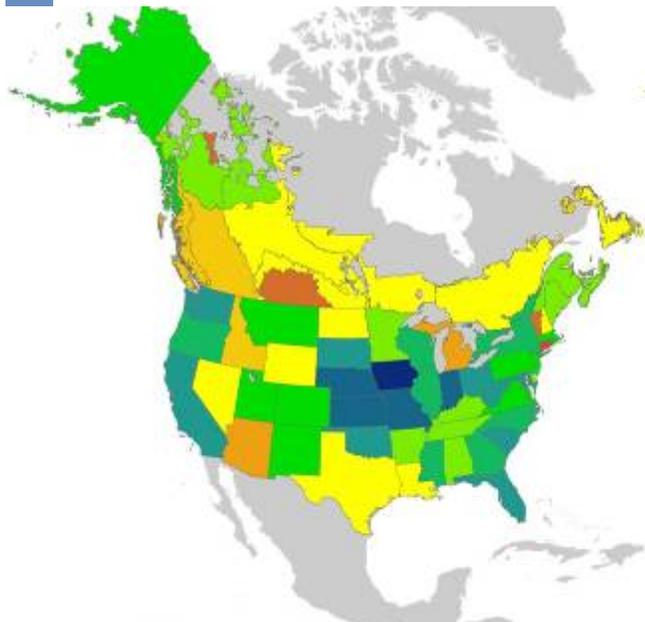
Forest Inventory
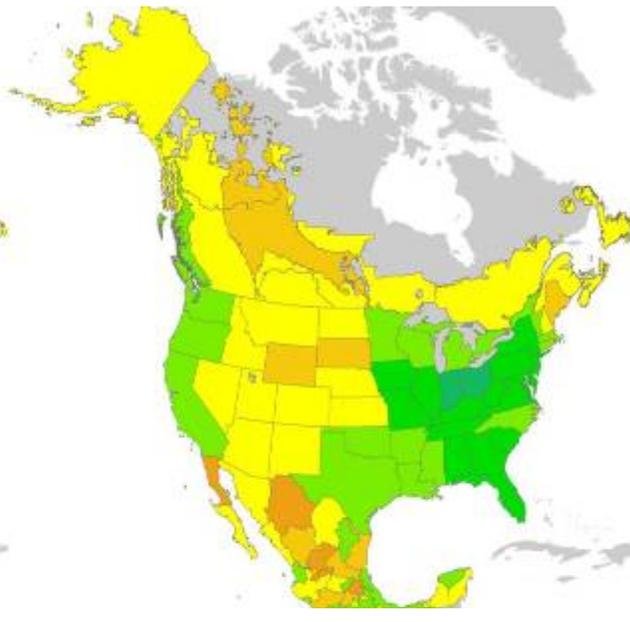
Forward Models (n=16)
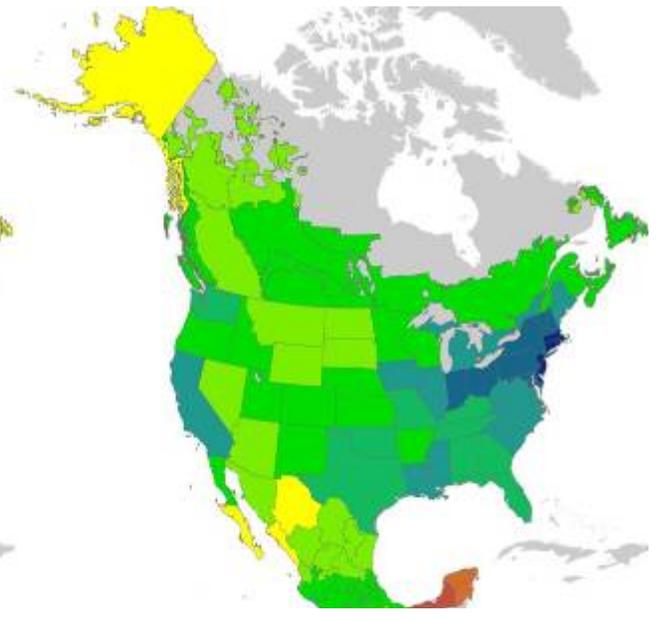
Inverse Models (n=7)

Net Ecosystem Exchange
(NEE; g C m^{-2}(forest) yr^{-1})

<-300   -150   -100   -75   -50   -25   +25   +50   > +75

Source: Dan Hayes
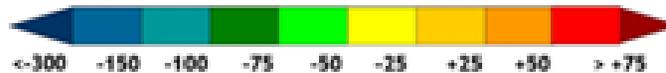
* negative values represent a land-based C sink

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Model / Inventory Comparison: Cropland C Flux

Croplands NEE, Canada

Croplands NEE, U.S.
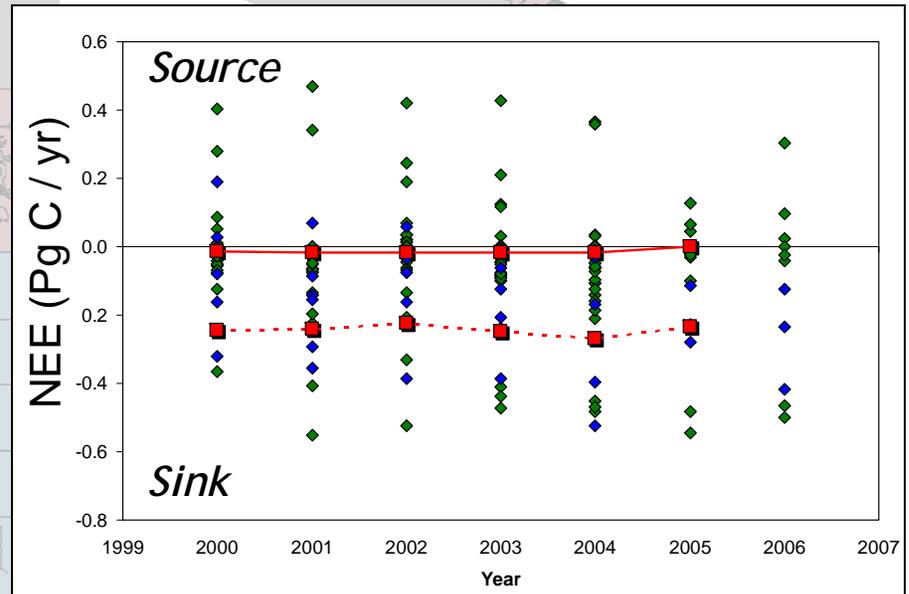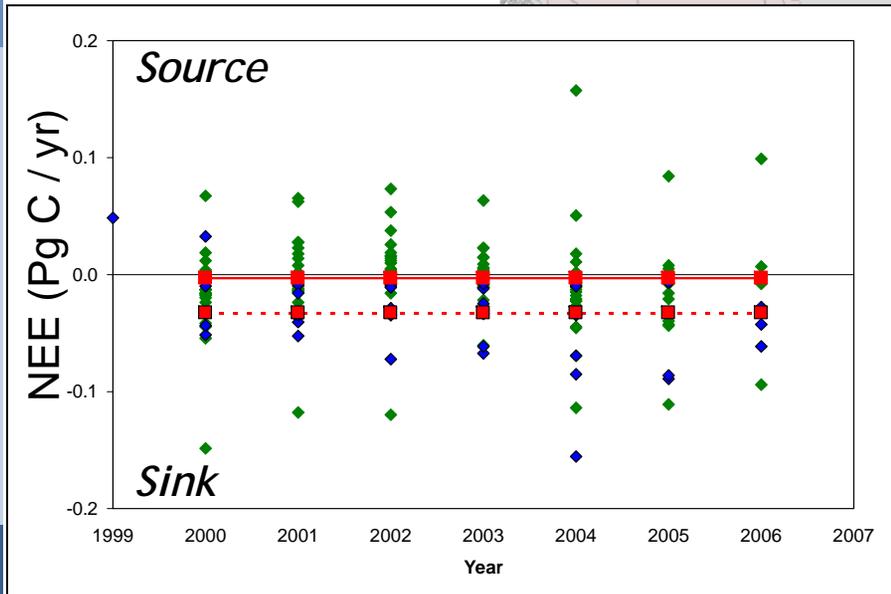
Forward Models   Inverse Models   Inventory Estimate
Consumed where grown
Exported

Source: Dan Hayes

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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 and than Inventory estimates
  - 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
  - Light-use efficiency vs. enzyme kinetics

- 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) at monthly or annual times

- □ **Begin a formal multi-scale synthesis**
  - ■ Sites, regions, continent, global
  - ■ Consistent modeling framework (driver data, inputs, etc.)
  - ■ Observations at multiple scales to assess models

- □ **Initiate a synthesis that includes land, rivers, and coasts**

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

Acknowledgements

Participants:

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

Sponsors:

Carbon Cycle IWG
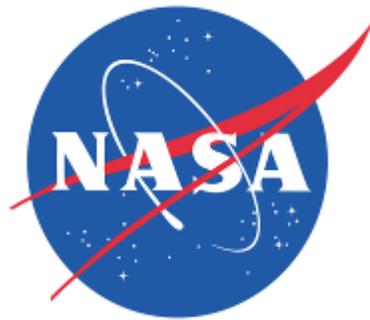
Interim Synthesis: Regional and Continental Models and Observations

- Initiated by MAST-DC and NACP investigators in 2007
- Provide a synthesis of main results from a broad range of investigations
  - Develop approaches to organizing information from field investigations to remotes sensing
  - Establish methods to evaluate information and uncertainties in data and models
  - Confront models with data
- Develop communication among NACP investigators.

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