Quantification of Spatial and Temporal Variability of North American Biospheric Carbon Flux Estimates

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Goal and Scope

A number of biospheric or processed-based models have been developed to estimate the magnitude of carbon sources and sinks across regional and continental scales. These models vary in complexity and tend to include a diverse array of processes that operate on widely different spatial and temporal scales. Both the complexity of the system being modeled, as well as the inherent differences among the various modeling approaches, make it difficult to ascertain which environmental and ecosystem drivers most strongly control carbon exchange and at what scale these drivers operate.

This study presents an inter-comparison of three biospheric models (VPRM, CASA, SiB3) that range in complexity from simple to more complex. The examined time period ranges from 2002 through 2004. Models are compared in terms of net aggregated flux by biome and for the North American continent. In addition, geostatistical structural analysis tools are used to examine the predicted spatial variability in monthly-average fluxes across North America.

Biospheric Models

Biospheric Models Examined*:

Carnegie Ames Stanford Approach (CASA):

2002 & 2003: NEP neutral fluxes used in TransCom 3 Continuous experiment generated by Randerson et al. (1997) and downscaled from monthly to 3-hourly fluxes using temperature and shortwave radiation and the method used by Olson and Randerson (2004).

2002-2004: CASA GFEDv2 *a priori* fluxes used in CarbonTracker (Peters et al. 2007) and modified to include the effect of fire on CASA-simulated carbon pools in soil and vegetation. Downscaled in the same manner as the 2002 & 2003 CASA TransCom Continuous fluxes.

Simple Biospheric Model (SiB) version 3.0:

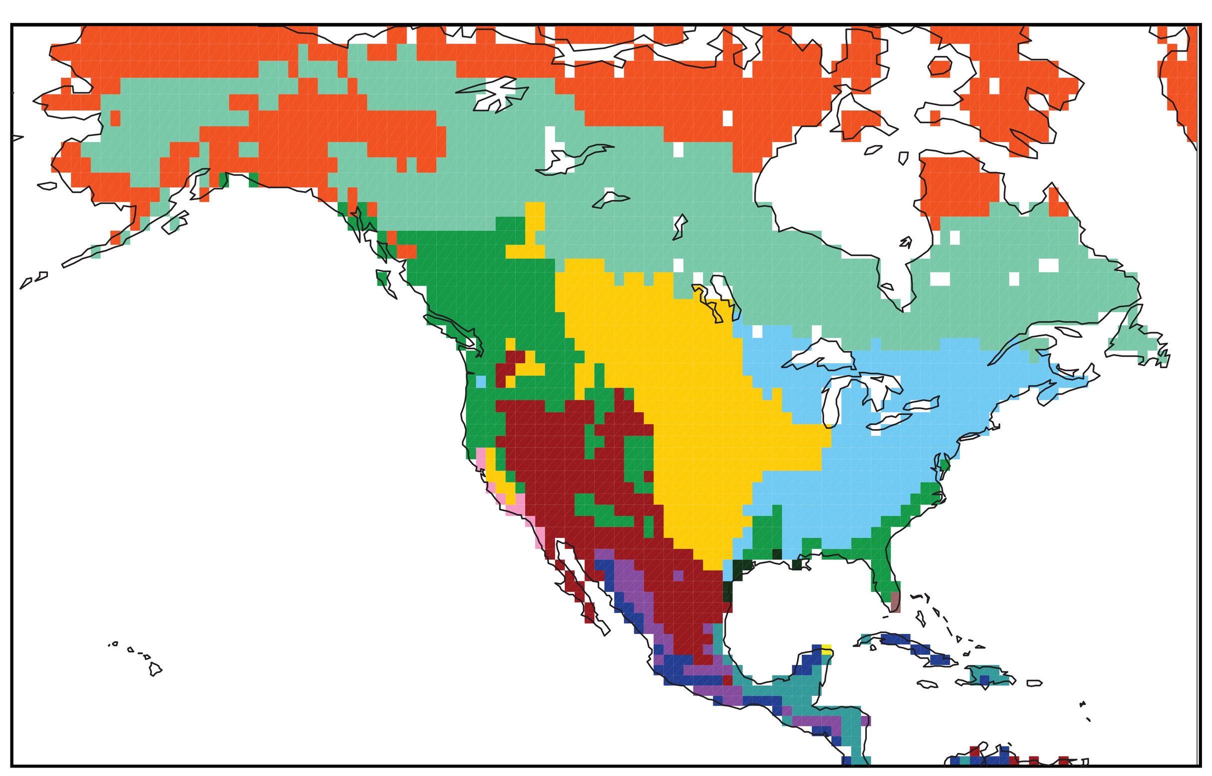
2002 & 2003: Input fluxes used in TransCom 3 Continuous experiment provided by Ian Baker at 3-hourly resolution.

Vegetation Photosynthesis & Respiration Model (VPRM):

2004: From Mahadevan et al. (2008) at 3-hourly temporal resolution.

* All fluxes were a spatial resolution of 1 degree by 1 degree.

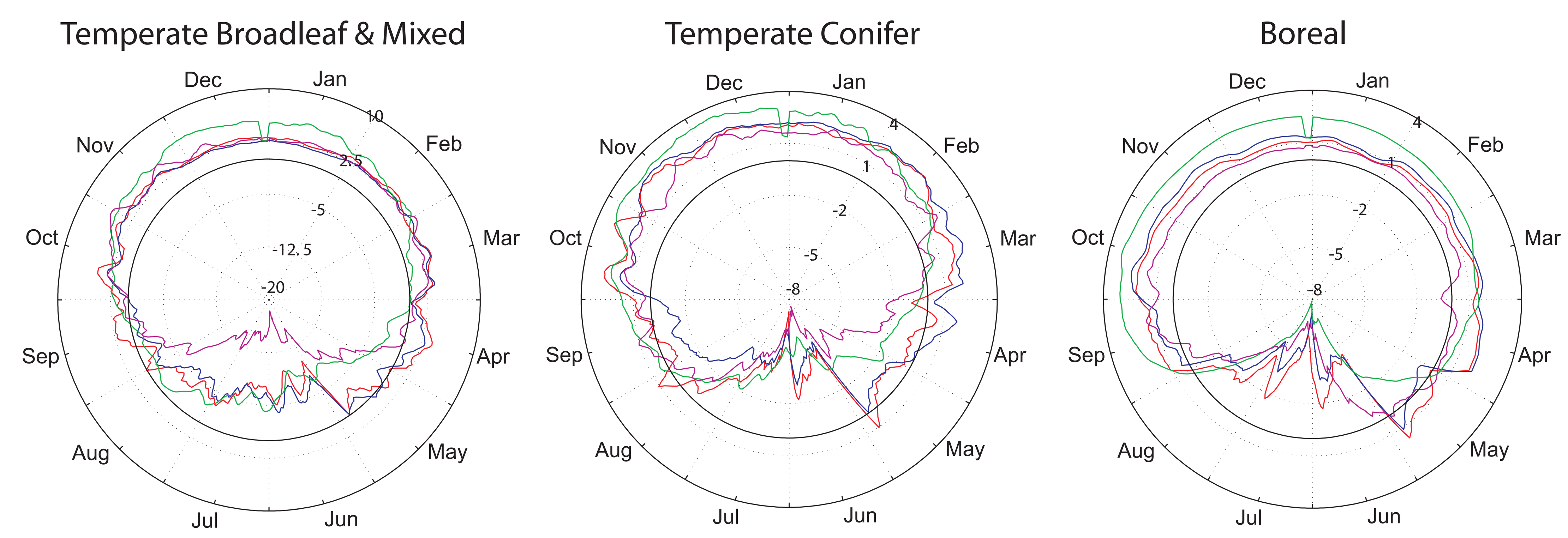
Biome Classification



- Tropical & Subtropical Moist Broadleaf Forests
- Tropical & Subtropical Dry Broadleaf Forests
- Tropical & Subtropical Coniferous Forests
- Temperate Broadleaf & Mixed Forests
- Temperate Coniferous Forests
- Boreal Forests / Tiaga
- Tropical & Subtropical Grasslands, Savannas & Shrublands
- Temperate Grasslands, Savannas & Shrublands
- Flooded Grasslands & Savannas
- Tundra
- Mediterranean Forests, Woodlands & Scrub
- Desert & Xeric Shrublands
- Mangroves

Biome Classification based on Olson et al. 2001 and the World Wildlife Fund. Similar biome regions were used in CASA and SiB. VPRM used the vegetation classes defined by the MODIS product from the International Geosphere Biosphere Program (IGBP).

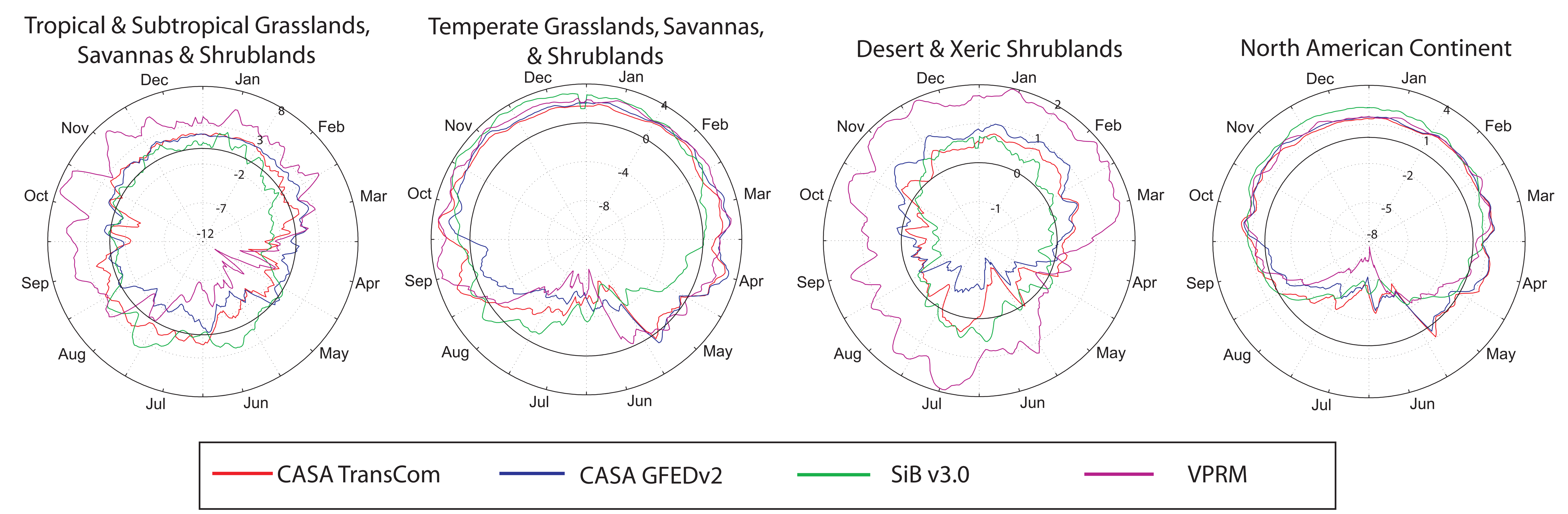
Net Flux in North America and Selected Biomes



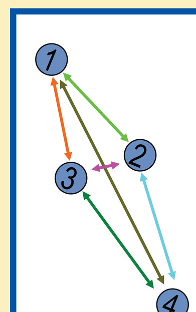
Effective daily net flux for a footprint of 100 km by 100 km in units of **Mg C/yr/10,000 km²**.

For selected biome types and for the entire North American Continent.

More variability is observed between models when aggregated up to the biome-scale compared to aggregation to the entire continent.

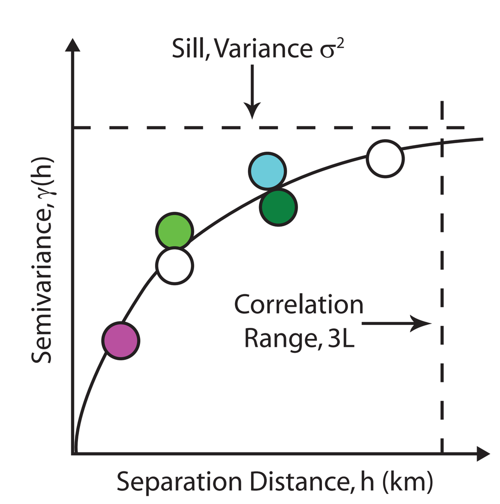


Quantifying Spatial Variability

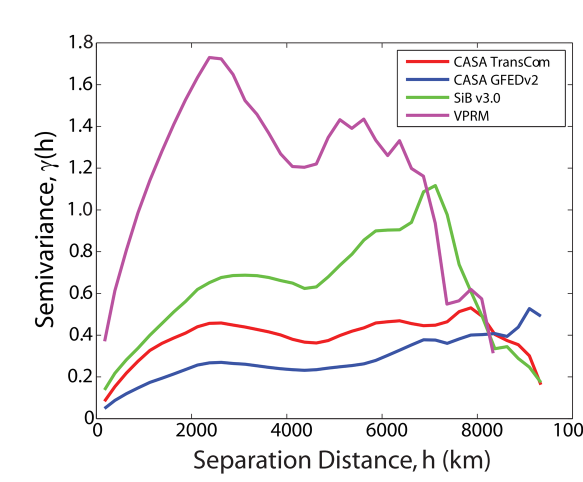


Variogram

Measure of variability between two points as a function of separation distance. The closer in space two points are, the greater their correlation.



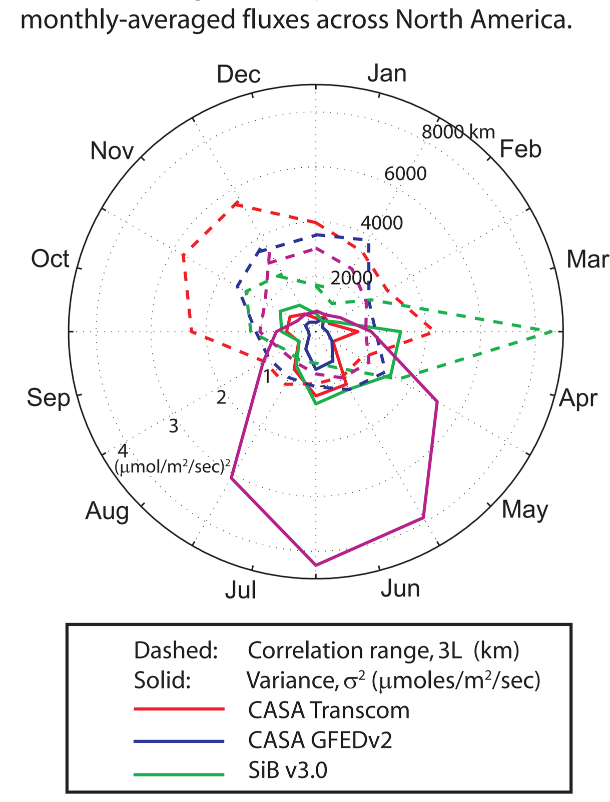
Mean monthly experimental variograms for North America for each of the biospheric models examined. Variograms shown below are the averages across months and years.



Restricted Maximum Likelihood (RML) was used to fit monthly spatial covariance parameters to an exponential semi-variogram model for each biospheric model.

$$\gamma(h) = \sigma^2(1 - \exp(-\frac{h}{L}))$$

Spatial covariance function parameters (variance and correlation range) of biospheric models based on monthly-averaged fluxes across North America.



Conclusions

Results indicate that the biospheric models examined have significantly different spatial correlation lengths and degrees of variability when compared at the continental scale. CASA and SiB show similar correlation ranges when compared across months, while correlation lengths in VPRM vary significantly over the course of the year, with shorter correlation lengths and greater variances during the growing season, compared to winter months.

A potential source of the overall continental-scale differences between the models is likely from variability in predicted fluxes at the regional or biome-scale. This small-scale variability in estimated fluxes between the models is influence by a variety of factors, including chosen model driver data (e.g., biome classification vegetative cover class) and is shown in the polar plots of net carbon flux for dominant biomes within the North American Continent. Thus, the degree of overall variability of the models appears to depend, to some extent, on the scale (temporal and spatial) at which estimated fluxes are compared.

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