

Seasonal Prediction of Ecosystems, Fire, Carbon Using NCEP/CFS and a Dynamic Vegetation Model

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1. Introduction

In recent years, many advances have been made in the science and practice of seasonal climate predictions. For example, seasonal climate predictions have attained operational status and have come to rely increasingly more on dynamical prediction models. Such advances notwithstanding, application of seasonal climate outlooks to applications of societal importance has been slow to materialize. The aim of this project is to develop one such application, *i.e.*, a capability to forecast terrestrial ecosystem productivity and carbon sources and sinks on seasonal-interannual time-scale. The modeling system is global, but the focus of validation and application will be for North America.

The development of an outlook capability for the ecosystem will rely on several components that have evolved following independent pathways and have reached a state of maturity in their respective domains of interest. The key effort here brings together these modeling and prediction component systems.

The modeling components of the predictive capability include:

- a) A dynamic Vegetation-Global-Atmosphere-Soil (VEGAS; Zeng *et al.* 2005, 2008) model with full terrestrial carbon cycle
- b) Operational climate forecasts at the Climate Prediction Center and dynamical seasonal forecasts based on the Climate Forecast System (CFS) (both at NCEP)

Specific targets include:

Developing a procedure to specify vegetation and soil initial conditions derived from some form of data assimilation system.

- a) Developing procedures to forecast ecosystem and carbon variables using ensemble climate prediction information from CFS
- b) Validation of prediction system based on hindcast skill by comparing model predictions against a suite of observed variables such as satellite vegetation index, CO₂ flux measurements, and assimilated carbon fluxes
- c) Comparison of the CFS based skill with other baseline estimates of skill for predicting eco-carbon variables, *e.g.*, prediction based on operational CPC forecasts
- d) Testing the prediction system in a real-time operational setting, getting feedbacks from a wider community, improving the system.

Deliverable of this project will be a seasonal forecasting system for terrestrial ecosystem productivity and carbon fluxes that later will be transitioned to operations using the Climate Test-Bed (CTB) infrastructure.

2. Hindcast experiments

We have conducted a 25-year hindcast experiment to explore the possibility of seasonal-interannual prediction of terrestrial ecosystem and the global carbon cycle. This has been achieved using a prototype forecasting system in which the dynamic vegetation and terrestrial carbon cycle model VEGAS was forced with the 15-member ensemble climate prediction and lead time up to 9 month from the NCEP/CFS climate forecast system. The results show that the predictability is dominated by the ENSO signal for its major

influence on the tropical and subtropical regions, including the Amazon, Indonesia, western US and central Asia. The hindcasted ecosystem variables and carbon flux show significantly slower decrease in skill compared to the climate forcing, partly due to the memories in land and vegetation processes that filter out the higher frequency noise and sustain the signal. (Examples shown in Figs.1 and 2)

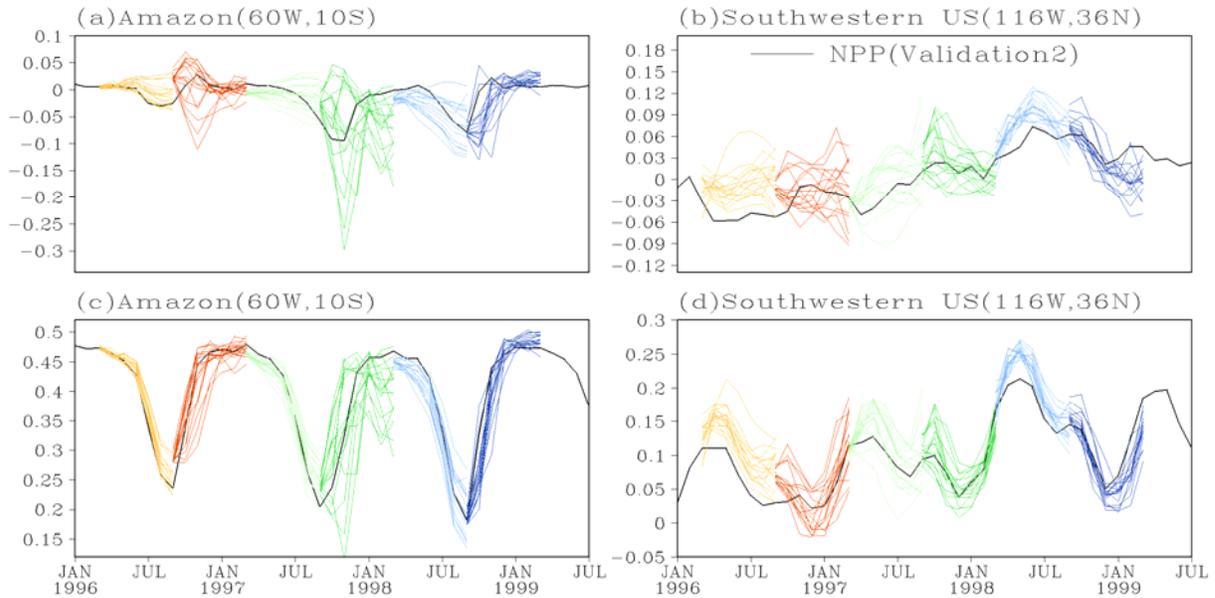


Fig. 1 Example of the CFS/VEGAS hindcast: a time section of the predicted Net Primary Productivity (NPP) anomalies $\text{kg C m}^{-2} \text{y}^{-1}$ for two grid points, one over the Amazon, the other one southwestern US, compared to the validation (black line). Each line represents one individual member of a 15-member ensemble forecast. For clarity, the forecasts were ‘thinned’ to show only every 6 months and for a 6-month long forecast while the actual forecasts were monthly and 9 month long. The top two panels are for anomalies while the lower panels include seasonal cycle

3. Pseudo-operational forecast

We have completed the initial setup of a one-way pseudo-operational forecast system. This is ‘pseudo’ in the sense that it was not actually issued, and the run was not always done in real time. However, it uses only the operational CFS input so it is what one would have got if it was done operationally. The system consists of the following key steps, which involved:

- A shell script was developed to automatically download CFS operational forecast once a day. These forecasts are archived only for 1 week, and the daily download is for safety.
- The data are processed by spatial interpolation. Climate variables such as precipitation and temperature anomalies are computed, then added to a climatology.

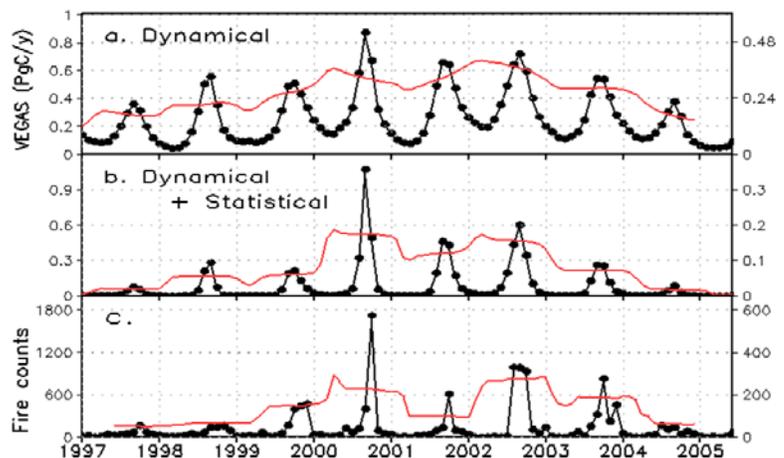


Fig. 2 Probabilistic prediction of direct carbon fluxes due to fire for the CONUS region (monthly in black and 12 month running mean in red) by (a) dynamical model using climate information alone, and (b) dynamical model but also including nonlinear effect of human management and fire suppression. Panel (c) shows satellite observations of fire counts. Large amount of carbon was released during major drought years of 2000 and 2002.

c) An ensemble of 9 climate predictions drives the vegetation/carbon model.

The forecast is conducted each month, with initial condition comes from the ensemble mean of the 1 month lead forecast from the previous month's forecast.

This system is being actively tested.

References

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