1. Prospect for Eco-Carbon Prediction

Climate prediction has in the past been applied to crop yield, malaria and other applications, typically based on statistical correlation. Here we test the feasibility of predicting ecosystems and carbon cycle on seasonal-interannual timescales using dynamical models both in climate and carbon cycle.

Two strands of recent research made this a real possibility:

- Significantly improved skill in atmosphere-ocean prediction system, such as CFS at NCEP.
- Development of dynamic ecosystem and carbon cycle models that are capable of capturing major interannual variabilities, when forced by observed climate anomalies.

A prototype prediction system where the NCEP/CFS climate prediction is used to drive the dynamic vegetation/carbon model VEGAS (Fig 1).

2. Major forecasting steps

1. 25-year (1981-2005) hindcasted climate dataset from NCEP/CFS (Saha et al., 2006) was preprocessed.
2. Spin-up the vegetation model to equilibrium using January 1981 climate forcing, to avoid any ‘shock’ to the vegetation state at model startup.
3. Run VEGAS for 9 month into future forced by CFS forecasts climate processed from Step 1. This is done using 15 CFS ensemble members (Fig 1).
4. The vegetation state variables such as leaf carbon predicted at the end of the first month above are saved, and averaged over the 15 member ensemble to serve as the initial condition for the next month’s forecast.
5. Repeat Steps 3 and 4, but for the next month, until the end of the hindcast period.

3. Results from a 25-year hindcast experiment

- Power of ensemble forecasting in capturing the likelihood of change (Fig 2).
- The hindcasts reproduce the major interannual variability, including two major El Nino events in 1982-83 and 1997-98, although the amplitude is underestimated (Fig 3).

4. Conclusions

We conclude that seasonal-interannual prediction of the ecosystem and carbon cycle is feasible. Such prediction will be useful for a suite of activities such as ecosystem management, agriculture and fire preparedness. The results show that the predictability is dominated by the ENSO signal for its major influence on the tropical and subtropical regions. Much of the predictability comes from regions with major ENSO teleconnection such as the Amazon, Indonesia, western US and central Asia. However, there is also important non-ENSO related predictability such as that associated with mid-latitude drought. Compared to the CFS predicted precipitation and temperature where skill deteriorates rapidly at longer lead time, the hindcasted NPP and carbon flux show significantly slower decrease in skill, especially for the global or tropical total carbon flux, likely due to the memories in land and vegetation processes that filter out the higher frequency noise and sustain the signal. Comparison of the dynamical prediction results with benchmark statistical methods show that the dynamical method is significantly better than either anomaly persistence or damping of the current climate anomalies. Using initial condition only leads to some predictability, consistent with the notion of a land-vegetation memory.

5. References