How NACP and the terrestrial community see themselves fitting into the new science plan

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Woods Hole, MA
How NACP and the terrestrial community see themselves fitting into the new science plan and what are the potential links to the OCB community?

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my background/biases

• physics, astrophysics
• boundary layer meteorology, flux measurement methods
• CO$_2$ flux and mixing ratio measurements and analyses
• carbon data assimilation, climate ethics
outline

• New carbon cycle science plan: early signs
• NACP - status and future
• Role of NACP in the new carbon cycle science plan
• Role of the terrestrial carbon cycle community in the new carbon cycle science plan
new carbon cycle science plan
Areas where the 1999 CCSP needs to be expanded or enhanced

1. Effects of human activities on carbon cycling
   (Humans are the largest cause of CO2/CH4 radiative forcing and probably the least predictable element of the global C cycle. Fossil emissions included. Broaden our ‘team’, don’t dilute it.)

2. Vulnerability and resilience of ecosystems to changes in carbon cycling and associated changes in climate (Ocean acidification.)

3. Efficacy and environmental consequences of carbon management policies, strategies, and technologies (1999 CCSP had lots of details about how to implement observations, but very little about modeling, prediction and management, though this was the stated goal of the research. Expand detail in these areas.)

Ken’s spin on things are in blue.
Current version of the major questions for the new Plan:

• How do natural processes and human actions affect the carbon cycle, on land, in the atmosphere, and in the oceans? (mechanistic understanding)

• How do policy and management decisions affect the levels of atmospheric carbon dioxide and methane? (evaluate and guide carbon/climate management)

• How are ecosystems, species, and resources impacted by increasing greenhouse gas concentrations, the associated changes in climate, and carbon management decisions? (impacts of atm C increase on ecosystems)
Likely elements called for in the next carbon cycle science plan

- Global analyses and international cooperation
- Sustained (and expanded) observational and experimental networks, network design research
- Predictive modeling and model hindcasting studies
- Focus on important (large C flux), dynamic, poorly understood portions of the carbon cycle (human emissions, high latitude ecosystems, tropics)
- Ocean acidification research
- Incorporation of disturbance (including human) into terrestrial ecosystem studies
- Increased importance of uncertainty assessment
- Increased involvement of the integrated assessment and policy analysis communities
- Emphasis on holistic climate system - ecological impact analyses (N2O, albedo, biodiversity)
NACP status and future
NACP Questions

1. What is the carbon balance of North America and adjacent oceans? What are the geographic patterns of fluxes of CO$_2$, CH$_4$, and CO? How is the balance changing over time? ("Diagnosis")

2. What processes control the sources and sinks of CO$_2$, CH$_4$, and CO, and how do the controls change with time? ("Attribution")

3. Are there potential surprises (could sources increase or sinks disappear)? ("Prediction")

4. How can we enhance and manage long-lived carbon sinks ("sequestration"), and provide resources to support decision makers? ("Decision support")
diagnoses
Carbon tracker results

Annual NEE (gC m\(^{-2}\) yr\(^{-1}\)) for 2000-2005 (left).
Summer NEE for 2002, 2004 (above).
Peters et al, 2007, PNAS
“Bottom-up” flux estimate example: Potter et al., 2007

Figure 8. Annual NEP.
FLUX TOWER UPSCALING

XIAO ET AL, 2008, AGR. AND F. MET.
Preliminary findings: “Inversions” show much more interannual variability and a larger North American sink vs. “forwards” models.

Courtesy A. Jacobson and D. Huntzinger. Being updated as we speak.
prediction
Uncertain prediction of future carbon fluxes

C^4MIP: comparison of coupled climate/carbon models

Large range of uncertainty (16 GtC yr^{-1} range in land flux, 6 GtC yr^{-1} range in ocean flux by 2100)

Friedlingstein et al., 2006
NACP status

• We are nearing “success” at regional and continental diagnoses of the CO\textsubscript{2} budget.

• Essential elements of our continental observation and analysis system are endangered.

• We need to engage whole-heartedly in research that is integrated with decision support. This will require:
  – Increased emphasis on prediction, model-data syntheses and model comparisons.
  – Increased emphasis on uncertainty assessment, network design, and data/metadata management.
  – Increased focus on human emissions of carbon and study of the mechanisms governing these emissions.

• We need to articulate which decisions we are supporting.
Draft updates of the 2005 NACP SIS

1. We need to transition essential elements of the observational, data management and analytic system to stable, long-term support.

2. We need a more explicit and precise discussion of the decision support goals to be integrated into the NACP. (C regulation. C/climate management)

3. We need new intensives to accelerate:
   - Integration of decision support into the NACP
   - Network design, uncertainty assessment and reduction
     • Potentially including new field or experimental work
   - Model-data syntheses and comparisons, including prediction
   - Predictive skill for large C flux, dynamic and poorly understood portions of the carbon cycle (e.g. human emissions, high latitude ecosystems)
role of the NACP in the new carbon cycle science plan
Envisioned role of the NACP in the new CCSP

- Demonstrate maintained continental to regional diagnoses and attribution of the C balance, including human emissions.
- Support carbon regulation via independent evaluation of the carbon balance of the continent.
- Aid carbon/climate management by greatly improving our ability to predict future C fluxes.
- Lead initiatives for global analyses and partnerships.
role of the terrestrial carbon cycle community
In the next carbon cycle science plan
Role of terrestrial carbon cycle community in the next CCSP

- Reach convergence of biogeochemical models and atmospheric inversions globally.
- Improve predictive skill, including expanding processes included in predictions (disturbance, nutrient cycling, …) and understanding of particularly important ecosystems (high latitudes, tropics).
- Increase understanding of the impact of carbon and climate management (or lack thereof) on ecosystems.
- Critically evaluate terrestrial carbon cycle knowledge used in integrated assessment models and other tools used to guide policy.
Terrestrial uptake of carbon ($\text{C yr}^{-1}$)

(details of flux magnitude and observations left ambiguous - could be applied to many regions or observations)

NACP interim syntheses?
A well-known example of establishing predictive skill with hindcasting.

Simulated annual global mean surface temperatures

- **(a) Natural**
  - Model: grey, Observations: red
  - Temperature anomalies (°C)
  - Year: 1850 to 2000

- **(b) Anthropogenic**
  - Model: grey, Observations: red
  - Temperature anomalies (°C)
  - Year: 1850 to 2000

- **(c) All forcings**
  - Model: grey, Observations: red
  - Temperature anomalies (°C)
  - Year: 1850 to 2000

Figure 4: Simulating the Earth’s temperature variations, and comparing the results to measured changes, can provide insight into the underlying causes of the major changes.
What is “good enough?”

Threshold for data that are ‘good enough’ for our decision support needs.

Investment in science to improve knowledge

This is when we are done. (What is this number?)

(Where are we on this curve?)

(What decisions are we supporting?)