

**Workshop organized by:**  
*Global Carbon Project (GCP)*  
*Earth System Science Network-Australia (ARC-ESS)*  
*Analysis, Integration and Modeling of the Earth System (AIMES)*

## **Earth System Feedbacks: Vulnerability of the Carbon Cycle to Drought and Fire**

Canberra, Australia  
5-8 June 2006

### ***Background***

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Over the last century we have seen major modifications of the water cycle including the distribution, variability and trends of rainfall, runoff, and evaporation. Such changes are thought to result to some degree from increasing emissions of human-driven greenhouse gases (GHG), and consequently, expected to become even larger during the course of this century as GHG emissions increase.

Global Climate Models predict major changes of the water cycle over the next 100 years including the increase of *i*) global precipitation, *ii*) water stress in some regions (eg, Amazon), and *iii*) inter-annual variability and extreme events (eg, droughts, floods).

Changes in water cycle variables such as precipitation, runoff, streamflow, soil moisture, and atmospheric vapor pressure impact carbon stocks and fluxes (e.g., soil and ecosystem respiration, production) and disturbance events such as fire frequency and intensity. Fully coupled carbon-climate models suggest that biogeochemical and vegetation structure changes can be forced by drought and fire, thereby altering carbon exchange by terrestrial ecosystems.

In fact, recent climate trends and higher intra- and inter-annual variability may have increased the amplitude of the seasonal cycle of CO<sub>2</sub>, however, it is not clear if or how these changes will lead to increased or decreased carbon storage.

### ***Scope***

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The workshop will explore interactions of energy, water and carbon in the earth system caused by drought and variability of the water cycle and its effects on carbon exchange, ecosystem respiration, and on disturbance frequency and emissions.

The time dimensions of interest include the recent past, current, and future changes and impacts, globally, and in drought-prone regions. Paleo times will also be considered.

Changes in the water cycle include:

- Short-term variability and extremes (seasonal)
- Long-term variability (annual)
- Trends (decadal)
- Thresholds

Terrestrial carbon processes are:

- Changes in vegetation structure
- Carbon exchange (Gross Primary Productivity, NPP, NEP, NEE)
- Ecosystem respiration
- Disturbance e.g., fire.

## ***Workshop Themes***

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### *Theme 1: Observations of Climate Change, Variability and the Carbon Cycle*

- Ground and remotely sensed observations of precipitation and temperature anomalies and trends, including soil moisture, run-off, streamflow and others.
- Atmospheric observations of CO<sub>2</sub> growth anomalies.
- Satellite observations of vegetation state and change.
- Ground observations of changes in carbon stocks and fluxes due to changes in climate variability and drought (eddy covariance, forest inventories, soil carbon, crop production, statistics on fire frequency and area burned, measurements of carbon emissions from fires, others).

### *Theme 2: Processes and Controls of Coupled Carbon-Water Cycles*

- What processes are driving the net carbon balance in drought cycles and increased climate variability (GPP, R<sub>e</sub>, Oxidation)?
- Disturbances (e.g., fire, insect damage, windthrow)
- Water use efficiency under elevated CO<sub>2</sub>
- Field experiments on carbon-water interactions (e.g., water exclusion experiments, FACE water treatments, transects across systems of changing water availability)

### *Theme 3: Modeling Present and Future Interactions of Carbon and Hydrological Cycles*

- What is the evidence of past and current trends in the hydrologic cycle?
- What are the future projections for climate change and variability?
- What are the current and future requirements of observations needed to address altered water cycle and carbon-water interactions?
- How do models implement disturbance and recovery at multiple scales?
- How do models handle critical uptake and emission processes, particularly emissions from fires and ecosystem respiration?
- What do models tell us about the key vulnerabilities in the carbon-water system and are there thresholds?
- Major families of models including:
  - Coupled carbon-climate GCMs (C<sup>4</sup>MIP family)
  - Dynamic Global Vegetation Models (DGVMs)
  - Data Assimilation and model-data fusion approaches.

### *Theme 4: Vulnerability and Ecosystem Services of Carbon-Water Cycles*

- What are ecosystem services associated with the coupled carbon-water cycles?
- How does extratropical wildfire affect ecosystem services?
- How does tropical wildfire affect ecosystem services?
- How do climate change and water resources and water resource management interact?
- What are vulnerability and sustainability issues of the carbon-water cycles?
- Case study: How do climate and management interact in rangelands?
- Case study: How do climate and management interact in forested ecosystems?
- Case study: A historical and archeological perspective on management and climate interactions

## ***Publications***

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A special issue is planned to be published with a combination of invited talks and synthesis papers resulting from the discussions in the workshop. We are exploring several possibilities including EGU and AGU journals and the possibility of fast publication in one of their open access web journals.

Other alternatives include Global Change Biology and other suggestions from participants.

A synthesis publication for Science or Nature will be written.

## **Earth System Feedbacks: Droughts and Vulnerability of the Carbon Cycle**

Canberra, Australia

6-9 June 2006

Draft Agenda

### *Theme 1: Observations of Climate Change, Variability and the Carbon Cycle*

1. Present and future changes in hydroclimatology – ask John Chruch
2. How the Earth water balance has changed over the last half a million years (using all measurements) – John Chapel, Australia
3. Long term contribution of emissions from fires to atmospheric CO<sub>2</sub> growth and anomalies – Ray Langenfelds, Australia
4. Australia continent-wide net carbon balance and processes driving it – Damien Barret, Australia
5. Integrated observations and modeling of terrestrial carbon and water exchange – Mike Raupach
6. Climate variability, land use and terrestrial carbon dynamics (Xiangming Xiao – USA)

### *Theme 2: Processes and Controls of Coupled Carbon-Water Cycles*

1. Carbon emissions from wildfires in Siberia and Indonesia during drought events - Florian Siegert, Germany
2. Drought and Vegetation Changes: Intersects between Ecophysiology and Biology (Alan Brashears)
3. The relative contribution of C emissions from soil respiration versus wildfires in the perturbation of the atmospheric CO<sub>2</sub> growth– Jim Randerson, USA
4. Ecosystem net carbon balance in Australia through drought events and the role of disturbances – Helen Cleugh, Australia
5. Effects of experimental droughts in Amazon on ecosystem processes – Daniel Nepstad, USA
6. *Greenness trend in China shows decline in desertification, still true?* – Jingyun Fang, China
7. *Trends in South America: interactions of climate and land use change* – Jose Paruelo, Argentina

### *Theme 3: Modeling Present and Future Interactions of Carbon and Hydrological Cycles*

1. The relative contribution of altered production and ecosystem respiration during extreme events - Andrew Friend, AUS or Alex Knoll, USA
2. Future climate variability and droughts predicted by coupled carbon-climate GCMs – C<sup>4</sup>MIP talk – (Inez Fung)
3. *Effects of warming and El Nino-drought experiments on ecosystem processes* – Yiqi Lou, USA
4. *Will increased water use efficiency under elevated CO<sub>2</sub> ameliorate the negative effects of future droughts?* Diane Pataki, USA or Chris Field, USA
5. *Heterotrophic respiration in a warmer planet* – Pete Smith, UK
6. The propagation (or not) of processes across spatial and time scales – Dave Schimel, USA
7. Dynamic Global Vegetation models and the treatment of C uptake, heterotrophic respiration, and emissions from other oxidation pathways (eg, fire) – Ron Nielson, USA,
8. Coupled carbon-climate GCMs and the treatment of C uptake, ecosystem respiration, and emission from oxidation pathways (eg, fire) – Pierre F, France.

9. Parameterization of Earth system models for the Australian terrestrial biosphere - Yingping Wang, Australia
10. Incorporating natural and anthropogenic fire frequency and emissions in coupled carbon-climate GCMs – Sergey Venevsky, Russia

*Theme 4: Vulnerability and Ecosystem Services of Carbon-Water Cycles*

1. Overview - Chris Field (USA)
2. Extratropical wildfire and ecosystem services - Werner Kurtz (CAN)
3. Drought and Human Dimensions – Indonesian Case Studies - Nepstad/Amazon (USA)
4. Climate Trends and Water Resources in Australia – Nevil Nicholls (Australia)
5. Carbon/Water Ecosystem Services and Sustainability - Brian Walker or Ian Noble (AUS)
6. Interactions between climate and management in rangelands - Steve Archer (USA)
7. Interactions between management and climate in forested ecosystems - Kathy Hibbard (USA)
8. Mayan interactions with drought and civilisation - Vern Scarborough (USA)