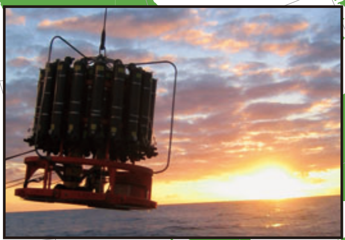
Global Carbon Project

Overview 2005-2006

The Global Carbon Project



A Framework for Internationally Co-ordinated Research on the Global Carbon Cycle

Earth System Science Partnership

DIVERSITAS GLOBAL IGBP CHANGE WCRP

www.globalcarbonproject.org

Science Steering Committee of the Global Carbon Project

Executive Committee Co-Chairs

Robert Dickinson, Georgia Institute of Technology, USA
Michael Raupach, CSIRO Earth Observation Centre, Australia
Oran Young, University of California at Santa Barbara, USA

SSC Members

Mike Apps, Canadian Forest Service
mapps@nrcan.gc.ca

Chen-Tung Arthur Chen, National Sun Yat-sen University
ctchen@mail.nsysu.edu.tw

Philippe Ciais, Commissariat a l'Energie Atomique
philippe.ciais@cea.fr

Mingkui Cao, Institute of Geographical Sciences and Natural Resources Research, CAS
caomk@igsnrr.ac.cn

Christopher Field, Carnegie Institution of Washington
chris@globalecology.stanford.edu

Anand Patwardhan, Indian Institute of Technology
anand@som.iitb.ac.in

Patricia Romero Lankao, Universidad Autonoma Metropolitana
prlankao@correo.xoc.uam.mx

Corinne Le Quéré, University of East Anglia and British Antarctic Survey
C.Lequere@uea.ac.uk

Nebojsa Nakicenovic, International Institute for Applied Systems Analysis
naki@iiasa.ac.at

Christopher Sabine, NOAA, PMEL
chris.sabine@noaa.gov

Riccardo Valentini, Disafri - University of Tuscia
rik@unitus.it

Yoshiki Yamagata, National Institute for Environmental Studies
yamagata@nies.go.jp

Forward

The carbon cycle is central to the Earth system, being inextricably coupled with climate, the water cycle, nutrient cycles and the production of plant life (biomass) by photosynthesis on land and in the oceans.

There is a growing appreciation that people have changed and will continue to change the climate of planet Earth. This has focused the attention of the scientific community, policy makers and the general public on the rising concentration of greenhouse gases, especially carbon dioxide (CO_2), in the atmosphere and on the carbon cycle in general.

Now we need to learn more about the implications of our changing the carbon balance–global warming, regional climate change, and severe weather events –and to find scientifically sound ways of living on planet Earth. Our very existence depends on it.

In recognition of the enormous scientific challenge and crucial importance of the carbon cycle for sustainability, the Global Carbon Project (GCP) was established in 2001.

The scientific goals of the GCP are to develop a complete picture of the global carbon cycle, including both its biophysical and human dimensions, and to foster regional carbon management based on sound science.

Please read on, contact us, join us...in this most exciting and urgent adventure.

Robert Dickinson
Michael Raupach
Oran Young
Executive Committee
Science Steering Committee of the GCP
July 2005

Contents

From the Amsterdam Declaration on Global Change 2001

Research carried out over the past decade under the auspices of the four programmes [IGBP, WCRP, IHDP, DIVERSITAS]... shows

- The Earth System behaves as a single, self-regulating system comprised of physical, chemical, biological and human components. The interactions and feedbacks between the component parts are complex and exhibit multi-scale temporal and spatial variability.
- Human activities, changes to Earth's land surface, oceans, coasts and atmosphere and to biological diversity, the water cycle and biogeochemical cycles are clearly identifiable beyond natural variability. ... Global change is real and is happening now.
- Surprises abound.
- In terms of some key environmental parameters, the Earth System has moved well outside the range of the natural variability exhibited over the last half million years at least.
- The Earth is currently operating in a no-analogue state.

[We] urge ... people of the world to agree that:

> - An ethical framework for global stewardship and strategies for Earth System management are urgently needed. The *business-as-usual* way of dealing with the Earth System...has to be replaced–as soon as possible–by deliberate strategies of good management that sustain the Earth's environment while meeting social and economic development objectives.
> - A new system of global environmental science is required. This is beginning to evolve from complementary approaches of the international global change research programmes and needs strengthening and further development. It will draw strongly on the existing and expanding disciplinary base of global change science; integrate across disciplines, environment and development issues and the natural and social sciences; collaborate across national boundaries on the basis of shared and secure infrastructure; intensify efforts to enable the full involvement of developing country scientists; and employ the complementary strengths of nations and regions to build an efficient international system of global environmental science.

The global change programmes are committed to working closely with other sectors of society and across all nations and cultures to meet the challenge of a changing Earth [through] new partnerships ... among university, industrial and governmental research institutions and dialogues [and] ... between the scientific community and policymakers.... Action is required to formalise, consolidate and strengthen the initiatives being developed. **The common goal must be to develop the essential knowledge base needed to respond effectively and quickly to the great challenge of global change.**

Berrien Moore III, Chair IGBP — Arild Underdal, Chair IHDP
Peter Lemke, Chair WCRP — Michel Loreau, Co-Chair DIVERSITAS
Challenges of a Changing Earth: Global Change Open Science Conference
Amsterdam, Netherlands, 13 July 2001

The Global Carbon Project

Scientists all over the world–among them, biologists, geologists, chemists, economists, and sociologists–are united through the Global Carbon Project, working to understand the global carbon cycle on the Earth and in the atmosphere. The GCP–an Earth System Science Partnership of the International Geosphere-Biosphere Program, the World Climate Research Program, the International Human Dimensions Program, and DIVERSITAS–stems from the Amsterdam Declaration on Global Change, 2001. (See Figure 1.)

A new way of conducting carbon cycle research

–one that is not conducted in isolation from research on energy systems or focused only on the biophysical patterns and processes of carbon sources and sinks–is the mission of the Global Carbon Project. GCP's vision is unique in important ways.

The problem is conceptualized from the outset as one involving fully integrated human and natural components; the emphasis is on the carbon-climate-human system and not simply on the biophysical carbon cycle alone.

The GCP develops new ways to analyze and model the integrated carbon-climate-human cycle.

The GCP provides an internally consistent framework for the coordination and integration of the many national and regional carbon cycle research programs that are being established around the world.

The GCP addresses questions of direct policy relevance, such as the management strategies and sustainable regional development pathways required to achieve stabilization of carbon dioxide in the atmosphere.

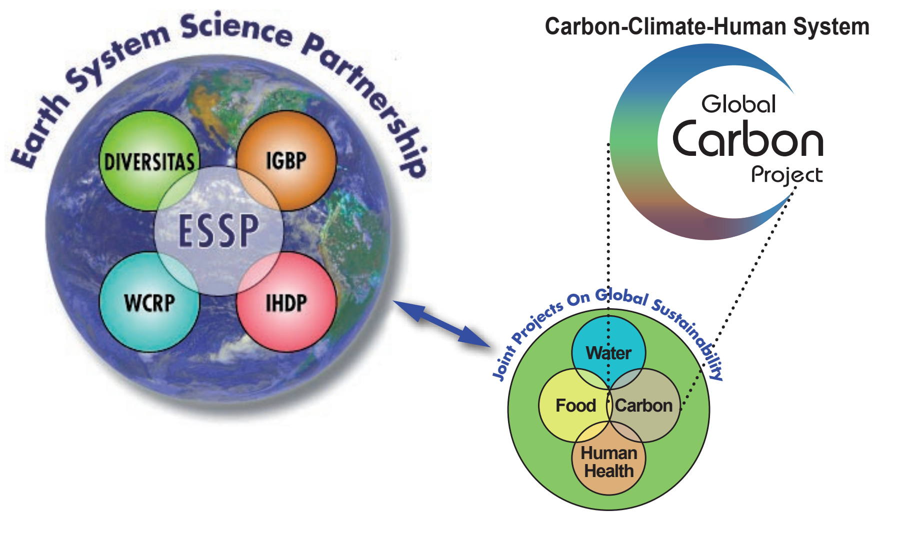


Figure 1. The GCP as Earth System Science Patnership

The Carbon Cycle, Global Warming, Climate Change & Weather

Carbon dioxide, one of the greenhouse gases, is largely responsible for making planet Earth the only planet that sustains life. For thousands of years, the Earth kept a steady average temperature of approximately 15°C (59°F), due to a steady concentration of carbon dioxide (CO_2) in the atmosphere. Very recently, that is in the 250 years since the Industrial Revolution, human activities have increased this concentration by more than 25 percent.

How could we do this? Simple. We changed both important dimensions of any balanced budget: we overspent and failed to save. We cleared land for cities and roads, chopped down forests that store carbon, and simultaneously used the Earth's long-term carbon assets, like coal, oil and gas (fossil fuels) for industry, transport, cooking, heating and cooling.

In other words, the way we organized our human societies altered the natural processes involved in the balanced cycling of carbon. Collectively and over a short period of time, we added so much to greenhouse gases that the Earth is warmer, and warming, leading to rapid change in climate systems (temperatures and precipitation) as they vary around the world. Subsequently, natural ecosystems are stressed, weather patterns are changing, and many economic activities are under increasing risk (Figure 2).

Now, more than ever, we need greater scientific understanding of how the carbon cycle works so that we can act responsibly with regard to the carbon of greenhouse gases.

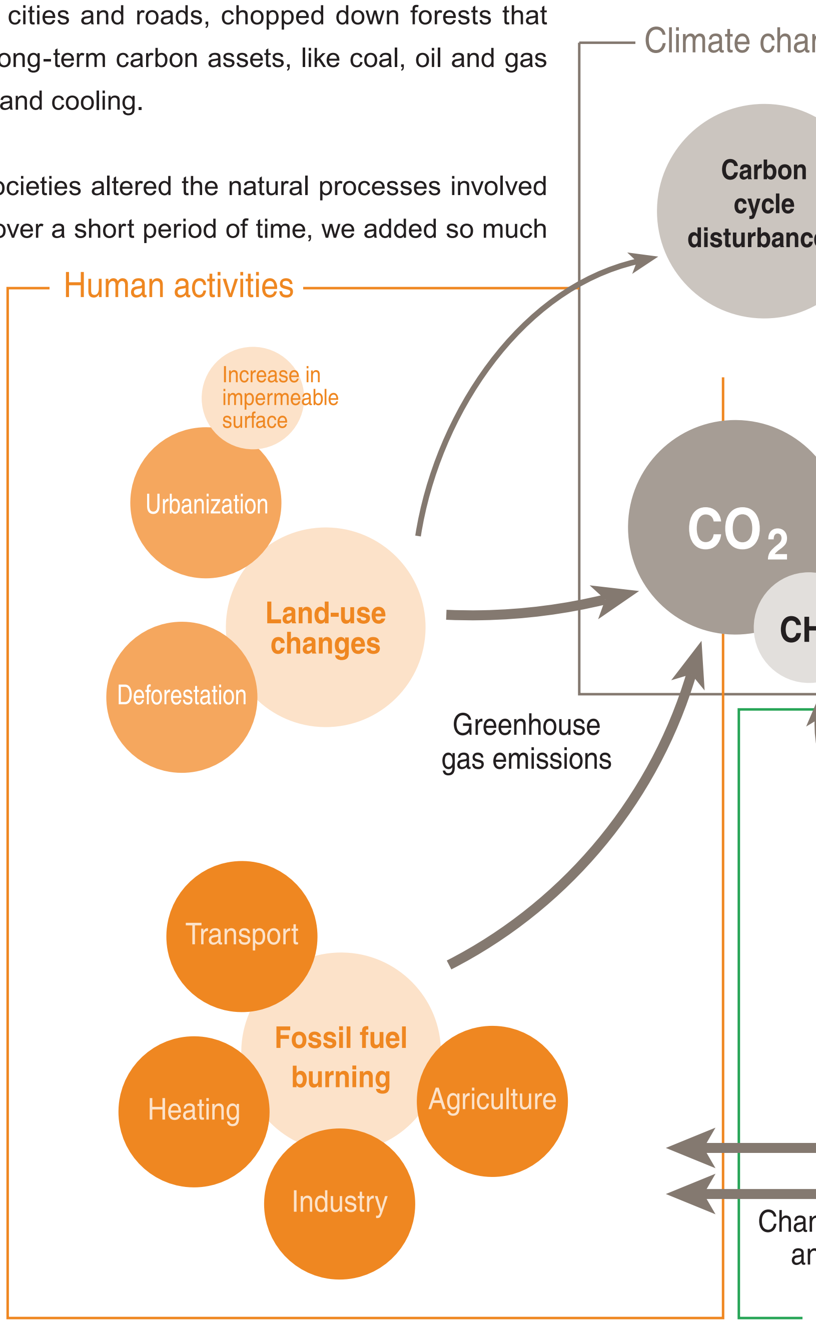
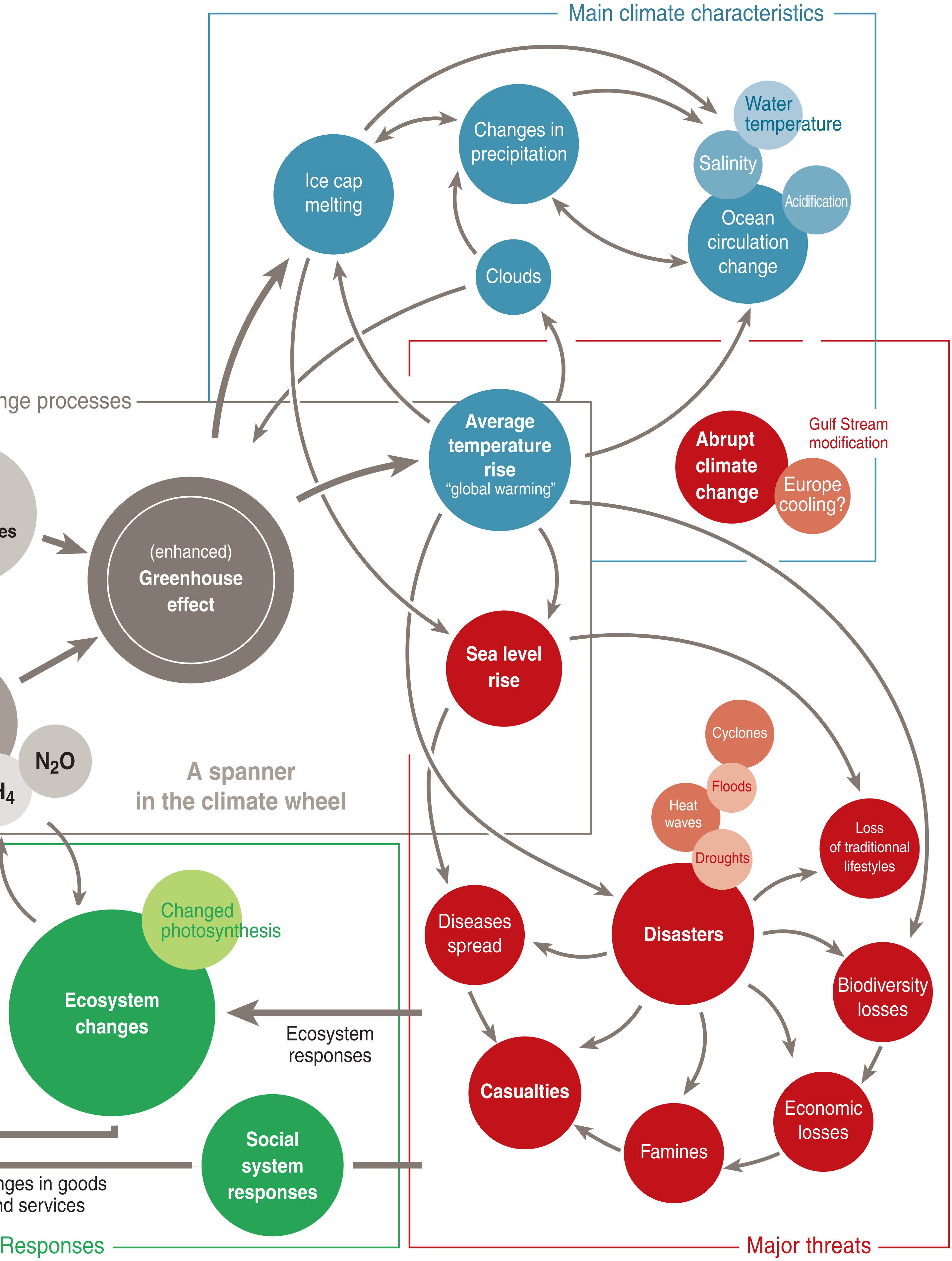


Figure 2. Carbon-climate-human System Connections



Adapted from United Nations Environment Programme/GRID-Arendal

Patterns and Variability

Carbon cycles, or flows, among major pools, including carbon in the atmosphere (mainly as CO_2); in the oceans (surface, intermediate waters, deep waters and marine sediments); in terrestrial ecosystems (vegetation, litter and soil); in rivers and estuaries; and in fossil carbon, which is being remobilized by human activities (Figure 3). Both the flows of carbon among these stores and the store contents vary widely across space and time.

Processes and Interactions

Carbon's interacting physical, biological, and physiological processes also interact with human processes that release fossil carbon. Some of these emerge as crucial controls on the global carbon cycle, *e.g.* the saturation of terrestrial sinks, the stability of the thermohaline circulation, and the behavior of the oceanic biological pump. Collectively, the dynamics of these processes determine the rate and magnitude of future climate change.

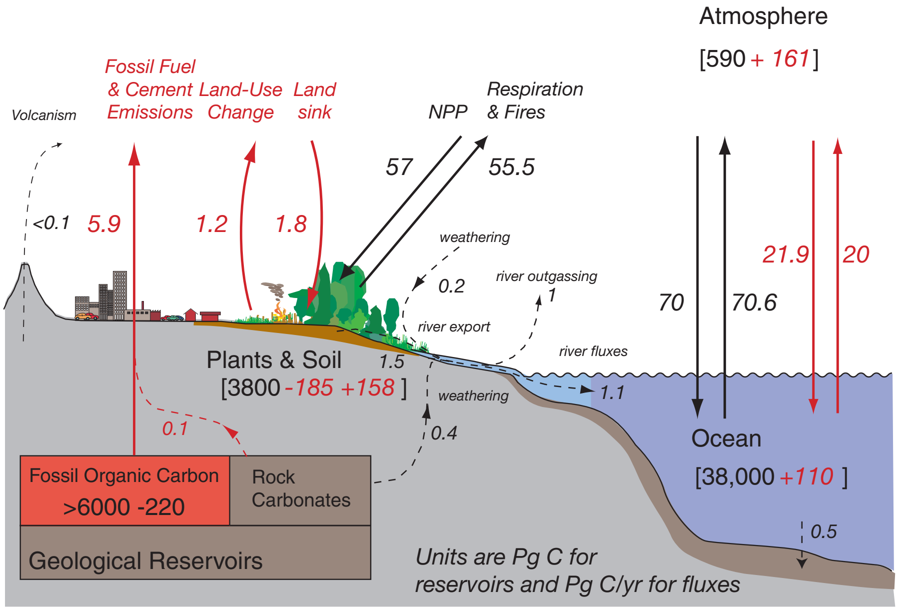


Figure 3. The Global Carbon Cycle, 1980-2000 Averages (Sabine *et al.* 2004); Red = human pertubations.

Vulnerabilities of the Carbon Cycle

Warming global climate and land-use change threaten carbon pools that currently contain hundreds of billion tons of carbon. Vulnerable pools include: soil carbon in frozen ground, soil carbon in high- and low-latitude wetlands, biomass-carbon in forests, methane hydrates in the coastal zone, and ocean carbon concentrated by the biological pump. Preliminary analyses indicate a risk over the coming century that may be larger than 200 ppm of atmospheric CO_2, rivaling the expected release from fossil-fuel combustion, thus accelerating climate warming and potentially stimulating even greater losses of carbon from vulnerable pools.

The Human Dimensions of the Carbon Cycle

Changes in land use and fossil-fuel emissions are the major human activities affecting the carbon cycle. But what leads to these activities are complex combinations of decisions, behaviors, conditions, and ideologies. We refer to these combinations conceptually as "P-O-E-T-I-Cs," or the systemic configuration of Population, Organization, Environment, Technology, Institutions, and Culture (Figure 4). Trends in global POETICs since the late 19th century resulted in a dramatic rise in annual CO_2 emissions (Figure 5). Broad overlapping trends over the last 150 years are reported in Table 1.

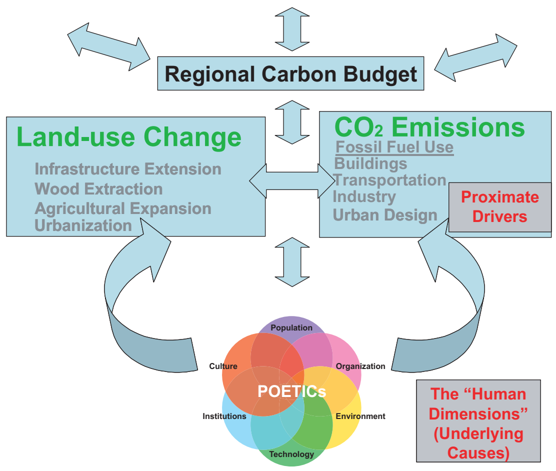


Figure 4. Proximate Drivers and Underlying Causes of Regional Carbon Budgets

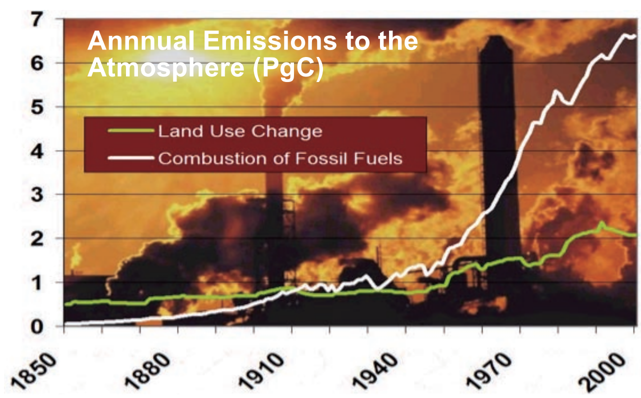


Figure 5. Annual CO_2 Emissions from Land-use Change and Fossil Fuel Combustion

Table 1. Selected Overlapping Conditions in Global POETICs, 1850-2000

	1850		*2000*
Population	1.4 Billion Rural Towns and Villages Some Large Cities	2.2 Billion Demographic Transition Urbanization, Suburbanization	6 Billion+ Mega-cities, High Fertility in Poorer Countries
Organization	Households Community-based Organizations	Colonial Expansion, World System of Stratification Gender and Ethnic Inequality Manufacturing	Extreme Poverty, Malnutrition Famine, Extreme Wealth Globalization Networks
Environment	Relative Abundance	Dwindling Resources Over-fishing 1 Billion Hectares for Agriculture	Environmental Degradation Deforestation, 1.5 Billion Hectares for Agriculture
Technology	Wood-burning Stoves Fossil-fuel Use Takes Off Industrialization in the Core	High Fossil-fuel Use in the Core Built Infrastructure Automobiles, Airplanes Atomic Bombs	Information and Bio-Tech. Space Exploration Industrialization in the Periphery
Institutions	Family Nation States Local Land-use Norms World consumption: $1.5 trillion	Capitalism, Socialism, Communism, Fascism, Imperialism, War, Global Organizations, Realism, World consumption: $4 trillion	Terrorism, War, Open-markets, International Regime Formation Global Civil Society World consumption: $24 trillion
Culture	Human Exemptionalism Manifest Destiny Domination of Nature	Nationalism, Technologism Materialism, Growth, Mass Consumption, Consumerism Modernism	Global Science Environmentalism Over Consumption in the Core Post-Modernism

Carbon Management

For managing the human dimensions of the global carbon cycle, the GCP conceives of the "global" as the collection of and interaction among locales where social processes interact with the carbon cycle in real places, as well as social space. We aim to coordinate numerous scientific explorations of the causes of the carbon-climate-human cycle at different scales to provide a framework for sound urban and regional carbon-cycle policy.

Urban and Regional Carbon Management (URCM) is the GCP initiative that coordinates research on place-based carbon budgets using a comparative and historical approach to urban, regional, and global carbon footprints, their determinants, trajectories, and management opportunities.

URCM's focus is on the relationship of regional and urban structures and processes to the global carbon cycle. Its goals are to understand and quantify:

- ✓ The direct carbon emissions of urban areas and regions
- ✓ The embedded carbon consequences of consumption patterns of urban areas and regions
- ✓ The drivers of direct and embedded carbon in terms of systemic configurations of Population, Organization, Environment, Technology, Institutions and Culture (or the POETICs of Place)
- ✓ The development paths by which current conditions evolved
- ✓ Key opportunities, threshold points and barriers for altering future development in ways which are synergistic with local concerns and multi-level governance structures, and
- ✓ Decision-support systems for carbon management at multiple scales.

Researchers around the world conduct URCM case studies to inform carbon management policies. Their research which combines relevant theoretical literature, POETICs data, carbon emissions and land-use information, and climate and weather statistics contributes to the developing URCM database (Figure 6).

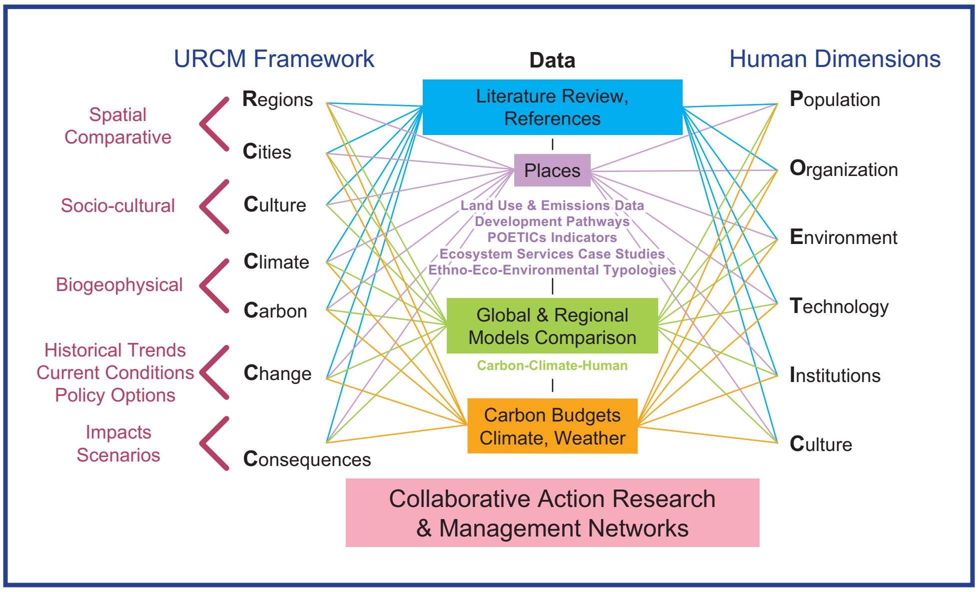
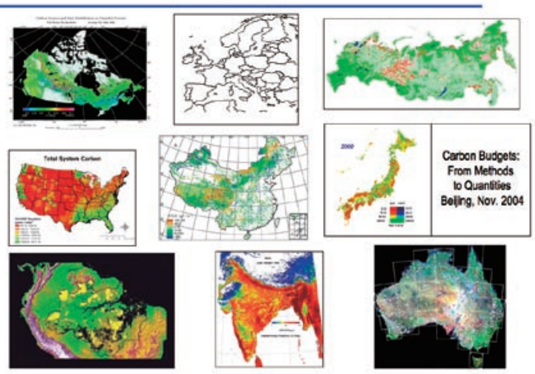


Figure 6. Connecting Carbon Footprints and Social Change at Multiple Scales in Space and Time

Support & Products

Science Framework and Other Products

First Results: Carbon Budgets for Selected Countries



References

Sabine, Christopher L. *et al.* 2004. "Current status and past trends of the global carbon cycle," Pp. 17-44 in Christopher B. Field and Michael R. Raupach (eds.) *The Global Carbon Cycle: Integrating Humans, Climate, and the Natural World.* Island Press.

Photos Credits

Hartman, Melanie. 2004. Garden at NIES, inside cover.

Sabine, Christopher. 2003. Ocean photo, cover.

Acknowledgement

National Institute for Environmental Studies(Japan) and the Center for Global Environmental Research sponsored this brochure.

GCP International Project Offices

www.globalcarbonproject.org

Canberra, Australia
Josep (Pep) Canadell
CSIRO Atmospheric Research
+61-2-6246-5631
pep.canadell@csiro.au

Tsukuba, Japan
Penelope Canan
National Institute for Environmental Studies
+81-(0)29-850-2672
penelope.canan@nies.go.jp

Contributing Offices/Programs

Beijing, PR China
Mingkui Cao
Institute of Geographical Sciences
and Natural Resources Research, CAS
+86-10-6488-9281
caomk@igsnrr.ac.cn

Jena, Germany
Annette Freibauer
CarboEurope
+49-3641-686726
afreib@bgc-jena.mpg.de

Paris, France
Maria Hood
International Ocean Carbon Coordination Project
IOC, UNESCO
+33 (0)1-4568-4028
m.hood@unesco.org

Washington, DC
Roger Hanson
Carbon Cycle Science Program Office
US Global Change Research Program
+1-202-419-3467
rhanson@usgcrp.gov