Greenhouse Gas Cycling and Terrestrial Ecosystems

The objective of this theme is to gain a better understanding of the exchange of greenhouse gas (GHG) fluxes between the terrestrial ecosystems and the atmosphere at various spatial scales.

Excerpt: Constraining and Handling Uncertainties of GHG Fluxes

(see http://www.iiasa.ac.at/Research/FOR/prog_reps.html: Forestry Scientific Directives 2006–2010: GHGs & Ecosystems)

The objectives are (1) to integrate bottom-up (inventories, remote sensing of terrestrial biosphere, biogeochemical modeling) with top-down approaches (atmospheric inversion, remotely sensed/directly measured atmospheric GHG concentrations) in order to constrain uncertainties of GHG flux assessments and thus to verify net GHG emissions to the atmosphere; and (2) to contribute to the handling of uncertain emission changes (including terrestrial biospheric flux changes) under the Kyoto Protocol and envisioning succeeding international negotiations.

At present, FOR has laid the groundwork to pioneer the merging of bottom-up/top-down (dual constrained) budgeting of net carbon/GHG emissions with the temporal detection of uncertain emission changes (termed emission signals, Nilsson et al., 2000, 2003; Stolbovoi and McCallum, 2002; Jonas and Nilsson, 2001; Jonas et al., 2004a,b,c). The integration of bottom-up (inventories, remote sensing of terrestrial biosphere, biogeochemical modeling) with top-down approaches (atmospheric inversion, remotely sensed/directly measured atmospheric GHG concentrations) is necessary to address verification of emissions, while the detection of emission signals is necessary to respond to the needs of the Kyoto Protocol, which is anchored in the world of emission changes (Graßl et al., 2003; House et al., 2003; Nilsson et al., 2001, 2002; Schulze et al., 2002; Steffen et al., 1998). Although strategically extremely important, this integration still goes widely unnoticed. Only if science succeeds in merging these two research areas will it be possible to take on a new role in (1) independently verifying any emission change reported under the Kyoto Protocol on the basis of “which net GHG fluxes the atmosphere has registered” (opposed to what we think the atmosphere has registered); and (2) rating any realized emission change in terms of its underlying uncertainty and thus in terms of its detectability. Considering where the research stands today, the FOR Program strongly believes that accomplishing this step will turn out to be a key scientific challenge for the global carbon community in the coming three to five years.

FOR’s Russian database on land resources and GHG fluxes is unique. Russia is one of the few signatory states of the Kyoto Protocol, which are sufficiently large to be also resolved in a bottom-up/top-down budgeting exercise. The overall goal of such an exercise is to contribute to a complete bottom-up/top-down coverage of the northern extra-tropical belt in close cooperation with CarboEurope (the carbon cycle research program of the European Commission covering Europe; http://www.carboeurope.org/) and the North American Carbon Program (covering the North American continent; http://www.esig.ucar.edu/nacp/) as well as the atmospheric inversion community.

Using FOR's terrestrial sink strength uncertainty for Russia as an additional/constraining a priori information to constrain Russia, the network of measurement sites is becoming sufficiently dense over the northern extra-tropical belt (continental view) to indeed put the Kyoto Protocol into a rigorous bottom-up/top-down uncertainty/verification context. However, further tests are required in the medium-term to see whether this result is robust. The elaboration of robust techniques, which permit the temporal detection of uncertain emission signals under the Kyoto Protocol to the UNFCCC, has so far not been rigorously addressed, neither prior to negotiating the Kyoto Protocol nor currently. The posteriori detection of emission signals, i.e., at the end of the Protocol's first commitment period, also goes still unresolved. This is all the more astonishing as it is clear that uncertainties and the associated risk of not complying with agreed-upon targets will have far-reaching consequences on pricing and trading GHG emission permits among countries. Together with the Systems Research Institute of the Polish Academy of Sciences, FOR has successfully tackled the issue of preparatory signal detection (see, e.g., http://www.ibspan.waw.pl/GHGUncert2004/index.htm).The rationale for conducting and improving uncertainty analyses is that (1) only by carrying out research on uncertainties can we handle uncertainties and make the post-Kyoto policy process more robust; (2) uncertainty analyses provide a standard for comparing national GHG inventories; (3) uncertainty analyses are crucial for improvements in methods and estimates of GHG emissions; (4) uncertainties play a crucial role in determining whether or not emission commitments are credibly met; and (5) uncertainties must be accounted if emissions are traded. It should be pointed out that midway signal detection and signal detection in retrospect are still not tackled at all. They, too, constitute key scientific challenges that need to be overcome prior to the first commitment period of the Kyoto Protocol.

However, even in those cases where science can become more specific with respect to some of the uncertainties that occur anywhere in between bottom-up/top-down budgeting and trading net emission changes, debate over how to deal with uncertainties is far from settled. For instance, what needs to be done if agreed-upon Kyoto targets do not outstrip uncertainty? Science is able to quantify for each country modified (detectable) emission reduction targets. (In fact, science can specify the complete set of uncertainty-detectability-risk characteristics of any country.) Will countries have to realize detectable emission signals before they are permitted to make economic use of their excess emission reductions? What will the market demand?

It immediately becomes clear that FOR's endeavors of treating uncertainty scientifically need to be accompanied by experts that are endowed with international negotiation experience because at the end of the day most of the uncertainty issues will have to be settled politically. To ensure an effective process, policy makers/negotiators need to understand how scientists measure uncertainty. However, scientists also need to be aware of the problems and opportunities that uncertainty may represent for policy makers/negotiators. To this end, FOR and PIN agreed to join forces with the aim at supporting international negotiations in the mid to long-term under the umbrella of the UNFCCC and the Intergovernmental Panel on Climate Change (IPCC). A suitable strategy to achieve this goal will be part of FOR's collaboration with PIN.

This project has currently a time horizon of three years starting in 2006. During the next 12–18 months the project will concentrate on elaborating the development of methodologies for assessment of uncertainties of bottom-up carbon budgets, carrying out continental experiments with atmospheric inversion experts by using inventory-based assessments as “bottom-up prior” and develop temporal detection techniques of emission changes.

Expected Results and Deliverables

- A cluster of models for integrated global assessment of the economic and biophysical impacts of the GHG management of terrestrial ecosystems for mitigation of climate.
- Assessment of GHG mitigation potentials by terrestrial ecosystems for Europe, the US, China and Japan.
- Terrestrial Biota Full Greenhouse Gas Budget for Russia, China, Ukraine and Central Asia.
- Bottom-up/top-down Full Carbon Budget for the Northern Extra-Tropical Belt.
- Methodology for sound uncertainty assessments of terrestrial GHG fluxes.