Vulnerability of the permafrost C pool

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Abstract
The stores of frozen carbon in the Siberian and North American arctic regions constitute a huge pool of carbon, about half the size of the atmospheric reservoir. Permafrost covered areas are prone to shrink in response to rising atmospheric temperatures, but few studies have yet attempted to estimate the sensitivity of frozen carbon stores. We designed a permafrost-carbon-energy model which couples the organic matter decomposition and methanogenesis processes with the diffusion of heat, water and gases through the soil column. Bacterial heat production appears to be a key process which can trigger and then dramatically accelerates the melting of frozen carbon. Model results, sensitivity and evaluation for the Cherskii area (North East Siberia) will be shown. The vulnerability of frozen carbon stores at northern latitudes as a function of rising temperature will then be characterized for different future warming scenarios, as well as the associated positive feedbacks on climate change.
Observations of the carbon dioxide sink in the Russian Federation during TCOS-Siberia

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Abstract
In the last decades, satellite and atmospheric inverse modelling studies have pointed towards Russia and Siberia as the area where one of the strongest sinks of carbon dioxide on earth is located. In this cold area, the sink would be particularly strong because of the observed quick temperature increase and the elongation of the growing season. There is some dispute on how strong the sink is, but an extended flux measurement program was lacking. We present now the results of 47 site-years of eddy flux measurements of carbon dioxide, collected at 12 sites over key land cover types in the Russian Federation (RF) during TCOS-Siberia. The measurements indeed suggest that substantial carbon dioxide uptake occurs in the RF. The forests form the strongest carbon dioxide sink (~200 g C m\(^{-2}\) yr\(^{-1}\)), followed by steppes (~140 g C m\(^{-2}\) yr\(^{-1}\)) and wetlands (bogs, tundra, ~60 g C m\(^{-2}\) yr\(^{-1}\)). Upscaling these site measurements using land cover classification maps leads to an estimated carbon dioxide uptake in the RF (17.1x106 km\(^{2}\), 11 % of the global land area) of 2.5 Pg C yr\(^{-1}\) or 42 % of the fossil fuel emissions. This number does not include emissions by fire, insect pests, slow ecosystem turnover and permafrost dynamics, nevertheless it suggests that the ecosystems in the RF play an important role in the global biogeochemical cycles and that feedbacks in the climate-ecosystem system are significant. We analyze the error bounds on these estimates and the inter-annual variability of the uptake. A comparison with estimates from inverse modelling and forest inventories is also made, suggesting that the Russian carbon balance is characterized by steady long-term uptake and intermittent rapid output (Slow in-Fast Out). The implications for process understanding, modelling and measurement strategies are discussed.
European wetlands: hotspots for GHG-emissions?

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wetland, germany, GHG-exchange, mitigation

Abstract
The principal functioning of peat-forming wetlands is the accumulation of carbon in the profile: For the EU-25 plus Russia’s European part Byrne et al. (2004) estimated the Carbon stocks of the peatlands as 42,000 Tg C. These huge amounts bear the risk of being emitted due to landuse- and climate-change. However, for the assessment of the actual climate warming effect of peatlands, the recent GHG-exchange is of principal interest. First estimates (Byrne et al., 2004) lead to around 52 Tg CO2-C-equiv. (100-year time horizon) for the overall emissions from these peatlands. Germany is second in emission (6.23 - 12 Tg CO2-C-equiv.; Byrne et al. 2004, Freibauer et al. in prep.), despite being just seventh in peatland extension of the respective area. For Germany peatlands are a major GHG-source, representing 2.3 to 4.5 % of German total emissions. This is mainly due to intensive agriculture on fen-peatlands. Hence even in Germany peatlands are hot-spots for GHG-emission.

However, the review of Byrne et al. (2004) showed that the knowledge base about the EF’s is still weak. Therefore a joint initiative was started to study with climate controlled chamber systems the full-year GHG-exchange budgets of different peatland ecosystems in Germany (Donauried 2005, Benedikteuern 2006 and further areas in the following years). The focus of the studies is on the comparison of different “treatments”: degraded versus restored ecosystems, intensive versus extensive land use, higher versus lower water table a.s.o. to get a span of conditions for modelling processes.

First results for ecosystem respiration of the Donauried fens show e.g. a differentiation between the grassland site (2.1 kg CO2-C m² a⁻¹) and the long-term restored sites with different sedge-communities (mean of 1.27 kg CO2-C m² a⁻¹). Whilst the drained sites had no significant CH4 flux the restored site emitted 0.3 to 1.3 kg C-equiv m² a⁻¹ as CH4. It is expected, that the NEE and N2O-fluxes, as well as the retained gases in the pore water will further differentiate the sites. It is hence unclear, whether restoration will effectively reduce greenhouse gas emissions from these degraded fen-peatlands. The final results will be shown in the conference after final processing and discussed within the frame of EU-peatland emissions.
Literature:
The latest on the Amazon carbon balance from the LBA flux community

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Abstract
There have been up to seven years of carbon flux measurements now across the Amazon at at least five main towers and up to seven additional towers. Despite this investment, so far reliable numbers for the carbon budget of the whole Amazon, supported by the whole community of LBA (Large scale biosphere-atmosphere experiment in Amazonia) have not been produced. Published estimates for isolated sites vary between a net source of up to 1 tonne per ha and a sink of up to five tonnes per hectare. Among others, a crucial difference between these estimates is the treatment of disturbed areas, nocturnal CO$_2$ drainage losses and assessing the role of less well investigated ecosystems and parts of the amazon (floodplains, western Amazon). Including other advances, these issues are now being investigated more thoroughly at several sites. We will report on the latest conclusions of a workshop, to be held in October, 2006 to arrive at more coherent estimates, as well as comment on the necessary steps forward to close the budget.
Variability and Vulnerability of Carbon Cycling in Africa: Diagnosing Controls on Regional Exchanges with Forward and Inverse Modeling

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Keywords
land-atmosphere water and carbon exchange, biophysical modeling, biomass burning, climate and vegetation interactions

Abstract
The African continent has a large and growing role in the global carbon cycle, with potentially important climate change implications. However, detailed knowledge about Africa's carbon dynamics remains remarkably limited. Using data from regional and global inventories as well as forward and inverse model analyses, we provide the first comprehensive assessment of the major carbon fluxes in and out of Africa. The continent contributes as much as 40% of the world's fire emissions, about 20% of global production and respiration, at least 20% of global land use emissions, and is a major source of interannual variability in global net carbon exchange. The continent's vast carbon stocks are highly vulnerable to climate change, evidenced by strong sensitivity of net ecosystem productivity and fire emissions to climate fluctuations. Regional hotspots of vulnerability to climate fluctuations and change are revealed with land surface and ecosystem modeling, as well as from analysis of remotely sensed biospheric states. In years ahead, Africa's land use pressures will undoubtedly increase and climate changes are anticipated to intensify drought cycles and make much of Africa warmer and dryer. Such changes will likely release CO\textsubscript{2} to the atmosphere as well as increase the magnitude of interannual variation in Africa's C fluxes by increasing Africa's biomass burning emissions and reducing the continent's net ecosystem productivity. If realized, these trends would have enormously important implications for global carbon dynamics and biospheric feedbacks to the climate system.