ESF - MOLTER Workshop

Global change and feedback from organic carbon dynamics

Defining research visions on how to quantify the molecular-level mechanisms driving soil organic matter turnover

(A three-day think tank at Lake Constance)

Date: **27-30/04/2009**
Location: **Zurich (CH)**
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> **To predict future concentrations of atmospheric CO_2 we urgently need a quantitative and mechanistic understanding of how (much) organic carbon is vulnerable to destabilization within the next decades. The aim of workshop is to define key future avenues of research to understand the processes driving terrestrial organic matter turnover forming the basis of future research initiatives.**

Why is it important to quantify the molecular-level mechanisms driving organic matter turnover in terrestrial systems?

Globally, terrestrial systems (including soil) store more organic carbon than is stored in the atmosphere as CO_2 but along with global change this pool is vulnerable to destabilization. Thawing permafrost, man-made ubiquitous atmospheric nitrogen deposition, and increasing summer droughts in Central Europe are just a few examples on the consequences already observed today.

Terrestrial ecosystems will provide a positive and amplifying feedback in a warming world, only the magnitude still remains uncertain (Heimann & Reichstein 2008). To be able to predict future concentrations of atmospheric CO_2 we urgently need a quantitative and mechanistic understanding of how much organic carbon is vulnerable to destabilization within the next decade to century, as nicely summarized in Nature by Trumbore and Czimczik (2008). At present, however, we are not able to predict the response of mineral organic matter to future environmental conditions. Due to lack of our mechanistic understanding we need to try to extrapolate observations from past situations into a future with ecosystems outside conditions of the past.

What have learned from past research efforts?
The main conclusions from a six year cooperative research program (2000-2006) funding some 20 working groups to work on 'soils as sinks and sources of CO_2' were the following.

- Selective preservation of certain recalcitrant organic compounds is *not* a major SOM stabilization mechanism. Organic fractions with slow turnover rates were mostly found in associartion with soils minerals, except for fire-derived organic matter (Marschner et al. 2008).

- Stabilization potentials of soils are specific to individual sites, and even within sites stabilization may vary with pedogenetic horizons (von Lützow et al. 2008, Spielvogel et al. 2008).
- Processes causing spatial inaccessibility and thus driving organic matter turnover are still poorly understood (von Lützow et al. 2008).

Some of the open questions include: What are the intrinsic properties of plant molecules that make them more susceptible to stabilization by sorptive interaction or physical protection? Which processes dominate in which soils, such as in old-young, clayey-sandy, tropical-boreal, neutral-acidic, oxic-mollic soils? Which novel high technology tools can we use to determine processes stabilizing organic carbon? How important are nano- and micro-scales configurations of soils to SOM sequestration?

What shall be the outcomes of this workshop?

The aim of the proposed workshop should be to

- bring together a small group of senior scientists in a stimulating think-tank like environment for three days.
- define the most promising key future avenues of research to follow.
- develop experimental approaches on how to understand the processes driving terrestrial organic matter turnover
- identify which combination of innovative high-technology tools and modeling approaches is needed to understand the process
- establish the foundation of near furture research initiatives (both bi- and multilateral) funded on national and European level and transatlantic research partnerships.
- summarize these research visions in a brief publication to be submitted for rapid communication in an open access journal such as *Biogeosciences* published by EGU.

References

Heimann M. & Reichstein M. 2008. Terrestrial ecosystem carbon dynamics and climate feedbacks. *Nature* 451, 289-292.

Marschner B. et al. How relevant is recalcitrance fort the stabilization of organic matter in soils? *Journal of Plant Nutrition and Soil Science* 171, 91-110.

Spielvogel S. Prietzel J., Kögel-Knabner I. Soil organic matter stabilization in acidic forest soils is preferential and soil type-specific. *European Journal of Soil Science* 59, 674-692.

Trumbore S. E. & Czimczik C. I. 2008. An uncertain future for soil carbon. *Science* 321, 1455-1456.

von Lützow M., Kögel-Knabner I. et al. 2008. Stabilization mechanisms of organic matter in four temperate soils: Development and application of a conceptual model. *Journal of Plant Nutrition and Soil Science* 171, 111-124.