PhD position in modeling of global biogeochemical cycles and agronomy

Title : Phosphorus limitation on global agricultural production, a new modeling approach

Summary

Phosphorus (P) is a key limiting nutrient for plant productivity in natural ecosystems. In agro-ecosystems, P is provided in the form of fertilizers, either inorganic or organic. P organic fertilizer corresponds to animal waste (manure) applied to fields and allows local P recycling. By contrast, mineral P fertilizer is derived from mines of phosphate rock, which is a finite and non-renewable resource [Reijnders , 2014].

At global scale, P management is far from optimal. Global P inputs to the soil of cropland are higher than P contained in harvested crops; but this budget displays a strong spatial heterogeneity. Indeed, 30% of cropland area are currently considered in P deficit, in particular in low income tropical countries [MacDonald et al., 2011]. P deficiency has an impact on crop performance, contributing to the "yield gap", i.e. the gap between actual and technically achievable potential yield. This is a source of great concern since it is established that agricultural demand (food and non-food) will increase in the future.

In this context, a major question is how global agricultural production will be constrained by P under the combined effect of resource depletion in P and its management. The proposed PhD is based upon the development, calibration and applications of the process based model ORCHIDEE-CROP that will be modified to include a full description of the P cycling in cultivated ecosystems.

Objectives

The aim of the proposed PhD is to evaluate the effect of soil P limitation on current and future agricultural production at global scale.

For such needs, the candidate will contribute to the development of a mechanistic modeling approach to simulate the crop response to soil P bioavailability at global scale. A model of P dynamic in agricultural soils as function of different drivers is currently being finalized at INRA in Bordeaux (UMR ISPA: Interaction between Soil Plant and Atmosphere). This model allows to simulate the spatial distribution of soil bioavailable P content at global scale depending on farming practices and natural processes. The candidate will work to incorporate this approach into a global process-oriented crop vegetation model (ORCHIDEE-CROP) to simulate the effect of soil P availability on agricultural production. ORCHIDEE-CROP is a model simulating the coupling between the water, carbon and energy cycles at ecosystem level. It has specially been modified and calibrated to represent the functioning of agro-ecosystems using the STICS agronomic model. ORCHIDEE-CROP currently lacks a mechanistic representation of the P cycle. Particular attention will be given on how to describe the mechanisms of coupling between carbon and P [Goll et al., 2012].

In a second step, the PhD student will evaluate the obtained model by comparing simulated and observed crop production over the last decades. He (She) will perform sensitivity tests to understand the uncertainties in the representation of different processes. This work will aim to accurately quantify the contribution of the P limitation to the "yield gap" for present-day conditions.

Finally, the PhD student will use the ORCHIDEE-CROP model fitted with P-limitations to assess how the pair (soil P fertility, agricultural production) will evolve in the future under simplified scenarios of resource management in P (e.g, shortage of P mineral fertilizer, etc.).

Host laboratories

The PhD student will be hosted in Bordeaux (France), at ISPA (Interaction Soil Plan Atmosphere, Joint Research INRA – Bordeaux Sciences Agro). Many short to intermediate visits to Paris in LSCE (Laboratoire de Sciences du Climat et de l'Environnement ; joint research CEA-CNRS-UVSQ) will be planned.
The PhD student will be supervised by Philippe Ciais (LSCE) and Bruno Ringeval (ISPA).

Starting day : 01/01/2016

How to apply?

The successful candidate should have, or expect to have, a Master 2 degree in physical, mathematical or environmental sciences. The candidate should have skills and deep interest in modeling. Knowledge in biogeochemistry and/or agronomy is preferred. For any question or application (in that case, enclose a CV), please send an e-mail to: bruno.ringeval@bordeaux.inra.fr

Application deadline: 21 April 2015