1st TERRABITES Symposium
Hamburg, Germany, 9-11 February 2010
TERRABITES-22

The role of tectonic uplift, climate, and vegetation in the long-term terrestrial phosphorous cycle

C. Buendia (1), A. Kleidon (1), and A. Porporato (2)

(1) Max Planck Institute for Biogeochemestry, Biospheric Theory and Modelling, Jena, Germany (cbuendia@bgc-jena.mpg.de), (2) Department of Civil Environmental Engineering, Duke University, Durham NC 27708, USA

Phosphorus (P) is a crucial element for life and therefore for maintaining ecosystems productivity. Its local availability to the terrestrial biosphere results from the interaction between climate, tectonic uplift, atmospheric transport, and biotic cycling. Here we present a mathematical model that describes the terrestrial P-cycle in a simple but comprehensive way. The resulting dynamical system can be solved analytically for steady-state conditions, allowing us to test the sensitivity of the P-availability to the key parameters and processes. Given constant inputs, we find that humid ecosystems exhibit lower P availability due to higher runoff and losses, and that tectonic uplift is a fundamental constraint. Particularly in humid ecosystems, these mechanisms seem essential to maintain long-term P-availability. The time-dependent P dynamics for the Franz Josef and Hawaii chronosequences show how tectonic uplift is an important constraint on ecosystem productivity, while hydro-climatic conditions control the P-losses and speed to reach steady-state. The model also helps describe how with limited uplift and atmospheric input, as in the case of the Amazon, ecosystems functioning must rely on mechanisms to enhance P-availability and retention. Our analysis underlines the need to include these mechanisms in global vegetation-atmosphere models for a reliable representation of the long-term terrestrial P cycle.