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On the linkages between the global carbon-nitrogen-phosphorus cycles

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State-of-the-art earth system models used for long-term climate projections are becoming ever more complex in terms of not only spatial resolution but also the number of processes. Biogeochemical processes are beginning to be incorporated into these models.

The motivation of this study is to quantify how climate projections are influenced by biogeochemical feedbacks. In the climate modeling community, it is virtually accepted that climate-Carbon (C) cycle feedbacks accelerate the future warming (Cox et al. 2000; Friedlingstein et al. 2006). It has been demonstrated that the Nitrogen (N) cycle suppresses climate-C cycle feedbacks (Thornton et al. 2009). On the contrary, biogeochemical studies show that the coupled C-N-Phosphorus (P) cycles are intimately interlinked via biosphere and the N-P cycles amplify C cycle feedbacks (Ver et al. 1999). The question as to whether the N-P cycles enhance or attenuate C cycle feedbacks is debated and has a significant implication for projections of future climate.

We delve into this problem by using the Terrestrial-Ocean-aTmosphere Ecosystem Model 3 (TOTEM3), a globally-aggregated C-N-P cycle box model. TOTEM3 is a process-based model that describes the biogeochemical reactions and physical transports involving these elements in the four domains of the Earth system: land, atmosphere, coastal ocean, and open ocean. TOTEM3 is a successor of earlier TOTEM models (Ver et al. 1999; Mackenzie et al. 2011).

In our presentation, we provide an overview of fundamental features and behaviors of TOTEM3 such as the mass balance at the steady state and the relaxation time scales to various types of perturbation. We also show preliminary results to investigate how the N-P cycles influence the behavior of the C cycle.

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