

## **Application of Fully Coupled Hydrology and Biogeochemistry CLM-PFLOTRAN Model to Simulate Soil C Stocks at NGEA Arctic Intensive Study Sites at Barrow, Alaska**

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### **Abstract**

In nature soil biophysical and biogeochemical processes are coupled spatially and temporally, which could not be ignored in High-Resolution Land Surface Models (LSM), due to complexity of process interactions occurring in locally inter-connected systems. In the Community Land Model (CLM), the land component of the Community Earth System Model (CESM), soil C-N processes and thermal-hydrology are not only implemented sequentially but also lateral connections in subsurface are not considered. PFLOTRAN is an open source, state-of-the-art massively parallel 3-D subsurface flow and reactive transport code. In this study, we extend the subsurface hydrological process coupling between CLM and PFLOTRAN to explicitly include soil biogeochemical reactive transports. The resulting coupled CLM-PFLOTRAN model is a high-resolution LSM capable of resolving 3-D soil hydrological-thermal-biogeochemical processes.

The classic CLM-CN reaction networks, degassing-dissolving of C-N relevant greenhouse gas species among soil solution and air, and soil N absorption processes are implemented in PFLOTRAN's reactive-transport framework. We compare soil C stock estimates from CLM alone and coupled CLM-PFLOTRAN simulations at the Next Generation Ecosystem Experiment-Arctic sites at the Barrow Environmental Observatory (BEO), AK. These intensive study sites are featuring with polygonal micro-topographic units, such as trough, center/edge for low/high/flat-centered polygons, and non-polygonal ground. Simulated results are compared against available soil C dataset to assess importance of coupled reactive-transport processes at fine scale in LSMs. Contributions of both soils and plant function types (PFT) to spatial variance of soil C from the two modeling approaches are discussed. Results indicate that two modeling approaches could produce very contrasting results across micro-topographic units. The developed CLM-PFLOTRAN framework will be used for regional evaluation of climate change caused ecosystem process responses and their feedbacks to climate system.

Key word: Soil C stocks, soil biogeochemistry, soil thermal-hydrology, synchronization, sequential, CLM-CN model, PFLOTRAN model, polygonal coastal tundra