Systems biology approach to bioremediation: Omics and hydrobiogeochemical processes

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Recent breakthroughs in our understanding of hydrobiogeochemical processes and genomics are leading to exciting new and cost effective ways to monitor and manipulate the environment and potentially produce bioenergy fuels as we also cleanup the environment. Indeed, our ability to sequence an entire microbial genome in just a few hours is leading to similar breakthroughs in characterizing proteomes, metabolomes, phenotypes, and fluxes for organisms, populations, and communities. Understanding and modeling functional microbial community structure and stress responses in subsurface environments has tremendous implications for our fundamental understanding of hydrobiogeochemical processes and the potential for making bioremediation breakthroughs. Monitoring techniques that inventory and monitor terminal electron acceptors and electron donors, enzyme probes that measure functional activity in the environment, functional genomic microarrays, phylogenetic microarrays, metabolomics, proteomics, and quantitative PCR are also being rapidly adapted for studies in Bioremediation. Integration of all of these new high throughput techniques using the latest advances in bioinformatics and modeling will enable break-through science in environmental biotechnology. A review of these techniques with examples from field studies and lab simulations from metal and radionuclide contaminated sties will be discussed.

North Atlantic melting water forcing of early deglacial warming in the Southern Ocean and two-step North Pacific ventilation: A transient GCM study with CCSM3

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The dramatic deglaciation climate evolution provides a key observation for studying the role of ocean circulation on deglacial CO_2 rise and for testing climate models. Here, we present the first transient climate simulation of the deglaciation evolution from the last glacial maximum to the early Holocene in a synchronously coupled general circulation model – CCSM3.

Our model simulates the major features of deglaciation evolution. In polar region, the deglacial warming trends from Greenland and Antarctic are well captured in the simulation mainly as the response to CO_2 increase, while the warming trend in Greenland has been interrupted by the millennial events caused by the variability of the Atlantic Meridional Overturning Circulation (AMOC). In North Pacific, the evolution of sea surface temperature (SST) mimics the evolution of the Greenland due to the atmospheric teleconnection. In South Pacific, the onset of deglacial warming occurred asynchronously at the surface: the warming started at 19ka in the Southern Ocean due to bipolar seesaw and 17ka in the tropics due to CO_2 rise. At intermediate and deep depth of Southern Ocean, the onset of the early deglacial warming occurs synchronously at 19ka. Sensitivity experiments were performed to demonstrate North Atlantic melting water forcing is causing the early deglacial warming of intermediate and deep depth of Southern Ocean.

Due to the atmospheric teleconnection, North Atlantic melting water forcing also induced two major ventilation events in North Pacific during Heinrich event1 and Younger Dryas with reduced ventilation during Bølling-Allerød. In the Southern Ocean, the ventilation was reduced due to the surface warming and reduced salinity caused by the reduction of brine rejection from sea ice. The 3~4 degree warming of intermediate and deep Pacific and the two-step ventilation of the North Pacific are two major features of the deglacial evolution in the Pacific and Southern Ocean and their implications for the deglacial atmospheric CO_2 rise will be discussed.