Enhancing the natural sulfur cycle to slow climate change

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We propose to stimulate the natural sulfur cycle in order to increase cloud reflectivity and cool large portions of the Earth. Previous field work and recent simulations using the Los Alamos Biogeochemical POP ocean model indicate that large regions of the Pacific and Southern Oceans could have higher primary productivity if iron or other nutrients were added. This would increase dimethyl sulfide (DMS) production by several factors. In the clean marine atmosphere, DMS is the chief source of cloud condensation nuclei (CCN) and additional CCN flux to the atmosphere would enhance cloud brightness. In regions where iron is limited, iron can be enhanced to about 1 nanomolar using ships or planes. Upwelling ocean pumps could be used in regions were macro nutrient are also needed.

During the Southern Ocean Iron Enrichment Experiments a ~ 225 km^2 area was fertilized with iron and 28 days later measured concentrations of DMS were about five-fold higher inside the patch versus outside (Wingenter et al., 2004, PNAS, 101, 8537–8541). During similar SO projects comparable increases of DMS were observed. If about 2 percent of the SO were enhanced in iron to similar nanomolar levels spaced throughout the SO and a similar response as observed during SOFeX, DMS production would increase 20 percent over the entire SO. The enhanced DMS flux may lead to 20 percent more CCN and albedo would increase from ~ 46.0 percent to 46.8 percent with an additional 3 Wm^{-2} reflected to space lowering the surface temperature 2 ^{o}C. It is difficult to predict the full outcome of such a large temperature drop over the SO without direct observations and full scale model simulations. Cooler temperatures may result in diminished break up of ice near Antarctica, inhibiting large ice masses, such as the Western Antarctic Ice Sheet (WAIS) from melting and raising sea level. To fertilize 2 percent of the SO south of 50^{o} S, about 22 kton of $FeSO_4$ are needed along with 30 ships over 30 days. Changes in albedo and chlorophyll would be validated by satellite measurements. One application of iron would require ~ $50 million. This is one illustration of biological leveraging of the sulfur cycle to cool Earth. Our model results indicate this method should also work in large areas further north in the Pacific and may work in other regions too. Less than 2 percent fertilization of the SO is probably needed to slow WAIS loss. This method may also cool other areas (Wingenter et al., 2007, Atmos. Environ., 41, 7373–7375). Note: Massive iron fertilization to sequester CO_2 is likely to overcool the region by several degrees resulting in diminished agriculture in surrounding areas.

We have started looking at wave driven upwelling pumps (P. Kithil, Atmocean) to increase primary and DMS productivity in low nutrient regions. The pumps can be configured to bring nutrient rich water from beneath the mixed layer to the surface. Several experiments have each been conducted with diameters ranging to 1 m and lengths up to 300 m. When positioned a few km apart, a considerable area of ocean could be enriched and DMS production may greatly increased.