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Arguments against ocean iron fertilization: Undesired environmental effects and feedbacks on climate

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The rate of biological photosynthesis in the oceans and hence the efficiency of the biological pump depends in part on the concentration and biological availability of major nutrients (CO2, N, P, Si) and essential metals (Fe, Mn, Cu, Ni, Zn, etc.). Many areas of the ocean are co-limited by N, however, some oceanic regions, the so-called high-nitrate, low-chlorophyll (HNLC) regions, are co-limited by trace metals, particularly iron. Since the early 1990s, numerous in-situ ocean iron fertilization (OF) experiments have been conducted, for example the LOHAFEX in 2009, in which a patch of 300 square kilometers in the South Atlantic was fertilized with iron. The idea behind these iron fertilization experiments is to mitigate anthropogenic CO2 in the atmosphere by stimulating the biological pump. However, large-scale OF could have severe negative environmental impacts and could offset the desired effect of OF on climate.

This paper will present results from laboratory and modeling studies from a variety of research groups (references will be included in the paper) that hint to the following potential negative impacts of OF:

1.) OF could cause changes in phytoplankton community structure and favor algal species that produce toxic substances.

2.) OF could lead to a massive outgassing of N2O into the atmosphere, which, in terms of radiative forcing, could overwhelm the atmospheric CO2 benefit initially achieved.

3.) Iron catalyzes light-induced transformations of colored dissolved organic matter (CDOM) and hence CDOM photobleaching, mainly in acidic aquatic systems. Stratification of water bodies further enhances CDOM photobleaching and, as a consequence, the penetration depth of the damaging solar UV-B radiation, which negatively impacts phytoplankton and thus the biological pump.

4.) OF could stimulate algal production of halocarbons that undergo light-induced reactions yielding halogen monoxide radicals (e.g. BrO, ClO, IO). These radicals in turn oxidize gaseous elemental mercury to Hg(II) which is deposited and undergoes methylation to form bioavailable and thus toxic methyl mercury. Furthermore, halocarbons may reach the stratosphere via troposphere-stratosphere mass exchange and participate in stratospheric ozone depletion. This effects of OF would be particularly problematic in the Southern Ocean since stratospheric ozone depletion in conjunction with greenhouse gases drives a stronger SAM, which increases the strength of westerly winds causing enhanced upwelling of carbon-rich deepwater.