There's a lot of enthusiasm in some circles for "geo-engineering" as a response to anthropogenic climate change, and a lot of skepticism about it in others. The appeal is obvious — controlling greenhouse gas emissions looks difficult, since our economies and many of our daily habits (at least in the developed nations, which are providing role models for the developing world) have been built on profligate fossil fuel use. For those with faith in human ingenuity, a technological fix can look like an easy way out. The skepticism has obvious roots as well. People have a history of trying to control nature, in ways that turn out either to cause unanticipated problems (like importing the rabbit to Australia, as Dan recently noted) or to be difficult and expensive to sustain (like replacing fish spawning habitat with hatcheries). Where you come down on that debate depends a lot on where you stand on the feasibility and desirability of human beings successfully controlling nature over the long term. That strikes me as the kind of fundamental philosophical divide that isn't likely to be bridged by any amount of discussion of the facts.

But there's another layer to the climate engineering debate where discussion might be more productive. That's the question of what exactly geo-engineering would have to control, and whether proposals floated so far would have the needed effects. To the extent that climate engineering proposals won't solve the problems greenhouse gases produce, people of various philosophical stripes might agree that the financial costs and ecological risks aren't worth it. So Cara's point that some proposals won't address ocean acidification is an important one.

Gabriele C. Hegerl and Susan Solomon make that point in a more general way in today's issue of *Science* magazine. They point out that "climate change is about much more than temperature change," so that discussions which use temperature changes as a proxy for the full suite of anthropogenic climate change are misleading. But those discussions are pervasive, and they have tended to drive people's thinking about solutions. Climate engineering proposals have accordingly tended to focus on reducing the temperature impacts of greenhouse gas accumulation in the atmosphere by reducing incoming short-wave radiation through measures like increasing the content of reflective aerosols (like SO2) in the atmosphere or erecting enormous mirrors to "shade" the earth from sunlight. Those measures obviously won't help the oceans, whose acidity depends on how much CO2 they dissolve, a function in turn of the level of atmospheric CO2 rather than of temperature. That's a point that Hegerl and Solomon don't directly address, but obviously an important one, to the extent that people care about changes in ocean productivity and in the suite of species the oceans support.

Hegerl and Solomon point out that there are other subtle effects of greenhouse gases that are overlooked by a narrow focus on temperature, and that those effects may make climate

engineering a more risky strategy than has been recognized. Greenhouse gases affect precipitation levels both directly, by reducing outgoing radiation, and indirectly, by increasing temperatures. Higher temperatures increase evaporation and therefore tend to increase precipitation (on a global basis). But trapping long-wave radiation reduces condensation in the atmosphere, and therefore reduces precipitation. Lowering temperatures by decreasing incoming short-wave radiation could be expected to shift that balance, meaning that the aerosol and mirror proposals could cause significant net reductions in global precipitation. According to Hegerl and Solomon, those effects are currently tough to model, globally and even more so locally. Before rushing to the technological fix, they suggest a need for careful examination of the multiple effects of greenhouse gas accumulation and the interaction of those effects with engineering approaches.