3. N. D. Mermin, *It's About Time: Understanding Einstein's Relativity*, Princeton U. Press, Princeton, NJ (2005), p. 22.

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Cool shades for hurricanes?

Kerry Emanuel's Quick Study of hurricane formation (PHYSICS TODAY, August 2006, page 74) inevitably lends itself to thoughts about the disruption of those storms. Weakening, as opposed to outright dissipation, might be easier to achieve and ultimately preferable, so that the energy involved can be released in a semicontrolled manner, as opposed to its being shunted elsewhere. Past ideas such as reducing evaporation or artificial upwelling of cold ocean water in the path of a hurricane would be case-by-case, resource-intensive operations that may well reduce storm intensity.

As a more far-fetched thought, have any calculations been undertaken to model a large, space-based sun shade to cut off the solar energy input to a storm system? If the Moon, approximately 3470 km in diameter and orbiting at around 384 500 km from Earth, can cast a shadow some 200 km wide during a solar eclipse, wouldn't a much smaller structure orbiting closer to Earth be sufficient to completely shade the eye of a typical Atlantic hurricane? Or perhaps more effectively, it could shade the early stages of storm formation farther out in the ocean. Using these approximate eclipse values to determine a working relationship between shade structure size, orbital height, and desired ground shadow yields roughly a 65-km-wide structure in Earth orbit at 3200 km. A real-world test of that relationship might be possible if there exist historic wind measurements observed during the timely intersection of hurricane and solar eclipse paths.

Granted, boosting the appropriately sized shade into orbit would be costly, but it could be used on numerous storms. Composed of ultrathin sections, each rigged with narrow, inflatable spars to create rigidity, a circular structure could be unfurled like an umbrella while a square structure could be unrolled. As with any space structure, the shade would wear with time, but even punctures from micrometeors or space junk would not necessarily degrade performance. Each section could be replaceable, and the spars self-sealing. Given the current state of materials science, this idea does not seem out of the realm of possibility. However, total weight might be problematic and necessitate multiple launches. Once it is deployed, common satellite systems could maintain it in geosynchronous orbit and allow for steering and tilting for variable storm tracks. A geostationary orbit might be optimal but unlikely due to limited real estate in that orbit and to the size of the shade.

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Emanuel replies: Michael Binkley advances an interesting idea to deprive tropical cyclones of their power source. In principle, it would work, if one could cool a strip of ocean roughly 100 km wide along the path of the cyclone. For average conditions in the tropics, a cooling of 2.5 °C would eliminate the necessary thermodynamic disequilibrium altogether, so even a 1 °C cooling would have a noticeable effect.

The technical difficulty here is one of time scale. The upper tropical ocean is typically well mixed by turbulence, through a depth of roughly 50 meters. To cool that layer by 2.5 °C, one would need to shut off sunlight for about 30 days, and roughly a week to achieve a 1 °C cooling. That is far longer than the time scales over which storm tracks can be predicted, and so one would be forced to cool a vast region of the tropical Atlantic Ocean. That would no doubt have unforeseen and probably undesirable consequences.

Given the high toll that hurricanes extract in human suffering, it is certainly worth contemplating means by which they might be tamed.

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Difficult deterrence decisions

The problem with Sidney Drell's rekindling the vision of Reykjavík in "The Challenge of Nuclear Weapons" (PHYSICS TODAY, June 2007, page 54) is that the steps advocated by George Shultz, William Perry, Henry Kissinger, and Sam Nunn cannot be carried out unilaterally or bilaterally. Even if the US and Russia were willing to abide by the program developed at the Hoover Institution, there is little indication that more volatile nuclear states, such as