Letter from the Desk of David Challinor
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A major incentive for me to write these monthly essays is the unexpected and rewarding knowledge I gain by doing so. Looking back over the past dozen years, I have written at least eight letters about global warming—its measurement, cause, rate of progress and consequences. It has been almost a year since hurricane Katrina struck the Gulf Coast, but the detritus of the devastation has yet to be cleaned up. Most meteorologists believe that hurricane frequency may continue to increase and now is the time to recognize this threat and prepare for it. This month's letter is about hurricanes and what I have learned about them from personal experience and from published research reports.

The first hurricane I experienced did not have a name, but has long been referred to as the "1938 New England one." It struck in September on the day my school in Concord, NH opened, while I was traveling on the shoreline train from Connecticut to Boston. When we reached the New London station at the mouth of the Thames River, the coach was rocking from side to side as the wind roared up the Sound from the southwest. We arrived safely at Boston's South Station, taxied to the North Station, climbed aboard the steam-powered "Cannon Ball" and reached Concord, NH at dusk. This must have been the height of the storm, because as we taxied through town we could hear, better than see, the giant elms for which Concord was famous, crashing down across the streets. The knowledgeable driver successfully took numerous side street detours to reach school. The next morning's light illuminated the devastation—mostly downed trees and power lines. The following winter, when two or three feet of snow covered the forest floor, the 11th and 12th graders lopped the branches off the jackstraw-jumbled fallen pine while the younger boys dragged the branches to clearings. There they were burned to reduce the fire hazard for the following summer and to enable the loggers to cut the stems into 16-foot lengths that horse teams hauled onto the ice-covered ponds for storage. By the end of WWII, these logs had all been milled in the war effort. Now, 65 years later, the next generation of white pine is ready for logging.

On to global warming and its consequences. In late May 2006, heavy rains around Concord, NH caused about as much flood damage as the wind had done in 1938. Since that earlier date, meteorologists have learned much about hurricanes and can now make nearly accurate predictions of their formation over the ocean and of the path they will follow to landfall. For example, the 2006 hurricane season began on 1 June and meteorologists are predicting an active U.S. coastal hurricane season of about 13 to 16 named storms. Of these, 8 to 10 will become hurricanes, with perhaps 4 to 6 being major ones, of which 2 to 4 could be category 3 or higher. As of now, these predictions bode for a season somewhat less violent than that of 2005. By comparison, Katrina was a

category 4 and Wilma, which struck Bermuda after crossing Florida, reached category 5—the most powerful hurricane ever recorded in the Atlantic.

Hurricane causes are complex; they are triggered by warm ocean water (>80ºF) and certain wind and air pressure patterns. For example, suppressed or low rainfall in the central Equatorial Pacific last year caused low wind sheer in the western Atlantic. Low wind sheer means that as the air ascends from the surface, wind direction varies only slightly. High wind sheer occurs when wind direction changes at different elevations. During last year's hurricane season, not only was wind sheer low but there were long periods of high pressure near the top of the atmosphere over the eastern U.S. That high air pressure aloft increased the area of low wind sheer and made it even lower. The lower the wind sheer, the more favorable the conditions to generate a hurricane. High wind sheer will disrupt the rising warm air mass at the center of a potential hurricane and often break it up.

Alberto, the first named tropical storm of the 2006 season, struck early in June and although it dumped considerable rain in Florida and adjacent states to the north, the winds were relatively modest (75mph). Conditions for subsequent storms, therefore, seem to be falling into place. Relatively prosperous citizens can and generally do take reasonable precautions: store drinking water to substitute for unavailable tap water, stock canned food, flashlights, etc. Poor families can seldom afford such an investment and must rely on public help which, as we all witnessed, was inadequate after Katrina struck New Orleans.

The general public, I believe, has a remarkably short memory of catastrophic events. For example, within a few decades after the devastating Anchorage earthquake in 1964, the City Council reversed its ban on house construction on the bluff overlooking the city, despite the geological evidence that the area was still just as vulnerable to earthquake damage. A second example: The Corps of Engineers worked at full speed to reconstruct the broken levees in New Orleans in time for the 2006 hurricane season; yet, by their own assessment, the rebuilt levees are designed to hold back only category 3 hurricanes and lower. Katrina was category 4.

Other countries have invested huge sums to protect against the worst storm in 10,000 years. Early last May, I drove along the 30km (18mi.) Afsluitdijk that bars the North Sea from the Zuiderzee. A four-lane highway runs its length and both sides of the 10m-high dike are well-protected by riprap. Its construction was an enormous investment, but it protects the huge polders reclaimed from this inland sea for agriculture. The British, too, have taken extraordinary precautions to protect London from exceptionally high tides. As a rower, I have experienced the force of the Thames' tidal currents well upstream of the city limits. In 1982 a 523m (1/3 mile) floating barrier was completed at a cost of £1.3 billion and eight years work. Although it may not be used for decades, its cost dwarfs that of the investment it would take to restore a flooded London.

New York City has been free of hurricanes since the 1800's. The 1938 hurricane made landfall just east of the city on Long Island and spared it from serious flooding.

New York, however, is especially vulnerable to hurricane-generated storm surges that result from a combination of low atmospheric pressure and high winds, which push a large volume of ocean water ahead of the storm. Like London, much of Manhattan's downtown financial district would be flooded by a not unprecedented 8m surge.

Much, but not all, of the vulnerable New York City area could be protected by rotating flood barriers 8m high, similar to those already in place on the Thames. Malcolm Bowman, a physical oceanographer at SUNY, Stony Brook, and his colleagues have proposed four barriers: at the Narrows between Brooklyn and Staten Island; at the mouth of Arthur Kill between Staten Island and Perth Amboy, NJ; at the entrance to Jamaica Bay to protect Kennedy airport; and the fourth at Hell Gate on the East River where it connects with Long Island Sound. Each proposed barrier would be three times as long as the English one and the estimated cost would run to tens of billions of dollars. This is a relatively trivial investment compared to the cost of evacuating an estimated 2.2 million people from Manhattan alone. Where would they go?

The evacuation of thousands of people from New Orleans a year ago gives a glimpse of the magnitude of the problem to be faced—ideally sooner rather than later—because with each hurricane-free year in northeastern USA, the odds increase for the next big one. Sadly, it will probably take a major flood to garner sufficient public support to take preventative steps. Most experts agree that the post-Katrina levees in New Orleans are only of marginal protection against a repeat category 3 storm, to say nothing of another category 4. The Gulf Coast is by no means the only vulnerable area; the densely populated shoreline from Florida to New England is in constant jeopardy. Sacramento, on the river delta at the north end of San Francisco Bay, is another vulnerable city crying for attention.

If long-range preventative measures can be undertaken by the Netherlands and England, there may be hope that our country can do likewise, but it is hard to be optimistic given our current national priorities. It is important, however, that as many coast-dwelling citizens as possible know the risk they are facing. Hence this letter and media of considerably wider distribution can all help to alert vulnerable citizens to a real impending threat to their well-being. The threat looms, but do we have the political speed and financial will to act now? That is the question.

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P.S. Much information for this letter came from Patrick Barry's article in *New Scientist*, "Sooner or later the water will arrive" p.8, June 13, 2006 and from National Public Radio's "Talk of the Nation: Science Friday" interview on Predicting the 2006 Atlantic Hurricane Season—May 26, 2006 (Ira Flatow and NOAH's Dr. Gerald Bell).