FORUM

Comment on "How Nature Foiled the 2006 Hurricane Forecasts"

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In a recent *Eos* article, *Lau and Kim* [2007] suggest that the increase in North Atlantic dust cover in 2006, relative to 2005, depressed ocean temperatures by as much as 1.2 K, and that this cooling was a key factor in the inaccurate forecasts for the last hurricane season. Despite the fact that tropical Atlantic Ocean temperatures in 2006 were the second highest on record and likely not the culprit for the near-normal hurricane activity (G. Bell et al., The 2007 North Atlantic hurricane season: A climate perspective, submitted to *Bulletin of the American Meteorological Society*, 2007), I argue that Lau and Kim exaggerated the well-known direct radiative forcing effect of dust on surface temperature [*Miller and Tegen*, 1998].

Using equation (1) from *Schollaert and Merrill* [1998], I estimated the shortwave forcing of ocean temperature by aerosols over the region of 70º–40°W and 15º–30°N (from Lau and Kim) using satellite-retrieved mean June 2005 and 2006 aerosol optical thickness values (0.19 and 0.24, respectively) and a mixed layer depth of 25 meters [*Kara et al.*, 2003]. My calculations show that this small change in aerosol optical thickness produces a cooling of the ocean of only 0.1 K, more than a factor of 10 smaller than the values reported by Lau and Kim. To cool ocean temperatures by 1.2 K with such a marginal change in aerosol optical thickness, the mixed layer depth would need to be an unrealistically shallow 2 meters. Also, dust cover in the 1980s and early 1990s was an order of magnitude larger than recent levels [*Evan et al.*, 2006, 2007]. If ocean temperature is as sensitive to changes in insolation as Lau and Kim suggest, dust loadings 15–25 years ago would have been coincident with relative reductions in ocean temperature far greater than the reported 1.2 K change between 2005 and 2006, which did not occur.

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Reply to Comment on "How Nature Foiled the 2006 Hurricane Forecasts"

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The two main objections of *Evan* [this issue] to our paper are that (1) the 2006 sea surface temperature (SST) in the Atlantic Ocean was actually above normal compared with the long-term climatology, and (2) the dust radiative forcing in 2006 was not substantially greater than in 2005 and could not have caused the large change in SST.

First, we recognize that 2006 was a climatologically warm year. However, the main focus of our study was on the abrupt cooling of the Atlantic SST from 2005 to 2006, not on the long-term variation. Hence this point is not germane to our study. Second, we suggested that Saharan dust may have been important in triggering a series of rapid feedback processes in the ocean-atmosphere system in the Atlantic in 2006 resulting in conditions that are unfavorable for hurricane formation. Therefore, the real question is, how much initial dust radiative forcing is sufficient to trigger the feedback processes? This is not a simple question to answer, because it depends on the timing of the aerosol forcing and the preexisting state of the large-scale coupled atmosphere-land-ocean system.

As noted by *Lau and Kim* [2007], major cooling of the Caribbean region (40º–70°W, 15º–30°N) began shortly after strong dust outbreaks in June. Therefore, the aerosol optical thickness (AOD) difference in June, not July, should be examined. Results from Moderate Resolution Imaging Spectroradiometer (MODIS) data show that there was a large increase in AOD in June 2006 (relative to June 2005) over the Atlantic, especially along the main transport region of Saharan dust (10º–20°N, 15º–65°W) (see Figure 1 in the online supplement to this *Eos* edition). The mean AOD over this region was 0.36 in 2005 and 0.49 in 2006, which represents a 30% increase in dust loading relative to 2005. This roughly translates to a reduction of surface shortwave flux of 8.0 watts per square meter. Over the western Atlantic and Caribbean region, the mean AOD was 0.18 in 2005 and 0.23 in 2006, corresponding to an increase of 28% and a reduction of surface solar radiation of 4.3 watts per square meter. This is much larger than the estimate of *Evan* [this issue].

Evan estimated the dust radiative forcing in terms of decrease of SST in °C per month using fixed mixed-layer depth of 25 meters in the Caribbean region. We note that large areas in the northern part of the subtropical western Atlantic have mixed-layer depth of 20 meters or less (see discussion in online supplement). Using the same calculation as Evan, but with the AOD values from MODIS, and for a range of mixed-layer depths of 15–25 meters, we have estimated the rate of cooling of the western Atlantic and Caribbean region to be in the range 0.1º–0.18°C per month. This is substantially larger than the estimates by Evan. The observed monthly mean cooling rate over the region in June 2006 relative to June 2005 was about 0.53°C. Compared with the aforementioned dust-induced SST cooling, this means that the solar attenuation effect by dust may have contributed up to 20–30% of the observed SST change.

By July–August 2006, the full atmospheric-ocean feedback triggered by the initial SST cooling was likely to have already been established, resulting in a much stronger and widespread SST cooling. As suggested by Lau and Kim, the feedback also may involve an anomalous atmospheric Walker-type circulation with relative sinking motion over the western Atlantic/Caribbean region. Both the cooler SST and the enhanced subsidence could suppress hurricanes.

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