Can marine cloud brightening moderate hurricanes?

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The Whitney and Hobgood 1997 paper shows that the frequency and severity of hurricanes depends on sea surface temperature. There is nothing special about 26.5 C. It is just a boundary definition.

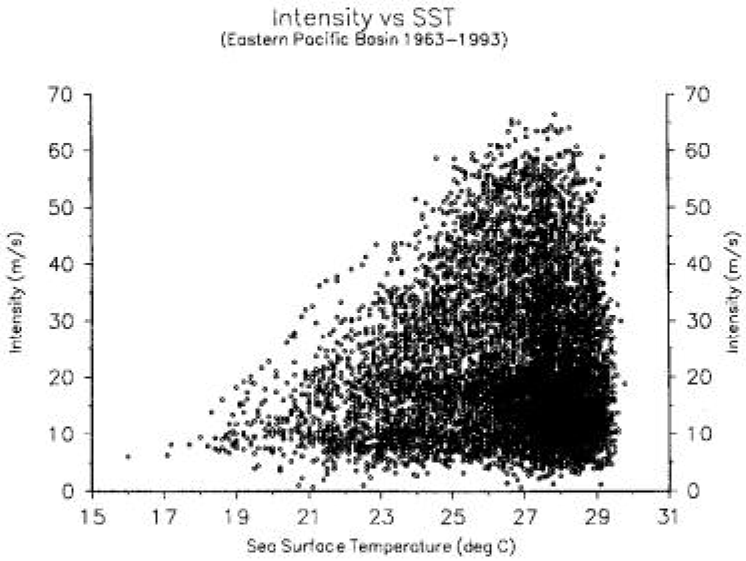
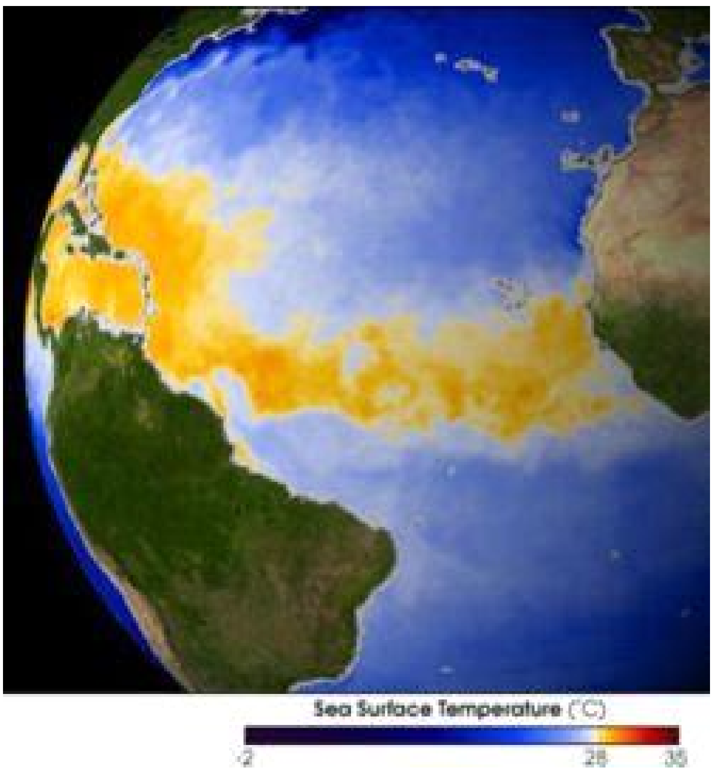


FIG. 1. Scatter diagram with the intensities and SSTs of all 11 062 observations in the 31-yr sample (1963–93). Intensities are corrected for storm translational speed.

The image below shows sea surface temperatures along the hurricane-breeding path from Africa to the Caribbean. Perhaps it is easier to stop them young.



Google Earth says path length $Lpth := 10000 \cdot km$ and width $Wpth := 2000 \cdot km$

so path area $Apth := Lpth \cdot Wpth = 2 \times 10^{13} \, m^2$

Assume that we want to reduce temperature to a water depth of $Zw := 2 \cdot m$ by $\Delta T := 3 \cdot K$

The density of sea water $\rho sw := 1020 \cdot \frac{kg}{m^3}$

Kaye and Laby say specific heat of sea water $SPHT := 3993 \cdot \frac{J}{kg \cdot K}$

so energy removal $Enr := Apth \cdot Zw \cdot \rho sw \cdot \Delta T \cdot SPHT = 4.887 \times 10^{20} \, J$

Assume that the solar input to the cloud top is $Sol := 300 \cdot \frac{watt}{m^2}$

and we want to do the cooling over $Time := 30 \cdot day$

The necessary change in reflectivity is $\Delta R := \frac{Enr}{Sol \cdot Apth \cdot Time} = 0.03143$

From Vallina 10.1029/2006GB002787 figures 4 and 7 we assume that the present concentration of cloud condensation nuclei over the equatorial Atlantic is $conc1 := \frac{125}{cm^3}$

Schwartz and Slingo equation 5b says fractional concentration change

$\Delta conc := \frac{\Delta R}{e^{0.75}} = 0.015$

If the depth of the marine boundary layer is $Zbl := 2500 \cdot m$

The number of extra nuclei needed is $Nnuc := Apth \cdot Zbl \cdot conc1 \cdot \Delta conc = 9.278 \times 10^{22}$

If the vessel spray rate is $Rspr := \frac{10^{17}}{sec}$ and we can rely on electrostatic charge on monodisperse drops give a coagulation loss of $Kcoag := 0.9$ and the drop life $Life := 1 \cdot day$

the vessel number is $Nvess := \frac{Nnuc}{Rspr \cdot Life \cdot Kcoag} = 11.932$

Caveats

Uneven nucleus concentration. Not enough wind to drive spray vessels. Wind in the wrong direction. Shorter nucleus life. Low cloud fraction. Competition from Sahara dust storms. The need for some gentle hurricanes to provide water . . . . . .

But if rain is the main nucleus-removal mechanism, a low cloud-fraction means a longer nucleus life. We could take much longer than 30 days to do the job.

I was surprised that the predicted vessel number is so low. A much higher number would still justify more rigorous calculations and the use of climate models.

Please email me at S.Salter@ed.ac.uk if you would like to correct my mistakes, suggest other values for the assumptions, copies of the papers mentioned, more information about the engineering design of spray vessels or a way to get an everywhere-to-everywhere transfer-function of marine cloud brightening.