Capital Weather Gang
The inside scoop on weather in the D.C. area and beyond

- Nor'easter *may* bring Sandy-stricken areas rain, coastal flooding next week
- October 2012: Third wettest and third warmest of the 2000s in Washington, D.C.
- Superstorm Sandy packed more total energy than Hurricane Katrina at landfall

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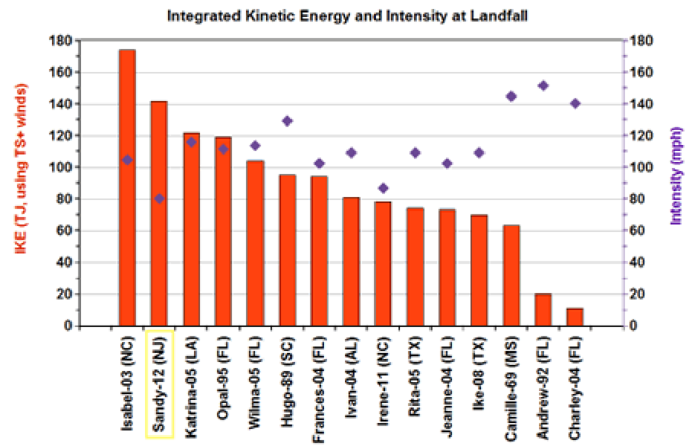
Superstorm Sandy packed more total energy than Hurricane Katrina at landfall

By Brian McNoldy



Integrated kinetic energy (IKE) and intensity of several historic U.S. landfalling storms. IKE is shown by the red bars, while the intensity is shown in the purple diamonds.

The horrific storm surge flooding in New Jersey and New York caused by Sandy was almost perfectly predicted well in advance, but was more extreme than the average person might expect from a minimal hurricane. That's where Sandy's immense size comes into play.

There is a metric that quantifies the energy of a storm based on how far out tropical-storm force winds extend from the center, known as Integrated Kinetic Energy or IKE*. In modern records, Sandy's IKE ranks second among all hurricanes at landfall, higher than devastating storms like Hurricane Katrina, Andrew and Hugo, and second only to Hurricane Isabel in 2003.

The above chart compares IKE and intensity for storms at the time they struck land (in the U.S.). Not all historic storms can be included because a detailed wind field analysis (required to compute IKE) is unavailable for storms in the distant past. But this chart shows the majority of high-ranking modern cases.

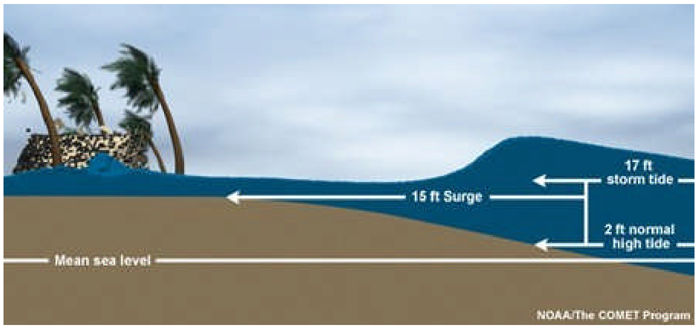
Sandy's IKE was over 140 Terajoules (TJ, 1 TJ = 1 trillion Joules = 277,778 kilowatt hours), meaning it generated more than twice the energy of the Hiroshima atomic bomb. At any given moment, many hurricanes contain more energy than an atomic bomb in their surface winds alone (even excluding winds at higher elevations and latent heat energy).

Though way down on the scale, I include Andrew and Charley in the chart to show how their small IKE contrast their high rankings on the Saffir-Simpson scale which is based solely on peak sustained winds. This demonstrates small intense storms generate far less energy than large weak storms.

Why does IKE matter?

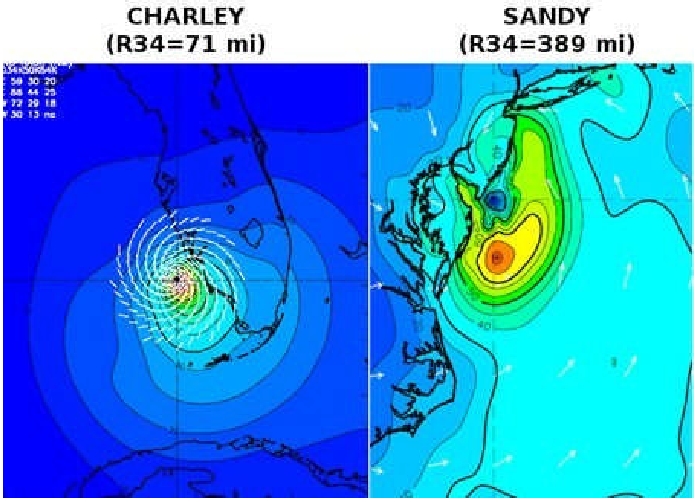
It has been demonstrated time and time again that the storm surge generated by a hurricane is not very well correlated with the storm's intensity or peak winds, but rather the storm's size - which the IKE metric captures. The area over which strong winds blow across the ocean is strongly related to the resulting storm surge potential.

Recall, the storm surge is the increased water level along the coast caused by winds continuously bulldozing the ocean onto the land. It builds long before a storm makes landfall. It simply raises the mean sea level from its normal level by a few to over 25 feet. Large violent waves typically occur on top of the storm surge.



Cartoon showing mean sea level, normal high tide sea level, a 15' storm surge coming between high and low tides, and a 17' storm tide resulting from a 2' lunar high tide plus the 15' storm surge.

In the figure below, two hurricanes (Charley '04 and Sandy '12) are shown side-by-side at the same scale. The color contours highlight wind speed, and are shaded identically. Charley was a Category 4 hurricane, while Sandy was a Category 1 hurricane (technically, it may have just transitioned to an extratropical cyclone an hour before landfall, but that's an academic difference that people on the ground don't care about), but clearly Sandy's wind field extended over a larger area, even though its peak winds were much weaker. As such, Sandy's IKE was 7 times Charley's and had a much more massive storm surge.



Surface wind fields of Category 4 Hurricane Charley and Category 1 Hurricane Sandy at landfall. (HRD)Of course, IKE is not the only factor in determining storm surge potential. Differences in coastal topography/bathymetry play a large role, so the specific landfall location matters.

The exact same storm hitting Charleston, S.C. will have a completely different surge potential than if it were hitting Miami, Galveston, New Orleans, or New York City (NYC). The stage of the normal lunar tides makes a large difference as well (Sandy made landfall exactly at high tide).

And in terms of human impacts, a landfall on or near a major city will certainly be worse than an identical landfall near a more rural stretch of coastline. Places like New Orleans, NYC, and Tampa are both low-lying AND heavily populated. But hurricanes don’t care where we build cities and how vulnerable those cities are.

Hurricane Katrina was “only” a Category 3 storm at landfall, yet ended up being the most costly natural disaster in our nation’s history due its impact on a vulnerable, highly populated low lying city. Sandy had Category 1 winds at landfall yet was able to create very significant storm surge over hundreds of miles of highly populated coastline. Katrina’s IKE was more concentrated, Sandy’s IKE was more spread out. This metric - more than wind speed - encapsulates the respective storms’ horrific effects. Sandy may end up as the second most costly storm in U.S. history. Given its top ranking IKE and the area it impacted, that should come as no surprise.

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* To calculate IKE, a high-resolution gridded wind field is created using all available aircraft, satellite, buoy, and ship data. Then, all grid points with surface wind speeds of 35 knots (or about 40 mph) or higher (tropical storm force) are identified. The wind speed at each of those points is squared, summed, and scaled, resulting in a single value, measured in tera-Joules.

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