Florida Climate Institute
AT FLORIDA STATE UNIVERSITY

Integrated Kinetic Energy (IKE)

IKE Versus the Saffir-Simpson Hurricane Wind Scale

The Saffir-Simpson scale is not truly representative of a storm's damage potential:

- The Saffir-Simpson scale is based on a 1-minute average sustained wind speed measured at a single location of the tropical cyclone — a variable that is barely observed outside of the given location and instant.
- IKE takes into account the size and distribution of wind around the center of the tropical cyclone.
- We are able to estimate the size of the tropical cyclone from the forecast of IKE.

Saffir–Simpson hurricane wind scale

Category	Wind speeds
Five	≥70 m/s, ≥137 knots ≥157 mph, ≥252 km/h
Four	58–70 m/s, 113–136 knots 130–156 mph, 209–251 km/h
Three	50–58 m/s, 96–112 knots 111–129 mph, 178–208 km/h
Two	43–49 m/s, 83–95 knots 96–110 mph, 154–177 km/h
One	33–42 m/s, 64–82 knots 74–95 mph, 119–153 km/h

A New Way to Quantify How Big and Bad A Hurricane Is

What do you really want to know when a hurricane is headed your way? Probably how much damage you can expect to your area, whether from wind, waves or some combination.

The Integrated Kinetic Energy (IKE) index is an improvement over the Saffir-Simpson scale most laypeople are used to. It goes beyond storm wind speed to take storm size into account. IKE sums up the square of the winds blowing around the center of the storm. We divide the storm into quadrants and square the strength of the winds in each until we reach the point toward the perimeter of the hurricane where they're measuring 40 mph or less.

For two comparable storms with similar intensity, the one with a larger span outward from the center of 40 mph winds and greater will have higher IKE. So IKE is a better representation of the overall destructive potential of a hurricane than just intensity. Moreover, IKE scales with the wind stress on the ocean surface, which is the primary reason for storm-generated surge and waves.

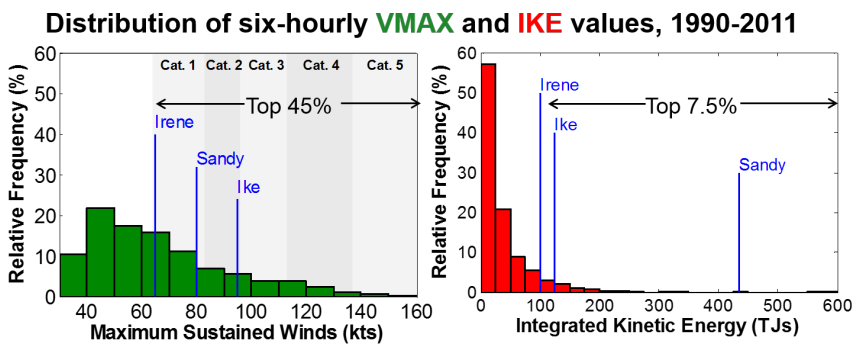

Figure 1: Relative frequency histogram of six-hourly maximum sustained winds (VMAX; left panel) and IKE (right panel) measurements in Atlantic TCs between 1990 and 2011. This sample includes 5498 fixes from 291 storms. Vertical lines are shown to indicate VMAX and IKE values for selected hurricanes just prior to a US landfall. The times of these IKE measurements are as follows: Ike 9/13/08 00Z; Irene 8/28/11 06Z; Sandy 10/29/12 18Z. The three storm points would fall in the top 45% of all TCs points in terms of VMAX and the top 7.5% of TCs in terms of IKE from 1990 through 2011.

Index Numbers versus Destruction on the Ground. Example: Hurricane Katrina

A historical comparison of high-impact events can help demonstrate why Hurricane Katrina – a Saffir-Simpson scale Category 3 storm at landfall in Mississippi – brought a storm surge that exceeded the previous benchmark for coastal Mississippi, set by SS Category 5 Hurricane Camille. Katrina's wind field displayed IKE (120 Terrajoules) values twice as large as Camille (60 Terrajoules), despite having a lower intensity.

Unfortunately many residents based their preparations on Camille's historical high-water marks and paid the price, with a resident quoted in the Biloxi, Mississippi Sun Herald after the 2005 storm saying "Camille killed more people yesterday than it did in 1969." Despite its lower intensity, Katrina's winds covered a much larger area than Camille, allowing it to do more damage, mostly via widespread coastal flooding.

Examples: Hurricanes Sandy & Irene

The advantages of IKE become even more apparent when we look at recent low-intensity, high-impact events. In 2012, Hurricane Sandy's huge wind field generated IKE values over 300 TJ, good enough for a 5.8 reading (out of 6) on the Powell-Reinhold (PR) surge destructive potential scale, while the Saffir-Simpson scale reading was only a 1. And Sandy wasn't an outlier on the Saffir-Simpson Scale.

Hurricane Irene, which affected North Carolina and New England in 2011, reached just over 115 TJ with a 5.1 PR rating, and Hurricane Ike, which struck Texas in 2008, had a wind field that filled the Gulf of Mexico with IKE of 150 TJ and 5.2 on the PR scale. But Irene and Ike on the SS scale rated just 1 and 2, respectively.

72-Hour IKE Forecast vs National Hurricane Center Advisories

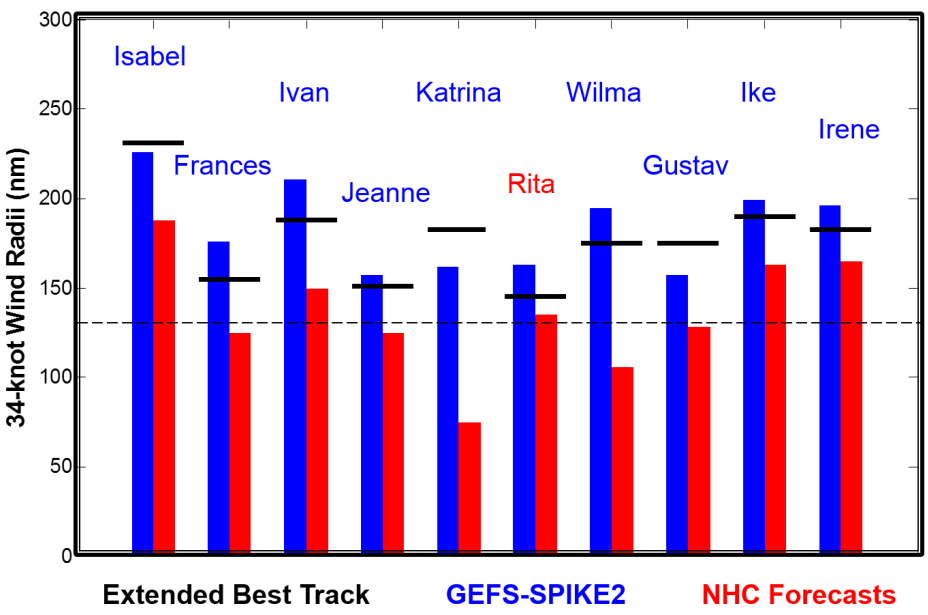

Figure 2: The wind radii (in nautical miles) of 34-knot winds retrieved from the 72-hour IKE forecast from SPIKE2 (blue bar), National Hurricane Forecast Advisory (red bar) and corresponding observations (black line) for 10 major Atlantic tropical cyclones that made landfall in the US.

Next Steps

1) Make the forecasts of IKE and wind radii for Atlantic tropical cyclones operational

2) Expand to other tropical ocean basins

3) Apply IKE for storm surge forecasts

4) Expand this work to a multi-model framework

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Relevant peer-reviewed research papers (available at http://coaps.fsu.edu/vasu-misra/all-publications):

- M. E. Kozar and V. Misra, 2014: Statistical Prediction of Integrated Kinetic Energy in North Atlantic Tropical Cyclones. Mon. Wea. Rev., 142, 4646–4657.
- V. Misra, S. DiNapoli, and M. Powell, 2013: The Track Integrated Kinetic Energy of Atlantic Tropical Cyclones. Mon. Wea. Rev., 141, 2383–2389.

Portions of this handout excerpted from:

- V. Misra and M. Powell, 2015: There are better ways to quantify how big and bad a hurricane is. The Conversation (June 3).