New Metrics for Hurricane Impacts

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- Risk Perception

Despite excellent forecasts and warnings, people act on perceived vulnerability

- Past experience influences perception (Baker 2006, Wilkinson and Ross 1970)
- Those who experienced significant loss are more likely to act in the future (Shulz et al 2005, Miletti 1992)
- Experiences from Hurricane Camille of 1969 influenced actions taken in Katrina
- Camille and Katrina were very different storms

Biloxi Sun Herald Sun, Sep. 21, 2008

Americans need a better way to assess the risk of hurricanes

Saffir-Simpson categories contribute to casualties

The Saffir-Simpson Hurricane Scale is lulling coastal residents into a fatally false sense of security. That's because the scale's five single-digit categories distort the danger of an approaching tropical weather system.

It happened during Hurricane Katrina, when some South Mississippians made the mistake of underestimating the hurricane's threat by comparing it to Hurricane Camille. Because Camille was a 5 on the Saffir-Simpson scale and Katrina was weakening into a 3, some people assumed Katrina was less of a threat to their lives and property.

That assumption cost some people their lives. Biloxi Mayor A.J. Holloway said the day after Katrina: "It looks like Hurricane Camille killed more people yesterday than it did in 1969." While Katrina's winds were slower than Camille's, its unprecedented storm surge was far deeper and deadlier.

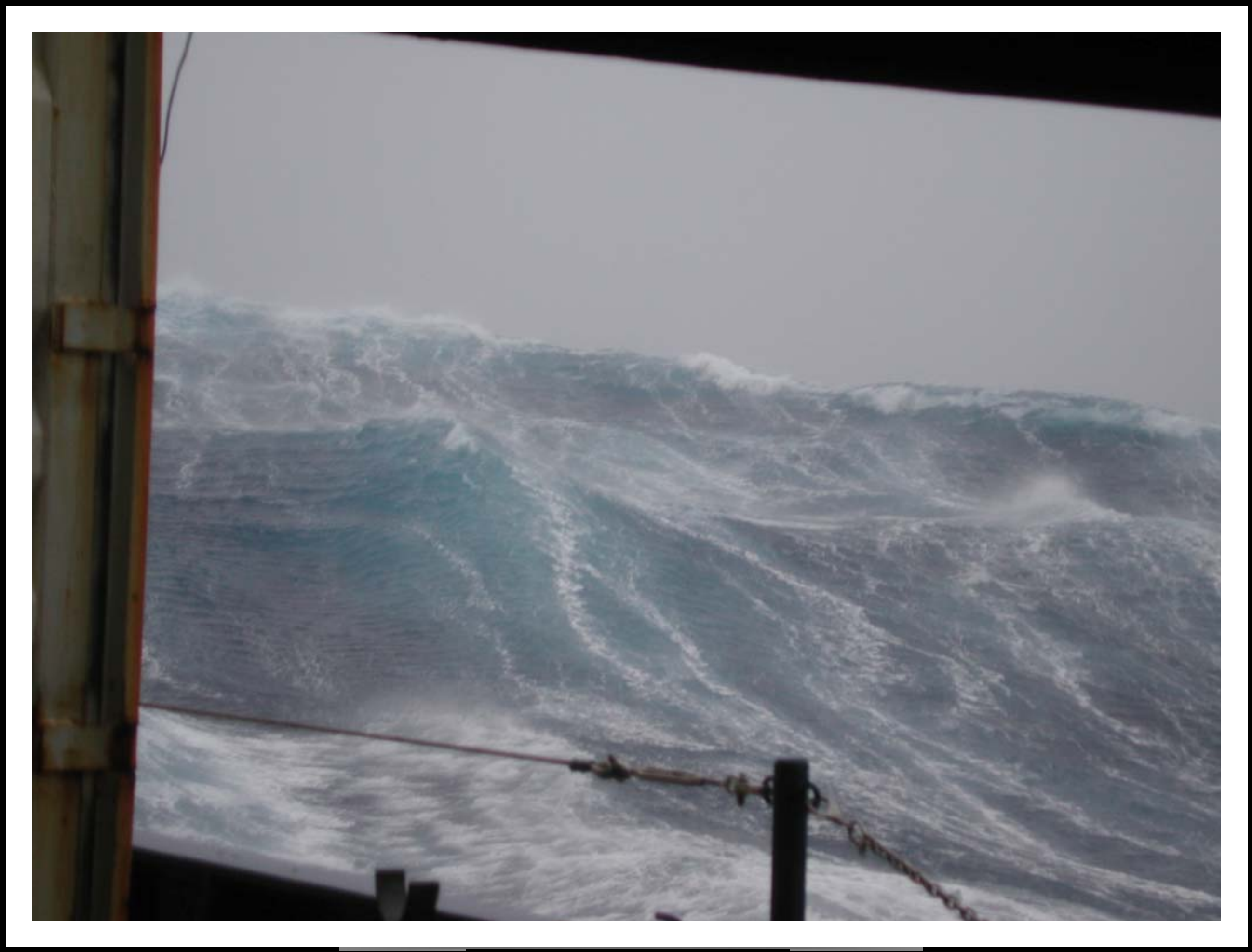
The same thing just took place in Texas, where coastal residents understandably but regrettably compared Hurricane Ike, a deceptively low-level Category 2, to previous higher-level storms and decided not to evacuate.

We appreciate that perfection is not possible.

- **Motivation for a new hurricane metric:**
  - Intensity is important but independent of size
  - Wind radii are important but independent of intensity
  - Destructive potential depends on both
  - We need a metric to convey this to the public

- ***Wind stress on the ocean scales with the square of the wind speed***

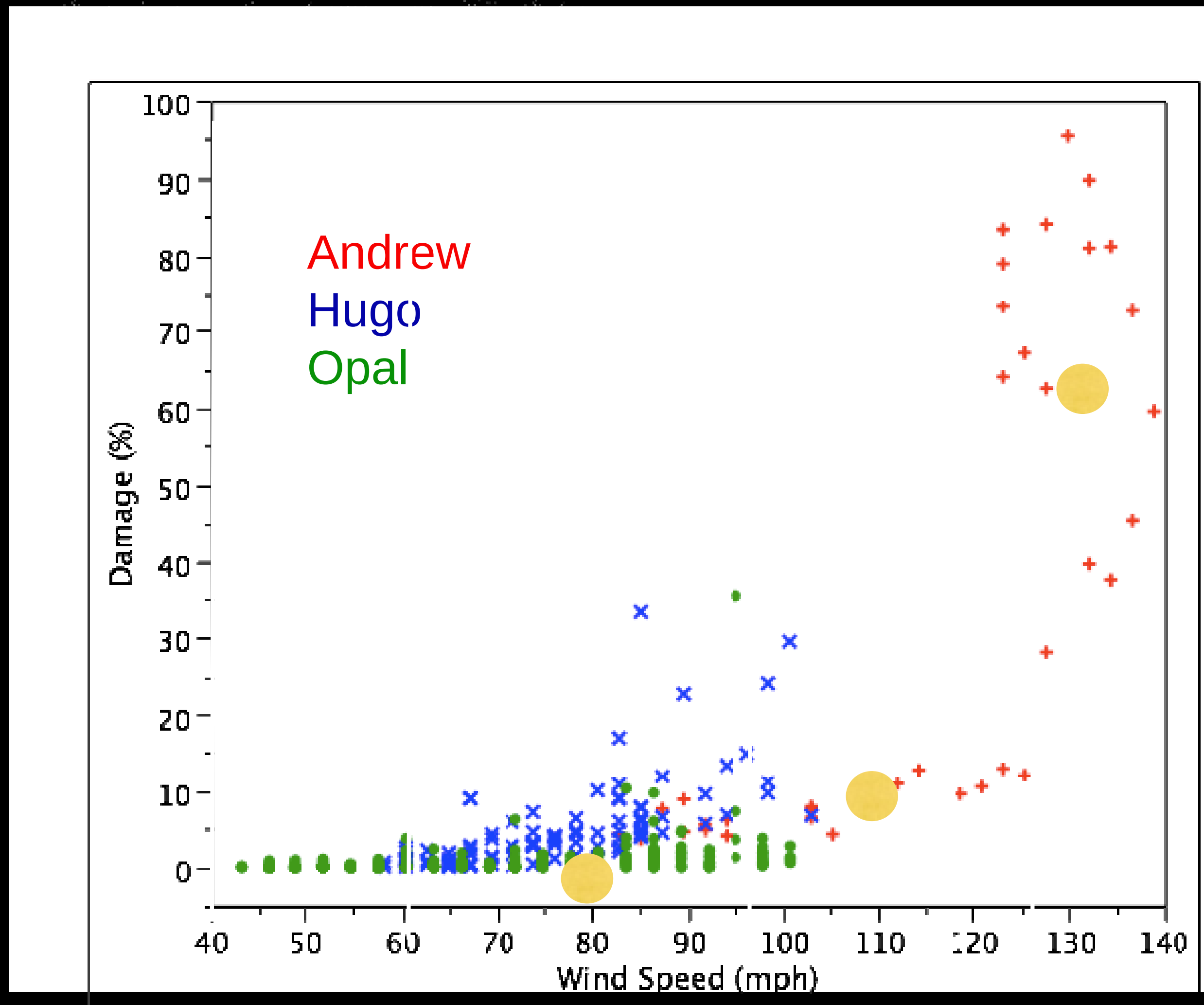
- ***Forces waves and storm surge***



Wind Damage increases dramatically at ~ 55 m/s

% Damage claim/insured value

Threshold damages
at 2%
12%
60%



Wind Speed

- **Integrated Kinetic Energy (IKE)**

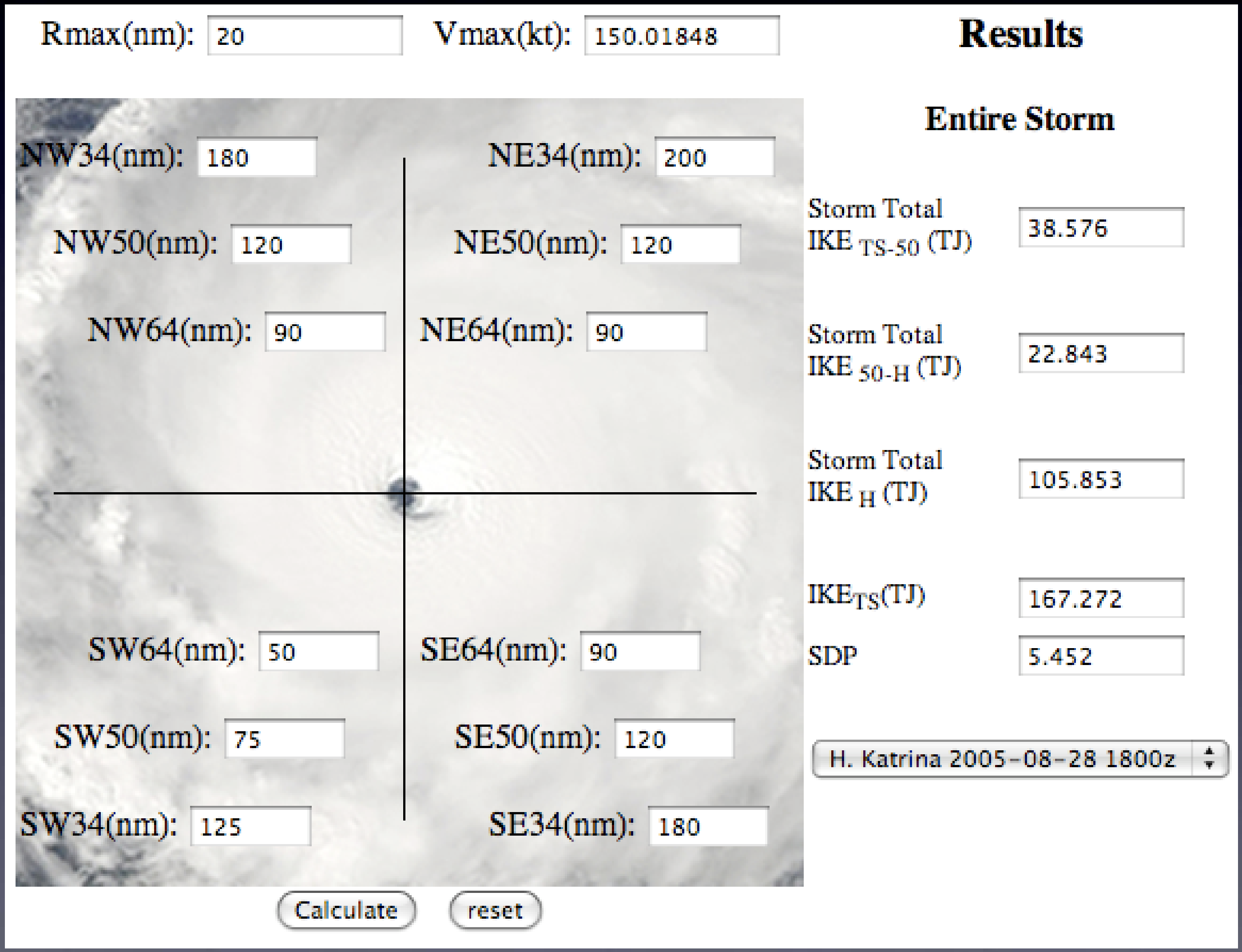
$$IKE = \int \frac{1}{2} \rho ws^2 dV$$

  - **Kinetic energy/ volume**
  - **Scales with the square of the wind speed and the areal coverage of damaging winds**
  - **Contributions of IKE over various wind thresholds**
  - **Sum grid cell KE ~ 5 x 5 km, 1 m deep at 10 m**
  - **IKE range from H*Wind archive**

- **Surge / Wave Destructive Potential (SDP):**
  - Depends on IKE from winds > tropical storm force
  - A large TS can be more destructive than small hurricane
  - Actual destruction depends on local effects

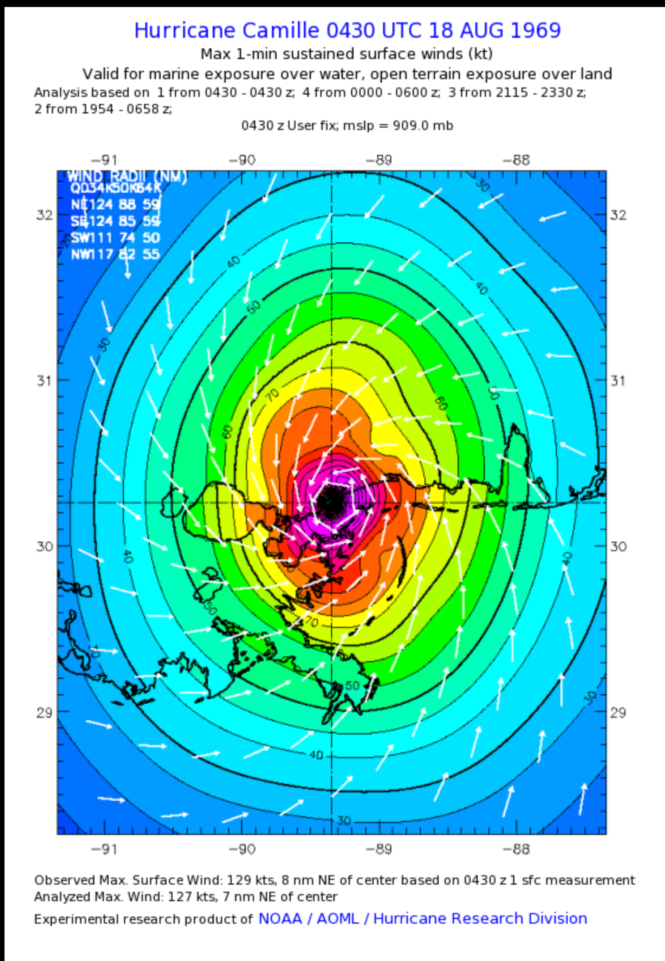
Kinetic Energy and SDP Calculator at:

www.aoml.noaa.gov/hrd/ike

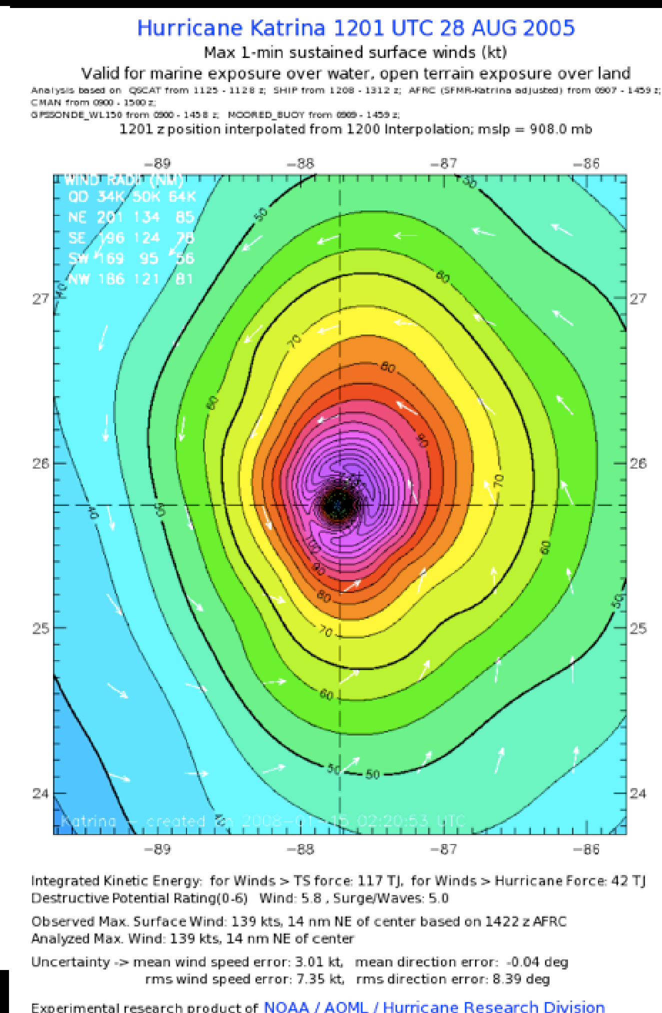


Integrated Kinetic Energy for winds > TS force in Terra Joules

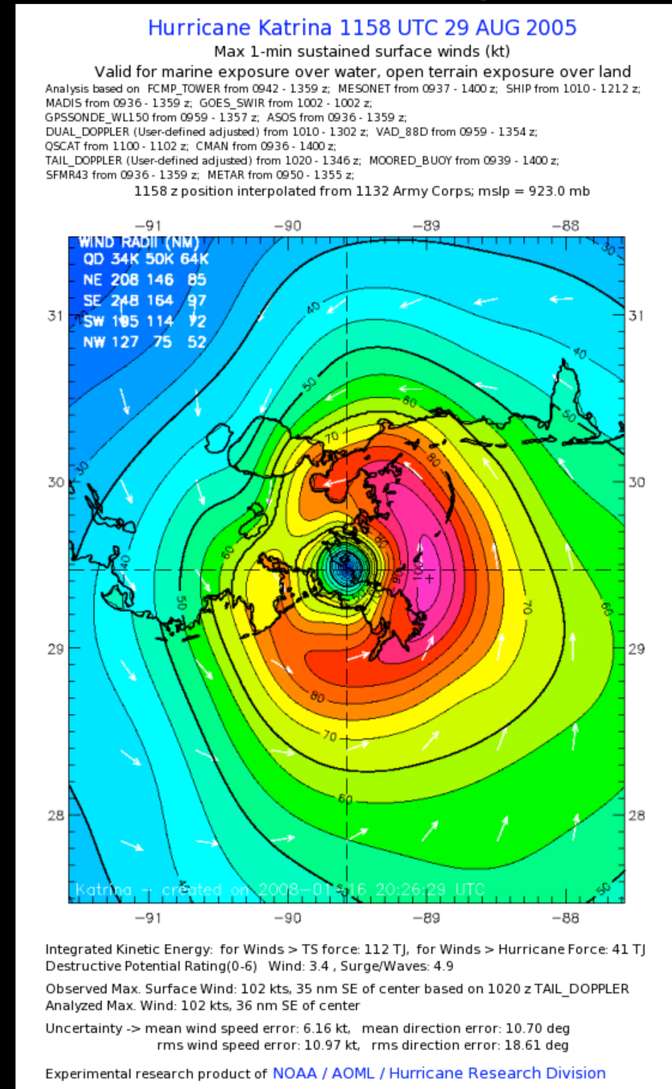
Camille Landfall 63 TJ



Katrina 28th 117 TJ

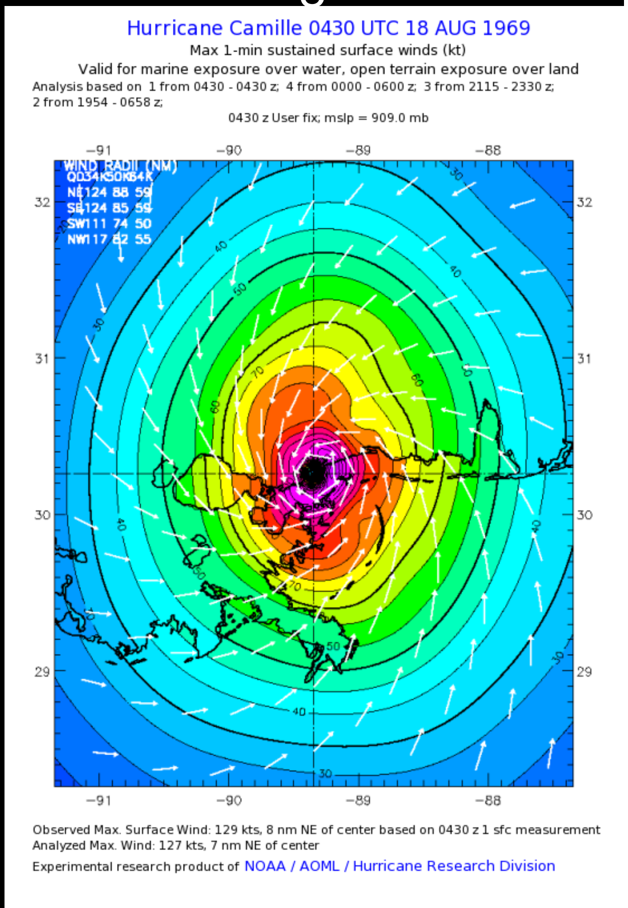


Katrina Landfall 112 TJ

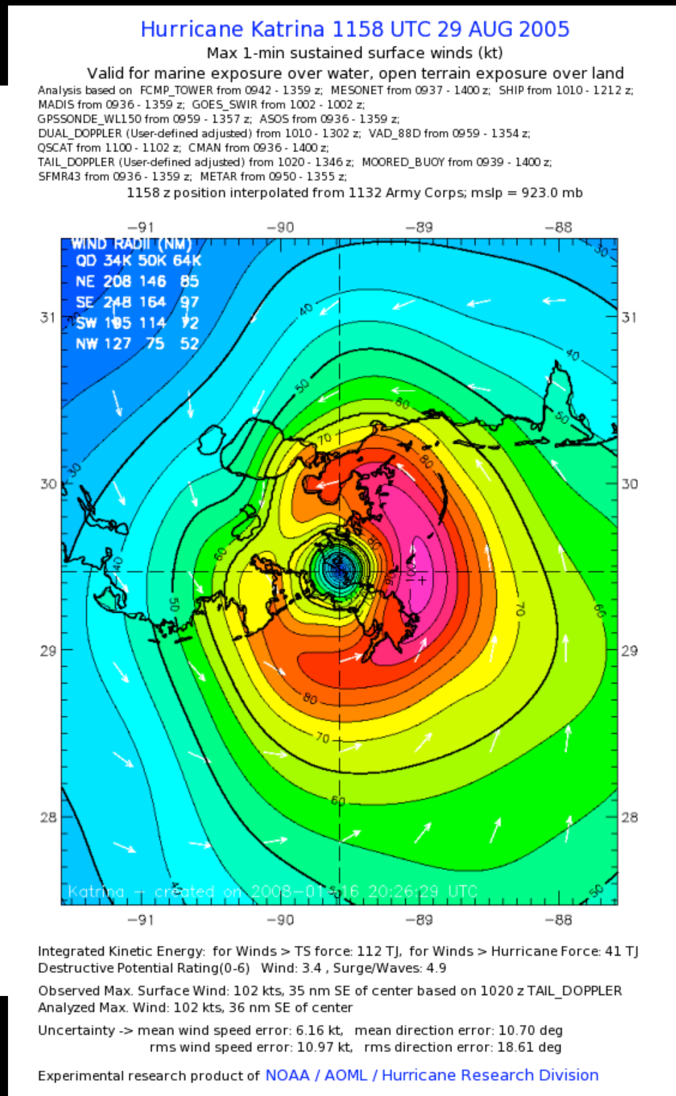


Integrated Kinetic Energy for winds > TS force in Terra Joules, SDP, SS

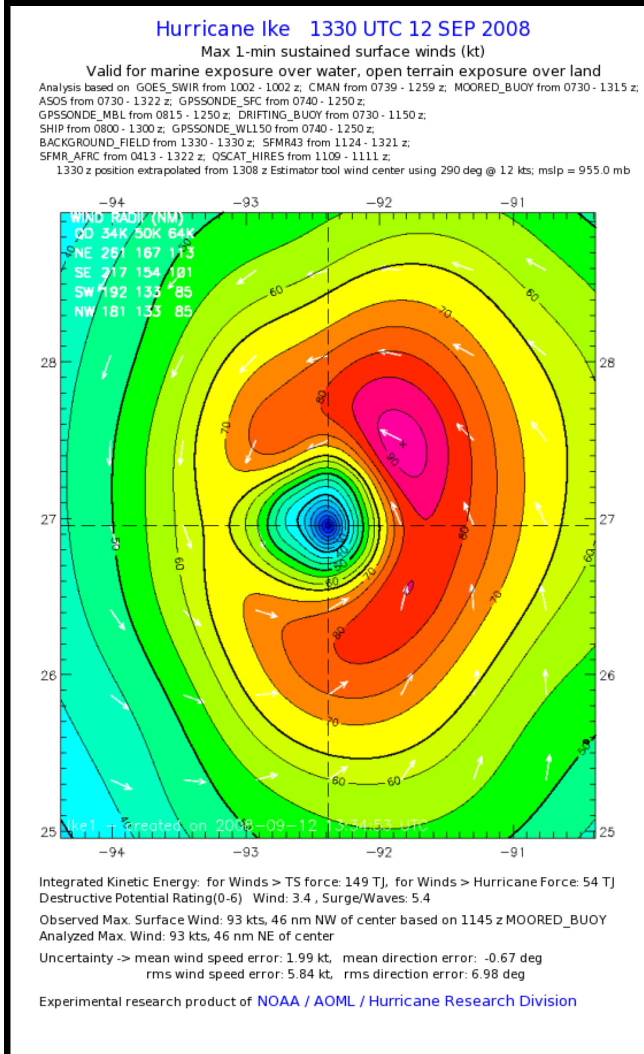
Camille Landfall
63 TJ SDP 4.1 SS 5



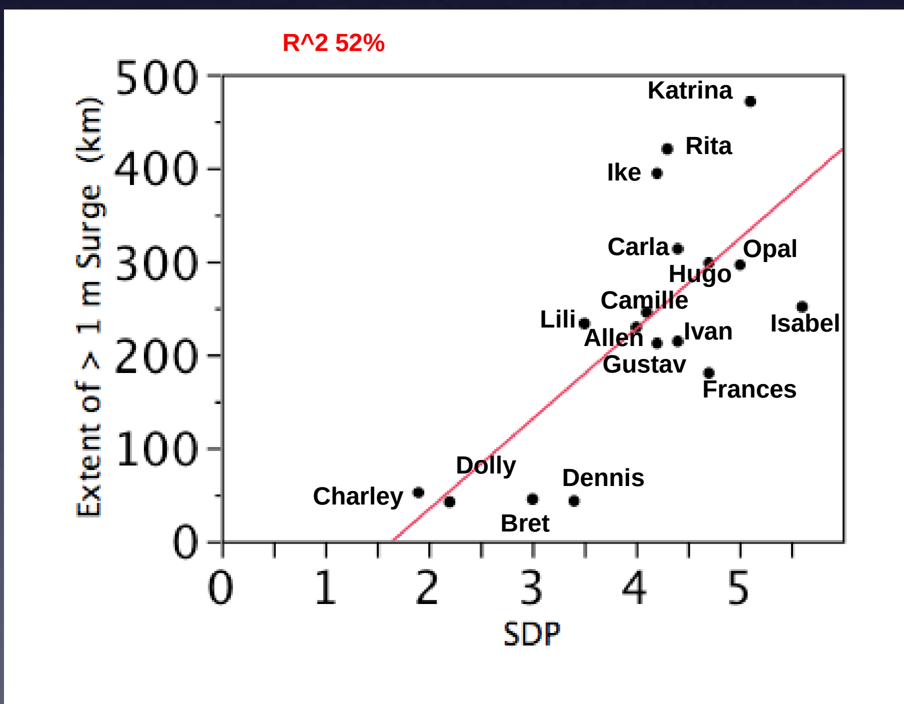
Katrina Landfall
112 TJ SDP 4.9 SS3

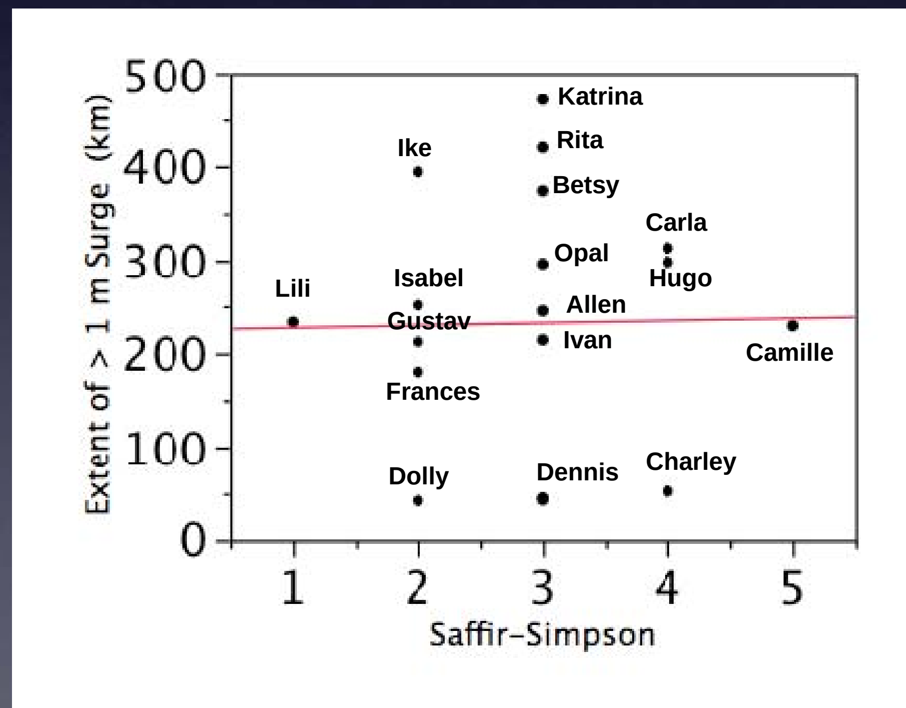


Ike day before Landfall
149 TJ SDP 5.4 SS 2



- SDP and SS comparison to Alongshore extent of >1 m surge inundation
  - *Irish and Resio 2009, in review, Ocean Engineering, using approach described in Irish and Resio, JPO 2008.*





- SDP is a means to compare storms based on oceanic wind field forcing alone

  - Correlates best with alongshore inundation relevant to evacuation and damage from surge and waves (r^2 of 52% for extent of surge >1 m (n=17 storms), 34% for > 2 m (n=14 storms)

  - Independent of bottom slope or coastline shape so correlation with peak surge height is smaller (r^2 of 10% compared to 8% for SS, 19 storms)

  - SDP can enhance the Saffir-Simpson scale for cases in which large wind fields supply ample forcing for surge and wave damage

  - SDP is relatively simple to compute, insensitive to the max wind value, with the same range as the SS scale

For more informaton see:
Bulletin of the American Meteorological Society
April 2007


TROPICAL CYCLONE DESTRUCTIVE POTENTIAL BY INTEGRATED KINETIC ENERGY

BY MARK D. POWELL AND TIMOTHY A. REINHOLD

The maximum sustained surface wind speed and the Saffir-Simpson scale are poor indicators of a hurricane's destructive potential; integrated kinetic energy is more relevant to damage by wind, storm surge, and waves.

The Hurricane Katrina disaster and recent studies examining hurrcanes and global climate change have generated discussion on tropical cyclone intensity and its relevance to destructive potential. Climate scientists are trying to determine whether hurricanes are becoming more frequent or destructive (e.g. Webster et al. 2005; Emanuel 2005), with resulting impacts on increasingly vulnerable coastal populations. People who lived in areas affected by Hurricane Katrina are wondering how a storm weaker than Hurricane Camille at landfall, could have contributed to so much more destruction. While intensity provides a measure to compare the maximum sustained surface winds (V_{MS}) of different storms, it is a poor measure ▶

H*Wind analysis of Hurricane Camille at landfall. See figure 1 on page 4 for more information.