A DETAILED OVERVIEW OF THE CME HURRICANE INDEX™ (CHI™)

The CME Hurricane Index™ (CHI™) was developed to provide a quick and easy-to-calculate estimate of hurricane damage. Losses may be caused by high winds that result in property damage, as well as by wind-driven coastal waters known as “storm surge” which can cause flooding and other water-related damage. Determining the dollar value of insured losses from a hurricane may take months – and sometimes years – as claims are filed by policy holders and payments are made to settle those claims.

By definition, a hurricane must have a maximum sustained 1-minute wind speed of at least 74 mph. Tropical cyclones with sustained wind speeds of 39 to 73 mph are referred to as “tropical storms” and those with sustained wind speeds less than 39 mph are called “tropical depressions.”

Popular measures of storm intensity such as the Saffir-Simpson Hurricane Scale (SSHS) are not highly correlated to hurricane damage. The SSHS, developed in 1969 by Herbert Saffir, a civil engineer on commission from the United Nations and Robert Simpson, the then-director of the National Hurricane Center, is used in the Atlantic and Northeast Pacific basins to estimate the potential for flooding and property damage, given a hurricane's intensity. Modeled after the Richter scale for earthquakes, the SSHS ranges from one to five, based on a combination of wind speed (used as a measure of damage to structures) and storm surge (used as a measure of flooding).

Safford-Simpson Hurricane Scale (SSHS)	Maximum Sustained 1-Minute Wind Speed (in mph)	Storm Surge (in feet)	Damage Description
Category 1	74 to 95	4 to 5	Minimal
Category 2	96 to 110	6 to 8	Moderate
Category 3	111 to 130	9 to 12	Extensive
Category 4	131 to 155	13 to 18	Extreme
Category 5	Over 155	Over 19	Catastrophic

Despite its popularity and frequent use by the news media, the SSHS contains a number of inherent design flaws that limit its usefulness as a measurement tool. First, the SSHS is limited to five categories, with no allowance for sub-categories or smaller increments to provide more granular measurements. As a result, a storm with a wind speed of 110 mph is classified as a Category 2 storm, while a storm with a wind speed of 111 mph is classified as a Category 3. While meteorologists may qualify such storms as a “strong Category 2” or a “weak Category 3,” respectively, the practical application of the SSHS is severely limited by its discrete, rather than continuous, nature. In contrast, the Richter scale for earthquakes, which provided the inspiration for the SSHS, is measured on a continuous scale.

A second, related shortcoming of SSHS is that all storms with wind speeds over 155 miles per hour are classified as Category 5 hurricanes. While damage from winds at this level would certainly be catastrophic, wind speeds have been measured far in excess of 155 mph. For example, Hurricane Camille in 1969 had sustained winds of 190 mph at landfall with gusts up to 213 mph, and several other hurricanes since that time have approached those levels.

A third issue with SSHS is that it does not consider the size, or diameter, of the storm. Size can vary considerably, and larger storms with a wider area have the potential to create greater damage, all else being the same.

To address these shortcomings, the CME Hurricane Index was developed by Dr. Steve Smith of Willis Re, building on recent work by Lakshmi Kantha at the Department of Aerospace Sciences at the University of Colorado at Boulder. Kantha's Hurricane Intensity Index and Hurricane Surge Index were combined into a single equation:

$$CHI = (V/V_0)^3 + (3/2)(R/R_0)(V/V_0)^2$$

where: V = maximum sustained 1-minute wind speed (in mph), and V is at least 74 mph
V_0 = 74 mph
R = radius of hurricane-force winds (in statute miles)
R_0 = 60 miles

Values for V and R are obtained from National Hurricane Center (NHC) Public Advisories, available at:

http://www.nhc.noaa.gov/archive/2011/index.shtml

Public Advisories are typically issued at intervals of three hours or less until a storm moves inland or dissipates. The text of NHC Public Advisory 48B for Hurricane Ike, just prior to landfall on September 13, 2008, is shown below.

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TTAA00 KNHC DDHHMM
BULLETIN
HURRICANE IKE INTERMEDIATE ADVISORY NUMBER  48B
NWS TPC/NATIONAL HURRICANE CENTER MIAMI FL   AL092008
200 AM CDT SAT SEP 13 2008

...EYE OF IKE MOVING ONTO THE TEXAS COAST NEAR GALVESTON....LANDFALL
EXPECTED IN THE NEXT HOUR OR TWO...

A HURRICANE WARNING REMAINS IN EFFECT FROM MORGAN CITY LOUISIANA TO
NORTH OF PORT ARANSAS TEXAS. HURRICANE CONDITIONS ARE EXPECTED TO
REACH THE COAST IN THE WARNING AREA LATER TODAY.

AT 2 AM CDT...0700 UTC...THE TROPICAL STORM WARNING IS DISCONTINUED
FROM PORT ARANSAS SOUTHWARD.  A TROPICAL STORM WARNING REMAINS IN
EFFECT FROM EAST OF MORGAN CITY TO THE MISSISSIPPI-ALABAMA
BORDER...INCLUDING THE CITY OF NEW ORLEANS AND LAKE PONTCHARTRAIN.

FOR STORM INFORMATION SPECIFIC TO YOUR AREA...INCLUDING POSSIBLE
INLAND WATCHES AND WARNINGS...PLEASE MONITOR PRODUCTS ISSUED
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BY YOUR LOCAL WEATHER OFFICE.

AT 200 AM CDT...0700Z...THE CENTER OF HURRICANE IKE WAS LOCATED NEAR LATITUDE 29.2 NORTH...LONGITUDE 94.7 WEST OR ABOUT 10 MILES... 15 KM...SOUTHEAST OF GALVESTON TEXAS AND ABOUT 60 MILES...100 KM...SOUTHWEST OF PORT ARTHUR TEXAS.

IKE IS MOVING TOWARD THE NORTHWEST NEAR 10 MPH...16 KM/HR. A NORTHWEST TO NORTH-NORTHWESTWARD MOTION IS FORECAST TO CONTINUE THIS MORNING...WITH A TURN TOWARD THE NORTH EXPECTED SATURDAY AFTERNOON. THE CENTER OF IKE SHOULD CROSS THE TEXAS COAST NEAR GALVESTON IN THE NEXT HOUR OR TWO...THEN MOVE OVER SOUTHEASTERN TEXAS THE REMAINDER OF SATURDAY MORNING.

DATA FROM NOAA DOPPLER WEATHER RADARS AND RECONNAISSANCE AIRCRAFT INDICATE MAXIMUM SUSTAINED WINDS REMAIN NEAR 110 MPH...175 KM/HR... WITH HIGHER GUSTS. IKE IS A STRONG CATEGORY TWO HURRICANE ON THE SAFFIR-SIMPSON SCALE AND COULD REACH THE TEXAS COAST AS A CATEGORY THREE...MAJOR HURRICANE...AT THE TIME OF LANDFALL. STRONGER WINDS...AS MUCH AS 30 MPH HIGHER THAN AT THE SURFACE...COULD OCCUR ON HIGH RISE BUILDINGS.

IKE REMAINS A VERY LARGE HURRICANE AND HURRICANE FORCE WINDS EXTEND OUTWARD UP TO 120 MILES...195 KM...FROM THE CENTER...AND TROPICAL STORM FORCE WINDS EXTEND OUTWARD UP TO 275 MILES...445 KM. HURRICANE CONDITIONS ARE OCCURRING ON THE TEXAS COAST BETWEEN FREEPORT AND SABINE PASS. THE NOAA AUTOMATED STATION AT SEA RIM STATE PARK TEXAS RECENTLY REPORTED 10-MINUTE AVERAGE WINDS OF 76 MPH...122 KM/HR...AND A WIND GUST OF 99 MPH...159 KM/HR.

THE MINIMUM CENTRAL PRESSURE JUST REPORTED BY AN AIR FORCE RESERVE HURRICANE HUNTER AIRCRAFT IS 953 MB...28.14 INCHES.

COASTAL STORM SURGE FLOODING OF UP TO 20 FEET...WITH NEAR 25 FEET IN SOME AREAS...ABOVE NORMAL TIDES ALONG WITH LARGE AND DANGEROUS BATTERING WAVES...CAN BE EXPECTED NEAR AND TO THE EAST OF WHERE THE CENTER OF IKE MAKES LANDFALL. THE SURGE EXTENDS A GREATER THAN USUAL DISTANCE FROM THE CENTER DUE TO THE LARGE SIZE OF THE CYCLONE. WATER LEVELS HAVE ALREADY INCREASED TO 9 TO 12 FEET ABOVE NORMAL TIDE LEVELS ALONG MUCH OF THE NORTHWESTERN GULF COAST.

DO NOT VENTURE OUTSIDE IN THE EYE. THE STRONGEST WINDS AND HIGHEST SURGE WILL LIKELY OCCUR NEAR OR JUST AFTER THE EYE MAKES LANDFALL.

IKE IS EXPECTED TO PRODUCE RAINFALL AMOUNTS OF 5 TO 10 INCHES OVER EASTERN TEXAS AND EXTREME SOUTHWESTERN LOUISIANA...WITH ISOLATED AMOUNTS OF 15 INCHES POSSIBLE.

ISOLATED TORNADOES ARE POSSIBLE TODAY OVER PORTIONS OF EASTERN AND SOUTHEASTERN TEXAS...AND SOUTHERN AND WESTERN LOUISIANA.

REPEATING THE 200 AM CDT POSITION...29.2 N...94.7 W. MOVEMENT TOWARD...NORTHWEST NEAR 10 MPH. MAXIMUM SUSTAINED WINDS...110 MPH. MINIMUM CENTRAL PRESSURE...953 MB.

THE NEXT ADVISORY WILL BE ISSUED BY THE NATIONAL HURRICANE CENTER AT 400 AM CDT.

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FORECASTER BEVEN/RHOME

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From this Public Advisory, "…maximum sustained winds remain near 110 mph…" (Paragraph 7) and "…hurricane force winds extend outward up to 120 miles…" (Paragraph 8). Therefore, the CHI value for Hurricane Ike, using the data from NHC Public Advisory 48B, is:

$$\text{CHI} = (110/74)^3 + (3/2)(120/60)(110/74)^2$$

$$= 3.2846 + (1.5)(2.0)(2.2096)$$

$$= 3.2846 + 6.6289$$

$$= 9.9135$$

$$= 9.9 \text{ (rounding to 1 decimal place)}$$

The CHI values for all landfalling hurricanes from 1998 through 2010 are summarized in the following table:

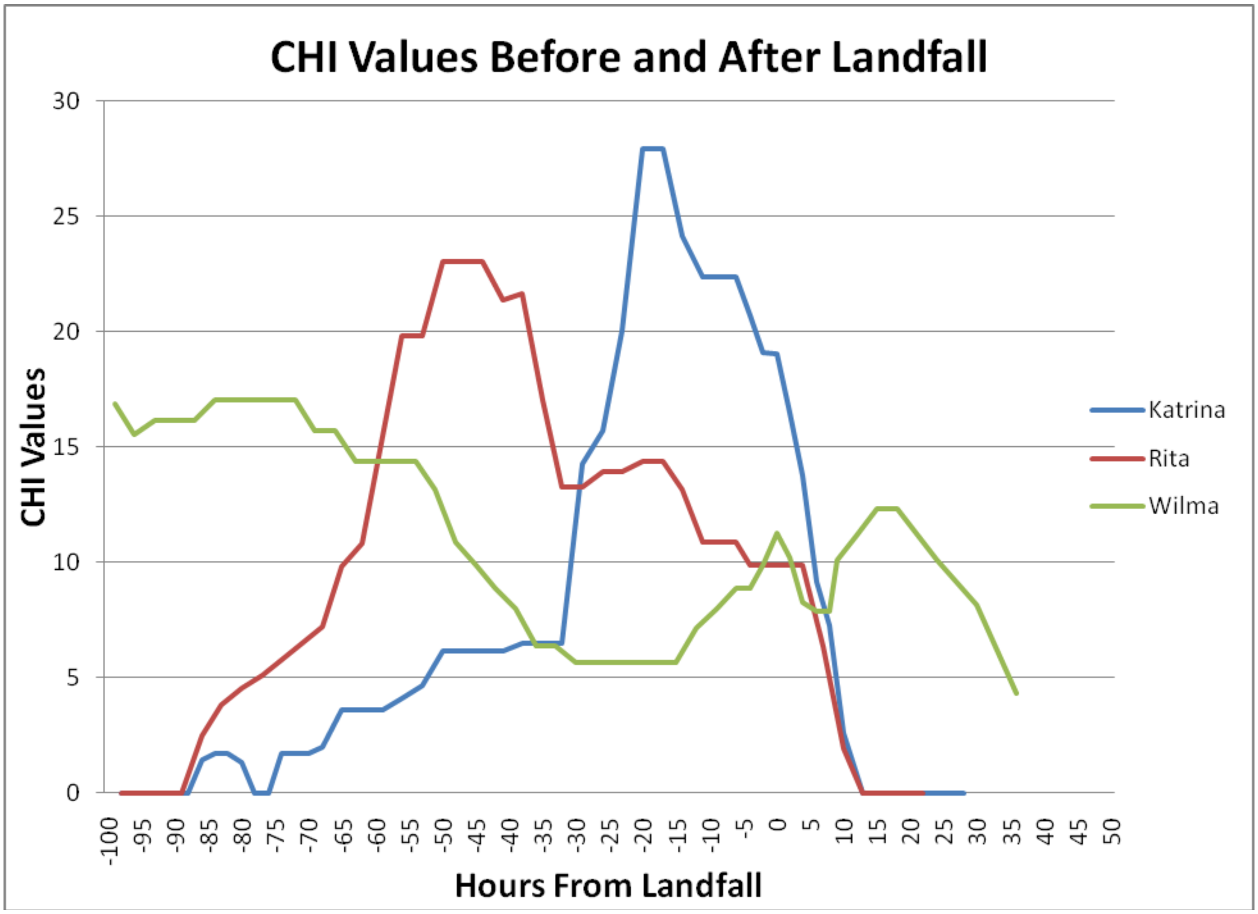
Name	**Year**	**Landfall**	**NHC Advisory Number**	**V (in mph)**	**R (in statue miles)**	**Saffir-Simpson Category**	**CHI Value**
Bonnie	1998	North Carolina	31B	115	115	3	10.7
Earl	1998	Florida	11	80	115	1	4.6
Georges	1998	Mississippi	51B	105	45	2	5.1
Bret	1999	Texas	17	140	40	4	10.4
Floyd	1999	North Carolina	34A	110	115	2	9.6
Irene	1999	Florida	9	75	30	1	1.8
Lili	2002	Louisiana	48A	100	60	2	5.2
Claudette	2003	Texas	27A	75	30	1	1.8
Isabel	2003	North Carolina	49A	100	115	2	7.7
Charley	2004	Florida	18	145	30	4	10.4
Frances	2004	Florida	44A	105	75	2	6.6
Ivan	2004	Florida	55B	130	105	3	13.5
Jeanne	2004	Florida	49B	115	70	3	8.0
Dennis	2005	Florida	25B	120	40	3	6.9
Katrina	2005	Florida	9	75	15	1	1.4
Katrina	2005	Louisiana	26A	145	120	4	19.0

Rita	2005	Texas/ Louisiana	26B	120	85	3	9.9
Wilma	2005	Florida	36	125	90	3	11.2
Humberto	2007	Texas	4	80	15	1	1.7
Ike	2008	Texas	48B	110	120	2	9.9

Notice that Katrina in 2005 made landfall twice: once in Florida, and once again in Louisiana.

Using 20 years of historical data, the CHI immediately preceding landfall and industry insured losses adjusted to 2005 constant dollars using the Consumer Price Index (CPI) had a correlation of 0.72. In contrast, the correlation between insured losses and the SSHS was just 0.54.

Because a CHI value can be calculated each time a NHC Public Advisory is issued, the CHI is highly responsive to changing conditions, and can be used to monitor a storm's damage potential prior to and immediately following landfall. To demonstrate this point, recall that the Gulf Coast experienced three major hurricanes in the 2005 season: Katrina, Rita and Wilma.



Several points should be emphasized. First, CHI values for an individual storm vary widely as the result of changing wind speeds and radius of hurricane-force winds. Second, the pattern of CHI values over time varies widely for different storms. Third, using CHI as a proxy for damage potential, Katrina's destructive power was far greater than Rita's or Wilma's, due to Katrina's combination of high winds and large size.

This high level of detail and responsiveness, plus the ability to update frequently using publicly-available data, make the CHI an ideal choice as the basis for the suite of hurricane futures, options, and binary contracts traded at CME.