Attribution of Extreme Events

Gabriel Vecchii
NOAA/GFDL
Princeton, NJ

Gabriel.A.Vecchi@noaa.gov
Attribution of global and regional surface average temperature change

“Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations.”

*very likely = 90-95% certainty

IPCC-AR4 (2007)
Katrina's real name

By Ross Gelbspan | August 30, 2005

THE HURRICANE that struck Louisiana yesterday was nicknamed Katrina by the National Weather Service. Its real name is global warming.
Nov. 29, 2005 — The nation is now wrapping up the 11th year of a new era of heightened Atlantic hurricane activity. This era has been unfolding in the Atlantic since 1995, and is expected to continue for the next decade or perhaps longer. NOAA attributes this increased activity to natural occurring cycles in tropical climate patterns near the equator. These cycles, called “the tropical multi-decadal signal,” typically last several decades (20 to 30 years or even longer). As a result, the North Atlantic experiences alternating decades long (20 to 30 year periods or even longer) of above normal or below normal hurricane seasons. NOAA research shows that the tropical multi-decadal signal is causing the increased Atlantic hurricane activity since 1995, and is not related to greenhouse warming. (Click NOAA

Research by NOAA scientists [..] and [..], currently in press with the Journal of Climate, describes the tropical multi-decadal signal and shows that it accounts for the entire inter-related set of conditions that controls hurricane activity for decades at a time.)
Extreme events as rolling dice

Two fair, six-sided dice.

What is average roll?
What are odds of:

Roll $\leq 3$?

Roll $\geq 12$?
Extreme events as rolling dice

What are odds of:
Roll $\leq 3$?
Roll $\geq 12$?

Two fair, six-sided dice.

What is average roll? 7
Extreme events as rolling dice

Two fair, six-sided dice.

What is average roll? 7

What are odds of:

Roll $\leq 3$? $\frac{3}{36}$  
Roll $\geq 12$? $\frac{1}{36}$
Extreme events as rolling dice

What are odds of:

Roll \leq 3?

Roll \geq 12?

What is average roll?

Add a dot to every side of one die.
Extreme events as rolling dice

What is average roll? 8
What are odds of:  (+1 or +14%)
Roll \leq 3?  Add a dot to every side of one die.
Roll \geq 12?
Extreme events as rolling dice

What are odds of:
- Roll \( \leq 3 \)?: \( \frac{1}{36} \)
- Roll \( \geq 12 \)?: \( \frac{3}{36} \)

What is average roll?
- \( \frac{1}{3} \) as likely or 66% less
- 3x likelier or 200% more

Add a dot to every side of one die.
Changing the mean climate can change the odds of extremes.

IPCC(2007)
Observed temperature extremes moving towards warm: fewer cold nights, more warm nights


Figure 2. Trends (in days per decade, shown as maps) and annual time series anomalies relative to 1961–1990 mean values (shown as plots) for annual series of percentile temperature indices for 1951–2003 for (a) cold nights (TN10p), (b) warm nights (TN90p), (c) cold days (TX10p), and (d) warm days (TX90p). Trends were calculated only for the grid boxes with sufficient data (at least 40 years of data during the period and the last year of the series is no earlier than 1999). Black lines enclose regions where trends are significant at the 5% level. The red curves on the plots are nonlinear trend estimates obtained by smoothing using a 21-term binomial filter.

D05109
ALEXANDER ET AL.: GLOBAL EXTREME INDICES
7 of 22

D05109

But, if you roll “boxcars”:
can you tell which set of dice you rolled?

Even if we knew it was a modified pair of dice
(e.g., roll 13), do we know:
When they were switched?
Who switched them?
2010 Russian heat wave was extreme but not completely impossible event, by some estimates. So: Can we attribute to AGW? Can we exclude AGW?

Dole et al. (2011, Geophys. Res. Lett.)
Extreme events as rolling dice

Climate doesn't just have six-sided dice, and we could be changing their shape.
Historically, Tropical Cyclones Form Over Warm Water

But warm water not enough, e.g. cyclones “like” an environment without strong wind shear to disrupt them, a moist mid-troposphere and a cool upper atmosphere.
One Temperature Predictor of Atlantic Hurricane Activity

Observed Activity
Absolute Atlantic Temperature

Vecchi, Swanson and Soden (2008, Science)
One Temperature Predictor of Atlantic Hurricane Activity

Vecchi, Swanson and Soden (2008, Science)
Two Temperature Predictors of Atlantic Hurricane Activity

Observed Activity
Absolute Atlantic Temperature

Observed Activity
Relative Atlantic Temperature

Vecchi, Swanson and Soden (2008, Science)
Two Statistical Projections of Atlantic Hurricane Activity

Observed Activity

Absolute Atlantic Temperature

Observed Activity

Relative Atlantic Temperature

Vecchi, Swanson and Soden (2008, Science)
...Add Dynamical Projections of Atlantic Hurricane Activity

Vecchi, Swanson and Soden (2008, Science)
Summary

• Observations, models and physical understanding allow attribution of global and continental temperature changes.

• Extreme temperature events (also precipitation) can be expected to change as planet warms: more warm extremes, fewer cold ones.

• For other extreme events (e.g., hurricanes) the expected influence of warming more uncertain.

• For single events, attribution is problematic:
  - Cannot attributed uniquely to AGW (fraction of risk maybe)
  - Cannot completely exclude AGW.

• We don’t confidently know odds of rare events even w/o AGW.