

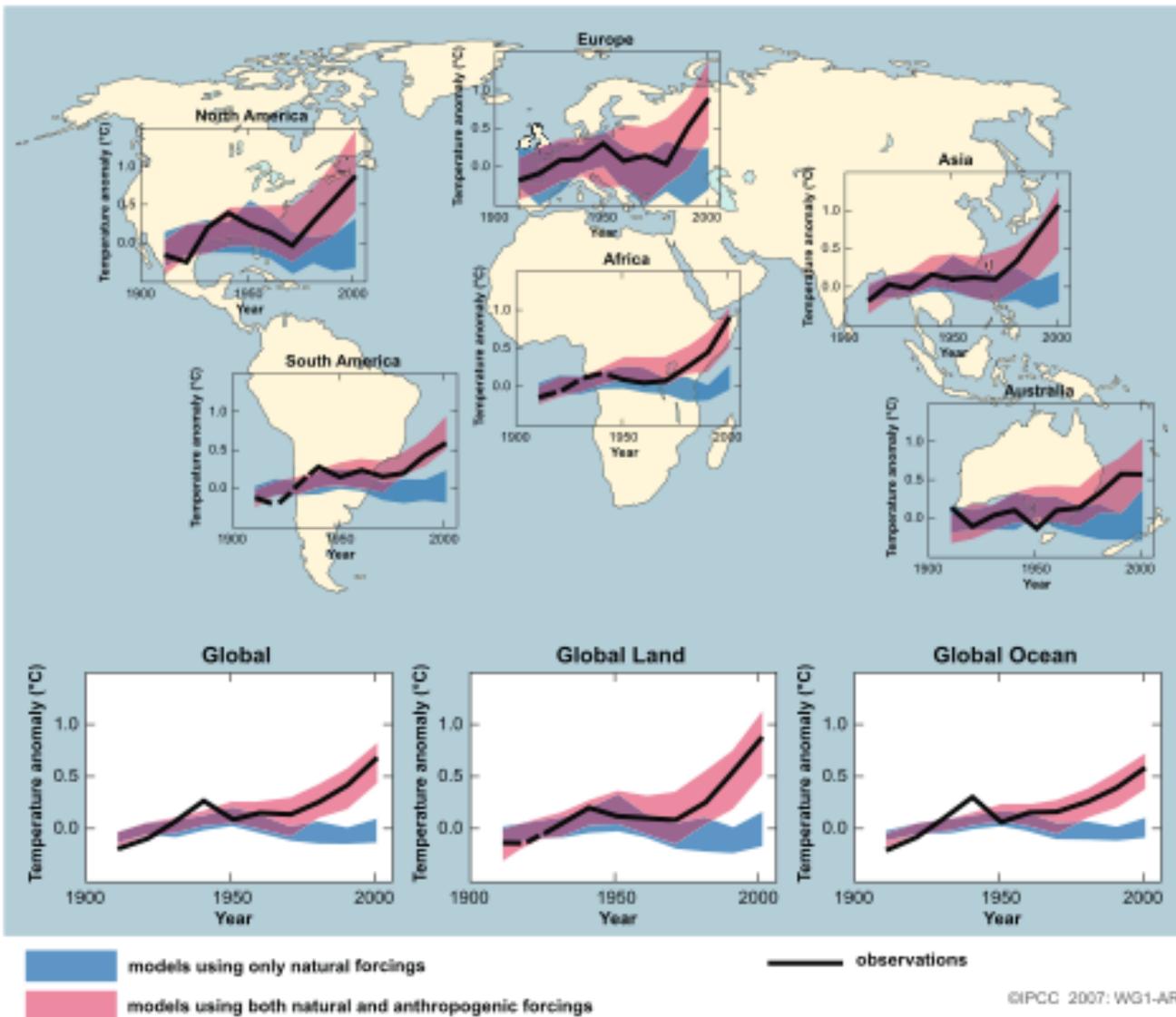


Attribution of Extreme Events

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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)



ROSS GELBSPAN

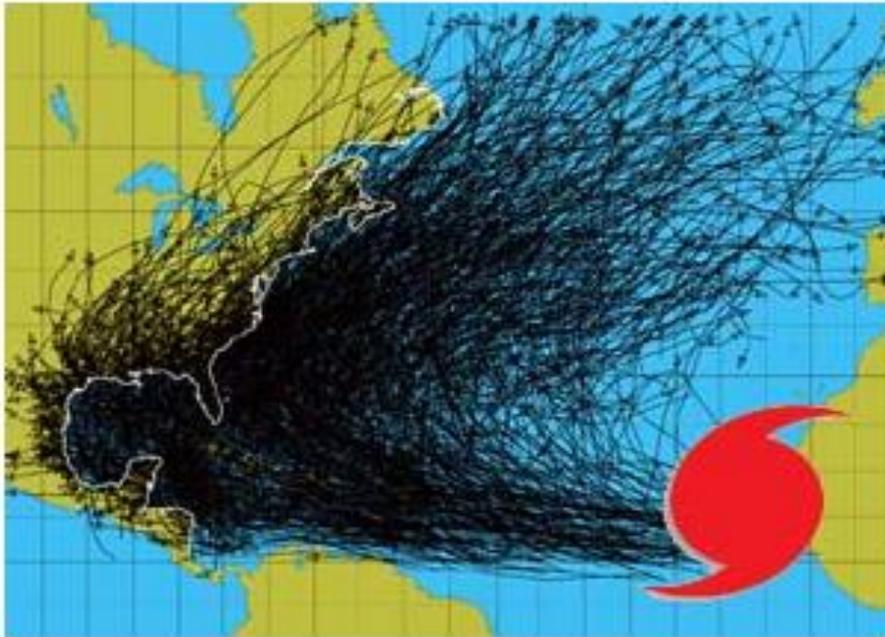
The Boston Globe

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.

NOAA ATTRIBUTES RECENT INCREASE IN HURRICANE ACTIVITY TO NATURALLY OCCURRING MULTI-DECADAL CLIMATE VARIABILITY *

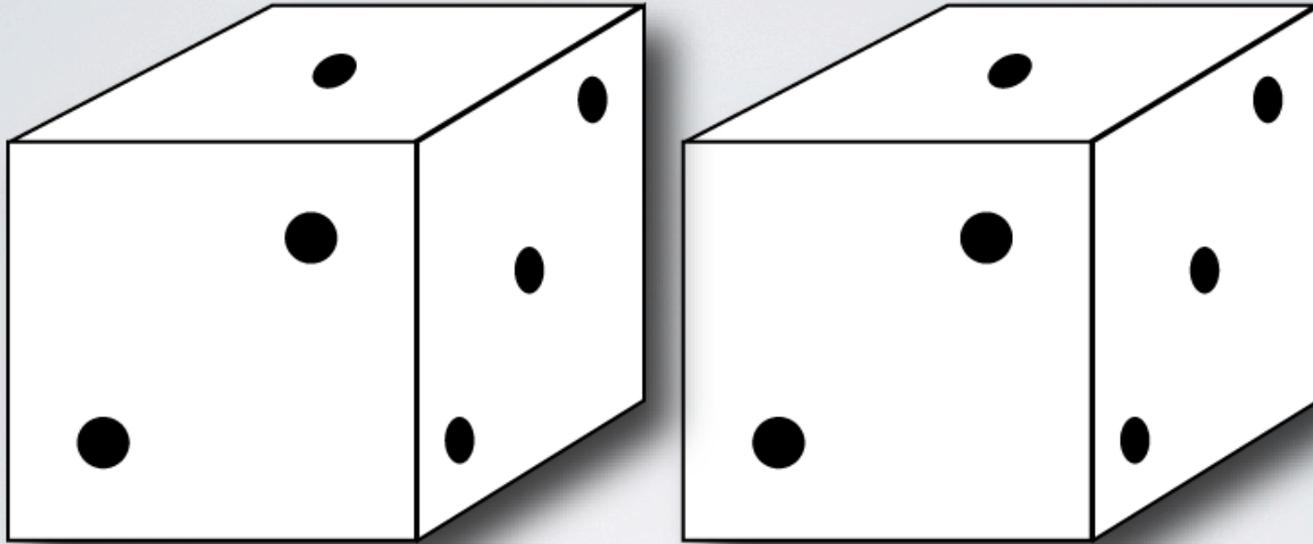


Nov. 29, 2005 — The nation is now wrapping up the 11th year of a new era of heightened [Atlantic hurricane activity](#). This era has been unfolding in the Atlantic since 1995, and is expected to continue for the next decade or perhaps longer. [NOAA](#) attributes this increased activity to natural occurring 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.

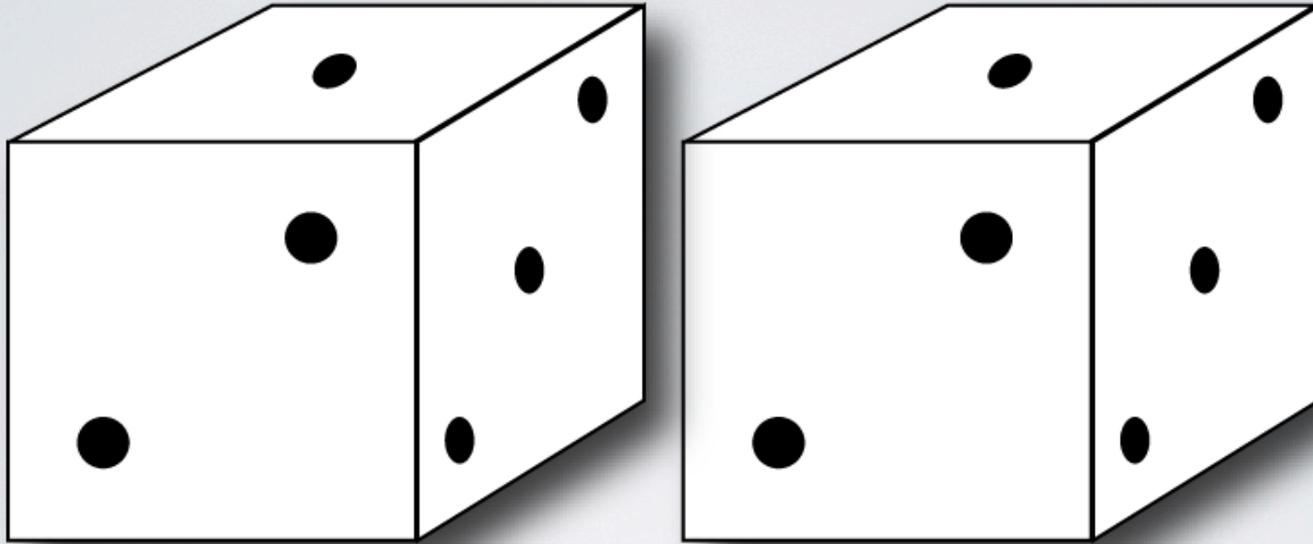
What is average roll?

What are odds of:

Roll ≤ 3 ?

Roll ≥ 12 ?

Extreme events as rolling dice



Two fair, six-sided dice.

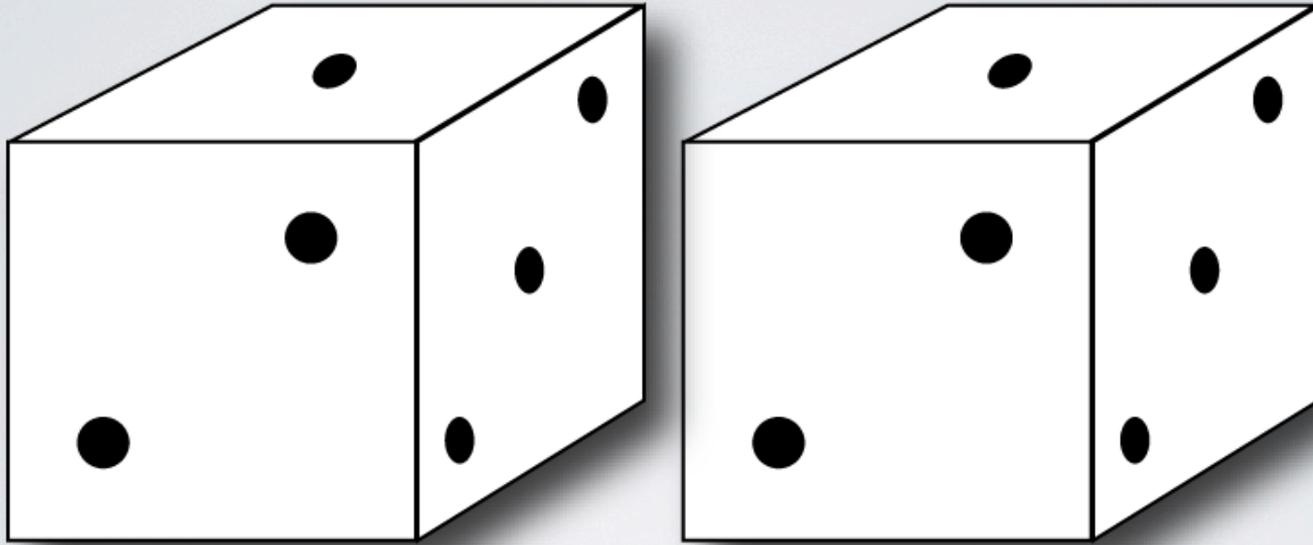
What is average roll? **7**

What are odds of:

Roll ≤ 3 ?

Roll ≥ 12 ?

Extreme events as rolling dice



Two fair, six-sided dice.

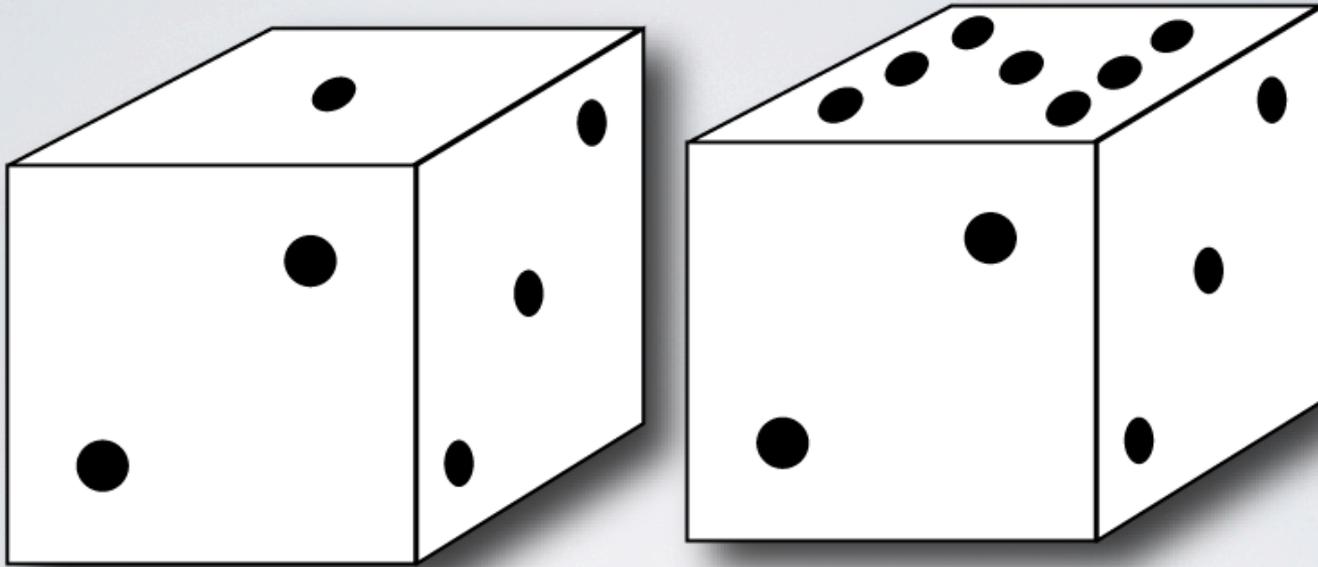
What is average roll? **7**

What are odds of:

Roll ≤ 3 ? **3/36**

Roll ≥ 12 ? **1/36**

Extreme events as rolling dice



What is average roll?

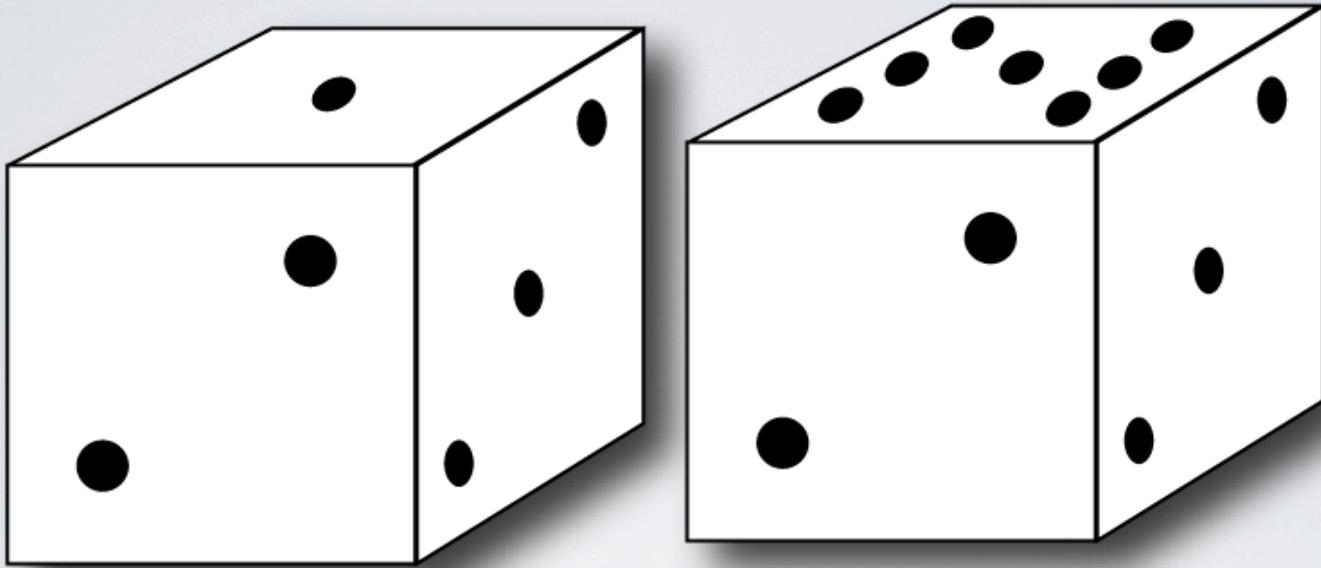
What are odds of:

Roll ≤ 3 ?

Add a dot to every side of one die.

Roll ≥ 12 ?

Extreme events as rolling dice



What is average roll?

8

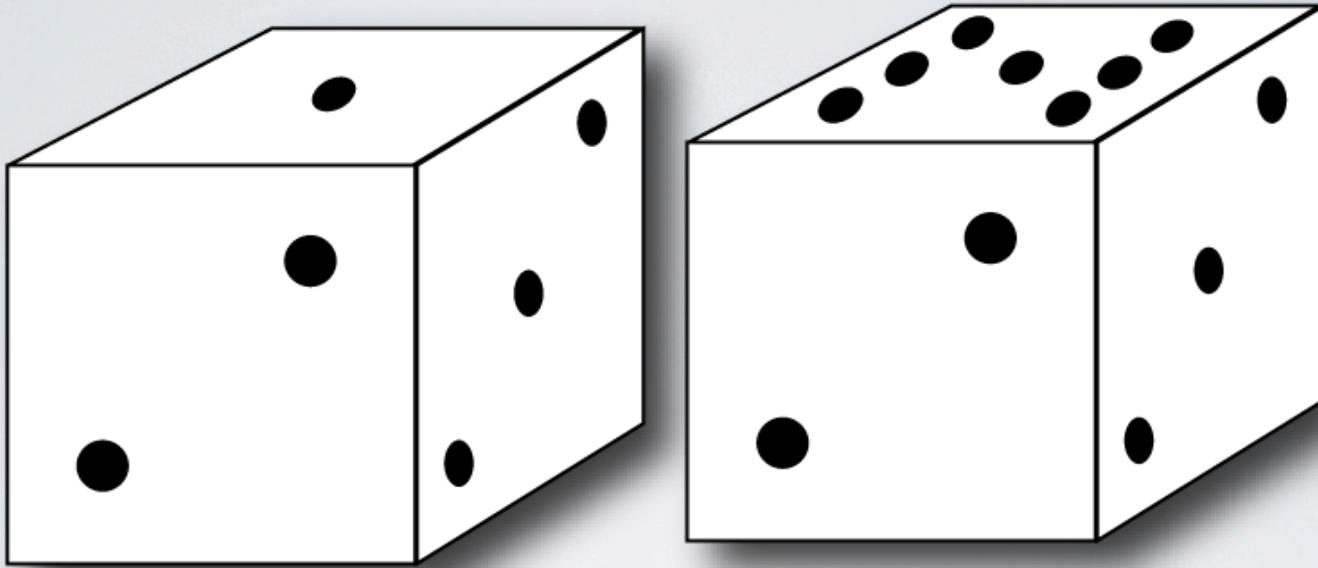
Add a dot to every side of one die.

What are odds of: (+1 or +14%)

Roll ≤ 3 ?

Roll ≥ 12 ?

Extreme events as rolling dice



What is average roll?

8

Add a dot to every side of one die.

What are odds of: **(+1 or +14%)**

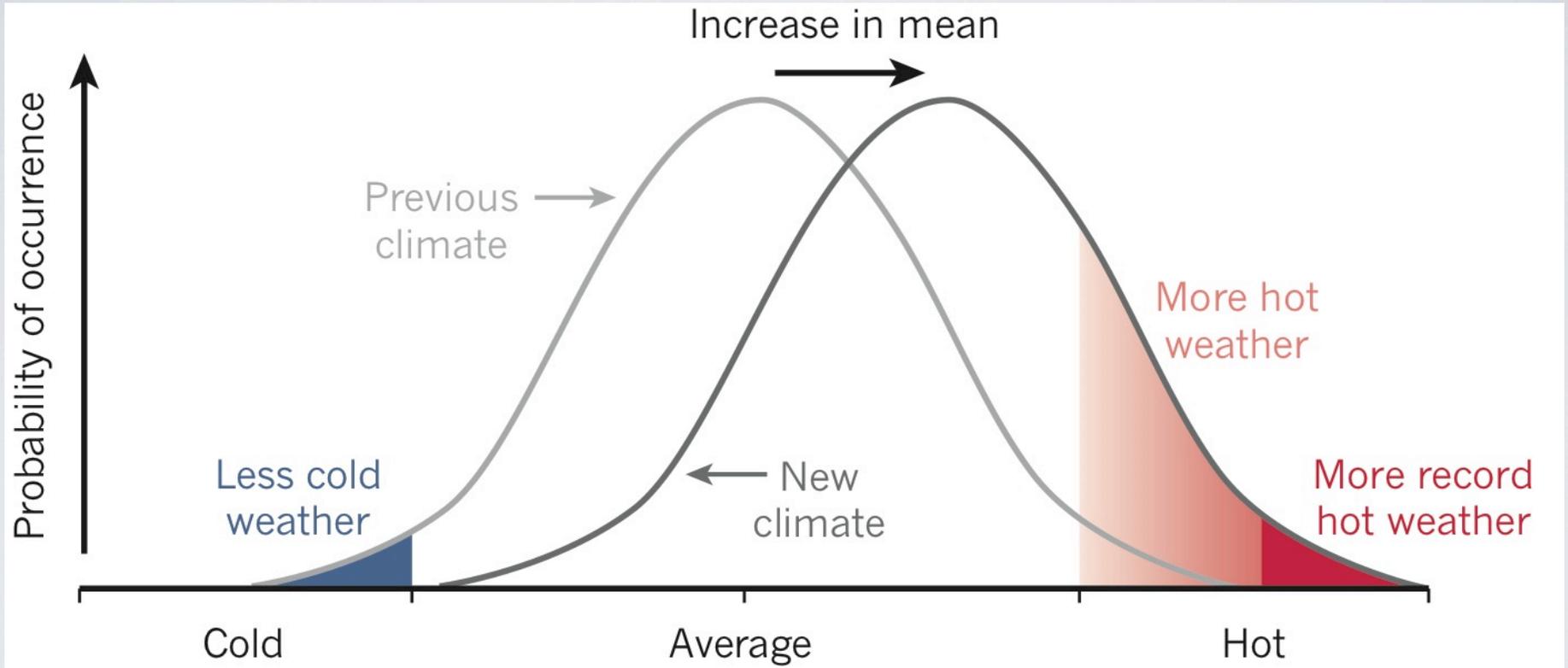
Roll ≤ 3 ? **1/36**

Roll ≥ 12 ? **3/36**

1/3 as likely or 66% less

3x likelier or 200% more

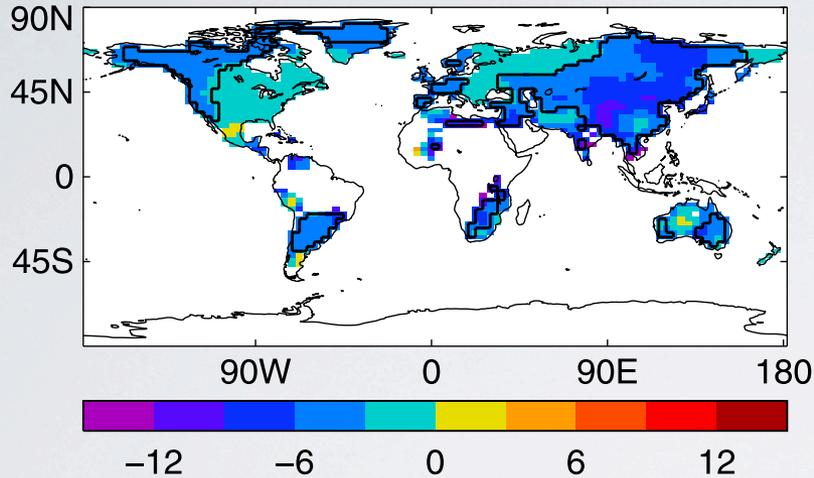
Changing the mean climate can change the odds of extremes



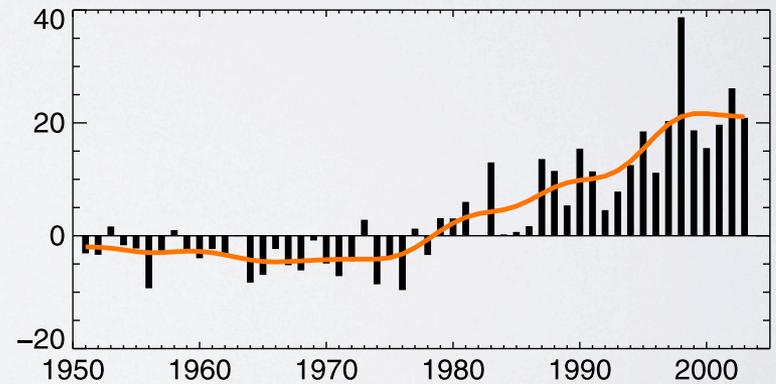
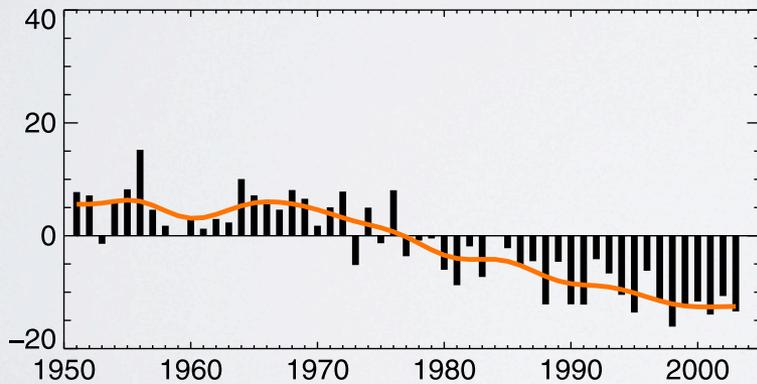
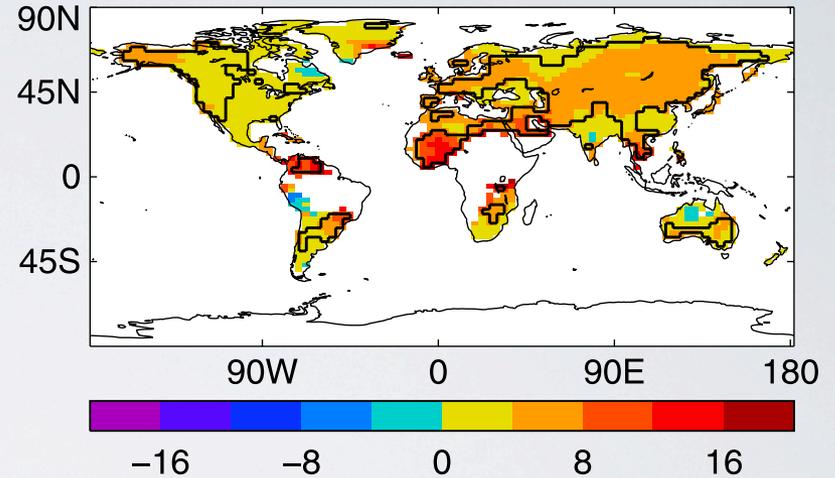
IPCC(2007)

Observed temperature extremes moving towards warm: fewer cold nights, more warm nights

(a) Cold nights

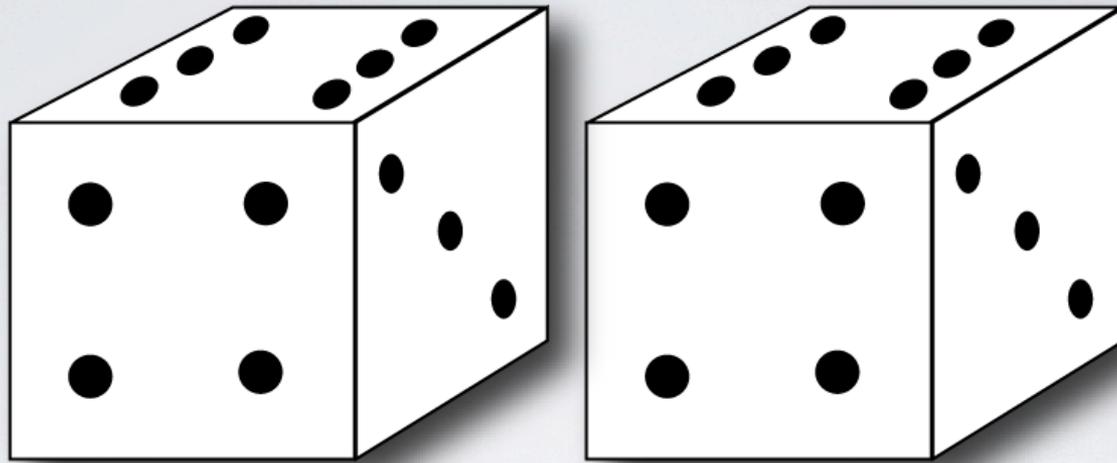


(b) Warm nights



Alexander et al. (2006, J. Geophys. Res.)

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



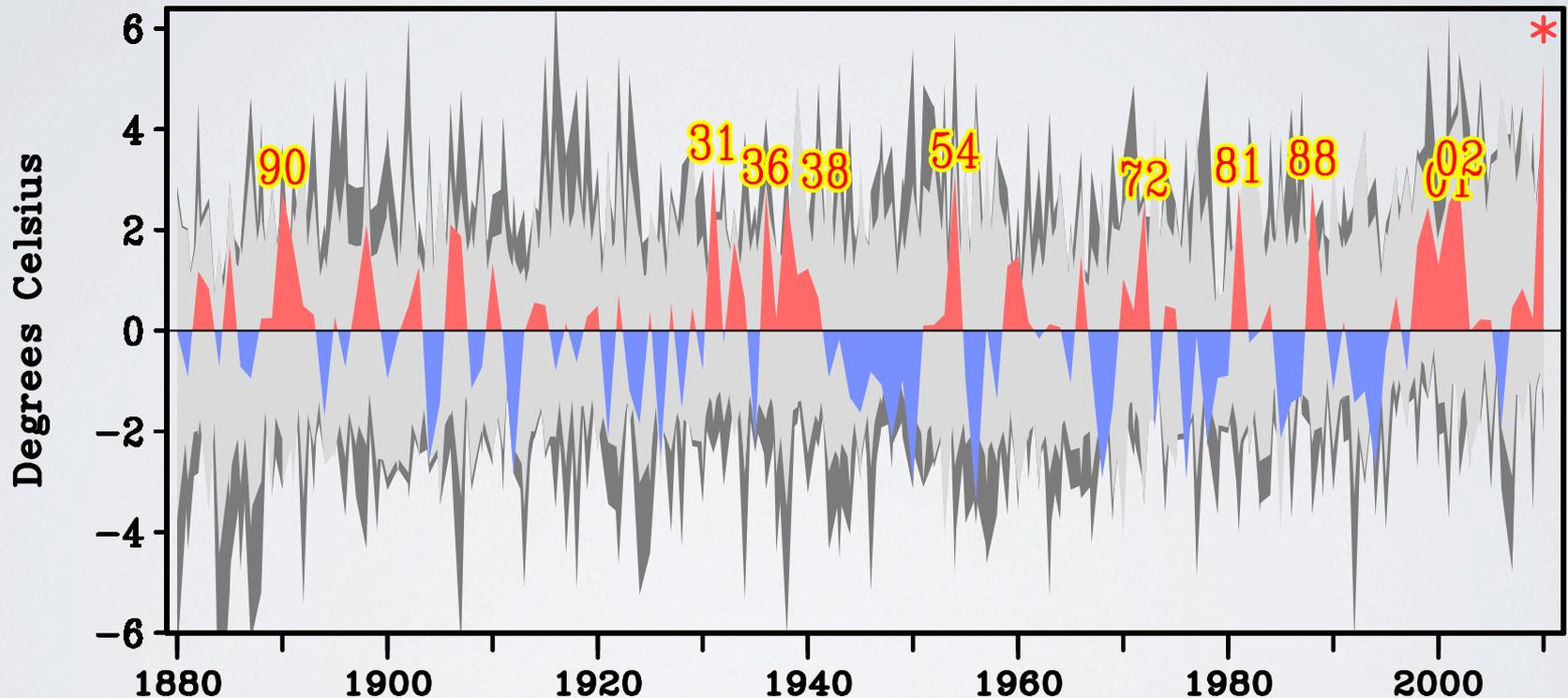
Even if we knew it was a modified pair of dice
(e.g., roll 13), do we know:

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?

Western Russia July Surface Temperature



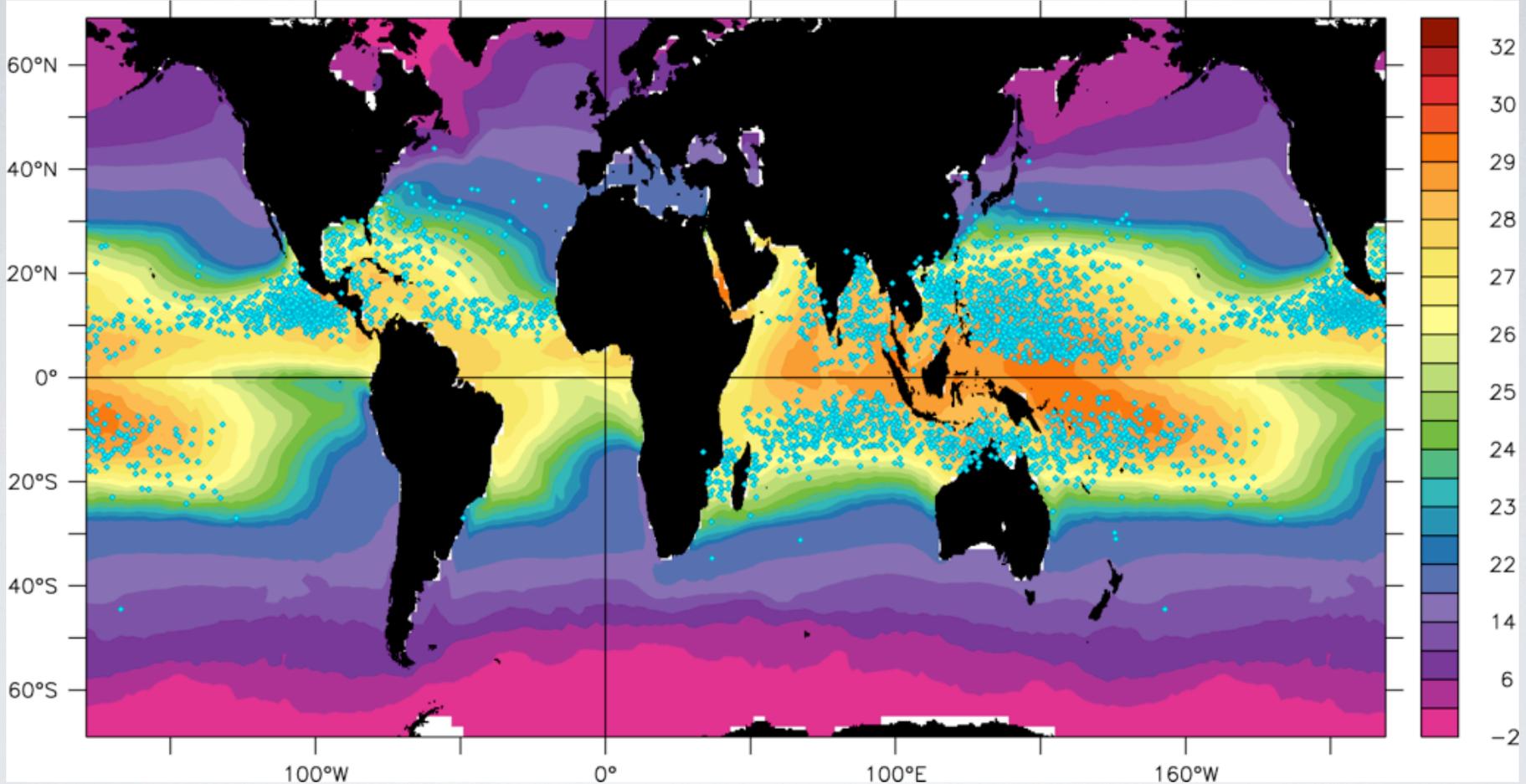
Dole et al. (2011, Geophys. Res. Lett.)

Extreme events as rolling dice



Climate doesn't just have six-sided dice,
and we could be changing their shape.

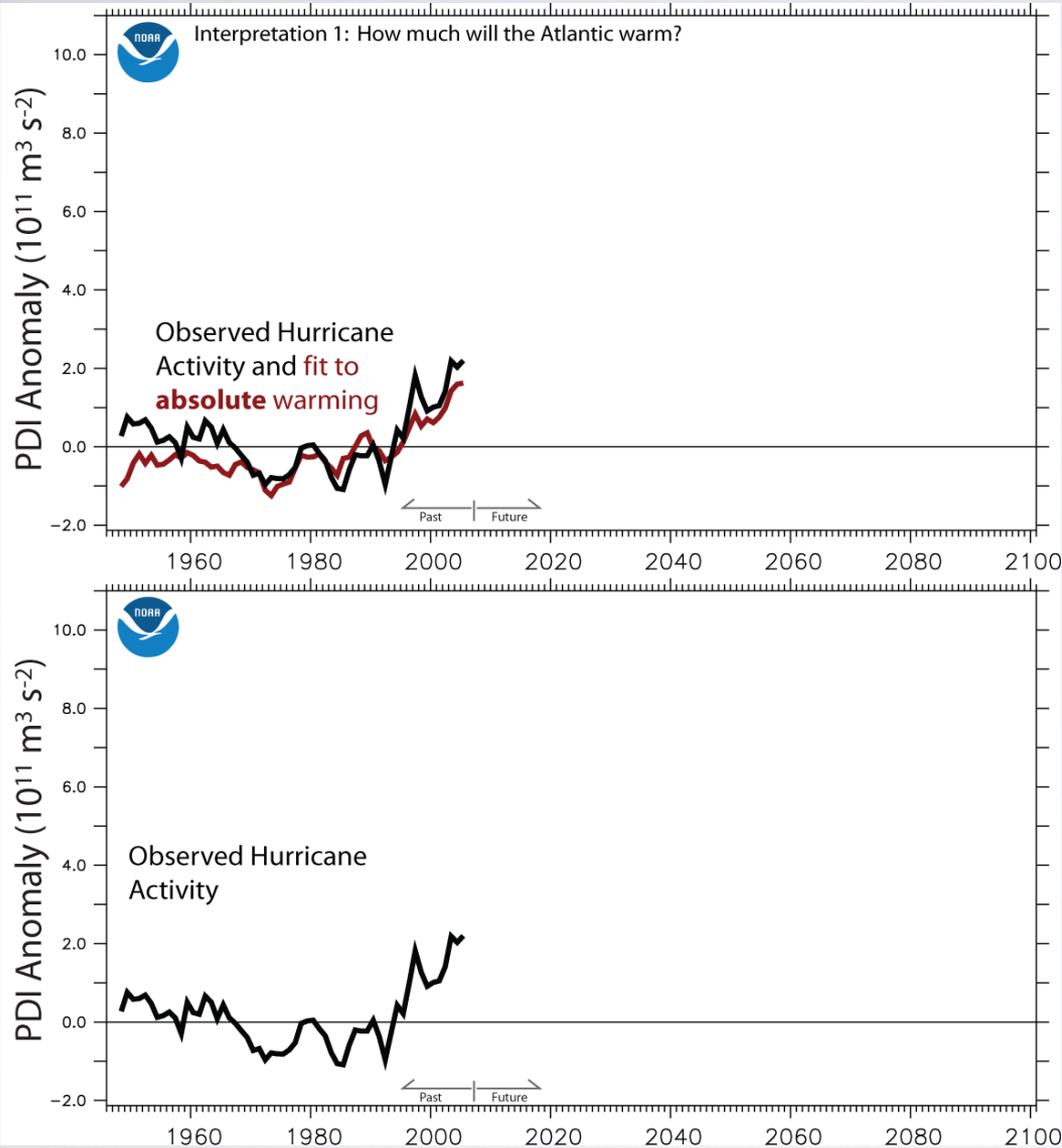
Historically, Tropical Cyclones Form Over Warm Water



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.

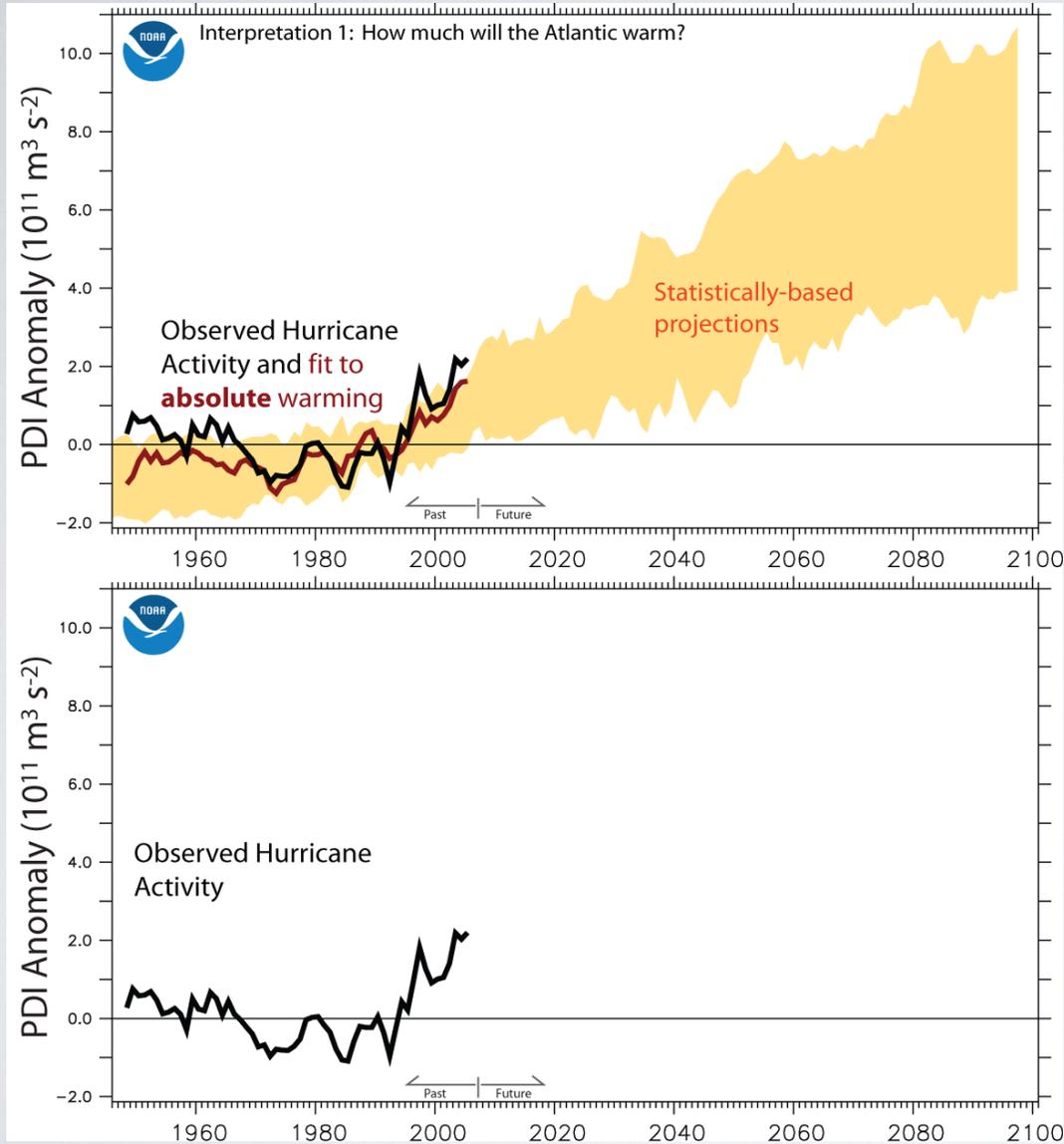
One Temperature Predictor of Atlantic Hurricane Activity

Observed Activity
Absolute Atlantic
Temperature



Vecchi, Swanson and Soden
(2008, Science)

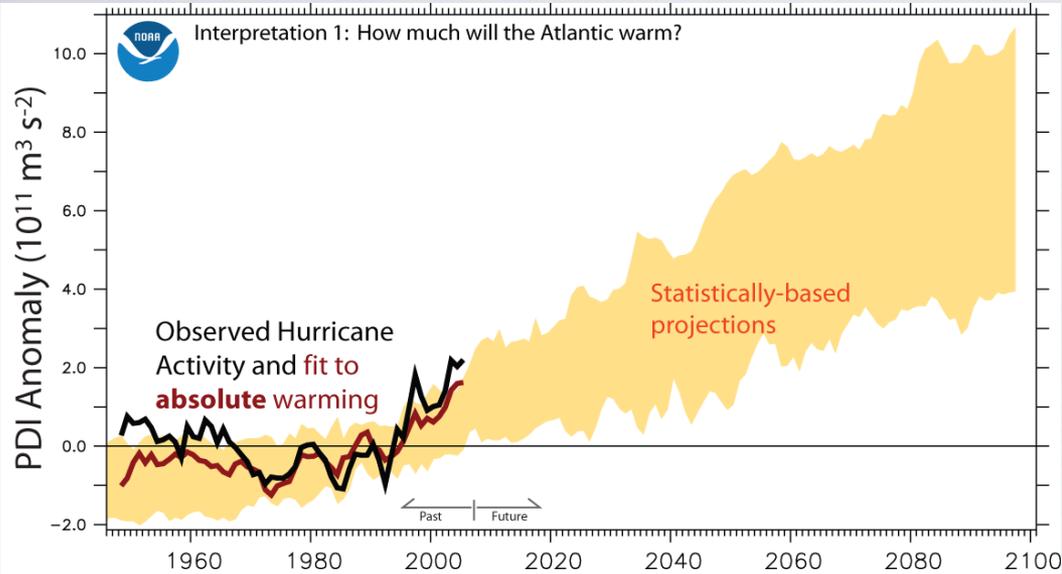
One Temperature Predictor of Atlantic Hurricane Activity



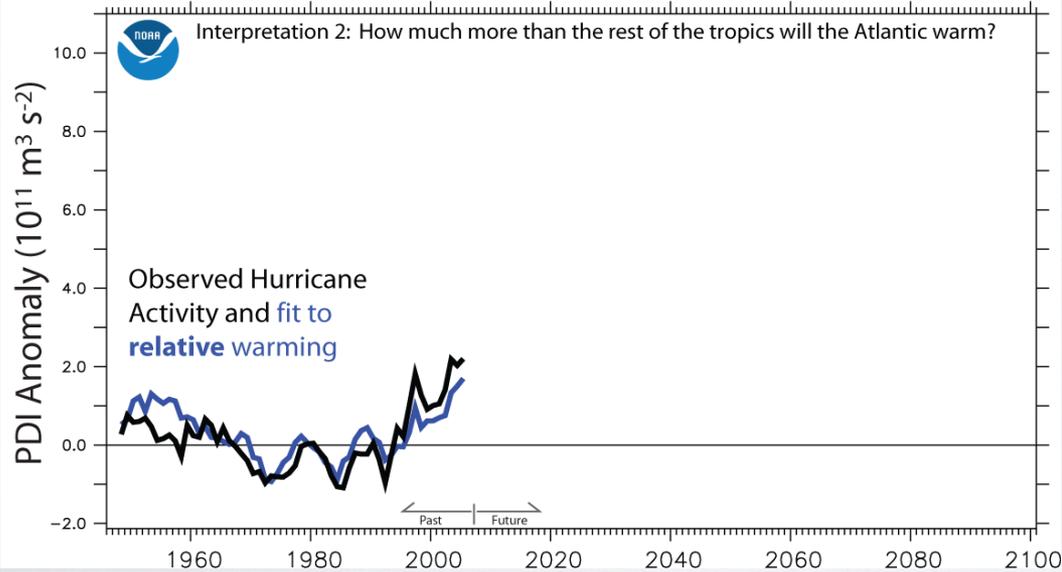
Observed Activity
Absolute Atlantic
Temperature

Vecchi, Swanson and Soden
(2008, Science)

Two Temperature Predictors of Atlantic Hurricane Activity



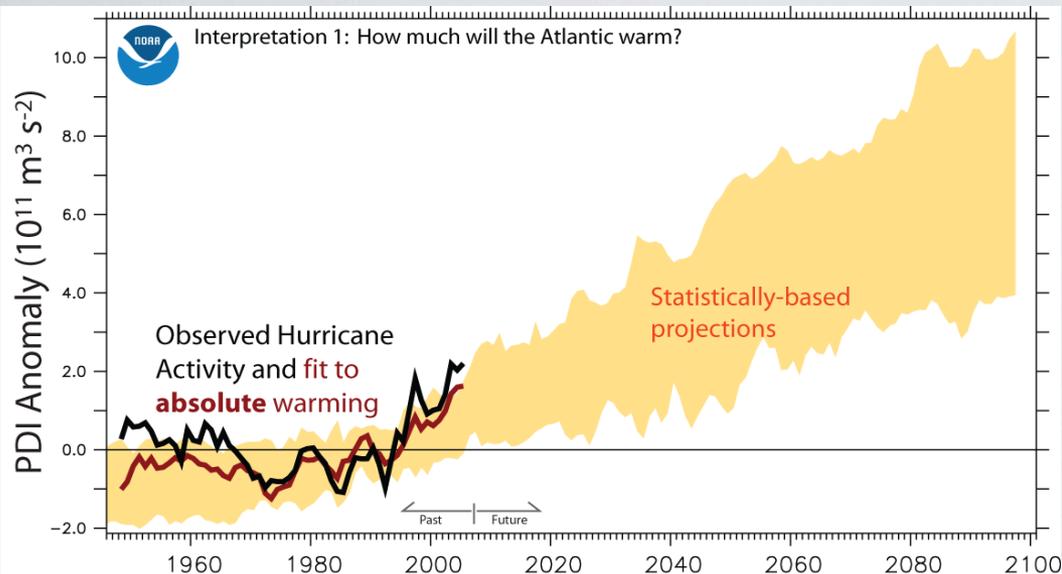
Observed Activity
Absolute Atlantic
Temperature



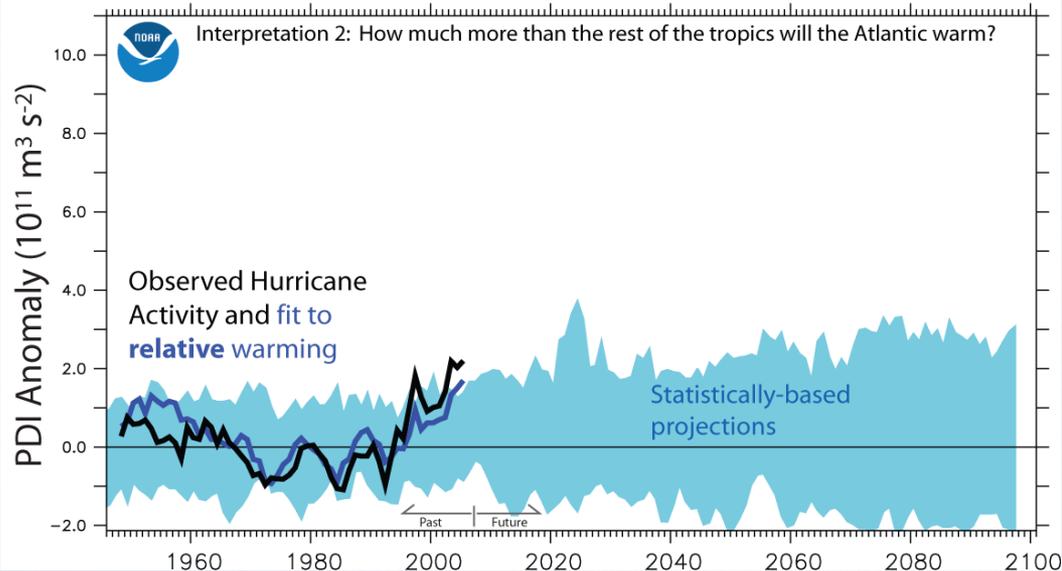
Observed Activity
Relative Atlantic
Temperature

Vecchi, Swanson and Soden
(2008, Science)

Two Statistical Projections of Atlantic Hurricane Activity



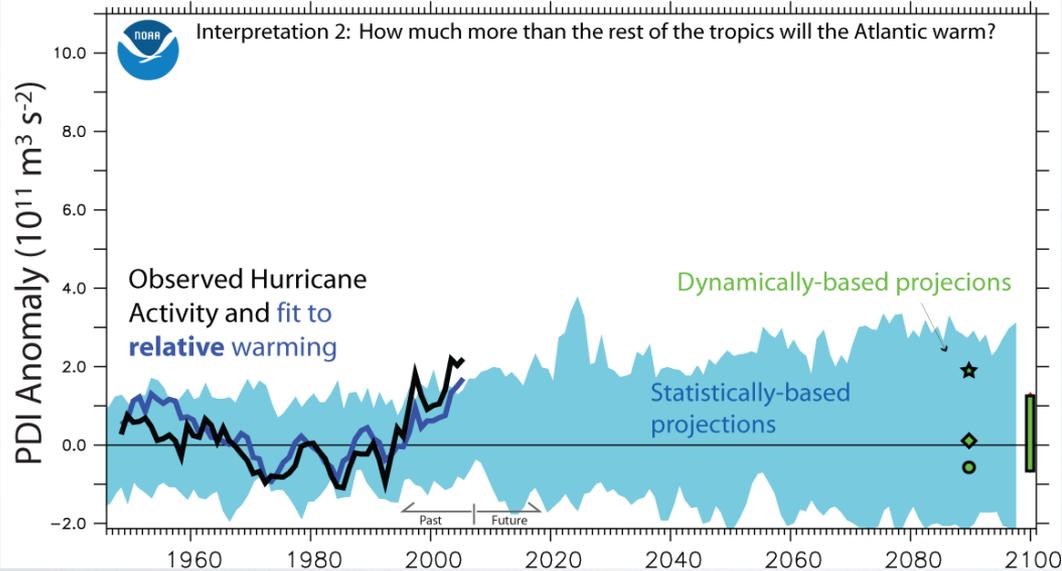
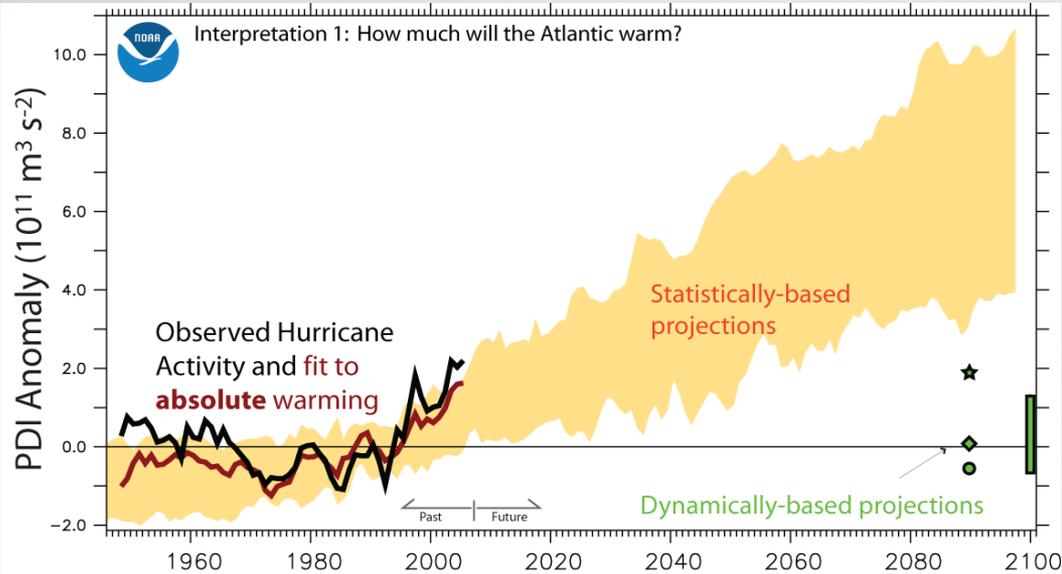
Observed Activity
Absolute Atlantic
Temperature



Observed Activity
Relative Atlantic
Temperature

Vecchi, Swanson and Soden
(2008, Science)

...Add Dynamical Projections of Atlantic Hurricane Activity



Observed Activity
Absolute Atlantic
Temperature

Dynamical Model
Projections

Observed Activity
Relative Atlantic
Temperature

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.