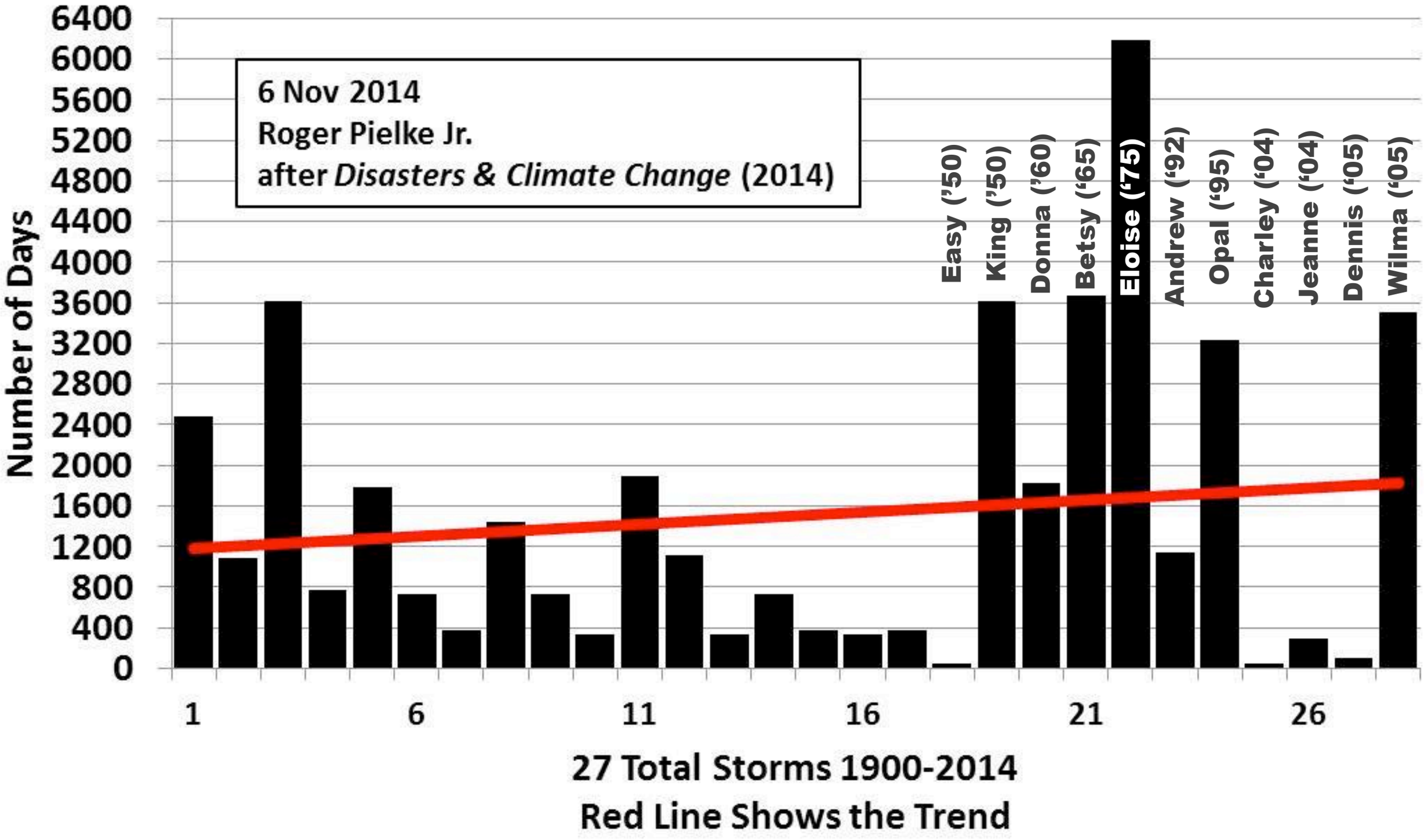
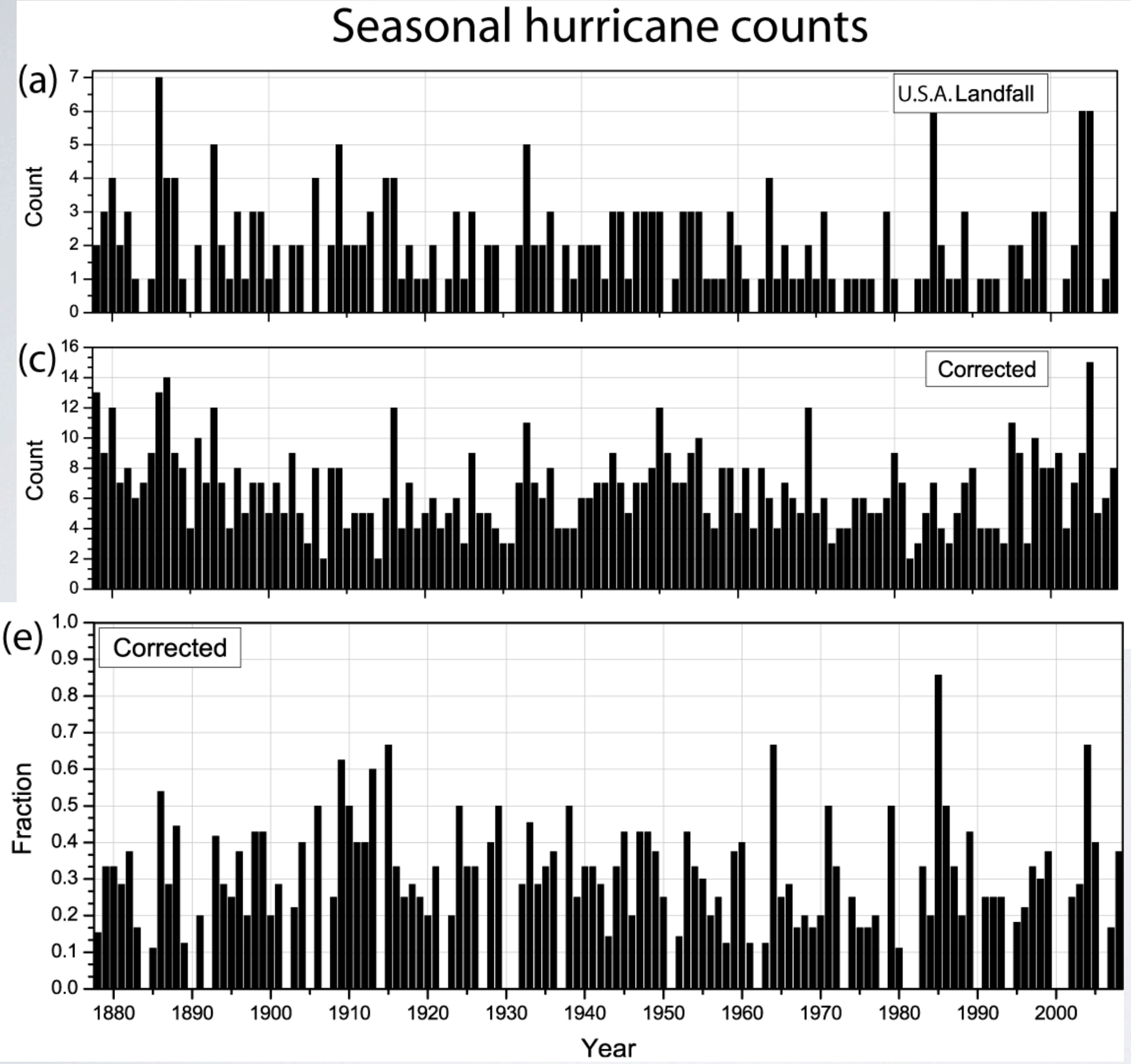
# The Next Season's Hurricanes

Gabriel Vecchi
NOAA/GFDL

Image: NASA.

# Days Between Major Hurricane (Cat 3, 4, 5) Landfalls in Florida: 1 January 1900 to 1 June 2015






U.S. Landfalling Hurricanes

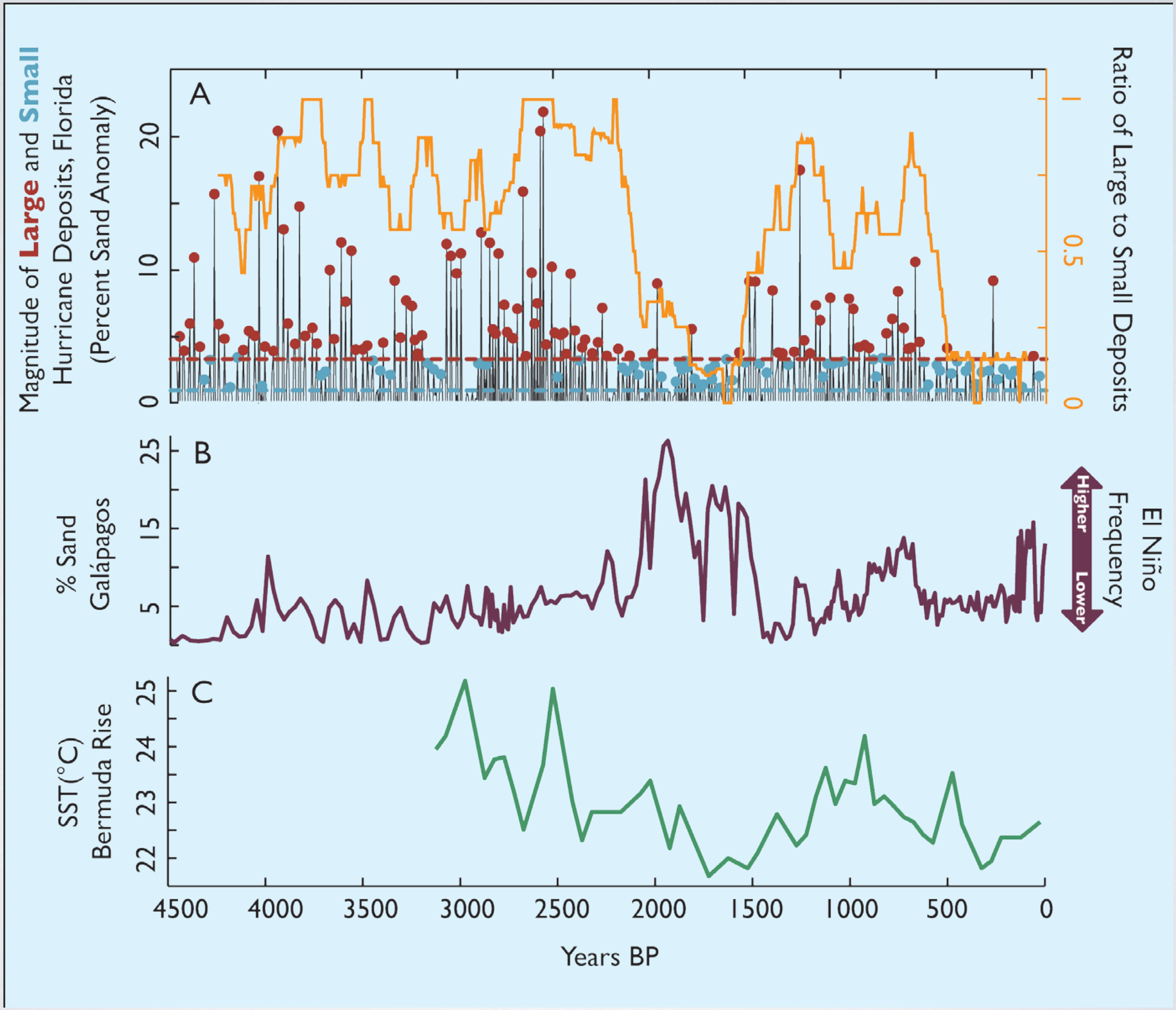
Basinwide Hurricanes

Fraction of Basinwide Hurricanes Making U.S. Landfall

*Vecchi and Knutson (2011, J. Clim.); Villarini et al. (2012, J. Clim.)*

# Last 4,500 years in Mullet Pond, FL

Estimate of Hurricane LF




*Lane and Donnely (2012)*

# Sources of & Limitations on Climate Predictability

Months to decades

hours to a month

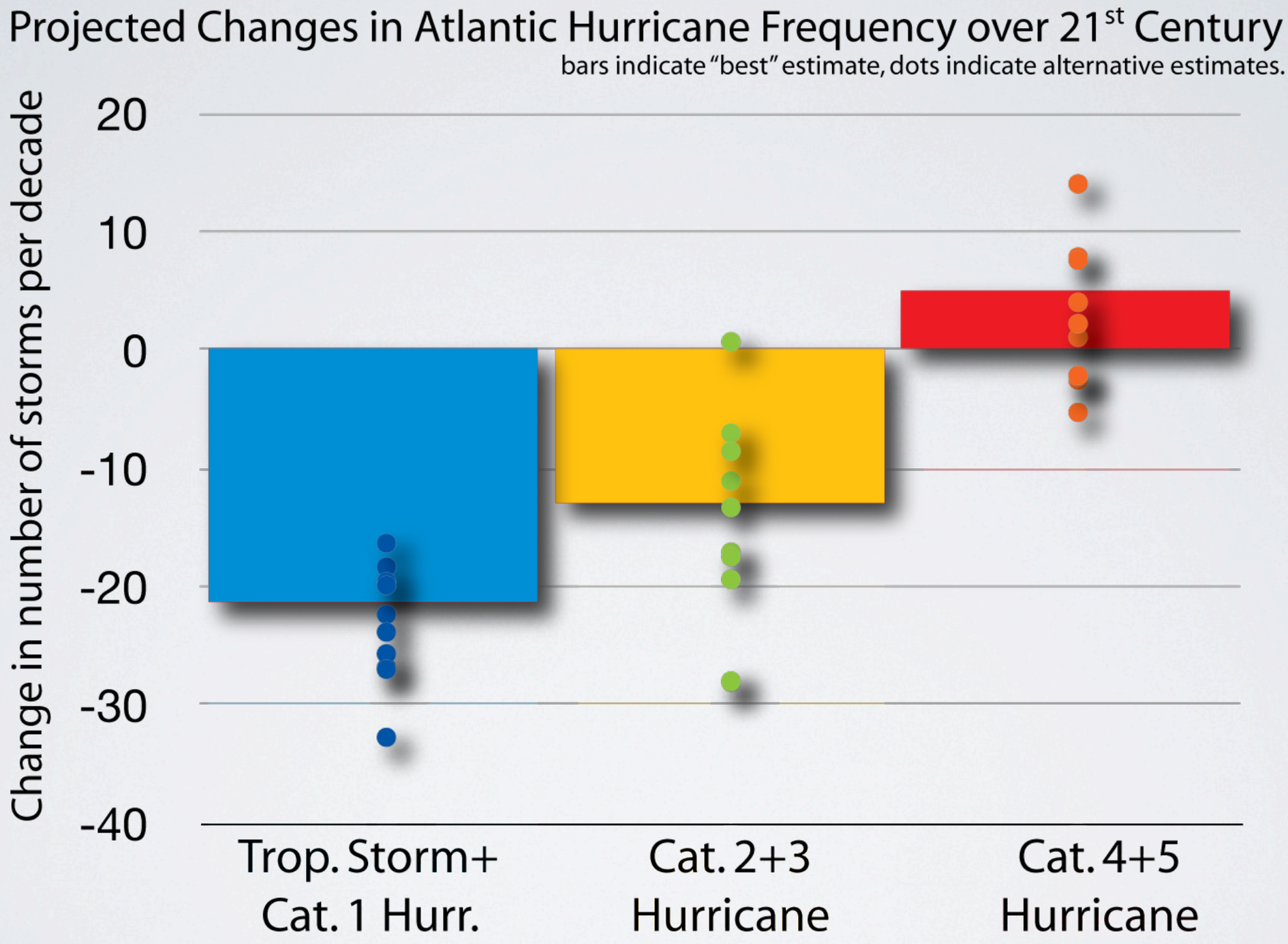
Evolution of initial state of ocean/atmosphere.
Need good models and observations of present and past

Many decades to centuries

Climate response to forcing
(*e.g.*, $CO_2$, soot/dust, sun, volcanoes, land use)
need good models and estimates of forcing

Predictability has inherent limits: need to be probabilistic.

# From Global Warming: basin-wide North Atlantic frequency decrease & intensity increase, so strongest storms may become more frequent




*Adapted from Knutson et al. (2013, J. Climate), see also Bender et al (2010, Science)*

# Elements of Climate Prediction System of Systems

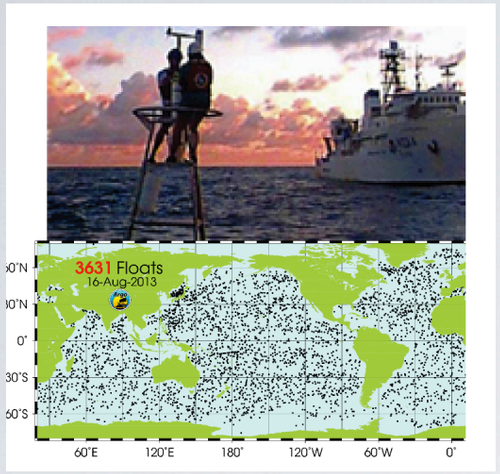
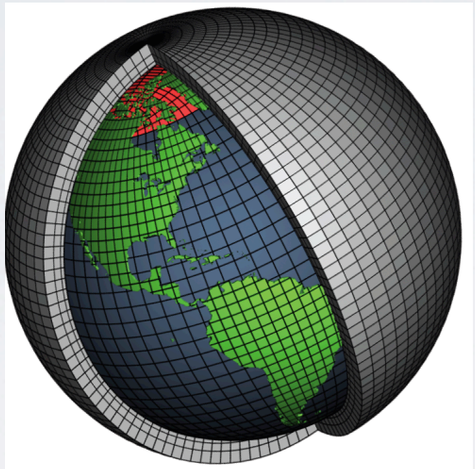
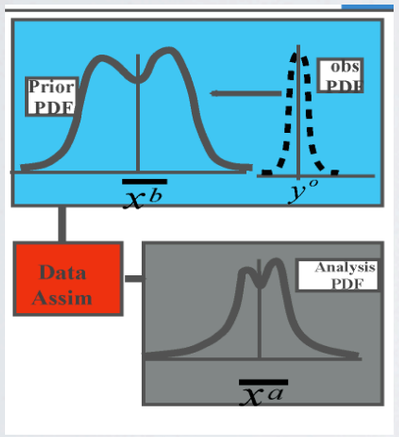



Image sources: NOAA/PMEL and Argo.ucsd.edu

Global climate observing system:
Sparse observations of many quantities across globe.



Dynamical modeling system:
Allows forward integration from present state, including expected changes in radiative forcing.




Data assimilation system:
Combines sparse observations with model, to estimate present state.
Usually based on dynamical model.

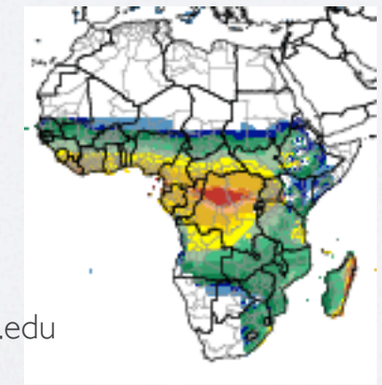
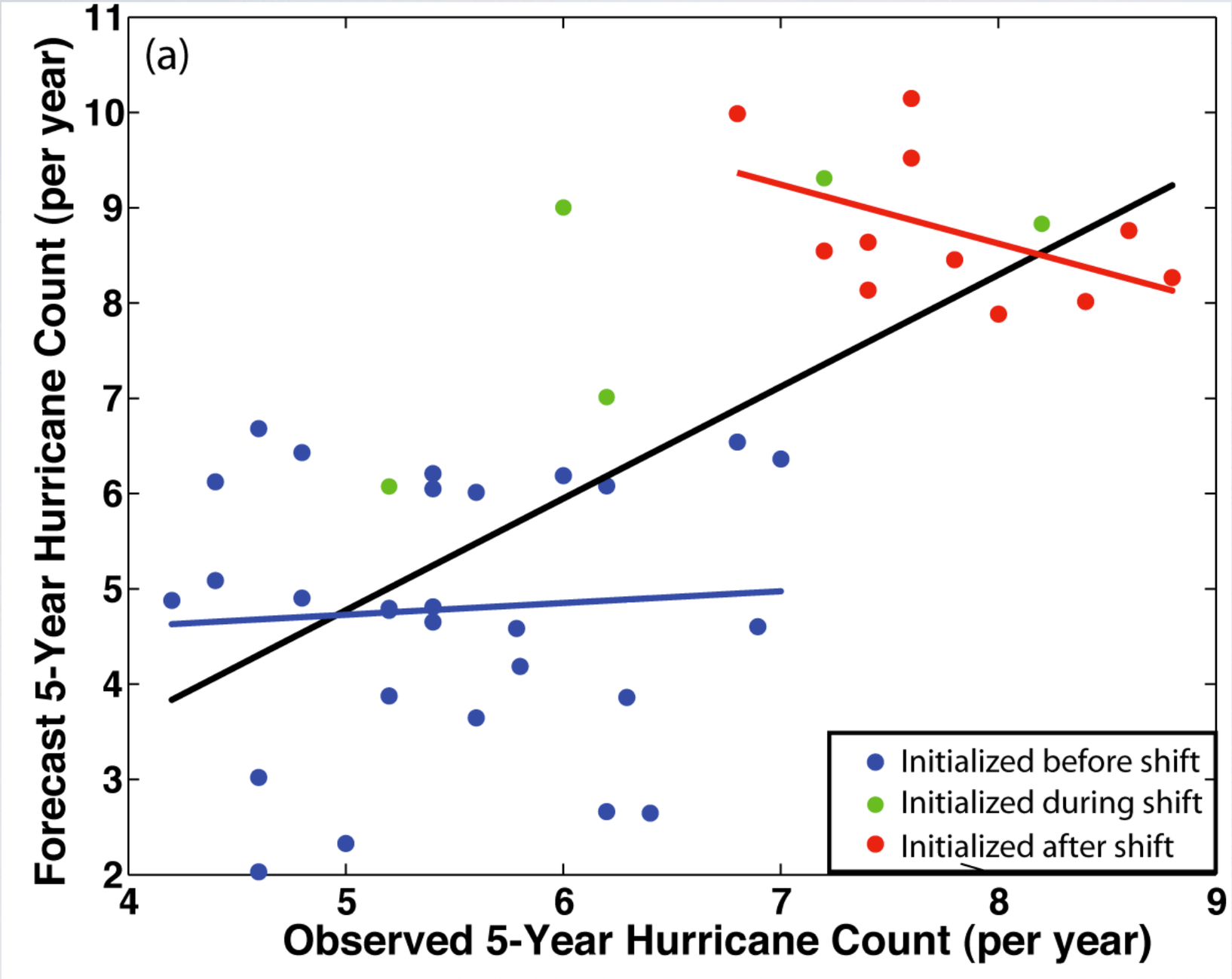


Image source: http://iridl.ldeo.columbia.edu

Analysis and dissemination system:
Take output from predictions and produce "useful" information, communicate predictions.

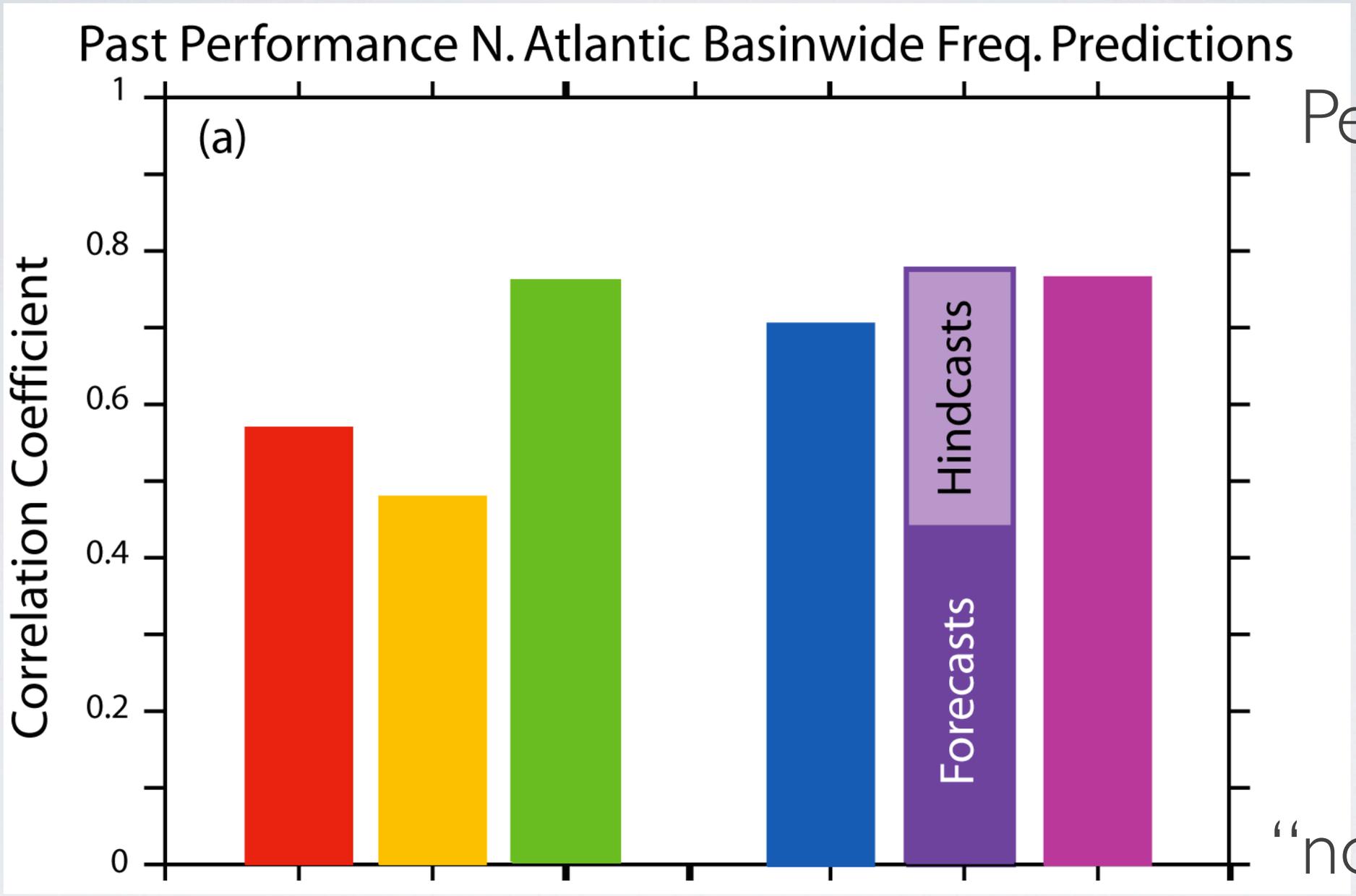
# Multi-year prediction of NA basin-wide frequency




Although there are some initial encouraging results for basin-wide frequency, they need to be treated with caution.

*Vecchi et al. (2013)*

# Seasonal Predictions of Hurricane Frequency in Atlantic have been getting more precise and accurate

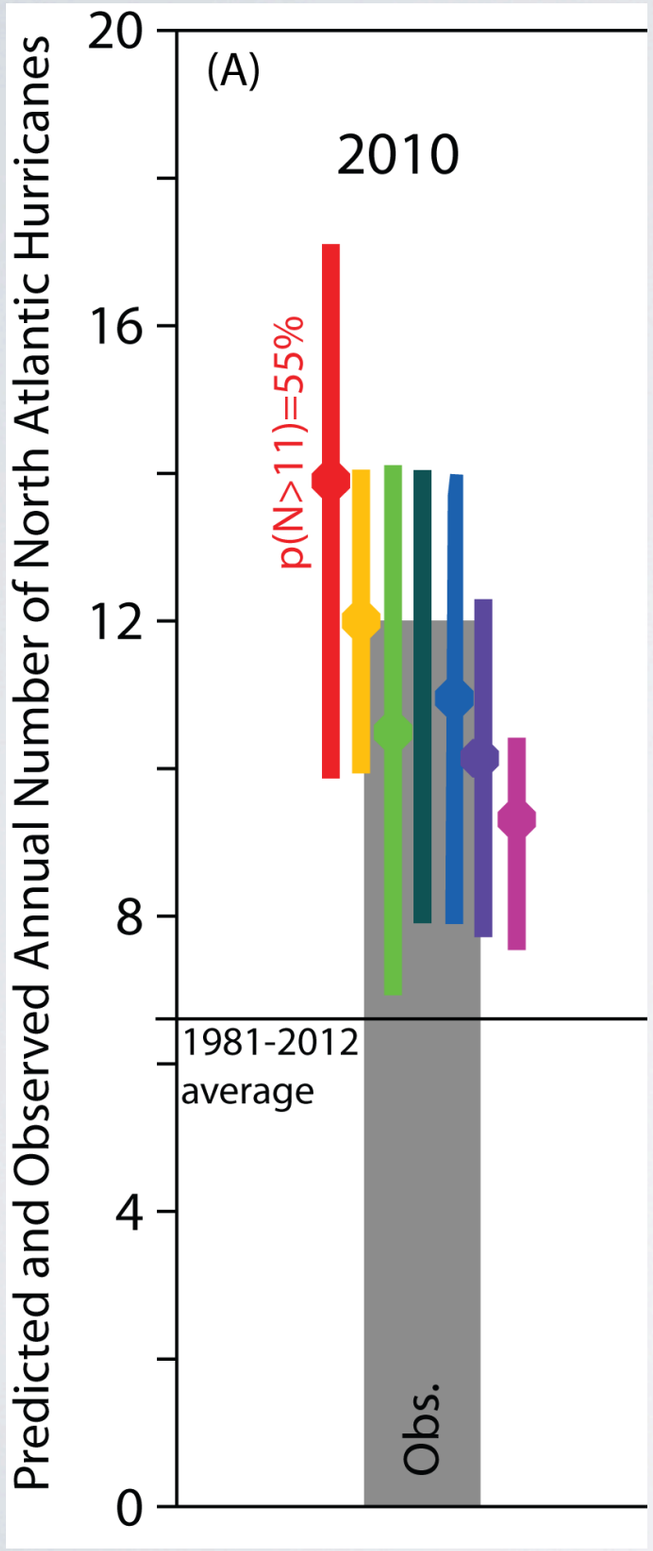


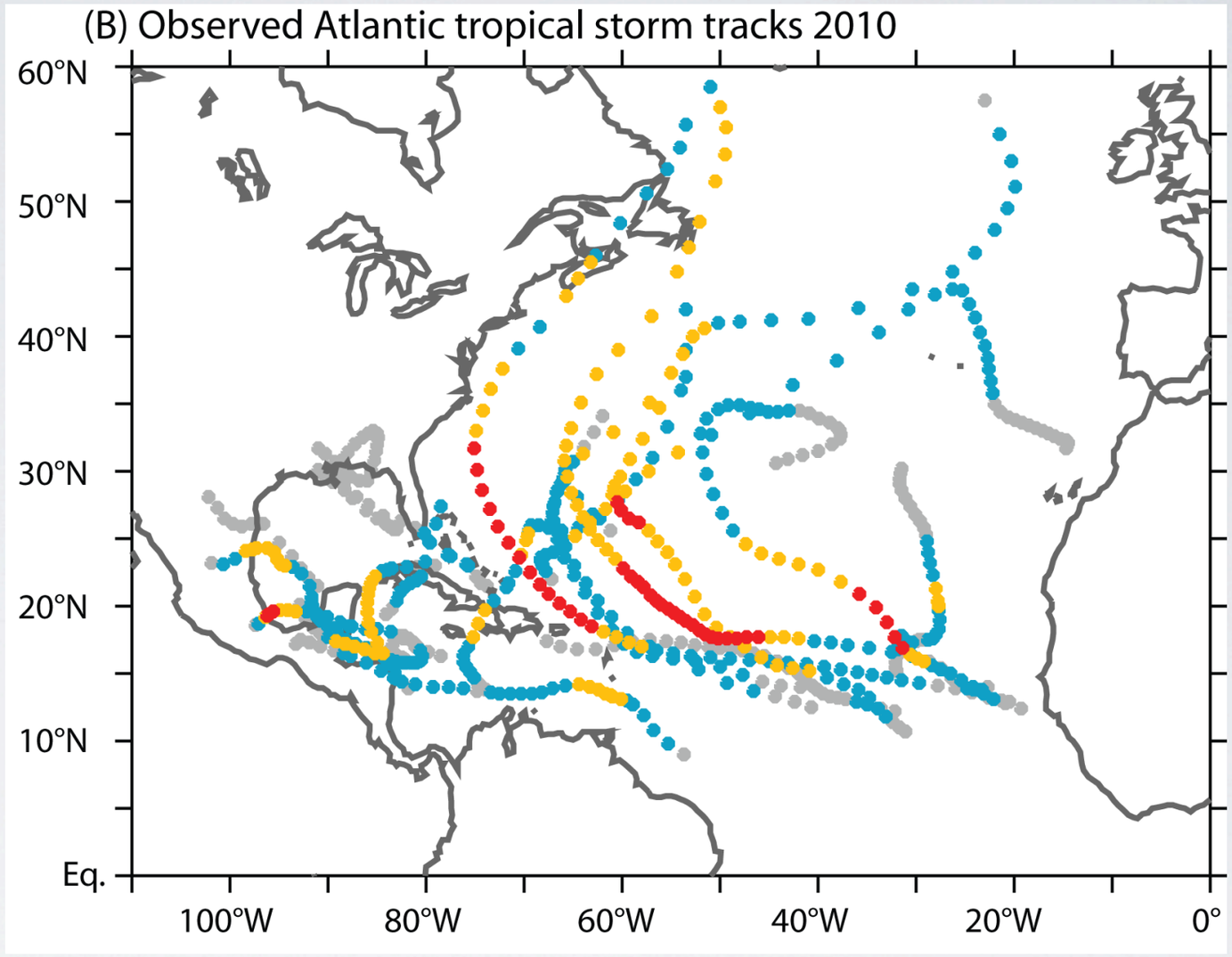

Perfect

"no skill"

Each bar is a different North Atlantic hurricane prediction system

# Correct predictions of basin-wide active 2010 but not of U.S. landfall absence

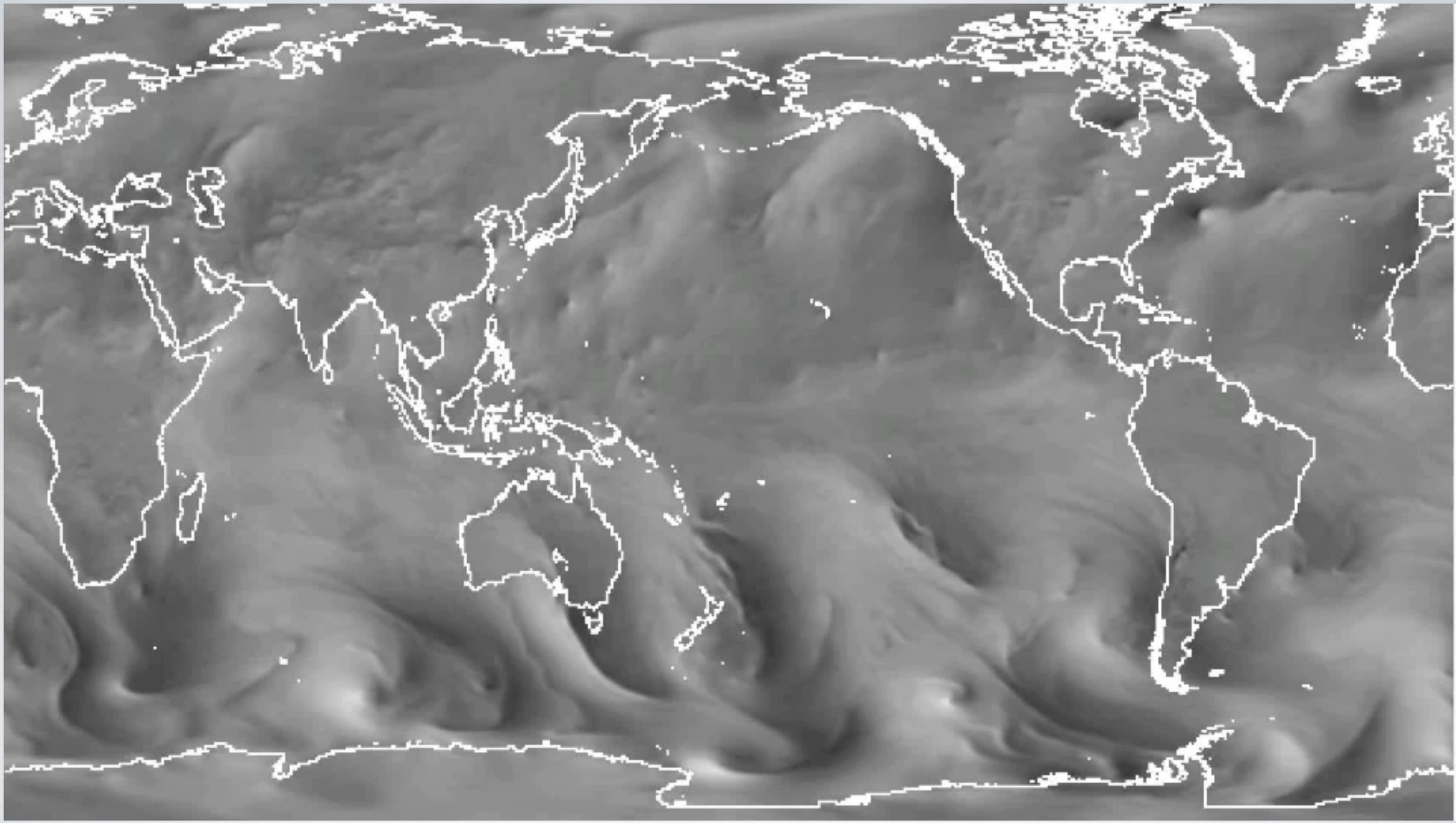



Can we reliably predict statistics of storms more regionally than "basin-wide" number?

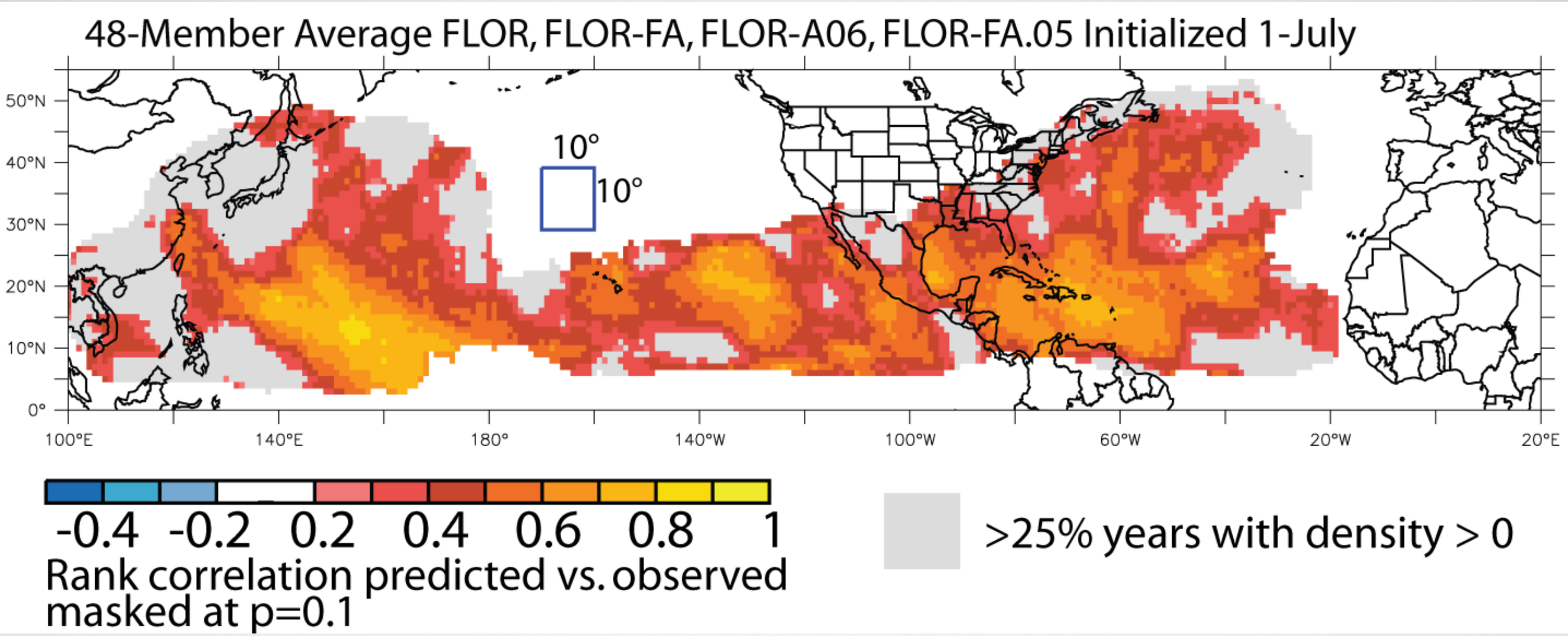
*Vecchi and Villarini (2014)*

100 days of single ensemble of 1-Aug-2005 initialized CM2.5-FLOR 10-m v



4xdaily 1-Aug through 8-Nov 2005

# Systems under development show promise at regional scales

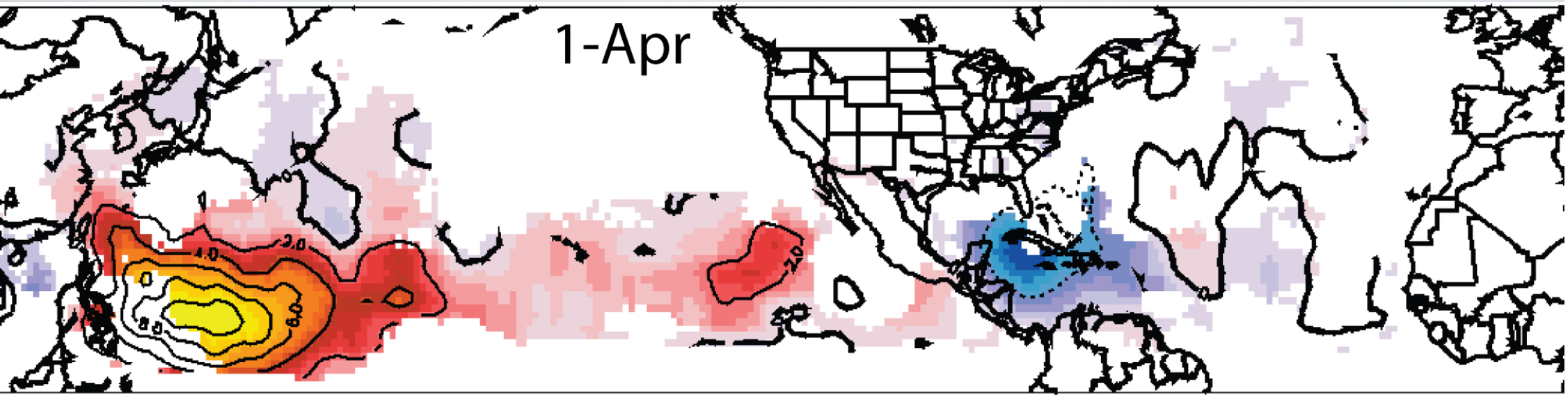



Shaded: "retrospecitve" predictions 1980-2012 tend to distinguish between years with many and few storms nearby

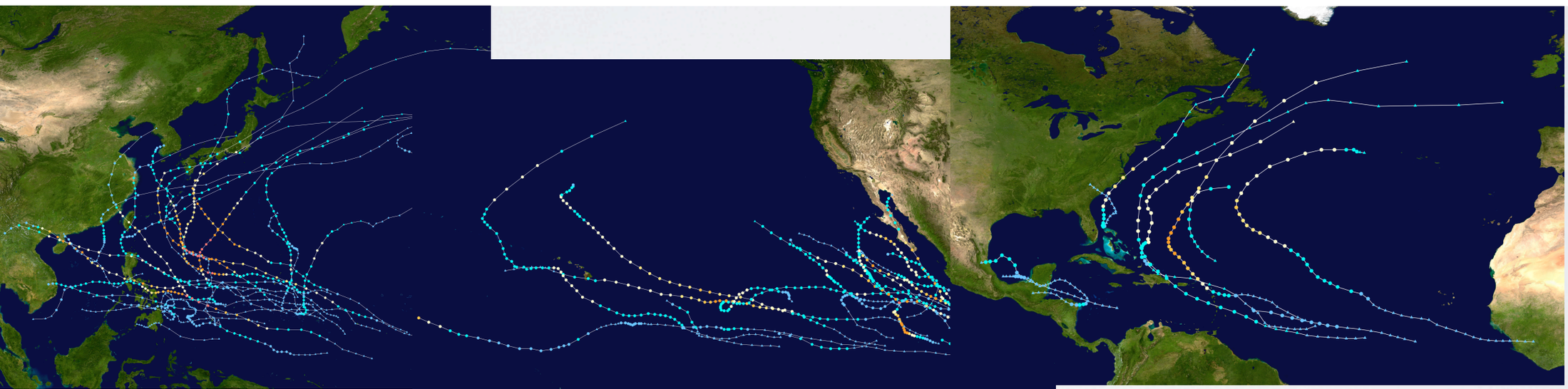
*(Vecchi et al. 2014, J. Clim.)*

***EXPERIMENTAL RESEARCH PRODUCT – NOT AN OFFICIAL OUTLOOK ***

# Experimental 2014 TC density forecasts




Anomalous TC density
TC Days/season



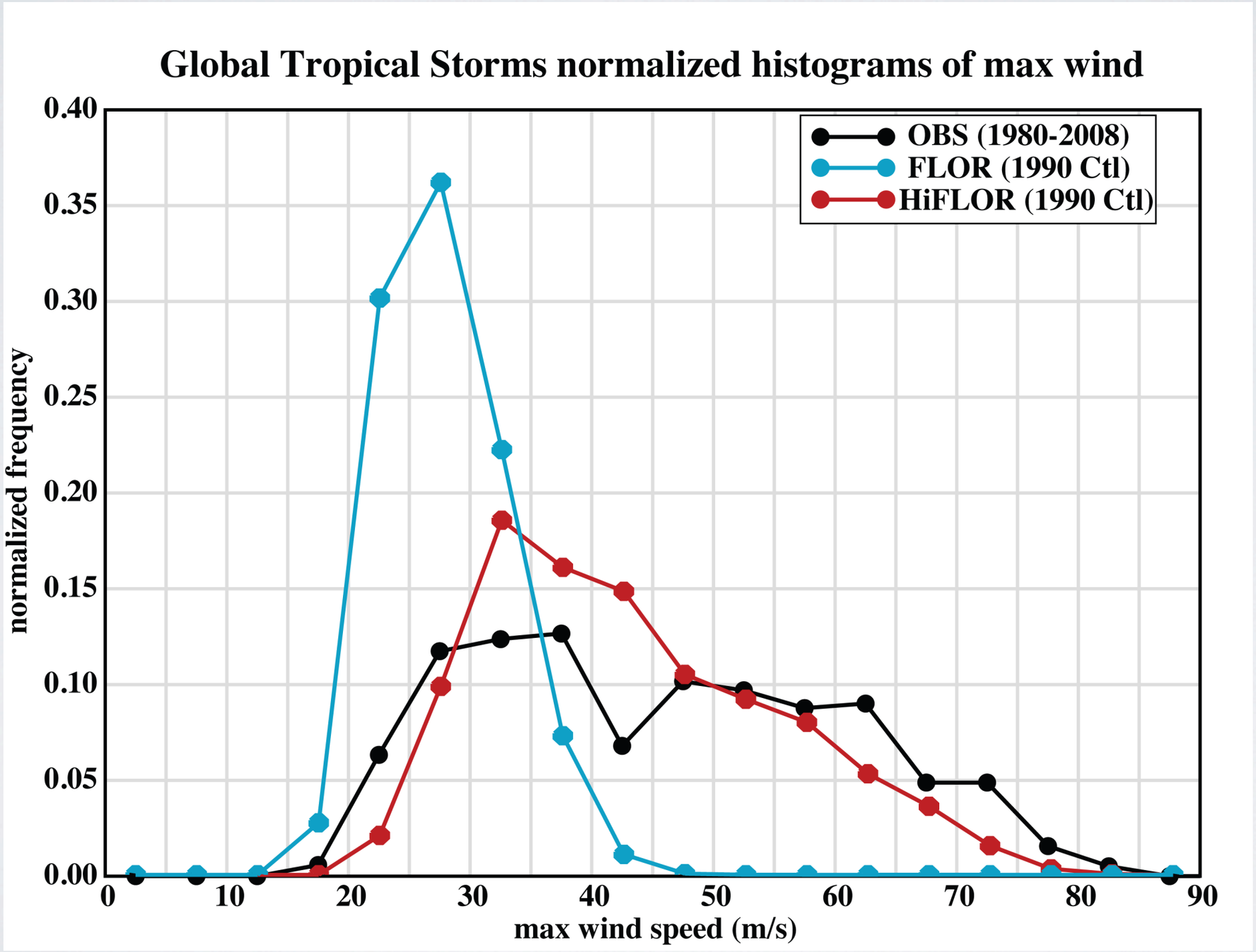
Actual 2014
Storms

*Source: wikipedia*

Forecasts of 2014 TC density anomaly with GFDL-FLOR-HAD13 initialized 1-April-2014 and 1-July 2014.
Contour: all values
Shade: locations with significant retrospective correlation

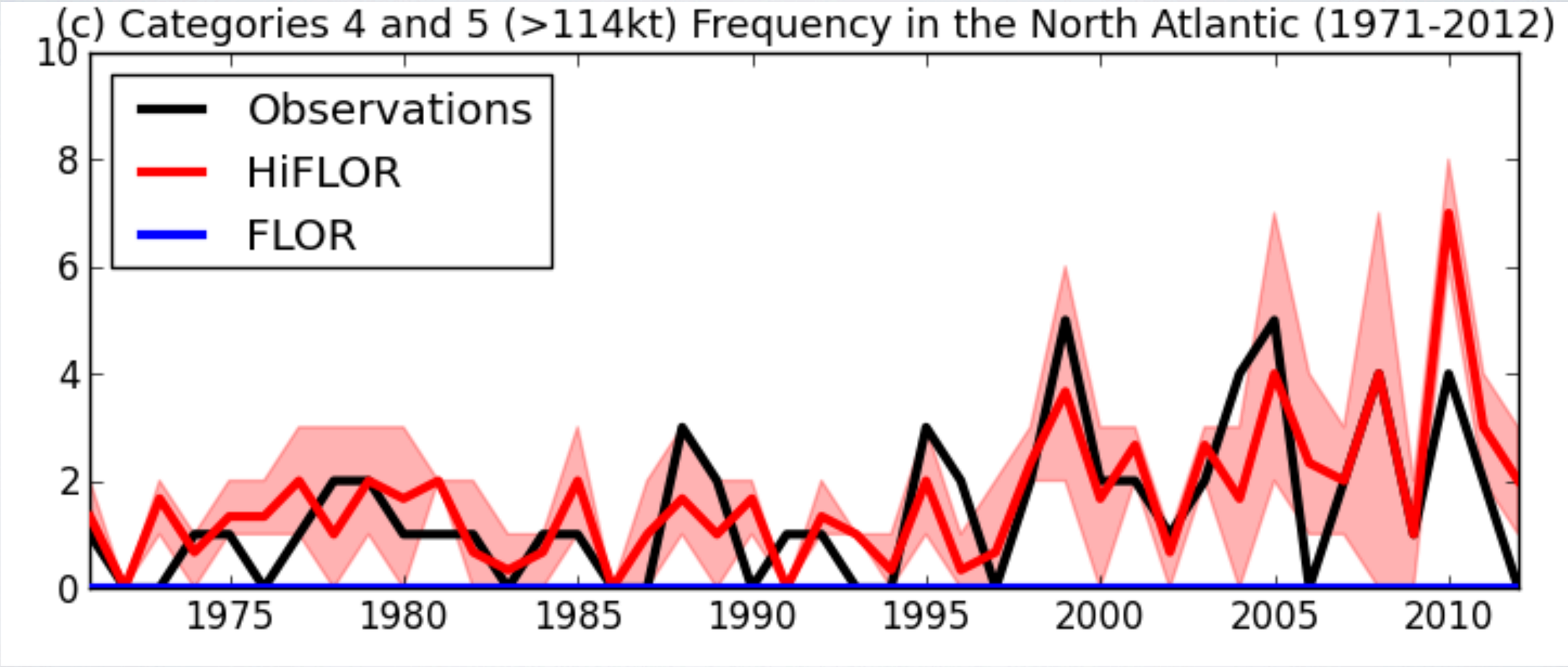
*(based on Vecchi et al. 2014, J. Clim.)*

Most impactful hurricanes tend to be strongest.
Need prediction models that can capture them. New prototype model ("GFDL-HiFLOR", first run May 2014) able to simulate Cat. 4-5s




*Murakami et al. (2015, in prep.)*

# New prototype NOAA-GFDL prediction model is able to recover history of Cat. 4-5s…experimental predictions underway…



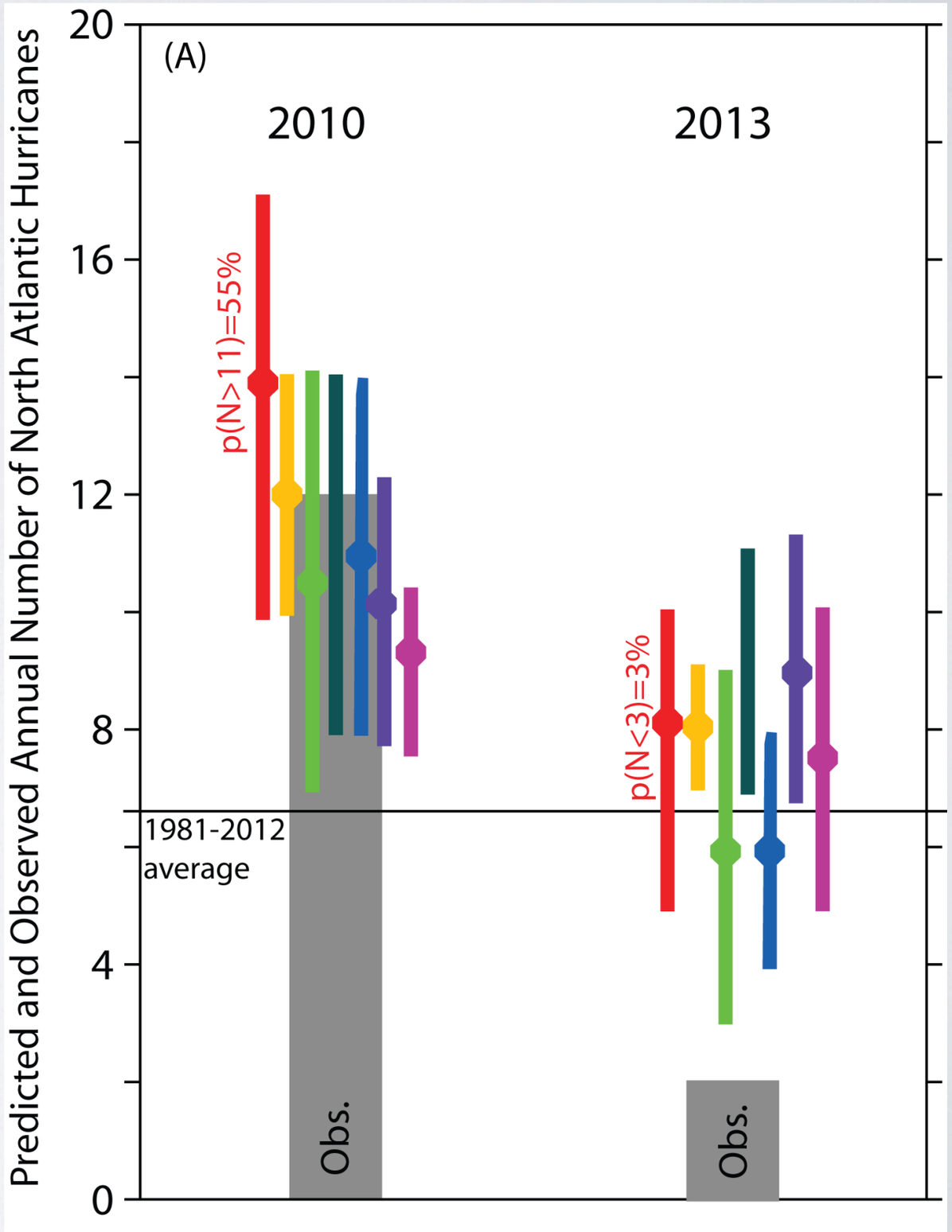

*Murakami et al. (2015, in prep.)*

# Because of "Butterfly Effect" forecasts should always be in terms of probabilities

- Climate system is *chaotic*: even the "best" prediction system conceivable will not be able to precisely predict upcoming season.

- If predictions are *reliable*, even things deemed unlikely will sometimes happen.

- Most useful way to communicate predictions depends on application.



# Summary

- We understand more than we did
- We have better tools than we did
- Our predictions are better than they used to be – and will probably continue to get "better" (more regional, more reliably probabilistic)
- There will always be limits on predictability and prediction skill