Detection and Prediction of Extremes: Tropical Cyclones

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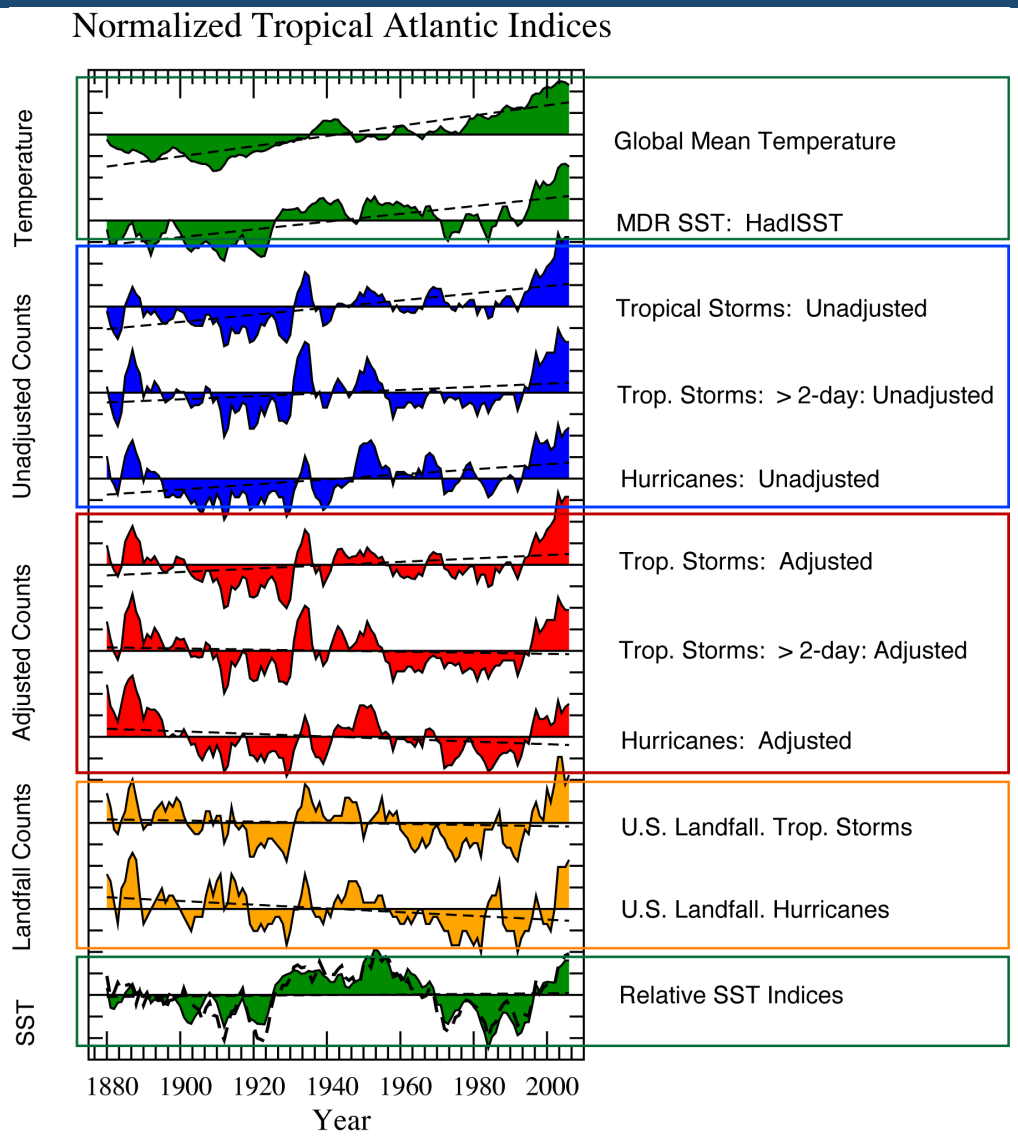
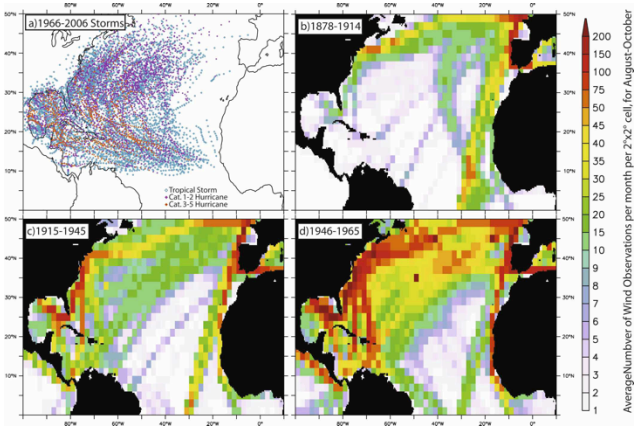
Recorded century-scale increase in Atlantic hurricane activity consistent with estimated impact of changing observing system



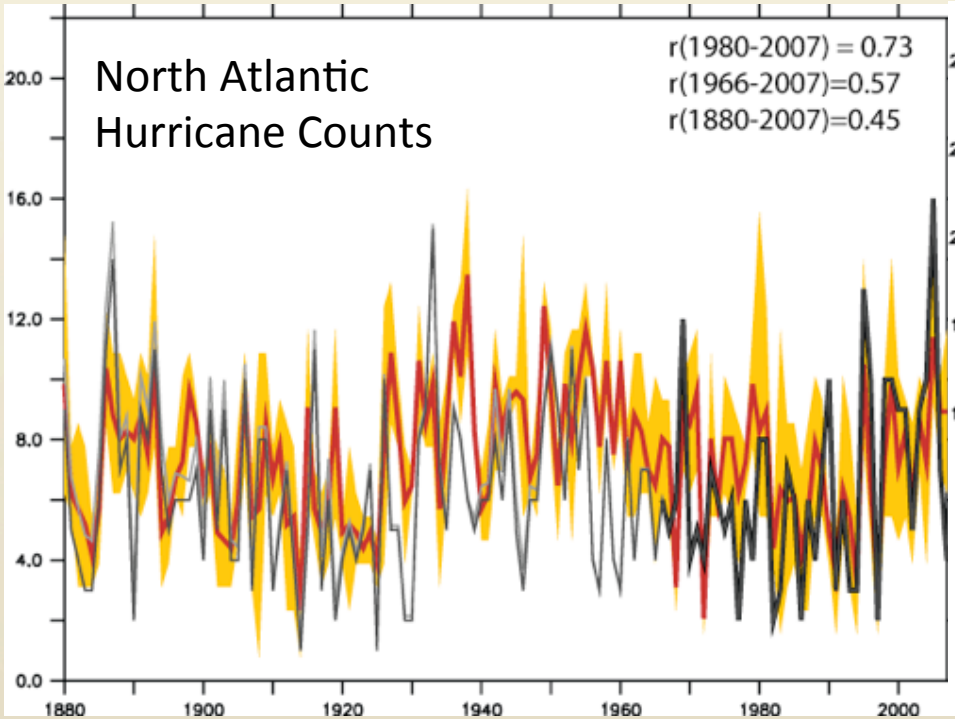
Adjustments to storm counts are based on ship/storm track locations and density

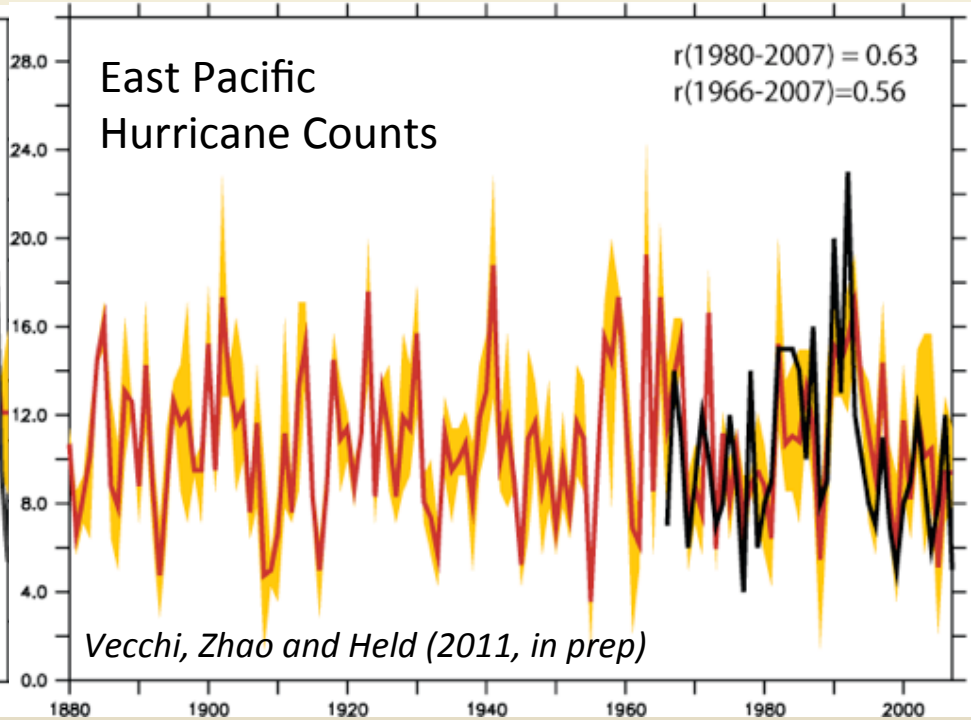


Vecchi and Knutson (2008),
Landsea et al. (2009),
Vecchi and Knutson (2011)
Villarini et al. (2011.b)

Evaluate hi-res model simulations with homogenized datasets

Observed **Model Mean** **Model Range**





- When forced with observed SST, a 100km version of GFDL-HiRAM recovers aspects of century-scale changes in North Atlantic hurricane activity.
- Suggests decadal variability in East Pacific may not be synchronized with North Atlantic.

Use homogenized data to build statistical models for exploration and projections

Family of statistical models based on observed hurricane activity and SST.

Use two predictors:

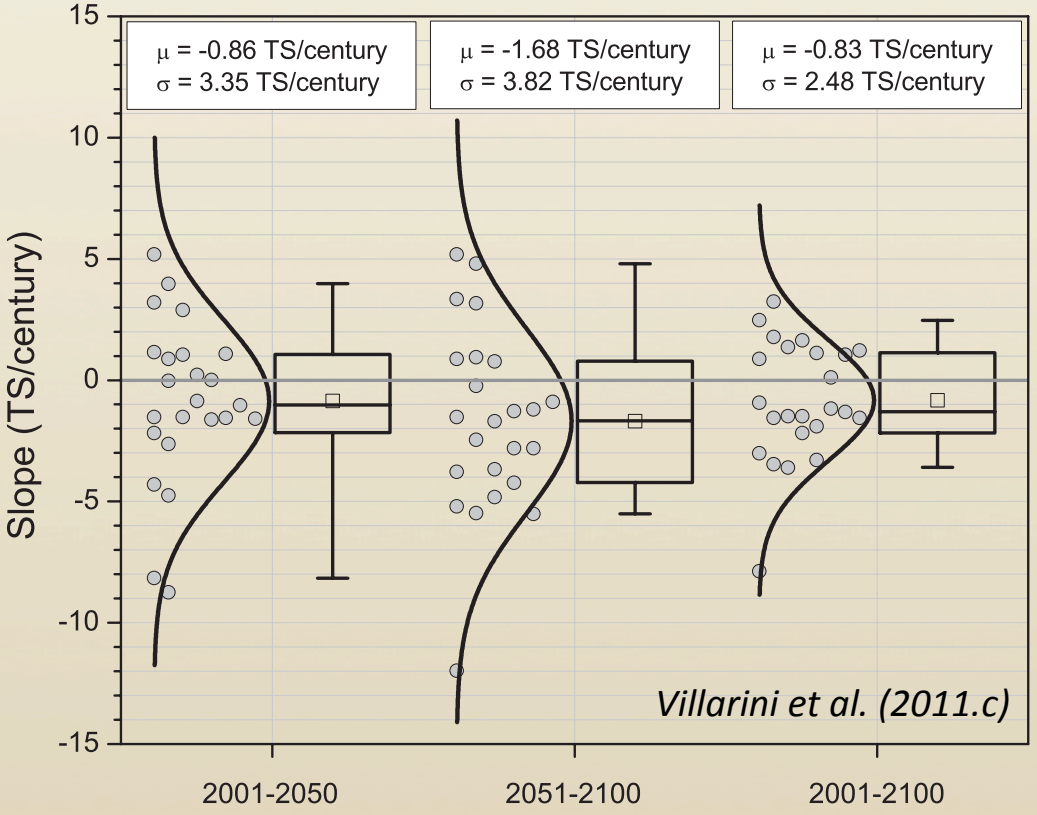
- Tropical Atlantic SST (positive)
- Tropical-mean SST (negative)

Consistent with high-res dynamical models, understanding on controls to hurricanes & "cheap".

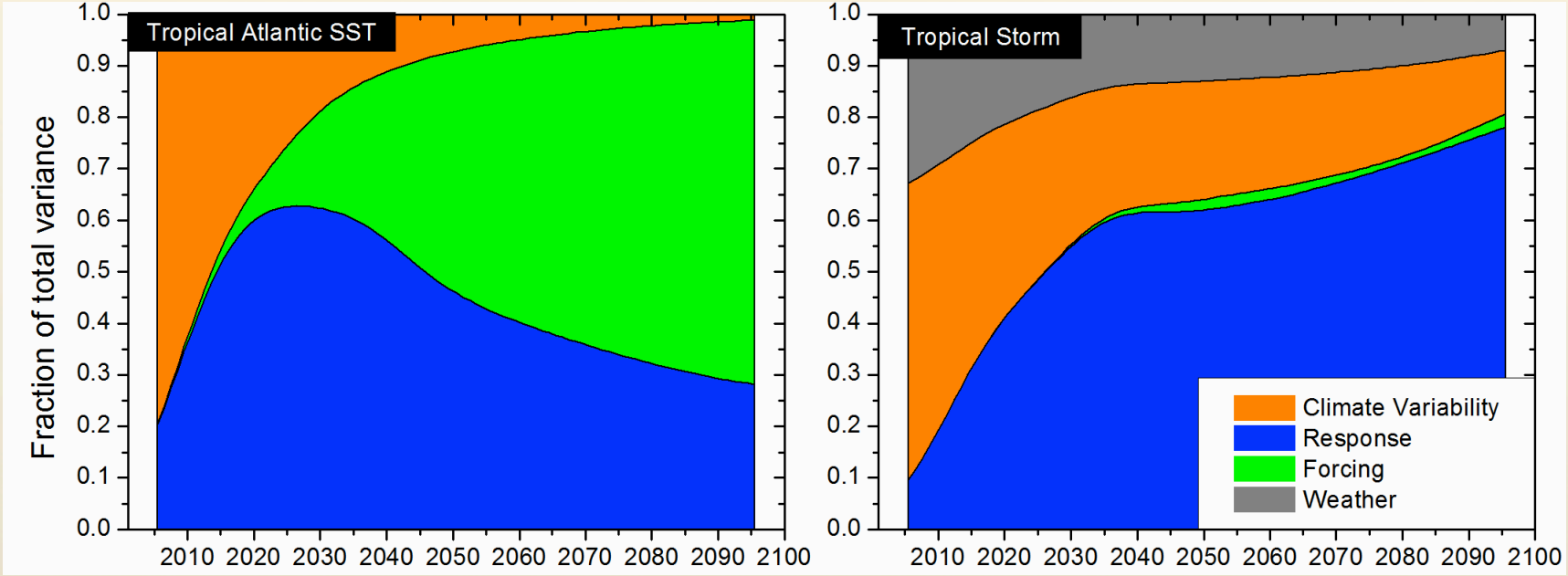
$$Rate = e^{a+bSST_{ATL}-cSST_{TRO}}$$

Knutson et al. (2008) Swanson (2008), Vecchi et al. (2008), Zhao et al. (2009, 2010), Villarini et al. (2010, 2011.a.,.c), Villarini and Vecchi (2011)

Projections of North Atlantic TS Count Trends Using Observationally-based Statistical Model and SST Projected by 23 CGCMs



Statistical models allow us to estimate sources of uncertainty for hurricane activity projections



Partitioning for North Atlantic SST resemble that for other regional SSTs:

- Short term: **Variability**
- Medium term: **Response**
- Long term: **Forcing** & *Response*

Even though Atlantic SST a predictor, partitioning for NA Tropical Storms distinct:

- Short term: **Variability**
- Medium term: **Response & Variability**
- Long term: **Response** & *Variability*

Villarini et al. (2011), Villarini and Vecchi (2011, in prep.)

Merge multiple tools and understanding to build experimental long-lead hurricane forecast system: skill from as early as October of year before

May & onward forecasts fed to NOAA Seasonal Outlook Team

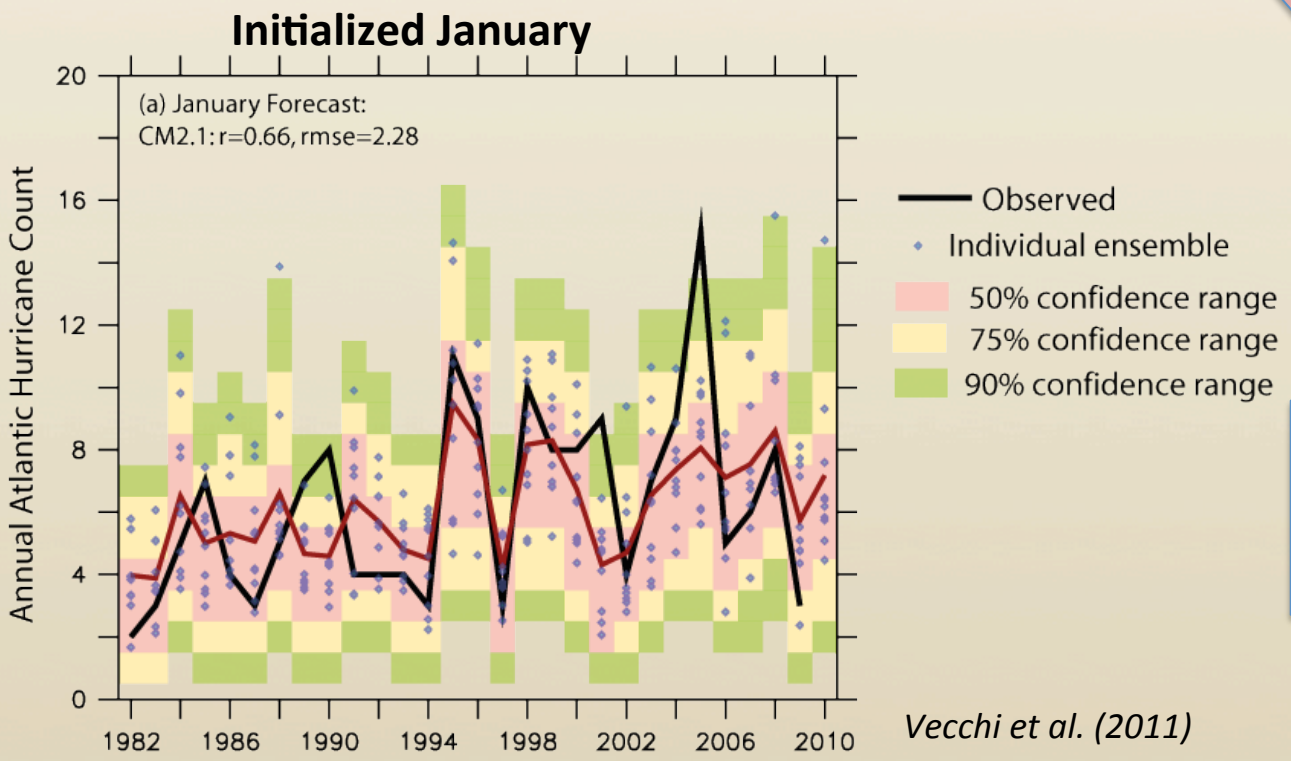
Run Hi-Res AGCM in many different climates. Count storms.

Build statistical model of the response of hurricanes in HiRAM

Use CM2.1 (and CFS) to forecast future values of Atlantic and Tropical SST

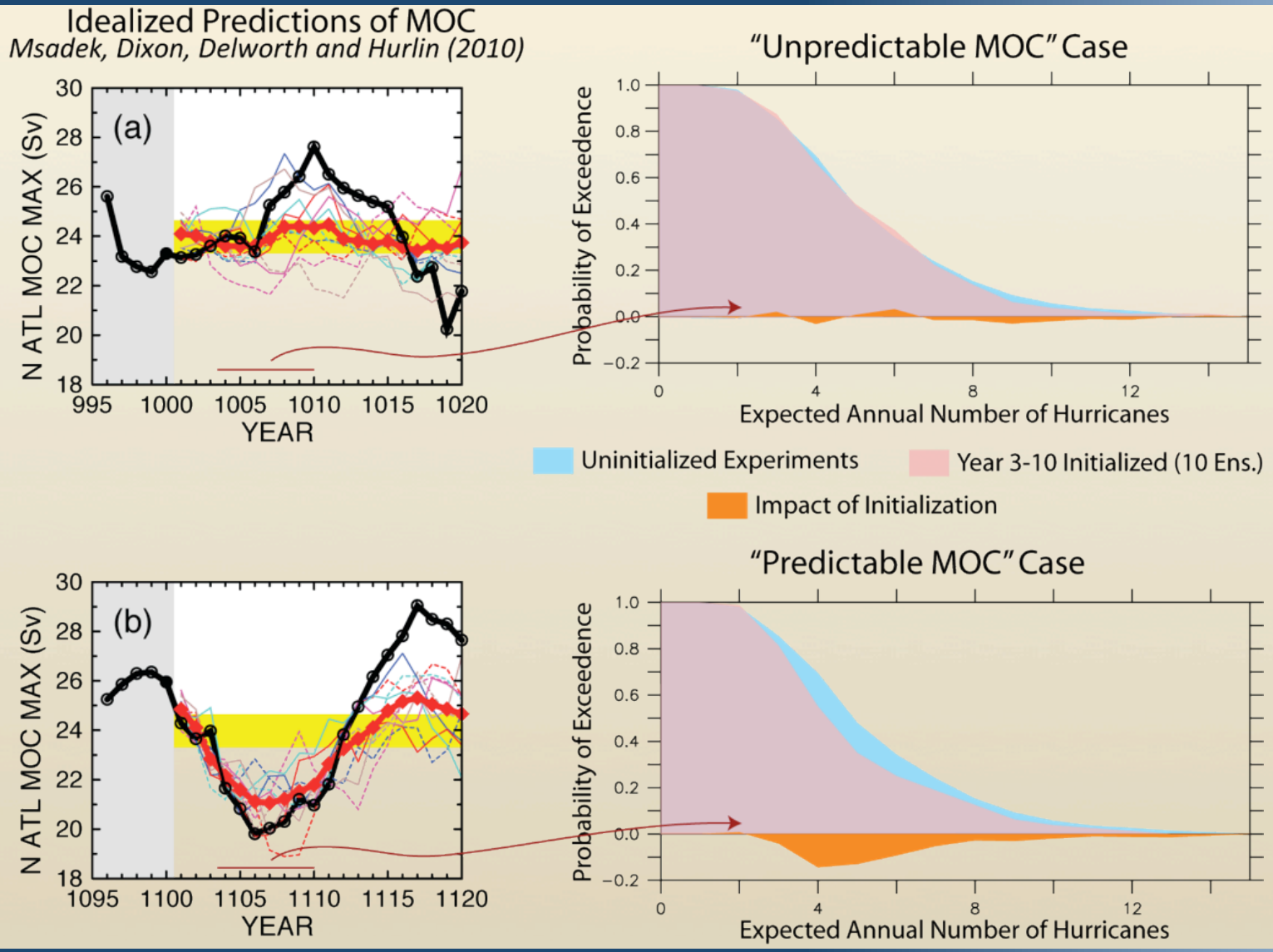
Apply Stat model to Predicted SST

Make Prediction of Full PDF of Hurricane Activity



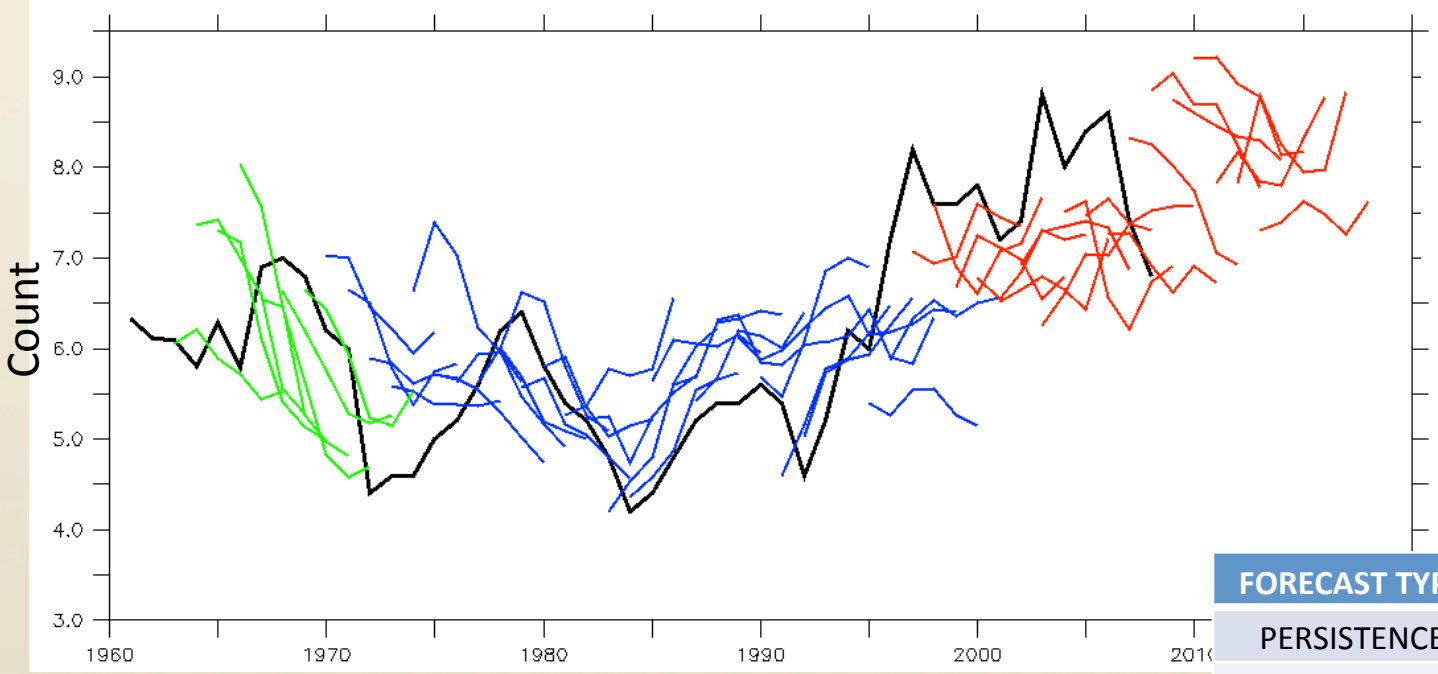
Vecchi et al. (2011)

Potential Decadal Predictability: Idealized studies indicate hurricane counts have some predictability when MOC predictable



Multi-year hurricane forecasts show strong retrospective correlation: What does this mean for actual forecasts?

Retrospective 1961-2008 initialized prediction of 5-year averaged North Atlantic hurricane count



50 years is a relatively short record with multiple changes in observing system, and one big "change-point": **Difficult to confidently assess skill.**

FORECAST TYPE	CORRELATION	
PERSISTENCE	0.36	
UNINITIALIZED	0.42	
YEAR 0-4 INIT		0.63
YEAR 1-5 INIT		0.66
YEAR 2-6 INIT		0.61
YEAR 3-7 INIT		0.59
YEAR 4-8 INIT		0.53
YEAR 5-9 INIT		0.61

2011-2015 from 2011

2016-2020 from 2011

Summary

- Recorded century-scale increase in Atlantic hurricane frequency consistent with observing system changes.
- Homogenized records & model-based dynamical insight allow simple statistical models to be built.
- Statistical models allow for projections across many GCMs. Key uncertainty sources:
  - GCM response in patterns of SST
  - Internal variability (some may be predictable, some not)
- Skillful long-lead (multi-season and multi-year) experimental forecasts using hybrid system: statistical models built on dynamical models + coupled prediction systems

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