Beyond downscaling

The *utility* of regional models for mechanistic studies

R. Saravanan
Texas A&M University

Christina M. Patricola, Xiaohui Ma, J. Steinweg-Woods, Raffaele Montuoro, and Ping Chang

All models are wrong, but some are useful.

- George E. P. Box

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Corollary

- Models should by judged by utility, not “realism”
  - “realism” and tuning are highly correlated
- Models are metaphors, not to be taken literally
  - Quantitative metaphors
  - Visual metaphors
  - Conceptual metaphors
- In the real world, the most powerful measures are visual or conceptual
  - The model hierarchy can help produce these

CMIP

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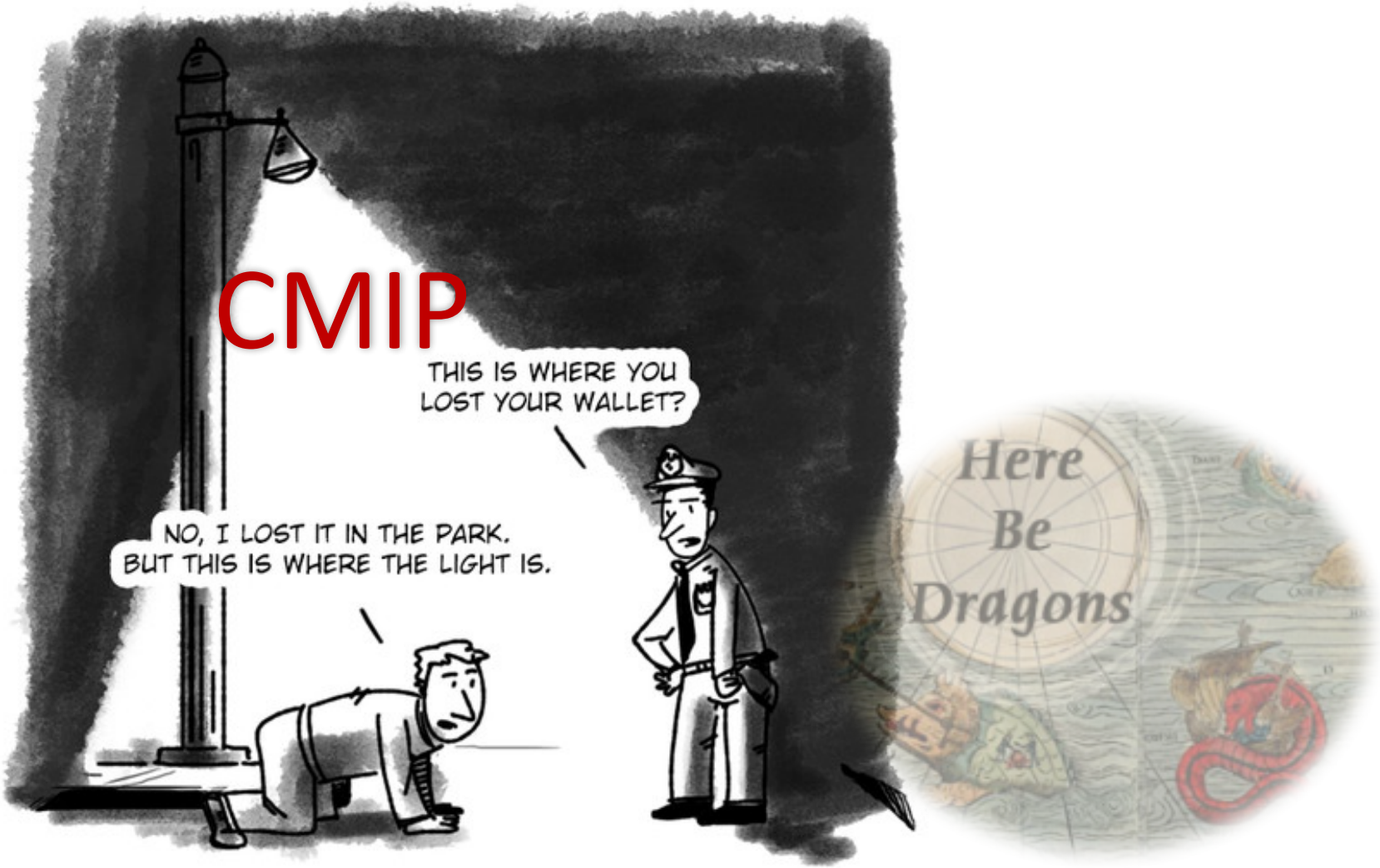
Climate sensitivity →

The urge to conform and be “realistic”



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The place of regional modeling in the hierarchy

Full global model		Full single column model
Simplified global model		Simplified single column model

The place of regional modeling in the hierarchy

Full global model	Full regional model	Full single column model
Simplified global model	Simplified regional model	Simplified single column model

- Practical difficulties in using regional models for *mechanistic* climate studies
  - Regional models have a "weather" pedigree
  - Atmosphere and ocean are not coupled
  - Parameterizations tend to be differ from climate model
    - ***A la carte vs. Set Menu (Windows PC vs. Mac)***

Questions

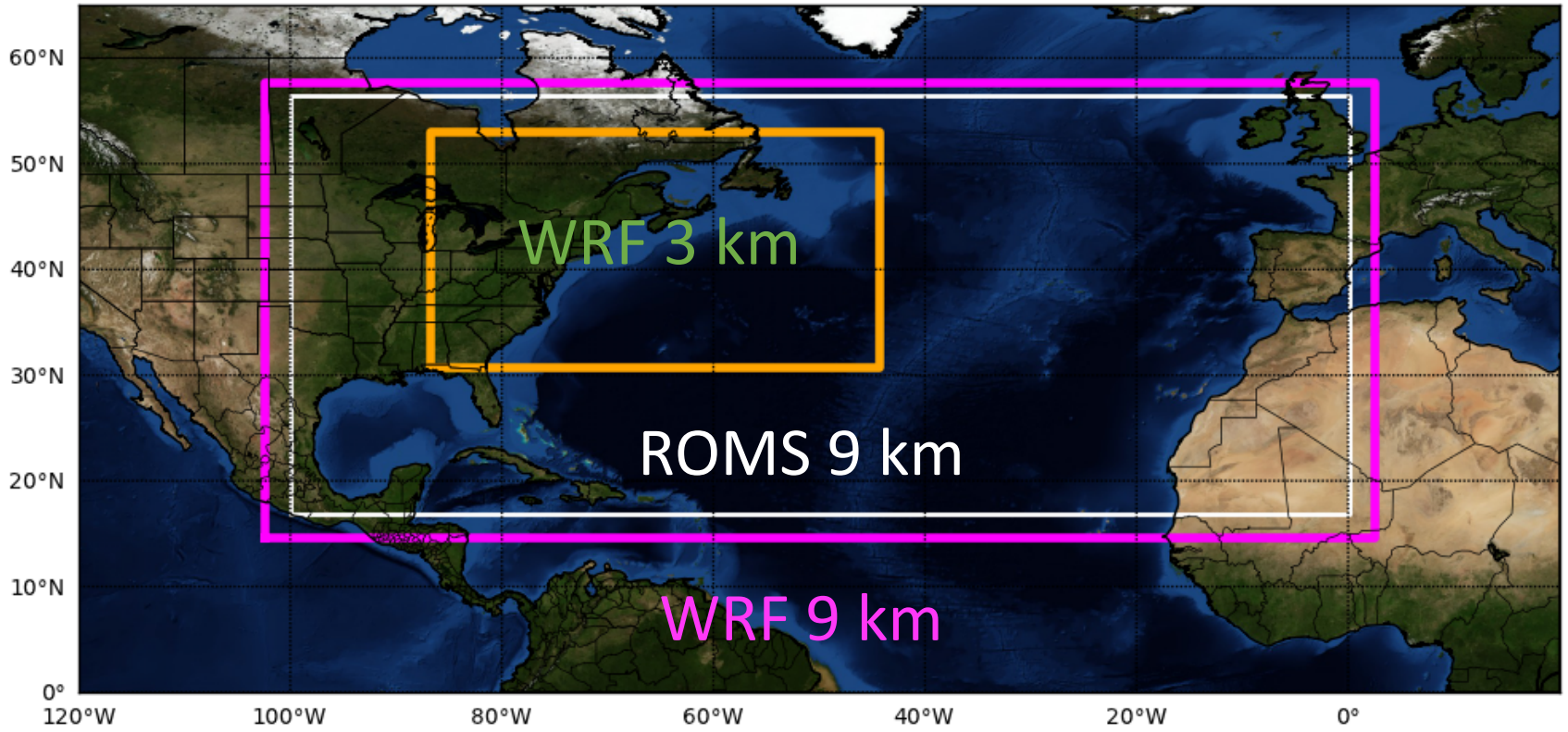
- Does “oceanic weather” affect atmospheric weather?
  - Ma. et al., *Scientific Reports, 2015*
- How do African Easterly Waves (AEW) affect hurricane genesis?
- How do EP and CP El Niños affect Atlantic hurricanes?
  - Patricola et al., *Nature Geoscience, 2015*
- Are midwest U.S. drought/flooding events caused by storms from the Pacific or by Atlantic SSTs?
  - Patricola et al., *Climatic Change, 2013*

À la carte vs. Set Menu

Whack-a-mole!

Coupled Regional Climate Model
WRF + ROMS

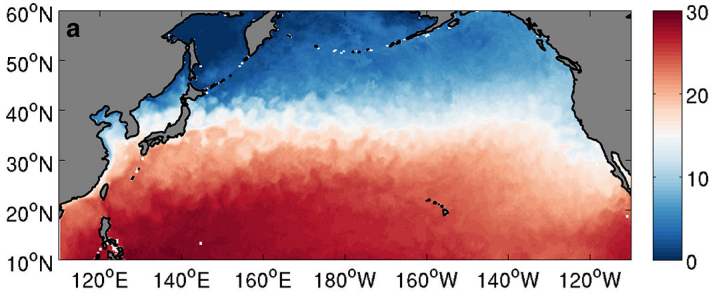
Sample domain



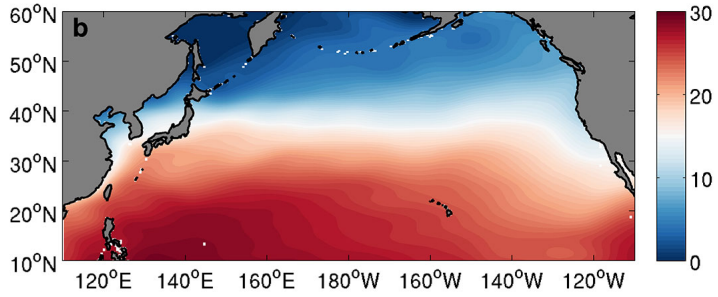
Does “oceanic weather” affect atmospheric weather?

Regional model with Unfiltered vs. Filtered SST

Observed SST (CTRL)



Loess-Filter Filtered SST (SMOOTH)



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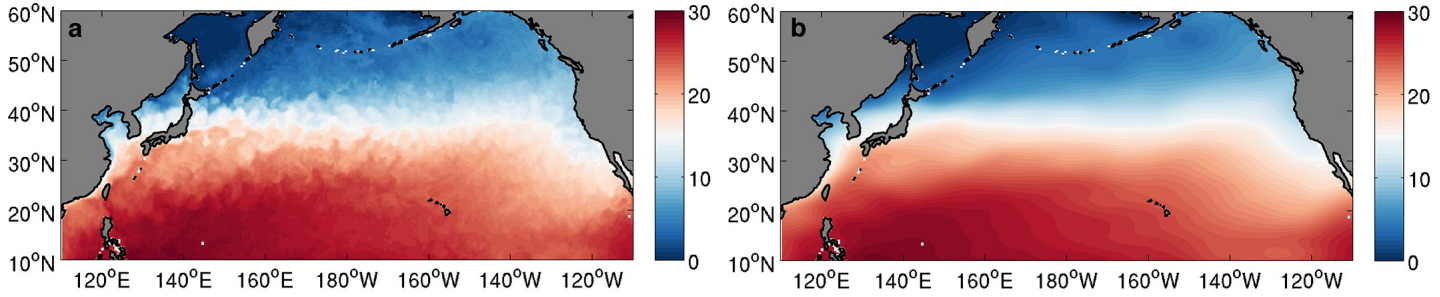
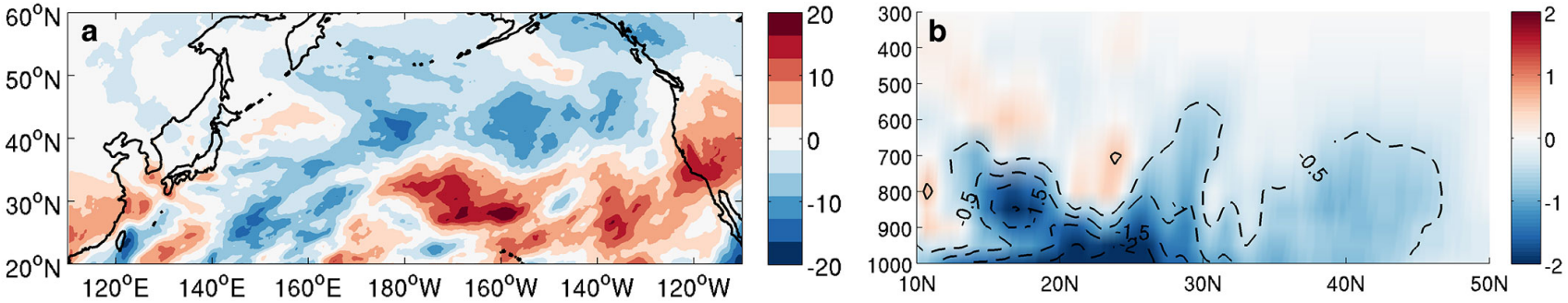
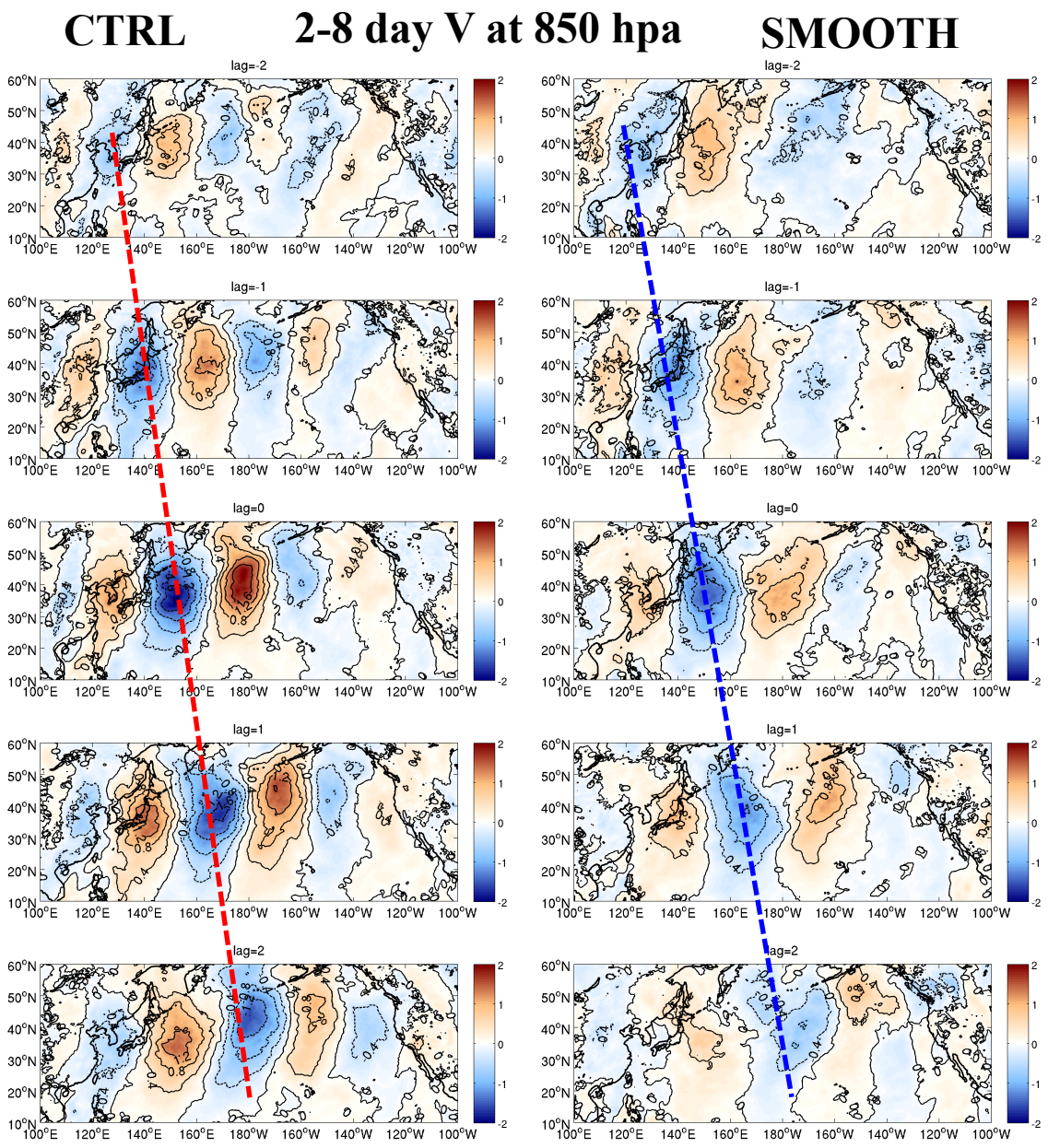


Water vapor mixing ratio (SMOOTH-CTRL)

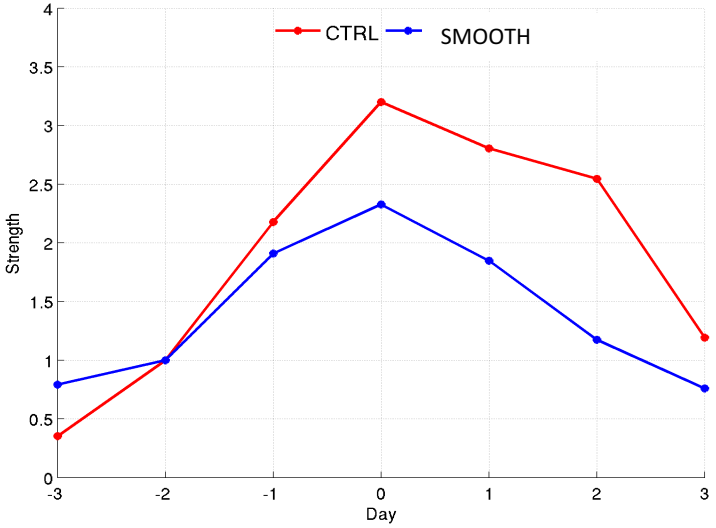


Ma, X. et al., 2015: Distant Influence of Kuroshio Eddies on North Pacific Weather Patterns? *Scientific Reports*

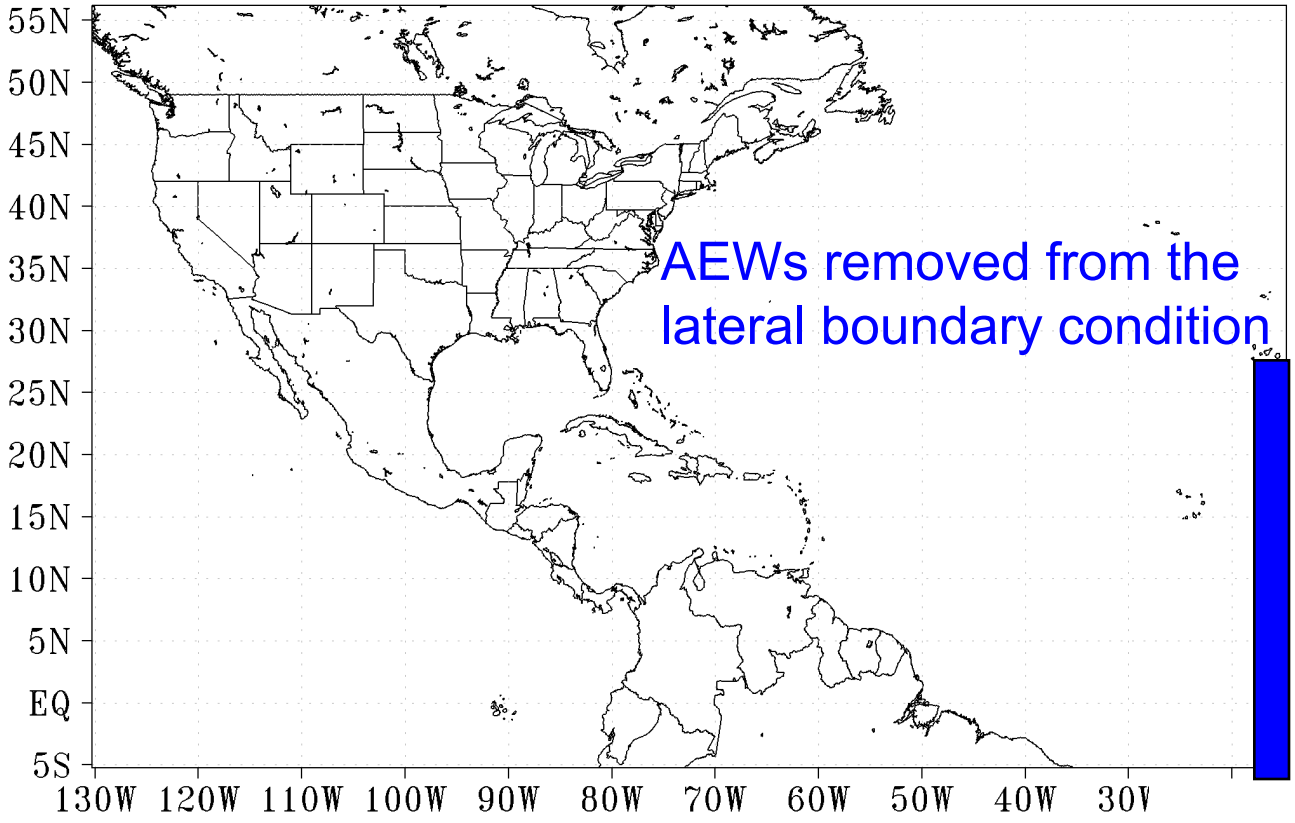
CTRL **2-8 day V at 850 hpa** **SMOOTH**



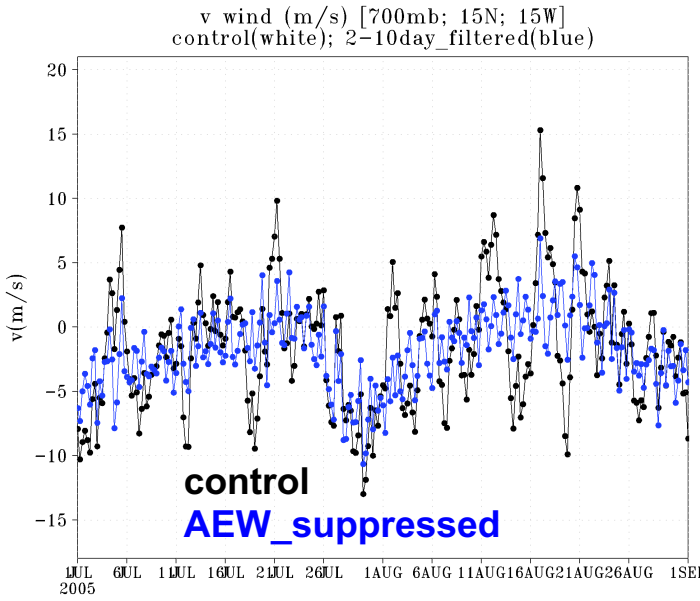
Storm Amplitude Evolution



Storms in MEFS decay more rapidly and exhibit longer zonal wave length compared to those in CTRL



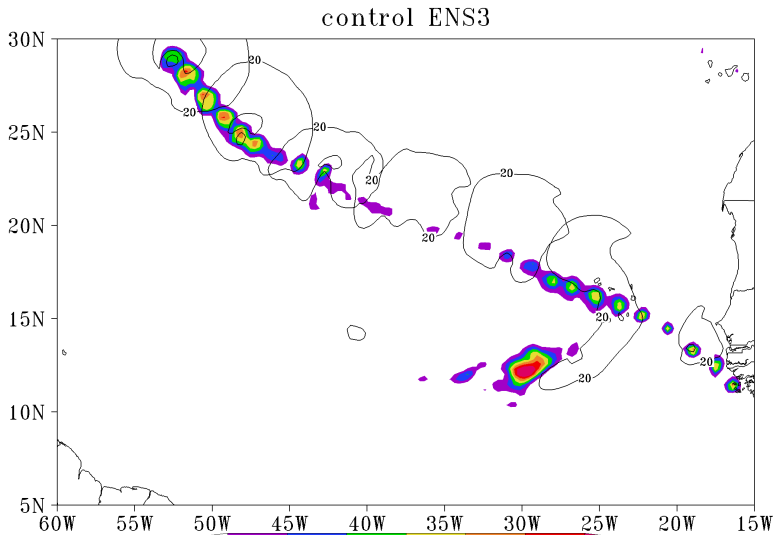
How do African Easterly Waves affect hurricane genesis?

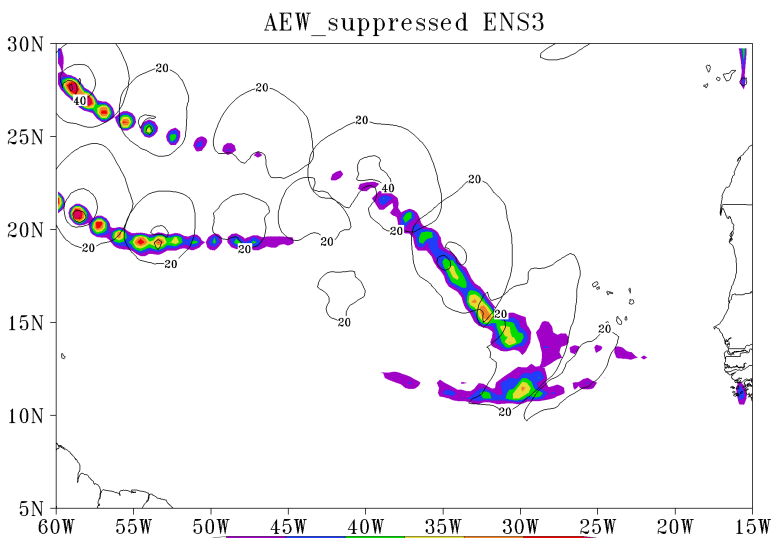


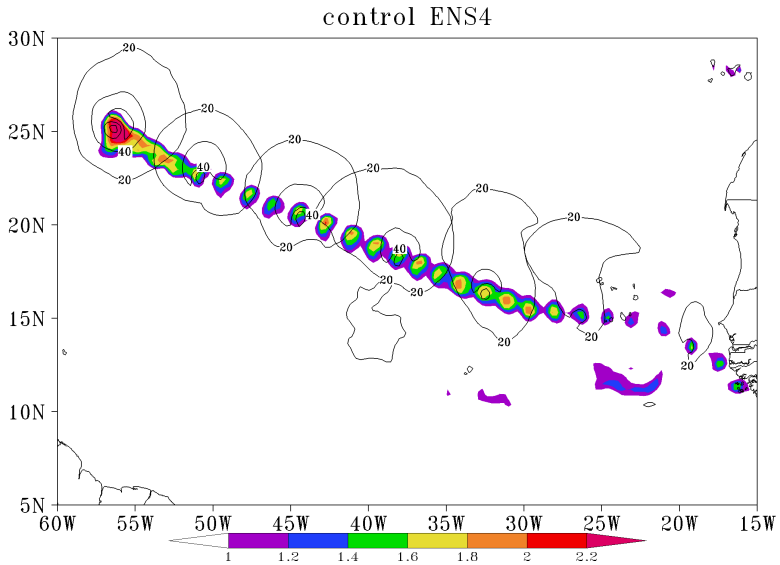
	control	AEW_ suppressed
Accumulated Cyclone Energy	168	192 [+15%]
Number of TCs	19.5	20.2 [+4%]
Number of category 2+	3.1	4.3 [+39%]
Number of TC days	105	117 [+11%]

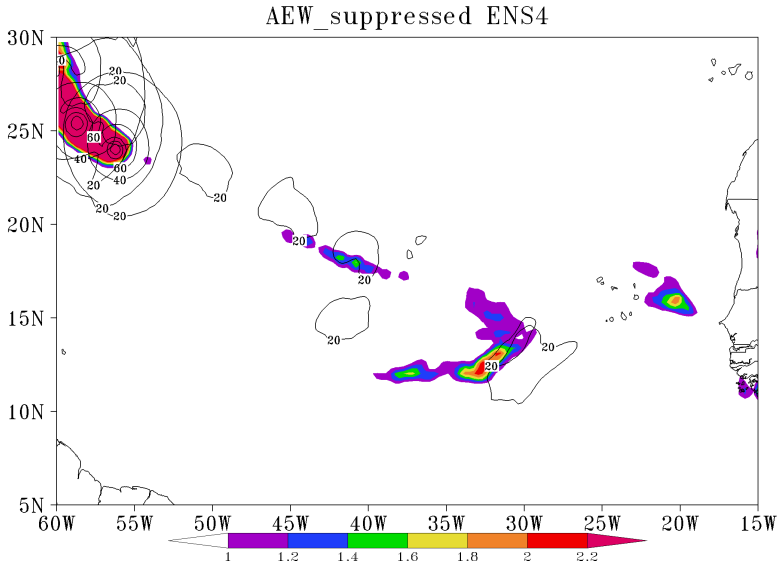
Simulated hurricane tracks

Control **vs.** **AEW_suppressed**



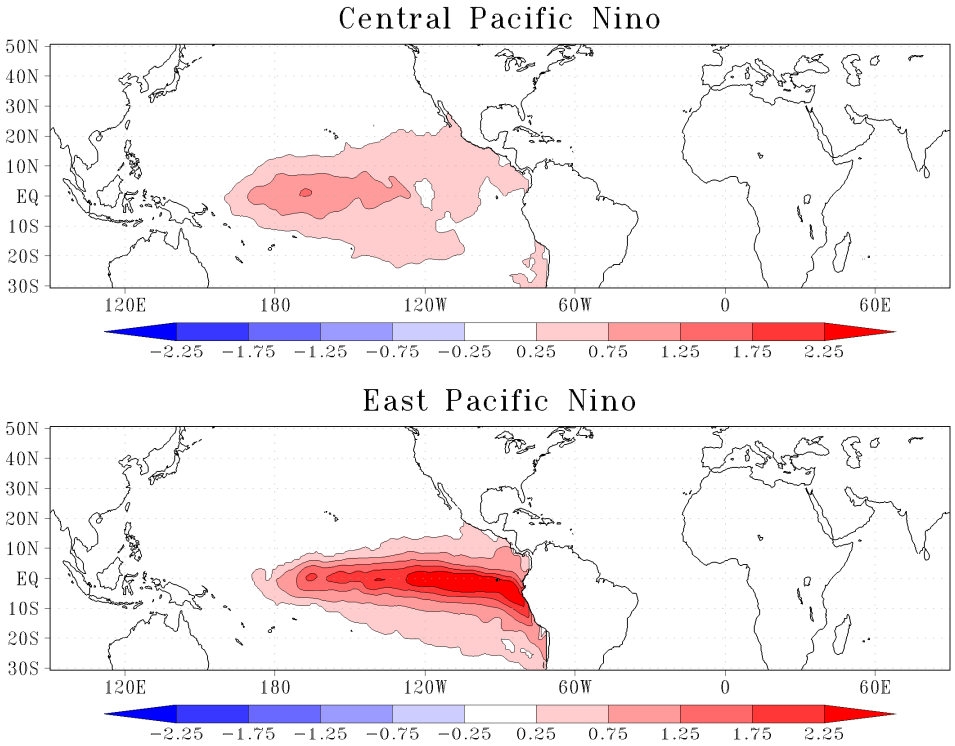




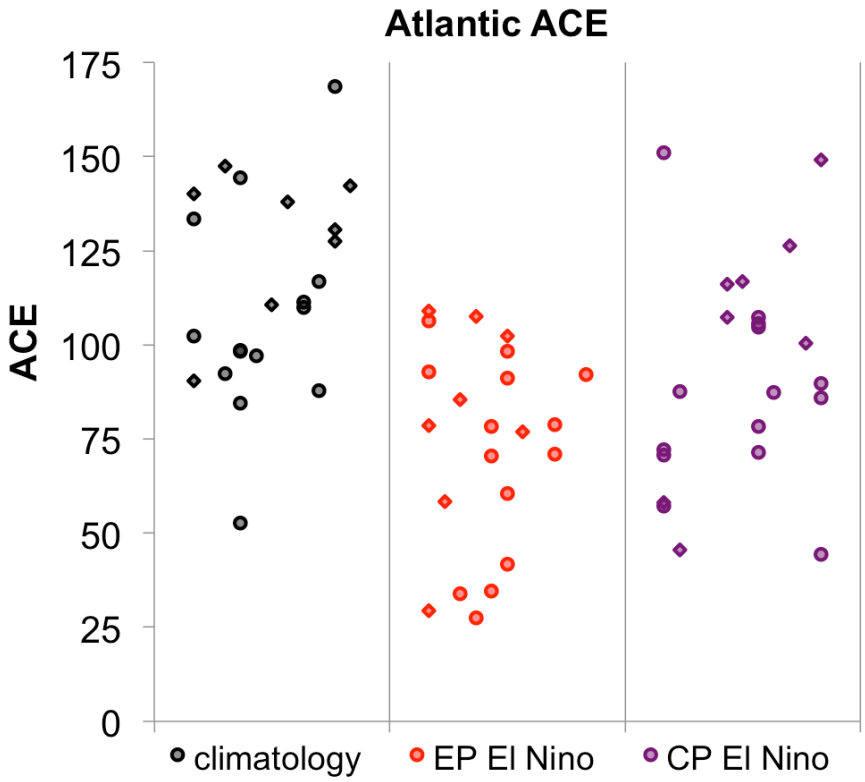


How do CP and EP El Niño affect Atlantic hurricanes?

SST forcings



Atlantic hurricane response to East and Central Pacific El Niño



Large stochastic variability among ensemble members

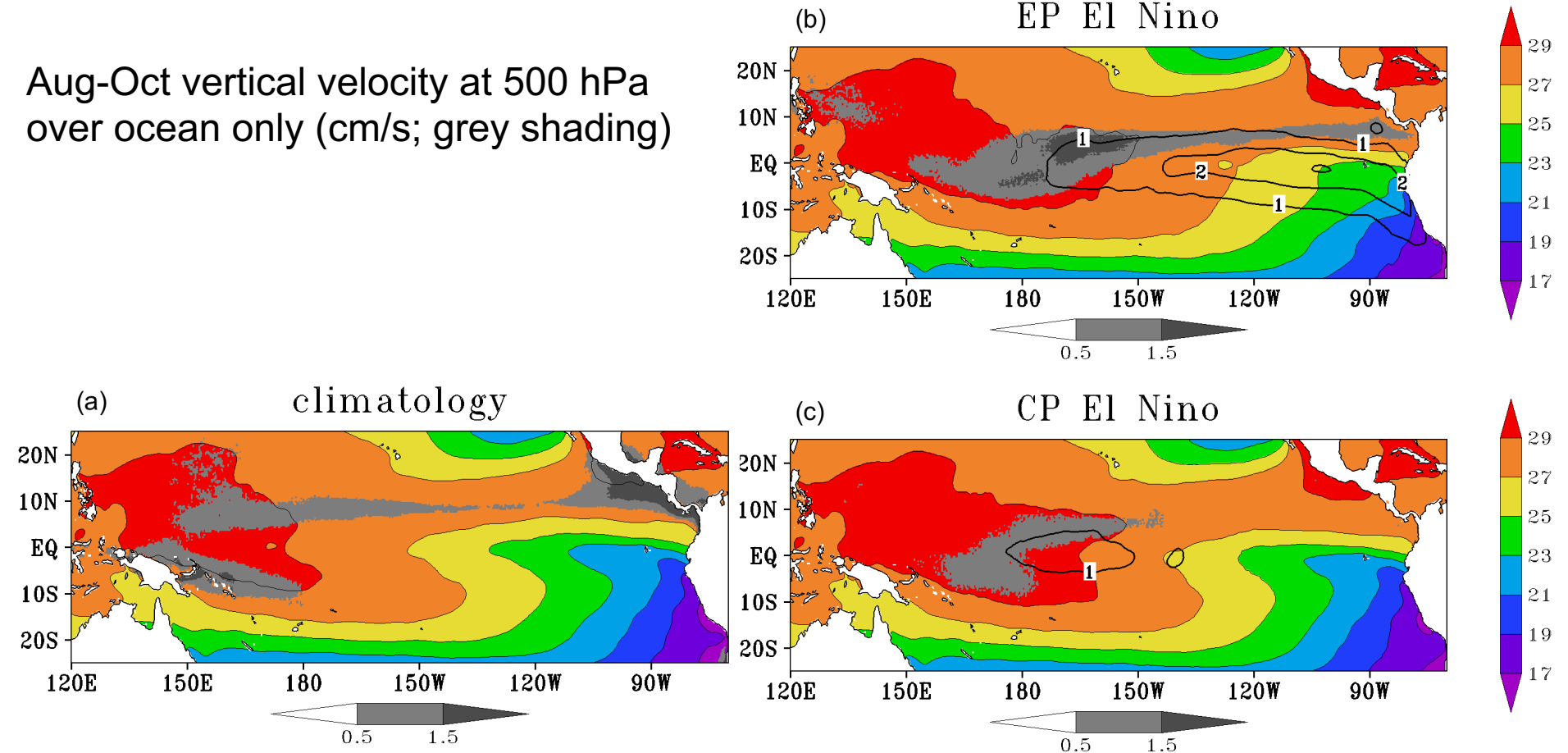
Seasonal (1 June – 1 December) Accumulated Cyclone Energy (10^4 knots^2)

Patricola et al., 2015: Degree of simulated suppression of Atlantic tropical cyclones modulated by flavour of El Niño, *Nature Geoscience*

SST threshold for deep convection

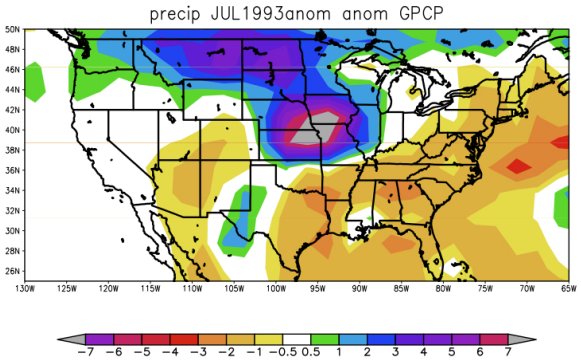
The Pacific SST warming in both El Nino types is sufficient to satisfy the threshold for tropical Pacific deep convection, leading to an eastward shift in convection.

Aug-Oct vertical velocity at 500 hPa over ocean only (cm/s; grey shading)

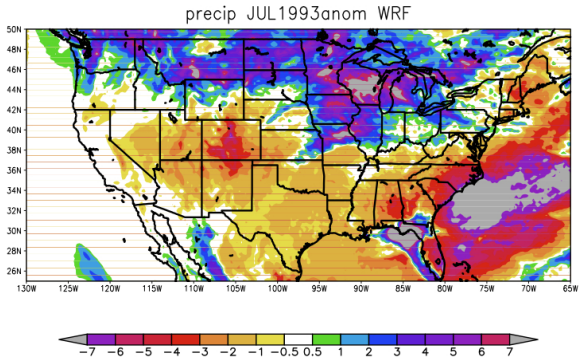


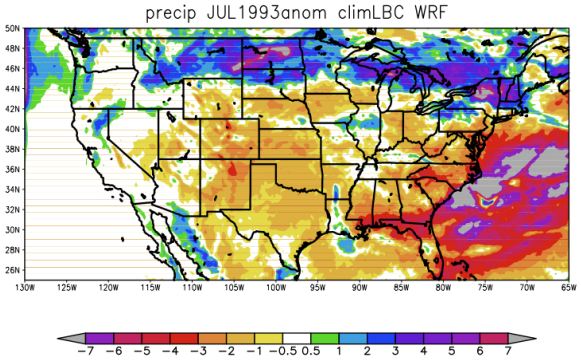
Effect of b.c. on precipitation anomalies: Midwest flood of 1993

GPCP (OBS)

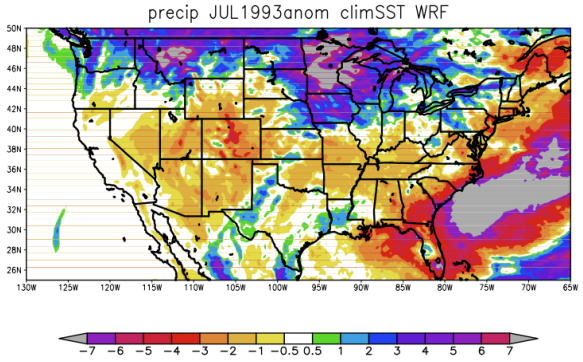


WRF (Observed BC)





Climatological Lateral BC



Climatological SST

Patricola et al., 2013: Impact of Atlantic SST and high frequency atmospheric variability on the 1993 and 2008 Midwest floods: Regional climate model simulations of extreme climate events. *Climatic Change*.

Tradeoffs in using regional models for mechanistic studies

- Pros:
  - Increased resolution
  - Control “noise”, i.e., external variability
  - Control upstream boundary conditions
- Cons
  - Difficult to set up in a manner consistent with global model
  - May underestimate “noise”
  - Boundary distortion

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~~Democracy~~ Using climate models is the worst form of ~~government~~ prediction, except for all the others.

Intro climate change course survey:

What topics do you find most difficult?

- ALL THE MATH
- Any math
- anything with math
- Climate Sensitivity, Radioactive Forcing
- Feedback
- Feedback math
- Forcing calculations
- Math
- Math
- Positive and negative feedback
- Radiative forcing
- …