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ROSENSTIEL SCHOOL of MARINE & ATMOSPHERIC SCIENCE

Predicting Environmental Hazards: Where Data Science and Computing Meet

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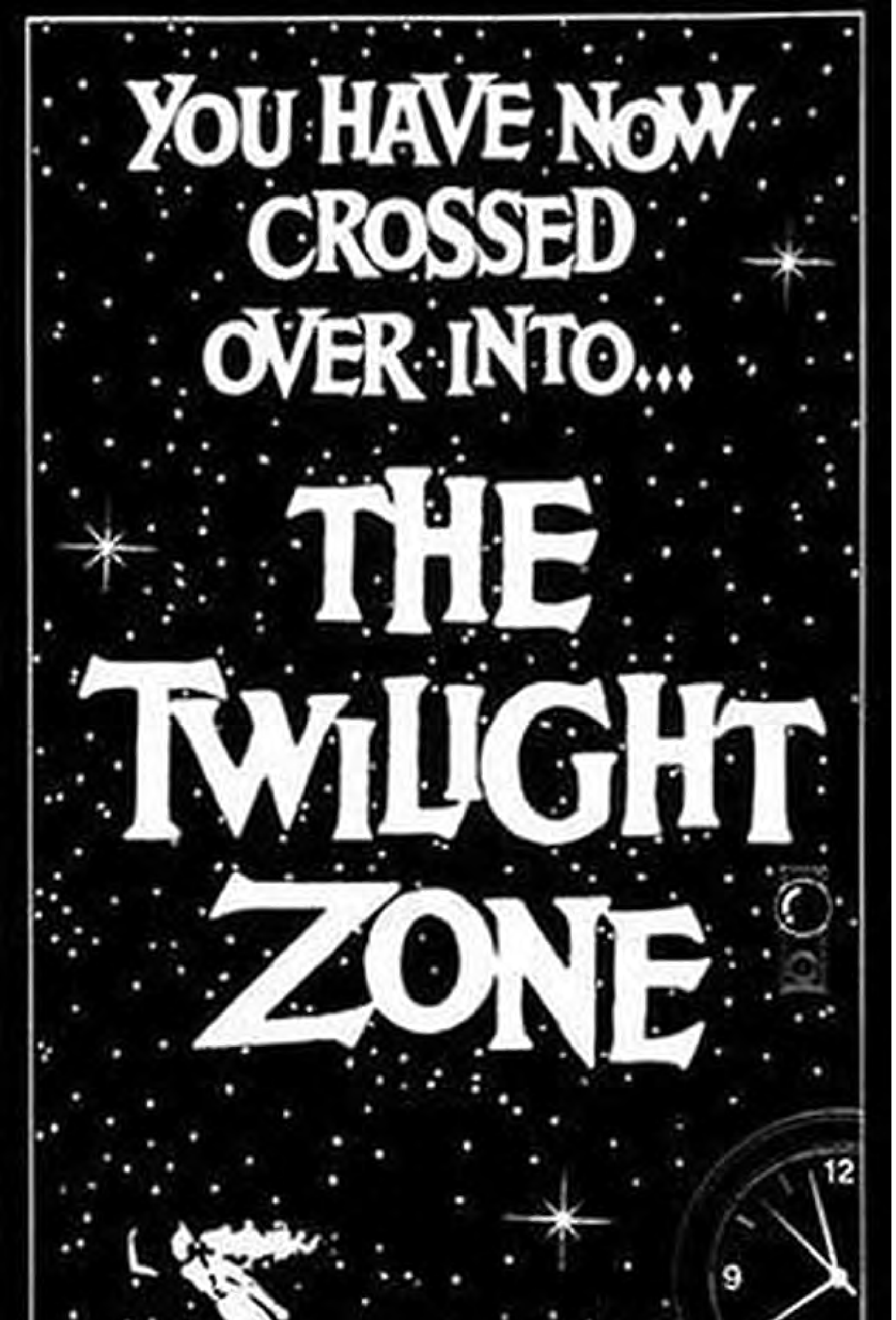

How Did I Get Here

- **The Twilight Zone**
- **Basement Flooding**
- **Applied Mathematics: Trying to Do Something Good**
- **Predicting Hazards**

How Did I Get Here

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Predicting Environmental Hazards: Where Data Science and Computing Meet

- The Challenge
- Predicting Across Time Scales
  - Wx – Sub-seasonal – Seasonal – Multi-year – Decadal
- Disruptors
  - Advances in Computing Power
  - Data Science Innovation

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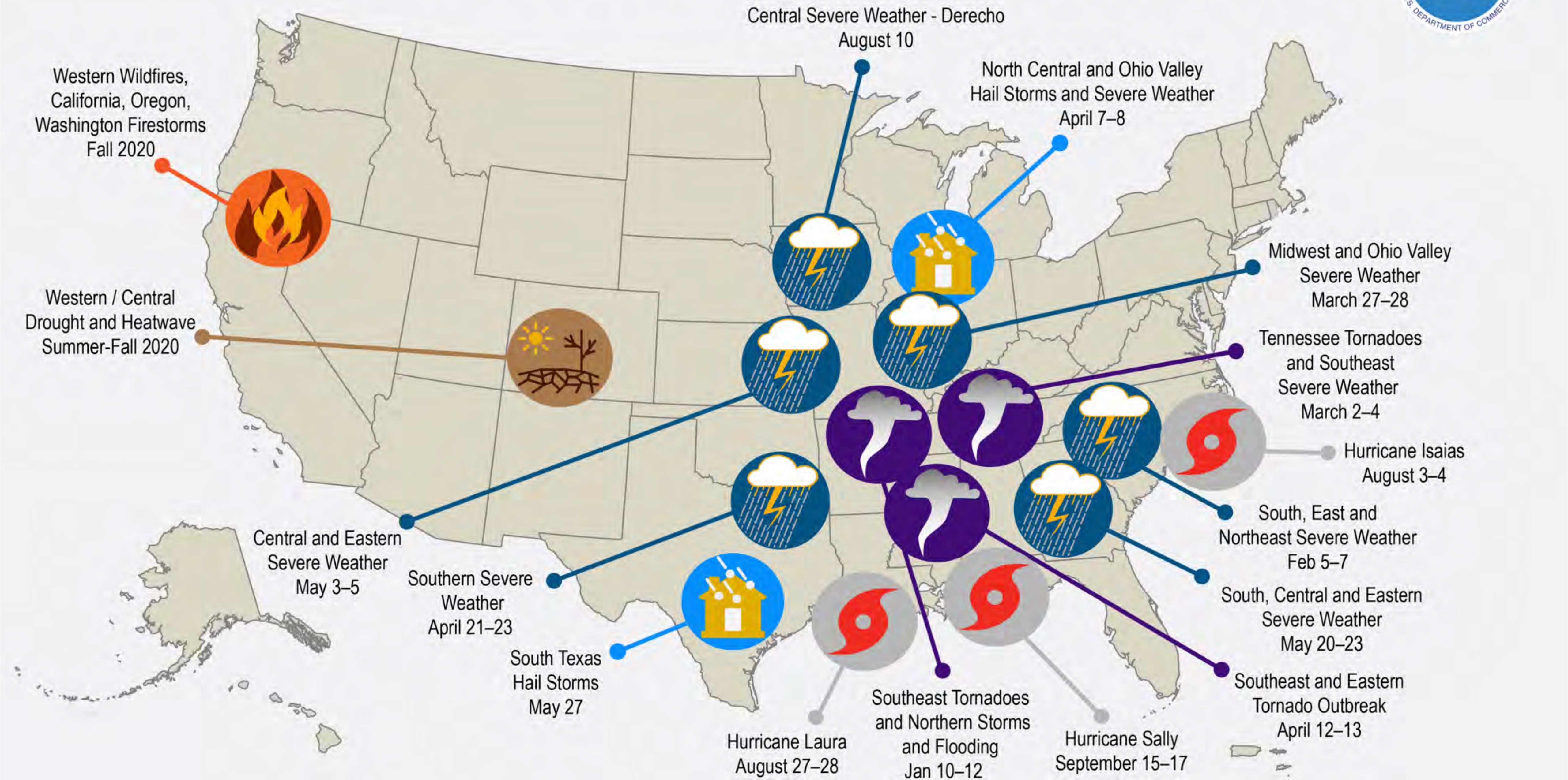
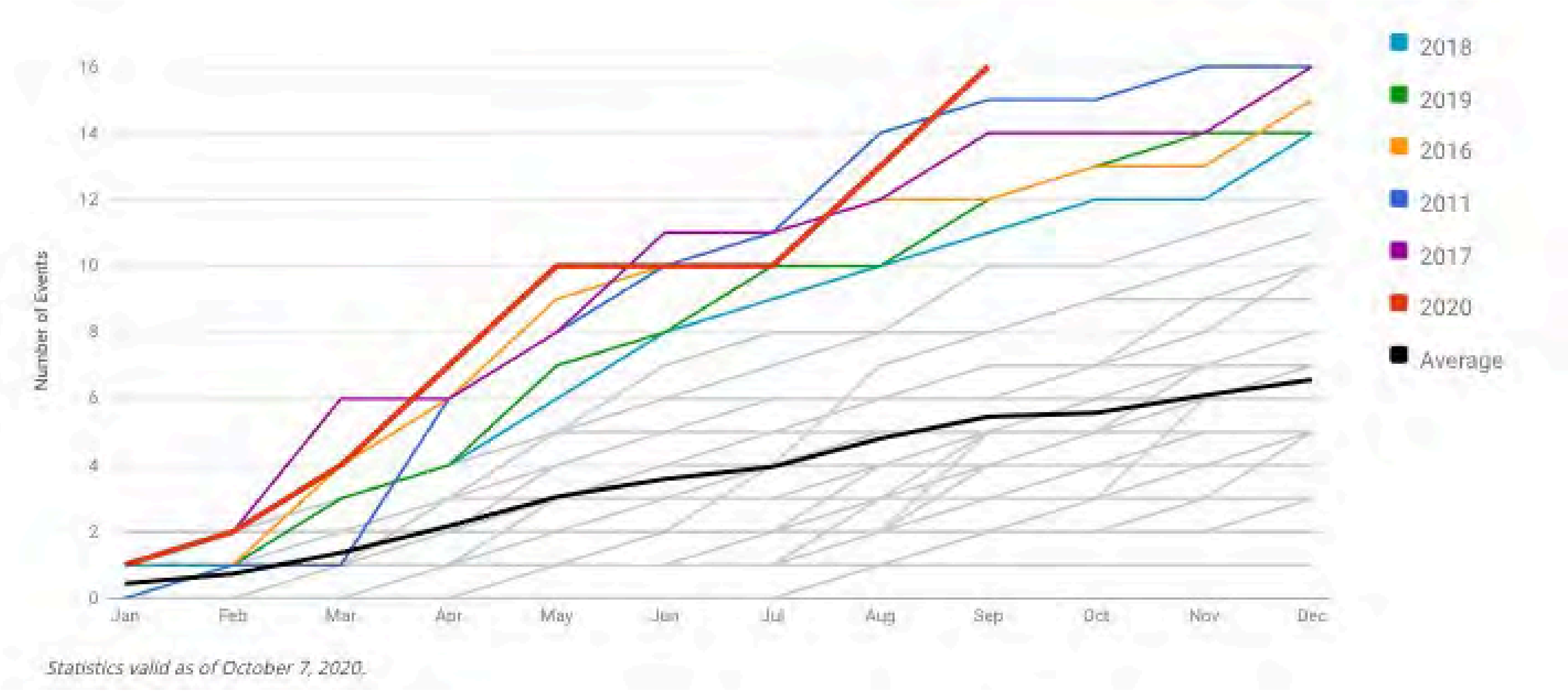
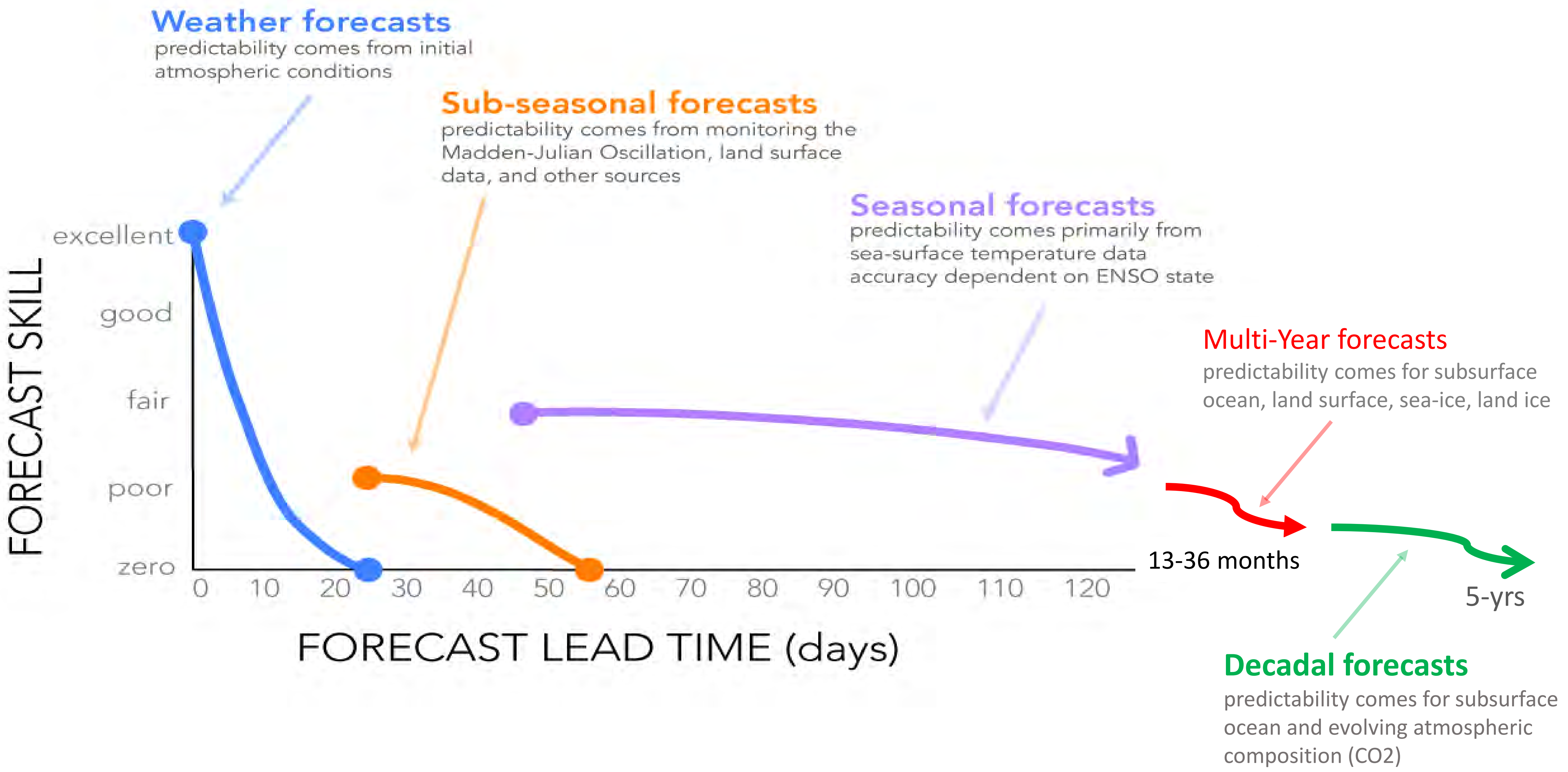
U.S. 2020 Billion-Dollar Weather and Climate Disasters



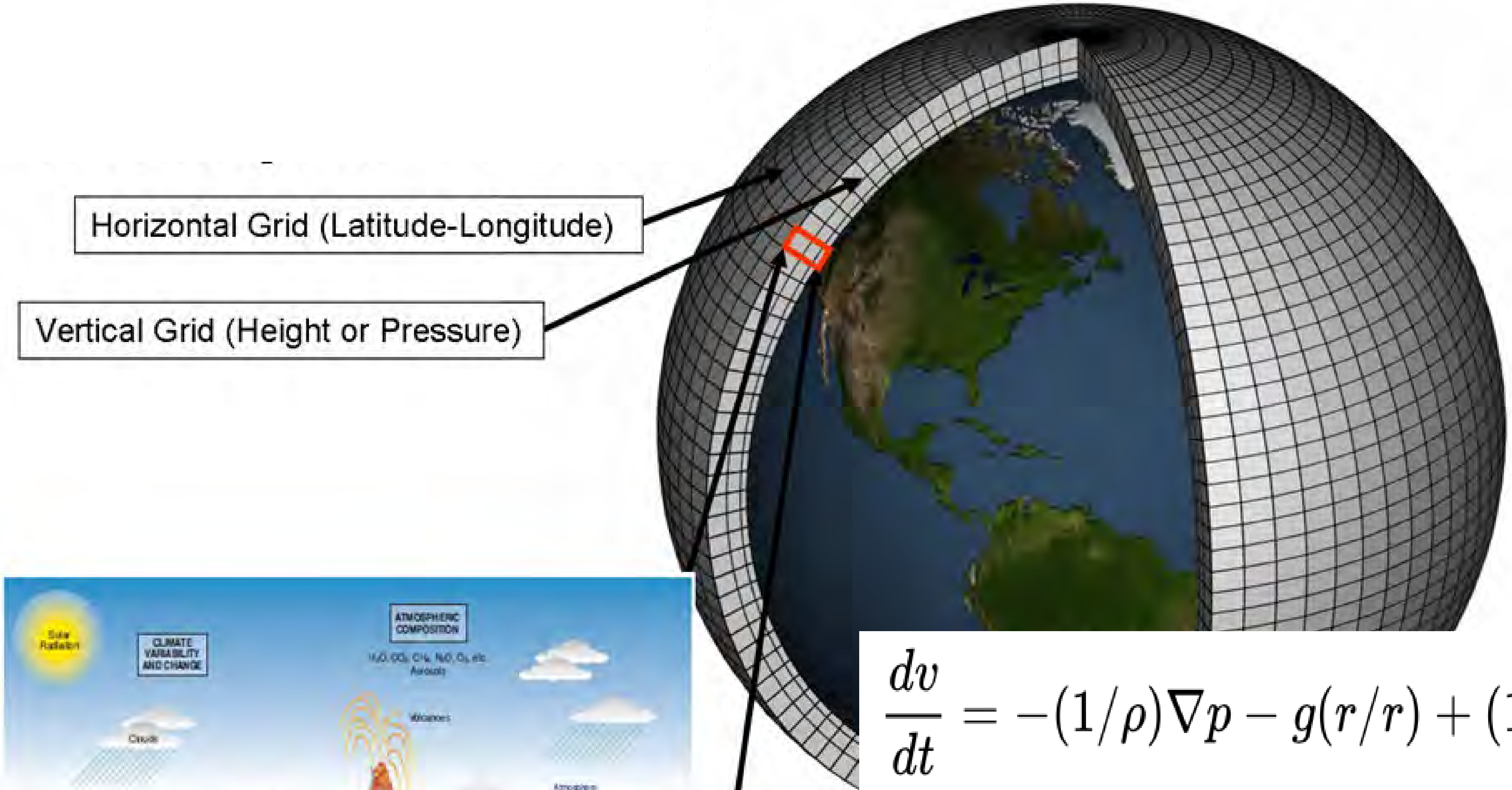
1980-2020 Year-to-Date Billion Dollar Disaster Events

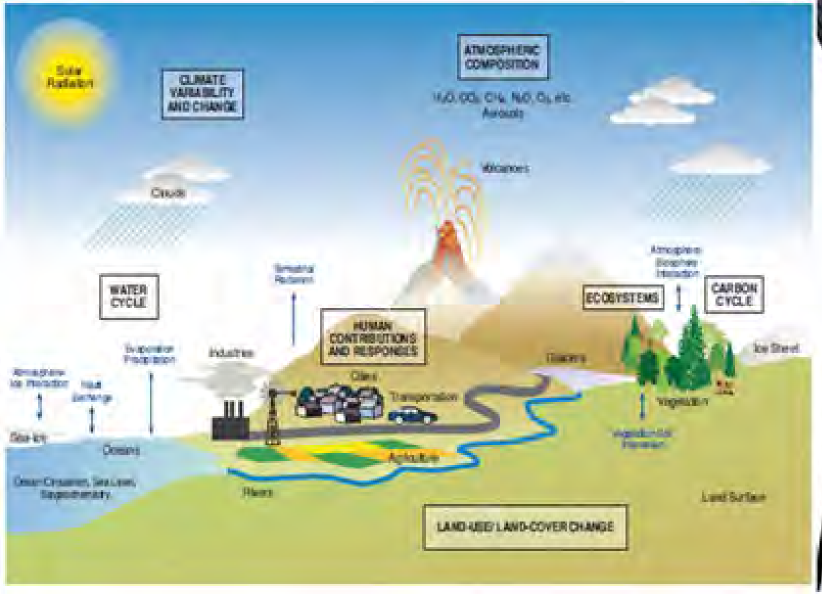


Prediction Across Time-Scales



Weather and Climate Model





$$\frac{dv}{dt} = -(1/\rho)\nabla p - g(r/r) + (1/\rho)\left[\nabla \cdot (\mu \nabla v) + \nabla(\lambda \nabla \cdot v)\right]$$

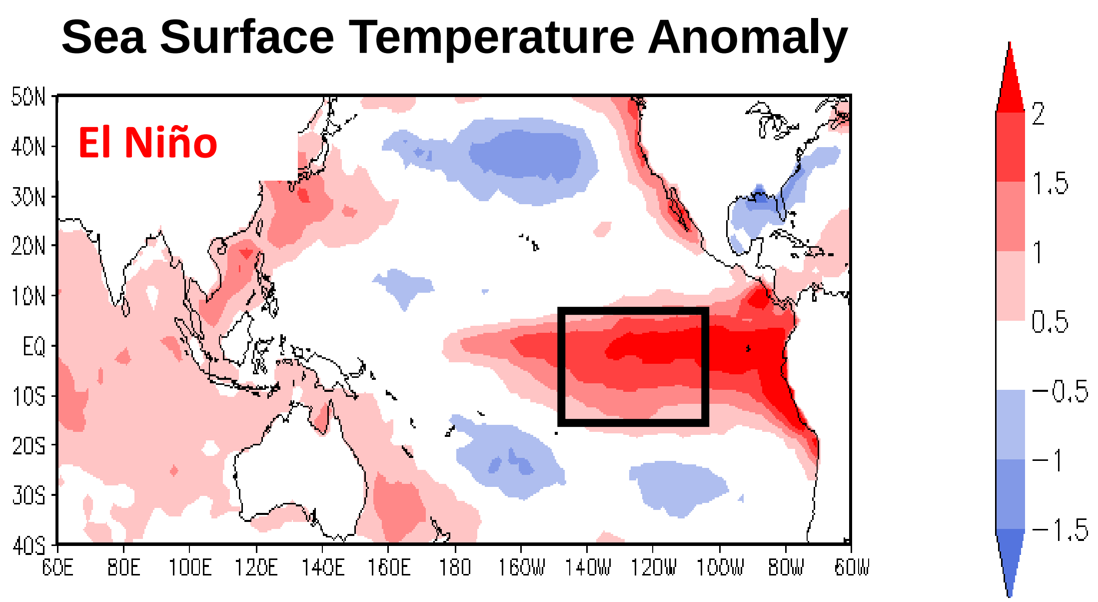
$$c_v \frac{dT}{dt} + p\frac{d\alpha}{dt} = q + f$$

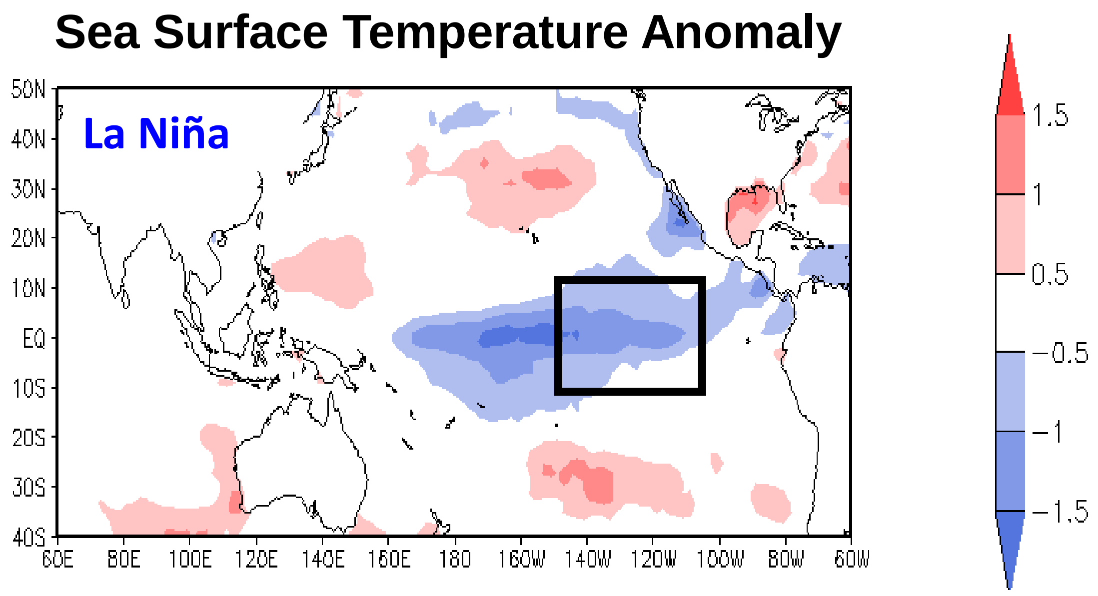
$$\frac{d\rho}{dt} + \rho \nabla \cdot v = 0$$

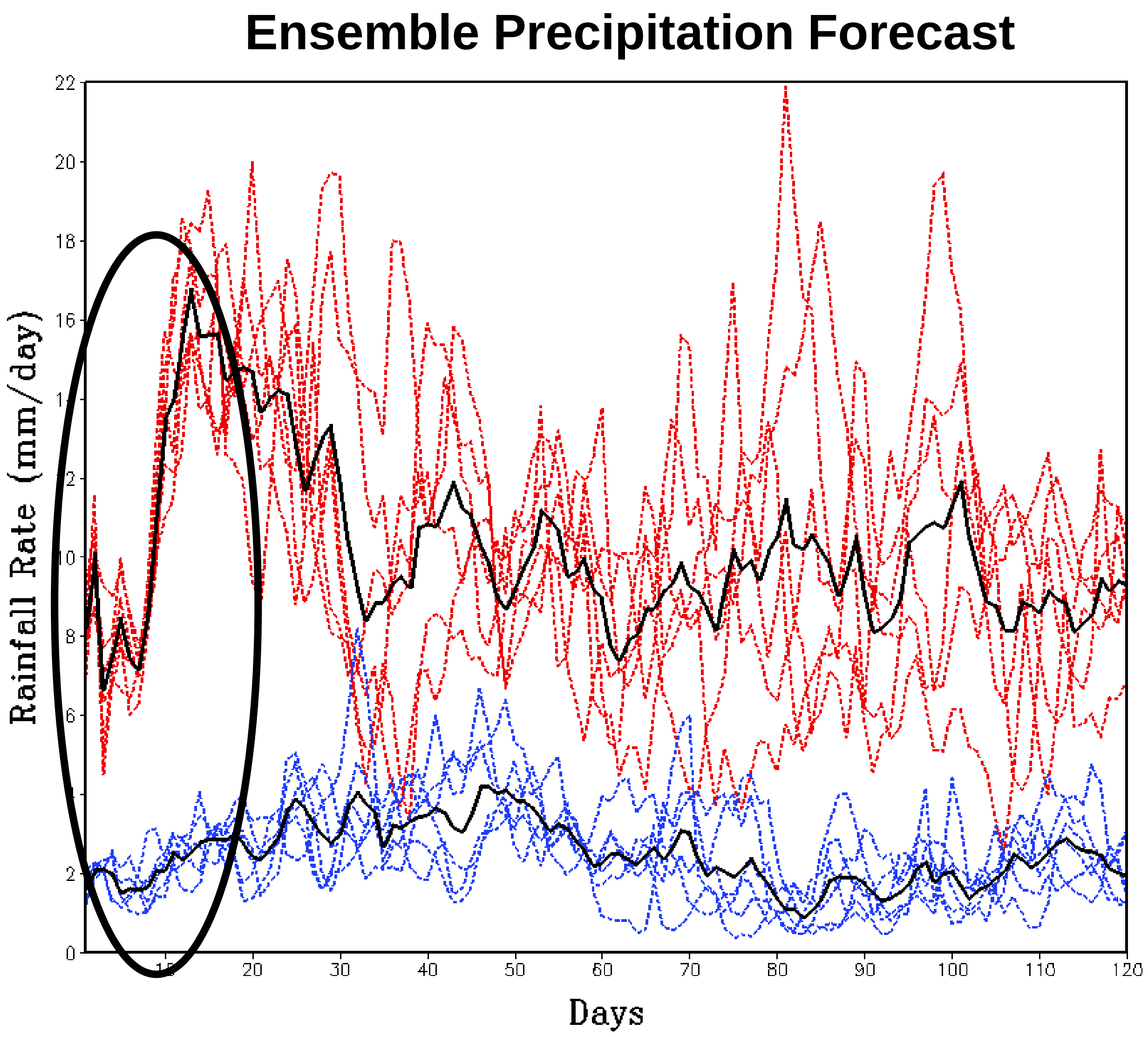
$$p = \rho R T.$$

Just the Atmosphere

Ex: Seasonal Forecasts







Near-term Climate Change: Projections and Predictability

Coordinating Lead Authors:
Ben Kirtman (USA), Scott B. Power (Australia)

Lead Authors:
Akintayo John Adedoyin (Botswana), George J. Boer (Canada), Roxana Bojariu (Romania), Ines Camilloni (Argentina), Francisco Doblas-Reyes (Spain), Arlene M. Fiore (USA), Masahide Kimoto (Japan), Gerald Meehl (USA), Michael Prather (USA), Abdoulaye Sarr (Senegal), Christoph Schär (Switzerland), Rowan Sutton (UK), Geert Jan van Oldenborgh (Netherlands), Gabriel Vecchi (USA), Hui-Jun Wang (China)

Contributing Authors:
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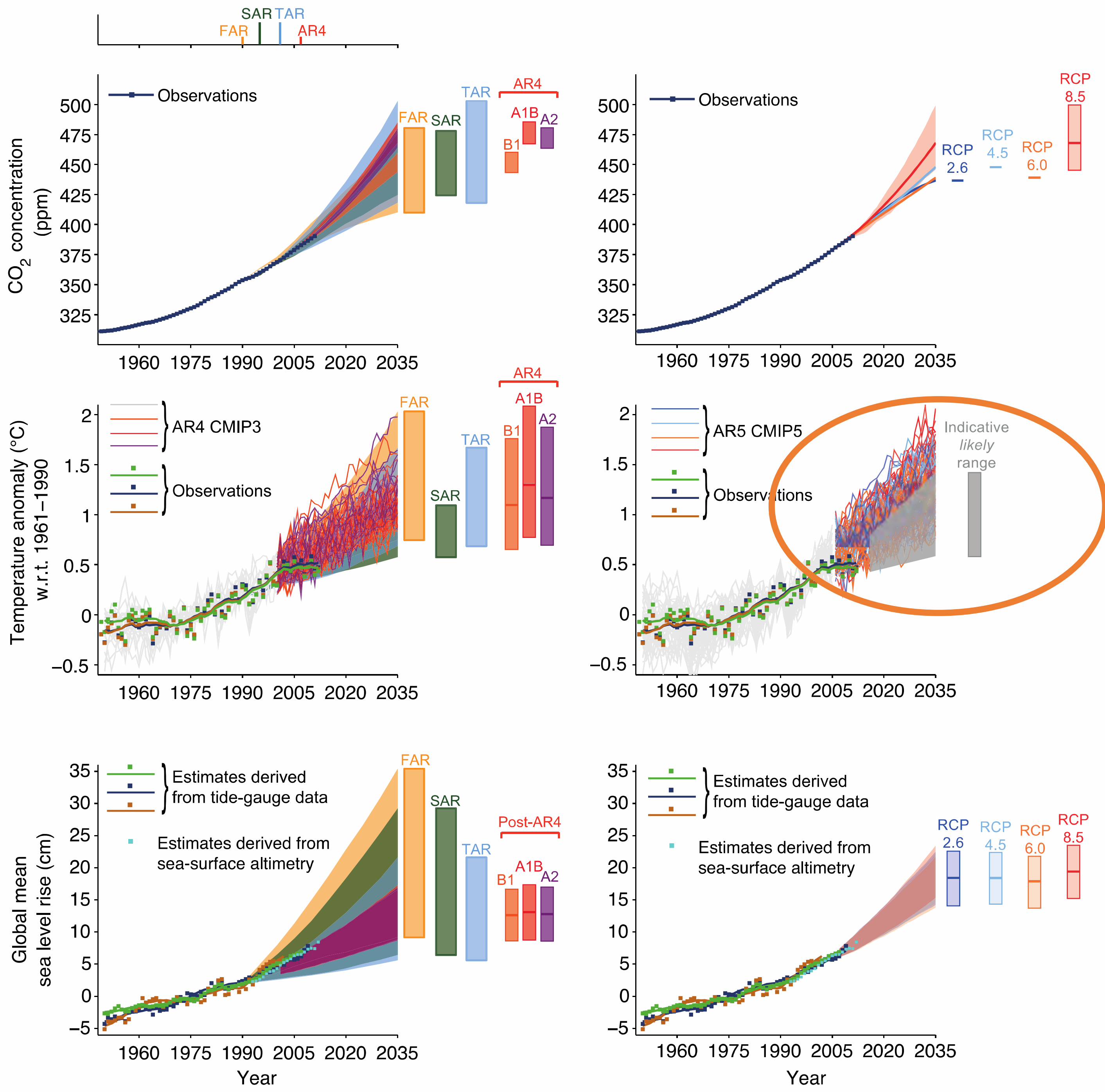

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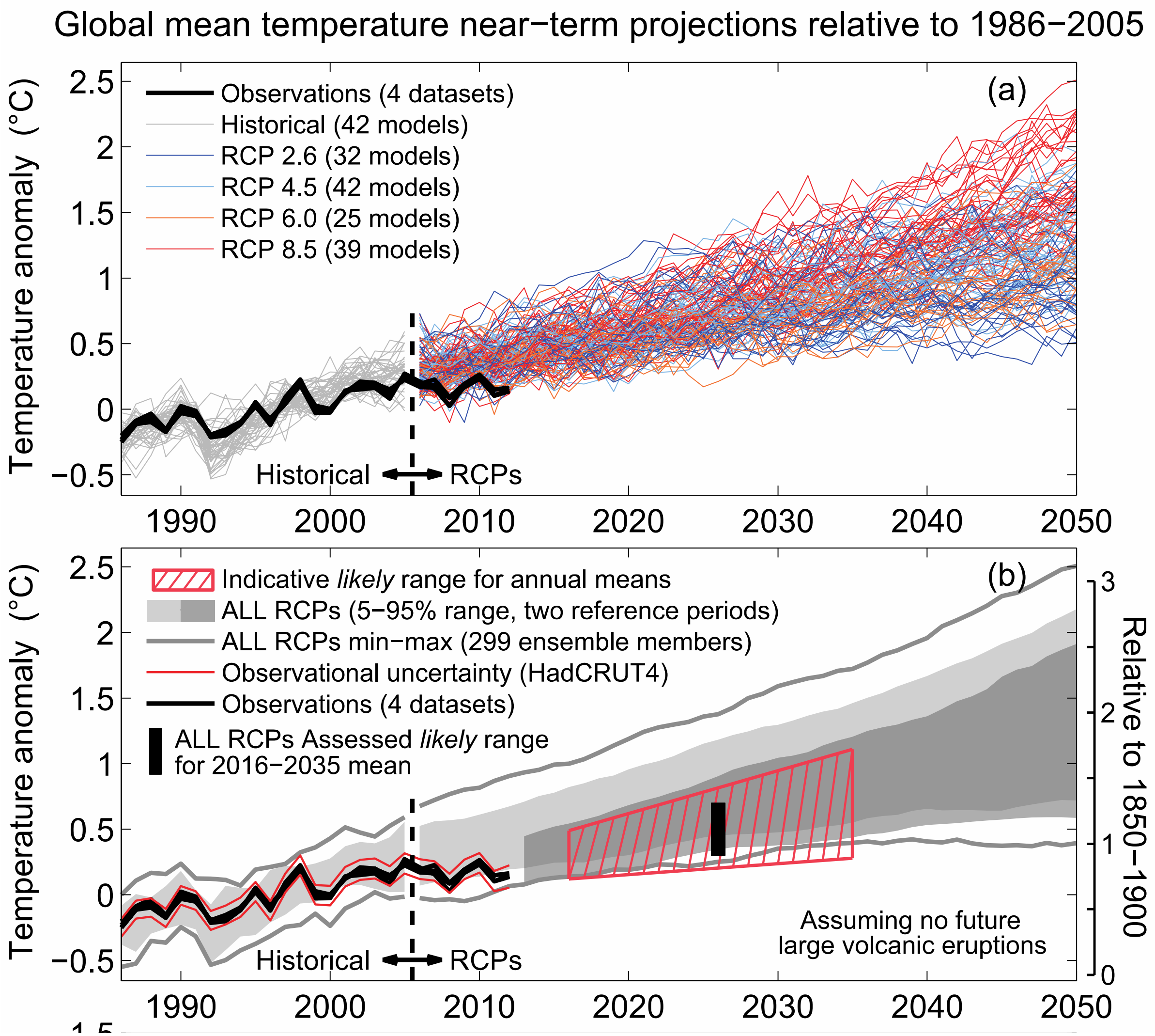
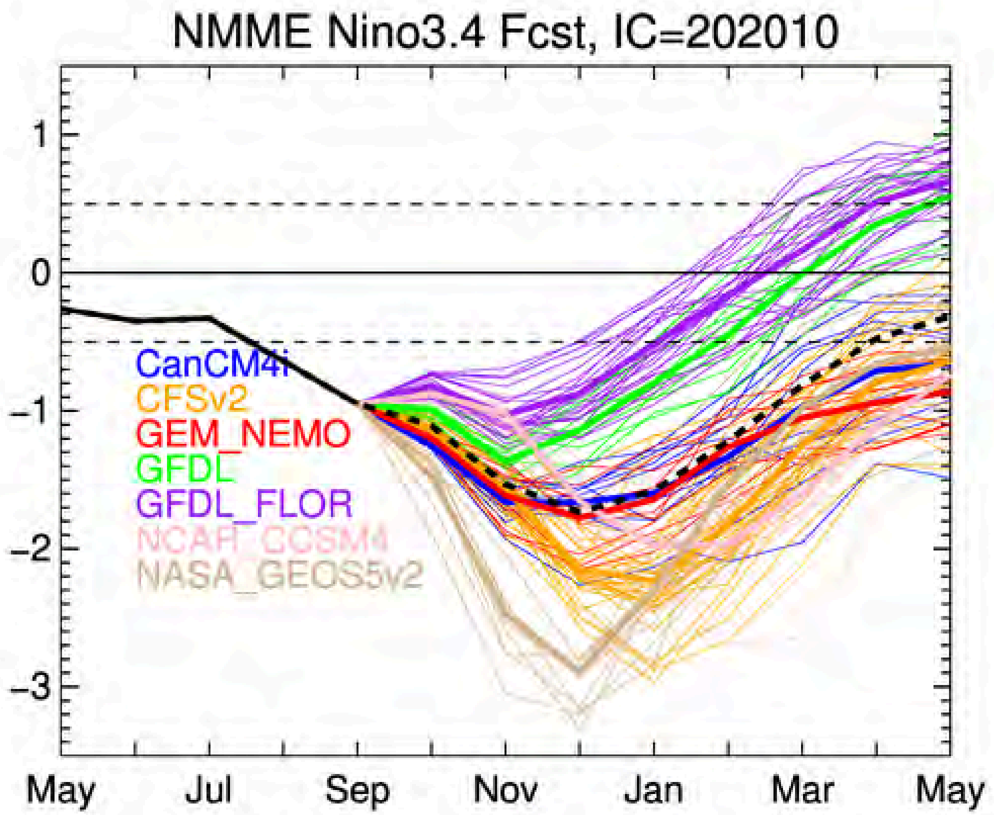


Predicting Seasonal Environmental Hazards



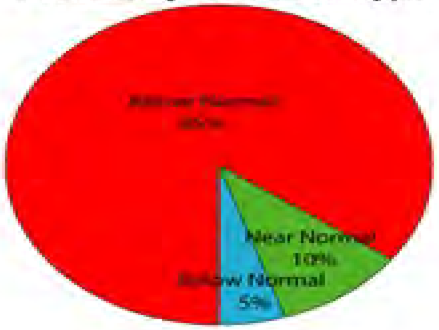
UM Leads a Multi-Agency, Multi-Institutional Effort to Improve NOAA Seasonal Operational Forecasts (2015)

NOAA's Updated 2020 Atlantic Hurricane Season Outlook

Updated Outlook

Above-Normal to Extremely Active

Probability of Season Type



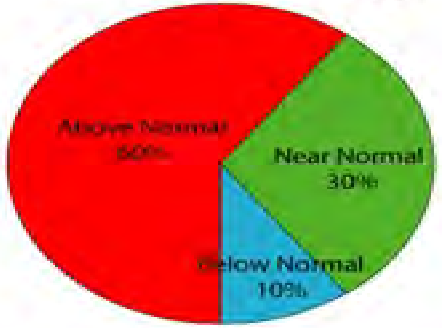
70% Probability For Each Range

August Update	
Named Storms	19-25
Hurricanes	7-11
Major Hurricanes	3-6
ACE (% median)	140%-230%

Outlook Issued 21 May

Above-Normal Activity Most Likely

Probability of Season Type



70% Probability For Each Range

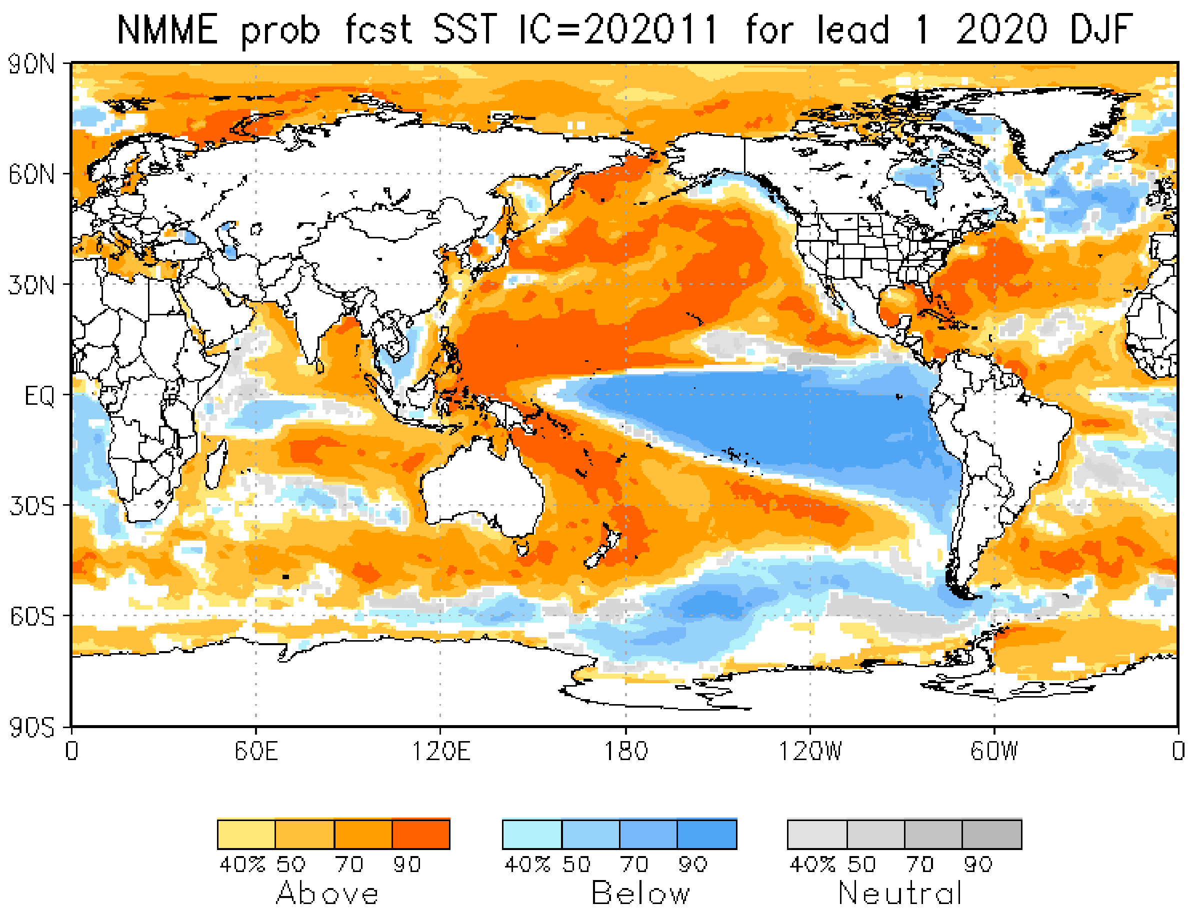
	May Outlook
Named Storms	13-19
Hurricanes	6-10
Major Hurricanes	3-6
ACE (% median)	110%-190%

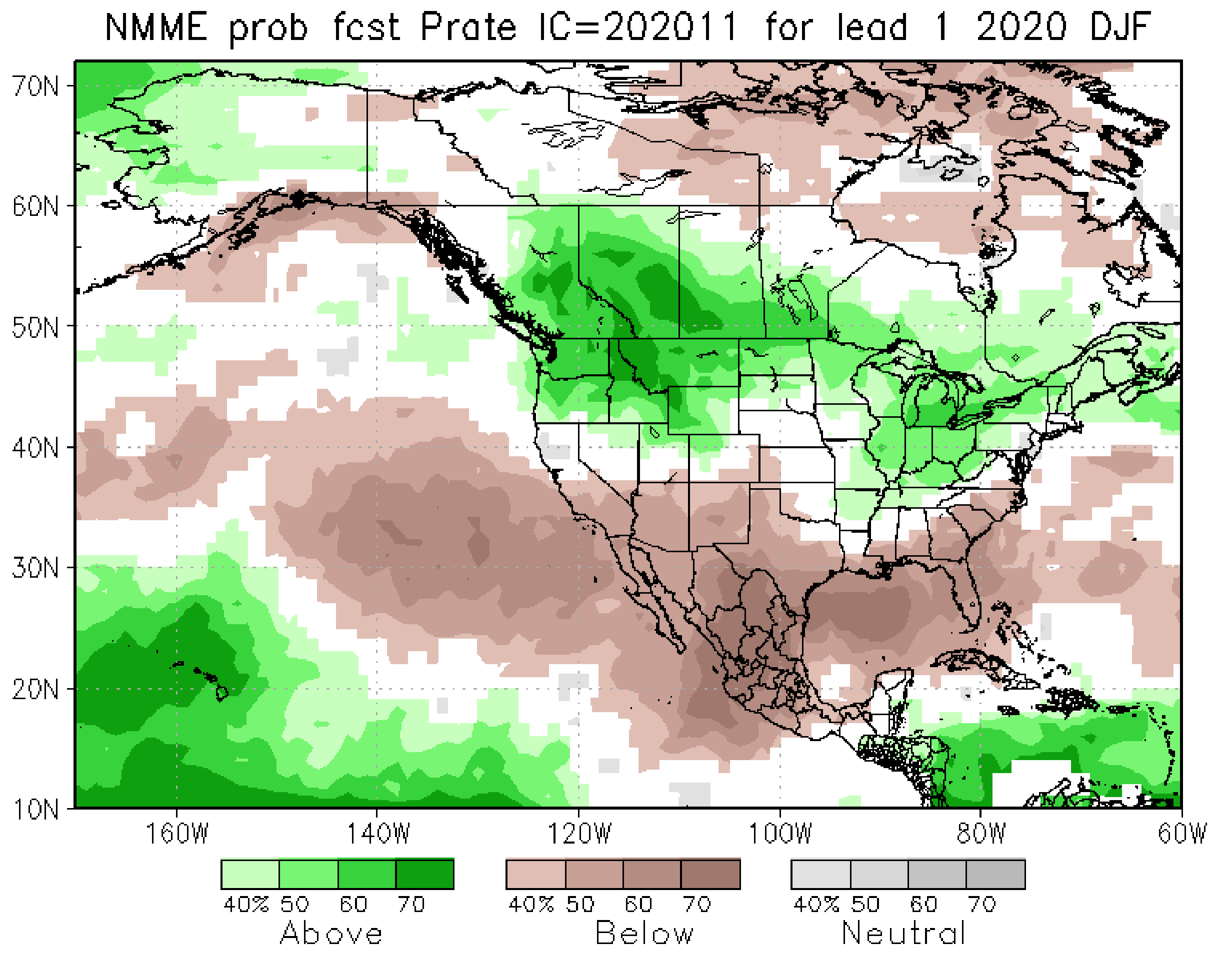
1981-2010 Averages

Named Storms	12
Hurricanes	6
Major Hurricanes	3
ACE (% median)	100%

(Left) An above-normal Atlantic hurricane season is now very likely (85% chance), and the potential for an extremely active season (ACE $\geq$ 165% of median) has increased from the May outlook (Right)

NMME Operational Seasonal Forecasts





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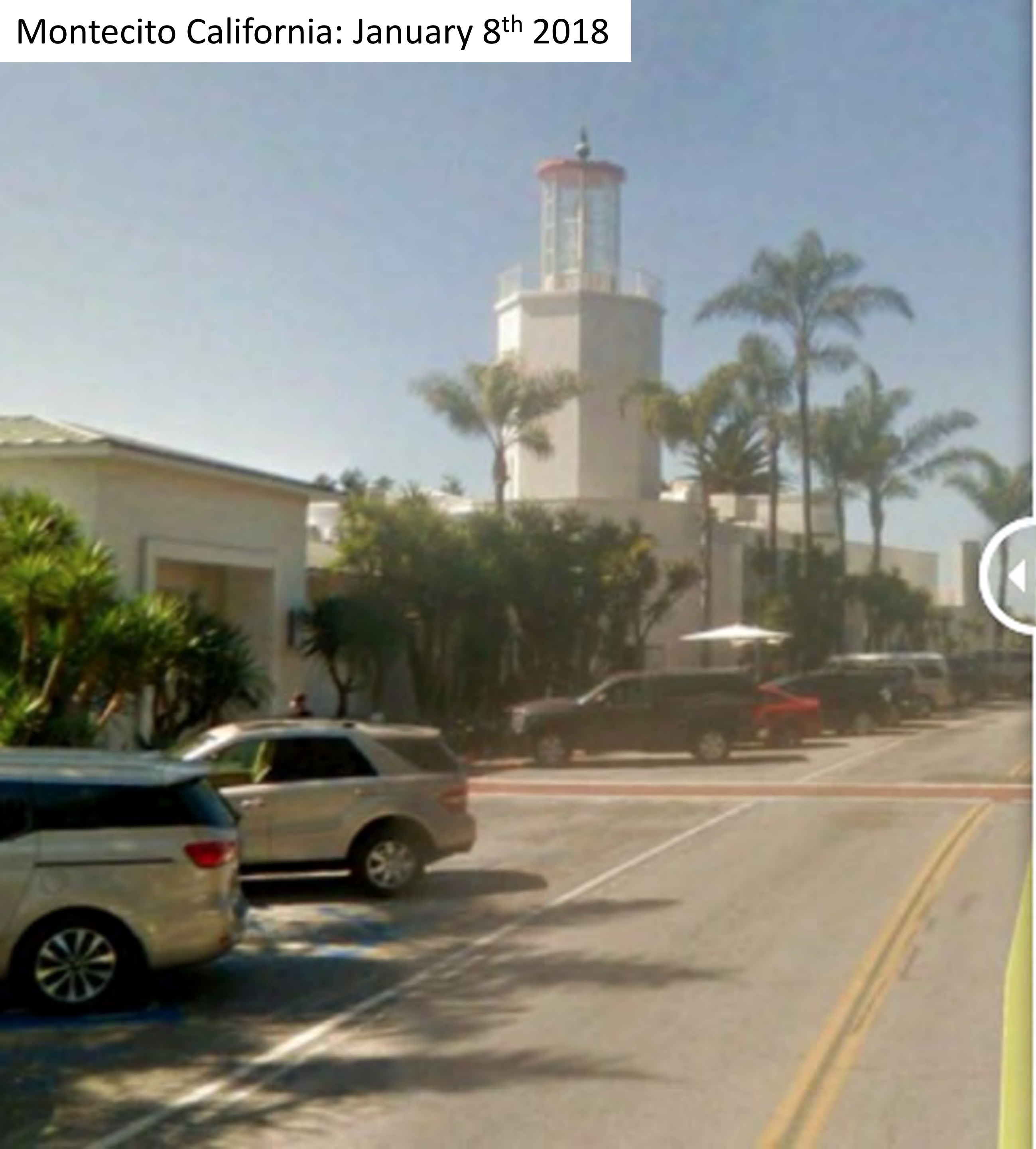
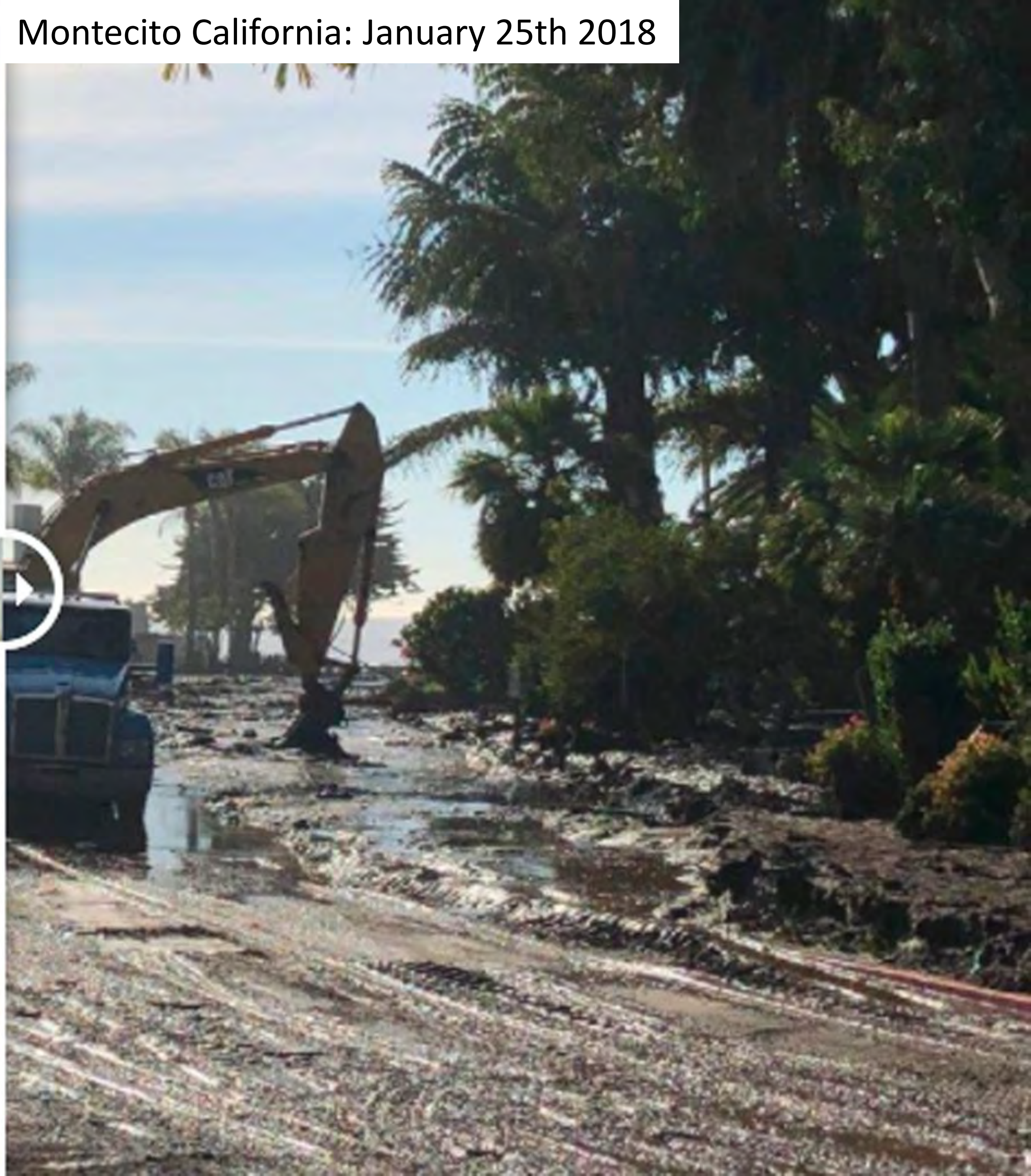
Montecito California: January 8th 2018



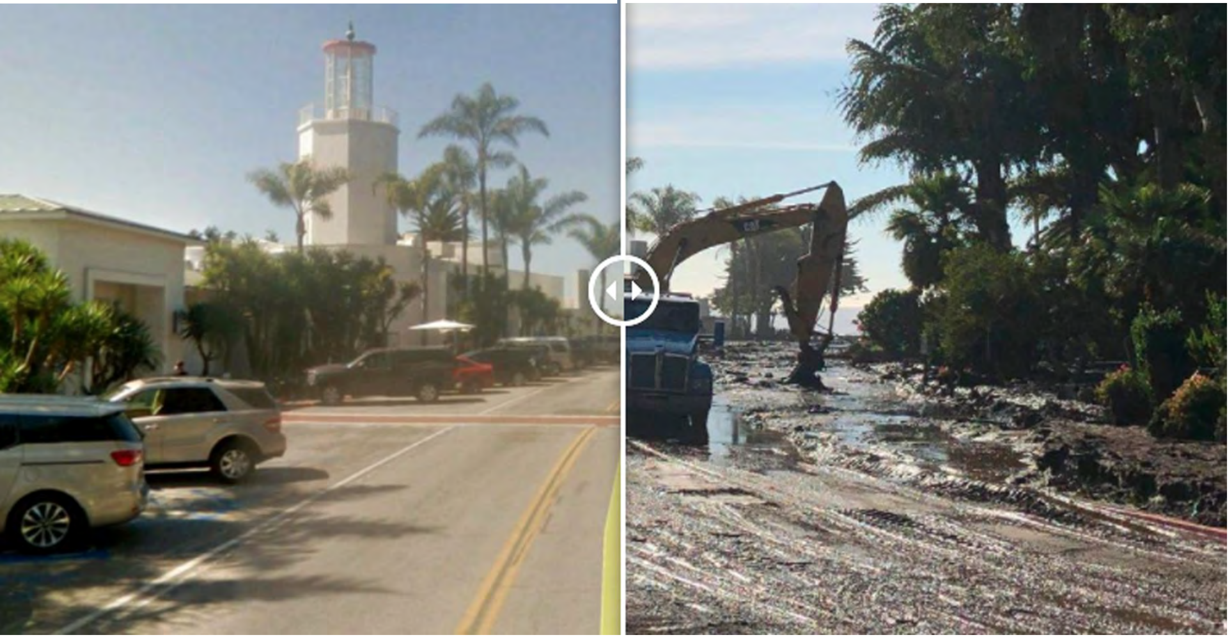
Montecito California: January 25th 2018



Improving Forecasts of Sub-Seasonal Flood Risk

Montecito California: January 8th 2018

Montecito California: January 25th 2018



UM-RSMAS Leads a Multi-Agency, Multi-Institutional Effort to Improve NOAA Sub-Seasonal Operational Forecasts

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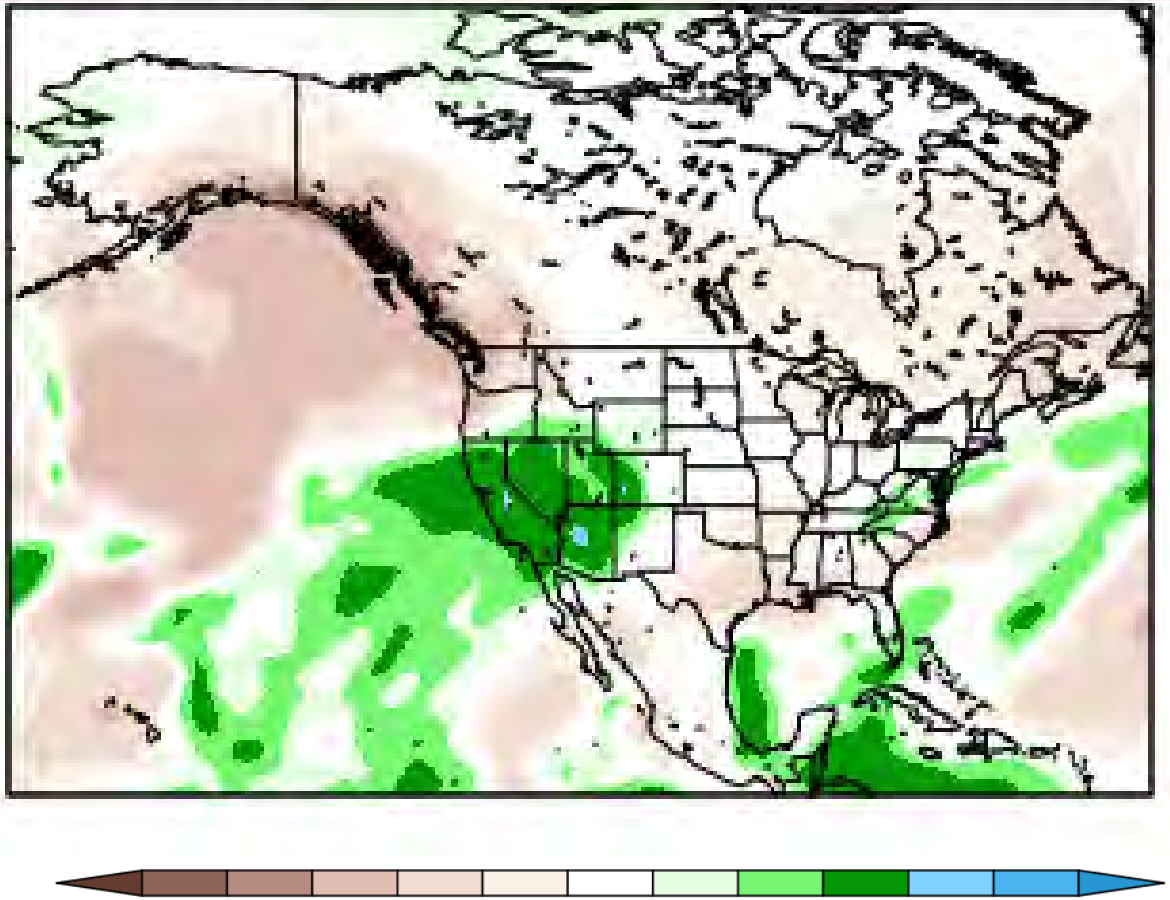
~ Customized Subseasonal Weekly Forecasts ~

Very Important Disclaimer: These experimental anomaly forecasts are produced by the Subseasonal Experiment (SubX) Project for research purposes. They are not official forecasts and are not guaranteed to be timely or accurate. For official subseasonal climate outlooks, please visit the NOAA/NWS Climate Prediction Center.

Begin by selecting a SubX model, variable, and desired forecast period. Then specify the domain by choosing one of the preset options or manually editing the Longitude and Latitude ranges. Use the check boxes for additional customizations. Click the SUBMIT button to generate the plot.

SubX-RSMAS: Montecito 3-Week Lead Flood Forecast Valid Week Ending Jan. 12, 2018



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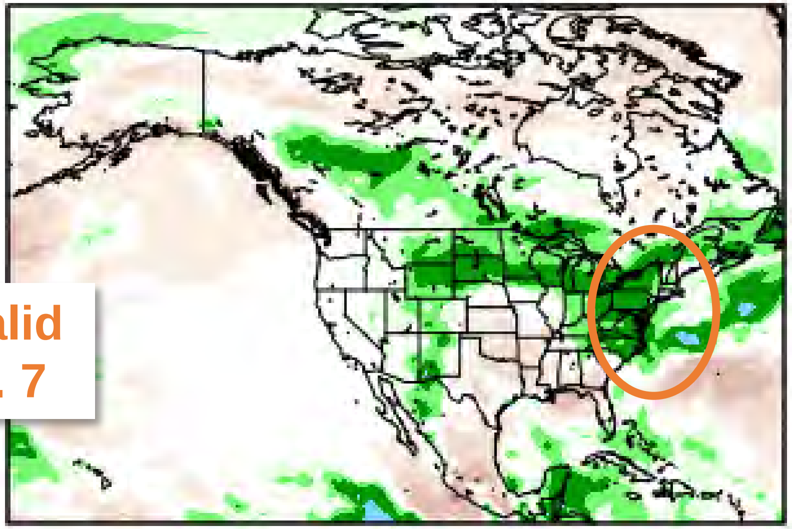
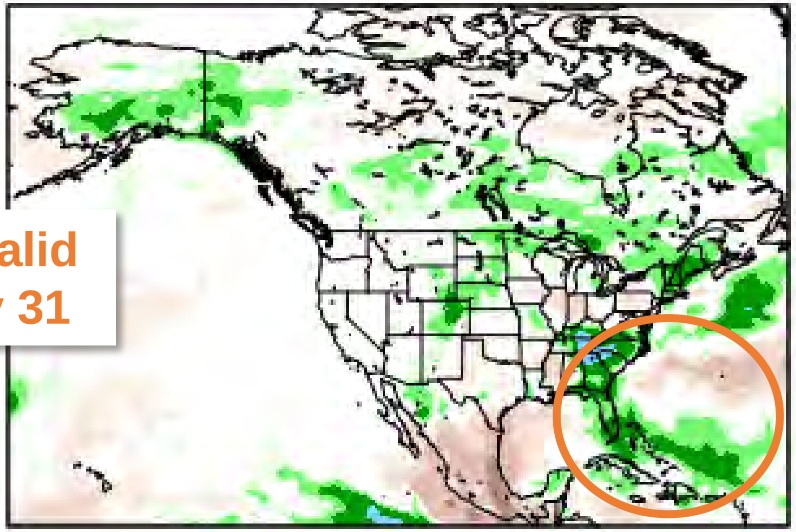
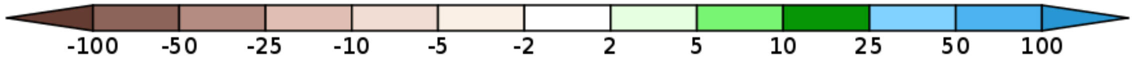


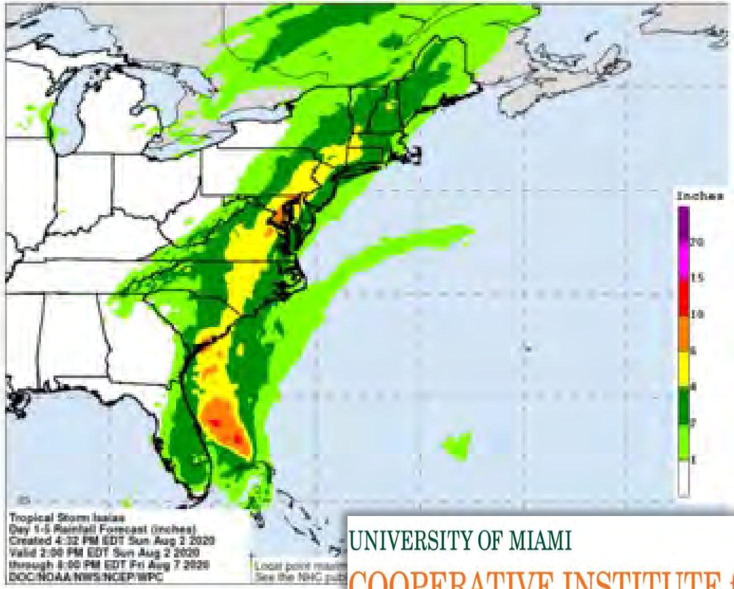
Week 3-4 Forecast: Valid 2-Weeks Ending Aug. 7

UM Led Sub-Seasonal Prediction Experiment (SubX)



Week 3-4 Forecast: Valid 2-Weeks Ending July 31





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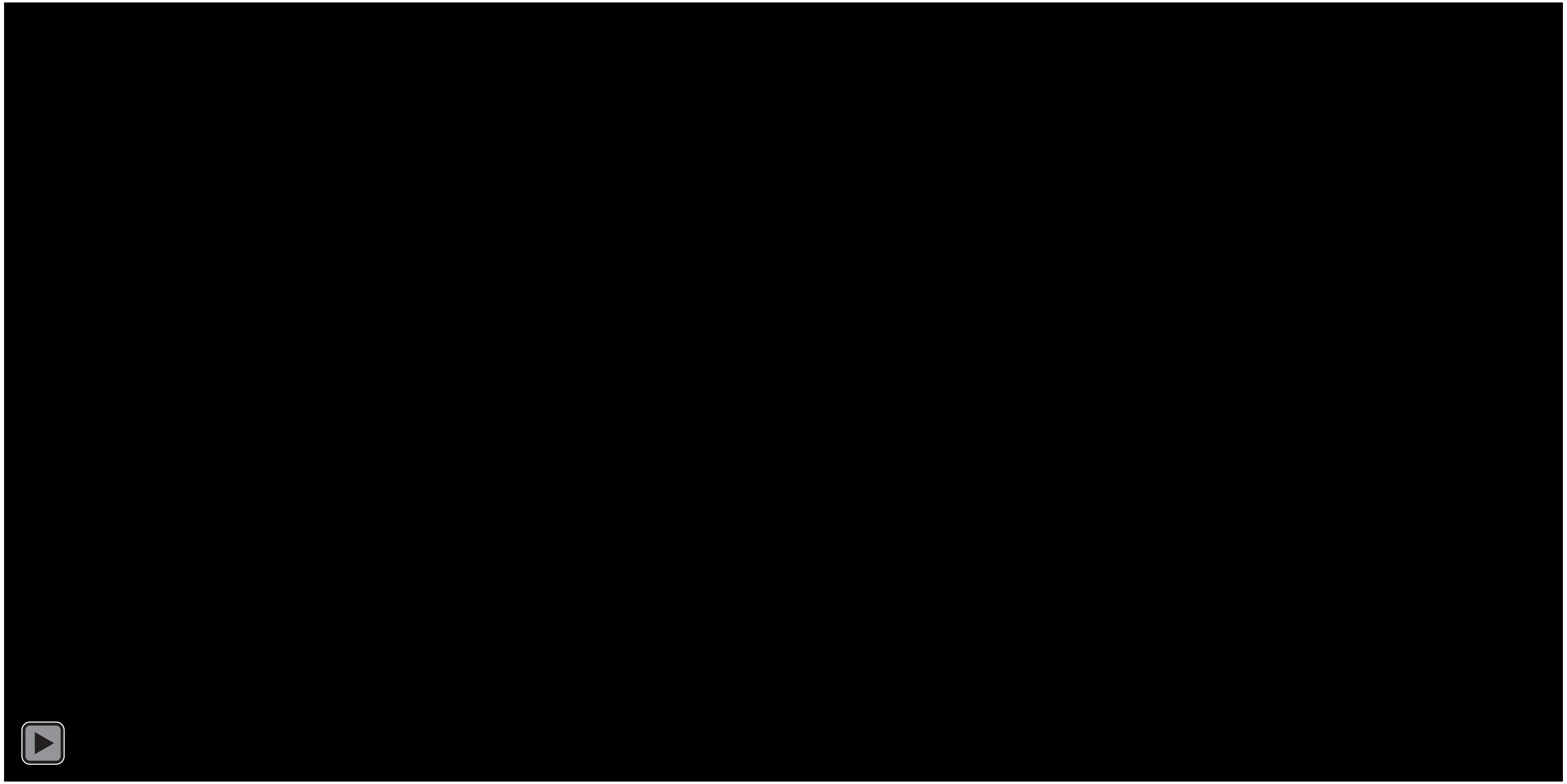
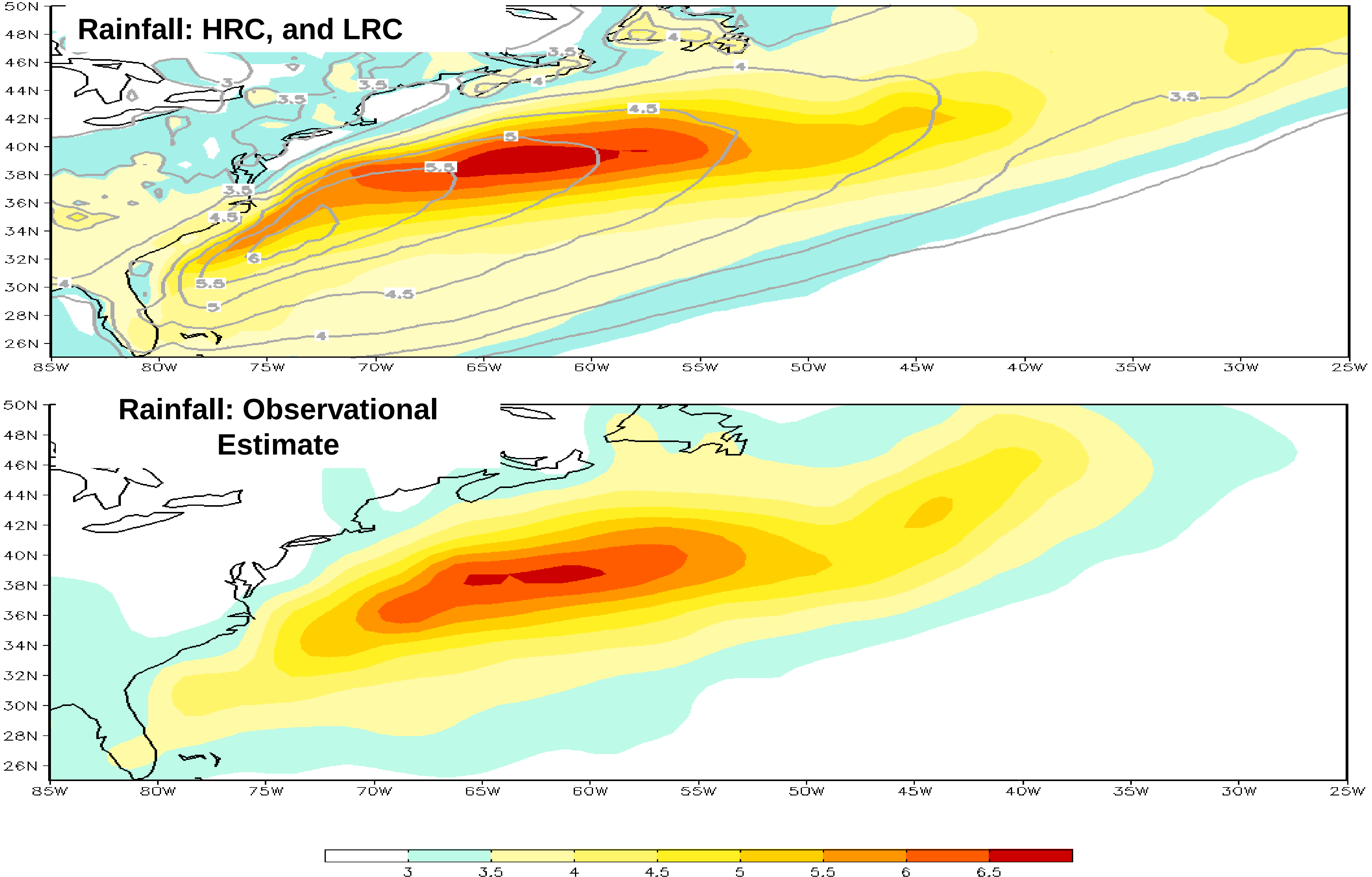
- **Predicting Across Time Scales**
  - **Wx – Sub-seasonal – Seasonal – Multi-year – Decadal**
- **Disruptors**
  - **Advances in Computing Power**
  - **Data Science Innovation**

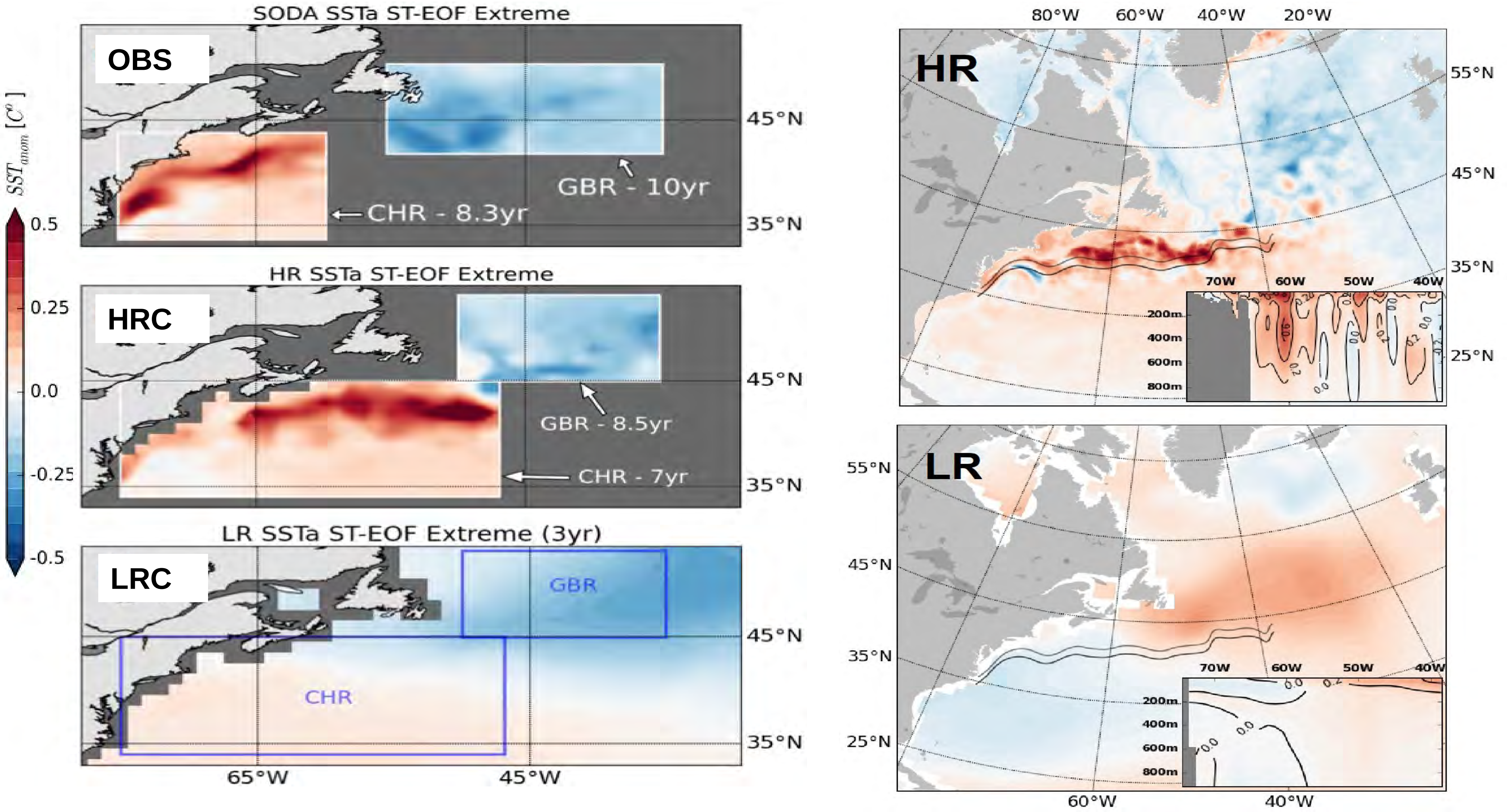
Standard climate simulation



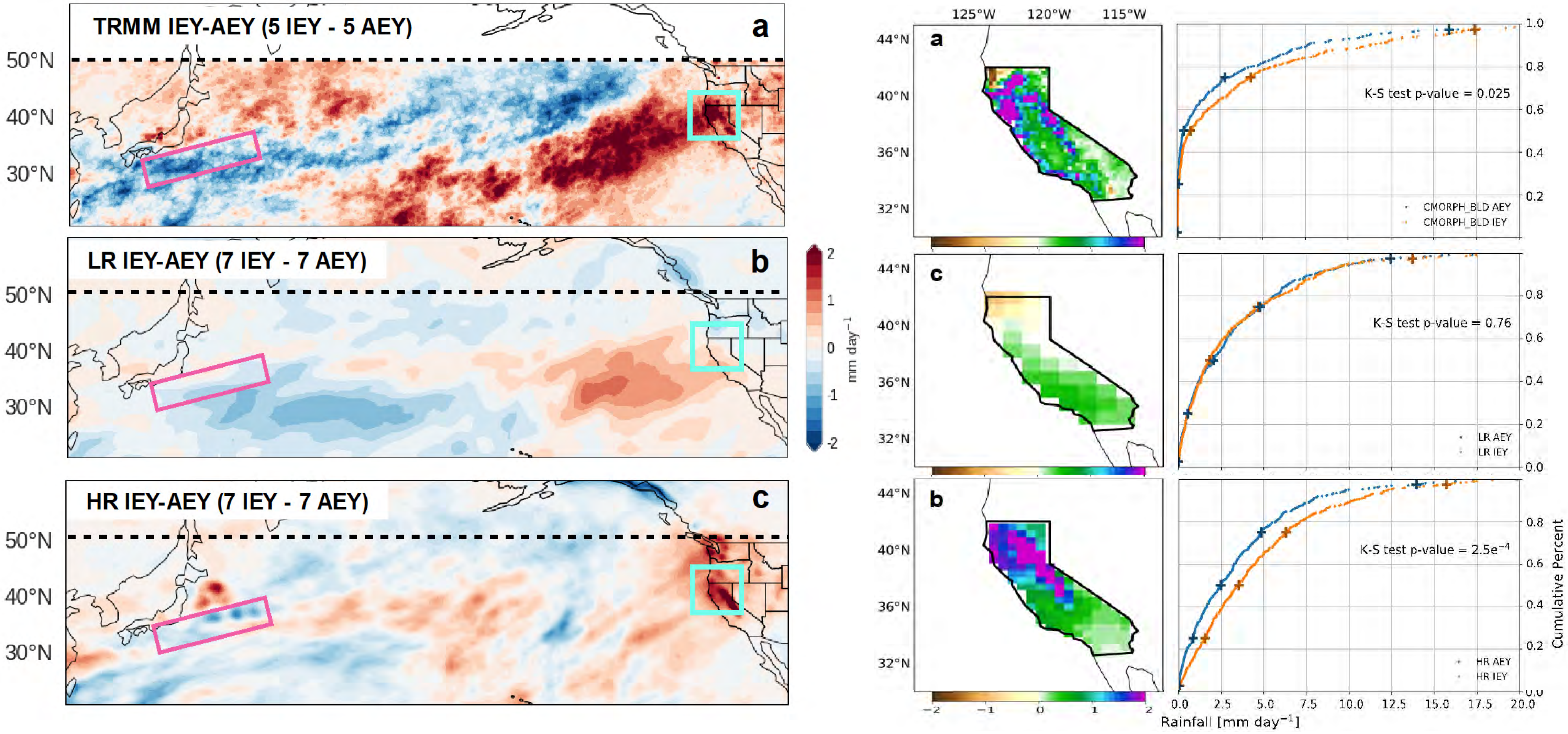
University of Miami's climate simulation


Rainfall: HRC, and LRC
50N
48N
46N
44N
42N
40N
38N
36N
34N
32N
30N
28N
26N
85W
80W
75W
70W
65W
60W
55W
50W
45W
40W
35W
30W
25W
Rainfall: Observational Estimate
50N
48N
46N
44N
42N
40N
38N
36N
34N
32N
30N
28N
26N
85W
80W
75W
70W
65W
60W
55W
50W
45W
40W
35W
30W
25W
3
3.5
4
4.5
5
5.5
6
6.5

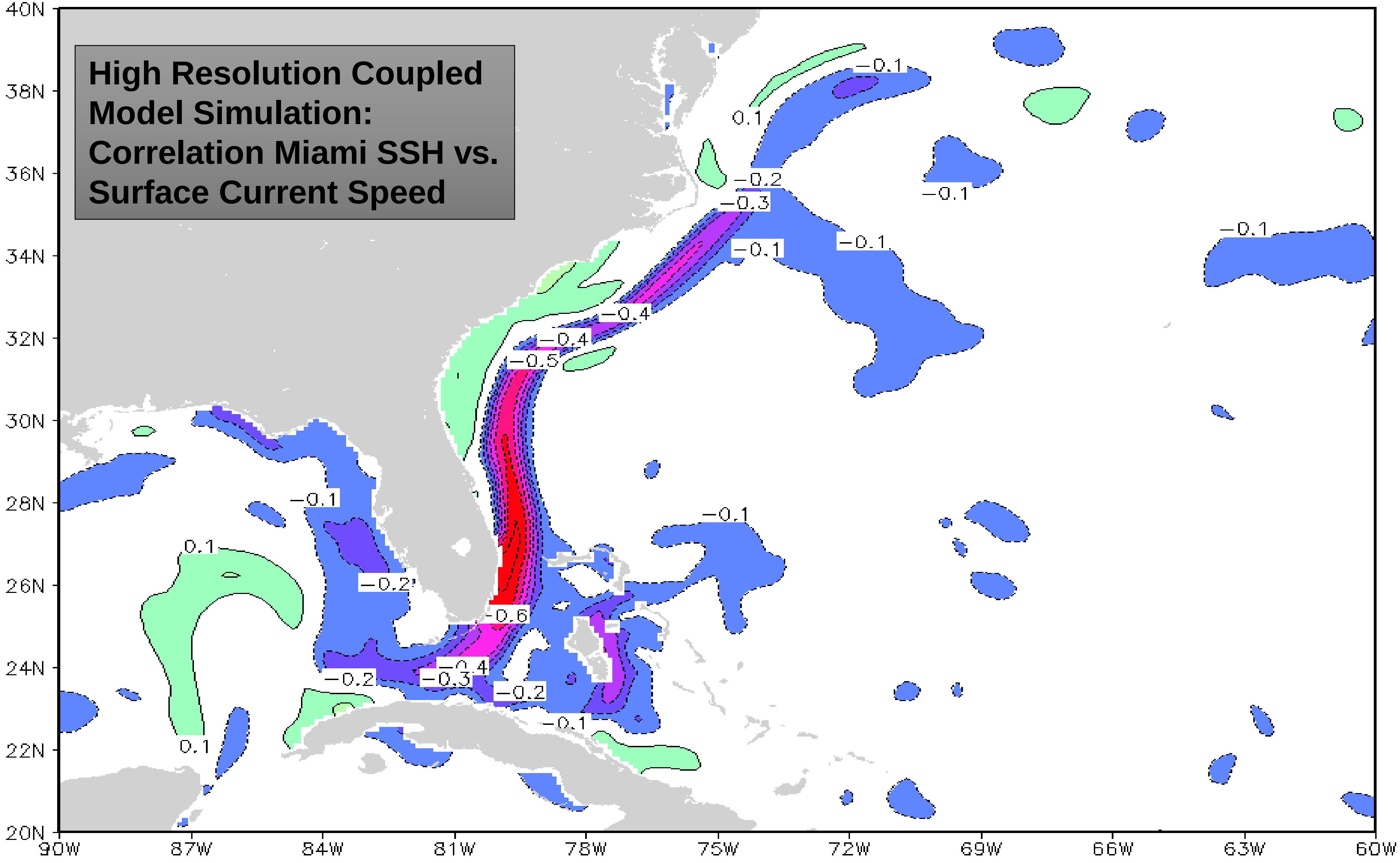
Natural Decadal Variability



Kuroshio Extension and Western North American Rainfall



Predicting Coastal Flood Risk From Days to Decades



Traditional vs. Data Science Approach

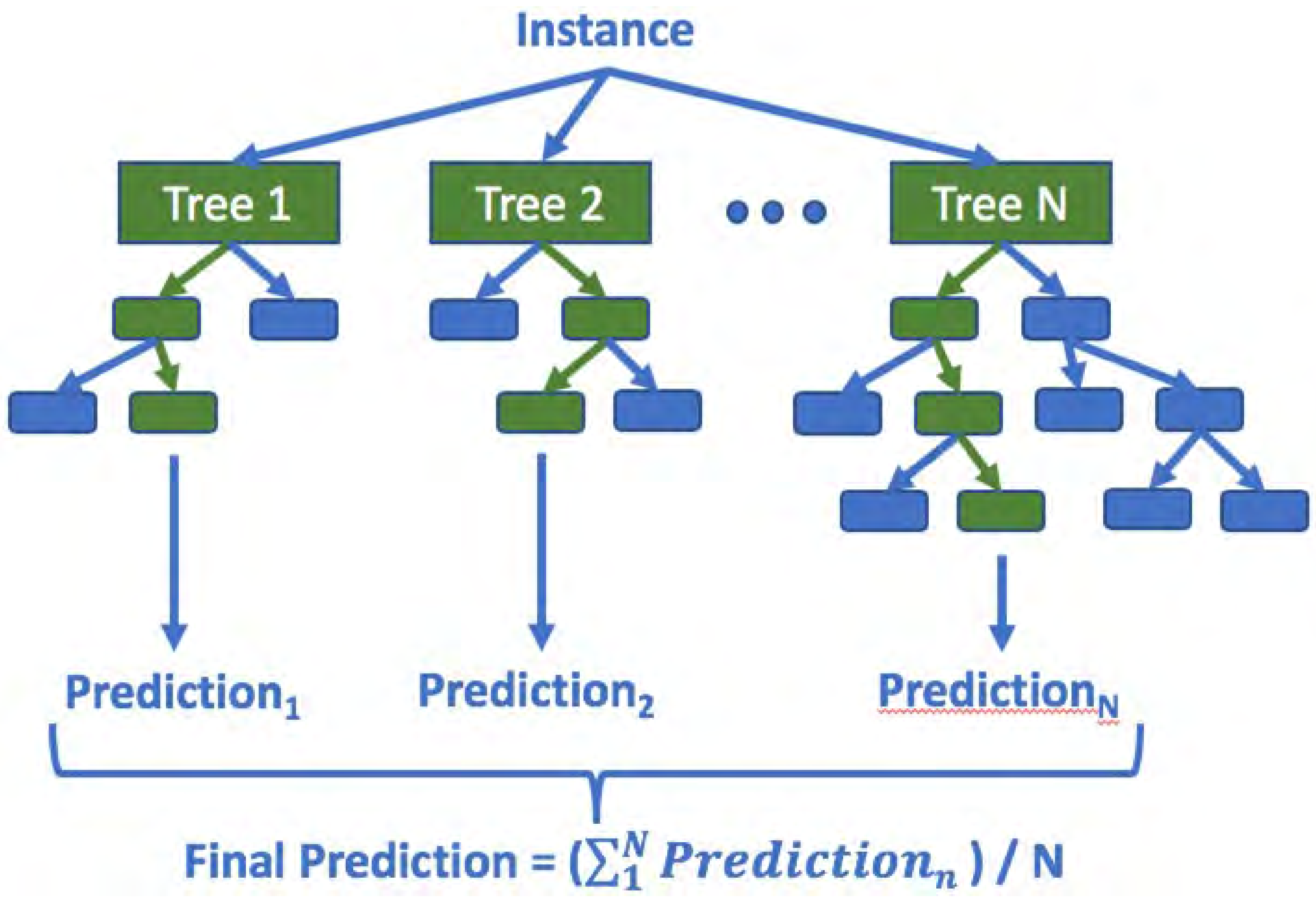
Traditional models

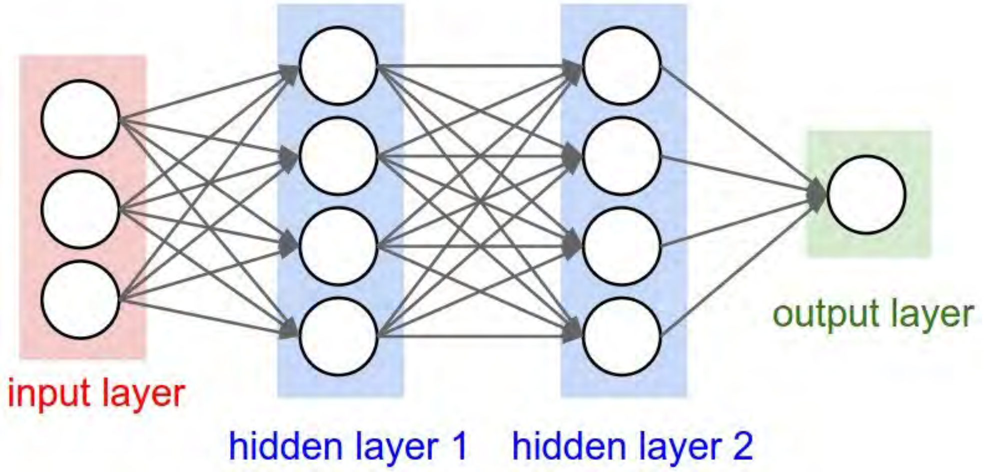
- Models are implemented in complex “one-off” code.
- Model algorithms are at odds with computer architectural trends.
- Data is a problem.

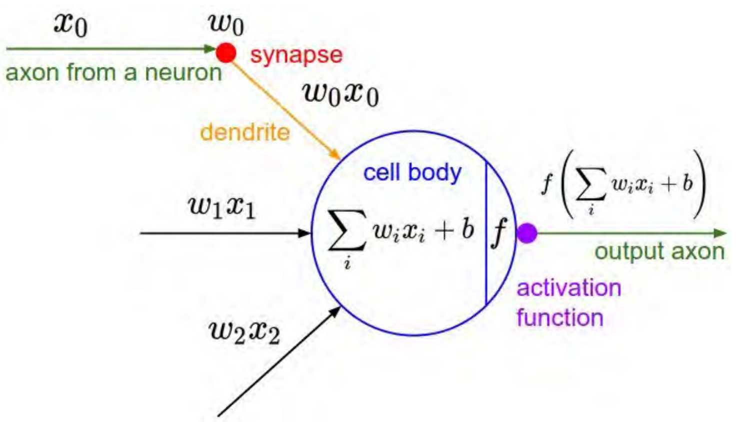
Machine learning

- Machine learning software implemented in reusable code.
- Machine learning is well aligned with architectural trends.
- Data is still a problem, but with machine learning it is also an opportunity.

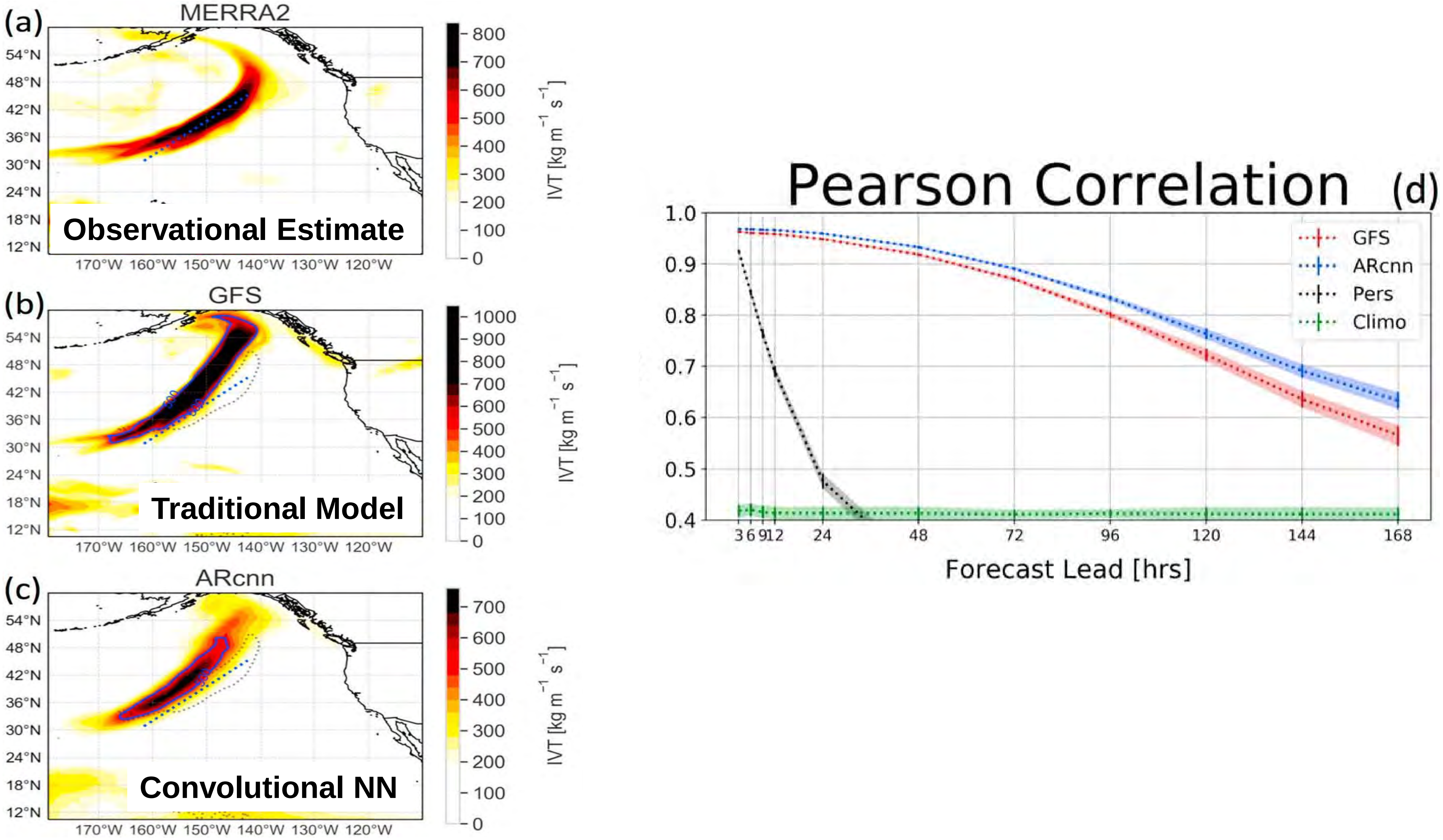
Random Forest and Neural Network Algorithms



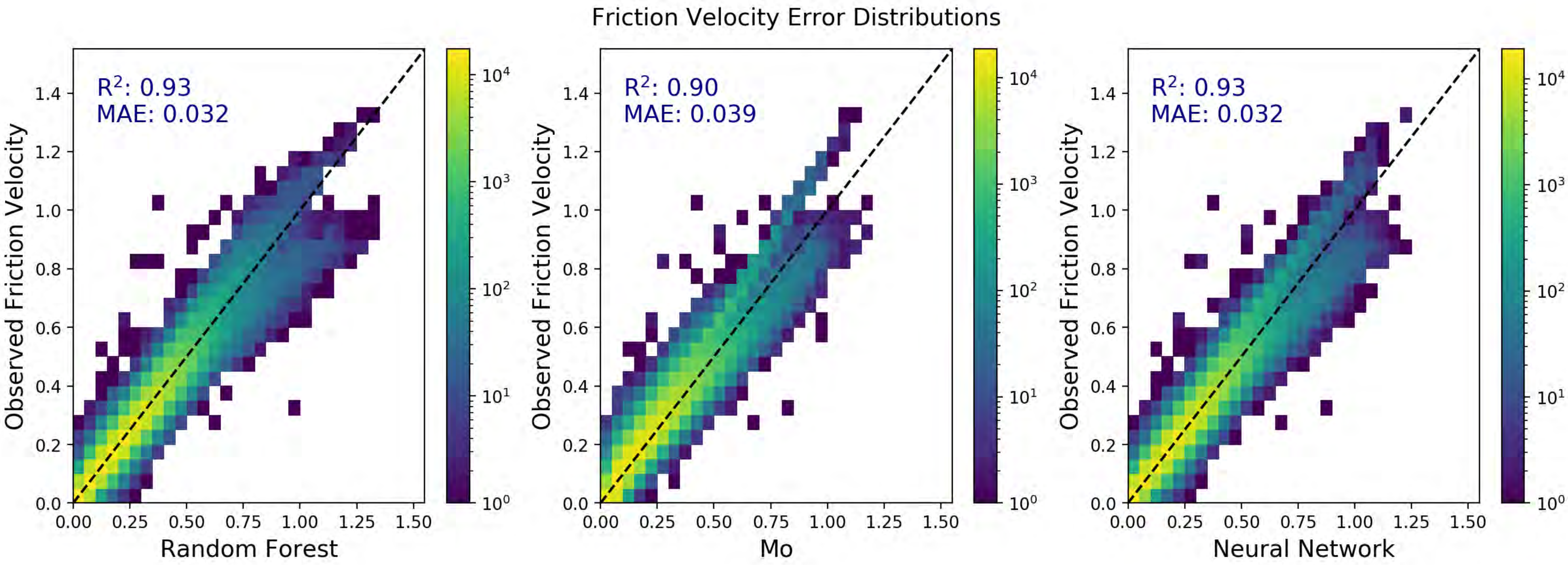




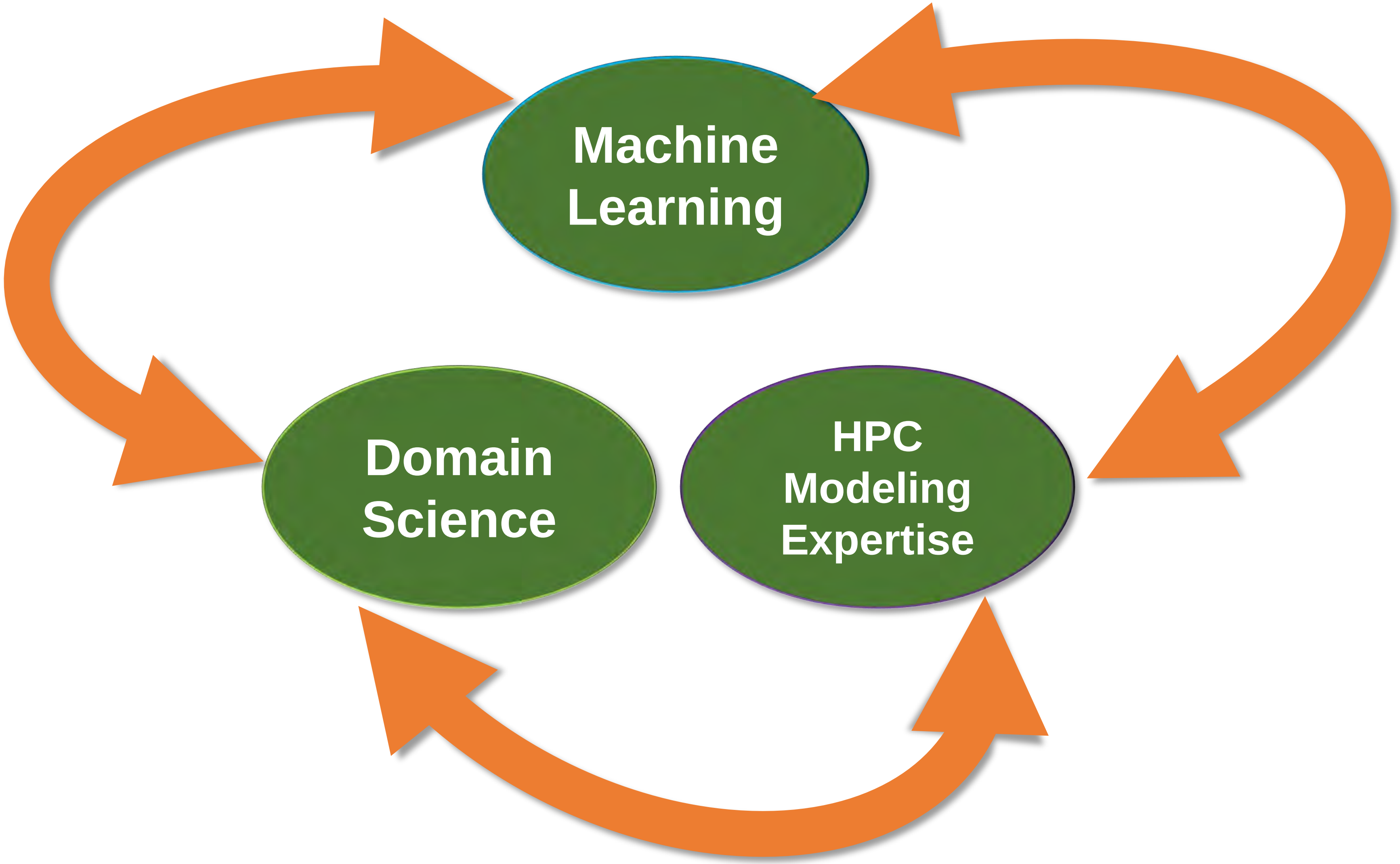
Pure Data Science Approach: Atmospheric Rivers Example



Combining Data Science with Traditional Model: Harder but More Versatile



Is this a New Way of Doing and Teaching Science?



Emerging Data Science Academic Programs Based on Expertise Demand

SubX and NMME Real-Time Forecasts