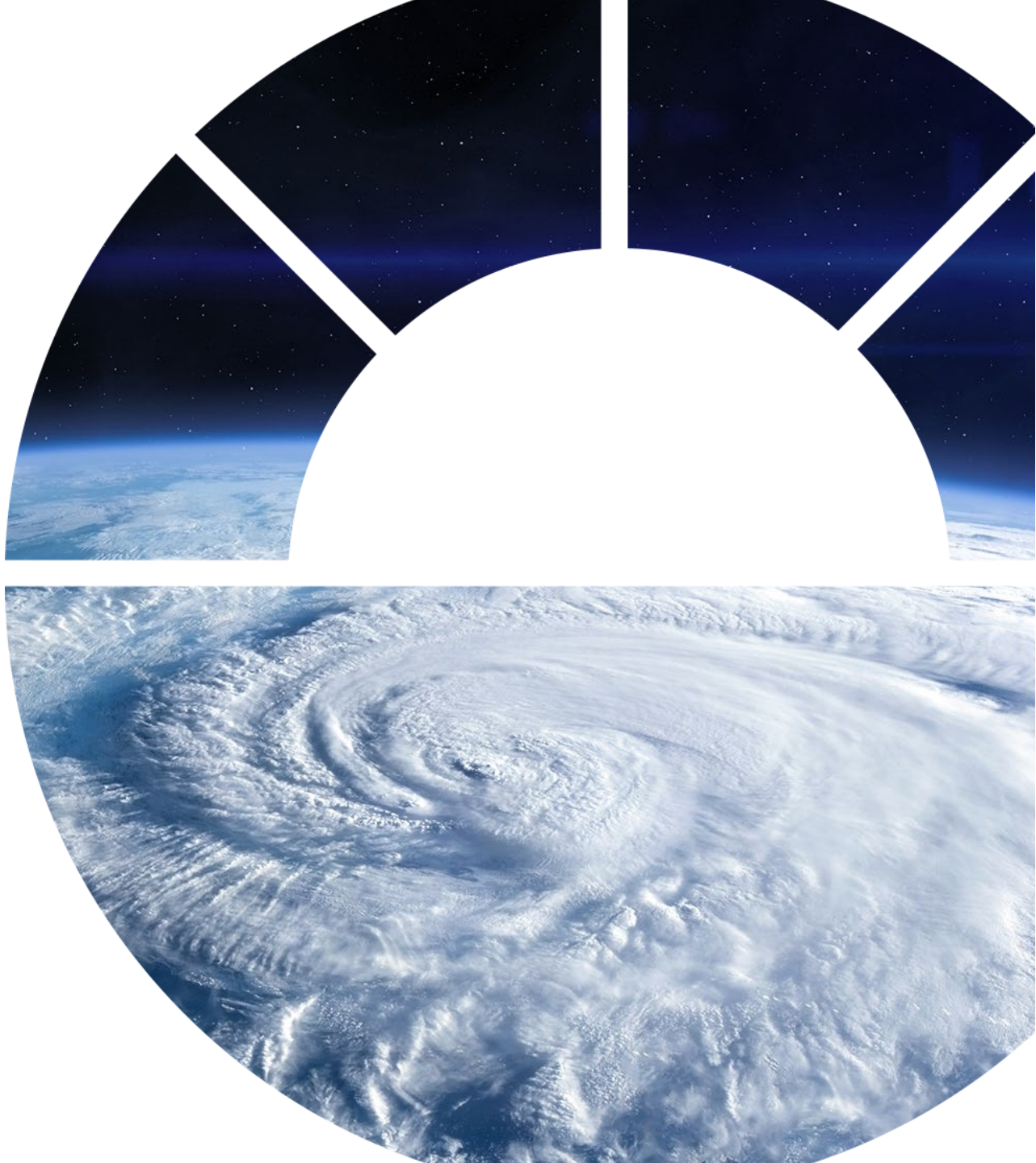
FREE WEBINAR

WEDNESDAY, MAY 15 | 12 PM EST

Preparing for the 2024 Hurricane Season



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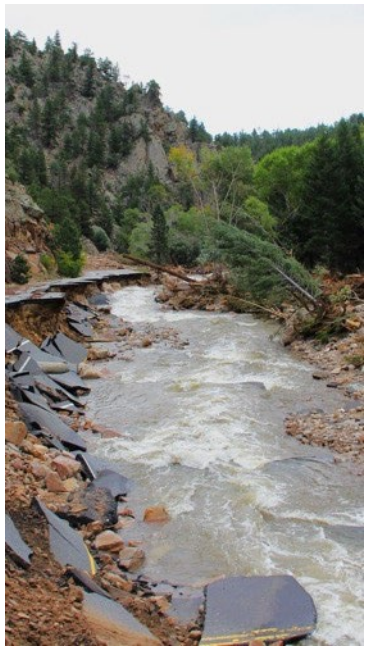
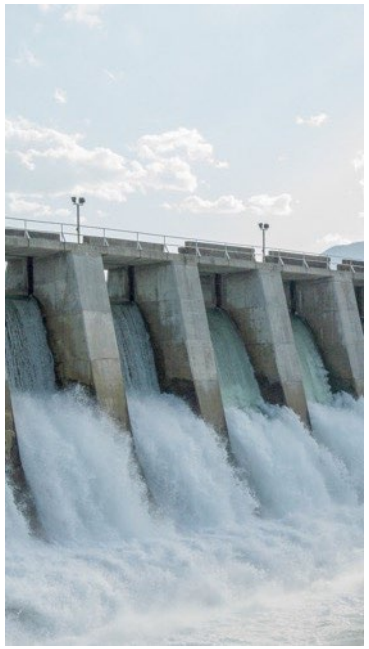
Before we get started….

- This webinar is being recorded. The recording will be available following the webinar.
- By default, all attendees are in listen-only mode and your microphone is muted.
- Have questions? Enter them in the questions chat box for Q&A at the end of our session.
- Feel free to contact us after the presentation at info@aem.eco.

At AEM, we empower communities and organizations to survive – and thrive – in the face of escalating environmental risks








System design expertise

Reliable sensing networks

Highest quality data

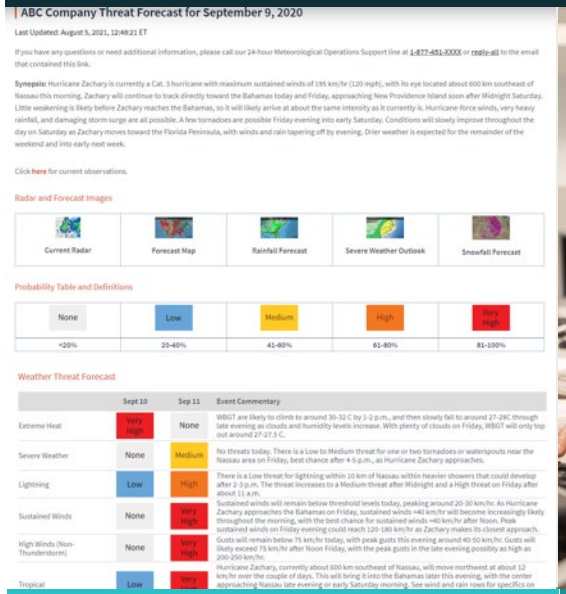
Actionable insights

Optimized decisions

Resiliency & Positive Outcomes

Portfolio of services to meet your specific needs

FORECAST COMMAND CENTER


ABC Company Threat Forecast for September 9, 2020

Last Updated: August 5, 2021, 12:48:21 ET

If you have any questions or need additional information, please call our 24-hour Meteorological Operations Support line at 1-877-451-XXXX or reply-all to the email that contained this link.

Synopsis: Hurricane Zachary is currently a Cat. 3 hurricane with maximum sustained winds of 195 km/hr (120 mph), with its eye located about 600 km southeast of Nassau this morning. Zachary will continue to track directly toward the Bahamas today and Friday, approaching New Providence Island soon after Midnight Saturday. Little weakening is likely before Zachary reaches the Bahamas, so it will likely arrive at about the same intensity as it currently is. Hurricane-force winds, very heavy rainfall, and damaging storm surge are all possible. A few tornadoes are possible Friday evening into early Saturday. Conditions will slowly improve throughout the day on Saturday as Zachary moves toward the Florida Peninsula, with winds and rain tapering off by evening. Drier weather is expected for the remainder of the weekend and into early next week.

Click here for current observations.

Radar and Forecast Images

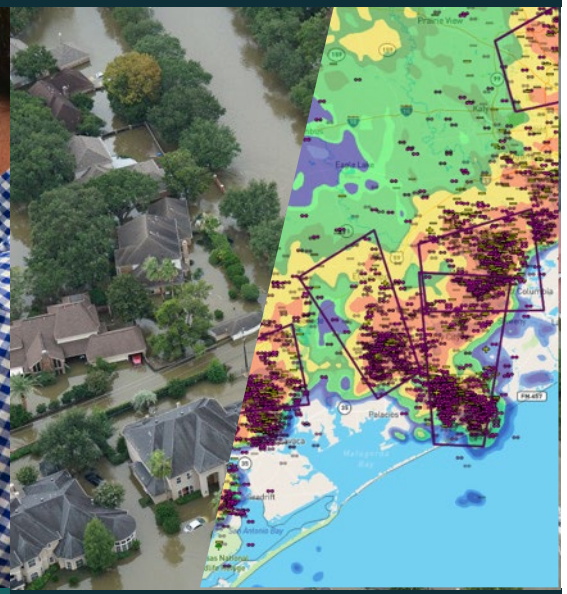
Current Radar	Forecast Map	Rainfall Forecast	Severe Weather Outlook	Snowfall Forecast

Probability Table and Definitions

None	Low	Medium	High	Very High
<20%	20-40%	41-60%	61-80%	81-100%

Weather Threat Forecast

	Sept 10	Sep 11	Event Commentary
Extreme Heat	Very High	None	WBGT are likely to climb to around 30-32 C by 1-2 p.m., and then slowly fall to around 27-28C through late evening as clouds and humidity levels increase. With plenty of clouds on Friday, WBGT will only top out around 27-27.5 C.
Severe Weather	None	Medium	No threats today. There is a Low to Medium threat for one or two tornadoes or waterspouts near the Nassau area on Friday, best chance after 4-5 p.m., as Hurricane Zachary approaches.
Lightning	Low	High	There is a Low threat for lightning within 10 km of Nassau within heavier showers that could develop after 2-3 p.m. The threat increases to a Medium threat after Midnight and a High threat on Friday after about 11 a.m.
Sustained Winds	None	Very High	Sustained winds will remain below threshold levels today, peaking around 20-30 km/hr. As Hurricane Zachary approaches the Bahamas on Friday, sustained winds >40 km/hr will become increasingly likely throughout the morning, with the best chance for sustained winds >40 km/hr after Noon. Peak sustained winds on Friday evening could reach 120-180 km/hr as Zachary makes its closest approach.
High Winds (Non-Thunderstorm)	None	Very High	Gusts will remain below 75 km/hr today, with peak gusts this evening around 40-50 km/hr. Gusts will likely exceed 75 km/hr after Noon Friday, with the peak gusts in the late evening possibly as high as 200-250 km/hr.
Tropical	Low	Very	Hurricane Zachary, currently about 600 km southeast of Nassau, will move northwest at about 12 km/hr over the couple of days. This will bring it into the Bahamas later this evening, with the center approaching Nassau late evening or early Saturday morning. See wind and rain rows for specifics on



Custom threat forecast deliverables

Conference call briefings

24/7 email and phone support

Weather event forensics

Today's speakers

MATT MEHALLOW
Meteorologist

AEM

CHRISTIAN SAYLES
Meteorologist

AEM

MARK ELLINWOOD
Meteorologist

AEM

JEFF LINDNER
Director, Hydrologic Operations Division | Meteorologist

Harris County (TX) Flood Control District

JAMES LOGAN
Water Sector Leader

AEM

Agenda

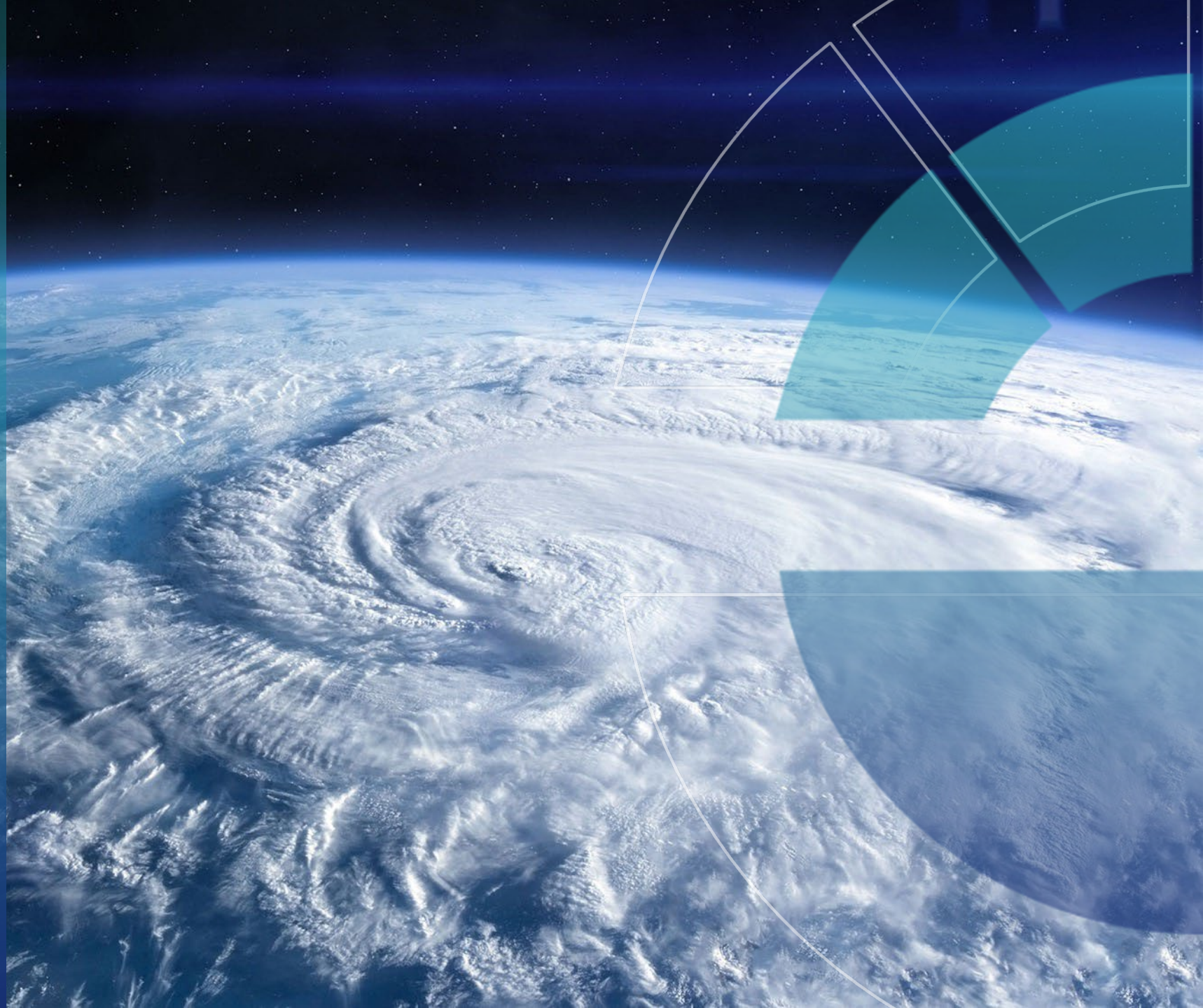
- Outlook for the 2024 Atlantic hurricane season
  1. Reviewing the 2023 Atlantic hurricane season
  2. Tropical cyclone climatology
  3. How climate factors influence the forecast
  4. The 2024 Atlantic hurricane forecast
- Panel discussion: Best practices for hurricane preparation
- Audience Q&A

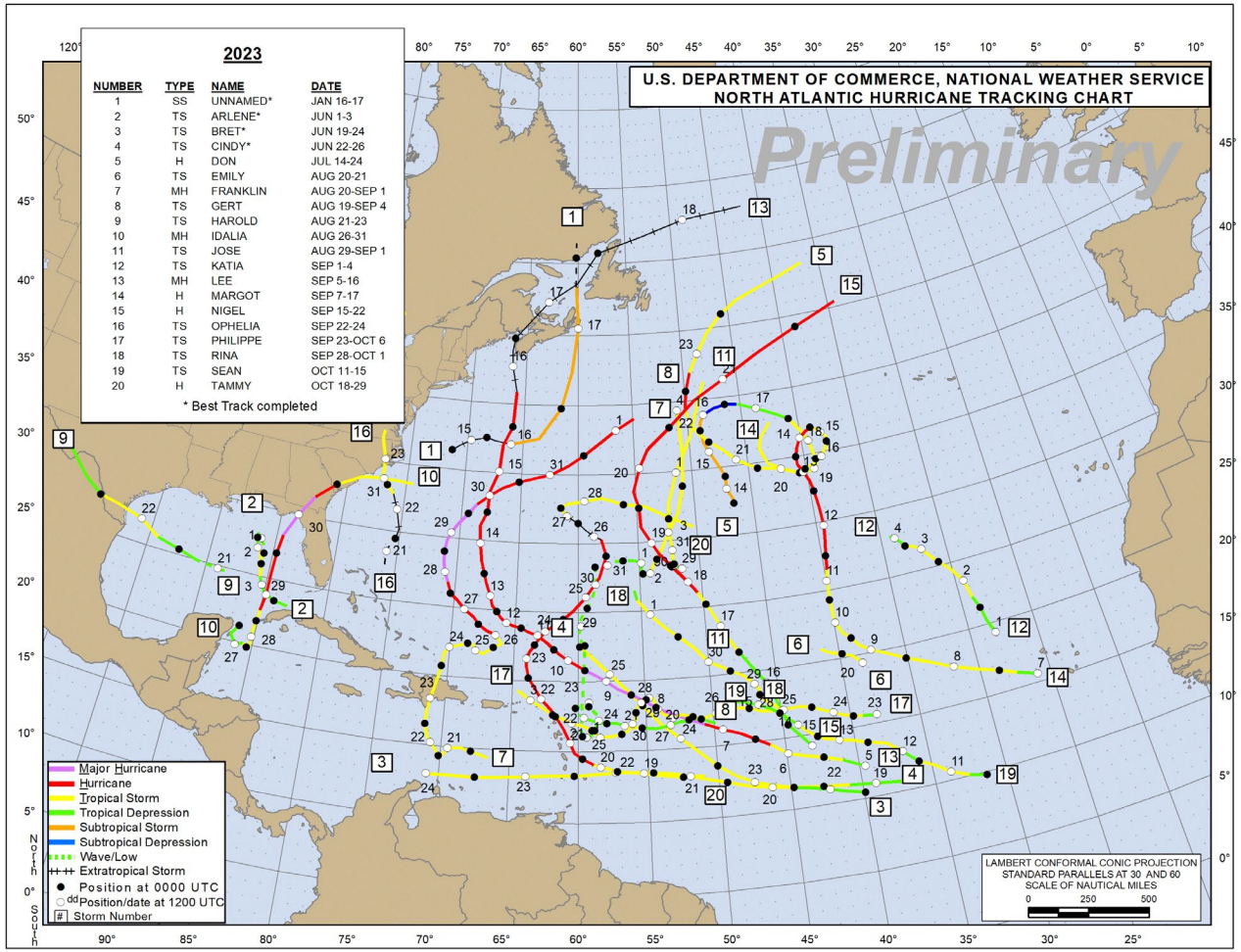
Poll questions

2024 Atlantic hurricane season outlook

01

2023 Atlantic hurricane season





Review of 2023 hurricane season

2023 Totals

- 20 Named storms
- 7 Hurricanes
- 3 Major Hurricanes
- 146 Accumulated Cyclone Energy (ACE)

2023 Atlantic hurricane season

Compared to normal

2023

- 20 Named storms
- 7 Hurricanes
- 3 Major Hurricanes
- 146 Accumulated Cycle Energy (ACE)

1991–2020 AVERAGES

- 14.4 Named storms
- 7.2 Hurricanes
- 3.2 Major Hurricanes
- 123 Accumulated Cycle Energy (ACE)

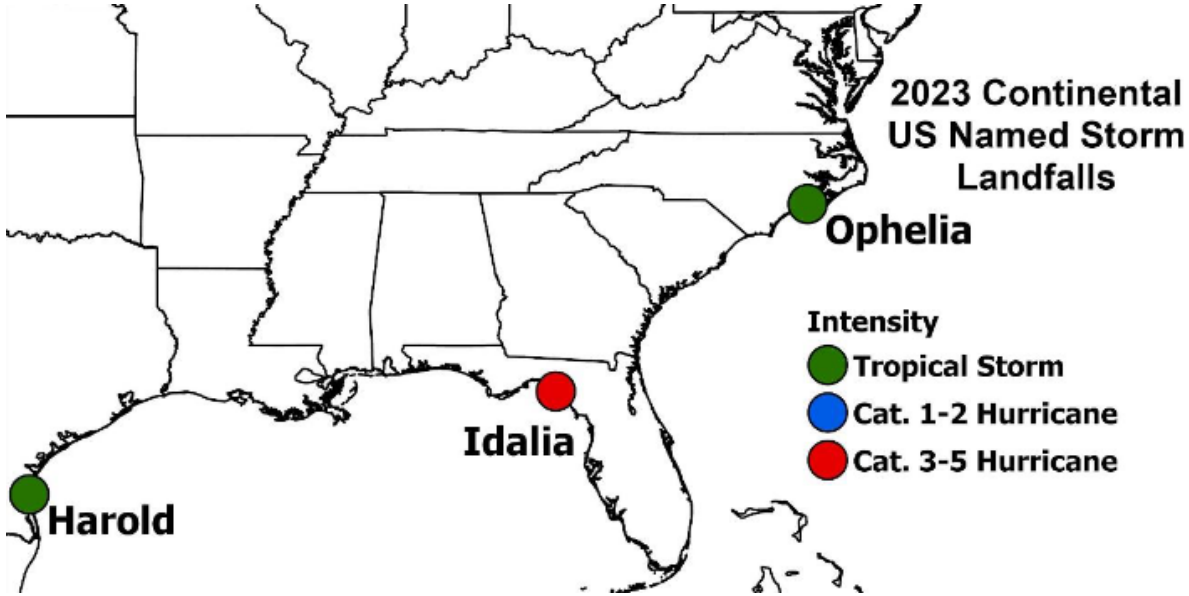


Image courtesy of Colorado State University

2023 Atlantic hurricane season

Versus our forecast

2023	AEM Forecast
• 20 Named storms	• 14 Named storms (12-17)
• 7 Hurricanes	• 6 Hurricanes (4-8)
• 3 Major Hurricanes	• 3 Major Hurricanes (2-4)
• 146 Accumulated Cycle Energy (ACE)	• 129 Accumulated Cycle Energy (ACE) (94-164)

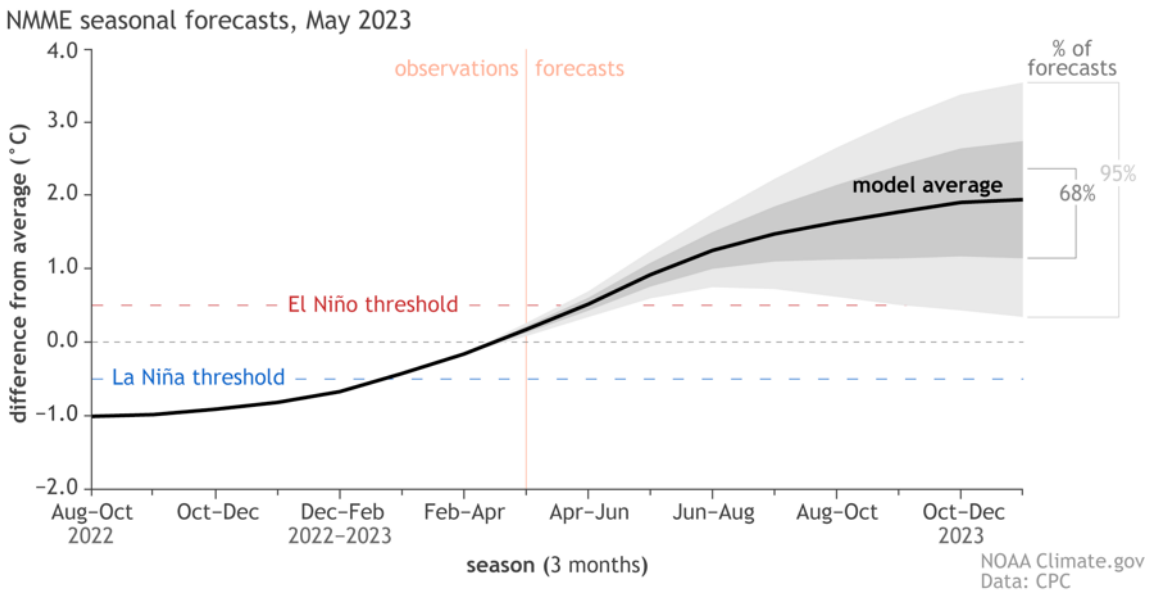
AEM 2023 percent chances

32% Above Normal | **51%** Near Normal | **17%** Below Normal

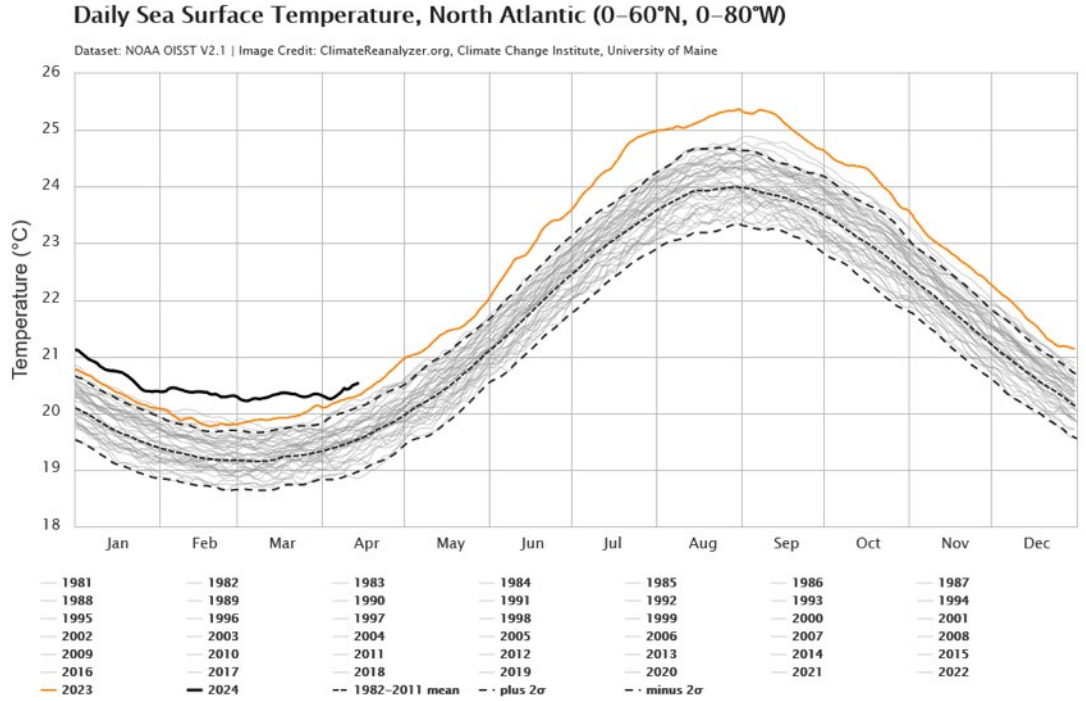
2023 Atlantic hurricane season

Main forecast variables

Developing El Nino



Very Warm Atlantic

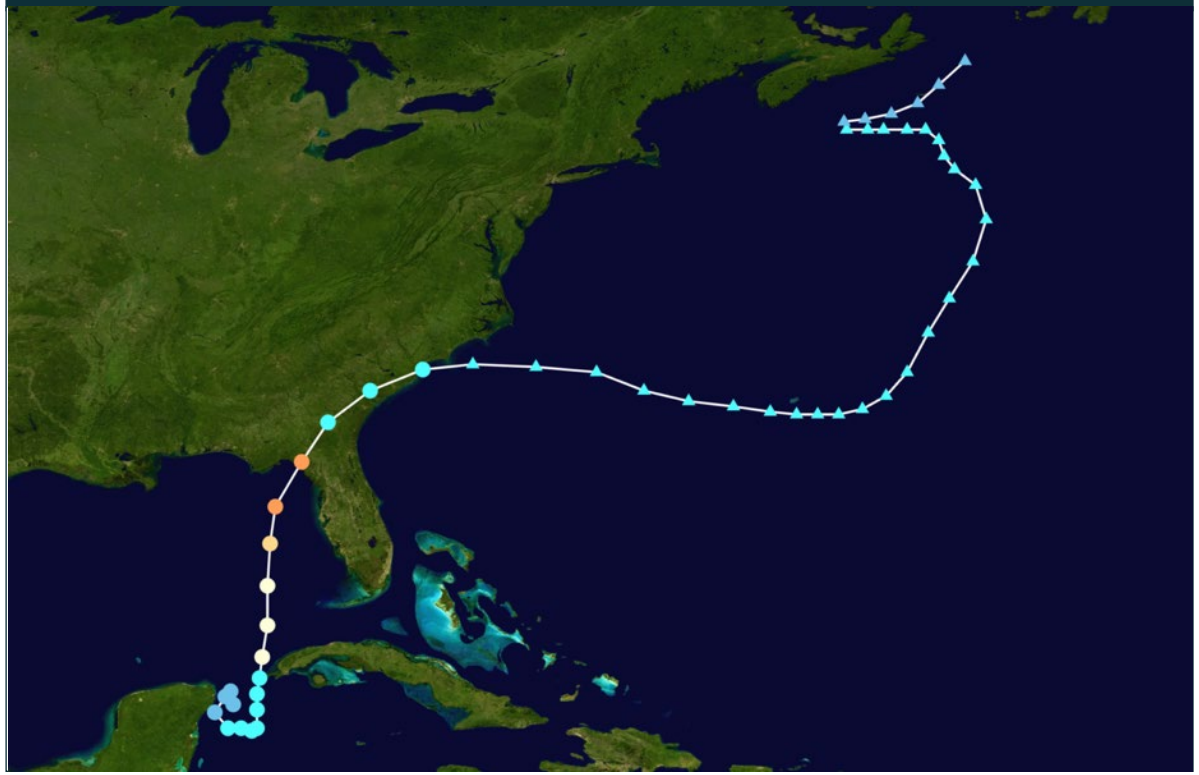


2023 Atlantic hurricane season

No retired Atlantic storms in 2023 (the first time there has been no retired Atlantic names since 2014)

Major Hurricane Idalia

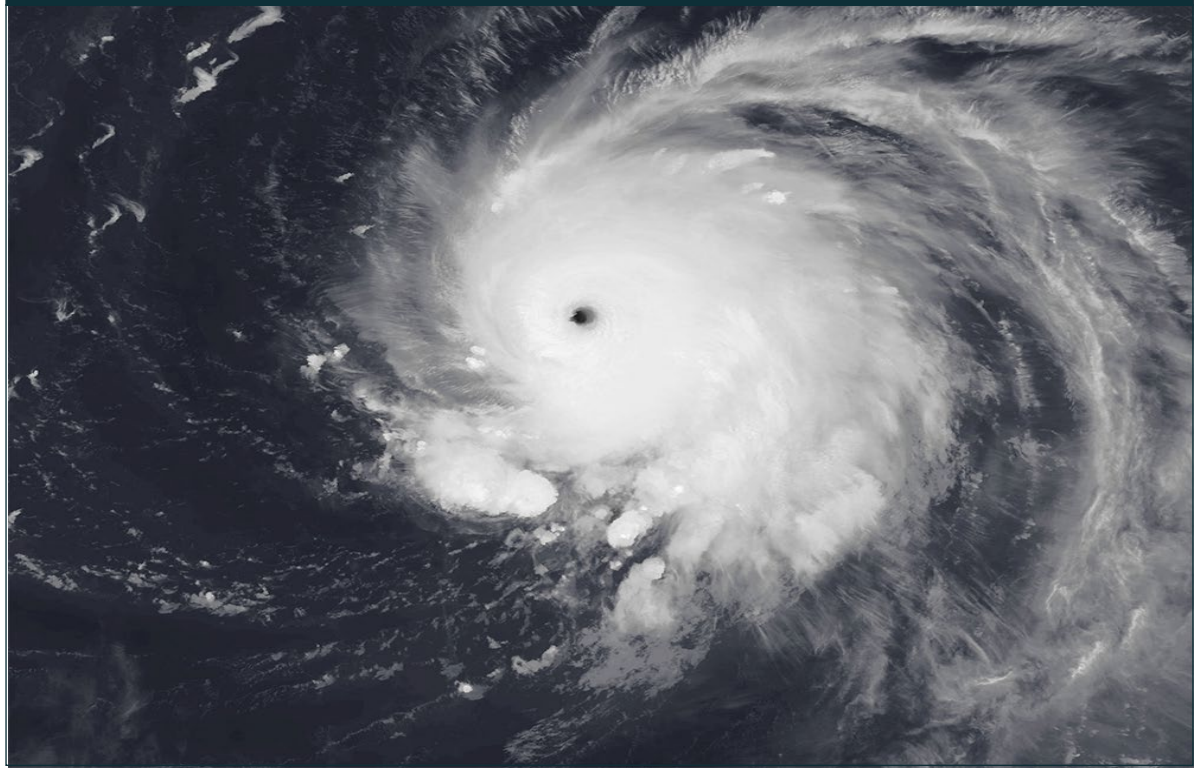
Peak: Cat 4, Landfall: Cat 3



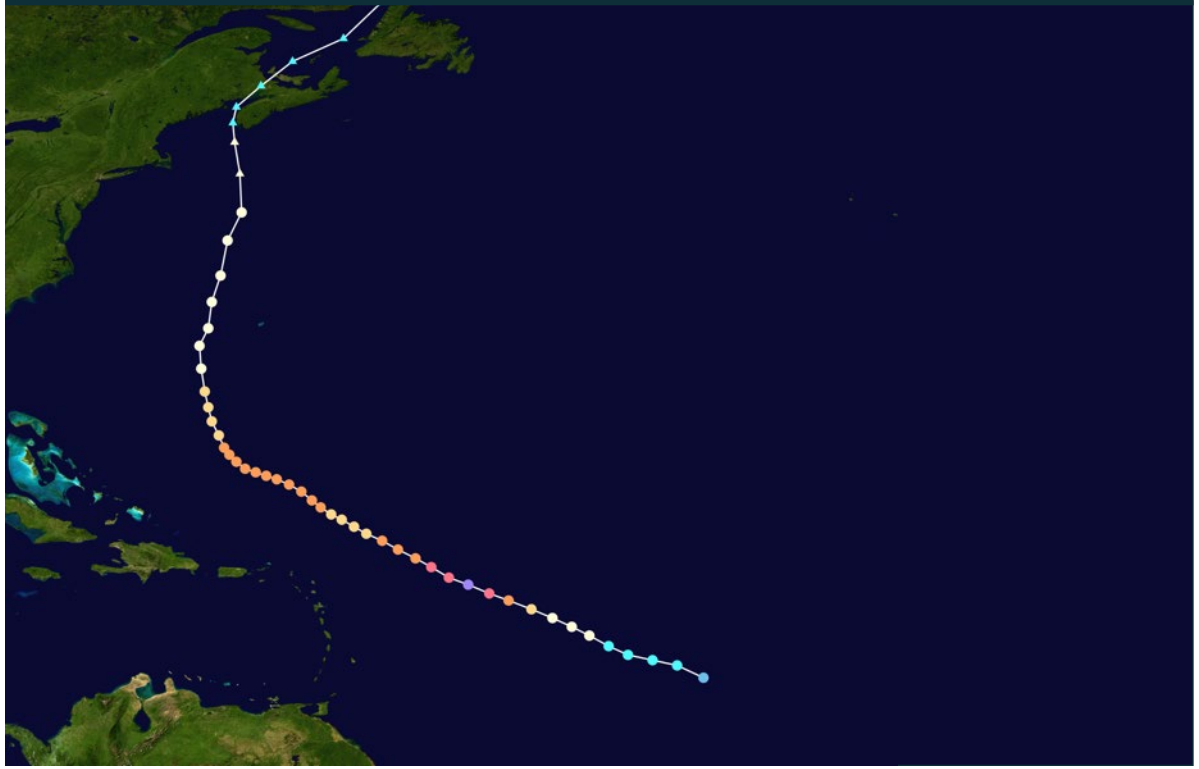
2023 Atlantic hurricane season

No retired Atlantic storms in 2023 (the first time there has been no retired Atlantic names since 2014)

Major Hurricane Lee



Peak: Cat 5, Landfall: Post-tropical



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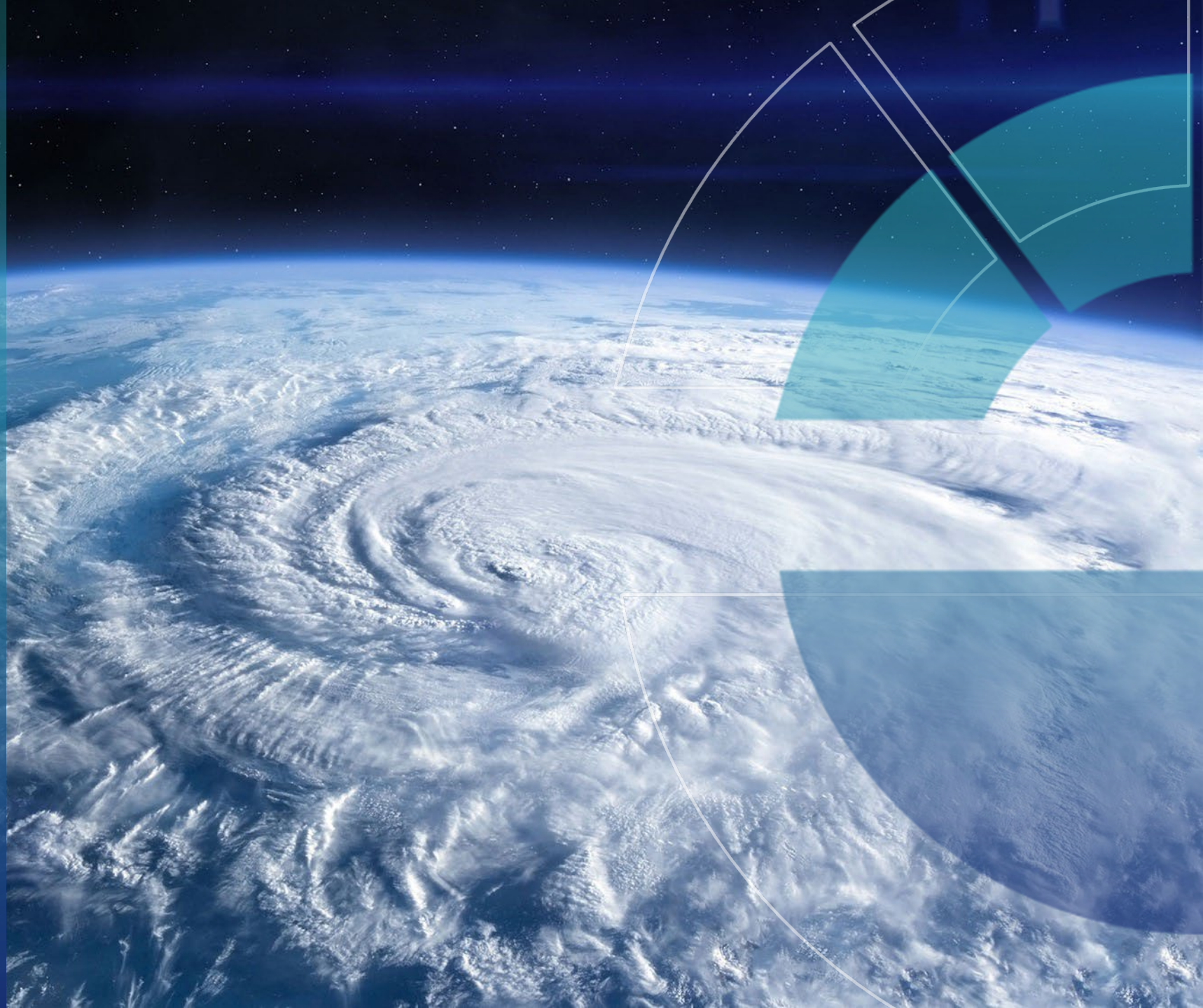
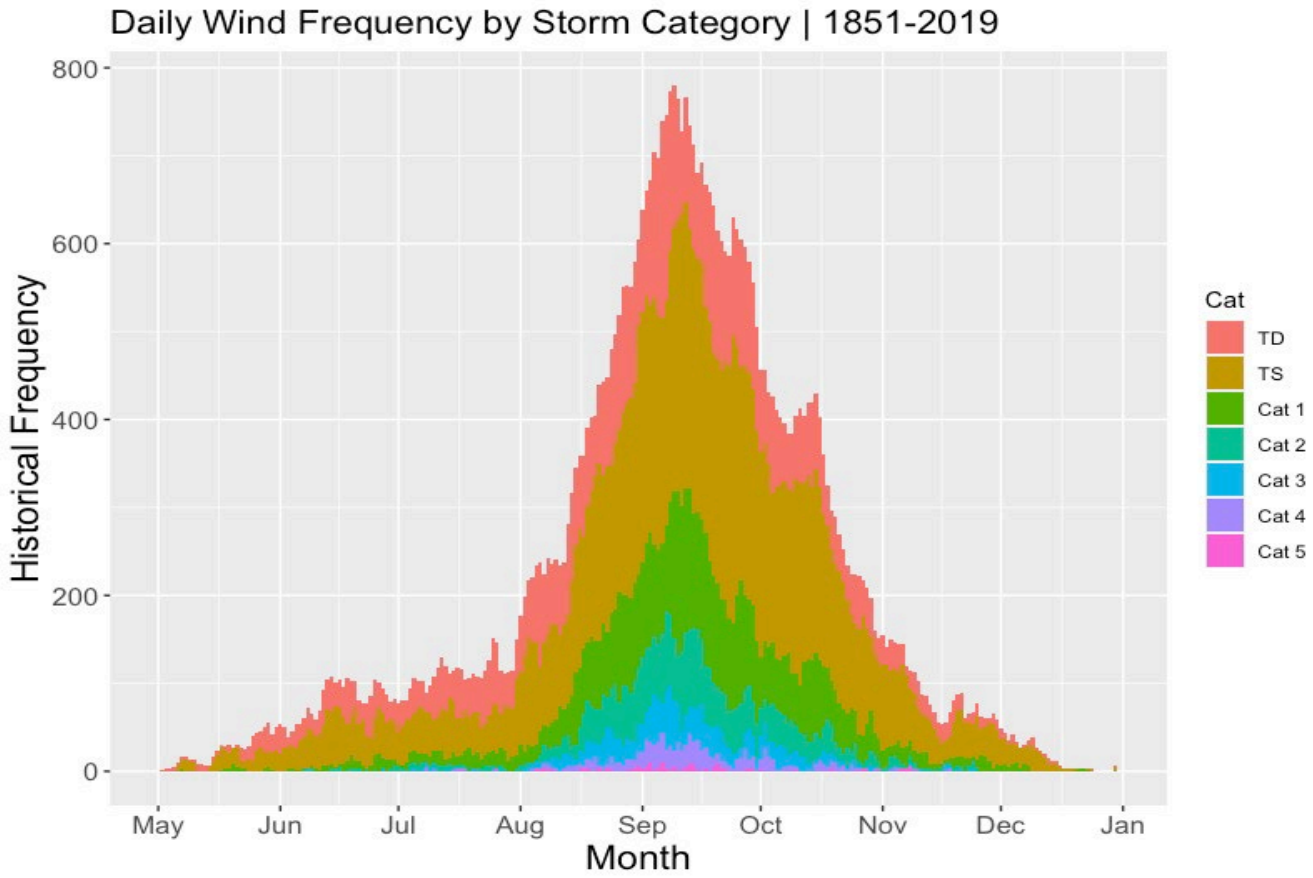
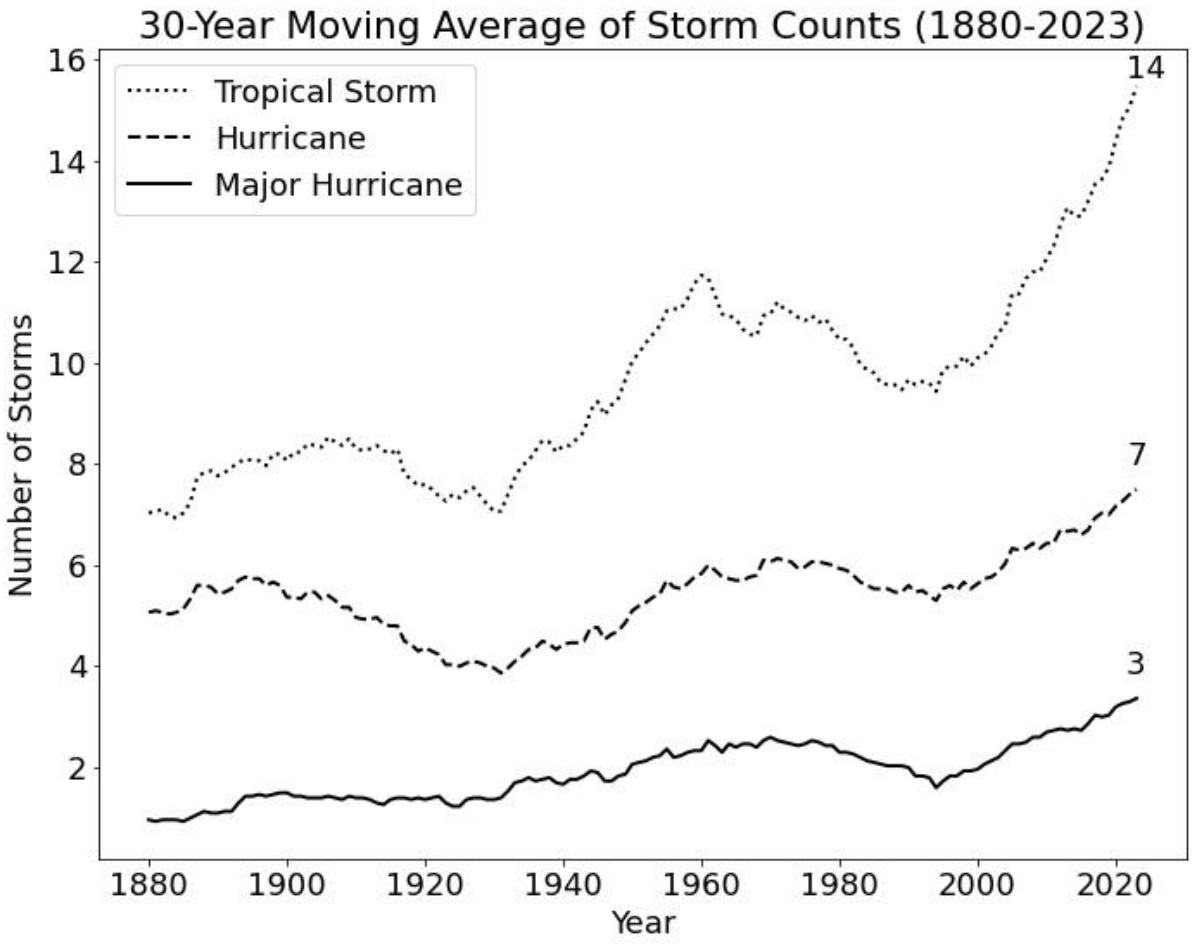
Tropical cyclone climatology





Climatology of Atlantic tropical cyclones

- Occasional storms develop early (before June 1)
- Peak activity in early September; secondary October peak
- August-October primary time for major hurricanes



Climate Normals for 1991 - 2020

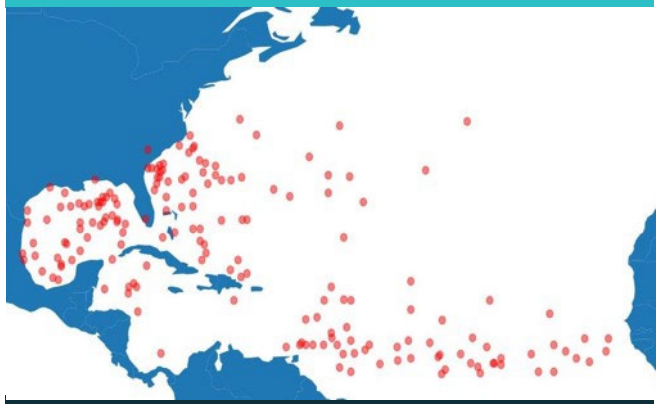
- 14 named storms, 7 hurricanes, 3 major hurricanes.
- Most of this period includes active era of Atlantic storms that began in mid 1990s.
- 1991–2020 normals are more active than the 1981–2010 normals.
- Largely due to ability to better identify relatively weak, short-lived systems that went undetected earlier in the record.

Typical tropical cyclone formation, June – August

June
1851–2023

Genesis Points = 135

July
1851–2023



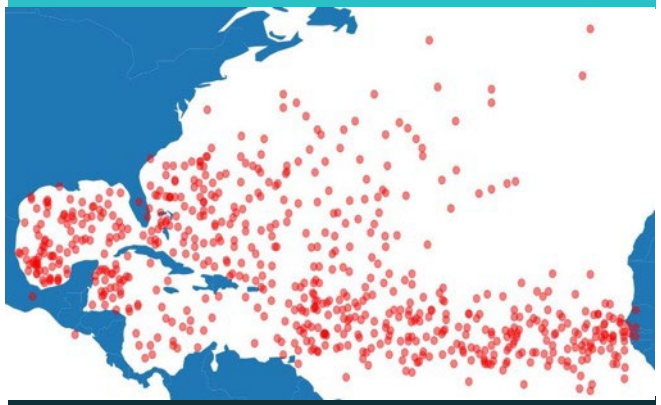
Genesis Points = 181

August
1851–2023

Genesis Points = 470

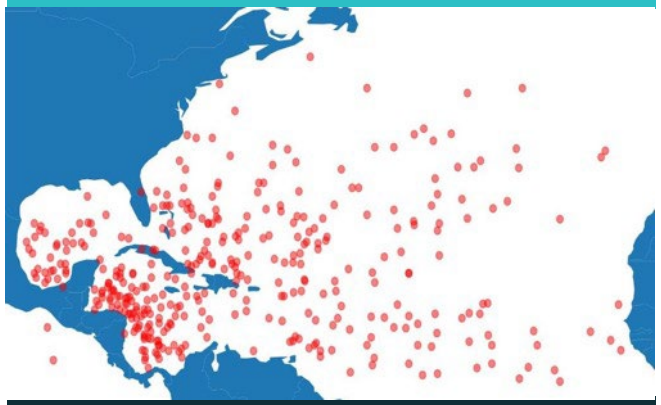
Typical tropical cyclone formation, Sept.–Nov.

September
1851–2023



Genesis Points = 660

October
1851–2023



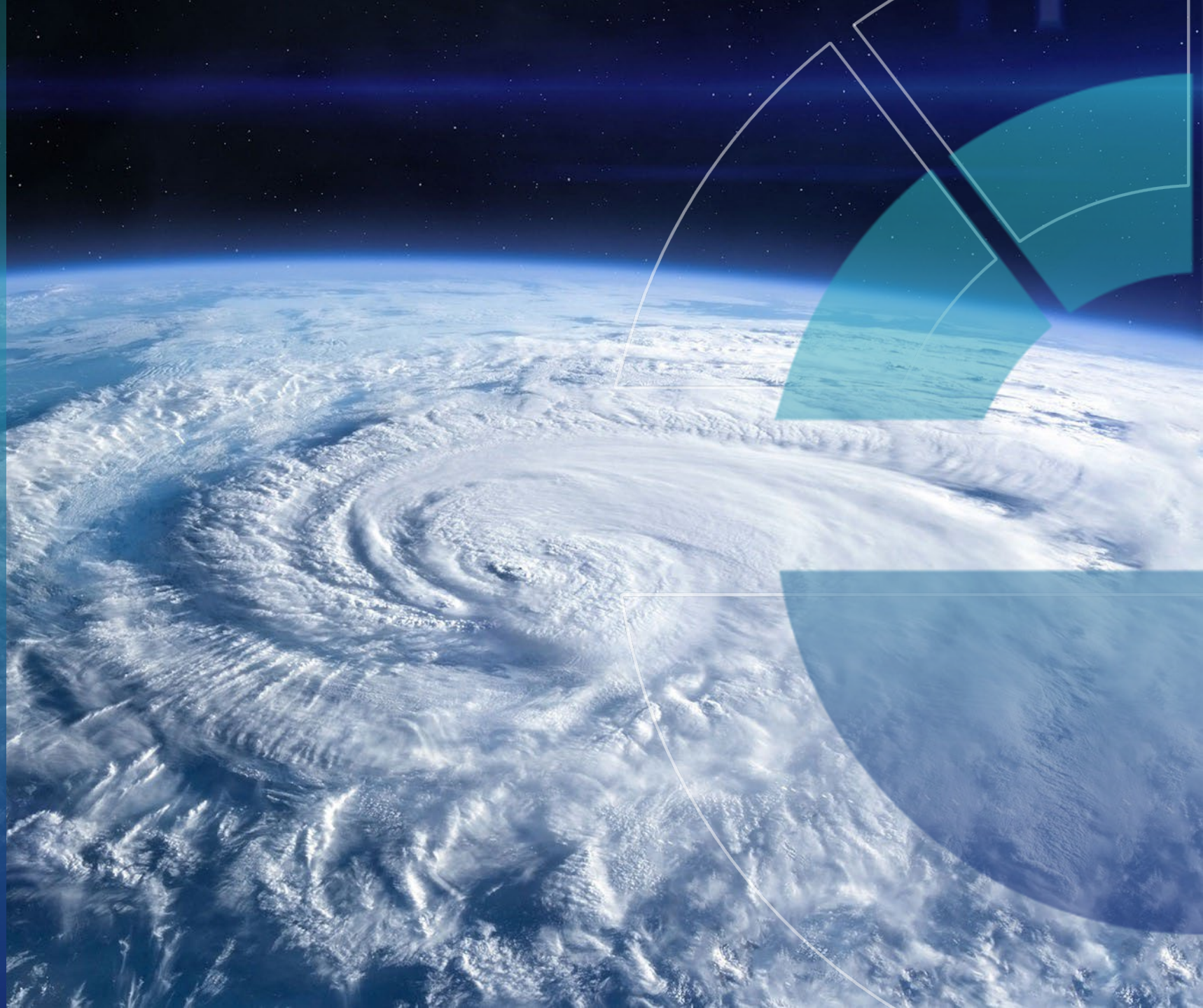
Genesis Points = 372

November
1851–2023

Genesis Points = 93

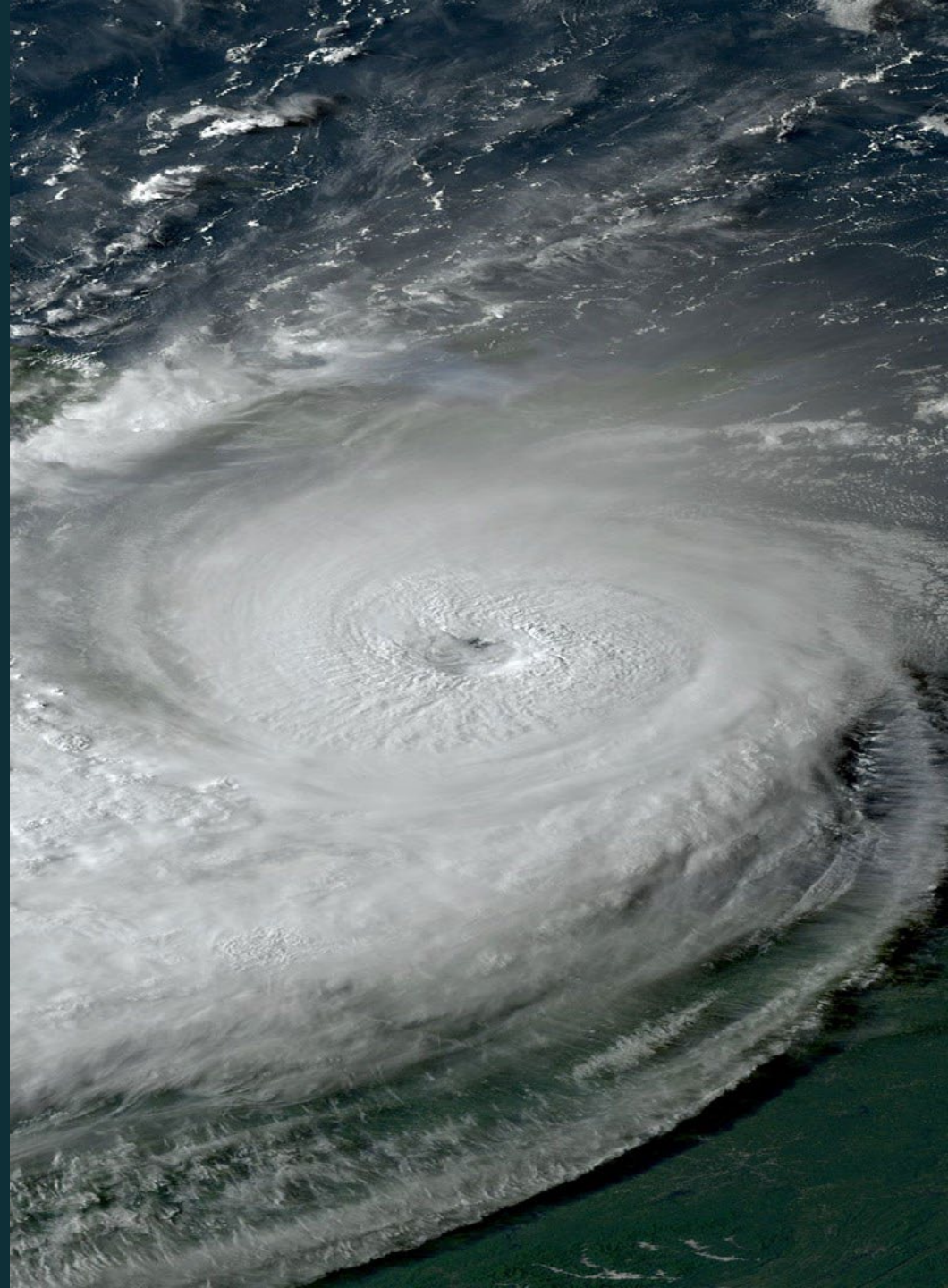
03

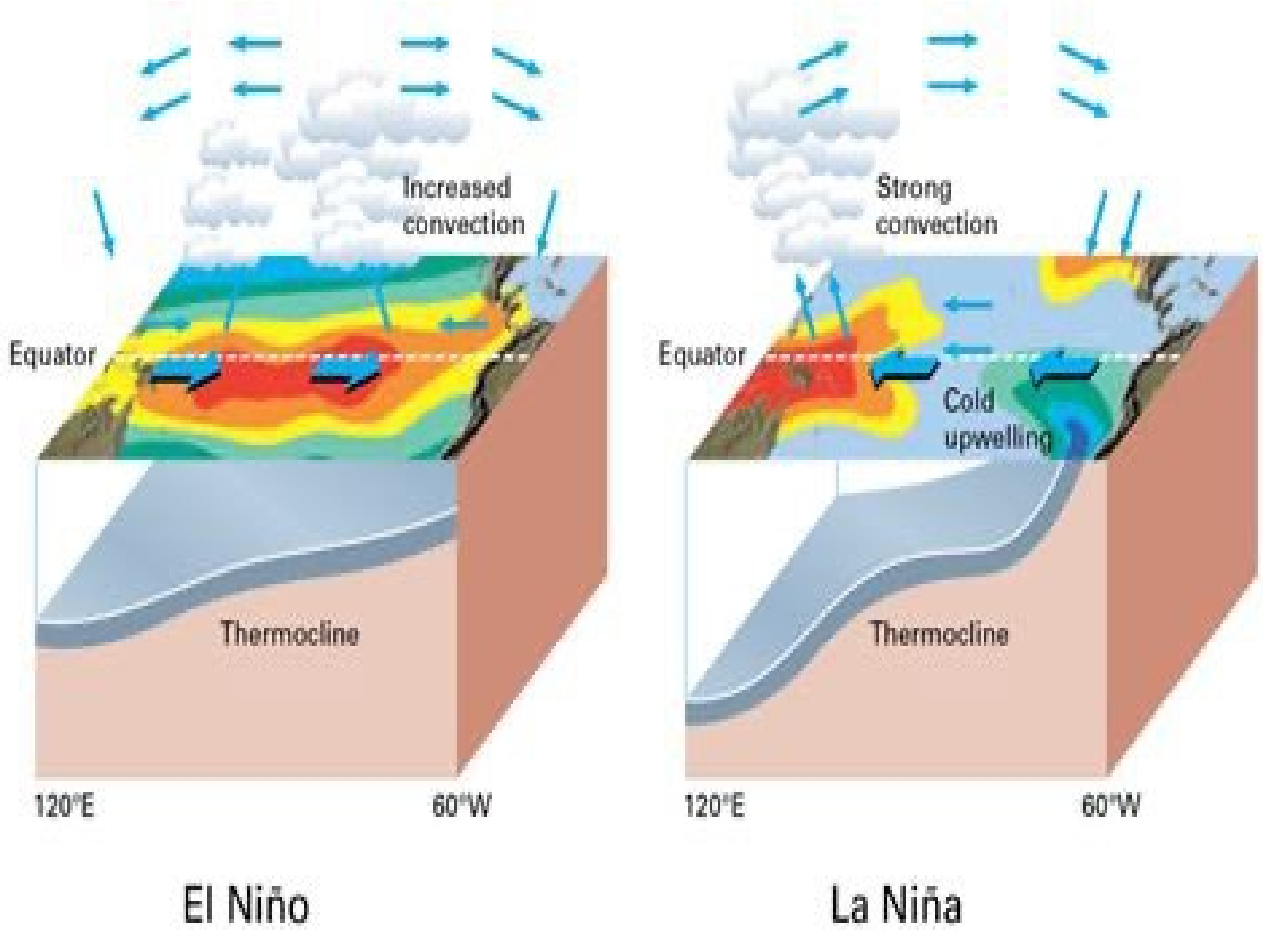
How climate impacts forecast



Key 2024 Atlantic Hurricane Outlook Factors

- El Niño/ La Niña (ENSO)
- AMO (Atlantic Multidecadal Oscillation)
- Saharan Dust

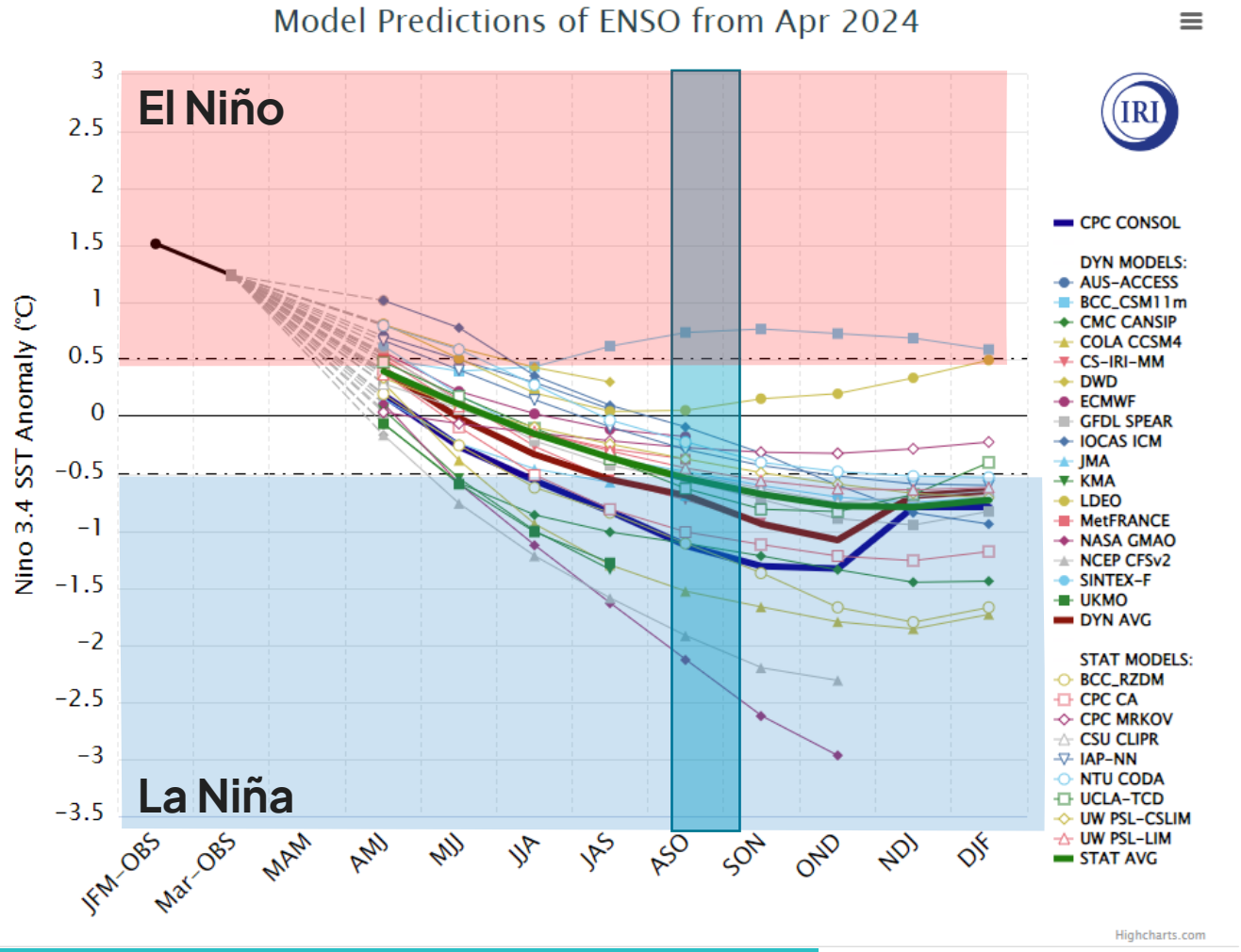




ENSO – El Niño Southern Oscillation

- A cyclical, periodic warming and cooling of the equatorial Pacific Ocean
- Typical circulation patterns seen during El Niño and La Niña.

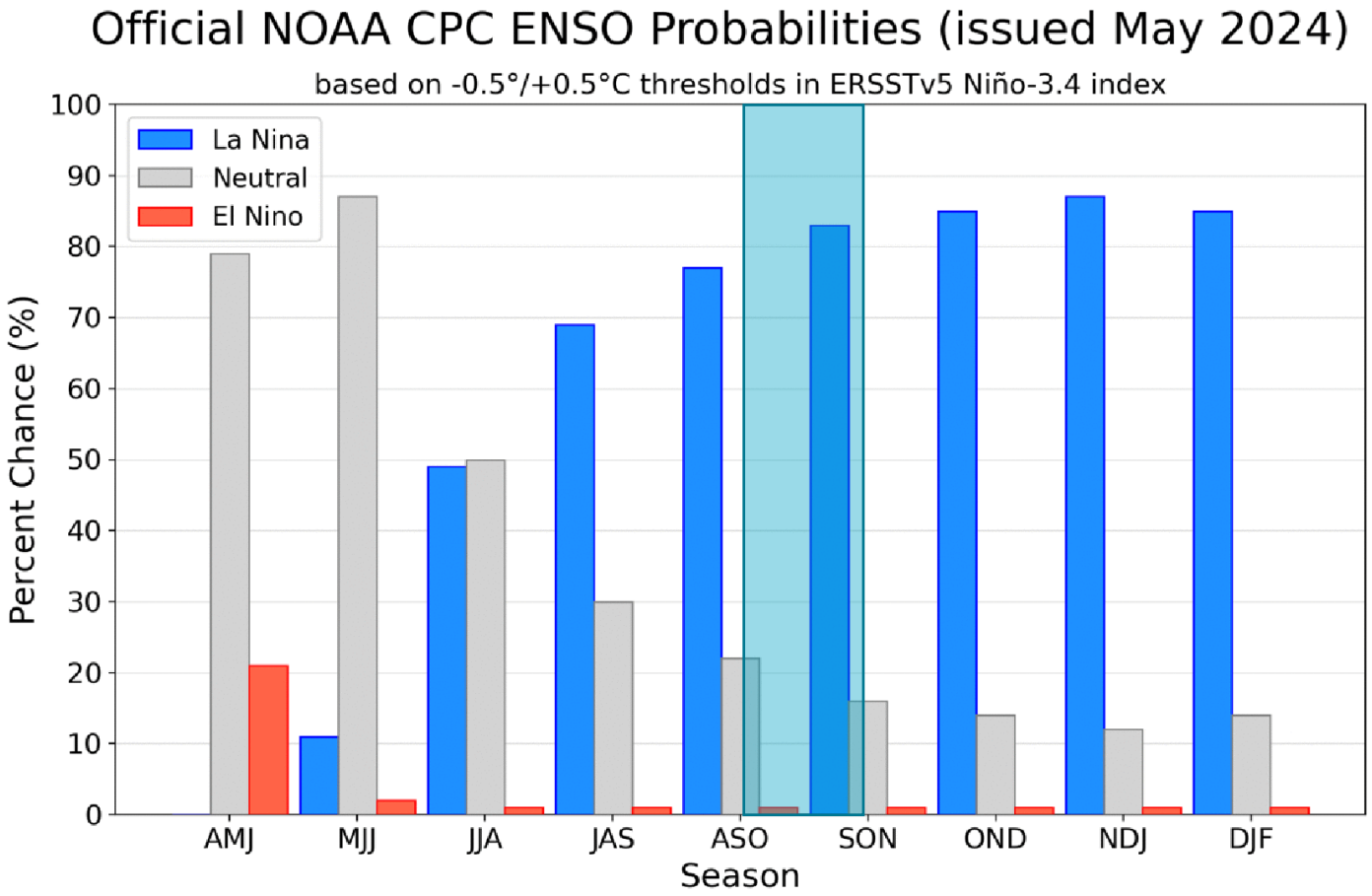
Source: WMO, El Niño/La Niña



Latest ENSO forecast projections

- Latest forecast projections favor El Niño shifting into ENSO-neutral conditions between April-May-June (AMJ) period.
- Weak La Niña conditions likely develop between the June-July-August (JJA) and July-August-September (JAS) periods.
- Weak La Niña likely remains in-effect through August-September-October (ASO).

Source: International Research Institute (IRI) for Climate and Society.

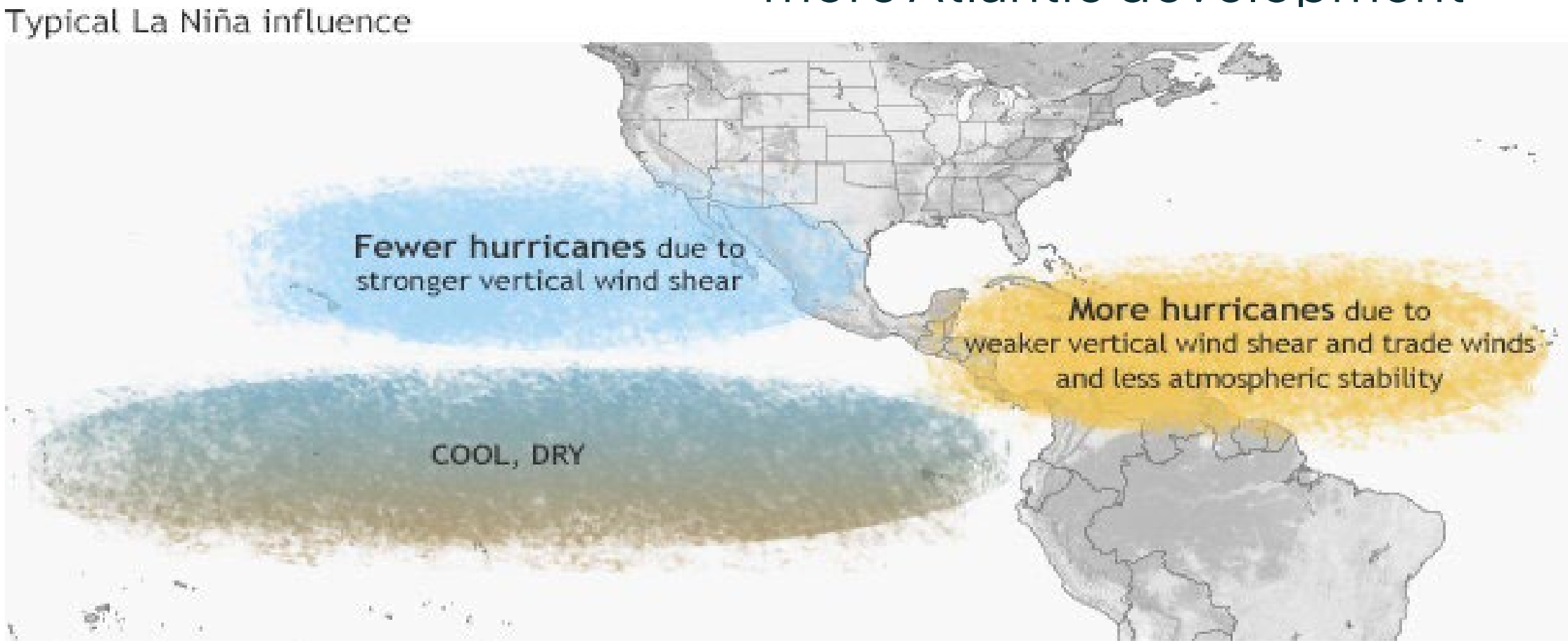


Latest ENSO forecast projections

- A transition from El Niño to ENSO-neutral is likely by June 2024
- La Niña likely develops between June-July-August (JJA) 2024.

Source: Climate Prediction Center, NOAA

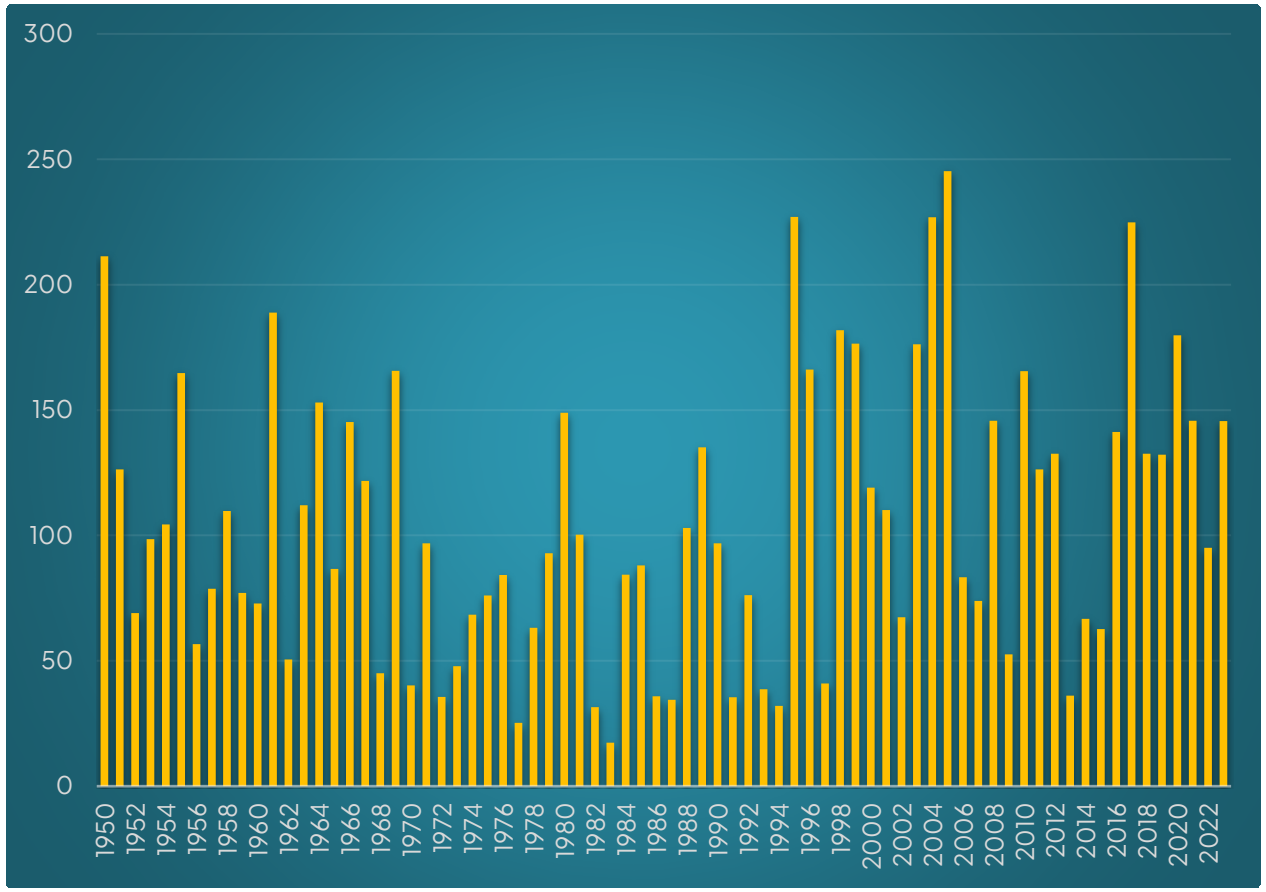
La Niña Impacts:
Lessened wind shear leads to more Atlantic development



Source: Climate Prediction Center, NOAA

Accumulated Cyclone Energy Index (ACE)

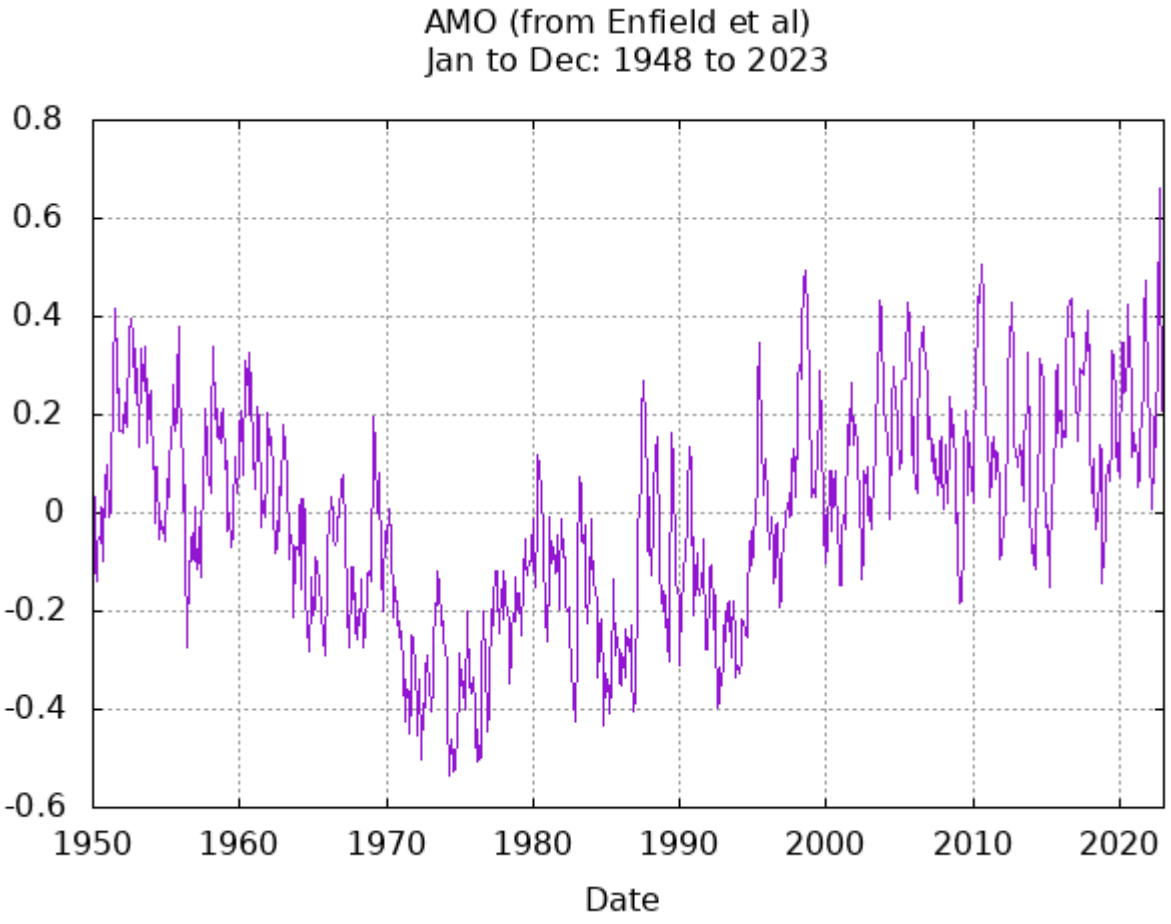
Annual ACE (1950-2023)



- ACE measures season-long tropical activity.
- Key factors in seasonal ACE values are intensity and duration.
- Average ACE value from 1950 to 2023 is 106.
- Our analog years of 1998, 2005, 2010, 2017 and 2020 measured ACE values greater than 150.
- Between 2000 and 2023, 10 different years were considered years where La Niña took place between the summer and fall. Of those 10 years, ACE values exceeded 200 twice (2005 and 2017).

Source: Data provided by Colorado State University

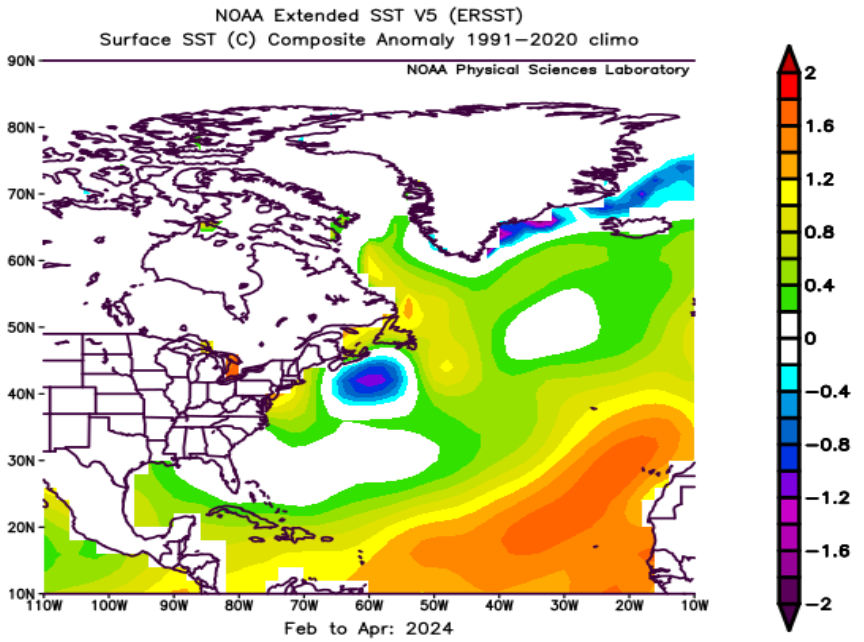
Atlantic Multidecadal Oscillation (AMO)

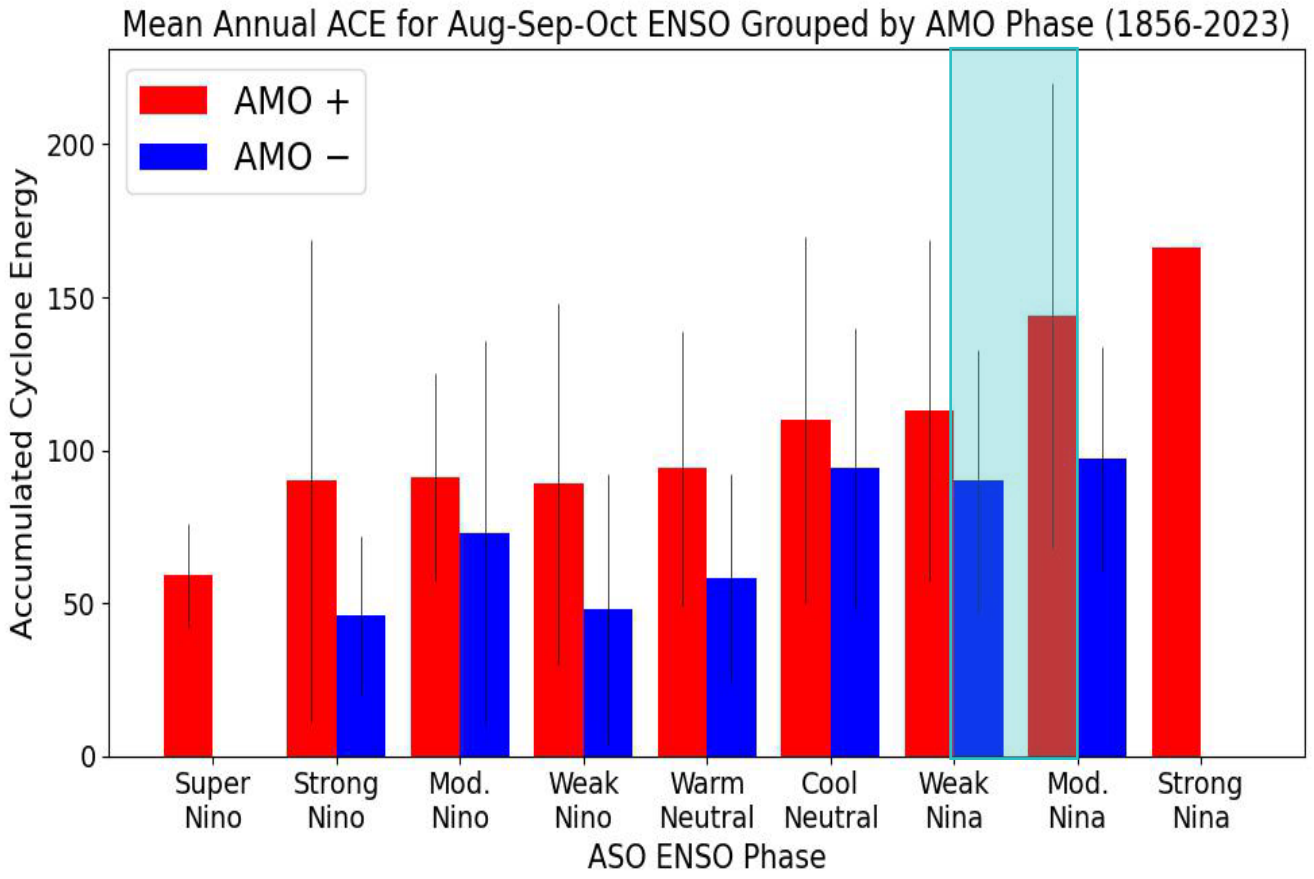


Source: NOAA PSL

- AMO is cyclical, generally lasting 20 to 30 years at a time.
- AMO has been in warm phase since 1995-1997.
- 2024 AMO Values:

February: 0.27 | **March:** -0.13 | **April:** 0.01



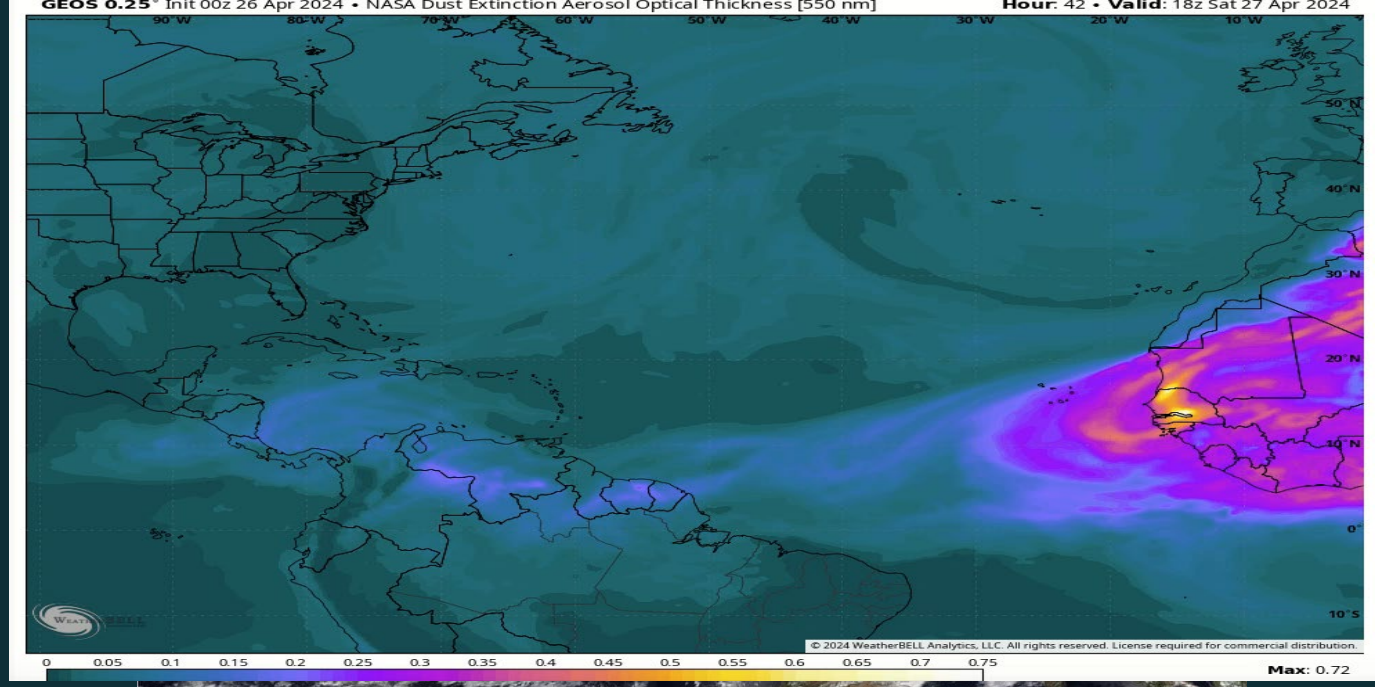


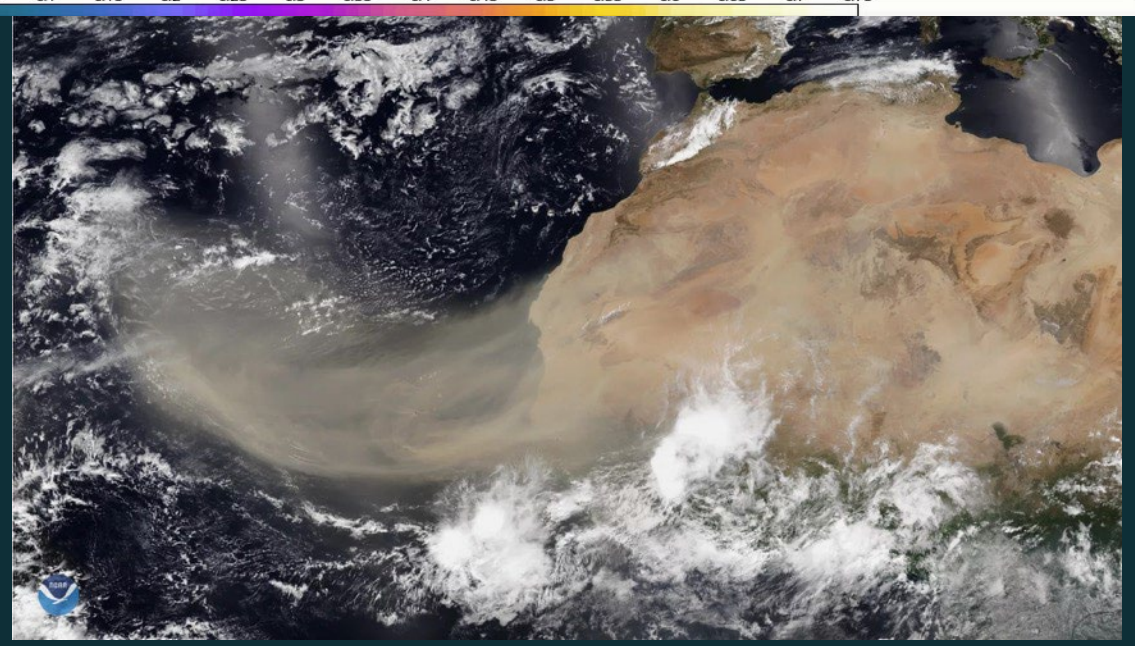
AMO and ENSO historical conditions combined

- AMO and ENSO combine to regulate Atlantic tropical activity.
- Clear AMO and ENSO pattern connection established.
- La Niña and positive AMO typically lead to a more active hurricane season.
- El Niño and positive AMO typically lead to less active hurricane seasons.

Wild card: Saharan dust

- Saharan dust comes from the Sahara Desert in Northern Africa.
- Thunderstorms and cyclones can produce high-speed winds that lift the dust and transport it thousands of miles through the air.
- The dust can travel around the globe to parts of Europe, South America, Central America, the Caribbean, and the United States.
- Semi-permanent Bermuda High pressure system over the Atlantic helps to transport dust towards the west.





Source: National Oceanic & Atmospheric Administration

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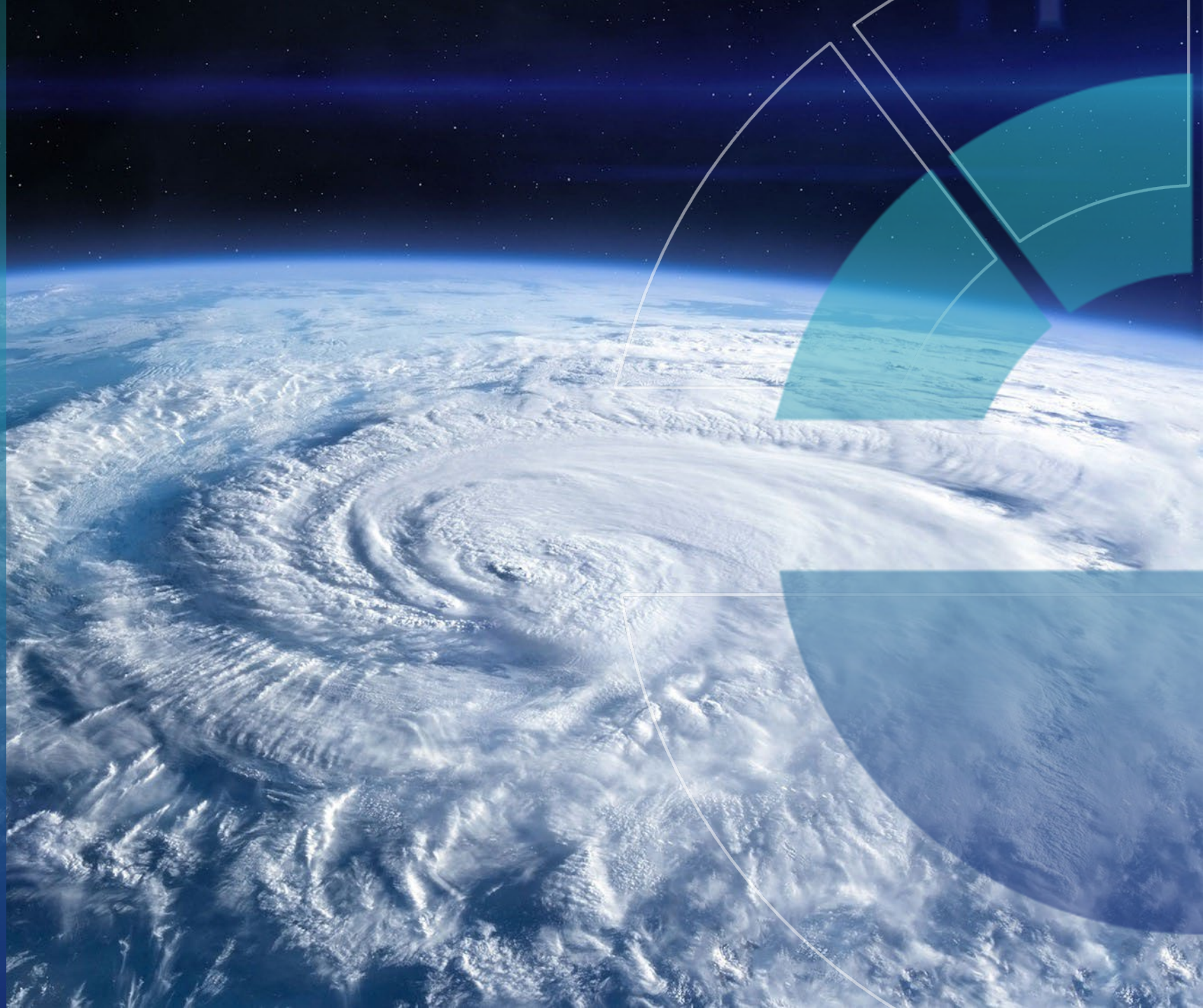
2024 Atlantic hurricane forecast



AEM 2024 forecast methodology

Machine Learning Model

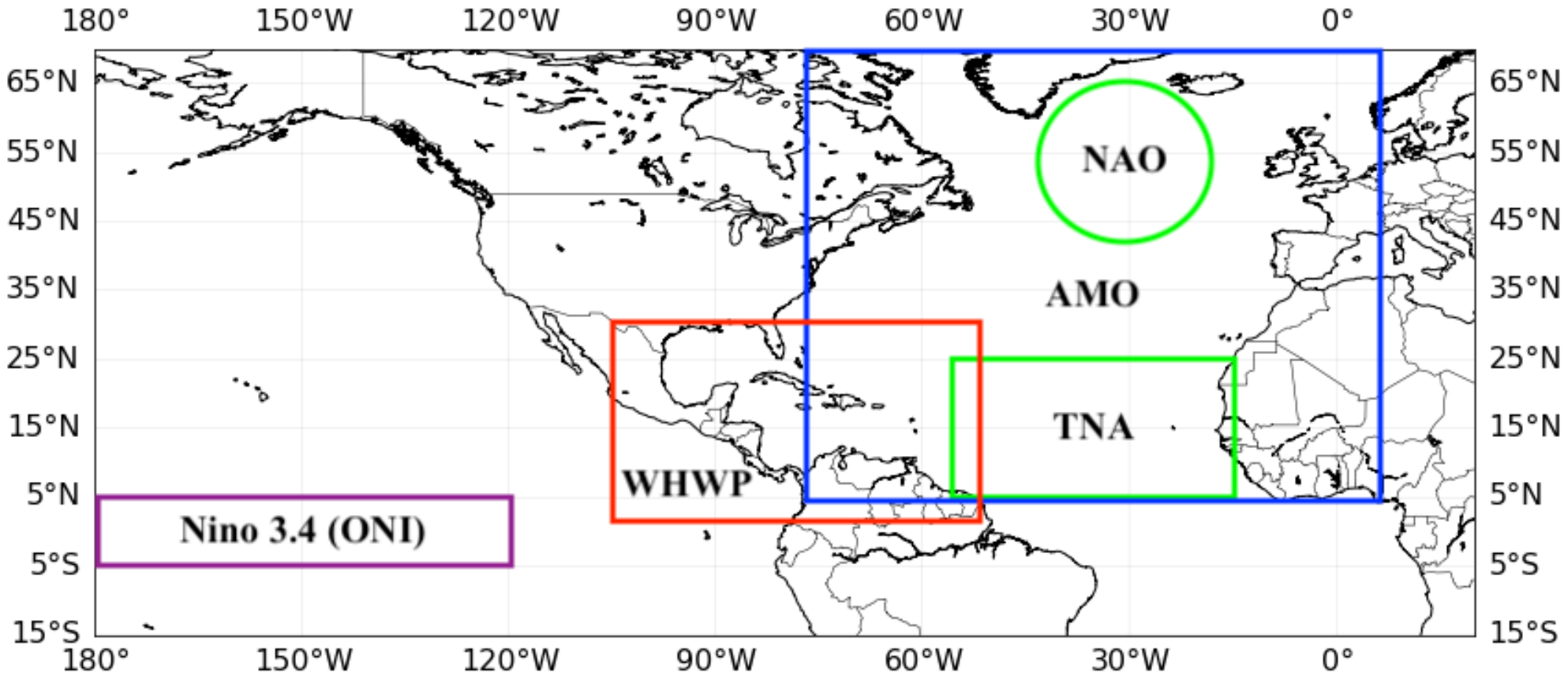
- Neural Network model is used to forecast ACE, the number of named storms, the number of hurricanes, and the number of major hurricanes.
- Model based on 44 years of data spanning 1980 to 2023.
- Utilizes several global atmospheric and oceanic predictors (e.g., ENSO, AMO, others).

Analogs

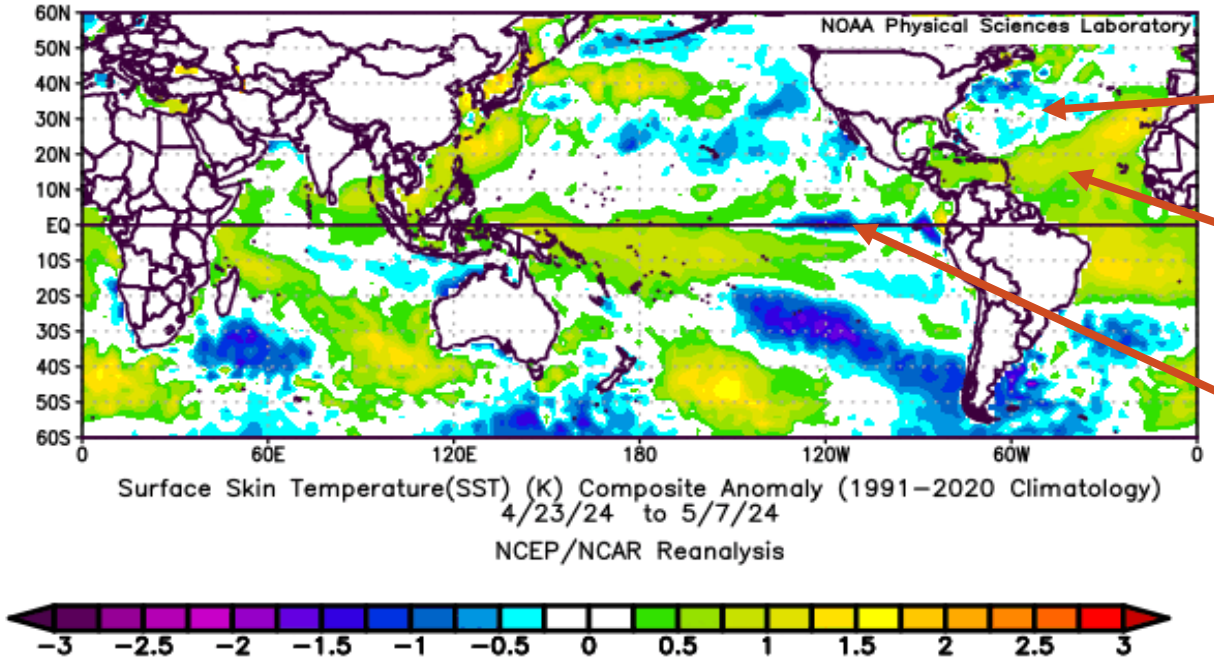
- Analogs are selected by the forecast team.
- Five years are chosen from when similar expected atmospheric and oceanic conditions from June to November occurred.
- Compute the average of ACE, number of named storms, hurricanes, and major hurricanes.

KEY FINAL STEP: Consider statistical model forecasts with analog averages, and make final adjusted prediction as needed.

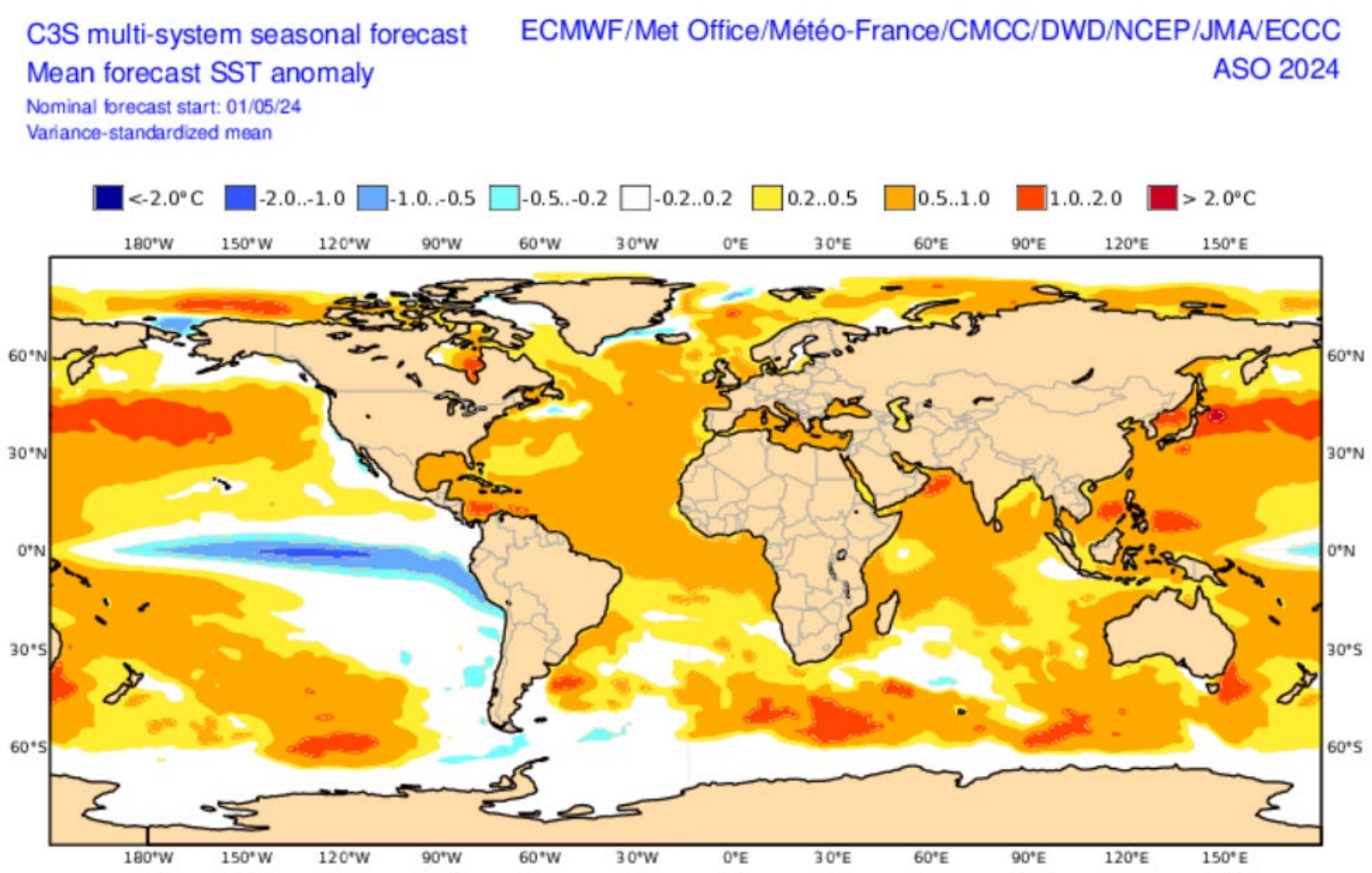
Model parameter locations



Latest Ocean Water Temperature Anomalies



- Cool anomalies across subtropical North Atlantic.
- Warm anomalies across main development region of Atlantic.
- El Niño nearing termination as rapid cooling continues over the eastern equatorial Pacific.



Forecast Sea Surface Temperature Anomalies

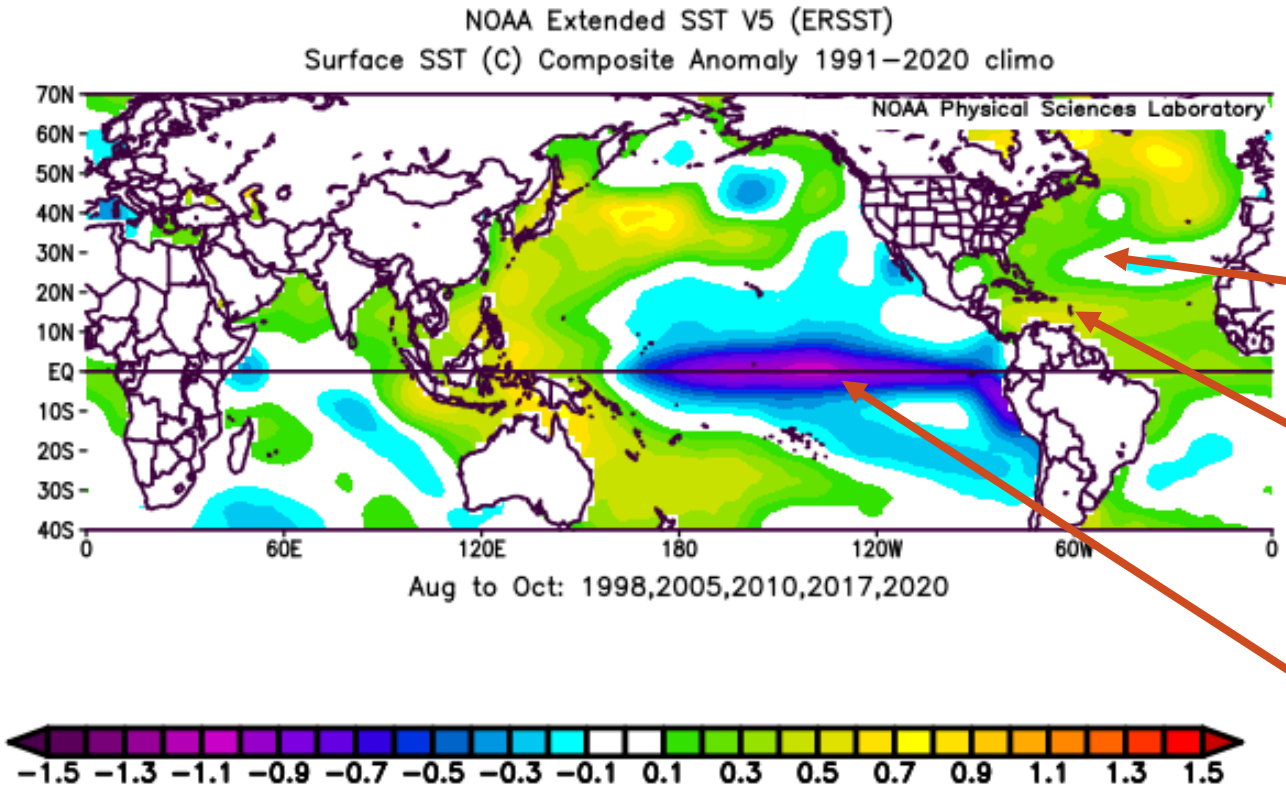
Analog years - Years with similar predictor patterns to 2024

YEAR	ACE	NAMED STORMS	HURRICANES	MAJOR HURRICANES
1998	181.8	14	10	3
2005	250.1	28	15	7
2010	165.5	19	12	5
2017	224.9	17	10	6
2020	180.4	30	14	7
Mean of Analog Years	200.5	21.6	12.2	5.6
Normal Tropical Season (1991-2020)	122.5	14.4	7.2	3.2

Years where Cool Neutral to Weak/Moderate La Nina occurred in Summer and Fall

A large and warm WHWP and positive AMO

Analog years point to well above NORMAL tropical activity for the upcoming season.



Analog Years August–October SST Anomalies

- Near average sea surface temperatures in subtropical Atlantic.
- Above average sea surface temperatures across the MDR into Caribbean, Gulf of Mexico and along the East Coast.
- Weak to moderate La Niña present in the equatorial Pacific Ocean.

Combining analogs with statistical model forecast

CATEGORY	STATISTICAL MODEL FORECASTS	MEAN OF ANALOGS	MEAN OF MODEL AND ANALOGS
ACE	193.7	200.5	197.1
Named Storms	20.5	21.6	21.1
Hurricanes	10	12.2	11.1
Major Hurricanes	5.4	5.6	5.5

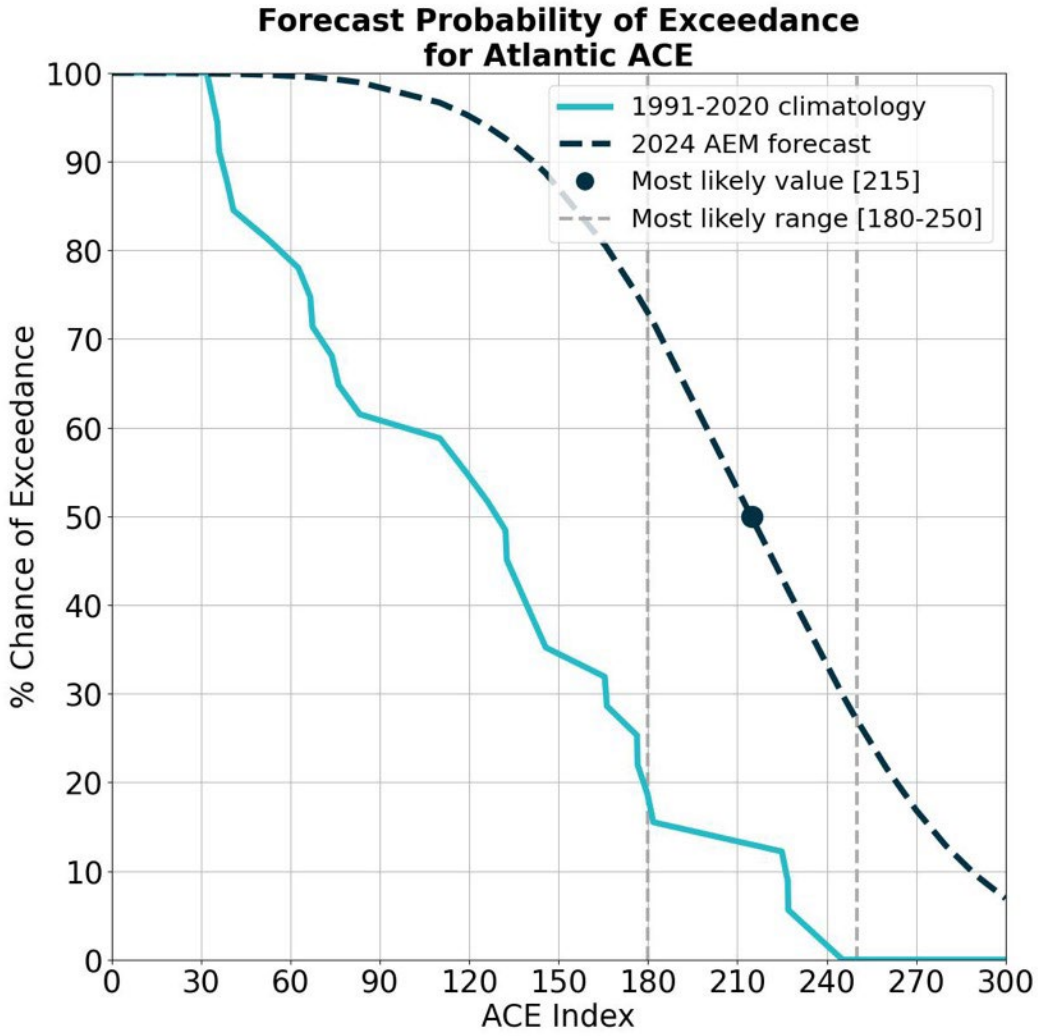
AEM 2024 Atlantic hurricane outlook:

Above Normal: 84% chance	**Normal:** 15% chance	**Below Normal:** 1% chance

CATEGORY	NORMAL(1991-2020)	FINAL FORECAST
ACE	75 to 155	215 (180-250)
Named Storms	12-16	23 (20-26)
Hurricanes	5-9	11 (9-13)
Major Hurricanes	2-4	6 (5-7)

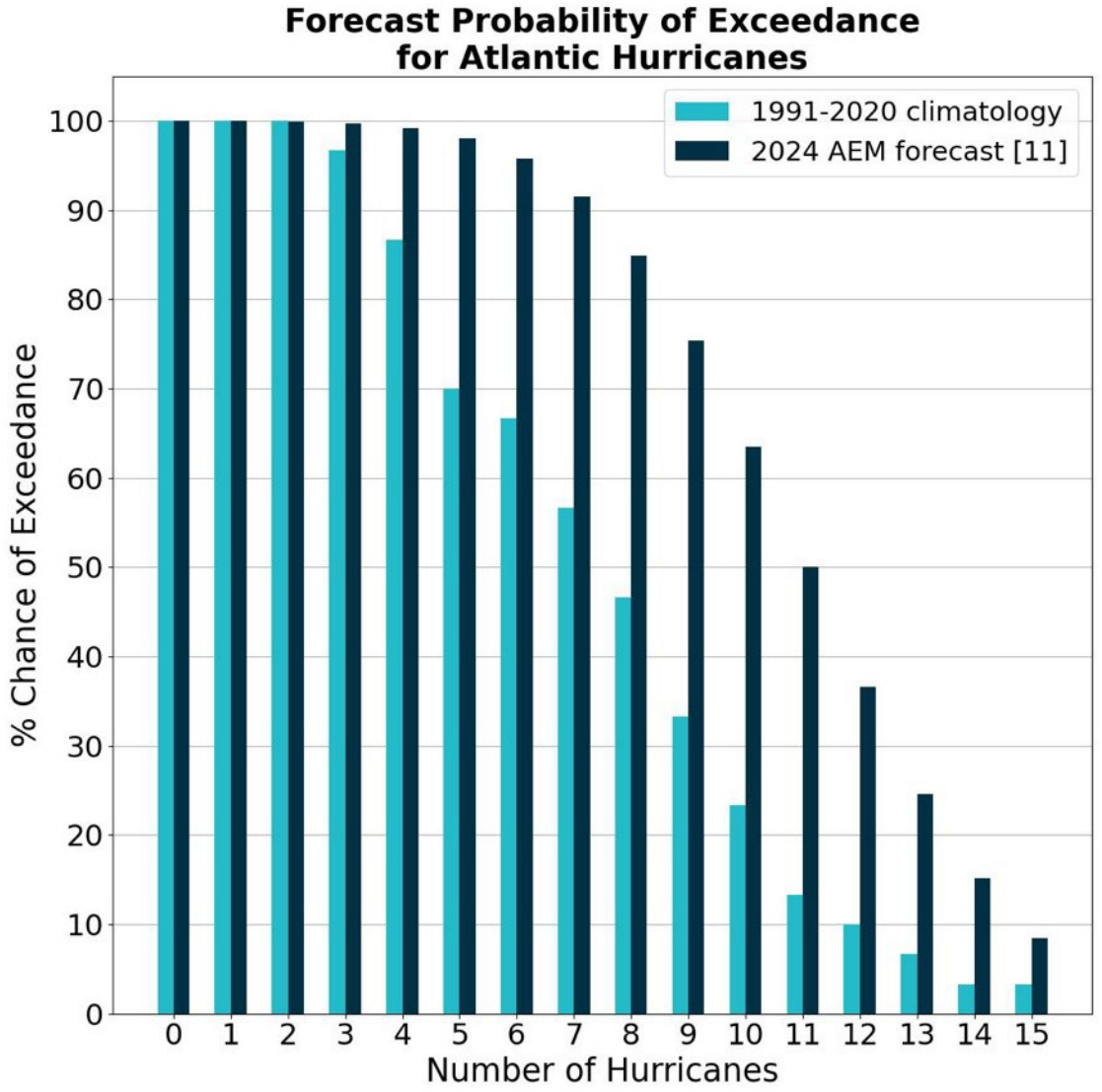
2024 probability of exceedance for ACE

- To better convey uncertainty in the forecast, Probability of Exceedance charts have been included to enable users to more accurately assess risk.
- The light blue line is the probability of a given ACE number being achieved based on 1991-2020 climatology.
- The dark blue dashed line displays the probability of ACE exceeding a given value based on our forecast of 215.



2024 probability of exceedance for hurricanes

- To better convey uncertainty in the forecast, Probability of Exceedance charts have been included to enable users to more accurately assess risk.
- The light blue bar is the probability of a given hurricane count being achieved based on 1991-2020 climatology.
- The dark blue bar shows the probability of a hurricane count being exceeded a given forecast value of 11.

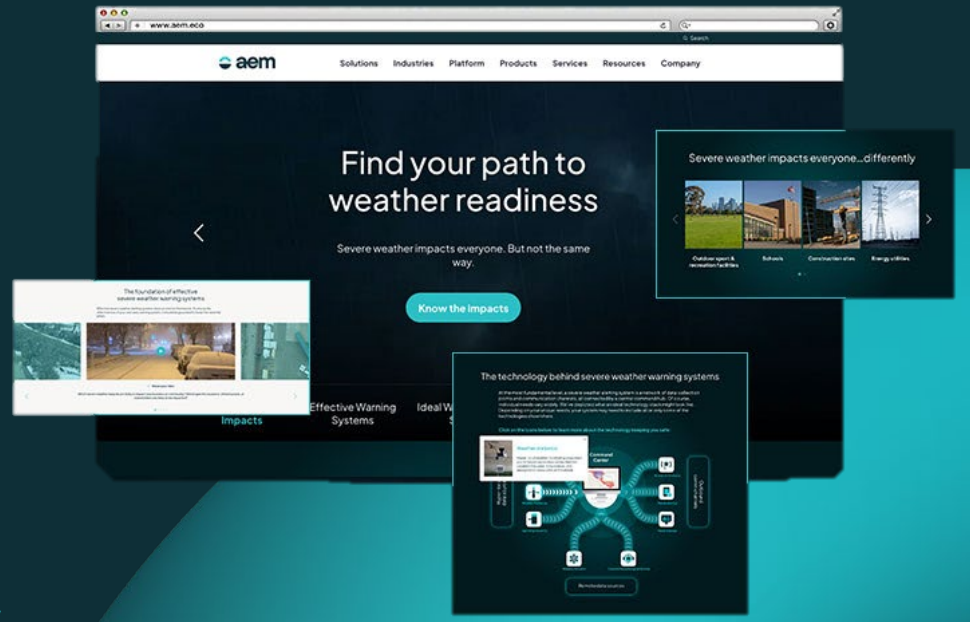



Panel discussion

Poll question


Audience Q&A

Get access to our interactive Severe Weather Readiness Guide



https://aem.eco/severe-weather-readiness-vision/

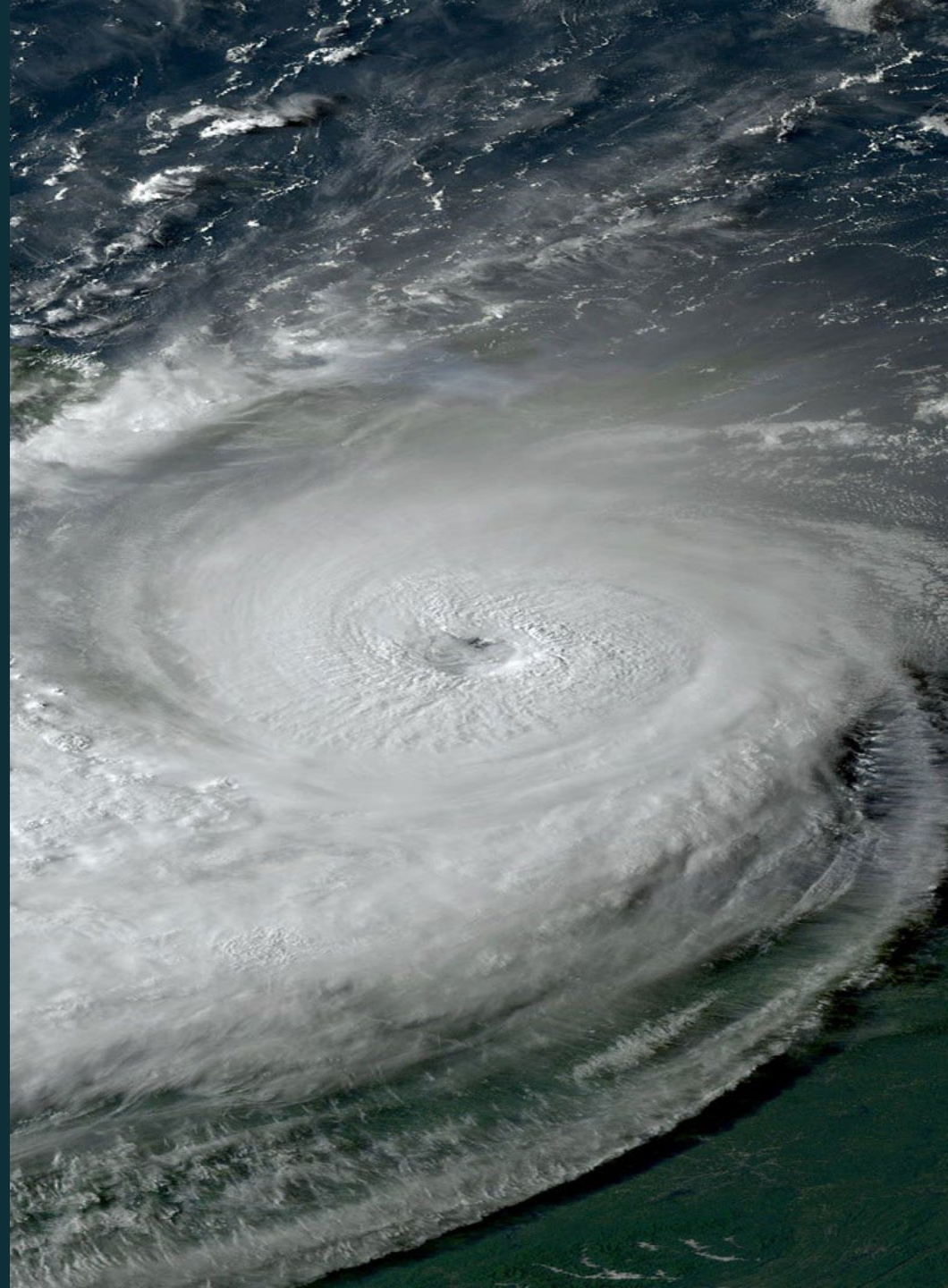
For more information, let's talk at:
info@aem.eco

aem.eco

Additional information

Tropical season safety, mitigation, and resiliency planning

- Understand the threats and vulnerabilities to your business and properties – utilize flood and disaster consultants as needed.
- Develop a plan that covers long-term needs, short-term and in-event processes, which will help mitigate loss and improve business resiliency while providing safety to personnel.
- Secure the resources for the plan – such as a single, trusted forecast source and a source for weather threat information - before, during, and after an event.
- Practice the plan well before tropical season starts to avoid last-minute confusion. Identify communication pathways for disseminating critical information about threats with clear actions.
- Perform a post-storm review of the processes to identify areas to improve.



Technical definitions and terminology explanations

KEY DEFINITIONS

- **Accumulated Cyclone Energy (ACE):** Sum of the Squares of 6-hourly Maximum Sustained Wind Speeds (in units of knots) for all Systems while they are at least Tropical Storm intensity.
- **Named Tropical Storm:** 1 Minute Sustained Winds > 33 kt (39 mph).
- **Hurricane:** 1 Minute Sustained Wind > 63 kt (74 mph).
- **Major Hurricane:** 1 Minute Sustained Wind > 95 kt (110 mph).

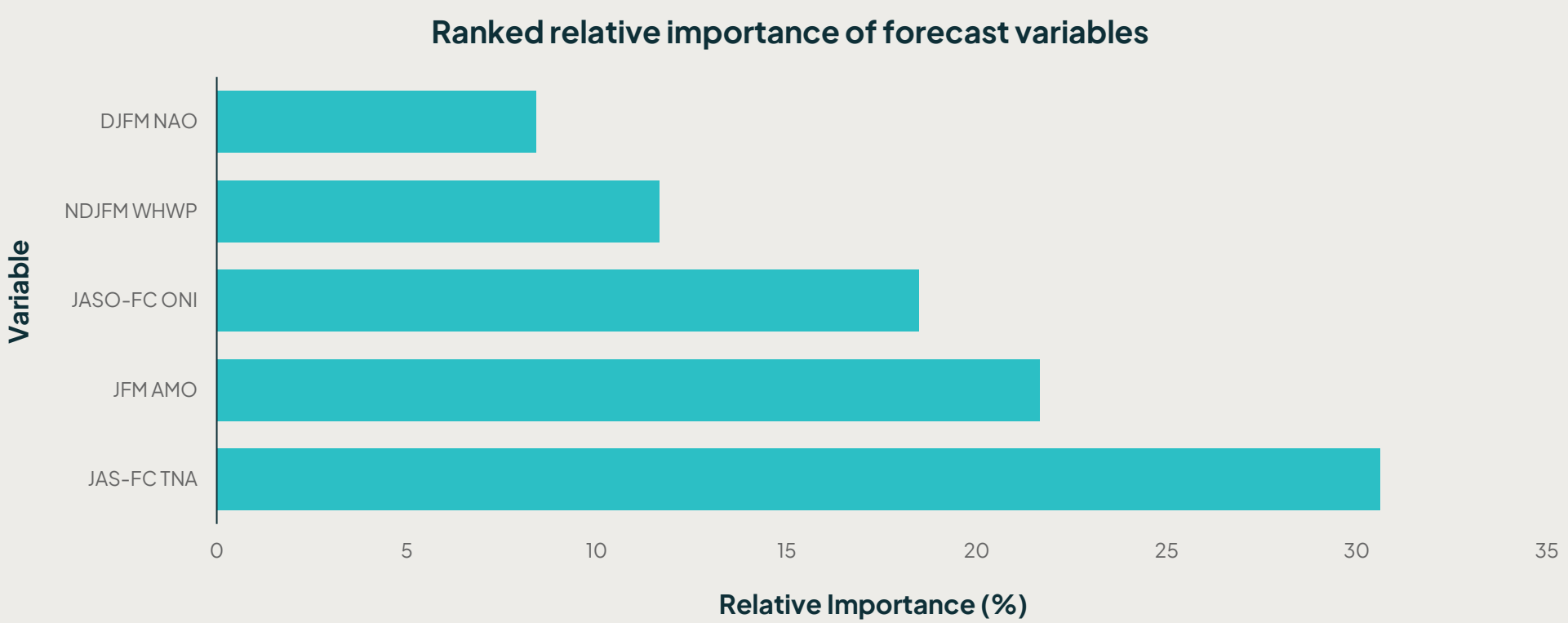
COMMENTARY ON OUR NEURAL NETWORK MODEL

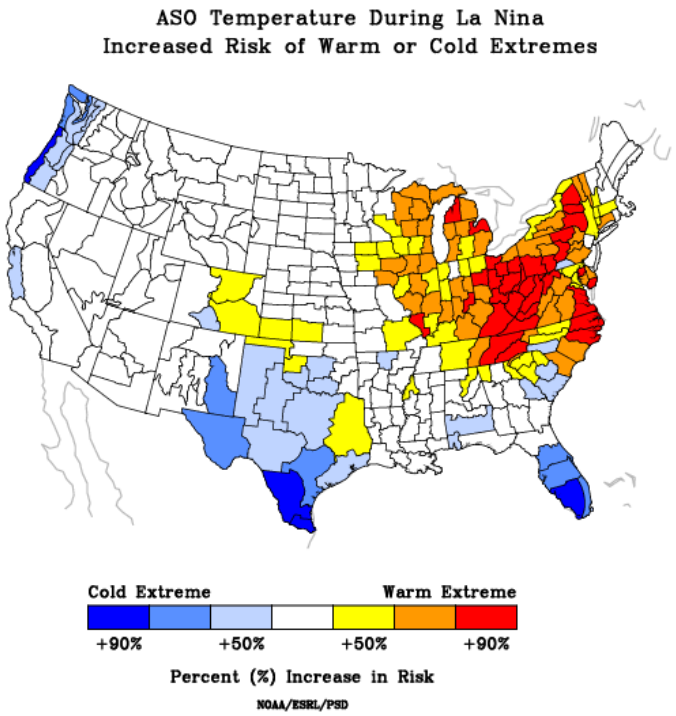
- Our statistical prediction forecast is based a neural network incorporating several predictors in the Atlantic ocean basin that have shown skill in seasonal ACE forecasting.
- Model is designed to run in April.
- Correlation coefficient, r, was calculated to be 0.77 for the 1980-2020 ACE hindcast period the model was developed on, demonstrating strong forecast skill.

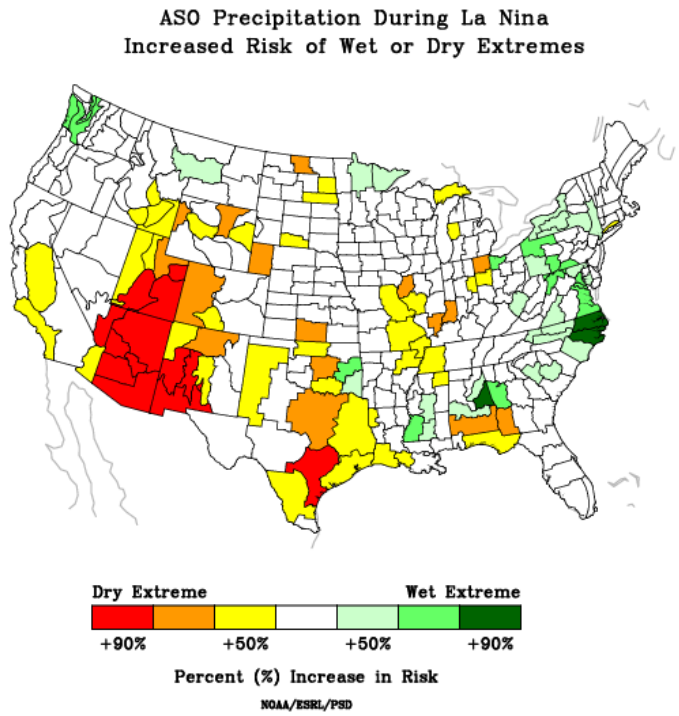
FORECAST PROBABILITY

- Final forecast probability is determined by the likelihood ACE will fall into a given tercile.
- Tercile groupings correspond to 1/3 (33.3%) of observed seasonal values in 1991 to 2020 climatology.
- Above normal seasonal ACE is therefore the highest 1/3 of recorded values, or >155.
- Normal seasonal ACE values are the middle 1/3 which are between 74 and 155.
- Below normal seasonal ACE values are <75.

Ranked importance of forecast variables

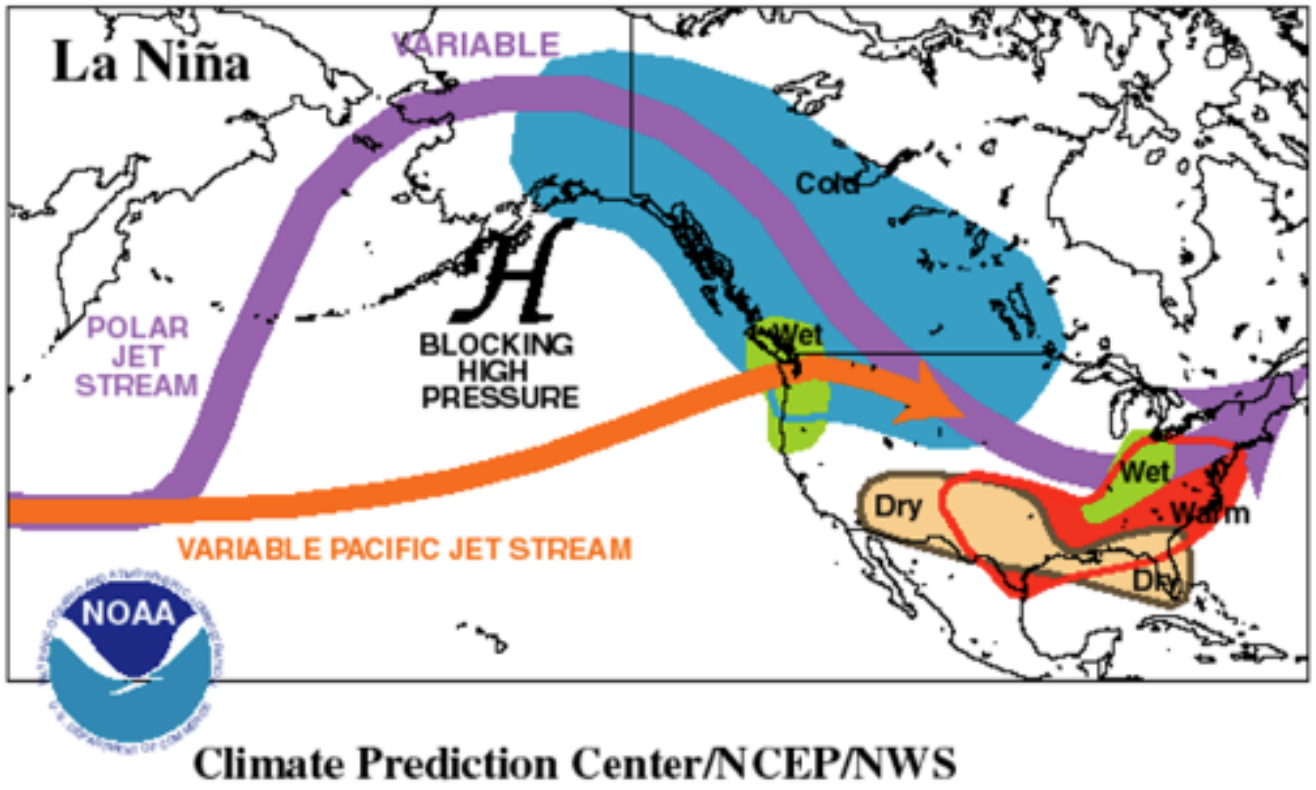






La Niña extremes

- During La Niña, temperatures can typically be well above average across the Midwest and Northeast. Meanwhile, temperatures tend to be cooler across the southern U.S.
- Similarly, the Desert Southwest tends to be drier during ASO whereas the East Coast tends to receive an increase in moisture.
- Mainly due to what's happening in the Pacific which affects the weather pattern in the CONUS.



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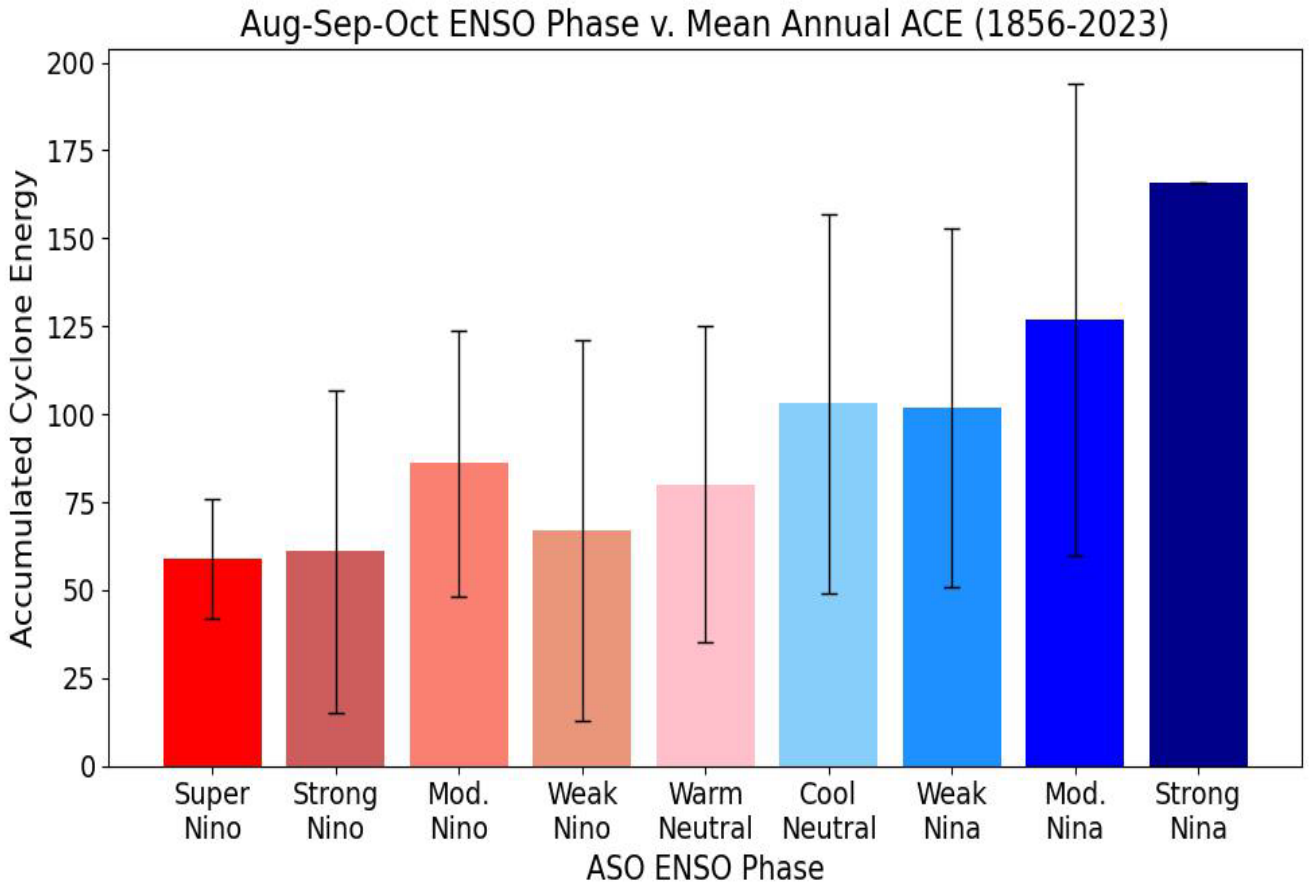

ENSO phases can have huge impacts on number and intensity of named storms during season

- La Niña typically favors above-normal named storm chances across the Atlantic.
- Storm intensity and duration in La Niña tend to be stronger and longer.
- ENSO-neutral can produce a larger spread of outcomes.
- El Niño usually leads to a reduction in Atlantic hurricane activity.
- El Niño typically leads to shorter duration and weaker intensity.

Atlantic SST anomalies

- Seasonal forecasts indicate above normal SSTs for the Atlantic Basin.
- Although it will be above normal, there seems to be a cooling that takes place across the Atlantic.
- Anomalies up to 1.5-degree Celsius.