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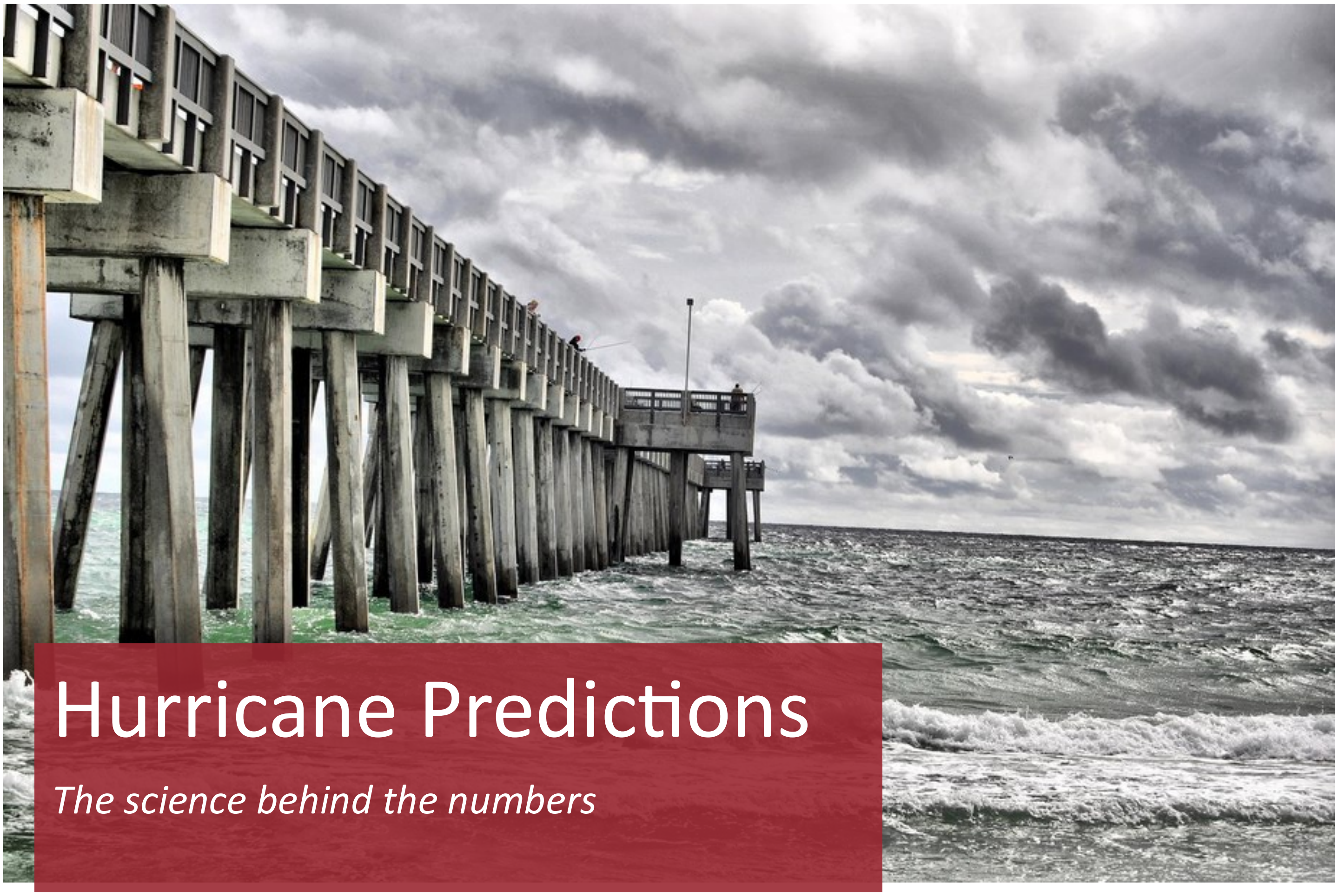
# ViewPoint

*Analyzing Industry Issues from an Independent Perspective*



# Hurricane Predictions

## *The science behind the numbers*

***As much of the country plans summer vacations,*** NOAA is actively studying weather patterns to predict the severity of the upcoming hurricane season.

Each year, in May and August, NOAA forecasts the number of named storms, hurricanes and major hurricanes (Category 3 – 5) using modeled predictions of regional and global atmospheric and oceanic conditions.

The following pages will examine contributing factors to an active or inactive hurricane season, as well as the 2016 season in context.

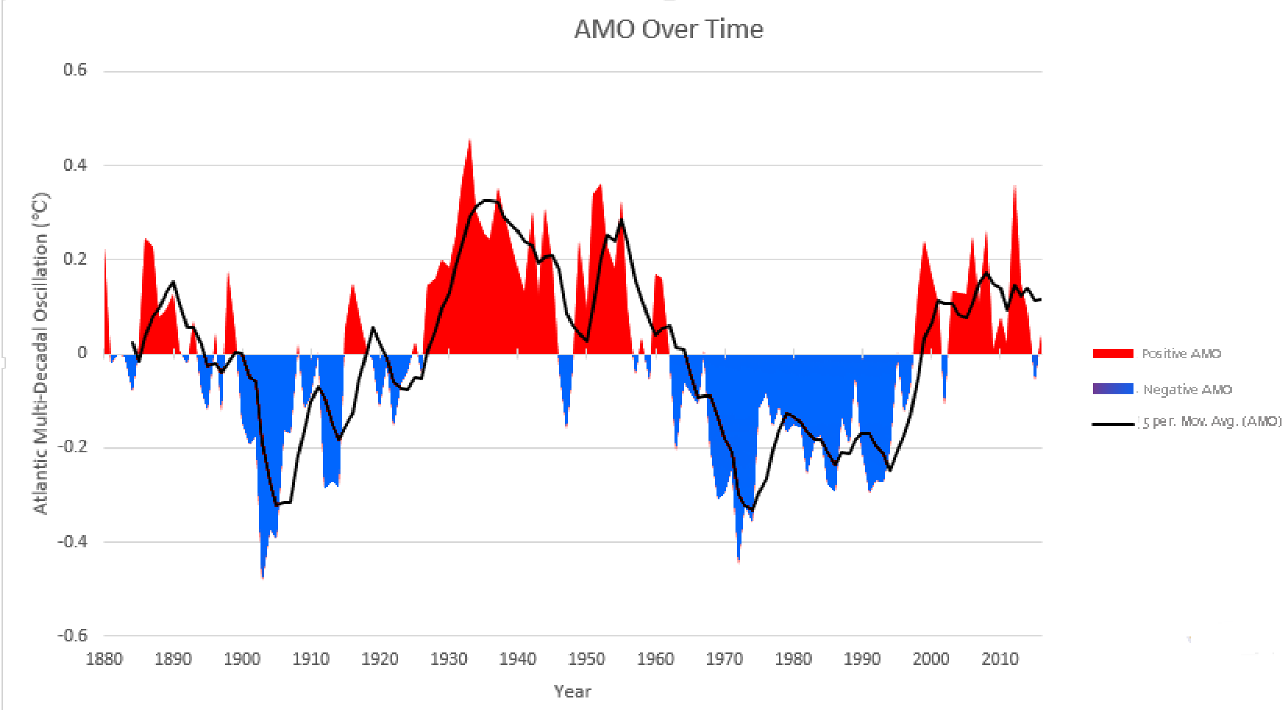
NOAA's May 2016 hurricane season prediction is near normal, with a range of 10-16 named storms, 4-8 hurricanes, and 1-4 major hurricanes.

The current factors affecting the forecast are:

- 70% likelihood of La Niña during peak months (August-October), favoring above average activity;
- Atlantic Multi-decadal Oscillation (AMO) has the possibility of becoming negative which, all else equal, suggests below average activity;
- Outbreak of the Saharan Air Layer (SAL) will most likely inhibit most tropical storms from developing until mid- August;
- Azores-Bermuda High in current location brings dry air and Easterly trade winds—pushing storms off the coast and discouraging US landfall.

## Atlantic Multi-decadal Oscillation ("AMO")

Positive or negative AMO results from the movement of heat northwards from the tropics by ocean currents. Characteristics of positive AMO results in stronger currents, favoring a high-activity hurricane season; while negative AMO produces weakened currents and a low-activity season. These periods of positive and negative AMOs can last between twenty to forty years. Currently, the U.S. is experiencing positive AMO, meaning a high activity-era. Note, while the number of storms has generally been within the predicted range, there is no correlation between accuracy of prediction and U.S. landfall.




### El Niño/Southern Oscillations (ENSO)

The ENSO is an irregular variation in Atlantic winds and the sea surface temperatures (SSTs) over the eastern Pacific Ocean. These variations result in two phases – El Niño and La Niña.

> **El Niño** occurs when the SSTs over the Pacific warm and produce greater Atlantic wind shear, which inhibits hurricane development.

> **La Niña** produces cooler SSTs in the Pacific and less wind shear in the Atlantic, favoring high-activity seasons.

When viewed over time, a low-activity era does not indicate that all seasons within that timeframe were low-activity; rather the majority were considered low-activity.

The combination of AMO and ENSO have the following affect on forecasting:

> **High-activity:** Positive AMO and La Niña
> **Near normal:** Positive AMO and El Niño
> **Low-activity:** Negative AMO and El Niño

Interestingly, since 1950 NOAA has not defined any near-normal eras.

### Accumulated Cyclone Energy (ACE)

ACE expresses the activity of individual cyclones, as well as that of an entire season. The factor is the sum of the maximum sustained surface wind speed, squared, every six hours (per storm), then scaled down by 10,000.

Seasonal ACE is the sum of all individual storm ACE calculations. The index is based on the median named storms for the 1981 – 2010 seasons.

This shorter time period better represents the accuracy of storms and the ability to identify weaker storms that may have been unrecorded in prior years. Since 1950, the three highest ACE recorded ratings were in 1995 (228), 2004 (227), and in 2005 (248) - all within the current high-activity era.

**High-activity** >120% of the median (111), meeting two of three conditions: ≥13 named storms, ≥7 hurricanes and/or ≥ 2 major hurricanes

**Low-activity** <71.4% of the median (66) or >71.4%, with ≤9 named storms, ≤4 hurricanes, and ≤1 major hurricanes

**Near-normal** typically in the range of 71.4%-120% of the median

### Azores-Bermuda High

The Azores-Bermuda High is a semi-permanent high pressure system that dominates the North Atlantic Ocean. This system moves towards the west during the summer and fall, and to the east during the winter and spring seasons.

When hurricanes develop, they follow the high's clockwise motion in the Atlantic. In 2004 and 2005, this high was more southwesterly than normal, which helped drive hurricanes toward the United States—Katrina, Rita and Wilma most prominently.

Other factors affect the movement of a hurricane, including the trade winds, which also push storms westward.

### Saharan Air Layer (SAL)

The SAL is a layer of hot Saharan air and mineral dust, originating from the Sahara desert. This air gets driven over the ocean, where it resides above the maritime air—extending between the Sahara Desert, West Indies and the U.S.

The SAL helps enhance the Atlantic trade wind inversion aloft. An inversion "caps", or sets a limit to, convection. Less convection equals weaker tropical cyclones. The base of most storm systems is often warmer than the air above, by 5°–10°C. The new

*Saharan Air Layer taken from the NOAA P-3 Orion*

warm air above the base from the Sahara creates an inversion, where temperature can increase with height. Solar radiation absorbed by the suspended mineral dust helps maintain the warmer temperature aloft.

The SAL suppresses tropical cyclone activity in the Atlantic, by:

1. **Introducing dry, stable air into the storm,** which helps evaporate the liquid droplets formed in clouds—cooling the air around it and making it sink;
2. **Enhancing vertical wind shear,** which limits the strength of a storm; and
3. **Augmenting Atlantic trade wind inversion**—dry air enhances the inversion aloft by driving air downward causing it to warm.

The SAL occurs in "outbreaks," meaning that there is not a discernible weather pattern that favors the formation for the entire season.

### Predicting the Hurricane Season

NOAA , as well as several private companies and universities predict the severity of the upcoming hurricane season. They produce two predictions, one in May and one around August. Each use their own models, calibrated for individual assumptions and biases. Not one organization is significantly more accurate— but each provide a reasonability check.

The chart to the right compares NOAA, Colorado

State University (CSU) and tropicalstormrisk.com (TSR). CSU's forecast began with the work of Dr. William M. Gray, Professor of Atmospheric Science, who was one of the first to observe the negative effects El Niño had on hurricane activity.

| Year | NOAA | Colorado State University | Tropical Storm Risk | Actual |
|---|---|---|---|---|
| 2005 | *12-15* | *15* | *N/A* | 28 |
| 2006 | *13-16* | *17* | *N/A* | 10 |
| 2007 | *13-17* | *17* | *N/A* | 15 |
| 2008 | *12-16* | *15* | *N/A* | 16 |
| 2009 | *9-14* | *11* | *N/A* | 9 |
| 2010 | *14-23* | *18* | *N/A* | 19 |
| 2011 | *12-18* | *16* | *14* | 19 |
| 2012 | *9-15* | *13* | *14* | 19 |
| 2013 | *13-20* | *18* | *16* | 14 |
| 2014 | *8-13* | *10* | *12* | 8 |
| 2015 | *6-11* | *8* | *10* | 11 |
| 2016* | *10-16* | *14* | *17* | 4* |

*Total storm predictions as of May for each year*

TSR is a website that specializes in tropical storm risks, with a team composed of experts in modeling and forecasting, as well as insurance and risk management.

Given the difficulty predicting all the contributing factors, the three still manage to put forth an accurate storm count range in the past 12 years. We examined the difference between each forecaster's May figures and the actual storm count for every year since 2005. The results show that TSR has the lowest average separation in the last five years between prediction and actual storm count, when compared to NOAA and CSU. On average, TSR's total storm count was off by 3.4 storms, compared to 3.7 and 3.6 for NOAA and CSU, respectively.

However two years, in particular, were inaccurate being 2005 and 2013. In 2005, NOAA forecasted an above-average season due to positive AMO. However NOAA underestimated the amplitude and the size of the anomalies associated with a positive AMO like sea surface temperature and wind shear. The SSTs in the Atlantic were the warmest they had ever been during that time; and wind shear was extremely low in the gulf region. That year gave rise to Katrina, Rita and Wilma—all among the 10 strongest U.S. hurricanes.

Conversely the 2013 season produced few hurricanes, following Sandy the prior year. NOAA overestimated the number of hurricanes by a difference of about seven, predicting 7-11 hurricanes but only 2 actually reached hurricane status. This extends into their prediction of major hurricanes being 3-6, but zero actually became major hurricanes. There were several influencing factors that year. A much higher than normal wind shear developed, with low moisture from the more dominant northerly trade winds and weak tropical waves off the coast of Africa.

When comparing the May forecasts to each firm's August forecasts, there is a dramatic improvement in each set of predictions. This is logical given there is two months of data for the current hurricane season and a better idea of anticipated changes to the contributing forecast factors.

Correlations between each set of predictions to the actual number of storms increases from May to August. The largest increase was for total storm count. All three organizations' total storm correlation coefficients increased to approximately 0.8 from May to August, marking a significant improvement. The biggest improvement is seen in NOAA's predictions. The correlation to actual storm count rises from 0.15 to 0.82. In comparison, CSU changed from 0.42 to 0.82 and TSR from 0.56 to 0.87.

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