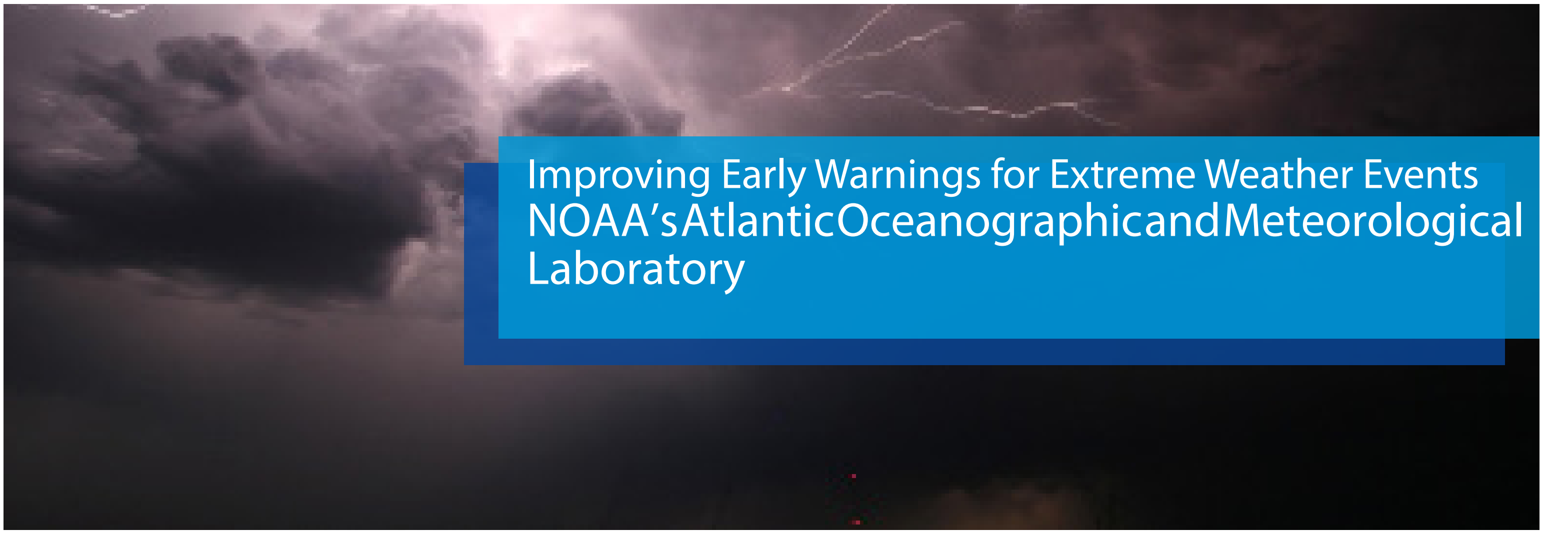
Improving Early Warnings for Extreme Weather Events NOAA's Atlantic Oceanographic and Meteorological Laboratory



Lightning over the Great Plains. Texas. May 12, 2009. Image Credit: NOAA/NSSL, VORTEX II.

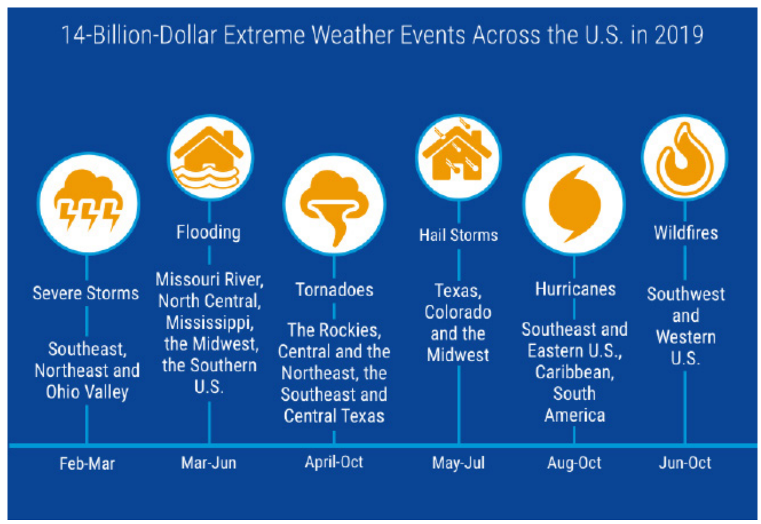
Financial Impacts from Extreme Weather Events

A recent nationwide survey indicated that weather forecasts generate $31.5 billion in economic benefits to U.S. households.[1] Since 1980, the U.S. has sustained 332 weather and climate disasters where overall damages reached or exceeded $1 billion (including Consumer Price Index adjustment in 2020 dollars); The total cost of these 332 events exceeds $2.275 trillion.[2]

Scientists at NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML) are working to improve the forecasts of five main disaster types: tropical cyclones, tornado-related severe storms, heat waves, extreme rainfall, and droughts. Improved weather forecasts provide emergency managers, government officials, businesses, and the public with more accurate and timely warnings to minimize catastrophic loss of life and damage to critical infrastructure. This effort is crucial for informing emergency management and public preparedness.

1 U.S. Department of Commerce/National Oceanic and Atmospheric Administration. (2018, June). NOAA By The Numbers: Economic Statistics Relevant to NOAA's Mission. Silver Spring, Maryland: United States.

2 NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2022).



Understanding Long-Term Ocean Dynamics Leads to Better Short-Term Prediction

Extreme weather events are responsible for devastating mortality and economic impacts in the United States, but current extreme weather forecasts are only able to accurately predict events a few days in advance. Because of this, there is a pressing need to expand the current severe weather forecast beyond the 7-10 day time scale. This is known as the subseasonal forecast (from 2 weeks to a month ahead).

Scientists at AOML are working to extend the forecast for extreme weather events by improving subseasonal-to-seasonal predictions. Researchers are making these improvements using a combination of oceanic and atmospheric observations and model simulations. For example, researchers at AOML study how temperature variations associated with El Niño and La Niña, as well as the Madden-Julian Oscillation, have far reaching impacts on global weather.

To more fully understand these connections, AOML has formed collaborative partnerships with NOAA's Climate Prediction Center, Geophysical Fluid Dynamics Laboratory, Physical Sciences Laboratory, and Environmental Modeling Center to advance our understanding of severe weather events affecting our nation with the goal of improving and extending their predictions to better protect life and property.

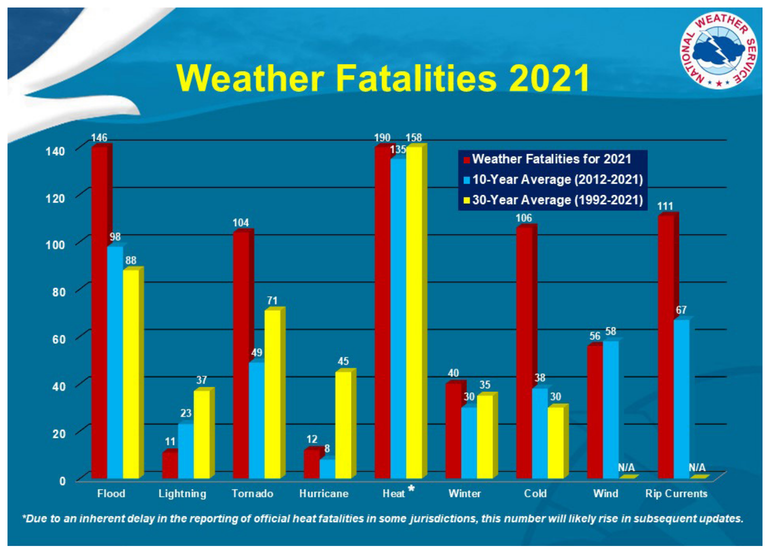
NOAA's Atlantic Oceanographic and Meteorological Laboratory
4301 Rickenbacker Causeway, Miami, Florida 33149
www.aoml.noaa.gov

An Ocean-Informed Forecast for Heat Waves, Tornadoes, Extreme Rainfall, and Droughts

In order to improve and extend the forecasts for extreme events beyond the 7-10 day time scale, it is vital to better understand and predict how the oceans drive global weather patterns. Certain spatial and temporal patterns of upper ocean heat and circulation variations can promote recurring weather patterns that can be monitored and studied using long-term observational data. For example, AOML scientists have shown that the strength of the East Asian Monsoon is directly linked to the occurrence of summer heat waves in the U.S.[1] In addition, recent work submitted for publication to the journal of Geophysical Research Letters demonstrates the role of the tropical Atlantic Ocean in modulating heat wave occurrence over the Great Plains.[2] AOML Scientists have also demonstrated meaningful prediction skills for tornado activity over the continental US on seasonal timescales.[3] In a recent study, AOML scientists show that the Madden-Julian Oscillation propagating across the tropical Indian and Pacific oceans modulates springtime tornado occurrence in the U.S.[4] In yet another recent study, AOML scientists identified a strong relationship between summer U.S. rainfall and the sea surface temperature contrast between the Pacific and Atlantic oceans.[5]

1 Lopez, H., S.-K. Lee, S. Dong, G. Goni, B. Kirtman, R. Atlas, and A. Kumar. East Asian monsoon as a modulator of U.S. Great Plains heat waves. Journal of Geophysical Research-Atmospheres, 124(12):6342-6358, doi:10.1029/2018JD030151 2019.
2 Lopez, H., Kim, D., West R., and Kirtman B. (submitted). Modulation of North American heatwaves by the tropical Atlantic warm pool., Geophysical Research Letters.
3 Lee, S. K., Lopez, H., Kim, D., Wittenberg, A. T., & Kumar, A. (2021). A Seasonal Probabilistic Outlook for Tornadoes (SPOTter) in the contiguous United States based on the leading patterns of large-scale atmospheric anomalies. Monthly Weather Review, 149(4), 901-919.
4 Kim, D., S.-K. Lee, and H. Lopez. Madden-Julian Oscillation-induced suppression of northeast Pacific convection increases U.S. tornadogenesis. Journal of Climate, 33(11):4927-4939, https://doi.org/10.1175/JCLI-D-19-0992.1 2020.
5 Kim, D., S.-K. Lee, H. Lopez, G.R. Foltz V. Misra, and A. Kumar. On the role of the Pacific-Atlantic SST contrast and associated Caribbean Sea convection in August-October US regional rainfall variability. Geophysical Research Letters, 47(11):e2020G087736, https://doi.org/10.1029/2020GL087736 2020.

In developing research, AOML scientists have found that the decadal southeast U.S. drought is influenced by nonlinear inter-ocean interactions between the Pacific and Atlantic Oceans. This research aids to understand how the non-linear interactions between the Pacific and Atlantic Oceans affect the southeast U.S. drought. Researchers at AOML have also shown that improved understanding of how El Niño and La Niña evolve in time and space could provide earlier warnings for extreme weather events in winter and spring. These studies have provided the critical background science needed to improve and develop subseasonal-to-seasonal forecast systems for extreme weather events affecting the U.S. (e.g., heat waves, tornadoes and droughts).



Weather-related fatalities in 2021, compared to 10 and 30-year averages. Image Credit: NOAA National Weather Service.

Supporting Forecast Improvement with the Global Ocean Observing System

Scientists at AOML developed a seasonal outlook for Atlantic hurricane activity based on the interbasin sea surface temperature (SST) contrast between the Atlantic and Pacific Oceans. This interbasin SST index was found to be a reliable predictor of seasonal hurricane activity.[1] Researchers at AOML also design, implement, maintain, and improve critical observation systems that provide long-term ocean and atmospheric datasets.

AOML leads environmental data collection technology using uncrewed underwater vehicle systems such as hurricane gliders and sailing drones and instrumentation such as Argo profiling floats, drifting and moored buoys, and expendable bathythermographs). Our scientists work closely with partners from private industry, academia, and other government agencies to pilot and deploy this technology throughout our global oceans. This network is known as the Global Ocean Observing System.

1 West, R., Lopez, H., Lee, S. K., Mercer, A. E., Kim, D., Foltz, G. R., & Balaguru, K. (2022). Seasonality of interbasin SST contributions to Atlantic tropical cyclone activity. Geophysical Research Letters, 49(4), e2021GL096712.

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