Advancing NOAA's Weeks 2–4 Prediction of Severe Weather

NOAA Oceanic and Atmospheric Research Severe Weather Weeks 2–4 Tiger Team

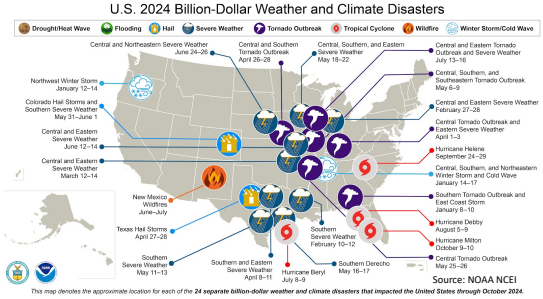
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Motivation

- Severe storms account for about half of all billion-dollar weather disasters in U.S. since 1980
- 2023 and 2024 had the most billion-dollar weather disasters on record: 28 and 24, respectively



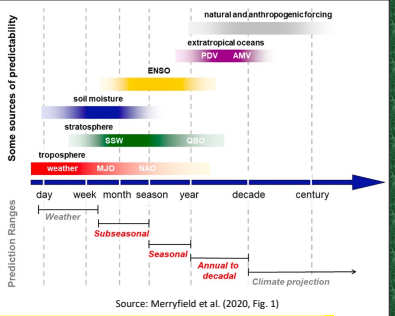
- OAR Critical Societal Challenge Area #1 highlights need to extend forecast lead times of extreme events to save lives, livelihoods, property and support healthy ecosystems

Goal

- Assess the state of the science for the extended range (weeks 2–4) severe weather research and forecasting problem and recommend a path forward on how to advance NOAA's science and forecasting capabilities

Forecasting on the Weather-Climate Interface

- Extended-range predictability is influenced by the multiscale two-way interactions among weather and subseasonal components of the climate system

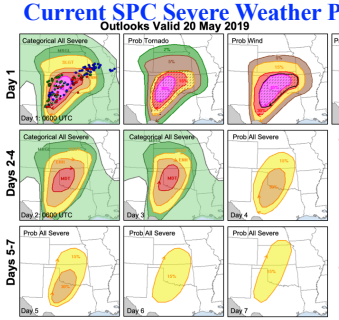


Source: Merryfield et al. (2020, Fig. 1)

- **National Weather Service operational extended-range (weeks 2–4) severe weather forecast products are currently not produced**

Operational Severe Weather Products

Current SPC Severe Weather Products

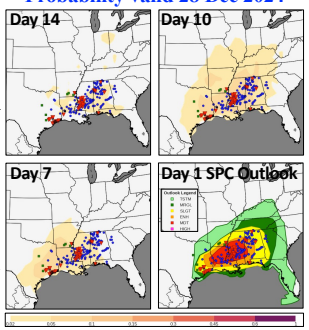


- SPC outlooks extend through day 8
- Days 4–8 outlooks forecast probability of severe weather within 25 miles of a point
- Forecast probabilities rarely issued for day 8
- WPC product suite includes daily days 3–7 U.S. Hazards outlook of temperature, precipitation, wind, wildfire, significant waves, and severe weather
- CPC product suite focuses primarily on temperature and precipitation outlooks at forecast leads ranging from days 6–10 through 3 months

Experimental Severe Weather Forecast Products

- Extended-range severe weather activity linked to large-scale teleconnections (e.g., ENSO, MJO, GWO) and monitored using an ingredients-based approach
- GEFS- and CFS-based extended-range to seasonal forecasts based on environment parameters have been tested by several groups, including NSSL, AOML, CPC, and SPC

Example experimental product: NSSL GEFS ML Total Severe Probability valid 28 Dec 2024



- Multi-index severe weather forecasts for week 2 are being tested by AOML and CPC
- GEFS machine learning (ML) extended-range daily and weekly forecast products are being tested at NSSL
- SHiELD model is being developed by GFDL and tested for extended-range to seasonal severe weather prediction in collaboration with NSSL and AOML

Research Challenges, Gaps, and Limitations

- Limited model data availability
  - Reforecasts have different size/frequency/output as operational systems
  - Computing and storage resources are limited
  - Convection-allowing forecasts require extreme HPC resources
- Lack of formal evaluation framework
- Heterogeneous coverage and lack of quality of observations complicate forecast verification
- Workforce
  - Funding opportunities for severe weather S2S research relatively limited
  - Limited Federal and CI FTEs to conduct/accelerate R&D
  - Weather & climate scientists often separated (Randall & Emanuel 2024)

Key Recommendations

- Research and Development:
  - Conduct basic (low RL) research to increase understanding of processes that influence severe weather in weeks 2-4
  - Develop extended-range severe weather prediction tools using current operational models and future/experimental models
  - Establish extended range severe weather forecasting experiment in Hazardous Weather Testbed (HWT) to evaluate forecasts
  - Assess added value of dynamical downscaling and ML/AI downscaling/postprocessing relative to the driving global models
  - Produce extended-range convection-allowing ensemble reforecasts for validation, assessment, and predictability studies
- User Engagement:
  - Engage with potential users and stakeholders (e.g., NWS, FEMA) to help inform the development of forecast products
  - Develop and foster relationships with federal agencies that have tools, observations, and products that can be useful for evaluating NOAA products and increasing process understanding
  - Develop public-private and international partnerships with the aim of optimizing resource efficiency and open collaborations

Extended-Range Forecasting Experiment in HWT

- The Virtual Extended Range Severe Weather Forecasting Experiment, a pilot program concept being tested in the NOAA HWT, will be hosted by NSSL and SPC early this spring during February–April 2025
- The experiment will serve as a venue where experimental extended-range severe weather forecast products can be systematically verified
- Participants will be involved in forecasting and verification activities, including issuing severe weather outlooks for days 8–10 and weeks 2 and 3