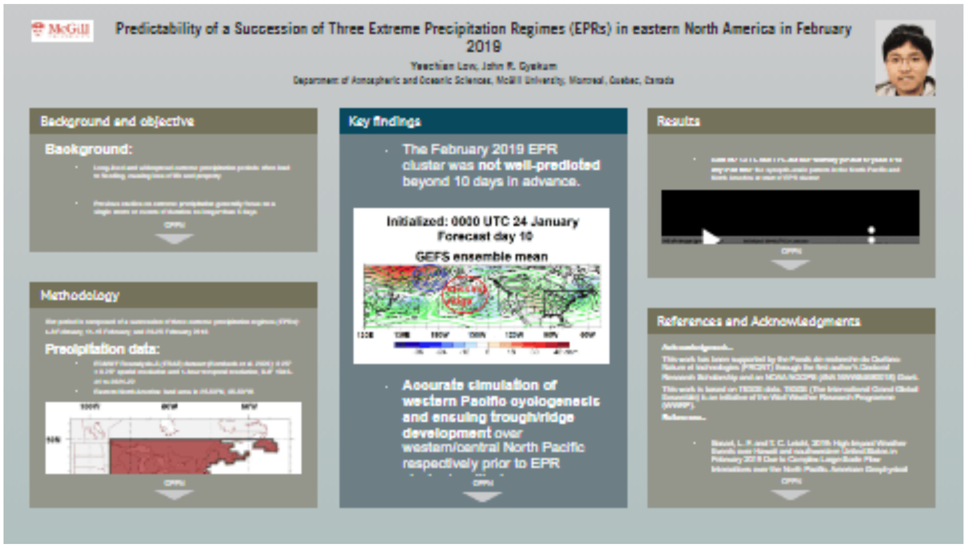
# Predictability of a Succession of Three Extreme Precipitation Regimes (EPRs) in eastern North America in February 2019

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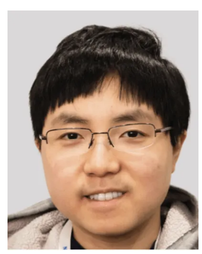


PRESENTED AT:

BACKGROUND AND OBJECTIVE

# Background:

- Long-lived and widespread extreme precipitation periods often lead to flooding, causing loss of life and property.

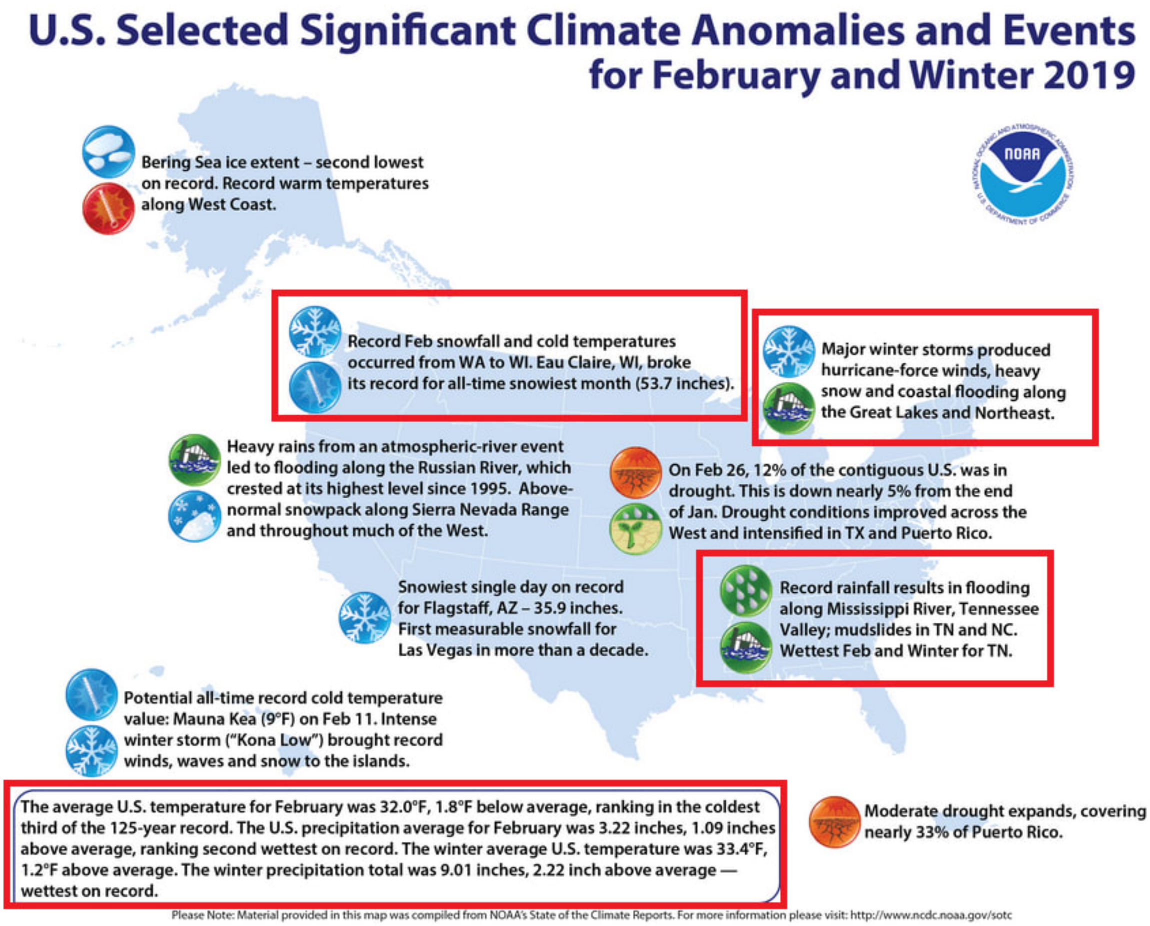
- Previous studies on extreme precipitation generally focus on a single storm or events of duration no longer than 5 days.

## Overview of 3 EPRs:

An unusual succession of 3 EPRs (4-8, 11-15, 20-25 February 2019) contributed to:

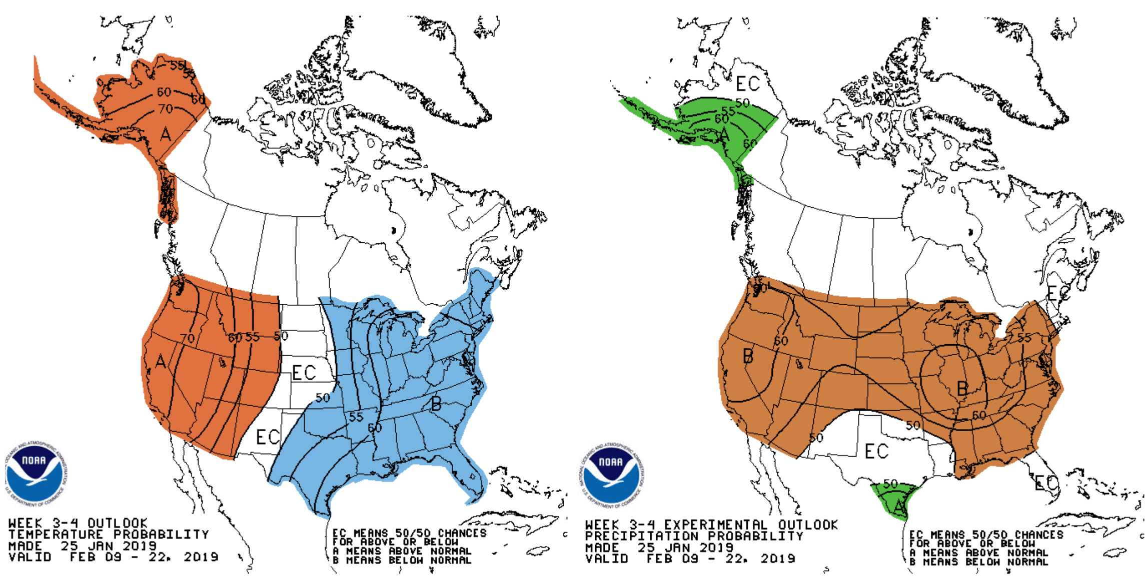
- **Record wet winter and 2nd wettest February** in the contiguous U.S.
- **Major flooding** in the Ohio and Mississippi Valleys
- **Unusually snowy winter** in upper Midwest U.S., ON, QC
- Large impacts also in western U.S.


*Left: Flooding in Brentwood, Tennessee. Right: Snow in Negaunee Township, Michigan.*

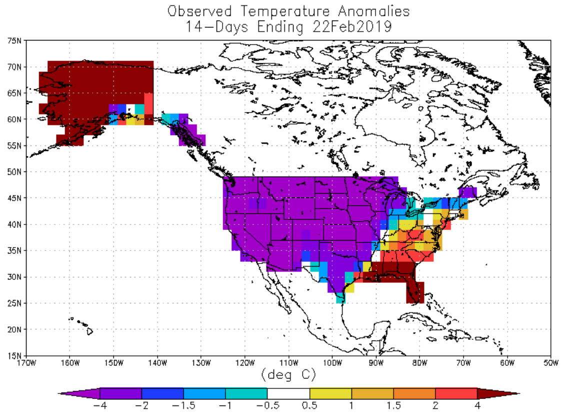


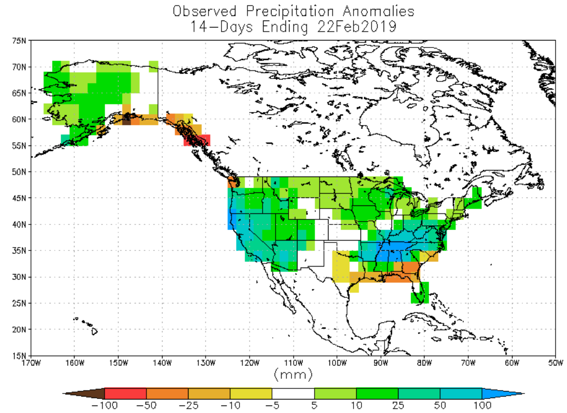

The exceptionally wet period of February 2019 in eastern North America was **not predicted beyond an 10-day lead time**.

# Climate Prediction Center forecast



# Verification



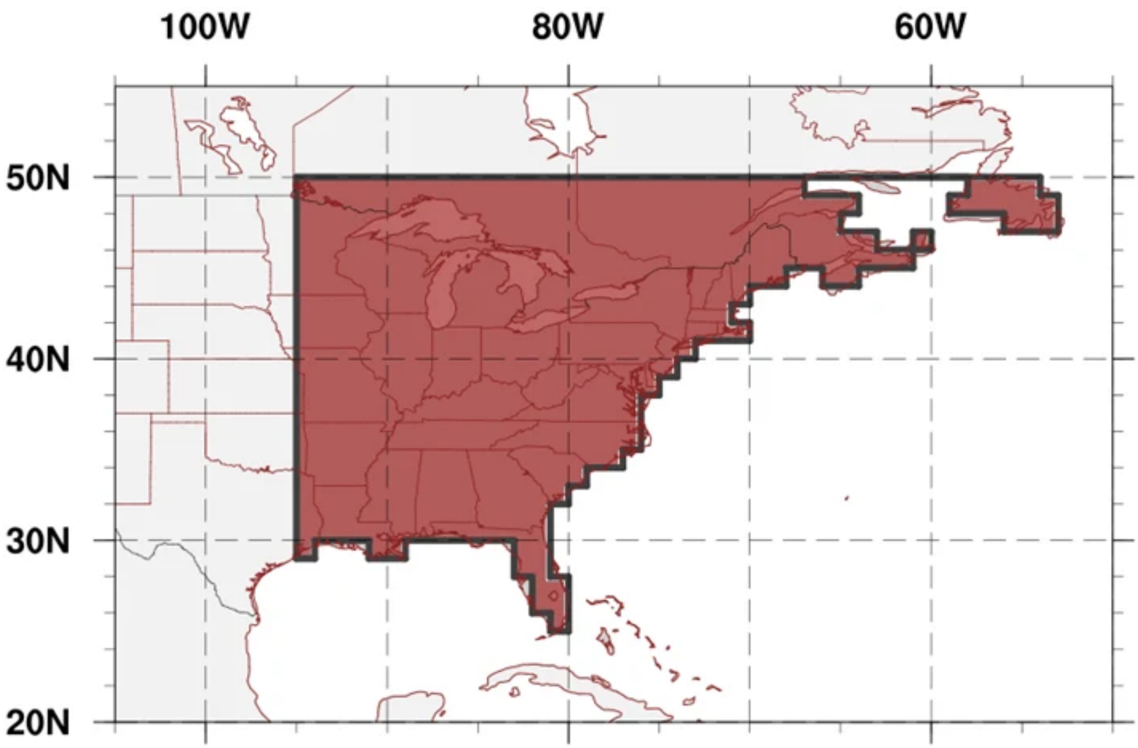

**Objective**: What synoptic-scale features in the North Pacific and North America are important to accurately predict such wet periods?

## METHODOLOGY

Wet period is composed of a succession of three extreme precipitation regimes (EPRs): 4-8 February, 11-15 February, and 20-25 February 2019.

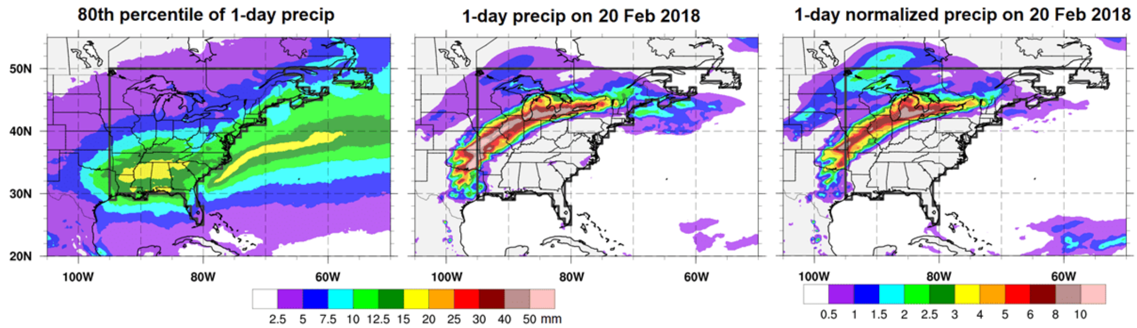
## Precipitation data:

- ECMWF Reanalysis-5 (ERA5) dataset (Hersbach et al. 2020): 0.25° × 0.25° spatial resolution and 1-hour temporal resolution, DJF 1940-41 to 2021-22.
- Eastern North America: land area in 25-50°N, 95-50°W.




## EPR definition:

- *Normalized* precipitation at each grid point = $\frac{\text{Daily precipitation}}{\text{80th percentile}}$
- *Extreme* precipitation volume over entire region: >=70th percentile of areal sum of normalized precipitation
- *Persistence* of extreme precipitation volume: >=5 consecutive days, except for 1-day breaks if >=2/3 of days meet extreme threshold

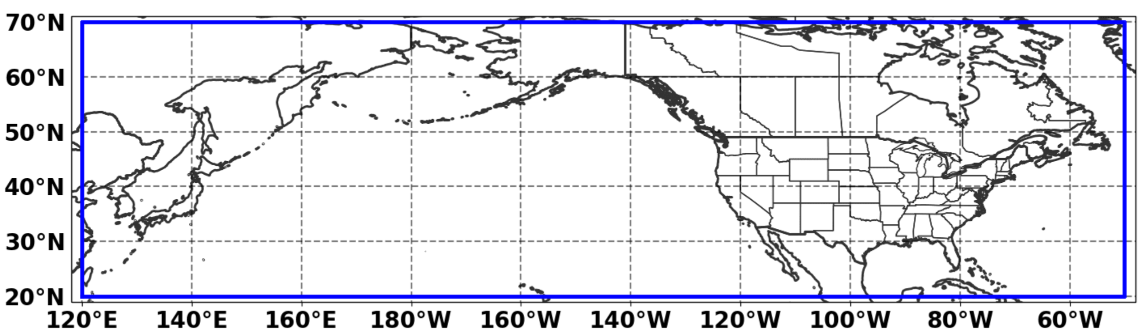



- More details in Low et al. 2022.

## Predictability:

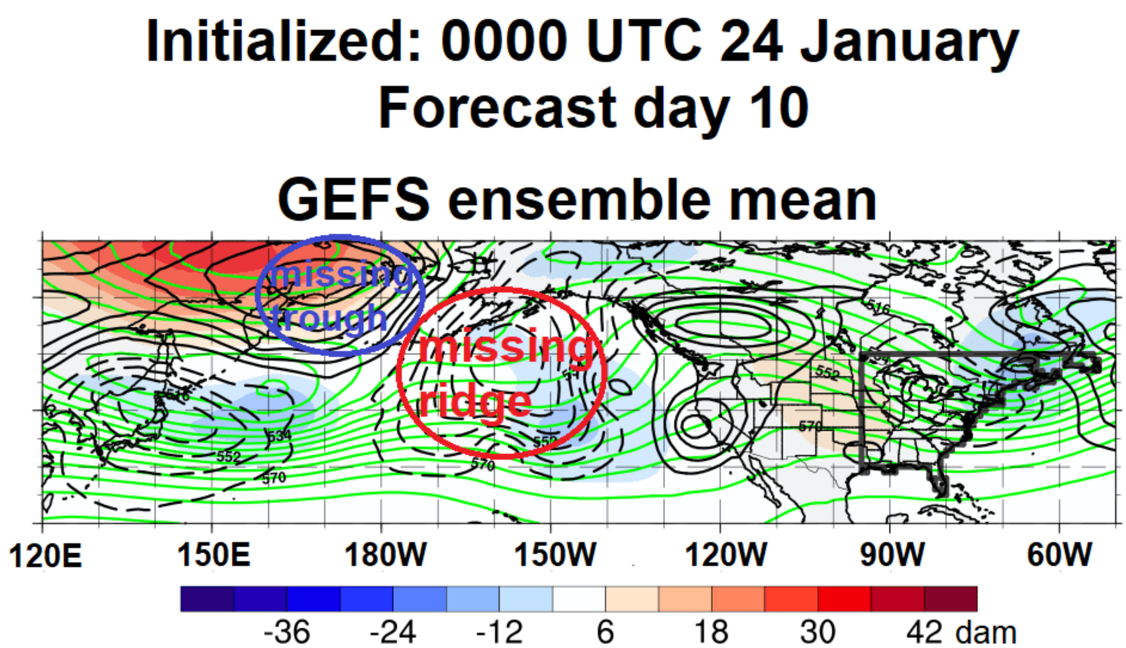
Model data: Real-time forecasts from NCEP's Global Ensemble Forecast System (GEFS) and ECMWF's Ensemble Prediction System (EPS), stored in The Interactive Grand Global Ensemble (TIGGE) dataset (Bougeault et al. 2010).

- Spatial resolution: 0.5° × 0.5°
- Temporal resolution: every 24 hours
- Number of ensemble members: 20 for GEFS and 50 for EPS
- Initialization times: 19 January to 23 February 2019
- Forecast lead times: 0 to 16 days
- Skill measure: 500-hPa height spatial anomaly correlation
- Uncertainty measure: 500-hPa height standard deviation over North Pacific and North America (blue area below).



KEY FINDINGS

- The February 2019 EPR cluster was **not well-predicted** beyond 10 days in advance.

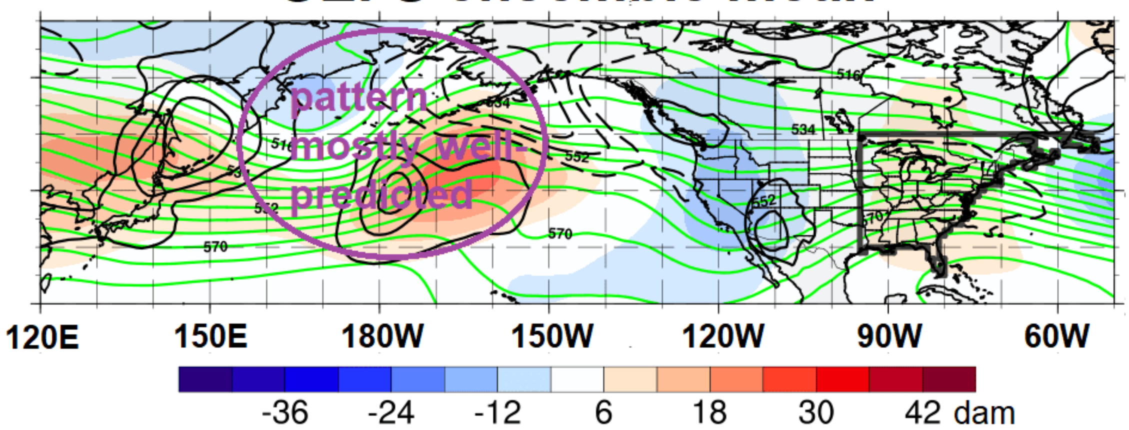



- **Accurate simulation of western Pacific cyclogenesis and ensuing trough/ridge development** over western/central North Pacific respectively prior to EPR cluster is critical.

- Models are **better at predicting the persistence** of the wet pattern after it starts.

# Initialized: 0000 UTC 13 February
# Forecast day 10

## GEFS ensemble mean



## RESULTS

- **Both the GEFS and EPS did not skillfully predict beyond a 10-day lead time** the synoptic-scale pattern in the North Pacific and North America at start of EPR cluster.

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- Model forecasts initially did not simulate well the strong, compact storm near the Kamchatka Peninsula with strong surface high pressure to southeast. The ensuing strong southerly flow of warm, moist air into the North Pacific led to a **latent heat-induced positive feedback loop that is absent in model forecasts**.

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- **It is critical to accurately simulate the build up of the trough and ridge** over the Kamchatka Peninsula and central North Pacific respectively in the days prior to the EPR cluster. Such upstream effects on predictability have been documented in Sisco 2021

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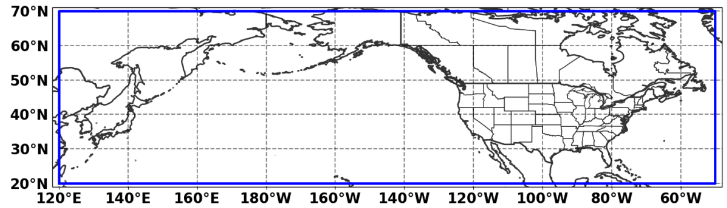
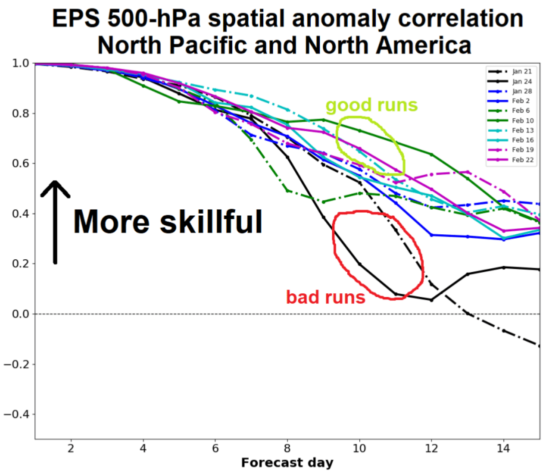
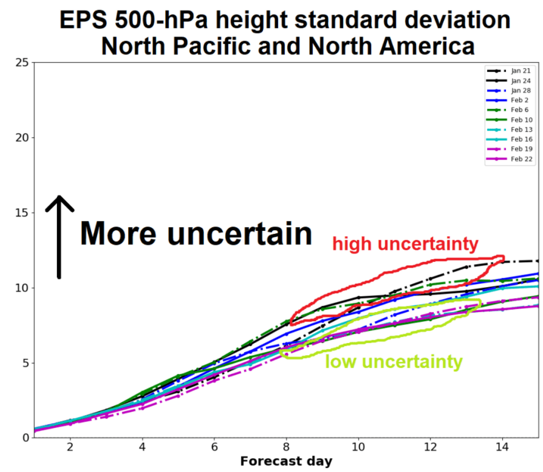
- Model predictability improved as the EPR cluster started and progressed.




- Models show **better skill at predicting the persistence** of the wet synoptic-scale pattern once it starts.

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# REFERENCES AND ACKNOWLEDGMENTS

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**References:**

- Bosart, L. F. and T. C. Leicht, 2019: High-Impact Weather Events over Hawaii and southwestern United States in February 2019 Due to Complex Large-Scale Flow Interactions over the North Pacific. American Geophysical Union, Fall Meeting 2019, https://ui.adsabs.harvard.edu/abs/2019AGUFMNH54A..02B/abstract
- Bougeault et al. (2010): The THORPEX Interactive Grand Global Ensemble. *Bull. Amer. Meteor. Soc.*, 91, 1059-1072, https://doi.org/10.1175/2010BAMS2853.1
- Fragkoulidis, G. and V. Wirth, 2020: Local Rossby Wave Packet Amplitude, Phase Speed, and Group Velocity: Seasonal Variability and Their Role in Temperature Extremes. J. Climate, 33, 8767-8787, https://doi.org/10.1175/JCLI-D-19-0377.1
- Hersbach, H., and Coauthors, 2020: The ERA5 global reanalysis. Quart. J. Roy. Meteor. Soc., 146, 1999–2049, https://doi.org/10.1002/qj.3803
- Hoell, A., M. Hoerling, J. Eischeid, and J. Barsugli, 2021: Preconditions for extreme wet winters over the contiguous United States. Weather and Climate Extremes, 33, https://doi.org/10.1016/j.wace.2021.100333
- Low, Y., J. R. Gyakum, and E. H. Atallah, 2022: Extreme Winter Precipitation Regimes in Eastern North America: Synoptic-Scale and Thermodynamic Environments. Mon. Wea. Rev., 150, 1833-1850, https://doi.org/10.1175/MWR-D-21-0255.1
- NCEI, 2019: Wettest winter on record for the contiguous United States, https://www.ncei.noaa.gov/news/national-climate-201902
- NWS Marquette: February 24th Winter Storm & Blizzard, https://www.weather.gov/mqt/Feb24Blizzard
- NWS Nashville: Late February 2019 Historic Rainfall and Widespread Flooding, https://www.weather.gov/ohx/lateFebruary2019flooding
- Sisco, A. The impact of North Pacific and North Atlantic baroclinic cyclones on downstream predictability, M.Sc. Thesis, University at Albany, State University of New York, 2021
- Swinbank et al. (2016): The TIGGE project and its achievements. *Bull. Amer. Meteor. Soc.*, 97, 49-67, https://doi.org/10.1175/BAMS-D-13-00191.1
- Zhou, X., Y. Zhu, D. Hou, Y. Luo, J. Peng, and R. Wobus, 2017: Performance of the New NCEP Global Ensemble Forecast System in a Parallel Experiment. Wea. Forecasting, 32, 1989-2004, https://doi.org/10.1175/WAF-D-17-0023.1

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TRANSCRIPT

# ABSTRACT

Long-lived and widespread extreme precipitation periods often lead to flooding, causing loss of life and property. Forecasting such periods is still a significant challenge. As an example, a succession of three extreme precipitation regimes (EPRs) in eastern North America in February 2019 contributed to major flooding in the Ohio and Mississippi Valleys, a record wet winter in the contiguous United States, and unusually snowy winter in Ontario and Quebec, especially north of the St. Lawrence River. This exceptionally wet period was not predicted by numerical weather models or the Climate Prediction Center (CPC) beyond a two-week lead time. We assess the farthest lead time at which the numerical weather models, specifically the NCEP Global Ensemble Forecast System (GEFS) and ECMWF Ensemble Prediction System (EPS), finally skillfully predicted the wet period. From the model data, I hypothesize relevant synoptic-scale features in the North Pacific and/or North America that are especially important to simulate to predict EPRs skillfully.

## REFERENCES


- Bosart, L. F. and T. C. Leicht, 2019: High-Impact Weather Events over Hawaii and southwestern United States in February 2019 Due to Complex Large-Scale Flow Interactions over the North Pacific. American Geophysical Union, Fall Meeting 2019, https://ui.adsabs.harvard.edu/abs/2019AGUFMNH54A..02B/abstract
- Fragkoulidis, G. and V. Wirth, 2020: Local Rossby Wave Packet Amplitude, Phase Speed, and Group Velocity: Seasonal Variability and Their Role in Temperature Extremes. J. Climate, 33, 8767-8787, https://doi.org/10.1175/JCLI-D-19-0377.1
- Hersbach, H., and Coauthors, 2020: The ERA5 global reanalysis. Quart. J. Roy. Meteor. Soc., 146, 1999–2049, https://doi.org/10.1002/qj.3803
- Hoell, A., M. Hoerling, J. Eischeid, and J. Barsugli, 2021: Preconditions for extreme wet winters over the contiguous United States. Weather and Climate Extremes, 33, https://doi.org/10.1016/j.wace.2021.100333
- Low, Y., J. R. Gyakum, and E. H. Atallah, 2022: Extreme Winter Precipitation Regimes in Eastern North America: Synoptic-Scale and Thermodynamic Environments. Mon. Wea. Rev., 150, 1833-1850, https://doi.org/10.1175/MWR-D-21-0255.1
- NCEI, 2019: Wettest winter on record for the contiguous United States, https://www.ncei.noaa.gov/news/national-climate-201902
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- Zhou, X., Y. Zhu, D. Hou, Y. Luo, J. Peng, and R. Wobus, 2017: Performance of the New NCEP Global Ensemble Forecast System in a Parallel Experiment. Wea. Forecasting, 32, 1989-2004, https://doi.org/10.1175/WAF-D-17-0023.1