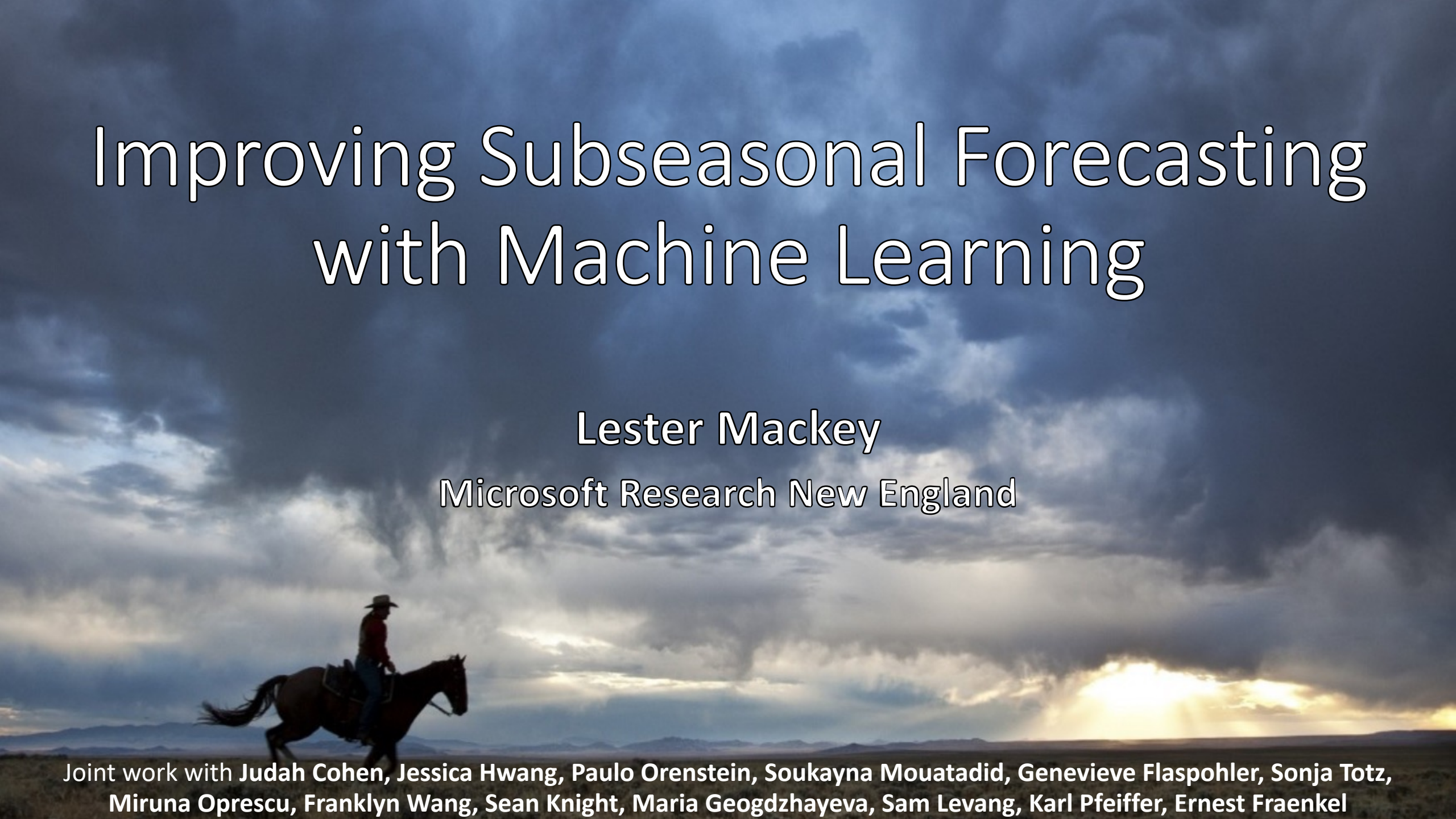
Improving Subseasonal Forecasting with Machine Learning

Lester Mackey

Microsoft Research New England



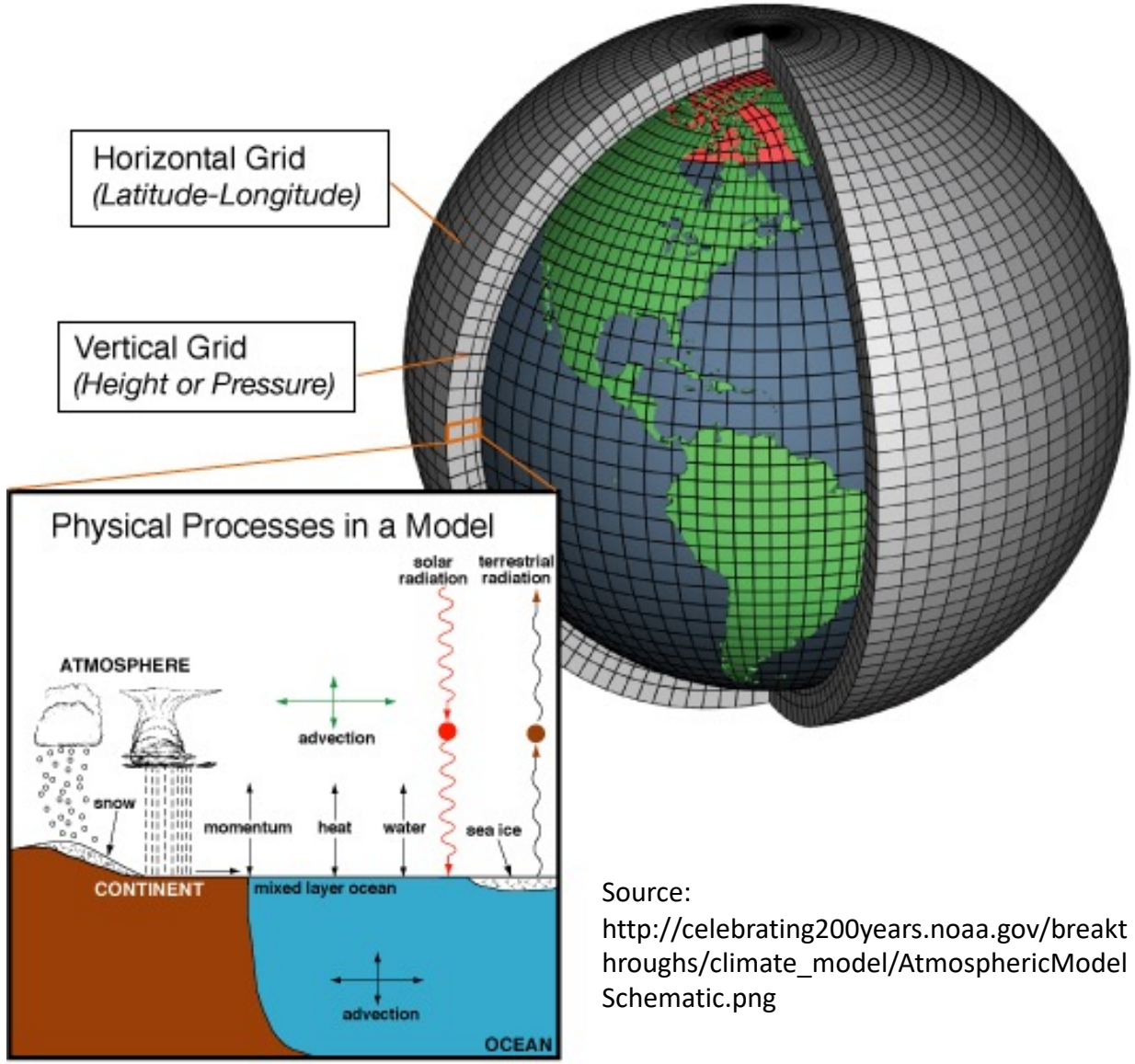
Joint work with **Judah Cohen, Jessica Hwang, Paulo Orenstein, Soukayna Mouatadid, Genevieve Flaspohler, Sonja Totz, Miruna Oprescu, Franklyn Wang, Sean Knight, Maria Geogdzhayeva, Sam Levang, Karl Pfeiffer, Ernest Fraenkel**

Judah Cohen

- Climatologist, director of seasonal forecasting at Atmospheric and Environmental Research
- Concern: Community not making the best use of historical data in weather / climate forecasting
  - Landscape dominated by **dynamical models**, purely physics-based models of atmospheric and oceanic evolution

Dynamical Models

- Initialized with current weather conditions estimated from measurements
- Simulate future weather / climate by discretizing partial differential equations using supercomputers
- Accuracy limited by chaotic nature: errors in inputs rapidly amplified
- Ensembles with varying initial conditions / model parameters often formed to capture uncertainty
- Sometimes *debiased* by comparing predictions to truth over recent years



Source: http://celebrating200years.noaa.gov/breakthroughs/climate_model/AtmosphericModelSchematic.png

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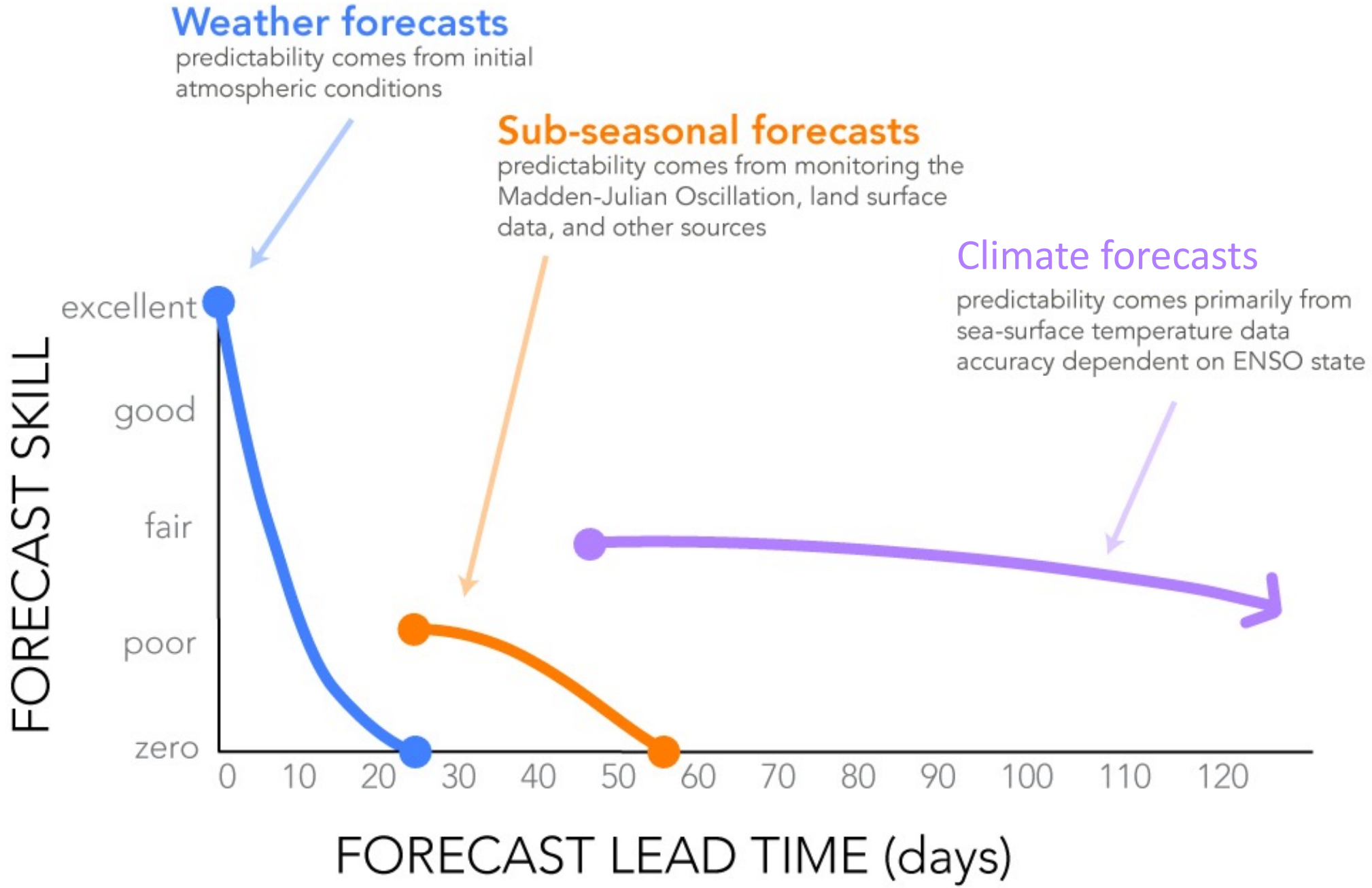
- Concern: Community not making the best use of historical data in weather / climate forecasting
  - Landscape dominated by **dynamical models**, purely physics-based models of atmospheric and oceanic evolution
- Concern: **Subseasonal forecasts** especially poor



Source: https://iri.columbia.edu/news/qa-subseasonal-prediction-project/

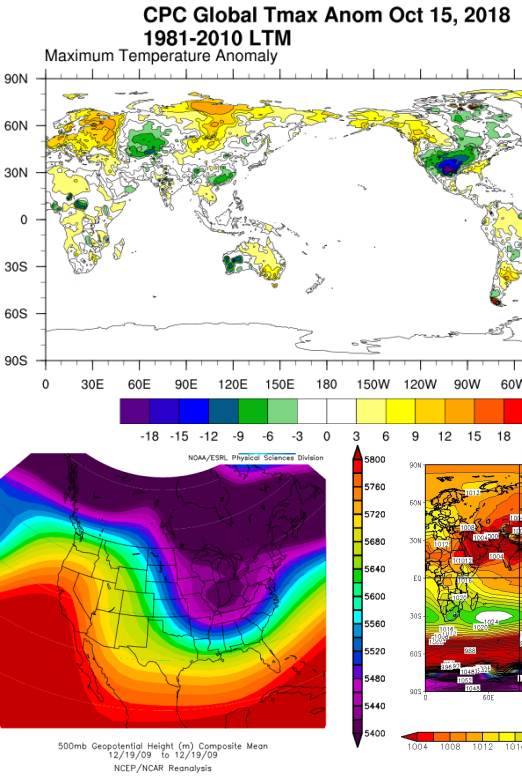
U.S. Bureau of Reclamation

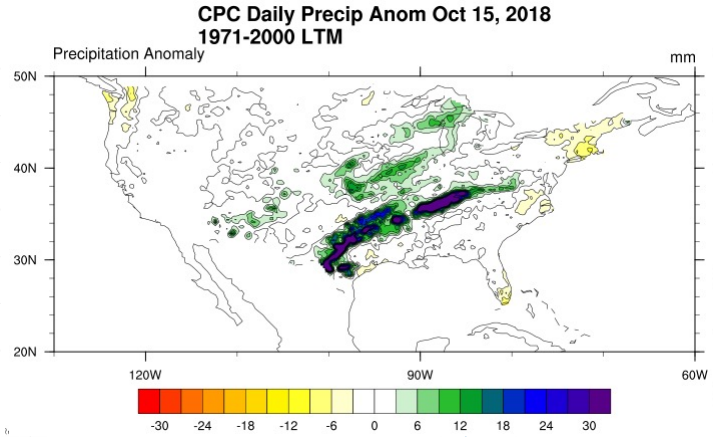
- "The mission of the [USBR] is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public."
- Manages water in 17 western states
  - Provides 1 out of 5 Western farmers with irrigation water for 10 million farmland acres
  - Generates enough electricity to power 3.5M U.S. homes
- "During the past eight years, every state in the Western United States has experienced drought that has affected the economy both locally and nationally through impacts to agricultural production, water supply, and energy."

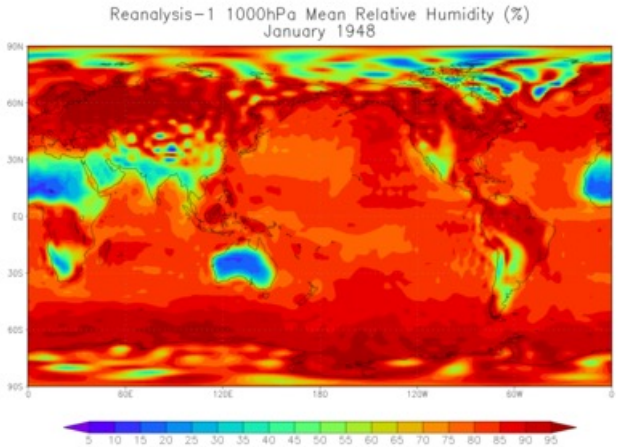
Credit: David Raff, USBR

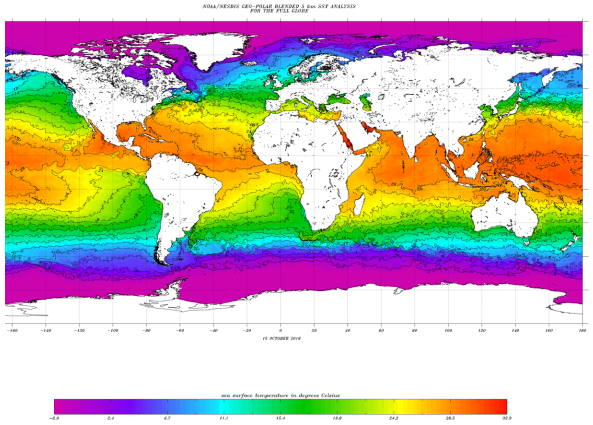
Our SubseasonalClimateUSA Dataset

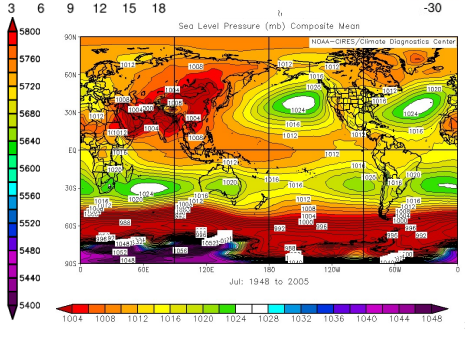
- To train and evaluate our models, we constructed a **SubseasonalClimateUSA dataset** from diverse data sources
- Updated daily + accessed via [subseasonal_data](#) Python package

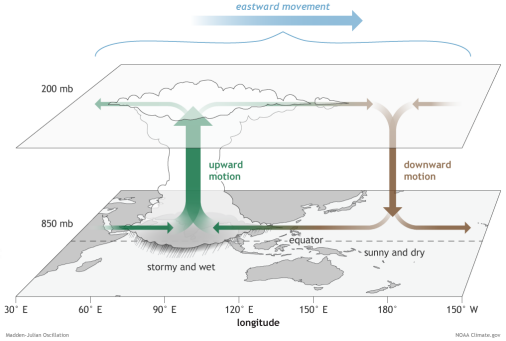


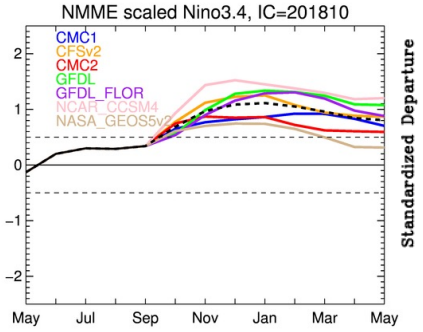


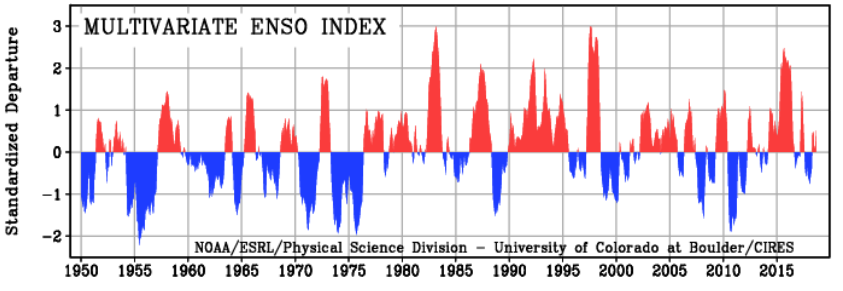




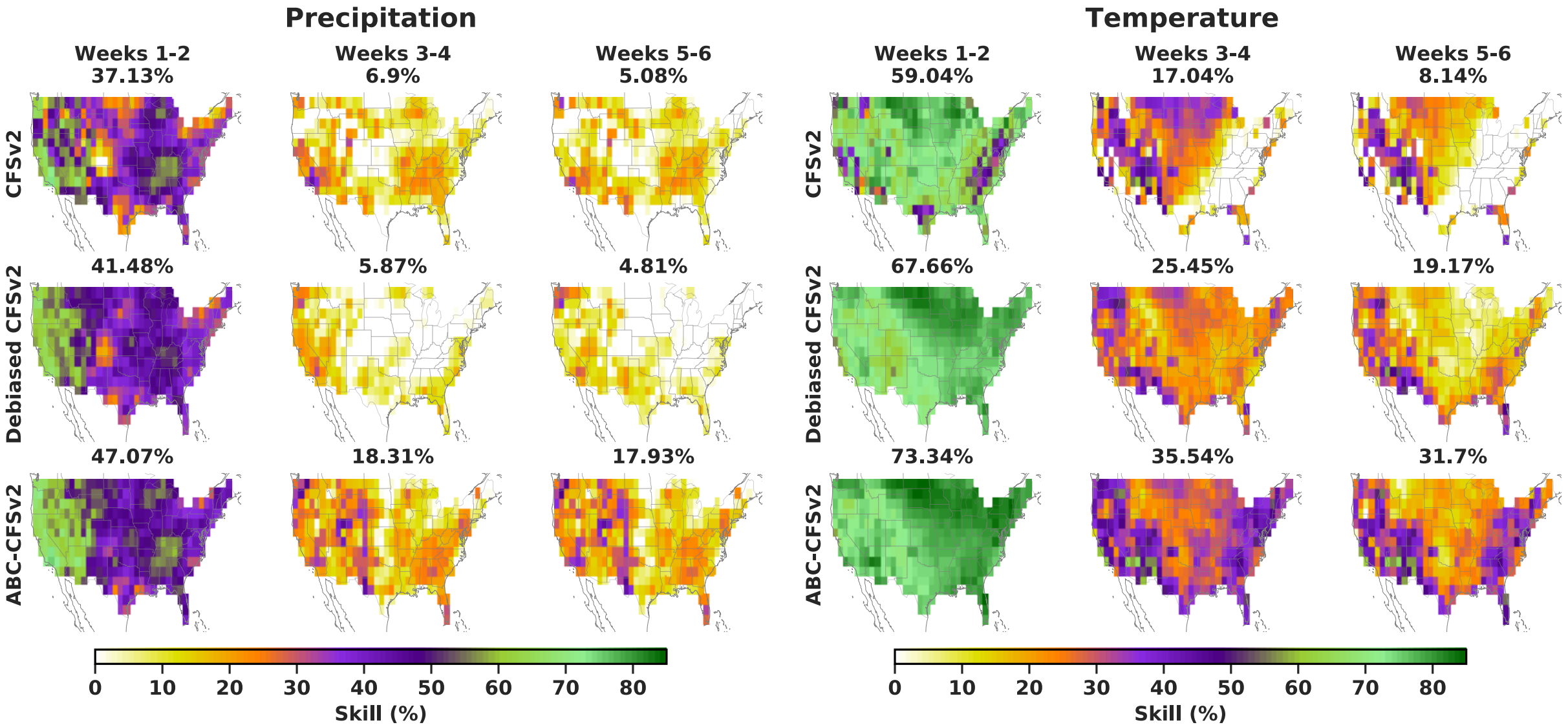








Adaptive Bias Correction (ABC): Hybrid Physics + Learning Model



- Doubles or triples the forecasting skill of US operational dynamical model (CFSv2)
- Outperforms state-of-the-art machine learning and deep learning methods

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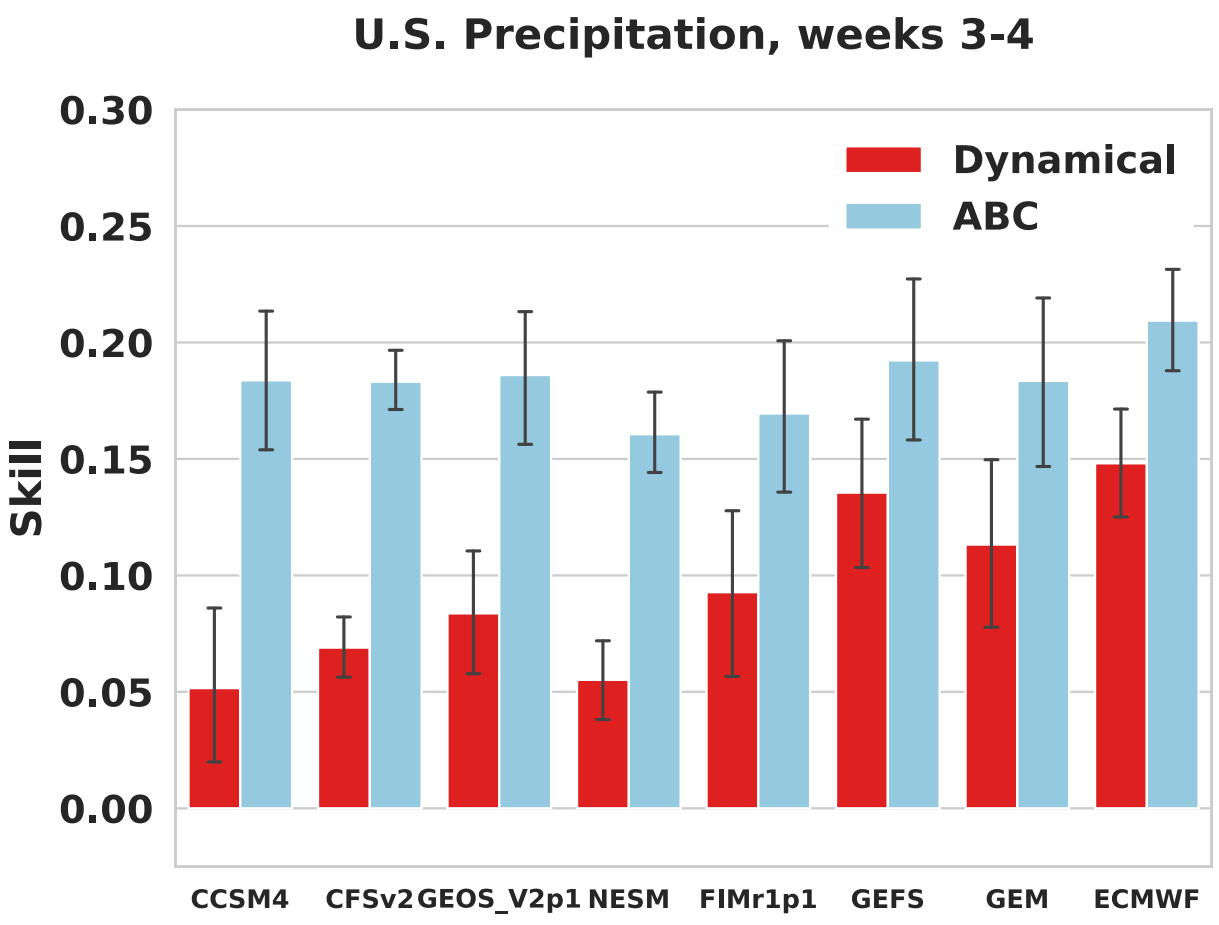

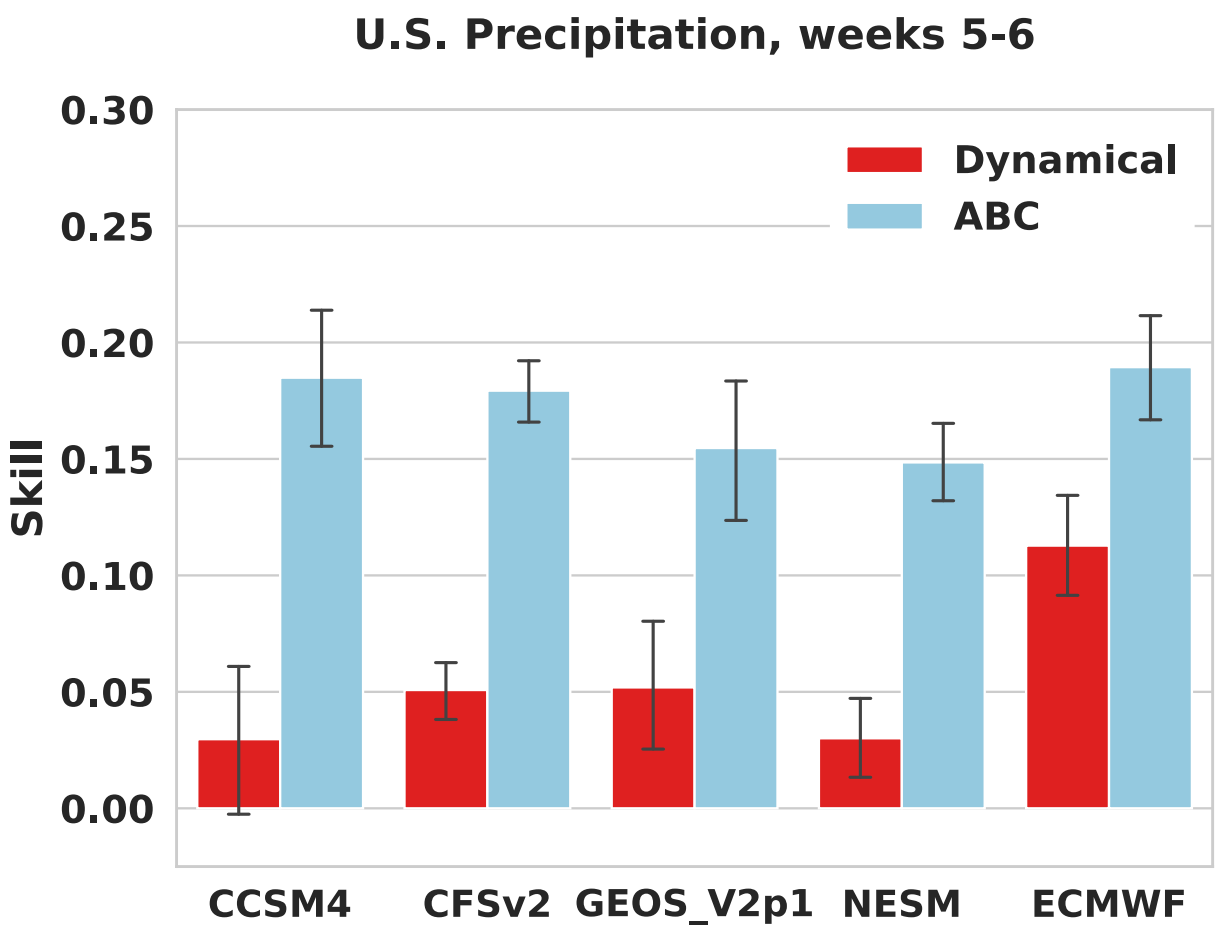

- Can be used to correct any dynamical model
- Including leading model from European Centre for Medium-Range Weather Forecasts

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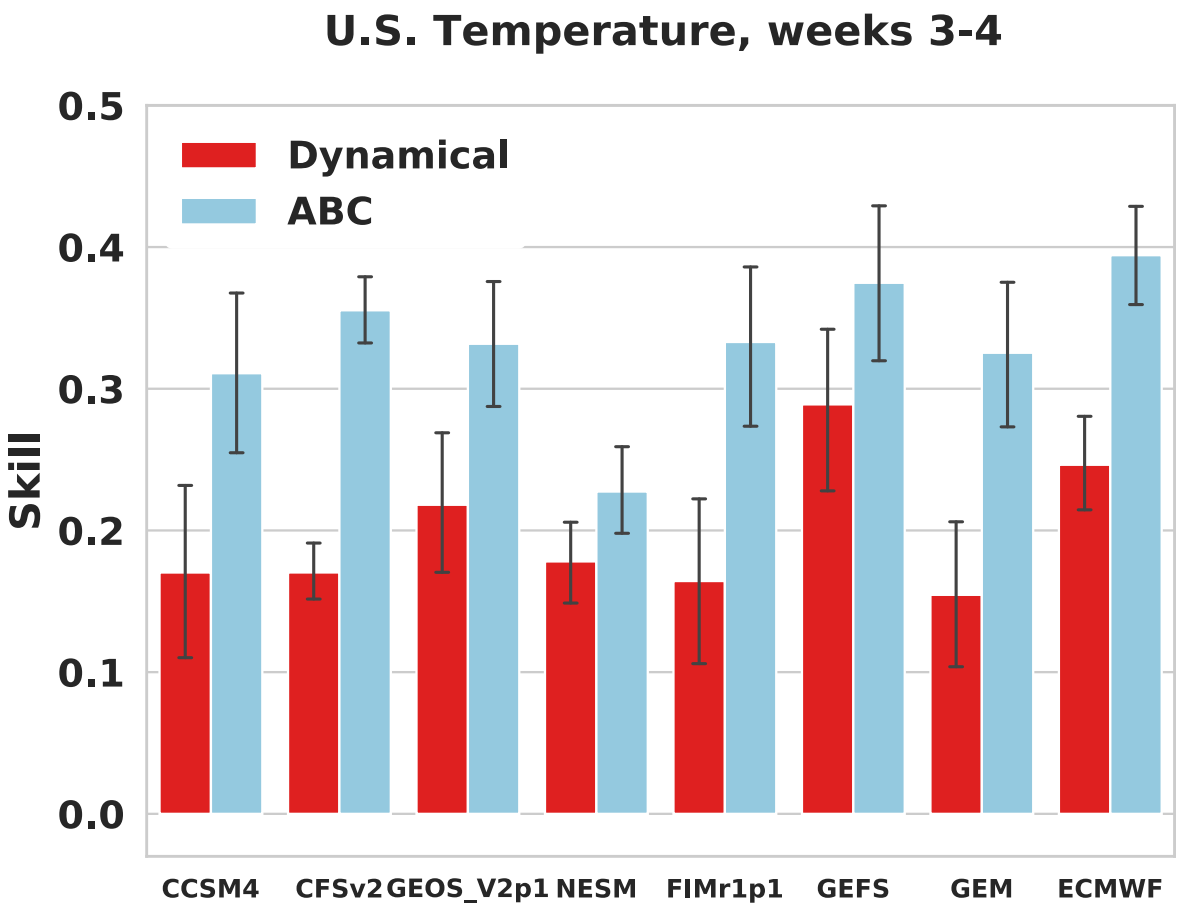

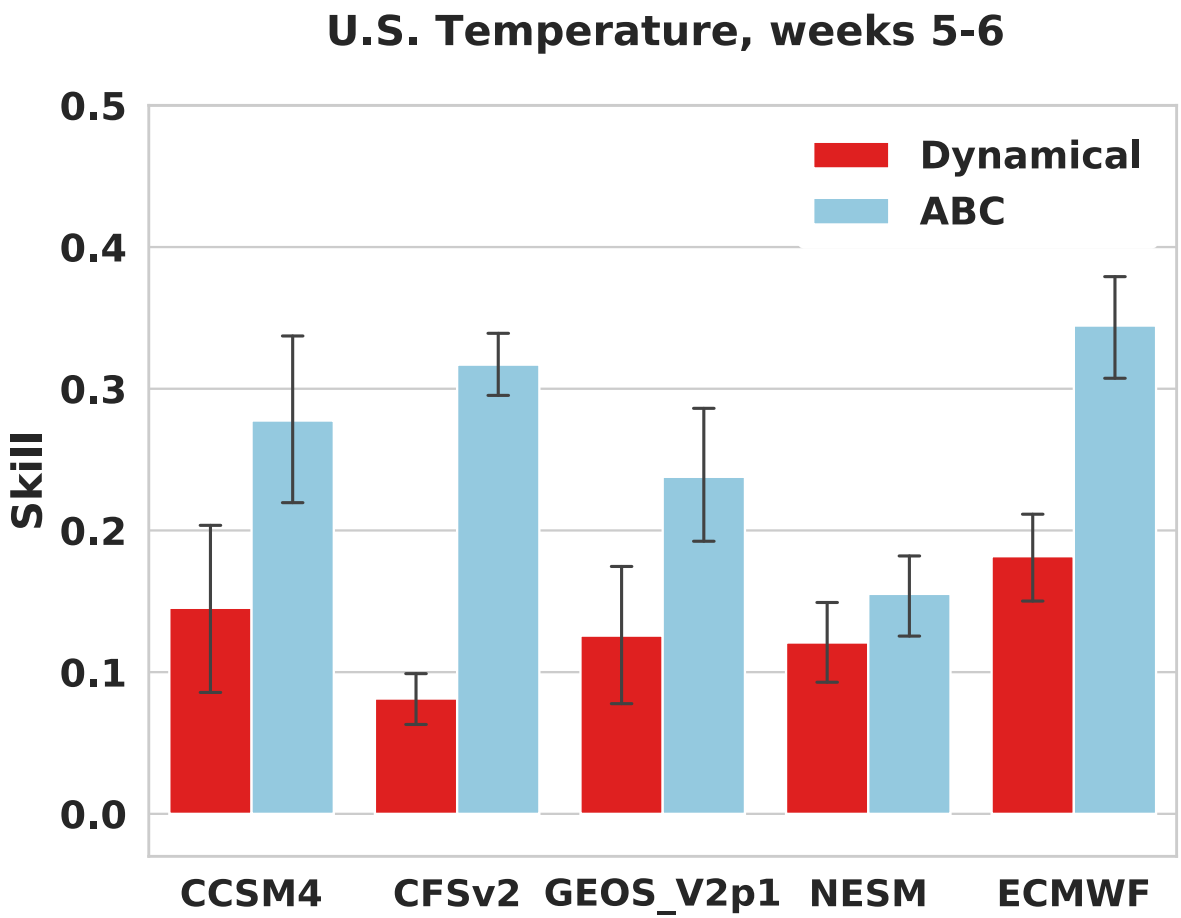

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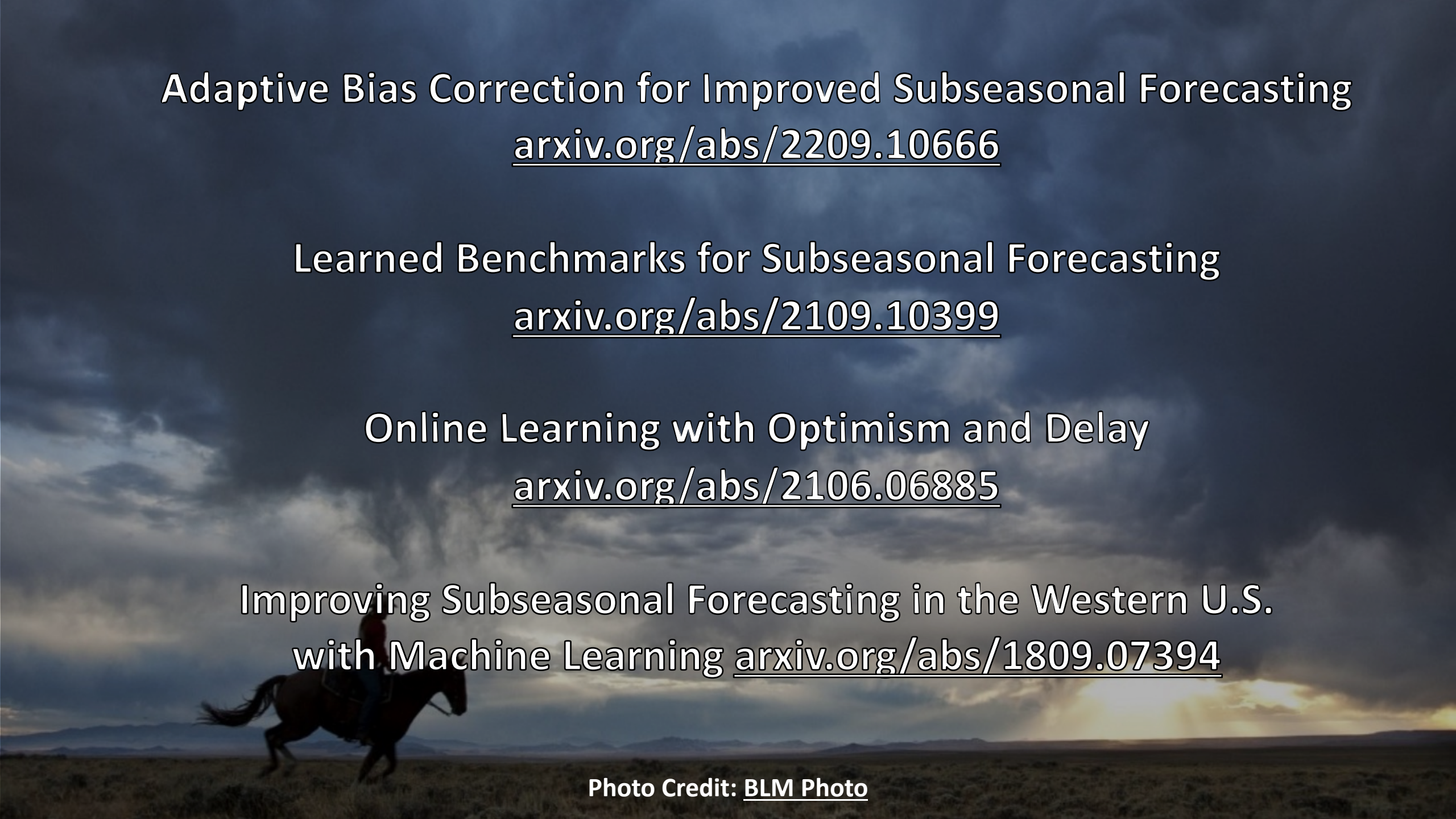
Adaptive Bias Correction for Improved Subseasonal Forecasting
arxiv.org/abs/2209.10666
Learned Benchmarks for Subseasonal Forecasting
arxiv.org/abs/2109.10399
Online Learning with Optimism and Delay
arxiv.org/abs/2106.06885
Improving Subseasonal Forecasting in the Western U.S.
with Machine Learning arxiv.org/abs/1809.07394
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