

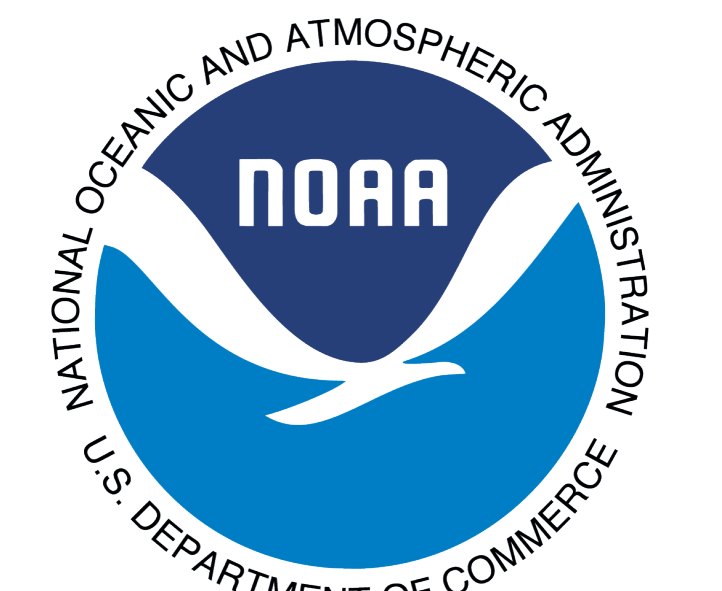


Impact of ensemble initialization on an extended wave forecast system

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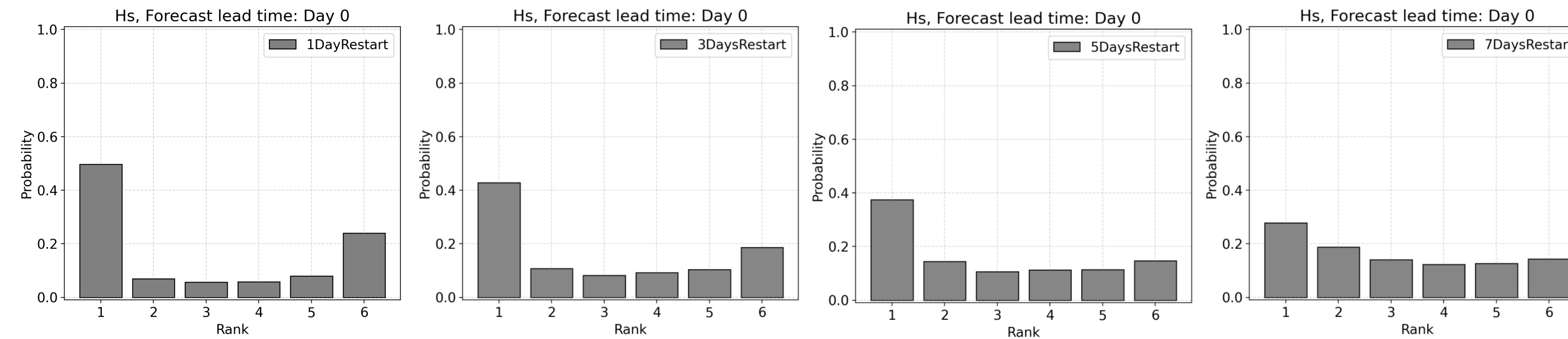
CIMAS Cooperative Institute for Marine and Atmospheric Studies (University of Miami, NOAA/AOML)
NCEP Environmental Modeling Center, National Centers for Environmental Prediction, National Weather Service, NOAA
ERDC US Army Corps of Engineers, Engineer Research and Development Center

Lynker/NCEP Lynker at Environmental Modeling Center, National Centers for Environmental Prediction, National Weather Service, NOAA

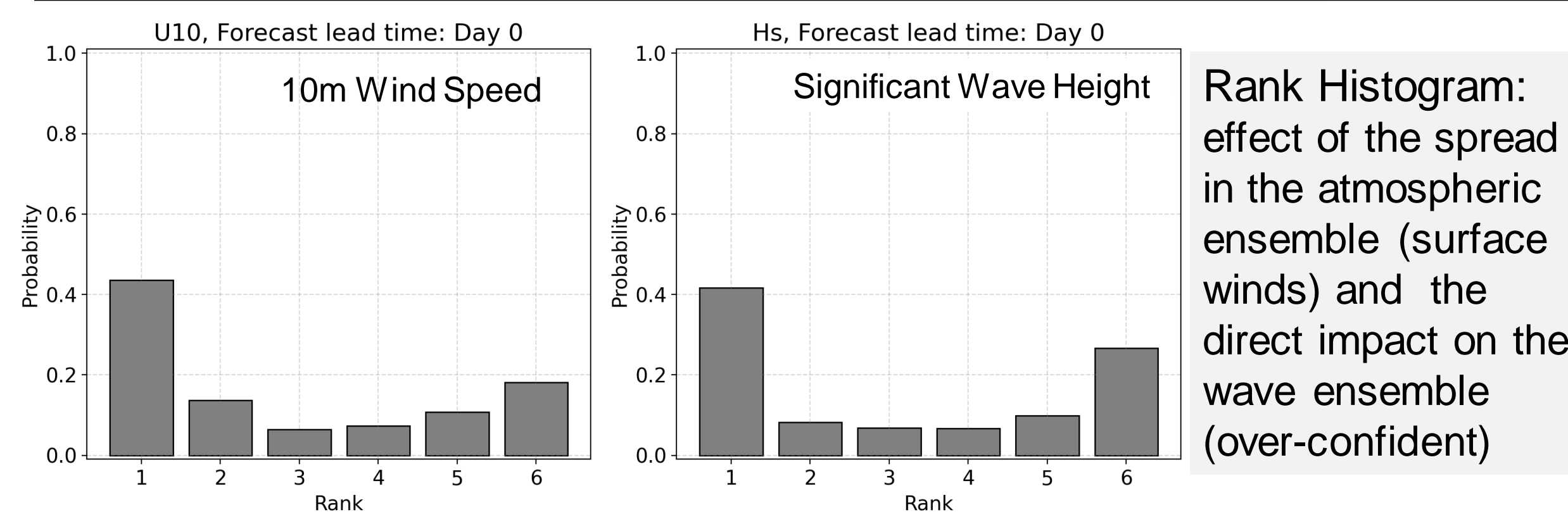
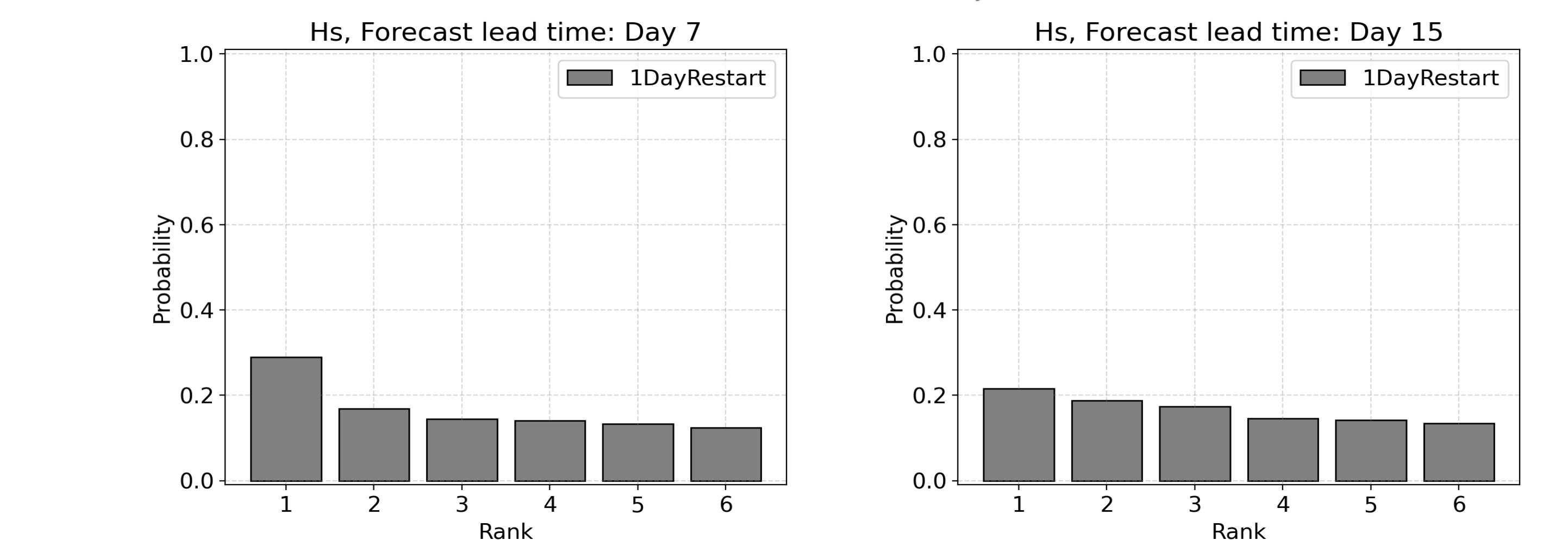
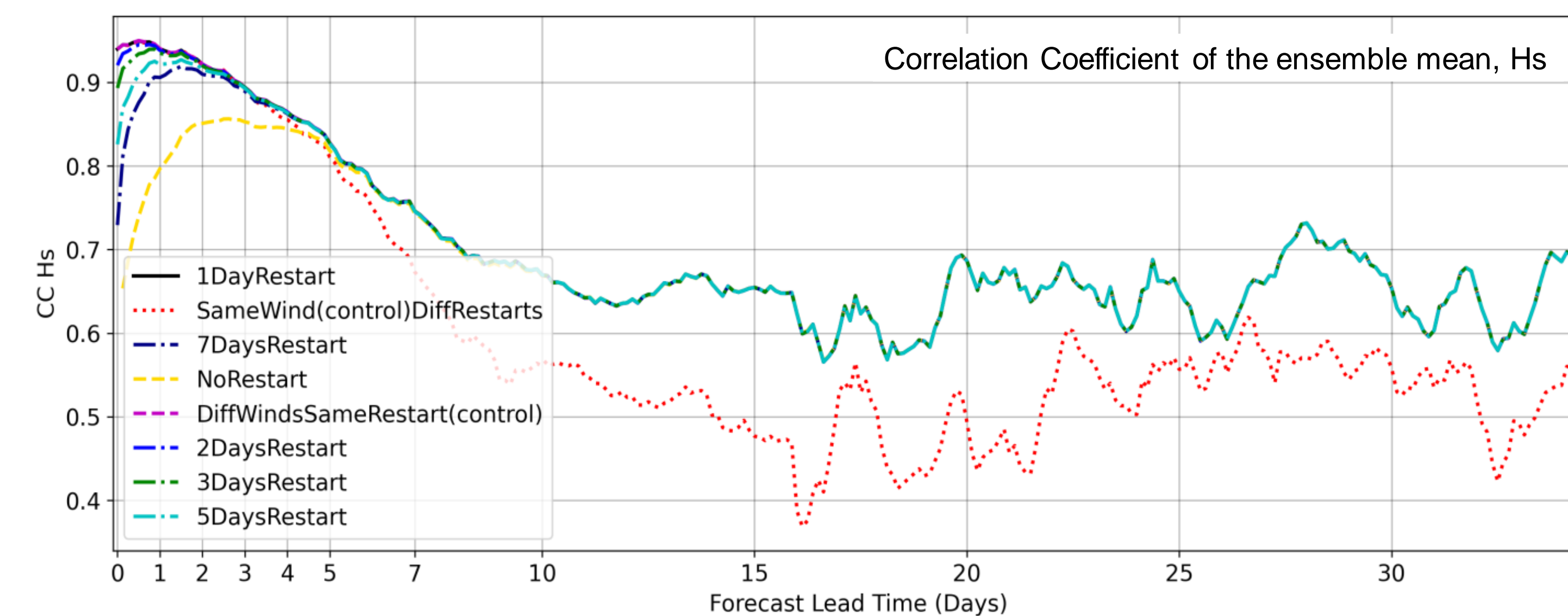
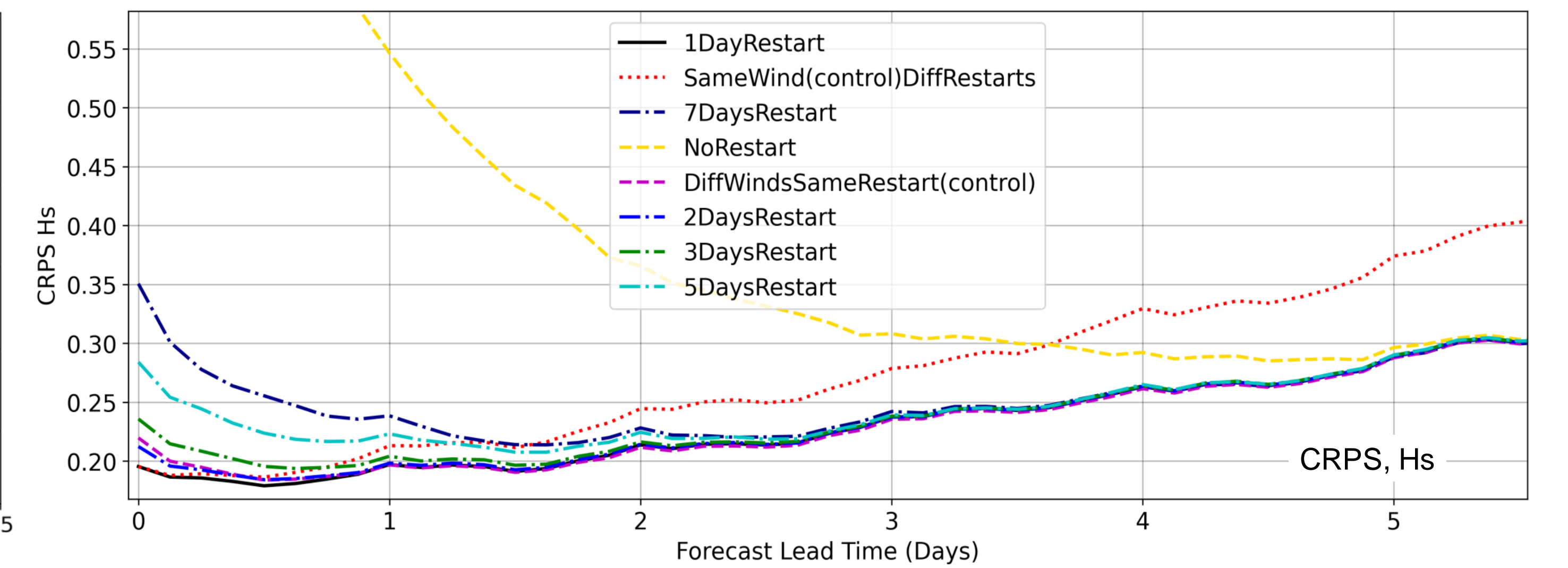
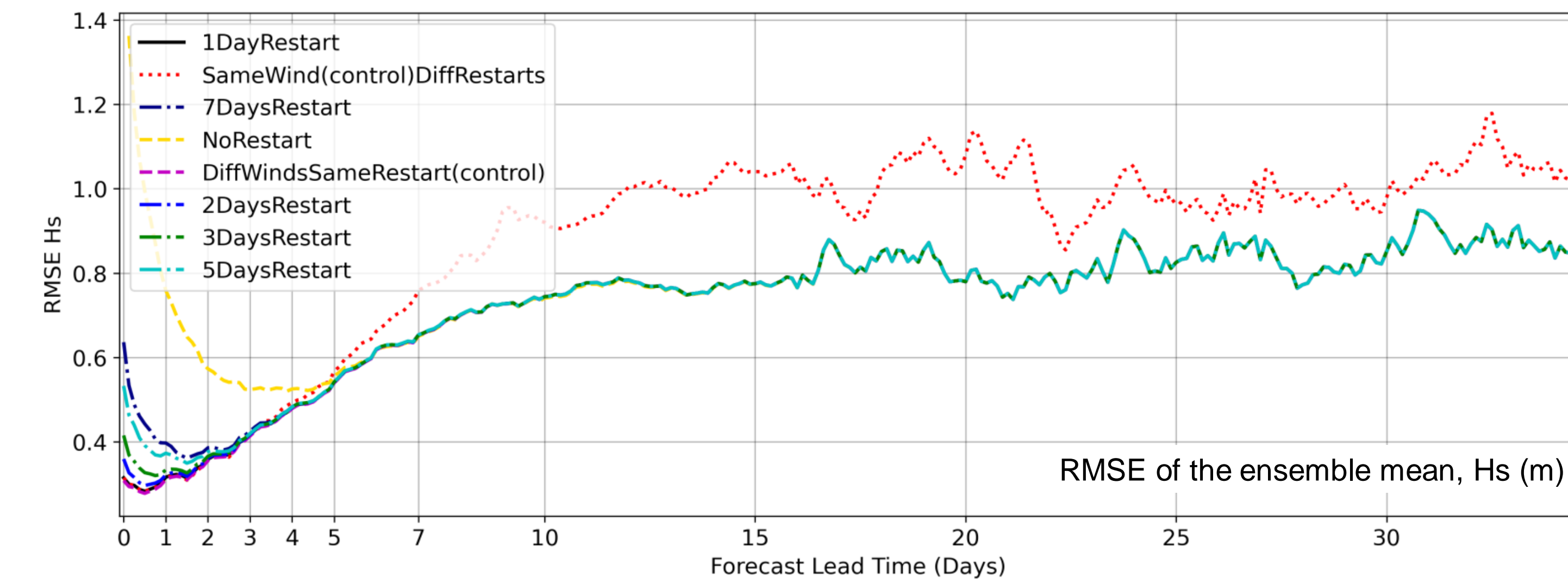
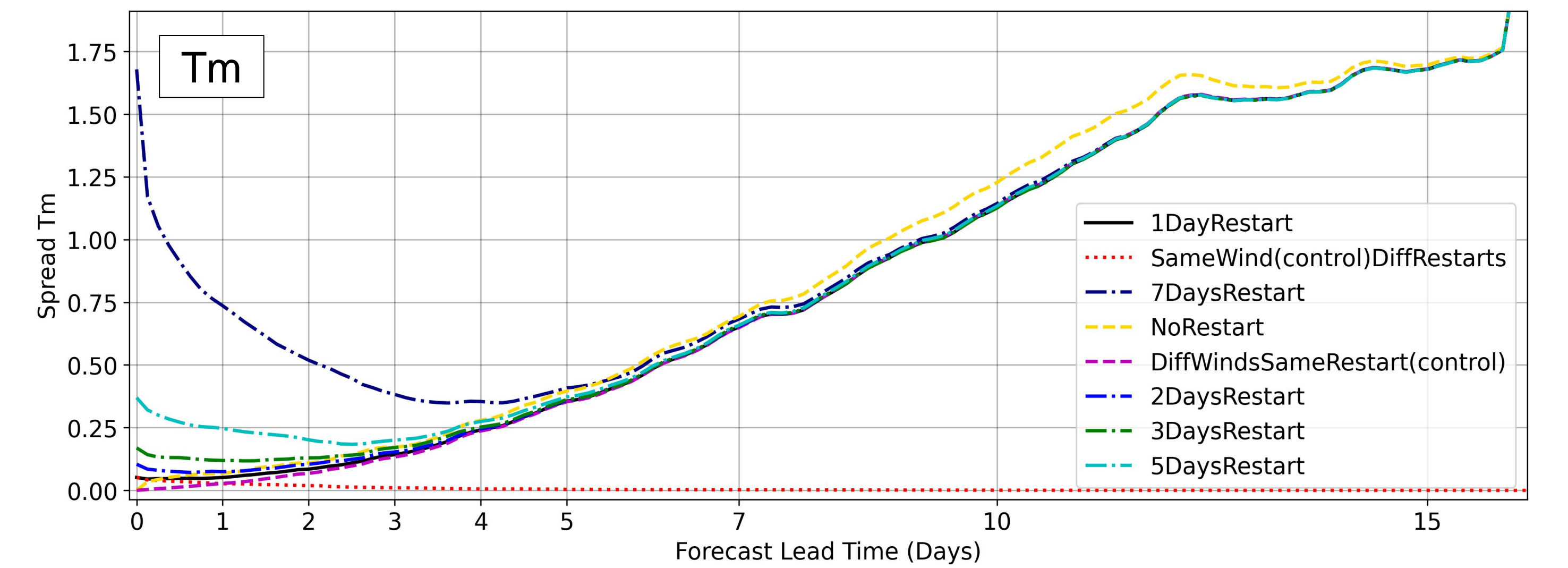
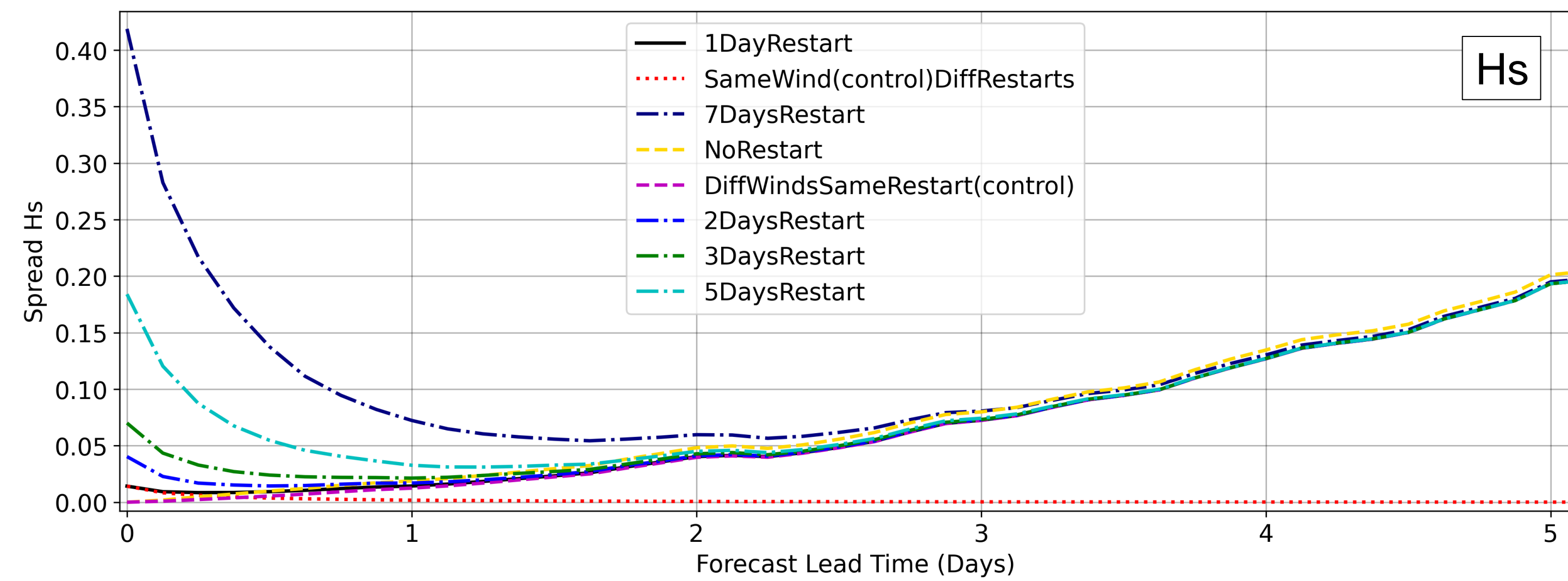


1. Introduction

- This study investigates the role of initial conditions (IC) and their impact on an extended wave forecast product.
- A reforecast has been produced using the NCEP's Global Ensemble Forecast System (GEFSv12): <https://noaa-nws-gefswaves-reforecast-pds.s3.amazonaws.com/index.html>
- The wave model WAVEWATCH III (v7.12) is forced by GEFSv12 reforecast winds (0.25°X0.25°)
- 3 wave grids: 2 Polar Grids 20 arc-min, 1 Global Grid 15 arc-min.
- 1 cycle per day (03Z)
- 5 ensemble members. Once a week (Wednesday) 11 members
- Forecast range up to 35 days
- Initial validation indicates the model is slightly under-spread at the analysis and first forecast hours.



- Rank histograms or Talagrand diagrams:
- U-shaped: Indicates insufficient spread (the ensemble forecast is over-confident);
 - High bias (positive): Shows the first bar with a higher probability;
 - Ideally flat: The ensemble is "reliable" when the rank histogram is approximately uniform; i.e., the model is well-calibrated, and the spread is appropriate.



2. Methodology and IC experiments

- Eight IC experiments were run for the period from 2016/08/24 to 2016/10/18: One extratropical cyclone in the North Pacific, and two hurricanes (Matthew and Nicole) in the North Atlantic ocean.
- No perturbations are added to the wave model so the spread comes from the wind input only. Each wave ensemble member is run with its corresponding atmospheric member.
- As an ensemble forecast, each member is independent and the spread is expected to increase with forecast time.
- Goal: reach optimal spread without introducing bias (flat Rank Histograms)
- The first five IC experiments vary the forecast lead time associated with the generation of restart files in WW3, from 24h to 7 days.
- One test is run with perturbed wind input members but using the same wave IC (same restart file, from the control member).
- Conversely, the following test uses different perturbed wave IC (from experiment 1) but applies the same wind input (control) to all the wave simulations (members).
- A final test was run with perturbed wind input members but without a restart file in WW3 (cold start).
- Validation using WW3-tools. Total of 7,158,315 model/buoy matchups and 30,621,735 model/satellite matchups.

<https://github.com/NOAA-EMC/WW3-tools>

3. Conclusions

- The ensemble spread of the wave component is primarily driven by the spread of the wind inputs, particularly beyond a 3-day forecast period.
- On average, the impact of initial conditions (IC) in the wave ensemble forecast is limited to the first five days.
- The lower scatter errors and higher correlation coefficients in the wave ensemble mean, compared to the control member, are benefits derived from the atmospheric ensemble spread (wind inputs).
- The impact of IC in the wave forecast system is felt at longer forecast lead times for the wave period compared to significant wave heights.
- Time-lagging can increase the spread in IC of the wave ensemble but may introduce errors that degrade short-term forecasts.
- Using 1-day restart files as IC for the next cycle results in low spread for the first forecast days but leads to optimal spread at longer ranges (week 2), as shown in the two rank histograms (left).