Evaluation of Hub-height Wind Forecasts Over the New York Bight

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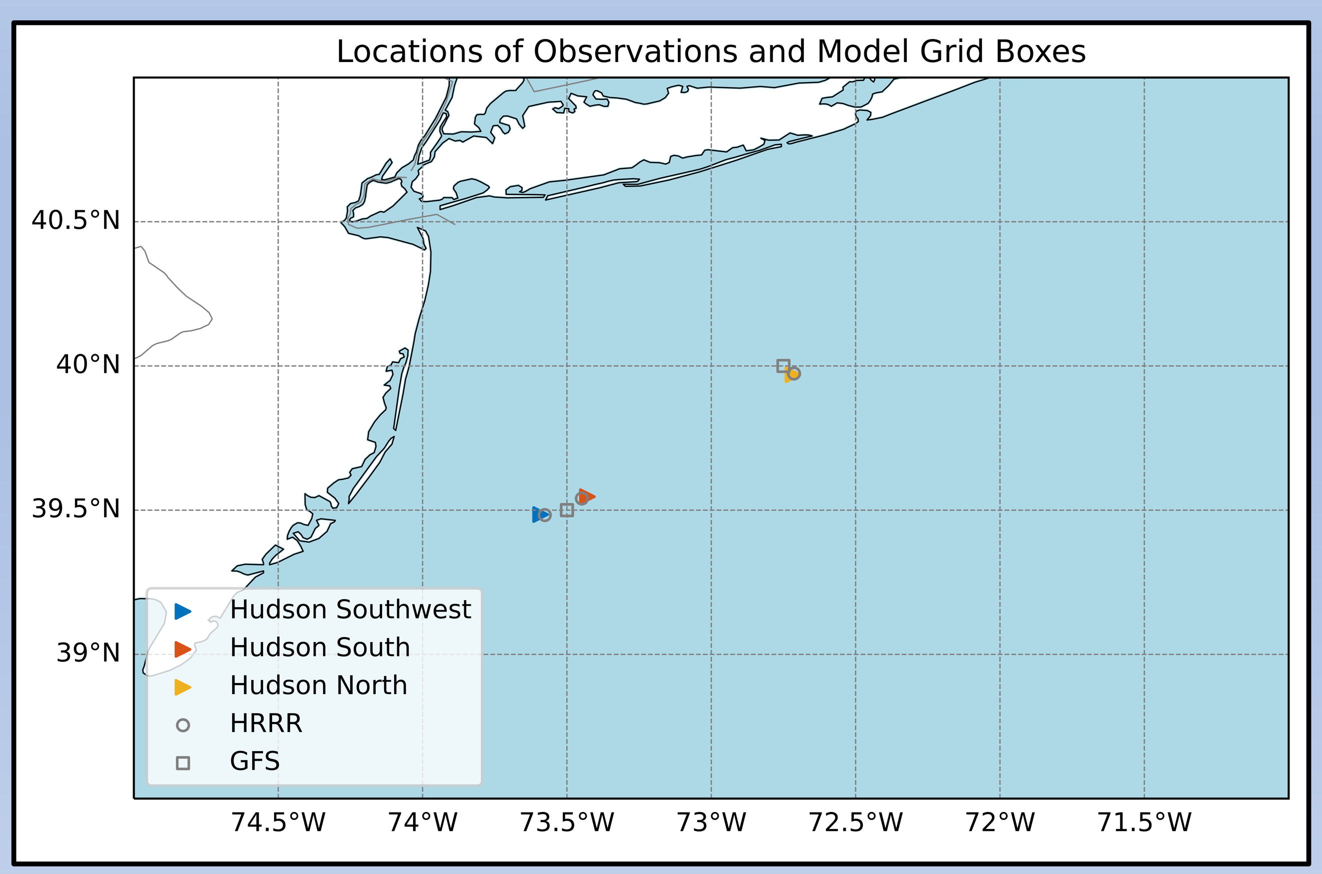
Introduction

As offshore wind energy development accelerates in the U.S., it is important to assess the accuracy of hub-height wind forecasts from numerical weather prediction models over the ocean. Leveraging approximately two years of Doppler lidar observations from buoys in the New York Bight, we provide an evaluation of 80-m wind speed forecasts from two state-of-the-art operational weather models.

Data and Methods

- 80-m wind speed at 10-min resolution from three floating Lidars deployed by the New York State Energy Research and Development Authority (NYSERDA) in the New York Bight



- High-Resolution Rapid Refresh (HRRR) atmospheric model v4 (3-km res.) and Global Forecast System (GFS) coupled atmosphere-ocean model v16 (13-km res.) valid at 0, 6, 12, 18 UTC for nearest grid boxes
- Examined the period of data overlap

Overlapping observational and model data availability at each location

	Hudson Southwest	Hudson South	Hudson North
HRRR	1/29/22 – 1/28/23	1/14/21 – 3/27/22*	12/2/20 – 9/14/21
GFS	1/29/22 – 1/28/23	3/14/21 – 3/27/22*	3/14/21 – 9/14/21

At Hudson South, an observational data gap exists between 8/22/2021 and 11/20/2021

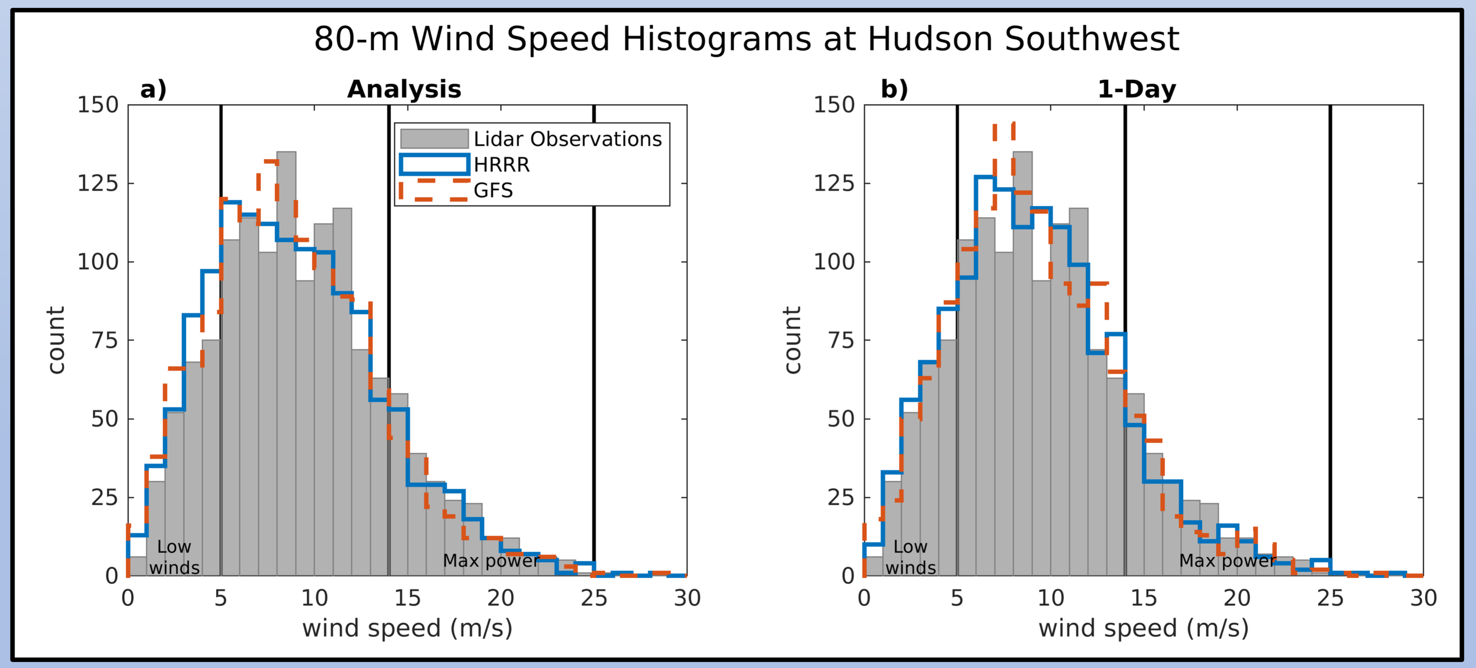
Contingency Table 1: Low Wind Speeds
"Event" defined as instance when observed wind speed < 5 m/s

	Obs < 5 m/s	Obs > 5 m/s
Model < 5m/s	hit	false alarm
Model > 5 m/s	miss	null

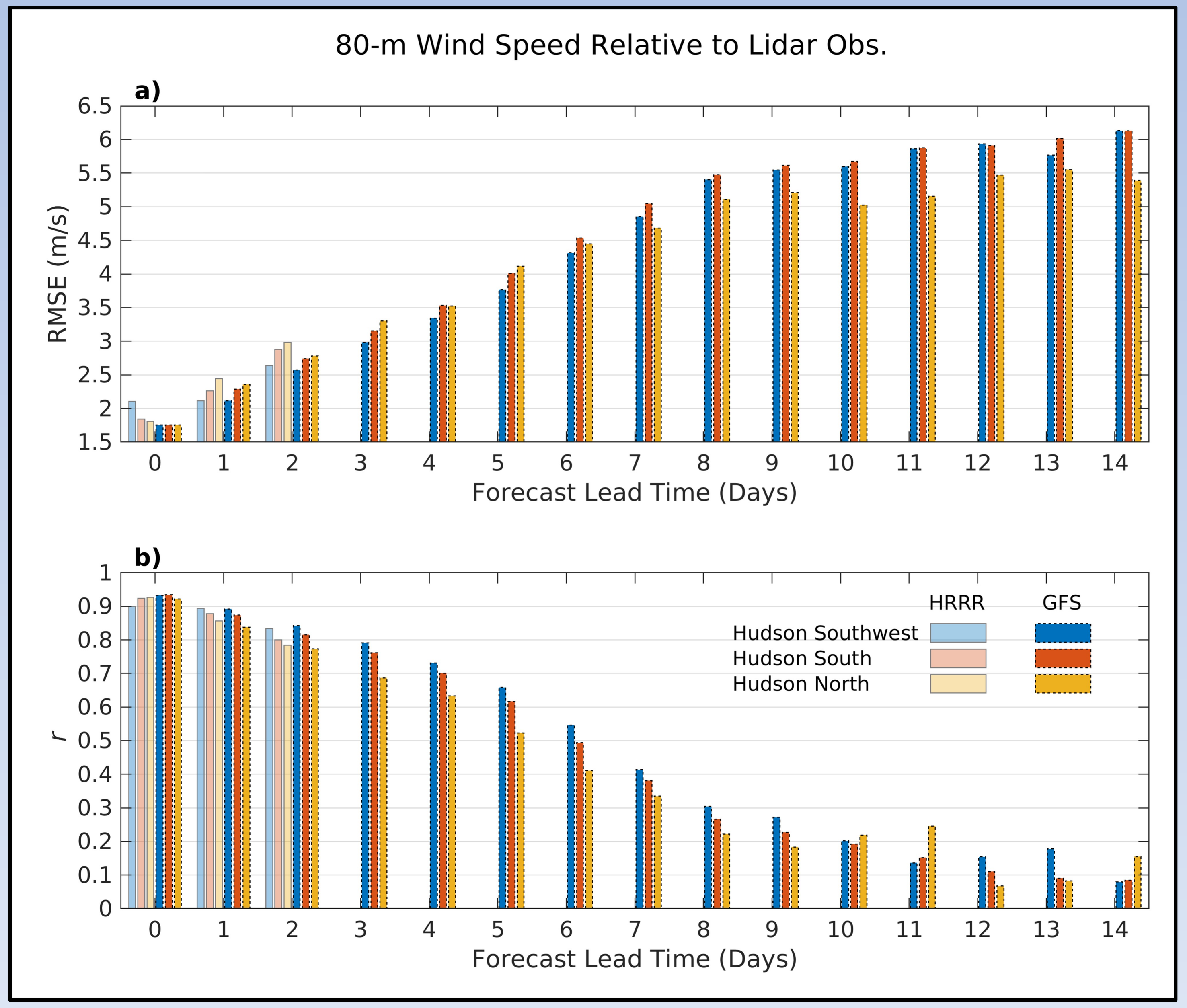
Contingency Table 2: Maximum Offshore Turbine Power
"Event" defined as instance when observed wind speed would produce max turbine power

	14 m/s ≤ Obs ≤ 25 m/s	Obs < 14 m/s or > 25 m/s
14 m/s ≤ Model ≤ 25 m/s	hit	false alarm
Model < 14 m/s or > 25 m/s	miss	null

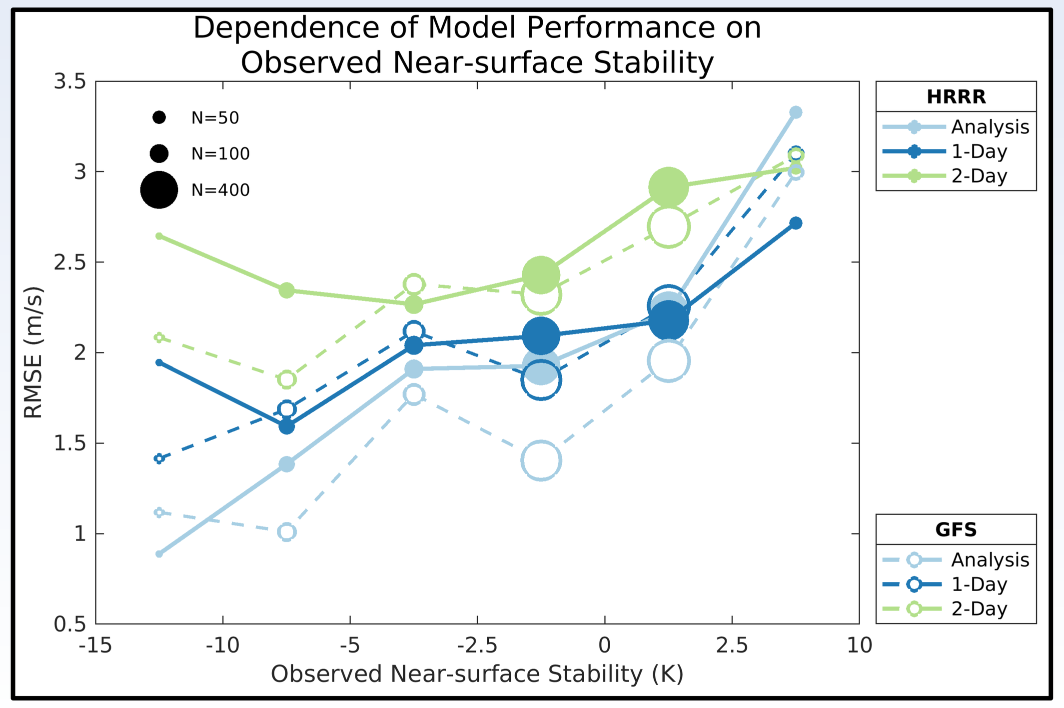
Climatology and Bulk Statistics



Observed and simulated 80-m wind speed histograms at the Hudson Southwest location. HRRR and GFS forecasts are for lead times of (a) zero days (the analysis) and (b) one day. For reference, in each panel, vertical lines indicate thresholds of 5 m/s, 14 m/s, and 25 m/s that separate regimes associated with low wind speeds and maximum offshore turbine power.

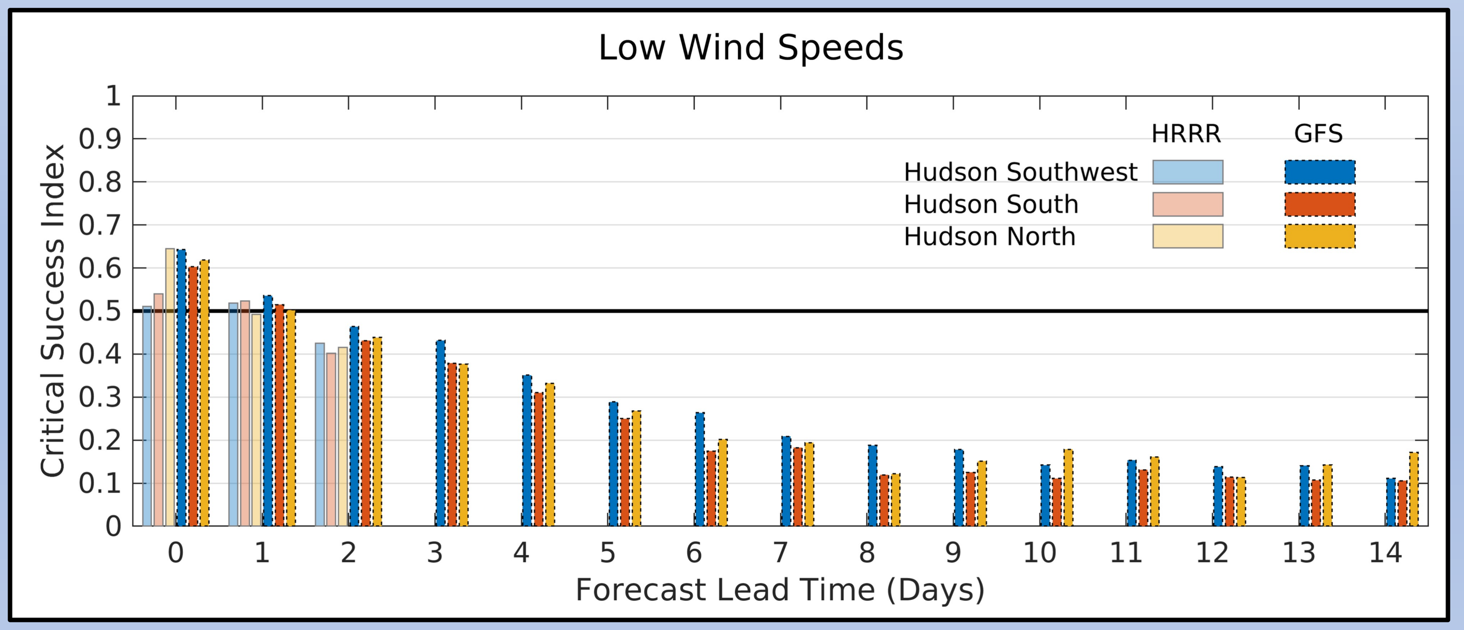


(a) Root mean square error and (b) Pearson correlation coefficient of 80-m wind speed simulated by the HRRR and GFS relative to observations. Forecast lead times are specified in units of days and represent increments of 24 hours. Each statistic is computed based on forecasts valid at 00, 06, 12, and 18 UTC for multiple lead times, so that each metric may be considered to represent the average model performance over the diurnal cycle.



RMSE of 80-m wind speed simulated by the HRRR and GFS relative to observations within intervals of near- surface static stability at the Hudson Southwest location. The size of the circles is proportional to the sample size (N) used to compute RMSE within each interval.

Contingency Table Metrics

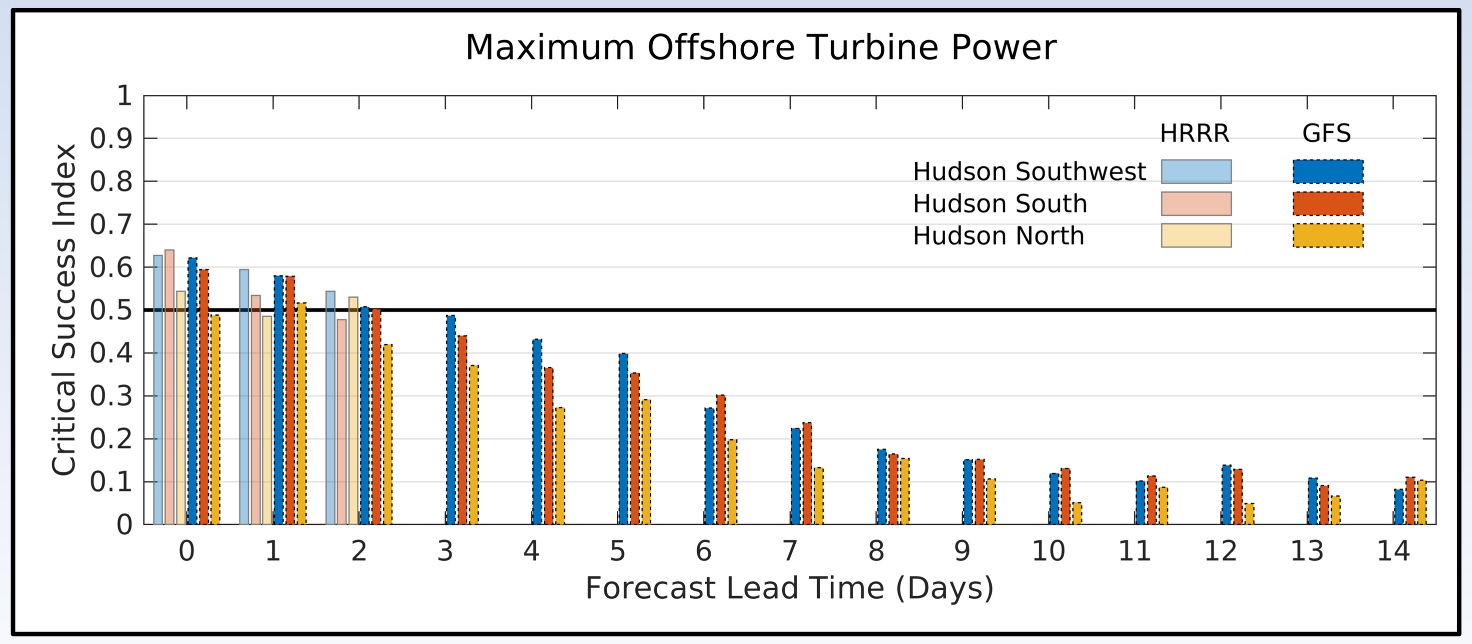


CSI of wind speeds less than 5 m/s produced by the HRRR and GFS.

Critical Success Index (CSI)

= hits / (hits + misses + false alarms) ≤ 1

If **hits > misses + false alarms,** then CSI > 0.5



CSI of wind speeds associated with maximum offshore turbine power (those between 14 and 25 m/s) produced by the HRRR and GFS.

Conclusions

- Despite different horizontal (3-km vs 13-km) grid spacing, vertical layering, initialization methods, and parameterizations of boundary layer mixing and surface-atmosphere interactions, the HRRR and GFS demonstrate similar and highly skillful short-term forecasts.
- Day-ahead forecasts also exhibit skill (CSI > ~0.5) in predicting quiescent winds and winds associated with max turbine power.
- By Day 10, GFS forecasts on average have almost no skill.
- Short-term forecast skill by the HRRR and GFS does not strongly depend on season or time of day, yet we find some dependence of the models' performance on near-surface stability.
- The high skill of the HRRR and GFS short-term forecasts validates their utility for offshore wind energy maintenance and operation.