

On the Predictability of Hurricane Track and Intensity Using an OSSE Framework



Bachir Annane¹, Lisa Bucci², Javier Delgado¹, Altug Aksoy¹, Robert Atlas³, S. T. Murillo³

¹ Univ. of Miami/CIMAS and NOAA/AOML/HRD, Miami, FL

² Univ. of Miami/RSMAS, Miami, FL

³ NOAA/AOML, Miami, FL

Observational Data

-Extracted from the Nature Run

-Outer domain (d01):

-Analysis domain, fits within the Nature Run outer domain and captures most of the storm life cycle

-9 km horizontal grid spacing (353x411 grid points) 61 vertical levels

-Inner domain (d02):

-Storm-following moving nest

-3 km horizontal grid spacing (179x339 grid points, ~4°x5°) 61 vertical levels

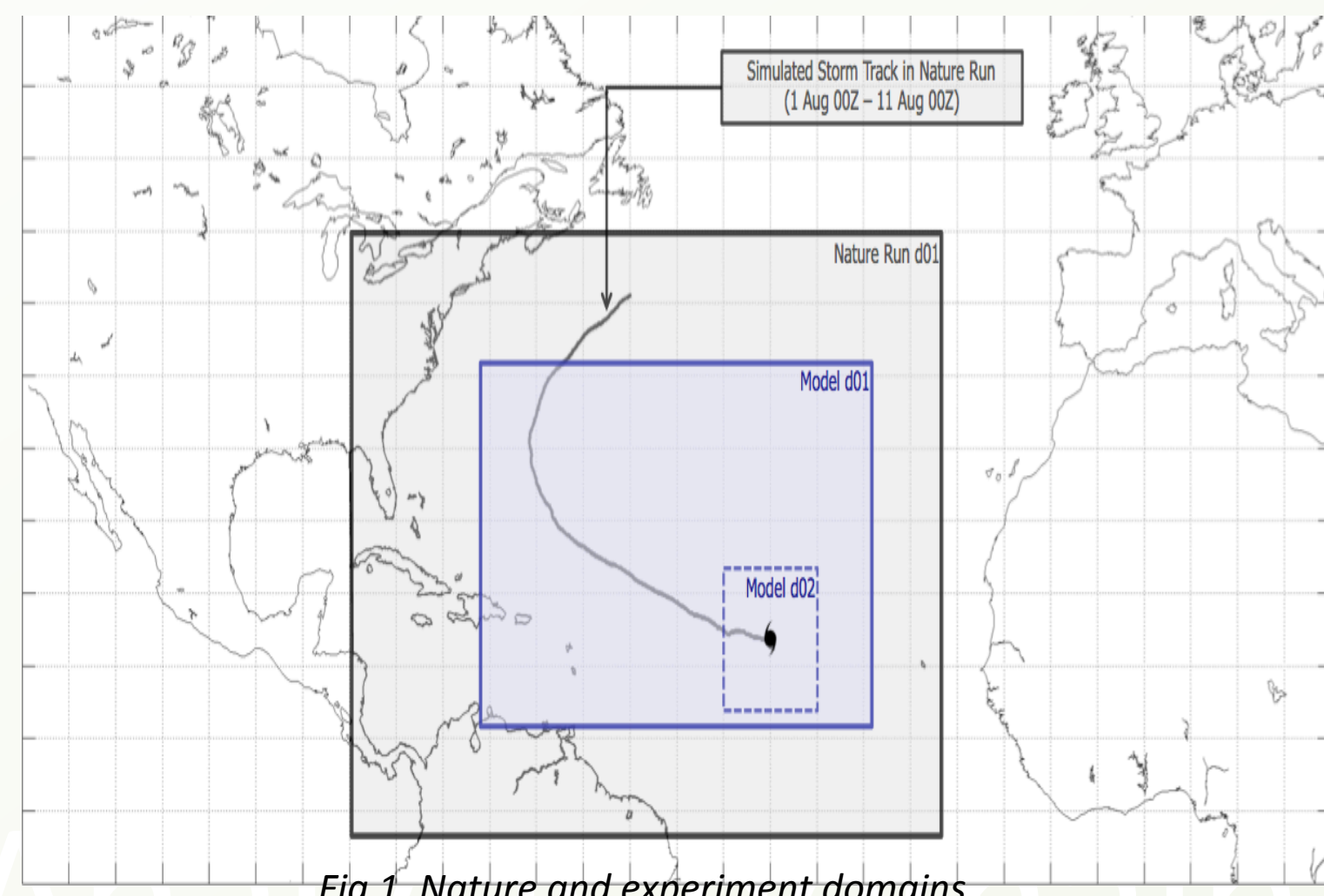


Fig 1. Nature and experiment domains.

Data:

-BUFR data is generated to span the WRF ARW nature run.

- Arrays of T,Q,U and V are at 27 km and 5 km horizontal resolution .

OSSE Framework

The regional OSSE (Observing System Simulation Experiment) framework described here was developed at NOAA/AOML and UM/RSMAS and features a high-resolution regional nature run embedded within a lower-resolution global nature run. Simulated observations are generated and provided to a data assimilation (DA) scheme which provides analyses for a high-resolution regional forecast model.

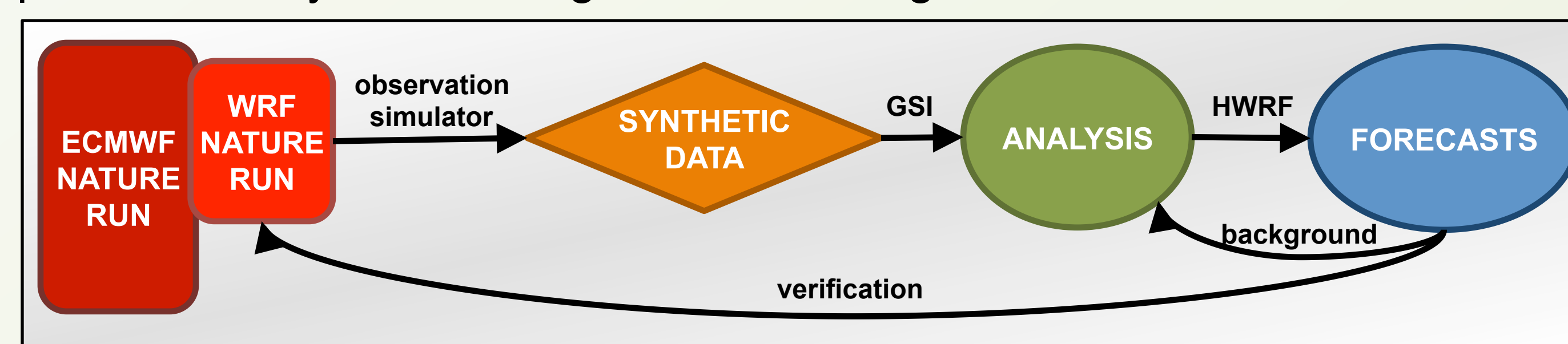


Fig 2. Basic flow chart of the regional OSSE framework.

Nature Runs

- ECMWF: low-resolution T511 (~40km) "Joint OSSE Nature Run"

- WRF-ARW: high-resolution 27km regional domain with 9/3/1 km storm-following nests (v3.2.1)

Data Assimilation Scheme

- GSI: Gridpoint Statistical Interpolation... a standard 3D variational assimilation scheme (v3.3). Analyses performed at 9km resolution.

Forecast Model

- HWRF: the 2014 operational Hurricane-WRF model (v3.5). Parent domain has 9km resolution, single storm-following nest has 3km resolution.

For these results, DA performed every 6 hours, forecast model run every 6 hours, each run producing a 5-day forecast, for total of 16 cycles.

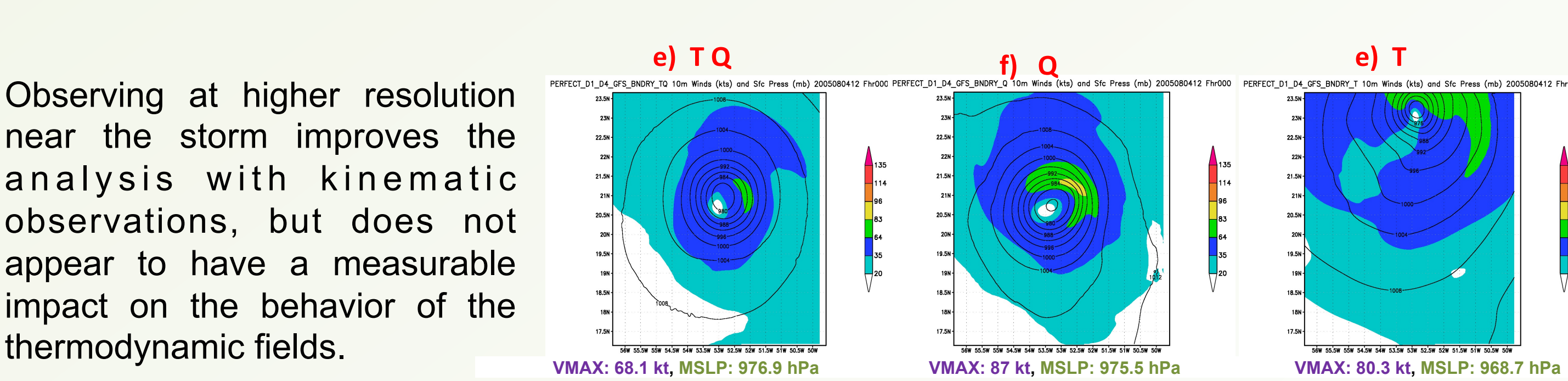
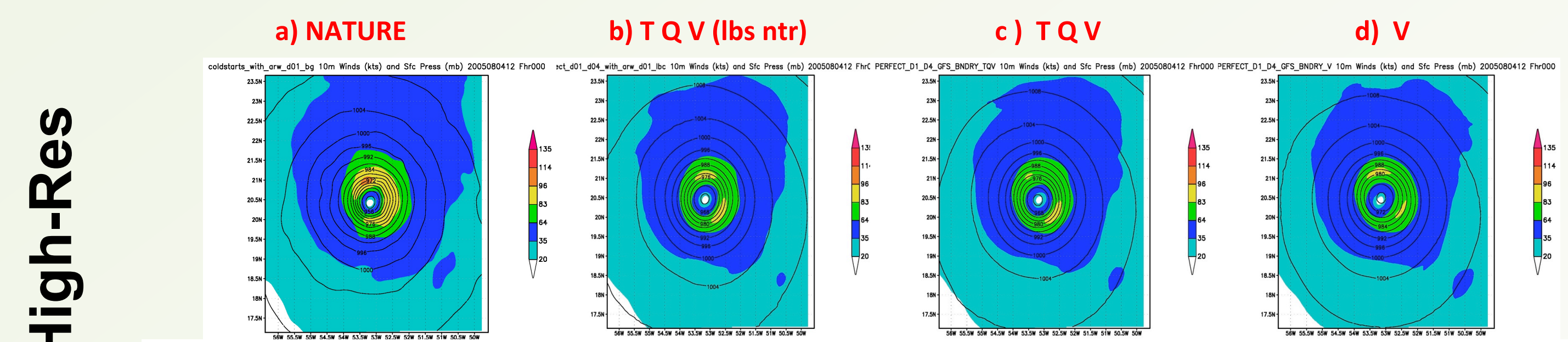
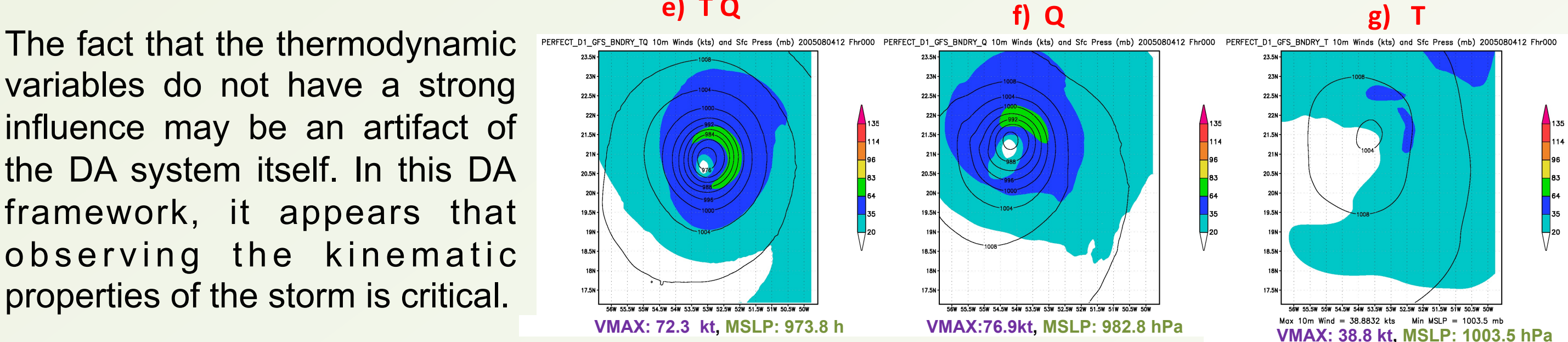
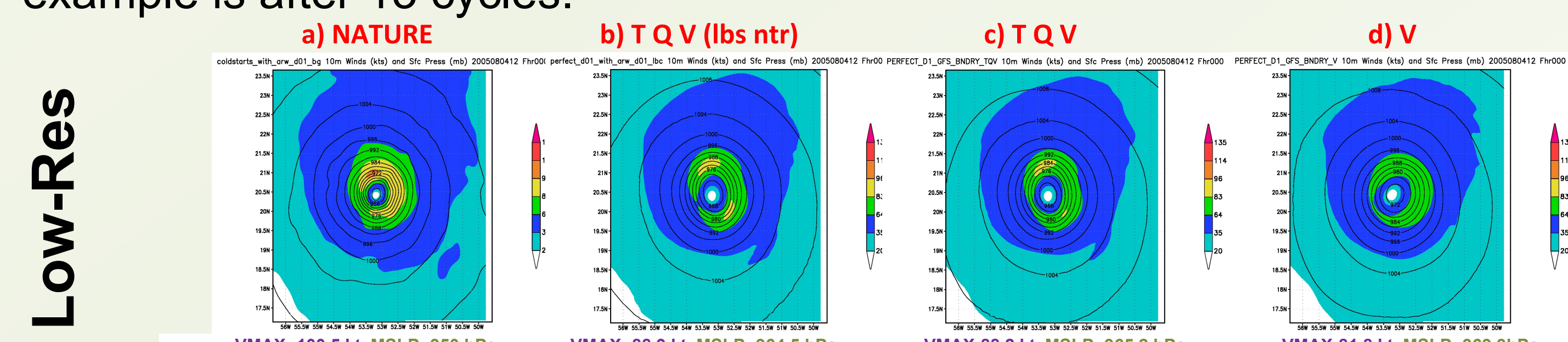
Experiments and Results

All experiments listed use identical configurations of GSI for data assimilation and HWRF for forecasts.

Experiment	Lateral Boundaries	Initialization	Resolution
Nature	Nature	Interpolation	9km
T Q V (lbc ntr)	Nature	Assimilate wind, temperature, moisture	High
T Q V (lbc ntr)	Nature	Assimilate wind, temperature, moisture	Low
T Q V	GFS	Assimilate wind, temperature, moisture	High
T Q V	GFS	Assimilate wind, temperature, moisture	Low
V	GFS	Assimilate wind	High
V	GFS	Assimilate wind	Low
T Q	GFS	Assimilate temperature, and moisture	High
T Q	GFS	Assimilate temperature, and moisture	Low
Q	GFS	Assimilate moisture	High
Q	GFS	Assimilate moisture	Low
T	GFS	Assimilate temperature	High
T	GFS	Assimilate temperature	Low

Analysis Storm Structure

- MSLP (contoured) and 10-m wind speed (shaded) are shown to illustrate the degradation in storm structure in the experiments above. This example is after 13 cycles.



The fact that the thermodynamic variables do not have a strong influence may be an artifact of the DA system itself. In this DA framework, it appears that observing the kinematic properties of the storm is critical.

Observing at higher resolution near the storm improves the analysis with kinematic observations, but does not appear to have a measurable impact on the behavior of the thermodynamic fields.

Skill Scores - Low Resolution Experiments

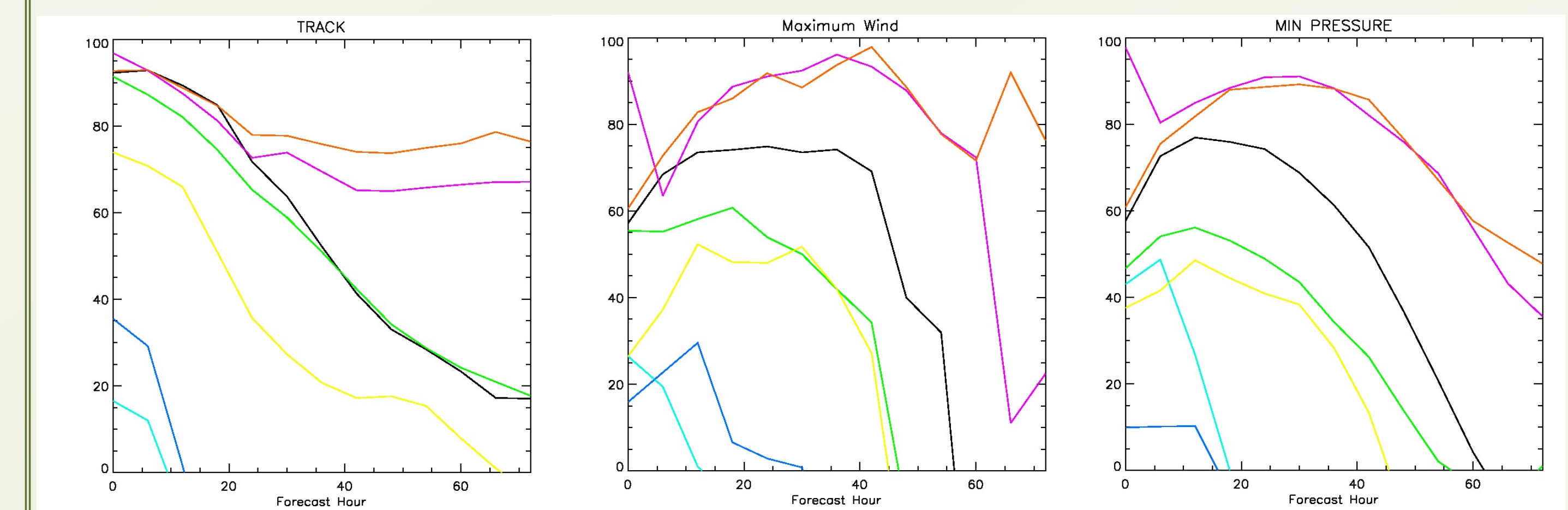


Fig 3. Skill scores over 16 cycles. Skill include track (left), peak surface wind (middle), and minimum surface pressure (right).

Skill Scores - High Resolution Experiments

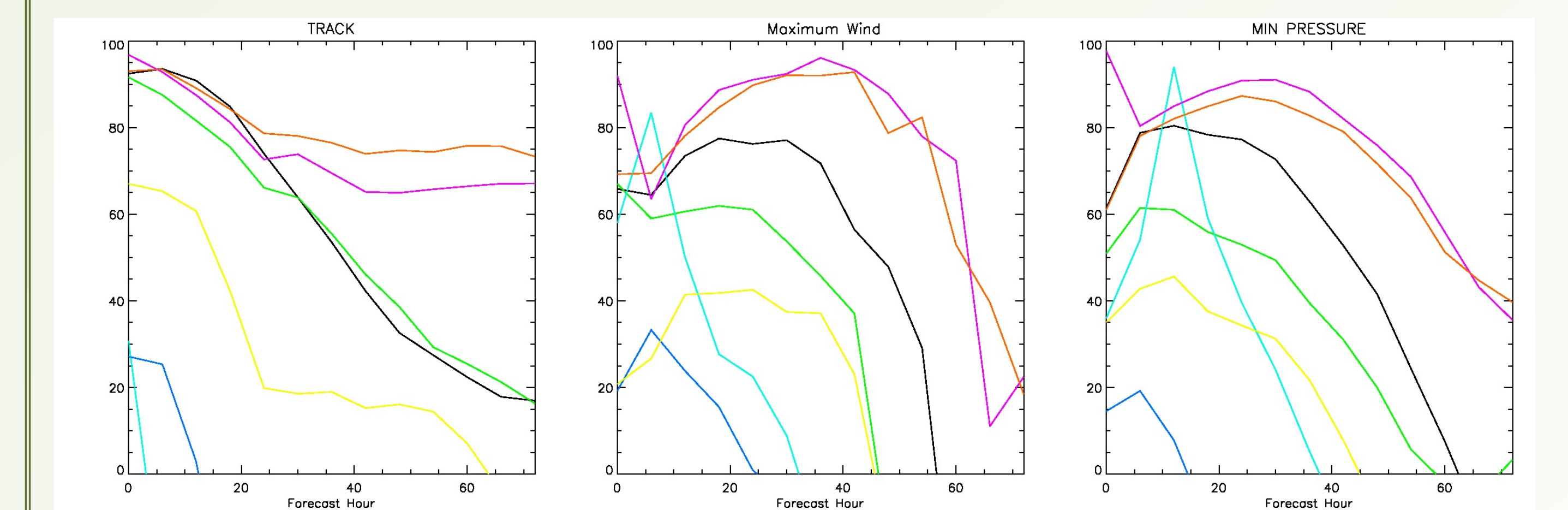


Fig 4. Skill scores over 16 cycles. Skill include track (left), peak surface wind (middle), and minimum surface pressure (right).

Summary

- Even with the perfect initial conditions and perfect boundary conditions, the predictability is quickly lost (compared to imperfect boundary conditions) within 12-18 hours.
- Adding kinematic observations improves predictability by about 1 day in terms of forecast lead time.
- Assimilating thermodynamic variables does not appear to have positive impact on the predictability of the simulated storm.
- A degradation in boundary conditions results in the loss of predictability of intensity/MSLP by about 1 day in terms of forecast lead time.
- High resolution experiments with kinematic observations have higher skill than lower resolution experiments.
- We have very few samples from one storm, so error statistics are not robust, but provide guidance for future studies.

Acknowledgements

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