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

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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

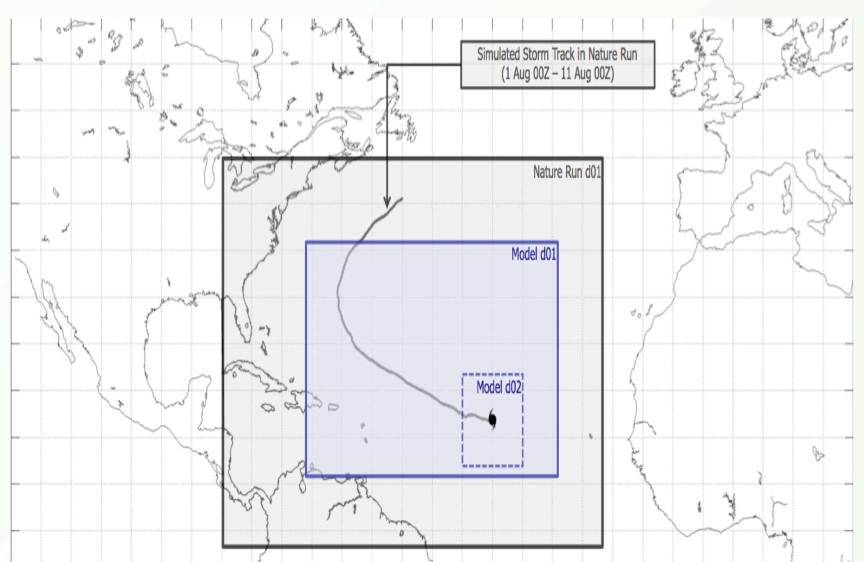


Fig 1. Nature and experiment domains.

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.

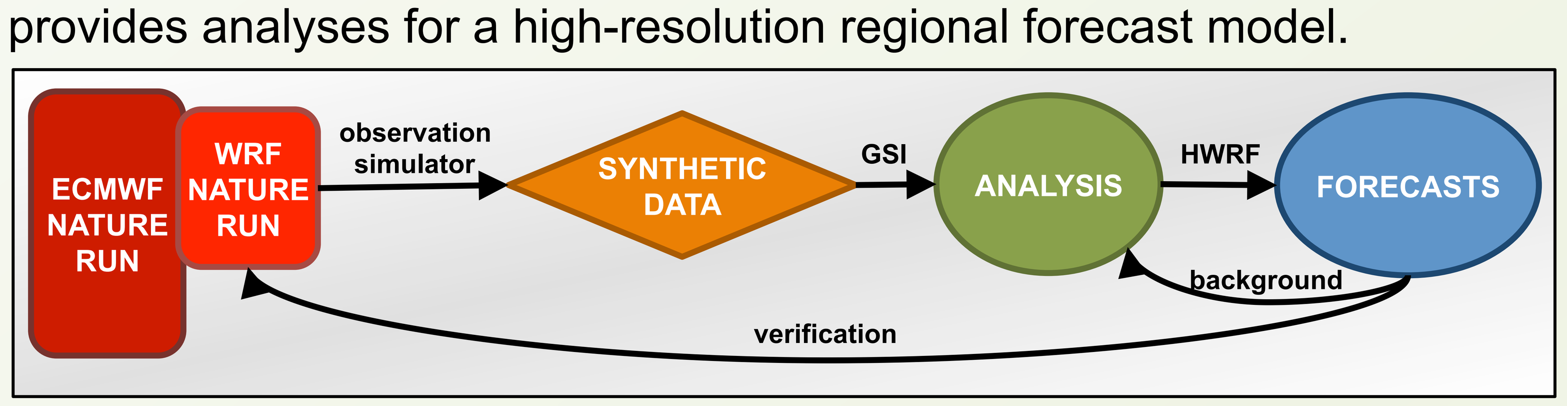


Fig 2. Basic flow chart of the regional OSSE framework.

▪ 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.

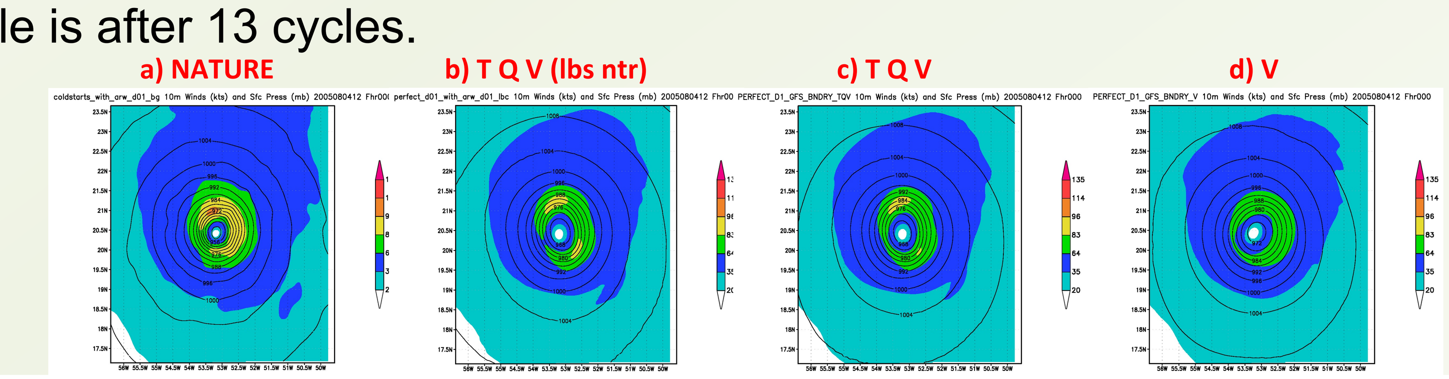
DEGRADATION ↓

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

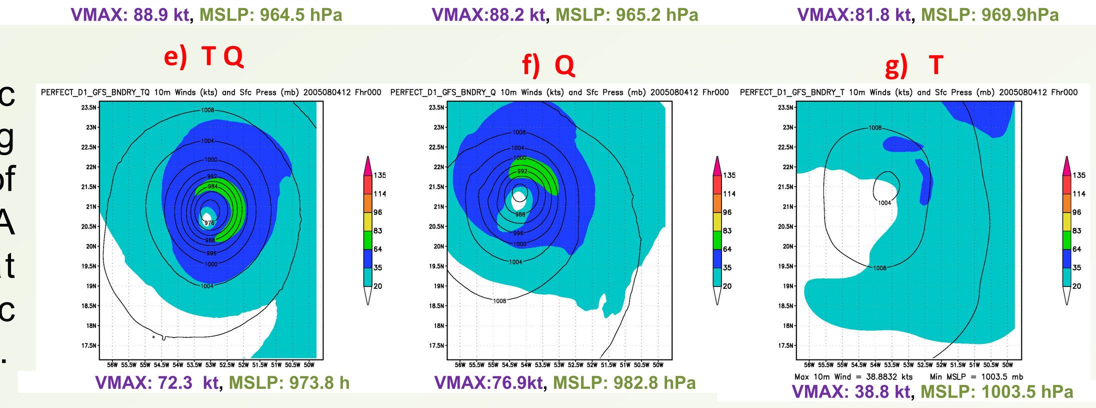
▪ Analysis Storm Structure

- 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.

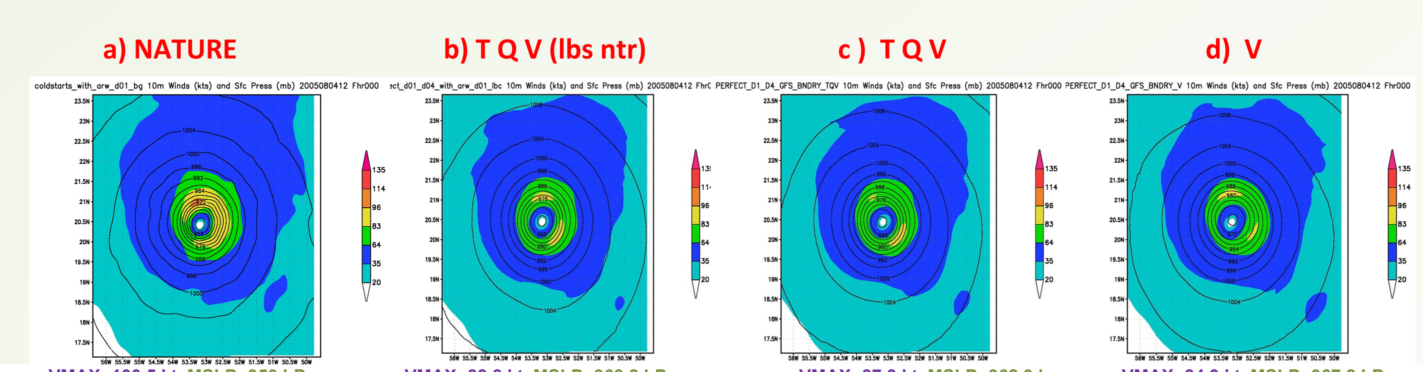
Low-Res



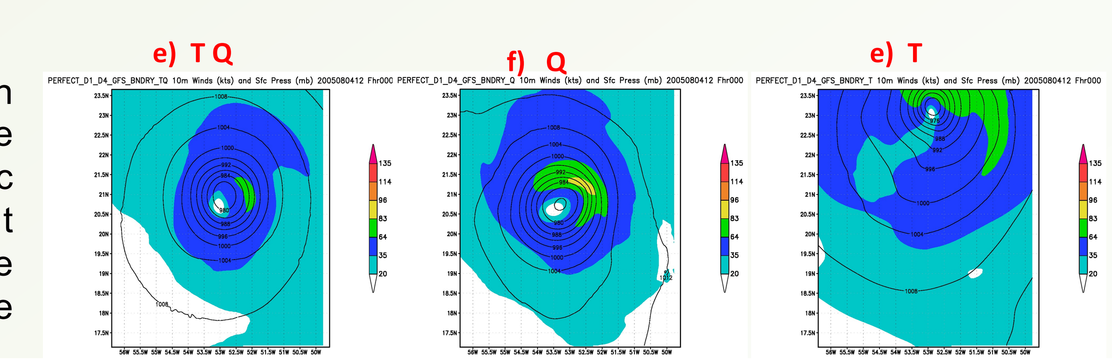
The fact that the thermodynamic variables do not have a strong influence may be an artifact of the DA system itself. In this DA framework, it appears that observing the kinematic properties of the storm is critical.



High-Res



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

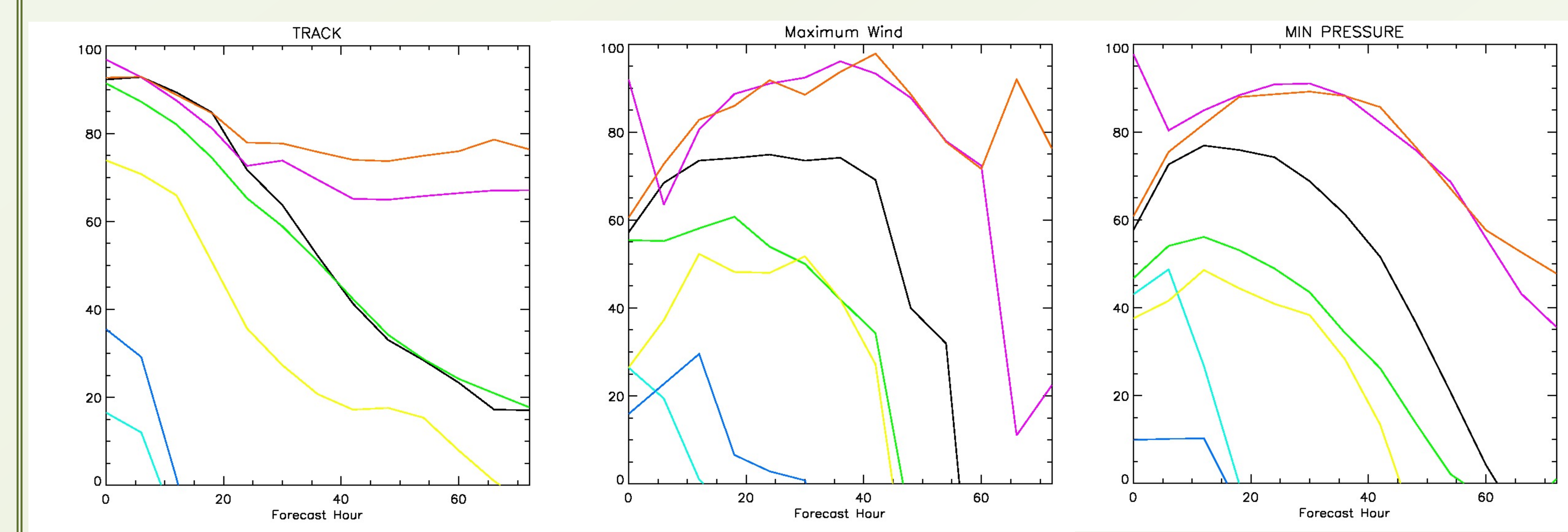
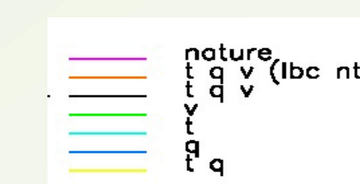


Fig 3. skill scores over 16 cycles. Skill include track (left), peak surface wind (middle), and minimum surface pressure (right).



▪ Skill Scores – High Resolution Experiments

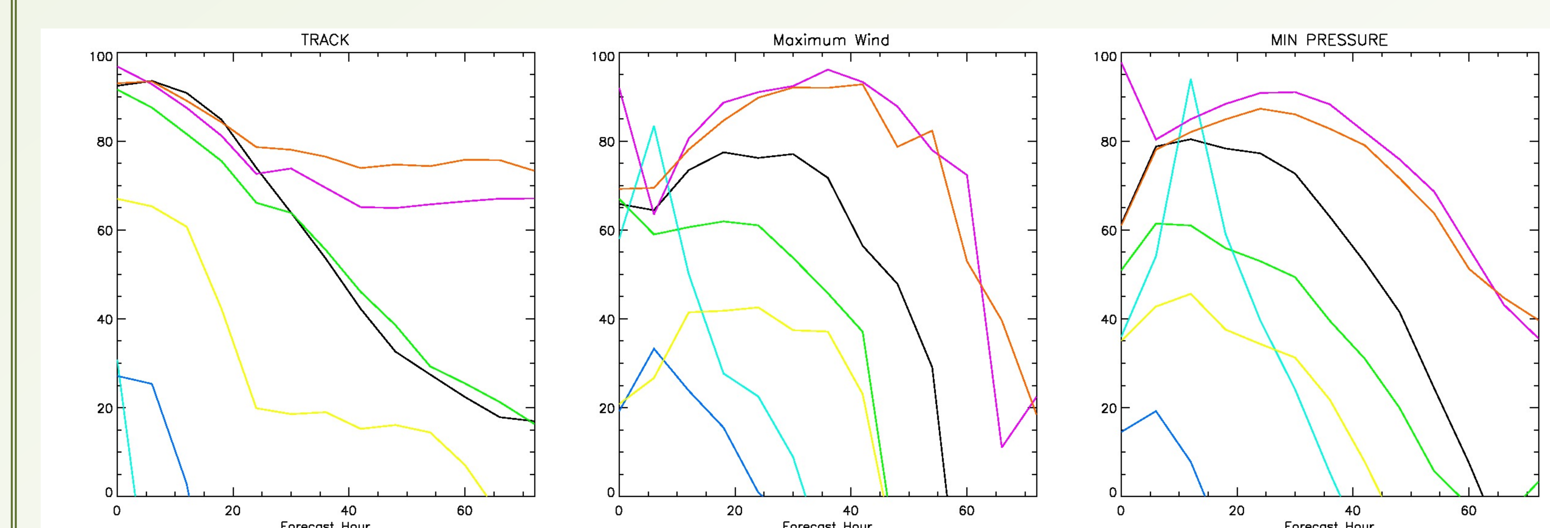


Fig 4. Skill scores over 16 cycles. Skill include track (left), peak surface wind (middle), and minimum surface pressure (right). .

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.

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