Sensitivity of an Idealized Hurricane to Physics Parameterizations: ARW vs. HWRF

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1. Introduction

The preliminary results from a series of idealized experiments with the Advanced Research WRF (ARW) model and the experimental Hurricane WRF (HWRF) model are presented. The purpose of the experiments is to compare the sensitivity of the intensification of an idealized hurricane to commonly used microphysics, radiation, and cumulus parameterization schemes. The comparison focuses on how the sensitivities of the 2 models to physics parameterizations differ with respect to the surface wind-pressure relationship and storm structure .

2. Model Setup

Both models are initialized with a weak axisymmetric vortex disturbance in an idealized tropical environment that is favorable for the vortex disturbance to develop into a hurricane. The initial mass and wind fields associated with the weak vortex disturbance are obtained by solving the nonlinear balance equation for the given wind distributions of the initial vortex (Wang 1995, MWR), and the prescribed background thermal sounding and winds.

- *f* plane located at 12.5ºN
- The prescribed axisymmetric vortex:
  - — maximum surface tangential wind: 15 m/s
  - — radius of surface maximum wind: 90 km
- Quiescent environment thermally corresponding to the Jordan sounding with a constant sea surface temperature of 29ºC
- Both models are run with 2 domains, a 9 km outer domain with a moving 3-km nest and 43 vertical levels

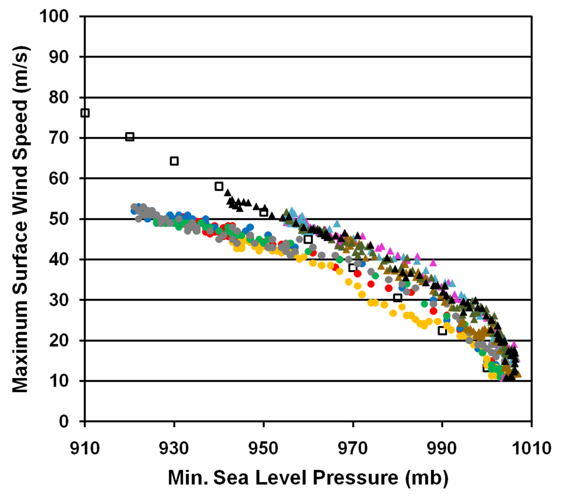
3. Sensitivity Experiments:

Experiment #	Marker	Dynamical core	Boundary Layer Scheme	Convective parameterization scheme (D1/D2)	Radiation Scheme	Microphysics scheme
1	Red Circles	HWRF	MYJ	SAS/SAS	NCAR	Ferrier
2	Blue Circles	HWRF	MYJ	SAS/SAS	NCAR	WSM 6
3	Yellow Circles	HWRF	MYJ	BMJ/BMJ	NCAR	Ferrier
4	Green Circles	HWRF	MYJ	SAS/SAS	GFDL	Ferrier
5	Gray Circles	HWRF	MYJ	None/None	NCAR	Ferrier
6	Magenta Triangles	ARW	MYJ	SAS/SAS	NCAR	Ferrier
7	Light Blue Triangles	ARW	MYJ	SAS/SAS	NCAR	WSM 6
8	Brown Triangles	ARW	MYJ	BMJ/BMJ	NCAR	Ferrier
9	Dark Green Triangles	ARW	MYJ	SAS/SAS	GFDL	Ferrier
10	Black Triangles	ARW	MYJ	None/None	NCAR	Ferrier

4.Sensitivity of Wind-Pressure Relationships and Storm Development to Physics Parameterizations

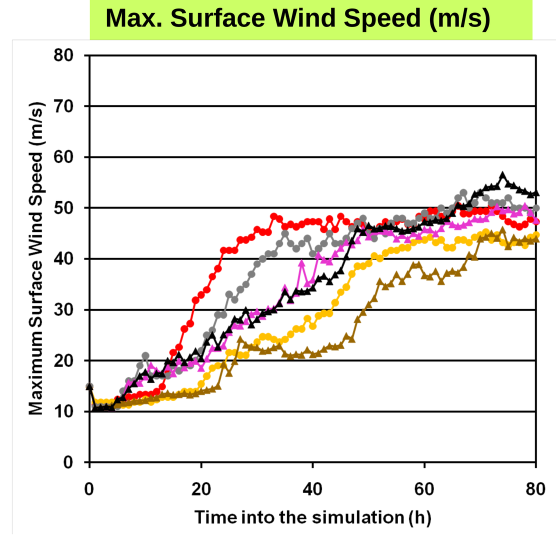
Wind-Pressure Relationship

All Experiments
HWRF-Circles
ARW-Triangles
Knaff and Zehr (2007,WAF)-Open squares

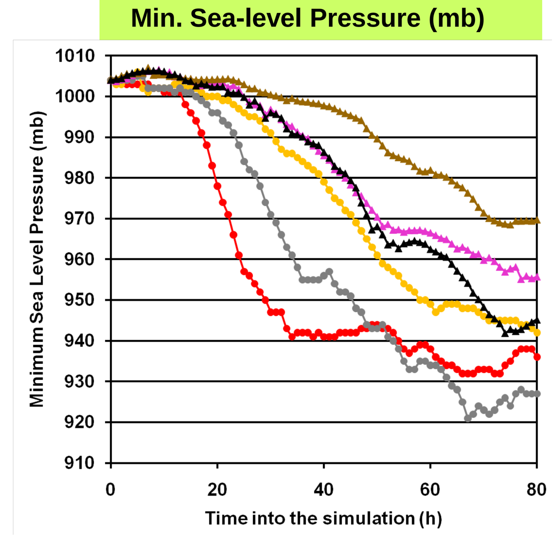


Sensitivity to Convective Parameterization Scheme Options

Max. Surface Wind Speed (m/s)



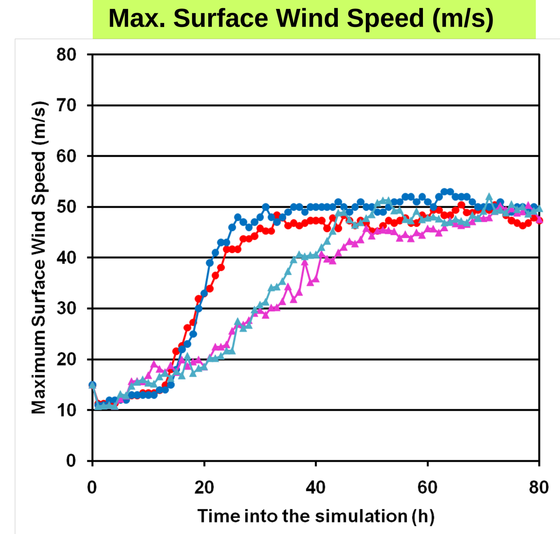
Min. Sea-level Pressure (mb)



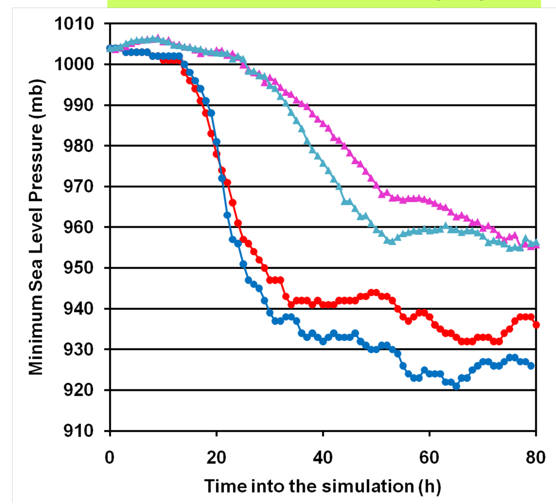
Magenta Triangles: ARW SAS
Brown Triangles : ARW BMJ
Black Triangles : ARW None
Red Circles: HWRF SAS
Yellow Circles: HWRF BMJ
Gray Circles: HWRF None

Sensitivity to Microphysics Parameterization Scheme Options

Max. Surface Wind Speed (m/s)



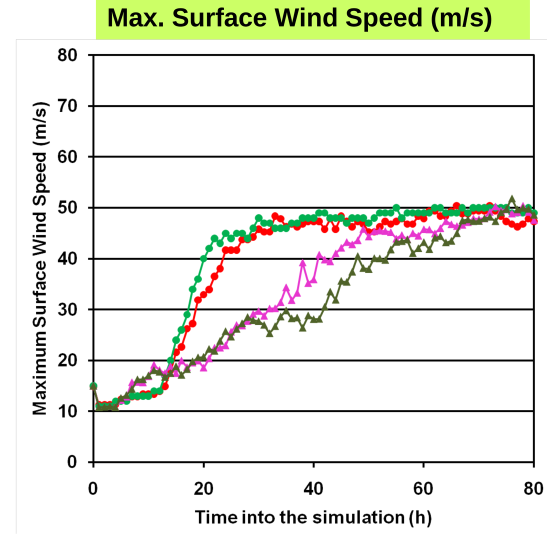
Min. Sea-level Pressure (mb)



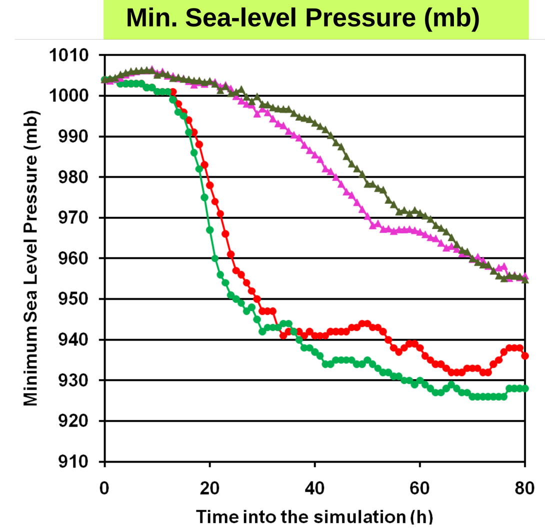
Magenta Triangles: ARW Ferrier
Light Blue Triangles : ARW WSM6
Red Circles: HWRF Ferrier
Blue Circles: HWRF WSM6

Sensitivity to Radiation Scheme Options

Max. Surface Wind Speed (m/s)

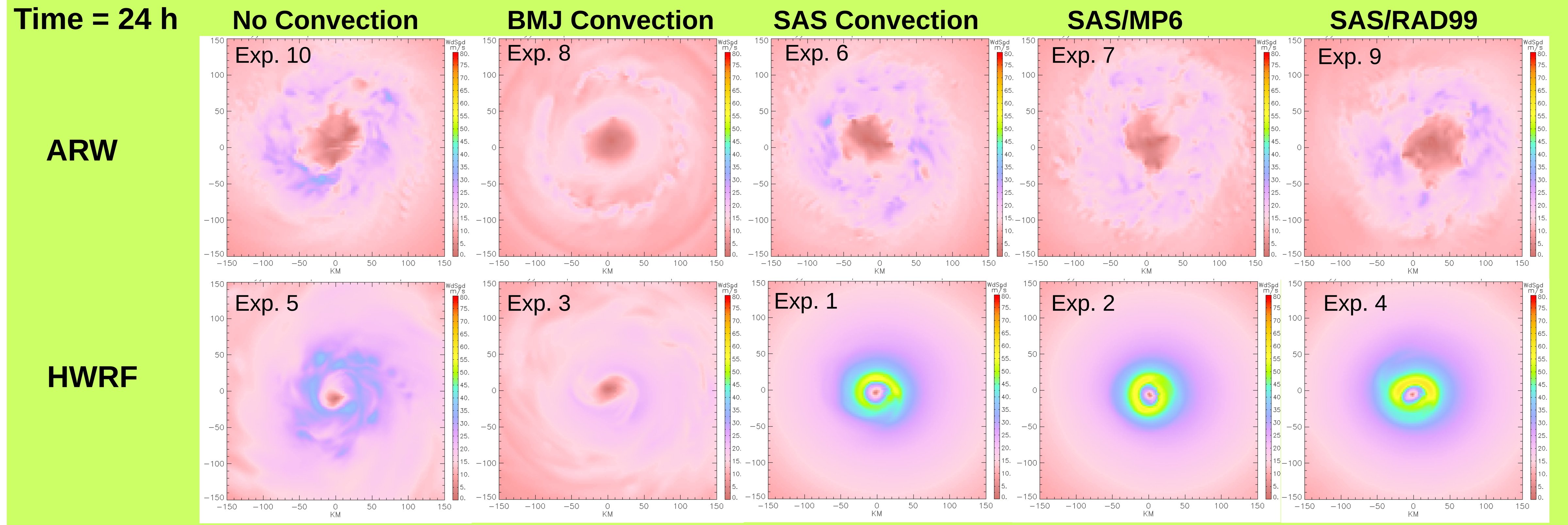


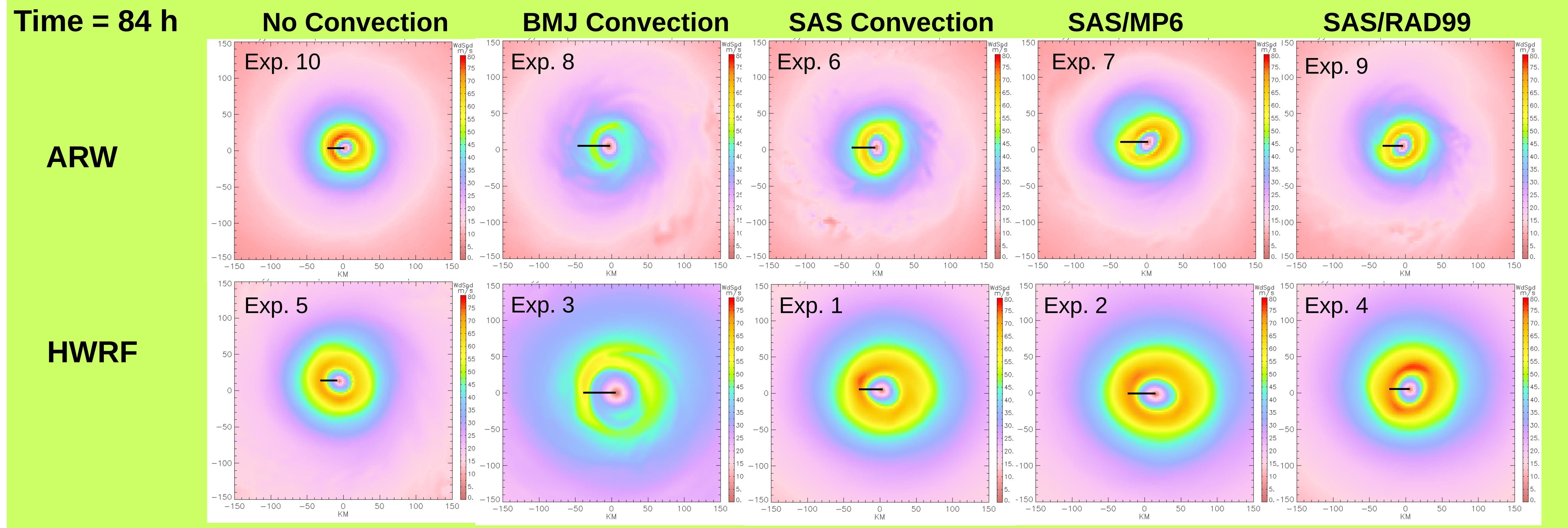
Min. Sea-level Pressure (mb)



Magenta Triangles: ARW NCAR
Dark Green Triangles : ARW GFDL
Red Circles: HWRF NCAR
Green Circles: HWRF GFDL

5.Sensitivity of Storm Structure to Physics Parameterizations: 850m mb Wind Speed at T=24h and T=84h





— = HWRF RMW

6. Preliminary Conclusions

- **ARW and HWRF have different wind-pressure relationships: the minimum sea level pressure in HWRF is less than the minimum sea level pressure in ARW at hurricane strength winds.**
- **The wind-pressure relationship in both models is not very sensitive to permutations of cloud and radiation physics.**
- **HWRF spins up faster than ARW.**
- **HWRF's radius of maximum wind (RMW) is overall greater than ARW.**
- **The biggest sensitivity for both models is to the convective parameterization scheme.**
- **The intensity and structure of the simulated storm are sensitive to microphysics and radiation permutations for both models.**
- **There is a need to include structural parameters in the model evaluation (e.g., RMW).**
- **A combination of observational analysis and theoretical understanding is needed to determine an "improved" operational physics configuration separately for each model.**