

Sensitivity of HWRF Forecasts to Cumulus Parameterizations

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Developmental Testbed Center

13th WRF Workshop, Boulder, CO

Motivation

Hurricane Forecast Improvement Project (HFIP) Physics Workshop: Stressing the need to test more physics options to see whether forecasts improve

Several researchers have shown sensitivity of cumulus to hurricane forecasts

Possible members in HWRF ensemble

Enhanced Interoperability

Acronym	Scheme	New in HWRF
HPHY	HWRF SAS (no shallow convection)	-
HNSA	SAS implemented by YSU (yes shallow convection)	Yes*
HTDK	Tiedtke	Yes ¹
HKF1	Kain Fritsh	-
	Grell	Yes, uncoupled



*Available in WRF3.4 ¹ Will be available in HWRF 3.4a

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HWRF Configuration

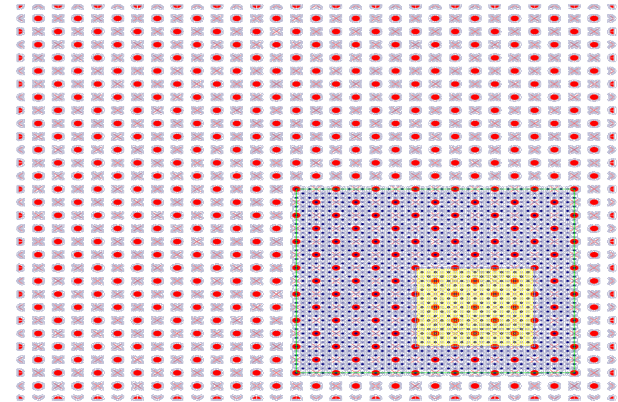
Microphysics: Ferrier

Land Surface: GFDL slab scheme

PBL: GFS PBL scheme

Longwave: GFDL

Shortwave: GFDL



(Courtesy Sam Trahan)

HWRF Version used for this study

HWRF Baseline with 27/9/3 km capability

27 km 75x75 degree

9 km ~10x10 degree

3 km ~5.5x5.5 degree

This is a branch of the developmental HWRF that was being tested for 2012 pre-implementation

No cumulus in the innermost domain

Ocean coupling with POM-TC

No GSI was used for this study.

The initial and boundary conditions are from GFS re-forecasts. These are retrospective runs done for 2010 and 2011 with the new GFS model



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Cases for the cumulus tests

2011 Atlantic	ID	Begin	End
Harvey	08L	081900	082206
Irene	09L	082100	082818
Katia	12L	082906	091012
Maria	14L	090618	091612
Ophelia	16L	092100	100306
Rina	18L	102318	102812

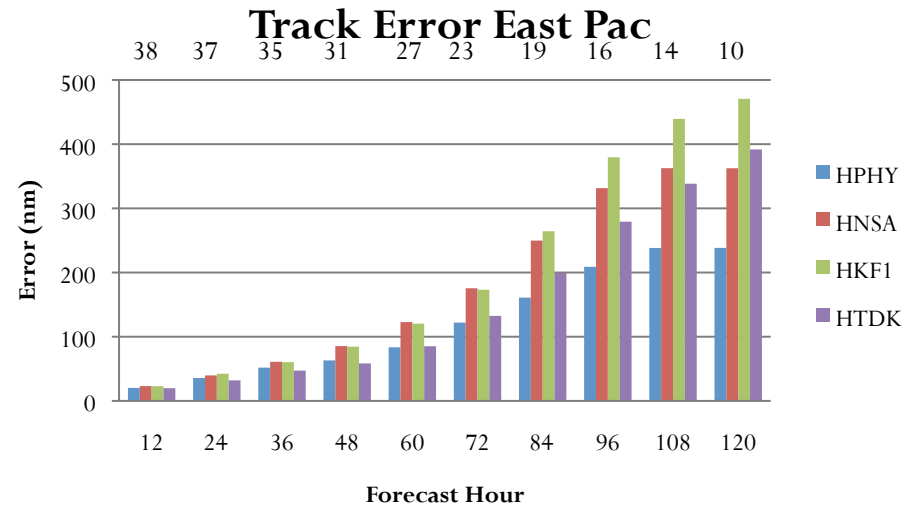
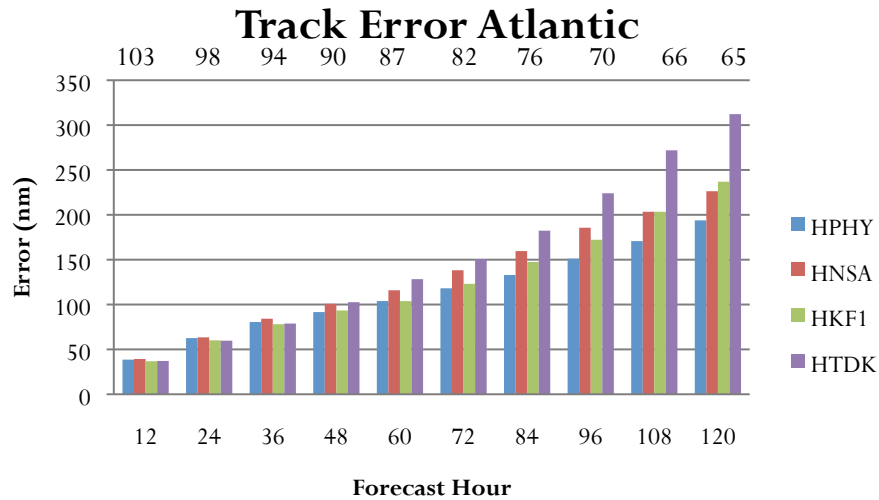
2011 Pacific	ID	Begin	End
Dora	04E	071812	072418
Eugene	05E	073112	080606
Fernanda	06E	081600	082000



Preliminary results from some of the above cases

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Track Errors



Pair wise difference

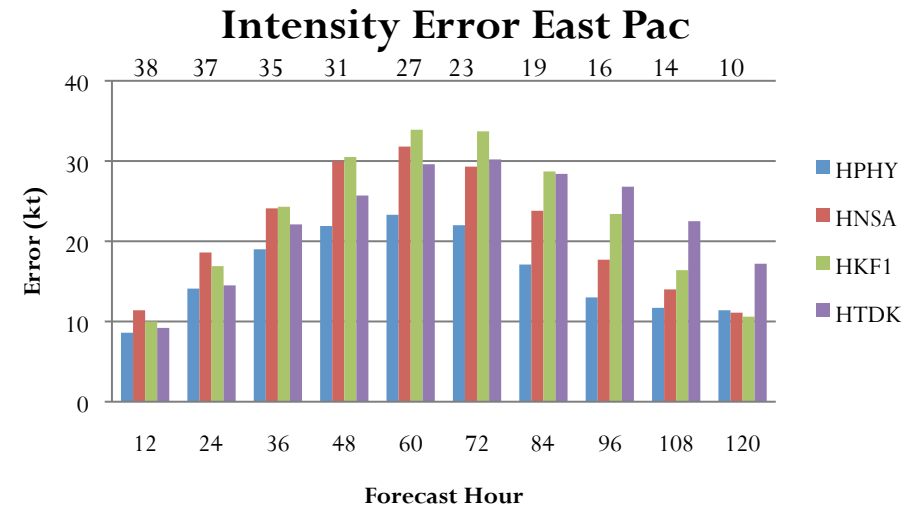
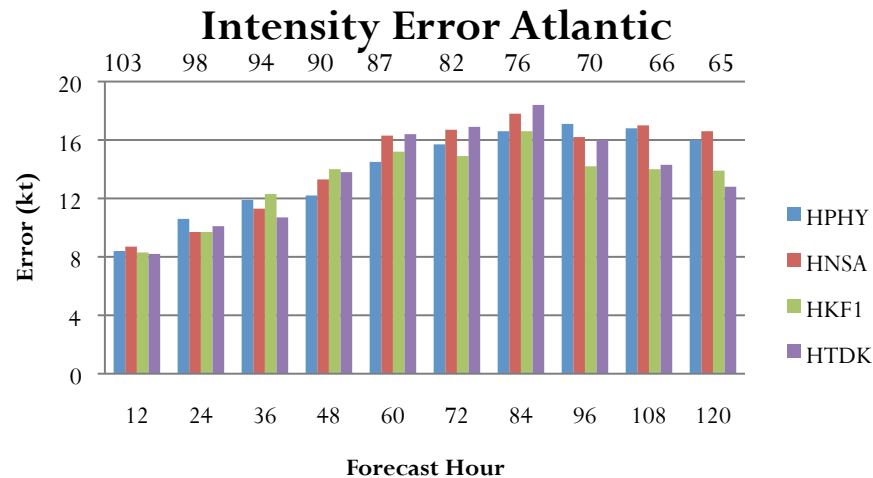
Atlantic

	12	24	36	48	60	72	84	96	102	108	120
HNSA											
HKF1											
HTDK											

Pacific

	12	24	36	48	60	72	84	96	102	108	120
HNSA											
HKF1											
HTDK											

Intensity Errors



Pair wise difference

Atlantic

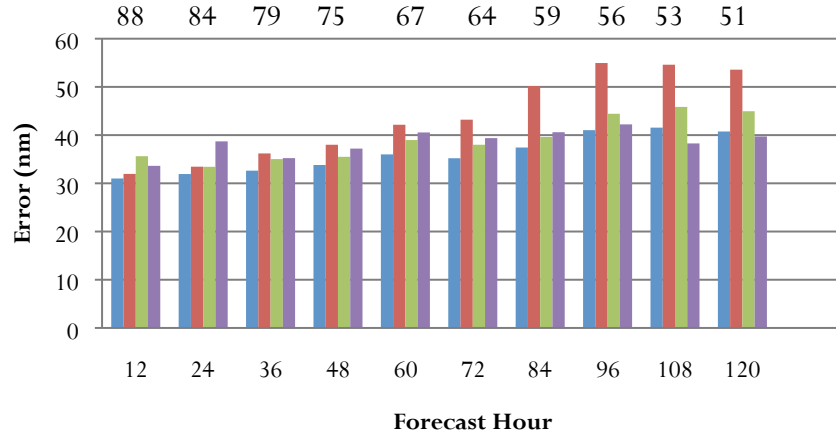
	12	24	36	48	60	72	84	96	102	108	120
HNSA											
HKF1											
HTDK											

Pacific

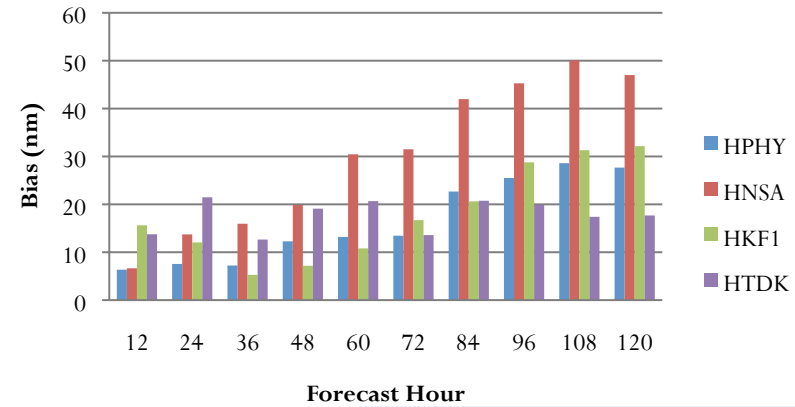
	12	24	36	48	60	72	84	96	102	108	120
HNSA											
HKF1											
HTDK											

Wind structure Atlantic

34kt Wind Error Atlantic

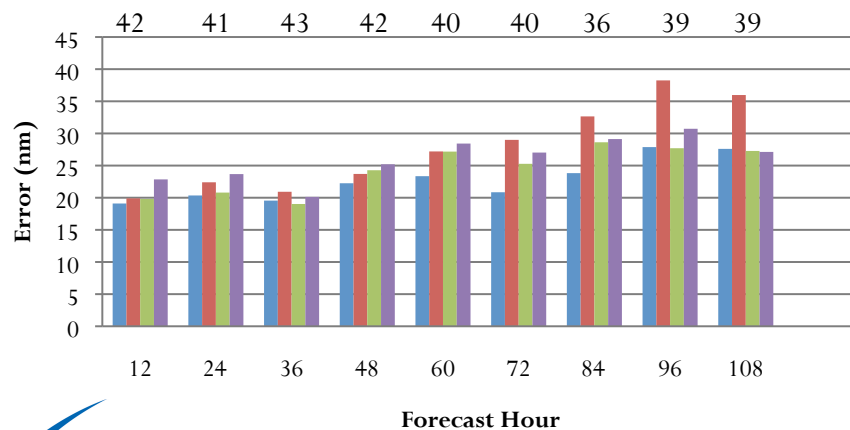


34kt Wind Bias Atlantic

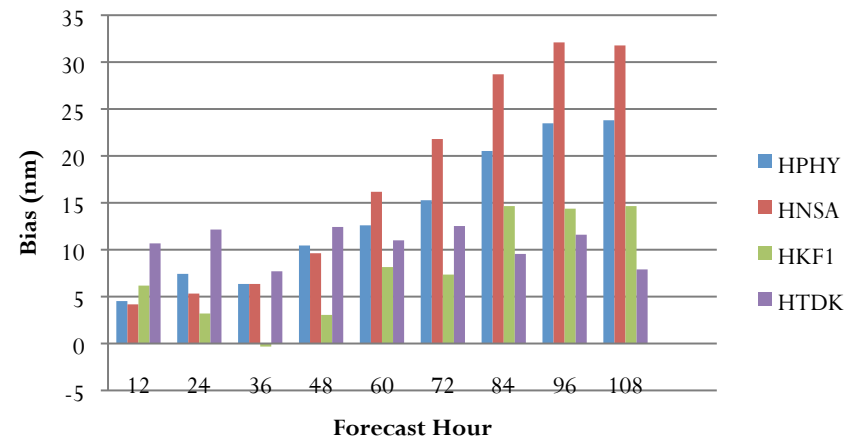


NSAS storm size increases with lead time

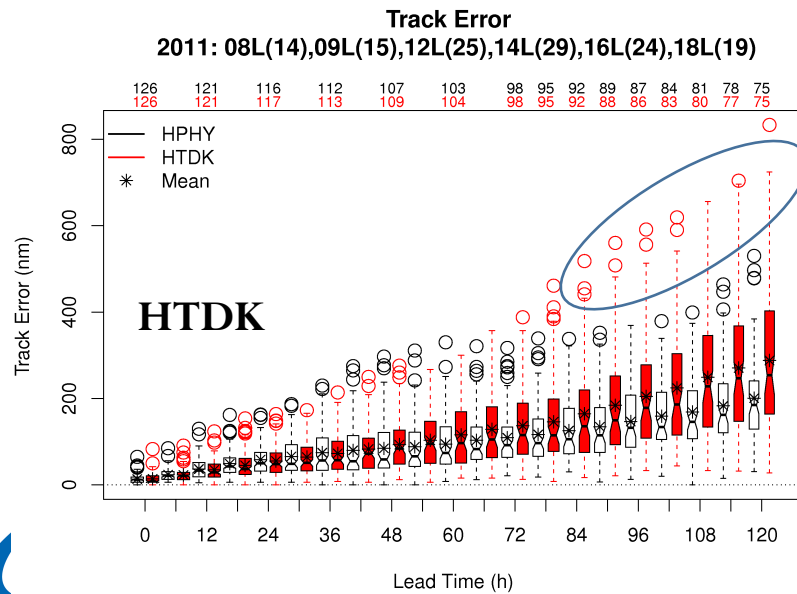
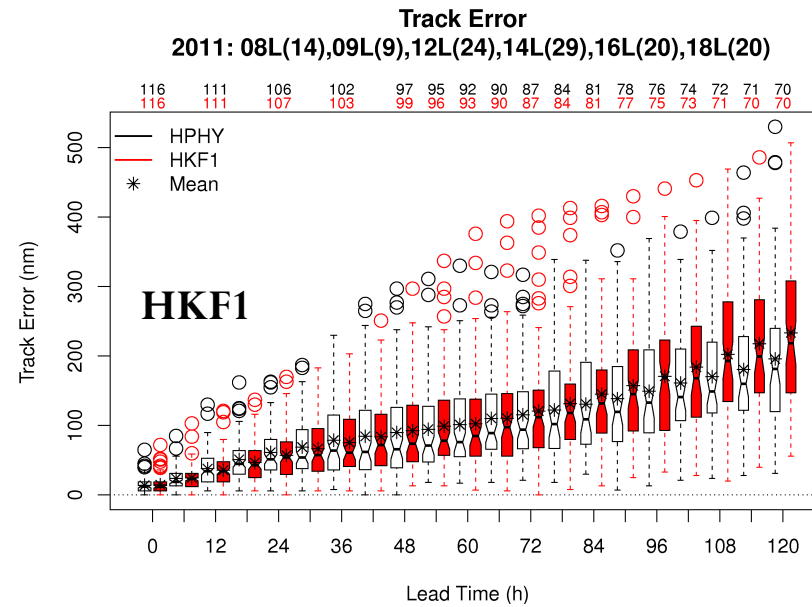
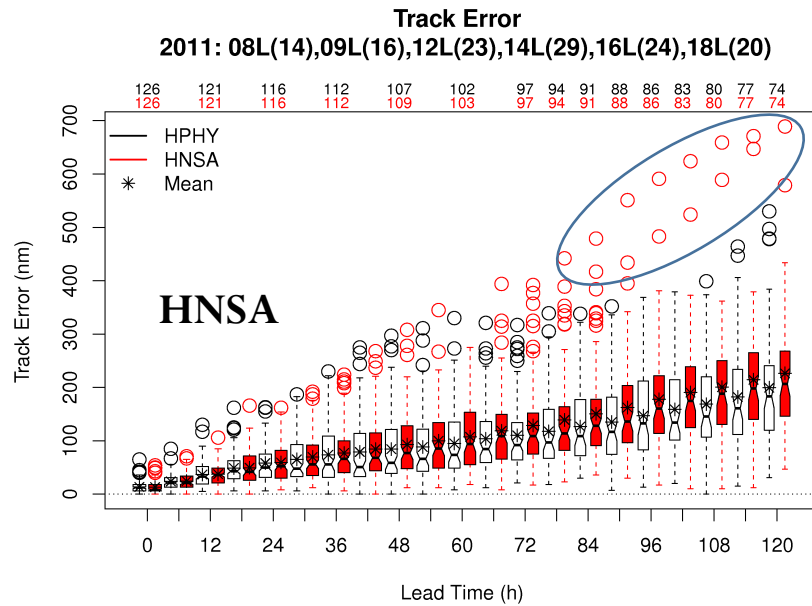
50kt Wind Error Atlantic



50kt Wind Bias Atlantic

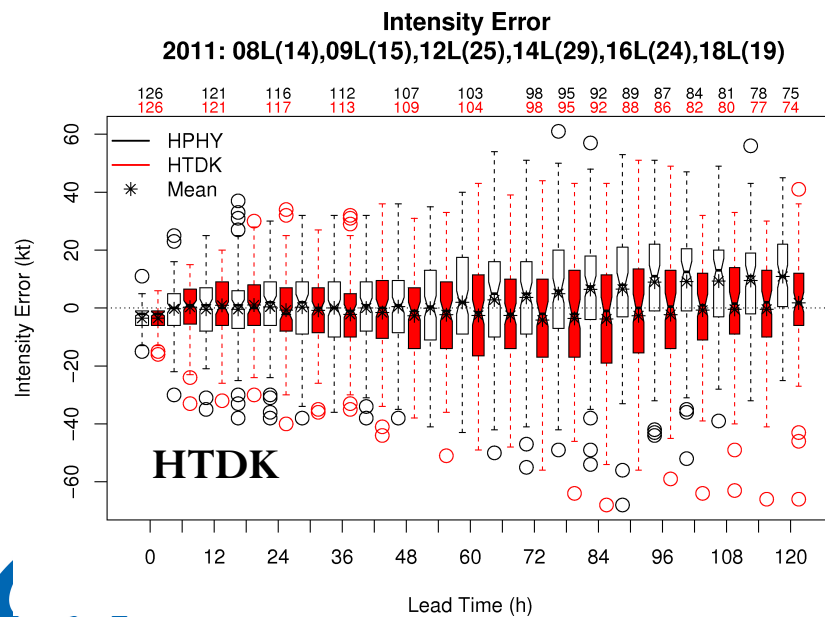
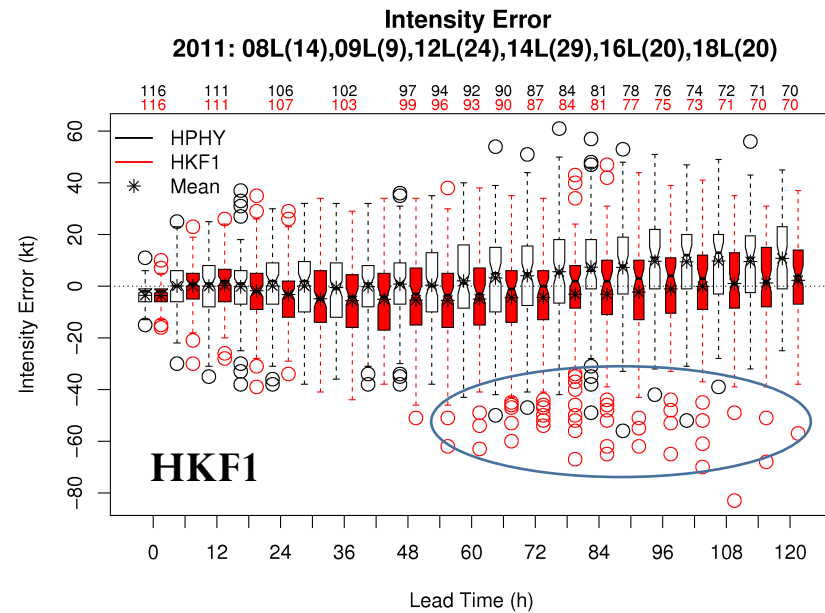
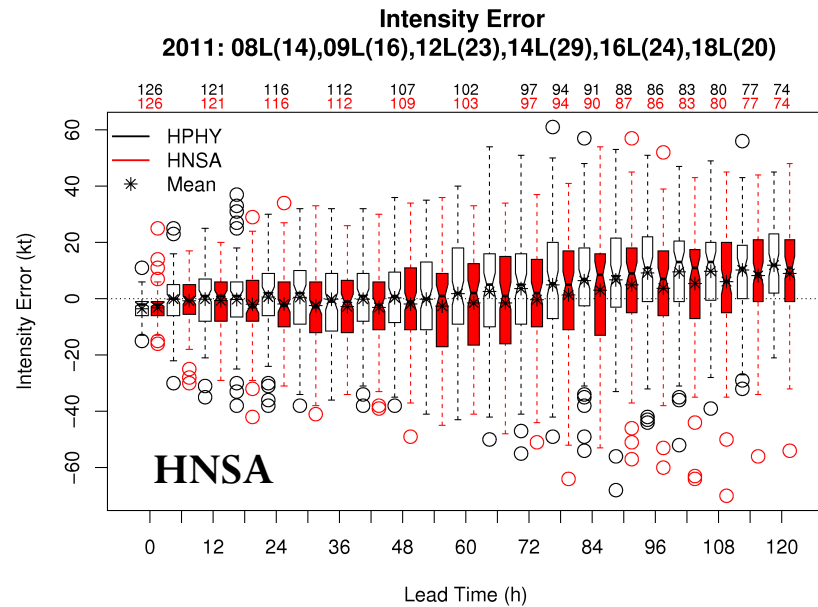


Track Errors Atlantic



HNSA and HTDK have large outliers

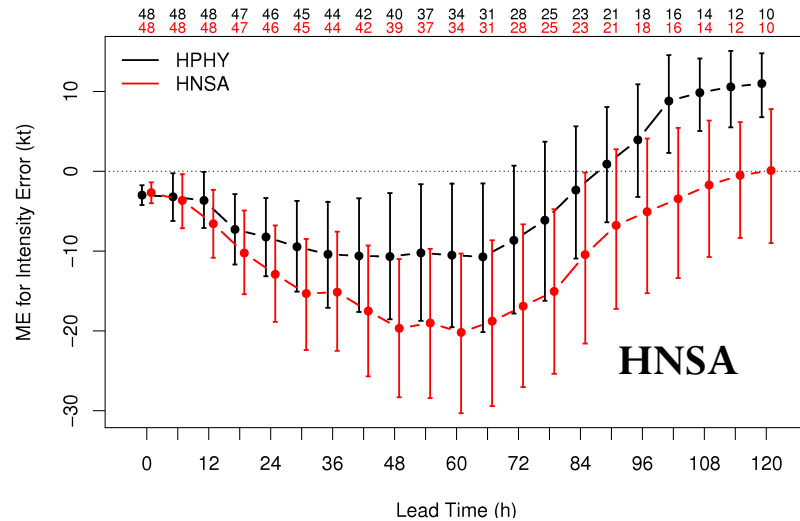
Intensity Bias Atlantic



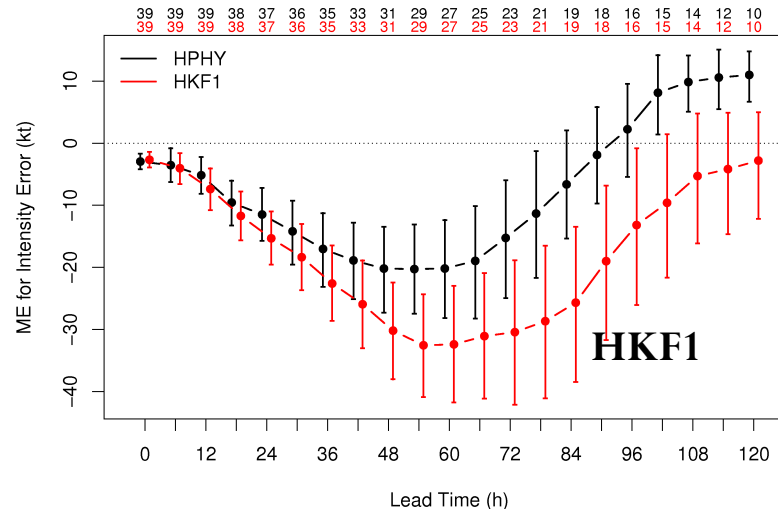
HPHY overestimates intensity
after 72 h.
HKF1, HTDK underestimates
intensity

Intensity Bias Eastern Pacific

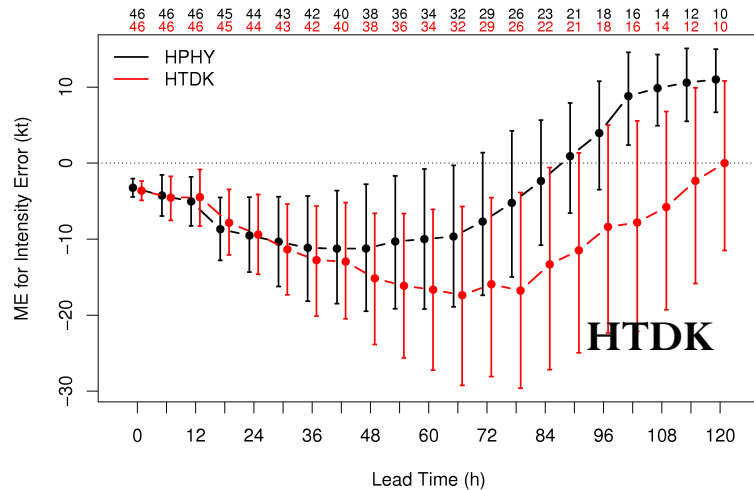
ME for Intensity Error
2011: 04E(17),05E(22),06E(9)



ME for Intensity Error
2011: 04E(8),05E(22),06E(9)



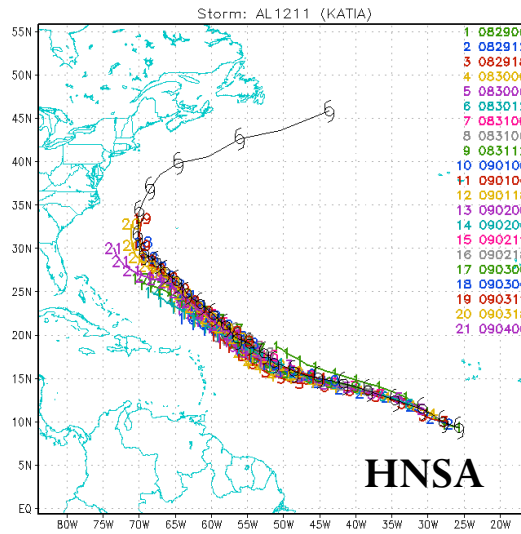
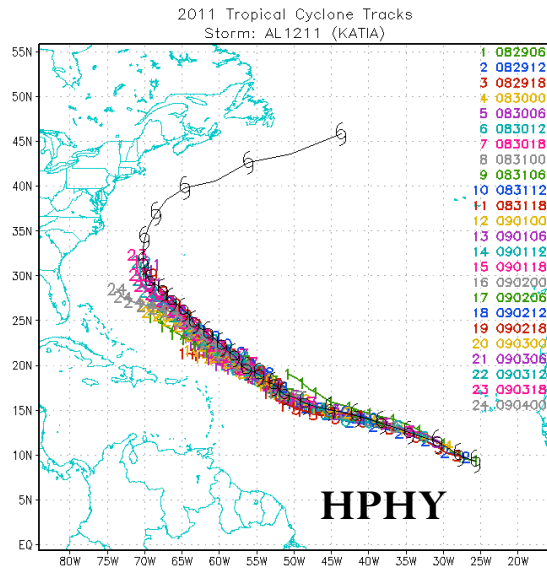
ME for Intensity Error
2011: 04E(15),05E(22),06E(9)



All schemes
underestimates intensity
Black line — HPHY

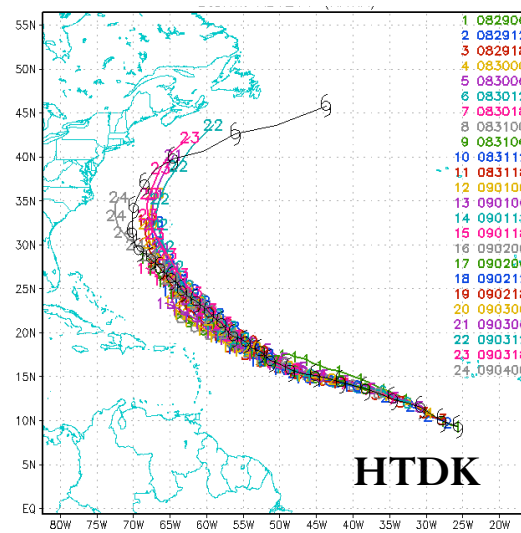
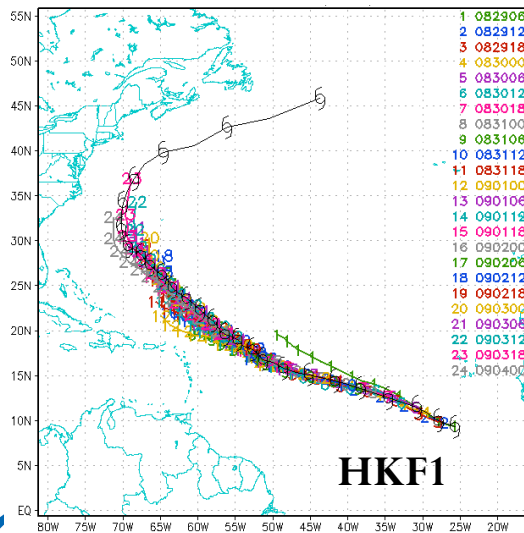


Katia Track forecasts

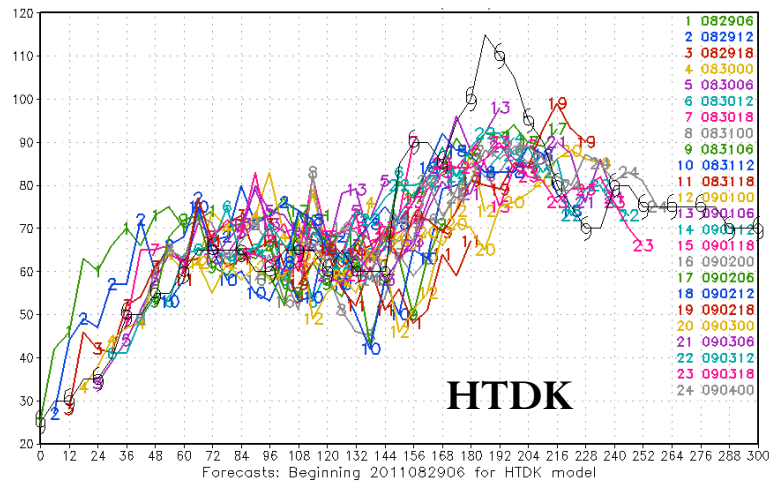
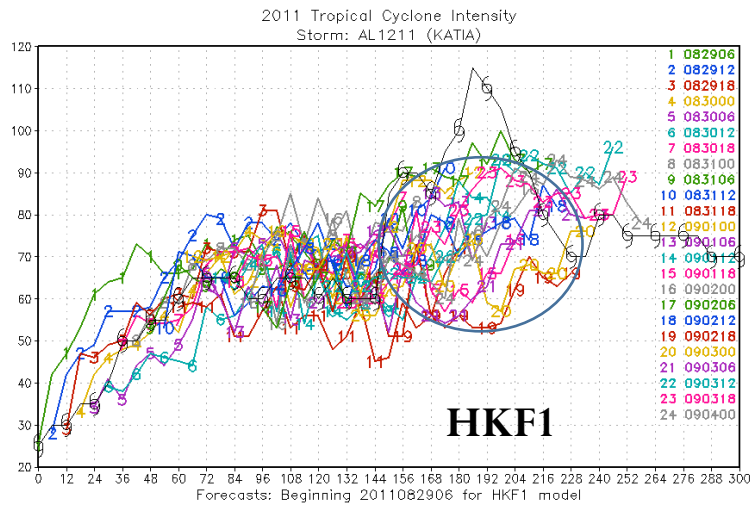
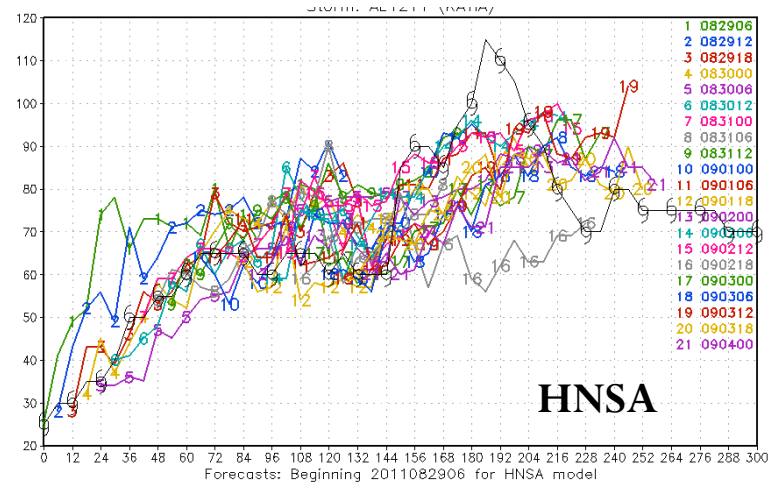
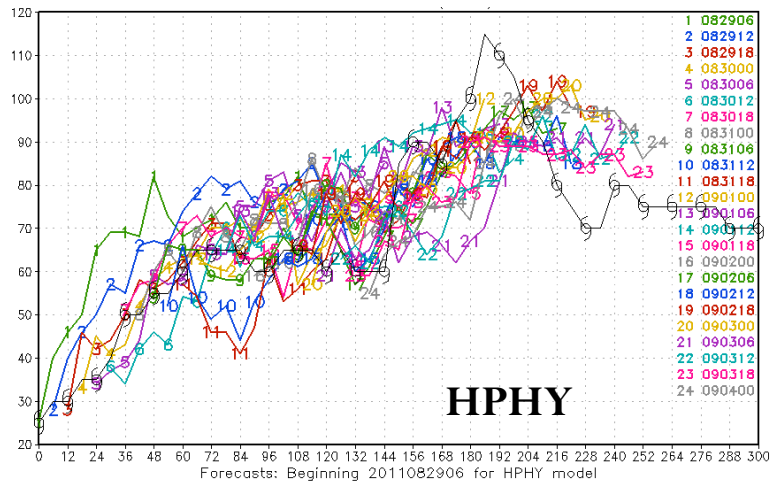


Tracks similar

HTDK tracks are
faster



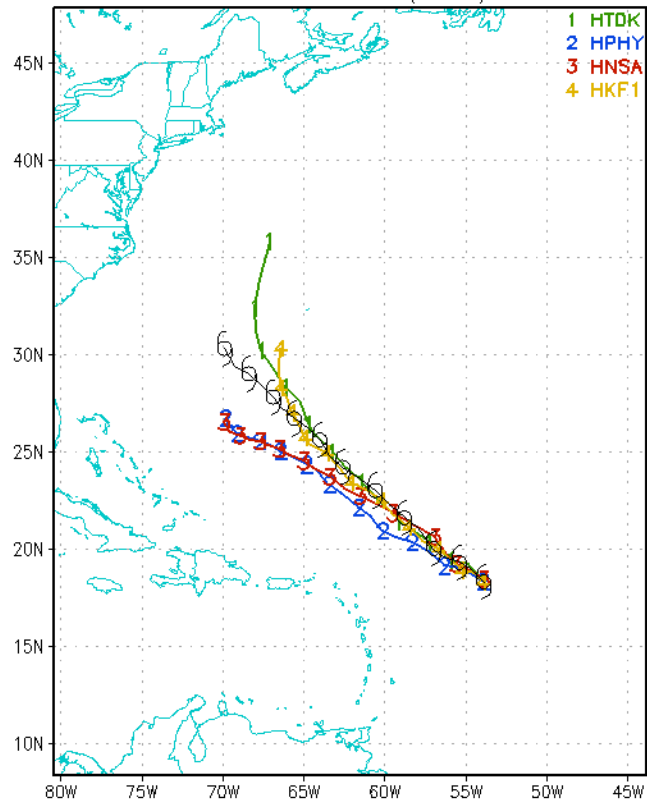
Katia Intensity forecasts



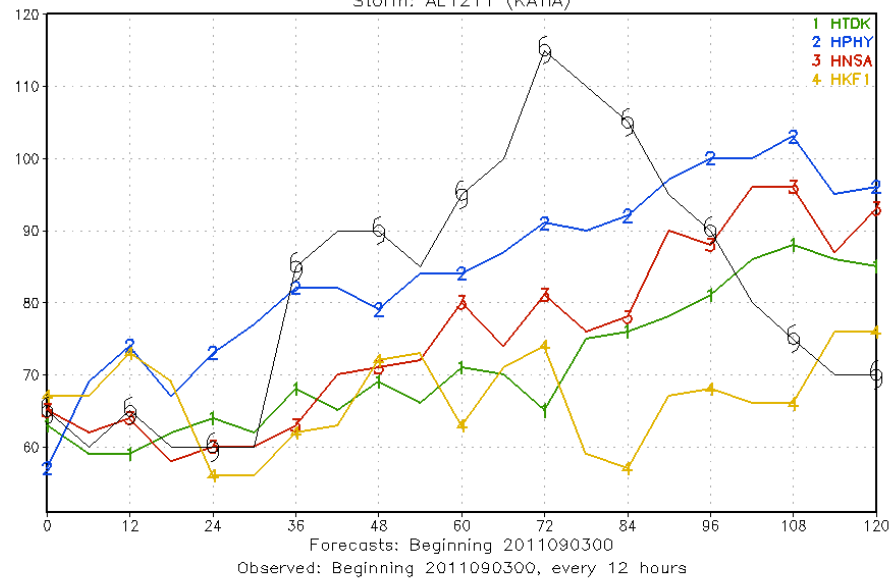
All the schemes failed to forecast the RI

Case Study: Katia Init 00Z 3 September 2011

2011 Tropical Cyclone Tracks
Storm: AL1211 (KATIA)

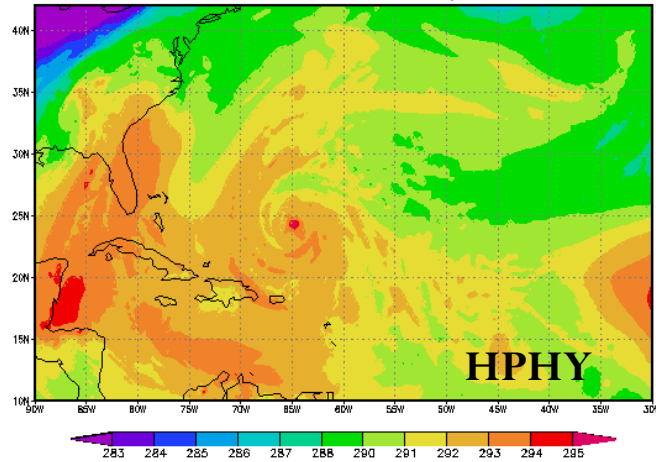


2011 Tropical Cyclone Intensity
Storm: AL1211 (KATIA)

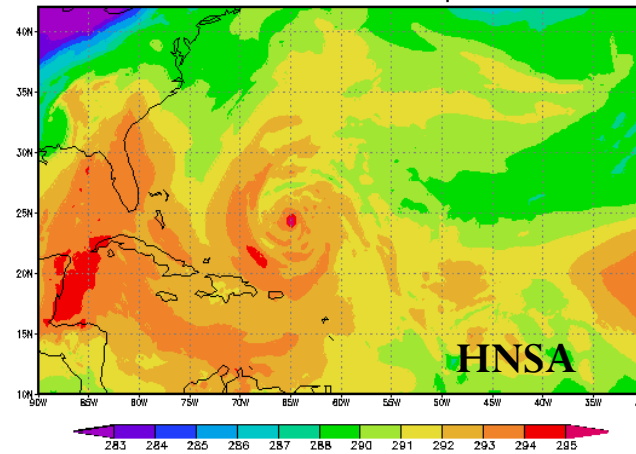


Temperature 850 hPa 72 h fcst Init: 00Z03Sep 2011

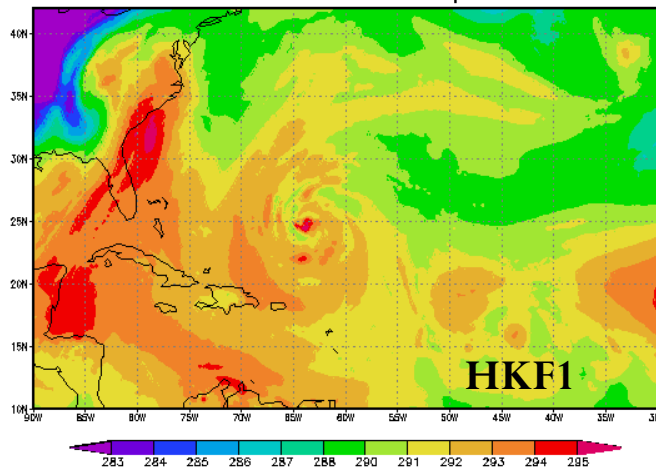
HPHY Katia 072hr 00Z03Sep2011



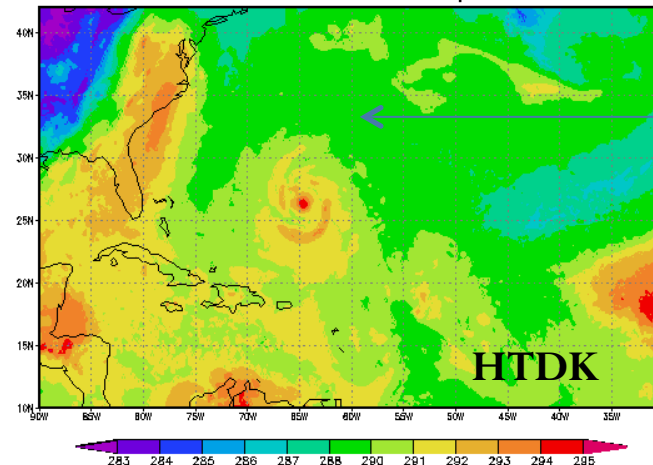
HNSA Katia 072hr 00Z03Sep2011



HKF1 Katia 072hr 00Z03Sep2011



HTDK Katia 072hr 00Z03Sep2011

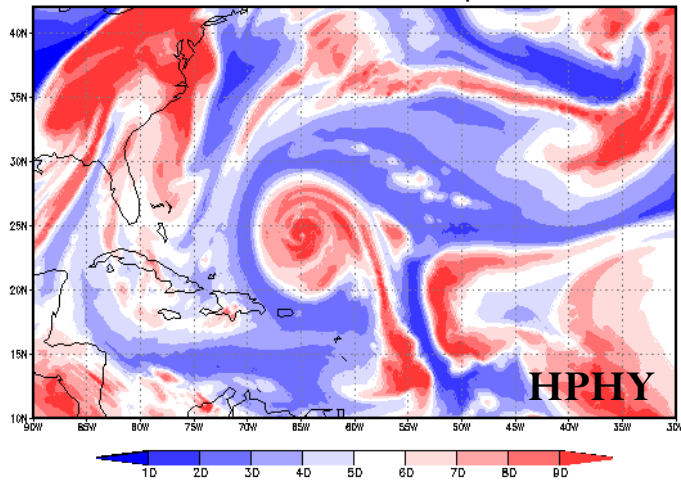


Large scale
features sensitive
towards cumulus
schemes

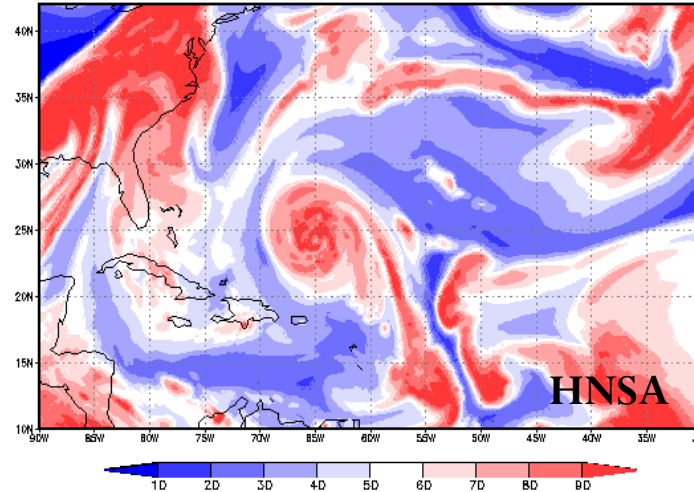
Colder
compared to
other schemes

Relative Humidity 700 hPa 72 h fcst Init: 00Z 03 Sep 2011

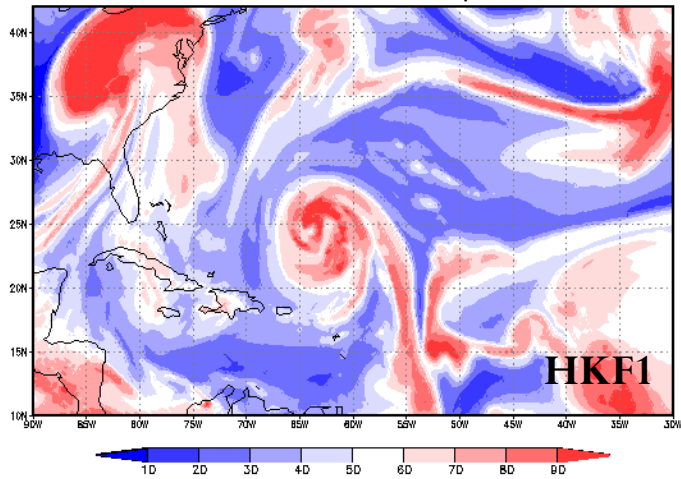
HPHY Katia 072hr 00Z03Sep2011



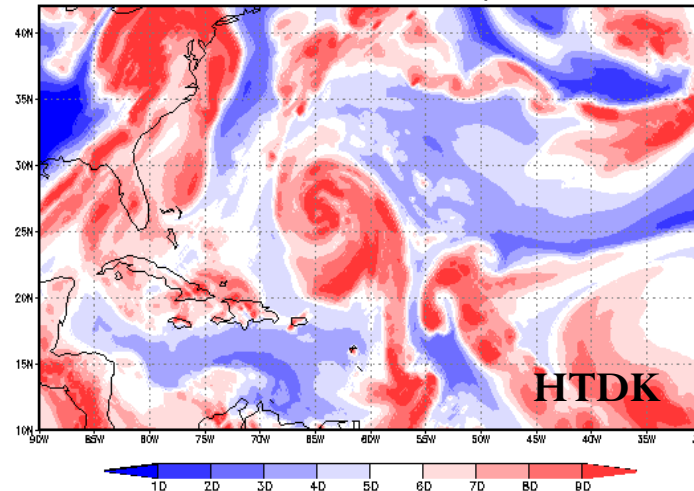
HNSA Katia 072hr 00Z03Sep2011



HKF1 Katia 072hr 00Z03Sep2011



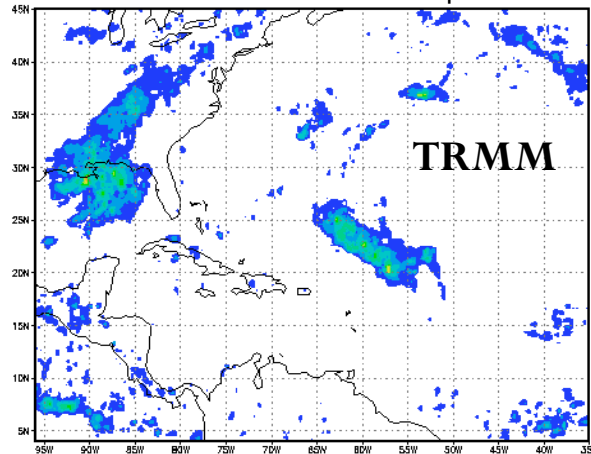
HTDK Katia 072hr 00Z03Sep2011



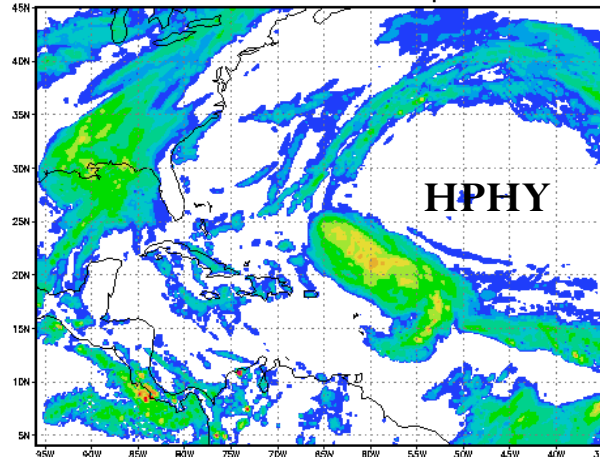
Large
sensitivity,
environmental
changes for diff
schemes

Large scale precipitation 72 h Init 00Z03Sep2011

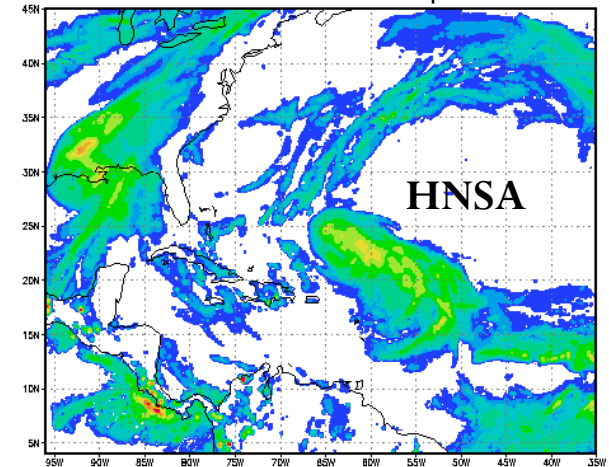
TRMM Katia 072hr INIT 00Z03Sep2011



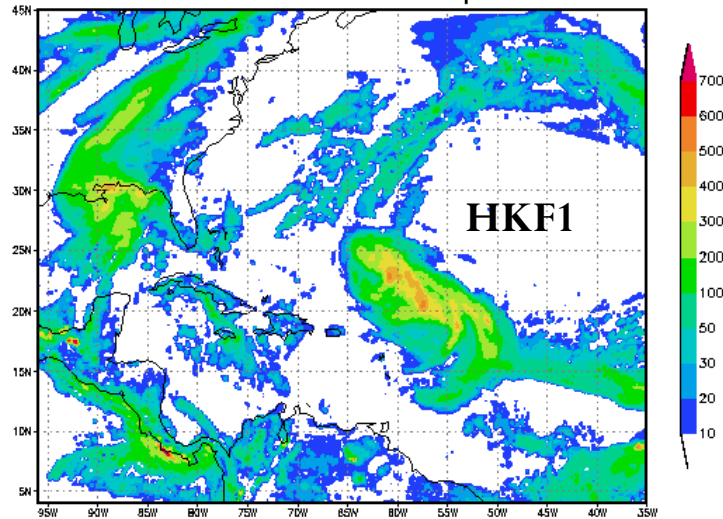
HPHY Katia 072hr 00Z03Sep2011



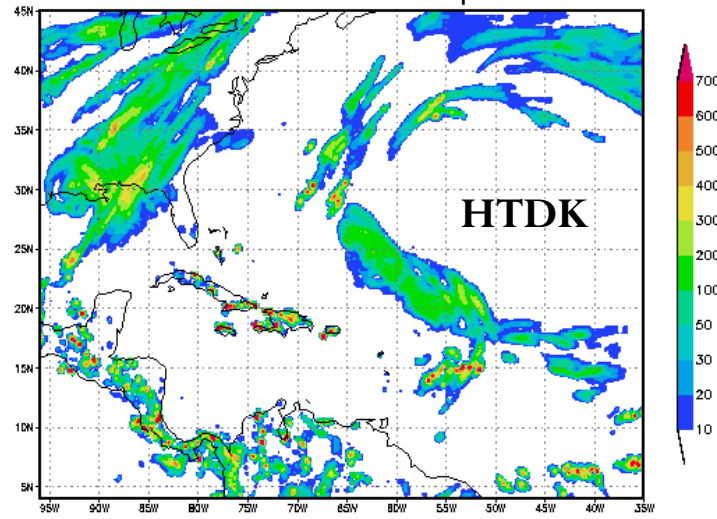
HNSA Katia 072hr 00Z03Sep2011



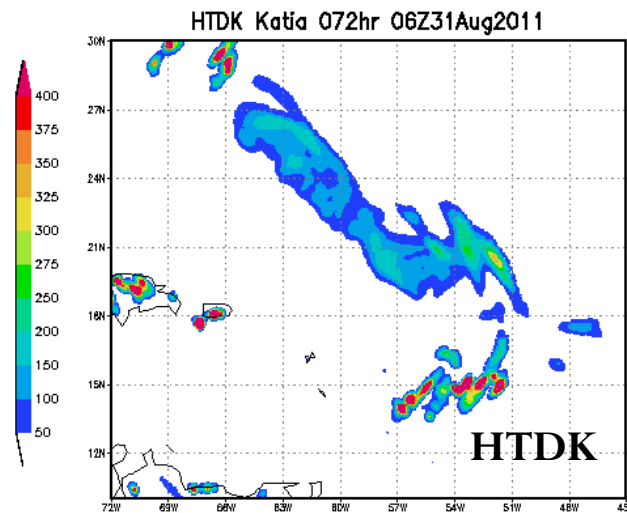
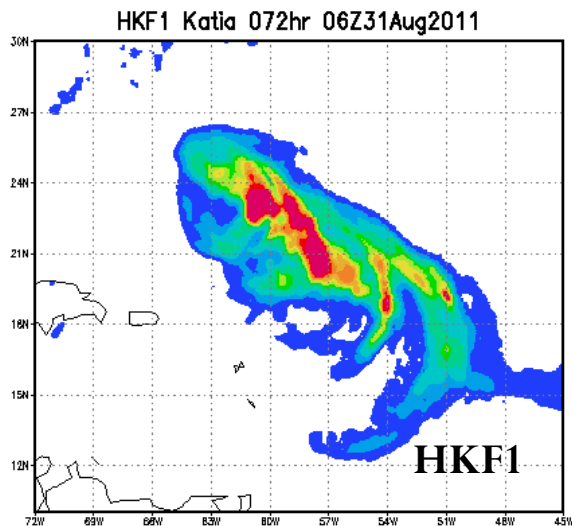
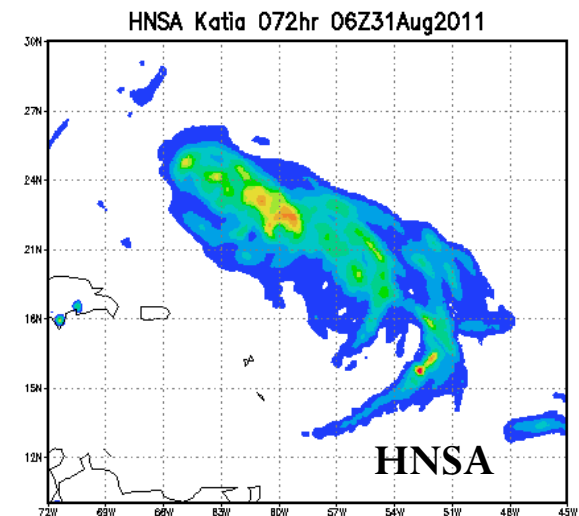
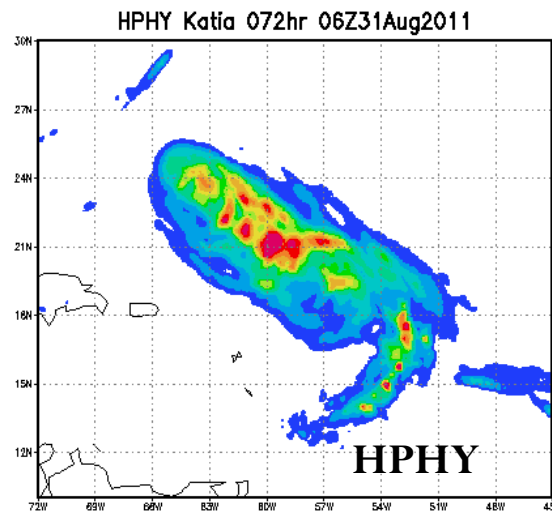
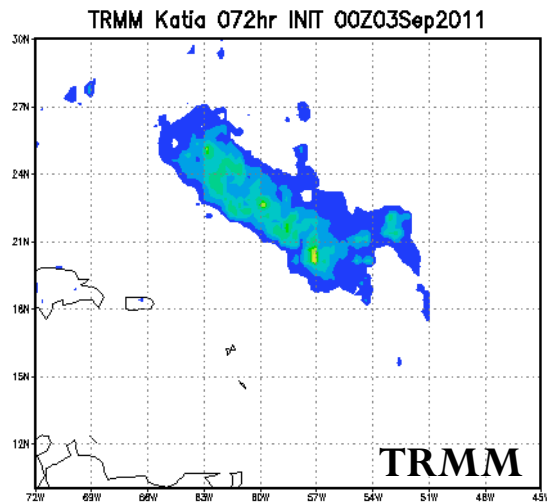
HKF1 Katia 072hr 00Z03Sep2011



HTDK Katia 072hr 00Z03Sep2011



Accumulated 72 h Precipitation forecasts

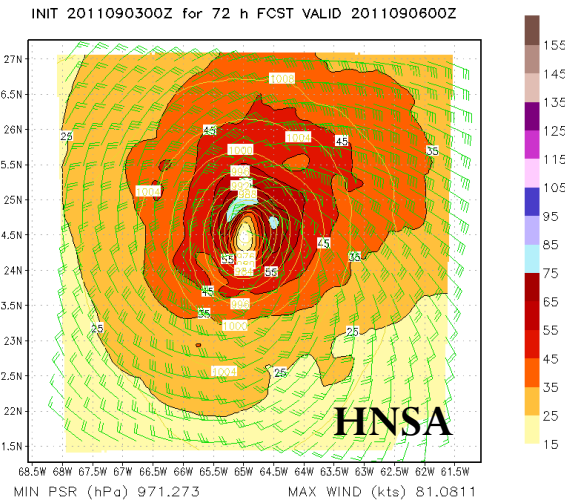
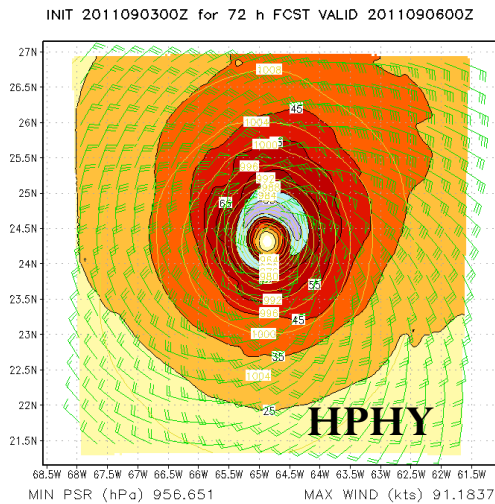


Tiedtke more realistic

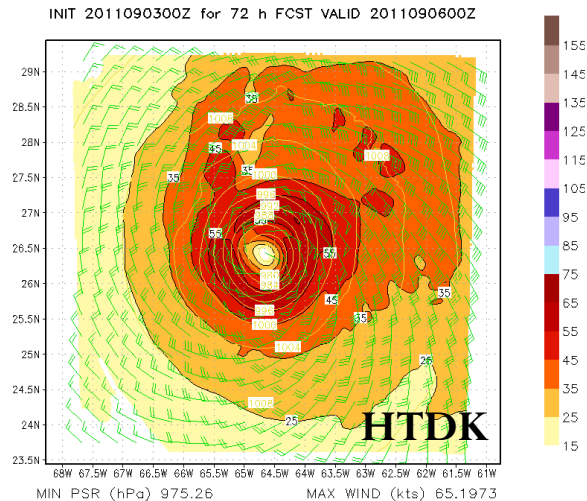
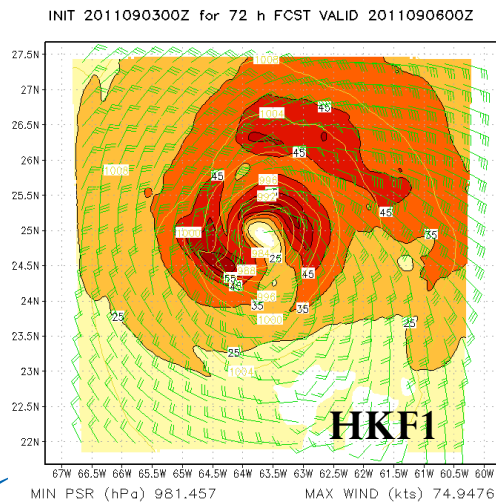
Overestimation of precipitation for other schemes

10m Wind structure

72 h fcst Init: 00Z 03 Sep 2011



All schemes have a larger storm structure compared to HPHY

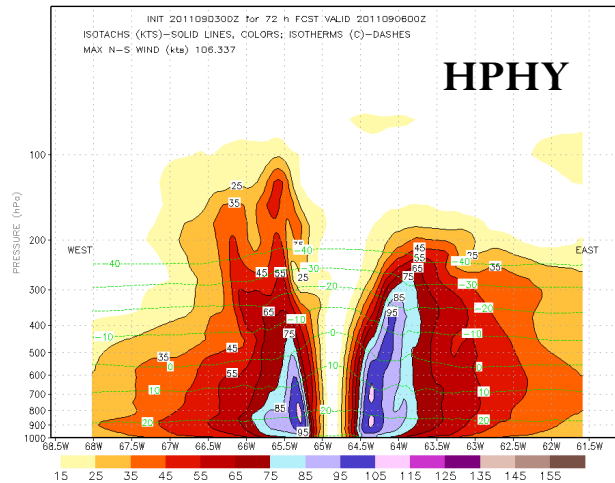


HPHY more organized
Symmetrical
structure around the
center

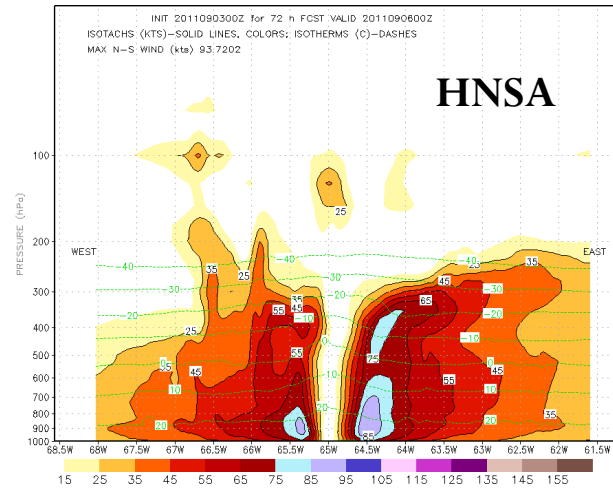
E-W Cross section Wind field

72 h fcst Init: 00Z 03 Sep 2011

HPHY KATIA 12I E-W CROSS SECT LAT=24.30



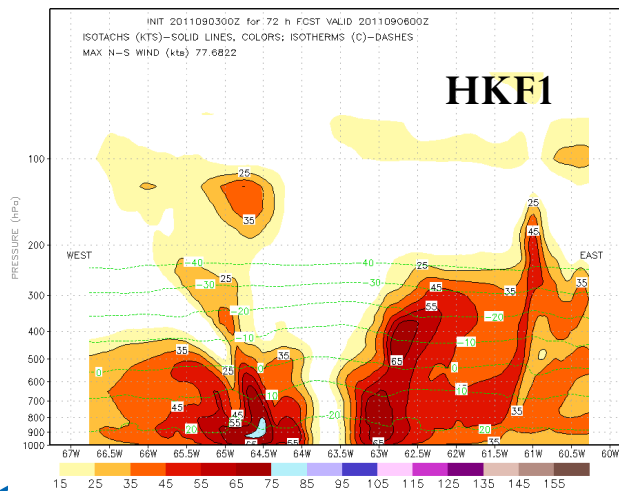
HNSA KATIA 12I E-W CROSS SECT LAT=24.50



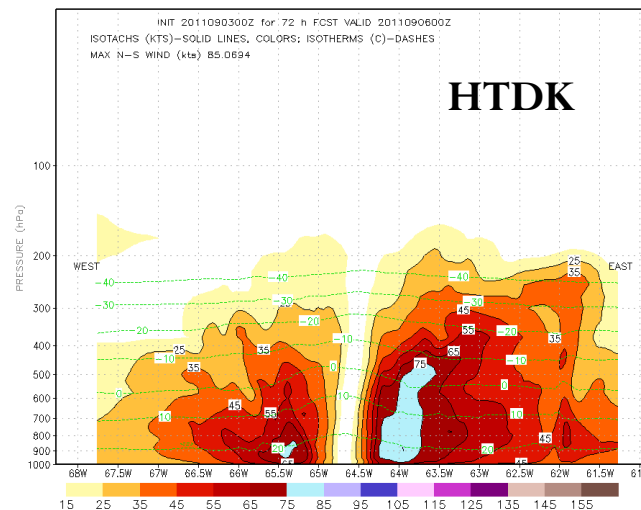
HPHY has
vertical
coherence
structure

Storm is deep
for HPHY

HKF1 KATIA 12I E-W CROSS SECT LAT=24.90



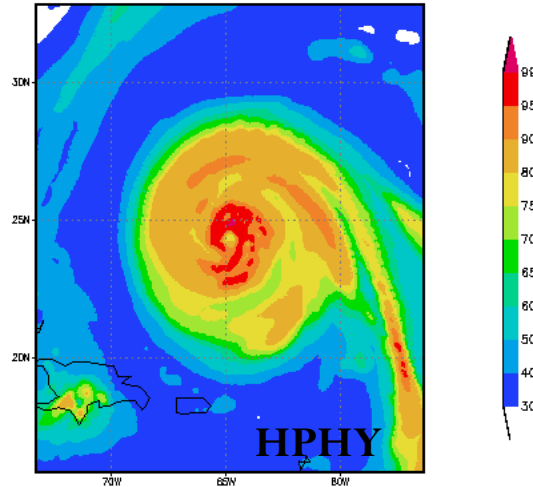
HTDK KATIA 12I E-W CROSS SECT LAT=26.40



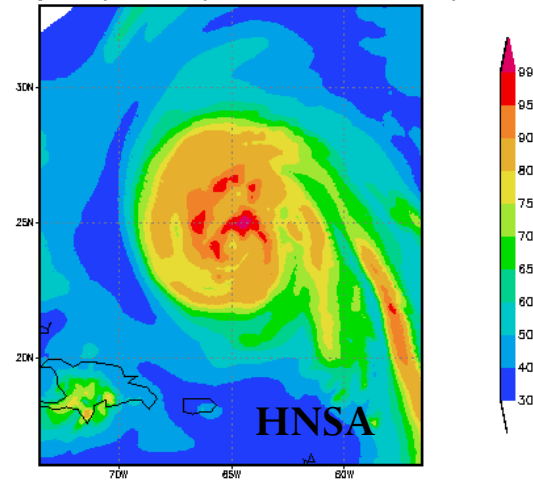
Relative humidity averaged 850-600 hPa

72 h fcst Init: 00Z 03 Sep 2011

HPHY Avg RH (850-600) Katia 072hr 00Z03Sep2011

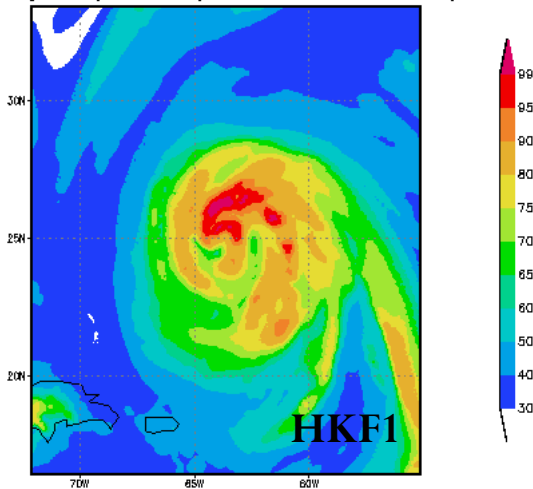


HNSA Avg RH (850-600) Katia 072hr 00Z03Sep2011

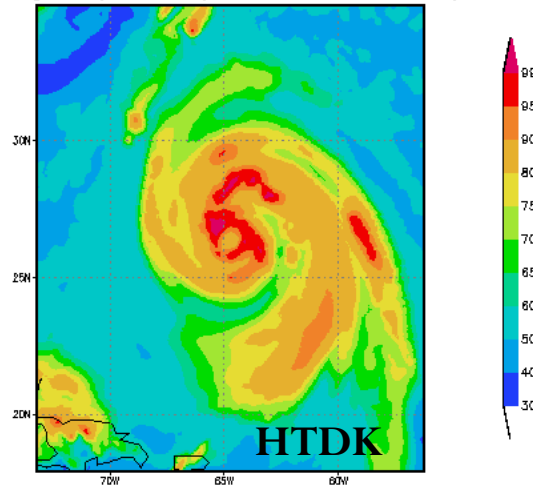


HPHY moist
around the
center

HKF1 Avg RH (850-600) Katia 072hr 00Z03Sep2011

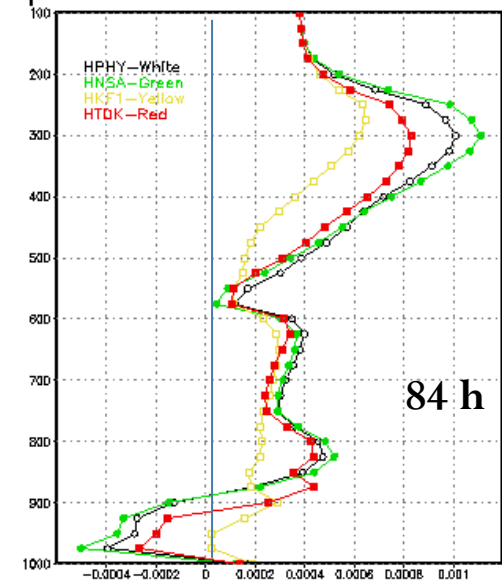
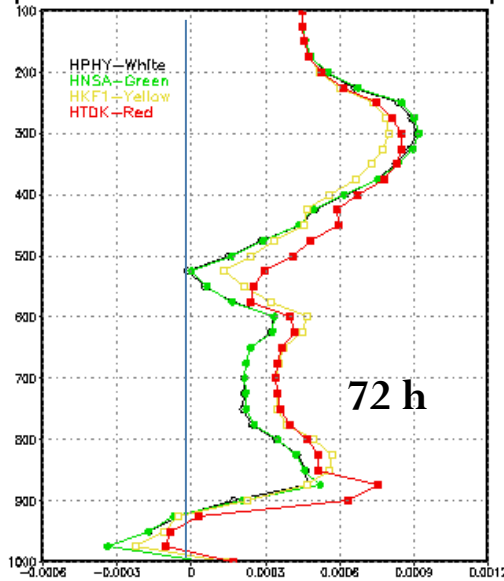
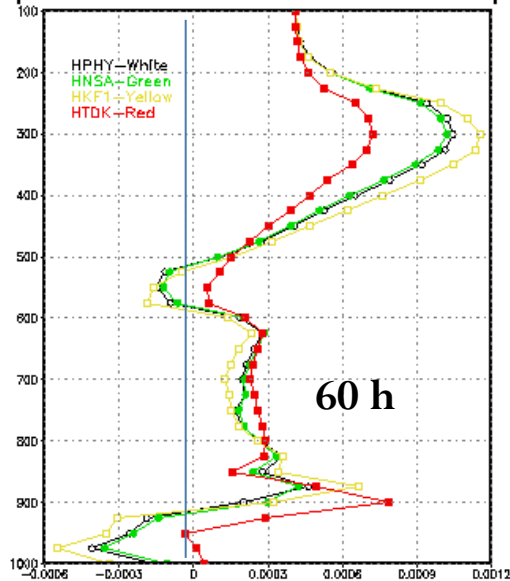


HTDK Avg RH (850-600) Katia 072hr 00Z03Sep2011



Instantaneous Temperature Tendency (K/s) from Cumulus Averaged 2 deg around the storm.

Temp Ten Cumulus Katia 060hr 00Z03Sep2011 Temp Ten Cumulus Katia 072hr 00Z03Sep201 Temp Ten Cumulus Katia 084hr 00Z03Sep201

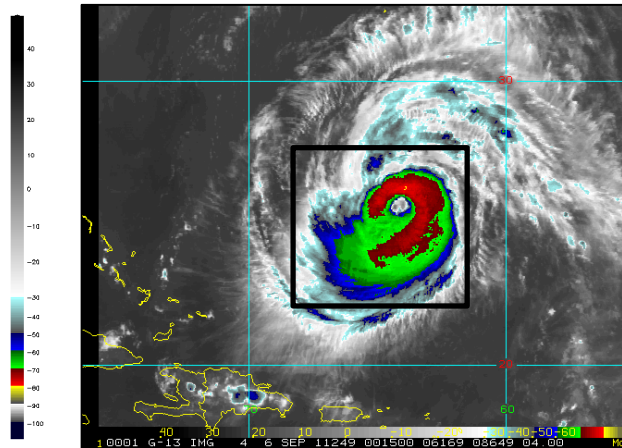
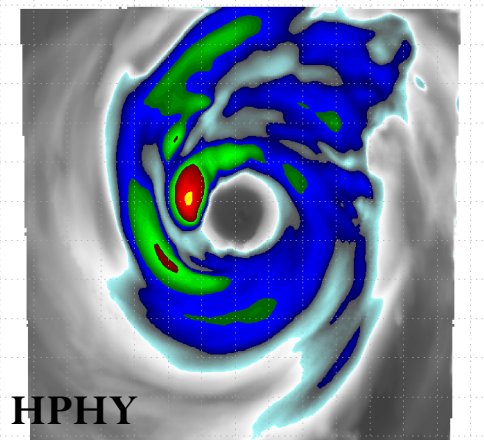


HPHY, NSAS have
relatively large
temperature tendency

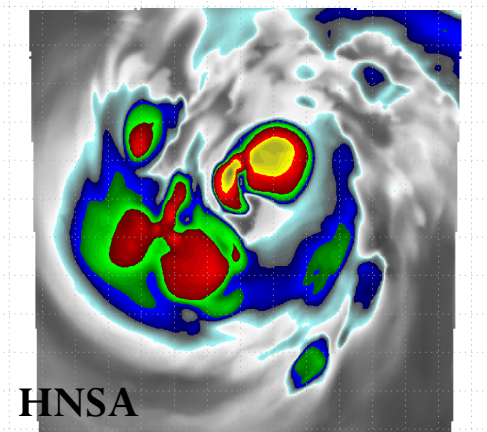


GOES IR

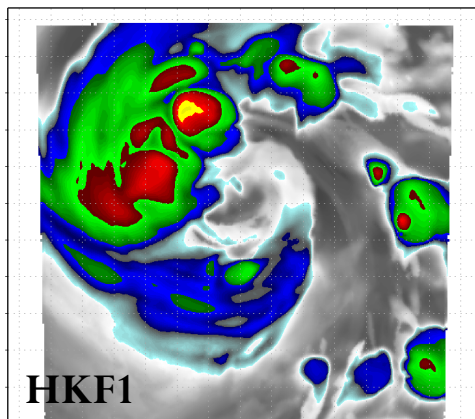
HPHY D03 DOMAIN GOES KATIA 12I



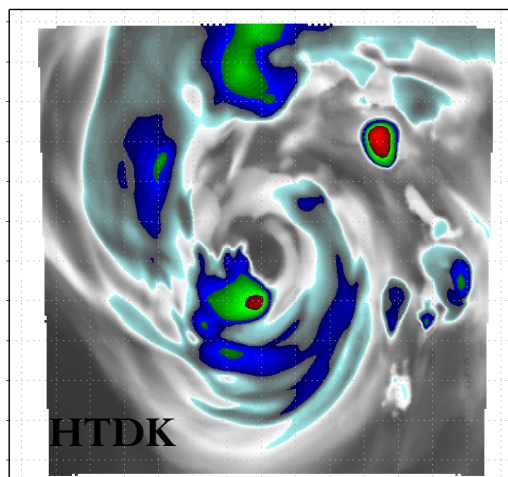
HNSA D03 DOMAIN GOES KATIA 12I



HKF1 D03 DOMAIN GOES KATIA 12I



HTDK D03 DOMAIN GOES KATIA 12I



HPHY has an annular structure

HTDK has a oval eye, not realistic

Summary and follow-up work

Expanded HWRF's interoperability

- Additional schemes now available for studies

Preliminary results

- HPHY is doing well in track forecasts compared to HNSA and HTDK
- There is no clear winner for intensity forecasts
- There is not a scheme readily available that will improve hurricane forecasting; improvements may be seen with additional tuning

Examined Katia's sensitivity to cumulus parm

- Large sensitivity, especially in storm structure and intensity, even though the cumulus is turned off in the innermost domain
- Sensitivity of the cumulus to large scale environment
- Very preliminary result and more in depth analysis needs to be done to study the behavior of different schemes

