HWRF sensitivity to cumulus schemes

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Motivation

HFIP Regional Model Team Physics Workshop (Aug '11): *Foci: Scientific issues on PBL and MP*

Follow-up Telecon (September 2011): –*Decision to test some schemes for composing a suite to run in 2012 HFIP Demo*

PBL: YSU, MYJ, MRF; **Microphysics:** WSM6, Ferrier, Thompson, WDM6
Cumulus: KF, SAS, Grell, Tiedke

Follow-up Telecon (October 2011): – *Schemes for composing a suite to run in 2012 HFIP Demo should be evaluated by April 1*
- Tests should be conducted in <u>idealized</u> and <u>real</u> configurations

	Schemes	Implement and test
Convection	SAS	NRL (Hodur and Doyle) HWRF(EMC)
	KF	NRL (Nachamkin and Jin) HWRF(DTC)
	Grell	HWRF(DTC)
	Tiedtke	NRL (Hodur and Doyle)

Process
- Implement scheme
- Test individual scheme
- Test physics suite

	Schemes	Implement and test
Planetary Boundary Layer	YSU	NRL (Hodur and Jin) HWRF(ESRL,HRD)
	New GFS	HWRF (EMC)
	MRF	HWRF(ESRL,HRD)
	MYJ	HWRF(ESRL,HRD,EMC)

	schemes	Implement and test
Microphysics	Ferrier	NRL (Jin and Ferrier) HWRF(EMC)
	WSM6	HWRF(DTC,EMC)
	WDM6	HWRF(DTC,EMC)
	Thompson	HWRF(EMC,DTC), NRL (Jin)
	Lin	NRL (Jin)

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Follow-up work conducted at DTC

Idealized capability

- Partnered with J-W Bao (ESRL) to add idealized capability to trunk of WRF
  - Preliminary capability added and will be in next HWRF release
  - Currently working on documentation and setting up example case study

Cumulus Parameterization

- Partnered with J. Dudhia (NCAR) to expanded HWRF interoperability
  - NSAS, Tiedke, Grell (uncoupled) are now available
  - Interoperability allow tests by DTC and also by general community
- Performed sensitivity experiments for Irene using various cumulus schemes

Microphysics

- Collected preliminary information on how to expand interoperability
- Performed tests of WSM5, WSM6, and Thompson on NMM single domain

Sensitivity of TC NWP to cumulus

Ma and Tan, 2009. Atmospheric Research.

- Three Pacific storms, ARW, 15 km, large sensitivity to trigger functions.

Li and Pu, 2009. J. Meteor. Soc. Japan.

- Emily (2005) ARW runs very sensitive to cu parm.

Torn and Davis, 2011. Manuscript submitted to ?

- Sensitivity of AHW to cu parm.

Spencer and Shaw, 2012. AMS – Krish symposium.

- More sensitivity to Cu Parm than MP or PBL for Typhoon Parma (ARW 3 km).

Krishnamurti, 2012. Tech Report to UCAR.

- Errors in cu heating in (old) HWRF are substantial compared to other physics.

Zhan, Tallapragada, and Tuleya, 2012. AMS – Krish.

- HWRF ensemble forecasting using various cumulus schemes for diversity.

HWRF 2012 Operational Test Plan

- Tests of SAS shallow convection, as recently implemented in GFS.

HWRF Configuration: 2011 operational

Physics	Scheme
Microphysics	Ferrier
Cumulus	Modified GFS SAS
PBL	GFS BLS
Radiation	GFDL

- Irene (2011)
- Cold started Aug 21, 00 Z
- Ran 5 days (20 cycles)
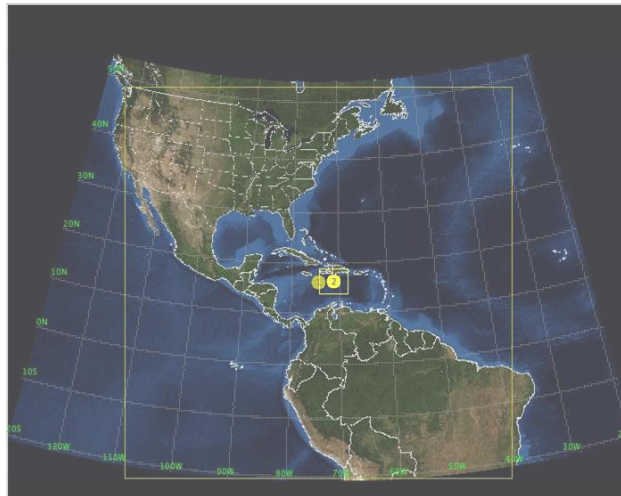
- Atmospheric outer domain
  - 75 x 75° , ~27 km
- Atmospheric nest
  - 6 x 6°, ~9 km

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Enhanced Interoperability

Acronym	Scheme	New in HWRF	Runtime (approx)
HPHY	HWRF 2011 operational SAS (no shallow convection)	-	40 min
HWSC	HWRF 2011 operational SAS (yes shallow convection)	-	60 min
HNSA	SAS implemented by YSU (yes shallow convection)	Yes	40 min
HTDK	Tiedtke	Yes	60 min
HPKF	Kain Fritsh	-	40 min
HKF2	Kain-Fritsh with new trigger	Yes	
	Grell	Yes, uncoupled	

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Irene tracks from various configurations
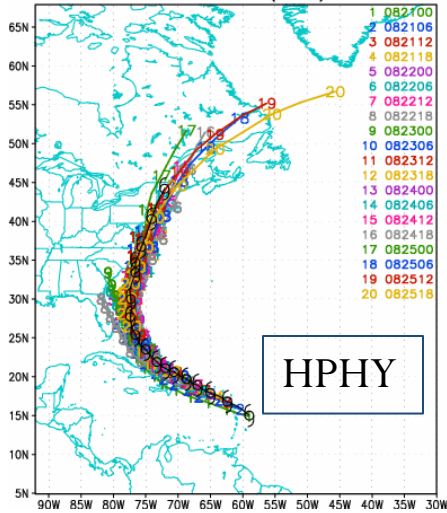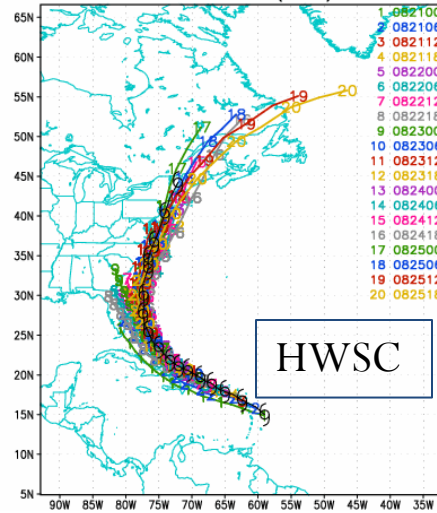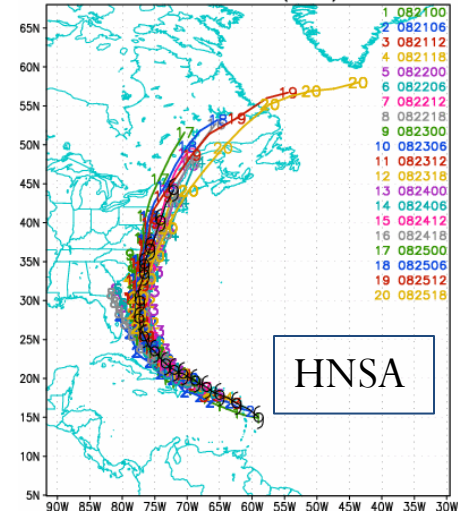
HPHY

HWSC

HNSA
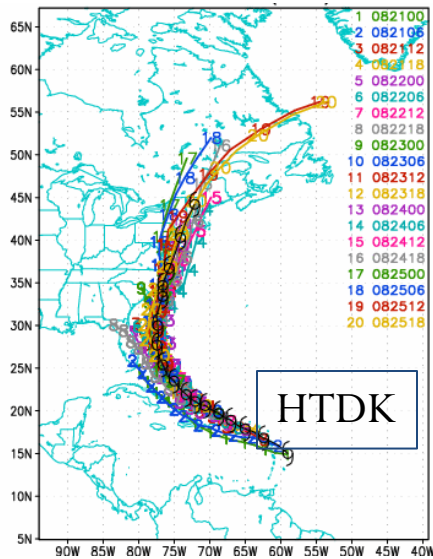
HTDK
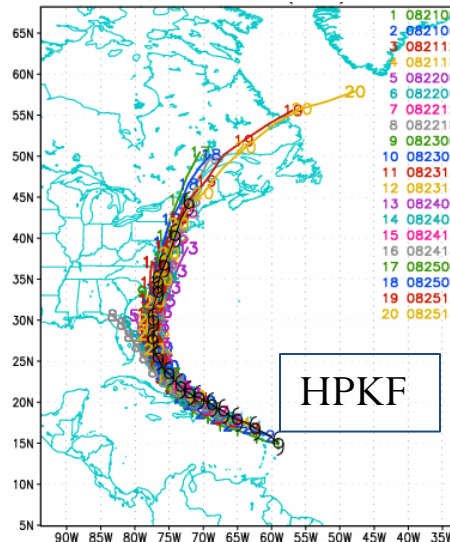
HPKF

20 Irene cases
- Overall similar tracks
- All have left bias for the first 9 cycles.

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Irene Vmax (kt) from various configurations
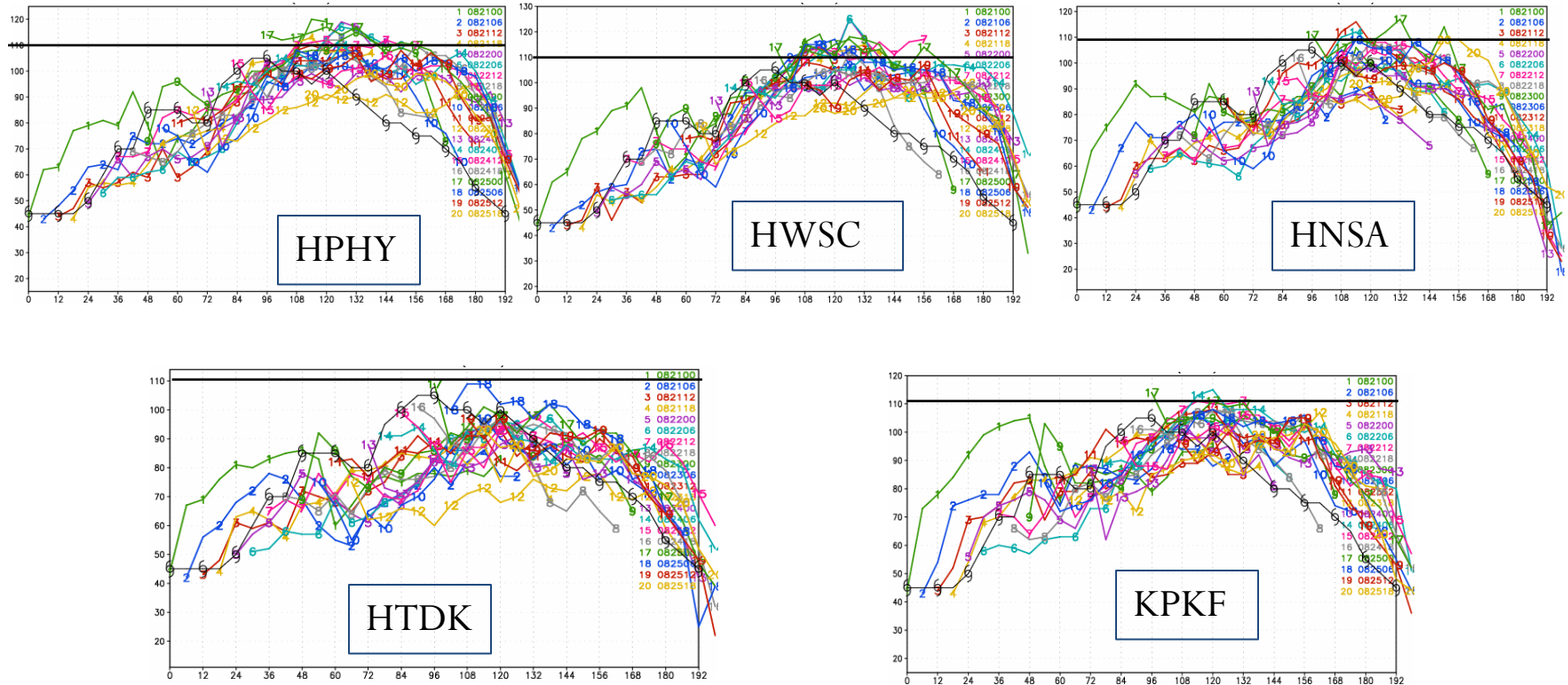
HPHY, HWSC: overestimated intensity especially after storm weakens
HNSA, HTDK: less overall intensity; capture weakening phase

Average errors for Irene (Aug 21 – 25)

Track Errors
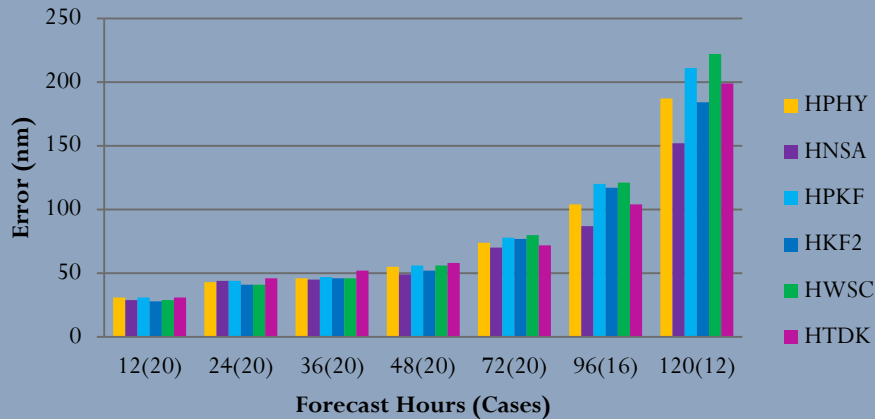
Track errors are similar except for 96 and 120 h. HNSA has least errors.

Intensity Error
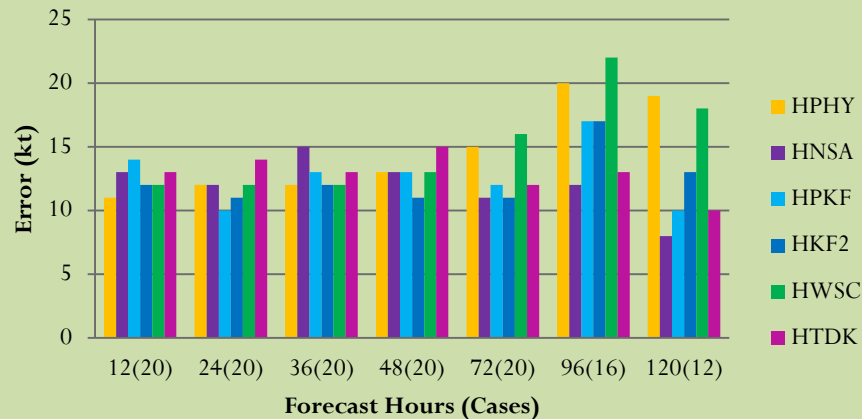
Cumulus schemes have large impact on intensity.
HNSA, HTDK have least errors after 48-h forecasts

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Intensity and Structure for Irene (Aug 21 –25)
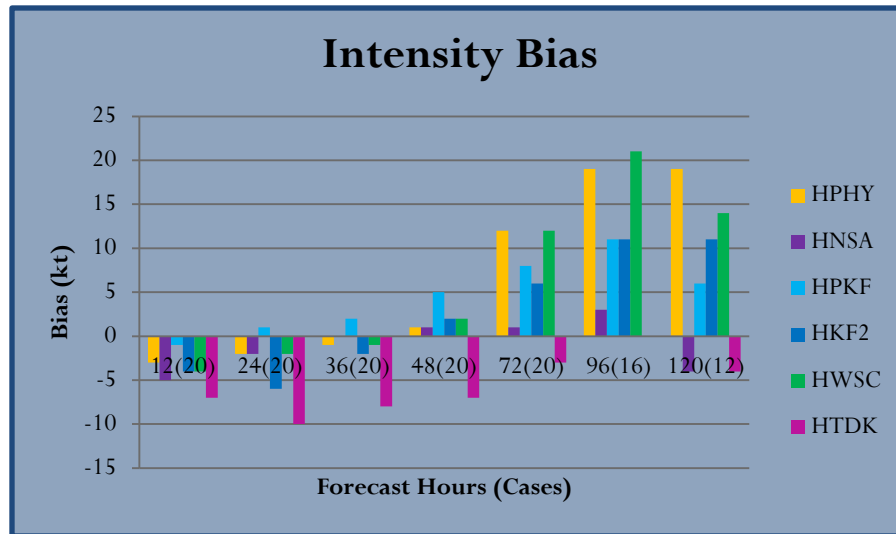
Intensity Bias

HPHY and HWSC have larger over intensification. HNSA and HTDK keep storm weaker.

64kt NE Wind Errors
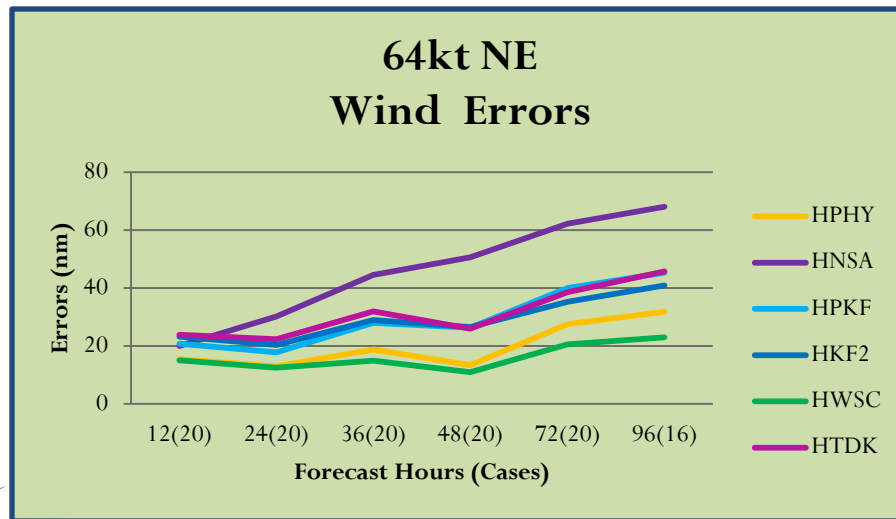
Schemes with weakest intensity produce largest storm.
HNSA has the largest storm structure (too large)

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Case Study: Irene initialized Aug 23, 00 UTC
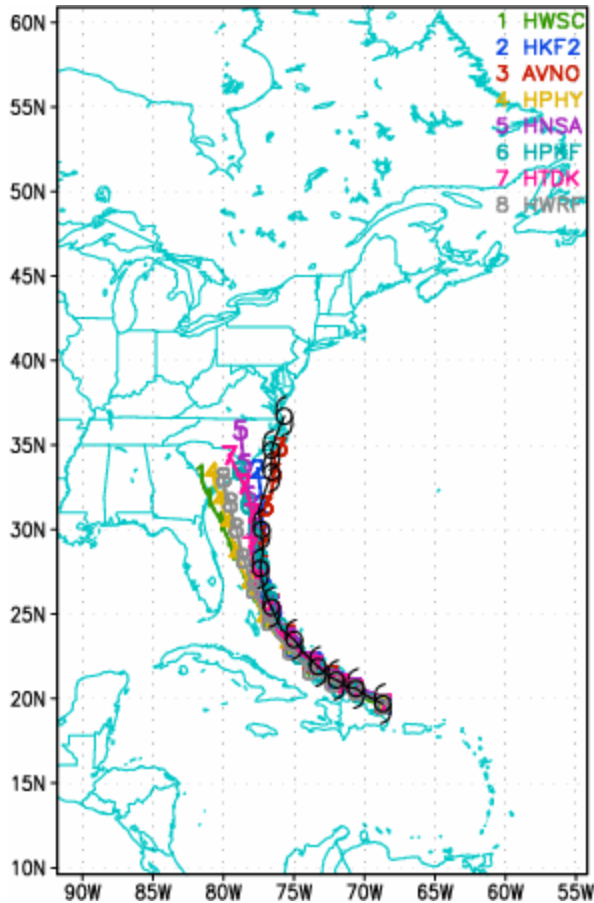
GFS has good track.
All HWRF configurations left of observed.
HPHY and HWSC largest error.
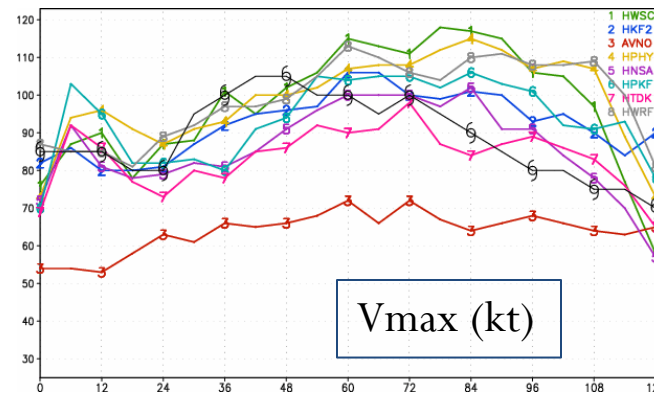
HPHY and HWSC have largest overestimation of intensity.

Vmax (kt)

Pmin (hPa)
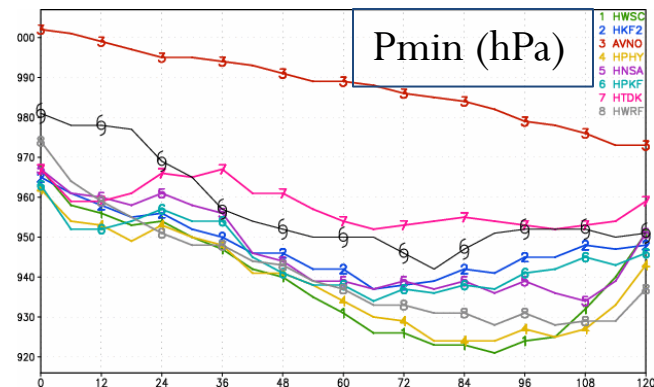
Irene init Aug 23, 00 UTC: 96-h 10-m wind (kt)
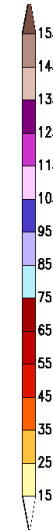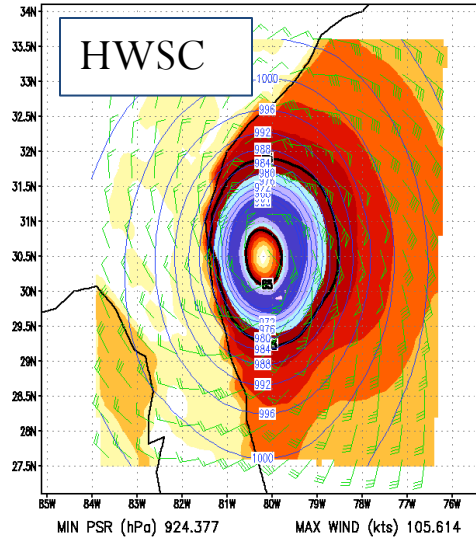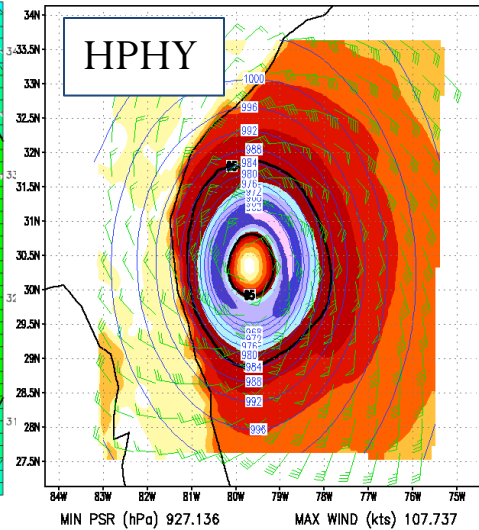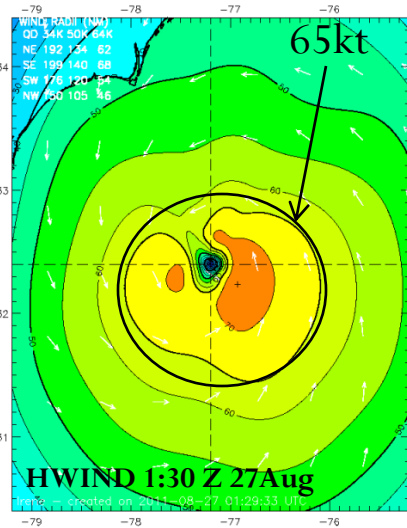
HPHY and HWSC are compact and strong
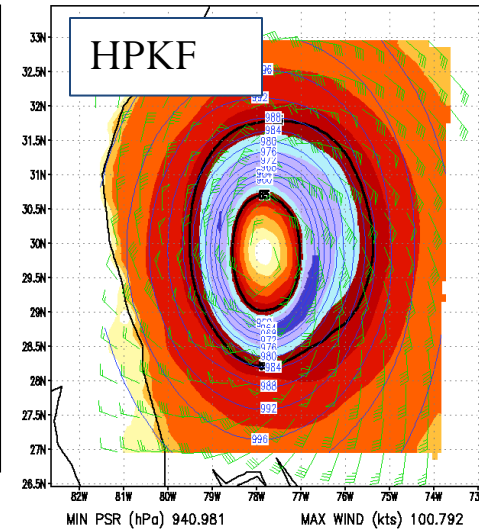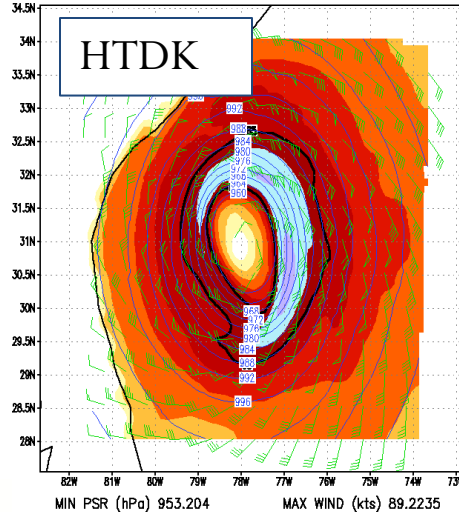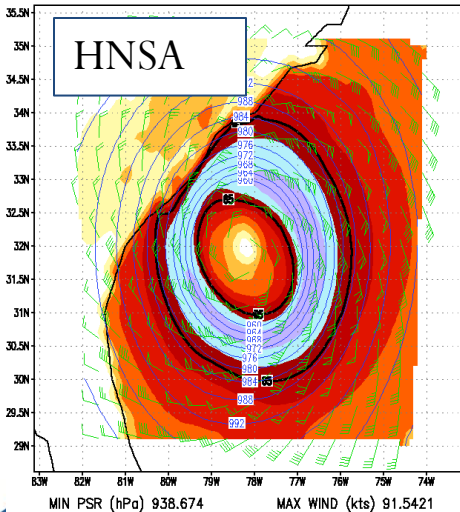
Weaker forecasts associated with broader storms

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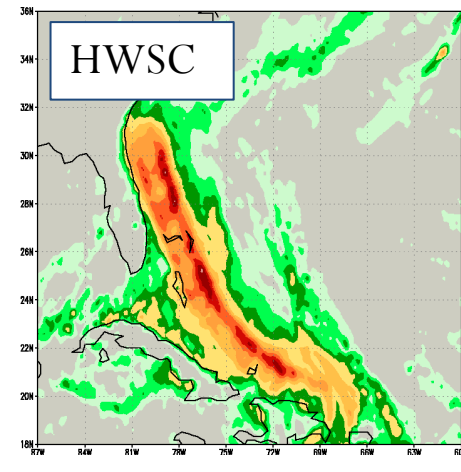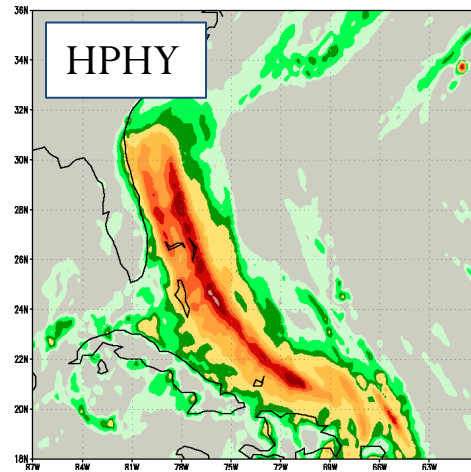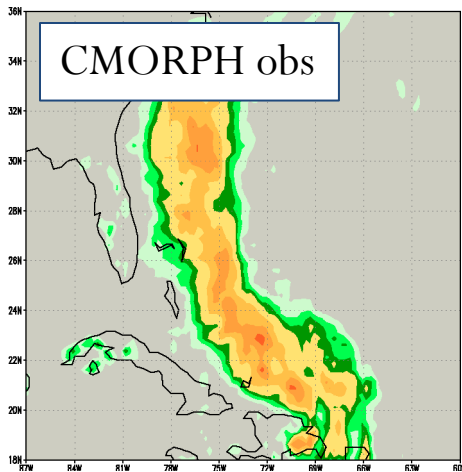
Irene init Aug 23, 00 UTC: 96-h lat flux W/m²
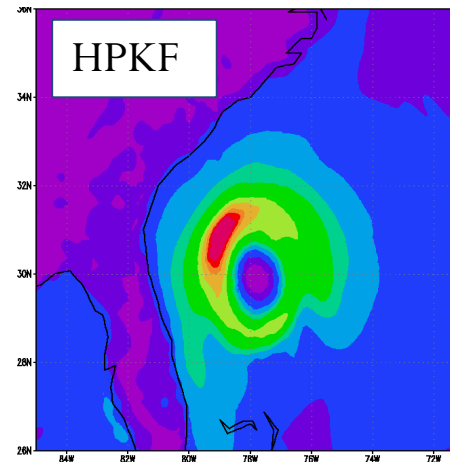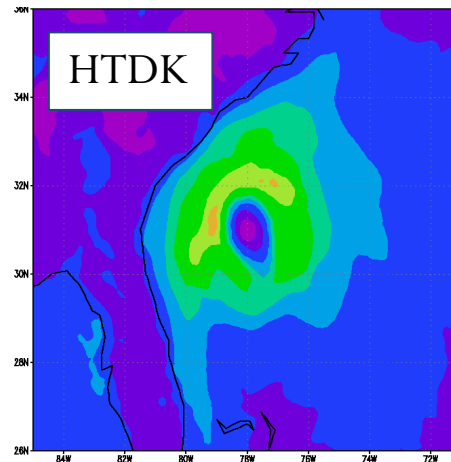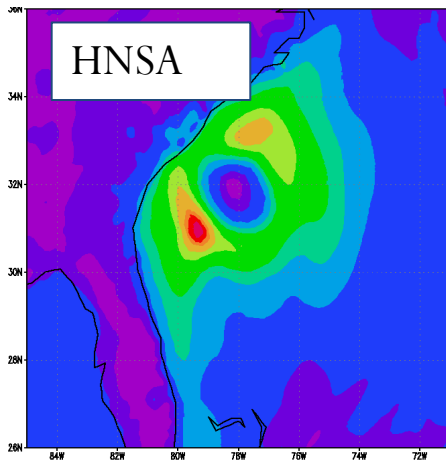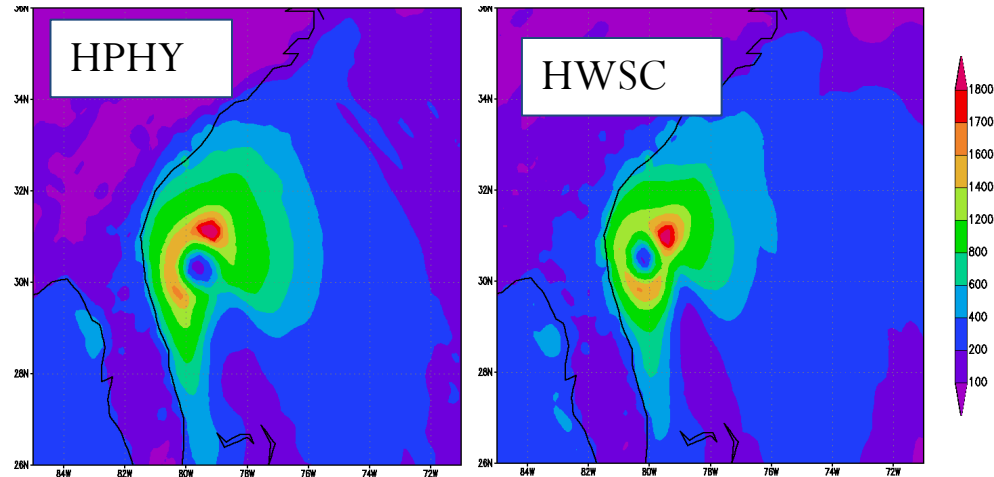
Variability in value and distribution of latent heat flux.

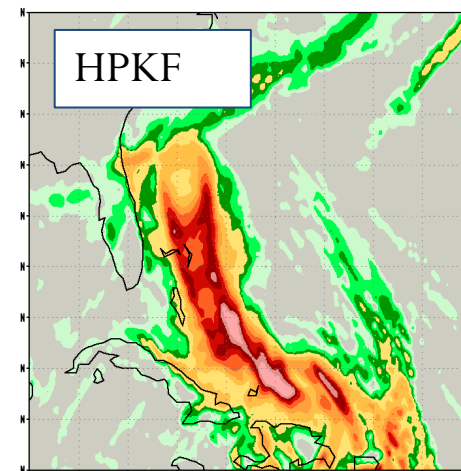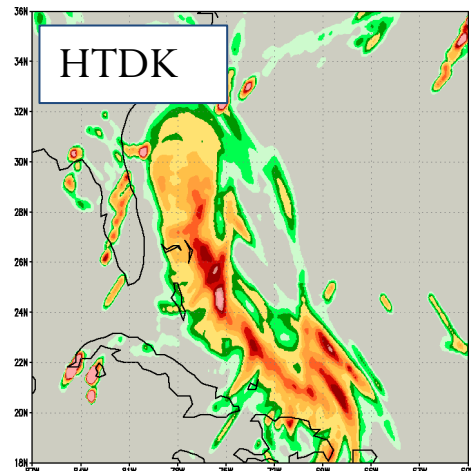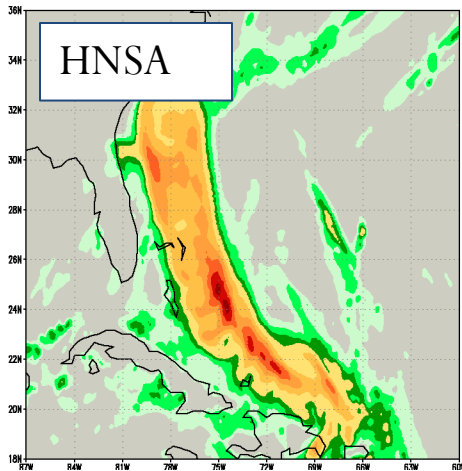# Irene init Aug 23, 00 UTC: 96-h sens flux W/m²
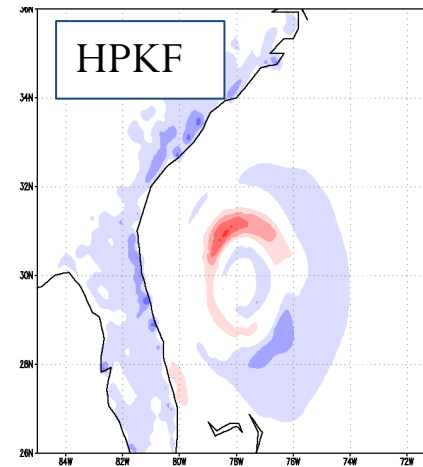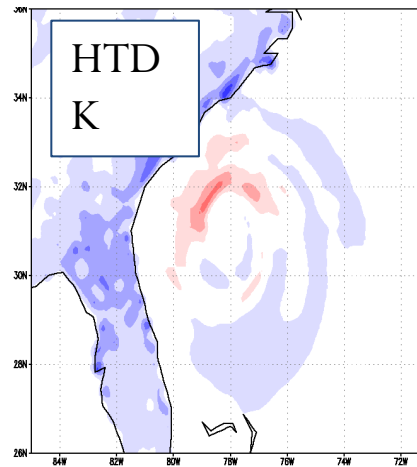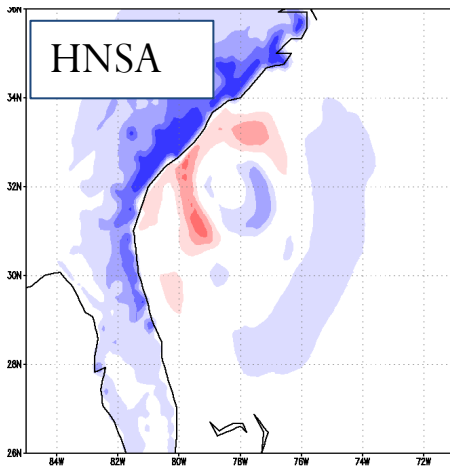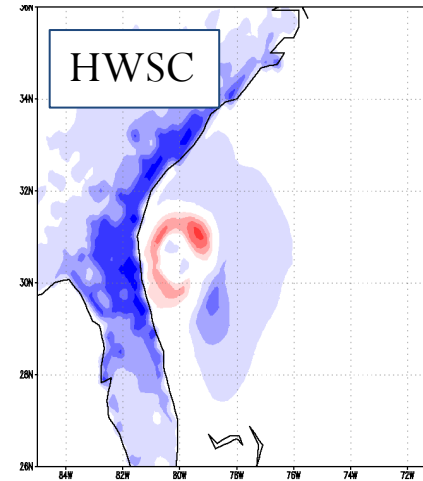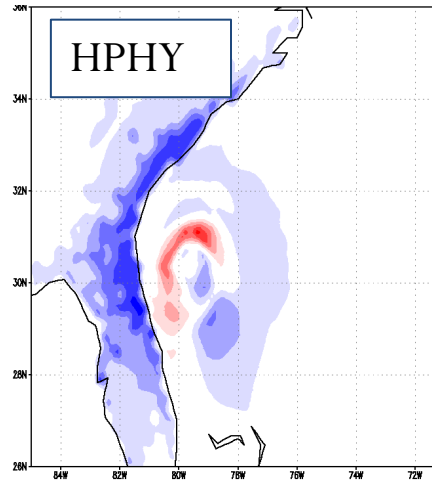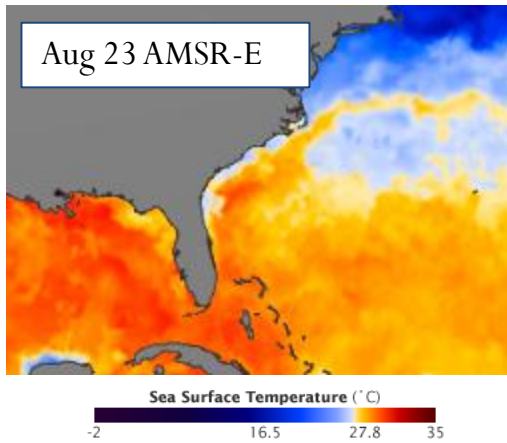
Variability in value and distribution of sensible heat flux.

Irene init Aug 23, 00 UTC: 96-h accum pcp mm

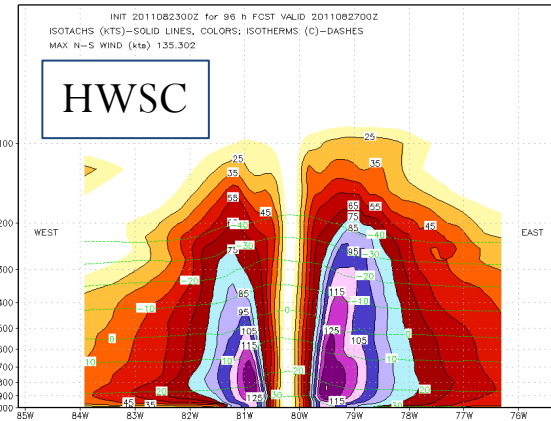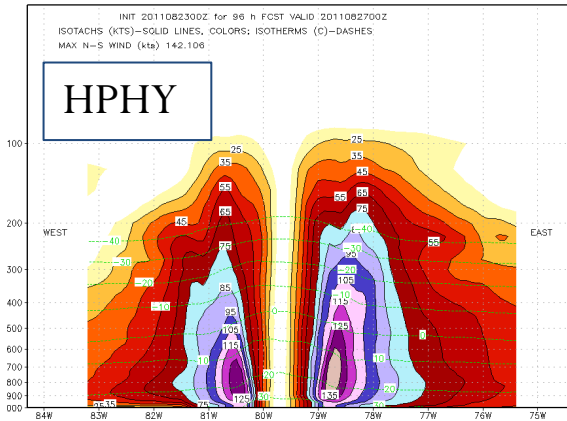All configs capture general pattern but overestimate rainfall.
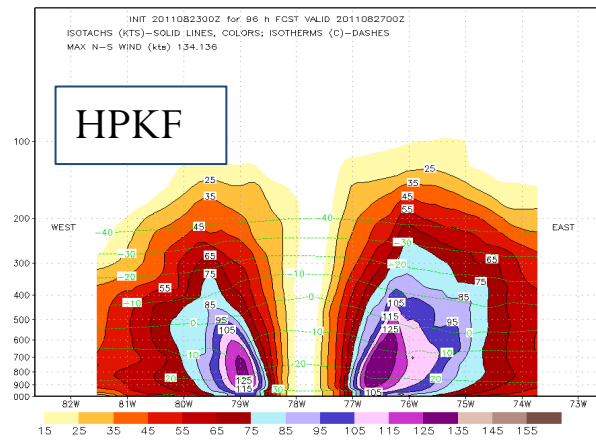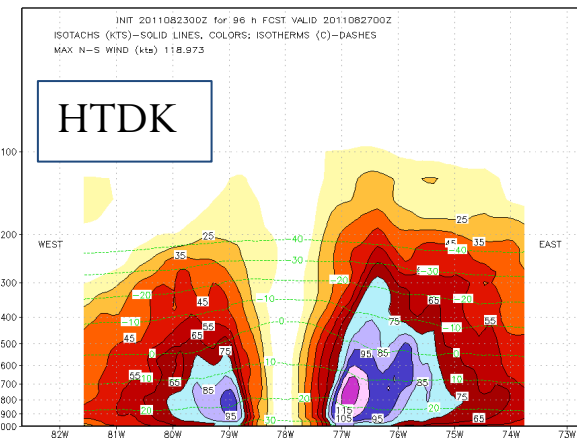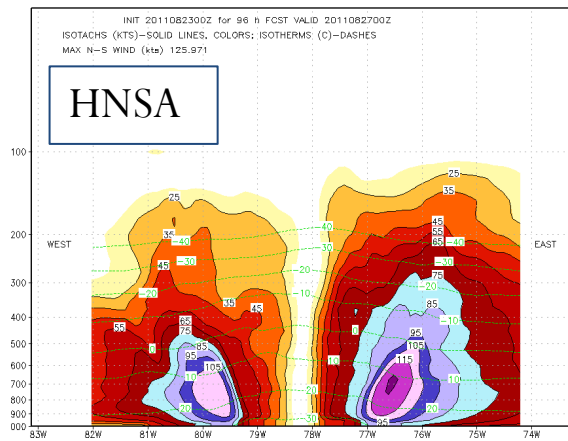
Large variations among configurations. HPFK highest accumulation.

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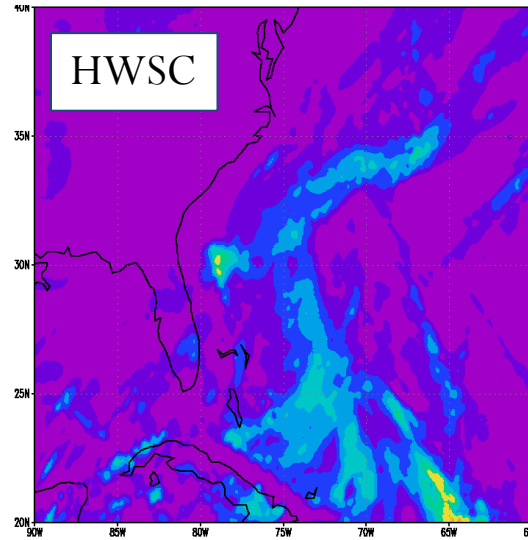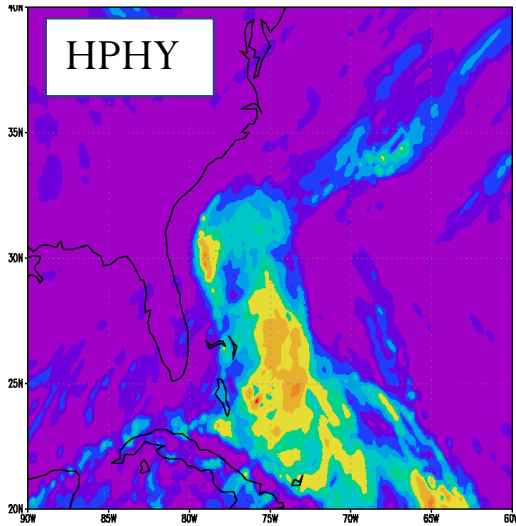# Irene init Aug 23, 00 UTC: 96-h isotachs (kt), isotherms (C)

Configurations with higher intensity are vertically stacked
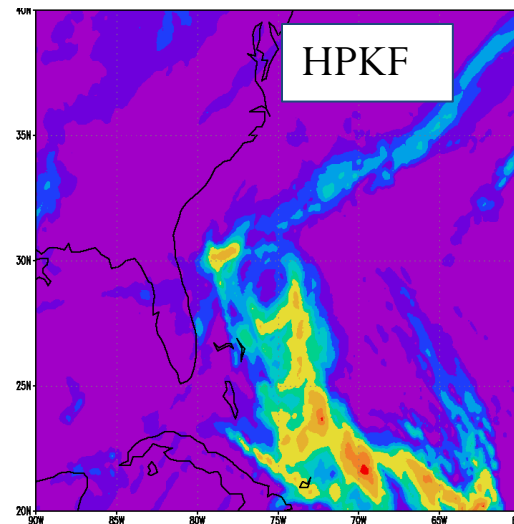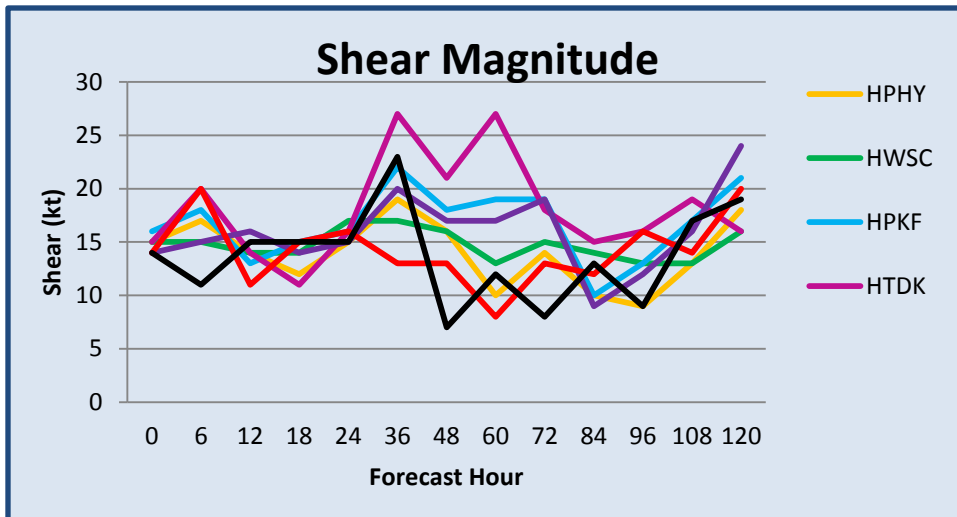
Irene init Aug 23, 00 UTC: 500-hPa Convective heating (K/s)

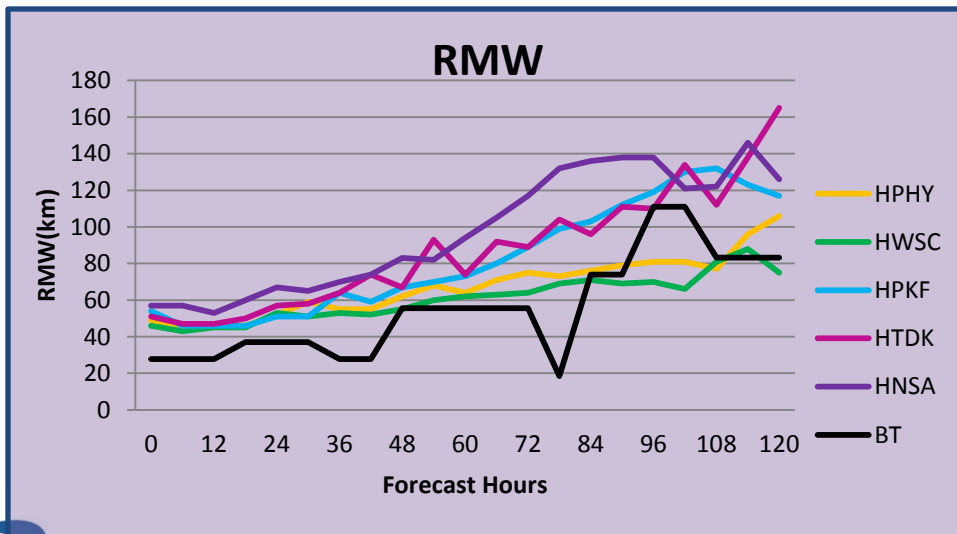Large differences in convective heating.

Irene init Aug 23, 00 UTC: SHIPS Shear and RMW

200-850 hPa shear is sensitive to cumulus parameterization.

Shear is annular average 200-800 km from center.

GFS forecast and analyses included for comparison.

RMW configurations with higher intensity make broader inner core.

Summary and follow-up work

Expanded HWRF's interoperability

- Additional schemes now available for studies

Examined Irene's sensitivity to cumulus parm

- Large sensitivity, especially in storm structure and intensity

Additional Work

- Repeat with additional storms with EMC released list of priority cases
  - Atlantic
    - Harvey: 2011081900 – 2011082206
    - Irene: 2011082100 – 2011082818
    - Katia: 2011082906 – 2011091012
    - Maria: 2011090618 – 2011091612
    - Ophelia: 2011092100 – 2011100306
    - Rina: 2011102318 – 2011102812
  - Pacific
    - Dora: 2011071812 – 2011072418
    - Eugene: 2011073112 – 2011080606
    - Fernanda: 2011081600 – 2011082000
- Repeat with three-domain configuration
- Refine analysis method (variables, levels, averaging procedures, observations)

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