Advancements in NOAA's Tropical Cyclone Modeling: Stream 1.5 and 2 Candidacy

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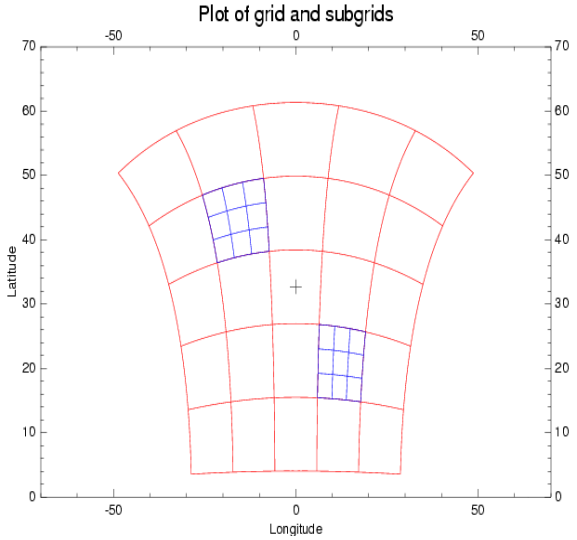
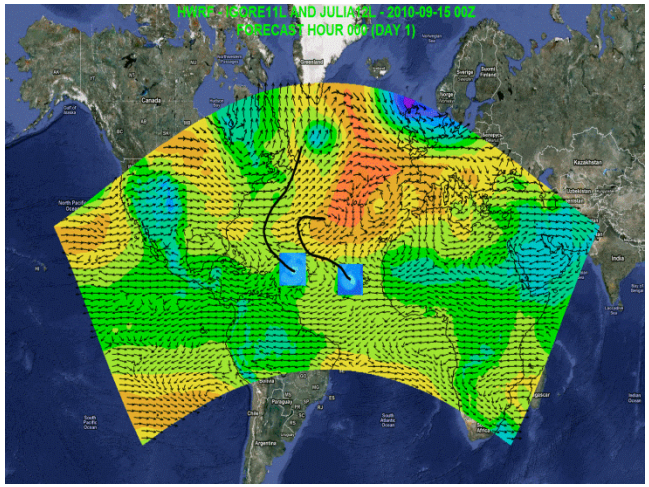
In 24/7/365 collaboration with Vijay Tallapragada *& the HWRF team at EMC!*
Partners: DA & Diag team, HRD; JPL/NASA; NRL;DTC;Purdue; IIT.New Delhi,India
Acknowledgements: Frank Marks and Robert Atlas

HWRF model developments: Nesting & Physics

- Advanced nesting algorithm providing scale spanning resolutions down to about 3 km
- Viable operational pathway at 27:9:3 & Potential transitions to operations in 2012
- Ongoing work with EMC: Extension of initialization algorithm down to 3 km resolution for operations
- Improved PBL physics consistent with observations
- Advanced diagnostics for high resolution forecasting
- Regional scale Hybrid DA

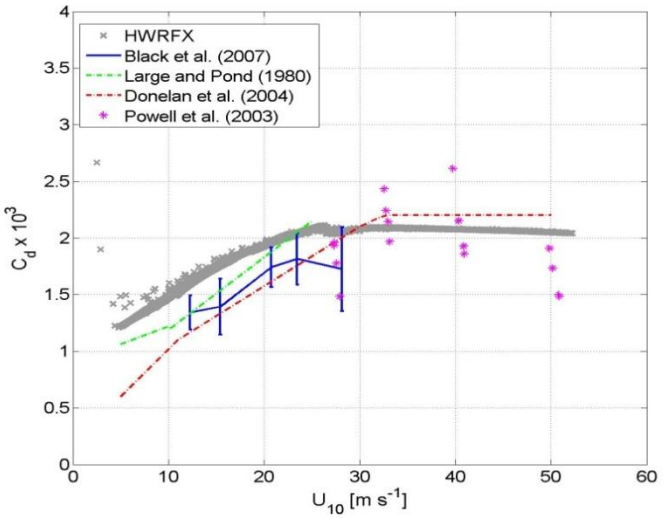


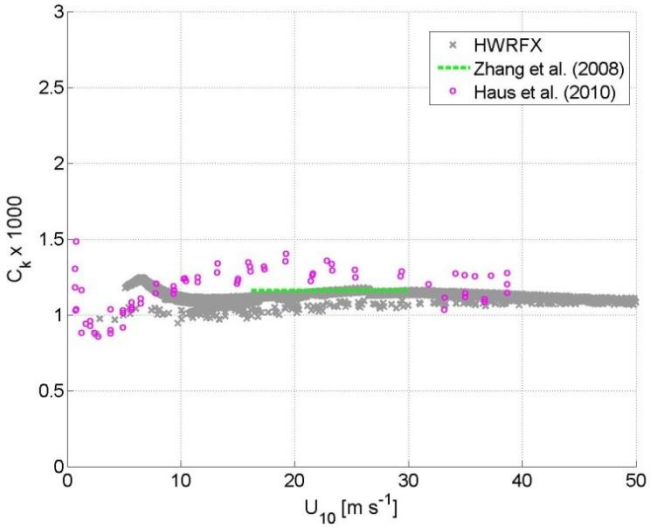


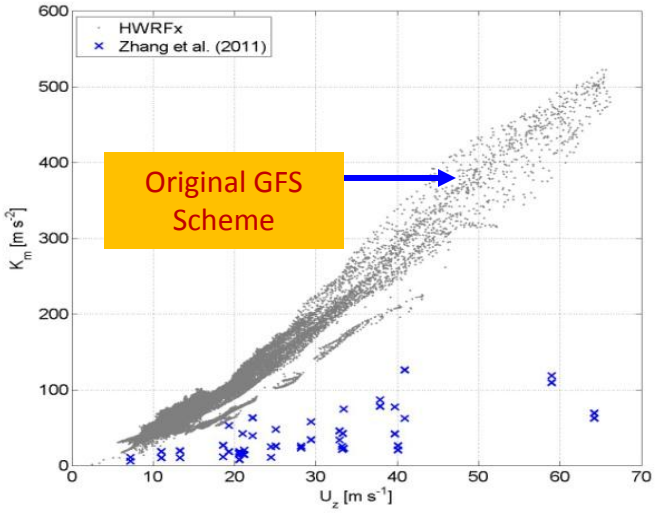
Model Configuration

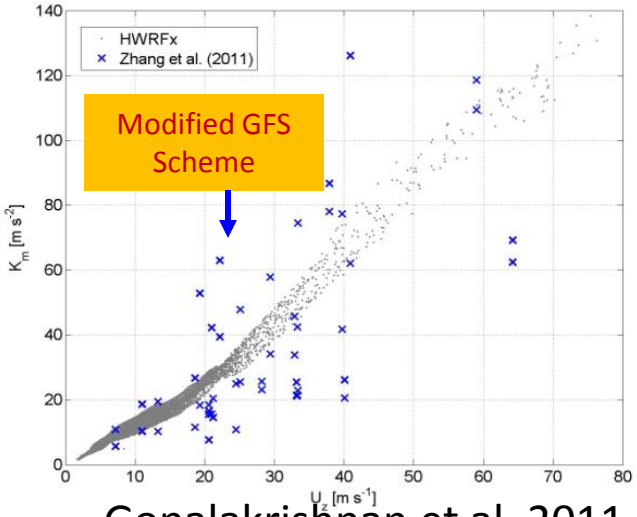
	Operational HWRF	Stream 1.5 HWRF	HWRF-GEN
Domain	27 KM: 77.76˚ X 77.76˚ 9 KM: 7.2˚ X 6.0˚	27 KM: 77.76˚ X 77.76˚ 9 KM: 10.56˚ X 10.2˚ 3 KM: 7.6˚ X 6.4	27 KM: 202.14˚ X 90.36˚ Fixed Center: 30˚N, 50˚W
Vortex Initialization	27-9 KM: Yes	27-9 KM: Yes 3 KM: No (Downscaling)	No
Cycling	Yes(Vortex only)	Yes (9 km domain vortex only)	No (Initialized by GFS analysis)
Ocean Coupling (Ocean model: POM)	27-9 KM: Yes	27-9 KM: Yes 3 KM: No (Downscaling)	No (GFS SST at initial time)
Platform	IBM	JET-Linux	JET-Linux
Physics schemes			
Microphysics	Ferrier	Ferrier	Ferrier
Radiation (SW)	GFDL	GFDL	GFDL
Radiation (LW)	GFDL	GFDL	GFDL
Surface Scheme	GFDL (2011 implementation)	GFDL (2010 implementation)	GFDL (2010 implementation)
PBL Scheme	GFS	GFS (Modified for HR implementation)	GFS
Cumulus Parameterization	New SAS	New SAS (27-9 KM) no CP (3 KM)	2010 SAS
Land Surface	GFDL Slab	GFDL Slab	GFDL Slab
GWD	Yes(27km); No(9km)	Yes(27km); No(9-3km)	No

Physics Sensitivities with 3 km HWRF: High Resolution PBL Physics Consistent with Observations (AOML/EMC/PSD)





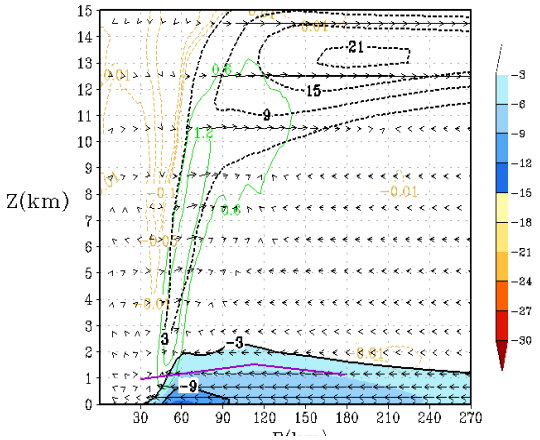




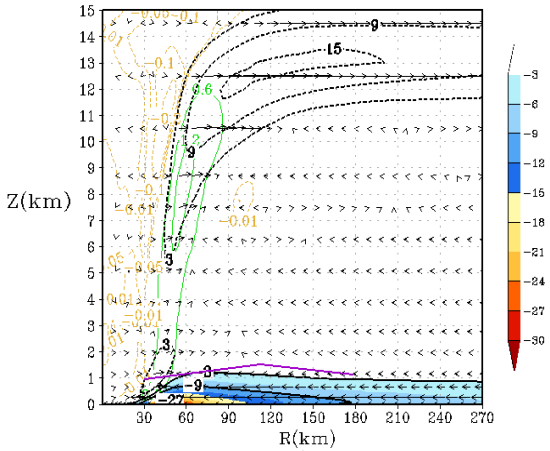
Gopalakrishnan et al. 2011

3 KM HWRF: Improved Structure Predictions

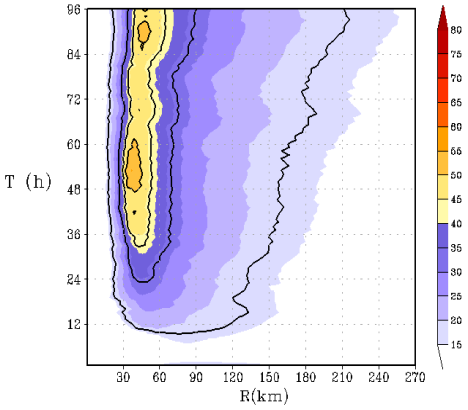
Original Formulation

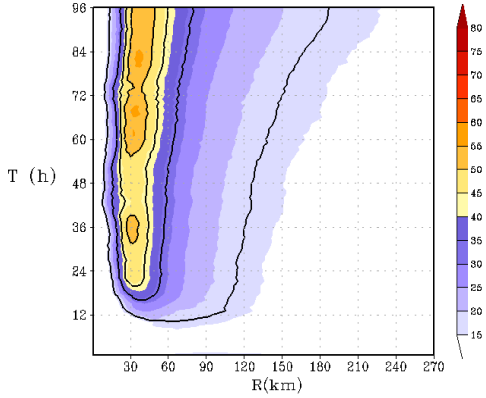


Latest Formulation



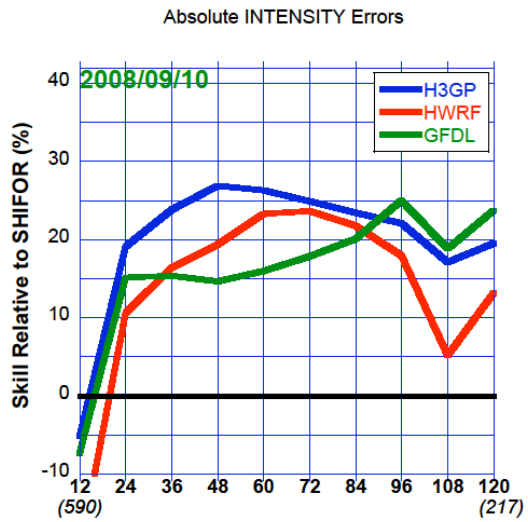
Azimuthally averaged secondary circulation: Radial Wind and W



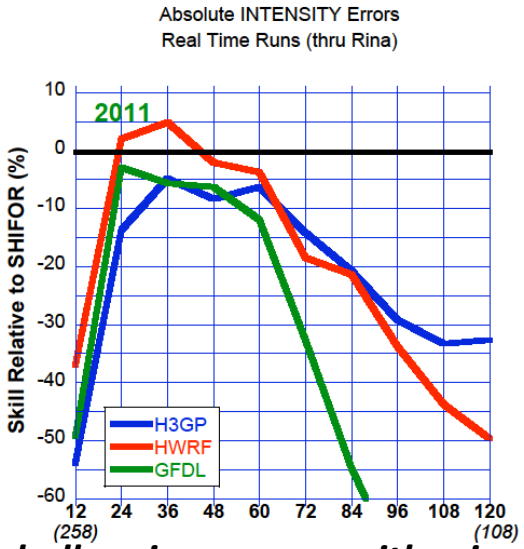


Hovemoller of 10-m wind speed

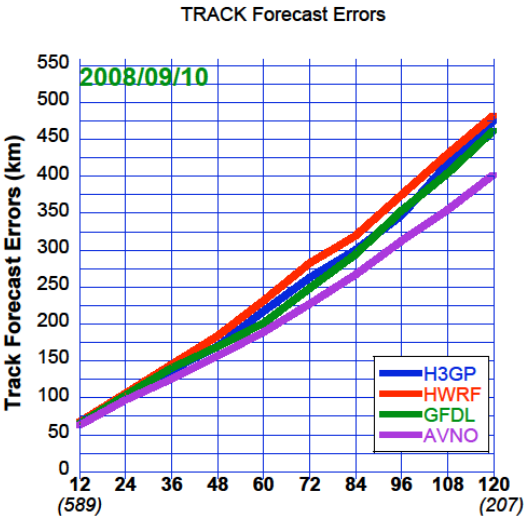
Verification Stats with the 27:9:3 configuration

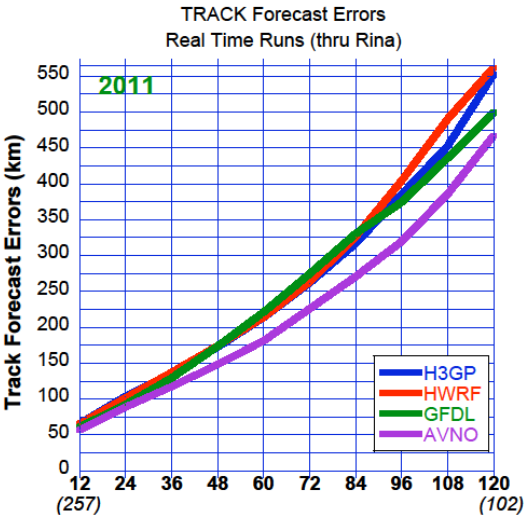


***H3GP*: Improved over *HWRF* & *GFDL* up to 96h**



***H3GP*: challenging season with mixed results**





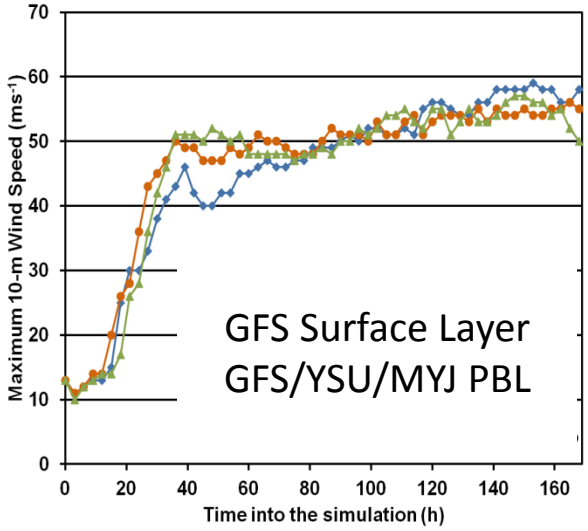
With the exception of GFD5 (parallel GFDL), Global Model (GFS) continue to provide improved track predictions

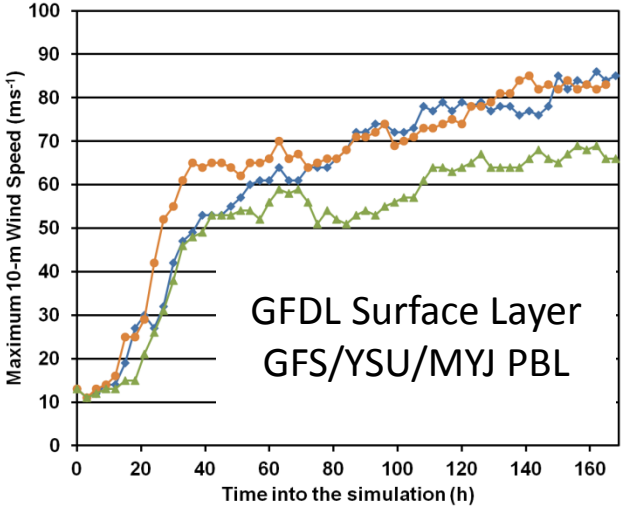
Towards an Improved PBL Package for the Operational 3-KM HWRF Model (PSD/HRD): Stream 1.5

❑ Assess the performance of the GFS, MYJ and YSU BL mixing schemes that are coupled with the same surface layer scheme (either the current GFDL SFCLAY scheme or an alternative better scheme) (Stream 1.5 Task).

❑ Establish a better understanding of the resolved and subgrid physical processes connecting the surface fluxes and moisture flux above the BL; and identify aspects in the HWRF representations of these processes that require improvement (Stream 2 Task).

❑ Recommend an improved combination of the surface layer, the BL mixing and the subgrid convection schemes to couple with the operational microphysics scheme for better representing resolved and subgrid moisture flux under high winds (Stream 2 Task).

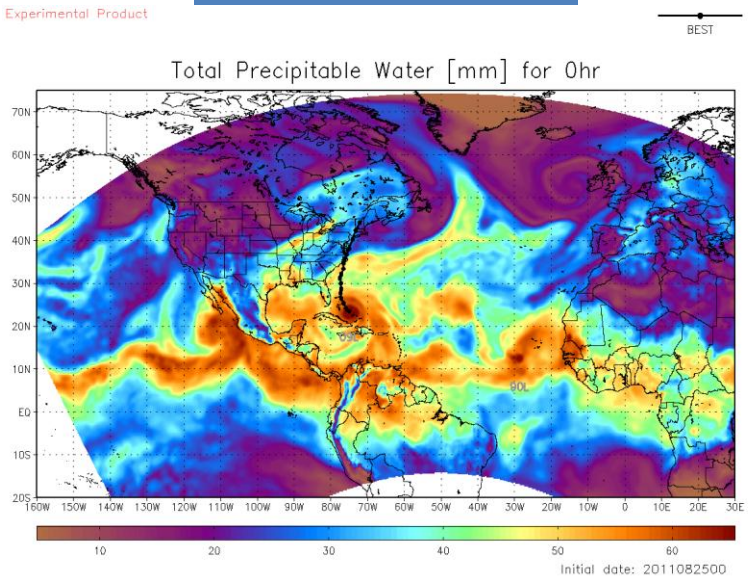


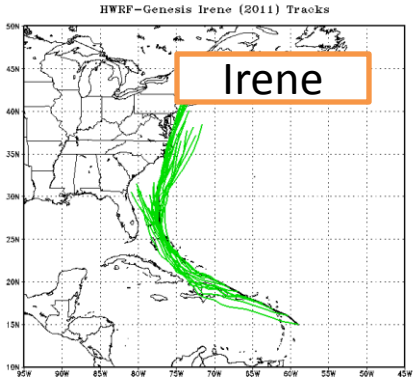


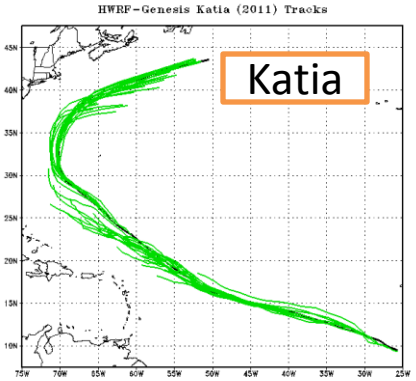
HWRF: A Tropical Prediction System for Stream 2

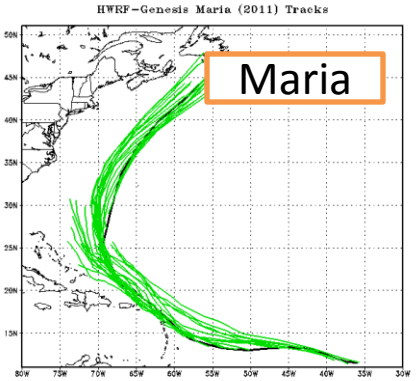
- Basin scale domain
- Appropriate for Hybrid DA
- 7 days forecast
- Regional ensembles/products
- Daily Tropical Outlook/genesis
- Computational Efficiency (27:9;about 2 h; 168 p)
- HWRF for WFO/ W nest over FL
- Hybrid DA for this system at 27 km resolution
- Explore multiple moving nest options at 3 km resolution

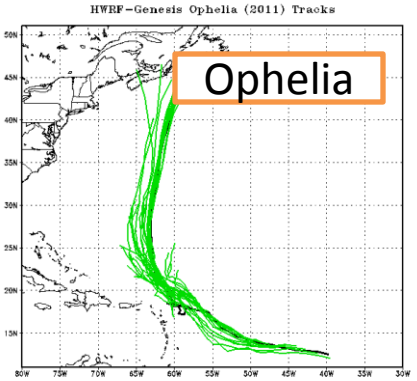
Basin Scale HWRF











HWRF EnKF/hybrid DA system development
HRD, PSD and NCEP collaboration: Stream 2

- Develop hybrid data assimilation capability for 3-km HWRF system
  - Implement HWRF model within framework of the global hybrid system
  - Shared GSI and EnKF algorithms
  - Use of satellite observations at increased resolution (less thinning)
  - Use of inner-core observations

- HWRF hybrid system configuration
  - Basin scale fixed-location outer domain - continuous DA cycling possibly with a restart using the global analysis
  - Moving nest(s) with partial cycling

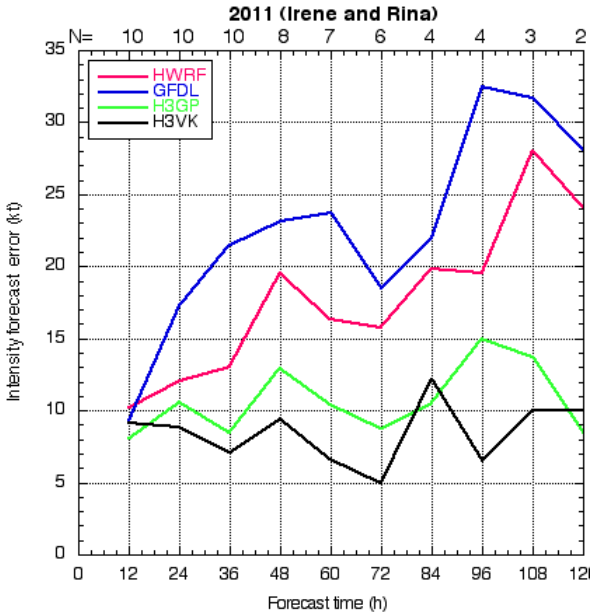
Vortex scale data assimilation using HEDAS with 3 km HWRF Model (HRD): Stream 1.5

❑ Assess the performance of inner core data assimilation with 3-km HWRF model

- Upgrade HEDAS with 3 km HWRF model version
- Run every 6 h when any aircraft data are available, not just Doppler data
- Assimilate satellite data such as cloud motion vectors and scatterometer data in the near environment, and oceanic surface observations (buoy/ship)

❑ Evaluate impact of including the estimates of microphysical state and vertical motion in initial condition

- Upgrade HEDAS to estimate microphysical prognostic variables and improve secondary circulation



Primary and secondary circulation in HEDAS cycling