Factors Affecting Genesis of Hurricane Karl (2010)

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OVERVIEW

Convective-permitting short-range ensemble forecasts initialized with ensemble Kalman filter (EnKF) analysis and perturbations are used to study factors affecting the genesis of Hurricane Karl (2010). The composite analysis of developed versus non-developed members shows that the middle-level moisture and low-level vorticity are primary contributors for tropical cyclone formation.

Numerical sensitivity experiments are also conducted to examine the impact of diurnal cycle. Preliminary analysis shows that the diurnal cycle could significantly affect genesis and storm intensity.

MODEL AND EXPERIMENT DESIGN

Model:	WRF ARW Version 3
Nesting:	3
Vertical levels:	40
Horizontal resolution :	40.5, 13.5 and 4.5 km
Cumulus:	Grell-Devenyi CPS for 40.5 km only
Microphysics :	WSM6
PBL:	YSU
Land surface:	5-layer thermal diffusion soil model
Radiation:	RRTM (LW) / Dudhia (SW)
Boundary conditions:	GFS operational forecasts
Ensemble initialization:	A 30-member EnKF (Meng&Zhang 2008) hybrid with 20% of GFS analysis

TRACK AND INTENSITY FORECAST UNCERTAINTY

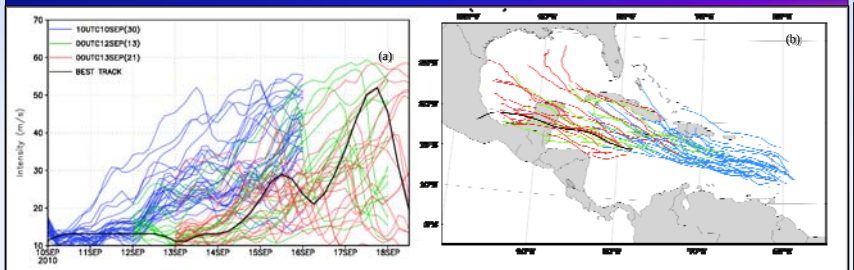

Figure 1 The observed and ensemble forecasted (a) intensity and (b) track of Hurricane Karl (2010). The black line represents the NHC best track and intensity estimate. Blue, green and red are the forecasts with initial time at 00Z10SEP2010, 00Z12SEP2011 and 00Z13SEP2011. About 30, 13 and 21 members of 30 develop to a tropical storm.

ENVIRONMENT UNCERTAINTY: DEVELOPER VS NON-DEVELOPER

Table 1.The composite environmental conditions of the non-developed and developed members with initial time at 00Z12SEP2011. Bold font indicates that the difference is statistically significant at 95% confidence level.

	RHTT (%)	VOR850 (10^{-5} S^{-1})	SHRD (m s^{-1})	SHRS (m s^{-1})	CAPE (J kg^{-1})	MPI (Kt)	GPI
NON-DEV (17)	**65.9**	**2.7**	**6.4**	5.0	**1442**	148.2	**112.8**
DEV (13)	**71.3**	**3.2**	**8.8**	5.9	**1323**	149.6	**126.5**

RHTT: 700 hPa-500 hPa relative humidity **VOR850**: 850 hPa relative vorticity **SHRD**: 200-850 hPa horizontal wind vertical shear
SHRS: 500-850hPa horizontal wind vertical shear **CAPE**: Convective available potential energy
MPI: Maximum potential intensity (Emanuel, 1986) **GPI**: Genesis potential index (Emanuel, 2006)

NON-DEVELOPED AND DEVELOPED MEMBERS

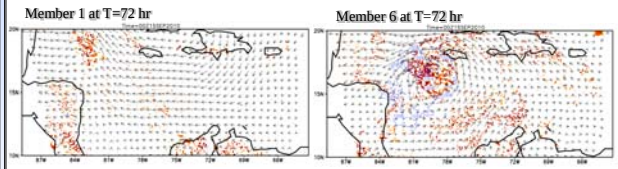

Figure 2. Sea-level pressure (contour), 700 hPa relative vorticity and wind fields forecasted by member 1 and 6 at T=72 hr.

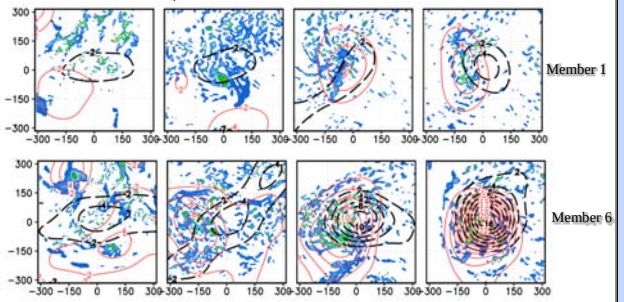

Figure 3. Horizontal distributions of relative vorticity at 500 hPa (shaded, 10^{-4} s^{-1}). The contours are relative vorticity in scales larger than 200 km at the surface (black, 10^{-5} s^{-1}) and 500 hPa level (red, 10^{-5} s^{-1}).

DIURNAL VARIATIONS OF STORM-SCALE VORTICITY, MOISTURE AND CONVECTION PRIOR TO AND DURING GENESIS

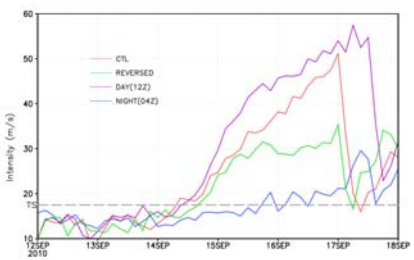

Figure 4. Intensity changes in the control run (CTL, member 6) and three sensitivity experiments.
REVERSED: As CTL, except that the day time and night time is reversed in the SW radiation scheme.
DAY: The time in the SW radiation scheme is fixed at 16Z local time.
NIGHT: The time is fixed at 00Z local time.

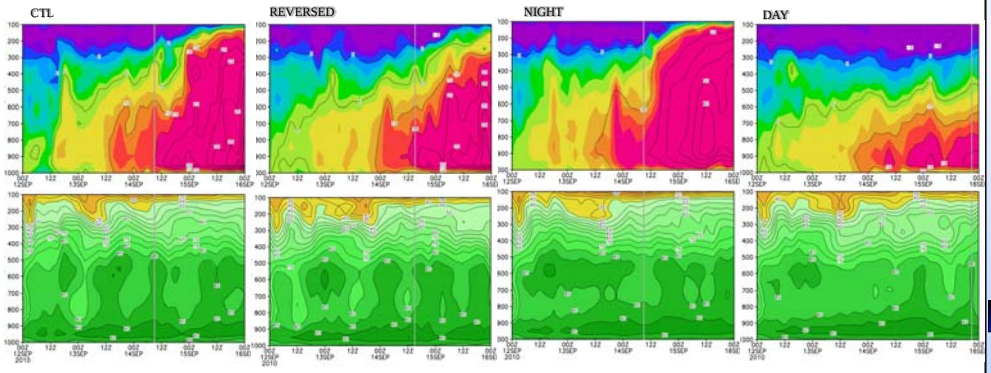

Figure 5. Time-height diagram of relative vorticity (upper panels) and relative humidity (lower panels) averaged within 225 km centered at the surface maximum. Gray line marks the time of tropical cyclone formation.

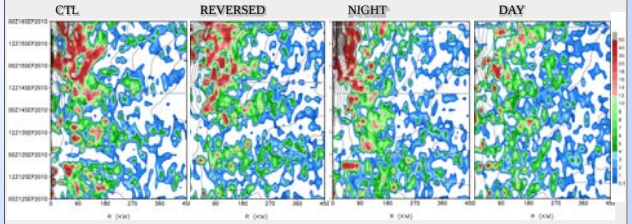

Figure 6. Time-radius diagram of azimuthally-averaged 500 hPa vertical velocity (shading, cm/s) and azimuthally-averaged 850 hPa tangential wind speed (contour, m/s).

FUTURE WORK

1. Compare with observations to understand the genesis process
2. Conduct further analysis to understand the role of diurnal cycles