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Role of Diabatic Heating on Tropical Cyclone Structure and Motion

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• *Microphysical assumptions influence tropical cyclone (TC) motion, as revealed in "real-ideal" hybrid WRF simulations (Fovell and Su 2007; Fovell et al. 2009, 2010a).* ***See Figure 1a****.*

• *Day 2-3 track spread comparable to recent average position error.*

• *Motion partly reflects differences in outer wind structure, modulating "beta drift".*

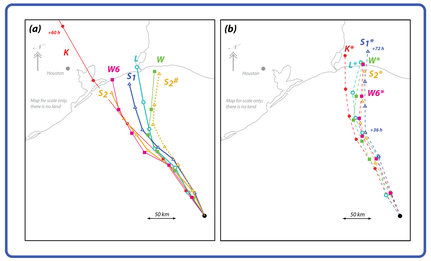

Figure 1:
Tracks of idealized TCs as a function of microphysics, including WSM3 (W), WSM6 (W6), Kessler (K), Lin (L), and two versions of Seifert-Beheng's dual moment scheme (S_1, S_2). Asterisk indicates CRF neglected. S_2# treats cloud ice as snow in CRF. Map for scale; there is no land. From Fovell et al. (2010a).

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• *Track variation vanished when cloud-radiative feedback (CRF) was neglected.* ***See Figure 1b****.*

• *Microphysics schemes differ in speciation of hydrometeors, which are treated differently by radiation parameterizations.*

• *CRF influenced two structural aspects:* ***azimuthally symmetric outer winds*** *&* ***azimuthal asymmetries near the core****.*

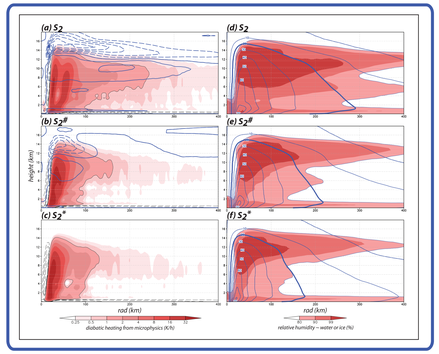

Figure 2:
Time-averaged fields of azimuthally symmetric components for three versions of S_2. Left: latent (shaded) and radiative (thick contoured) heating due to microphysics. Latent cooling indicated with thin contours. Right: relative humidity (shaded) and tangential wind (thick contoured). 20 m/s wind contour bolded.

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• *Radiative forcing owing to hydrometeors consists of weak cloud top cooling above even smaller warming. Yet, CRF impacts radial and vertical structure of latent heating.* ***See Figure 2, left****.*

• *With CRF, anvils are more radially extensive with stronger outer winds, modulating beta drift and track.* ***See Figure 2, right****.*

• ***Figure 3*** *shows difference field for S_2 with and without CRF.*

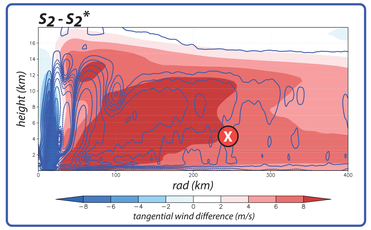

Figure 3:
Difference between S2 and S2* symmetric tangential velocity (shaded) and latent heating (with ±0.5, 1, 2, 4, and 8 K/h contours). "X" indicates induced cyclonic flow.

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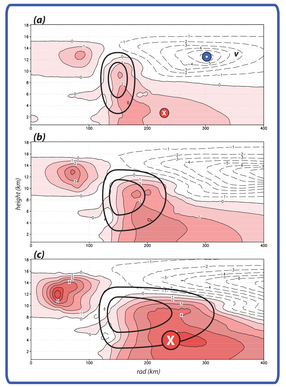
• *The response to midtropospheric heating* ***in isolation*** *is studied with a dry version of the Rotunno-Emanuel (1985) model and a heat source mimicking the outer region latent heating difference field.* ***See Figure 4****.*

• *Heating provokes cyclonic winds beyond and beneath the source and is sensitive to its radial extent.*

Figure 4:
Tangential wind response in dry Rotunno-Emanuel model to maintained heating (heavy 0.3 K contours) with magnitude and structure suggested by WRF storms.

Minor heating can make a major difference



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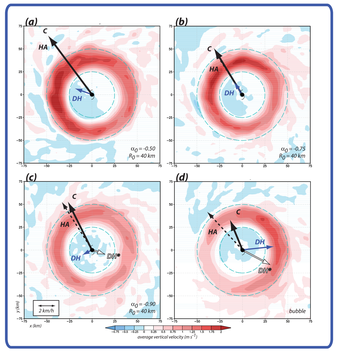
• *The* ***asymmetric*** *distribution of diabatic heating is also important, as it can act to work with or against motion. This can be examined via the potential voriticity (PV) budget, as in Wu and Wang (2000).*

• *In* ***Figure 5****,* ***C*** *represents storm motion, and* ***HA*** *is the contribution to motion from horizontal PV advection.* ***DH*** *reflects PV tendency due to all diabatic heating, while* ***DH**** *is* ***DH****+vertical PV advection.*

Figure 5:
Surface-3.5 km average vertical velocity, storm vector ***C***, and motion contributions from ***HA***, ***DH*** and ***DH**** for four cases with similarly sized eyewalls. ***DH**** absent when negligible. Storm motion speeds vary between 3.3-12 km/h.

Storm motions vary from 3.3-12 km/h



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• ***Summary****: microphysical assumptions, including fallspeed, hydrometeor speciation, and interaction with radiation, directly and indirectly influence the symmetric and asymmetric storm structure. Symmetric winds establish the beta drift that can be constructively or destructively affected by asymmetries in the diabatic heating.*

• *This is important for tuning operational models, for example.*

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• *Related work*

Fovell, R. G., and H. Su, 2007: Impact of cloud microphysics on hurricane track forecasts. *Geophys. Res. Lett.*, **34**, L24810, doi:10.1029/2007GL031723.
Fovell, R. G., K. L. Corbosiero, and H.-C. Kuo, 2009: Cloud microphysics impact on hurricane track as revealed in idealized experiments. *J. Atmos. Sci.*, **66**, 1764-1778.
Fovell, R. G., K. L. Corbosiero, A. Seifert, and K.-N. Liou, 2010a: Impact of cloud microphysics on hurricane track forecasts. *Geophys. Res. Lett.*, **37**, L07808, doi:10.1029/2010GL042691.
Fovell, R. G., K. L. Corbosiero, and H.-C. Kuo, 2010b: Influence of cloud-radiative feedback on tropical cyclone motion: Symmetric contributions. Preprints, 29th Conf. on Hurricanes and Tropical Meteorology, Amer. Meteor. Soc.

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This work was supported by NSF grant ATM-0554765. Computing resources provided by Aerospace Corp..