On passive microwave signatures in rapidly intensifying tropical cyclones

S. W. Nesbitt, D. S. Harnos, G. M. McFarquhar, B. F. Jewett
Department of Atmospheric Sciences, University of Illinois at Urbana-Champaign

Introduction

Rapid Intensification (RI) remains a key TC forecast problem (Rappaport et al. 2009); Kaplan and DeMaria (2003): ΔV/Δt > 30 kt / 24 h

Environmental and internal storm processes influence RI:

- Mesovorticies (Nolan and Montgomery 2002)
- Convective bursts (Braun et al. 2006)
- Eyewall axissymmetry (Frank and Ritchie 1999; Nolan and Grasso 2003; Rogers 2010)
- Eyewall convective asymmetry, vortical hot towers (Nguyen et al. 2008, Montgomery and Smith 2011)
- Role of environmental shear and VHTs (Molinari and Vollaro 2010)

How can operational passive microwave imagery help in understanding and predicting these processes and pathways?

Prior work examining PMW imagery and TC intensity

Rain rate: Rodgers et al. (1994), Rao and MacArthur (1994), Rodgers and Pierce (1995)
Scattering intensity and spatial coverage: Rao and McCoy (1997), Cecil et al. (1999)
Patterns: Kieper et al. (2008, AMSHURR); Kieper (2010, AMSHURR) – "cyan ring" prior to RI, "warm rain" in 37 GHz composite imagery, Edson and Lander (2002, AMSHURR); Edson and Ventham (2008, AMSHURR) noted features of bursts and banding in 85 GHz ice scattering; Harnos and Nesbitt (2011) noted rings of modest ice scattering in low shear, more intense less organized convection in high shear

Aims + Methods

Examine high resolution simulations of RI

- PMW overpasses come relatively infrequently (~2-6 h)
- Can simulations of PMW observations shed light on dynamical mechanisms (e.g., areal coverage of precipitation, convective intensity) that occur prior to and during RI?
- Tool: 1 km Research and Forecasting (WRF) + U. Nagoya/NASA Goddard *Satellite Data Simulator Unit* (SDSU) – simulations of Earl (2010, high shear) and Ike (2008, low shear) described on Harnos poster

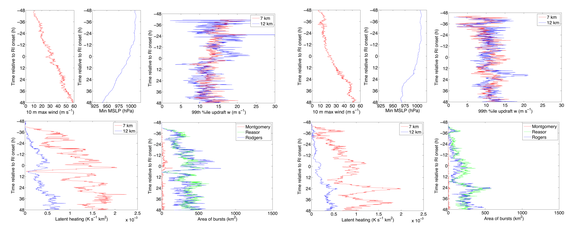
> Mie scattering code, with microphysical assumptions in WRF, melting layer
> Water vapor emission and surface radiation code
> Instrument sampling geometry and sensor characteristics
> Simulate characteristics of:
> Global Precipitation Measurement mission Microwave Imager (GMI)
> similar footprints to TMI and AMSR-E conically scanning geometry
> Channels (GHz) 10 h v, 18 h v, 23 v, 36 h v, 89 h v
> GPM Dual-frequency Precipitation Radar
> Ku (13 GHz) + Ka (35 GHz) reflectivities (nadir geometry)

Examine 22-yr HURSAT-MW Dataset

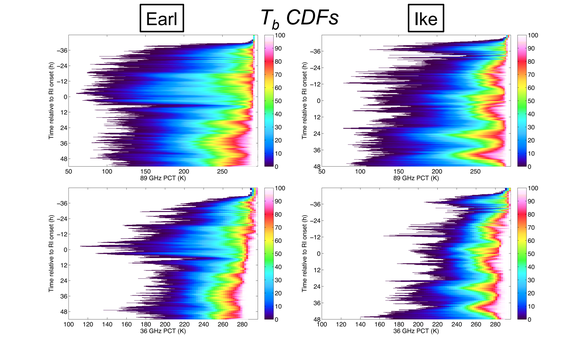
- SSM/I (courtesy Ken Knapp, NCDC) and TMI 0.08° Cartesian-gridded PMW overpasses of TCs ('87-'08)
- IBTrACS (International Best Track Archive for Climate Stewardship) v3r3 global best track data (NCDC)

Simulation PMW characteristics

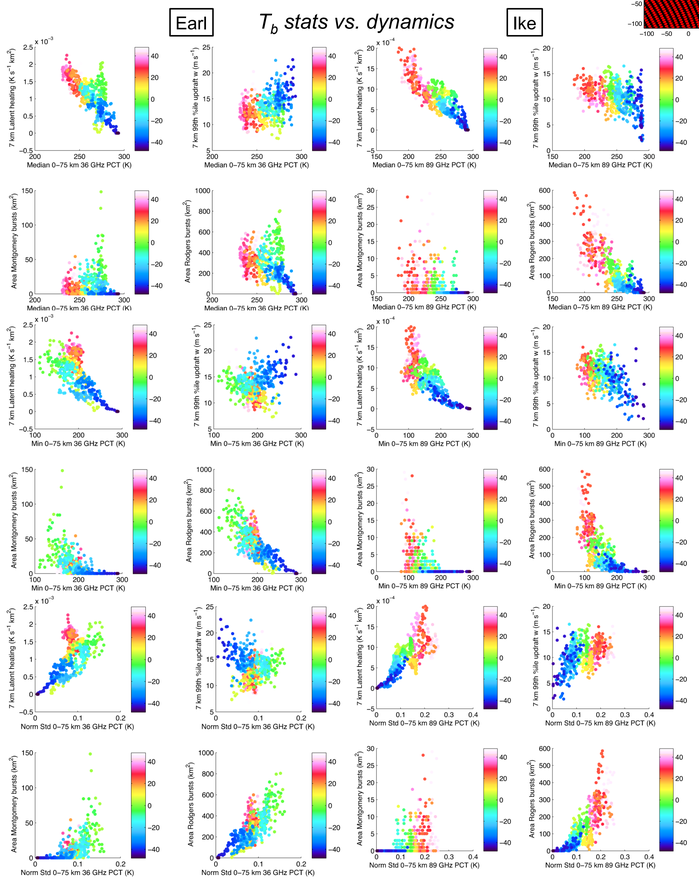
Earl — *Storm dynamics* — Ike



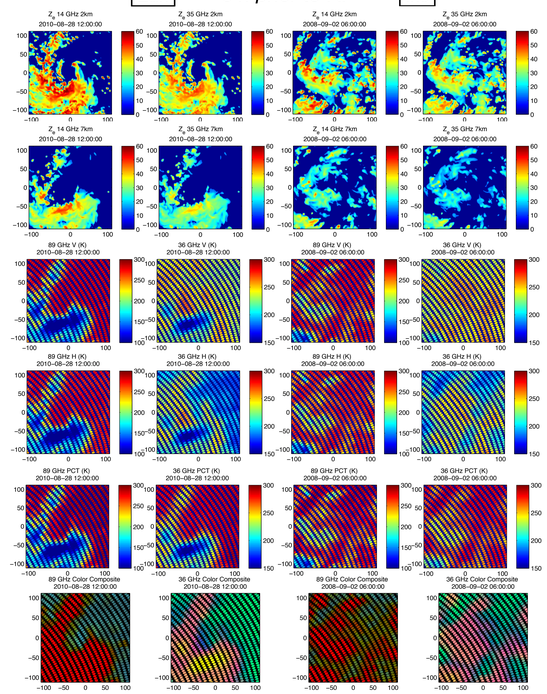
Earl — T_b *CDFs* — Ike



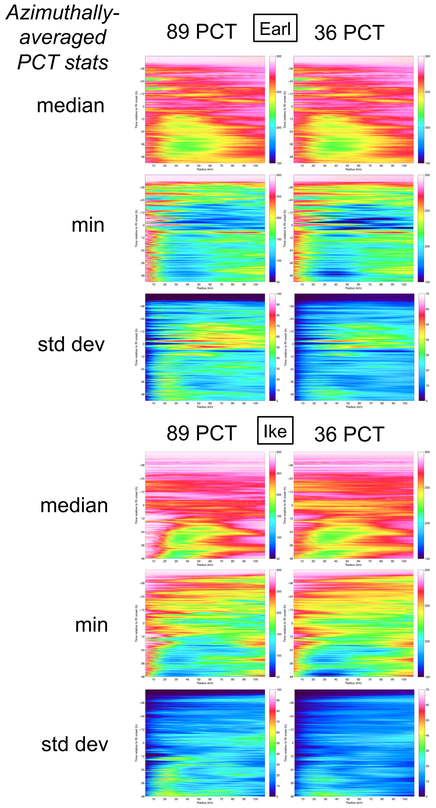
Earl — T_b *stats vs. dynamics* — Ike



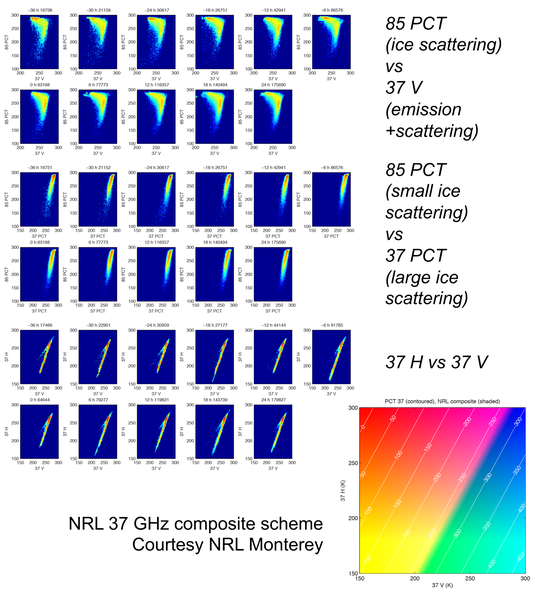
Earl — *6 h prior to RI* — Ike



Azimuthally-averaged PCT stats



Observed 37 & 85 T_bs w.r.t. RI onset



Conclusions

Earl simulation (high shear): Prior to RI, deep, intense azimuthally asymmetric ice scattering from convective bursts/VHTs; During RI: moderate intensity convection and stratiform
Ike simulation (low shear): Prior to RI, wide coverage of moderate scattering from convection; During RI (subphase): intense scattering from convection, azimuthally symmetric convective bursts/VHTs
Proxies for bursts and heating need exploration for retrievals

No systematic relationships between "cyan" and RI in model case studies or observations in space or time

Intensity of ice scattering may be overdone in models compared with obs database (> sub 1 km grid spacing) – would be consistent with biases found in other simulations in tropical convection

Acknowledgments

Acknowledgements:
NRL Tropical Cyclone Team
S. Durden and S. Tanelli, JPL

Funding: NASA Hurricane Science Research Program (Ramesh Kakar), NASA ESS Fellowship

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