Wind and Humidity Structures of Tropical Storm Cindy: CPEX Observations and WRF Simulations

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Introduction

• CPEX field campaign captured the environmental thermodynamic and dynamic conditions as well as convective structure of Tropical Storm Cindy (2017).

• We are particularly interested in the role of environmental moisture and internal storm structure in affecting Cindy’s development.

• High-resolution WRF simulations are conducted for Cindy and evaluated against CPEX and satellite observations.

- Major Finding 1: Simulated storm structures are sensitive to initial moisture distributions.

- Major Finding 2: Latent heat release of convective disturbances is critical to storm development.
CPEX Flight Tracks During Cindy

IMERG GPM Rain Rate

June 19

June 20

June 21
GOES-R Cloud Top Temperature
GPM Rain and MERRA-2 SLP

Orange line: MERRA2 Sea Level Pressure (SLP)
Blue dashed line: 400 km to best track TC center
Hurricane symbol: best track storm center
WRF Simulations

• WRF V3.8.1
• 2 nested domains
• New Simplified Arakawa-Schubert cumulus scheme at 9 km; no cumulus scheme at 3 km
• Morrison 2-moment microphysics scheme
• RRTMG SW and LW radiation scheme
• MYJ PBL scheme
• Initial/boundary conditions from ERA-Interim
• Three initial times:
  • 6/18 18Z
  • 6/19 00Z
  • 6/19 06Z
Moisture Structures in WRF Initial Conditions

850 hPa

500 hPa

ERA-I

AIRS

6/18 18Z

6/19 06Z
Comparison of three WRF simulations
WRF Initial at 18_18Z
WRF Initial at 19_00Z
WRF Initial at 19_06Z
Moisture Structure E-W Composite
2017/06/20

HAMSAR

Init1818Z+48 hr

Init1900Z+42 hr

W Init1900Z+42 hr E

Init1906Z+36 hr

Dropsonde

Distance to storm center (km)

Height (km)

Distance to storm center (km)

Distance to storm center (km)

Distance to storm center (km)

RH (%)
Moisture Structure N-S Composite
2017/06/20
Temperature Structure E-W Composite
2017/06/20

- Dropsonde
- Init1818Z+48 hr
- Init1900Z+42 hr
- Init1906Z+36 hr

Distance to storm center (km)
Height (km)

T (C)
Temperature Structure N-S Composite
2017/06/20

Dropsonde

Init1818Z+48 hr

Init1900Z+42 hr

Init1906Z+36 hr
Simulations without latent heat release
EnKF Performance (Analysis)
(Results courtesy Masashi Minamide, masashi.minamide@jpl.nasa.gov)

Assimilation of GOES-16 brightness temperature (with Adaptive Observation & Background Error Inflation (AOEI and ABEI) methods) worked well in constraining the convective activity during CPEX

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Summary

• WRF simulations approximately capture Cindy’s moisture and wind structures and the evolution of precipitation, but the results are sensitive to initial moisture distributions.

• Composite analysis based on the distance to storm center yields meaningful comparisons between the aircraft observations and WRF simulations.

• Latent heating of convection is essential to the development of cyclonic circulation.