An Examination of Summertime Cyclones in the Context of the Classical Warm Conveyor Belt Definition Established During the Cool Season

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1. Introduction

- Warm Conveyor Belt
  - A narrow stream of air that transports large amounts of heat, moisture, and westerly momentum (Glossary of Meteorology)
  - Air which originated far south of the low in the warm sector, moved north, and joined the upper-level westerly flow northeast of the low center (Carlson, 1980)

Study Objectives:
- WCBs and deep convection have been shown to be the primary mechanisms for transporting pollution during the cool season
- Characteristics of lifting and transport mechanisms observed during INTEX-A are documented and compared to the classical cases

2. Data

- MM5 Domain:
  - Positionned over United States and western Atlantic
  - 6 km horizontal separation
  - 40 vertical sigma levels

- Initialization Data:
  - Initial and lateral boundary conditions obtained from 3-D global reanalyses prepared by NCEP and available from NCAR
  - 6-hour intervals
  - Horizontal resolution
  - FDDA employed to nudge the model toward synoptic analyses

- MM5 Parameterization:
  - Kain-Fritsch cumulus parameterization scheme
  - MRF PBL
  - Simple Ice (Dudhia) microphysical scheme

- Model Output:
  - Hourly wind data from MM5 used to calculate forward air trajectories out 2 days
  - In addition to MM5 output parameters, convective upward mass flux from Kain-Fritsch archived

- 700 hPa grid scale vertical motion utilized in forward trajectory calculations

- 19 Jul 2004
- Broad region of low pressure along east coast at 12 UTC

3. Classical WCB Case (05 Dec 1977)

- Synoptic Pattern:
  - 25 Dec 1977
  - Minimum central pressure 982 hPa at 12 UTC
- Forward Trajectories and Mass Flux:
  - At infl. 700 hPa grid scale vertical motion utilized in forward trajectory calculations
- Warm conveyor belt (WCB), cold conveyor belt (CCB), and dry intrusion (DI)

- 2 day forward trajectories starting at 900 hPa, indicating location of possible WCB
- Largest ascent near cyclone center


- Synoptic Pattern:
  - 17 July 1556 UTC
  - Sub-grid scale convective UMF found at INTEX-A trajectory locations, but not at Carlson’s trajectory locations
  - 2 day forward trajectories indicate air lofted from the boundary layer to the free troposphere in all cases

- Forward Trajectories and Mass Flux:
  - 700 hPa grid scale convective upward mass flux (not included in trajectory vertical motion) interpolated to 4-D trajectory locations
  - Note lower magnitude than Carlson’s case

- Sub-grid scale normalized upward convective mass flux
- Maximum value over output frequency shown

- 2 day forward trajectories starting at 900 hPa, indicating location of possible WCB
- Largest ascent away from cyclone center

5. Additional WCB Cases:

6. Discussion

- Study Objectives:
  - Define WCB
  - Maximum central pressure 992 hPa at 12 UTC

- Characteristic of lifting and transport mechanisms observed during INTEX-A are documented and compared to the classical cases

- Sub-grid scale convective UMF found at INTEX-A trajectory locations, but not at Carlson’s trajectory locations
- 2 day forward trajectories indicate air lofted from the boundary layer to the free troposphere in all cases

- Classical WCB ascent is gradual and does not rise rapidly until reaching the warm front (near the cyclone)

7. Results

- Summertime transport resembles the WCB, however, lofting often takes place very quickly (away from the cyclone) due to convection
- Convection dominates lofting in the summertime

- Classical WCB ascent is gradual and does not rise rapidly until reaching the warm front (near the cyclone)

- Sub-grid scale convective UMF found at INTEX-A trajectory locations, but not at Carlson’s trajectory locations
- 2 day forward trajectories indicate air lofted from the boundary layer to the free troposphere in all cases

- Cooling, humidity, and temperature advection terms (not shown) all support downward vertical transport in Carlson’s case
- These patterns are much weaker in warm season than Carlson’s
- Sub-grid scale convective UMF found at INTEX-A trajectory locations, but not at Carlson’s trajectory locations
- 2 day forward trajectories indicate air lofted from the boundary layer to the free troposphere in all cases

- Convective upward mass flux from Kain-Fritsch archived
- Note lower magnitude than Carlson’s case

- Sub-grid scale normalized upward convective mass flux
- Maximum value over output frequency shown

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