Polar Satellite Microwave Observations of Severe Convective Storms: A Study of Post-Tropical Cyclone Sandy as a Mesoscale Convective System

UMBC

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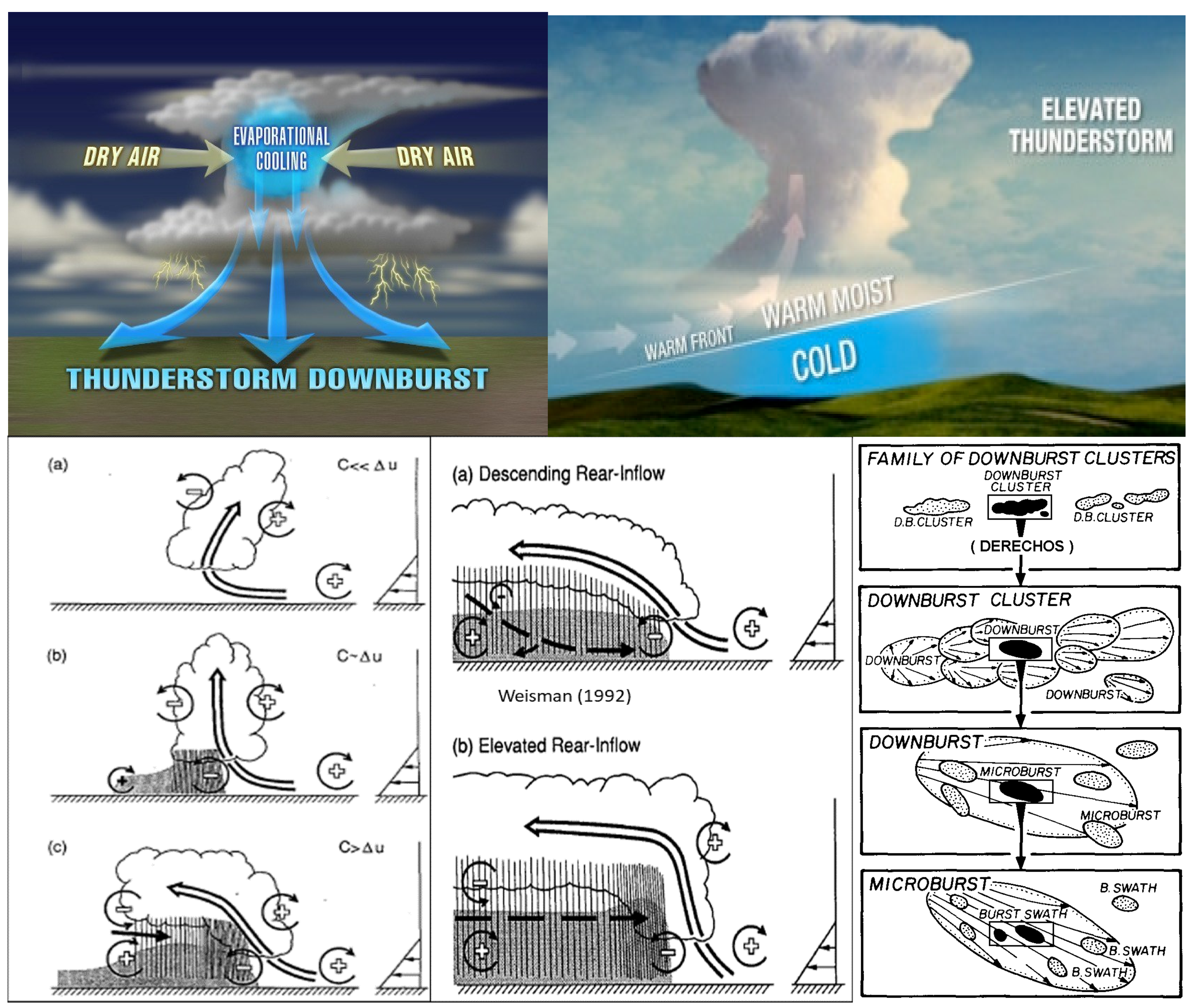
1. INTRODUCTION AND BACKGROUND

Convective storms that generate hail, lightning, and damaging winds have been identified as a formidable hazard to life and property. Even more impactful are stronger storms that generate and loft liquid-phase hydrometeors to high altitudes where freezing occurs and collisions between drops, graupel, and ice crystals lead to electrification. Condensate loading, sometimes combined with the lateral entrainment of subsaturated air in the storm middle level, initiates the convective downdraft. The subsequent melting of frozen hydrometeors and subcloud evaporation of liquid precipitation, in conjunction with precipitation loading, result in the cooling and negative buoyancy that accelerate the downdraft in the unsaturated layer. A **downburst**, in general, is defined as a **strong downdraft** that induces an outburst of damaging winds at or near the ground, and a **microburst** as a very small downburst with an outflow diameter of less than 4 km and a lifetime of less than 5 minutes.

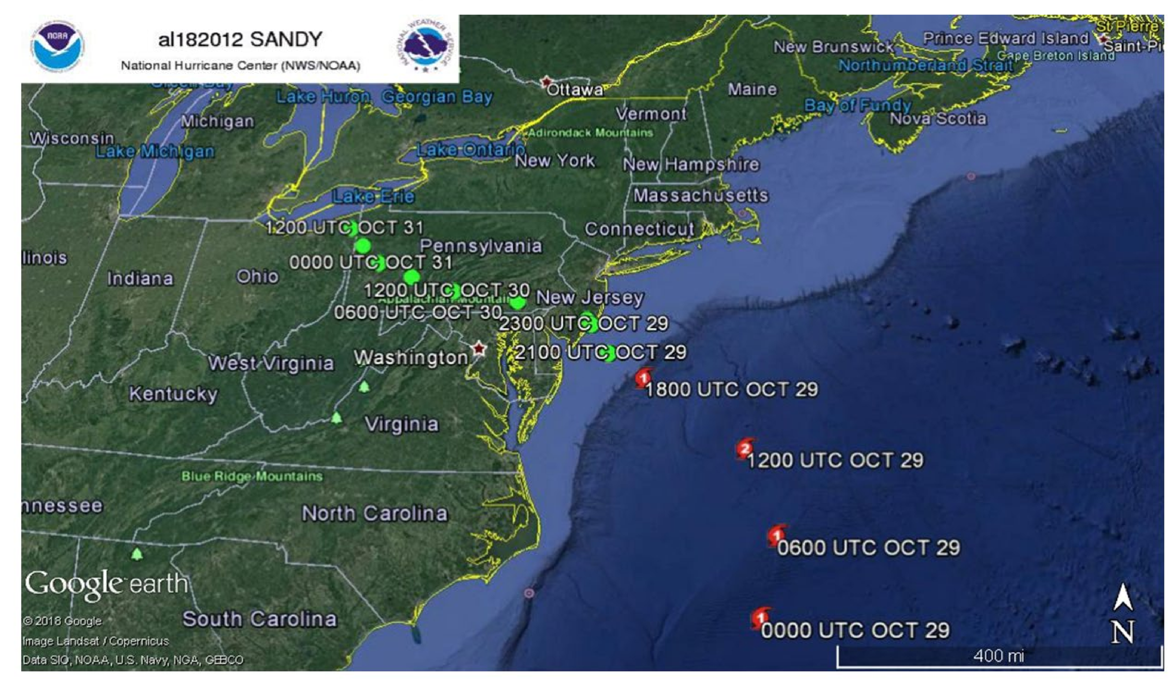


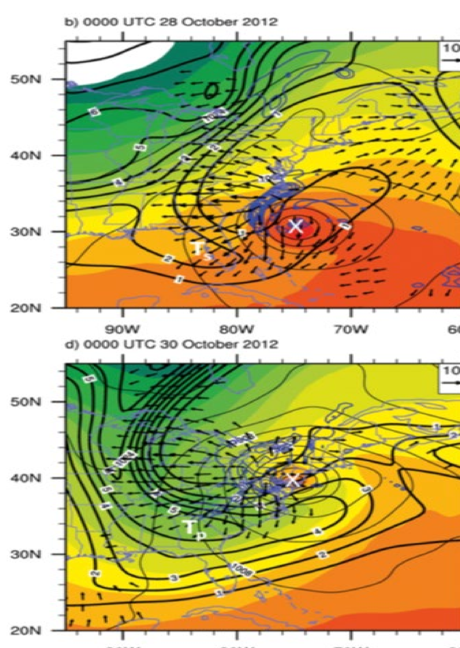
Conceptual models of downburst generation within ordinary thunderstorms and mesoscale convective systems.

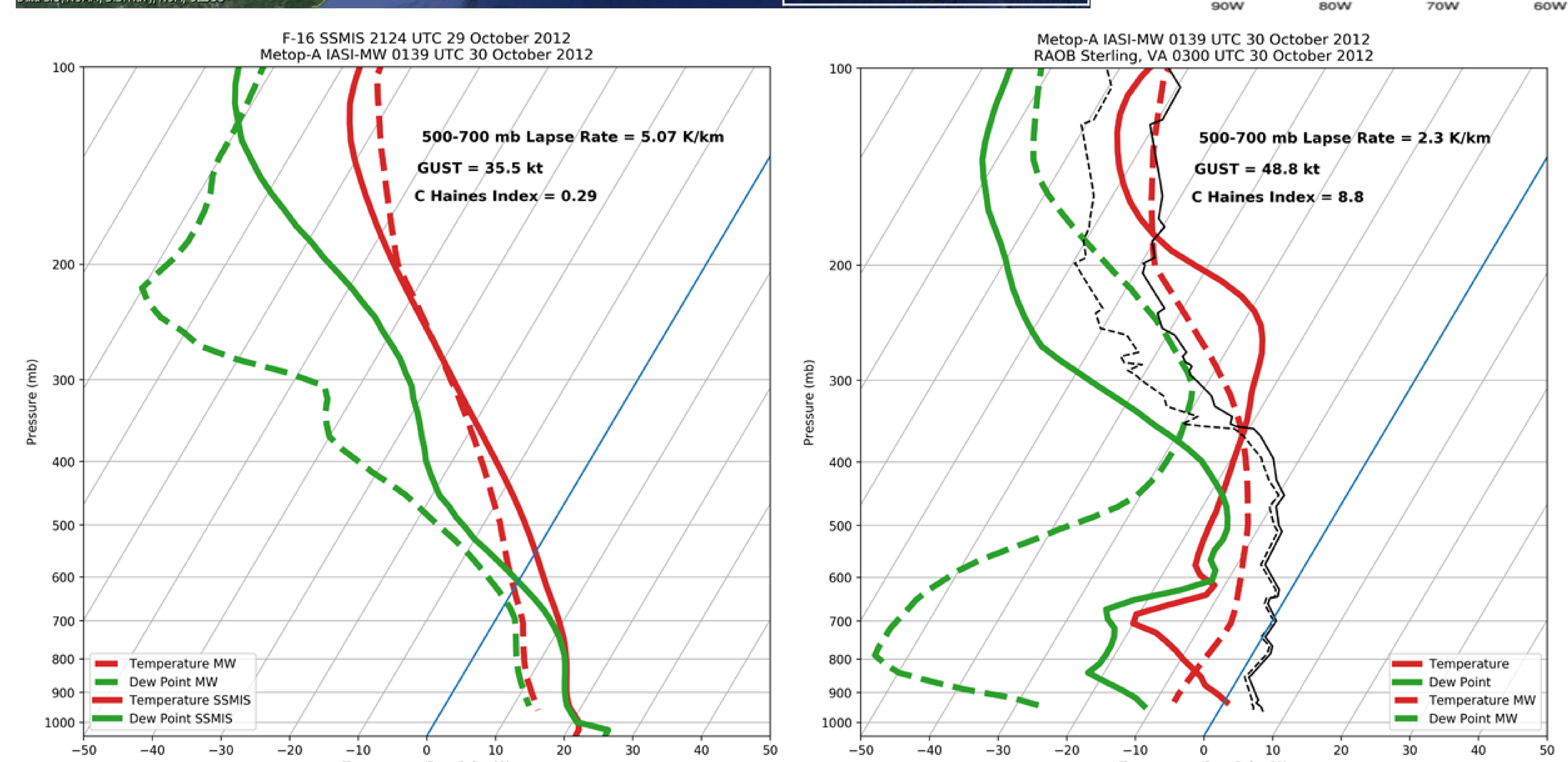
Elevated convection involves the process of convective lifting of air initiated above the planetary boundary layer and can be locally enhanced by diabatic heating in a zone of frontogenesis. This process can be especially favored with landfalling tropical cyclones that interact with a baroclinic environment that establishes a solenoidal circulation superimposed on a frontal boundary. The baroclinic setting that favors frontogenesis in the vicinity of a tropical cyclone (TC), which can eventually result in extratropical transition (ET), also favors the significant intrusion of mid-tropospheric "dry" (unsaturated) air that typically impinges on the front or right semicircles of the tropical cyclone. Initially associated with large scale TC tornado outbreaks, the midlevel dry intrusion into remnant eye wall convection and inner convective rainbands may also favor severe and damaging surface outflow (downburst) winds fostered by evaporational and sublimational cooling and enhanced by ice-phase precipitation loading and downward horizontal momentum transport.

2. Extratropical Transition and Landfall of Post-TC Sandy, 29-30 October 2012

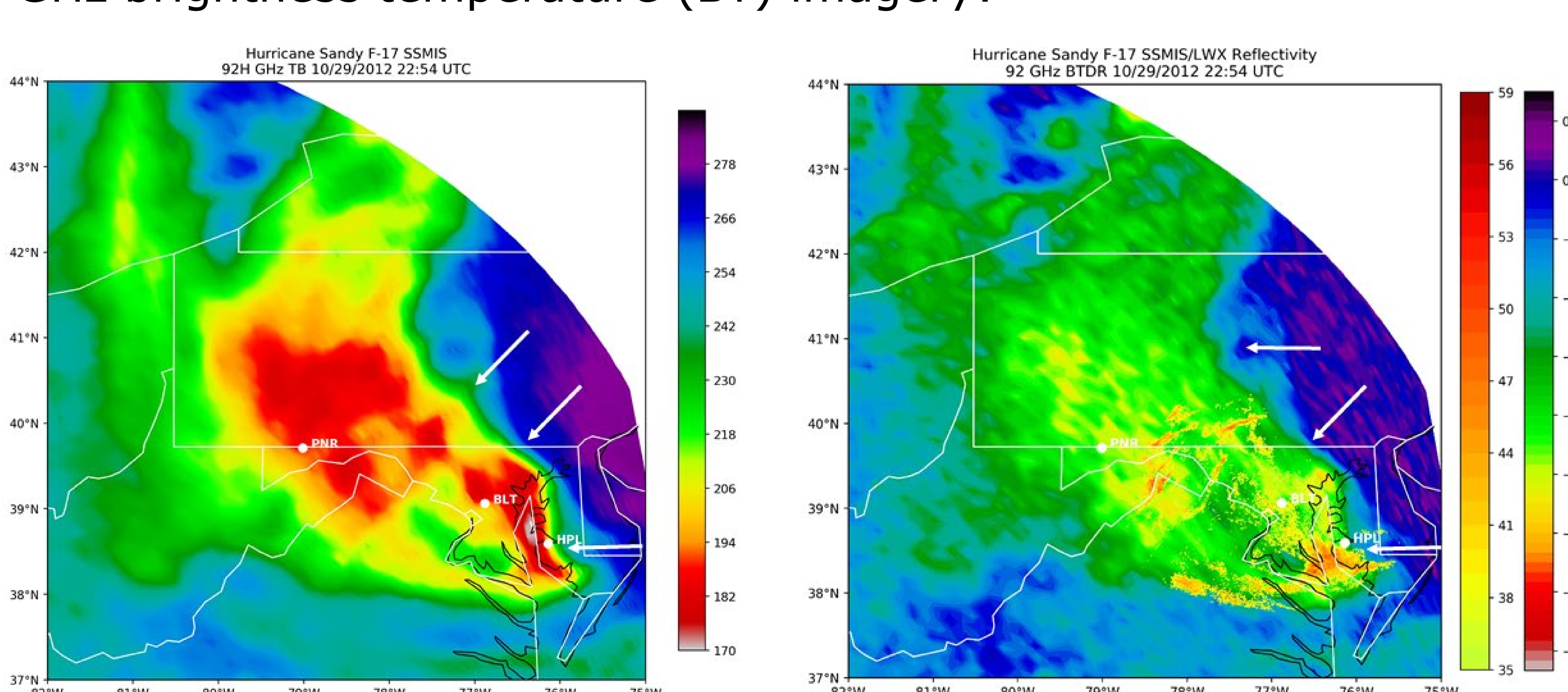
During the evening of 29 October 2012, category 1 Post-Tropical Cyclone (TC) Sandy made landfall on the Atlantic coast of New Jersey near Atlantic City. Prior to landfall, Sandy was in the process of extratropical transition (ET) that entailed a warm core seclusion (WCS) stage that resulted in a secondary peak in intensity. This type of ET favored the development of a band of heavy precipitation in the left-front quadrant of the storm and the subsequent generation of severe and damaging surface winds over the Mid-Atlantic region as Post-TC Sandy tracked westward inland.





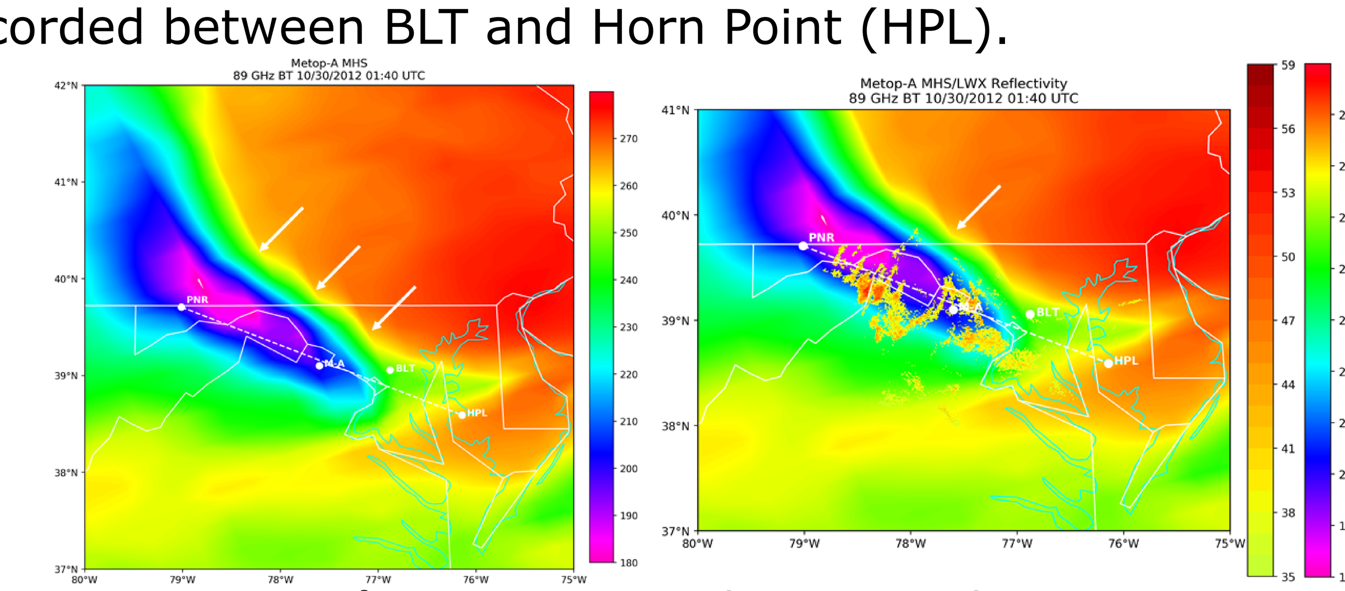


DMSP F-16 SSMIS and Metop-A IASI microwave (MW) sounding profiles display significant mid-tropospheric drying near the TC center at the time of landfall (left) and farther inland within the left-front quadrant (right). A convective rainband developed in the potential vorticity (PV) gradient region south of the eye of Post-TC Sandy, with a prominent dry-air intrusion apparent in F-17 SSMIS 92 GHz brightness temperature (BT) imagery:

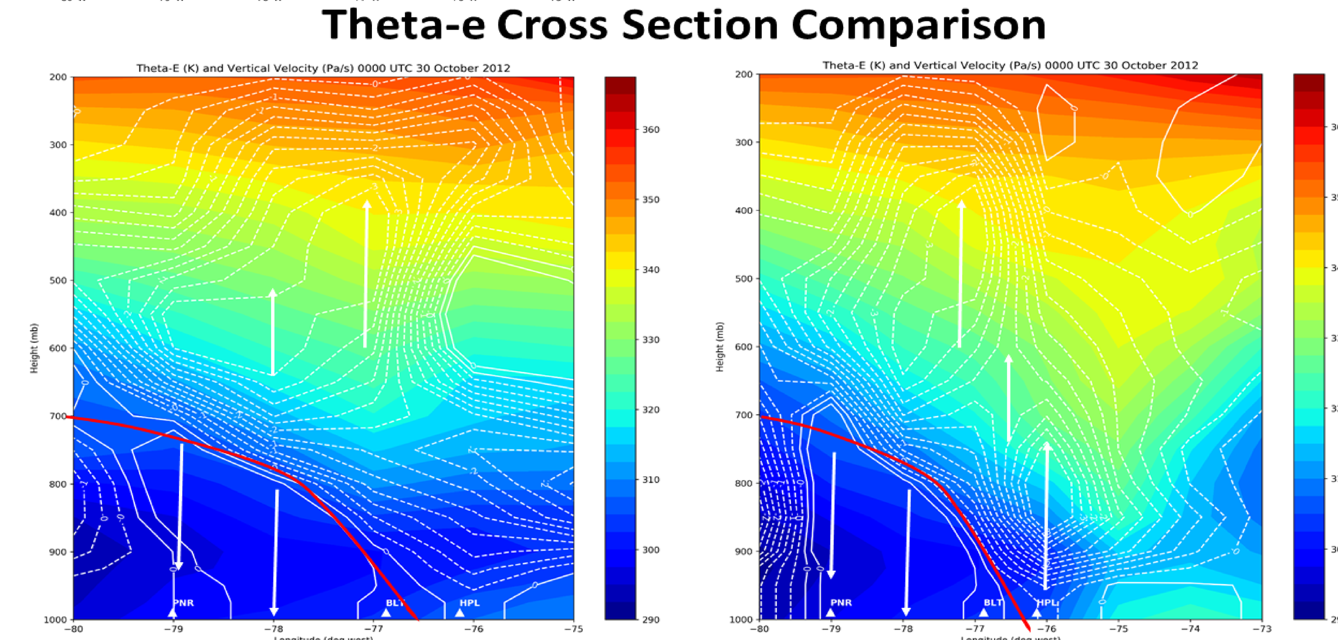


3. Elevated MCS Development after TC Landfall

GFS Final ("FNL") Operational Global Analysis dataset at 0000 UTC 30 October 2012, near the time of Sandy's landfall, is applied to study the vertical structure of the troposphere in the left-front quadrant region. Theta-e cross sections more effectively show this region as a large elevated mesoscale convective system (MCS) with strong, warm updrafts, overlying cold downdrafts that comprise the cold pool region over Piney Run (PNR) to Beltsville (BLT), Maryland. Evidently, the theta-e profiles correspond to maximum surface winds recorded between BLT and Horn Point (HPL).

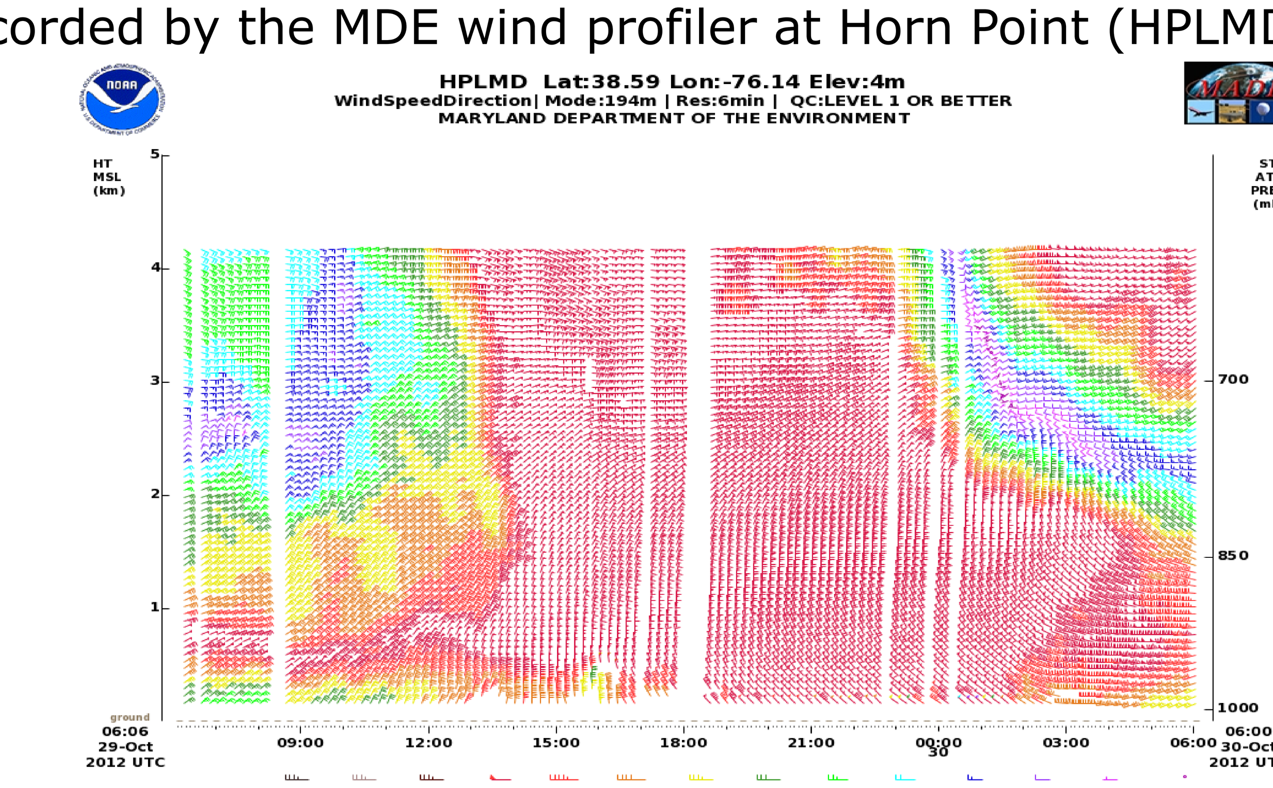


Theta-e Cross Section Comparison



Cross Section from PNR-HPL — Latitudinal (zonal) cross section at 39° N

Theta-e cross section imagery highlights the role of elevated convection in the left front quadrant of the post-TC in the generation of heavy precipitation and damaging winds, as recorded by the MDE wind profiler at Horn Point (HPLMD):



References are available by request.

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