Upper-Level Precursors Associated with Subtropical Cyclone Formation in the North Atlantic Basin

(Oral Presentation)

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Oceanic cyclones exhibiting properties of both tropical and extratropical systems have been categorized as subtropical cyclones (STCs) since the early 1950s. The opportunity to investigate the roles of baroclinic and diabatic processes during the evolution of STCs from a potential vorticity (PV) perspective motivates this study. The development of STCs requires the existence of a baroclinically unstable environment, quasigeostrophic forcing for ascent, and the production of lower-to-midtropospheric PV by diabatic heating. Previous studies have established that STC formation is associated with weak lower-tropospheric baroclinicity, significant lower-to-midtropospheric PV, and relatively cold upper-tropospheric air accompanying intrusions of midlatitude PV streamers into the subtropics. The hybrid nature of STCs makes them potential candidates to become tropical cyclones (TCs) via the tropical transition (TT) process.

We will investigate the roles of baroclinic and diabatic processes during the evolution of STCs by calculating three PV metrics from the NCEP Climate Forecast System Reanalysis 0.5° gridded dataset. The three PV metrics quantify the relative contributions of: 1) lower-tropospheric baroclinic processes, 2) midtropospheric diabatic heating, and 3) upper-tropospheric dynamical processes during the evolution of individual cyclones. Quantification of these three contributions reveals the changing PV structure of an individual cyclone, indicates fluctuations in the dominant energy source of the cyclone, and aids in distinguishing between cyclone types.

A cyclone-relative composite analysis of North Atlantic STCs identified in a 1979–2010 climatology will be presented to document the structure, motion, and evolution of upper-tropospheric features linked to STC formation. This composite analysis highlights precursor midlatitude anticyclonic wave breaking (AWB) events that inject relatively cold upper-tropospheric air into the subtropics in association with PV streamers. Such intrusions of relatively cold upper-tropospheric air can help to destabilize the subtropical troposphere and facilitate the development of the deep convection that can serve as a catalyst for STC formation. A synoptic overview of STC Sean (2011) will be presented as an illustrative case of STC formation. Sean formed beneath the fractured equatorward end of an elongated PV streamer on the equatorward side of a fold-over ridge produced by an antecedent AWB event. An evaluation of the relative contributions of lower-tropospheric baroclinic processes, midtropospheric diabatic heating, and upper-tropospheric dynamical processes during the evolution of STC Sean (2011) reveals the reduction of upper-tropospheric PV and enhancement of midtropospheric PV during TT, as well as an enhancement of lower-tropospheric baroclinicity as the cyclone becomes extratropical.