Exploring Damaging Winds During Extratropical Transition of Tropical Storm Michael over North Carolina

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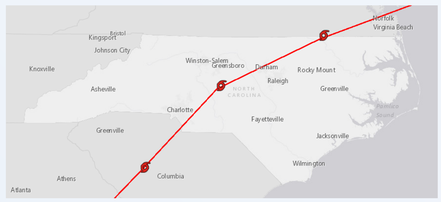
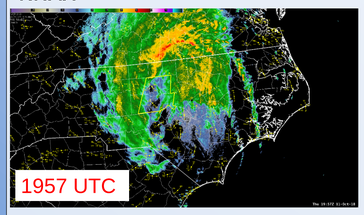
Introduction

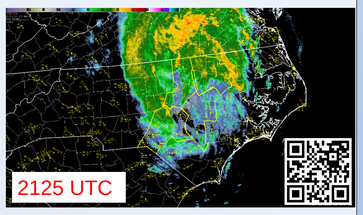


During the morning of 11 October 2018, a weakening Tropical Storm Michael approached North Carolina from the southwest. Amidst a background of tropical storm force winds and in a statically stable environment, damaging 50 to 60 mph winds developed on the western side of Michael as it passed through central North Carolina and southern Virginia during the afternoon. Downed trees, power outages, and structural damage were reported across the northwest Piedmont of North Carolina. We hypothesize that these gusts were further enhanced by the interaction of Michael, which was undergoing extratropical transition, with a polar front crossing the central Appalachians. This study investigates Michael's extratropical transition and damaging wind gusts using observational and numerical weather prediction (NWP) data. While the corridor of damaging wind gusts was well-simulated by high-resolution NWP guidance and identified by operational forecasters, it presented a challenge regarding how best to message the associated threats and impacts.

Radar and Warnings

KRAX



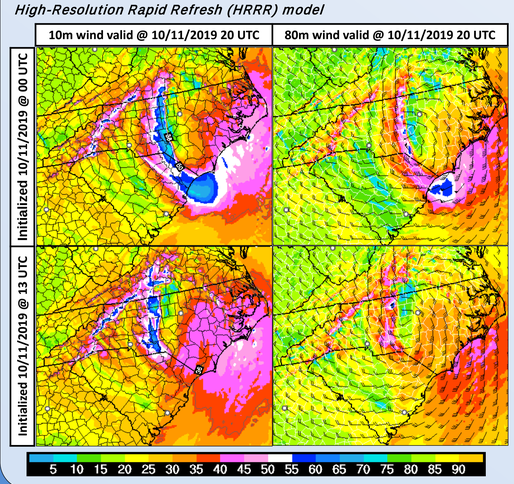


- 6 severe thunderstorm warnings issued
- 26 counties covered by a severe thunderstorm warning

Scan the QR code for a radar animation.

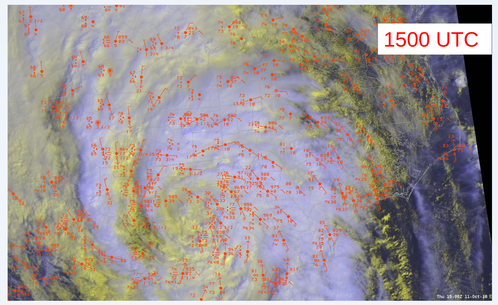
Model Detection

High-Resolution Rapid Refresh (HRRR) model

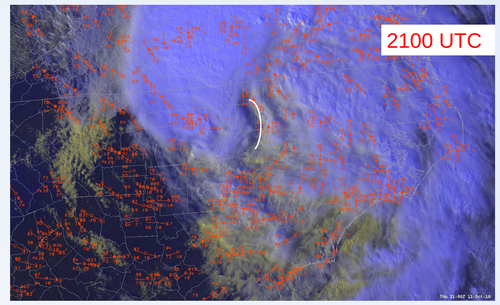


- Both 10m and 80m winds showed the potential for damaging winds
- Wind gust potential up to 70kts
- Explicit wind prediction up to 60kts in areas

GOES-16 Satellite Indicators



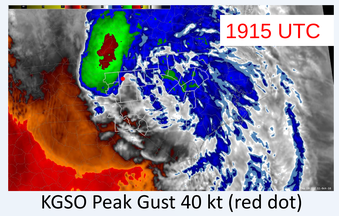
(a)



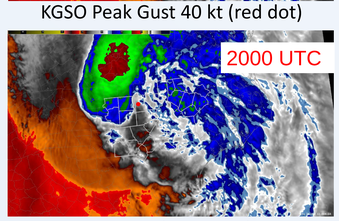
(b)

(a)1500 UTC 11 OCT 2018: Daytime Cloud Convection RGB imagery showing Michael still exhibiting tropical characteristics with the center over the NC/SC border near Charlotte, NC, and (b) 2100 UTC: Michael showing signs of extratropical transition, with the northern half of the outer rainband widening and turning inward towards the new low forming around a jet enhancement annotated above.

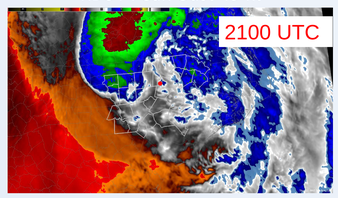
Water Vapor



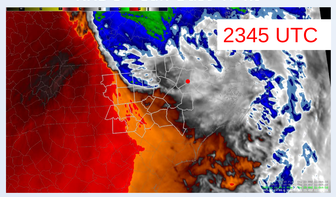
KGSO Peak Gust 40 kt (red dot)



KBUY Peak Gust 49 kt

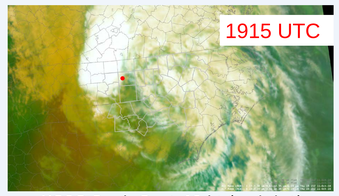


KRDU Peak Gust 47 kt



KRWI Peak Gust 53 kt

Air Mass RGB



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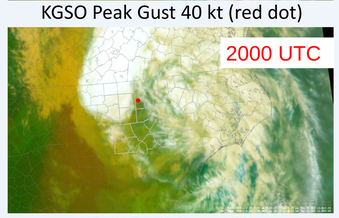

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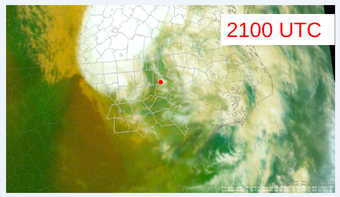

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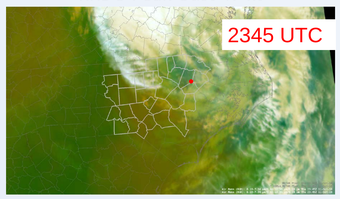
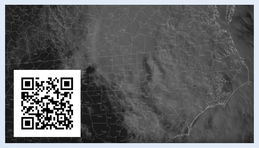


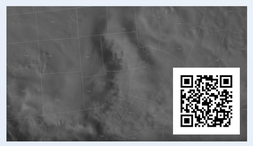
KRWI Peak Gust 53 kt

Extratropical transition (ETT) was evident in the Air Mass RGB from GOES-16. The once-distinct storm center began to elongate NW to SE as it moved toward the northeast, signaling the ETT and an areal expansion of the wind field. Darker red and orange shades WSW of the center as it crosses the Carolinas are indicative of drier air and a possible PV maximum that may have served to enhance the surface winds.

Visible Satellite Animation

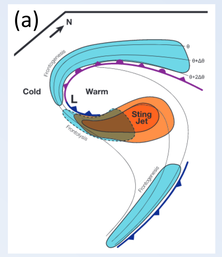


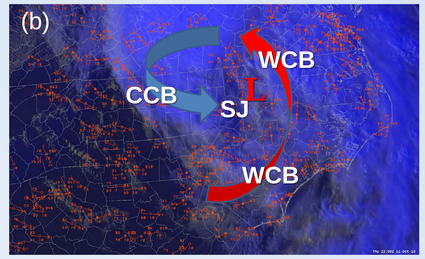
Scan the QR code for a wide animation of the extratropical transition.



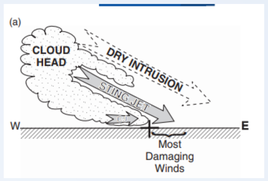
Scan the QR code for a zoomed animation of the damaging wind-producing feature.

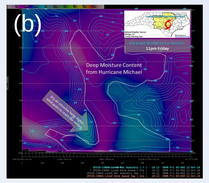
Sting Jet or Something Else?

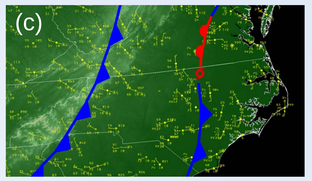




(a) Schematic from Martinez-Alvarado et al. (2014) illustrating the location of a sting jet in an extratropical cyclone, and (b) Daytime Cloud Convection RGB imagery from Michael with potential sting jet (SJ), cold conveyor belt (CCB), and warm conveyor belt (WCB) features labeled around the newly forming low pressure center.







(a) Conceptual model from Clark and Gray (2018) of a cross-section through the frontal-fracture region of an ETC. The west-east section shows the sting jet descending from mid-levels within the cloud head, beneath the descending dry intrusion and above the cold conveyor belt. (b) Social media graphic from WFO RAH depicting GFS20 39-hr forecast of dry air intrusion. (c) Surface analysis from 2200 UTC with Michael transitioning to an extratropical cyclone. One feature not observed was the classic back-bent front from the Shapiro-Keyser Model (Shapiro and Keyser 1990).

Messaging Challenges

While tropical storm warnings were in effect in central NC, NWS Raleigh wanted to highlight the markedly stronger winds capable of producing damage. Severe thunderstorm warnings were issued to highlight these particularly dangerous winds and heighten awareness that these winds would be different than what people had been experiencing. While this decision was not without controversy, its intended goal of encouraging people to take notice and seek extra protection was rooted in striving to provide the best service possible. We plan further investigation of the impact of such warnings in tropical situations, along with consideration of other options for future such events.

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Acknowledgments

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