Understanding the Cyan Ring Signature in 37-GHz Passive Microwave Imagery through Airborne Radar

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1. Research Goal

Understanding the physical structures that produce the 37-GHz color composite cyan ring signature

- The cyan ring signature, indicative of warm rain, is often associated with rapid intensification (Kieper and Jiang 2012, GRL)
- Current hypothesis: The cyan ring is produced by rain being advected azimuthally beyond the parent deep convection of the eye wall by a strong primary circulation

2. The 37-GHz Color Composite

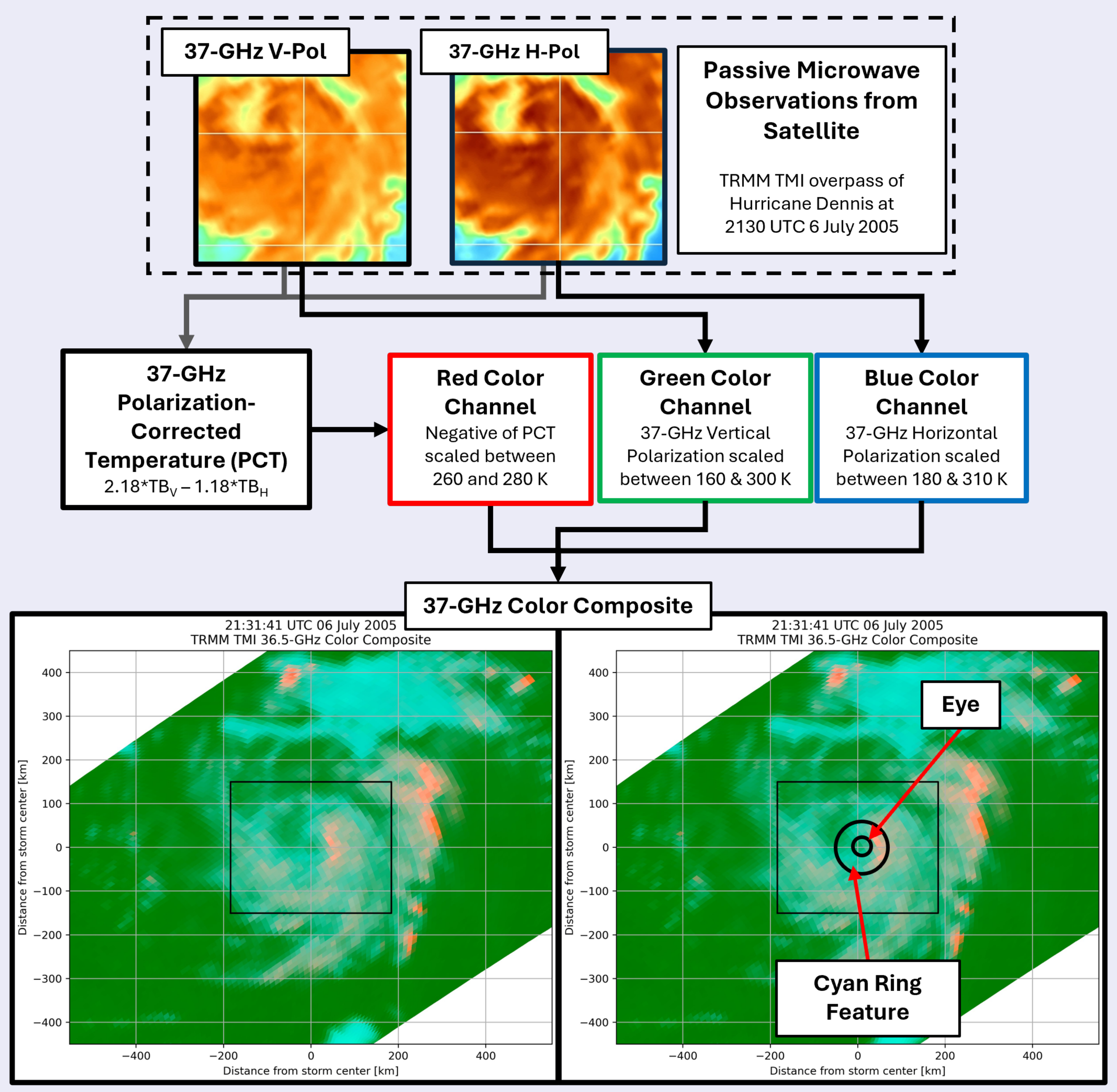

Fig. 1. 37-GHz color composite imagery is generated using (top row) the horizontal and vertical polarization channels. (middle row) The red, green, and blue color channels are populated by byte-scaled arrays of the polarization-corrected temperature, vertical polarization, and horizontal polarization, respectively, and these three color channels are combined to produce (bottom row) the final RGB image. The inset horizontal and vertical polarization images in the top row are taken from the NRL Monterey tropical cyclone website.

3. Airborne Data

- Airborne data presented here were collected as part of the NASA Tropical Cloud Systems and Processes (TCSP) field campaign

EDOP NASA ER-2

- X-band Doppler radar
- Two beams: one at nadir and one pointing 30° forward
- Vertical structure of precipitation
- Along-track wind from dual-Doppler analysis

AMPR NASA ER-2

- Passive microwave radiometer: 10 GHz, 19 GHz, 37 GHz, 85 GHz
- Cross-track scan; polarization depends on angle
- Identify cyan ring by comparison with satellite data

LF Radar NOAA WP-3D

- C-band radar mounted on lower fuselage
- 360° horizontal scan pattern
- Map horizontal structure of precipitation features

4. Overview of Dennis (2005)

- Dennis underwent a rapid intensification shortly after genesis (Fig. 2 top)
- During this initial rapid intensification, Dennis was observed by TRMM, followed ~3.5 hours later by the NASA ER-2 and NOAA WP-3D
- Central dense overcast present during overpass (Fig. 2 right) started forming with a series of convective bursts just east of the circulation center between 1400 and 1800 UTC 6 July

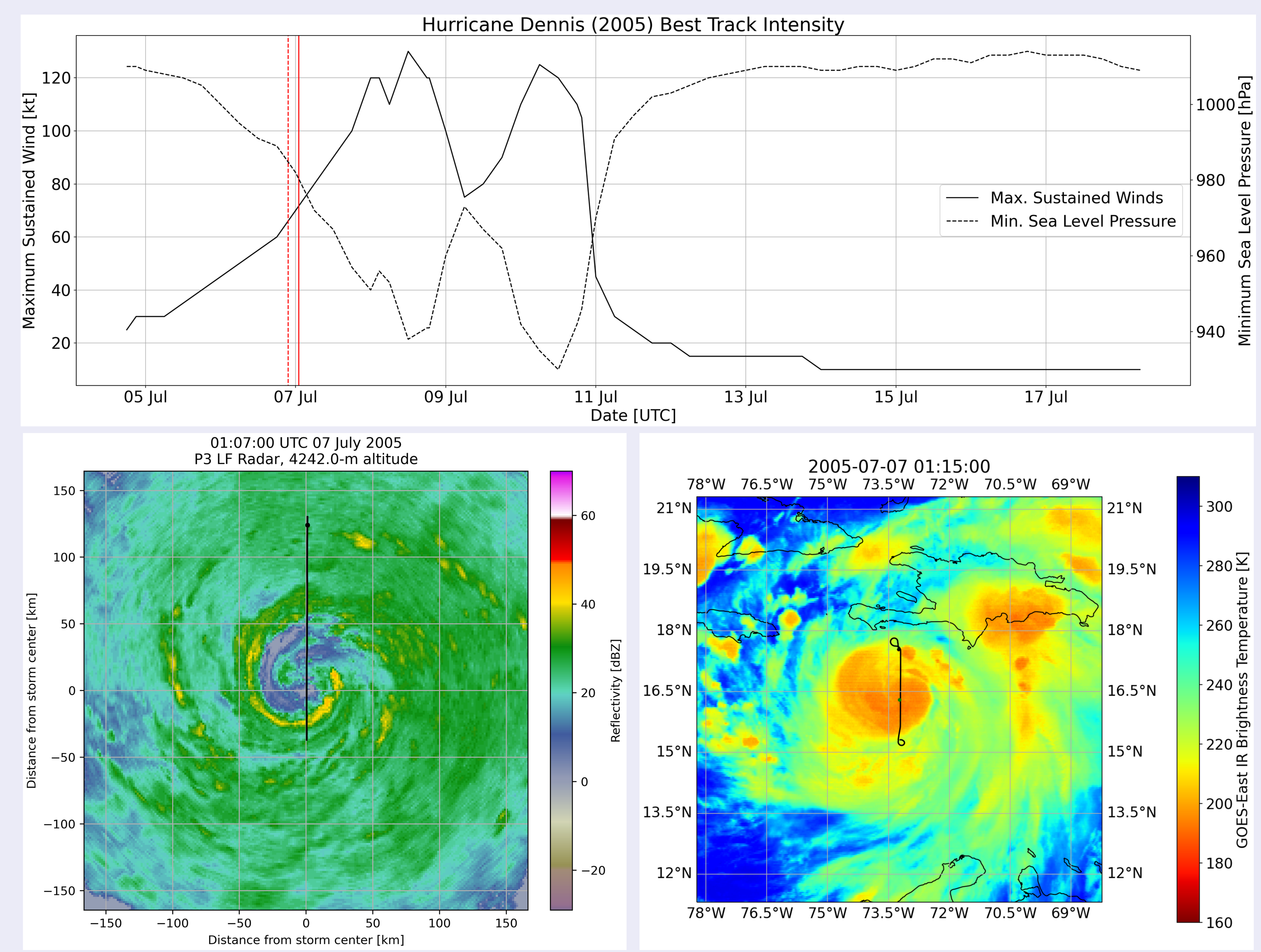

Fig. 2. Hurricane Dennis (top) best track intensity time series, (left) P3 lower fuselage radar view valid at 0107 UTC 7 July, and (right) GOES-East IR image valid at 0115 UTC 7 July 2005. The solid and dashed red lines on the intensity time series indicate the times corresponding to the ER-2 flight leg of interest and the TRMM overpass of interest, respectively. The ER-2 flight leg of interest is indicated by the black line.

5. Passive Microwave View of the Cyan Ring

- Location of ER-2 flight leg corresponds to location of cyan ring as of TRMM overpass, ~3.5 hours prior (Fig. 4 left)
- AMPR imagery indicates some features remain at the flight leg time: deep convection to the northwest of the eye; weakness in the eye wall, unclear if weakness extends to western side of eye wall at 37 GHz

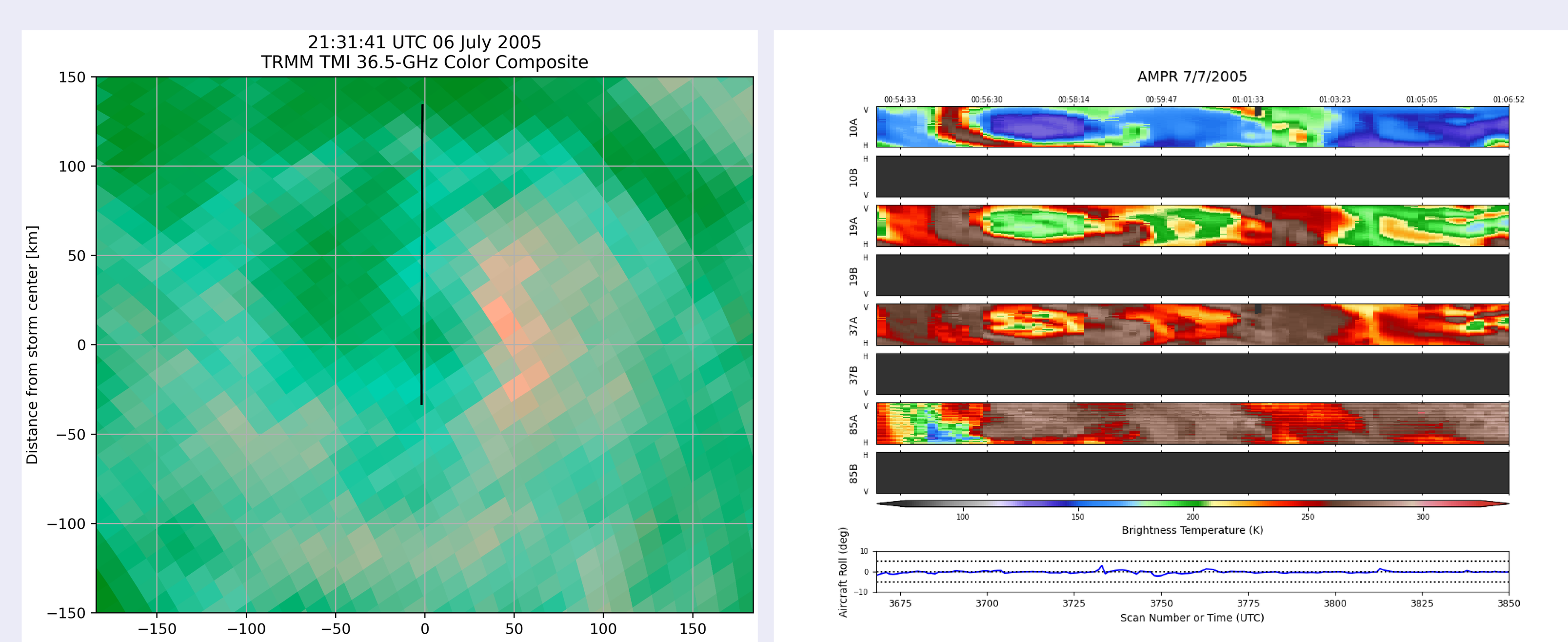

Fig. 3. (left) TRMM TMI 36.5 GHz color composite image valid at 21:31 UTC 6 July 2005. (right) AMPR swath strips from the ER-2 flight leg of interest for each of the AMPR frequencies. Note, AMPR only had the 'A' feed horn installed during the TCSP field campaign. The vertical black line in the left panel indicates the storm-relative location of the ER-2 during the AMPR swath strips. The AMPR strip plot was produced using the pyAMPR python package.

6. Radar View of the Cyan Ring

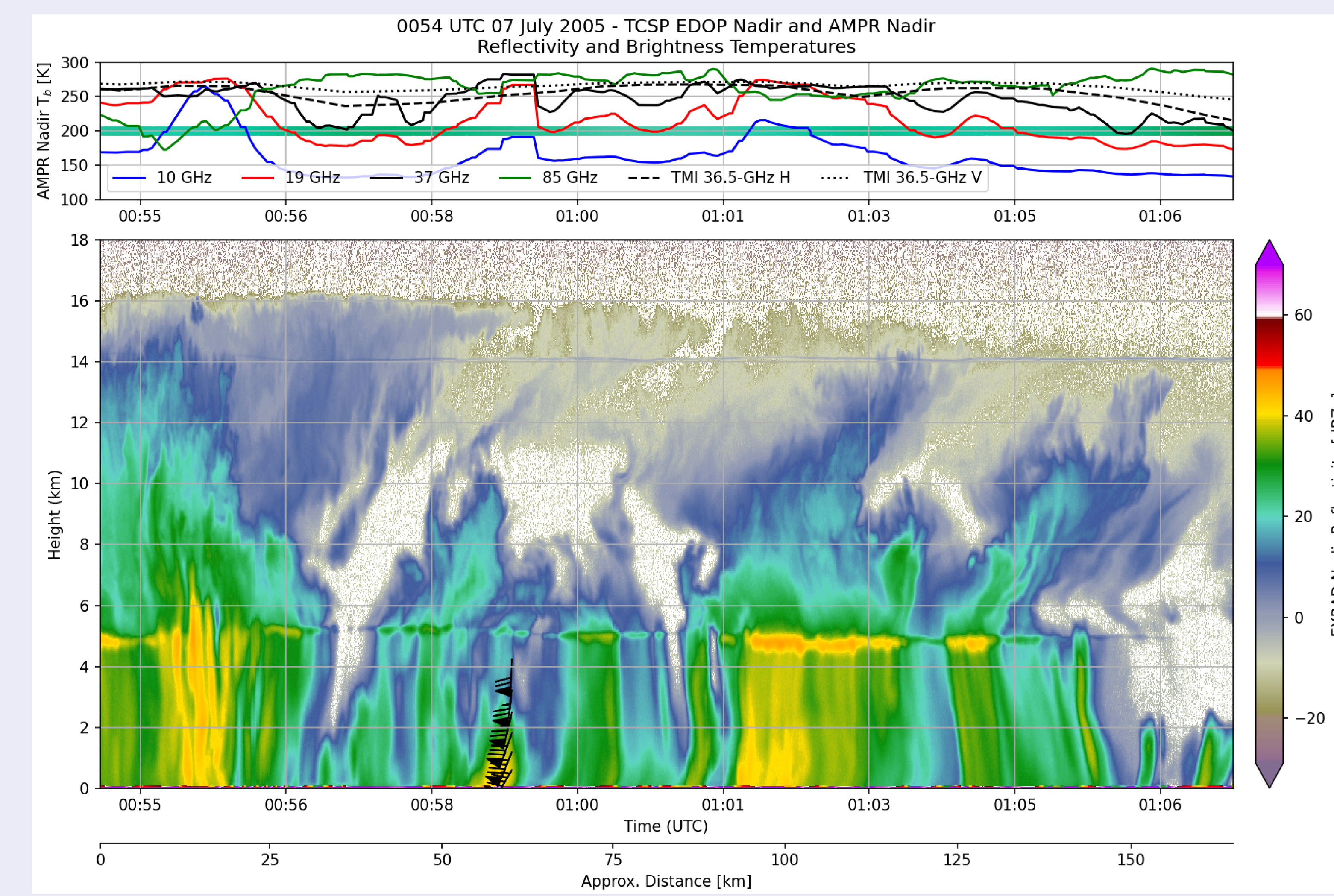

Fig. 4. EDOP nadir-antenna reflectivity curtain with (top) corresponding nadir traces of AMPR brightness temperatures and the TRMM TMI horizontal and vertical polarization channels and color composite (green-blue line) at the storm-relative location corresponding to the ER-2 overpass. A dropsonde-observed wind profile is depicted, in knots, by the wind barbs.

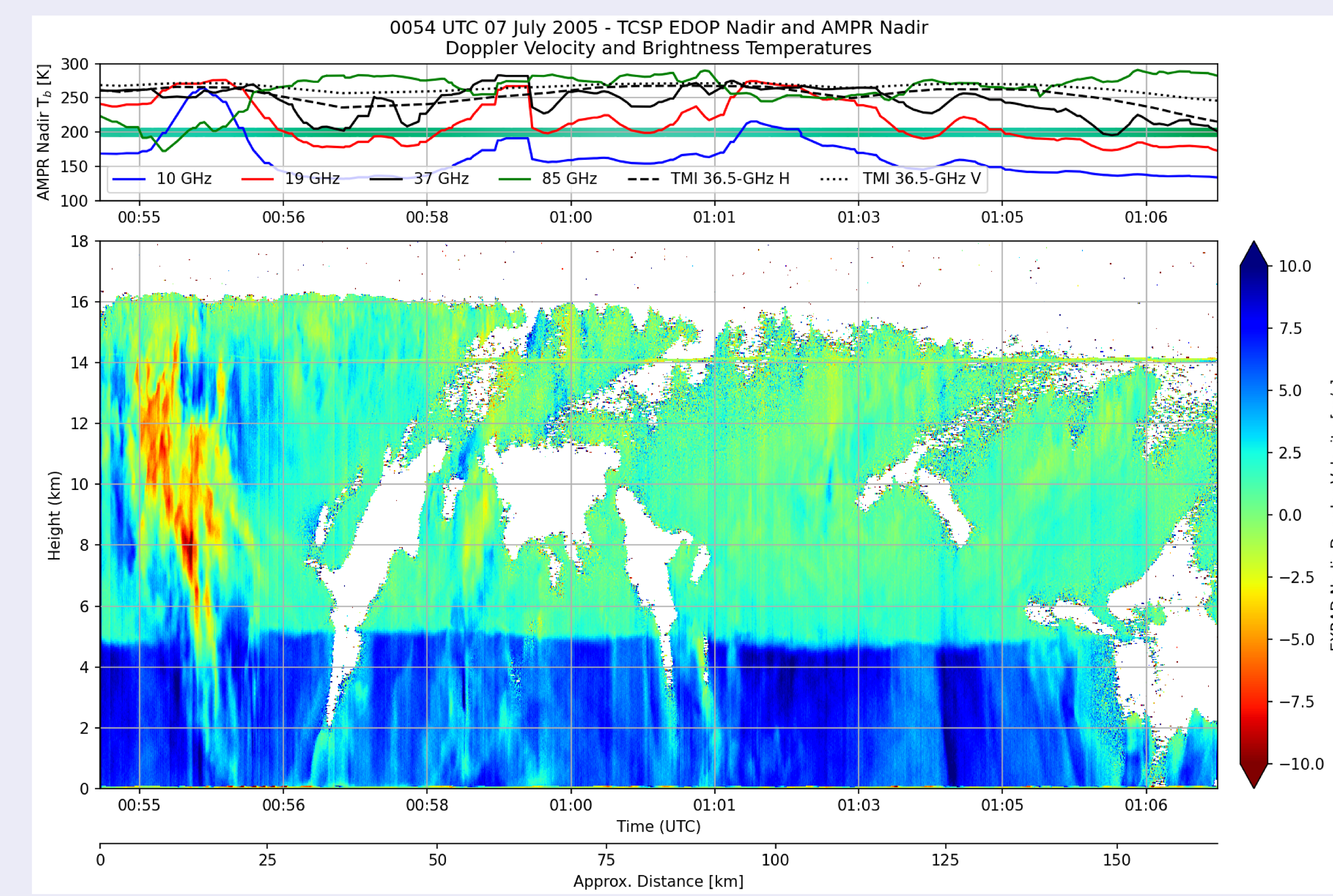

Fig. 5. As in Fig. 4, EDOP nadir-antenna Doppler velocity is depicted. Positive (blue) values indicate particle motions away from the radar (i.e., downward).

Conclusions

- EDOP indicates light rain in the developing northern eye wall collocated with the storm-relative location of the cyan ring in the TRMM overpass.
- Given the strong horizontal winds, early results tentatively support the hypothesis that the cyan ring is produced by rain advected out of deep convection located azimuthally upstream

Acknowledgements

The authors would like to thank Timothy Lang for his help in interpreting the AMPR data and developing the pyAMPR python package. Additionally, the authors would like to thank the Hurricane Research Division for providing the lower fuselage radar data. Finally, the authors are indebted to the participants of the TCSP field campaign for their efforts in collecting the data used here (http://dx.doi.org/10.5067/TCSP/DATA101). This work was supported by NASA grant number 80NSSC23K1527.

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