Low-Frequency Gravity Waves within MCS Stratiform Regions

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Objective: Identify observational evidence of low-frequency gravity wave generation by MCSs, and their subsequent impacts on the wind field.

MC3E 20 MAY 2011 MCS

WAVE IDENTIFICATION: LONG-LIVED, TRAILING STRATIFORM MCS

Using consistent high-pass filtered pressure signals, we can identify 4 wave-like features moving roughly NE across Oklahoma in the MCS stratiform region.

Calculations estimate ground-relative wave speeds of ~5-15 m s^{-1}, roughly agreeing with mode n=2, 3, or 4 speeds.

Horizontal wind perturbation profiles agree with n=2 structure.

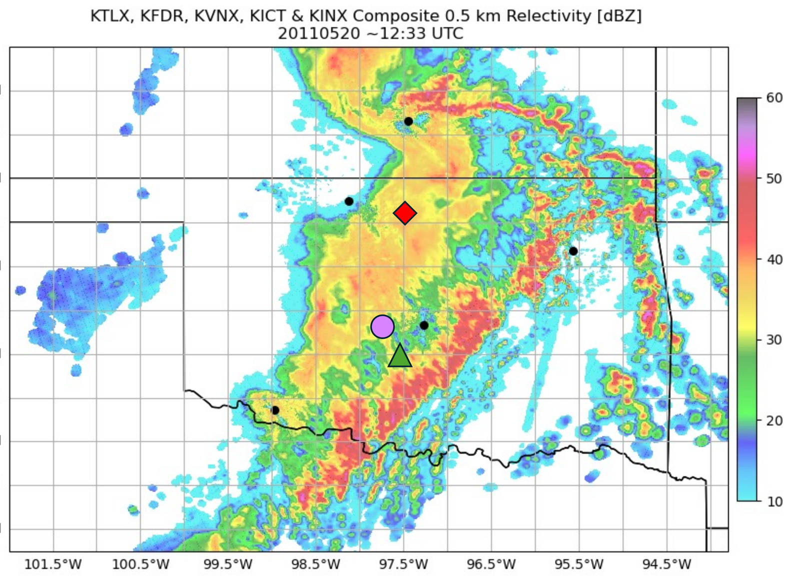

Fig. 1: Composite 0.5-km reflectivity. Purple, green, and red shapes denote the locations of the MINC Mesonet station, PRCO2 NOAA wind profiler, and SGP CF, respectively.

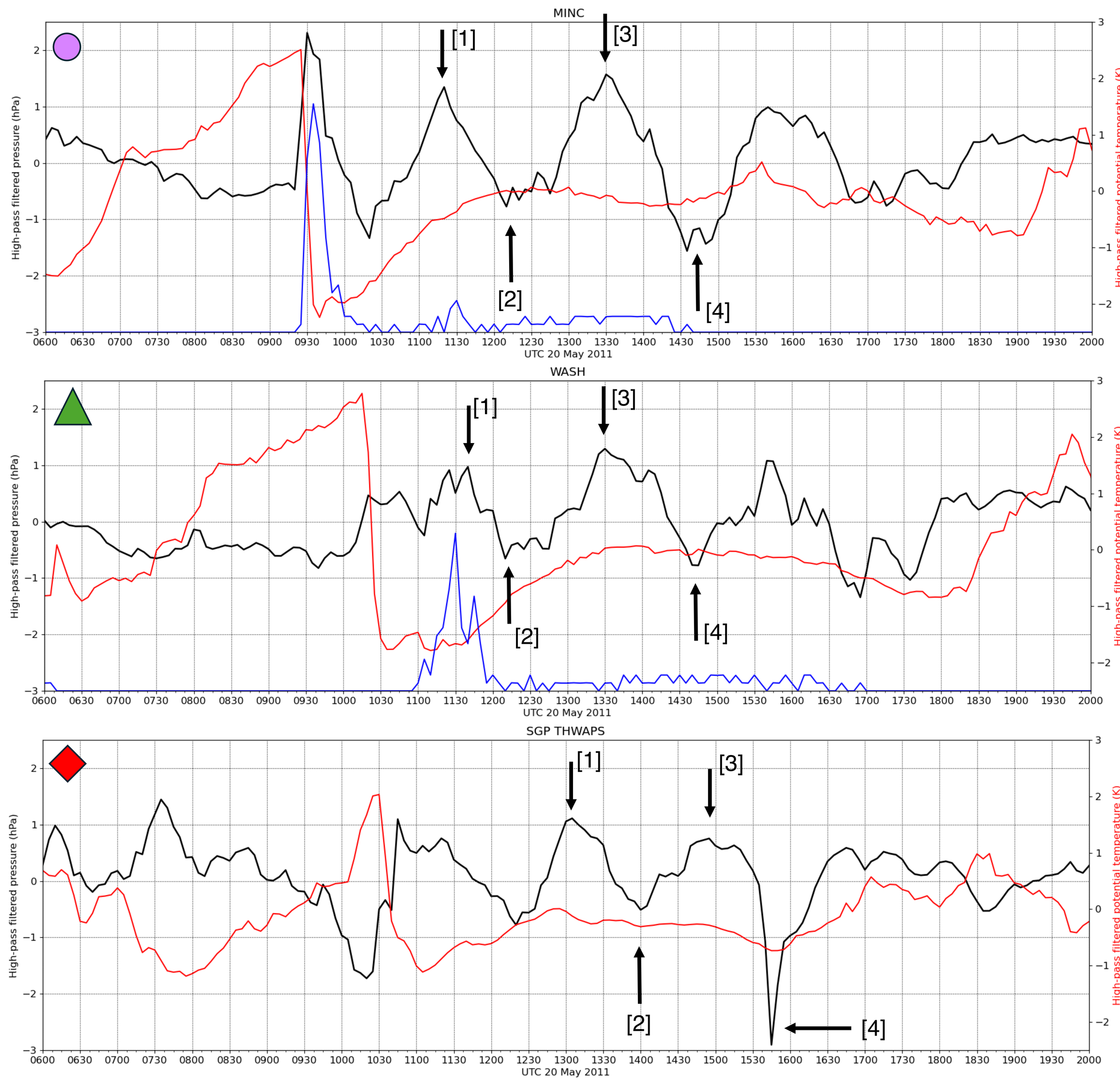

Fig. 2: High-pass filtered pressure (black, hPa), temperature (red, °C), and unfiltered rain rate (blue, mm 5 min^{-1}). Plots from top to bottom are the Minco, OK Mesonet station (MINC; purple circle), Washington, OK Mesonet station (WASH; green triangle, co-located with profiler PRCO2), and SGP Central Facility (red diamond). SGP THWAPS station does not include rainfall. High-pass Lanczos filter with 82-h cutoff period was used.

REAR-TO-FRONT FLOW PERTURBATIONS

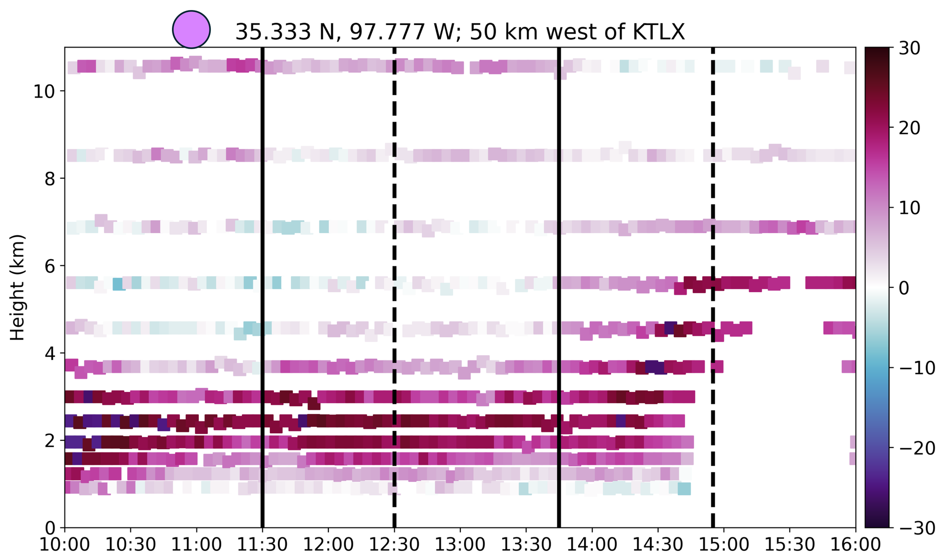

Fig. 3: Time-height cross-section of KTLX radial velocity (m s^{-1}) from a point 0.5° W of KTLX (near the Mesonet station MINC, shown as a purple circle in Fig. 1). The sign of the velocity field has been switched so positive is toward the radar (and hence, from the west) to match Fig. 6.

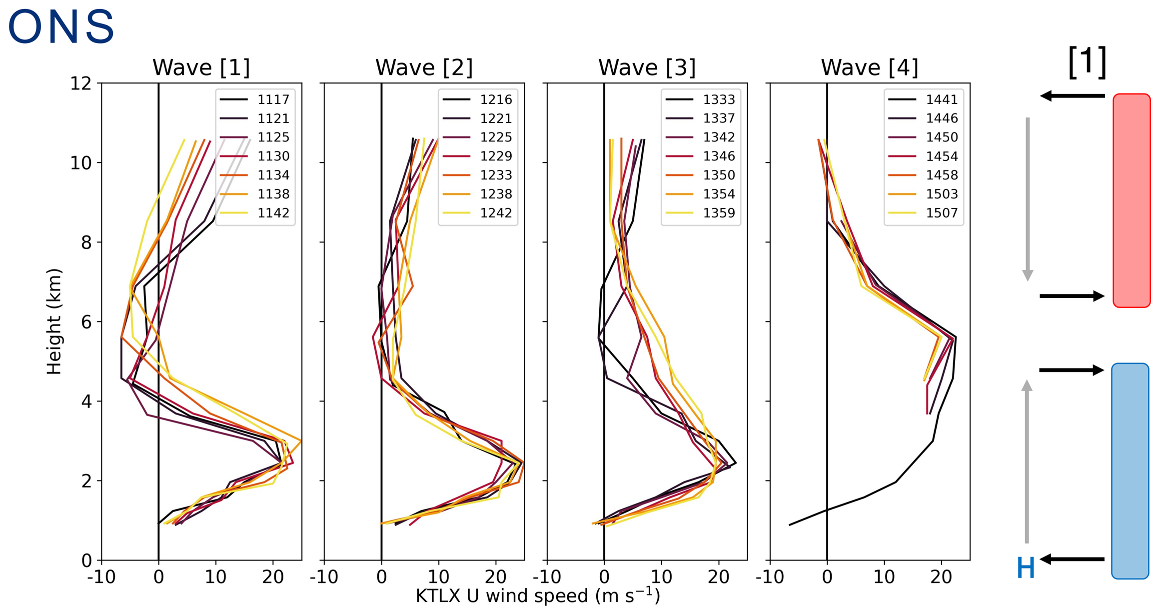

Fig. 5: KTLX wind profiles from the same point 0.5° W of KTLX (purple circle in Fig. 3). Positive velocity is from the west. Each profile is drawn from a separate volume scan within 15 minutes of a wave passage. Volume scan base time displayed in legend.

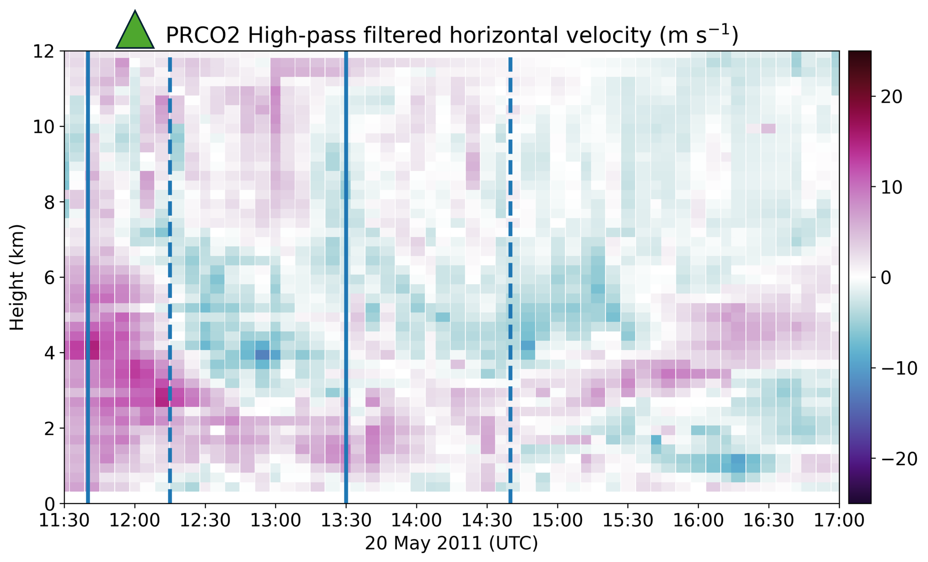

Fig. 4: Time-height cross-section of high-pass filtered U wind speed (m s^{-1}) from the PRCO2 NOAA wind profiler (shown as a green triangle in Fig. 1). Positive velocity is from the west. A high-pass Lanczos filter with cutoff period of 36 h was used here.

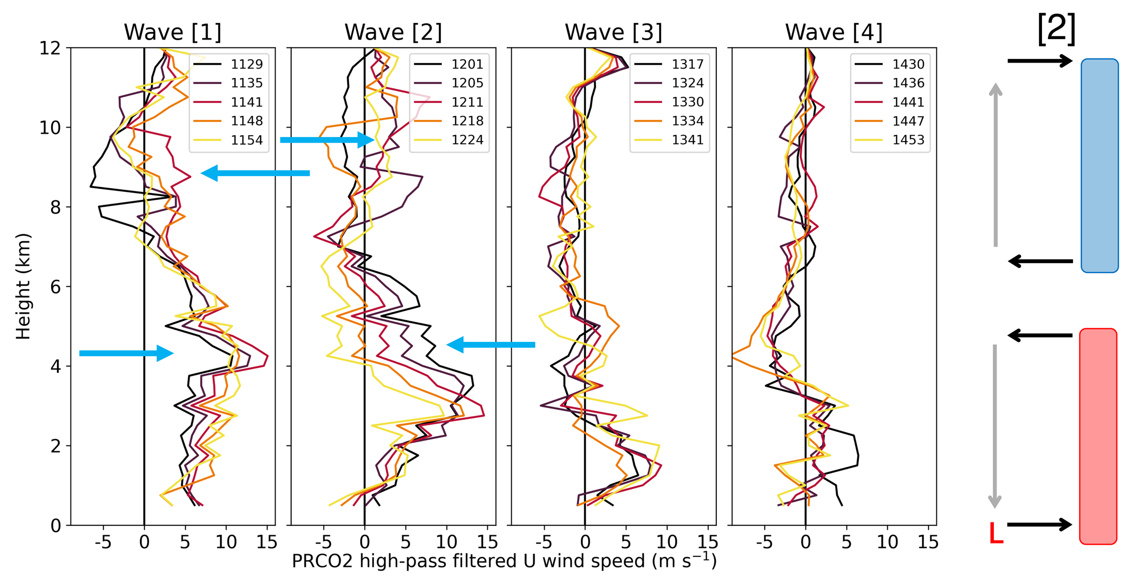

Fig. 6: High-pass filtered U wind profiles from the PRCO2 wind profiler (green triangle in Fig. 1). Positive velocity is from the west. Profile time displayed in legend.

PECAN 17 June 2015

WAVE IDENTIFICATION: SHORTER-LIVED, PARALLEL/TRAILING STRATIFORM MCS

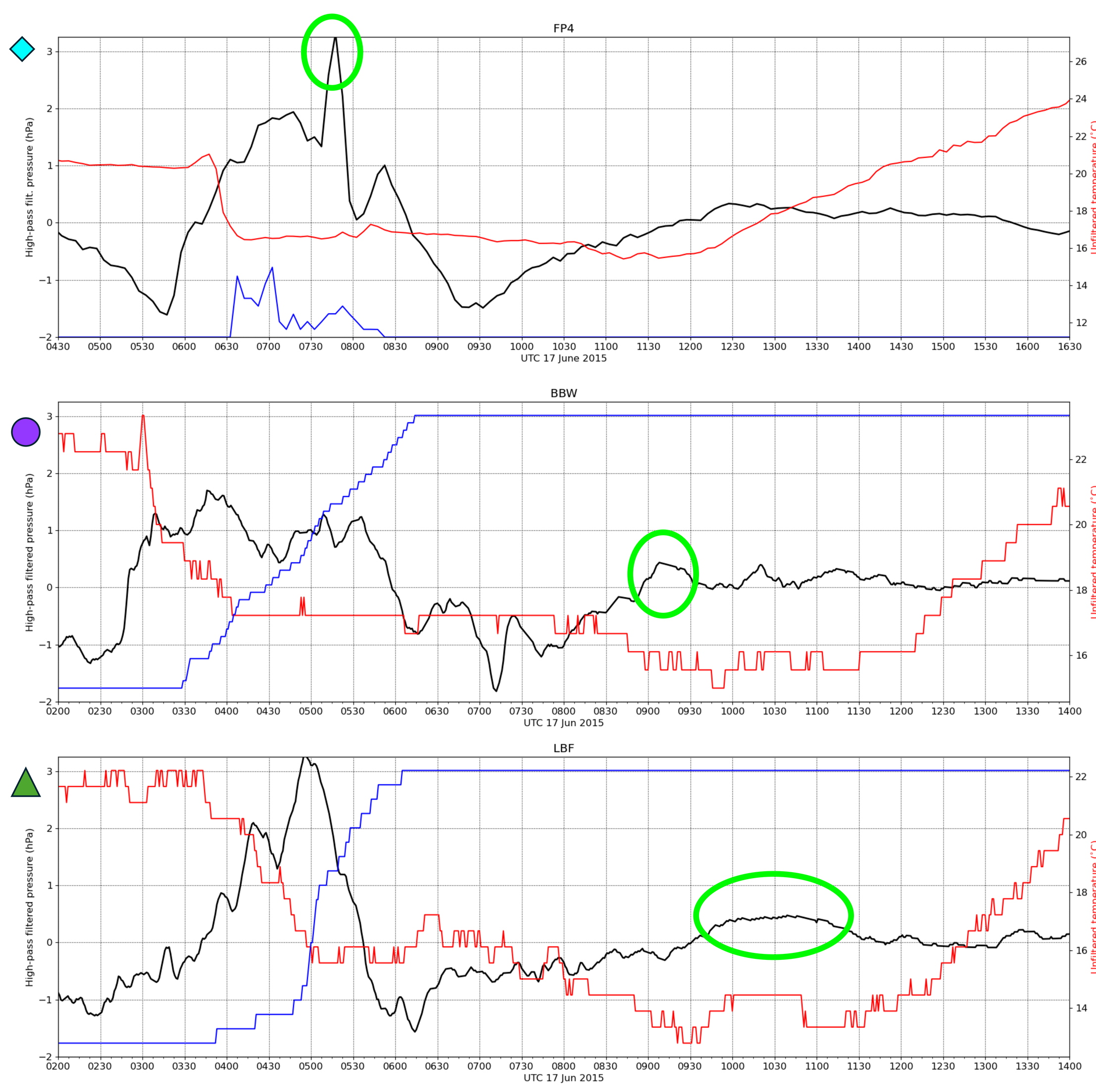

Fig. 7: As in Fig. 2, but for the (top to bottom) FP4 PECAN site (aqua diamond), Broken Bow, NE ASOS station (BBW; purple circle), and North Platte, NE ASOS station (LBF; green triangle). Stations shown in Fig. 8.

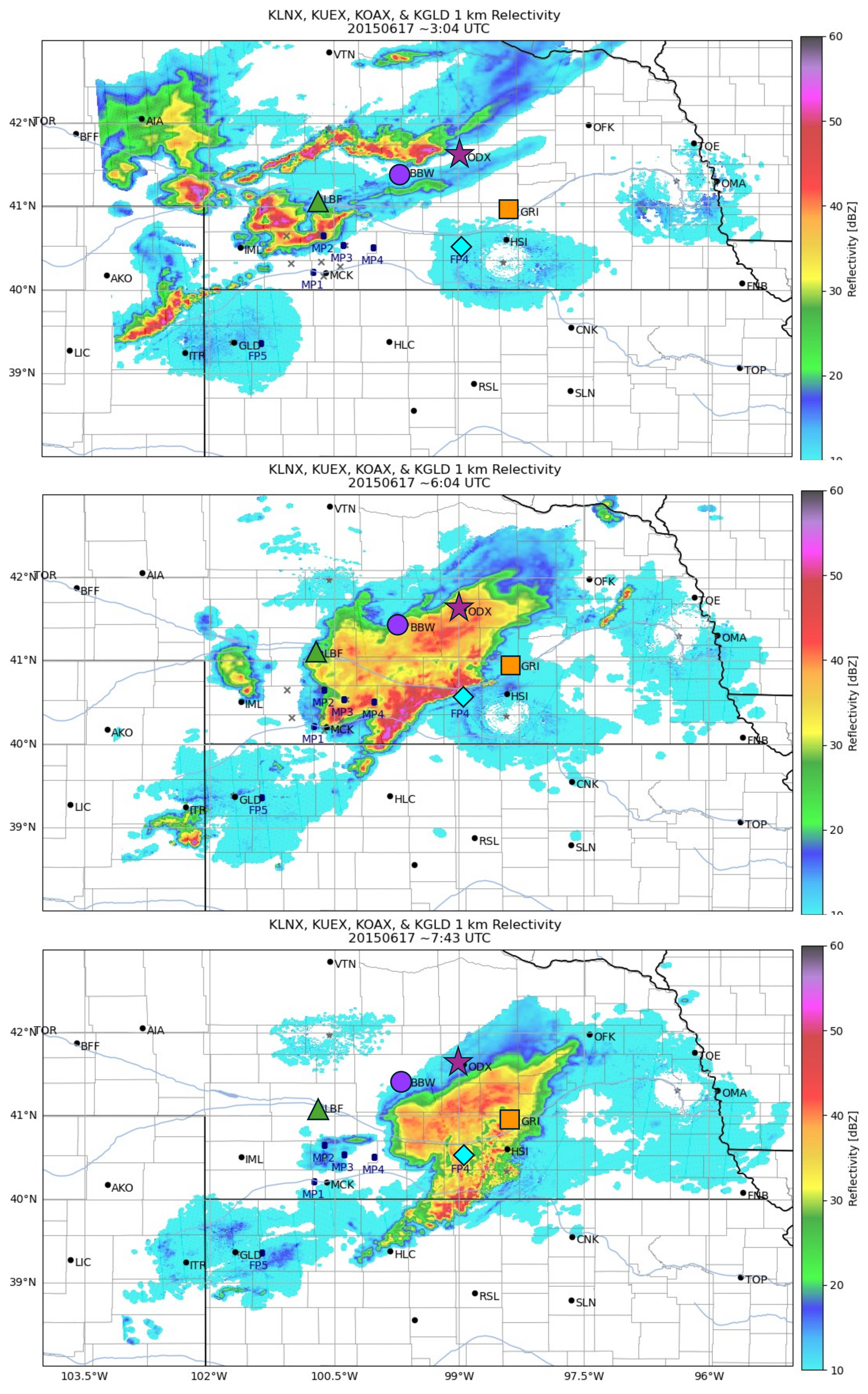

Fig. 8: Composite 1-km reflectivity (dBZ).

ADVANCE FLOW PERTURBATIONS

Fewer wave-like features are evident behind the convective line, but that could be due to fewer surface pressure reports. One potential n=1 mode wave is visible moving to the NW following convective line dissipation (see above).

A possible n=1 wave is also evident moving SE ahead of the system. Horizontal wind perturbation profiles roughly agree with n=1 structure.

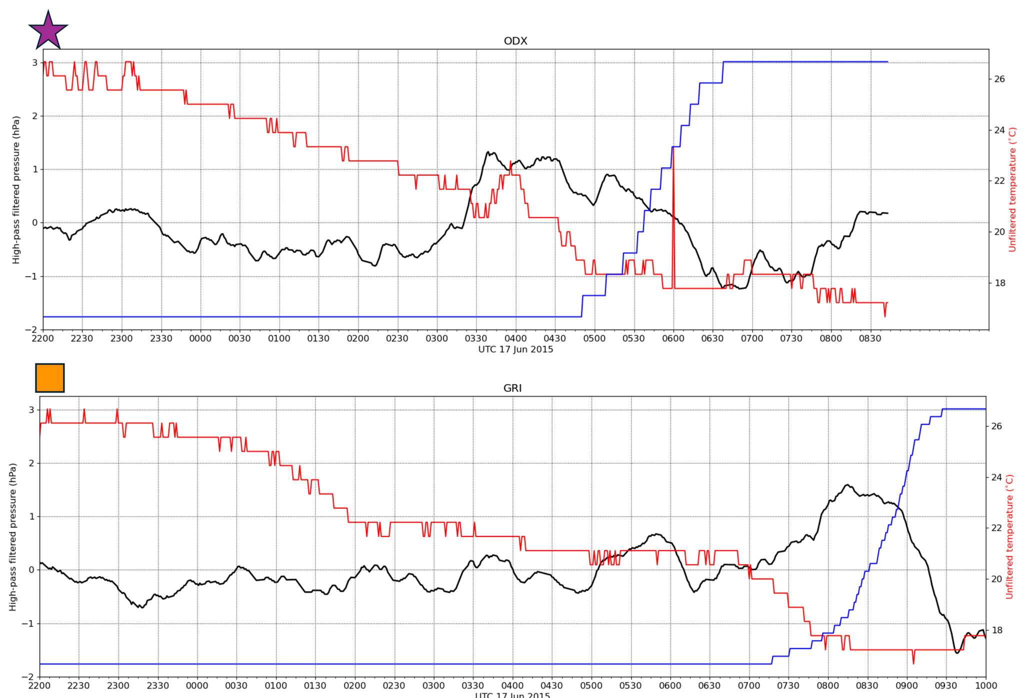

Fig. 9: as in Fig. 7, but for the (top to bottom) Ord, NE ASOS site (ODX; purple star) and Grand Island, NE ASOS station (GRI; orange square). Stations shown in Fig. 4.

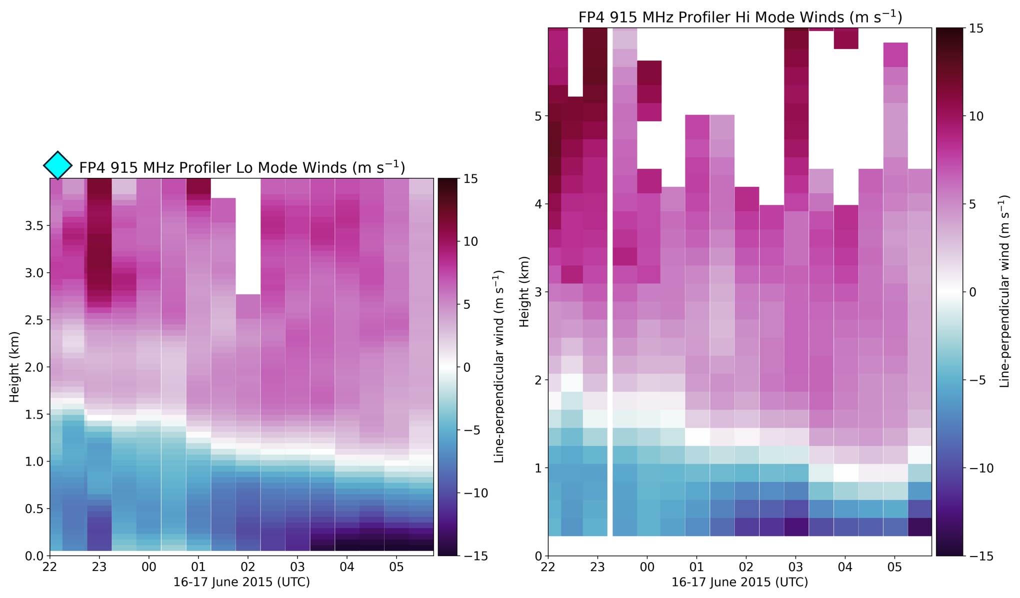

Fig. 10: 915 MHz horizontal winds from the PECAN FP4 site (blue diamond in Fig. 4) from low mode (left) and high mode (right). The MCS line-perpendicular wind components are shown; the MCS line is assumed to extend from SW (235°) to NE (45°). Positive line-perpendicular winds are from the NW.

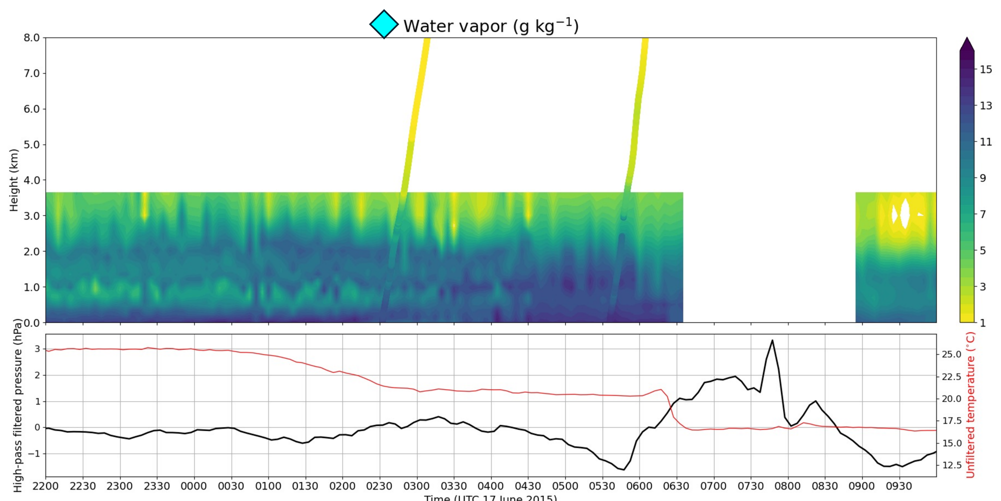

Fig. 11: Water vapor (g kg^{-1}) from the FP4 AERI and released soundings (top). High-pass filtered pressure (hPa, black) and unfiltered temperature (°C, red) from the FP4 surface station. High-pass filter uses an 82.4-h cutoff period.

Conclusions and Future Work

Low-frequency gravity waves are observed to be generated by MCSs and propagate both forward and rearward from the convective line. The types of wave modes produced appear to vary widely across cases. This behavior could be an observational issue, but it is replicated in high-resolution WRF-LES simulations of the same cases. (See Dillon Blount's poster!)

Perturbations of the horizontal wind field surrounding each MCS are observed in conjunction with these waves. The vertical profiles of the perturbations roughly agree with theoretical wave modes.

Future work will use the already conducted WRF-LES simulations to quantify the impact of the waves on the horizontal wind field and identify the waves' generating mechanisms.

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Py-ART was used to process the KTLX data (Helmus and Collis 2016).