Comparing WRF Simulation of a Polar Low Case to Observed Data from COMBLE

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Introduction

- Polar lows (PLs) are intense mesoscale low pressure systems that form over open water during a cold air outbreak (CAO).
- PLs can cause hazardous conditions for coastal communities and marine vessels.
- The PL case that will be used for this simulation and comparison occurred during 02/04/2020.
- The peak of the PL was around 1230 UTC 02/04/2020 where some of the strongest convection was seen.
- The DOE-funded Cold Air Outbreaks in the Marine Boundary Layer Experiment (COMBLE) provided an investigation into CAOs collecting data from multiple CAO and PL cases in the sub-Arctic region.

Methodology

- The Weather Research and Forecasting (WRF) model simulation ran from 02/03/2020 2000 UTC to 02/04/2020 2300 UTC
- Two domains were set up with output frequency set to 1 hour
- Horizontal resolution was set to 9 km for D01 and 3 km for D02
- Number of grid points 250 x 250 for D01 and 151 x 130 for inner domain
- Number of vertical levels was set to 45
- ERA-5 reanalysis data was used for initial and boundary conditions

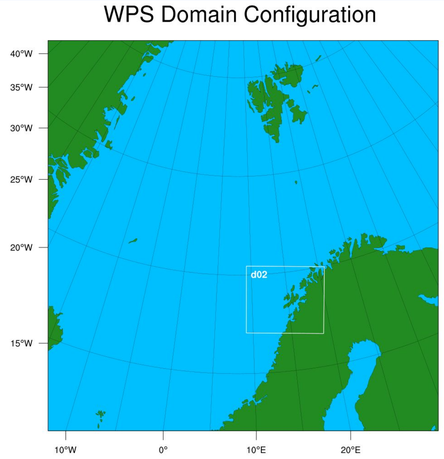


Figure 1: A map of the domain used for WRF simulation

Results

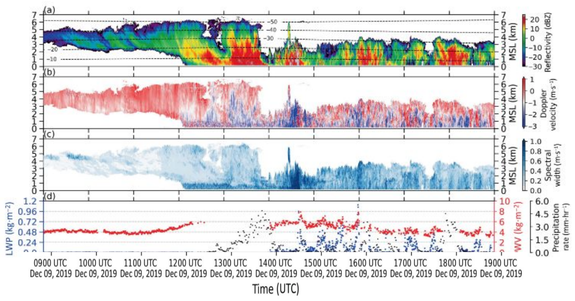


Figure 2: Ten hour vertical transects of (KAZR) reflectivity, velocity, spectral width, liquid water path, and precipitation rate. Source: Lackner et al. (2023)

- This figure allows us to see times when the storm peaked in intensity in this region based off of values which can be seen on the right side of the figure.

Results (cont.)

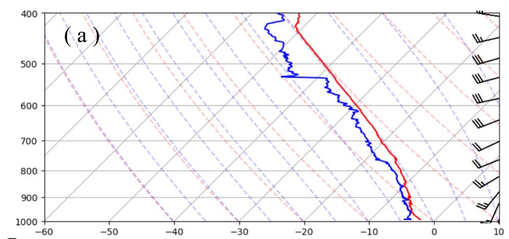


Figure 3a: observed sounding at 1111 UTC 02/04/2020

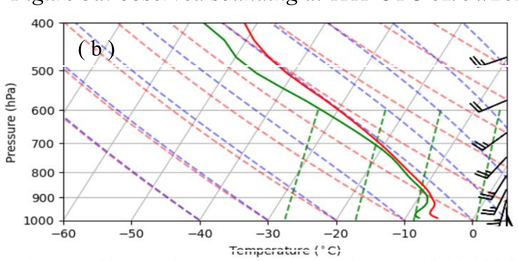


Figure 3b: Model simulated sounding at 1200 UTC 02/04/2020

- As seen in Figures 3a and 3b, the model simulated sounding can accurately predict the wind speed and direction.
- The model creates a more humid boundary layer compared to the observed sounding
- The model simulation has the temperature being much cooler at 400 hpa compared to the observed value

- As seen in figures, 4 there are four panels each on the date of 02/04/2020. The figure shows the WRF model simulation of the PL. The figures show the evolution of the PL in time increments of 3 hours.

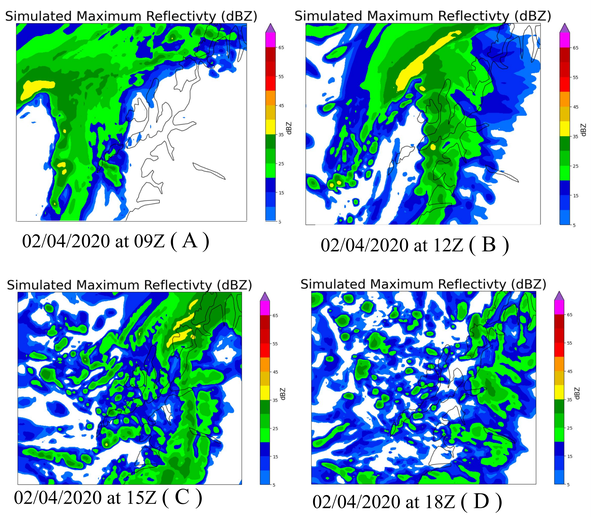


Figure 4: Model simulated reflectivity from 1200 - 0100 UTC 02/04/2020

- Figure 5a shows the satellite imagery from the PL case. Figure 5b shows the model simulated TOA outgoing longwave radiation through the WRF model
- What can be seen is that observed satellite imagery is much more detailed with cloud structure and picks up on the smaller cells.
- What can also be seen for the WRF models simulation of this is that it struggles to create a defined cloud structure for the PL

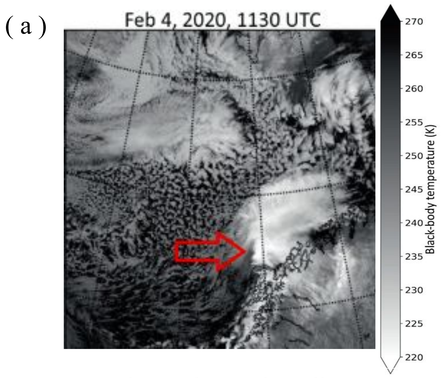
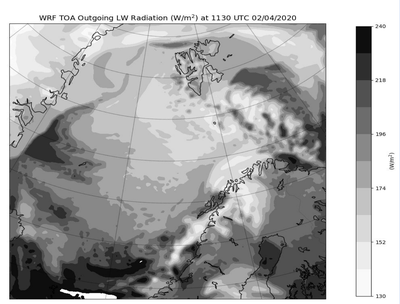


Figure 5 shows observed satellite imagery on top (A)and model simulated outgoing longwave radiation at the bottom (B). Source of (A): Lackner et al. (2023)



Conclusion

- After running a WRF model simulation on the 02/04/2020 polar low case, multiple observations can be made. While the model did recreate the PL that occurred, it struggled in some areas, but still provided some great results.
- The model was not able to pick up on a lot of the individual cells that occurred, and with the sounding the model had a much cooler atmosphere.
- Future work can be interpreting more areas of data and comparing, and trying a different physics scheme on the model

Acknowledgments

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Reference

Lackner, C. P., Geerts, B., Wang, Y., Juliano, T. W., Xue, L., Kosović, B., et al. (2023). Insights into the relation between vertical cloud structure and dynamics of three polar lows: observations from COMBLE. *Q. J. R. Meteorological Soc.* 149, 2992–3013. doi:10.1002/qj.4543