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Observations of Cold Fronts over Appalachian Piedmont during MU-PAST

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Abstract

MU-Piedmont-area Arctic Storm Tracking (MU-PAST) is a research project involving over 35 undergraduate meteorology majors designed to study the structure and evolution of winter season Arctic fronts as they progress across the Appalachian piedmont region. The project takes a 3-pronged approach: 1) a climatological study of cold fronts affecting the region; 2) a field campaign where three teams conducted balloon-borne upper-air profiles, and; 3) a numerical simulation initialized with observational data. This poster will present the data collected by the upper-air profiling systems at the three sites: one fixed and two mobile sites. These data, and data from regional NWS stations, are used to characterize the structure and evolution of the front and initialize the model simulations.

The passage of fronts is a key factor influencing the weather conditions over the midlatitudes. A front can be defined as the interface between air masses of differing density and origin, featuring a strong horizontal temperature gradient (Markowski & Richardson 2010). Consequently, frontal passage over a given area is marked by a change in temperature, humidity, pressure, and wind direction. In some cases, these differences between adjacent air masses can induce disturbed weather conditions. The arctic front, that semi-permanent and semi-continuous boundary between a mass of arctic air and a mass of polar air, can often push south into the midlatitudes during the wintertime. This type of front often breeds winter weather events affecting the Appalachian piedmont region, a plateau region between the Appalachian Mountains Atlantic coastal plain.

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This paper will document the field campaign in which teams of students deployed to targeted locations to conduct a series of upper-air profiles to observe and characterize the structure and evolution of the different air masses and the boundary that separates them.

Method

Millersville University operates a fixed field site at the Lancaster County Solid Waste Management Authority (LCSWMA) in Creswell, PA, approximately 10 km from campus. The site provides a setting for launching our RS41-SGP Vaisala radiosondes (a balloon borne instrument used to collect atmospheric data at different levels), an acoustic sodar (an instrument used to measure wind speeds by detection of sound waves and how they scatter), micropulse LiDAR (an instrument that determines the altitude of clouds) , and if necessary, a 10-meter flux tower. The tower was not used in this investigation of fronts because of the availability of a 10-meter tower with conventional meteorological measurements. A Vaisala CL-61 Ceilometer was used in place for the MPL-4 micropulse LiDAR. In addition to the fixed sites, the University operates two mobile radiosonde systems that can be deployed to any location, but for this study were configured in a linear array with the fixed site located at a pivot point so that the orientation of the array could be approximately parallel to the orientation of the frontal boundary (Fig. 1).

On campus, measurements were obtained using the MU Meteorology programs Automated Surface Observing System (ASOS), which includes a present weather detection system (Vaisala PWD 22) and the CL-61 Ceilometer for precipitation type and intensity, and cloud/PBL height, respectively (Fig. 4). Complementing the upper-air profiles obtained by the MU-PAST team, students incorporated the 00 UTC and 12 UTC soundings from PIT, CCX, and WAL, and IAD to create a regional depiction of the weather conditions associated with each frontal passage. An example of the plotted upper-air profile for Pittsburgh, PA for 12 UTC 24 Feb 2021 is shown in Fig. 5. The NWS rawinsonde network provides upper-air profiles twice a day. By adding to the NWS profiles the swarm of three soundings separated by 3 to 6 hours depending on the propagation speed of the frontal systems, a detailed characterization of the weather condition across the regions can be assessed.

Results and Conclusion

Results and conclusions await the time when we can again access the servers that store much of the observational data that was collected during the first two case studies, data that will be presented at the 2021 Made in Millersville student research event.

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References

Arctic oscillation (ao). Retrieved February 13, 2021, from https://www.ncdc.noaa.gov/teleconnections/ao/

Climate prediction center - Teleconnections: North Atlantic oscillation. Retrieved February 13, 2021, from https://www.cpc.ncep.noaa.gov/products/precip/CWlink/pna/nao.shtml

Markowski, P., and Y. Richardson, 2010: *Mesoscale Meteorology in Midlatitudes.* Wiley-Blackwell, 115 pp.

Sinclair, V. A. (2013). A 6-yr Climatology of Fronts Affecting Helsinki, Finland, and Their Boundary Layer Structure, Journal of Applied Meteorology and Climatology, 52(9), 106-2124. Retrieved Mar 4, 2021, from https://journals.ametsoc.org/view/journals/apme/52/9/jamc-d-12-0318.1.xml

Wpc surface analysis zoom, pan, animation and archives. Retrieved Winter, 2021, from https://www.wpc.ncep.noaa.gov/html/sfc-zoom.php

Lamraoui, F., Booth, J. F., & Naud, C. M. (2018). WRF Hindcasts of Cold Front Passages over the ARM Eastern North Atlantic Site: A Sensitivity Study, Monthly Weather Review, 146(8), 2417-2432. Retrieved Mar 3, 2021, from https://journals.ametsoc.org/view/journals/mwre/146/8/mwr-d-17-0281.1.xml

Lamraoui, F., Booth, J. F., Naud, C. M., Jensen, M. P., & Johnson, K. L. (2019). The interaction between boundary layer and convection schemes in a WRF simulation of post cold frontal clouds over the ARM East North Atlantic site. Journal of Geophysical Research: Atmospheres, 124, 4699– 4721. https://doi.org/10.1029/2018JD029370

National Center for Atmospheric Research: Mesoscale & Microscale Meteorology Laboratory. (2021). Weather Research and Forecasting Model. https://www.mmm.ucar.edu/weather-research-and-forecasting-model

Skamarock, W. C., Klemp J.B., Dudhia, J., Gill, D. O., Liu, Z., Berner, J., Wang, W., Powers, J. G., Duda, M. G., Barker, D. M., Huang, X. (2019). A Description of the Advanced Research WRF Model Version 4. NCAR Technical Notes, NCAR/TN-556+STR

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Appendix

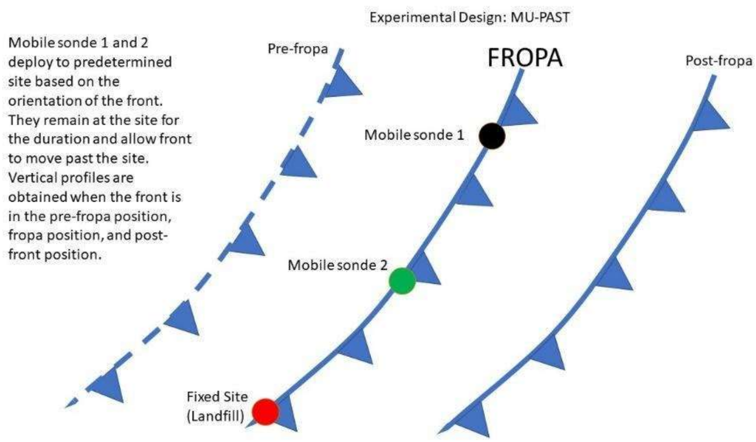

Figure 1: Schematic of the radiosonde network for an arbitrary frontal passage. The mobile sites pivot about the fixed site to capture the pre-frontal-passage (fropa), fropa, fropa, and post-fropa environments with simultaneous, sequential, upper-air profiles.

Figure 2: In addition to the radiosonde upper-air profiles (Fig. 2), students carried hand-held Kestrels® to document the surface conditions. At the fixed site, a medium frequency acoustic sodar with a radio acoustic sounding system extension provided time-height measurements at 30-second intervals of 3-D wind, virtual temperature, and turbulence statistics for the duration of the project (Fig. 3).

Figure 3: Students after finishing the assembly of the MFAS with RASS extension

Figure : Millersville ASOS with present weather detector and ceilometer.

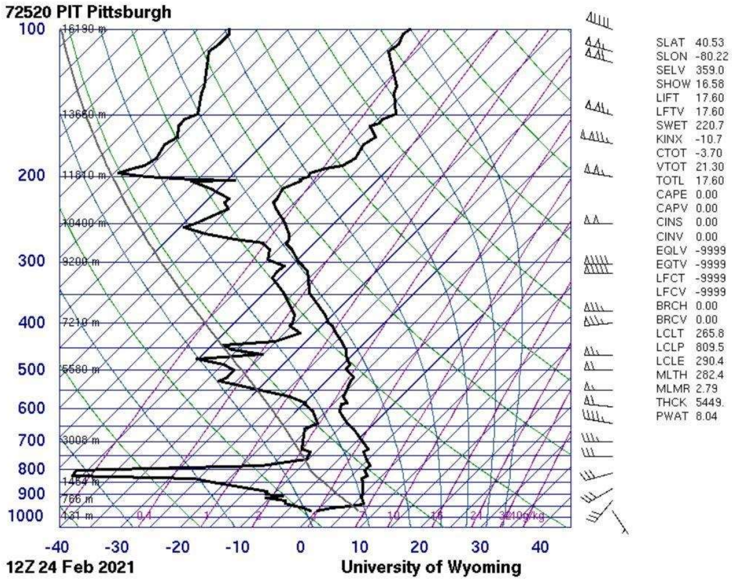

Figure 5: Pittsburgh, PA upper air sounding for 12 UTC 24 Feb 2021

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