Using Polarimetric Observations from WSR-88Ds to Identify and Classify Smoke from Wildland Fires

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Introduction and Background

- The current WSR-88D hydrometeor classification algorithm uses the biological scatterers class (BS) to describe returns from multiple different scatters, including:
  - Birds, bats, insects, military/aviation chaff, and **smoke**
- Difficult to distinguish between these scatterers due to similar values in dual-polarization variables (i.e., don't have distinct membership functions for fuzzy logic classification).
- Difficult to know where smoke may be using the current HCA, especially in fields of BS classification (Figure 1).
- We are addressing this issue by exploring adding a new smoke class using the current fuzzy logic algorithm, a new smoke class replacement algorithm, and with machine learning models.

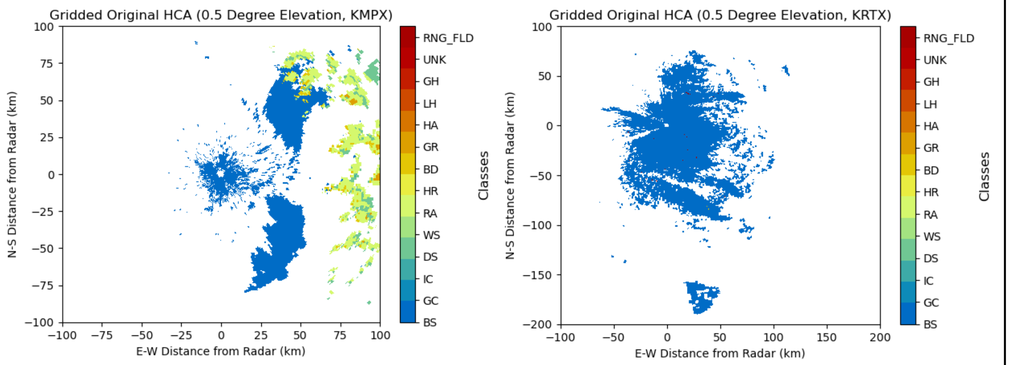
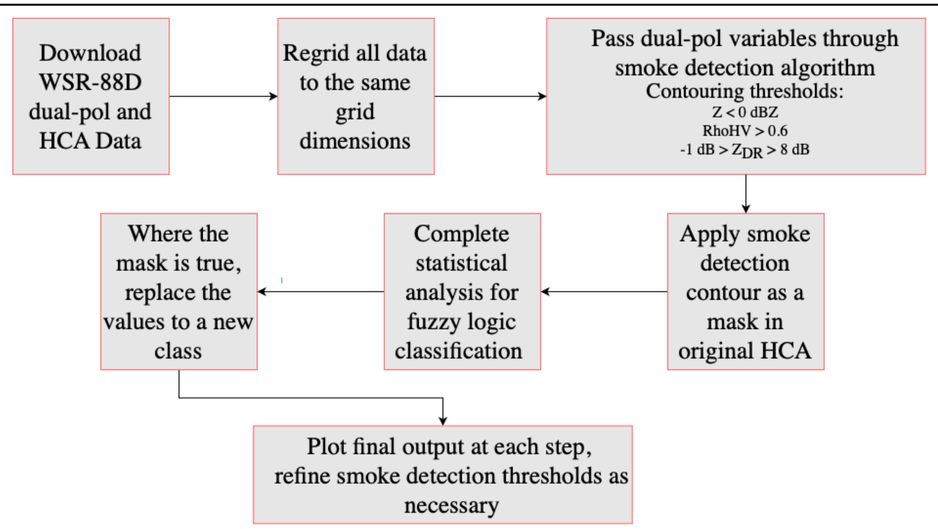


Figure 1. Gridded original hydrometeor classification for a.) KMPX (Minneapolis-St. Paul, MN) on 3rd , March 2024 and b.) KRTX (Portland, OR) on 8th, September 2020.

Methods



Results

Snake Trail Fire, MN, 2024-03-03 21:33:37Z

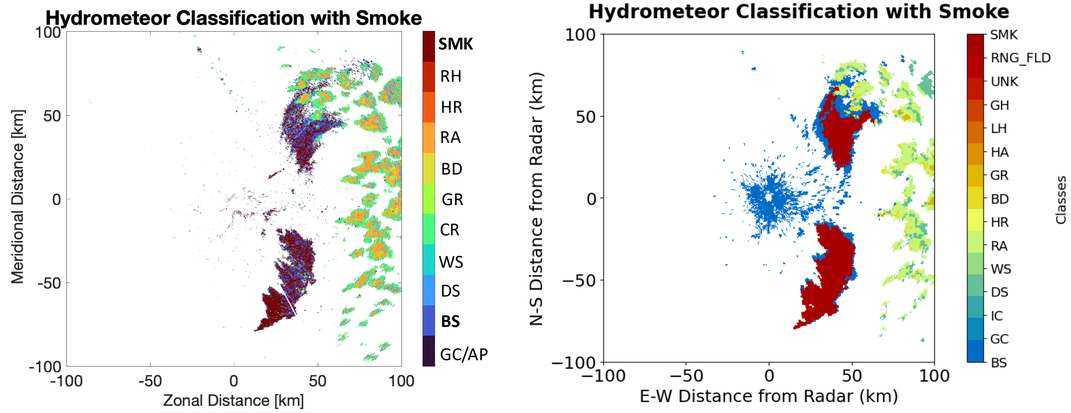


Figure 2. Classification output for a.) fuzzy logic with smoke and b.) the smoke class replacement at 21:33:37Z for the Snake Trail fire.

Labor Day 2020 Fires, OR and WA, 2020-09-08 20:08:14Z

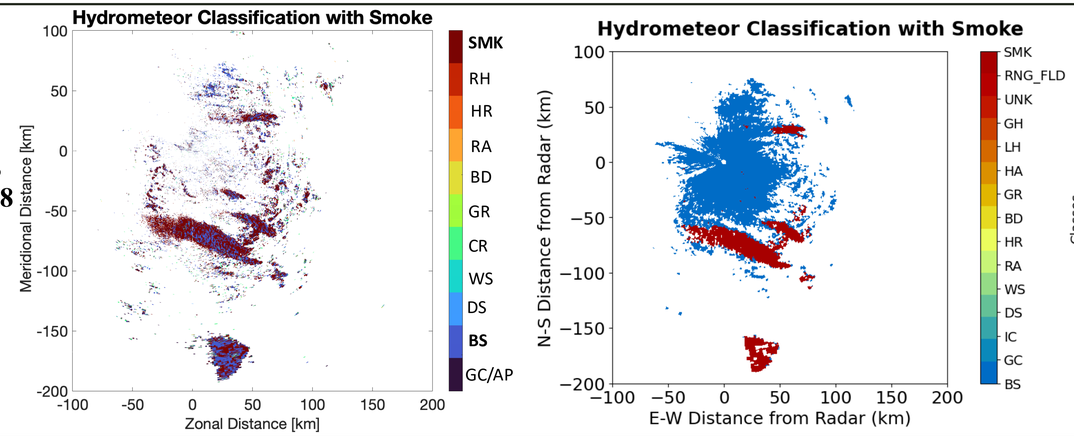


Figure 3. Classification output for a.) fuzzy logic with smoke and b.) the smoke class replacement at 20:08:14Z for the Labor Day 2020 fires.

Conclusions and Future Work

- The smoke plume dual-pol variables were characterized by:
  - ρ_{HV} between 0.25-0.6, much less than hydrometeors
  - Z_{DR} between -2 and 1 dB near the turbulent updraft over the fire and 2-8 dB downstream of the fire
  - Reflectivity from 0 to 45 dBZ, with high reflectivity near the active fire
- A distinct smoke class was not found to successfully add a smoke class to the current fuzzy logic architecture.
- The smoke class replacement algorithm performed well in most cases, though areas of clutter like wind turbines and mountainous terrain show areas of erroneous smoke classification.
- We are working on applying machine learning models to this classification problem.

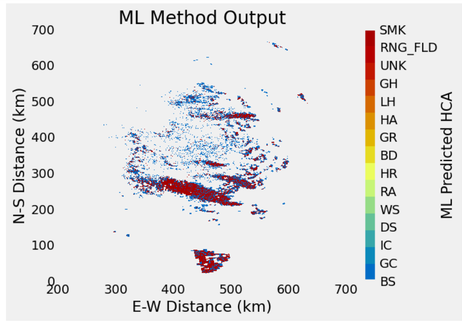


Figure 4. Predicted HCA classes using a trained random forest model for the same case as Figure 3.

Citations:
[1] Helmus, J.J. & Collis, S.M., 2016: The Python ARM Radar Toolkit (Py-ART), a Library for Working with Weather Radar Data in the Python Programming Language. *Journal of Open Research Software.* **4(1),** 25, http://doi.org/10.5334/jors.119