Using GOES Satellite and Radar to Estimate Precipitation Intensity from Convective Snow Squalls

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OVERVIEW

- Convective snow squalls are typically shallow features
- Often associated with heavy snow rates and hazardous driving conditions
- Radar beam often overshoots convective snow squalls at distances as close as 75-100 km from the radar location
- Terrain also causes beam blockage
- Difficulties monitoring and assessing squall intensity
- Satellite products can be utilized to augment radar gaps
- The goals of this project include:
  - Provide operational meteorologists a tool to better analyze (or "nowcast") convective snow
  - Establish relationships between GOES cloud products, radar data and in-situ observations
  - Create a database of events as training for a real time Machine Learning algorithm to estimate snow squall severity (similar to ProbSevere)

CONVECTIVE SNOW HAZARDS IN PENNSYLVANIA

- **Snow squall warnings most frequent in the Northeast United States (Figure 1a)**
- **Snow squall warning hot spots in Central and Eastern Pennsylvania (Figure 1b)**
- **Radar blockage from terrain at KCCX poses difficulties in assessing snow squall severity**
  - **Can lead to significant travel disruption and impacts (Figure 2)**

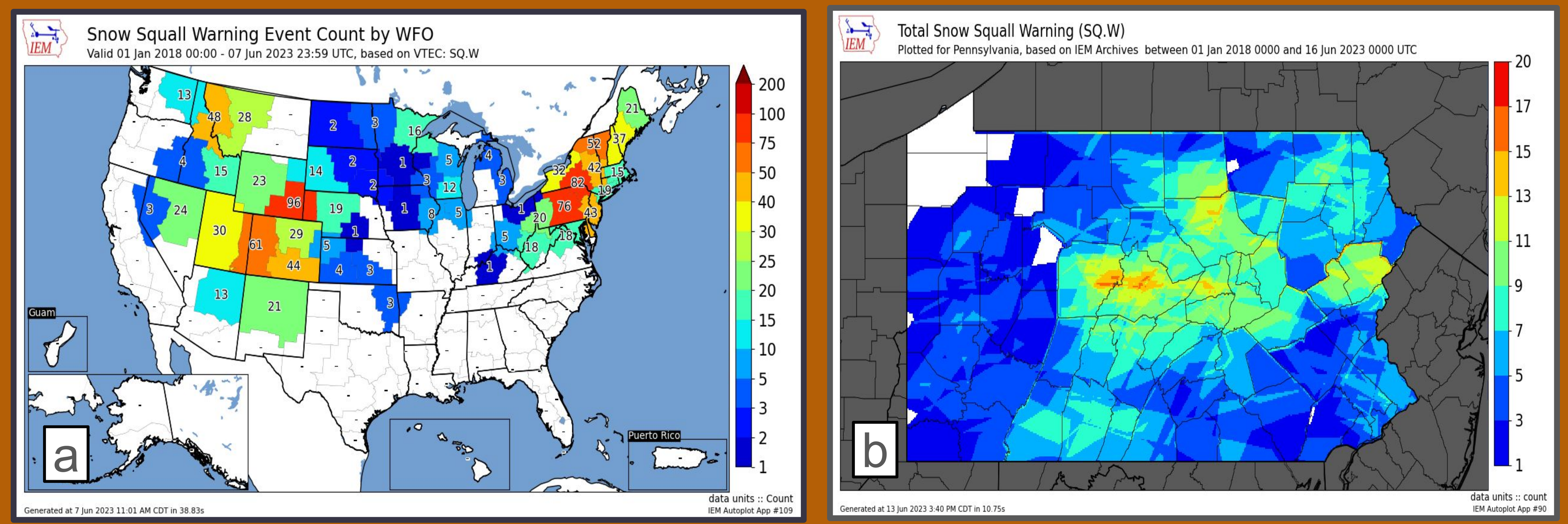

Fig. 1: Plots generated from the Iowa Environmental Mesonet showing the total number of snow squall warnings by Weather Forecast Office (WFO) (a), and in Pennsylvania (b) since 2018.

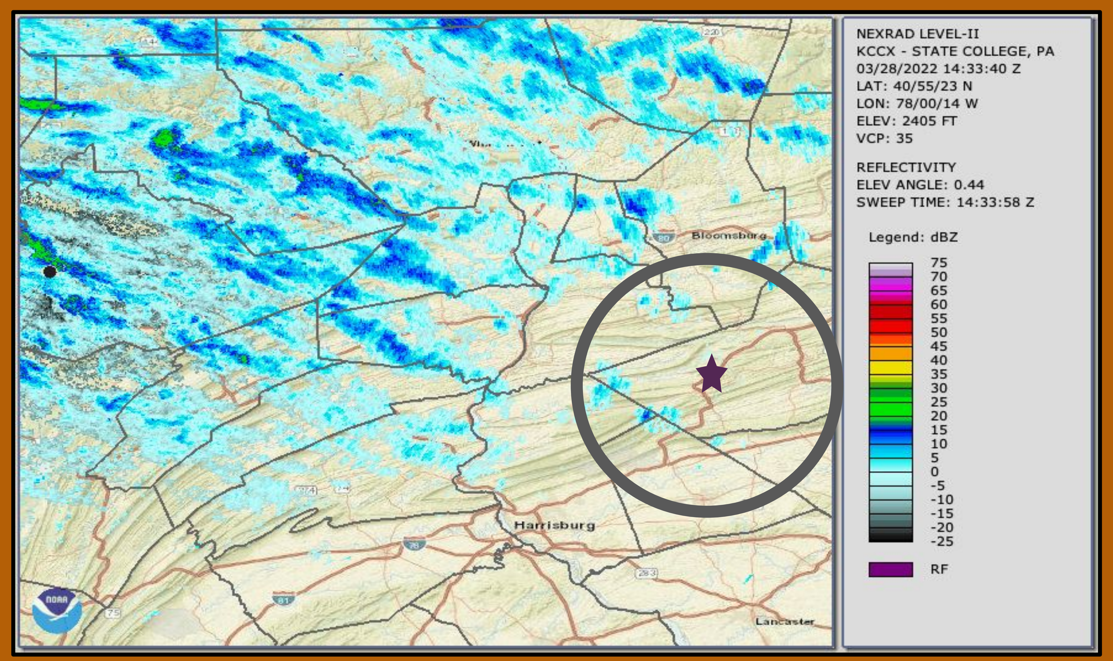

Fig. 2: Radar reflectivity base scan from KCCX on 28 March 2022 (1430 UTC). The star and circle denote the approximate location of a 50-car pileup in Pennsylvania facilitated by radar beam blockage

RADAR, SATELLITE, AND IN-SITU DATA

- **Satellite**: GOES-16 era (December 2017 - current) **(Figure 3)**
  - Cloud Optical Depth
  - Cloud Water Path

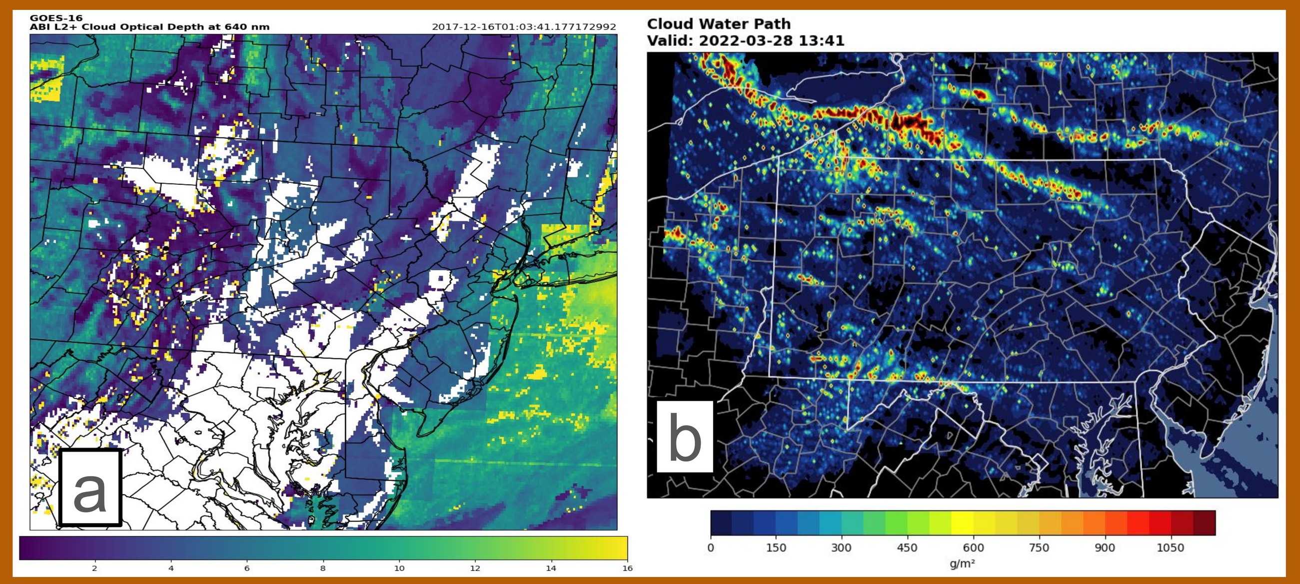

Fig. 3: Example of the Cloud Optical Depth (a) and the Cloud Water Path (b) satellite products used.

- **Radar:** NEXRAD Level II State College, PA (KCCX) radar files used and transposed onto a 1km cartesian grid **(Figure 4)**

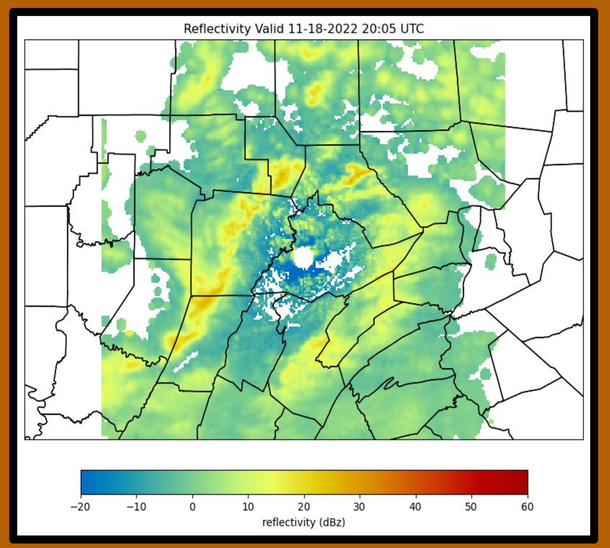

Fig. 4: Example of radar reflectivity from KCCX transposed onto a cartesian grid

- **In-Situ Data:** Visibility taken from the High Resolution Rapid Refresh (HRRR) model **(Figure 5)**

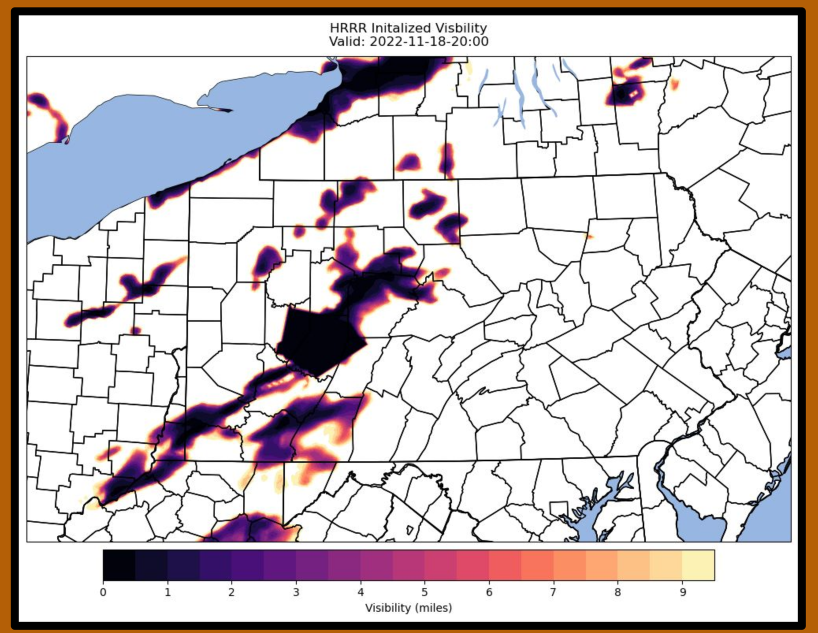

Fig. 5: Example of HRRR visibility taken at forecast hour 0 (initialization)

RESULTS

- The cloud water path product in **Figure 6a** was most strongly correlated with reflectivity
  - More exploration of this co-location with the larger dataset could yield more meaningful results
- Cloud Optical Depth in **Figure 6b** does not seem to have a strong relationship with visibility or reflectivity
  - Reflectivity and Visibility have a stronger relationship
  - Better spatial and temporal scales could shed light on these relationships further

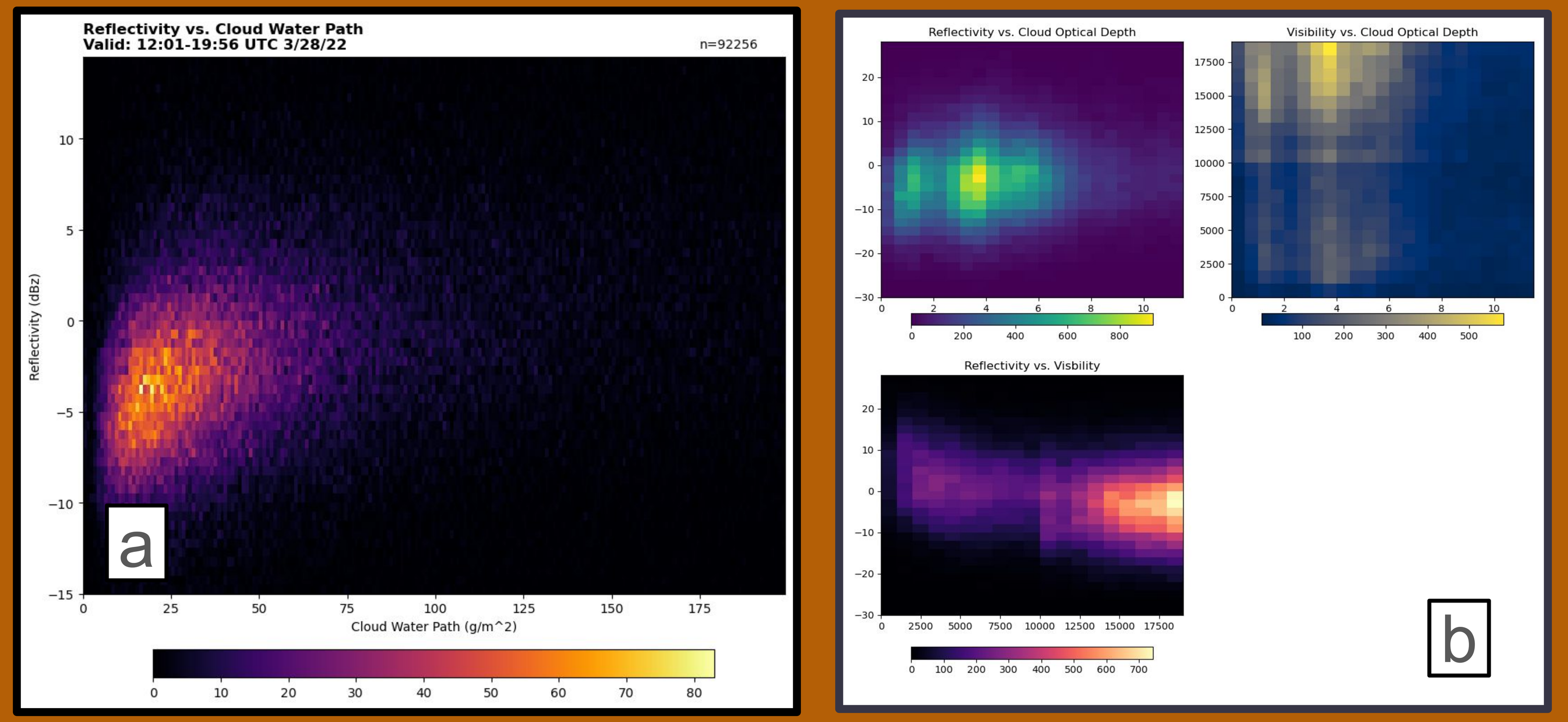

Fig. 6: A plot comparing the cloud water path product and radar reflectivity (a), and three plots comparing reflectivity, visibility, and cloud optical depth (b)

FUTURE DEVLOPMENT

The future development of this product can be described in three stages:

1. **Growing the Database:** Snow squall event archive and classification, along with the retrieval of relevant environmental parameters
2. **Machine Learning:** Ingestion of data into a machine learning algorithm—possible ML visibility product?
3. **Operational Implementation and Verification:** Incorporation of tool for operational use and verification with in-situ observations

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