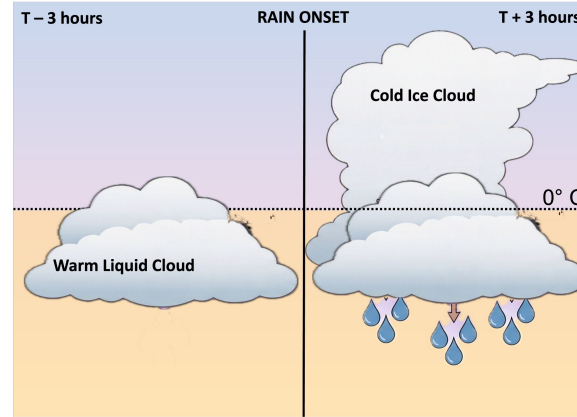


Motivation

Cloud Top Phase Before Rainfall	Cold	Cold → Cold Cold Rain or High Cloud + Warm Rain	Cold → Warm High Cloud + Warm Rain
	Warm	Warm → Cold Multi-Layered	Warm → Warm Warm Rain
		Cold	Warm

Cloud Top Phase During Rainfall



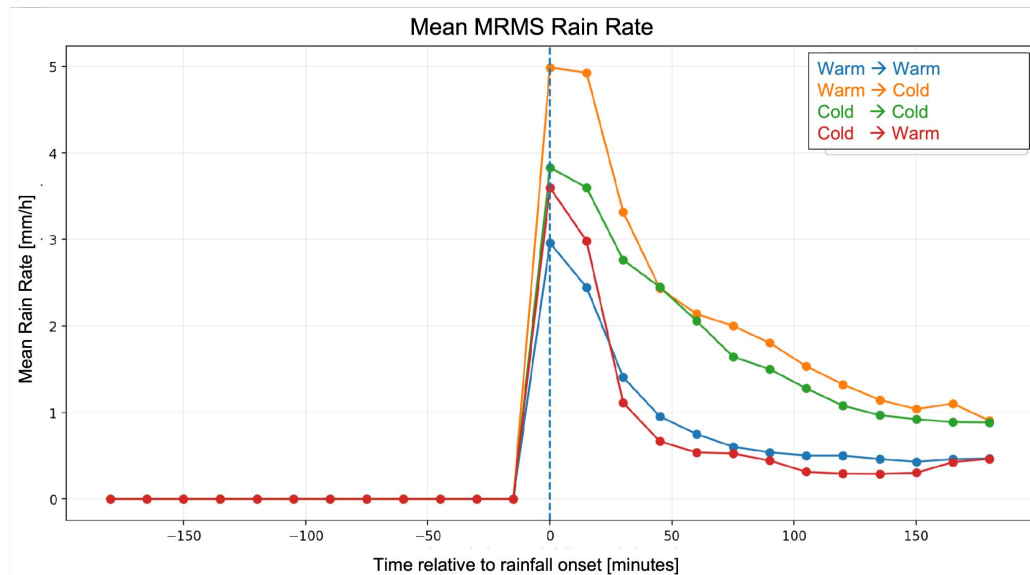
Cloud top phase transitions reflect processes associated with **precipitation development**

Objective

- **Predict cloud top phase** during rainfall using satellite (GOES) and environmental variables before rainfall onset
- **Identify the key pre-onset physical signals** most strongly contributing to phase predictions

Dataset

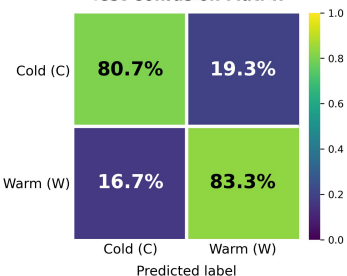
- **118,157 samples across 353 Smoky Mountain storms**
- **6-hour window centered on rainfall onset**
 - -3 hr to +3 hr
- GOES-R satellite **Advanced Baseline Imager (ABI)**
 - Brightness temperatures from channels 8-11 & 13-16
- **ERA5 atmospheric and environmental variables** from the European Centre for Medium-Range Weather Forecasts
- **Pre- and post- onset cloud top phase labels**



Warm → Cold processes produce intense precipitation compared to other phases.

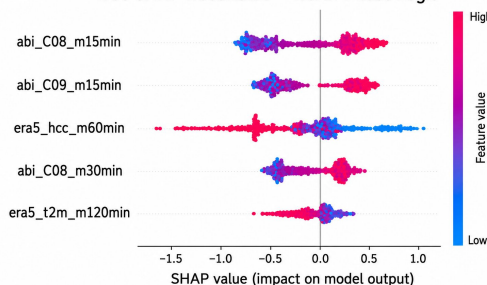
Extreme Gradient Boosting (XGBoost)

Test Confusion Matrix



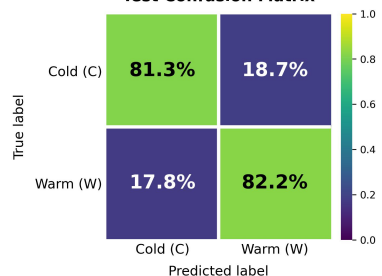
Event Type	Test - Correct Prediction Rate
W→W	85.62%
C→C	92.69%
W→C	52.91%
C→W	65.40%

Tree SHAP Beeswarm — Warm-Phase Logit



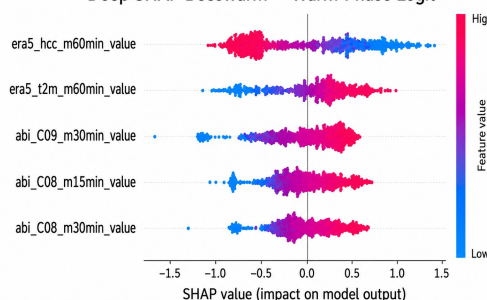
Convolutional Neural Network (CNN)

Test Confusion Matrix



Event Type	Test - Correct Prediction Rate
W→W	86.43%
C→C	94.73%
W→C	49.89%
C→W	54.31%

Deep SHAP Beeswarm — Warm-Phase Logit



Summary

Primary Drivers:

ABI Channel 08 - Upper-level water vapor

ABI Channel 09 - Mid-level water vapor

ERA5 High Cloud Cover & Temperature

Observations from geostationary satellites have the potential to identify multi-layered processes.

Future Work

Dataset improvements:

Separate high clouds

Detailed cloud classes instead of warm/cold

Other neural networks:

Stronger regularization

Improved sequential data handling

Utilize and/or predict transition timing