Developing a Machine Learning Snowfall Detection Algorithm for the GPM Microwave Imager (GMI)

Intern: Yucheng Shao; Supervisor: Dr. Yongzhen Fan

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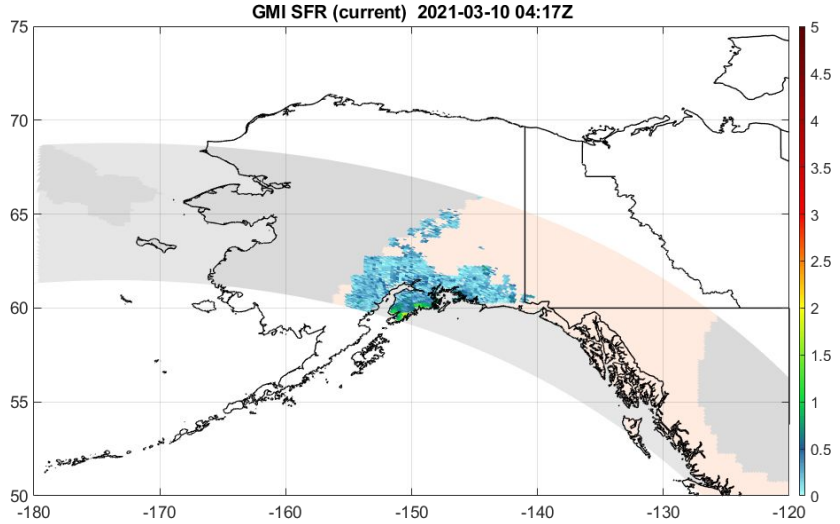
Introduction to NOAA Snowfall Rate product (SFR)

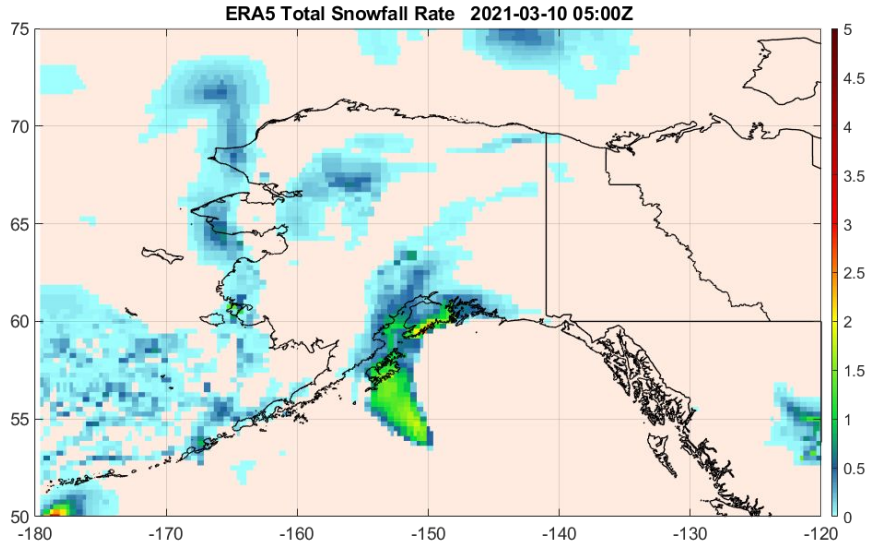
- ➔ Global liquid equivalent snowfall rate estimation from passive microwave sensors in near real-time.
- ➔ 9 SFR products from S-NPP, NOAA-20, NOAA-19, Metop-B/C, GPM, F16, F17 and F18.

Objectives

- ➔ Current snowfall detection (SD) model: logistic regression (LR) model trained from satellite & ground observation
  - ◆ SD does not work well below ~ -6^{0}C/21^{0}F
  - ◆ SD is not applicable below ~ -15^{0}C/7^{0}F
- ➔ Use machine learning to extend SD to cold regions.
- ➔ Improve overall snow detection performance

Current LR model





ERA5 Total Snowfall Rate

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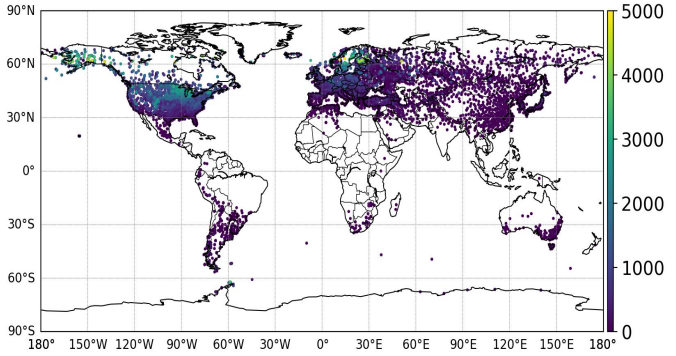
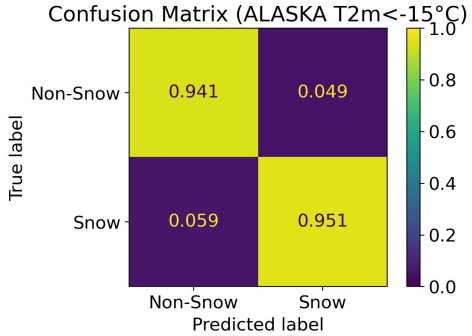
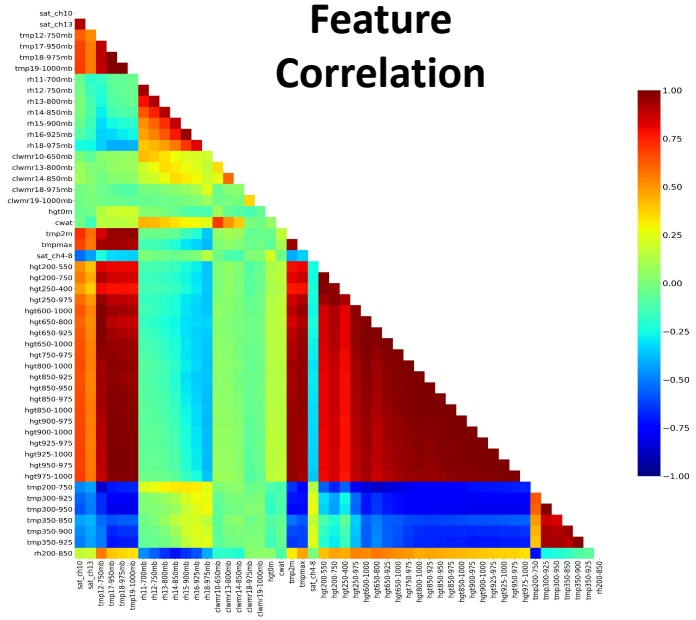
Process

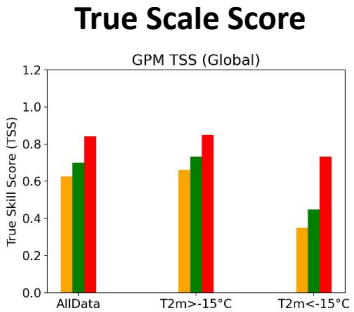
- ➔ Collocate NOAA ISD ground observations, satellite observations, & GFS model analysis data.
- ➔ Select 30 most important features for snowfall detection.
  - ◆ 800 features in total, some highly correlated (red or blue)
  - ◆ Feature analysis for satellite observations only, GFS analysis only, & all features
- ➔ Train & test XGBoost, DNN, Random Forest models
  - ◆ Compare performance (TSS, POD, FAR, HSS)

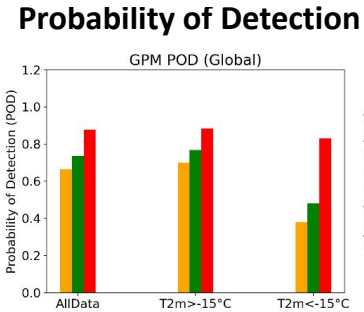


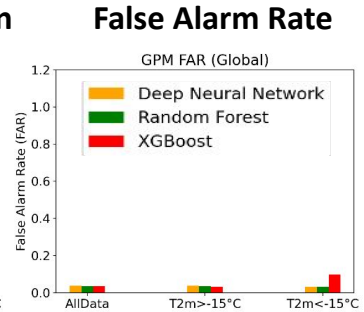
2016-2020 ISD Data

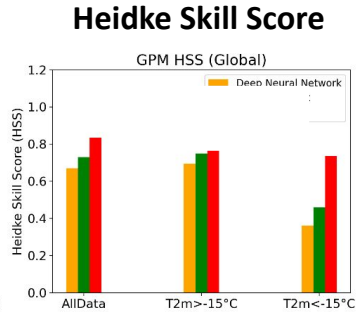












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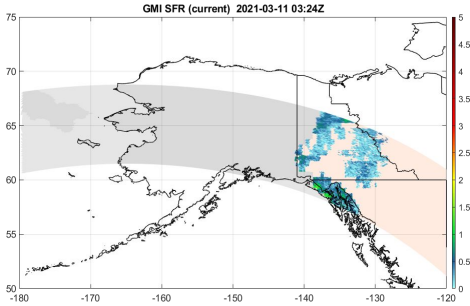
Results

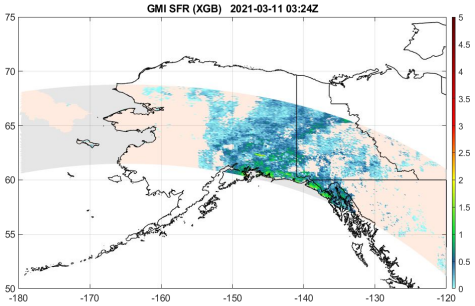
- ➔ XGBoost has best performance, especially under cold conditions
- ➔ Major improvement of XGB: able to classify snowfall in cold regions, like winter seasons in Alaska
  - ◆ 2m air temperature below -15^0 C.
- ➔ Over warm regions, e.g. CONUS, ML SD model works better than previous logistic regression model

Alaska

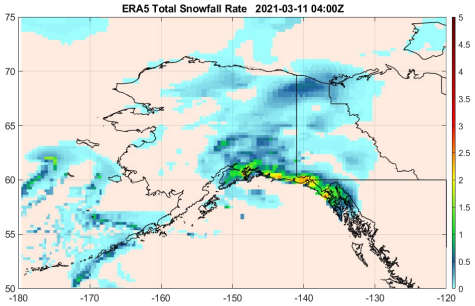
Current model



XGBoost

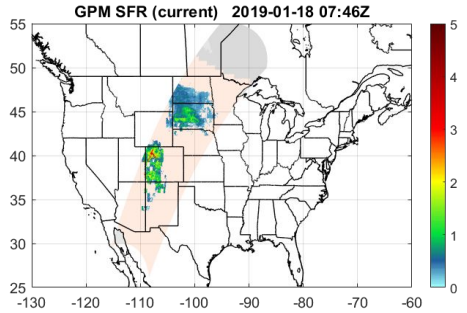


ERA5 Total Snowfall Rate

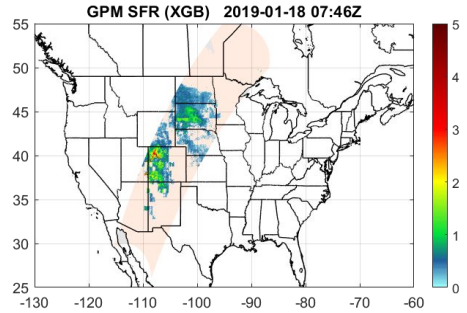


CONUS

Current model



XGBoost



ERA5 Total Snowfall Rate