CISESS Science Meeting
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Predicting GLM Flash Rate Class:
Deep Neural Network Approach

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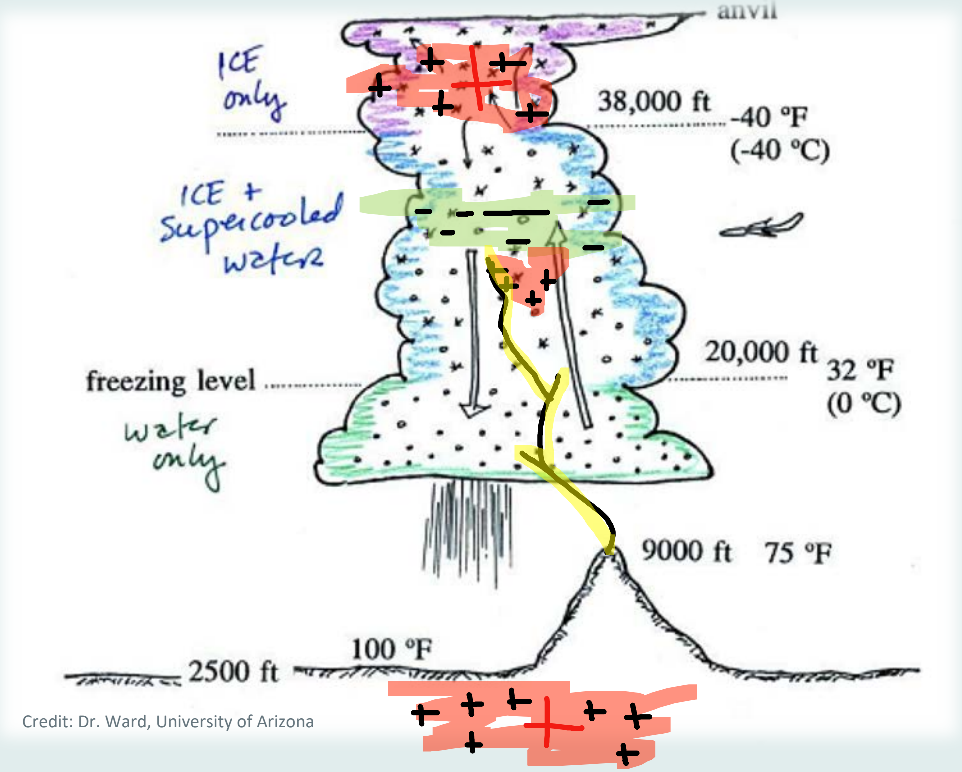
Objectives

- The overall objective
  - Goal: Improve hurricane forecast by assimilating GLM observations
  - Challenge: GLM observed features (e.g. flash rate) are not common model parameters
  - Solution: Use a *link* between existing model parameters and GLM observations

- Project objective
  - Build a representation of the link between model parameters and GLM observations

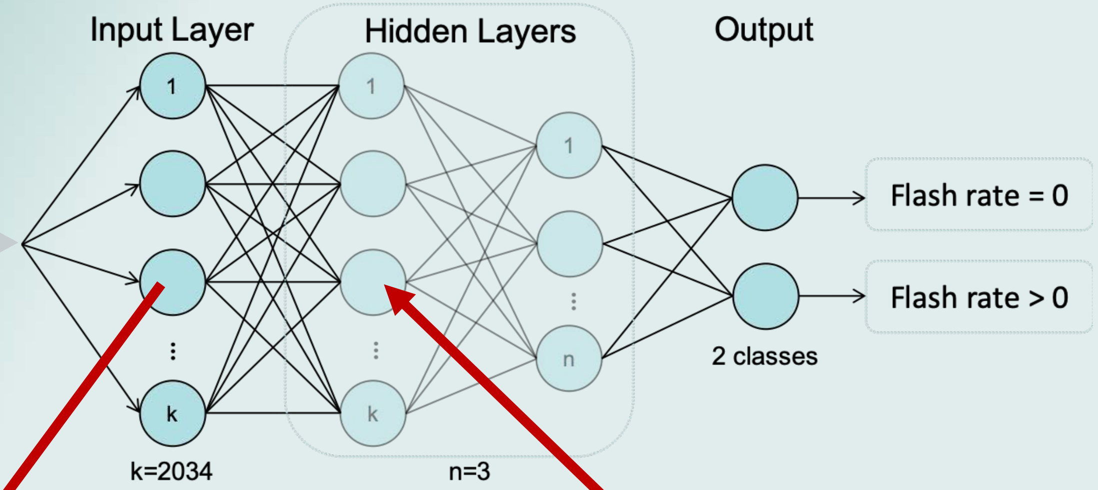
Predict GLM flash rate using h-WRF output



Credit: Dr. Ward, University of Arizona

Deep Neural Network Model

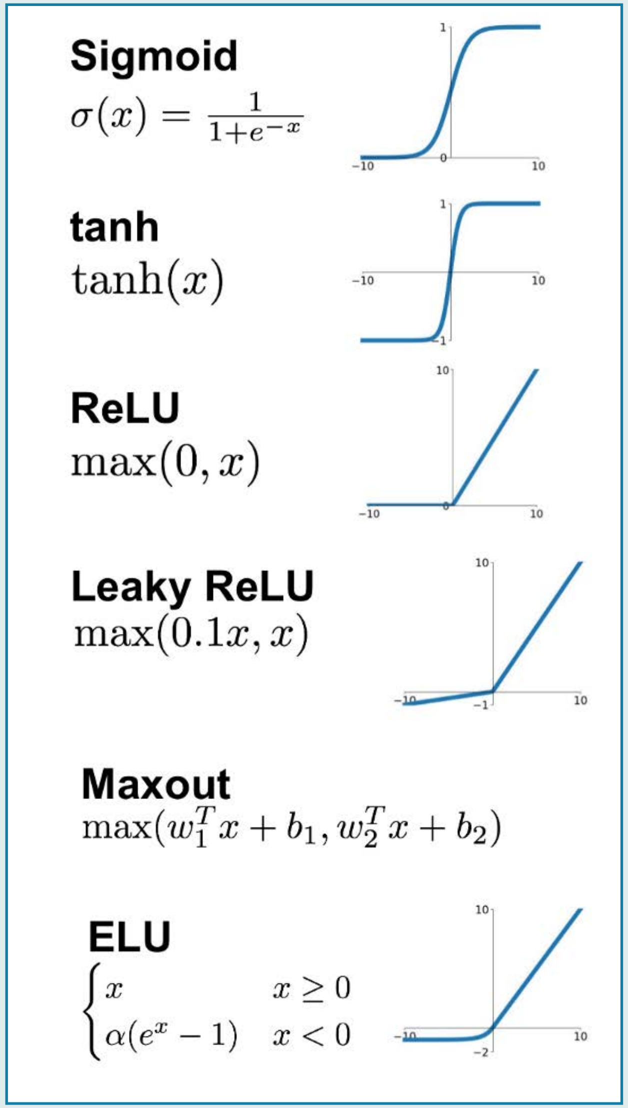
Fully connected



Q_{ice} x W + $Const$ = x → Activation Function → Y

Allows for non-linear links !

Activation Function



Data

- Predictors (features) – HWRF output

3-D features

- Total condensate
- Total ice content
- Rime factor
- Specific humidity
- Cloud water mix ratio
- Ice mix ratio
- Snow mix ratio
- Water vapor mix ratio
- Vertical velocity
- Super-cooled liquid water flag

2-D features

- Accumulated precip
- Instantaneous convective precip
- Accumulated convective precip
- Top of conv. levels
- Richardson number
- updraft fractions
- Max vert wind @ 400 mb
- potential t
- 10m wind

- Predictands (labels) – GLM observations

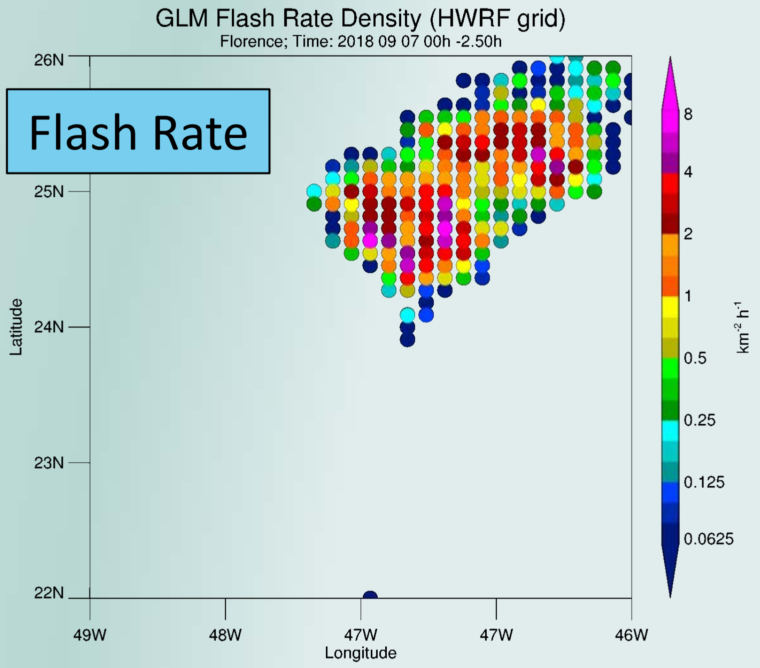
Flash Classes

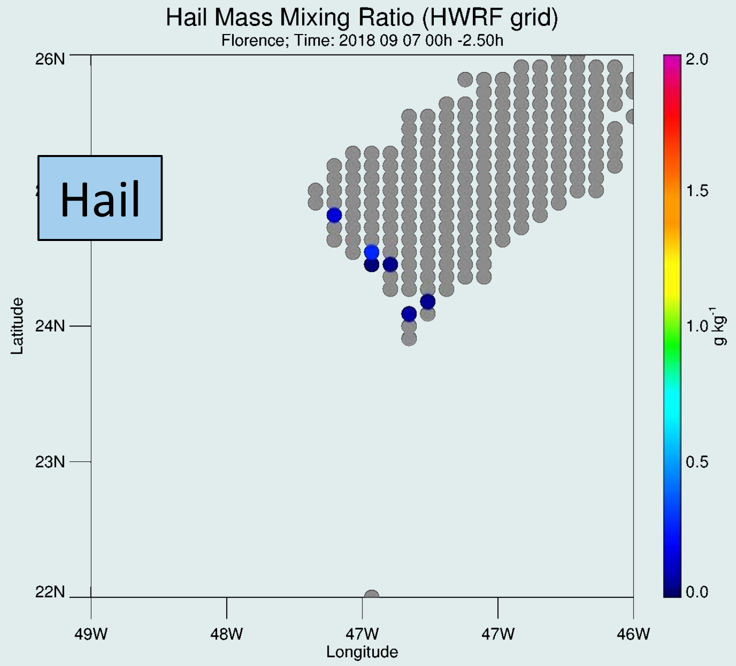
- 2 classes: yes/no lightning
- 3 classes: no-, low-, high-flash rate
- 4 classes: no-, low-, moderate-, high-flash rate

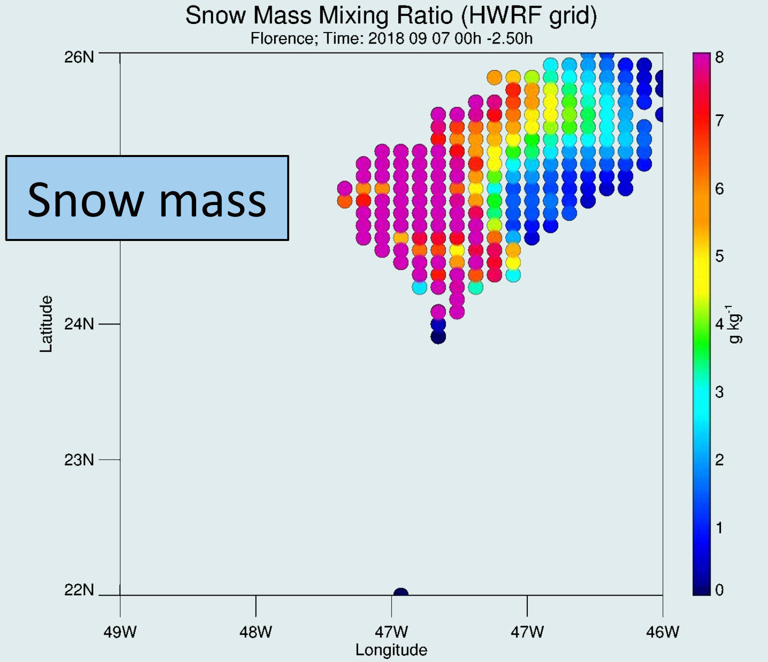
Flash Rate

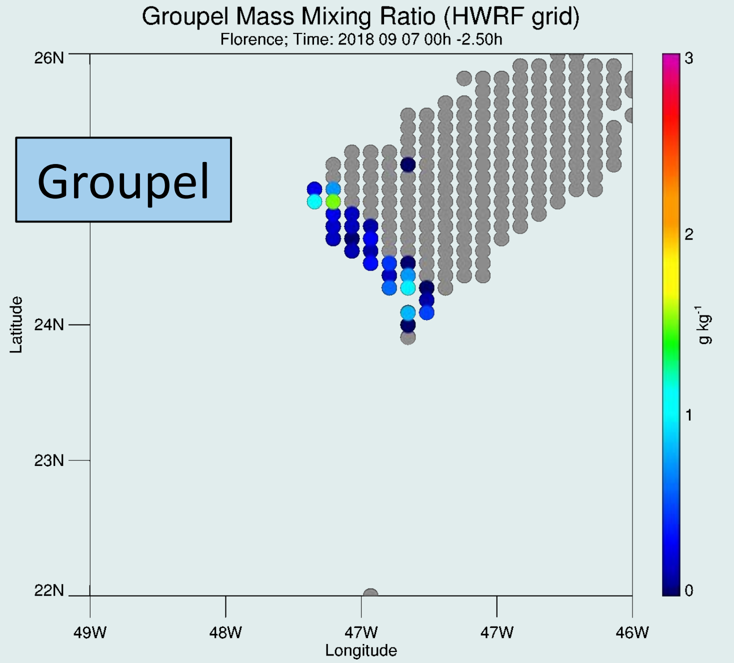
- Flash rate

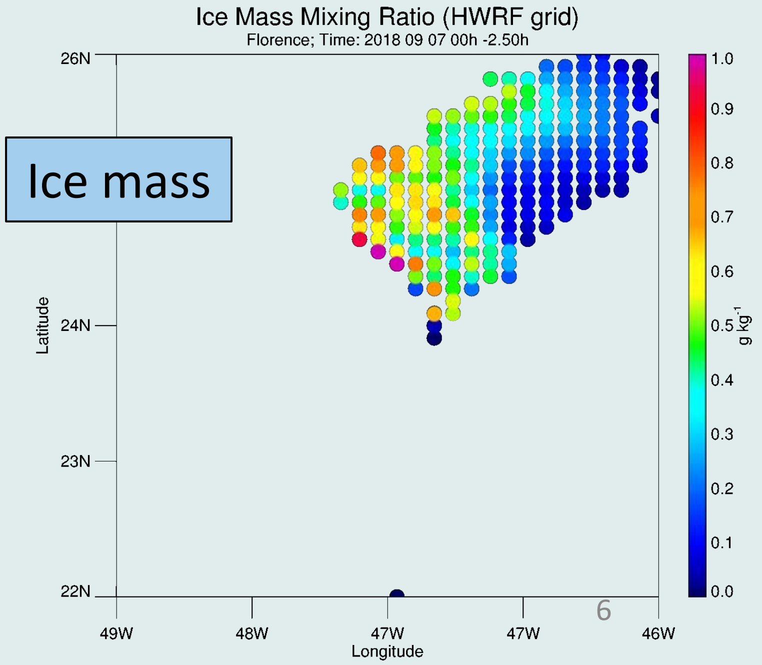
- Note: All mixing ratios here are totaled accounting for delta-pressure but not weighted for geopotential
- Hail is often completely missing
- Graupel is slightly better but still questionable in sense how much it correlates with the FR value

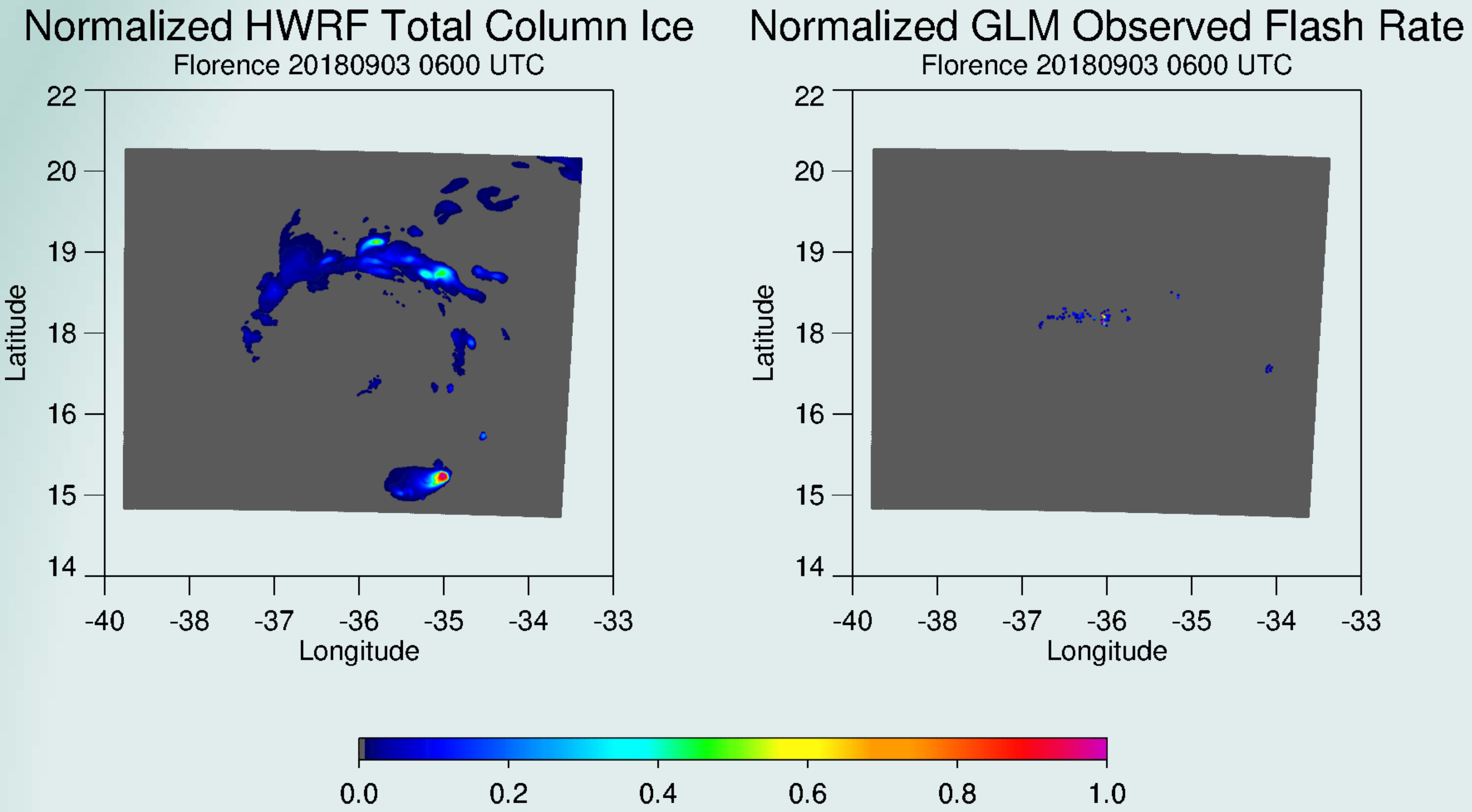






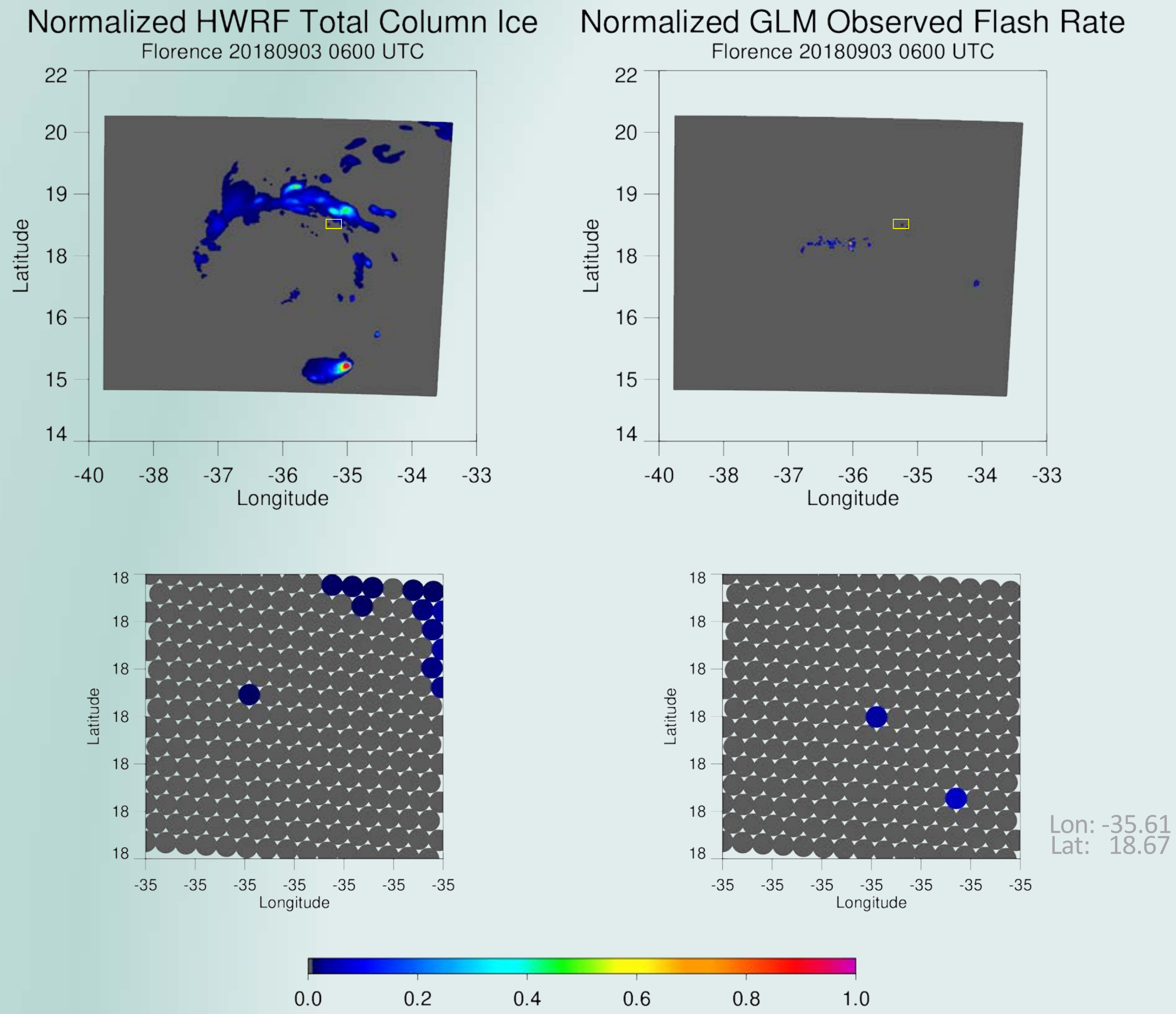




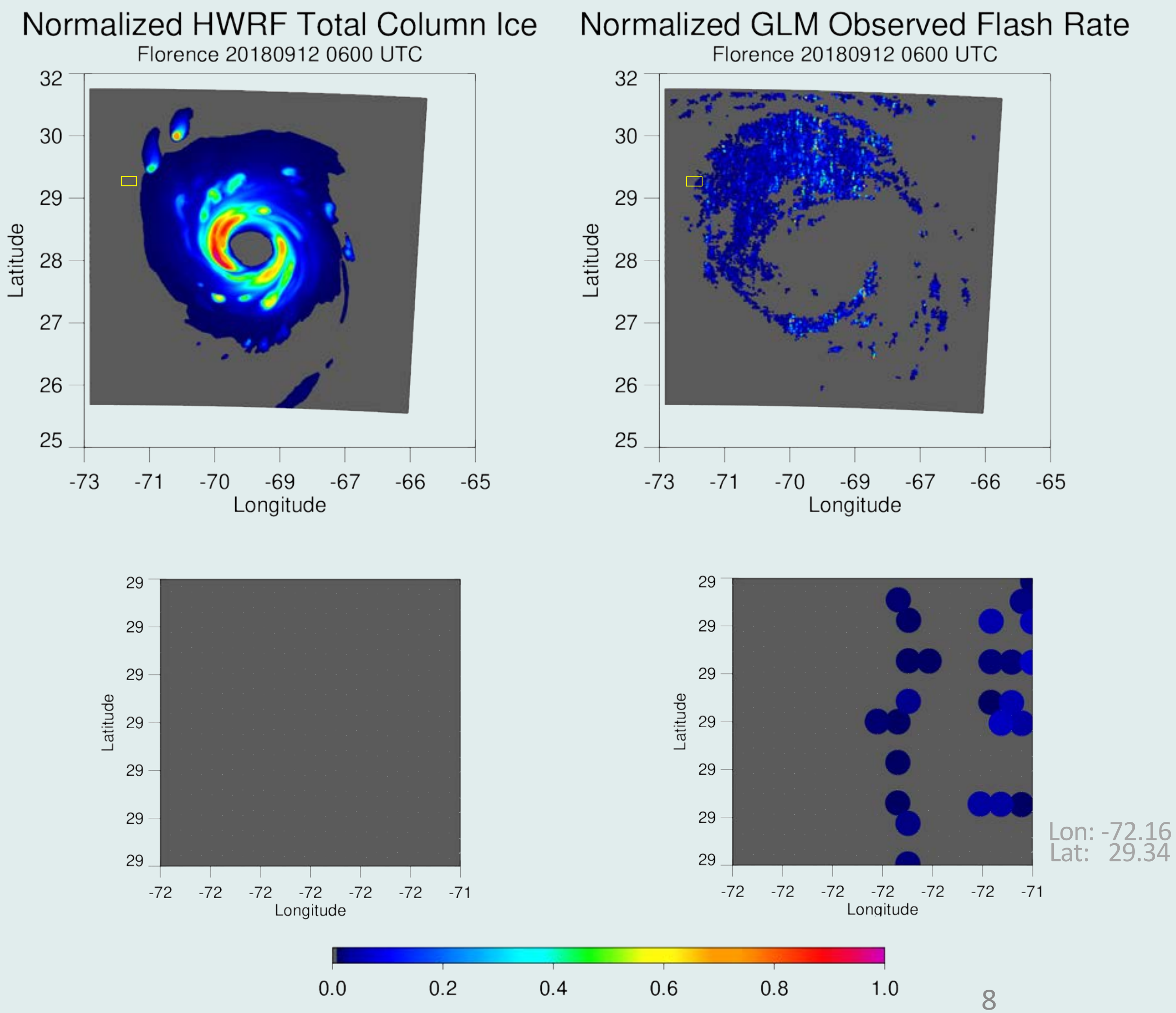

Normalized HWRF Total Column Ice
Florence 20180903 0600 UTC
Normalized GLM Observed Flash Rate
Florence 20180903 0600 UTC
Latitude
22
20
19
18
16
15
14
Longitude
-40
-38
-37
-36
-35
-34
-33
0.0
0.2
0.4
0.6
0.8
1.0

Training dataset
– Relating HWRF output and GLM observations –

Hwrf Output | **GLM obs**

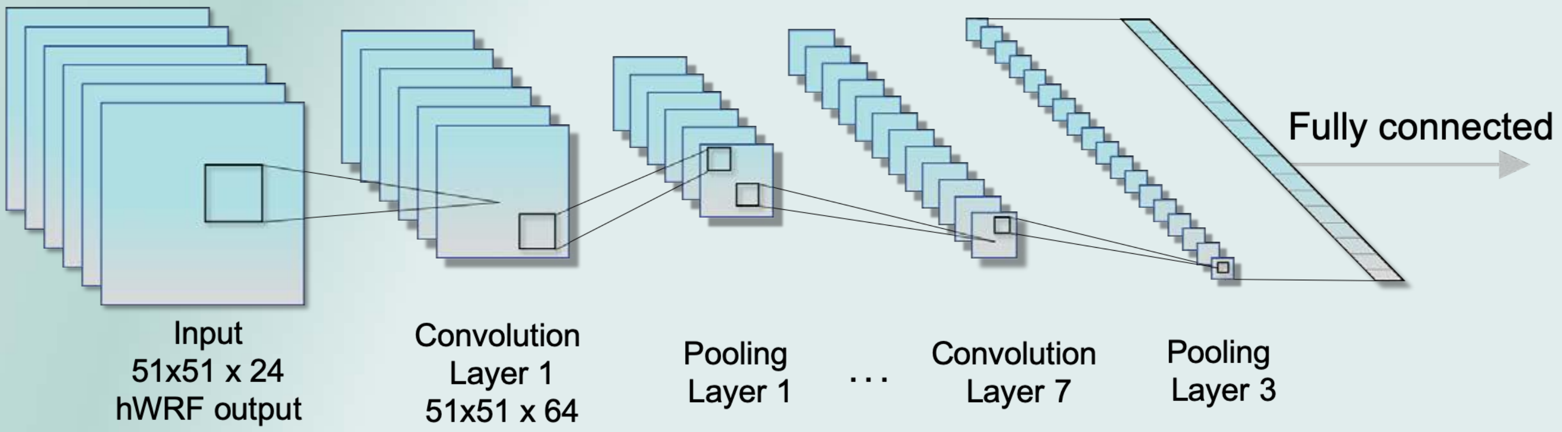


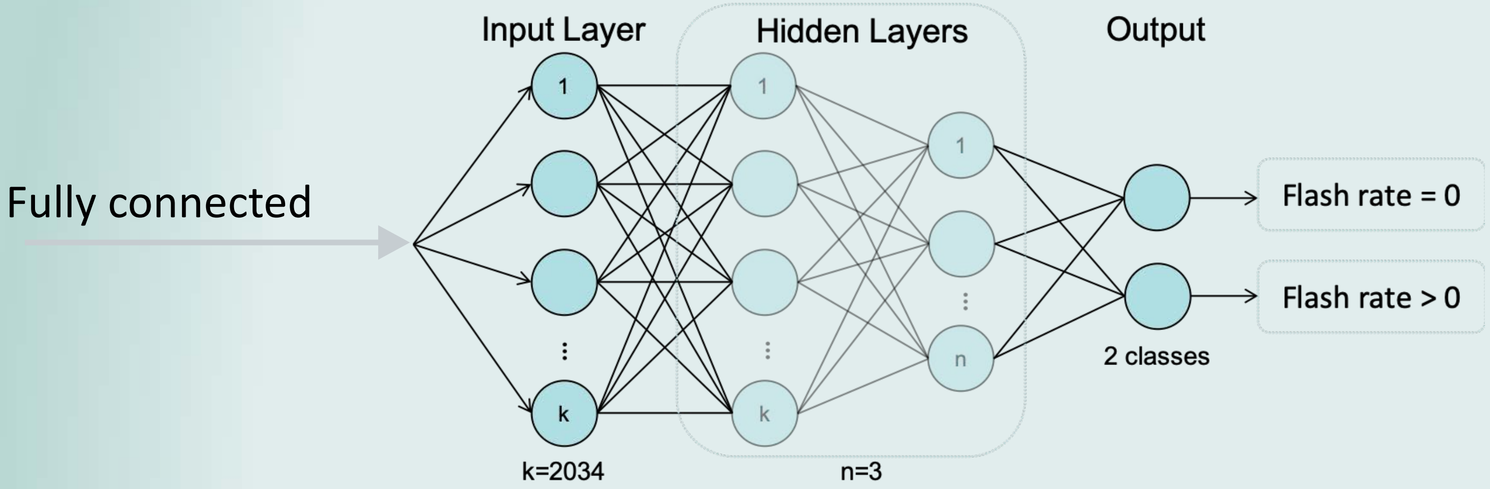
Hwrf Output | **GLM obs**



Deep Neural Network Model

2D Convolutional Neural Network model





CNN Architecture: (51, 51, 24)
================================
Total params: 402,178
Trainable params: 400,898
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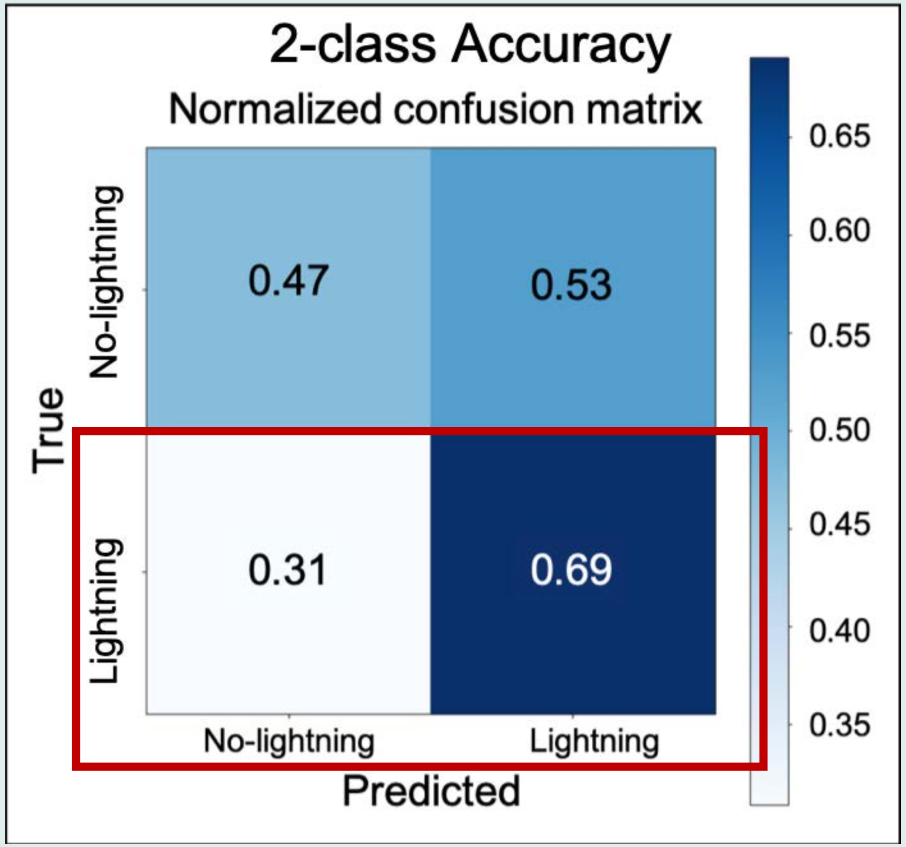
Results and Summary

- Focus was on construction of a flexible DNN system. Developed are:
    - Input pipeline (flexibility to ingest any number of input features of multiple dimensions)
    - Model architectures: Fully Connected and CNN
    - Inference models (for testing the results on independent datasets)

- Initial result for the 2-class experiment (yes/no lightning) stands at overall accuracy of 60% with probability of 70% to correctly detect lightning when occurred.
- Currently performed tests on multiple class tasks suggest that models are generally biased towards no-lightning or low-lightning class.



3-class Accuracy [%]

		Predicted		
		Low	Mod	High
True	Low	74	11	15
	Mod	64	15	21
	High	52	11	37