Precipitation Forecasting Using U-Net Architecture

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W251: Deep Learning in the Cloud and at the Edge
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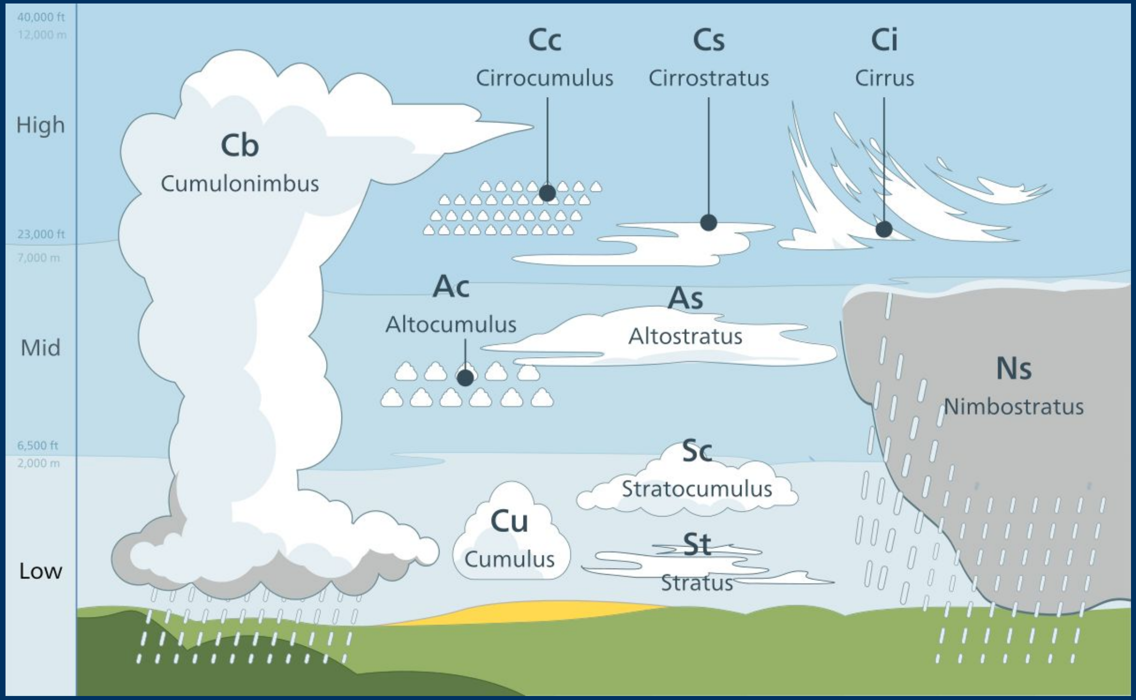
Project Overview

Objective: Generate accurate precipitation radar forecasts using U-Net convolutional network architecture.

- Standard is to use ensemble models and perturbed simulated data
- Model training completed on Nvidia Tesla V100
- Strongest model is set up to be deployed at edge for inference

Background Research



- Clouds are further subdivided based on the level of their bases above sea level. The cloud classification is not straightforward as clouds may take on many forms, many of which continually change
- We can forecast precipitation based on the cloud cover. It is also possible to use precipitation as a means of identifying cloud type.
- We chose to explore the potential of predicting the cloud and rain radar imagery from actual cloud and rain radar images.

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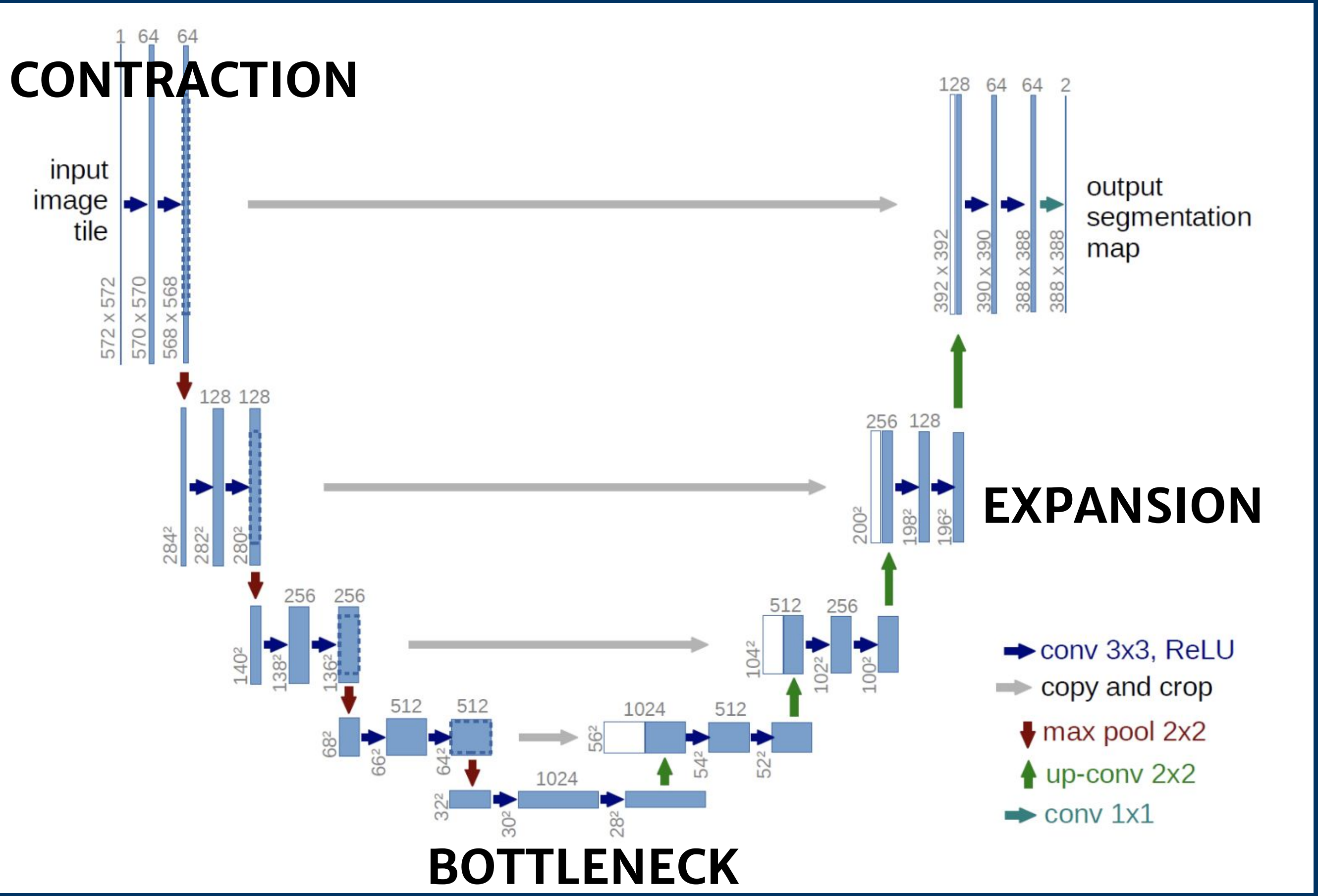
The Data

Characteristics of the dataset used to train our model:

- 49700 rain radar images captured
- Every pair was captured at exactly one hour interval
- Number of locations defined by latitude and longitude used: 530
- World coverage: USA and Europe

Model: U-Net Architecture



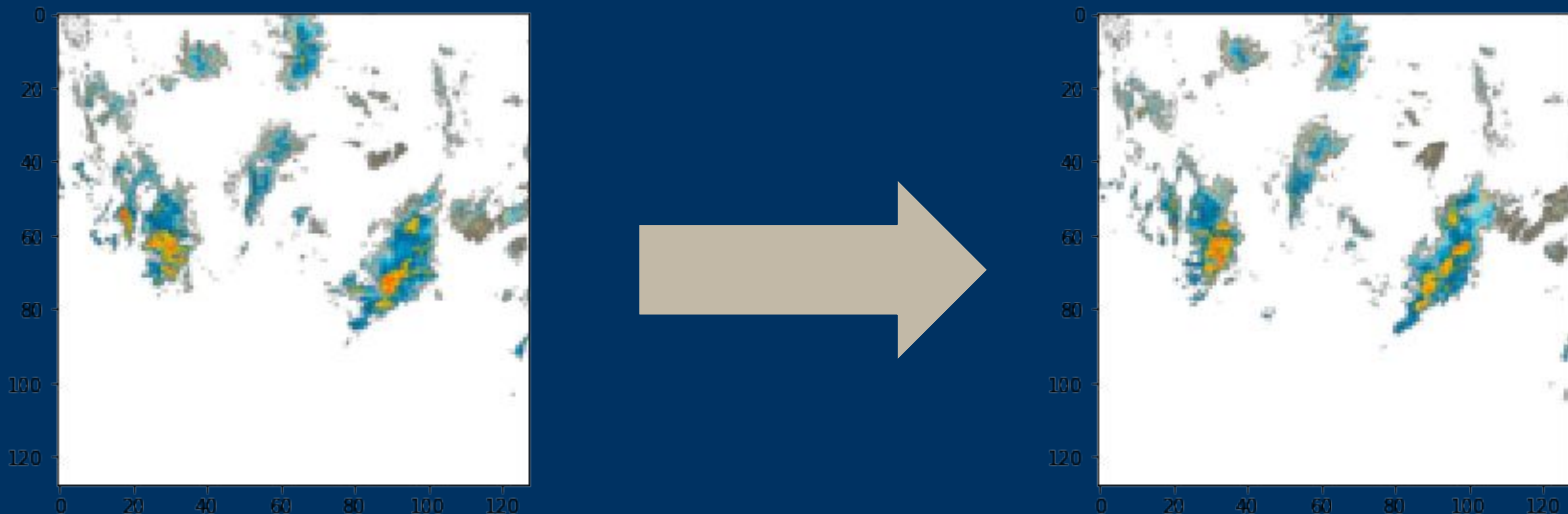
Our Implementation

- Keras API on top of Tensorflow
- Model trained on NVIDIA Tesla V100 in cloud
- Images re-sized to 128X128, 4 channels
- 1,941,300 fully trainable parameters (baseline model)

Key Architecture Changes

- Predict pixel values between 0 and 1
- Predict 4 output channels
- MSE metric

Baseline Model



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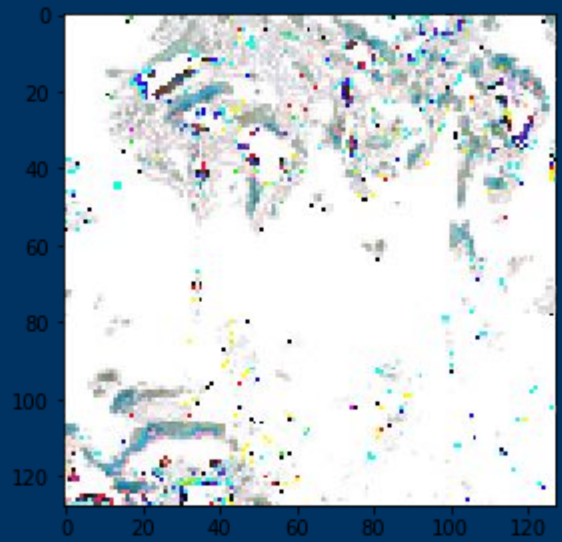
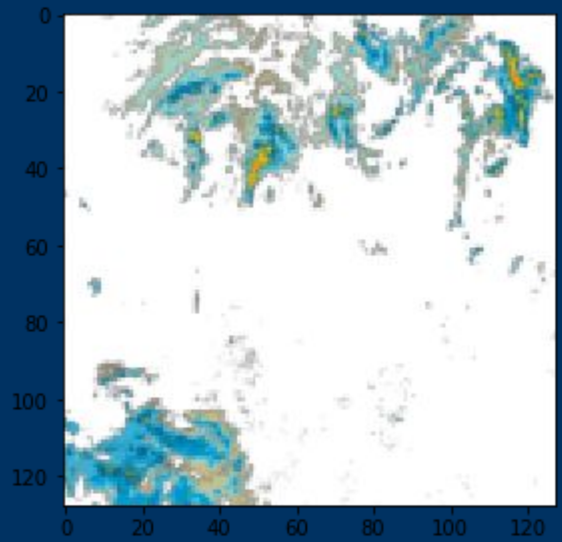
Second Model: Incorporating Trend

Third Model: Difference Only





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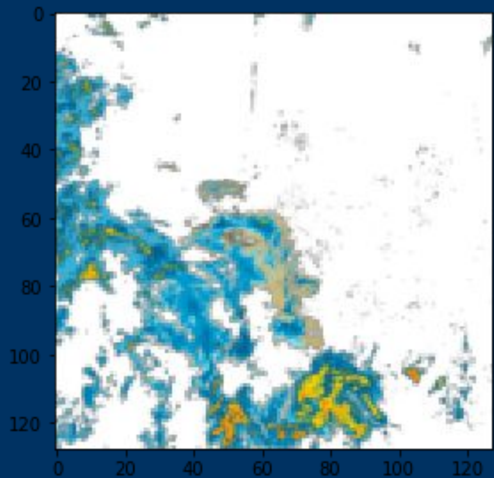
Results: Model Performance

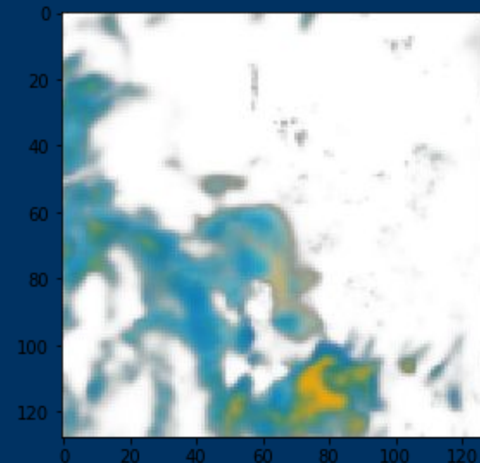
Model Iteration	Time per epoch	Validation loss	Validation MSE
1 (Baseline)	~70sec	0.10166	0.0054
2 (Include "difference")	~82sec	0.10067	0.0052
3 (Difference only)	~66sec	0.10561	0.0065

Results: Prediction Quality

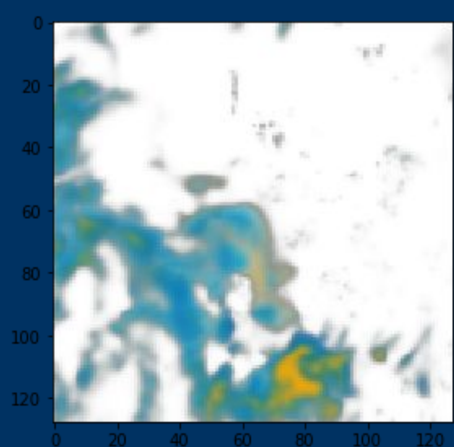
Target Output



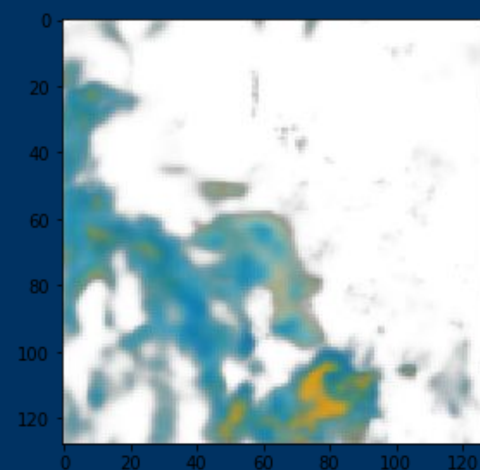
Prediction 1



Prediction 2



Prediction 3



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Errors, Possible Solutions

- Blur
- Model memory
- Location-specific models

Live Inference Demo

Conclusion + Future work

Summary of current model performance:

- Strong precipitation intensity forecasts
- Weak directional movement forecasts

Next Steps:

- Increase corpus of precipitation radar image pairs (45k → 4.5M)
- Better image resolution
- Larger image area (City → Country/Continent)
    - Help capture macro weather patterns
- Alternative evaluation metric to assess directional movement forecast in isolation (i.e. IoU)