AI in the Atmosphere: Transforming Cloud Fraction Parametrization for Better Predictions

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Introduction

- Clouds are vital atmospheric phenomena that significantly influence weather and climate dynamics on Earth.
- Cloud Fraction: This term is more specific and typically refers to the proportion of a given area (like a grid cell in a climate model) that is covered by clouds. It is usually expressed as a decimal or a percentage.
- Cloud Cover: This term generally refers to the total area of the sky that is covered by clouds. It is often expressed in oktas (eighths of the sky) or as a percentage.
- We have attempted to predict cloud fraction with the application of Physics informed neural network(PINN).

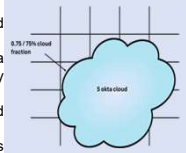


Fig:1 illustrates difference between cloud fraction and cloud cover.

Motivation

- Clouds encompass a substantial fraction of the Earth's surface (Hahn et al., 2001) and play a critical role in modulating the planet's energy budget (Harshvardhan et al., 1989). The variety of cloud types, along with their pronounced spatial and temporal variability, significantly influences the dynamics of the radiation budget.
- Estimating cloud fraction in partially cloudy areas is a long-standing issue, typically based on satellite (Minnis 1989; Rossow et al. 1993), aircraft (Wood and Field 2000; Rodts et al. 2003), and ground-based observations (Fairall and Hare 1990; Clothiaux et al. 1999; Pfister et al. 2003).

Objective

To use physics-based ML model to define cloud fractions.

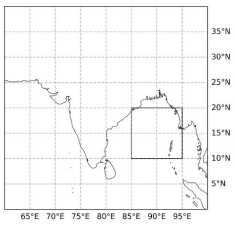
❖ Data

Simulation data (3Km)

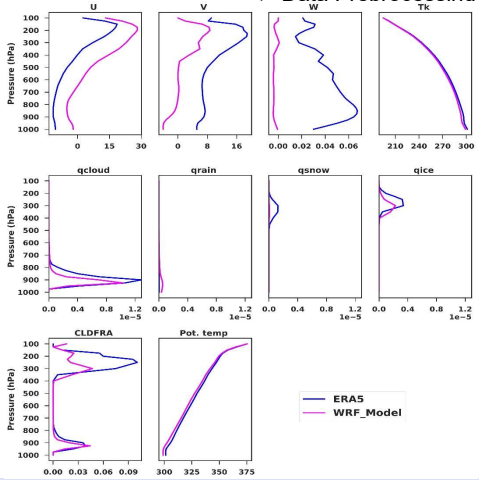
- We have used WRF model simulation (3hourly) at 3 km resolution for year 2016 (01-Mar to 29-jun) for our purpose.
- We have used cloud fraction , mixing ratios , temperature , relative humidity at pressure levels .

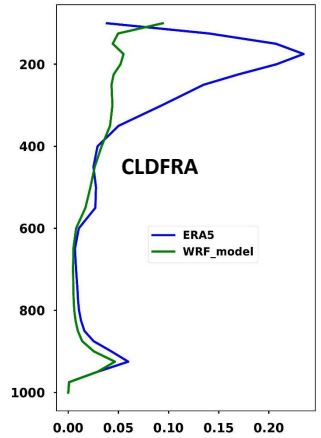
ECMWF Reanalysis-5 (25km)

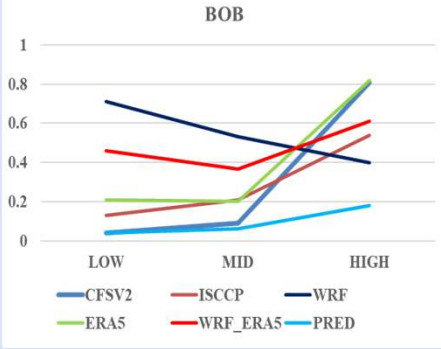
- We have used hourly data for year 2016 (01-Mar to 29-jun).
- We have used cloud fraction , mixing ratios , temperature , relative humidity at pressure levels for our purpose.



❖ Data Preprocessing







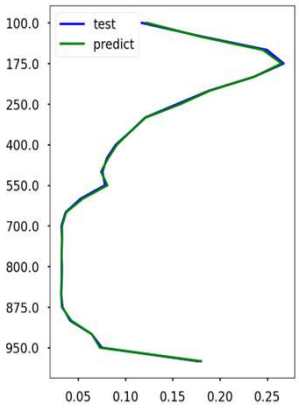
CNN architecture

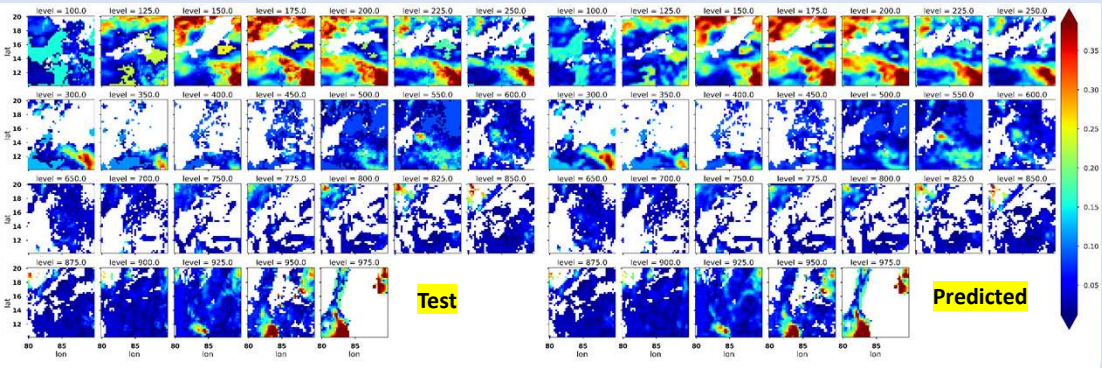
- ✓ Mean of WRF and ERA5.
- ✓ Train /test/ validation at 60%/20%/20%.
- ✓ Loss function: Mean absolute error
- ✓ Backbone: Resnet
- ✓ Epochs: 55
- ✓ Batch size: 3
- ✓ activation :Relu
- ✓ Learning rate: $1e^{-3}$
- ❖ Randomised temporal axis to maximise uncertainty.

Evaluating Model Performance

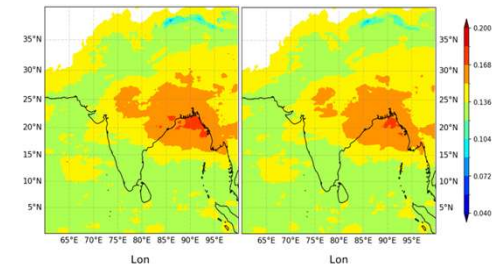
➢ Predicted cloud fraction

✓ Spatial of cloud fraction with respect to vertical pressure levels during a single time index shown.





Spatio temporal mean of cloud fraction w.r.t. all test timesteps



Comparison of Test and Predicted Data at 100hPa.

- Total time-period 01-01-1998 to 31-12-2019.
- All the CNN architecture remains same.
- Instead of BOB we have done Over India.

Future work

1. Train-test-validation for all pressure levels for a minimum of 30 years data over Indian subcontinent.

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As we blend technology with meteorology, the clouds are telling a clearer story than ever before!

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