

ERA5 Atmospheric Profiles

MODIS Observations

We train a machine learning model to generate MODIS observations from ERA5 atmospheric profiles to study:

How much do atmospheric environmental conditions constrain cloud organization patterns?

Experimental Results

True tile

Generations

The model simulates realistic cloud morphologies and the power spectra of CloudFlow match the true MODIS data.

Further validation is needed to assess the model's reliability under different cloud regimes.

Flow Matching

c

$z = e * (1 - t) + x * t$

x

$v = (x - z) / (1 - t)$

$v_pred = (UNet(z, MultiHeadAtt(c)) - z) / (1 - t)$

Atmospheric Profiles: **c**

Optimization objective: $l2_norm(v_pred, v)$

The model learns to generate MODIS data by *learning to denoise* MODIS tiles that have been corrupted with random noise.

Attention Process

$$Att(Z) = \text{softmax} \left(\frac{Q(ZW_k)^T}{\sqrt{d_a}} \right) ZW_v$$

An attention encoder compresses the ERA5 variables from 37 pressure levels into an 8-dimensional feature vector.

Connecting CloudFlow to EarthCARE

Currently, we solely use atmospheric profiles (of temperature, humidity, and wind) from reanalysis data as conditioning information.

Incorporating aerosol and cloud microphysical properties measured from EarthCARE will allow us to build a model that can be used to measure the relative importance of different environmental conditions for different cloud regimes.