Generating CloudSat Reflectivity Using Passive Microwave Brightness Temperatures and cGANs

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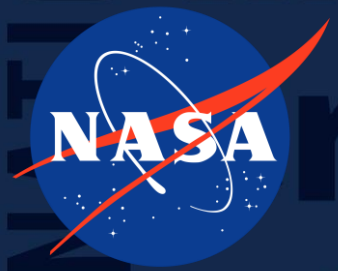

Acknowledge funding from NASA Precipitation Measurement Missions program

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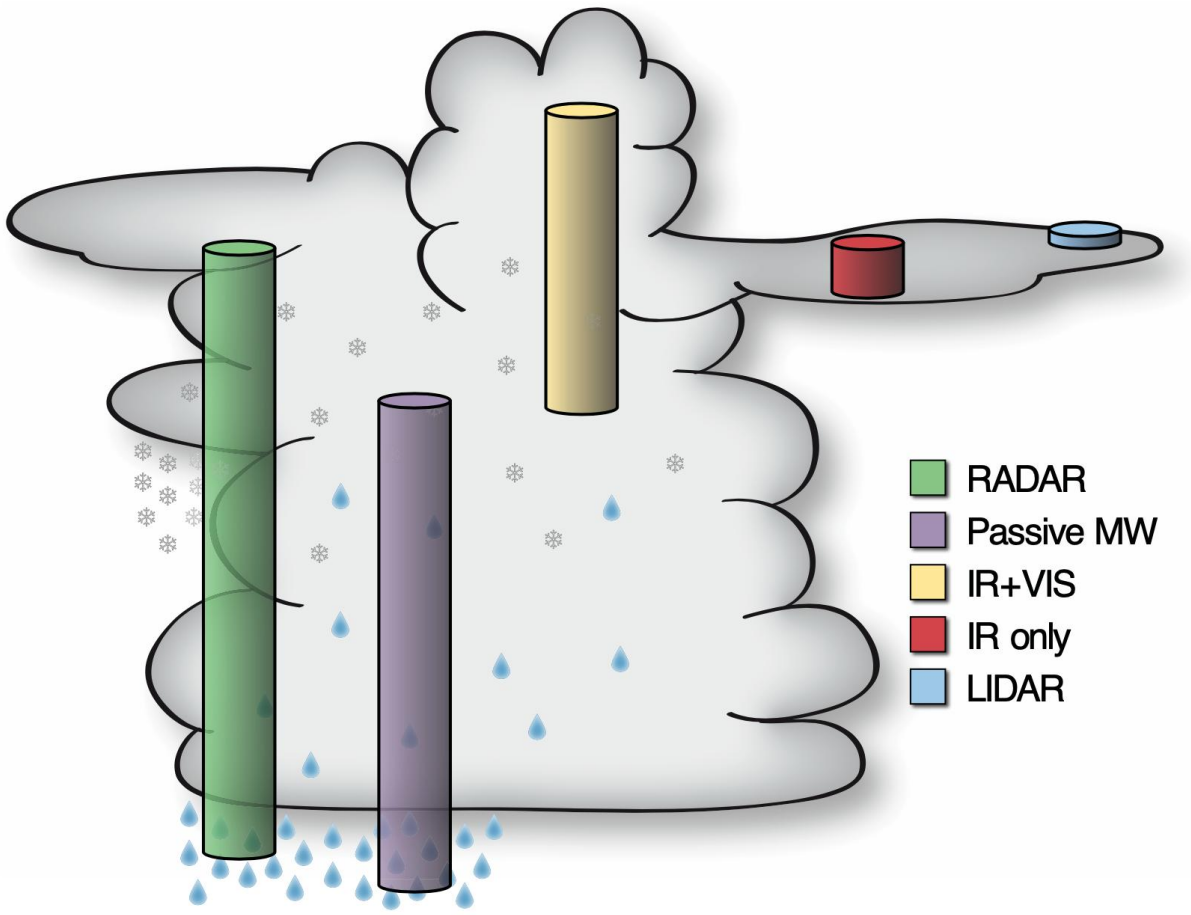
Motivation

- Passive sensors cannot directly observe the vertical profile of hydrometeors
  - Bayesian retrievals trained on cloud model data and radar retrievals; results mixed (Elsaesser et al. 2015)
- Determining cloud profiles is a difficult challenge for modern passive sensors
  - Can deep learning be an alternative & cheaper approach?



Adapted from Eliasson et al. 2011

Data Sources

- NASA CloudSat
  - Profiling radar (CPR)
- NASA Global Precipitation Measurement
  - Microwave Imager (GMI)

- CloudSat-GPM Coincidence Dataset
  - Prepared by Joe Turk, JPL, July 25 2016
  - Spans from March 2014 to June 2016
  - Matched within +- 15-minute time intervals
  - Daytime only

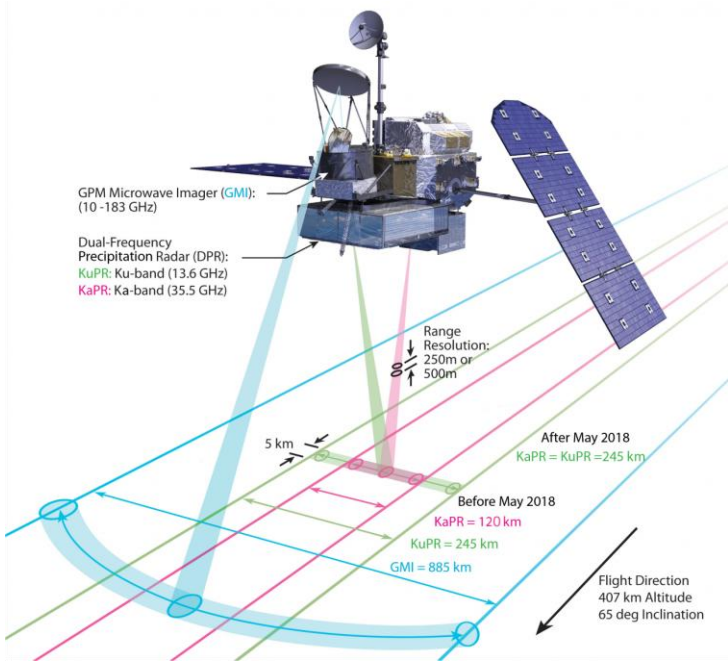


Image from: https://gpm.nasa.gov/missions/GPM

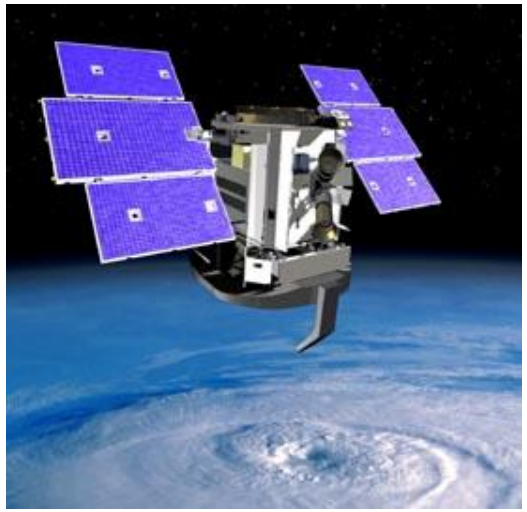
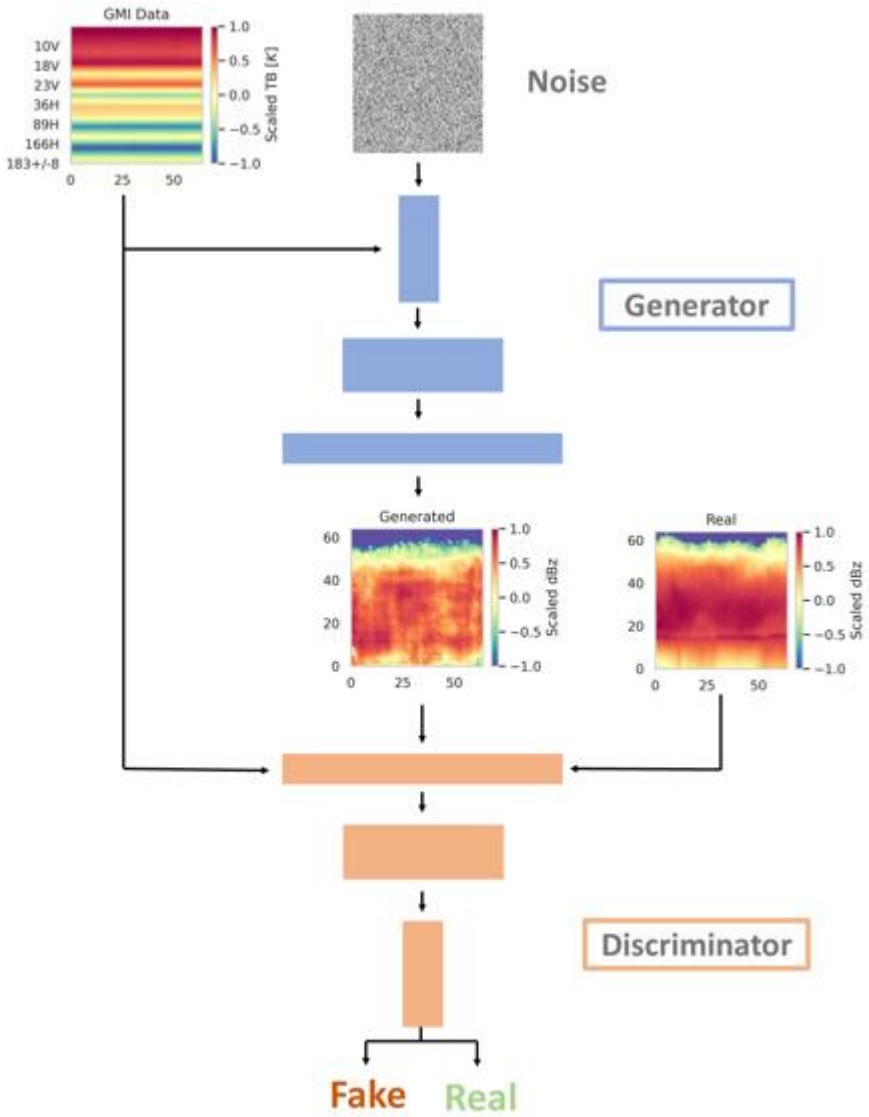


Image from: https://cloudsat.atmos.colostate.edu/education/satellites

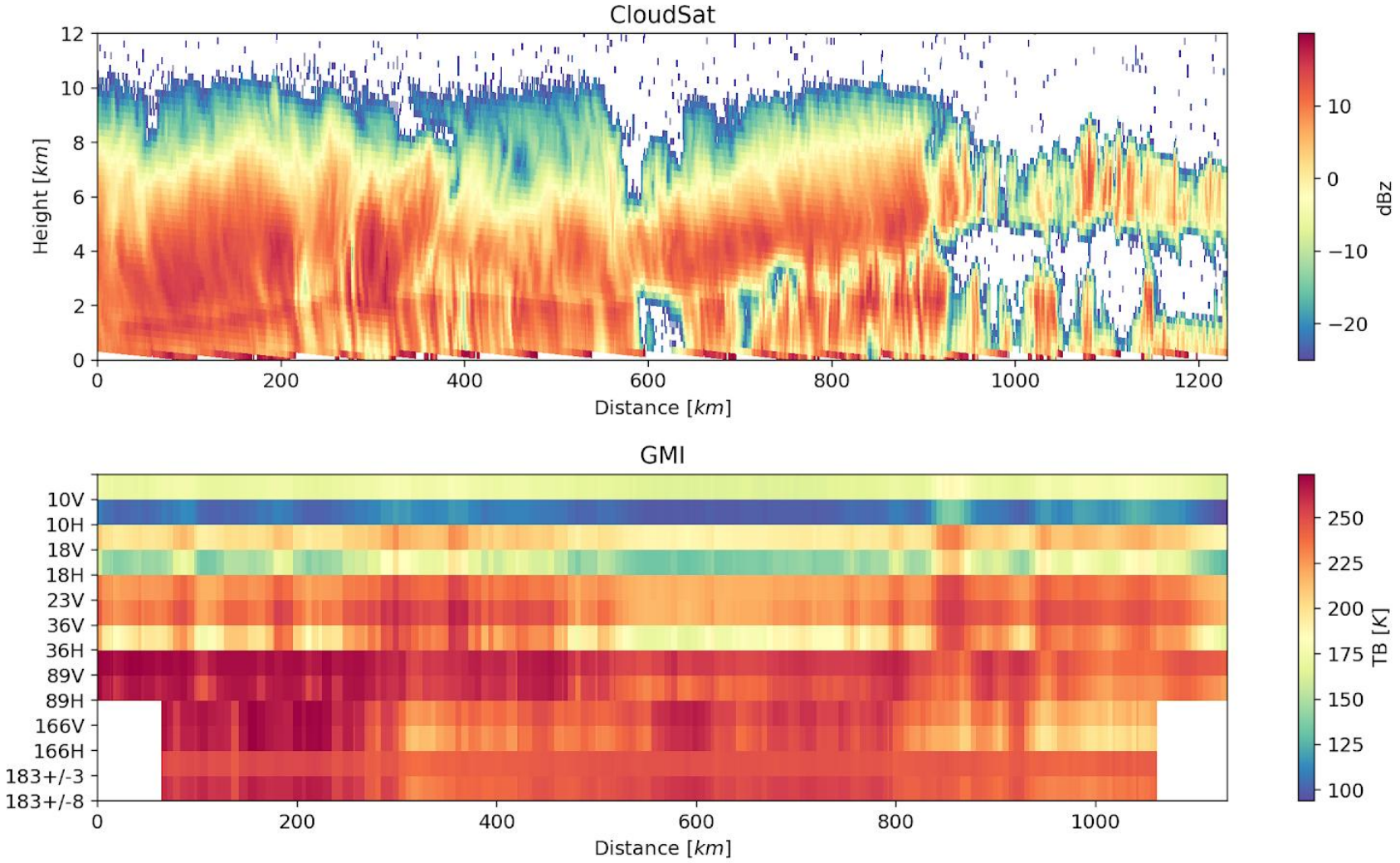
What is a GAN/cGAN?

- GAN is a deep learning methodology for creating generative outputs
- Two components
  - Generator
  - Discriminator
- Goal is to synthesize images that cannot be distinguished between real/generated

- cGAN is special because it can generate an example based on a specific label



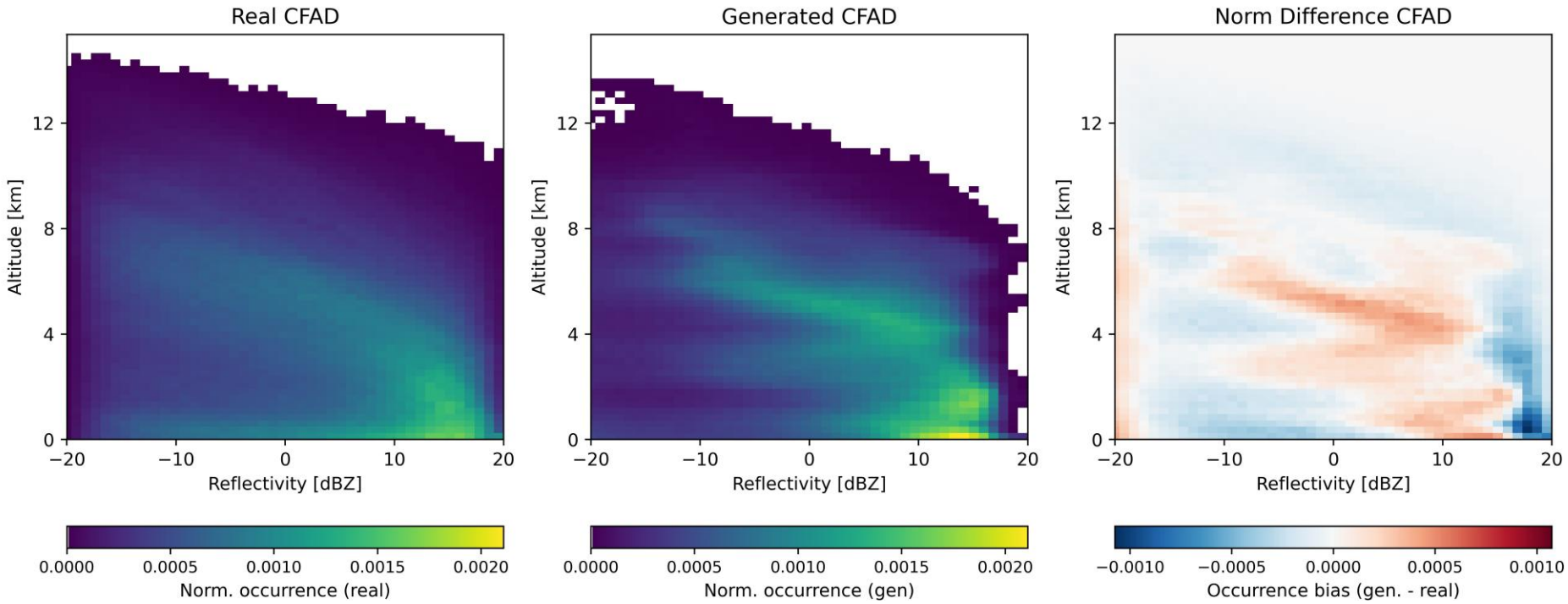
Example of Input Data



Goal is to use the information in the observed multi-channel brightness temperature fields to reconstruct the vertical profiles of radar reflectivity observed by CloudSat

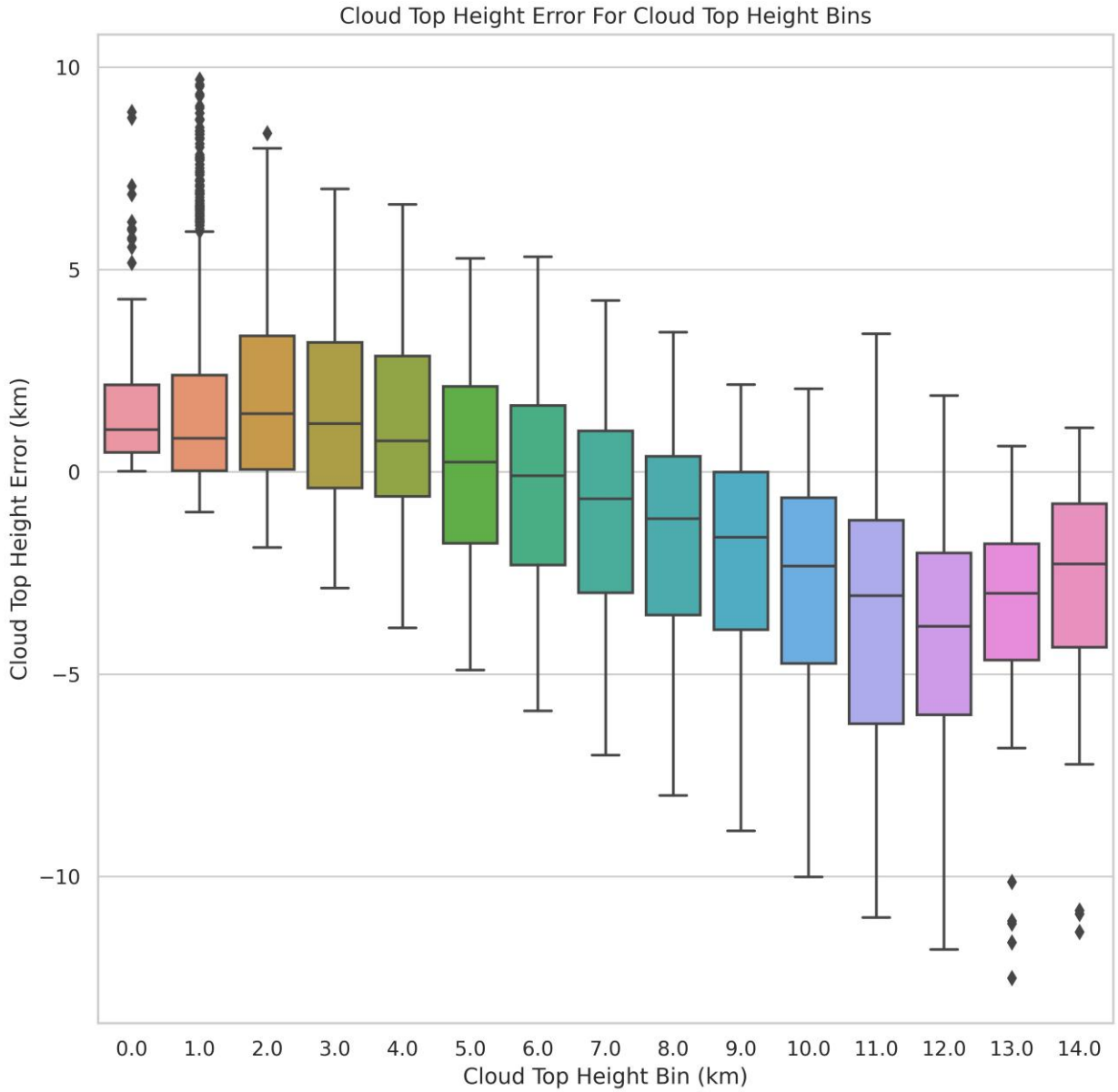
Statistical Results

- Mean Cloud top bias of -304m
- Compared to MODIS bias of -540m Mitra et al. (2020)

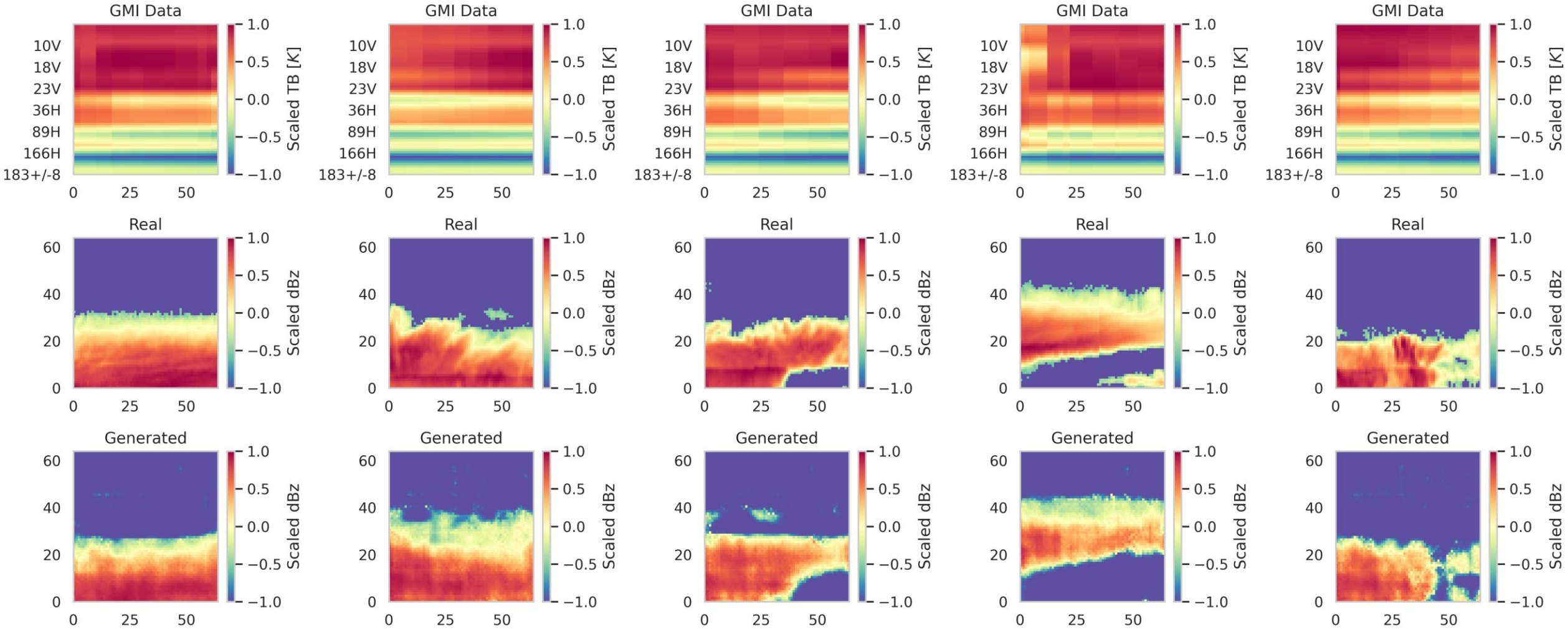


Relative Errors

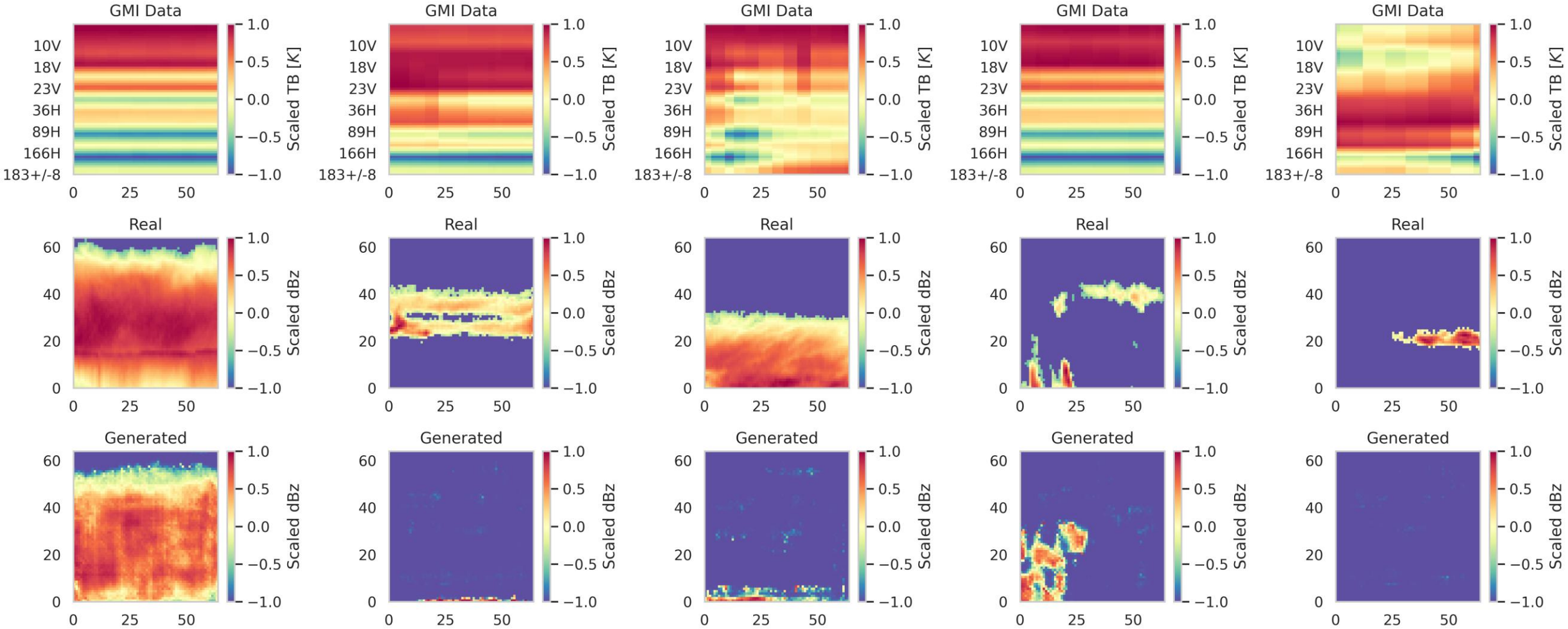
- Shift in error from positive to negative as cloud-top height increases
- Performs best for cloud top heights in mid altitudes
- High altitude clouds perform worse



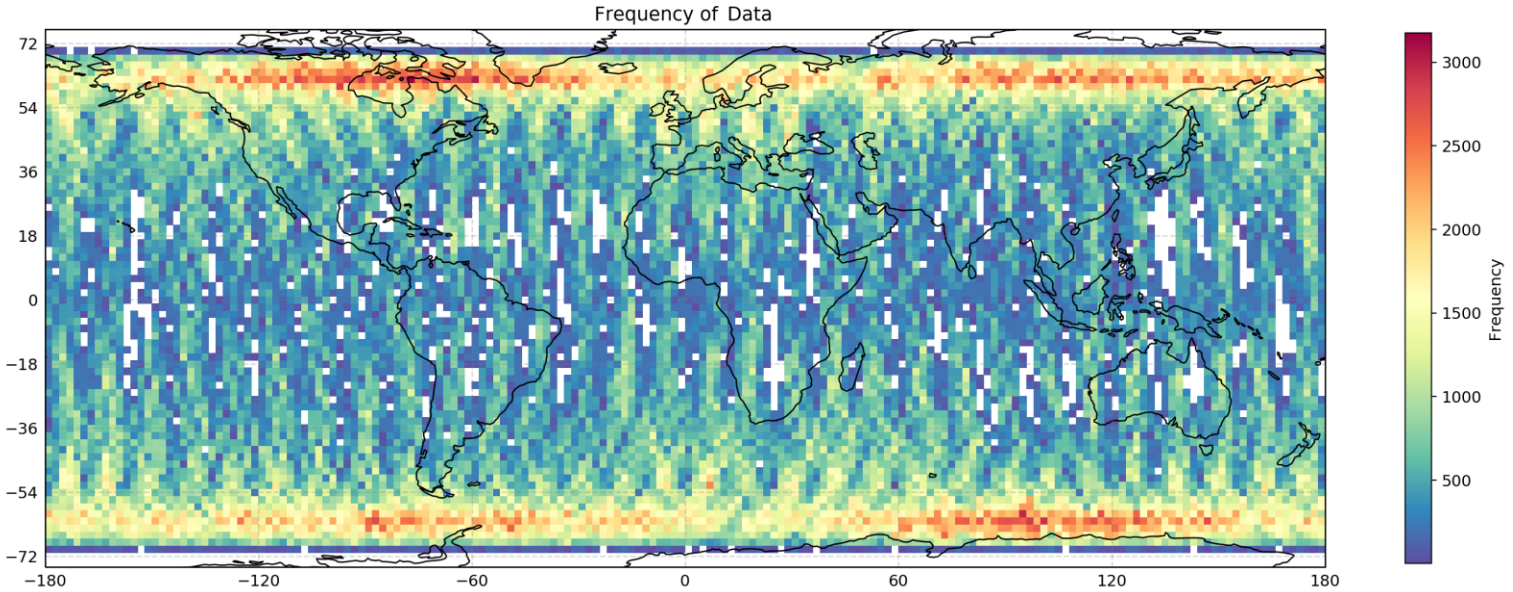
Scene Generation Successes

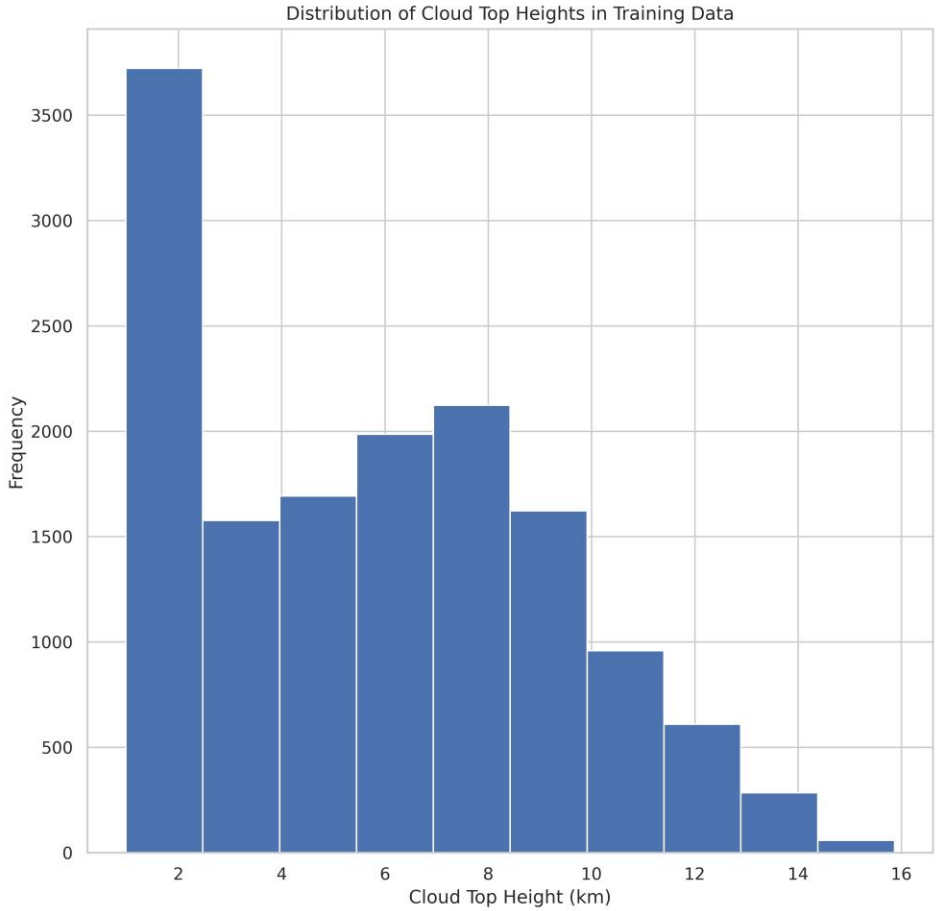


Scene Generation Tragedies

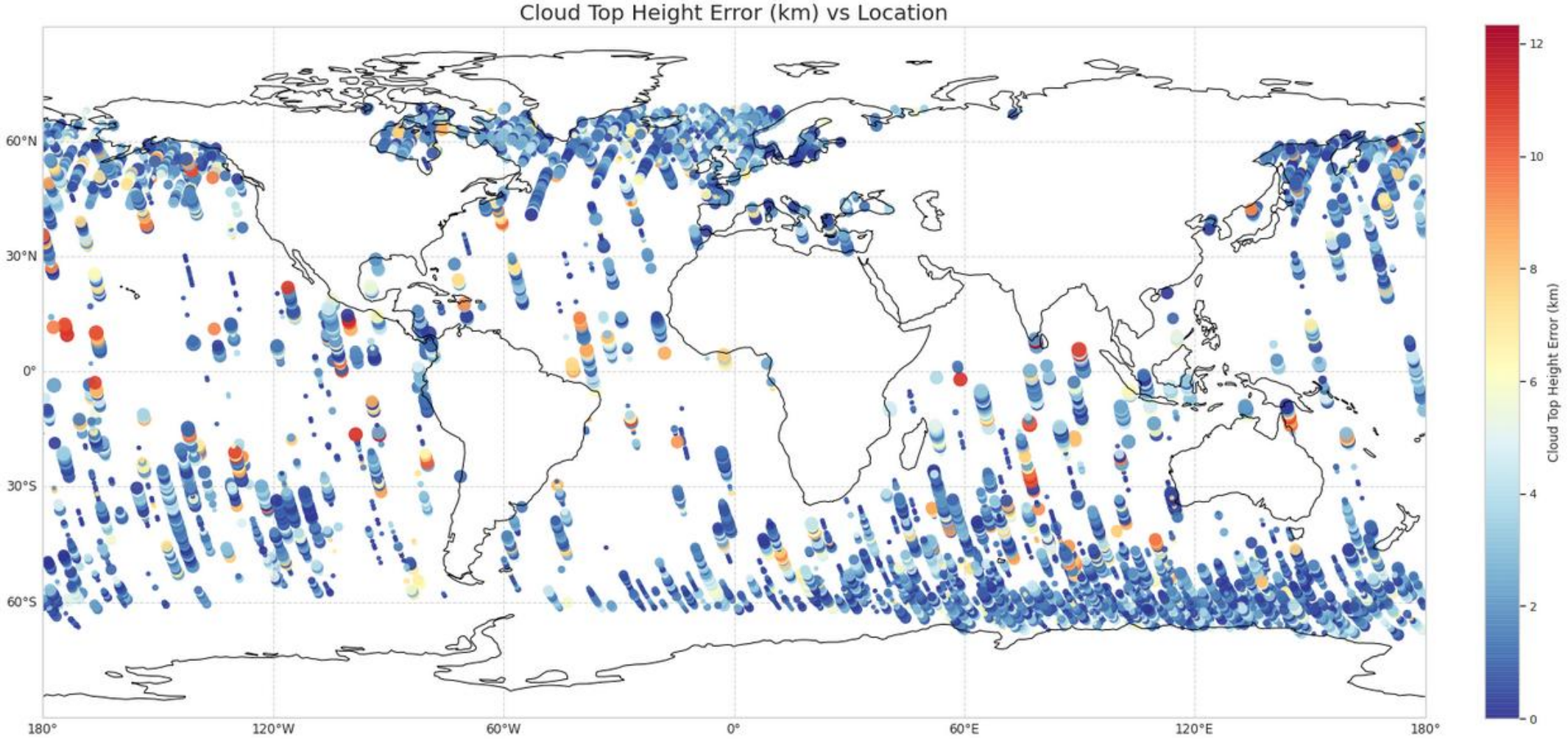


Challenge – Data Variability





Geographic Distribution of Errors



Summary

- Difficult learning radiative transfer from brightness temperatures
- Model is capable of outputting plausible CloudSat images
- Model has promise

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Email any questions!

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