20th ANNUAL CMAS Conference
Nov 1-5 | Virtual

Application of a Partial Convolutional Neural Network for Estimating Missing TROPOMI NO_2 Remote Sensing Information

Yannic Lops[1], Arman Pouyaei[1], Masoud Ghahremanloo[1], Yunsoo Choi [1]*, Jia Jung[1]

Presenter: Yannic Lops

1. Department of Earth and Atmospheric Sciences, University of Houston

*Corresponding Author: ychoi23@central.uh.edu

CMAS Conference, November 2021

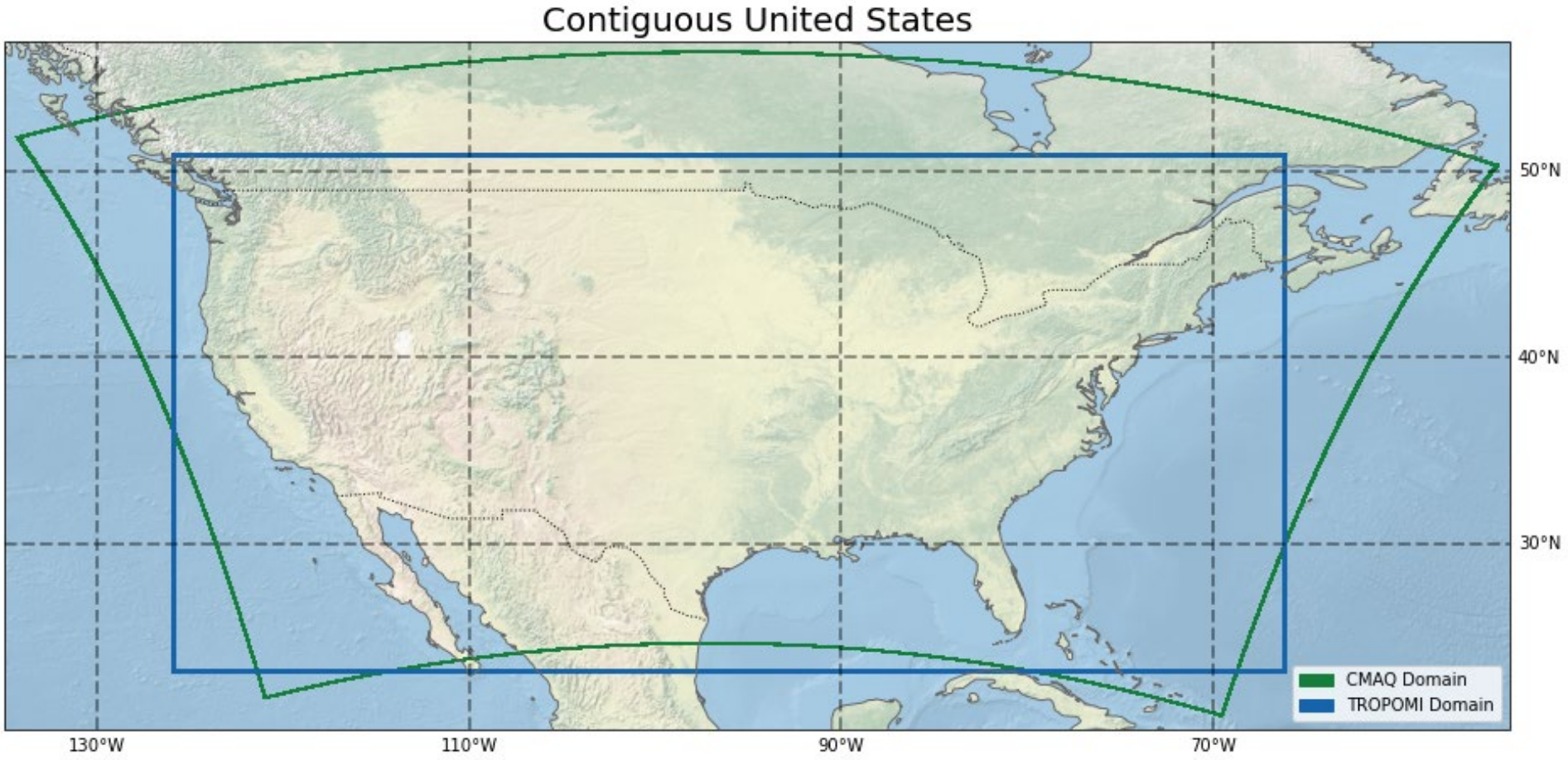
Motivation of Study

- Data Assimilation of remote sensing data to improve CMAQ accuracy

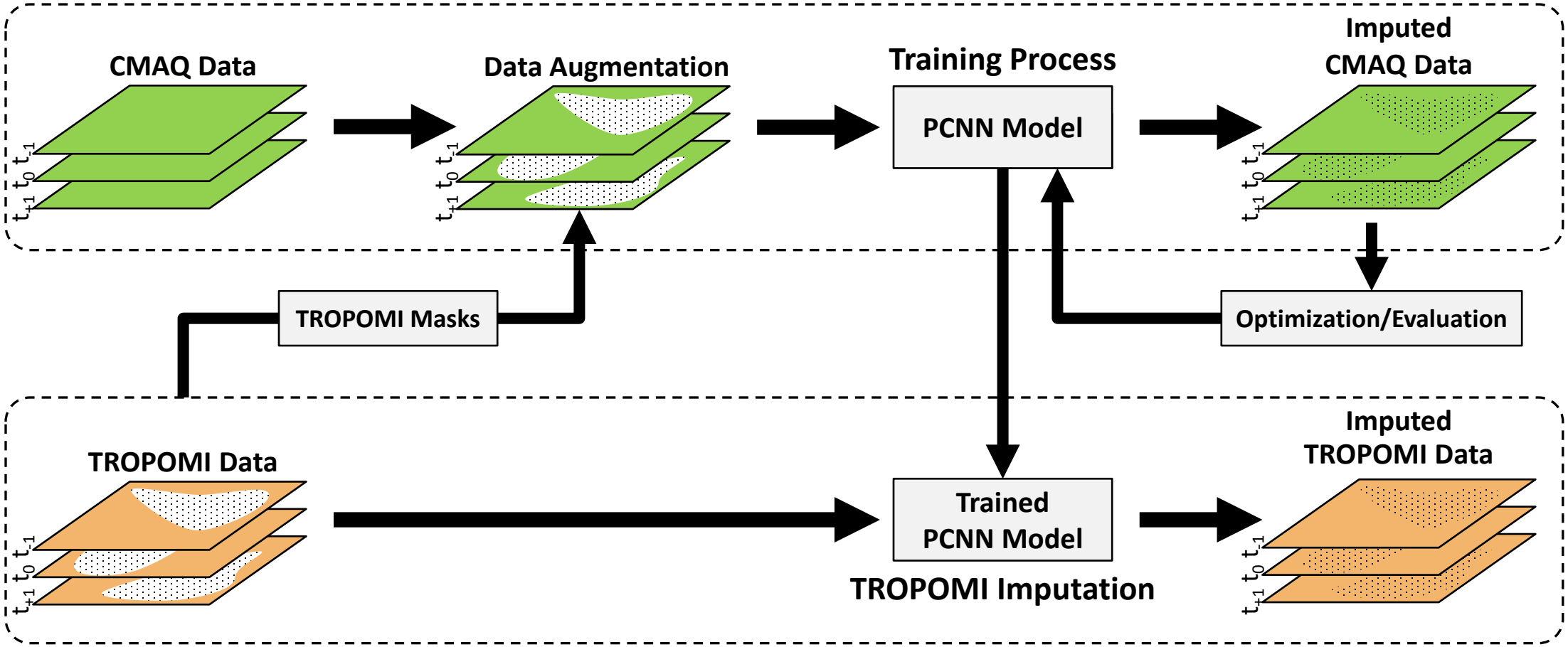
- Remote sensing datasets impacted by:
  - cloud cover contamination
  - false reflectance
  - significant biases within the data
  - sensor errors corrupt data

- Solutions?
  - Averaging → reduce the temporal resolution
  - Imputation → uncertainties and computational cost

Study Area – CONUS Region

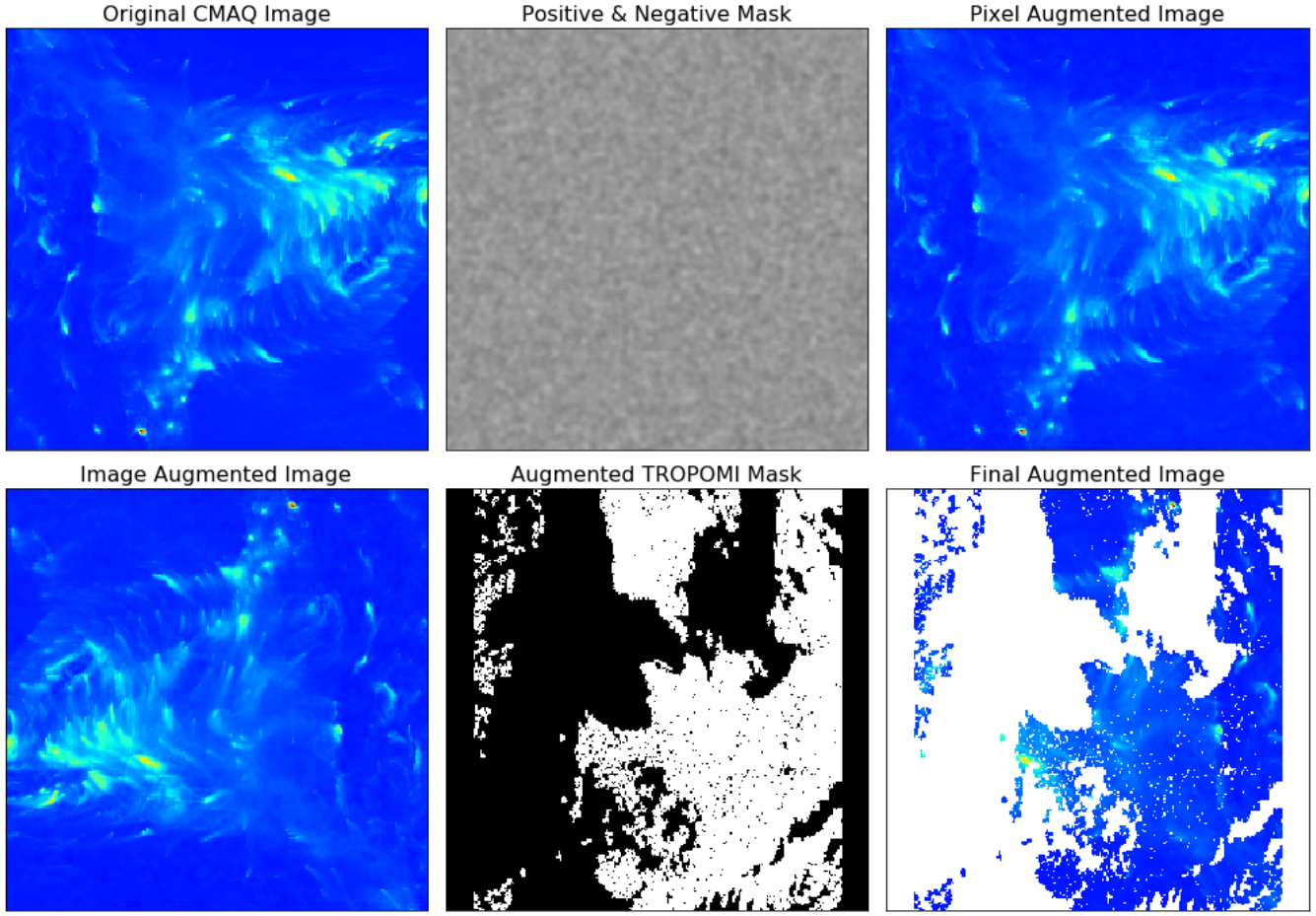


Spatio-Temporal Partial CNN Imputation System

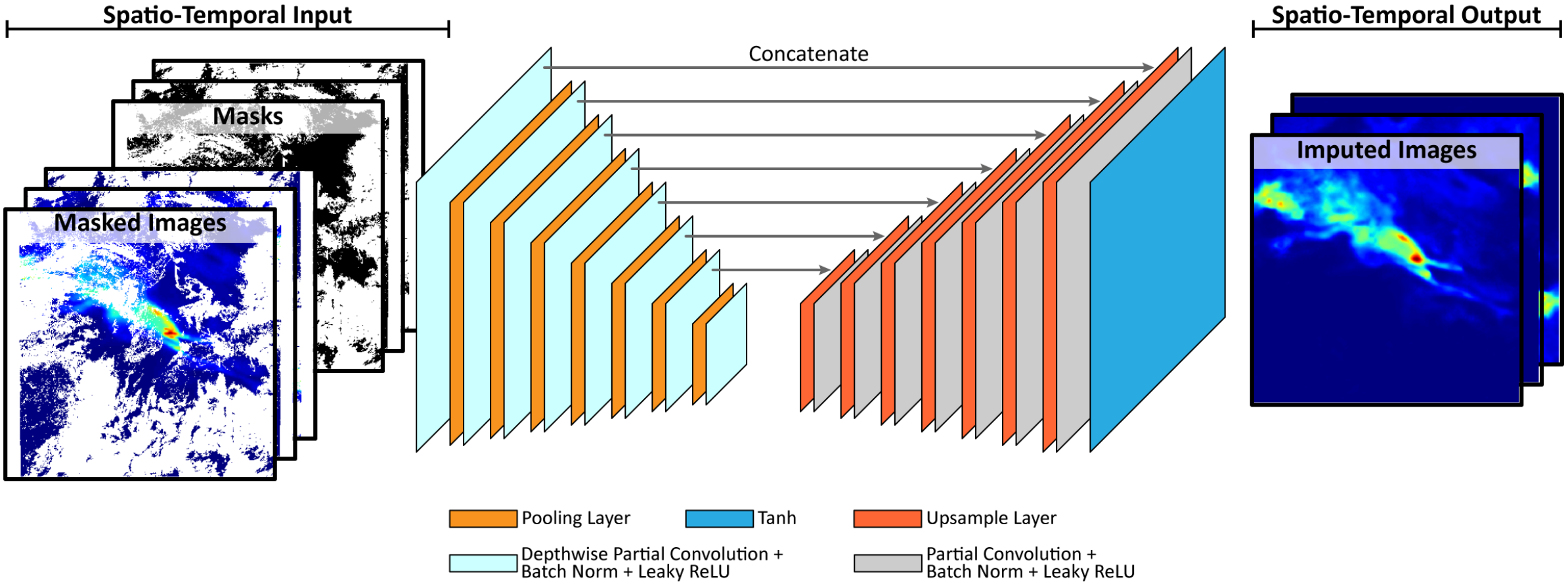


Data Set-up – CMAQ Data Augmentation

- 3-step data augmentation
  - Application of white noise feature/mask on CMAQ image
  - Image augmentation of processed CMAQ image
  - Application of randomly selected missing TROPOMI data mask
- Increases training samples
- Reduces overfitting
- Improves model robustness

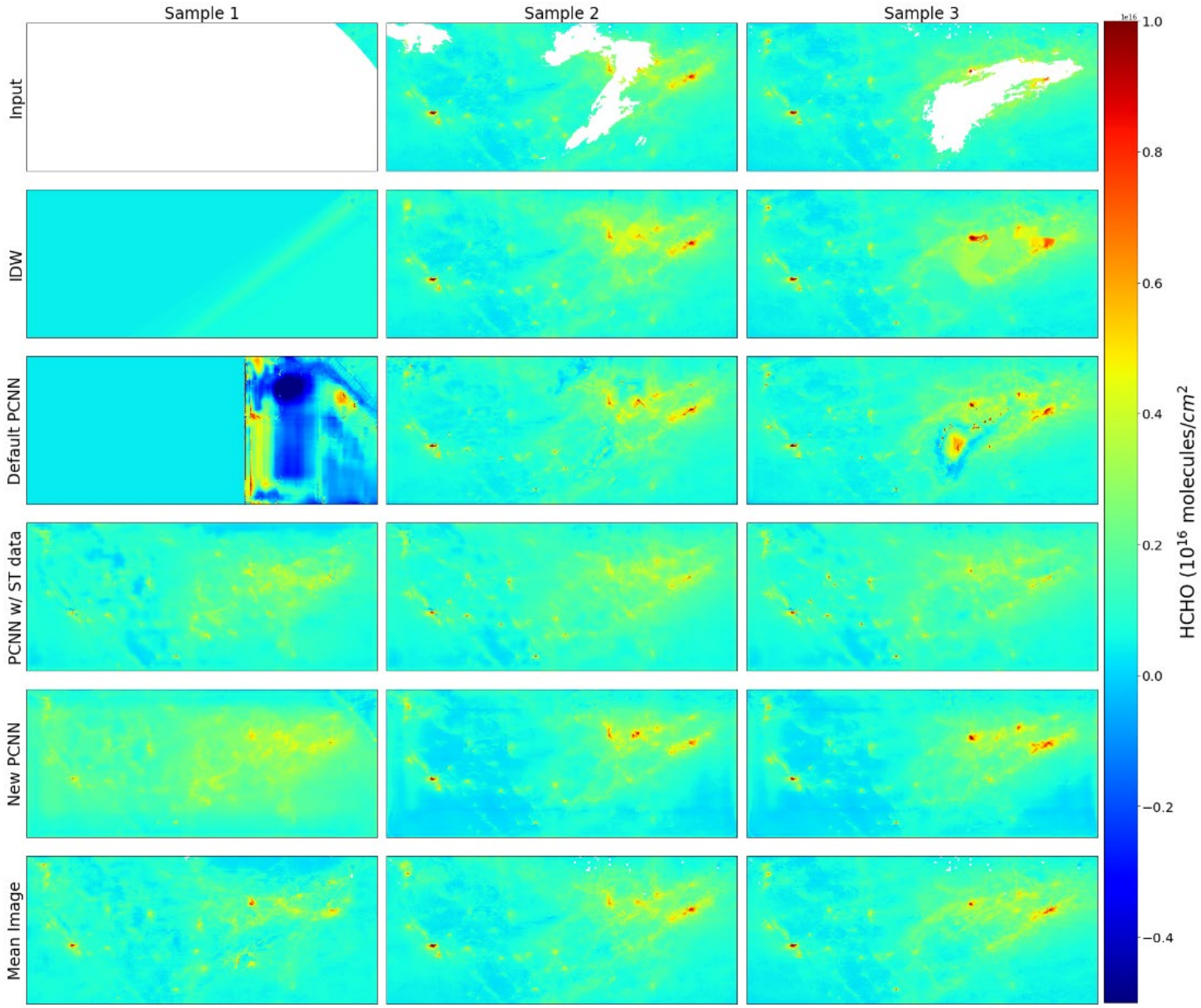


Depthwise Partial CNN Architecture

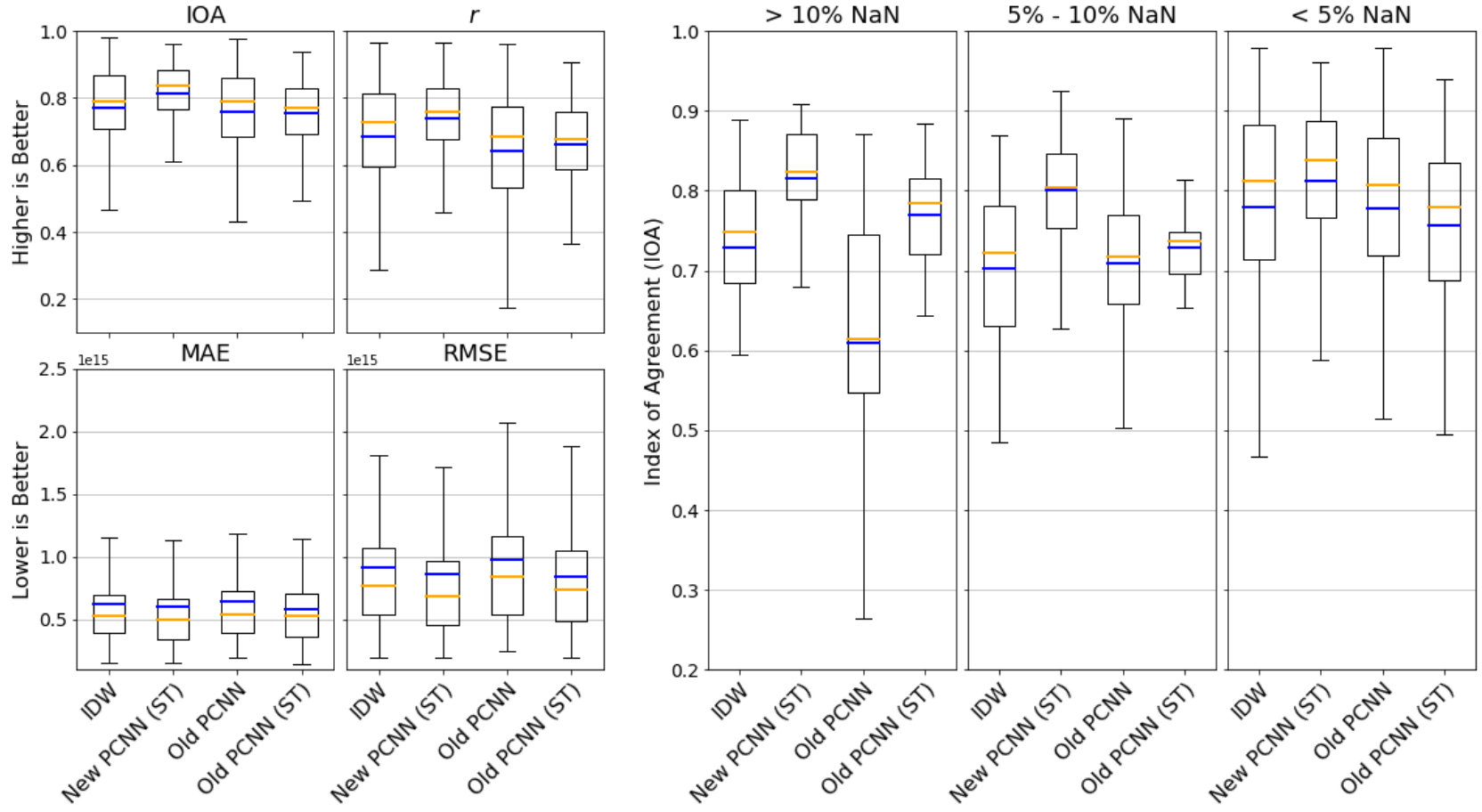


Model Comparisons

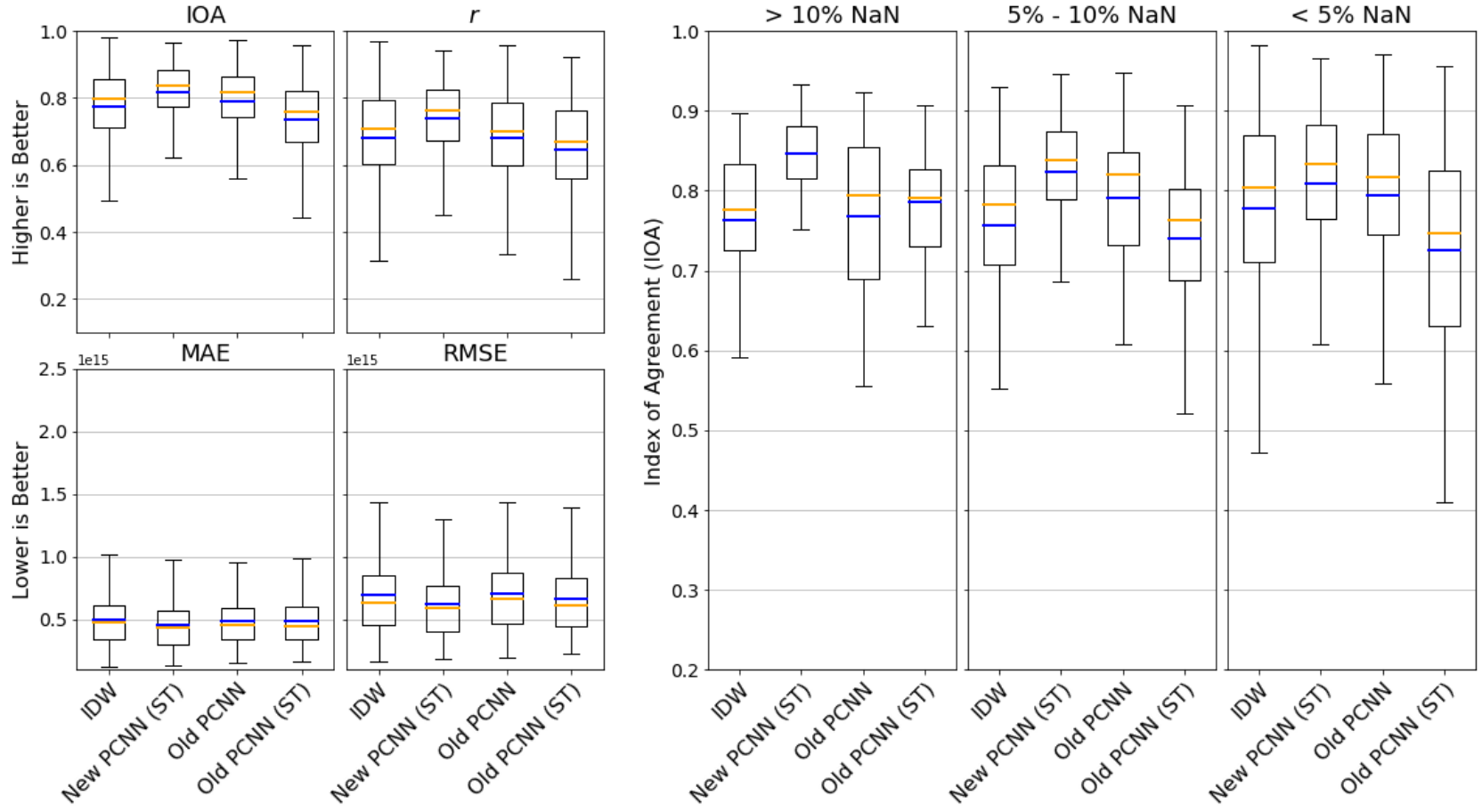
- Evaluate model performances based on weekly mean of NO_2 column data and receive the respective daily masks
- Non-spatio-temporal imputation models = less consistent
- Patio-temporal imputation models = more consistent



Model Comparisons – Statistics (2019)

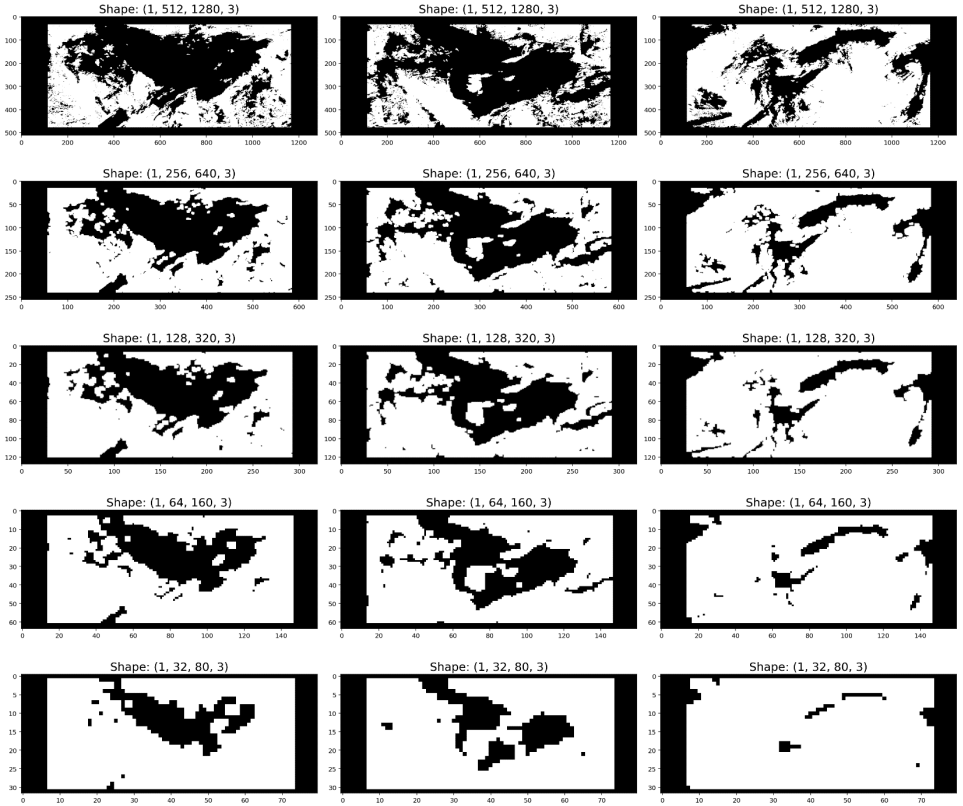


Model Comparisons – Statistics (2020)

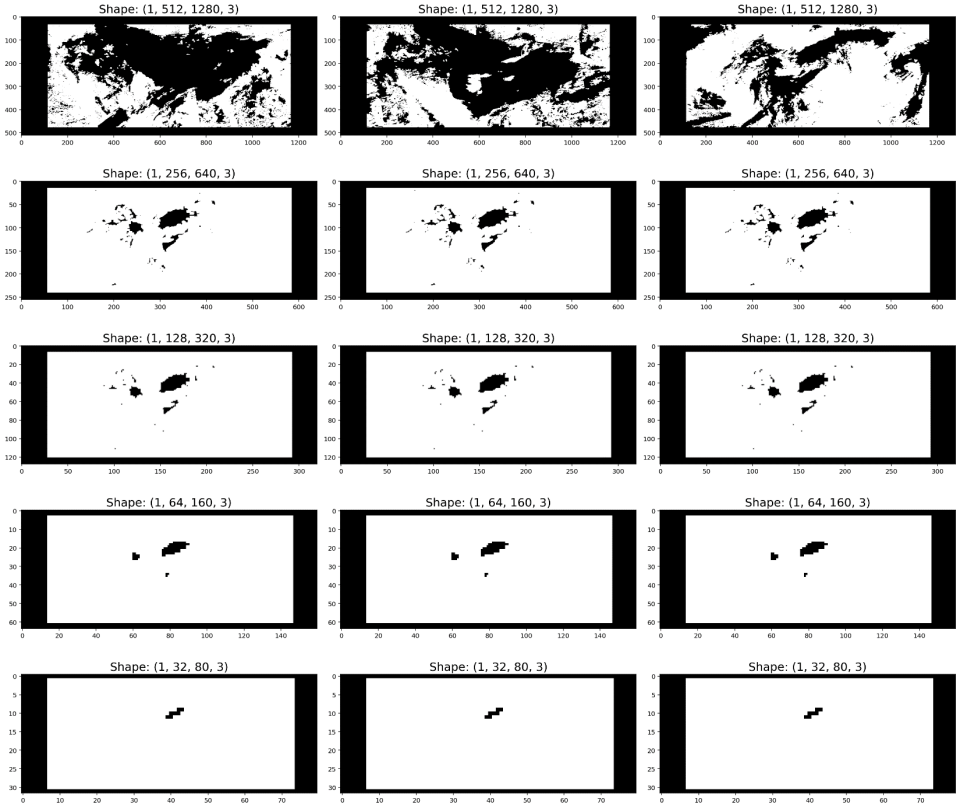


Partial CNN Comparisons – Mask Padding

DEPTHWISE PARTIAL CNN



REGULAR PARTIAL CNN



Summary

- Application depthwise convolutions facilitate the performance of the model's imputation capability with spatio-temporal data

- CMAQ model data with image augmentation is sufficient for the Depthwise Partial CNN to accurately imputing remote sensing data and be generalized for the purpose

- **The system can:**
  - Efficiently, and in near-real-time, impute TROPOMI images
  - Impute image at varying sizes and amounts of missing data from what it was trained with
  - Improve CMAQ simulations with data assimilation → better CMAQ simulations and accuracy → further improve PCNN model for imputation

Acknowledgements

The research has been supported through funding from the Oak Ridge Associated Universities (ORAU) Directed Research and Development

Thank you for your Attention

Questions?