A Deep Learning Approach for Intelligent Thinning of Satellite Data

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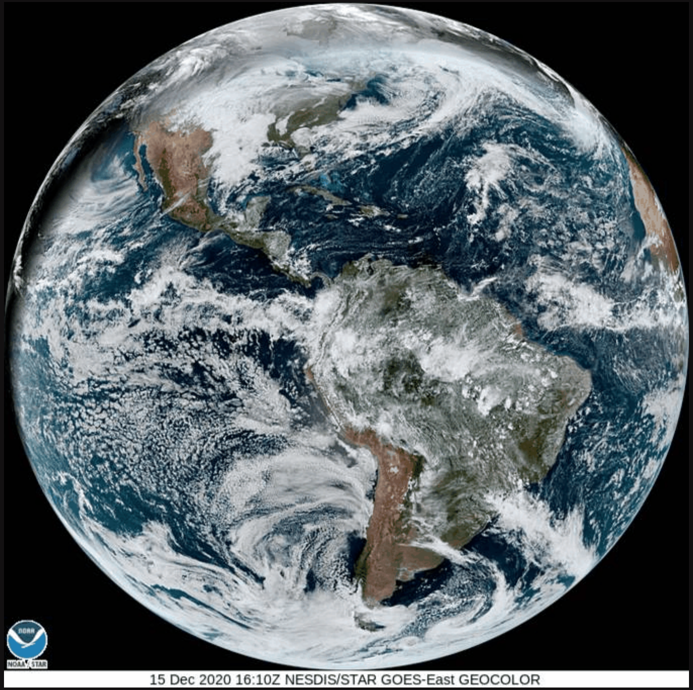
Background

- Multi/hyper spectral platforms provide rich datasets
- Data outpaces processing ability, operational cadence
- Can we compress spatial and spectral information and minimize artifacts?
- Deep learning → nonlinear dimensionality reduction



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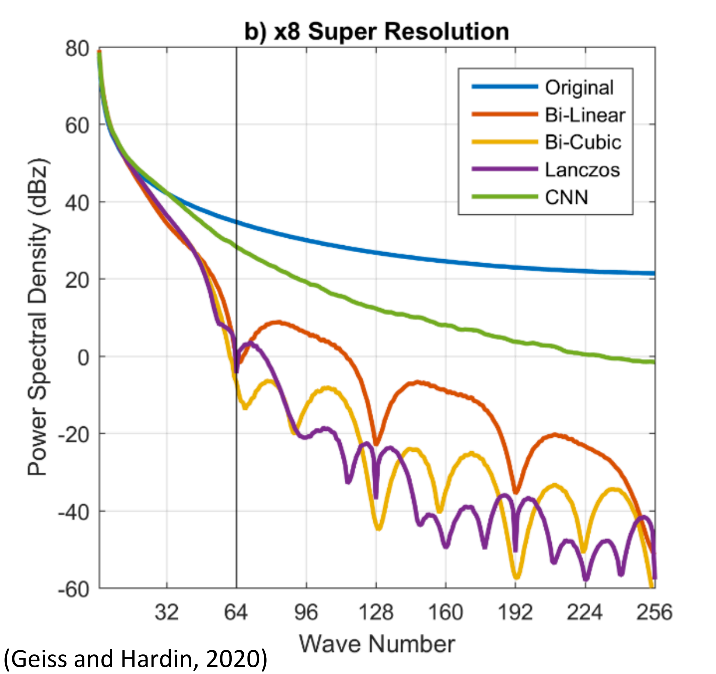
Is Deep Learning a good fit for this problem?

- Lossy Compression
  - High compression ratios
  - Simpler techniques introduce artifacts
- Multi/hyperspectral Data
  - Nonlinear PCA
  - Spectral and spatial covariances
- **Onboard processing**
  - SWaP at the edge
  - 2-3 TOPS / W



(Geiss and Hardin, 2020)

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MyRadar’s Mission & Use Case

- MyRadar
  - Democratizing environmental intelligence in a changing climate
  - GPU data processing + nowcasting + alerts
- HORIS Smallsat Platform
  - Hyperspectral imagers
  - Neuromorphic chipset
  - Demanding duty cycle
  - Faster detection –> alerting

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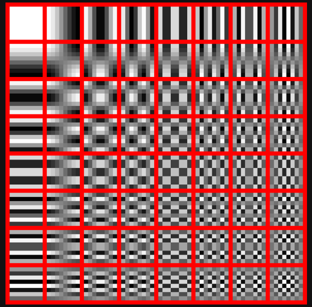
Experimental Setup

- GOES-E Full Disk L2 MCMIP
  - ~5 TB / year
  - 2019 training
  - 2020 test
- Azure NC24rs_v2 VM
  - 4x GPU
  - Virtualized blob FS
  - Tensorflow 2.3
    - Hybrid Sequential/functional API
    - Data generator for streaming data

- 20-100 epochs per run
- Data standardization but no ZCA/PCA sphering
- Compare to Discrete Cosine Transform (JPEG)



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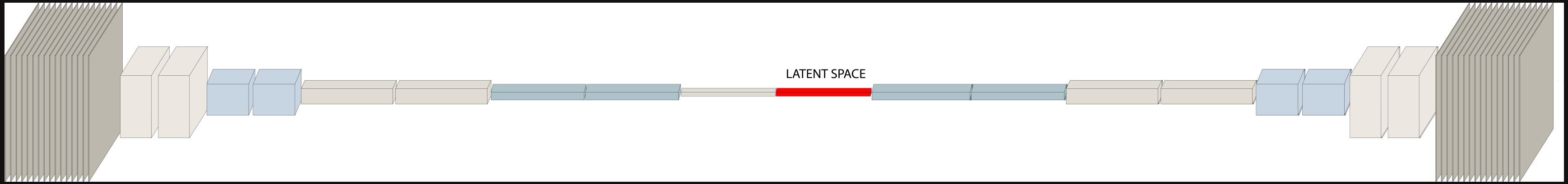
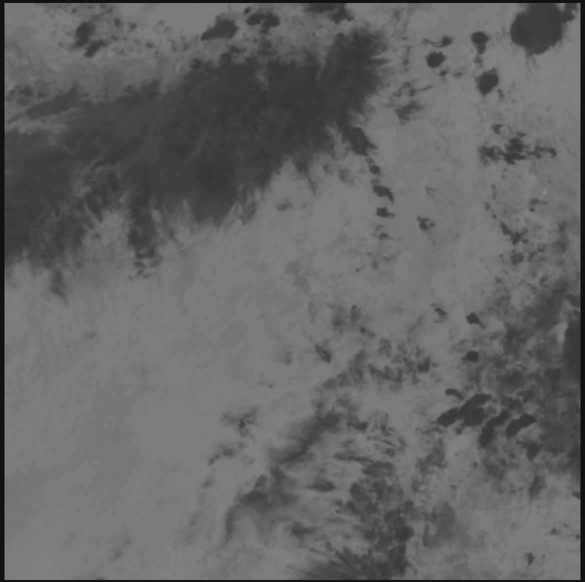
Autoencoder

- Fully-convolutional = agnostic to input dimensionality
- Residual (local) skip connections
- Batch normalization
- Dropout

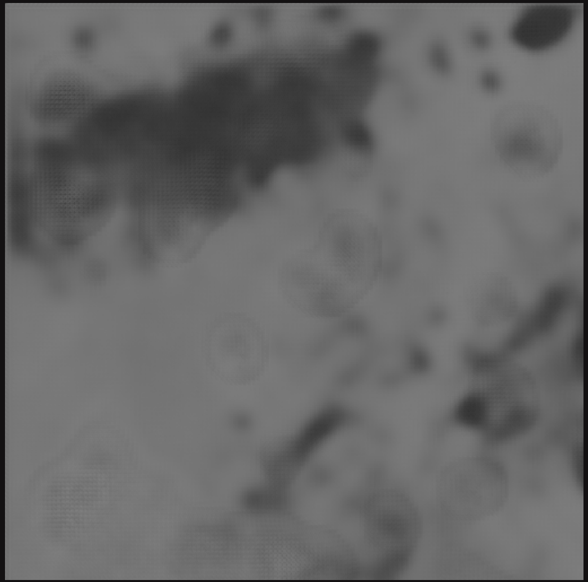


Results – 32/1 compression

Original



NN-32



DCT-32

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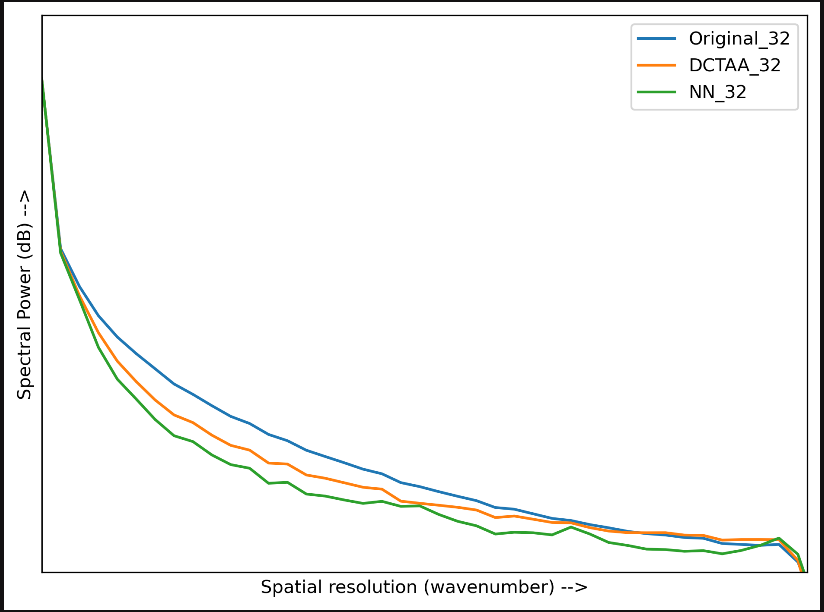
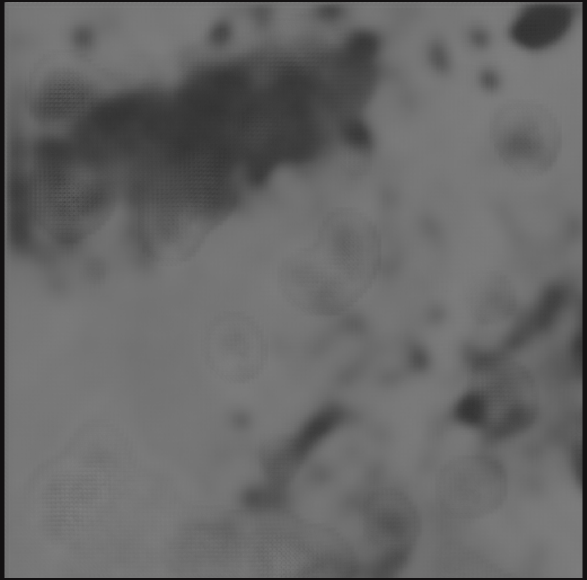
Results – 32/1 compression



- 1% MAE for NN and DCT
- Gaussian AA filter

Results – 32/1 Compression

NN-32

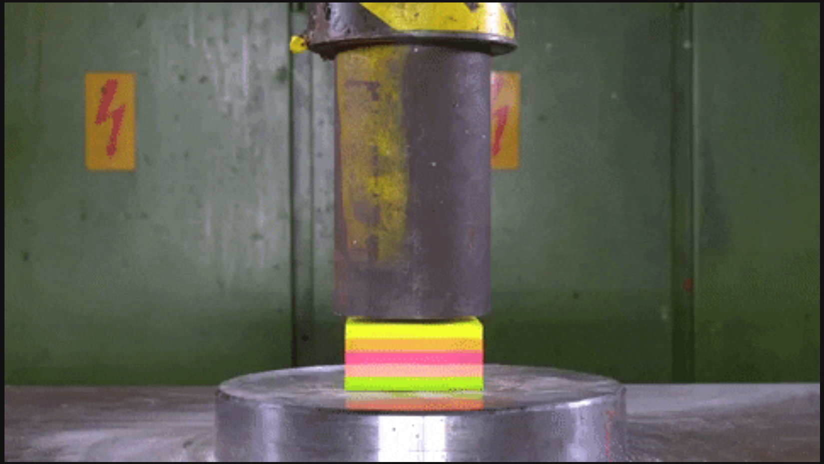


DCT-32

DCTAA-32

Extreme Compression?

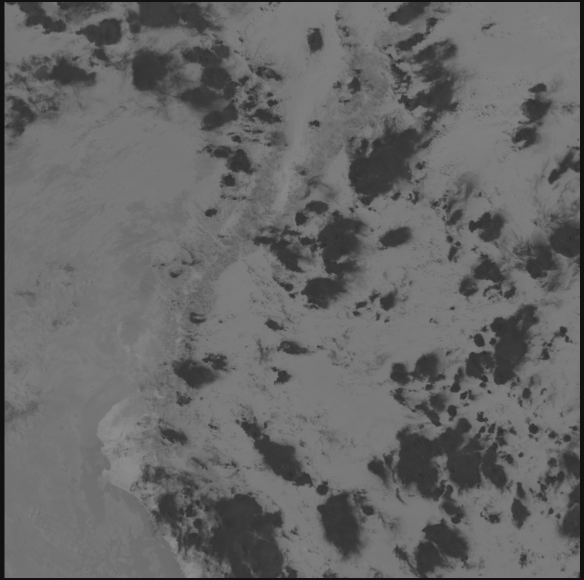
- Typical max DCT-II compression ratio is 144:1
- DCT MAE at 144:1 = 3%
- What is the compression ratio for NN with the same MAE?
- **2048/1**



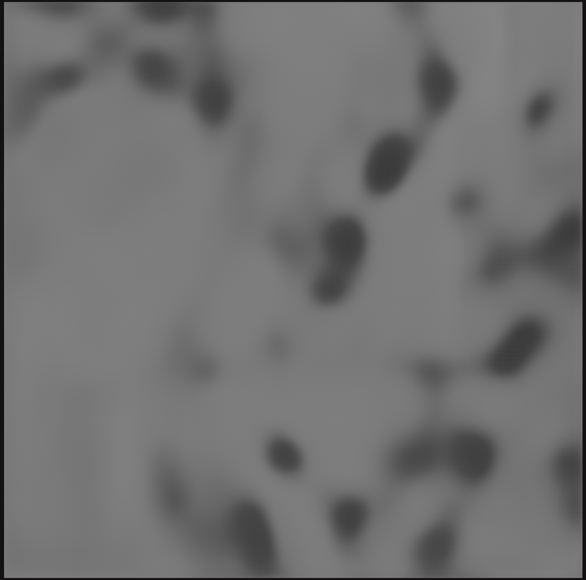
(The Hydraulic Press Channel)

Results – 3% MAE Max Compression

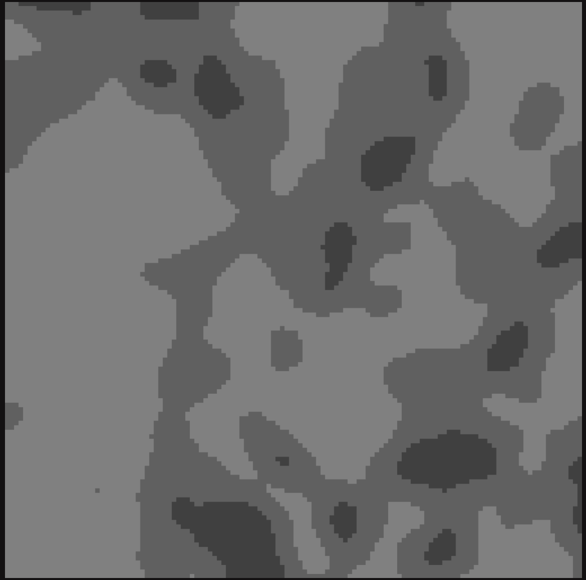
Original



NN-2048



DCTAA-144



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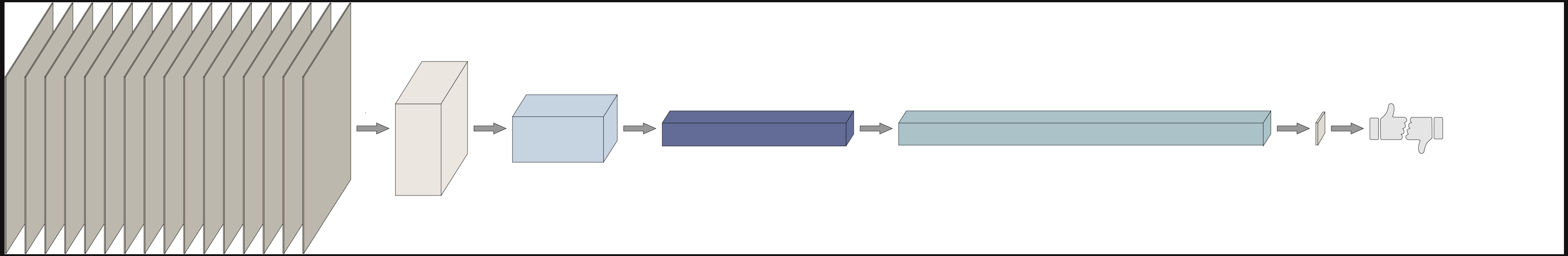
How do we improve the texture?

- Adversarial Training
- FC PatchGAN
- GAN Loss ∝ A * L1 loss + (1 – discriminator loss), A>>1



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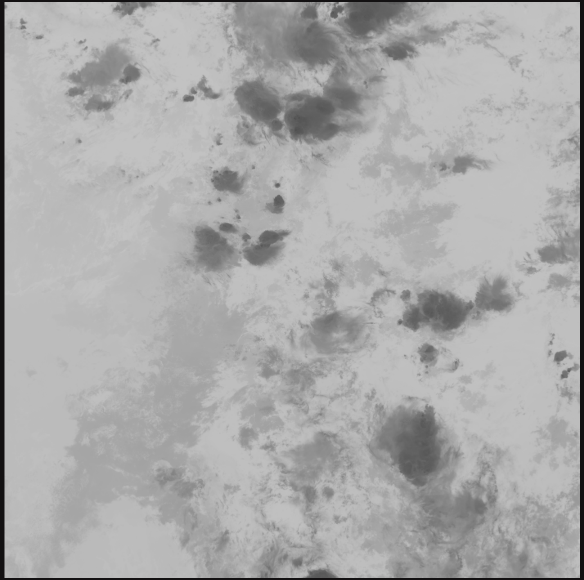
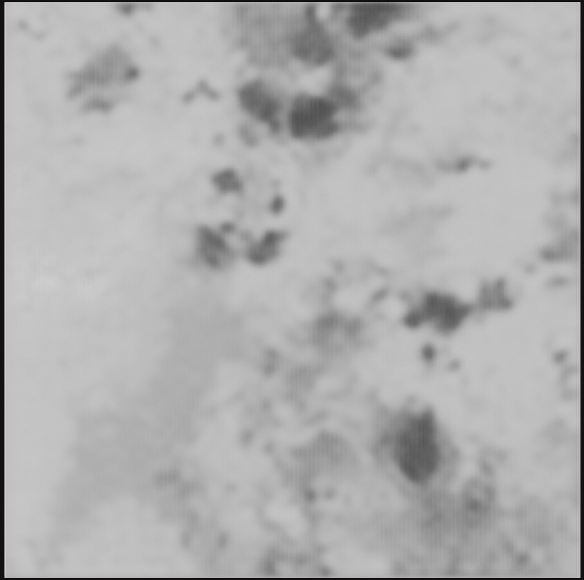
EARLY Results – 32/1 Adversarial Training

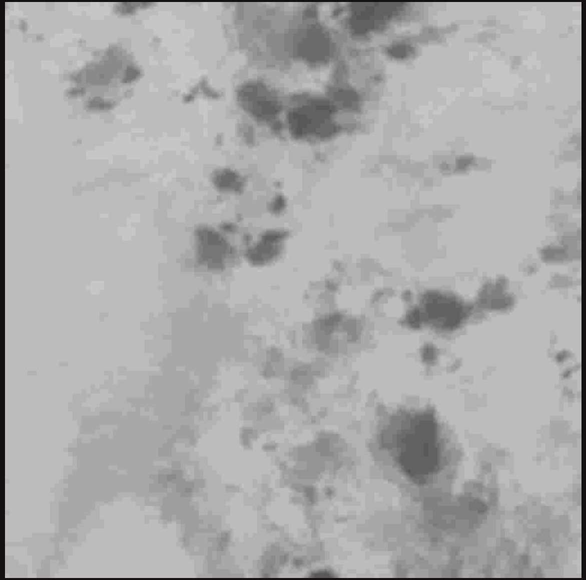
Original



NN



DCT



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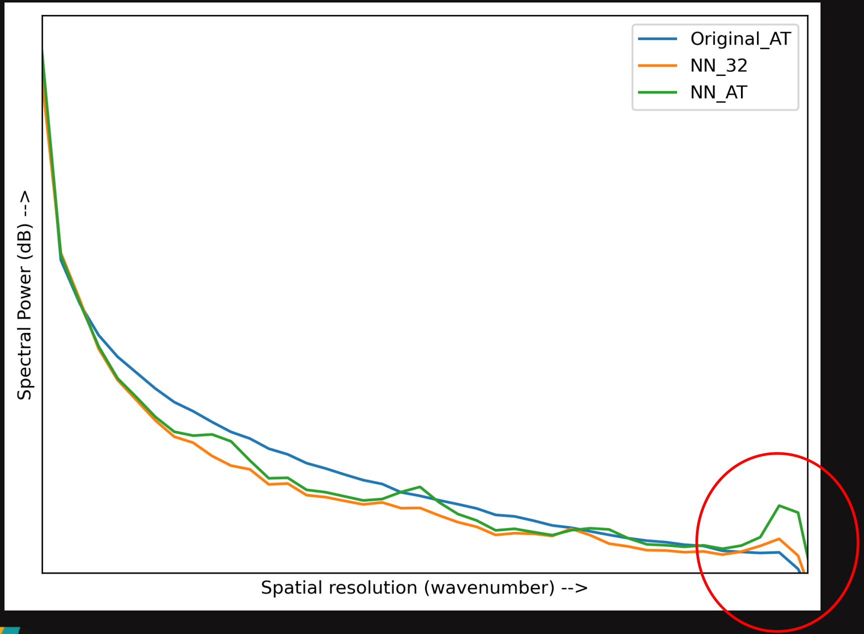
EARLY Results – 32/1 Adversarial Training



- Improving spectral power over L1 loss learner
- Data QC issue leading to spurious crosshatching
- Stay tuned!

Conclusions / Next Steps

- Autoencoder achieves larger compression ratios than DCT for comparable MAE
- Facilitates hyperspectral data processing with limited SWaP

- Model optimization
- Transfer learning to HORIS sensor suite
- On-orbit AI compression

Acknowledgements

- NOAA/NESDIS, Organizing Committee
- AI for Earth Computing Grant
- Darin MacRae, Annalisa Graziano

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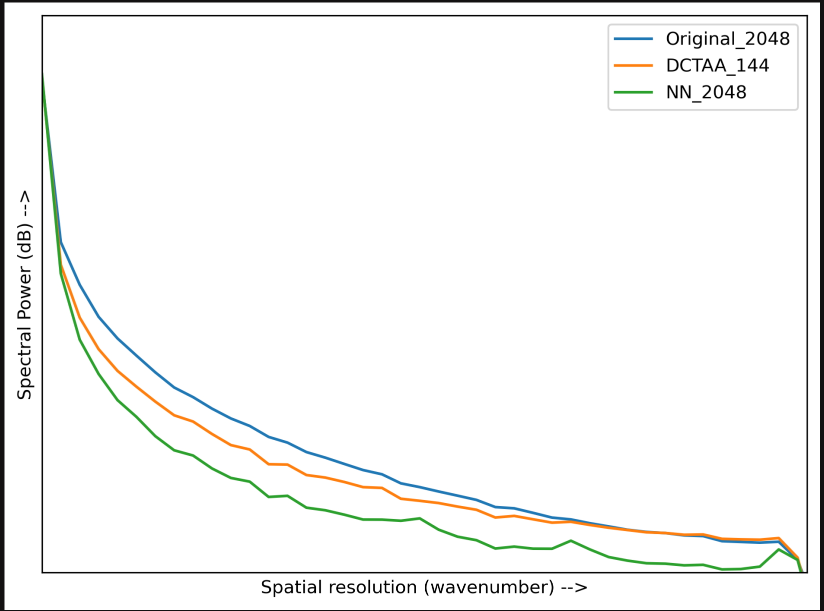
Extra – 3% MAE Max Compression



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