# Removing Radio Frequency Interference from Auroral Kilometric Radiation with Stacked Autoencoders

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## BACKGROUND

Radio emissions from the Earth's auroral regions are a **rich data source for space science**. However, measuring these signals, both from ground-level and space-borne sensors, poses a data quality challenge.

We utilize a supervised learning approach to **maximize science data recall from noisy data**.

## AURORAL KILOMETRIC RADIATION

Auroral Kilometric Radiation (AKR) is a type of coherent radio emission that can be studied to complete our understanding of the relationships among space environments.

These goals have motivated scientific collaborations operating ground-level sensors at the South Pole Station and developing satellite-born radio sensors [1], which measure high-intensity emission AKR events.

However, measuring these signals poses a data quality challenge, as many interference sources [2] can add noise to the observations (Figure 1).

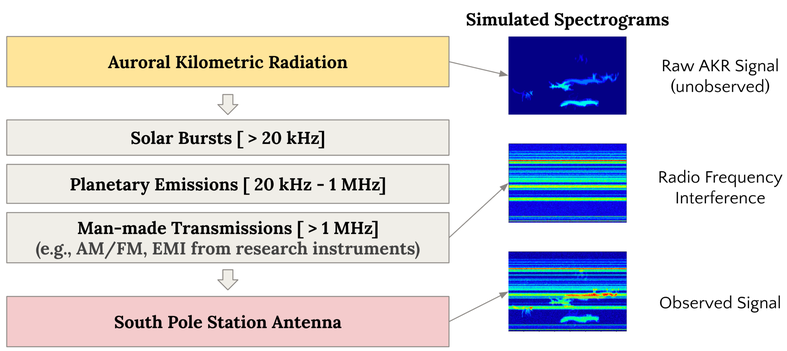



Figure 1. Observed AKR data is noisy and difficult to interpret for scientific analysis.

## METHOD

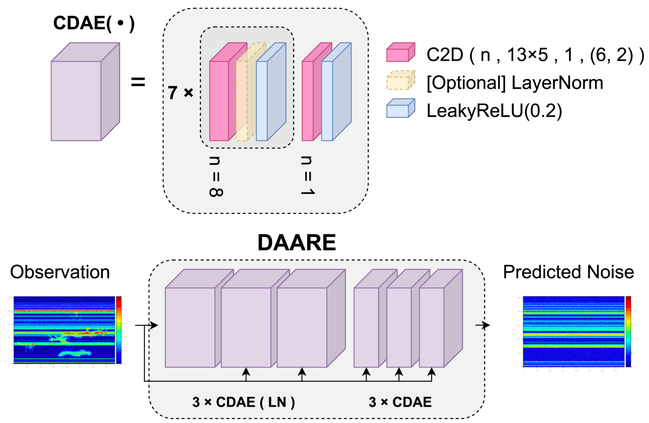
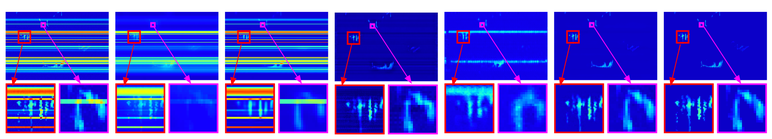



Figure 2. Overview of modeling architecture.

Successively trained autoencoder components (Figure 2) are trained on simulated data to identify noise. At each successive component, a skip-connection with the observation is inputted. Finally, the underlying AKR signal can be obtained by subtracting the predicted noise from the input observation.

## SIMULATED DATA RECOVERY



| | AKR Observation | Bilateral Filtering | Block-matching and 3D filtering | Fast and Flexible Denoising Network | Vision Transformer | **Our Method** | Ground Truth |
|---|---|---|---|---|---|---|---|
| PSNR (dB) (Optimal PSNR (dB)) | | 19.8 | 17.7 | 38.3 | 23.5 | **42.2** | ∞ |
| SSIM (Optimal SSIM) | | 0.773 | 0.555 | 0.917 | 0.817 | **0.981** | 1.00 |

Figure 3. Quantitatively on simulated data, our method is able to remove noise efficiently on AKR spectrograms, outperforming baseline filtering- and deep-learning-based denoising methods on peak-signal-to-noise-ratio (PSNR) and structural similarity (SSIM).

## REAL OBSERVED DATA RECOVERY

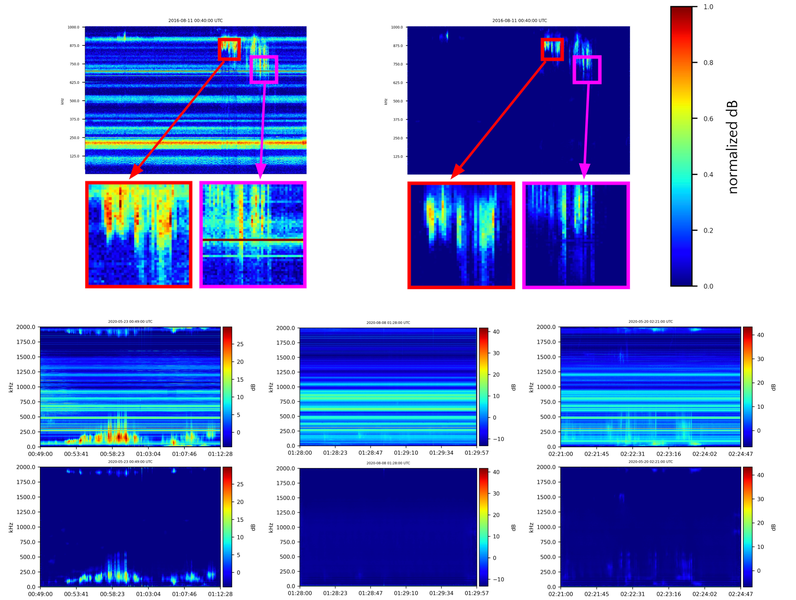



Figure 4. Our method can recover low-intensity signals without producing additional artifacts not present in the original observation. This method can be tuned to favor precision or recall of data, depending on the use-case.

## DISCUSSION & FUTURE WORK

In controlled simulations, our method is able to quantatively recover the original signal with high fidelity (Figure 3). On real AKR observations, our method recalls real signals without creating additional artifacts (Figure 4).

We intend for this work to encourage future work bridging supervised signal processing with the space sciences.

## REFERENCES

[1] Philip J Erickson, Crew Geoffrey, Michael Hecht, Mary Knapp, Frank Lind, Ryan Volz, James LaBelle, Frank Robey, Kerri Cahoy, Benjamin Malphrus, et al., "Aero: Auroral emissions radio observer," in Small Satellite Conference, 2018.

[2] Michael D Desch, "A quantitative assessment of rfi in the near-earth environment," in Low Frequency Astrophysics from Space. Springer, 1990.