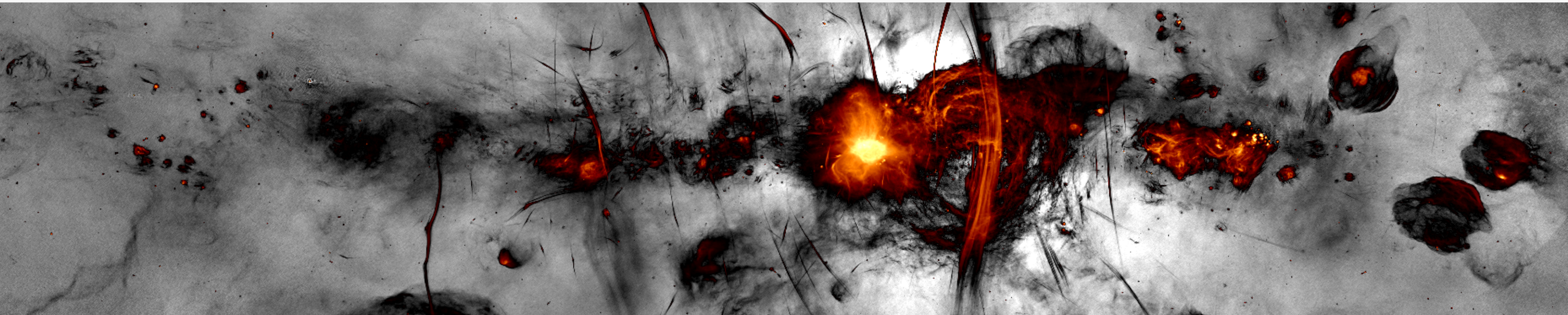


IMPLICIT NEURAL REPRESENTATIONS

FOR RADIO ASTRONOMY

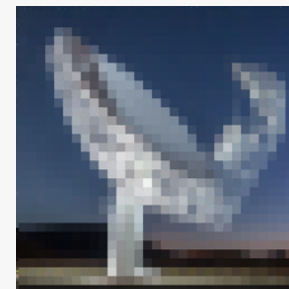
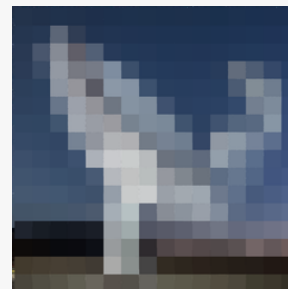
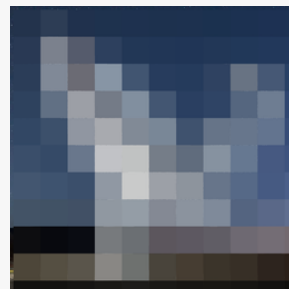
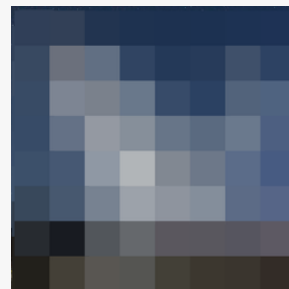
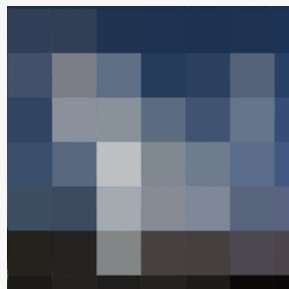


JANIE DU PREEZ, BRIAN WELMAN, EMIL MEINTJES, EMMA TOLLEY

SWISS SKA DAYS
2 SEPTEMBER 2026

THE PROBLEM OF PIXELS

RETHINKING HOW WE REPRESENT IMAGES

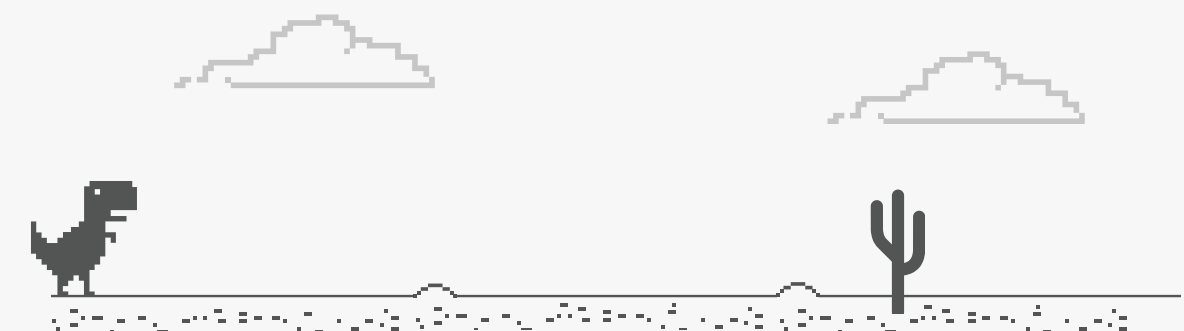


FIXED GRIDS

DIFFICULTY WITH
REPROJECTION

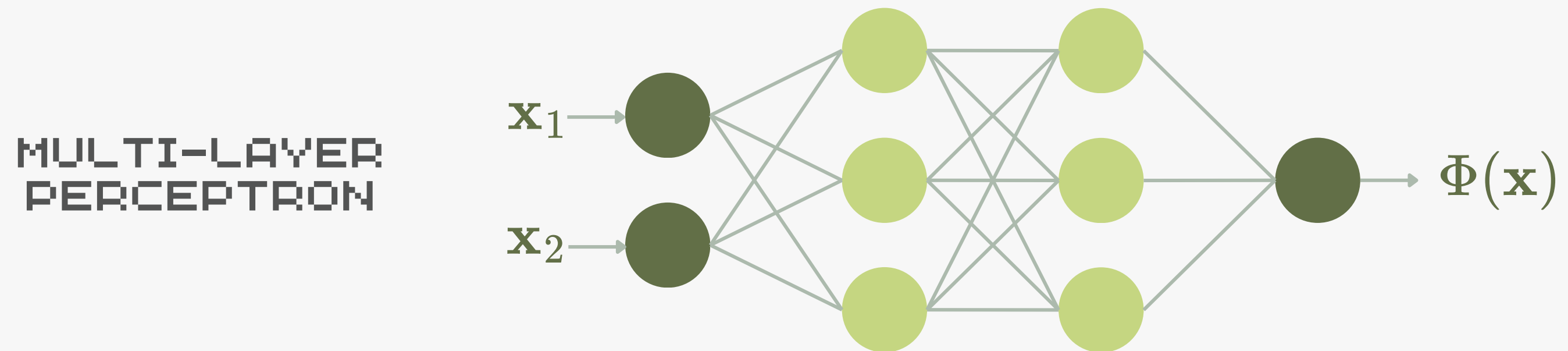
HIGHER RESOLUTION
= LARGER FILES

What if we represented images as continuous functions instead?

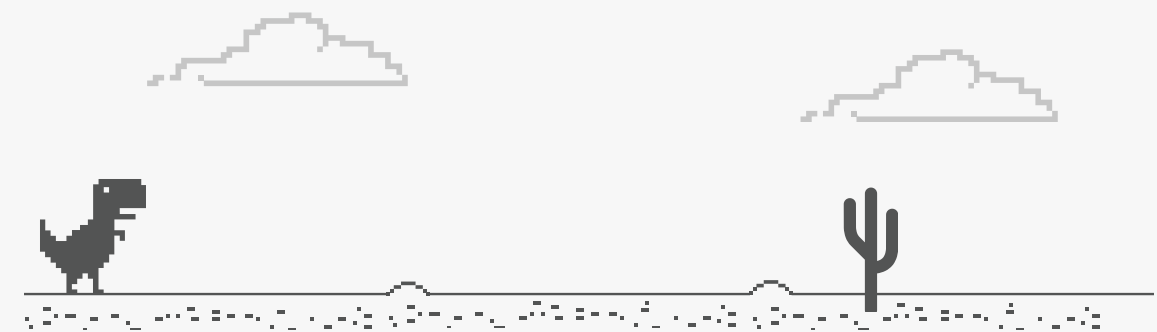


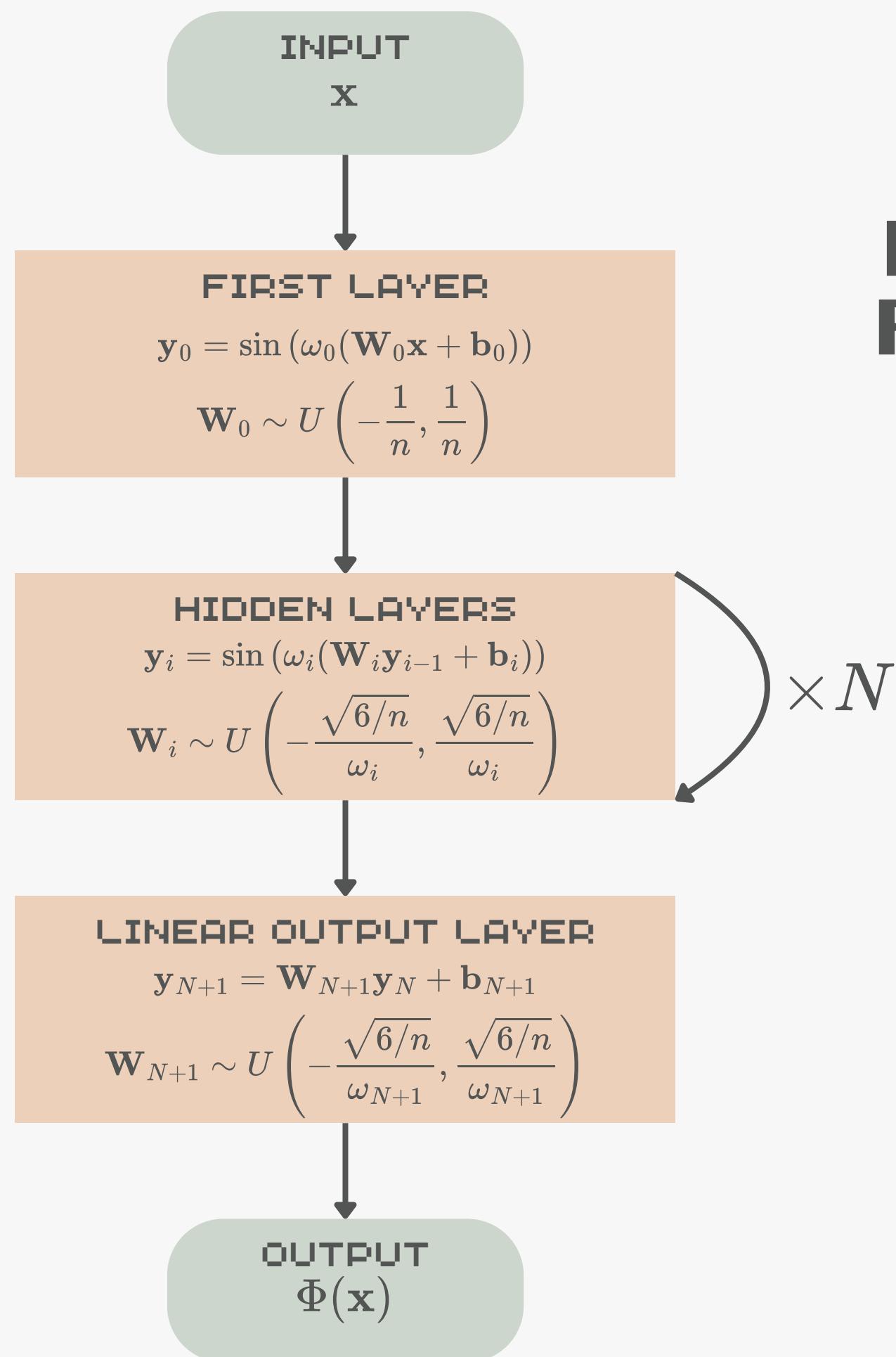
IMPLICIT NEURAL REPRESENTATION

We can train a neural network to represent an image as a continuous function



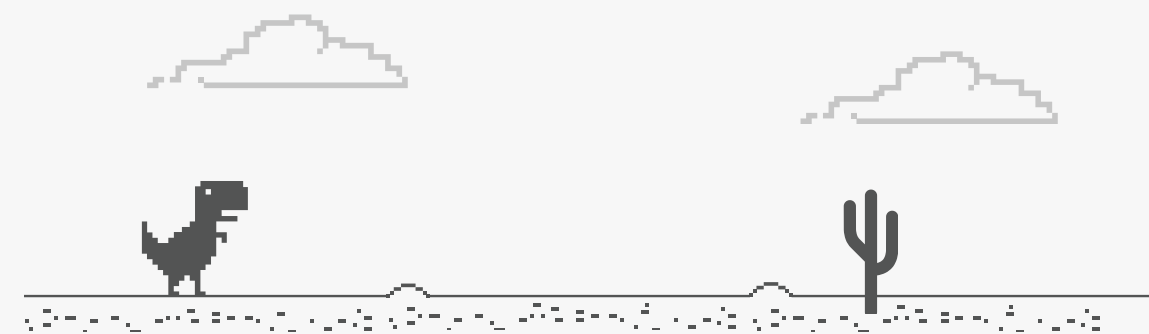
$$\mathbf{x} \mapsto \Phi(\mathbf{x})$$





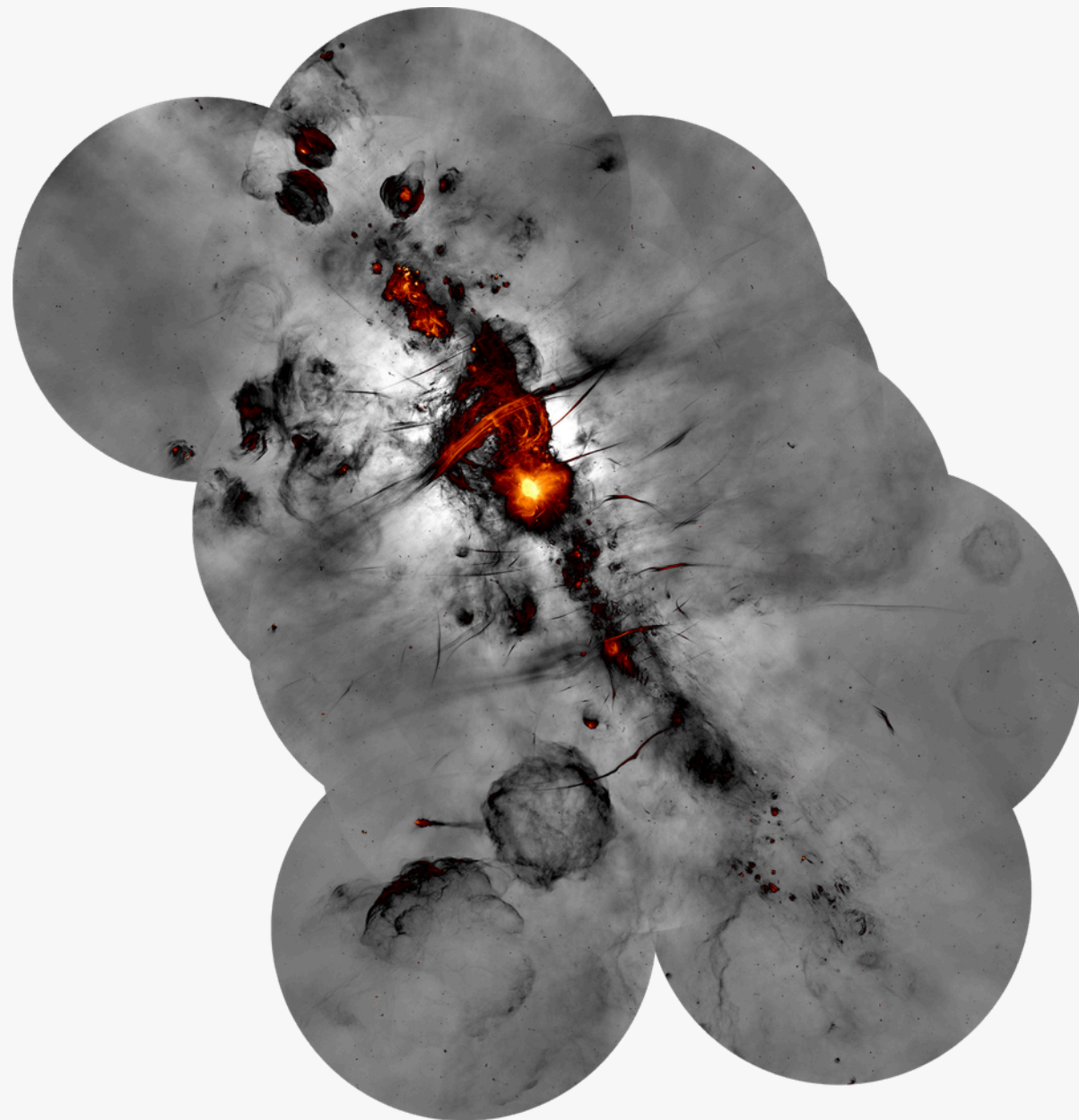
LEARNING THE CONTINUOUS FUNCTION WITH SINUSOIDS

SIREN - SITZMANN ET AL. (2020)



TEST CASE

MEERKAT GALACTIC CENTRE MOSAIC - HEYWOOD ET AL. (2022)



HIGH DYNAMIC RANGE

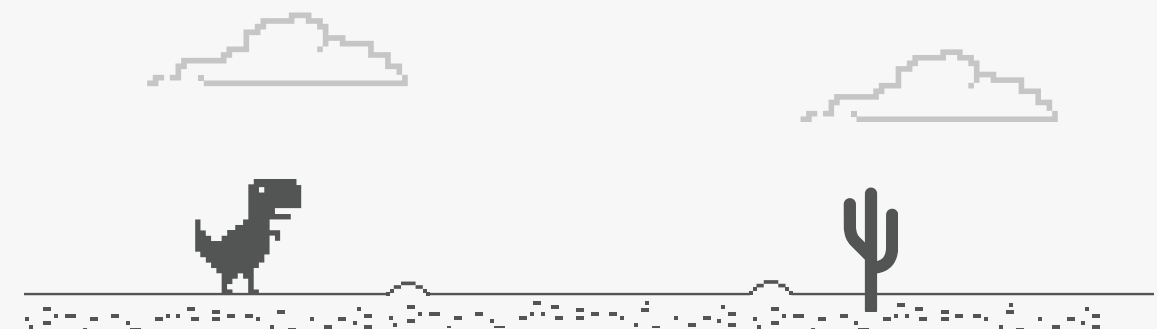
COMPACT SOURCES

FILAMENTS

DIFFUSE EMISSION

COMPLEX MORPHOLOGY

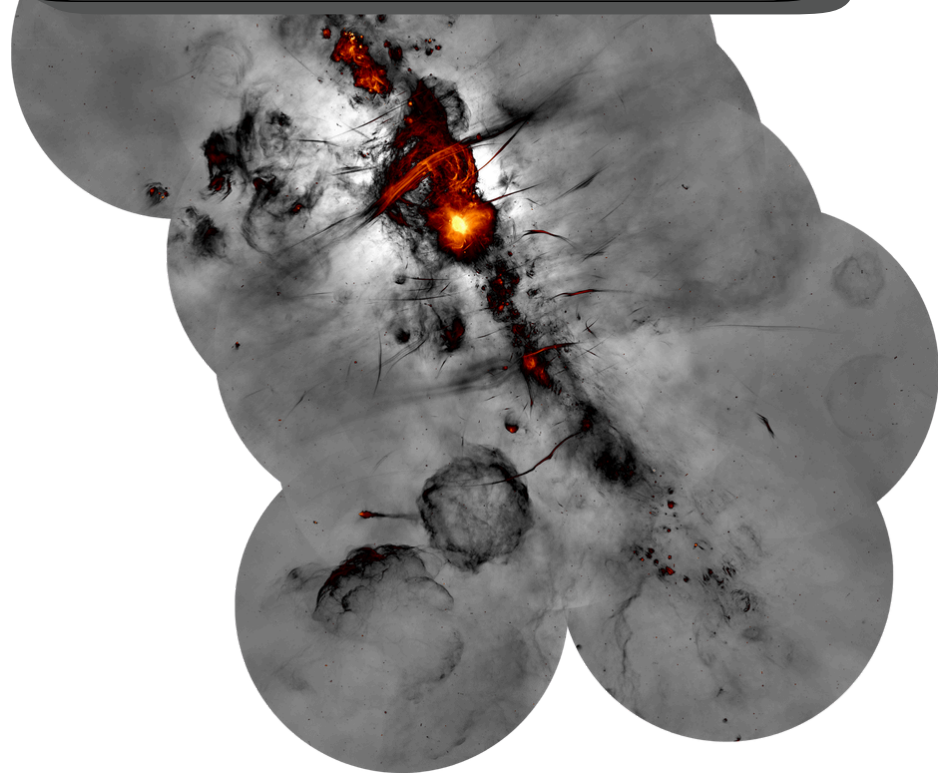
LARGE DATA SIZE



SPECTRAL BIAS

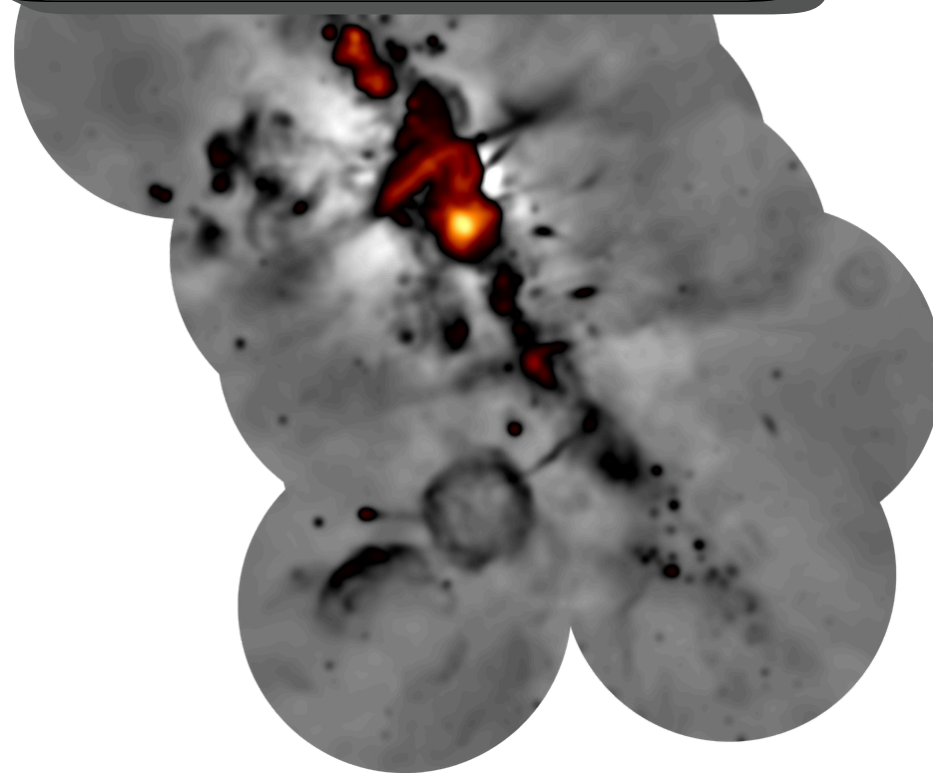
THE PROBLEM WITH FITTING HIGH-FREQUENCY COMPONENTS

FULL IMAGE



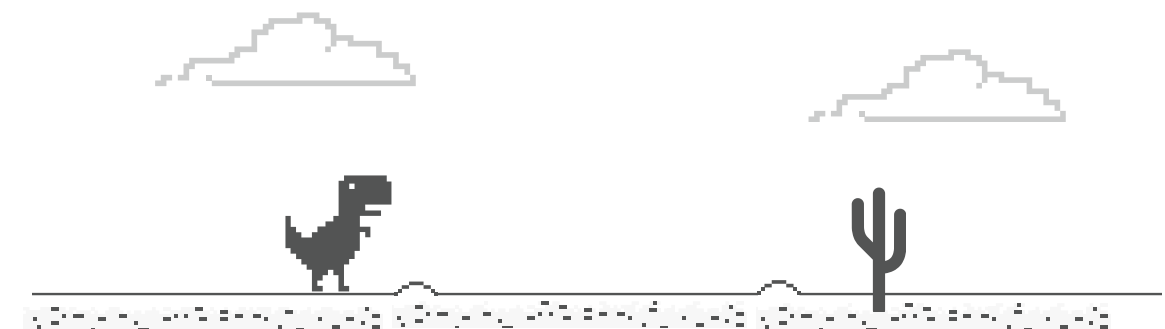
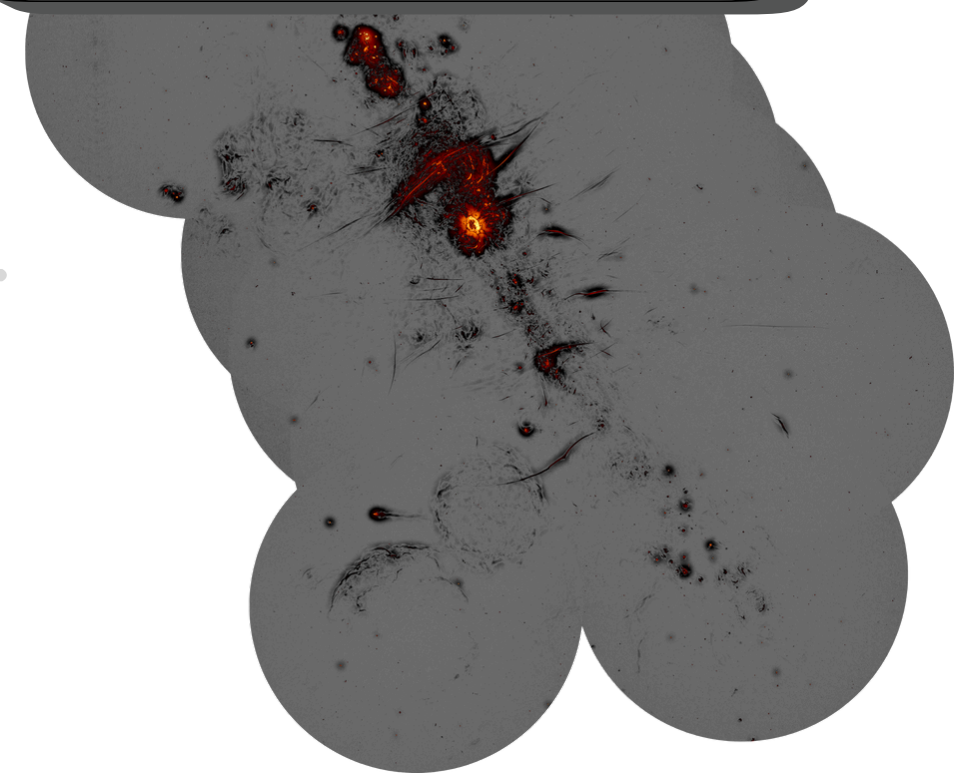
=

LOW-FREQUENCY

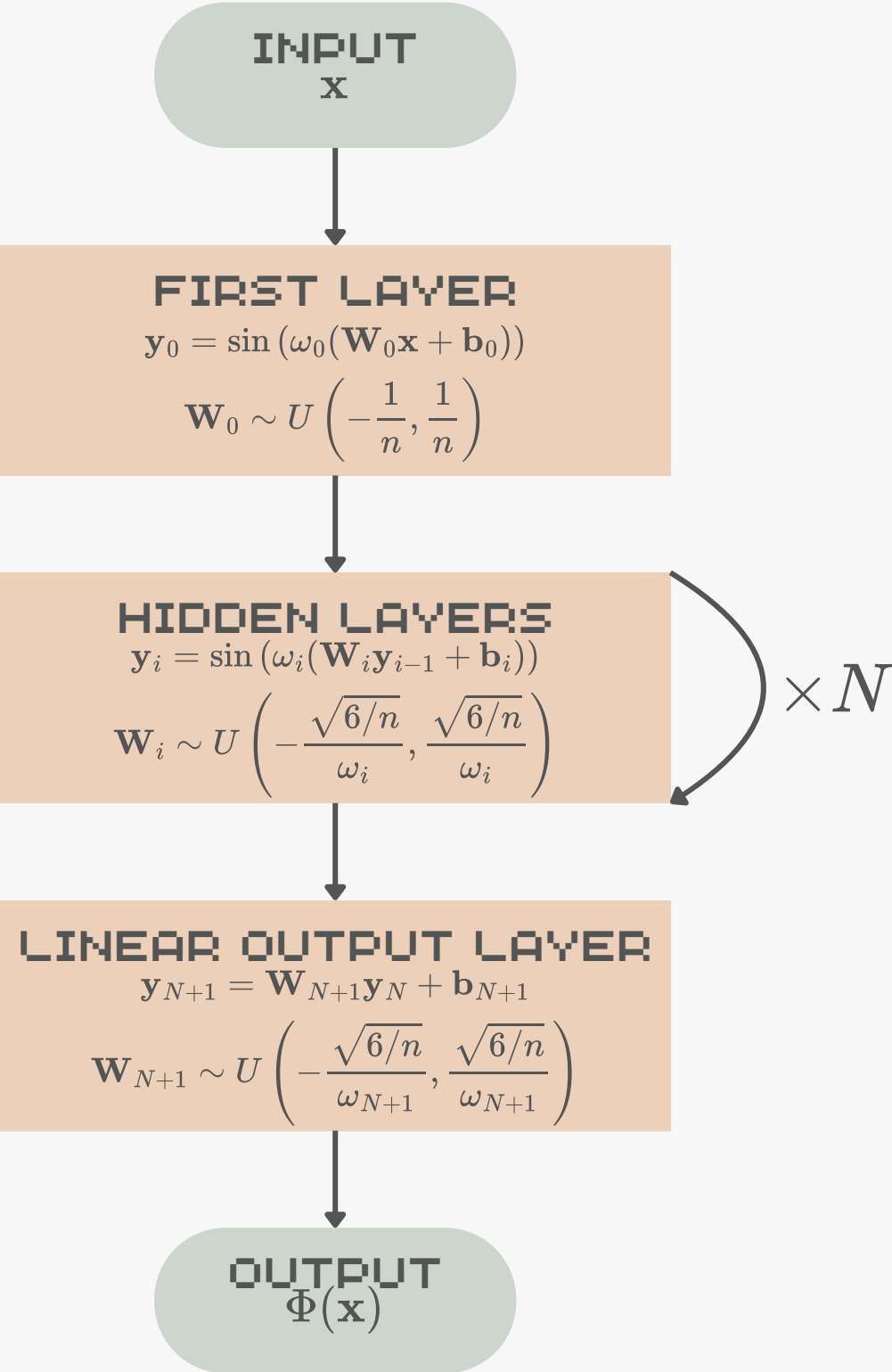


+

HIGH-FREQUENCY



ALTERNATIVE ARCHITECTURES



WINNER (SIREN²)
CHANDRAVAMSI ET AL. (2025)

Normal SIREN:

$$\mathbf{W}_i \sim U\left(-\frac{1}{\omega_i} \sqrt{\frac{6}{n}}, \frac{1}{\omega_i} \sqrt{\frac{6}{n}}\right)$$

WINNER:

$$\mathbf{W}'_i = \mathbf{W}_i + \text{gaussian noise}$$

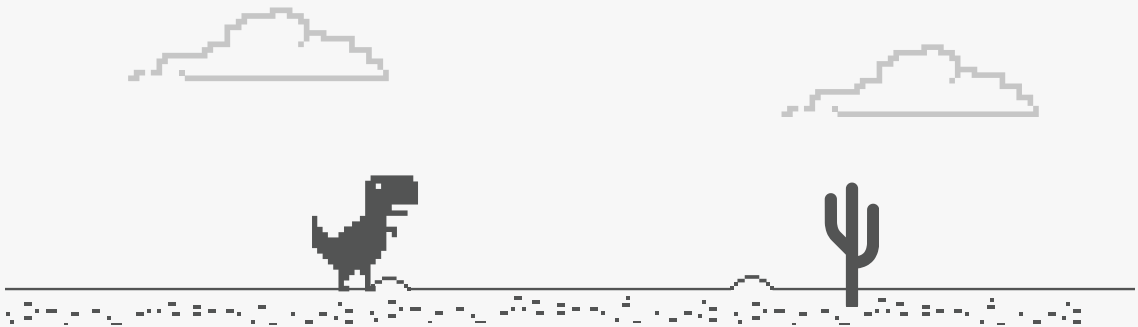
FINER
LIU ET AL. (2024)

Normal SIREN:

$$\mathbf{y}_i = \sin(\omega_i \mathbf{z}_i); \quad \mathbf{z}_i = \mathbf{W}_i \mathbf{x} + \mathbf{b}_1$$

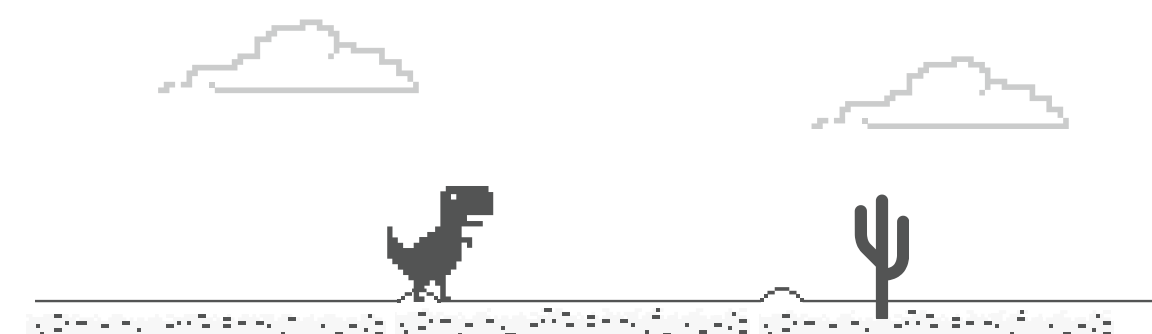
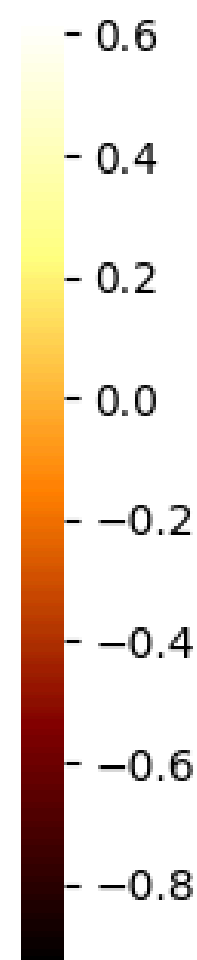
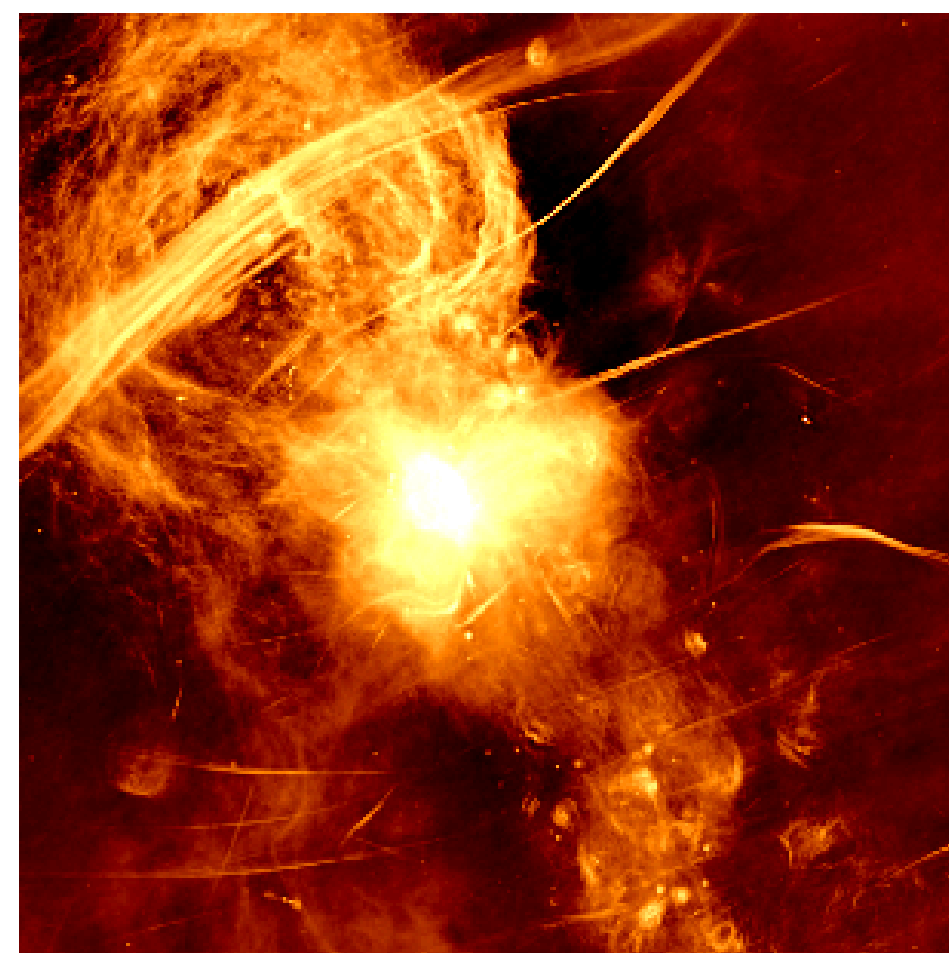
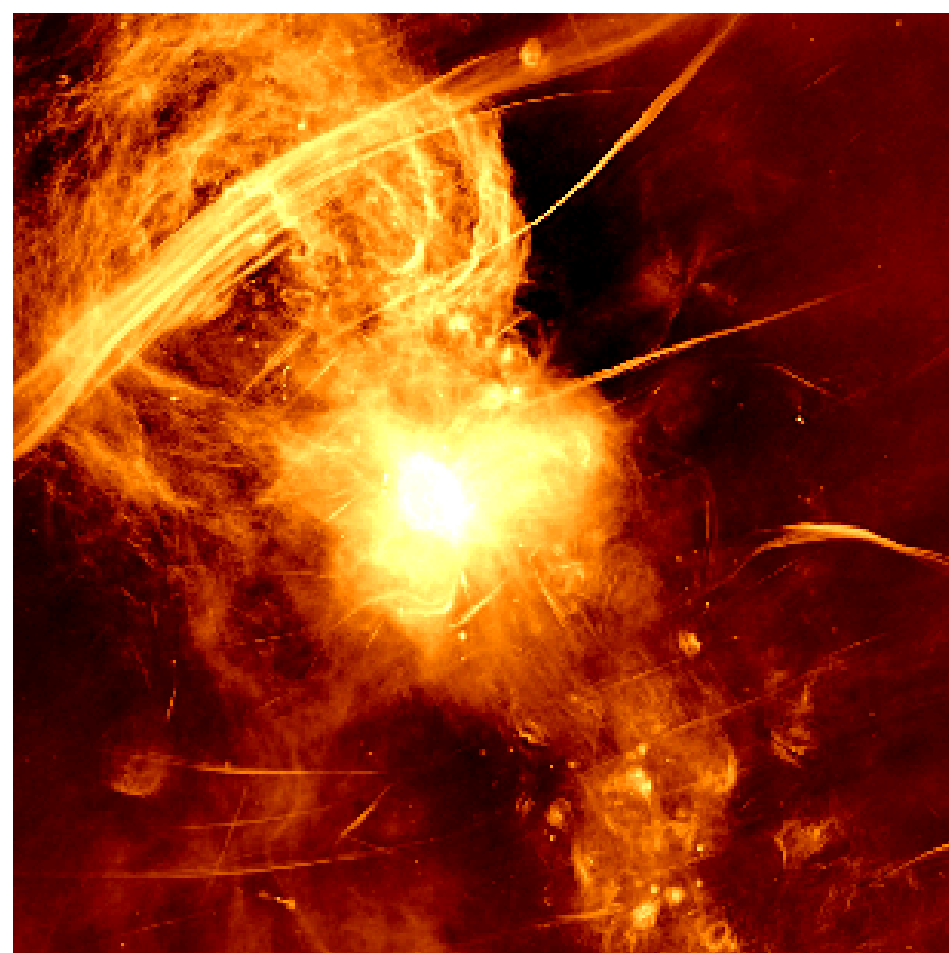
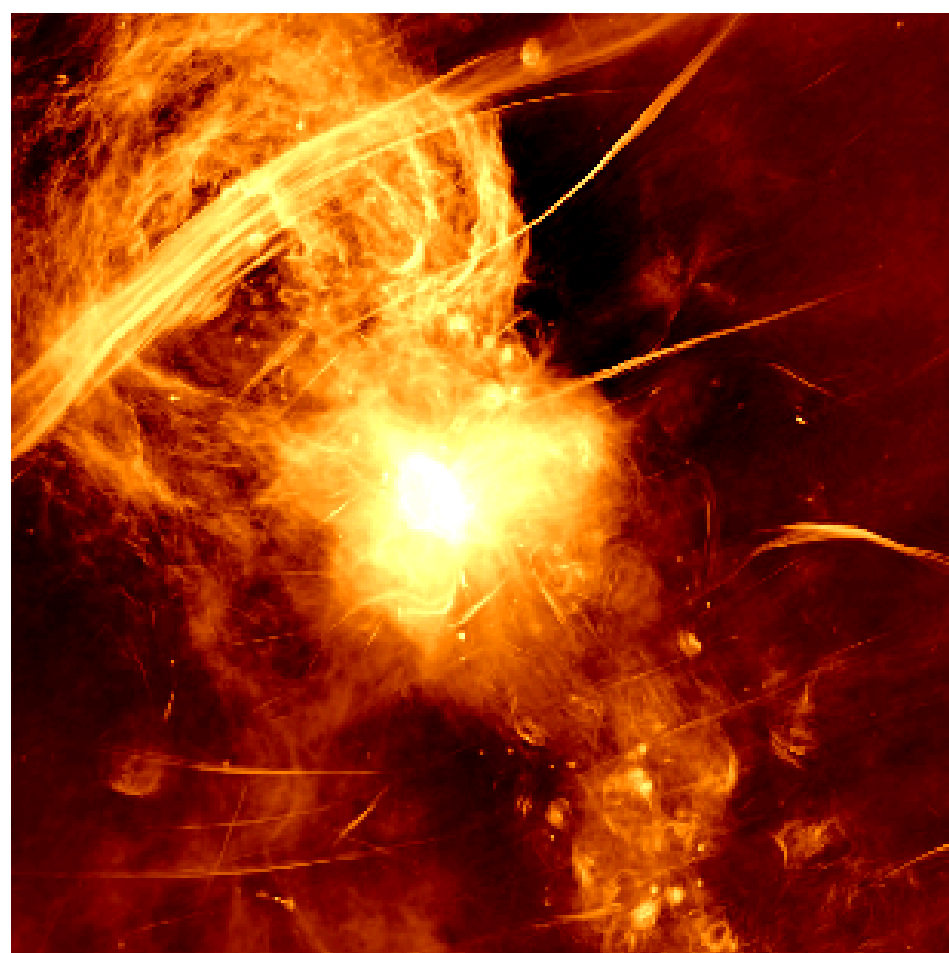
FINER:

$$\mathbf{y}_i = \sin(\omega_i(|\mathbf{z}_i| + 1)\mathbf{z}_i)$$



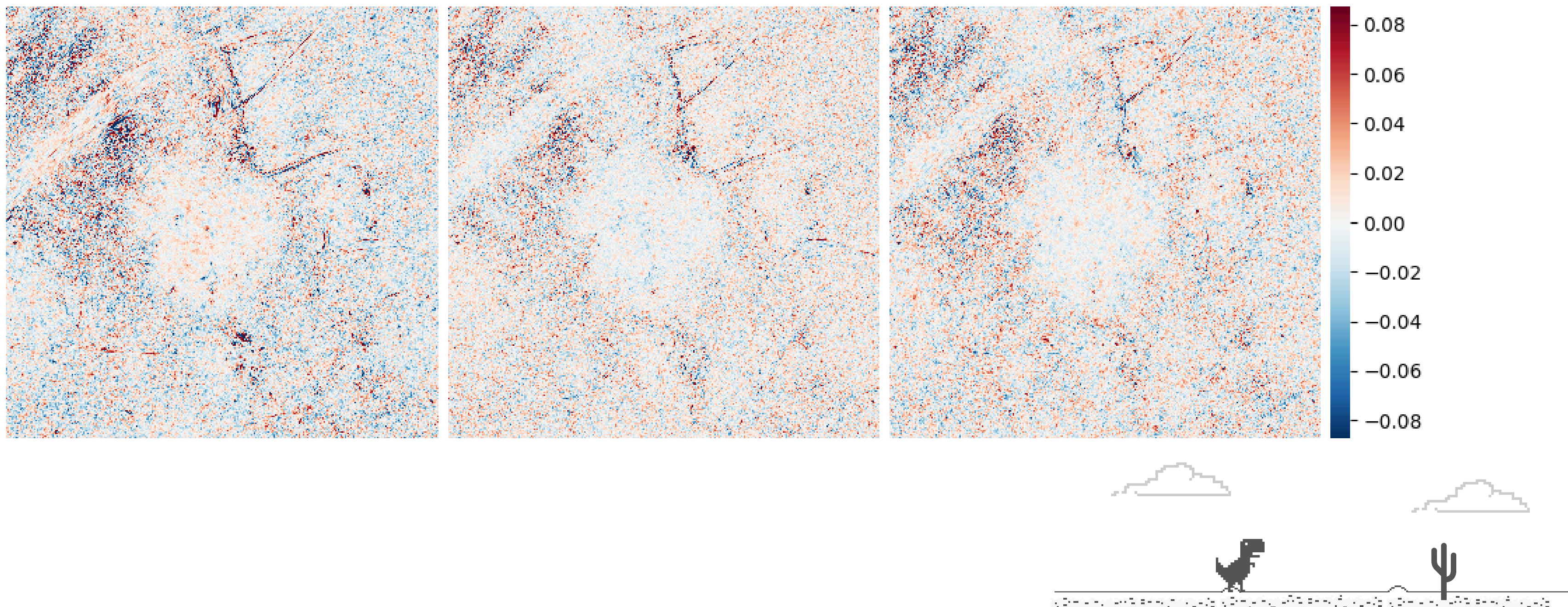
COMPARING ARCHITECTURES

SIREN VS WINNER VS FINER



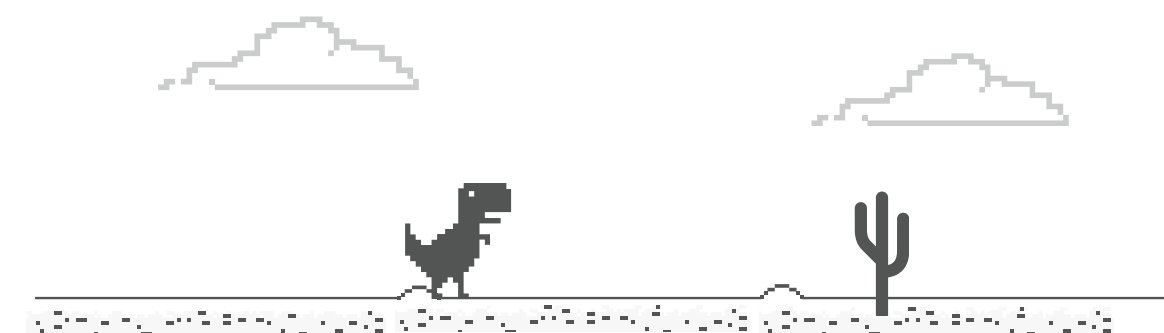
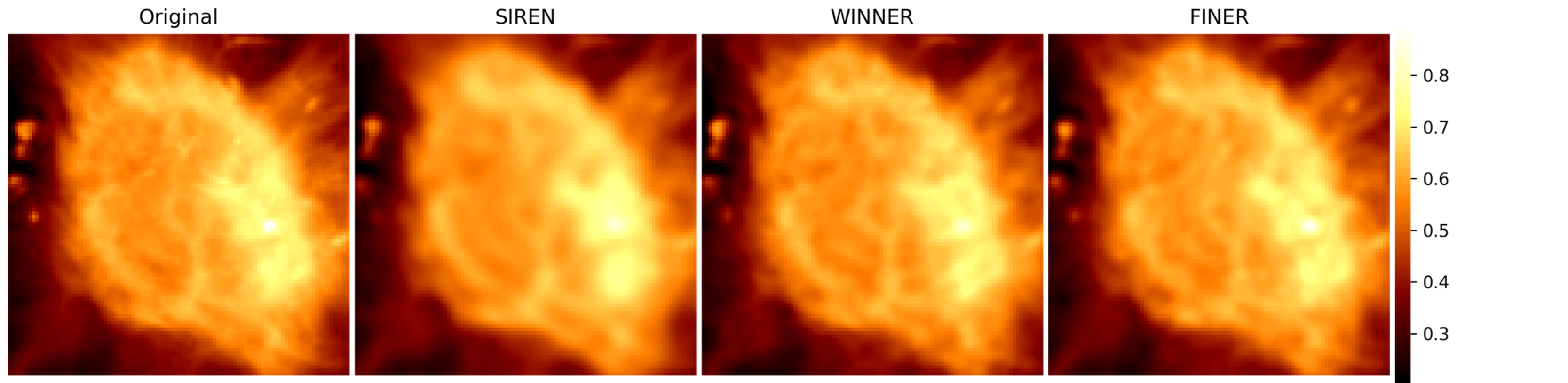
COMPARING ARCHITECTURES

SIREN VS WINNER VS FINER



COMPARING ARCHITECTURES

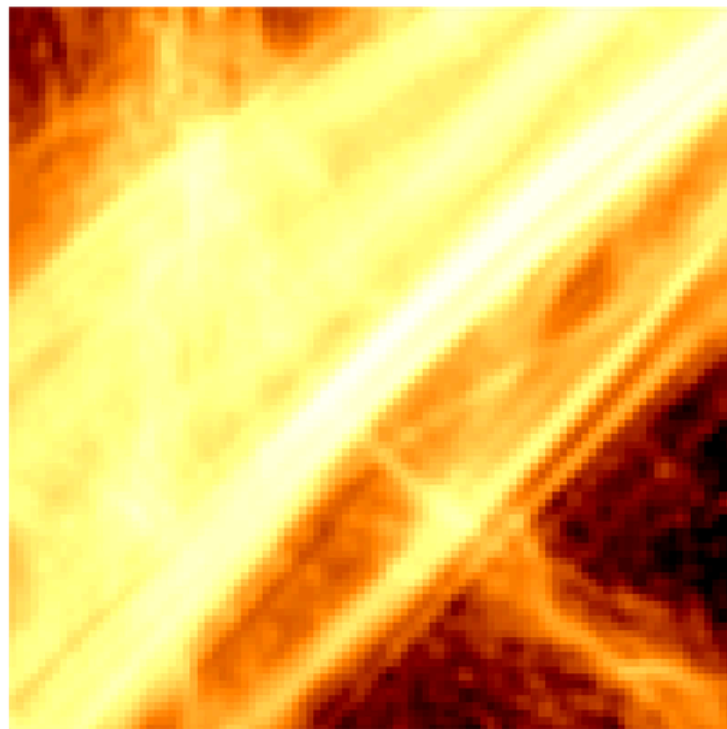
ZOOMED REGION 1



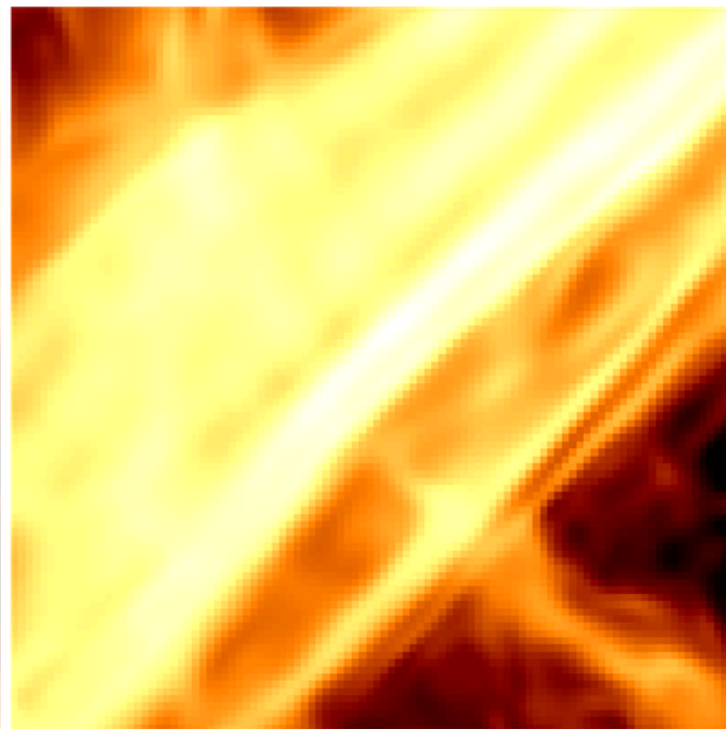
COMPARING ARCHITECTURES

ZOOMED REGION 2

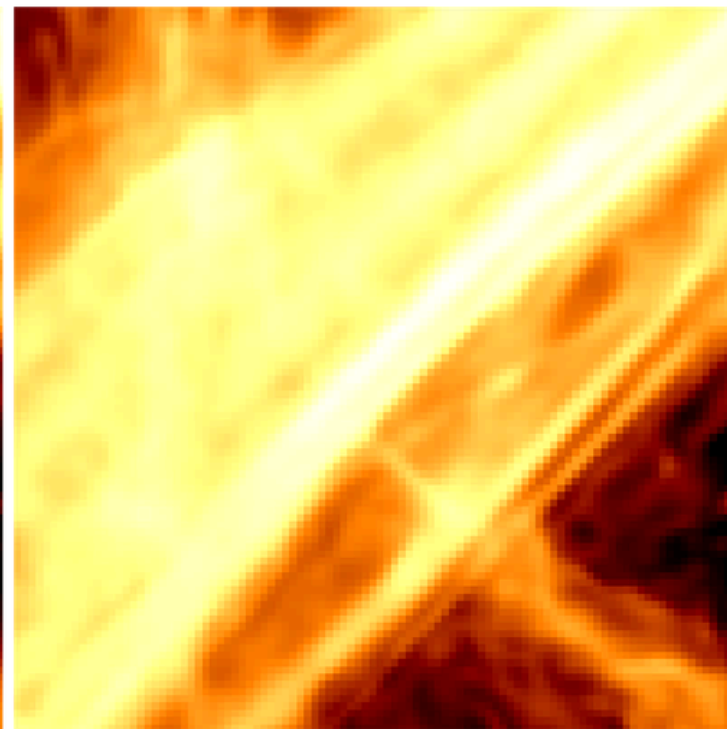
Original



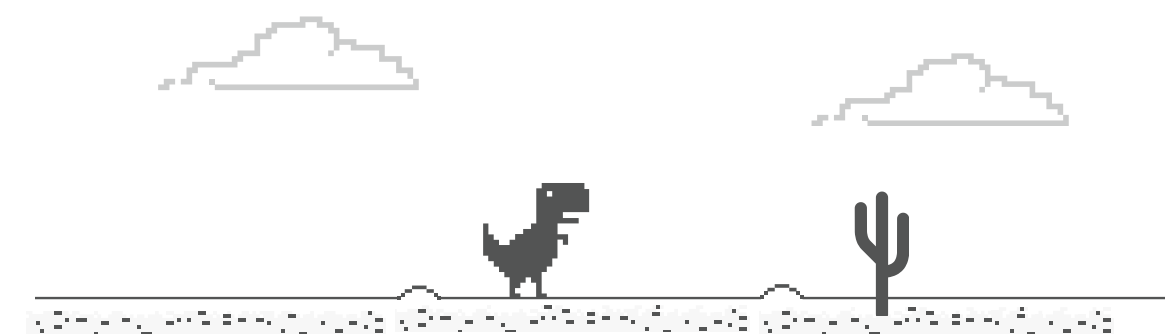
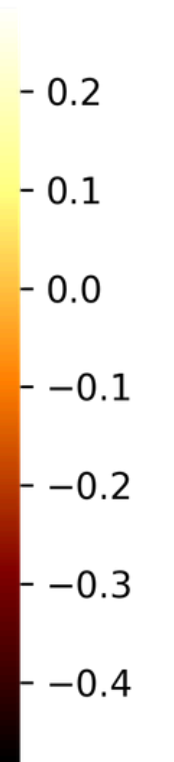
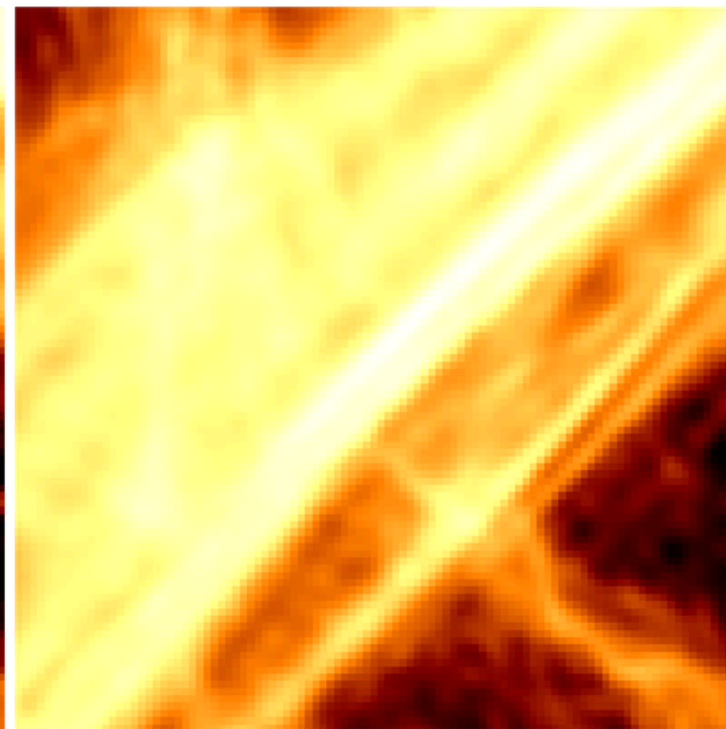
SIREN



WINNER



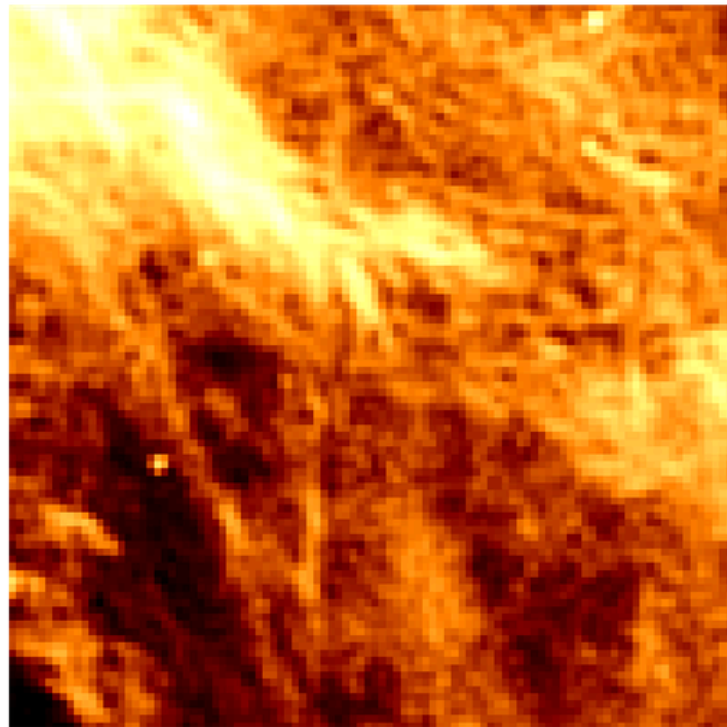
FINER



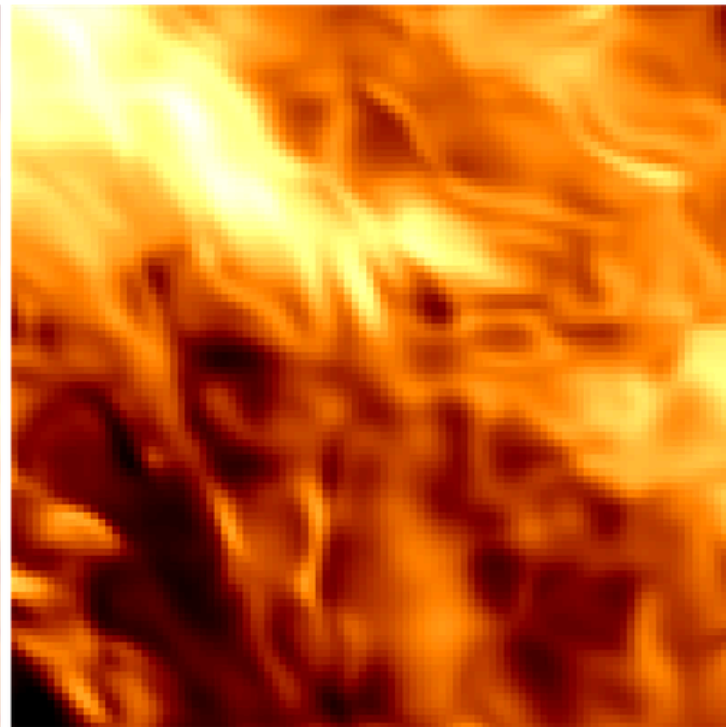
COMPARING ARCHITECTURES

ZOOMED REGION 3

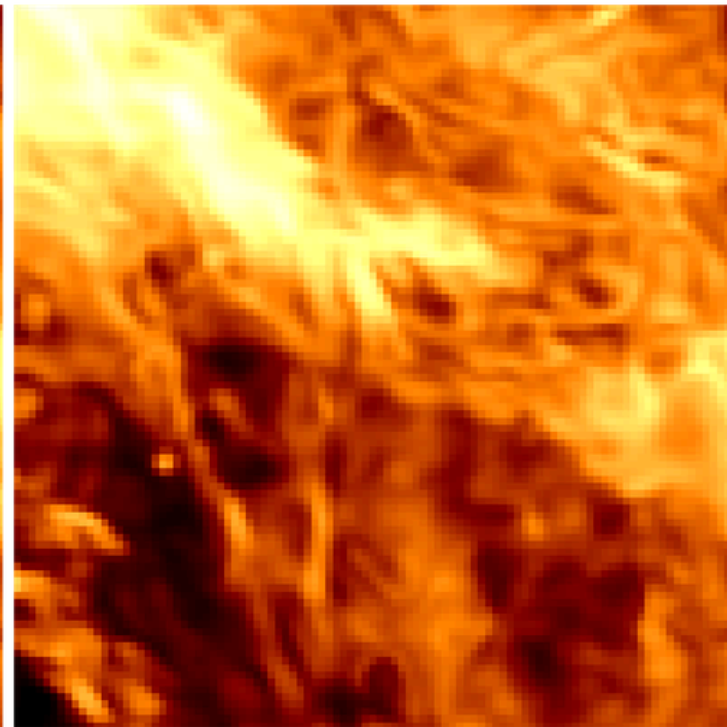
Original



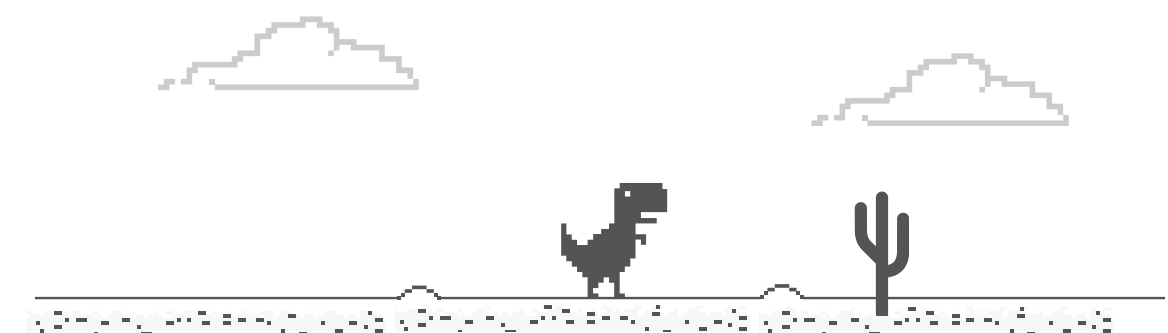
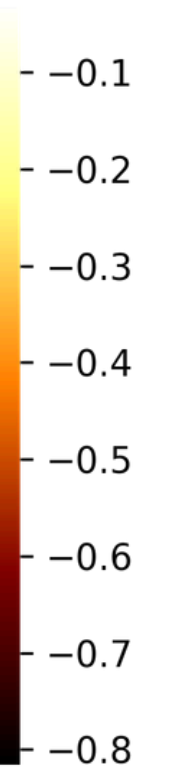
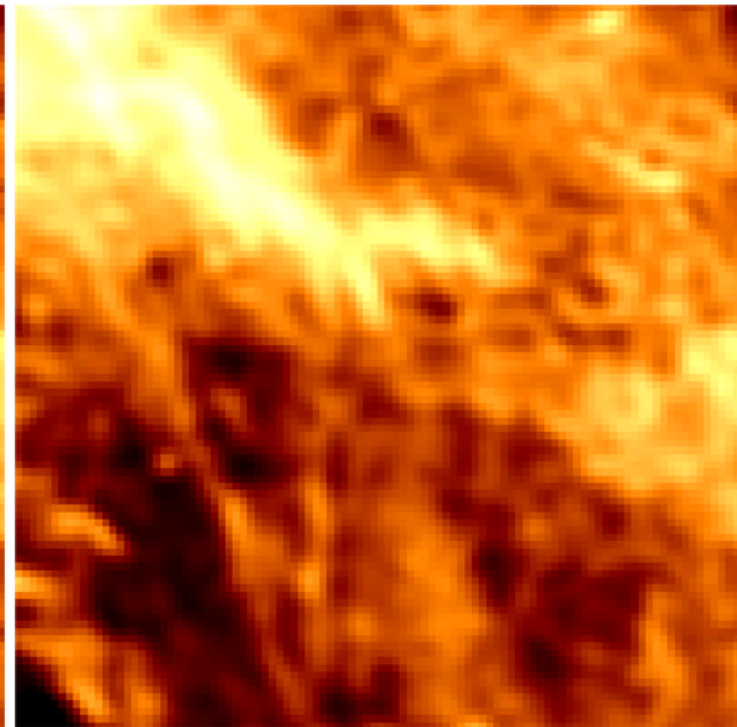
SIREN



WINNER



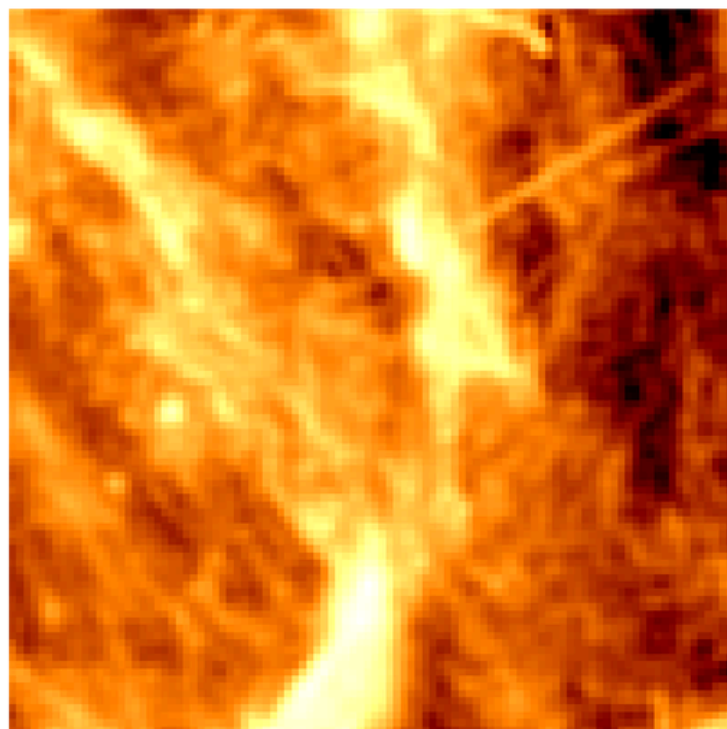
FINER



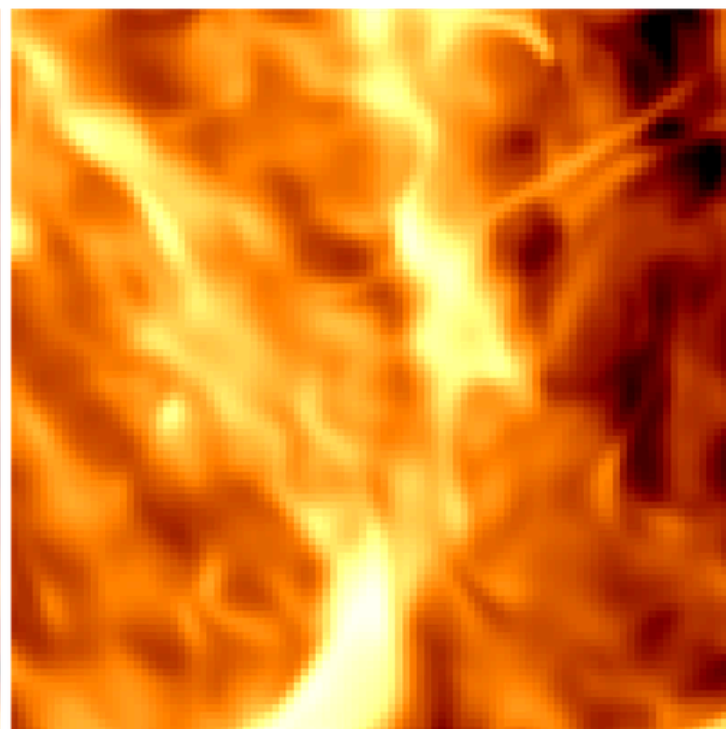
COMPARING ARCHITECTURES

ZOOMED REGION 4

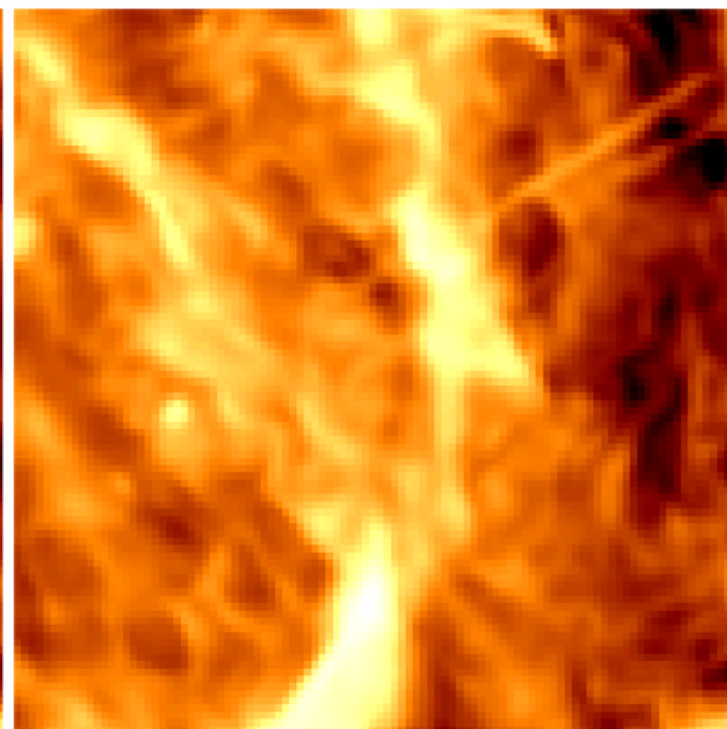
Original



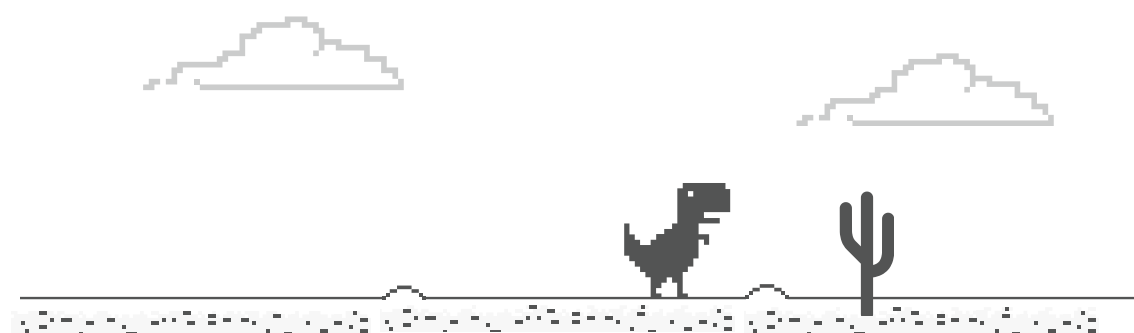
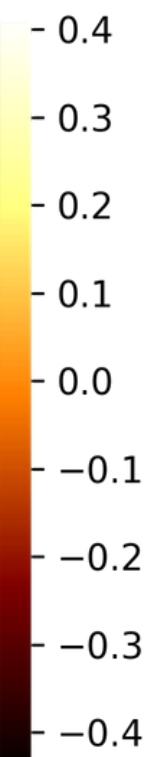
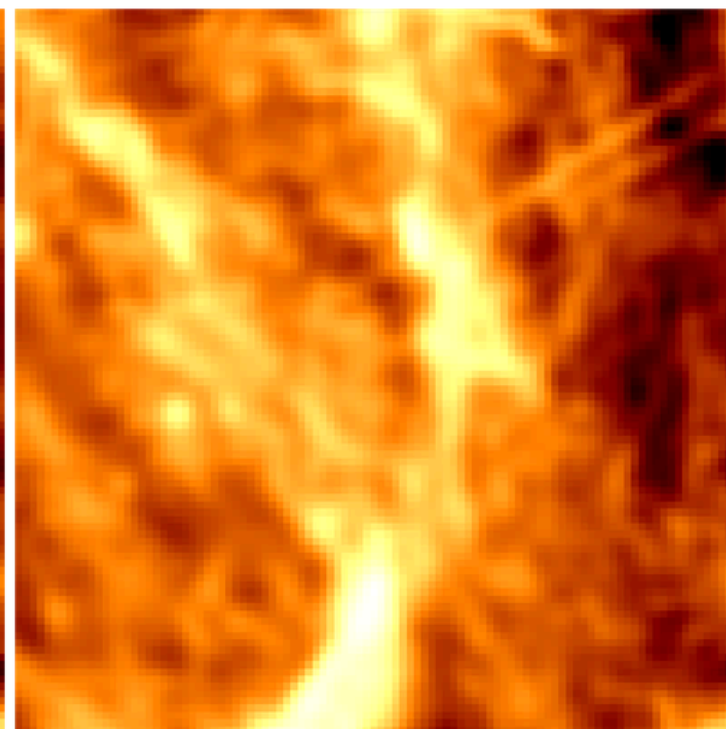
SIREN



WINNER

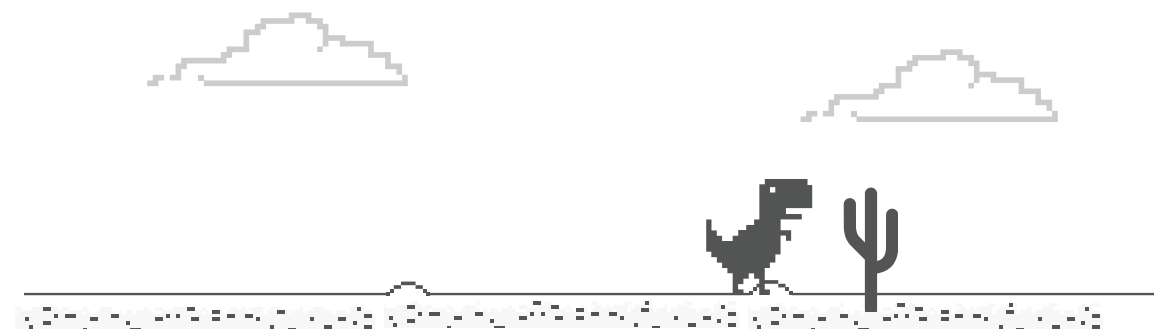
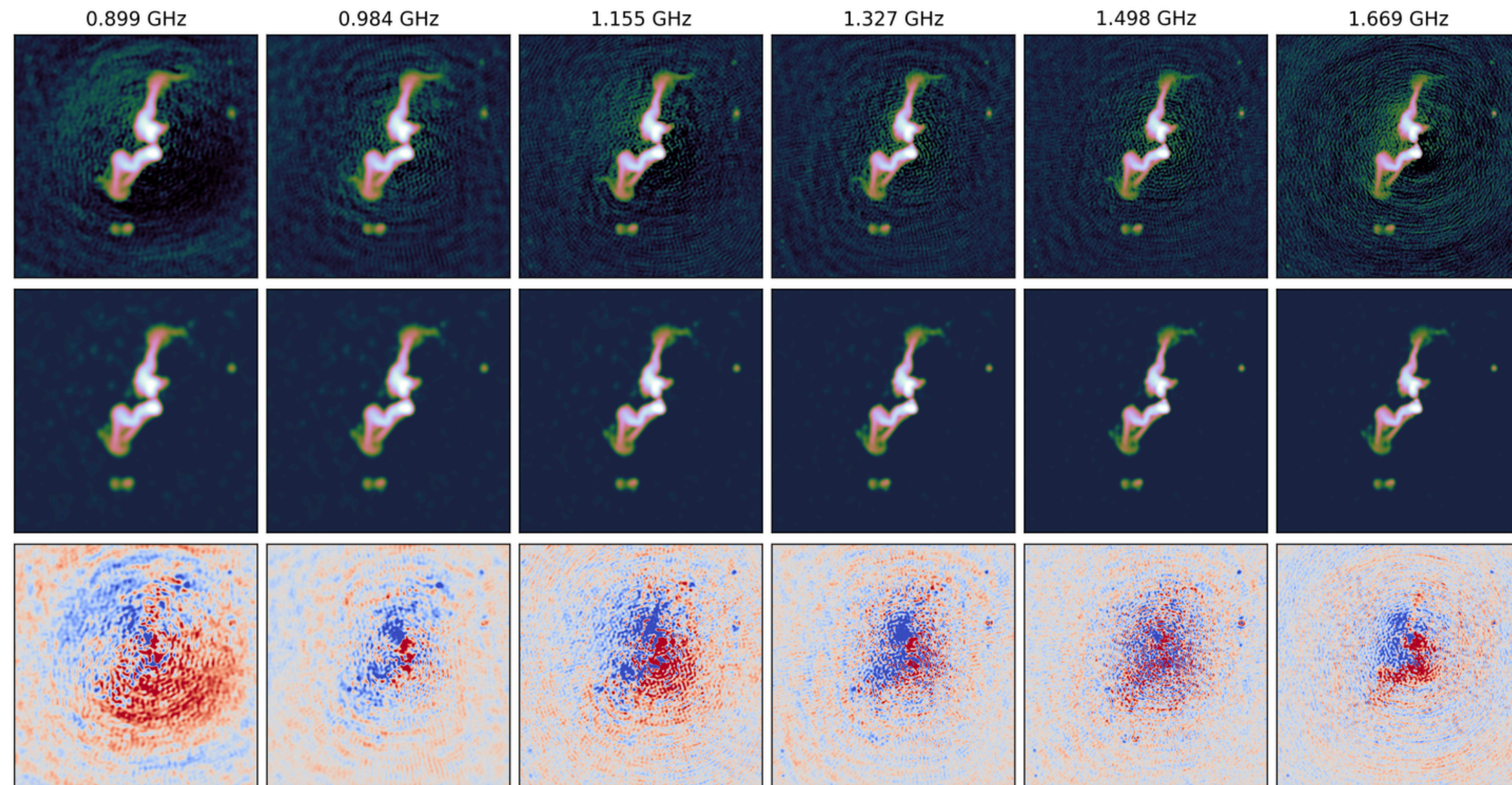


FINER



HIGHER DIMENSIONS

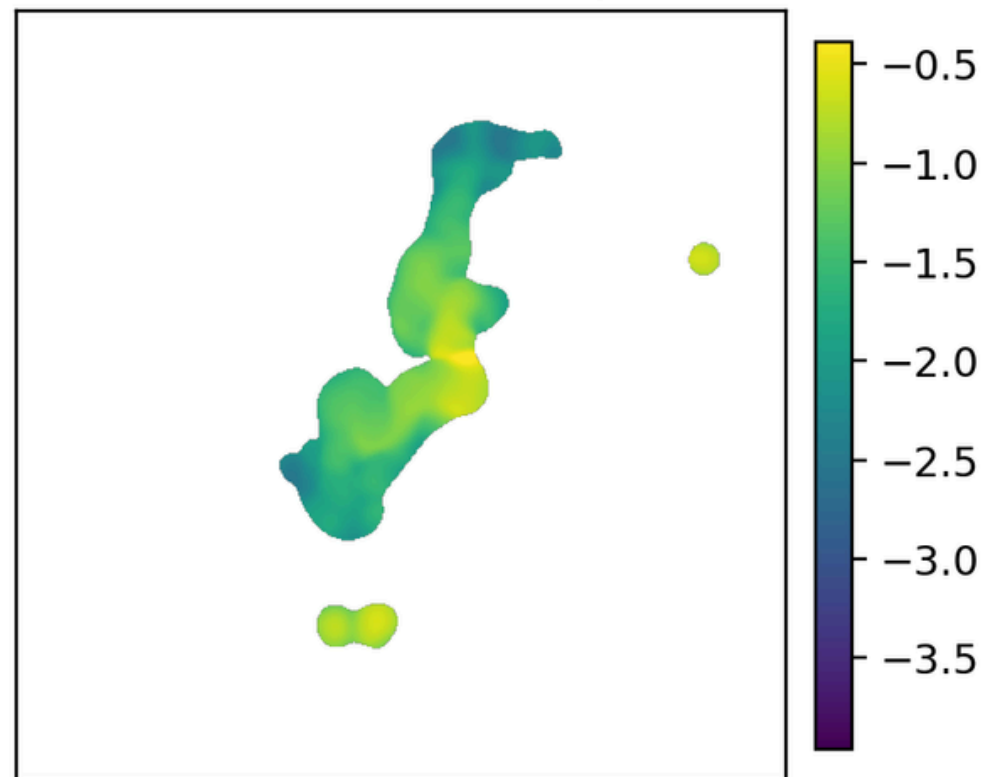
FITTING AN IMAGE CUBE



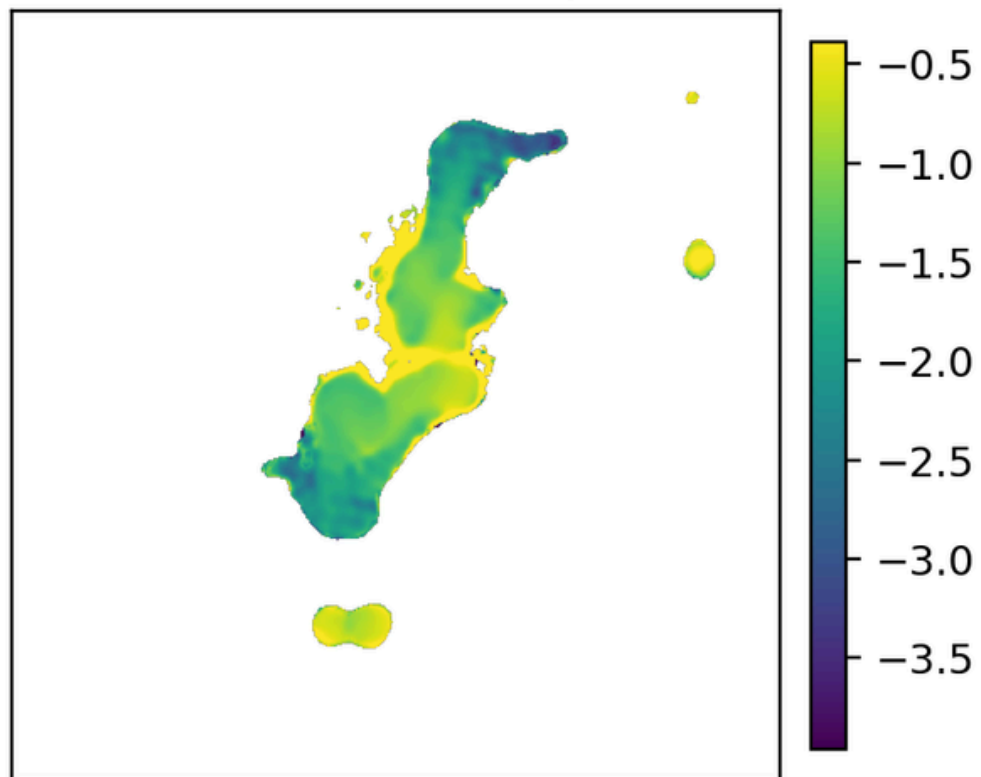
HIGHER DIMENSIONS

FITTING AN IMAGE CUBE

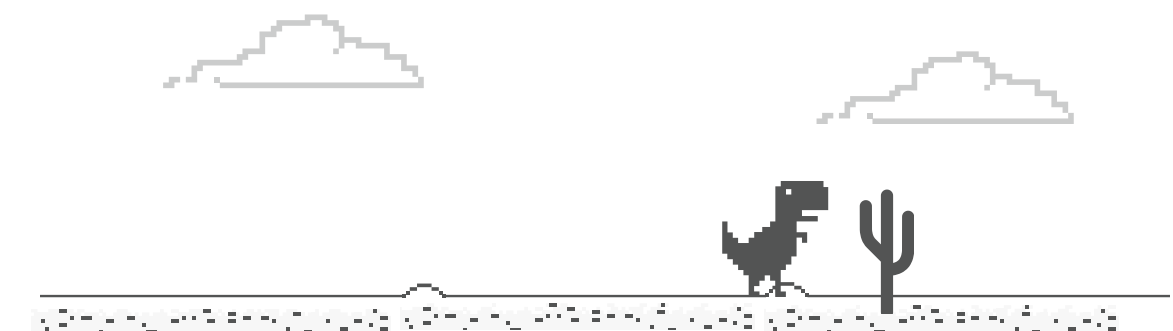
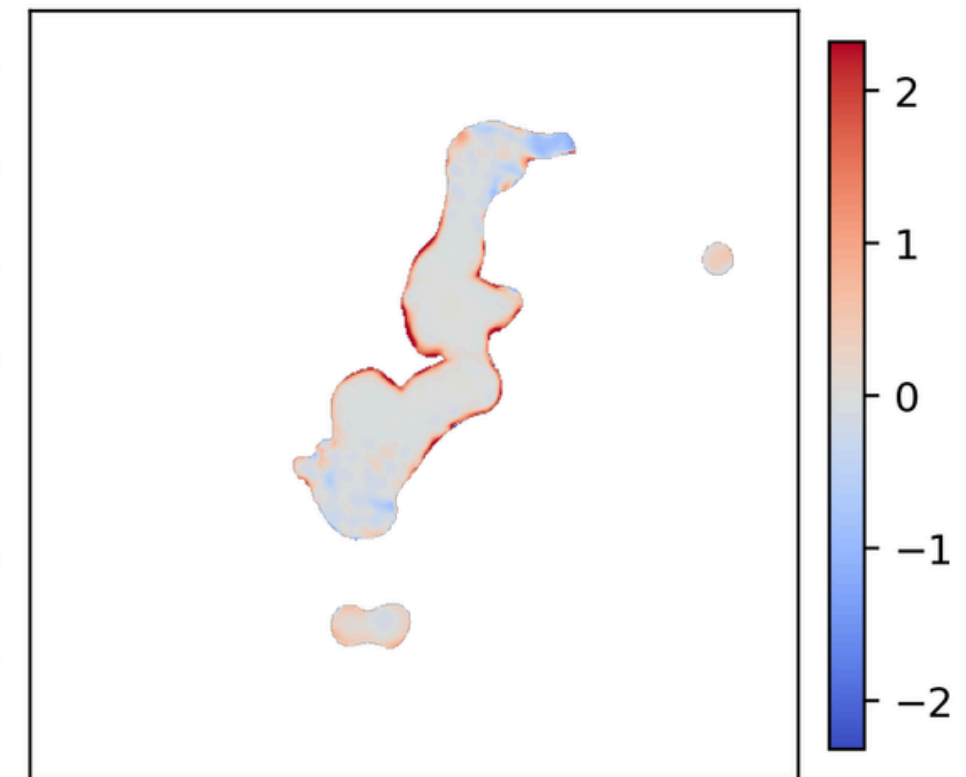
Structured observed-space α



Classical observed-space α

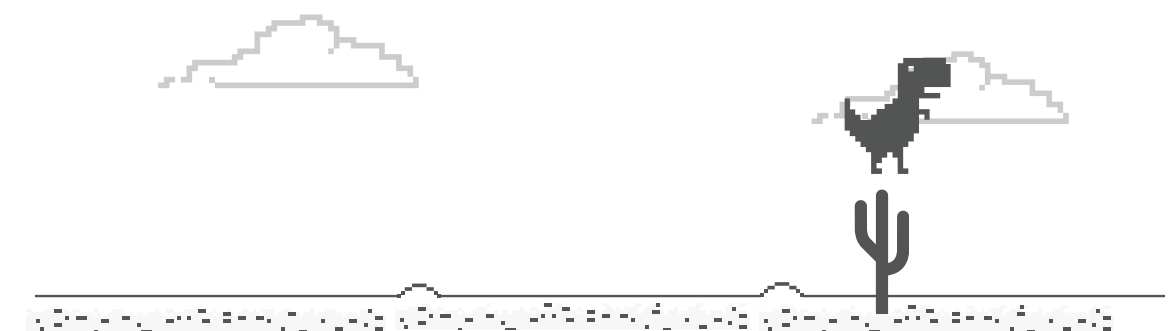
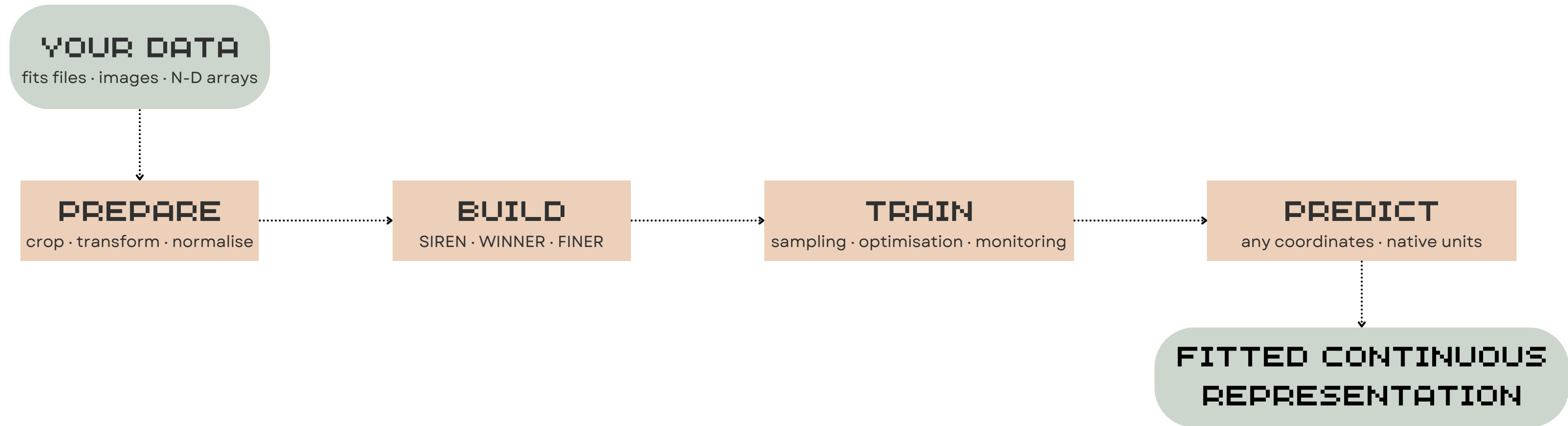


Classical – structured observed



SINETHESIS

INR PYTHON PACKAGE FOR ASTRONOMY



SINETHESIS

INR PYTHON PACKAGE FOR ASTRONOMY

READY TO TRY OUT AN INR?

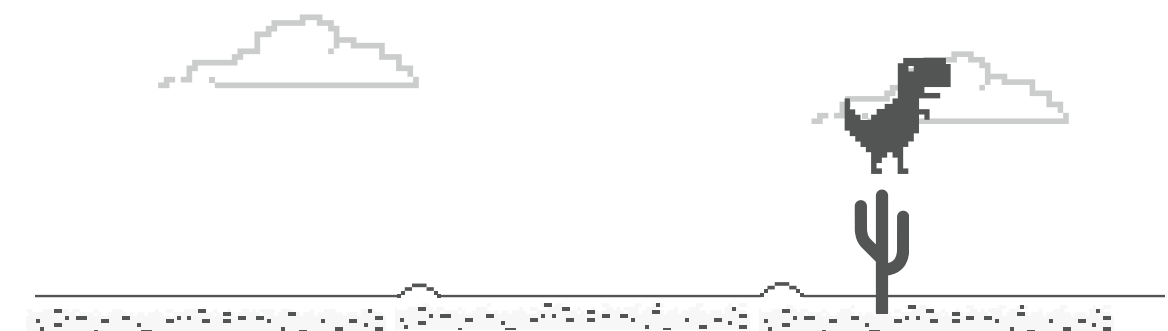
SINETHESIS IS BEGINNER FRIENDLY!

- User-friendly interface
- Default parameters automatically chosen for your dataset
- Smart validation
- Resource-aware
- Can run on your laptop

KNOW WHAT YOU ARE DOING?

SINETHESIS IS FOR EXPERTS TOO!

- Native PyTorch
- Flexible
- Control the architecture
- Control optimisation and scheduling
- Custom metrics



ANY QUESTIONS?

