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ICSC
Centro Nazionale di Ricerca in HPC, Big Data and Quantum Computing

Extending Galactic Foreground Emission with Neural Networks

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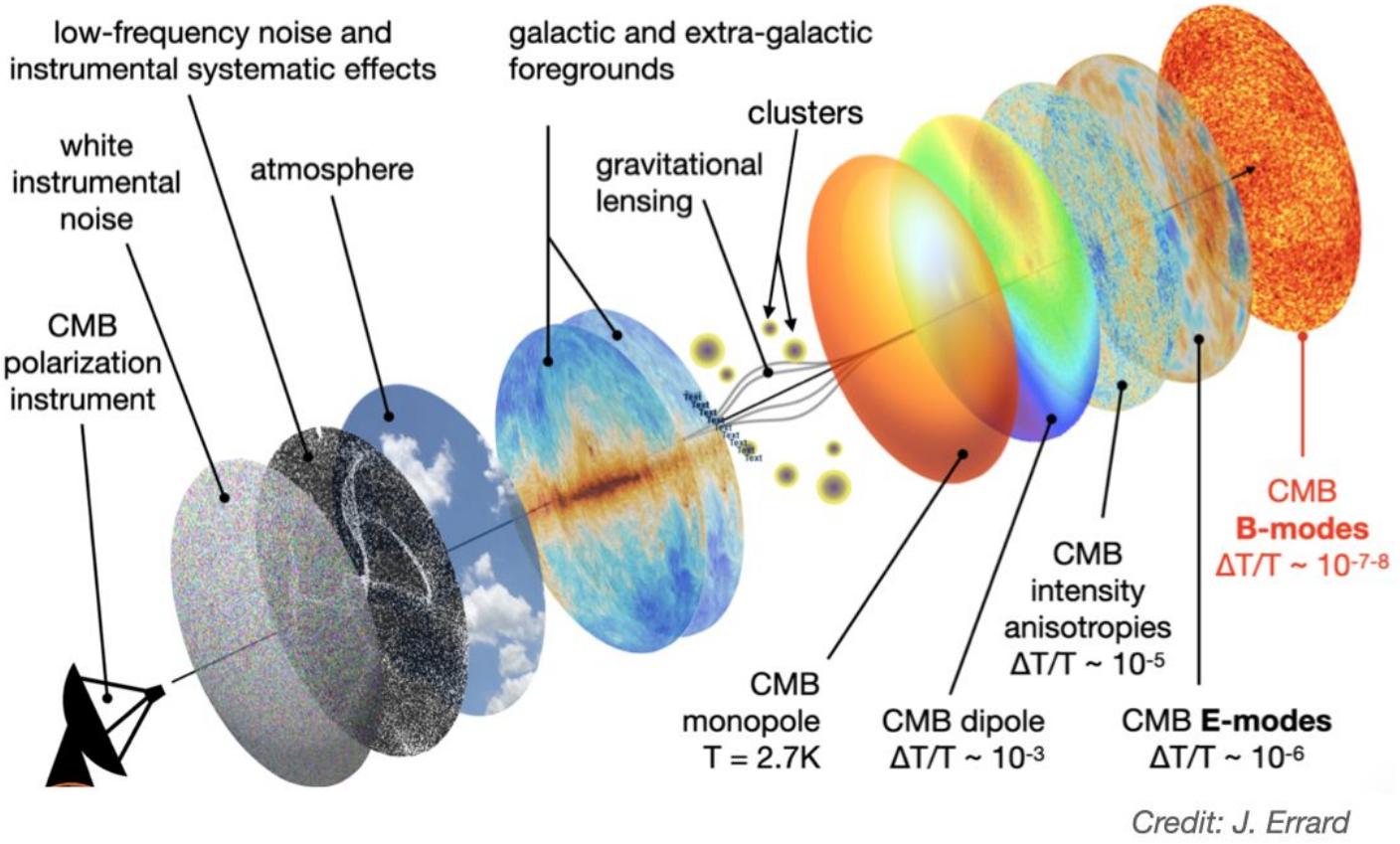
AI in Astronomy Workshop, Catania, May 21 2025

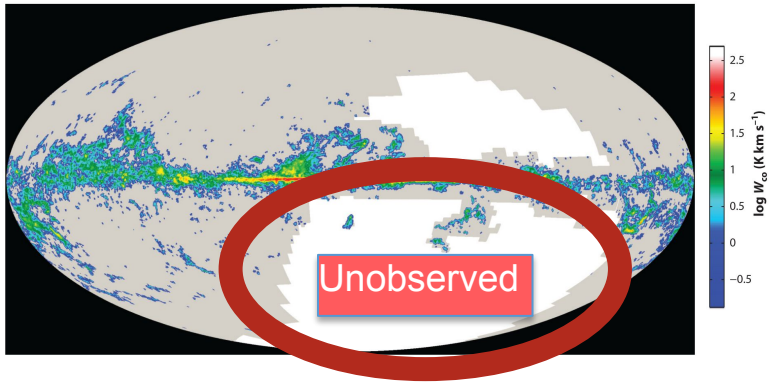
Scientific Rationale

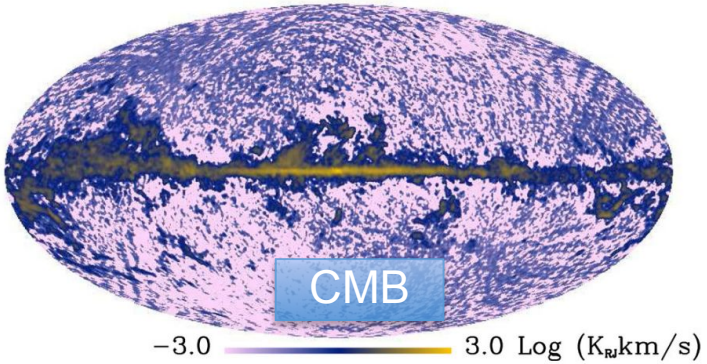
The Milky Way acts as a *foreground* wrt Cosmic Microwave Background (CMB)



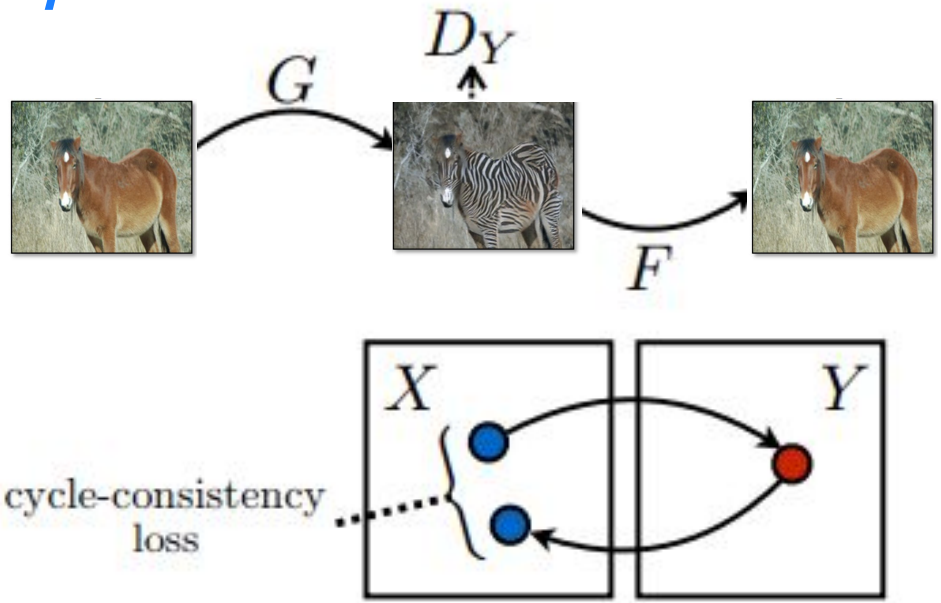
Scientific Rationale

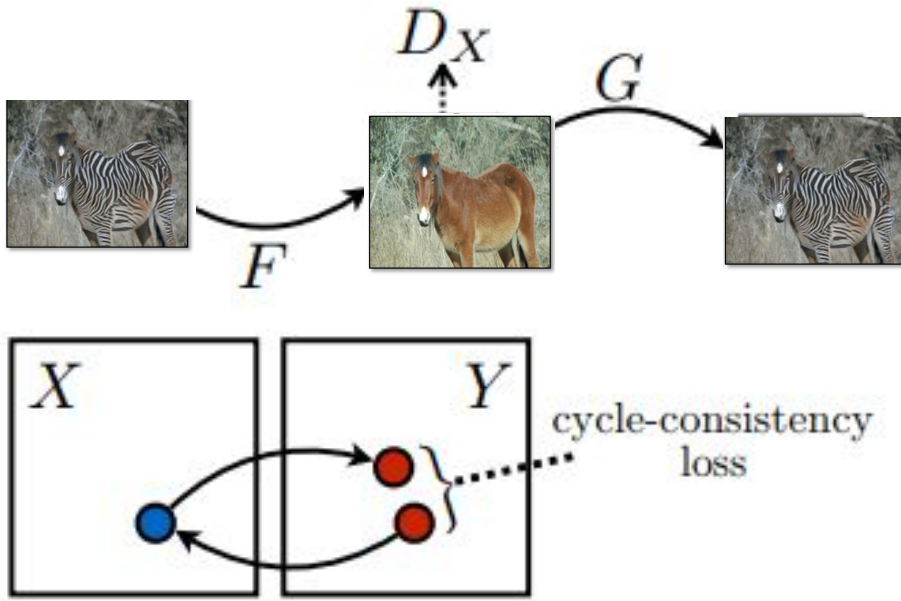
- Full sky maps of Galactic emissions are needed for cosmological observations.
- There are regions that are not observed … yet
- In the same area, CMB ground telescopes are observing…
- *Planck* data observed full sky,BUT also full of noise





Cycle-GAN in a nutshell

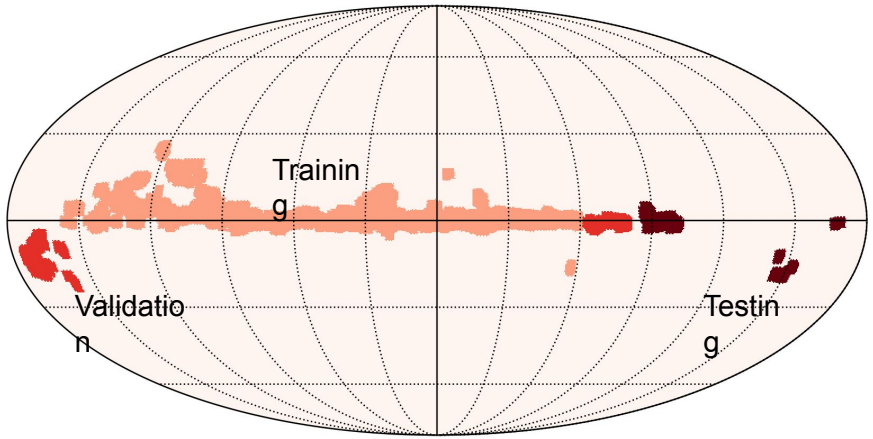




= binary Cross-Enthropy

Technical Objectives, Methodologies and Solutions

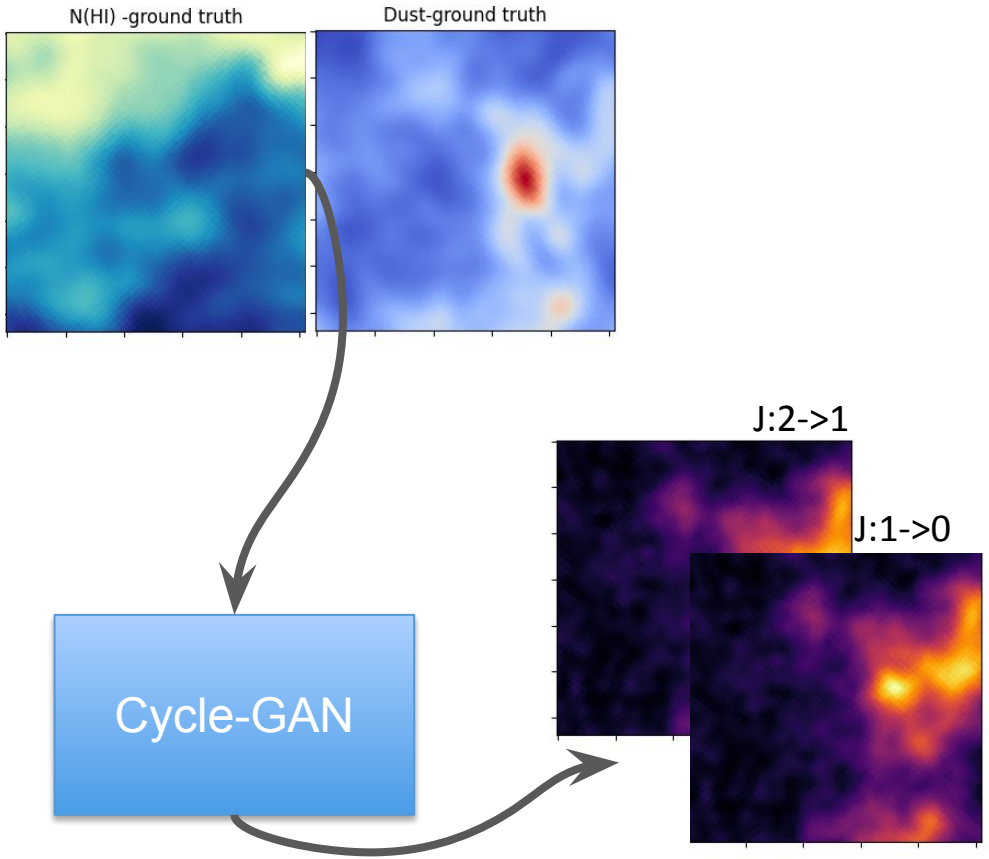
- Build training set from available data (*Planck, HI4Pi)*
- Identify Galactic regions of bright emission, low noise contribution,-> high SNR >8
- Create the training set from those areas
- 10,488 (training),1166 (validat.) , 747(test.)



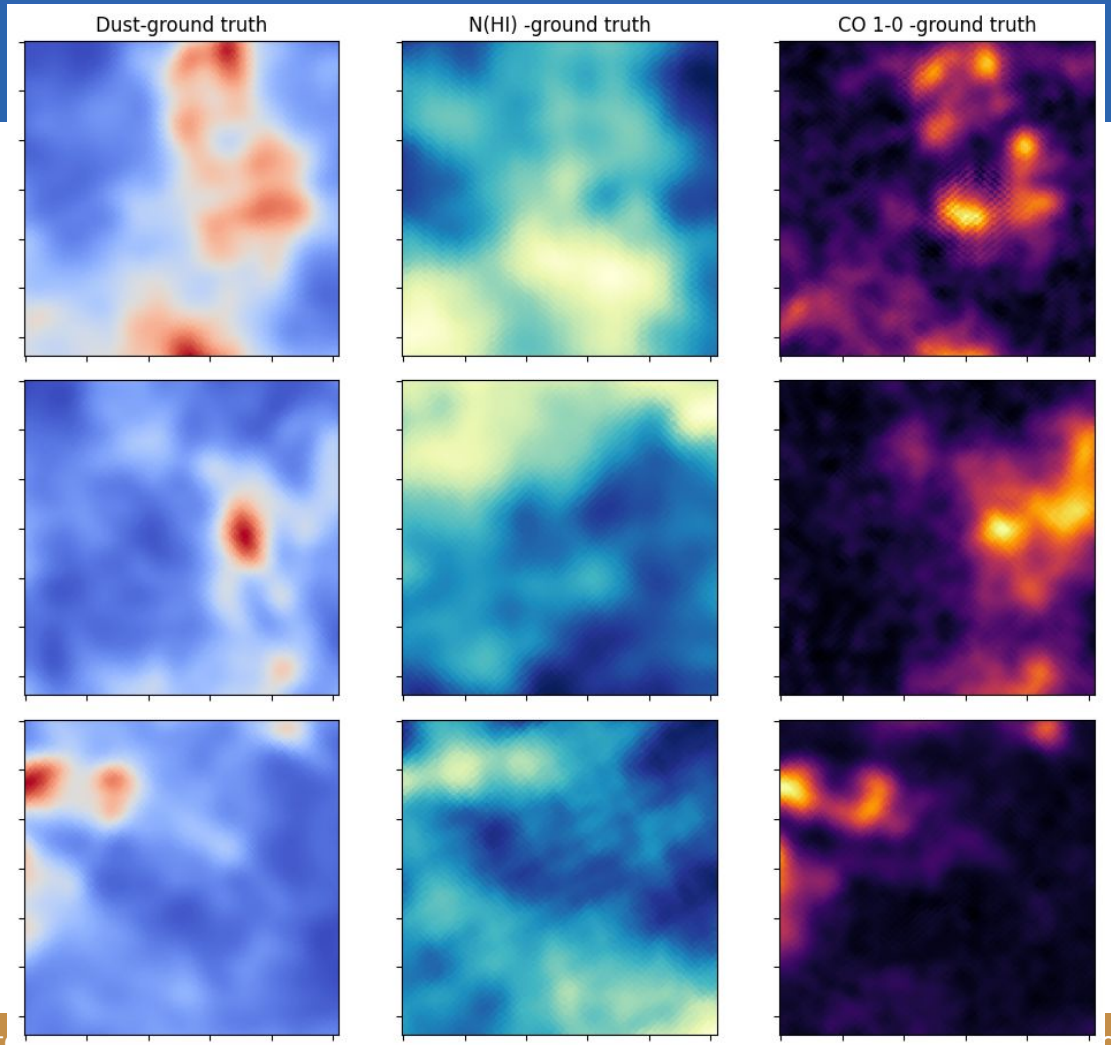
Methodologies

Training Cycle-GAN

- batch size= 16 (progressively increasing to 128)
- 2 input channels (dust and HI)
- 2 targets (CO J:1-0 and J:2-1)
- training time performed on NVIDIA A100-SXM4-40GB (4GPUs @**NERSC**)
- 3x3 deg2 maps (128x128)
- added random gaussian noise (sigma=0.3)
- 14,000 epochs
- 80% accuracy



Results on Test set



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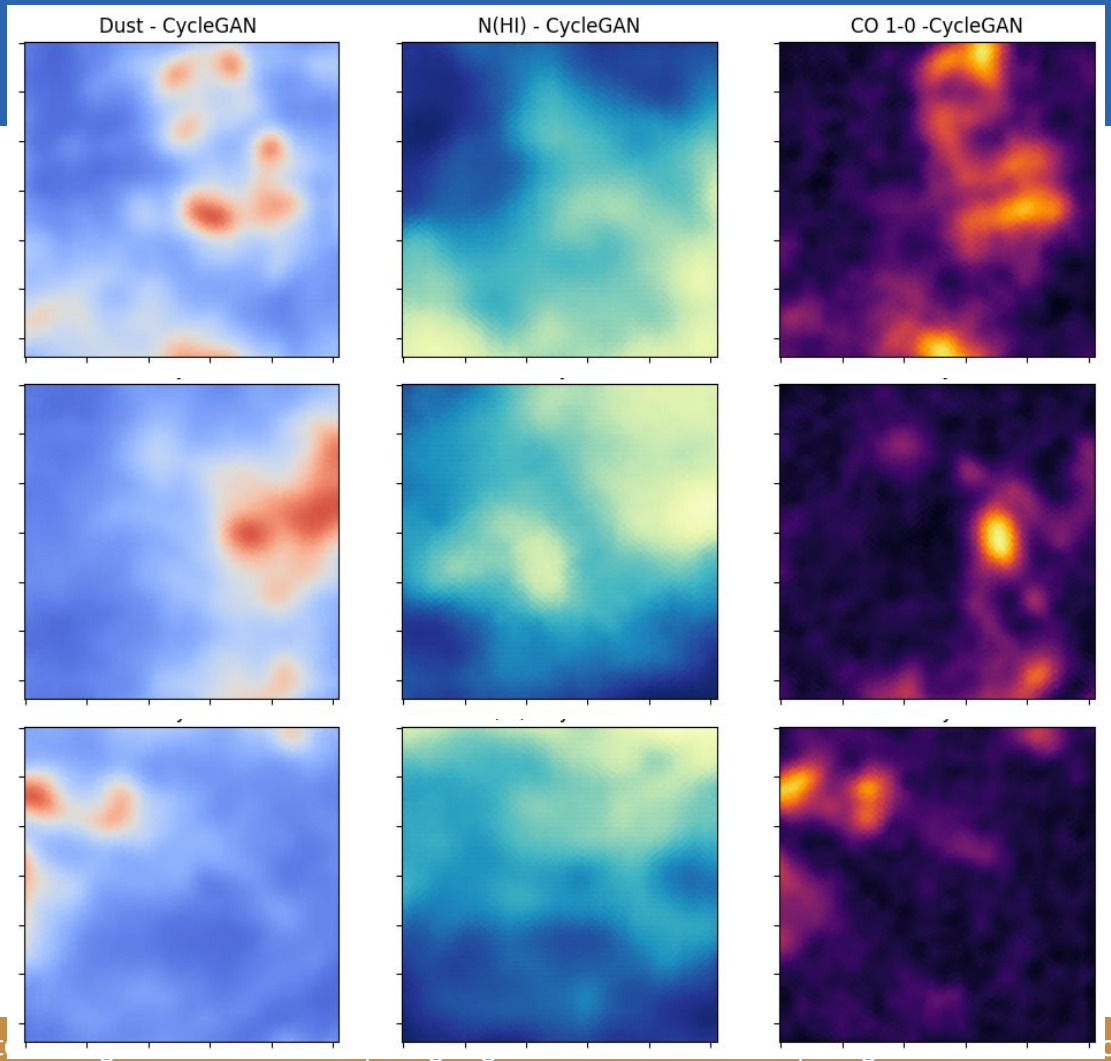

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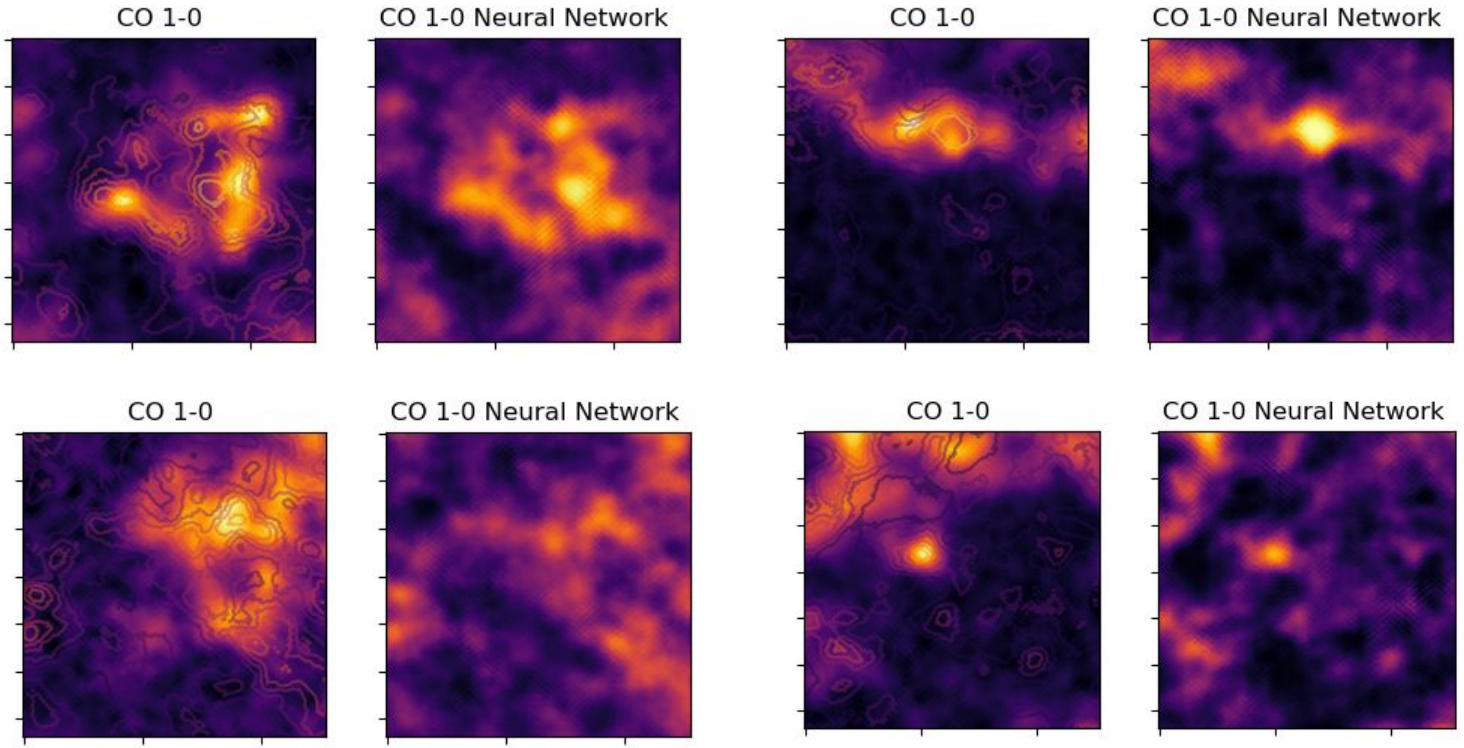
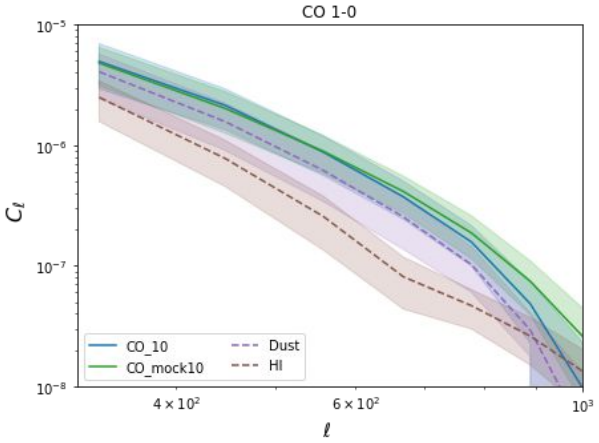
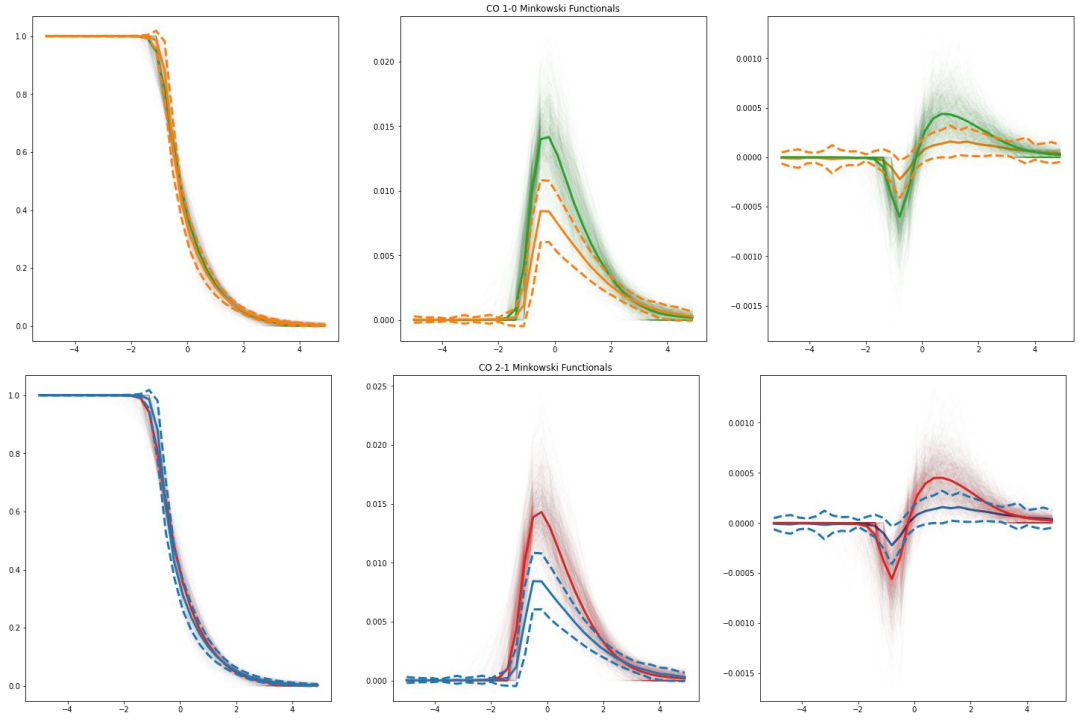


Quality of predictions - Figures of Merit

Power Spectra (2pt stat.)



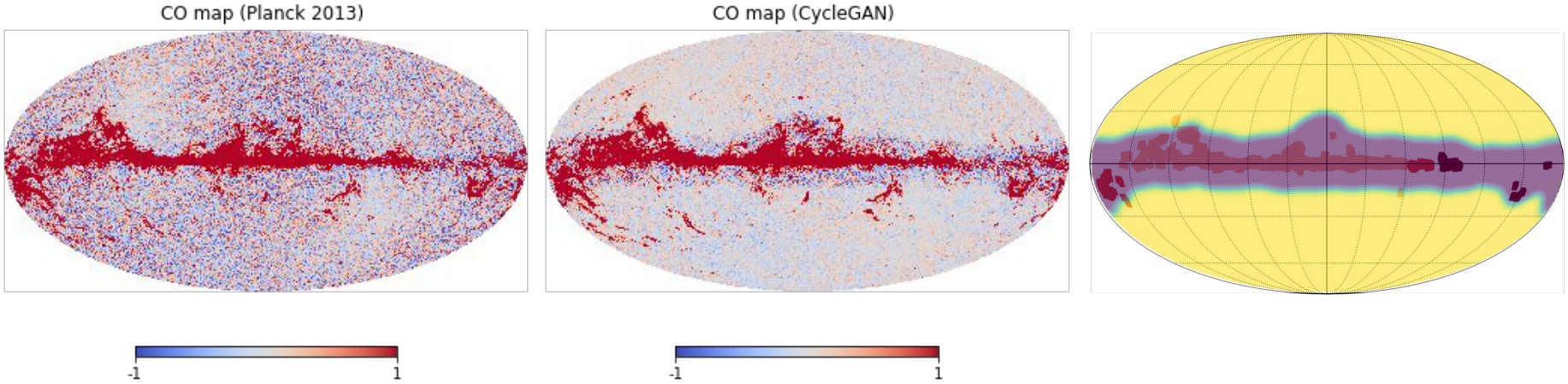
Minkowski Functionals (high-order stat.)

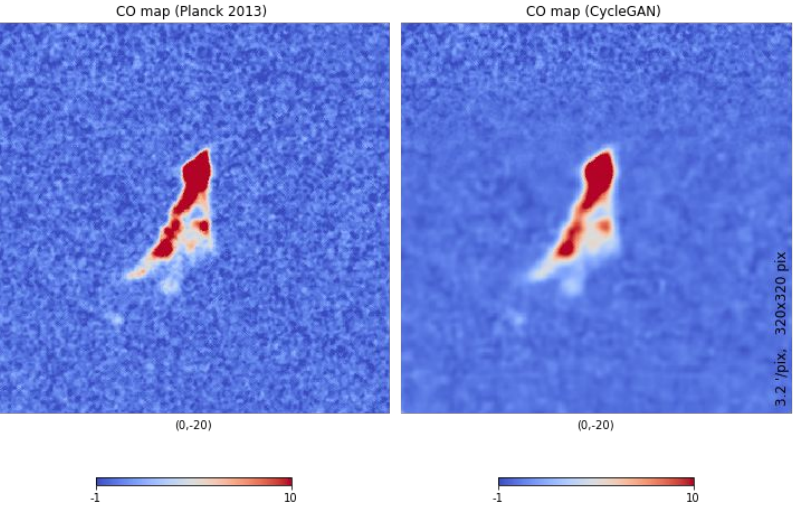


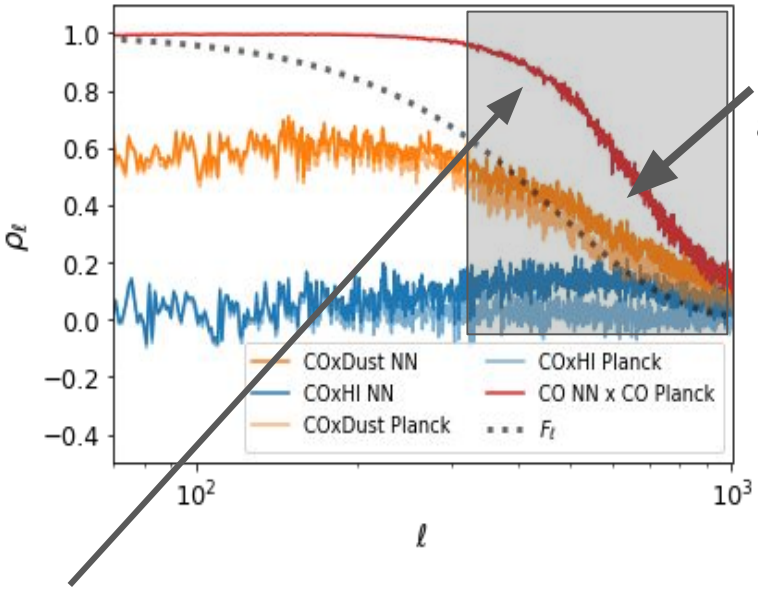
Building a new Galactic model

Predictions CO emission in regions where it has been never observed, so far.

Reprojection of 50M pixels with MPI, 140 kcpuh @**Perlmutter - NERSC**







noise and angular resolution

synthetic scales injected

Summary

- Generative networks show promising results in learning highly non linear and non Gaussian correlations observed in the physics of the ISM
- We have filled the gaps in the regions where observations are currently lacking
- Maps will be publicly released and integrated as novel suite of models in the Python Sky Model for CMB experiments