Generative Adversarial Networks for Cosmology Mass Maps
(Simulation Emulation)

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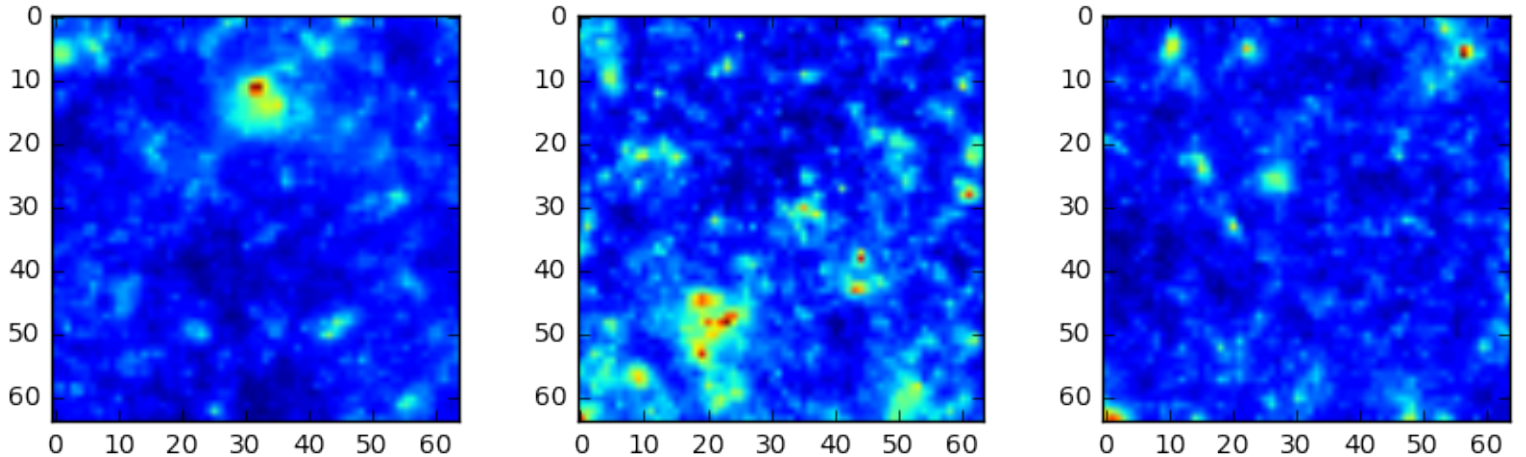
Cosmology Mass Maps Simulator Emulator



Basic idea:

Cosmologist need to run computationally expensive simulations of the mass density maps of the universe with different parameters σ = (σ1, σ2, …). The evolution of the universe is not deterministic, i.e. you can get “different” mass maps for the same set of parameters σ*.

We are exploring GANs to help in reducing the computational time. A reliable GAN dual might also be used to extract features or summary statistics.

The fidelity of the generated images can be checked using a cosmologist metric (“summary statistics”).

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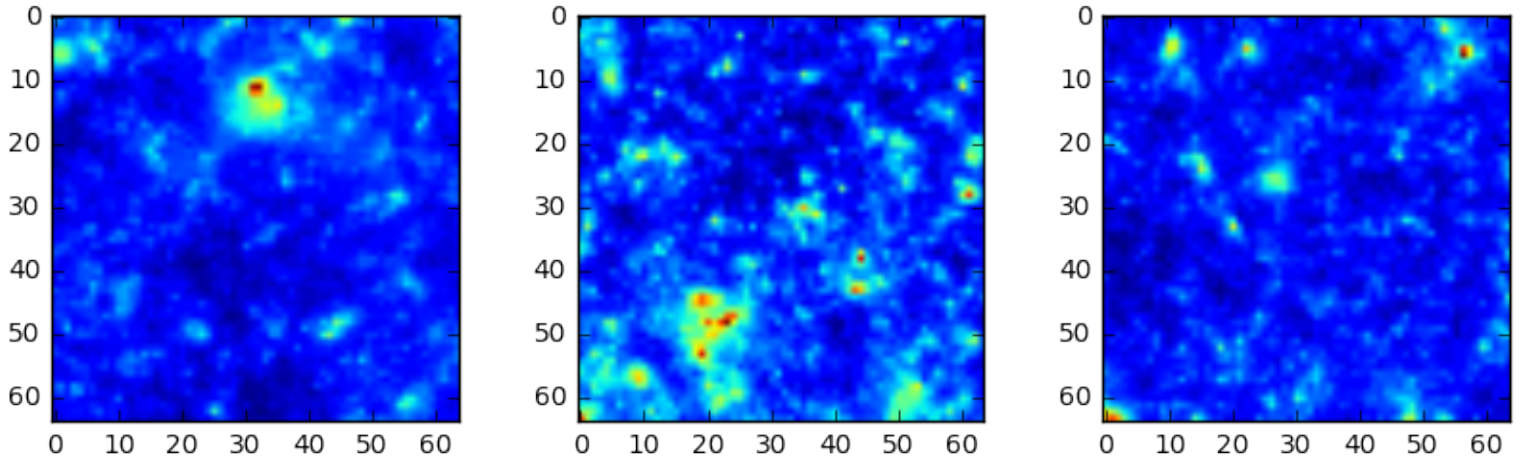
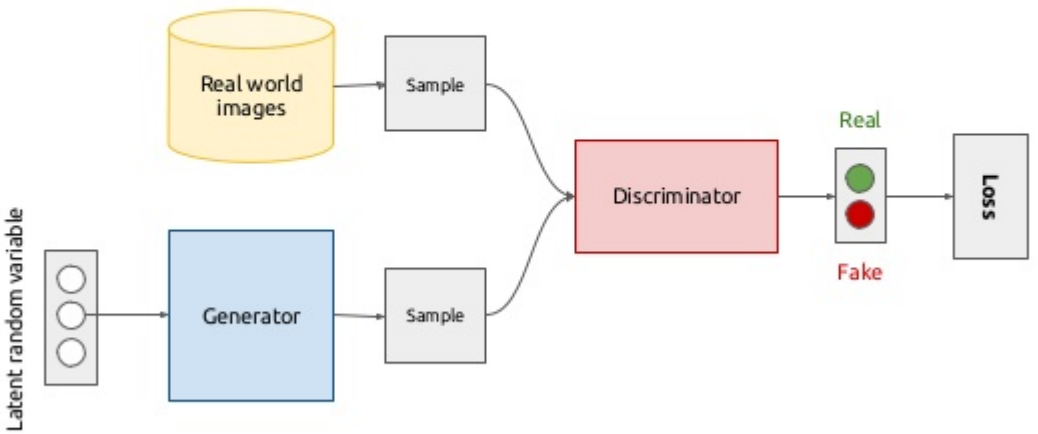


Dataset:

1000 1024x1024 mass maps generated at one σ* point. It is possible to generate more if needed.

- **Ultimate goal:** a conditional/parametric generator G(σ, z), where σ is the cosmologists vector of parameters and z is a vector of random noise
- **Current goal:** G(z) which will generate images at the fixed point σ* of our test sample

Generative Adversarial Networks



Kevin McGuinness

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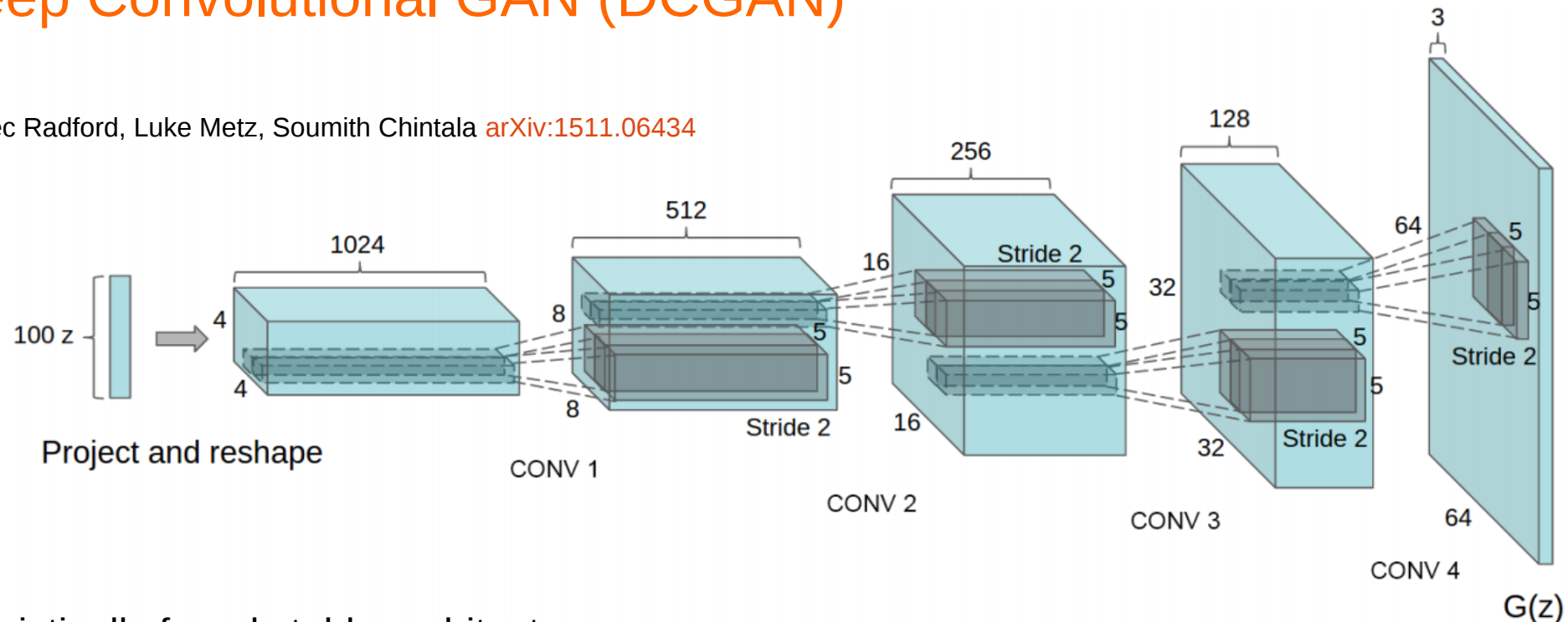
Deep Convolutional GAN (DCGAN)

Alec Radford, Luke Metz, Soumith Chintala arXiv:1511.06434

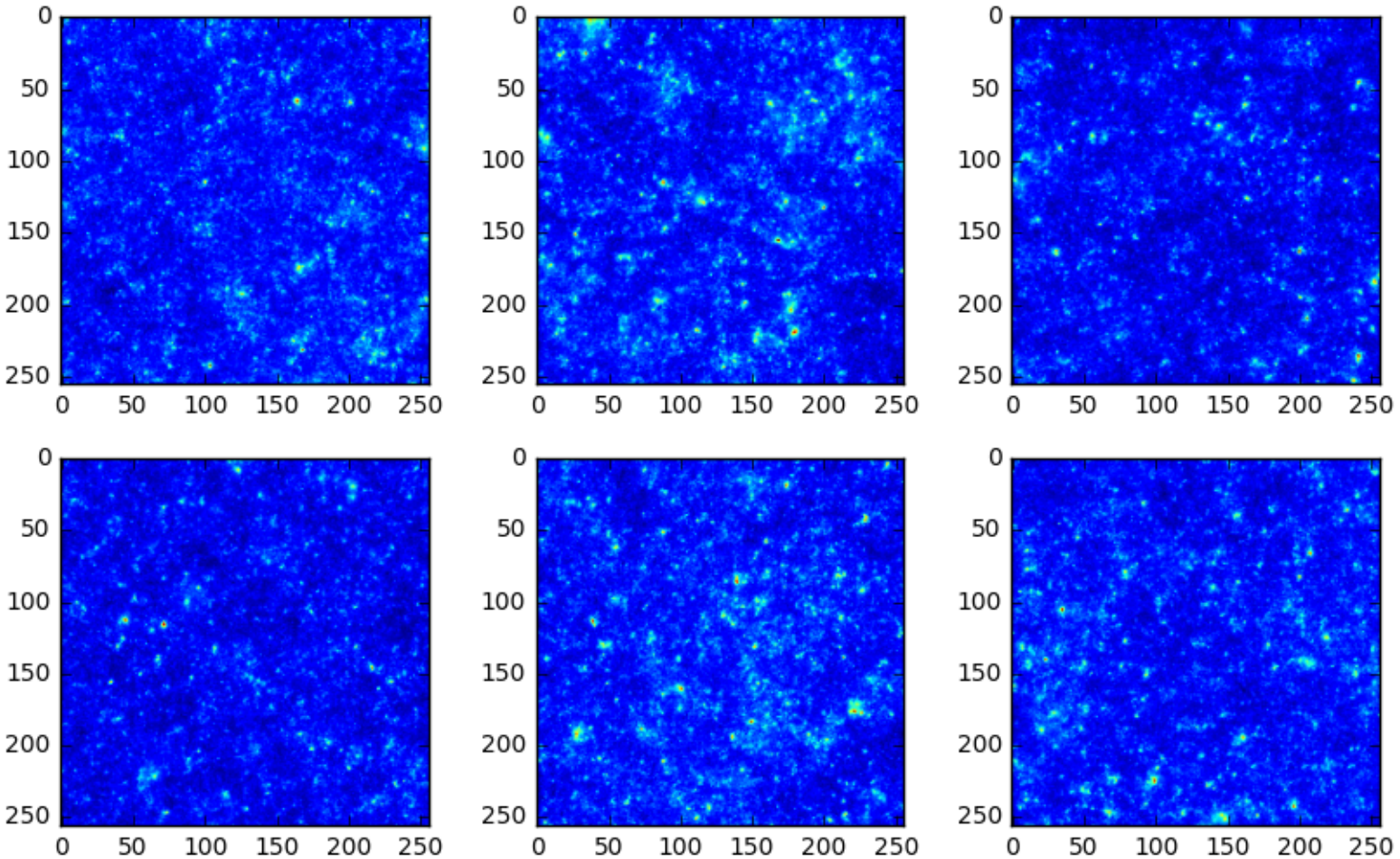


Heuristically found stable architecture

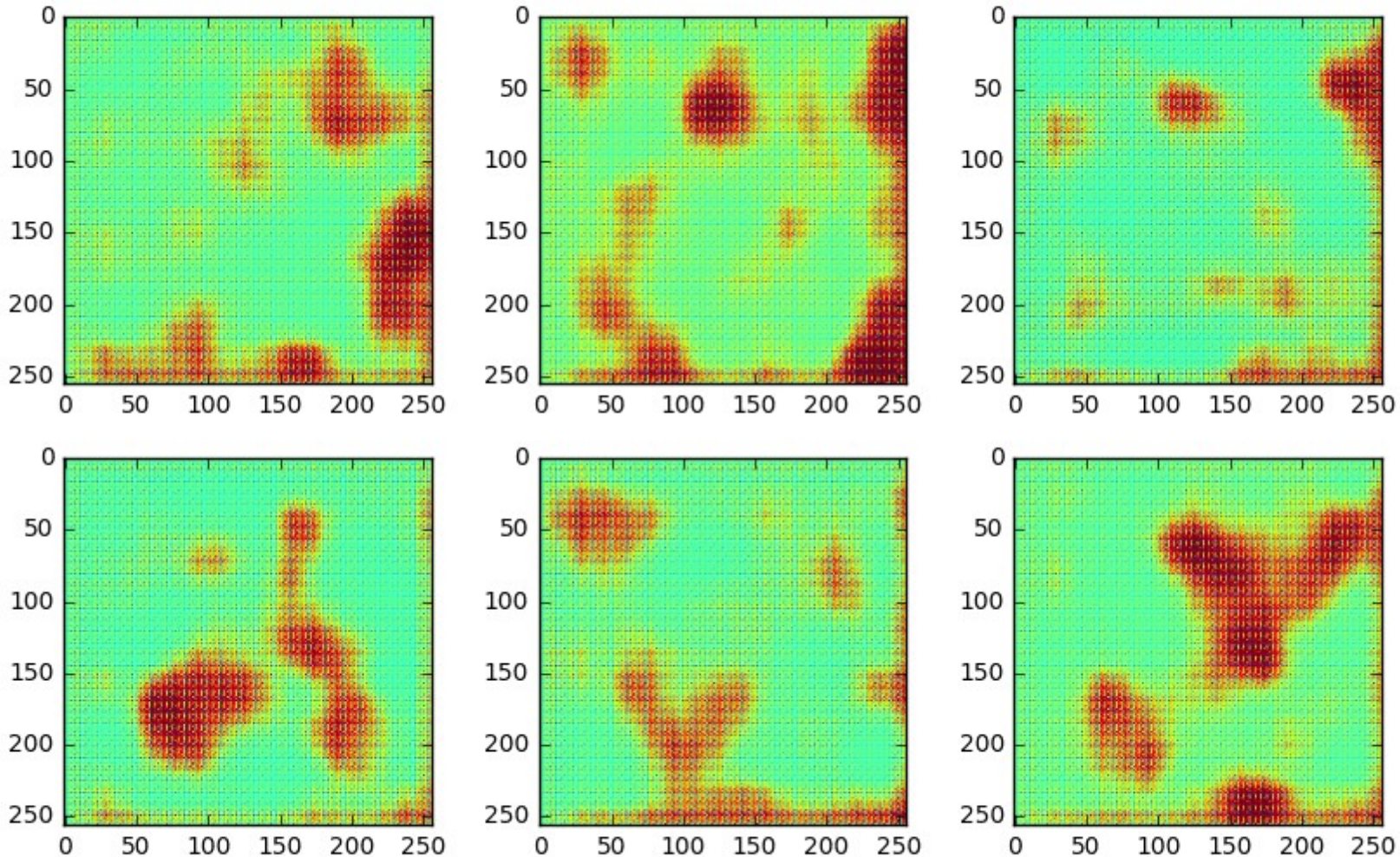
Architecture guidelines for stable Deep Convolutional GANs

- Replace any pooling layers with strided convolutions (discriminator) and fractional-strided convolutions (generator).
- Use batchnorm in both the generator and the discriminator.
- Remove fully connected hidden layers for deeper architectures.
- Use ReLU activation in generator for all layers except for the output, which uses Tanh.
- Use LeakyReLU activation in the discriminator for all layers.

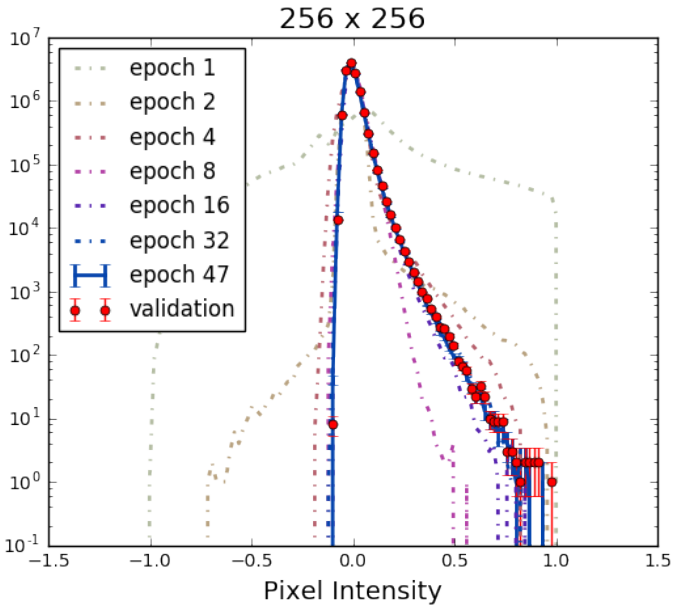
Cosmo DCGAN 256x256

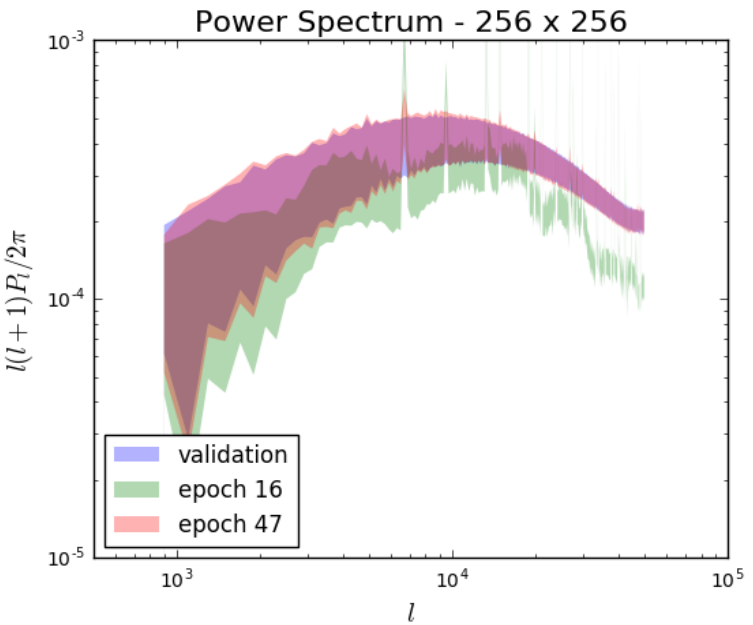


Cosmo DCGAN 256x256



Cosmo DCGAN 256x256





First order statistics (left) and 2-pt correlations (right) are reproduced with high fidelity in generated images.

Outlook

- Train on 512x512 and 1000x1000 maps with larger networks
- Explore architectures for parametric generators