

# DEEP LEARNING IN SOLAR PHYSICS

a. asensio ramos

@aasensior

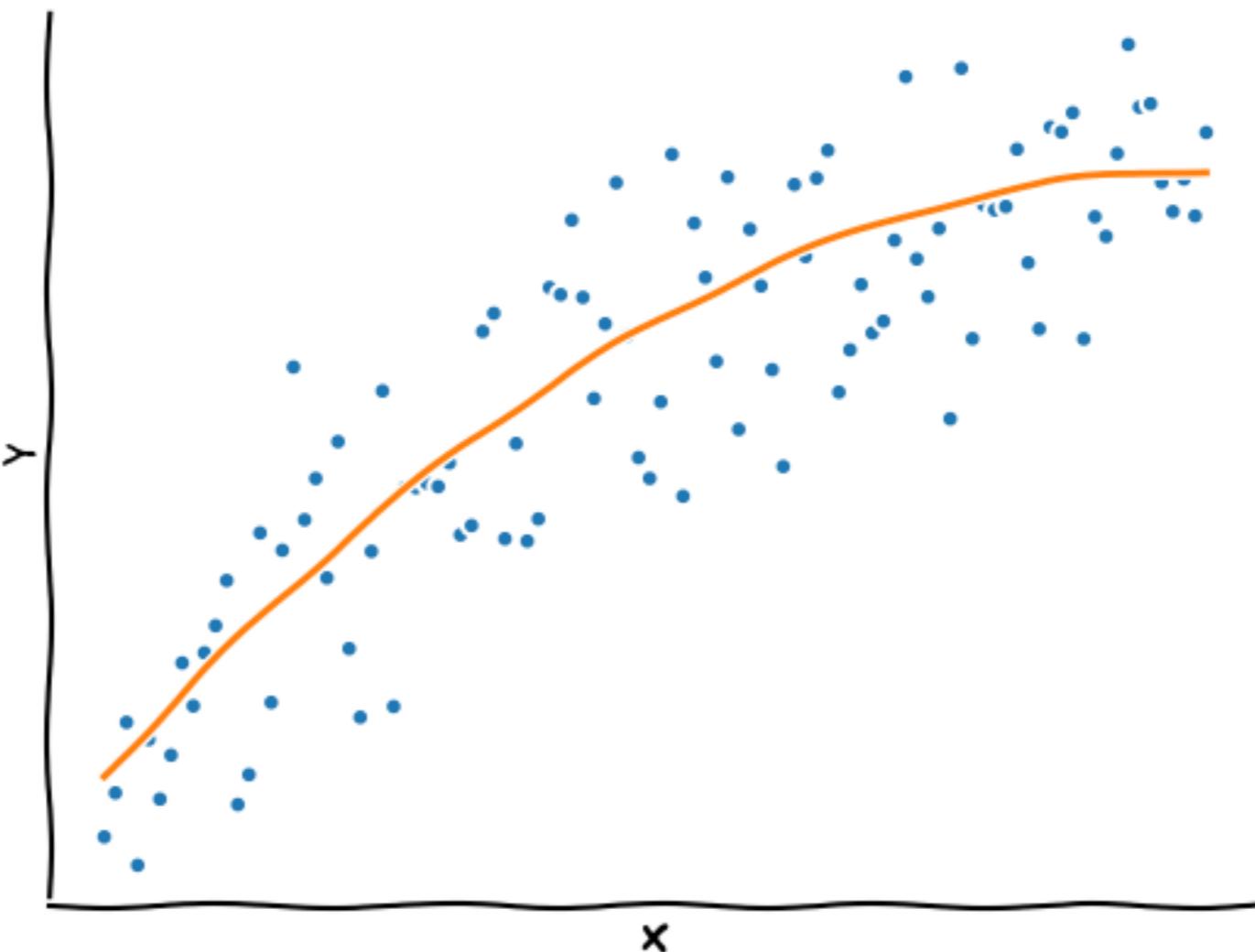
[github.com/aasensio](https://github.com/aasensio)



# what is machine learning?

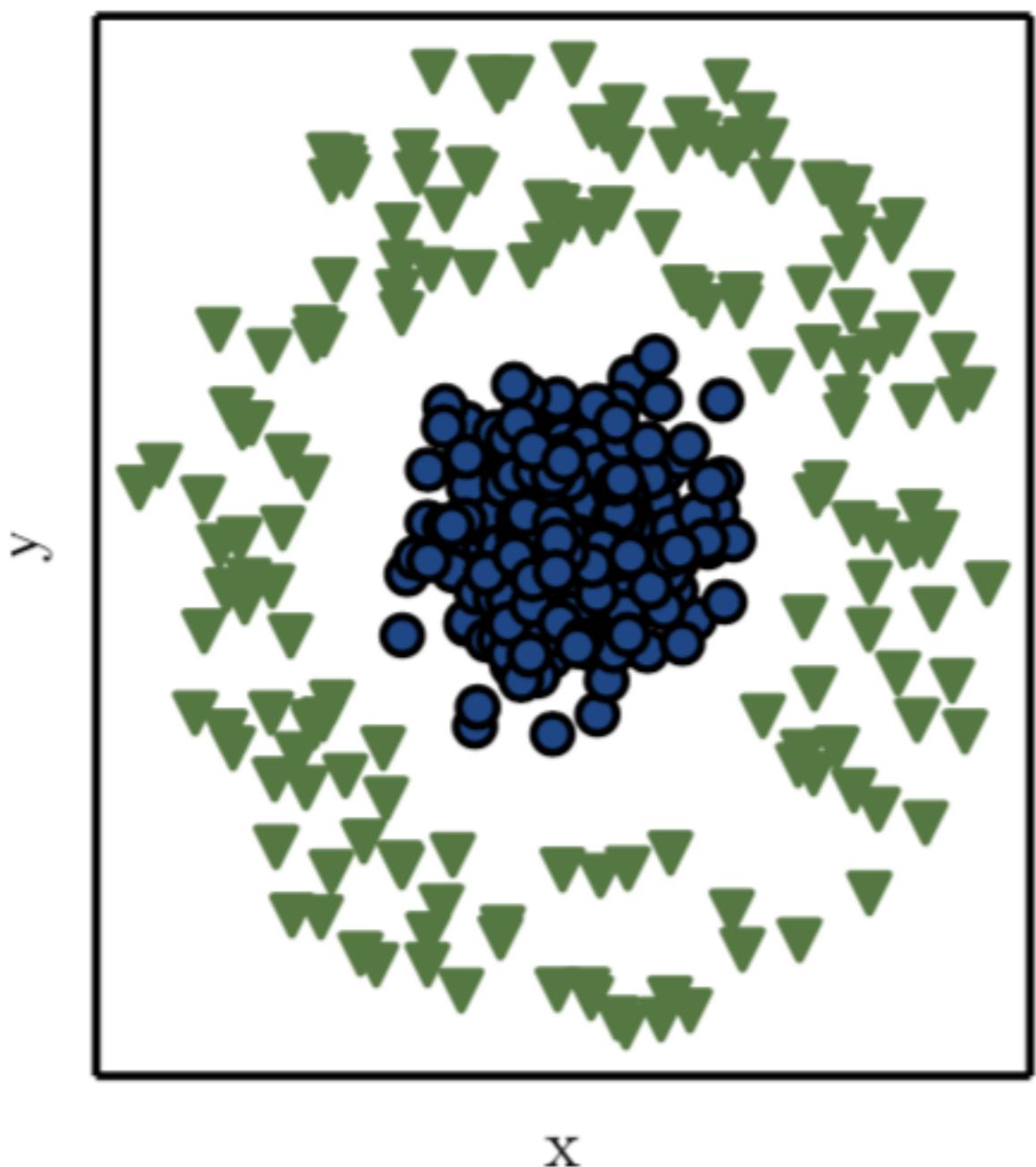
Using statistical techniques to give computers the ability to progressively improve performance on a specific task with data, without being explicitly programmed.

# REGRESSION

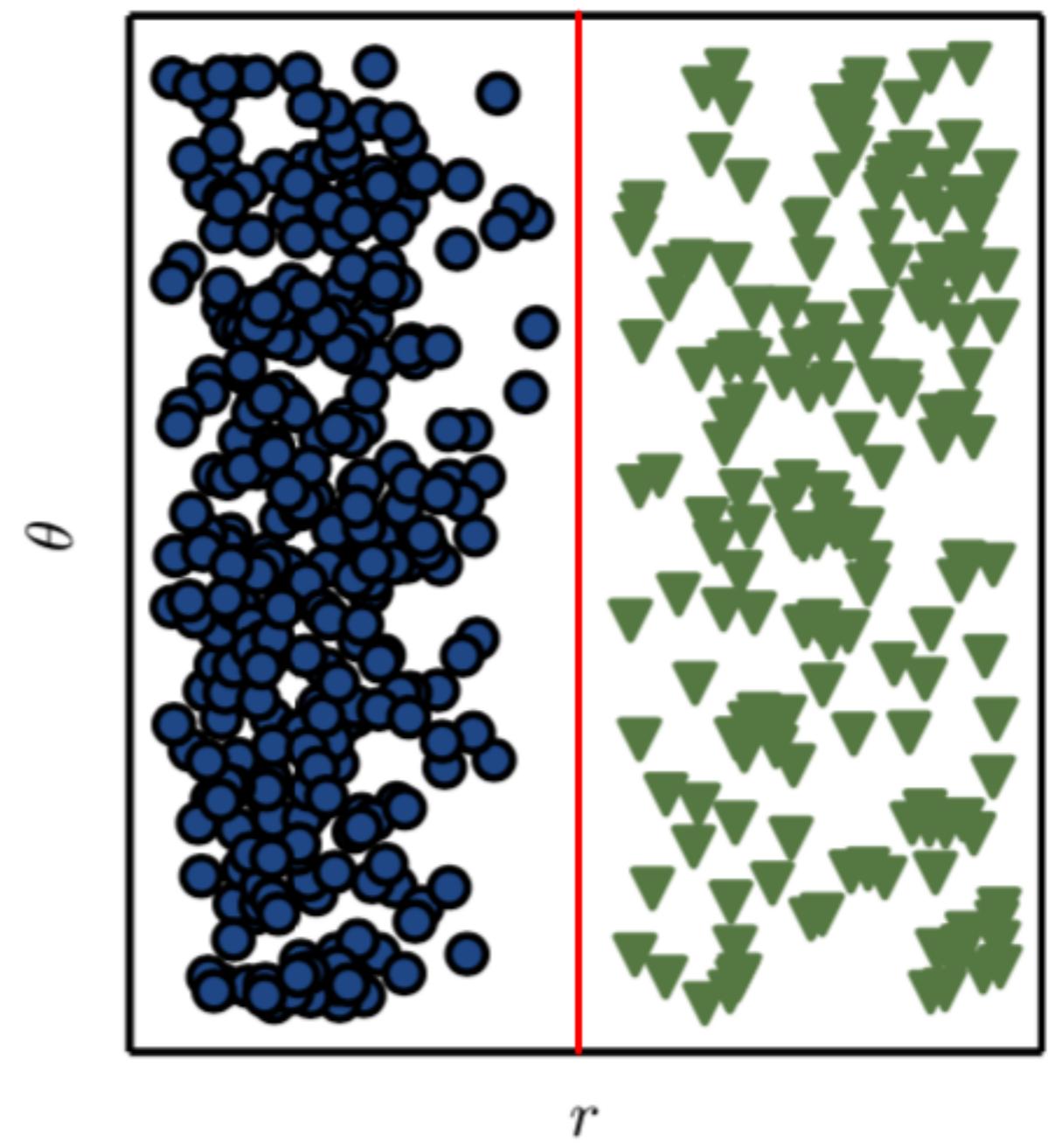


# CLASSIFICATION

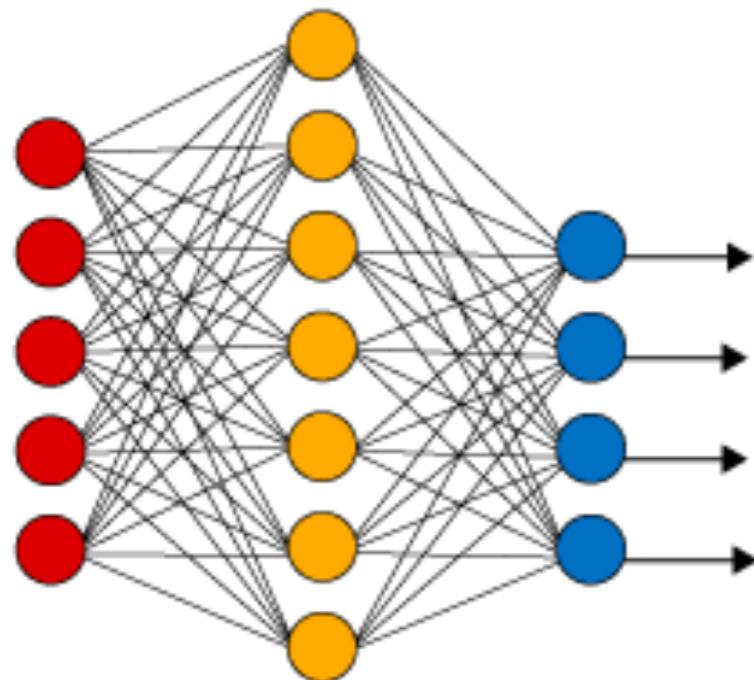
Cartesian coordinates



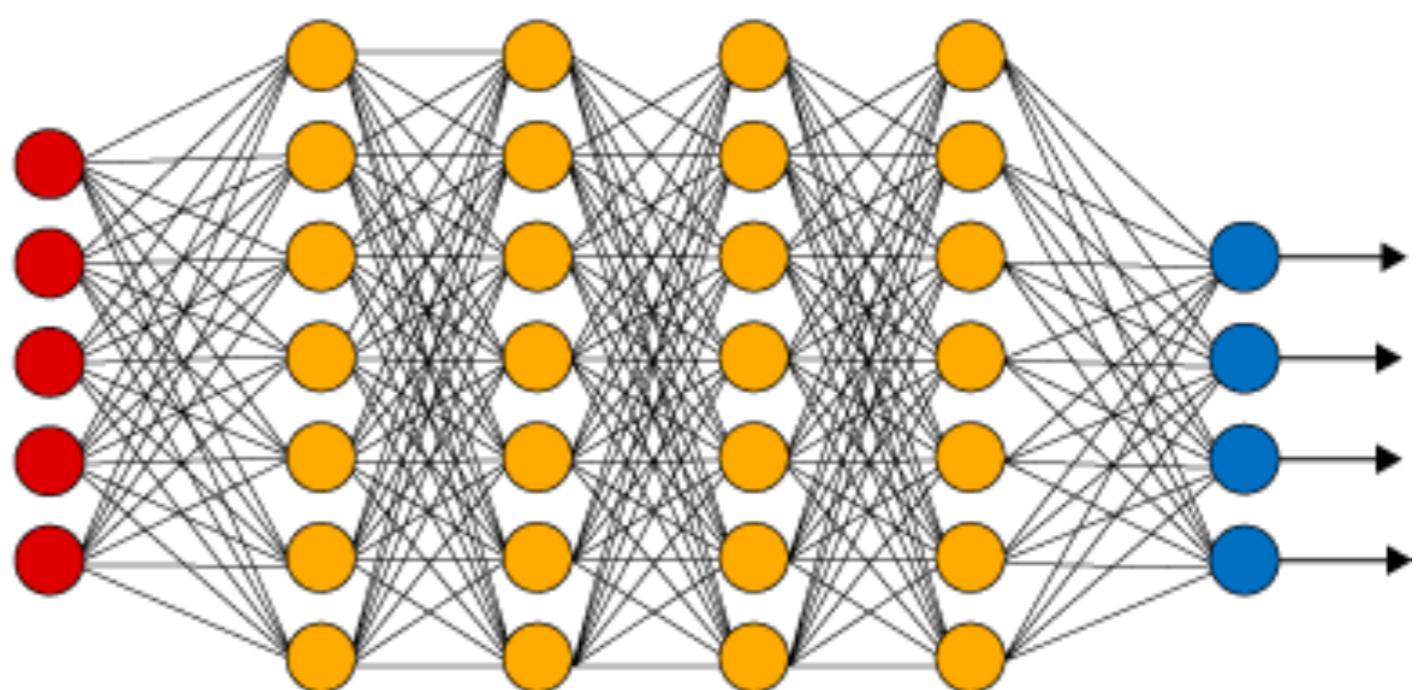
Polar coordinates



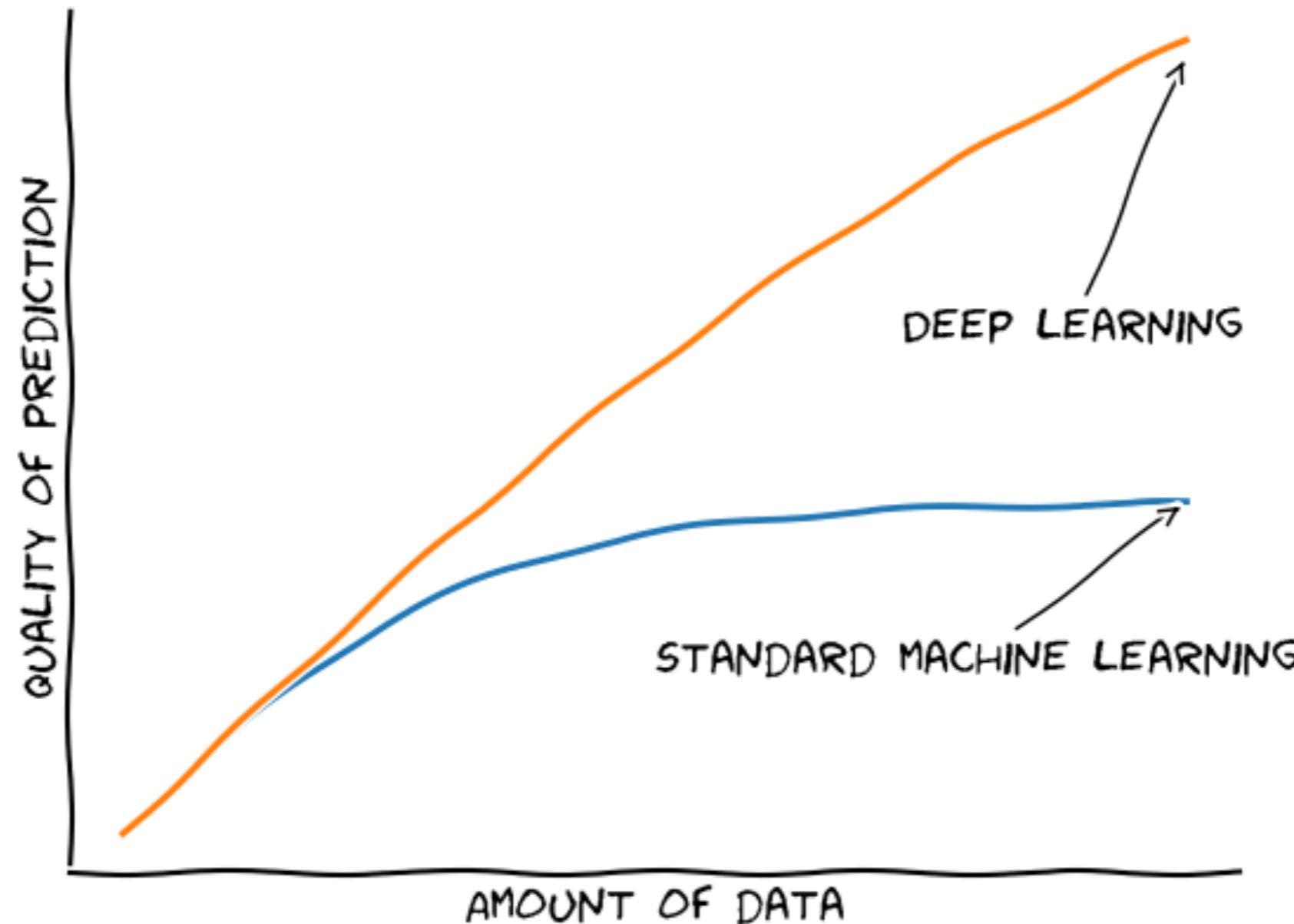
# CLASSICAL ML



# DEEP LEARNING

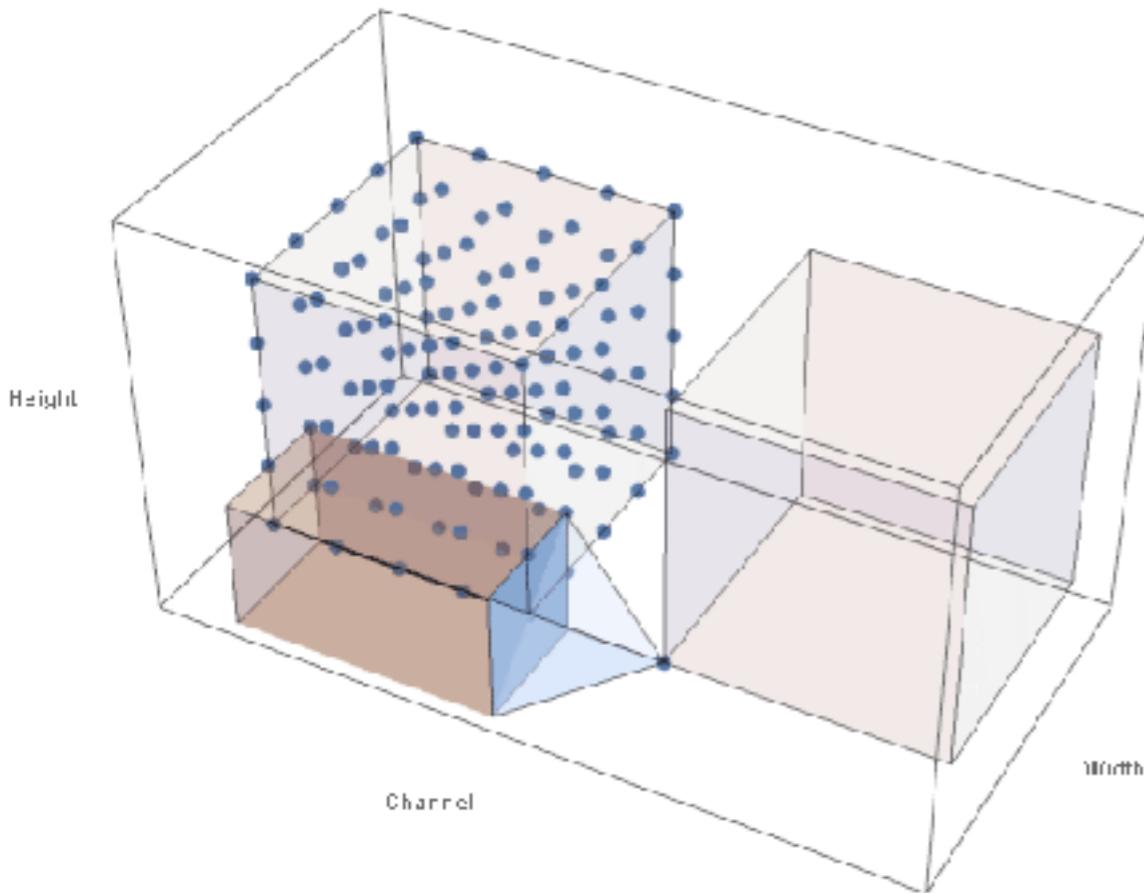


# WHY DEEP LEARNING?

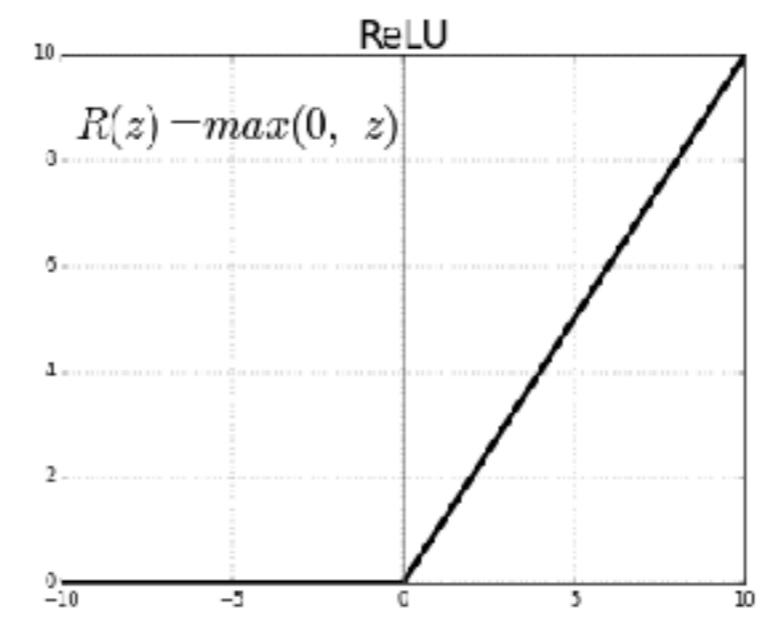


Curse of dimensionality

# BASIC INGREDIENTS



Convolution

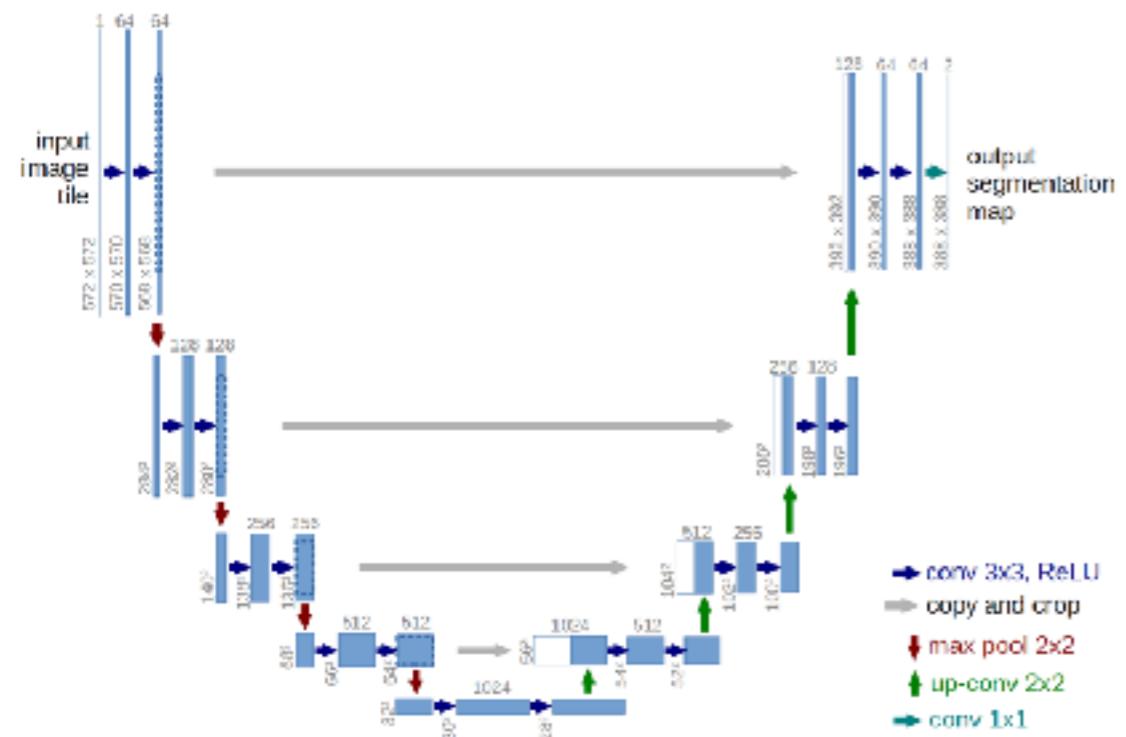


Activation

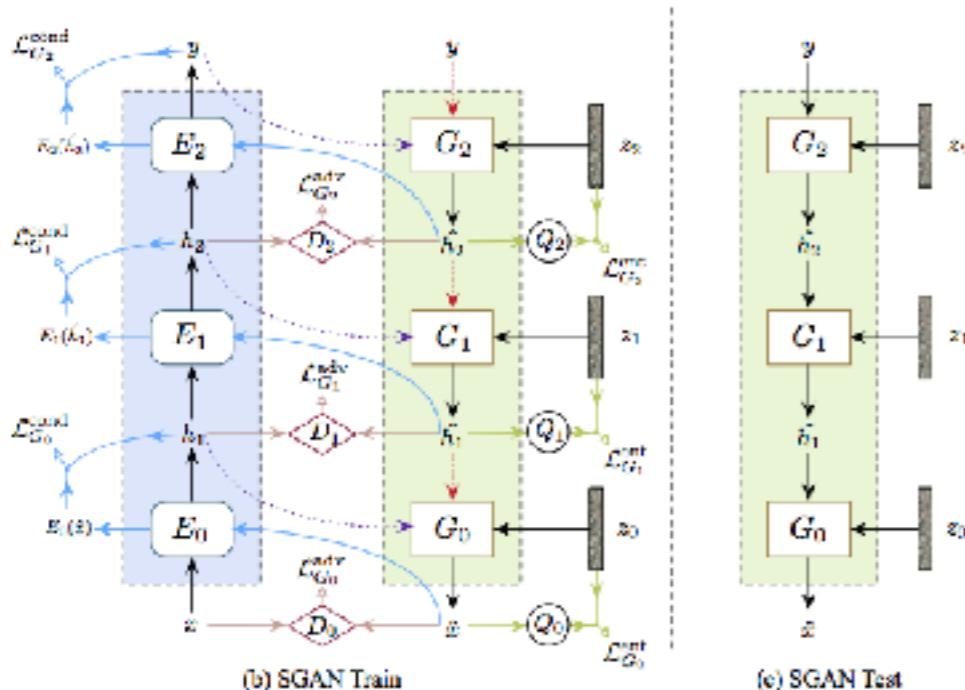
$$f = \|\mathbf{O} - \mathbf{T}\|_2^2$$

Loss

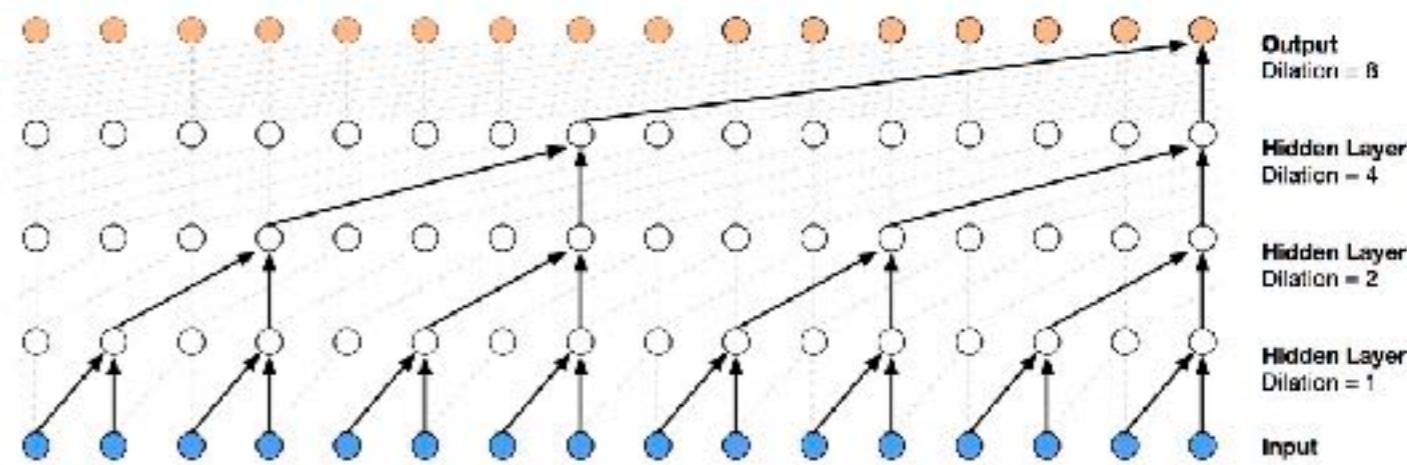
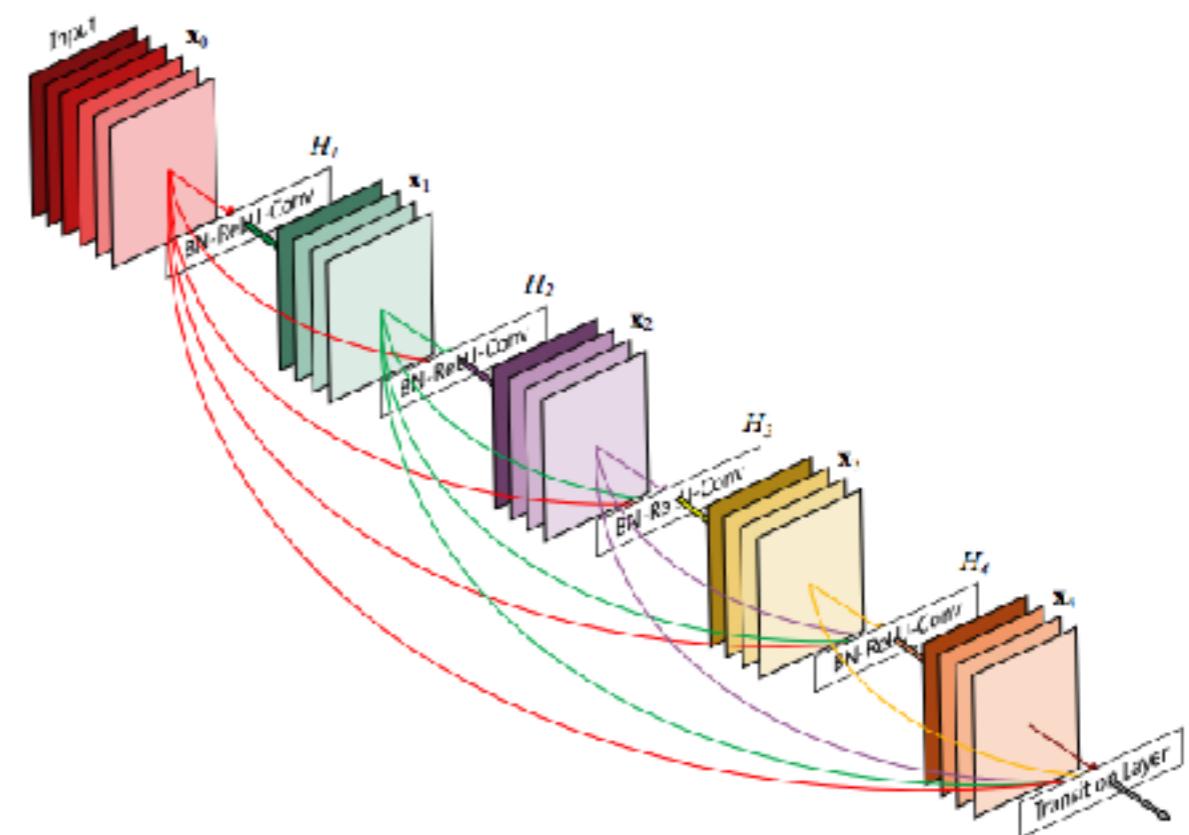
# ENORMOUS LANDSCAPE



- conv 3x3, ReLU
- copy and crop
- ↓ max pool 2x2
- ↑ up-conv 2x2
- conv 1x1

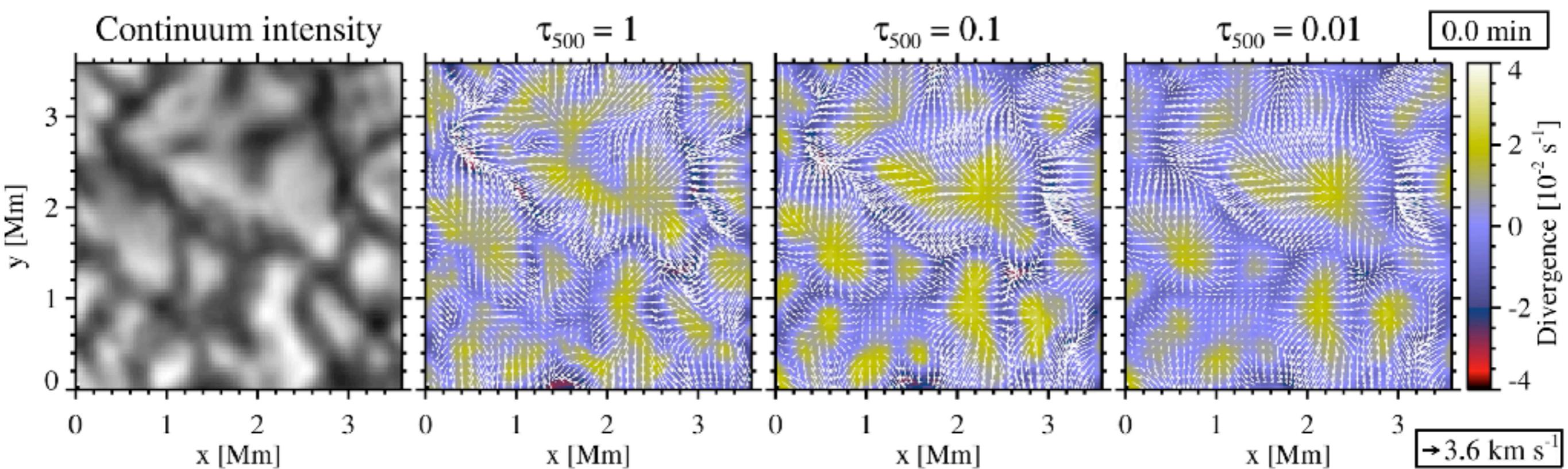


(c) SGAN Test

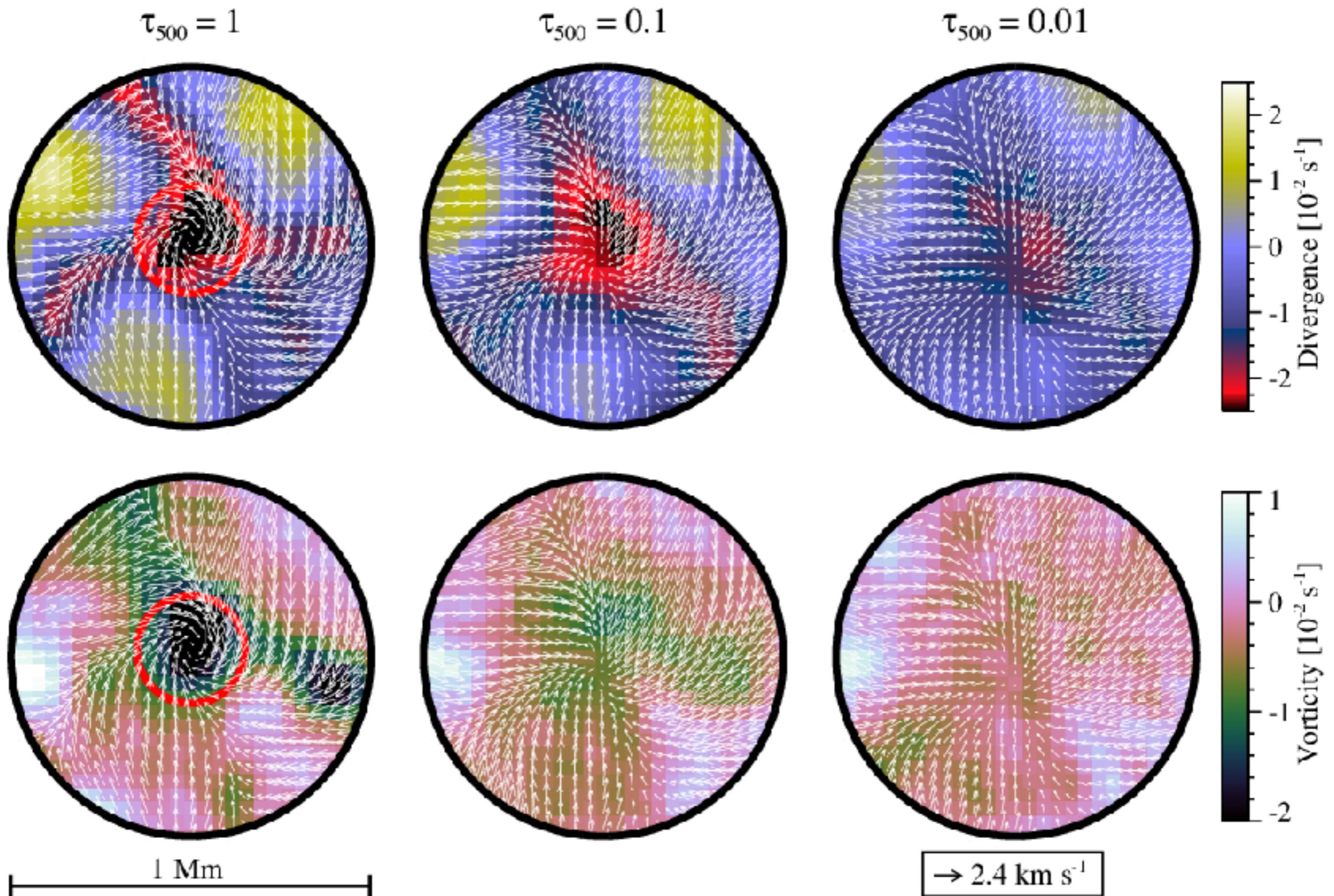


Output Dilation = 8
Hidden Layer Dilation = 4
Hidden Layer Dilation = 2
Hidden Layer Dilation = 1
Input

measuring velocities

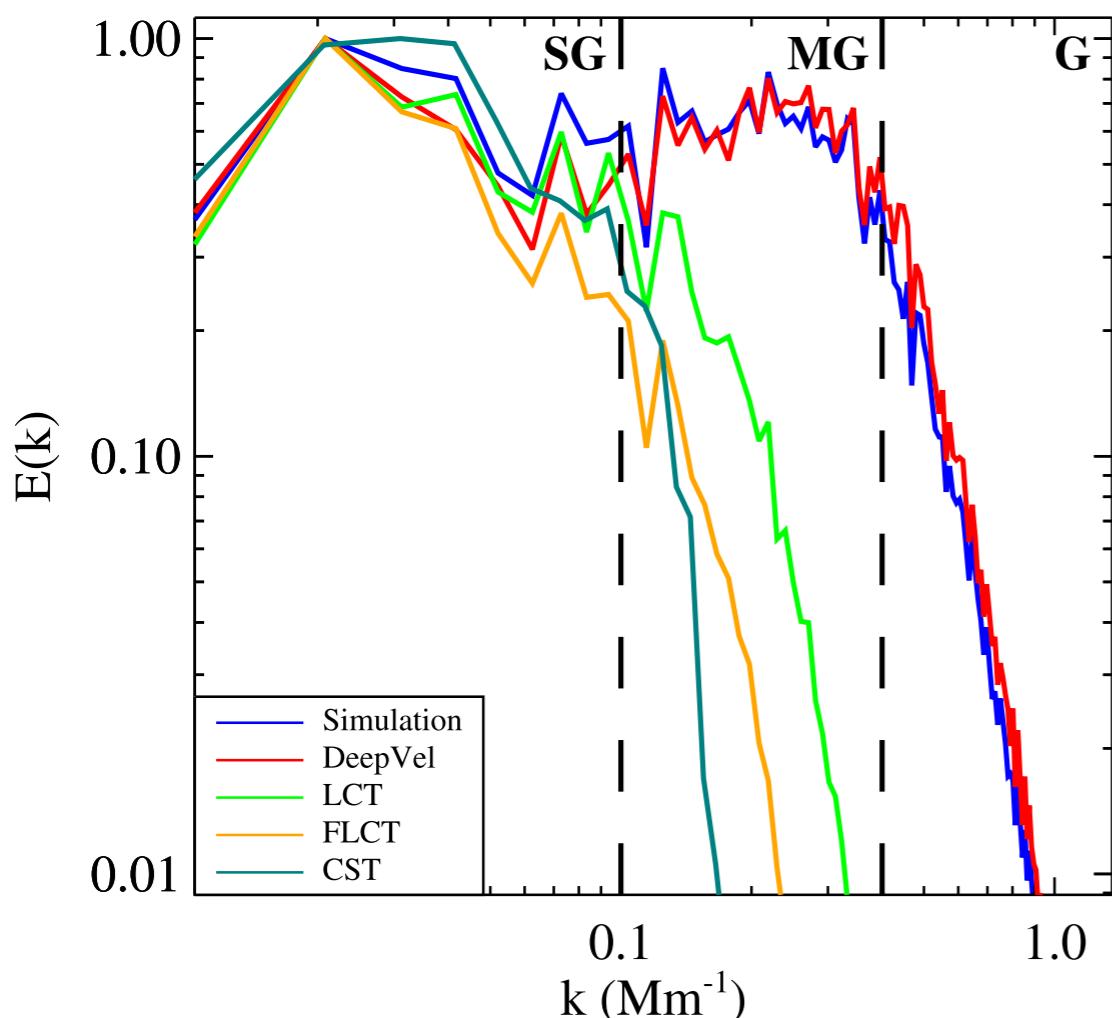


# SMALL SCALE VORTEX FLOWS

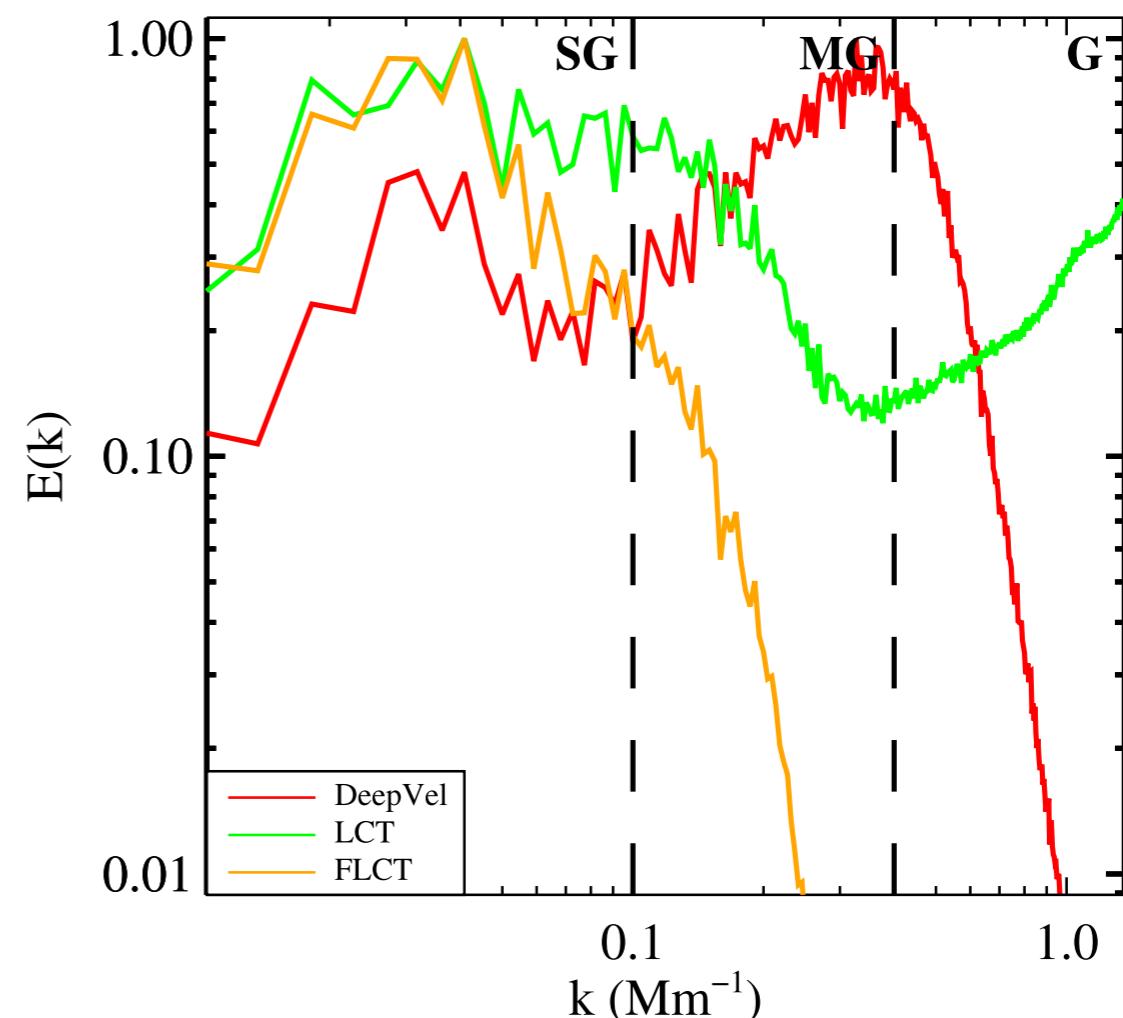


# KINETIC ENERGY SPECTRUM

## Simulations



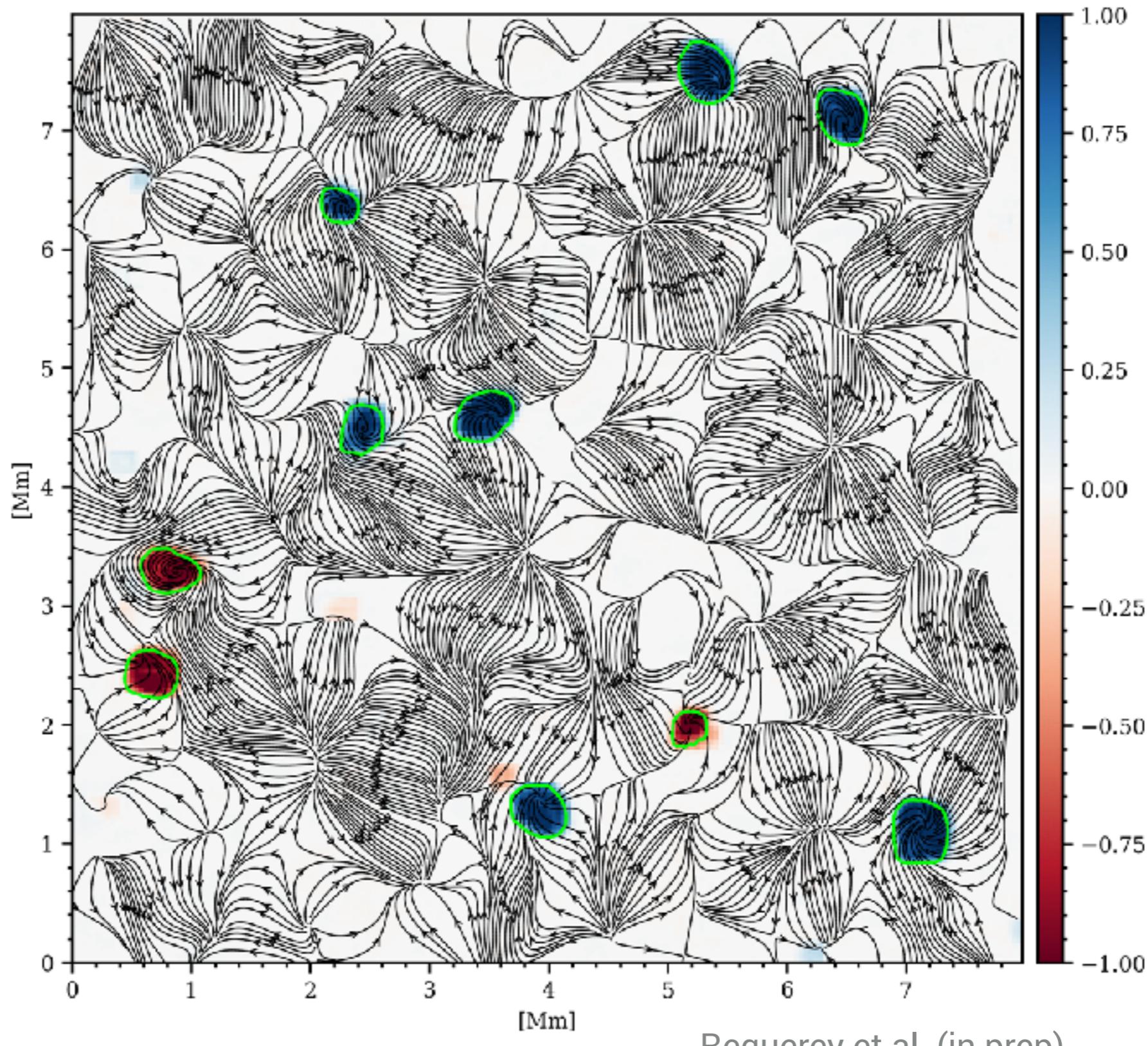
## SDO/HMI



Tremblay et al. (2018)

# VORTEX DETECTION

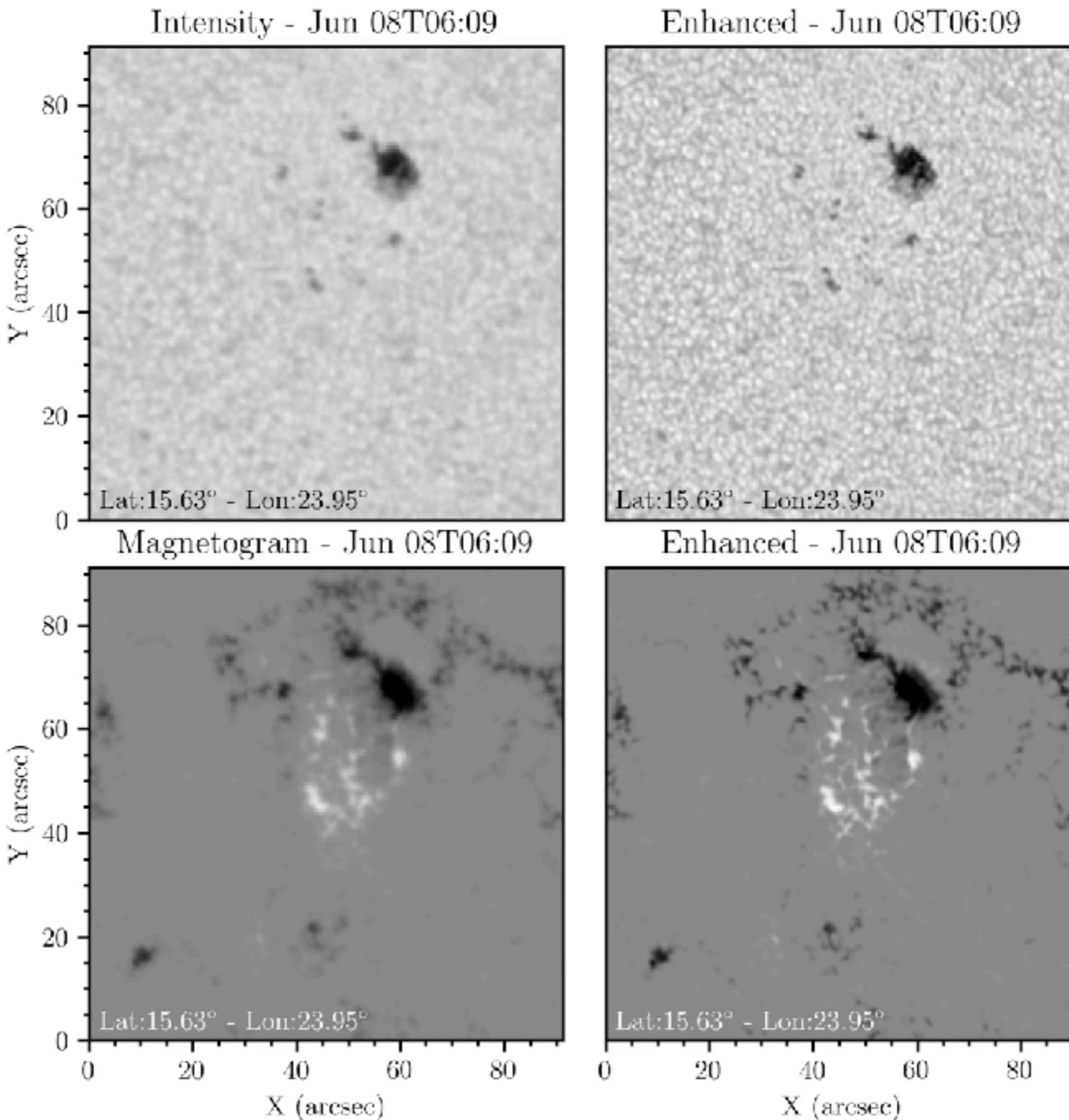
DeepVortex



Requerey et al. (in prep)

enhancing HMI images

# ENHANCE <https://github.com/cdiazbas/enhance>

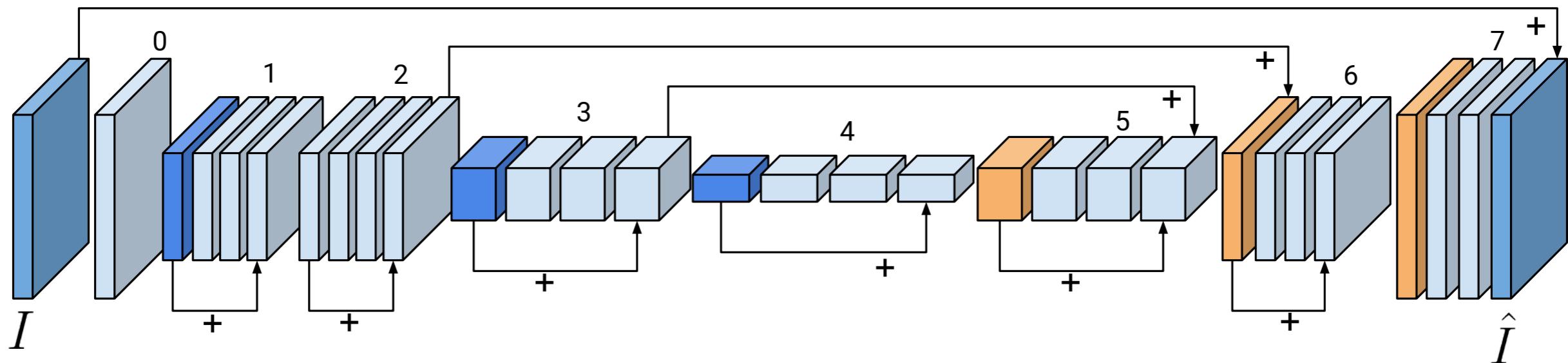


courtesy of S. Castellanos Durán

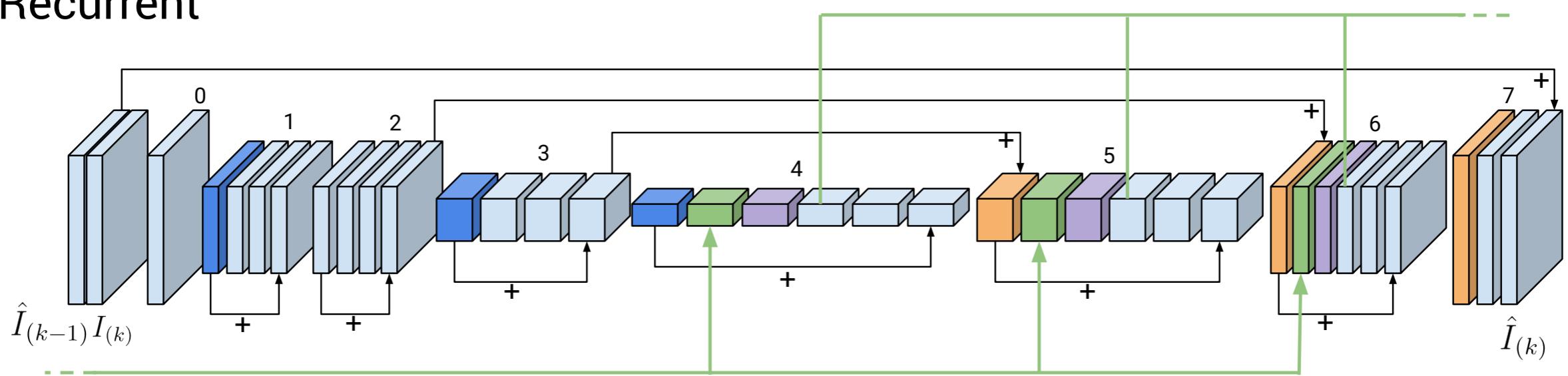
real-time multiframe deconvolution

# MULTIFRAME BLIND DECONVOLUTION

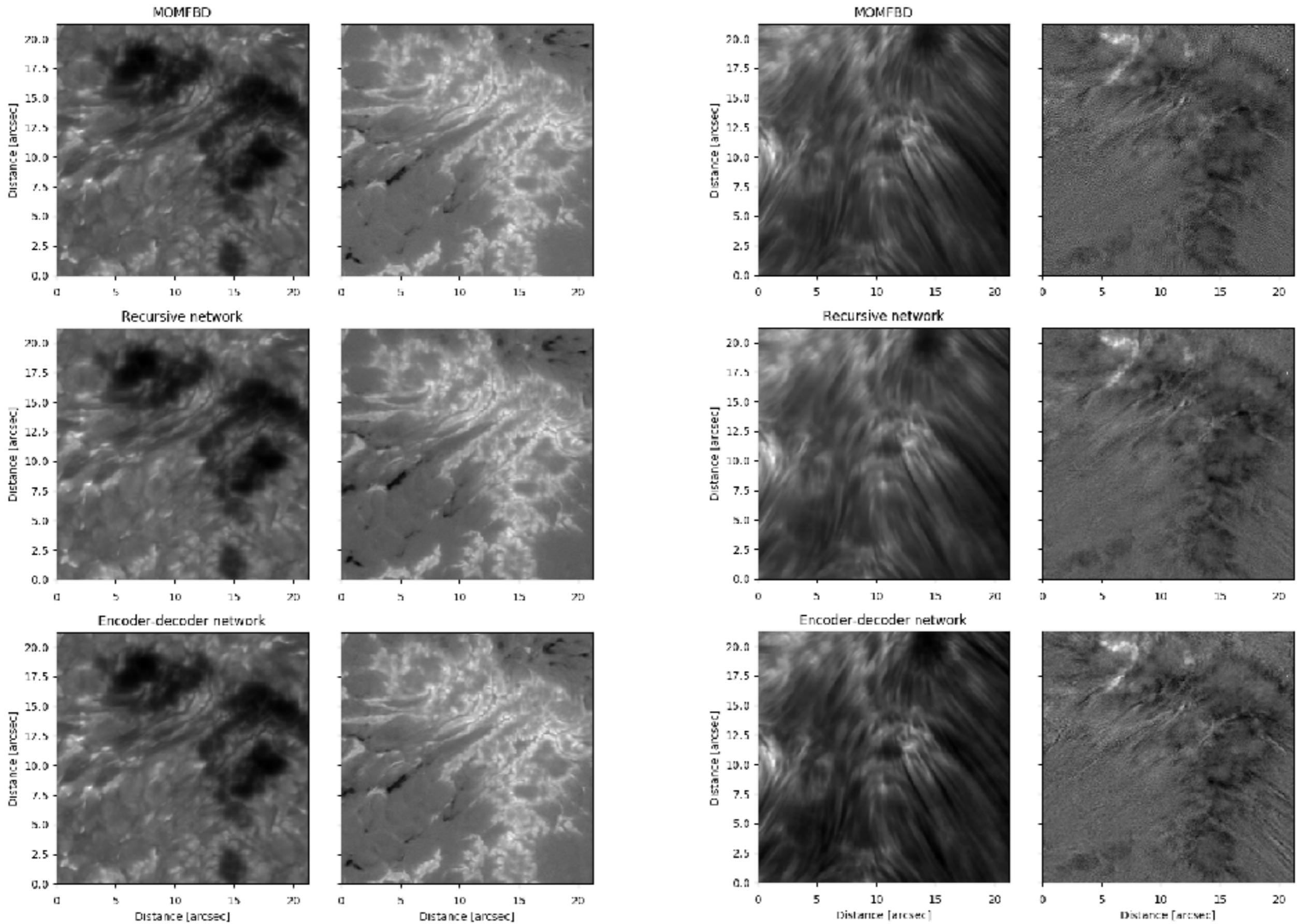
## Encoder-decoder



## Recurrent

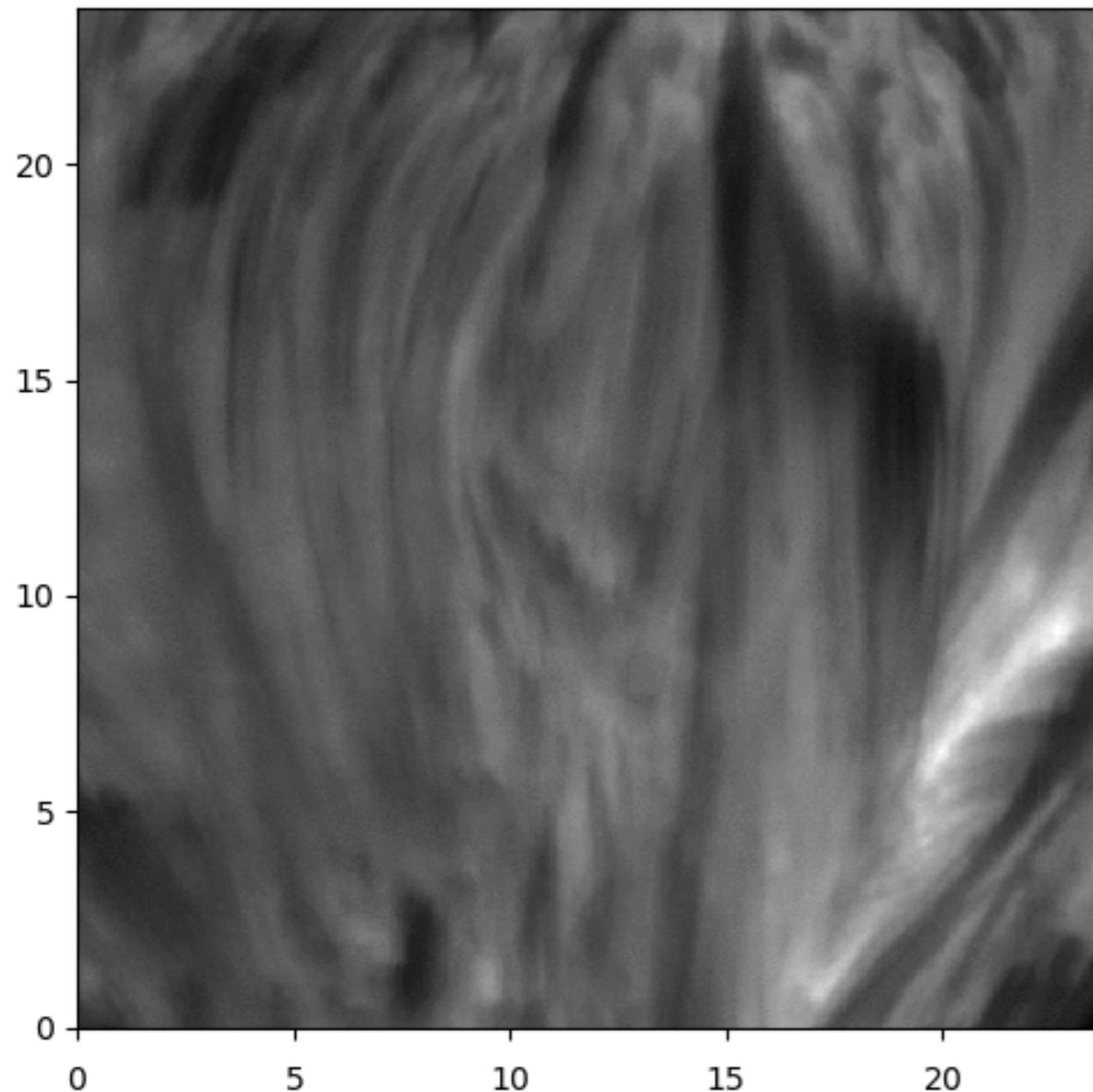


# POLARIMETRY

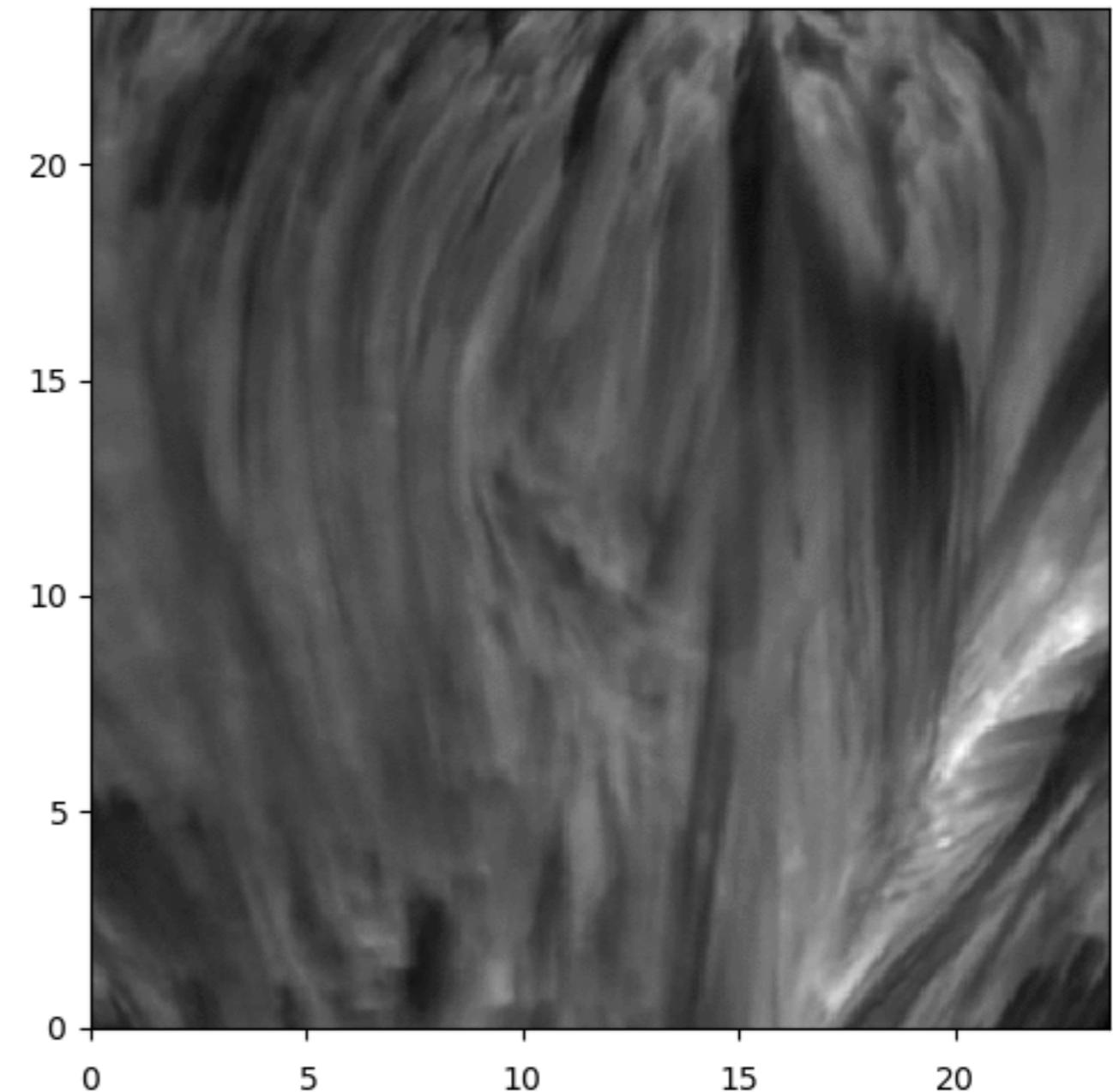


# GENERALIZATION TO UNSEEN DATA

Frame



NN

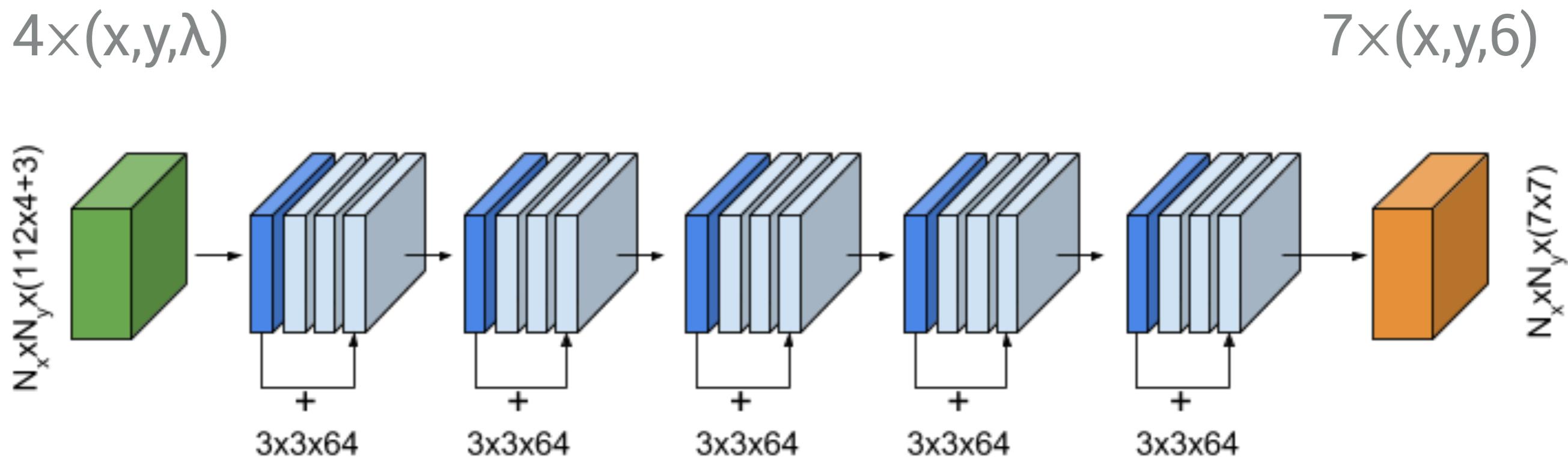


100 images/s

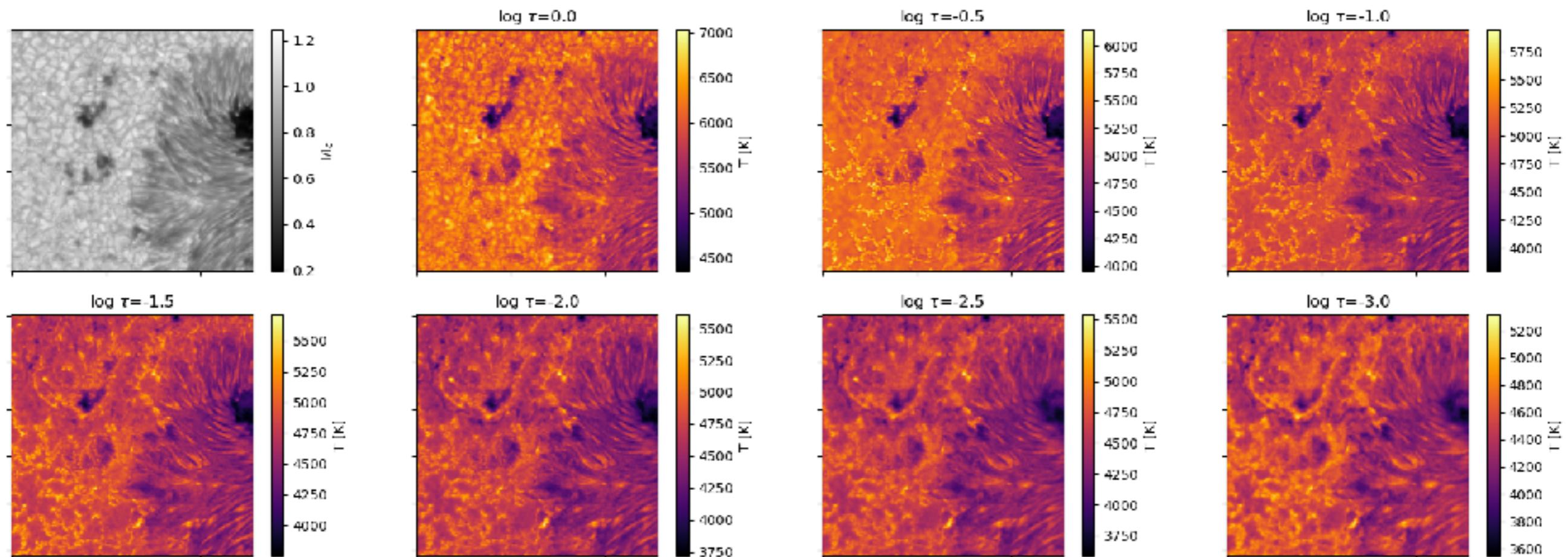
3D inversion of Stokes profiles  
with height information

warning: WIP!!

# 3D INVERSION OF STOKES PROFILES

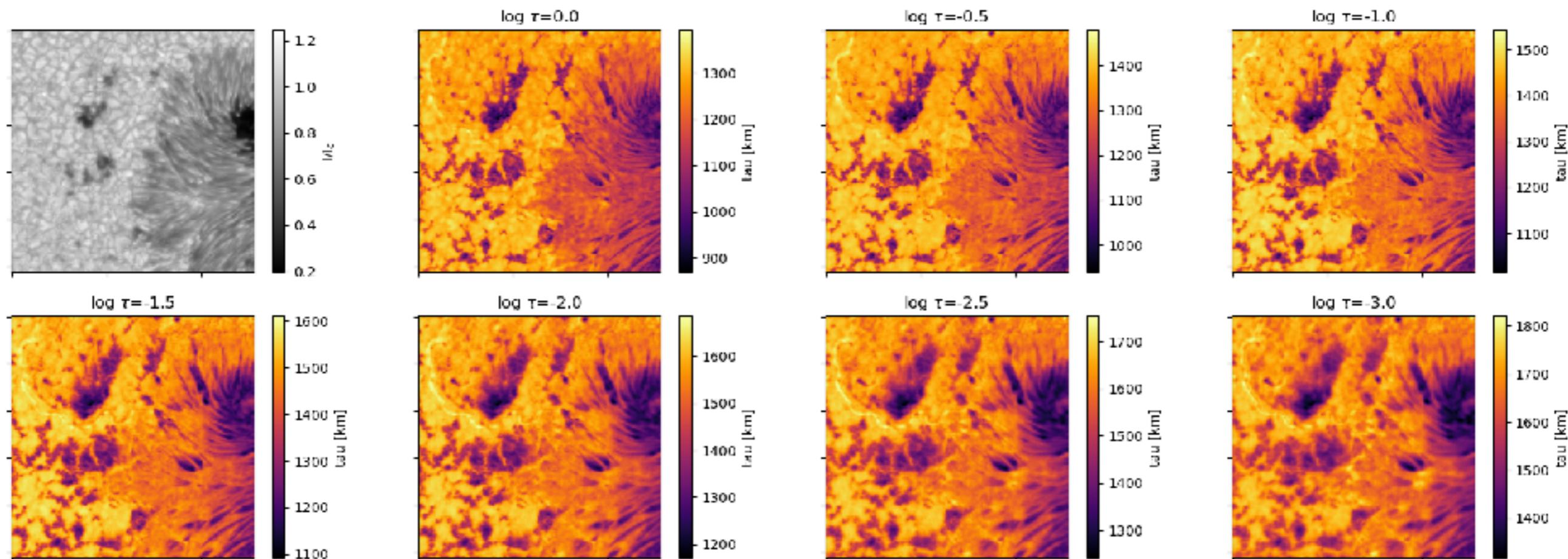


# HINODE INVERSION - TEMPERATURE

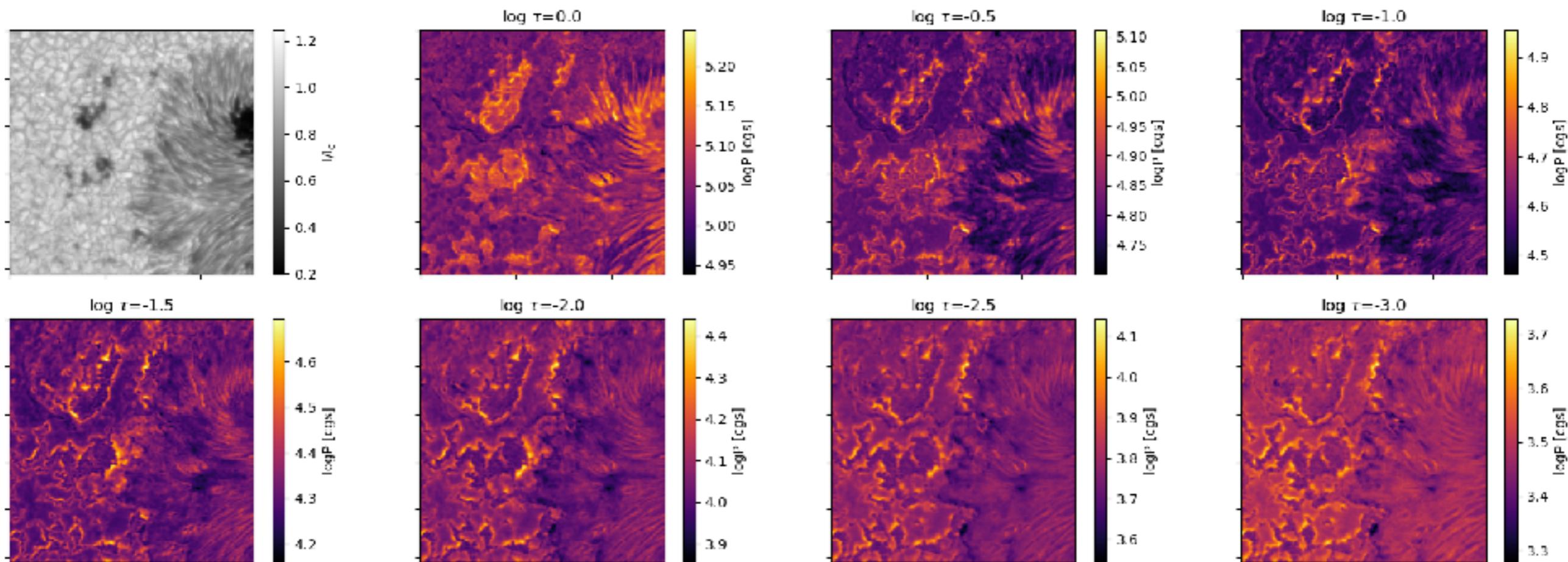


256x256 pixels in 80 ms in an off-the-shelf GPU

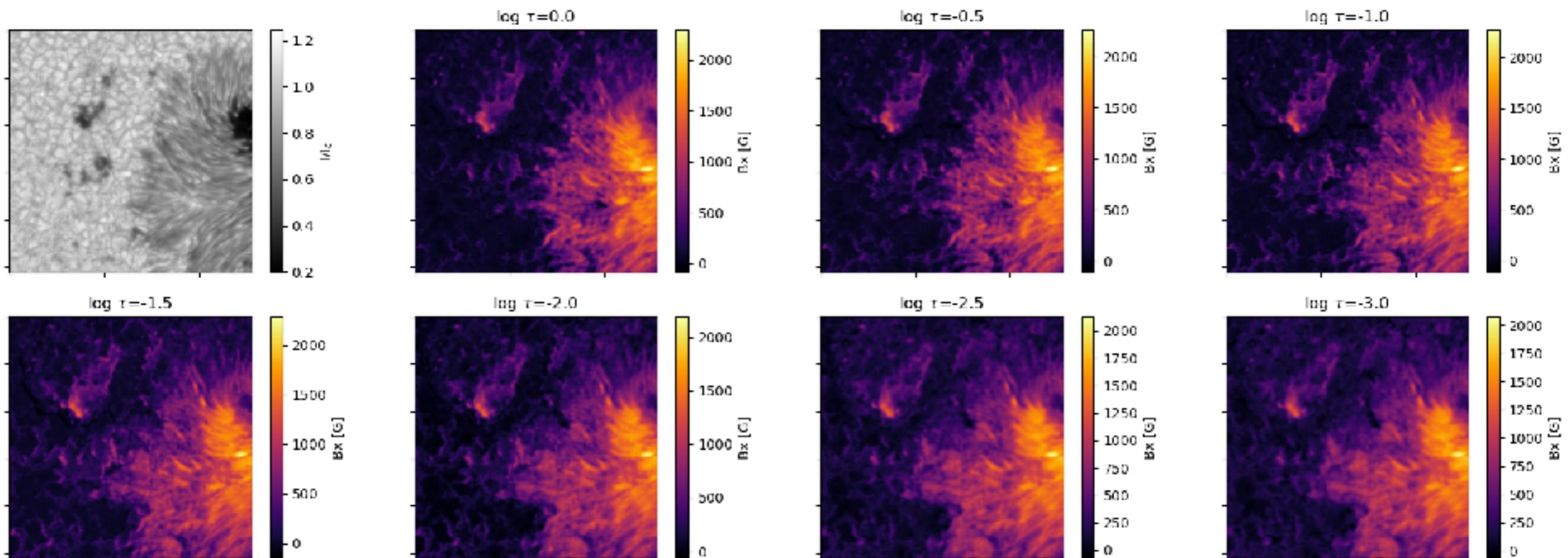
# HINODE INVERSION - WILSON DEPRESSION!



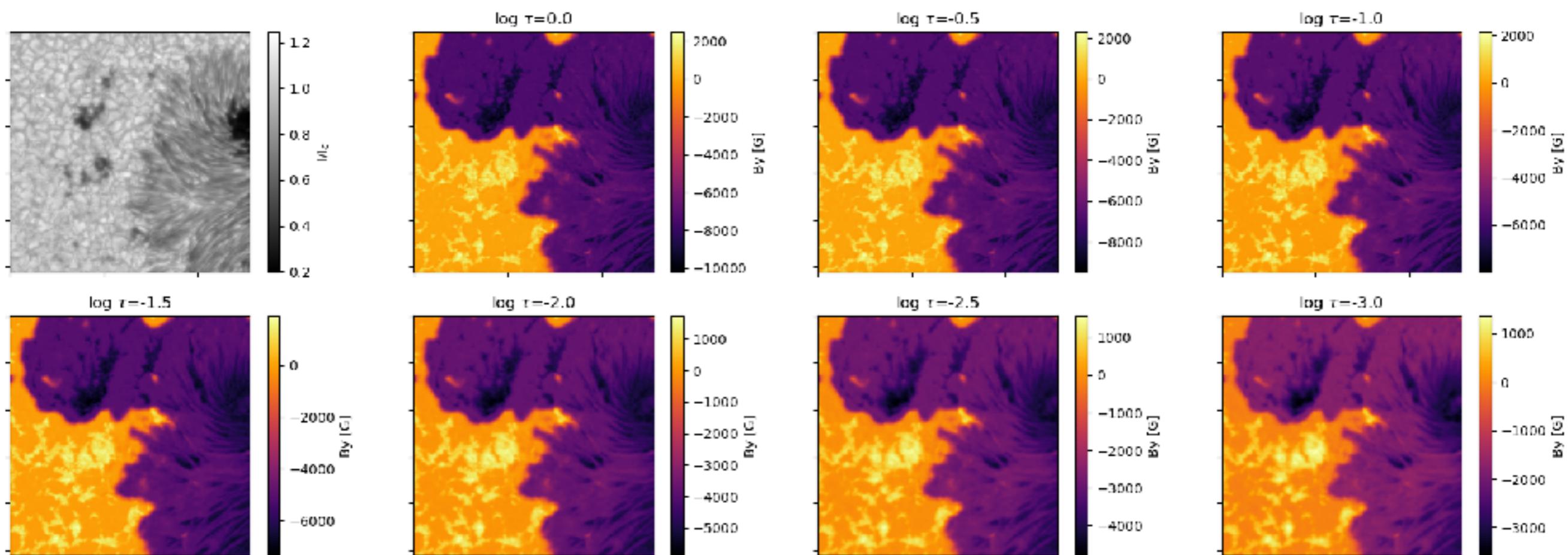
# HINODE INVERSION - GAS PRESSURE!



# HINODE INVERSION - $B_x$



# HINODE INVERSION - $B_Y$



# CONCLUSIONS

- very fast image correction
  - deployment on the SST
- 3d inversion of Stokes profiles
  - more snapshots for training
  - more potential applications