Imaging of the farside of the Sun using conditional generative adversarial networks Challenges and Reality

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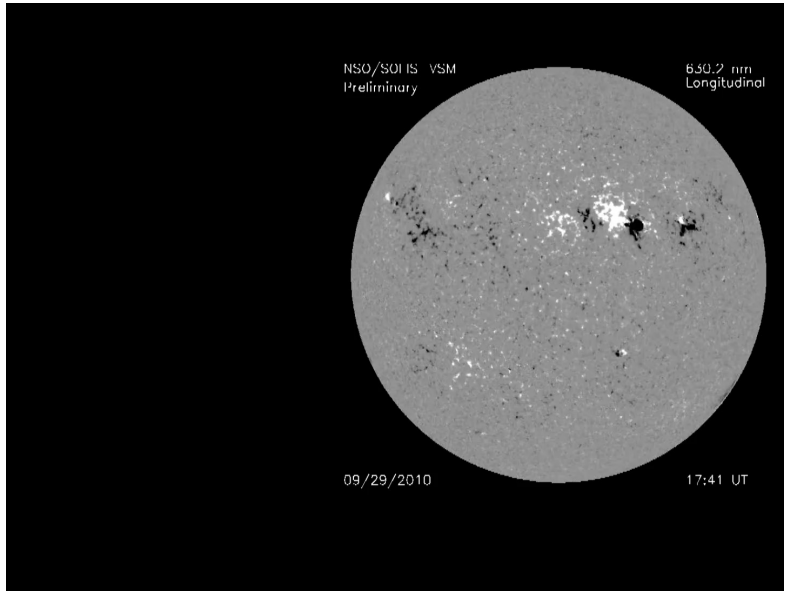
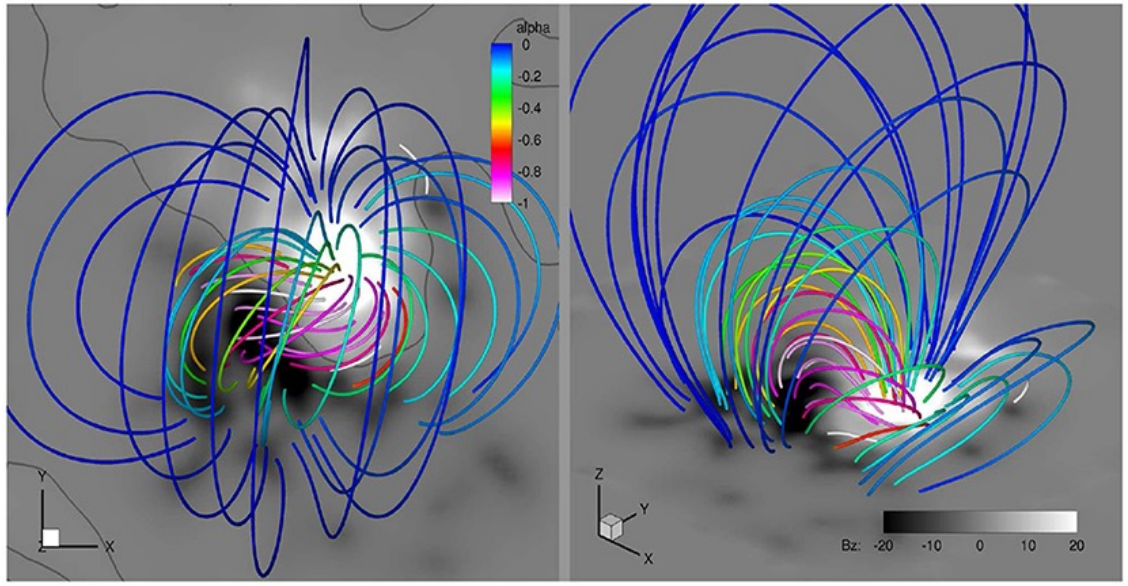




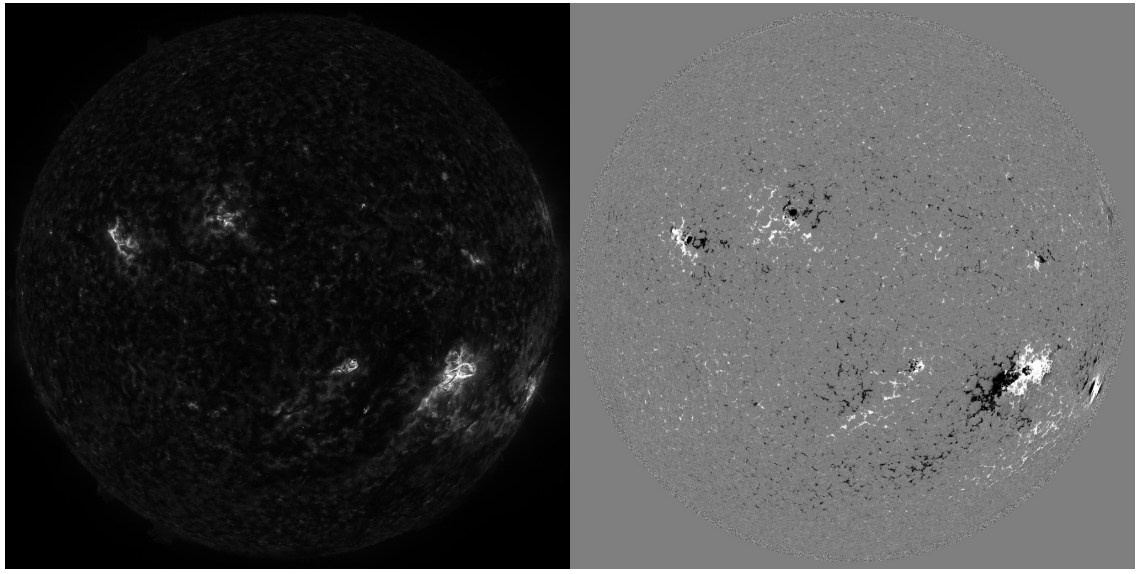
Solar astronomers use this technique to observe the ever-evolving solar magnetic field. Traditional methods involve creating a synoptic map, which show the solar surface at several points in time.

Challenge:

1.Understand cGANs
2.The main obstacle to image augmentation with Generative Adversarial Networks (GANs) is the need for a large amount of training data after Data processing
3.More successful at imaging large active regions than imaging small active regions

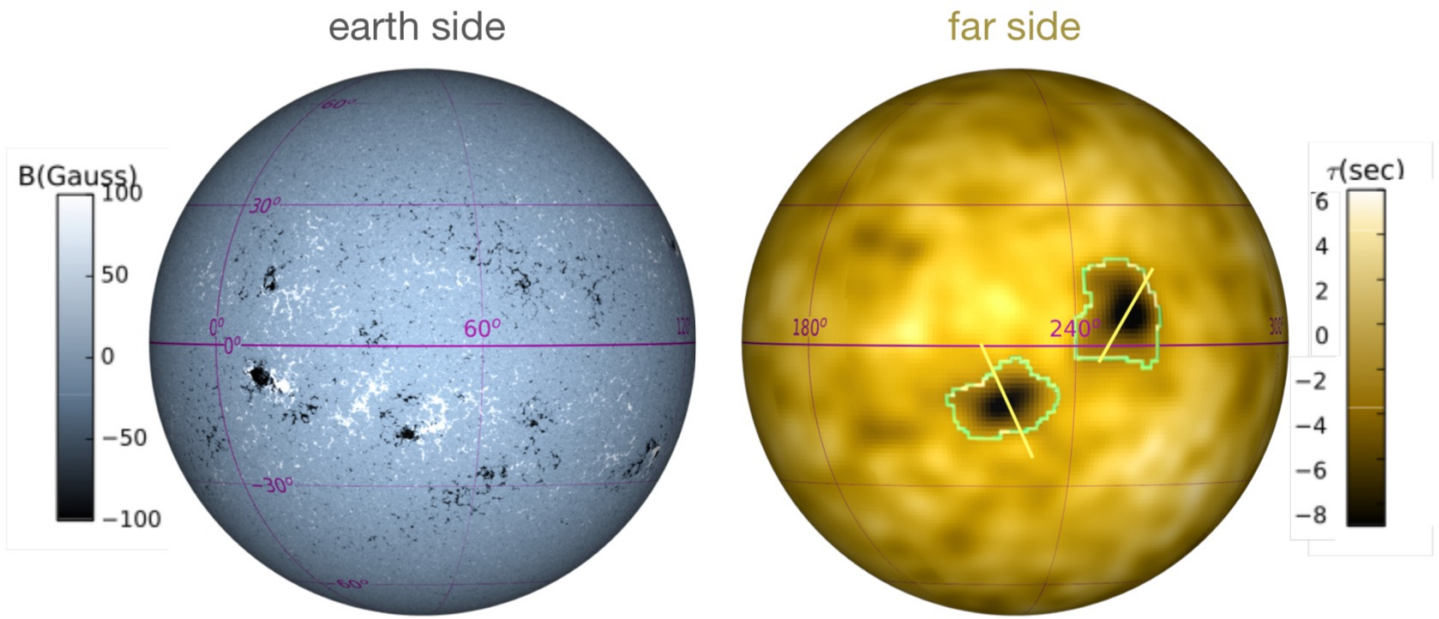
Reality:

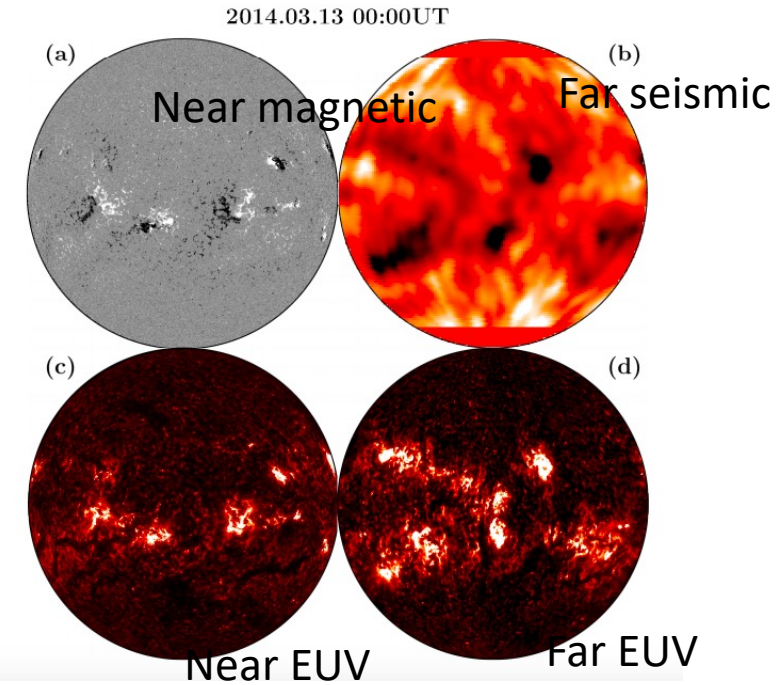
Farside: UV Image (left) and AI Magnetograms (right)



Data collection

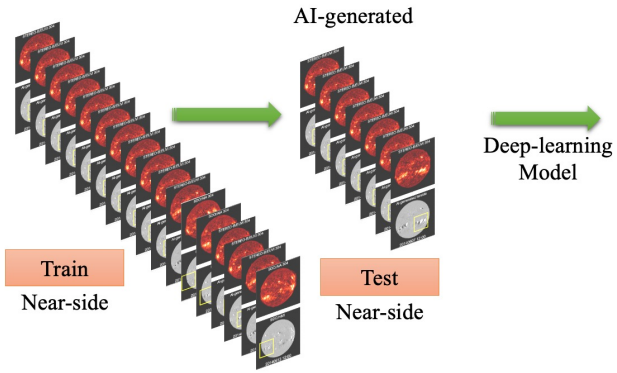
- Python : open-source python packages: Sunpy, Tensorflow and Keras
- Download fits data (SDO AIA/HMI, STEREO EUVI and phase maps):
  ./Scripts/Data_collection.sh or
  sbatch ./Scripts/Data_collection.sh (Monarch).
  The STEREO data is downloaded such that it is synchronised with the phase maps.



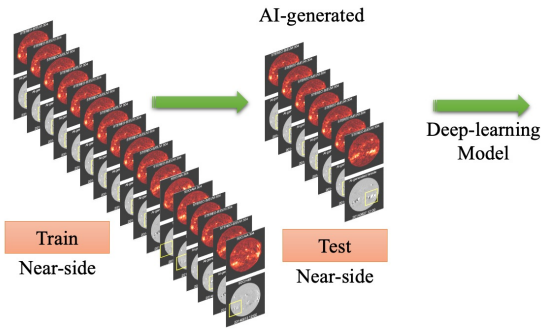


Data processing

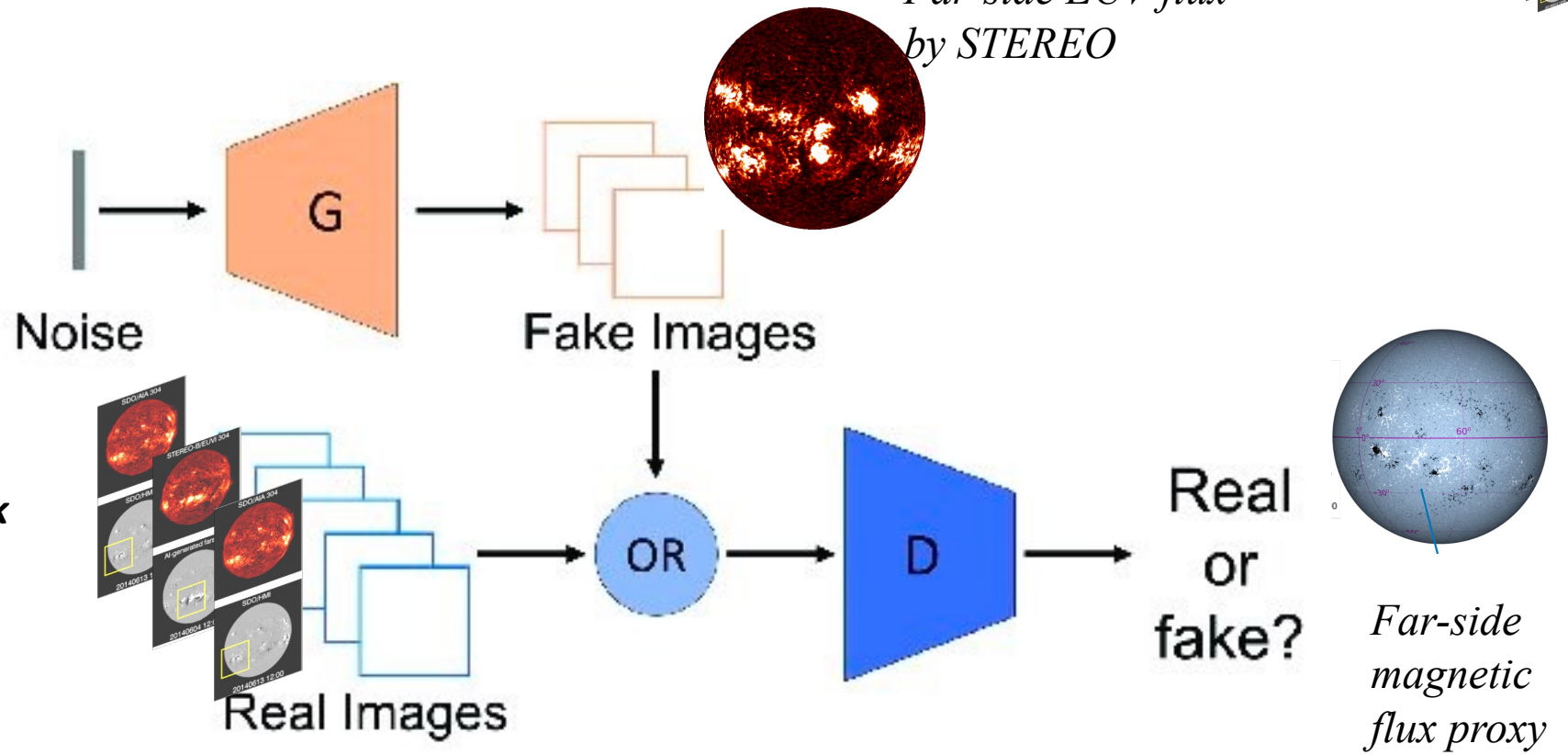
- Converting SDO and STEREO fits data into local numpy arrays (.npy), and get percentiles of the data
- Reproject the seismic maps (phase maps) from a Carrington Heliographic projection to a Helioprojective-cartesian projection, convert to numpy arrays and get percentiles.
- Remove outliers in each dataset
- Change saturation for EUV and magnetogram data
- Normalise data (put data between -1 and 1 for magnetograms, and between 0 and 1 for the other datasets)
- Remove trends in EUV data caused by instrument degradation
- Create a database (image.db) that maps the connections between the different data types



The pipeline for generating synthetic magnetograms from EUV 304 Angstrom full-disk solar images.
Trains by comparing SDO EUV images with SDO magnetograms.



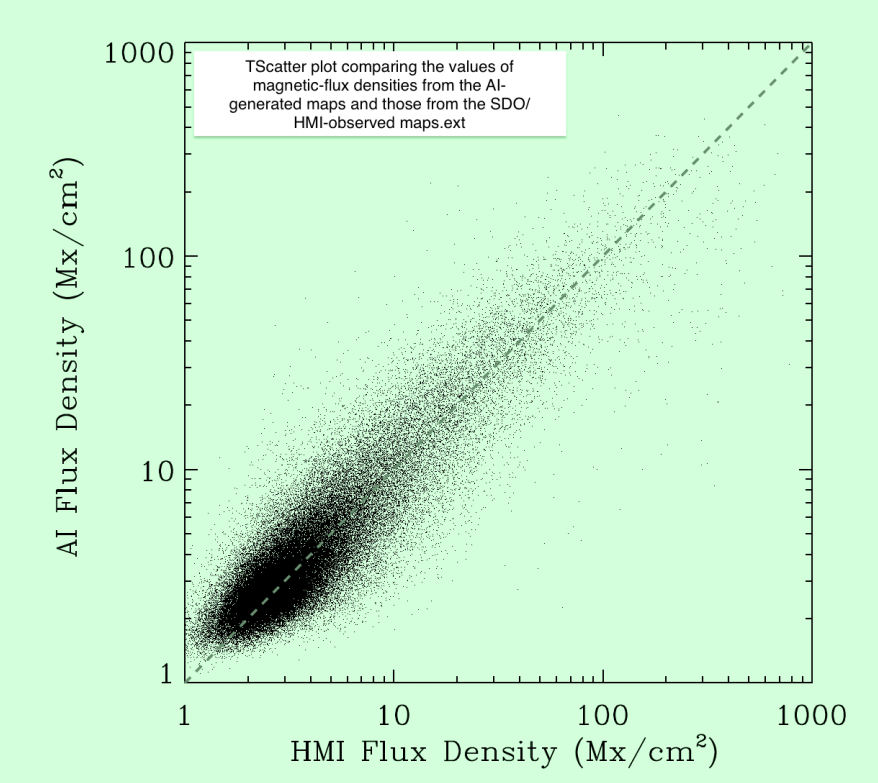
Far-side EUV flux by STEREO



The deep-learning ***Generative Adversarial Network*** *is trained with near-side observations by AIA and HMI.*

Far-side magnetic flux proxy

Kim et al. (2019) "Solar farside magnetograms from deep learning analysis of STEREO/EUVI data" Nature Astronomy Letters



Evaluation:

Getting the unsigned magnetic flux vs time

- The python script: `Data_processing/get_unsigned_flux.py` gets the unsigned flux for a given dataset of normalised magnetograms, and saves it as a numpy file in the directory `Data/unsigned_flux`.
- the script `Scripts/get_flux_UV_GAN.sh` can be used to run this file on the HMI dataset, and the output of the UV GAN, with options to specify the model, iterations etc.
- the script `Scripts/get_flux_Seismic_GAN.sh` can be used to run this file on
- The file `Plotting/plot_flux.py` plots given fluxes vs time, and can be run the output of the Seismic GAN, again with options to specify the model, iterations etc. using `Scripts/plot_flux_UV_GAN.sh` or `Scripts/plot_flux_Seismic_GAN.sh` to make plots corresponding to the UV GAN or Seismic GAN respectively. These pltos can be found in `Plots/flux`.

Comparing GAN outputs with true magnetograms

- You can make plots comparing the synthetic magnetograms with the true magnetograms, by running `Scripts/compare_magnetograms.sh`, and specifying the model, and iterations. The output will be in the folder: `Data/[model]_on_[testing set]/ITER[iteration]_comparison`

Miscellaneous Plotting:

Our model may be improved with modification on the cGAN network architecture and tuning on the hyperparameters.