Photometric Properties of Solar Faculae: Comparison of MHD Simulations with Observations

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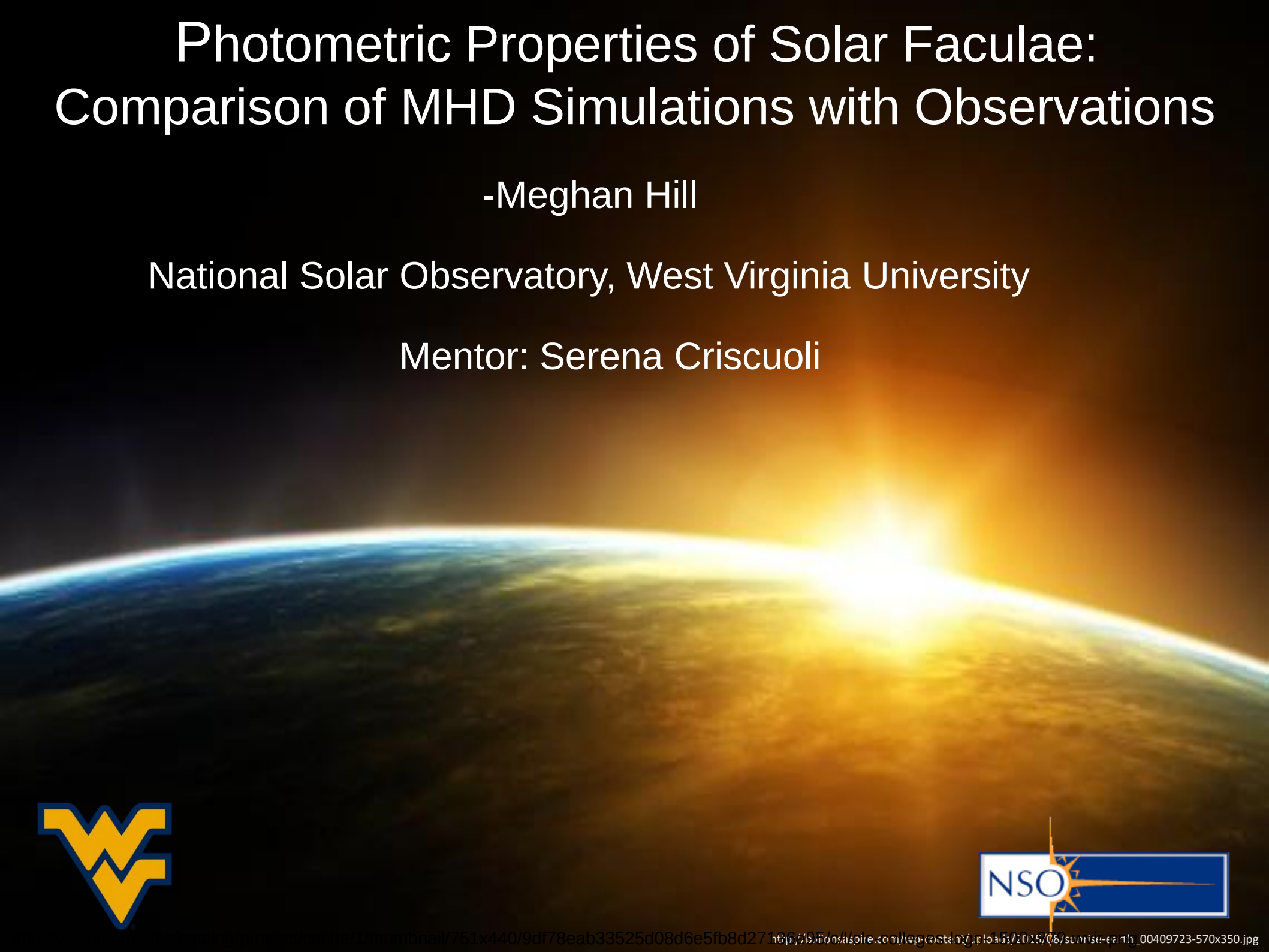


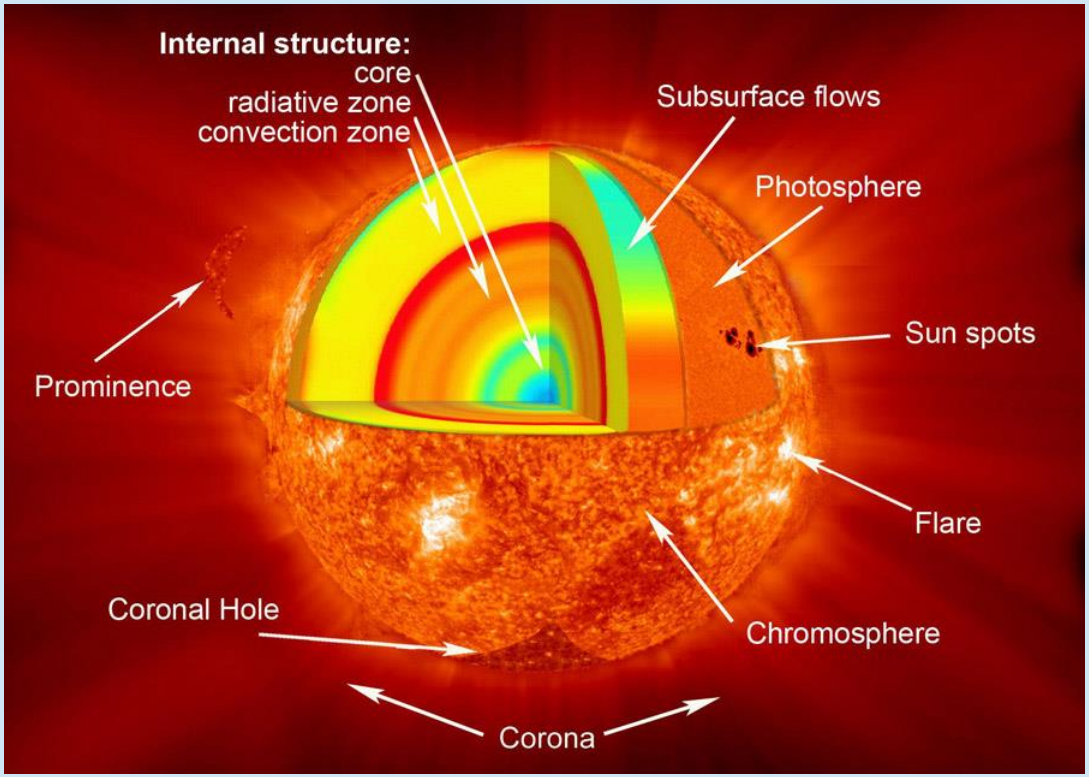
Motivations

- Solar radiation at different temporal scales affect the Earth atmosphere and climate
- Measurements of irradiance variations obtained at different wavelength ranges are therefore extremely important to understand and model the physical processes that describe the interaction of solar radiative energy and Earth atmosphere
- Obtaining long (at least one solar cycle) and reliable time series is an extremely difficult; there are discrepancies
- One – Dimensional Models and observations have too much variation to be reliable measurements of solar irradiance

Project: we investigate whether, and to what extent, MHD simulations obtained with the Stagger code can reproduce photometric properties of facular regions in the photosphere derived from observations obtained at the Dunn Solar Telescope.

The Sun

- Quiet and Active Regions
- Photosphere, Chromosphere, Corona
- Main Focus: Photosphere



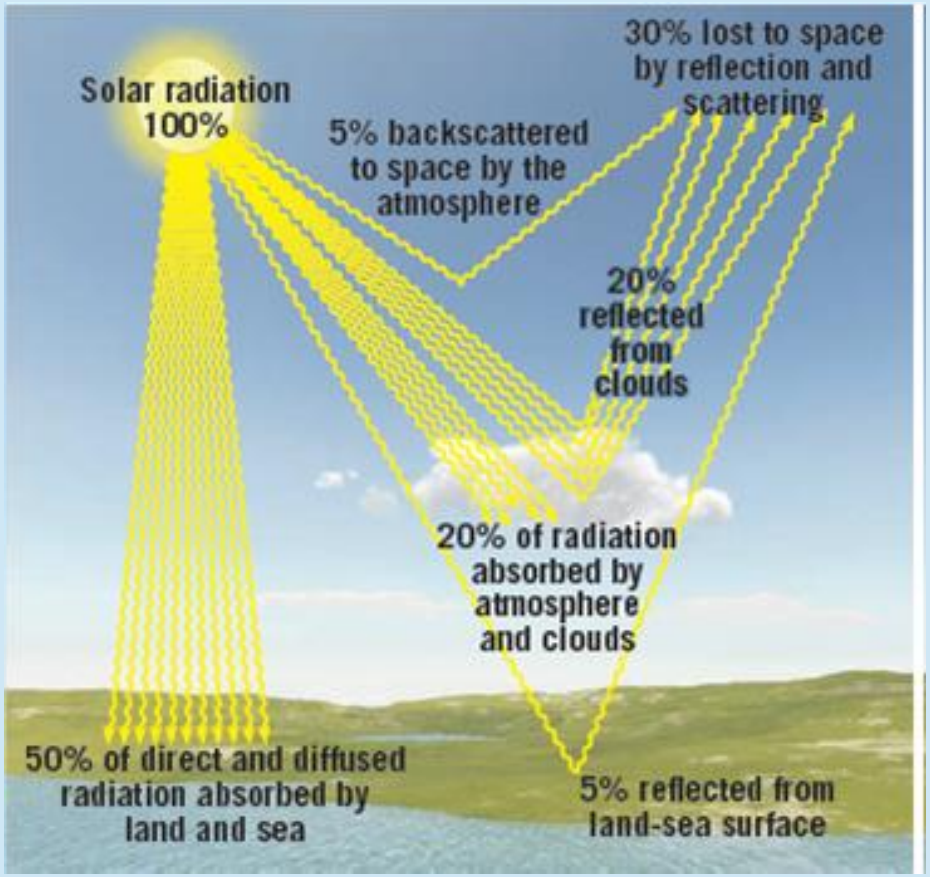
https://scied.ucar.edu/sites/default/files/images/large_image_for_image_content/sun_regions_900x640.jpg

Solar Irradiance

- Irradiance – defined as the power per unit area
- Solar Irradiance – radiant energy from the Sun
- Total Solar Irradiance – when all the radiant energy is measured
- Solar Spectral Irradiance – when the radiant energy is measured as a function of wavelength

Climate Change

- Solar Radiation
- Question: How much and to what extent does solar variation impact our climate?
- Solar Maximum and Minimum and the 11 year cycle



http://mgh-images.s3.amazonaws.com/9780321958006/13356-16-4IEE2.png

Measuring Solar Irradiance

- SORCE Mission
- Spectral Irradiance Monitor Instrument
- Total Solar Irradiance Monitor Instrument

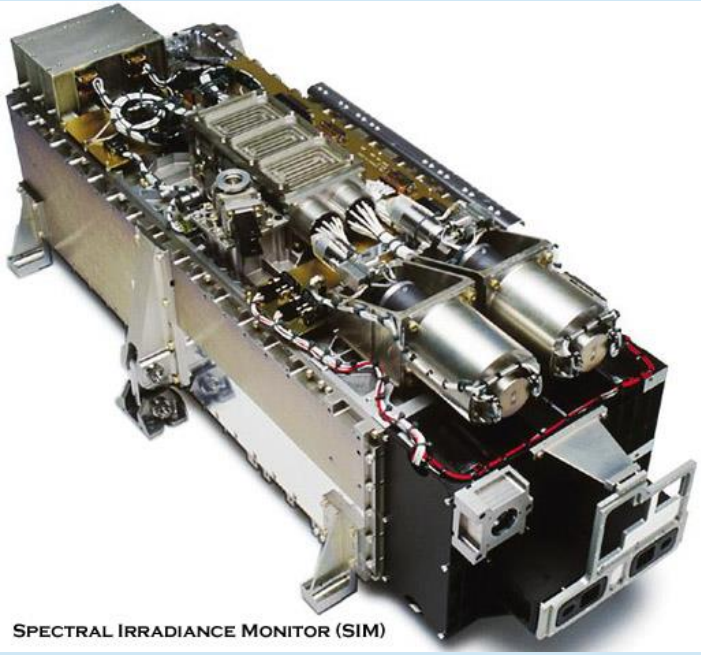
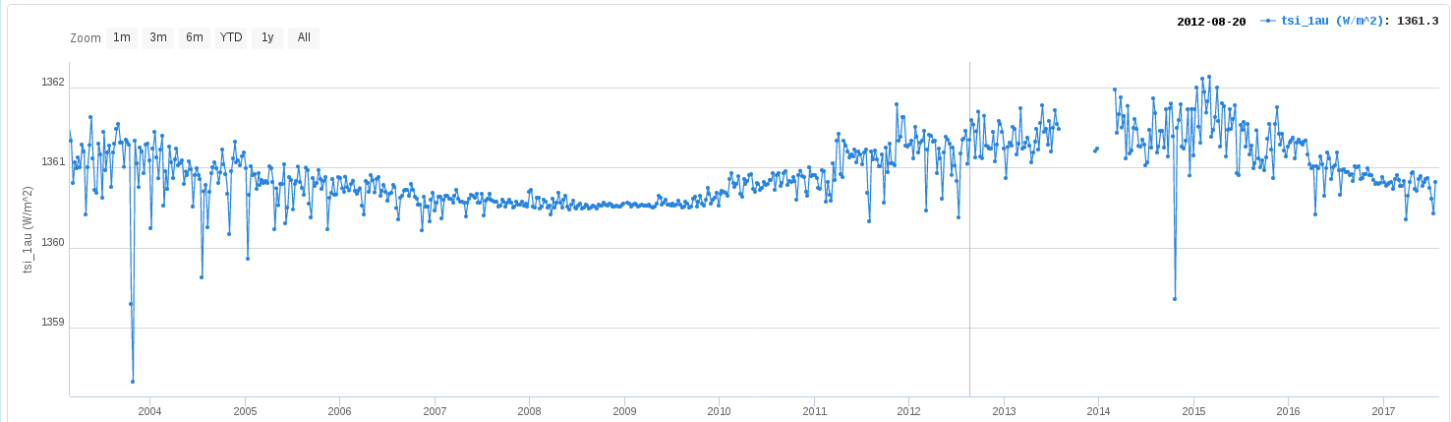


Photo Credit: LASP

SORCE Total Solar Irradiance – Time Series



SORCE Solar Spectral Irradiance - Spectral

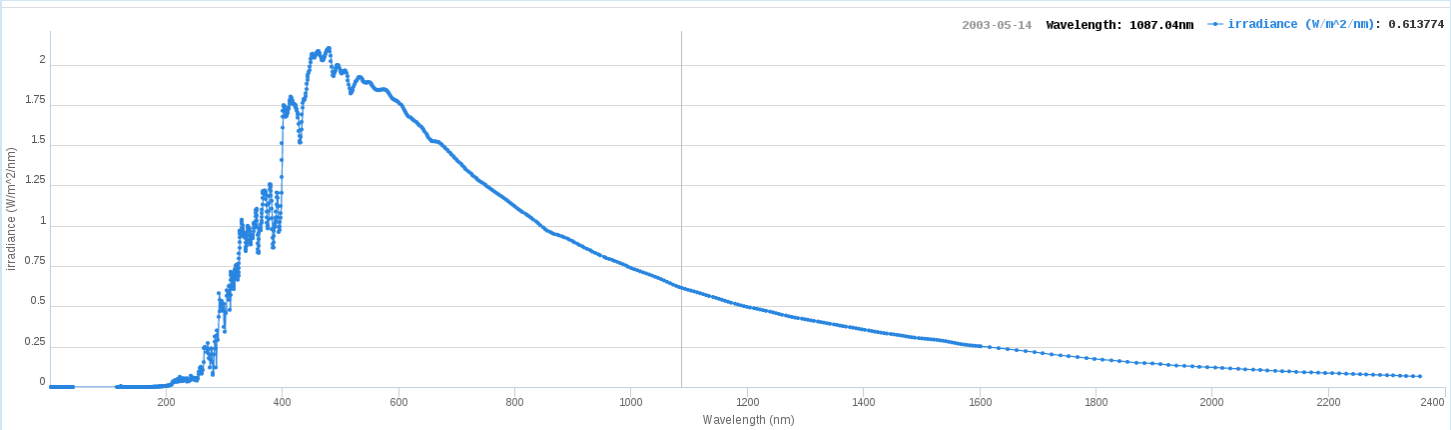


Photo Credit: LASP

Measurements of TSI are difficult to produce

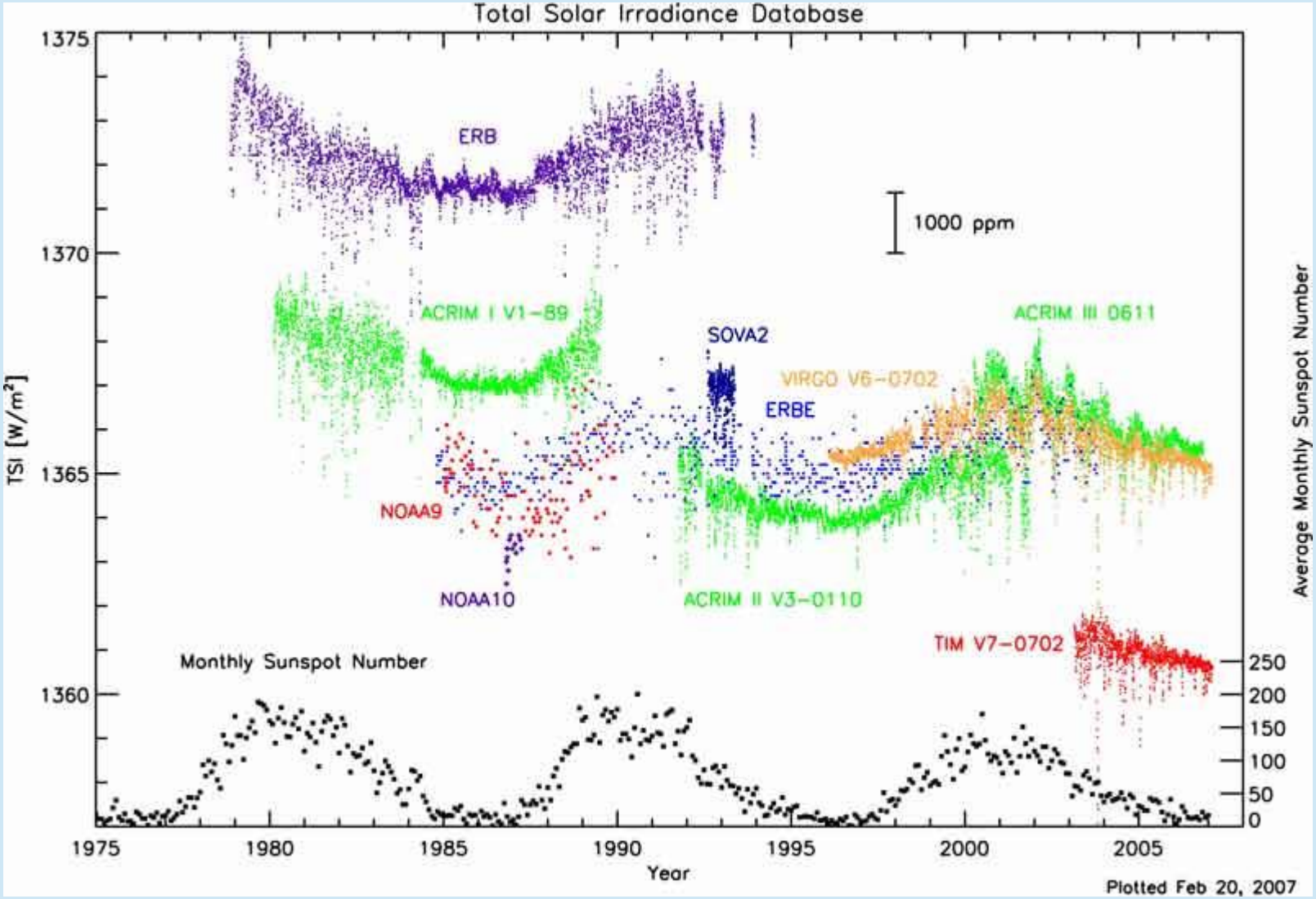
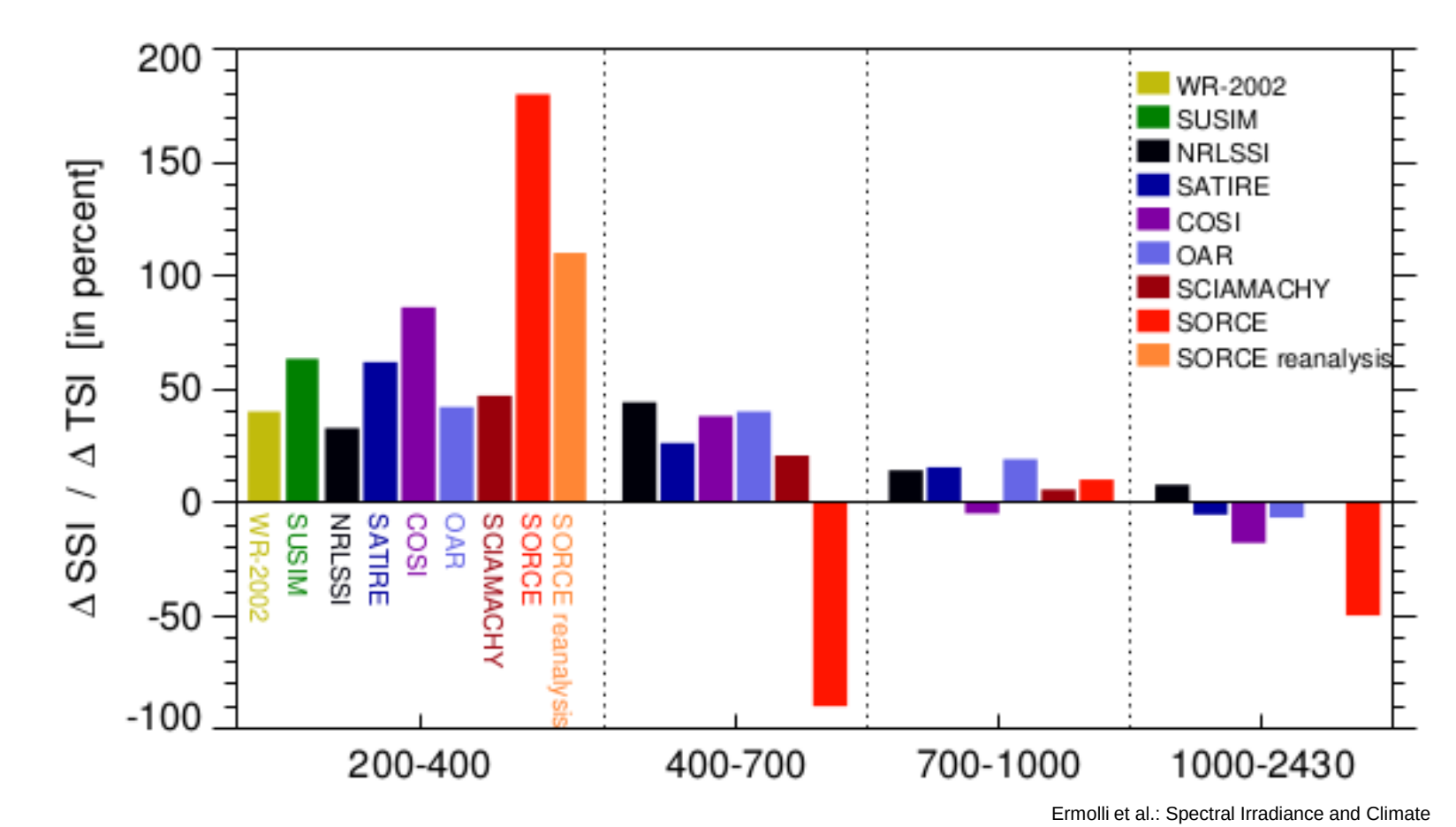


Photo Credit: LASP

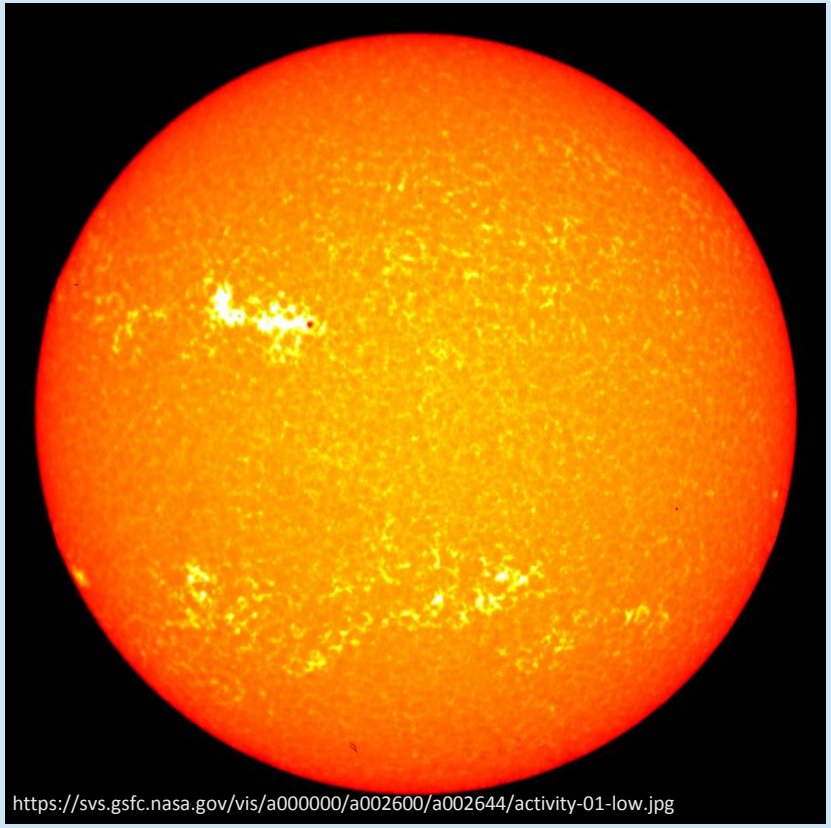
SSI changes over solar cycle as derived from measurements and models



Ermolli et al.: Spectral Irradiance and Climate

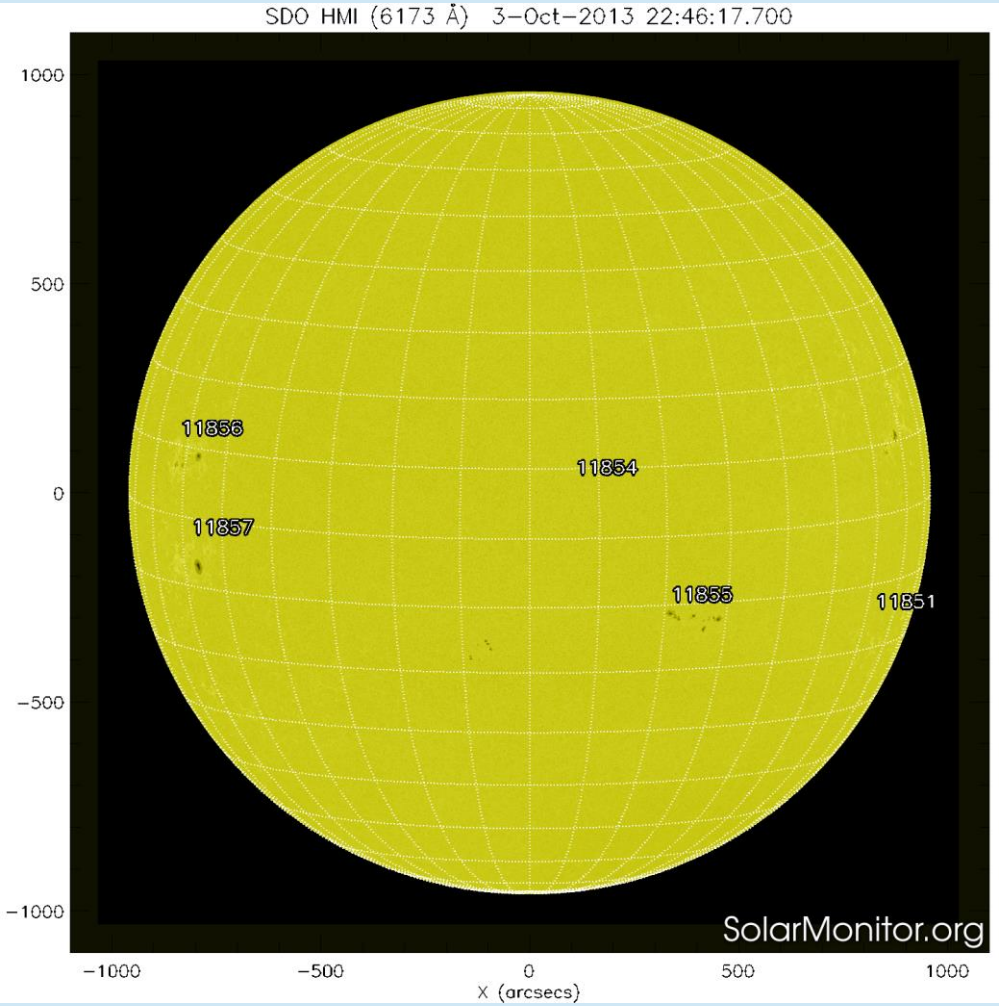
Observations

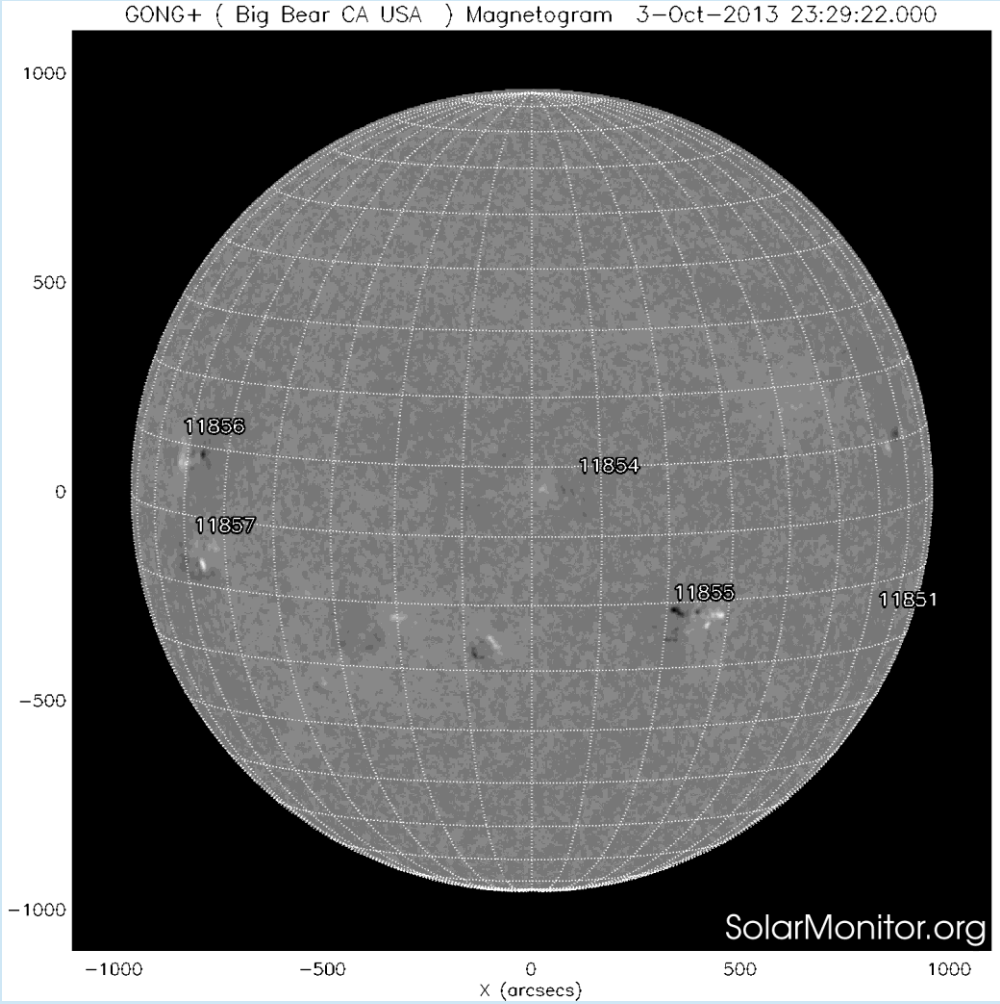
- 15 observations taken October 3rd, 2013
- Dunn Solar Telescope at Sunspot, New Mexico
- Center disk
- Measuring the photometric properties
- Comparing these measurements with three-dimensional MHD simulations


https://svs.gsfc.nasa.gov/vis/a000000/a002600/a002644/activity-01-low.jpg

https://delange.org/National_Solar_Observatory_Sacramento_Peak/Dunn_Solar_Telescope5.jpg

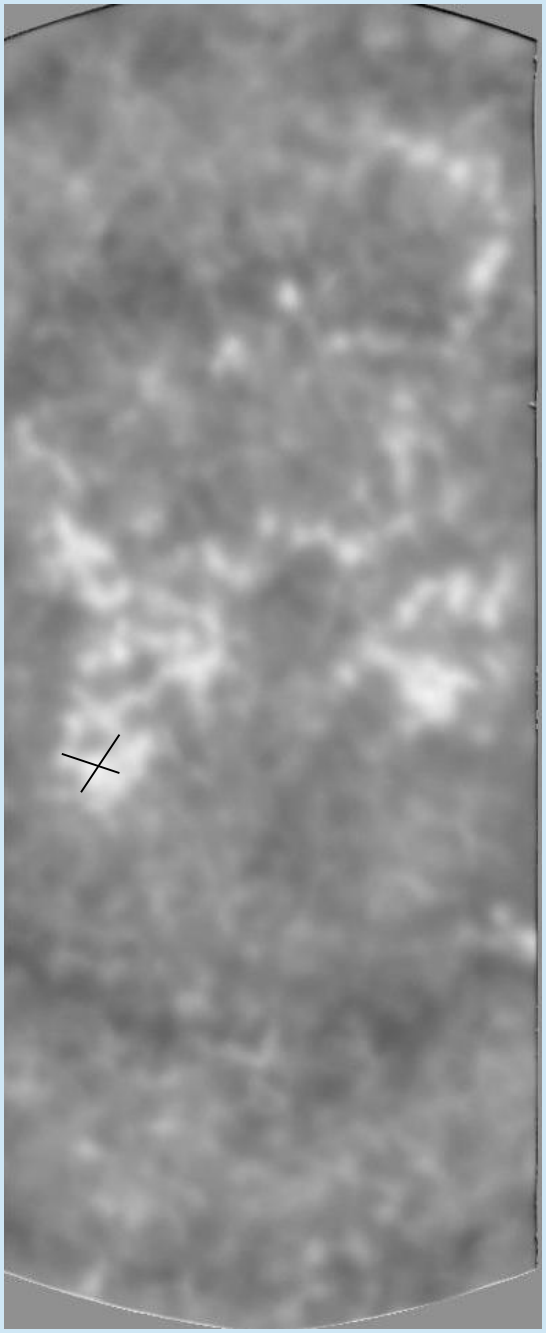
Images of Sun taken on October 3rd, 2013



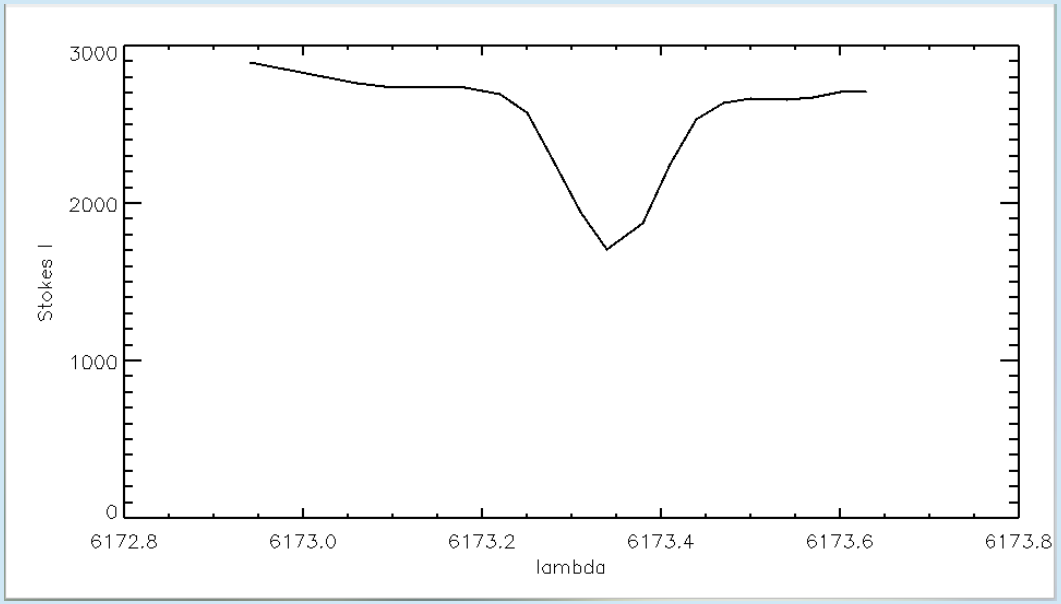


https://www.solarmonitor.org/?date=20131003

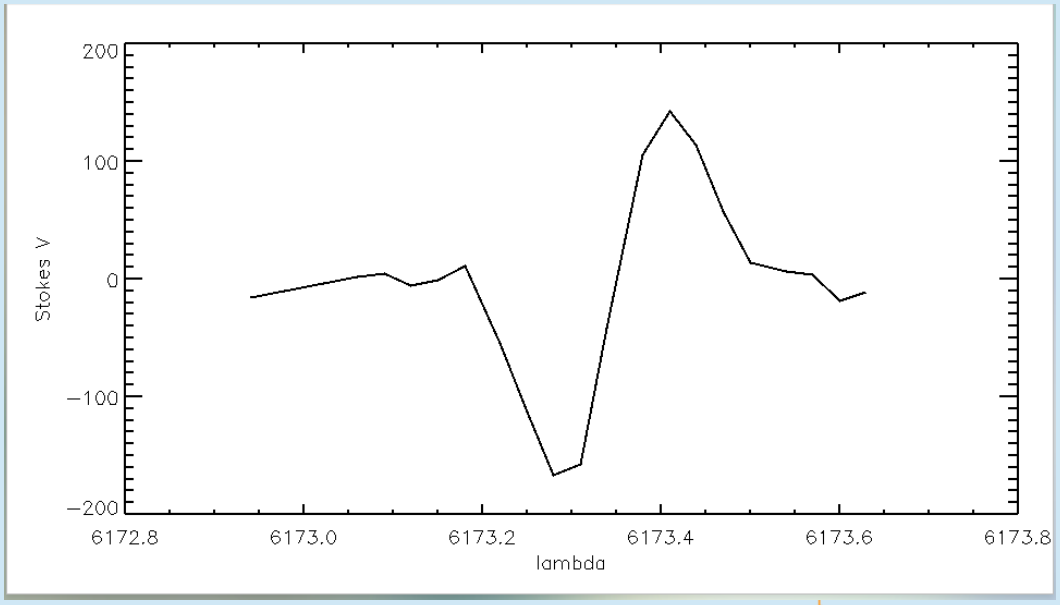
Stokes I Intensity of the Core



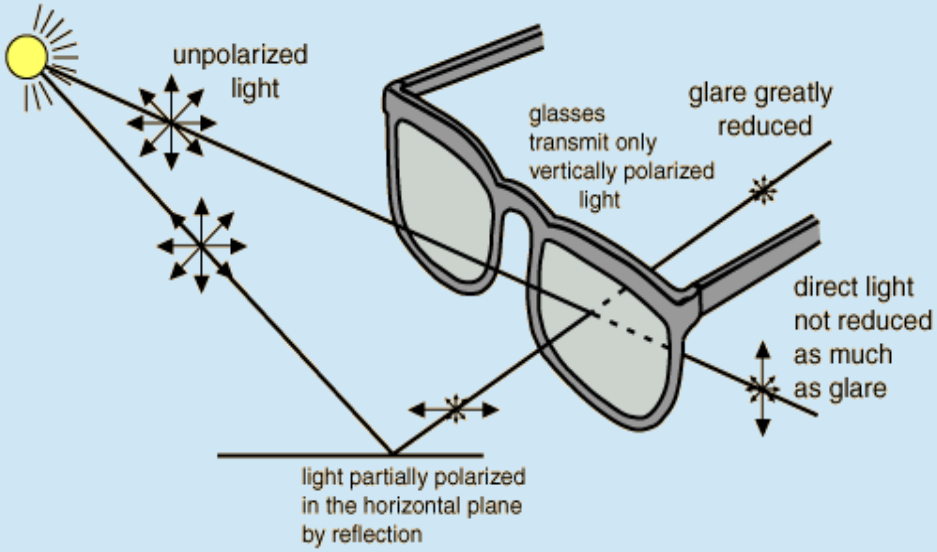
Stokes I graph



Stokes V graph



Polarization and Stokes Parameters



$$\mathbf{I} = \begin{bmatrix} I \\ Q \\ U \\ V \end{bmatrix} = \begin{bmatrix} I & Q & U & V \end{bmatrix}^T$$

https://www.ess.uci.edu/~cmclinden/link/xx/img73.gi

http://assets.openstudy.com/updates/attachments/4f175a76e4b0aeb795f5672a-jamesj-1326931194153-sunglass.gif

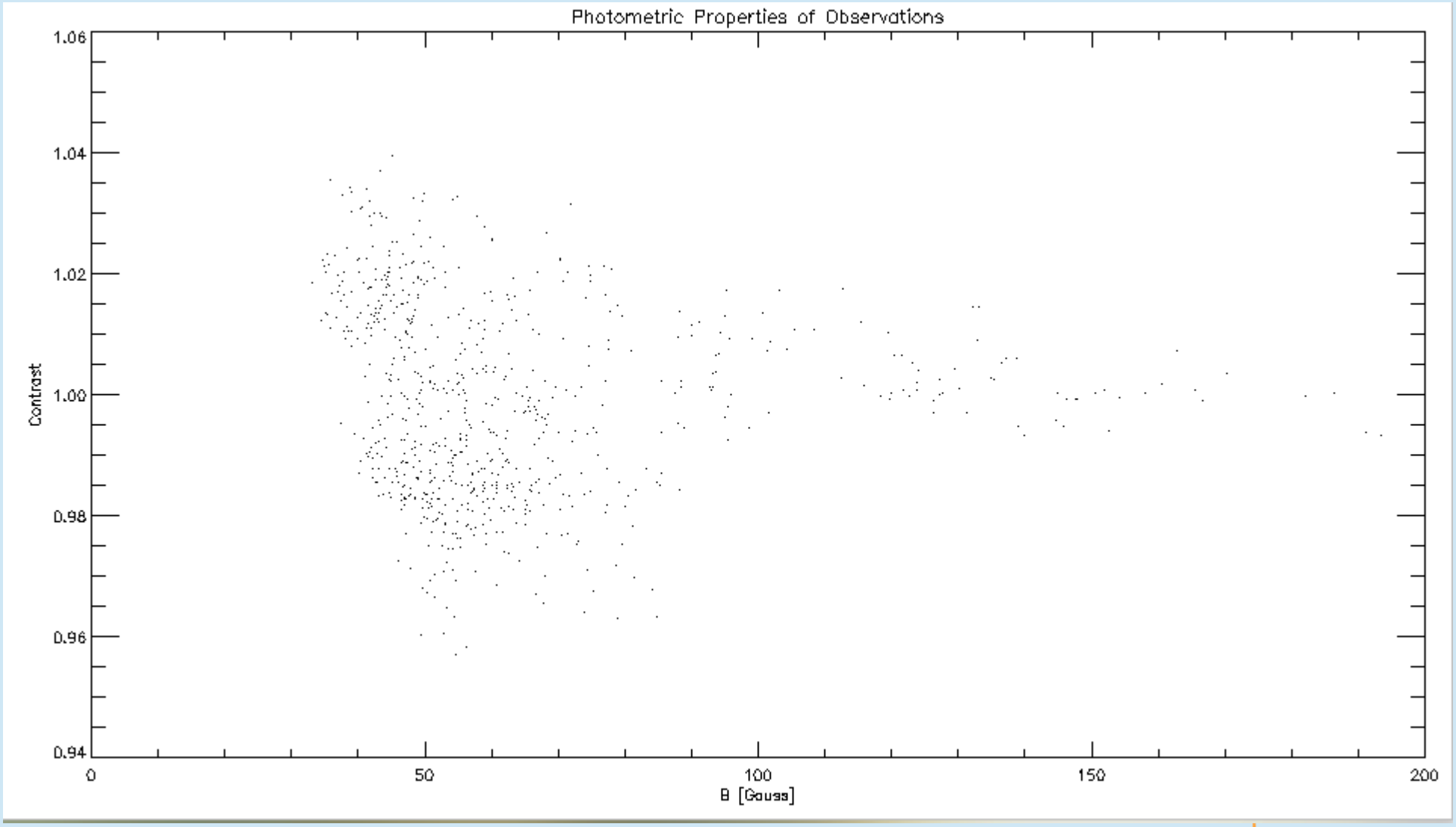
COG Method

- Image measurements can be affected by limitations in observational and data-reduction procedures
- “To measure the longitudinal field averaged over the observed area”
- Measures the displacement of the center of gravity
- Independent of spectral resolution

Data analysis

- Split Stokes I image into 67x67 pixel boxes
- Pixels → arcseconds; 67x67 → 6x6”
- Created two codes on IDL to measure average intensity, rms contrast of magnetic field and quiet region

Results for Observations

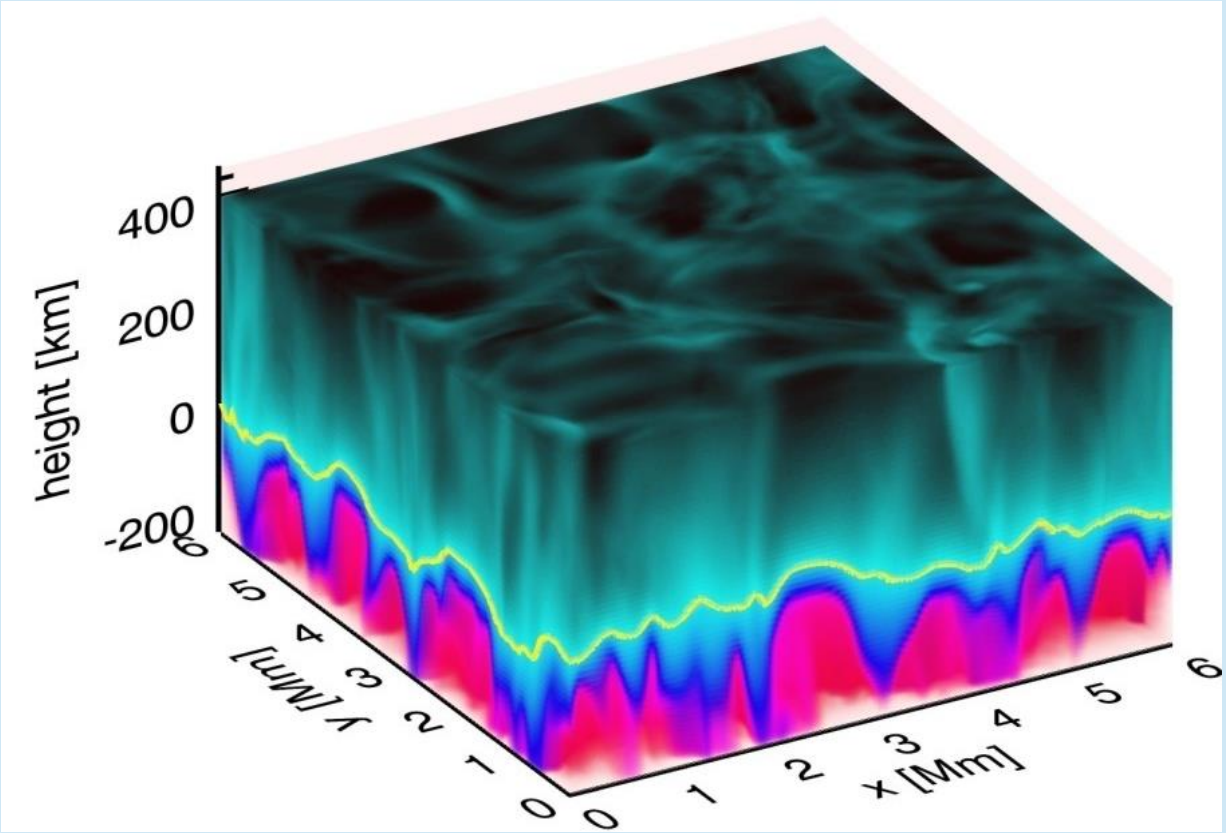


What are MHD Simulations?

Magneto Hydro Dynamic

MHD30G

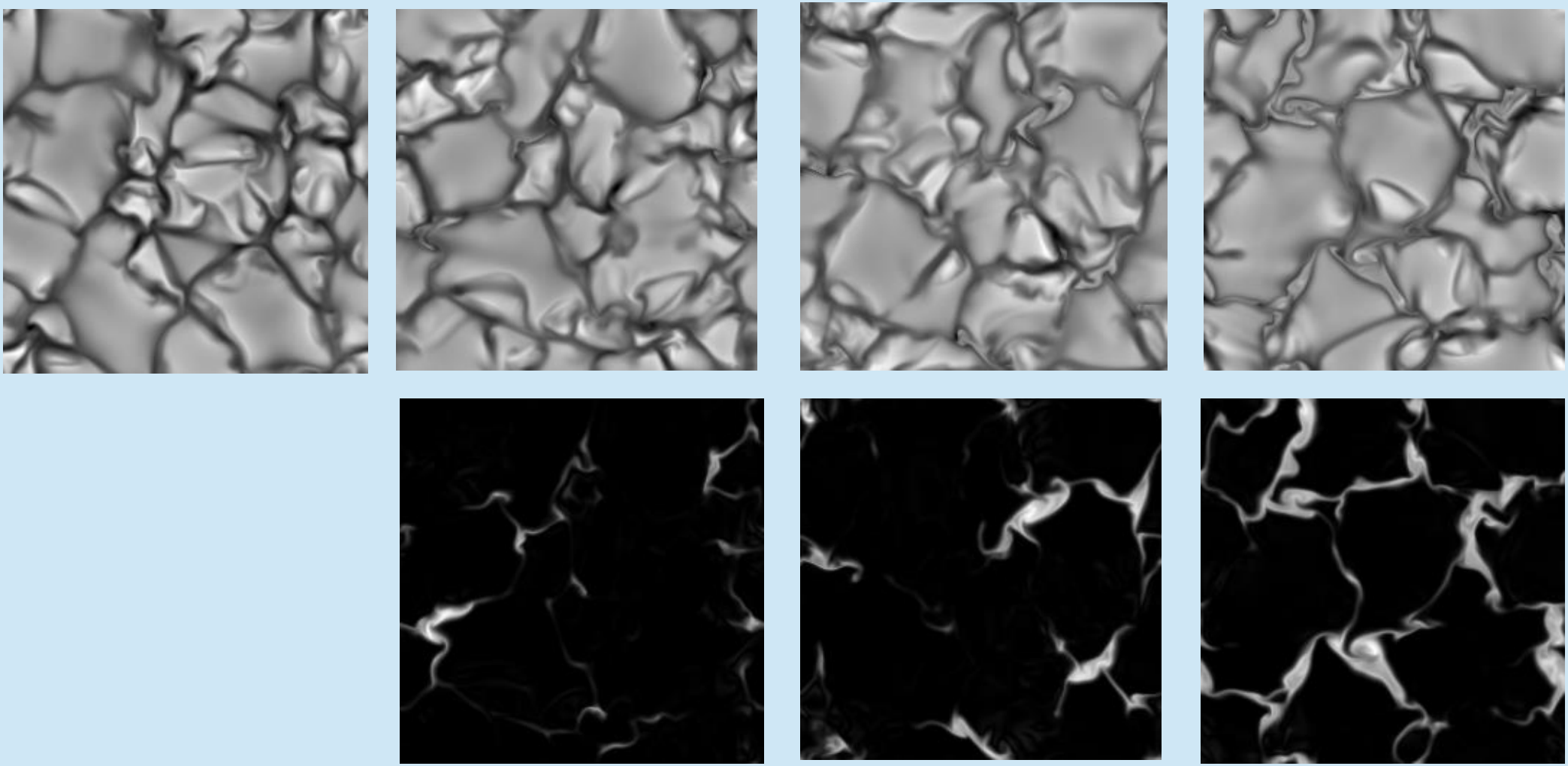
Δx = 24 km
Δz=20 km
6x6 Mm
Z = [-250,600] km
Φ=30G



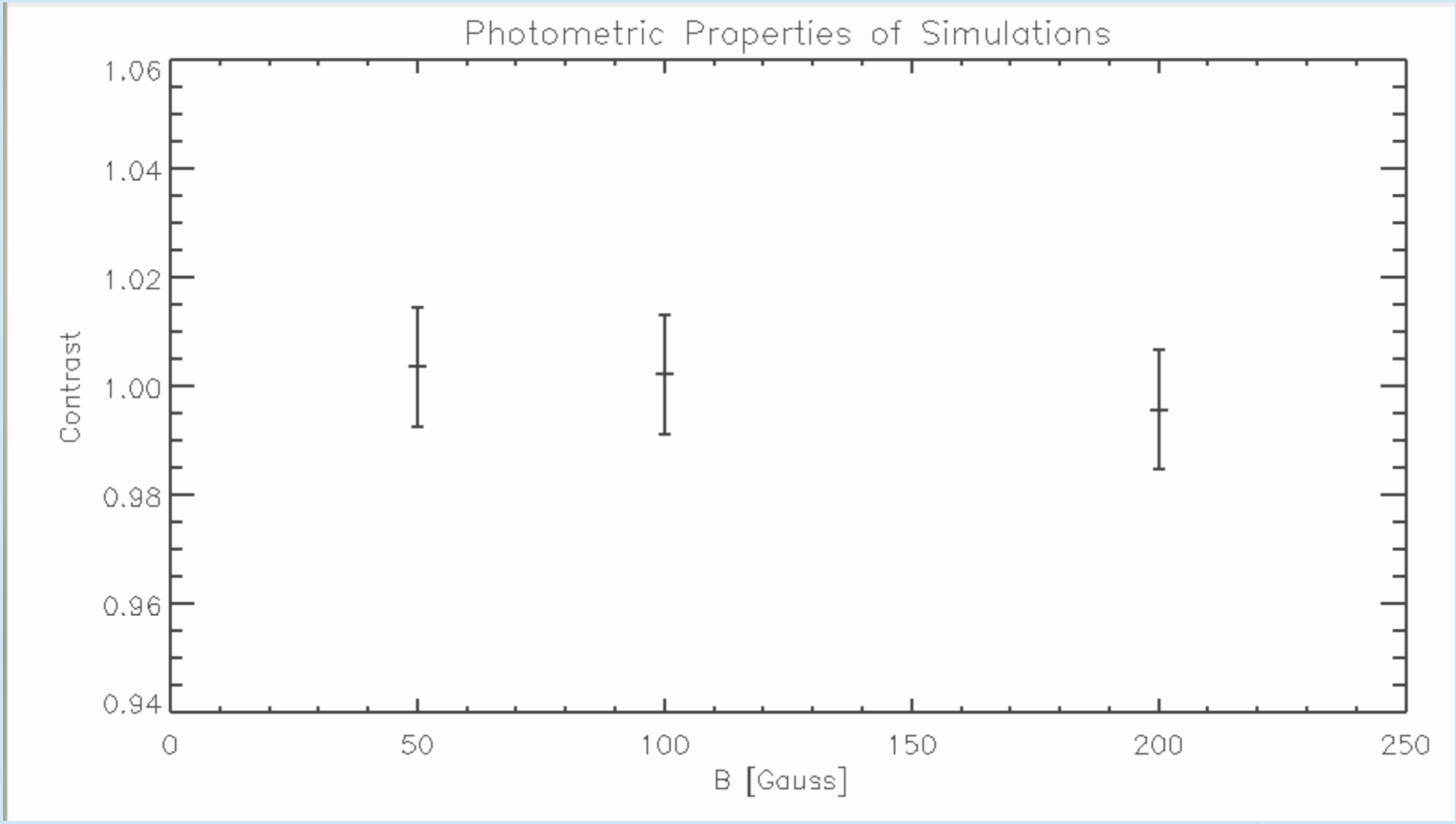
MHD Simulations

- 252 x 252 pixel boxes
- Images at different magnetic field strengths: 50, 100, 200
- Plotted the average Contrast of the photometric data and produced the standard deviation error for each

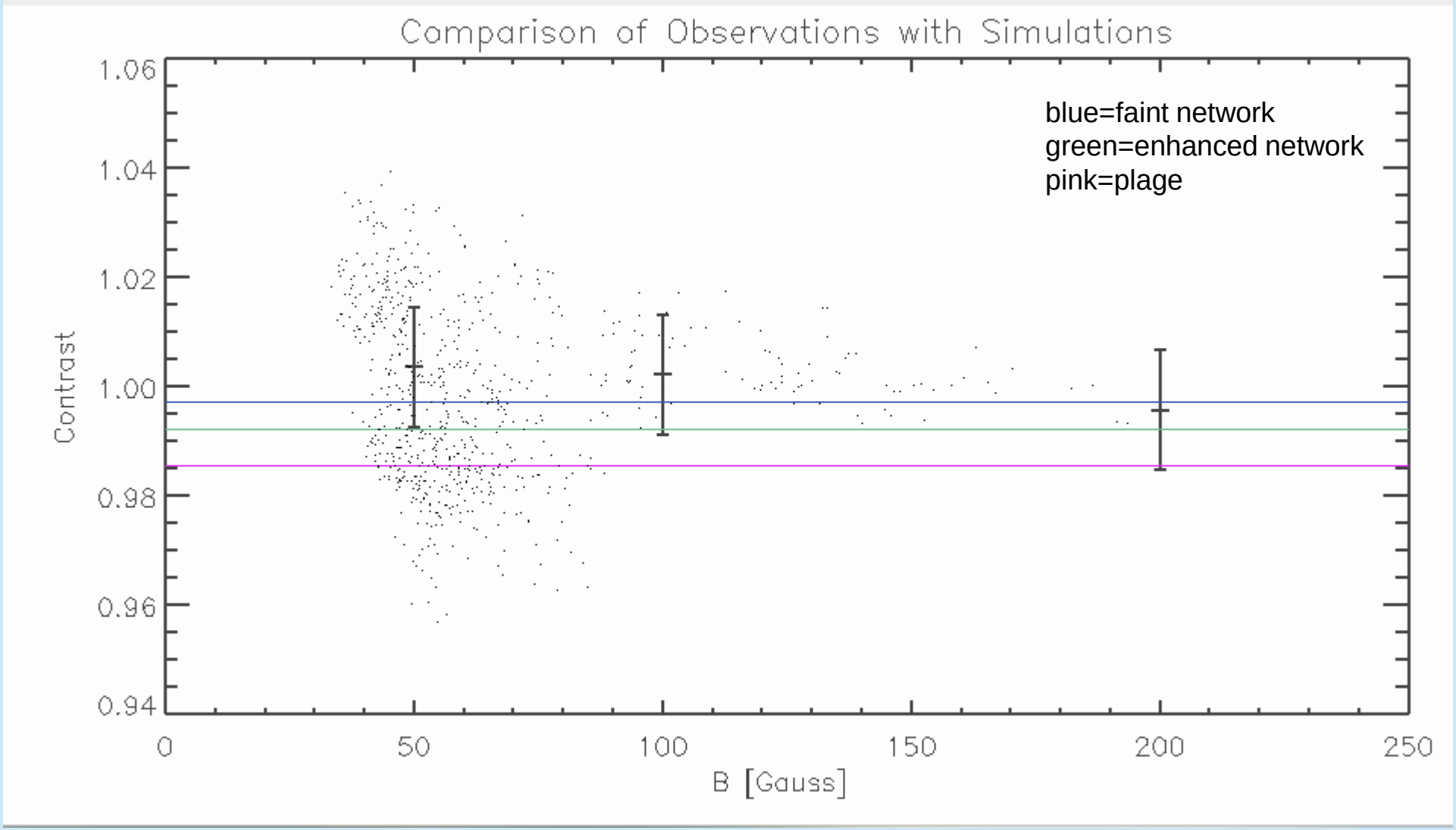
MHD Simulations



Results for MHD Simulations



Final Results



Conclusions and Future Work

- 3D MHD simulations slightly better than 1D simulations
- Future: Take into account seeing and scattered light

THANK YOU!