

Research Proposal for “Solar synoptic maps at multiple passbands and their long-term evolution”

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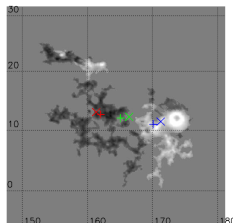
Section 1

Introduction

Active Region

Active Region(AR) on the sun is known as an extended area threaded with strong magnetic fields across the surface.

Because of vast free energy stored in these magnetic fields, ARs are the major source of various solar activities(flare, CMEs, etc.).



SDO

SDO(Solar Dynamics Observatory), is a NASA mission that has been observing the Sun since 2010. It is in an inclined geosynchronous orbit around Earth.

There are three instruments on it:

- **HMI**(Helioseismic and Magnetic Imager)
- **EVE**(Extreme Ultraviolet Variability Experiment)
- **AIA**(Atmospheric Imaging Assembly)



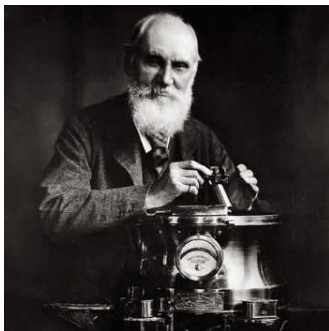
SDO-HMI

There are four main types of HMI data:

- **Dopplergrams**(maps of solar surface velocity)
- **Continuum Filtergrams**(broad-wavelength photographs of the solar photosphere)
- **Line-of-sight and Vector Magnetograms**(maps of the photospheric magnetic field)

In this research, magnetograms from HMI is mainly used.

Richard Christopher Carrington



Richard Christopher Carrington(1826-1875)
an English **amateur** astronomer

Carrington Rotation

As we all know, the solar rotation period is approximately 24.47(day).

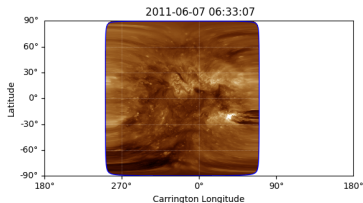
However, The **Carrington Rotation** is an average value defined on the basis of the solar rotation period, taking into account the periodic changes in the Sun's magnetic field and other activities. It is approximately 27.2753(day).

A unique number is given to the rotation called the **Carrington Rotation Number**, which is CR2272 now.

Carrington Coordinates

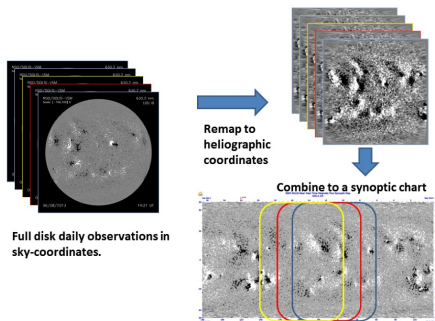
In the **Carrington Coordinate System**:

- Longitude is defined as the angle measured from a specific reference point on the solar surface. It changes with solar rotation, completing a 360-degree rotation in a Carrington Rotation.
- Latitude is similar to Geographic Coordinate System.





Synoptic Map



Synoptic Maps are used to visualize the evolution of solar activity from one Carrington Rotation to another.

Section 2

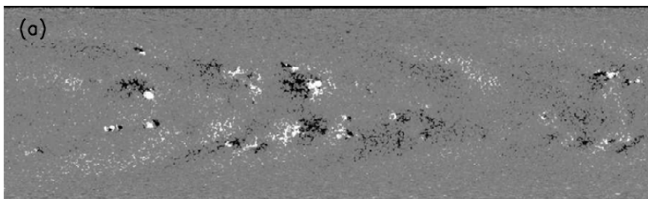
Review of Previous Studies

The Automated AR Identification System

CREED

AR is an extended area of relatively strong magnetic fields

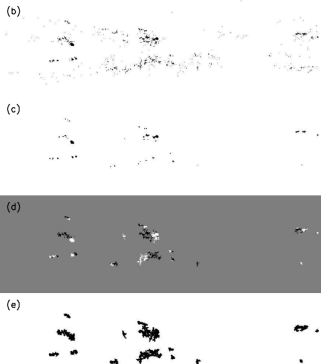
- **Input:** A synoptic map in a full CR of the sun.
 - X-axis: Carrington Longitude
 - Y-axis: Carrington Latitude





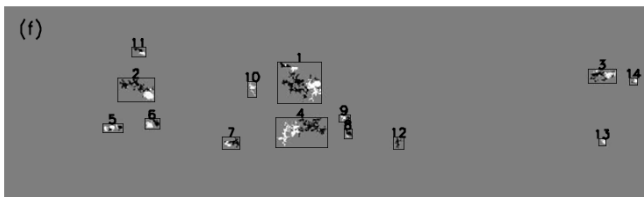
The Automated AR Identification System

- **Pre-processing:** Noise Reduction, Cropping, Standardization, Enhancement...



The Automated AR Identification System

- **Extract AR:** Merge the neighbouring part and extract.



It should be noted that the automated result of AR is not exactly equal to NOAA catalog made by human inspectors.

Statistical Properties Of ARs

In [Zhang et al. 2010](#), they analyzed the 23rd solar cycle by the automated system:

- 1730 ARs were identified by the auto system.
- The mean and maximum magnetic flux of individual ARs are $1.67 \times 10^{22} Mx$ and $1.97 \times 10^{23} Mx$, while that per Carrington rotation are $1.83 \times 10^{23} Mx$ and $6.96 \times 10^{23} Mx$.
- The frequency distributions of ARs with respect to both area size and magnetic flux follow a log-normal function.

Statistical Properties Of ARs

- Decrease the detection thresholds and thus increase the number of detected ARs, the frequency distribution largely follows a power-law function.
- The equatorward drifting motion of the AR bands with solar cycle can be described by a linear function superposed with intermittent reverse driftings.

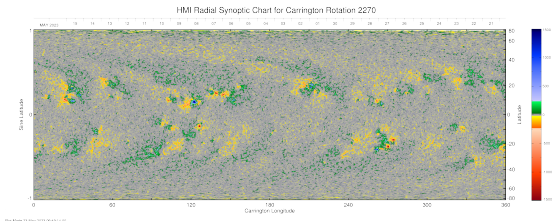
Section 3

Motivation

Motivation

In Zhang et al. 2010, the data used was from SOHO-MDI and it focus on the 23rd solar cycle.

However, with the higher resolution data transferred from SDO-HMI after 2010, maybe more interesting statistical properties can be found in the 24th solar cycle.



Motivation

With these questions, I will do this research.

Section 4

Research Design

Research Design

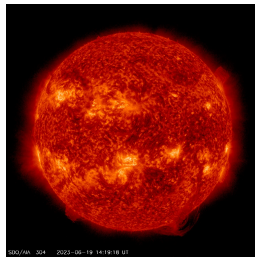
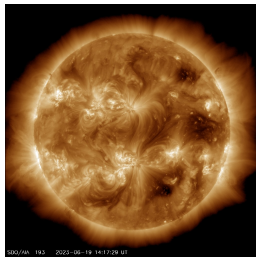
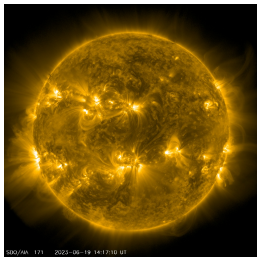
In this research, I will:

- 1** Write programs to download data from SDO and generate multi-wavelength synoptic map's database which contains long-term evolutionary information about the sun from the photosphere to the corona.
- 2** Analyze the information and automatically extract parameters(location, size of ARs etc.)
- 3** Analyze the evolutionary patterns of these parameters during the 24th solar cycle.
- 4** Summarize the results and public a high-level academic paper.

Research Design

It is also needed to read papers and gain scientific research skills and tools during the whole research.

Through this research, I hope that I can become an beginner researcher in Solar Physics.



Section 5

Timeline

Timeline

Because of the uncertainty of time arrangement, there isn't an exactly timeline.

As it is requested in Undergraduate Innovation Training Program, the project's deadline can be one year or two years later. The completion time will depend on my research progress.



References

- 1 Zhang, J., Wang, Y., & Liu, Y. (2010). Statistical properties of solar active regions obtained from an automatic detection system and the computational biases. *The Astrophysical Journal*, 723(2), 1006.
- 2 Georgoulis, M. K., Titov, V. S., & Mikić, Z. (2012). Non-neutralized electric current patterns in solar active regions: origin of the shear-generating Lorentz force. *The Astrophysical Journal*, 761(1), 61.
- 3 SDO(Solar Dynamics Observatory)
- 4 Synoptic Maps-NSO(National Solar Observatory)
- 5 HMI and MDI Synoptic Charts
- 6 MagneticField-JSOC_ Wiki
- 7 SunPy
- 8 WIKIPEDIA, The Free Encyclopedia
- 9 Richard Carrington

Thanks

Thank you for listening!