

Coronal Hole Properties in Solar Cycle 24

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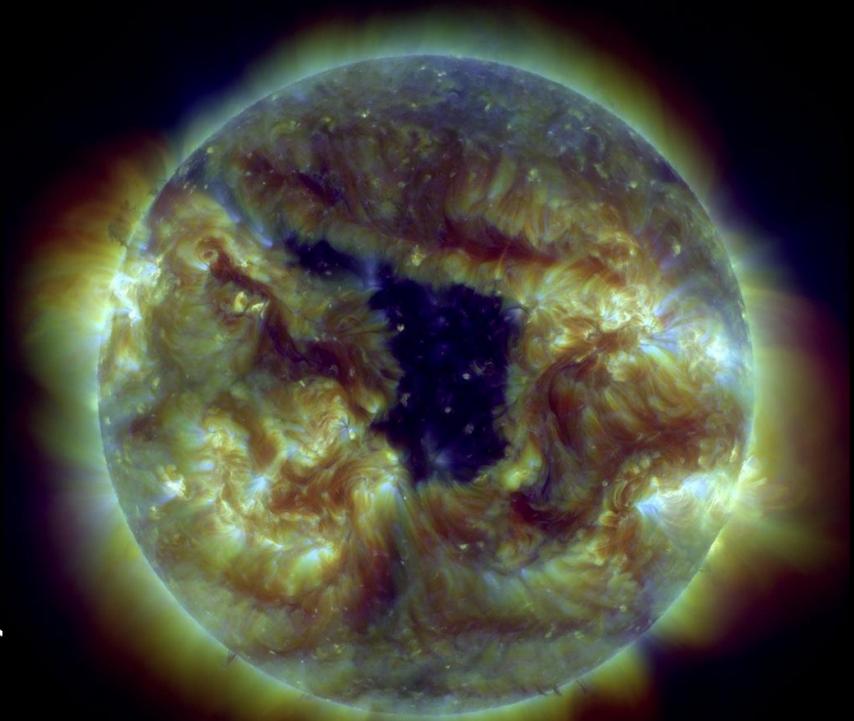
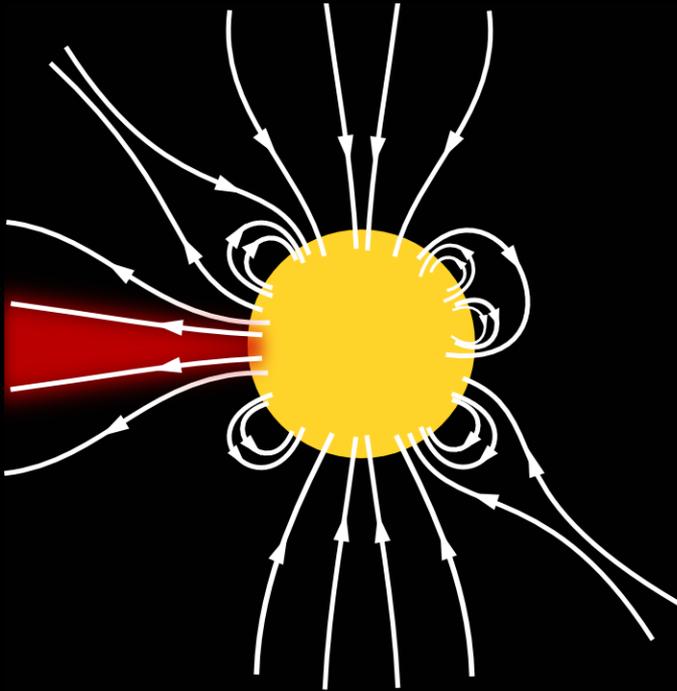
Dr. Mari Paz Miralles
Harvard-Smithsonian Center for Astrophysics



What is a Coronal Hole?

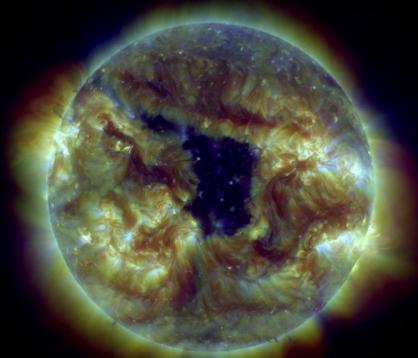
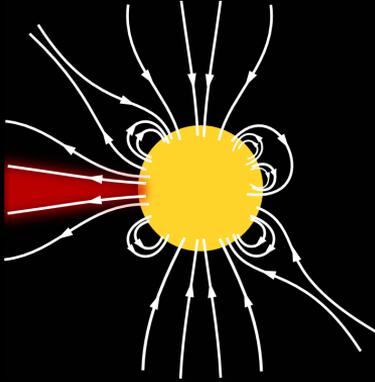
Regions of open magnetic flux in the solar corona.

Appear as discrete dark patches in EUV images of the solar atmosphere.



What is a Coronal Hole?

Regions of open magnetic flux in the solar corona.



Appear as discrete dark patches in EUV images of the solar atmosphere.

Source of the fast (500 - 800 km/s) component of the solar wind.

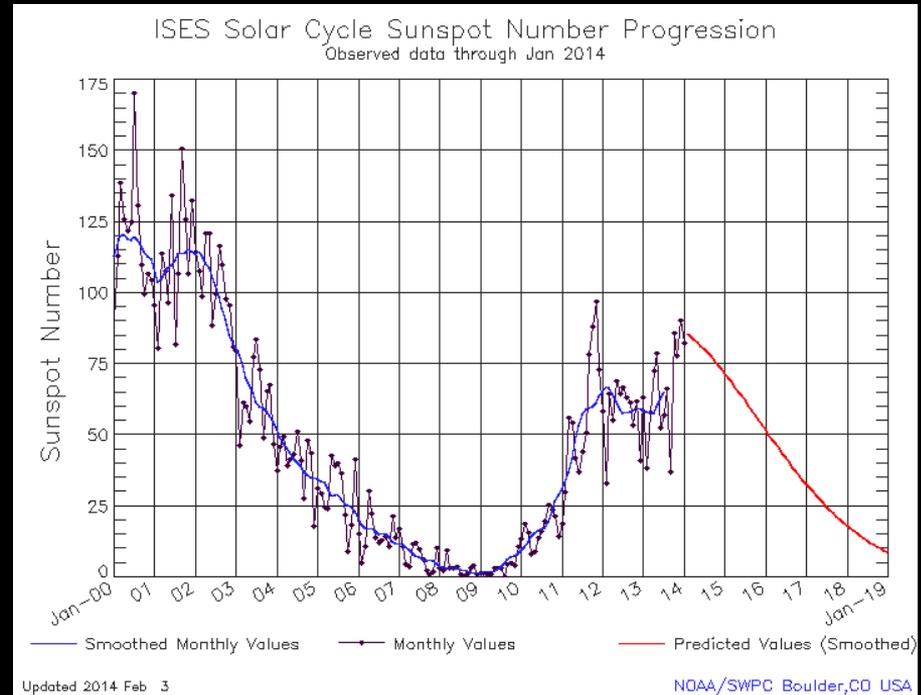
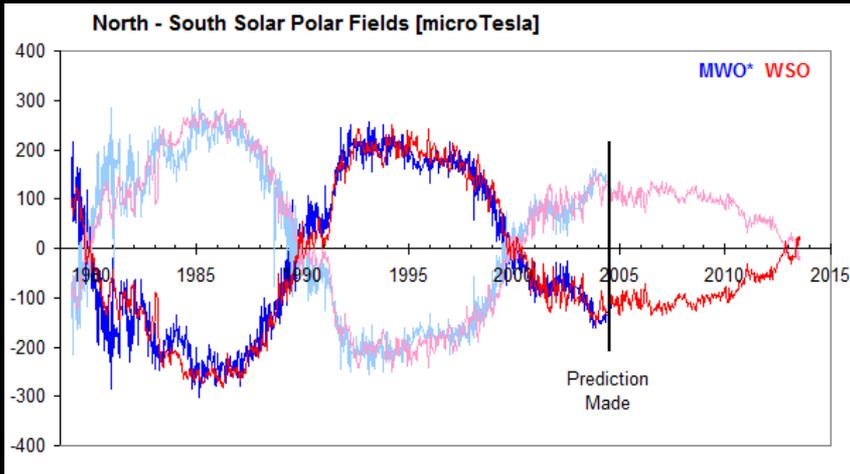
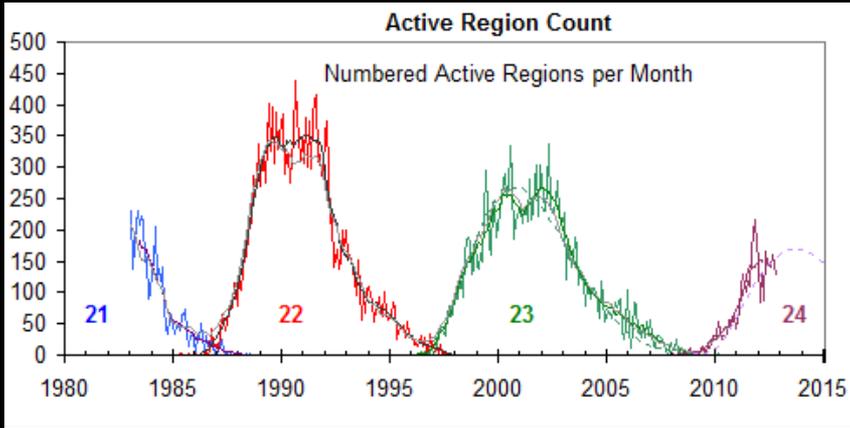
Affects space weather at 1 AU...
Auroras!



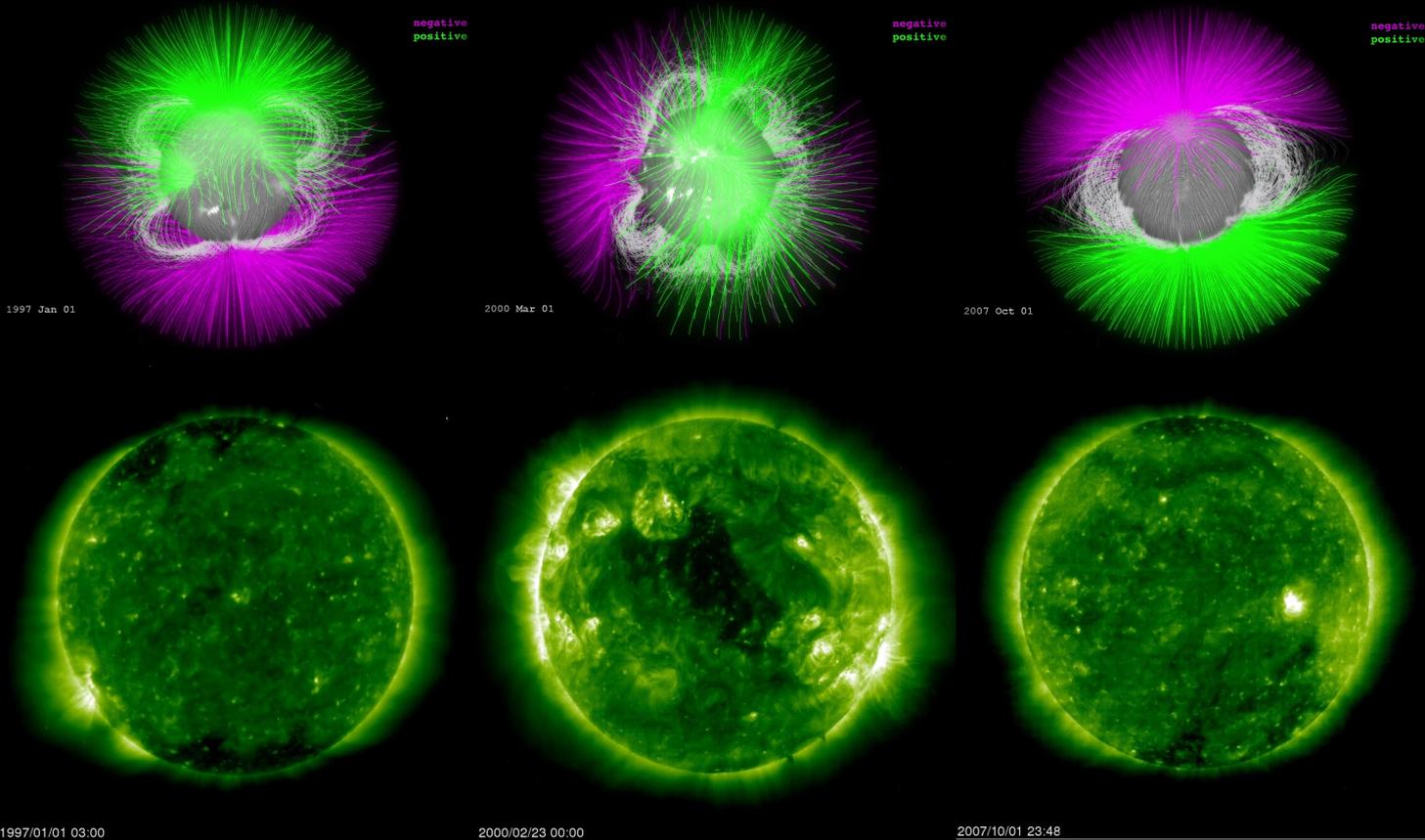
What is the Solar Cycle?

Periodic variation in levels of solar activity driven by changes in the solar magnetic field.

Cycle 24 is anomalous.



Coronal Holes and the Solar Cycle



Motivation

Cycle 24 exhibits anomalous behavior in the form of weak polar magnetic fields and low levels of solar activity. Any effects on coronal holes in other latitudes of the Sun?

Never before seen population of large equatorial coronal holes during solar minimum.

No existing large sample studies of the properties of coronal holes in cycle 24.

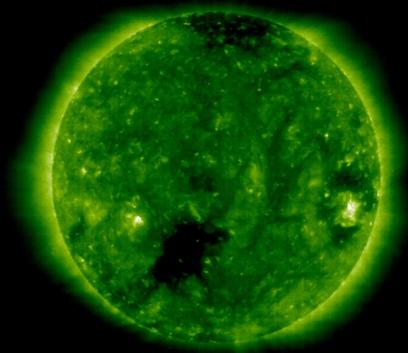
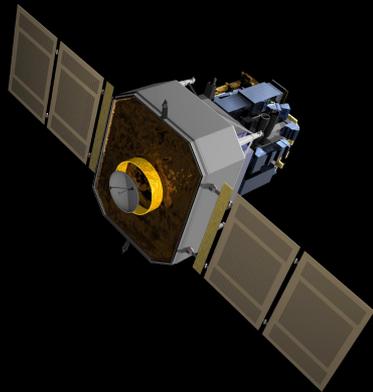
What I set out to do:

Study of the properties of coronal holes and their wind using space-based instruments during solar cycle 24 (current solar cycle that started on Dec 2008).

Characterize coronal holes in the solar atmosphere (magnetic field, area, size, lifetime)

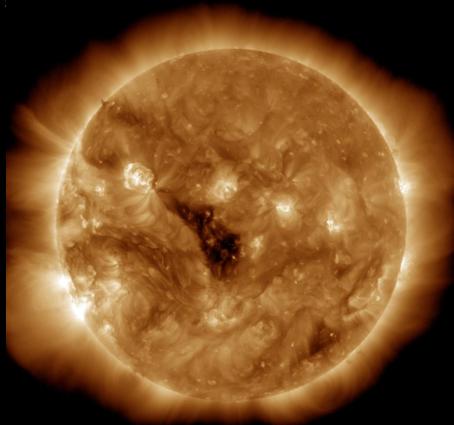
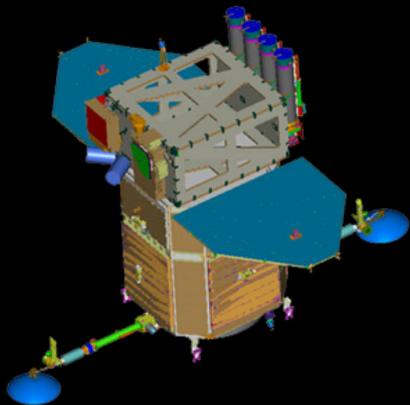
Characterize the wind streams associated with the coronal holes (densities, temperatures, velocities) at 1 AU

Creating an EUV Catalog



SOHO/EIT

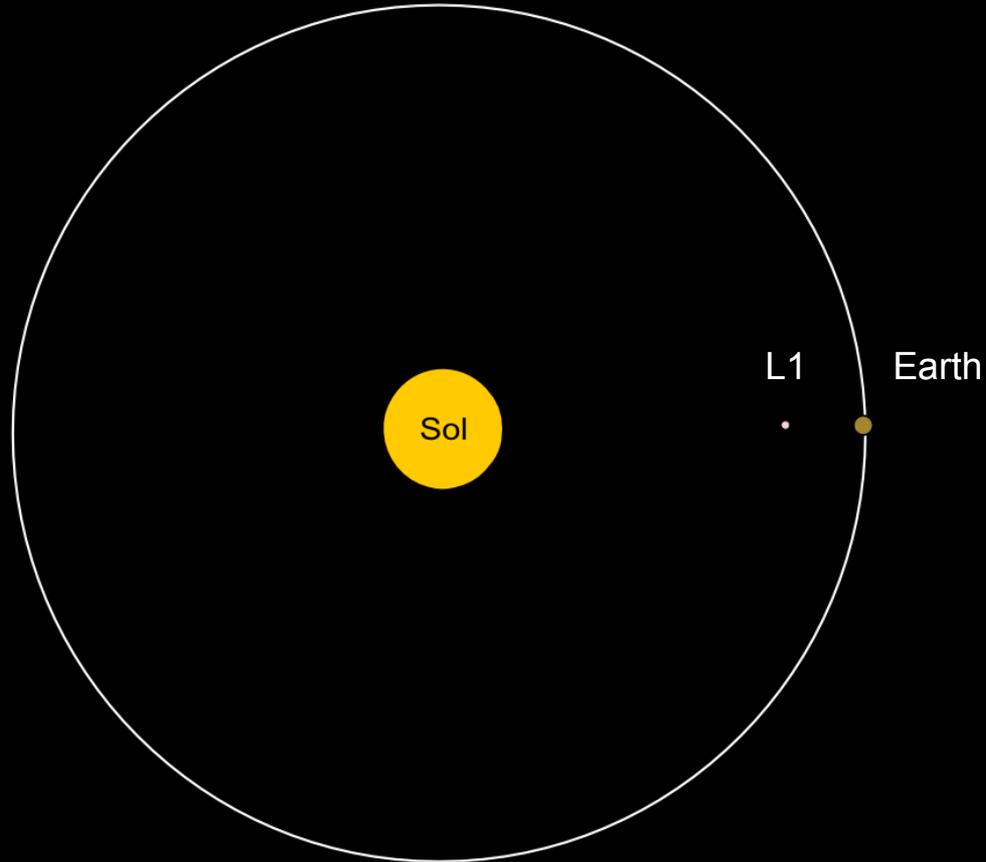
January 2007 to June 2010
12 minute cadence
2.63 arcsecond per pixel res.
195 Angstrom



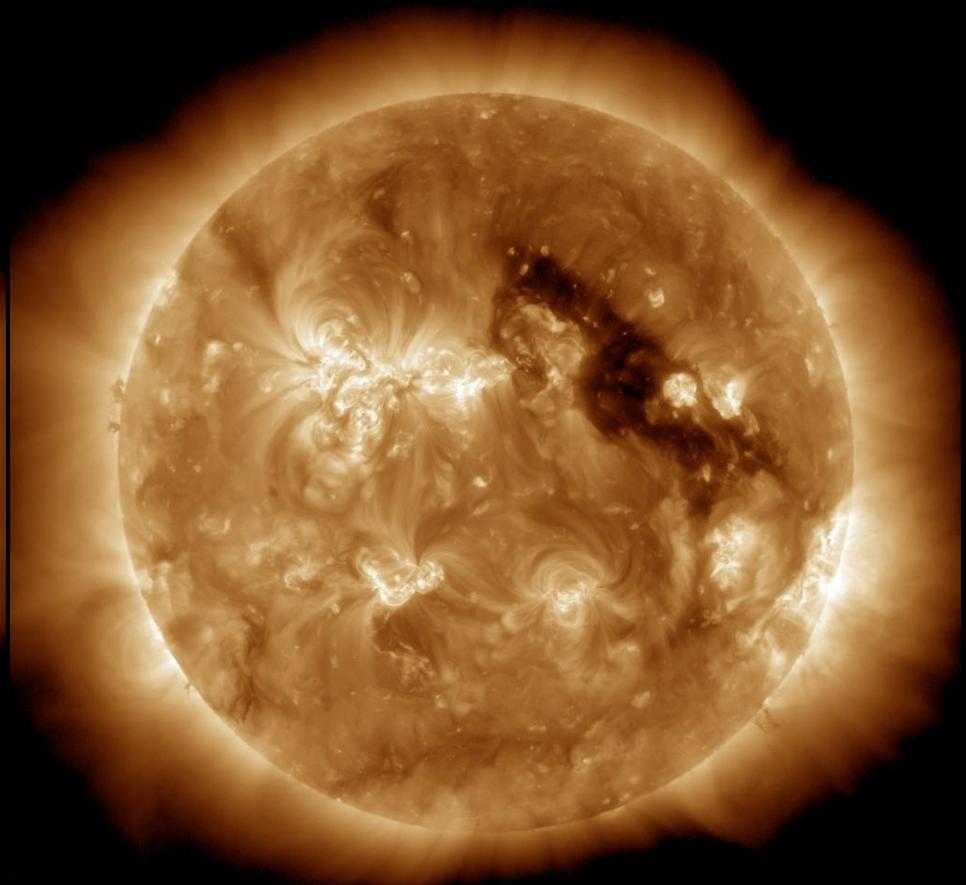
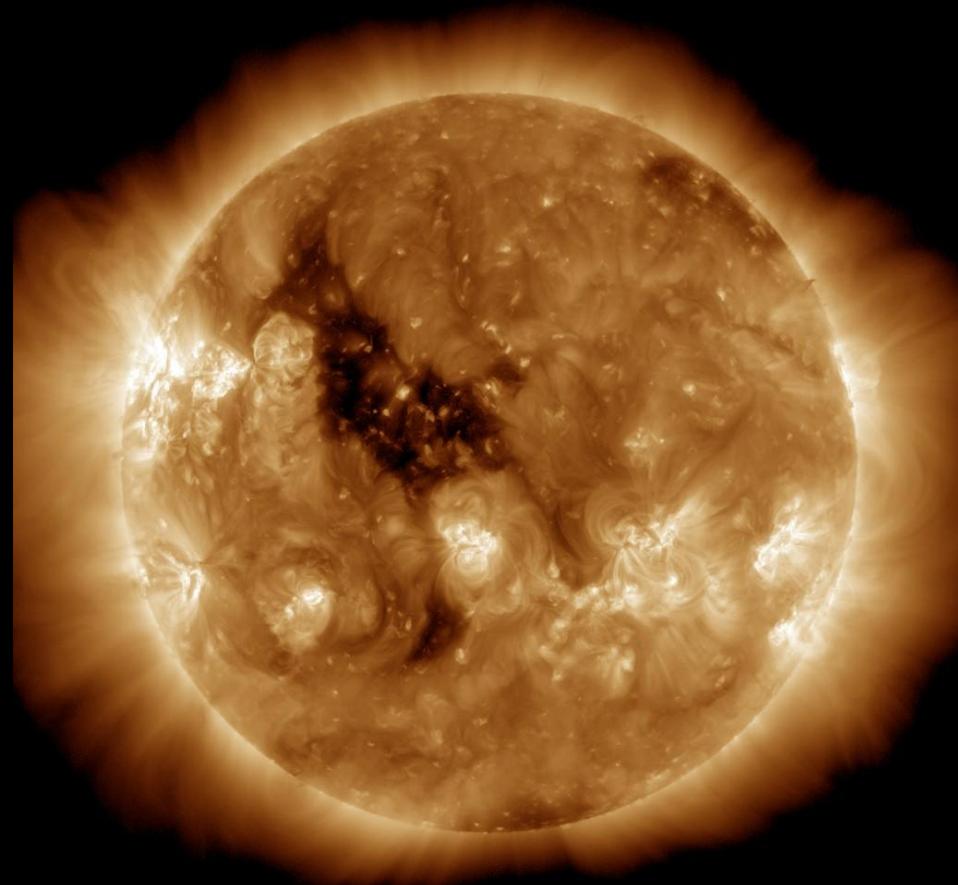
SDO/AIA

June 2010 to February 2014
12 second cadence
.6 arcsecond per pixel res.
193 Angstrom

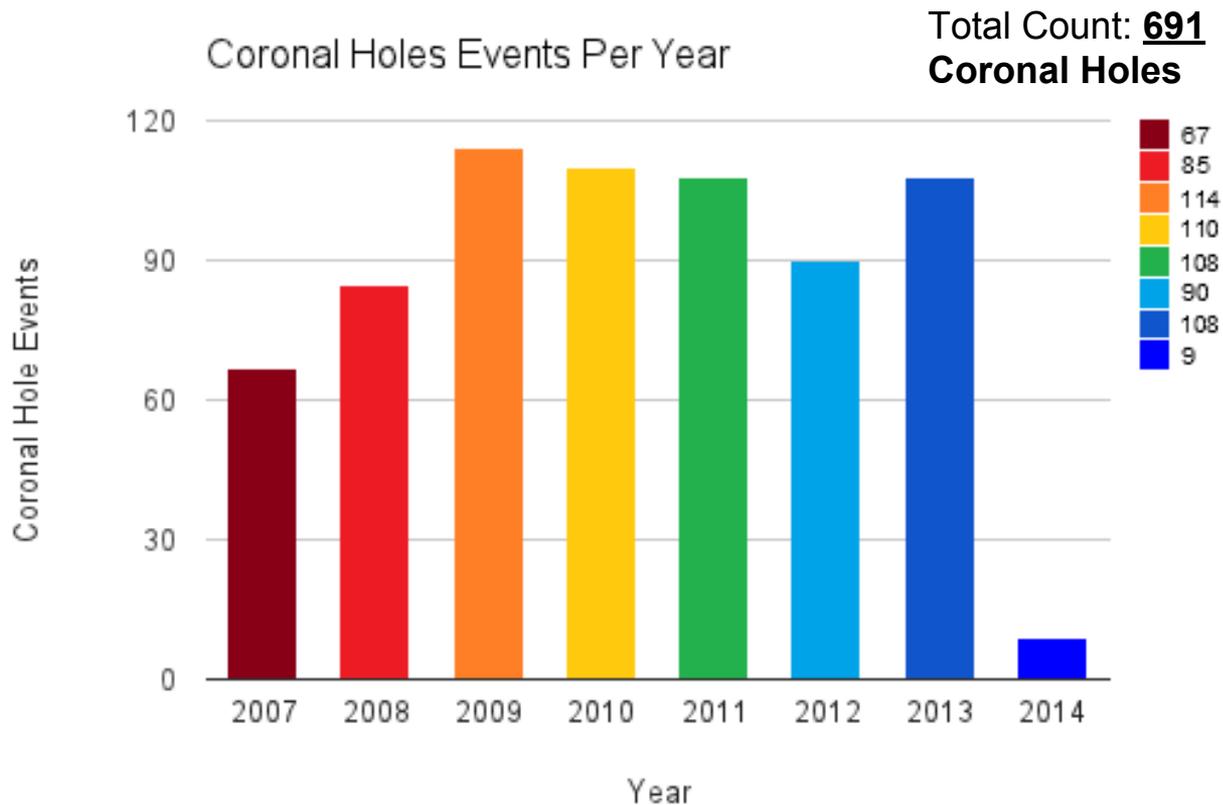
Creating an EUV Catalog



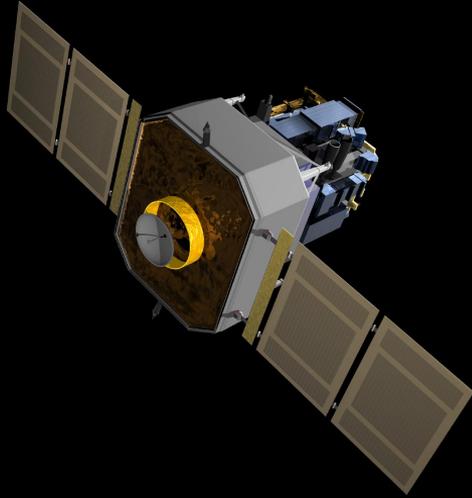
Creating an EUV Catalog



My EUV Catalog



Wind Stream Identification



SOHO/ CELIAS MTOF PM

Proton Density, Velocity, and Temperature

30 second temporal resolution

1 hour averages

2007 to 2014



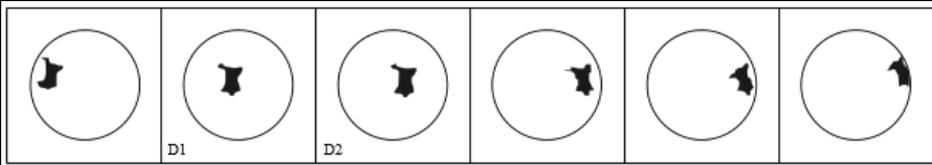
ACE/SWEPAM

Proton Density, Velocity, Temperature, and
alpha to proton ratio.

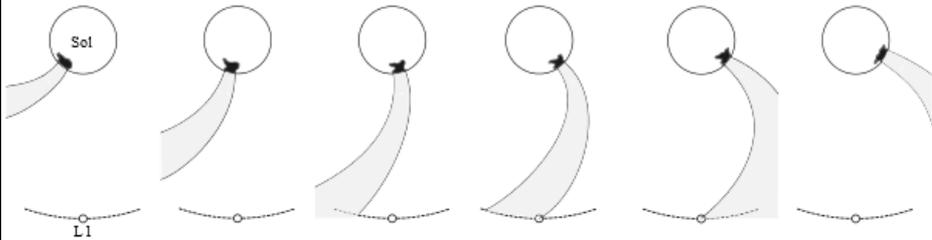
64 second temporal resolution

12 min averages

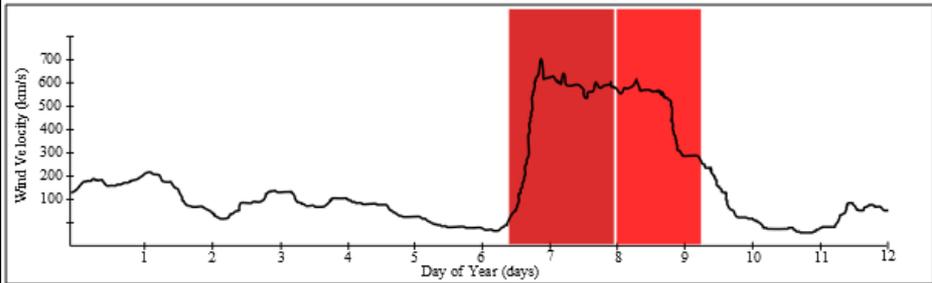
2007 to 2013



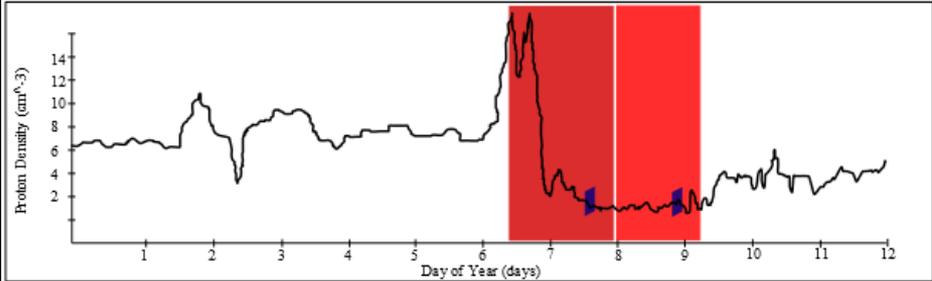
EUV Imaging of coronal hole trajectory across visible solar hemisphere.



Wind stream trajectory.



Wind velocity (km/s) detected at L1 as a function of time (day of year).

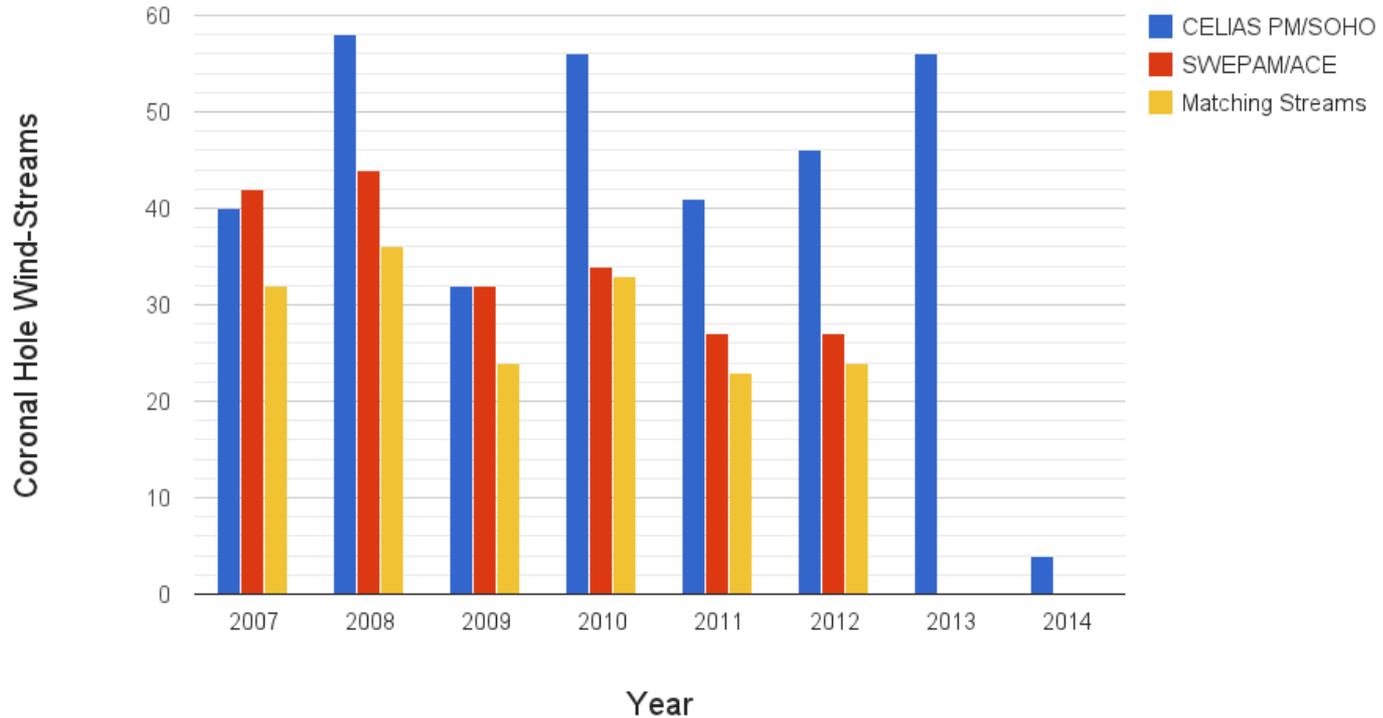


Wind density (p/ cm^{-3}) detected at L1 as a function of time (day of year).

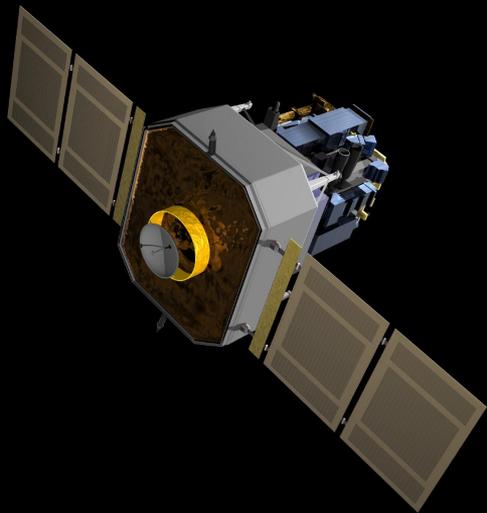
My Wind Stream Catalog

Total Count: **363**
Wind Streams

Coronal Hole Wind-Streams Per Year



Area and Magnetic Flux Calculation

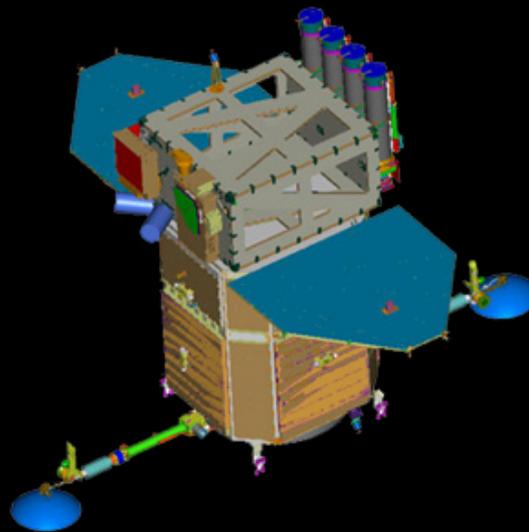


SOHO/ MDI

4 arcsecond per pixel resolution

96 minute cadence

January 2007 to June 2010



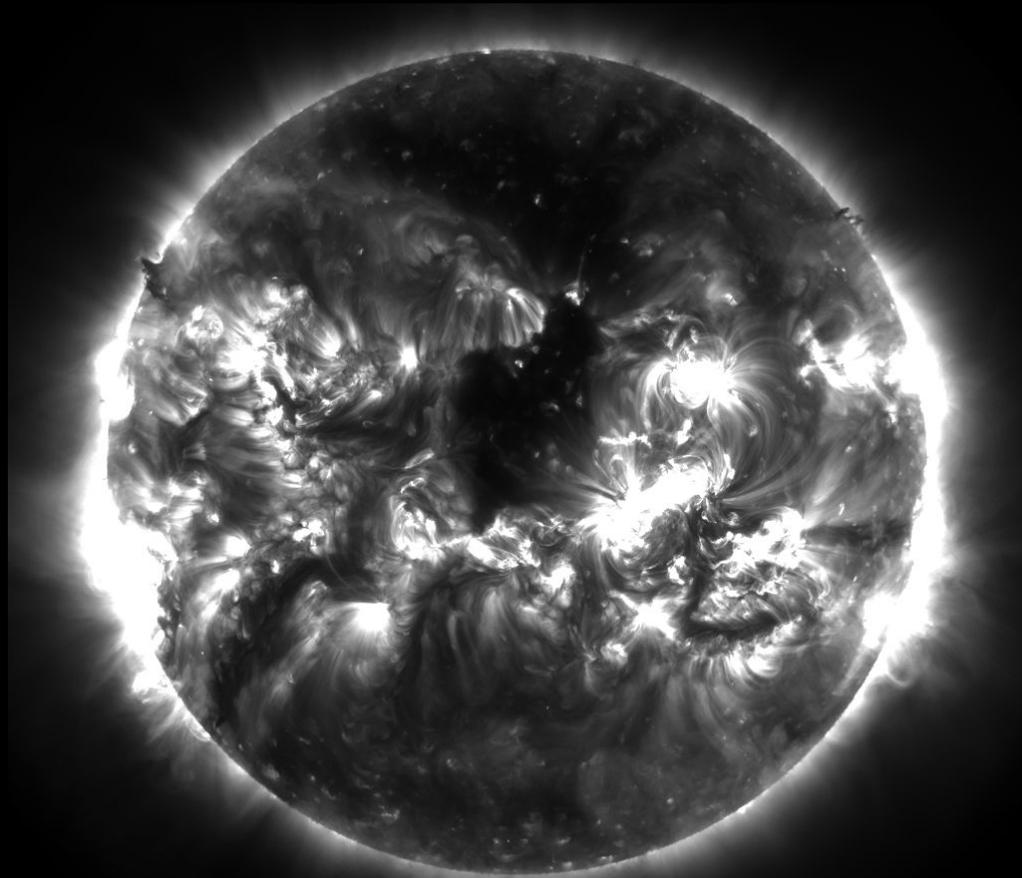
SDO/ HMI

1 arcsecond per pixel resolution

45 second cadence

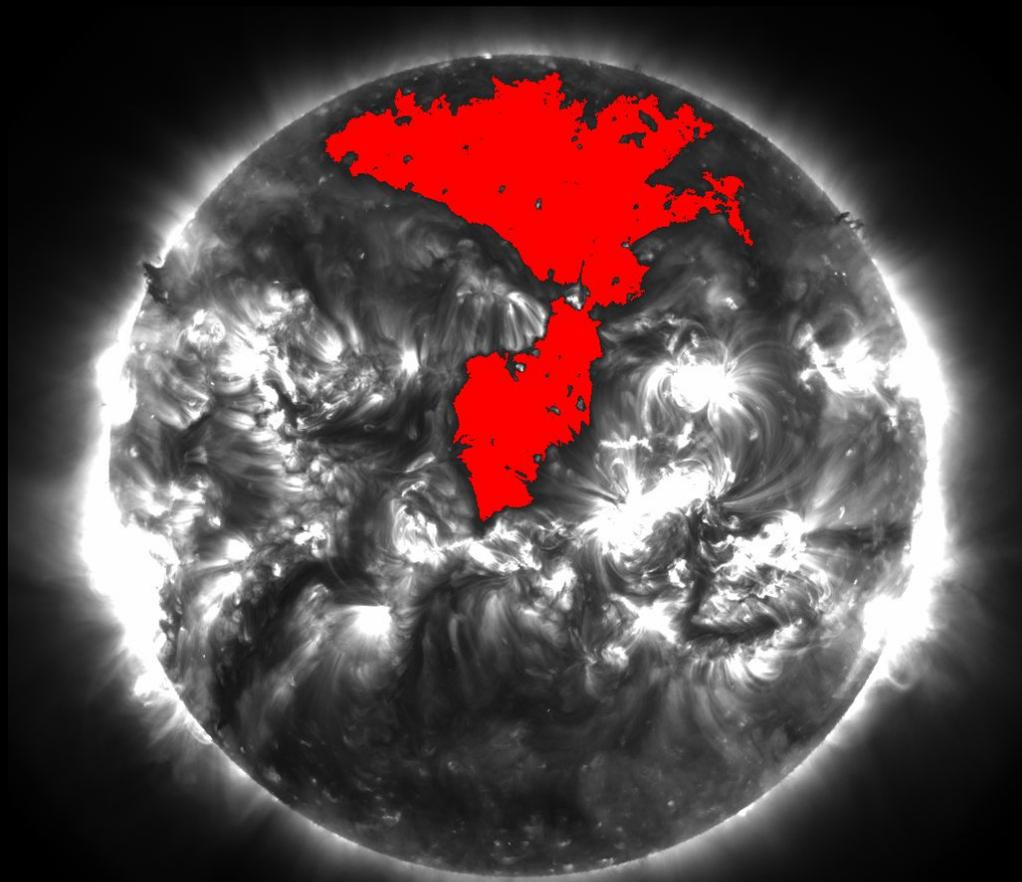
June 2010 to January 2014

Area Calculation



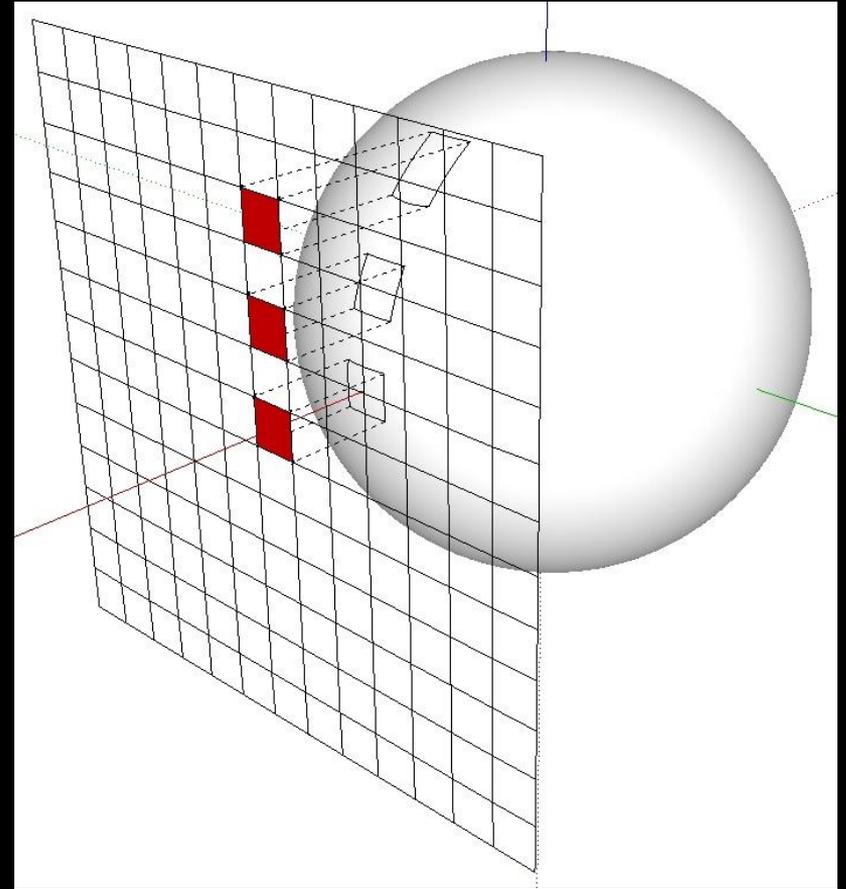
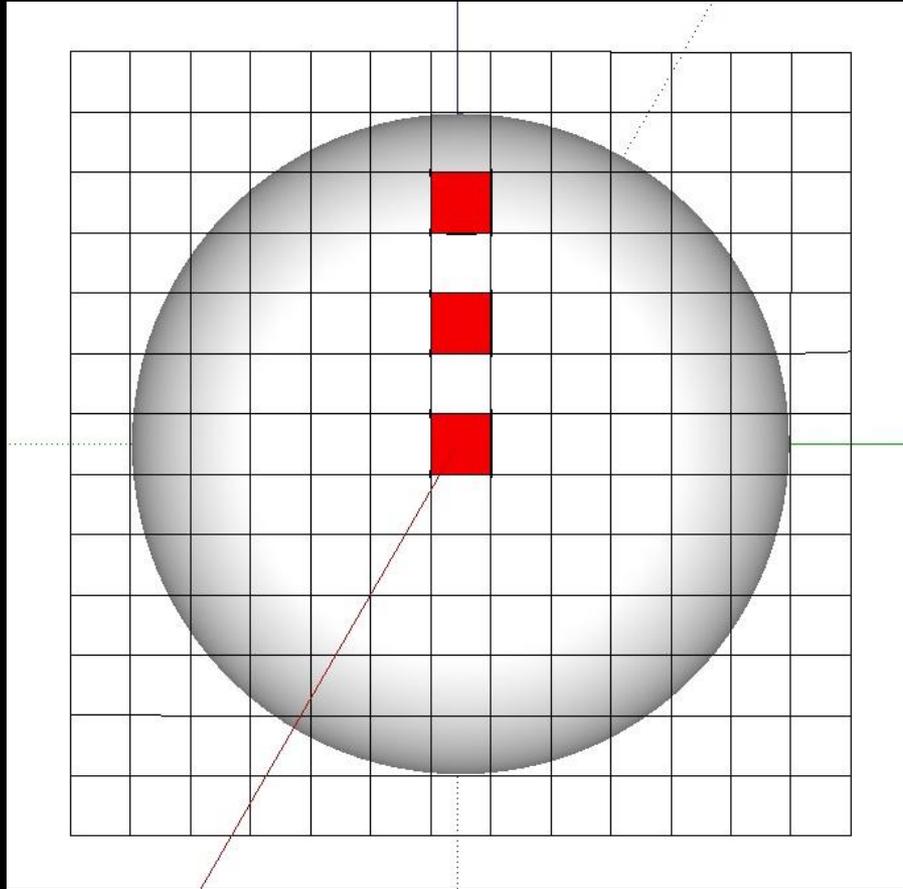
SDO/AIA 195 A

Area Calculation

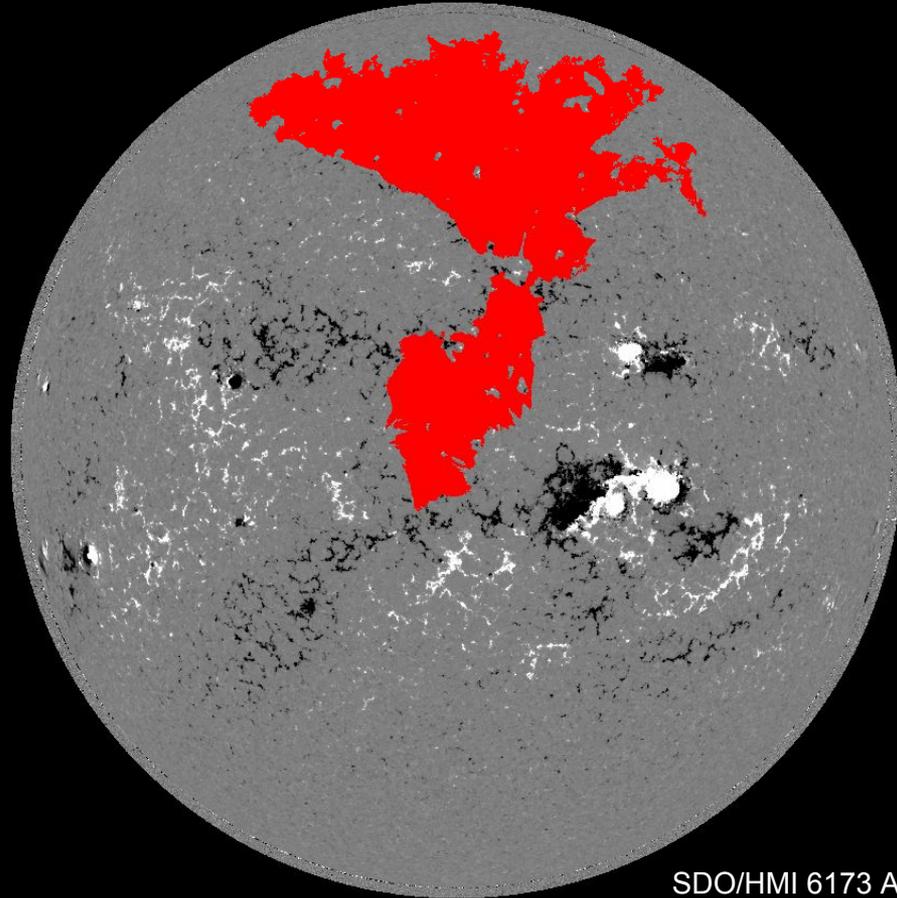


SDO/AIA 195 A

Area Calculation

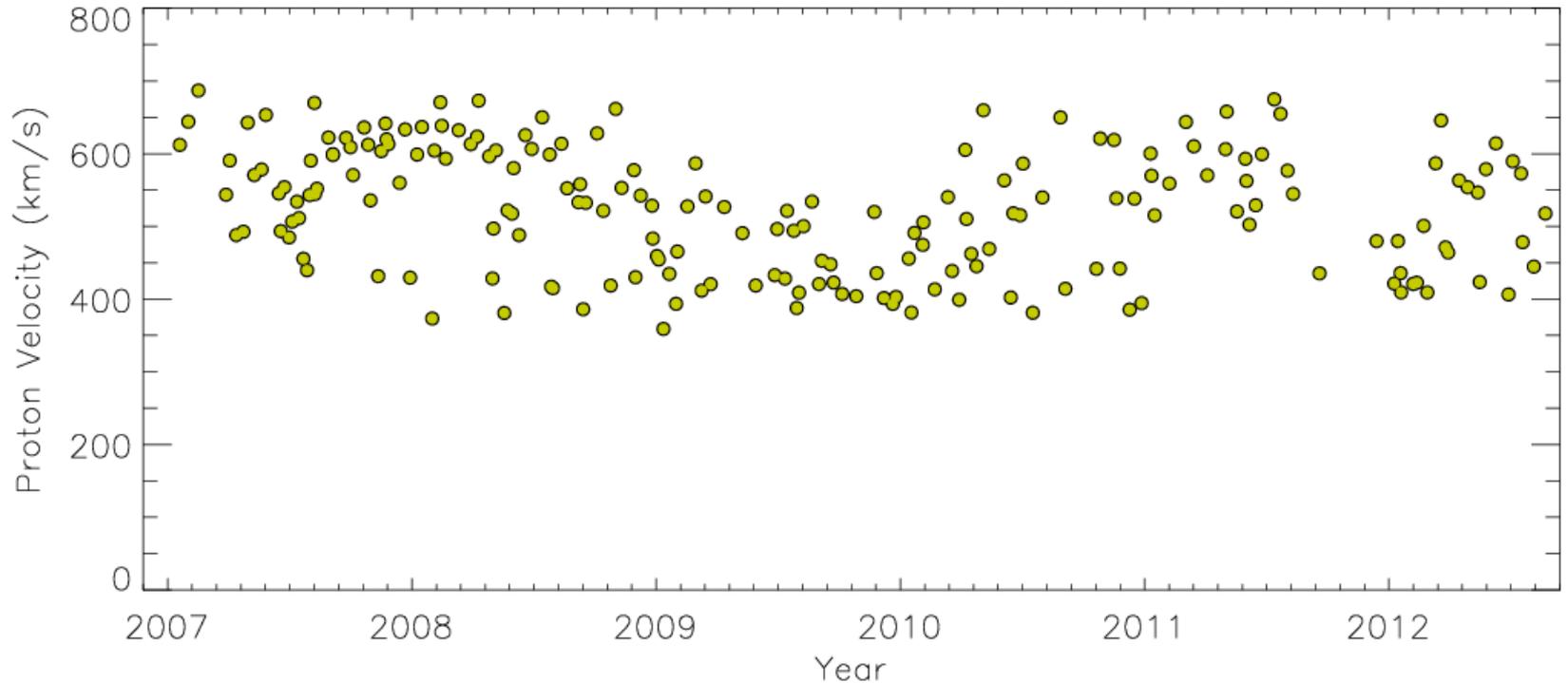


Magnetic Field Calculation

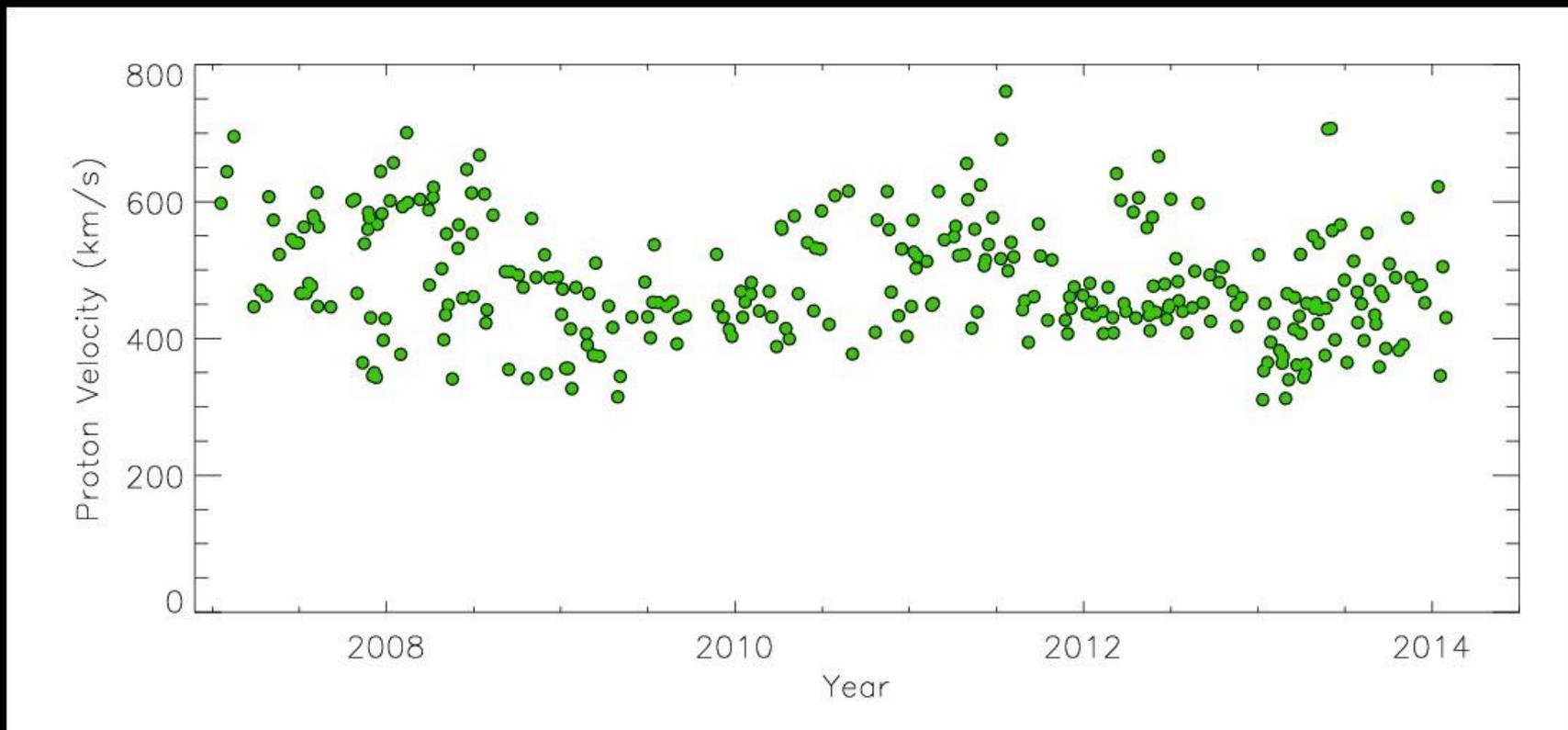


SDO/HMI 6173 A

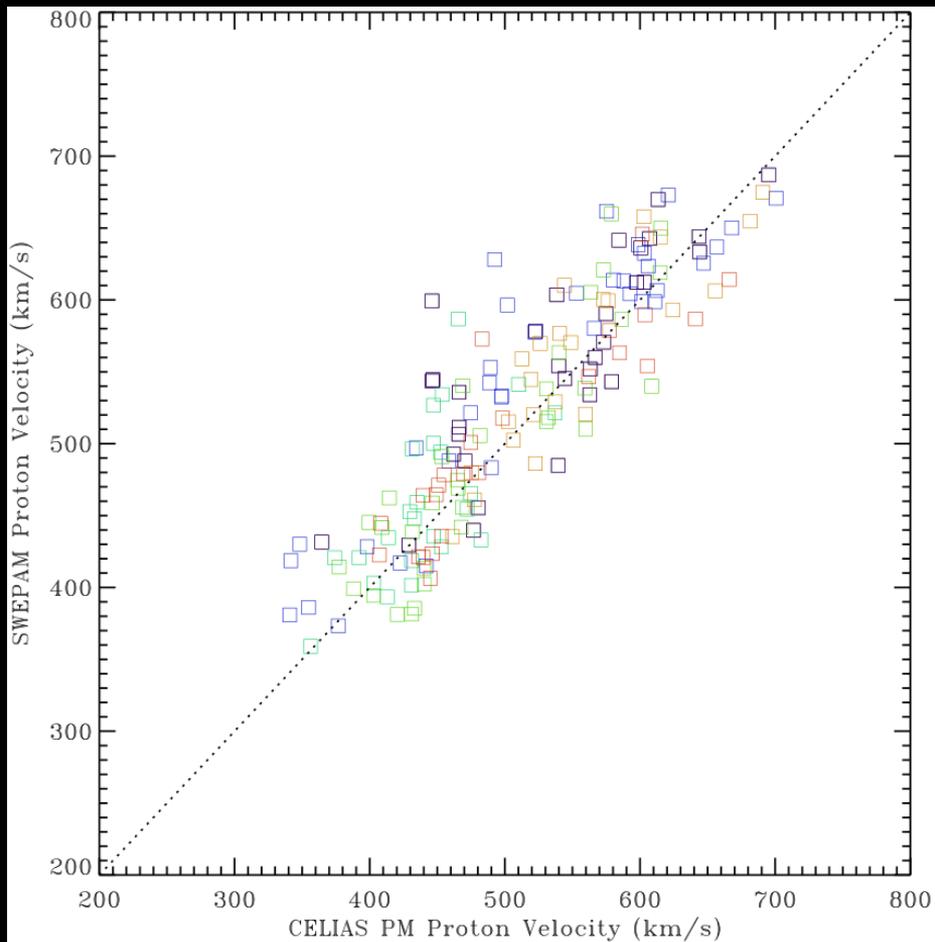
Avg. CH Wind Speed in Solar Cycle 24: ACE/SWEPAM



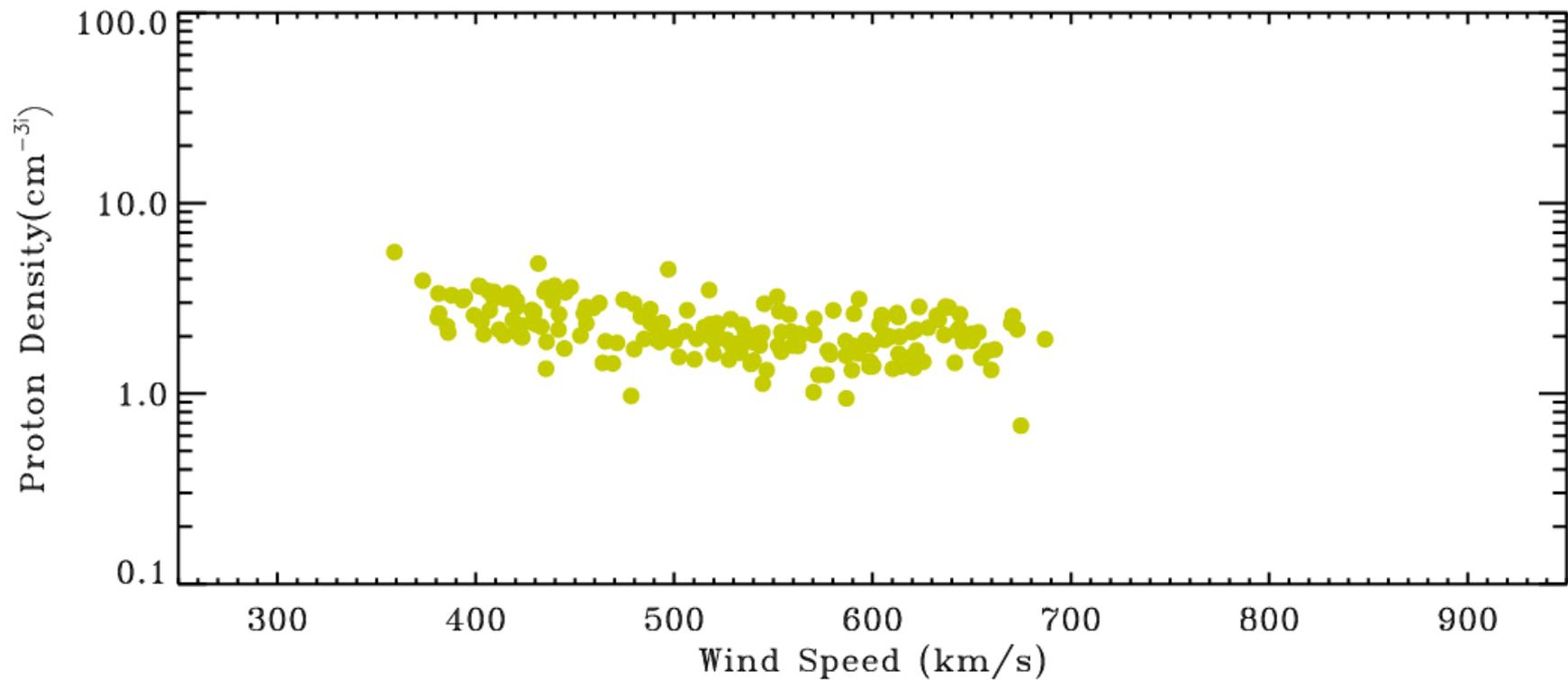
Avg.CH Wind Speed in Solar Cycle 24: SOHO/CELIAS MTOF PM



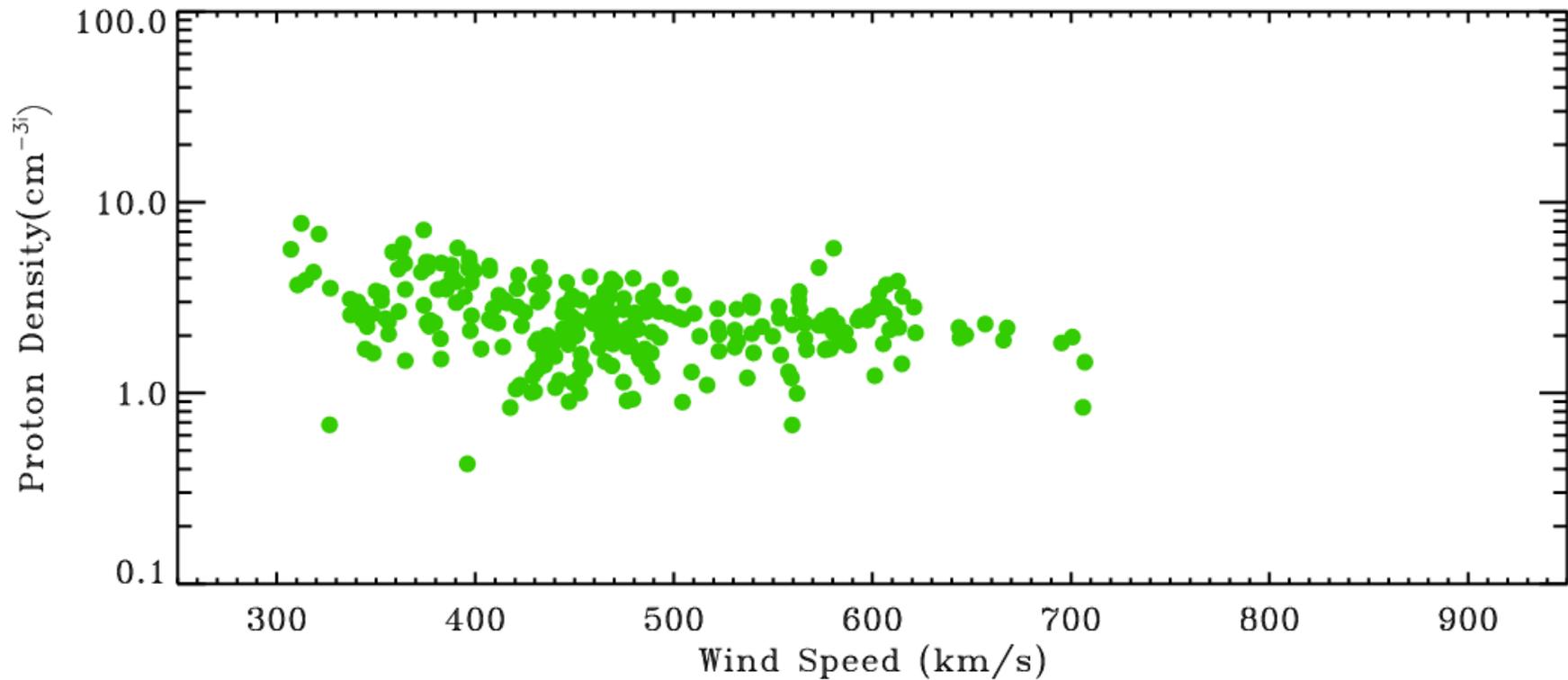
SOHO/CELIAS PM vs. ACE/SWEPAM



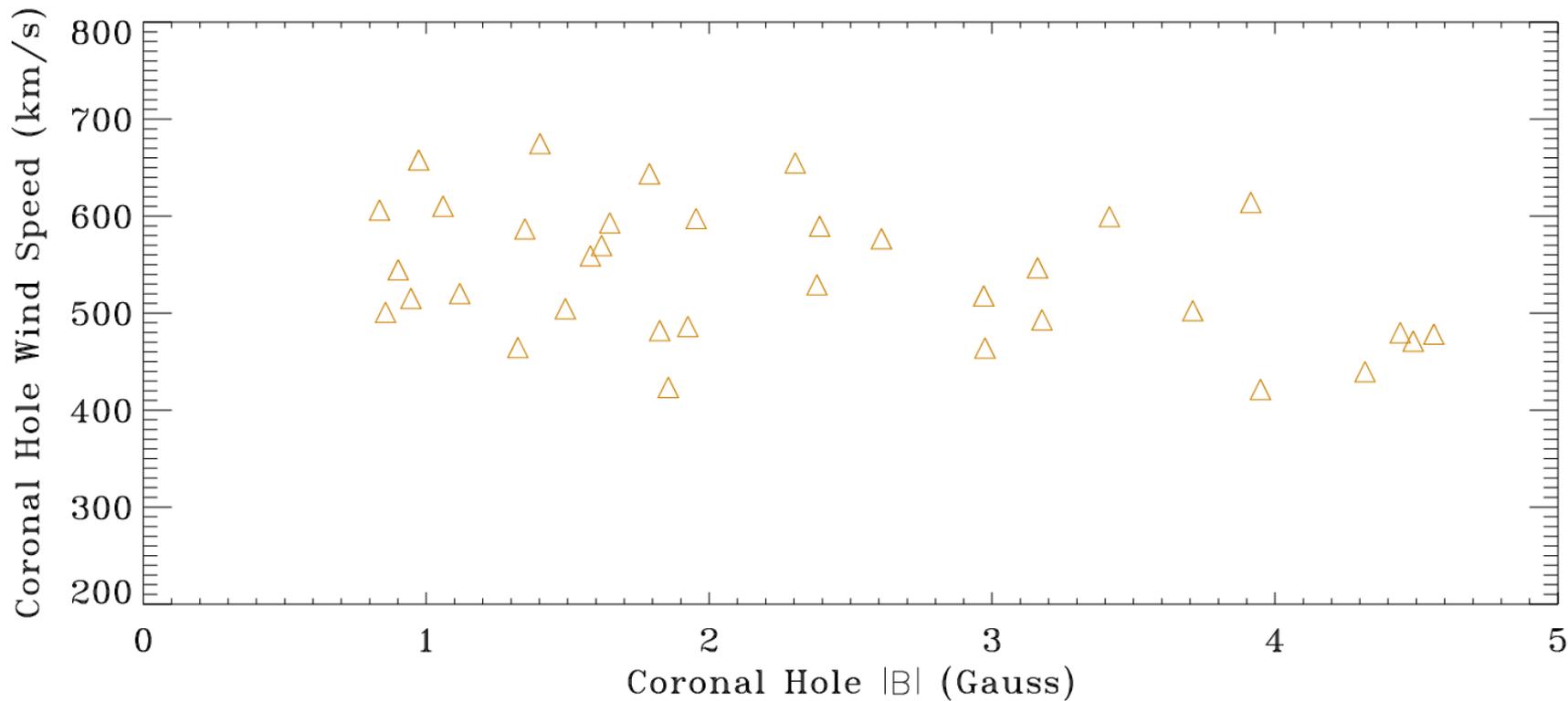
Wind Density vs. Wind Speed: ACE/SWEPAM



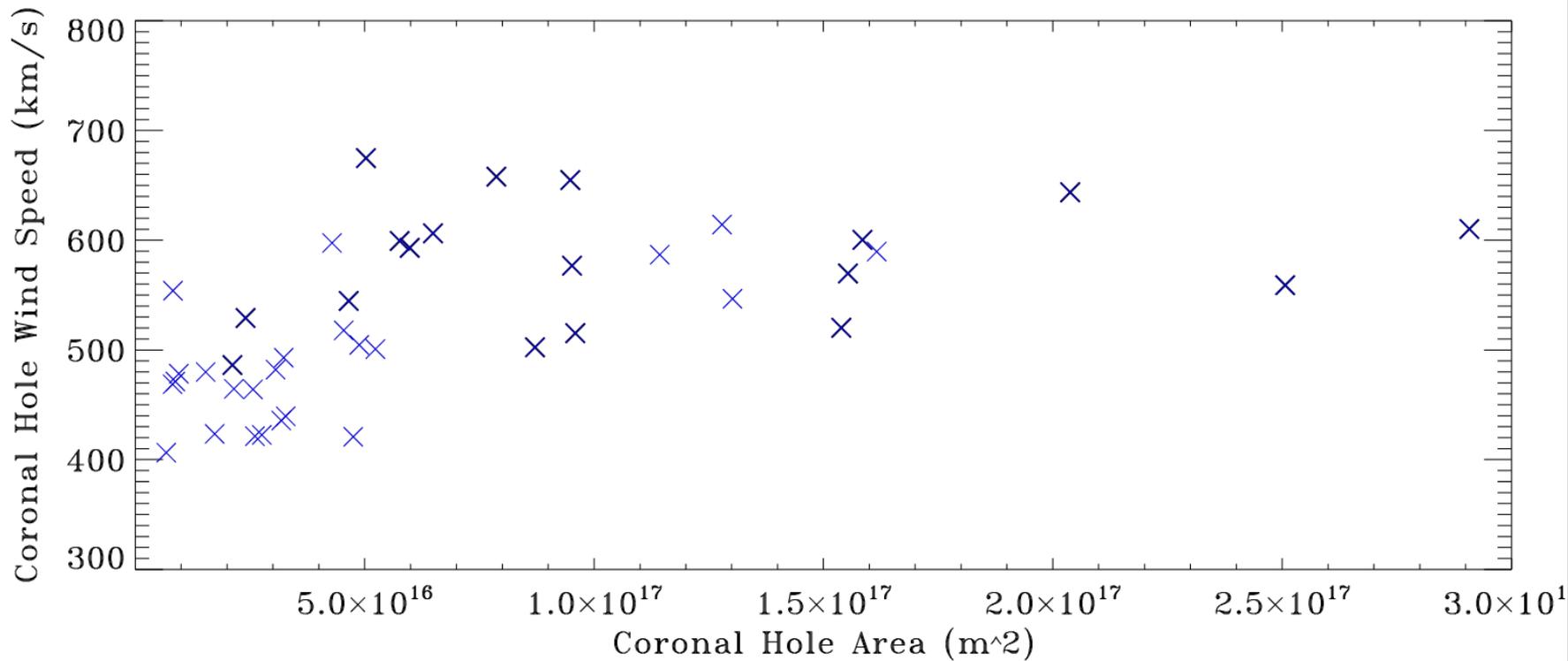
Wind Density vs. Wind Speed: SOHO/CELIAS PM



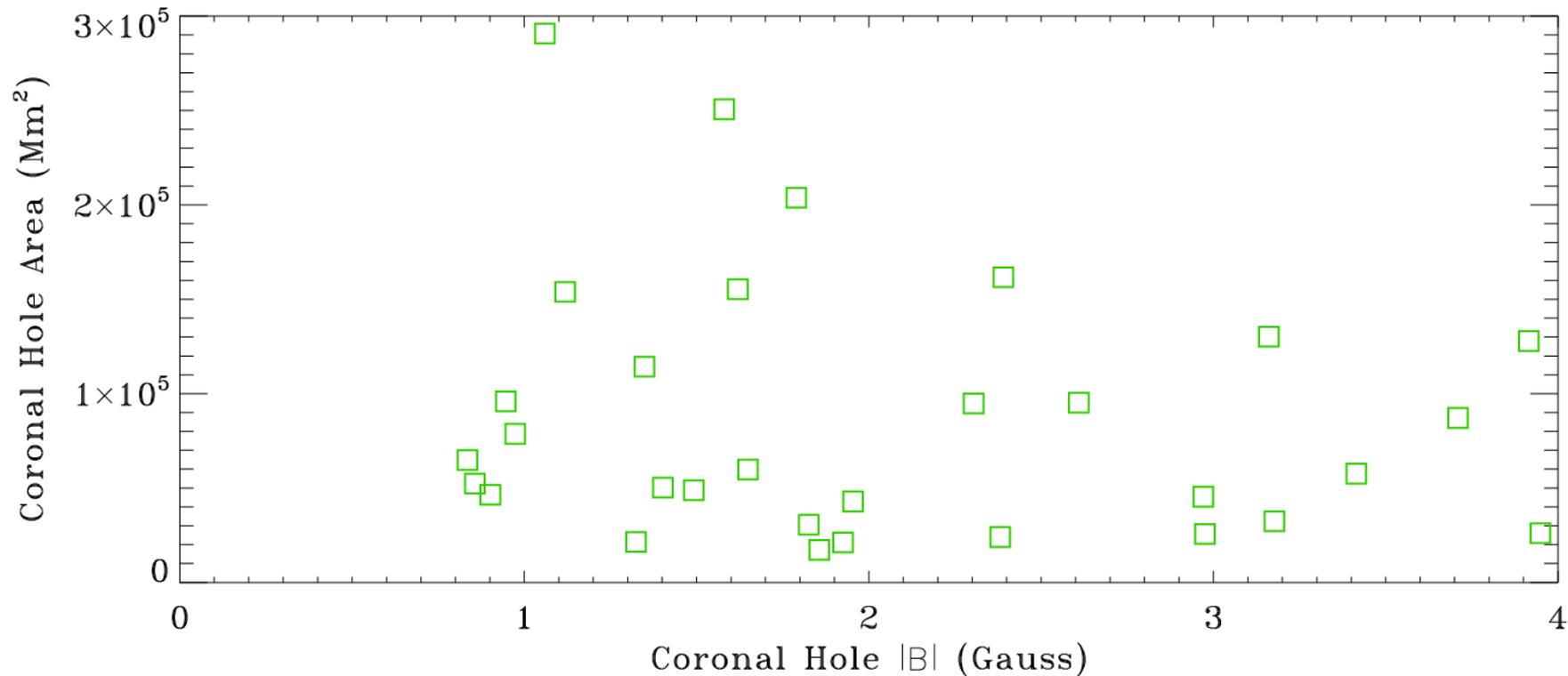
Coronal Hole Wind Speed vs. Line-of-Sight Magnetic Flux



Coronal Hole Wind Speed vs. Coronal Hole Area



Coronal Hole Area vs. Line-of-Sight Magnetic Flux



Summary of Results

Created a catalogue of 691 coronal holes from solar cycle 24. The most complete in existence for the current cycle.

Surveyed area, LOS magnetic flux, wind speed, density, and temperature for 363 of these holes and their associated wind streams.

Found some trends, there seems to be:

Anticorrelation between coronal hole magnetic flux and coronal hole area and wind velocity.

Anticorrelation between coronal hole wind speed and density.

Correlation between CH wind speed and area

Summary and Future work

Equatorial coronal holes in cycle 24 play an important role as sources of solar wind.

During solar minimum (2007-2009): large coronal holes dominated the fast solar wind.

In particular in 2009: smaller holes producing slower wind (< 500 km/s).

During 2010 to now solar maximum: larger coronal holes are present.

Future work will involve the comparison with cycle 23 and theoretical models of solar wind heating and acceleration

Acknowledgments

Prof. Jim Moran

Fellow Astro 99rs!

Dr. Mari Paz Miralles

Questions?