Evolution of the Global Coronal Morphology

Joan Burkepile, Giuliana deToma, Art Hundhausen, Don Kolinski and Leonard Sitongia

High Altitude Observatory, NCAR, Boulder CO
Mauna Loa Solar Observatory

White light images from 1980 to present

http://mlso.hao.ucar.edu

MK4 K-coronameter
White Light Corona: Solar Max

1991

2003
Declining Phase

Solar magnetic axis tilted with respect to solar rotational axis

Hundhausen 1993
Solar Minimum

1986 1996 2008 – Sep ’09
White Light (pB)  1980 to Jan 2009

1.3 Solar Radii

NORTH POLE


1.8 Solar Radii

SOUTH POLE

NORTH POLE

NORTH POLE
At low heights brightest structure over active regions

Sept 7, 2005
At far left: MK4; near left: PSPT CaIIK

2008: Smaller polar holes; Dipole not as dominant

At far left: Jan 1996 MK3
Near left: Jan 2009 MK4
DAILY MEAN IMF POLARITY FROM THE OMNI WEB PAGE

RED: Positive (Away from Sun)
Blue: Negative (Toward Sun)
Yellow: Non-Parker spiral
Brightness Variations

[Graph showing brightness variations over time, with mass in grams on the y-axis and years from 1980 to 2010 on the x-axis. The graph includes two plots: one with raw data and another with smoothed data over 27 points.]
Solar Cycle variation in mass of corona between 1.2 and 2.2 solar radii vs. latitude

TOTAL CORONA:  
- Solar Max: $2.5 \times 10^{17}$ g
- Solar Min: $5 \times 10^{16}$ g

- Factor of 5  Total Corona
- Factor of 3  Equator  $+/- 22.5^\circ$
- Factor of 7  22.5° to 67.5°
- Factor of 10 Polar regions $> 67.5^\circ$
Estimate Mass of Corona

Mauna Loa measurements begin at 1.2 solar radii:

• Above first two coronal scale heights
• Account for polarization brightness Thomson scattering function

Solar Maximum: \[ 2.5 \times 10^{17} \times e^2 / 0.3 = 6.2 \times 10^{18} \text{ g} \]

Solar Minimum: \[ 5. \times 10^{16} \times e^2 / 0.3 = 1.2 \times 10^{18} \text{ g} \]
Solar Maximum: $6.2 \times 10^{18}$ g
Solar Minimum: $1.2 \times 10^{18}$ g

Solar wind mass loss per day $\sim 10^{17}$ g

CMEs: Avg CME mass $5 \times 10^{15}$ g
Solar max: $5 / \text{day} = 2.5 \times 10^{16}$ g
Solar min: $0.5 / \text{day} = 2.5 \times 10^{15}$ g

Boundary condition at top of chromosphere:

Solar max: $8. \times 10^{-5}$ g/cm$^2$

Solar min: $1.9 \times 10^{-5}$ g/cm$^2$

*Anderson and Athay 1989* column mass top of chromosphere
$\sim 6 \times 10^{-6}$ g/cm$^2$
Coming in 2012: The Next Generation Mauna Loa Coronagraph

10 x better signal to noise: Detect HALO CMEs, coronal waves, radial density profiles in coronal holes (coronal heating, solar wind acceleration)

15 x better temporal resolution: New CME dynamics, coronal waves (New: 15 sec Current: 3min.)

Field-of-view down to 1.05 solar radii:

2D detector – New, uniform spatial resolution

Current instrument is at end of its lifetime (30 years old)

See Don Kolinski’s poster for more information
Conclusions

• Brightness changes from max to min
• Coronal mass changes 5x over cycle
• Brightest structures over active regions
• Cycle 23:
  – Max and min brightness similar to Cycle 22
  – Longer (periodic) declining and min phase
  – May never reach a simple dipole coronal configuration
  – Implications for solar wind: Less drift in IMF sector structure; more tilted heliospheric current sheet