Polar Faculae: A Proxy for the Evolution of the Solar Polar Field During the Last 100 Years

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THE SOLAR CYCLE
Current Understanding
Discovered by Schwabe (1843) while trying to find an intra-mercurial planet.

- Alternating peaks in solar activity (maxima), followed by quiet periods (minima).
- Time variation is predominantly cyclic, mean period is 11 years.
The Solar Cycle in a Nutshell

Poloidal $r - \theta$

Toroidal $\phi$
The Solar Cycle in a Nutshell

Poloidal: \( r - \Theta \)  

Toroidal: \( \phi \)

Differential Rotation

Credit: J. J. Love
The Solar Cycle in a Nutshell

Poloidal $r - \Theta$

Toroidal $\phi$

Differential Rotation
Active Region Emergence and Decay
UNDERSTANDING LONG-TERM SOLAR VARIABILITY
A problem of data
We have an imbalance in long-term observations...

Poloidal \( r - \theta \)

Toroidal \( \phi \)

- **400 Yrs** Sunspot numbers
- **150 Yrs** Sunspot Areas
- **40 Yrs** Magnetic Data

- **40 Yrs** Magnetic Data
So for all practical purposes we have been studying only half a system:

We need a proxy that can allow us to better establish the connection between the toroidal and poloidal phases of the solar cycle.
SOLAR FACULAE
And their associated magnetic fields
Photospheric patches which are brighter than the surrounding quiet Sun.
They are easier to observe near the limb

Credit: B. De Pontieu
They are believed to be associated with concentrations of magnetic field.

Spruit 1976; 1977; Keller et al. 2004
Can be used to estimate solar polar fields

SOHO/MDI Intensigram

SOHO/MDI Magnetogram
Can be used to estimate solar polar fields

SOHO/MDI Intensigram

SOHO/MDI Magnetogram
NEIL SHEELEY’S FACULAR DATA
An invaluable treasure
“A very good example of how to minimize observational biases”

H. W Babcock

- Using plates for daily integrated sunlight of the Mount Wilson Observatory.
- Best plates were chosen to maximize polar coverage (Feb-Mar for South and Aug-Sep for North).
- Plates were marked and then randomized in time and orientation.
- Polar Faculae were counted by hand and averaged for each time interval.
Neil’s Observational Campaigns

- 1906-1964 (Sheeley 1966)
- 1960-1975 (Sheeley 1976)
- 1975-1990 (Sheeley 1991)
- 1985-2007 (Sheeley 2008)
Calibrating the data

- There is a systematic underestimation of faculae from one campaign to the next one.
- We use the slope to cross calibrate campaigns.
Calibrating the data

- There is very good agreement across campaigns once the calibration is applied.
Comparing to magnetic field measurements

- We compare the facular series with 40 years of Wilcox Solar Observatory data.
- We find very good agreement between the time evolution of polar faculae numbers and polar field strength.
WHAT COMES NEXT...

Future work
Remaining Issues

• Polaroid stopped producing the film used by the Wilcox Solar Observatory. This may lead to an underestimation of polar field.

• Independent measurements of polar faculae are useful if one wants to standardize the data-series.
Measuring polar faculae and fields *automatically* with SOHO/MDI
Using Hinode/SOT polar field measurements

Ito et al. 2010
And once we have the database...

- We will combine it with a sunspot area database (for example that of Balmaceda et al. 2009).

- Study the relationship between sunspot group properties during and polar fields.

- Study the long term evolution of both solar maximum and solar minimum together.

- We will finally be able to look at the complete cycle picture.
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