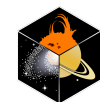


# Workshop Summary & Critique

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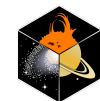


## Overall appreciation

I have not been an active part of the SSN community before and was therefore not aware of the rationale and timeliness of the current SSN Workshop series.

I am impressed to see that **the Workshop series has a clear goal and is close to reaching this goal.**

It was also gratifying to see that a side issue like the **Livingston-Penn claim** of a systematic change of the sunspot properties could be **put to rest**, so that the Workshop could focus on its real goal.



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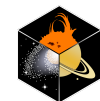
## Why is the SSN series important ?

SSN is an index with considerable subjectivity, depending on manual determinations with small telescopes, so why do we need it ?

**Analogy with the cosmic distance scale:** One needs a ladder of widely different techniques valid in a sequence of partially overlapping regimes.

Similarly to explore the **history of solar variability** we need a **ladder** of overlapping regimes **that connect the present physical parameters** (TSI, magnetograms, UV radiance, etc.) **with the distance past**. The time scale from the present back to Galileo can only be bridged by the SSN, which in turn allows the ladder to be continued by isotope methods, etc.

SSN should be presented and justified in this context, not in isolation.



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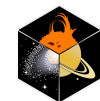


## Primary goal (as I see it)

- **Transform the current SSN time series**, from Galileo to the present time, to a scale that is homogeneous in terms of counting criteria (those of Wolf and Wolfer) and has no  $k$  factor (i.e.,  $k = 1$ ).
- The transformed time series will not be called “International Sunspot Number” any more, but the “**Wolf number**”.

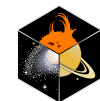
$$W = 10 G + S .$$

- While  $W$  should be used by the international community as the reference solar activity index, other counting methods (spot weighting) and proxies will be explored in parallel, and their correlations with the  $W$  number will be studied.
- We are grateful to Leif Svalgaard for his magnificent and thorough exploration of previous counting methods and putting his finger on the problem areas, identifying what will be needed to eliminate these problems and letting us see the way to move forward.



## Rationale and criteria how to define $W$

- Use as few rules as possible.
- Maximize transparency and simplicity.
- Minimize subjectivity.
- Optimize consistency with the counting method defined by Wolf and Wolfer.  
This implies giving each spot weight 1, but in large spots with multiple distinct umbrae count the umbrae as separate spots. Keep Wolf's convention of multiplying the group number by 10 and adding the spot number without weights.
- Set  $k = 1$  (since  $k = 0.6$  is a confusing historical artifact) to make the meaning of the sunspot number better understood and logical.



## Future beyond the establishment of the Wolf number

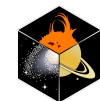
While spot weight 1 should be used for the new Wolf number, it may be useful to continue in parallel to also count with weighted numbers, for comparison. Comparison with AAVSO remains of interest.

Errors in the group number may be reduced by making use of magnetic-field data.

To improve our understanding of the physical role and meaning of the Wolf number, one should explore its correlation with various types of proxies.

Examples of such proxies:

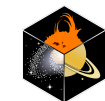
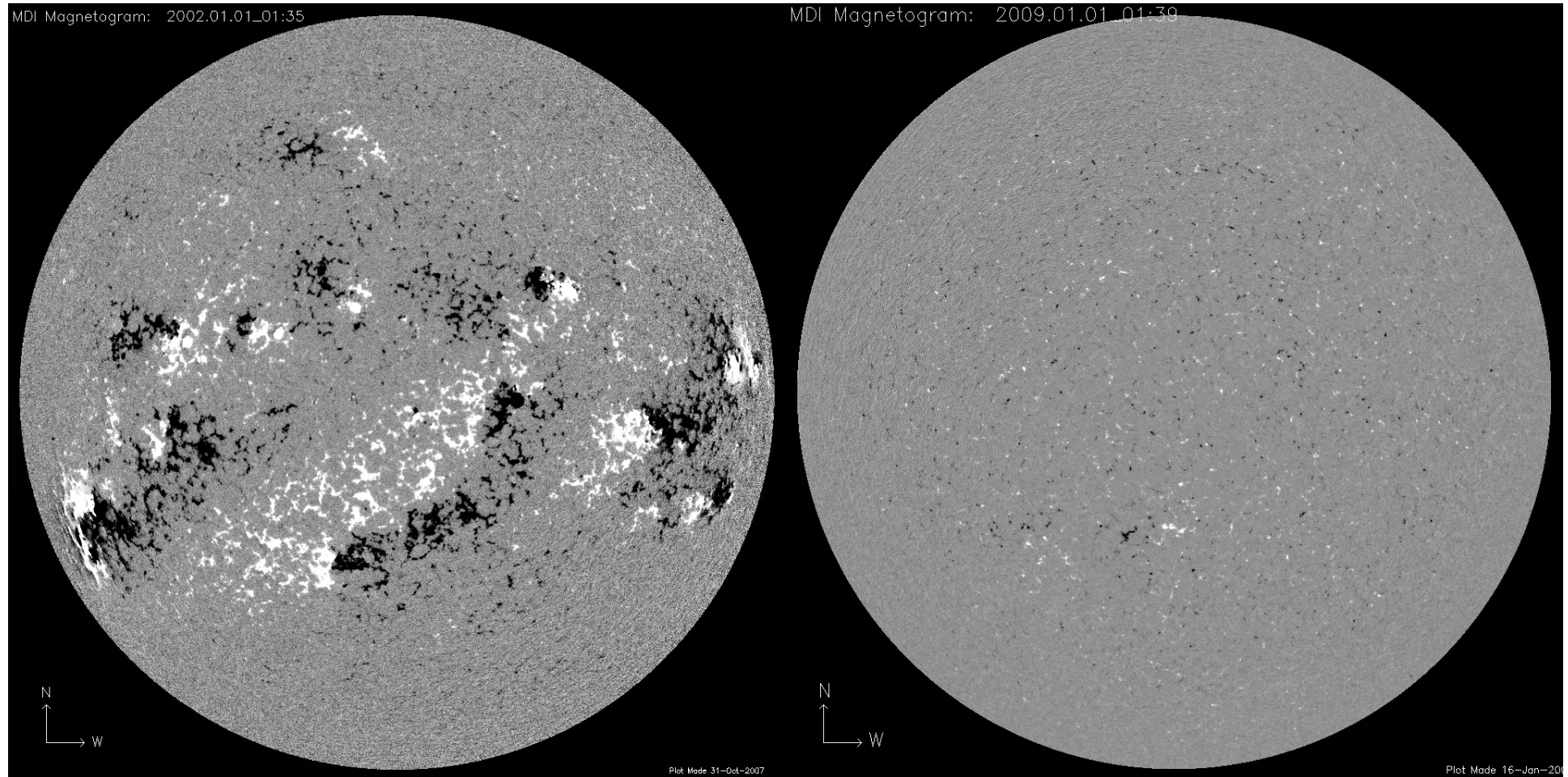
- Average unsigned magnetic flux
- Ca H&K chromospheric emission
- 10 cm radio flux
- Geomagnetic indices



**Example of physical proxy:**  
The Sun's global magnetic pattern  
is closely related to the sunspot number

2002

2009



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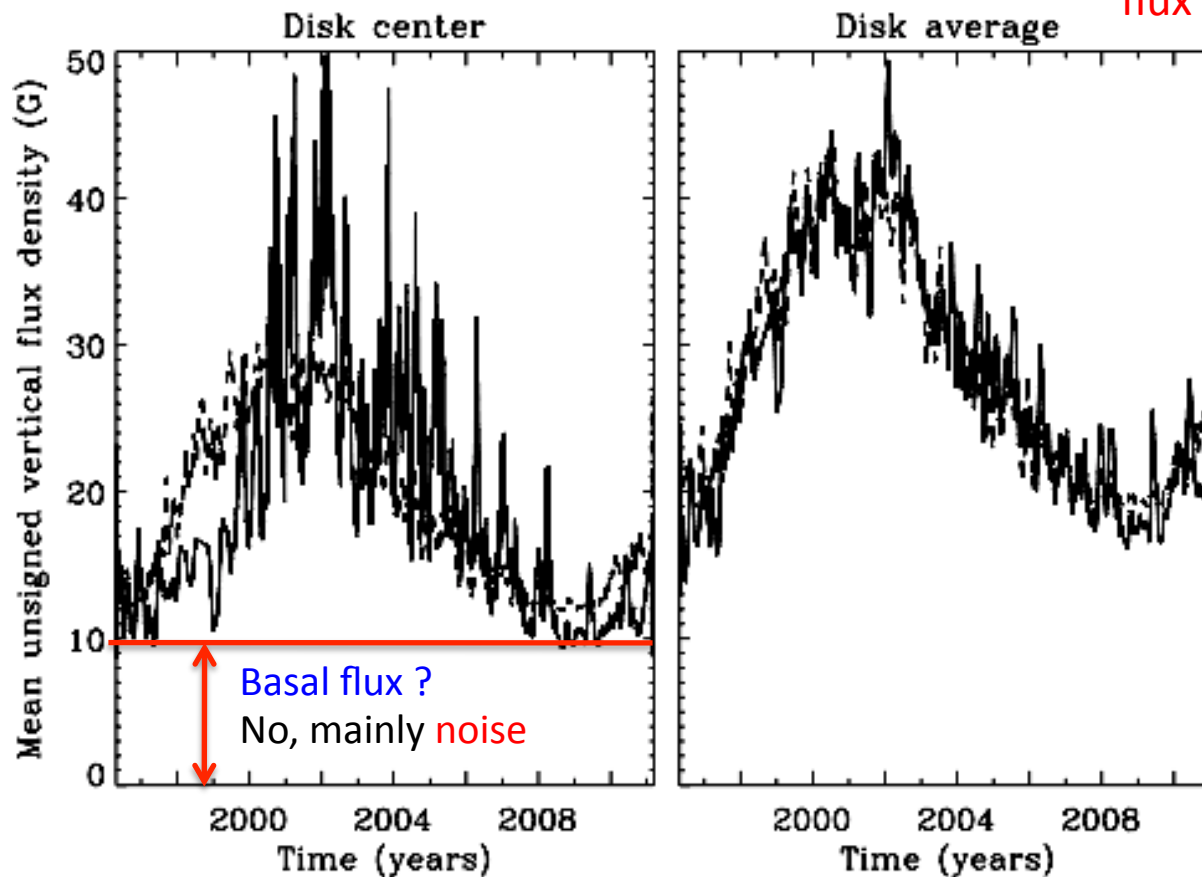




Solid curves: Monthly average of the unsigned vertical flux density  $|B_v|$ , averaged over a circular region around disk center with radius  $r$  (in units of the radius of the solar disk)  $< 0.1$  (left panel) and  $< 0.9$  (right panel).

The dashed curve is the second-order fit function in terms of the sunspot number  $R_z$ ,  $b_0 + b_1 R_z + b_2 R_z^2$ , where  $b_0$  represents the average unsigned flux density in the absence of sunspots.

There is a nearly one-to-one relation between the disk-averaged unsigned flux density and the sunspot number.



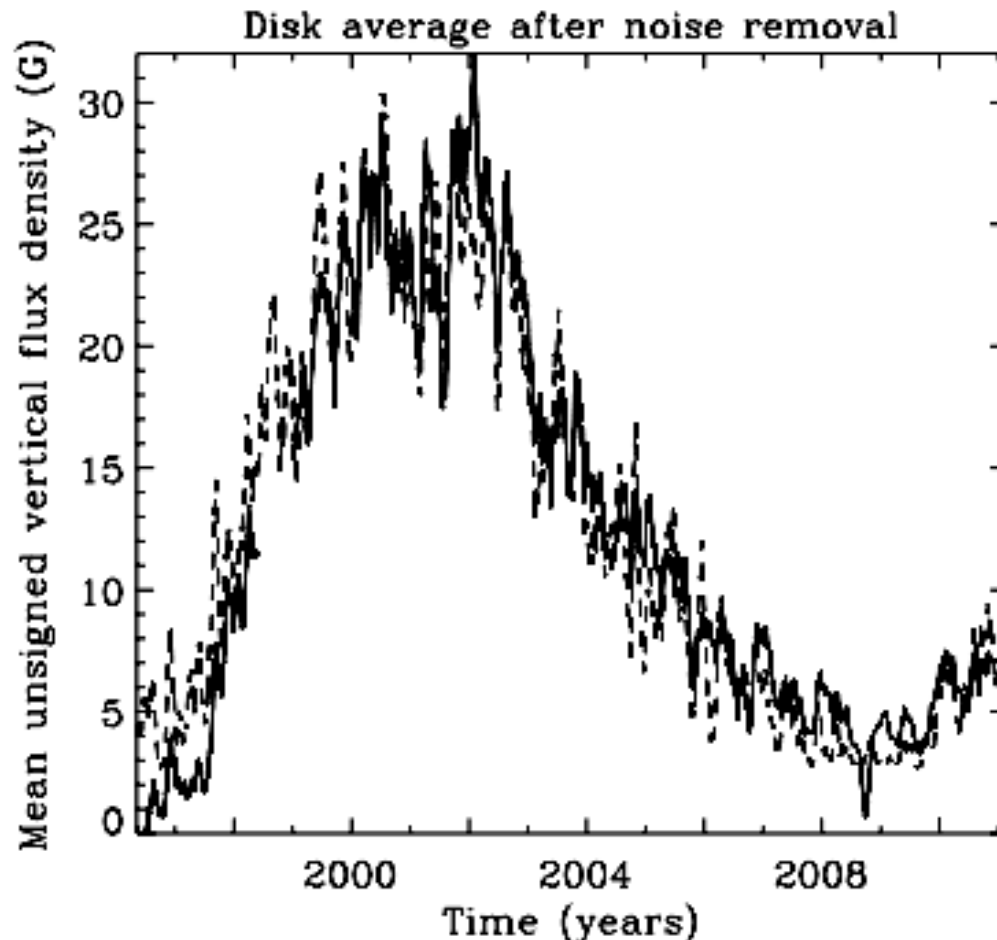
The flux curve is shifted upwards by about 10 G due to noise in  $|B_v|$ , implying that the minimum (basal) flux is probably close to zero.



## Cycle variation of the unsigned flux density after noise removal

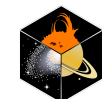
Solid curve: Monthly average of the unsigned vertical flux density  $|B_v|$ , averaged over a circular region around disk center with radius  $r$  (in units of the radius of the solar disk)  $< 0.9$ , after the noise contribution has been removed.

The dashed curve is the second-order fit function in terms of the sunspot number  $R_z$ ,  $b_0 + b_1 R_z + b_2 R_z^2$ , where  $b_0$  represents the average unsigned flux density in the absence of sunspots.



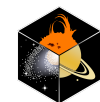
Coefficient  $b_0$ , which represents the basal flux density in the absence of sunspots, is **2.7 G**.

At activity maximum there is 10 times more flux on the Sun than the basal level

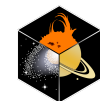


This example shows that the average unsigned vertical magnetic flux density has a remarkably tight correlation with the sunspot number, but only when we average the magnetogram over the whole solar disk.

The correlation is poor when averaging only over the disk center region. The global magnetic field properties are essential, although the sunspots only occupy small fractions of the solar surface.



Many thanks to SOC for planning this focused and successful Workshop series, and to LOC (Renzo, Michele and all the support staff at IRSOL and Specola) for a perfect organization, including the enjoyable excursions and the Social Dinner !



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