

4th Sunspot Number Workshop Locarno, Switzerland, 19-23 May 2014

# Why the Sunspot Number Needs Re-examination

E.W. Cliver National Solar Observatory Sunspot, NM 88349

# It's used

### Evolution of the solar irradiance during the Holocene\*,\*\*

L. E. A. Vieira<sup>1,2</sup>, S. K. Solanki<sup>1,3</sup>, N. A. Krivova<sup>1</sup>, and I. Usoskin<sup>4</sup> (2011)

We compute the sunspot area, i.e. the fraction of the disk covered by all sunspots on the solar disk, by making use of a linear relationship to the sunspot number (*R*) (*Fligge & Solanki 1997; Balmaceda et al. 2009; Hathaway 2010*):

# Unusual activity of the Sun during recent decades compared to the previous 11,000 years

S. K. Solanki<sup>1</sup>, I. G. Usoskin<sup>2</sup>, B. Kromer<sup>3</sup>, M. Schüssler<sup>1</sup> & J. Beer<sup>4</sup>





## Cyclic loss of open solar flux since 1868: The link to heliospheric current sheet tilt and implications for the Maunder minimum

M.J. Owens<sup>1,2</sup>, M. Lockwood<sup>1</sup>

(2012)

Observed <sup>10</sup>Be (Linear) 12 <sup>10</sup>Be (3rd order) <sup>4</sup>C (Linear) 10 <sup>4</sup>C (3rd order) OSF [x10<sup>14</sup> Wb] Model  $[S_{10} = \phi(R + 10)]$ 8 0 1650 1700 1750 1800 1850 1900 1950 2000

... we use the cyclic variation of the fractional open solar flux (OSF) loss rate with sunspot number to reconstruct OSF back to 1610.

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#### MODELING THE SUN'S MAGNETIC FIELD AND IRRADIANCE SINCE 1713

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... we now take the flux emergence rate to be proportional to the observed yearly sunspot numbers

### Waldmeier relations and the solar cycle dynamics by the mean-field dynamos

#### V.V. Pipin<sup>1</sup>, D.D. Sokoloff<sup>2</sup> and I.G. Usoskin<sup>3</sup>

<sup>1</sup>Institute of Solar-Terrestrial Physics, Russian Academy of Sciences, Irkutsk, 664033, Russia, email: pip@iszf.irk.ru <sup>2</sup>Dept. of Physics, Moscow State University, Moscow, 119991, Russia, email: sokoloff.dd@gmail.com <sup>3</sup>Department of Physics, University of Oulu, Oulu, 900014, Finland, email: ilya.usoskin@oulu.fi (2012)

Abstract. The long-term variability of the sunspot cycle, as recorded by the Wolf numbers, are imprinted in different kinds of statistical relations which relate the cycle amplitudes, duration and shapes. This subject always gets a special attention because it is important for the solar activity forecast. We discuss statistical properties of the mean-field dynamo model with the fluctuating  $\alpha$ -effect. Also, we estimate dynamical properties of the model for the long and short time-scale and compare it with the dynamics of the sunspot numbers data sets. The various incarnations of the sunspot number time series (monthly SSN, 13-month smoothed SSN, yearly SSN, etc.) are arguably the most intensely studied time series in astrophysics, As measured by the number of published research paper pages per data points.

Charbonneau (2010)

### It's used for important applications

- Climate change
- Solar dynamo modeling
- Long-term solar variability



└Unrefereed ■ Refereed



**Publication** Year

# We have two sunspot numbers



Hoyt & Schatten (1994)

With no consensus on which is more accurate

- Vieira et al. (2011) | (1700-present); G (1610-1700)
- Solanki et al. (2004) G (1610-present)
- Owens et al. (2012) G (1610-1995); (1996-present)
- Wang et al. (2005) **G** (1713-1996)
- Pipin et al. (2013) (1750-present)

A long-term term parameter is needed to tie space-age measurements of solar & solar wind activity to the cosmogenic nuclide data from tree-rings (14C) and ice cores (10Be)

- Sunspot number (since 1610)
- Geomagnetic data (since ~1840)

### Goals of the SSN Workshops workshop

- Reconcile the International and Group SSN series
- Publish a vetted and agreed upon single SSN time series with error bars
- Document tools that can be used to keep track of the SSN for the foreseeable future (regular ionospheric variation, F10, sunspot area)

### Progress is being made ...

- Related efforts (Svalgaard, Lockwood, Beer) ISSI Team
- Independent efforts: Leussu et al. (2013); Lockwood et al. (2014)
- Historical Archive of Sunspot Observations (HASO), hosted by the Library of the University of Extremadura
- Method for maintaining SSN homogeneity based on sunspots
- Preliminary 1610-present series

### Workshop ground rules

- Schedule is fluid
- Ask questions anytime