Sunspot Area Measurements from Debrecen

Testing the Sunspot Number with Detailed Datasets

András LUDMÁNY, Judit MURAKÖZY

and the Debrecen team:
Tünde BARANYI, Lajos GYŐRI, Marianna KORSÓS, Norbert GYENGE

Research Centre for Astronomy and Earth Sciences, Hungarian Academy of Sciences
Heliophysical Observatory, Debrecen, Hungary

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Possible checking of hidden trends in the sunspot number dataset by means of detailed sunspot datasets containing information on individual spots.

- GPR - Greenwich Photoheliographic Results, 1874-1976
  spots only for three decades (in printed form)

- Kislovodsk sunspot dataset (not used here),

- DPD - Debrecen Photoheliographic Data, since 1977

- SDD – SOHO/MDI-Debrecen sunspot Data (1996-2010)

- Historical solar images

Next slides: brief introductions of these datasets

DPD: 1977-2012, all spots and groups, on a daily basis, no magn. data

Debrecen Photoheliographic Data

Győri, L., Baranyi, T., Ludmány, A.

If the DPD data are used in any publications, please refer to this paper:
Győri, L., Baranyi, T., Ludmány, A., Photospheric data programs at the Debrecen Observatory, Proc. IAU Symp., 273, 403-407, 2011.

1. Introduction

The Debrecen Photoheliographic Data (DPD) sunspot catalogue is compiled as a continuation of Greenwich Photoheliographic Results (GPR). This program has been commissioned by the International Astronomical Union. The basic data in a sunspot catalogue are the heliographic positions and the areas of the sunspots. The data are supplemented with images of sunspot groups, scans of full-disk white-light observations, and magnetic observations as well as their user-friendly HTML presentation. The catalogue is mainly based on our own (Debrecen and Gyula) full-disk white-light observations but gaps in this time series are filled by solar images from other observatories.

Description of the data: DPDformat.txt and README.txt.

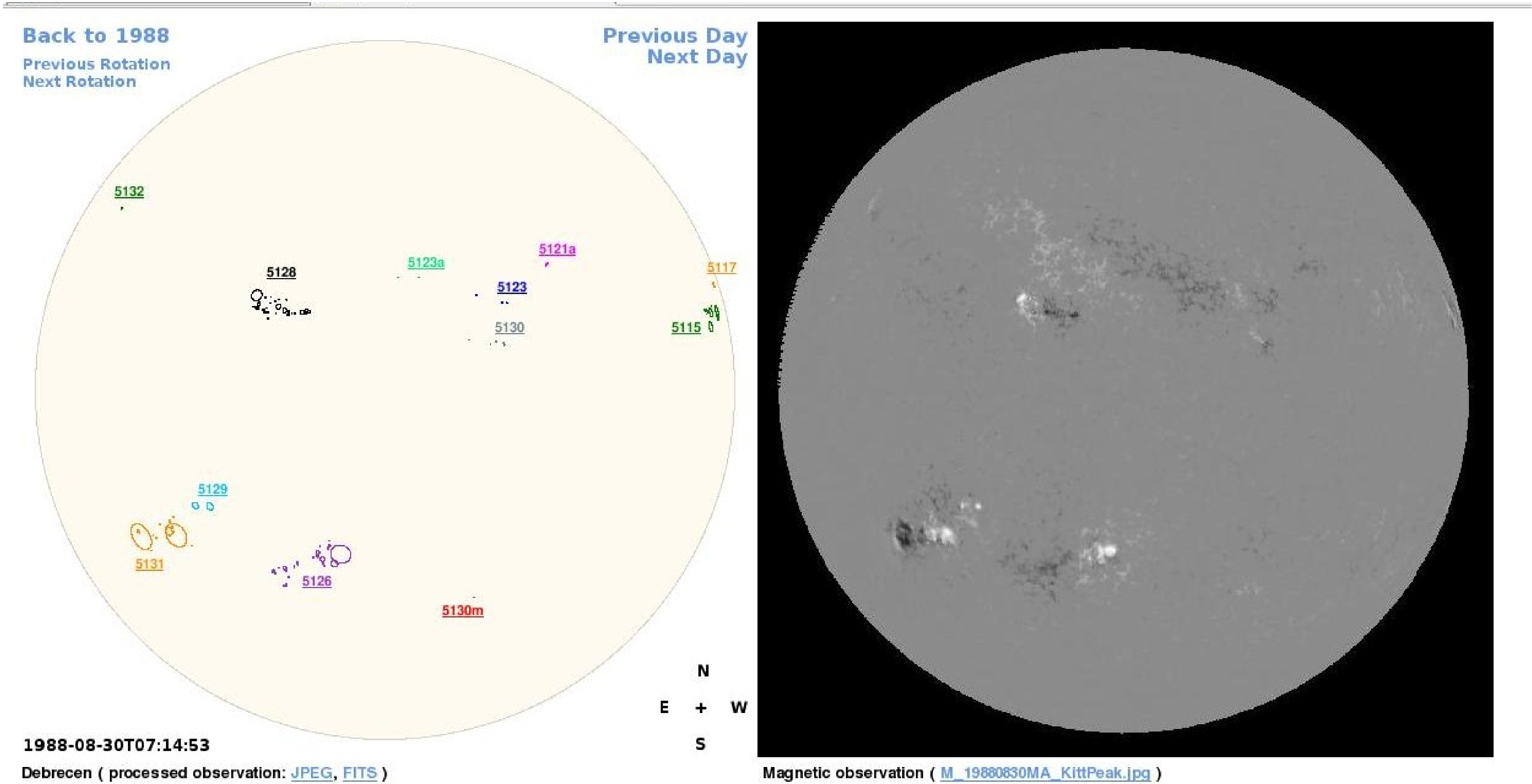
Sunspot data and images of DPD are now available for the following years (with its status and the date of the last modification) (see also the *Table of data availability*):

-	-	-	-	in progress	in progress	in progress	1977 preliminary incomplete 2012-05-23	1978 preliminary incomplete 2012-03-14	1979 preliminary incomplete 20[illegible]-01-04
1980 preliminary incomplete 2012-06-01	1981 preliminary incomplete 2011-04-10	1982 preliminary incomplete 2012-06-04	1983 preliminary incomplete 2012-06-06	1984 preliminary incomplete 2012-05-29	1985 preliminary incomplete 2011-06-27	1986 final complete 2010-07-21	1987 final complete 2010-07-21	1988 final complete 2010-07-21	1989 preliminary complete 2012-07-03
1990 preliminary incomplete 2010-07-21	1991 preliminary incomplete 2010-07-21	1992 preliminary incomplete 2010-07-21	1993 final complete 2010-07-21	1994 final complete 2010-07-21	1995 final complete 2010-07-21	1996 final complete 2010-07-21	1997 final complete 2010-07-21	1998 final complete 2010-07-21	1999 final complete 2011-06-04
2000 preliminary complete 2010-07-21	2001 preliminary complete 2012-06-08	2002 preliminary complete 2010-07-21	2003 preliminary complete 2010-07-21	2004 preliminary complete 2011-01-09	2005 preliminary incomplete 2010-08-23	2006 final complete 2011-01-04	2007 final complete 2010-07-21	2008 final complete 2010-07-21	2009 final complete 2010-07-21
2010 preliminary complete 2011-08-26	2011 preliminary incomplete 2012-02-17	2012 preliminary incomplete 2013-01-07	2013 preliminary incomplete						

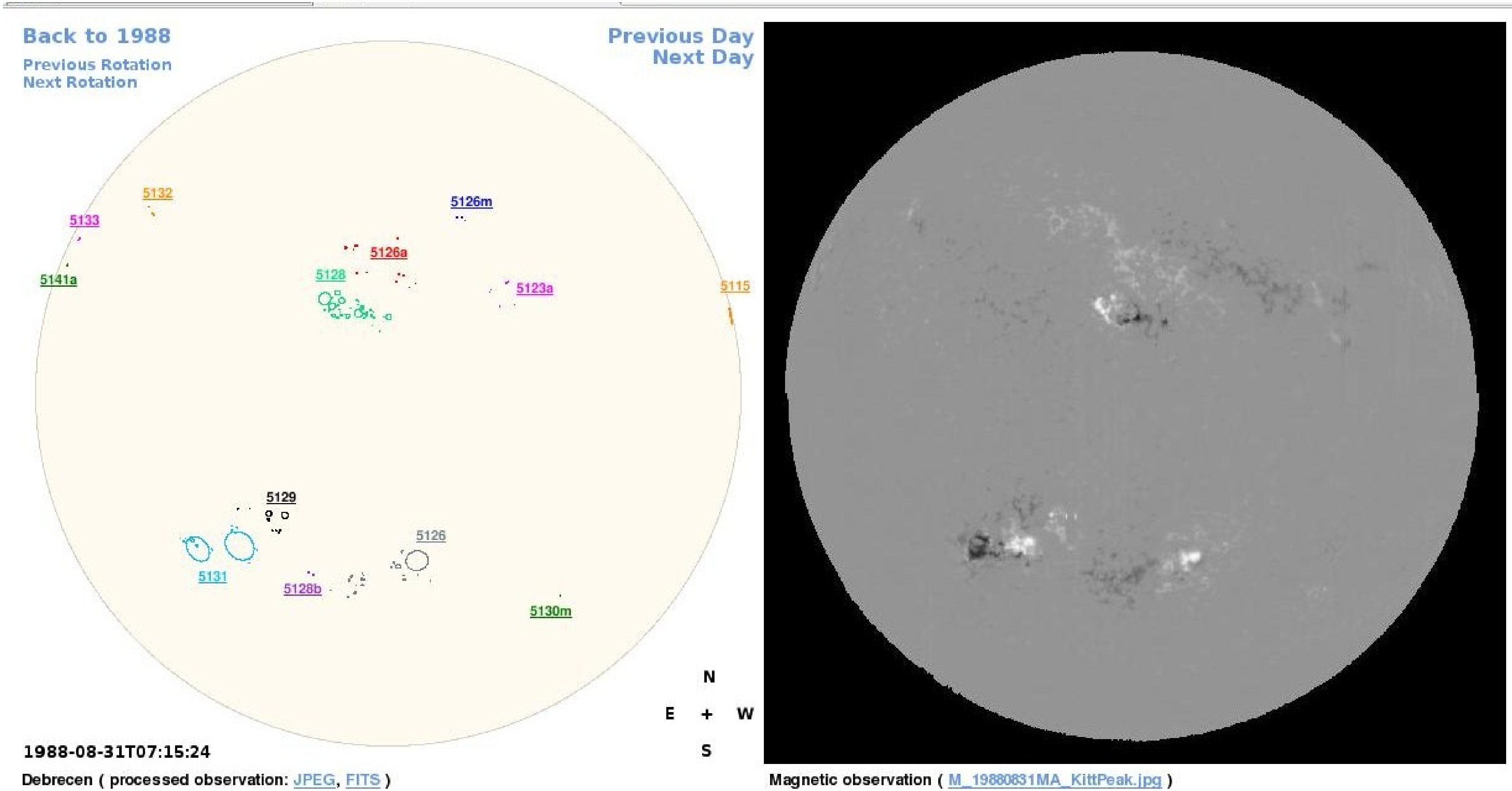
The time series of the daily data is also available (dailyDPD1977_2013.txt), and all the data and images can be downloaded from our ftp site in a direct way.

Additional table: tilt angles of sunspot groups derived from DPD.

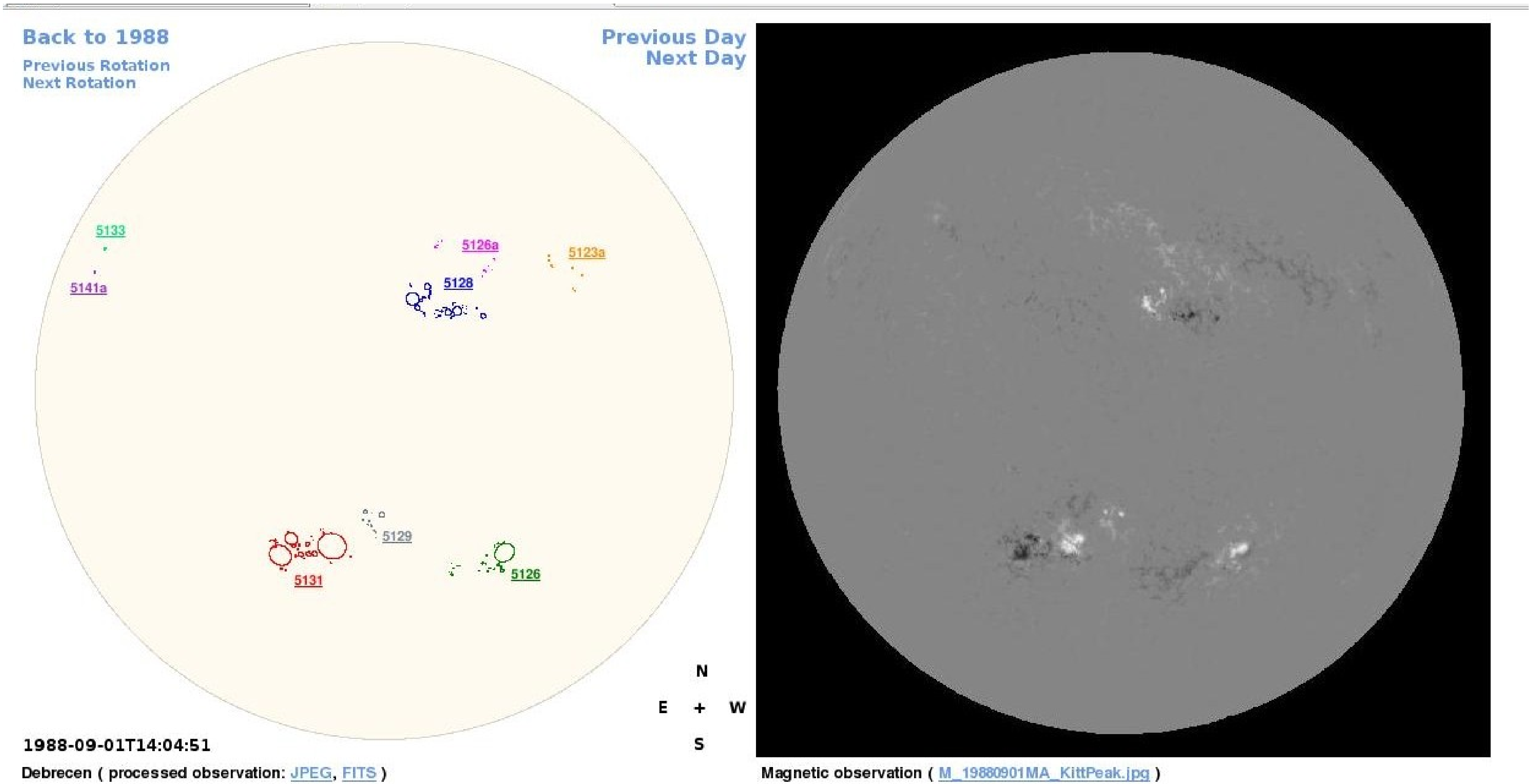
Presentation of the DPD: three consecutive days in 1988



Presentation of the DPD: three consecutive days in 1988



Presentation of the DPD: three consecutive days in 1988



SDD: 1996-2010, all spots and groups, on a 1.5 hourly basis, with magn. data

Back to the front page of the observatory

SOHO/MDI - Debrecen Data (SDD)

Győri, L., Baranyi, T., Ludmány, A.

If the SDD data are used in any publications, please refer to this paper:
Győri, L., Baranyi, T., Ludmány, A., Photospheric data programs at the Debrecen Observatory, Proc. IAU Symp., 273, 403-407, 2011.

The production of data was done within the WP2(Photosphere) of **SOTERIA** (**SO**lar-**TER**restrial **I**nvestigations and **A**rchives) project (FP7/SP1-Cooperation/1, Nov 2008 - 31 Oct 2011). The aim of the related tasks was to cover the entire SOHO-era with the most detailed data of sunspots, sunspot groups and photospheric faculae derived from MDI (Michelson Doppler Imager) continuum images and magnetograms with a ~1 image/hour temporal resolution. The MDI data are available by courtesy of the SOHO/MDI research group at Stanford University. SOHO (Solar and Heliospheric Observatory) is a mission of international cooperation between ESA and NASA.

Data and Image Products: (All ftp) **Additional tables:** tilt angles of sunspot groups derived from SDD. **Additional tool:** MySQL query for SDD

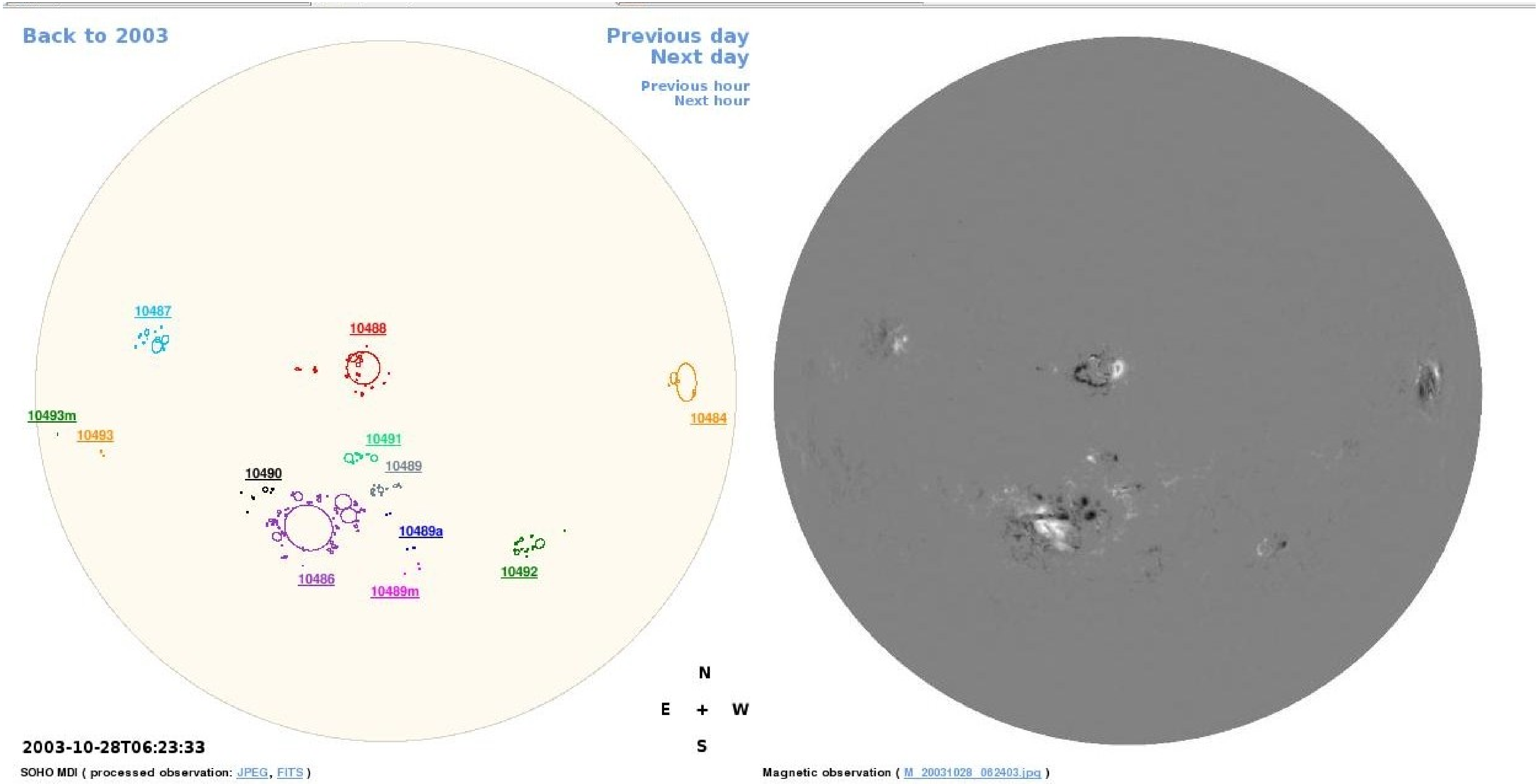
Year	Selected original Level 1.8. full-disk images		Processed enlarged full-disk images (solar north at the top)		Sunspot and sunspot group data (see SDDformat.txt)				Facular data (see SDDformat.txt)	
Graphical presentation of sunspots	Continuum intensity (fits.gz)	Magnetograms (fits.gz)	Contrast enhanced intensity images (jpg)	Magnetograms (jpg)	Full-disk catalogue of sunspots (txt)	Catalogue of sunspots and sunspot groups (txt)	Images of sunspot groups with numbering of spots (jpg)	Processed 16-bit negative images of sunspot groups (fits)	Full-disk catalogue of continuum faculae (txt)	Graphical presentation of faculae
1996	1996I	1996M	1996fd_jpg	1996M_jpg	fdSDD1996	SDD1996	1996group_jpg	1996group_fits	facSDD1996	1996
1997	1997I	1997M	1997fd_jpg	1997M_jpg	fdSDD1997	SDD1997	1997group_jpg	1997group_fits	facSDD1997	1997
1998	1998I	1998M	1998fd_jpg	1998M_jpg	fdSDD1998	SDD1998	1998group_jpg	1998group_fits	facSDD1998	1998
1999	1999I	1999M	1999fd_jpg	1999M_jpg	fdSDD1999	SDD1999	1999group_jpg	1999group_fits	facSDD1999	1999
2000	2000I	2000M	2000fd_jpg	2000M_jpg	fdSDD2000	SDD2000	2000group_jpg	2000group_fits	facSDD2000	2000
2001	2001I	2001M	2001fd_jpg	2001M_jpg	fdSDD2001	SDD2001	2001group_jpg	2001group_fits	facSDD2001	2001
2002	2002I	2002M	2002fd_jpg	2002M_jpg	fdSDD2002	SDD2002	2002group_jpg	2002group_fits	facSDD2002	2002
2003	2003I	2003M	2003fd_jpg	2003M_jpg	fdSDD2003	SDD2003	2003group_jpg	2003group_fits	facSDD2003	2003
2004	2004I	2004M	2004fd_jpg	2004M_jpg	fdSDD2004	SDD2004	2004group_jpg	2004group_fits	facSDD2004	2004
2005	2005I	2005M	2005fd_jpg	2005M_jpg	fdSDD2005	SDD2005	2005group_jpg	2005group_fits	facSDD2005	2005
2006	2006I	2006M	2006fd_jpg	2006M_jpg	fdSDD2006	SDD2006	2006group_jpg	2006group_fits	facSDD2006	2006
2007	2007I	2007M	2007fd_jpg	2007M_jpg	fdSDD2007	SDD2007	2007group_jpg	2007group_fits	facSDD2007	2007
2008	2008I	2008M	2008fd_jpg	2008M_jpg	fdSDD2008	SDD2008	2008group_jpg	2008group_fits	facSDD2008	2008
2009	2009I	2009M	2009fd_jpg	2009M_jpg	fdSDD2009	SDD2009	2009group_jpg	2009group_fits	facSDD2009	2009
2010	2010I	2010M	2010fd_jpg	2010M_jpg	fdSDD2010	SDD2010	2010group_jpg	2010group_fits	facSDD2010	2010
Quick-Look 2010	QL_2010I	QL_2010M	QL_2010fd_jpg	QL_2010M_jpg	-	QL_SDD2010	QL_2010group_jpg	QL_2010group_fits	-	-
Quick-Look 2011	QL_2011I	QL_2011M	QL_2011fd_jpg	QL_2011M_jpg	-	QL_SDD2011	QL_2011group_jpg	QL_2011group_fits	-	-

ACKNOWLEDGMENTS

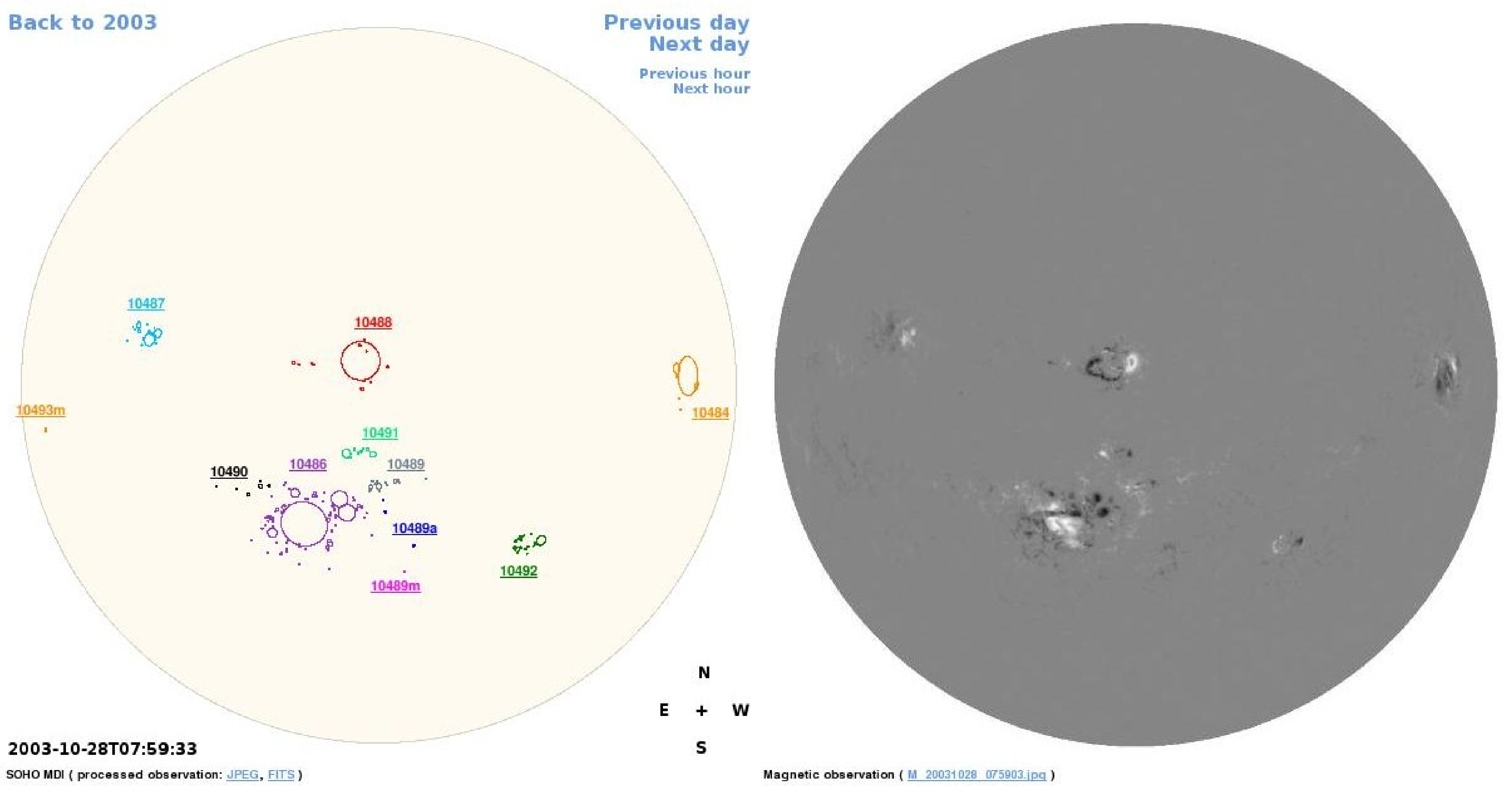
SEVENTH FRAMEWORK PROGRAMME

Nemzeti Fejlesztési Ügynökség

SDD, 28 Oct. 2003, 06:23:33 UT



SDD, 28 Oct. 2003, 07:59:33 UT

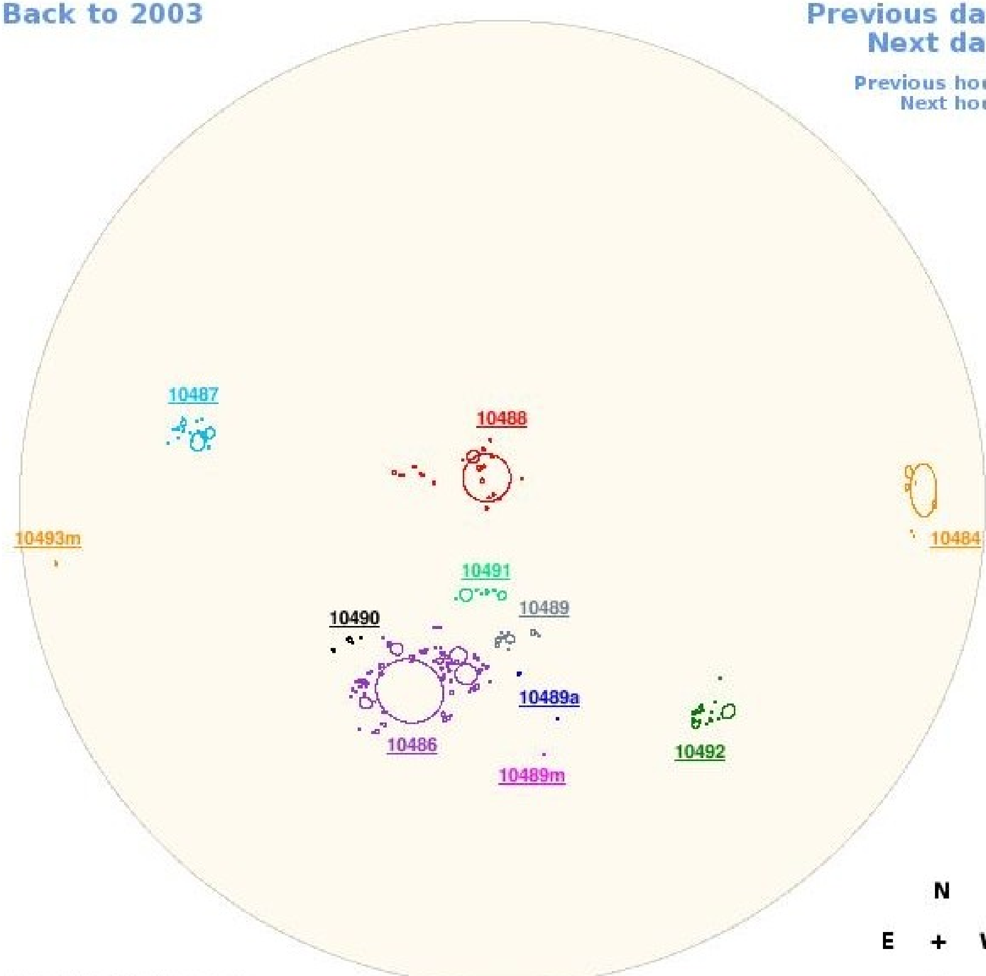


SDD, 28 Oct. 2003, 09:35:33 UT

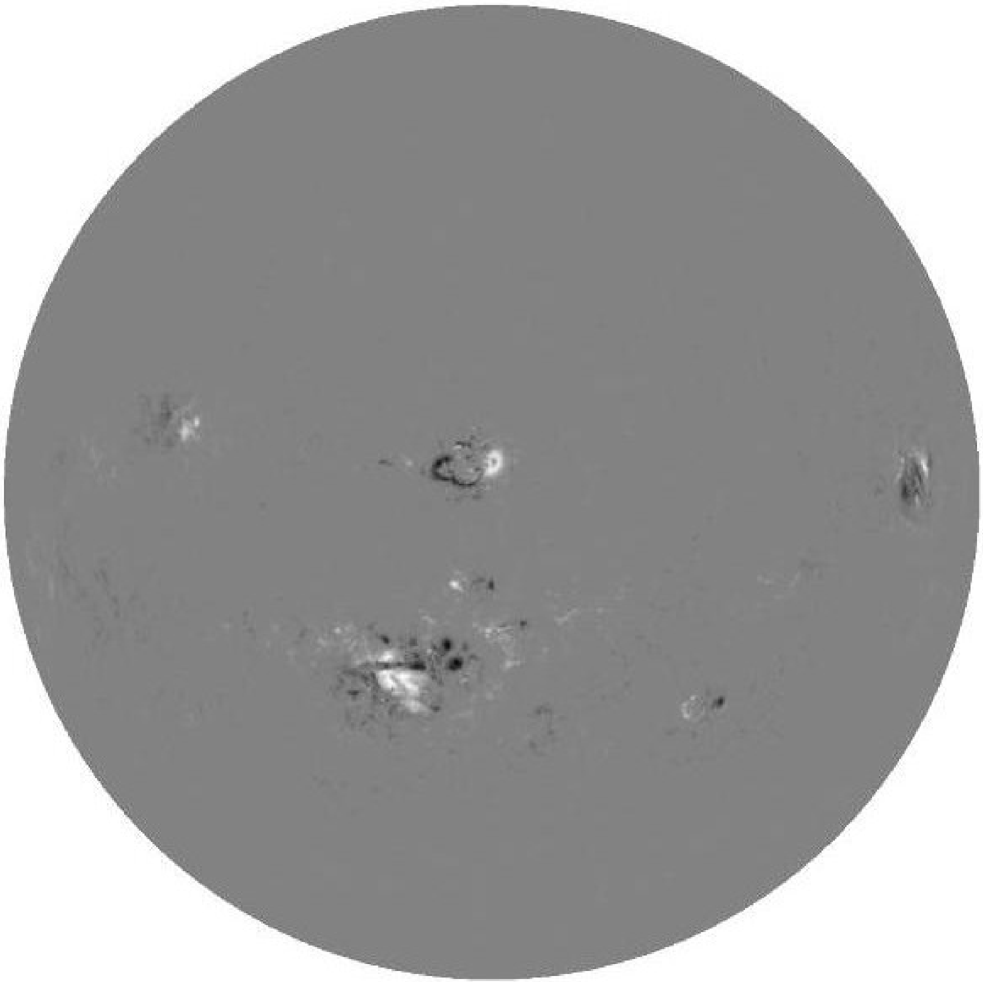
Back to 2003

Previous day
Next day

Previous hour
Next hour



N
E + W
S



2003-10-28T09:35:33

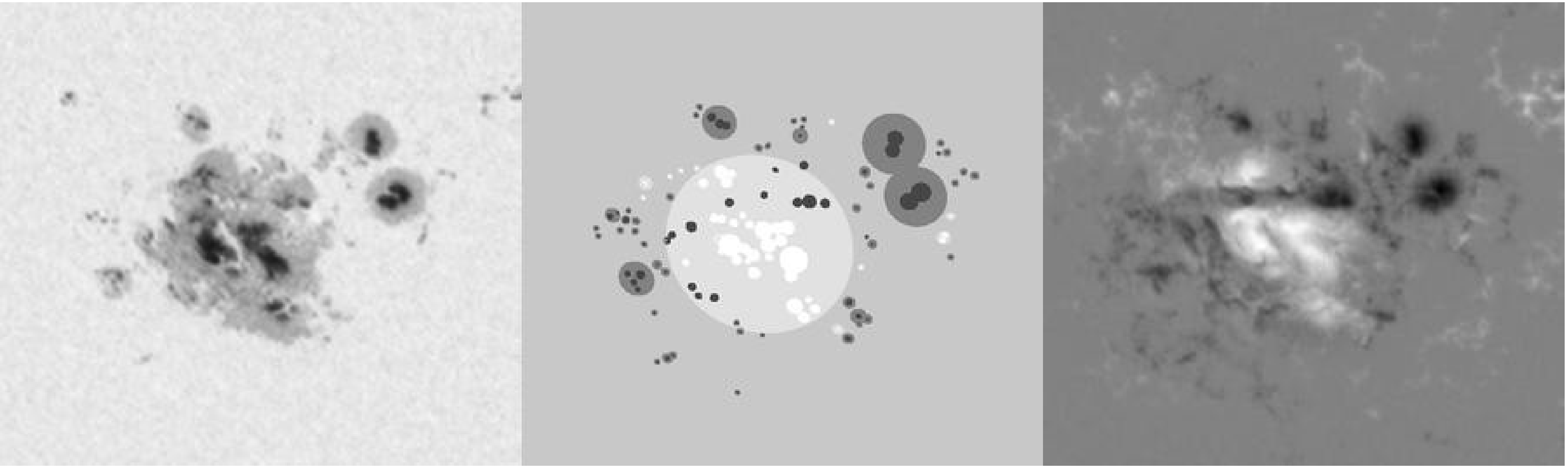
SOHO MDI (processed observation: JPEG, FITS)

Magnetic observation (M_20031028_093603.jpg)

To demonstrate the detailedness of SDD: 2003 Oct 28, NOAA 10486 (Halloween) 06:23:33 UT
data of 35 spots out of the 110 spots identified in the group
g row: group data, s rows: spot data:

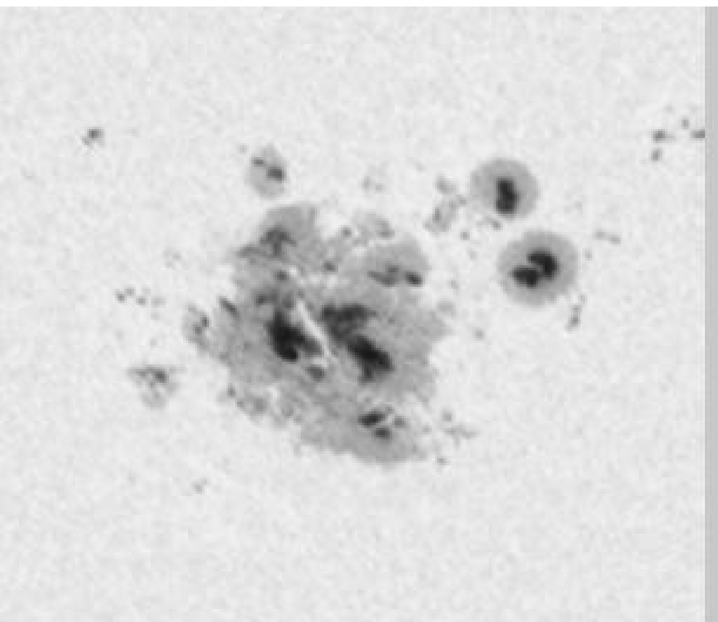
								No	U p	U+P p	U c	U+P c	B	L	dL	fi	r	magn. U	magn. P
g	2003	10	28	06	23	33	10486		871	6175	478	3391	-17.59	285.51	-12.39	151.98	0.4333	513.2	21.5
s	2003	10	28	06	23	33	10486	1	0	9	0	5	-15.06	294.24	-3.66	169.68	0.3456	-931.0	-807.2
s	2003	10	28	06	23	33	10486	2	0	6	0	3	-14.90	293.76	-4.14	168.27	0.3445	-1065.0	-945.9
s	2003	10	28	06	23	33	10486	3	0	6	0	3	-15.40	293.39	-4.51	167.57	0.3537	-305.0	-165.5
s	2003	10	28	06	23	33	10486	4	0	7	0	4	-16.89	293.15	-4.75	167.86	0.3782	739.0	354.3
s	2003	10	28	06	23	33	10486	5	0	5	0	3	-18.73	293.10	-4.80	168.74	0.4074	-700.0	-482.2
s	2003	10	28	06	23	33	10486	6	0	8	0	4	-14.05	293.06	-4.84	165.72	0.3333	-755.0	-721.5
s	2003	10	28	06	23	33	10486	7	3	22	2	12	-17.72	292.89	-5.01	167.70	0.3923	606.0	83.7
s	2003	10	28	06	23	33	10486	8	3	-7	2	-7	-17.98	292.76	-5.14	167.54	0.3967	749.3	999999
s	2003	10	28	06	23	33	10486	9	0	6	0	3	-13.64	292.79	-5.11	164.63	0.3280	-950.0	-765.5
s	2003	10	28	06	23	33	10486	10	0	3	0	2	-14.09	292.70	-5.20	164.74	0.3356	-853.0	-730.7
s	2003	10	28	06	23	33	10486	11	47	495	25	264	-15.82	291.89	-6.01	163.97	0.3664	-2139.4	-722.3
s	2003	10	28	06	23	33	10486	12	39	-11	21	-11	-16.24	291.35	-6.55	162.96	0.3754	-1741.4	999999
s	2003	10	28	06	23	33	10486	13	30	511	16	269	-13.45	290.83	-7.06	158.99	0.3352	-2288.2	-660.5
s	2003	10	28	06	23	33	10486	14	24	-13	13	-13	-13.99	290.70	-7.20	159.20	0.3441	-1715.2	999999
s	2003	10	28	06	23	33	10486	15	0	10	0	5	-18.18	289.64	-8.26	160.64	0.4135	-1288.0	-886.6
s	2003	10	28	06	23	33	10486	16	0	6	0	3	-15.56	289.67	-8.23	158.27	0.3740	-1297.0	-962.3
s	2003	10	28	06	23	33	10486	17	0	11	0	6	-21.63	289.25	-8.65	162.48	0.4666	-846.0	-855.4
s	2003	10	28	06	23	33	10486	18	0	2	0	1	-17.84	289.41	-8.49	159.85	0.4098	-870.0	-717.8
s	2003	10	28	06	23	33	10486	19	2	15	1	8	-14.94	289.46	-8.44	157.10	0.3661	-1187.2	-604.8
s	2003	10	28	06	23	33	10486	20	0	4	0	2	-19.24	289.09	-8.81	160.37	0.4321	229.0	234.8
s	2003	10	28	06	23	33	10486	21	0	6	0	3	-21.85	288.85	-9.05	161.90	0.4717	-631.0	-441.5
s	2003	10	28	06	23	33	10486	22	3	31	2	17	-21.50	288.83	-9.07	161.61	0.4667	-1170.4	-625.8
s	2003	10	28	06	23	33	10486	23	0	9	0	5	-16.56	289.02	-8.88	157.78	0.3929	-1304.0	-1007.0
s	2003	10	28	06	23	33	10486	24	4	18	2	10	-20.86	288.45	-9.45	160.41	0.4593	-524.7	-254.3
s	2003	10	28	06	23	33	10486	25	3	15	2	9	-22.55	288.30	-9.60	161.38	0.4845	-230.3	-140.0
s	2003	10	28	06	23	33	10486	26	0	13	0	8	-22.12	287.86	-10.04	160.28	0.4806	160.0	280.7
s	2003	10	28	06	23	33	10486	27	0	4	0	2	-12.76	288.09	-9.81	150.97	0.3439	528.0	430.2
s	2003	10	28	06	23	33	10486	28	10	4411	5	2440	-16.37	287.64	-10.26	154.53	0.3991	-1888.2	253.9
s	2003	10	28	06	23	33	10486	29	10	-28	6	-28	-21.19	286.87	-11.03	157.74	0.4727	1249.0	999999
s	2003	10	28	06	23	33	10486	30	23	-28	12	-28	-16.30	286.95	-10.95	152.97	0.4030	-1721.2	999999
s	2003	10	28	06	23	33	10486	31	4	-28	2	-28	-20.76	286.61	-11.29	156.89	0.4683	1201.7	999999
s	2003	10	28	06	23	33	10486	32	15	-28	9	-28	-21.58	286.33	-11.56	157.12	0.4815	1165.2	999999
s	2003	10	28	06	23	33	10486	33	8	-28	4	-28	-14.69	286.79	-11.11	150.62	0.3816	-1319.9	999999
s	2003	10	28	06	23	33	10486	34	0	4	0	2	-12.66	286.89	-11.01	147.92	0.3525	-906.0	-731.2
s	2003	10	28	06	23	33	10486	35	0	3	0	1	-13.02	286.79	-11.11	148.26	0.3584	-1003.0	-881.1

SDD, 28 Oct. 2003, NOAA10486, 06:23:33 UT

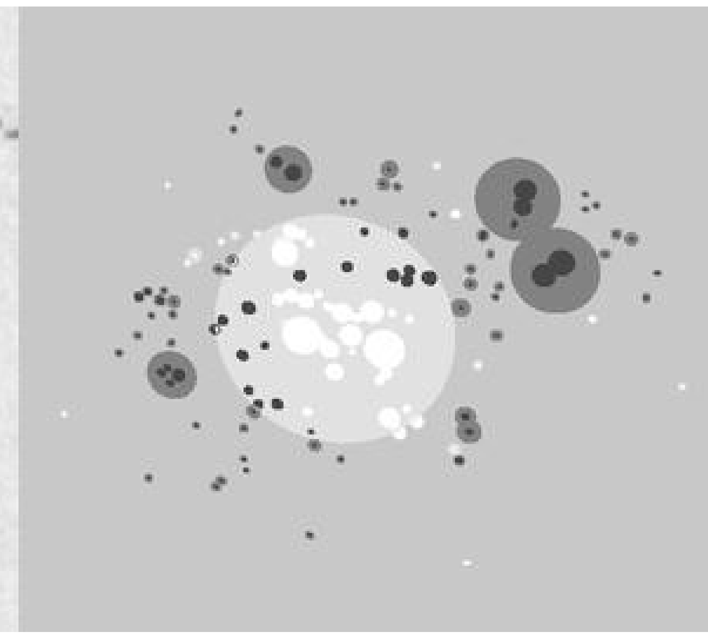


Continuum | Cartoon drawn from the position, area and polarity data in the SDD | Magnetogram

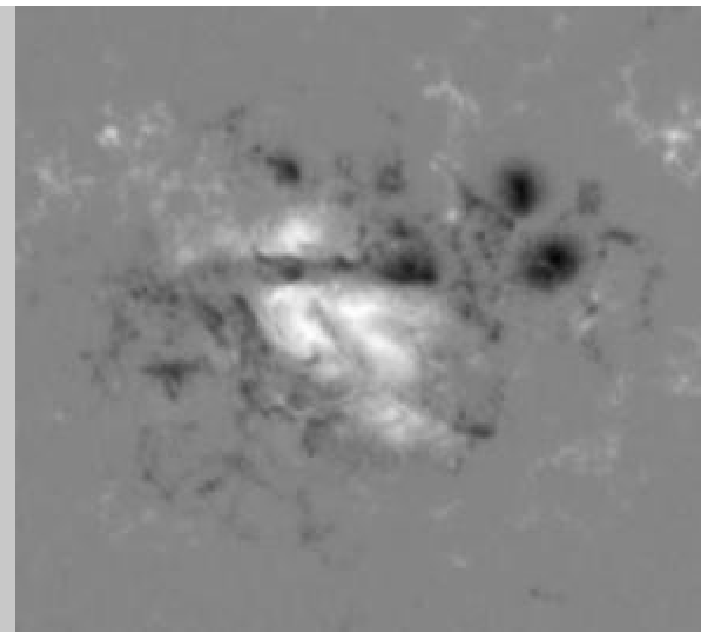
SDD, 28 Oct. 2003, NOAA10486, 07:59:33 UT



Continuum

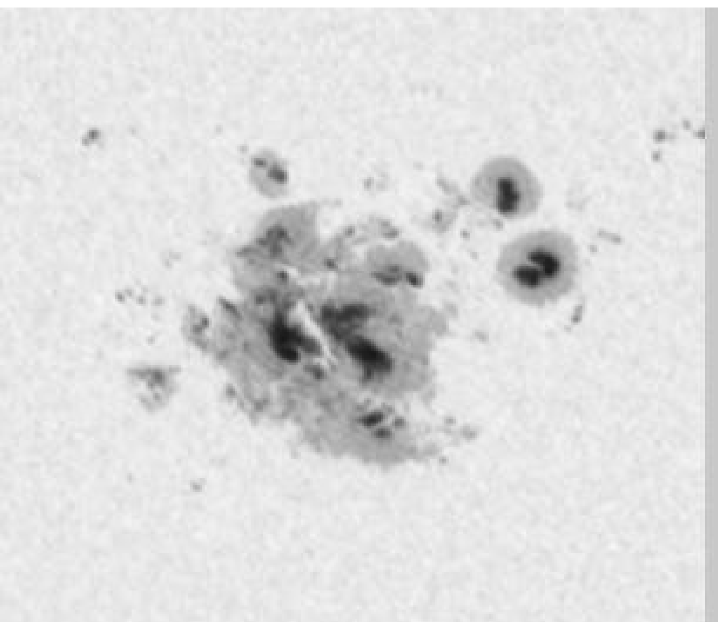


Cartoon drawn from the position, area and polarity data in the SDD

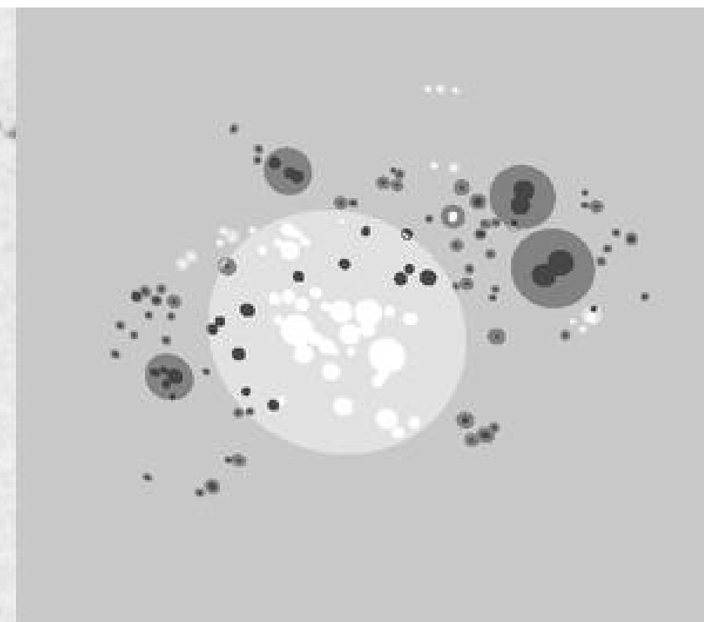


Magnetogram

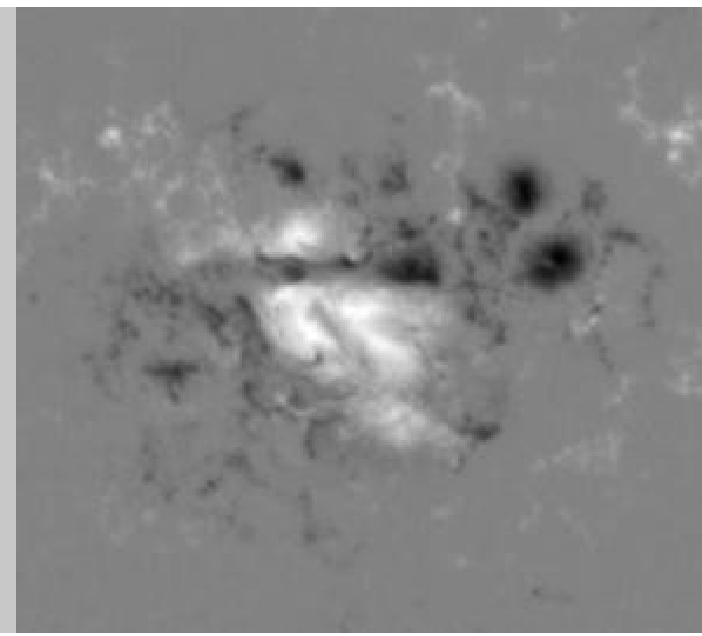
SDD, 28 Oct. 2003, NOAA10486, 09:35:33 UT



Continuum



Cartoon drawn from the position, area and polarity data in the SDD



Magnetogram

A historical observational material:

Hungarian historical solar drawings

Our observatory hosts two historical solar image databases containing heritages of two former observatories.
The first of them was observed at Ógyalla Observatory founded by Miklós Konkoly-Thege (1842-1916). We have solar observations taken here between 1872 and 1891.
The other set of solar drawings was observed at the Haynald Observatory in Kalocsa between 1880 to 1919.

ÓGYALLA OBSERVATORY

		1872 (76 days)	1873 (14 days)	1874 (81 days)	1875 (45 days)	1876 (23 days)	1877 (40 days)	1878 (38 days)	1879 (74 days)
1880	1881 (202 days)	1882 (224 days)	1883 (203 days)	1884 (191 days)	1885 (221 days)	1886 (178 days)	1887 (129 days)	1888 (111 days)	1889 (70 days)
1890 (73 days)	1891 (145 days)								

HAYNALD OBSERVATORY

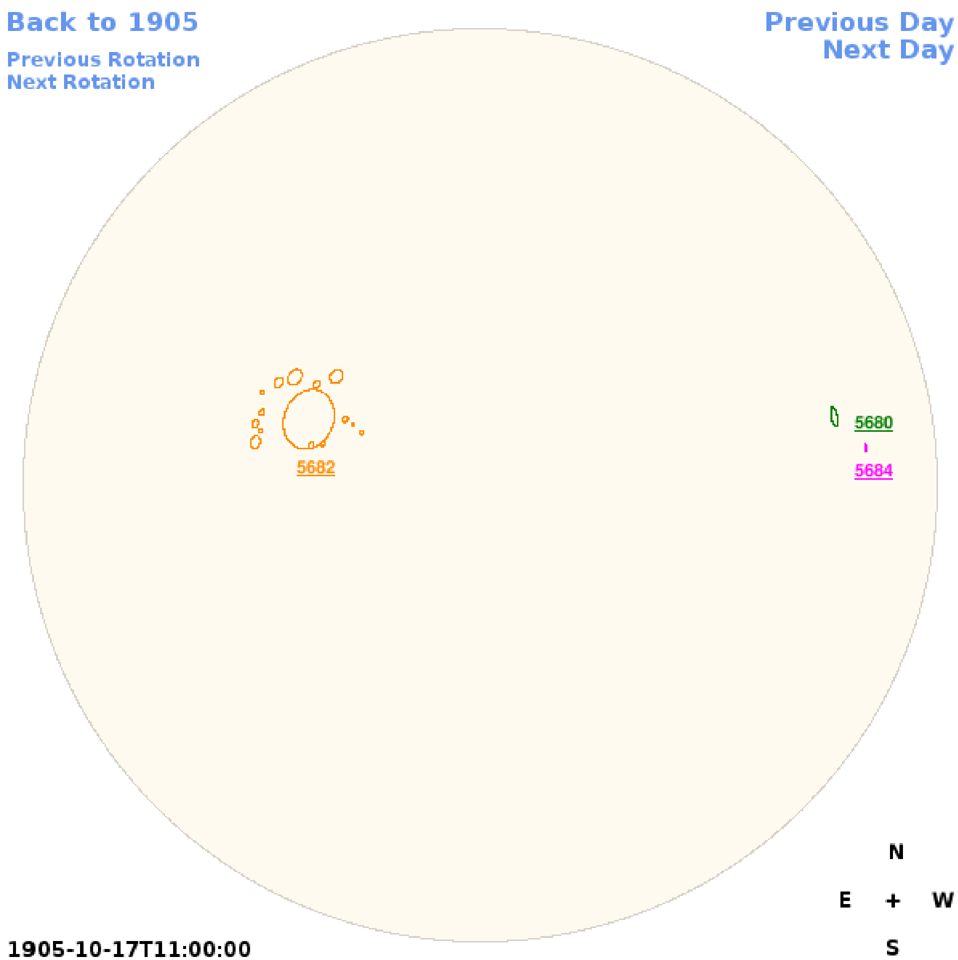
1880 (92 days)	1881	1882	1883 (107 days)	1884 (210 days)	1885 (248 days)	1886 (227 days)	1887 (197 days)	1888 (154 days)	1889
1890	1891 (253 days)	1892 (234 days)	1893 (165 days)	1894 (271 days)	1895 (257 days)	1896 (129 days)	1897 (61 days)	1898 (147 days)	1899 (156 days)
1900 (127 days)	1901 (67 days)	1902 (116 days)	1903 (227 days)	1904 (185 days)	1905 (213 days)	1906 (257 days)	1907 (259 days)	1908 (256 days)	1909 (254 days)
1910 (246 days)	1911 (176 days)	1912 (119 days)	1913 (68 days)	1914 (137 days)	1915 (216 days)	1916 (231 days)	1917 (15 days)	1918 (64 days)	1919 (14 days)

ACKNOWLEDGMENTS

SEVENTH FRAMEWORK PROGRAMME

Nemzeti

Comparison of the sunspot data reconstructed graphically from the GPR to the drawings from Kalocsa and the ISSN in Oct. 1905.

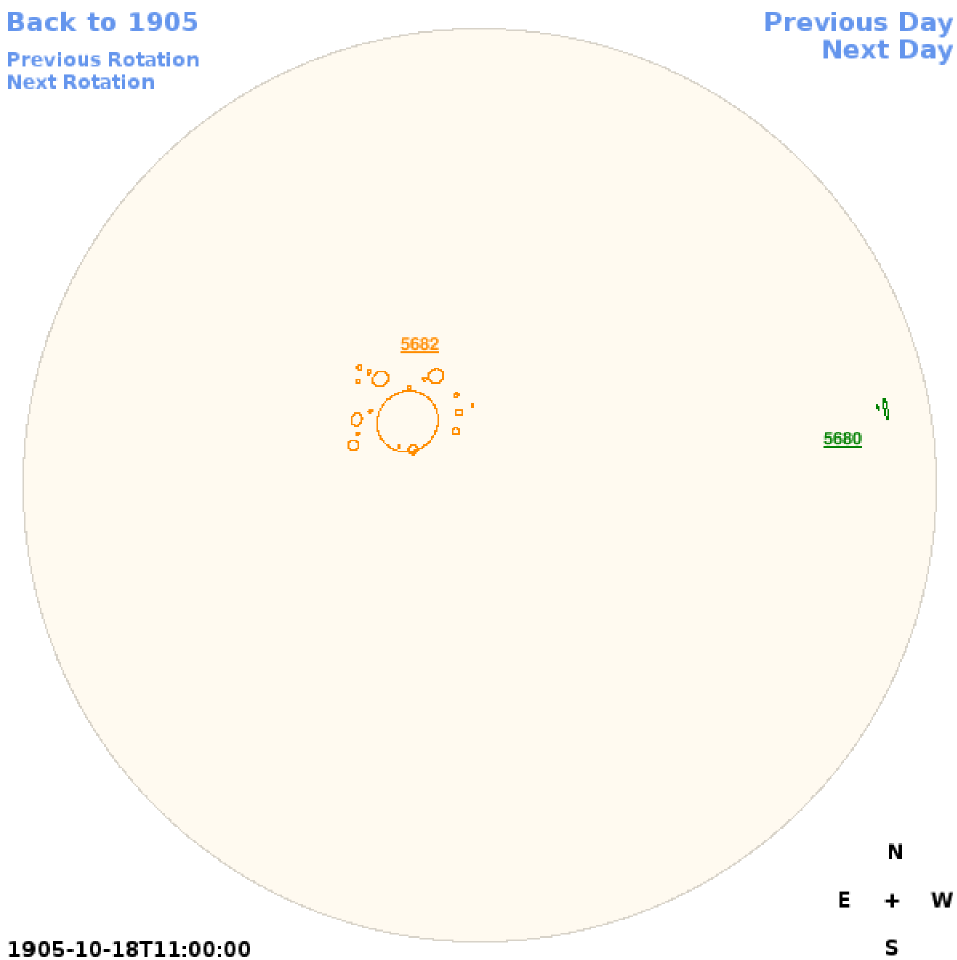


Greenwich, 1905 Oct.17
SN=45

ISSN=119

Kalocsa, 1905 Oct.18
SN=121

Comparison of the sunspot data reconstructed graphically from the GPR to the drawings from Kalocsa and the ISSN in Oct. 1905.

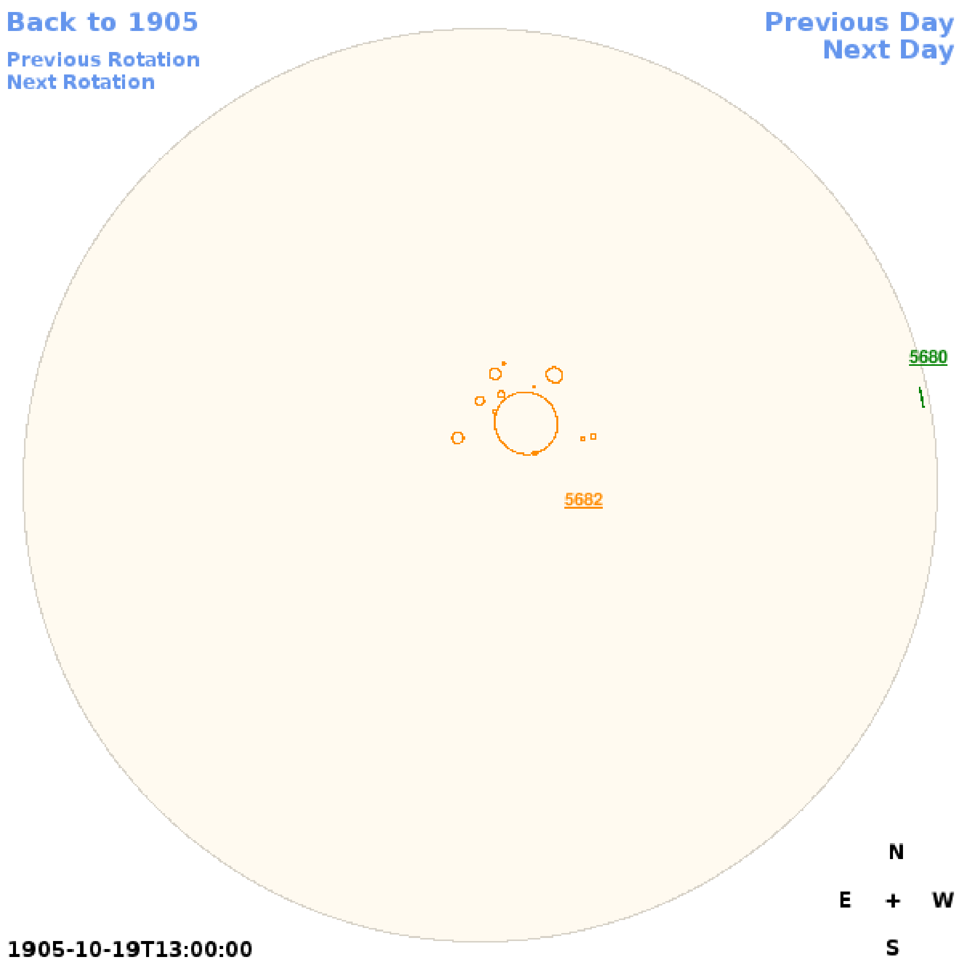


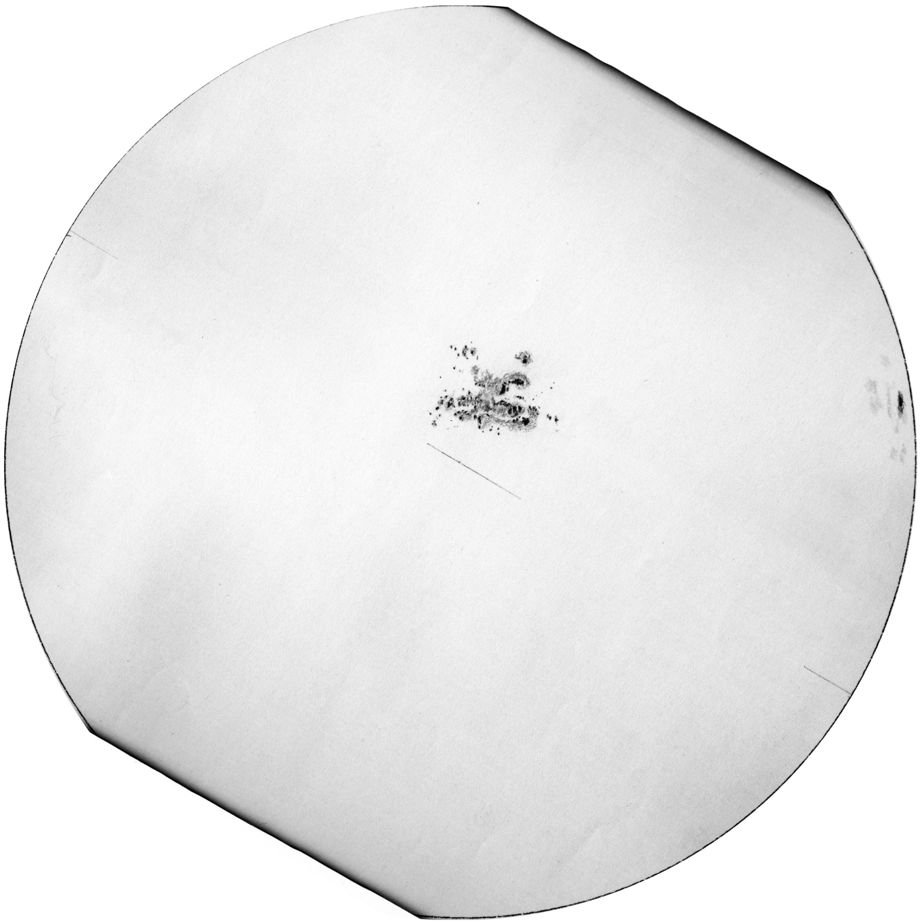
Greenwich, 1905 Oct.18
SN=40

ISSN=142

Kalocsa, 1905 Oct.19
SN=129

Comparison of the sunspot data reconstructed graphically from the GPR to the drawings from Kalocsa and the ISSN in Oct. 1905.



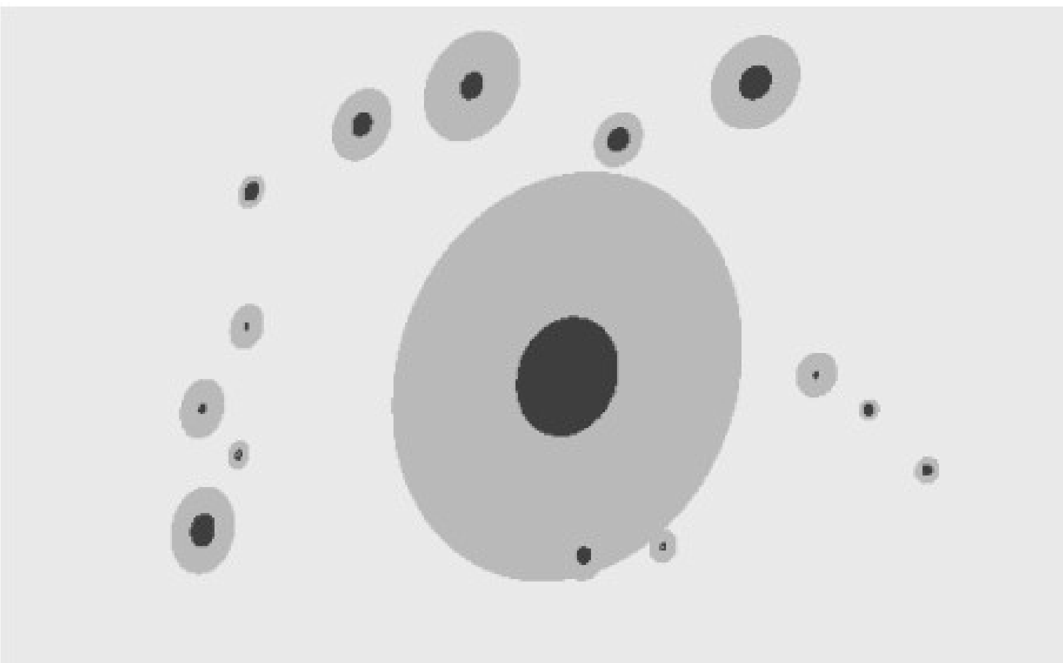


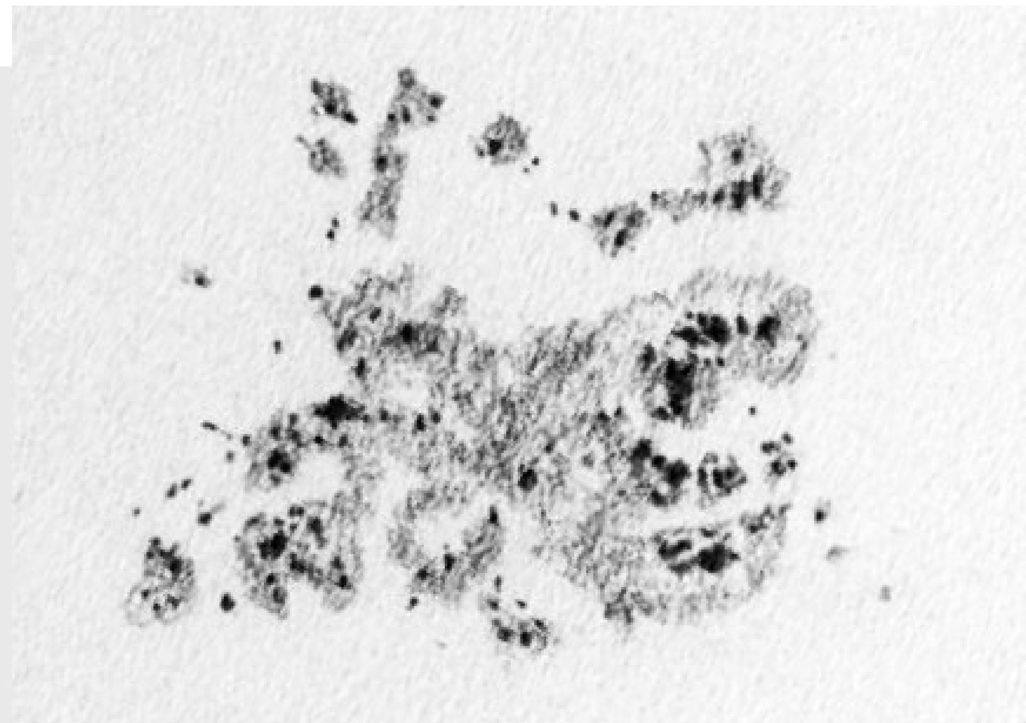
Greenwich, 1905 Oct.19
SN=31

ISSN=84

Kalocsa, 1905 Oct.20
SN=114

Comparison of the sunspot data reconstructed graphically from the GPR to the drawings from Kalocsa and the ISSN in Oct. 1905. No.5682

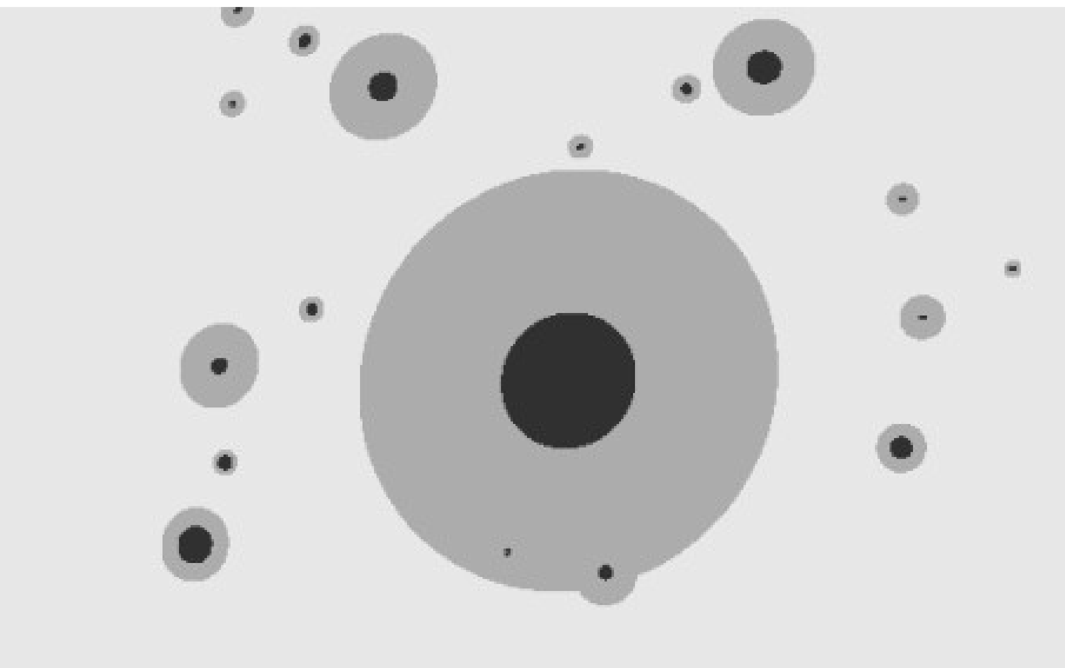


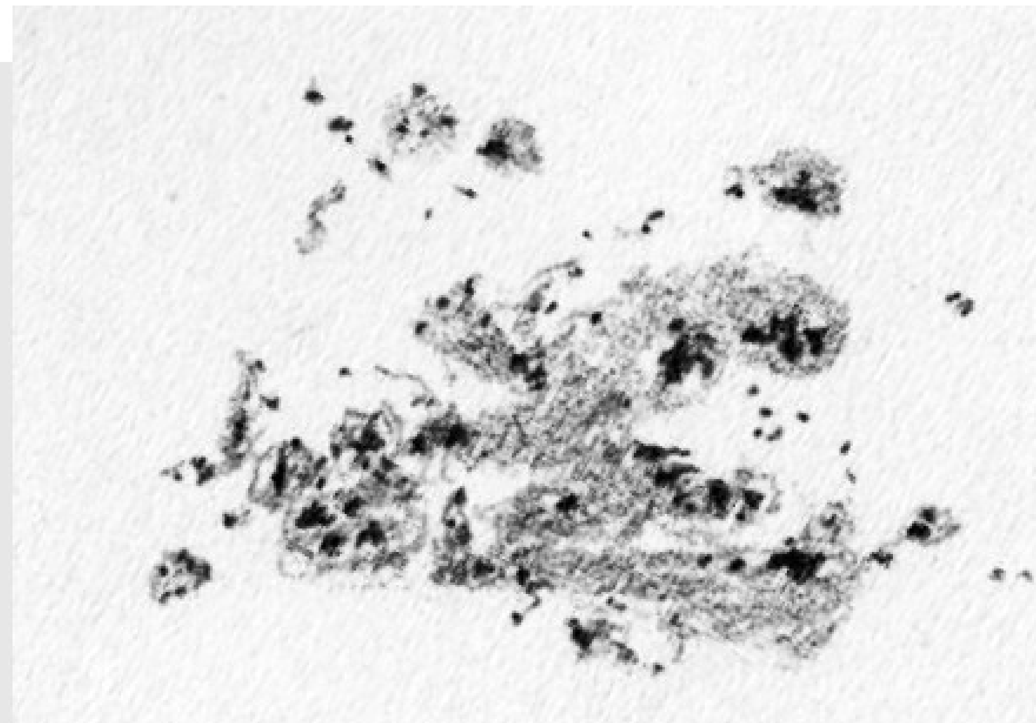


Greenwich, 1905 Oct.17
SN=15

Kalocsa, 1905 Oct.18
SN=101

Comparison of the sunspot data reconstructed graphically from the GPR to the drawings from Kalocsa and the ISSN in Oct. 1905. No.5682

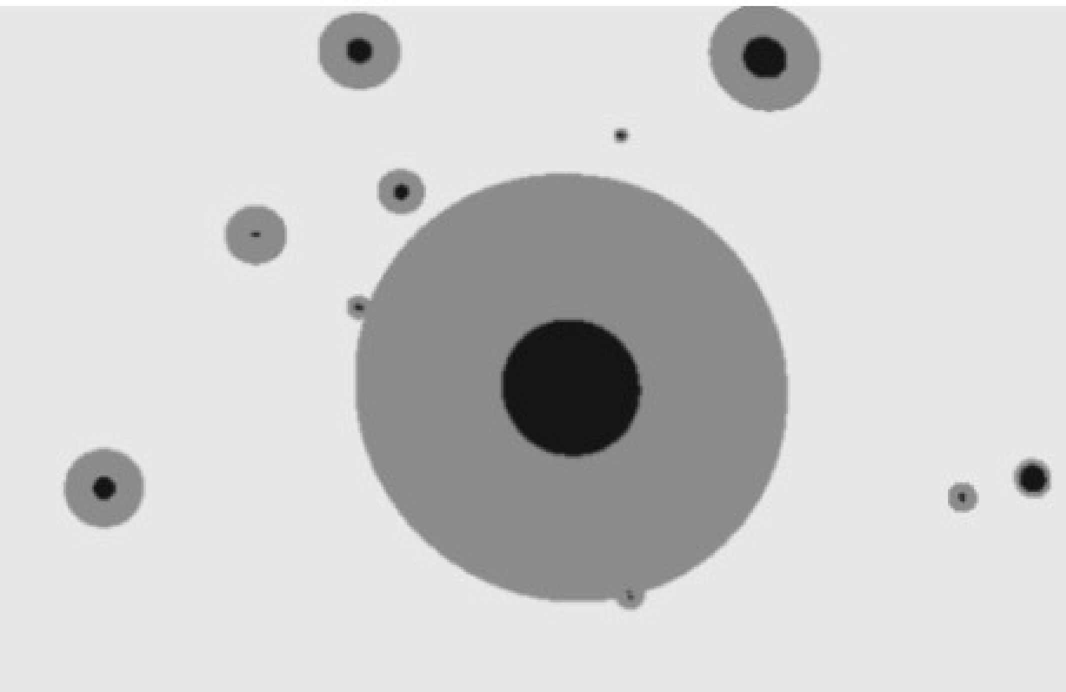




Greenwich, 1905 Oct.18
SN=18

Kalocsa, 1905 Oct.19
SN=109

Comparison of the sunspot data reconstructed graphically from the GPR to the drawings from Kalocsa and the ISSN in Oct. 1905. No.5682



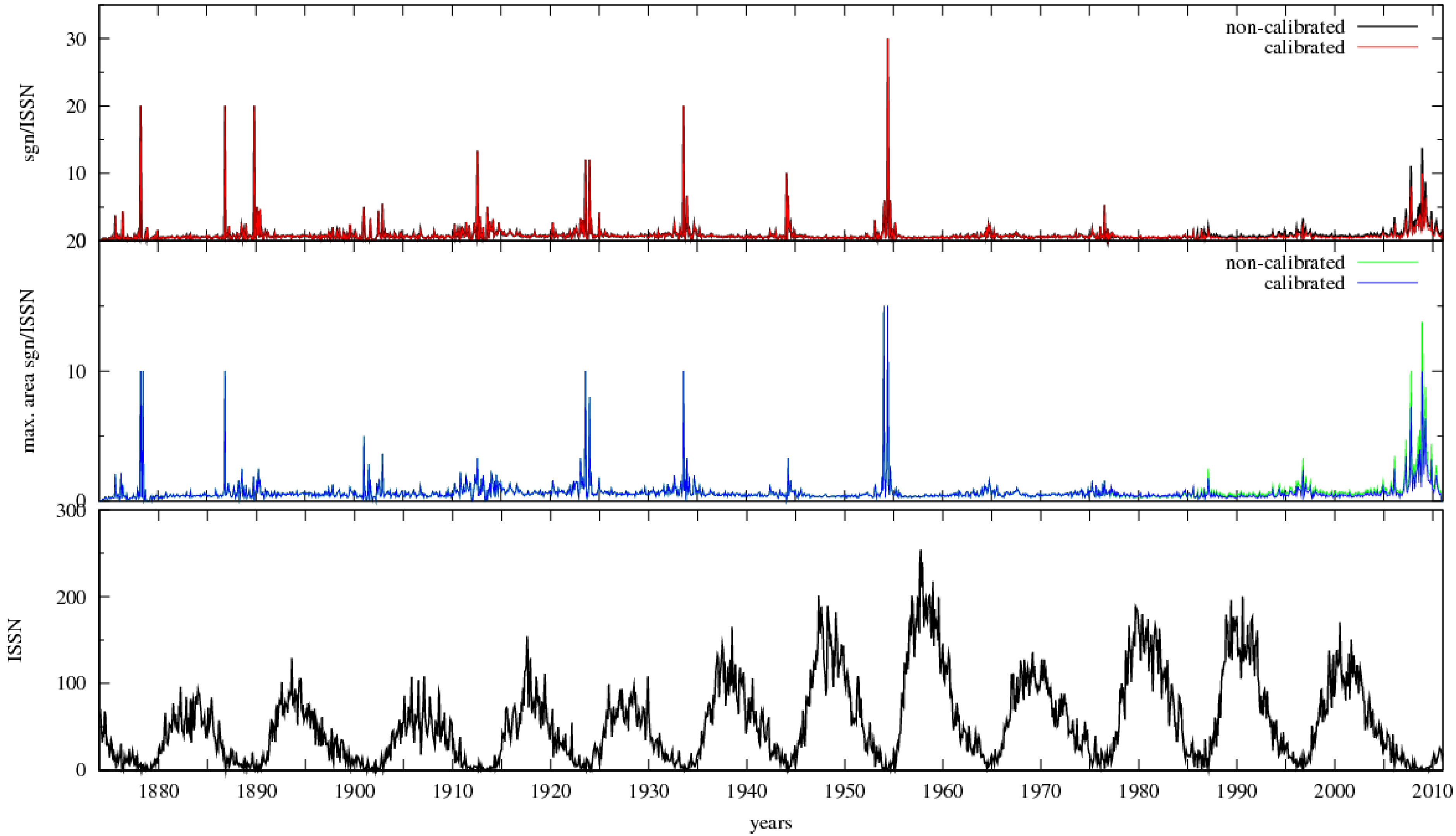
Greenwich, 1905 Oct.19
SN=11

Kalocsa, 1905 Oct.20
SN=94

Comparison of the Sunspot Group Number (SGN) from GPR and the Sunspot Number (SN), monthly means

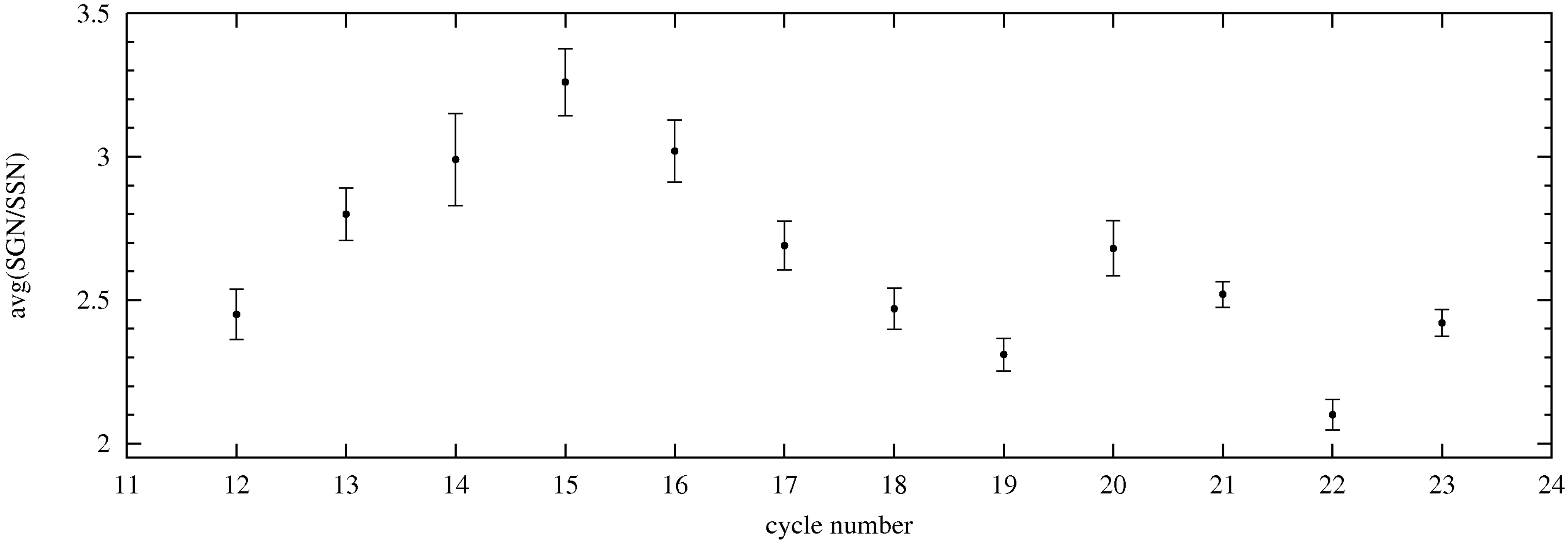
SGN/SN

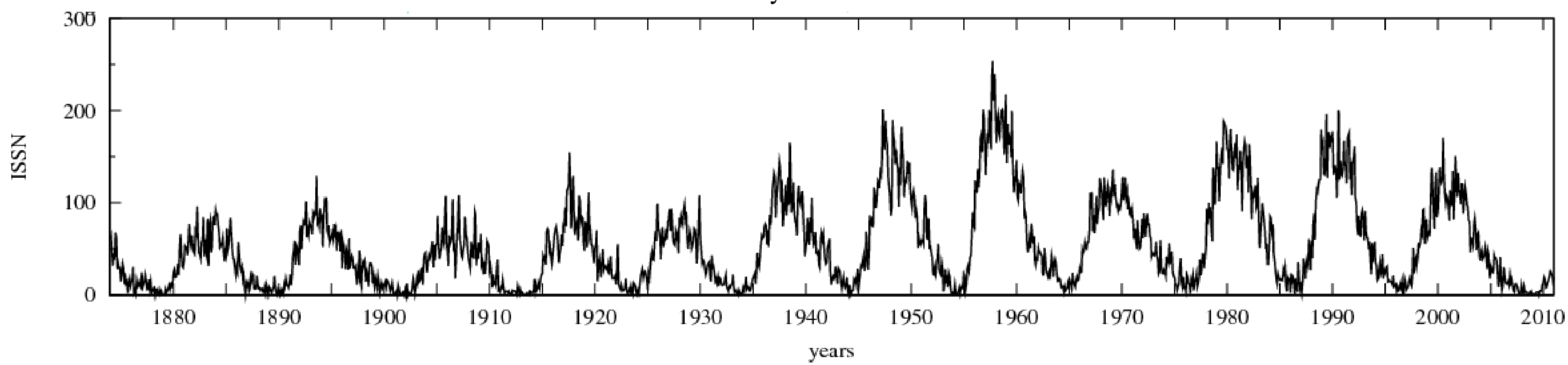
SG area / SN



The cyclic means of SGN/SN ratio are computed for the inner 5 years of the cycles because of the high errors in minima

Cyclic means of the ratio SGN/SN





Waldmeier's involvement cannot be pointed out in the long term variation of the cyclic mean ratio of SGN/SN, but there are long trends.

1. What can be the sources of the inhomogeneities in long sunspot datasets?

- atmospheric seeing
- instrumental (objective)
- registration technique – visual, graphic, photographic, electronic
- personal bias (selection criteria)
- robustness of SN definition
- mistakes
- unrevealed variations of solar origin

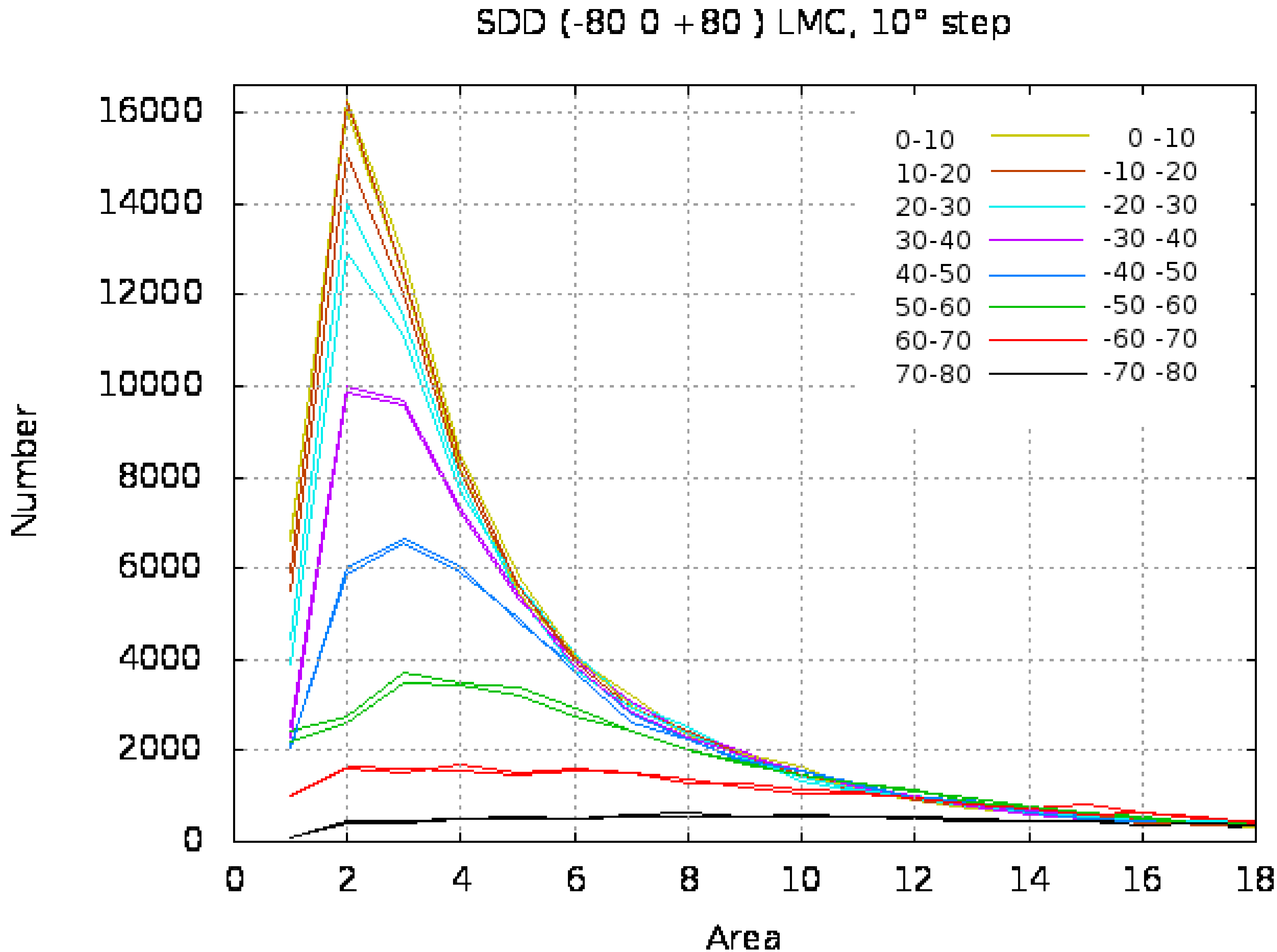
2. What could be the most reliable independent parameter to detect the varying performance of the determination of ISSN?

proxies? - connections may be weak
GPR? - also inhomogeneous
reprocessing the old observations?
if yes, the different techniques may also result inhomogeneity

A possible parameter for the era of existing observations:

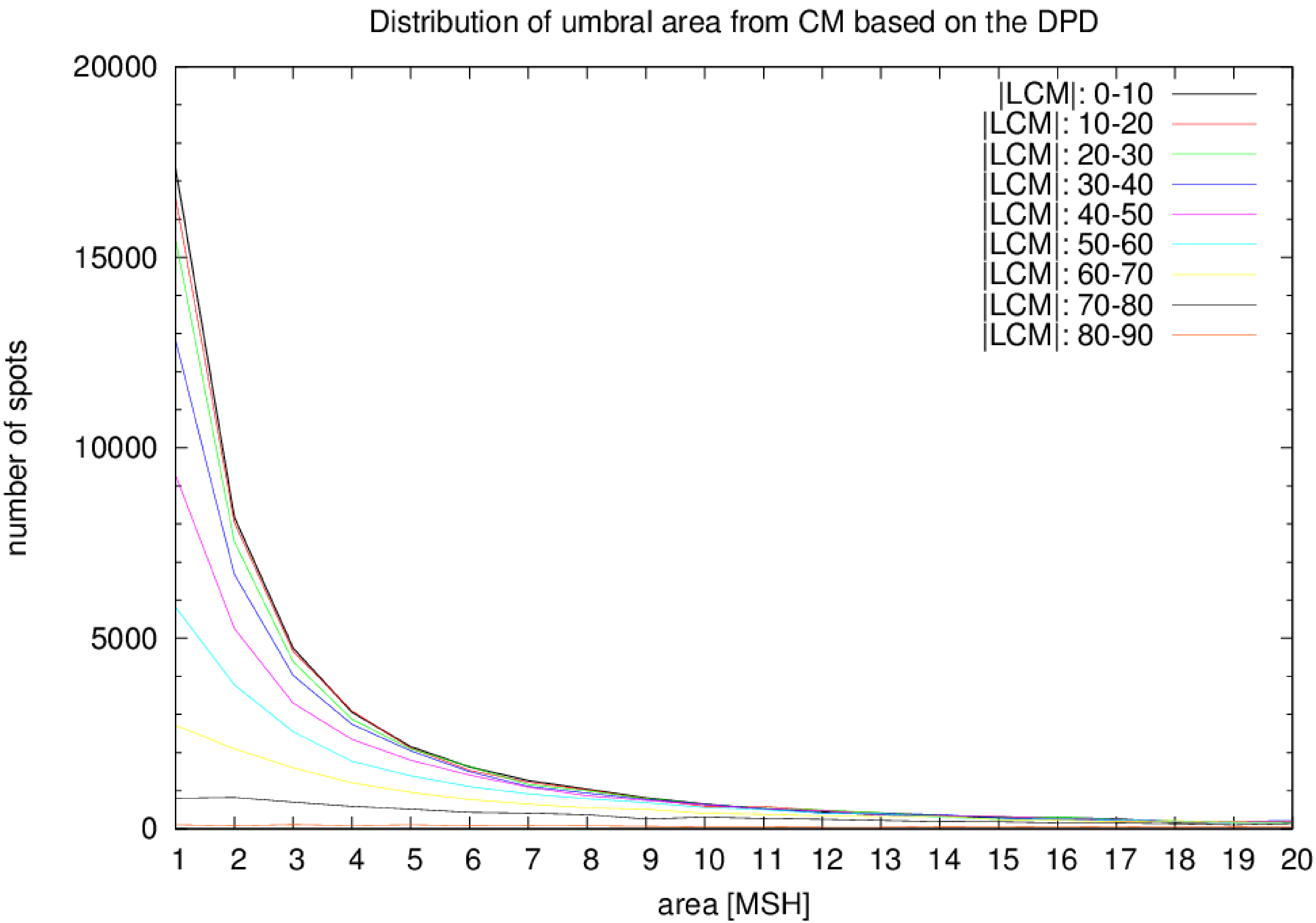
total area of sunspot umbrae

Problem of areas: varying observability of the spots across the disc
Umbral area distribution at different CM-distances, SDD, 1996-2010

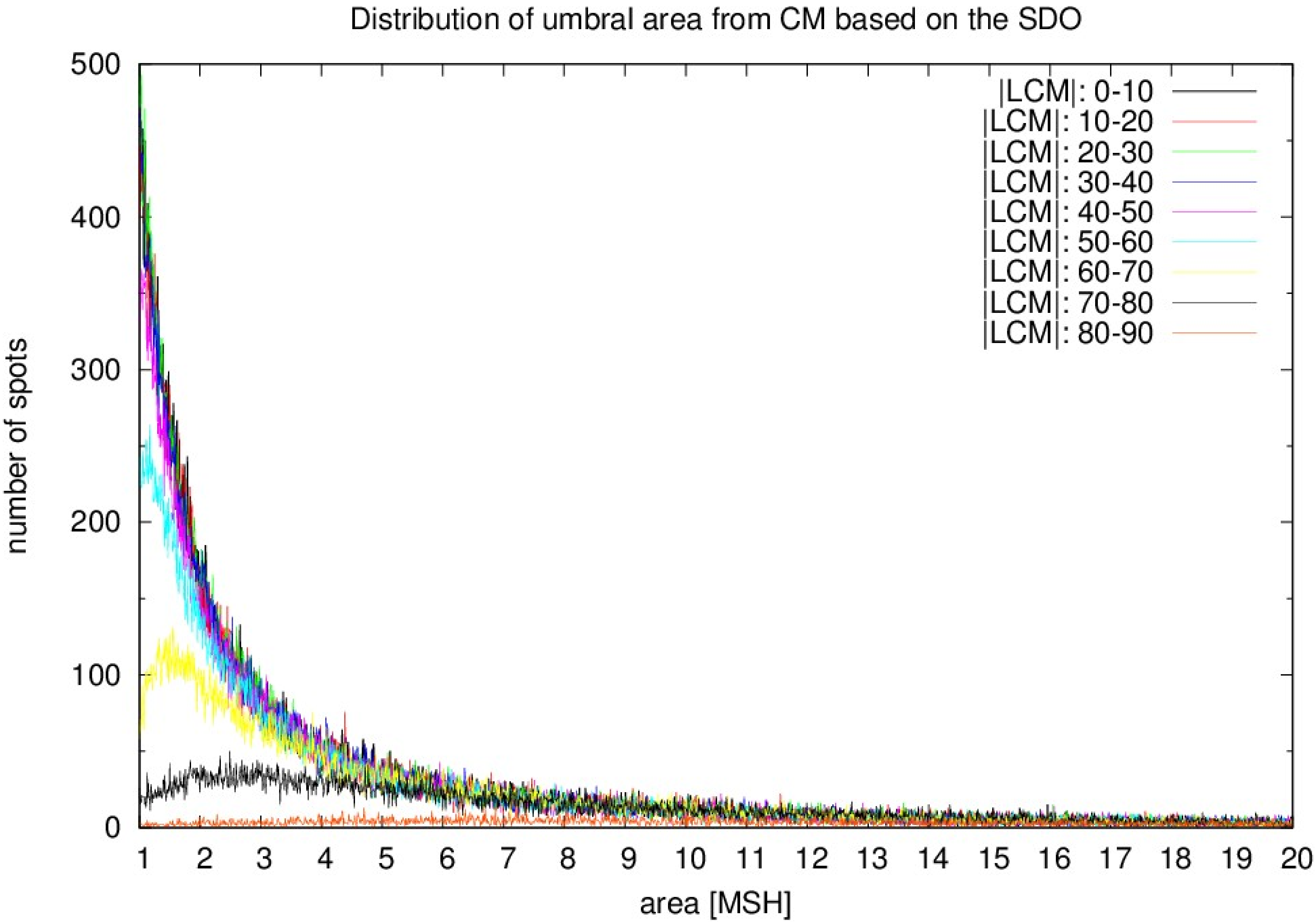


In the SDD the CMD-dependence is only insignificant for umbrae larger than 7MSH

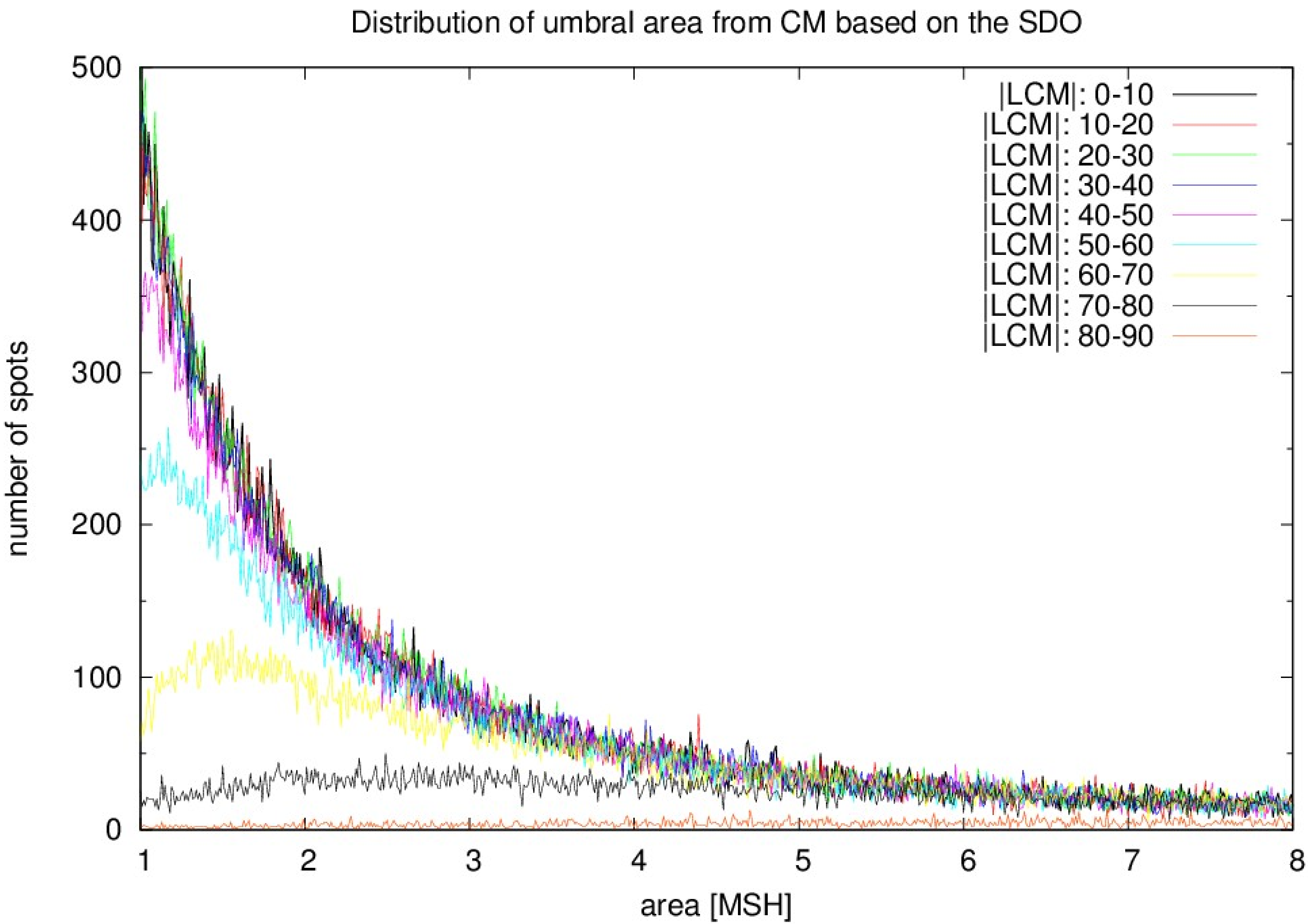
The same distributions from the DPD, 1977-2012
the 1 MSH umbrae are better represented because of the higher resolution



The same distributions from the HMIDD, 2010-2012



The same distributions from the HMIDD, 2010-2012



This CMD-dependence imposes the same constraint on each sunspot dataset, it could apparently be disregarded.

However, it makes questionable, whether the daily sunspot number is a real measure of the activity.

It may have a significant daily variability even if all spots remain the same at the same locations during two weaks, just because of the variable observability.

The monthly values are real.

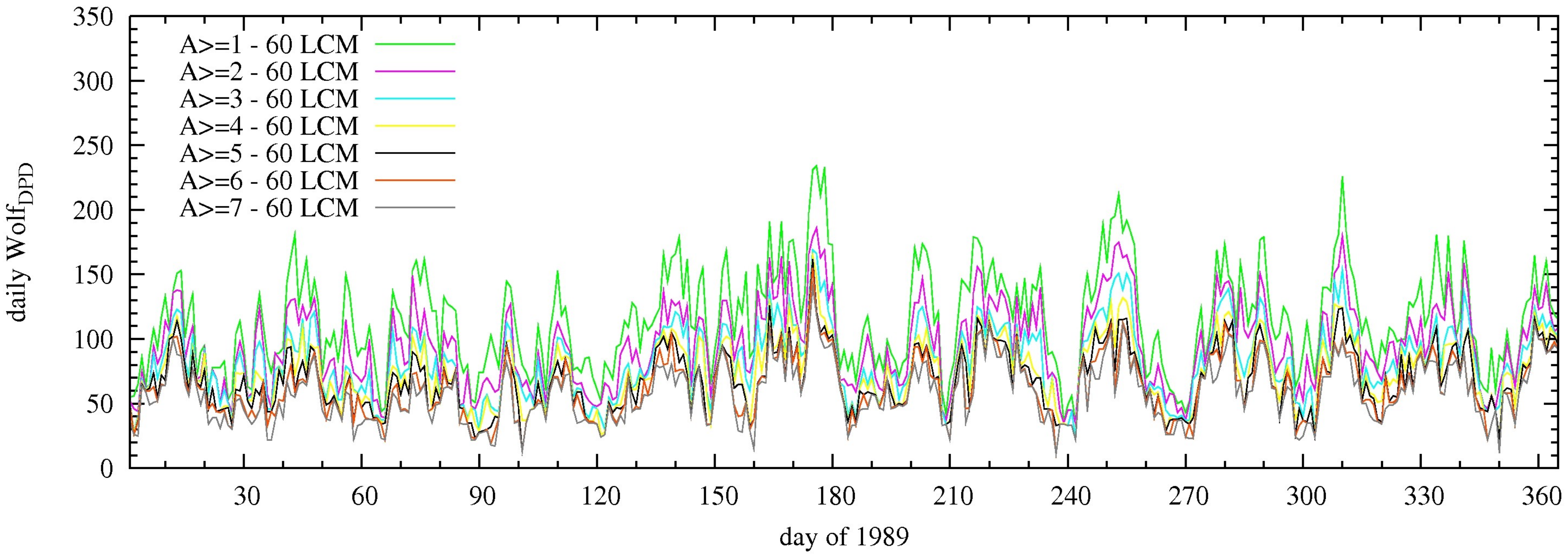
Should we omit the spots below an area limit?

This could even increase the inhomogeneity
because of the difficulties of area measurements.

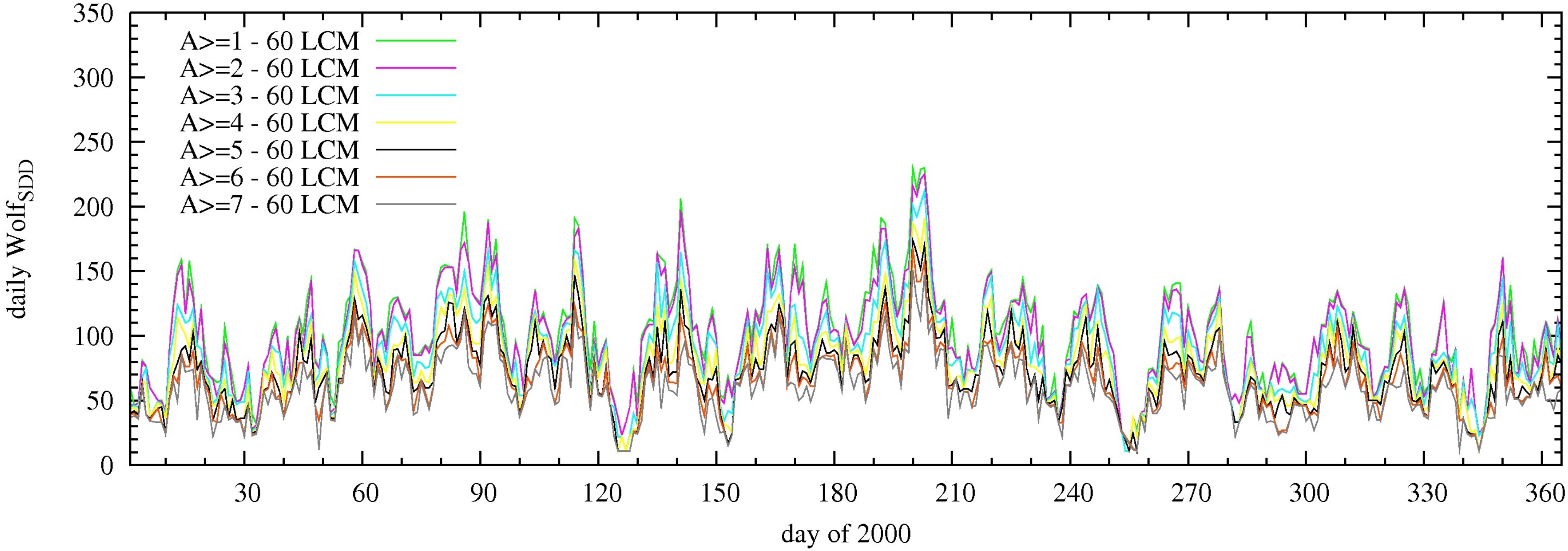
Next slides:

what happens if the smaller spots (from 1 o 7 MSH)
are omitted from the data?

Daily Wolf- numbers in 1989 from the data of DPD, sunspots within ±60º CMD (Central Meridian Distance) are considered



Daily Wolf- numbers in 200 from the data of SDD, sunspots within ±60º CMD (Central Meridian Distance) are considered



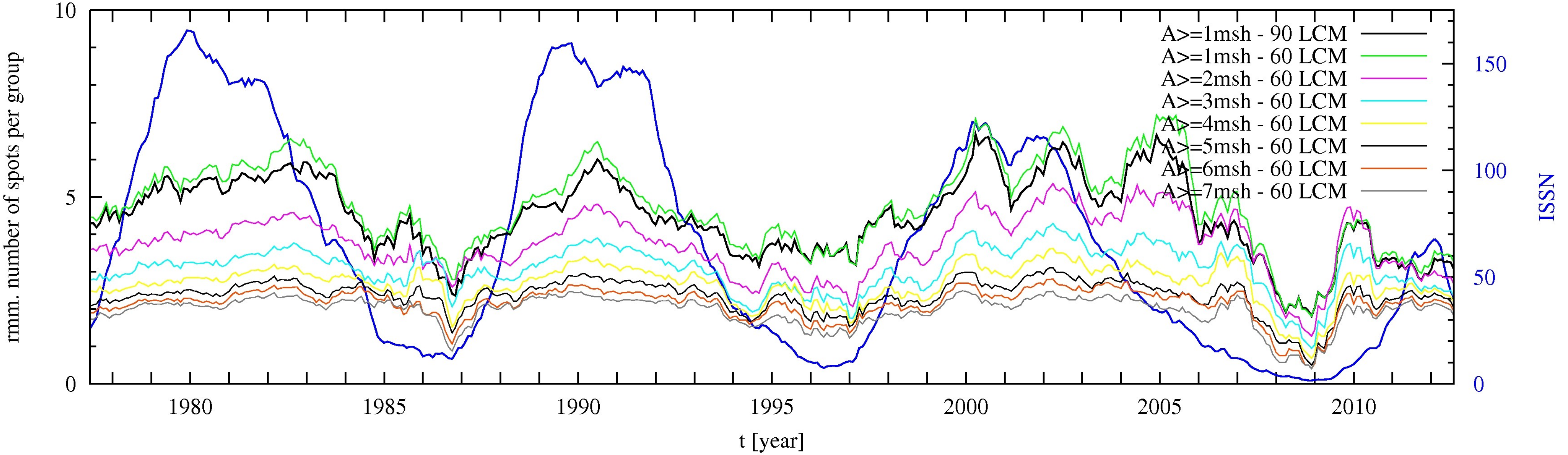
Variation of the number of spots in the groups

What is the real weight of the groups?

How stable is the Wolf-definition?

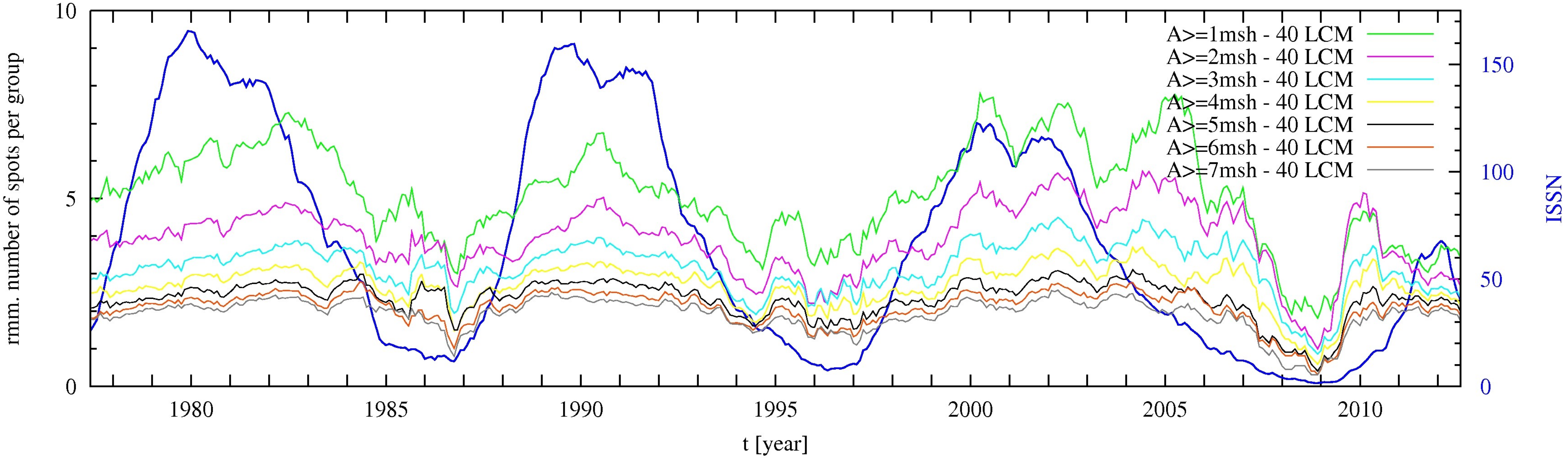
How stable is the Wolf-definition?

Number of spots in groups at maximum area within ±60º CMD in the DPD era



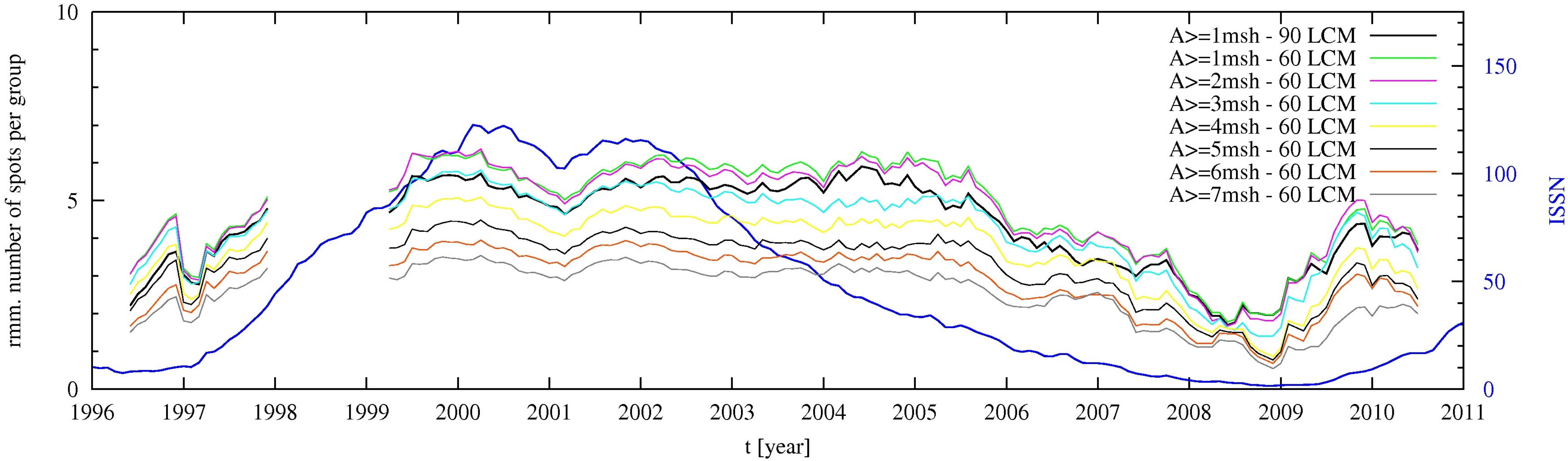
How stable is the Wolf-definition?

Number of spots in groups at maximum area within ±40º CMD in the DPD era



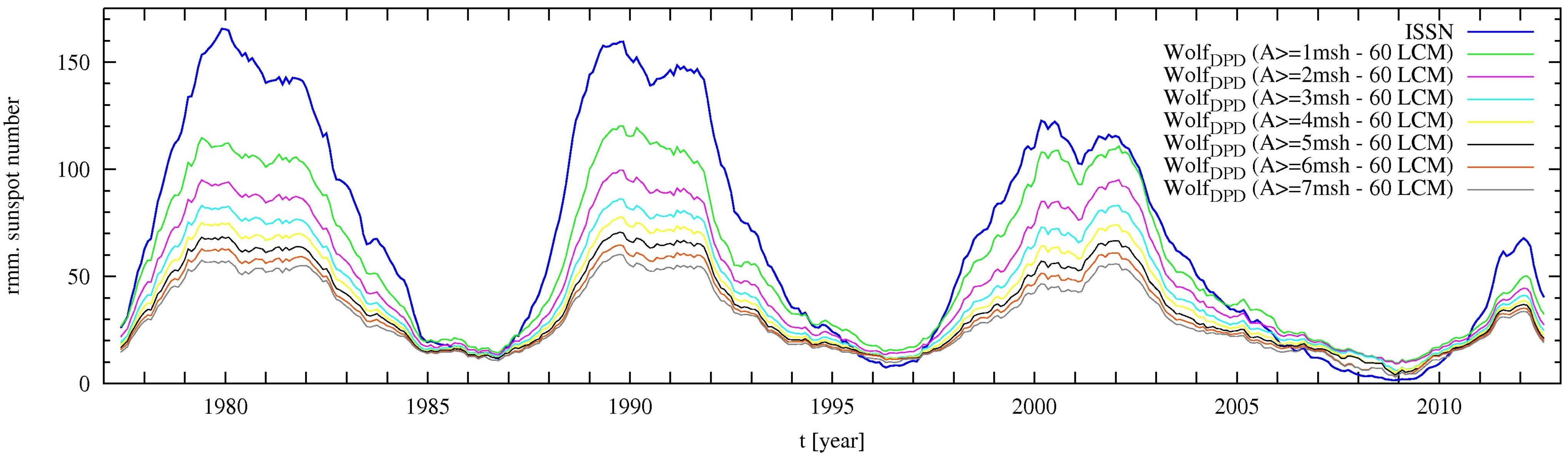
How stable is the Wolf-definition?

Number of spots in groups at maximum area within ±60º CMD in the SDD era



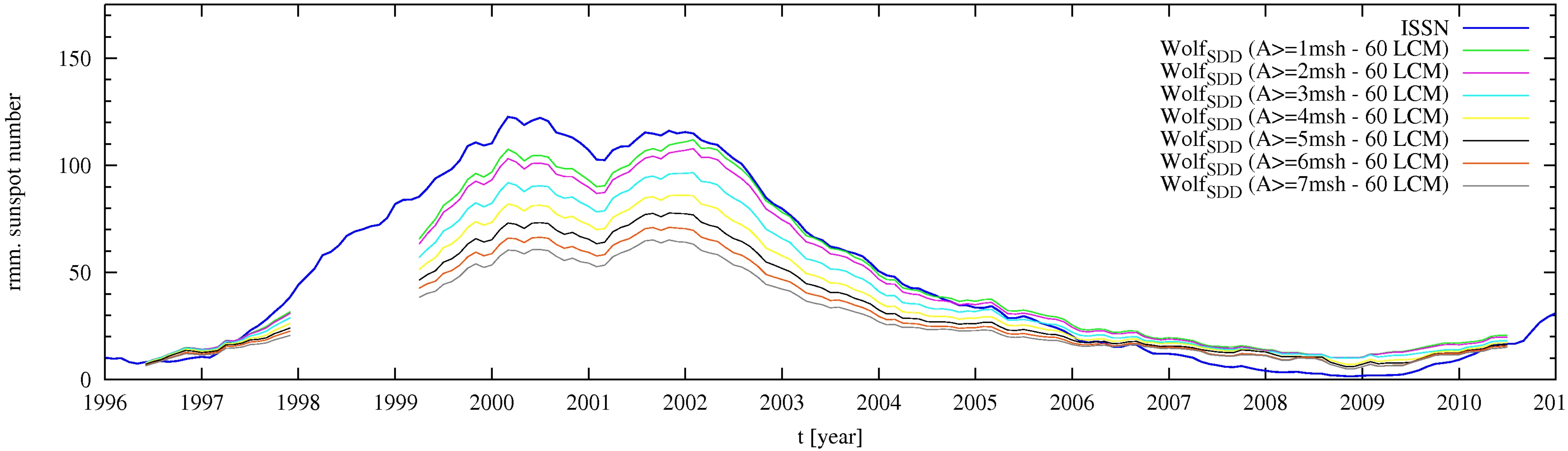
How stable is the Wolf-definition?

Cyclic time profiles of ISSN and the DPDWolf within ±60º CMD
11-monthly running means



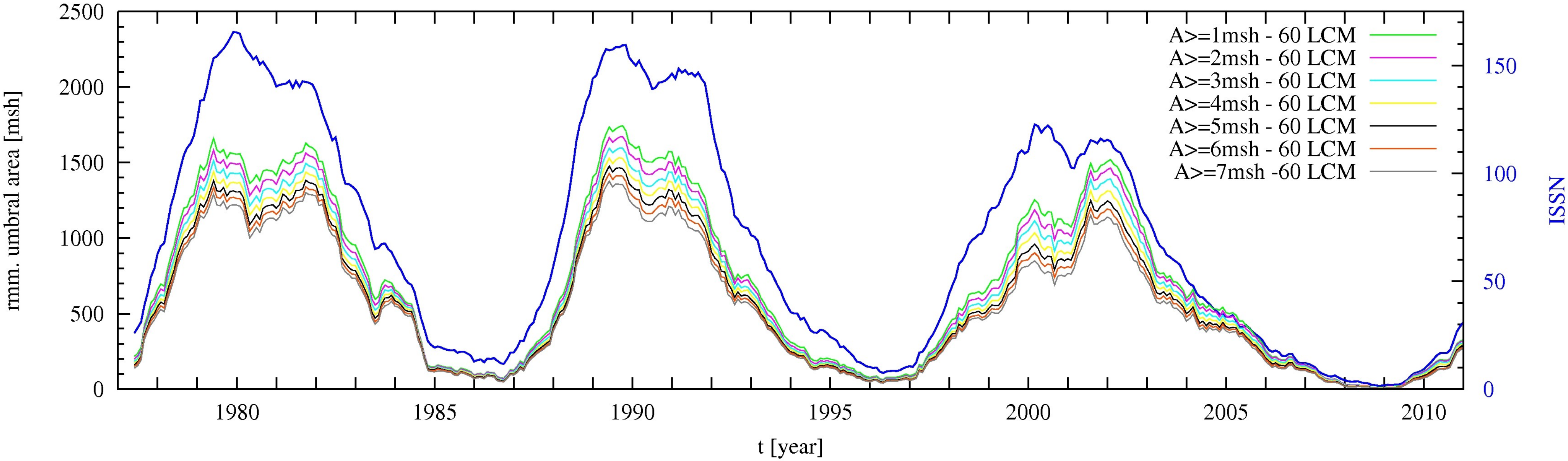
How stable is the Wolf-definition?

Cyclic time profiles of ISSN and the SDDWolf within ±60° CMD
11-monthly running means

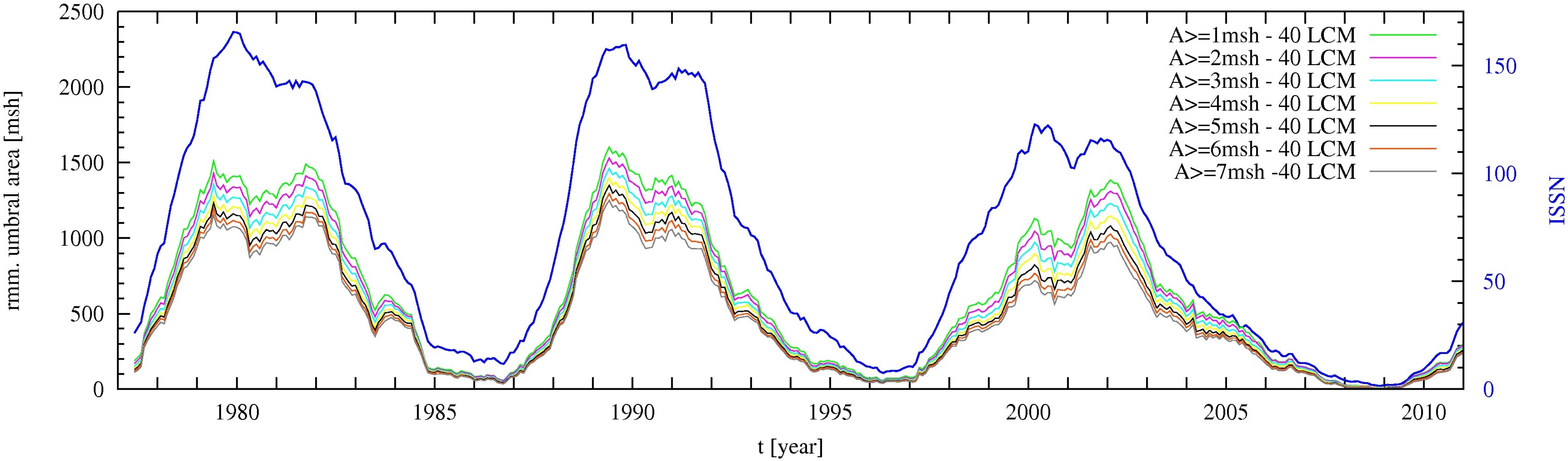


A possible reference parameter: total area of sunspots measurable on the disc

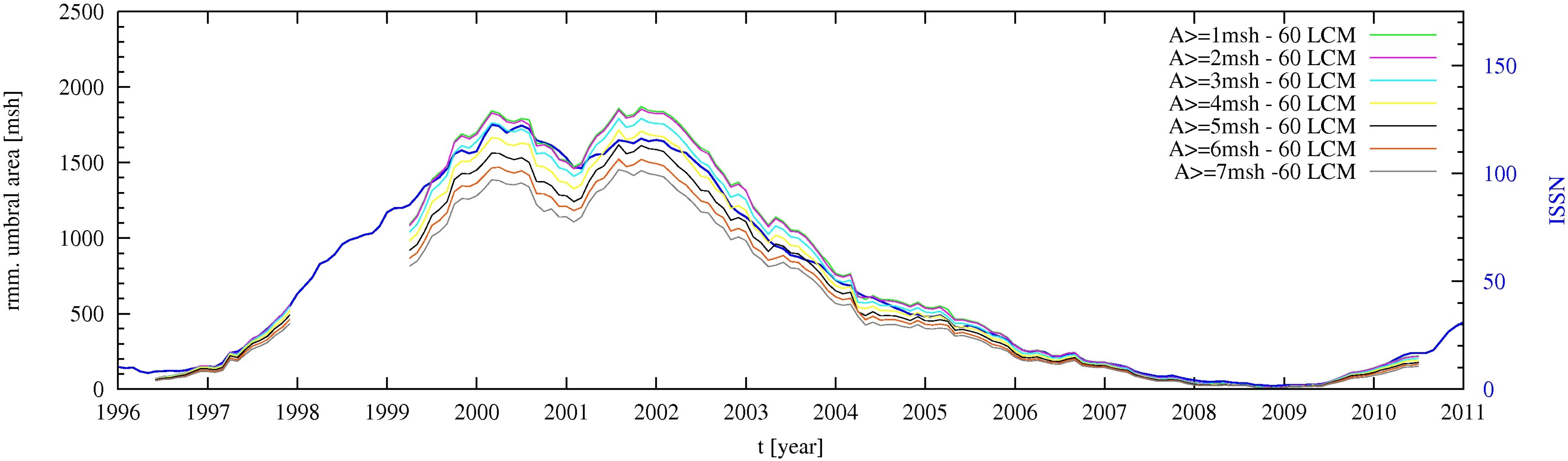
Total umbral area vs ISSN in the DPD era
monthly means of group areas taken at the highest size
smoothed with an 11-month window
±60º CMD



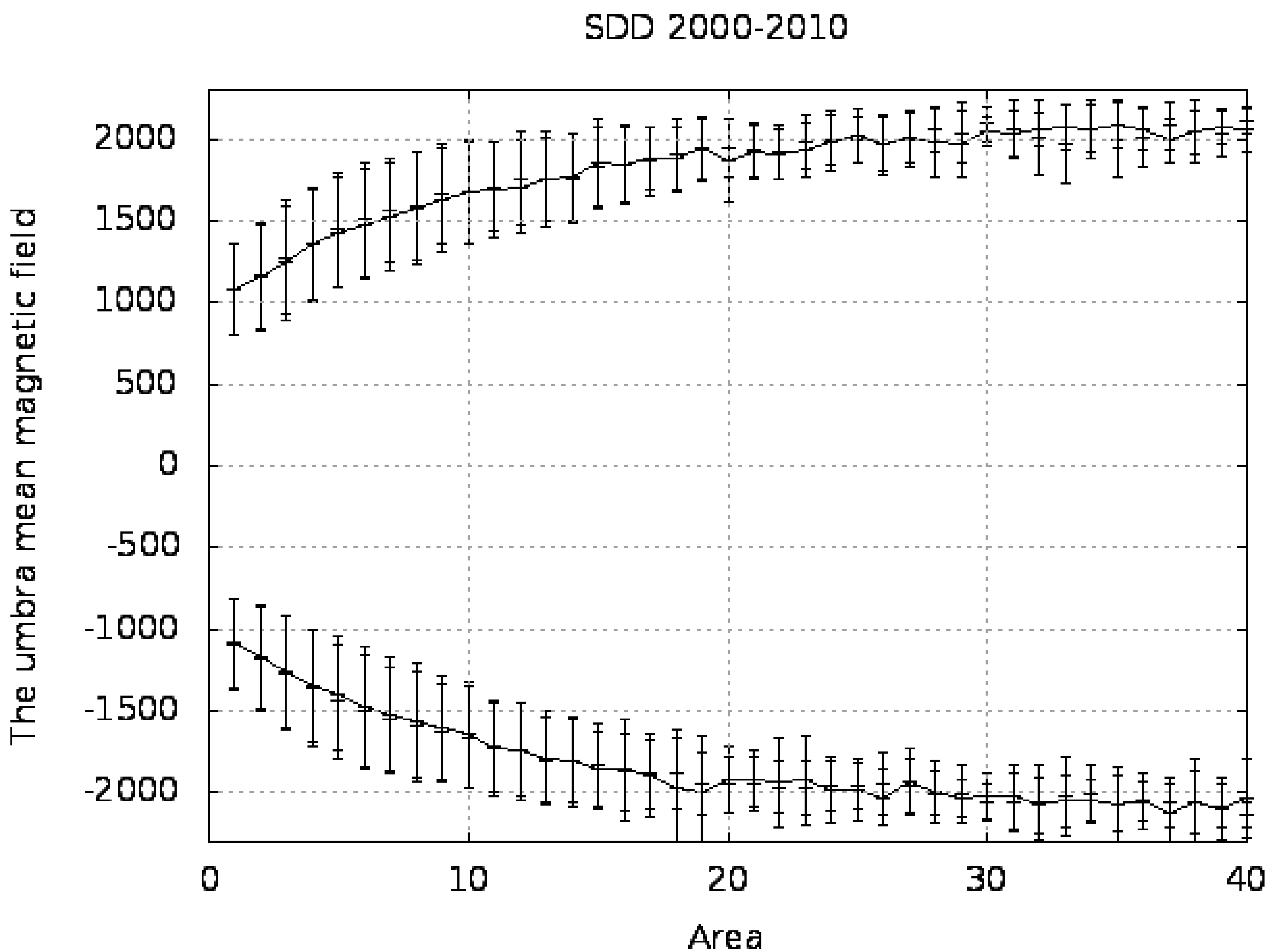
Total umbral area vs ISSN in the DPD era
monthly means of group areas taken at the highest size
smoothed with an 11-month window
±40º CMD



Total umbral area vs ISSN in the SDD era
monthly means of group areas taken at the highest size
smoothed with an 11-month window
±60º CMD



Another possible measure: total amount of emerged magnetic flux by using the area [MSH] – mean magnetic field [gauss] relationship obtained from the SDD data in the 10º environment of the solar disc center.



The total magnetic flux for all spots observable on the solar disc:

$$\mathrm{TMF} = \left[\sum K \times f(A_i) \times A_i \right]_{LP}$$

A_i : Area of i-th umbra

$f(A_i) = B_i$ the mean magnetic field of the i-th umbra (see previous frame)

K: a factor between the umbral and total fluxes

LP: leading polarity

A long-term program in Debrecen to establish an alternative sunspot parameter for the assessment of activity level:

Phase 1: monthly emerged flux by using SDD data
- Calculating TMF (previous slide) at the maximum phase of each group
- Summarizing all these TMF values for the entire month.

Phase 2: extension of the method for those area observations where no magnetic data are available.

Ultimate aim: to obtain monthly values of the total emerged flux for all time intervals covered by solar disc observations.

Advantage: this parameter is physically better established than the Wolf-definition based on spot counts.

THANK YOU