

# Sunspot Decay on a Large Statistical Sample by Using High-resolution Data Base

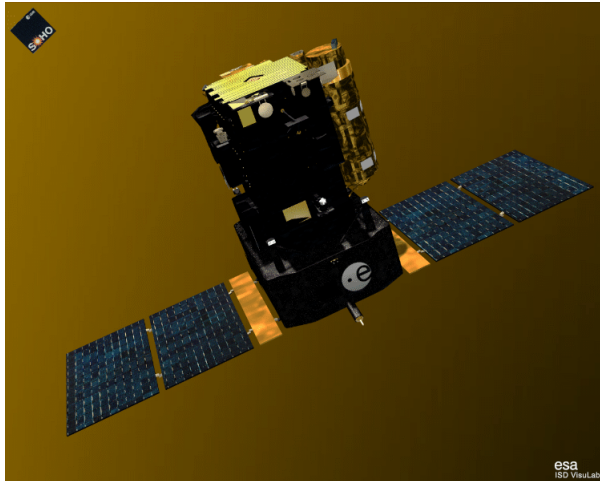
Judit Muraközy

MTA CsFK Csl

June 03, 2019.

# Solar and Heliospheric Observatory/Michaelson Doppler Imager

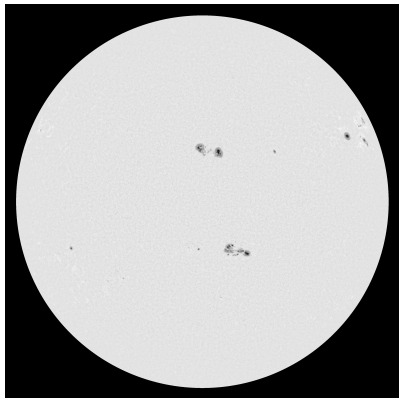
1996 – 2011



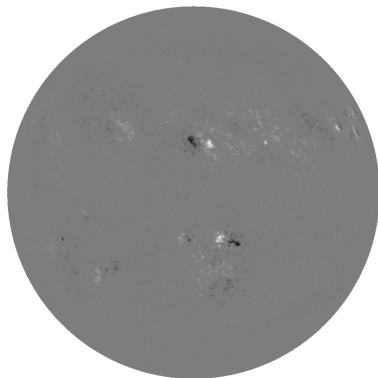
Launched Dec. 02, 1995 and it was a joint mission between ESA and NASA.

## SoHO/MDI observations

June 03, 1999 11:11:33



white-light



magnetogram

# SoHO-Debrecen Data (SDD)

Tevékenységek Firefox webböngésző

szé apr 24, 23:08:28

Sunspot Database - MOZILLA FIREFOX

Sunspot Database - SOHO - Mozilla Firefox

Fenyisolarobs.csfk.mta.hu/en/databases/SOHO/

Keresés

## SOHO/MDI - Debrecen Sunspot Data (SDD)

published by Györfi, L., Baranyi, T., Ludmány, A.

The production of data was done within the WP2(Photosphere) of SOTERIA/Solar-TERrestrial Investigations and Archives) project (FP7/SPI-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](#)

Description of the rainbow-colored columns:

- Graphical presentation of sunspots of the year
- Selected original Level 1.8, full-disk images: *Continuum intensity (fits.gz) / Magnetograms (fits.gz)*
- Processed enlarged full-disk images (solar north at the top): *Contrast enhanced intensity images (jpg) / Magnetograms (jpg)*
- Sunspot and sunspot group data (see [SDDformat.txt](#)):
  - 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)
- Facular data (see [SDDformat.txt](#)): *Full-disk catalogue of continuum faculae (txt) / Graphical presentation of faculae of the year*

### DATA BY HOURLY OBSERVATIONS

1996	1996I	1996M	1996I1.jpg	1996M.jpg	ftsDD1996	SDD1996	1996group.jpg	1996group.fits	facSDD1996	1996
1997	1997I	1997M	1997I1.jpg	1997M.jpg	ftsDD1997	SDD1997	1997group.jpg	1997group.fits	facSDD1997	1997
1998	1998I	1998M	1998I1.jpg	1998M.jpg	ftsDD1998	SDD1998	1998group.jpg	1998group.fits	facSDD1998	1998
1999	1999I	1999M	1999I1.jpg	1999M.jpg	ftsDD1999	SDD1999	1999group.jpg	1999group.fits	facSDD1999	1999
2000	2000I	2000M	2000I1.jpg	2000M.jpg	ftsDD2000	SDD2000	2000group.jpg	2000group.fits	facSDD2000	2000
2001	2001I	2001M	2001I1.jpg	2001M.jpg	ftsDD2001	SDD2001	2001group.jpg	2001group.fits	facSDD2001	2001
2002	2002I	2002M	2002I1.jpg	2002M.jpg	ftsDD2002	SDD2002	2002group.jpg	2002group.fits	facSDD2002	2002
2003	2003I	2003M	2003I1.jpg	2003M.jpg	ftsDD2003	SDD2003	2003group.jpg	2003group.fits	facSDD2003	2003

# SoHO-Debrecen Data (SDD)

1999

MURAKÖZY\_PRIMORSKO\_2019\_POSTER.odg - LibreOffice Draw

Mozilla Firefox

Bétkes: Z Zimbra; Worksh: Index; Hidden; Movem; Connection; Google; SZTAKO; Free, Po; Worksh: FAQ [e]; Aeroshutt; Canon; fitting; Feny; X; learning; Minimu; +

fenyl.solarobs.csfk.mta.hu/SDD/1999/index.html

Legtöbbször látogatott Getting Started

2019. máj. 24., p.00.46.29

## SOHO/MDI - Debrecen Sunspot Data 1999

Catalogues: combined data: [SDD1999.txt](#), hourly data: [hSDD1999.txt](#), group data: [gSDD1999.txt](#), spot data: [sSDD1999.txt](#)

Images of sunspot groups: [1999group\\_fits\\_1999group.jpg](#)

Full-disk intensity observations: [1999f01](#) (original), [1999f04.jpg](#)

Magnetic observations: [1999M](#) (original), [1999M.jpg](#) (quick-look, solar north at the top)

January	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
February	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
March	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
April	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
May	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
June	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
July	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
August	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
September	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
October	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
November	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
December	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

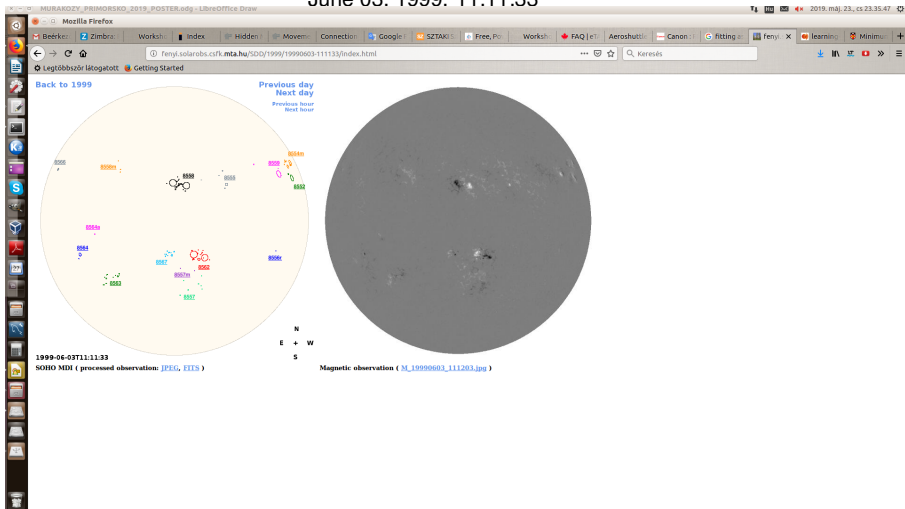
### ACKNOWLEDGMENTS



The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 218816 between Nov 2008 and Oct 2011. The EC contribution to the costs of the SOTERIA project was 75%, 10% of the SOTERIA-related costs of the Heliospherical Observatory was supported by the National Development Agency (Nemzeti Fejlesztési Ügynökség) under grant agreement n° BONUS\_HU\_08-BONUS\_HU\_08/2009-003, and 15% was the institutional contribution.

# SoHO-Debrecen Data (SDD)

June 03. 1999. 11:11:33



# SoHO-Debrecen Data (SDD)

8558 NOAA. June 03. 1999 11:11:33

MURAKÖZY, PRIMORSKO, 2019, POSTER.odg - LibreOffice Draw

Mozilla Firefox

Becker: Zimbra: Worksh: Index: Hidden: Movem: Connection: Google: SZTAKI: Free, Po: Worksh: FAQ | en: Aeroshutt: Canon: fitting: Fenyl: X: learning: Minimu: +

→ C: bekerked leveles-jmurakozy@gmail.com - Gmail  
Legtöbbször látogatott: Getting Started

ta.hu/SDD/1999/19990603-111133/19990603-111133\_8558.html

Keresés

group	Proj. U	Proj. WS	Corr. U	Corr. WS	B	L	LCM	Pos. angle	r	MU	MP
8558	220	1457	114	753	15.36	283.54	2.09	352.48	0.2800	34.7	-2.0

[previous](#) or [next](#) observation for the same group / [back to the solar disc](#)

SOHO MDI 1999-06-03 11:11:33 UT

50M6-MDI 6/3/1999 11:11:33 UT NOAA 8558

spot	Proj. U	Proj. WS	Corr. U	Corr. WS	B	L	LCM	Pos. angle	r	MU	MP
1	5	611	3	315	13.81	287.31	5.87	338.04	0.2666	1632.6	817.5
2	11	-1	6	-1	14.38	287.16	5.72	339.32	0.2746	1623.5	999999
3	5	-1	3	-1	13.97	286.91	5.46	339.63	0.2667	1839.1	999999
4	66	-1	34	-1	15.40	286.58	5.13	342.47	0.2875	2045.4	999999
5	-4	-1	-4	-1	14.75	286.52	5.07	341.92	0.2768	999999	999999
6	7	-1	3	-1	13.97	286.38	4.93	341.46	0.2637	1841.5	999999
7	0	5	0	3	12.35	286.10	4.66	340.28	0.2362	728.0	632.3
8	3	-1	2	-1	14.79	286.03	4.58	343.60	0.2750	1609.6	999999
9	5	-1	2	-1	14.83	285.79	4.34	344.47	0.2745	1333.1	999999
10	0	4	0	2	13.08	285.27	3.82	344.48	0.2437	546.0	497.2
11	0	6	0	3	14.58	284.97	3.52	347.09	0.2671	289.0	403.1
12	0	7	0	4	15.24	284.77	3.33	348.29	0.2771	57.0	302.1
13	0	45	0	23	15.48	284.24	2.80	350.27	0.2795	1126.0	499.7

By using the magnetic field data one can distinguish between the leading and following sunspots.

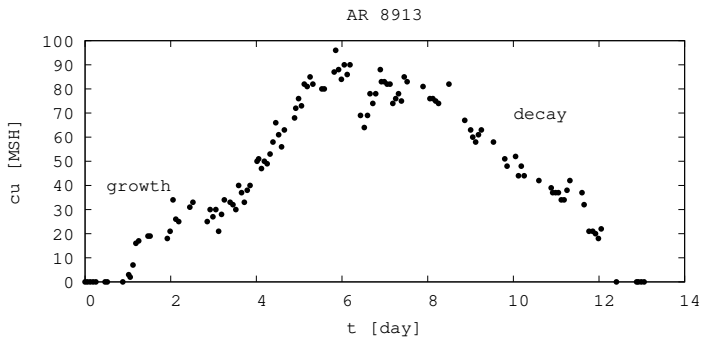
There are 35 sunspots in this group. Altogether there are 432 data for only this sunspot group at that time.

## Requirements for the data

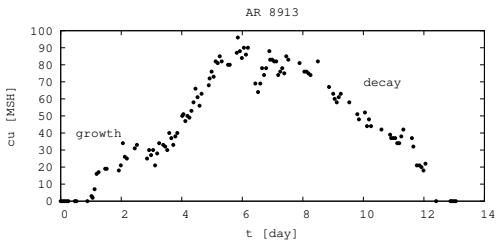
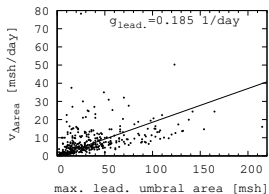
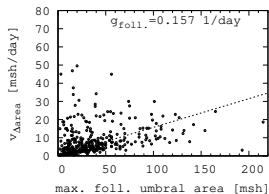
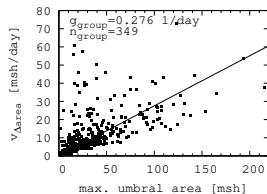
- ▶ Sunspot groups which growth at least 4 days
- ▶ and they show decay pattern at least 2 days
- ▶ equilibrium area = maximum area
- ▶ area = umbral area
- ▶ should be two opposite polarities at the maximum area of sunspot groups  $\Rightarrow$  clear growth phase of the groups



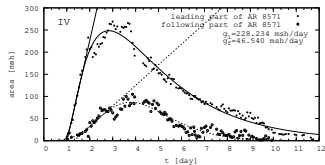
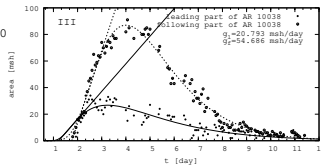
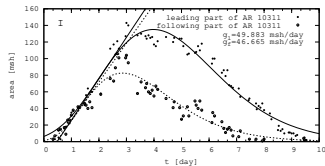
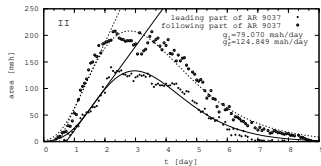
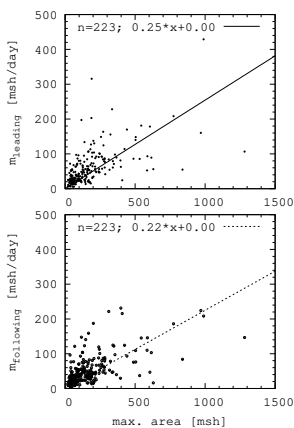
# Growth and decay



## Growth rates



# Analytical growth rate

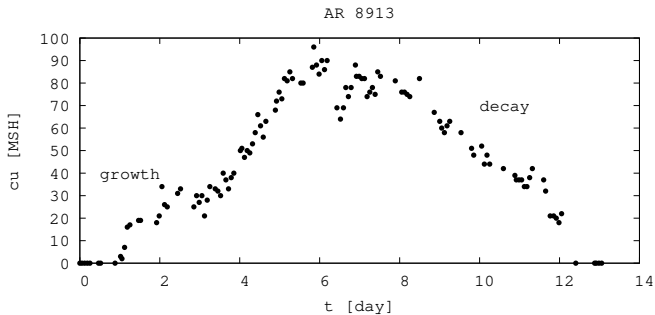


## Requirements for the sample groups

- ▶ groups with maximum area are at least 40 % higher than their area at the time of the first and last observations
- ▶ lifetime of the groups is at least 8 days
- ▶ the time-span of their decay is at least 4 days  $\Rightarrow$  clear area maximum
- ▶ equilibrium area = maximum area
- ▶ area = umbral area
- ▶ should be two opposite polarities at the maximum area of sunspot groups

Real and checked decay and its investigation. The number of the sample is 267.

## Decay rates of sunspot groups and their parts

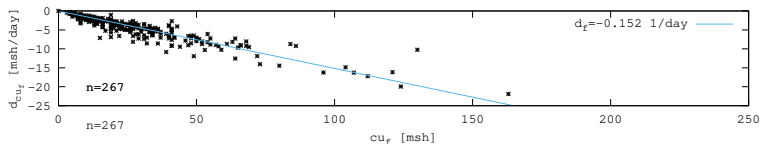
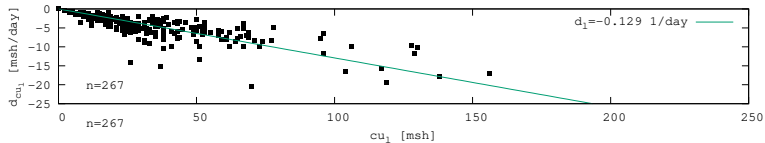
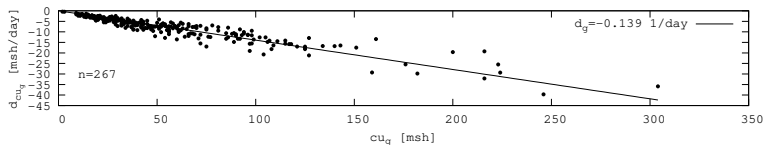


$$V_U = \frac{CU_{f65} - CU_m}{t_{f65} - t_m}$$

or we can use the average value of the daily variations of umbral area

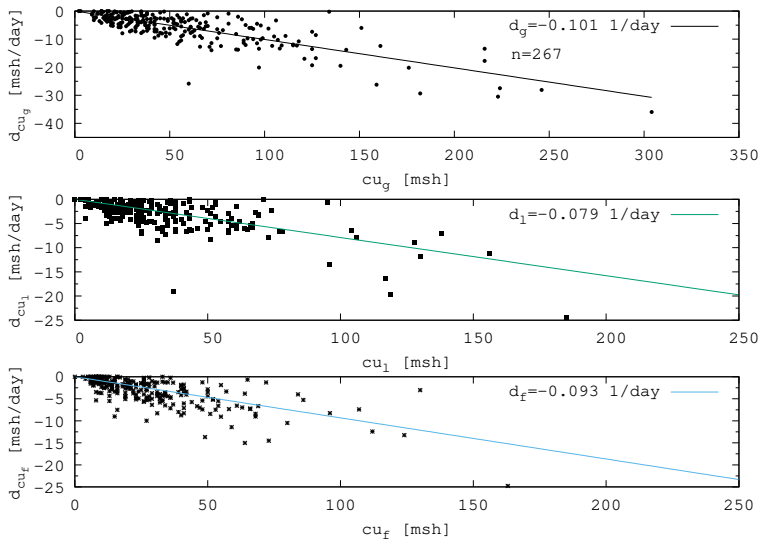
## Decay rate – umbral area

sunspot group – leading part – following part



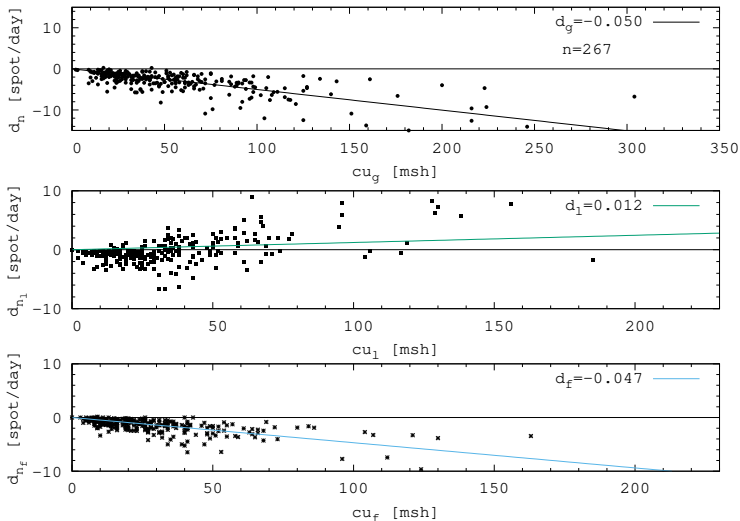
## Decay rate – area (average daily variation)

sunspot group – leading part – following part



# Decay rate – number of groups

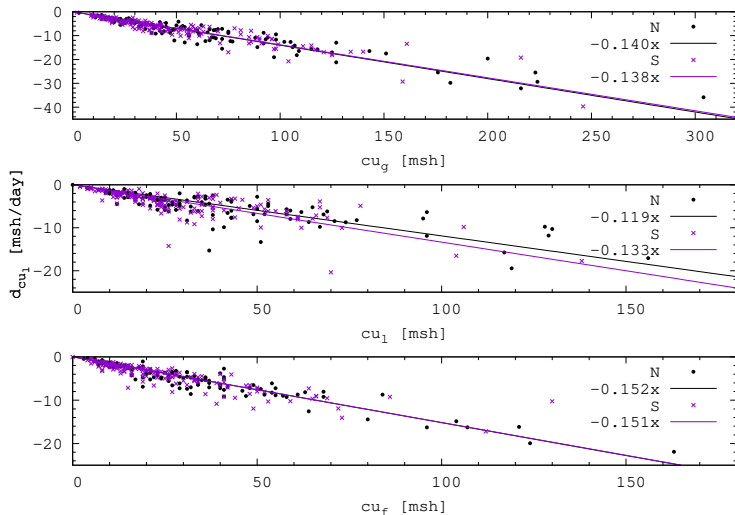
sunspot group – leading part – following part



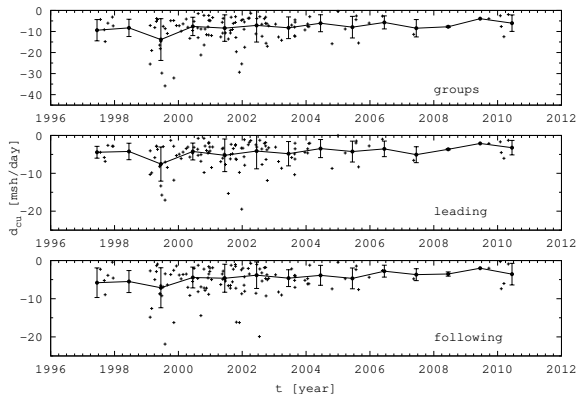


# Solar hemispheric decay rates

sunspot group – leading part – following part



# Cycle dependence



Cycle dependence can not be pointed out obviously. This needs more analyzes.

## Some papers about sunspot decay...

- ▶ Petrovay et al. 1997, Sol.Phys.: Based on two years (1977-1978) data, but only for those sunspots that larger than 10 MSH. There is linear relationship between the decay rate and the diameter of the sunspot. The sunspot decay is governed by the turbulent diffusion.
- ▶ Norton et al. 2017, ApJ : studied 10 sunspot groups by using observations of SDO/HMI. They focused mainly on the growth, but studied the decay as well, however there are less data for the decay.  
Area dependence of the growth: larger groups emerged faster than smaller ones.  
The decay rate is half of the growth rate.  
The growth rate of the leading part is higher than the following part.  $\Rightarrow$  these results are as ours, but this study can investigate only 10 sunspot groups
- ▶ there is no leading-following separation, or the number of the sample is too low to study cycle dependencies

## Summary

- ▶ The growth rate is higher than the decay rate
- ▶ The decay rate of the following part is higher than the leading one
- ▶ N-S asymmetry can not be pointed out clearly during the decay
- ▶ Cycle dependence can not be pointed out clearly as well.

Thank you for your attention!

This work is funded by the NKFIH OTKA FK2018 project under the contract number 129137.