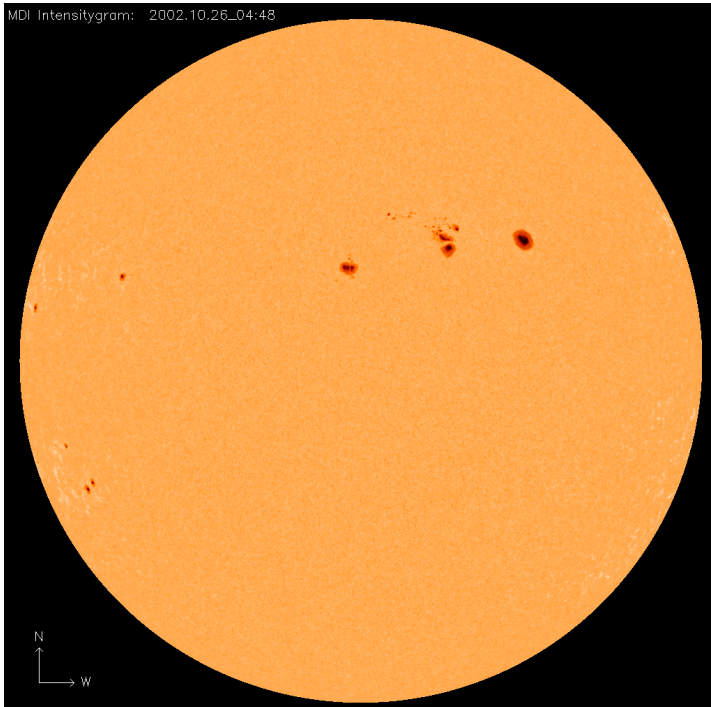
The big CV-project

Jan Janssens

Asten, NL

30 May 2009

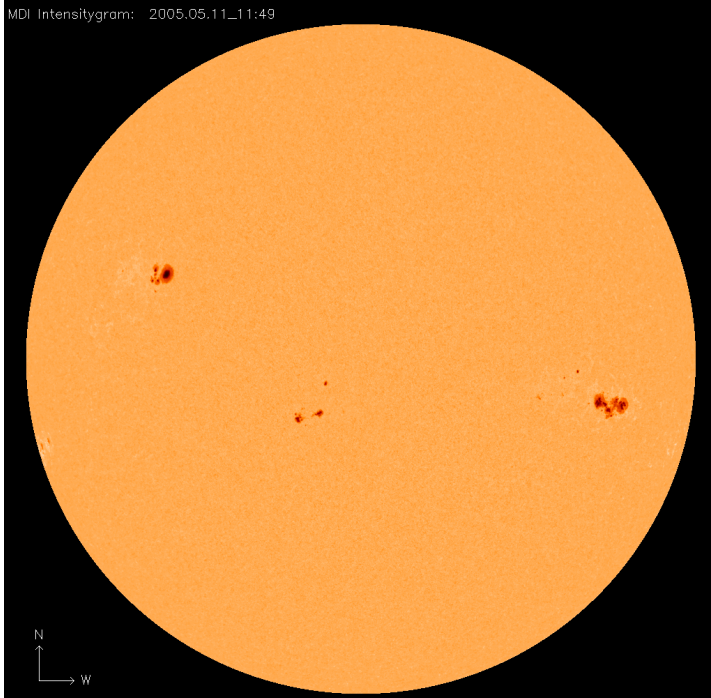


The problem…

26 Oct 2002 **# Flares**

R=81 **C: 2**

SA=1820 MH **M: 0**



11 May 2005 **# Flares**

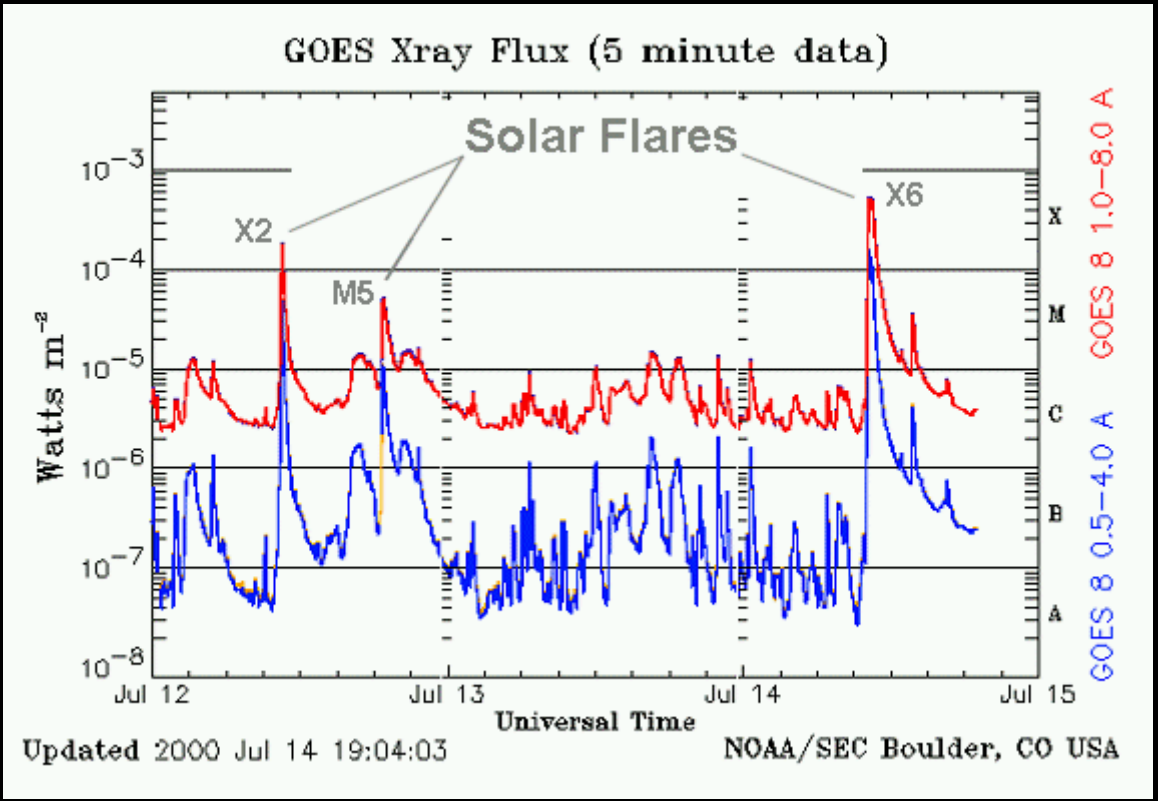
R=82 **C: 9**

SA=1862 MH **M: 2**

The Classification Value (CV)

- Based on the McIntosh-classification
  - Introduced in 1966 by Patrick McIntosh
    - Final version published in 1990
  - 3 letter-code
    - Z: Waldmeier-classification (modified)
    - p: Shape of the main spot
    - d: Internal distribution of sunspots within the group
  - Especially a tool developed for the daily prediction of flares

Classification of röntgenflares



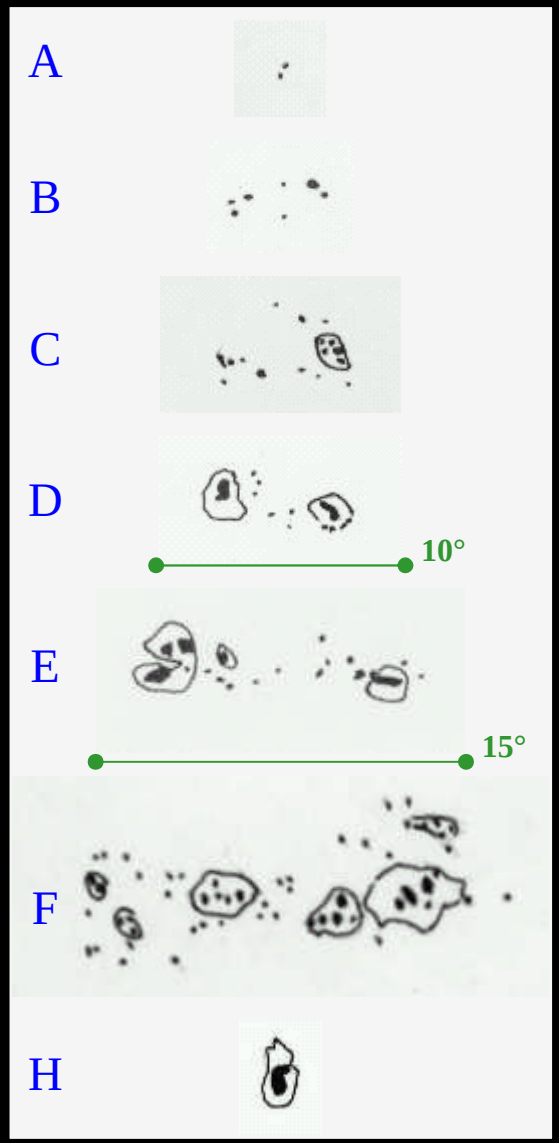
Power C:M:X : 1 : 10 : 100
Number C:M:X : 89 : 12 : 1
Fluence = Σ flare maximum

The McIntosh-classification

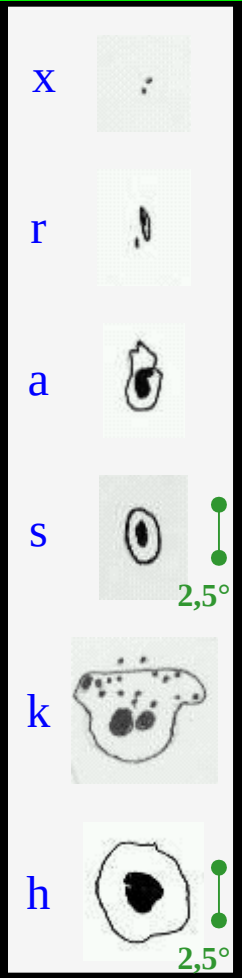
- 3 components
  - Z: Modified Waldmeier (Zürich) classification
    - Unipolar or bipolar group?
    - Penumbra or no penumbra?
    - Penumbra on one or both sides of the group?
    - Length of the group (>10°? >15°?)
  - p: Shape of penumbra main spot
    - Rudimentary or mature penumbra?
    - Symmetrical or asymmetrical main spot?
    - N-S-diameter of main spot (>2,5°?)
  - d: Internal distribution of the spots
    - Spots between leading and following main spots?
    - Is there internally at least 1 spot with mature penumbra?
- 60 possible combinations

The McIntosh-classification

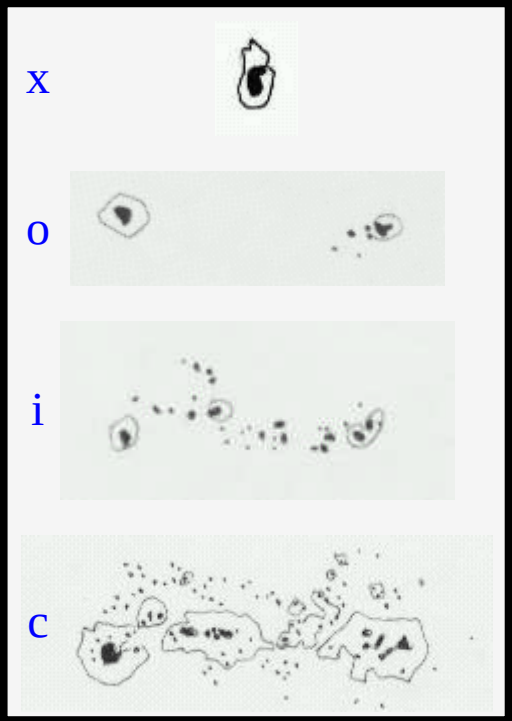
Modified Waldmeier class



Shape & symmetry penumbra main spot



Internal distribution sunspots



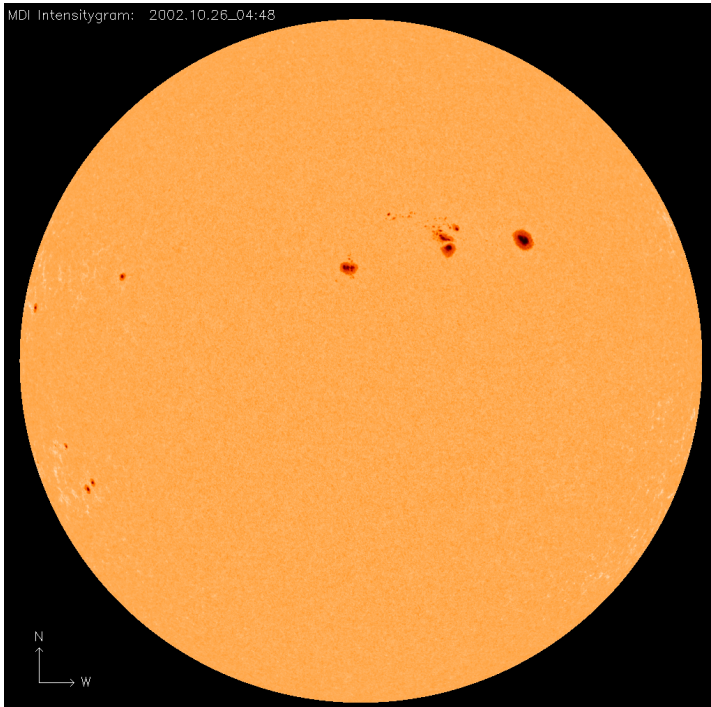
Drawings: Kanzelhöhe Observatory

Classification Value

- Kjell Inge Malde
  - August 1981
    - Each combination gets a score from 1 to 60
      - From Axx = 1 to Fhc = 60
    - Based on
      - longer “survival” of s/h-groups vs. a/k-groups
      - Complexity from internal sunspot distribution
    - Important indicator in prediction of solar flares
  - Determination CV-USAF => November 1971
- McI and CV now also used by NOAA, SIDC,… and many other professionals and amateurs

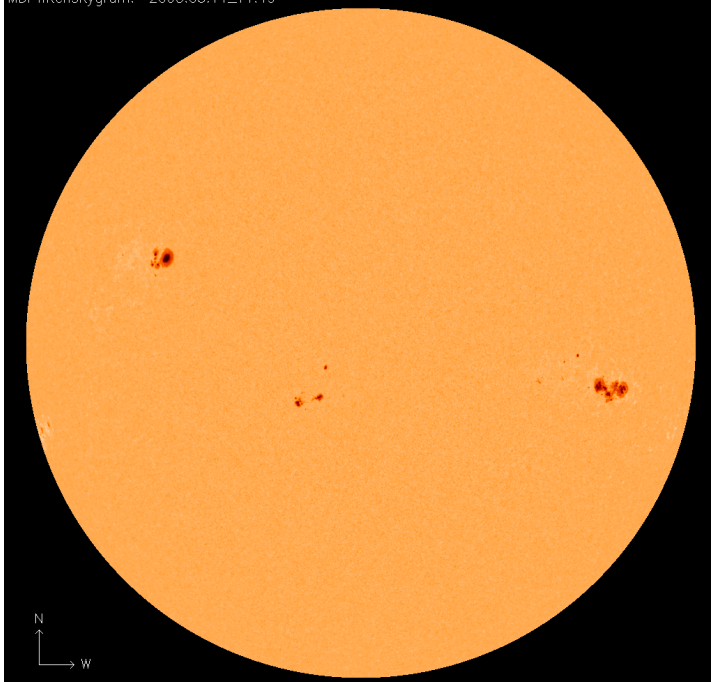
Classification Value

Axx 1					
Bxo 2 Bxi 3					
	Hrx 4	Cro 5 Cri 6	Dro 13 Dri 16	Ero 14 Eri 17	Fro 15 Fri 18
	Hax 7	Cao 8 Cai 9	Dao 19 Dai 22	Eao 20 Eai 23	Fao 21 Fai 24
	Hsx 10	Cso 11 Csi 12	Dso 25 Dsi 28 Dac 31 Dsc 34	Eso 26 Esi 29 Eac 32 Esc 35	Fso 27 Fsi 30 Fac 33 Fsc 36
	Hkx 37	Cko 38 Cki 39	Dko 43 Dki 46	Eko 44 Eki 47	Fko 45 Fki 48
	Hhx 40	Cho 41 Chi 42	Dho 49 Dhi 52 Dkc 55 Dhc 58	Eho 50 Ehi 53 Ekc 56 Ehc 59	Fho 51 Fhi 54 Fkc 57 Fhc 60



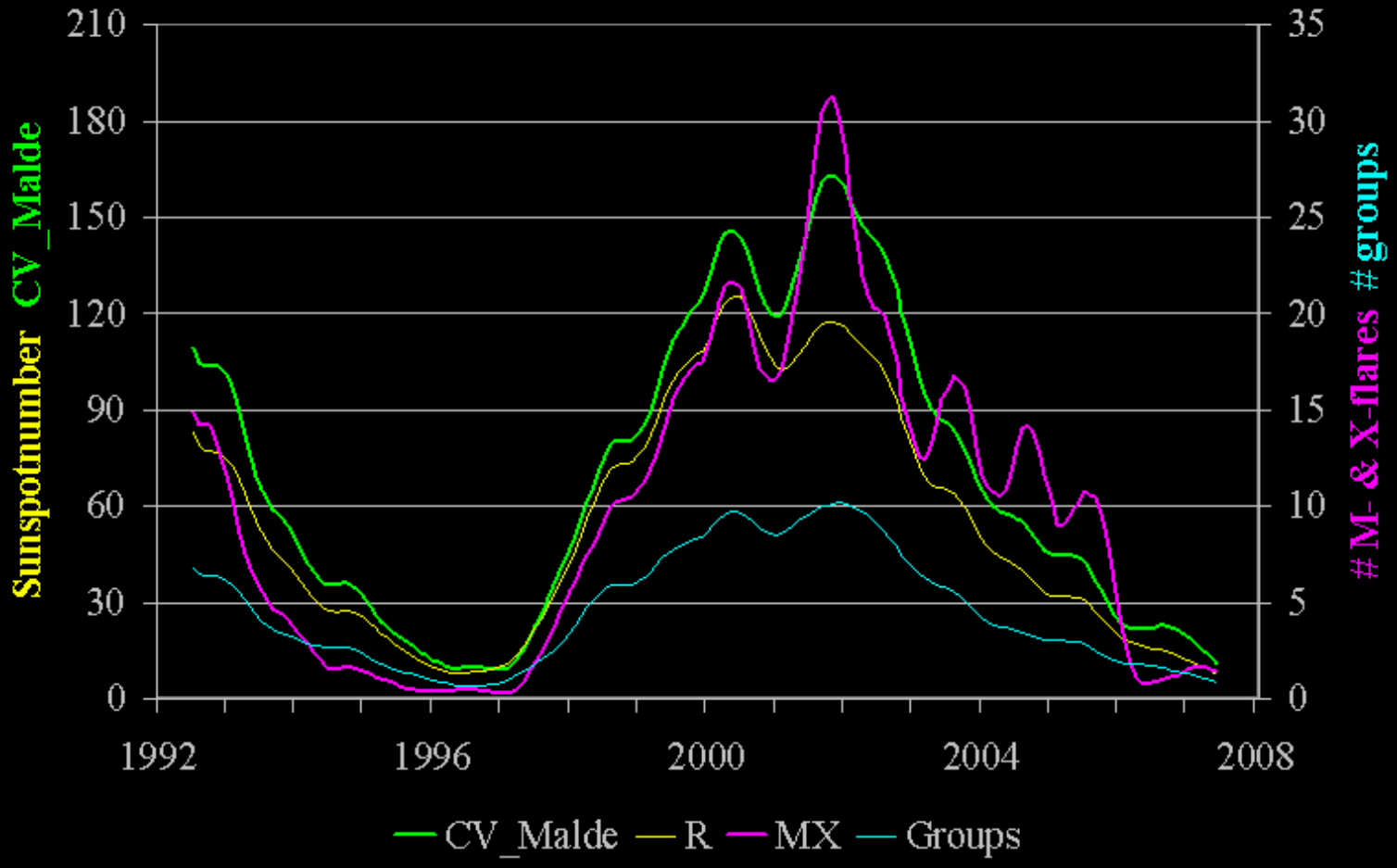
The problem…
The solution…

26 Oct 2002	# Flares	CV
R=81	C: 2	88
SA=1820 MH	M: 0	



11 May 2005	# Flares	CV
R=82	C: 9	133
SA=1862 MH	M: 2	

CV vs. Flares vs. R

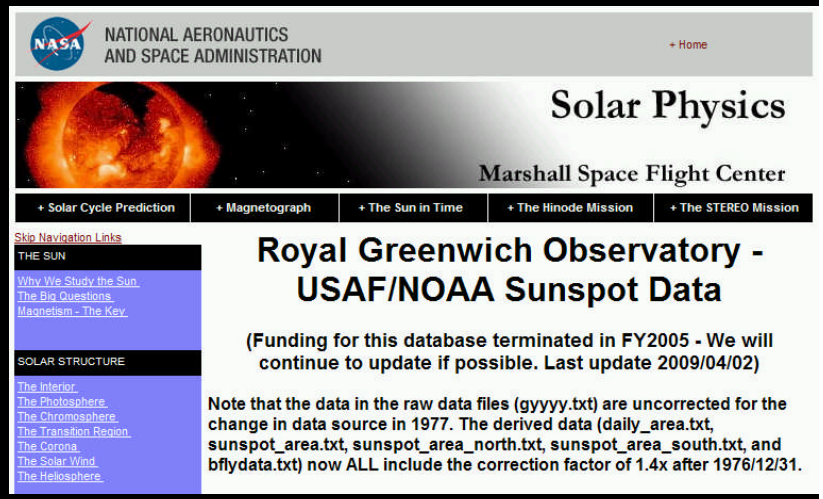


Practical problems with CV

- Limited timeseries
  - CV-USAF since 1971, CV-Malde since 1981
- Only total CV
  - No distinction between solar hemispheres
- Several observers
  - Higher reliability vs. Longterm consistency
- Correlation with flare-activity
  - Better than sunspotnumber
    - E.g. in period 2000-2002
  - Not always that good
    - E.g. in period 2003-2005

The big CV-project

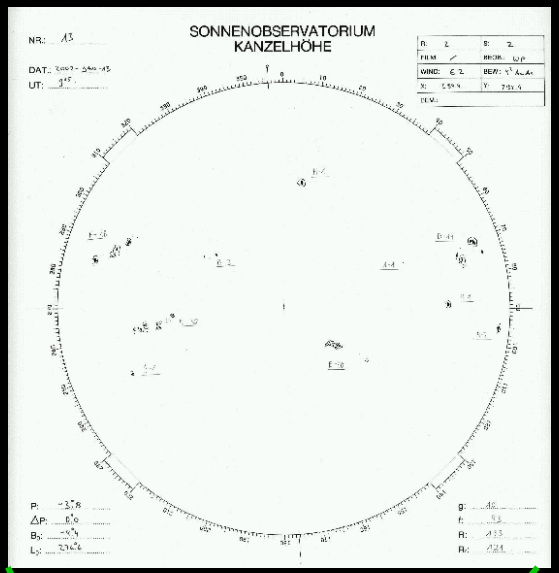
- Kanzelhöhe Observatory
  - Drawings from 1944 – now
    - Interruption 1966-1968
  - http://cesar.kso.ac.at/
- Greenwich-NOAA data
  - Data from 1874 – now
    - NOAA since 1976
  - http://solarscience.msfc.nasa.gov/greenwch.shtml



The big CV-project

http://solarscience.msfc.nasa.gov/greenwch/g2002.txt

2002	112.500	9779	B	0	0	0	120	0.583	19.7	268.0	29.0	-13.0
2002	112.500	9780	A	0	0	0	30	0.999	259.8	14.0	-10.0	93.0
2002	112.500	9781	A	0	0	0	80	0.786	92.9	229.0	-5.0	-52.0
2002	112.500	9782	B	0	0	0	320	0.893	77.6	219.0	9.0	-62.0
2002	112.500	9783	A	0	0	0	90	0.968	99.2	205.0	-10.0	-76.0
2002	113.500	9772	A	0	0	0	30	0.812	252.3	322.0	-17.0	54.0
2002	113.500	9773	BGD	0	0	0	530	0.866	291.4	325.0	16.0	57.0
2002	113.500	9775	BG	0	0	0	180	0.680	267.5	311.0	-5.0	43.0
2002	113.500	9776	B	0	0	0	20	0.502	301.1	294.0	11.0	26.0
2002	113.500	9778	BGD	0	0	0	140	0.251	143.1	259.0	-16.0	-9.0
2002	113.500	9779	A	0	0	0	130	0.567	3.1	266.0	30.0	-2.0
2002	113.500	9781	A	0	0	0	60	0.627	92.4	229.0	-5.0	-39.0
2002	113.500	9782	B	0	0	0	280	0.760	75.5	220.0	8.0	-48.0
2002	113.500	9783	A	0	0	0	160	0.904	100.1	203.0	-11.0	-65.0
2002	113.500	9784	A	0	0	0	10	0.866	121.1	210.0	-29.0	-58.0
2002	113.500	9785	B	0	0	0	110	0.821	72.0	215.0	12.0	-53.0
2002	114.500	9772	A	0	0	0	30	0.918	253.5	322.0	-17.0	67.0
2002	114.500	9773	BGD	0	0	0	460	0.952	288.4	325.0	16.0	70.0



Microsoft Excel - G2002Kanz

Bestand Bewerken Beeld Invoegen Opmaak Extra Data Venster Help

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Year	Month	DD,ddd	Group	Type	Obs Um Are	Obs Area	Corr Um Are	Corr Area	r	rho	Car Long	Lat	Elong	Mcl	C50	Remarks		
130	2002	1	12	9780	A	0	0	0	30	0.999	-56.4	14.0	-10	93					
131	2002	1	13	9783	A	0	0	0	160	0.904	56.4	203.0	-11	-65	Hax				
132	2002	1	13	9784	A	0	0	0	10	0.866	49.1	210.0	-29	-58	0				
133	2002	1	13	9785	B	0	0	0	110	0.821	54.5	215.0	12	-53	Dao				
134	2002	1	13	9782	B	0	0	0	280	0.760	55.5	220.0	8	-48	Hax		Area???? Split from Kanz D		
135	2002	1	13	9781	A	0	0	0	60	0.628	57.2	229.0	-5	-39	Hax				
136	2002	1	13	9778	BGD	0	0	0	140	0.252	34.2	259.0	-16	-9	Cao		Kanz E????		
137	2002	1	13	K02002									5	-30	Axx				
138	2002	1	13	9779	A	0	0	0	130	0.566	3.1	266.0	30	-2	Hax				
139	2002	1	13	9776	B	0	0	0	20	0.502	-49.1	294.0	11	26	Bxi				
140	2002	1	13	9775	BG	0	0	0	180	0.680	-57.2	311.0	-5	43	Eac	no			
141	2002	1	13	9772	A	0	0	0	30	0.813	-54.6	322.0	-17	54	Hax		Area?		
142	2002	1	13	9773	BGD	0	0	0	530	0.866	-53.4	325.0	16	57	Fac	no			
143	2002	1	14	9783	A	0	0	0	140	0.787	56.3	203.0	-11	-52					
144	2002	1	14	9784	A	0	0	0	0	0.742	47.3	211.0	-28	-44					

Added if not in database

>50% spotcoverage

"0" if not observed

Split if necessary

Comments

Internal distribution of sunspots

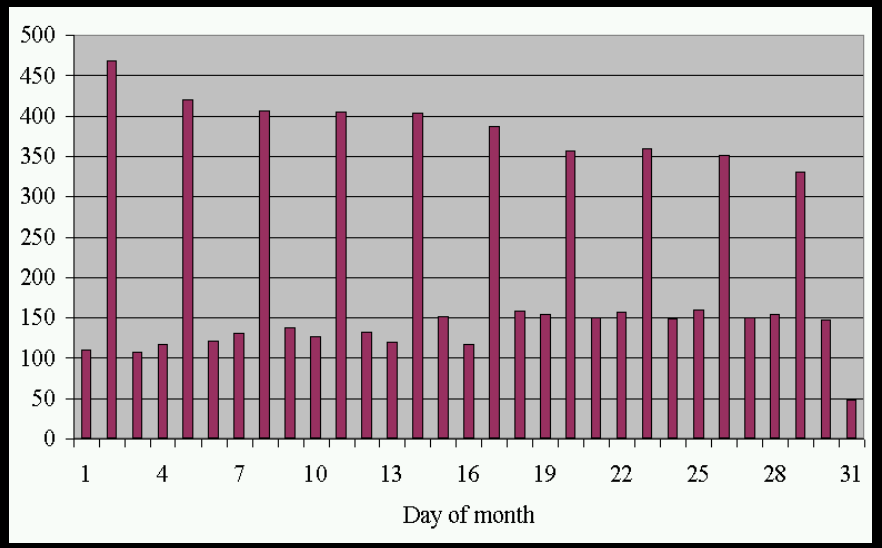
- Additional distinction
  - Only for groups with a "compact" distribution of sunspots
  - If area penumbra > 50% of total area covered by group
    - "t" (C50: yes)
  - If not
    - "c" (C50: no)
- "Normal" McIntosh classification
  - All "c"

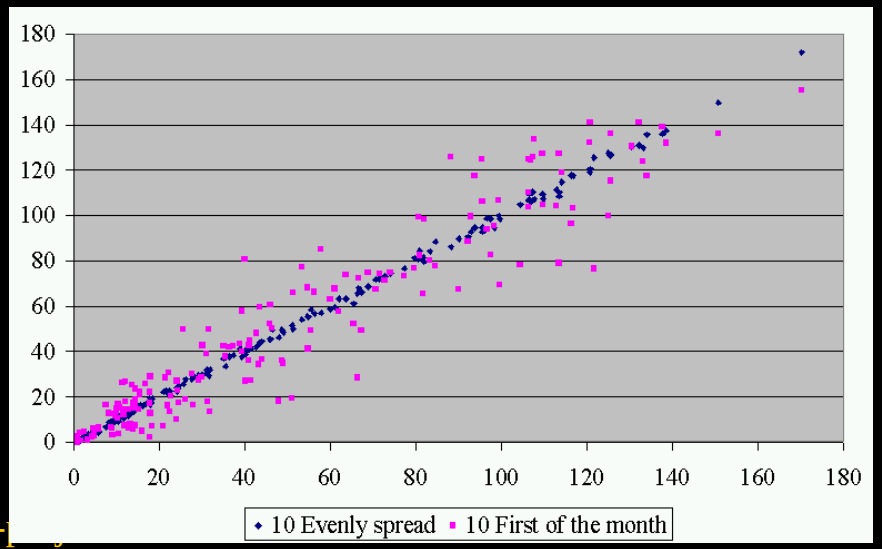
Fkt

Fkc

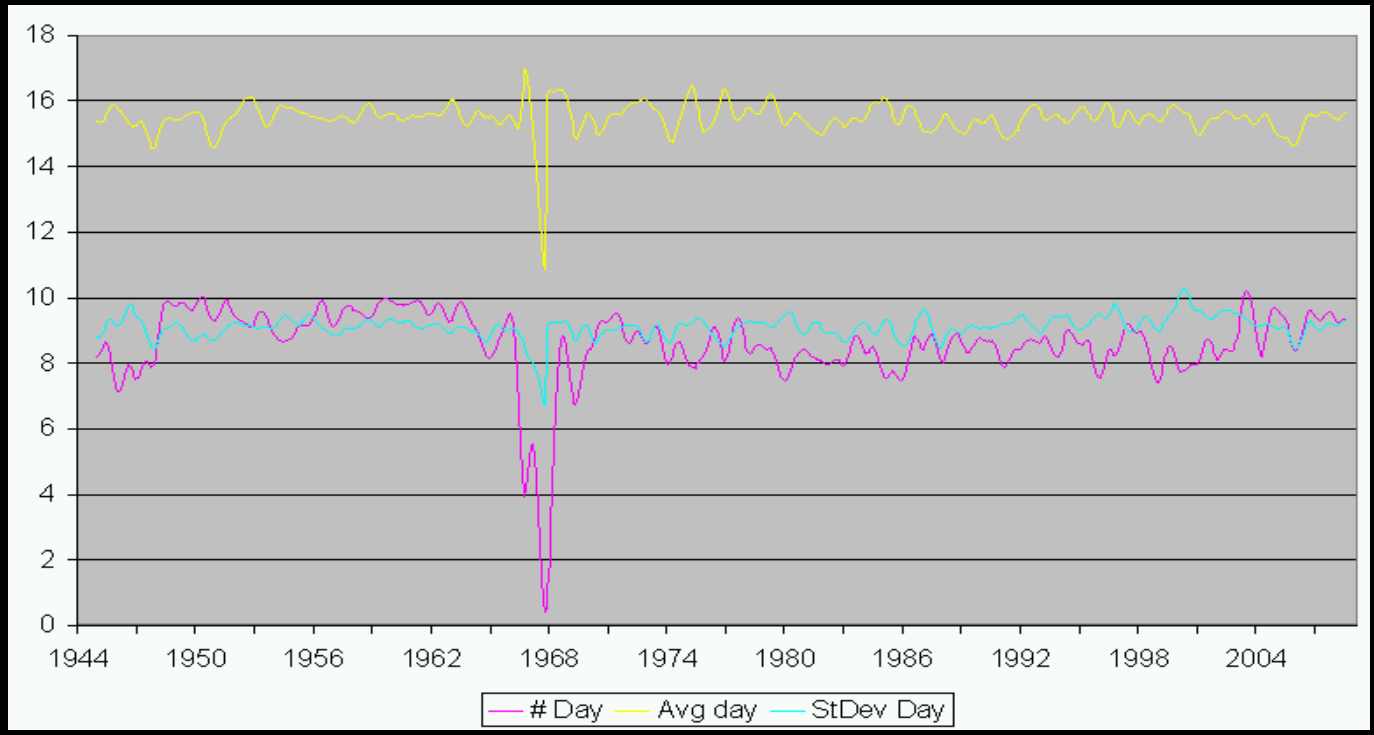
The big CV-project

- Not for every day
  - Goal: 8 to 10 observations per month
  - Equal distribution over the month
    - E.g. 2, 5, 8, 11, 14, 17, 20, 23, 26, 29 (Avg. 15,5; St. Dev. 9,1)
      - Sunspotnumber: r^2 = 0,999
  - Unequal spread
    - E.g. first 10 days of the month (Avg. 5,5; St. Dev. 3,0)
      - Sunspotnumber: r^2 = 0,904





The big CV-project

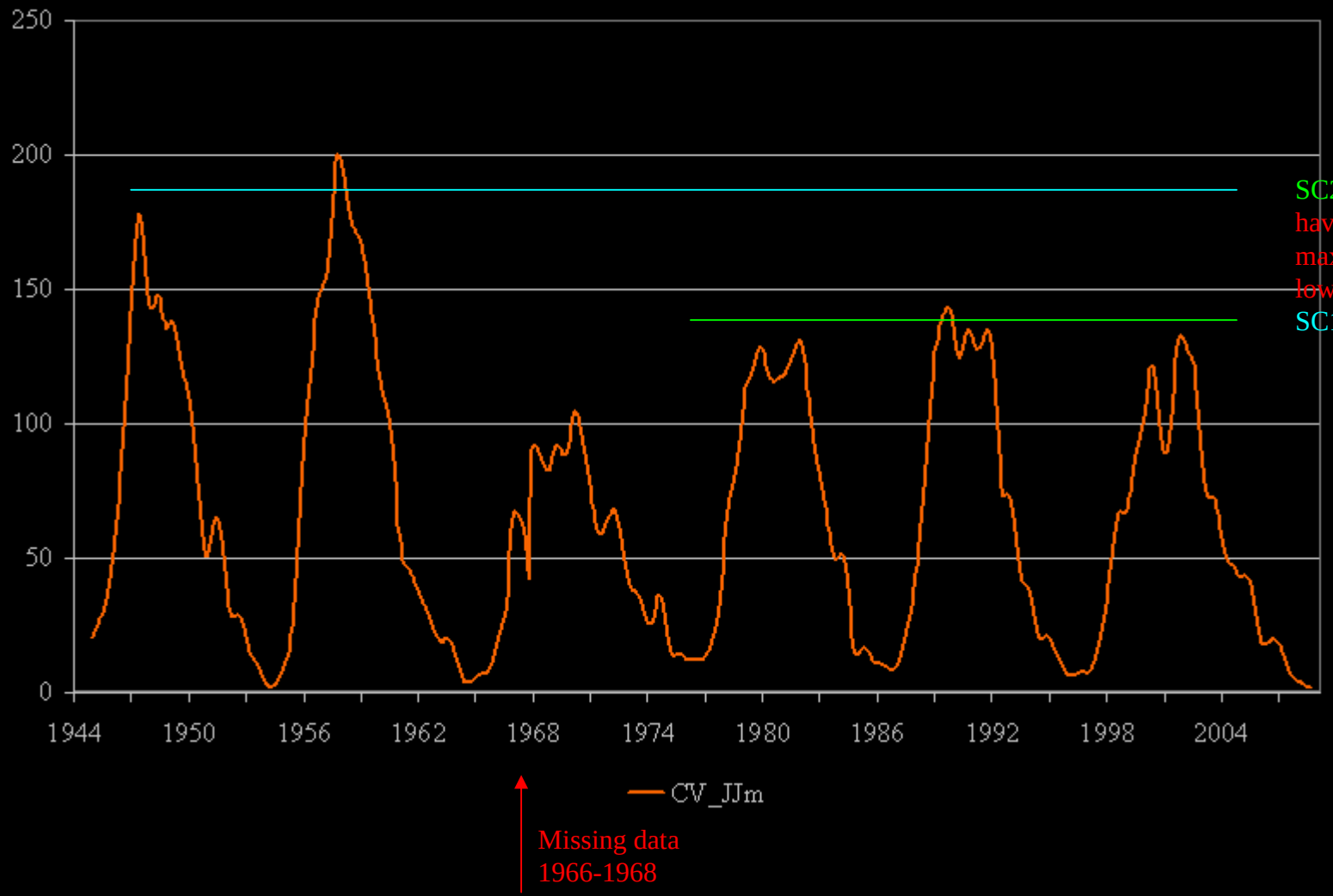


- Smoothed evolution per month of
  - Number of observation days per month (9 +/- 1)
  - Average day per month (15)
  - Spread on average (+/- 9)
- => OK, except for the period 1966-1968

The big CV-project

- In total:
  - 6694 observation days
  - 43751 evaluations
    - 6591 eliminations (“0”)
    - 630 spotless days
    - 36530 McI-classifications
- Performed during 2 periods
  - 1944-1971: Nov 2004 – Aug 2005
  - 1972-2009: Nov 2008 – Mar 2009
- Additional control and changes
  - For all a/k vs. s/h and for all c-groups
  - April 2009 => changes mentioned in files
  - There are still mistakes in the group-classifications…
    - Not always consistent

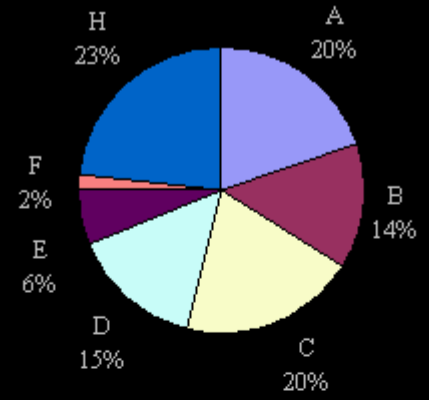
CV-evolution 1944-2009

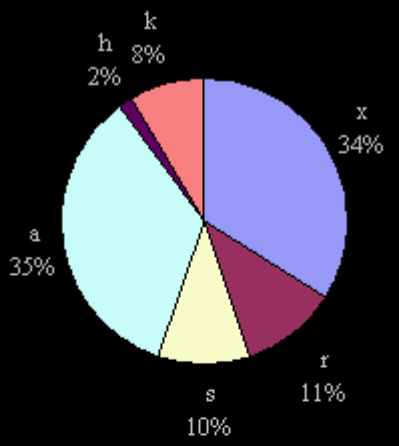


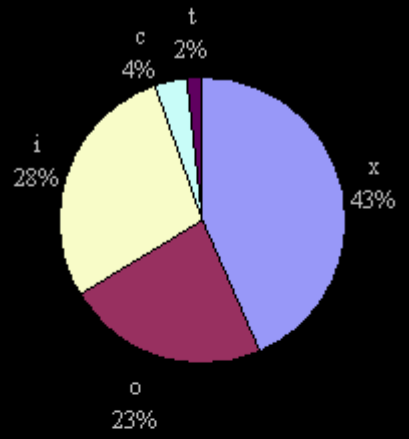
Janssens vs. McIntosh

(1944-2008) vs. (1969-1976)

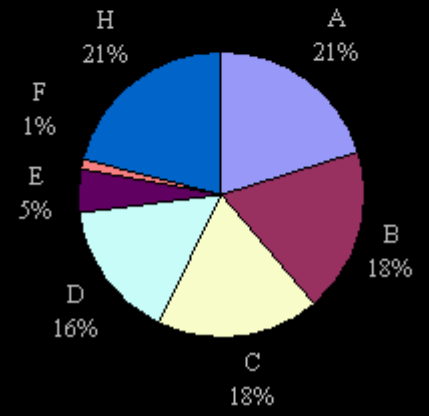
Janssens

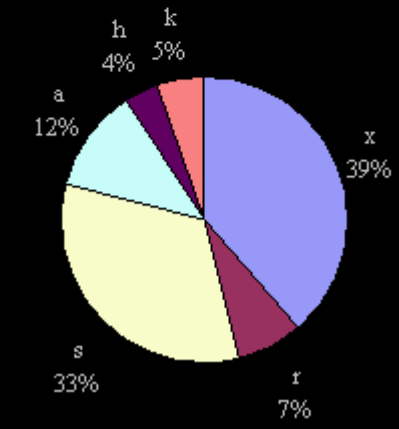


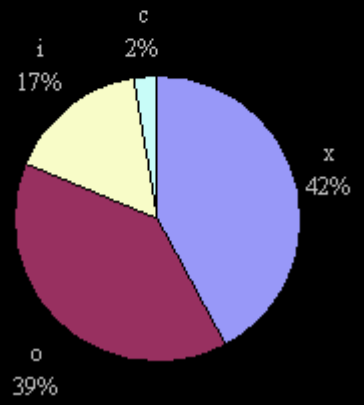




McIntosh







Modified Waldmeier class	Shape & symmetry penumbra main spot	Internal distribution sunspots

Janssens vs. McIntosh

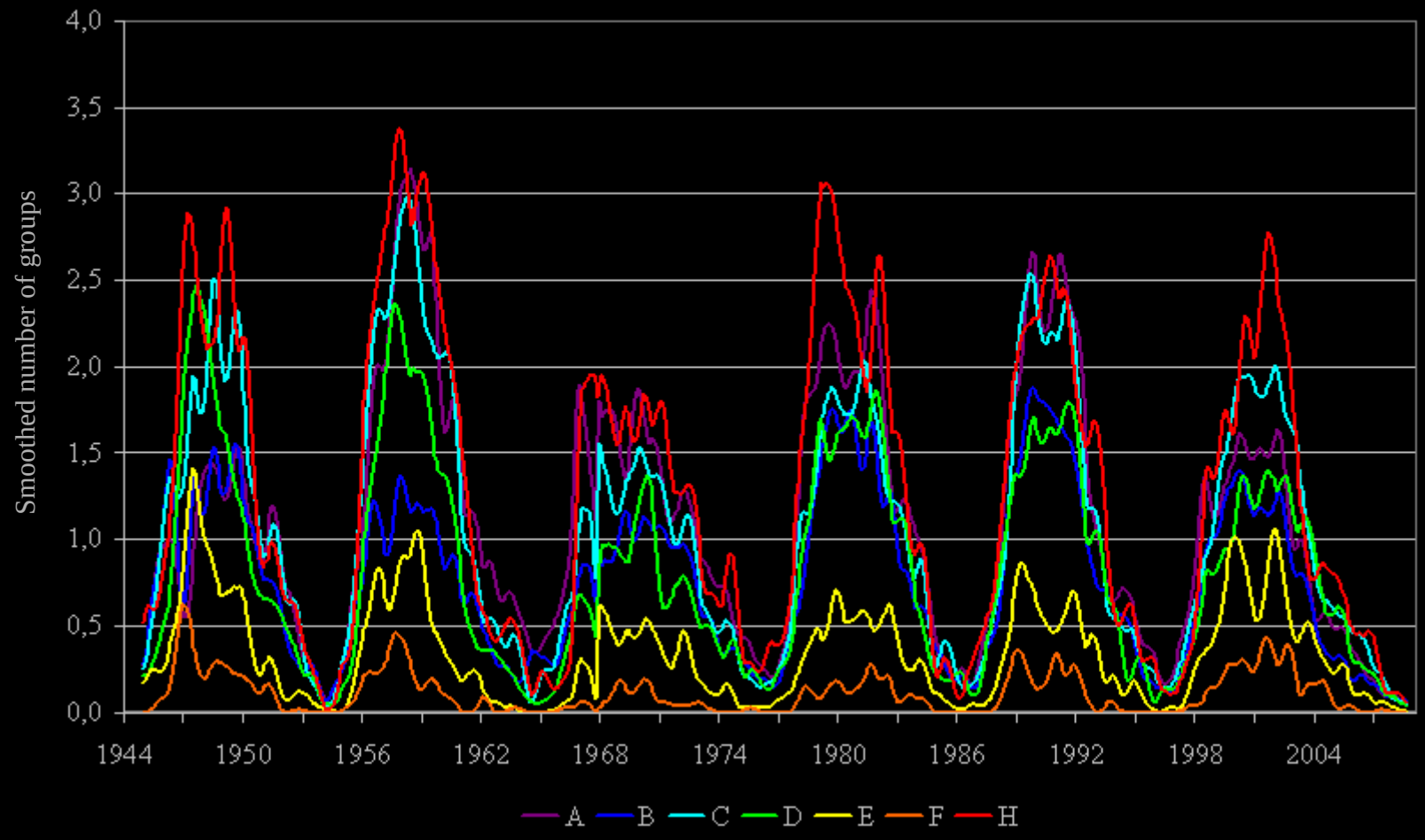
- Modified Waldmeier class
  - No significant differences
- Shape & symmetry of penumbra main spot
  - Many more a/k than s/h (ratio 3:1 vs. 1:3)

s	small, symmetric (like Zurich class J). Largest spot has mature, dark, filamentary penumbra of circular or elliptical shape with little irregularity to the border. There is either a single umbra, or a compact cluster of umbrae, mimicking the symmetry of the penumbra. The north–south diameter across the penumbra is $\leq 2.5°$.
a	small, asymmetric. Penumbra of the largest spot is irregular in outline and the multiple umbrae within it are separated. North–south diameter of penumbra $\leq 2.5°$.

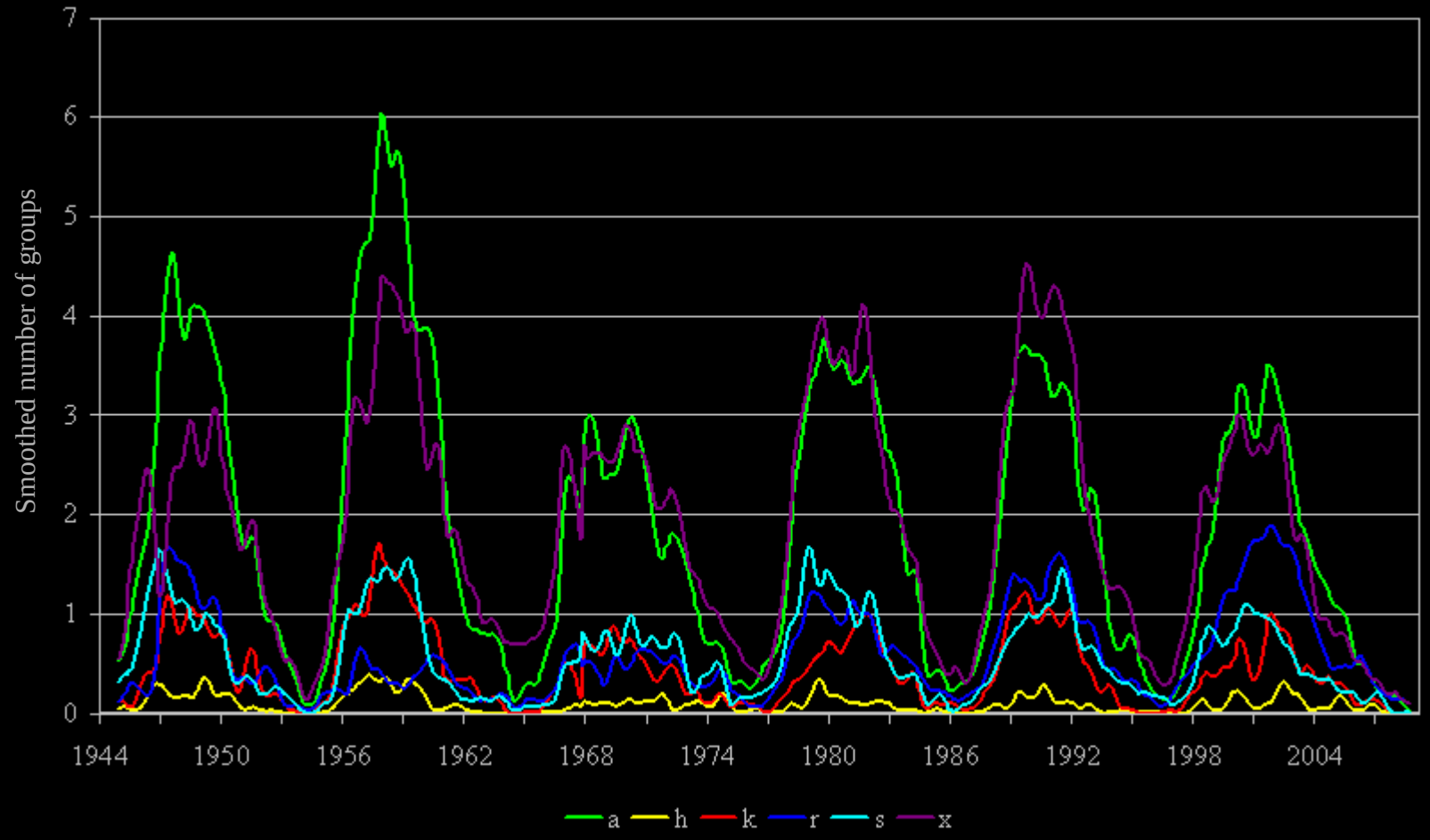
  - Janssens-classifications are based on 6 complete cycles, McIntosh-classifications contain only decreasing branch of moderate SC20
- Internal distribution of sunspots
  - o/i: Kanzelhöhe drawings show also many (too) small spots
  - "i" demands multiple spots

Examples (JJ)
(errors possible…)

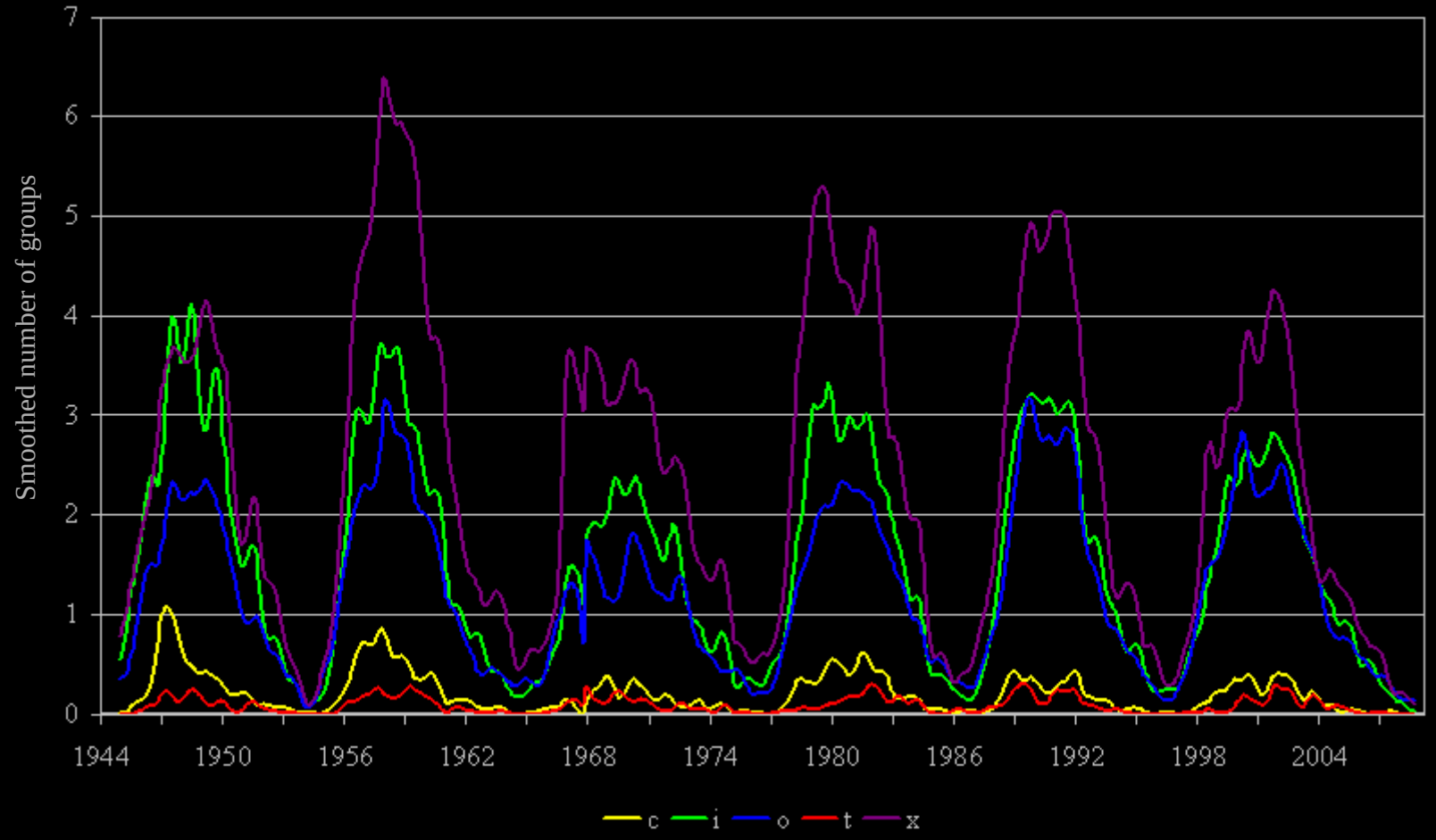
McIntosh – 1st Component
Waldmeier



McIntosh – 2nd Component
Shape & Symmetry Penumbra Main Spot

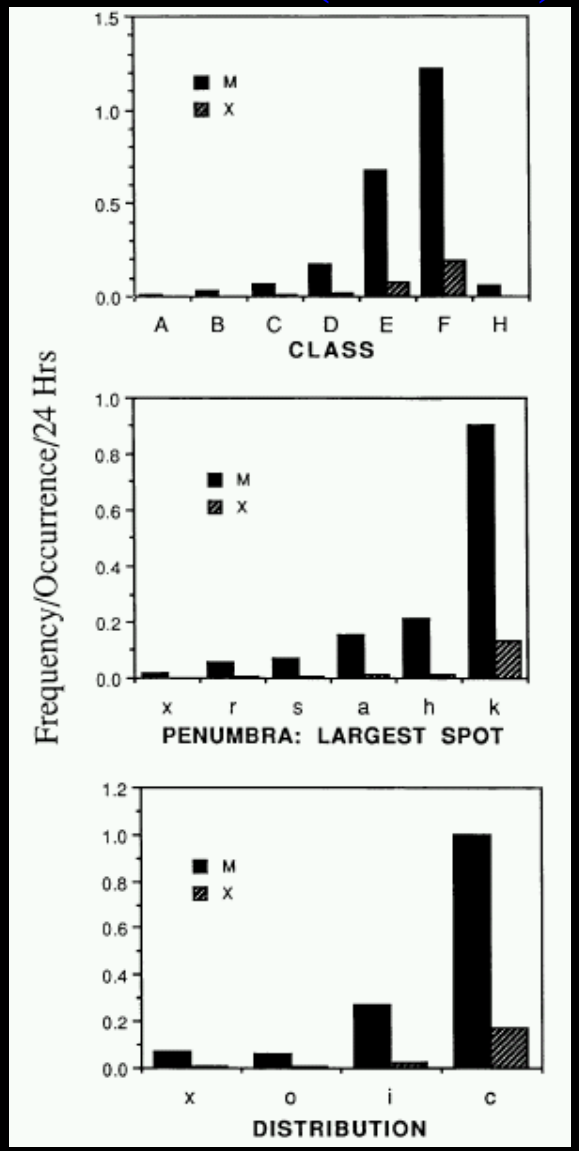


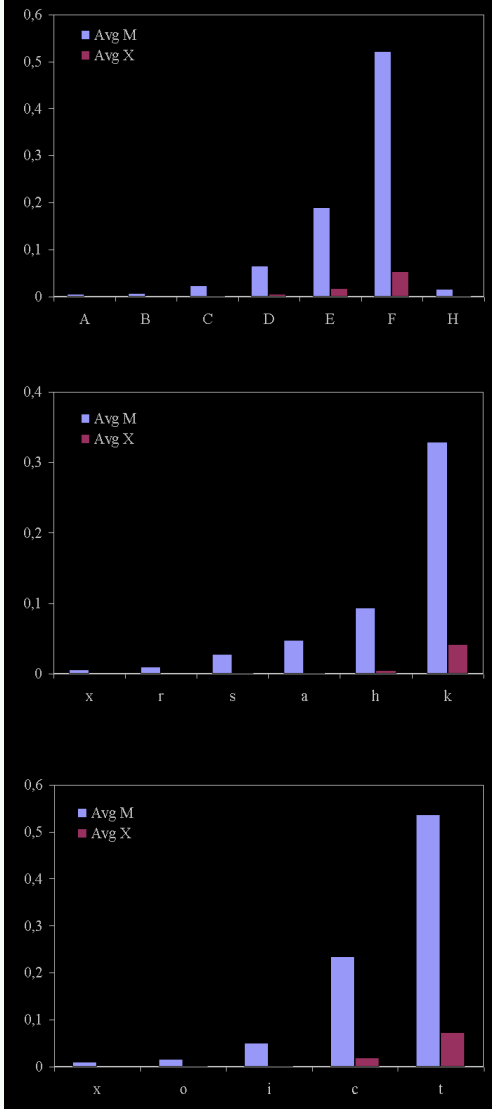
McIntosh – 3rd Component
Internal distribution sunspots



Kildahl vs. Janssens

(1969-1976) vs. (1976-2008)





Flare-ratio

- Excellent agreement
  - McIntosh & JJ differentiate active from inactive types of sunspotgroups
- Absolute values differ due to different calculation method
  - Kildahl: # MX-flares of a group linked to the frequency of the type (McIntosh)
  - Janssens: total # MX-flares of a group linked to maximum CV of that group during its transit over the solar disk
  - Groups of same type that did not produce a flare were also taken into account
- Distinction between “c” and “t” is important
  - “t” produces 2 to 3 times more M & X-flares

3 CV_JJ -series

- CV_JJm
  - Based on McIntosh-classification
  - Use of Malde's CV (1 => 60)
- CV_JJ+ en CV_JJx
  - McIntosh-classification + 12 "t" classes (=72)
  - Ratios flare-fluence of 3 components McI:
    - $FF = (W_r \,.\, s_r \,.\, d_r)^{1/3}$ ***(Bornmann, 1994)***
      - CV_JJ+ : (+/-) ranking from 1 to 72 i.a.w. FF↑
      - CV_JJx : i.a.w. FF and reduced to 100 (Fkt)

CV_JJ+

Axx 1					
Bxo 2 Bxi 3					
	Hrx 4	Cro 5 Cri 6	Dro 13 Dri 16	Ero 14 Eri 17	Fro 15 Fri 18
	Hsx 7 Hax 10	Cso 8 Csi 9 Cao 11 Cai 12	Dso 22 Dsi 23 Dao 24 Dai 25	Eso 29 Esi 30 Eao 33 Eai 34	Fso 35 Fsi 36 Fao 37 Fai 38
	Hhx 19	Cho 20 Chi 21	Dho 31 Dhi 32 Dsc 39 Dst 40	Eho 41 Ehi 42 Esc 51 Est 52	Fho 47 Fhi 48 Fsc 57 Fst 58
	Hkx 26	Cko 27 Cki 28	Dko 43 Dki 44 Dac 45 Dat 46	Eko 53 Eki 54 Eac 55 Eat 56	Fko 59 Fki 60 Fac 61 Fat 62
			Dhc 49 Dht 50 Dkc 67 Dkt 68	Ehc 63 Eht 65 Ekc 69 Ekt 71	Fhc 64 Fht 66 Fkc 70 Fkt 72

CV_JJx

Axx 1					
Bxo 2 Bxi 2					
	Hrx 2 Hsx 2	Cro 2 Cso 3	Dro 4 Dso 5	Ero 5 Eso 7	Fro 8 Fso 10
	Hax 3	Cri 3 Cao 4	Dri 5 Dao 6	Eri 8 Eao 9	Fri 11 Fao 13
	Hhx 4	Csi 5 Cho 5	Dsi 7 Dho 8	Esi 10 Eho 12	Fsi 15 Fho 17
	Hkx 6	Cai 6 Chi 7 Cko 9	Dai 9 Dhi 11 Dsc 12 Dko 13	Eai 13 Ehi 17 Esc 18 Eko 20	Fai 19 Fhi 23 Fsc 25 Fko 28
			Dac 15 Dst 17	Eac 23 Est 26	Fac 32 Fst 37
		Cki 13	Dki 19 Dhc 19	Eki 28 Ehc 28	Fki 40 Fhc 40
			Dat 22 Dht 28 Dkc 32 Dkt 48	Eat 33 Eht 42 Ekc 48 Ekt 71	Fat 47 Fht 59 Fkc 68 Fkt 100

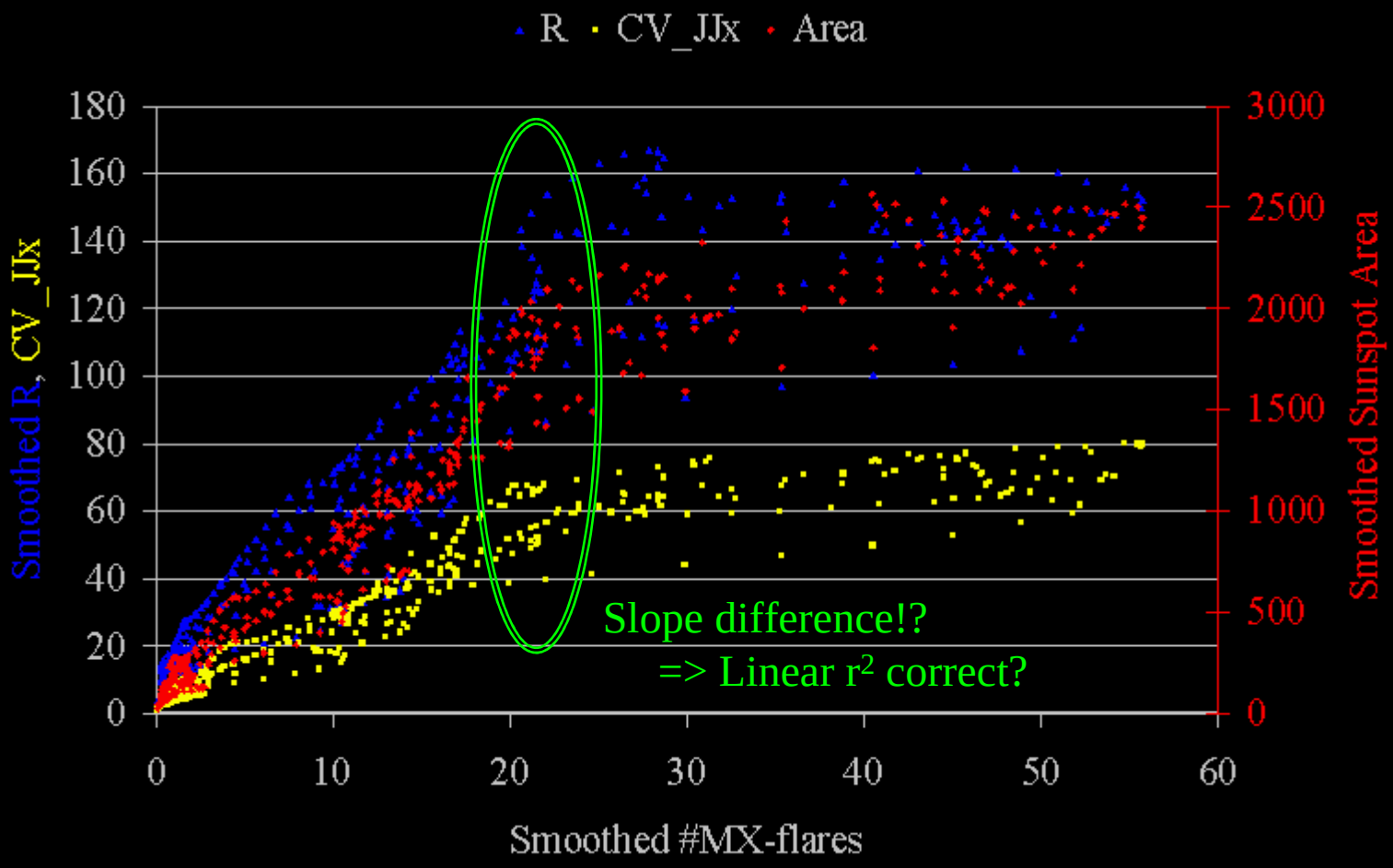
Correlations with raw monthly values

1981-2008 –Linear – r^2

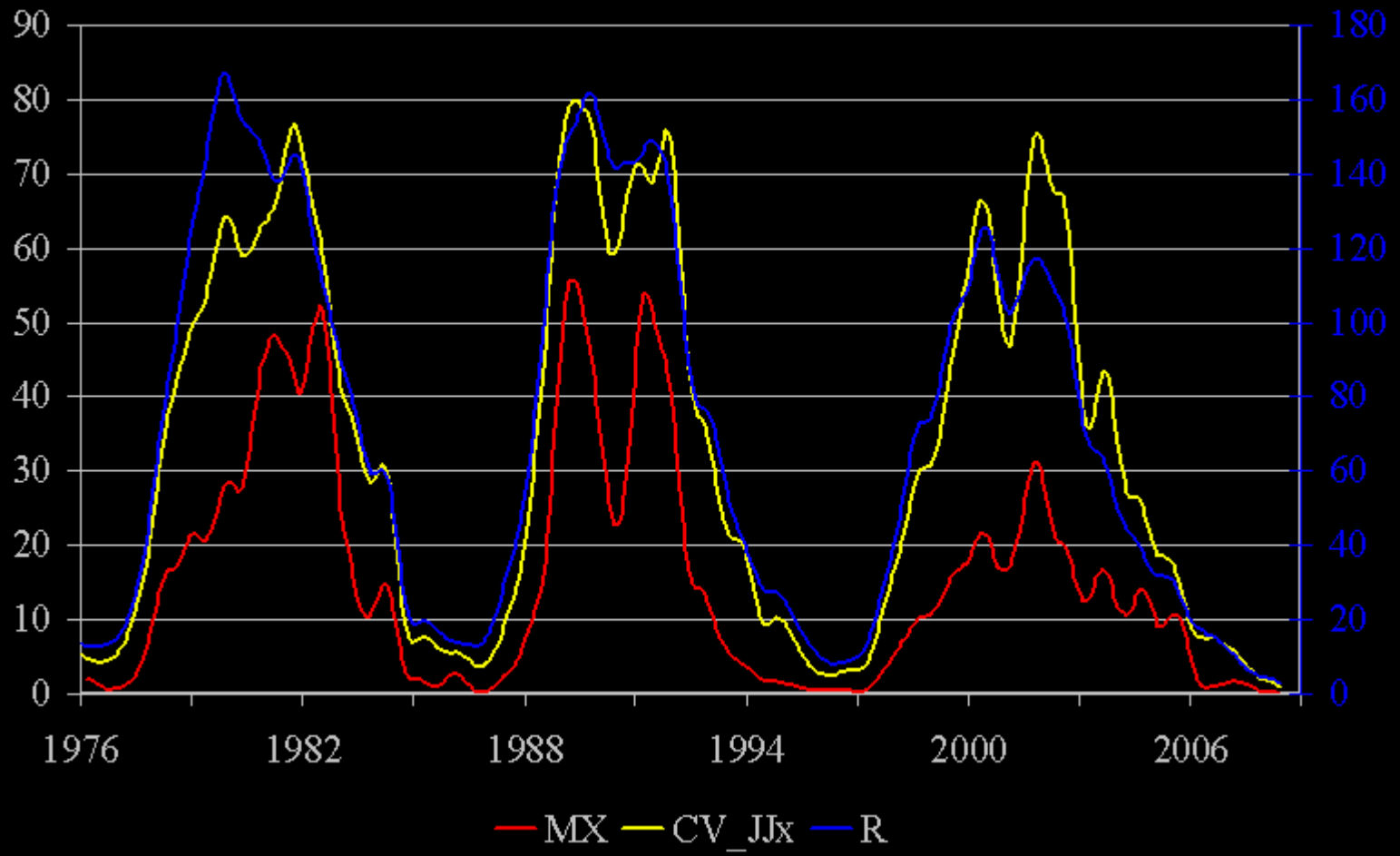
RadioFlux		CMX		MX		XFl	
RadioFlux	1,000	Area	0,821	Area	0,647	Area	0,523
R	0,954	CV_USAF	0,788	CV_JJx	0,624	CV_JJx	0,475
CV_Malde	0,934	RadioFlux	0,787	RadioFlux	0,548	RadioFlux	0,420
CV_USAF	0,931	CV_JJ+	0,779	CV_JJ+	0,533	CV_JJ+	0,401
CV_JJ+	0,927	R	0,762	CV_JJm	0,511	CV_JJm	0,388
CV_JJm	0,923	CV_JJx	0,762	R	0,496	R	0,373
Area	0,899	CV_JJm	0,759	CV_USAF	0,485	CV_USAF	0,364
CV_JJx	0,870	CV_Malde	0,750	CV_Malde	0,459	CV_Malde	0,348

- CV_JJx is great for high-energy-flares & fluence!
  - Much better than other CV-dataseries
  - CV_Malde best for Radioflux
  - CV_USAF best for total number of CMX-flares
- Sunspot Area remains best overall, but labor-intensive!

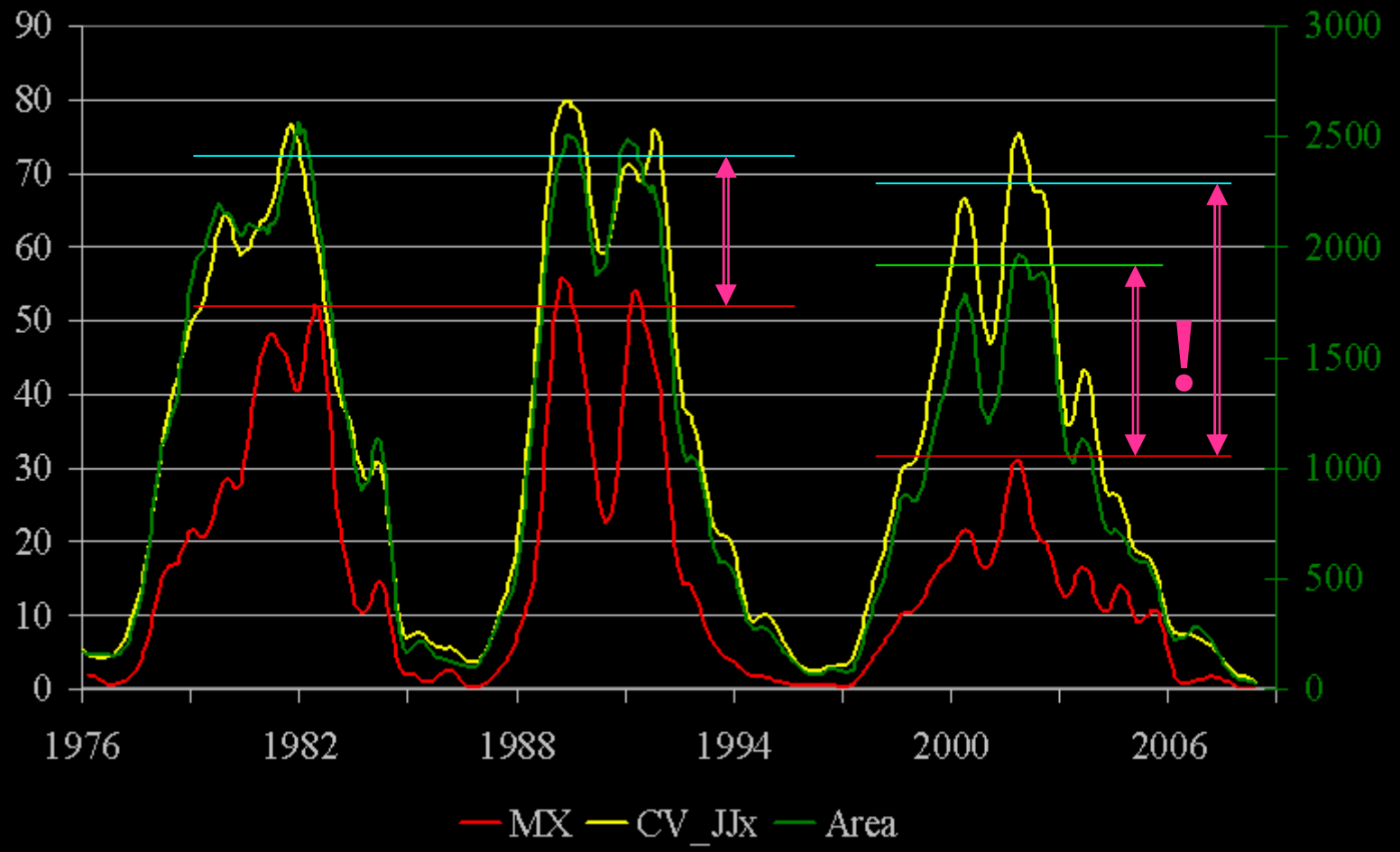
Correlations with smoothed monthly values 1976-2008



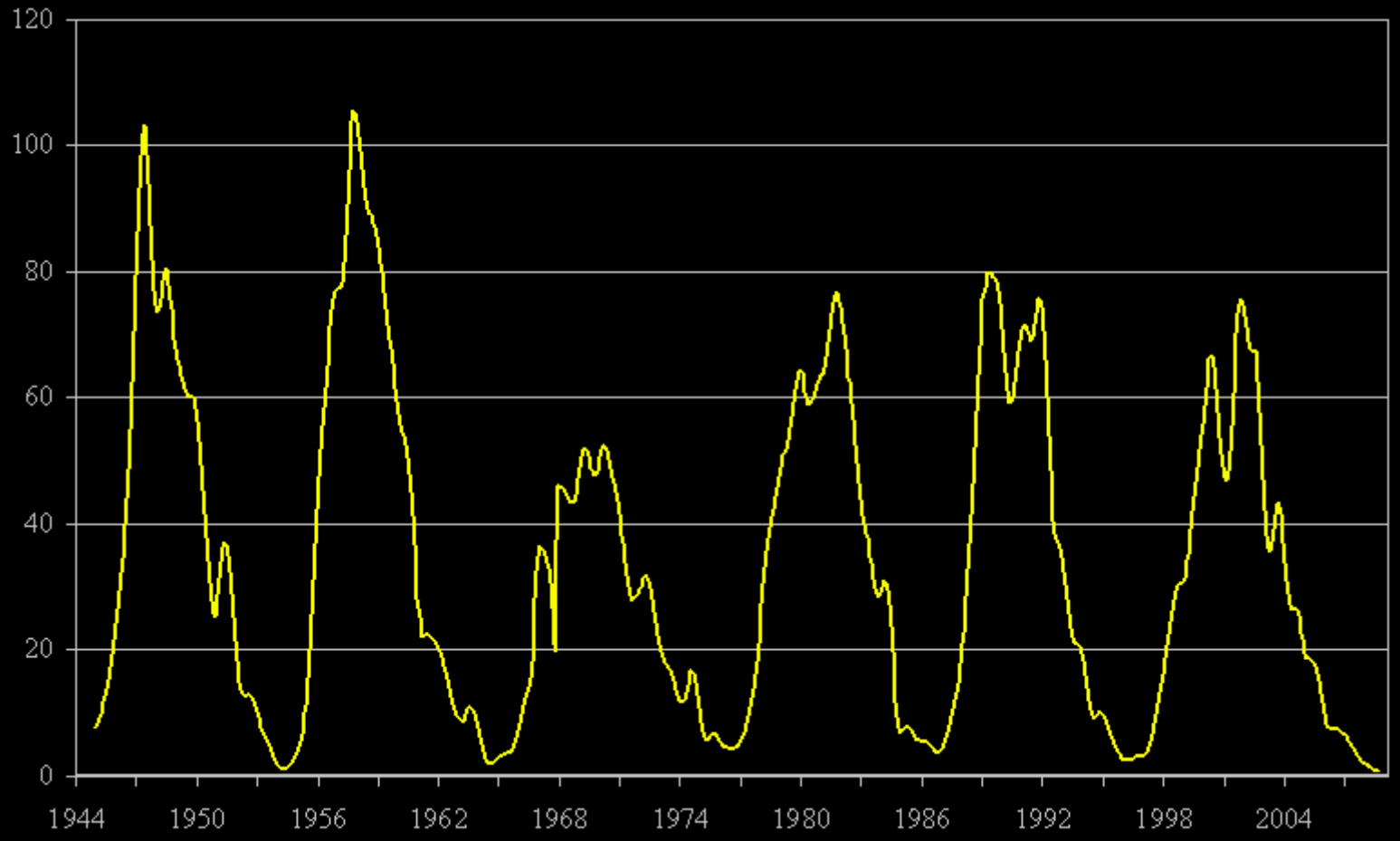
MX vs. CV_JJx vs. R



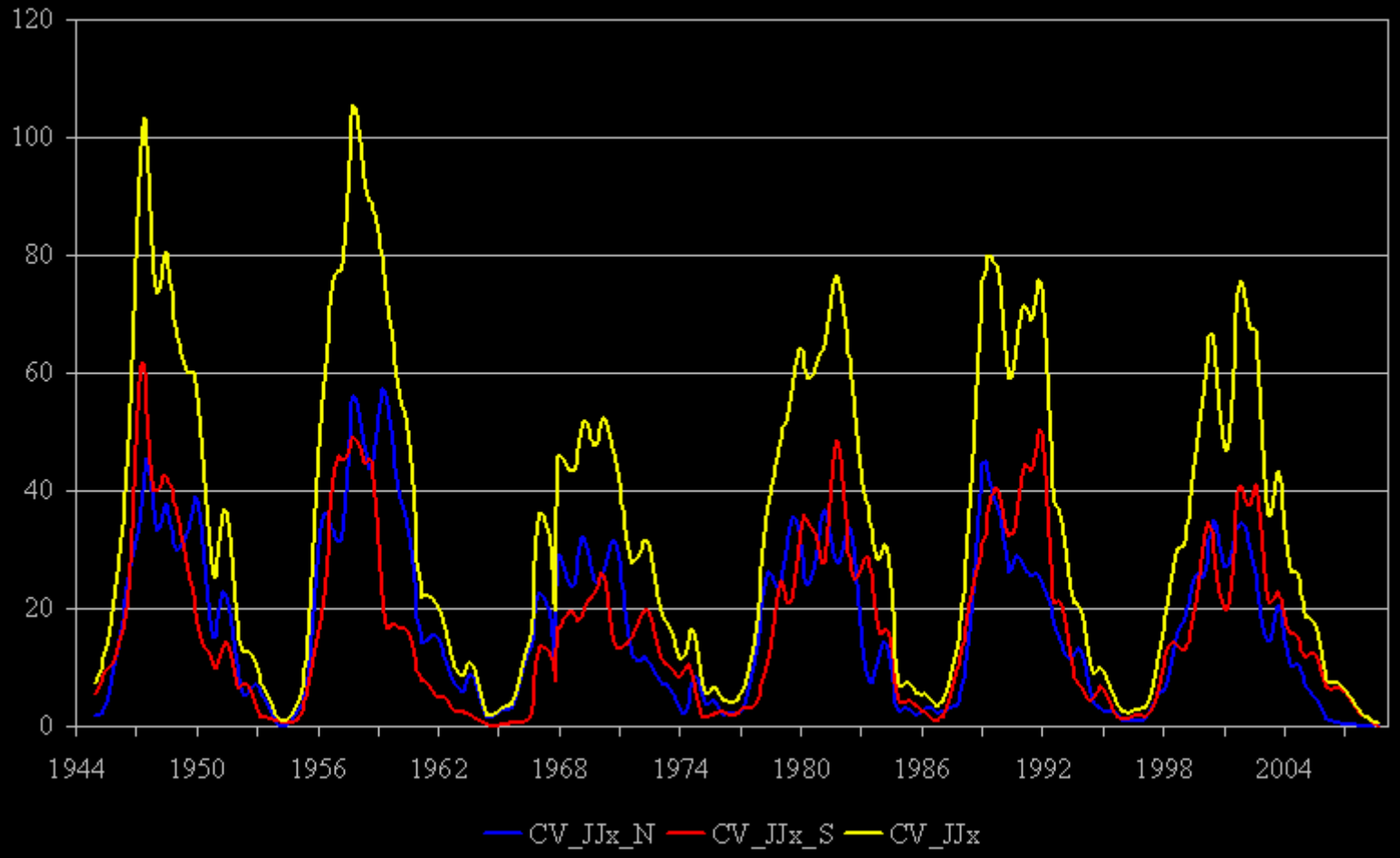
MX vs. CV_JJx vs. Area



CV_JJx-evolution 1944-2009

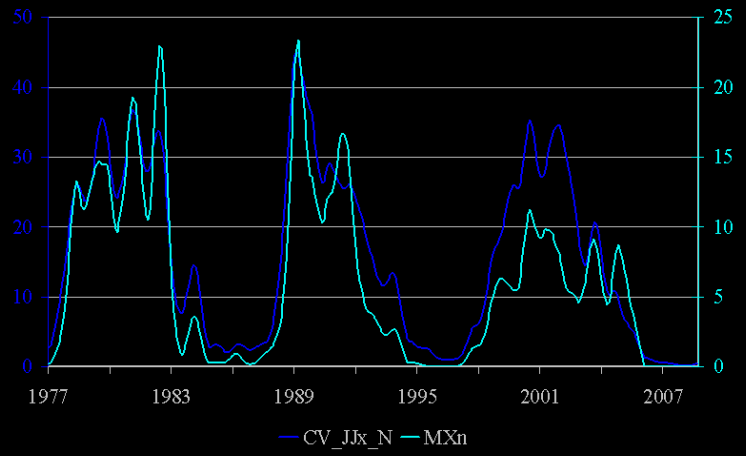


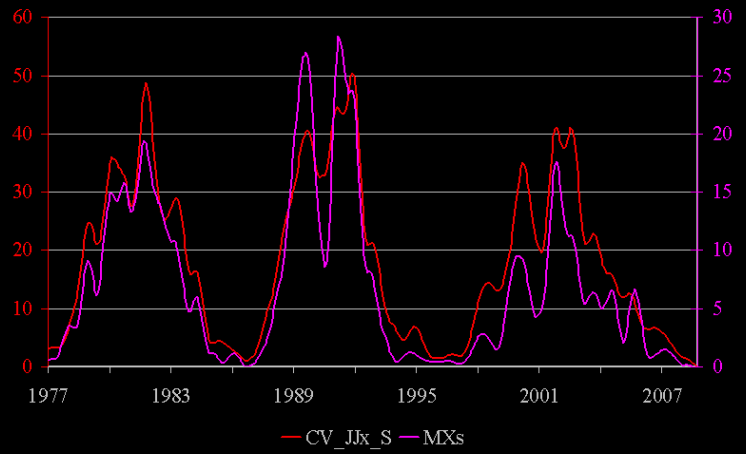
Evolution CV_JJx per hemisphere



CV_JJx vs. MX
Comparison per hemisphere

- Compared to MX-flares assigned to a group
  - N+S < Total MX
- Exist very good agreements
- SC23: CV_JJx > MX
  - Not necessarily a classification problem
    - Area has same “problem”, but less explicit
    - Flare-reporting (H-alpha)
    - Physical: Livingstone&Penn?
- Periodicity (12-24 months)
  - In both hemispheres
  - Linked to Tachocline?





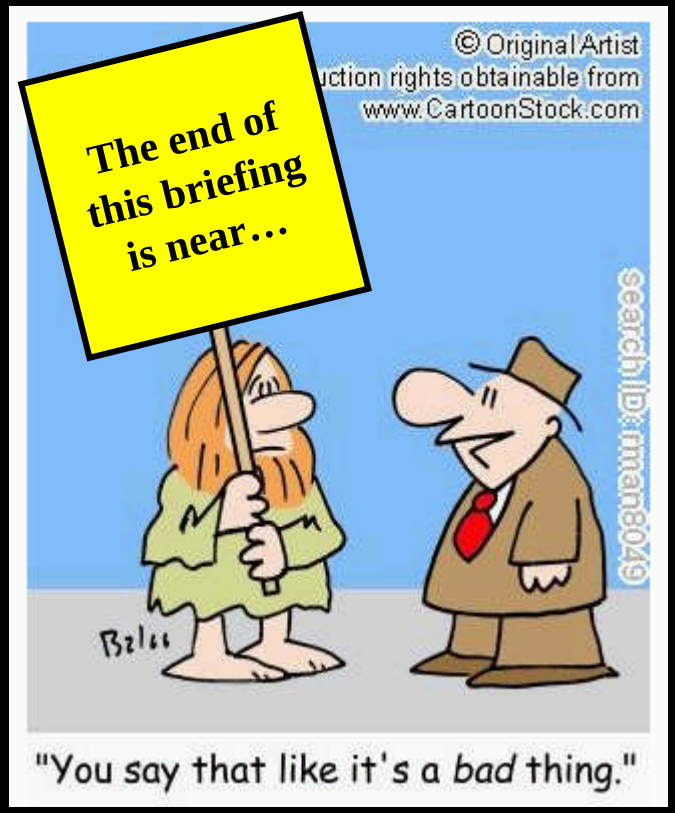
To do…

- Redo classifications again?...
- Booklet with clear examples for the various McIntosh-classifications
- Research on the correctness of the sunspot area of the groups in MSFC-database
- Standard-deviations in flaring-statistics
  - Why do some groups flare while other, of the same type, don’t?
- …

Data sources

- Sunspot-drawings: Kanzelhöhe Observatory (CESAR)
  - http://cesar.kso.ac.at/synoptic/draw_years.php
- Sunspot-data and Area: Greenwich/NOAA @ MSFC
  - http://solarscience.msfc.nasa.gov/greenwch.shtml
- Sunspot numbers @ SIDC
  - http://sidc.oma.be/
- CV-data (Malde & USAF) @ Helios
  - http://www.cv-helios.net/
- Flare-data and RadioFlux @ NGDC/NOAA
  - ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/

Questions?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