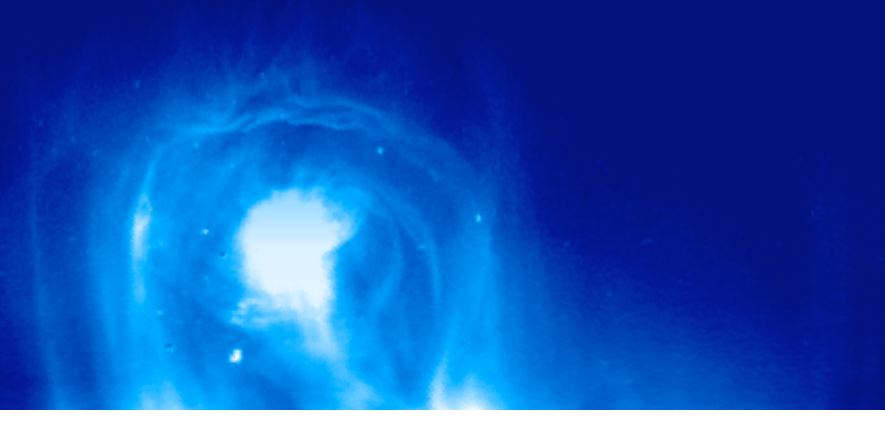
Alles wat je wilde weten over het zonnevlekkengetal (maar nooit durfde vragen)

Petra Vanlommel

Bijdragen van Ronald Van der Linden, Laurence Wauters en Frederic Clette



SIDC: Solar Influence Data analysis Center

Onderzoeksgroep

WDC and RWC

World Data Center
For the Sunspot Index

Regional Warning Center
For Western Europe

Alles wat je wilde weten …
Werkgroep Zon, 8 nov 2008

De hamvraag

Wat in de toekomst? 2012

deep minimum – totale uitroeieng

- De fysica van zonnevlekken
- Variaties op
  - korte termijn
  - middellange termijn
  - lange termijn
- De wiskunde van zonnevlekken

Zonnevlekken

Chinezen
Galileo Galilei
Ontdekking cyclus
Differentiële rotatie
Link uitbarstingen-vlekken
Wolfgetal

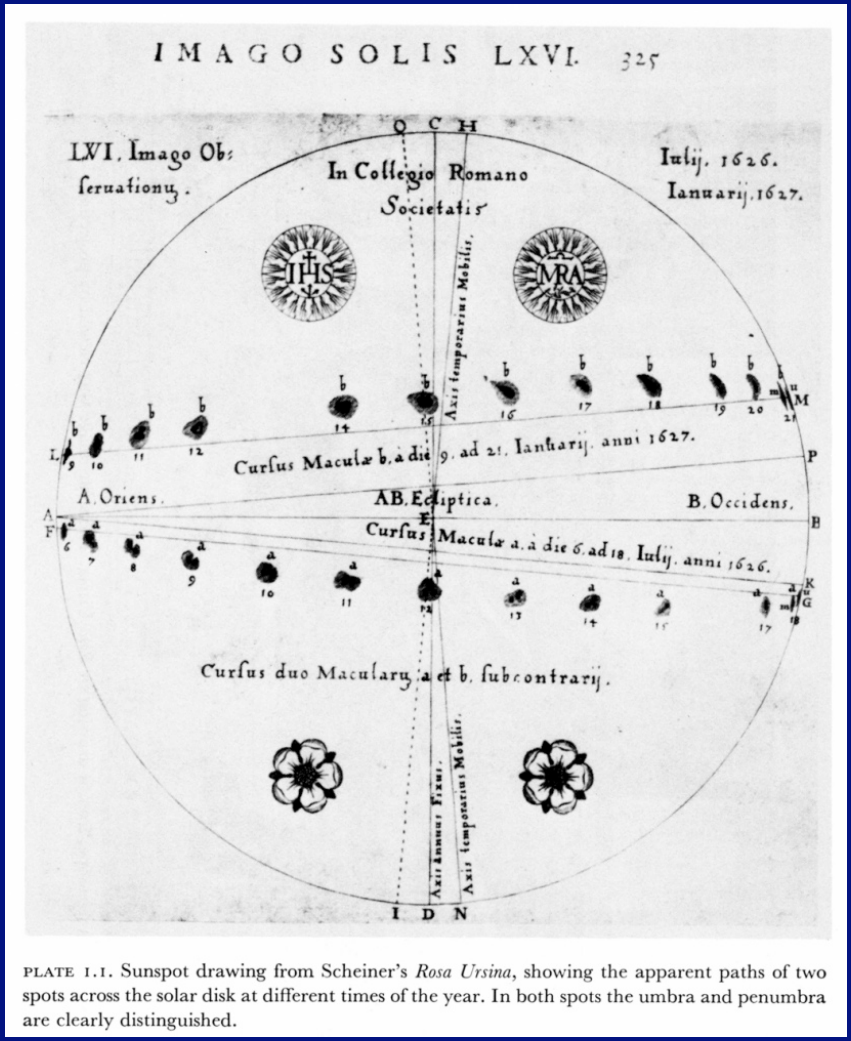
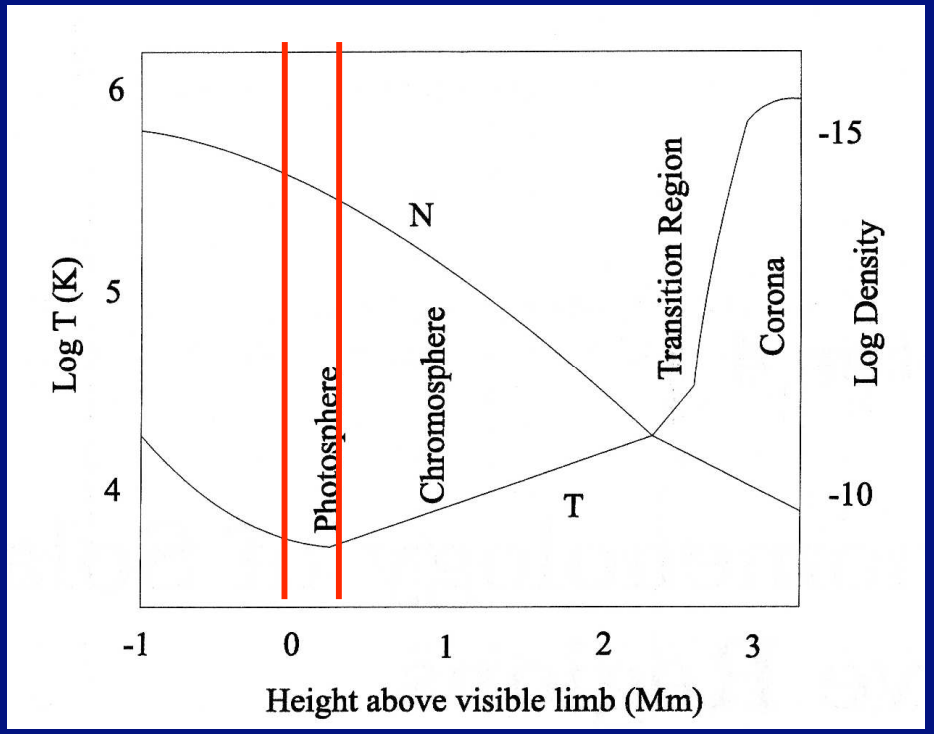


PLATE 1.1. Sunspot drawing from Scheiner's *Rosa Ursina*, showing the apparent paths of two spots across the solar disk at different times of the year. In both spots the umbra and penumbra are clearly distinguished.

Alles wat je wilde weten …
Werkgroep Zon, 8 nov 2008

De fotosfeer

- De diepste laag van de zonneatmosfeer
- dikte van 500 km, 0.5 boogsec.
- De temperatuursgradient in de fotosfeer blijft negatief (de temperatuur daalt met de hoogte) tot een temperatuursminimum, die dan ook de top van deze laag aangeeft.
- Straalt in zichtbaar licht.

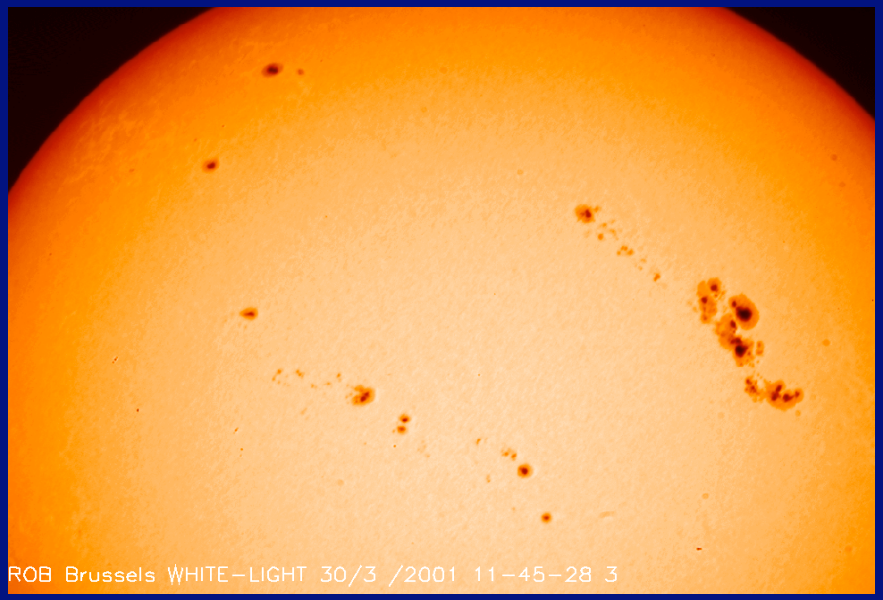


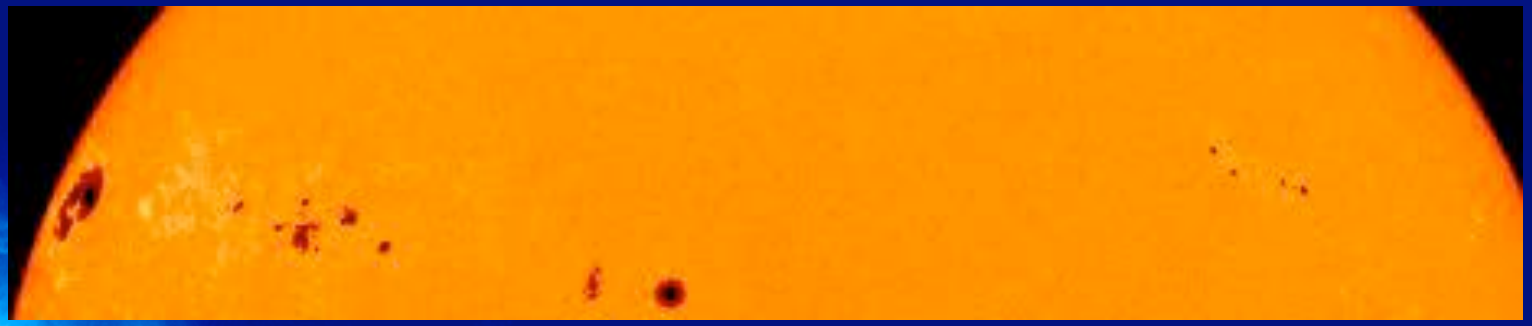
Zonnevlekken zijn donkere gebieden in de fotosfeer.

De kleinste vlekken hebben geen structuur (diameter D < 2 500km)

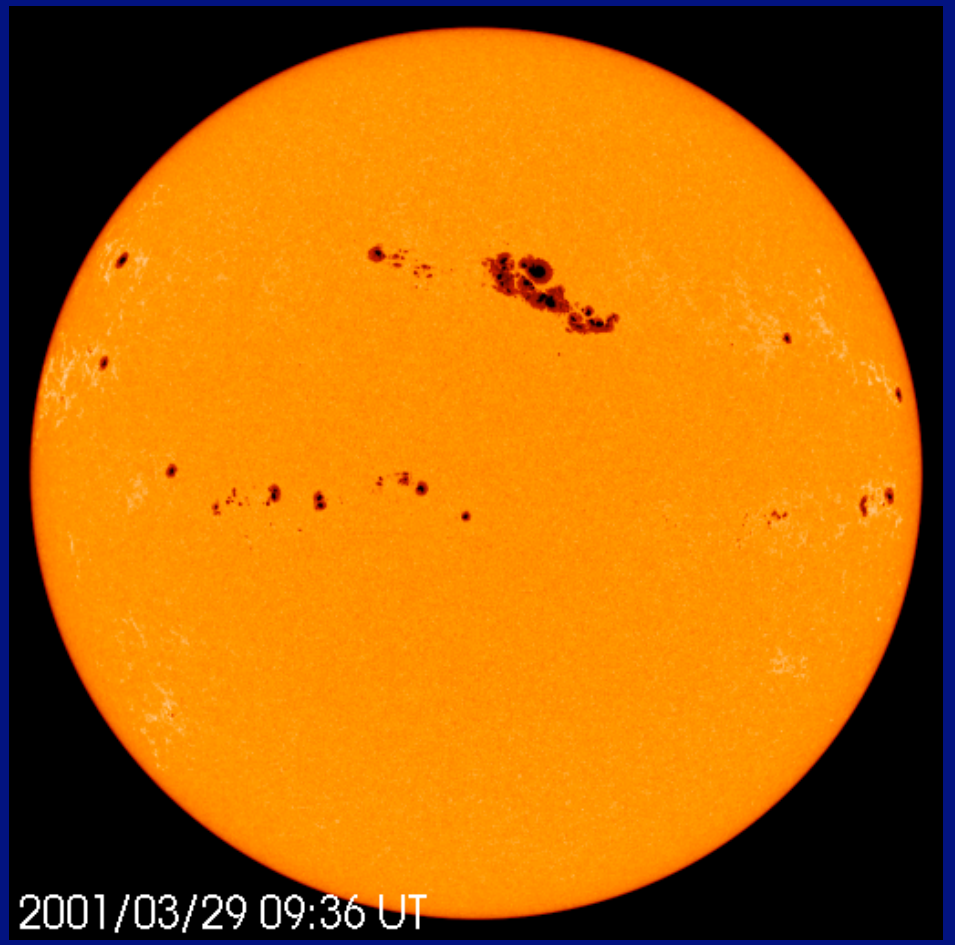
Voor D >2 500km, bestaan de vlekken uit 2 zones:

- **Centrale Schaduw**:
  - Diameter =10 tot 15 000 km
  - Lichtsterkte = 5 tot 30% $I_{Fotosfeer}$
- **Halfschaduw**:
  - Diameter : tot 50 000km
  - Lichtsterkte = 50 tot 70 % $I_{Fotosfeer}$

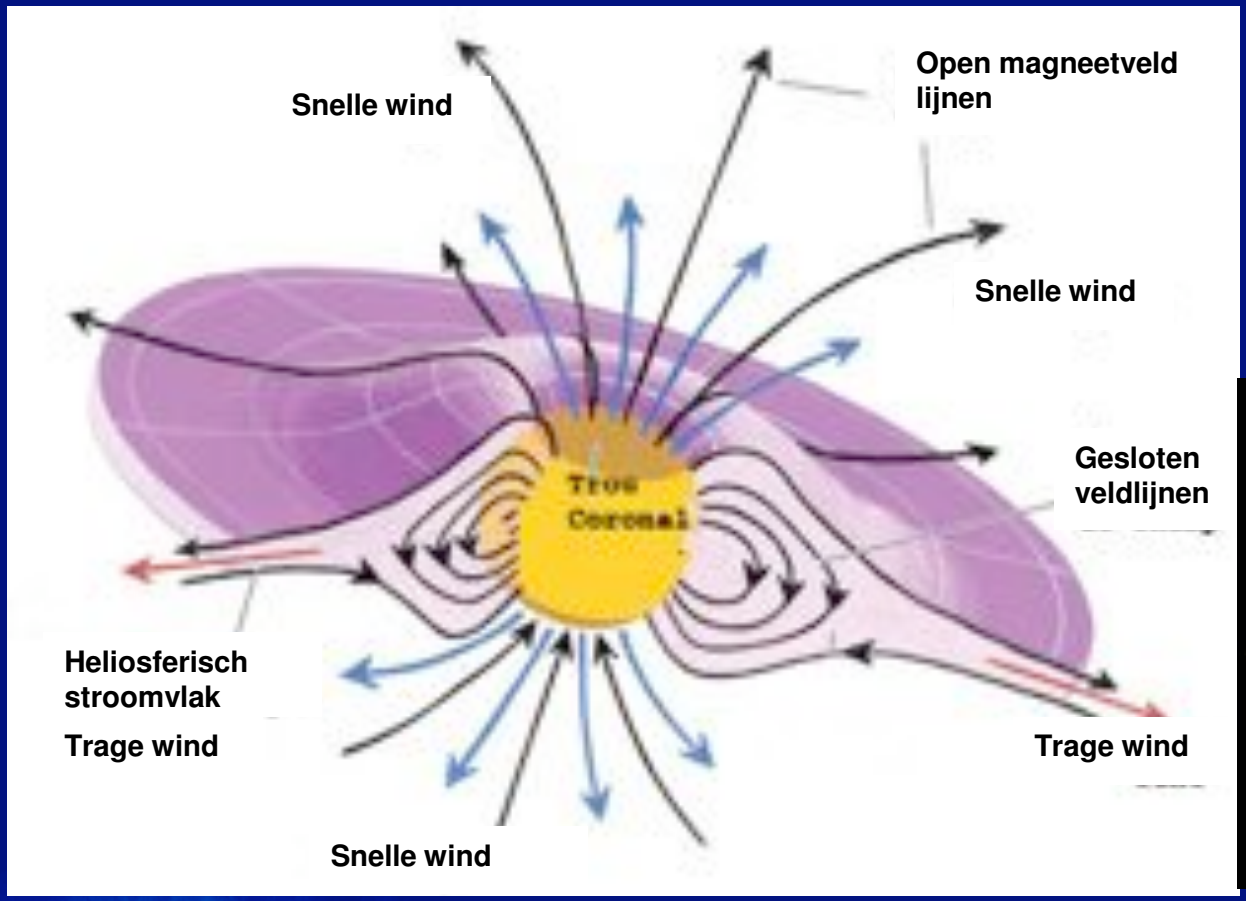


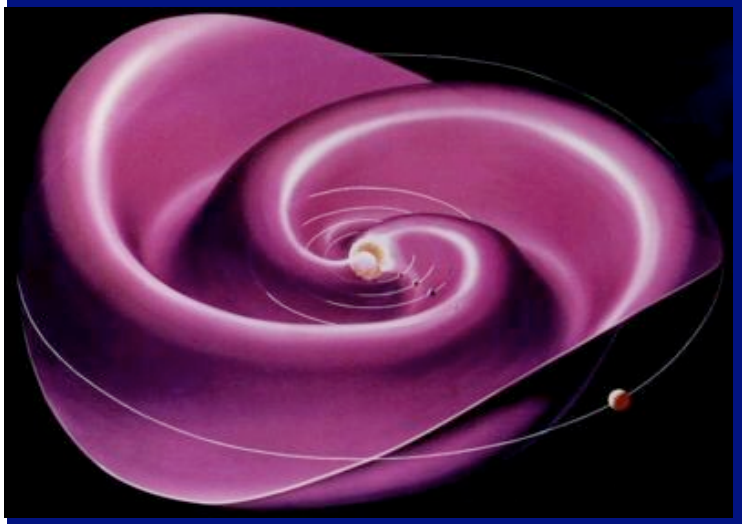


- De vlekken leven enkele uren tot enkele maanden.
- De temperatuur van de centrale schaduw is 4 000K, in plaats van 5 800K voor de normale fotosfeer.
- Vlekken vormen langwerpige groepen, meestal uitgerokken in de oost-west richting. Ze kunnen tot 50 vlekken bevatten en zich uitsmeren over 20 lengtegraden.
- Deze groepen spreiden zich uit over 2 strips tussen de 5e tot de 40e breedtegraad.

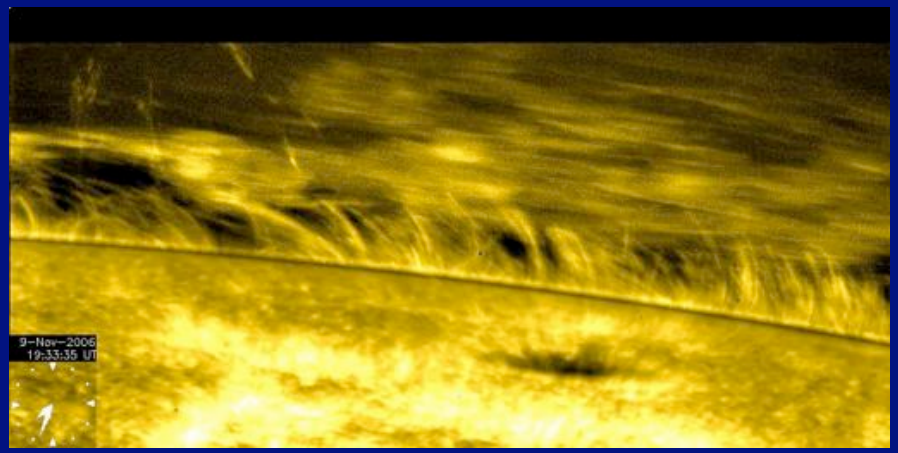


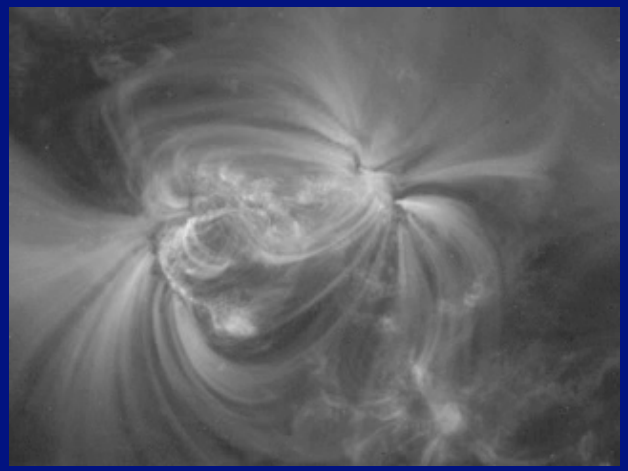
Zon als dipool

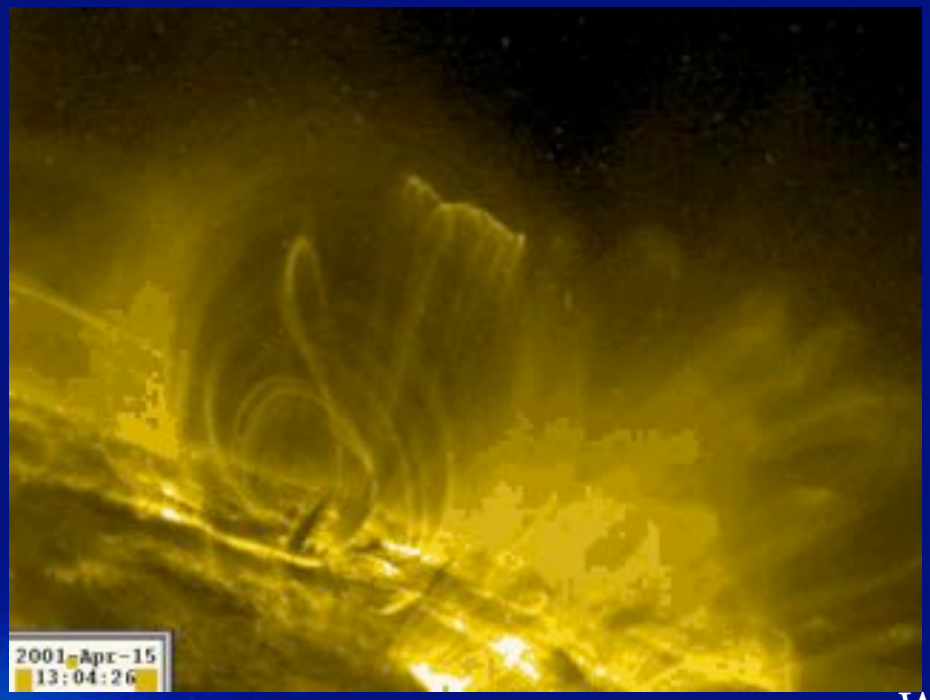


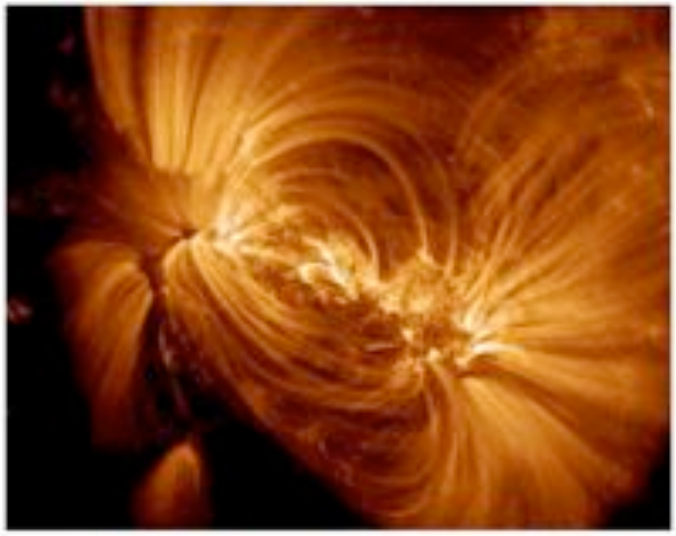


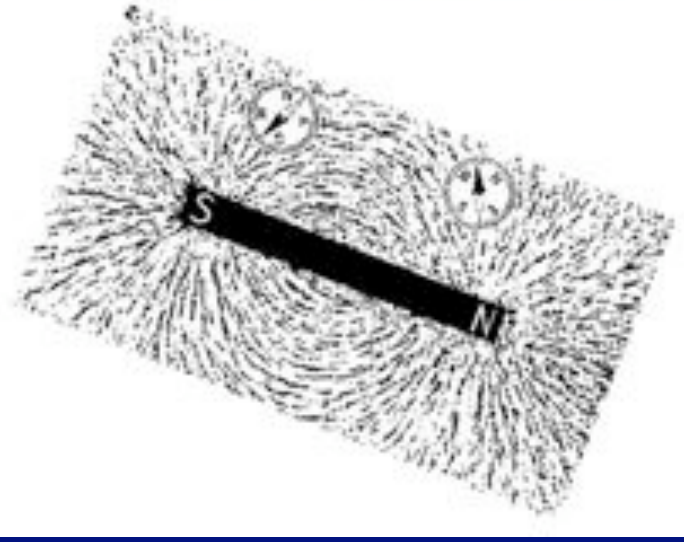
Lokaal magneetveld







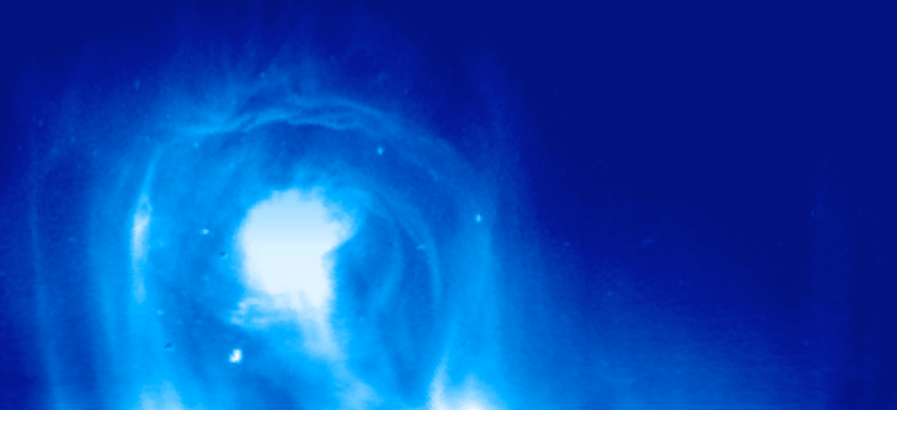




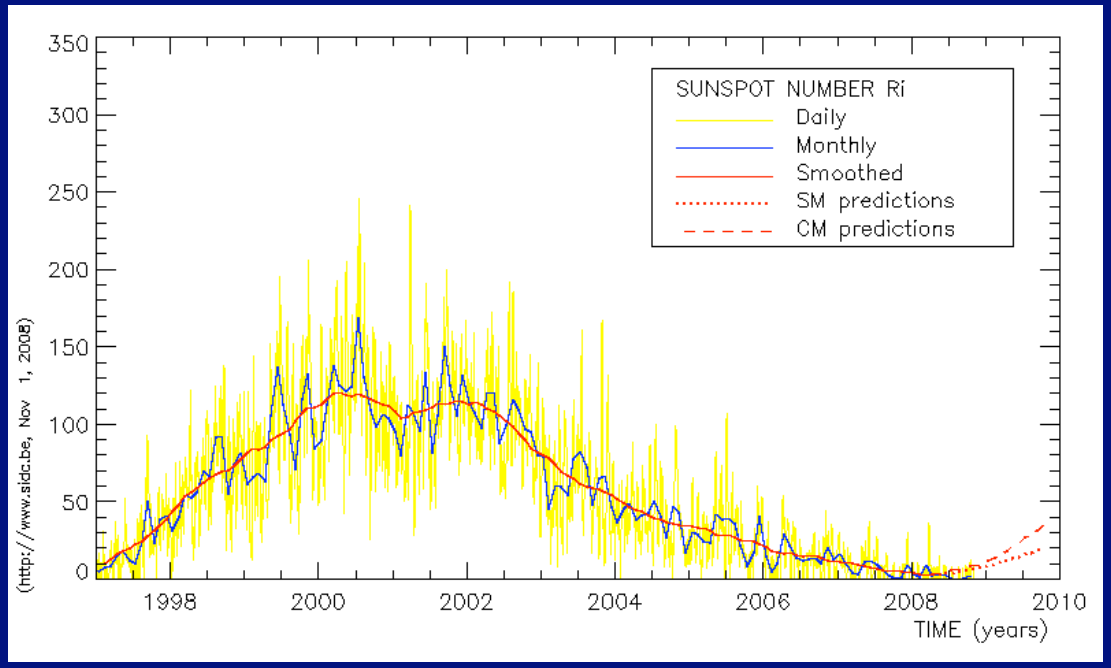
Alles wat je wilde weten …
Werkgroep Zon, 8 nov 2008

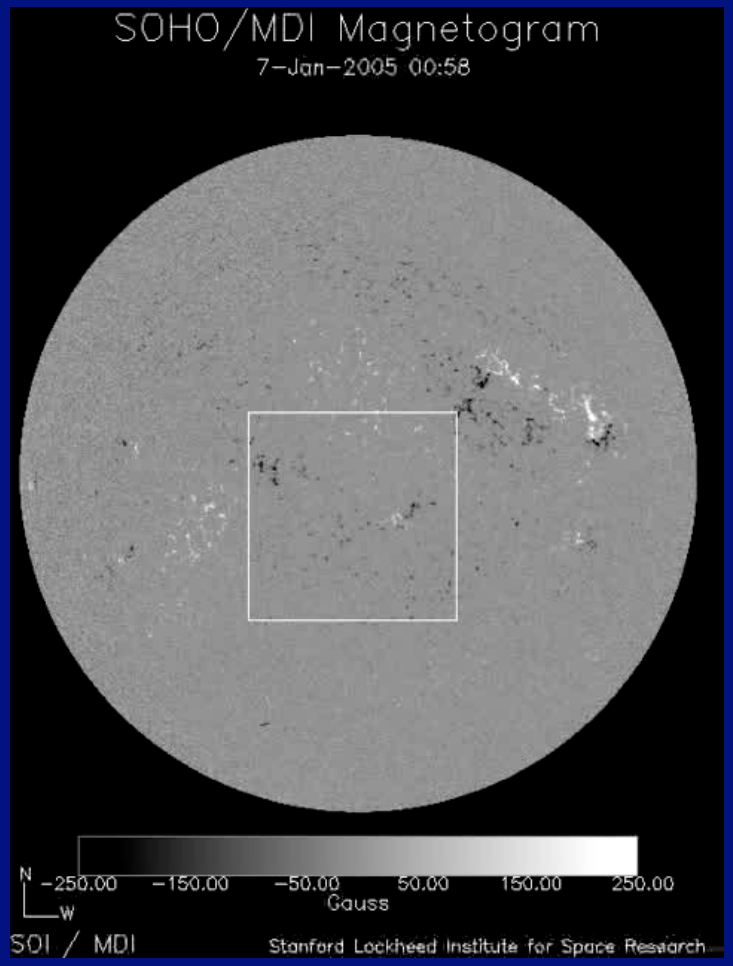
Zonneactiviteit

De zonneactiviteit is het geheel aan fenomenen waarbij energie op een impulsieve manier wordt vrijgegeven in de zonne-atmosfeer, en die gegenereerd wordt door de evolutie en brutale transformatie van magneetvelden die doorheen het zonneoppervlak lopen.



Variatie op korte termijn





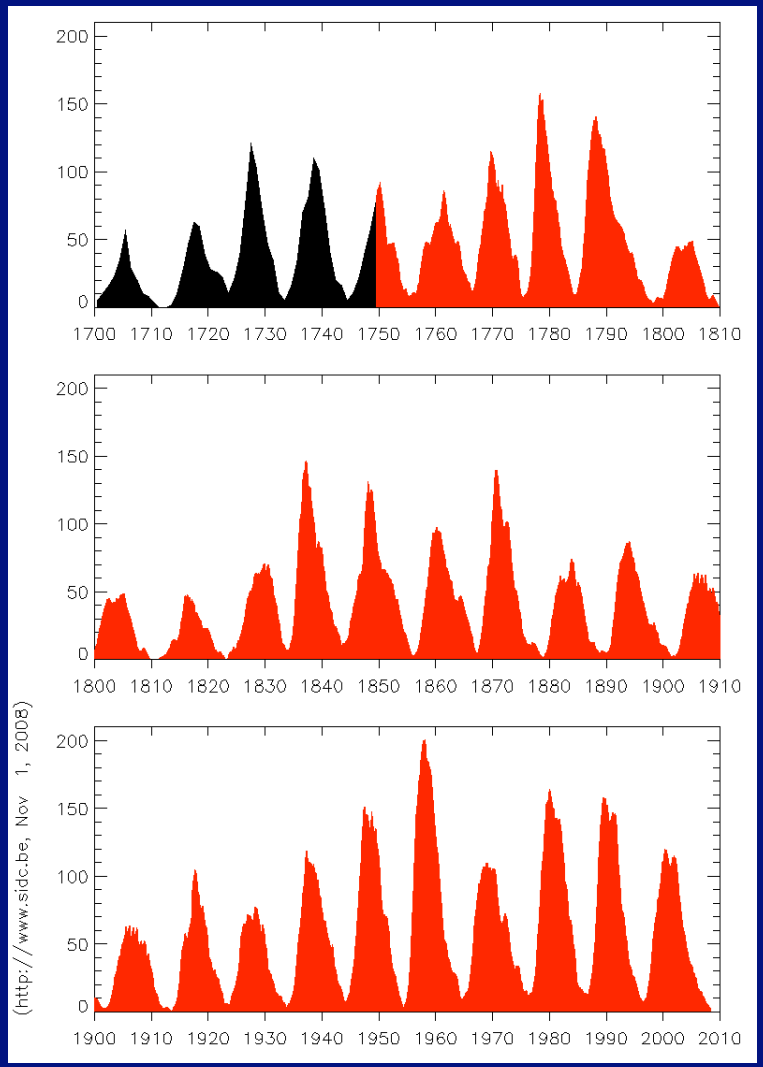
Middellange termijn: de zonnecyclus

Het aantal vlekken en groepen varieert over een cylcus met variabele amplitude en periode, van ongeveer 11 jaar.

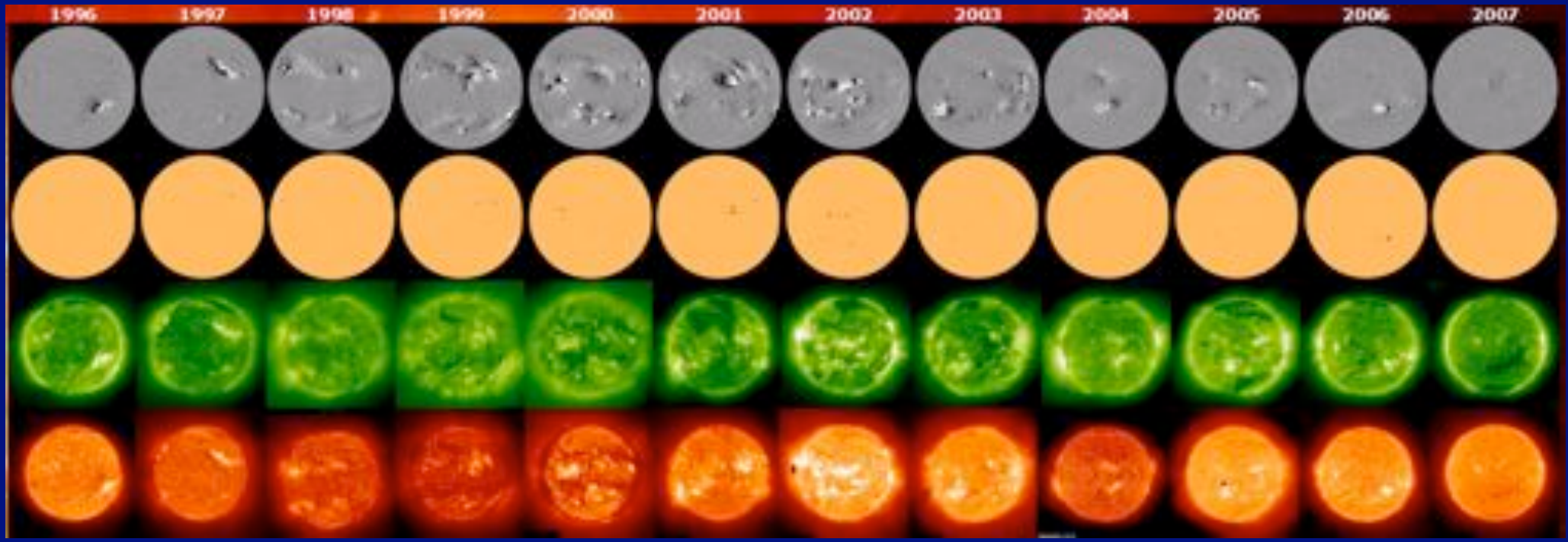
- De waargenomen periodes varieren tussen 8 en 14 jaar.

- Iedere cyclus wordt gekenmerkt door een sterke toename, in 4 jaar, gevolgd door een gemiddelde daling van 7 jaar.

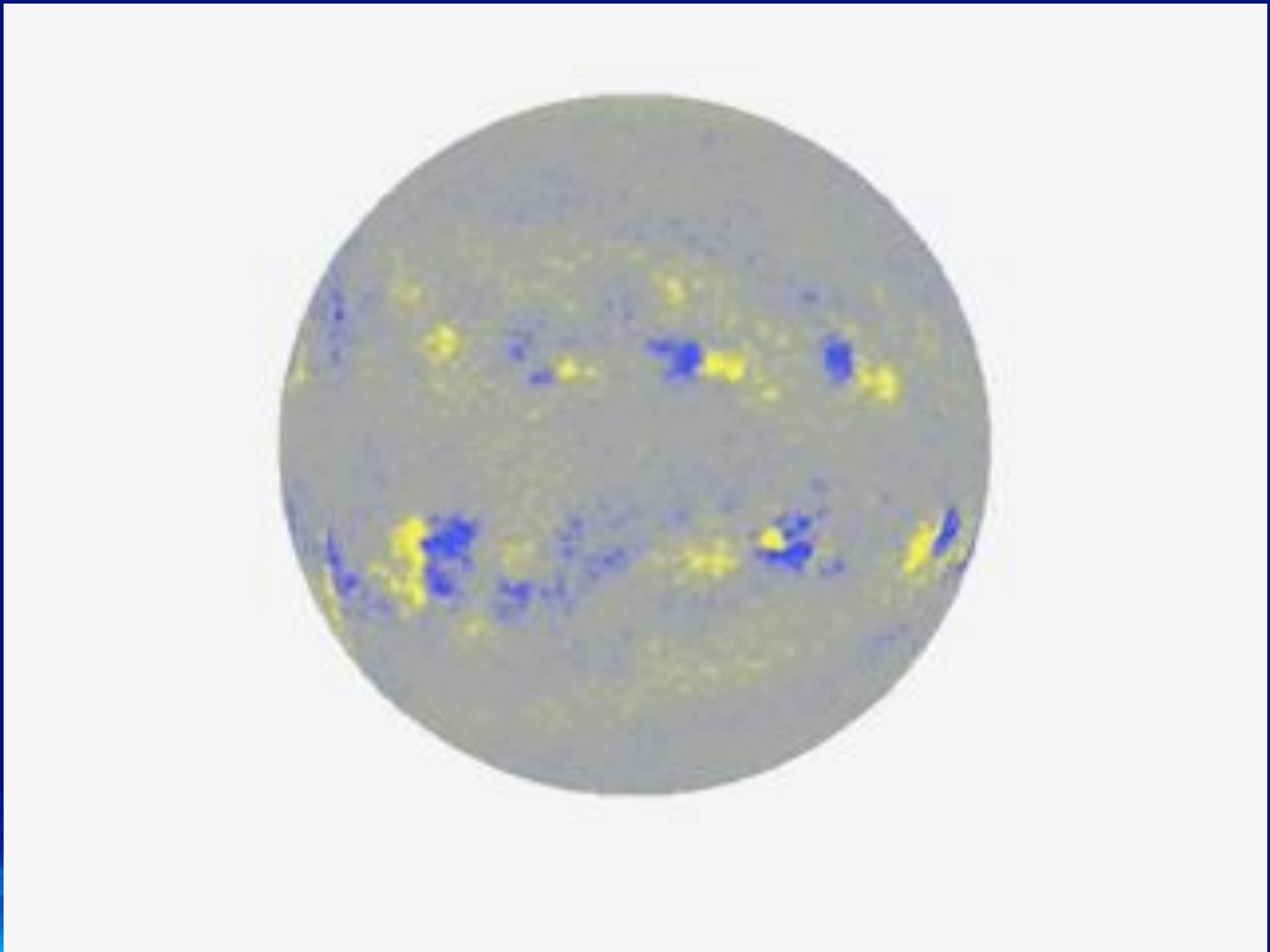
- De amplitude van de cycli is ook variabel met extreme maxima van 48 in 1817 tot 200 en 1958.



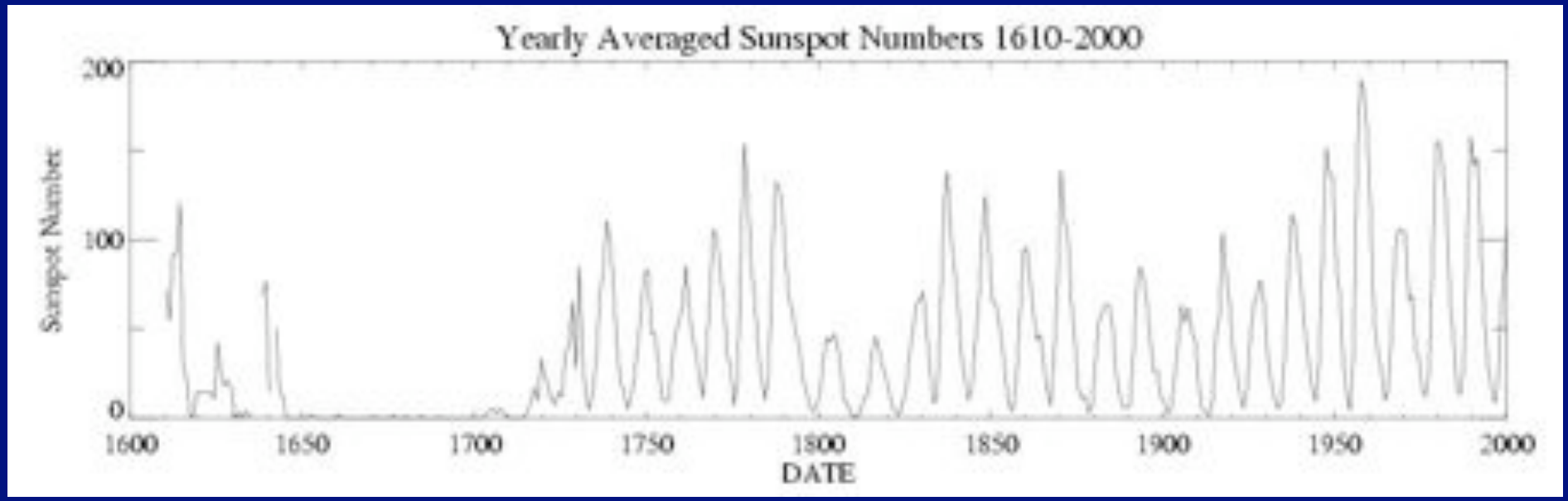
Variaties op middellange termijn



Cyclische drift



Lange termijn



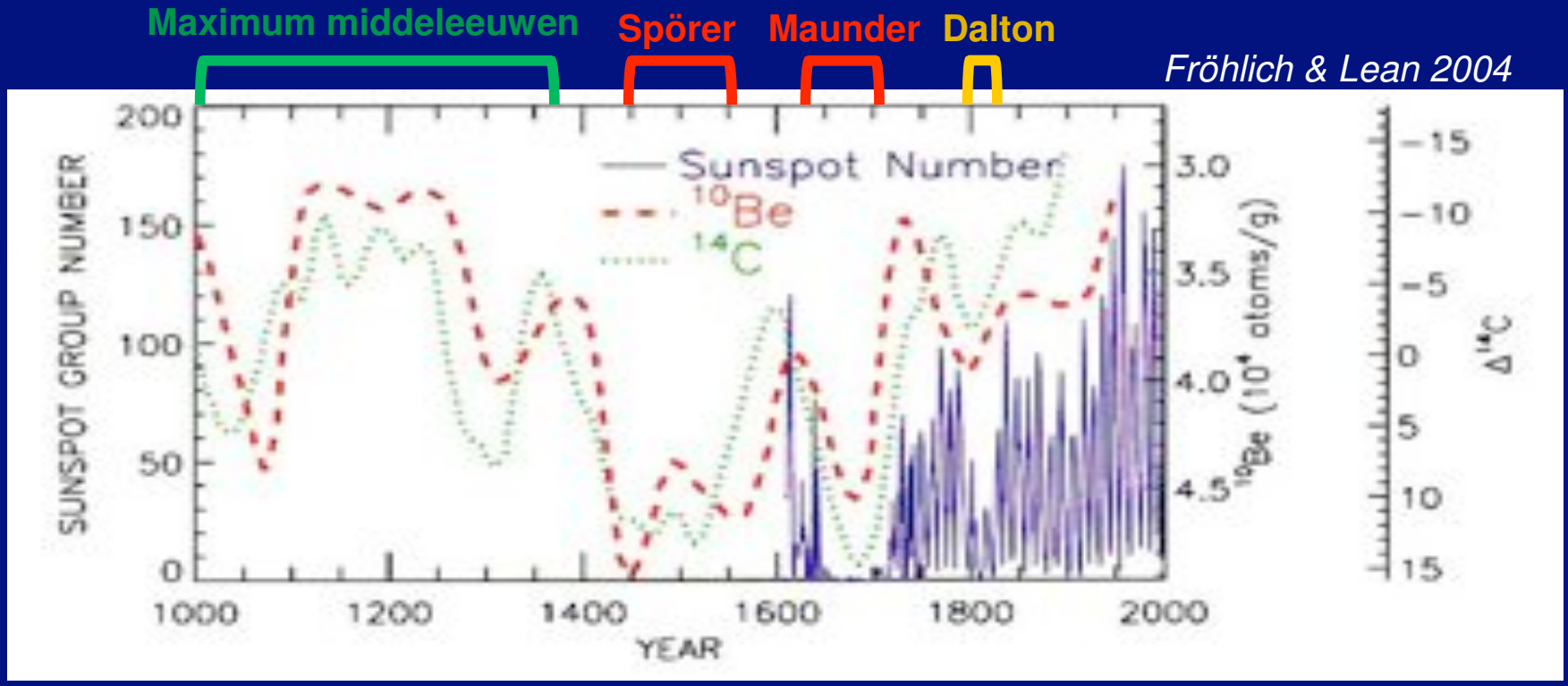
Maunderminimum
De Kleine Ijstijd

Dalton minimum

SIDC development

- 1981- 1994: First actions (André Koeckelenbergh):
  - **Computerization** of the processing of observations
  - Call to new observers: **doubling of the contributing stations** (from 40 to 80)
    - New processing method including all stations
    - Improved accuracy and stability of the index
- 1994 – 2002: Dir. Pierre Cugnon
  - Introduction of **quality control**: detection of possible drifts.
    - References: subset of 20 "high quality" stations (incl. Locarno) and $F_{10.3}$, occasional comparisons with R_A (AAVSO).
    - Identification of additional reference stations
  - New Ri forecast method: **"Combined method"** (Denkmayr & Cugnon, 1997, Hanselmeier et al. 1999): non-parametric regression method.
    - Combination of Waldmeier "standard curves" method with a precursor method (aa index)
  - August 1992: **hemispheric sunspot number**:
    - Subset of 30 to 50 stations
    - Normalized to the total R_i index

Zonneactiviteit: grote minima



- Groot middeleeuws maximum: 1000 -1450 *(colonisatie van Groenland door de Vikings)*
- Minimum van Spörer: 1450 - 1550
- Minimum van Maunder: 1650 - 1710
- Klein minimum van Dalton: 1800 - 1820

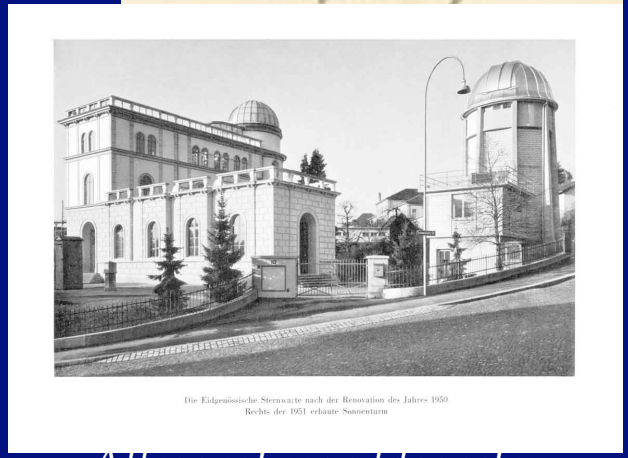
Wolf's correlatie: gefundeerd giswerk

R=10G+S

WOLF-rationaliteit
Zelfde schaal met observaties in verleden
Groep-telling heeft hetzelfde gewicht dan vlek-telling

Fysisch inzicht:
Index voor zonneactiviteit

→emerging magnetic flux
→ontstaan van zonnevlekken
→wanneer B verdwijnt (plages): geen bijdrage tot R



Die Eidgenössische Sternwarte nach der Renovation des Jahres 1950
Rechts der 1951 erbaute Sonnenturm

Volgende correlatie

$R = K\,(10\,G + S)$

S number of sunspots

G number of sunspot groups

K reduction coefficient, scaling factor, quality index

Wolfer

INDEX:
Added number or letter that orders a parameter in a category

Wolf number

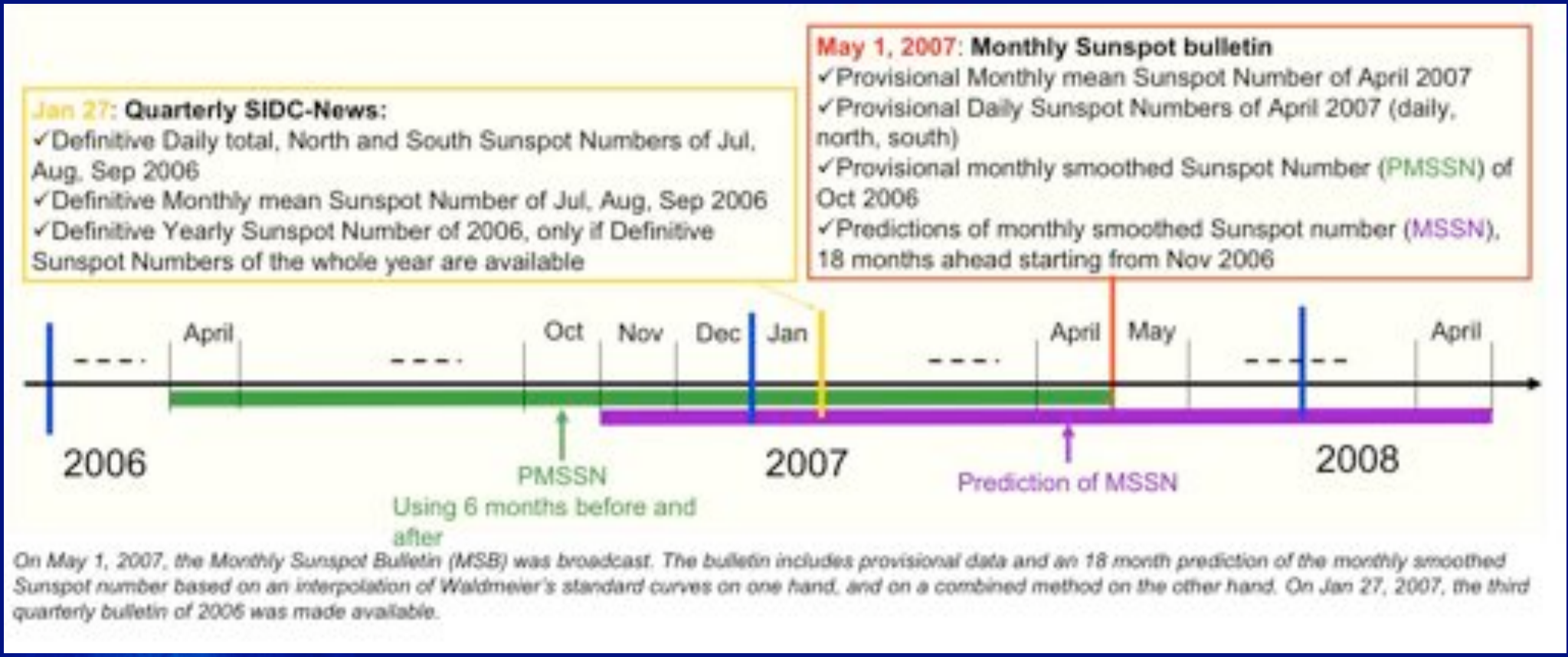
Sunspot Number= K*Wolf number

The International Sunspot Number: Ri

Kinds of sunspot numbers

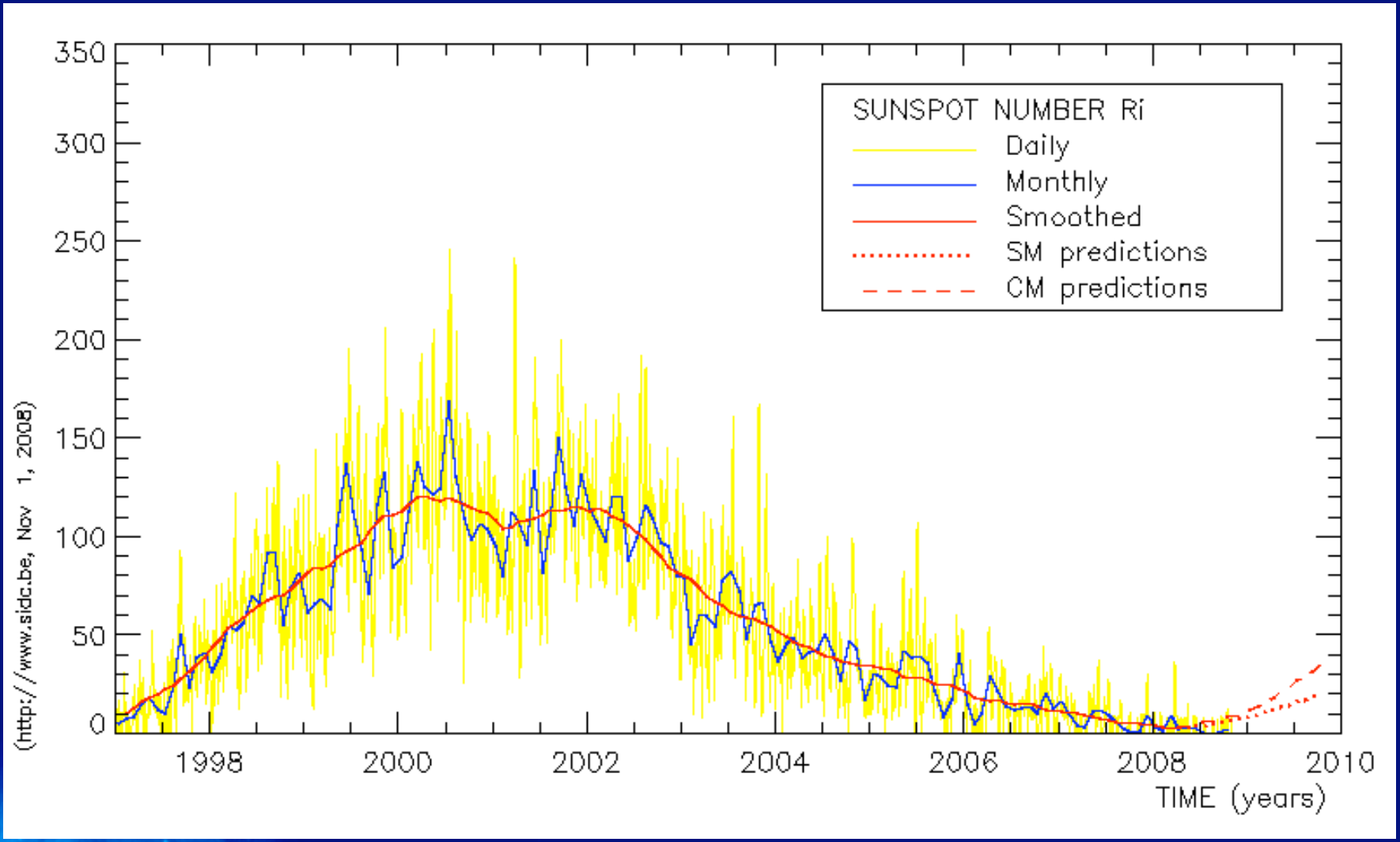
NAME	Appearance	Details	Nr stations
ESTIMATED	Daily	Today, yesterday	Day ~ 10 Day-1~ 20
PROVISIONAL	Monthly	Daily: Total,N->S Monthly: SN,MSSN,Prediction of MSSN (18 months)	~ 70 ~ 40/day
DEFINITIVE	Quarterly	Daily: Total,N,S MmSN, YmSN	PISN + 6

In een figuur

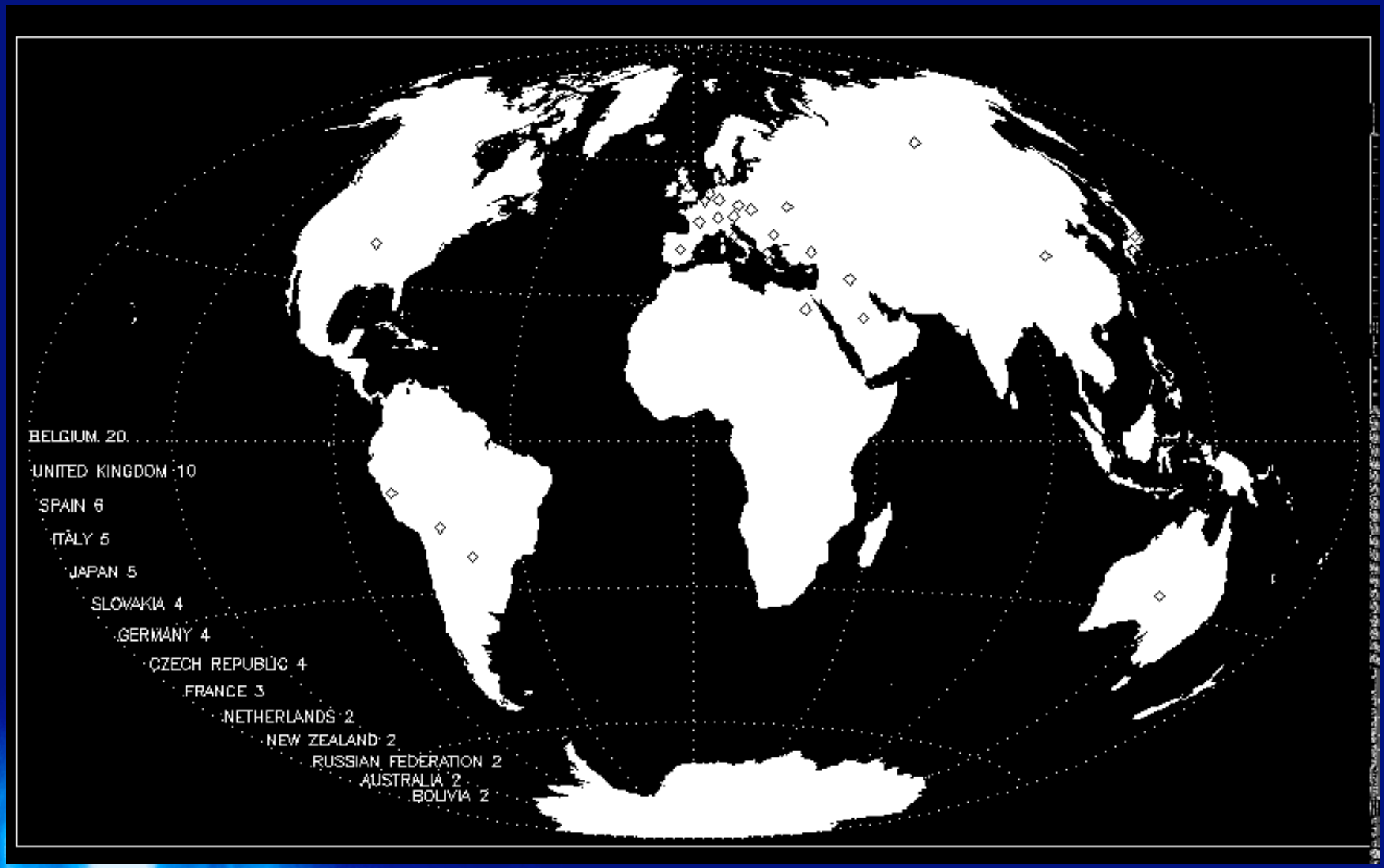


On May 1, 2007, the Monthly Sunspot Bulletin (MSB) was broadcast. The bulletin includes provisional data and an 18 month prediction of the monthly smoothed Sunspot number based on an interpolation of Waldmeier's standard curves on one hand, and on a combined method on the other hand. On Jan 27, 2007, the third quarterly bulletin of 2006 was made available.

In een grafiek



Geografische spreiding



Berekening EISN

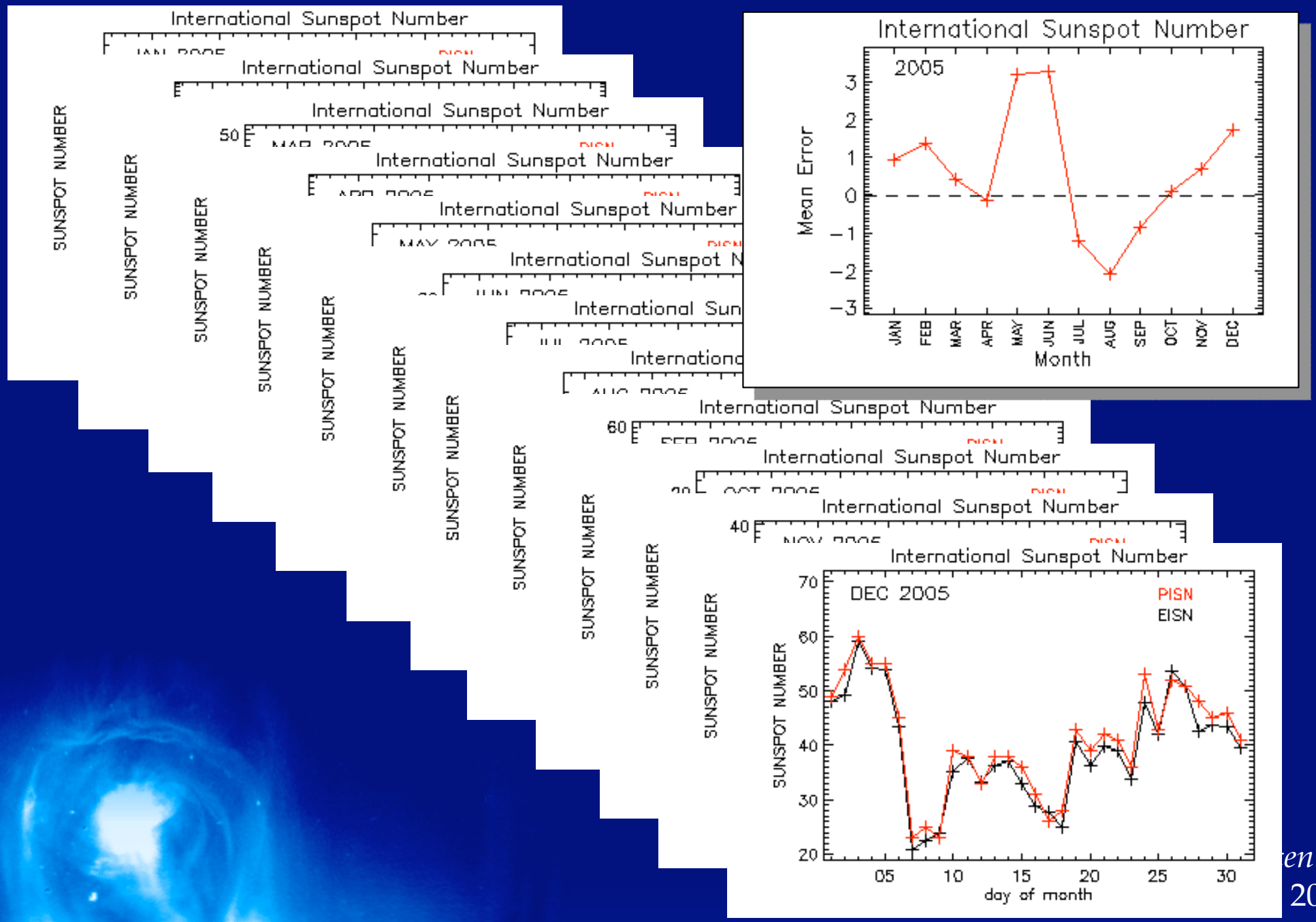
```
; if more then 2 stations, throw out the outliers
  IF AS gt 2   THEN BEGIN
    group       = SN[1:n_obs]
    medianvalue = median(group,/EVEN)
    newgroup    = abs(group-medianvalue)
    ;mad=median absolute deviation
    mad=2.0*median(newgroup,/EVEN)
    FOR I=1,n_obs DO BEGIN
     IF mad lt abs(SN[i]-medianvalue) THEN BEGIN
      SN[i] = !VALUES.F_NAN
      AS    = AS-1
     ENDIF
    ENDFOR
  ENDIF

; calculate the EISN
  EISN=mean(SN,/NAN)
```

Mean

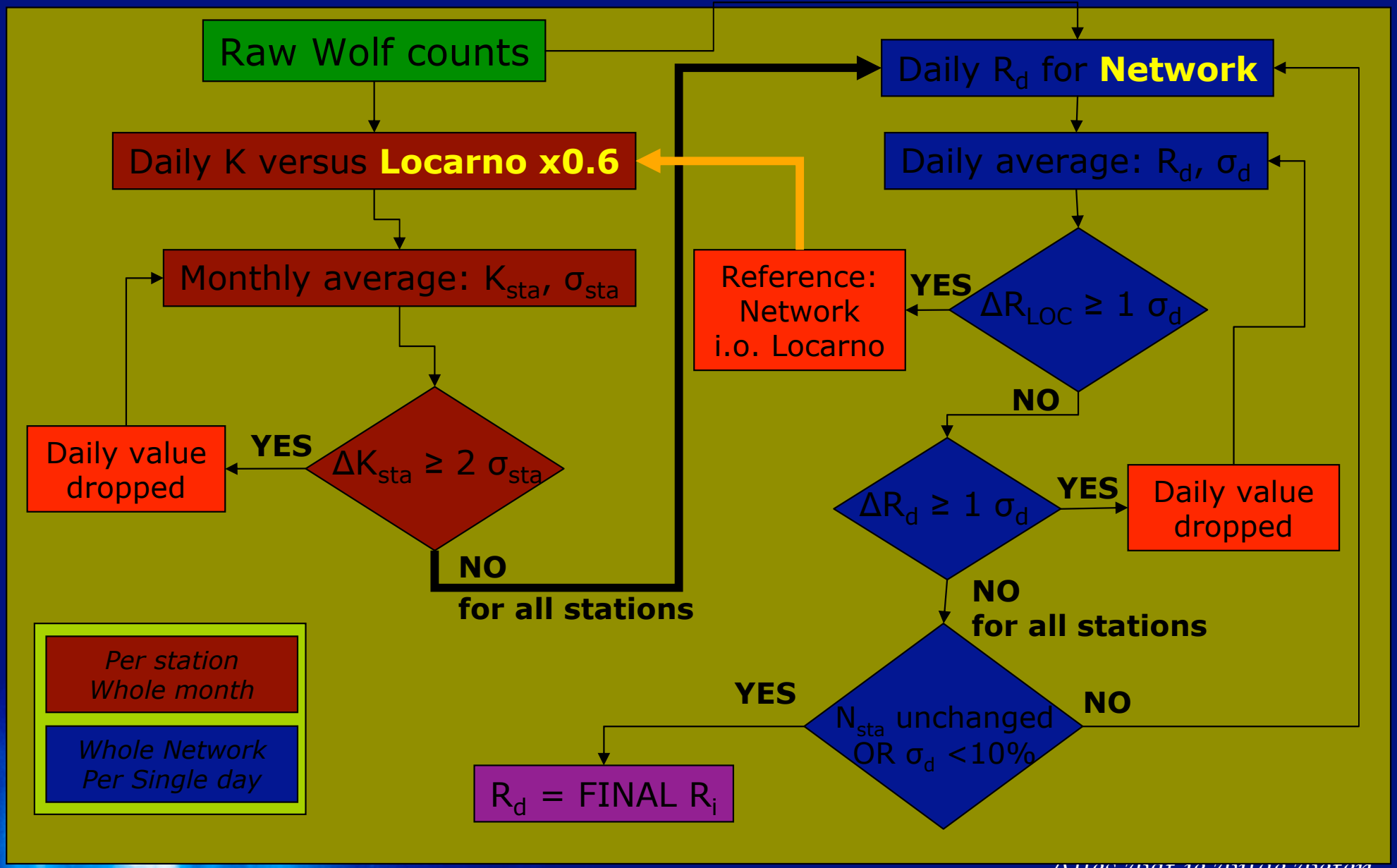
Standard deviation

- OUTLIERS: BN-principle based on Rousseeuw and Leroy
- No calculation of K: mean value of the previous year

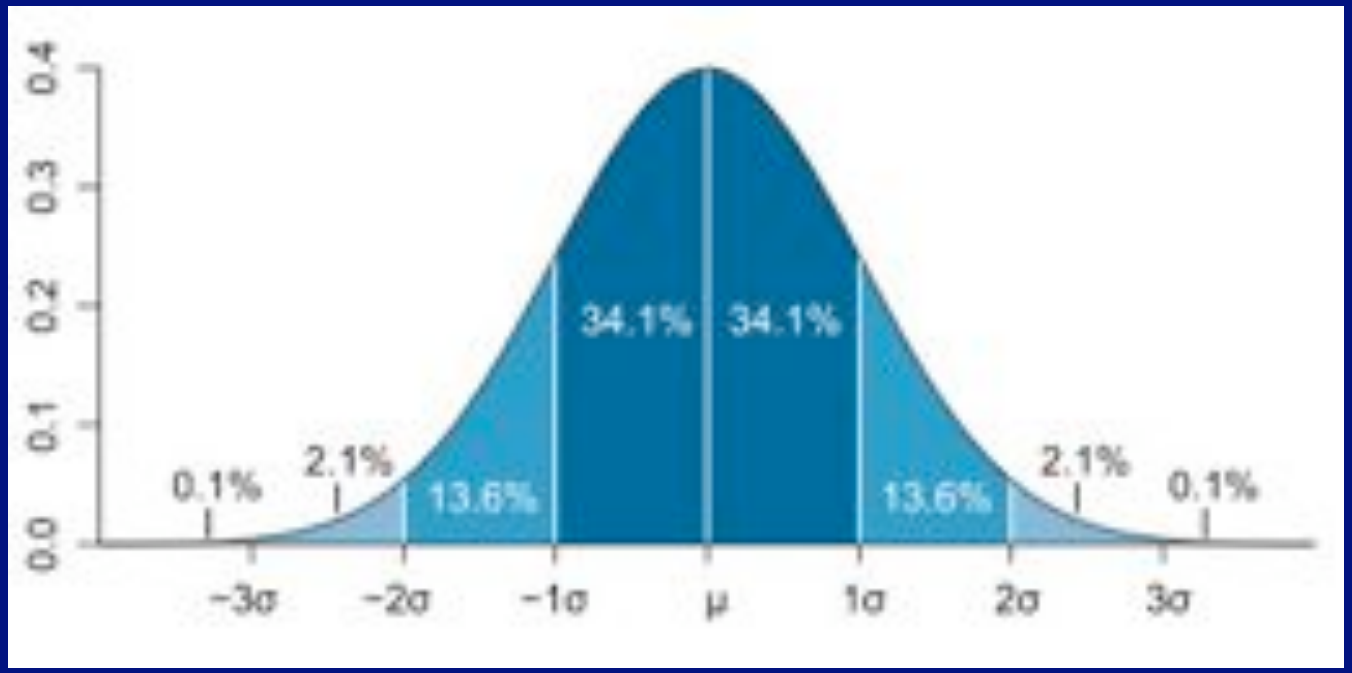
EISN versus PISN



Berekening PISN



Process



Provisional computation: Ri(dt)=AVG(K_ST*Wolf_ST)

K_ST computation for the month

- first estimation with Locarno pilot Station
- Exclusion values following standart deviation (2 sigma)
- if number of 0 values is biggest the 80% ->K_ST of past year
  →second estimation of new K
- first wolf reduction
- Exclusion values following standart deviation to reduced Wolf of pilot STATION (1 sigma)
- if number of 0 values is biggest the 80% ->K_ST of past year
  →monthly K factor

Wolf reduction computation (Ri) with monthly K for each Station

- exclusion values following standard deviation (1 sigma)
- Iteration until Sigma/Avg<10% or number of stations is constant or number of Stations < 4
- if number of 0 values is biggest the 80% -> first reduced Wolf

Berekening DISN

Similar to provisionnal but 3 months later due to additionnal stations
Analysis of results comparared to PISN

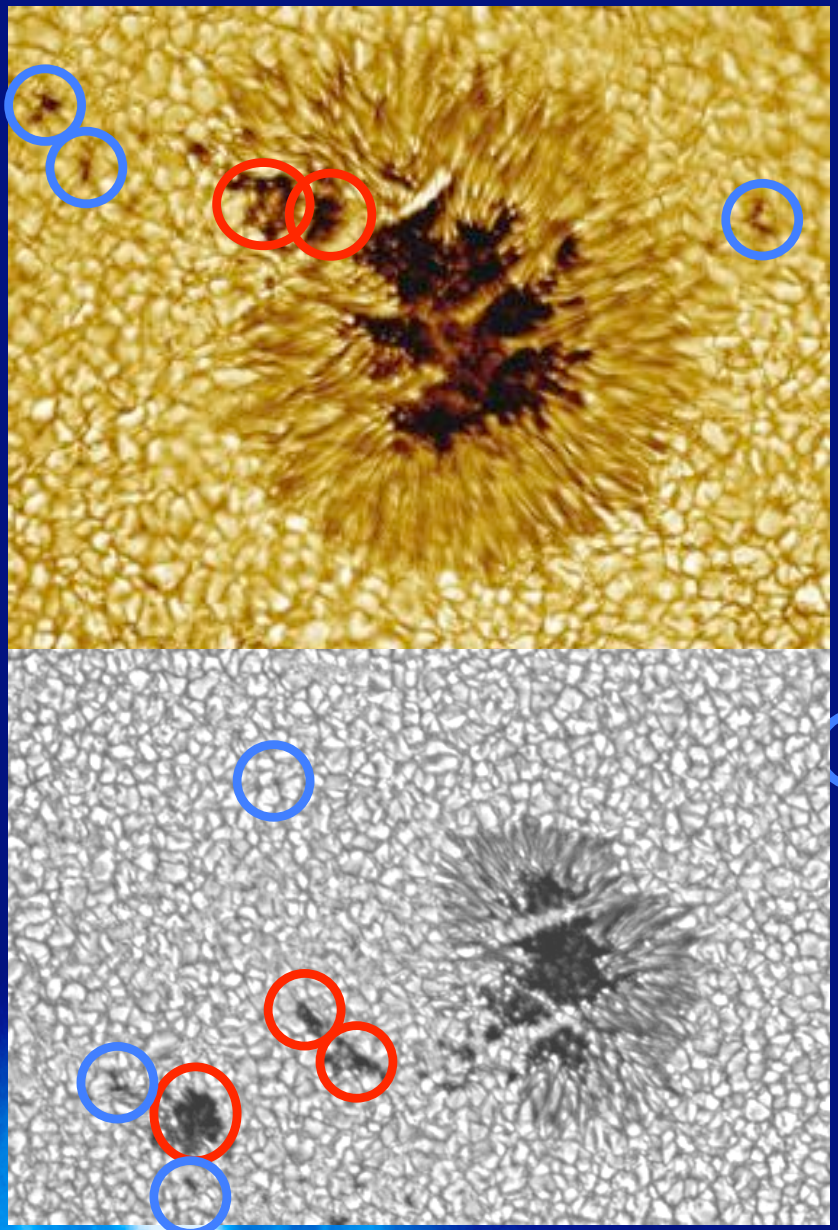
Definitie spot-pore

Source	Spot diameter	Spot lifetime	Pore diameter	Pore lifetime
Bray & Laughhead 1964	With penumbra		Without penumbra	
Waldmeier *(Husar 1967)*	>3″ (2000km) = 1 granule	> 30 min	< 3″	< 30min
Bruzec & Durrant 1977	>10″ (6000km)	> 1 day	< 5″	< 1 day
McIntosh 1981	> 4″ (2500km) = 1 granule		< 4″	

Observationele definitie

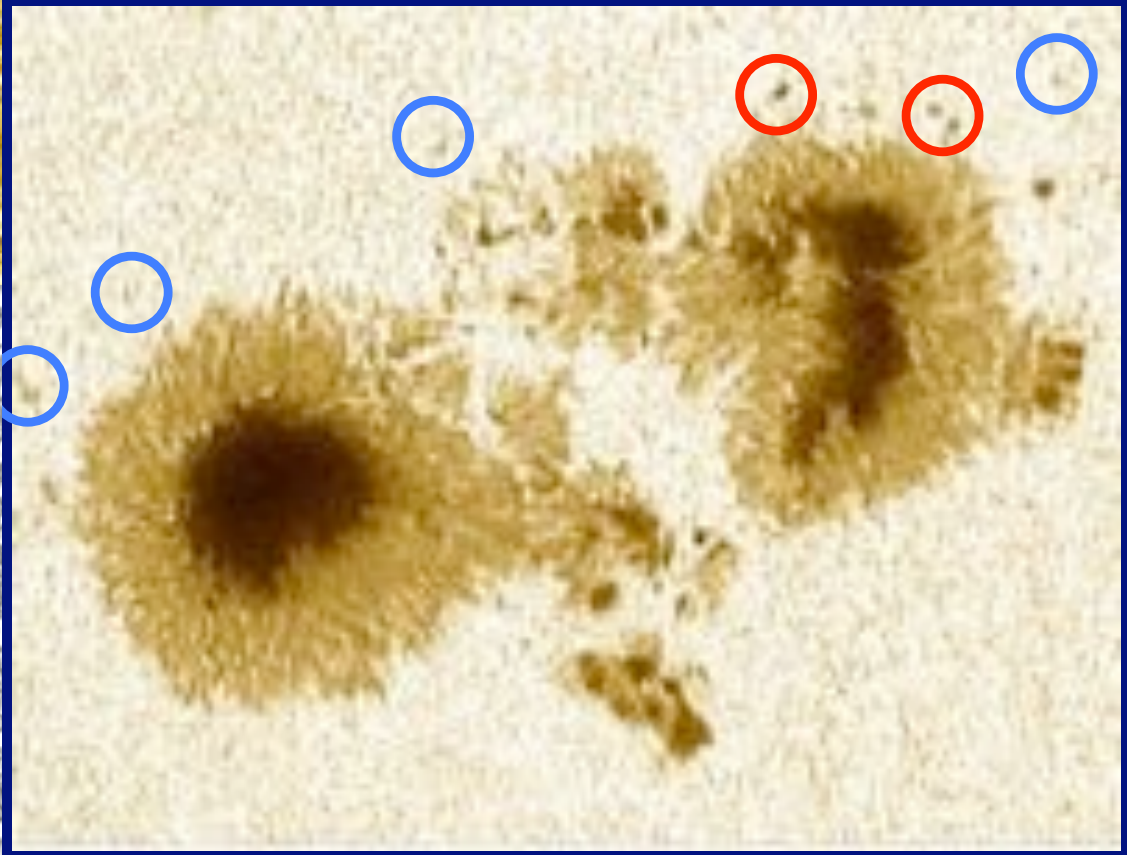
	Diameter	Lifetime	Outline	Contrast	Penumbra
Pore	< 3″ < 2500km	< 30 min	Fuzzy Irregular	low	none
Sunspot	> 3″ > 2500 km	> 30 min	Sharp ~ round	High Dark core	none

Pores and spots

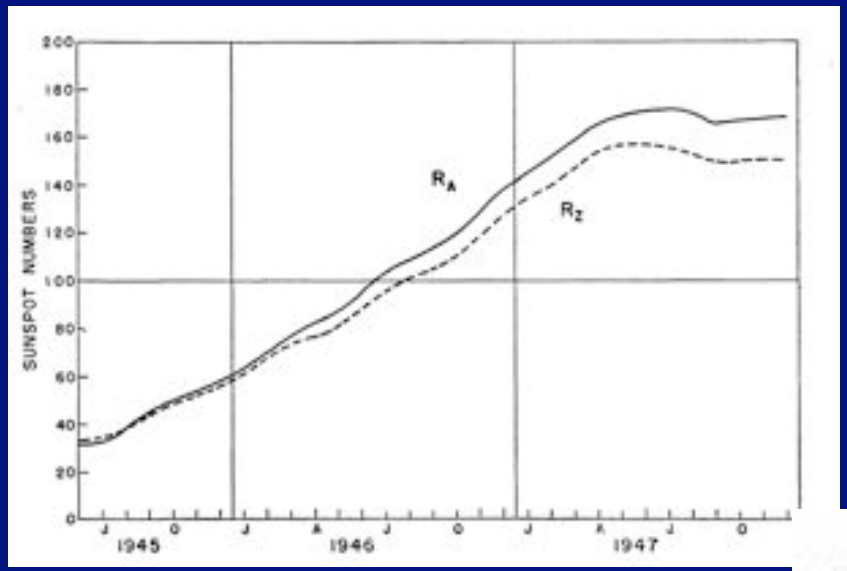


Sunspot

Pore



Controversy US vs Zürich sunspot index



Shapley, A. 1949

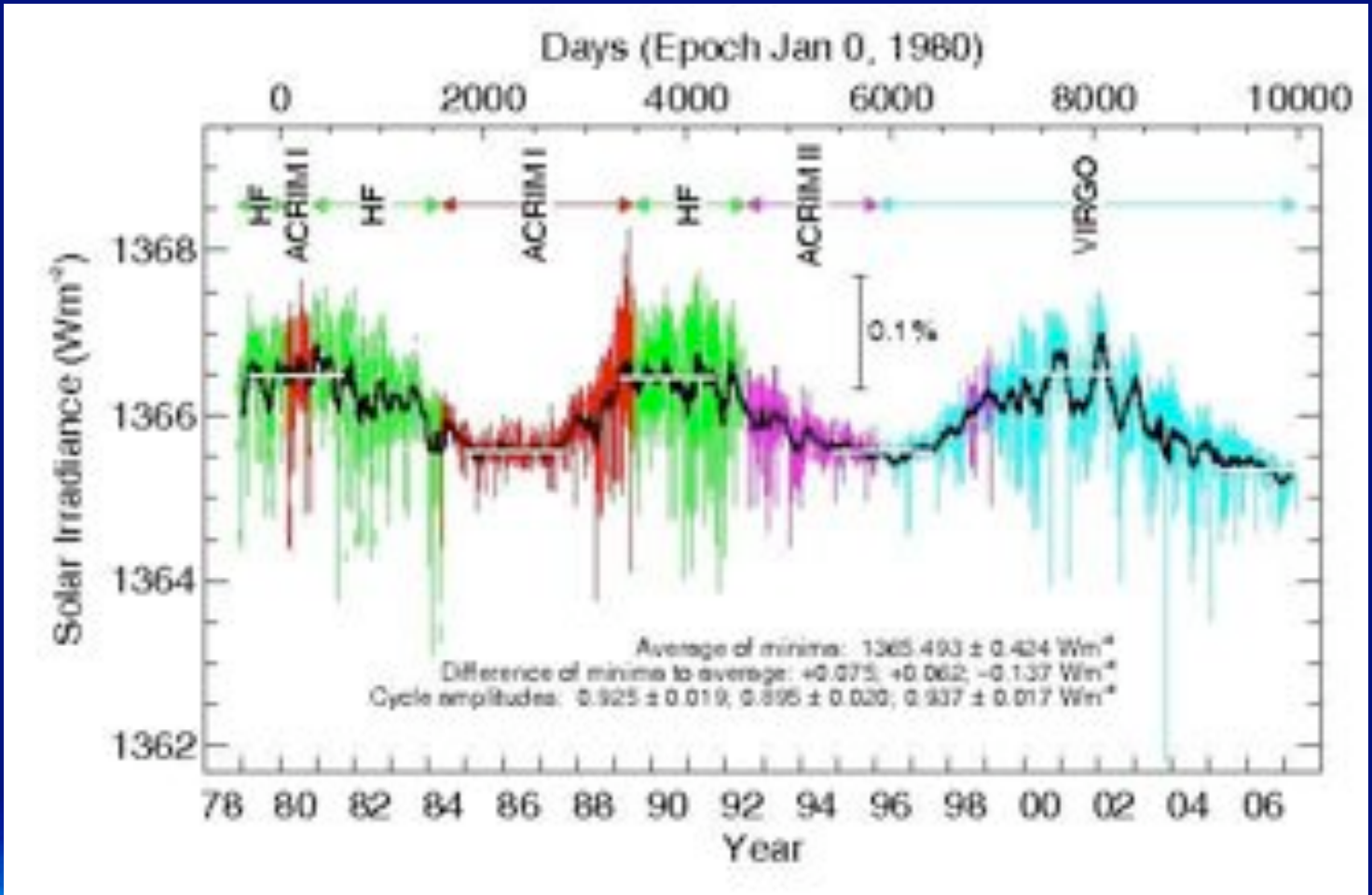
As you may know the Executive Council and the XXIst Plenary Meeting of COSPAR held in Innsbruck (Austria) in May/June 1978, adopted among others the following Decision No. 6/78 proposed by Working Group 4 (see COSPAR Information Bulletin No. 82, August 1978, p.25):

"COSPAR,
noting that there are plans to discontinue the continuous observations from which the Zurich sunspot numbers are derived,
strongly recommends to the appropriate national organisation the continuation of these long-term observations which are vital and irreplaceable for improvement of our understanding of solar-terrestrial relationship,
and,
further recommends that IAU, IUGG, URSI and other interested organisations support the continuation of these essential observations."

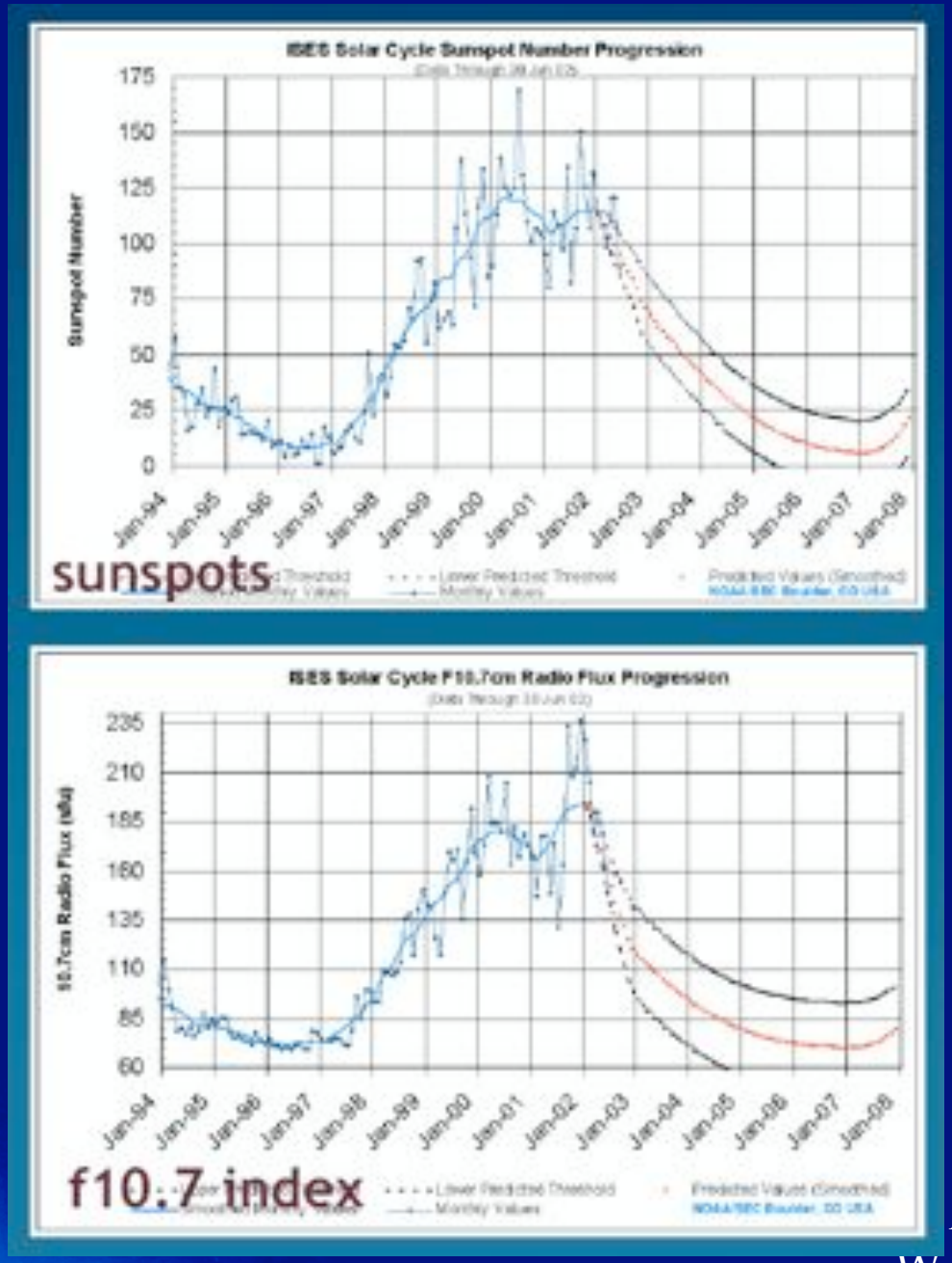
It is to be expected that the IAU Commission 10 (Solar Activity) will present a resolution to the same effect to the XVIIth General Assembly in

Alles wat je wilde weten …
Werkgroep Zon, 8 nov 2008

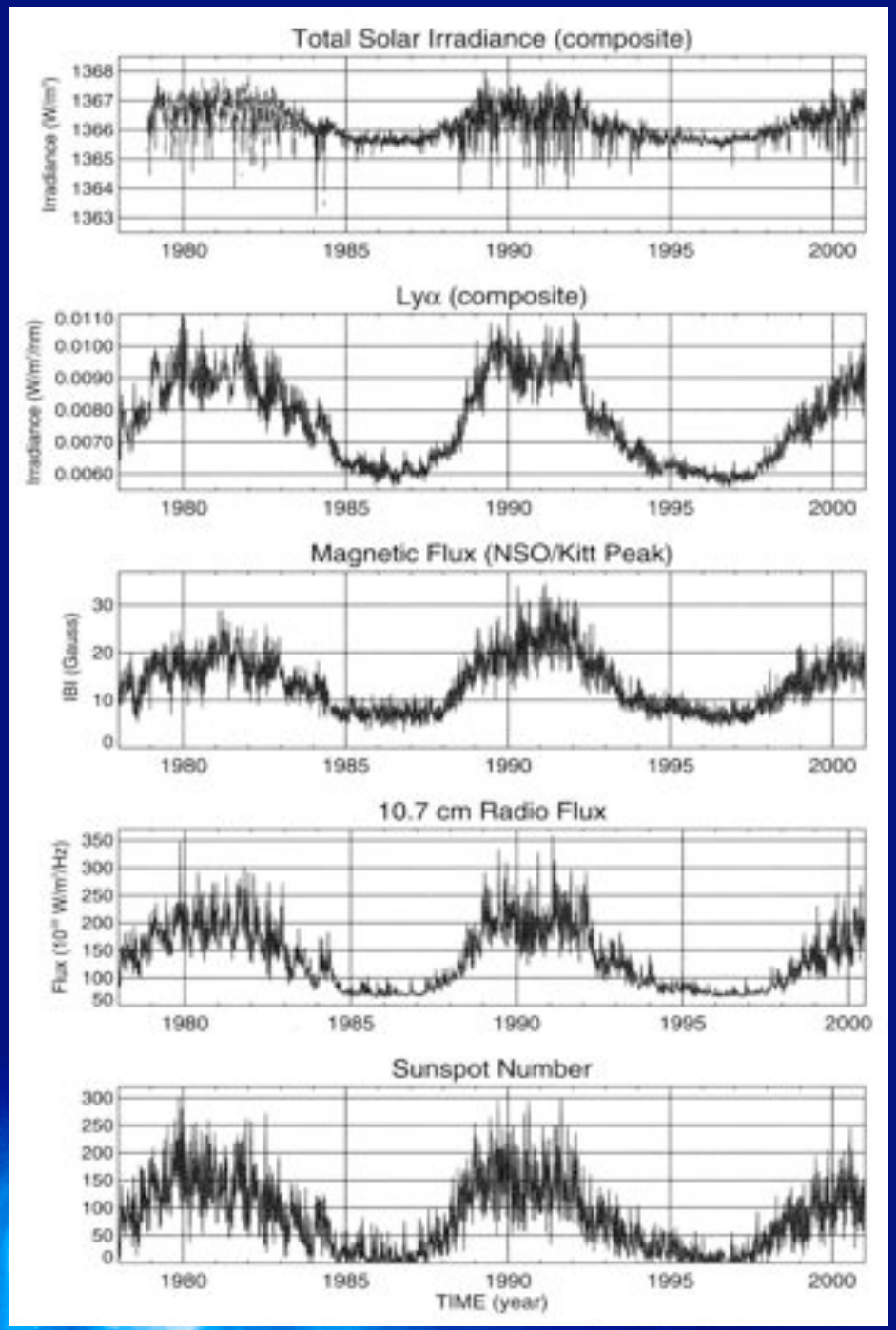
Andere indices: zonneconstante

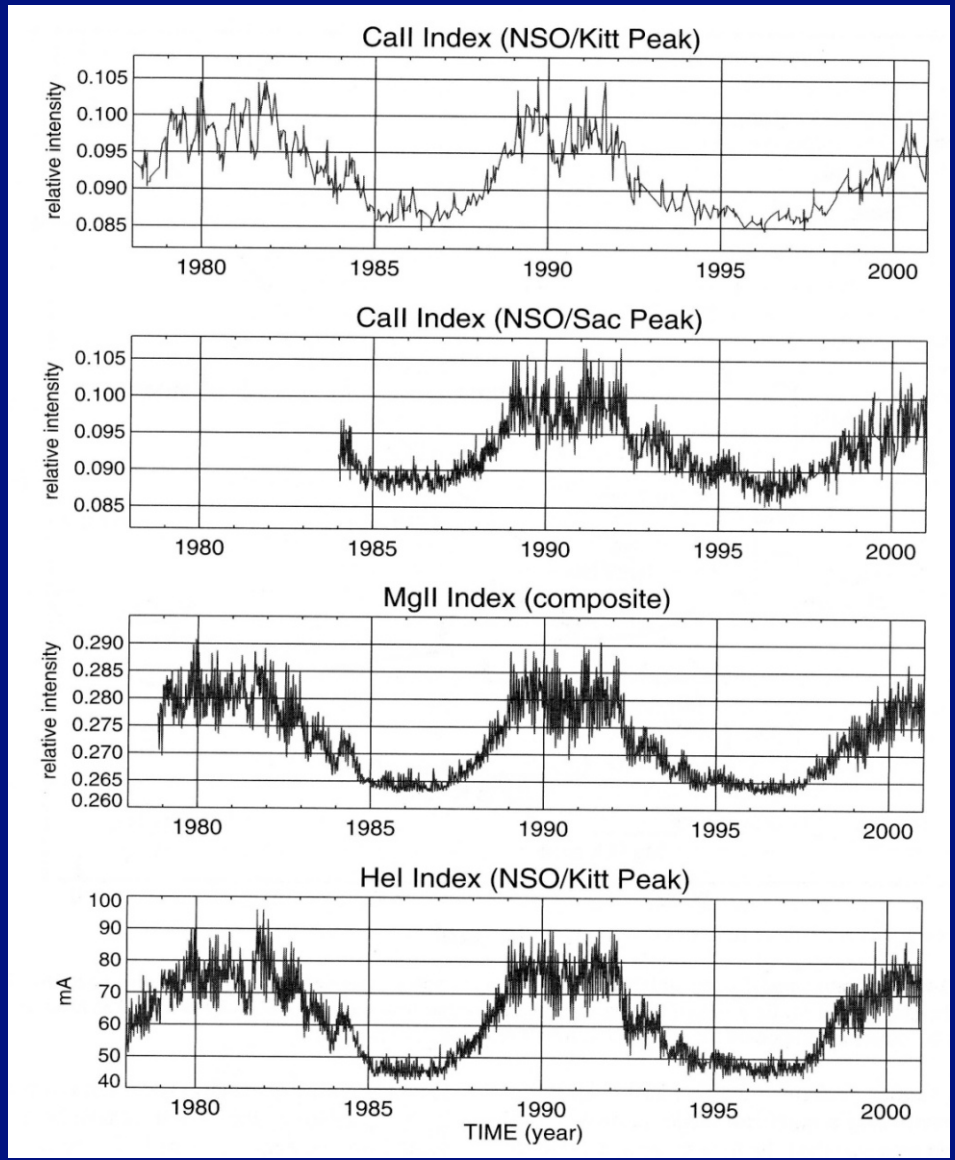


Andere indices



Alles wat je wilde weten …
Werkgroep Zon, 8 nov 2008





’Proxy’ tijdsreeksen voor de periode 1975 tot 2001 *(G. De Toma)*

Alles wat je wilde weten …
Werkgroep Zon, 8 nov 2008

De vragen

Vuur!