СРЕДНЕСРОЧНОЕ ПРОГНОЗИРОВАНИЕ ЧИСЛА И ПАРАМЕТРОВ КОРОНАЛЬНЫХ ВЫБРОСОВ МАССЫ

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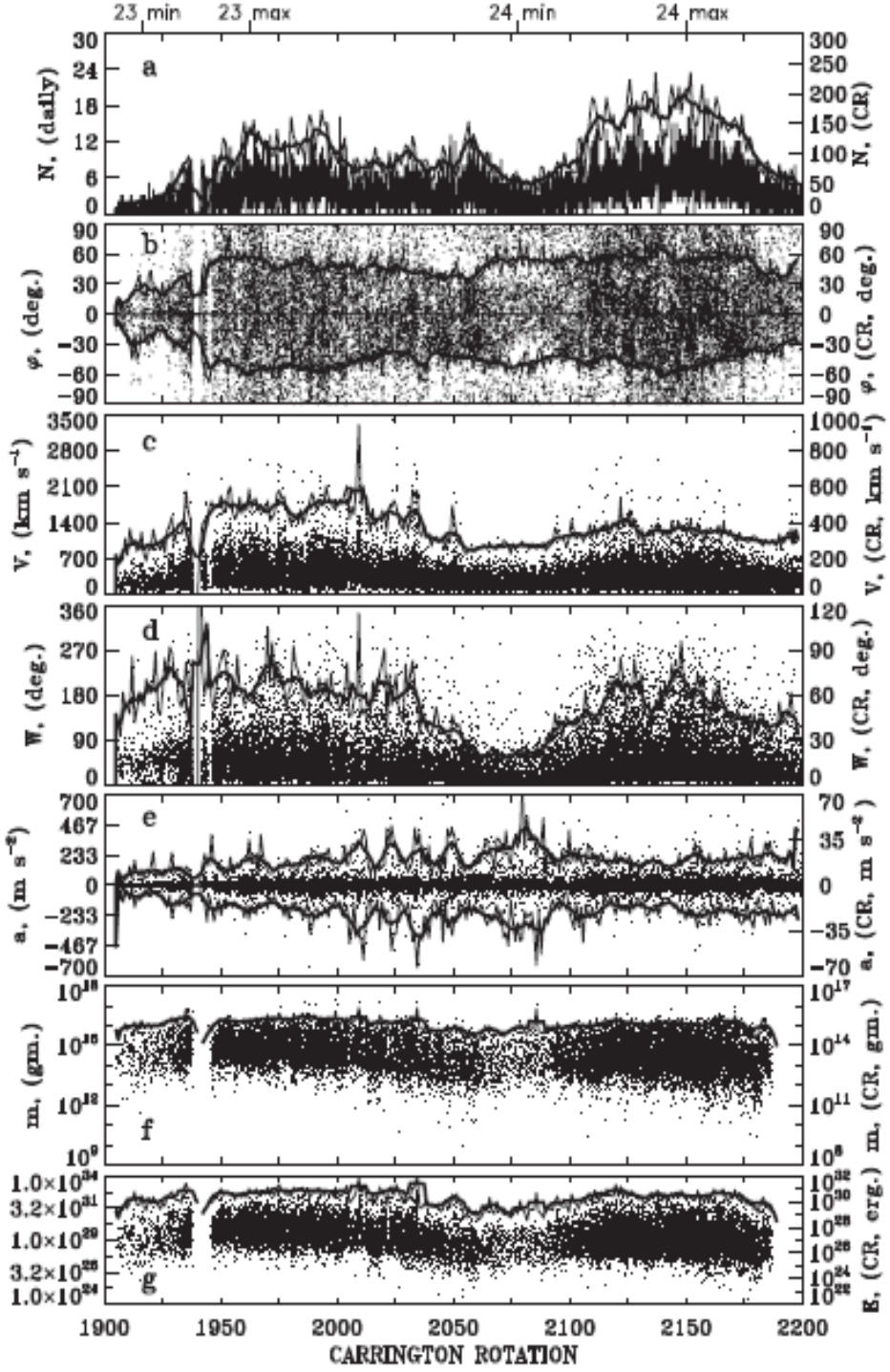


CMEs in cycles 23 and 24

(a) CME rate,

(b) latitudinal location,

(c) speed,

(d) angular width,

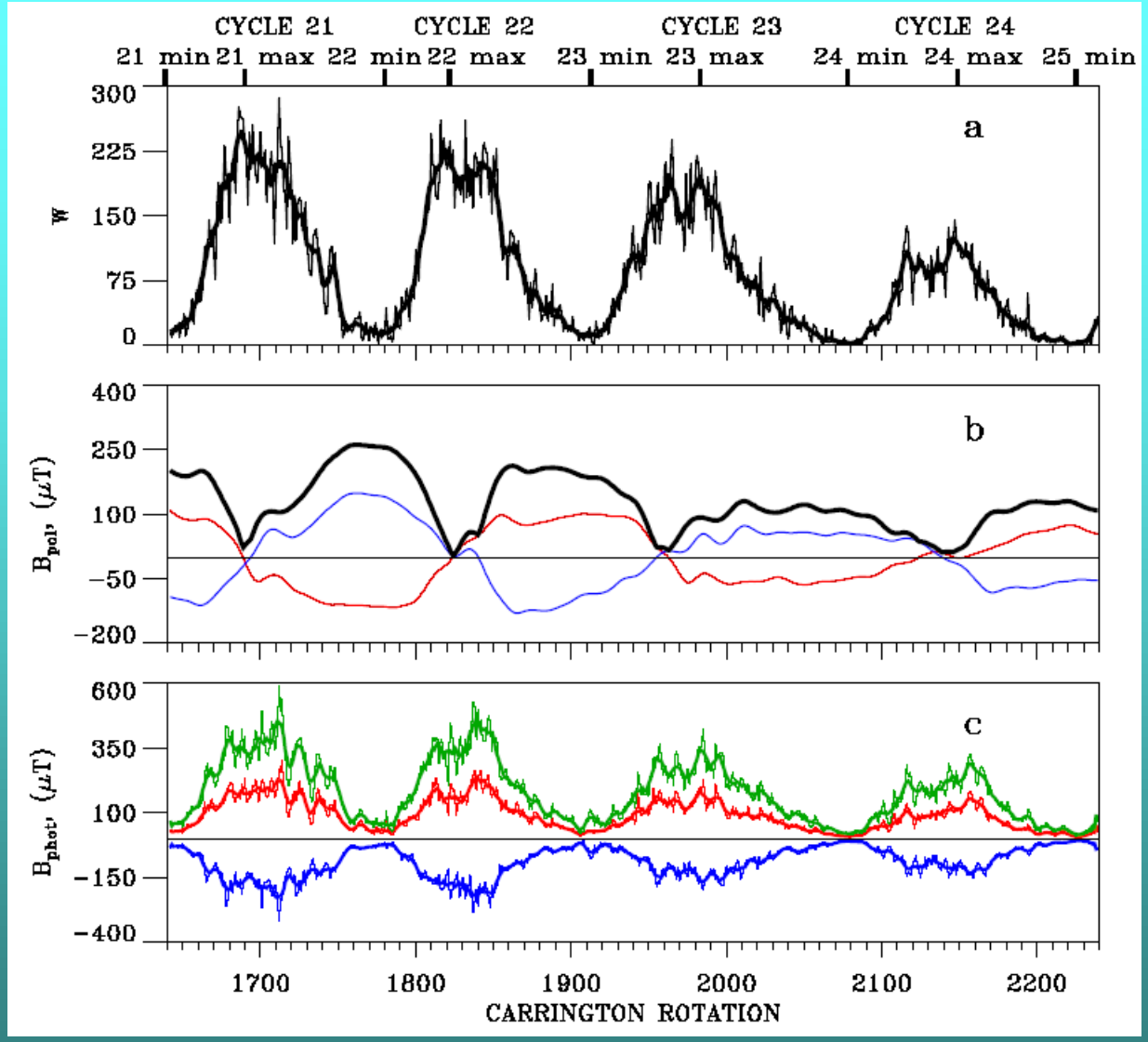
(e) acceleration,

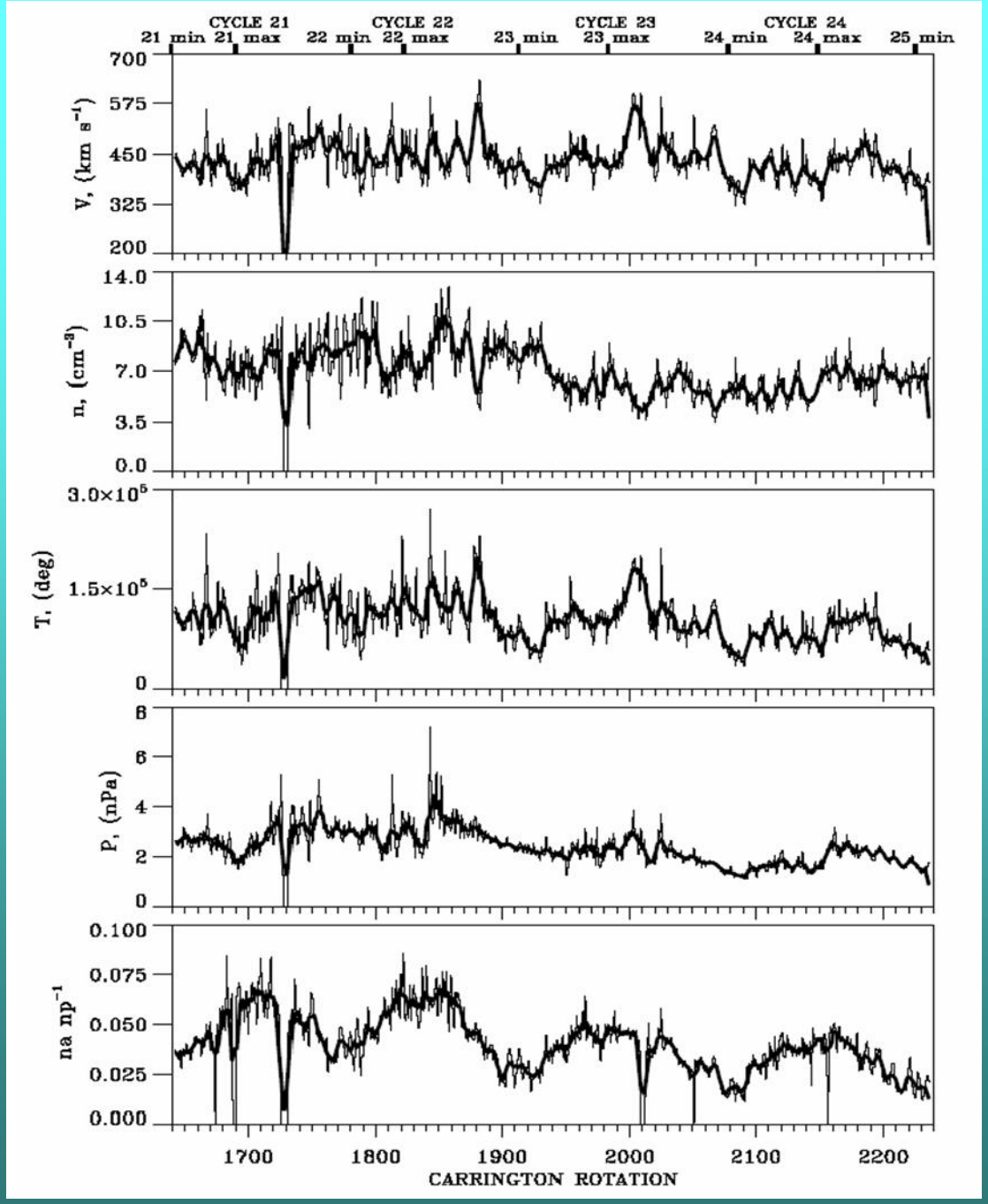
(f) mass,

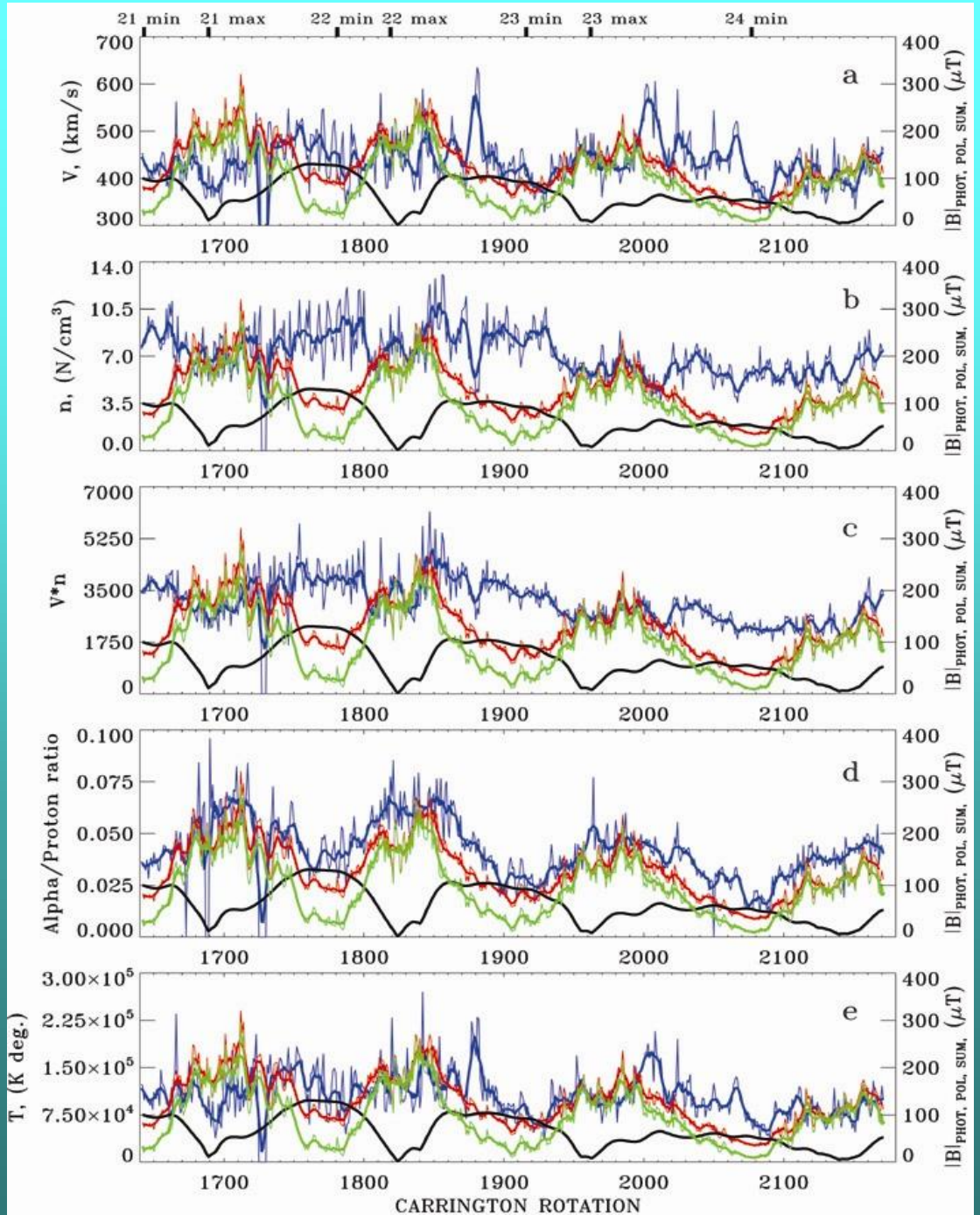
(g) energy.

Dots - each CME. Thin lines - and thick lines 7CR-averaged data..

N= 13924 Cycle 23, N=15074 Cycle 24


CYCLE 21
CYCLE 22
CYCLE 23
CYCLE 24
21 min
21 max
22 min
22 max
23 min
23 max
24 min
24 max
25 min
a
W
300
225
150
75
0
b
B_{pol}, (μT)
400
250
100
−50
−200
c
B_{phot}, (μT)
600
350
100
−150
−400
1700
1800
1900
2000
2100
2200
CARRINGTON ROTATION


CYCLE 21
CYCLE 22
CYCLE 23
CYCLE 24
21 min
21 max
22 min
22 max
23 min
23 max
24 min
24 max
25 min
V, (km s⁻¹)
700
575
450
325
200
n, (cm⁻³)
14.0
10.5
7.0
3.5
0.0
T, (deg)
3.0×10⁵
1.5×10⁵
0
P, (nPa)
8
6
4
2
0
na np⁻¹
0.100
0.075
0.050
0.025
0.000
1700
1800
1900
2000
2100
2200
CARRINGTON ROTATION

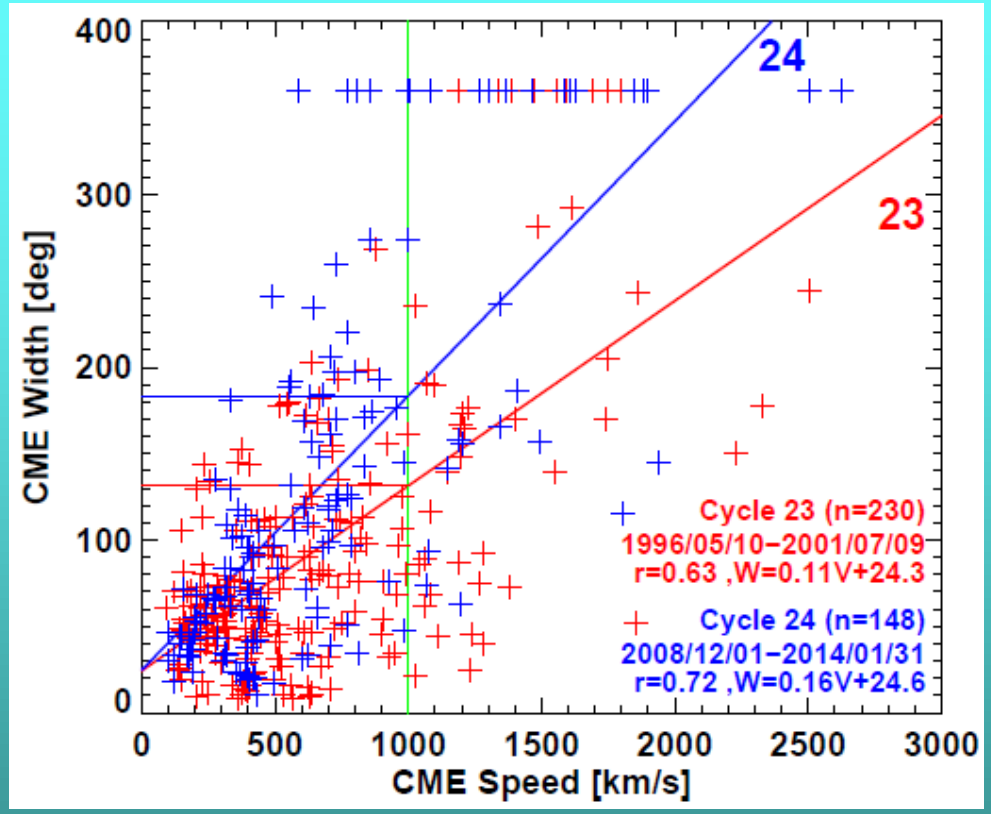


B polar

B photosphere

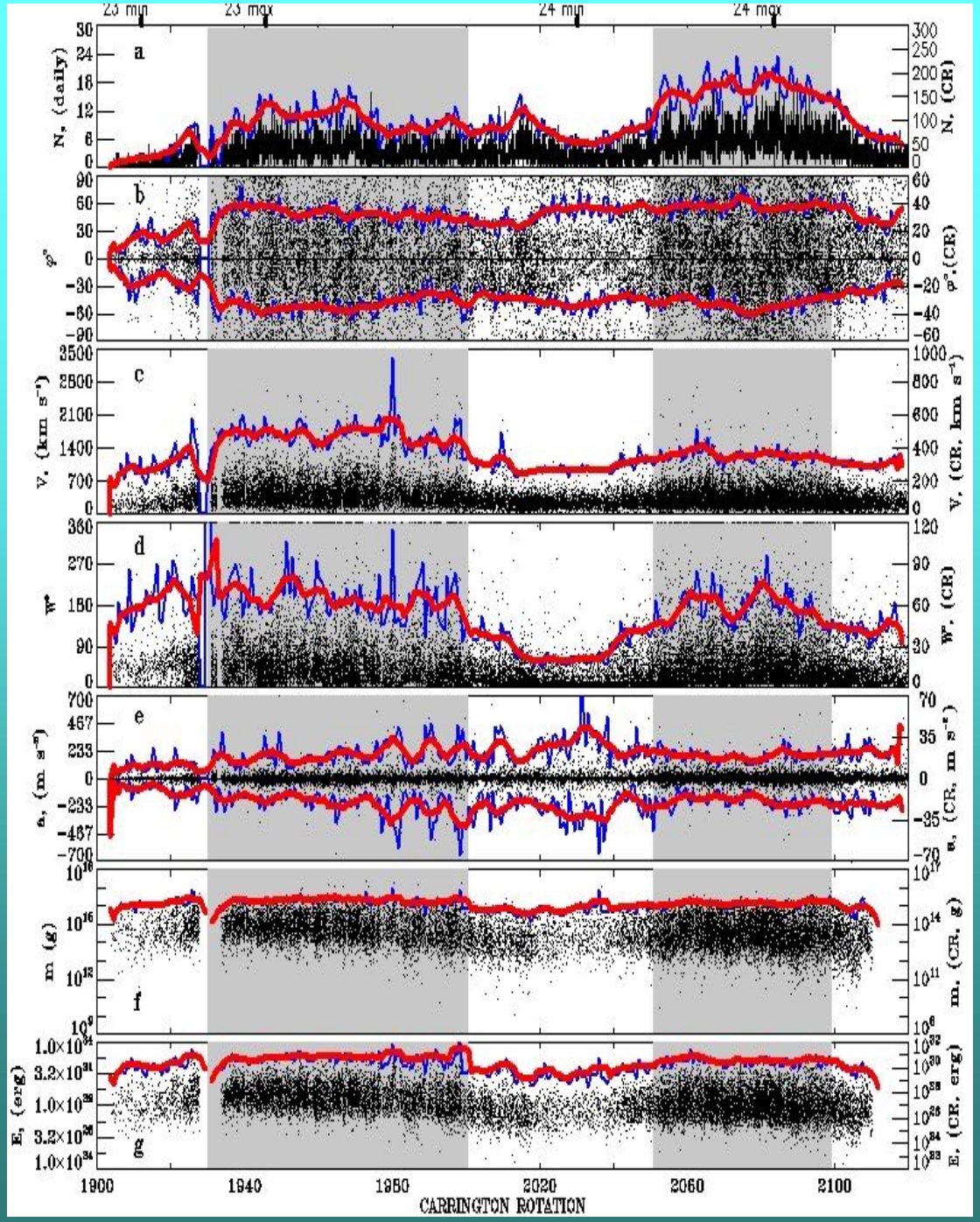
B sum

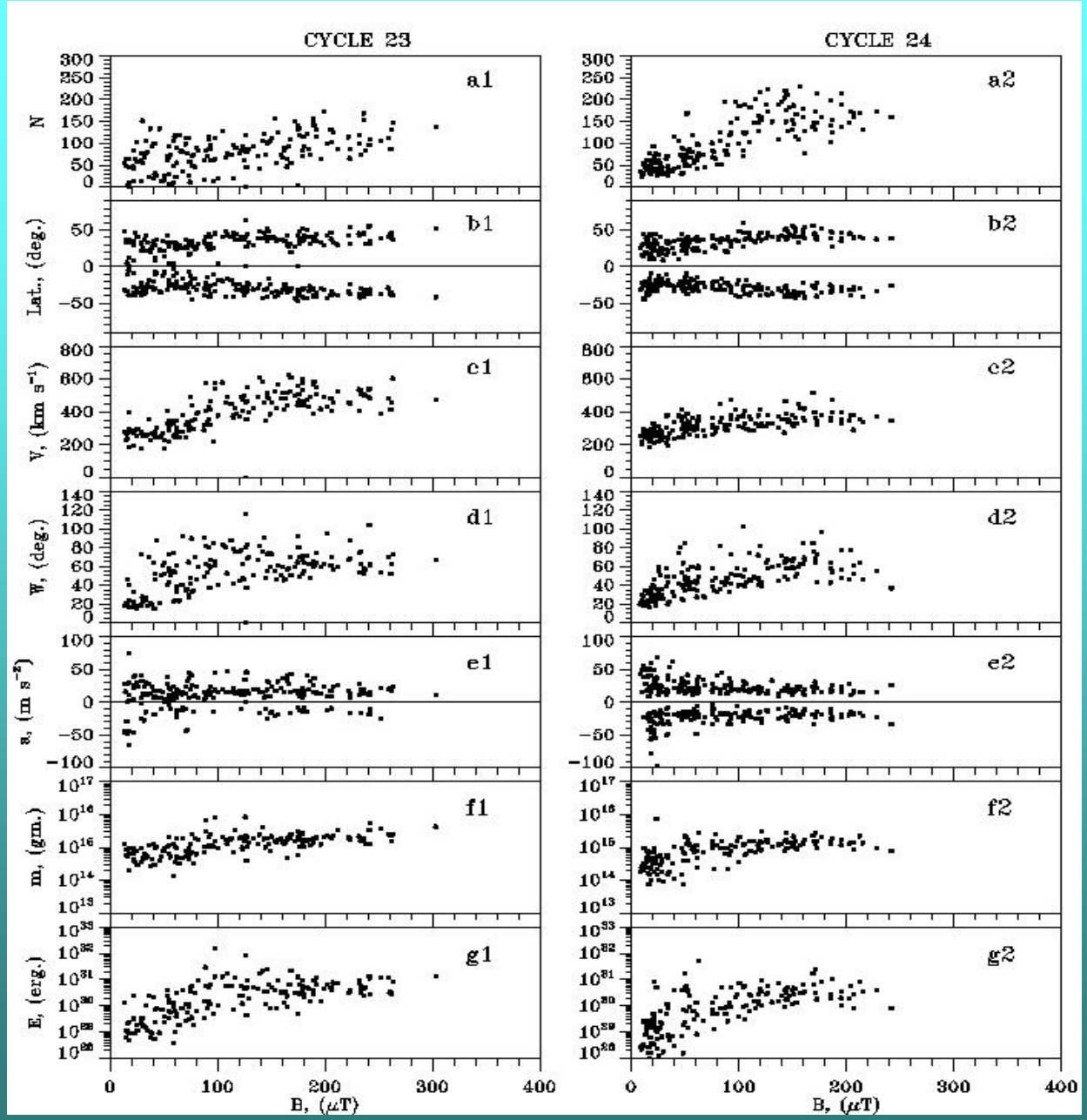
Solar wind parameter

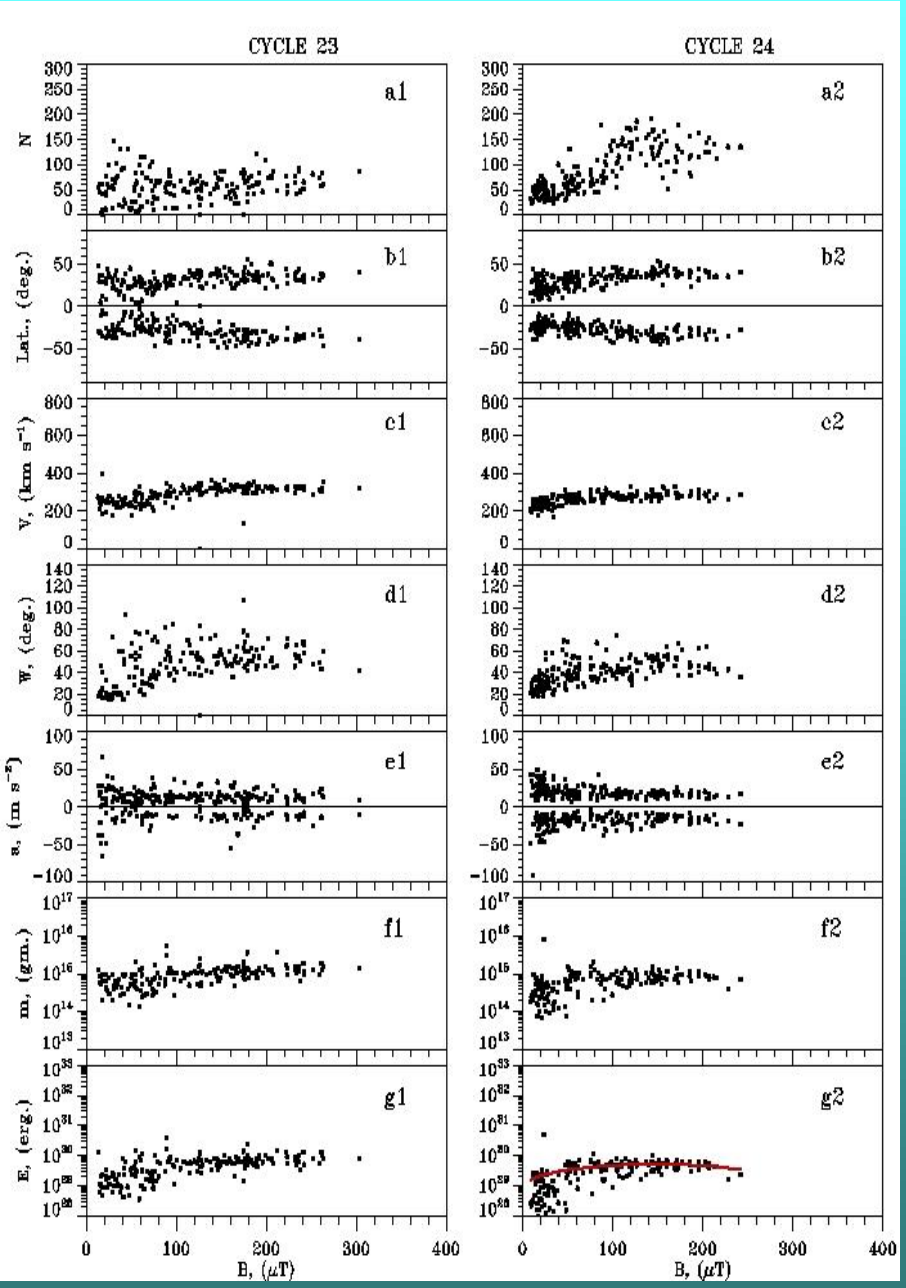


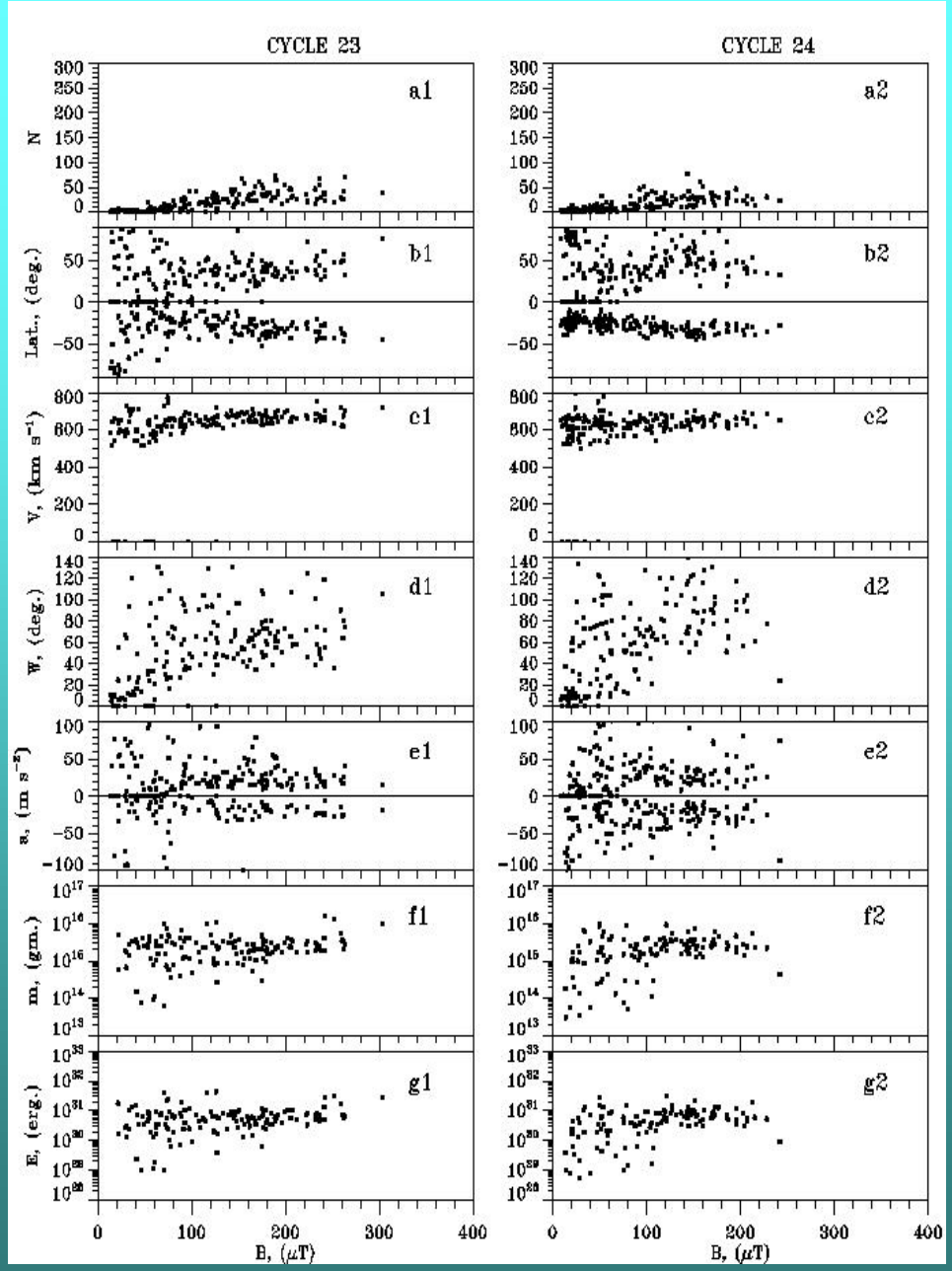
Scatterplots between CME speed (V) and angular width (W) for cycles 23 (red) and 24 (blue). The regression lines and the correlation coefficients are indicated on the plot. The width difference at 1000 km/s (green line) is substantial between the two cycles.

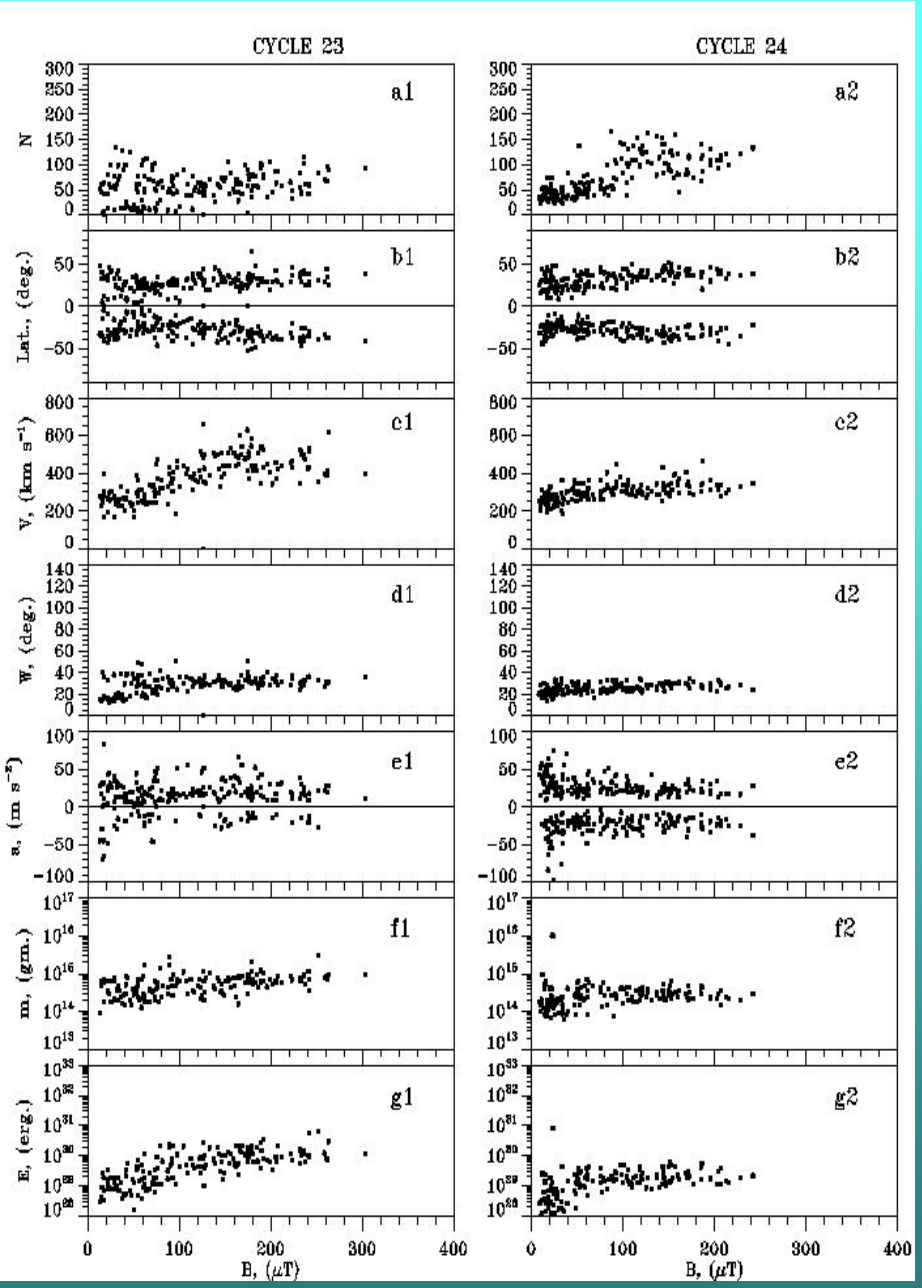
Gopalswamy, N. et al., GeoRL, 2014

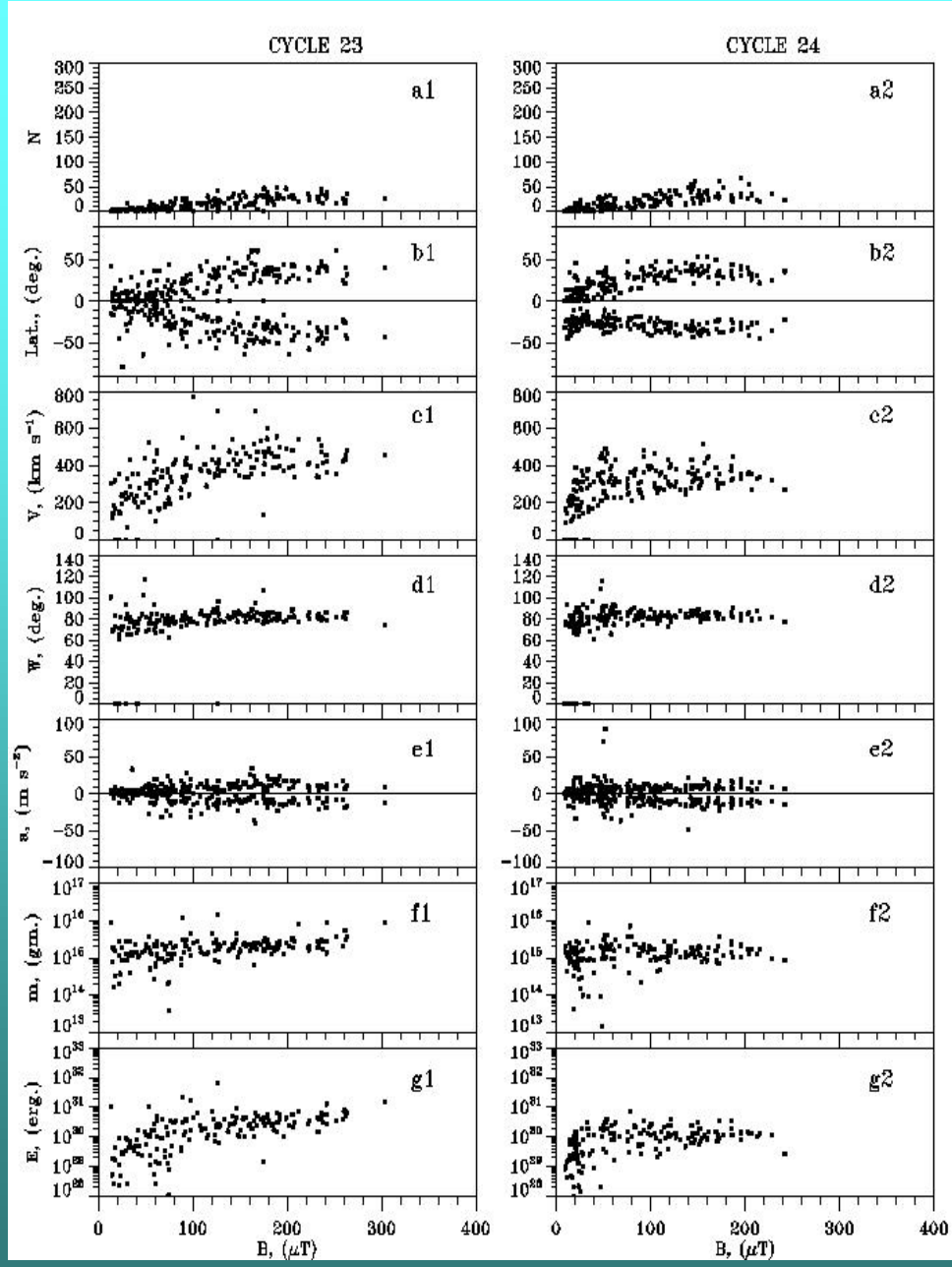

23 min
23 max
24 min
24 max
a
N, (daily)
N, (CR)
b
φ°
φ°,(CR)
c
V, (km s⁻¹)
V, (CR, km s⁻¹)
d
W°
W°, (CR)
e
a, (m s⁻²)
a, (CR, m s⁻²)
f
m (g)
m, (CR, g)
g
E, (erg)
E, (CR, erg)
1900
1940
1980
2020
2060
2100
CARRINGTON ROTATION

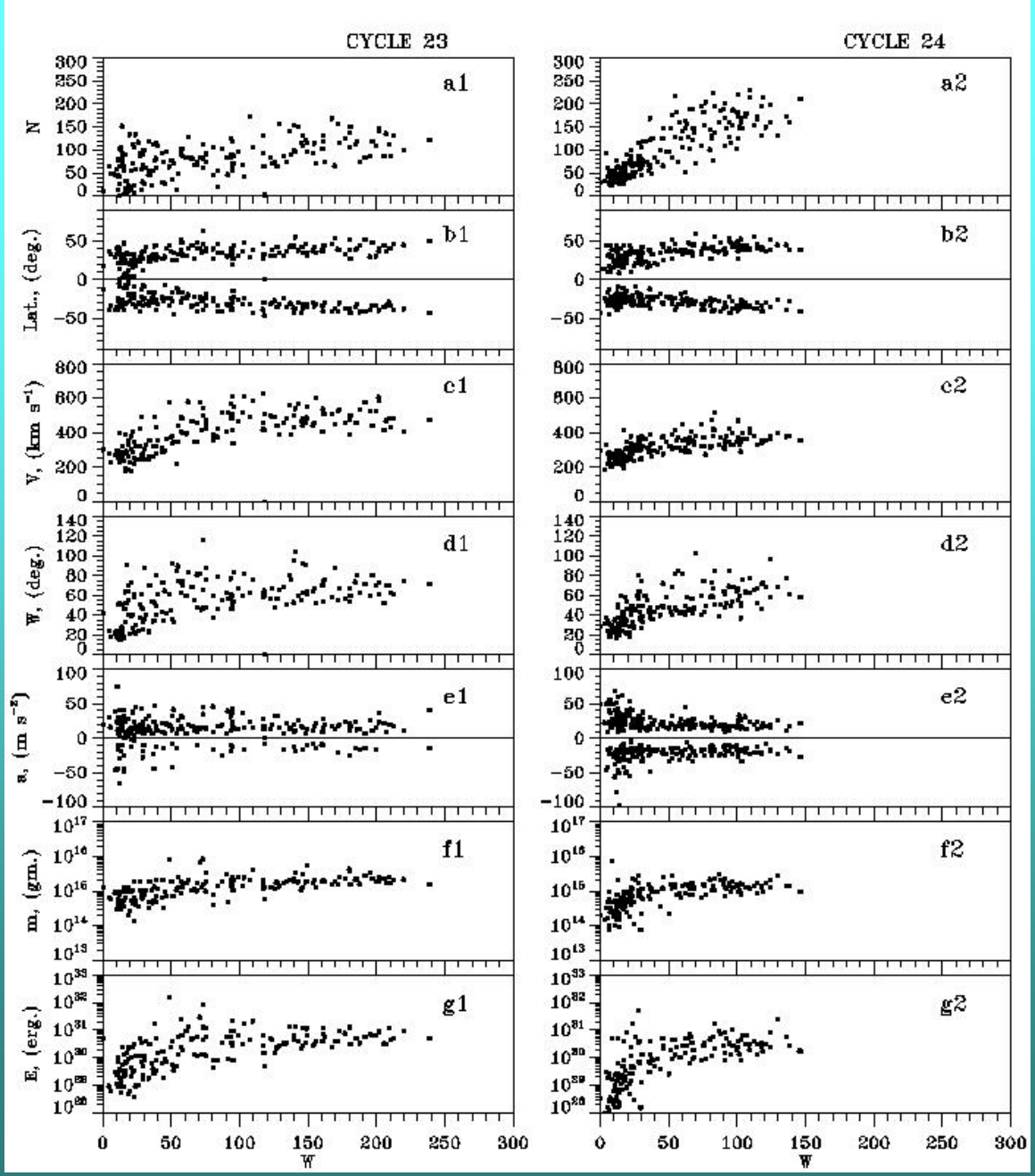

CYCLE 23
CYCLE 24
a1
a2
b1
b2
c1
c2
d1
d2
e1
e2
f1
f2
g1
g2
N
Lat., (deg.)
V, (km s^{-1})
W, (deg.)
a, (m s^{-2})
m, (gm.)
E, (erg.)
B, (μT)
B, (μT)

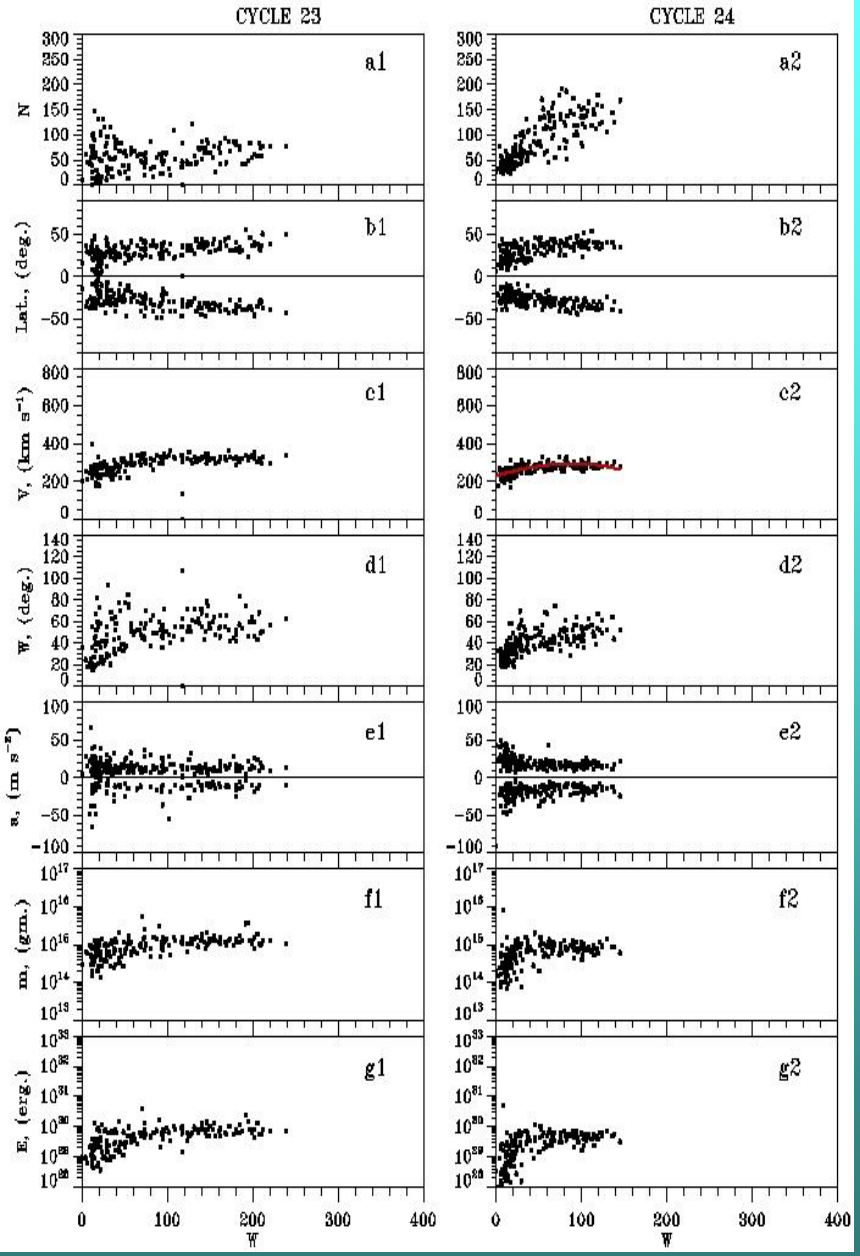

CYCLE 23
CYCLE 24
a1
a2
b1
b2
c1
c2
d1
d2
e1
e2
f1
f2
g1
g2
N
Lat., (deg.)
V, (km s^{-1})
W, (deg.)
a, (m s^{-2})
m, (gm.)
E, (erg.)
B, (μT)

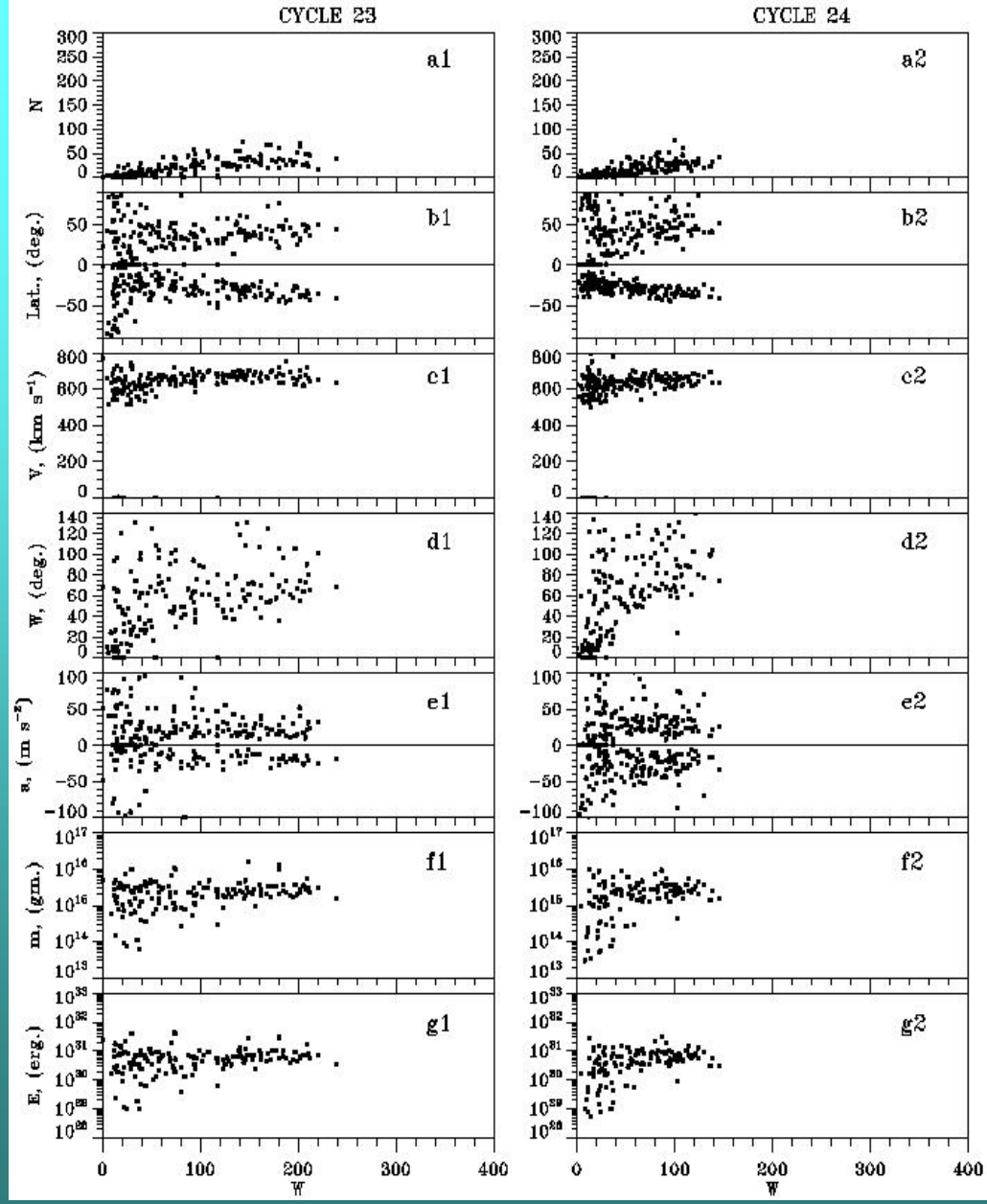

CYCLE 23
CYCLE 24
a1
a2
b1
b2
c1
c2
d1
d2
e1
e2
f1
f2
g1
g2
N
Lat., (deg.)
V, (km s^{-1})
W, (deg.)
a, (m s^{-2})
m, (gm.)
E, (erg.)
B, (μT)

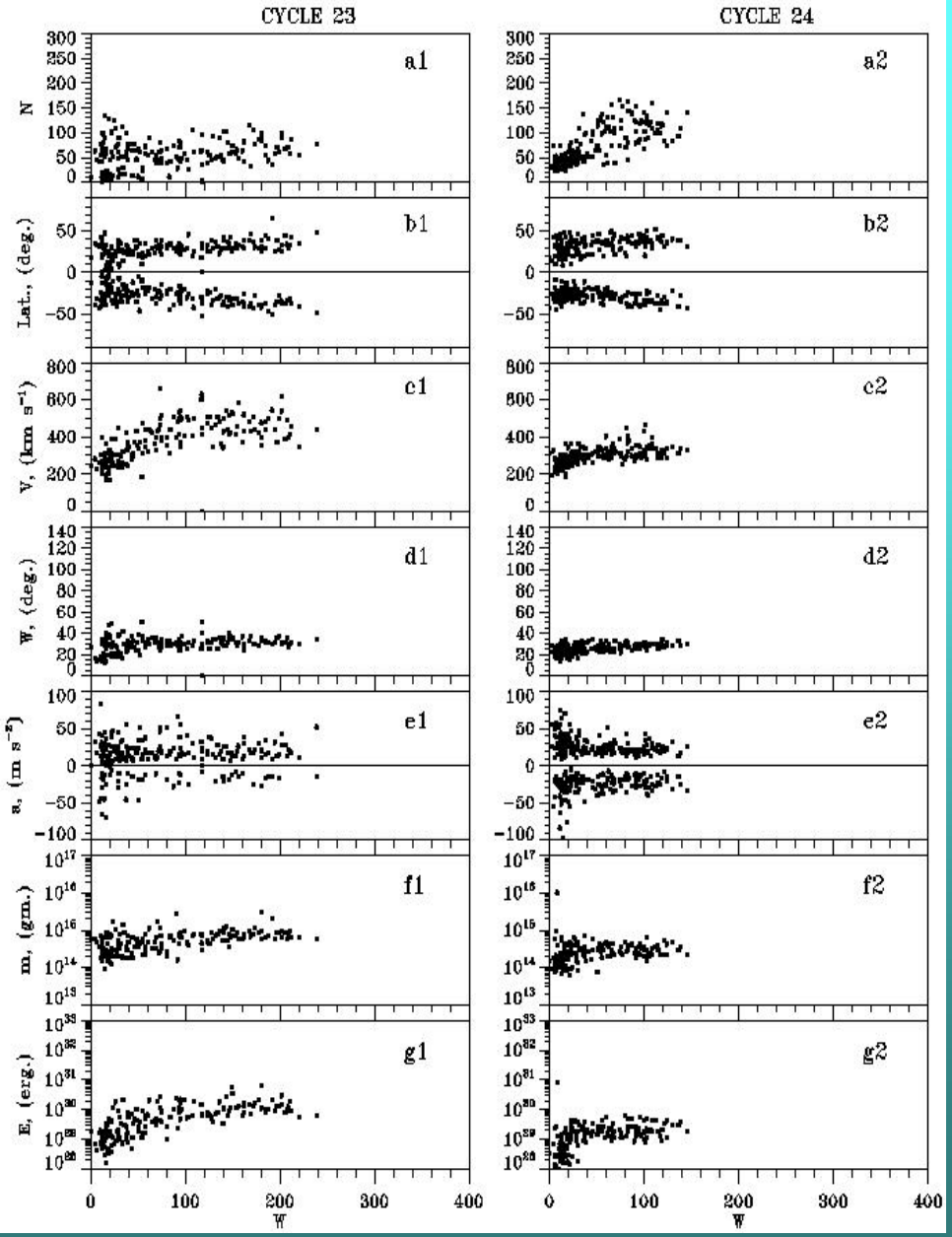

CYCLE 23
CYCLE 24
a1
a2
b1
b2
c1
c2
d1
d2
e1
e2
f1
f2
g1
g2
N
Lat., (deg.)
V, (km s^{-1})
W, (deg.)
a, (m s^{-2})
m, (gm.)
E, (erg.)
B, (μT)

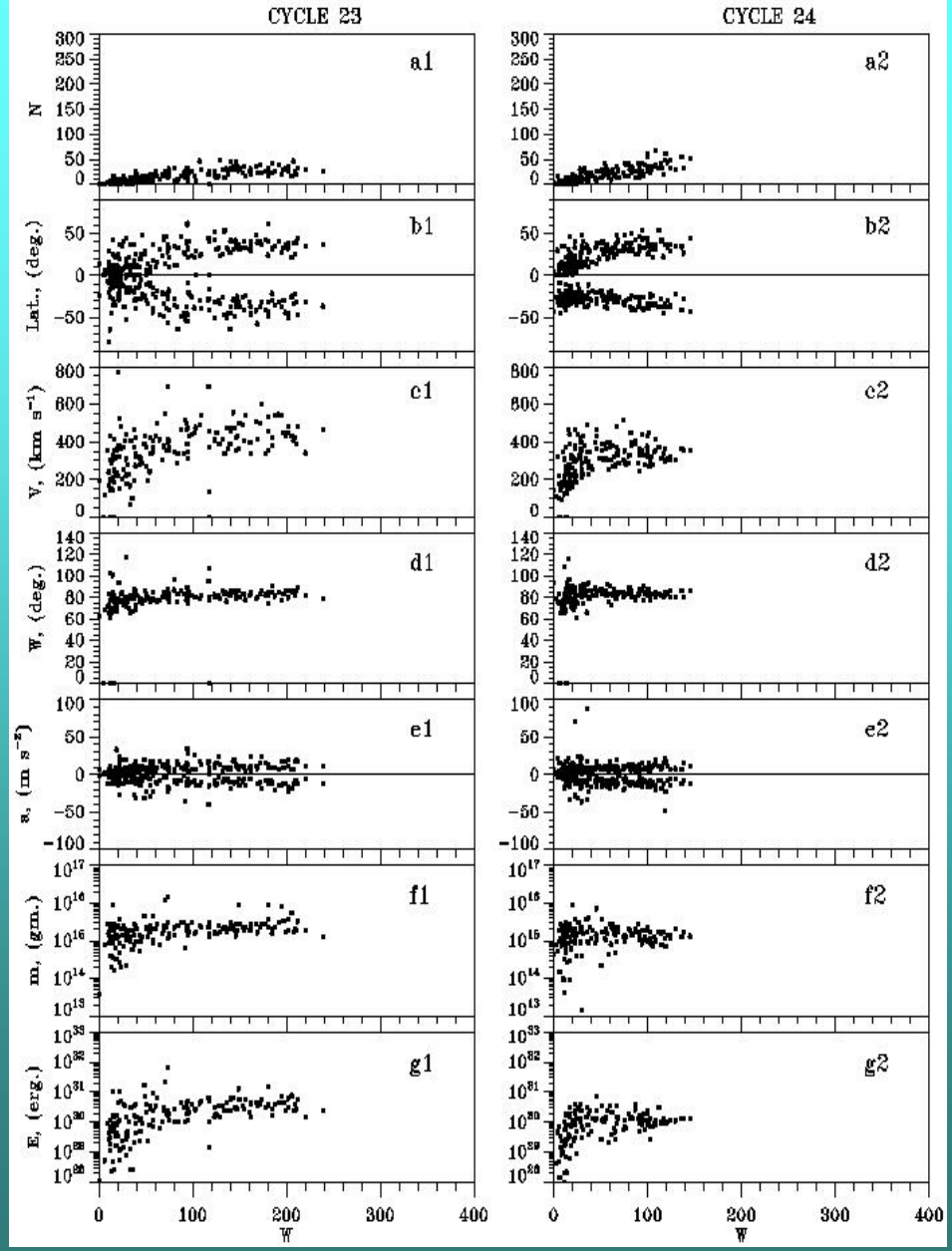

CYCLE 23
CYCLE 24
a1
a2
b1
b2
c1
c2
d1
d2
e1
e2
f1
f2
g1
g2
N
Lat., (deg.)
V, (km s^{-1})
W, (deg.)
a, (m s^{-2})
m, (gm.)
E, (erg.)
B, (μT)

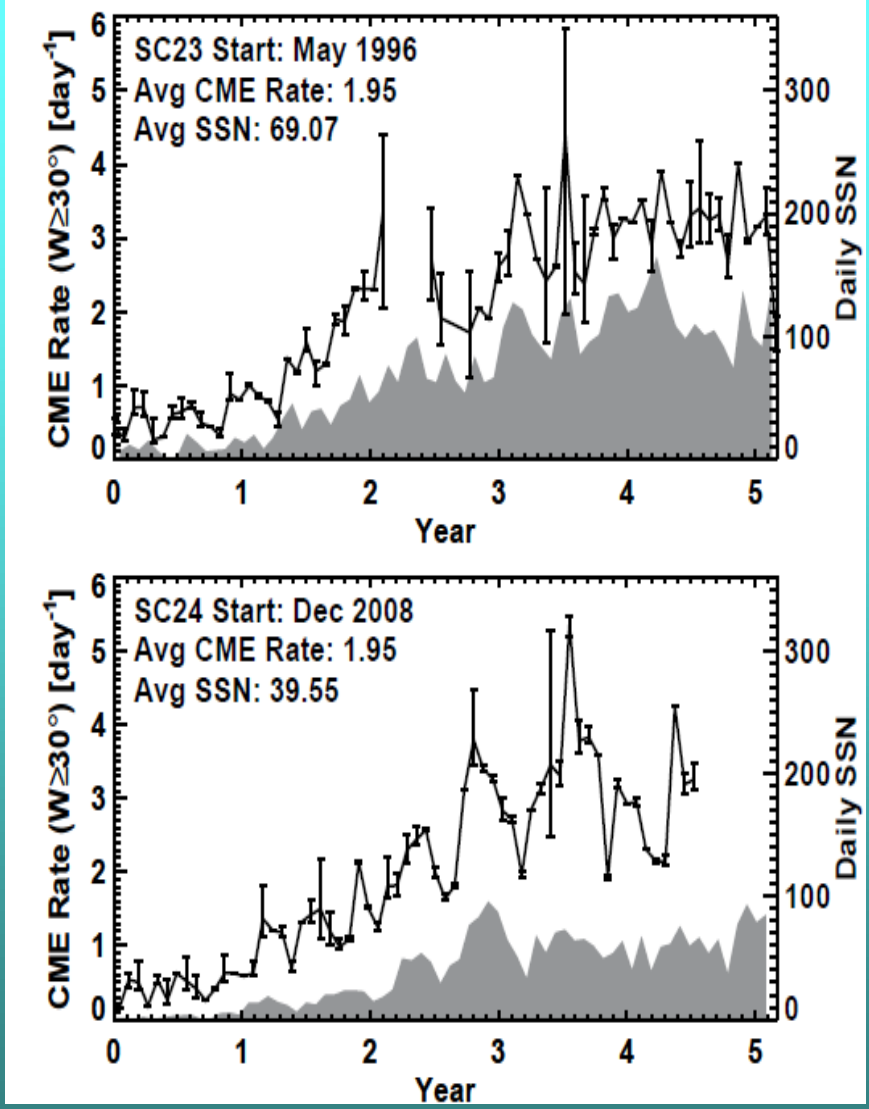

CYCLE 23
CYCLE 24
a1
a2
b1
b2
c1
c2
d1
d2
e1
e2
f1
f2
g1
g2
N
Lat., (deg.)
V, (km s^{-1})
W, (deg.)
a, (m s^{-2})
m, (gm.)
E, (erg.)
W
W


CYCLE 23
CYCLE 24
a1
a2
b1
b2
c1
c2
d1
d2
e1
e2
f1
f2
g1
g2
N
Lat., (deg.)
V, (km s⁻¹)
W, (deg.)
a, (m s⁻²)
m, (gm.)
E, (erg.)
W


CYCLE 23
CYCLE 24
a1
a2
b1
b2
c1
c2
d1
d2
e1
e2
f1
f2
g1
g2
N
Lat., (deg.)
V, (km s⁻¹)
W, (deg.)
a, (m s⁻²)
m, (gm.)
E, (erg.)
W


CYCLE 23
CYCLE 24
a1
a2
b1
b2
c1
c2
d1
d2
e1
e2
f1
f2
g1
g2
N
Lat., (deg.)
V, (km s^{-1})
W, (deg.)
a, (m s^{-2})
m, (gm.)
E, (erg.)
W


CYCLE 23
CYCLE 24
a1
a2
b1
b2
c1
c2
d1
d2
e1
e2
f1
f2
g1
g2
N
Lat., (deg.)
V, (km s^{-1})
W, (deg.)
a, (m s^{-2})
m, (gm.)
E, (erg.)
W

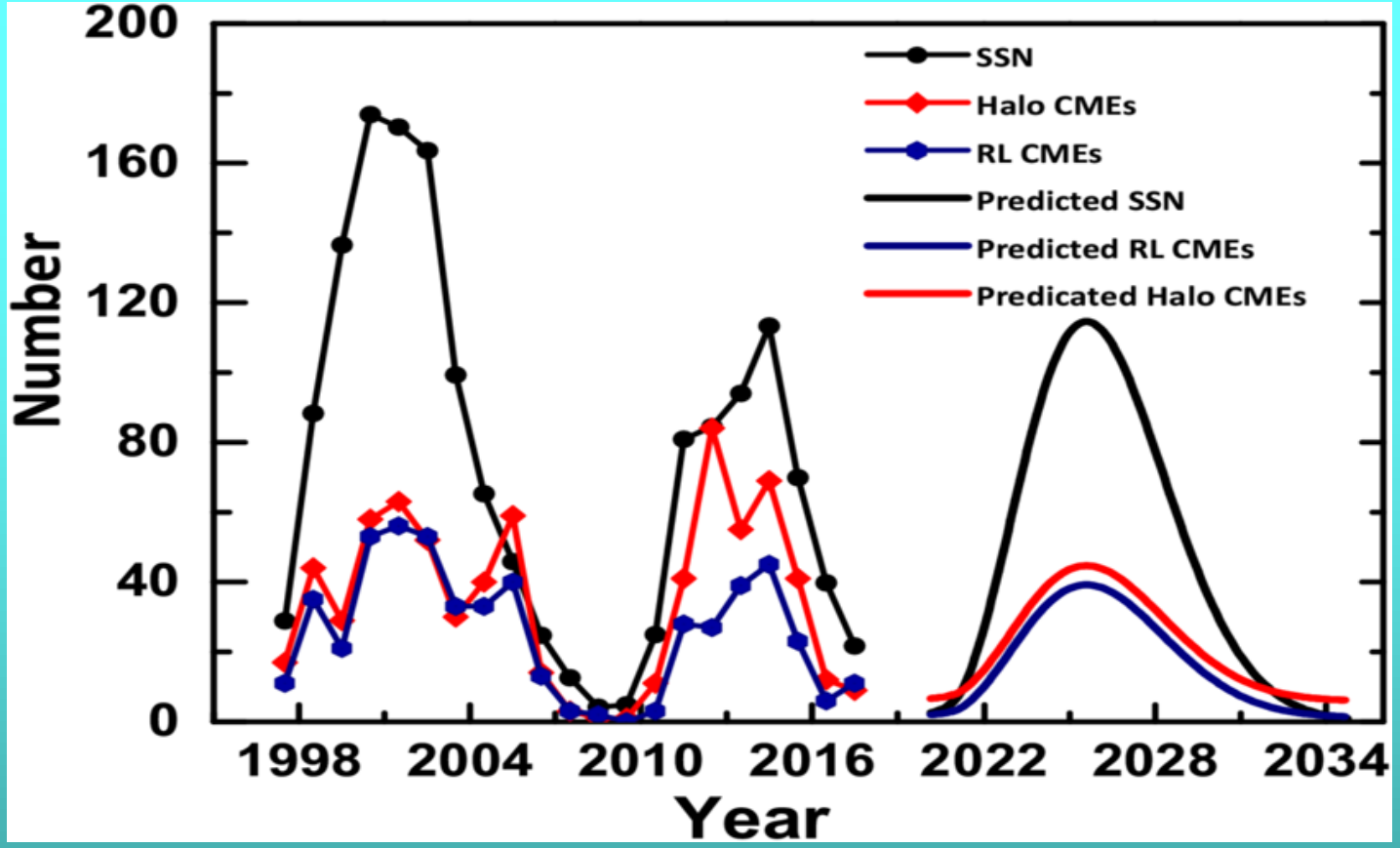


CME daily rate averaged over Carrington Rotation (CR) period.

The plot in gray is the daily international sunspot number (SSN) obtained from Solar Influences Data Center.

For definitiveness, we have included only CMEs with the width (W) ≥30 deg. This will eliminate the uncertainty due to narrow CMEs from the disk center missed by the coronagraph.

Gopalswamy, N. et al., GeoRL, 2014



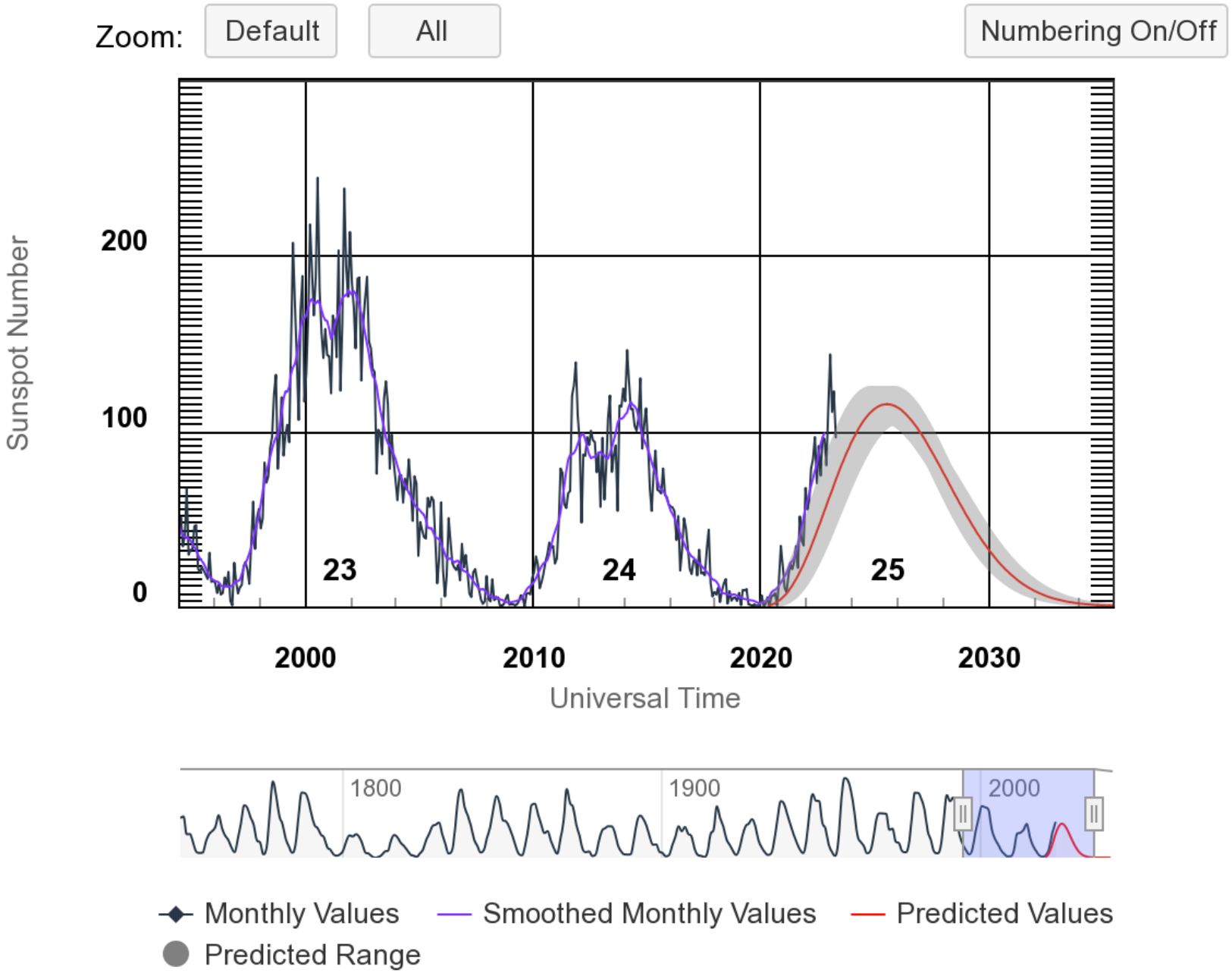
Predicted numbers of sunspot, RL CMEs, halo CMEs in SC 25 are drawn along with the data for SC 23 and SC 24.

$$\mathrm{RLCR} = 0.332 \times \mathrm{SSN} + 1.134$$

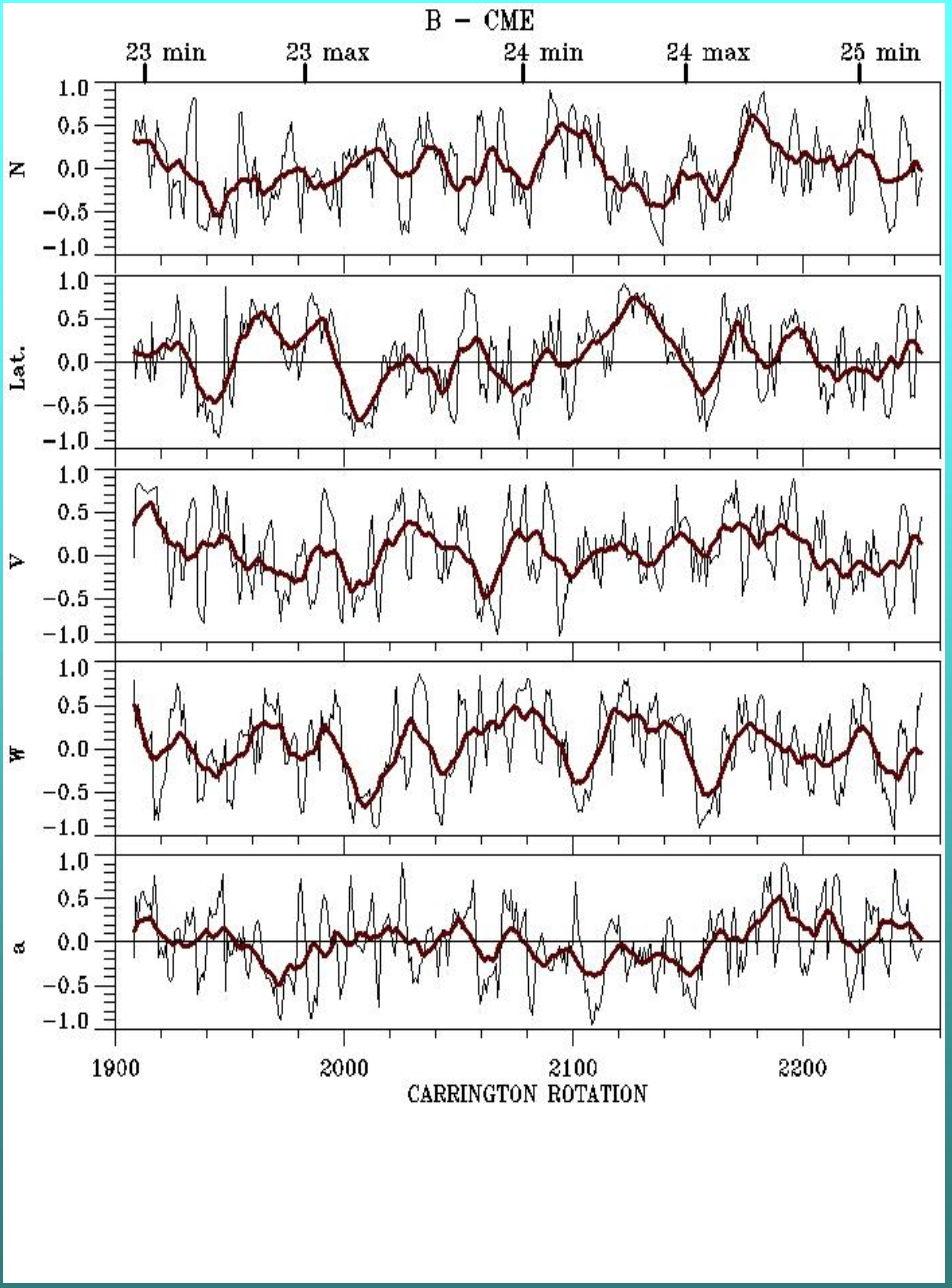
$$\mathrm{HCR} = 0.339 \times \mathrm{SSN} + 5.795$$

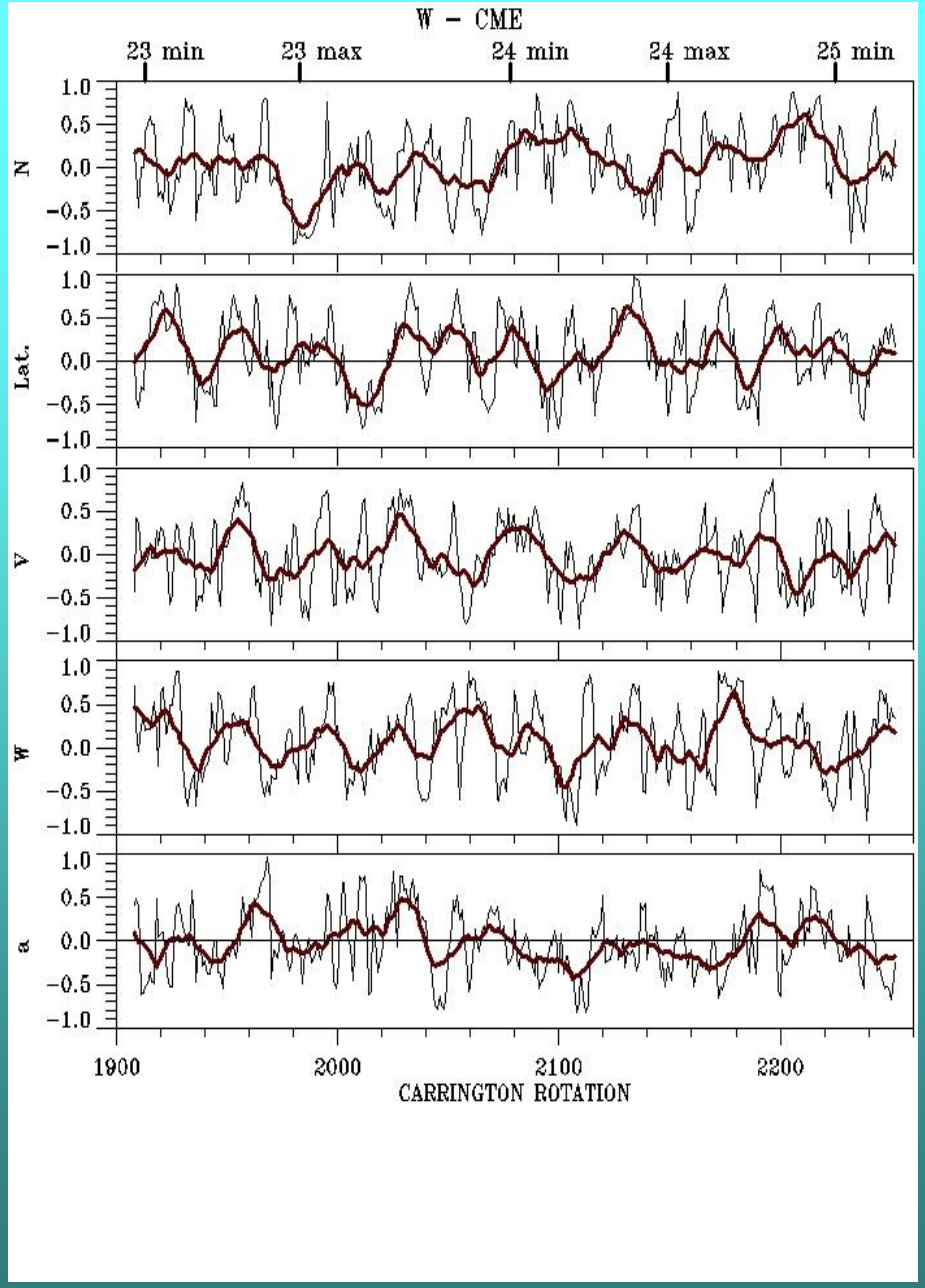
Shanmugaraju, A. et al., Solar Phys., 2021

ISES Solar Cycle Sunspot Number Progression

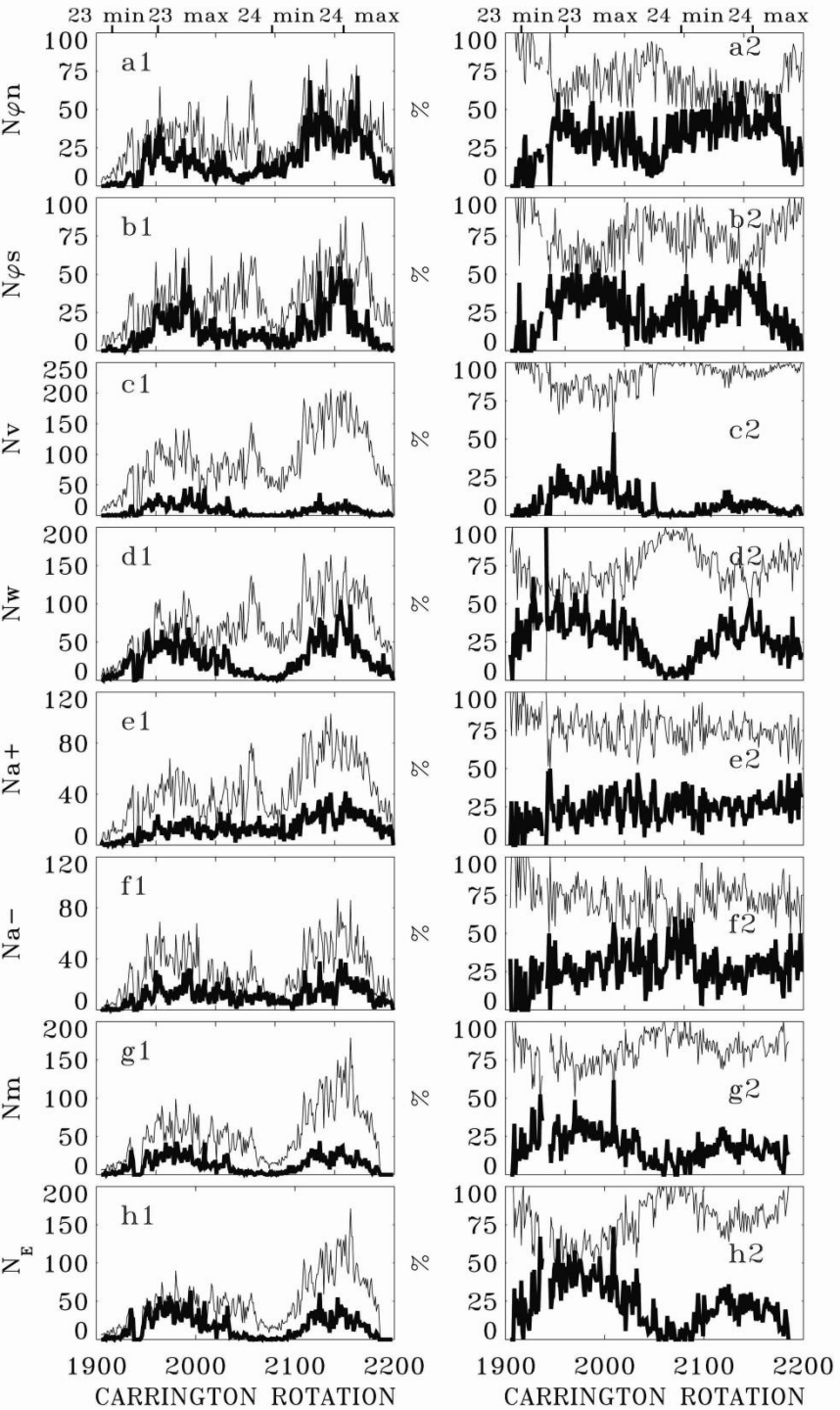


Space Weather Prediction Center


B – CME
23 min
23 max
24 min
24 max
25 min
N
Lat.
V
W
a
1.0
0.5
0.0
−0.5
−1.0
1900
2000
2100
2200
CARRINGTON ROTATION


W – CME
23 min
23 max
24 min
24 max
25 min
N
Lat.
V
W
a
1.0
0.5
0.0
−0.5
−1.0
1900
2000
2100
2200
CARRINGTON ROTATION

Temporal evolution of the number of different types of CMEs.



Lat. > I 40 I deg.

Lat. <= I 40 I deg.

V <= 700 km/c

V > 700 km/c

W <= 60 deg.

W > 60 deg.

a <+20 m/c2
a >= +20 m/c2

a <+20 m/c2
a >= +20 m/c2

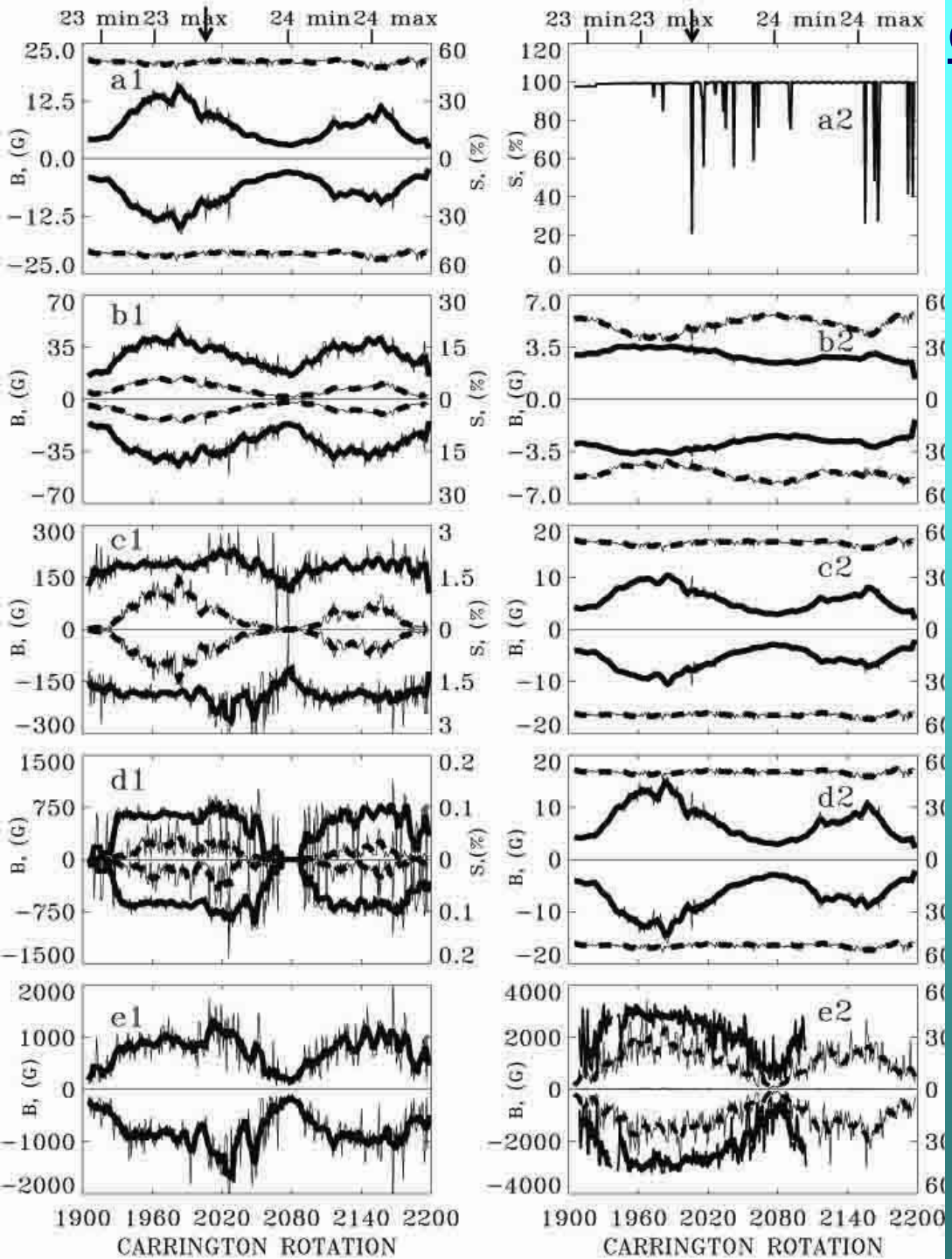
m < 2×10^{15}

m >= 2×10^{15}

e < 10^{30}

e >= 10^{30}

Thick lines (thin lines) indicate the number of CMEs with parameters greater than (equal to or less than) the corresponding limit (left panels) and their fraction (in percent) of the total number of CMEs (right panels) in each CR.



Cycle evolution of CR-averaged photospheric magnetic fields.

Solid lines - magnetic field strengths of positive and negative polarity, dashed lines - their area in percent.

(a1) All magnetic fields,

(a2) area of the synoptic map used in each CR

(b1) B>±10 G,

(b2) B<=±10 G

(c1) B>±100 G,

(c2) B<=±100 G

(d1) B>±500 G,

(d2) B<=±500 G

(e1) max and min of magnetic fields in CR (e2) max of positive- and negative-polarity magnetic fields from the SOHO/MDI (solid lines) and WSO (dashed lines) photospheric synoptic maps.

ВЫВОДЫ

- Циклические изменения крупномасштабных фотосферных полярного и не полярного магнитных полей (компонент ГМП) определяют долговременные, на масштабах КО и более вариации ММП и параметров солнечного ветра. Наблюдается снижение как полярного, так и не полярного магнитных полей от 21 к 24 циклам. Снижение ГМП привело к изменению параметров корональной плазмы и межпланетной среды, и оказало большое влияние на изменение числа и параметров КВМ.
- Число КВМ возросло с 13924 в 23 цикле до 15074 в 24 цикле. Снижение напряженности ГМП облегчило эрупцию КВМ и из мощных АО, и из слабых АО, и полей с низкой напряженностью, что привело к росту числа КВМ.
- Слабые и мощные КВМ изменяются по разному в ходе циклов солнечной активности. Число мощных КВМ следует циклическим изменениям характерным для пятенной активности и остается, приблизительно, на одном уровне в 23 и 24 циклах, а число слабых КВМ резко возрастает в 24 цикле.

БЛАГОДАРЮ ЗА ВНИМАНИЕ !