Coronal Hole Studies from SOHO/CDS: Some Recent Results

- **Introduction**
  -Coronal hole – importance, properties
  -PCH & ECH

- **Data**
  -SOHO/CDS observations
  -EUV emission lines

- **Results**

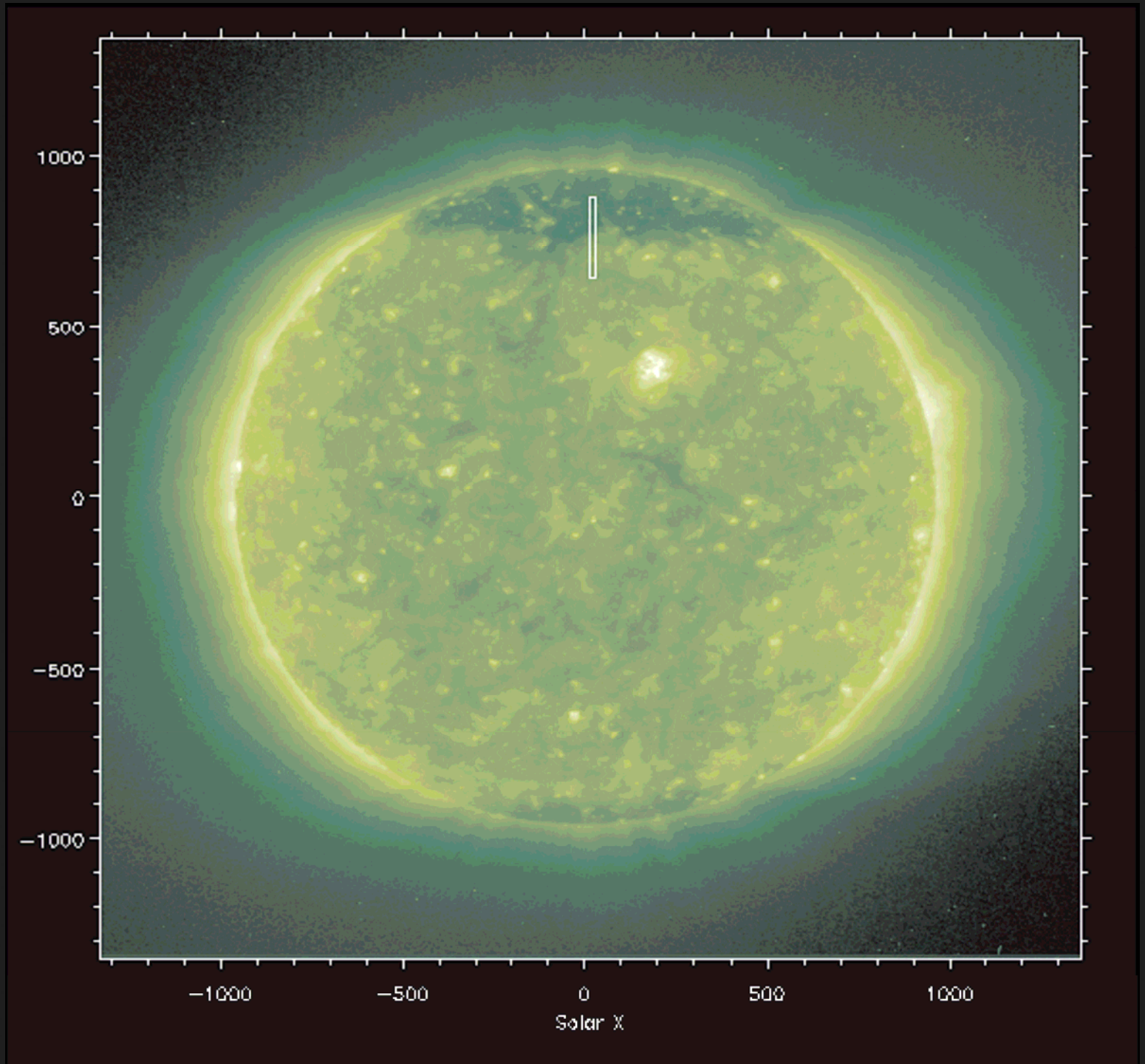
- **Conclusions**

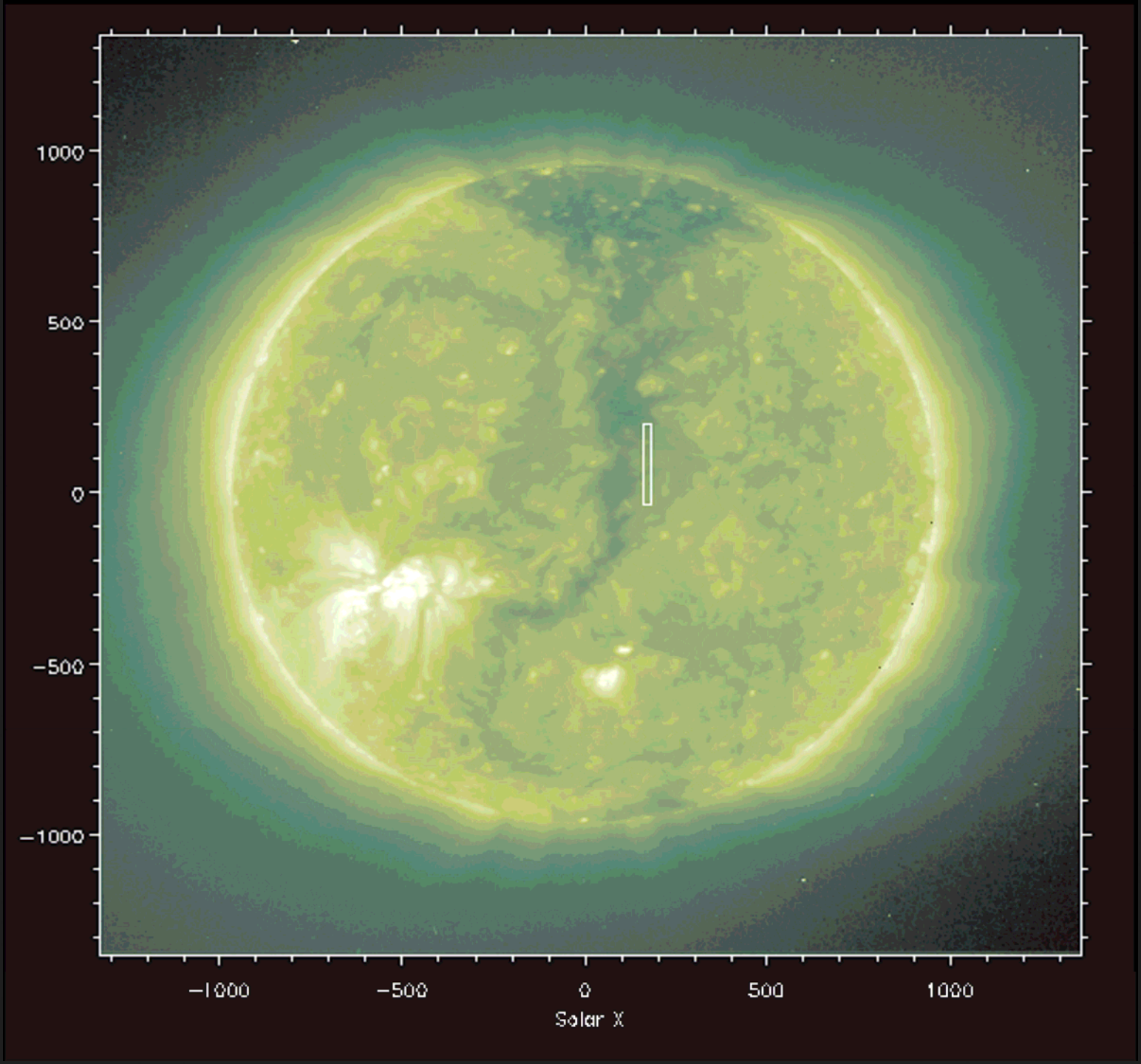
Introduction

Coronal Holes:

– low temperature, low density regions on the Sun, predominantly unipolar, open magnetic fields

-give rise to high-speed solar wind streams that cause geomagnetic storms.


1000
500
0
−500
−1000
−1000
−500
0
500
1000
Solar X


1000
500
0
−500
−1000
−1000
−500
0
500
1000
Solar X

- Waldmeier (1957) is probably the modern discoverer of coronal holes

- noticed persistent low emission regions in the monochromatic images of corona from ground-based coronagraphs - called them holes (Locher in German)

- synoptic observations from OSO series in early 70s - established that coronal holes are real, 3-dimensional objects & fairly common

- one main source of information - SKYLAB - space mission lasted for about 8 months - 28 May 1973 to 4 Feb 1974 -period of declining solar activity, ideal to observe coronal holes

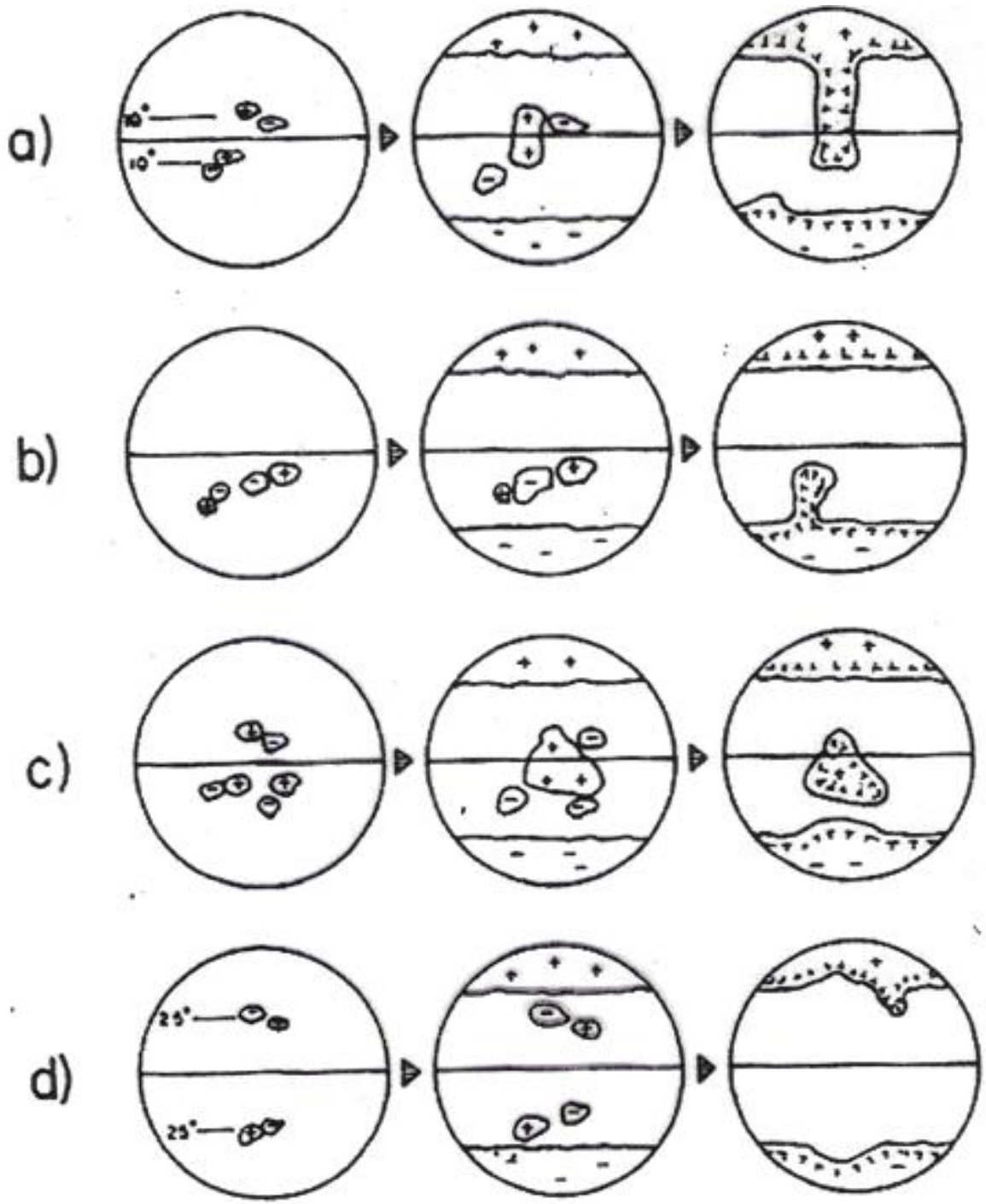
- Evolution - solar cycle dependence

  -- at solar minimum - largely confined to poles with opposite polarity at N & S

  -- as cycle progresses polar holes shrink - low-latitude holes appear

  -- near solar maximum, polar holes disappear - re-emerge with their polarity reversed

  -- as cycle declines, polar holes increase in size


a)
b)
c)
d)
25°
25°

Data

- SOHO - CDS(Coronal Diagnostic Spectrometer) Observations - present study uses data - Aug-Sept 1996 – 24 data sets

- Observed spatial window - 240’’x60’’ – part of coronal hole, boundary & quiet Sun

- low intensity of emission lines in coronal holes – both spatial & temporal averaging – spatial resolution 20’’

Details of emission line parameters and correlation coefficients.

No.	Ion	λ (Å)	T (MK)	PQS	EQS	PCH	ECH
1	OIII	599.59	0.11	0.20	0.25	-0.03	0.27
2	OIV	608.40	0.19	0.19	0.21	-0.01	0.26
3	NeIV	542.89	0.19	0.27	0.32	0.06	0.30
4	OV	629.73	0.25	0.29	0.30	0.04	0.30
5	NeVI	562.80	0.43	0.27	0.34	0.14	0.34
6	NeVII	561.73	0.52	0.30	0.40	0.26	0.31
7	MgVII	367.7	0.66	0.55	0.60	0.36	0.29
8	SiVIII	316.22	0.81	0.64	0.59	0.57	0.41
9	MgVIII	315.01	0.81	0.55	0.49	0.52	0.35
10	MgIX	368.06	0.95	0.81	0.75	0.75	0.63
11	SiIX	349.9	1.07	0.94	0.91	0.82	0.64
12	MgX	624.94	1.10				

Results

-identification of coronal hole & quiet Sun region – intensity contours of Mg X 625 A line

-intensity histograms of Polar Coronal Hole (PCH), Polar Quiet Sun (PQS), Equatorial Coronal Hole (ECH), Equatorial Quiet Sun (EQS)

-histograms of polar hole for the lower TR lines OIII, OIV, NeIV, OV and NeVI are shifted towards the bright side.

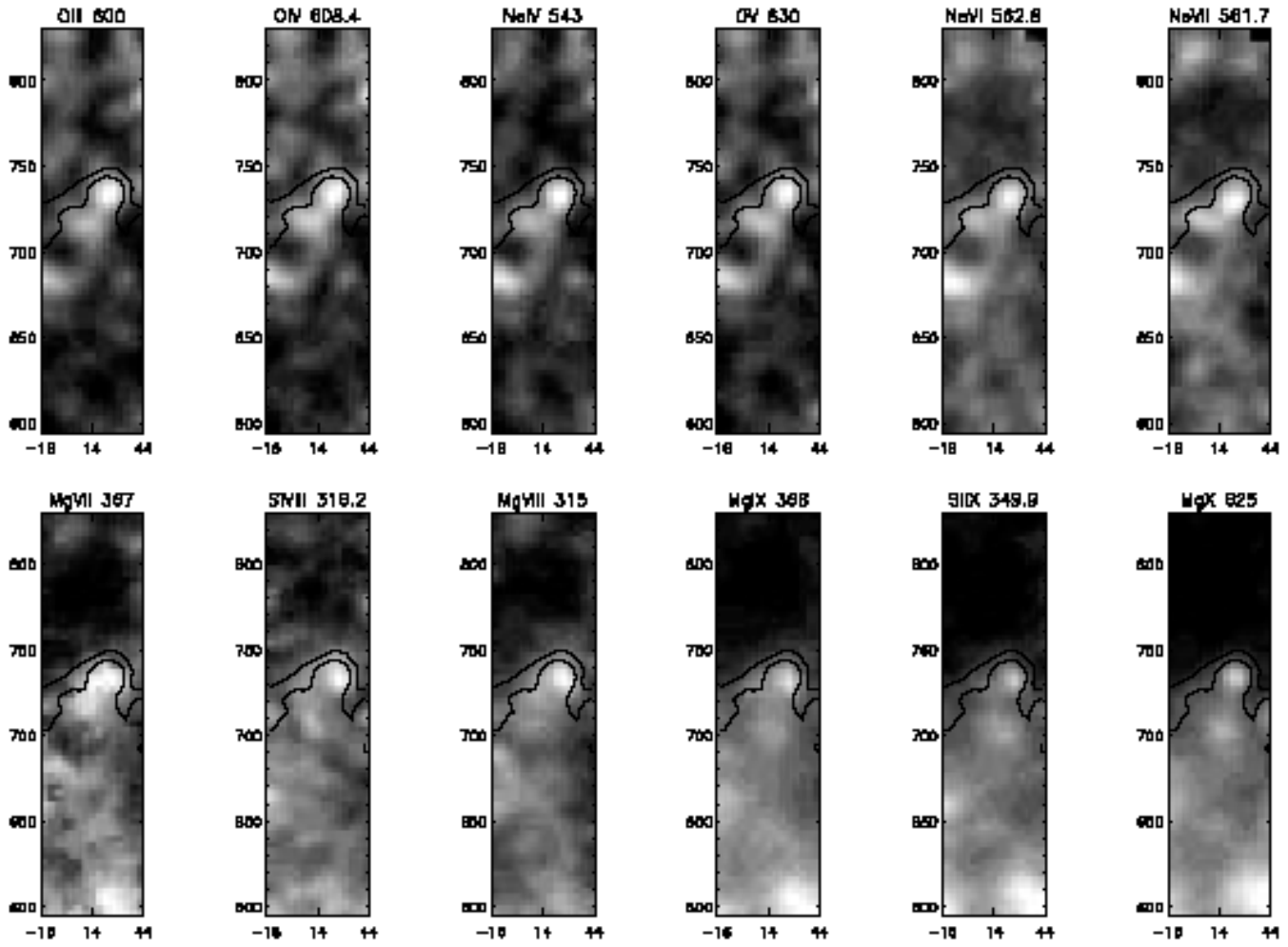


Fig. 5.— Observed window from polar regions in various emission lines. Contours represent coronal hole (PCH, upper part) and quiet Sun (PQS, lower part). The axes show the X and Y coordinates in arcsec.

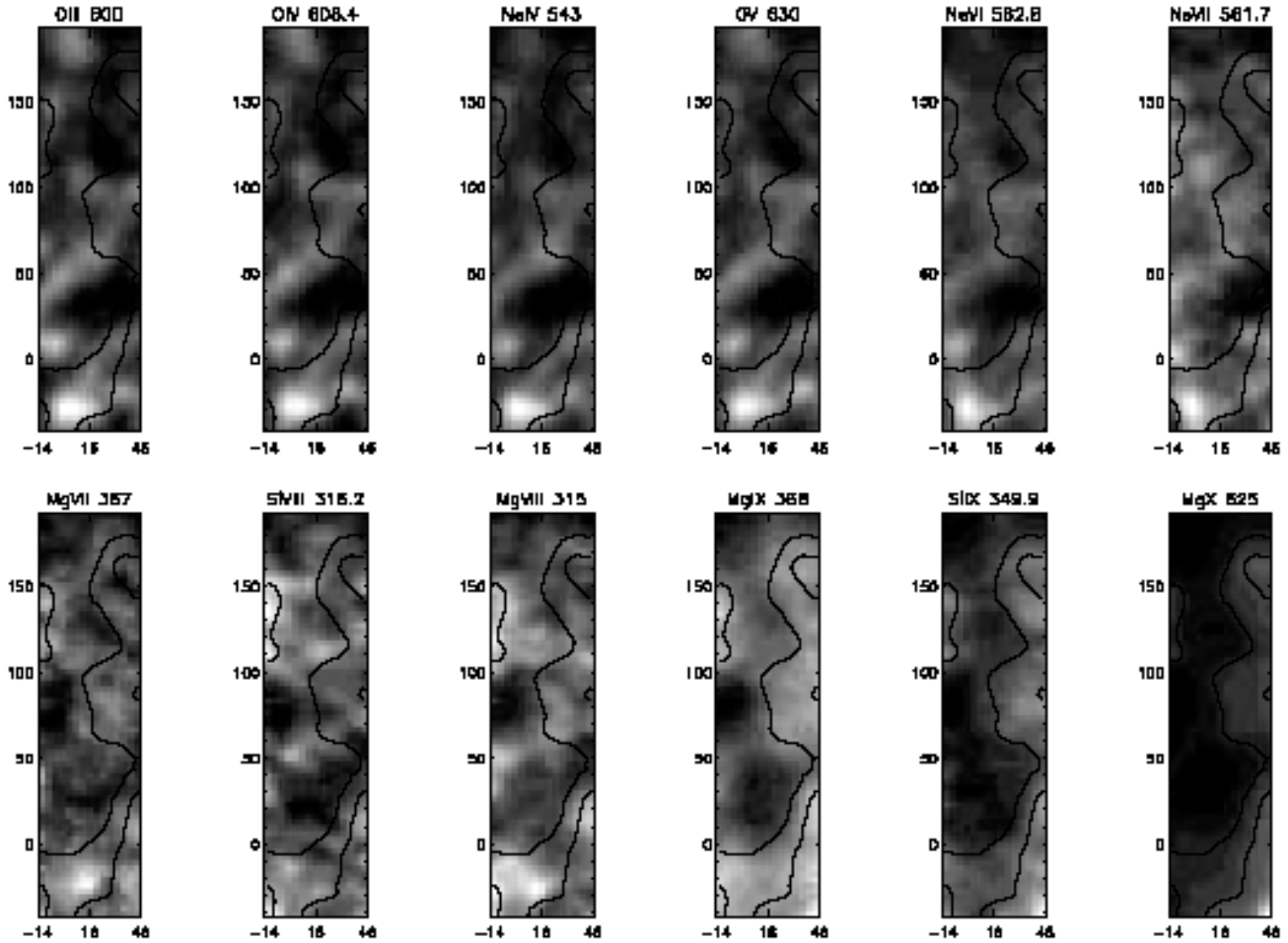
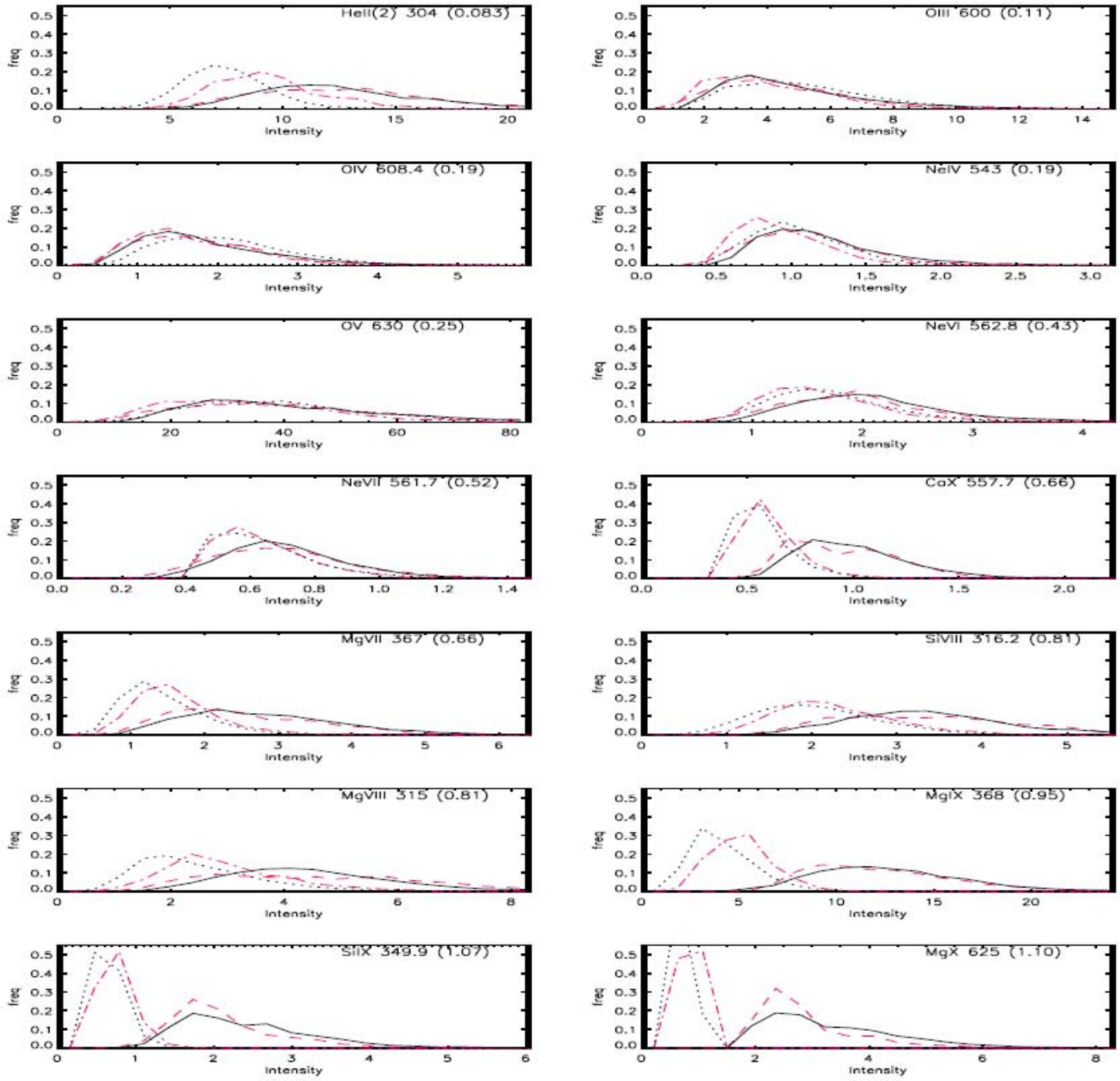
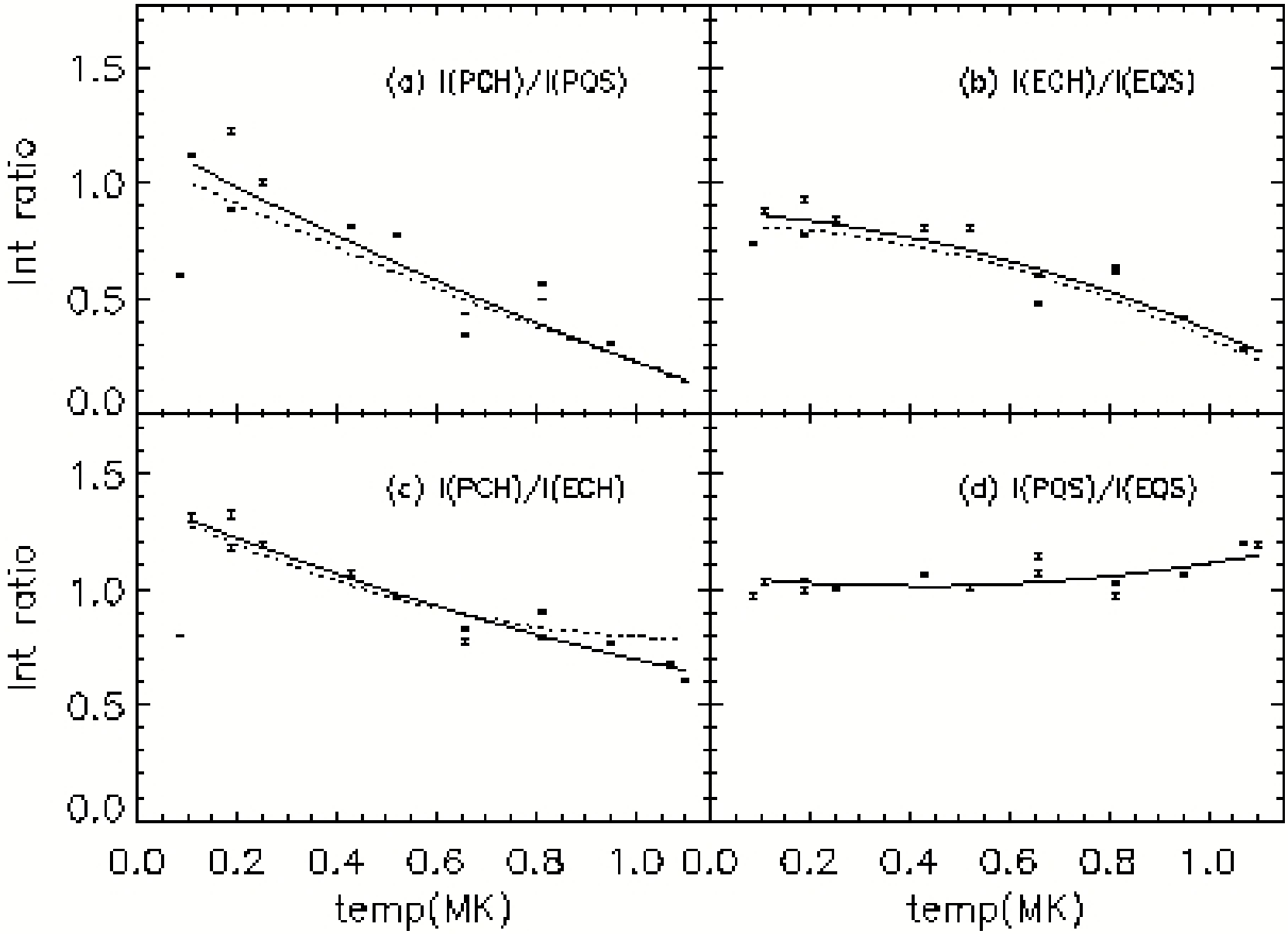


Fig. 6.— Same as Fig. 5 but for equatorial regions. Coronal hole (ECH) is on the left and quiet Sun (EQS) on the right.


HeII(2) 304 (0.083)
OIII 600 (0.11)
OIV 608.4 (0.19)
NeIV 543 (0.19)
OV 630 (0.25)
NeVI 562.8 (0.43)
NeVII 561.7 (0.52)
CaX 557.7 (0.66)
MgVII 367 (0.66)
SiVIII 316.2 (0.81)
MgVIII 315 (0.81)
MgIX 368 (0.95)
SiIX 349.9 (1.07)
MgX 625 (1.10)
freq
Intensity


(a) I(PCH)/I(POS)
(b) I(ECH)/I(EQS)
(c) I(PCH)/I(ECH)
(d) I(POS)/I(EQS)
Int ratio
Int ratio
temp(MK)
temp(MK)
0.0
0.5
1.0
1.5
0.0
0.2
0.4
0.6
0.8
1.0

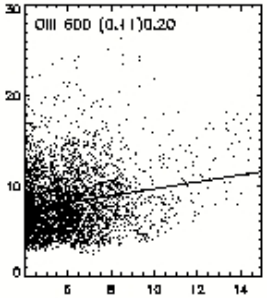
- for each line, we have obtained the intensity correlation coefficient with the upper-most line Mg X 625 ˚A.

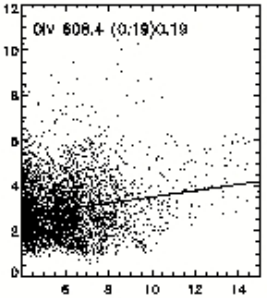
- behaviour of correlation coefficients found for the equatorial coronal hole is similar to that seen in the quiet Sun region - a weak correlation for the lower transition region lines which then increases with height.

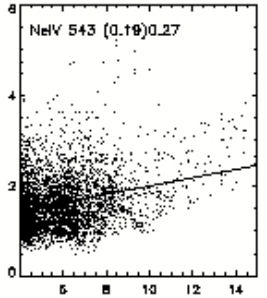
- expected behaviour - as line forming regions come closer to the corona, the correlation in intensity will tend to increase.

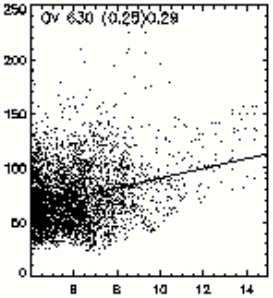
- in the case of the polar coronal hole, the intensities of the lowest lines show no correlation at all with the Mg X line.

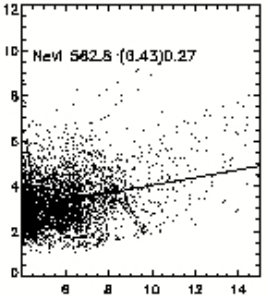
- It is known that the depth of the transition region is five times less in the quiet Sun than in a polar coronal hole. Hence, the similarity in behaviour of the equatorial coronal hole to that of the quiet Sun suggests that the depth of the TR may be less in the equatorial coronal hole than in the polar coronal hole.

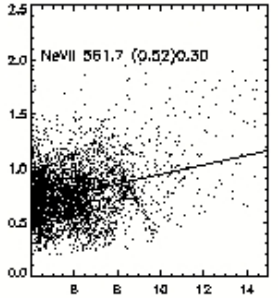

OIII 600 (0.11)0.20

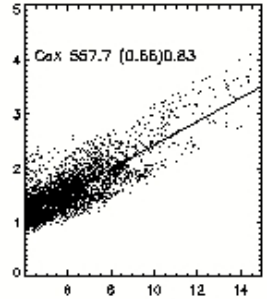

OIV 608.4 (0.19)0.19

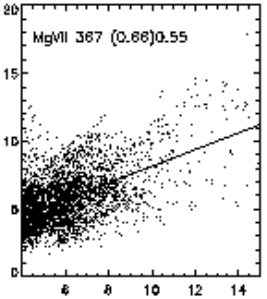

NeIV 543 (0.19)0.27

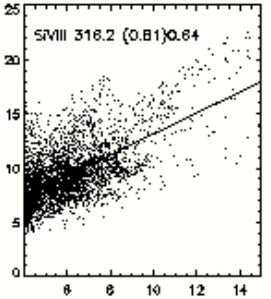

OV 630 (0.25)0.29

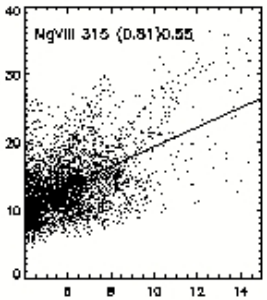

NeVI 562.8 (0.43)0.27

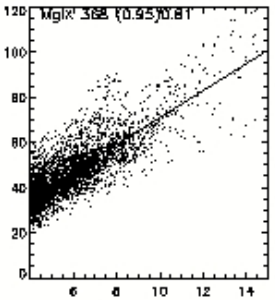

NeVII 561.7 (0.52)0.30

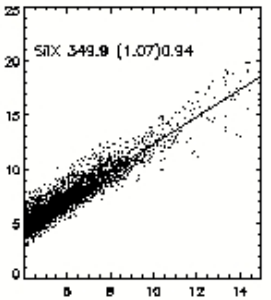

CaX 557.7 (0.55)0.83

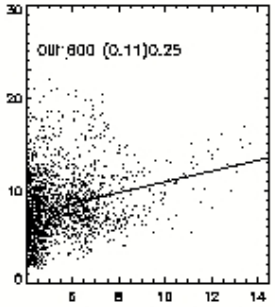

MgVII 367 (0.66)0.55

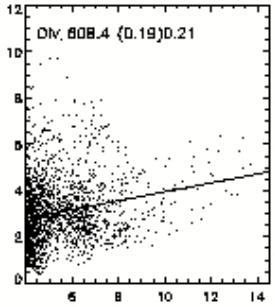

SiVIII 316.2 (0.81)0.64

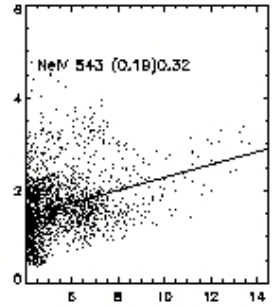

NgVIII 315 (0.81)0.55

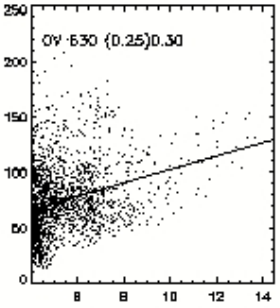

MgIX 368 (0.95)0.81

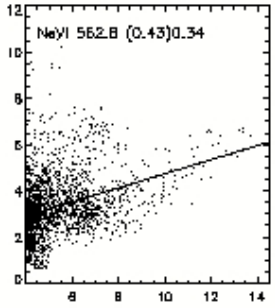

SiIX 349.9 (1.07)0.94

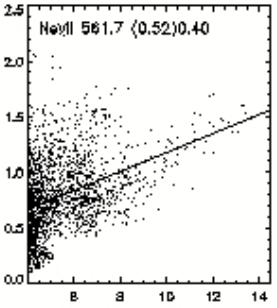

OIII 600 (0.11)0.25

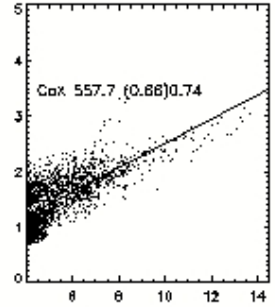

OIV 608.4 (0.19)0.21

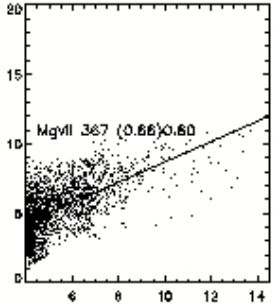

NeV 543 (0.18)0.32

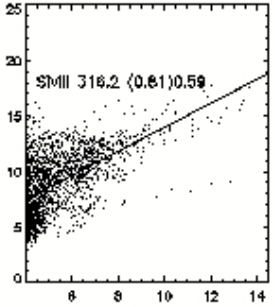

OV 630 (0.25)0.30

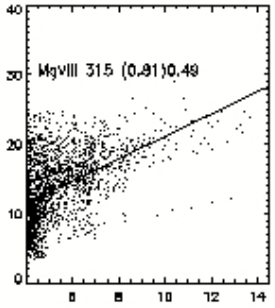

NeVI 562.8 (0.43)0.34

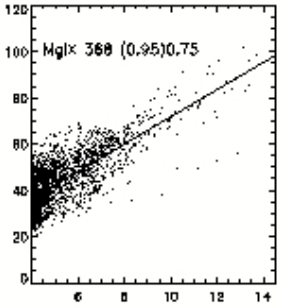

NeVII 561.7 (0.52)0.40

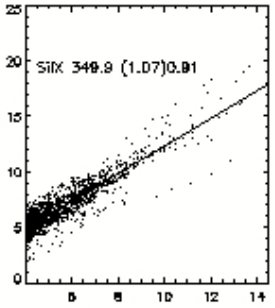

CaX 557.7 (0.66)0.74

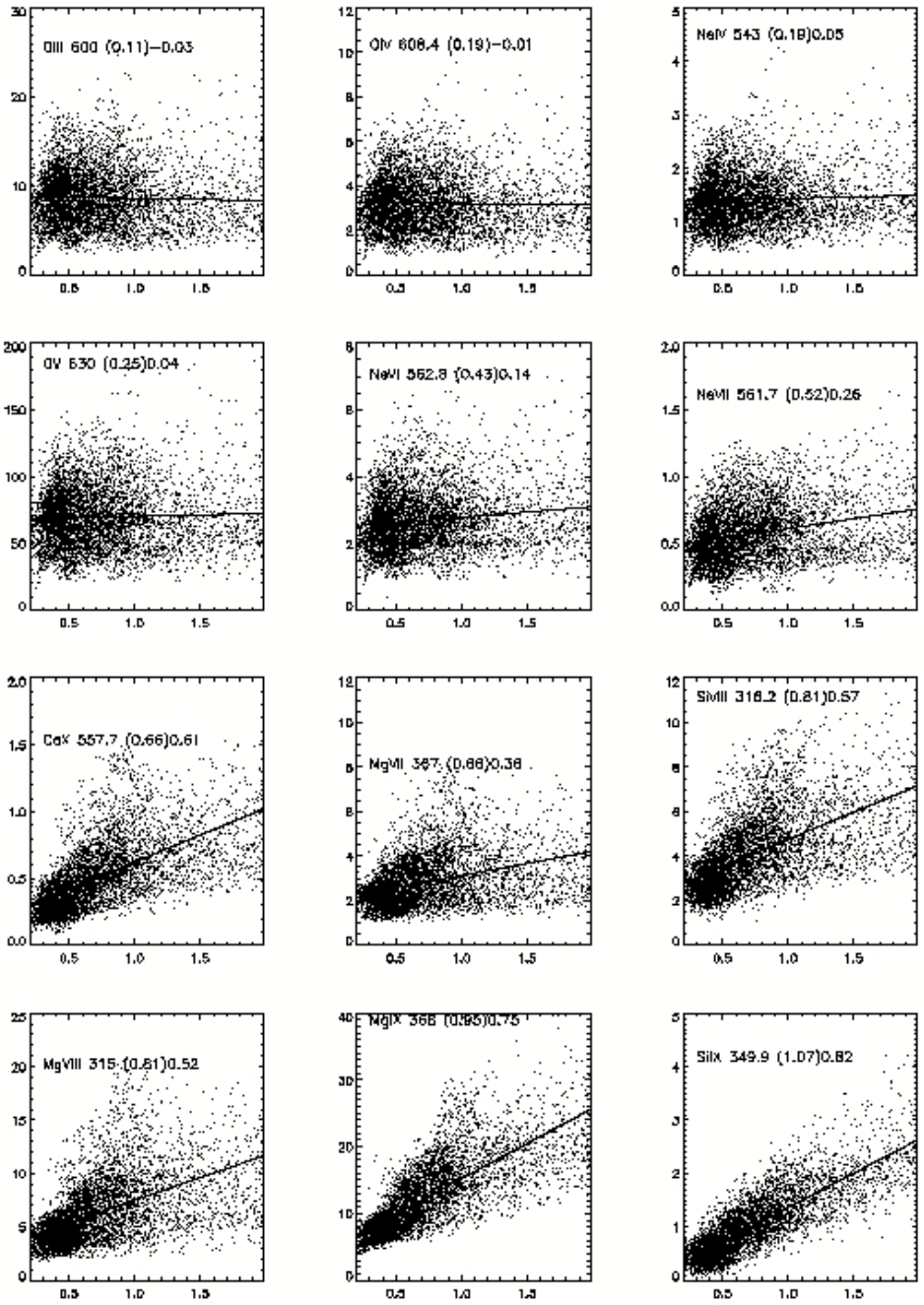

MgVII 367 (0.66)0.60

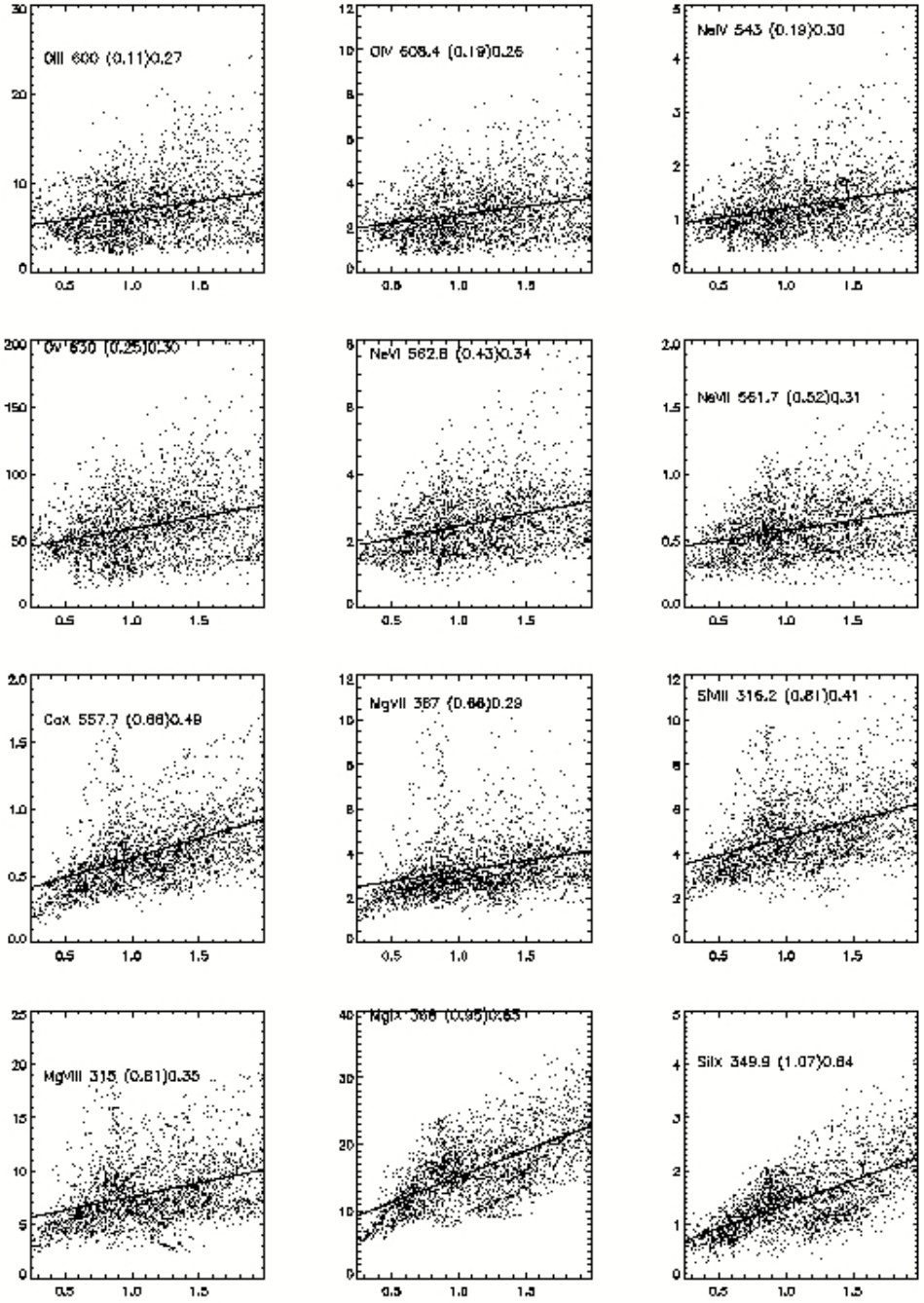

SiVIII 316.2 (0.81)0.59


MgVIII 315 (0.81)0.49


MgIX 368 (0.95)0.75


SiIX 349.9 (1.07)0.91


OIII 600 (0.11)−0.03
OIV 608.4 (0.19)−0.01
NeIV 543 (0.18)0.05
OV 630 (0.25)0.04
NeVI 562.8 (0.43)0.14
NeVII 561.7 (0.52)0.26
CaX 557.7 (0.66)0.61
MgVII 367 (0.68)0.38
SiVIII 316.2 (0.81)0.57
MgVIII 315 (0.61)0.52
MgIX 368 (0.95)0.75
SiIX 349.9 (1.07)0.82


OIII 600 (0.11)0.27
OIV 608.4 (0.19)0.26
NeIV 543 (0.19)0.30
OV 630 (0.25)0.30
NeVI 562.8 (0.43)0.34
NeVII 561.7 (0.52)0.31
CaX 557.7 (0.88)0.49
MgVII 367 (0.88)0.29
SiVII 316.2 (0.81)0.41
MgVIII 315 (0.81)0.35
MgIX 368 (0.95)0.65
SiIX 349.9 (1.07)0.84

Conclusions

-Intensities of EUV emission lines in a polar coronal hole, its equatorial extension, the ‘Elephant’s Trunk’, and the adjacent quiet Sun regions at different heights of the solar atmosphere from the lower TR to the corona.

-PCH appears to be brighter than the ECH for lower TR lines.

-Also, behaviour of correlation coefficients is similar in PQS, EQS and ECH while it differs in the PCH - suggest that the depth of the transition region is less in the equatorial coronal hole than in the polar coronal hole.