Istituto Nazionale di Astrofisica

A case study of sodium intensity and dynamics in the exosphere of Mercury: July 2008

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Boulder, MESSENGER-BEPICOLOMBO workshop November 2nd 2010

THEMIS 0.90 m Solar Telescope

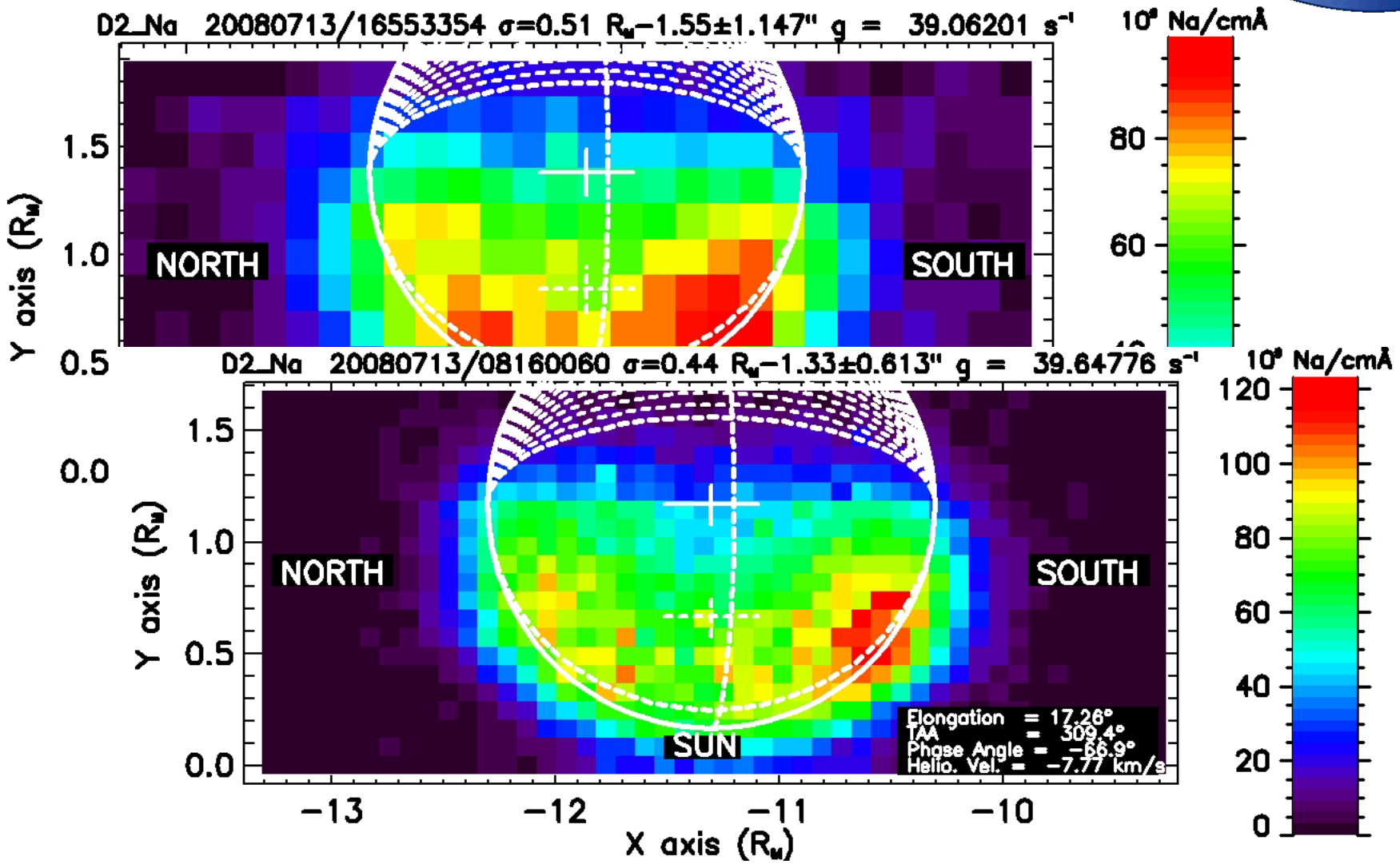
F/16 Ritchey-Chretien telescope in alt-az mounting
Helium filled telescope tube
MTR mode for multiline spectropolarimetry

Spectral range 400 to 1000 nm at :
R ~ 220,000 Slit: 0.5" & 120 " long
R ~ 400,000 Slit: 0.25" & 70 " long
(low and high resolution)

Spectral resolution 0.027 Å to 0.016 Å
Spectral dispersion 10.2 to 6 mÅ
Two individual cameras:
D1 Na at 5896 Å & D2 Na at 5889 Å

THEMIS – Observatorio del Teide, Tenerife
Lat.: N 28° 18' 12.42" Long.: W 16° 30' 32.04"
Elevation: 2429 m

Four years of campaign (2007-2010) : ~ 100 days of observation


D2_Na 20080713/16553354 σ=0.51 R_M=1.55±1.147" g = 39.06201 s⁻¹
10⁹ Na/cmÅ
NORTH
SOUTH
Y axis (R_M)
D2_Na 20080713/08160060 σ=0.44 R_M=1.33±0.613" g = 39.64776 s⁻¹
10⁹ Na/cmÅ
NORTH
SOUTH
SUN
Elongation = 17.26°
TAA = 309.4°
Phase Angle = −66.9°
Helio. Vel. = −7.77 km/s
Y axis (R_M)
X axis (R_M)

THEMIS Mercury database

2007: May, 4 days, 14 scans
October, 3 days, 18 scans

2008: April, 8 days, 44 scans
July, 8 days, 52 scans
September, 4 days, 7 scans
November, 3 days, 5 scans

2009: **April, 8 days, 73 scans**
June, 7 days, 33 scans
July, 1 day, 3 scans
August, 6 days, 32 scans
October, 9 days, 43 scans

2010: May, 7 days
June, 5 days
July, 6 days
September, 6 days

Selected periods orbital conditions

1) July 2008, 12th to 18th

TAA 299° ÷ 341°

Phase Angle -73° ÷ -45°

Illum. Disk 64 ÷ 85%

Dusk terminator

Eclipt. Latitude -3.6° ÷ +1.3°

2) June 2009, 24th to July 1st

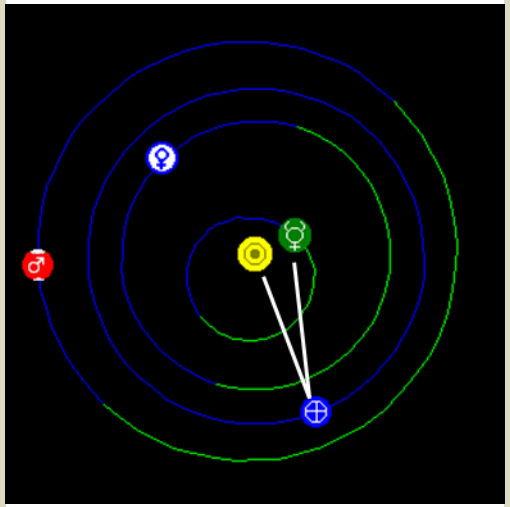
TAA 280° ÷ 315°

Phase Angle -75° ÷ -51°

Illum. Disk 62 ÷ 80%

Dusk terminator

Eclipt. Latitude 6.9° ÷ 4.3°



3) October 2009, 16th to 26th

TAA 70° ÷ 112°

Phase Angle -42° ÷ -16°

Illum. Disk 86 ÷ 97%

Dusk terminator

Eclipt. Latitude -5.4° ÷ -1.8°

4) April 2009, 17th to 24th

TAA 36° ÷ 75°

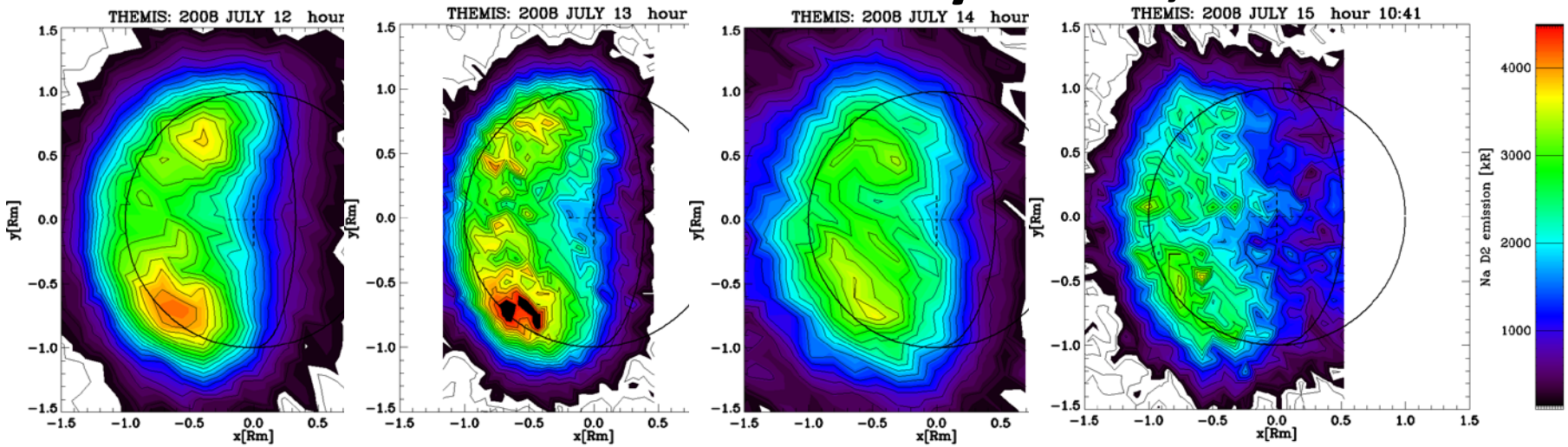
Phase Angle 69° ÷ 98°

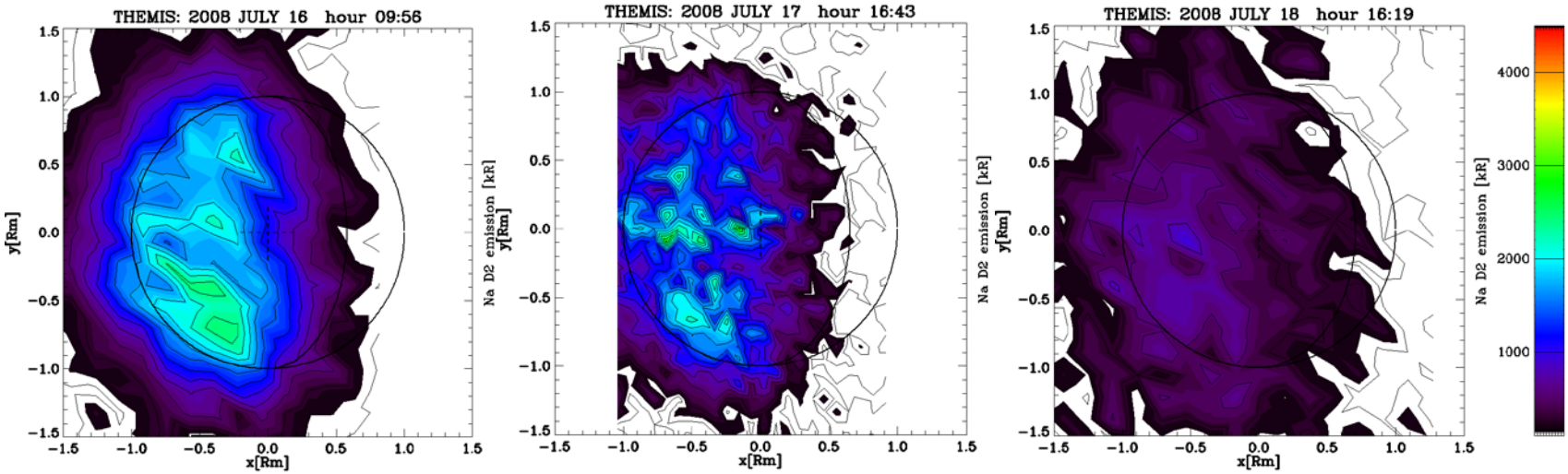
Illum. Disk 67 ÷ 43%

Dawn terminator

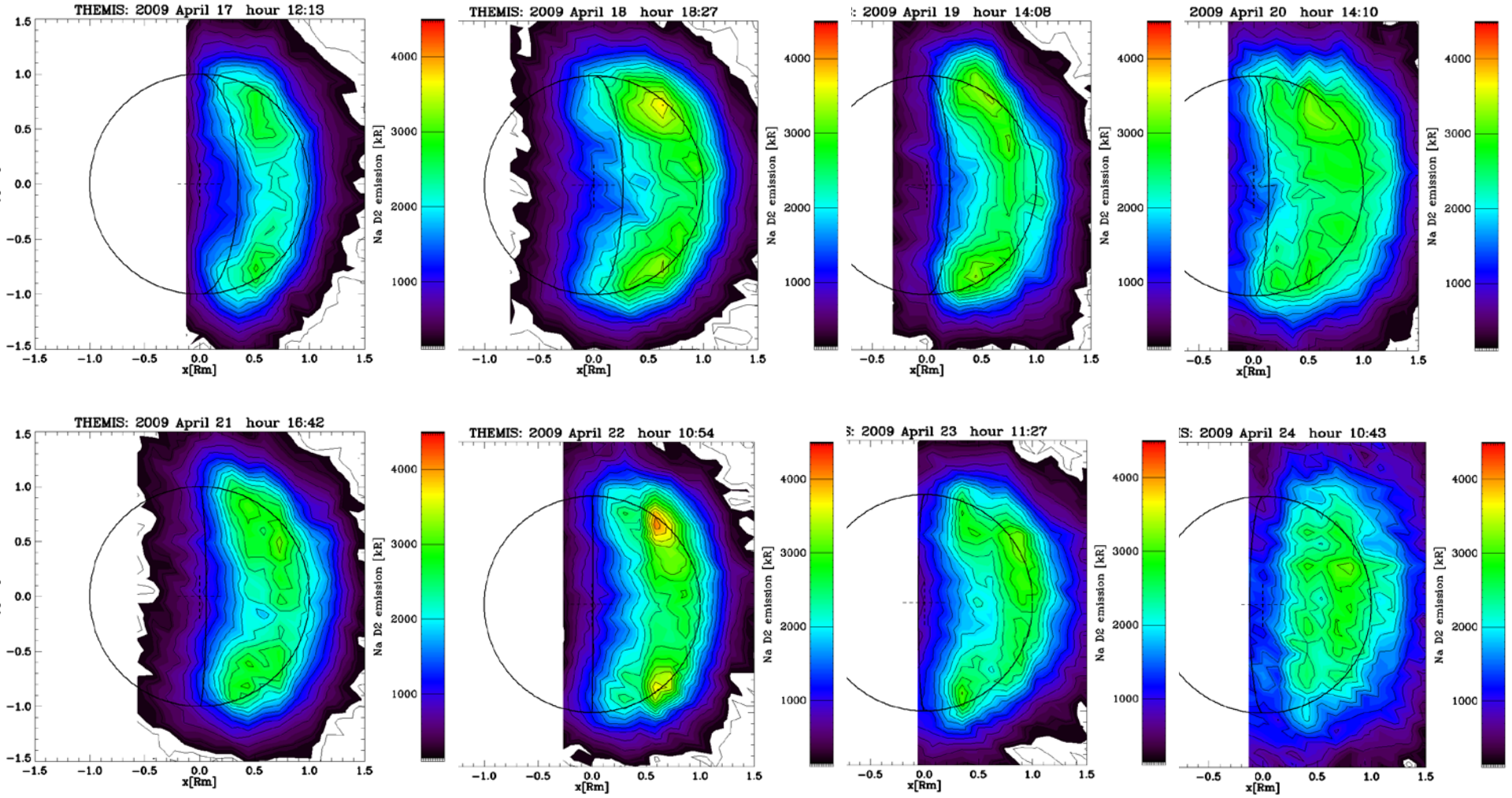
Eclipt. Latitude 6.4° ÷ 6.8°

Period 1: July 12-18, 2008

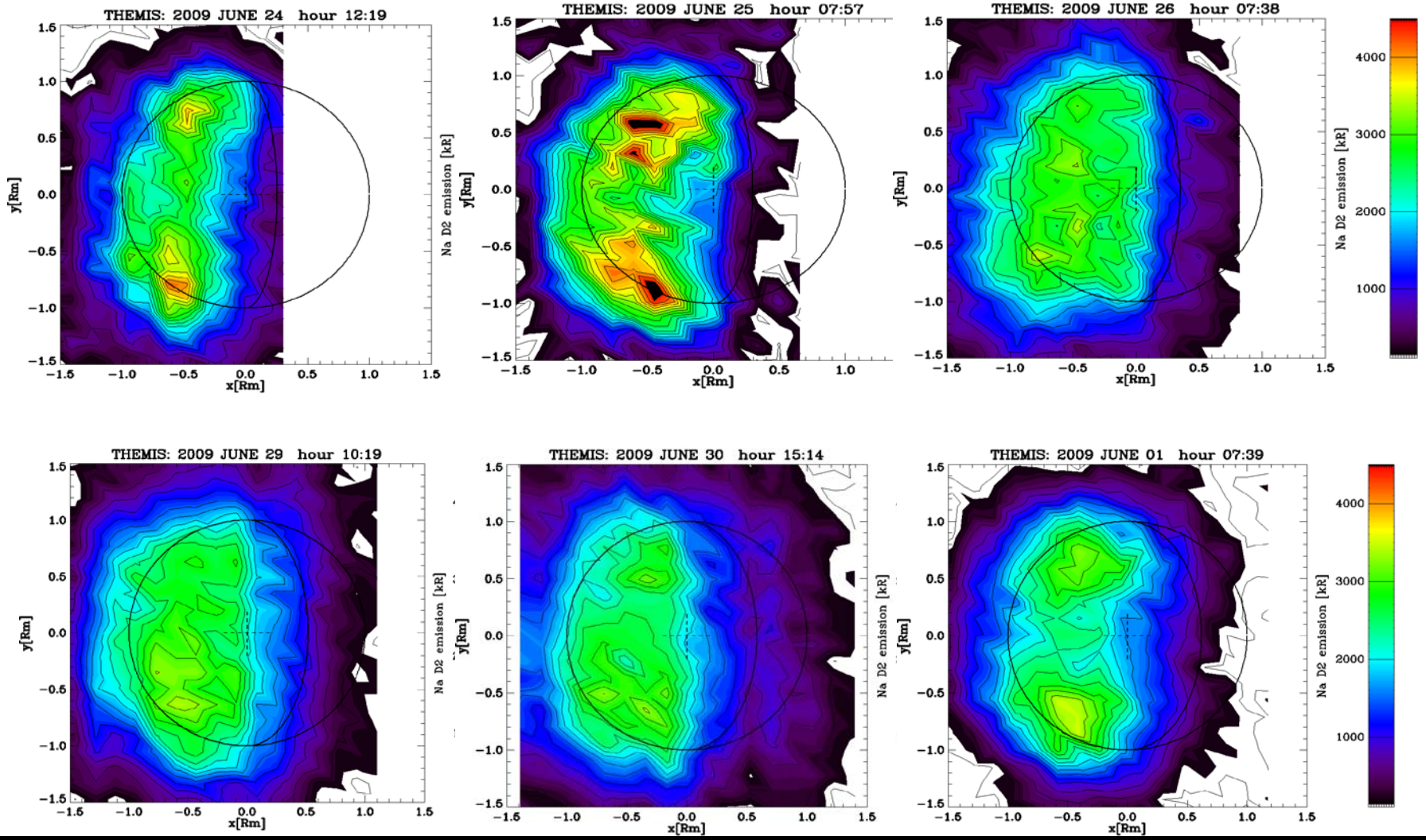




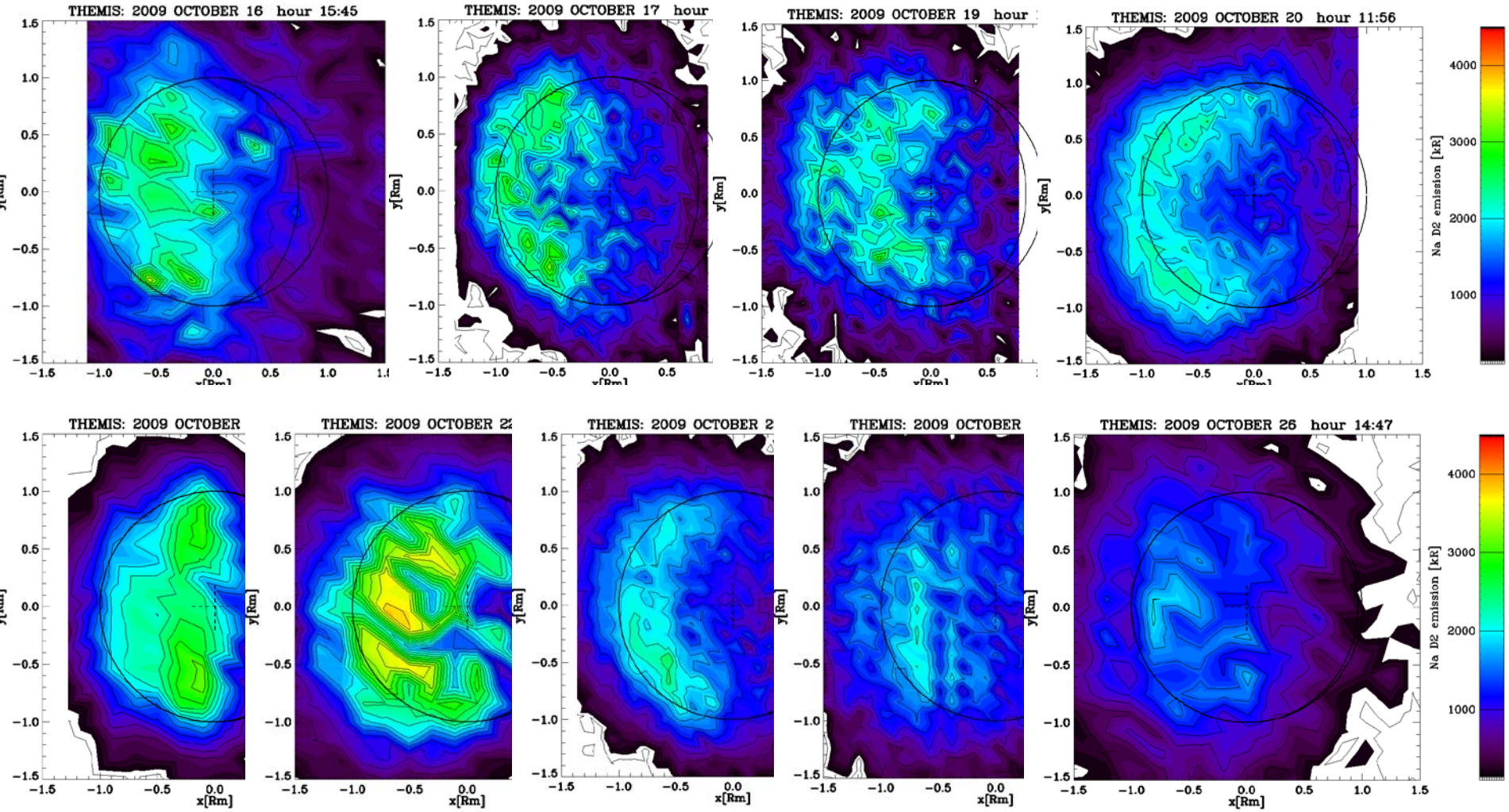
Period 2: April 17-24, 2009

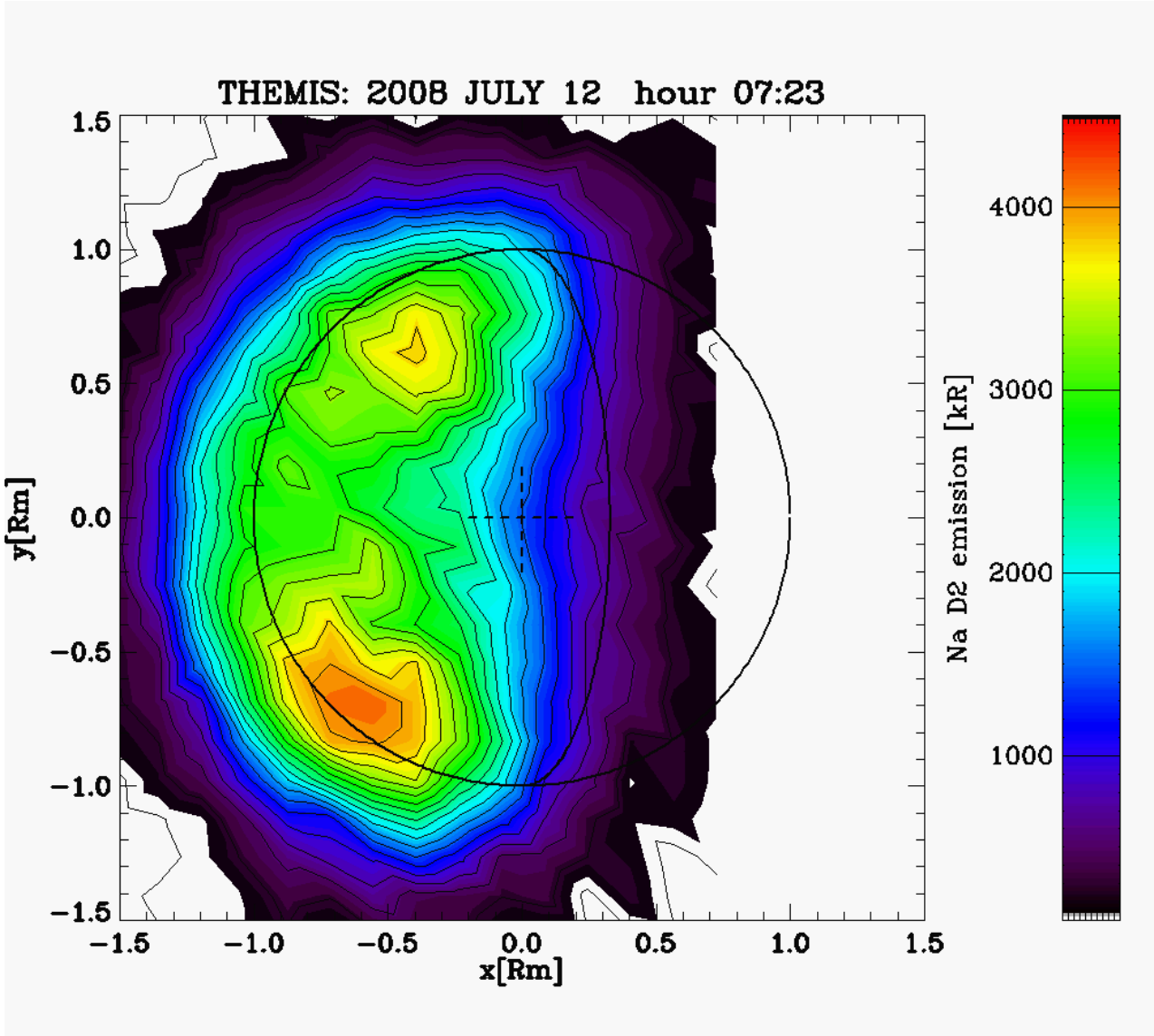


Period 3: June 24-July 1, 2009

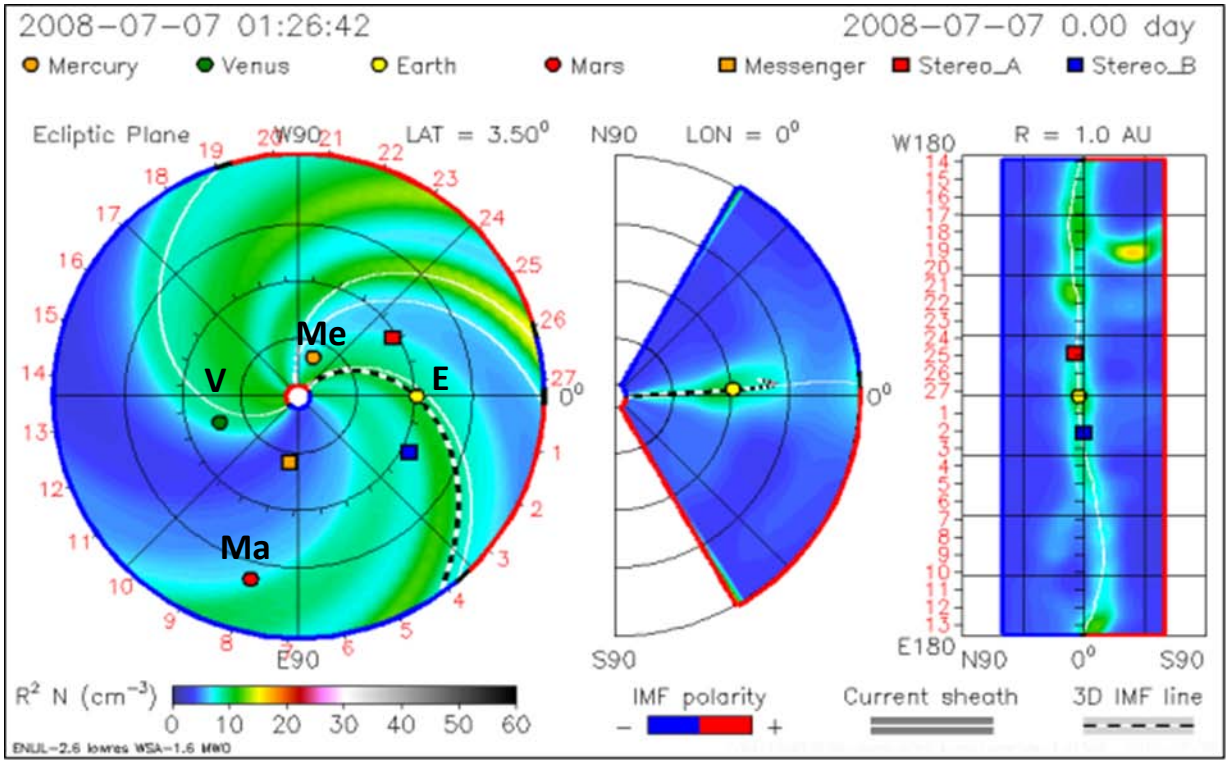


Period 4: October 16-26, 2009

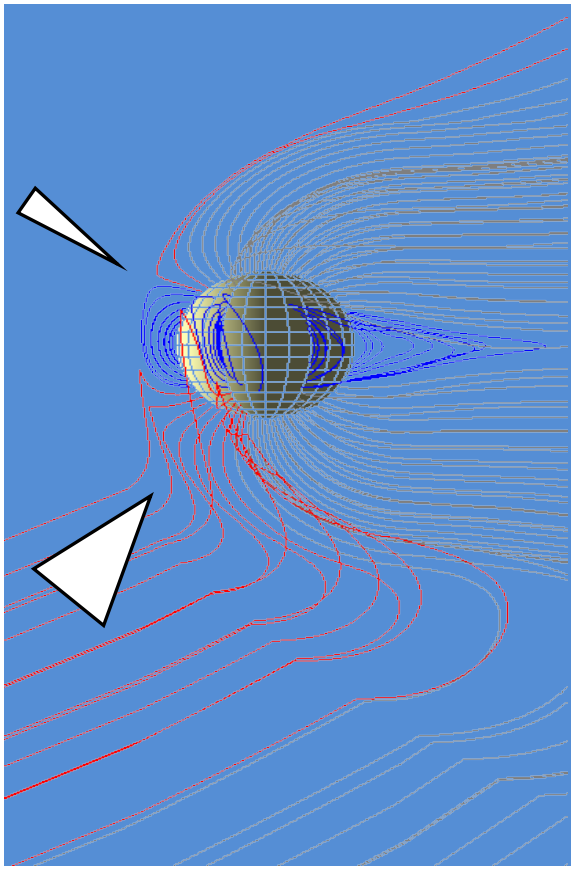



THEMIS: 2008 JULY 12 hour 07:23
y[Rm]
x[Rm]
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
Na D2 emission [kR]
4000
3000
2000
1000

The IMF geometry on the ecliptic plane is derived by:

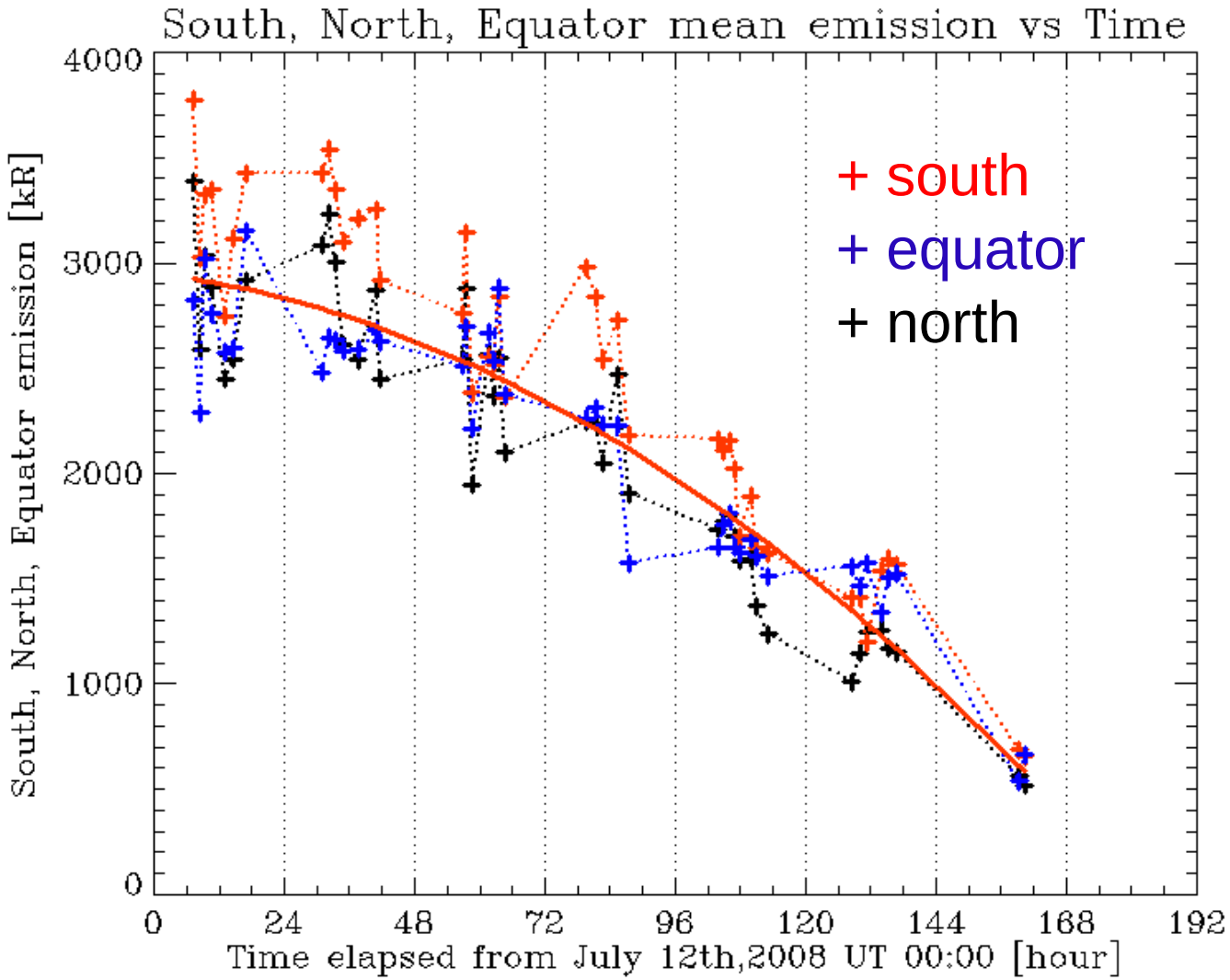


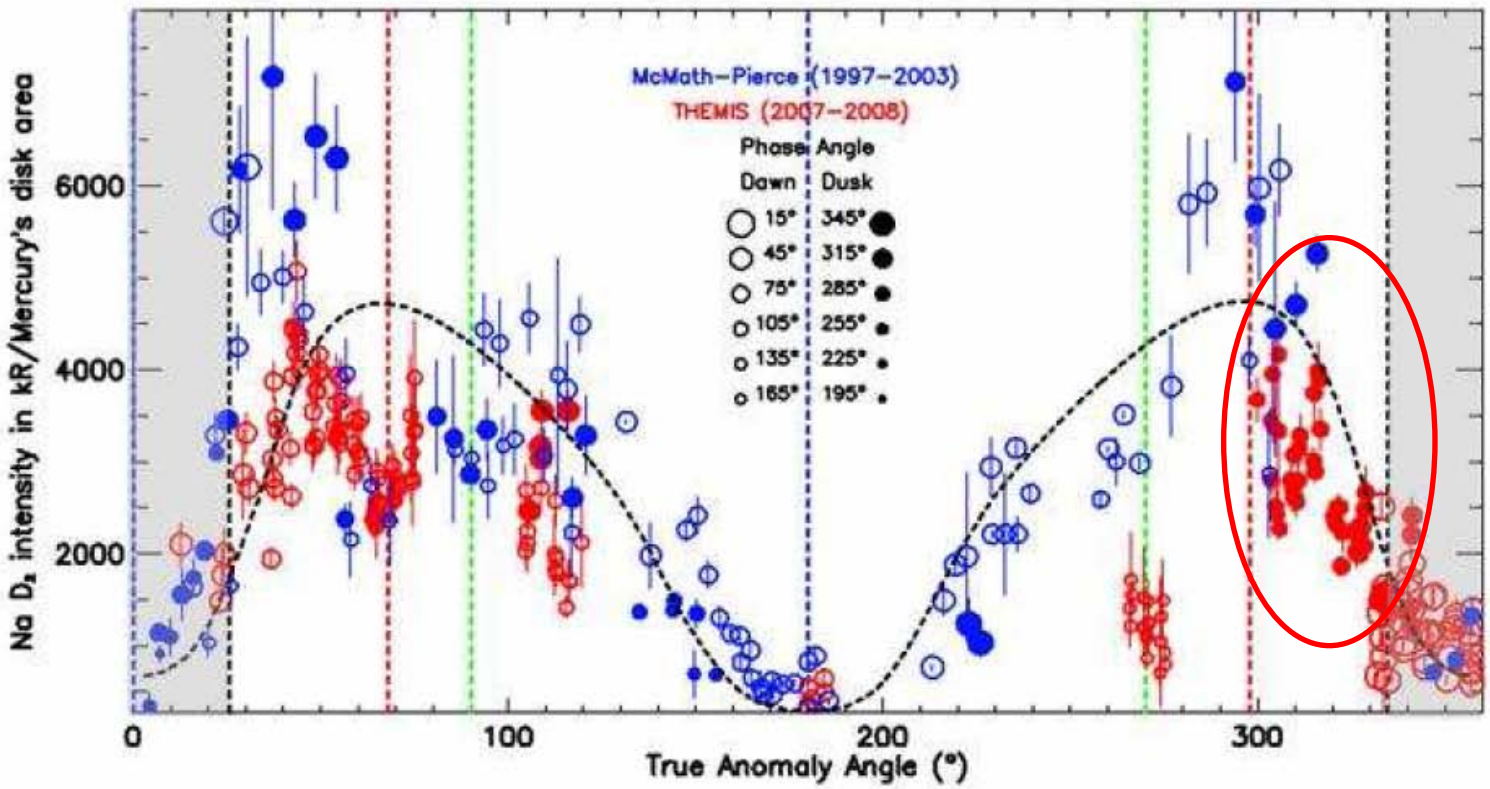
CCMC (http://ccmc.gsfc.nasa.gov/models/index.php)



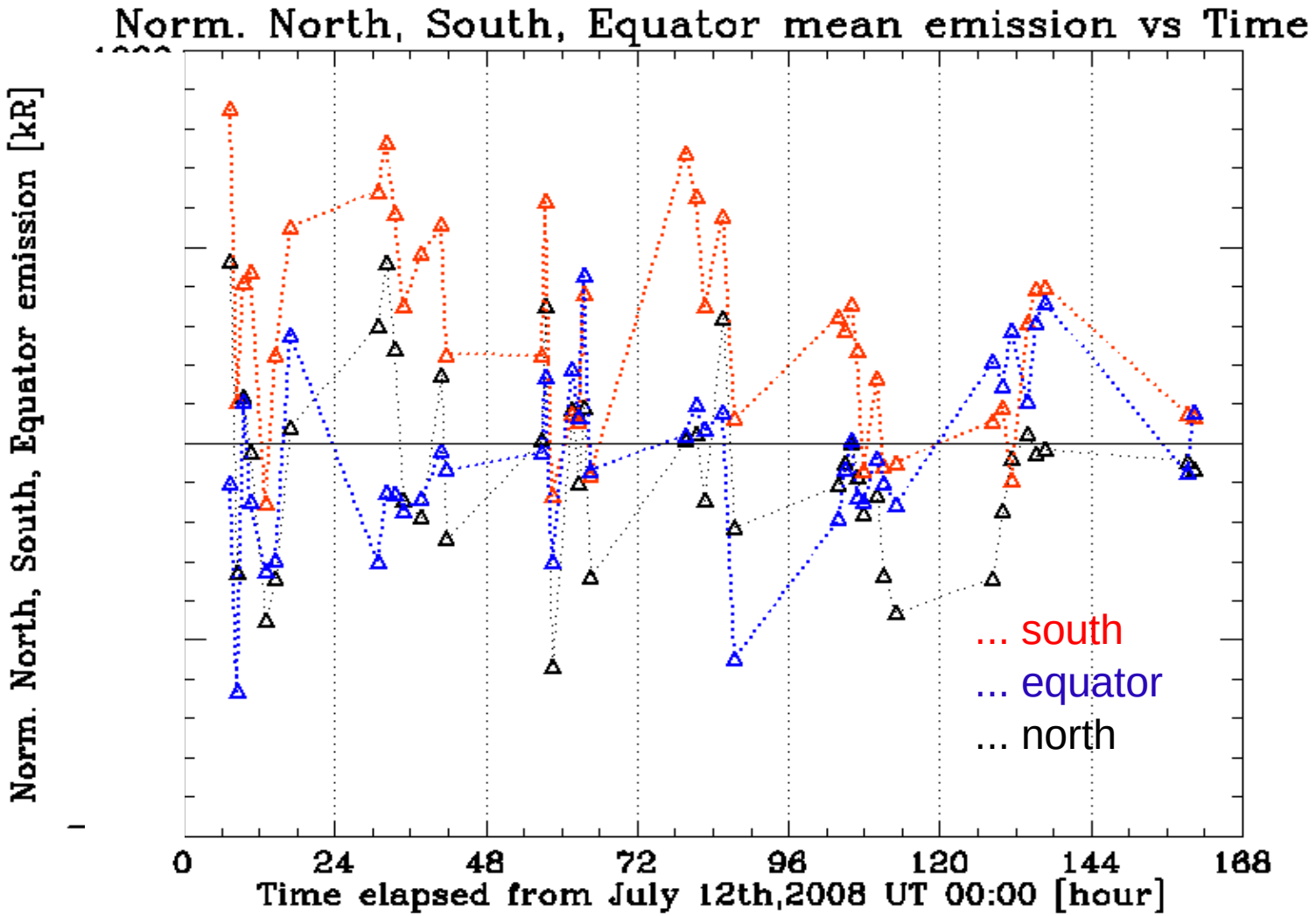
Massetti et al., PSS 2007

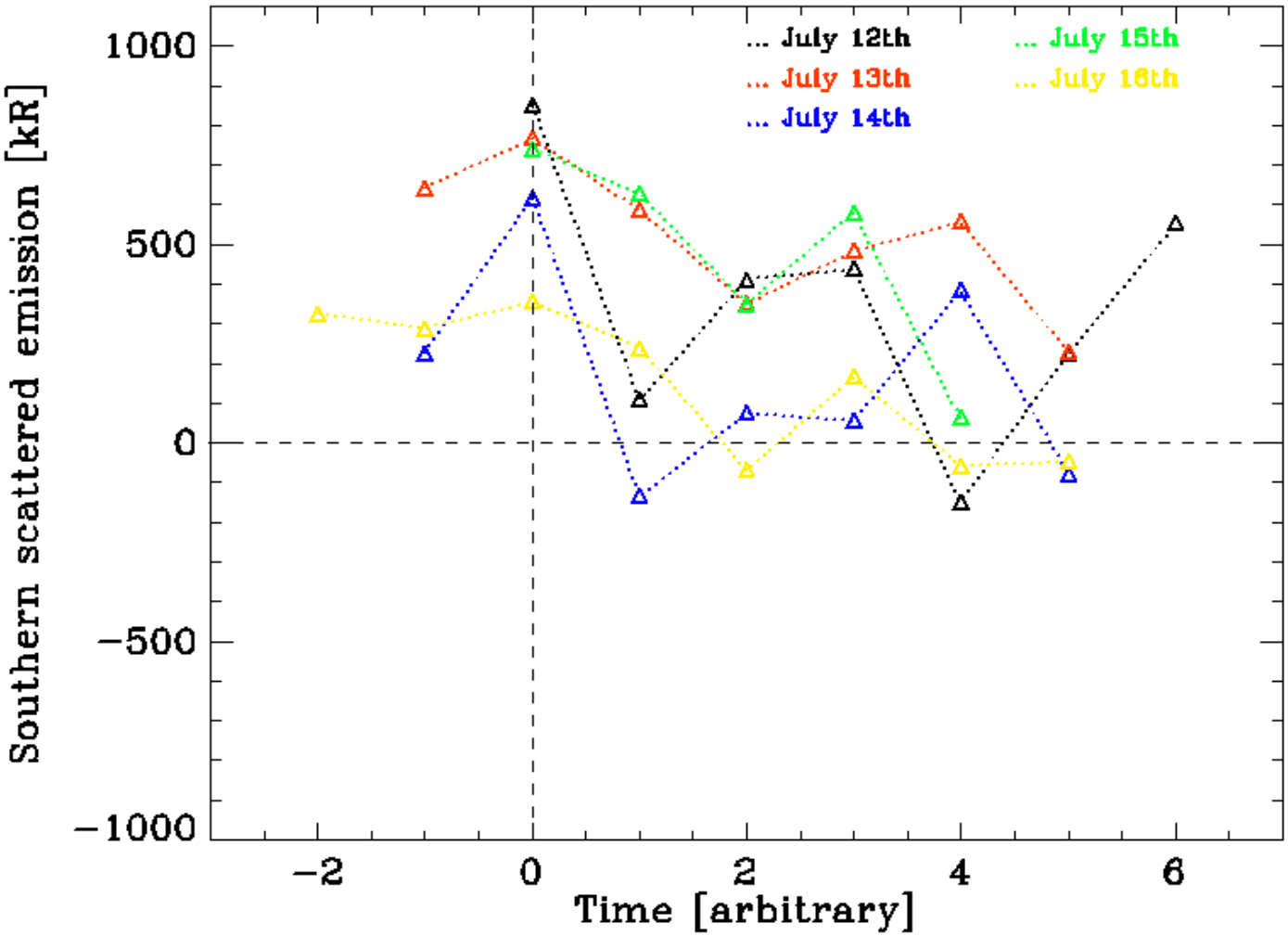
Mercury is in the blue sector and also the Earth is in the blue sector in accordance with the ACE data at L1. This supports a Bx>0 configuration.

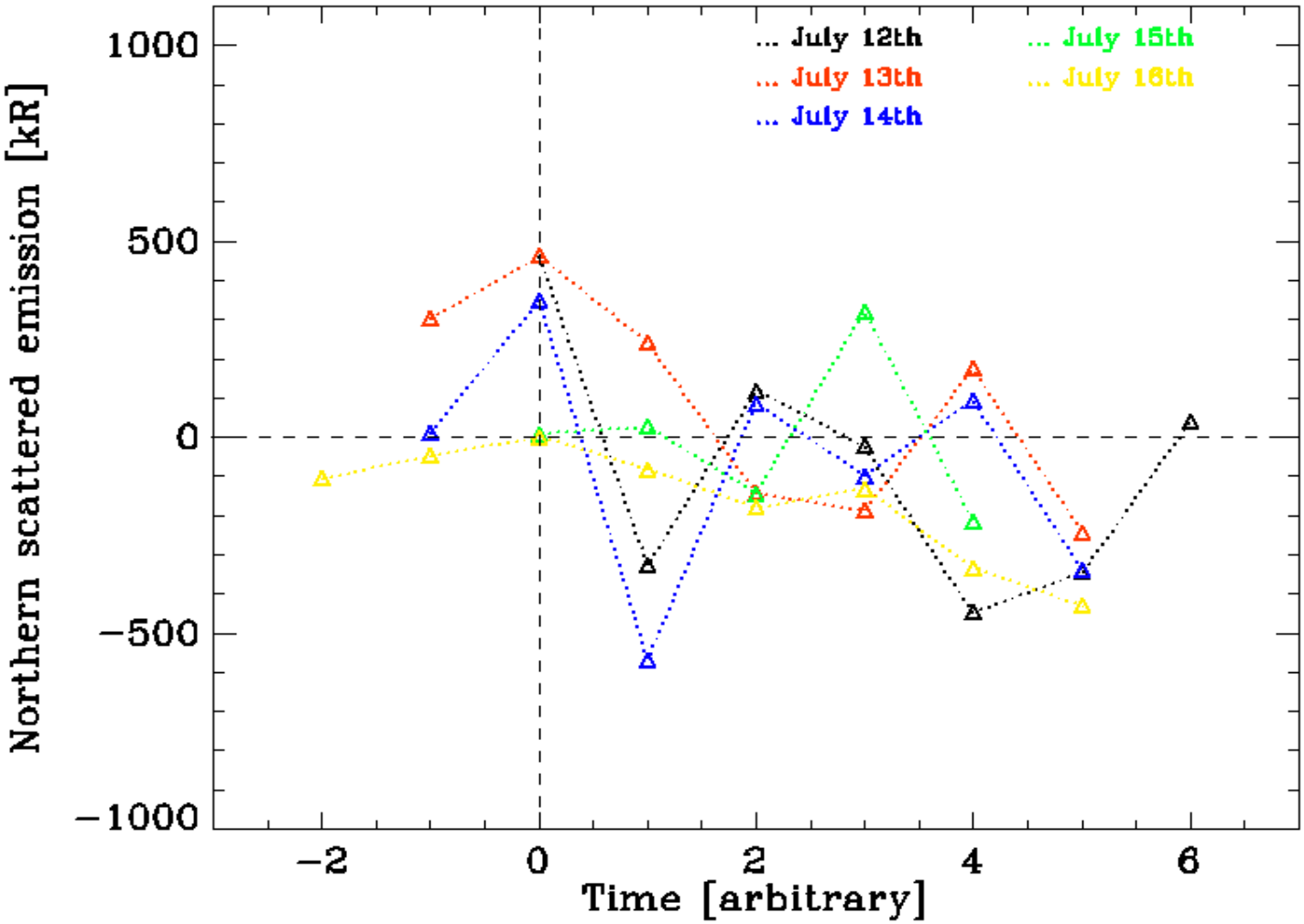

South, North, Equator mean emission vs Time
South, North, Equator emission [kR]
4000
3000
2000
1000
0
0
24
48
72
96
120
144
168
192
Time elapsed from July 12th,2008 UT 00:00 [hour]
+ south
+ equator
+ north

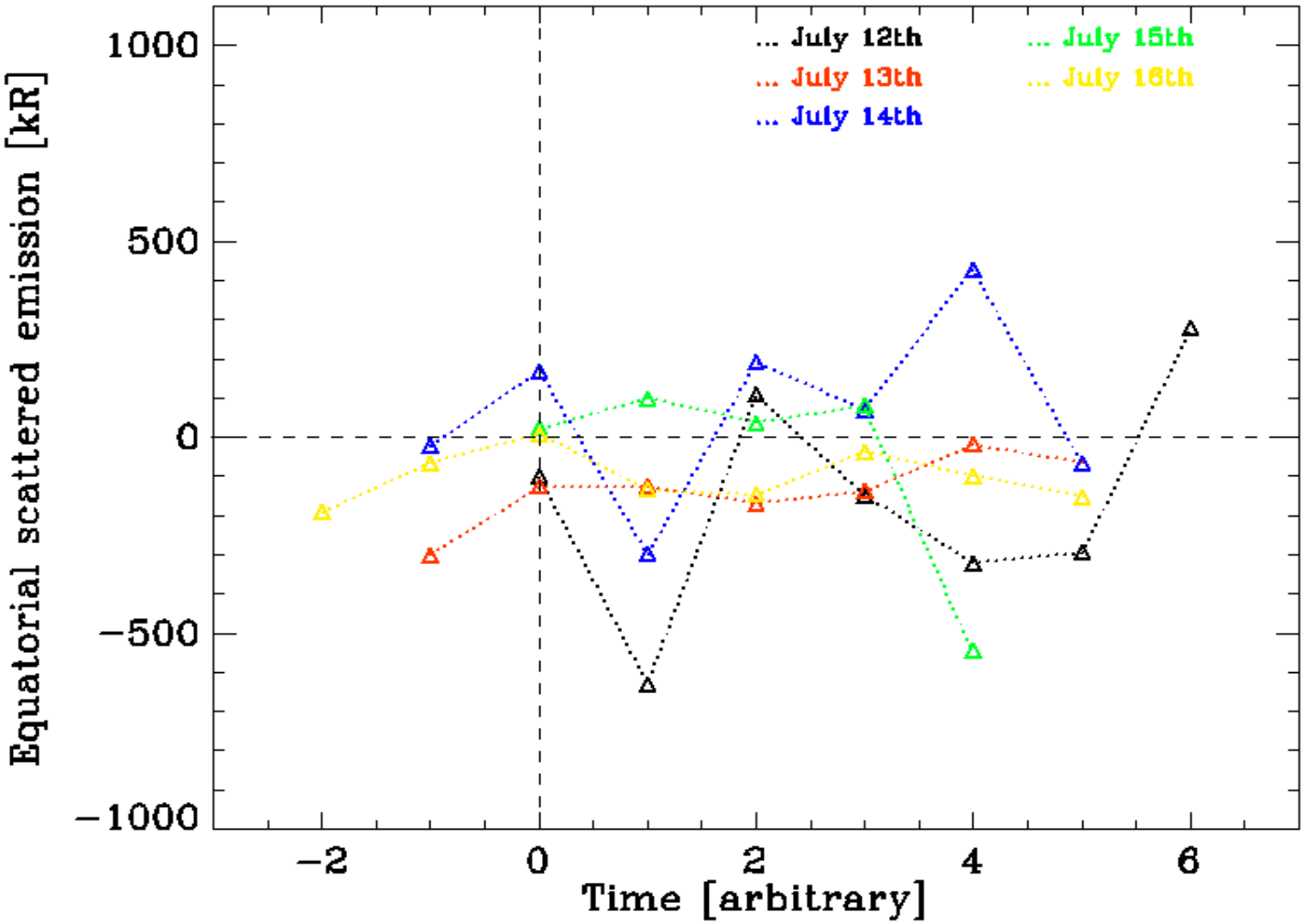


(from Leblanc et al., ICARUS, 2010)


Norm. North, South, Equator mean emission vs Time
Norm. North, South, Equator emission [kR]
0
24
48
72
96
120
144
168
Time elapsed from July 12th,2008 UT 00:00 [hour]
... south
... equator
... north


... July 12th
... July 13th
... July 14th
... July 15th
... July 16th
1000
500
0
−500
−1000
Southern scattered emission [kR]
−2
0
2
4
6
Time [arbitrary]

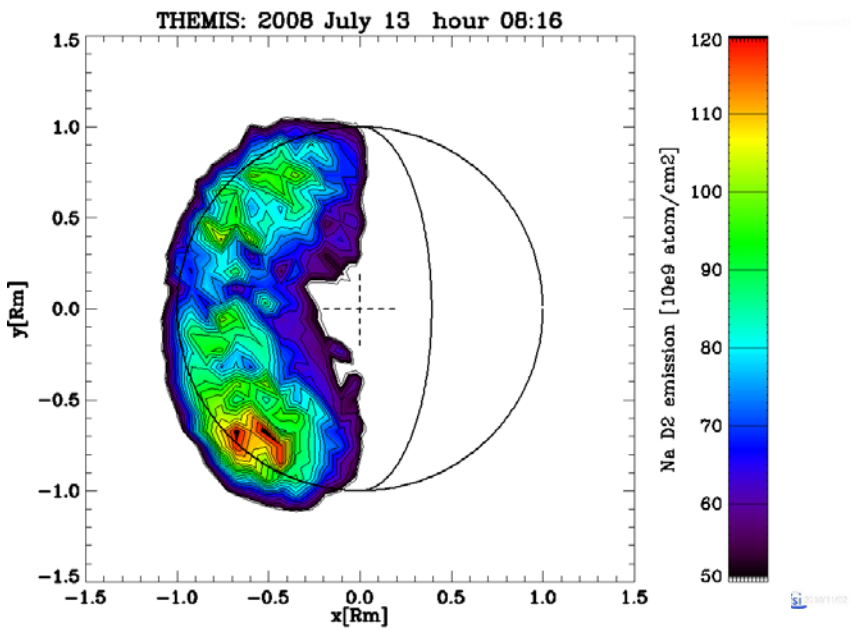

... July 12th
... July 13th
... July 14th
... July 15th
... July 16th
1000
500
0
−500
−1000
Northern scattered emission [kR]
−2
0
2
4
6
Time [arbitrary]

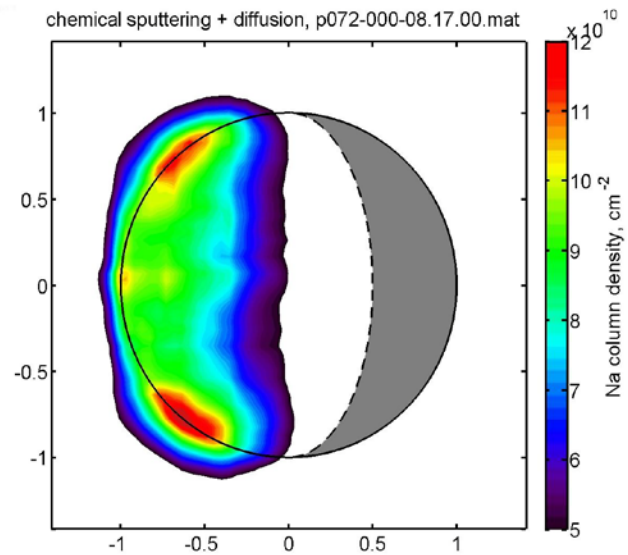

... July 12th
... July 13th
... July 14th
... July 15th
... July 16th
1000
500
0
−500
−1000
−2
0
2
4
6
Equatorial scattered emission [kR]
Time [arbitrary]

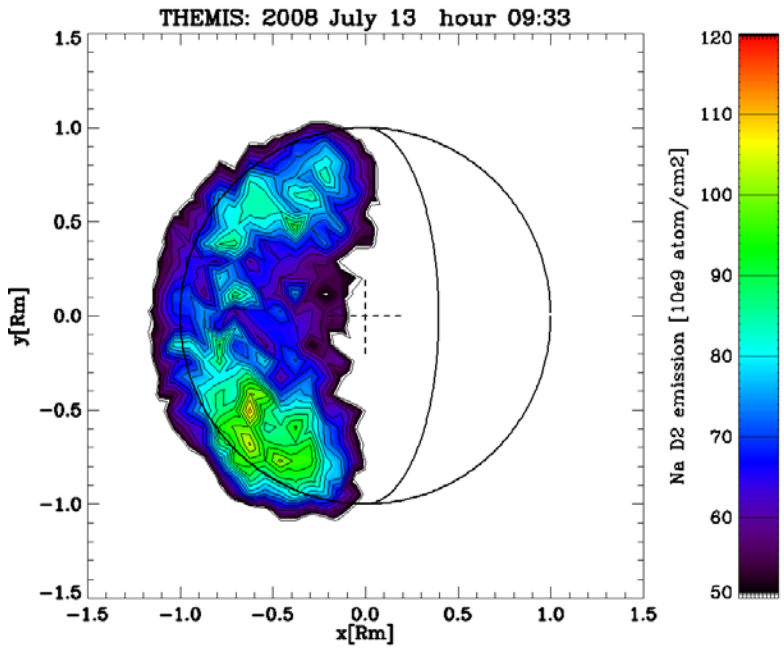
July 13th, 2008

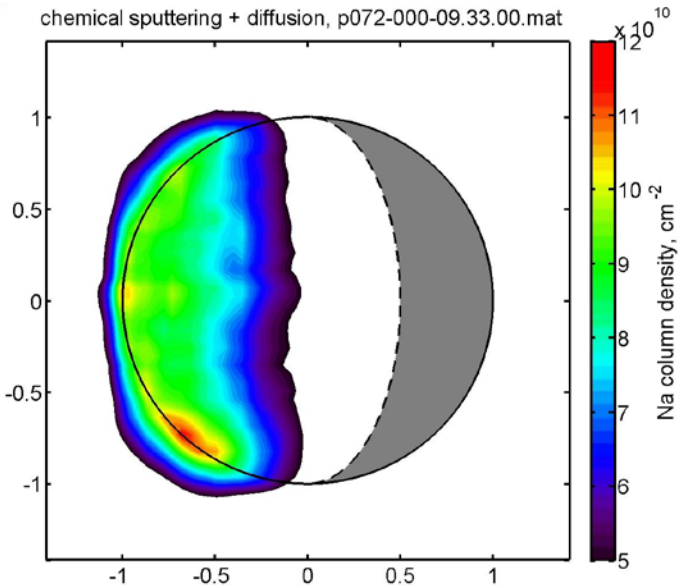
Comparison:

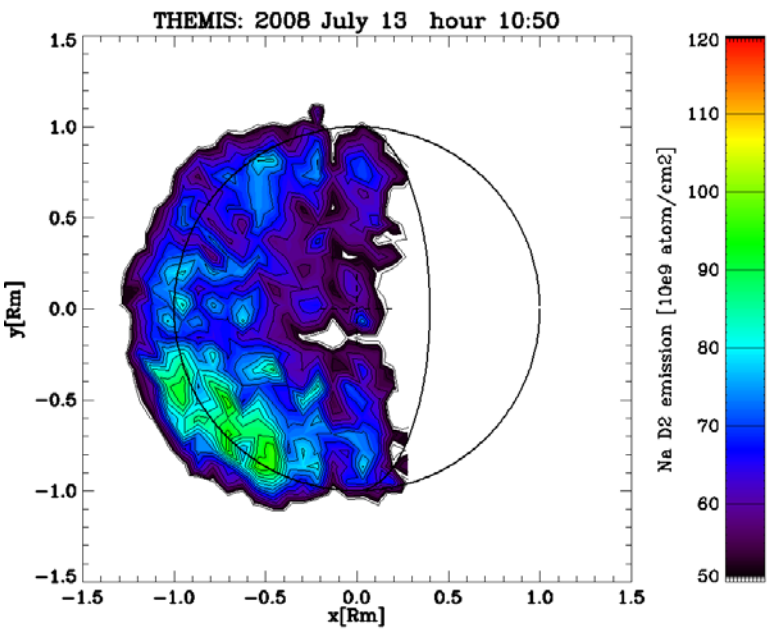
Observations vs Simulations

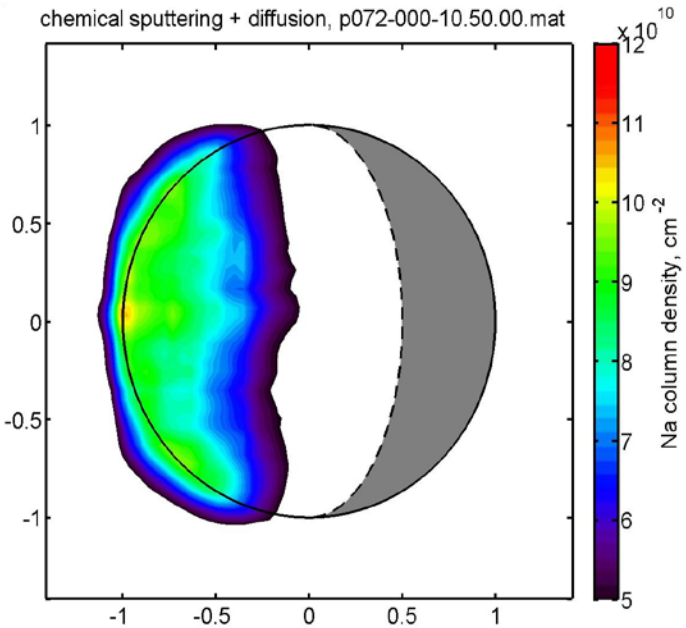


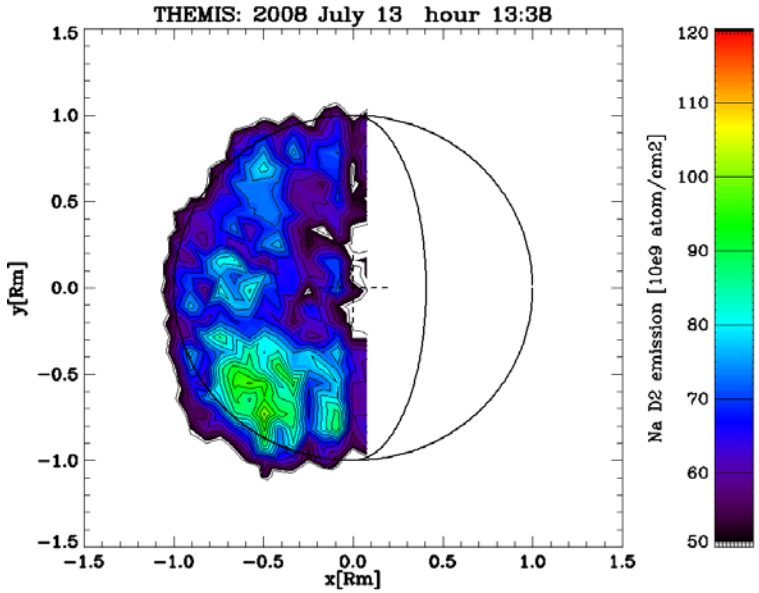


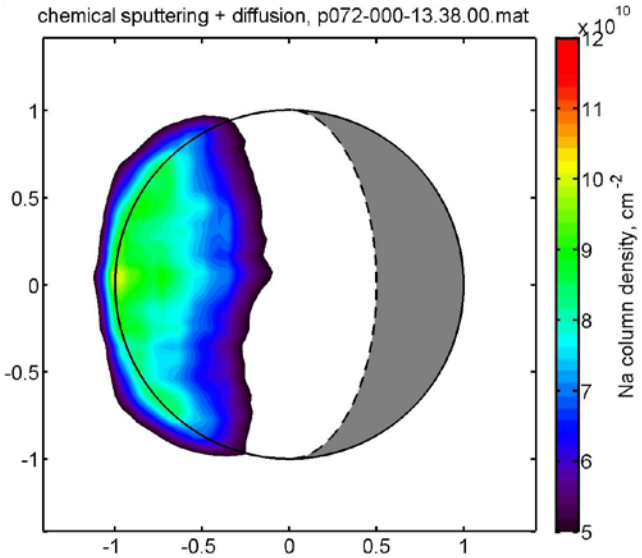

THEMIS: 2008 July 13 hour 09:33
y[Rm]
x[Rm]
Na D2 emission [10e9 atom/cm2]

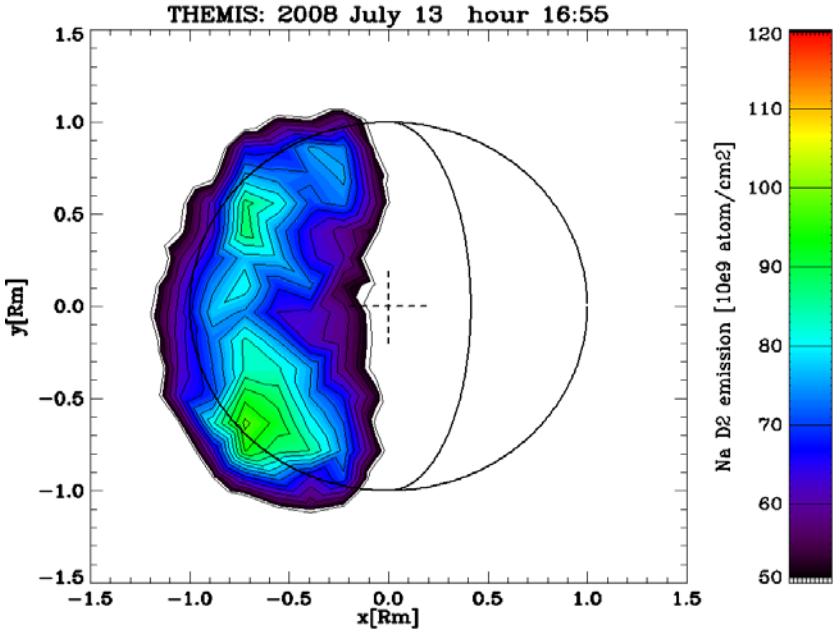

chemical sputtering + diffusion, p072-000-09.33.00.mat
x 10^10
Na column density, cm^-2

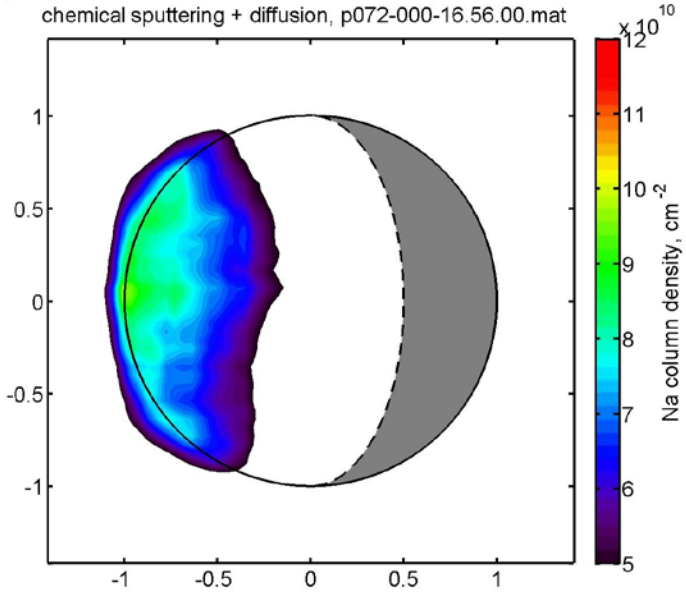

THEMIS: 2008 July 13 hour 10:50
y[Rm]
x[Rm]
Na D2 emission [10e9 atom/cm2]


chemical sputtering + diffusion, p072-000-10.50.00.mat
x 10^10
Na column density, cm^-2

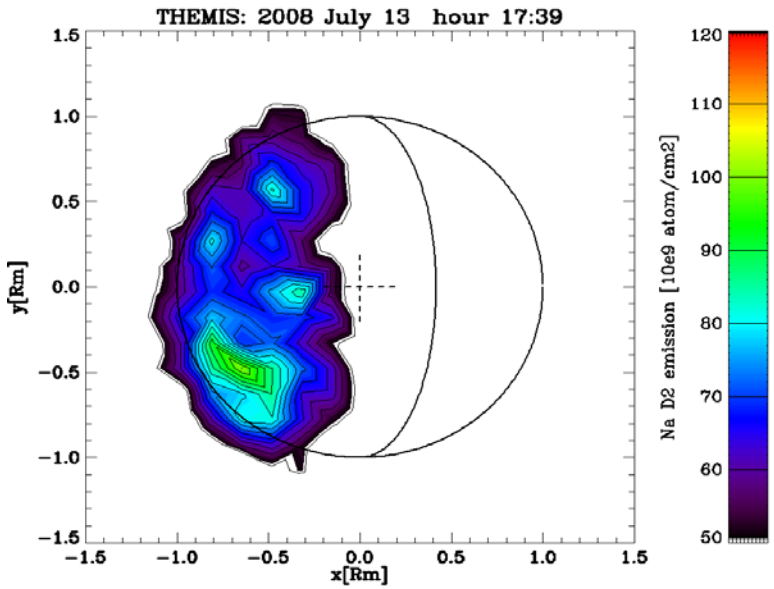

THEMIS: 2008 July 13 hour 13:38
y[Rm]
x[Rm]
Na D2 emission [10e9 atom/cm2]

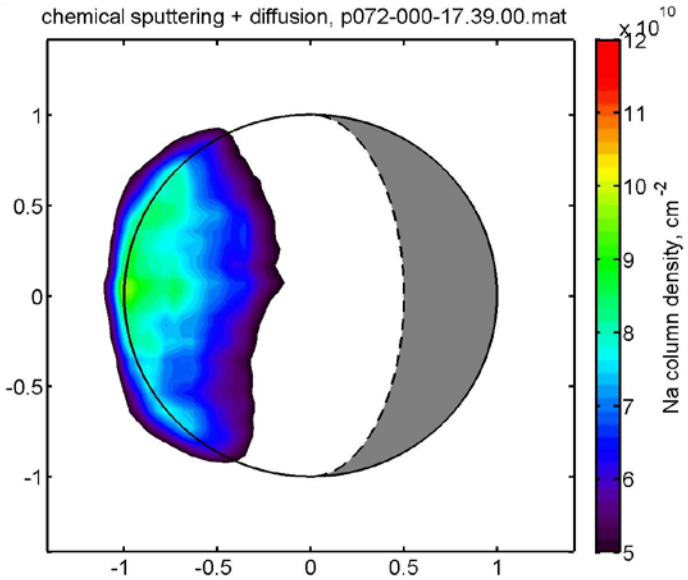

chemical sputtering + diffusion, p072-000-13.38.00.mat
x 10^10
Na column density, cm^-2


THEMIS: 2008 July 13 hour 16:55
y[Rm]
x[Rm]
Na D2 emission [10e9 atom/cm2]


chemical sputtering + diffusion, p072-000-16.56.00.mat
x 10^10
Na column density, cm^-2

Agreement between the observation and simulation performed is promising, reproducing both the decrease rate and the intensity reasonably well, before the second peak occurs





(See A. Mura presentation on Wednesday 3rd,session 4).

(preliminary) Conclusions

1) interesting results from THEMIS observations thanks to daily runs of up to 10-12 hours.

2) intensity variations on scales of 1 hour and more are clearly visible.

3) the analysis of the period of July 2008 (8 consecutive days) permits the (still partial) analysis of a longer period evolution, in accordance with TAA position, and with the modeled Bx component of the IMF.

4) daily peaks are observed as well, with a persistence of the southern emission, and an 'echo' in the northern emisphere, while the equatorial emission appear to be not directly related to them.

5) our model simulation is in reasonable agreement with the observed evolution on July 13th 2008, suggesting an improved comprehension of the causes of the processes acting on a time-scale of few hours.