Mg and Mg^+ retrieval results from SCIAMACHY limb mesosphere-thermosphere measurements

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LIMB-13

This presentation participates in the student award contest

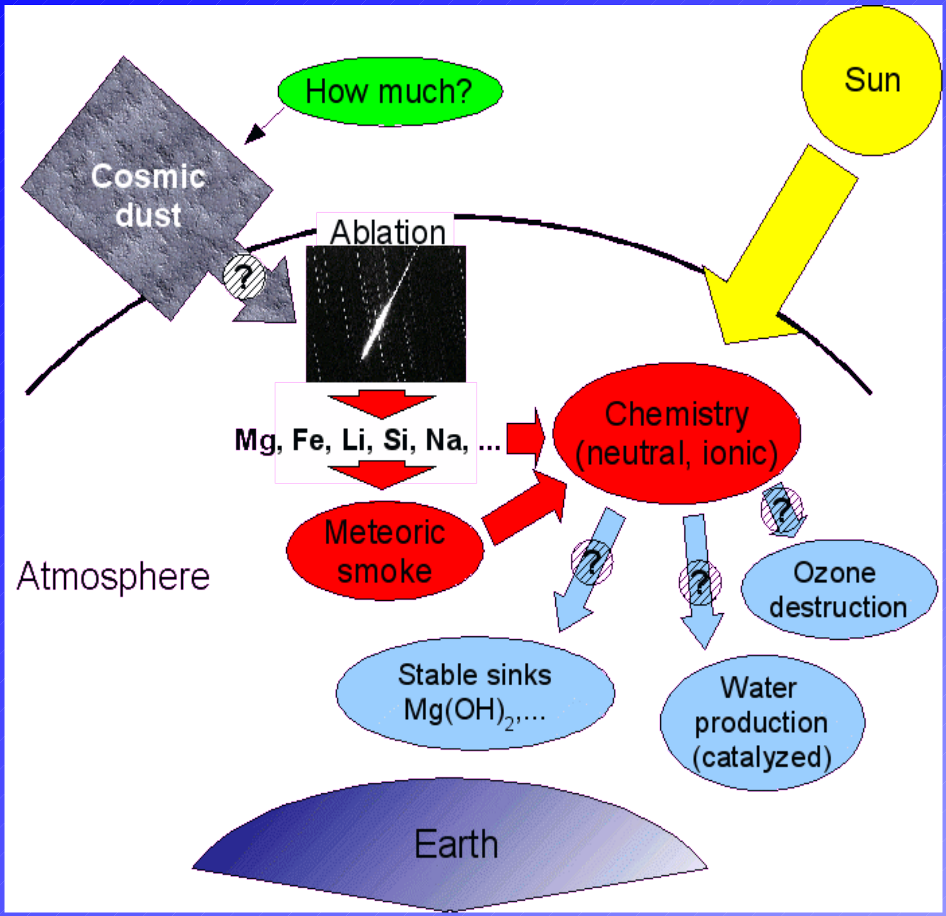
Metals in the MLT

Motivation

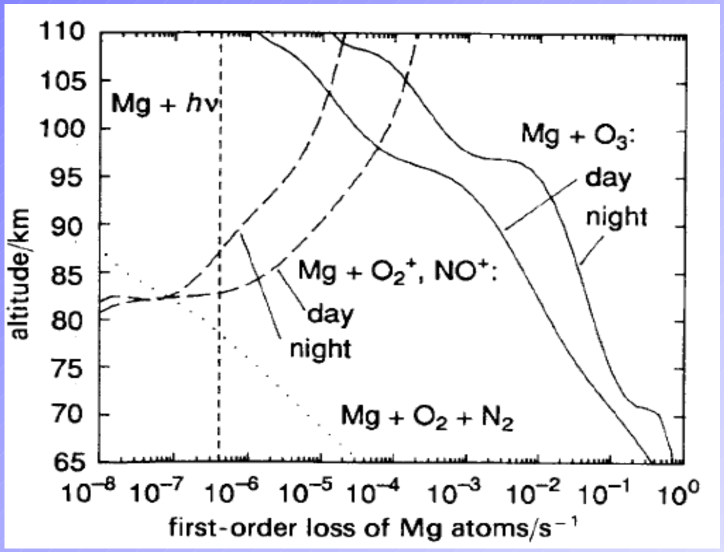
- MLT region can hardly be probed by in situ instruments as balloons fly too low and satellites too high,(and rockets too sparsely)
- Atomic metals and ions show very strong emissions in the MLT, easy to detect there by remote sensing

- If time resolution is high, e.g. for lidar measurements metals are tracer species for wave propagation in this region and into the upper atmosphere (also used for temperature and wind speed retrievals)

- Meteoric dust particles cannot be detected itself (low emissivities)
- Meteoric dust particles are possible condensation nuclii for cloud formation
- Total daily meteoric input into the earth atmosphere is very uncertain 1 t/day to 200 t/day
- Metals and ions play a role in the Formation of sporadic E_s layers in the ionosphere, which have a strong impact to radio communication

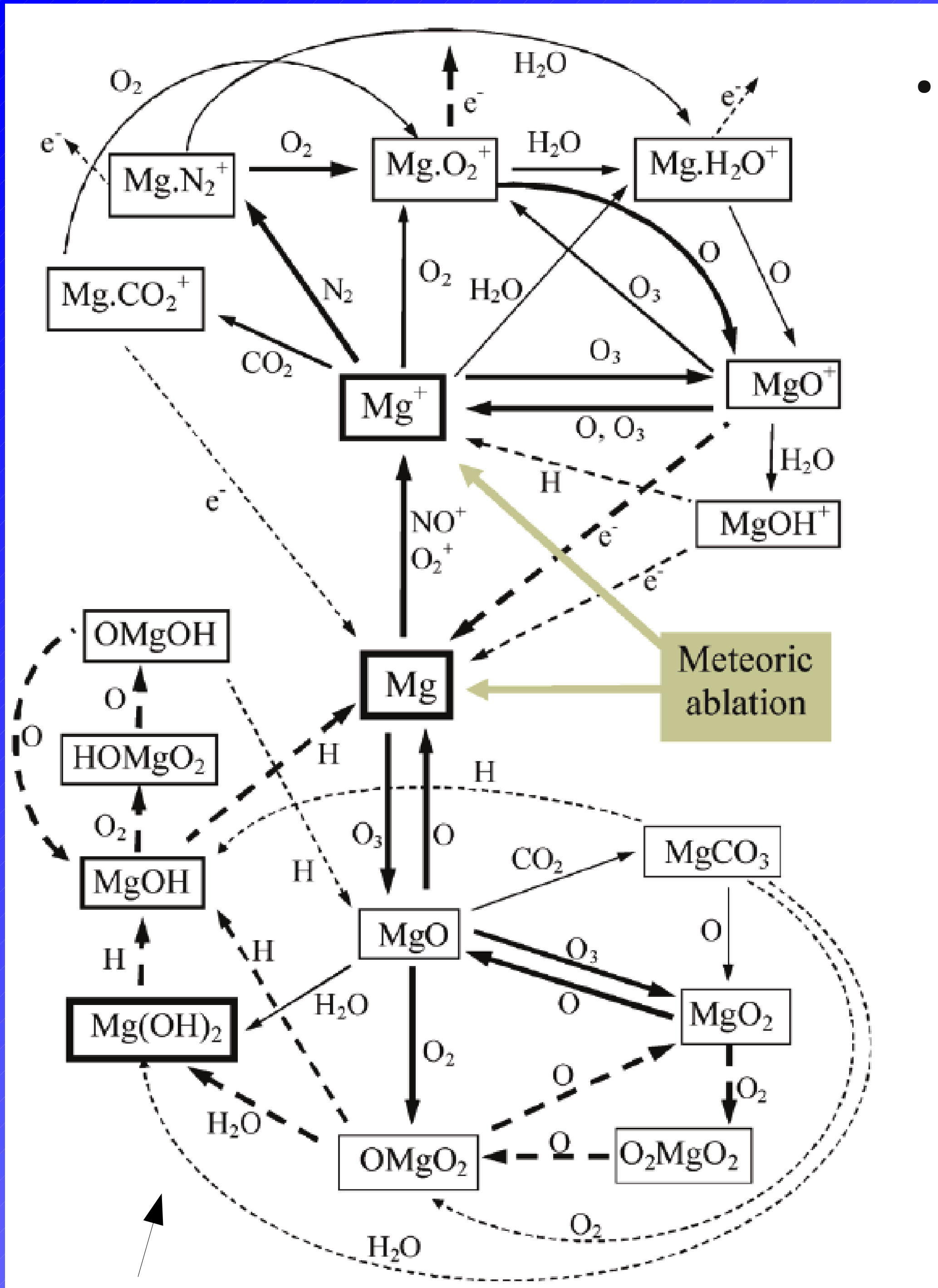


- Meteors entering earth's atmosphere ablate around 100 km altitude, depending on meteoride's mass, velocity entry angle and metals boiling point
- A small fraction of the ablated metals is ionized
- Ablated metal atoms react with ozone into reservoir species or get ionized by $O2^+$ and NO^+

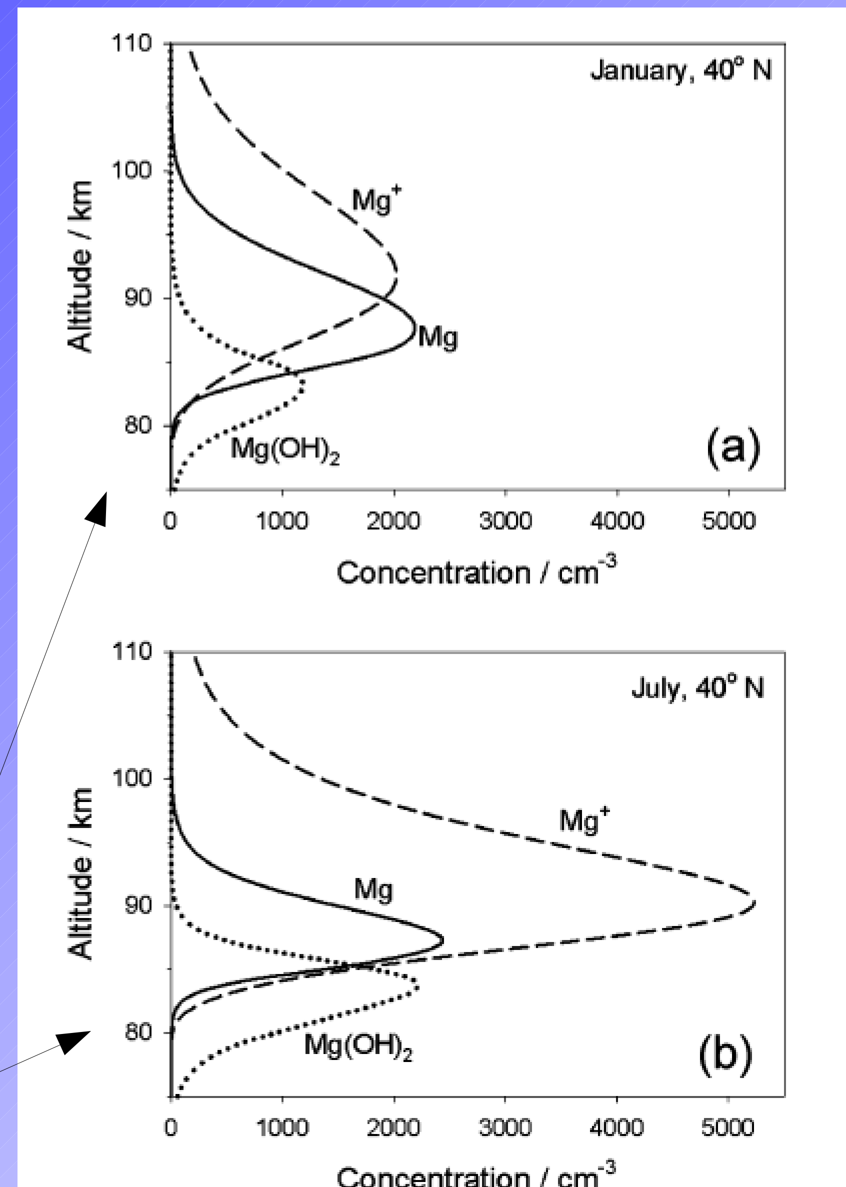


From Plane and Helmer, Faraday Discuss.,100, p.411-430,1995

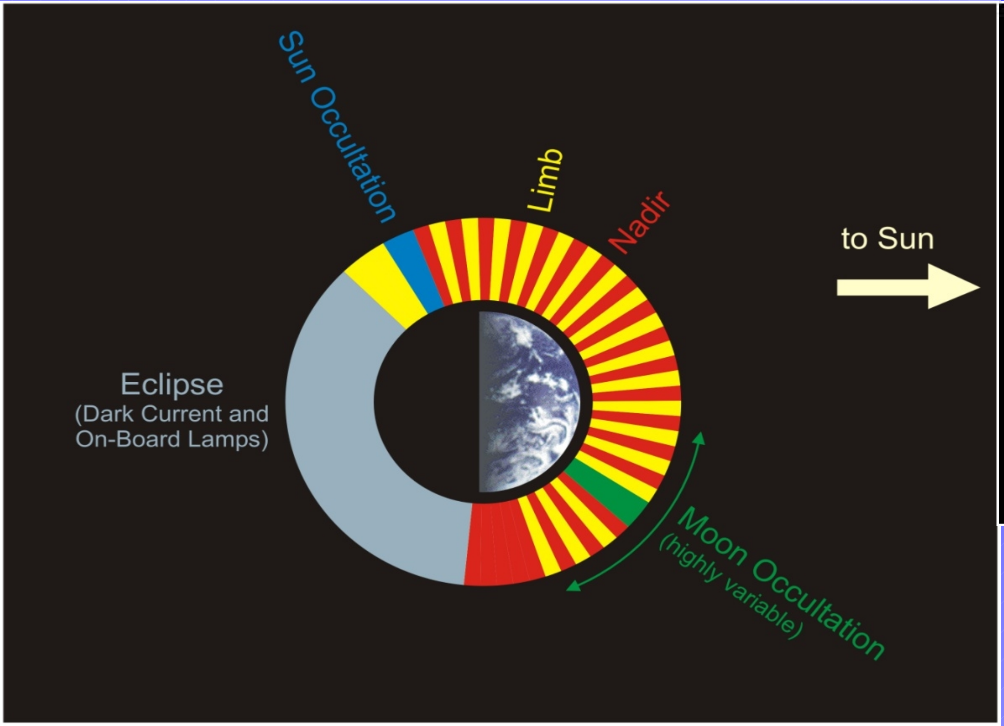
- Formation of Mg layer at around 90 km and Mg^+ layer slightly above

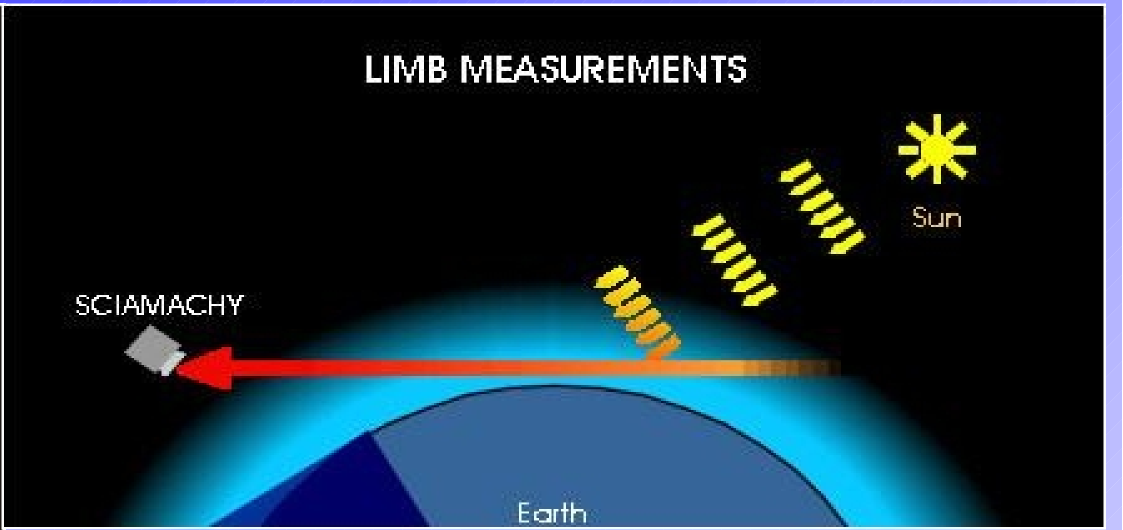


From Plane and Whalley, J. of Chemistry A, p.6240,2012



Sciamachy-Limb MLT states

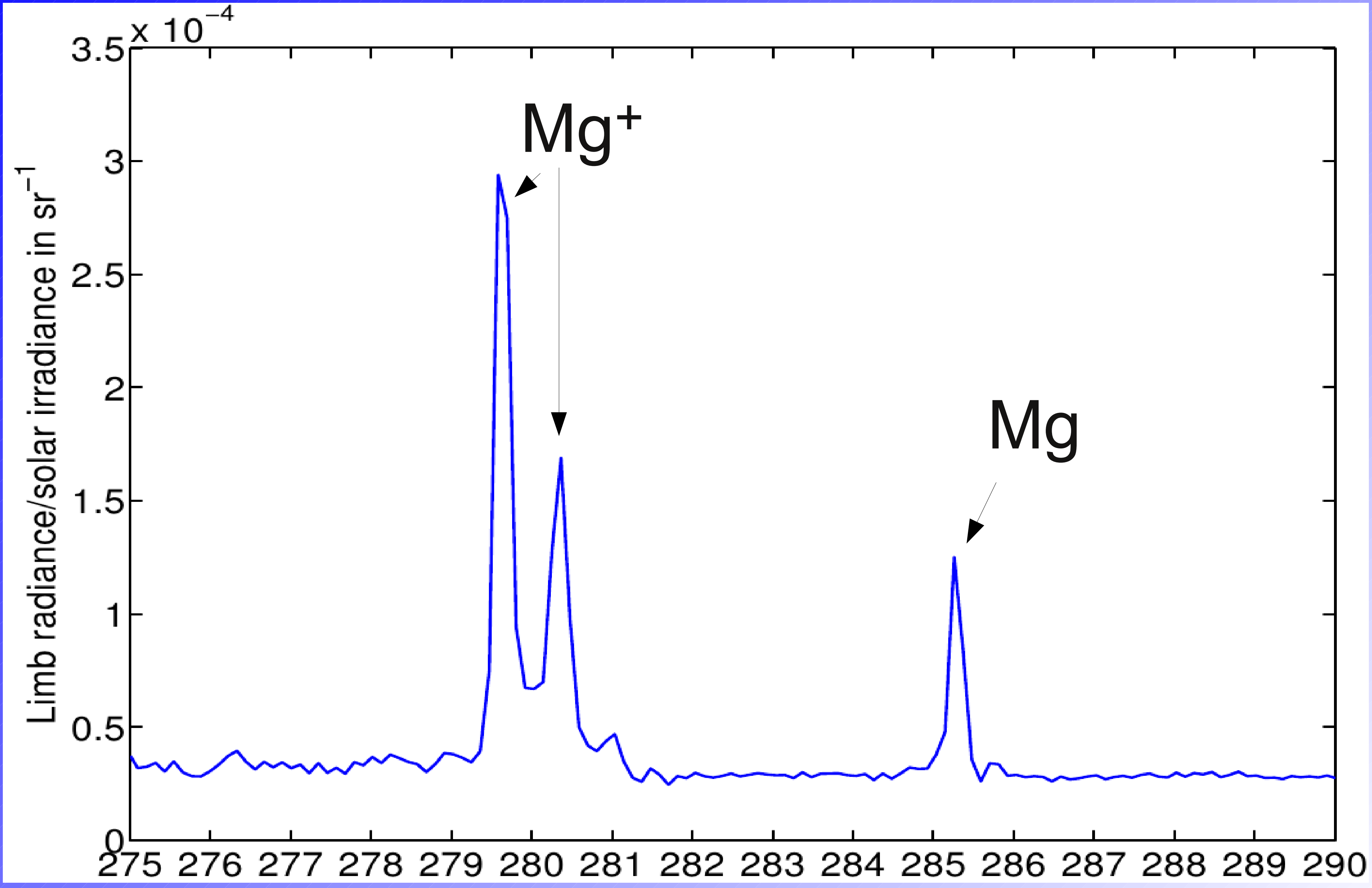




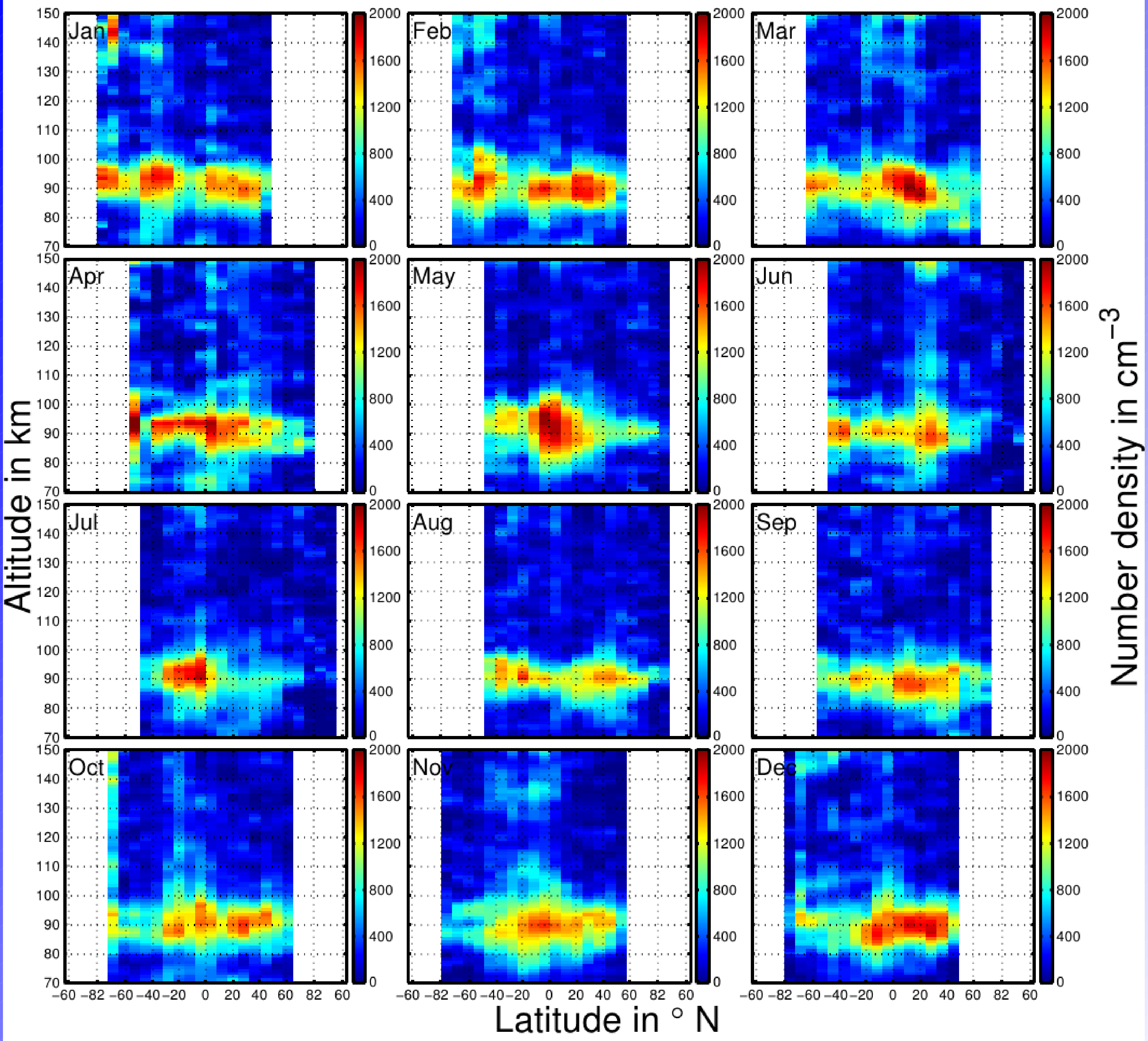
- Nominal limb states scan from 0 km to 90 km altitude (2002-2012)

- Limb MLT states scan from 53.5 to 150 km in 3 km steps + additional dark current measurement at 350 km
- since mid 2008 until 2012
- performed nearly every 2 weeks with15 consecutive orbits (one day of data)
- Details of the Mg/Mg+ retrieval algorithm can be found in
  Langowski et.al., AMTD, 6, 4445-4509, 2013 (in disc. since May 22)

Results for Mg/Mg^+

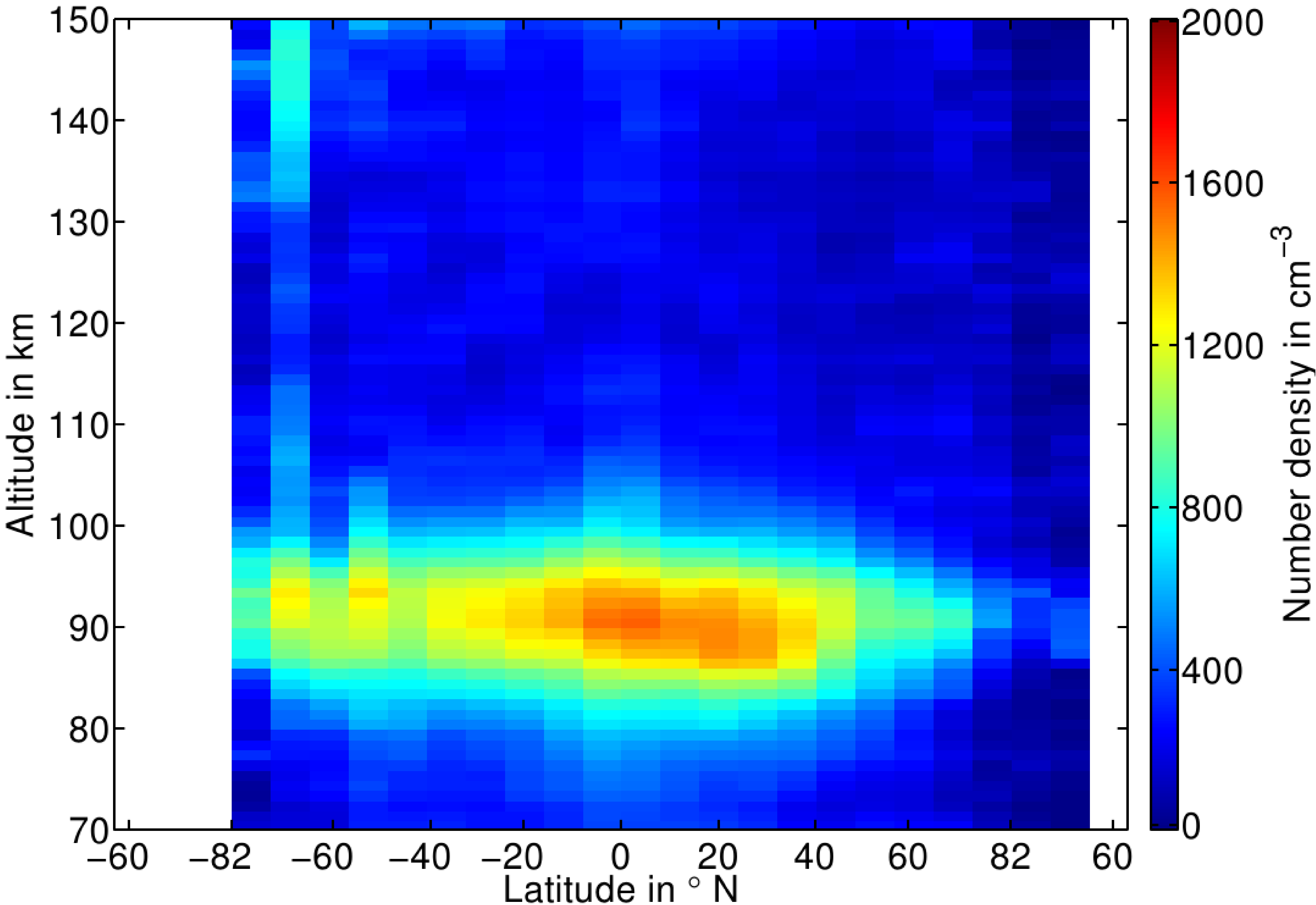


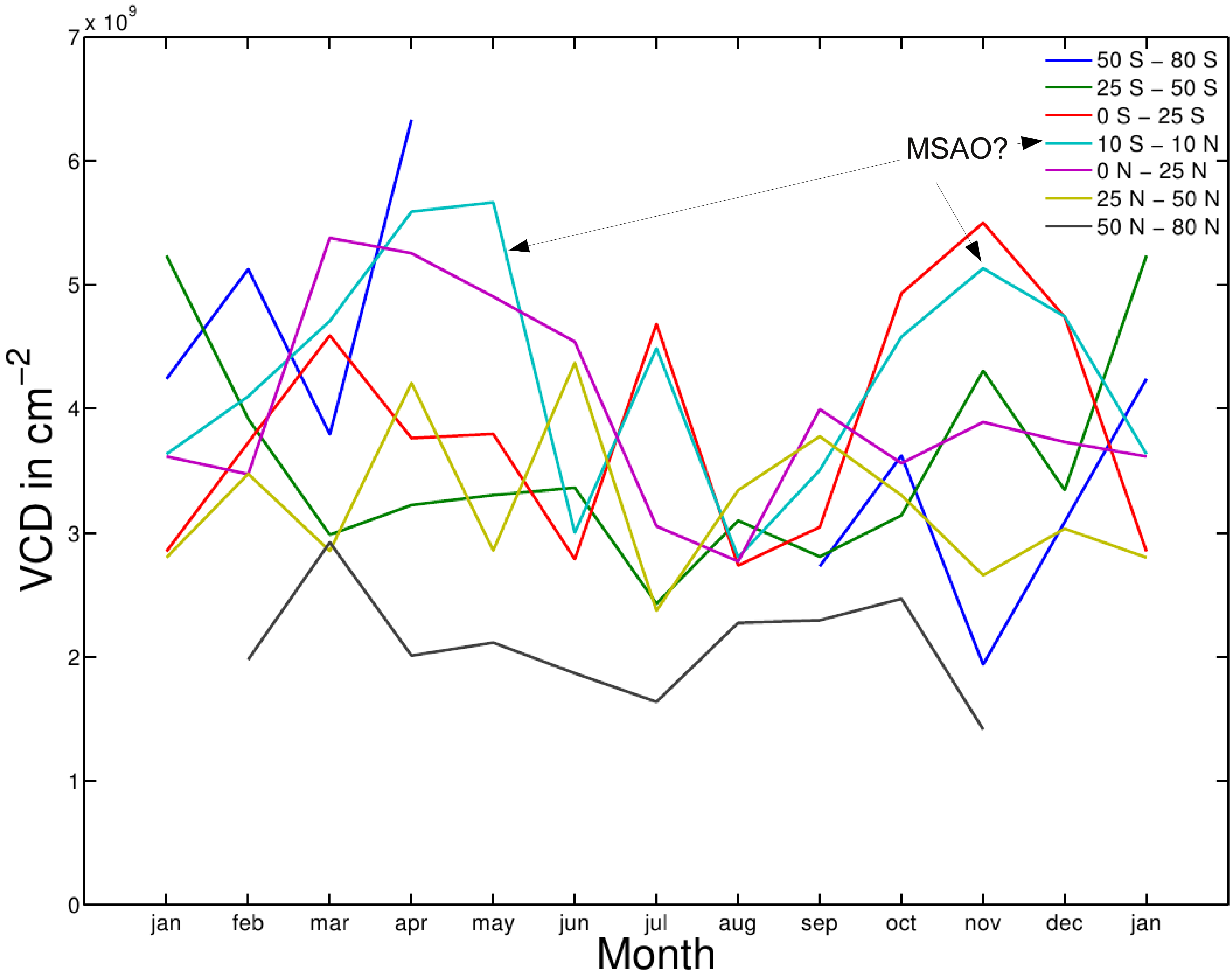
Mg



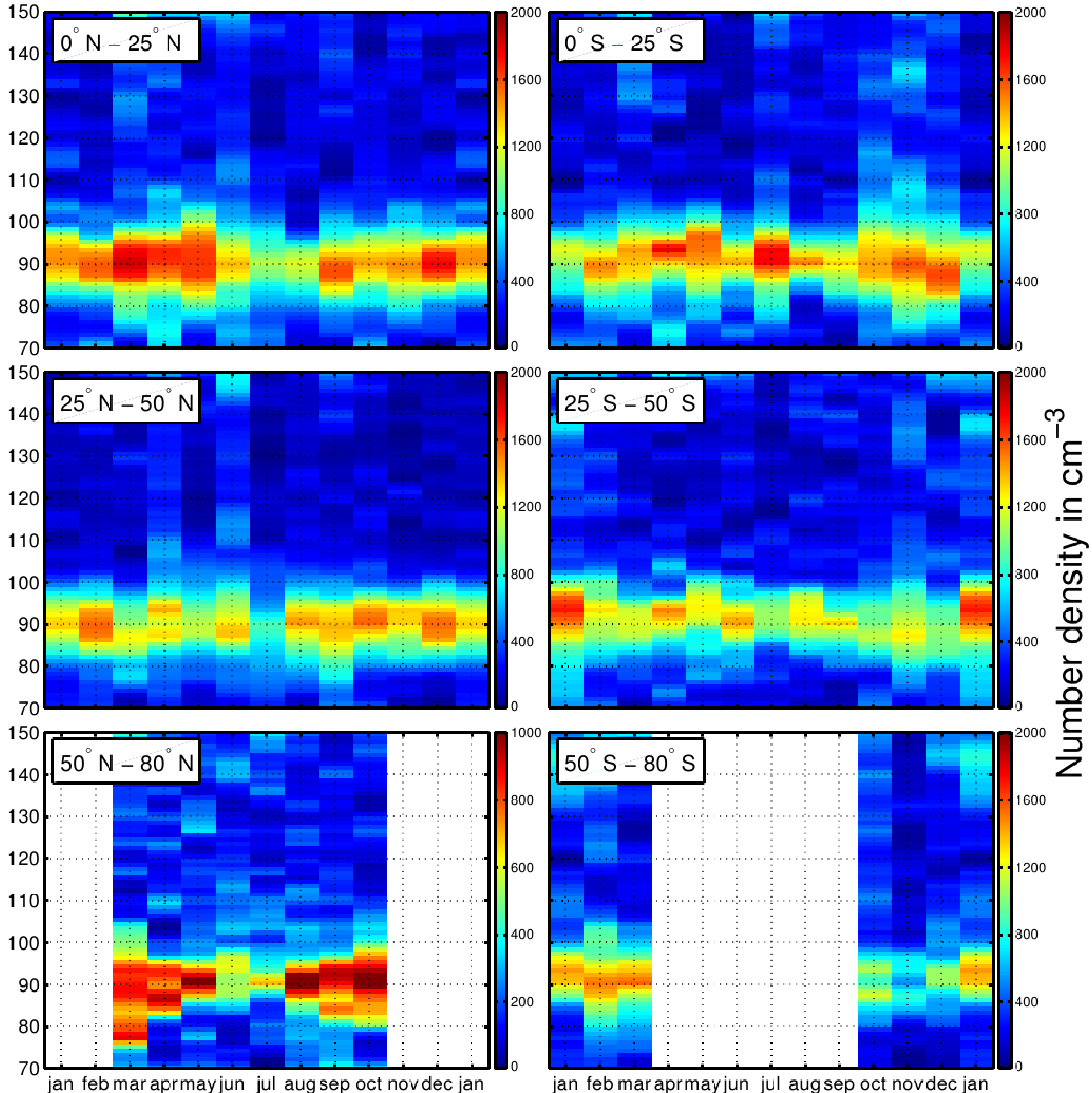
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Altitude in km
Number density in cm^{-3}
Latitude in ° N
150
140
130
120
110
100
90
80
70
2000
1600
1200
800
400
0
−60 −82 −60 −40 −20 0 20 40 60 82 60

4-years average Mg density

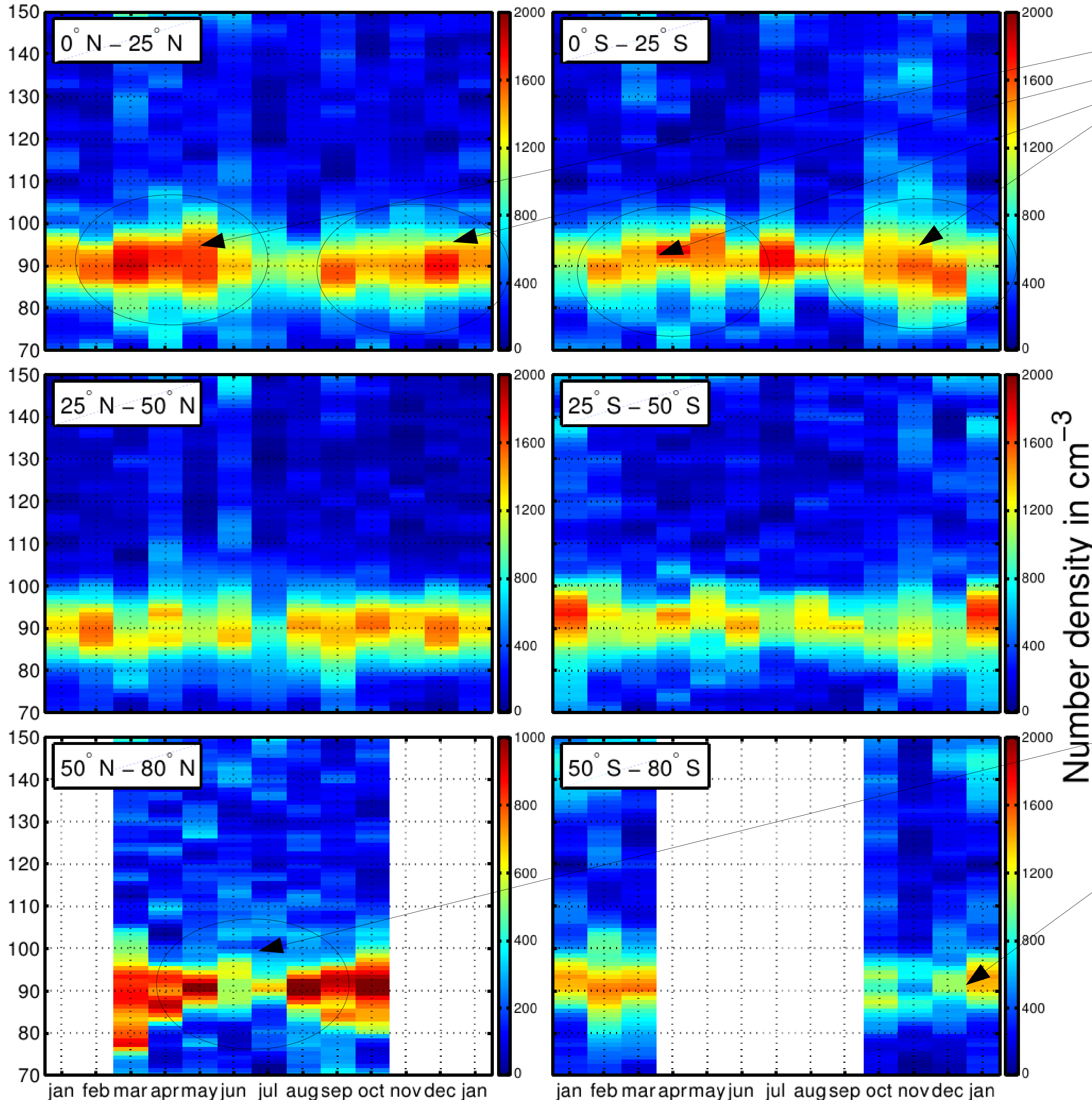




x 10^9
50 S – 80 S
25 S – 50 S
0 S – 25 S
10 S – 10 N
0 N – 25 N
25 N – 50 N
50 N – 80 N
MSAO?
VCD in cm^−2
0
1
2
3
4
5
6
7
jan
feb
mar
apr
may
jun
jul
aug
sep
oct
nov
dec
jan
Month



- Peak altitute close to 90 km
- Low seasonal variability compared to month to month variation
- Very different behavior at poles

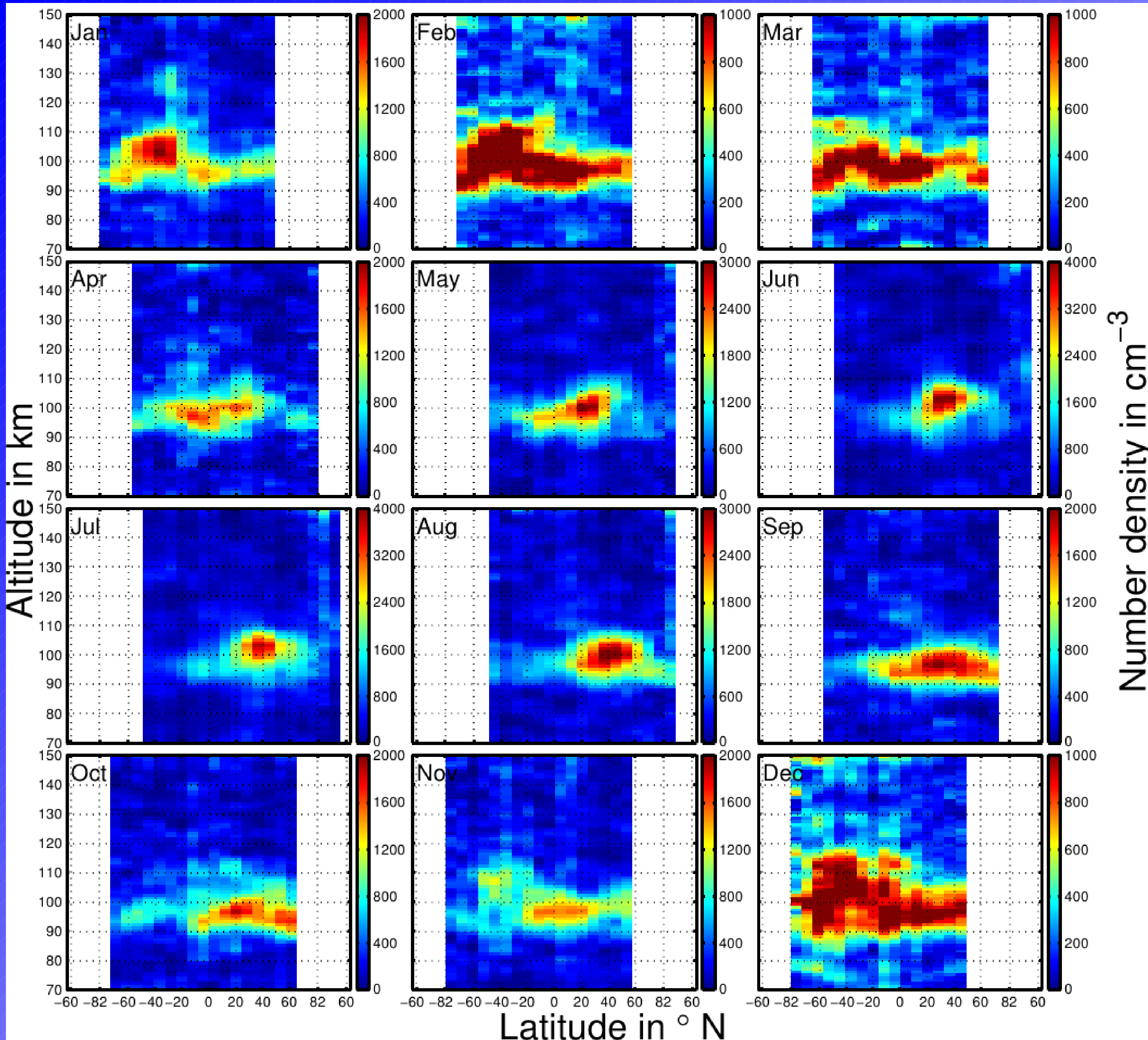


- MSAO?

- PMC formation?
- Difference North/Southpole to ion transport on magnetic field lines?

Mg^+

- Similar results for 279,6 nm line and 280,4 nm line
- Only 279,6 nm line shown here

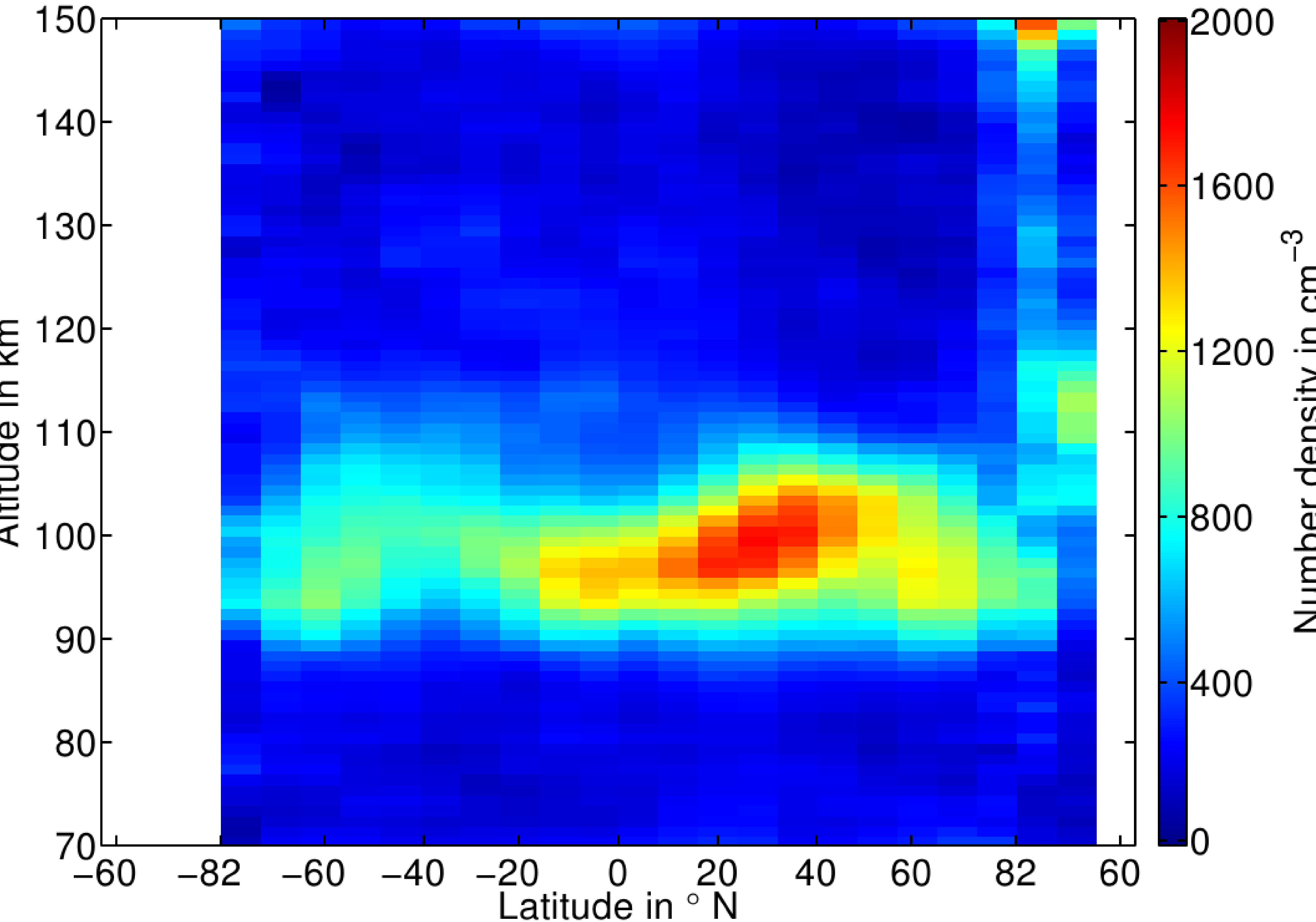


Summer Maximum

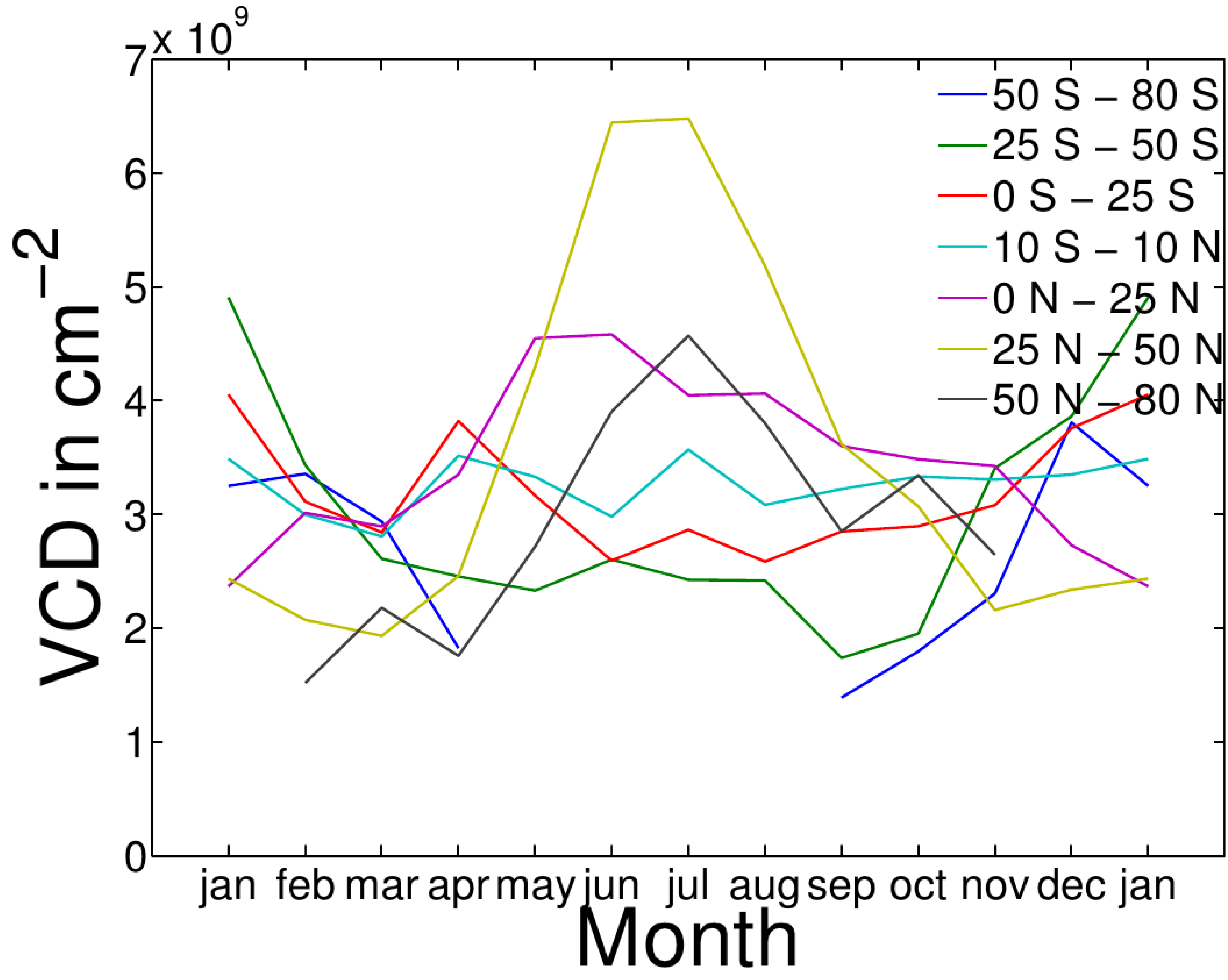
Highest density at 20°-50°

Peak altitude higher at mid latitudes than at equator

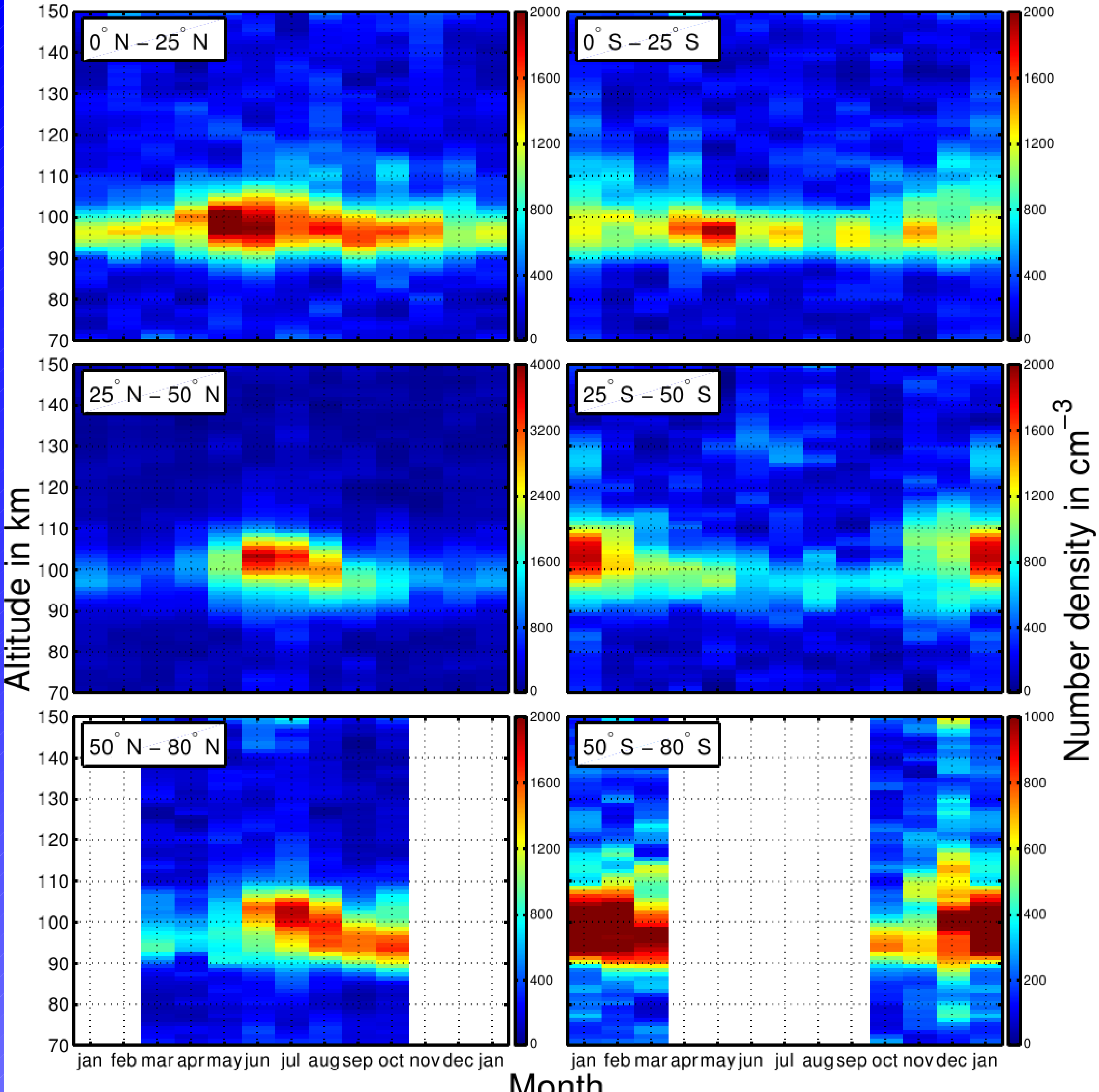
Asymmetry between N/S hemisphere



150
140
130
120
110
100
90
80
70
Altitude in km
−60
−82
−60
−40
−20
0
20
40
60
82
60
Latitude in ° N
2000
1600
1200
800
400
0
Number density in cm−3



x 10^9
0
1
2
3
4
5
6
7
VCD in cm^-2
jan
feb
mar
apr
may
jun
jul
aug
sep
oct
nov
dec
jan
Month
50 S – 80 S
25 S – 50 S
0 S – 25 S
10 S – 10 N
0 N – 25 N
25 N – 50 N
50 N – 80 N

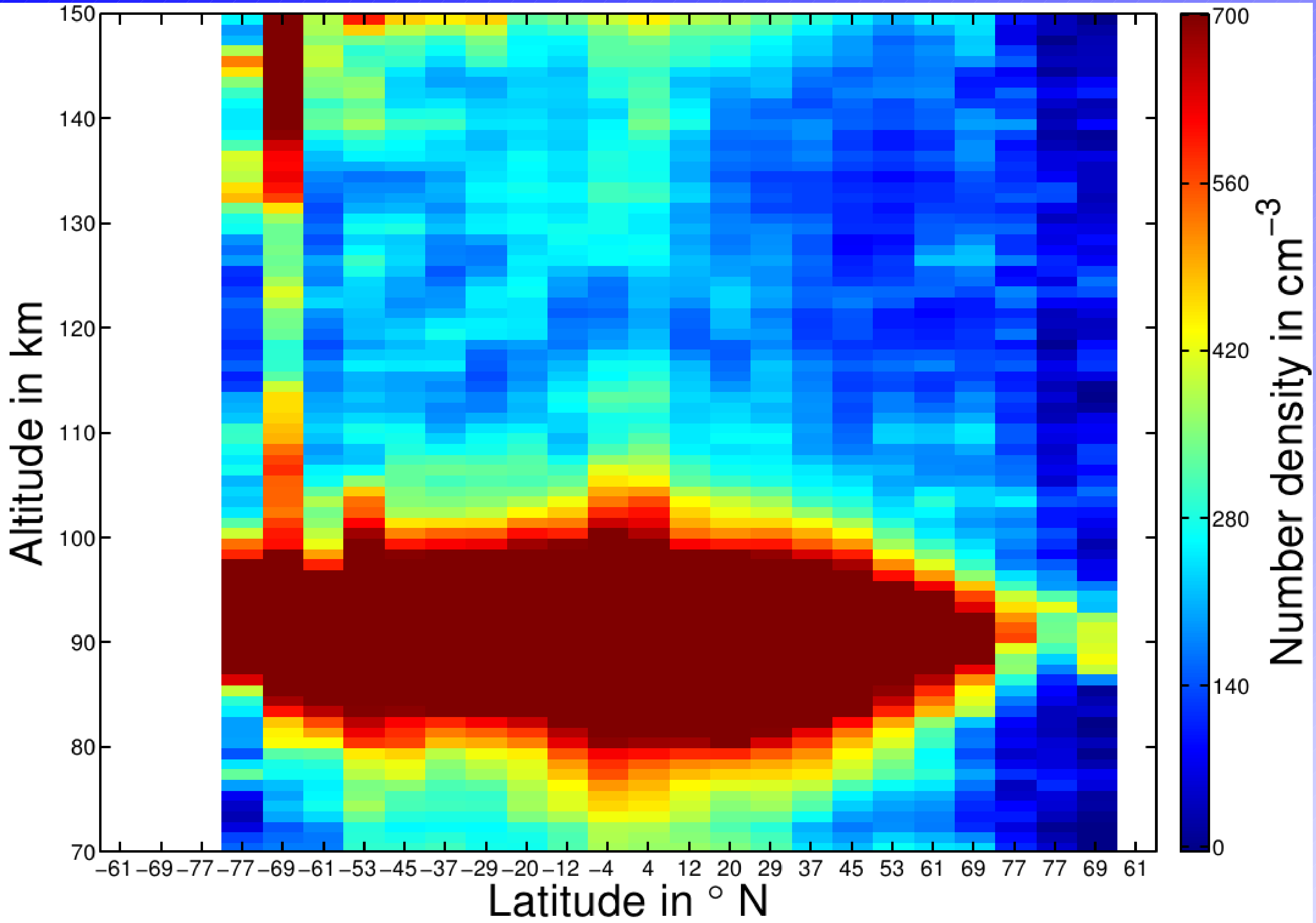


Seasonal variation of peak altitude

Peak altitude up to 10 km higher in summer than in winter

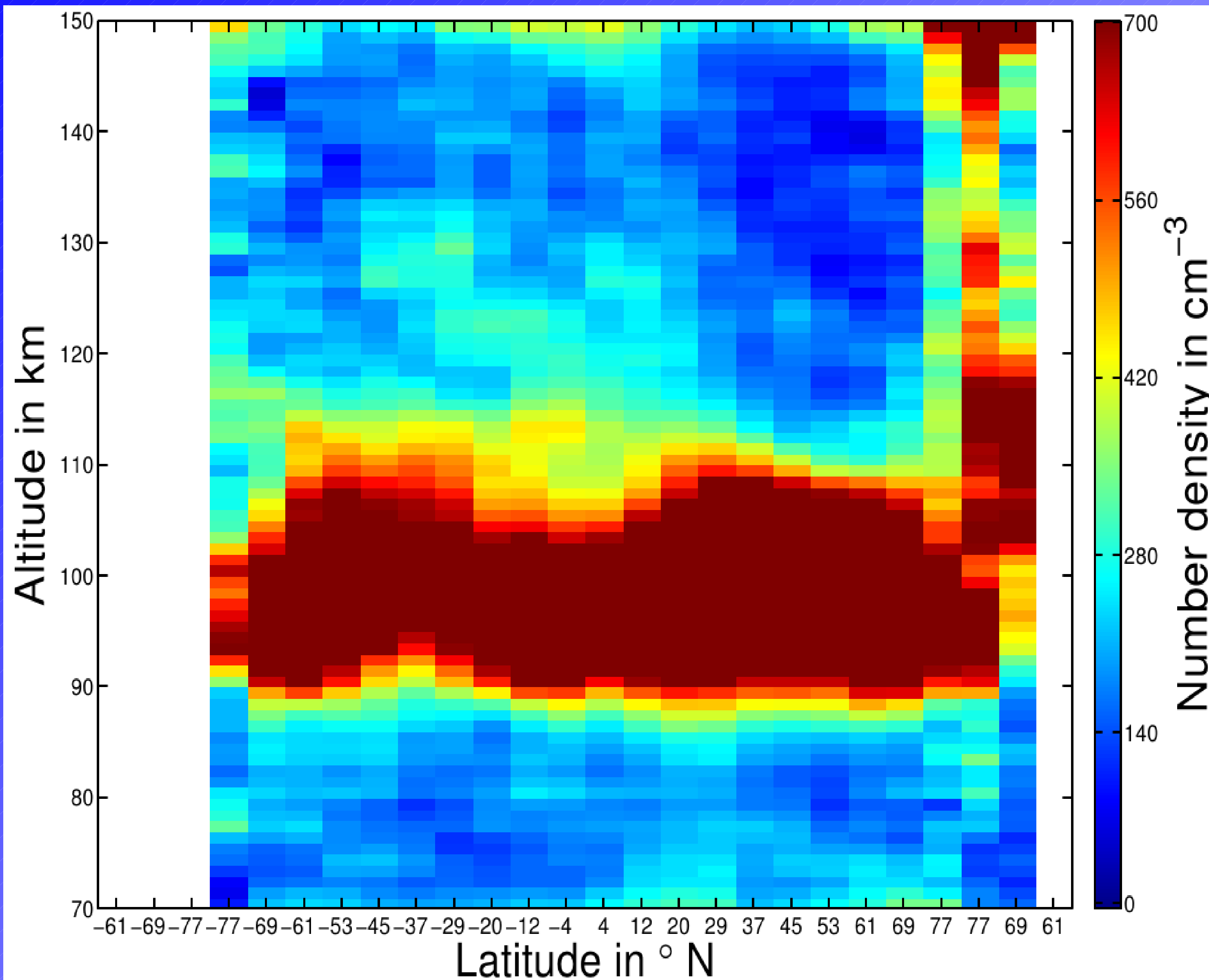
Mean peak altitude lower at the equator

Densities above Peak altitude



Mg

Above 100 km highest densities at equatorial latitudes and southern hemisphere



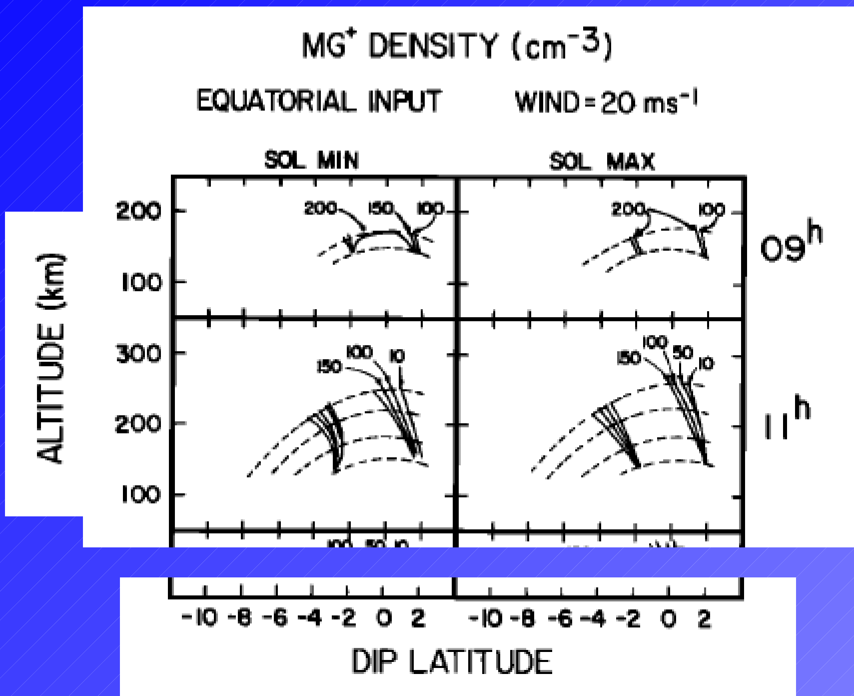
Mg$^+$

Density above peak region high, where peak altitude is low

High density at equator

High density at polar night side

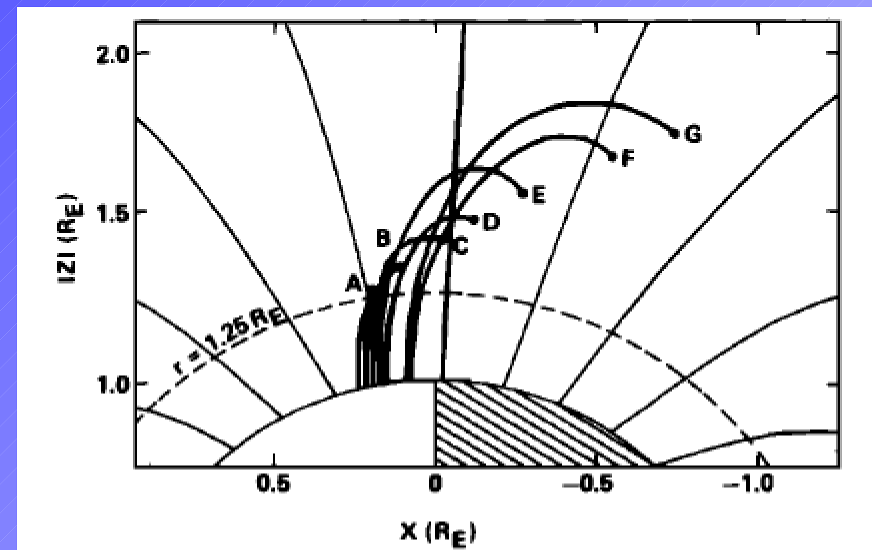
Equatorial outflow



From Fesen et al,JGR,Vol 88, A4, p 3211,1983

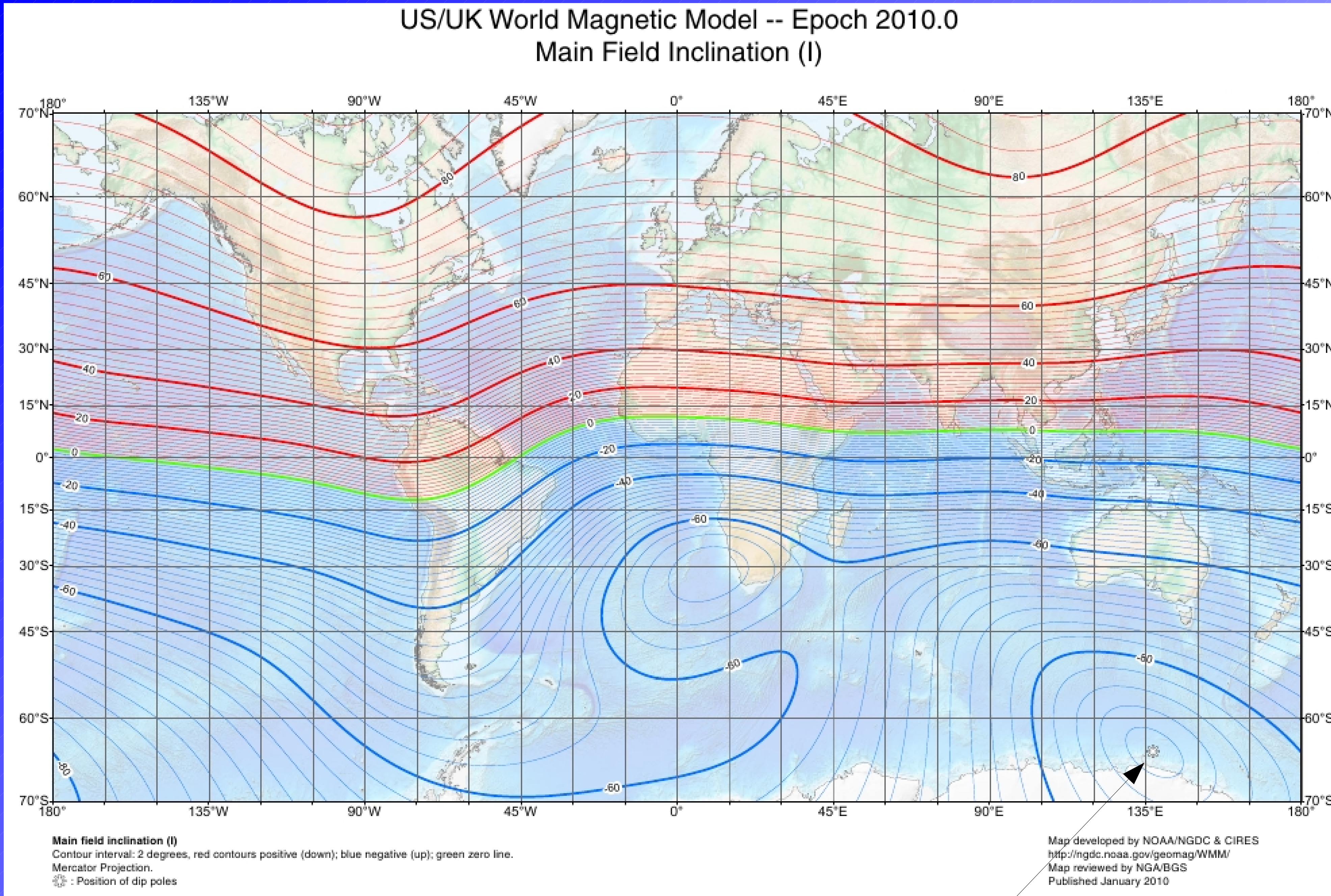
- Earth B field pointing from N->S
- Ions and electrons gyrate with different gyroradii and direction -> E Field E->W perpendicular to B field
- ExB Drift perpendicular to both in vertical direction leads to upward transport of ions

Cleft ion fountain

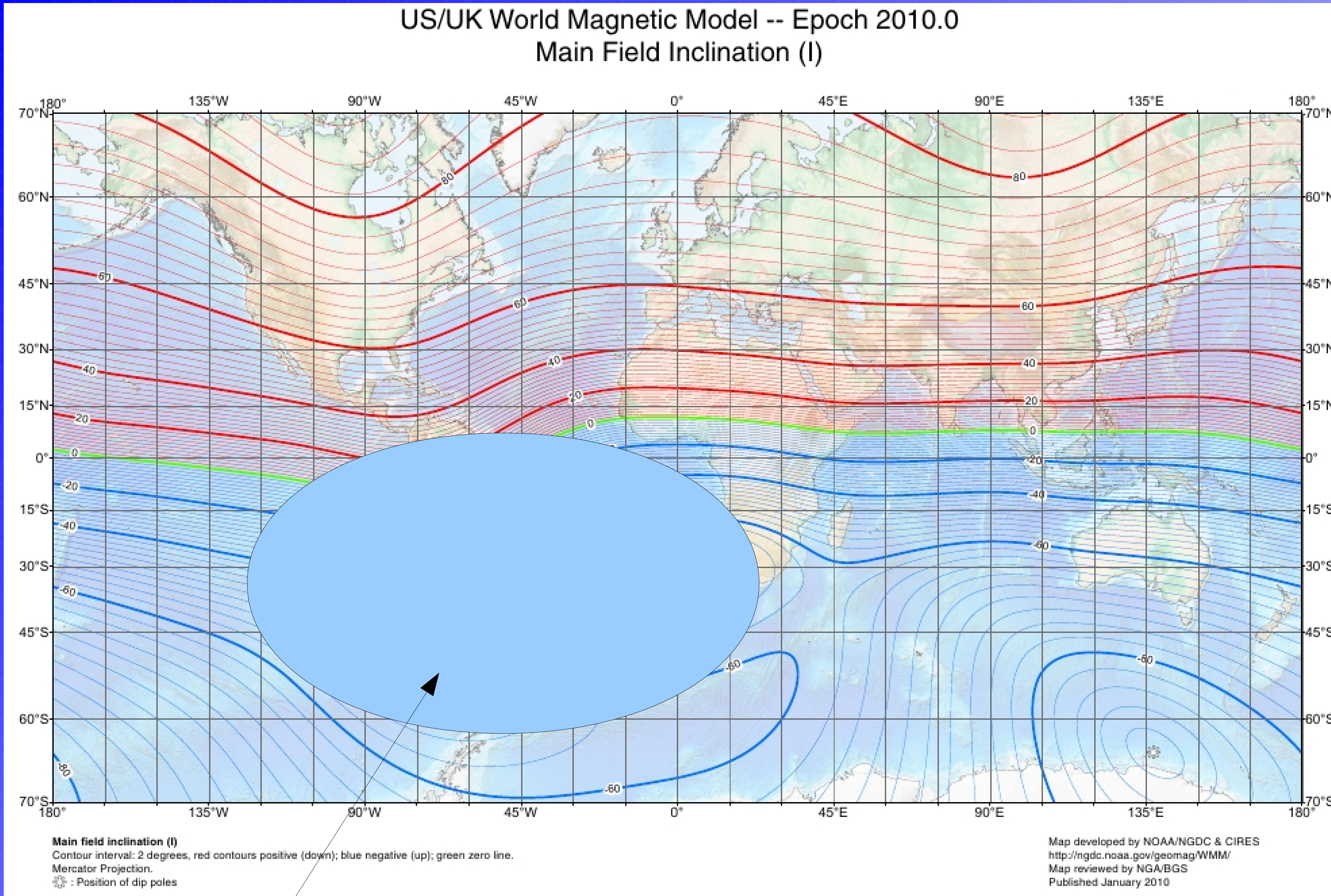


O+ transport from Lockwood et al,JGR,Vol 90, A10, p 9736,1985

- Earth B field lines close at pole
- Ions move along field lines
- Upward transport at dayside
- Heavy ions are transported downwards at nightside through sedimentation



- Northpole 82° Southpole 65°



SAA region, excluded in averaging

No good match of geomagnetic and geographic southpole

Summary

- Mg Peaks at 90 km
- Shows only few seasonal variations, beside possibly MSOA
- Mg+ Peaks at 95 to 105 km
- Mg+ shows strong seasonal variation in Density and Peak altitude, with summer maximum
- Peak altitude shows latitudinal dependence with Peak altitudes at mid latitudes up to 10 km higher than at the equator
- Typical FWHM of Mg/Mg^+ layer 12-15 km
- Mg^+ shows increased density above the peak region, where peak altitude is low
- This can be explained by vertical transport mechanism in the ionosphere

Thank you for your attention

Thanks to EOARD for funding this project!