Thermospheric Variability MCDP Work

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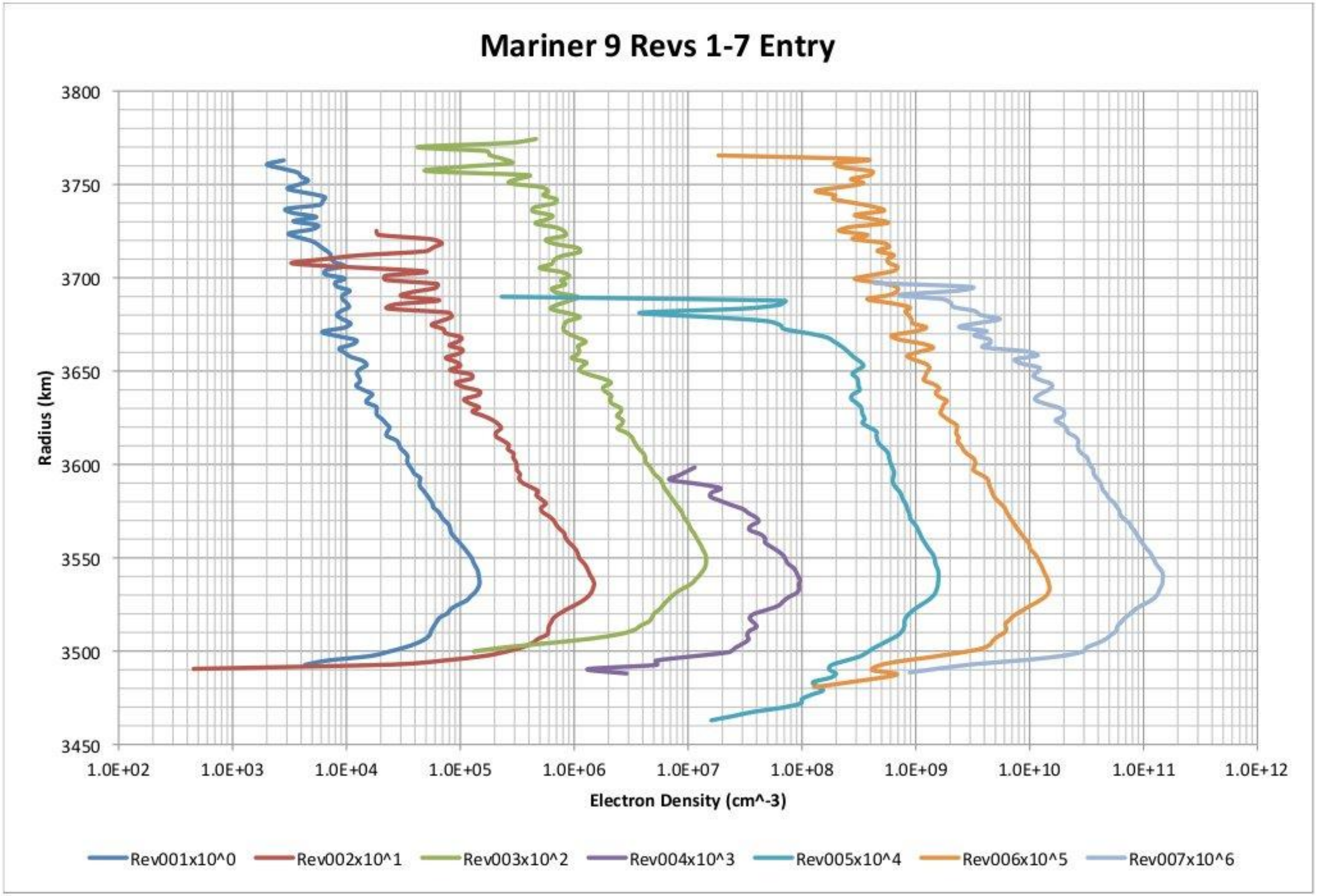
But first… Mariner 9 radio occultation electron density profiles



~100 found at NSSDC

Extend to ~400km Ionopause height (Unlike MGS)

Spans immense dust storm

Better geographical and SZA coverage than MGS

Anyone want digital copies of these ~100 profiles?

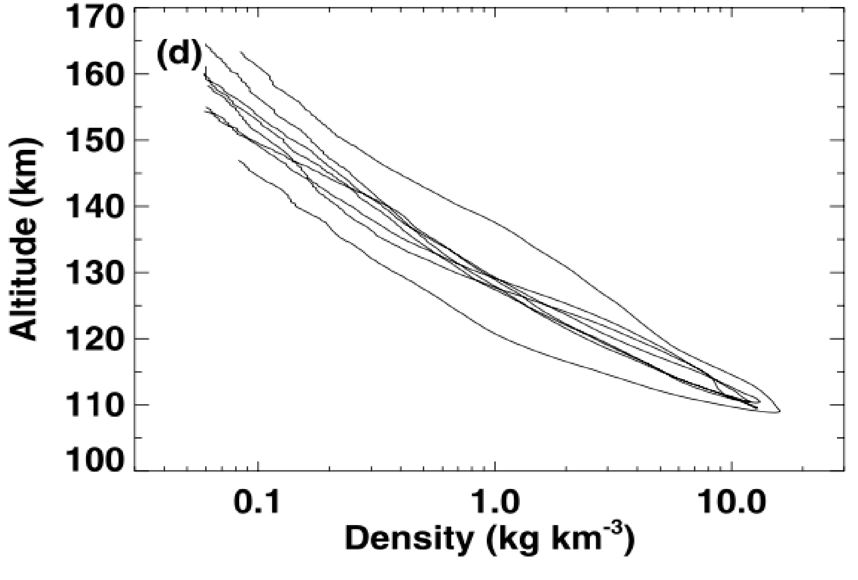
What's the weather like at 150 km?

- Climate = What you expect (predictions from models)
- Weather = What you get (less predictable from numerical models)

- Operations need predictions of <u>both</u>
- I'm working on some data products associated with empirical measurements of thermospheric variability

Aerobraking accelerometers

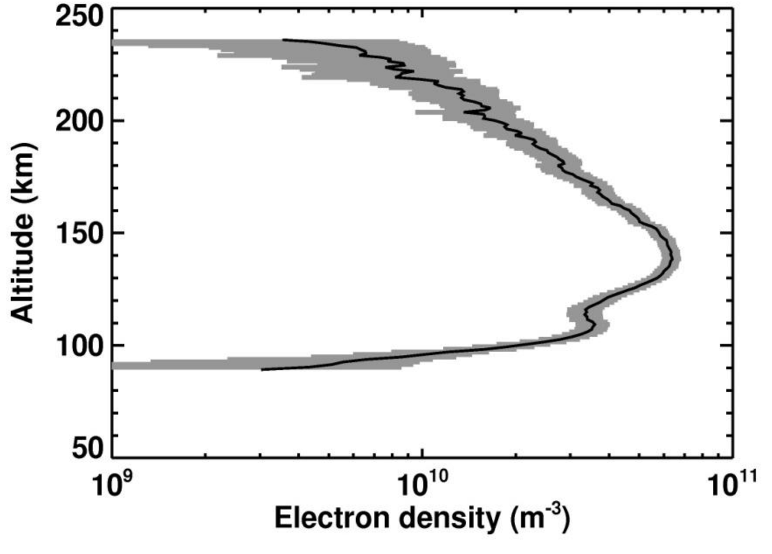
- MGS, ODY, MRO sampled range of seasons, locations, times of day, solar cycle, etc
- Density profiles, as well as density scale heights
- Pressure proportional to density x scale height

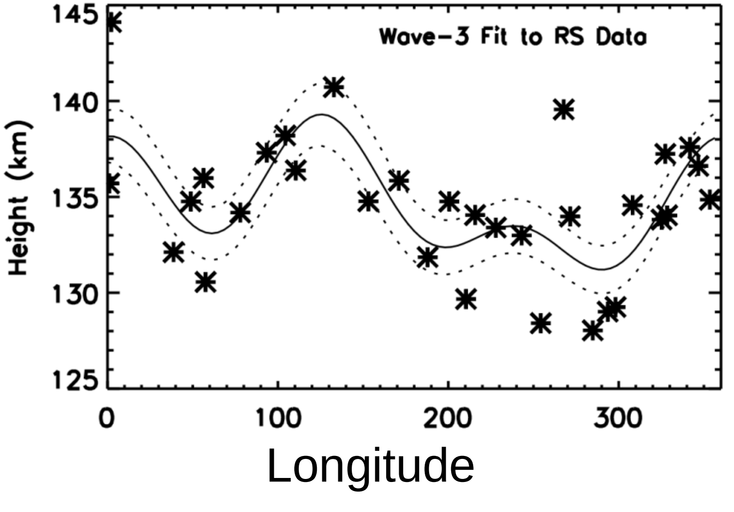


These four profiles should be identical

MGS RS ionospheric data

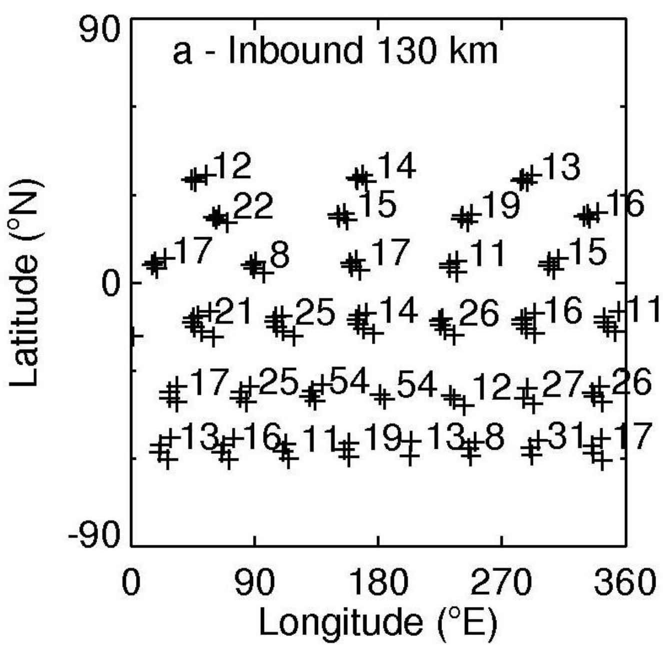
- 5600 profiles of electron density vs altitude
- Altitude of peak occurs at predictable pressure level
- Width of peak indicates neutral temperature





Task 1 (Intrinsic variability)

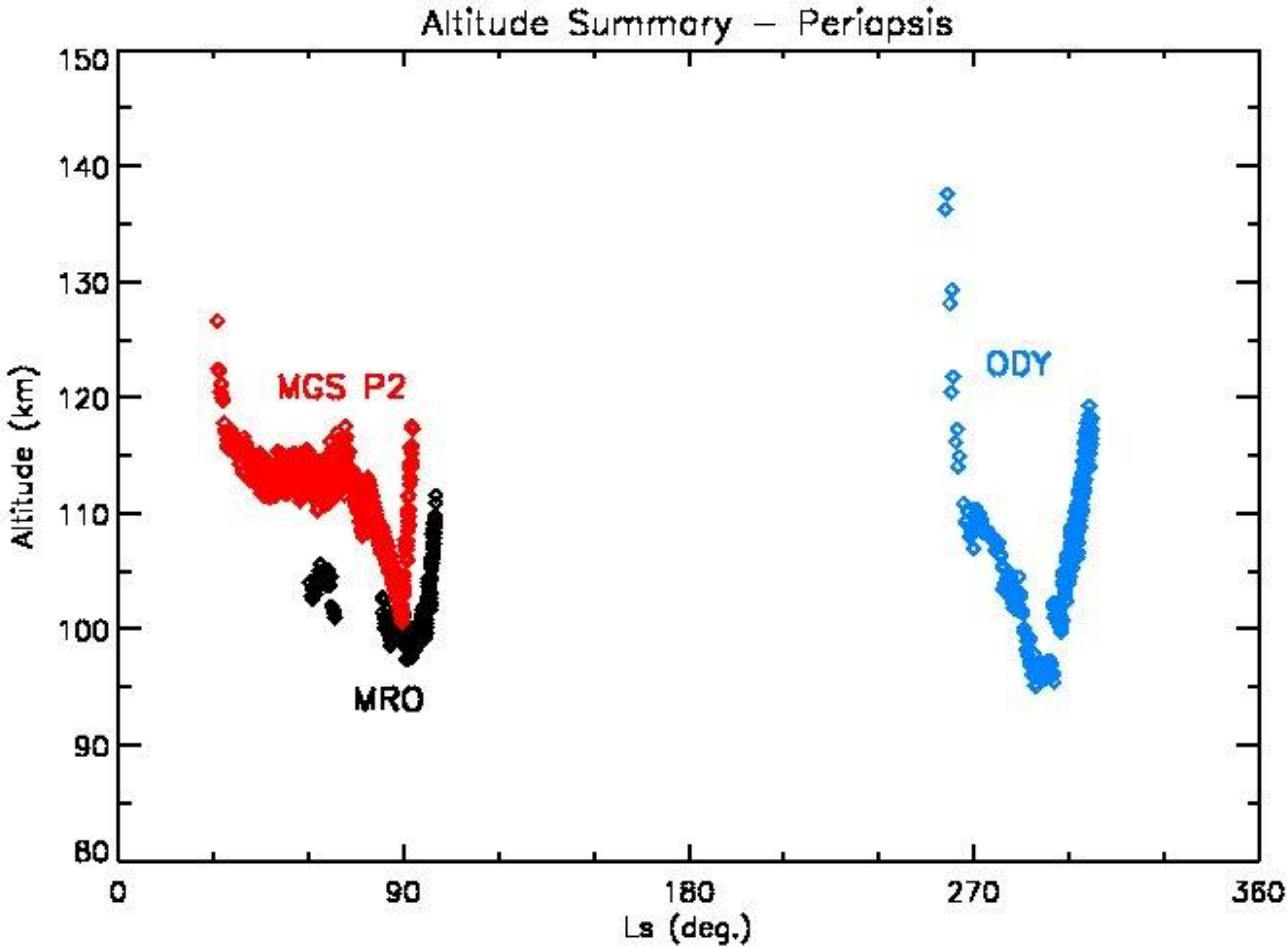
- Variability at same Ls, latitude, longitude, LST, altitude (everything but day-to-day)
- Occurs for aerobraking when period x N = sol

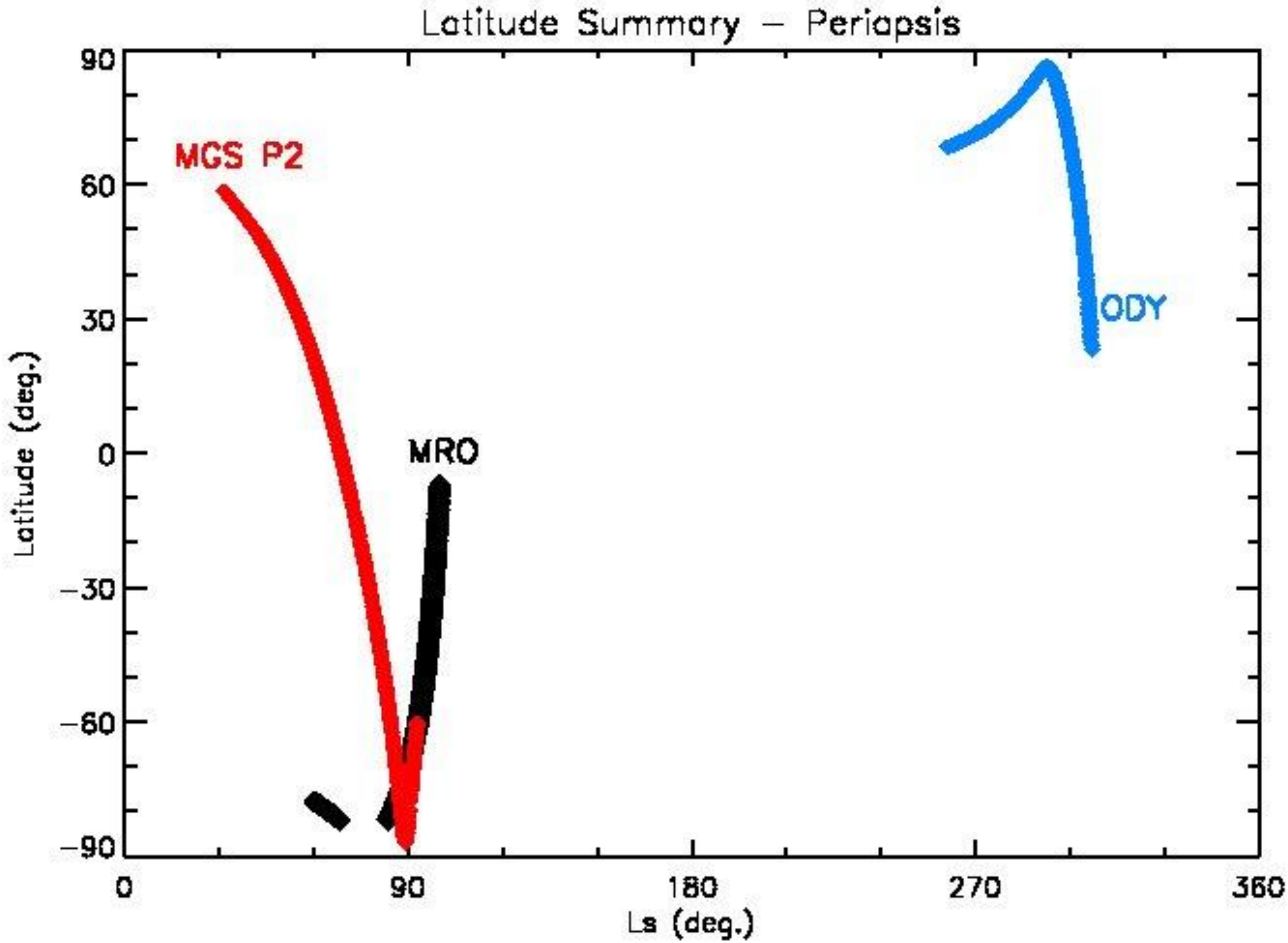


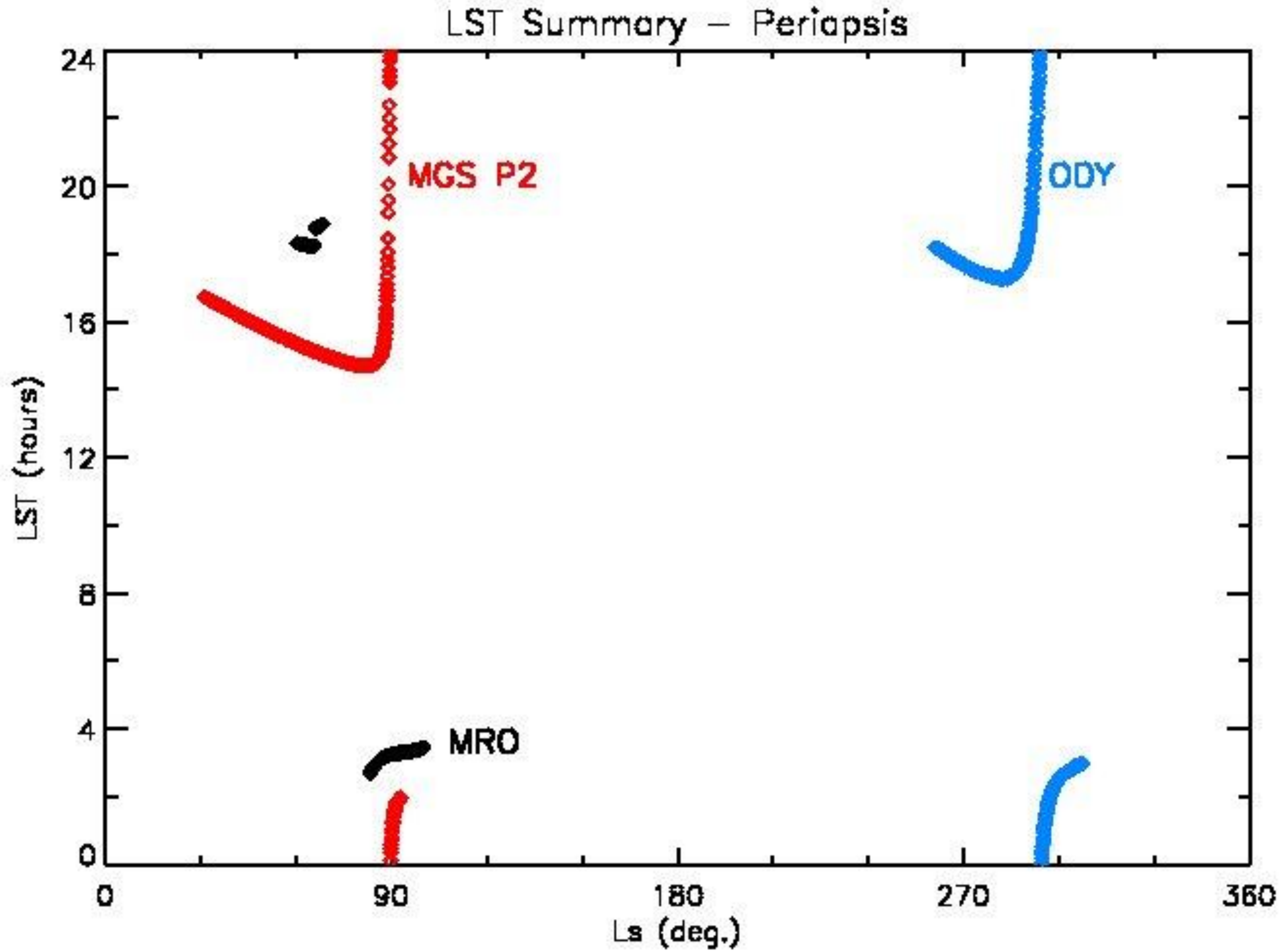
Numbers are standard deviation of selected density measurements relative to mean

Task 1 – Accelerometer results

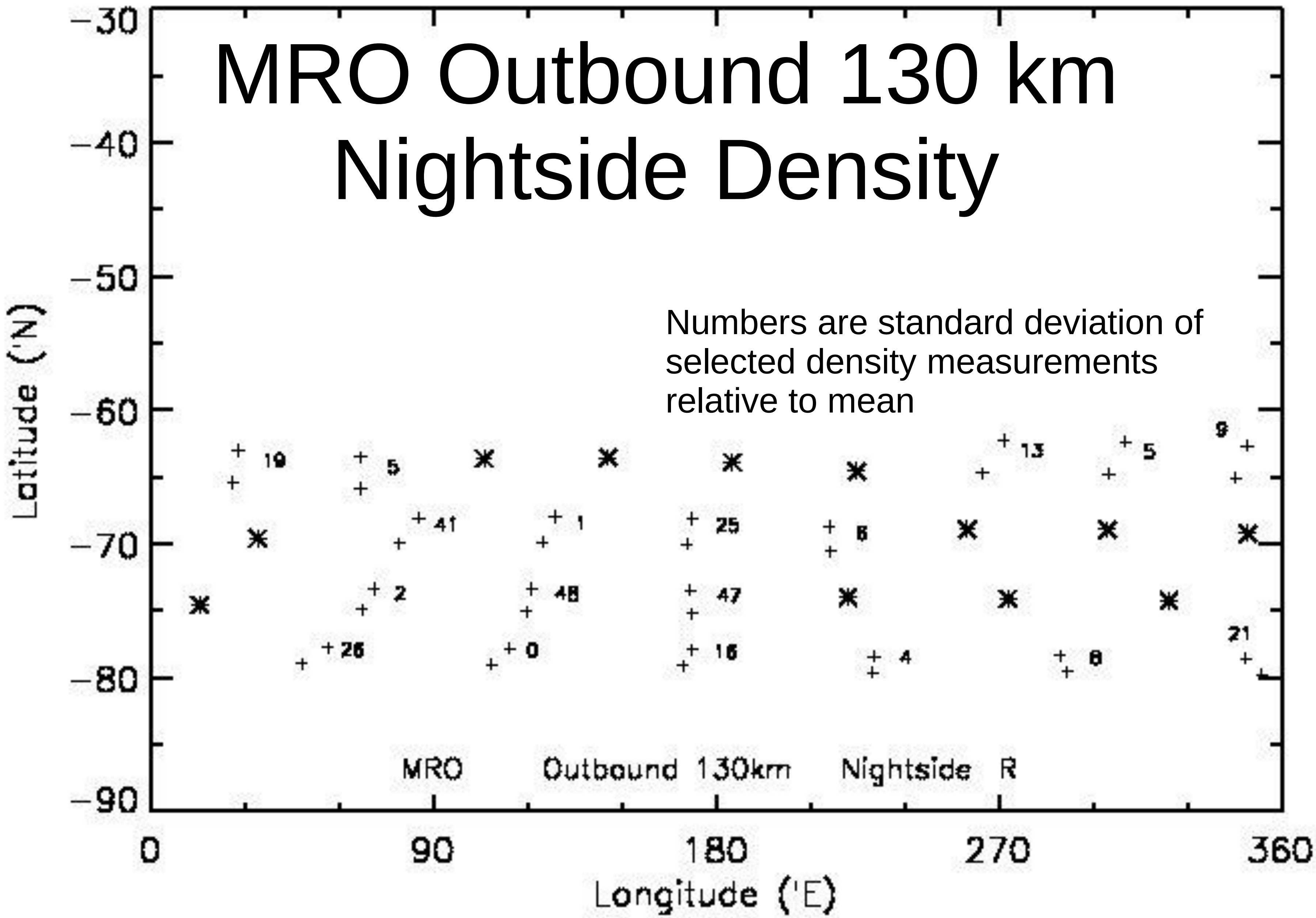
- MGS, ODY, MRO
- Inbound and outbound
- Dayside and nightside
- 100 km to 160 km in 10 km intervals
- Density, density scale height, pressure(-ish)


Altitude Summary – Periapsis
Altitude (km)
150
140
130
120
110
100
90
80
0
90
180
270
360
Ls (deg.)
MGS P2
MRO
ODY

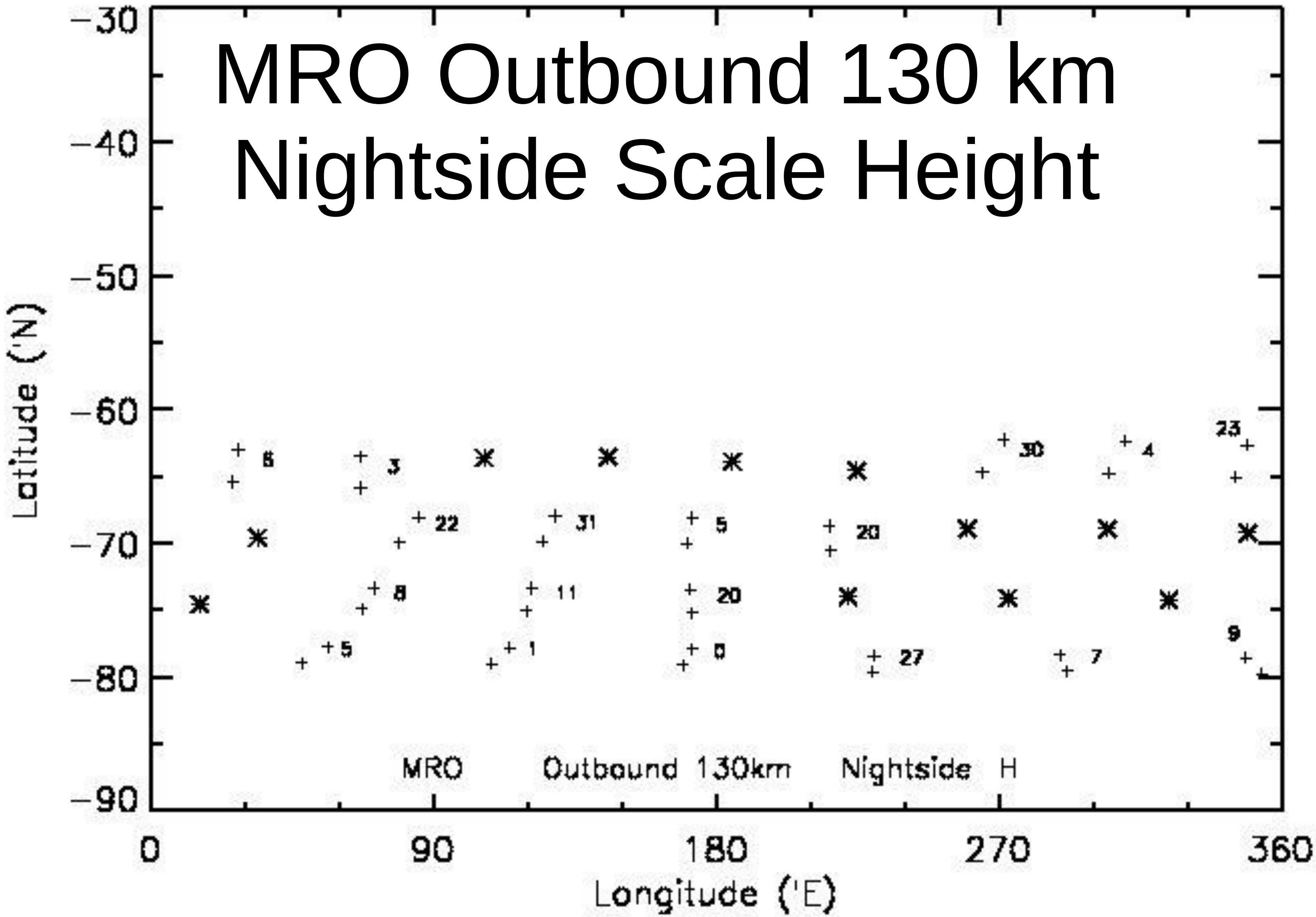

Latitude Summary – Periapsis
MGS P2
MRO
ODY
90
60
30
0
–30
–60
–90
Latitude (deg.)
0
90
180
270
360
Ls (deg.)


LST Summary – Periapsis
LST (hours)
Ls (deg.)
MGS P2
ODY
MRO
0
4
8
12
16
20
24
0
90
180
270
360

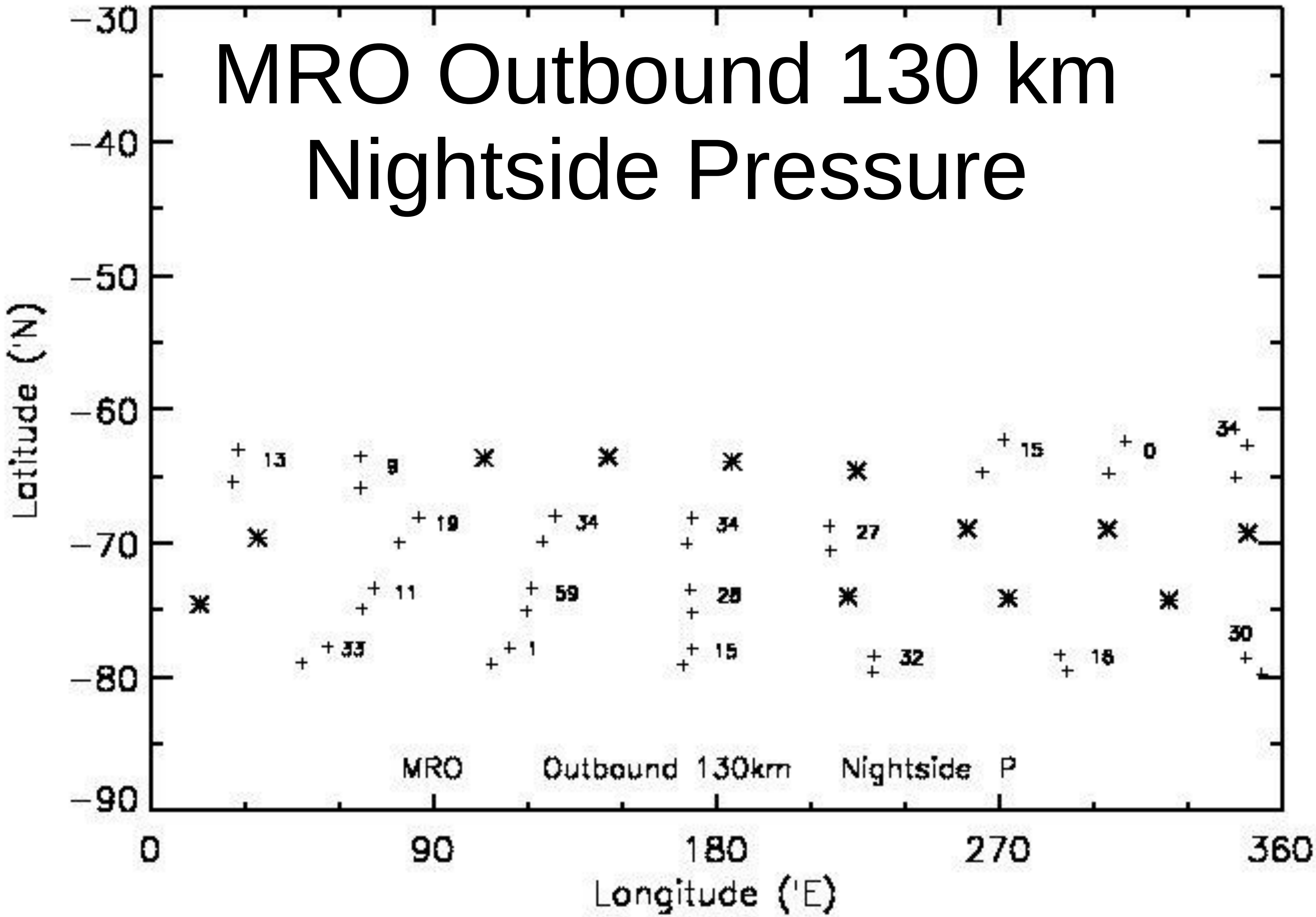
MRO Outbound 130 km Nightside Density



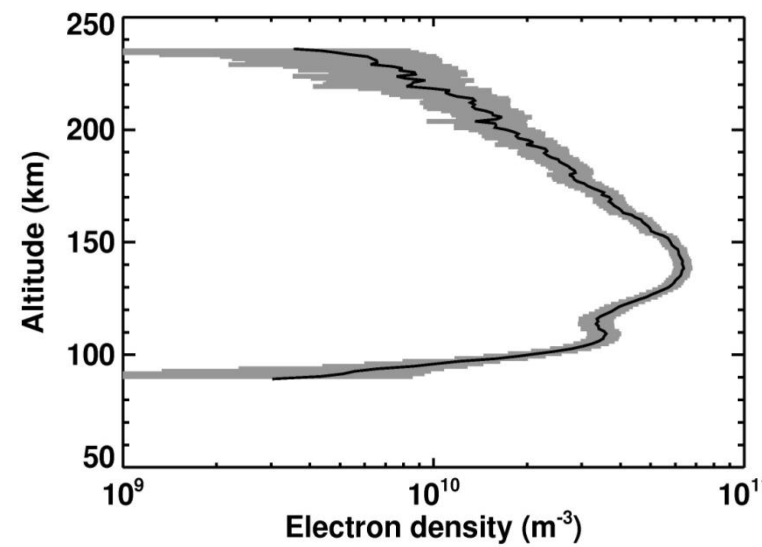
MRO Outbound 130 km Nightside Scale Height



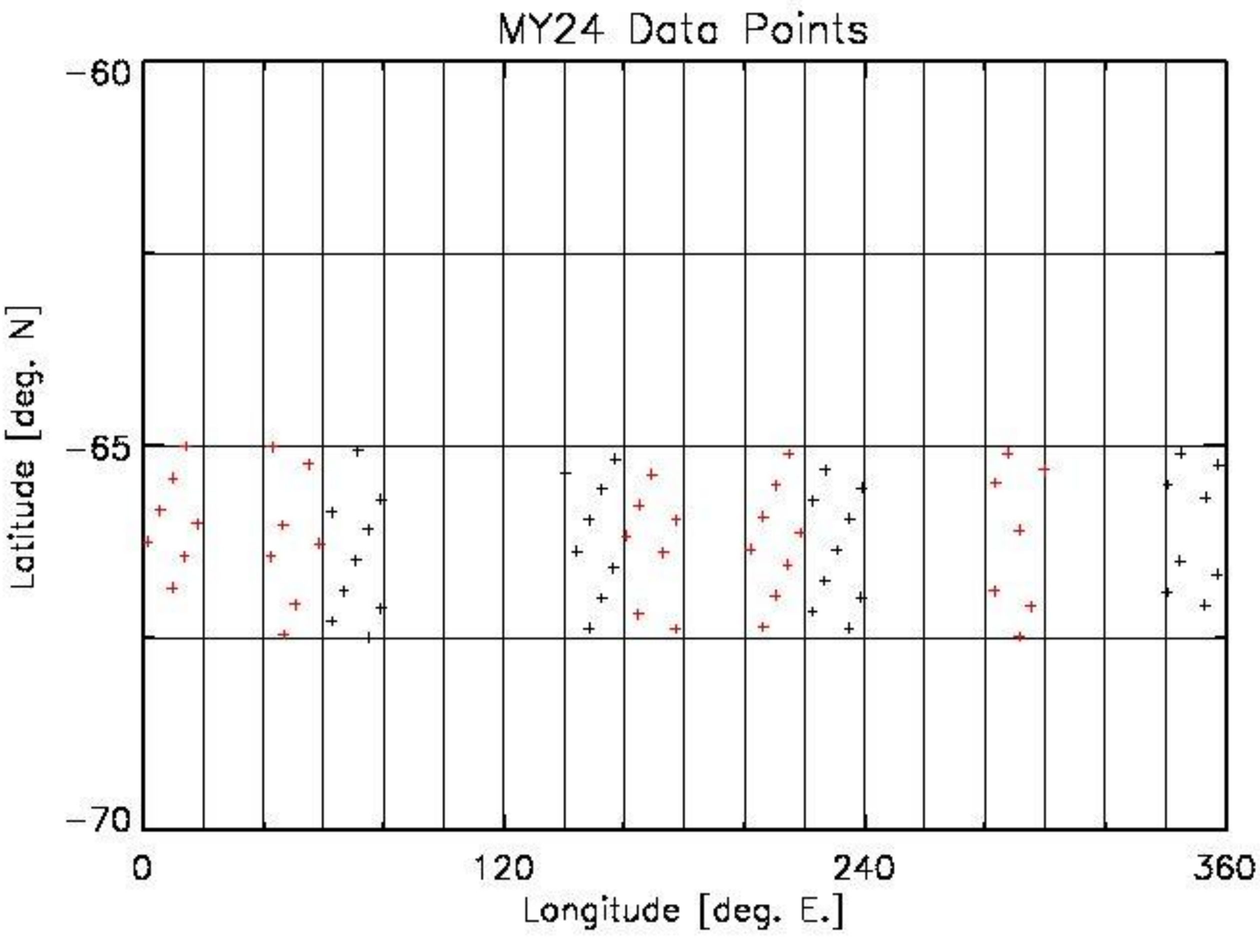
MRO Outbound 130 km Nightside Pressure



Task 1 – Radio science results

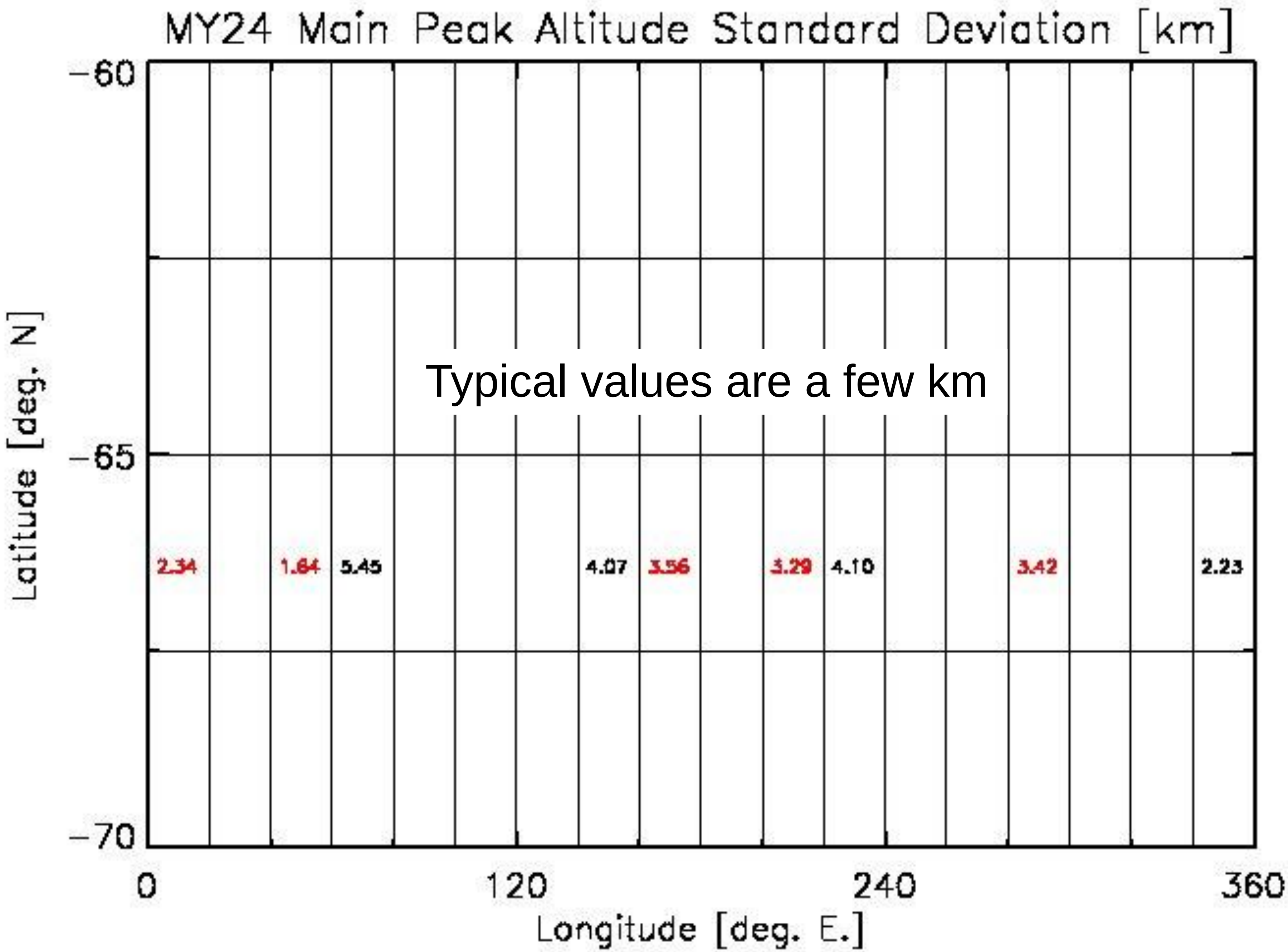


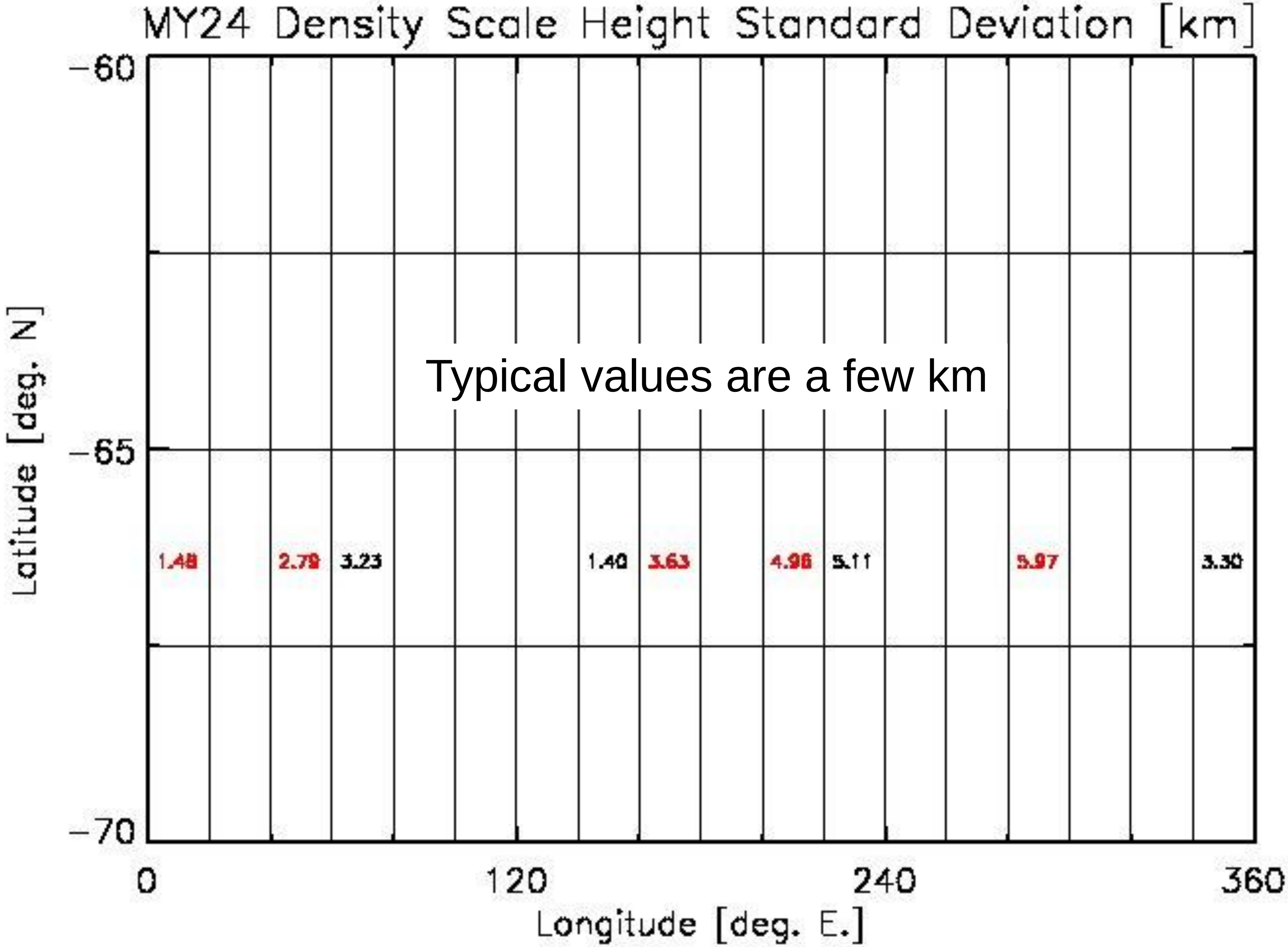
- MGS
- Mars Years 24, 25, 26, and 27
- Variations in peak altitude and fitted scale height
- Also peak altitude changes normalized by scale height (can be used to get sense of variations in pressure at fixed altitude)



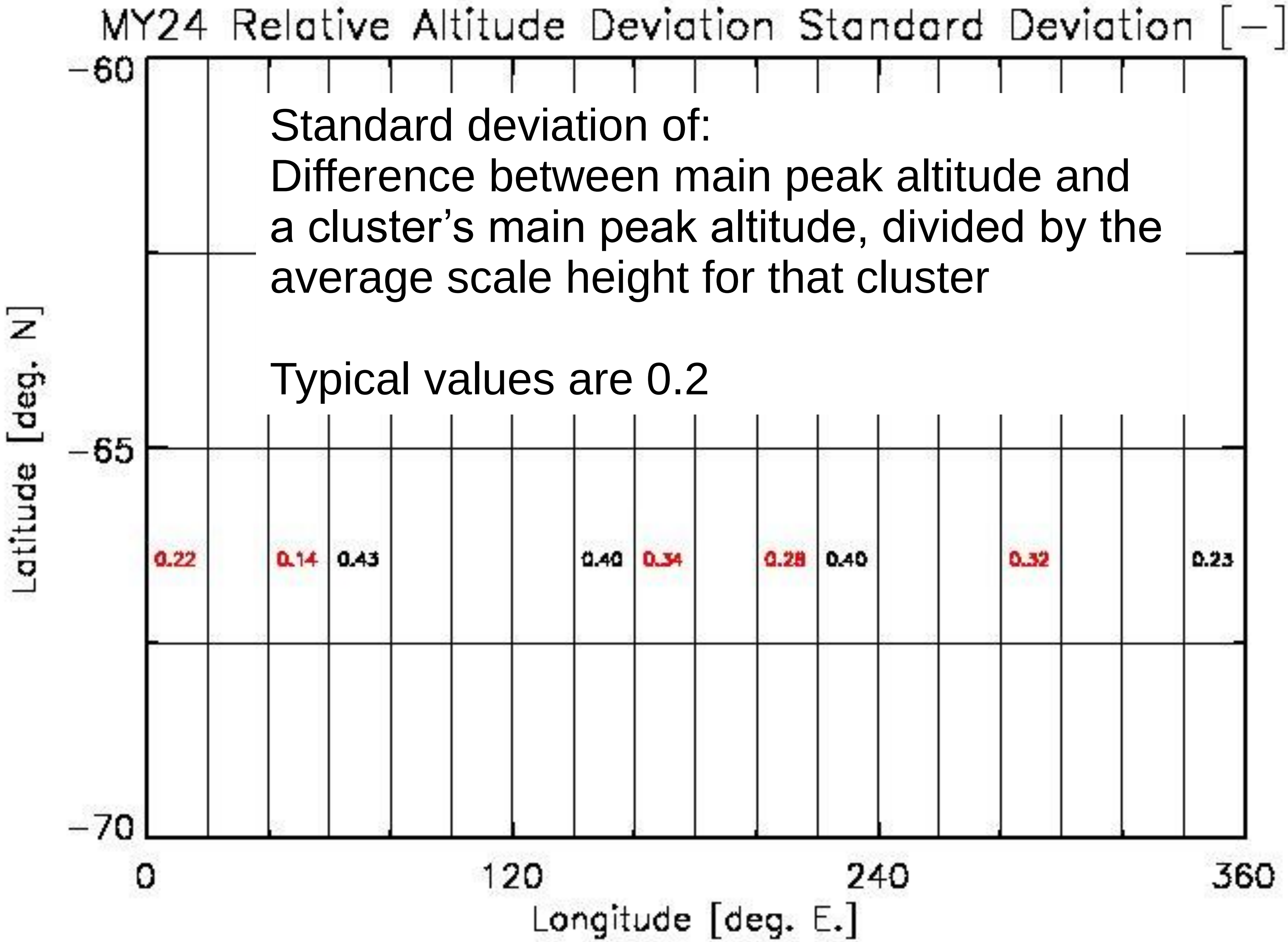
2.5 degree latitude spacing
20 degree longitude spacing
1 hour LST spacing
15 degree Ls spacing

Need 7 points in a 4-D box to define a cluster


MY24 Main Peak Altitude Standard Deviation [km]
Typical values are a few km
-60
-65
-70
Latitude [deg. N]
2.34
1.64
5.45
4.07
3.56
3.29
4.10
3.42
2.23
0
120
240
360
Longitude [deg. E.]

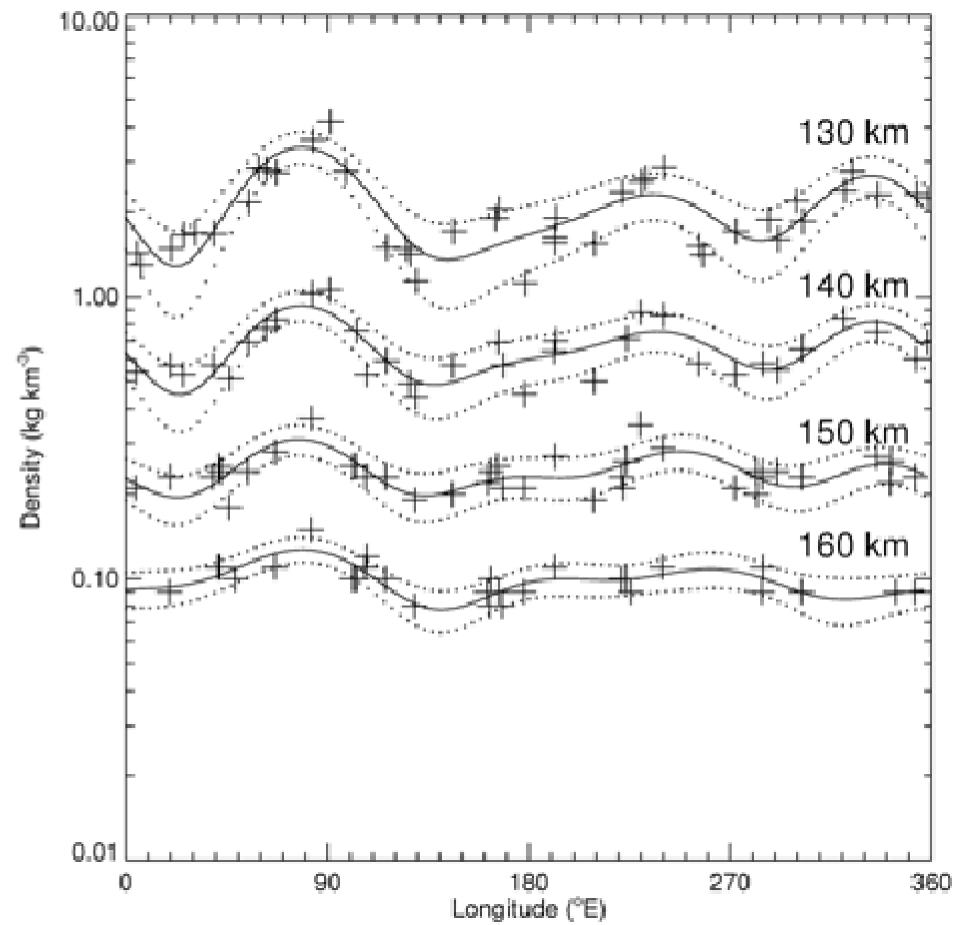


MY24 Density Scale Height Standard Deviation [km]
Typical values are a few km
1.48
2.79
3.23
1.40
3.63
4.96
5.11
5.97
3.30
-60
-65
-70
Latitude [deg. N]
0
120
240
360
Longitude [deg. E.]

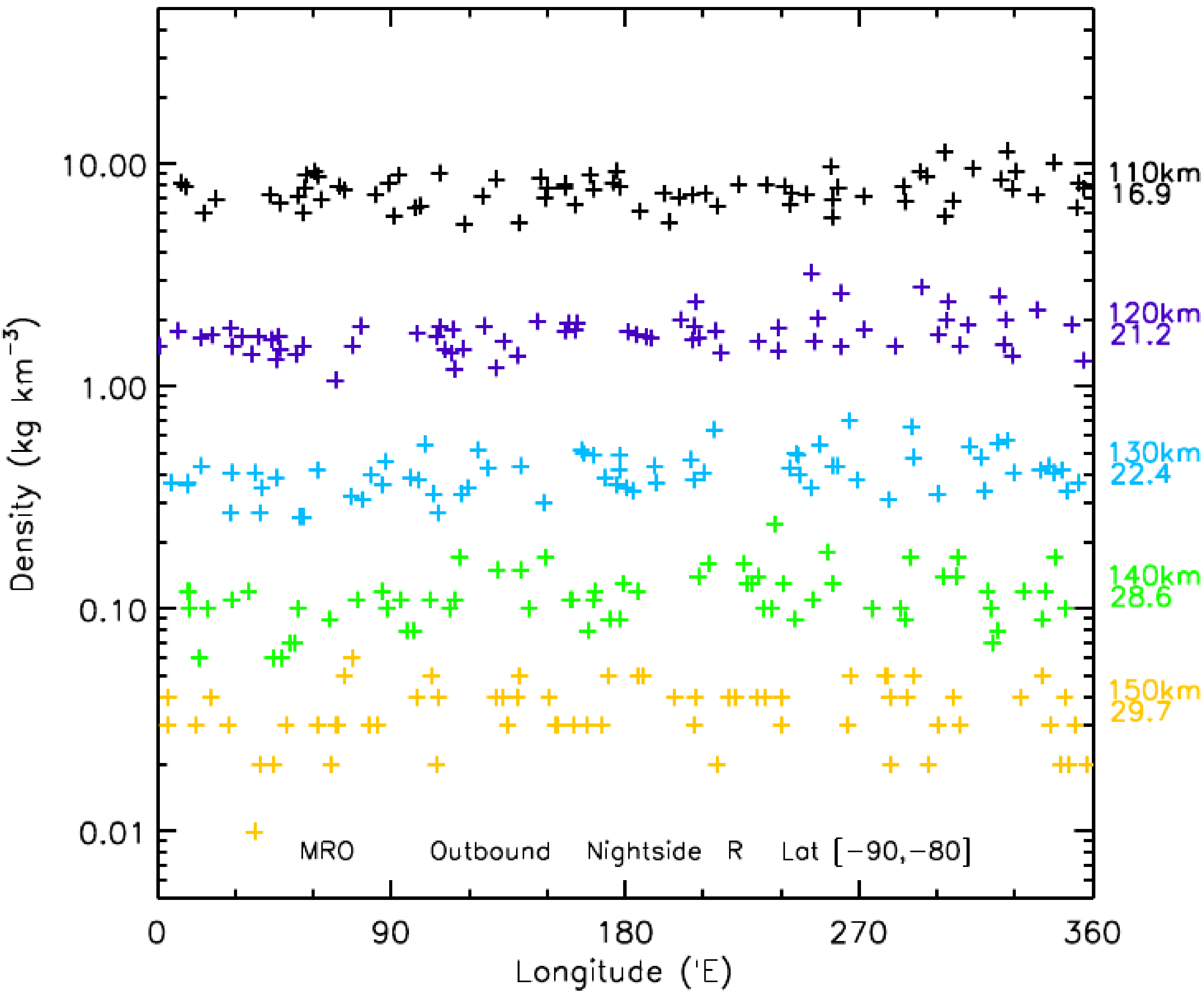

MY24 Relative Altitude Deviation Standard Deviation [–]
Standard deviation of:
Difference between main peak altitude and
a cluster's main peak altitude, divided by the
average scale height for that cluster
Typical values are 0.2
−60
−65
−70
0
120
240
360
Latitude [deg. N]
Longitude [deg. E.]
0.22
0.14
0.43
0.40
0.34
0.28
0.40
0.32
0.23

Task 2 (Variations with longitude)

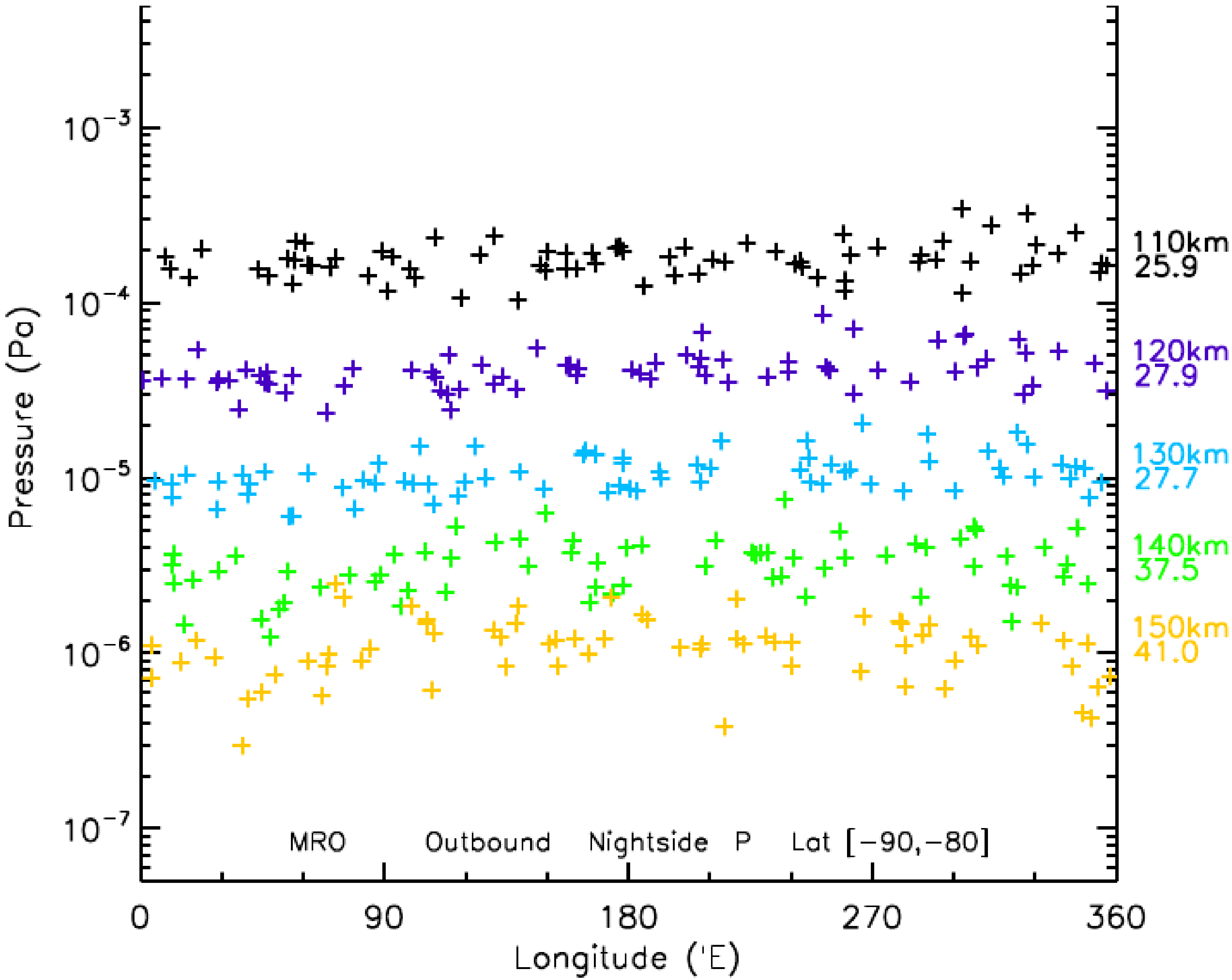
- Longitude has a surprisingly large effect on thermospheric densities and temperatures
- Report standard deviation of density, etc, at fixed Ls, latitude, LST, altitude
- Identify conditions where thermal tides are strong



MRO Outbound Nightside Density from 90S to 80S



MRO Outbound Nightside Pressure from 90S to 80S



Task 2 – Radio science results

Similar sort of approach, using variations in peak altitude and fitted scale height

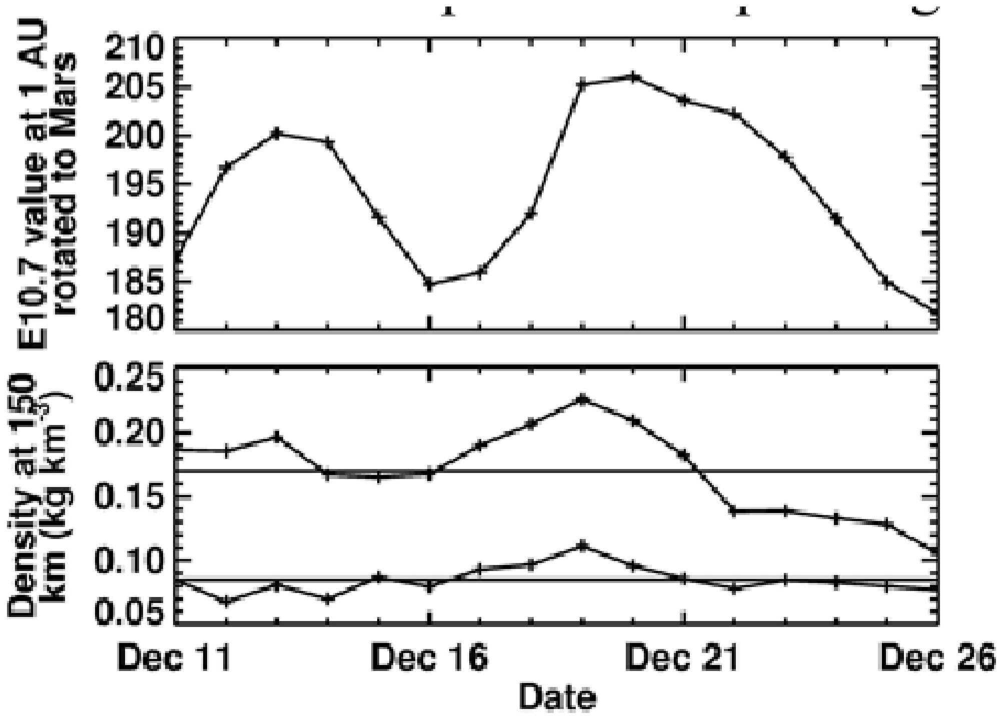
Select Mars Year (e.g. 27) and latitude range (e.g. 60N to 70N)

Find that selected subset of data forms groups with narrow range in Ls (~15-30 deg) and LST (1-2 hrs)

Look at variations with longitude for each group

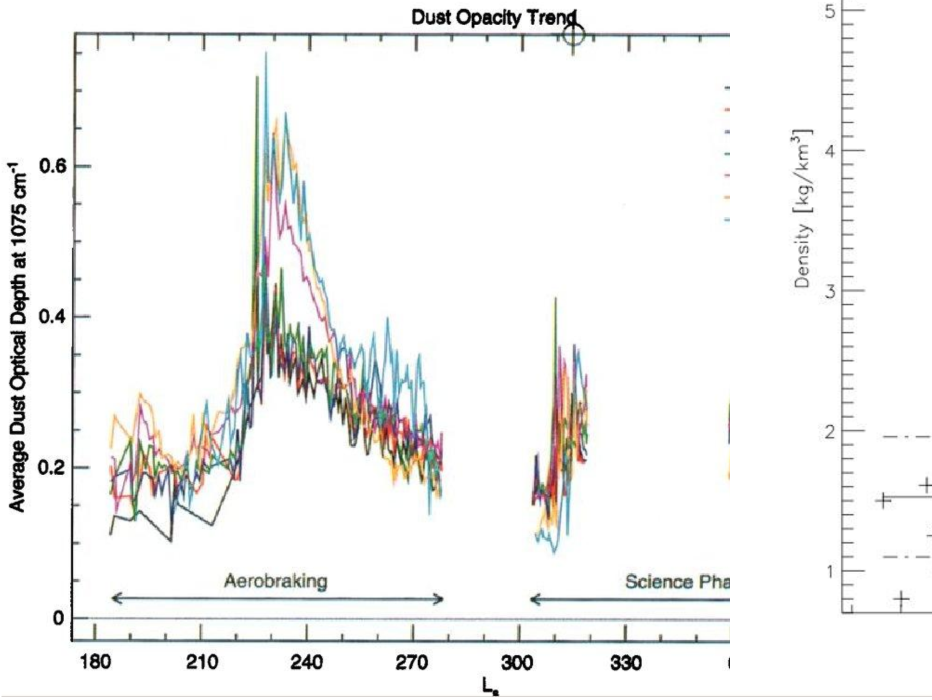
Task 3 (Response to extreme solar events) – <u>not yet started</u>

- Solar flares
- CMEs
- Responses not well-known, may be small and hard to measure
- May be large at times

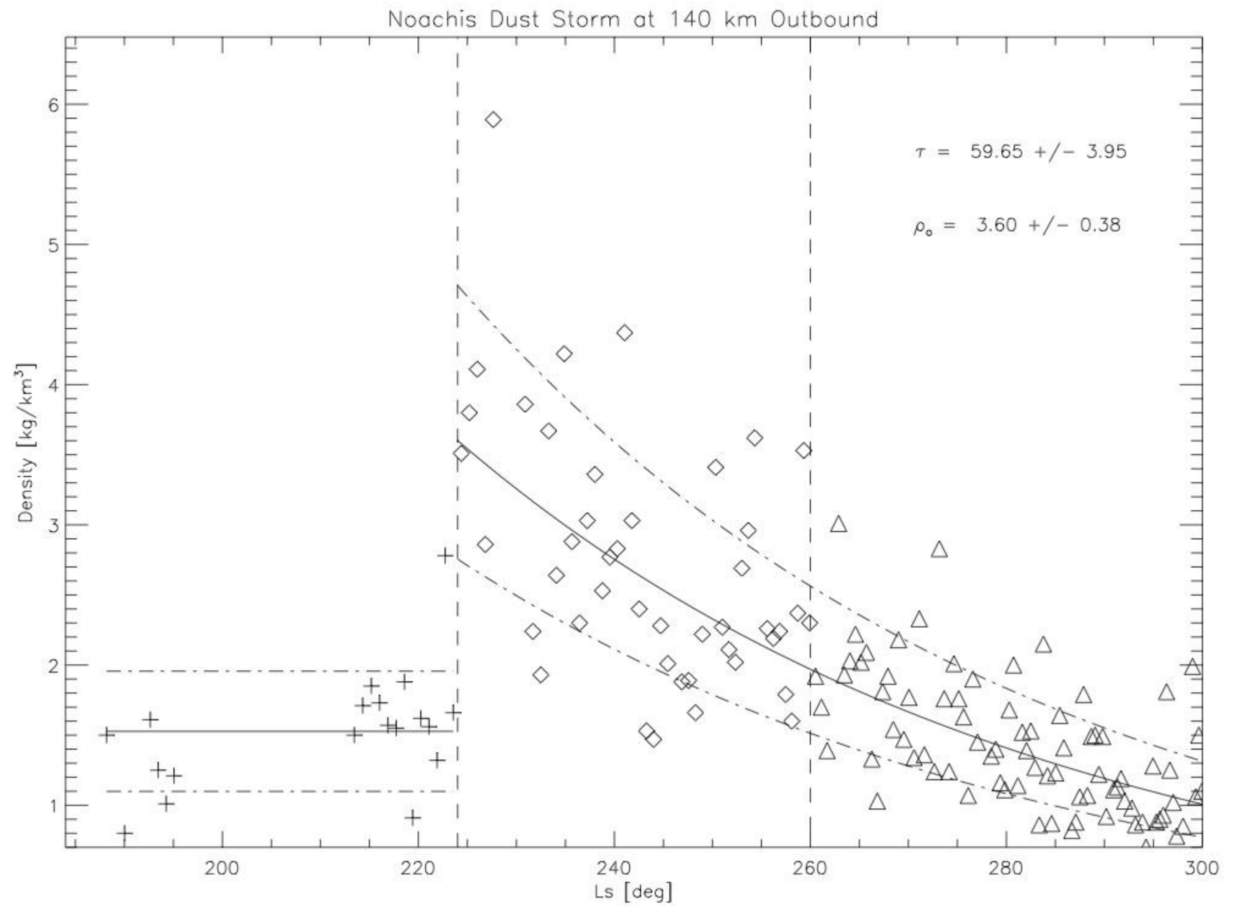


Densities at 150 km increase during period of high solar EUV flux

Task 4 (Response to dust storms)

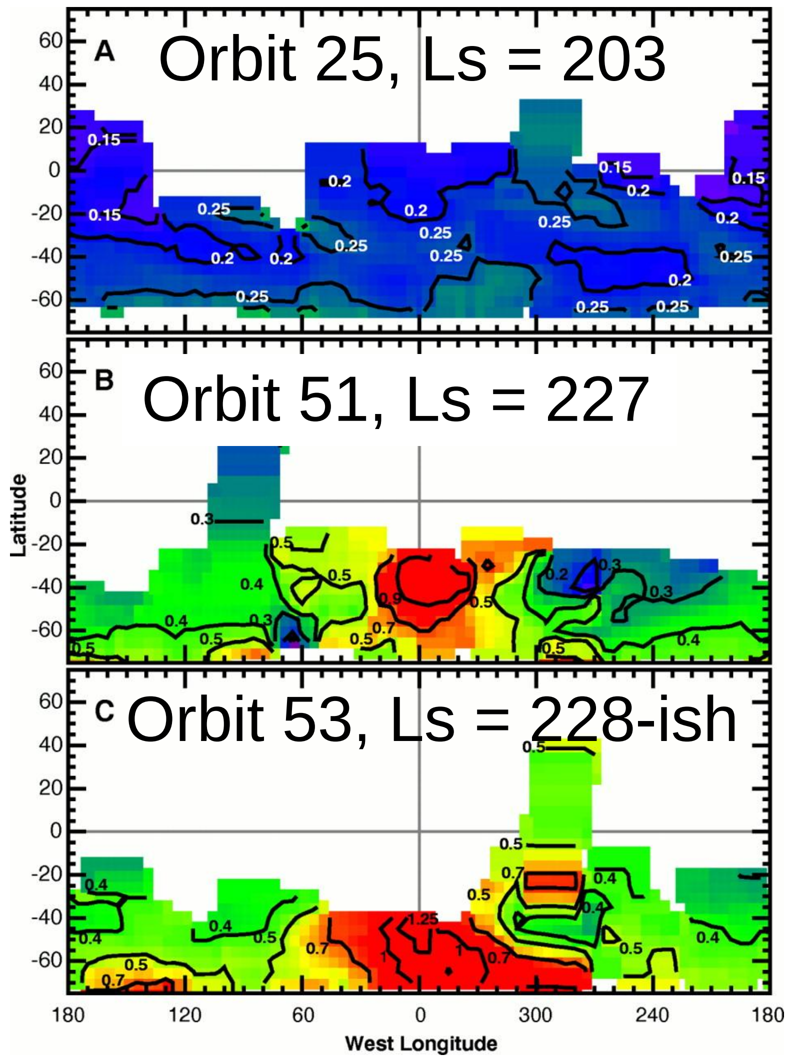


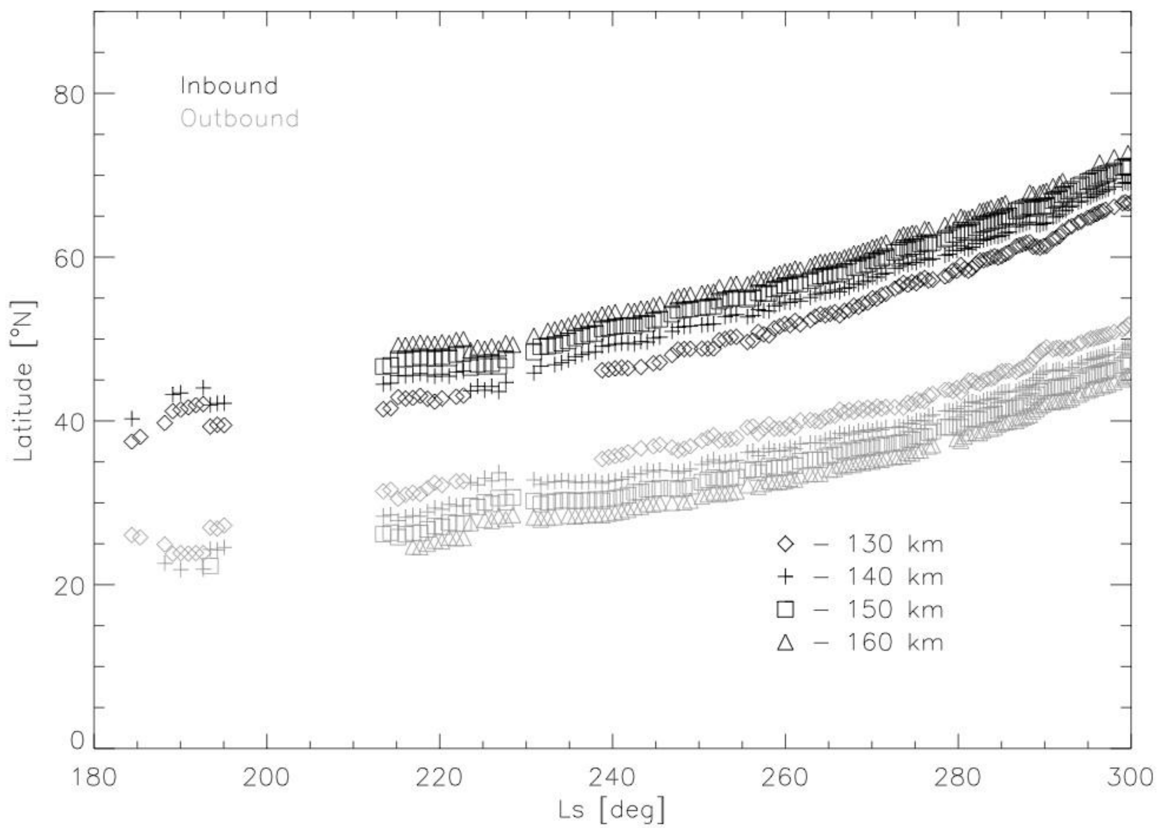
MGS TES dust opacity Noachis dust storm during aerobraking



MGS Accelerometer density at 140 km outbound during dust storm

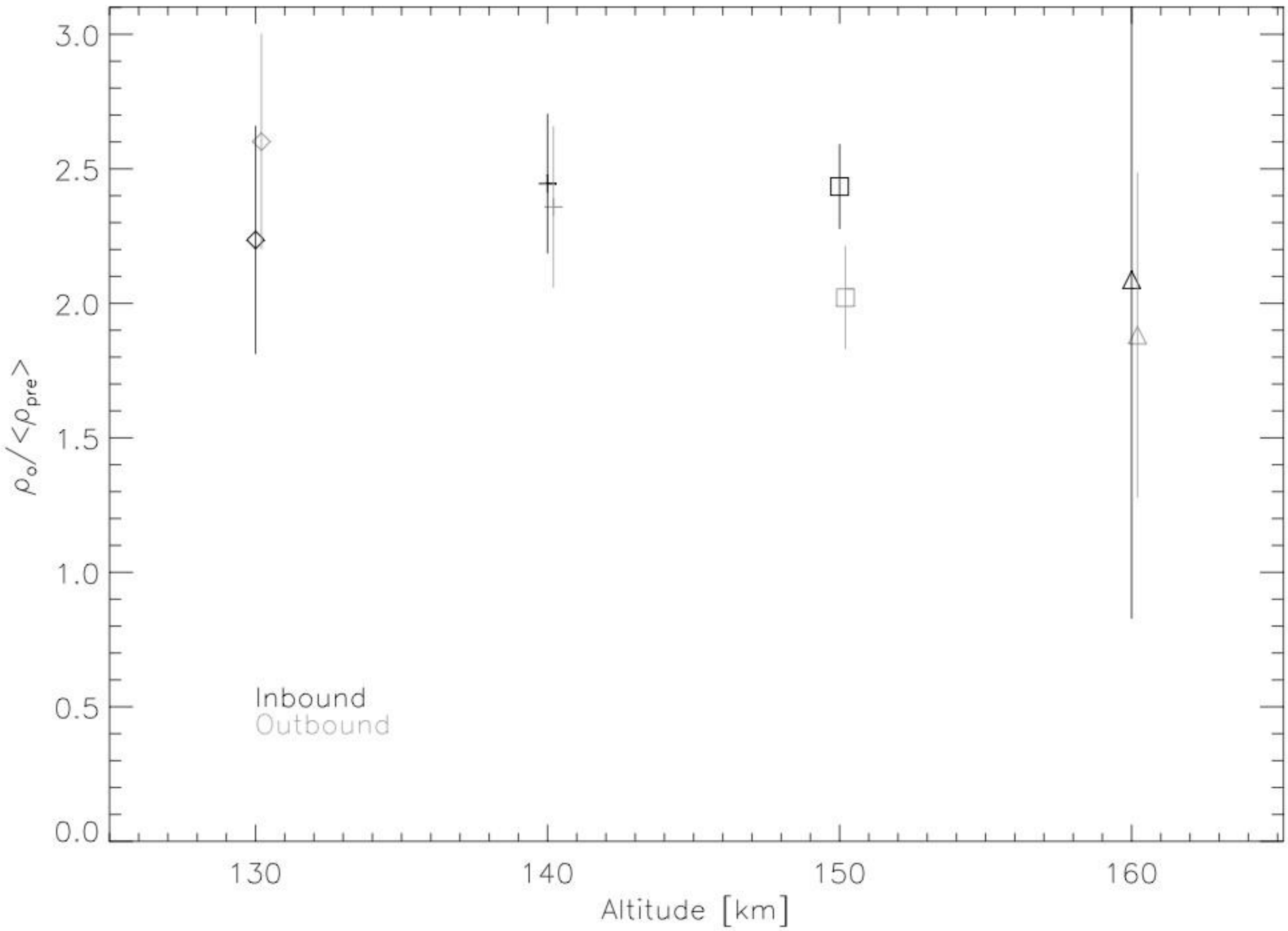
Where's the dust?





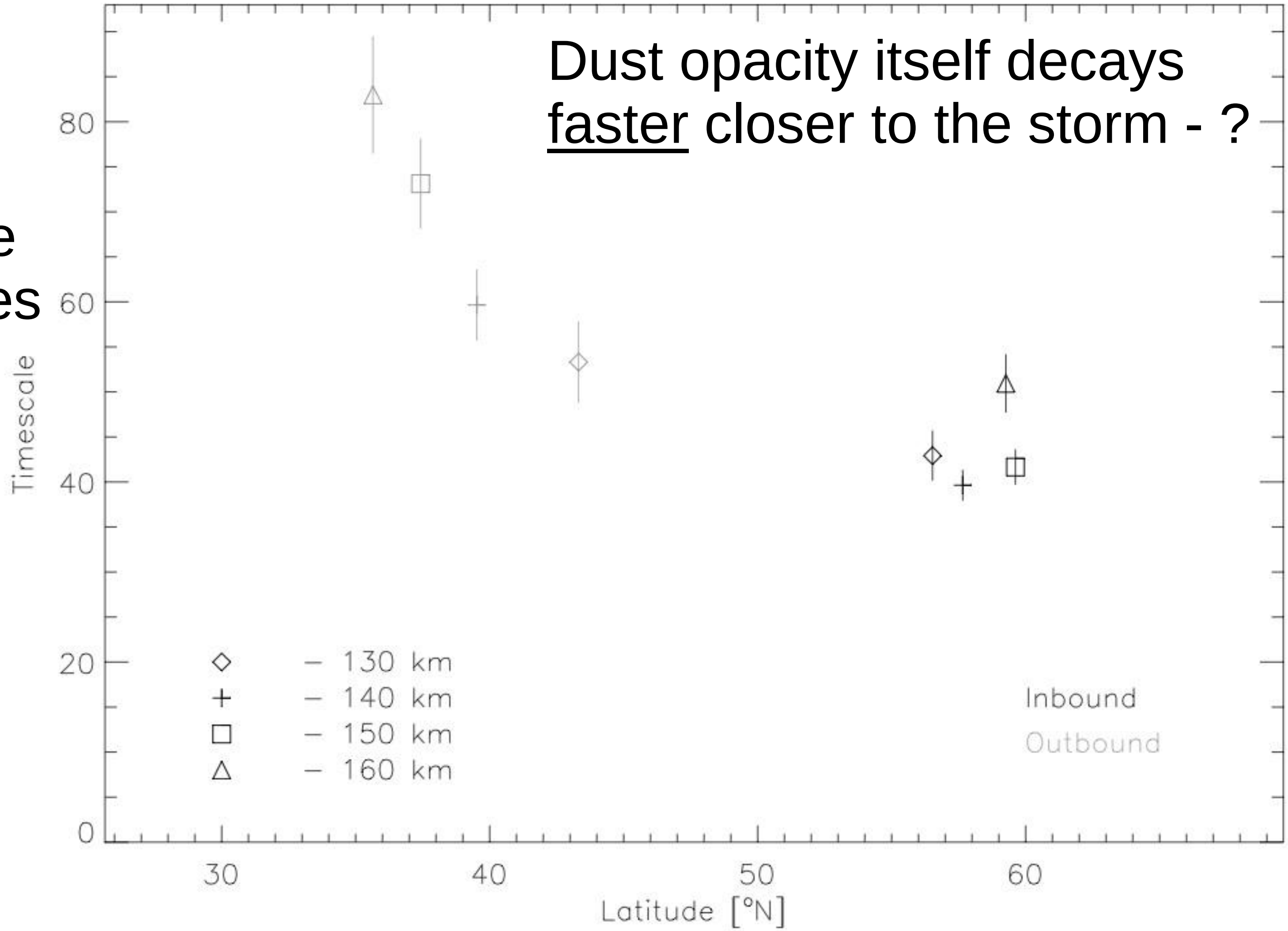
Inbound data at 50N
Outbound data at 30N
Storm at 50S

Density enhancement ~ 2.5



Decay timescale is longer closer to the storm

Decay timescale in degrees of Ls



Next steps on this Task

- ODY aerobraking started in waning phase of a dust storm
- Some MGS radio occultation data (>60N) likely to encompass dust storm conditions

Conclusions

- Tasks 1 and 2 (basic statistics of variability) completed, but deliverables are gigantic set of tables/figures without much interpretation
- Task 4 (dust storm) well underway, results so far are operationally and scientifically interesting
- Task 3 (extreme solar events) will be started soon