OZONE RETRIEVED FROM SPICAM STELLAR OCCULTATIONS

COMPARISON WITH LMD/SA MARS CLIMATE MODEL

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SPICAM DATA

UV stellar occultations :

- Spectrum is monitored as the star rises or sets at Mars limb.

- Transmission is calculated from the stellar spectrum outside the atmosphere

- Spectral inversion is done to retrieve CO_2, O_3 and dust densities along the line of sight.

Variation of the ozone slant density as a function of altitude is then inverted in the range 20 to 80 km

=> vertical profile of ozone density.

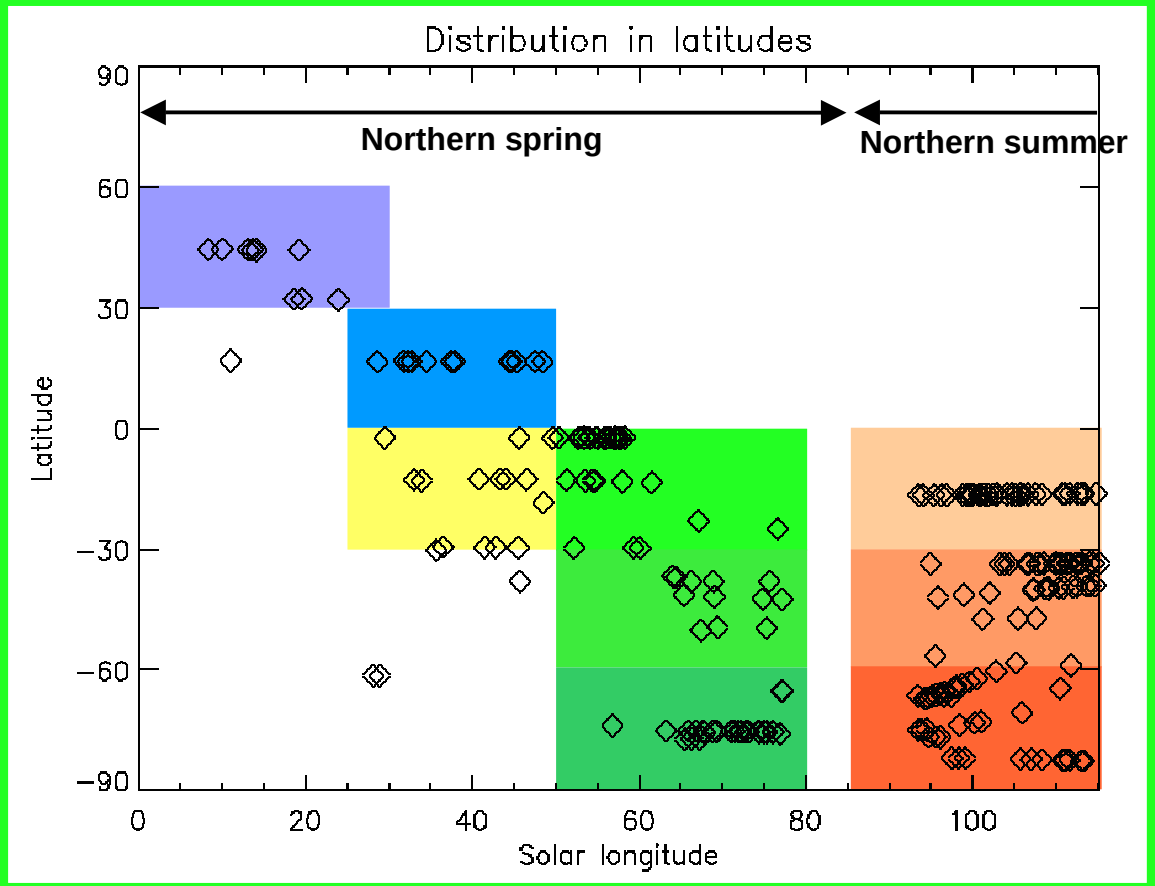
Lower limit : extinction of the signal by atmospheric dust, reaching deeper levels as Ls increases.

Detection level is of the order of 10^8 cm^{-3}

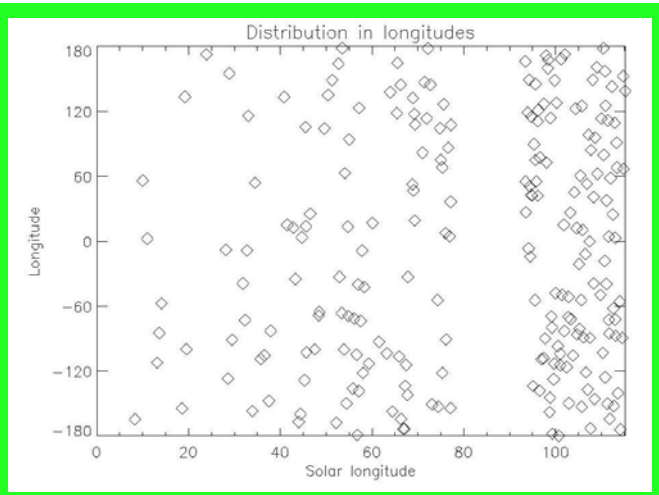
227 vertical profiles have been retrieved so far, between Ls=8° and Ls=115°.

SPATIAL AND SEASONAL DISTRIBUTION

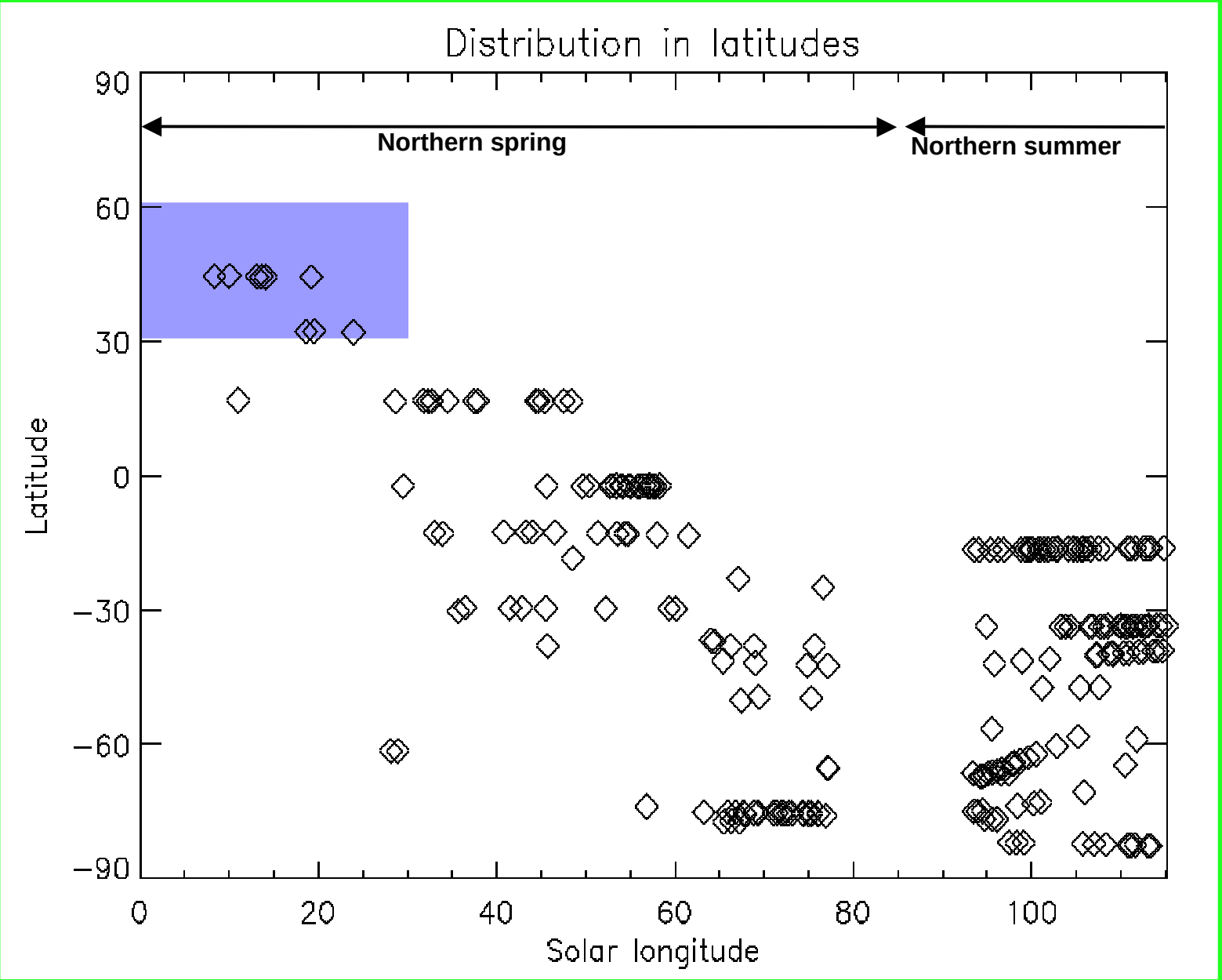
So far, analysed data cover 9 « regions » in the Season-Latitude plan



The longitude dimension is fairly sampled

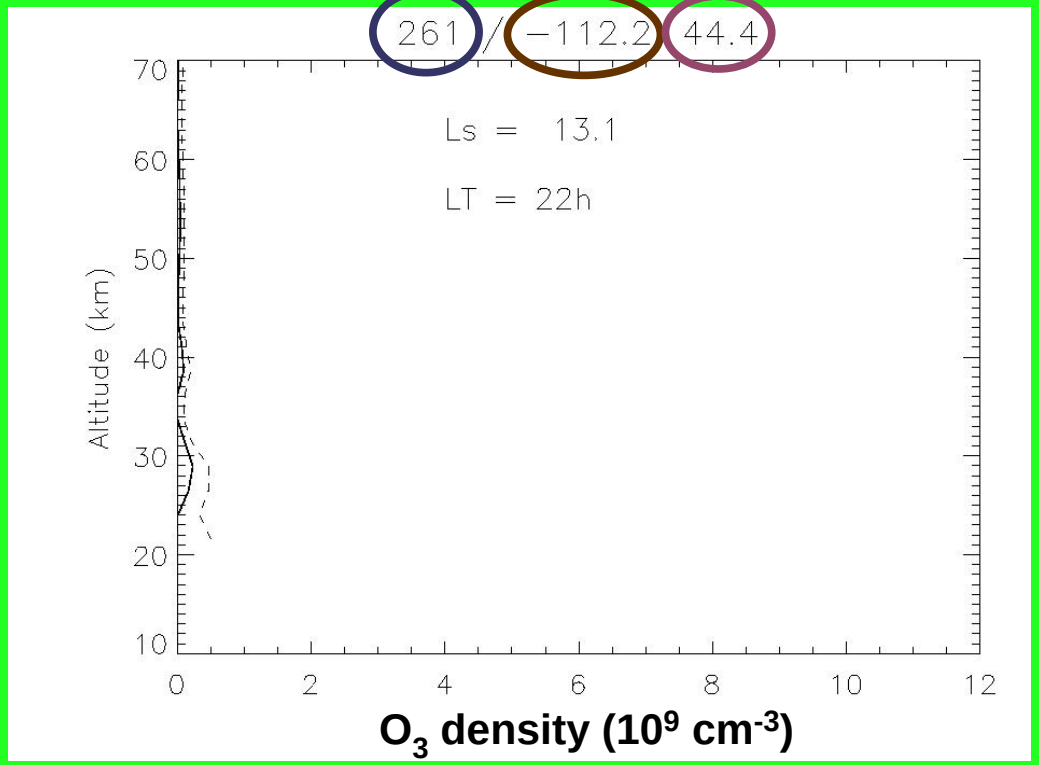


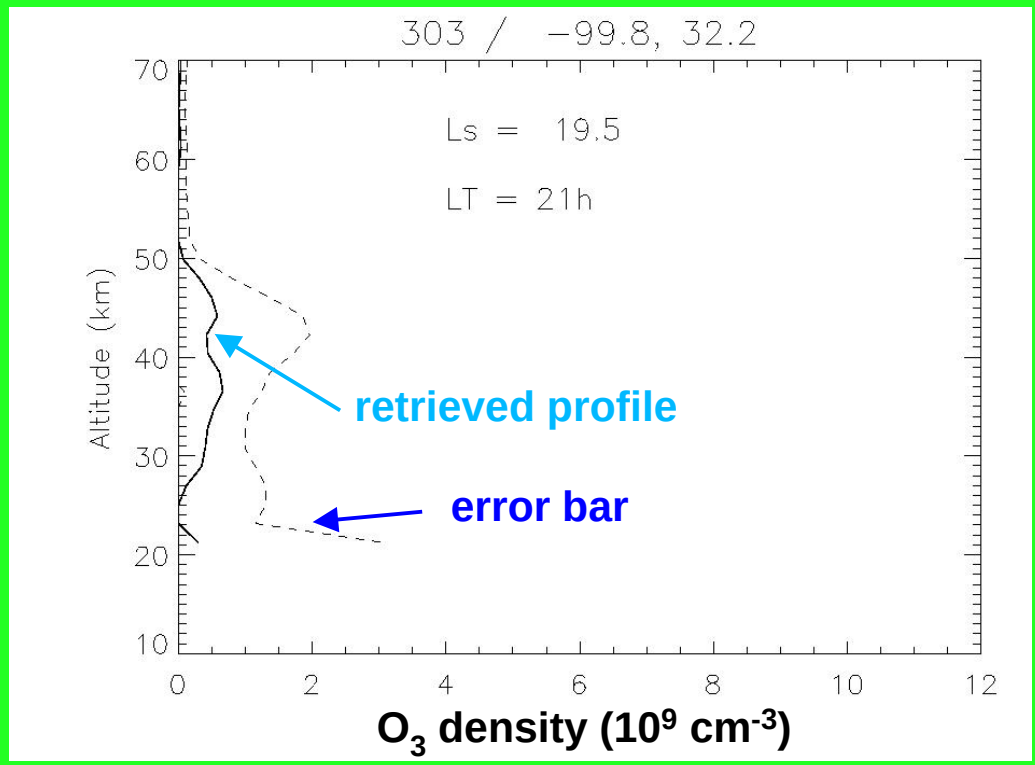
Ls = 0-30°: Early Spring / 30-60° N



Ls = 0-30°: Early Spring / 30-60° N

Orbit number longitude latitude



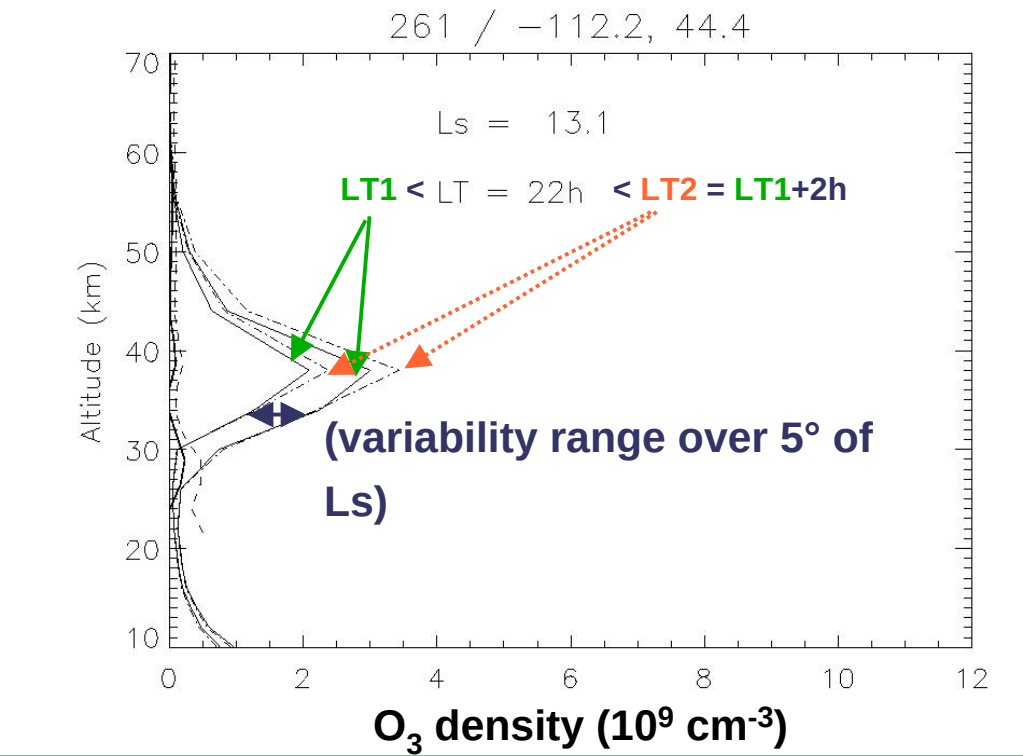


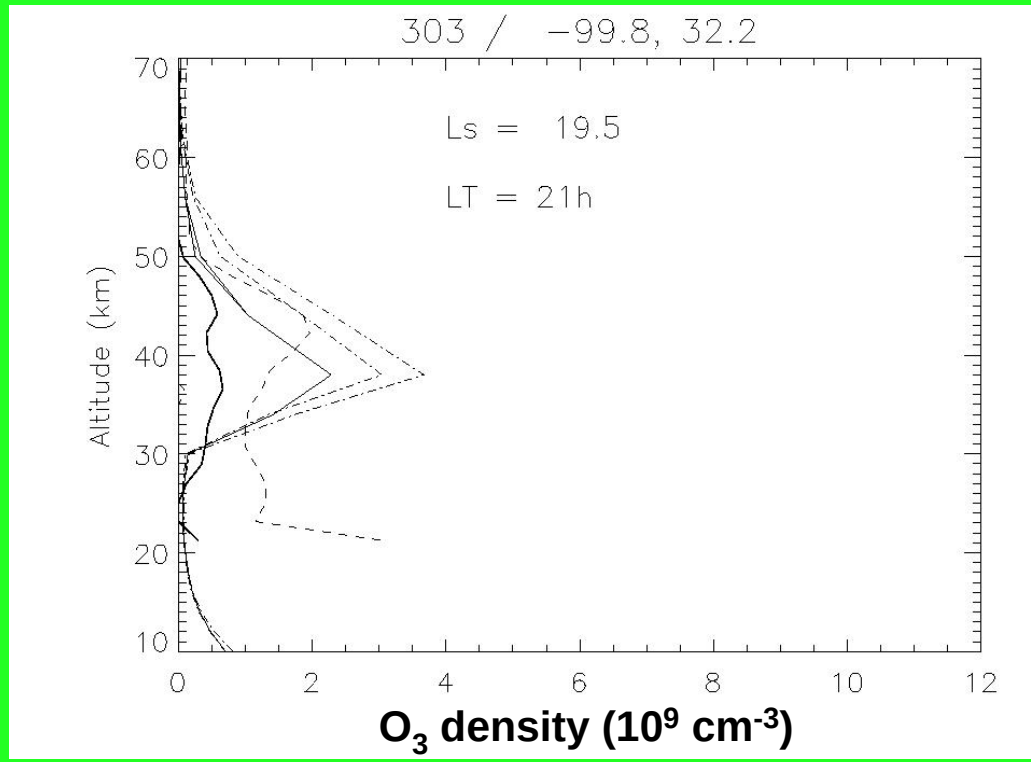
Two representative samples

Little, or no ozone is retrieved for this region.
Densities are close to the limiting noise level.

Ls = 0-30°: Early Spring / 30-60° N

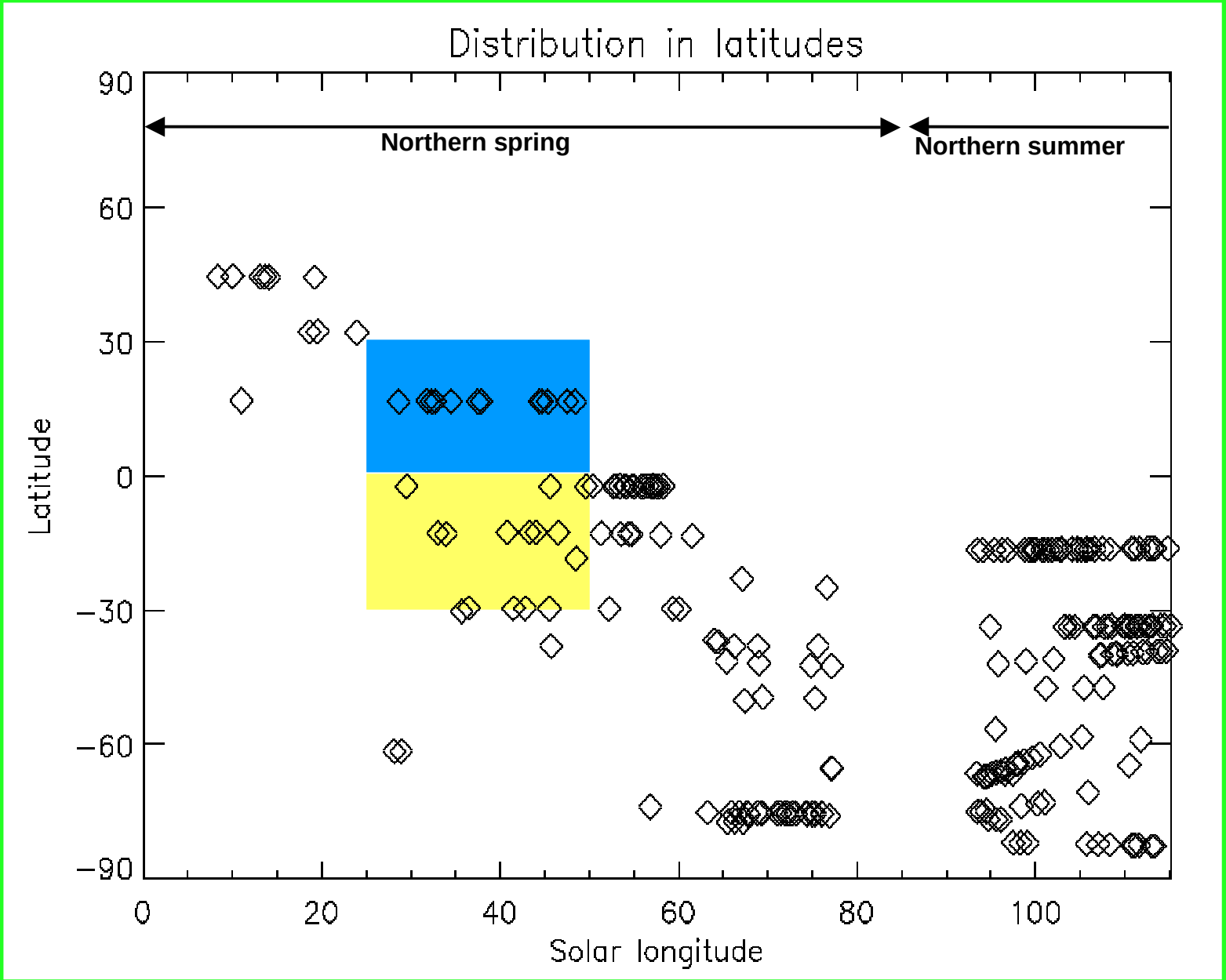
Comparison to LMD MGCM :



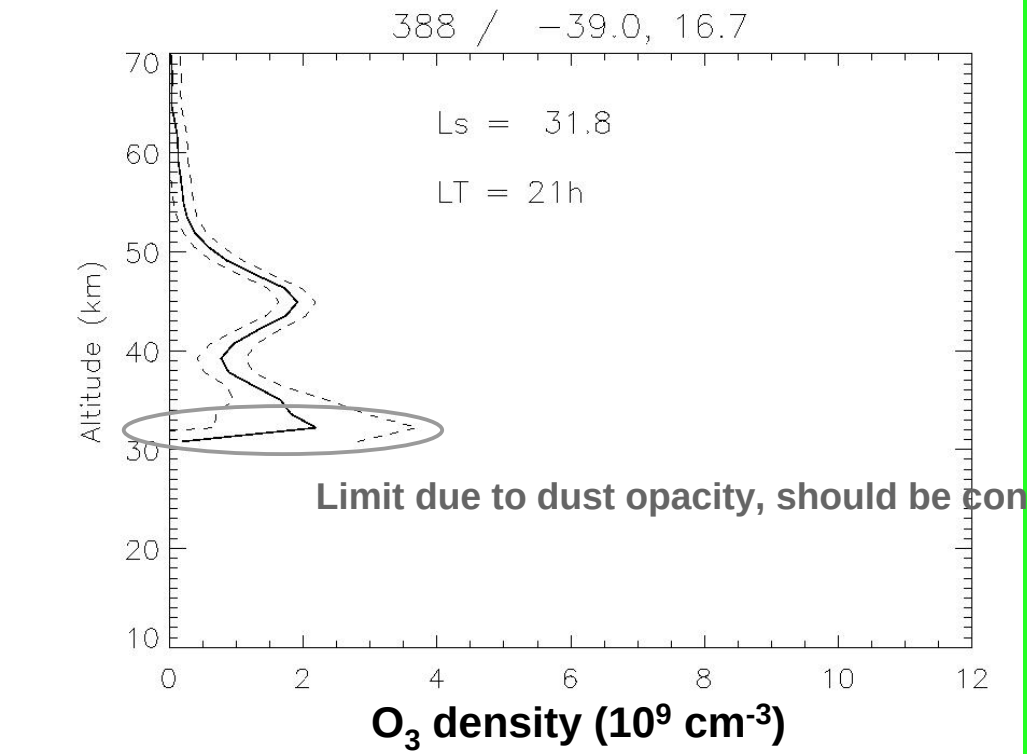


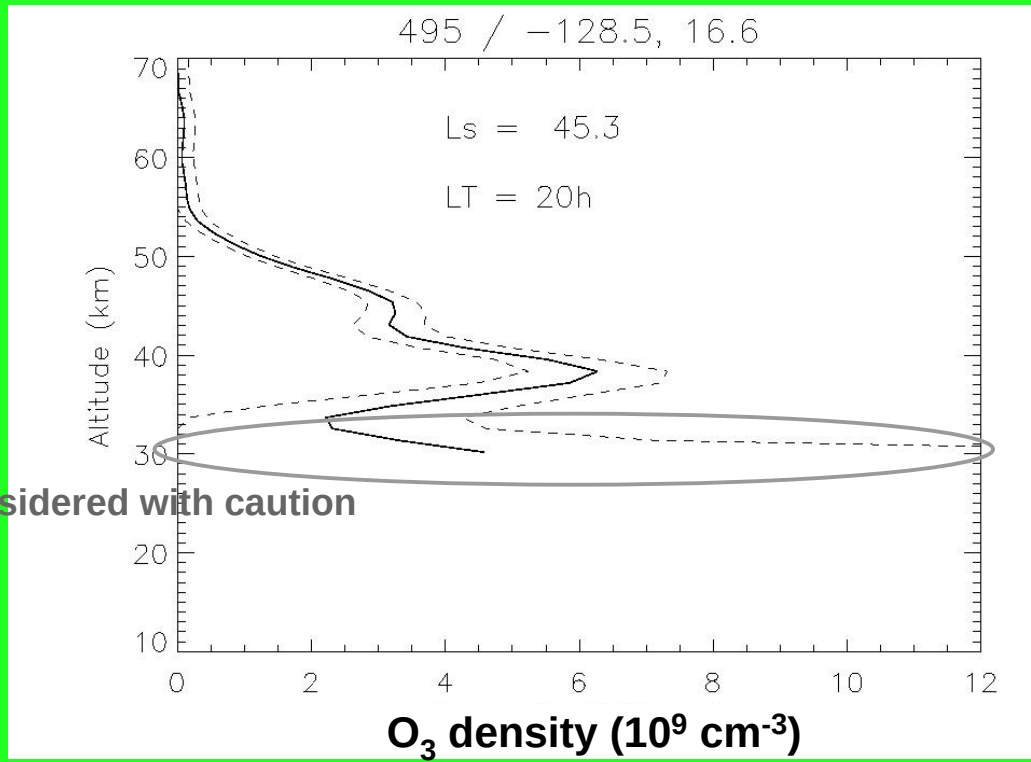
The model, in the corresponding conditions, is predicting a nocturnal ozone layer.

Ls = 25-50°: Mid Spring / 0-30° N
Mid Fall / 0-30° S



Ls = 25-50°: Mid Spring / 0-30° N





Limit due to dust opacity, should be considered with caution

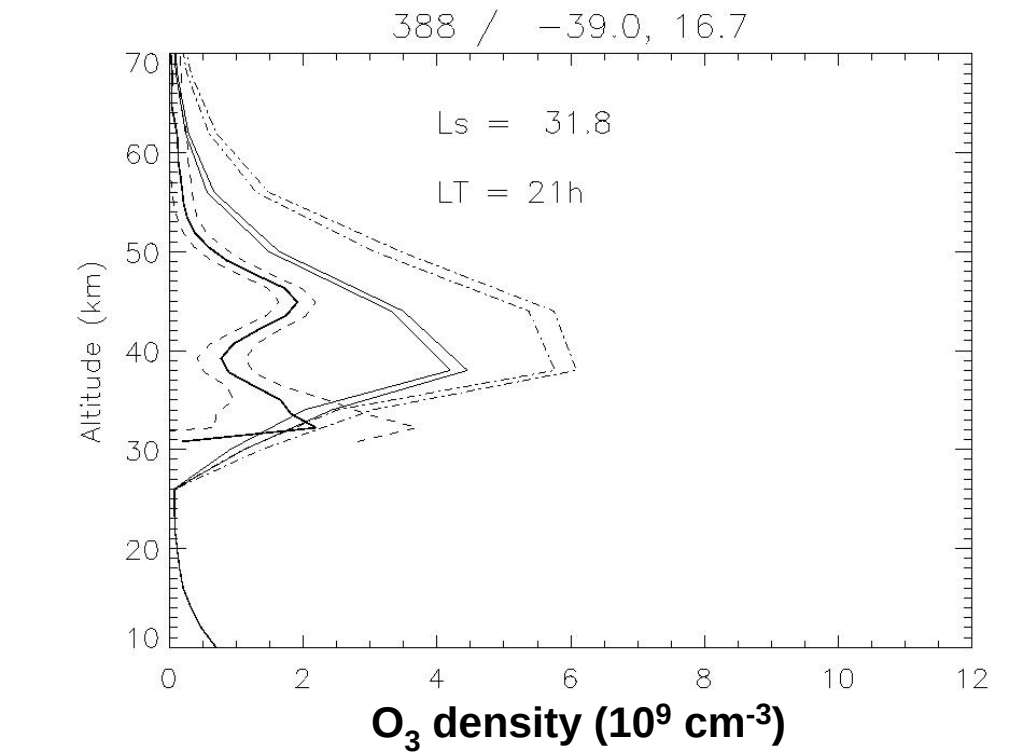
Two representative samples

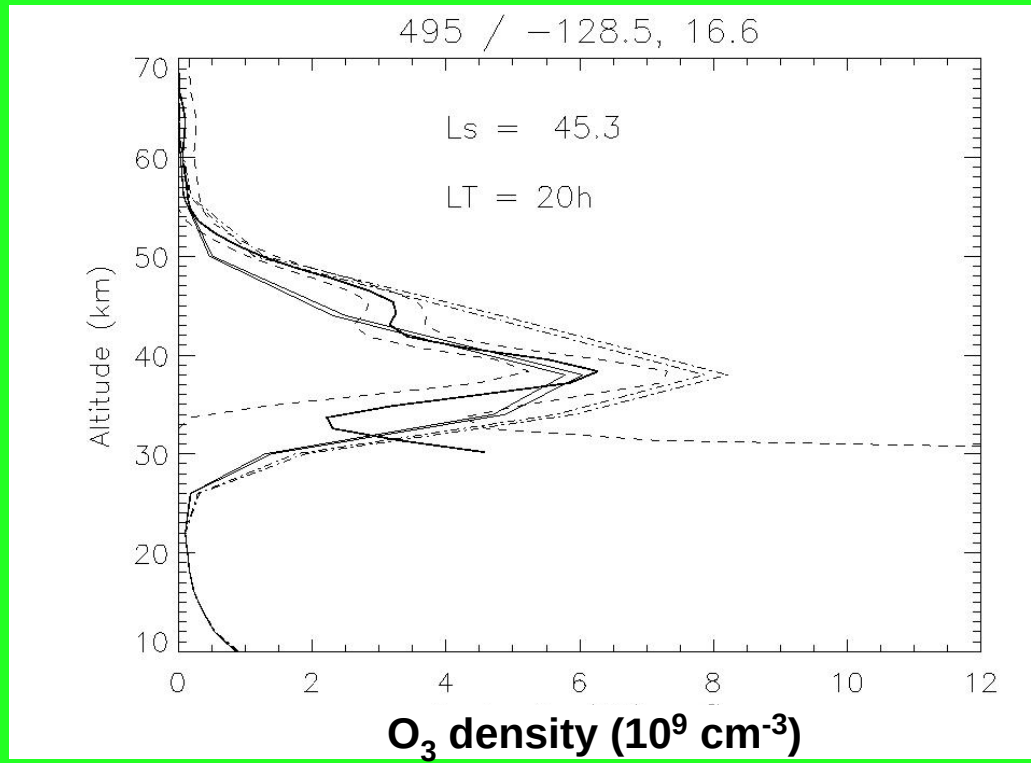
Ozone layer, between 40 and 50 km altitude

Peak value tends to increase with Ls, with a peak altitude decreasing.

Ls = 25-50°: Mid Spring / 0-30° N

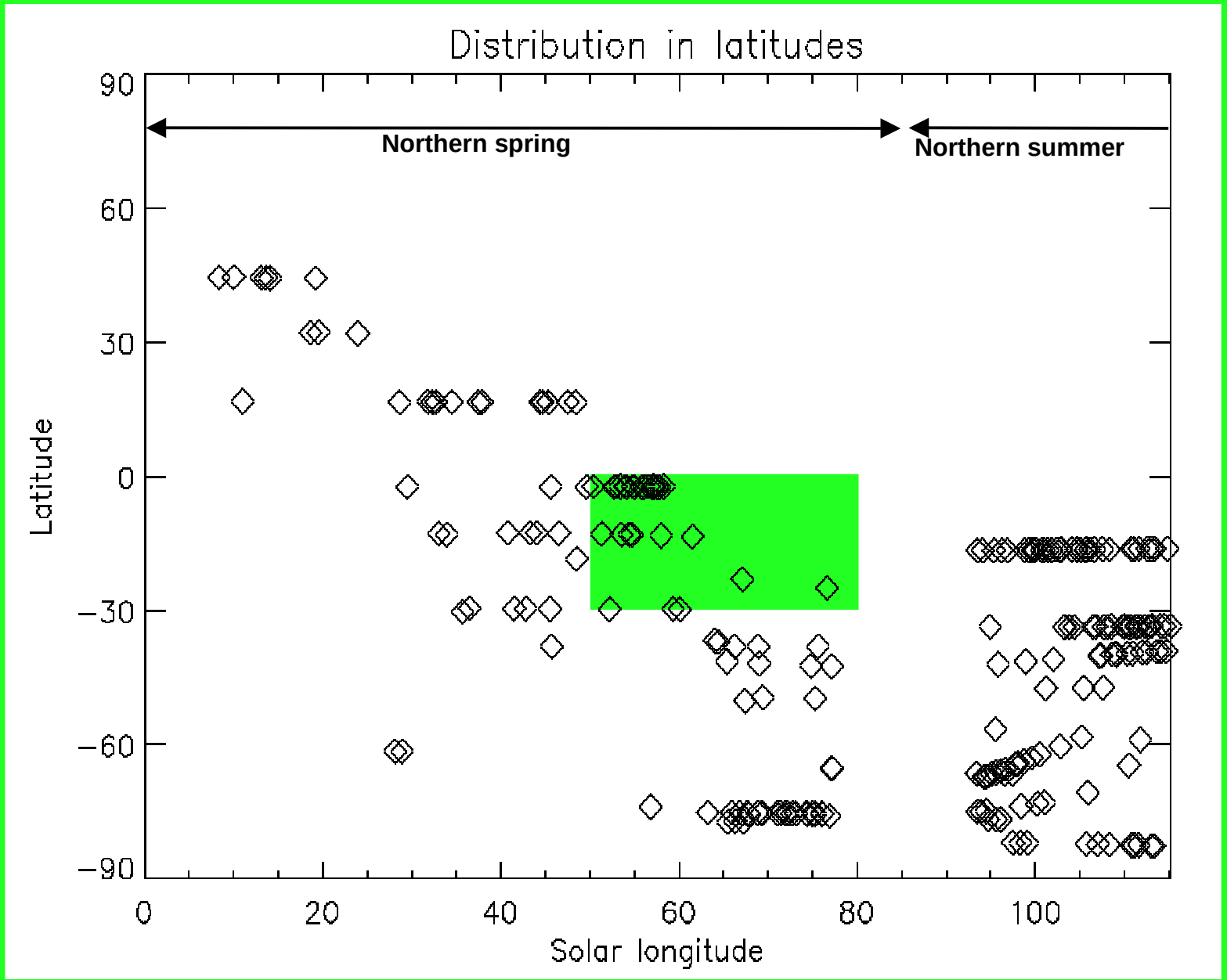
Comparison to LMD MGCM :

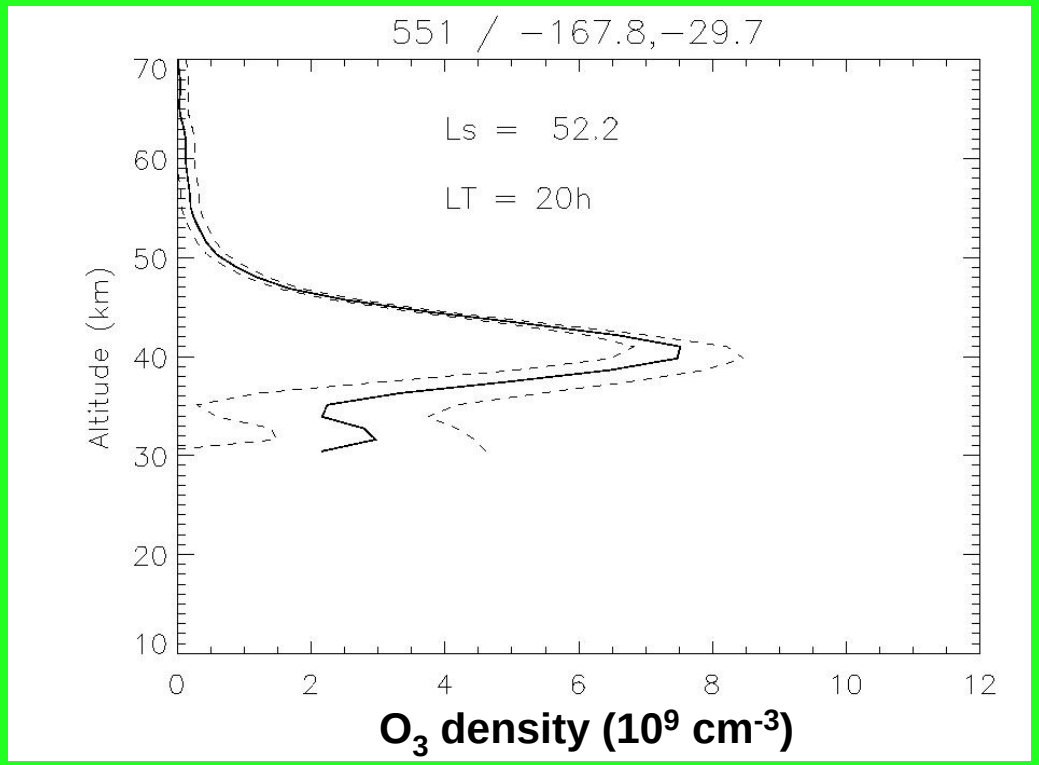


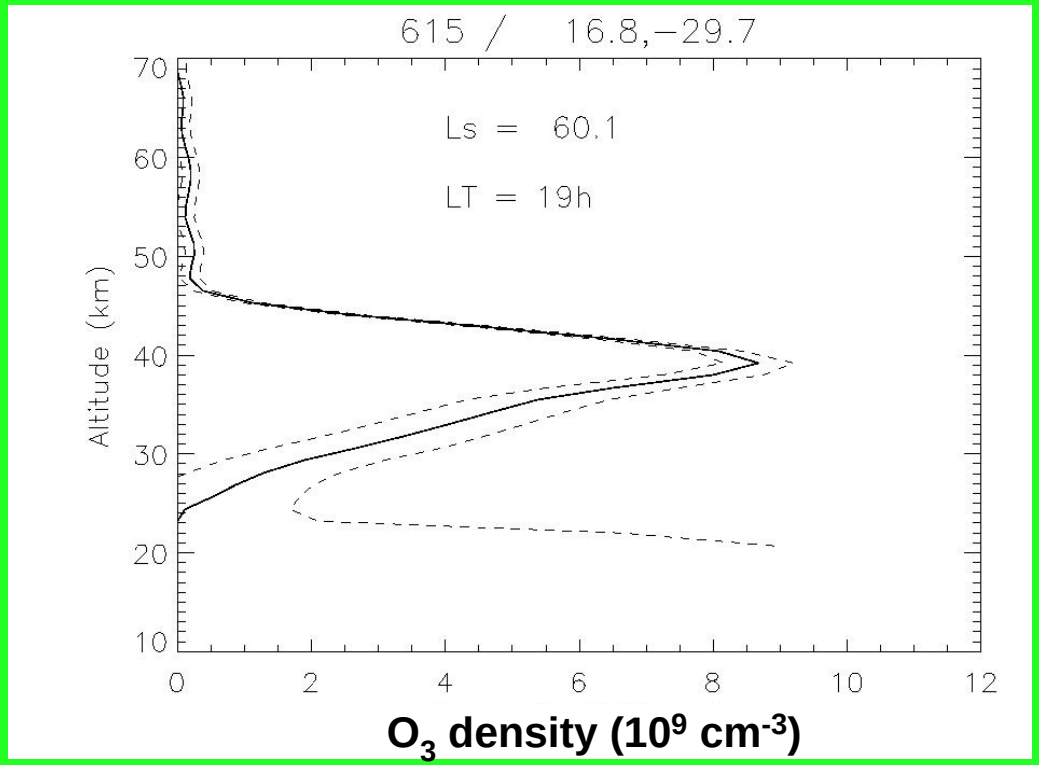


Ozone layer predicted by the model has only a small increase with Ls.

Observations and model are in good agreement after Ls ~ 40°, though the observed layer is often thinner than predicted.


Distribution in latitudes
Northern spring
Northern summer
Latitude
Solar longitude
90
60
30
0
−30
−60
−90
0
20
40
60
80
100

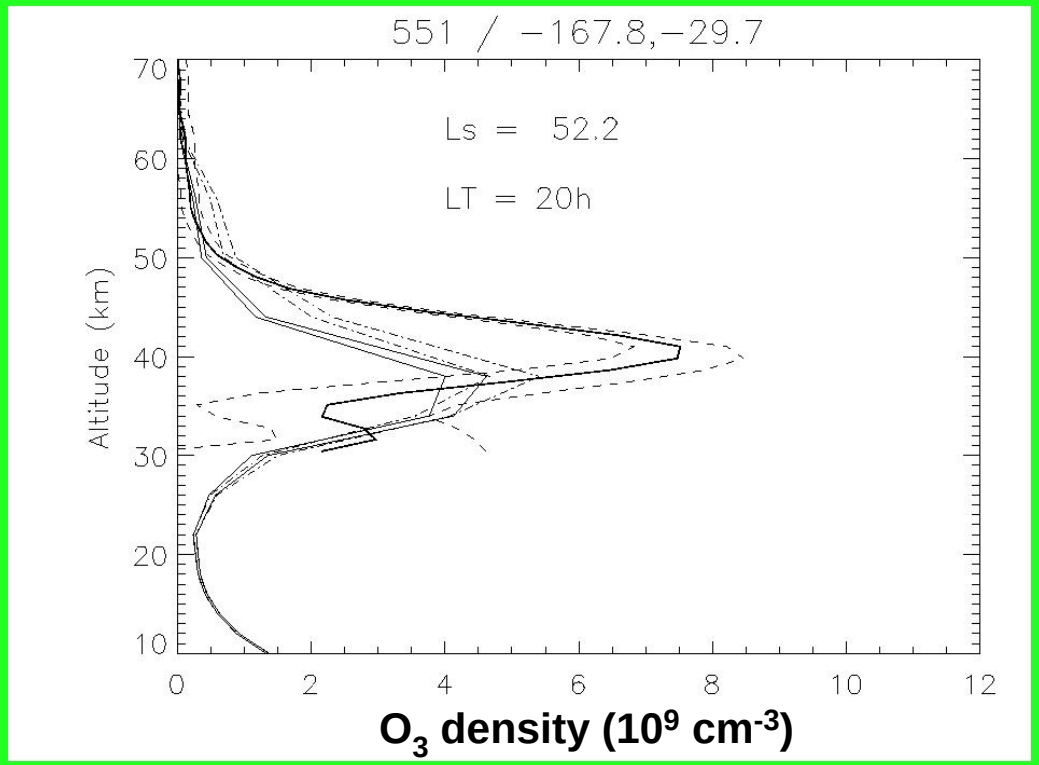


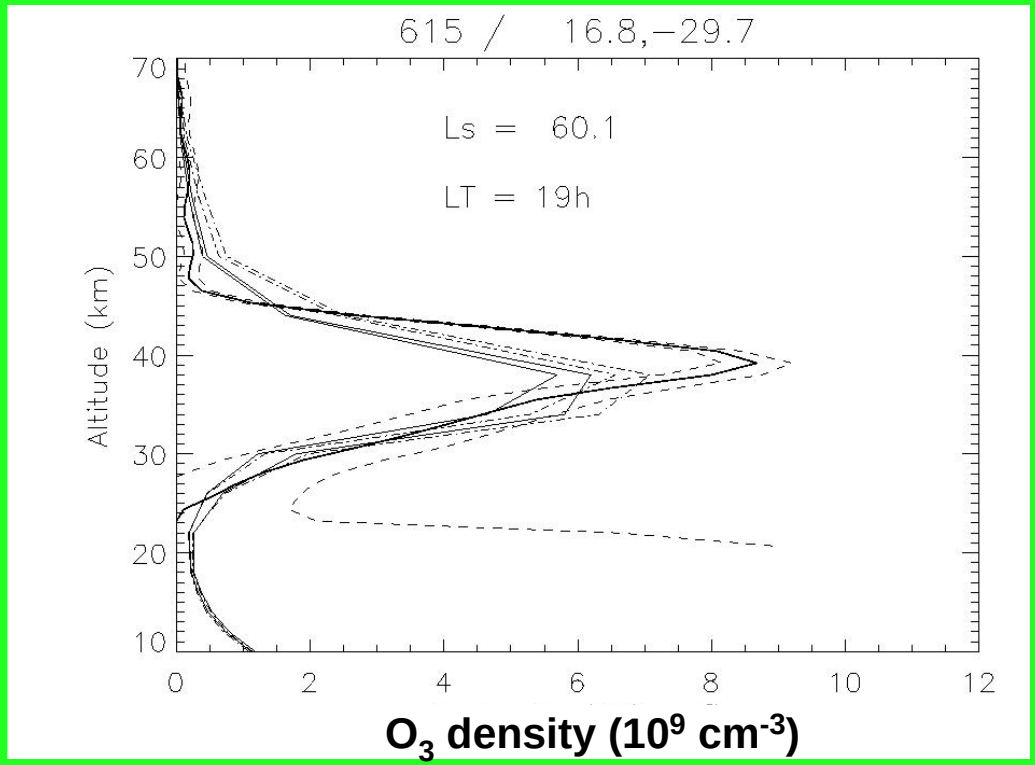


Two representative samples

No more increase in the observed peak of ozone, though variability is present.

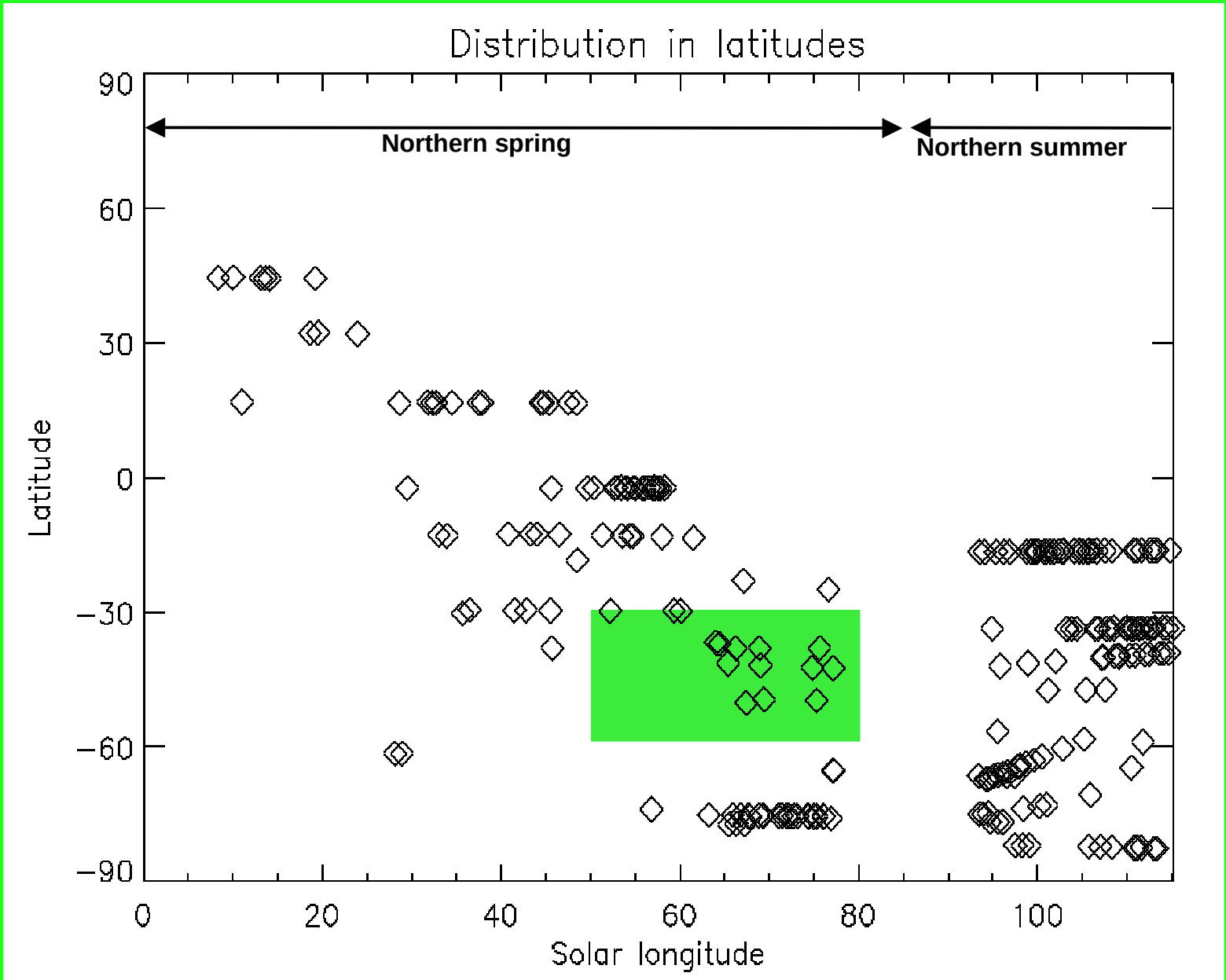
Comparison to LMD MGCM :



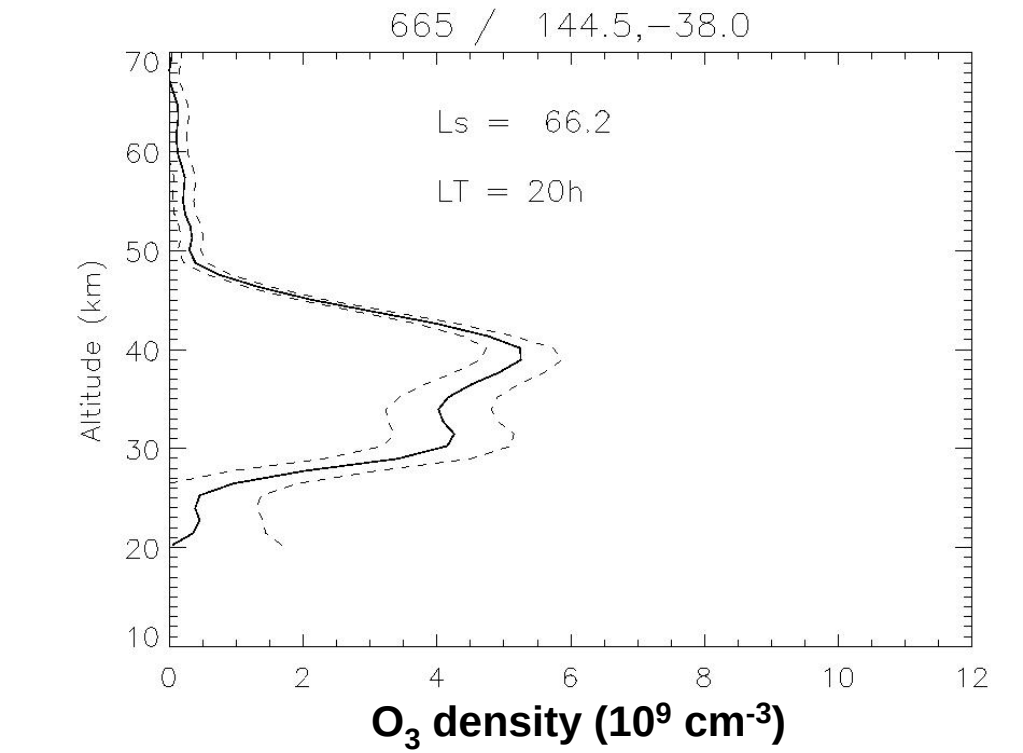


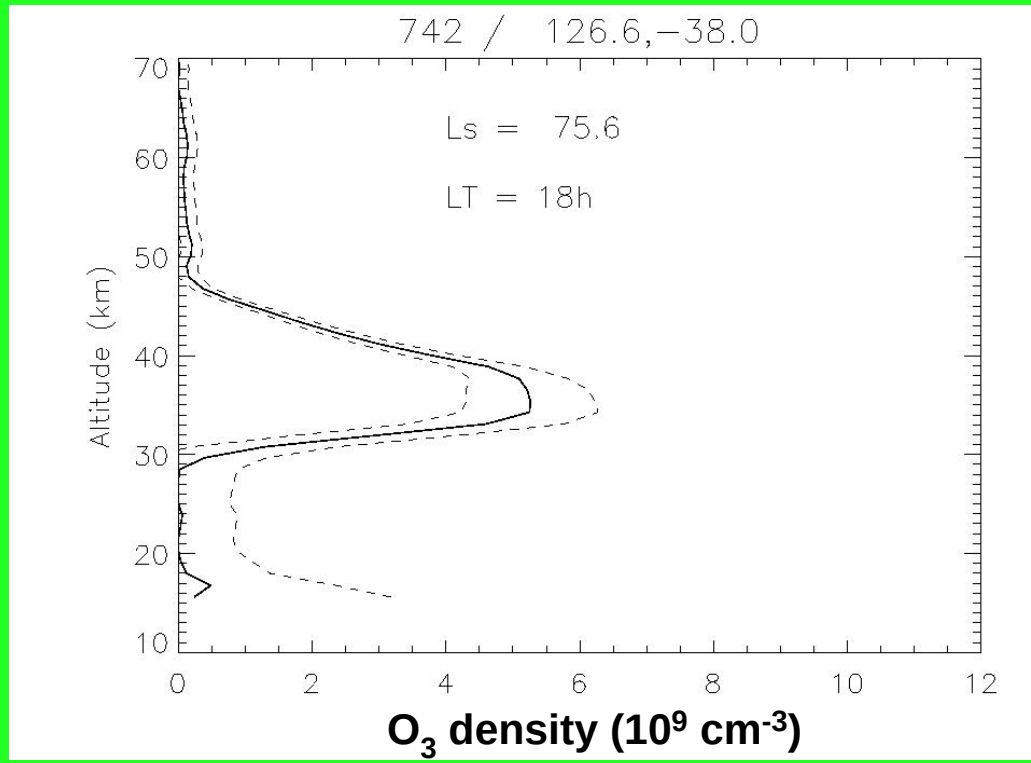
Very good agreement between modeled and observed nocturnal ozone layers, though thickness is still frequently over-estimated.

Ls = 50-80°: Late Fall / 30-60° S



Ls = 50-80°: Late Fall / 30-60° S



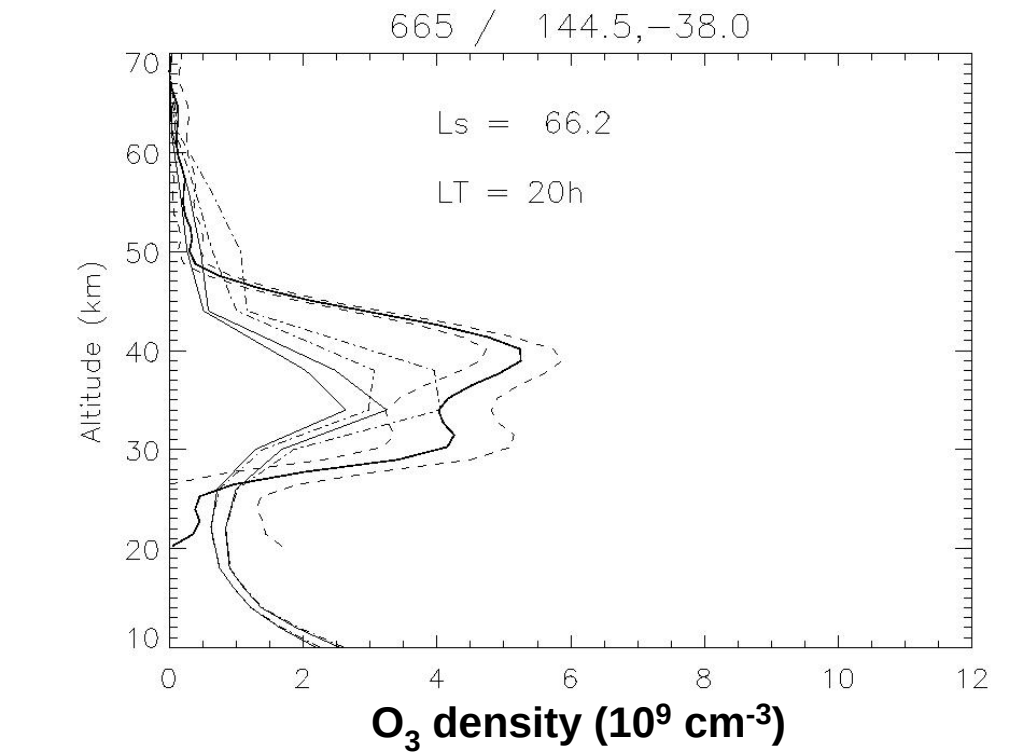


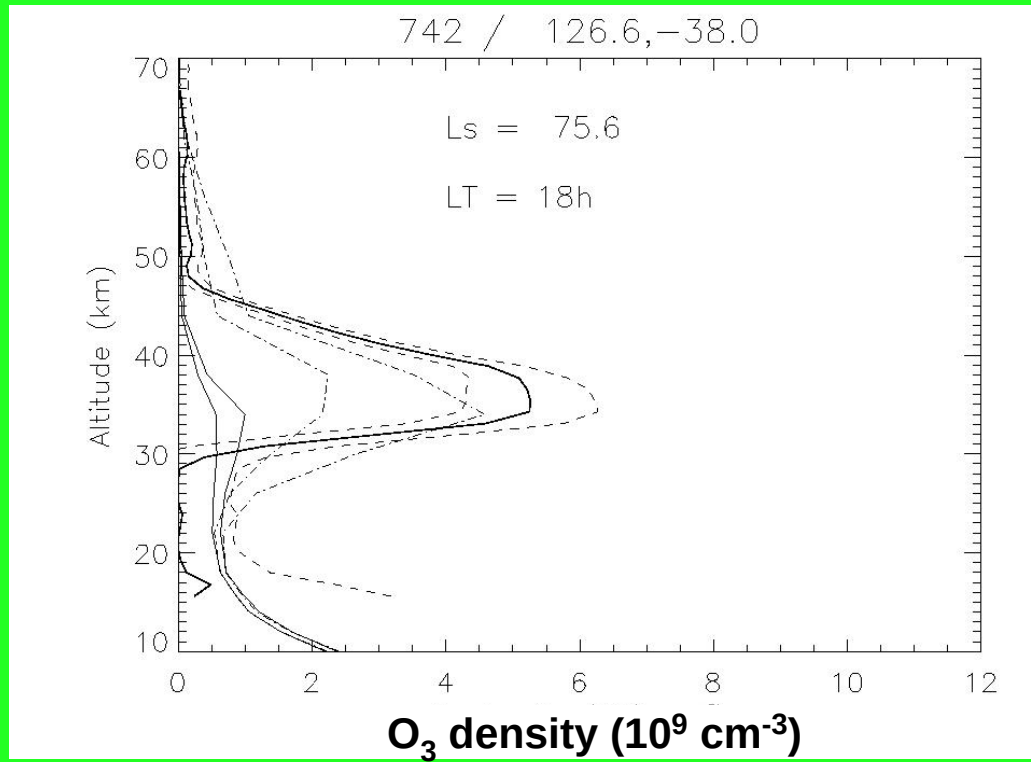
Two representative samples

Observed ozone layer is thicker, with a peak around 35-40 km altitude.
Some structure is occasionnaly visible in the layer.
The retrieval limit (due to dust) goes down to ~20 km altitude.

Ls = 50-80°: Late Fall / 30-60° S

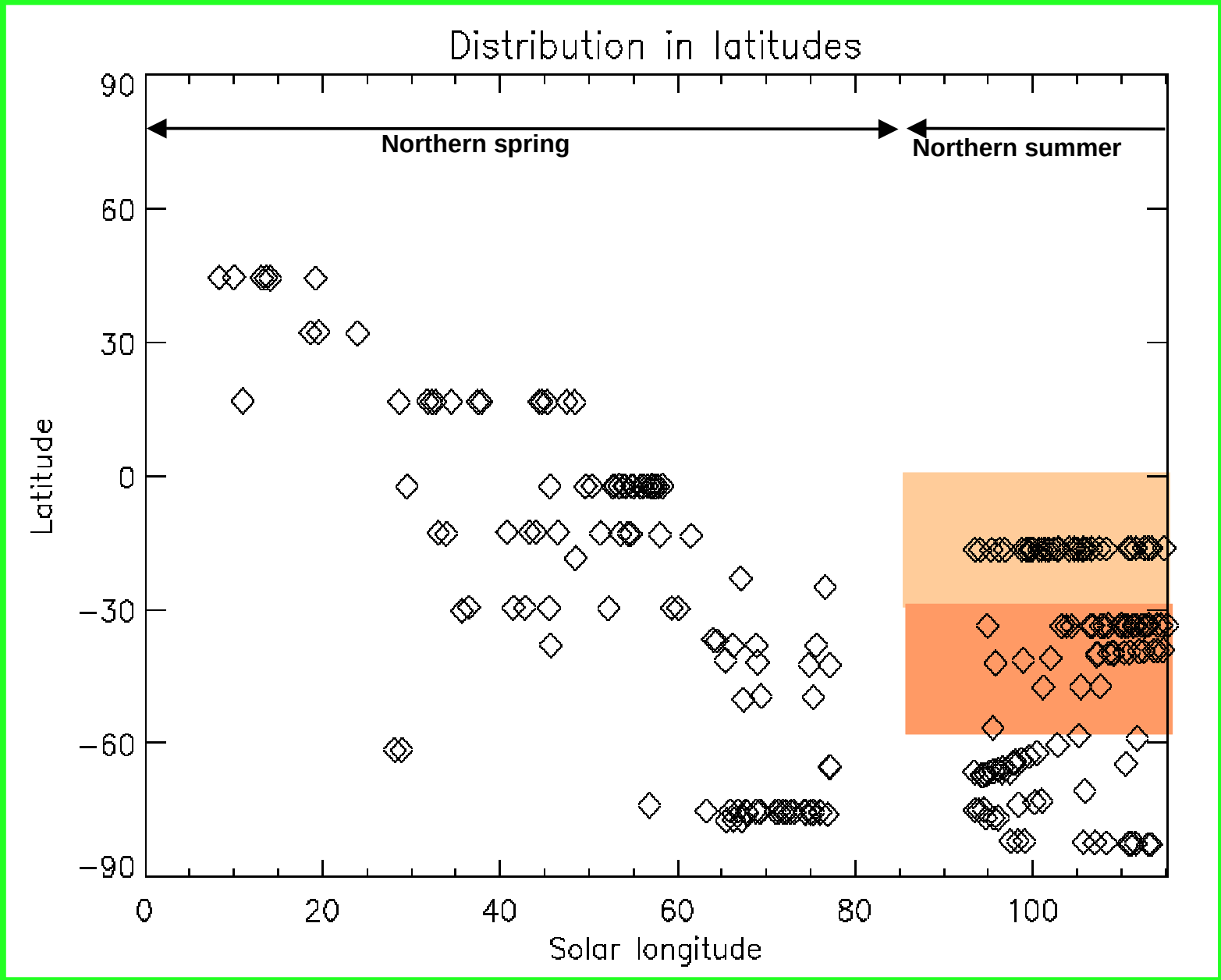
Comparison to LMD MGCM :



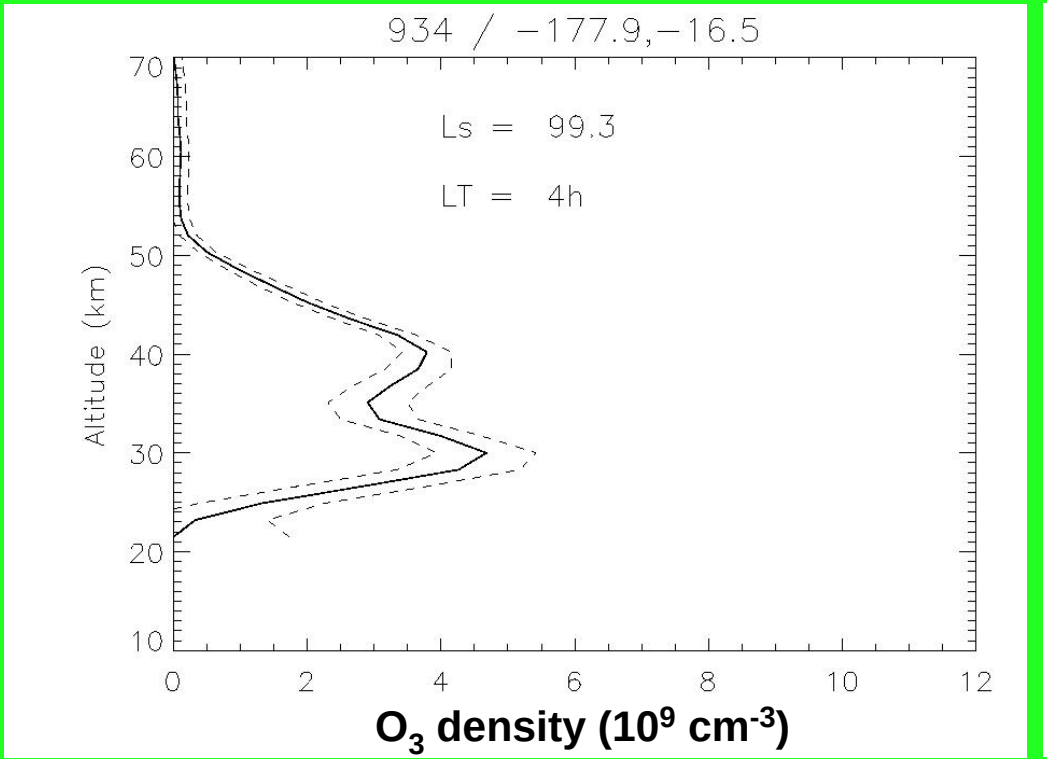


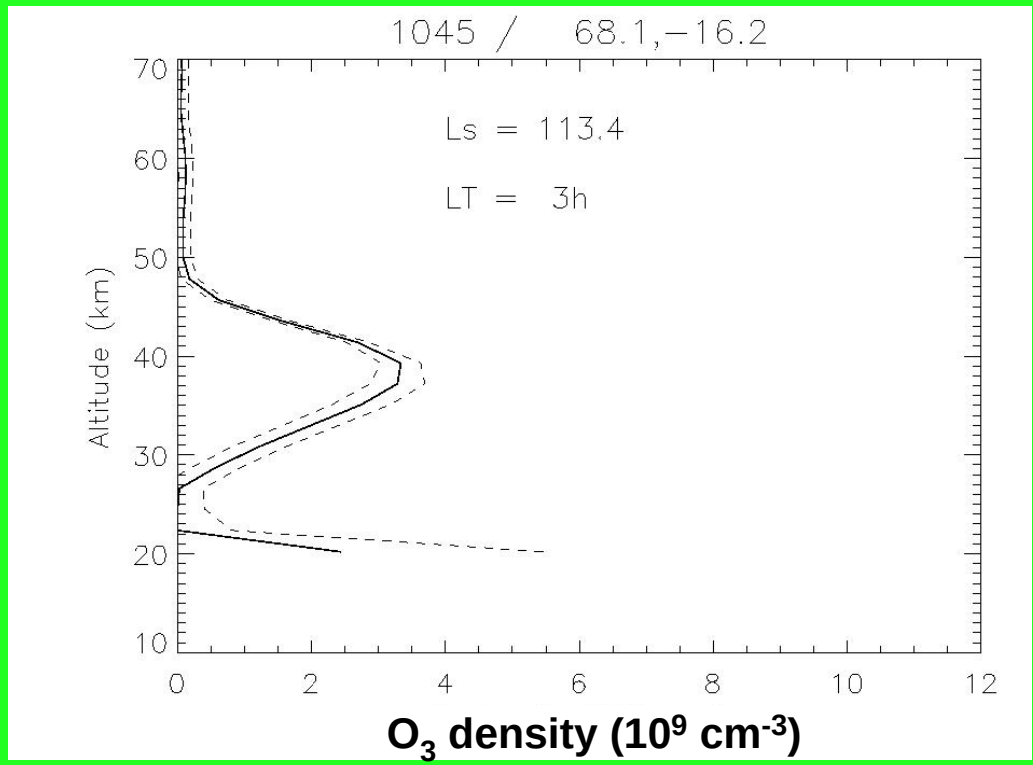
Thickness is better fitted, but peak values are often slightly under-estimated.

Ls = 90-115°: Early Winter / 0-30° S
30-60° S



Ls = 90-115°: Early Winter / 0-30° S



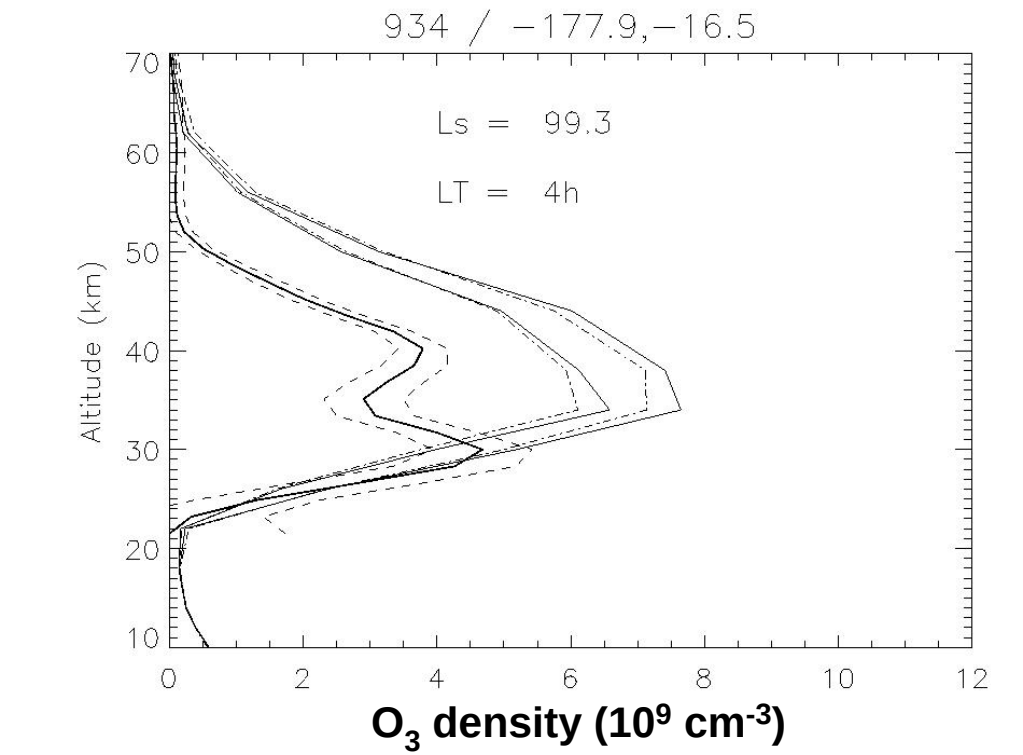


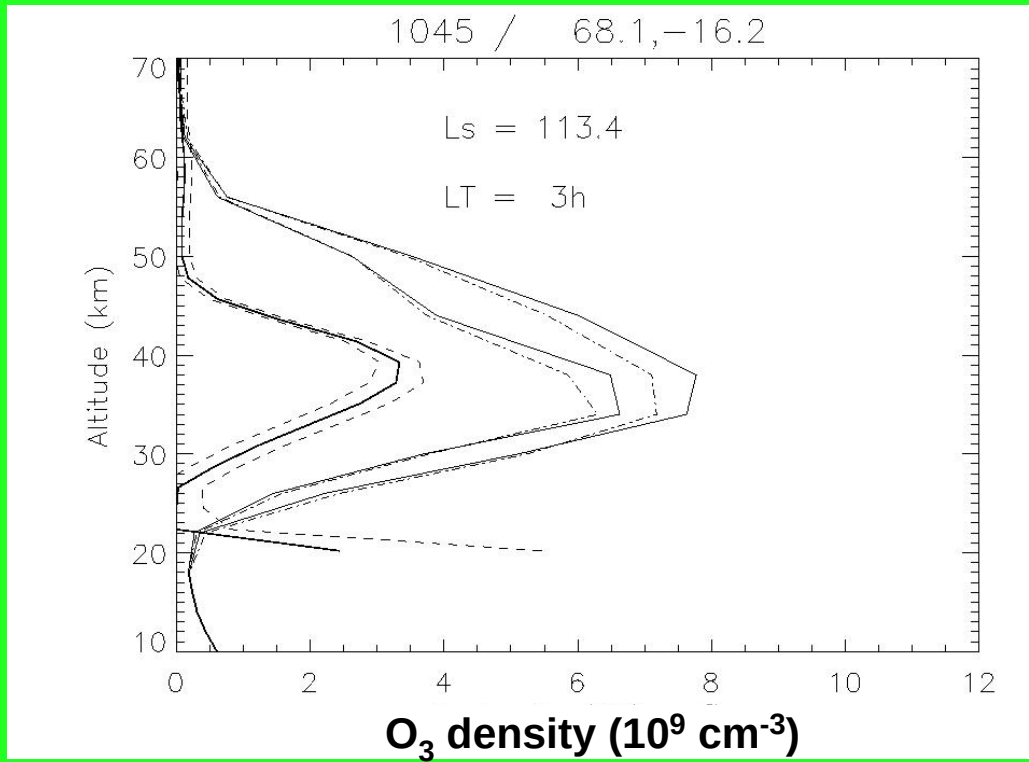
Two representative samples

In winter, the ozone layer appears thicker.
In some cases, a double peak is visible (around 30 and 40 km).
The peak value tends to decrease with Ls.

Ls = 90-115°: Early Winter / 0-30° S

Comparison to LMD MGCM :

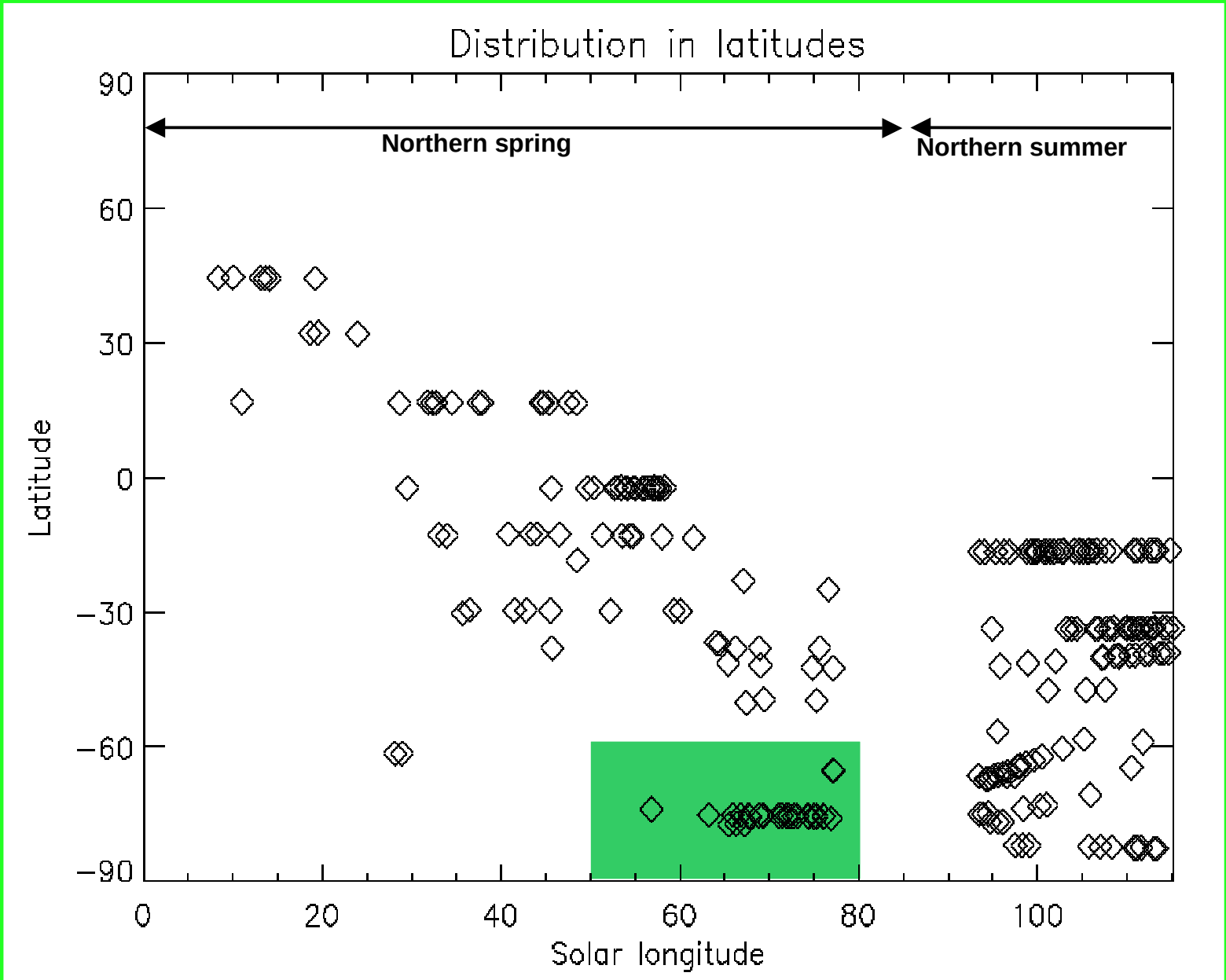




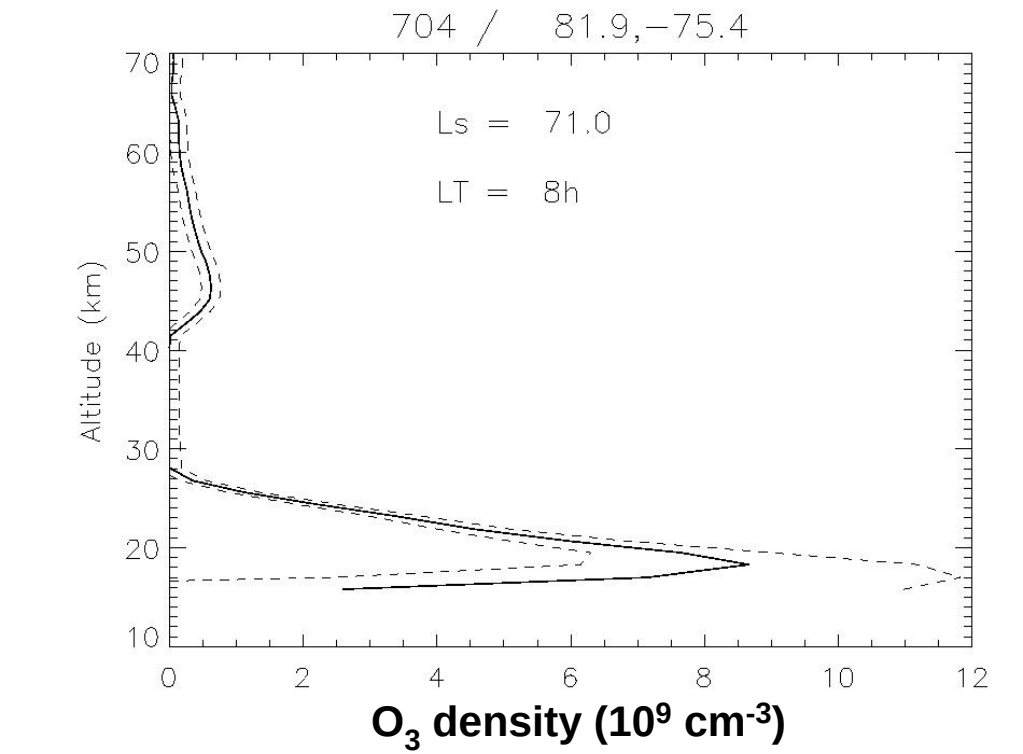
No predicted decrease of the peak

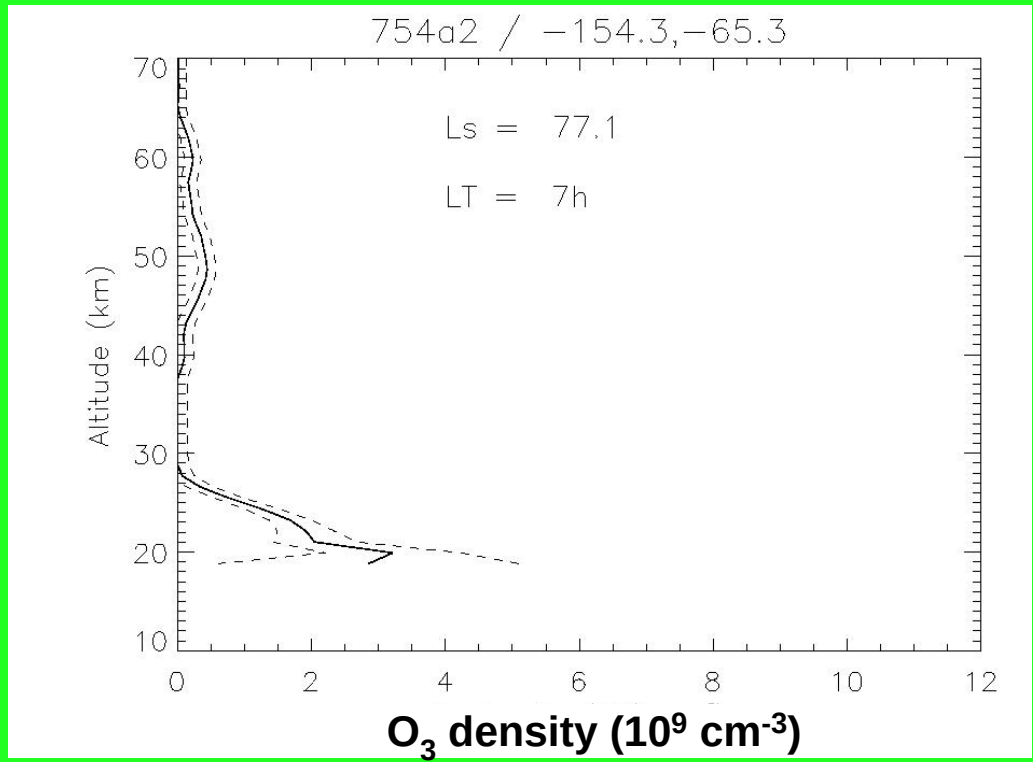
No double peaks are predicted

Ls = 50-80°: Late Fall / 60-90° S



Ls = 50-80°: Late Fall / 60-90° S





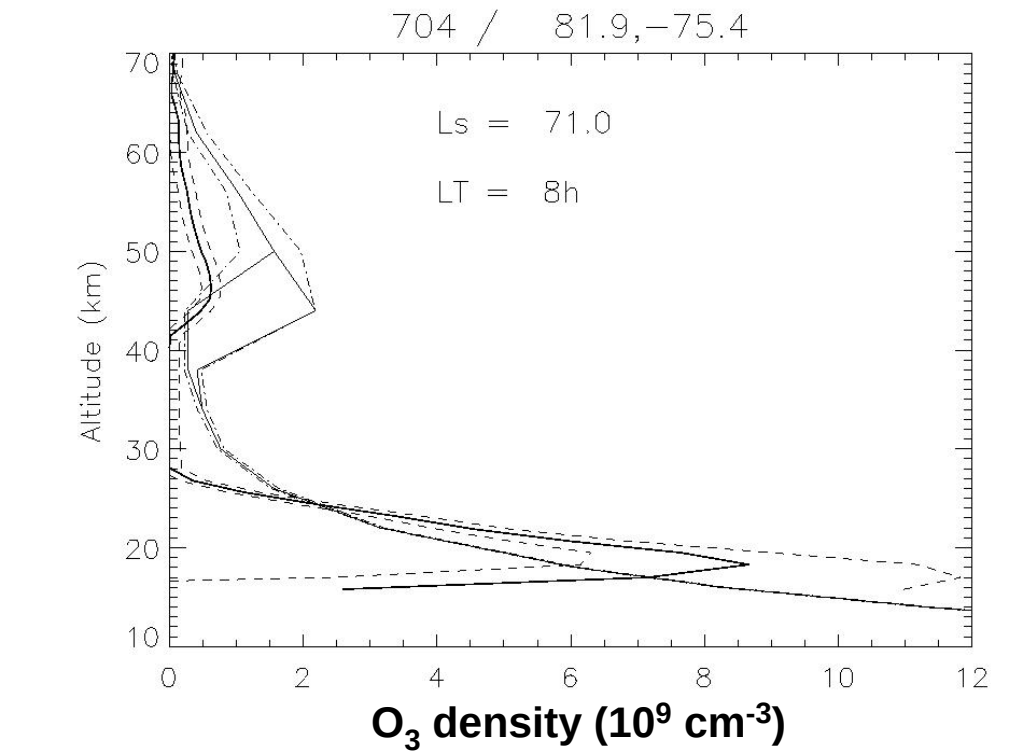
Two representative samples

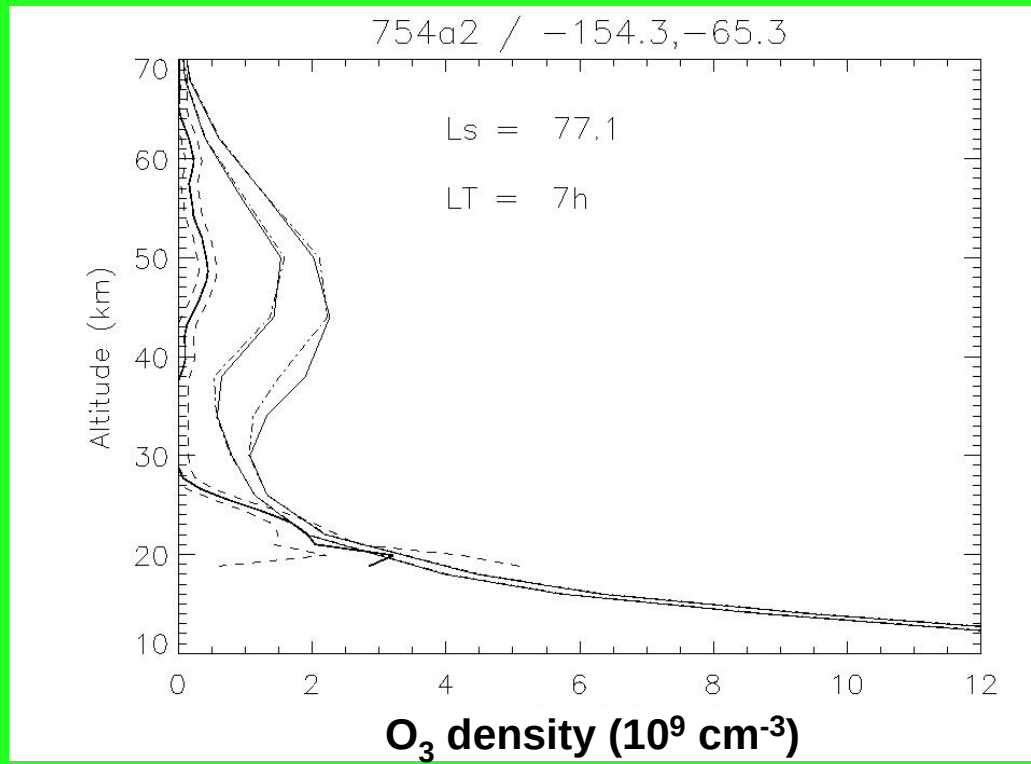
At high latitude, a very small ozone layer is seen at 50 km altitude, just above the noise level.

The top of a surface layer appears above 20 km altitude (surface ozone accumulates when water is condensing at the pole).

Ls = 50-80°: Late Fall / 60-90° S

Comparison to LMD MGCM :

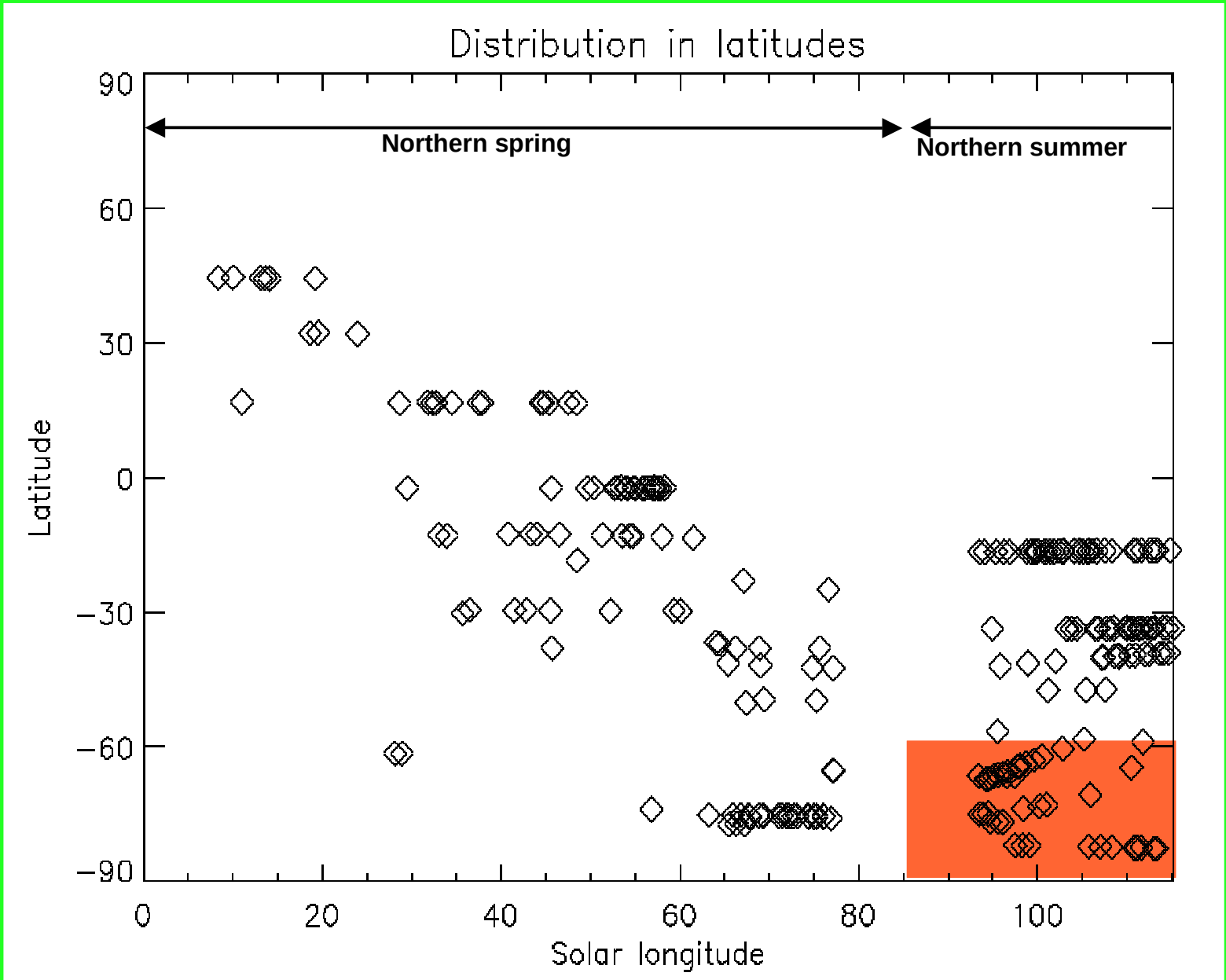




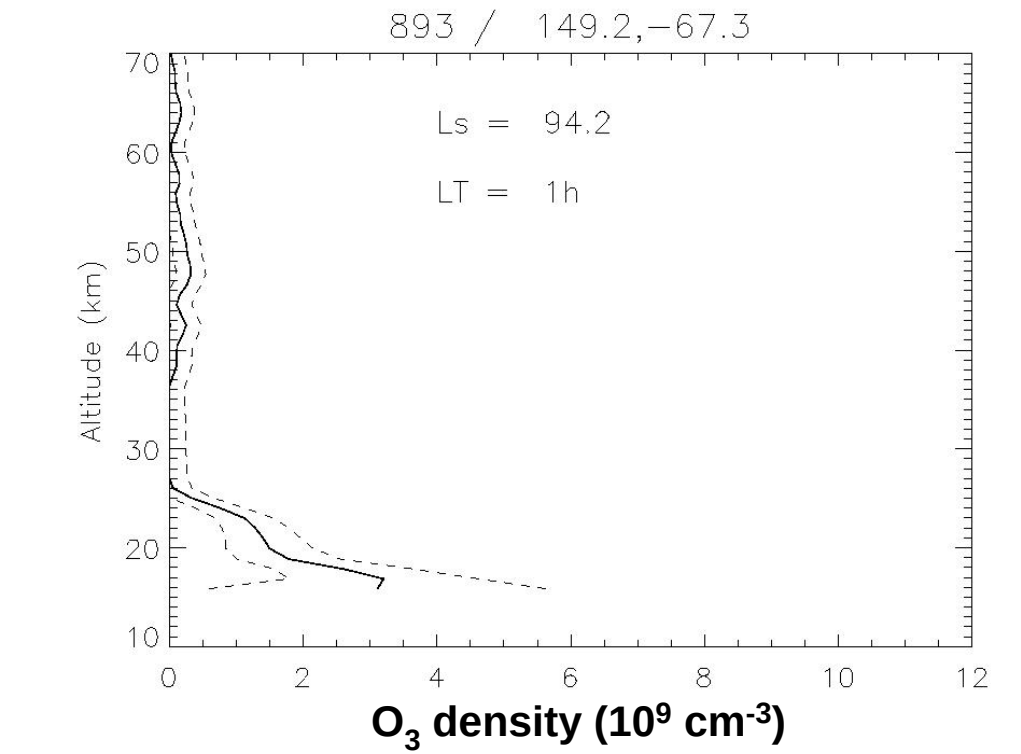
Predicted ozone layer is over-estimated compared to observations, but the peak altitude is in agreement.

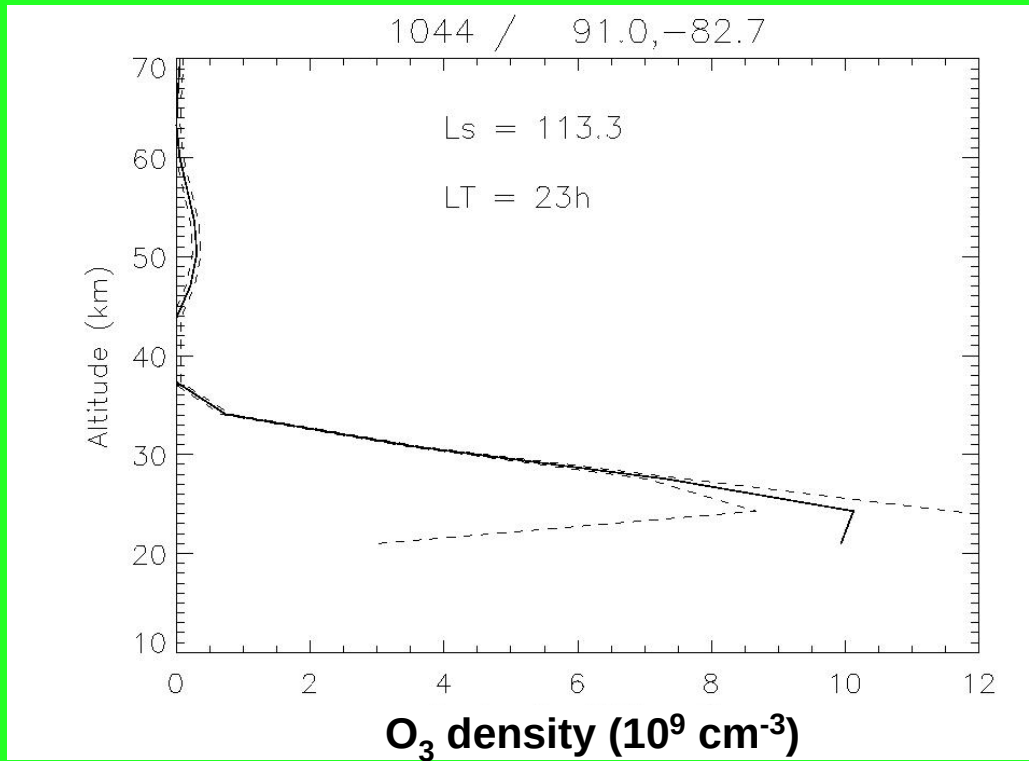
The surface layer is in good agreement in most cases, though its vertical scale height seems higher than observed.

Ls = 90-115°: Early Winter / 60-90° S



Ls = 90-115°: Early Winter / 60-90° S





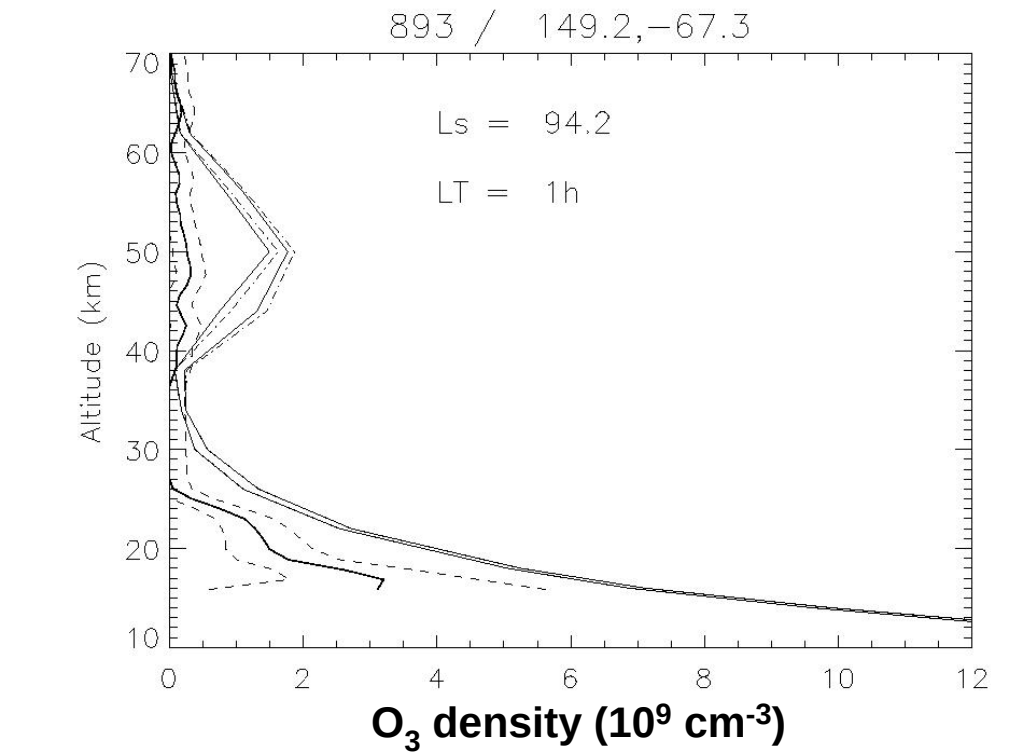
Two representative samples

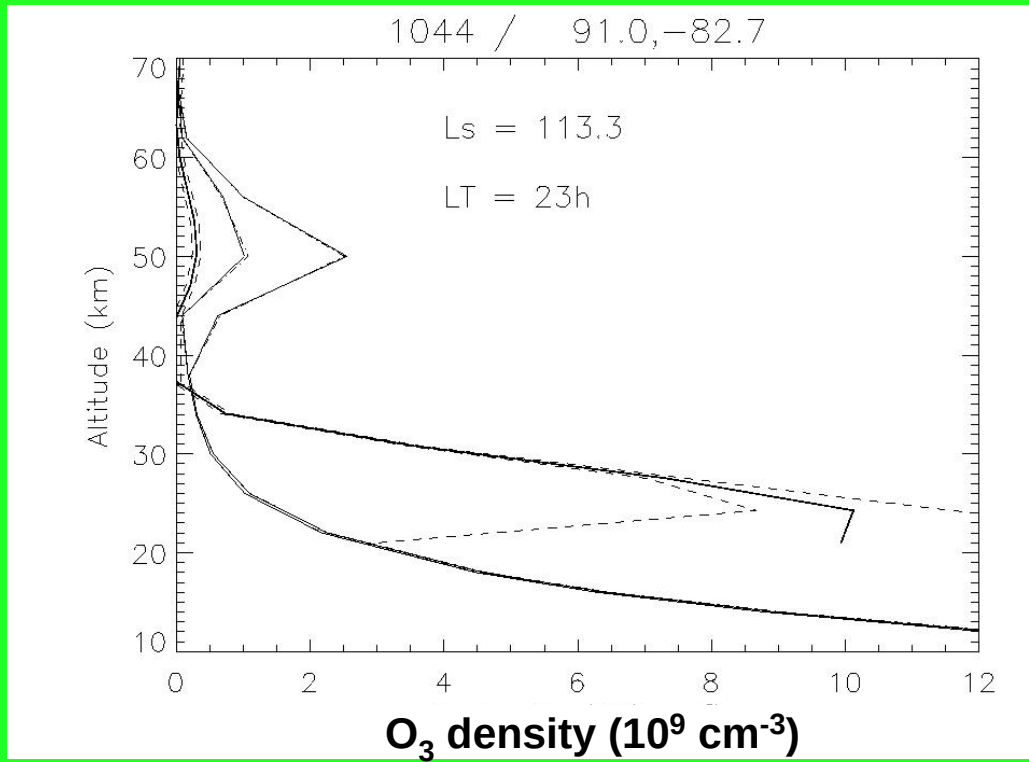
Little or no ozone is visible around 50 km altitude.

The surface layer appears above 20 km altitude, and increases significantly with Ls, and for latitudes close to the pole.

Ls = 90-115°: Early Winter / 60-90° S

Comparison to LMD MGCM :





Surface layer is over-estimated for latitudes < 70°, but significantly under-estimated at latitudes around 80°.

CONCLUSION

SPICAM UV stellar occultations have been analysed
=> ozone vertical profiles above ~20-30 km altitude.

northern spring and early summer (Ls=0 to 115°) covered.
9 regions covered in the season-latitude plan, mostly over the southern hemisphere.

A nocturnal ozone layer is observed around 40km altitude in most conditions, except :
- in the northern early spring, for Ls < 30°.
- at high southern latitudes, where the ozone layer is barely detected around 50 km altitude.
The peak abundance of ozone in this layer is mostly in the range 5-10 10^{9} cm^{-3}.
In some cases, structures (e.g. double peaks) are seen within the ozone layer.

At high southern latitudes, the top of a surface layer is visible above the retrieval limit (due to dust) around 20 km altitude.
This layer increases with Ls, and can reach as high as 35 km at latitude ~80°.

The LMD Mars Climate Model has predicted this nocturnal ozone layer (Lefèvre et al., JGR 109, 2004).
Altitude and abundance are generally in good agreement with observations for Ls > 40°.

Discrepancies between observation profiles and model:
- For early spring in the northern hemisphere, the ozone layer is increasing only after Ls ~30°, when in the model, it is already present at spring equinox.

- The ozone layer visible in the southern hemisphere is decreasing during early winter, which is not the case in the model profiles.

- The predicted ozone layer is usually thicker than the observed one, and does not feature structures corresponding to those observed in some profiles.

- For high southern latitudes, a 50 km altitude layer is predicted, but appears to be significantly over-estimated compared to observations.

- The surface layer predicted over high latitudes during fall and winter seems over-estimated for latitudes less than 70°, but largely under-estimated at latitude ~80°S.