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Mapping of Martian CO from NOMAD solar occultation measurements during MY 34.



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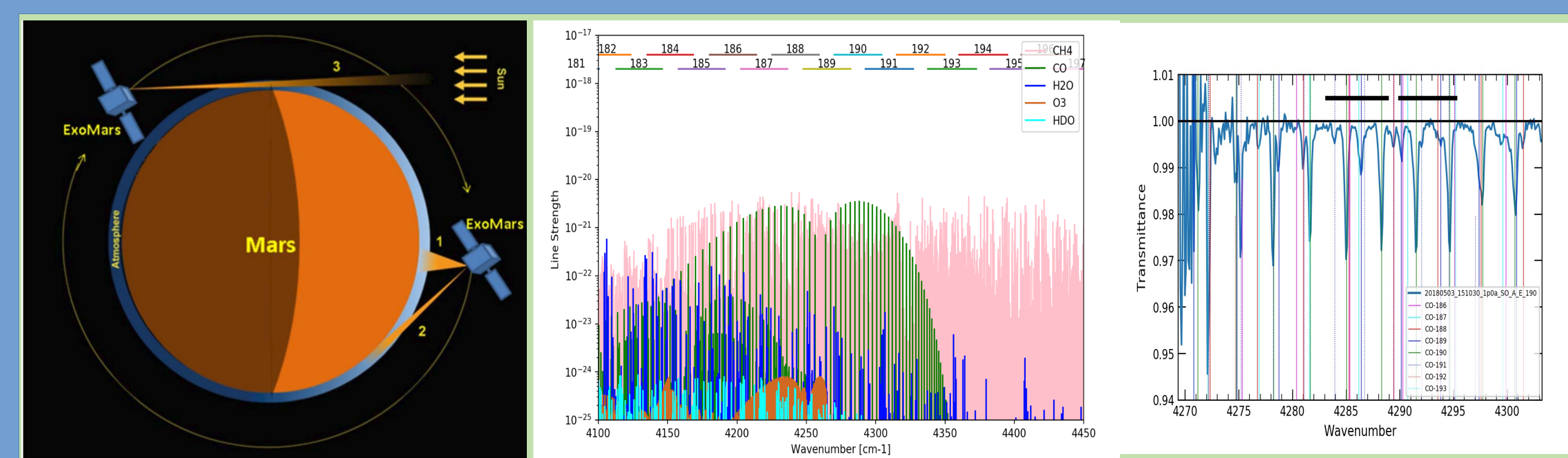
Introduction

Link with photochemistry: CO is produced in the Mars' upper atmosphere by the photolysis of CO₂ and destroyed in low altitudes mostly via reaction with hydroxyl radicals (OH)[2]. Thus CO is closely linked to the stability of this CO₂ atmosphere and with key photochemical processes including the H₂O cycle.

Dynamical tracer: Due to its long lifetime, CO can be used as dynamical tracers.

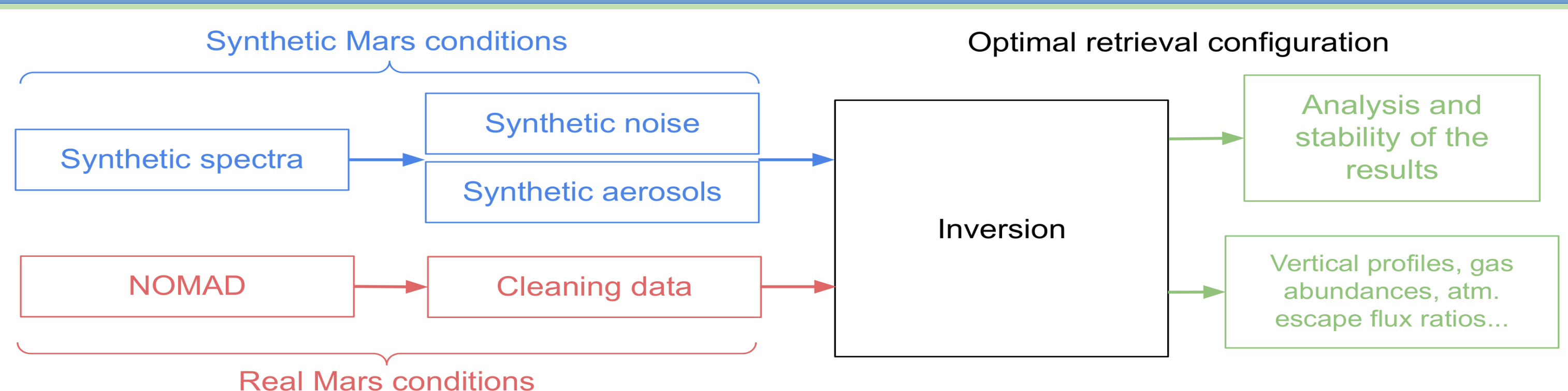
Goal: In addition to nadir column abundances (from instruments like CRISM or NOMAD-LNO[1]) the systematic mapping in the limb (solar occultation) offers an excellent opportunity to improve the description of the CO vertical distribution.

NOMAD Measurements



Observation mode of the solar occultation (SO) channel, location of known absorption bands of atmospheric species in part of the NOMAD spectral range, and the contribution of lines from different diffraction orders, a typical complication in spectrometers using acousto-optic filters like NOMAD. SO channel operates in the spectral range 2.3 – 4.3 μm which includes different diffraction orders. In these diffraction orders lie strong CO absorption lines.

Retrieval Method



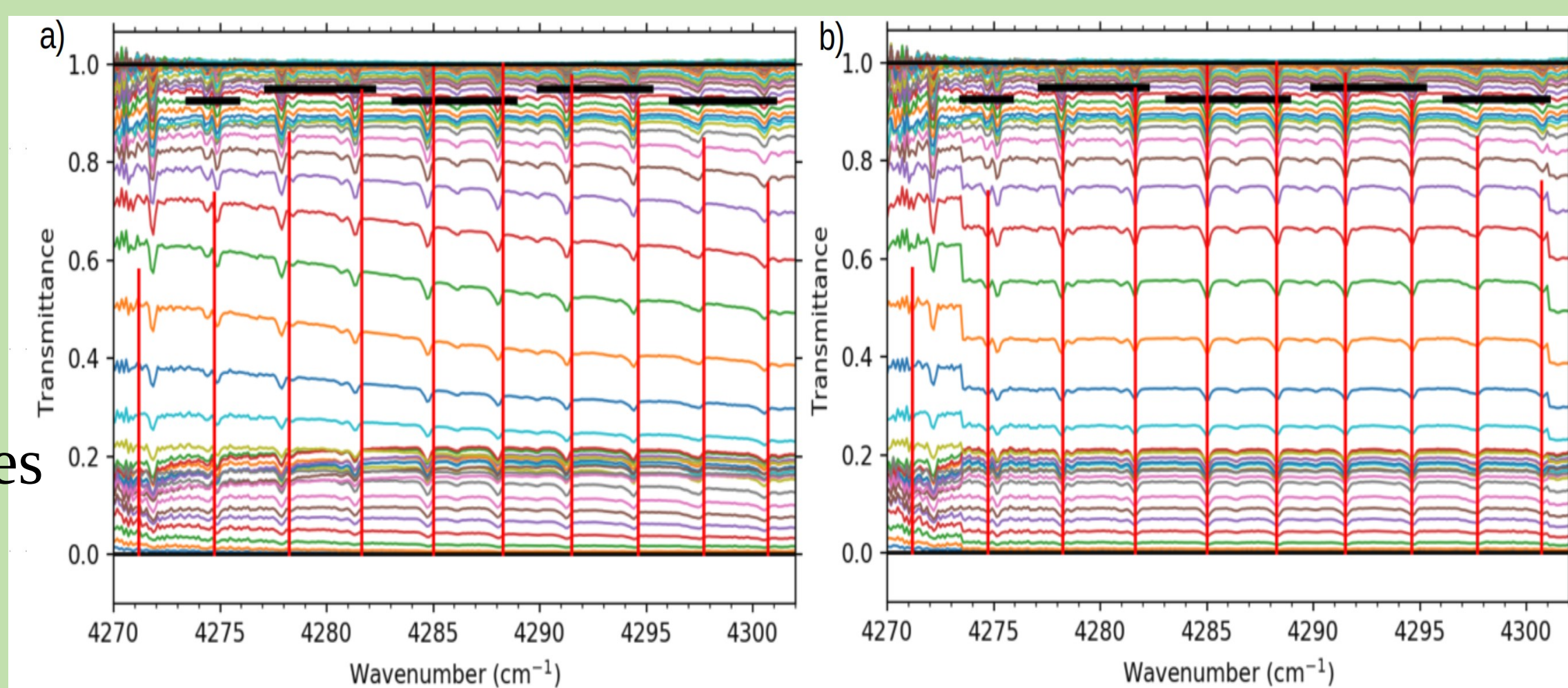
We retrieve gas abundances[3][5][8], temperature[3] and aerosols[4] from NOMAD level 1A calibrated transmittances using a state-of-the-art retrieval technique. CO is obtained from the NOMAD spectra in two major steps.

1) Preprocessing

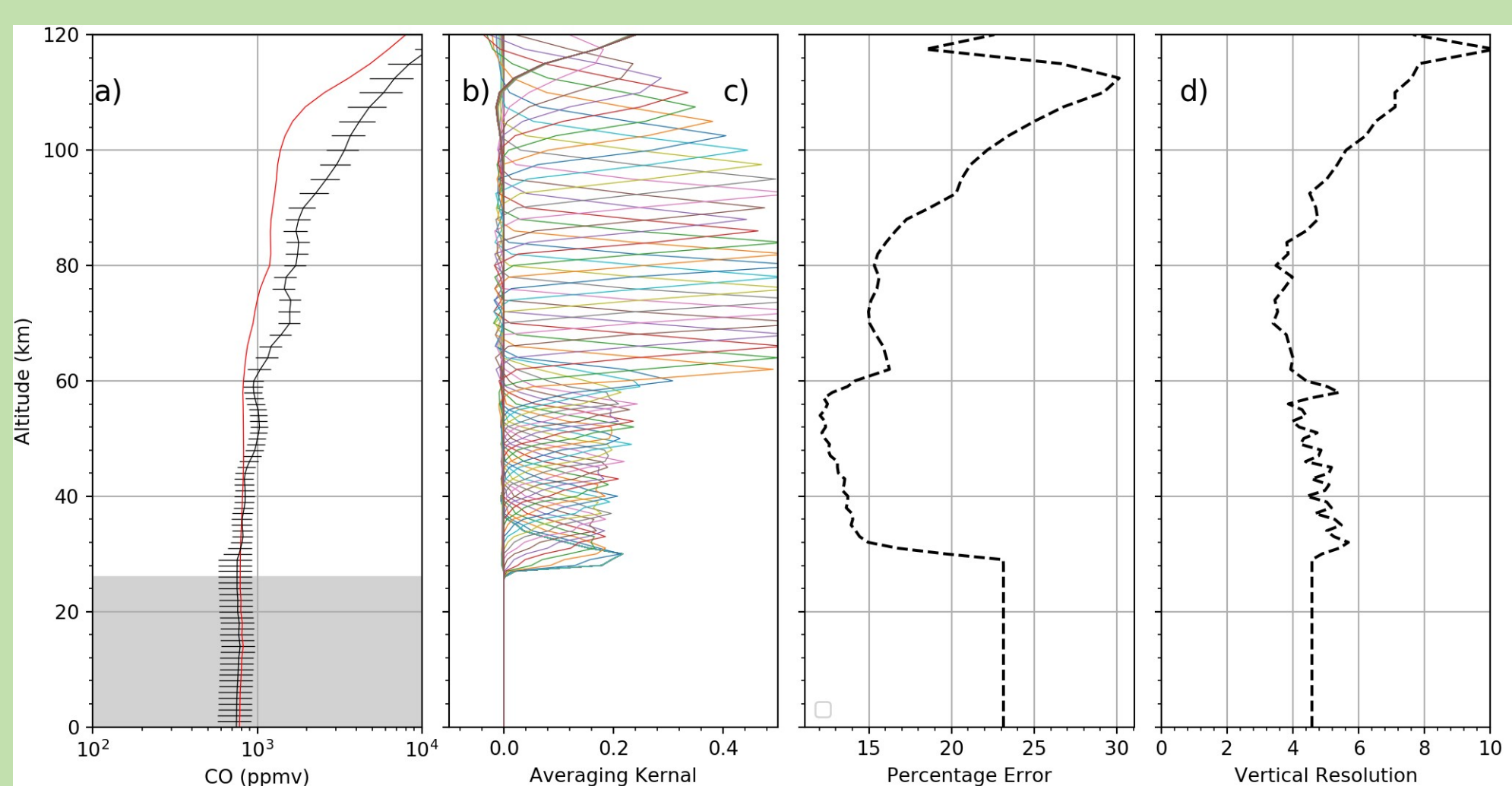
Before Cleaning

After Cleaning

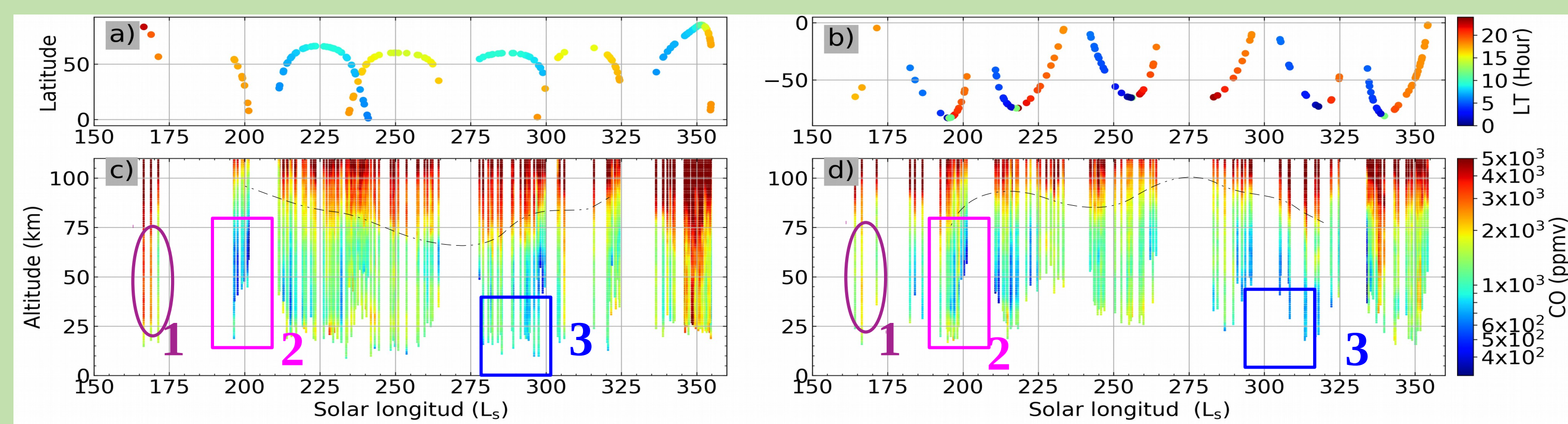
NOMAD spectra suffers spectral bending and residual spectral shift. We perform Cleaning/removal of residual spectral issues like bending and spectral shift, via comparison with synthetic spectra at each altitude.



2) **Inversion:** We use a well known forward model and iterative solver (KOPRA and RCP [7]) obtaining quality retrievals like these one, with retrieval errors 5-30% and vertical resolution around 4 km.



CO Distribution



CO profiles from 1st year of TGO operation (second half of MY34)

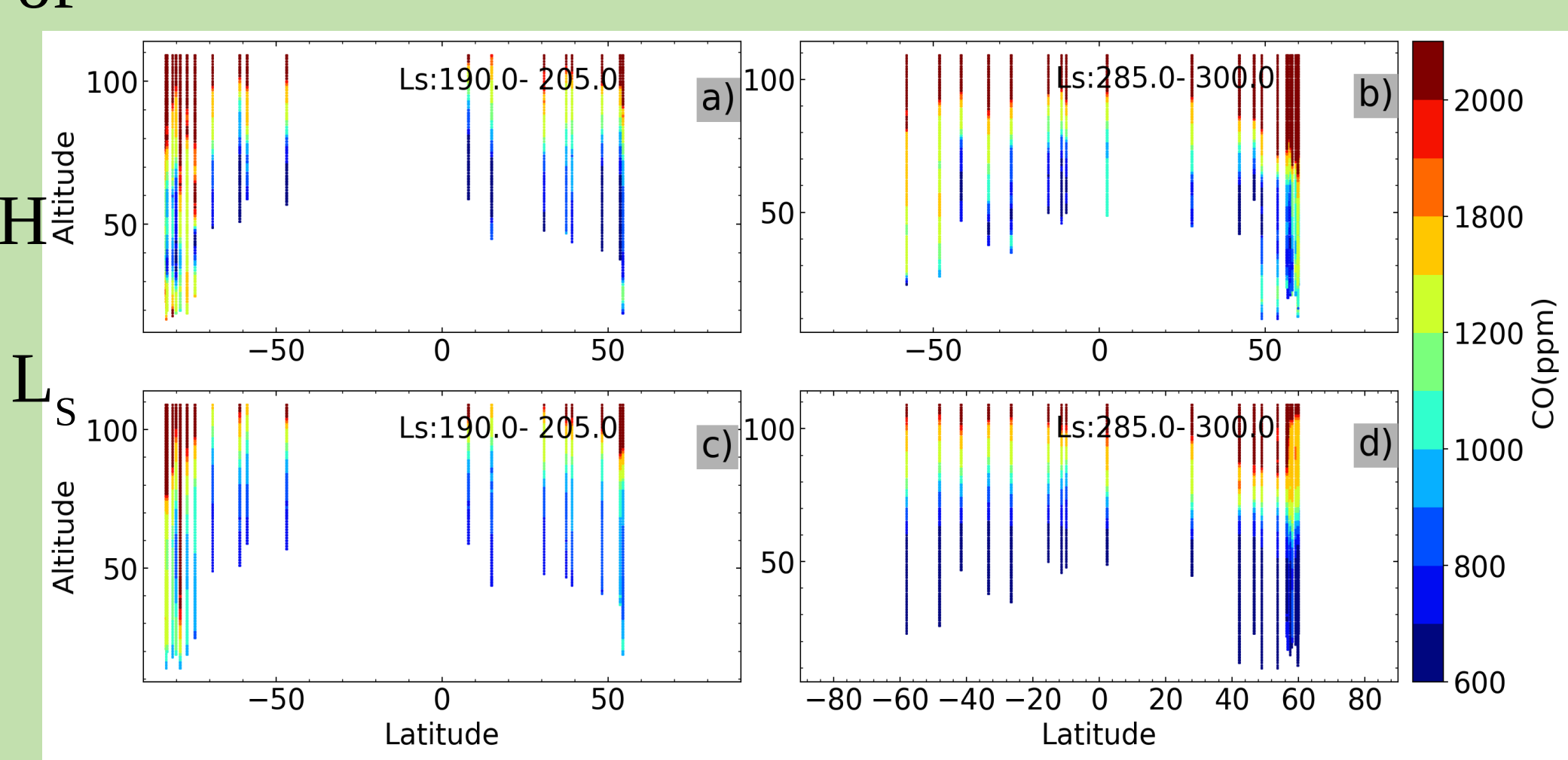
- 1) The downwelling of CO seems to vary following the black iso-contour. Over the northern hemisphere, the downwelling is strong down to 60km during Ls=270° while over the southern hemisphere, it is limited to higher altitudes.
- 2) Few lower atmospheric features of the CO distribution are highlighted with colored geometrical shapes and these are **1**, equinoctial increase, **2**, depletion during GDS and **3**, depletion during southern summer.

Latitudinal Distribution

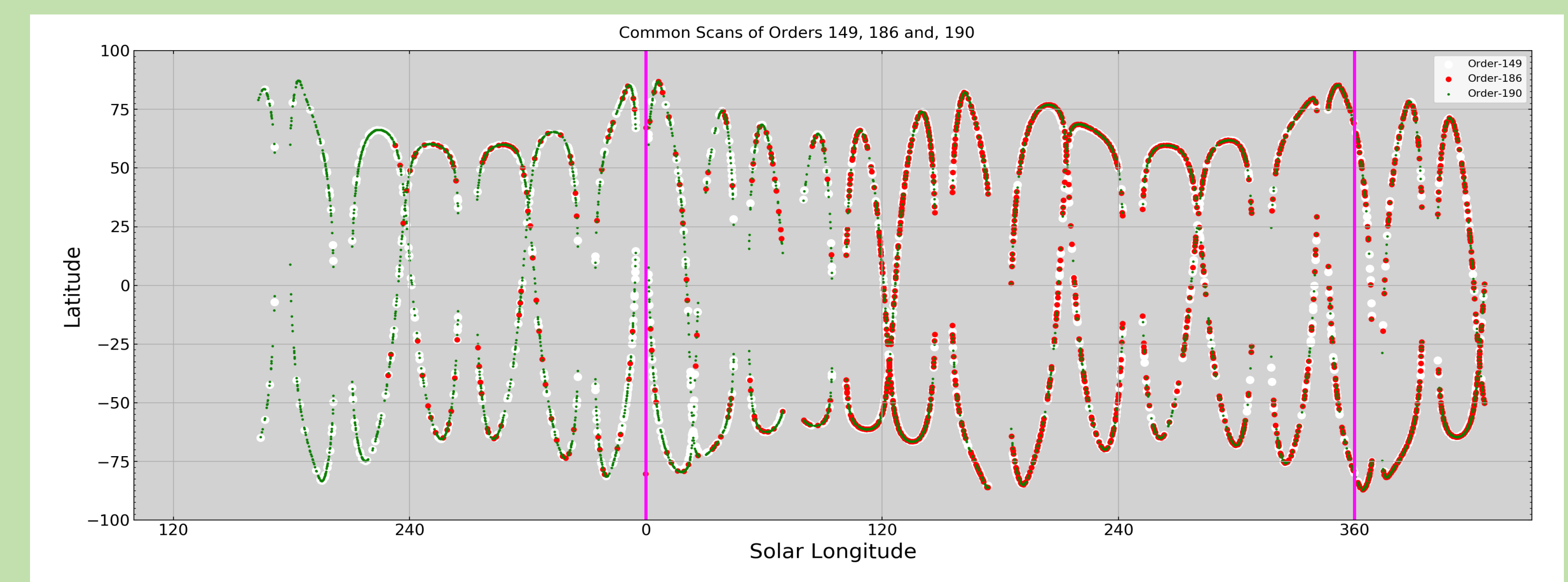
Panels a and c: Increase of CO due to hemispheric Hadly cell, even at low altitudes over the high SH latitudes.

Panels b and d: During Ls = 285.0 – 300.0 a fully developed global inter-hemispheric circulation can be seen in the CO distribution.

Latitude distribution for selected seasons



Future Work



- 1 To extend from half to 2 MY of measurements. This will include variable dust scenarios (with / without GDS).
2. To retrieve from common scans for orders 186 and 190. Depending on saturation of the absorption lines, Order 186 should have more information in the lower altitudes and order 190 should have better information in the higher altitudes.
3. To better characterize the error (including spectral error correlations), which should improve retrievals at the higher-most altitudes.

References

1. Smith, Michael D., et al. "The climatology of carbon monoxide on Mars as observed by NOMAD nadir-geometry observations." *Icarus* 362 (2021):114404.
2. McElroy, M. B., & Donahue, T. M. (1972). Stability of the martian atmosphere. *Science*, 177 (4053), 986–988.
3. López-Valverde et al, (2022) Martian atmospheric temperature and density profiles during the 1st year of NOMAD/TGO solar occultation measurements, *JGR*, 2022, submitted.
4. Stolzenbach, et al (2022). Martian atmospheric aerosols composition and distribution retrievals during the 1st Martian year of NOMAD/TGO solar 941 occultation measurements. *JGR*, 2022, submitted.
5. Brines et al (2022) Water vapor vertical distribution on Mars during the perihelion season of MY34 and MY35 from ExoMars TGO/NOMAD solar occultation measurements. *JGR*, 2022, submitted.
6. Vandaele et al (2018). NOMAD, an integrated suite of three spectrometers for the exoMars trace gas mission: Technical description, science objectives and expected performance. *Space Science Reviews*, 214 (5), 1–47.
7. Jurado Navarro, Ángel Aythami. "Retrieval of CO₂ and collisional parameters from the MIPAS spectra in the earth atmosphere." (2016).
8. Modak, et al (2022), Retrieval of Martian atmospheric CO vertical profiles from NOMAD observations during the 1st year of tgo operations measurements, *JGR*, 2022, Submitted.