

4.6 Special Cases

In this section three additional molecules are considered which require some modification to the current operational retrieval algorithm: CO, NO and CO₂.

4.6.1 CO

CO emissions in the infrared are strongly influenced by non-LTE processes, particularly at high altitude and in the day-time, although CO itself does not have any significant diurnal variation in concentration. This suggests that a nighttime LTE retrieval might be feasible when the non-LTE effects are small enough to be ignored (corresponding to option 1 in section 1.7). Alternatively, since CO is a relatively simple molecule, the non-LTE emission may be closely approximated by a single ‘vibrational temperature’ profile. In principle, therefore, a joint-microwindow selection could be performed to retrieve both CO and its vibrational temperature (option 4 in section 1.7). The question is whether it is possible to discriminate between in the two spectral signatures, i.e., whether the respective Jacobians are distinct.

Microwindows selected for the two cases are listed in Tables 29 and 30 and plotted in Figs. 57 and 58. In both cases the limit of 10000 measurements restricts the number of microwindows selected.

Table 29: CO nighttime (LTE) Microwindows

MW	Waveno. Range	Alt.	NPts	NUse
1	2138.575 2141.525	6 68	2023	1671
2	2156.025 2159.025	6 68	2057	1772
3	2150.200 2153.200	6 52	1815	1333
4	2054.925 2057.925	6 68	2057	968
5	2133.900 2136.900	6 42	1573	1340
6	2110.175 2113.125	6 27	952	632
Total:			10477	7716

Table 30: Joint CO, T_{vib} day-time (non-LTE) Microwindows

MW	Waveno. Range	Alt.	NPts	NUse
1	2157.675 2160.650	6 68	2040	2040
2	2133.875 2135.725	6 68	1275	1274
3	2111.200 2111.975	6 68	544	544
4	2055.250 2058.250	6 68	2057	1392
5	2138.825 2141.825	6 68	2057	1893
6	2145.725 2148.725	6 68	2057	1732
Total:			10030	8875

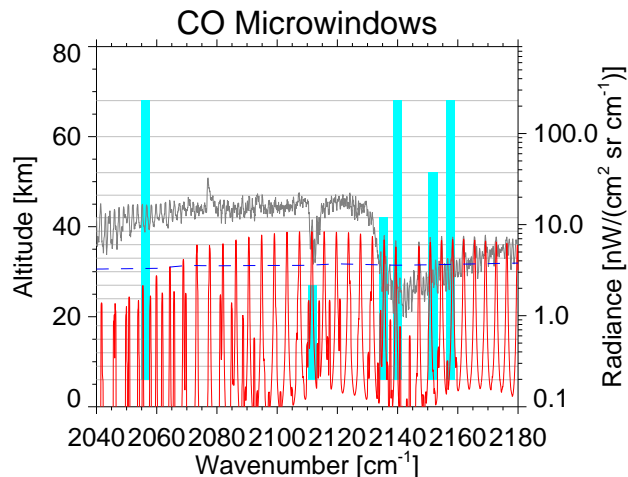


Figure 57: CO nighttime (LTE) microwindows and the CO spectrum.

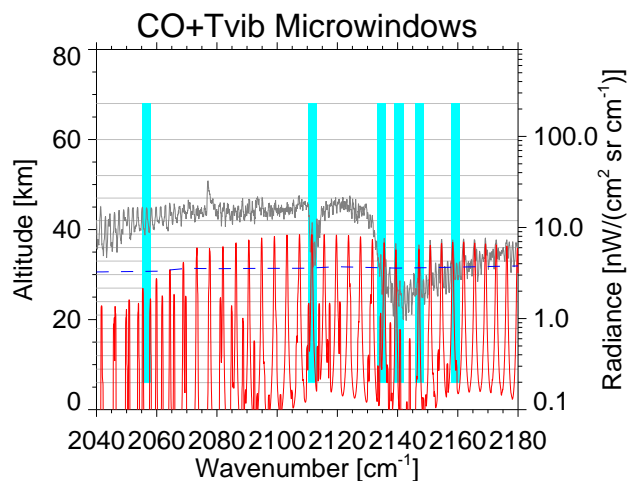


Figure 58: Joint CO, T_{vib} day-time (non-LTE) microwindows and the CO spectrum.

Fig. 59 shows the CO profile and expected accuracy for the LTE case, and Fig. 60 the (kinetic–vibrational) temperature profile and expected accuracy for the non-LTE case. Results are summarised in Fig. 61.

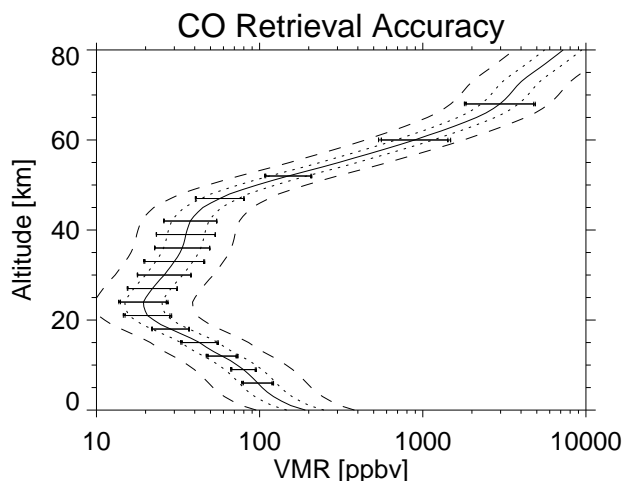


Figure 59: CO profile and retrieval errors for a mid-latitude night-time scenario assuming LTE. The dashed lines represent the $\pm 100\%$ *a priori* uncertainty and the dotted lines the $\pm 30\%$ limit of ‘useful’ accuracy. Inner ticks on error bars are precision, outer ticks are accuracy.

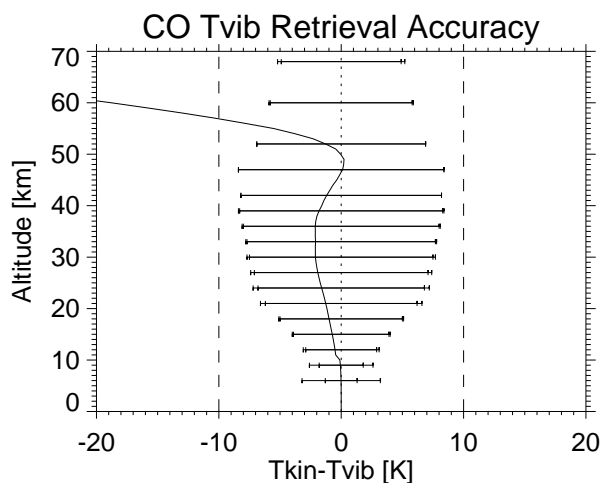


Figure 60: Difference between the kinetic and vibrational temperatures, and retrieval errors for mid-latitude day-time scenario assuming a joint $\text{CO}, T_{\text{vib}}$ retrieval. The dashed lines represent the ± 10 K *a priori* retrieval uncertainty.

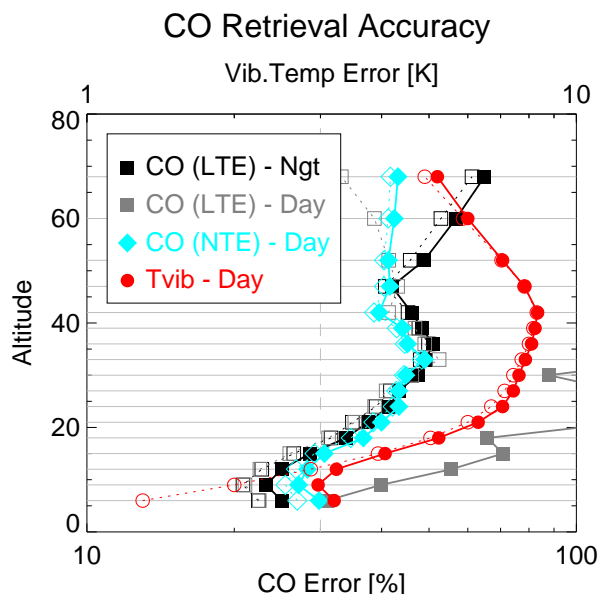


Figure 61: Retrieval accuracy profiles for CO assuming LTE in nighttime and daytime scenarios, and for CO (NTE) jointly with T_{vib} (top axis) in the daytime. Solid symbols/lines are accuracy, open symbols/dashed lines are precision.

From Fig. 61 it can be seen that the day-time non-LTE retrieval is slightly worse than the night-time LTE retrieval from 6–24 km, altitude, but both are capable of giving accuracy better than 30%. From 27–47 km results are comparable and, while the NTE retrieval is better above 47 km, the accuracy (40%) is probably not useful. However, for both cases the accuracy is limited by precision (i.e., S/N) and, given the regularity of the CO spectrum, it should be possible to improve on this by adding further (possibly narrower) microwindows.

Fig. 61 also shows the accuracy that would result if the LTE microwindows were used during the daytime, clearly illustrating that non-LTE effects cannot be ignored during the daytime.

The conclusion is that CO can be retrieved to useful accuracy in below 25 km either at nighttime (ignoring non-LTE effects) or in the daytime including a vibrational temperature retrieval. However, because of the wide spacing of CO lines and low MIPAS S/N in the the D-band, a relatively large number of microwindows/measurements (therefore high CPU cost) would be required.