Feofilov et al, $CO_2(v_2)$-O quenching rate coefficient derived from coincidental SABER/TIMED and Fort Collins lidar observations of the mesosphere and lower thermosphere, Atmos. Chem. Phys. Discuss, 11, 32583-32600, (2011).

Referee Comments: S. W. Bougher (U. of Michigan)

1. **General Comments:**

This is an important paper that seeks to address a long-standing problem of the CO_2 cooling rates in the Earth's MLT region. Specifically, the crucial CO_2-O quenching rate (k_{VT}) is uncertain. Values obtained in the laboratory or retrieved by fitting numerous space observations vary by up to a factor of 3-4. This same quenching rate also has very important implications for the CO_2 cooling rates (and the corresponding heat budgets) of the upper atmospheres of Venus and Mars (e.g. Bougher et al., 1999)

In this paper, a new technique is being used to retrieve the k_{VT} rate , for which the synergy of two instrument datasets is being utilized to extract this rate and study its behavior in the MLT region of Earth. The two datasets selected from SABER/TIMED (including vertical profiles of $I_{15}(z)$, O(z), and $CO_2(z)$) and the Fort Collins lidar (including T(z) over ~80-110 km) are spatially and temporally overlapping. Calculations of $I_{15}(z)$ are also carried out making use of the NLTE ALI-ARMS code package. These datasets and model simulations are used together to minimize of the difference between the measured and simulated 15-micron radiances ($I_{15}(z)$ by varying the k_{VT} rate at each altitude. A similar approach has been used before for other Earth studies (Feofilov et al., 2009), and seems well suited to the k_{VT} rate retrieval studies in this paper. Overall, this methodology is valid, and the results are discussed in an appropriate and balanced way.

The scientific results and conclusions are presented in a clear, concise, and well structured manner. The paper is well organized. The Figures and single table are well designed, easy to comprehend, and also well suited to the discussion in the paper. Appropriate consideration is given to related work, including noteworthy references in most cases. However, one additional reference is suggested. A few grammar issues exist; they are quite small and easily corrected. Overall, this is a well written paper with a great presentation.

2. **Specific Comments:**

   a. **The most important component for the CO_2-O k_{VT} rate retrieval in your method is the average [O] density that you use!** How do numerical calculations of climatological [O] densities (at the same location and season) compare with those derived from averaging the SABER observations? Future work should also include similar studies utilizing SABER measured [O] averaged at other locations at different times and seasonal conditions in association with overlapping lidar measurements. This may be difficult, but it is necessary to confirm that the averaging technique you use yields similar k_{VT} rates regardless of location and season.

   b. **The only detailed calculations to date related to α(z) come from Kharchenko et al. (2005)**. Quenching of hot [$O(^1D)$] largely by ambient O, O_2 and N_2 collisions likely produces hot [$O(^3P)$] in the 80-110 km region. The key issue here is the thermalization timescale for these hot [$O(^3P)$] atoms (about 1eV from the [$O(^1D)$] quenching) in both elastic and inelastic collisions with the ambient atmosphere (see Figure 8 of Balakrishnan et al., 1998). Very short thermalization timescales are likely in this 80-110 km region. Therefore, detailed photochemical/energy calculations of α(z) for Earth are needed to confirm whether your suggested mechanism (i.e. hot O collisions as a source of $CO_2(v_2)$ level excitation over ~80-110 km) is valid or not. Some discussion of this is needed.

   c. **Summary section**. The significant impacts of this CO_2-O k_{VT} rate upon heat balance calculations of other planets and their dayside temperatures (e.g. Venus and Mars) is not discussed, but should be.

These planetary "laboratories" (particularly Venus) can provide insight into the solution of this problem at Earth. A self-consistent treatment of this CO_2-O VT rate across Earth, Venus and Mars upper atmospheres is needed. In short, your call for additional studies should include these planetary upper atmospheres, and the radiative cooling calculations of all three of these upper atmospheres in general circulation models (i.e. Bougher et al., 1999) should be performed in accordance with the fractionizing you define in equation #4. The fraction (α) of total $O(^3P)$ density which corresponds to hot atoms will need to be re-evaluated for each planetary upper atmosphere, especially in those regions where CO_2 cooling serves as the primary IR radiator (see Bougher et al., 1999).

3. Technical Corrections.

a. Pg. 32586, line 5: ".. frequency of collisions is lower and the vibrational level populations…."
b. Pg. 32587, line 25: "…uncertainties in the k_{VT} coefficient."
c. Pg. 32588, line 22: "…It is important to choose…."
d. Pg. 32590, line 14: "..shown in Fig. 2c fit well…"
e. Pg. 32591, line 22:"…which seems justified usage of…"
f. Pg. 32592, line 2: Do you instead really want (1-α) in the first term of equation 4? Or is there an embedded sign in the term that I do not see?
g. Pg. 32592; line 12: Same as above regarding the factor of (1-α) in term #1 of equation 5?
h. Missing key reference that is needed:

Bougher, S. W., S. Engel, R. G. Roble, and B. Foster, Comparative Terrestrial Planet Thermospheres : 2. Solar Cycle Variation of Global Structure and Winds at Equinox, J. Geophys. Res., 104, 16591-16611, (1999).