Corrigendum to "Summer time Fe depletion in the Antarctic mesopause region" by Viehl et al.

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Abstract

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It has been brought to our attention that there is an error in the expression for A on page 100 of *Viehl et al.* (2015a). The quotient of concentrations in the equation for A was expressed as:

$$\begin{aligned}\frac{[\mathrm{O}]}{([\mathrm{O}]\,[\mathrm{O_2}]\,[\mathrm{M}])^2} &= \frac{[\mathrm{O}]_{eff}}{\left([\mathrm{O}]_{eff}[\mathrm{O_2}]_{eff}[\mathrm{M}]_{eff}\right)^2}\left(\frac{T}{T_{eff}}\right)^5 \\ &\approx \frac{[\mathrm{O}]_{eff}}{\left([\mathrm{O}]_{eff}[\mathrm{O_2}]_{eff}[\mathrm{M}]_{eff}\right)^2} e^5 \exp\left(\frac{-5T_{eff}}{T}\right)\end{aligned}$$

where the *eff* subscript indicates values at the reference temperature of $T_{eff} = 136\,\mathrm{K}$. The factor of e^5 was mistakenly omitted from the equation for A. Since $e^5 \approx 148$, A is 3×10^6, rather than 2×10^4 as stated in the paper. This means

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that the fit through the lidar observations of [Fe] versus T in Figure 3 (the blue curve) cannot be explained solely by temperature-dependent gas phase chemistry under the assumptions and simplifications made.

In fact, since this paper was published the photolysis rate of FeOH, J (FeOH), has been shown by some of the authors to be around $6 \times 10^{-3}\,\mathrm{s}^{-1}$, which is even larger than the value listed (for R13) in Table 1 (*Viehl et al.*, 2015b). This further increases A and questions the simplifications. Moreover, ~~in the recent report~~ *Viehl et al.* (2015b) concluded that the much larger photolysis rate leads to a nearly complete depletion of FeOH during sunlit periods. FeOH can therefore not be a significant reservoir for Fe around summer solstice. Hence, the fundamental assumption of a temperature dependent partitioning between FeOH and Fe made by *Viehl et al.* (2015a) is not justified in the polar summer mesosphere.

Nevertheless, the major conclusion of the paper stands: that the summertime depletion of the Fe layer is not caused primarily by the heterogeneous removal of Fe (and its compounds) on polar mesospheric ice cloud (PMC/NLC) particles. The clear observational evidence for this is described in Section 3.2 of the paper. Further evidence is provided from 3D model simulations of the Fe layer in the Whole Atmosphere Community Climate Model (WACCM-Fe) (*Feng et al.*, 2013). Simulations were performed for the location of Davis (69°S), both with PMC formation and the uptake of Fe species as described by *Feng et al.* (2013), and also without PMC uptake. Figure 1 shows the Fe density at 86 km, recorded every 30 minutes for the months of December and January. The simulation with PMC uptake is shown in black, and without uptake in red. The temperature-dependence of

the Fe density is essentially identical for both scenarios, demonstrating that PMC uptake plays a limited role. Furthermore, the fraction of iron that is in the form of atomic Fe remains roughly constant ($\approx 60\%$) over the 125–180 K temperature range (not shown). Thus, the 7-fold increase in Fe density with temperature may be explained due to a change in the total iron density.

This indicates that dynamics plays an important role: when upwelling is strongest, the divergence of Fe-poor air from the middle mesosphere produces low Fe densities and simultaneously the coldest temperatures. Hence, Fe density and temperature are positively correlated. This interpretation is supported by the reported uplift of the Fe-layer at Davis (*Viehl et al.*, 2015a). However, Fe atoms do not constitute a passive tracer and the complex temperature dependent interaction with the background atmosphere needs to be considered when quantitatively investigating the upwelling. Further modelling work, high resolutive vertical and horizontal wind observations as well as laboratory studies of important chemical reaction rates are required to determine the contributions by upwelling and temperature dependent chemistry.

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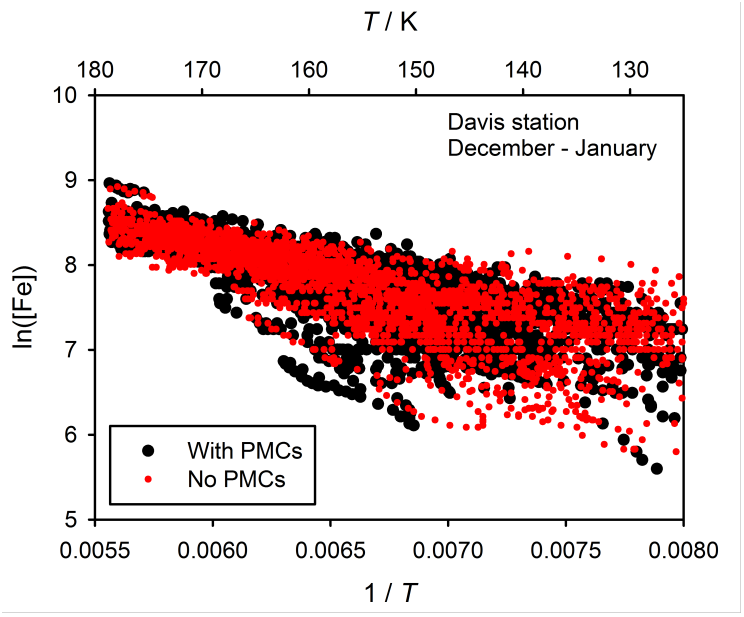

Figure 1: Fe density at 86 km as a function of temperature, from WACCM-Fe simulations with PMC formation and uptake of Fe species (black points) and in the absence of PMC uptake (red points).

References

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