

# ***Interactive comment on “Modelled Effects of Temperature Gradients and Waves on the Hydroxyl Rotational Distribution in Ground-Based Airglow Measurements” by Christoph Franzen et al.***

## **Anonymous Referee #1**

Received and published: 18 April 2019

### General comments:

This manuscript deals with an interesting effect not properly addressed by previous studies on the population of rotational levels of hydroxyl radicals in the mesosphere / lower thermosphere region of the Earth's atmosphere. The simple fact that kinetic temperature varies within the altitude range of the OH emission layer (for a wave or tidal perturbation possibly dramatically) will lead to an apparent deviation of the population of higher rotational states from LTE in ground-based observations. While this effect may not explain the majority of observed non-thermal populations of higher rotational levels, it certainly is an interesting effect that should be reported and considered in

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future studies. For this reason this manuscript is of interest to the aeronomy community and should eventually be published in my opinion. I ask the authors to consider the (mainly minor) comments below.

Specific comments:

Page 3, line 15: “from the empirical model of the US Naval Research Laboratory Mass Spectrometer and Incoherent Scatter radar (NRLMSISE-00)” sounds a little odd and is misleading. I suggest something like: “from the US Naval Research Laboratory’s Mass Spectrometer and Incoherent Scatter radar model (NRLMSISE-00)”

Page 4, line 1: “The temperature dependent rate coefficients for THESE reactions”

Should this perhaps be “.. for THIS reaction”? The statement seems to refer to reaction (2) only.

Page 5, line 16: “Where  $A_w(z)$  is a function of altitude”

Please provide more information on the altitude dependence of the wave amplitude, perhaps show a plot.

Page 5, same line: “and  $\phi_w$  for this example is defined as zero at an altitude of 74 km”

This statement suggests that the phase is altitude dependent. Is this really the case? I assume it is constant – then the reference to a specific altitude (74 km) can be removed.

Page 5, same paragraph: It would be good to state here already, whether the assumed wave perturbation may really occur in the atmosphere, or whether this is an extreme case that essentially never occurs.

Page 6, line 12: “Where  $N_{\{v\}}$  is the integral of the vibrational band VER”

Is this really the case? I think  $N_{\{v\}}$  is not an integrated VER, but rather the total (integrated) population of the  $v'$  level. Otherwise the units don't fit.

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Page 7, Figure 3, upper abscissa legend: Please add a space between “1.5” and “2.5”

Page 8, line 7: “the original background profile is retrieved”

I suggest replacing “retrieved” by “obtained”. For me as a “retrieval person” “retrieved” here means the temperature retrieval using the OH technique.

Page 8, line 8: only a minor comment, but “higher and lower temperatures” is perhaps more accurate than “warmer and colder temperatures”, because temperature cannot really be warm/cold. I leave it up to the authors to decide, whether they want to change this.

Page 9, Figure 4: It would be good to separate the two panels a little, add some space between panel a and b.

Page 9, line 18: “The first three rotational levels reproduce the same population as an atmosphere in LTE characterised by a single temperature”

It’s not entirely clear, whether this statement refers to the results of Pendleton et al. (1993). I think this is the case and suggest stating this explicitly.

Page 10, line 7: “In Fig. 5(a) the non-linearity of the temperature fit increases with both wave strength and vertical wavelength”

Looking at the Figure, this statement is not generally correct, is it? There are different regimes showing different behavior, e.g., for a vertical wavelength of 10 km, beta decreases with increasing amplitude. Please rephrase this sentence.

Page 10, line 9: “Figure 5 (b) shows the phase that yields the highest . . .”

The Figure does not show the phase, but the apparent excess population for the phase with . . . Please rephrase.

Page 11, line 10: “Instead it is due to the”

It’s not clear, what “it” refers to in this sentence. I assume it is “the difference in the ap-

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parent excess population” mentioned a few sentences above. Please state it explicitly.

Page 12, line 9: “The simulations executed here show that these temperature profiles can change the populations of the different rotational lines”

I have two comments on this sentence: 1) it is not surprising that temperature affects the rotational population of a vibrational state and I think this is not what you actually intend to say. The important point is that the vertical temperature variation leads to an apparent non-thermal population for an observer on the ground, right? 2) can “rotational lines” be populated? The rotational “states” or “levels” are populated and they give rise to the emission.

Typos etc.:

General: The section titles are all upper cases, which – I believe – is not the ACP standard.

Page 1, reaction (1): The “-“ sign inside the parentheses may be interpreted as a minus sign and I think it is not really necessary.

Page 3, caption of Figure 1, line 1: “red- dashed” -> “red-dashed” ?

Page 4, line 3: “Loss processes include losses DUE to O” ?

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Interactive comment on Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2019-318>, 2019.

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