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Atmospheric Chemistry and Physics Discussions

Interactive comment on "A nitric acid dataset from IASI for polar stratospheric denitrification studies" *by* Gaetane Ronsmans et al.

Anonymous Referee #1

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In this manuscript, Ronsmans et al. present vertical column amounts of nitric acid (HNO3) as derived from IASI observations over the Southern Hemisphere between 2008 and 2017. These are analysed in comparison with temperatures at 50 hPa to characterize the depletion of gas-phase HNO3 in the wintertime Antarctic polar vortex by uptake in polar stratospheric clouds (PSCs). As a measure for the onset of HNO3 depletion, the so-called 'drop-temperature', as defined by the minimum curvature of the HNO3 column amounts against time, is introduced.

After the foreseeable end of limb-observations in the microwave and thermal infrared spectral region, measurements from operational weather satellites by nadir sounding spectrometers will be the only possibility to inform about trace gases, like HNO3, which are important to describe the state of the stratosphere in the midst of intensifying cli-

mate change. Though not being able to derive vertical profiles, it is a least possible to derive total column amounts of HNO3 from the IASI instruments on the operational Metop weather satellites.

The major part of the data (2008-2016) reported in this manuscript was already published in Ronsmans et al. (2018), also together with temperatures at 50 hPa. For example, Fig. 4 (top) of the actual manuscript is a zoom of Fig. 3 of Ronsmans et al. (2018) to the southern latitudes with one Antarctic winter added. To derive reliable conclusions from these measurements, an in-depth characterization of these datasets on HNO3 is indispensable. While Ronsmans et al. (2016) provide a first validation of the observations by comparison with FTIR solar absorption measurements, a characterization given the extreme conditions within the dark Antarctic polar vortex is missing. This is one of the majors concerns why I think the paper should not be published in ACP in its present form. However, it should be quite straightforward to provide at least a first comparison with HNO3 observations by the Microwave Limb Sounder (MLS) which has a large temporal and spatial overlap with the IASI dataset.

Specific comments:

L3, 'good vertical sensitivity':

This has not been shown in this paper. It is necessary to demonstrate this for the dataset discussed here given the cold Antarctic stratosphere.

L8, 'denitrification':

Are you certain, that 'denitrification' is also used for the uptake of HNO3 in particles? Perhaps 'removal from the gasphase'.

L59, 'a maximum sensitivity in the mid-stratosphere around 50 hPa':

This must be shown here for the extreme conditions in the Antarctic vortex - also since all later analyses in the paper use temperatures at 50 hPa. What is the vertical variability of this level of maximum sensitivity within the development inside the vortex, especially later in the winter when, due to sedimentation of PSC particles, HNO3 concentrations at those levels are very low?

L79, 'The total columns yield a total retrieval error of 10% and a low bias (10.5%) compared to ground-based FTIR measurements (Hurtmans et al., 2012; Ronsmans et al., 2016).':

As these numbers are used also later in the manuscript, their validity has to be confirmed for the condition in the dark vortex, which cannot be achieved with comparisons to sun-dependent FTIR observations. As mentioned above, I strongly suggest to perform comparisons with the MLS dataset.

L105, 'These high HNO3 levels result from low sunlight,. . .':

This is not the only, and probably not the central explanation for the increasing column amounts. Dynamical effects on total columns of stratospheric gases (downwelling within the vortex) have to be considered.

Figure 2:

I think the vertical dashed line '10Jun09' does not fit to the minimum of the solid blue curve (?)

L154, 'in the areas of potential vorticity smaller than -10. . .'

PV at which potential temperature level is used here?

L159, 'Note that the HNO3 time series has been smoothed':

As the drop temperatures (and dates) are introduced as the central new method presented in the manuscript, it is necessary to explore their behaviour in more detail. Can you give an estimate of the error of this measure by considering e.g. the effect of the numerical smoothing. Please show also the 1st derivative to be able to judge on the uncertainties of the 2nd derivative. How do the drop temperatures vary when using different pressure levels (e.g. 70 hPa)?

L184, 'The calculated drop temperatures vary significantly between $\sim$180 and $\sim$210 K. These high extremes are only found in very few cases and should be considered with caution as they correspond to specific regions above ice shelves with emissivity features that are known to yield errors in the IASI retrievals':

I find the discussion around the deviations of the drop temperatures very confusing. At the beginning of the manuscript it is stated, that the error of the measured total column amounts is in the order of 10%. Here it is argued that 'above ice shelves' it might be higher. Also, in Fig. 5 one can see that there are large regions over eastern Antarctica where drop temperatures are often clearly above 195K even inside the red circles. This is not explained satisfactorily in the manuscript. Here, again, it would be important to investigate on the reliability, consistency and homogeneity of the IASI HNO3 values. As mentioned above, this could be accomplished with a comparison to MLS observations.

L195, 'Overall, despite these limitations, the spatial variability in the drop 50 hPa temperatures for IASI total HNO3 is well in agreement with the natural variation in PSCs nucleation temperatures':

Given the extended areas where the drop temperatures are larger than 195K, this statement is not convincing.

L204, 'denitrification phase':

See statement about 'denitrification' above.

L230, 'To the best of our knowledge, it is the first time that such a large satellite observational data set of stratospheric HNO3 concentrations is exploited to monitor the evolution HNO3 versus temperatures.'

This sounds somehow exaggerated given all the previous work on HNO3/temperature/PSCs, e.g. by use of the MLS dataset and also since the correlation with temperature has already been shown in Ronsmans et al., 2018.

Technical comments:

L27, ‘(e.g. (Toon. . .))’:

I think the inner bracket level is not necessary.

L30, ‘sedimentation(Lambert. . .’:

Space missing

L34, ‘temperature’:

‘temperatures’

L51:

Bracket levels?

L102, ‘The red vertical line in Fig. 1a and Fig. 1b’:

There is no vertical red line in Fig. 1a. You mean horizontal?

L106, references:

Brackets seem wrong.

Figure 2, caption, ‘in the70—’:

Space missing.

L155, ‘and the total HNO3 depletion are the coldest’:

Makes no sense.

L164, ‘temperature are’

‘temperatures are’

References

Ronsmans, G., Wespes, C., Hurtmans, D., Clerbaux, C., and Coheur, P.-F.: Spatio-temporal variations of nitric acid total columns from 9 years of IASI measurements –

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