Replies to the comments of Reviewer #2

General comments:
This is solid scientific contribution that sheds additional light on the transport of volcanic emissions during the NABRO eruption into the lower stratosphere. It contributes new insights that both compliment earlier papers on this eruption and enhance our understanding of troposphere-to-stratosphere transport in the tropics. In order to remove some existing ambiguities in this paper, I ask that the authors address the specific comments that follow.

We would like to thank the referee for his/her careful reading, review and useful comments which definitely helped to improve the paper. All suggestions have been followed in the revised manuscript.

Specific comments:
Page 31163, lines 11-16: This sentence is too long and awkward – particularly the use of 'markedly'

We have changed the original sentence to:

'The OSIRIS/Odin limb sounder for instance measured its largest aerosol load since it was launched in 2001. Other instruments that witnessed this process include CALIOP/CALIPSO lidar (Sawamura et al.,2012;Bourassa et al.,2012;Vernier et al.,2013), a network of ground-based lidars (Sawamura et al.,2012;Uchino et al.,2012) and a CCD camera (Mateshvili et al.,2013).'

Page 31163, lines 27-28: Imprecise, recommended change: 'offsetting global warming' to 'offsetting the radiative forcing of greenhouse gases'.

We agree and corrected this.

Page 31167, lines 15-17: 'better than any forward model could ever do'? This is a very strong statement. Can you prove this? Do you actually think that you can anticipate any forward model that could ever be conceived?

The main idea of this statement is that real observations will always beat simulations since these always dependent on a number of assumptions and simplifications (e.g. discretizing the atmosphere in homogenous layers). We believe therefore that a statement like this is true by definition for traditional forward models. It is not however unimaginable that a forward model could be constructed which is fed statistical data of the observations it is simulating. To include this scenario we changed the sentence to 'better than any *traditional* forward model could do'

Pages 31167-8: The use of 'apparent column' and 'true column' is somewhat confusing and imprecise. By 'column', I understand you to mean 'a vertical profile of constituent concentrations'. So, is the 'true column' the actual concentrations and 'apparent column' an estimate of the actual concentrations? Regardless of the accuracy of my interpretation, some clarification is warranted.
Pages 31167-8: The distinction between 'apparent column' and 'true column' seems disingenuous (unless the interpretation in the previous comment is totally wrong). Any measurement is an estimate of the actual value and the estimates of 'poor' measurements only differ from 'good' estimates in magnitude of the error – not in the existence of error. Please reformulate the discussion so that you explain why your method reduces error – not as a claim that your retrieve values are 'true'.

Here, column represents the (total) amount of molecules per unit of surface.
Here 'apparent column' is the value obtained after a *linear retrieval using a fixed Jacobian*. This definition is given on page 31167 L7. *The 'true column'* is the value obtained after an iterative fit to cope with non-linearity. So the word 'true' indeed does not signify a retrieval without error.

In the revised manuscript we have therefore avoided the use of the expression "true columns". In addition we have reformulated several passages for clarity:

- Page 31167 lines 6-8 now reads "The conditions of the retrieval, namely constant Jacobians K and linearity are usually not satisfied. The quantity x is therefore an apparent column which should be interpreted as a qualitative estimate of the column."
- Page 31167 lines 17-18: We removed the word 'true'
- Page 31167 lines 26-7 now reads: "Retrievals performed in this way, then yield quantitative estimates of the column amounts and heights, as opposed to the apparent columns discussed above."

Pages 31169, line 25: Change 'extend' to 'extent'

We removed this sentence now altogether following a comment of reviewer #1.

Pages 31170, line 17: Provide context for altitudes; e.g., 'Displayed altitudes reach...'

Corrected

Pages 31170, line 18: Change 'Central in' to 'Central to'

Corrected

Pages 31170, line 22: Change 'either' to 'any'

Corrected

Pages 31171, line 25: Change 'below 20°' to 'south of 20°'

Corrected

Pages 31172, lines 4-5: Change 'conclusion from such data only' to 'conclusions from such data alone'

Corrected

Pages 31172, line 14: Please use a more meaningful phrase than 'reveals an excellent match' –for example –'reveals that the trajectories capture important features of SO2 transport'.

Corrected to 'reveals that the trajectories match the retrieved SO_2 transport features'.

Pages 31176, line 11: Choose a more meaningful descriptor than 'excellent match'

Pages 31176, lines 12-13: The phrase 'with agreement almost systematically below 2 km' is awkward and confusing. Do you intend to say something like 'altitude discrepancies are, for the most part, less than 2 km'?

We have reformulated this sentence now as 'Despite these limitations, altitude discrepancies between observed IASI retrieved SO_2 altitude and CALIOP aerosol measurements are for the most part, less than 2 km'.

Pages 31176, line 24: Again –'excellent'? This is a solid scientific paper why ruin it?

The sentence now reads 'The CALIOP data reveals that the performance of the algorithm for plumes located below meteorological clouds, is not any worse than in cloud free scenes.'

Pages 31177, line 3: Excellent! (just joking) Please change it.
Pages 31177, line 5: The standard deviation of the differences can't possibly be 0.1. The standard deviation can never be negative. I think you might mean that the bias is 0.1. From your plot I would guess that the standard deviation is closer to 1 km (maybe it's 1.3?). Also, a correlation of 0.68 is hardly 'excellent' when comparing two fields that should be identical. This corresponds to only 46% explained variance.

The notation in the original sentence 'with mean and standard deviation of the differences equal to −0.1 ± 1.3km' was meant to represent mean differences of -0.1 with a standard deviation of 1.3. When interpreting the correlation coefficient, one should keep in mind that there are uncertainties on both products, not just on the IASI height retrievals. The MLS SO2 product has a vertical resolution around 3 km. As a test, we performed a numerical simulation where a reference altitude was drawn uniformly between 10 and 20 km and superimposed with Gaussian noise of 2 km (to represent the IASI) and 1.5 km (to represent MLS). The correlation coefficient between these two equals 0.73 (a value which can also be obtained analytically). Given the issues with collocation and the fact that IASI and MLS might be sounding different air masses in case of overlaying plumes, we therefore think that the 0.68 correlation coefficient is still very good and in line with the expectations.

We have now rewritten the sentence to make the notation more clear (and also got rid of the 'excellent'): 'Given the measurement uncertainties of both products, the plot reveals a good match between both instruments, with a mean bias of -0.1 km, a standard deviation of 1.3 km and a correlation coefficient of 0.68.'

Pages 31177, line 10: Change the phrase 'The agreement between the two instruments is very good' to something like 'The agreement between the two instruments is not as good as it is during the early days of the plume'.

Corrected, the full sentence now reads:

'The agreement between the two instruments is not as good as it is during the early days of the plume, especially in the parts where the aged higher altitude plume overlays fresher lower altitude plumes