Atmos. Chem. Phys. Discuss., 13, C11960–C11963, 2014
www.atmos-chem-phys-discuss.net/13/C11960/2014/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Dispersion of the Nabro volcanic plume and its relation to the Asian summer monsoon" *by* T. D. Fairlie et al.

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Received and published: 5 February 2014

The paper investigates the dispersion of erosol released by the Nabro volcano in June 2011. It combines a transport study employing trajectory clusters and observational evidence. Taking a close look at the transport pathways of the Nabro aerosol to the lower stratosphere, the paper addresses a highly disputed question. This analysis is complemented by an estimate of the radiative forcing and thus the effect on climate exerted by the Nabro plume.

Focusing mainly on the first two weeks after the eruption, the paper provides convincing evidence that much of the stratospheric aerosol enhancements observed during that time period can only be explained by a significant part of the Nabro plume being

injected directly into the stratosphere. At the same time, it acknowledges that "there is little doubt that much of the erupted material was injected into the upper troposphere" (in agreement with Clarisse et al., 2013) and that some of this tropospheric plume may have been lofted and added to the stratospheric load at a later stage. Thus, I find the paper much more balanced than some of the work published on this issue over the past two years.

The scientific significance, the well presented chain of arguments leading to the conclusions, and the balanced nature of the paper lead me to fully recommend publication in ACP. I only have a couple of sugestions to revise some wording that leaves room for misinterpretation, and a few technical corrections.

Minor comments:

A) Entrainment in the Asian anticyclone

In the introduction (on page 33179) and in several other places throughout the paper, it is stated that the "volcanic plume was initially entrained by the Asian anticyclone circulation" and that the "Asian anticyclone provides significant 'containment' of the aerosol for the first two weeks". While the plume indeed started to follow the anticyclonic flow pattern typical for the region and season at all levels where significant amounts of aerosol were injected, the terms "entrained" and "containment" may be interpreted in terms of the known transport barrier exerted by the Asian anticyclone in the upper troposphere (the strong isolation of the air inside the anticyclone from the rest of the world has been demonstrated using observations of several tropospheric and stratospheric tracers by Park et al., 2008). However, I don't think that this transport barrier applies to all levels relevant to the Nabro aerosol.

To illustrate my point, I refer to another volcanic case study that has been described by Vernier et al. (listed in the current paper as Vernier et al., 2011b in the current paper). The reference mainly deals with the ATAL (referred to in the Fairlie et al. conclusions), but describes an interesting observation in 2009, following the June 7th

Sarychev eruption: "The last period (Jul-Aug-2009) is highly perturbed by the Sarychev volcanic plume located between 14–20 km and bypassing the Asian anticyclone region on its upper part, consistent with a vertical isolation of the anticyclone from the stratosphere at 18 km." The strong horizontal and vertical isolation between the inside of the anticyclone ("home" of the ATAL) and the Sarychev aerosol throughout July and August is clearly visible in Figures 1d and 3d of that paper respectively.

Now, if the entire Nabro plume had been not only entrained in the "Asian anticyclone flow pattern" but also in the "Asian anticyclone containment vessel", then I would not expect it to spread out over more or less the entire northern hemisphere by August in the way that Figures 7 and 8 in the current paper (or other satellite observations such as the OSIRIS data) suggest. This behaviour rather suggests the Nabro aerosol that was injected to 18 km and above to move around and over the "Asian anticyclone containment vessel" rather than being trapped inside, in analogy to the Sarychev case. On the other hand, Nabro material injected between about 15 km (i.e. the LZRH) and the 18 km vertical transport barrier may well be trapped inside the anticyclone (the position of all trajectories released below 370 K in a narrow latitude band in Figure 5 supports that). I would expect this material to stay there and slowly be lofted into the stratosphere, a possibility that you consider in your ATAL analogy at the end of your conclusions (but I would expect timescales of weeks rather than months for reaching the stratosphere).

B) Magnitude of radiative forcing

Statements that "the associated radiative forcing is relatively small" and "the radiative effect of the Nabro volcanic aerosol appears embedded in the natural variability" may easily be interpreted in a way that the radiative forcing of the Nabro aerosol was insignificant. This would be very surprising given the conclusions of Vernier et al., 2011a, and Solomon et al, 2011. It would be helpful to clarify this and maybe compare your deduced Nabro stratospheric aerosol enhancement and radiative forcing to the results described for other volcanoes in the past decade in the aforementioned references.

Technical corrections:

Page 33179, line 9: the first reference should be Vernier at al., 2011a (there are three Vernier et al., 2011 in the reference list). And I don't think that the Bourassa, 2013, reference (i.e. their response comment in Science) is an appropriate reference in the context of aerosol loading over the past decade.

Page 33183, line 3: add "the" in front of "volcano"

Page 33184, lines 18 to 28: in the text, you repeat a lot of information that is already in the figure caption. I think it is enough to have this descriptive information (such as colors, etc.) only once (preferably in the caption) and in the text only state the key results and implications of what the figure shows.

Page 33186, line 3: the reference is Müller et al., not Muller et al.

Page 33191, lines 13: the sentences should be separated by a period, not a comma, before "Fig. 8 also illustrates...

Page 33191, line 16: should be "resulted", not "resulting"

References:

Clarisse, L., Coheur, P.-F., Theys, N., Hurtmans, D., and Clerbaux, C.: The 2011 Nabro eruption, a SO2 plume height analysis using IASI measurements, Atmos. Chem. Phys. Discuss., 13, 31161-31196, 2013.

Park, M., Randel, W. J., Emmons, L. K., Bernath, P. F., Walker, K. A., and Boone, C. D.: Chemical isolation in the Asian monsoon anticyclone observed in Atmospheric Chemistry Experiment (ACE-FTS) data, Atmos. Chem. Phys., 8, 757-764, 2008.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 33177, 2013.