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Atmospheric Chemistry and Physics Discussions
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Interactive comment on "A novel technique including GPS radio occultation for detecting and monitoring volcanic clouds" *by* Riccardo Biondi et al.

Anonymous Referee #1

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This is an interesting and provocative paper that should be published after careful consideration of the reviewers' comments.

This reviewer is convinced that there is a volcanic signal in the RO anomaly profiles after the Puyehue (2011) and Nabro (2011) eruptions. The warming signature associated with the Nabro eruption, presumably due to the SO2 content of the plume, is especially convincing. The agreement of the RO estimated plume tops with the CALIOP measurements (Fig. 1) and the comparison of the anomaly profiles in the several months following the eruptions (Fig. 2) with the anomaly profiles in the same regions in the same months in years without eruptions (Fig. 3) support the claim that the RO anomaly profiles are providing evidence of the plumes.

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Discussion paper

While the results from two cases may not be 100% convincing, they are original and are compelling enough to be published in hope of stimulating further studies on other volcanoes.

My biggest concern is how soon after the eruptions do the horizontal scales of the plumes become large enough to produce atmospheric effects that are large enough to be detected by RO observations. With an RO observation horizontal averaging length scale (footprint) of 150 to 300 km, the scale of the plume would have to grow to at least 500-1000 km before RO observations would be likely to occur within the plume and detect its effects. The question is how long does it take for the plume to advect and disperse over a band 1000 km or greater in width (latitudinal extent)? A MODIS photograph taken 13 June, 2011, the day after the NABRO eruption, shows a plume spreading downwind towards the northwest with a width approximately 300 km 900 km downwind from the eruption.

http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=50988

This suggests that the plume would be difficult to detect by RO the first day after the eruption, but would be detectable by RO within a few days after the eruption. A modeling study by Timmrect et al. (2003), as discussed in the modeling review paper by Textor et al. (2005) see Fig. 5, gives an indication of the rate of spread of the Pinatubo eruption (1991). By 9 days the plume is approximately 30° latitude wide (more than 3,000 km). By 16 days the plume covers much of the atmosphere between 30°S and 30°N, or more than 6,500 km wide. To the extent that these figures are representative, one would expect RO to be able to sample the plume starting a few days after the eruption, certainly after a week. This paper considers perturbations through 20 days after the eruptions, so I think there should be sufficient RO observations to detect the perturbations. The Pinatubo case is mentioned in the paper (Lines 186-188), but please clarify which volcano you are referring to that sentence “spreading SO2 in the atmosphere more than 60 degrees in latitude. . ..”. I think you are referring to Pinatubo not Nabro.

This sampling issue should be discussed by the authors. The review article by Textor et al. (2005) discusses the spreading of volcanic plumes and should be referenced (the current draft has no references to modeling studies.)

In the future, studies of this type would be greatly strengthened by model simulations of the volcanoes being studied. Of course this is beyond the scope of this initial paper.

Related to the sampling and scale issues are the photographs in Fig. 1. They are too small to be effective and there are no horizontal scales on them. I suggest replacing them with much larger, clearer photographs with a scale indicated (a 5°x5° grid superimposed would be very useful). Some NASA photos of Puyehue are available at http://www.nasa.gov/topics/earth/features/20110606-volcano.html . The one at 15:37 UTC June 6 (the day after the eruption is a good one).

Related to the sampling issue, the authors should explain what is meant by "co-located" (Lines 194-194). For determining the co-located RO points, how are the Puyehue and Nabro clouds defined?

A few specific suggested edits:

Line 197 Add "with RO" after ". . ..cloud structure"

Line 266 - I am not sure that "primary" is the best word to describe the first (lowest) tropopause, which is thought to be caused by the volcanic cloud, and "secondary" to describe the original or main tropopause. I would suggest something like "lower tropopause (pink area) and original (main) tropopause (cyan area)."

Line 281 – I suggest replacing "climatological" with "non-volcano" In this same paragraph, was the reference climatology from which the anomalies were computed the 2001-2012 mean (same as for the volcano anomalies)? If so, please say this.

Lines 335-336- I suggest rewording "RO observations can contribute to improved detection and monitoring. . ."

The paper has very few typos-I found one in line 501 (“Determination”).

References

Textor et al., 2005; numerical simulation of explosive volcanic eruptions from the conduit flow to global atmospheric scales. Annals of Geophysics, Vol. 48, Aug/Oct., p. 817-842.

Timmreck et al., 2003: Aerosol chemistry interactions after the Mt. Pinatubo eruption. In Volcanism and the Earth's Atmosphere, A. Robock, Ed., Am. Geophys. Un. Monograph Vol. 64, p. 155-177.

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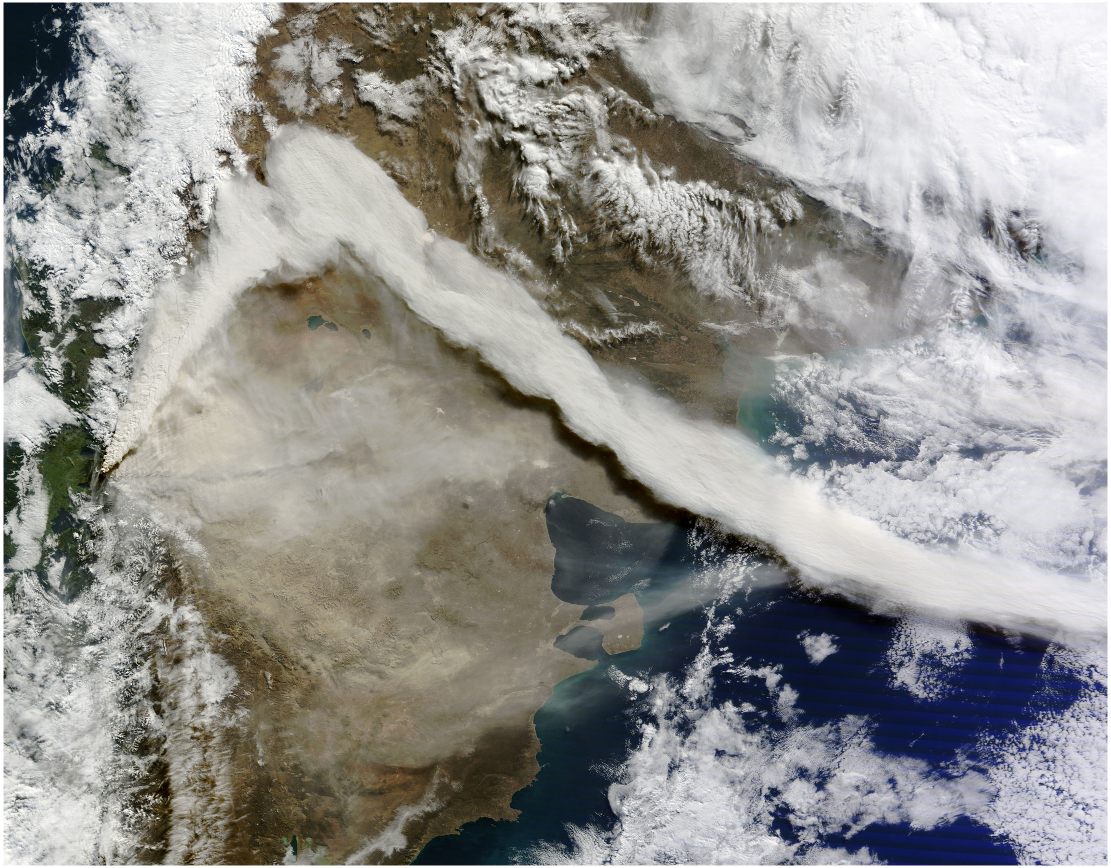

Fig. 1. MODIS photo of Puyehue day after eruption

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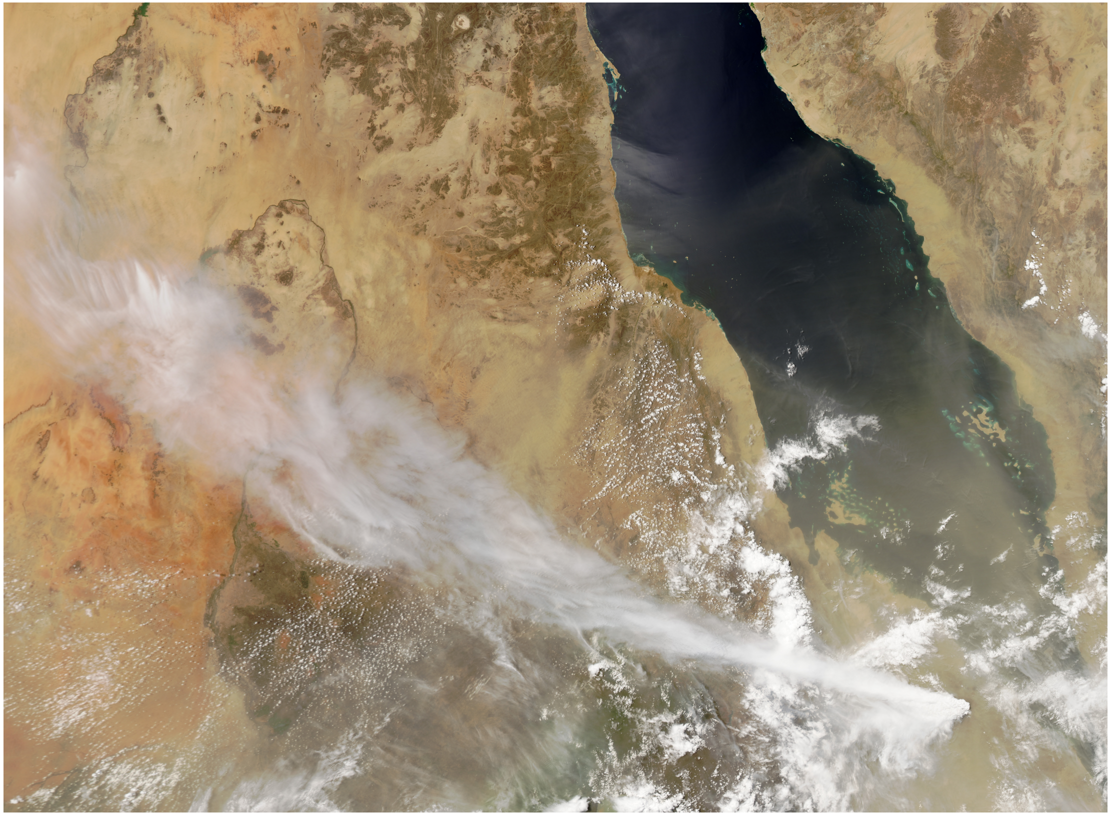

Fig. 2. MODIS photo of Nabro day after eruption