**Response to the comments of Reviewer #1**
**Review of "Nabro volcano aerosol in the stratosphere over Georgia, South Caucasus from ground-based spectrometry of twilight sky brightness" by N. Mateshvili et al.**

The authors thank the reviewer for providing constructive comments on the manuscript. Below are our responses to the individual comments.

*Measurements at two different periods are presented: Oct. 2009 – August 2011 and 1991 during Pinatubo event (with a re-analysis of "old" measurements). The link between the two periods is hard to follow. I understand that the authors want to present various measurements obtained in different conditions, but the actual presentation gives the feeling that 2 different papers are mixed together. I suggest adding few sentences to explain why observations obtained 20 years apart are presented and can be compared to the new ones.*

To explain why we discuss the two different periods of measurements, the following two paragraphs are included:

**2.2 The first and the second purple light**
In this paper we describe two kindred phenomena; both caused by the presence of the stratospheric aerosol layer - the first and the second purple light. The first purple light, more or less intensive, is observed at red visible - near infrared wavelengths 15-25 minutes after sunset or before sunrise even in volcanically quiet periods. After strong volcanic eruptions yellow and orange colors are also observed.
The second purple light is a quite rare phenomenon which is observed only after strong volcanic eruptions. A very deep red color of the sky persists more than an hour after sunset. The second purple light was observed after the Krakatoa eruption (The eruption of Krakatoa and subsequent phenomena. Report of the Krakatoa Committee of the Royal Society, 1888). It was also observed after the Pinatubo eruption (Mateshvili et al., 2005). To discuss the origin of both the first and the second purple light we consider here two datasets, one of which was acquired recently and another - after the Pinatubo eruption.

**7.2 Twilight sky brightnesses at SZAs larger than 95º**
As we have seen above, stratospheric aerosol disturbs significantly the twilight sky brightness in the SZA range 91º–95º. It is interesting to see if the presence of volcanic aerosol can disturb twilight sky brightness at higher SZAs. Dataset I was acquired in city conditions and therefore the measurements at SZAs larger than 95° were strongly affected by light pollution. To understand how stratospheric aerosols can affect twilight sky brightness at higher SZAs, we consider Dataset II – measurements acquired in rural conditions. To model twilight sky brightnesses at high SZAs the Monte Carlo technique was used.

***Page 2 lines 15-17:*** *The authors (shortly) refers to some satellite measurements; they can add references to balloons and aircraft measurements on the stratosphere free of volcanic aerosols coming from major eruption (e. g. Renard et al. (2008), J. Geophys. Res., 113, D21303, doi:10.1029/2008JD010150).*

The following text will be added as a response:
Andersson et al., 2013, investigated composition and evolution of volcanic aerosols from the eruptions of Kasatochi, Sarychev and Eyjafjallajökull in 2008–2010 based on CARIBIC (Civil Aircraft for Regular Investigation of the atmosphere Based on an Instrument Container) observations. Aerosol particles of 0.08–2 μm aerodynamic diameter were collected. They

determined that the main components of the volcanic aerosol were sulphate, ash and carbonaceous material, where the source of the latter is supposed to be low-altitude tropospheric air that is entrained into the volcanic jet and plume. In samples collected in the volcanic cloud from Eyjafjallajökull ash and sulphate contributed approximately equal amounts to the total aerosol mass (45 %). In samples collected following Sarychev and Kasatochi ash was a minor part of the aerosol (1–7 %) while sulphate (50–77 %) and carbon (21–43 %) were dominating.
Renard et al., 2008, considered balloon-borne and satellite measurements and tried to distinguish between the liquid and solid particles from the tropopause to the middle stratosphere in different geophysical conditions. They detected mineral particles of different origin in the 22–30 km altitude range.

***Page 8 lines 19-23****: This approach works well for spherical aerosols, but can be inaccurate in case of solid particles. There are solid particles in such part of the atmosphere, as shown by many papers (e. g. Blake, D. F., and K. Kato (1995), J. Geophys. Res., 100, 7195-7202; Murphy et al. (1998), Science, 282, 1664-1669). How the presence of such particles could bias the retrieval, or add some uncertainties?*

The following discussion will be included in the paper:

We cannot determine from our measurements the composition of aerosol; therefore we use some climatological data to estimate aerosol optical parameters. To estimate the uncertainties of our results due to the presence of mineral dust at high altitudes we assumed a total single scattering albedo of 0.99 (Pueschel et al., 1992) for aerosol in the lower stratosphere and 0.93 (the single scattering albedo roughly estimated using results of Petzold et al., 1999) in the upper troposphere. The corresponding optical depth uncertainties were 2-13%.

***Page 15 line 5****: The presented extinction curves could be validated by balloon or satellites measurements. I understand that it is a long job to find a good coincidence between the observations presented here and balloon/satellite data. Nevertheless, a short discussion showing that the retrieved extinction values are of the same order of mean extinction values obtained during Pinatubo period and during the recent period is necessary.*

The following discussion will be included in the paper:

The aerosol extinction profiles which correspond to volcanically quiet period have large uncertainties. For these profiles it makes no sense to validate extinctions. Therefore we consider only averaged optical depths and validate them using OSIRIS data (Bourassa et al.,2012). Extinction profiles acquired after the Nabro eruption have lower uncertainties and can be validated. Unfortunately there were no balloon or lidar measurements in the considered period close enough to Tbilisi. We tried to compare our extinction profiles with GOMOS ones but did not find close enough coincidences. Nevertheless, GOMOS aerosol extinction profiles (see Fig 1, the profiles were retrieved in the frame of the AERGOM project) show that the Nabro aerosol cloud was very dense, with extinctions up to $2\text{-}3 \cdot 10^{-3}$ at 17 km altitude which is consistent with our results.
Comparison with SAGE II aerosol extinctions observed 1-2 months after the Pinatubo etuption in 1991 (Bingen et al., 2000; Bauman et al., 2003) allows to conclude that the Nabro aerosol cloud was about 10 times less dense than the Pinatubo one. The high level of

extinctions observed over Tbilisi after the Nabro eruption was caused by the fact that the $SO_2$ - enhanced air masses were transported directly towards Georgia.

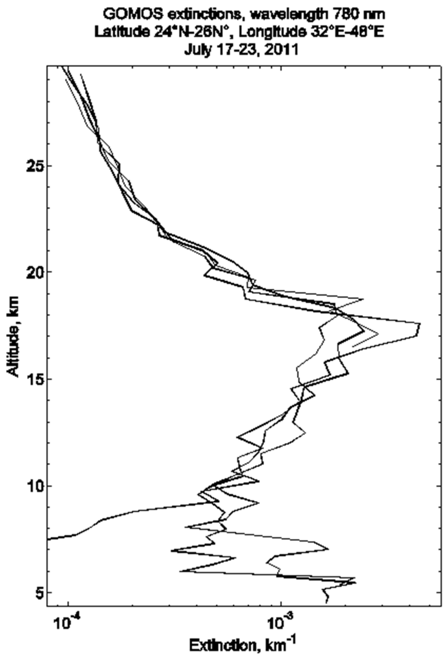


Fig.1 GOMOS aerosol extinction profiles retrieved in the frame of the AERGOM project

***Page 16 lines 11-18:*** *The authors say that Japan lidar measurements are in good agreement with their results. Same conclusions are given with OSIRIS measurements. A figure showing the comparison, or a table with hard numbers, must be provided to convince the reader.*

As a response to the comment the following table will be included:

| Date | Place | Instrument/method | Aerosol layer altitude, km | Reference |
|---|---|---|---|---|
| July, 10-23 | 33°N-36°N, 130°E-140°E | Ground-based lidar | 17-18 | Uchino et al., 2012 |
| July, 1 | 37°N-44°N, 51°E-53°E | Lidar, CALIPSO | 15-19 | Bourassa et al., 2012 |
| July, 17-23 | 24°N-28°N, 32°E-48°E | Stellar occultations, GOMOS | 17 | This paper |
| July,7-Sept., 17 | 40°N-50°N, zonally averaged | OSIRIS | 16-18 | Bourassa et al., 2012 |
| July, 14 | 41°43’N, 44°47’E | Twilight measurements | 19 | This paper |
| July,18-Aug., 3 | 41°43’N, 44°47’E | Twilight measurements | 17 | This paper |

***Figure 14****: The x-scale legend is missing.*
Corrected

***Figures 15 b and c:*** *The figures are too small and are difficult to read.*
Corrected