General Answer to Referee 1

The Referee is right when says that the numerical parameters reported in this work and the MODIS-TIR data of the examples are specific for Mt. Etna volcano. It was clearly written in the last sentence of the abstract: "*By recomputing the parameters of the polynomial relationships, the VPR procedure can be easily extended to other ash types and applied to different volcanoes*." And also in the description of the procedure (pag. 8863 lines 15-20): "*In the present work the multispectral radiometer MODIS on board Terra and Aqua satellites (Barnes et al., 1998; http://modis.gsfc.nasa.gov/) has been considered and the procedure has been adapted for the Mt. Etna volcano (Sicily, Italy), using specific atmospheric profiles to compute the MODTRAN simulations used to prepare the procedure. Finally, the present version of the procedure is valid only for a specific ash type (see below)*". To determine these parameters we used 30 years of monthly mean sea surface temperature (SST) of the Mediterranean Sea around Sicily and the monthly mean atmospheric profiles (PTH) measured at the WMO station of Trapani (Sicily) and used the altitude of the plume and the ash type considered typical of Mt. Etna.
To avoid any possible misunderstanding the title has been changed into "***A new simplified approach for the simultaneous retrieval of SO_2 and ash properties in tropospheric volcanic clouds: an application to Mt. Etna volcano***".
However, we remark that the proposed procedure scheme, applied in the article on two Mt.Etna eruptions, can be adapted to many different situations and volcanoes by using local surface characteristics and atmospheric profiles, plume geometries and ash types.
Once the procedure parameters have been calculated for a specific volcano, the only additional required inputs are the plume altitude and temperature, and their uncertainties have been used to assess the ash and SO_2 retrieval errors (see Paragraph 4.2). About the choice of the ash type and the discussion on the associated retrieval errors, please refer to the author answer to the specific comment *p. 8869 ll. 11ff.*
Finally, we considered "diffusion" as a synonymous of "scattering"; to avoid any misunderstanding the term "scattering" will replace "diffusion" in the whole text, including the symbols in the equations (e.g. τ_{pdv} has been changed into τ_{psv}).

Specific comments:

p. 8860 l. 22: (and elsewhere): It is not really clear from the paper, what the authors mean with "ash type". I assume that the mineralogical composition is meant, which (besides other influences) is a function of the volcanic setting (e.g. the composition is different between volcanoes at subduction zones and mid-ocean ridges). Or is a class of ash composition (like dacite, rhyolite, andesite) meant here in a broader sense? The same confusion may arise from the use of the phrase "atmospheric profiles". Although it is rather clear to me that temperature and humidity are meant, it is nowhere precisely described what profiles the authors refer to and what the impact is.
We refer to the ash type as the class of ash composition (basalt, andesite, pumice etc., see for example Corradini et al., JARS 2008; Newman et al., JGR, 2012(*)). In this case the ash type considered is pumice and is characterized by the optical properties tabulated by Volz (1973) (see p8869, l. 11-12).
About the phrase "atmospheric profiles" it is true that it was not specified the atmospheric fields used. The WMO Upper Air sounding contains wind direction and speed, pressure, temperatures, and relative humidity. We'll add in the procedure description (page 8863) the exactly meteorological fields used to compute MODTRAN simulations: pressure, temperature and relative humidity (PTH).
(*) Newman, S. M., L. Clarisse, D. Hurtmans, F. Marenco, B. Johnson, K. Turnbull, S. Havemann, A. J. Baran, D. O'Sullivan, and J. Haywood (2012), A case study of observations of volcanic ash

from the Eyjafjallajökull eruption: 2. Airborne and satellite radiative measurements, J. Geophys. Res., 117, D00U13, doi:10.1029/2011JD016780.

p. 8861 l. 12: It is not at all clear to me what the different between a "plume" and a "dispersed volcanic cloud" is. Moreover I would advise to be careful with the use of "volcanic cloud", as many times volcanic eruptions also eject large amounts of highly buoyant water vapour, which then forms "real" clouds in the meaning of water droplets / ice crystals around or within the plume of volcanic ash.
Volcanic plumes injected into the atmosphere are transported downwind and dispersed. Or one or more isolated clouds can be injected into the atmosphere by a discontinuous volcanic emission. When these clouds travel away from the source their volcanic origin might not be always easily assessed with a single satellite image, and they can be confused with meteorological clouds. The distinction between volcanic and meteorological clouds based on satellite data it is possible under specific conditions, and it is an important issue addressed by a number of published papers (i.e. Prata, 1989a, cited in the article references). Referee 1 is right when says that volcanic eruptions often form large clouds of water droplets/ice. This water content can also mask and prevent the detection of emitted gases and/or ash presence, but this is due to the limitations of our detection and discrimination techniques. In general, clouds of volcanic origin contain ash and/or gases that are not present in meteorological clouds.

p. 8861 l. 23: I doubt that SEVIRI has global coverage.
Referee 1 is right. Text changed.

p. 8862 l. 14: It would be good to see a reference for the statement that volcanic ash absorbs in the whole TIR window, as e.g. quartz aerosol has only very weak absorption around 12µm.
We'll replace "absorbs" with "attenuates" in the text. The references "Watson et al., 2004", "Corradini et al., 2009" and "Kearney and Watson, 2009" will be added.

p. 8863 l. 21: "more times a day" in most regions means exact twice daily for each satellite, resulting in four observations per day.
In some cases (area of interest on the edges of the MODIS image) also more than 4 observations per day are possible. Therefore we think that it is better the general form "more times a day".

p. 8863 l. 24: I do not really like the word "dirtied" in this context. "Attenuated" would be a much better and more appropriate choice.
Referee 1 is right, we'll replace "dirtied" with "attenuated".

p. 8864 l. 9: NDVI is not a TIR method, consequently I would suggest not to refer to it here.
In this phrase the features of simplicity, friendly use and fast response of the models are put in evidence, not their spectral range.

p. 8865 l. 9: How far is "not too far"?
This point is not relevant to the new text of the article. "Not too far" has been removed.

p. 8865 ll.16ff.: I wonder what happens if the plume would be embedded in ice clouds often forming above volcanic vents... Is there any cloud mask involved in the algorithm?
A cloud mask is not used until now, but obviously it could be added to the procedure. However, the ash signal still has to be present to be detected. If water or ice are not negligible in the plume, the results of both VPR and LUT procedure are not valid.

p. 8866 l. 24 and elsewhere: What the authors describe is the effect of scattering, which is important in TIR radiative transfer through volcanic ash. It thus would be more appropriate to correctly refer to "scattering" instead of "diffusion".
The referee is right, we'll replace "diffusion" with "scattering".

p. 8867 l. 21: Are these numbers also representative for other regions of the world? In the abstract and conclusions the authors comment on the potential global applicability of the method. Therefore it would be necessary to determine Delta-T globally...
The parameter values are specific for only Mt. Etna area. See also general answer.

p. 8868 eq. (7): How is the single scattering albedo determined? Does it come from the Volz optical properties?
The Equation (7) doesn't contain explicitly the single scattering albedo. However, all the ash optical properties (single scattering albedo, extinction coefficient and asymmetry parameter) were computed from the volcanic ash refractive index tabulated by Volz using the Mie code developed by the Earth Observation Data Group (EODG) of the Atmospheric Oceanic and Planetary Physics Department of the Oxford University.
(http://www.atm.ox.ac.uk/code/mie/index.html)

p. 8869 l.1/l.5: How are the values 0.965 respective 0.98 obtained?

In literature (e.g. "Watson et al., 2004") the value of τ_{pd} is between 0.9 and 1. During the set-up of the procedure, we compared plume transmittance τ_p derived from MODTRAN simulations with that obtained by eq. (8) with some τ_{pdv} values choosen between 0.9-1. First we considered a unique constant τ_{pdv} but we immediately realized that a value of τ_{pdv} close to 1 worked better for the transparent pixels in the plume, while a smaller value better represented the optically thick pixels in the plume. The current couple of empirical values reported in the paper gives the quite good described results (fig. 3).

p. 8869 ll. 11ff.: How representative are the Volz optical properties for Etna volcanic ash? How do they compare to others, e.g. from Pollack et al. (1973)? Is Mie theory applied in the MODTRAN simulations, i.e. are spherical particles assumed? What is the uncertainty brought about by this assumption? eq. (13): How is the extinction efficiency determined?
Up to date no laboratory measurements exist of the Etna volcanic ash refractive index. Because of the Etna ash composition characteristics, the Volz refractive index is generally accepted to be a good approximation of the real particles (Corradini et al., 2008). However a sensitivity studies have been already realized to estimate the ash retrieval errors due to the uncertainty on ash type (Wen and Rose, 1994, Corradini et al., 2008). In Corradini et al. 2008, two different ash type were considered: pumice-Volz (1973) and andesite-Pollack (1973). The results show that the differences between the ash mass, effective radius and AOD retrievals using the two ash type is always less than the 20%.
As written above the Mie code has been used to compute the ash optical properties from the ash refractive index, i.e. the particles have been considered spherical. Yang et al., (2007) and Newman et al., (2012) showed that this is a good approximation in case of dust-like particles in the thermal infrared spectral range. Would be very interesting to extend the cited studies by considering different ash refractive indexes, but this is out of the scope of this paper.
As the other optical properties, also the extinction coefficient is obtained by applying the Mie code to the Volz refractive index.

p. 8875 l. 6: Both, Z and T of the plume have to be known a priori. Especially in fast response cases: how is this achieved? What is used as first guess for plume height and temperature?

Moreover, how reliabhle is the assumption that ash and SO2 plumes are found at the same height? The grimsvötn eruption 2011 weas a very good example that this is not always the case.
In both the LUT and VPR procedures the top plume temperature (T) is computed as the brightness temperature of the opaques volcanic cloud pixels generally present near the volcanic vents (Prata and Grant, 2001; Corradini et al., 2008, 2009, 2010). Under the approximation of thermodynamic equilibrium with the surrounding atmosphere, the volcanic cloud altitude (Z) is computed by comparing the estimated temperature with the temperature profile directly measured (WMO profiles) or computed by models (ECMWF for example) in the same region at the same time. If no opaque pixels are present the altitude can be extracted by comparing the volcanic cloud direction with the wind direction profile directly measured or computed by models in the same region at the same time.
About the plume altitude, if the atmospheric profile is not available, other volcanological methods can be used in VPR procedure, such as for example using VIS and/or TIR ground images, see Andronico et al., 2008 (*).
In the LUT procedure the ash and SO_2 altitudes can be handled separately, while in the VPR procedure this aspect is not yet considered.
(*) Andronico, D., Scollo S., Caruso S., and Cristaldi A.: The 2002–03 Etna explosive activity: Tephra dispersal and features of the deposits, J. Geophys. Res., 113, B04209, doi:10.1029/2007JB005126, (2008).

p. 8877 l. 26: What is a "heavy radiative transfer code"?
The correct use of MODTRAN code could be quite complex for many users. However we'll erase "heavy" from this sentence.