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Istituto Nazionale di  
Geofisica e Vulcanologia

Catania, 30 November 2015

Dear **Anonymous Referee 1**,

Herewith, we report our answers to revisions regarding the manuscript **“PM<sub>10</sub> measurements in urban settlements after lava fountain episodes at Mt Etna, Italy: Pilot test to assess volcanic ash hazard on human health”** by Daniele Andronico and Paola Del Carlo for possible publication in **NHESS**.

The manuscript now comprises 20 double-spaced pages (submission item: “REVISION”) and includes 10 figures and 1 table.

We made the revisions as requested modifying the text and figures 4 and 6, inverting figures 2 and 3, and adding the new figure 9 (with the previous 9 becoming now figure 10). In this letter we explain how and where the reviewer comments have been incorporated in the manuscript.

In our opinion, the main focus of this work is to prove the formation of PM<sub>10</sub> during and immediately after the tephra fallout deposition in urban areas produced by Etna explosive activity. On this basis, our contribution would help guide future studies on the potential risk related to the exposure of PM<sub>10</sub> particles in this area. Thus, in the revised version, we have stressed this point in order to convince the reviewers and the Editor that our results can represent a starting point to stimulate new studies about this much undervalued problem in the Etnean territory, as is clearly proved in a recent medical study that acute respiratory and cardiovascular diseases, and ocular disturbances, have significantly increased during the ash exposure caused by the 2002 Etna eruption.

We indicated the changes in an annotated version of the revised manuscript file (submission item “Revision\_AndronicoDelCarlo\_nhess-2015-145”).

I certify that the Co-Author Paola Del Carlo is aware of this revision.

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Yours sincerely,

Daniele Andronico

## Answer to Anonymous Referee 1

### GENERAL COMMENTS

*The manuscript by Andronico and Del Carlo deals with the problem of “thoracic” ash (P10) at Etna volcano, at two different times following a lava fountain event. The manuscript is clear and concise, and written in a plain English.*

*The topic is important and of sure interest for an international journal. Despite all these facts, however the presented data appear insufficient to sustain some of the conclusions presented by the authors. In particular, the rationale for data collection should be planned more accurately and adapted to the main topics of the discussion. Some of the data presented (grain size, morphology of the ash material) are not sufficiently discussed, and should be implemented with some additional analyses in order to reinforce the proposed conclusions.*

In the revised paper we have added new analyses and data to better support proposed conclusions (see also the specific comments). Although it is evident that it is impossible to collect new data on the 15 November 2011 lava fountain and related deposit, we made an effort to recover additional data on the grinding process so that that Reviewer 2 may appreciate the improvement of our work in the revised manuscript.

### SPECIFIC COMMENTS –

*data were collected at three different sites immediately following, and 1 month after, the eruption. As stated by the Authors, all the measured concentrations of PM 10 so clearly refer to problems of ash resuspension. Unfortunately, data are in some cases of difficult interpretation due to a biased measurement set up. In fact, the measures at the three sites were collected at three different distances from the ground (from 40 to 100 cm), making them poorly comparable in the absence of a clear, data-based discussion about the possible development of a vertical gradient in the ash concentration. - no data on wind velocity is given, and data on road traffic very scarce; these data are essential, especially if the authors want to demonstrate the prevalence of the latter factor on ash remobilization.*

We added a few sentences which describe the main effective limits of our procedure (duration of the measurements and height of the DustTrak) in the “Methods” chapter (3.1 DustTrak measurements) at new lines 175-183). Concerning the wind velocity, in the literature the study of the factors influencing the remobilization of volcanic ash following volcanic eruptions is not so well quantified and/or discussed (Leadbetter et al., 2013); for example, Hobbs et al. (1983) reported for Mt. S. Helens that even modest wind speeds of few meters per second are sufficient to lift the ash; while other authors (Fowler and Lopushinky, 1986) put a threshold of 3 m/s for giving effective resuspension of ash. In any case, we found only meteorological stations located several km away from and around our measurement sites, providing discontinuous as well extremely different values of wind velocity (thus suggesting they were not useful for our purposes).

*Also, the distance from the road should be clearly indicated.*

Concerning this specific request we have added distances from the road in the text (at new lines 166-167).

*I suppose that, in the case of a very localized factor of remobilization like road traffic, large vertical and horizontal gradients in the ash concentration are expected; - authors suggest that PM10 is mainly related to secondary ash production by grinding of the scoria related to intense traffic. The presented data on ash morphology could help in defining this, but they are not sufficiently expanded and discussed, in order to bring a real improvement of the general understanding of the problem. As an example, it could be useful to have data on clast roundness compared with the roundness of the primary products, before being intensely remobilized.*

We provided data only on clast roundness about the primary deposits because unfortunately we do not have the possibility to recover further samples (see new lines 243-244).

*- grain size analyses are only partially exhaustive for two reasons:*

*i) they are only partial, as data stop at phi 5 (no data on PM10 are given);*

Data stopped at phi 5 because the tephra deposit is coarse and in the grain-size there is no ash finer than phi 5. This is a crucial point that evidences the importance of car traffic in the remobilization and mechanical breakage of the deposit as the primary cause of the PM10 particulate matter formation.

*ii) data on material directly sampled from the road (so experiencing grinding by vehicular traffic) should be given, in order to document the increase of the finer-grained fractions;*

In the revised paper we added in the Discussion chapter results from analyses carried out after a lava fountain episode occurring in 2007. Such analyses show the grain-size distribution related to 2 different samples, collected a few meters of distance from each other, one not modified and the other altered because ground down by vehicular traffic. Results prove our final thesis, in particular how effective passing vehicles are in making the primary tephra deposit finer (see new paragraph 5.2 Quantitative estimation of the tephra grinding by car passage in the Discussion chapter at lines 298-320).

*To face all these problems, I so suggest a thorough rethinking of the manuscript, with the addition of new data. In particular, in the collection of new data, a suited strategy should be planned, trying to measure both vertical and horizontal gradients in ash concentration at each site. In this case, a general picture of the distribution of PM10 concentration could be given, and discussion and conclusions would be largely supported by the data.*

As reported in the previous answers, it is impossible to follow this strategy for the past explosive events, as Reviewers 1 suggests, adding new data coming from a “collection of new data... trying to measure both vertical and horizontal gradients in ash concentration at each site”. 4 years have passed from the studied event and the “boundary conditions” to carry out new measurements are obviously impossible to find again. We are prepared to improve this method in the future, following procedures and strategies suggested by all the Reviewers (most of which already reported in the literature), and specific indications to adopt in the Etna territory.