

## **Authors' Response to Anonymous Referee #1, RC1 (21 Jul 2021):**

In this authors' response, the text (normal style) answers point by point to the comment of the anonymous Referee #1 (text in bold). The text in blue corresponds to the authors' change in the manuscript.

**RC1 from the anonymous Referee #1:**

### **General comments**

**This study describes European Natural Airborne Disaster Information and Coordination System for Aviation (EUNADICS-AV) Early Warning System (EWS). The EUNADICS EWS greatly extends the existing Support to Aviation Control System (SACS) automatic alert system for airborne volcanic sulfur dioxide SO<sub>2</sub> and ash to include other airborne hazards (dust, smoke and radionuclide clouds) with creation of multiple new alert products (email and web pages with NRT maps, data files) and convenient formats (NetCDF). These new data are provided by EUNADICS partners and external data sources. The EUNADICS system further combines satellite data with the European ground-based networks (lidar and passive) and regional measurements from volcanic observatories in Iceland and Sicily.**

**EUNADICS serves European users, primarily Volcanic Ash Advisory Centers (VAACs) in London and Toulouse that have operational responsibility for volcanic ash advisories and forecasts. New message formats (NetCDF alert data products) will facilitate using the alerts to initialize plume dispersion models.**

**There is room for English and punctuation improvements, which would make paper easier to read. Many sentences need re-wording and/or clarification. Specific suggestions are mentioned below.**

**I found the paper informative and suitable for publication after language and syntax improvements.**

OK thank you, this will be addressed.

### **Specific comments**

**The aviation hazards satellite data sources are comprehensive, except for direct readout data for Iceland and Europe from Satellite Measurements from Polar Orbit (SAMPO) service (<https://sampo.fmi.fi/products>). Using SAMPO data would help reducing alert latency time and geographical coverage of the EUNADICS system.**

Thank you for highlighting this aspect. FMI is partner of EUNADICS. Note that we use Very Fast Delivery from FMI (i.e., over Europe) and GINA (i.e., over Alaska). The following text has been added in section 4.1.1:

Note that a very fast delivery of OMI and OMPS data retrievals (time delivery of ~45 min for northern region, i.e. near Europe and Alaska) is provided by the Finnish Meteorological Institute (FMI) and the Geographic Information Network of Alaska (GINA), as satellite data are received at Sodankylä, Finland, and Fairbanks, Alaska (see <https://sampo.fmi.fi>).

**Abbreviations should be explained when first used.**

OK, thank you. Done

**Consider removing abbreviation from the title.**

The only acronym of the title is EUNADICS, which is the name of the system. We would prefer keeping this acronym in the title. As mentioned in the technical corrections, the abbreviation is now explained in the first line of the abstract.

**Technical corrections**

**Abstract is not clear to a general reader, not familiar with the EUNAUDICS project. I suggest explanation of the abbreviation “EUNADICS” in the abstract.** OK done in the first line of the abstract.

**45 ATM – explain abbreviation** done

**47 have shown significant** OK thx

**48 satellite[s]** done

**51 e.g.[,]** done

**55 service[s]** done

**57 to proceed – consider changing this verb** we change by: the interest of implementing

**58 ... highlighting the capability of operating early warnings ... - consider re-wording** done:

EUNADICS EWS has also shown the need to implement a future relay of radiological data (gamma dose rate and radionuclides concentrations in ground-level air) in case of nuclear accident. This highlights the interest of operating early warnings with the use of homogenised dataset

**75 implication in meteorological processing... – clarify** done:

Due to atmospheric transport, airborne particle cloud may also travel to area several thousand kilometres apart from the source. Such airborne particles can impact atmospheric dynamics, bringing difficulties to understand meteorological process (Knippertz and Todd, 2012). It can also cause worrying implication and damage for the aviation (Casadevall...).

**80 particles** done

**81 satellite [data]** done

**84 It makes it possible as it can to provide information** We think we can leave the text as it is: It makes it possible as it can provide information

**94 <https://meteoalarm.org>** done, thx for this updated web link

**149 The results - objectives?** replacement done

**153 Copernicus Atmosphere [Monitoring] Service (CAMS)** done

**165-166 ... specialization [in] atmospheric transport modelling** done

**Figure 1: SAMPO service** We don't think we should include SAMPO service in Figure 1 (in the list of the existing service used by EUNADICS EWS) as technically we don't use it. We get data from GINA and FMI, not from SAMPO. If a better Very Fast Delivery (VFD) can be obtained than the one already provided by GINA and FMI, this is something we should consider in the future activity of EUNADICS. Note that we added a reference to the VFD from FMI and GINA, and we mentioned SAMPO in section 4.1.1.

**186 boards** done

**195 i.e.,** done

**207 were** done

**217 possibility -> discussion with ?** replacement done

**218 Tables 1 and 2 -> 2 and 3?** Thx, done

**227 overpass** done

**243 particulate matter (PM)** as the abbreviation PM is not used in the manuscript, there is no need to put (PM). Particle matter has been replaced by particulate matter

**243 volcanic ash total column [number or mass density]** done, using mass density

**245 averaging kernel** done

**250 We reviewed ...** done

**252 products** done

**253 section 2.2?** The requirements for data integration is in section 2.3 and the inventories of observations in section 2.2, as mentioned in the text:

Requirements for the data integration (section 2.3) have been considered to define a list of data product candidates (Tab. 1 and 2) from inventories of satellite, in-situ and ground-based observations (section 2.2).

**276, 277 .. Observatory which operates ...** done

**281 e.g.,** done

**296 e.g.,** done, note that a coma after e.g. has been added in all the manuscript

**308 at NOAA** done

**312 MWOs – explain abbreviation** done

**316 aim at -> with the goal of supporting ...** done

**317 satellites** done

**345 use ground observations** done

**404 when** done

**405 up to the lower stratosphere – why not in the middle and upper stratosphere?** Thank you, we replace lower stratosphere by upper stratosphere (even this is rare and extreme events)

**405 Eight? satellites sensors ...** Thank you, done

**407 Yang et al., [2007] - OMI product has been replaced with conceptually new OMI SO<sub>2</sub> product: Li et al., New-generation NASA Aura Ozone Monitoring Instrument (OMI) volcanic SO<sub>2</sub> dataset: Algorithm description, initial results, and continuation with the Suomi-NPP Ozone Mapping and Profiler Suite (OMPS), Atmos. Meas. Tech., 10, 445-458, doi:10.5194/amt-10-445-2017, 2017.** Thank you, you are right, I removed Yang et al. 2007 in the reference. I also added Li in the references (it as missing)

**415 between 3 and 21 km, - why is the upper limit 21km?** The upper limit was chosen after careful examination of several eruptions, as a lot of false detections above 21 km were observed. This is actually expected as the sensitivity to altitude, which relies on H<sub>2</sub>O-SO<sub>2</sub> spectral interferences decreases with altitude (as there is less and less water vapour).

**421 e.g.,** done

**423 expressed in Kelvin degree (K)** done

**432 missing reference: Virtanen et al., (2014)** done

**438 to define** done

**443 illustrates** done

**447 a fast? ash detection** done

**448 i.e.,** done, note that a coma after i.e. has been added in all the manuscript

**469 presented** done

**470 is based** done

**487 is obtained ?** OK done

**503 triggered** we put triggers

**Figure 13, left map: should the white box show station Finokalia (Crete), shown on the right?** Done, Finokalia, already shown "Fi", is now highlighted by an arrow and the name Finokalia has been added.

**549 ash advections have not been observed** done

**555 networks** done

**560, 561, 566: e.g.,** done

**608 ZAMG and STUK – explain abbreviations** done

**609 ZAMG** done

**610 remove "have been designed"** done

**613 delete "proceeding". ... is implemented?** Done, the text now is:

[Both data sources are ultimately released by STUK after filtering of the EURDEP data is implemented and collecting the EMERCON information](#)

**643 new alert products** done

**644 creates** done

**667-670 repeat of 645-650** OK thank you, these lines have deleted

**683 quantity product – just use product** done

**715 nuclear central - plant?** done

**749 remove "thanks to"** done

**751 explain TRL** done, this text has been added:

[In case of a future operationalisation of EUNADICS activity for TRL \(Technology Readiness Levels; see H2020, Annex G of the General Annexes\) of 5 and higher, i.e., system prototype demonstration in operational environment, all the NRT observations will be visible on the EUNADICS data portal.](#)

**753 i.e.,** done

**757 allows consultation -> visualization?** OK, done

**763 burst -> cloud** done

**801 remove “same”** done

**814 consider** done

**839 is operated -> is implemented ?** OK, done

**855 NCAP fiel -> file?** OK, done

**857 details** done

**P36 868 possible** done

**870 link not found** done. We don't know why the link in the pdf was corrupt. Anyway, now this should work. The link has been simplified and the text is the following:

[https://sacs.aeronomie.be/alert/SO2\\_202102241052\\_202102281322\\_LNK\\_TROPOMI.nc](https://sacs.aeronomie.be/alert/SO2_202102241052_202102281322_LNK_TROPOMI.nc) is the link to the NCAP provided in the alert webpage (Fig. 25) of the notification (Fig. 24) result of the paroxysm at Etna on 28 February 2021.

**873 MWOs – explain** done, abbreviation (Meteorological Watch Offices) is now already explained in section 3.1 of this manuscript

**890-891 was designed with the goal of ...** done

**891 passed** done

**895 obtained -> has been demonstrated?** done

**899 satellites** done

**906 has developed** done

**907 notifications** done

**908 include** done, concern has been replaced by include

**913 better spatial resolution – better than what?** ‘better’ has been replaced by ‘high’:

[the use of polar orbiting NRT measurements with high spatial resolution \(under 10 km\)](#)

**916 Only one aspect** done

**919 interest -> usefulness?** done

**920 of using EUNADICS system in** done

**921 activity about -> utility for ...** done

**925,930 in the framework of ...** done

The following text:

EUNADICS consortium will now target an operationalisation of its activity, in the frame of SESAR H2020, with the objective of completing TRL 6 (demonstration in a relevant environment). EUNADICS EWS passes with success the performance verification.

has been modified to

EUNADICS consortium will now target an operationalisation of its activity with the objective of completing TRL 5 (validation in a relevant environment) and TRL 6 (demonstration in a relevant environment) in the framework of further SESAR developments. EUNADICS EWS passes with success the performance verification in a limited environment (TRL4).

**928 proceeding -> implementing** done

**958 the alert** done

**971 details** done

**972 provided** done

**991 e.g.,** done

We hope this document answers properly to the specific comments addressed by Referee #1. We are very grateful for this review and all the technical corrections. We apply all of them and hope this will make the paper easier to read.

Thank you very much for this review. Best regards,

Hugues Brenot and co-authors