

Dispersion Of Atmospheric Aerosols in The May 2021 Volcanic Eruptions Over Mount Nyiragongo

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Abstract- Eruption of volcanoes has been associated with release of aerosols in the atmosphere that compromise the air quality in a trans-boundary manner. This study examined the flow of pollutants emanating from Mount Nyiragongo during the May 2021 eruption. Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model was used to compute air parcel trajectories over the Mountain. The results of the findings revealed that between 1.9×10^{-16} mass/m³ to 2.4×10^{-10} mass/m³ of unspecified pollutants were injected in the atmosphere within the fourth week of May; 2021. The pollutants are observed to shift positions with height of volcanic ash over the area of study. The study recommends a post volcano impact assessment to estimate the health impact of the eruptions over neighboring regions.

Indexed Terms- Volcano, Pollution, HYSPLIT

I. INTRODUCTION

Volcanic ash from volcanic eruptions are sources of pollutants but also rich soils for agricultural production [1]. The aerosols from volcanic eruptions can be washed down by wet deposition few days to weeks after eruption while others will be transported by long distance processes to other regions. The volcanic ash has been associated with respiratory health hazards e.g., as reported in [2],[3]. The volcanic ash also destroys crops and infrastructure impacting on all sectors of the economy within the affected regions as observed in [4] and an aviation safety risk [5]. The volcanic Ash displays different chemical characteristics related to the type of parent material and weathering as found in [6] and [7] that observed a strong volcanic acid signal corresponding to inter-hemispheric transport of volcanic ash from source of a volcanic eruption.

Studies in [8] investigated emissions in the stratosphere of volcanic ash with sulphur dioxide

composition while findings of a study in [9] investigated transport and dispersion of atmospheric pollutants over east Africa during the Ol doinyo lengai volcanic eruption in July 2007 and march 2008. The study applied the HYSPLIT trajectory modelling method to simulate spatial and temporal distribution of volcanic gases and particulate matter after the eruption. The results of their study revealed that the effluents were transported to northern Tanzania and the Kenya - Tanzania border. Some relatively small concentration of pollutants traced to Lake Victoria in a period of 48 hours.

Mount Nyiragongo in Goma, Democratic Republic of Congo is an active volcano that has undergone volcanic processes over time. The population is rapidly increasing just 15 kilometers away from the mountain despite multi-hazard probability of occurrence of volcanic eruptions [10]. The terrestrial and atmospheric movement of volcanic matter can affect other regions near and far from source as observed in [11] where the 2012 eruptions on the mountain has been associated with phreato-magmatic lacustrine eruptions in the neighboring Lake Kivu.

There is a continuous need to carry out a post volcanic assessment of the impacts of an eruption and this can involve simulating the flow of the particles to examine the spatial and temporal extent of the volcanic ash. HYSPLIT methodology has been applied to model pollutant process as observed in the studies [12] and [13] Juma et al.,(2020). This study examined the concentration of masses emanating from the volcanic ash associated with the May 2021 volcanic eruptions on Mount Nyiragongo in Goma, DRC.

1.1 Objectives

The main objective of this investigation was to determine the spatial and temporal characteristics of volcanic masses associated with the May 2021 eruptions on Mount Nyiragongo.

1.1.1 Specific Objectives

The following specific objectives were pursued:

- i. Simulate mass concentrations of the volcanic ash over the region
- ii. Simulate the direction of flow of the volcanic masses over the region

II. MATERIALS AND METHODS

2.1 Data

HYSPLIT model utilized the Global Data Assimilation System (GDAS) data. Concentration (mass/m³) was averaged between 0 to 100 meters initiated at 0000 May 22; 2021 over the area of study at 3470 meters above ground level at an average integration period of 1 hour and dry deposition rate of 0.1cm per second. The maximum and minimum mass concentrations were generated.

Ash columns were generated at a summit of 11384 feet over Mount Nyiragongo in a medium profile characterized with reduced ash amount owing to the fact that the eruption had subsided.

Results were reported in figures. The profile of pollutants by height was plotted using the model over the area of study under same conditions as in figure one at single mass release quantity. The results are found in figure two below.

III. RESULTS, DISCUSSION AND CONCLUSION

Figure 1 below shows the concentration of masses of pollutants over the area of study. It can be observed that pollutant masses reduced in concentration with distance away from source at ground level.

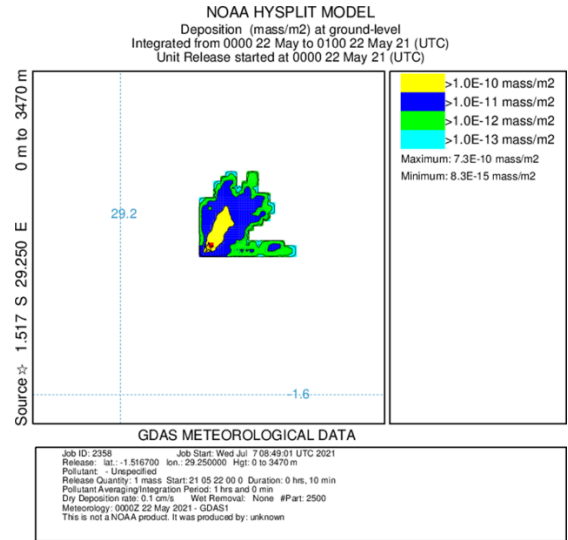


Figure 1: Mass deposition at ground level

The results of changes in polluting particle positions with height can be observed in figure 2 below.

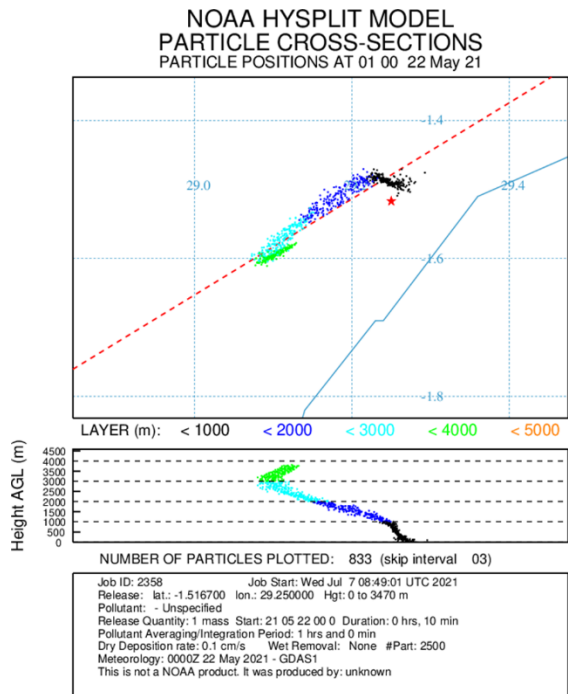


Figure 2: Changes in particle positions of pollutants with Height over Mount Nyiragongo

The findings of the investigation revealed that particles decreased with height up to around 3000 meters above ground level and later increased by height. The study therefore observed changes in particle positions with height over the study area.

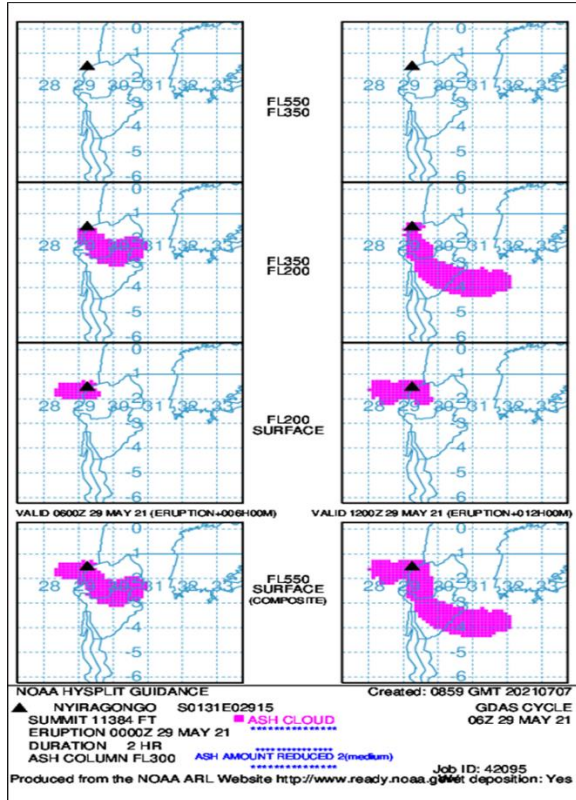


Figure 3: Volcanic Ash patterns over Mount Nyiragongo

The results in figure 3 show patterns of volcanic ash columns over the area of study that can be applied for aviation purposes. Flight levels can be observed including upper and lower flight levels in hundreds of feet. The composite layer (Surface to FL550) is recommended for satellite imagery intercomparisons. Dispersion of ash was observed to shift with height or flight levels over the area of study.

CONCLUSION AND RECOMMENDATIONS

The study observed that between 1.9×10^{-16} mass/m³ to 2.4×10^{-10} mass/m³ of unspecified pollutants were injected in the atmosphere within the fourth week of May; 2021. The findings of this investigation also revealed that masses of pollutants reduced in concentration with distance from source and changed positions with height above ground where they seem to shift steadily towards lower layers up to 3000 meters above ground level and shift towards high layers. The study recommends a comprehensive post eruption study to assess the socio-economic and biophysical impact of the eruption.

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