

### Abstract

The island of Puerto Rico is regularly impacted by Saharan dust and volcanic ash produced by volcanic activity of Soufrière Hills volcano located at Montserrat Island. In this study, was conducted an evaluation of the distribution of particulate matter  $PM_{10}$  in two air quality stations (Fajardo and Guaynabo). This data will help to identify the occurrence of Saharan dust and volcanic ash events during the period 2005-2007. Results demonstrated that major occurrence of Saharan dust and volcanic ash that impacting local air quality was observed from June to September. The presence of volcanic ashes on the island depends on the Soufrière Hills volcano's activity, the speed and direction of the wind from the summit of the volcano, the severity of the rash and the duration of the same. However, the appearance of volcanic ash events may be associated with the trade winds, the mechanism related to the Saharan dust events.

### Introduction

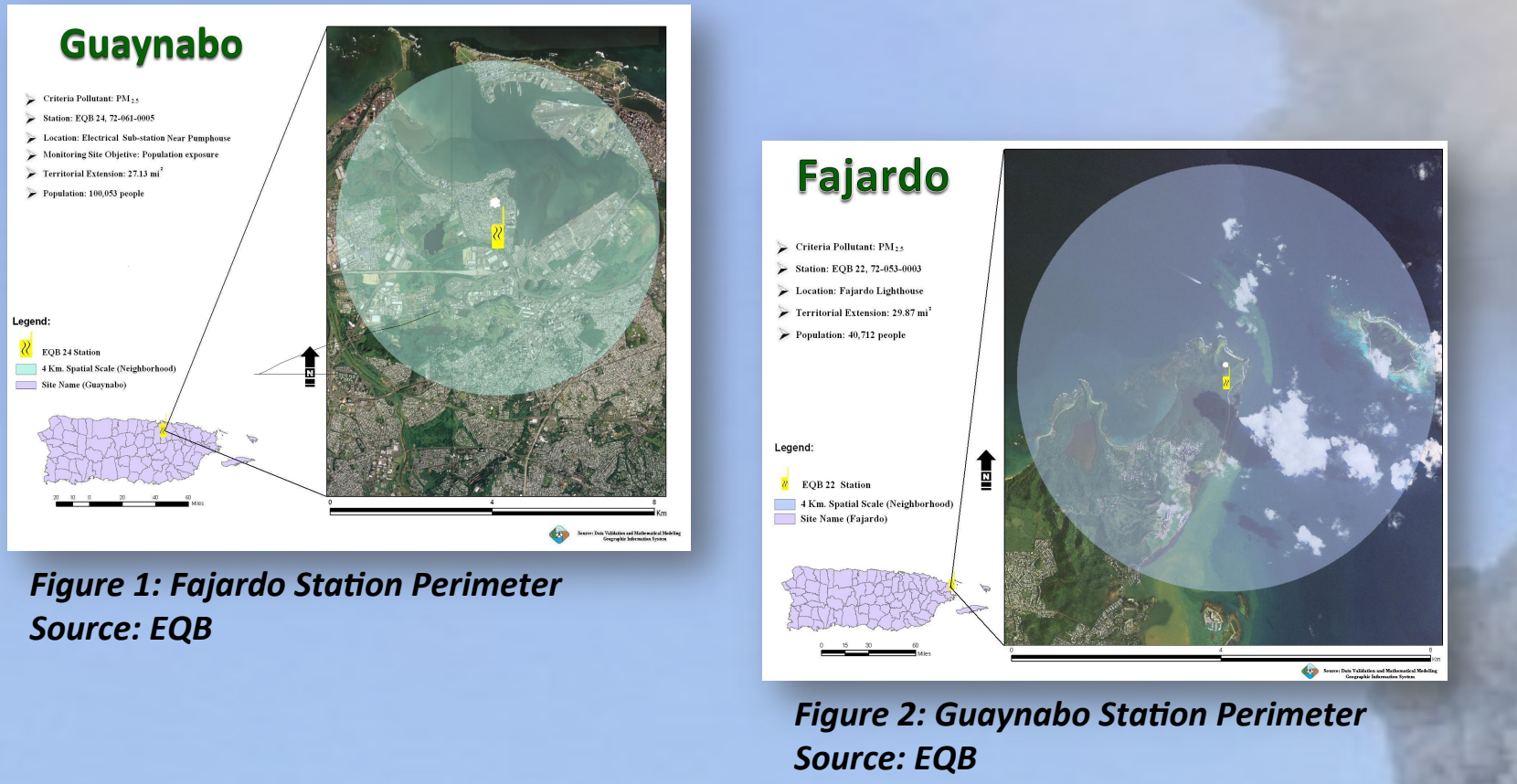
Air pollution comes from both natural and man-made (anthropogenic) sources as volcanic activities, chemicals dumped to the atmosphere, burning material. Among others, some of these particles may cause discomfort, disease or death to humans, damage other living organisms such as food crops, or damage the natural environment or built environment. Among those natural phenomena there are two events that may affect Puerto Rico Island air quality for the past years. These are the Saharan dust and the volcanic ashes coming from the Soufrière Hills volcano located on the island of Montserrat. During the occurrence of these events air quality become altered.

The Saharan dust consists of particulate material dragged by the action of strong winds that originate by the passage of watercourses to the South of the Sahara desert in North Africa. This wind speeds more than 22.3 mph, raising the dust which together with atmospheric instability produces a trough. Then particulate material is captured by the trade winds, strong easterly winds that makes the particulate reach the Atlantic Ocean. The Saharan dust phenomenon crossing the Atlantic can happen at any time of year but it has been associated with the trade winds and summer season. Saharan dust occur mostly in summer, a minimum occurrence in observed during winter. The events of ashes of Soufrière Hills volcano are caused by sudden eruptions, continuous steams and sulfur emissions.

### Objective

- Identify the occurrence and distribution of Saharan dust and volcanic ash cloud coming from Soufrière Hills volcano activity through the evaluation of measurements of particulate matter ( $PM_{10}$ ) in two stations (Fajardo and Guaynabo) in the northeast of Puerto Rico.
- Evaluate the possible impact and occurrence of volcanic ash clouds coming from Soufrière Hills volcano and compare them with the occurrence of particulate matter being altered by volcanic ash events identified in the study stations.

### Study Area



### Methods

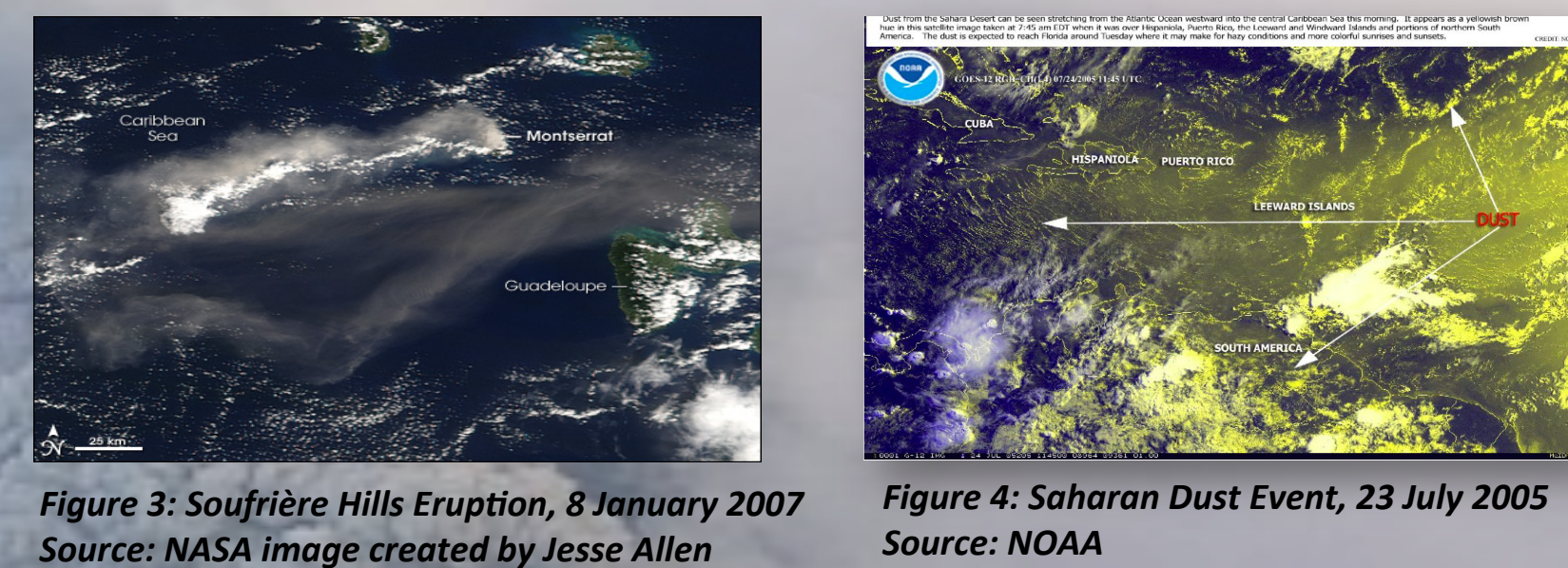
Two measurement stations of particulate matter  $PM_{10}$  from the Environmental Quality Board (EQB) in Puerto Rico were selected to conduct this study. These stations are located at Fajardo and Guaynabo municipalities. Both stations collect particulate matter samples daily. Guaynabo station (EQB 24) is located in an urban area and Fajardo station (EQB 22) in a rural area. In addition, the Fajardo station is not impacted by emissions from industries, only by environmental conditions. While Guaynabo station registers emissions from industries and vehicular traffic in the area. Both stations were analyzed during 2005, 2006 and 2007 and it was calculated the total average natural events (dust and ash) for each month per year and the total annual average of natural events (dust and ash).

Both stations showed primary  $PM_{10}$  particles emitted directly from diverse sources. The particulate matter  $PM_{10}$  are particles with an aerodynamic diameter of 10 micrometers or less. The EQB have different stations of sampling in accordance with the parameters to be measured. This agency had protocols to define the diverse particles that could found in their stations. Saharan dust and volcanic ash events were identified based on a specific protocol followed by the evaluation of staff of the National Weather Service and EQB. The instrument used to measure  $PM_{10}$  is the *Hi-Volume Size Selective Inlet* (SSI), it collects suspended particles with an aerodynamic diameter equal or less than 10 microns using an inert filter of quartz. Another instrument used for sampling is the TEOM, on which the particles enter and pass through tubes of acceleration where more than 10 micron particles are trapped while those of 10 microns or less continue towards the translator (mass traducer).

Data from Soufrière Hills volcanic activity was found in NOAA Satellite and Information Center and from database of Washington Volcanic Ash Advisory Center (VAAC). This data was used to evaluate volcanic ash cloud direction from study period. The occurrence of volcanic ash cloud was identified in terms of direction by month and year in order to show the distribution of the volcanic ash cloud according to the volcanic activity during 2005-2007. Graphics were made to show the most prevailing volcanic ash cloud direction during all months.

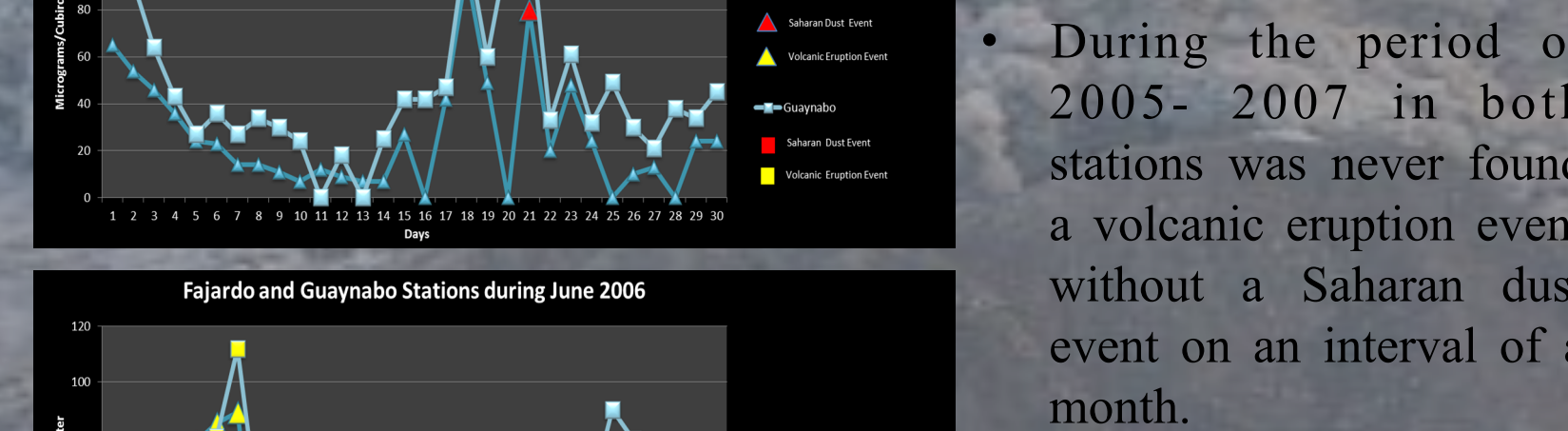
### Results

#### Volcanic Ash Events and Saharan Dust Events $PM_{10}$ Measurement Stations

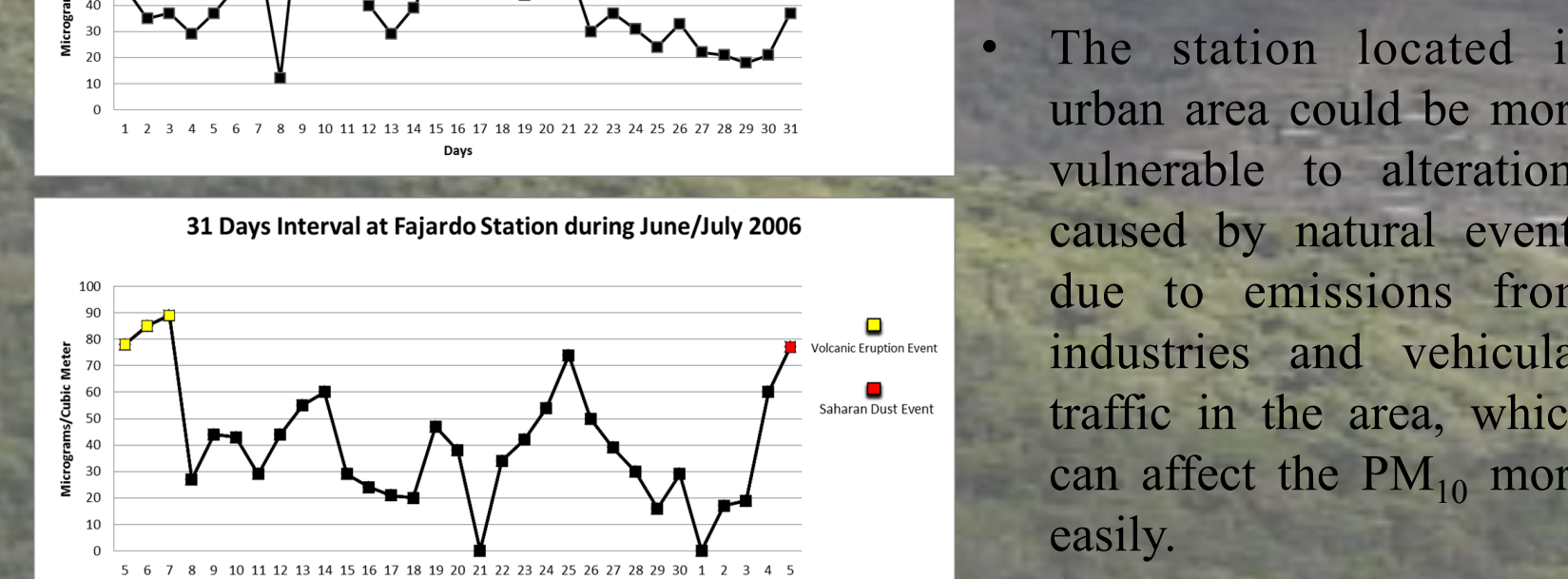


MONTH	2005				2006				2007			
	Saharan Dust Event	Volcanic Ash Event	Saharan Dust Event	Volcanic Ash Event	Saharan Dust Event	Volcanic Ash Event	Saharan Dust Event	Volcanic Ash Event	Saharan Dust Event	Volcanic Ash Event	Saharan Dust Event	Volcanic Ash Event
JANUARY	0	0	0	0	0	0	0	0	0	0	0	0
FEBRUARY	0	0	0	0	0	0	0	0	0	0	0	0
MARCH	0	0	0	0	0	0	0	0	0	0	0	0
APRIL	0	0	0	0	0	0	0	0	0	0	0	0
MAY	0	0	0	0	0	0	0	0	0	0	0	0
JUNE	0	0	0	0	0	0	0	0	0	0	0	0
JULY	0	0	0	0	0	0	0	0	0	0	0	0
AUGUST	0	0	0	0	0	0	0	0	0	0	0	0
SEPTEMBER	0	0	0	0	0	0	0	0	0	0	0	0
OCTOBER	0	0	0	0	0	0	0	0	0	0	0	0
NOVEMBER	0	0	0	0	0	0	0	0	0	0	0	0
DECEMBER	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL NATURAL EVENTS	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL NATURAL EVENTS DURING PERIOD 2005-2006	37											

- Summer was the season that both stations registered most of the Saharan dust and Volcanic ash events.
- During June 2005 and 2006, volcanic ash events and Saharan dust events all occurred in the same month except Fajardo station during June 2006.



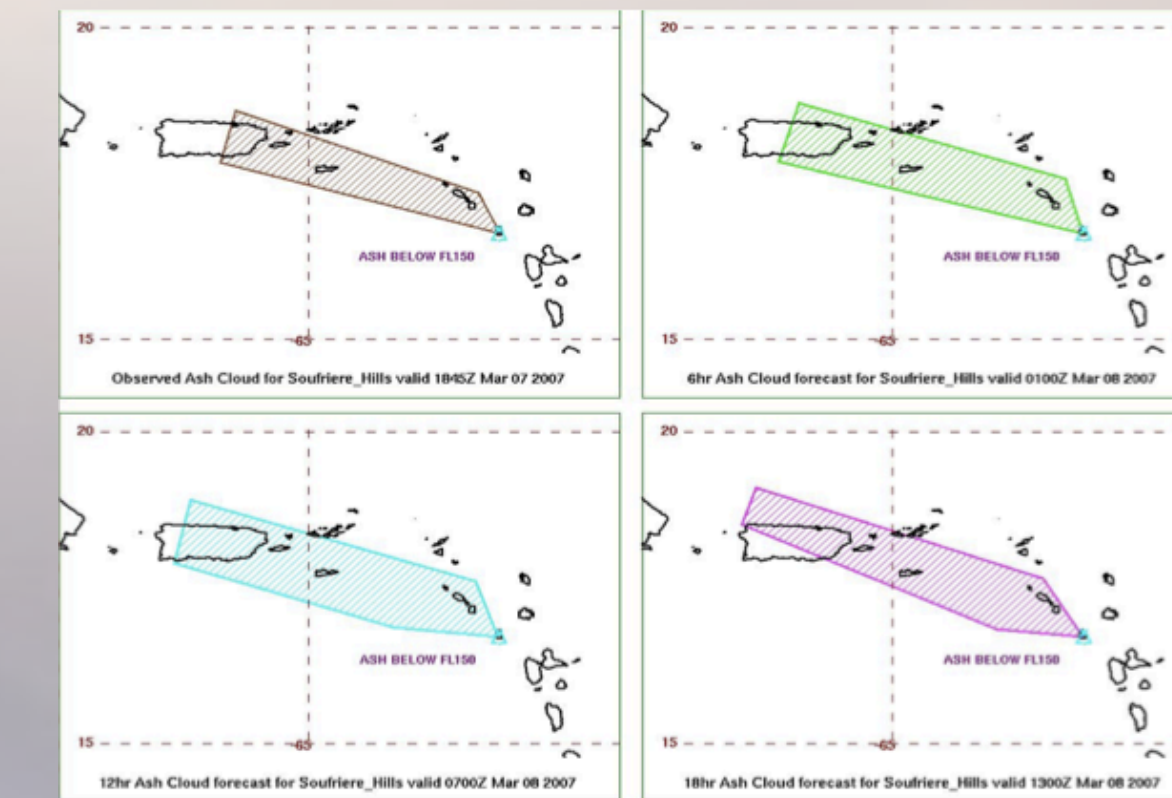
- During the period of 2005- 2007 in both stations was never found a volcanic eruption event without a Saharan dust event on an interval of a month.
- According to the spatial analysis, it was observed that the total of natural events during the period 2005-2007 was higher in Guaynabo station than in Fajardo station.



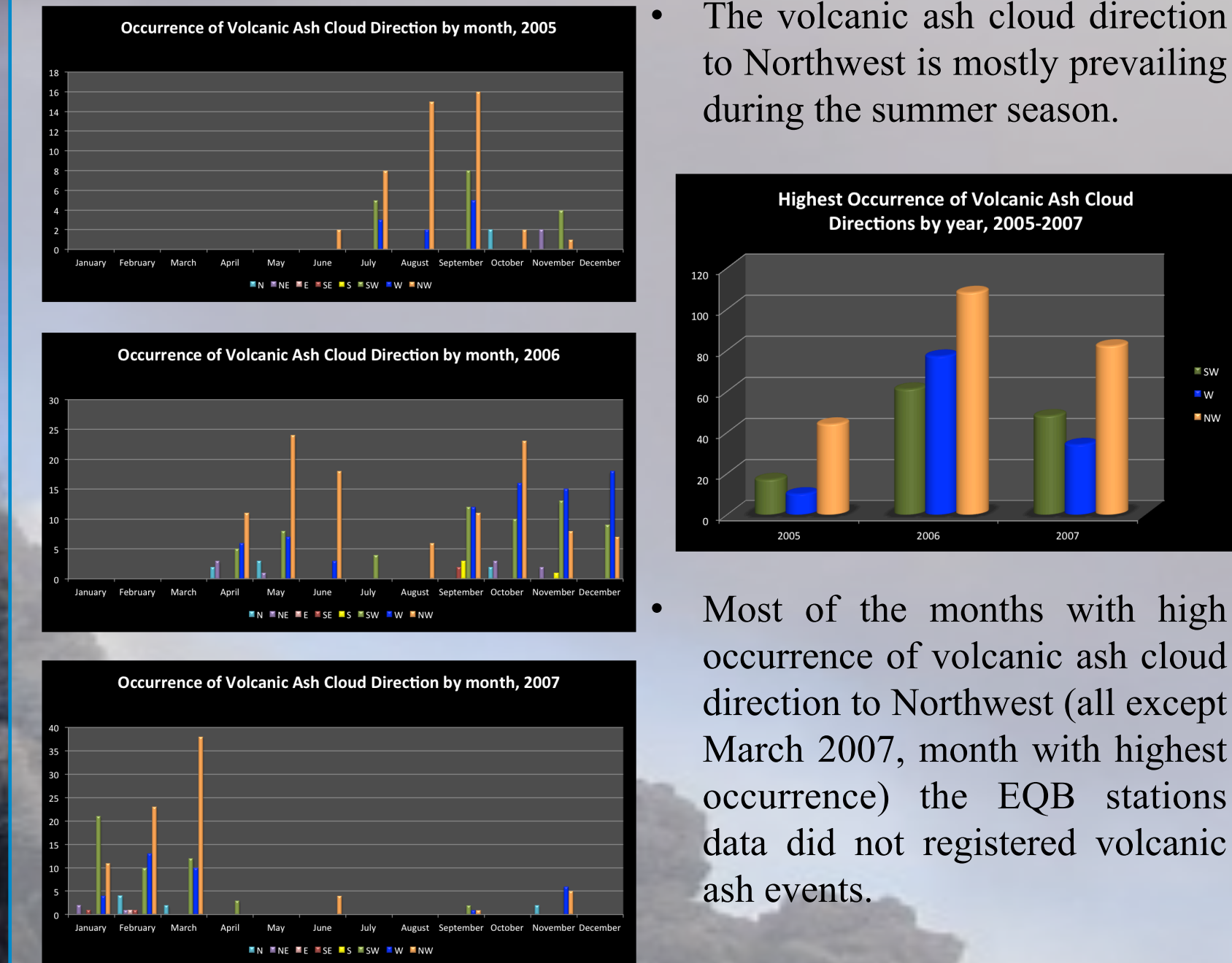
- The station located in urban area could be more vulnerable to alterations caused by natural events due to emissions from industries and vehicular traffic in the area, which can affect the  $PM_{10}$  more easily.

### Results continued

#### Volcanic Ash Cloud Direction



**Figure 5: Volcanic Ash Cloud, 7-8 March 2007**  
Source: NOAA, Washington VAAC



- The volcanic ash cloud direction to Northwest is mostly prevailing during the summer season.
- Most of the months with high occurrence of volcanic ash cloud direction to Northwest (all except March 2007, month with highest occurrence) the EQB stations data did not registered volcanic ash events.
- Northwest, West and Southwest were the volcanic ash cloud directions with the highest occurrence during the period of 2005-2007. Northwest showed the highest occurrence.
- During 2007 the volcanic activity began more early than the other two years. The year 2007 was the only year that showed volcanic activity during January, February and March. Also, the Guaynabo station registered a unique volcanic ash event during March, 2007.
- During all months that occurred volcanic ash events (June 2005, June 2006 and March 2007) the mayor occurrence of volcanic ash cloud direction was Northwest (NW).

### Conclusions

- The results showed a possible relation between Saharan dust and volcanic ash events, the trade winds could be the mechanism that relates both events.
- Northwest is the most prevailing direction of volcanic ash cloud during 2005-2007. This means that Puerto Rico is at high risk of being impacted by Soufrière Hills volcanic ash cloud.
- During summer, both stations registered most of the Saharan dust and volcanic ash events and the volcanic ash cloud direction with mayor occurrence was Northwest (NW). Also, the trade winds are more prominent during summer than any other season.
- During winter months, the highest occurrence of volcanic ash cloud direction was not to Northwest. Also, during winter both stations didn't registered Saharan dust or volcanic ash events.
- These data could be used as a guide to evaluate events occurrence and its relation with air quality risk in population areas. Investigations about this matter could help in the preparedness, mitigation and management of volcanic ash risks.

### Recommendations

- Search for specific trade wind data and prevailing wind speed and direction of Puerto Rico to identify possible relations with these events especially with volcanic ash events.
- A specific databank of tropical and subtropical storms should be developed to evaluate possible relationships with saharan dust and volcanic ash events since there have been other studies that show how climate can be affected by volcanic ash and saharan dust.
- A specific database of tropical waves could be useful for studying possible associations with Saharan dust and volcanic ash events because according to the Environmental Quality Board of Puerto Rico, satellites had showed that the largest concentration of Saharan dust lies on the anticyclonic side of tropical waves, and in Puerto Rico this events takes place by their passage through the Caribbean.

### References

State and Condition of Environment in PR Report 2004-2005-2006. Air Resources, Environmental Quality Board.

### Acknowledgements

I am grateful for the efforts of Maritza Olivares and Javier Rodríguez at the Environmental Quality Board, to provide the data for this study. Thanks are also extended to Dr. Rafael Méndez Tejada of the Department of Natural Sciences at University of Puerto Rico, Carolina Campus.

- Quality Assurance Project Plan "División de Validación de Datos y Modelaje Matemático" Air Quality Program. Environmental Quality Board.
- NOAA Satellite and Information Center. Washington DC, Volcanic Ash Advisory Center (VAAC).