Identification of the Airspace Affected by the Presence of Volcanic Ash by Processing Satellite Images, Case Study: Popocatepétl Volcano Area

José Carlos Jiménez-Escalona (jjimeneze@ipn.mx)
Instituto Politecnico Nacional Escuela Superior de Ingenieria Mecanica y Electrica Unidad Ticoman
https://orcid.org/0000-0001-9309-5245

Ramon S. Aparicio-García
IPN ESIME Unidad Ticomán: Instituto Politecnico Nacional Escuela Superior de Ingenieria Mecanica y Electrica Unidad Ticoman

Julie Roberge
IPN ESIA Zacatenco: Instituto Politecnico Nacional Escuela Superior de Ingenieria y Arquitectura Zacatenco

José Eduardo Ávila-Razo
IPN ESIME Unidad Ticomán: Instituto Politecnico Nacional Escuela Superior de Ingenieria Mecanica y Electrica Unidad Ticoman

José Luis Poom-Medina
UNISON: Universidad de Sonora

Oliver Marcel Huerta-Cháves
IPN ESIME Unidad Ticomán: Instituto Politecnico Nacional Escuela Superior de Ingenieria Mecanica y Electrica Unidad Ticoman

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Research

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Abstract

A volcanic eruption can affect large areas of the atmosphere around the volcano. Commercial aviation uses these zones the airspace as a navigation zone. Encountering these ash clouds can cause severe damage to different parts of the aircraft, mainly the engines. This work aims to generate a predictive tool based on the frequency of affectation of the airspace areas around a volcano with eruptive activity, taking the Popocatépetl volcano as a case study. Was carried temporal wind analysis at different atmosphere levels to identifying direction towards which wind disperses ash in year months. This information shown two representative seasons in the direction of dispersion: the first from November to May and the second from July to September, taking into account that June and October are transitional months and therefore do not present a predominant direction. To identify the ash cloud and estimate its area, a set of MODIS images was compiled that recorded the activity in the period 2000-2014. These satellite images were subjected to a semi-automatic digital pre-processing of binarization by thresholds according to the level of the Brightness Temperature Difference between band 31 and band 32, followed by manual evaluation of each binarized image. The result of those above pre-processing was a set of pixels with spatial (longitude and latitude) and temporal (date) description, from which the history of the areas affected by ash permanence was obtained. Additionally, a set of pixels evaluated and labeled in table form could be used as training data for future artificial intelligence applications to automatically detect and discriminate ash clouds.

Full Text

Due to technical limitations, full-text HTML conversion of this manuscript could not be completed. However, the latest manuscript can be downloaded and accessed as a PDF.

Figures

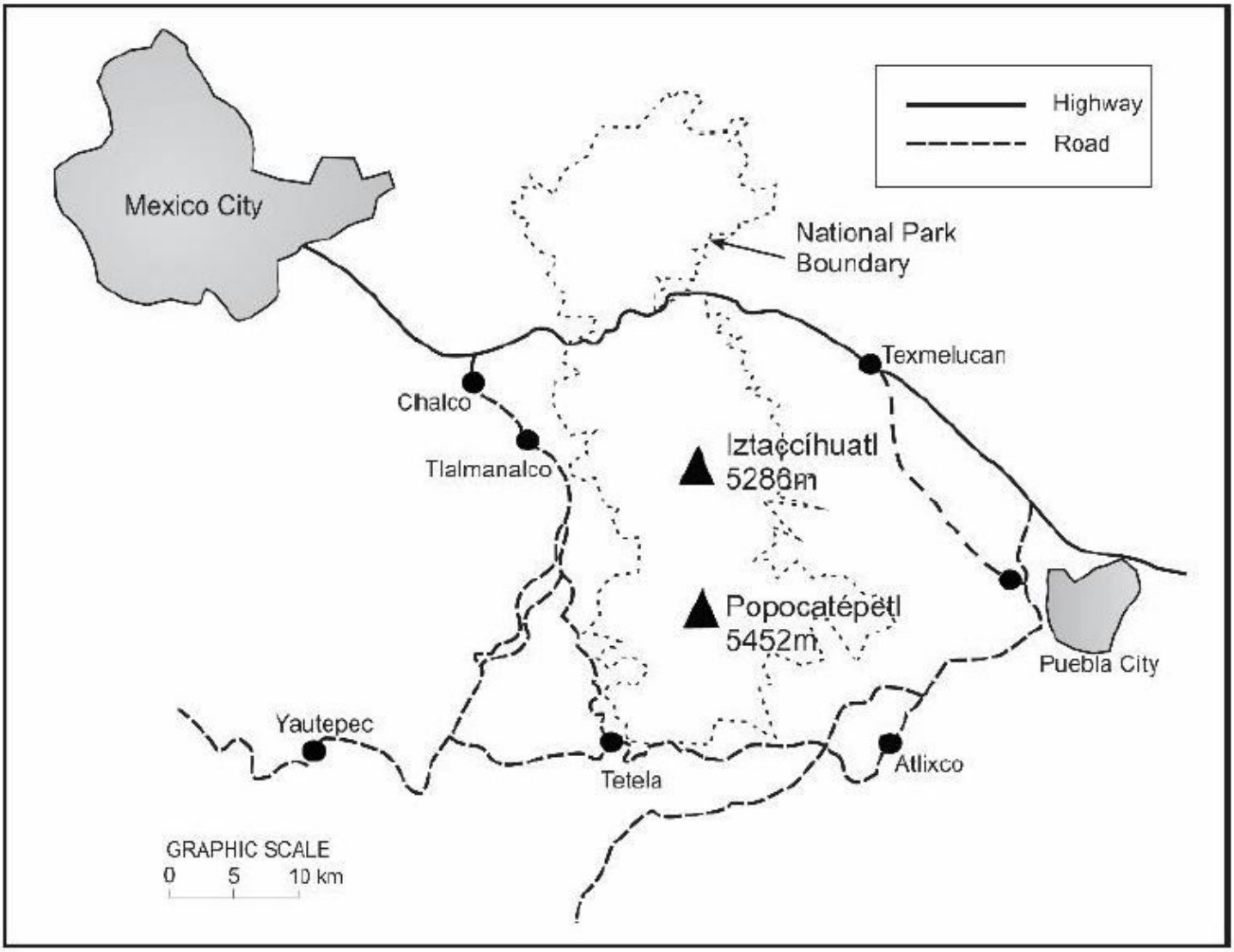

Figure 1

Towns and airports around the Popocatepetl volcano. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

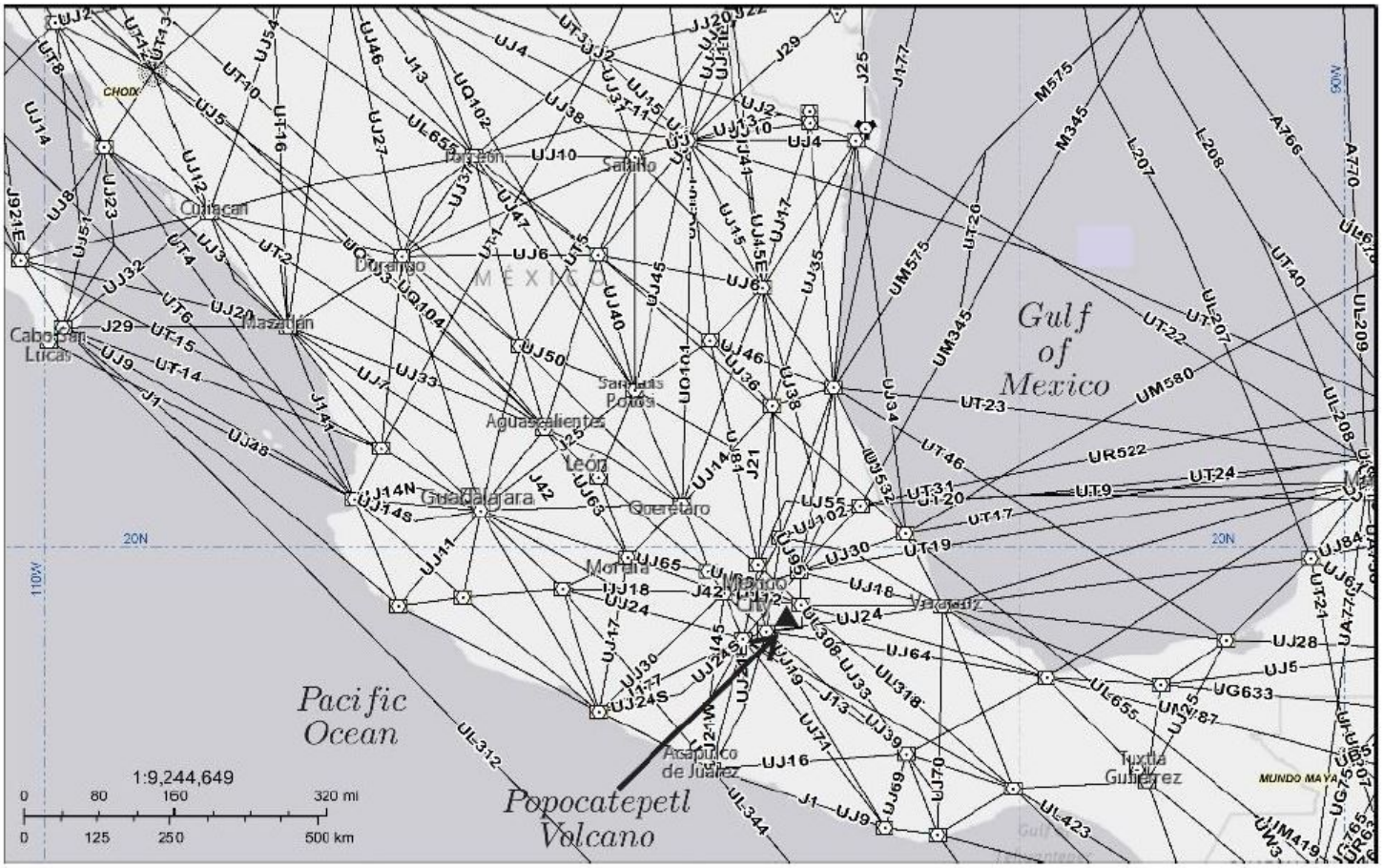

Figure 2

Airway map of central Mexico. Popocatepetl volcano is pointed in the central part of the country. (Modified from aeronautical chart of the upper airspace H2, published by SENEAM (Servicio a la Navegación en el Espacio Aéreo Mexicano, in spanish). Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

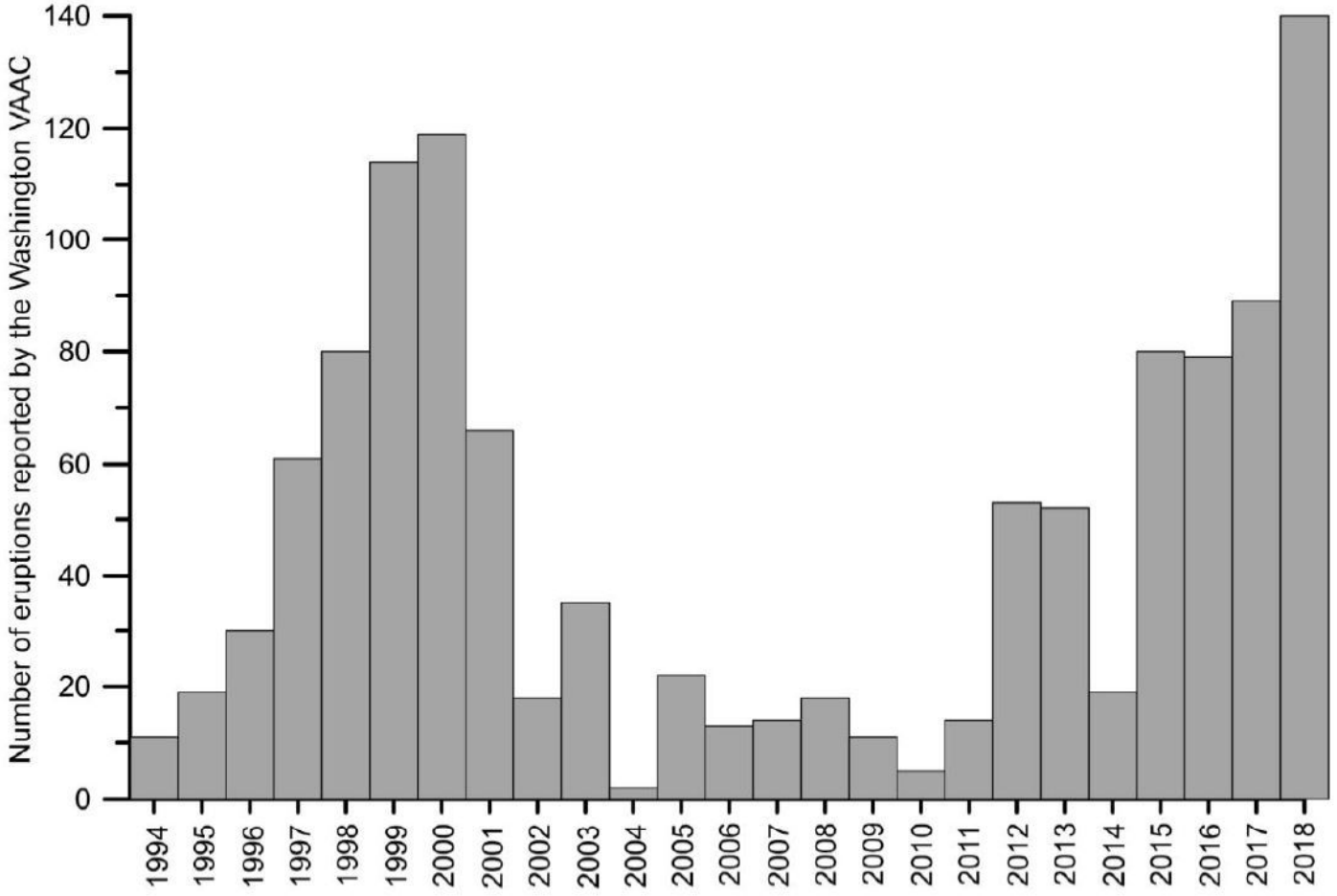

Figure 3

Historical activity of last eruptive period of Popocatepetl volcano. The information was obtained in VAAC reported in a period since 1999 to 2018.

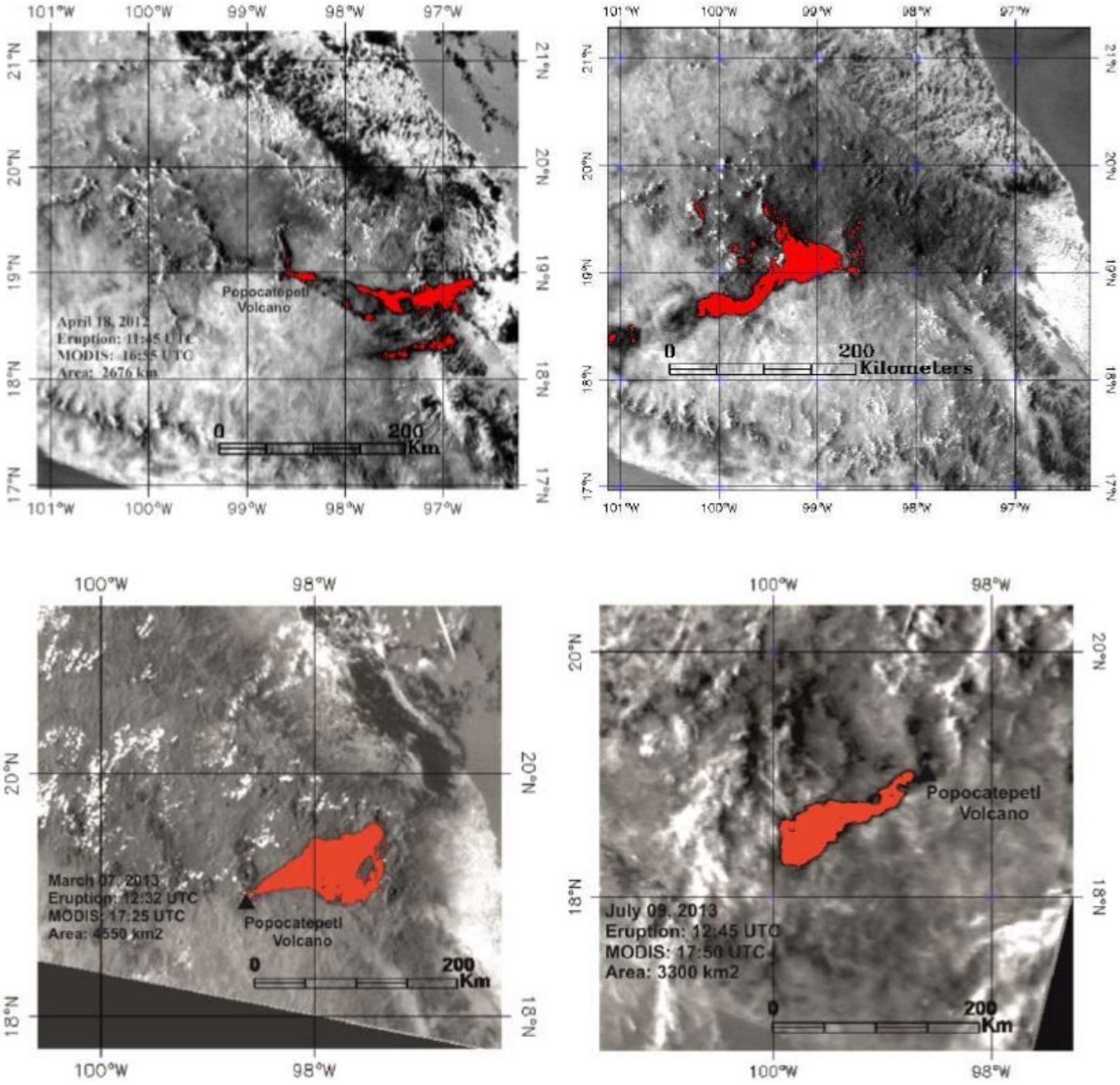

Figure 4

Volcanic Ash clouds from Popocatepetl volcano identify in the MODIS image.

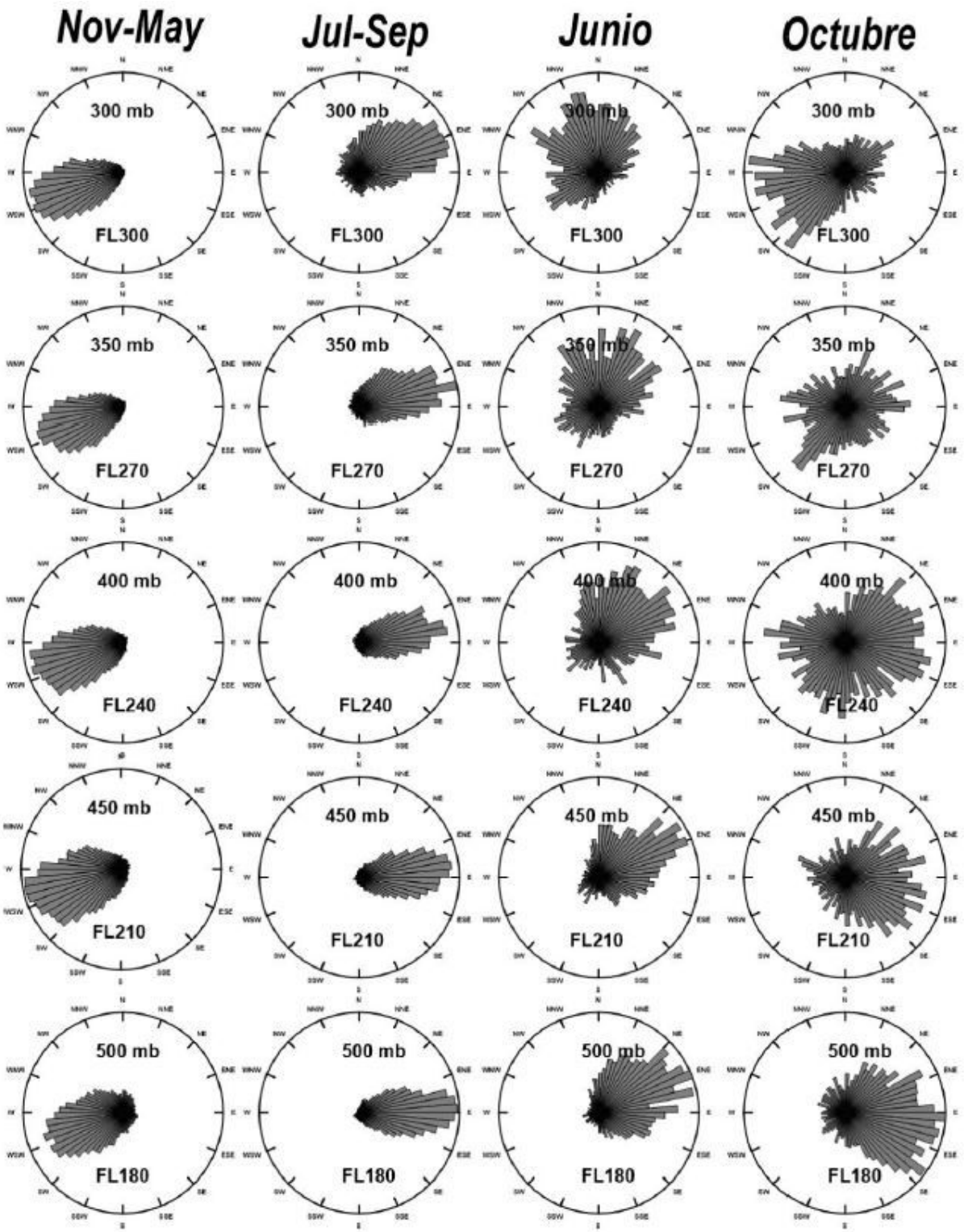

Figure 5

Wind profiles over the crater area of the Popocatépetl volcano, obtained from NOAA Reanalysis data for a period of 20 years, at pressure levels of 500 mb to 300 mb. Wind data was statistically analyzed separately for each month of the year, associating the trends in the months of the year.

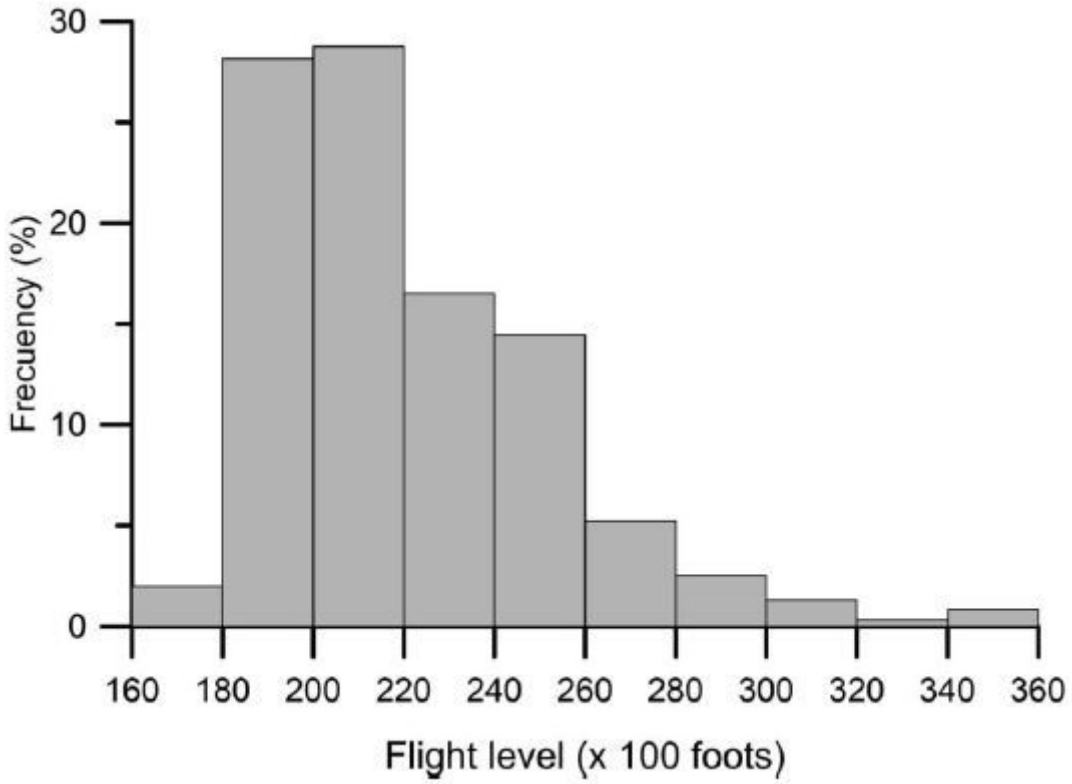

Figure 6

Histogram of the altitudes where were identifying volcanic ash clouds by the Washington VAAC in the period from 2000 to 2014. The altitudes are expressed in the nomenclature of flight levels (FL) in hundreds of feet above the sea level. This is because it is reported as support for air navigation.

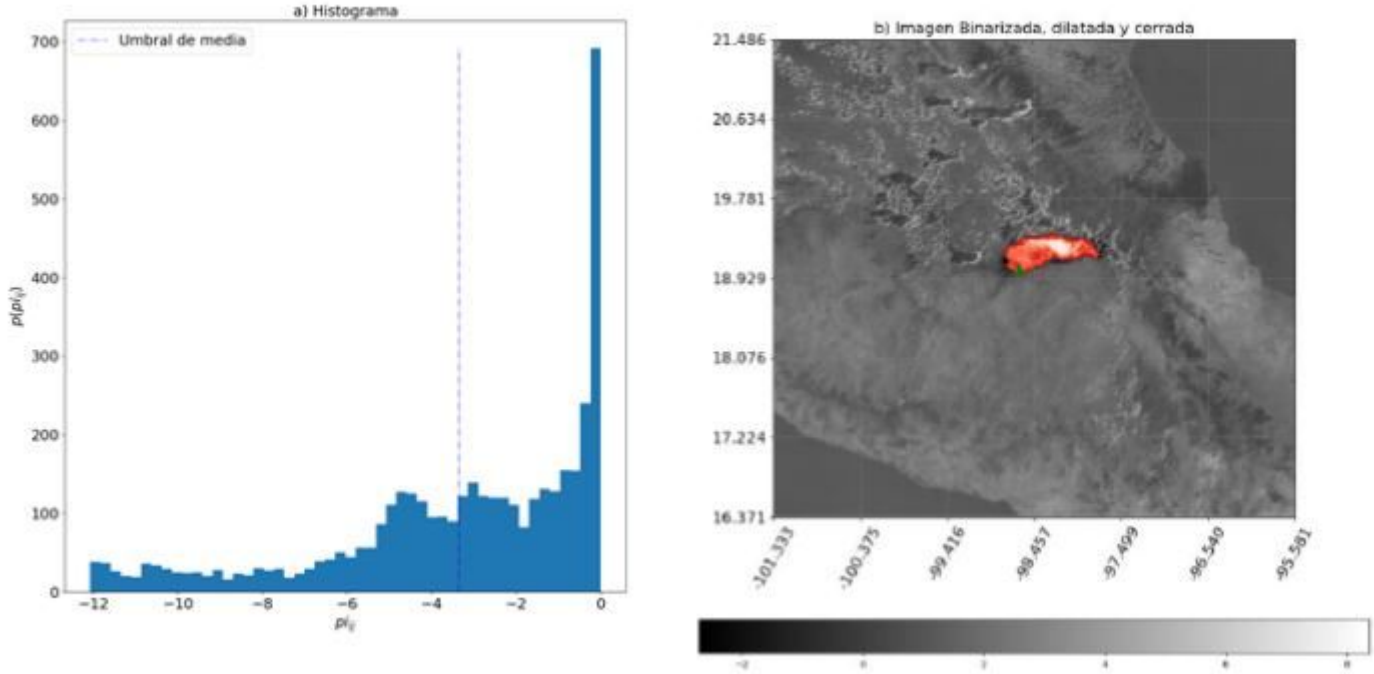

Figure 7

Pre-processing of satellite images using media thresholding (a) and morphological operations

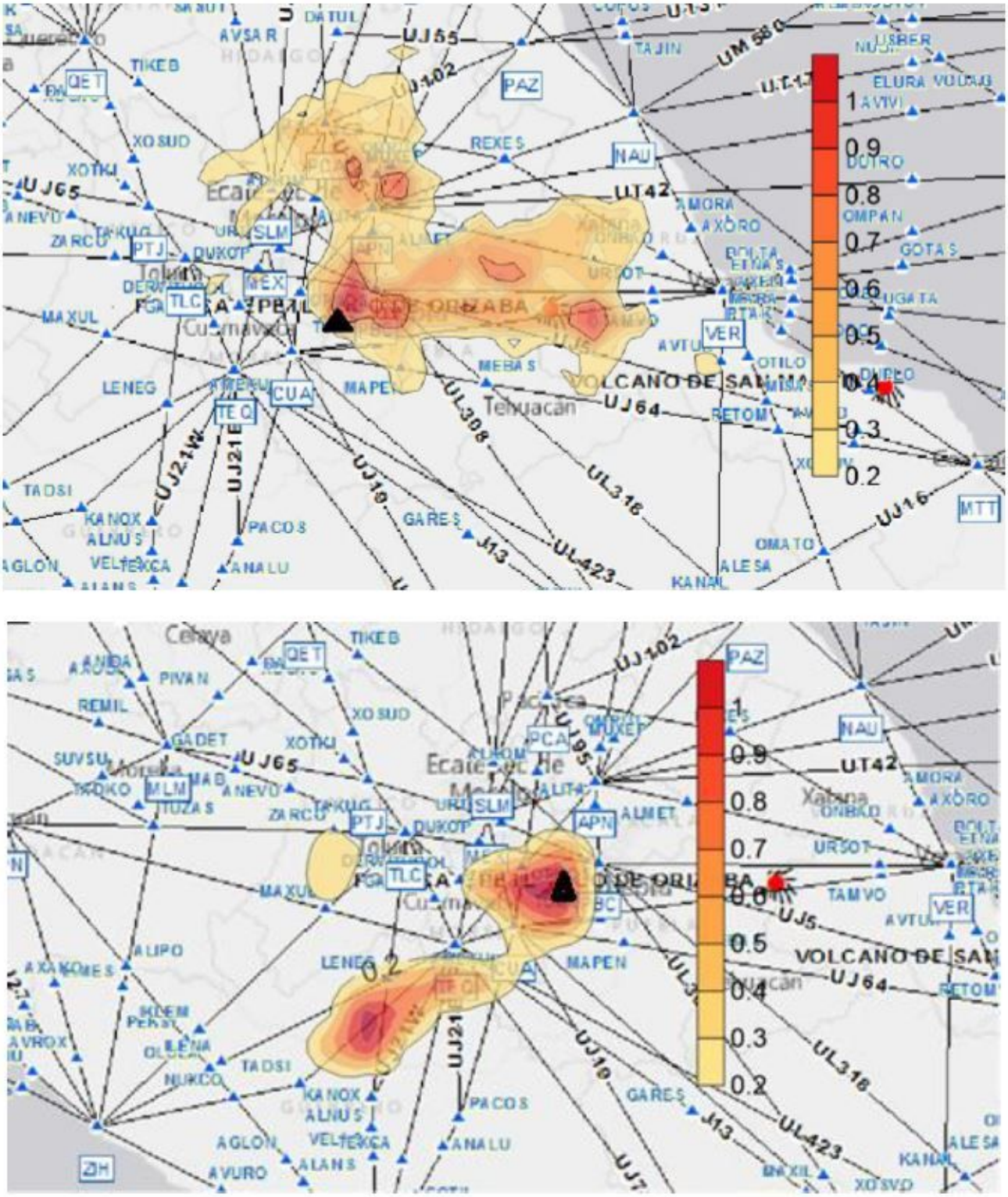

Figure 8

Areas with a high probability of being affected by volcanic ash in the event of an eruption of the Popocatépetl volcano. In the upper part during the November-May period and in the lower part during the July-October period.

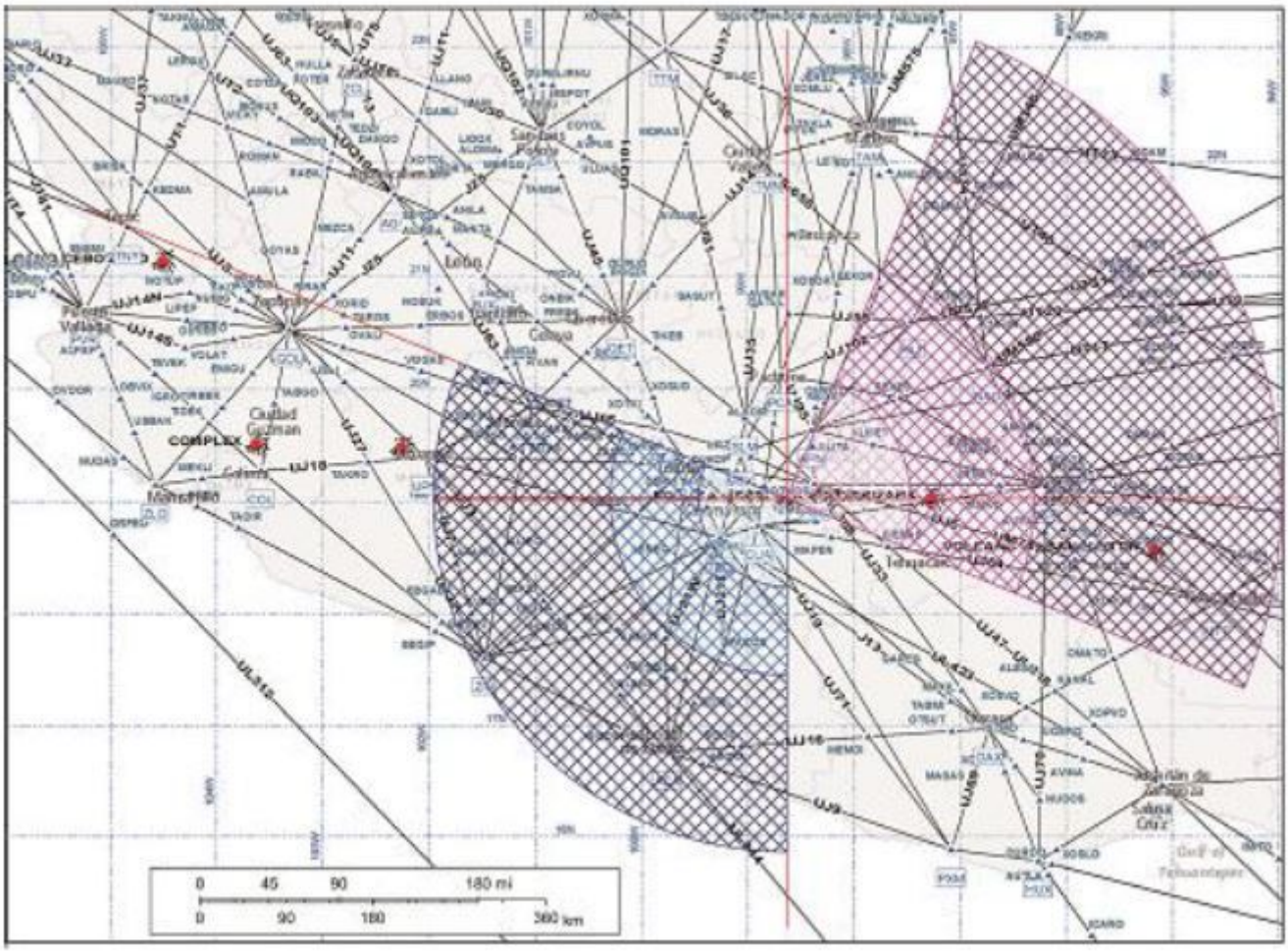

Figure 9

Delimited area considering the movement of a volcanic cloud transported by the wind in the seasons of the year defined by the wind direction. Identify three areas of safety: the first with a radio considering an hour of displacement by wind speed. Given the maximum wind speed in different years, the trend in the NNE - ESE area of wind speed was taken as 70 kts, and in the defined area W - S it took a wind speed of 50 kts. The second level of safety is defined by the hours of transport with a critical wind speed. The third zone with a transport of 4 hours with a critical wind speed.