Multiparametric measurements of the 2021 Tajogaite eruption on La Palma, Canary Islands, Spain

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1. Licence

2. Citation

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3. Abstract

This data repository contains electrical and seismic tremor measurements, thermal infrared imagery, atmospheric conditions and information on plume heights that were recorded and collected during the 2021 Tajogaite eruption on La Palma, Canary Islands, Spain. The 2021 Tajogaite eruption lasted from 19 September until 13 December 2021.

4. Electrical data

The electrical data was recorded using the Biral Thunderstorm Detector BTD-200. This sensor consists of two antennas, the primary and secondary antenna, which detect slow variations in the electrostatic field (within a frequency range of 1-45 Hz) resulting from charge neutralisation due to electrical discharges. It records at a sample rate of 100 Hz.

The sensor was installed in two consecutive locations. BTD1 was installed NNW at 2.65 km distance from the active craters (28.635°N, 17.876389°W) and recorded from 11-26 October 2021. BTD2 was installed SW at 1.77 km distance from the active craters (28.602365°N, 17.880475°W) and recorded from 27 October until the end of the eruption.

4.1. Data processing

Processing the electrical data involved an analog-to-digital converter (ADC) to digitise the raw voltage output from both antennas into a voltage (V) used for calculation by the internal processors. Note that the measured voltage is proportional to the rate of change in the electrostatic field induced on the antennas, not the voltage of the discharge source itself. The covariance value [V^2] between the primary and secondary antenna signals was calculated over a moving window of 16 samples with a step size of 1 sample and then converted to ADC.

4.2. File description

The electrical data can be found in folder "***2024-002_Vossen-et-al_BTD_electrical_data***". These data files contain the electrical data recorded using the Biral Thunderstorm Detector BTD-200 during the 2021 Tajogaite eruption between 11 October and 18 December 2021. Each file typically contains six hours of data (if there are no data gaps due to low power for example).

Each filename indicates the location of the BTD (BTD1 or BTD2), the starting date (yyyy-mm-dd) and time (hh_mm_ss) of the file in UTC and a short description of the four data columns inside the file (unixtime, primary, secondary and covariance).

The variables of all files are defined as:

Table 1: *Definition of variables in the files of folder* ***2024-002_Vossen-et-al_BTD_electrical_data***

Column header	unit	Description
Column_1_Unix_timestamp_ [seconds_since_01/01/1970]	-	Unix timestamp of each data point, which is the time in seconds since 01/01/1970. All time is provided in UTC
Column_2_Primary_antenna_ measured_voltage_[V]	Volts [V]	The measured voltage recorded by the primary antenna
Column_3_Secondary_antenna_ measured_voltage_[V]	Volts [V]	The measured voltage recorded by the secondary antenna
Column_4_P:S_covariance_[V^2]	[V^2]	The covariance value between the primary and secondary antenna

5. Seismic tremor data

Seismic tremor measurements were made every 50 seconds between 10 September and 20 December 2021 at seismic station PLPI (28.5722°N, 17.8654°W), which was operated by Instituto Volcanológico de Canarias (INVOLCAN).

5.1. Data processing

The seismic tremor data is filtered in order to provide the volcanic tremor amplitude within the Very Long Period (VLP, 0.4-0.6 Hz) and the Long Period (LP, 1-5 Hz) frequency bands.

5.2. File description

The seismic tremor data can be found in folder "***2024-002_Vossen-et-al_Seismic_tremor***". The file "*VLP_and_LP_amplitudes.dat*" provides the Very Long Period and Long Period amplitudes every 50 seconds between 10 September and 20 December 2021.

Table 2: *Column definition of file VLP_and_LP_amplitudes.dat in folder* ***2024-002_Vossen-et-al_Seismic_tremor***

Column header	unit	Description
Year	-	Measurement year in 4 digits
Month	-	Measurement month in 2 digits
Day	-	Measurement day in 2 digits
Hour	-	Measurement hour in 2 digits
Minute	-	Measurement minute in 2 digits
Second	-	Measurement second in 2 digits
VLP_amplitude	-	Very Long Period amplitude
LP_amplitude	-	Long Period amplitude

6. Thermal data

Thermal videography was done through the temporary installation of an InfraTec HD thermal infrared (TIR) video camera. The TIR camera was installed NNW from the active craters at a distance of 4.3 km (28.649361°N, 17.882279°W) and was focused on the explosive activity at the eruptive vents. It recorded almost continuously between 3-8 November 2021 with a maximum definition of 640x480 pixels at 15 frames per second (fps). A Jenoptik IR 1.0/30 LW objective was used, resulting in a pixel resolution of ~3.6 m at the active vents. The camera software corrected the effects of atmospheric absorption *in situ*, based on temperature, air humidity and distance between the camera and the active craters.

6.1. File description

The thermal infrared data (.png) can be found in folder "***2024-002_Vossen-et-al_Thermal_data***". Here we provide the single thermal infrared frames that were extracted from the videos at one-minute time intervals. The scale on the axes has been converted from pixels to meters (2304x1728 m). The colours indicate relative temperatures, where yellow/orange is hot and blue is cold. The full thermal infrared dataset is available upon request from the corresponding author.

Each filename starts with “Thermal_frame” and then shows the date (dd-Nov-yy) and time (hhmmss) in UTC at which the thermal infrared frame was taken. Note that there are data gaps due to periods of time where the camera was not recording.

7. Atmospheric data

Atmospheric data was obtained from both weather balloon measurements at Güímar (station nr. 60018) on Tenerife, which were provided by the University of Wyoming, Department of Atmospheric Science (http://weather.uwyo.edu/), as well as from two ground-based weather stations at El Paso and Roque de los Muchachos operated by State Meteorological Agency (AEMET) of Spain on La Palma.

7.1. Analytical procedure

From the weather balloon measurements on Tenerife, atmospheric conditions were obtained for three different isotherms (0°C, -10°C and -20°C) at noon and midnight (UTC) between 1 September and 31 December 2021. For each isotherm, the closest temperature value and the corresponding atmospheric pressure (hPa), height (meters above sea level), temperature (°C) and relative humidity (%) were collected. To determine whether the atmospheric conditions on Tenerife are also representative for the conditions on La Palma, the weather balloon measurements were compared to two AEMET ground-based weather stations on La Palma, one at El Paso and one at Roque de los Muchachos. The atmospheric conditions that were measured at a height closest to 844 m (elevation of El Paso station) and 2223 m above sea level (elevation of Roque de los Muchachos station) were obtained from the weather balloon measurements and then compared to the conditions measured at the ground-based weather stations.

7.1. File description: Atmospheric data

The atmospheric data can be found in folder "***2024-002_Vossen-et-al_Atmospheric_conditions***". The atmospheric data has been split into two Excel files. One Excel file is named "***60018-Guimar-Tenerife_University-of-Wyoming.xlsx***", which contains the weather balloon measurements done at Güímar (station nr. 60018) on Tenerife. The other Excel file is named "***El-Paso-and-Roque-de-los-Muchachos-stations_AEMET.xlsx***", which contains the data of the AEMET ground-based weather stations at El Paso and Roque de los Muchachos on La Palma.

The "***60018-Guimar-Tenerife_University-of-Wyoming.xlsx***" file contains three different sheets:

- The first sheet "*Data at different isotherms*" contains the atmospheric conditions at three different isotherms (0°C, -10°C and -20°C) measured with the weather balloons at noon and midnight (UTC) between 1 September and 31 December 2021. We extracted the atmospheric data that corresponded to the temperature values closest to the desired isotherms. For each isotherm we provide the corresponding atmospheric pressure (hPa), height (meters above sea level), temperature (°C) and relative humidity (%).
- The second sheet "*Measurements at ~844 m a.s.l.*" contains the atmospheric conditions that were measured at a height closest to 844 m above sea level, which corresponds to the elevation of the AEMET weather station at El Paso. Measurements were taken at noon and midnight (UTC) between 1 September and 31 December 2021. The data includes the pressure (hPa), height of the measurement (meters above sea level), temperature (°C), relative humidity (%), wind direction (degrees) and wind speed (knot).
- Similarly, the third sheet "*Measurements at ~2223 m a.s.l.*" contains the atmospheric conditions that were measured at a height closest to 2223 m above sea level, which corresponds to the elevation of the AEMET weather station at Roque de los Muchachos.

The "***El-Paso-and-Roque-de-los-Muchachos-stations_AEMET.xlsx***" file contains two different sheets:

- The first sheet "*El Paso station*" contains the atmospheric data measured at the El Paso station.
- The second sheet "*Roque de los Muchachos*" contains the data measured at the Roque de los Muchachos station. Measurements were taken every hour between 1 September and 21 December 2021 and the time is given in UTC. The data includes the elevation of the respective station (meters above sea level), temperature (°C), wind speed (km/h), wind direction, gust (km/h), gust direction, precipitation (mm), pressure (hPa) and humidity (%). Table 3 provides the degrees corresponding to the wind and gust directions. Note that for certain periods not all parameters were publicly available at the time of obtaining the files, in which case the Excel cells are empty.

Table 3: *The wind and gust directions are based on the following range in degrees:*

Wind and gust direction	Degrees
North	0-30
North-East	31-60
East	61-120
South-East	121-150
South	151-210
South-West	211-240
West	241-300
North-West	301-330
North	331-360

Table 4: *File "60018-Guimar-Tenerife_University-of-Wyoming.xlsx" - Sheet 1 "Data at different isotherms" in folder* ***2024-002_Vossen-et-al_Atmospheric_conditions***

Column header	unit	Description
Year	-	Measurement year in 4 digits
Month	-	Measurement month in 2 digits
Day	-	Measurement day in 2 digits
Hour	-	Measurement hour in 2 digits
Minute	-	Measurement minute in 2 digits
Atmospheric pressure (hPA) around 0°C	hPa	Atmospheric pressure around 0°C isotherm
Height (m a.s.l.) around 0°C	m a.s.l.	Elevation around 0°C isotherm
Temperature (°C) around 0°C	°C	Closest temperature measurement to 0°C isotherm
Relative humidity (%) around 0°C	%	Relative humidity around 0°C isotherm
Atmospheric pressure (hPA) around -10°C	hPa	Atmospheric pressure around -10°C isotherm
Height (m a.s.l.) around -10°C	m a.s.l.	Elevation around -10°C isotherm
Temperature (°C) around -10°C	°C	Closest temperature measurement to -10°C isotherm
Relative humidity (%) around -10°C	%	Relative humidity around -10°C isotherm
Atmospheric pressure (hPA) around -20°C	hPa	Atmospheric pressure around -20°C isotherm
Height (m a.s.l.) around -20°C	m a.s.l.	Elevation around -20°C isotherm
Temperature (°C) around -20°C	°C	Closest temperature measurement to -20°C isotherm
Relative humidity (%) around -20°C	%	Relative humidity around -20°C isotherm

Table 5: *File "60018-Guimar-Tenerife_University-of-Wyoming.xlsx" - Sheet 2 "Measurements at ~844 m a.s.l." and sheet 3 "Measurements at ~2223 m a.s.l." in folder* ***2024-002_Vossen-et-al_Atmospheric_conditions***

Column header	unit	Description
Year	-	Measurement year in 4 digits
Month	-	Measurement month in 2 digits
Day	-	Measurement day in 2 digits
Hour	-	Measurement hour in 2 digits
Minute	-	Measurement minute in 2 digits
Pressure [hPa]	hPa	Pressure around 884/2223 m elevation
Height of measurement [m a.s.l.]	Meters above sea level (m a.s.l.)	Closest elevation measurement to 884/2223 m above sea level
Temperature [°C]	°C	Temperature around 884/2223 m elevation
Relative humidity [%]	%	Relative humidity around 884/2223 m elevation
Wind direction [deg]	Degrees	Wind direction around 884/2223 m elevation
Wind speed [knot]	Knot	Wind speed around 884/2223 m elevation

Table 6: File "El-Paso-and-Roque-de-los-Muchachos-stations_AEMET.xlsx" - Sheet 1 "El Paso station" and sheet 2 "Roque de los Muchachos station" in folder ***2024-002_Vossen-et-al_Atmospheric_conditions***

Column header	unit	Description
Year	-	Measurement year in 4 digits
Month	-	Measurement month in 2 digits
Day	-	Measurement day in 2 digits
Hour	-	Measurement hour in 2 digits
Minute	-	Measurement minute in 2 digits
Elevation of El Paso/Roque de los Muchachos station	Meters above sea level (m a.s.l.)	Elevation of AEMET ground-based weather station
Temperature (°C)	°C	Temperature at station
Wind speed (km/h)	km/h	Relative humidity at station
Wind direction	-	Wind direction at station
Gust (km/h)	km/h	Wind speed at station
Gust direction	-	Gust direction at station
Precipitation (mm)	mm	Precipitation at station
Pressure (hPa)	hPa	Pressure at station
Humidity (%)	%	Humidity at station

8. Plume height data

Plume height data was obtained from the Toulouse Volcanic Ash Advisory Center (VAAC) and the Plan de Emergencias Volcánicas de Canarias (PEVOLCA). The Toulouse VAAC obtained information from satellite data as well as from the Volcano Observatory Notice for Aviation (VONA) compiled by the Instituto Geográfico Nacional using a camera of the Instituto Astrofísico de Canarias. This camera was located 16.5 km north of the active vents at an altitude of 2365 m above sea level. Information on the plume heights was generally reported at regular times during the day (03:00, 09:00, 15:00 and 21:00 UTC) between 19 September and 15 December 2021, unless otherwise stated in their bulletins (https://vaac.meteo.fr/volcanoes/la-palma/). PEVOLCA also obtained information from the camera of the Instituto Astrofísico de Canarias, but reported the plume heights only once per day (typically mornings) between 20 September and 14 December 2021.

8.1. File description

The plume height data can be found in folder "***2024-002_Vossen-et-al_Plume_height_data***". The data has been split into two Excel files. "*Plume_heights_PEVOLCA.xlsx*" contains the observations made once per day between 20 September and 14 December 2021 by the Plan de Emergencias Volcánicas de Canarias (PEVOLCA). We have assigned noon (12:00 UTC) as a fixed time of the day to plot the data. "*Plume_heights_Toulouse_VAAC.xlsx*" contains the data provided by the Toulouse Volcanic Ash Advisory Center (VAAC) between 19 September and 15 December 2021, which was extracted from their bulletins. Note that the Toulouse VAAC reports the highest flight levels affected by volcanic ash, which may deviate from the height of the eruption column itself.

*Table 7: File "Plume_heights_PEVOLCA.xlsx" in folder **2024-002_Vossen-et-al_Plume_height_data***

Column header	unit	Description
Year	-	Observation year in 4 digits
Month	-	Observation month in 2 digits
Day	-	Observation day in 2 digits
Hour	-	Observation hour in 2 digits
Minute	-	Observation minute in 2 digits
PEVOLCA_plume_height_[m_asl]	m a.s.l.	Plume height above sea level as reported by the Plan de Emergencias Volcánicas de Canarias (PEVOLCA)

*Table 8: File "Plume_heights_Toulouse_VAAC.*xlsx" in folder **2024-002_*Vossen-et-al_Plume_height_data***

Column header	unit	Description
Year	-	Observation year in 4 digits
Month	-	Observation month in 2 digits
Day	-	Observation day in 2 digits
Hour	-	Observation hour in 2 digits
Minute	-	Observation minute in 2 digits
Toulouse_VAAC_plume_height_[m_asl]	m a.s.l.	Plume height above sea level (converted from flight level to meters) as reported by the Toulouse Volcanic Ash Advisory Center (VAAC)