



Area of Interest: Erta Ale Volcano, Ethiopia

Dates Covered: 10 – 21 July 2025

Purpose/Caveats: This event response report was produced to assist situational awareness and rapid response efforts. It represents best endeavours at the time of issue. Analysis and interpretation of the data is preliminary, which may not reflect the most up-to-date or complete information due to the evolving situation.

Authors: Edna Dualeh (Bristol), Lin Way (Bristol), Juliet Biggs (Bristol), Milan Lazecky (Leeds), Tim Wright (Leeds), Alessandro La Rosa (University of Pisa), Carolina Pagli (University of Pisa), Derek Keir (University of Southampton, University of Florence), Raphael Grandin (IPGP, Université Paris Cité), Ben Esse (Manchester), Mike Burton (Manchester), Elias Lewi (Addis Ababa University), Atalay Ayele (Addis Ababa University).

Reviewed by: Sue Loughlin (BGS), Sophie Butcher (BGS) and Lara Smale (BGS).

Acknowledgements: The analysis and report was produced in collaboration with Addis Ababa University, and the projects: VolcScatter (ESA Fellowship); Space It Up (MiUR and ASI); MAST (ERC Consolidator); ADD-ON - Afar Dallol Drilling - Earth Observatory (ICDP); University of Manchester postdoctoral funding for BE; and University of Bristol PhD scholarship to LW.

Plain language summary:

Erta Ale volcano in Afar, Ethiopia hosts a permanent lava lake and often produces lava flows. On 15 July 2025, it erupted explosively producing ash and sulfur dioxide plumes. Analysis of satellite imagery revealed pit crater collapses of at least 170 m in the north (summit) caldera and lava flows from the south caldera that reached up to 1.1 km to the west and up to 2.3 km to the east. Satellite measurements of thermal activity and sulfur dioxide emissions peaked on 15 July (4 – 10 kt/day) and remain elevated. Caldera activity was accompanied by subsurface magma migration south-eastwards from Erta Ale in the direction of Hayli Gubbi volcano ([12 km SE](#)) and Lake Afrera (42 km SE). Satellite measurements of surface deformation show that the subsurface magmatic intrusion reached a length of 30 km by 21 July. The intrusion was associated with some small earthquakes (above M3.3), peaking during 20-21 July.

Background:

Erta Ale volcano in Afar, Ethiopia hosts an almost persistent basaltic summit lava lake. Following an overflow of the lava lake, a flank fissure eruption occurred on 21 January 2017 (GVP, 2017). Lava flows and post-eruptive deformation continued through 2019 (Moore et al., 2019; Xu et al., 2020; Gosling et al., 2025). Lava lake overflows and thermal anomalies were continuously observed to July 2025 (GVP, 2025a). Erta Ale has two calderas, the northern (summit) caldera, which contains two active pit craters, and the southern relic caldera (Fig 1A).

Recent Activity:Eruptive activity

An explosive eruption occurred on 15 July 2025 and was reported by observers on the ground (e.g. <https://watchers.news/2025/07/15/erta-ale-volcano-eruption-dense-ash-emission-ethiopia-july-2025/>; <https://www.youtube.com/watch?v=vXsCe0XEmIE>). The eruption was accompanied by ash plumes (GVP, 2025b) originating from the north caldera as observed in optical satellite imagery (PlanetScope, Fig 1C). Optical and SAR satellite imagery show that the north and south pit craters collapsed (Fig 1C). SAR radar shadow measurements estimate a minimum collapse of at least 170 m and 57 m for the north and south pit craters respectively.

Thermal anomalies were observed on 15-21 July 2025 approximately 6 km south of the lava lake collapse (MIROVA VIIRS 375; Fig 1A, Fig 2D-F). The anomalies peaked in intensity on 15 July and have gradually subsided since (Fig 2H). Lava flows originated from a line of vents (~1.5 km long) within and outside the caldera (Sentinel-2 SWIR, Fig 1F). The lava flows reached ~1.1 km and 2.3 km to the west and east respectively (PlanetScope and Sentinel-2 SWIR, Fig 1F, H). The majority of these flows were emplaced on the 15 July with some distal activity on the 16 July (Sentinel-2 SWIR, Fig 1F). No new flows were observed following 16 July.

Thermal anomalies and small plumes were observed 3-4 km to the southeast of Erta Ale's South East caldera towards Hayli Gubbi volcano (Sentinel-2 SWIR, Fig 1G). These were not observed during initial lava flow emplacement (VIIRS, Fig. 2D), appearing by the evening of 15 July.

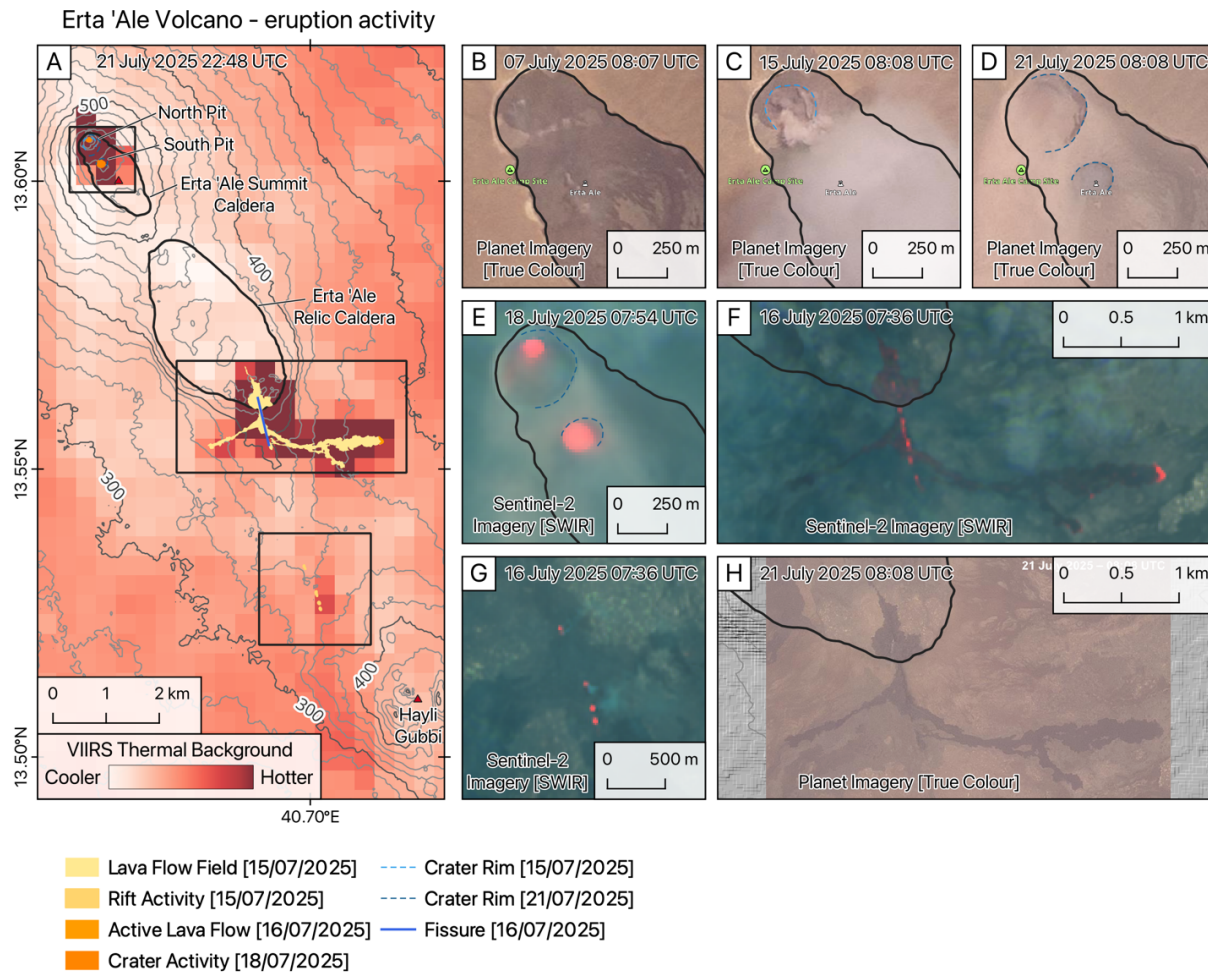


Fig 1: (A) Eruption activity observed between 15 – 21 July from optical and thermal imagery (PlanetScope, Sentinel-2) overlain on VIIRS thermal image (21 July). (B-D) Progressive collapse of north and south pit observed by PlanetScope imagery (07, 15, 21 July). (E) Thermal anomaly in north and south pit observed with Sentinel-2 SWIR imagery on 18 July. (F-G) Active vents and lava flow fronts observed between Erta Ale and Hayli Gubbi by Sentinel-2 SWIR imagery on 16 July. (H) Extent of lava flow observed by PlanetScope imagery (21 July). PlanetScope animation: https://www.planet.com/stories/erta_ale_july2025-MVm1S_8Hg

SO₂ emissions were detected by the TROPOspheric Monitoring Instrument (TROPOMI) from 15 July, with plumes visible every day after the eruption so far, up to 23 Jul (Fig. 2A-C). These were analysed using two methods to produce SO₂ emission rates, the “Disk Method” (Grandin et al, 2024) and “PlumeTraj” (Esse et al, 2025), which both indicate high emission rates (4 – 10 kt/day) on 15 July, followed by a drop to lower emission rates (2 – 5 kt/day) emissions on the following days. The low altitude of the plumes (~2 km a.s.l.) and presence of meteorological cloud means that these values are likely underestimates, but they capture the time-variation of the emissions.

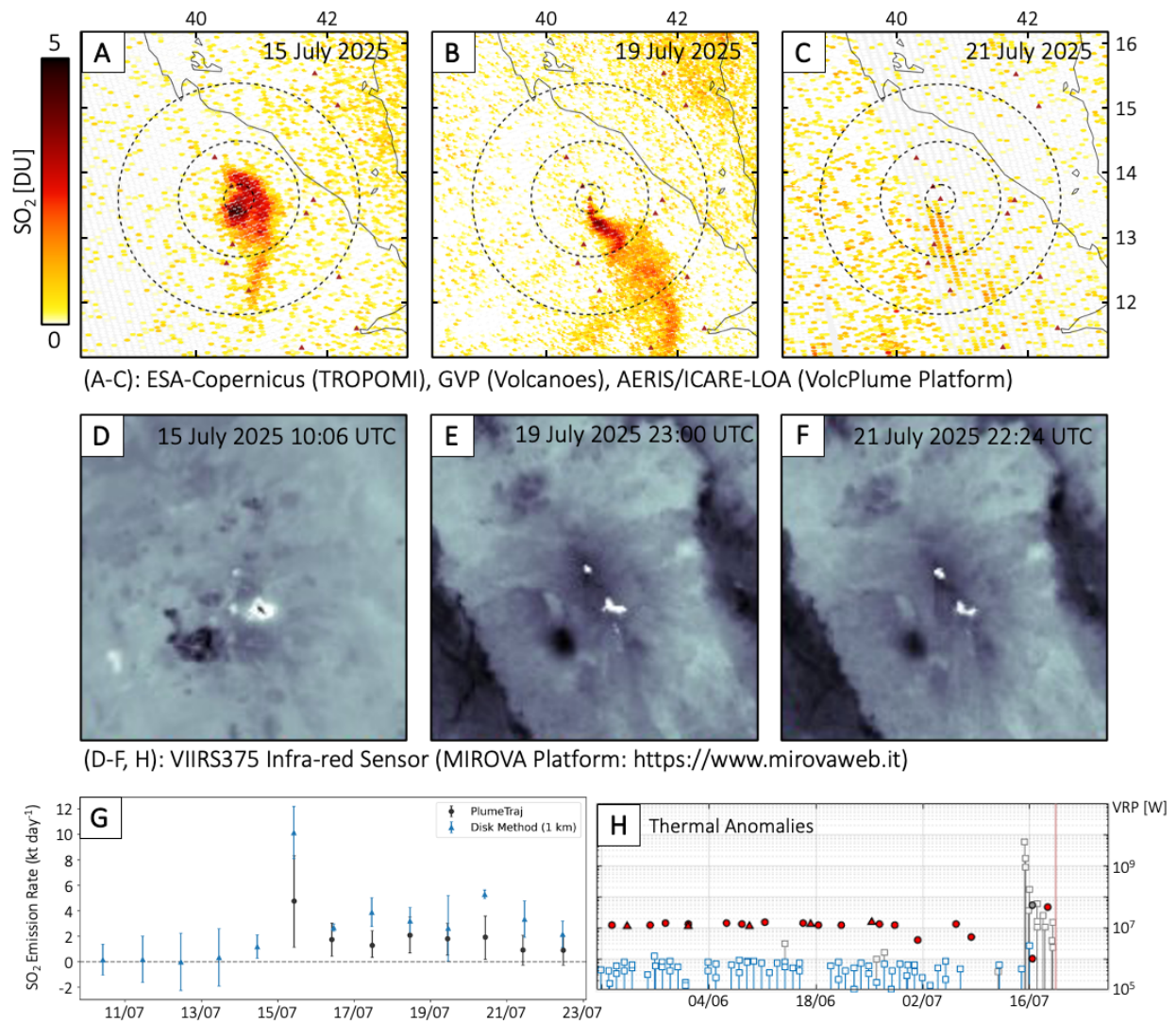


Fig 2: (A-C) SO₂ emissions at Erta Ale observed by TROPOMI Sentinel-5P. (D-F) Thermal anomalies correlated with Erta Ale lava lake, new lava flows and vents along rift. Timeseries show (G) SO₂ emissions from PlumeTraj (black dots) and the Disk Method (blue triangles), and (H) thermal anomalies from MIROVA (red symbol: number of hot pixels within summit. blue stem: Volcanic Radiative Power, VRP, from MIR observation) began on 15 July. SO₂ emissions from the Disk Method (Grandin et al., 2024) were computed from the 1-km TROPOMI product, masking pixels with a column amount smaller than 0.1 Dobson Units, and using wind speed derived from ERA-5 reanalysis at 850 hPa pressure level (altitude ~ 1.5 km). PlumeTraj emissions are calculated as daily means of emissions above 50% of the maximum for that day to mitigate the effects of cloud.

Propagation of dike intrusion from Erta Ale

Sentinel-1 interferograms spanning the eruption show deformation patterns consistent with a ~ 5 km long contracting dike at Erta Ale and a longer opening dike extending from the south of Erta Ale towards Hayli Gubbi. The dike intrusion measured about 10 km long on 16 July (Fig 3a). The subsequent interferogram covering the period 9-21 July suggests that the intrusion propagated 20 km further south-eastwards past Hayli Gubbi towards Lake Afrera over 5 days,

reaching a length of about 30 km on 21 July and causing more than 1 m of motion towards the satellite (Fig 3b,c). Discontinuities provide evidence of multiple surface-rupturing faults, and subsidence of a ~2 km wide graben along the southern-most segment of the dike.

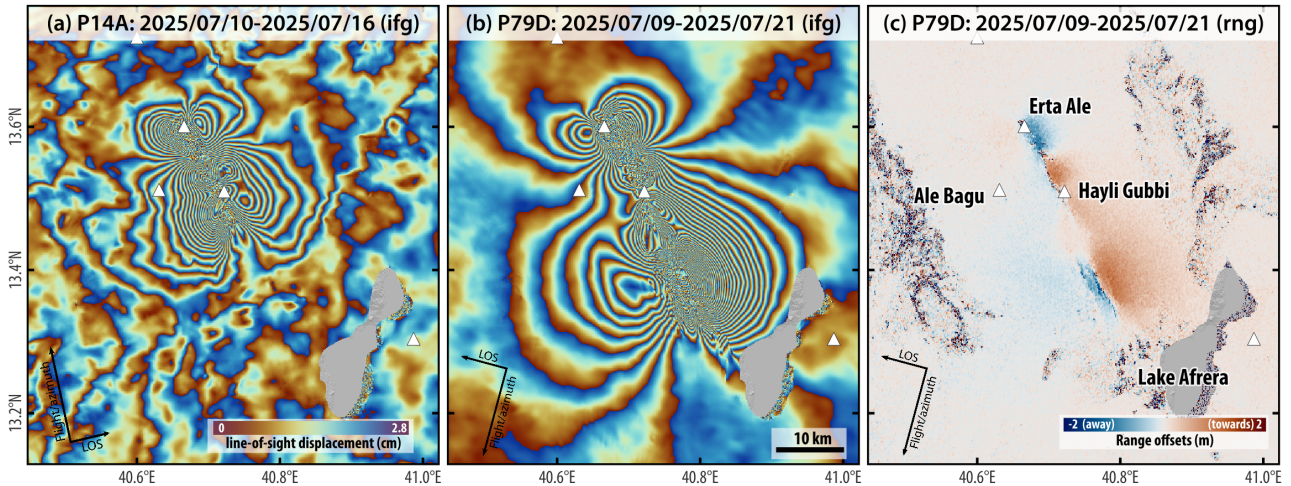


Fig 3: Lateral extent of deformation increased from (a) 18 km on 16 July to (b) 35 km on 21 July observed from Sentinel-1 ascending and descending interferograms. Deformation is likely associated with a shrinking dike beneath Erta Ale, and a longer opening dike which propagated south-eastwards. Each fringe (a-b) represents 2.8 cm of satellite line-of-sight (LOS) displacement, red-to-blue indicates range increase. (c) Range offsets from the descending track show motion from the shrinking and opening dikes, and subsidence of a ~2 km wide graben in the southern segment of the dike during the period 9-21 July. Blue represents motion away, and red is motion towards the satellite.

Preliminary dike modelling

We modelled the deformation observed at different time periods by inverting the ascending and descending Sentinel-1 interferograms separately (Fig. 4). Preliminary models of uniform dike opening/contraction during 10 – 16 July suggest contraction of a ~3 km-long dike, corresponding to a volume loss ~0.01 km³ beneath the northern summit caldera, and opening of a ~11 km-long, segmented dike, corresponding to a total intruded volume ~0.05 km³ beneath the southern relic caldera. Models of deformation during 9 – 21 July show increased dike opening/contraction, along with further south-eastward propagation of the southern dike by ~11 km. The northern contracting dike extends from the surface to a maximum depth of ~2-3 km, whereas the southern opening dikes extend to a maximum depth of ~6 km. Estimates of total volumes during 9 – 21 July indicate 0.03 km³ of volume loss for the dike beneath the northern caldera, and ~0.2 km³ of volume increase for the southern dike.

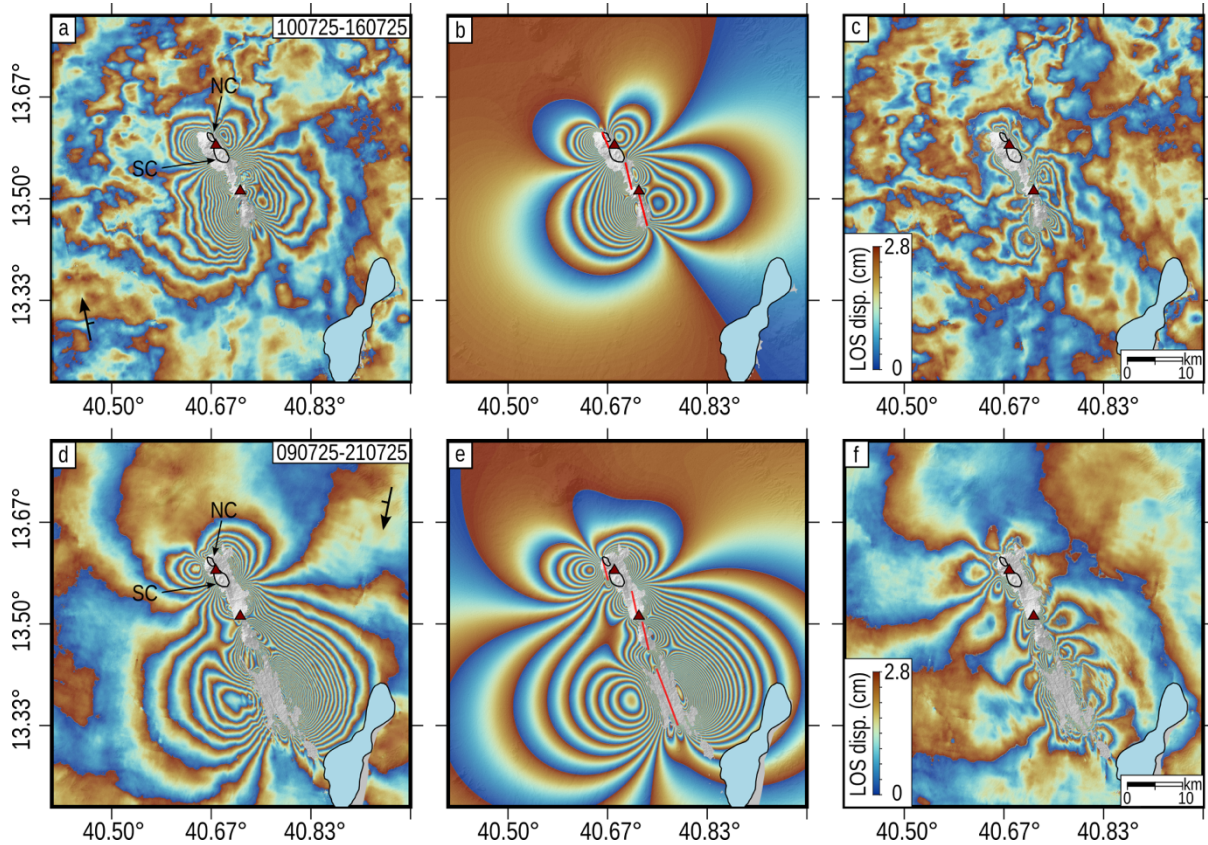


Fig 4: Preliminary models of Sentinel-1 interferograms assuming uniform dike opening/contraction. Observed ascending interferogram (a), model (b) and residual (c) for the time-period 10 - 16 July. Observed descending interferogram (d), model (e) and residual (f) for the time-period 9 – 21 July. Red triangles are the volcanoes Erta Ale (north) and Hayli Gubbi (south). The red lines are the projection of the dikes at the surface. NC = North (summit) Caldera, SC = South Caldera.

Seismicity

Using a similar approach to that in La Rosa et al. (2023), the continuous seismic data from the seismic stations FURI (near Addis Ababa) and ATD (in Djibouti) were manually inspected from the start of 14 July to end of 22 July 2025. Twenty earthquakes with P-S wave delay times of ~67 seconds at FURI and ~43 seconds at ATD, suggest earthquake locations consistent with the Erta Ale region at ~540 km and ~350 km distances respectively. Earthquakes were only observed from near the end of the 17 July onwards, with notable peaks in seismic activity at the start of the 20 July and the end of the 21 July (Fig 5a). Estimates of the earthquake magnitudes show that they are all above M3.3 (Fig 5b). The distinct break in slope in the magnitude-frequency plot shows we only recorded all the earthquakes above M3.8 (Fig 5b). The observations suggest that only intrusion of the southernmost segment of the dike was associated with any observed earthquakes.

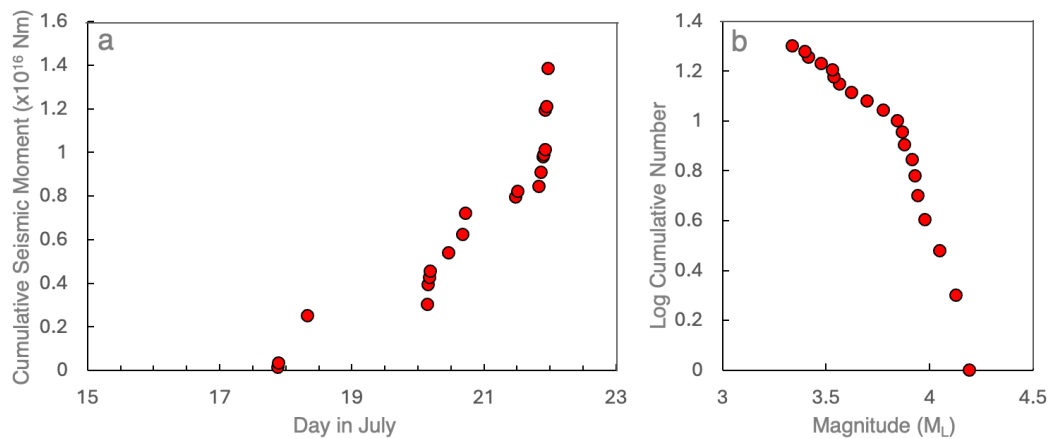


Fig 5. Record of seismic activity from the Erta Ale region. a) Cumulative seismic moment release through time, b) Gutenberg - Richter plot showing the magnitude distribution of the earthquakes. All earthquakes recorded are above M3.3, and the magnitude of completeness indicated by the change in graph slope is M3.8.

Forward look:

We will continue to monitor lava flow extents, lava lake levels, gas emissions, and surface deformation with upcoming SAR, optical and hyperspectral satellite images. We will continue to monitor the seismic activity with regional seismic stations. This, in combination with other data, observations and models, will provide evidence on which the potential evolution of the event can be considered. The next Sentinel-1 image was acquired on 22 July and will be shown in our next report.

Data used:

- InSAR and SAR backscatter images collected by the European Sentinel-1 satellites, processed using the COMET LiCSAR system (<https://comet.nerc.ac.uk/comet-lics-portal/>) and ISCE2 (InSAR Scientific Computing Environment v2 at <https://github.com/isce-framework/isce2>)
- Copernicus Sentinel-2 optical and SWIR imagery, and Sentinel-5P TROPOMI SO₂ retrievals (<https://browser.dataspace.copernicus.eu/>), VolcPlume portal (<https://volcplume.aeris-data.fr/>) and SO₂ Flux Calculator tool (<https://dataviz.icare.univ-lille.fr/so2-flux-calculator>)
- High-resolution optical imagery collected by the PlanetScope satellites of the Planet Lab constellation (<https://www.planet.com/>). PlanetScope SuperDove products are copyright of Planet company, provided by R. Grandin (IPGP) under "Education and Research Standard License n°81527".
- MIROVA (Middle Infrared Observations of Volcanic Activity) provide detections of VIIRS thermal hotspots (https://www.mirovaweb.it/NRT/volcanoDetails_VIR.php?volcano_id=221080)
- Continuous seismic data from FURI (near Addis Ababa) and ATD (Djibouti) available in near real time from the Earthscope Data Management Center (DMC) <https://ds.iris.edu/ds/nodes/dmc/>. ATD seismic station is from the GEOSCOPE network (Institut de physique du globe de Paris (IPGP) and Ecole et Observatoire des Sciences de la Terre de Strasbourg (EOST), 1982).

References

- Esse, B., Burton, M., Hayer, C., La Spina, G., Pardo Cofrades, A., Asensio-Ramos, M., Barrancos, J., Pérez, N., 2025. Forecasting the evolution of the 2021 Tajogaite eruption, La Palma, with TROPOMI/PlumeTraj-derived SO₂ emission rates. *Bull Volcanol* 87, 20.
<https://doi.org/10.1007/s00445-025-01803-6>
- Global Volcanism Program, 2017. Report on Erta Ale (Ethiopia) (Crafford, A.E., and Venzke, E., eds.). *Bulletin of the Global Volcanism Network*, 42:7. Smithsonian Institution.
<https://doi.org/10.5479/si.GVP.BGVN201707-221080>
- Global Volcanism Program, 2025a. Erta Ale (221080) in [Database] Volcanoes of the World (v. 5.3.0; 17 Jul 2025). Distributed by Smithsonian Institution, compiled by Venzke, E. <https://doi.org/10.5479/si.GVP.VOTW5-2025.5.3>
- Global Volcanism Program, 2025b. Report on Erta Ale (Ethiopia) (Sennert, S, ed.). *Weekly Volcanic Activity Report*, 9 July-15 July 2025. Smithsonian Institution and US Geological Survey.
- Gosling, J., Dualeh, E. W., & Biggs, J. (2025). Analysis and automatic detection of lava flows using SAR backscatter applied to the 2017 eruption of Erta'Ale Volcano, Ethiopia. *Bull Volc* (in revision). Available through ResearchSquare <https://doi.org/10.21203/rs.3.rs-5003481/v1>
- Grandin, R., Boichu, M., Mathurin, T., & Pascal, N. (2024). Automatic estimation of daily volcanic sulfur dioxide gas flux from TROPOMI satellite observations: Application to Etna and Piton de la Fournaise. *Journal of Geophysical Research: Solid Earth*, 129(6), e2024JB029309.
<https://doi.org/10.1029/2024JB029309>
- Institut de physique du globe de Paris (IPGP) and Ecole et Observatoire des Sciences de la Terre de Strasbourg (EOST). (1982). *GEOSCOPE, French global network of broad band seismic stations*. Institut de physique du globe de Paris (IPGP), Université de Paris.
<https://doi.org/10.18715/GEOSCOPE.G>
- La Rosa, A., Raggiunti, M., Pagli, C., Keir, D., Wang, H., & Ayele, A. (2023). Extensional earthquakes in the absence of magma in northern Afar: Insights from InSAR. *Geophysical Research Letters*, 50, e2023GL102826. <https://doi.org/10.1029/2023GL102826>
- Moore, C., Wright, T., Hooper, A., & Biggs, J. (2019). The 2017 Eruption of Erta 'Ale Volcano, Ethiopia: Insights Into the Shallow Axial Plumbing System of an Incipient Mid-Ocean Ridge. *Geochemistry, Geophysics, Geosystems*, 20(12), 5727–5743.
<https://doi.org/10.1029/2019GC008692>
- Xu, W., Xie, L., Aoki, Y., Rivalta, E., & Jónsson, S. (2020). Volcano-Wide Deformation After the 2017 Erta Ale Dike Intrusion, Ethiopia, Observed With Radar Interferometry. *Journal of Geophysical Research: Solid Earth*, 125(8), e2020JB019562.
<https://doi.org/10.1029/2020JB019562>