



Integrating high-resolution, small scale imagery into EPOS

Examples of drone- and ground-based measurements

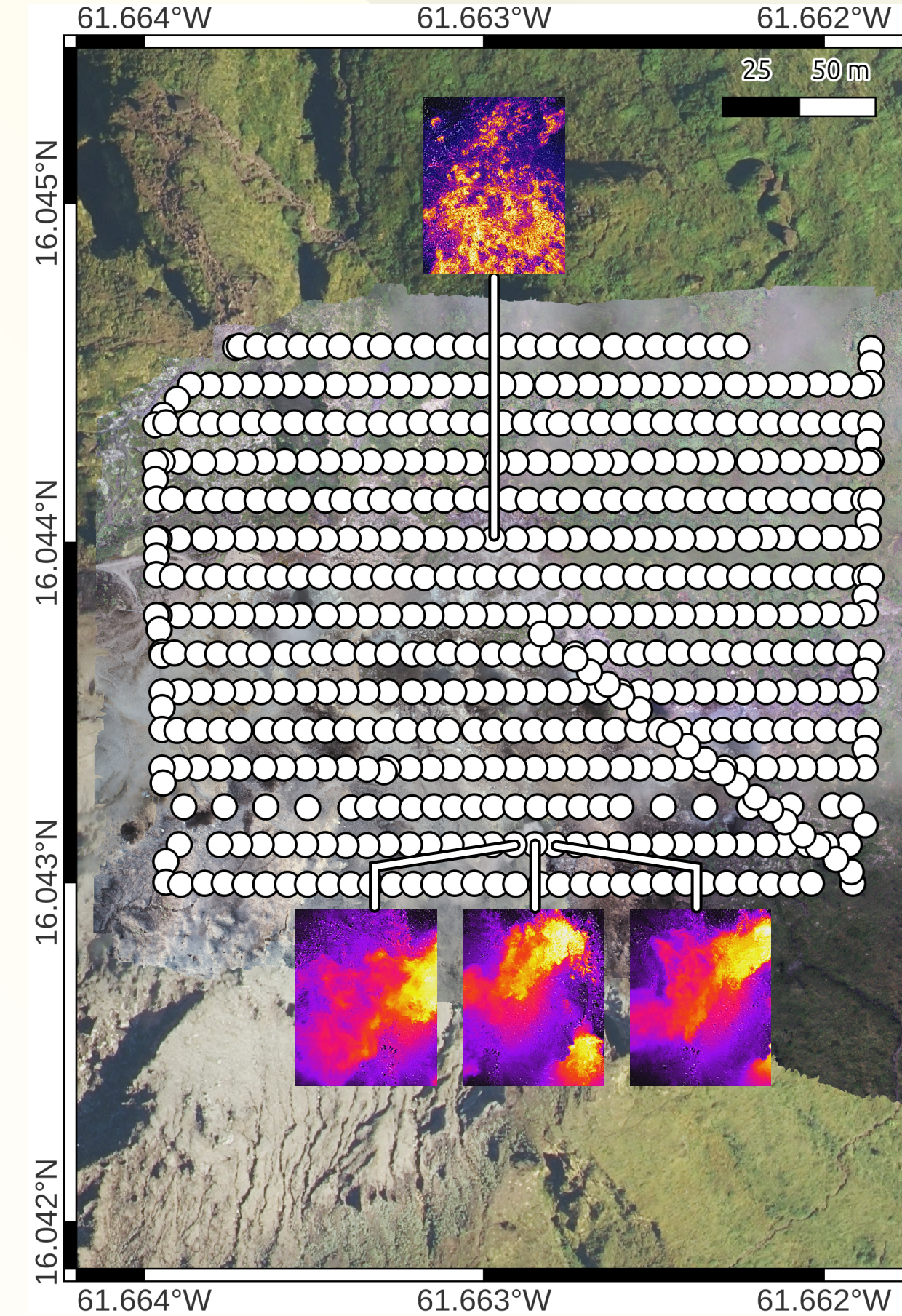
D. E. Jessop, SNOV-CNRS-OPGC for the Volcano TCS

Thermal orthoimages at la Soufrière de Guadeloupe

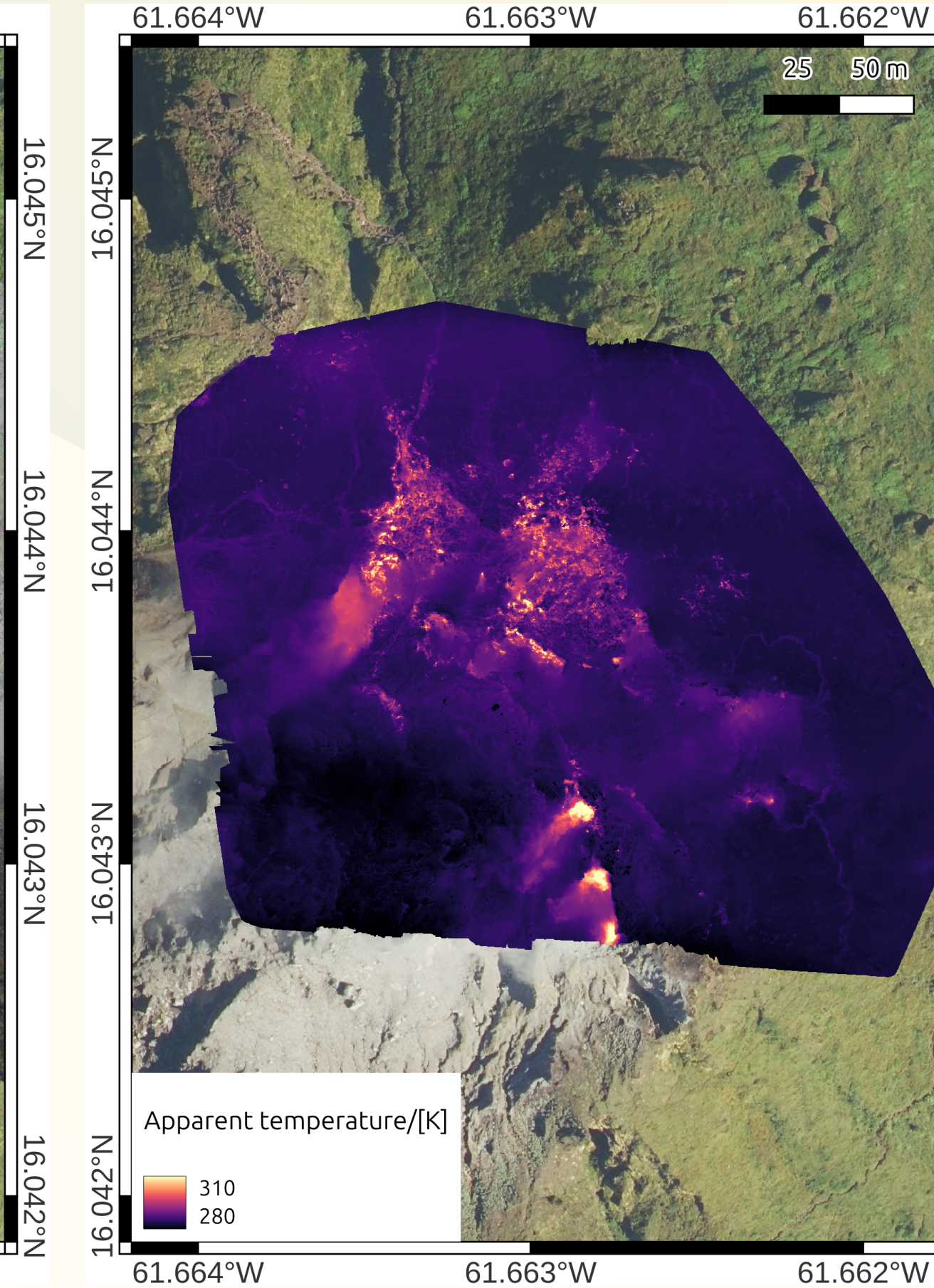
- Individual thermal images acquired during drone overflights
- Orthoimage produced using Structure from Motion software (OpenDroneMap)
- Thermal flux and anomalies for monitoring evolution of volcanic unrest.
- Orthoimages have resolution ~1 cm. 250 m span images take up 500 Mb in disc space.
- GeoTIFF format provides rich metadata.



Drone platform + camera during takeoff



Flight path and example thermal images



Thermal orthoimage over visible baselayer (Jessop, 2024)

Orthoimage Metadata

Driver: GTiff/GeoTIFF
Files: 2021108_ZFNN_Thermal_orthophoto_modified_T_reduced.tif
Size is 26225, 22408
Coordinate System is:
PROJCRS["WGS 84 / UTM zone 20N",
BASEGEOGCRS["WGS 84",
DATUM["World Geodetic System 1984",
ELLIPSOID["WGS 84",6378137,298.257223563,
LENGTHUNIT["metre",1]],
ID["EPSG",32620]]
Data axis to CRS axis mapping: 1,2
Origin = (642910.464419999974780,1774340.059690000023693)
Pixel Size = (0.010000000000000,-0.010000000000000)
Metadata:
AREA_OR_POINT=Area
Image Structure Metadata:
COMPRESSION=DEFLATE
INTERLEAVE=BAND
PREDICTOR=2
Corner Coordinates:
Upper Left (642910.464, 1774340.060) (61d39'50.72"W, 16d 2'40.91"N)
Lower Left (642910.464, 1774115.980) (61d39'50.77"W, 16d 2'33.62"N)
Upper Right (643172.714, 1774340.060) (61d39'41.90"W, 16d 2'40.85"N)
Lower Right (643172.714, 1774115.980) (61d39'41.94"W, 16d 2'33.56"N)
Center (643041.589, 1774228.020) (61d39'46.33"W, 16d 2'37.24"N)
Band 1 Block=26225x1 Type=Float32, ColorInterp=Gray
Min=-275.458 Max=378.157
Minimum=-275.458, Maximum=378.157, Mean=285.132, StdDev=3.213
NoData Value=-3.4028235e+38
Metadata:
STATISTICS_APPROXIMATE=YES
STATISTICS_MAXIMUM=378.15667724609
STATISTICS_MEAN=285.13206036033
STATISTICS_MINIMUM=-275.45779418945
STATISTICS_STDDEV=3.212941738232
STATISTICS_VALID_PERCENT=75.59

Magnetic field detection at Piton de la Fournaise, La Réunion

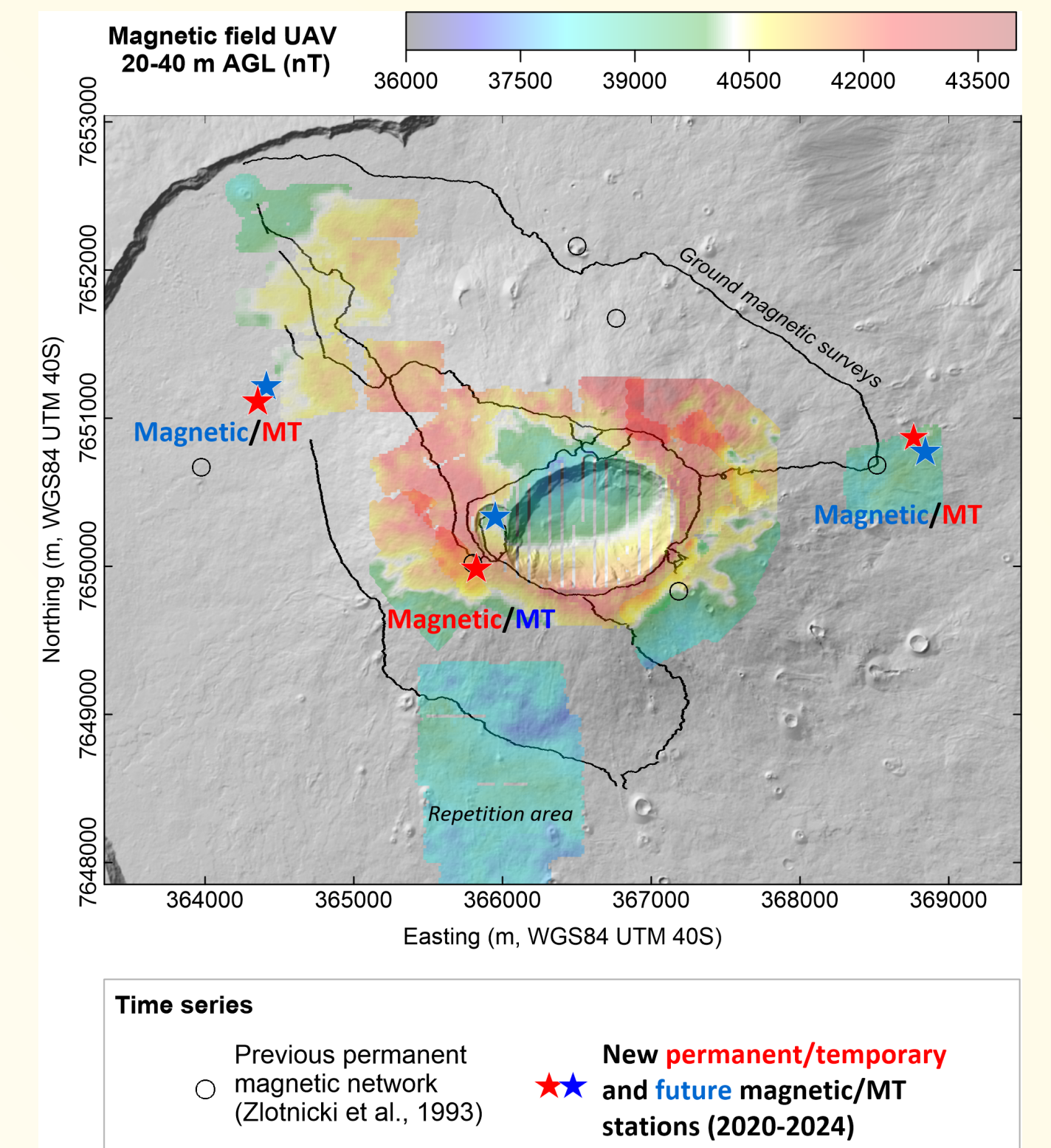
- Detecting resistivity and magnetisation anomalies and quantification of spatio-temporal evolution provide powerful tools for imaging volcanic systems at various scales and provide warning tools for volcanic events.
- Information on intrusive, hydrothermal activity and formation of preferential pathways for fluid transfer.



QTFM magnetometer mounted on drone



Ground-based permanent magnetometer station (Piton de la Fournaise)



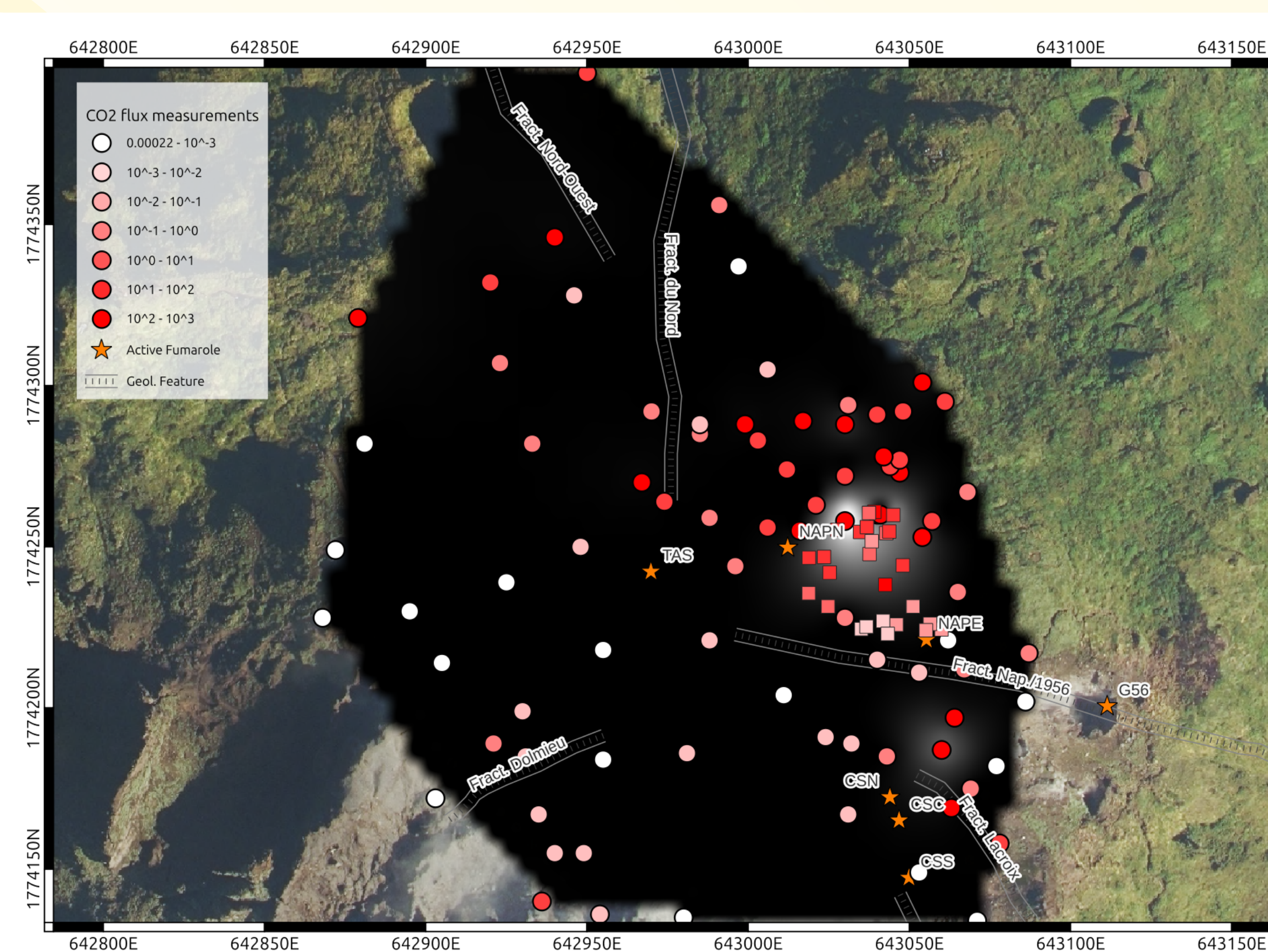
Magnetic anomalies from drone + ground-based measurements, Piton de la Fournaise (following Gailler et al., 2022)

CO₂ soil flux measurements at la Soufrière de Guadeloupe

- Accumulation chamber is used to acquire individual soil flux measurements + GPS coordinates.
- Interpolation via Kriging/sGs -> GeoTIFF format
- Flux measurements inform about volcanic activity at depth, can be used to detect fractures and more permeable structures.



Accumulation chamber for CO₂ flux measurements



Individual measurements and interpolated map overlying visible orthoimage (Klein et al., 2024)

Interpolated image metadata

Driver: GTiff/GeoTIFF
Files: ./Klein_et_al_2023_BV/figures/CO2_SGS_mean.tif
Size is 226, 271
Origin = (642864.500000000000000,1774400.500000000000000)
Pixel Size = (1.000000000000000,-1.000000000000000)
Image Structure Metadata:
INTERLEAVE=BAND
Corner Coordinates:
Upper Left (642864.500, 1774400.500)
Lower Left (642864.500, 1774129.500)
Upper Right (643090.500, 1774400.500)
Lower Right (643090.500, 1774129.500)
Center (642977.500, 1774265.000)
Band 1 Block=226x4 Type=Float64, ColorInterp=Gray
Min=0.600 Max=5387.580
Minimum=0.600, Maximum=5387.580, Mean=79.857,
StdDev=119.290
NoData Value=-3.4028234663852886e+38
Metadata:
STATISTICS_MAXIMUM=5387.580078125
STATISTICS_MEAN=79.856944986981
STATISTICS_MINIMUM=0.60004699230194
STATISTICS_STDDEV=119.28989259292
STATISTICS_VALID_PERCENT=67.99

References

- Gailler, L., Labazuy, P., Régis, E., Peltier, A. and Ferrazzini, V. (2022) "Active structures and thermal state of the Piton de la Fournaise summit revealed by combined UAV magnetic and thermal infrared measurements", *Volcanica*, 5(1), pp. 61–74. doi: 10.30909/vol.05.01.6174.
- Jessop, D. E. (2024). Thermal orthophoto, summit of la Soufrière de Guadeloupe volcano, 08/11/2021 [Data set]. OPGC. doi:10.25519/5S7X-X334.
- Klein, A. et al. (2024). *Bull. Volcanol.* 86.4. doi: 10.1007/s00445-024-01713-z.