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TAKING THE PULSE OF OUR PLANET FROM SPACE

Multi instruments field campaigns for thermal analysis and gas measurements in Italian geothermal sites

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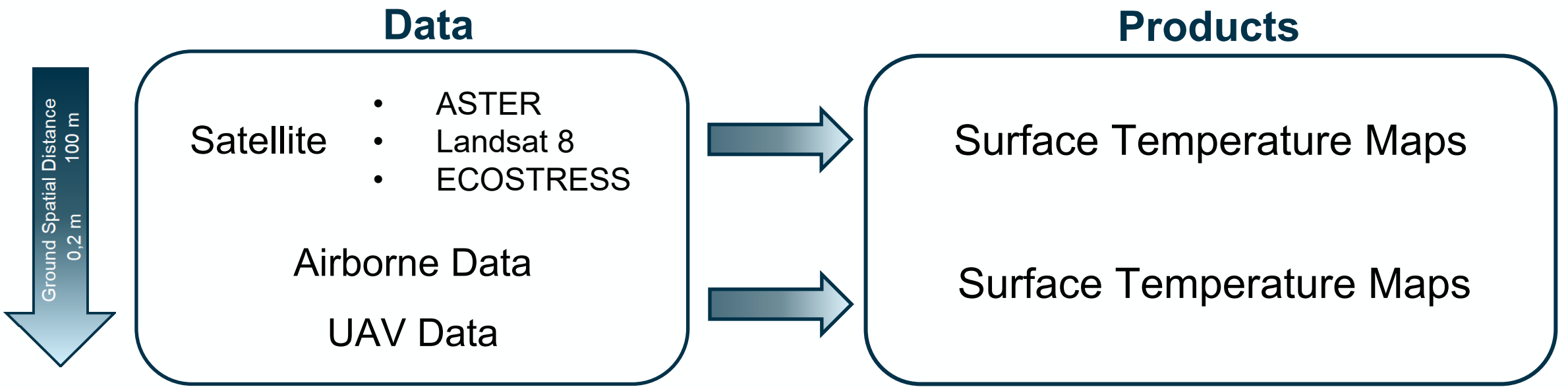
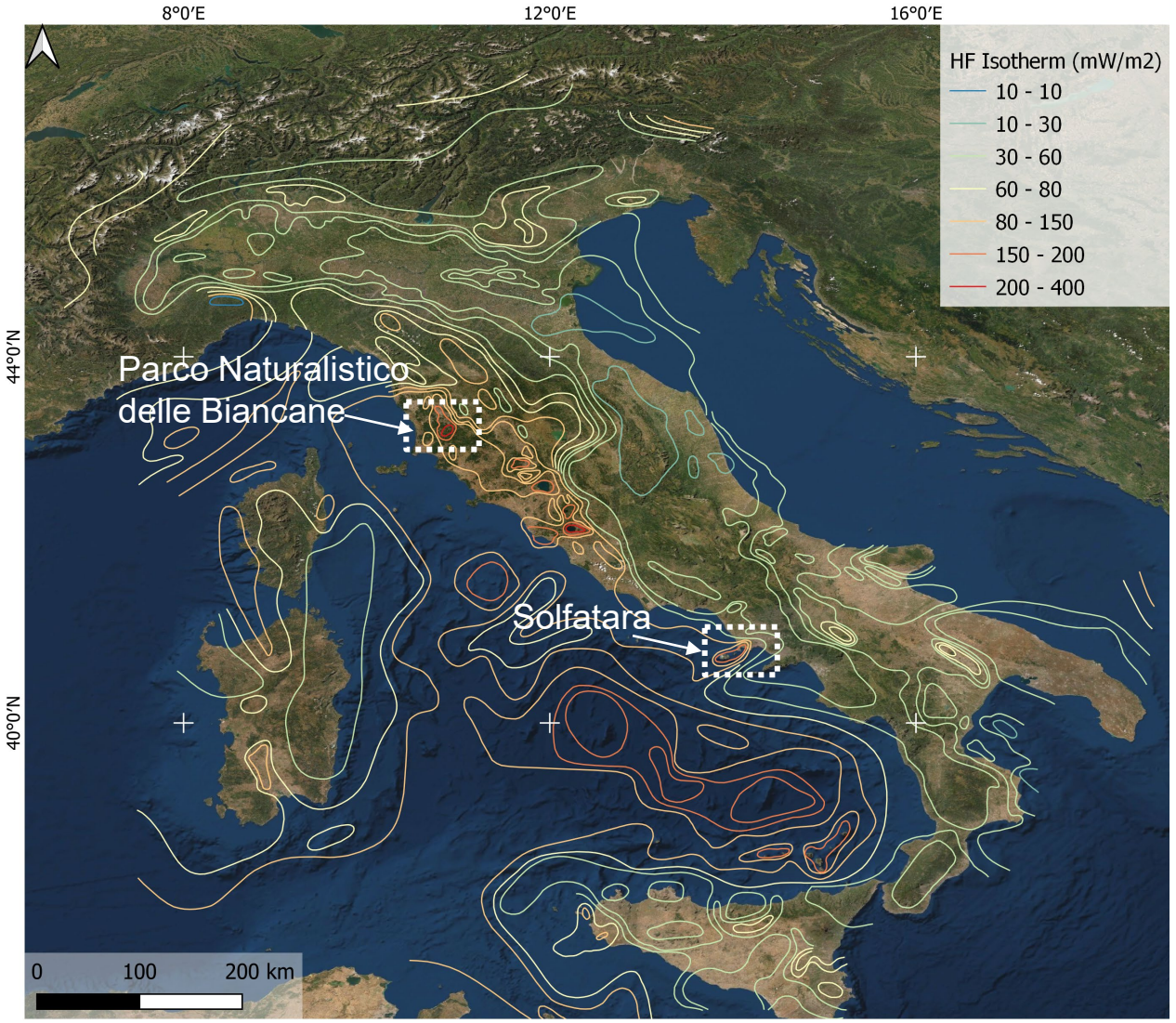
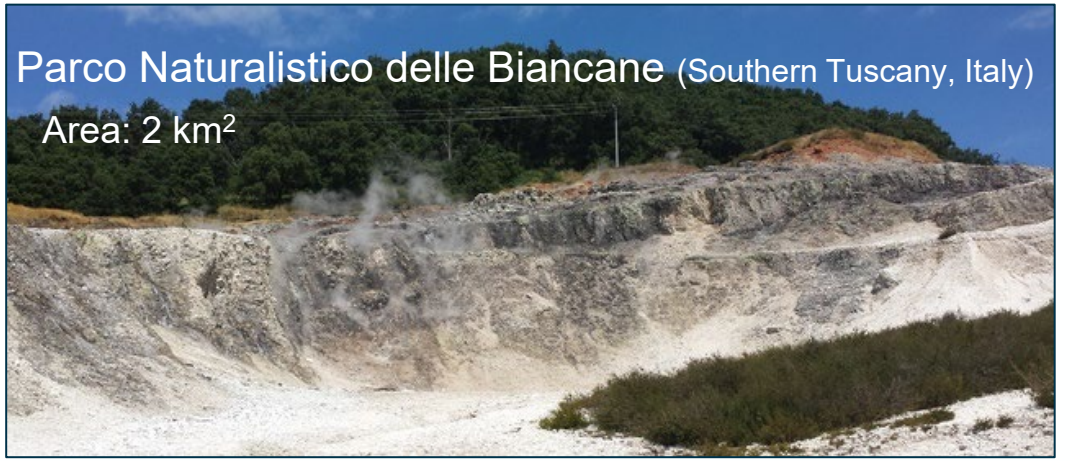
Multi-instrument Analysis in geothermal area



Test Site	Parco Naturalistico delle Biancane Soythern Tuscany, Italy	Solfatara-Campi Flegrei, Naples, Italy

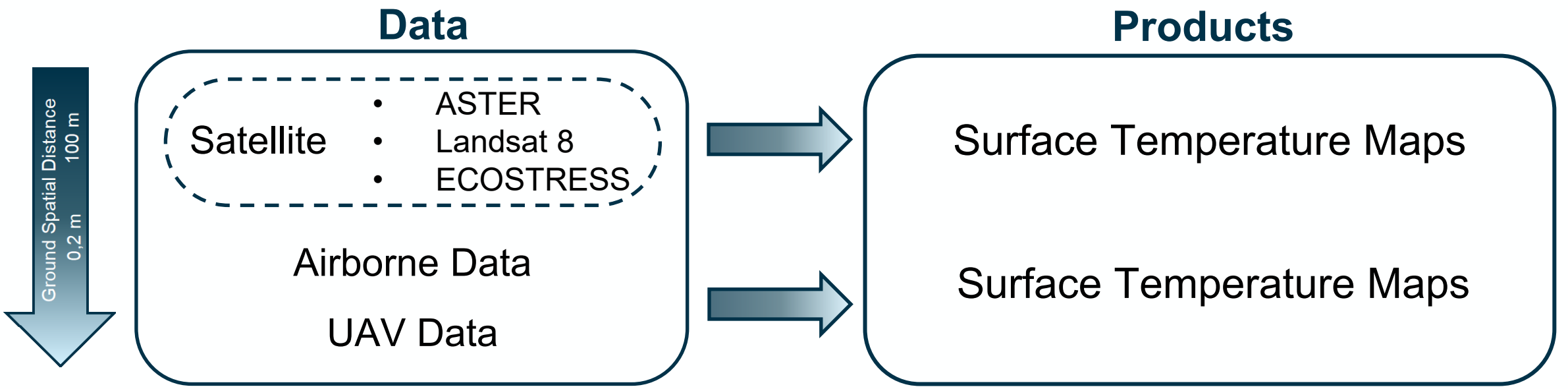
Test Sites


8°0′E
12°0′E
16°0′E
44°0′N
40°0′N
HF Isotherm (mW/m2)
10 - 10
10 - 30
30 - 60
60 - 80
80 - 150
150 - 200
200 - 400
Parco Naturalistico delle Biancane
Solfatara
0
100
200 km


Parco Naturalistico delle Biancane (Southern Tuscany, Italy)
Area: 2 km²

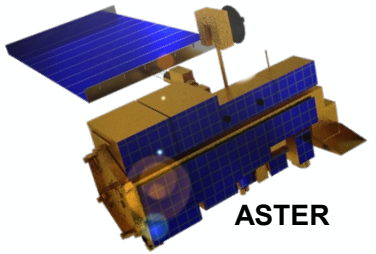

Solfatara (Naples, Italy)
Area: 1,3 km²

Multi-instrument Analysis in geothermal area



Satellite Data

Description	ASTER	Unit
Number of thermal spectral band	5	-
Measured band centers	8.29; 8.63; 9.07; 10.66; 11.32	µm
Measured FWHM per band	0.35; 0.35; 0.35; 0.7; 0.7	µm
Pixel at nadir	90	m
Swath width	60	Km
Revisit time	16	day



ASTER

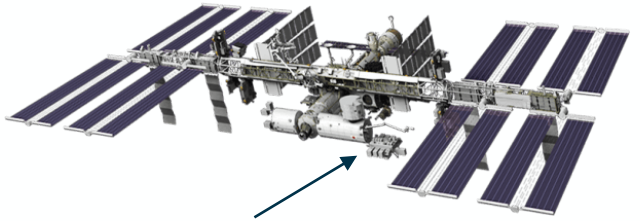
ASTER is one of the more versatile satellite imagers used for studies of thermal anomalies; it can estimate surface temperatures with several thermal infrared spectral channels.

TIRS/Landsat 8 images, while having fewer spectral channels and slightly lower spatial resolution than ASTER, provide additional temperature data for estimating and monitoring LST on active volcanoes as well as geothermal areas.

Landsat 8, launched on 2013

Description	L8	Unit
Number of thermal spectral band	2	-
Measured band centers	10.9; 12.0	µm
Measured FWHM per band	0.6; 1.0	µm
Pixel at nadir	100	m
Swath width	185	Km
Revisit time	16	day

Description	ECOSTRESS	Unit
Number of thermal spectral band	5 (3 from 2019)	-
Measured band centers	8.29*; 8.78; 9.20*; 10.49; 12.09	µm
Measured FWHM per band	0.354; 0.310; 0.396; 0.410; 0.611	µm
Pixel at nadir	69x38	m
Swath width	384	Km
Revisit time	~ 4-5	day

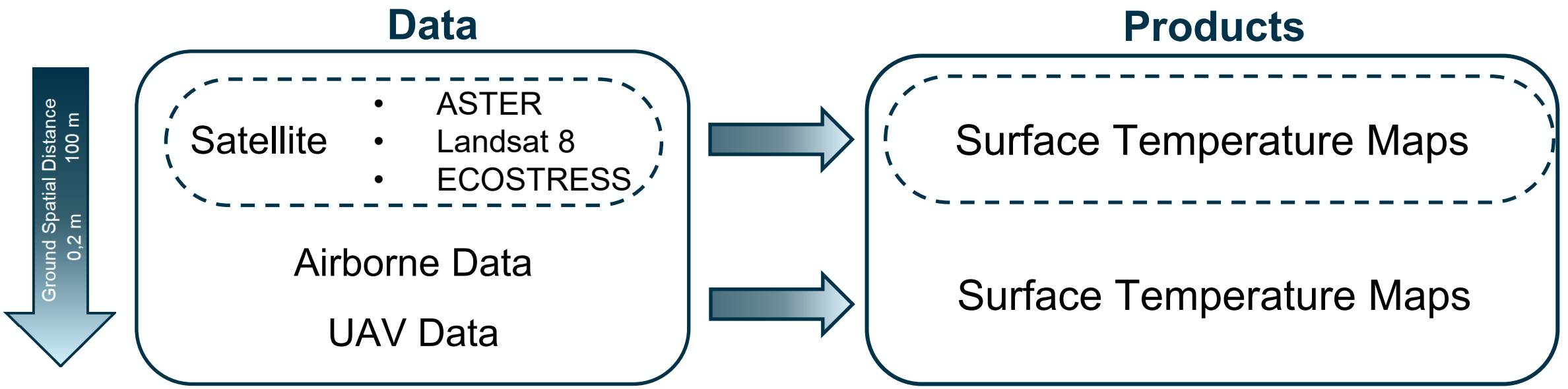


ISS, **ECOSTRESS**

The recent ECOSTRESS sensor, very similar to ASTER, could increase the number of data

* Not available

Multi-instrument Analysis in geothermal area



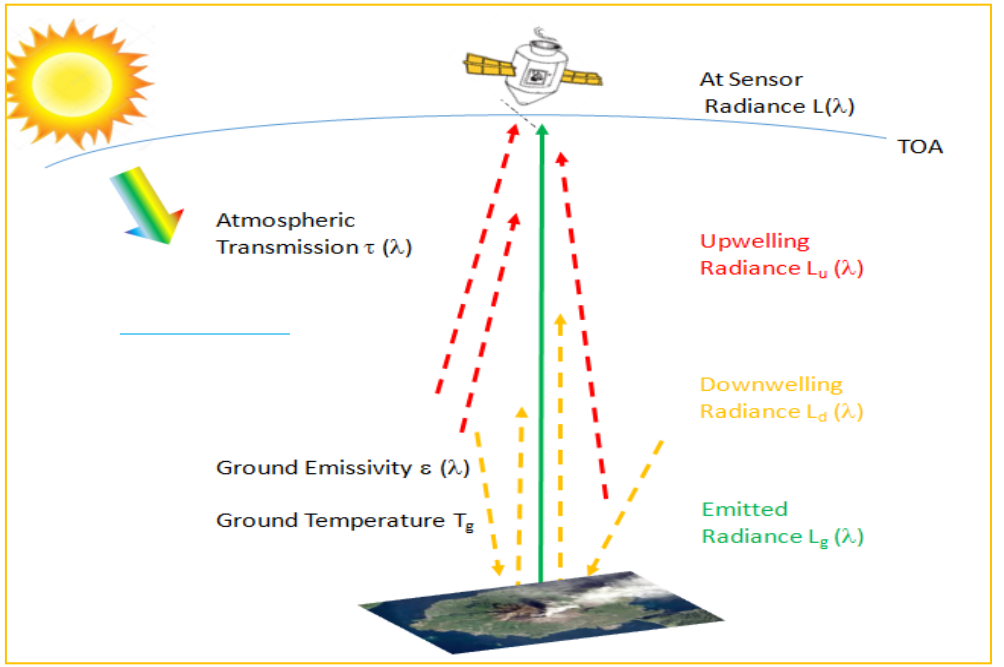
LST from satellites

The radiance measured by sensor satellite: $\mathbf{L(\lambda)=\varepsilon(\lambda)\tau(\lambda)B(\lambda)\,(T_g)+(1-\varepsilon(\lambda))\,\tau(\lambda)L_d(\lambda)+L_u(\lambda)}$

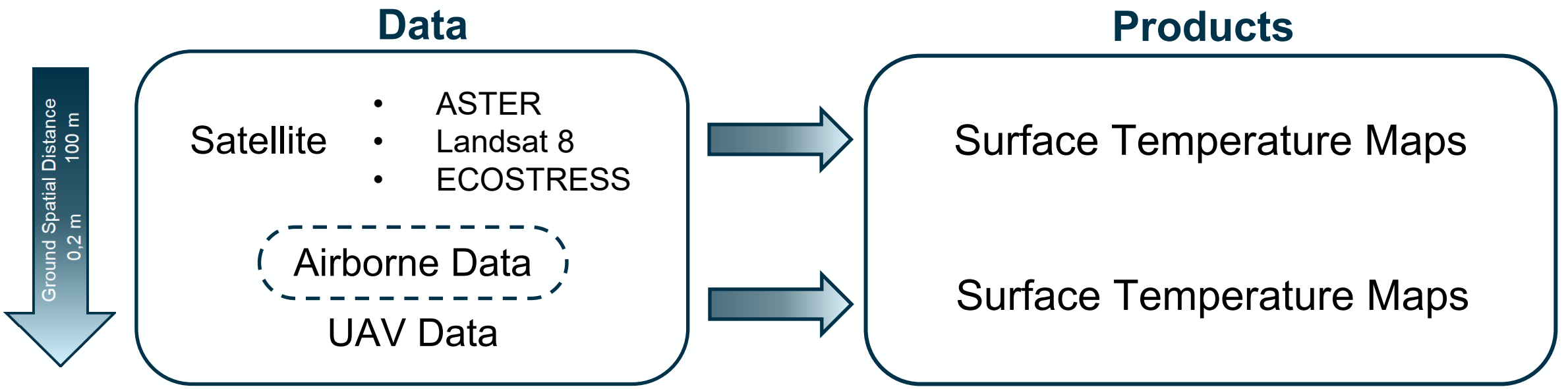
is calculated by applying the inverse of Plank's equation, before this it's necessary to remove the atmospheric contribute by using MODTRAN.

It simulates transmittance $\tau(\lambda)$, up-welling radiance $L_u(\lambda)$ and down-welling radiance $L_d(\lambda)$

$$T = \frac{c_2}{\lambda \, ln\left[\frac{\varepsilon(\lambda)\, c_1}{\pi\, \lambda^5\, L(\lambda)} + 1\right]}$$



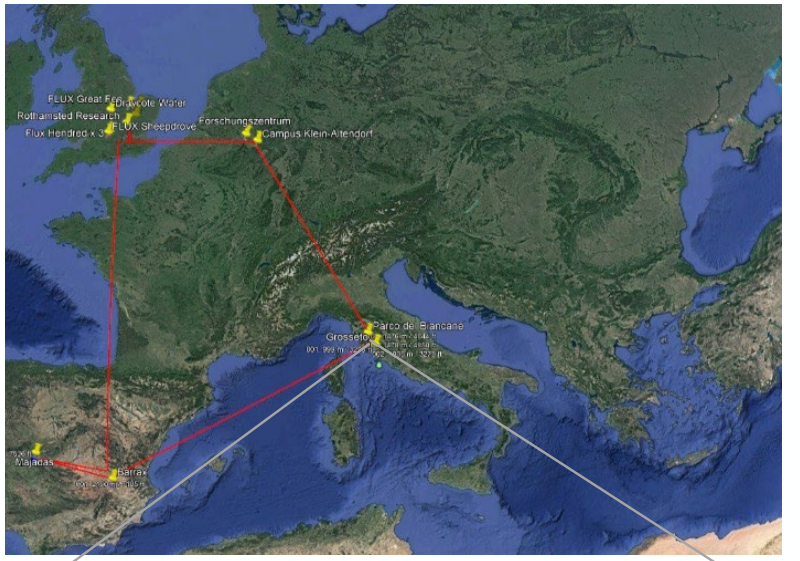
Multi-instrument Analysis in geothermal area



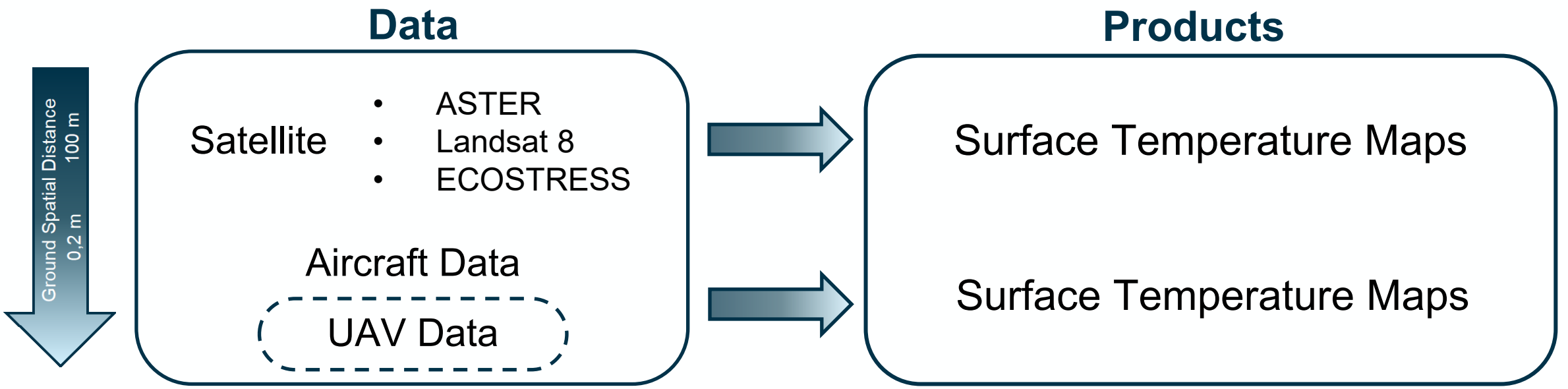
Airborne Data – HyTES mission

Thermal Hyperspectral Spectrometer

Instrument Characteristic	HyTES
Mass (Scanhead)	12K9
Power	400W
Volume	1m x 0.5m (cylinder)
Number of pixels x track	512
Number of bands	256
Spectrat Range	7.5 - 12 um
Spectral Sampling Interval	4.5um/256, i,e. 17 nm
Frame speed	35 or 22 fps
Integration time (1 scanline)	28 or 45 ms
Total Field of View	50 degrees
Calibration (preflight)	Full Aperture Biackbody
Detector Temperature	40K
Spectrometer Temperature	100K
Slit Length and Width	20 mm x 39 um
IFOV	17.066
Pixel Size/Swath at 2,000 m fight altitude	3.41m/1868.33m
Pixel Size/Swath at 20,000 m flight altitude	34.13m/18683 31m

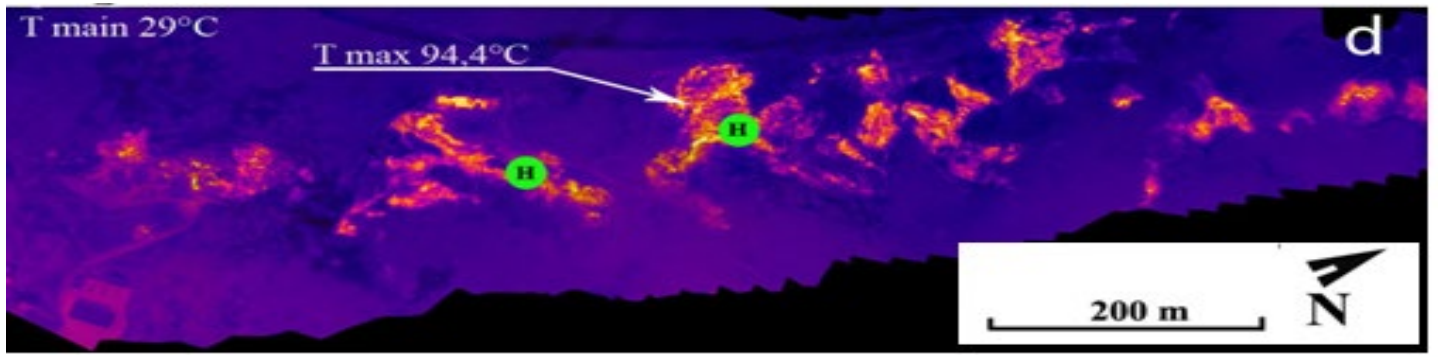


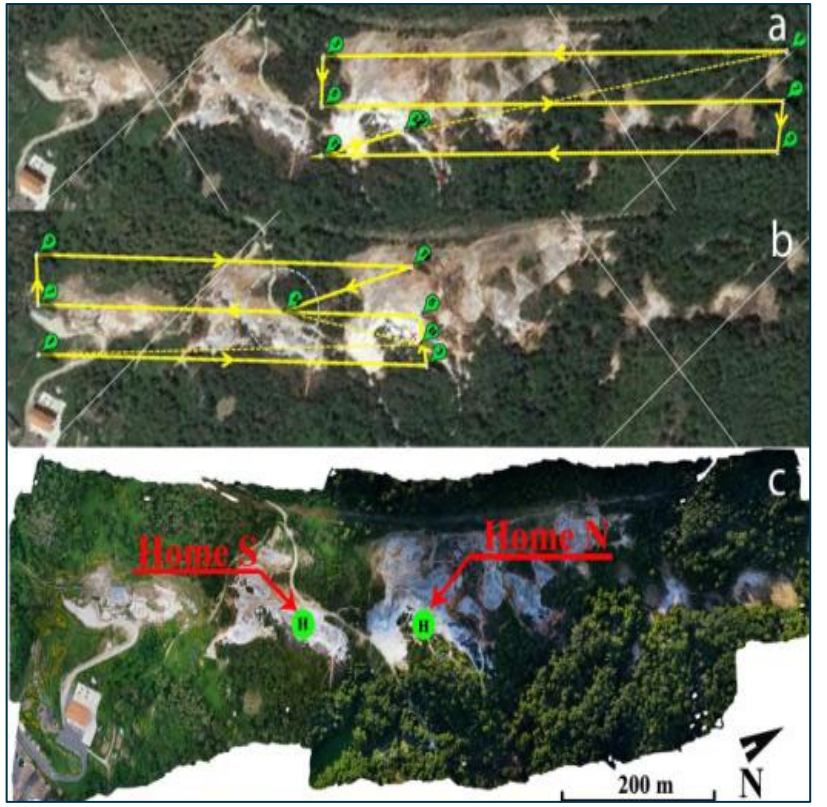
Multi-instrument Analysis in geothermal area



UAV Data – Drone

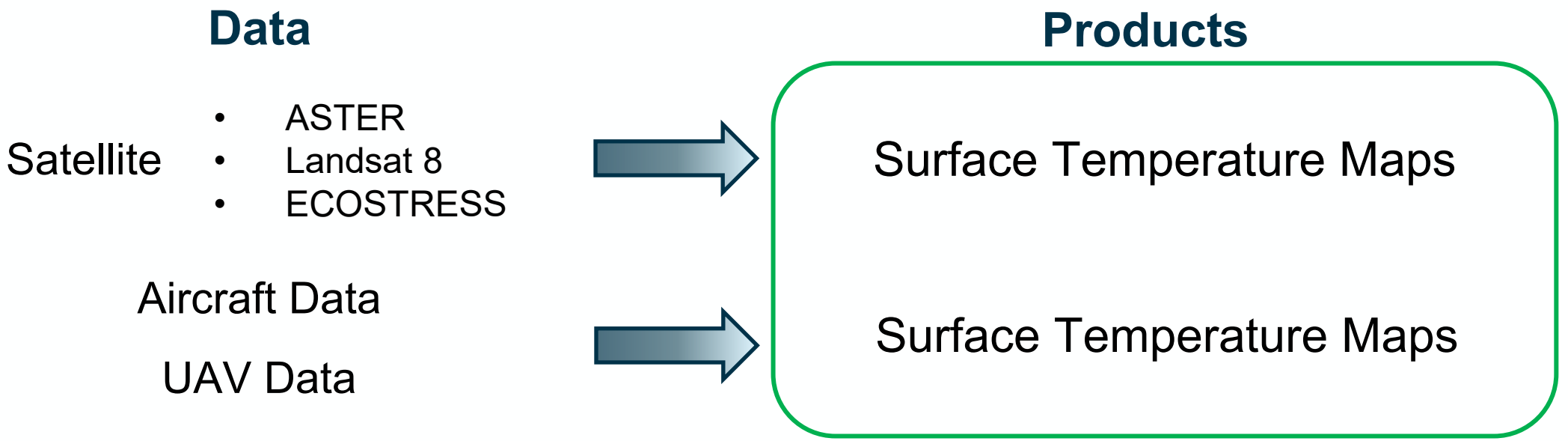
Unmanned Aerial Vehicle	
Drone Type	FlyBit
Payload	FLIR VUE PRO R
Volume	1m x 0.5m (cylinder)
Pixel size	0.2 m





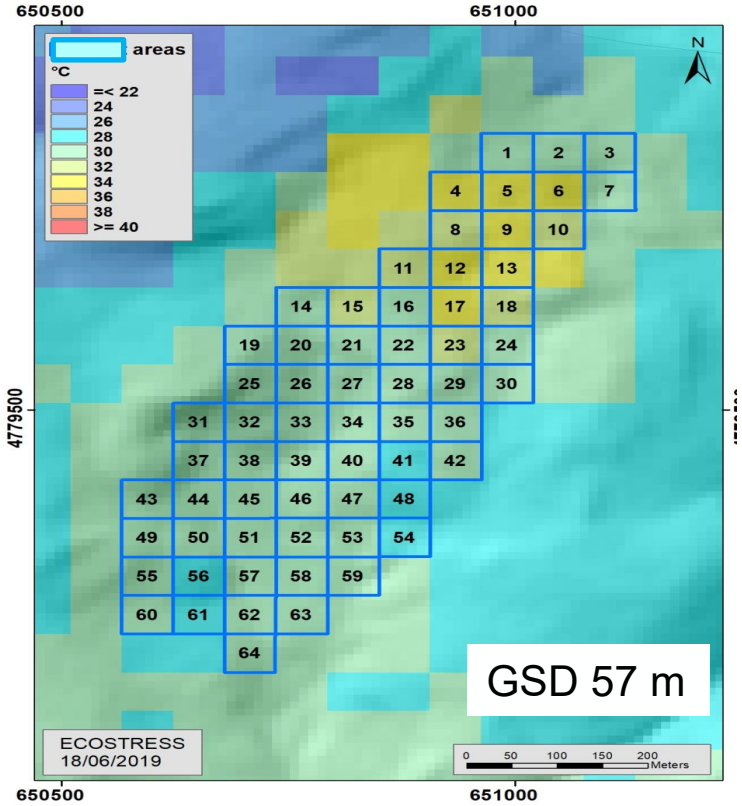
Flight map at Parco Naturalistico delle Biancane

Introduction to Results: Parco delle Biancane

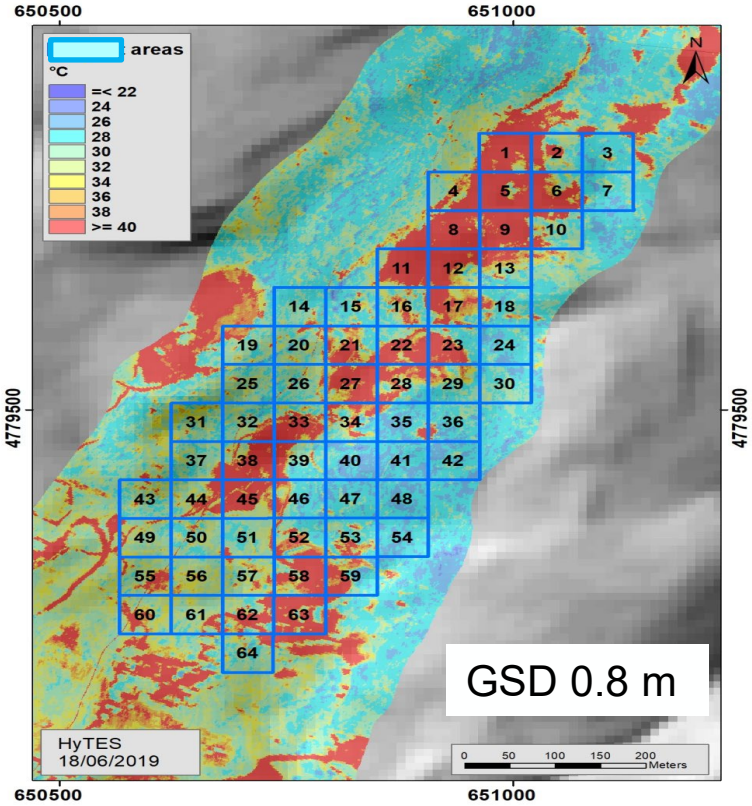


Data Comparison: Parco delle Biancane

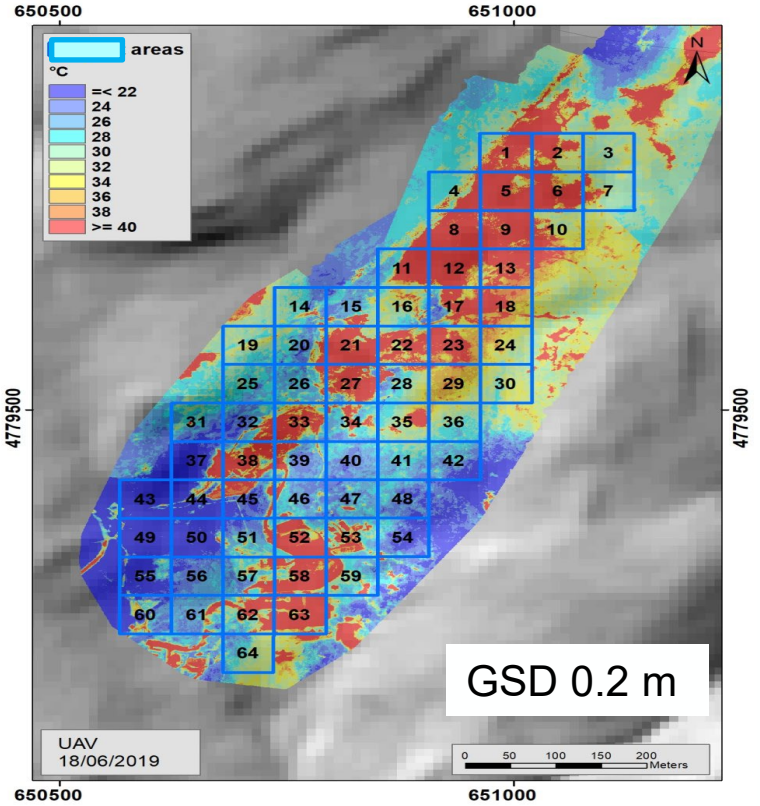
ECOSTRESS



HyTES

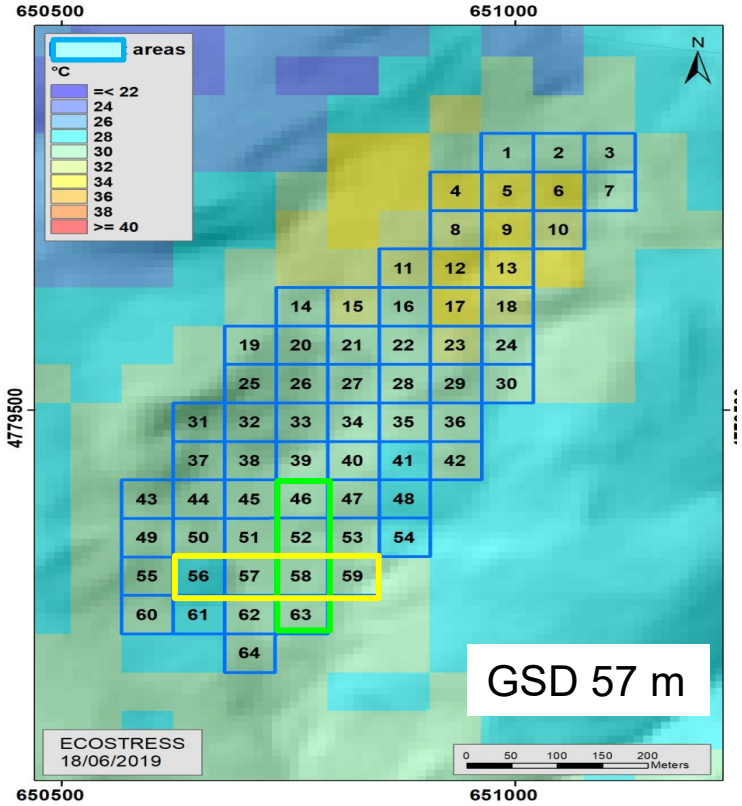


UAV (Drone)

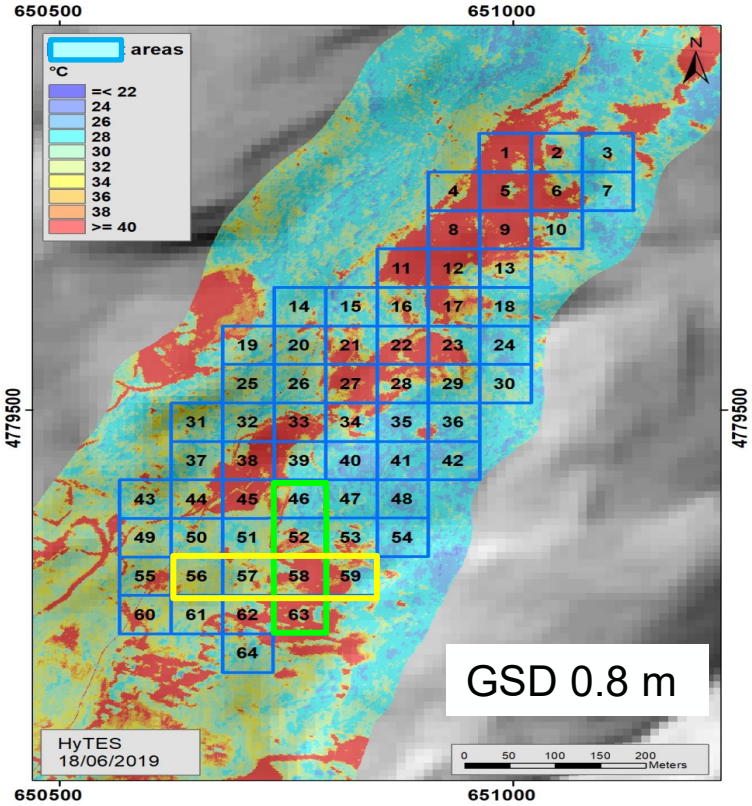


Data Comparison: Parco delle Biancane

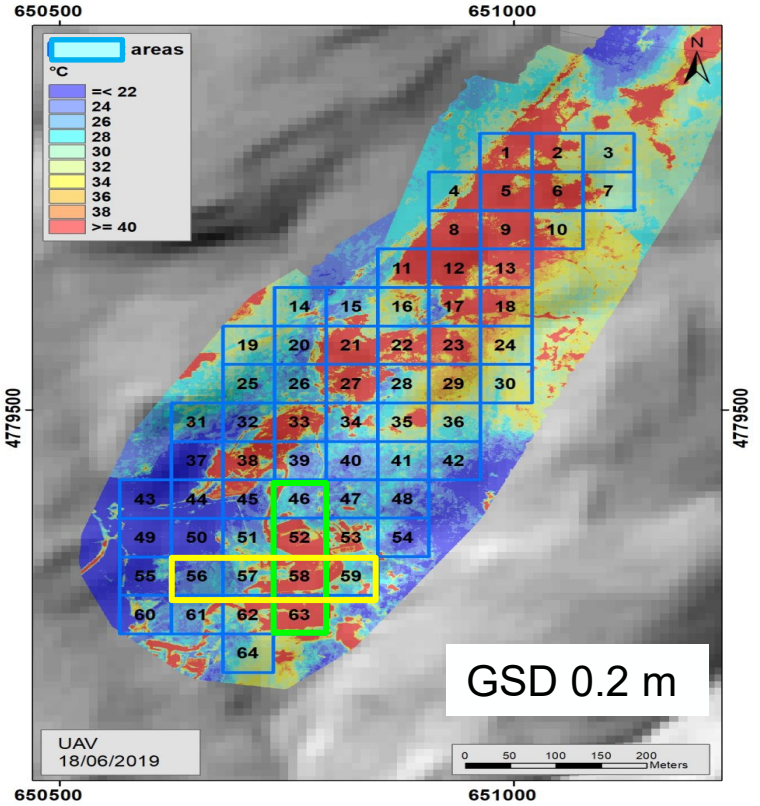
ECOSTRESS



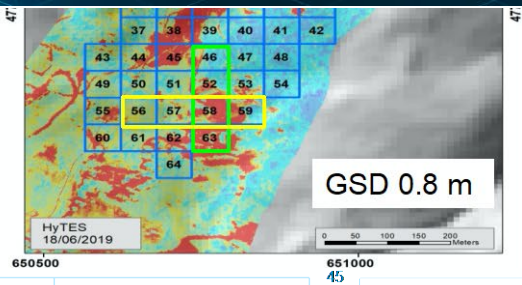
HyTES

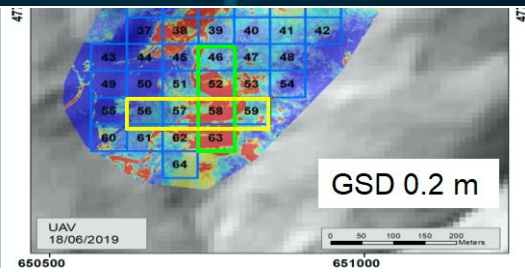


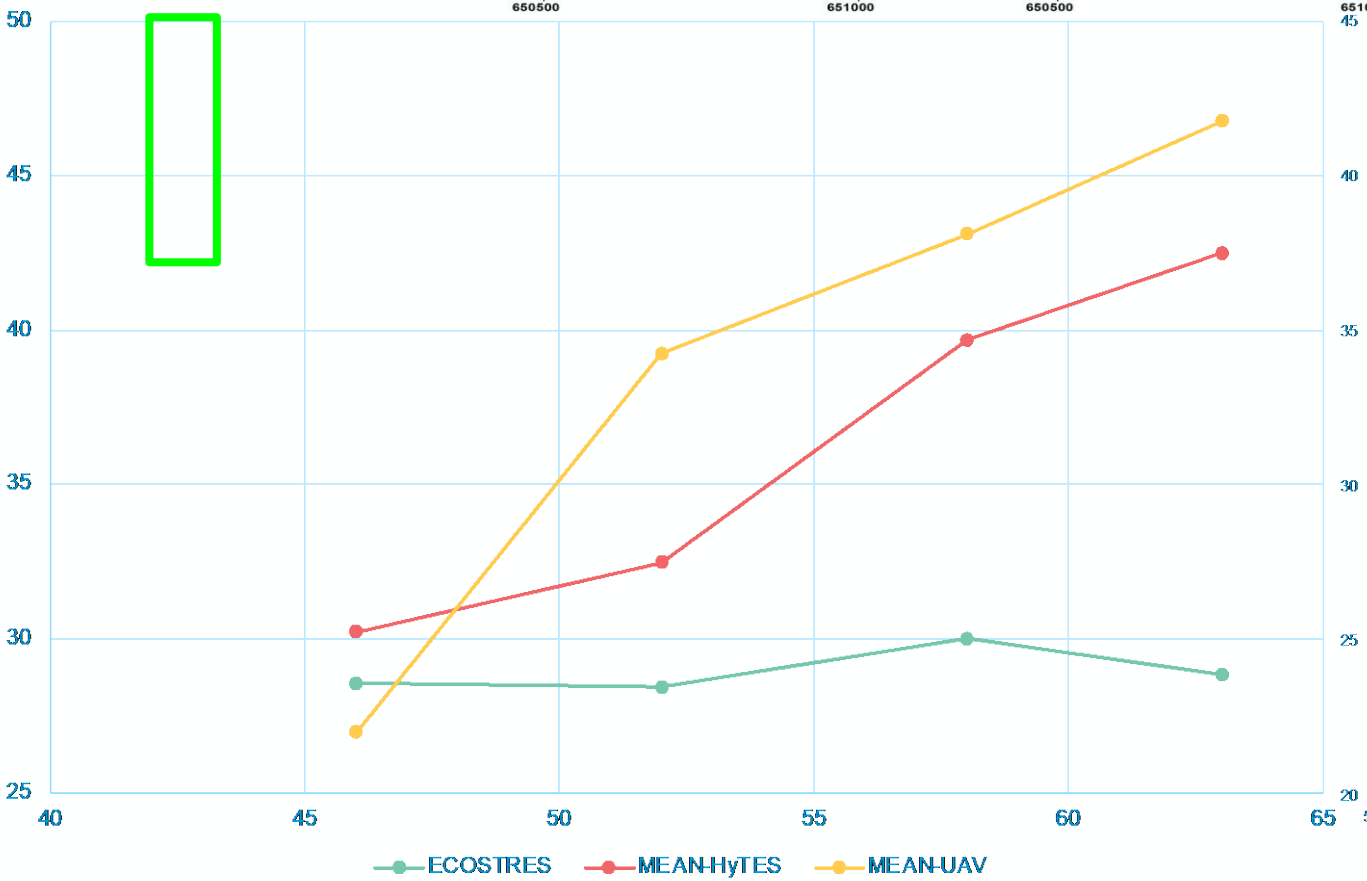
UAV (Drone)

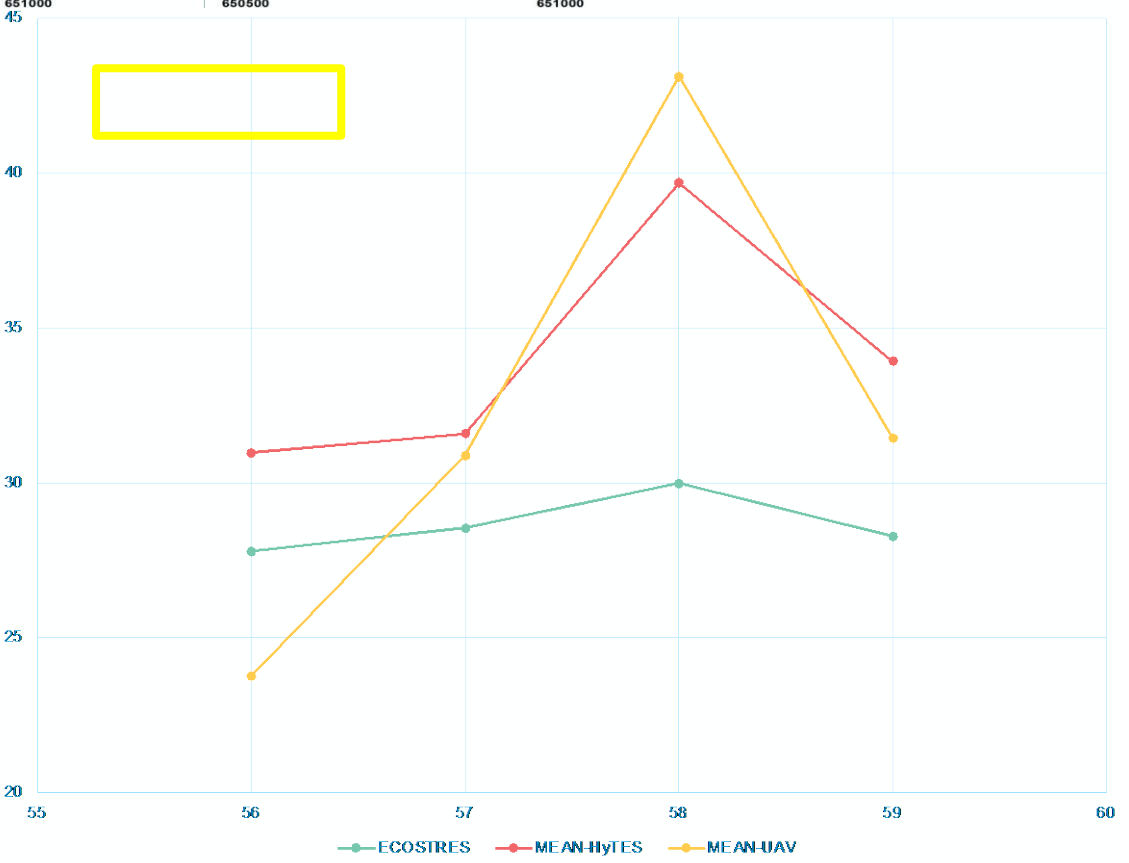


Data Comparison: Parco delle Biancane

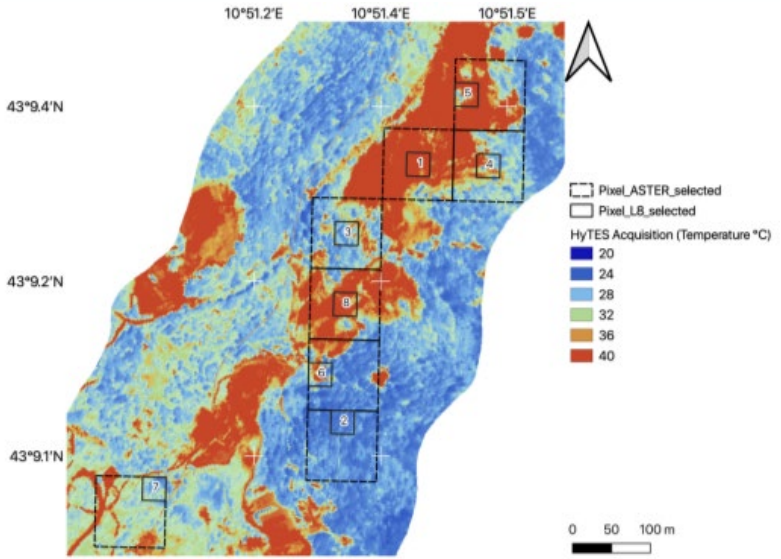


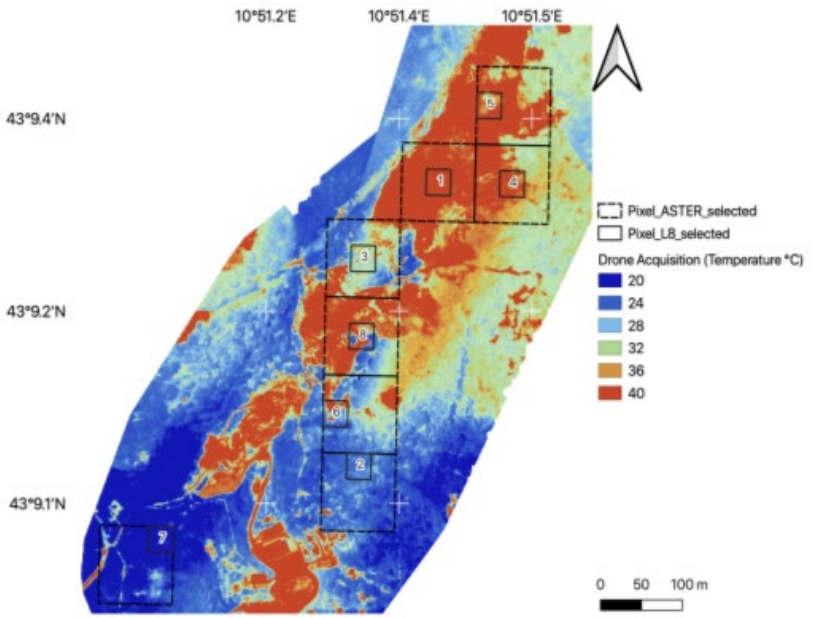






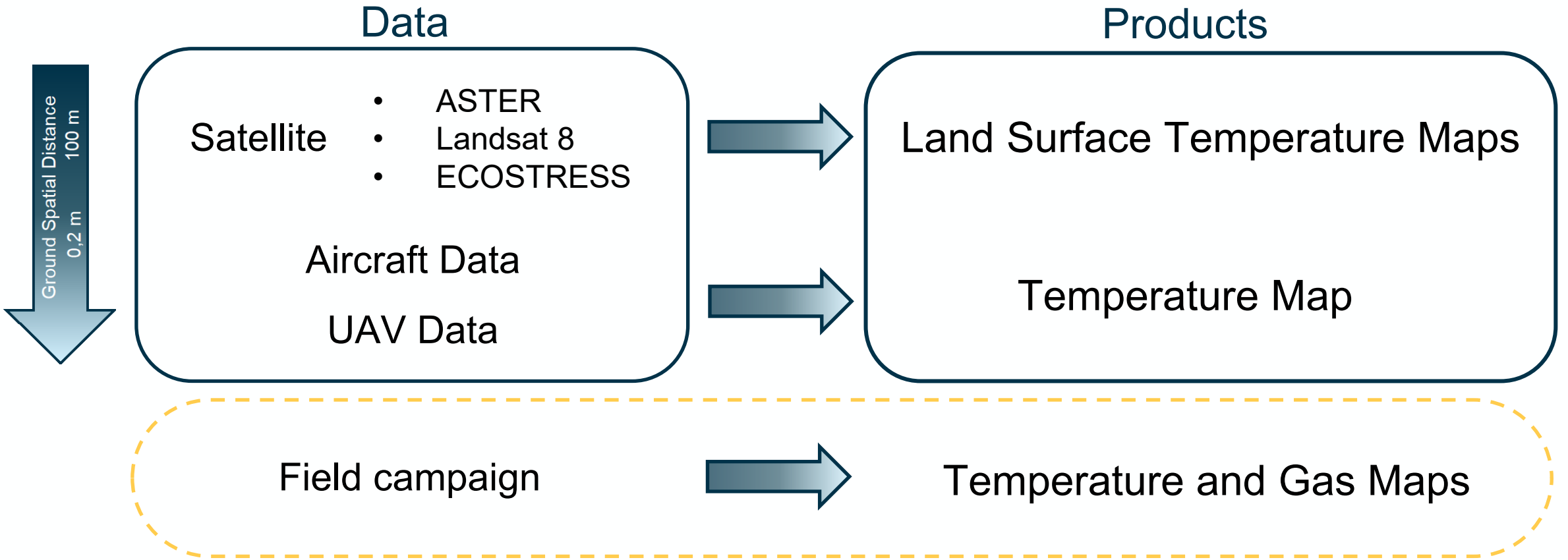
Data Comparison: Parco delle Biancane



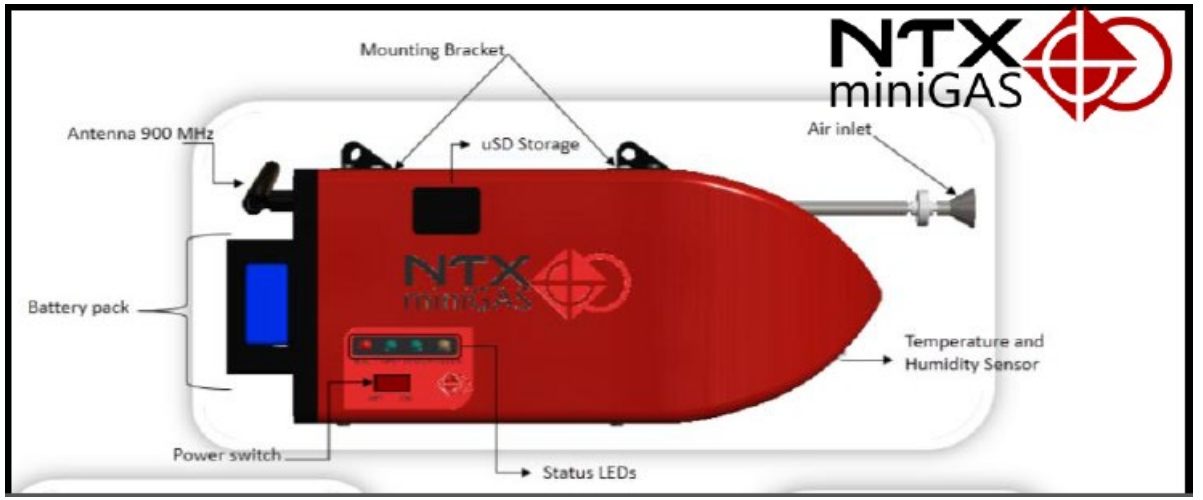


PEARSON COEFFICIENT	**HyTES** (0.8 m) June 18th 2019	**UAV** (0.2m) June 18th 2019
Landsat 8 (30 m) June 17th 2019	0.86	0.95
ASTER (90 m) June 16th 2019	0.79	0.77

Ongoing Steps: Field Campaign analysis



Ongoing Steps: Biancane



Specs	MiniGAS NTX V1
Weight	1.2 Kg (Battery included)
Processor	Arduino
Chemical Sensor	SO2, CO2, H2S, and 2 possible more
Physical Sensor	T, P, RH%, GPS
Dimensions	25 x 12 x 6 (cm)
Flow	1.2 lpm

The miniGAS systems allows the acquisition of real-time information such as temperature, pressure, relative humidity, SO2, H2S, CO2 concentration contained in degassing plume and fumaroles, with GPS geolocation. The acquired data are both stored in the sensor and transmitted to a computer for real time viewing information. Information in the form of 3D concentration maps can be returned.

Ongoing Steps: Minigas-NTX Parco delle Biancane

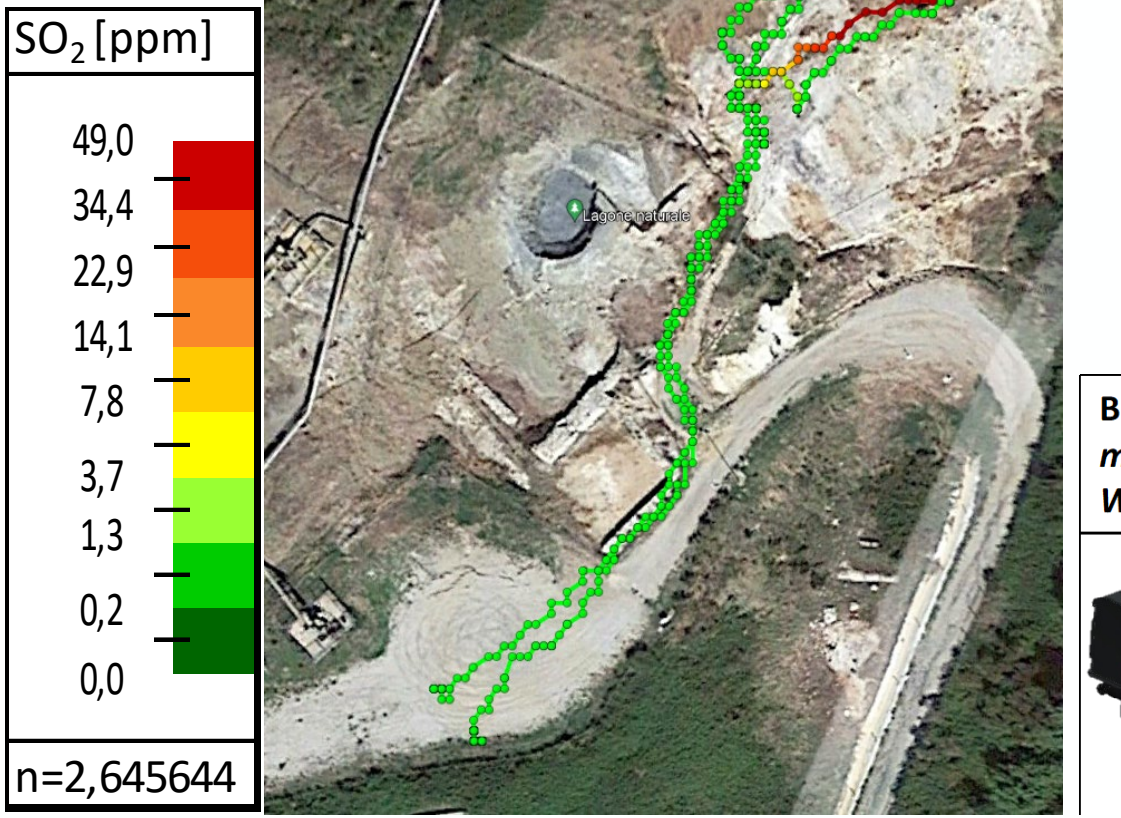
SO_2 MAP

Sensors platform	Check time	Start time	Shutdown time	Performance
miniGAS-NTX-P-a1-4S	05/10/2022 17:40	05/10/2022 17:54	05/10/2022 18:02	OK

Start time: 05/10/2022 17:54:26
Max. Altitude: 624,7 mAMSL
Max. altitude time: 18:00:48
Shutdown time: 05/10/2022 18:02:18
Total time (hh:mm:ss): 0:07:52

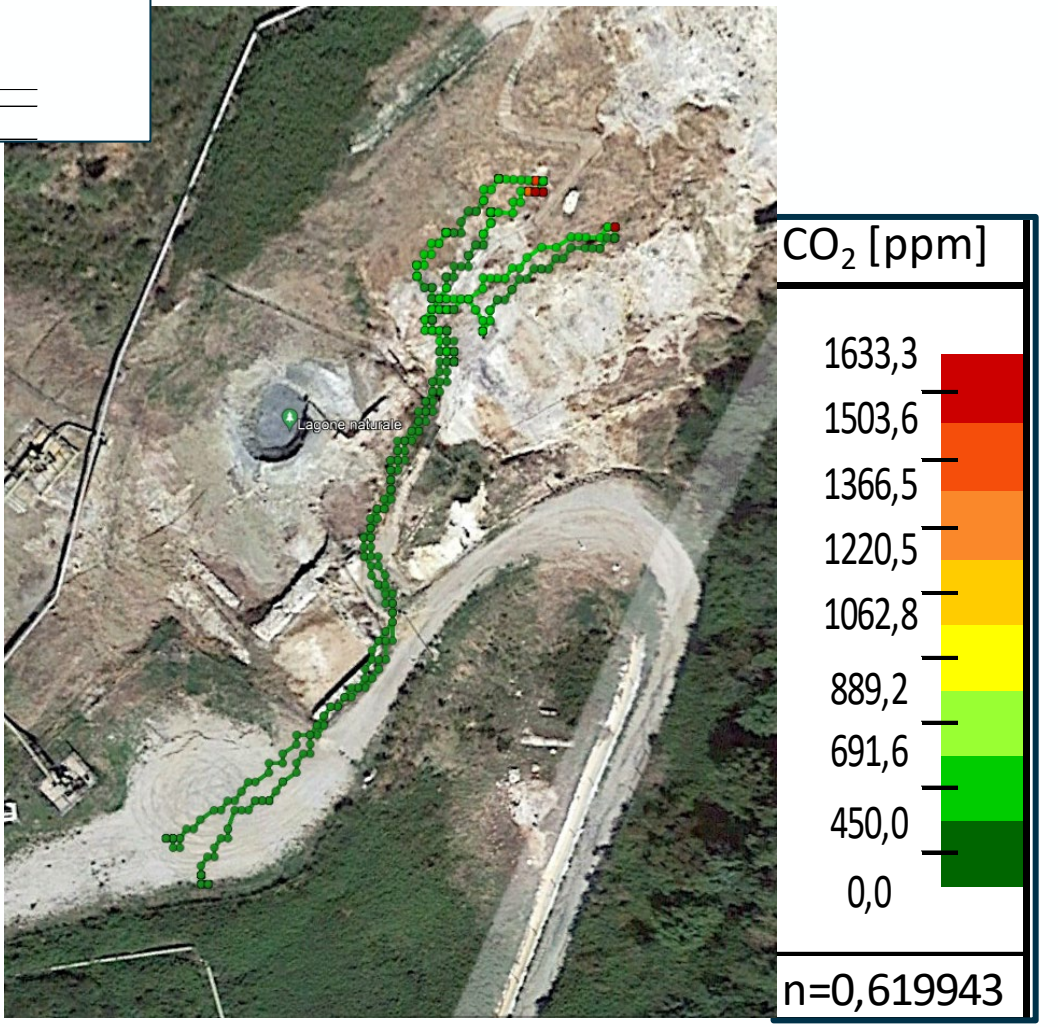
Max. SO2_(0-10ppm) : 1.22 ppm
Max. H2S_(0-50ppm) : 18.37 ppm (Lat.:43.15491°, Long.:10.85636° @ 610.7 m AMSL)

Max. CO2_(0-2000ppm) : 991.9 ppm (Lat.:43.15411°, Long.:10.85573° @ 621.2 m AMSL)

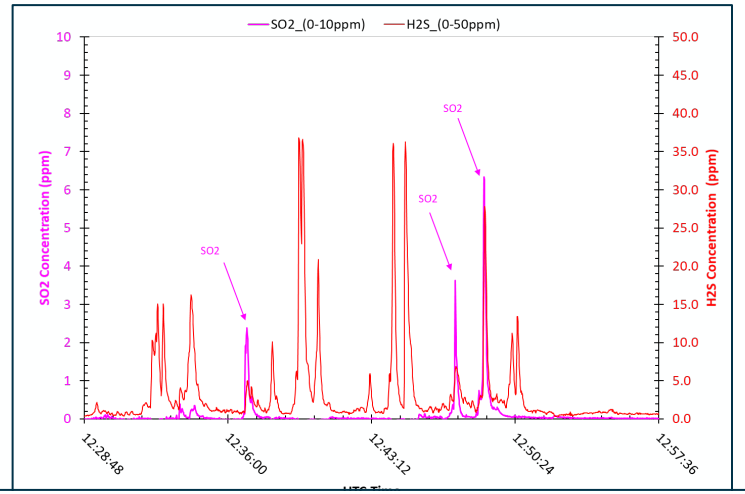


Biancane *9 May 2022*
miniGAS NTX-PRO
Walking Survey

CO_2 MAP



Ongoing Steps: Minigas-NTX Parco delle Biancane



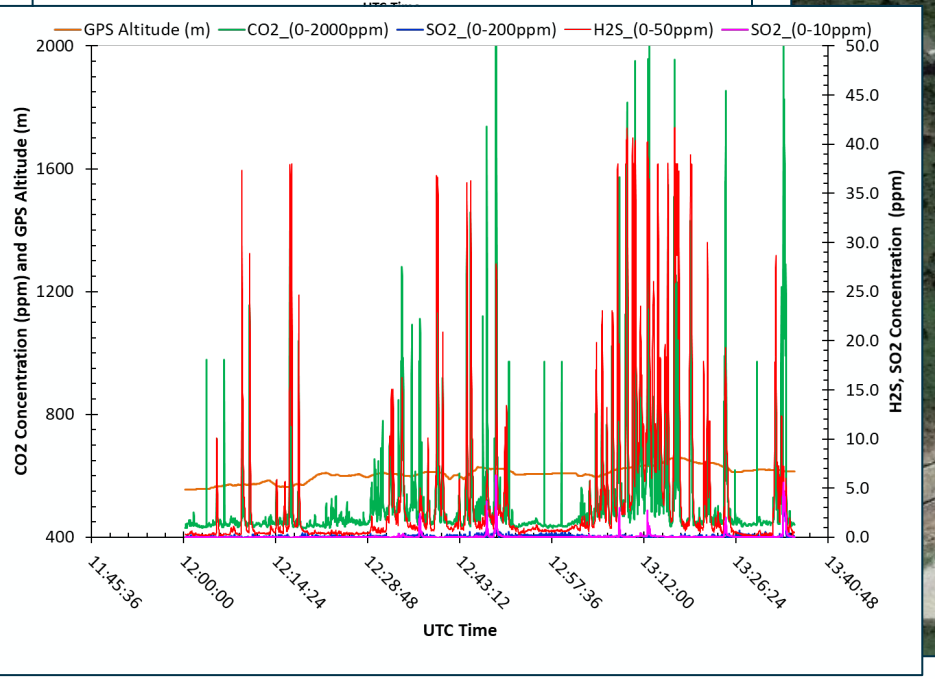
Sensors platform	Check time	Start time	Shutdown time	Performance
miniGAS-NTX-P-a1-4S	05/09/2022 12:00	05/09/2022 12:04	05/09/2022 13:35	OK

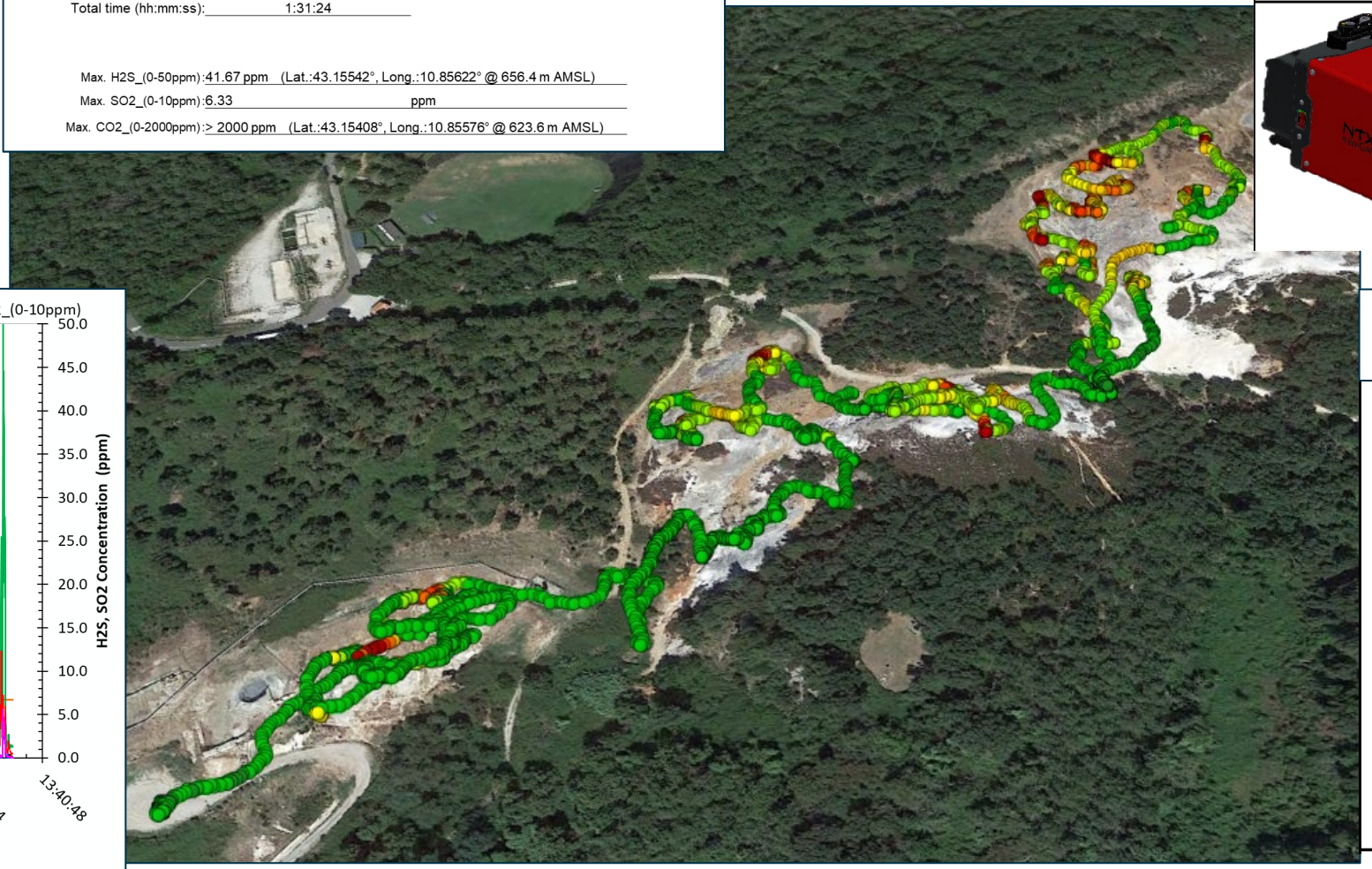
Start time: 05/09/2022 12:04:06
Max. Altitude: 657,9 mAMSL
Max. altitude time: 13:17:53
Shutdown time: 05/09/2022 13:35:30

Total time (hh:mm:ss): 1:31:24

Max. H2S_(0-50ppm): 41.67 ppm (Lat.:43.15542°, Long.:10.85622° @ 656.4 m AMSL)
Max. SO2_(0-10ppm): 6.33 ppm
Max. CO2_(0-2000ppm): > 2000 ppm (Lat.:43.15408°, Long.:10.85576° @ 623.6 m AMSL)

Biancane *9 May 2022*
miniGAS NTX-PRO
Walking Survey





H2S
(0-50ppm)

41,7
29,6
19,9
12,5
7,0
3,4
1,2
0,2
0,0

Ongoing Steps: Minigas-NTX Piscarelli (near Solfatara)

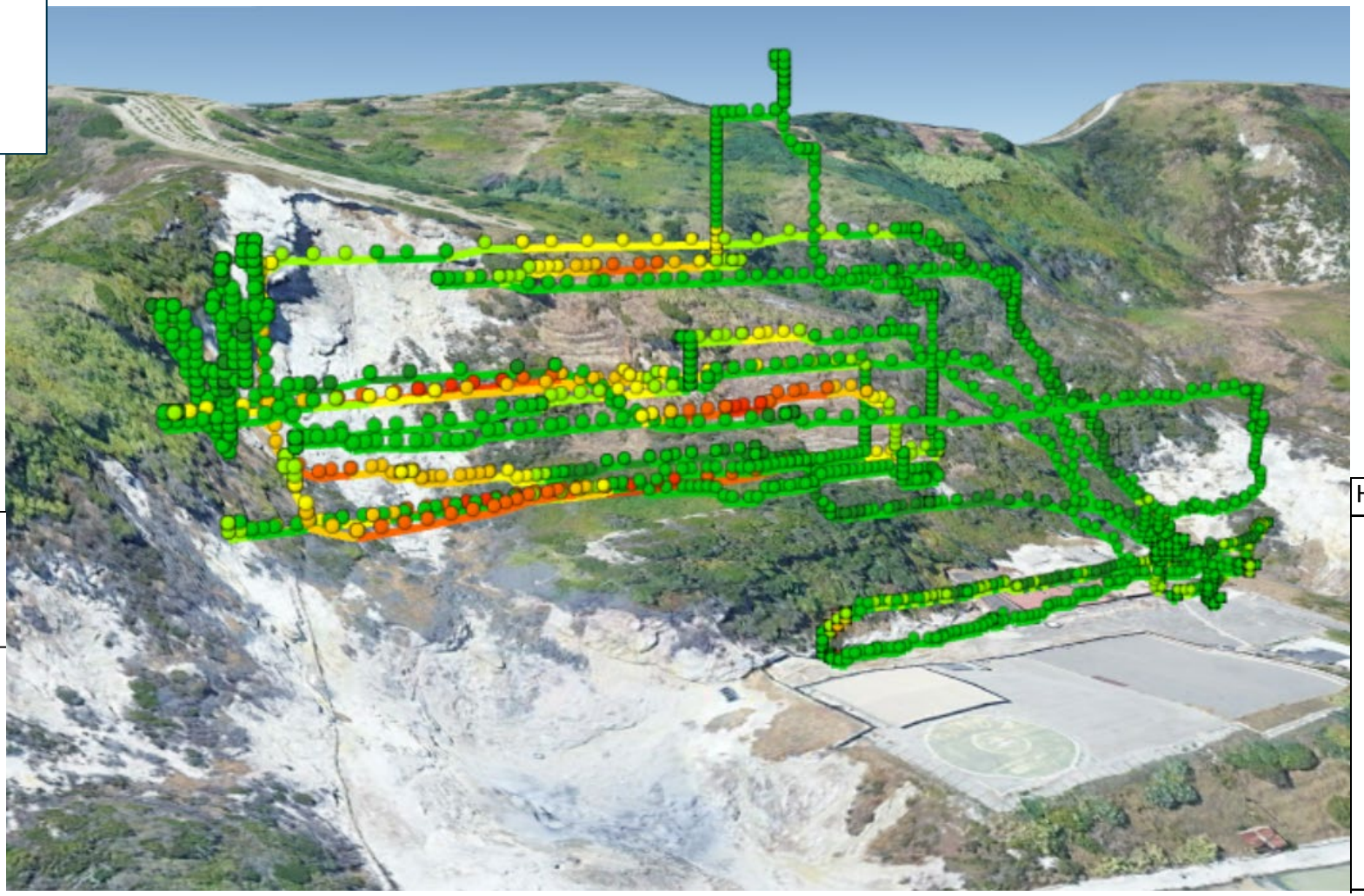
Sensors platform	Check time	Start time	Shutdown time	Performance
miniGAS-NTX-P-a1-4S	11/24/2021 09:50	11/24/2021 10:03	11/24/2021 12:04	OK

Start time:	11/24/2021 10:03:43
Max. Altitude:	166,2 mAMSL
Max. altitude time:	11:16:41
Shutdown time:	11/24/2021 12:04:05
Total time (hh:mm:ss):	02:00:22

Max. H2S_(0-50ppm) : 39,13 ppm (Lat.:40,82949°, Long.:14,14661° @ 86,4 m AMSL)

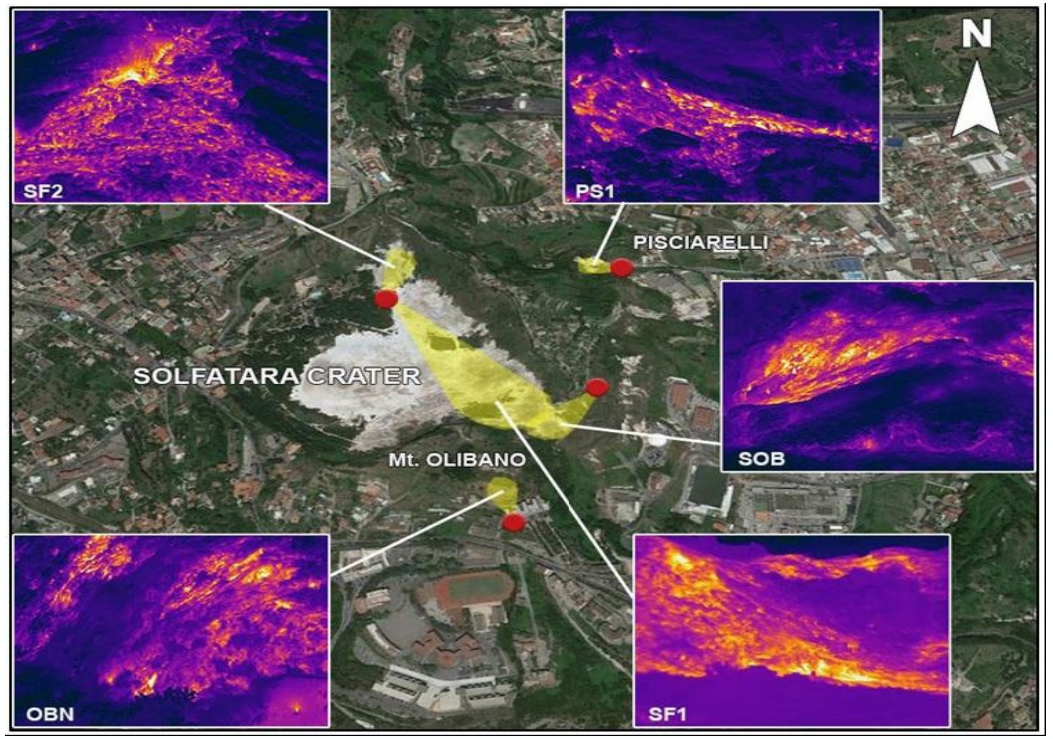
Max. CO2_(0-2000ppm) : > 2000 ppm (Lat.:40,83007°, Long.:14,14618° @ 81,4 m AMSL)

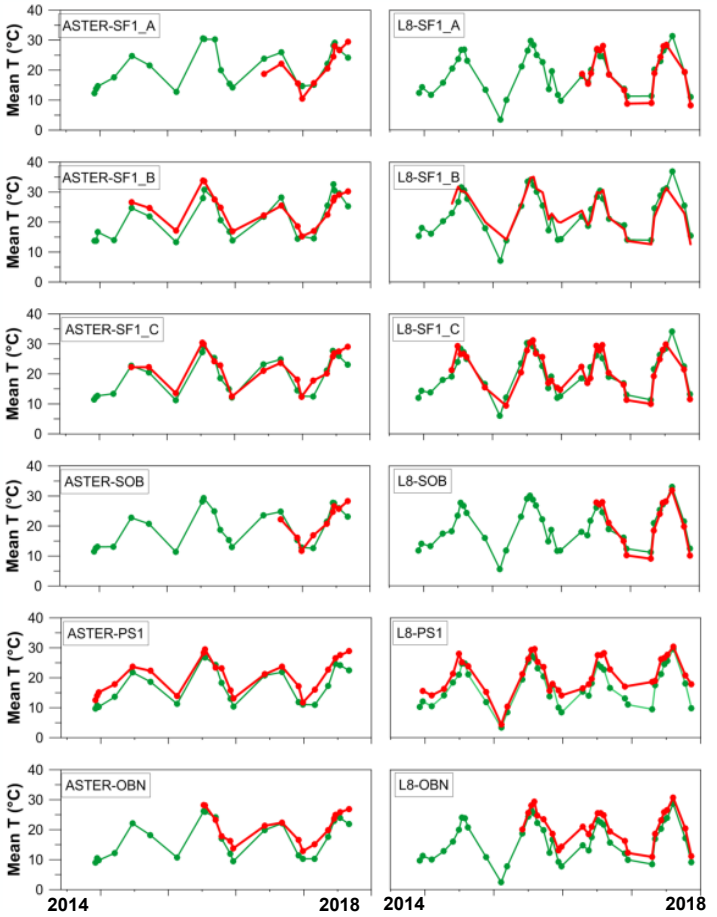
Pisciarelli *24Nov 2021*
miniGAS NTX-PRO
Drone Survey



Ongoing Steps: Solfatara Thermal Camera

Fixed Thermal Camera at Solfatara





We are confident about the methodology used to retrieve Surface Temperature Value from Satellite Data

Conclusion

Thank You
for the Attention !!

For any questions, please contact PhD **Malvina Silvestri** at **malvina.silvestri@ingv.it**