Investigating the 3D distribution of GEM (Gaseous Elemental Mercury) in the lower atmosphere via a UAV (Unmanned Aerial Vehicle) - Lumex® assemblage

EGU General Assembly 2024

Sharing is encouraged

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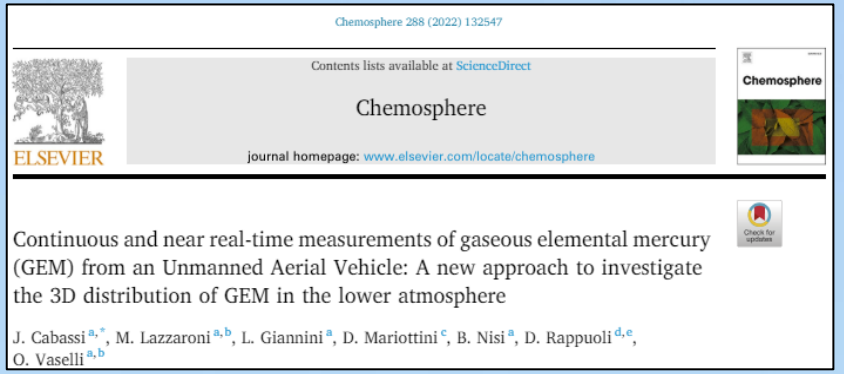

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Continuous and near real-time measurements of gaseous elemental mercury (GEM) from an Unmanned Aerial Vehicle: A new approach to investigate the 3D distribution of GEM in the lower atmosphere

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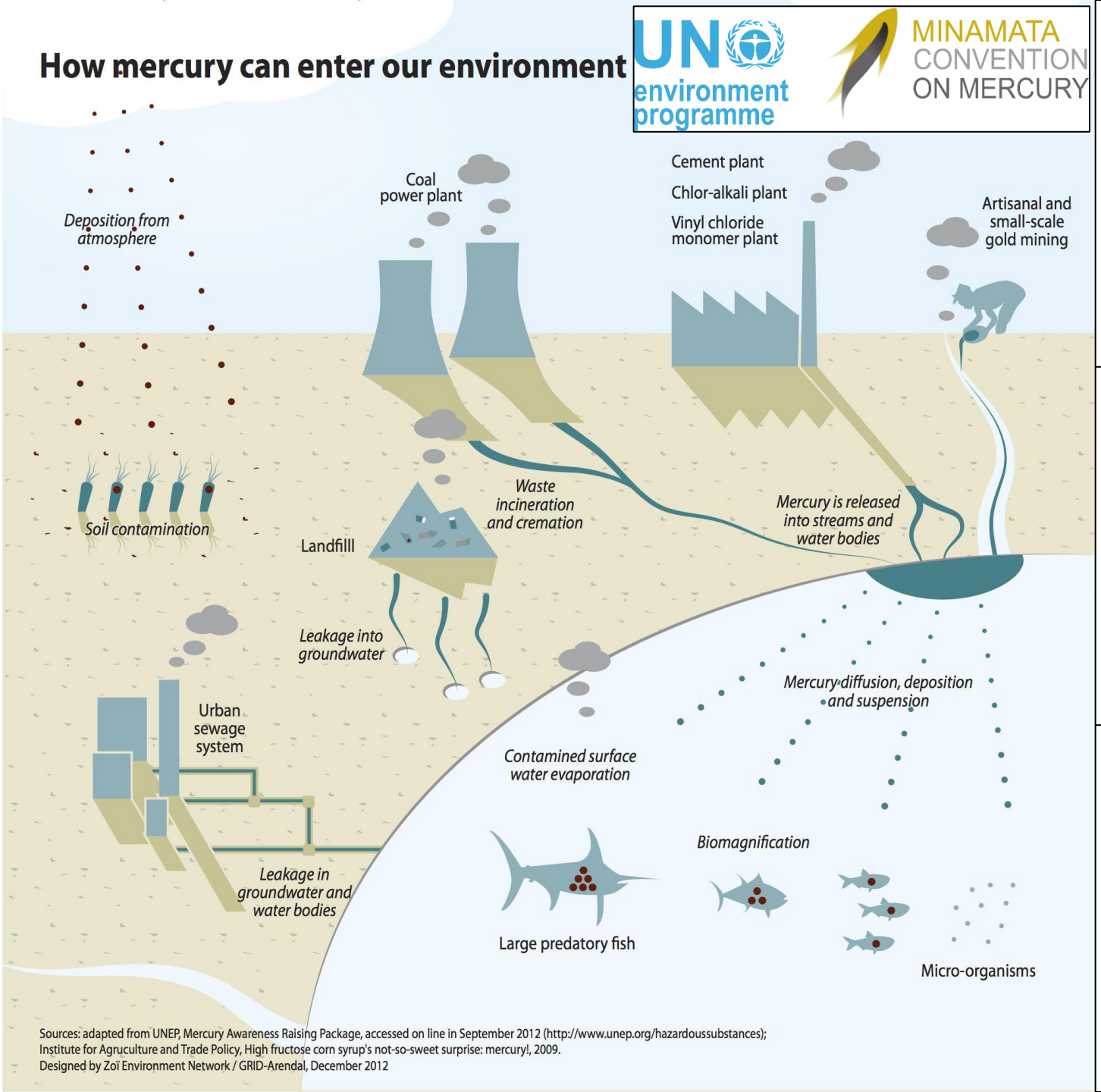


Mercury is a toxic and noxious element for humans and ecosystems and gaseous elemental mercury (GEM or Hg^0) is considered a global and dangerous air pollutant

GEM is released by a variety of both natural and anthropogenic sources

MAKE MERCURY HISTORY

Proposing innovative measurement methods and techniques for gaseous mercury is becoming crucial to monitor the presence and behavior of mercury pollution sources and enforce the knowledge on mercury dispersion mechanisms according to the provisions of the Minamata Convention on Mercury

Unmanned Aerial Vehicles (UAVs) currently represent the new frontier of air pollutants monitoring, since they can be used in many different contexts, ranging from major cities to active degassing volcanoes

As for gaseous mercury, first applications using a UAV were only recently made, since continuous monitoring is generally performed at ground level and at fixed points or by moving along pre-defined transects with portable devices, whereas atmospheric measurements are usually performed via airships

e.g.

e.g.

Environmental Science and Pollution Research (2018) 25:13195–13202
https://doi.org/10.1007/s11356-018-1775-y

SHORT RESEARCH AND DISCUSSION ARTICLE

CrossMark

Adaption and use of a quadcopter for targeted sampling of gaseous mercury in the atmosphere

Oscar Black[1] · Jingjing Chen[2] · Austin Scircle[1] · Ying Zhou[2] · James V. Cizdziel[1]

Science of the Total Environment 917 (2024) 170457

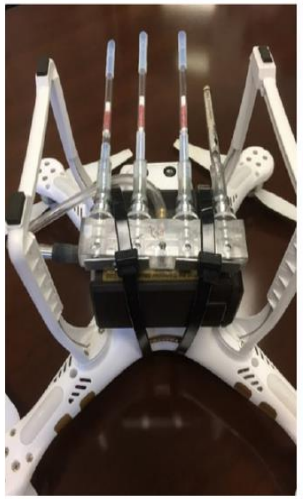
Contents lists available at ScienceDirect

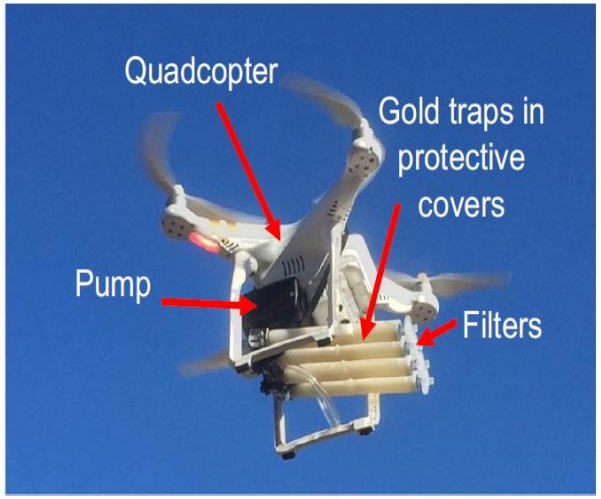
Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

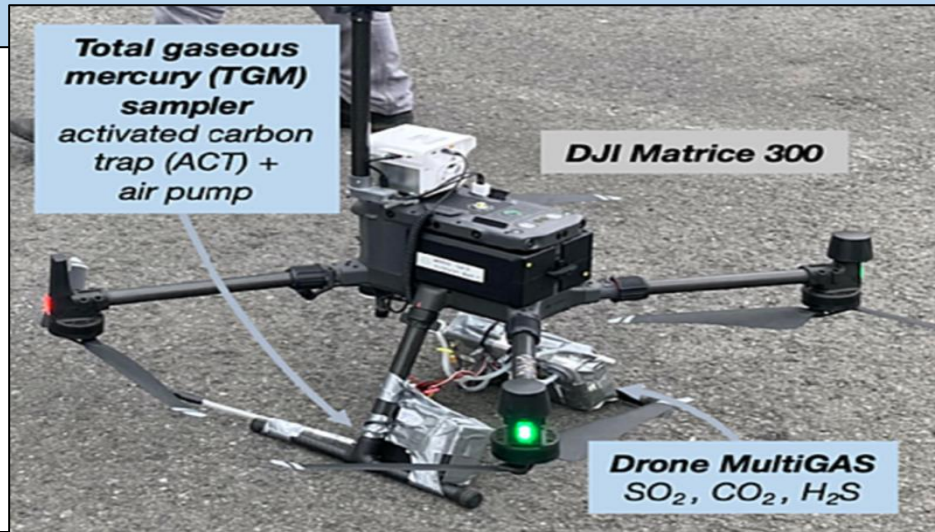
Exceptionally low mercury concentrations and fluxes from the 2021 and 2022 eruptions of Fagradalsfjall volcano, Iceland

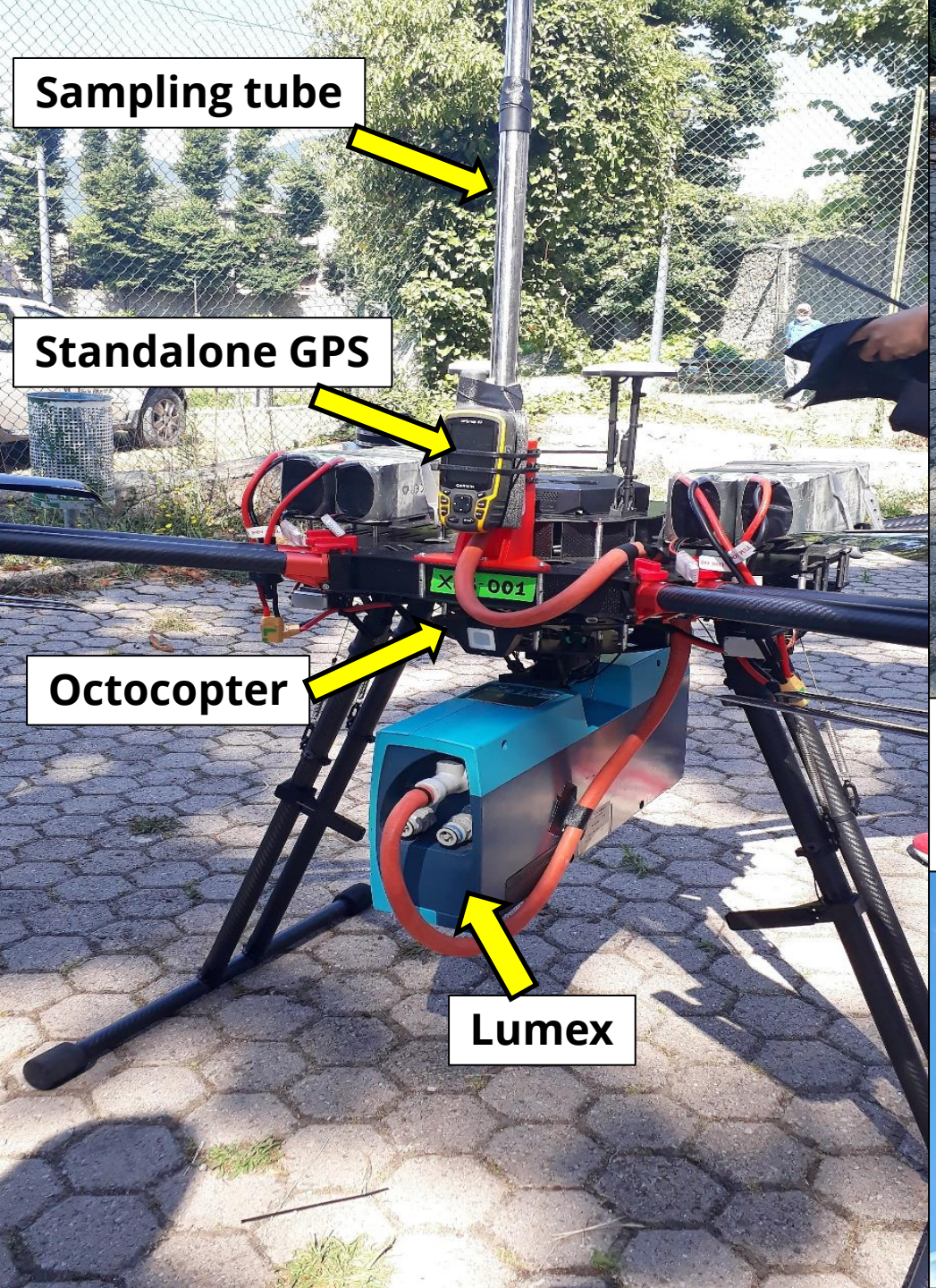
Brock A. Edwards[a,b], Melissa A. Pfeffer[c], Evgenia Ilyinskaya[d], Barbara I. Kleine-Marshall[e], Céline L. Mandon[f], Adam Cotterill[g], Alessandro Aiuppa[h], Peter M. Outridge[a,b], Feiyue Wang[a,*]





To the best of our knowledge, direct, continuous and near real-time measurement are not so far reported by mounting a portable instrumentation for GEM determination on an UAV

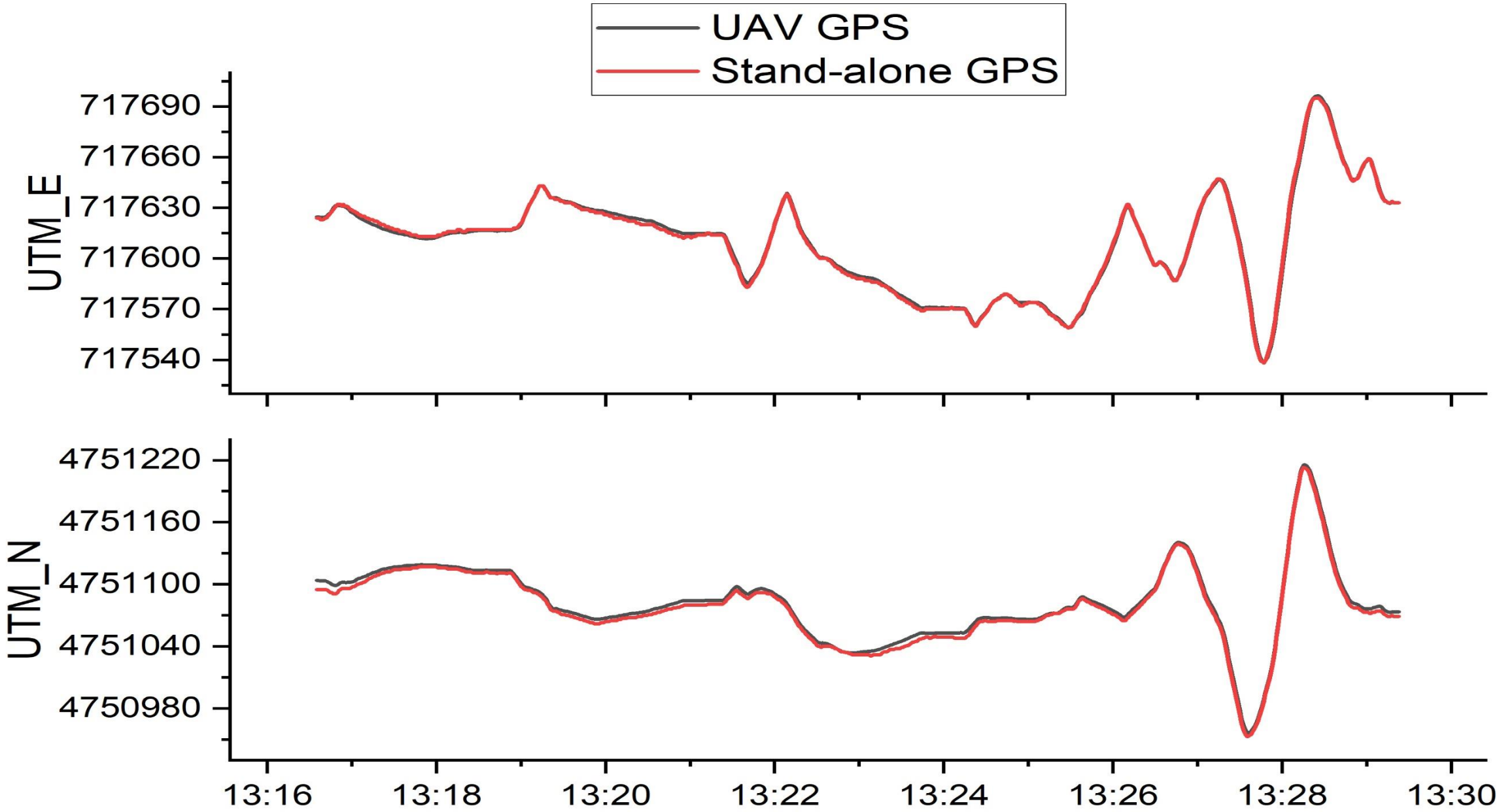




First attempt to measure GEM in near real-time with a Lumex RA-915M (Zeeman atomic absorption spectrometer) mounted on an UAV (i.e. Hammer X8B heavy-lift coaxial octocopter)

System optimized through:

- **vertical sampling tube connected to Lumex to overcome the rotors strong airflows**
- **batteries for power supply**
- **UAV ability to land in small spaces and stop at desired altitudes**

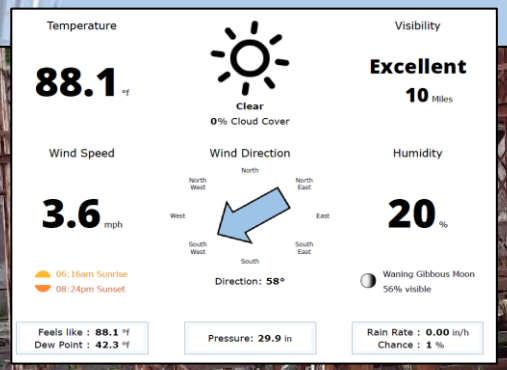


Required: the correct synchronization of Lumex and UAV GPS, since the internal clocks of the two devices work independently, being separate components. This issue was bypassed by setting the same data acquisition frequency and synchronizing the stand-alone GPS and the Lumex. Consequently, each single value had its own corresponding georeferencing data

Case study…former Hg mining area

Abbadia San Salvatore, i.e. the most important site of cinnabar exploitation and mercury production of the Mt. Amiata Hg district


6 selected sites pertaining to both mining facilities and surrounding urban and inhabited zones
Pozzo Garibaldi
Laghetto Verde
Asciugatoi Vecchi
Forni
former mining area
Abbadia San Salvatore
Stadio
Altone
Google Earth
© 2021 Google
300 m
N
Stadio
flight route carried out by the UAV-Lumex pair
Altone
Laghetto Verde
Pozzo Garibaldi
Asciugatoi Vecchi
Forni



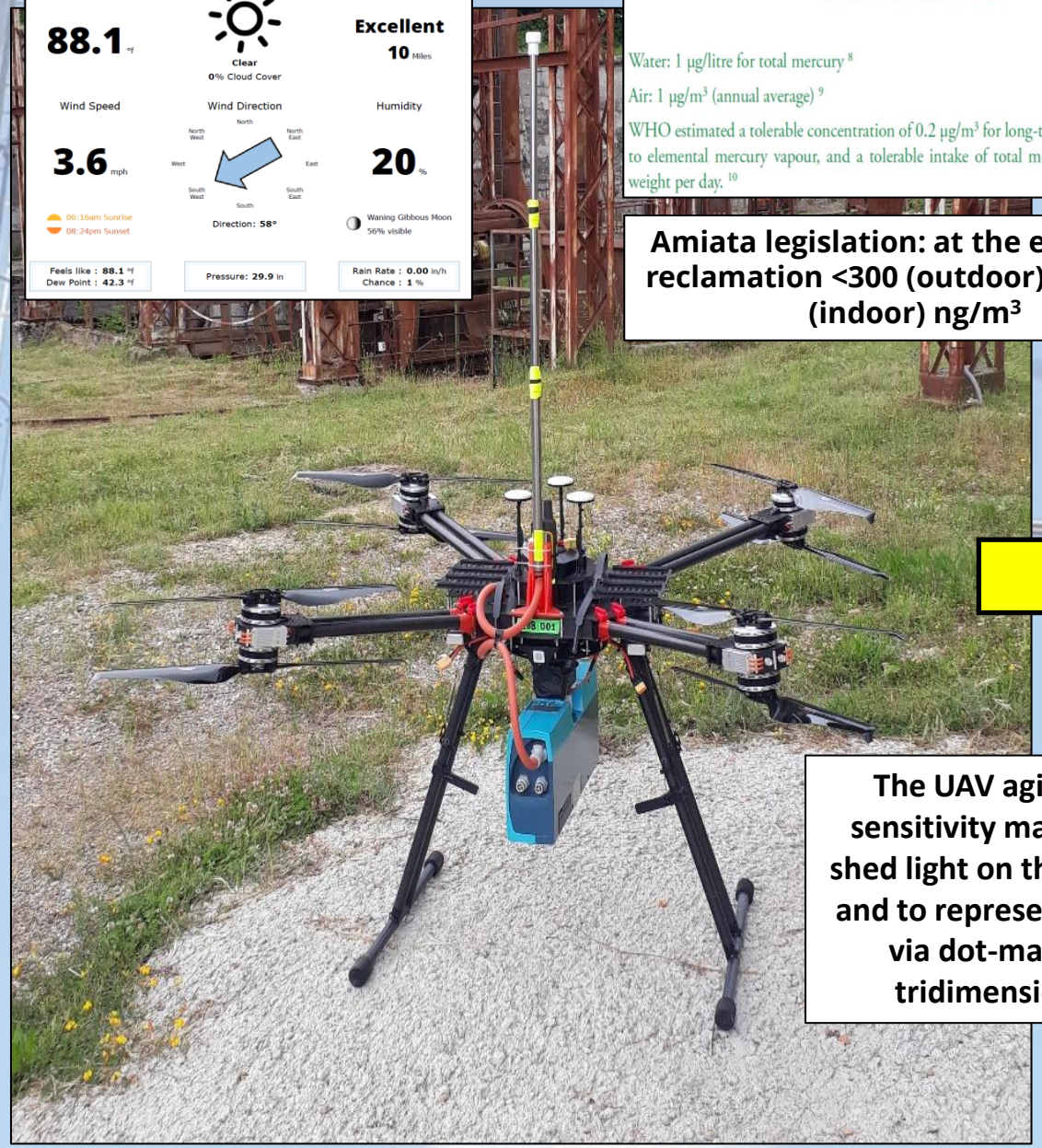
WHO Guideline Values

Water: 1 µg/litre for total mercury [8]

Air: 1 µg/m³ (annual average) [9]

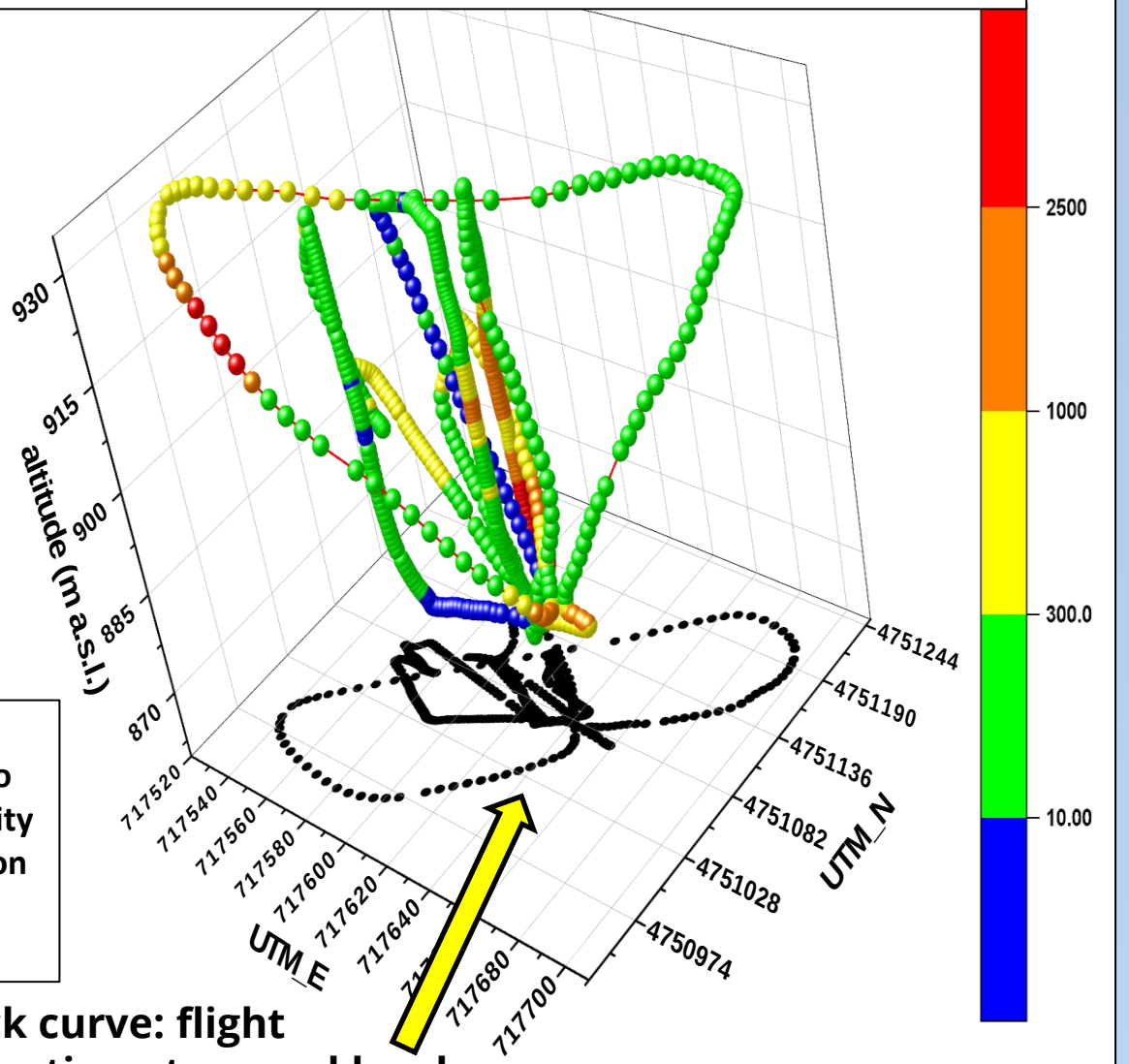
WHO estimated a tolerable concentration of 0.2 µg/m³ for long-term inhalation exposure to elemental mercury vapour, and a tolerable intake of total mercury of 2 µg/kg body weight per day. [10]

Amiata legislation: at the end of the reclamation <300 (outdoor) and <500 (indoor) ng/m³



The UAV agility and Lumex sensitivity made it possible to shed light on the GEM variability and to represent its distribution via dot-map, providing a tridimensional profiling

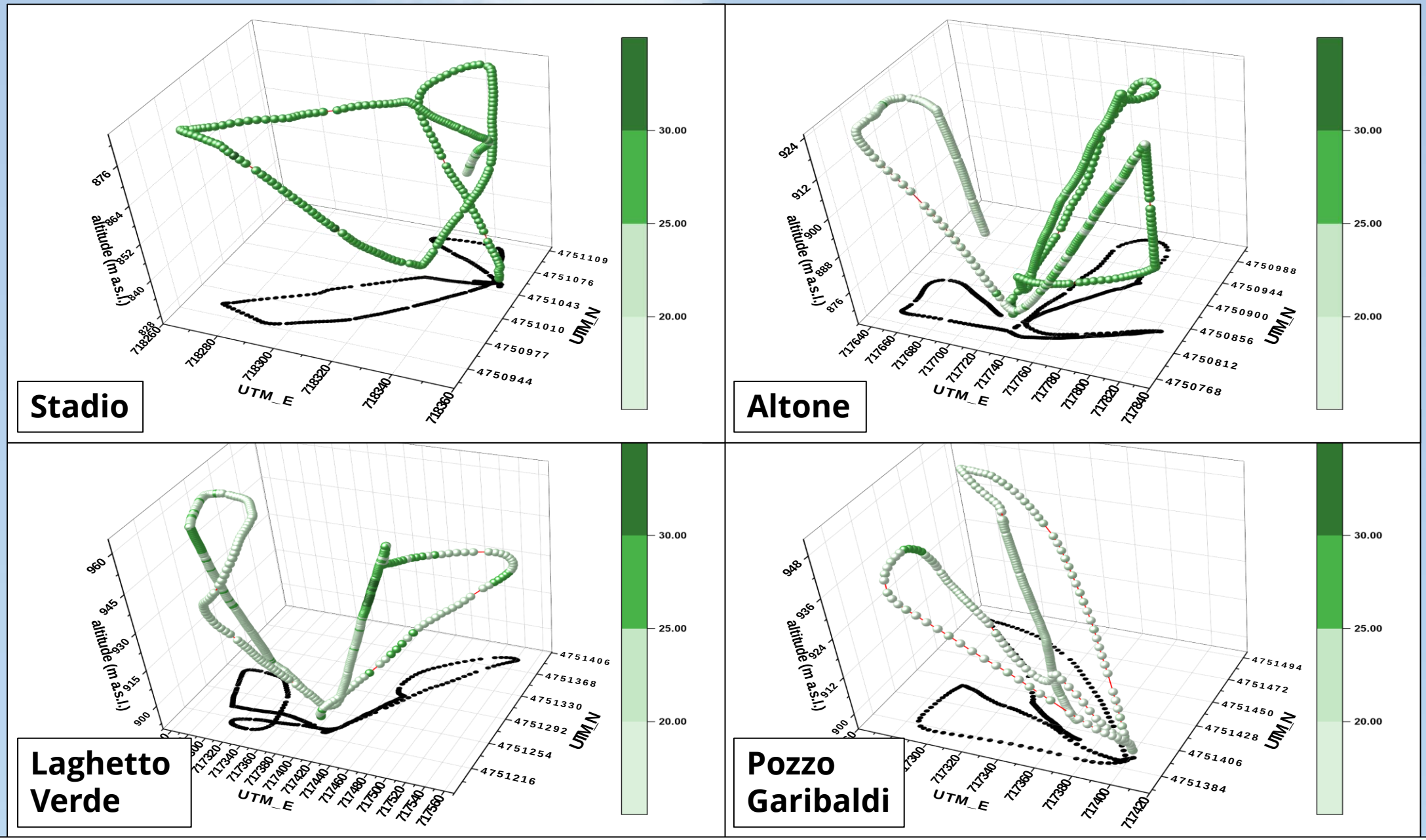
3D dot-maps allowed to verify whether the guideline concentrations were exceeded



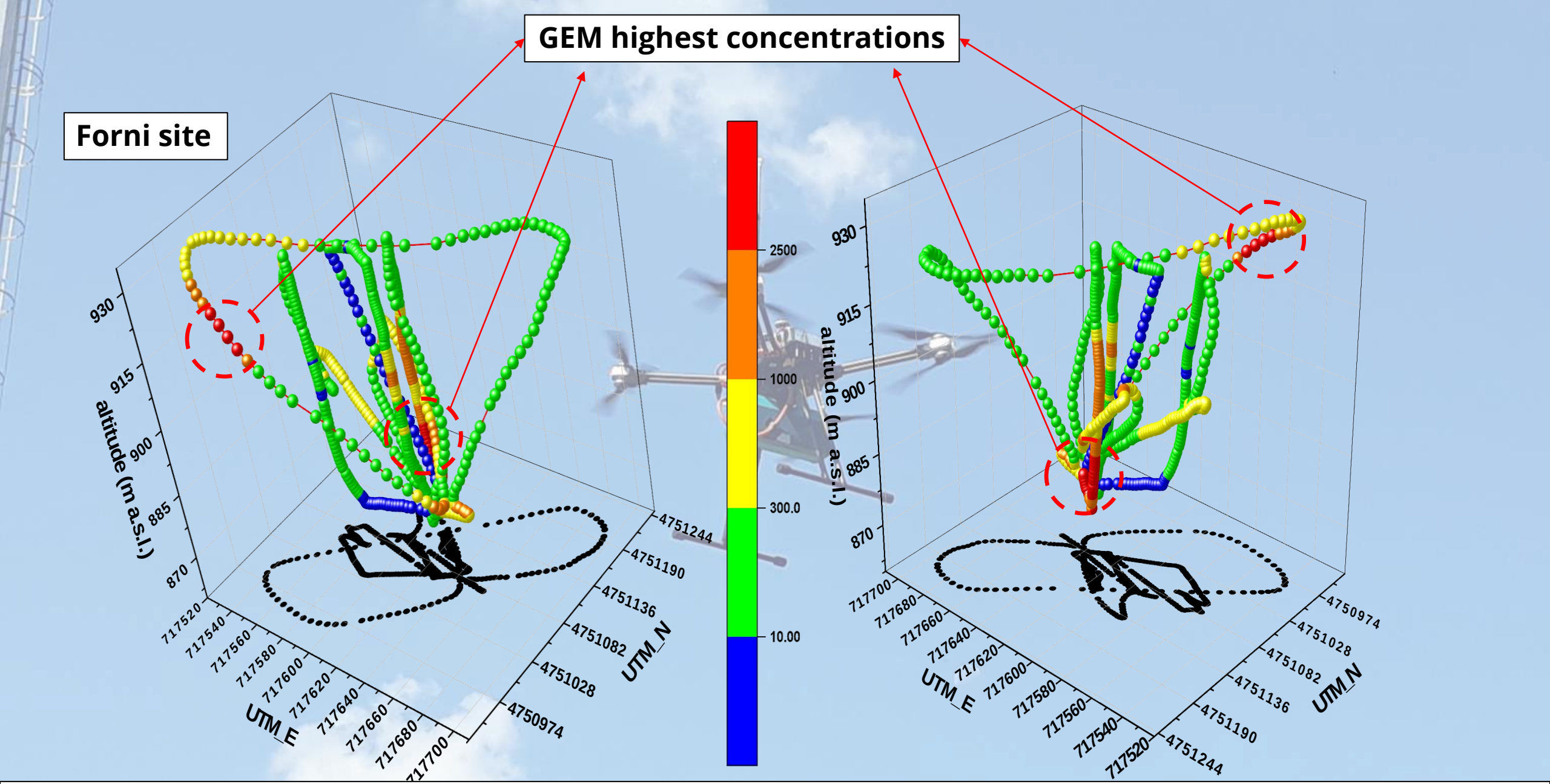
black curve: flight projection at ground level

Lumex + UAV

3D spatial distribution of GEM

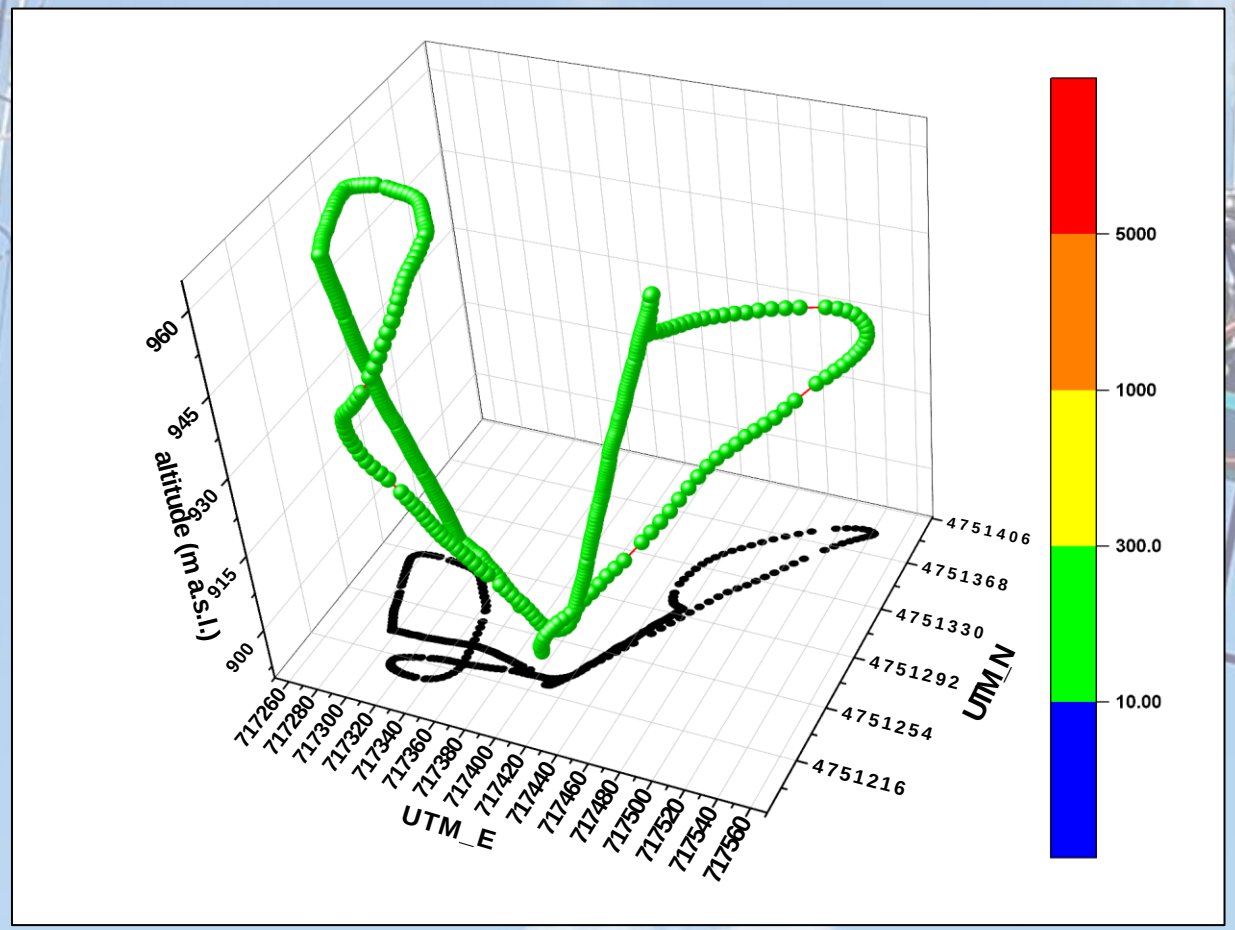


GEM concentrations in the urban area and close to already reclaimed areas remained at relatively low values and did not change substantially both horizontally and vertically

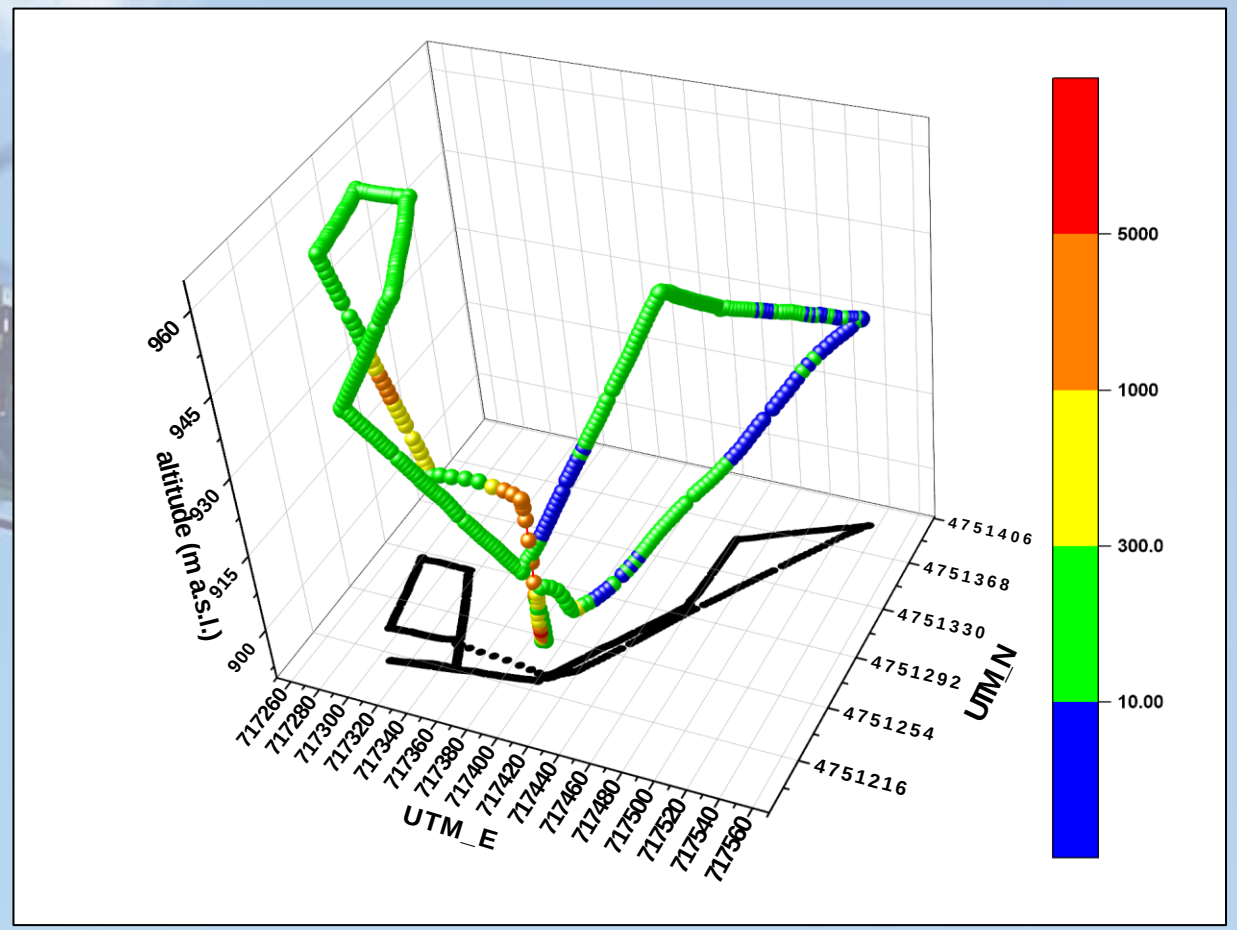


GEM showed significant variations and the maximum values near the facilities containing the old furnaces, concordantly with a GEM increase with either decreasing heights or downwind

Moreover, all flights were standardized based on previously acquired data thanks to the method accuracy and the UAV pilot experience, allowing reprogramming and repeating the routes at later times, thus highlighting significant differences in GEM contents



August 2020



June 2021

Laghetto Verde site, same route, different time: different concentrations and atmospheric conditions


THANKS FOR YOUR ATTENTION!