



HERA: A Multi-Sampling System For Distributional Analysis Of Microorganisms Within The Troposphere

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Abstract

The HERA (High Elevation Research in Aerobiology) platform was engineered to collect microorganisms at tropospheric to lower stratospheric elevations for laboratory analysis of microbial metabolic activity and density via high-altitude balloons. The platform features sensors for altitude, humidity, temperature, UVA, and pressure, which are continuously recorded during sampling to provide contextual data for interpreting microbial metabolic activity and density. HERA enables systematic investigation of microbial distributions and densities via an incubation chamber and filter system, supporting studies of atmospheric transport, cloud microbiology, and microbial biosignatures, which are relevant to astrobiology, agriculture, and microbiology.

Methodology

The HERA platform utilizes a vacuum pump operating at 10 L min^{-1} to create a flow through a filter and incubation chamber, which will retain any aerosol particles and microorganisms greater than $0.2 \mu\text{m}$. This filtration is conducted using a 25 mm flat polycarbonate filtration disc that sits inside the custom aluminum cassette chamber and manifold (Fig. 3,4). After sampling has been conducted, the filters are removed and taken for laboratory analysis.

Results

Preliminary testing has been conducted at $\sim 30 \text{ m}$. Deuterium stable isotope probing and SYBR staining are currently being performed on the collected samples.

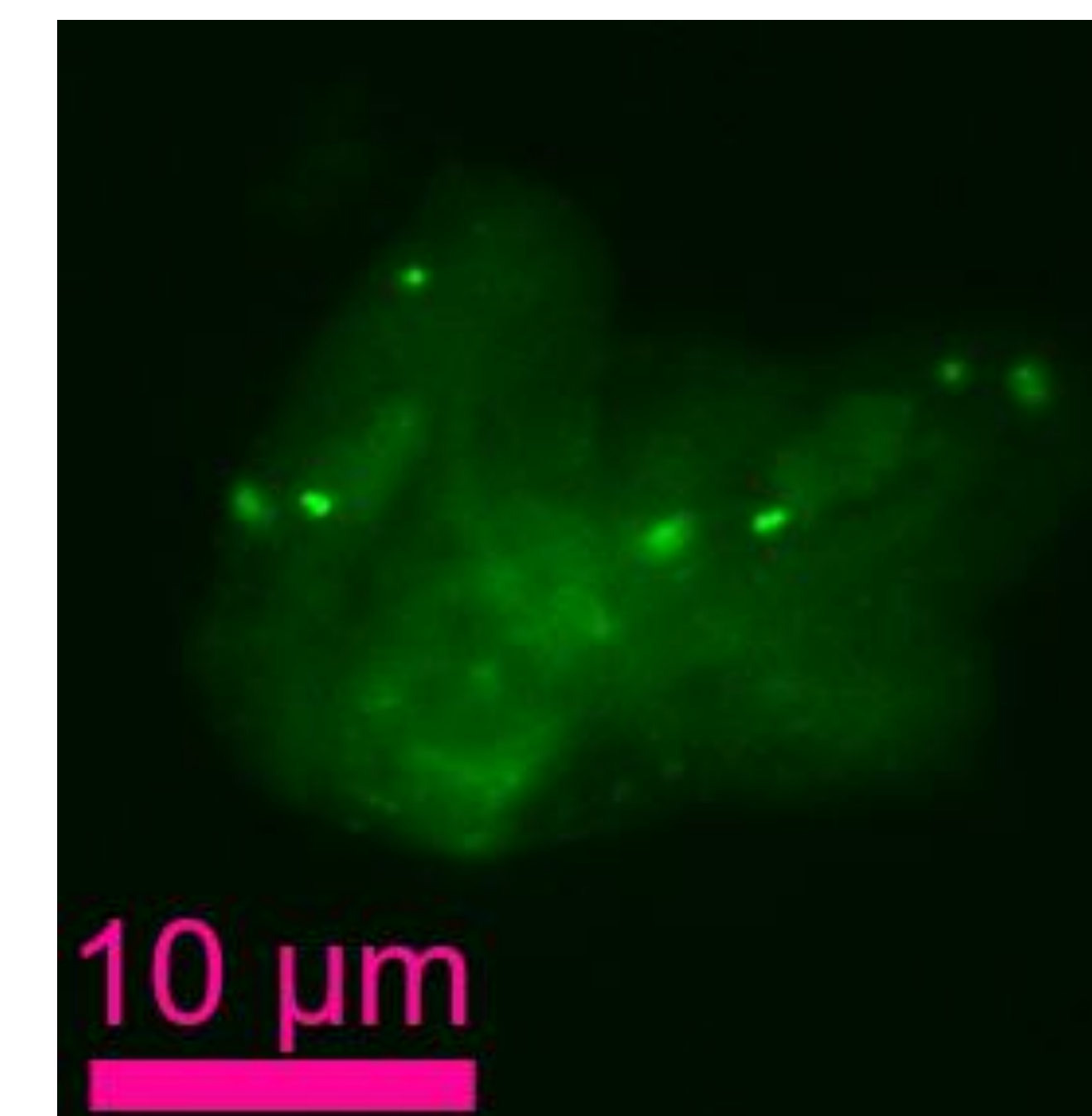


Fig 5. SYBR Stain of an Environmental Sample Collected From Tempe, Arizona.

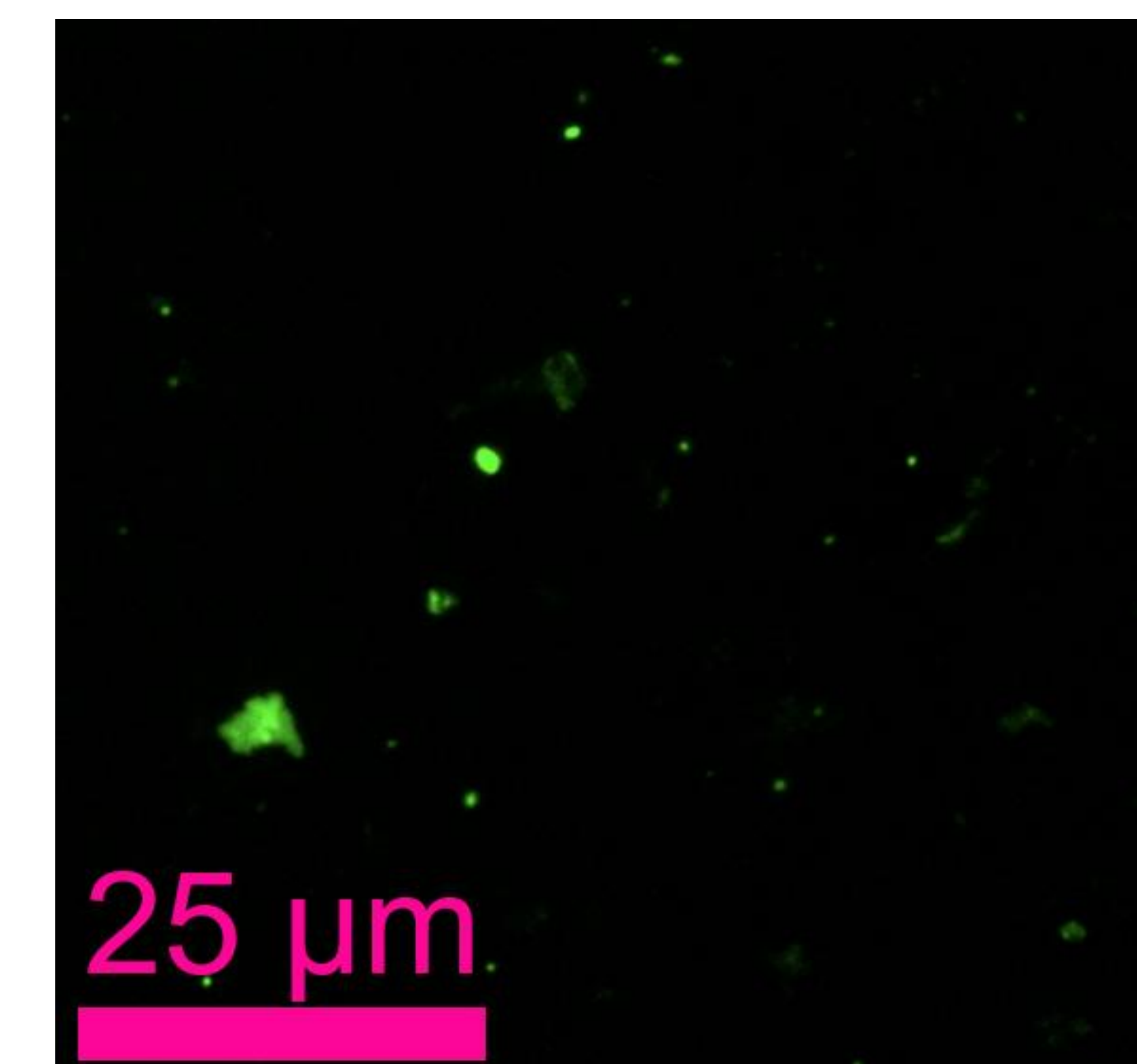


Fig 6. SYBR Stain of an Environmental Sample Collected From Tempe, Arizona.

Conclusion

HERA demonstrates a practical approach to sampling airborne microorganisms. By comparing the metabolic activity and density of airborne microorganisms in different regions and, ultimately, at different altitudes, HERA will be able to advance the understanding of atmospheric microbial distributions. This will contribute to our understanding of long-range dispersal and ecosystem connectivity. This work is important for establishing a foundation that can be applied to studies of atmospheric habitability beyond Earth.

Future work

- Administration of gaseous isotope labels for examination of active metabolism within the upper troposphere.
- Sampling at the summit of Mount Humphreys (4.26 km elevation)

References

- <https://doi.org/10.1093/ismejo/wrae092>
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[2] Lappan, R., Thakar, J., Molares Moncayo, L., Besser, A., Bradley, J. A., Goordial, J., Trembath-Reichert, E., & Greening, C. (2024). The atmosphere: A transport medium or an active microbial ecosystem? *The ISME Journal*, 18(1)

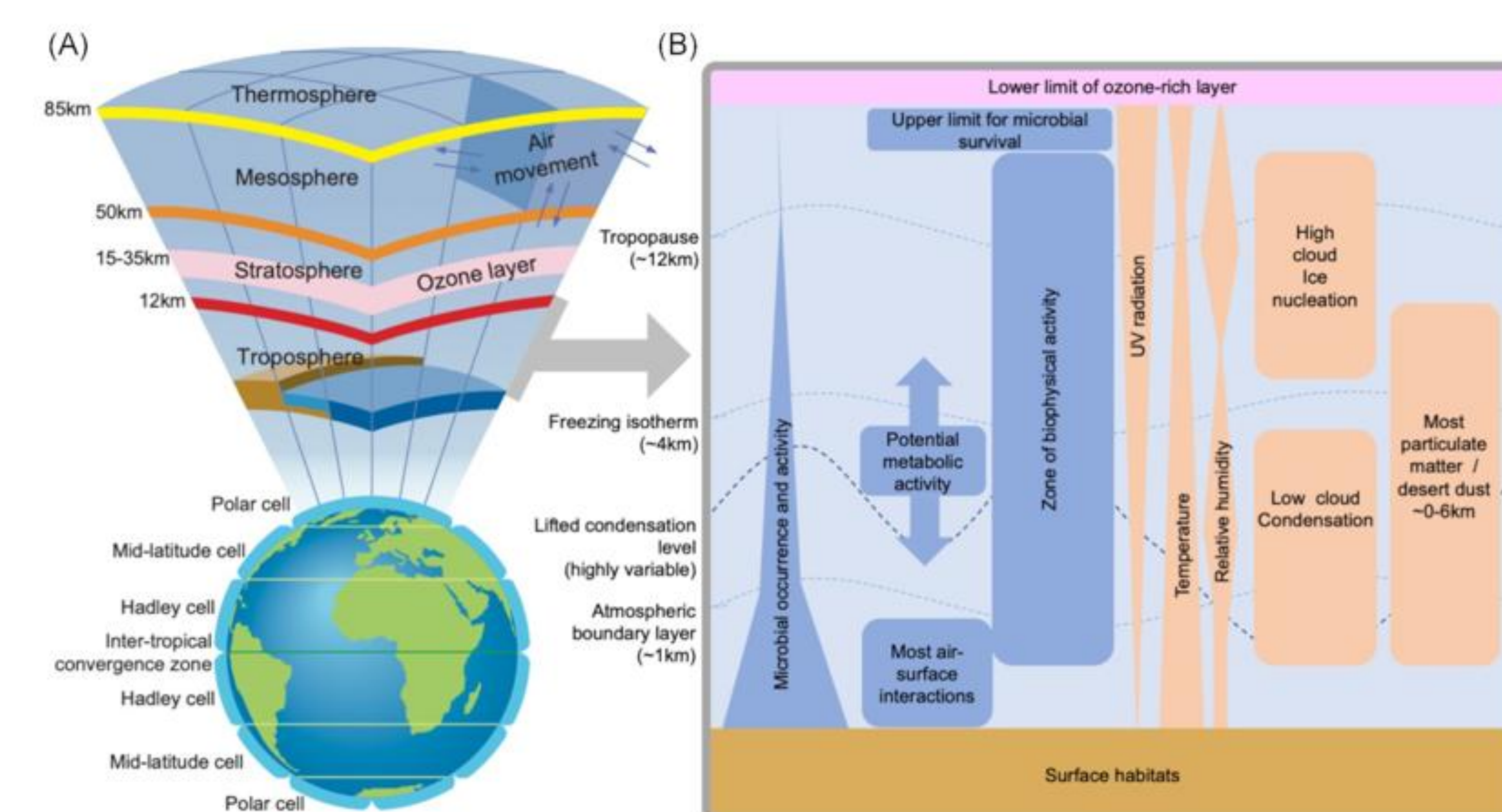


Fig 1. Defining the atmospheric ecological niche. (Šantl-Temkiv, 2022)

Introduction

The troposphere is known to be a transport medium for atmospheric microorganisms with cell abundances near $10^4 - 10^5 \text{ cells m}^{-3}$, and an estimated total cell density in the troposphere of $5 \cdot 10^{22} \text{ cells}$ (Lappan, 2024). However, the distribution, activity, and roles of atmospheric microorganisms at tropospheric altitudes remain poorly understood. HERA was designed to answer this question, featuring a filtration section to collect atmospheric microorganisms and a chamber capable of performing stable isotope probing, along with sensors to monitor and collect atmospheric data.

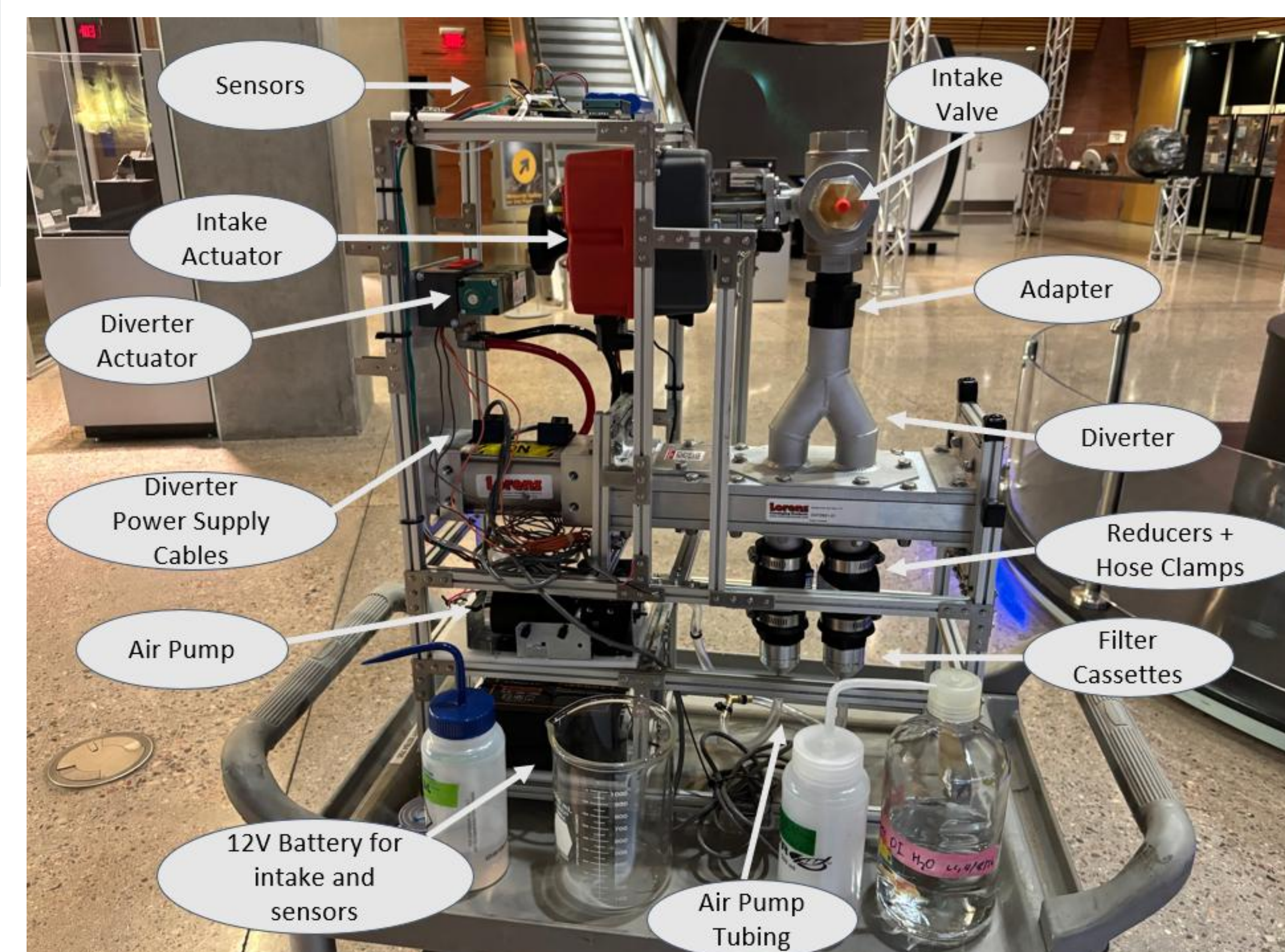


Fig 3. HERA System Architecture and Flow.

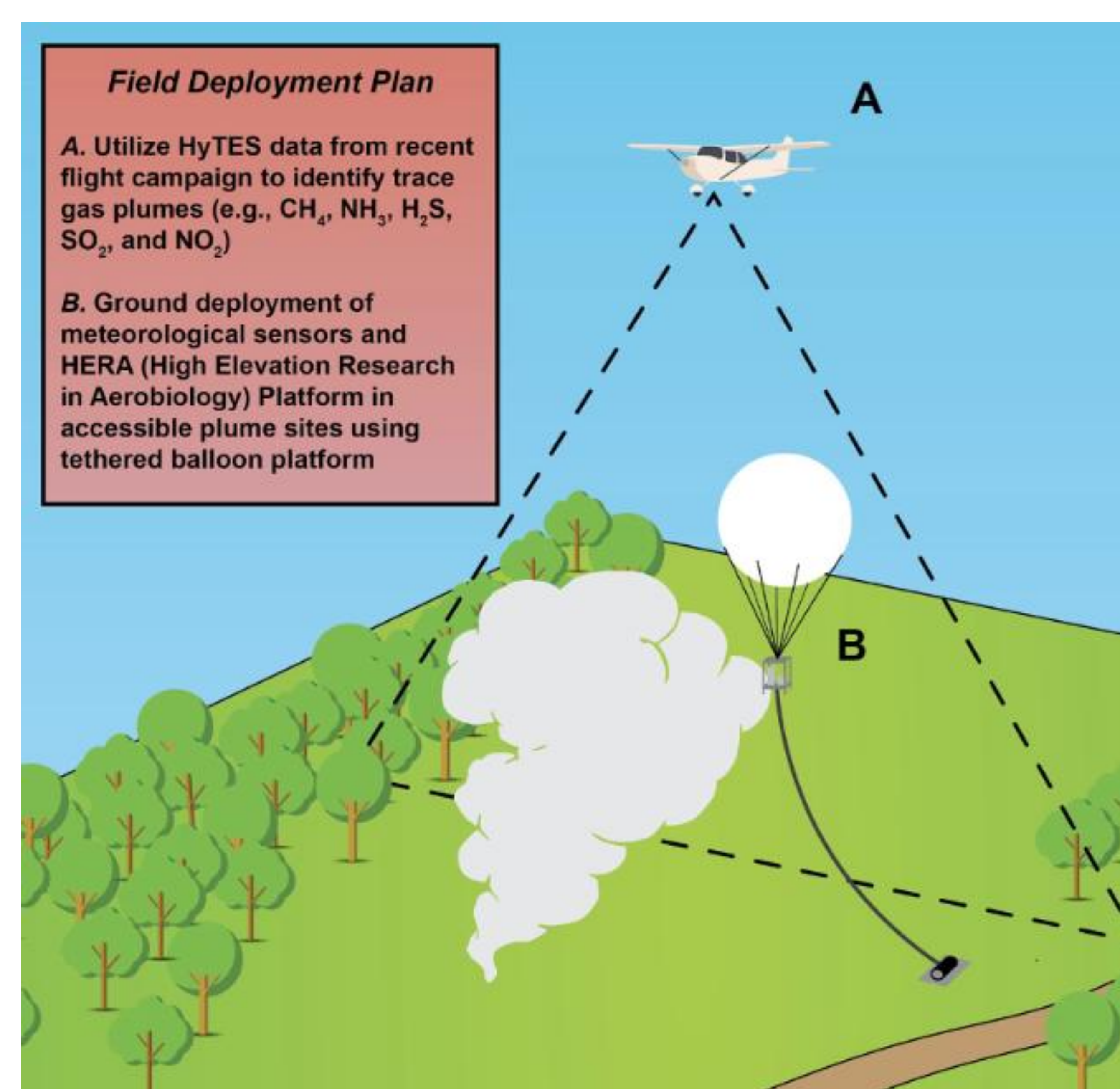


Fig 4. HERA Deployment Plan