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Earth System Science Across Scales and Organizations: Distributed IoT, Virtual Networks, and Integration of Airborne and Spaceborne Remote Sensing

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Introduction

- Public and private collaborations enable the combination of real-time Internet of Things (IoT) sensing data, national infrastructure scale monitoring, and airborne and satellite-based remote sensing.
- These partnerships can accelerate the fusion of different data modalities to support broader scientific and monitoring objectives and increases the value of each respective component.
- When combined with cloud-based computing, the ability to create virtual networks with rapid, real-time products radically increases the accessibility of datasets and scientific insights.

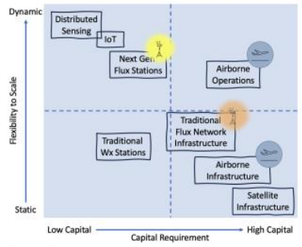


Figure 1: Conceptual representation of earth system science monitoring assets, and how they relate in terms of flexibility to scale and level of capital investment.

Real-Time IoT Sensing

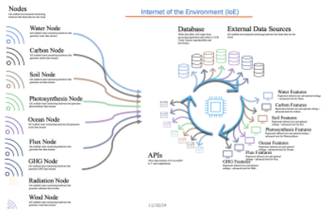


Figure 2: Conceptual representation of IoE enabled sensors, connected to LI-COR Cloud.

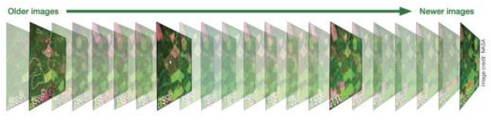
- The Internet of the Environment (IoE, a subset of IoT, enables the real-time evapotranspiration, carbon and sensible heat flux monitoring, providing critical data on environmental parameters to enhance the accuracy and reliability of earth system monitoring.
- Distributed sensing at each node location provides even greater spatial and temporal measurements of atmospheric and biogeochemical processes.
- Data is ingested, processed, and visualized in real-time using cloud-based computing, to reduce time to analysis.

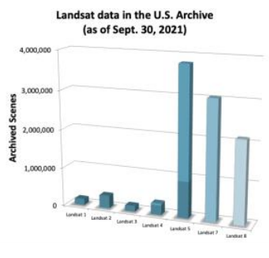
Figure 3: Image of an airborne monitoring asset operated by NASA. ([1])

Airborne Remote Sensing

- Airborne sensing platforms, equipped with hyperspectral and atmospheric composition retrievals, offers high-resolution data on atmospheric and surface conditions.
- This airborne data expands ground-based IoT sensors, providing a much broader spatial coverage.

Spaceborne Remote Sensing





Figures 4,5,6: Landsat 9 rendering ([2]), conceptual representation of historical imagery for an area of interest., quantity of Landsat data in the NASA archive.

- National infrastructure scale investment in satellite remote sensing provides very extensive coverage and long-term data records essential for monitoring global environmental changes, land use, vegetation function, atmospheric conditions.
- The volume of data generated by satellite remote sensing continues to increase, with data from the Landsat program generating tens of millions of scenes available in the U.S. Archive. ([3])

National and Global Infrastructure Scale Monitoring

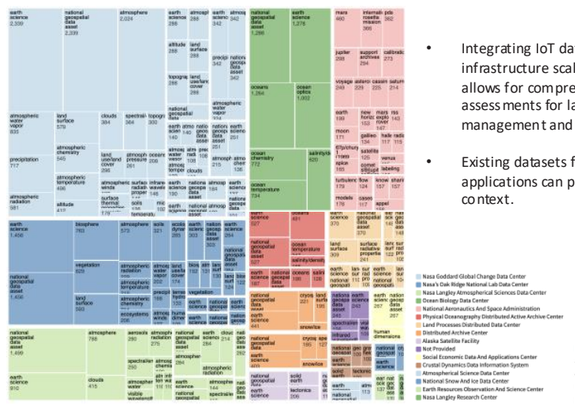


Figure 7: Overview of NASA's data archive assets, which can be combined with new flexible monitoring assets for further science. ([4])

- Integrating IoT data with national infrastructure scale monitoring systems allows for comprehensive environmental assessments for large-scale environmental management and policy-making.
- Existing datasets from a broad range of applications can provide valuable historical context.

WHyMSIE Project

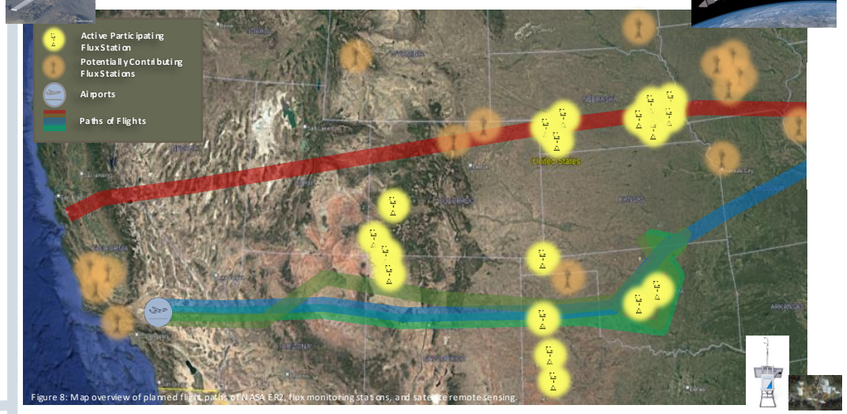


Figure 8: Map overview of planned flight paths of NASA ER2, flux monitoring stations, and satellite remote sensing.

- The NASA WHyMSIE (West-coast and Heartland Hyperspectral Microwave Sensor Intensive Experiment) project ([5]), conducted in 2024, integrates LI-COR IoE sensors, high altitude NASA ER2 airborne sensing), and spaceborne satellites, into a comprehensive monitoring system.
- This system demonstrates the potential for enhanced earth system science monitoring by providing accurate, real time data on evapotranspiration, carbon flux, sensible heat, and land surface conditions.
- The fusion of these data sources enables a detailed analysis of environmental changes, supporting effective management and policy decisions.
- The value of the national investment into monitoring infrastructure is increased when combined with flexible and dynamic private monitoring networks.

References

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