

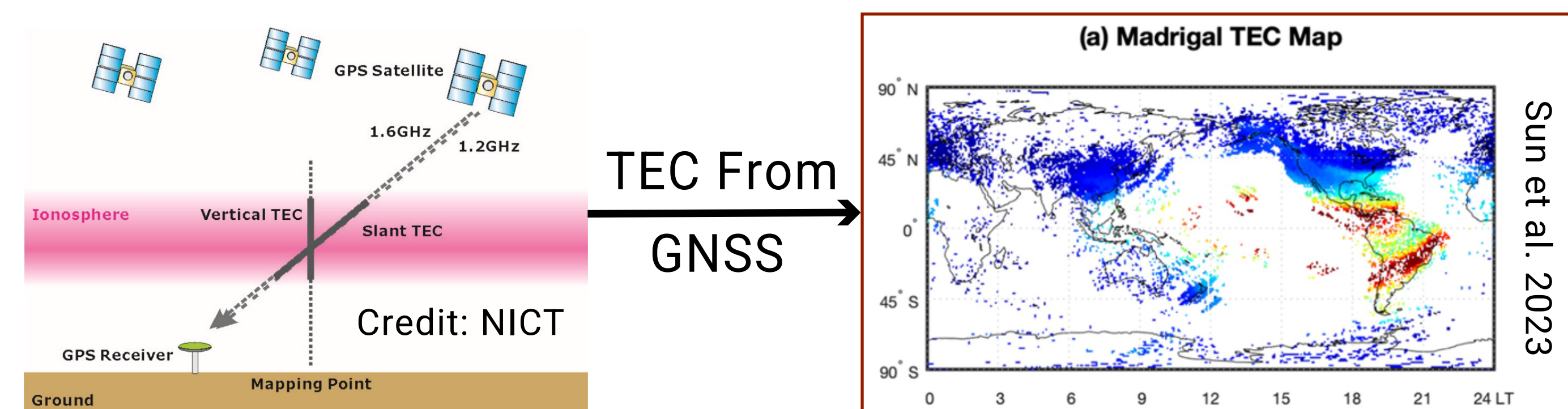
Multi-Source Data Fusion for Global TEC Map Construction with VISTA Algorithm

Hang Liu, Shasha Zou, Grace Kwon, Lei Liu & Mary Smirnova

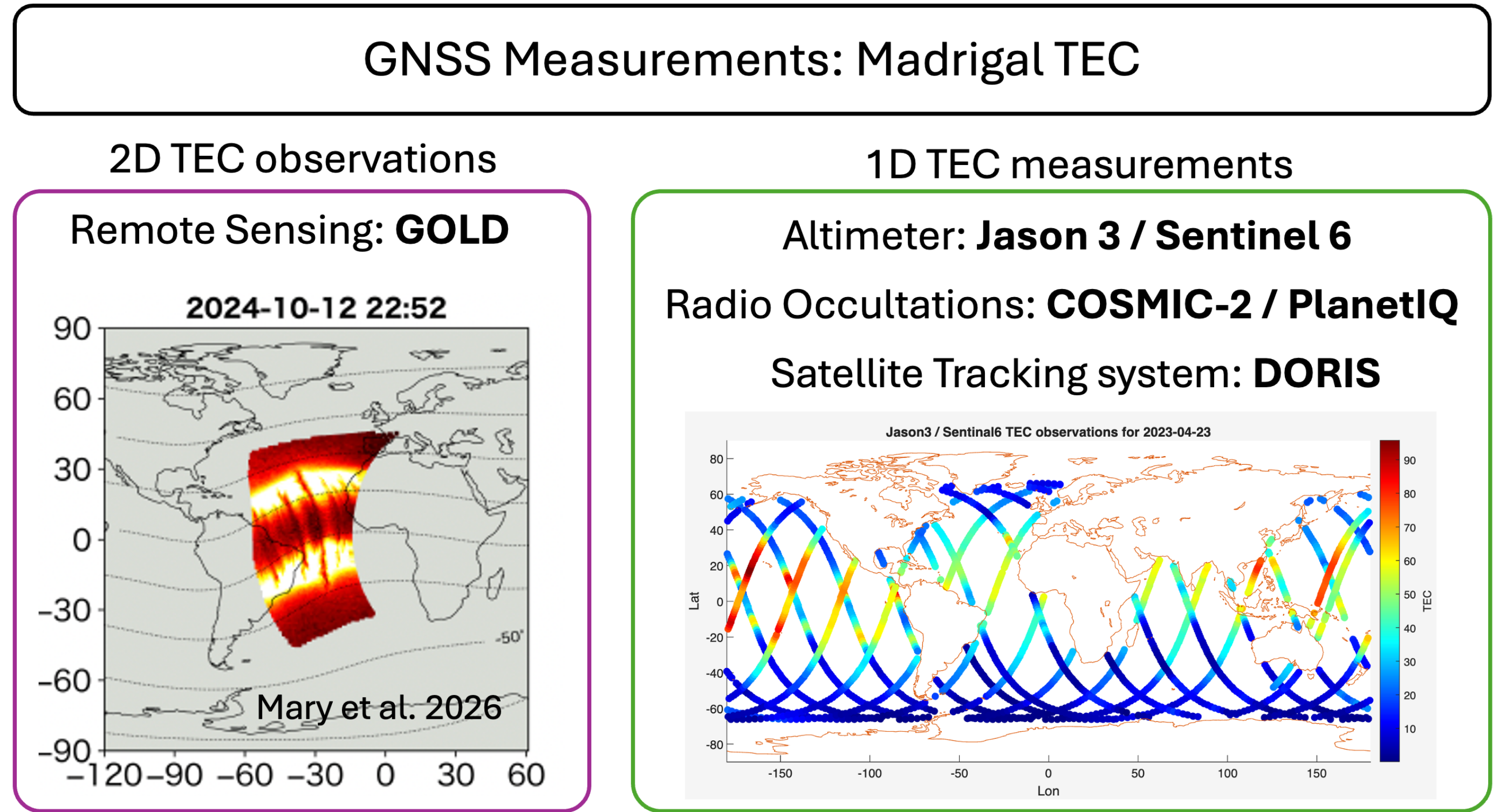


Introduction

- **Total electron content (TEC)** plays a critical role in space weather research & radio science ionospheric correction.
- **VISTA** reconstructs global TEC maps from Madrigal TEC, offering **spatial smoothness, temporal continuity, & multi-scale structure preservation**.
- **Madrigal TEC** (from GNSS) is sparse & uneven, especially over oceans, **limiting VISTA's performance**.
- **Fusing complementary data sources** enhances the performance of VISTA in capturing multi-scale ionospheric variations, especially over oceans.



Data Source



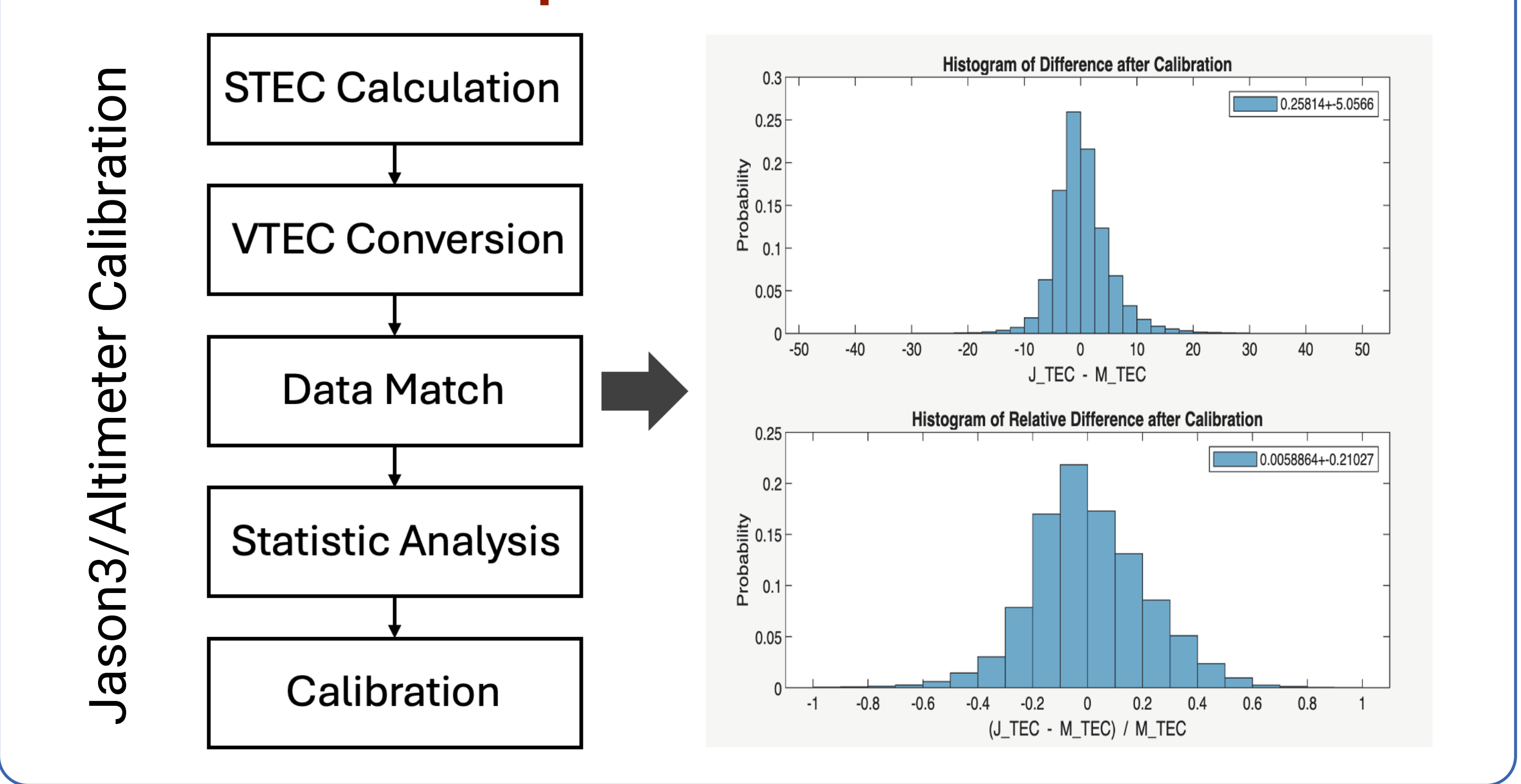
§ Multi-source observations & Flexible framework for future data

Data Calibration

Criteria for Data Calibration

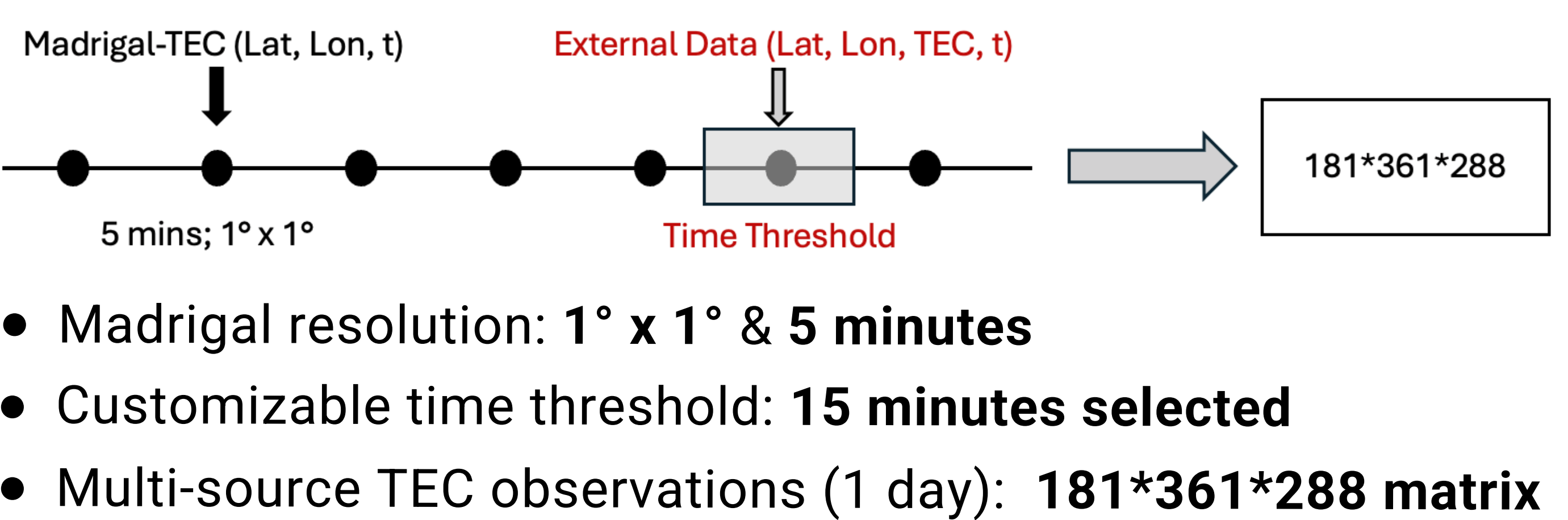
- **Benchmark: Madrigal TEC** --> Calibrate data to close Madrigal
- **Individually tailored process** --> Unique characteristics
- **Equal weight** --> Treat all data in VISTA with same weight

Example of Data Calibration

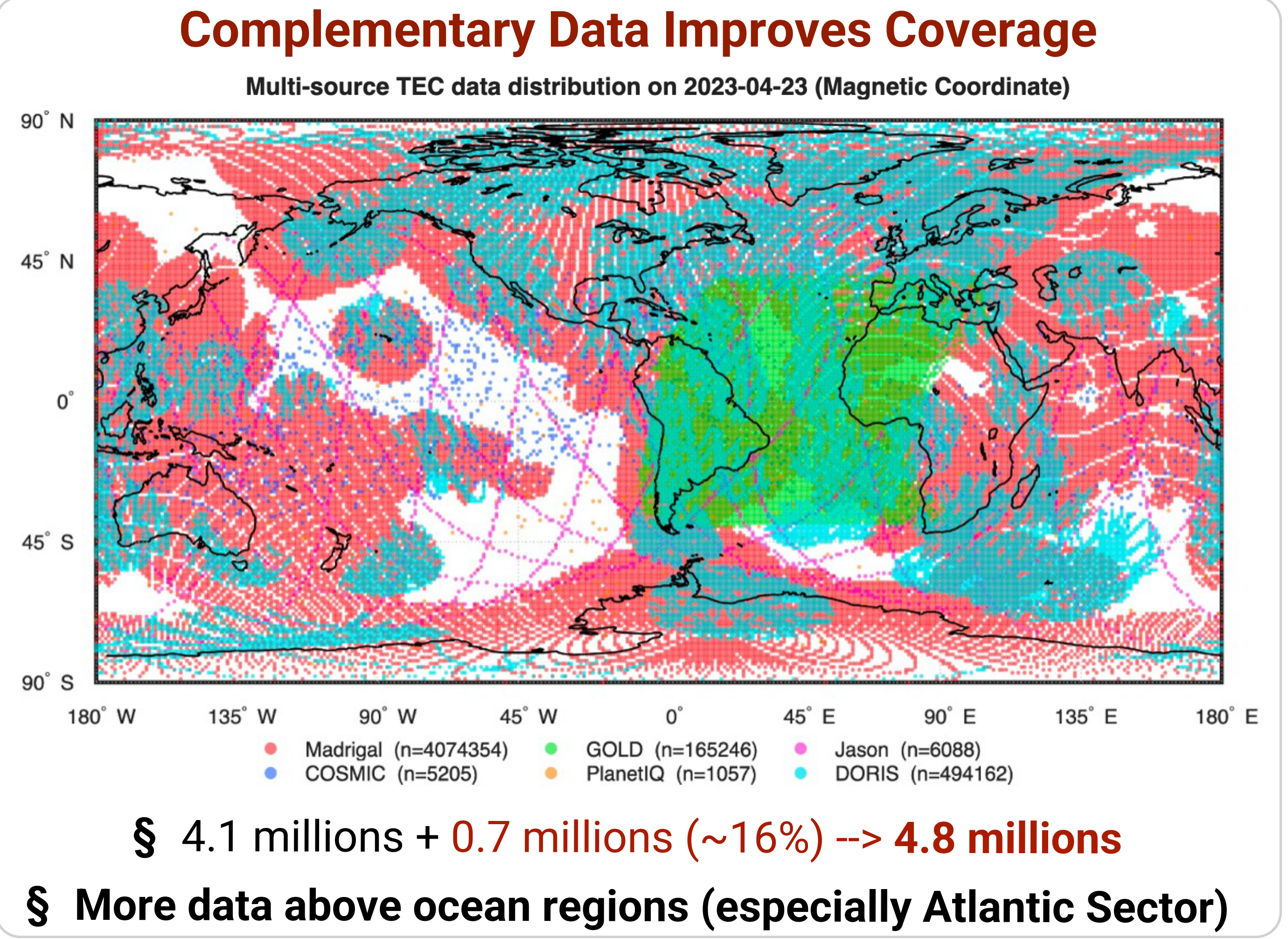


Data Combination

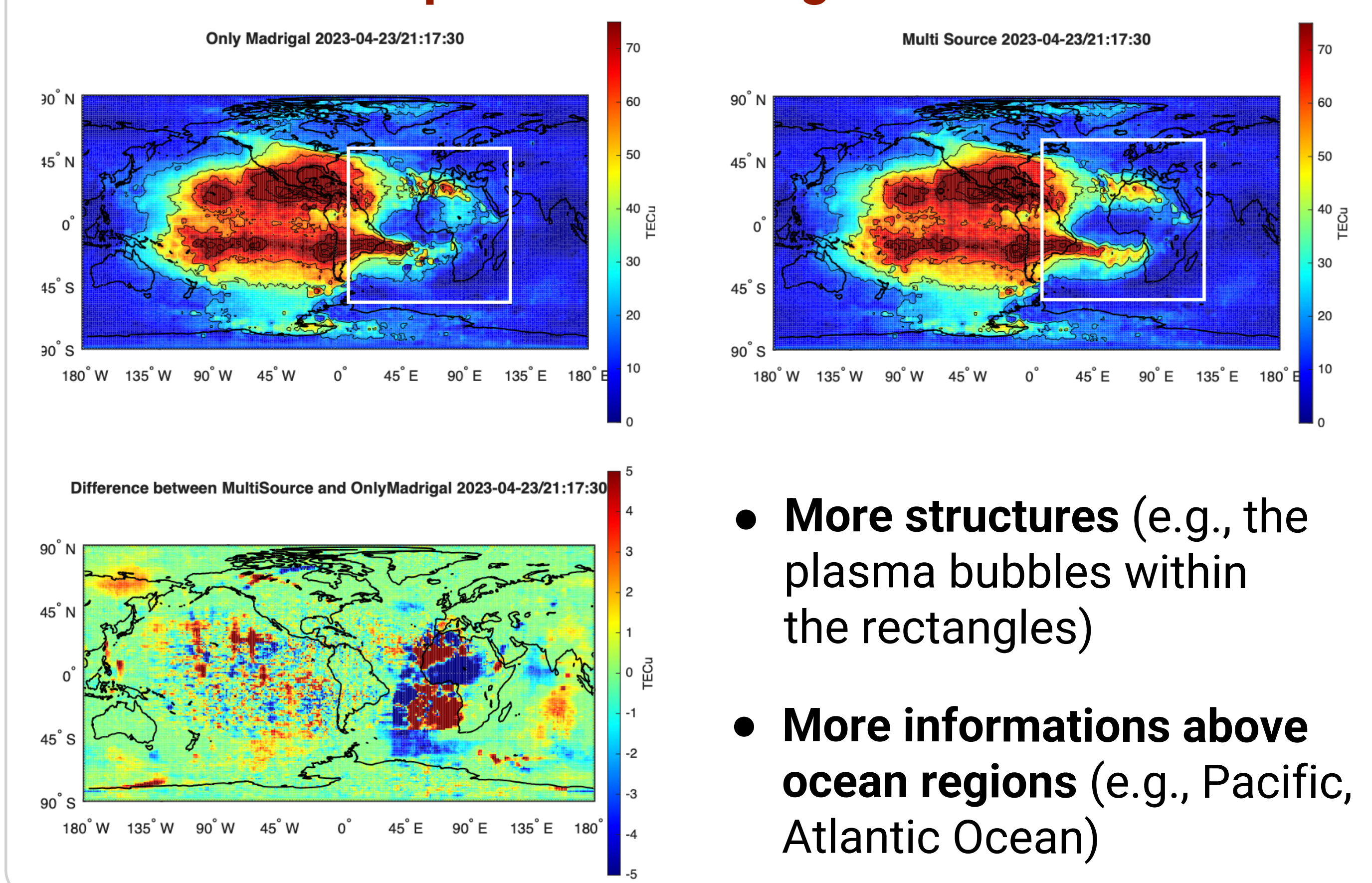
Workflow of Data Combination



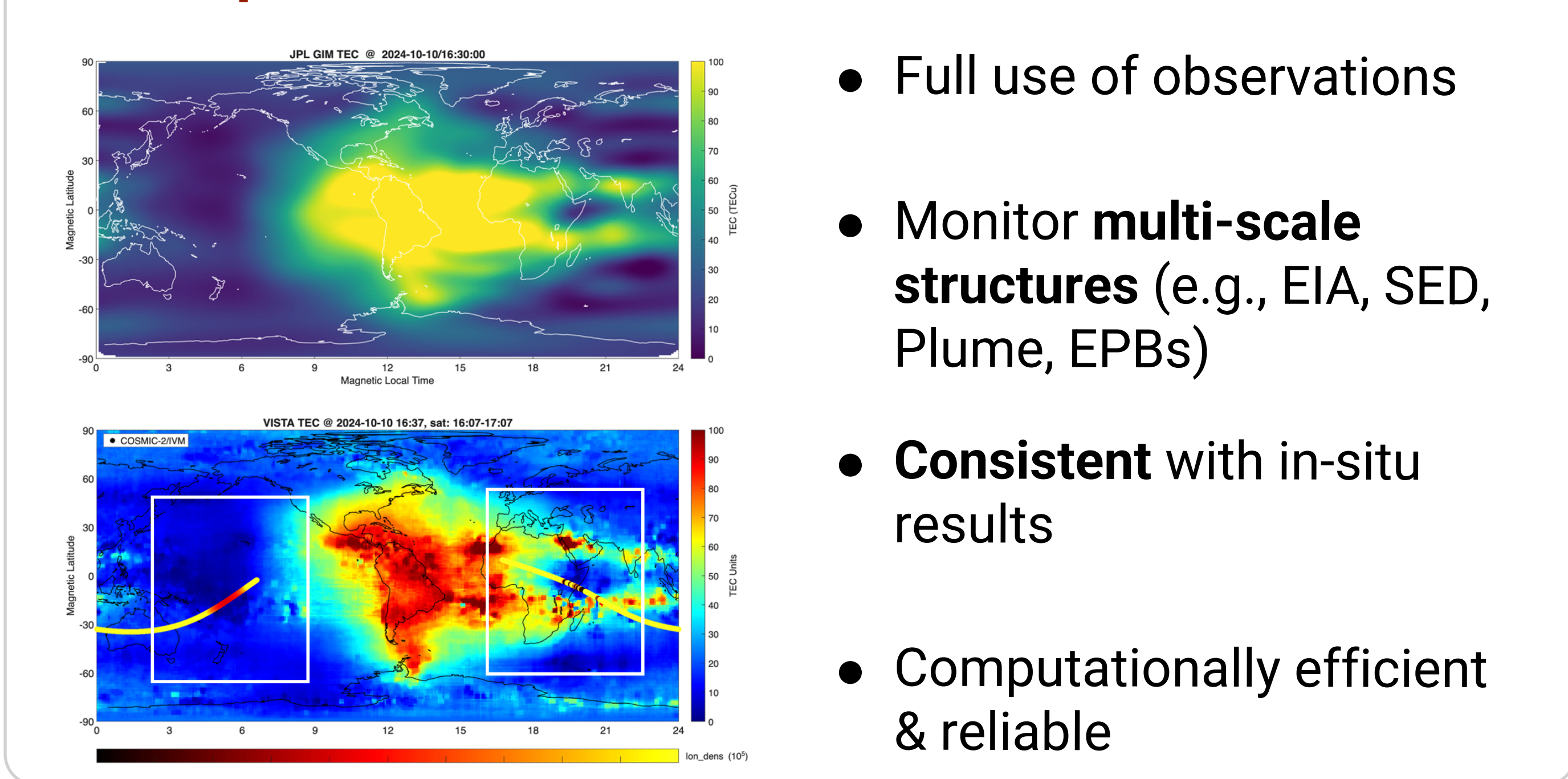
Results



Comparison with Original VISTA



Comparison with JPL GIM / In-situ Measurements



Conclusion

To overcome the limitations of previous VISTA model caused by GNSS-TEC:

1. **Multi-source datasets** are fused into VISTA to generate new-version global TEC maps;
2. **Clear improvements** especially over ocean regions;
3. **Advanced tool** for space weather and radio-science;
4. **Valuable validation dataset** for simulations (e.g., physical models, machine learning, & AI).

Selected References

1. Sun et al. "Matrix completion methods for the total electron content video reconstruction." The Annals of Applied Statistics 16.3 (2022): 1333-1358.

2. Smirnova, M., et al. "Calibration and Fusion of GOLD-Inferred TEC Data with Ground-Based TEC." Space Weather, vol. 24, 2026, p. e2026SW004978, <https://doi.org/10.1029/2026SW004978>.