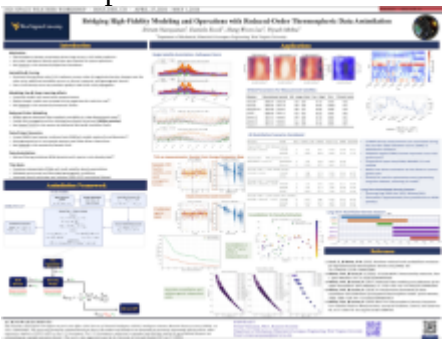
Sriram
Narayanan
West Virginia University
Daniele Sicoli, West Virginia University
Piyush Mehta, West Virginia University
Poster
Accurate thermospheric mass density knowledge is critical for precise orbit determination, collision avoidance, and Space Situational Awareness/Space Domain Awareness (SSA/SDA). While physics-based General Circulation Models offer comprehensive atmospheric understanding, their computational demands preclude real-time use. Empirical models, though efficient, struggle to capture nonlinear thermospheric behavior, particularly during storm events. This work presents a data assimilation framework leveraging a reduced-order thermospheric model to bridge this gap toward operational SSA/SDA capability.
The framework centers on a reduced-order representation of thermospheric density dynamics derived from high-fidelity physics-based simulations, capturing dominant variability modes and their dependence on solar and geomagnetic drivers while enabling rapid propagation and real-time updating. Two reduced-order model classes are considered: a nonlinear sparse identification approach with control inputs (SINDyc) and a linear dynamic mode decomposition baseline (DMDc), both embedded within a Kalman filtering architecture for sequential density observation assimilation.
The framework is evaluated using in situ density measurements from CHAMP, GRACE/GRACE-FO, GOCE, and Swarm missions spanning diverse altitudes, local times, and geomagnetic conditions. Assimilation significantly improves density estimation accuracy over open-loop predictions, particularly during geomagnetically active periods. The nonlinear formulation consistently outperforms the linear baseline under limited observational coverage. A second evaluation phase incorporates the High Accuracy Satellite Drag Model (HASDM) and two-line element (TLE)-based orbital data, demonstrating compatibility with operational pipelines without proprietary inputs.
The framework delivers dynamically consistent density estimates, supports multi-satellite assimilation, and operates at computational costs suitable for real-time use. Future work includes heterogeneous measurement fusion and exploration of particle-based and generative modeling approaches, advancing reduced-order thermospheric data assimilation as an enabling technology for next-generation SSA/SDA systems.

Poster PDF
Narayanan-Sriram.pdf
Poster session day
Wednesday, April 29, 2026
Poster location
3
Meeting homepage
2026 Space Weather Workshop
Download to PDF