COSMIC 2 POD Thermospheric Density Data Jan 1 to July 3 2024

Recent Progress

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UCAR COMMUNITY PROGRAMS COSMIC

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Overview

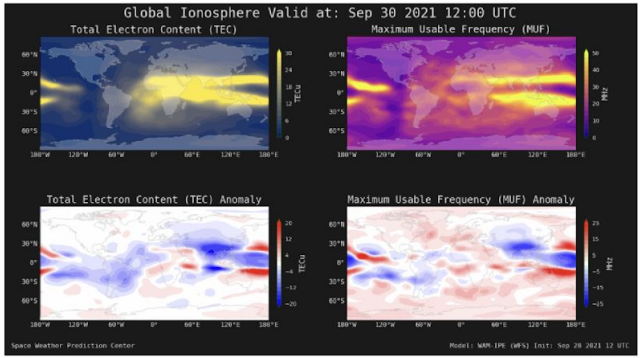
- As more satellites are launched into Low-Earth Orbit (LEO), it has become critical to predict orbits precisely to avoid collision with other satellites or space debris. Satellite collisions not only cause the loss of satellites, moreover they create additional debris and exacerbate an already burgeoning space debris population. If LEO space traffic is not carefully managed, we will face a future with ever increasing space debris, rendering space flight more precarious or even impractical. Atmospheric drag is the largest perturbing force in the LEO regime and is by far the most difficult to predict.
- The COSMIC-2 mission is a six-satellite constellation (24° inclination, ~580 km altitude) operated jointly by NOAA, the US Space Force, and the Taiwan Space Agency, with UCAR providing the operational data processing center.
- For this effort, we will use the COSMIC-2 POD to derive thermospheric neutral mass density from the non-conservative acceleration using sophisticated aerodynamic force models, following the removal of the solar radiation pressure (SRP) acceleration. These products will then be provided to SWPC for assimilation into their operational Whole Atmosphere Model and Ionosphere Plasmasphere Electrodynamics (WAM-IPE) model.

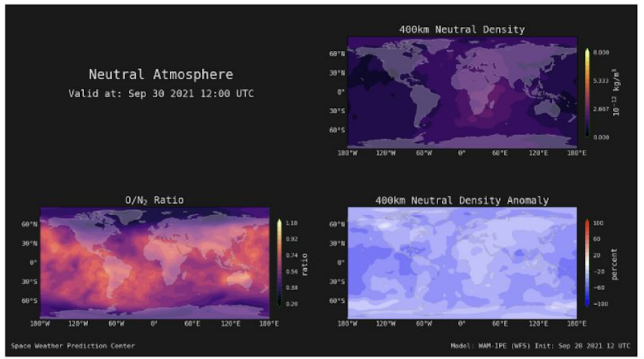
WAM-IPE Operational Model at SWPC

Whole Atmosphere and Ionosphere Plasmasphere Electrodynamics Model

- An extension of the US weather model to 600 km altitude coupled with a plasma component of the atmosphere.
- Includes all the lower atmosphere weather and dynamics processes, as well as all the additional T-I physics (including electrodynamics and plasma processes)
- WAM provides the 3D fields for neutral winds, temperature, density, major species composition O, O_2, N_2. for drag. The plasma component, IPE, provides plasma densities and velocities, and temperatures in the ionosphere and plasmasphere for communications and navigation impacts
- WAM-IPE has been in operation since July 2021 with the latest upgrade in Aug 2023. Two operational CONOPS provide T-I nowcast as well as forecast two days in advance

https://www.swpc.noaa.gov/products/wam-ipe



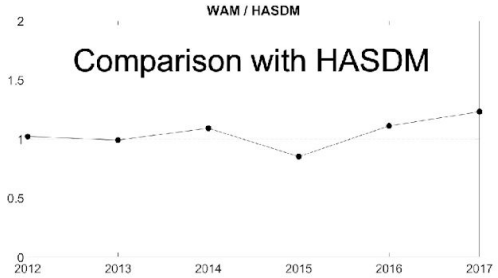


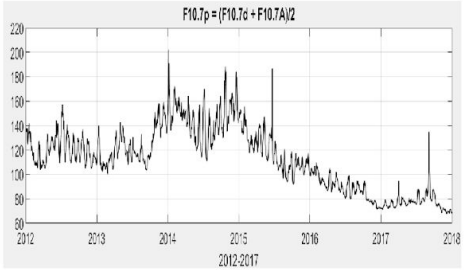
Fang 2025

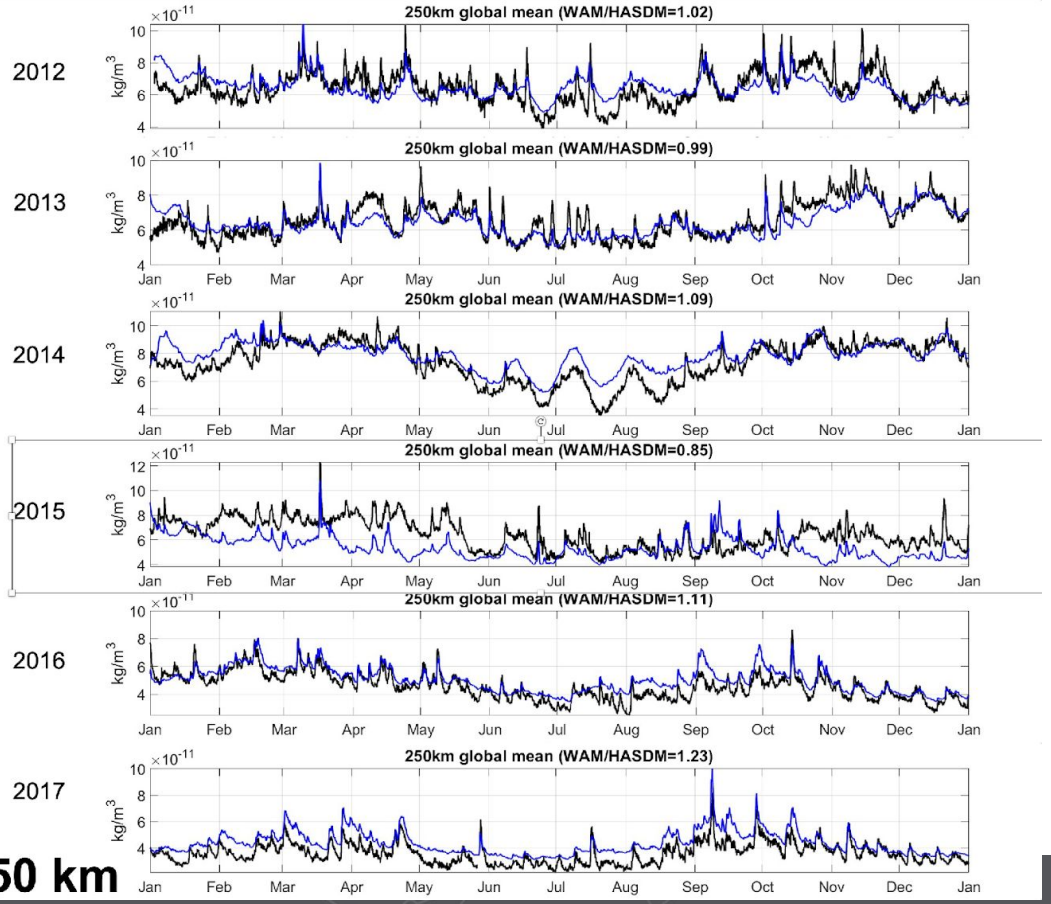
NOAA Operational Model and HASDM Compairson (Fang 2025)

Neutral Density Validation

Multi-year simulations from WAM-IPE

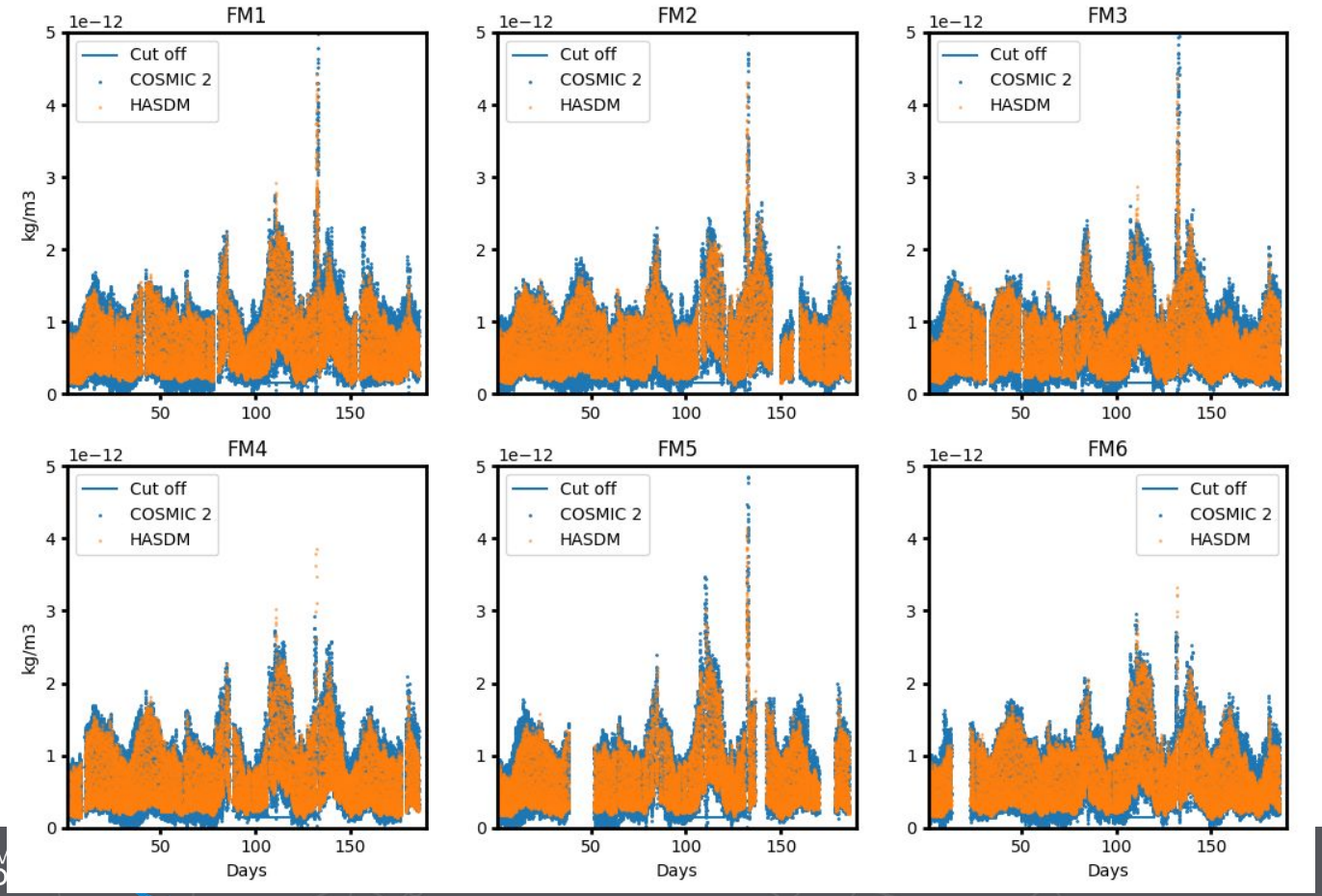




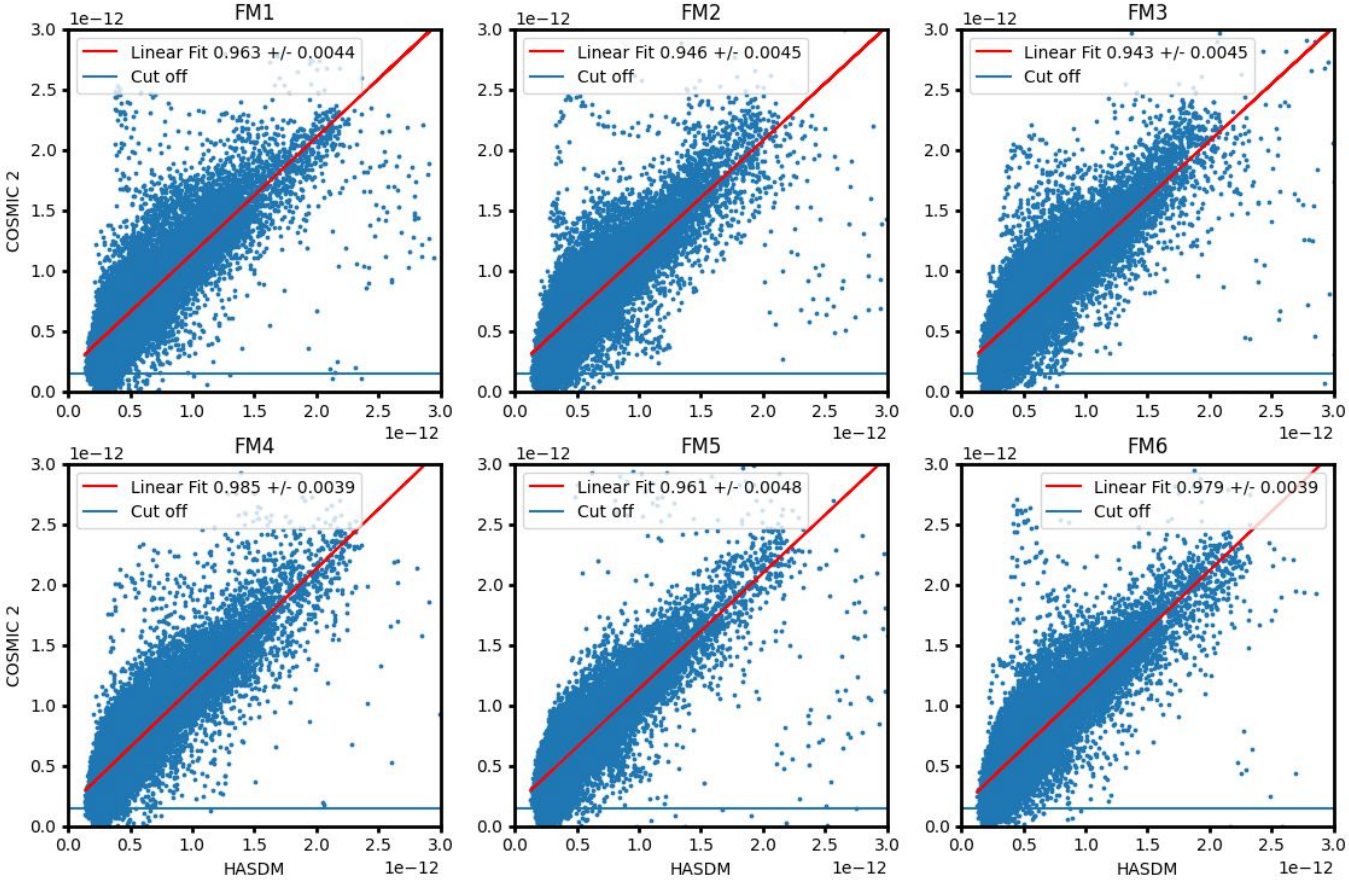


250 km

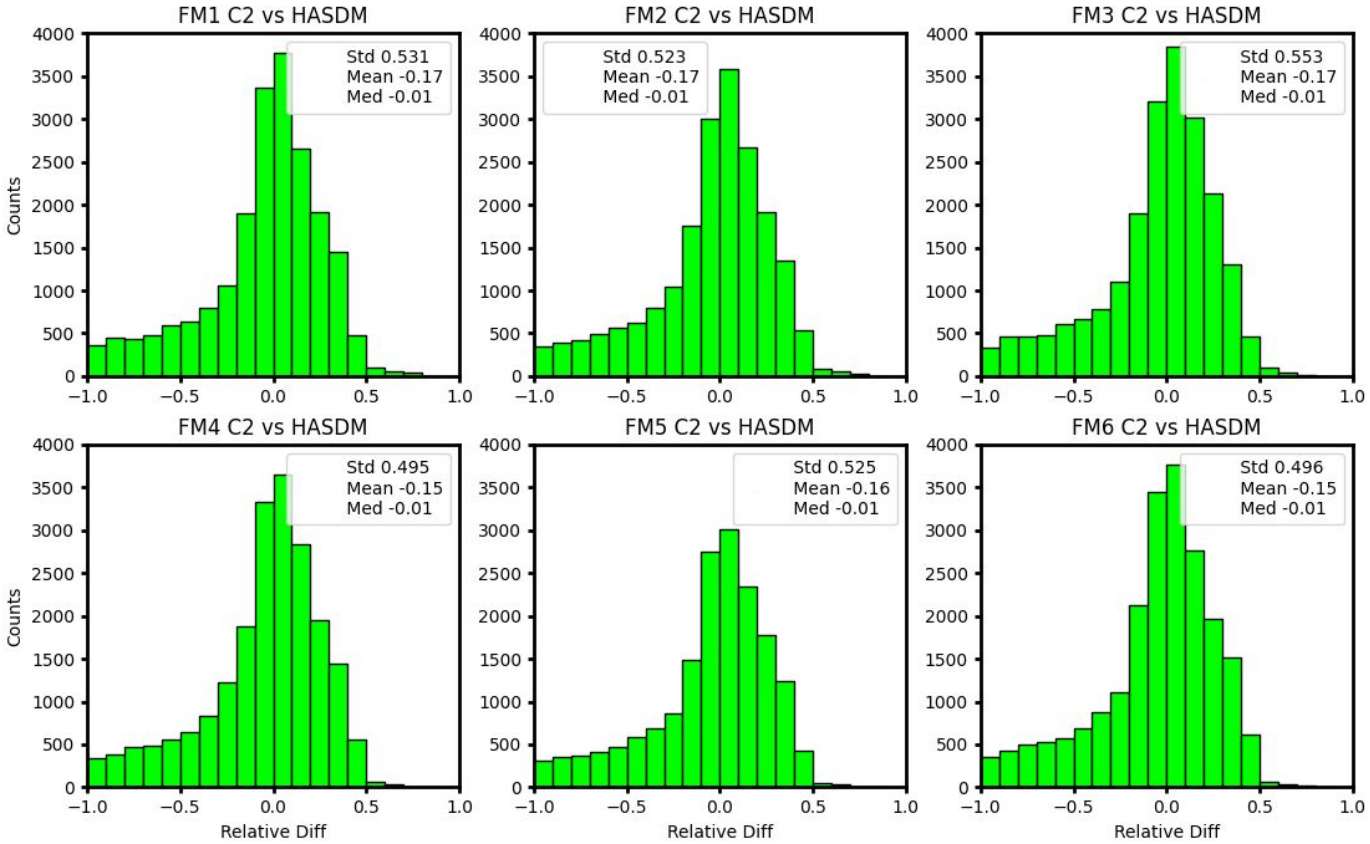
COSMIC Thermospheric Density Daily Variations Jan 1 to July 3, 2024



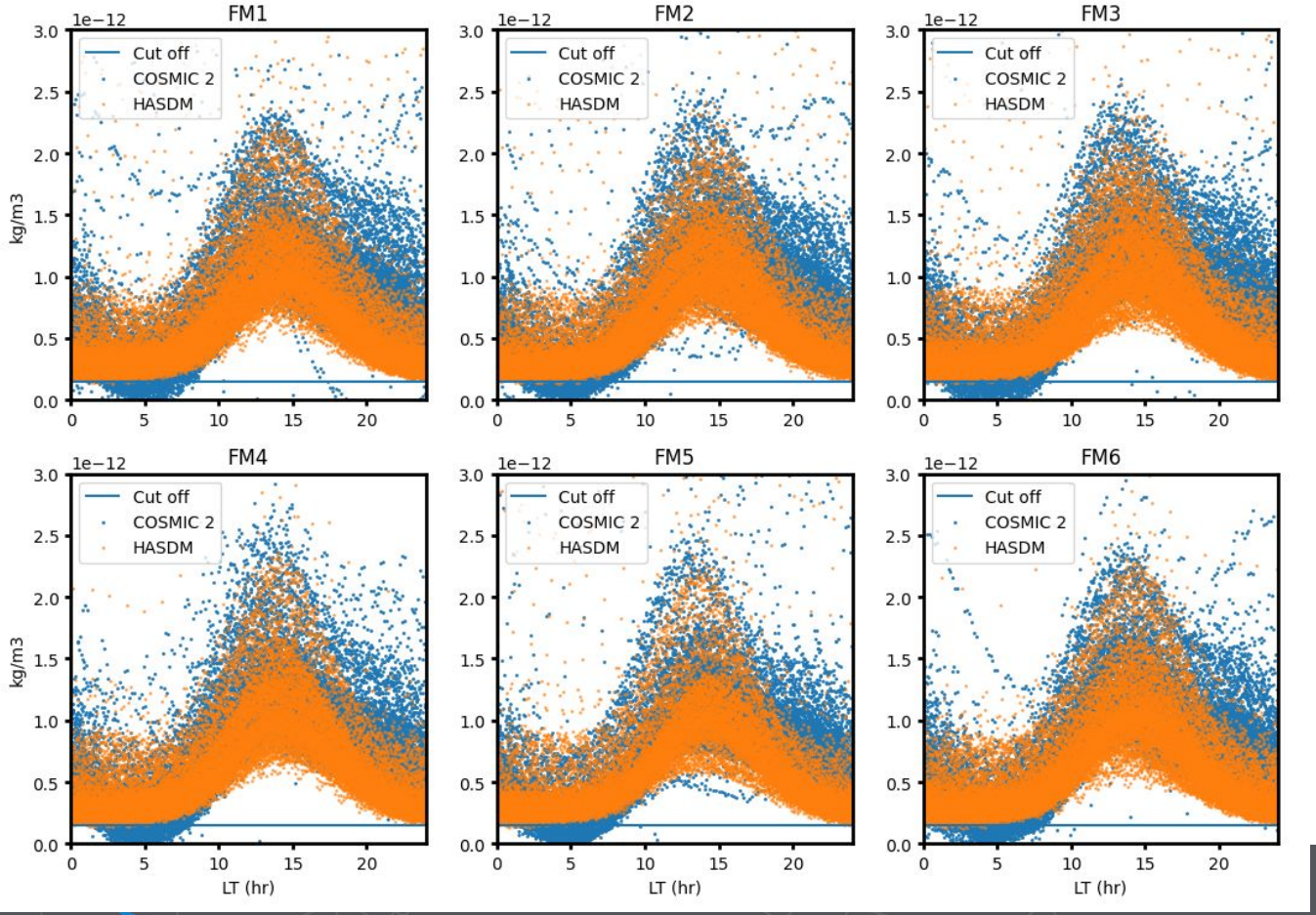
COSMIC vs HASDM 2024 Day 1 – 185 (Jan 1 to July 3)



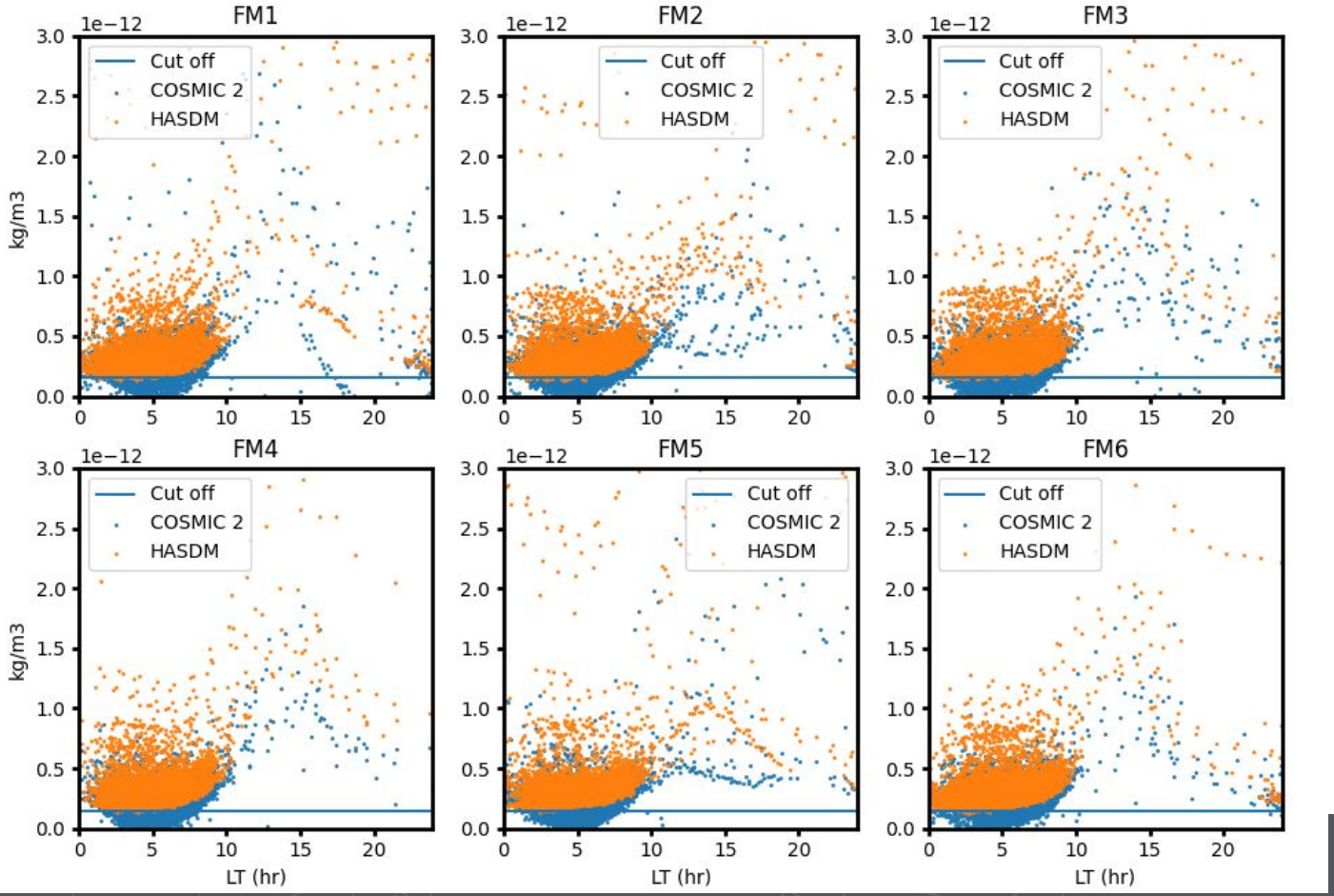
Histograms of COSMIC 2 (with scaling) vs HASDM



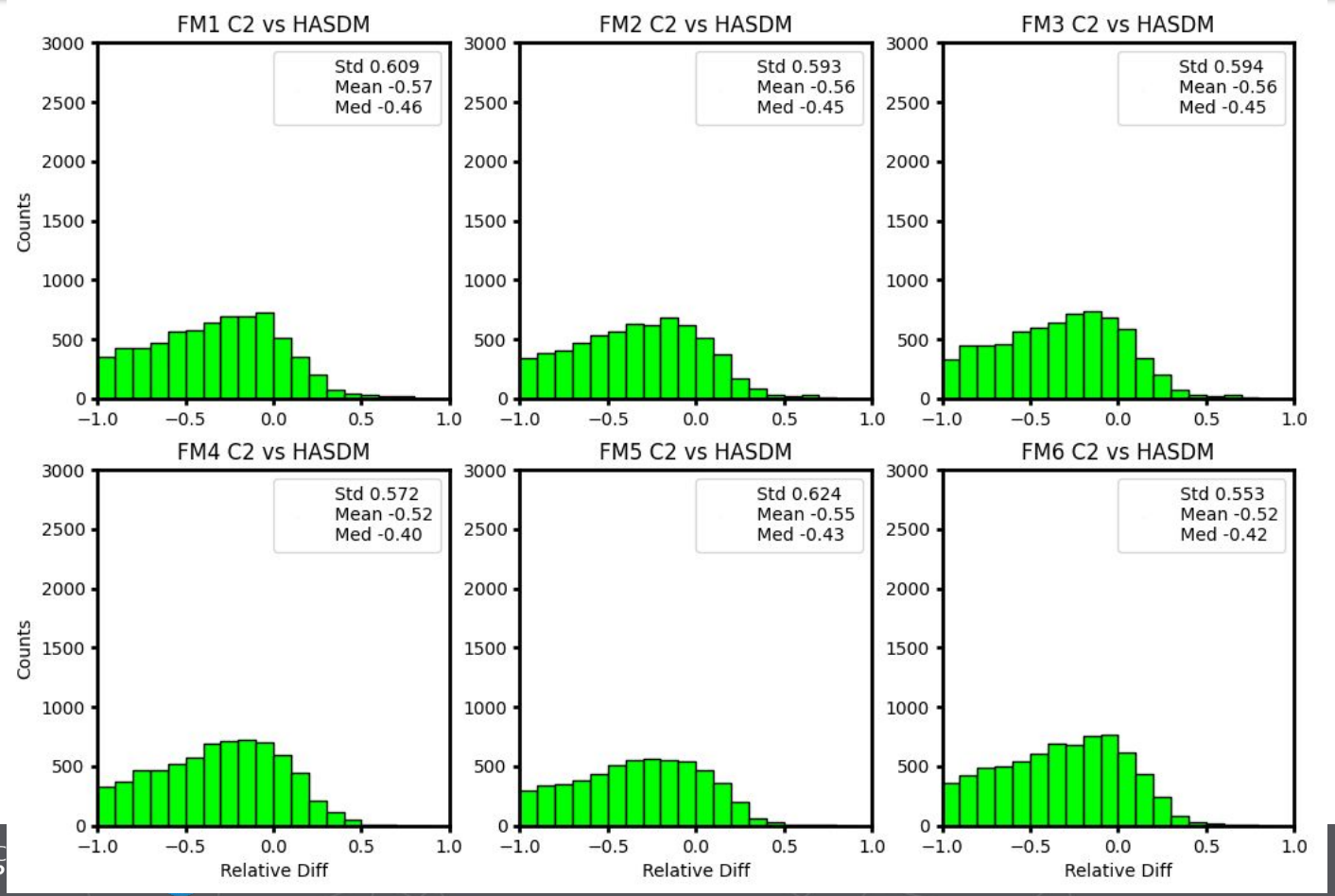
Density Local Time Variations



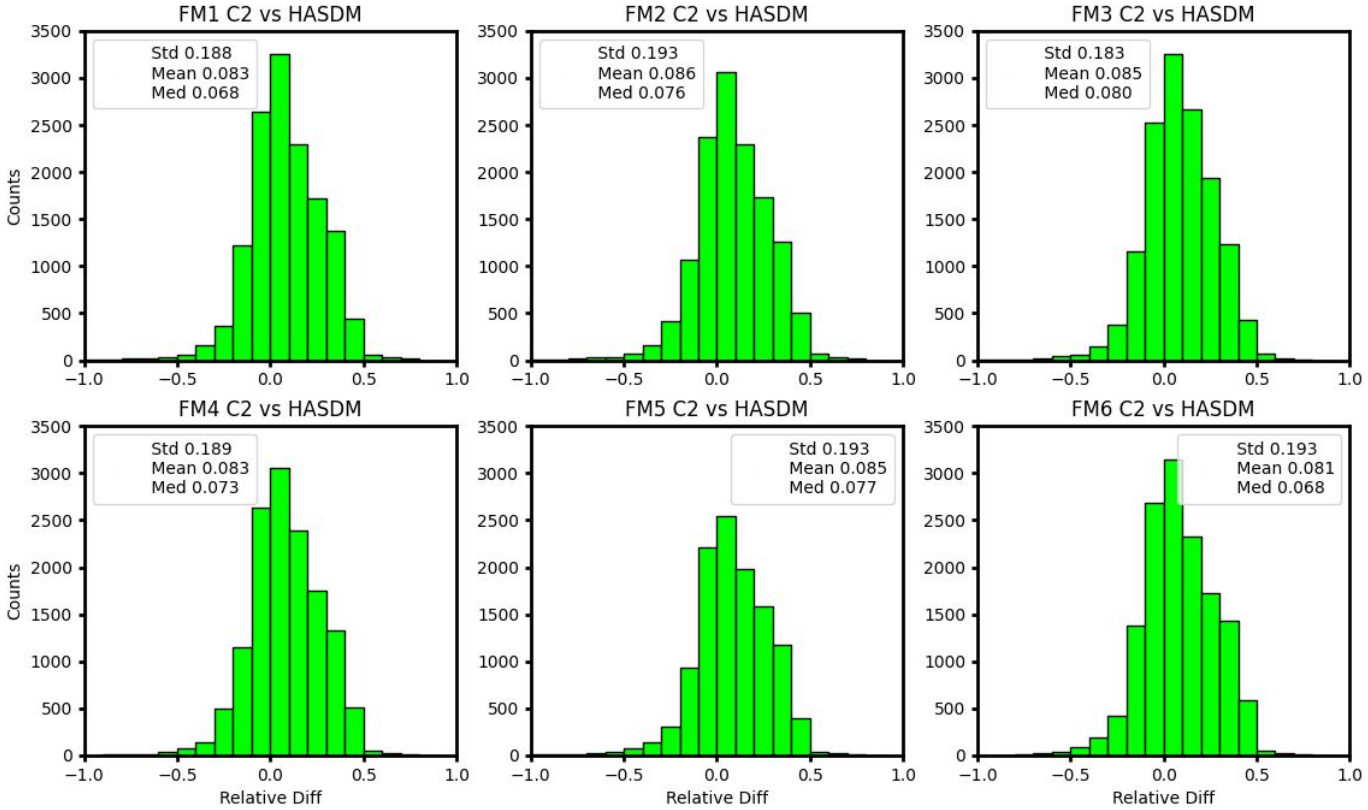
Relative Difference less -50% (C2 < HASDM)



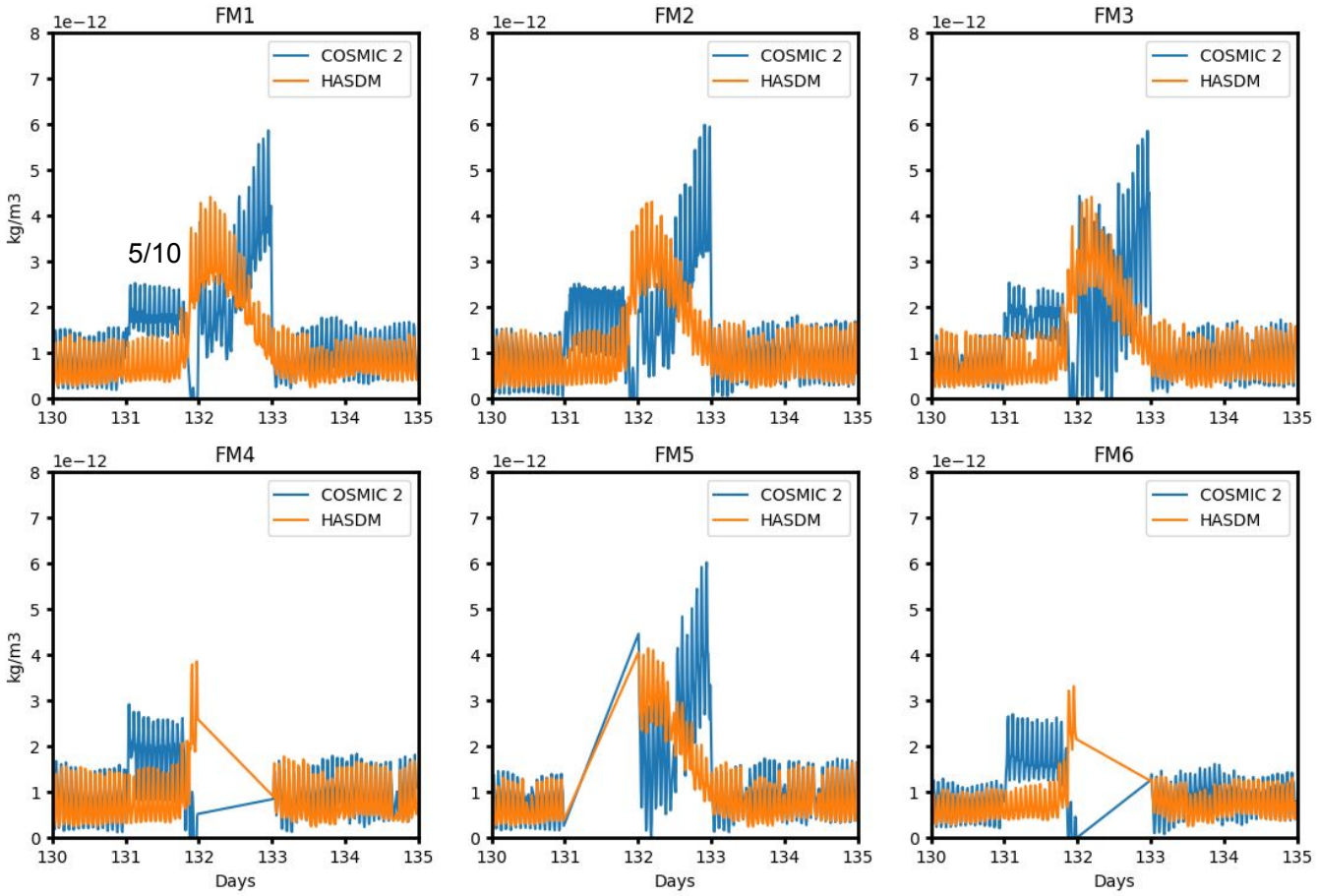
Nighttime data LT < 10 Jan 1 to July 3, 2024



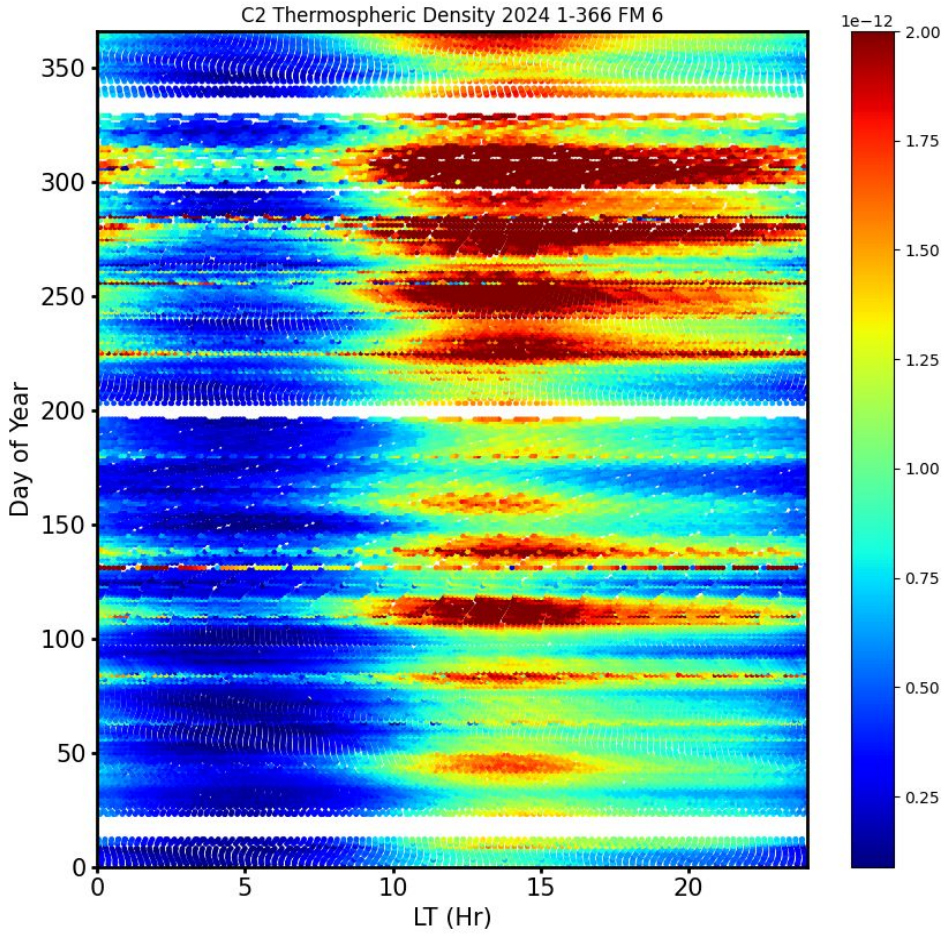
Daytime data (LT > 10) Jan 1 to July 3, 2024 (without outliers)



C2 and HASDM Densities May 10, 2024 Storm Event



LT and Daily Variations of Density



Summary

- The C2 POD densities agree with the HASDM results very well.
- The 27-day solar rotation signature is clearly seen in the C2 POD data.
- The daytime data deviations from HASDM after removal of outliers are ~19%.
- The C2 nighttime data are underestimated by 55% with a deviation about 60%.
- The overall C2 vs HASDM comparisons yield a ratio of about 0.96 (noting the daytime data has a large effect on the ratio).
- The POD files during the May 10, 2024 storm may be affected resulting density errors.