Comparison between FORMOSAT-7/COSMIC2 IVM Ion Density and TGRS Electron Density

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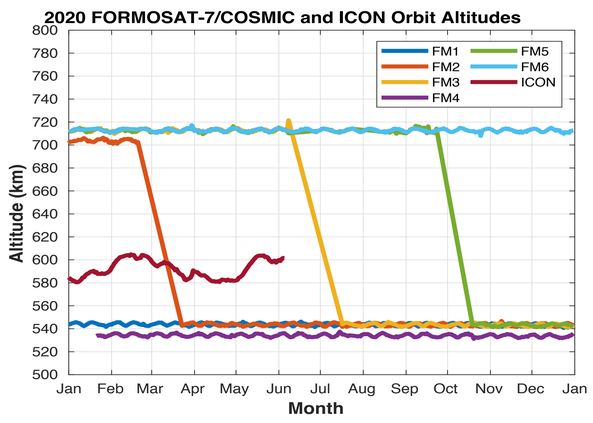
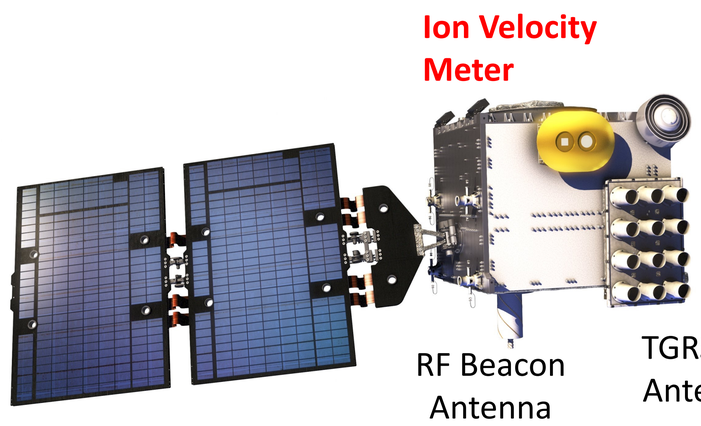
Motivation

- Both TGRS and IVM payloads onboard the F7/C2 satellites provide an unprecedented opportunity for validation with abundant collocated observations.
- Validate the F7/C2 IVM ion density with the TGRS orbit electron density.
- Evaluate the data quality and error distributions in terms of local time, magnetic latitude, month, and orbital altitudes.

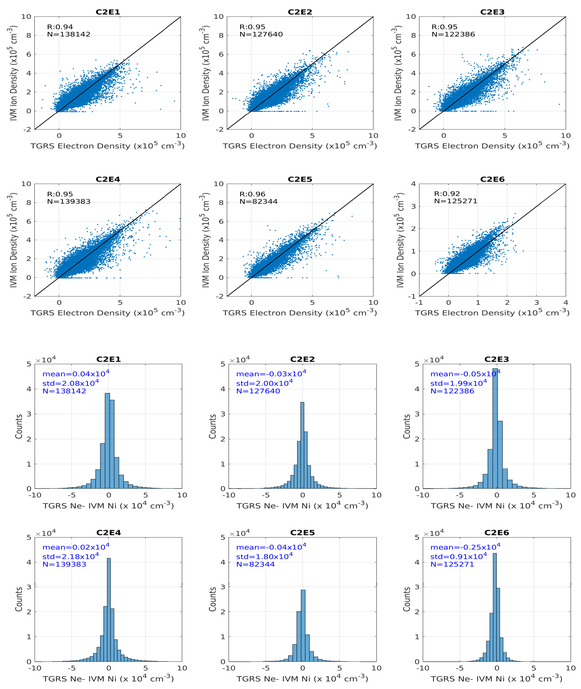


FORMOSAT-7/COSMIC2 Dataset



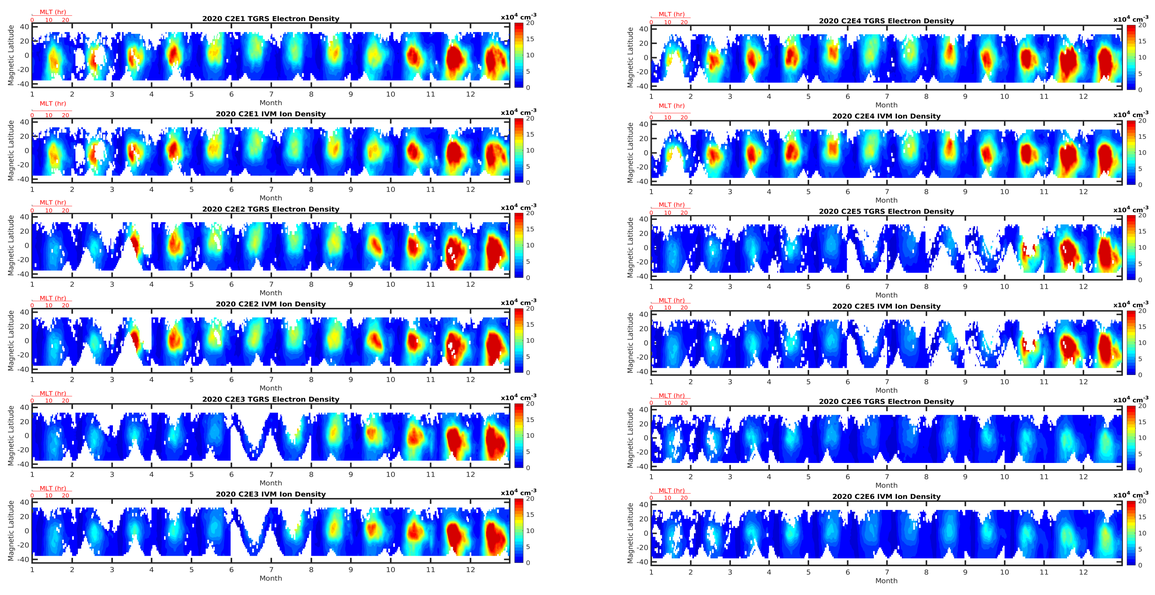
- **Ion Velocity Meter (IVM): Ion density**, composition, temperature, and drift.
- **Tri-GNSS Radio Occultation System (TGRS):**TEC and **electron density**

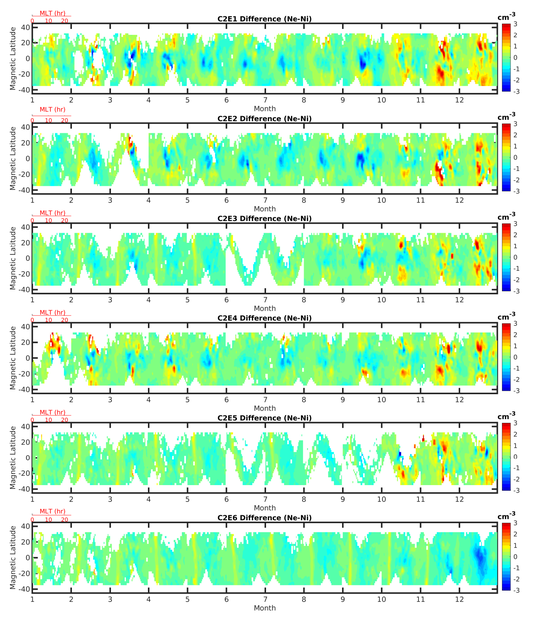
Results and Discussions



- The collocated observations are selected for comparison by restricting the distance and time within 100 km and 1 sec universal time throughout the year of 2020.
- The TGRS orbit electron densities are generally consistent with the IVM ion density observations with correlation coefficients of 0.94, 0.95, 0.95, 0.95, 0.96, and 0.92 for C2E1-C2E6, respectively.
- The mean density differences for each of satellites are around -0.03×10^4–0.02×10^4 cm^{-3} with standard deviations ranging from ~0.91×10^4–2.18×10^4 cm^{-3}.

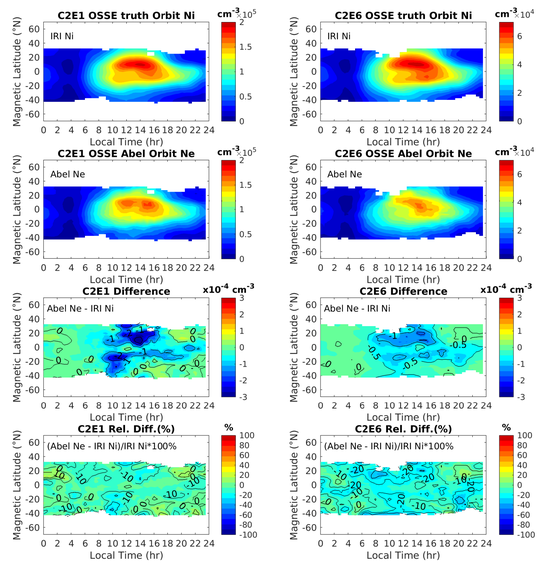
- The morphologies of EIA in TGRS orbit electron density is nearly identical to the IVM ion density observations, implying that both TGRS and IVM observations should be precise and accurate.





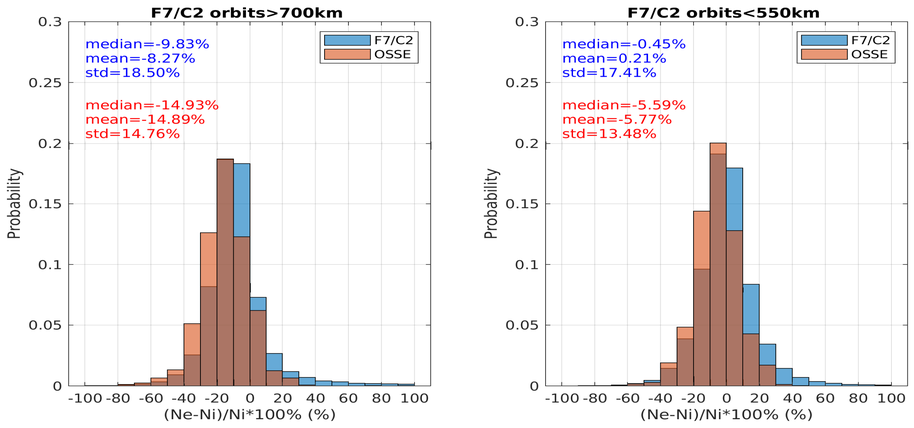
- At lower orbit, significant decreases of about 0.5×10^4 –2.5×10^4 cm^{-3} (-20–-10% relative errors) in TGRS electron density around the daytime EIA region (~08:00-18:00 LT).
- The TGRS electron density tends to be greater than the IVM ion density by 10-20% around the negative error EIA regions during the daytime
- At higher orbit, the error maps show smaller decrease of about -0.5×10^4–-1×10^4 cm^{-3}(-30–-10% relative errors) in TGRS electron density around the daytime EIA region.
- Nearly zero bias (-30–0% relative errors) at ~18:00-08:00 LT.

Observing System Simulation Experiments (OSSEs)



- The realistic RO LOS geometries between F7/C2 (FM1 and FM6) and GNSS satellites are utilized to simulate the synthetic calibrated TECs by inserting the LOS geometries into the IRI model.
- The synthetic orbit electron density can be calculated by fitting a square root function of $TEC_{cal}(r_0)$ for the upper most ~10 km under the assumption of a circular orbit and constant electron density along the orbit track.

$$TEC_{cal}(r_0) \approx 2N_e(r_{orb})\sqrt{2r_{orb}(r_{orb}-r_0)}$$



- The OSSE results reveal that the orbit electron density tends to be smaller than the ion density in the daytime EIA region and are nearly the same during the nighttime at both orbit altitudes, which is consistent with the F7/C2 observations.

Summary

- Comparison shows that the TGRS orbit electron densities are consistent with the IVM ion density with high corelation coefficients of 0.92-0.96.
- The mean density differences for each of satellites are around -0.03×10^4–0.02×10^4 cm^{-3} with standard deviations ranging from ~0.91×10^4–2.18×10^4 cm^{-3}, demonstrating a good precision between the TGRS and IVM observations.
- The morphologies of EIA between the TGRS and IVM density observations are nearly identical, demonstrating that both F7/C2 payloads are reliable to provide accurate topside ionosphere observations.
- The TGRS orbit electron density tends to be smaller than the IVM ion density in the daytime EIA region, which could be due to the spherical symmetry assumption in TGRS orbit electron density estimation.
- The OSSE results are comparable to the F7/C2 observations, suggesting that the IVM ion density should be accurate.