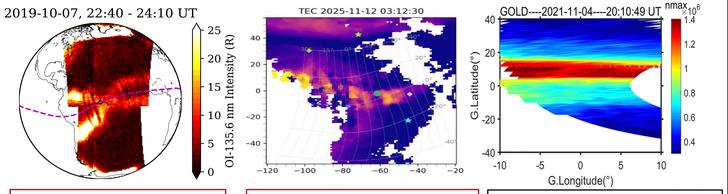
Equatorial Ionization Anomaly Crest Merging During 19-20 January 2026 Geomagnetic Storm

Tapendra Sodari[1] (txs9779@mavs.uta.edu), Zihan Wang[1], Yu Hong[2], Yuxi Chen[3], Robert Kerr[4]
1.University of Texas at Arlington 2. NSF National Center for Atmospheric Research, Boulder 2. University of Michigan, Ann Arbor 3. Computational Physics Inc., Lowell

EQIT-19
Wednesday

1. Background

Equatorial Ionization anomaly (EIA) primarily forms due to eastward electric field. The merged EIA crests have been observed during both geomagnetically quite and active times.



During quiet time. Downward vertical drift + Lower atmospheric forcing. Lasker, et al. (2024)

During MP; Min Dst -231nT at ~04 UT. large equatorward winds + westward PPEF. Zou et al., (2026)

During RP; Min Dst ≈ - 110 nT at 13:00 UT DDEF + meridional neutral winds. Wu, et al. (2025)

Objective: To investigate underlying physical mechanism driving EIA crest merging during the main phase of 19-20 January 2026 geomagnetic superstorm.

2. Data and Model

Data:

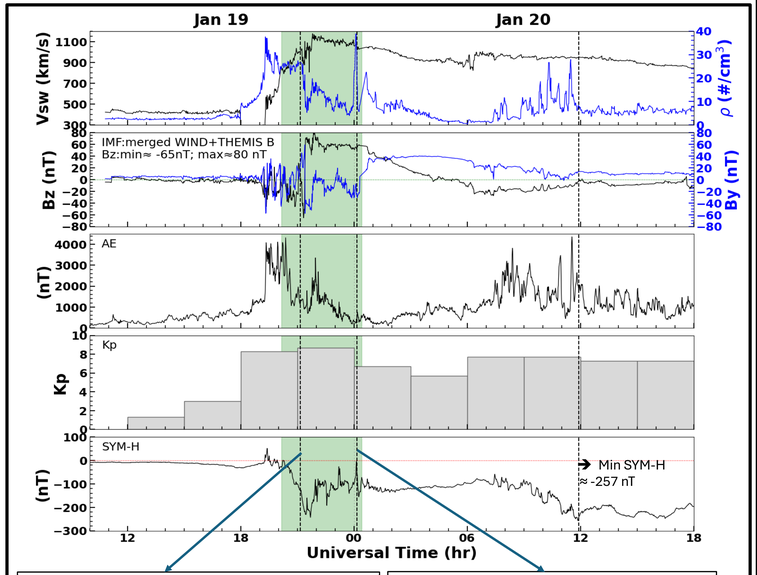
- GOLD level 2 NMAX + Madrigal TEC
- neutral winds at Millstone Hill (42° N, 72° W)

Model setup:

Global Ionosphere Thermosphere Model (GITM) with self-consistent 3D dynamo

- High Latitude forcing and auroral precipitation: SWMF/ Ridely Ionosphere Model based AMIE files

3. Geomagnetic Conditions



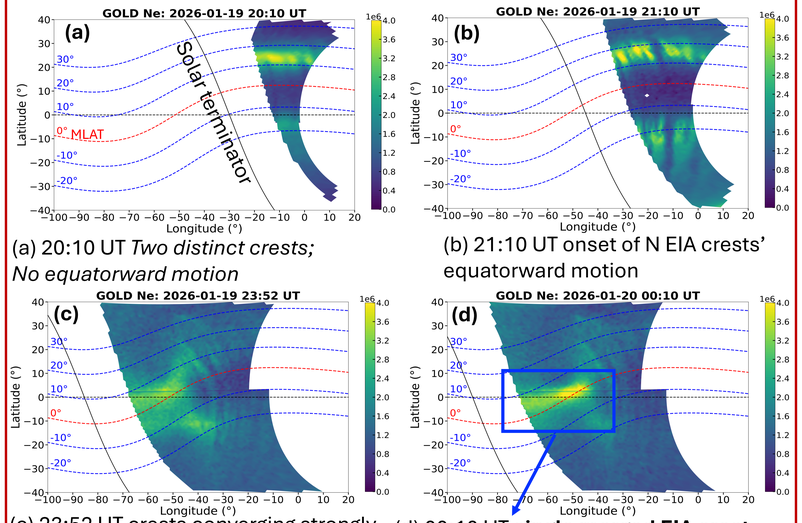
21: 10 UT onset of Equatorward motions of crests

00:10 UT **single EIA crest near 35° W longitude**

Green shaded region: GOLD observation period on 19 January.

4. Results: Observations

Evolution of EIA crest Merging as observed in GOLD Ne



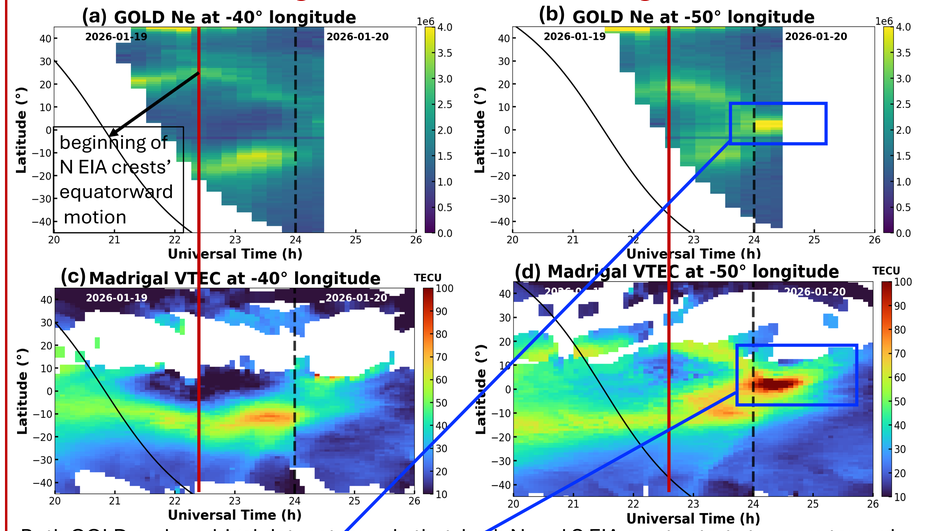
(a) 20:10 UT *Two distinct crests; No equatorward motion*

(b) 21:10 UT onset of N EIA crests' equatorward motion

(c) 23:52 UT crests converging strongly toward the geomagnetic equator

(d) 00:10 UT **single merged EIA crest near 35°W!!**

Keogram of GOLD Ne and Madrigal VTEC

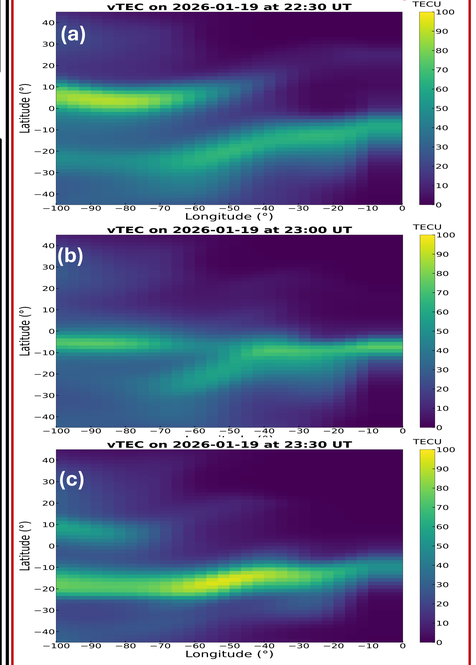


Both GOLD and madrigal dataset reveals that both N and S EIA crests starts to move toward the equator and merge near 00 UT on January 20. The merging is stronger near 50°W lon.

5. Results: GITM simulations (Preliminary)

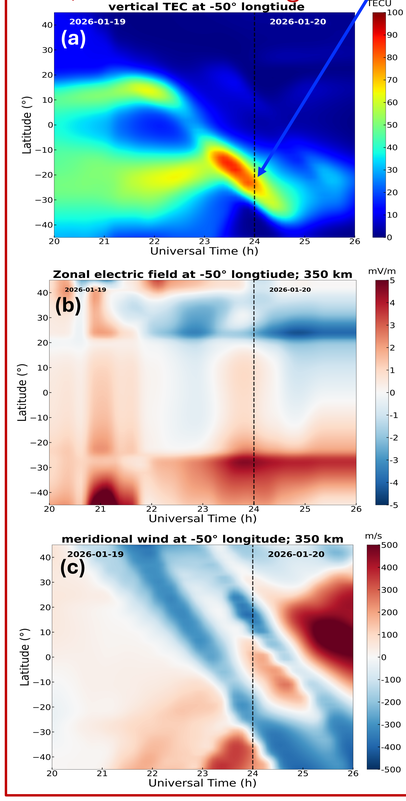
Same longitude (−50°): **GOLD Ne/Madrigal TEC shows merged EIA** → GITM TEC expands poleward

simulated VTEC on 19 January



(a): Two distinct EIA crests. **(b)**: A partial merge appears east of −50° longitude. **(c)**: Strong hemispheric asymmetry — dominant S crest; weak/absent N crest.

TEC, wind and EF Keogram at -50° lon; LT ≈ UT - 3.33

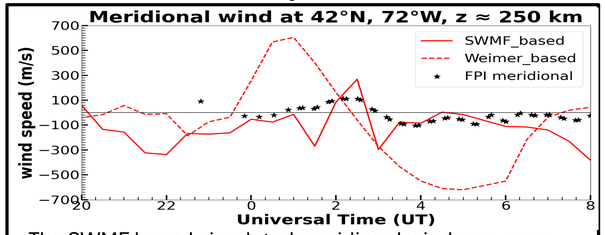


(a) vTEC: Two distinct EIA crests with equatorward motion after 22 UT. However, after 23 UT, the southern crest expands; N crest is absent—unlike equatorward motion and merge as seen in GOLD/Madrigal data

(b) Zonal electric field: At S low lats, stronger eastward (+ve/red) electric field after 23 UT → stronger upward E×B → drives the poleward expansion. In N low lats, the E.F is westward after 22 UT but then switches to eastward momentarily before turning westward near 24:20 UT.

(c) Meridional wind →SH: strong northward (+ve/red) from 20 to 23 UT; NH: southward from 22 to 23 UT → supports the equatorward motion of crests from 22 to 23 UT. Southward wind at low lats after 23 UT and strong eastward electric field may explain poleward motion of SEIA crest.

6. Data-model comparison



The SWMF based simulated meridional winds are more consistent with FPI observed winds. However, the large difference in their magnitudes exist from 1 to 5:30 UT.

7. Main Take ways and Future works

- Within 3 hours of equatorward movement, both N and S EIA crests merged into single EIA crest near 35°W longitude. GOLD Ne and Madrigal TEC are consistent on timing.
- At −50°, unlike observation, the GITM simulated SH TEC near crest expands poleward instead of merging.

Future work:

- Match model's neutral winds with FPI data.
- Investigate why the simulated electric field is +ve in SH.
- Separate the E-field (PPEF/DDEF) vs wind roles using the continuity equation (E×B vs wind vs chemistry).

8. Acknowledgements and References

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Lasker et al. (2024). 10.1029/2023JA032224
Wu et al., (2025). 10.1029/2024JA032896
Zou et al., (2026). 10.1029/2025GL121182