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Analysis of the January 2026 G4 Geomagnetic Storm through Multi-Instrument Observations

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Motivation

On Jan. 19, 2026, geomagnetic conditions reached NOAA G4 levels starting at 18:00 UT, corresponding to a severe geomagnetic storm. This event is generally attributed to a coronal mass ejection (CME) with a strong solar flare on Jan. 18. However, the CME truly arrival time on Earth was earlier than the one predicted by NOAA/SWPC WSA-Enlil model and later the one estimated by CWA. To investigate this discrepancy, this study integrates multi-instrument observations and modeling tools. The primary goal is to enhance operational awareness of these critical factors, thereby extending the lead time required for critical infrastructure protection and operational preparedness across various sectors.

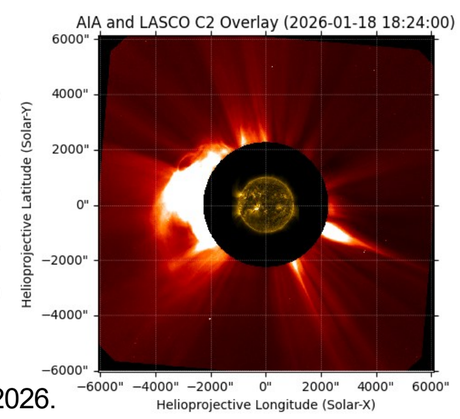

Figure 1. Solar image for CME on Jan. 19, 2026.

Review Jan 2026 G4 Geomagnetic Storm

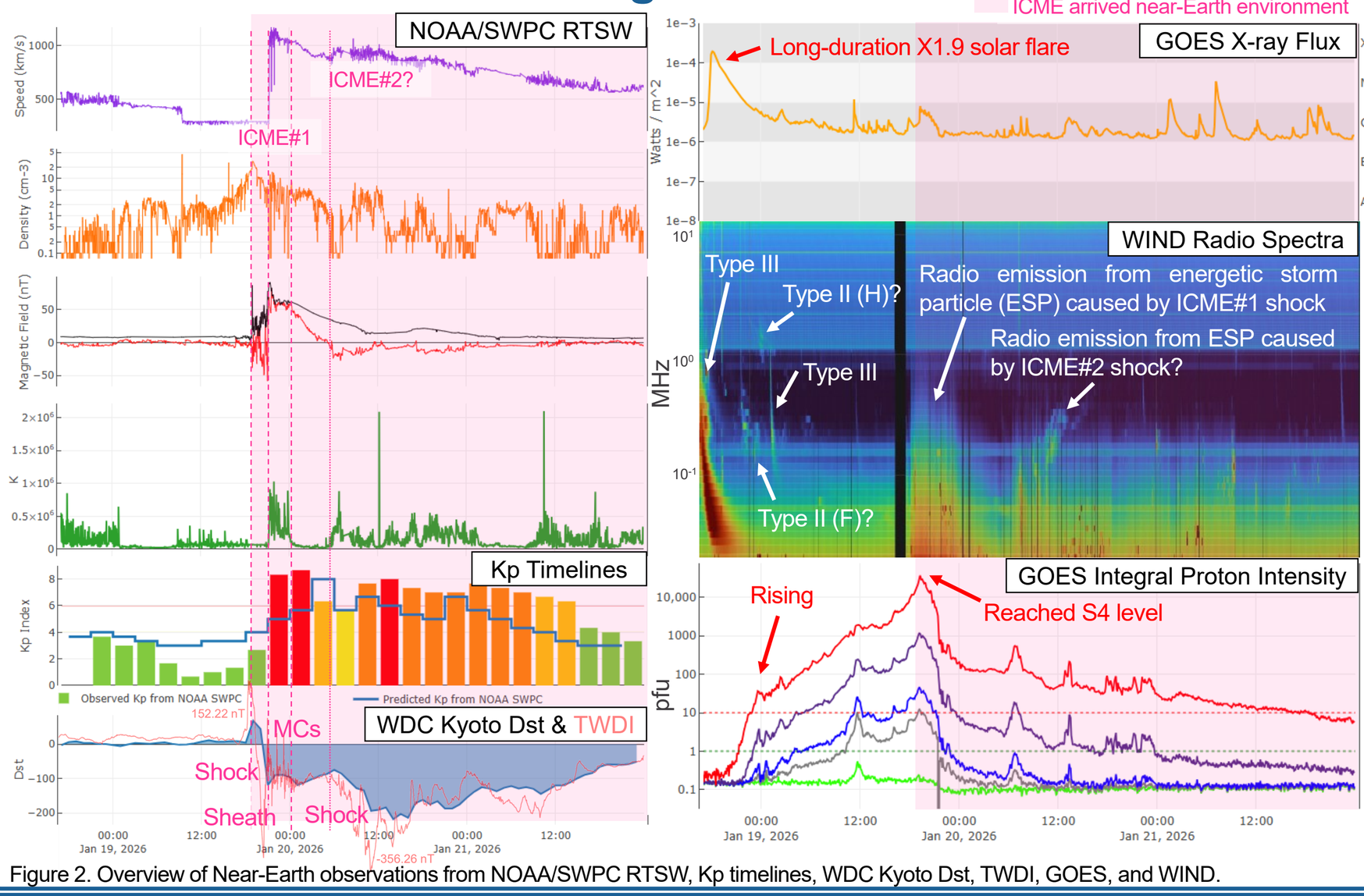

Figure 2. Overview of Near-Earth observations from NOAA/SWPC RTSW, Kp timelines, WDC Kyoto Dst, TWDI, GOES, and WIND.

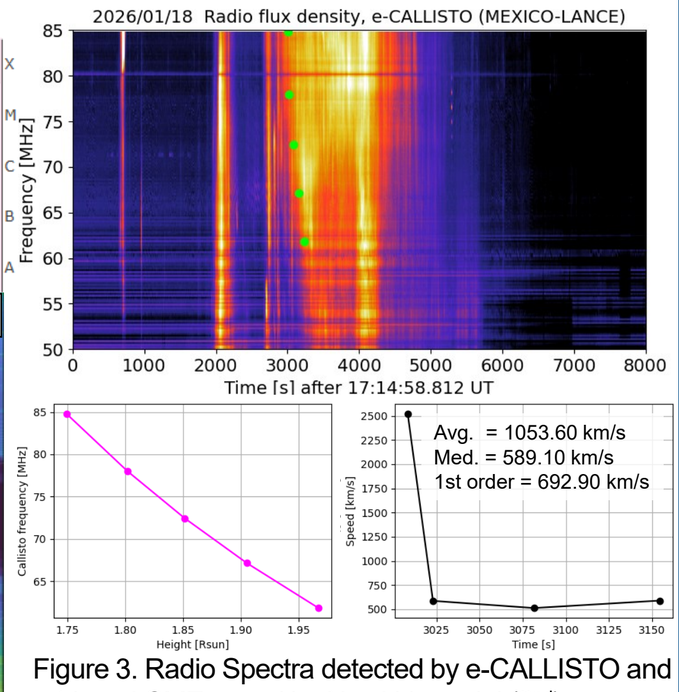

Figure 3. Radio Spectra detected by e-CALLISTO and retrieved CME speed by Newkirk model (2nd).

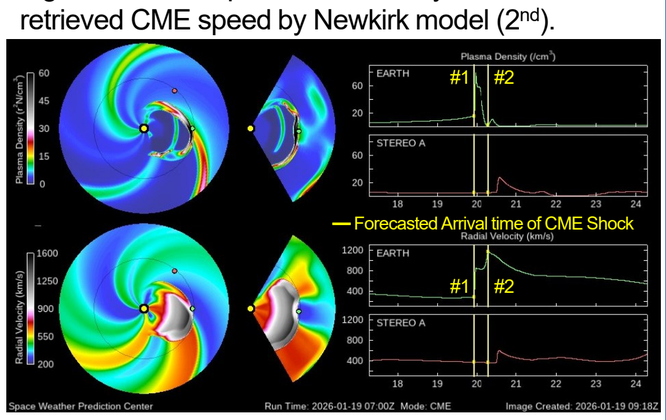

Figure 4. WSA-Enlil model result by NOAA/SWPC.

Analysis and Results

Table 1. CME parameters estimated by three different cases.

Case Type (Event ID)	Start Time (01/18UT)	Source Position (Lat°, Lon°)	Half Angle (°)	Radial Velocity (km/s)
CME#1				
PyCAT run by CWA	18:12	-17, -10	45	1740.85
SRB detection by CWA	18:05	-	-	1053.60
WSA-Enlil model(B1807)	21:30	0, -21	51	1111
CME#2				
PyCAT run by CWA	18:24	-17, -10	45	1566.77
WSA-Enlil model(B1808)	20:24	-16, 28	36	1647
CME#3				
PyCAT run by CWA	-	-	-	-
WSA-Enlil model(B1810)	19:58	-10,5	53	1720

Table 2. Arrival time of ICME structures with different estimated cases and observed results.

ICME structures	Shock	Sheath	MCs
Case Type (Event ID)	Arrival Time for Earth (UT)		
CME#1			
Observed results	01/19 18:51	21:24	01/20 00:00
PyCAT run by CWA	01/19 17:15	*	*
SRB detection by CWA	01/19 23:31	*	*
WSA-Enlil model(B1807)	01/19 22:00	*	*
CME#2			
Observed results	01/20 06:40?		
PyCAT run by CWA	01/19 19:49	*	*
WSA-Enlil model(B1808)	01/20 07:00	*	*

(*The arrival time of sheath and MCs are defined by interplanetary magnetic filed which wouldn't retrieve by PyCAT, SRB detection, and WSA-Enili model.)

Discussions

- CME velocities estimated by PyCAT, SRB, and WSA-Enlil model are over 1000 km/s. Regarding arrival times, PyCAT results were slightly earlier than observed, whereas both SRB and WSA-Enlil estimates lagged behind the actual event.
- Our comparison shows that regardless of whether observational or modeling methods are used, there is still a deviation of over one hour. Notably, current methods remain unable to accurately predict the specific arrival times of ICME sheaths and Magnetic Clouds (MCs).

Future Plans

- By combining multi-viewpoint CME observations from instruments such as STEREO-A/COR-1,-2 and HI, GOES-19/CCOR-1, SOLAR-1/CCOR-2, and solar radio observations, we aim to enhance the accuracy of CME parameters, particularly the angular half-width.
- Tried to input the CME parameter for the Enlil solar wind model to validate the estimates provided by CWA forecasters.

References and Acknowledgements

- This research utilized SunPy (v7.1.1), CCMC/ISWA System, NextGen Federal Systems/Space Weather Analyst™, and PyCAT (NOAA/SWPC & UKMO).
- Data sources included the MEXICO-LANCE station (e-CALLISTO), NOAA/SWPC WSA-Enlil model, and observations from SDO/AIA, SOHO/LASCO-2, WIND/WAVES, and GOES-18 (X-ray & Proton Flux). We also used NOAA/SWPC RTSW, estimated/predicted Kp indices, WDC Kyoto Dst and CWA Taiwan Disturbance Index (TWDI) values.

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