Impact of Space Weather on Small Satellites

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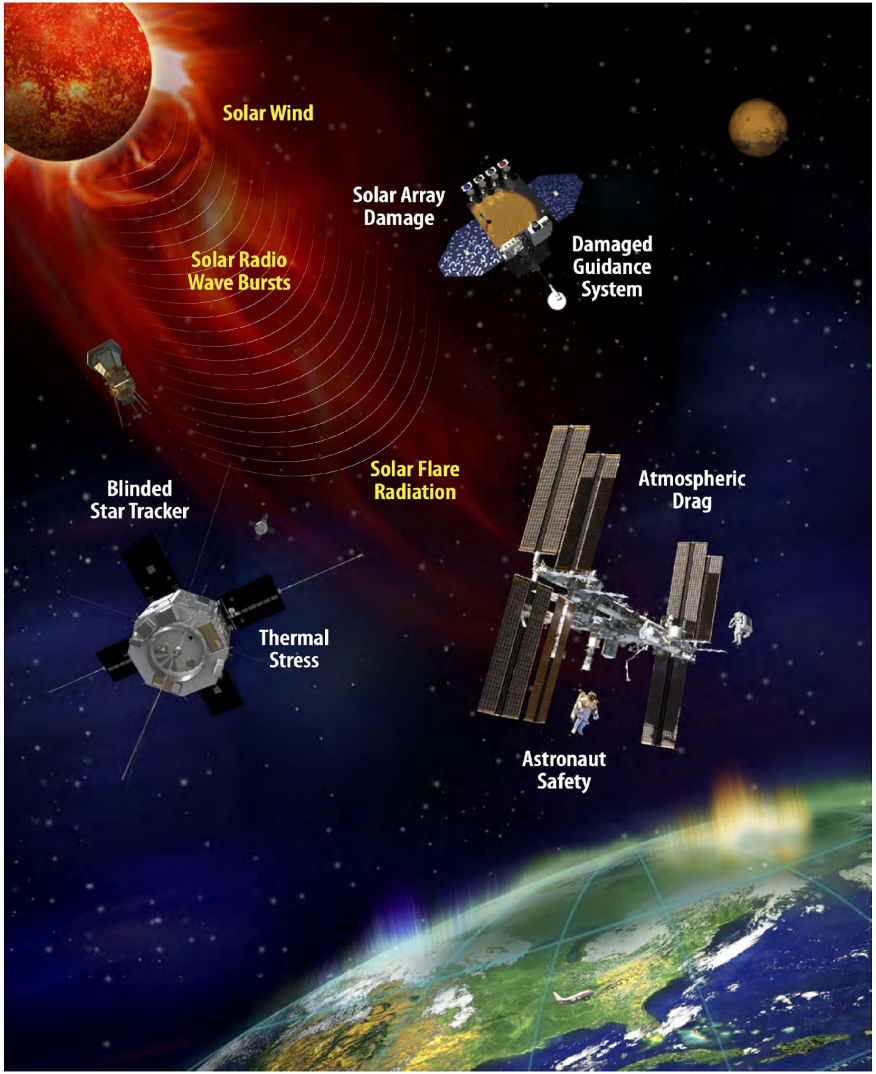
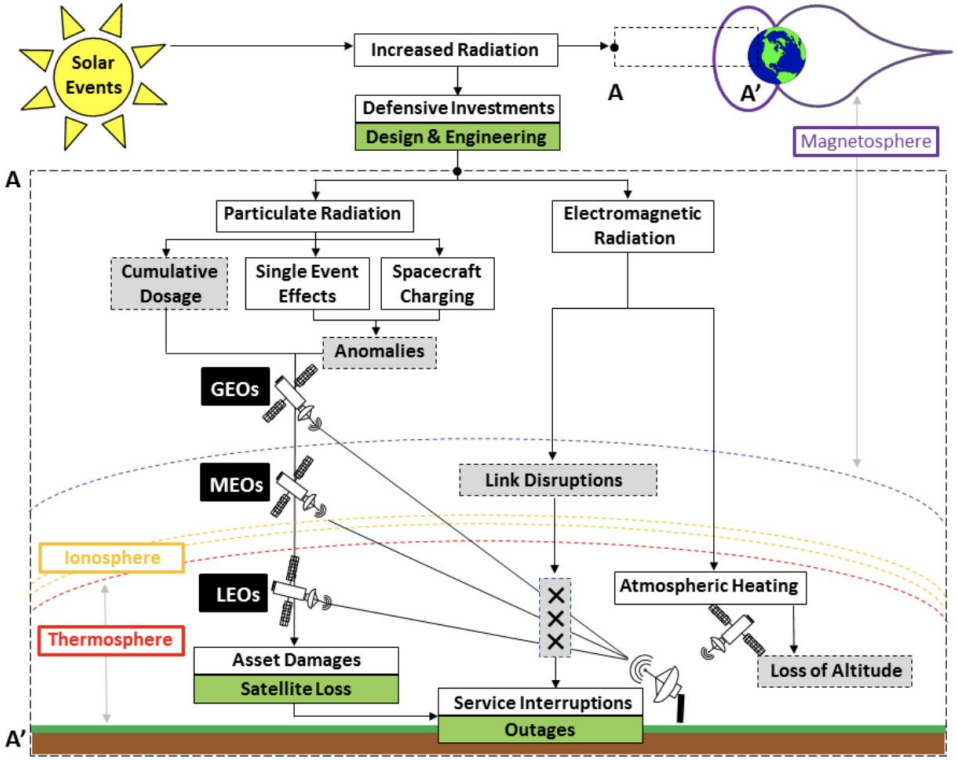
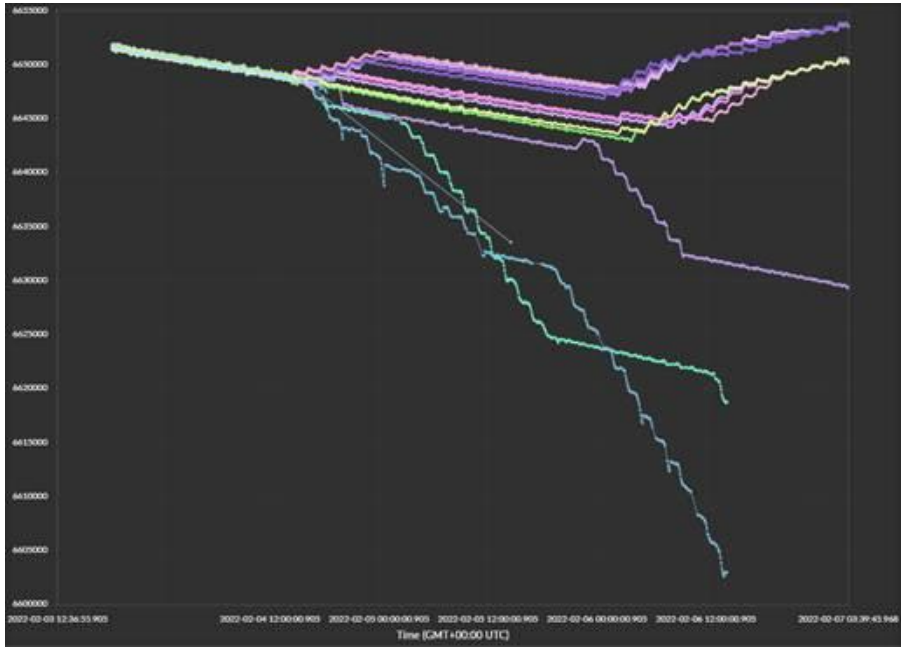
Space Weather Impacts



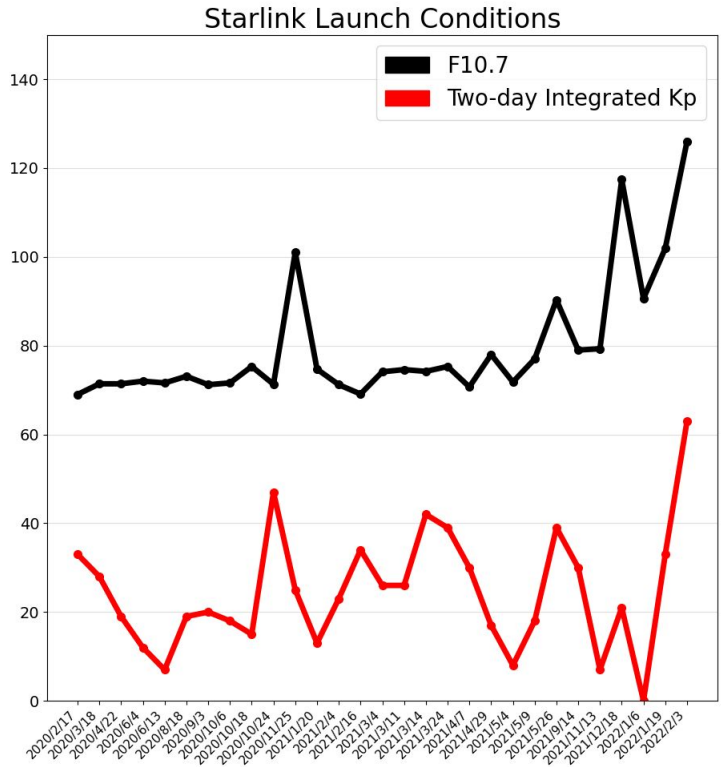


The Starlink Incident on Feb 4th, 2022



- On 3rd February at 1:13 pm EST (18:13 UTC), a SpaceX Falcon 9 launched 49 Starlink satellites to low Earth orbit (350 x 210 km, 53°) from the Kennedy Space Center in Florida. SpaceX reported the loss of up to 38 of the 49 satellites when they encountered increased atmospheric drag due to a geomagnetic storm while they were in orbit-raising maneuvers. https://www.spacex.com/updates/ (8th Feb 2022).

Space Weather Conditions for Prior Launches

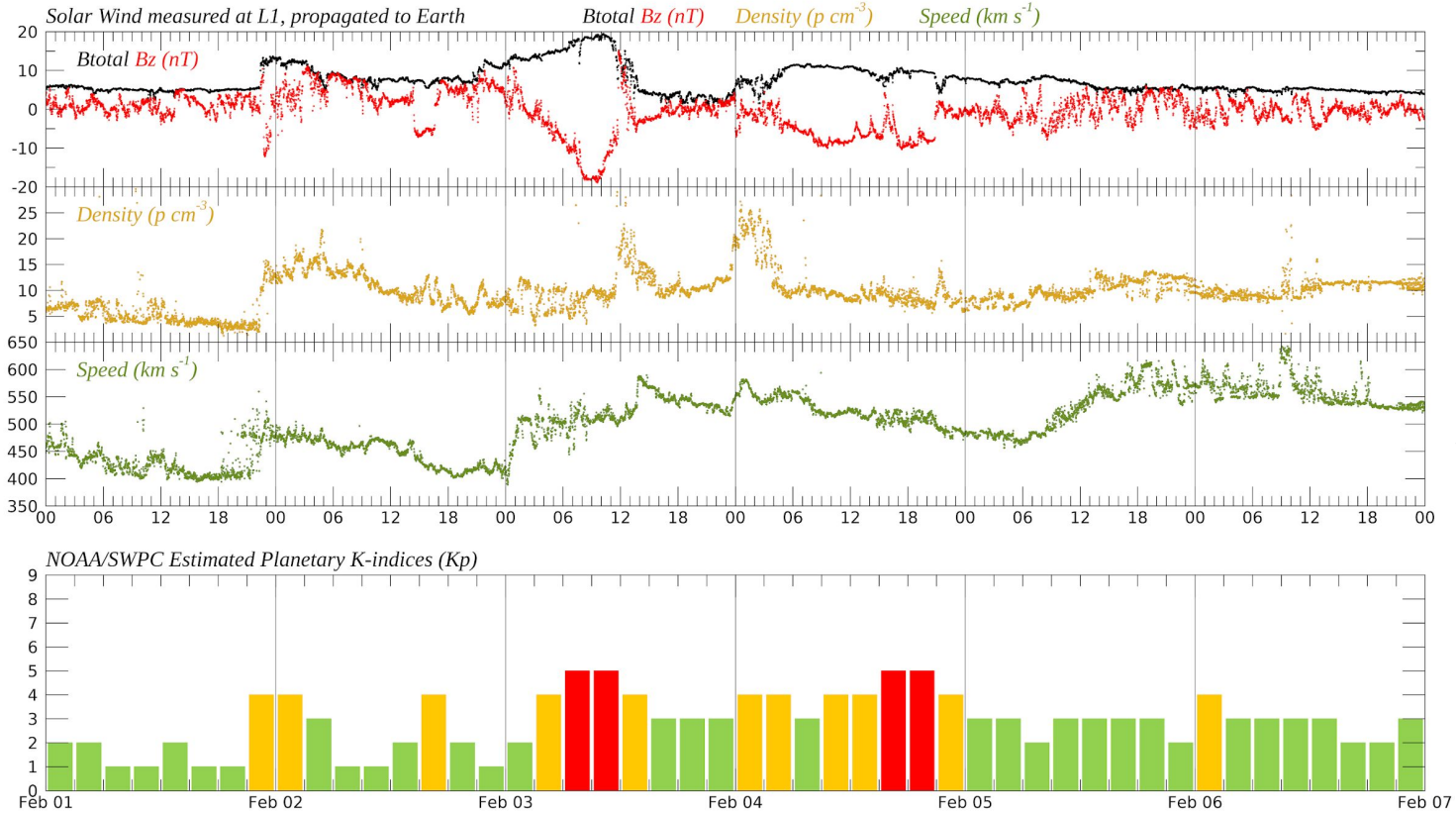


- F10.7 and two-day integrated Kp for all SpaceX Starlink launches that went into an orbit with perigees lower than 275 km.
- Both indexes suggested a much more perturbed conditions for this launch compared to prior launches.

Solar Wind Simulation

- A series of Earth-directed and partial Earth-directed Coronal Mass Ejections (CMEs) were observed between 29-31 January 2022. The CMEs were not particularly strong and were expected to arrive at Earth as early as 02 February 2022.
- The WSA-ENLIL prediction of solar wind plasma density and velocity for a model run with background solar conditions starting at at 00:00 UT on the 31st January, 2022.

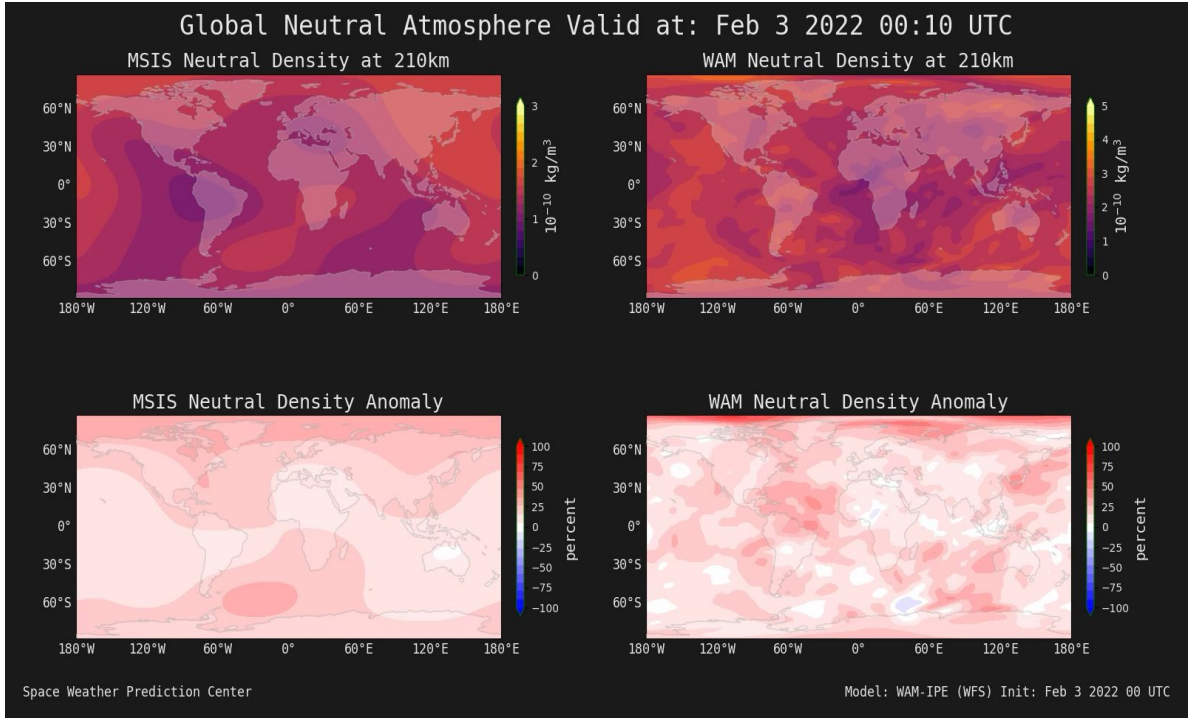
Space Weather Conditions



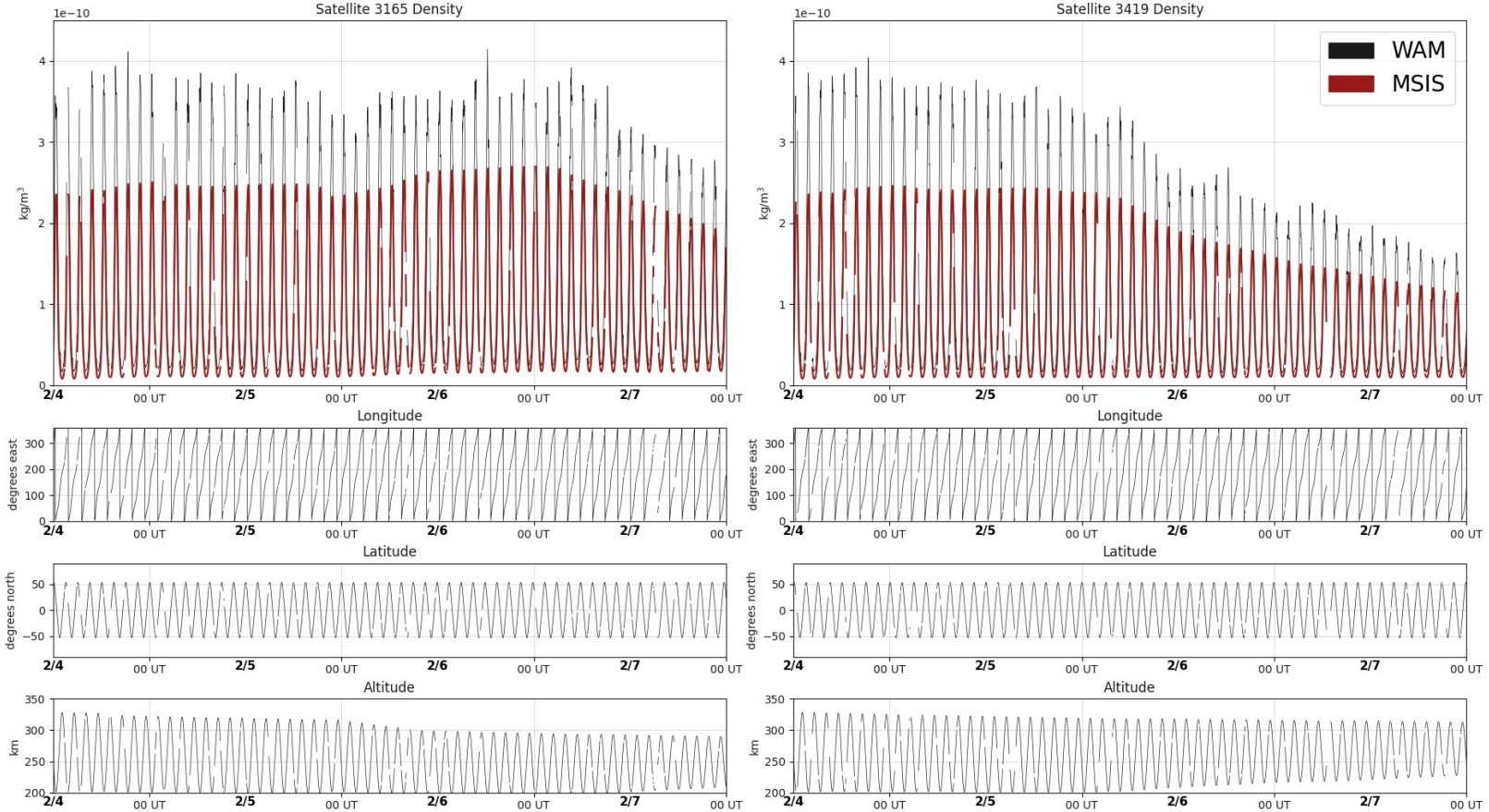
Minor geomagnetic storm conditions were observed on 3-4 Feb. Localized regions of moderate to strong geomagnetic levels were reported at high latitudes on 3 Feb prior to launch and the next day on 4 Feb.

Neutral Density Environment

WAM and MSIS neutral density at 210 km

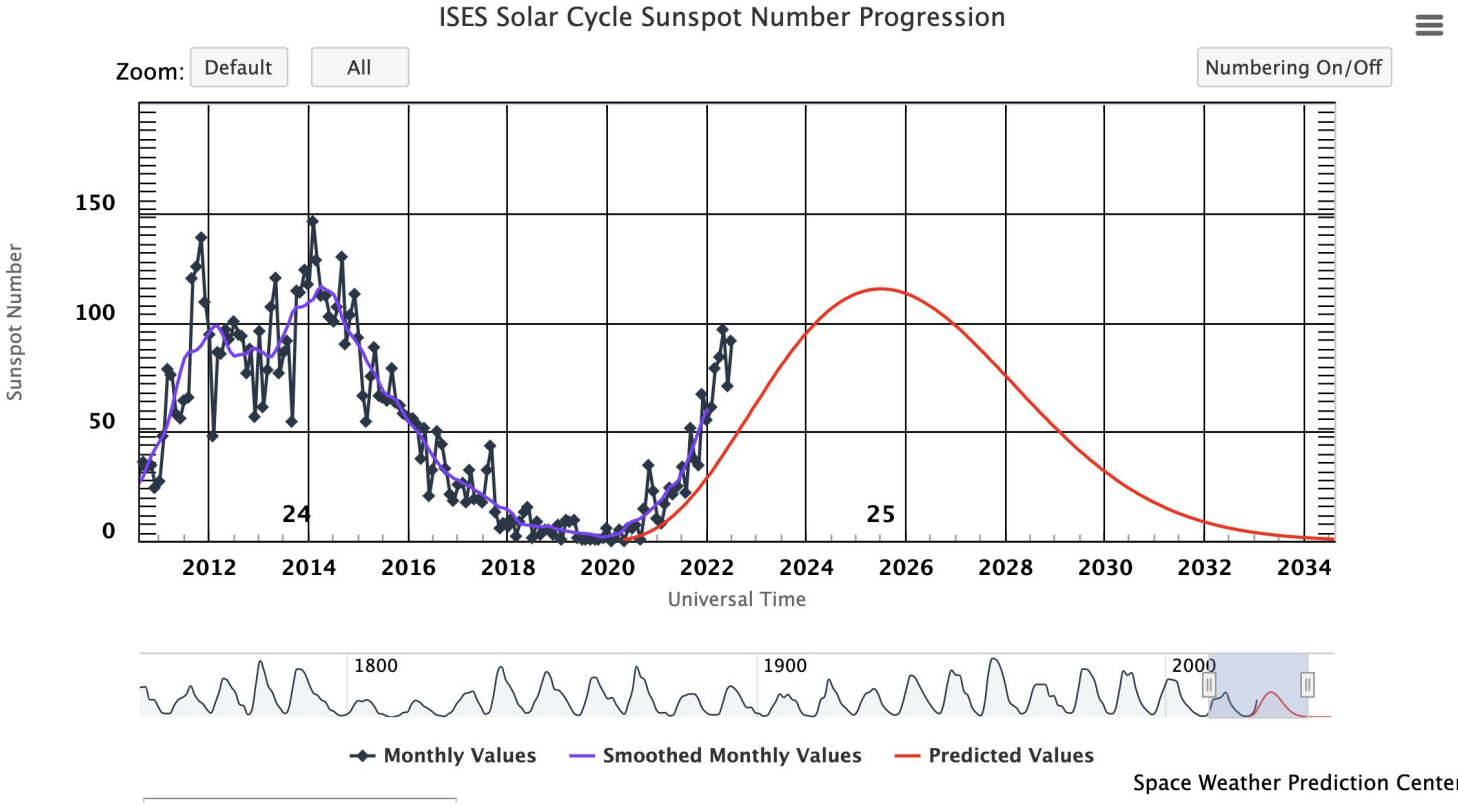


- SWPC's operational model, the coupled Whole Atmosphere Model - Ionosphere Plasmasphere Electrodynamics (WAM-IPE), captured the enhanced neutral density globally. The model currently provides 2-day forecasts every 6 hours.
- WAM-IPE calculates the atmospheric conditions from the ground all the way to ~600 km follows the US Weather Forecast System to provides upper atmosphere weather. Solar radiation (F10.7) and solar wind parameters (Bz, velocity, density) are used in our simulations.



WAM have shown a much higher density environment compared to MSIS model that Starlink uses (Fang et al., Space Weather, under revision)

Solar Cycle 25



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