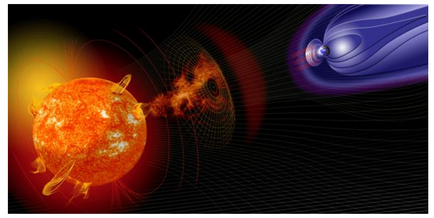
# Solar Cycle 25 Model Prediction Comparisons: An Engineering Perspective



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## Motivation:

The **solar cycle prediction** is important to in-space laboratories such as the International Space Station (ISS), Figure 1. Understanding when the **solar maximum** occurs and for how long is vital for planning how often the ISS requires **orbit raising maneuvers** (ORM) being in a low-Earth orbit (LEO).

**Figure 1:** The ISS as of 10/4/18 (NASA)

## Solar Cycle Prediction:

Knowledge of the **thermosphere density** and ISS's **drag coefficient** aid in the prediction of how fast the ISS's orbit decays. Modeling the thermosphere involves information about future states of the **solar radio flux** (F10). The F10 prediction is provided monthly to the ISS Program by MSFC Engineering for such ORM planning, e.g., Figure 3.

Times before the historic F10 database can be populated by using correlation functions between times when the sunspot number and F10 overlap.

Difficulties arise in the solar cycle prediction when the observed data has two peaks (see Figure 4), attributed to lag of activity between the northern and southern hemispheres of the Sun.

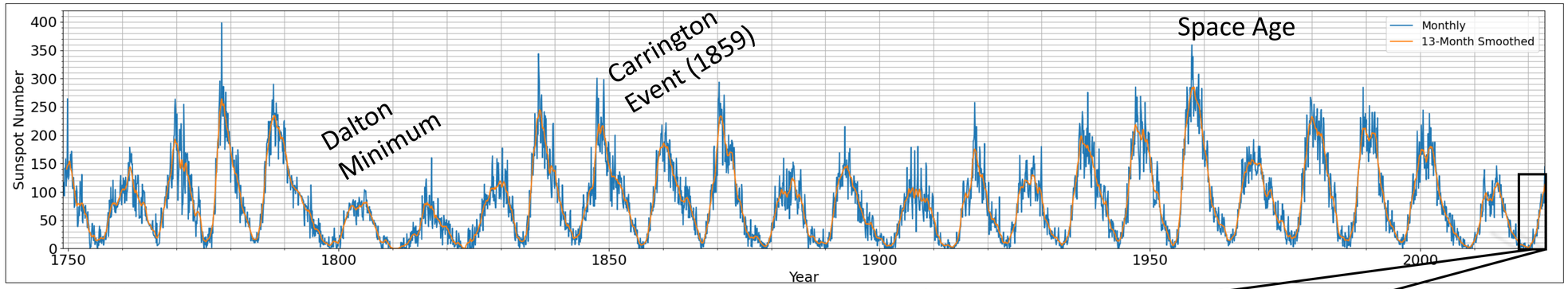


**Figure 2:** Recalibrated historic sunspot number and 13-month smoothed sunspot number (www.sidc.be/SILSO/datafiles) [1]

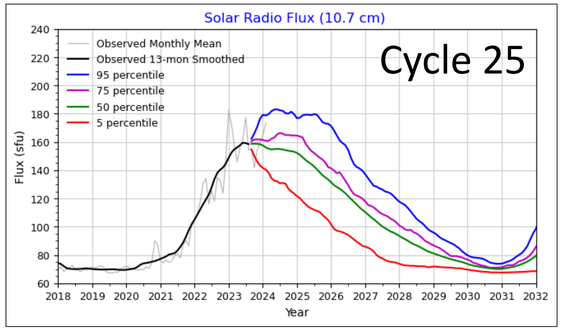


**Figure 3:** The March 2024 MSAFE [3] prediction of the F10 solar radio flux (www.nasa.gov/solar-cycle-progression-and-forecast/)

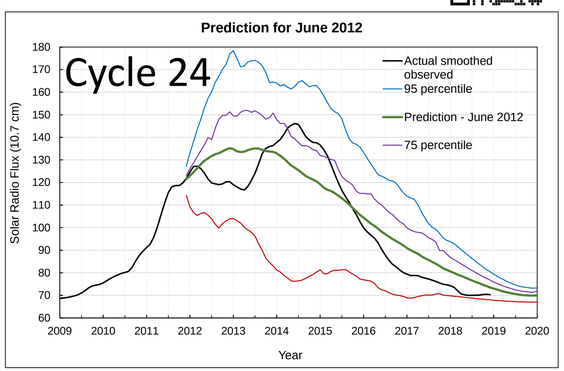


**Figure 4:** The June 2012 MSAFE [3] prediction of the F10 solar radio flux, overlaid with the future observations (https://www.nasa.gov/solar-cycle-progression-and-forecast/archived-forecast/)

## Solar Cycle Prediction Comparisons:

Several solar cycle predictions are available to the public. In Figure 5, three such predictions are shown for sunspot number, provided by:

- **Royal Observatory of Belgium**, Sunspot Index and Long-Term Solar Observations (SILSO)
- **NASA Marshall Space Flight Center**, MSFC Solar Activity Future Estimation (MSAFE)
- **NOAA Space Weather Prediction Center** (SWPC)

## Forward Work:

Understanding how various solar cycle prediction models perform at different points in the cycle can be insightful to satellite owners and flying laboratories such as ISS. Due to the increase of assets in LEO and plans for a commercial space station, it is even more imperative to have improved solar inputs to thermosphere models for drag estimation.

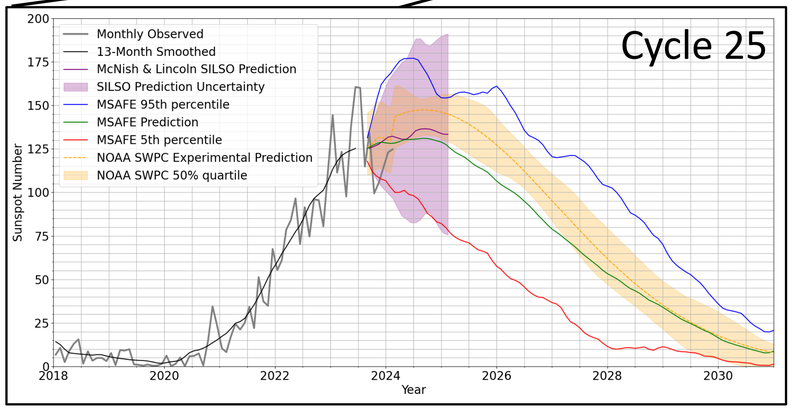


**Figure 5:** Comparison of various sunspot number predictions for solar cycle 25 showing McNish & Lincoln SILSO [2], MSAFE [3], and NOAA SWPC [4]

## Acknowledgements

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## References

[1] Clette, F., Svalgaard, L., Vaquero, J.M., Cliver, E. W., 2014: Revisiting the Sunspot Number. A 400-Year Perspective on the Solar Cycle, Space Science Reviews, Volume 186, Issue 1-4, pp. 35-103. DOI: 10.1007/s11214-014-0074-2
[2] McNish A.G. & Lincoln J.V. 1949, Trans. Am. Geophys. Union 30, 673-685
[3] Niehuss, K.O., Euler Jr, H.C. and Vaughan, W.W., 1996. Statistical technique for intermediate and long-range estimation of 13-month smoothed solar flux and geomagnetic index (No. NASA-TM-4759)
[4] https://testbed.swpc.noaa.gov/products/solar-cycle-progression-updated-prediction-experimental