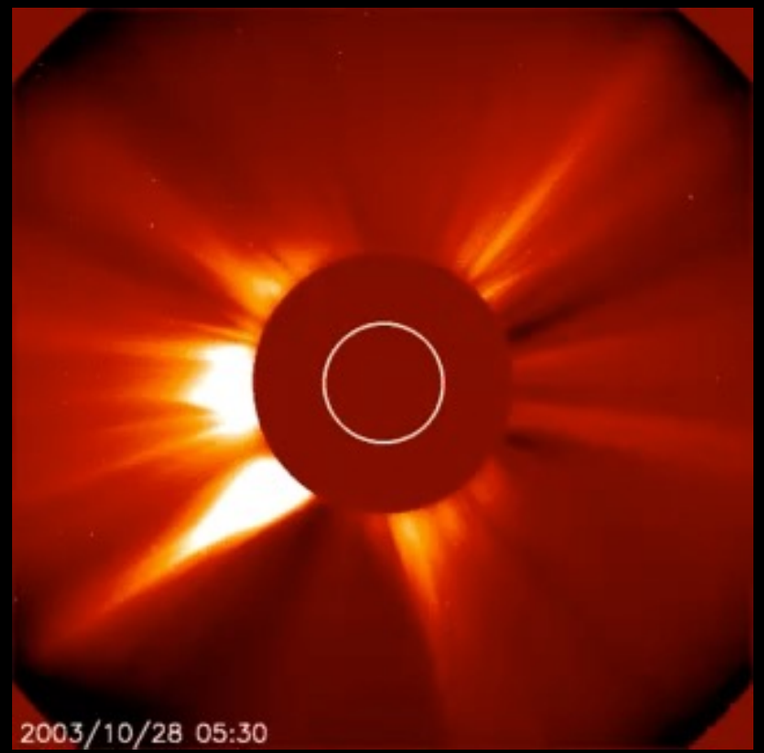
AI-Enabled Space Weather Predictions

The Sun constantly sheds solar material into space, both in a steady flow known as the “solar wind,” and in shorter, more energetic bursts from solar eruptions. When this solar material strikes Earth’s magnetic environment (its “magnetosphere”), it sometimes creates so-called geomagnetic storms. The impacts of these magnetic storms can range from mild to extreme, but in a world increasingly dependent on technology, their effects are growing ever more disruptive.

Geomagnetically induced currents (GICs) result from the interaction of the solar wind with Earth's magnetosphere and are catastrophic to our technologically dependent society. Since GIC data is proprietary, the time variability of geomagnetic perturbations is used as a proxy, and forecasting these perturbations at high spatial resolution and time cadence is important.

This work developed a deep learning-based model to forecast these perturbation measurements at arbitrary spatial resolutions and at high time cadence, using only solar wind measurements. The model outperforms, or at worse has consistent performance with benchmark models, and can provide quick, accurate forecasts at high time cadence across the whole globe.



This movie, captured by NASA’s Solar and Heliospheric Observatory (SOHO), shows two eruptions from the Sun called coronal mass ejections, which blasted charged particles into space on Oct. 28 and 29, 2003. Some of these high-energy particles hit SOHO’s camera, creating what looks like snow. These blasts were part of a string of solar storms around Halloween of that year, which triggered a blackout in Sweden and caused disruptions to communications, aircraft, and spacecraft (including SOHO). In SOHO’s view, a disk blocks direct light from the Sun so that fainter features near it can be seen, while the white circle represents the location and size of the Sun.

V. Upendran,et al., 2023:“Global Geomagnetic Perturbation Forecasting Using Deep Learning,” Space Weather, Vol. 20, 6.