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Kevin Lee, University of California, Los Angeles / NASA Jet Propulsion Laboratory
Oral
Space weather early warning depends on detecting solar wind transients at the Sun-Earth L1 Lagrange point within a 30-80 minute window preceding geomagnetic impact. Data-driven methods can detect complex multivariate transient signatures that threshold-based methods miss, yet they typically collapse the result into a single anomaly score with no physical attribution. We present PISCES (Physics-Informed Solar-wind Convolutional autoEncoder for Space-weather), a convolutional autoencoder that learns the standard solar wind by integrating seven physics constraints into the training loss: self-consistency of the magnetic field vector, smoothness of the proton entropy and total pressure, the temperature-velocity correlation, the Parker spiral angle, and smoothness of the plasma beta and dynamic pressure. Our model is trained on 11 years of unlabeled 1-minute cadence NASA OMNI data from 2005 to 2015. At inference, the output is decomposed into 15 sub-scores spanning magnetic, plasma, and physics-violation channels, identifying the violated physical relationships and providing event-type hints such as interplanetary shock, magnetic ejecta, and compression region. On a 2018-2024 held-out set with 2.97 million windows and 863 catalog events, PISCES achieves a PR-AUC of 0.193, competitive among unsupervised baselines. PISCES identifies which physical relationships are violated rather than reporting only a scalar anomaly score, making it well-suited for space weather applications.
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