Team Interstellar :- Identification of Halo CME events using Aditya L1 Data.

Powered by H2S

Feature-1 Early Warning

A)PARTICLE FLUX MONITORING

1.Dynamic Flux baseline-using 12 hour rolling IQR baseline.
2.High energy particle tracking- tracks bins >=8
3.Persistence logic-avoids false positive

B)PHYSICS BASED VALIDATION

1.Cross-validation with plasma data
2.Cross-entropy Divergence- measures asymmetry.

C)WARNING GENERATION

1.Confidence score calculation-based on anomaly severity.
2.Cooldown logic-to avoid repeated alerts

What we did?

Identifying Halo CME in order to issue warning signals by creating two features that do not rely on the traditional methods that use coronagraph imagery

FEATURE 1 : SWIS+STEPS

FEATURE 2 : SWIS+MAG

Our Colab Links :- Realtime Shock Detection Prototype
Warning System Prototype

Feature-2 Shock Detection

A)ENGINEERED FEATURES

1.Plasma Beta 2.Alfven Speed
3.Mach Numbers 4.Flux Entropy
5.Entropy Gradient

B)SHOCK DETECTION

1.Anomaly Detection: Using Mahalanobis distance on Plasma Vector.
2.Physics based validation: Using RH classification and Engineered features.

C)MODEL TRAINING

1.Trained a CNN-LSTM-Attention Model on validated shocks.
2. Used Monte Carlo Dropout to give uncertainity along with PVSS.

Why CNN-LSTM-Attention

A)CNN

Captures local patterns over a short window

B)LSTM

Understands longer time based patterns identified by CNN.

C)Attention Mechanism

Focuses on important timestamps by assigning weights

Our Prototype

A)FEATURE-1

1.72-hr statistical analysis on flux data from 8-10 Oct 2024 → 21 warnings detected.

B)FEATURE-2

1.Trained model on data of Aug 2024.
2.Tested on 72-hr window from 8-10 Oct 2024.
3.Peak observed at known CME event.

Planned Improvements

A)TRAINING DATA

Train model on larger data instead of 1 month

B)BETTER FEATURE VALIDATION

Change the current > 1.5 check and better use directional sense from cross entropy.

C)MODEL ARCHITECTURE

Trying a GRU or PINNs to reduce computational costs.