

Petrus

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Georgia State University

Rafal Angryk and the GSU Astro-informatics Cluster (Georgia State University)

Poster

The Georgia State University Astro-informatics Cluster is a strongly integrated interdisciplinary research group between the departments of Computer Science and Physics & Astronomy. Since its foundation in 2014 the cluster has been solely focused on space weather prediction.

Our current research program consists of over a dozen projects, each carried out in parallel by faculty and their graduate and undergraduate students. Each project forms a building block for a comprehensive and unique space weather data mining and forecasting using cutting edge machine learning and modeling approach. Several of these projects are presented at this meeting in more detail here in posters by our graduate students.

In my contribution I will present the overall design and architecture of our prediction system, the place of each individual effort within it, and describe future projects to complete the system.

A partial list of efforts underway or completed is:

- Thoroughly verified, complete, connected, and machine learning ready data bases of flares, CME's, and SEP's (benchmarks), made publicly available
- A Systematic search for flare precursors in magnetic and spectral data, including use of GSU's South Pole Observatory data, polarity inversion line morphology, and GONG H-alpha filament observations
- A computer science study of the machine learning method and data requirements for optimal space weather prediction
- Mitigation of solar limb limitation of the quality of magnetic field data for machine learning
- Integration of SoHO EIT and MDI data labels with those from HMI and AIA on SDO
- Flare prediction from time series data rather than static snapshots
- Constructing synthetic time series data for improving forecasting
- Simulated real-time predictions

This is merely a sample of projects going on. None of this work would be possible without the dedication and persistence of our standing army of students.

**The Space Weather Prediction Effort at GSU: Many Projects in Parallel, With a Unified Architecture.**  
*Peter C. Martens, Rishi A. Agrawal, The Data Mining Lab Members*




**GSU Data Mining Lab**, a truly interdisciplinary collaboration between GSU Computer Science and Solar Physics, consisting of 72 graduate students and faculty, founded in 2014 by Prof. Agrawal (CS) and Martens (Solar).

**Our Objective:**  
Produce the best possible machine learning space forecast forecasting algorithm.

**Our Method:**  
Conduct multiple small focused research projects in parallel – typical professors and graduate students from both computer science and solar physics on one project.

Each project falls under one of the categories on the right and is an indispensable part of the final integrated space weather prediction system.

**Current Projects:**

- 1. Produce highest quality data benchmarks for ML training and testing** (thoroughly vetted and cross-correlated, greater flux)
- 2. Address weaknesses in ML methods for solar activity** (non-instantaneous, synthetic time series, solar flare outliers, improved performance measures, optimal training windows, simulated real time predictions, posters: *Generators, Simulators, All, Synthetic*)
- 3. Go beyond traditional VMS, produce magnetic field predictor data** (chromospheric wave generation, lower Chromospheric filament chirality, morphology of polarity inversion lines, EUV generation, MHD and solar AR classes, world wide neuron detection network data (poster: *AdaptiveML*), improve VMS tool data with AR imagery)
- 4. Combine the above into an integrated pipeline** → *Dark* → *CME* → *SEP* prediction system

**DL4M benchmarks flux distribution**



**Simulated Real-time Prediction**



**Chromospheric Wave generation, solar flare warning**

**For the Future:** Integrate simulation codes with ML techniques – ML on “cheap” commercial simulations in real time, simulation results use “guided” ML approaches (e.g. decision trees).

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