

# Spacecraft Anomaly Analysis and Prediction System – SAAPS



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# SAAPS

## Spacecraft Anomaly Analysis and Prediction System

- ESA Contract 11974/96/NL/JG(SC):
  - Development of AI Methods in Spacecraft Anomaly Predictions
- Extension of the SPEE study
- Two year project (April 1999 - June 2001)
- Database and software

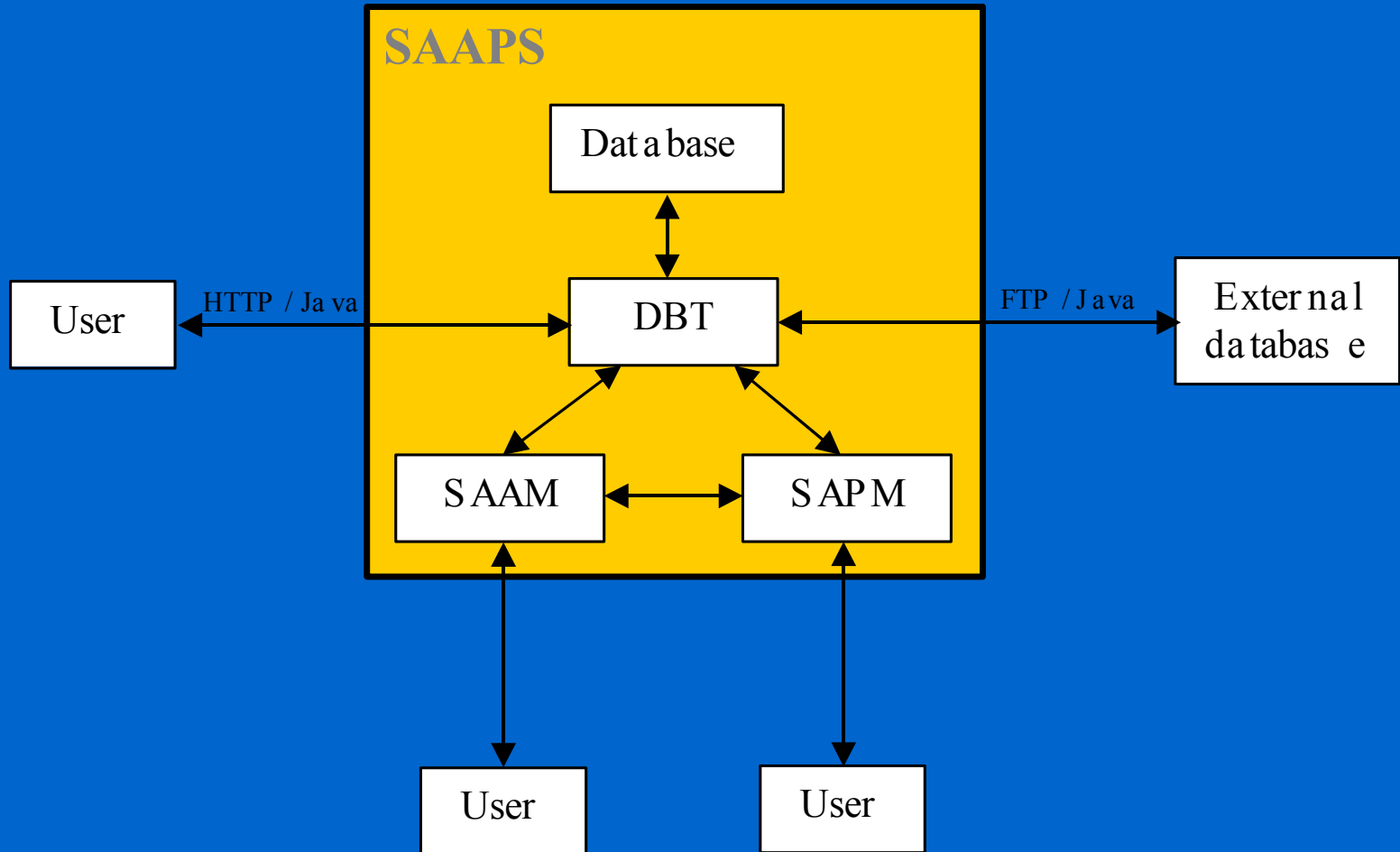
# Purpose

Develop tools for the analysis and prediction of spacecraft anomalies.

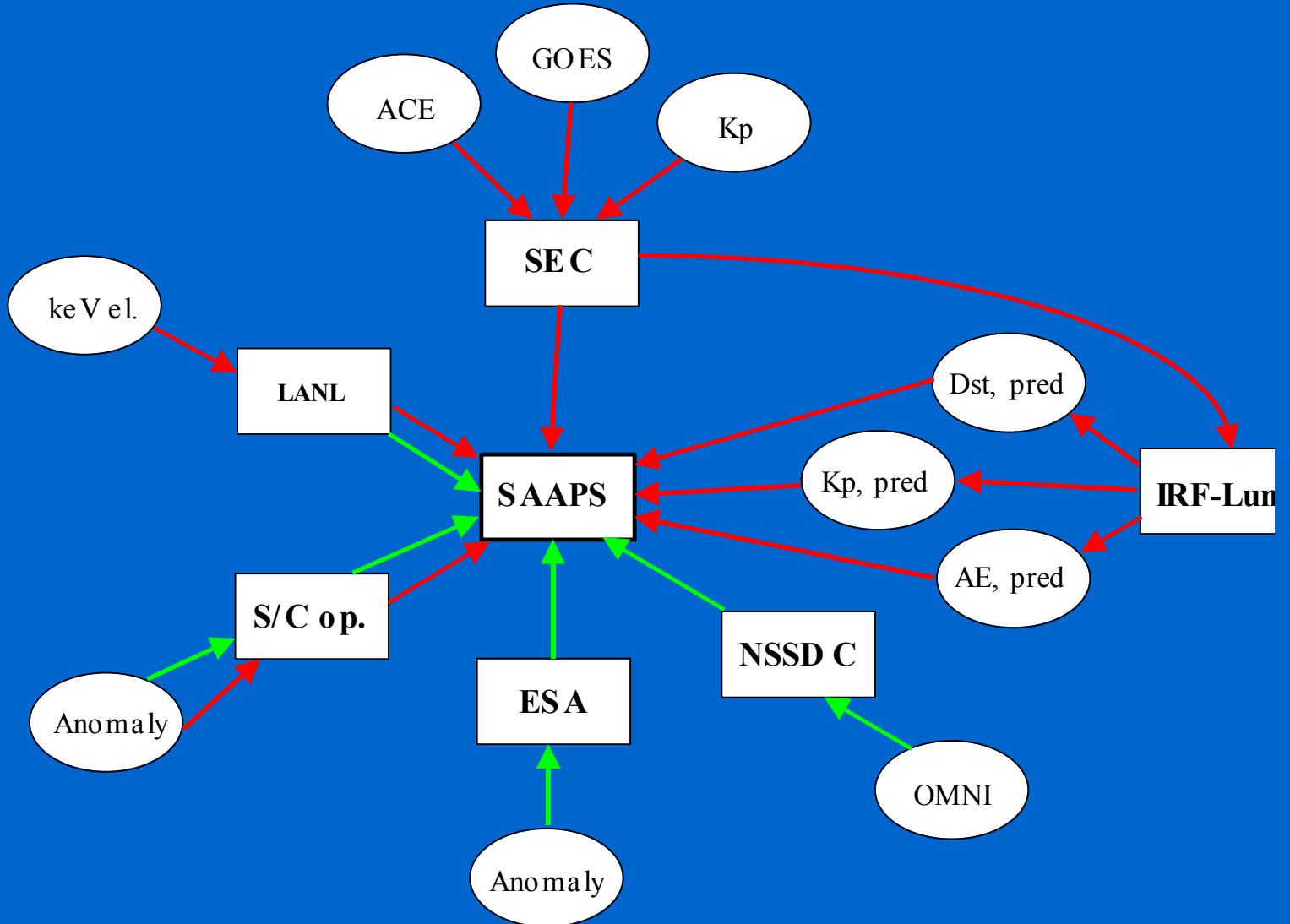
# Approach

- Statistical methods for the analysis.
- Artificial intelligence (AI) based models, such as neural networks, for predictions.
- Real time operation.
- Database of space weather data and spacecraft anomalies.

# The model



# SAAPS Data Sources



# SAAM

## Spacecraft Anomaly Analysis Module

- Plotting tools
- Statistics
  - Superposed epoch analysis
  - Correlations (linear and entropy based)
  - Cluster analysis
  - Pattern definition and search
- Guidelines
- Estimate best prediction model

**Data Plotter**

http://sol.lund.irf.se

SEC Alerts SOHO Vel. & Dens. Apple N

### Data Plotter

Database objects

- ACEmagDB
- ACEmagHourlyDB
- ACEsweDB
- ACEsweHourlyDB
- AEDB
- DstDB
- GOES08partDB
- GOES08xrayDB
- GOES10partDB
- GOES10xrayDB

Start

2003

10

31

Inspect Latest

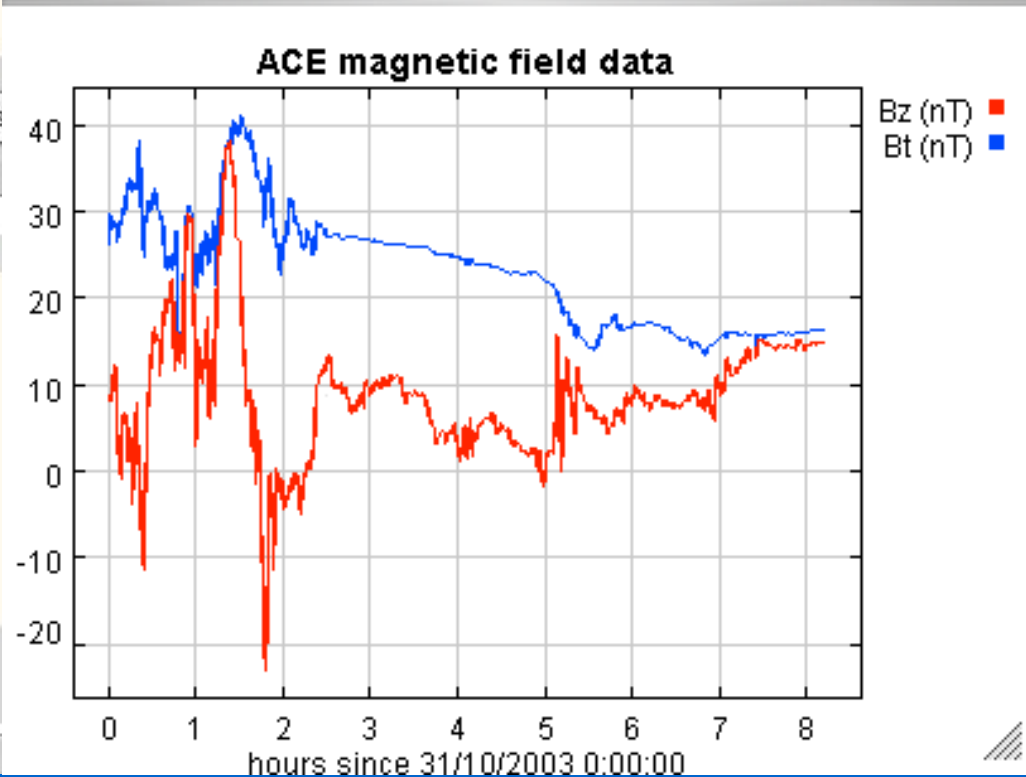
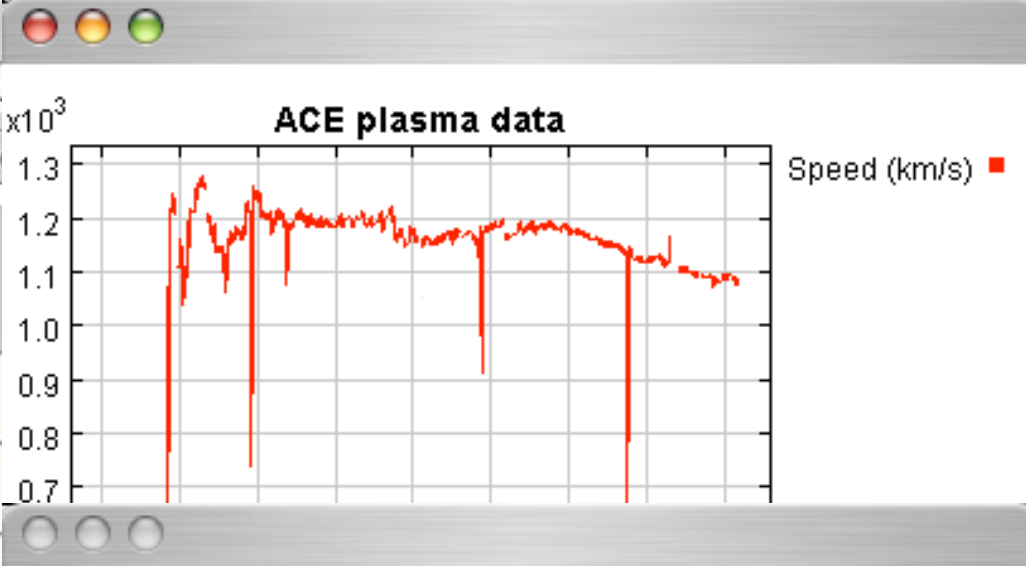
X Axis Data

- Time
- Density
- Speed

Y Axis Data

- Density
- Speed

Plot Help



# SAPM

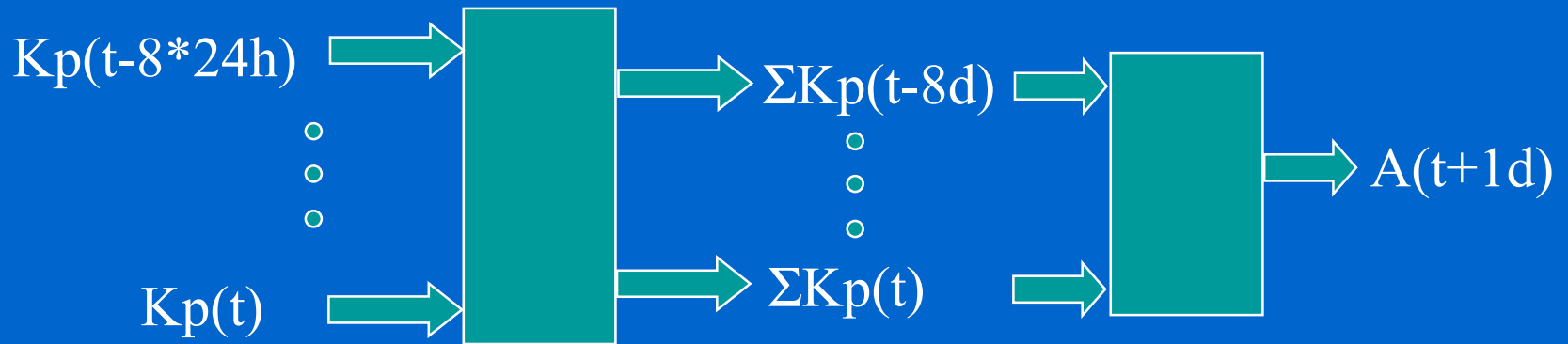
## Spacecraft Anomaly Prediction Module

- Neural network based prediction models
- Real time forecast
- Connects to SAAM for analysis
- Anomaly index (?) and/or
- Spacecraft dependent anomaly predictions

# Anomaly index?

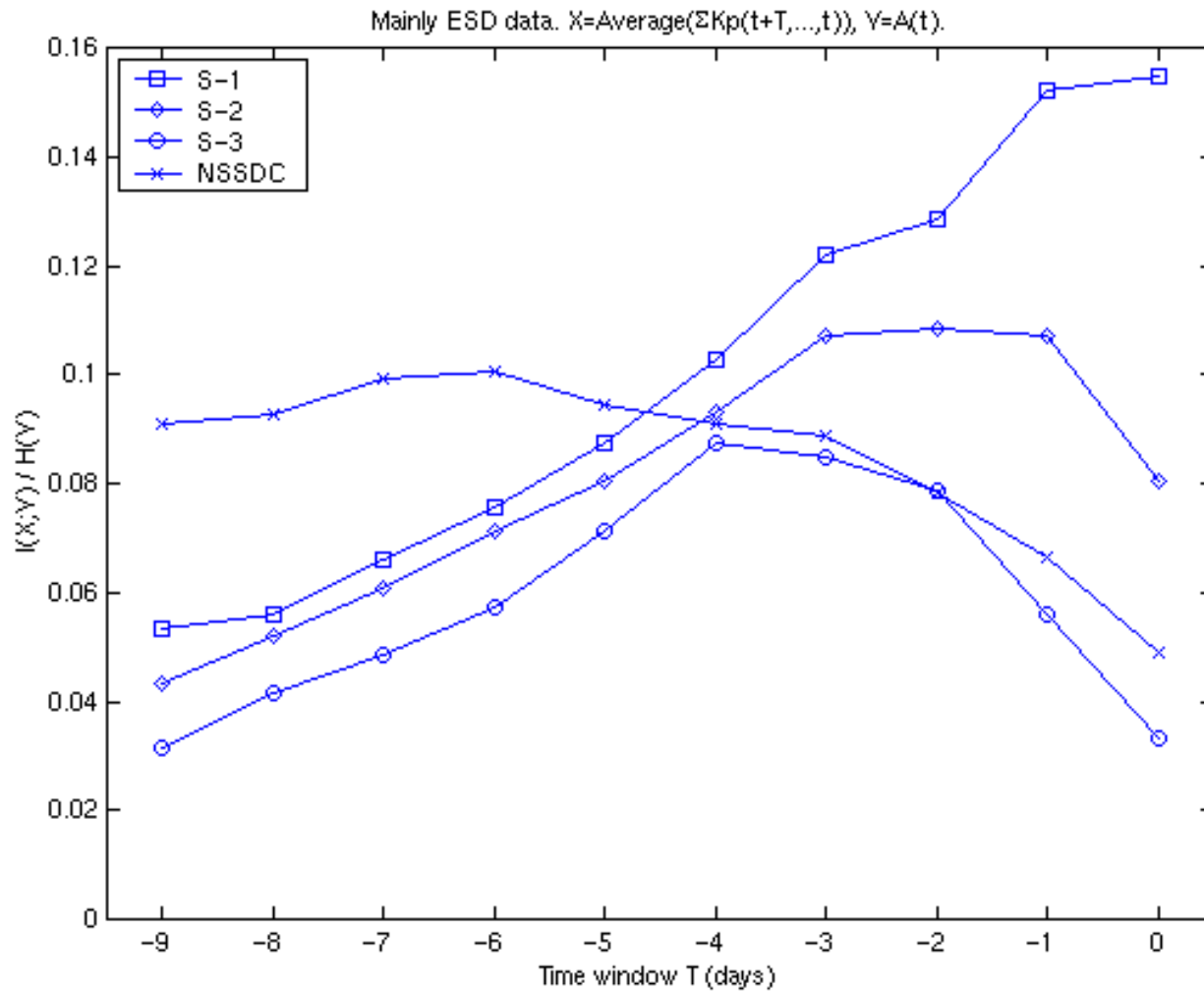
	<b>S1</b>	<b>S2</b>	<b>S3</b>	<b>NSSDC</b>
<b>S1</b>	1.00	0.02	0.03	0.03
<b>S2</b>	0.02	1.00	0.04	0.04
<b>S3</b>	0.02	0.02	1.00	0.11
<b>NSSDC</b>	0.02	0.02	0.10	1.00

# $\Sigma K_p$ based predictions

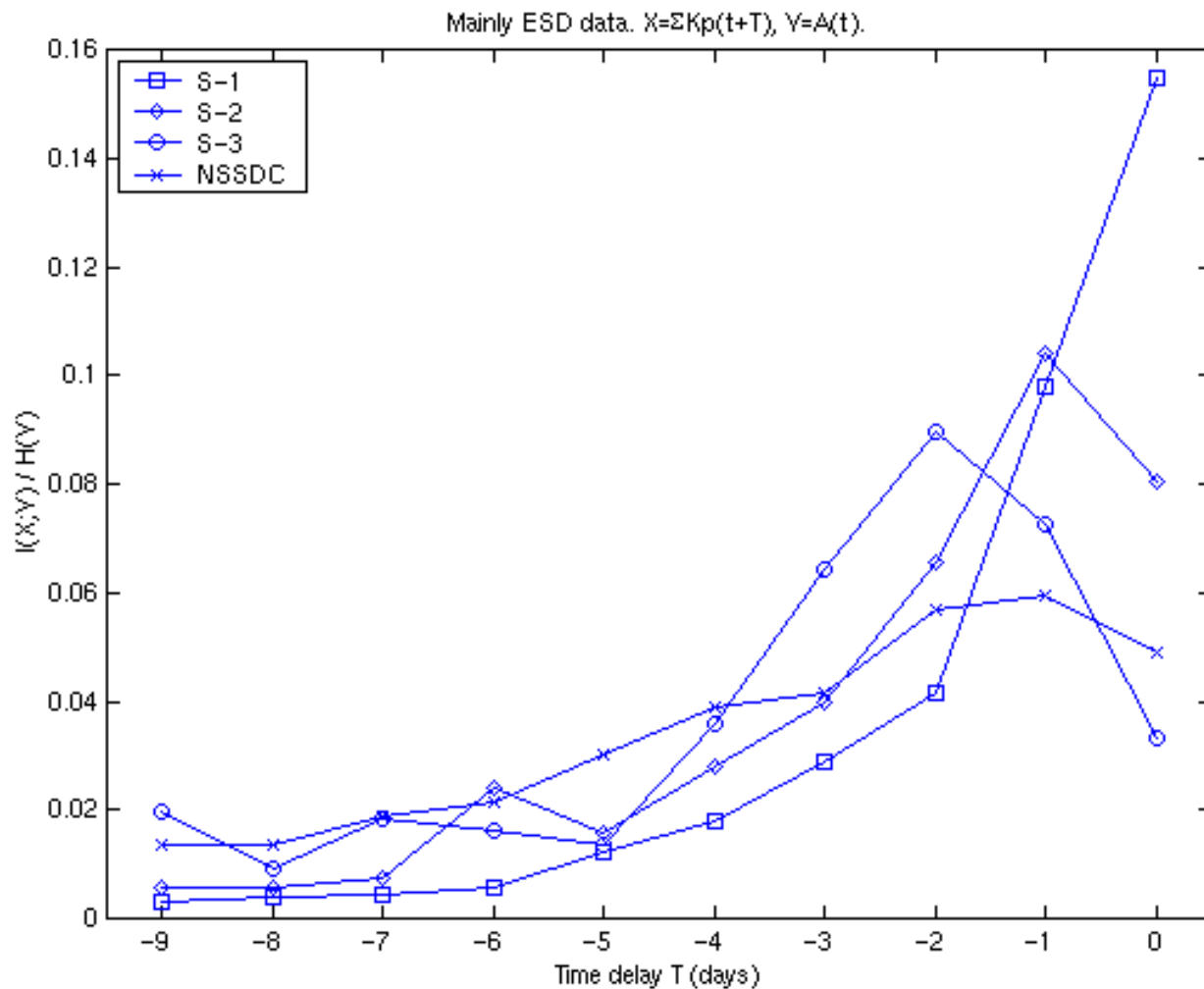


- Satellite specific model (geostationary)
- Fraction of correct classifications is 0.65 on balanced test set

# Mutual information between average $\Sigma Kp$ and ESD anomaly data



# Mutual information between $\Sigma Kp$ and ESD anomaly data



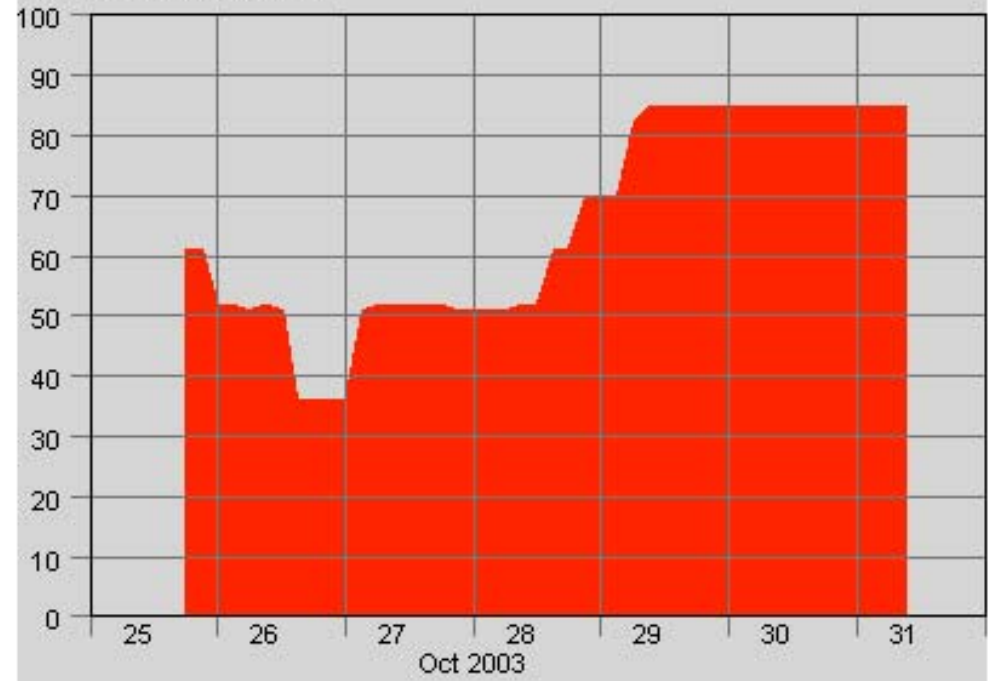
### Anomaly Predictions

- Model
- Anom 001
  - Anom 002
  - Anom 003

Model Info ...

Year	2003
Month	10
Day	31

Probability for an anomaly.




Today Plot Help

# SAAPS part of RWC-Sweden


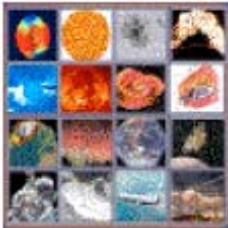
RWC-Sweden

http://www.lund.irf.se/rwc/

SEC Alerts SOHO Vel. & Dens. Apple Netscape.com .Mac Amazon eBay Yahoo! Google News MySQL Conn...umentation




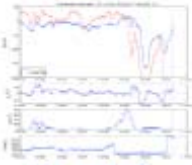
## Regional Warning Center Sweden (RWC-Sweden)

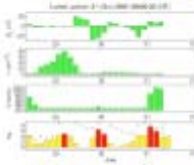



### FORECASTS

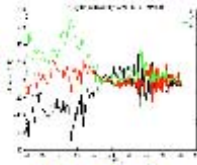
### DATA


**Lund Space Weather Forecast Service**  
  
[More info](#)

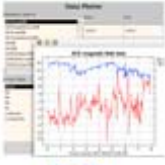
**Dst**  
  
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# Issues

- SAAPS Applets
  - communicate over port 2001 => Firewall problems.
  - use of RMI for data access => RMI might be a problem on specific OS.
- SAAPS uses non-standard database engine.

# Future

- SAAPS database and models will be merged with the IRF-GIC Pilot Project.
- A standard database engine will be used (MySQL).
- More development on the anomaly prediction models are necessary.

# IRF SAAPS Server

<http://www.lund.irf.se/saaps/>

# ESTEC SAAPS Server

<http://em450.wm.estec.esa.nl:6668/saaps/>

# New ACE data set

- A new ACE data set will soon be released
  - Merged MAG and SWEPAM data
  - 64 second resolution
- <http://www.srl.caltech.edu/ACE/ASC/level2/index.html>

# Lund Dst model

[www.lund.irf.se/rwc/dst/models/](http://www.lund.irf.se/rwc/dst/models/)

- Matlab
- Java