PROGRESS Review Meeting - Helsinki

WP 3

IRF-Lund PROGRESS Database/REST
&
Task 3.5 - Develop new AE forecast models

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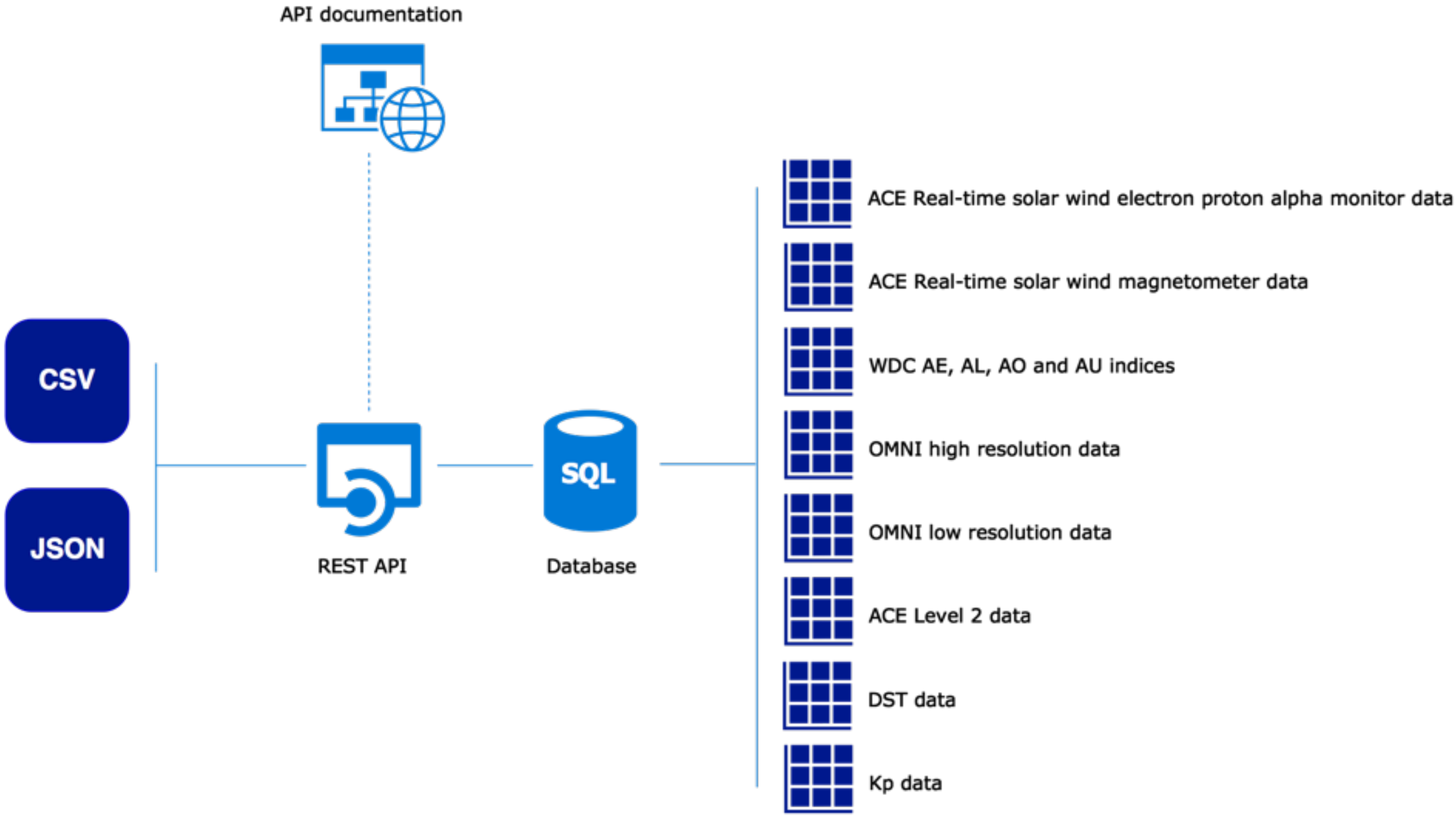
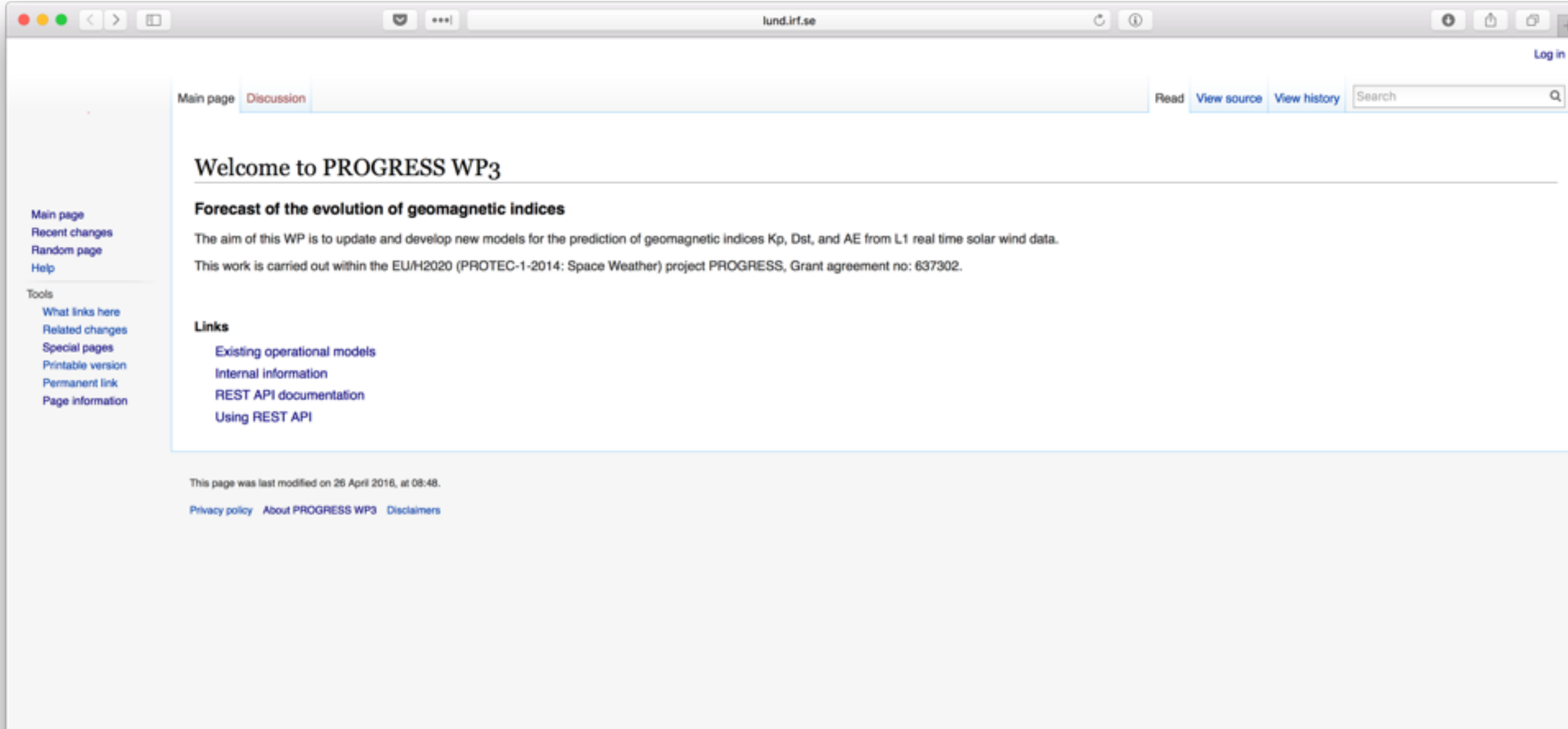
Task 3.5 - Develop new AE forecast models

- The models used by PROGRESS (IMPTAM and VERB) require geomagnetic indices such as Kp, AE, and Dst as input parameters. One of the aims of PROGRESS is, therefore, to re-evaluate and improve the current tools used to forecast geomagnetic indices.
- Task 3.5 in Months 16-30 (IRF, USFD, SRI NASU-NSAU)
- Data analysis (AE) and pre-processing (Just started using Python/Pandas)
- As a first step we will implement a NN back propagation model for comparison.
- Next, the NN model (Elman) in Gleisner and Lundstedt [2001] shall be implemented and verified (Task 3.3). Later other models like e.g. SVM will also be implemented.
- The classifications and categorisation methods (Task 3.4) shall also be applied to provide insight to appropriate parametrisation of the high resolution (minute) solar wind and AE data. E.g., the approach in Gleisner and Lundstedt [2001] was to use 10 minute averages, however, averages are not always the most suitable way of reducing the complexity as important features may be missed. Again, the formulated verification strategy (Task 3.3) shall also be applied to the models.

PROGRESS REST Service

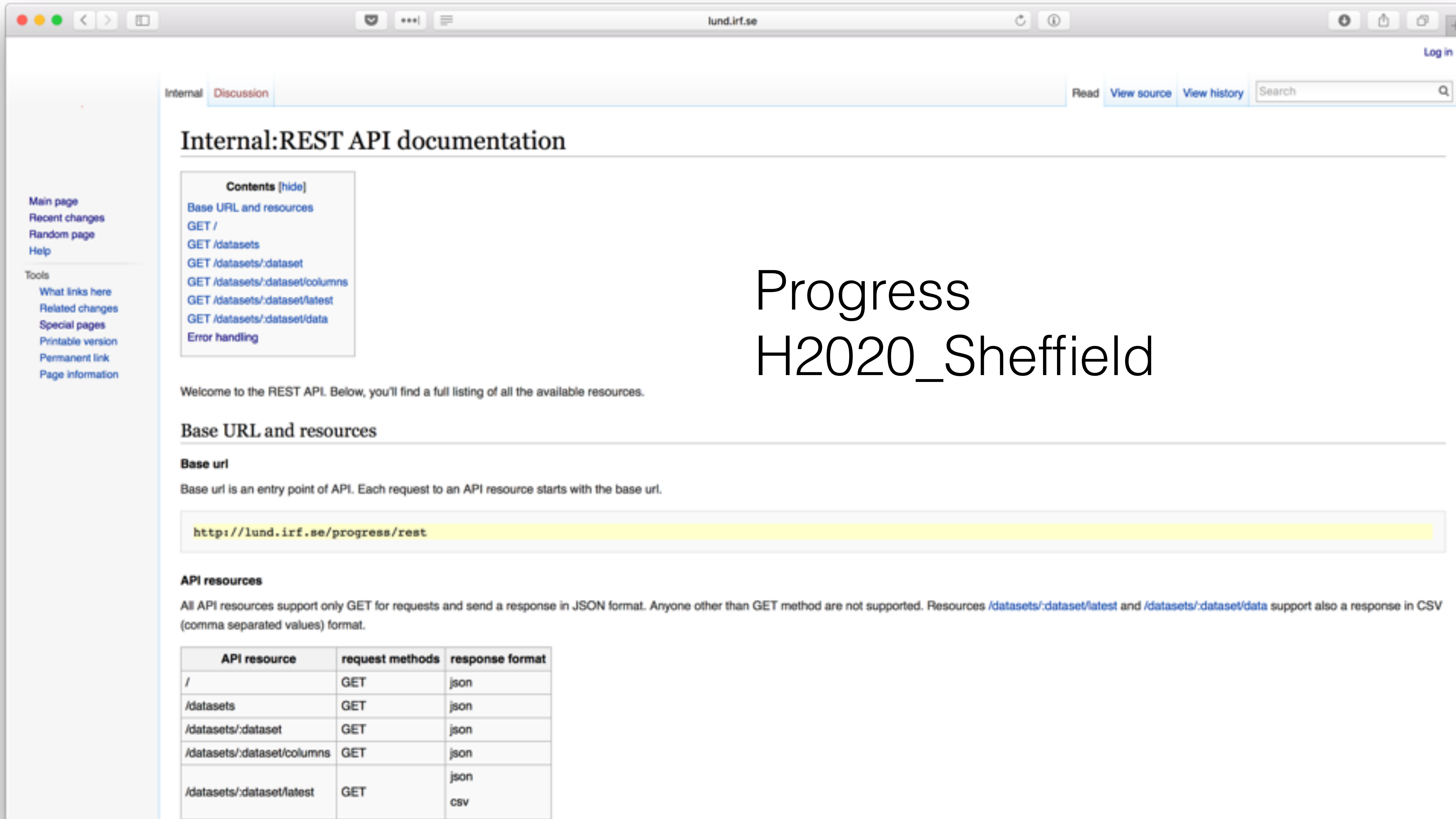


PROGRESS REST Service



http://lund.irf.se/progress/wiki/Main_Page

REST API Documentation



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Internal:REST API documentation

Contents [hide]

Welcome to the REST API. Below, you'll find a full listing of all the available resources.

Base URL and resources

Base url

Base url is an entry point of API. Each request to an API resource starts with the base url.

```
http://lund.irf.se/progress/rest
```

API resources

All API resources support only GET for requests and send a response in JSON format. Anyone other than GET method are not supported. Resources /datasets/:dataset/latest and /datasets/:dataset/data support also a response in CSV (comma separated values) format.

API resource	request methods	response format
/	GET	json
/datasets	GET	json
/datasets/:dataset	GET	json
/datasets/:dataset/columns	GET	json
/datasets/:dataset/latest	GET	json csv

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Using REST API

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Internal:Using REST API

Here are a few examples that demonstrate how to use REST API with Python, Matlab and curl tool.

cURL

```
# get a list of all datasets
curl 'http://lund.irf.se/progress/rest/datasets'

# get the latest datapoint in omni_lro dataset in csv format
curl 'http://lund.irf.se/progress/rest/datasets/omni_lro/latest'
```

Find more examples of using cURL with REST API on REST API documentation page.

Python

requests package

```
import requests


# get a list of all datasets in json format
response = requests.get('http://lund.irf.se/progress/rest/datasets?format=json')
json = response.json()
datasets = json['resources']
print(datasets)


# get the latest data point in omni_lro dataset in json format
response = requests.get('http://lund.irf.se/progress/rest/datasets/omni_lro/latest?format=json')
json = response.json()
latest = json['data']
print(latest)


# catch API error
response = requests.get('http://lund.irf.se/progress/rest/datasets/omni')

if response.status_code != 200:
    print(response.text)
```

http://lund.irf.se/progress/rest/datasets

Existing models forecasting AE

- Existing models:
  - Goertz et al. (1993)
  - Hernandez et al. (1993)
  - Vassiliadis et al. (1995)
  - Gleisner & Lundstedt (1997)
  - Gleisner & Lundstedt (2001)
  - (Bala & Reiff 2012)
  - Amariutei & Ganushkina (2012)

- Operational forecast models:
  - Laboratory for Atmospheric and Space Physics (LASP)
  - The AE model consists of an empirically derived set of equations (Luo et al. 2013)
  - The inputs are 10-minute averages of the solar wind density, speed, IMF B vector and magnitude B, and 10-minute interpolated values from the daily F10.7 index.

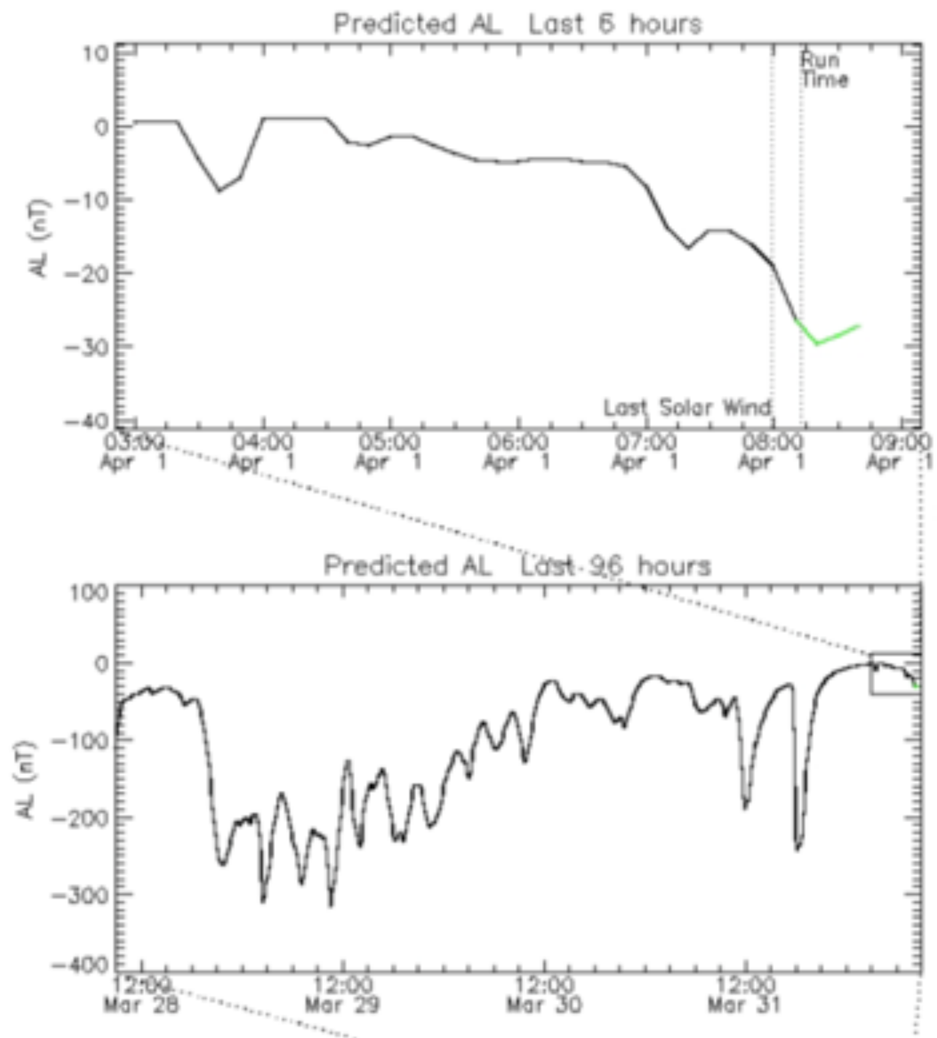
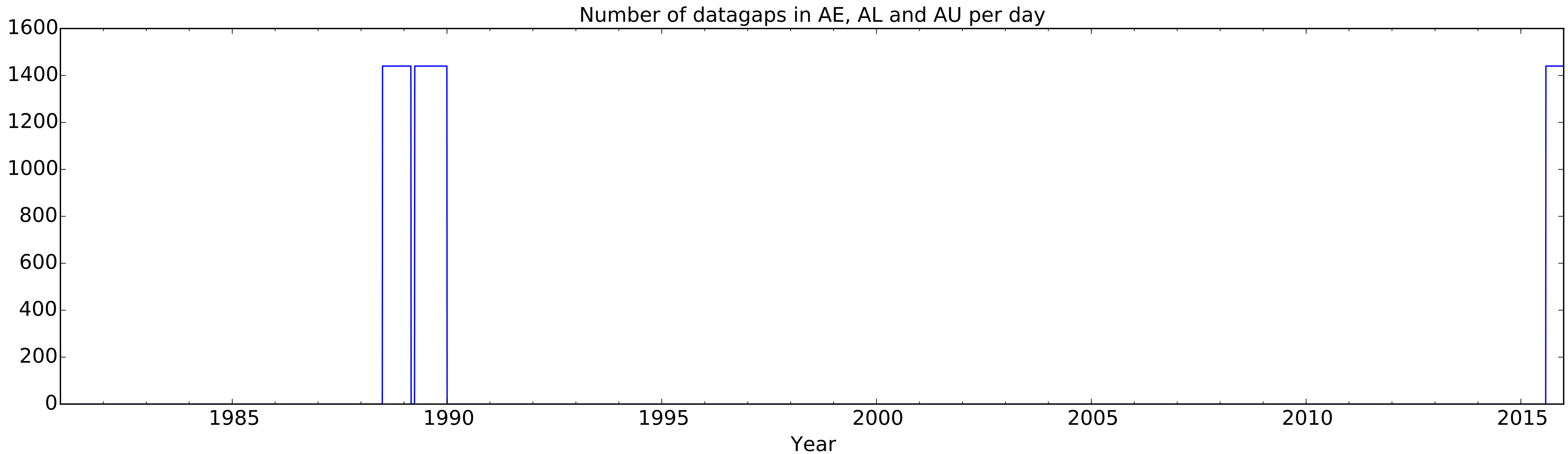


Figure 7: LASP *AE* forecast at 2015-04-01 08:49 UT.

Summary of AE data

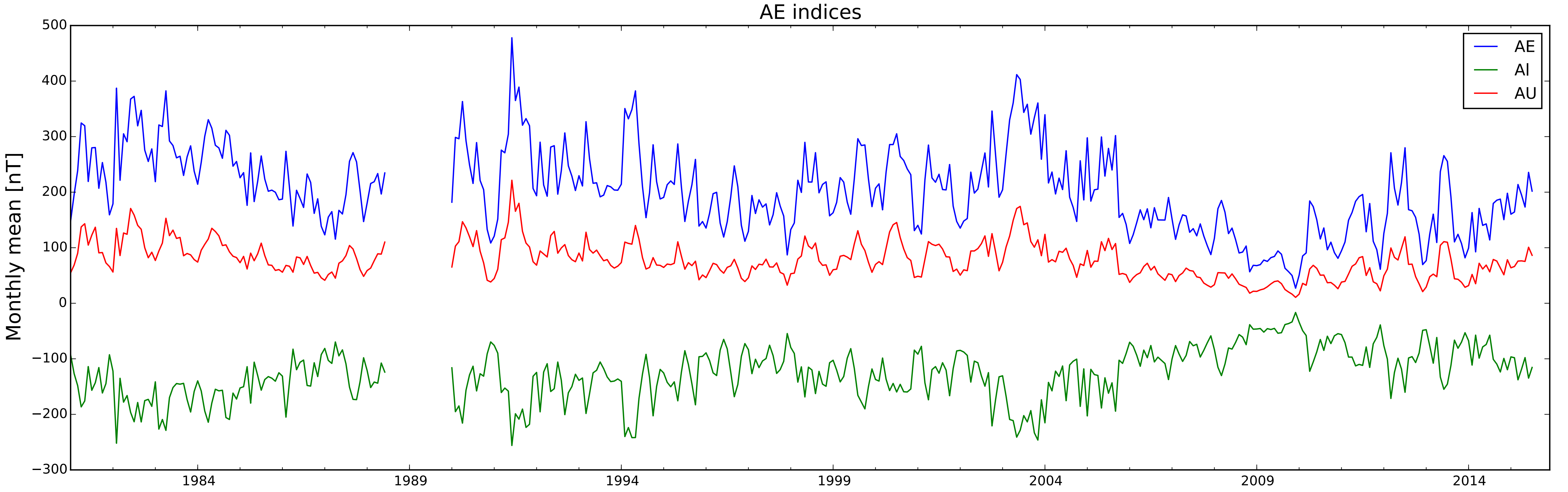
- AE is available from PostgreSQL DB at IRF-Lund
- AE indices consists of AL, AU and AE
- Obtained from the OMNI dataset
- There are 17441280 1-minute values of AE indices
- Covers the period: 1981-01-01 to 2015-12-31
- Range in AE: 1 to 5220 nT
- Range in AL: -5636 to 201 nT
- Range in AU: -1134 to 2261 nT

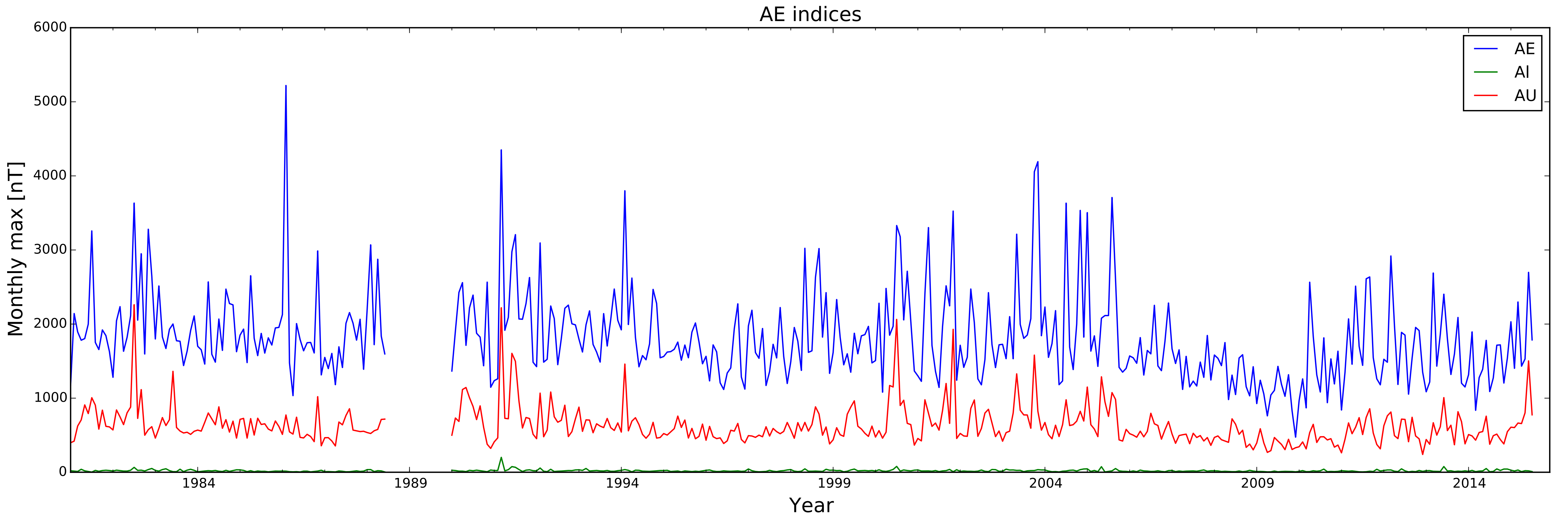
Missing data



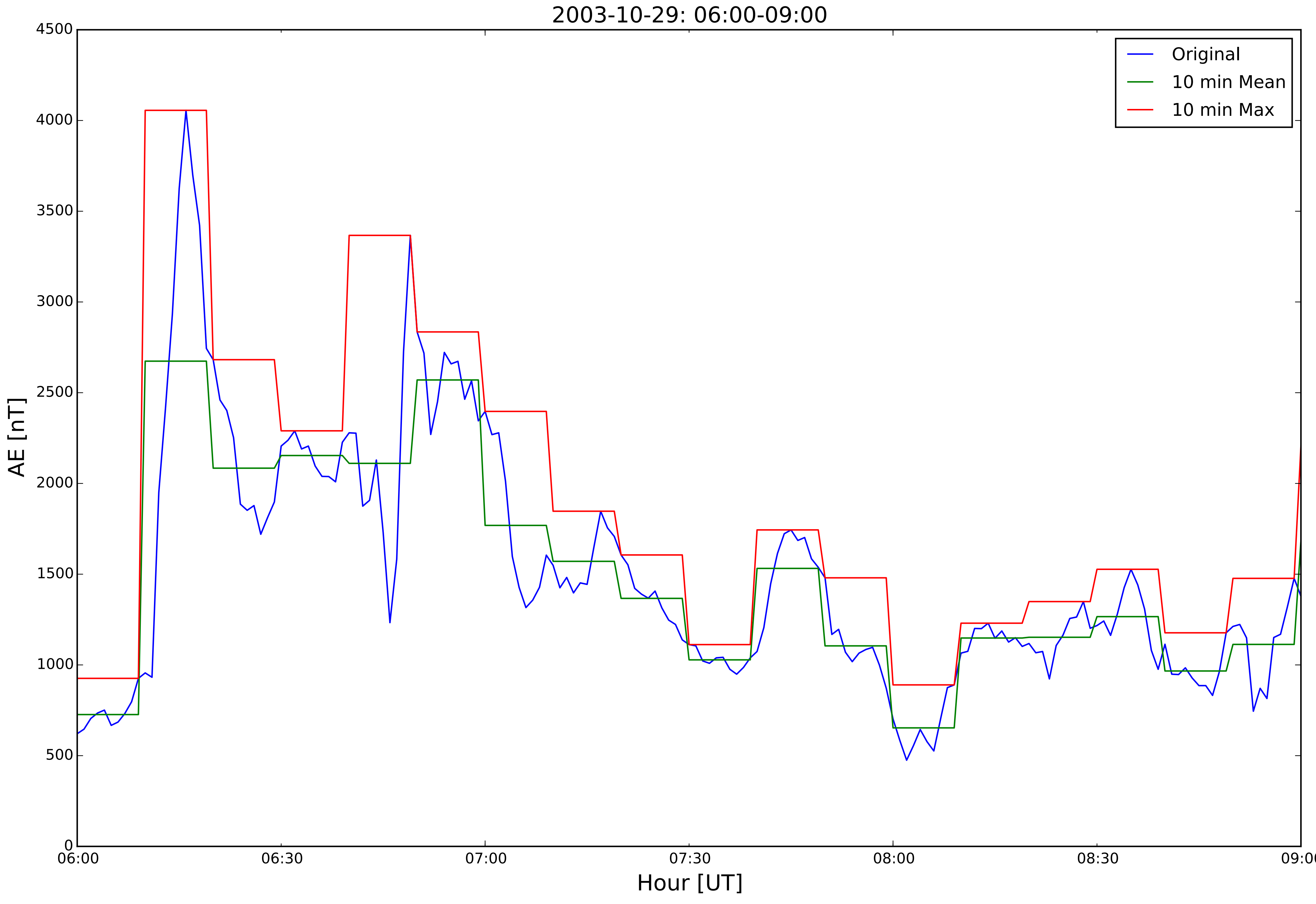
- Number of missing datapoints: 966240 = 671 days
- This is equal to 5.5% of the data set
- The missing data is located in time to:
  - 1988-07-01 to 1989-02-28
  - 1989-04-01 to 1989-12-31
  - 2015-08-01 to 2015-12-31
- Note: There are no missing data during ACE

AE data

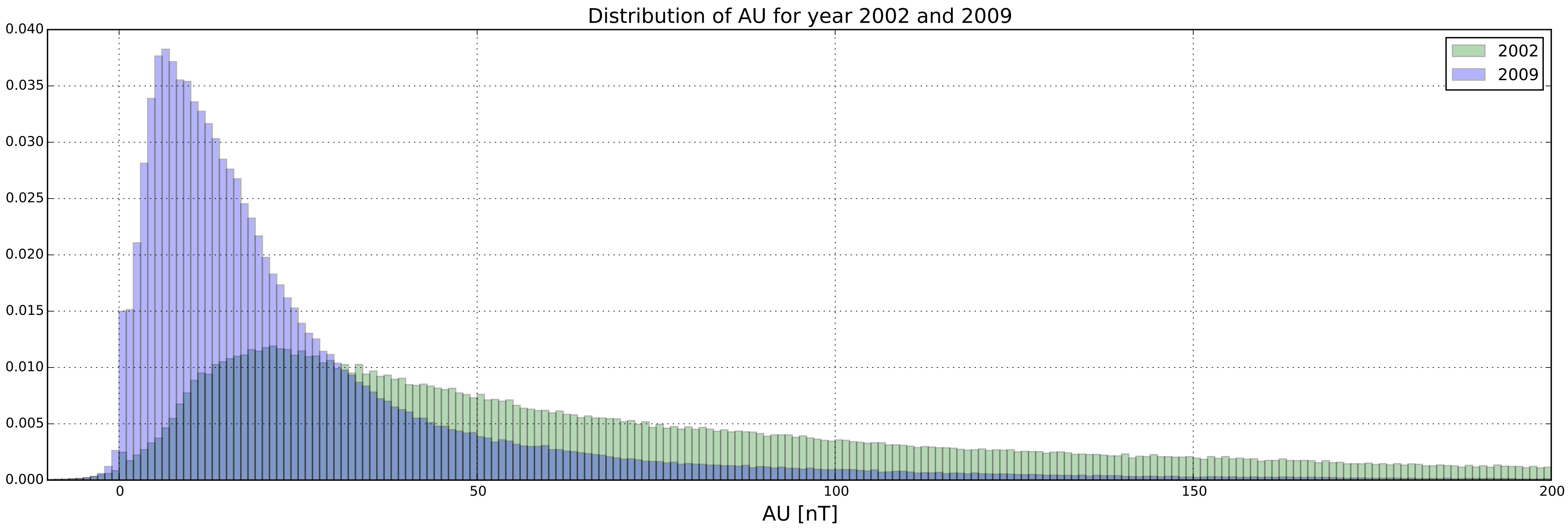

AE indices
AE
AI
AU
Monthly mean [nT]
500
400
300
200
100
0
−100
−200
−300
1984
1989
1994
1999
2004
2009
2014

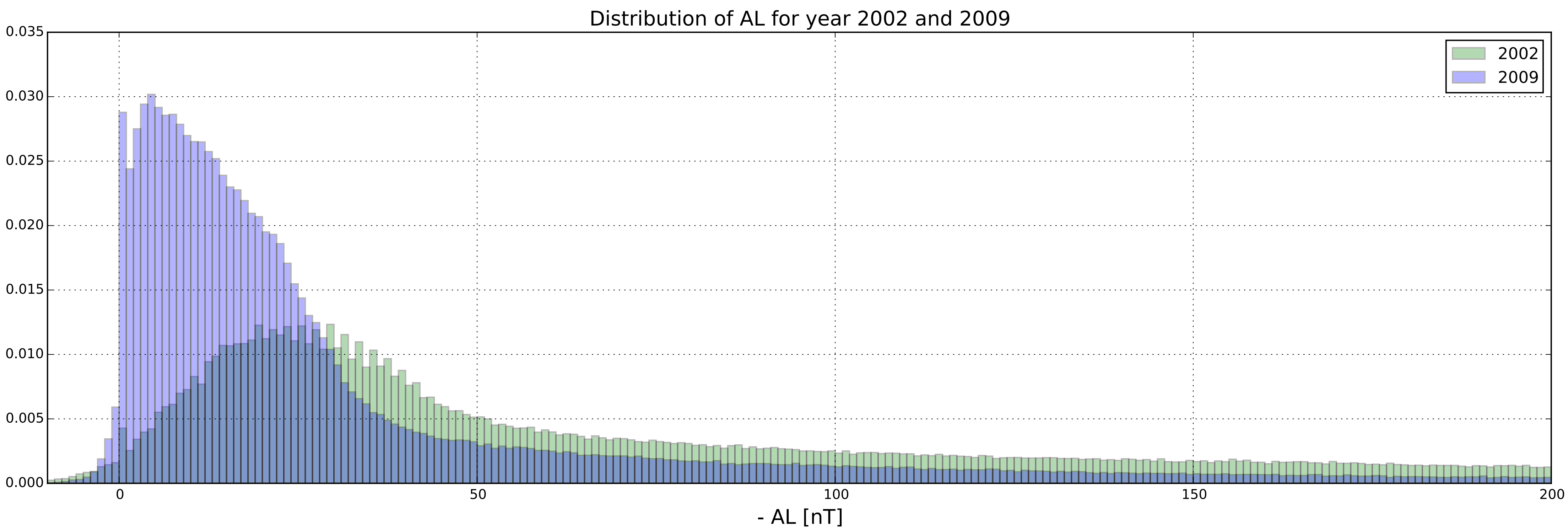

AE indices
AE
AI
AU
Monthly max [nT]
6000
5000
4000
3000
2000
1000
0
1984
1989
1994
1999
2004
2009
2014
Year

Resampled AE data

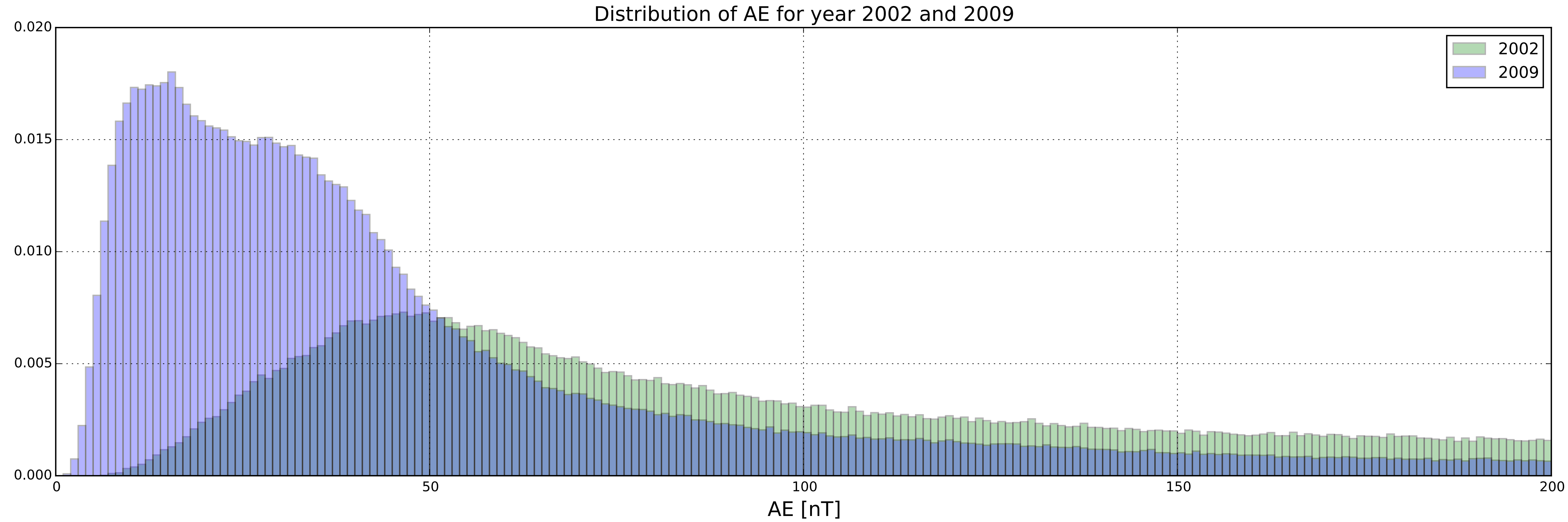


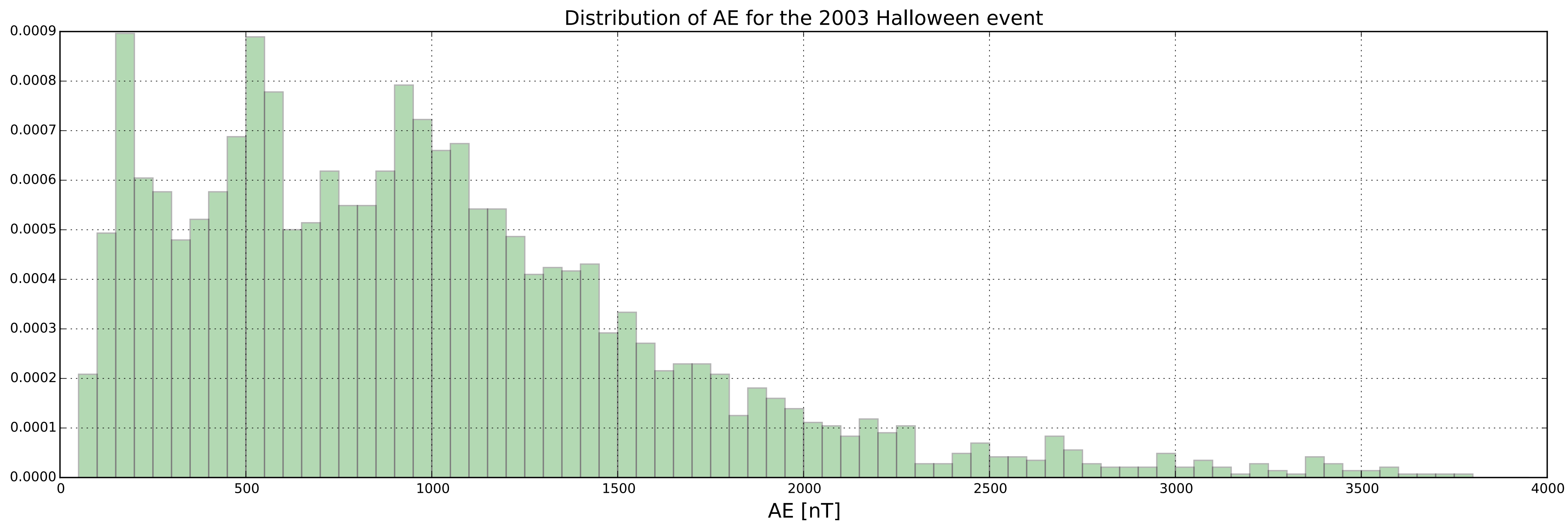
Distribution of AU and AL data



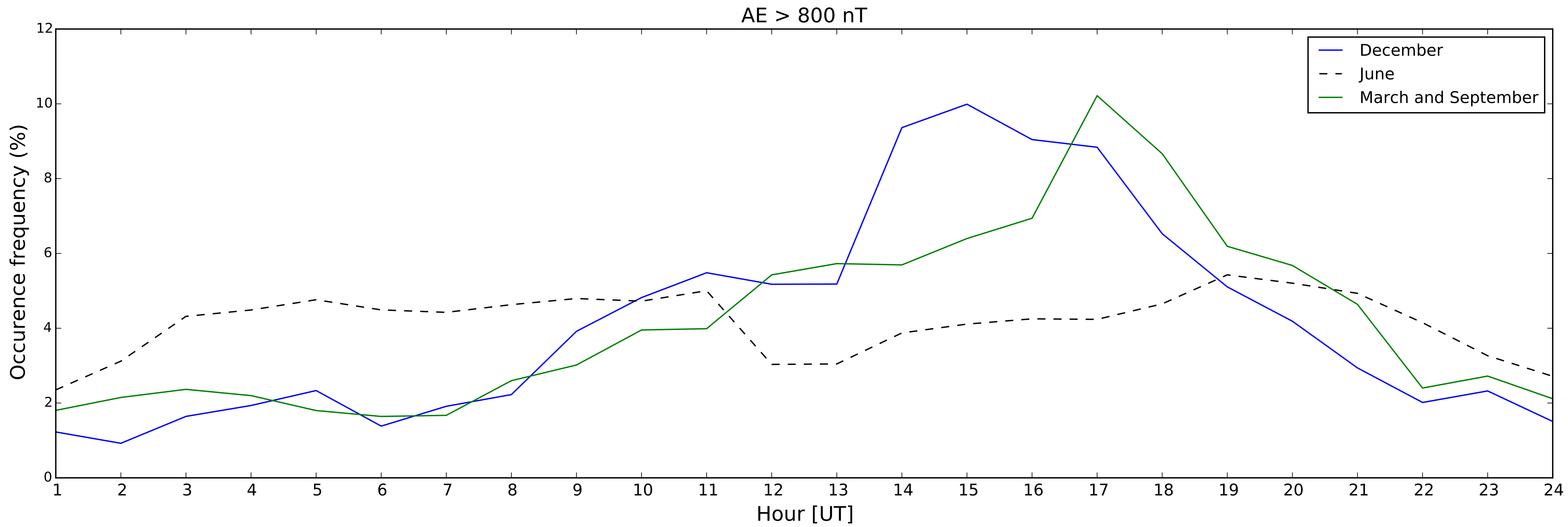


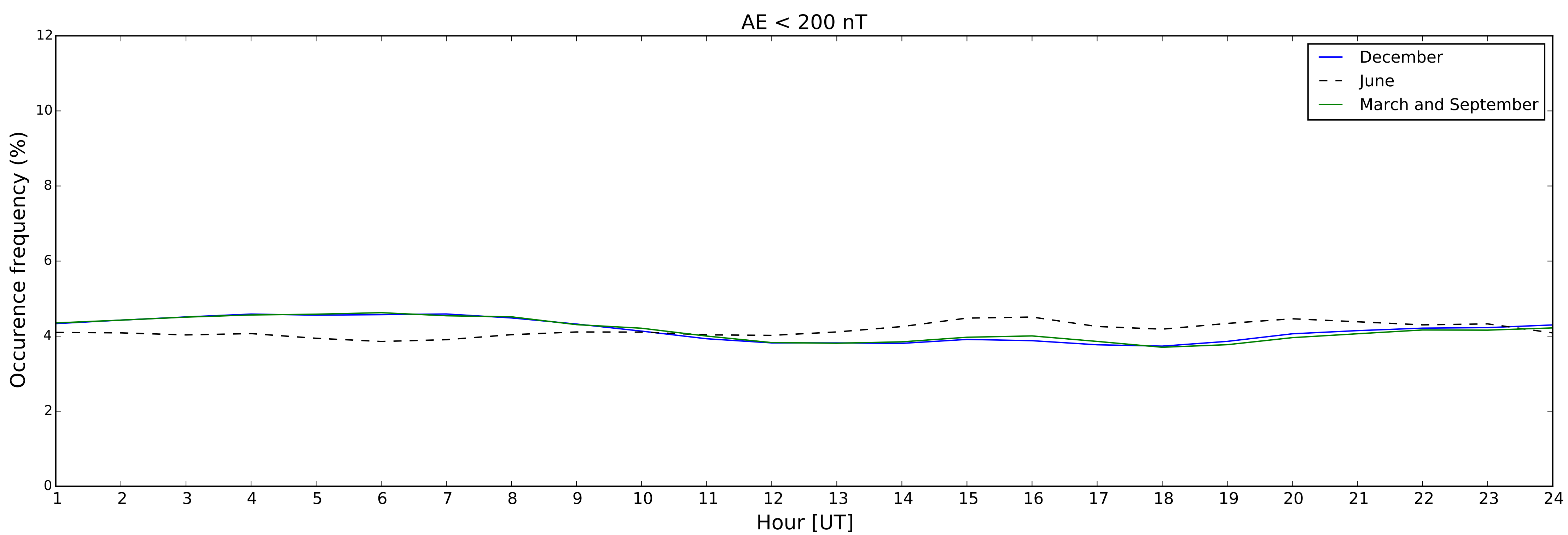
Distribution of AE data and Halloween event





Seasonal and UT dependence in AE index





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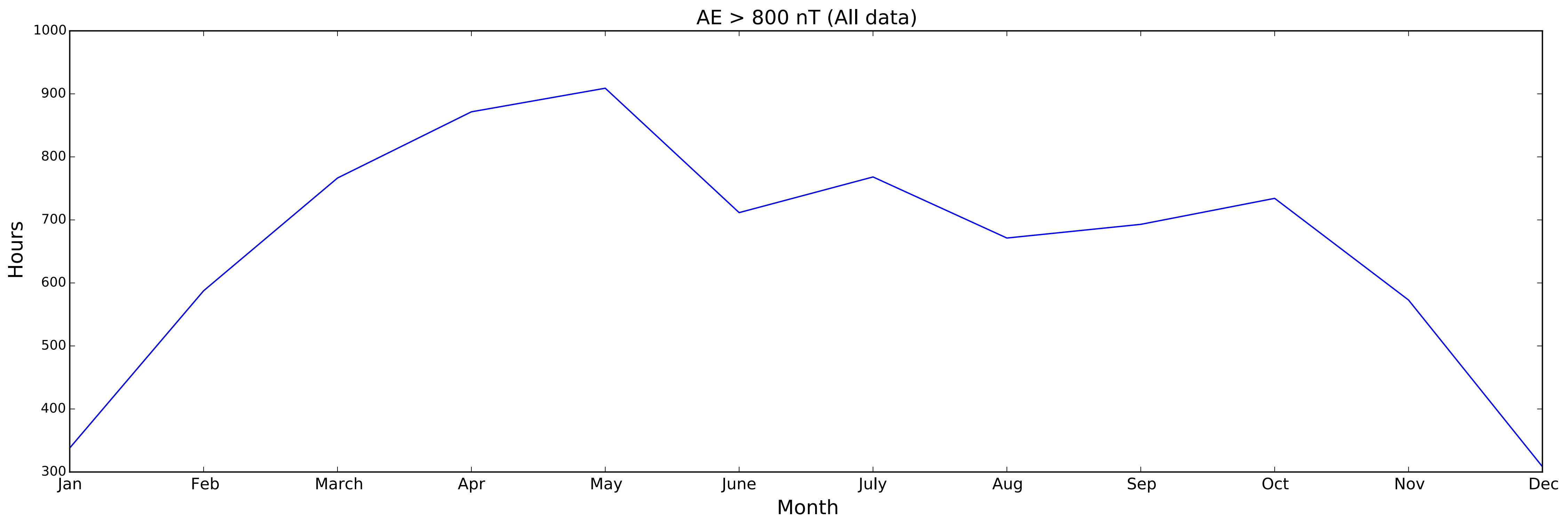
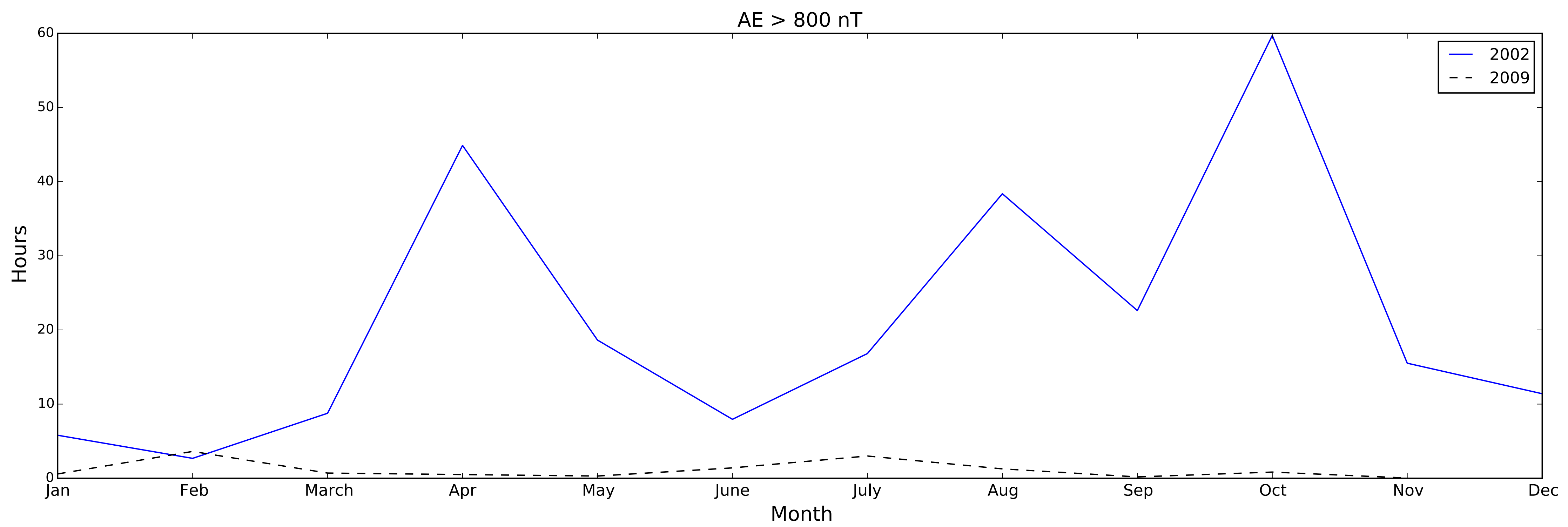
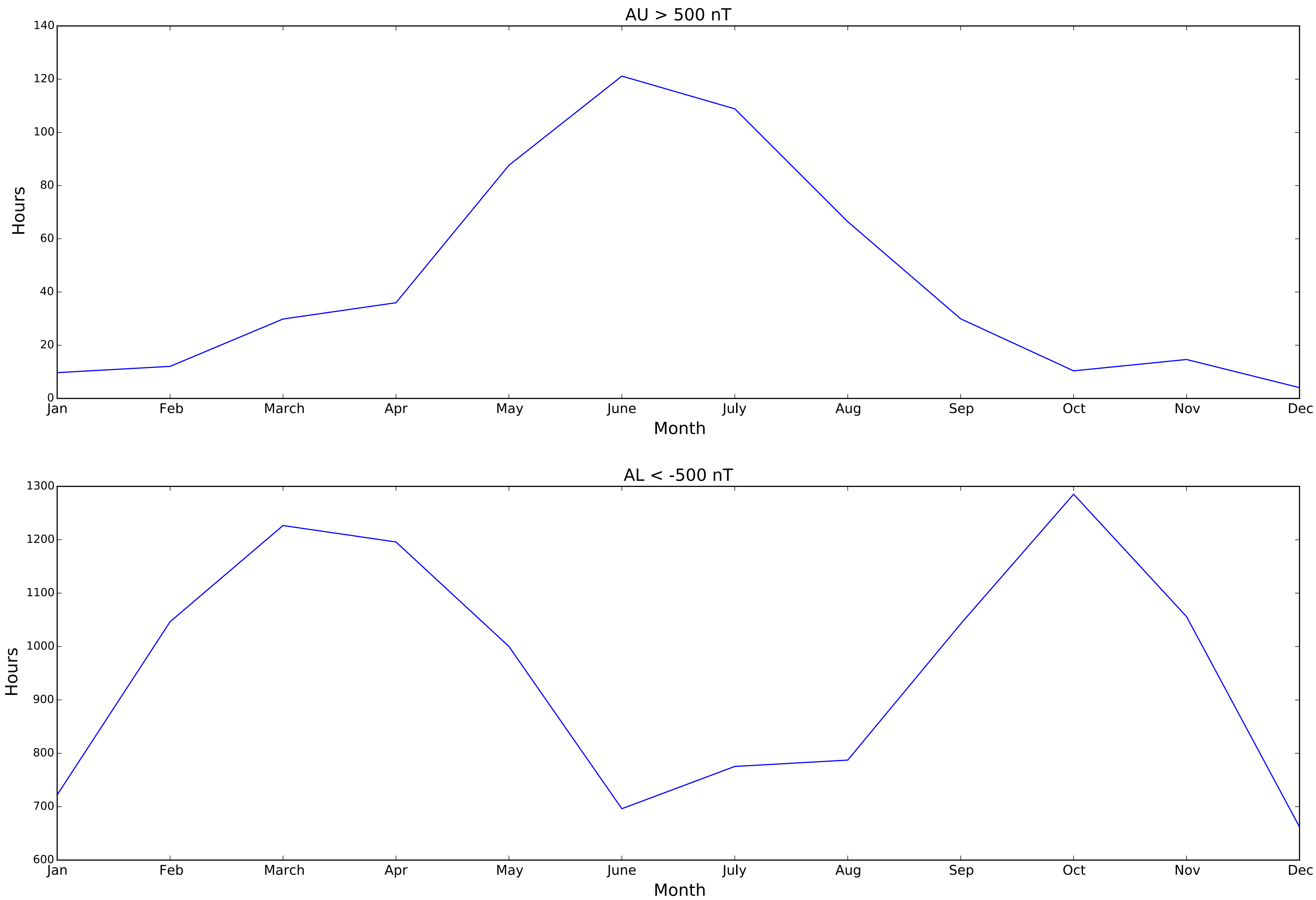
Seasonal variation in AE index





Seasonal variation in AL and AU index



Discussion

- What is the most important part of AE forecasts? Is it the storm onset, the length of the substorms, the magnitude or all of them?
- The physical meaning of AE is less obvious compared to AU and AL. AU and AL may therefore be better to forecast than AE.
- Discontinuities (at end of month) may occur due to the removal of quiet time reference levels but should be negligible.
- Interference on the resulting AE indices:
  - Induction effects at AE stations. How big?
  - *H*-component not always normal to electrojets?
  - Deviation of AE stations from *ideal distribution (~ 68^o - 71^o)*.
- Underestimate intensity of electrojets (and AE indices) during low (poleward) and high (equatorward) auroral activity.
- A substorm may be observed in only AU or AL. Therefore not enough to forecast only AU or AL.

Conclusions

- A PostgreSQL database and a REST service have been implemented. The REST service will be used internally at IRF but can be accessed remotely within the project.
- Although AE (and AL, AU) are global indices, they show a UT dependence.
- Based on a preliminary analysis, AE data should be selected to cover both different seasons, UT and years with both low and high solar activity.
- Forecast AU and AL individually and perhaps combine them to AE forecast.