



# **Extended Forecasting Kp User's Guide**



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# 1 Introduction

## 1.1 Overview

The primary purpose of the Kp Forecast system is to provide AFWA the capability to predict Kp. Kp is a 3-hour index that is commonly used to characterize the global planetary geomagnetic disturbances caused by the solar wind over a 3-hour period. (The K indices are generally used to indicate the solar wind effects on the earth's magnetic field; the subscript "p" means "planetary" and designates a global magnetic activity index.) The official Kp index is derived using data acquired at the selected 13 ground-based magnetic observatories which lie between 46 and 63 degrees north and south geomagnetic latitude: Lerwick (UK), Eskdalemuir (UK), Hartland (UK), Ottawa (Canada), Fredericksburg (USA), Meannook (Canada), Sitka (USA), Eyrewell (New Zealand), Canberra (Australia), Lovo (Sweden), Rude Skov (Denmark), Wingst (Germany), and Witteveen (The Netherlands). Based mainly on the horizontal components of the magnetic field measured by these stations, the Kp index discriminates conservatively between the true magnetic field perturbations and the quiet-day variations.

The value of Kp ranges in 28 steps from 0 to 9, indicating very quiet to very disturbed level respectively, with fractional parts expressed in thirds of a unit. The scale is quasi-logarithmic and the integer values are subdivided into thirds commonly expressed with symbols + and -, e.g. 0, -1, 1, 1+, 2-, 2, ...9. For many applications, it is often easier to express the fractional values explicitly without using the + and - symbols. For example, Kp values of 3+ = 3.3 = 3 and 1/3, and 5- = 4.7 = 4 and 2/3, etc.

Many models for the near-Earth space environment need Kp to predict various parameters such as atmospheric density, ionospheric conductivities, auroral particle precipitation boundaries, ionospheric and magnetospheric electric field etc. Unfortunately, Kp indices are published with significant time delay. The purpose of the Forecasting Kp project is to provide a predicted Kp using inputs from the ACE satellite.

The Extended Forecasting Kp model is based on a neural network that ingests forecasted solar wind data from the HAF code (*Fry, et al*) and outputs a Kp forecast for 1 to 4 days in advance at a 6 hour cadence.

## 1.2 Statement of purpose

The purpose of this document is to provide the operator with a description of the software components and to describe the options available to the user.

## 2 Operation Description

In the following sections, all referenced scripts, commands, and filenames are specified with the assumption that the user is currently in the base installation directory. That is, all command-line examples are relative to this directory, which varies according to where the software was installed.

### 2.1 Processing

The Extended Kp Forecasting system will generate and log all of the predictions. However, it relies on having a local data archive regularly updated (so that predictions are generated from the most recent data). For this reason, the `haf.csh` script should be run once before the Extended Kp Forecasting system is started, by typing:

**`<your_installation_directory/scripts/haf.csh`**

After the initial data update, this script should be established as a cron job to run once daily. It will process the latest HAF data and generate plots of the system's predictions for easy visual browsing of the output.

Once the data is present, the user can start the Kp Forecasting system, there is a `run.sh` (located at `jar` directory) which can start the KpPredictor application, or just type

```
java -classpath /tmp_mnt/project/upos/extendKpForcast/jar/predictor.jar  
predictor.KpPredictor
```

Once the system has been started, it can be run in the background. At a specified time, it will check for the presence of new data and generate predictions.

### 3 Operation

#### 3.1 User Edited Files and Parameters

There is a single setup file that manages the location of the input data and output products which controls the behavior of the extended Kp Forecasting process. The following setup file **must** be modified before executing the Kp Forecasting process: <your\_installation\_directory>/scripts/haf.csh,. A sample of the above-mentioned setup file can be found in Appendix B. The following table lists the variables in the above-mentioned setup file as well as their purpose. These values can be altered if desired using any UNIX compatible editor.

haf.csh

Logical	Description
KP	Directory path to where the Kp Forecasting software is installed.
IMAGES	Directory path to the output area where the .gif output files produced by the Kp Forecasting software are stored.
HOME_PATH	Directory path to where the rplot software is stored.
BIN_PATH	Directory path where the rplot executable is stored.
USR_BIN_PATH	Directory path to where the system executables are stored.
FONT_PATH	Directory path to where the fonts used by the rplot software is stored.
SLEEP_PATH	Directory path to where the UNIX command "sleep" is stored.
JAVASOFT	Directory path to where the neural network software is installed.

There is a single configuration file, `urls_for_data.prop` that contains all the necessary locations of data files for use by the neural network. This file is located in the "<your installation directory>/jar/urls" directory. A sample file can be found in Appendix B. The following table lists the variables and specifies their purposes. These values can be modified using any text editor. In most cases, no modifications will be necessary.

Logical	Purpose
DATAPATH	Base directory for the forecasting software.  Note: If this location is modified, the ace.csh script will need to be updated

	as well, so that the data can go to the proper location.
INPUT_1DAY_URL	File used to store the most recent 1 day ahead HAF input data
INPUT_2DAY_URL	File used to store the most recent 2 days ahead HAF input data
INPUT_3DAY_URL	File used to store the most recent 3 days ahead HAF input data
INPUT_4DAY_URL	File used to store the most recent 4 days ahead HAF input data
RESULT_1DAY_URL	File used to store the most recent 1 day ahead forecast made by the system.  Note: If this location is modified, the ace.csh script will need to be updated as well, so that the plotting software knows where the result is located.
RESULT_2DAY_URL	File used to store the most recent 2 days ahead forecast made by the system.  Note: If this location is modified, the ace.csh script will need to be updated as well, so that the plotting software knows where the result is located.
RESULT_3DAY_URL	File used to store the most recent 3 days ahead forecast made by the system.  Note: If this location is modified, the ace.csh script will need to be updated as well, so that data goes to the proper location.
RESULT_4DAY_URL	File used to store the most recent 4 days ahead forecast made by the system.  Note: If this location is modified, the ace.csh script will need to be updated as well, so that data goes to the proper location.
ERROR_LOG_URL	File containing any errors logged by the system as it operates.
WEIGHT_SAVE_URL	Directory containing the weight files used by the neural network.

XTRANSF_URL	Directory containing the transformer file used by the neural network.
-------------	---

### 3.2 Data Files

The extended Kp Forecasting system relies on HAF input data. Below is a sample input file for HAF data. The header consists of the number of hours simulated, the year of the starting time of the simulation, the month of the starting time of the simulation, the day of the starting time of the simulation, the hours of the starting time of the simulation, the Carrington Rotation number, the AU distance of the Earth, and the magnetic field parameter type. The file includes eleven columns: The hour of the simulation, the solar wind speed, the particle density, magnetic field parameters (Bx, By, Bz, and /B/, theta and phi, the latitude of the Earth and the longitude of the Earth. The proton density and bulk speed are propagated and averaged to create the file nn\_oneday.dat, nn\_twoday.dat, nn\_threeday.dat and nn\_fourday.dat for use by the neural network. Note that the fill value for this data is -9999.9.

```

192 2005    7    9    0 2032  1.0    2
  0.00  387.66    2.28    0.76   -0.83   -0.15    1.13   -7.69
312.54    3.73   210.87
  1.00  385.98    2.27    0.74   -0.81   -0.13    1.10   -6.54
312.28    3.74   210.91
  2.00  384.33    2.18    0.74   -0.82   -0.10    1.11   -4.95
312.01    3.74   210.95
  3.00  382.81    2.25    0.77   -0.87   -0.06    1.16   -3.02
311.78    3.75   210.99

```

Below is a sample of a few lines from the file nn\_oneday.dat, which is used as one of the input files to the neural network. It is the result of merging the propagated and averaged HAF data. The columns consist of the hour of simulation, the solar wind speed, the particle density, Bx, By, Bz, /B/, theta the latitude of the Earth, and the longitude of the Earth.

```

  4      2005      7      13      3
  3.00  600.19    0.87   -4.63    0.74    0.04    4.69    0.41
170.95  4.15   214.77
  9.00  571.36    1.24   -4.54    1.07   -0.24    4.67   -2.88
166.69  4.17   215.01
 15.00  562.72    3.54   -3.85    3.42   -0.61    5.91   -5.00
146.18  4.20   215.24
 21.00  554.36    4.79   -4.00    1.11    0.13    4.15    1.79
164.49  4.22   215.48

```

### 3.3 Outputs

The extended Kp Forecasting system outputs a 4-day prediction. Plots of these values and of the HAF input data are produced.

### **3.3.1 Predictions**

The most recent predictions are written to separate text files, the locations of which are specified in the configuration file as

`RESULT_1DAY_URL`, `RESULT_2DAY_URL`, `RESULT_3DAY_URL` and `RESULT_4DAY_URL`. An invalid prediction is output with the current time and a `-9999` value for the prediction.

### **3.3.2 Data plots**

The Kp Forecasting system generates plots once daily of the IMF and SW data for the day and for the week. The most recent of these plots can be accessed by viewing the included `index.html` web page via a web browser.

### **3.3.3 Prediction plots**

In addition, the system generates a plot of the 4-Day forecast. The most recent of these plots can be accessed by viewing the included `index.html` web page via a web browser.

An example of the output plots is shown in Appendix C.

## 4 Related Documentation

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## **Appendix A      Acronyms and Abbreviations**

<b>Acronym</b>	<b>Definition</b>
ACE	Advanced Composition Explorer
AFWA	Air Force Weather Agency
APL	Applied Physics Laboratory of Johns Hopkins University
ASCII	American Standard Code for Information Interchange
Bx	X component of the Interplanetary Magnetic Field
By	Y component of the Interplanetary Magnetic Field
Bz	Z component of the Interplanetary Magnetic Field
GIF	Graphic Interchange Format
HTML	Hypertext Markup Language
IMF	Interplanetary Magnetic Field
JHU	Johns Hopkins University
Kp	Geomagnetic index that indicates the global geomagnetic disturbances
MAG	Magnetometer (ACE Instrument)
NOAA	National Oceanic and Atmospheric Administration
SWEPAM	Solar Wind Electron, Proton, and Alpha Monitor (ACE Instrument)
UPOS	University Partnering for Operational Support
USAF	United States Air Force

## Appendix B Sample Configuration Files

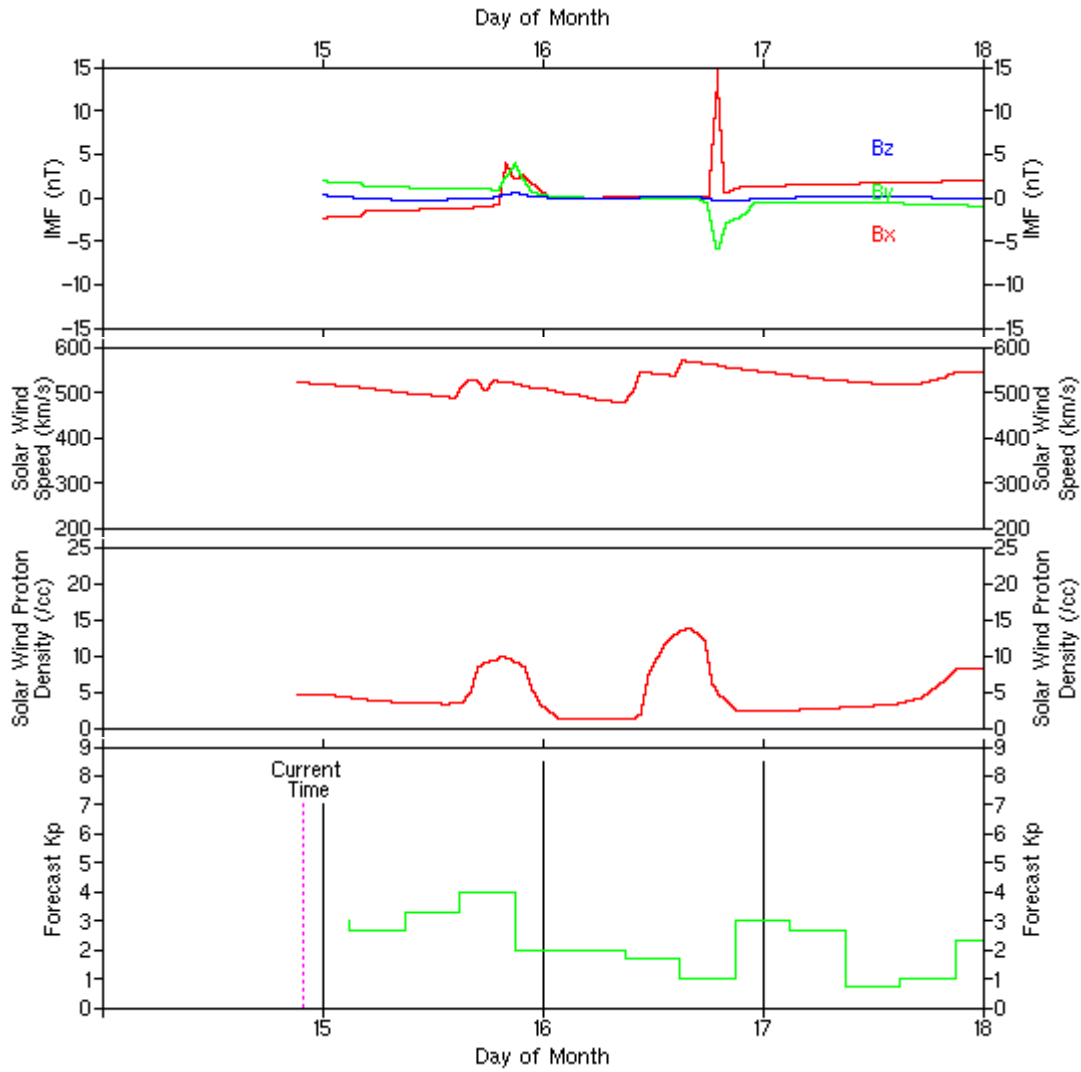
### haf.csh

```
#####  
#  
# Filename: haf.csh  
#  
# Description: This executive script controls the data acquisition  
# and processing of the Extended Forecasting Kp software system.  
# It calls the functions necessary to process the  
# real-time HAF data and to create plots of the data  
# values and predictions.  
#  
# Arguments: none  
#  
# Author: Linda Burke/Bruce Toth  
# JHU/APL  
# 11100 Johns Hopkins Road  
# Laurel, MD. 20723-6099  
#  
# Created: June 2005  
# Tested : June 2005  
# Modified: Based upon Janice Schofield's script from 2004.  
#  
#####  
  
set now=`date +"%m%d_%H%M"`  
set today = `date +"%m%d"`  
  
####Base directory variables####  
setenv UPOS /disks/dm006/KPHAF_final  
setenv KP /disks/dm006/KPHAF_final  
#####  
  
setenv IMAGES ${KP}/html/images  
setenv HOMEPATH ${KP}/rplot  
setenv BINPATH ${HOMEPATH}/bin  
setenv USR_BINPATH ${HOMEPATH}/usr/bin  
setenv FONTPATH ${HOMEPATH}/tables/general/fonts  
setenv SLEPPATH /software/gnu/bin  
setenv JAVASOFT /project/upos/extendKpForecast  
  
#run IDL code/JAVA software/plotting software$KP/scripts/KPHAF_end_to_end.pl  
  
echo "Copying images to html folder"  
cp $KP/rplot/pkp/*.gif $IMAGES  
#cp $KP/rplot/pkp/*.png $IMAGES
```

## urls\_for\_data.prop

```
##URLS for data items
DATAPATH=file\:/project/upos/extendedKpForecast
INPUT_1DAY_URL=file\:/dat/nn_oneday.dat
INPUT_2DAY_URL=file\:/dat/nn_twoday.dat
INPUT_3DAY_URL=file\:/dat/nn_threeday.dat
INPUT_4DAY_URL=file\:/dat/nn_fourday.dat
RESULT_1DAY_URL=file\:/dat/nn_output_oneday.dat
RESULT_2DAY_URL=file\:/dat/nn_output_twoday.dat
RESULT_4DAY_URL=file\:/dat/nn_output_threeday.dat
RESULT_4DAY_URL=file\:/dat/nn_output_fourday.dat
ERROR_LOG_URL=file\:/history/error_log.dat
WEIGHT_SAVE_URL=file\:/nn/weightRepos
XTRANSF_URL=file\:/nn/transformer
```

## Appendix C Sample Output Plots



Plots most recently generated on Thu Jul 14 15:58:24 UT 2005

## **Appendix D      Contact Information**

Refer all science/model questions to [simon.wing@jhuapl.edu](mailto:simon.wing@jhuapl.edu).

Refer all software/web questions to [janice.schofield@jhuapl.edu](mailto:janice.schofield@jhuapl.edu).