Documentation for

# CISM_DX

## The Center for Integrated Space Weather Modeling Data and Model Explorer

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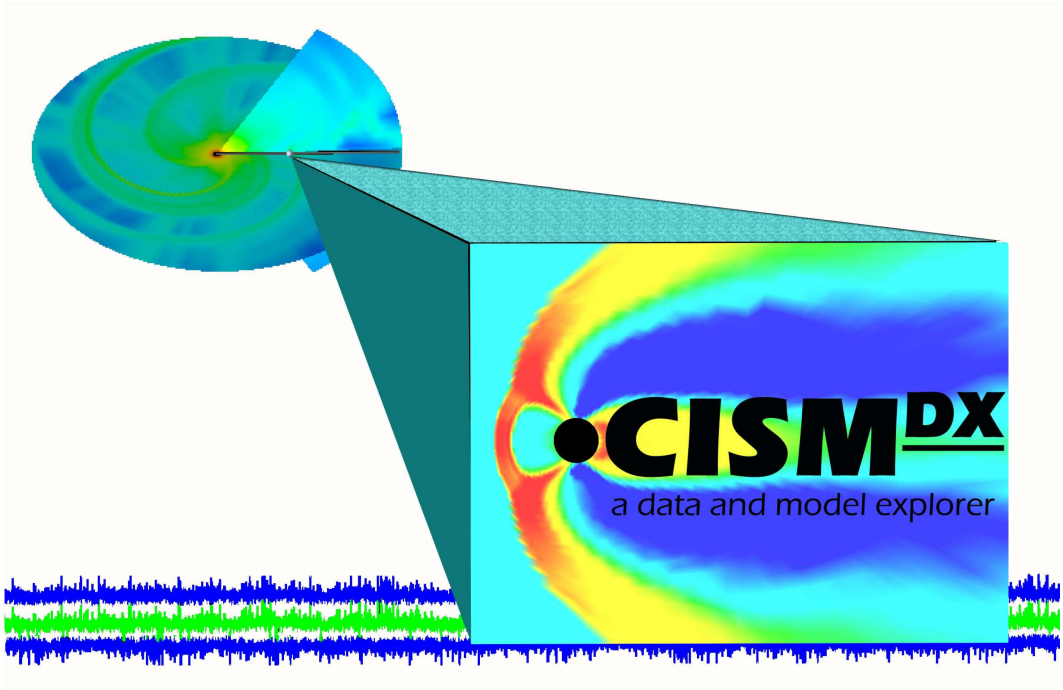
December 20, 2007

*A community–developed suite of integrated*
*data, models,*
*and data and model explorers,*
*for research and education*

**Documentation for Version 0.57**



# Contents

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# 1 Introduction

## 1.1 Scope of the project

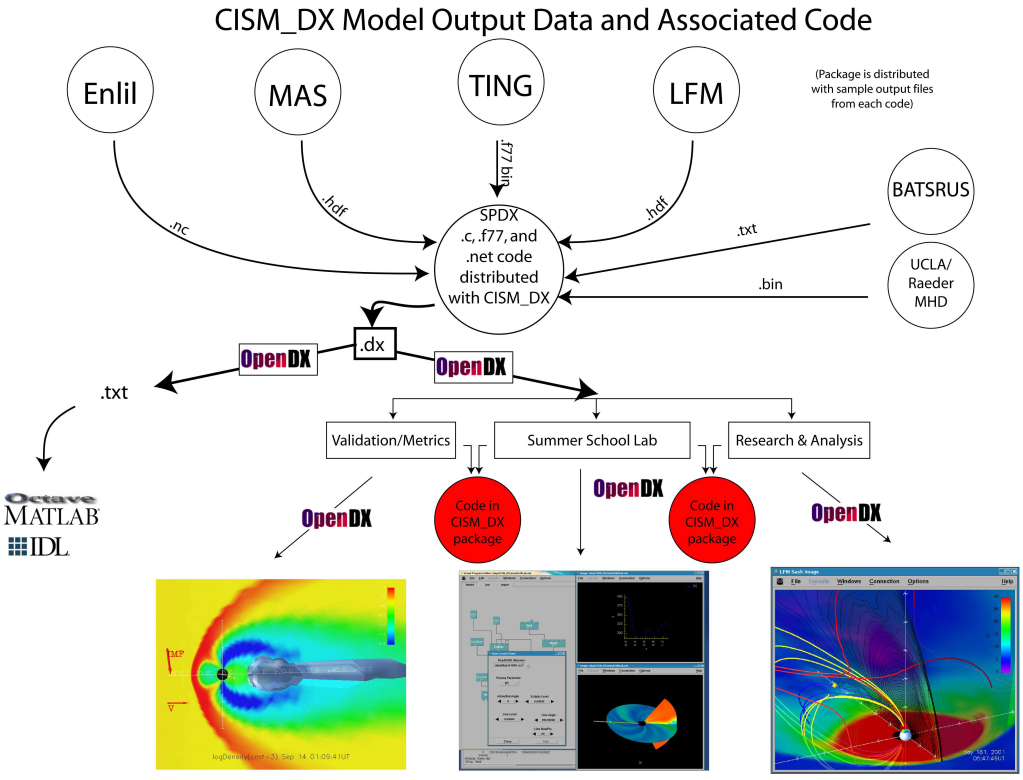


Figure 1: Schematic of the numerical model data visualization capabilities and codes distributed in the CISM_DX package. Output data files from many numerical models are transformed into the OpenDX data structure.

The CISM Data Explorer is a collection of tools for space physics researchers and students. This project began in response for a need to simplify model (both empirical and numerical) and data (both measurement and model output) exchange between CISM group members. CISM_DX is a guided development effort with contributions from many students and scientists. The code base is composed primarily of extensions and codes written for OpenDX (a 3–D visualization and GUI package) and Octave (a numerical analysis program with scope similar to IDL and Matlab, and a syntax similar to Matlab). The CISM_DX package contains:

- Historical time series data sets (1–30 years in length at 1–day to 1–minute resolution) put into a standard file format and form. The data sets are provided with code for display in IDL, Matlab, Octave, and OpenDX. See Section **??**.
- Code for side–by–side visualization and analysis of the output of many space physics numerical models;
- A catalog of simulation runs with instructions on the responsible scientist or student, information about where the data are located, and a list of programs that can be used to browse the data files;
- Code for doing validation and metric studies of CISM models using data in the standard data set distributed with CISM_DX;
- Code for running the CISM Forecast model, and
- Tools, provided with with examples of their use, for space physics research, including coordinate transformation programs, scripts that transform data from many data providers into a standard file format and form, and standard geophysical and solar community models.

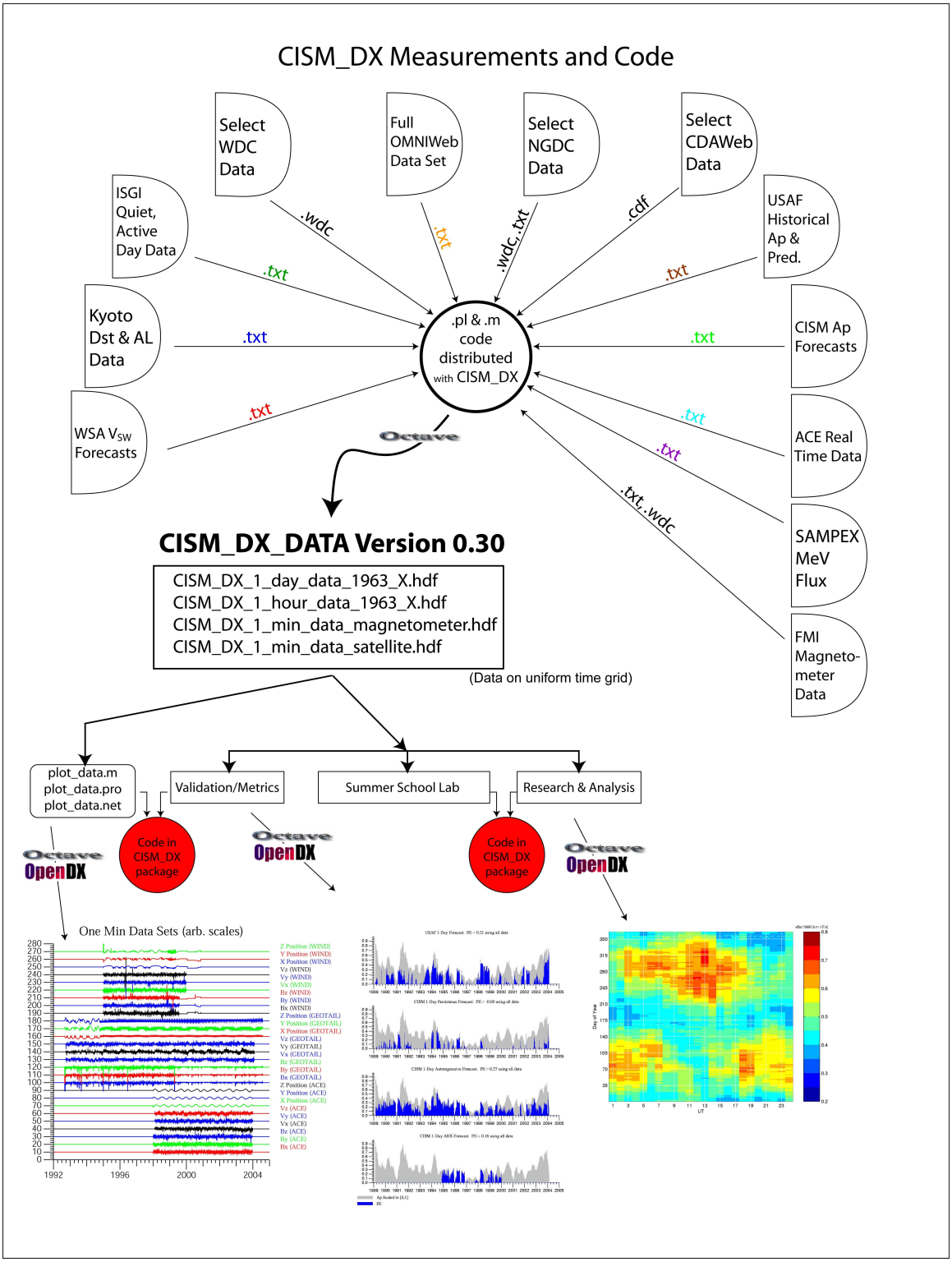


Figure 2: Schematic of the measurement data visualization capabilities and codes distributed in the CISM_DX package. Measurement data in many different file formats are transformed into a common file format using Octave/Matlab scripts. The CISM_DX distribution contains code for reading these files in Matlab, Octave, OpenDX, and IDL. The distribution also contains code that has used these data for the summer school, validation, or research.

Figure 1 is a schematic of the numerical model data visualization capabilities and codes distributed in the CISM_DX package. Figure 2 is a schematic of the measurement data visualization capabilities and codes distributed in the CISM_DX package.

The most important aspect of this project its use as a research coordination tool. CISM_DX is not just a set of codes ("networks") written for visualization in OpenDX. It is much more general than this. The CISM Data Explorer is a collection of contemporary tools for space physics researchers and students. It relies on well–documented programs and examples written in C, FORTRAN, Octave, OpenDX, and Perl. These codes are integrated with wrapper programs so that a user generally only needs to interact with OpenDX and/or Octave.

We intend to make CISM_DX useful to the widest possible audience. We recognize that many users may not want to learn how to write programs for Octave or OpenDX; they may only be interested in extracting information from CISM_DX for analysis or visualization using their own software. In future releases we will move toward this ideal. In this release a user has the ability to extract data from the measurement data set; in the future there will be equivalents for numerical data. It has been noted that we have nearly developed a data and model file standard, because a user could use the CISM_DX package to automate the conversion of many different data and file formats into a single format. At present no community standard exists; we are keenly aware of this and hope that this package will either stimulate or facilitate the creation of a standard or framework. Currently, we tell those associated with CISM that their data conforms to our standard if it can be easily viewed in CISM_DX. In many cases, the model author does not have to write a data reader; one of the many users of this package will usually write a file reader and tell us what libraries we need to include as part of the CISM_DX install process.

For visualization, OpenDX was chosen because (a) it is Open Source, (b) it is (nearly) platform independent, and (c) SPDX already had the capability to view model runs for many space physics numerical models.

For high–level computation and analysis, Octave was chosen because (a) it is Open Source, (b) it is (nearly) platform independent, and (c) many Matlab scripts are compatible with it. Although many space physics researchers and students prefer IDL over Matlab, Octave was chosen primarily because we believe that the combination of (a) and (b) will lead to code that can be used long into the future, even if Octave is no longer popular; old Octave code can be called by a wrapper program, much in the same way that wrapper programs are written for the Tsyganenko code described above.

For low–level computation and analysis, we prefer to use anything that can be compiled by the GNU compilers. These compilers run on nearly every operating system and will thus allow for the largest possible user base. One disadvantage is that GNU compilers cannot compile programs written in all languages. For example, code written in FORTRAN 90 may not compile with the GNU FORTRAN compiler. Our approach is to write and include as much code for which speed is not a limitation in a language that can be compiled with a GNU compiler. One issue that we will face in the future is how to incorporate programs written in newer or specialized languages while still keeping the CISM_DX package cross–platform compatable.

Although initially developed by a few people, our hope is to have many contributors to the CISM_DX code base.

```
Contributors to CISM_DX
```

A list of desired contributions is given in Section 1.2 below.

## 1.2 Contributing to the project

When making a contribution, remember that the goal is for a scientist or student to be able to test and compare new ideas with previous results without having to re-create and re-program everything themselves. Ideally the contribution is compilable with the GCC compiler or an Octave or OpenDX program. However, we may be interested in programs for viewing CISM_DX data in any popular language, including those written for non–open source programs such as IDL and Matlab. In the future submission templates will be made available so that a student or researcher can submit the package for review and have it work seamlessly with an existing CISM_DX installation. Until these templates are available, these are the submision guidelines.

**Style guide and Submission Process**

1. Always split data cleaning functions from the main function. Try to use functions already in CISM_DX. If a data cleaning function does not exist, consider generalizing and submitting yours.

2. Always give demos for using your code with synthetic data and/or real data. If the code does not require data, provide demos that show a typical use of your program. Try to use data already in the CISM_DX_DATA directory. If it does not exist, consider making a request for its addition.

3. In the code include a comment that includes your name, the date, and when and on what operating system your program was tested on.

4. Email your package (or link for large packages) with a short description to the CISM_DX user mailing list `cismdx_user@miranda.colorado.edu`. Your contribution will be reviewed and feedback will be provided.

5. After testing your code, we will attempt to incorporate your code or package into the CISM_DX distribution, possibly after making minor changes. Your code will be versioned. If you make any changes and wish to re-submit the new version, please edit and re–submit the CISM_DX version of your code. If you wish to directly access the CVS repository, contact Andy Clark (`aclark@bu.edu`).

**Review Criteria**

1. Is it easy to get the code running?

2. Is a demo included that demonstrates typical usage of the code and/or provides a comparison with a figure or result in a paper or other work.

3. Are the comments sufficient for others to be able to study, modify, or improve upon the code?

4. Is there a brief description of your program that can be included in this document?

**Consideration for Future development**

If you have a feature that you would like to see added, please ask one of the developers or send email to `cismdx_user@miranda.colorado.edu`.

- **Links with data providers:** For example, NGDC has a command line program that allows one to obtain data with a short command. It would be straightforward to call this from Octave or OpenDX. That is, one could create a simple program that takes inputs of time span and downloads and plots data from a GOES–10 satellite to the screen. If the user requests the same data in the future, the program would need to recognize that the data was already downloaded, which makes this problem more complex.

- **Links with the simulation run database:** We will consider if it desirable to have a program that automatically gets model data from an internet site using `wget` if does not find it on your local computer. Currently Octave calls `wget` in this manner if it does not find a required data file for the uniform time series data set.

- **Educational content:** This document currently contains examples used in the CISM Summer School. However, there is much room for additional educational material. For example, demos that explain both measured data and model output and compares what you see on the screen with figures in textbooks and journal papers.

- **Installation:** We are always looking for ways to simplify the install process. For Linux, it would be useful to use the `yum` program to assist in the installation of support packages. We are also considering creating a Knoppix Live CD.

- **Science Nuggets:** We would like to expand this document so that it contains more "Science Nuggets" in a form similar to the Sash.net discussion.

## 1.3 Mailing list

The mailing list for CISM_DX and it resides on

`http://miranda.colorado.edu/mailman/listinfo/cismdx_user`

Users and contributors are encouraged to subscribe to it. All questions, announcements for new releases, and submission of new and discussions of OpenDX networks and Octave mfiles, are handled through this mailing list.

In addition, there is a more specific mailing list for developers. Bug reports, CVS repository activities, and the review process is handled through `cism-devel-cism_dx@bu-ast.bu.edu`.

## 1.4 Running the CISM Forecast Model

The directory `CISM_FMs/` contains networks and data needed for running and validating many of CISM's empirical models. An overview of each is given in Section 2.8.

To run the forecast models, start Octave with CISM_DX extensions by executing `cismdx_octave` and typing
`run_forecast_models` at the Octave prompt. The result of the forecast models can be viewed by pointing a web browser to the file `CISM_FMs/web_page/index.htm`. The forecast models can be run from Matlab, but you must execute `Octave/CISM_DX_startup.m` before invoking `run_forecast_models` from the Matlab command line.

# 2 List of CISM_DX programs

## 2.1 OpenDX example networks in `CISM_DX/example_networks/`

**Online Documentation and Screenshots for OpenDX example networks in CISM_DX**

Or, if you have installed CISM_DX, point your web browser at

**Online Documentation and Screenshots for OpenDX example networks in CISM_DX**

## 2.2 OpenDX macros in the directory `CISM_DX/macros/`

**Online Documentation and Screenshots for OpenDX macros in CISM_DX**

Or, if you have installed CISM_DX, point your web browser at

**Online Documentation and Screenshots for OpenDX macros in CISM_DX**

## 2.3 OpenDX modules in `CISM_DX/OpenDX/modules`

OpenDX modules are maintained as a part of a separate CVS tree named SPDX (Space Physics Data Explorer). SPDX is a set of OpenDX "outboard" modules. These modules are binary programs that can be called only from OpenDX. These modules are for doing tasks such as reading binary files or linking to external Fortran and C libraries. The user interacts with these programs by wiring connections to the associated module in a network. Example use of these programs can be found in the networks described in the previous section.

**Online Documentation and Screenshots for OpenDX modules in CISM_DX**

Or, if you have installed CISM_DX, point your web browser at

**Online Documentation and Screenshots for OpenDX modules in CISM_DX**

## 2.4 OpenDX networks in `CISM_DX/OpenDX/`

**Online Documentation and Screenshots for OpenDX networks in CISM_DX**

Or, if you have installed CISM_DX, point your web browser at

**Online Documentation and Screenshots for OpenDX networks in CISM_DX**

## 2.5 Octave/Matlab codes in `CISM_DX/Octave/`

The following is a list of .m scripts that can be executed using either Matlab or Octave (with startup flag –traditional). All of the functions have been tested using Matlab 6.5.0 and Octave 2.1.50 on Red Hat Enterprise Linux 3.0, and Windows XP. We are working to make most of these files work under both Matlab and Octave. Subdirectories `matlab_only` and `octave_only` contain either functions included for cross–compatibility or functions that are not planned to be made cross compatable.

**Online List of Octave scripts in CISM_DX**

Or, if you have installed CISM_DX, point your web browser at

**List of Octave scripts in CISM_DX**

## 2.6 IDL programs in CISM_DX/IDL/

A few IDL programs are included for the user that wants to browse the CISM_DX data set.

**Online List of IDL scripts in CISM_DX**

Or, if you have installed CISM_DX, point your web browser at

**List of IDL scripts in CISM_DX**

1. CISM_DX/IDL/
   - make_plots_1_day.pro Used to plot the uniform time series data set. A more general set of tools for reading hdf files can be found at http://cimss.ssec.wisc.edu/~gumley/sds_read.html http://cimss.ssec.wisc.edu/ gumley/sds_read.html
   - create_pseudo_LFM_input.pro Example of creating an ASCII SW data file which can be read by the LFM code. Creates a .ps plot file of this data.

## 2.7 Perl programs in CISM_DX/Perl/

**Online List of Perl scripts in CISM_DX**

Or, if you have installed CISM_DX, point your web browser at

**List of Perl scripts in CISM_DX**

Most of these programs are called by a m–file in in mfiles/make_uniform_time_series. They are generally used during the process of transforming data files into the common format in the uniform time series data set.

1. asc2dat.pl Extracts 1–minute magnetometer data from all files named "*.ASC" in the current directory. Output files are named *_H and have seven columns corresponding to YYYY MM DAY HH MM SS COL1, where COL1 is the first data column in the .ASC file.
2. cat_swepam_files.pl Concatanates all real–time ACE SWEPAM data files obtained from the SEC ftp site in the current directory that have names containing "1m.dat" after removing the headers. Note that the output file is not sorted with respect to time and repeated values may exist. The output file is all_data_1m.dat is put into standard format using parse_swepam_data.m.
3. grab_lines.pl Grabs lines with numbers listed in filenenameL out of filenameA. Note that filenameL should be a single line containing integers separated by spaces.
4. ima2matrix.pl Transforms all data from *.ima files in the current directory into a single file.
5. probe_spidr.pl Reports information about all ground magnetometer data in all spidr*.txt files in the current directory.
6. parse_Ap_data.pl Creates two data files YYYY_MM_DD_HH_MM_SS_Ap.dat and Ap.dat using all files named YYYYMMAK.txt and 7day_AK.txt in the current directory. These two files have the same number of rows. The file YYYY_MM_DD_HH_MM_SS_Ap.dat has six columns
   (year, month, day, hour, minute, second, Ap). The file Ap.dat has only one column which is Ap values from column 7 of YYYY_MM_DD_HH_MM_SS_Ap.dat. Note that the output file is not sorted with respect to time and repeated values may exist.
7. perlop.pl Used by mfiles/matlab_only/perlop.pl. Evaluates a Perl regular expression on each line of a file. Used for extracting data from a file with interspersed text.

8. `qd2matrix.pl` Transforms all data from ISGI quiet day files in current directory into a single file. Replaces Jan, Feb, with 01, 02, etc. Replaces A with .1, K with .2, and * with .3.

9. `remove_lines.pl` Removes lines listed in filenenameL of filenameA with lines of filenameB. If filenameL is 1 3 7, replaces lines 1,3,7 of filenameA with lines 1,2,3 of filenameB. If not specified, output file is named filenameA_modified. Note that filenameL should be a single line containing integers separated by spaces.

10. `set_paths.pl` Called during install of CISM_DX. Used for changing paths in `.cfg, .net, .general, .mdf, .htm, .html` files that were transfered from another computer. (OpenDX uses absolute paths in these files.) See header for documentation. See `install_RH*` for examples of usage.

11. `spidr2dat.pl` Extracts magnetometer data from all SPIDR spidr_*.txt files containing 1-hour magnetometer data in the current directory. Output files have seven columns corresponding to YYYY MM DAY HH MM SS DATA.

## 2.8 Forecast models code in `CISM_DX/models/`

This directory contains the data and source code needed for locally running and validating many of CISM's fast–executing research and forecast models. These models can be run using real–time or historical data.

For example, to run the **Ap** models, start Octave and cd to `models/Ap/` and type main. The program `main.m` will attempt to download real–time data, call all of the models that predict Ap, and then call the plotting programs `plot_output.m`, `plot_output1.m`, and `plot_output2.m` which create .eps and .jpg files to view the results from a web page.

The figure on the right (see also Fig. **??**) shows the results of predicting Ap with the CISM FM as generated by the code `models/Ap/validation/Ap_validation.m`. For a skill score we chose the *Prediction Efficiency* $PE$ over the time interval 1989–2004 for the 1 day forecast. In blue we plot the $PE$ and in gray the actual Ap value scaled between zero and unity. The top model shows that USAF achieves a $PE = 0.21$; the second panel demonstrates that persistence is not a good predictor; the third panel uses the autoregressive scheme to obtain a $PE = 0.27$; the bottom panel employs the ARX method with ACE solar wind data for a limited temporal window.

If you have an Ap model that you want to add, simply create a subdirectory for your model. Then add a line in main.m to call your model. Also add lines for loading your output in `ensemble_prediction.m` and `plot_output.m`. You will probably need to write wrapper programs to convert input/output to/from your data format listed in the Ap model description below.

1. **Models in the directory** `Ap/`
   Contains three data-derived Ap prediction models.
   **Required input:** The past 30 days of 24–hour Ap index data;
   ARX model also needs 30 most recent 24–hour averaged measurements of $V_{SW}$
   **Output data:** Prediction of daily–averaged Ap.
   **In–sample data:** Data from 1990–1997.
   **Validation Results:** See directory `Ap/validation/` and Figure **??**.

   **Available Input files**

   - YYYY_MM_DD_HH_MM_SS_Ap.daily.dat, with space delimited columns of Year, Month, Day, Hour, Minute, Second, and values of Ap. The integer 99999 is used as an flag.
   - YYYY_MM_DD_HH_MM_SS_V.daily.dat, with space delimited columns of Year, Month, Day, Hour, Minute, Second, and daily–averaged values of solar wind velocity. The integer 99999 is used as a flag.

   **Output file**

   - T_combined.dat, which has space delimited columns 1–6 of Year, Month, Day, Hour, Minute, Second. Columns 7–14 are the model prediction at 1–7 day lead time. Flag or fill value is 99999.

If model does not provide predictions for a given lead time, the corresponding column should be filled with 99999.

**References:** *McPherron* [1998], *McPherron* [1999]

2. **Models in the directory** `B_dB_dt/`
   – not available yet
   Contains two models, one for surface magnetic field and the other for its time derivative.
   **Required input:** Six most recent 30–minute averages of $V_x$ and IMF $B_z$.
   **Output data:** 30–minute average of $B$ and $|dB/dt|$
   (to be compared with 30–minute average of $|dB/dt|$ derived from 1–minute data).
   **In–sample data:** Data from 12 IMAGE magnetometers at 1–minute resolution Day 23, 1998–Day 365, 1999. (See references for list of magnetometer sites.)
   **Validation Results:** See README in this directory for information.
   **References:** *Weigel et al.* [2002] *Weigel et al.* [2003]

3. **Models in the directory** `Electron/`
   Contains a $>$ 2 MeV prediction model.
   **Required input:** 24–hour average of $V_{SW}$.
   **Output data:** 24–hour average of log($J_e$) for L=1.1,1.2, ..., 10.0.
   **In–sample data:** SAMPEX data from 1993–2000.
   **Validation Results:** not validated.
   **References:** *Vassiliadis et al.* [2002a] *Vassiliadis et al.* [2002b] *Vassiliadis et al.* [2003]

4. **Models in the directory** `Solar_Wind_Velocity/`
   Contains four models that predict the solar wind velocity at L1:
   Autoregressive, Persistence, and the WSA model driven by two data sources (MWO = Mount Wilson Observatory, and WSO = Wilcox Solar Observatory). Code for WSA model is not currently distributed with the package.
   **Required input:**
   **Output data:** Prediction of daily-averaged solar wind velocity at L1.
   **In–sample data:**
   **Validation Results:** not validated.
   **References:**

## 2.9 Code in CISM_DX/required_packages or in the developer package

This directory contains programs, libraries, or wrapper code that are not part of the CISM_DX CVS tree but required to run certain Octave functions or OpenDX networks. The original code and any patches that were required are included.

For each library there are one or more directories that contain wrapper programs that allow the library to be called from other programs. To reduce the number of these wrapper programs, we are starting to write only wrappers these libraries for Octave, because Octave functions can be called from OpenDX (OctaveOp.net). Octave can also be called from Matlab and IDL, but these programs have not been written.

- **cxform** A C library by R. Boller and E. Santiago for transforming between geocentric and heliospheric coordinate systems. The SPTransform module links to this library.
- **geopack03** The GEOPAK library by N. Tsyganenko.
- **geopack** The 2001 GEOPAK library by N. Tsyganenko.
- **HDF4.1r5** The HDF libraries by NCSA that are used by SPDX modules.
- **Octave** A numerical programming and matrix manipulation language.
- **PFSS** The Potential Field Source Solver routines by Janet Luhman. Wrappers have not been written for these Fortran functions.

- **TSDS** Set of Octave/Matlab programs for Time Series Data Sets, by R.S. Weigel.
- **SPDX** The Space Physics Data Explorer package led by Mike Wiltberger.
- **Tsyganenko_*** The Tsyganenko external magnetic field models. Several SPDX and Octave programs link to this library.
- `mlp/mlp.c` Evaluates a MultiLayer Perceptron (a.k.a. a Neural Network). For more information, see comments in header. Used on Weigel's B and dB/dt model. Will be available when the forecast model is included in the CISM_DX package.

# 3 List of CISM_DX data

Directories or files in **gray** are not distributed in `CISM_DX_DATA`. These data files reside on **re.bu.edu** in the directory `/raid/cismdx/CISM_DX_DATA-Full/`.

## 3.1 Directory `CISM_DX_DATA/measurements/original_data/`

## 3.2 Directory `CISM_DX_DATA/measurements/uniform_time_series/`

## 3.3 Data files in `CISM_DX_DATA/measurements/short_data_sets/`

1. **ace_halloween_2003.dat**

   Data from the Halloween 2003 storms. During the storm, the ACE SWEPAM instrument did not function for much of the time. Needs documenting. Send email to the user email list if you are interested in this data set.

2. **bargatze_all.dat** The substorm data set (34 $AL$ and $VB_s$ data at a 2.5 minute resolution) analyzed in *Bargatze et al.* [1985] and in many subsequent works.

3. **bla_mcp.asc, bla_mcp.lis** The isolated substorm data set analyzed in *Blanchard and McPherron* [1995]. There are a total of 121 substorm intervals, which includes $VB_s$ and $AL$ data at one–minute time resolution.

## 3.4 Data files in `CISM_DX_DATA/real_time_data/`

Data in these directories obtained during calls to the CISM Forecast Model (FM). These directories contain a historical archive of all real time data used as inputs to the CISM FM to make real time forecasts. These data files have also been transformed from their original format and put in one of the standard CISM_DX HDF files.

1. Data in the directory `data_ace/`

   Contains ACE real time data downloaded from the SEC web site during a call to the CISM FM.

2. Data in the directory `data_Ap/`

   Contains real time Ap data downloaded from the SEC web site during a call to the CISM FM.

3. Data in the directory `data_solar/data-synoptic/`

   Contains the solar synoptic maps as downloaded by CISM FM in the subdirectories `MWO` and `WSO`.

4. Data in the directory `data_solar/data-wsa/`

   Contains the recent WSA predictions as downloaded by CISM FM in the subdirectory `predictions` and the recent solar surface maps in the subdirectories `MWO` and `WSO`.

## 3.5 Data files in `CISM_DX_DATA/model_output/`

1. Data in the directory `batsrus-data/`

   new3d.dat.gz, new3d__mhd_2_n001000.dat, newy0_mhd_1_n001000.dat

2. Data in the directory `enlil-data/`

   **cr1892b-reduced.nc**
   **cr1896-reduced-trunc.nc**
   **May12-00***id*.**nc** for *id* $\in (00, 04, 08, 12, 16, 20)$

3. Data in the directory `lfm-data/`

   **Initial_Conditions_1-3.**{**animate,hdf,dat**}
   **Initial_Conditions_1-3_SW-SM.dat**
   **north-imf.hdf**, **south-imf.hdf**, **west-imf.hdf**
   **sw-T5-cism.dat**, **T5-cism.dat**

4. Data in the directory `lfm-data/SASH-data/`

   **Jun01-23-reduced.hdf**
   **rundata_30Jun01.dat**
   **solarwind_30Jun01.rot.SM.dat**

5. Data in the directory `lfm-data/Guild/` Data used by Tim Guild in his research.

6. Data in the directory `lfm-data/Huang/` Data used by Elly Huang in her research.

7. Data in the directory `lfm-ting-data/`

   **Joule_LFM_AGU_2003_1_minute.dat**
   **Joule_LFM_TING_AGU_2003_1_minute.dat**

8. Data in the directory `lfm-ting-data/LFM_TING/`

   **Ting-climate-base-ion.dat**, **Ting-climate-ion.dat**
   **Mike_AGU_Data.txt**

9. Data in the directory `mas-data/`

   **bp001.hdf**, **br001.hdf**, **bt001.hdf**, **jp001.hdf**, **jr001.hdf**, **jt001.hdf**, **vp001.hdf**, **vr001.hdf**, **vt001.hdf**, **p001.hdf**, **rho001.hdf**, **t001.hdf**
   **bp002.hdf**, **br002.hdf**, **bt002.hdf**, **jp002.hdf**, **jr002.hdf**, **jt002.hdf**, **vp002.hdf**, **vr002.hdf**, **vt002.hdf**, **p002.hdf**, **rho002.hdf**, **t002.hdf**

10. Data in the directory `mas-data/car-data/`

    For Carrington rotation numbers $cr = 1930...1939$ the following data files: **belt***cr*.**dat**, **conmwo***cr*.**dat**, **eqss***cr*.**dat**, **op***cr*.**dat**, **sheet***cr***hi2.dat**, **sheet***cr***polar.dat**

11. Data in the directory `McPherron-Ap-data/`

    **McPherron_Ap_1_day_Autoregressive.dat**
    **McPherron_Ap_1_day_Persistence.dat**

12. Data in the directory `raeder-data/`

    b365.3df.021600.gz, b365.grid, b404.3da.019440.gz

13. Data in the directory `ting-data/`

    **cmite7001.hdf**

14. Data in the directory `wsa-data/`

    **saved_vel_imf_e.dat**
    **WSA_V_v0_1_1_day_1963_2002.dat**
    **WSA_V_v0_2_1_day_1963_2002.dat**

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# 5 Version History

**Version 0.11**

Menus, data sets from many sources, and data from empirical and inverse models were integrated with SPDX to form the first version, 0.11. The concept was presented to part of the CISM Executive Council in January, 2004. The program was named CISM_DX, the CISM Data eXplorer. The 0.X distributions will consist of alpha and beta versions that include source code and a suite of well–documented example applications.

**Versions 0.12 - 0.24**

The older versions of CISM_DX (0.21–0.23) can be re-built out of the CVS repository and are available upon request. The previous version (0.24) of CISM_DX and CISM_DX_DATA are still posted on `http://lasp.colorado.edu/cism/CISM_DX` in the .tar.gz format.

The tarballs for CISM_DX are:

- version 0.11 (1/06/04)
- version 0.12 (1/23/04)
- version 0.13 (2/06/04)
- version 0.14 (2/11/04)
- version 0.15 (3/01/04)
- version 0.16 (3/15/04)
- version 0.17 (3/16/04)
- version 0.18 (3/23/04)
- version 0.21 (4/02/04)
- version 0.22 (4/02/04)
- version 0.23 (6/09/04)
- version 0.24 (8/02/04)
- version 0.34 (12/10/04)
- version 0.36 (01/15/05)
- version 0.42 (03/20/05)
- version 0.43 (06/31/05)
- version 0.50 (09/21/05)
- version 0.57 (05/21/06)

Starting with version 0.21, the CISM_DX distribution has been ingested into the CISM CVS repository named VIZ on the host **re.bu.edu** at Boston University.

Additionally, useful multi-platform codes have been split out of the CISM_DX distribution and now reside in CISM_DX_Auxiliary version 0.22. This portion of the CISM_DX package, and subsequent versions of CISM_DX_DATA are being maintained by R.S. Weigel.

Since version 0.23 all Linux auxiliary functions have been folded into CISM_DX thus eliminating the directory CISM_DX_Auxiliary. For the time being, it continues to exist for the Windows XP and Macintosh versions.

Bugs that were reported with versions 0.22 through 0.24 are fixed in the current version. In particular, relative paths replace the absolute paths wherever meaningful, thus reducing the number of path corrections at install time to a minimum. With version 0.25 we introduced a new "generic" installation script. Execution scripts that drive the network tutorials, the major networks, and the CISM forecast models were also added.

The models in the `models/` directory and the Octave files in the `mfiles/` directory were extensively rewritten. They recently became part of the CISM Forecast Model that is running at NOAA SEC.

**Version 0.30**

This is the version that was released following the All–Hands meeting in September, 2004. The installation script was re-worked so that it lets the user know what programs are being installed and where the code will reside. Ideally, a single package containing all necessary components would be distributed on a CD, but the current network install script allows us to work around complex licensing issues because we are not distributing licensed software, but are only facilitating the steps a user would have to take in order to use CISM_DX.

Much of the dependence on .mat and .txt files has been removed. Nearly all of the code that does data analysis now uses data from extracted from the .hdf files distributed with CISM_DX.

**Version 0.34**

First public release. New programs for auto-downloading and browsing uniform time series data set were included. Linux installation was simplified by pre-compiling code. SPDX now has links to libraries for geocentric and heliospheric transforms, a TING reader, and a preliminary network that allows OpenDX to call Octave functions.

**Version 0.36**

Second public release. Major change was upgrade to use of OpenDX 4.3.2. This broke several SPDX modules which were fixed in a later release.

**Version 0.42**

SPDX modules were fixed. Some documentation was moved to web pages and screenshots of OpenDX-interpreted programs were created. An Perl script that generates documenation based on text in .net and .m files is not used to generate the web documentation.

**Version 0.50**

New directory structure and browser interface to demos. Time series data sets integrated with the TSDS package, which will be maintained as a separate project.

**Version 0.57**

Documentation and usability improvements. New packaging method.

# References

Bargatze, L. F., D. N. Baker, R. L. McPherron, and E. W. Hones, Magnetospheric impulse-response for many levels of geomagnetic activity, *J. Geophys. Res-Space Phys.*, *90*, 6387–6394, 1985.

Blanchard, G. T., and R. L. McPherron, Analysis of the linear response function relating AL to VBs for individual substorms, *J. Geophys. Res.*, *100*, 19,155–19,166, 1995.

McPherron, R. L., Determination of linear filters for predicting AP during January 1997, *Geophys. Res. Lett.*, *25*, 3035, 1998.

McPherron, R. L., Predicting the Ap index from past behavior and solar wind velocity, *Phys. Chem. Earth (C)*, *24*, 45–56, 1999.

Vassiliadis, D., A. J. Klimas, S. Kanekal, D. Baker, and R. S. Weigel, Long-term solar-cycle, and seasonal response of magnetospheric energetic electrons to the solar wind speed, *J. Geophys. Res*, *107*, 10.1029/2001JA000,506, 2002a, http://lasp.colorado.edu/cism/text/Vassiliadis_2002_Long_Term_SAMPEX.pdf.

Vassiliadis, D., R. S. Weigel, A. Klimas, S. Kanekal, and R. Mewaldt, Modes of energy transfer between the solar wind and the inner magnetosphere, *Phys. Plasmas*, *10*, 463–473, 2002b, http://lasp.colorado.edu/cism/text/Vassiliadis_2003_Modes_of_Energy_Transfer.pdf.

Vassiliadis, D., A. J. Klimas, R. S. Weigel, D. N. Baker, E. J. Rigler, S. G. Kanekal, T. Nagai, S. F. Fung, R. W. H. Friedel, and T. E. Cayton, Structure of Earth's outer radiation belt inferred from long-term electron flux dynamics, *Geophys. Res. Lett.*, *30*, 2003, http://lasp.colorado.edu/cism/text/Vassiliadis_2003_Structure_of_Radiation_Belt.pdf.

Weigel, R. S., D. Vassiliadis, and A. Klimas, Coupling of the solar wind to temporal fluctuations in ground magnetic fields, *Geophys. Res. Lett.*, *29*, 2002.

Weigel, R. S., A. Klimas, and D. Vassiliadis, Solar–wind coupling to and predictability of ground magnetic fields and their time derivatives, *J. Geophys. Res.*, *108*, 2003.