Readme for OVATION Prime
15 October 2014

OVATION Prime

The OVATION Prime model was developed using energetic particle measurements from the polar-orbiting Defense Meteorological Satellite Program (DMSP) satellites and considers four types of aurorae: two types of discrete electron aurorae (monoenergetic and broadband) and two types of diffuse aurorae (electron and ion) [Newell et al., 2010]. The OVATION Prime model is written in IDL and was developed at Johns Hopkins Applied Physics Laboratory (JHU-APL) by Patrick Newell and co-workers. The model package may be freely downloaded from SourceForge. This document explains how the package may be downloaded and how to run the code in IDL. This version has a wrapper with which to run the code. Parameters can be set in a configuration structure. Relevant URLs that are embedded in this text are also listed at the end of this document.

Two other relevant documents are included in this distribution and they are named seasonalmodel.doc and status.doc.

There is a mailing list. Please visit this page to subscribe:
https://lists.sourceforge.net/lists/listinfo/ovation-prime-users

1. Setup

1a. IDL Code

The latest tested version of the community model can be retrieved from SourceForge.

1b. OMNI2 Data Files

The model requires solar wind files for *ap_inter_sol.pro*. For historical runs, files for any year of interest can be copied from the NASA OMNI2 repository and put in the local *omni2* directory. The file names have the format *omni2_yyyy.dat* where *yyyy* is the year. A description of this data, including the applied timeshift, is available here.

2. Running the Model for Retrospective Times

The program *ov_loop.pro* is a wrapper which runs the model over a date/time range. The main program in the model is *season_epoch.pro.* The system configuration structure, *!ov_config,* defines a variety of parameters for the programs. The variables in the structure can be manually set in *ov_config.pro*. The model was tested using IDL 8 but should also run successfully using IDL 7.

To run OVATION Prime using the *ov_loop* wrapper in IDL, a user should
(1) Set the user adjustable parameters in a configuration file. To create a new configuration file, modify a copy of ov_config_template.txt which is in the *config* directory.
(2) Set the directory and path name for the configuration file in *ov_config.pro*.
(3) Save and compile *ov_config.pro*.
(4) Compile and run *ov_loop.pro.*

3. Running the Realtime Model

The program *ov_realtime.pro* is a wrapper which runs the model using real-time data collected from the ACE spacecraft, which are time shifted to the magnetosphere. The routine *swpc_get_ace_realtime.pro* retrieves ACE 1 minute magnetic field and flow velocity observations from the SWPC real-time repository then time shifts and averages the result into 1 hour averages. Time shifting is done using the halfway-in-between method in a manner similar to that employed in the creation of the OMNI2 dataset as documented here.

To run OVATION Prime using the *ov_realtime* wrapper in IDL, a user should

(1) Set the user adjustable parameters in a configuration file. To create a new configuration file, modify a copy of ov_config_template.txt which is in the *config* directory.

(2) Set the directory and path name for the configuration file in *ov_config.pro*.

(3) Save and compile *ov_config.pro*.

(4) Run *ov_realtime.pro.*

(5) Inspect the output in the user defined output directory.

* The current ov_realtime.pro makes several "spawn" calls to create additional output formats (e.g. PDF) and gzip the txt output. These calls are currently functional within most Unix like environments and have been encapsulated accordingly - e.g. Windows users should not be affected.

4. Configuration Options

The system configuration structure *!ov_config* contains a variety of user-settable parameters. As a system structure, these variables are easily accessible in all of the OVATION Prime programs. The parameters are set in *ov_config.pro*. The structure contents, descriptions of each parameter, and example values (following the colons) are listed below. The element "path0" should generally be set to the directory where the package was unzipped. This element is empty by default and thus must be set for *ov_config.pro* to compile.

path0:	*Enter path to package here (examples below)*
do_test:1	*0: don't run tests, 1: run text file tests, 2: run plot file test* If set to run tests 1 or 2, most of the other parameters except directory pathnames are automatically set in *ov_config.pro* .
epoch_start:julday(10, 24, 2011, 20, 0, 0)	start of model run: julday(mon, day, yr, hour, min, sec)
epoch_end: julday(10, 24, 2011, 20, 0, 1)	end of model run: julday(mon, day, yr, hour, min, sec)
epoch_delta_minute: 60.	step size in time for model run
do_psfile:1	0: don't create plot file(s), 1: create plot file(s)
do_txtfile:0	0: don't create data text file(s), 1: create text file(s)
do_interpolation: 1	0: no interpolation, 1: do simple interpolation in midnight region
n_types:4	number of types of output files: should match number of elements in atype0 and jtype0 arrays

atype:[0, 1, 2, 3]	auroral types: 0=diff, 1=mono, 2=wave, 3=ions
jtype:[1, 1, 1, 2]	output types: 1=electron energy flux, 2=ion energy flux, 3=e- number flux, 4=ion number flux,5=e- average energy 6=ion average energy
dir_col: *path0*	color file directory
dir_log: *path0*+'output\logs\'	log file directory
dir_omni2: *path0*+'omni2\'	omni2 directory
dir_output: *path0*+'output\'	output directory
dir_premodel: *path0*+'premodel\'	premodel directory
dir_testdata: *path0*+'testdata\'	test_data directory
do_database:1	MySQL database updates. Used for ov_realtime. Required additional setup. Get Mark Buie files (badpar.pro, mysqlcmd.pro, openmysql.pro).
show_model_stats:1	*0: don't show model stats on draw_je plots (e.g. number of satellite days and empirical range)*

A pathname variable, not in the structure but available at the top of *ov_config.pro* , is used to define the directory path in the structure:

e.g., path0='C:\AIDLWorkspace\ovation_pr_orig\'

The loop routine will run faster if the chosen jtypes are either all number fluxes or all not number fluxes (i.e., if jtypes are all 1,2,5,or 6, or if jtypes are all either 3 or 4.)

4. Output Files

OVATION Prime produces data text (.txt) files and postscript (.ps) plots (and .png and pdf using the real-wrapper). For each pass in *ov_loop.pro*, the number of each type of file produced is *!ov_config.n_types* for auroral types and output types defined by *!ov_config.atype* and *!ov_config.jtype*, respectively. For instance, for the example values in Section 3, there will be four .txt files and four .ps files. The program *ov_read_output.pro* reads much of the structure of the ASCII files, and can be easily modified to read more of the output. The .ps files can be viewed with the free Ghostscript software available at http://www.cs.wisc.edu/~ghost/ or can be converted to PDFs using the ps2pdf linux command. At present there is an error in the number flux plots in that the numbers cannot be read on color bar. To create a total auroral power map, you can just add up the powers from the files for the four types of aurora.

5. Test Routines

There are several test procedures that can be used to verify that code changes do not impact the model output. The test procedures compare current model output with test data generated from the "original" JHU code in January 2012. The test data is stored in the directory named *testdata*. To run the tests, set the *do_test* option to the appropriate test case in *ov_config.pro* and then recompile *ov_config*. Available test cases are:

0	do not run a test case
1	do a comparison of output text files for energy fluxes
2	create test plots for energy fluxes to compare with the stored test data
3	do a comparison of output text files for number fluxes
4	create test plots for number fluxes to compare with the stored test data

5a. Test Routine 1

Test 1 tests the OVATION Prime code by determining any difference in the calculation of the energy fluxes and hemispheric power relative to the ASCII data in the test directory. The test is currently set to run for files from 24 Oct 2011, 14:00 UT through 25 Oct 2011, 3:00 UT in hourly steps for all four auroral types. The times were chosen because they cover a wide range of activity. The details of these times are given in Appendix I. Outputs are the total fluxes and total hemispheric power for the new and test data. These values in these pairs should match. The average and max errors for flux and hemispheric powers are also given. The values should all be zero. The calculations are sums over all four types of aurorae.

5b. Test Routine 2

This test routine creates plots of the energy fluxes for the four auroral type. The plots can be manually compared with the plots in the directory*testdata*. (Parameters for the date and time of the output files which are created are set at the bottom of *ov_config.pro,* and so could be changed to match the date and time of other plots that are in *testdata.*)

5c. Test Routine 3

Same as Test 1 except for number fluxes. Hemispheric power is not calculated.

5d. Test Routine 4

Same as Test 2 except for number fluxes.

6. Interpolation

The option *!ov_config.do_interpolation* does interpolation over the wedge near midnight which had little DMSP input into the model. The interpolation is linear along MLAT lines in the wedge. The wedge dimensions are defined in the routine and in the routine three parameters which can be adjusted are so noted. The initial choice of values is loosely based on Plate 1 of *Sotirelis and Newell* (2000). An example of the impact of the interpolation is shown in Figure 1. Interpolation will be applied to both the plots and the text files.

The interpolation routine should be used judiciously. It is a very simple algorithm that attempts to improve the data in the wedge-shaped region where little or no DMSP data was available for the model development. It will have no positive impact during low activity when the aurora is not in the region that is interpolated, and but rather, may smear out stray high points. The interpolation is most useful for high activity periods such as that shown in Figure 1.

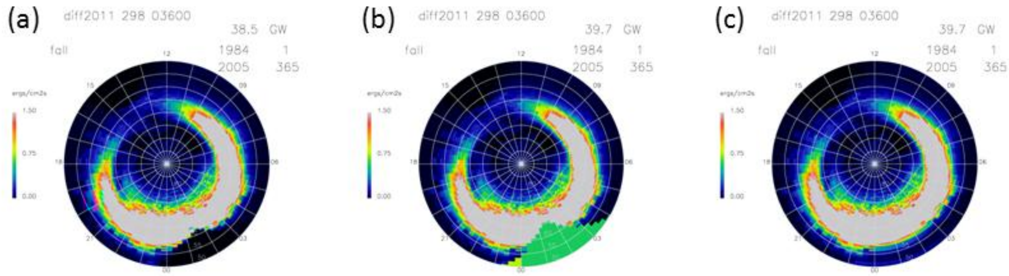

Figure 1. An example of the impact of interpolation on the model output. (a) OVATION Prime output of diffuse aurora during high activity. (b) Green wedge indicates region of interpolation. Lighter green is pre-midnight times. (c) Model output for same aurora as in (a) but with interpolation over region shown in (b).

7. OVATION Prime Directories and Subroutines

Directories

output- directory where postscript and text files are created
premodel- directory with the necessary data files to run season_epoch

Files, Routines and Functions

ap_inter_sol.pro- interpolated solar wind hourly averages
boro.pro- evaluates Borovsky's function
draw_je.pro- creates postscript and text files
fast_get_jea.pro- returns the data, without writing files
season_epoch.pro- primary program, creates precipitation map for specified date and time
season_weights.pro- weights the seasons
sol_coup.pro- required for ap_inter_sol
utilities_season.pro- multiple small programs required to run season_epoch

Files, Routines and Functions used for Realtime Routine

References

Machol, J. L., J. C. Green, R. J. Redmon, R. A. Viereck, and P. T. Newell (2012), Evaluation of OVATION Prime as a Forecast Model for Visible Aurorae, Space Weather, 10, S03005, doi:10.1029/2011SW000746.

Newell, P.T., T. Sotirelis, K. Liou, C.-I. Meng, and F.J. Rich (2007), A nearly universal solar wind-magnetosphere coupling function inferred from 10 magnetospheric state variables, *J. Geophys. Res.*, *112*, A01206, doi:10.1029/2006JA012015.

Newell, P. T., T. Sotirelis, and S. Wing (2009), Diffuse, monoenergetic, and broadband aurora: The global precipitation budget, *J. Geophys. Res.*, *114*, A09207, doi:10.1029/2009JA014326.

Newell, P. T., T. Sotirelis, and S. Wing (2010), Seasonal variations in diffuse, monoenergetic, and broadband aurora, *J. Geophys. Res.*, *115*, A03216, doi:10.1029/2009JA014805.

Sotirelis, T. and P. T. Newell (2000), "Boundary-oriented electron precipitation model," *J. Geophys. Res.*, *105* (A8), 18,655-18,673.

URLs

SourceForge Project Page: https://sourceforge.net/projects/ovation-prime/
OMNI2 Repository: ftp://nssdcftp.gsfc.nasa.gov/spacecraft_data/omni/
SWPC ACE Repository: http://www.swpc.noaa.gov/ftpdir/lists/ace/
Time Shifting Solar Wind: http://omniweb.gsfc.nasa.gov/html/omni2_doc.html#shift
Mark Buie's MySQL libarary: http://www.boulder.swri.edu/~buie/idl/idl.html
Ghostscript: http://www.cs.wisc.edu/~ghost/

Appendix I. Kp and Fluxes during 24-25 October 2011

Here are the data that were used to choose the test date/time ranges.

Kp values in test range

yyyy-MM-dd HH:mm	Kp
2011-10-24 00:00	2.0
2011-10-24 03:00	0.0
2011-10-24 06:00	2.0
2011-10-24 09:00	0.0
2011-10-24 12:00	0.0
2011-10-24 15:00	1.0
2011-10-24 18:00	5.0
2011-10-24 21:00	7.0
2011-10-25 00:00	6.0
2011-10-25 03:00	6.0
2011-10-25 06:00	5.0
2011-10-25 09:00	3.0
2011-10-25 12:00	3.0
2011-10-25 15:00	2.0
2011-10-25 18:00	2.0
2011-10-25 21:00	1.0

Energy fluxes as generated by OVATION Prime

Times chosen for .ps files in /testdata are shown in bold.

All times are included as .txt files in /testdata.

hour	diff flux	mono flux	wave flux	ion flux	
24 OCT 2011					
12.0000	**6.4822000**	**1.7835300**	**0.71749400**	**1.8058600**	
13.0000	6.0948300	1.6830800	0.69864900	1.7559400	
14.0000	5.8756500	1.6076800	0.68111300	1.7234700	
15.0000	6.1294000	1.6922200	0.69450000	1.7609000	
16.0000	6.4416200	1.7723400	0.71804100	1.8067400	
17.0000	6.9021500	1.9306900	0.80570700	1.8696100	
18.0000	7.3477000	2.1111300	0.86974300	1.9379100	
19.0000	10.148300	3.2480200	2.3562400	2.3969500	
20.0000	**18.300400**	**6.7055400**	**4.6106800**	**3.9532200**	
21.0000	19.553400	7.3616500	4.9975300	4.2077900	
22.0000	15.131800	5.1736900	3.7905600	3.3296500	
23.0000	24.121000	10.311300	6.4802300	5.1819900	
25 OCT 2011					
0.0000	34.243700	20.606000	11.731400	7.9665800	
1.0000	**38.519800**	**26.099000**	**16.487800**	**9.9218400**	<<<peak
2.0000	37.923300	25.252900	15.493200	9.5326300	
3.0000	34.094700	20.417900	11.618900	7.9214800	

Appendix II.   Revision History

1.0.0 season_software_20120330.zip

Original contents of season_model.zip file retrieved from JHU/APL website on 2012/03/30.
In this case, the SVN tag 1.0.0 did not include the premodel files necessary for computing number flux model output. So the original distribution (season_software_20120330.zip) is the appropriate download.

2.0.0

Added JM's efficiency improvements.

2.1.0

The version 1.0.0 premodel/ directory was missing files needed for computing number fluxes (missing from original zip file).

Appendix III. Developer Notes

1. Suggested Tagging for New Version

```
VERSION=2.1.0
MESSAGE="Release $VERSION"
svn copy svn+ssh://rredmon@svn.code.sf.net/p/ovation-prime/code/trunk
svn+ssh://rredmon@svn.code.sf.net/p/ovation-prime/code/tags/$VERSION -m "$MESSAGE"
```