Documentation
Ionosonde NmF2 model version 3

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About the Model

This model represents a set of localized NmF2 models based on multi-year observations from numerous ionosondes located at low and middle latitudes. Model reproduces NmF2 at the location of each ionosonde as a function of solar activity, day of the year, universal time, and geomagnetic activity. The goal of the model is to provide accurate description of NmF2 behavior at given locations. Current model version (Version 3) includes 43 locations with publicly available data; the length of the data record varies with location.

Files and Directories

File/Folder	Details
mat*	Directory containing the model coefficients
call_nmF2.m	Main routine to call the nmF2 model. Details in next section
examples.m	MATLAB script containing several examples of call_nmf2 usage
fism2f107.m	Utility to convert fism2 index to F10.7 based on quadratic relation.
f1072fism.m	Utility to convert F10.7 to fism2 index based on quadratic relation.
get_indices_dist.m*	Routine to get various geophysical indices like F10.7, fism2, ap3 etc.
f107_2_fism.mat*	Internally used by f1072fism.m.
fism_2_f107.mat*	Internally used by fism2f107.m
geoindices.mat*	Internally used by get_indices_dist.m
norms.mat*	MATLAB file containing information of standardization of various geophysical indices. Internally used by get_indices_dist.m.
documentation	This file.

* For internal use by model

call_nmF2 usage

This routine is the primary interface for the NmF2 model. It can be used in three different ways. Syntax for each is as follows:

Syntax	Use
[fof2, nmf2, geoind] = call_nmf2(station, time);	To get NmF2 on given day(s) based on historical geophysical indices retrieved from the get_indices_dist function. The output is same size as 'time'.
[fof2, nmf2] = call_nmf2(station, doy, fism, ap3);	To get NmF2 at user provided fixed Solar and Geomagnetic activity levels. 'fism' and 'ap3' are scalars. The output is same size as 'doy'.
call_nmf2()	To display list of available ionosonde models and their geographic coordinates.

Where,

station	Four-letter string for the Ionosonde station
time	Date and UT time in MATLAB datetime format (can be scalar, matrix or nd array)
ap3	ap3 index
fism	FISM2 index. Use function f1072fism to get a reasonably equivalent value of FISM2 to F10.7.
geoind	Structure which contains the ap3, f10.7 and fism2 index at 'time'. The three geophysical indices can be retrieved as geoind.ap3, geoind.f107, geoind.fism2 respectively.
doy	Fractional day of year (fraction is UT hour/24). doy can be scalar, vector or multi-dimensional array.

Converting between F10.7 (sfu) and integrated fism2 index

Since most of the researchers are acquainted with solar activity in terms of F10.7 index, additional routines are provided to empirically convert between the fism2 and F10.7 index. These routines are based on a quadratic relation between two indices. Following is the syntax for each routine:

Function call	Use
fism = f1072fism(f107);	Given the F10.7 index in sfu, return integrated fism index.
f107 = fism2f107(fism2);	Given the integrated fism2 index, return the F10.7 (sfu) index.

Vectorized code

Call_nmf2 code is vectorized for fast performance. It is recommended to call this function with vector or matrices rather than making individual calls for each time. Following is an example of efficient and bad calls to call_nmf2:

Scalar Call (bad performance)	Vector Call (recommended)

sdate = datetime([2011 1 1 0 0 0]);
edate = datetime([2011 12 31 23 0 0]);
time = (sdate:hours(1):edate)';
for ii=1:length(time)
[fof2(ii),nmf2(ii)] = call_nmf2('JICA',time(ii));
end
	sdate = datetime([2011 1 1 0 0 0]);
	edate = datetime([2011 12 31 23 0 0]);
	time = (sdate:hours(1):edate)';
	[fof2,nmf2] = call_nmf2('JICA',time);

Model behavior under special circumstances

Scenario	Model behavior
call_nmf2 is called with too high or low solar flux levels Lower limit of model = 65 sfu equivalent of fism2 Upper limit of model = 260 sfu equivalent of fism2	Model provides output at the lower or upper boundary of solar flux and a warning message is displayed
call_nmf2 is called with dates when all the required geophysical indices are not available	Model will return NaN for such dates.

Data Sources

- Auto scaled Ionosonde data from Lowell GIRO Data Center (LGDC)
- Manually scaled Ionosonde data from World Data Center (WDC) for Ionosphere and Space Weather.
- Geophysical indices from Madrigal Database.
- Flare Irradiance Spectral Model 2 (FISM2) index from Laboratory for Atmospheric and Space Physics (LASP)

Contributions

Larisa Goncharenko (lpg@mit.edu): Conceptualization; methodology; development of initial versions of models (Versions 1 & 2); funding acquisition; supervision

Dupinder Singh (dupinder@mit.edu): development of current version of the model (Version 3); implementation of FISM2 solar proxy; software development; data curation; visualization

Feedback and bug reports

Please send comments, suggestions, and bug reports to:

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