

M_ISSION: a MATLAB-based software for multi-GNSS Ionospheric
scintillation index calculation and analysis

User Manual

written by Dongsheng Zhao and Peicheng Zhang

China University of Mining and Technology

December 2024

Contents

1. Introduction.....	1
2. Development Environment and Configuration.....	2
(1) Software Installation	2
(2) Data File Processing	2
(3) Data Organization Structure	3
(4) Software Launch	3
3. M_ISSION	4
(1) Ionospheric Scintillation Factor Calculation Interface	7
Common Parameter Settings.....	8
ROTI and AATR Factor Calculation.....	9
DIXSG Factor	10
$\sigma_{\phi f}$ Factor.....	11
(2) Factor Visualization Interface	12
(3) Scintillation Factor Analysis Interface.....	14
4. Example Data.....	18
5. Acknowledgments.....	19
6. Appendix.....	20

1. Introduction

Dense and accurate monitoring of ionospheric scintillation is crucial for understanding the patterns and driving mechanisms of ionospheric disturbances, and holds significant importance for enhancing the reliability and robustness of GNSS positioning and communication systems. Research on ionospheric scintillation indices derived from geodetic receivers represents one of the key approaches to achieving dense monitoring of ionospheric scintillation. In recent years, numerous scholars have proposed various ionospheric scintillation indices applicable to geodetic receivers. However, there remains a lack of an open-source software platform capable of integrating multiple ionospheric indices. This limitation indirectly hinders the widespread utilization of these diverse scintillation indices and restricts the broader application of globally distributed, dense geodetic receiver networks in ionospheric scintillation monitoring. To address this gap, we have developed M_ISSION—a MATLAB-based software for multi-GNSS Ionospheric scintillation index calculation and analysis

The primary function of M_ISSION is to compute scintillation indices, including ROTI, IAATR, AATR, DIXSG, and $\sigma_{\phi f}$, using 30-second interval observation data from geodetic receivers. The software supports batch processing of data from four major satellite navigation systems: GPS, GLONASS, Galileo, and BDS. Additionally, it enables graphical analysis of regional ionospheric disturbances based on computed scintillation indices.

Table 1 Definitions of Terms

No.	Term or Abbreviation	Descriptive Definition
1	GNSS	Global Navigation Satellite System
2	ROTI	Rate of change of TEC index
3	AATR	The Along Arc TEC Rate
4	RMSAATR	The Along Arc TEC Rate Index
5	DIXSG	Disturbance Ionosphere Index Spatial Gradient
6	DIXSGp	Global DIXSG Index
7	$\sigma_{\phi f}$	30-second sampling interval phase scintillation index

2. Development Environment and Configuration

(1) Software Installation

This software is developed under the MATLAB environment. It is recommended to install it in a dedicated directory on a non-system drive (e.g., **D:\MATLAB\M_ISSION** on the D drive) to avoid system disk space constraints or permission issues. Users do not require additional MATLAB toolboxes for calculating scintillation indices with M_ISSION. However, installation of the MATLAB geographic mapping toolbox M_map is necessary if plotting DIXSG results is required, enabling subsequent data visualization and analysis.

(2) Data File Processing

If the downloaded data is in ZIP format, please extract it to a designated location first.

The software does not support direct reading of data within compressed files.

(3) Data Organization Structure

To facilitate management and usage, please store downloaded data in separate folders categorized by type and date. Folder names should clearly indicate the date and data type to enable efficient retrieval and referencing. For example, for observation data with GPS time 2024 March 24 (day of year, DOY = 84), the folder path should be structured as:

D:\MATLAB\M_ISSION\input_o_and_r_file\24084

Precise ephemeris files should be stored in

D:\MATLAB\M_ISSION\input_sp3_file\24084

Clock and antenna phase files should be stored in

D:\MATLAB\M_ISSION\input_clk_and_atx_file\24084

The read observation data should be stored in MAT format in

D:\MATLAB\M_ISSION\OBS\24084

The read ephemeris data should be stored in MAT format in

D:\MATLAB\M_ISSION\SP3\24084

Intermediate data such as elevation angle and azimuth data, cROT, ivtall should be stored in MAT format in

D:\MATLAB\M_ISSION\ivELE\24084

D:\MATLAB\M_ISSION\ivcROT

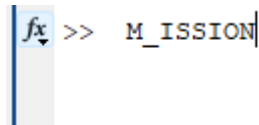
D:\MATLAB\M_ISSION\ivtall

For other result files, the paths will be introduced in detail in the relevant computation modules along with examples.

(4) Software Launch

To enable MATLAB to recognize and run the code of M_ISSION, you need to add the folder containing the M_ISSION source code to the MATLAB search path. In

MATLAB, go to the Home tab, click on Set Path, and then select Add Folder. Choose the folder where M_ISSION is installed (e.g., **D:\MATLAB\M_ISSION**), and click Save. After the folder has been added to the search path, you can launch the software by typing the following command in the MATLAB command window,

A screenshot of the MATLAB command window. The prompt 'fx >>' is visible, followed by the command 'M_ISSION' which is currently being typed, indicated by a vertical cursor line at the end of the text.

For direct access, double-click M_ISSION.mlapp to open the MATLAB App Designer interface, which allows for software modification or direct launching. Ensure all prerequisite files are correctly located in their designated directories prior to initialization.

3. M_ISSION

The M_ISSION software uses graphical user interface (GUI) programming techniques and is designed with three main functional modules: the Ionospheric Scintillation Factor Calculation Module, the Scintillation Factor Visualization Module, and the Scintillation Factor Analysis Module. In the Ionospheric Scintillation Factor Calculation Module, users can perform tasks such as calculating ROTI, AATR, DIXSG, and $\sigma_{\phi f}$ indices, as well as configure various common parameters, including the paths for observation data and precise ephemeris data, system options, adjustment of cutoff elevation angles, and configuration of cycle slip detection parameters. This module also supports custom settings for the sensitivity of DIXSG, grid size, latitude and longitude range, as well as the specification of paths for clock bias, antenna phase files, and adjustment of filtering thresholds. The Scintillation Factor Visualization Module focuses on interpreting the results of any scintillation factor calculation for specific satellites, while the Scintillation Factor Analysis Module emphasizes comparing and validating the accuracy of ROTI, AATR, DIXSG, and $\sigma_{\phi f}$ factor time series, and

provides a two-dimensional gridding function for ROTI and DIXSG factors. The implementation process of the software is shown in Figure Fig. 1 Implementation flow of M_SSION software.

The M_SSION software is specifically designed to process geodetic receiver data with a 30-second sampling interval. It is fully compatible with both Rinex 3 and Rinex 2 formats and can quickly output and validate intermediate files, including cROT, elevation angle, and azimuth angle. Additionally, it supports batch calculations of ROTI, IAATR, AATR, DIXSG ionospheric scintillation factors for GPS, Galileo (GAL), GLONASS (GLO), and BeiDou (BDS) systems, as well as the $\sigma_{\phi f}$ factor for the GPS system.

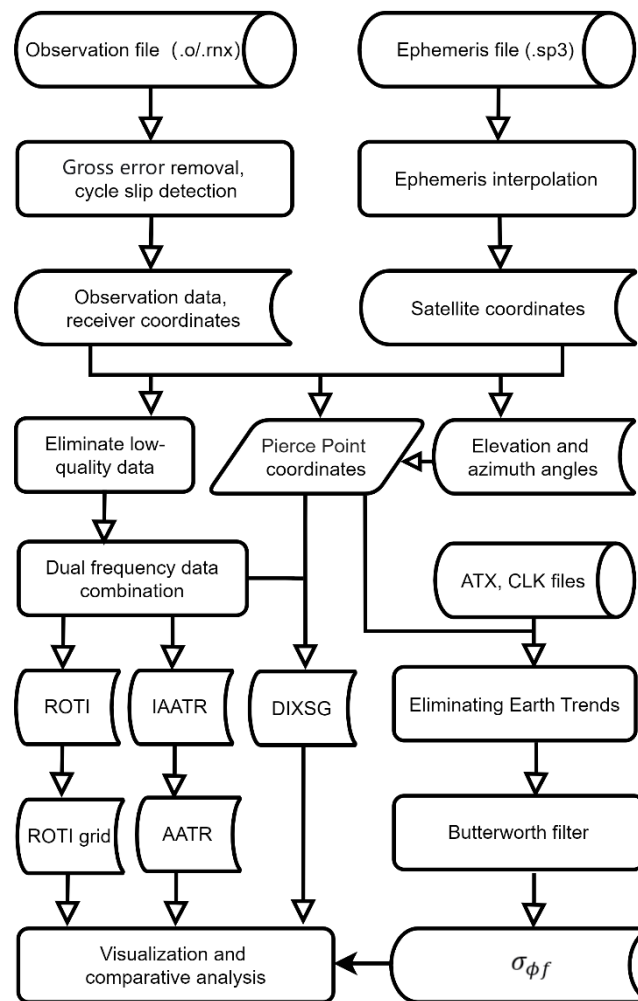


Fig. 1 Implementation flow of M_SSION software

Fig. 2 M_SSION Software Main Interface illustrates the graphical interface of the M_SSION software, featuring three core modules accessible via the top navigation bar. The default interface corresponds to Module 1, which provides configurable parameters for scintillation index computation. To demonstrate module functionalities, we utilize observational data from 30 Canadian stations acquired on March 24, 2024 (GPS time), stored in the directory:

D:\MATLAB\M_SSION\input_o_and_r_file\24084

The screenshot shows the MATLAB App window for the M_SSION software. The title bar includes the MATLAB logo and the text 'MATLAB App'. The main window has a title 'M_SSION' and three tabs: 'Factor calculation' (active), 'Result drawing', and 'comparative analysis'. The interface is organized into several sections:

- input**: Contains fields for 'Rinex' and 'Sp3' with folder selection icons. It also has a 'Lim' field set to '30' and a 'System Selection' section with checkboxes for 'GPS' (checked), 'GLO', 'GAL', and 'BDS'. Below this is a 'Cycle Slip Detection' section with a toggle switch set to 'off'.
- ROTI & AATR**: Contains two input fields and buttons labeled 'ROTI' and 'AATR'.
- DIXSG**: Contains fields for 'level' (5), 'first' (100), 'step' (50), 'Lat' (-90 to 90), 'lon' (-180 to 180), 'dlat' (1), and 'dlon' (0.5). It also has a button labeled 'DIXSG'.
- SIGMAPHI**: Contains fields for 'CLK' and 'ATX' with folder selection icons. It also has a 'cutoff_freq' field set to '0.9' and checkboxes for 'L1' (checked) and 'L2'. Below this is a button labeled 'sigma phi'.

Fig. 2 M_SSION Software Main Interface

(1) Ionospheric Scintillation Factor Calculation Interface

The first module of M_ISSION is the Ionospheric Scintillation Factor Calculation Module, which is divided into two parts: common parameter design and scintillation factor calculation, as shown in Fig. 3. During the calculation process, the first step is to select the path of the required data files. For calculating ROTI, AATR, and DIXSG, observation data files (.o/.rnx) and precise ephemeris files (.sp3) are needed. Additionally, For the $\sigma_{\phi f}$ calculation, it is necessary to additionally include the clock bias files (.clk) and antenna phase files (.atx). Then, parameter settings need to be configured, including cutoff angle, satellite system selection, and cycle slip detection options. Furthermore, for DIXSG calculation, latitude and longitude range, as well as sensitivity level, need to be set. For the $\sigma_{\phi f}$ calculation, users must select the L-band to be calculated and specify the normalized cutoff frequency for the Butterworth filter.

M_ISSION

Factor calculation | Result drawing | comparative analysis

input

Rinex

Sp3

Lim

off on

Cycle Slip Detection

System Selection

☒ GPS ☐ GLO

☐ GAL ☐ BDS

ROTI & AATR

DIXSG

level first step

Lat ~ dlat

lon ~ dlon

SIGMAPHI

CLK

cutoff_freq

☒ L1 ☐ L2

ATX

Fig. 3 Ionospheric Scintillation Factor Calculation Interface

Common Parameter Settings

In M_ISSION, the Rinex selection box allows users to choose the folder containing the observation data. It supports reading RINEX 2 or 3 format observation data for GPS, GLONASS, Galileo, and BeiDou systems. When running the index calculation program, it automatically reads carrier phase data and receiver coordinates for all four navigation satellite systems, saving the corresponding MAT data in the specified folder.

The Sp3 selection box allows users to select the folder containing the satellite ephemeris files. By reading the standard exchange format (SP3) of the satellite orbits

from the day before, the current day, and the following day, M_ ISSION uses 9th-order Lagrange interpolation to calculate the satellite orbit information and save the data in MAT format.

The Lim input box allows users to set the cutoff angle to exclude low-quality data. The Cycle Slip Detection option enables or disables cycle slip detection. The System Selection option allows users to choose which satellite systems will be included in the calculation.

ROTI and AATR Factor Calculation

The calculation of ROTI and AATR factors requires only the setting of common parameters. After that, click the corresponding Run button. Upon completion of the program, the program runtime is displayed in the text box. During AATR calculation, both the instantaneous AATR parameter and RMSAATR are saved.

As an example, let's use data from the YEL2 station for the index calculation demonstration. After selecting the observation and precise ephemeris files, set the cutoff angle to 30° and enable cycle slip detection, then check the four satellite systems: GPS, GLONASS (GLO), Galileo (GAL), and BeiDou (BDS). Clicking the ROTI button will start the corresponding calculation. The calculation time will be displayed within the software window. The resulting data is automatically stored in MAT file format in the following folders:

D:\MATLAB\M_ ISSION\resROTI (for individual system ROTI data)

D:\MATLAB\M_ ISSION\resROTI\Multi_system_ROTI_in_one_mat (for the integrated ROTI data from all four systems).

The storage folders and data formats are shown in Fig. 4 and Fig. 5.

Similarly, AATR data can be calculated. AATR will generate the AATR and RMSAATR data for each system, as well as for the integrated data from all four systems. The storage paths and formats are the same as for ROTI.

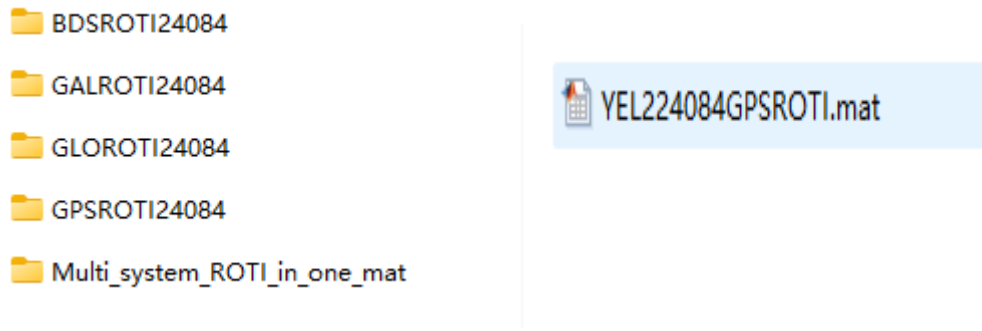


Fig. 4 ROTI Data File Storage Format

GPSROT1								
2880x32 double								
	19	20	21	22	23	24	25	
2263	0.0908	NaN	NaN	0.1823	NaN	NaN	NaN	
2264	0.0978	NaN	NaN	0.1843	NaN	0.2758	NaN	
2265	0.0978	NaN	NaN	0.1021	NaN	0.2775	NaN	
2266	0.1249	NaN	NaN	0.1003	NaN	0.1436	NaN	
2267	0.1363	NaN	NaN	0.1384	NaN	0.1137	NaN	
2268	0.1169	NaN	NaN	0.1513	NaN	0.1172	NaN	
2269	0.1289	NaN	NaN	0.2078	NaN	0.1112	NaN	
2270	0.1645	NaN	NaN	0.2203	NaN	0.1925	NaN	
2271	0.1980	NaN	NaN	0.2166	NaN	0.1962	NaN	
2272	0.2105	NaN	NaN	0.2070	NaN	0.1946	NaN	
2273	0.2187	NaN	NaN	0.2382	NaN	0.2219	NaN	
2274	0.2222	NaN	NaN	0.2432	NaN	0.2061	NaN	
2275	0.2267	NaN	NaN	0.2467	NaN	0.2024	NaN	
2276	0.2180	NaN	NaN	0.2498	NaN	0.2131	NaN	

Fig. 5 ROTI Data Format

DIXSG Factor

The calculation of the DIXSG index requires setting the latitude and longitude range of the data, the unit size of the grid, as well as sensitivity and step size to reduce the runtime, making grid division and plotting easier. The default setting is for a global range. As an example, for the data of 30 stations in Canada on March 24, 2024, the cutoff angle is set to 30° with cycle slip detection enabled, and the four satellite systems (GPS, GLONASS, Galileo, and BeiDou) are selected. The longitude range is

set from -142° to -52° , the latitude range is from 37° to 73° , and the grid size is set to $1^{\circ} \times 1^{\circ}$. The sensitivity is set to 5, incrementing from 100 to 250.

Upon running the program, the results are stored in **D:\MATLAB\M_SSION\resDIXSG\GPSDIXSG24084**, with similar storage paths for the other satellite navigation system results. The results are divided into regional DIXSG data and global DIXSGp data. The parameter settings and storage path format are shown in Fig. 6 and Fig. 7.

It should be noted that the software calculates DIXSG by constraining the distance between effective piercing points to 1000 km. While this threshold is applicable to both global and regional scales, it is not a fixed parameter and requires adjustment based on factors such as station network configuration and data quality. In the Appendix of Part VI of the User Manual, we have provided partial experimental explanations specifically addressing this scenario.

The figure shows a software interface titled 'DIXSG'. It contains several input fields and a button. The fields are: 'level' with value 5, 'first' with value 100, 'step' with value 50, 'Lat' with range 37 ~ 73, 'lon' with range -142 ~ -52, and 'dlat' with value 1. There is a button labeled 'DIXSG'.

Fig. 6 DIXSG Calculation Interface for Data from 30 Stations

The figure shows a table with the following data:

D:\MATLAB\M_SSION\resDIXSG\GPSDIXSG24084\GPS24084DIXSG.mat				
			DIXSG	
<input checked="" type="checkbox"/>	LL	1x24	624576	cell
<input checked="" type="checkbox"/>	MBL	1x5	40	double
<input checked="" type="checkbox"/>	aDIXSG	1x24	192	double

Arrows indicate that 'LL' points to 'DIXSG' and 'aDIXSG' points to 'DIXSGp'.

Fig. 7 DIXSG and DIXSGp Data Storage Paths and Format

$\sigma_{\phi f}$ Factor

The calculation of the $\sigma_{\phi f}$ factor requires the additional selection of the precise clock file and antenna phase correction file. Furthermore, the phase carrier band should be

selected as either L1 or L2. Next, the normalized cutoff frequency for the sixth-order high-pass Butterworth filter must be set. The calculation method for the normalized cutoff frequency is as follows:

$$W_n = \frac{f_e}{\frac{f_s}{2}} \quad (1)$$

In the formula, W_n represents the normalized cutoff frequency, f_e is the cutoff frequency in Hz, and f_s is the sampling frequency in Hz.

The generated $\sigma_{\phi f}$ result data is stored in the folder **D:\MATLAB\M_ISSION\resSIGMAPHI\GPSsigmaphi24084**. The data format is similar to that of ROTI and AATR, and will not be further elaborated here.

(2) Factor Visualization Interface

After the ionospheric scintillation factor calculations are completed, time-series trend plots can be generated in this interface. First, select the path to the generated factor data and click the "Plot" button. For ROTI, AATR, and $\sigma_{\phi f}$ indices, the corresponding valid data and satellite identifiers will be displayed. You can choose the valid satellite results based on the displayed information. The numbers are separated by commas (e.g., 2, 3, 4) or you can input [2 4] to display the results for satellites 2, 3, and 4 individually for that specific index.

For example, using the YEL2 station data from March 24, 2024, and data from 30 stations in the region, the visualization results for ROTI, RMSAATR, DIXSGp, and DIXSG are shown in Figures Fig. 8 to Fig. 11. The trend plots for AATR and $\sigma_{\phi f}$ are similar to those for ROTI.

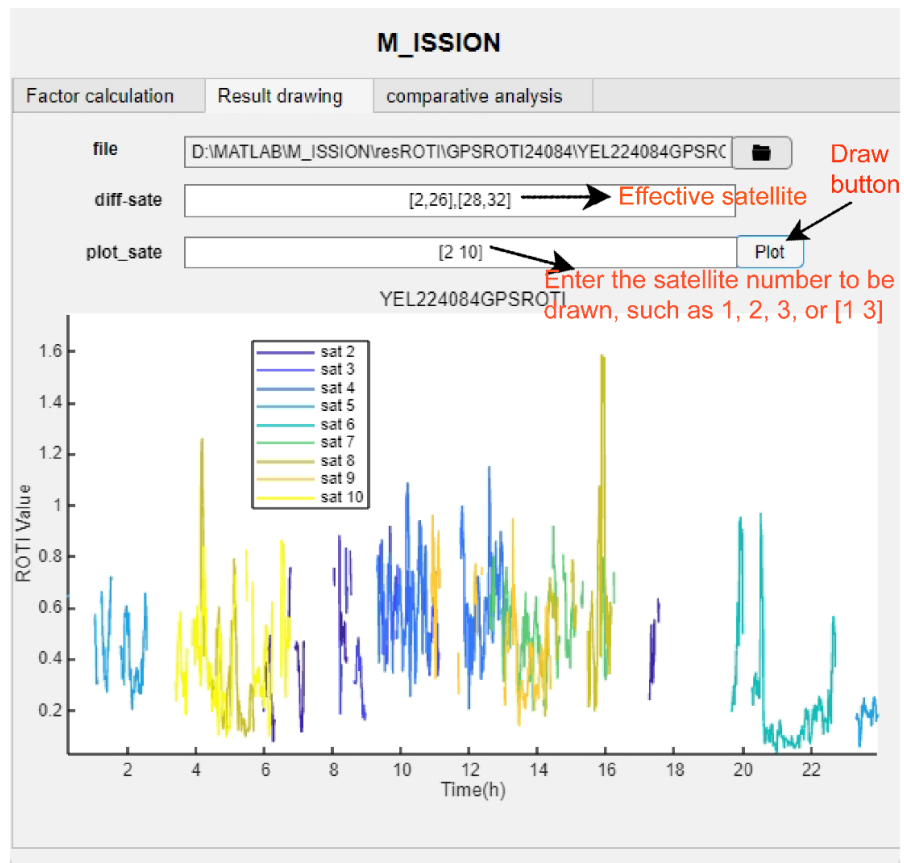


Fig. 8 Trend of ROTI Factor for Satellites 2-10

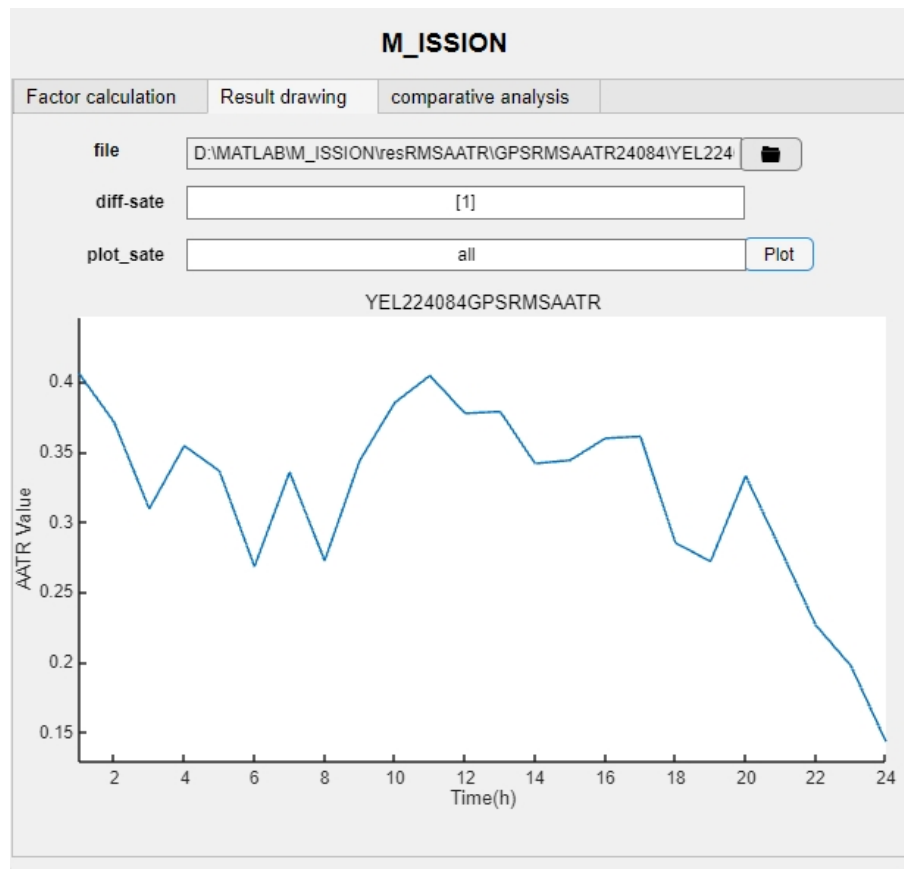


Fig. 9 Trend of RMSAATR Index

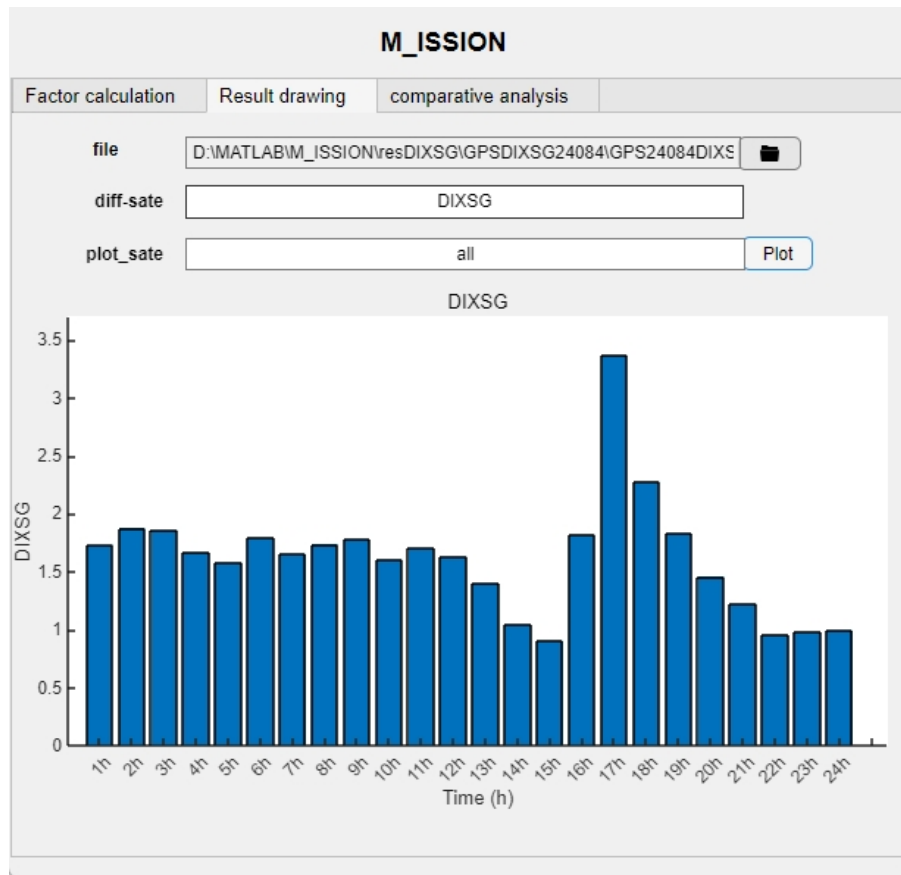


Fig. 10 Global Histogram of DIXSGp Factor

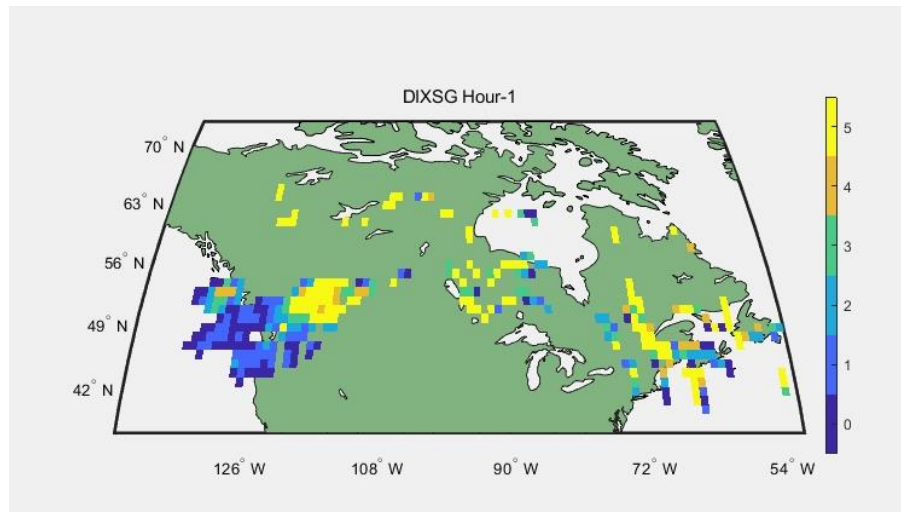


Fig. 11 First Hour Trend Map of DIXSG Factor for the Region

(3) Scintillation Factor Analysis Interface

The Scintillation Factor Analysis Interface is divided into three submodules: Multi-System Index Validation, Multi-Index Validation, and Regional ROTI and DIXSG

Validation. The first submodule, Multi-System Index Validation, takes the ROTI data from the YEL2 station on March 24, 2024, as an example. The mat data containing the results from all four systems is selected. After the data selection, the indicators for the valid navigation systems will turn green. At this point, you can either check or uncheck the corresponding system with the green indicator, and you can also set the time interval for the data display. The results are shown in Figure Fig. 12.

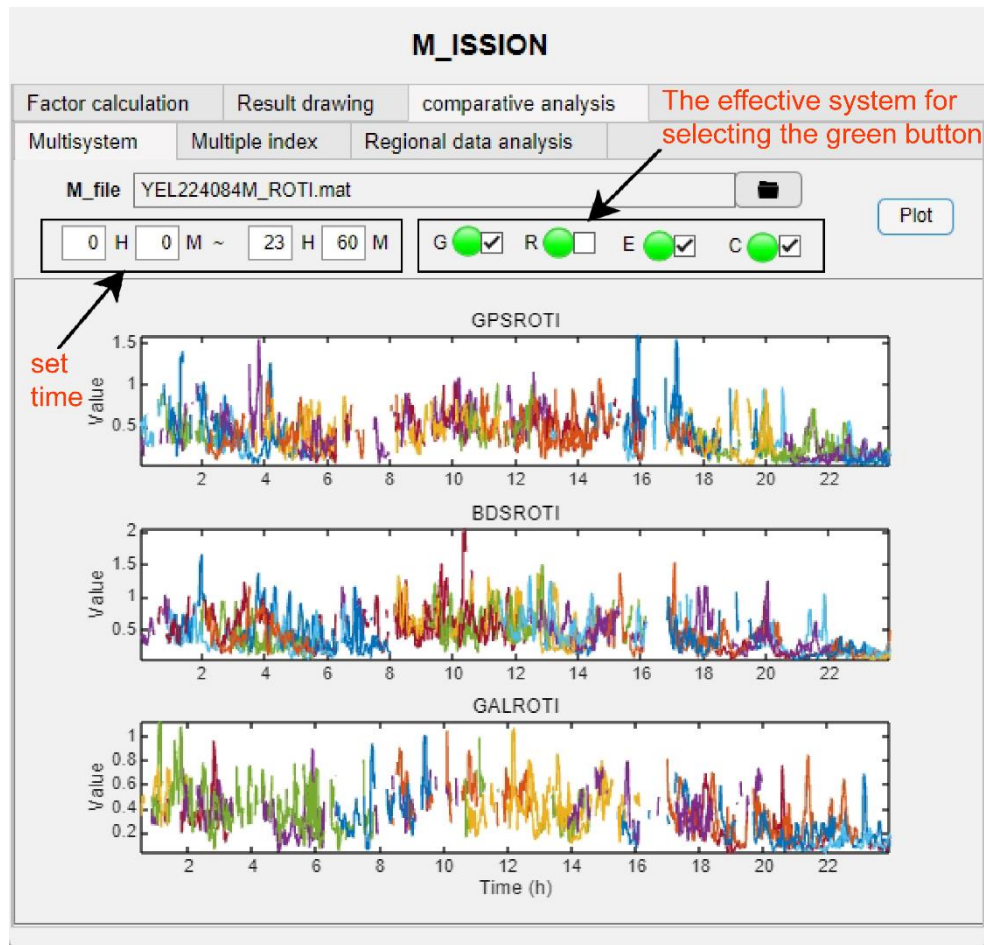


Fig. 12 ROTI Multi-System Comparison Analysis

The second submodule is Multi-Index Validation, where up to four indices can be selected for cross-validation. After selecting the relevant indices, click "Run" to execute the process. Additionally, selections can be canceled by clicking the "×" symbol. Using the YEL2 station data from March 24, 2024, as an example, the results are shown in FigureFig. 13.

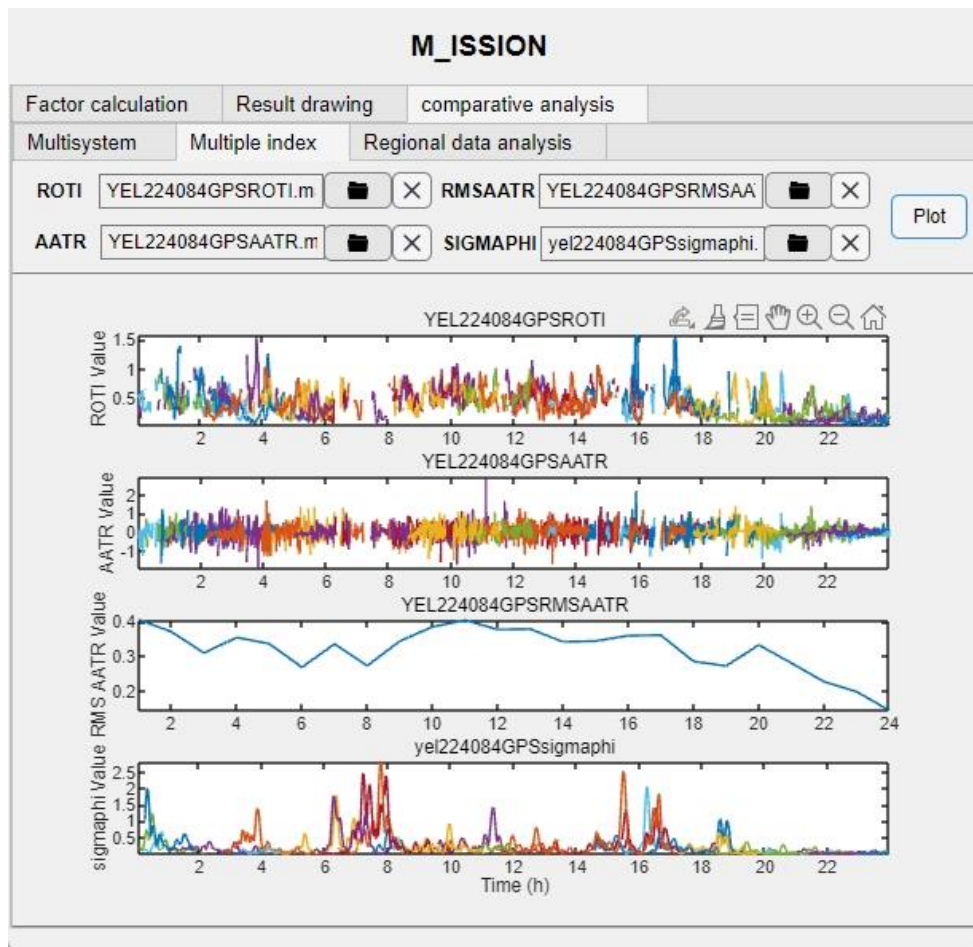


Fig. 13 Cross-Comparison of Four Indices

The third submodule is Regional DIXSG and ROTI Validation. This module has two functions: the first function involves selecting the folder where the ROTI data generated by the ionospheric scintillation factor calculation module is stored. Users can set the latitude and longitude range and grid size, and run the program to obtain the regional ROTI data. The generated regional ROTI data will be stored in the **D:\MATLAB\M_ISSION\resROTI\regionalROTI** folder. The second function allows users to select the generated regional ROTI data and DIXSG data. After inputting the corresponding time (1-24 hours) and clicking "Run," regional validation can be performed. The module interface and results are shown in Figures Fig. 14 and Fig. 15.

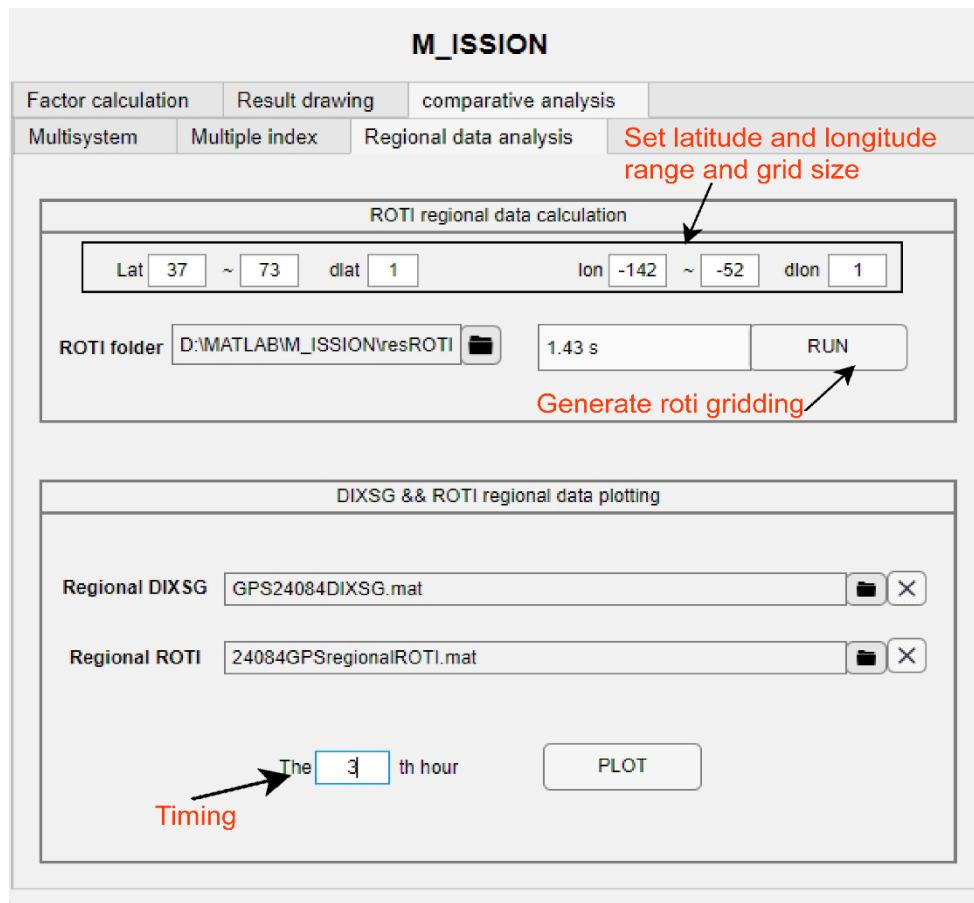


Fig. 14 Running Interface and Related Settings

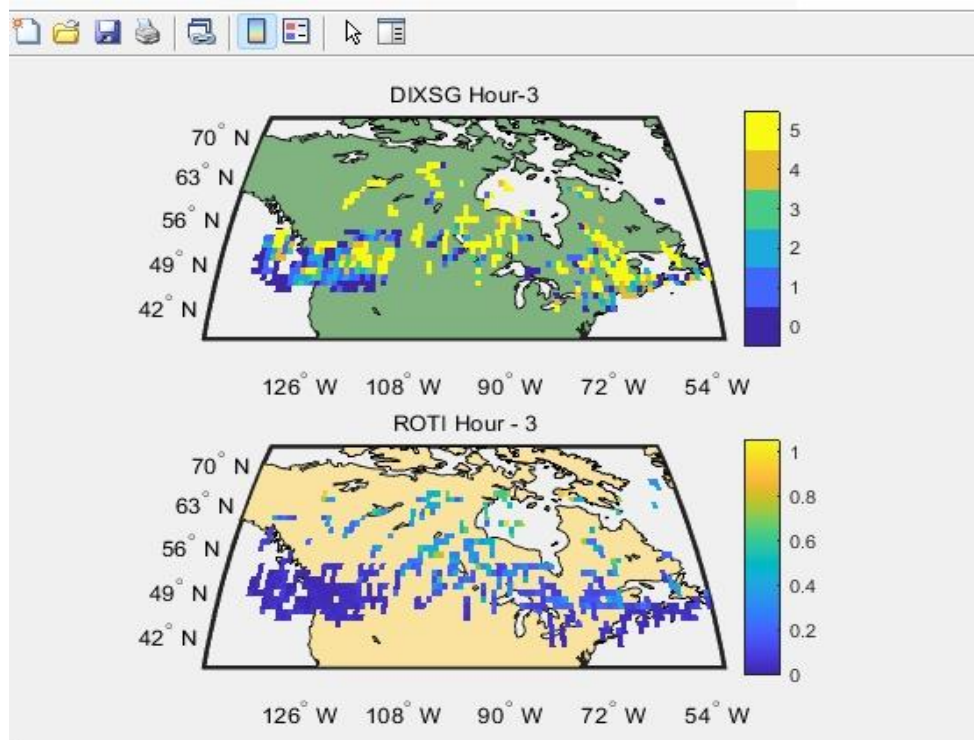


Fig. 15 3rd Hour GPS DIXSG (Top) and GPS ROTI (Bottom) Regional Validation

4. Example Data

To help users quickly master the usage of M_ISSION software, we provide sample data, including observation data from the four-system observation station YEL2 in the Canadian region on March 24, 2024 for four-system index calculation experiments, and observation data from 6 other stations for calculating the regional DIXSG index. The longitude range is set to -140° to -105° , and the latitude range is set to 42° to 56° . We also provide precise ephemeris files for the day before, the current day, and the day after the observation time; antenna phase files; and precise clock difference files. The details are shown in Table 2, and the sample data is included in the example folder of the software package. In actual calculations, the DIXSG index calculation for a region should include data from more stations to provide sufficient data coverage. In this sample data, only a small regional range was selected for demonstration and convenient data upload purposes.

Table 2 Experimental Data

Files	Name
Observation	yel20840.24o,albh0840.24o,nano0840.24o,bamf0840.24o, uclu0840.24o, holb0840.24o, chwk0840.24o
Orbit	COD0MGXFIN_20240830000_01D_05M_ORB.SP3 COD0MGXFIN_20240840000_01D_05M_ORB.SP3 COD0MGXFIN_20240850000_01D_05M_ORB.SP3
Clock	COD0MGXFIN_20240840000_01D_30S_CLK.CLK
Antenna	igs20.atx

5. Acknowledgments

We would like to thank IGS (<https://www.igs.org/data-products-overview/>), CHAIN (http://chain.physics.unb.ca/chain/pages/data_download), and CODE, CDDIS MGEX product archives (<https://cddis.nasa.gov/archive/gnss/products>), as well as other organizations for providing the data and products. The software draws on the design concepts and open-source code from the GPS Solutions Toolbox (<https://geodesy.noaa.gov/gps-toolbox/>). Special thanks go to the authors of M_GIM (<https://doi.org/10.1007/s10291-022-01370-9>), Chunyuan Zhou, Ling Yang, Bofeng Li, and Timo Balz, and the authors of PPPH (<https://doi.org/10.1007/s10291-018-0777-z>), Berkay Bahadur and Metin Nohutcu.

6. Appendix

Selected Experiments on DIXSG Parameter D Selection

We utilized data from the Canadian region on March 24, 2024, to conduct experiments addressing the distance selection issue in DIXSG factor validation prior to software construction, as illustrated in Figure 16. Selected distances D were 200, 500, 1000, 2000, and 3000 km ($d < D$). The results indicate that DIXSGp values across all distance ranges generally exhibited a negative correlation with Dst value variations. At the 12th time interval, the DIXSGp value for the 1000 km distance displayed a declining trend, contrary to the Dst value changes, while other distances showed rising trends consistent with the Dst index. Overall, DIXSGp values calculated using the 1000 km distance demonstrated higher magnitudes during magnetic storms compared to other distances, yet approached zero-state more closely during subsequent geomagnetic quiet periods. This suggests enhanced representation of rapid variations and superior sensitivity compared to other distance thresholds.

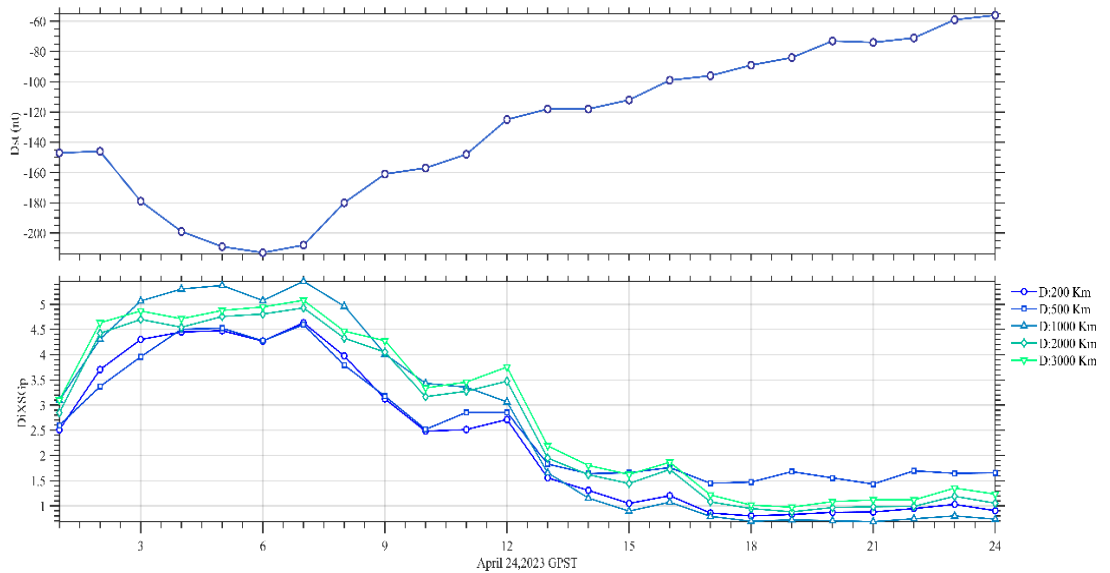


Fig. 16 The Dst index and DIXSGp values calculated under varying distance parameters

In the software, we have designed the distance threshold as 1000 km, and the calculated DIXSG values were compared with ROTI values as shown in Figures 17 and 18. DIXSG values under distances of 200, 500, 2000, and 3000 km are presented in

Figures 19 to 22. The results demonstrate similar variation patterns to those mentioned earlier. Using ROTI as a reference, excessively small D values result in an excessively sparse DIXSG distribution, while overly large D parameters induce spurious overestimation of values. This observation aligns with our earlier analysis of distance-dependent sensitivity characteristics.

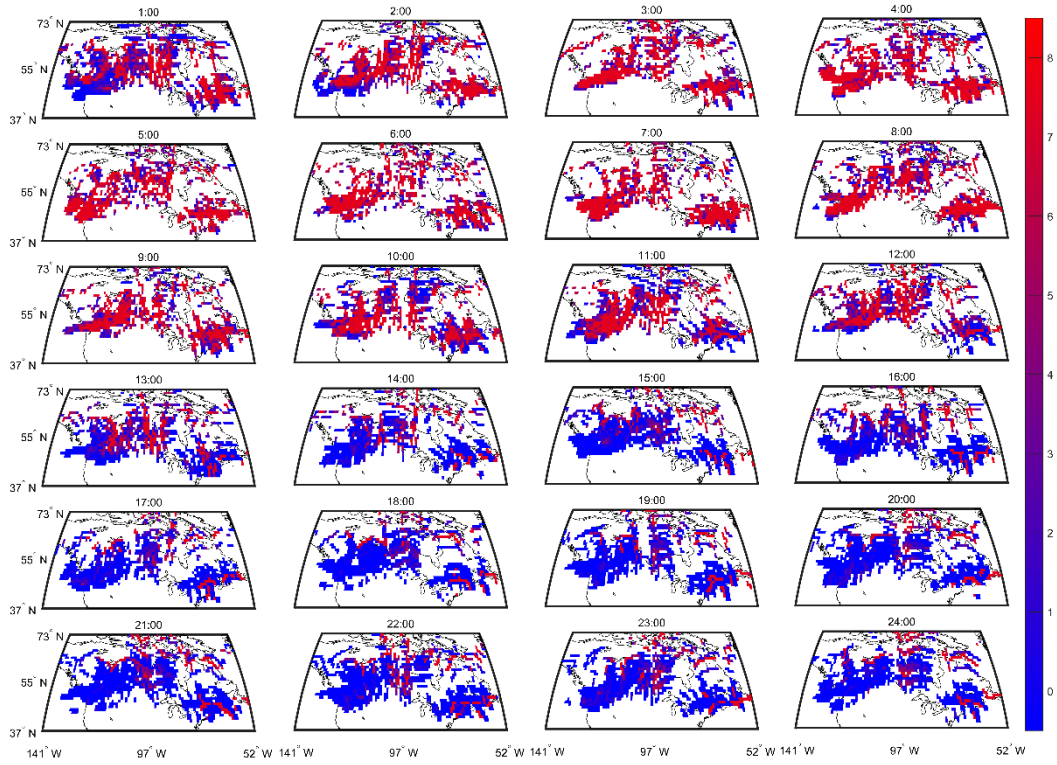


Fig. 17 D=1000km, DIXSG variation in the Canadian region from 1:00 to 24:00 (UTC) on April 24, 2023.

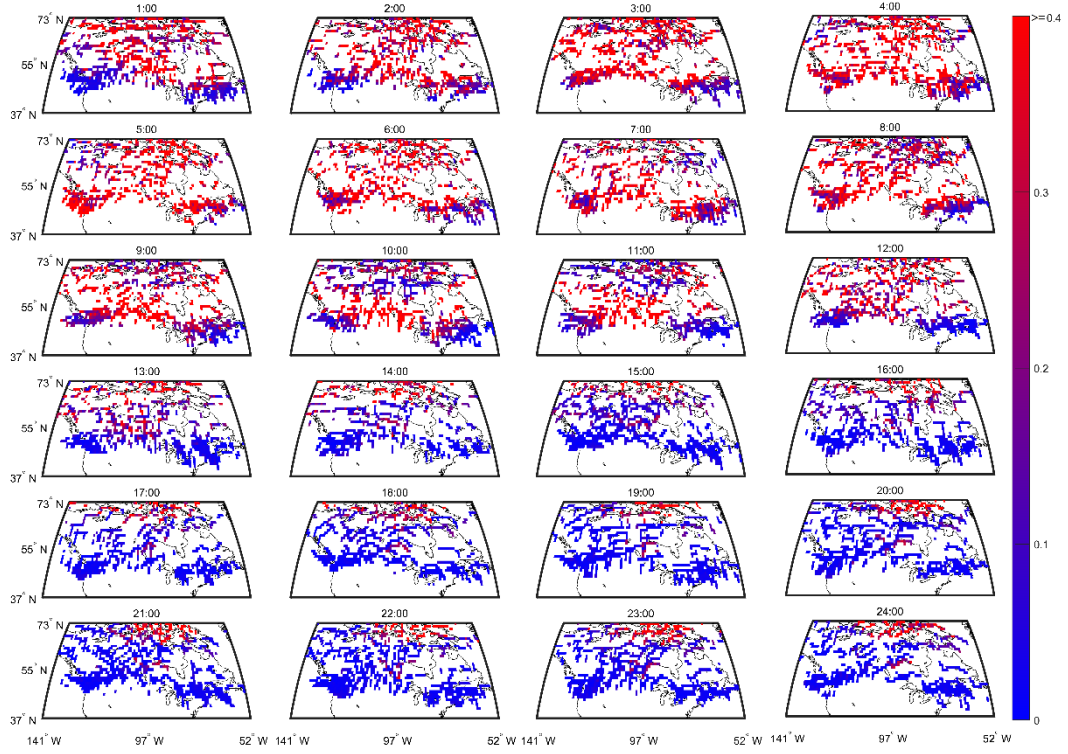


Fig. 18 ROTI variation in the Canadian region from 1:00 to 24:00 (UTC) on April 24, 2023

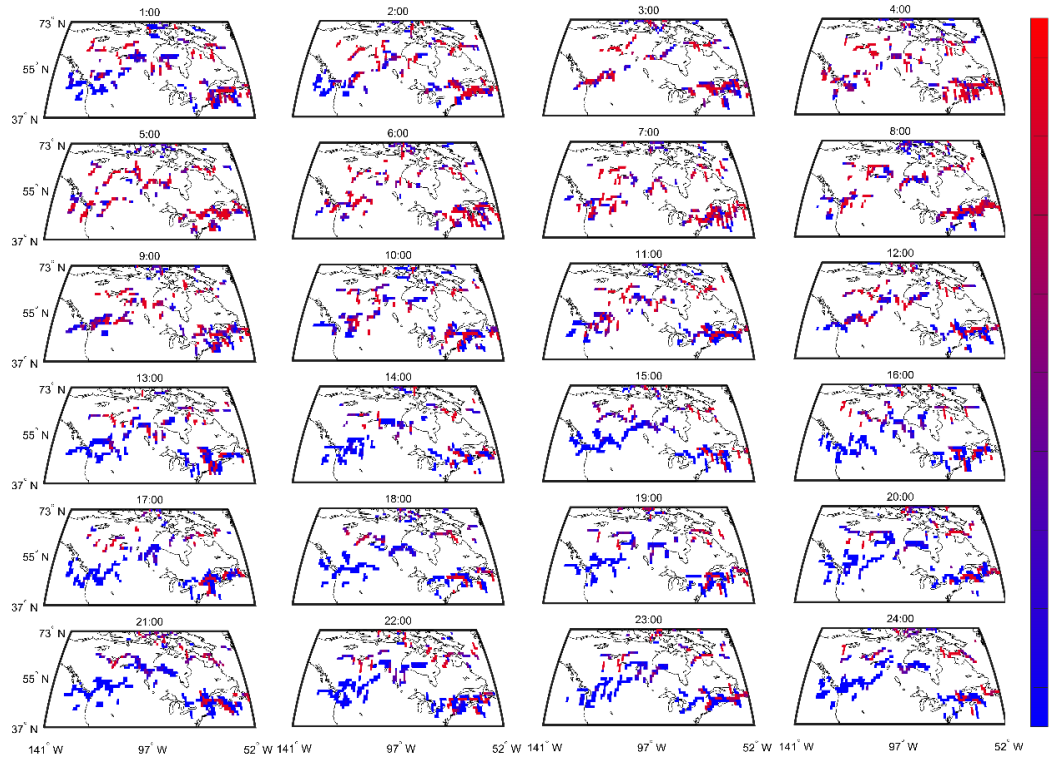


Fig. 19 D=200km, DIXSG variation in the Canadian region from 1:00 to 24:00 (UTC) on April 24, 2023.

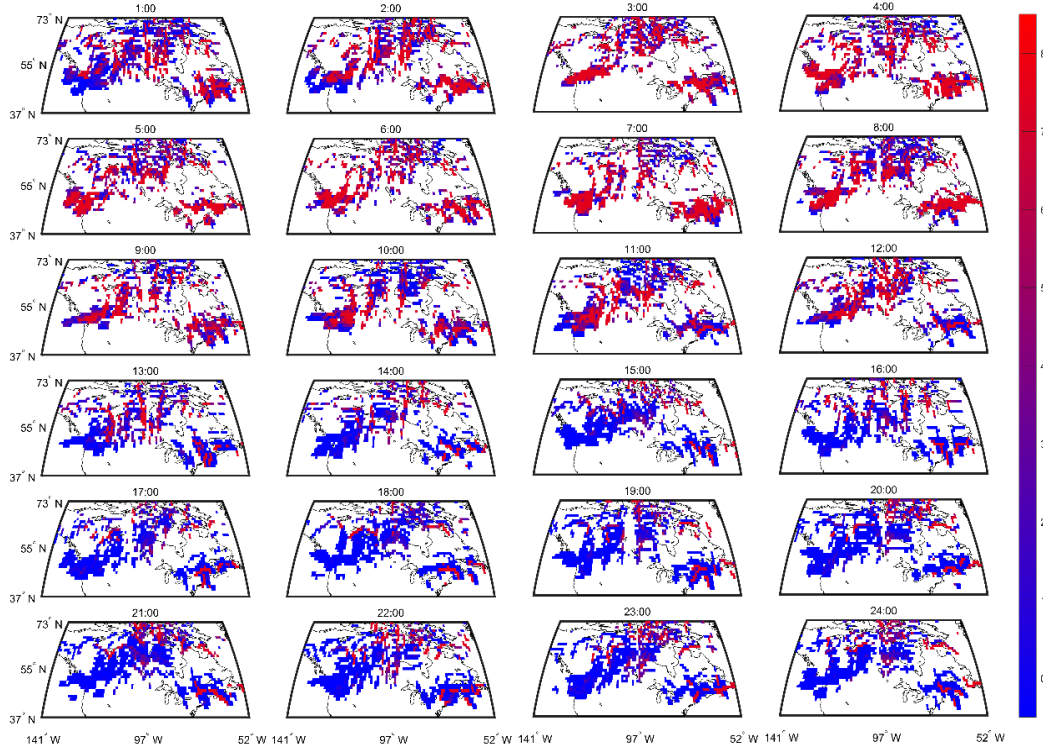


Fig. 20 D=500km, DIXSG variation in the Canadian region from 1:00 to 24:00 (UTC) on April 24, 2023.

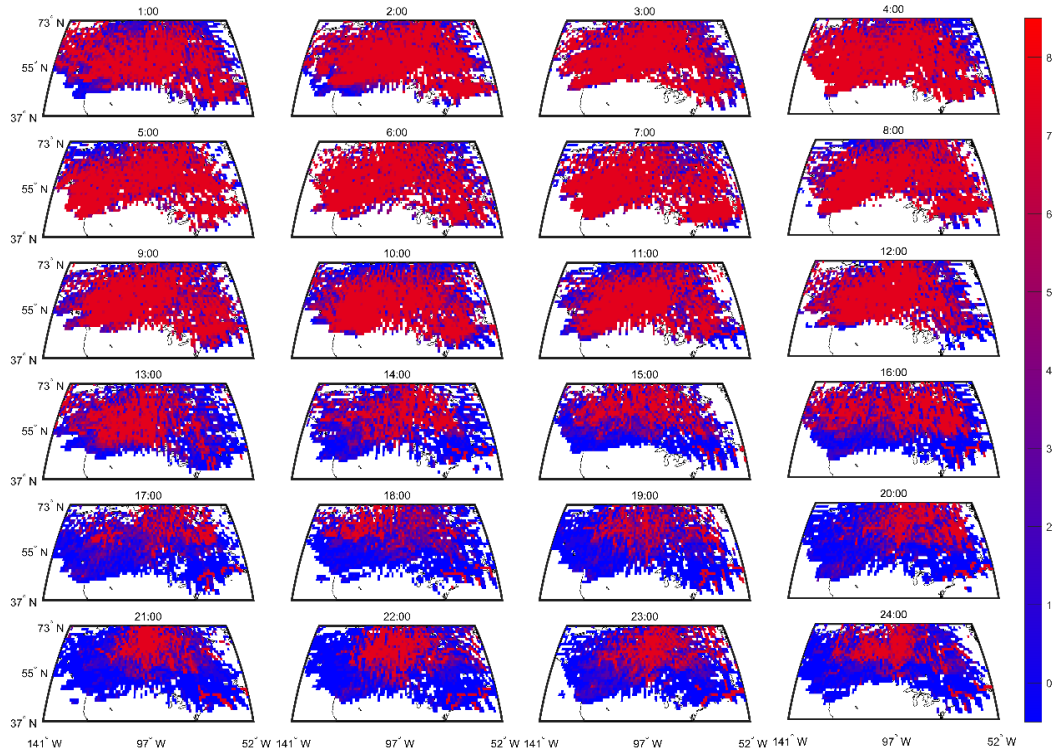


Fig. 21 D=2000km, DIXSG variation in the Canadian region from 1:00 to 24:00 (UTC) on April 24, 2023.

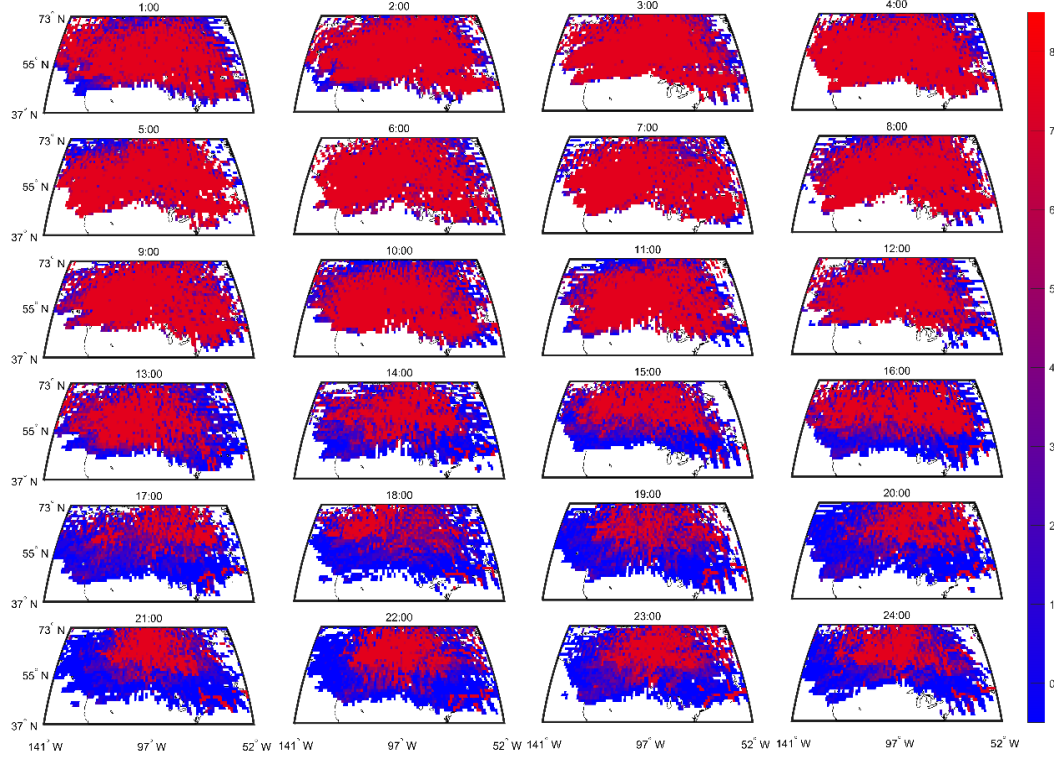


Fig. 22 $D=3000\text{km}$, DIXSG variation in the Canadian region from 1:00 to 24:00 (UTC) on April 24, 2023.

In addition, we conducted analogous analyses on global datasets to identify D parameter selections with optimal regional and global compatibility. Below we present partial global validation results, using January 1, 2025 as an example. Notably, Figure 24 employs over 400 global stations for computation ($D=1000\text{ km}$), while Figure 25 utilizes our curated network of 80 stations ($D=5000\text{ km}$). This approach explicitly considers the influence of reference station distribution and configuration on parameter selection. The results demonstrate that the 1000 km threshold achieves favorable compatibility under dense station coverage, whereas sparser networks may adopt larger D values to enhance spatial resolution. However, larger D values risk introducing extraneous noise that obscures precise characterization of ionospheric gradient variations. Therefore, D parameter selection should be dynamically adapted based on station distribution patterns and data quality metrics. In our software, we recommend the 1000 km distance threshold as a compatible default while retaining flexibility for context-specific adjustments.

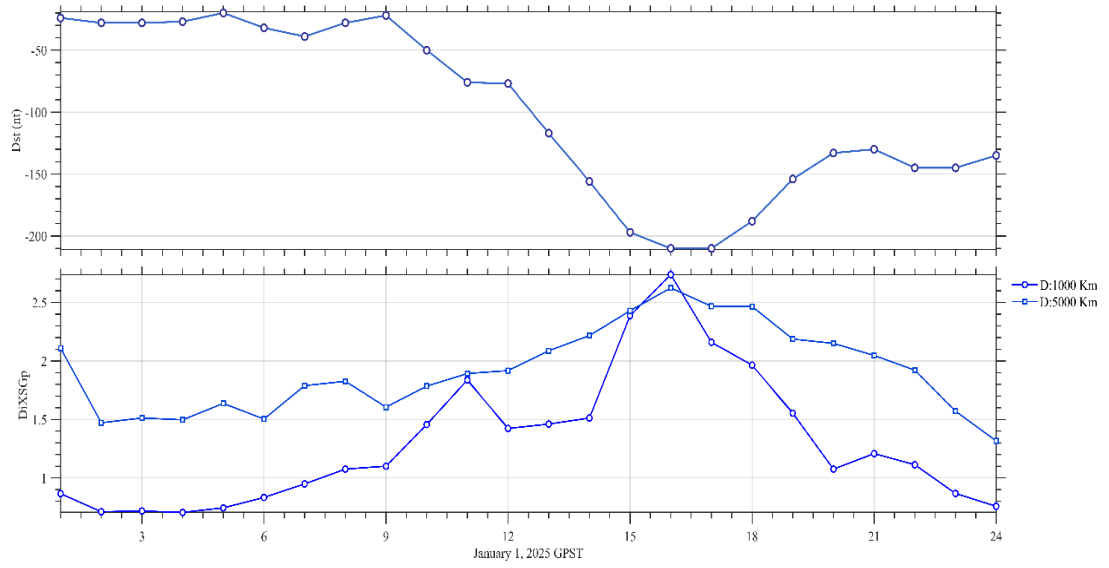


Fig. 23 On January 1, 2025, the Dst index and DIXSGp index

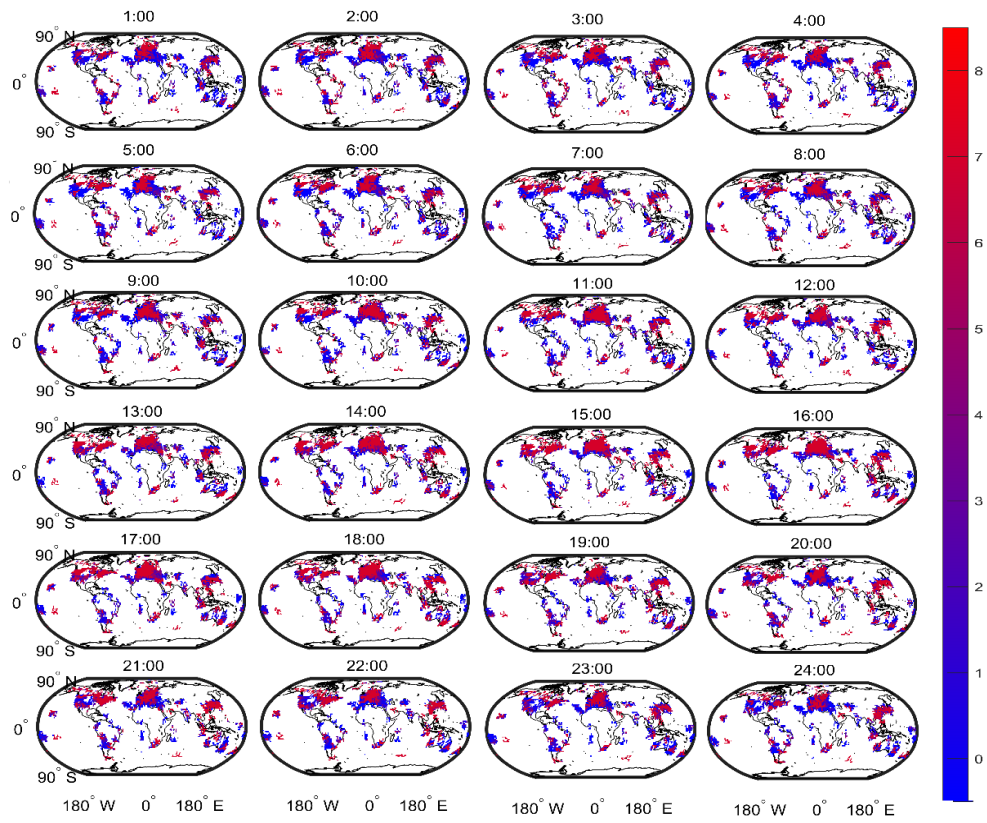


Fig. 24 400 sites, D=1000km, 24-hour Globally Computed DIXSG Map

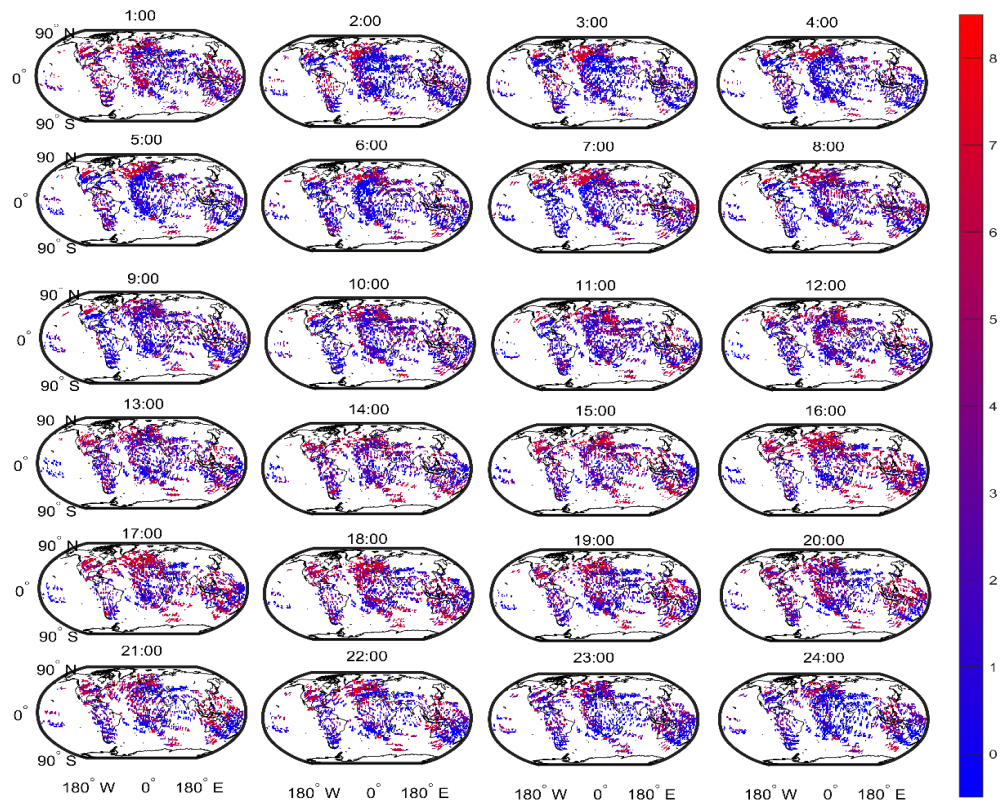


Fig. 25 80 sites, $D=5000\text{km}$, 24-hour Globally Computed DIXSG Map