BDViSim-User Manual

V1.0

Software: BDViSim

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Download link: https://github.com/LECUT/BDViSim

BDViSim online access link: http://111.75.254.205:8083/

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1. Introduction

The BeiDou visual simulation (BDViSim) platform is a web application that can be accessed through web browsers with WebGL support, such as the latest versions of Google Chrome, Firefox, Microsoft Edge, and Opera. BDViSim follows a B/S architecture and utilizes computer simulation, network technology, and multimedia technology. The front-end is developed using HTML, CSS, and JavaScript, while the back-end is implemented in Python with the Flask framework. With Cesium virtual earth engine as the development platform, five functional modules of orbit cognition, orbit calculation, constellation simulation, service performance and satellite link are designed and implemented.

2. Installation

(1) Download software

First download the software from Github (https://github.com/LECUT/BDViSim). The file directory structure is illustrated in Fig. 1. Within this structure, the 'ionex' directory is a function package for parsing ionospheric files. The 'static' directory is used to store static files , such as JS, CSS styles, pictures, and orbit calculation data etc. The 'templates' directory is used to store HTML files. The 'Test_data' directory is used to store the test data of the data import function of the orbit calculation module. The 'Output_files' directory is used to store the coordinate results and error sequence diagrams of orbit calculation modules. 'app.py' is the main function, 'datacal.py' is the calculation function, 'ftpdown.py' is the data download function, and 'UEREcal.py' is the function to calculate the UERE value.

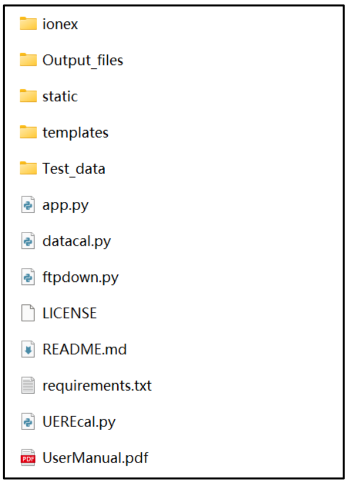


Fig. 1: The project directory of BDViSim.

(2) Python environment building

BDViSim is written in Python 3.10, so it is necessary to have Python (version 3.x) installed. It is recommended to use the Python compiler PyCharm to open the project directory. After that, the project requisites can be installed by referring to the requirements.txt file.

(3) Running the BDViSim

Once the environment is set up, you can run 'app.py' using the compiler. By default, the project runs on port 83, so please ensure that the port is not already in use. If needed, you can change the port. Once run successfully, BDViSim can be accessed locally through any web browser. The home page is shown in the Fig. 2.

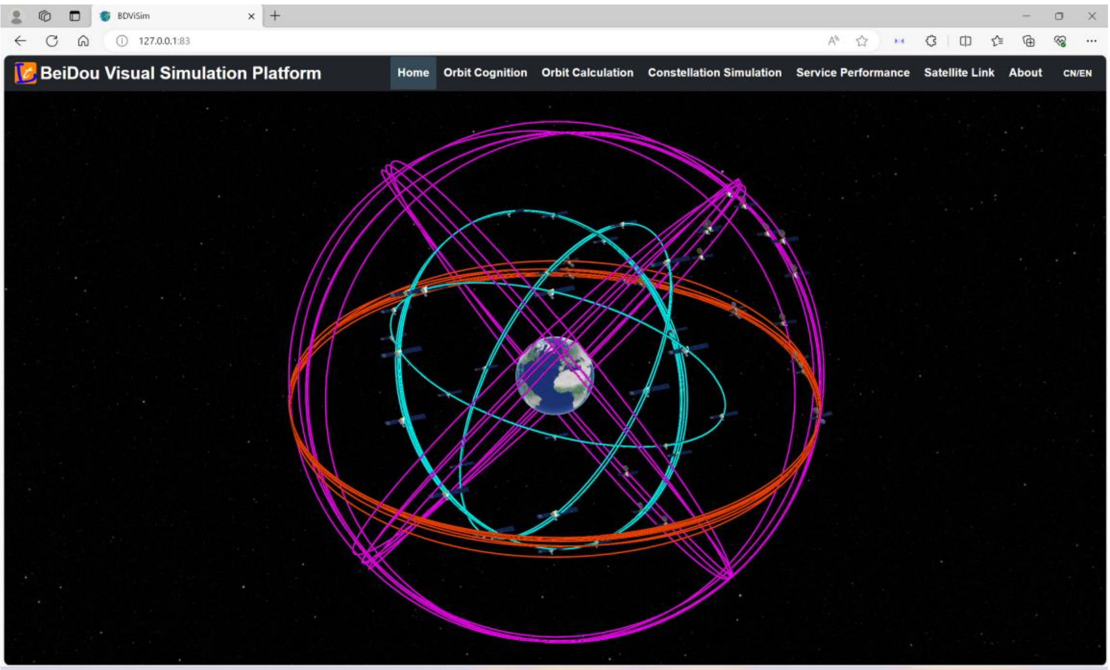


Fig. 2: The home page of BDViSim.

3. Modules

3.1 Orbit cognition

The orbit cognition page is shown in Fig. 3. On the left side of the page, there is a control panel (Fig. 3a) consisting of six sliding strips. These strips are used to adjust the size of Keplerian six-orbit parameters, including the long semi-axis, orbital eccentricity, right ascension of ascending node, orbital inclination angle, perigee angle, and true perigee angle. By adjusting these parameters, corresponding satellite orbits can be generated. At the upper right corner of the page, there is a toolbar (Fig. 3b) which includes several buttons. The home button allows the perspective to be reset to the initial position. The dimension selection button enables switching between 2D, 2.5D, and 3D display modes. The layer selection button allows users to choose different map image layers and terrain. Lastly, the navigation instruction button provides instructions on how to use the page when clicked.

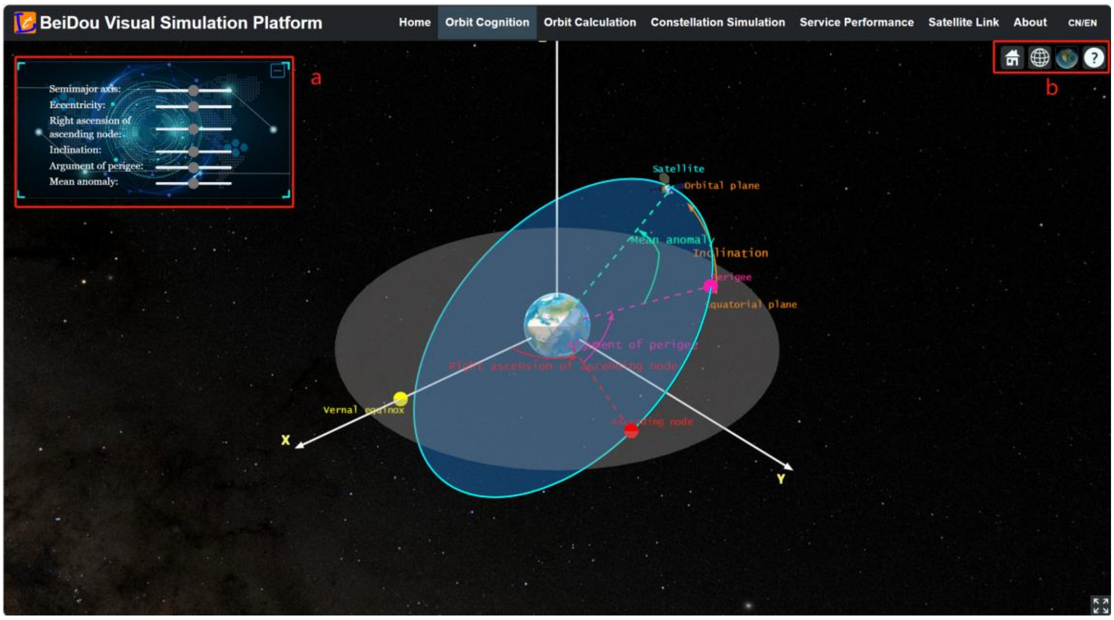


Fig. 3: The Orbit Cognition page.

3.2 Orbit Calculation

The orbit calculation page is shown in Fig. 4.

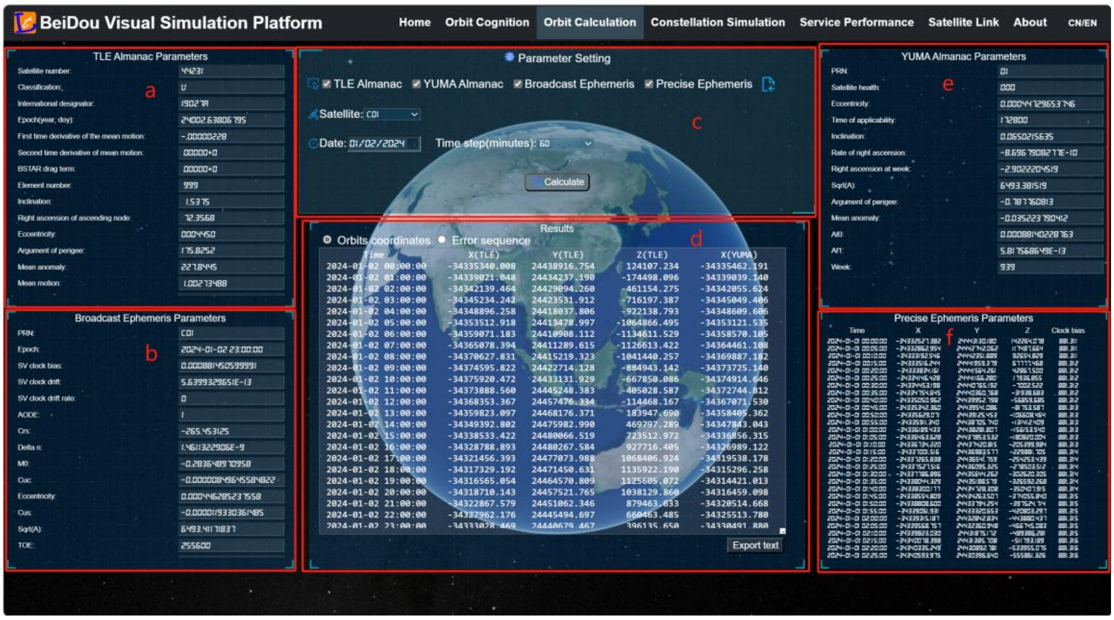
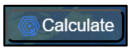


Fig. 4: The Orbit Calculation page.

(1) Fig. 4a displays the TLE almanac parameter information. The TLE data is analyzed and includes the following parameters: Satellite number, Classification, International

designator, Epoch, First time derivative of the mean motion, Second time derivative of mean motion, BRTAR drag term, Element number, Inclination, Right ascension of ascending node, Eccentricity, argument of perigee, Mean anomaly, Mean motion, and Revolution number at epoch.

(2) Fig. 4b displays the broadcast ephemeris parameter information. The broadcast ephemeris data is analyzed and includes the following parameters: PRN, Epoch, SV clock bias, SV clock drift, SV clock drift rate, AODE, Crs, Delta n, M0, Cuc, e Eccentricity, Cus, sqrt(A), Toe Time of Ephemeris, Cic, OMEGA0, Cis, i0, Crc, omega, OMEGA DOT, IDOT, L2 Code, BDT Week, L2 P Code, SV Accuracy, Satellite Health, TGD1 B1/B3, TGD2 B2/B3, Transmission time of message, and AODC.

(3) Fig. 4c is the parameter setting bar for orbit calculation. The four check boxes in the first row are used to select almanac/ephemeris data for orbit calculation. The import data button  on the right is used to import local ephemeris/almanac data. Clicking on it will open a dialog box for importing data, as shown in Fig. 5. The second line consists of a satellite selection drop-down box, which is used to select the satellite for calculation. The third line is used to set the time parameters. Once the parameters are set, clicking the 'Calculate' button 

will generate the calculation results.

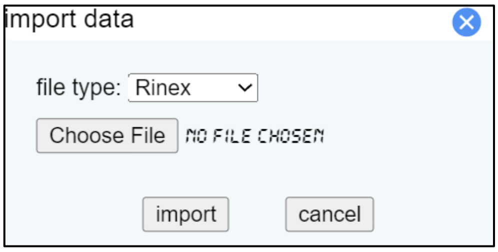


Fig. 5: The import data dialog box.

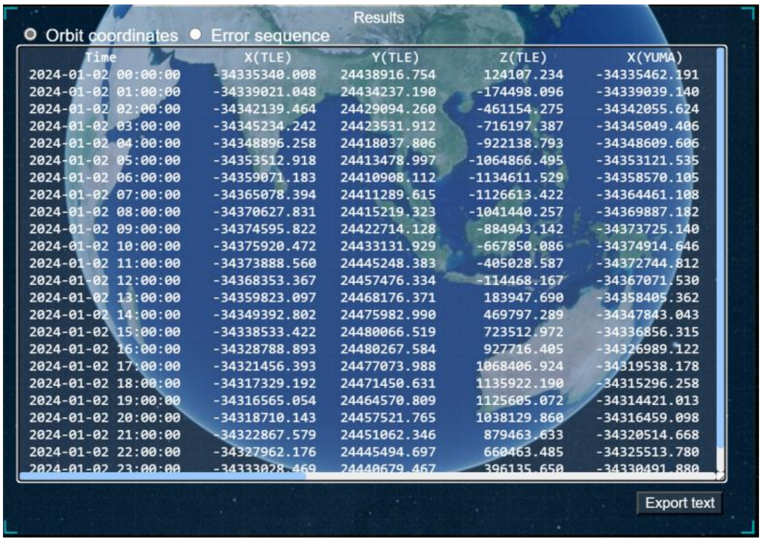
Usage of import data function:

① Select the file type to be imported through the drop-down box, and then click the Choose File button to select the file to be imported.

② In turn, import the Rinex data 'hour0070.24b', TLE data 'BDSTLE2024-01-07.txt', YUMA data 'conv0070.24alc', and SP3 data 'WUM0MGXULT_20240070000_01D_05-M_ORB.SP3' in the 'Test_data' directory respectively (The import of Rinex data needs to wait for about 30 s, and the rest of the data is relatively fast).

③ Finally, click the 'Calculate' button to get the calculation results of the imported data.

(4) Fig. 4d is the result bar, which is used to show the orbit coordinate results and orbit error sequence results, as shown in Fig. 6 and Fig. 7, respectively. In the lower right corner are the export diagram and export text buttons. After clicking, the browser automatically downloads the orbit coordinate text results and error sequence diagram.



Time	X(TLE)	Y(TLE)	Z(TLE)	X(YUMA)
2024-01-02 00:00:00	-34335340.008	24438916.754	124107.234	-34335462.191
2024-01-02 01:00:00	-34339021.048	24434237.190	-174498.096	-34339039.140
2024-01-02 02:00:00	-34342139.464	24429094.260	-461154.275	-34342055.624
2024-01-02 03:00:00	-34345234.242	24423531.912	-716197.387	-34345049.406
2024-01-02 04:00:00	-34348896.258	24418037.806	-922138.793	-34348609.606
2024-01-02 05:00:00	-34353512.918	24413478.997	-1064866.495	-34353121.535
2024-01-02 06:00:00	-34359071.183	24410908.112	-1134611.529	-34358570.105
2024-01-02 07:00:00	-34365078.394	24411289.615	-1126613.422	-34364461.108
2024-01-02 08:00:00	-34370627.831	24415219.323	-1041440.257	-34369887.182
2024-01-02 09:00:00	-34374595.822	24422714.128	-884943.142	-34373725.140
2024-01-02 10:00:00	-34375920.472	24433131.929	-667850.086	-34374914.646
2024-01-02 11:00:00	-34373888.560	24445248.383	-405028.587	-34372744.812
2024-01-02 12:00:00	-34368353.367	24457476.334	-114468.167	-34367071.530
2024-01-02 13:00:00	-34359823.097	24468176.371	183947.690	-34358405.362
2024-01-02 14:00:00	-34349392.802	24475982.990	469797.289	-34347843.043
2024-01-02 15:00:00	-34338533.422	24480066.519	723512.972	-34336856.315
2024-01-02 16:00:00	-34328788.893	24480267.584	927716.405	-34326989.122
2024-01-02 17:00:00	-34321456.393	24477073.988	1068406.924	-34319538.178
2024-01-02 18:00:00	-34317329.192	24471450.631	1135922.190	-34315296.258
2024-01-02 19:00:00	-34316565.054	24464570.809	1125605.072	-34314421.013
2024-01-02 20:00:00	-34318710.143	24457521.765	1038129.860	-34316459.098
2024-01-02 21:00:00	-34322867.579	24451062.346	879463.633	-34320514.668
2024-01-02 22:00:00	-34327962.176	24445494.697	660463.485	-34325513.780
2024-01-02 23:00:00	-34333028.469	24440679.467	396135.650	-34330491.880

Fig. 6: The orbit coordinates results.

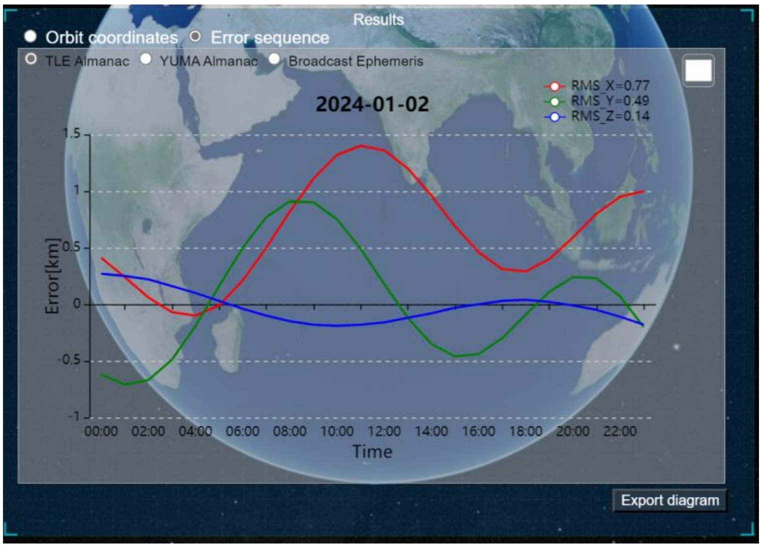


Fig. 7: The error sequence result.

(5) Fig. 4e displays the YUMA almanac parameter information. The YUMA data is analyzed and includes the following parameters: PRN, Satellite health, Eccentricity, Time of applicability, Inclination, Rate of right ascension, Right ascension at week, Sqrt(A), Argument of perigee, Mean anomaly, Af0, Af1, and Week.

(6) Fig. 4f displays the precise ephemeris parameter information. The precise ephemeris data is analyzed and includes the following parameters: Time, X coordinates, Y coordinates, Z coordinates, and Clock bias.

3.3 Constellation Simulation

The constellation simulation page is shown in Fig. 7.

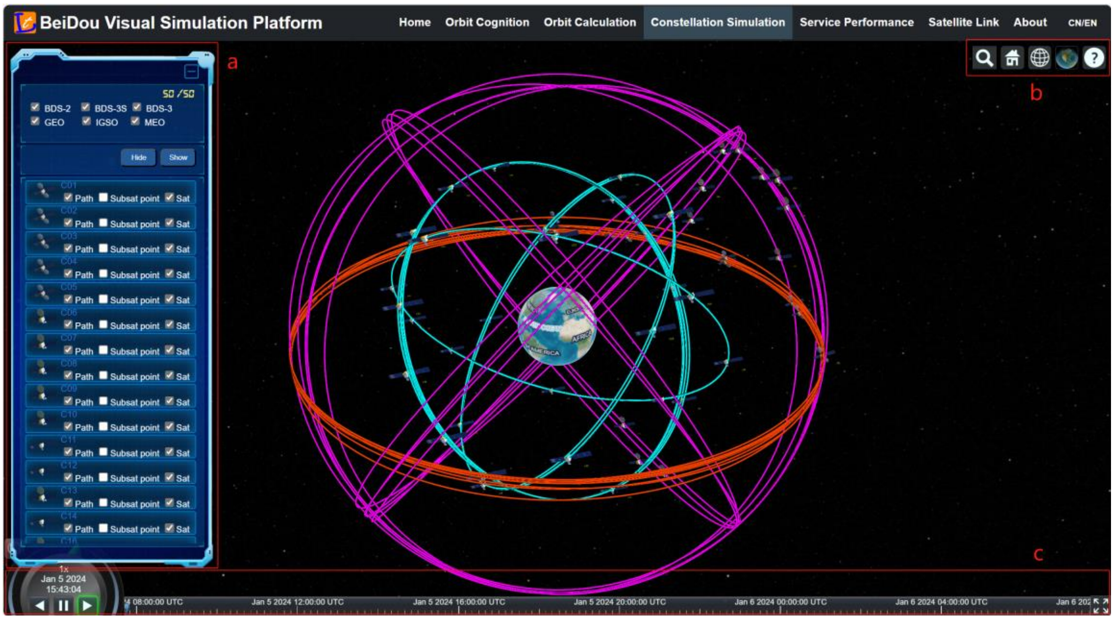


Fig. 8: The Constellation Simulation page.

(1) Fig. 8a shows the control panel, which has several functions:

①The first column is used to screen satellites based on satellite systems (BDS-2/BDS-3S/BDS-3) and orbit types (GEO/IGSO/MEO). The number of screening satellites and the total number of satellites are displayed in the upper right corner.

②The second column contains hide and show buttons to control the display and hiding of selected satellites and orbits.

③The third column displays all screened satellite control modules. By clicking on the left satellite icon  or the first row of satellite PRN 

of a single satellite module, the perspective of the satellite is tracked and its information is displayed in the upper right corner of the page (Fig. 9). The second row of the panel 

includes three check boxes to control the display and hiding of the orbit path, sub-satellite point, and satellite label.

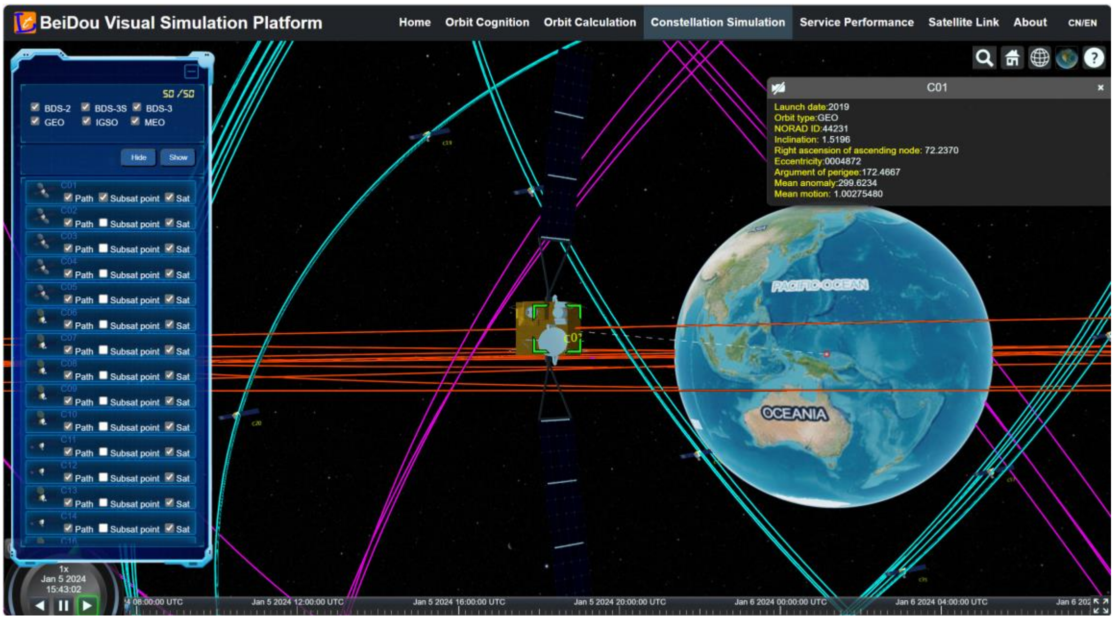


Fig. 9: Satellite perspective tracking.

(2) Fig. 8b shows the toolbar, including search button, home button, dimension selection button, layer selection button and navigation instruction button. The search button can enter latitude and longitude or place name to find the destination on the earth, and other button functions are consistent with the previous introduction. Click on the dimension selection button to switch to the 2D and 2.5D, as shown in Fig. 10 and Fig. 11, respectively.

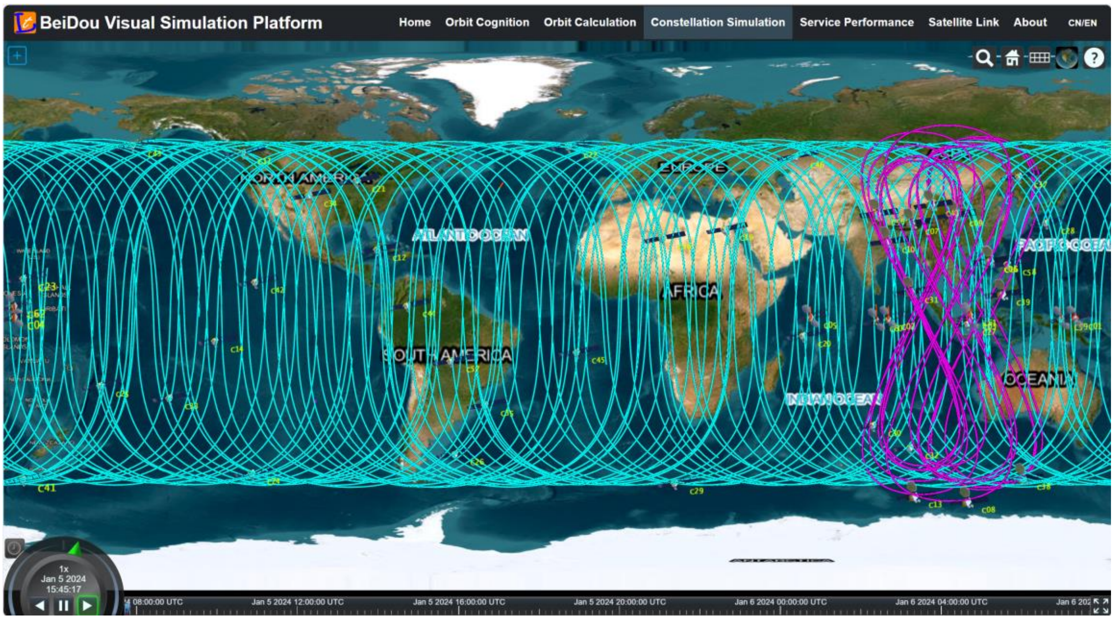


Fig. 10: 2D effect.

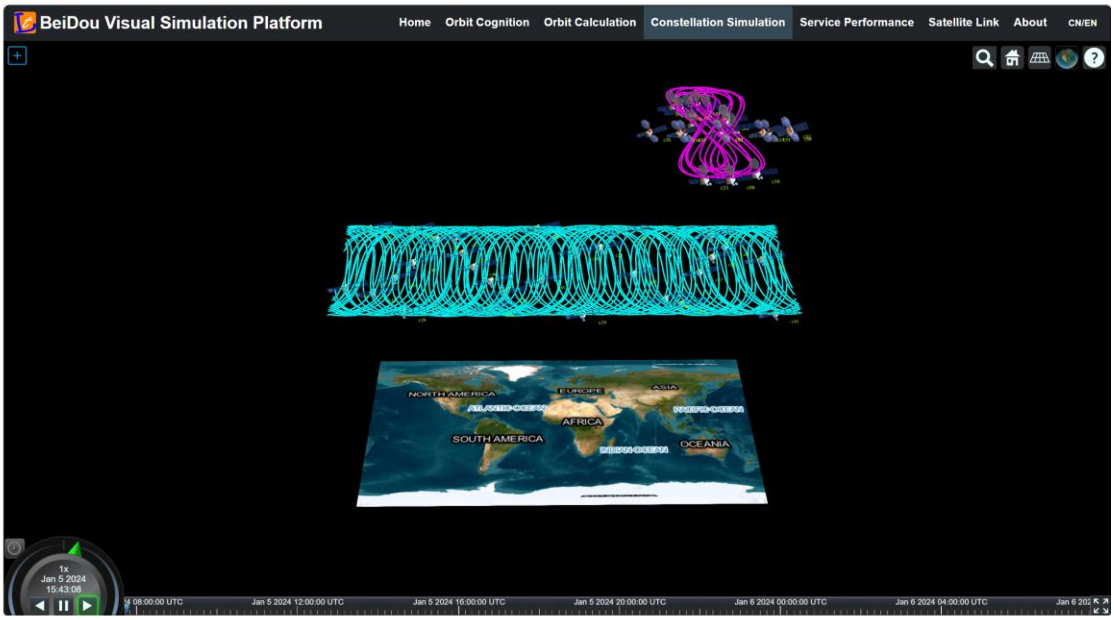


Fig. 11: 2.5D effect.

(3) Fig. 8c shows the animation control panel, that controls the time and time flow of the simulation effect.

3.4 Service Performance

Service performance mainly includes three modules: World, Area, and Station.

(1) The World service performance page is shown in Fig. 12:

① Fig. 12a shows the control panel, and can be opened by clicking the unfold button in the upper left corner of the page. The upper two columns of the control panel can select the satellite to participate in the performance calculation. The third column is the parameter setting, which can set the date, elevation cutoff and spatial resolution. After the setting is completed, click the Run button, and the corresponding visual chart will be drawn according to the calculation results.

② Fig. 12b is used to switch the three functional modules: World, Area, and Station.

③ Fig. 12c is used to display the visualization effect achieved by Cesium (only the Area and the station module are displayed). The toolbar in the upper right corner includes search button , home button and label display and hide button . The first two buttons are consistent with the previous introduction. The third label display and hide button is used to control the display and hiding of satellite and ground station name label in the Station module.

④ Fig. 12d is a time control, which is used to display the corresponding time of the page and control the playing and pausing of the animation effect.

⑤ The surrounding of the page is visual charts drawn according to the service performance indexes, including the Number of satellites chart, the GDOP chart, the PDOP chart, the HDOP chart, the VDOP chart, the TDOP chart. And the Ionospheric electron content chart. The user can interact with the chart, and the result range can be limited by dragging the legend bar. The mouse falls on the pixel point of the chart to display the corresponding information.

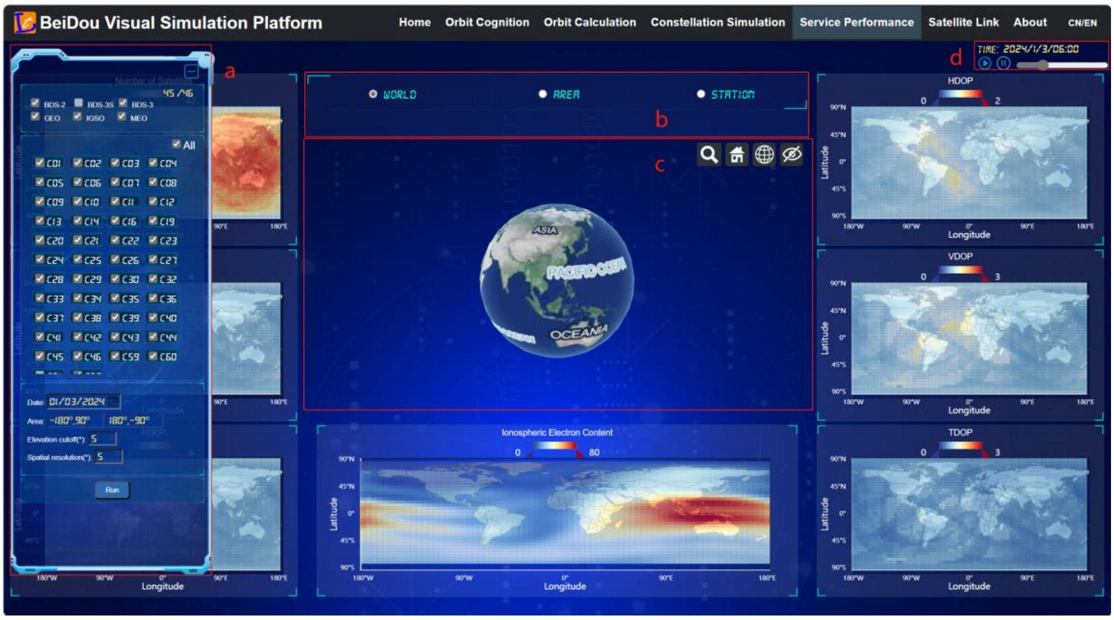


Fig. 12: The World service performance page.

(2) The Area service performance:

① First, you need to select an area on the map. The operation method is to hold down the left mouse button and drag the area selection box to select the area, as shown in Fig. 13.

Fig. 13: Area selection.

②After area selection, the service performance chart of the corresponding area will be displayed, and the type is consistent with the World module, as shown in Fig. 14.

Fig. 14: The Area service performance page.

(3) The Station service performance page is shown in Fig. 15:

① When switching to this page, the control panel will automatically expand (Fig. 15a). Users have the option to follow the default settings or customize parameters such as the satellites, station name, date, station longitude and latitude, height, elevation cutoff, and stochastic model involved in the calculation.

② After selecting the desired settings, clicking the Run button will generate visual results of the station service performance. The generated charts include the Elevation chart, the Number of satellites chart, the DOPs (GDOP/PDOP/HDOP/VDOP/TDOP) chart, the Ionospheric electron content chart, the visibility chart, the Station accuracy chart, and the Skyplot.

③ Fig.15b is the satellite tracking map of the station. Through the connect link between the ground station and the visible satellite, the satellite tracking is simulated.

Fig. 14: The Station service performance page.

3.5 Satellite Links

The satellite link page is shown in Fig. 16. The upper left corner of the page is the control panel (Fig. 16a), which is used to control the display and hiding of different types of satellite links. The types of satellite links include the satellite-ground link, the same orbit plane inter-satellite link (ISL), the different orbit plane ISL, the high-middle orbit plane ISL.

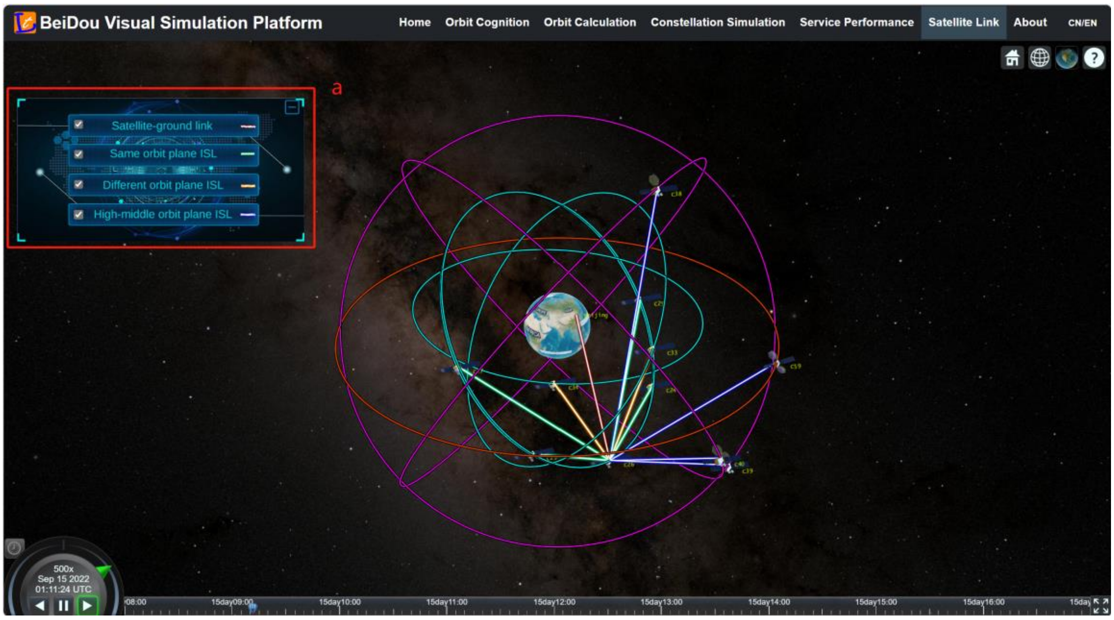


Fig. 16: The Satellite Links page.