MAP-LAB: A MATLAB Graphical User Interface for generating maps for geodetic and oceanographic applications

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INTRODUCTION

MAP-LAB is a MATLAB-based Graphical User Interface (GUI), created for producing maps and visualizing data sets related to geodetic and oceanographic applications. The main idea behind the design of MAP-LAB was to provide MATLAB users and researchers with an efficient and easy-to-use GUI to generate maps without the need of writing scripts or using MATLAB's command window. MAP-LAB utilizes the capabilities of the *M_Map* mapping toolbox, which is a library of functions and tools aided to plot geospatial information. Focus is given on creating regional and global maps related to geodesy and ocean studies. Examples of selected data sets are produced to demonstrate the potential of MAP-LAB software.

DATA SETS

Five different sets of data are used to provide visualization examples related to geodetic and oceanographic observations. For Figures 3 and 6, the EGM2008 geopotential model (Pavlis et al., 2012) is used to derive values of geoid undulations and deflections of the vertical respectively. The coordinates of a local 3D GNSS network and their uncertainties are used to visualize the measurement distribution and the error ellipses given in Figures 4 and 5 respectively. Global daily 5-km data of sea surface temperature (Liu et al., 2006) are used to produce the map of sea surface temperature for one day of observations (09/06/2016) given in Figure 7. Averaged 1-degree data of sea surface salinity, measured by the Soil Moisture and Ocean Salinity (SMOS) satellite mission (Zhang et al., 2016), are used to create the map of sea surface salinity presented in Figure 8. Data of total magnetic field intensity (Chulliat et al., 2014) for one day of observations (14/06/2016) and with 1 degree spatial resolution are used in order to produce the map of the magnetic field presented in Figure 9. All map examples use different parameters for the projection, coastline and grid appearance.

SOFTWARE DESCRIPTION

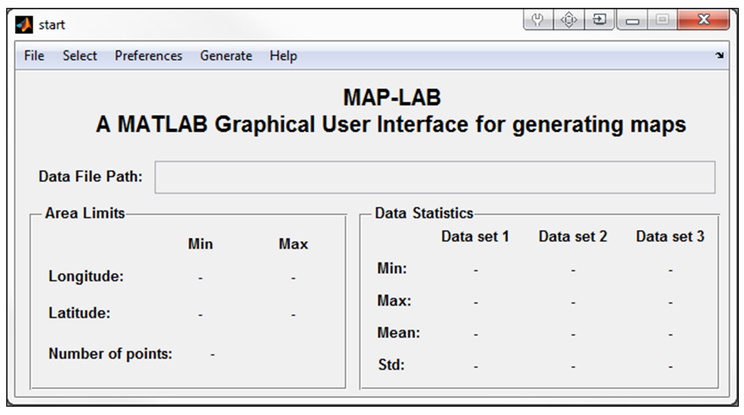

Figure 1 – Main form

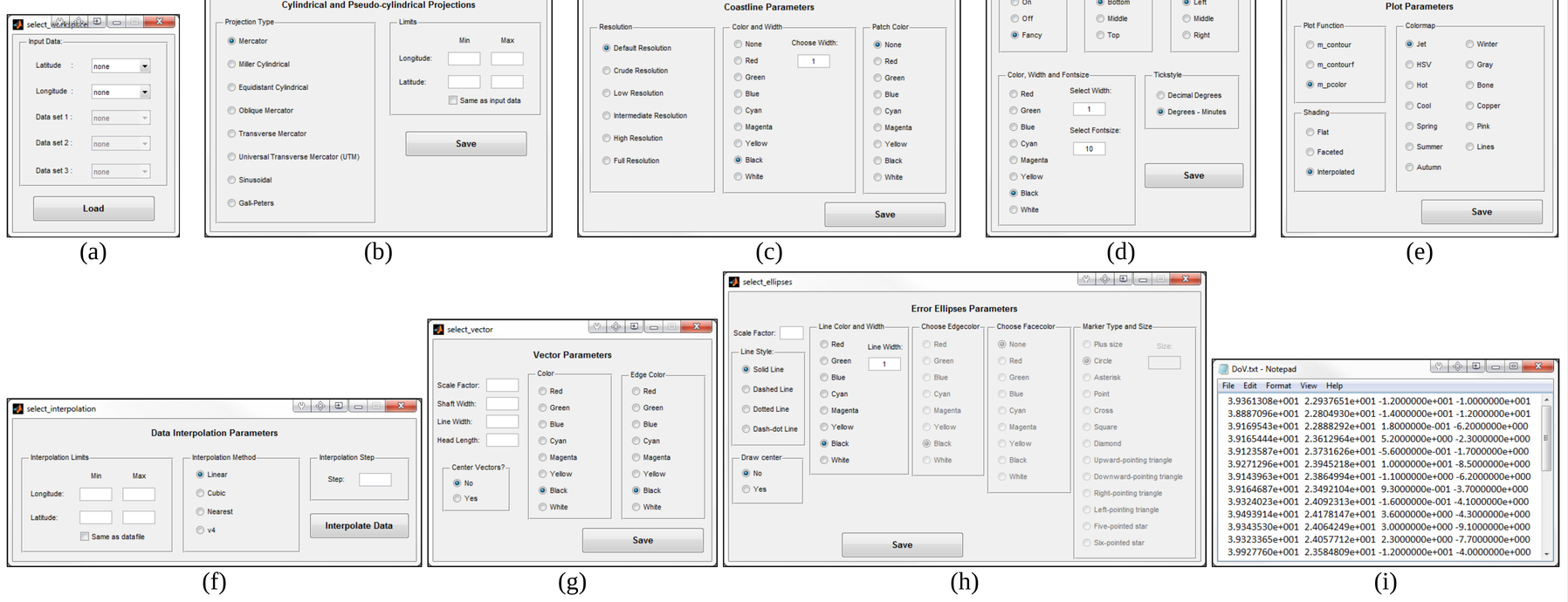

Figure 2 – GUI forms for different map attributes

1. Map Types

MAP-LAB has the potential to generate the following maps:

- **Contour maps**
- **Vector maps**
- **Error ellipses maps**
- **Data distribution maps**

2. Input data format

MAP-LAB has the ability to import data from files and from MATLAB's Workspace (Figure 2-a). Acceptable data file format are ***ASCII*** or ***.mat*** files with more than two and less than six columns. The first and second column of the data file should contain the latitude and longitude coordinates respectively. At least three columns of data are required for a contour map, four columns for a vector map and five columns for an error ellipses map. Example of a four-column file is given in Figure 2-i.

3. Projections

The following projections of *M_Map* toolbox are implemented in the MAP-LAB software:

- **Azimuthal projections:** Stereographic, Orthographic, Equal-Area, Equidistant, Gnomonic, Satellite
- **Cylindrical and Pseudo-cylindrical projections:** Mercator, Miller Cylindrical, Equidistant Cylindrical, Oblique Mercator, Transverse Mercator, Universal Transverse Mercator, Sinusoidal, Gall-Peters
- **Conic projections:** Albers Equal-Area, Lambert Conformal
- **Miscellaneous projections:** Hammer-Aitoff, Mollweide, Robinson

The user can define the **longitude** and **latitude limits** of the projected area. MAP-LAB has the ability to automatically recognize the limits of the input data and define the projection parameters. The GUI for the cylindrical and pseudo-cylindrical projections is given in Figure 2-b.

4. Coastline Parameters

The following five resolutions of the Global Self-consistent, Hierarchical, High-resolution Geography coastlines have been implemented into MAP-LAB:

- **Crude**
- **Low**
- **Intermediate**
- **High**
- **Full**

The **coastline color** and **width** can be defined by the user. When ocean data are loaded into the software, land areas can be masked using a **patch color** for the coastline (Figure 2-c).

5. Grid Parameters

The grid options that are implemented into the MAP-LAB software are:

- The **type of grid box**
- The **axes label location**
- The **color**, **width**, and **size of the font**
- The **tickstyle**.

The x-axis and y-axis alignment of the grid is important, especially when producing global maps. The tickstyle of the grid labels can be in decimal degrees or in degrees-minutes-seconds format. The grid parameters are given in Figure 2-d.

6. Plot and Data Interpolation Parameters

The user can choose between three available plotting functions, contained in the *M_Map* toolbox, that produce:

- **Contour maps** (*m_contour*)
- **Filled contour maps** (*m_contourf*)
- **Pseudo-color maps** (*m_pcolor*)

All MATLAB's shading and colormap types are also implemented. Before plotting the scalar field derived from the input data, the interpolation of input data should be performed in a rectangular grid. MAP-LAB uses four interpolation methods:

- **Linear**
- **Cubic**
- **Nearest**
- **V4**

All parameters described are presented in Figures 2-e and 2-f.

7. Vector and Error Ellipses Parameters

MAP-LAB enables the user to create vector field maps using the *M_Map* function *m_vec*. Two data sets are required to define the error ellipses shape, i.e., the East-West component and the North-South component. The vector parameters implemented are:

- The **scale factor** , which controls the relative size of the vectors
- The **shaft** and **line width**
- The **head length** and **color**

A new feature of MAP-LAB (not included in the *M_Map* toolbox) is the capability of creating error ellipses maps. In this case, three data sets are required to define the error ellipses shape, i.e., the semi-major axis, the semi-minor axis and the azimuth of the semi-major axis (angle from the y-axis). The parameters that should be defined by the user inside the MAP-LAB GUI environment are:

- The **scale factor**
- The **color** and **linetype** of the ellipses
- The **color**, **size** and **markertype** of the ellipses center.

All vector and error ellipses parameters are given in Figures 2-g and 2-h.

EXAMPLES

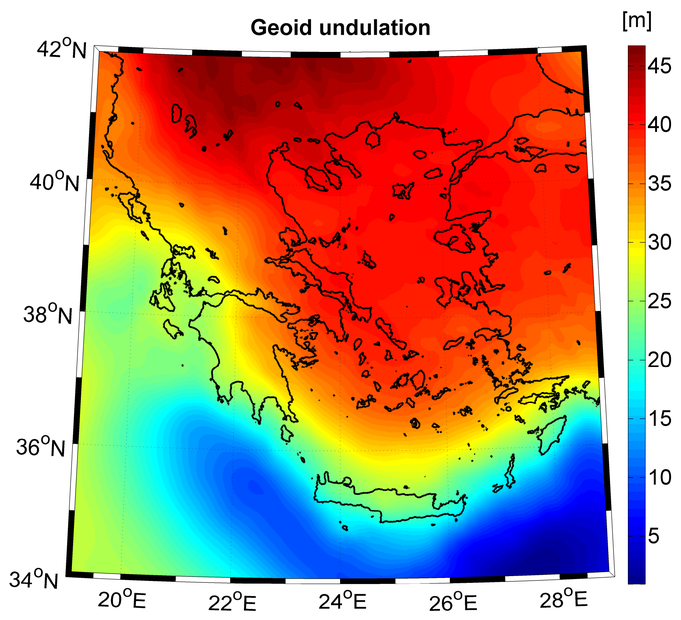

Figure 3 – Geoid undulation

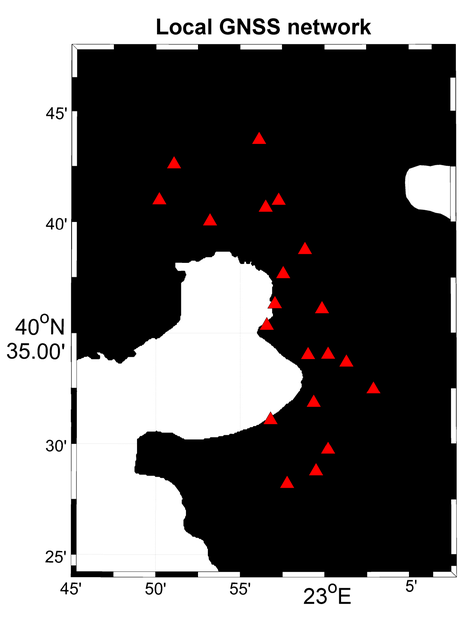

Figure 4 – Local GNSS network

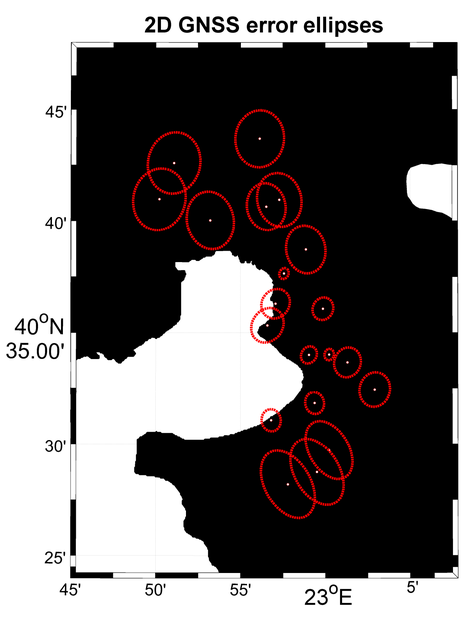

Figure 5 – 2D GNSS error ellipses

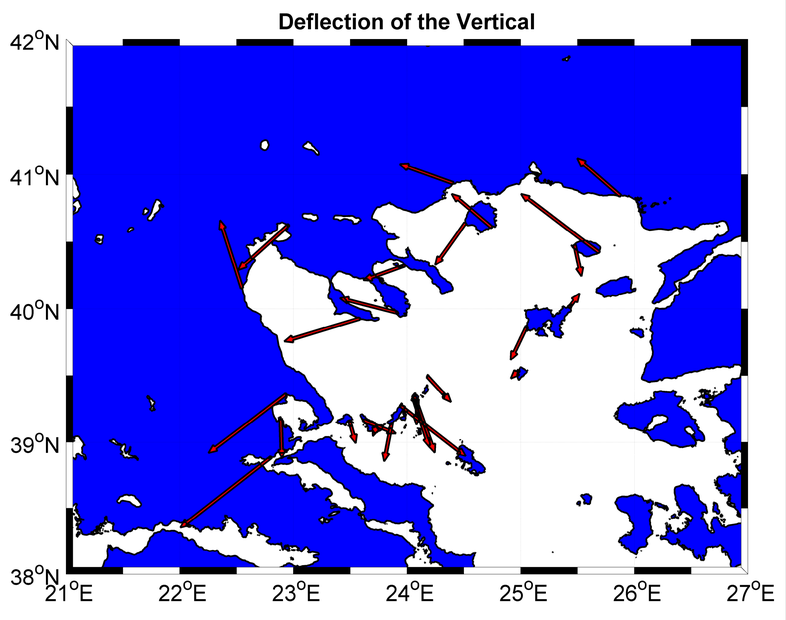

Figure 6 – Deflection of the vertical

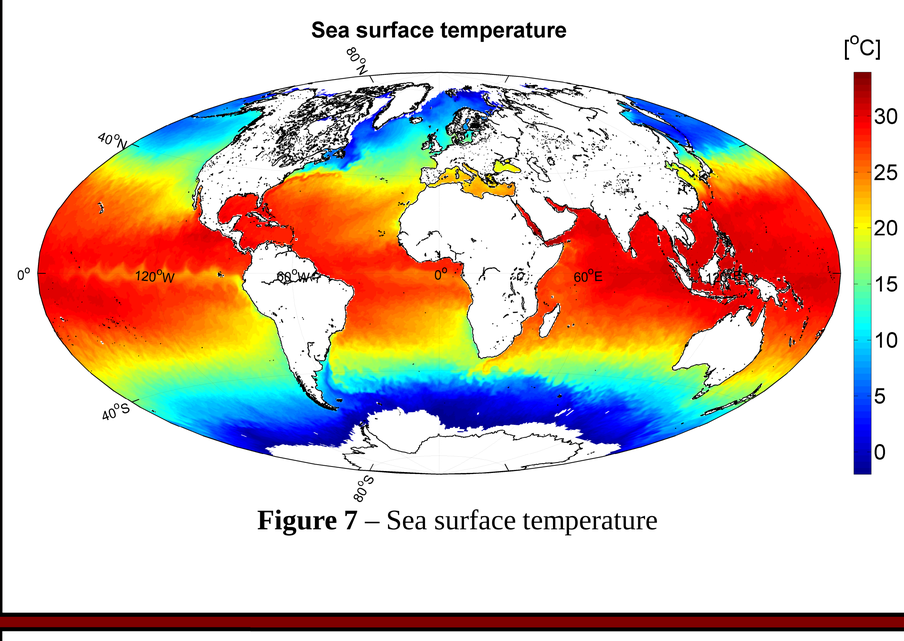

Figure 7 – Sea surface temperature

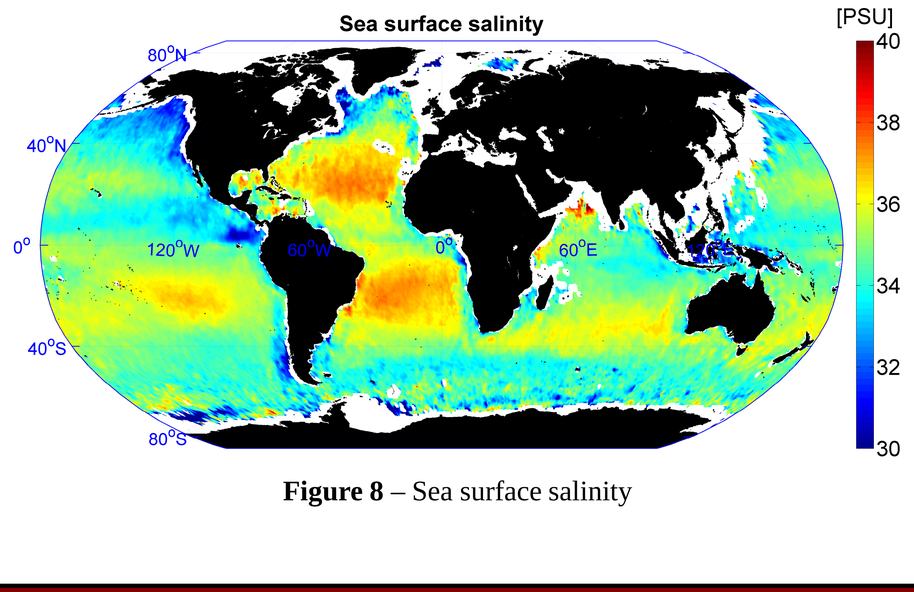

Figure 8 – Sea surface salinity

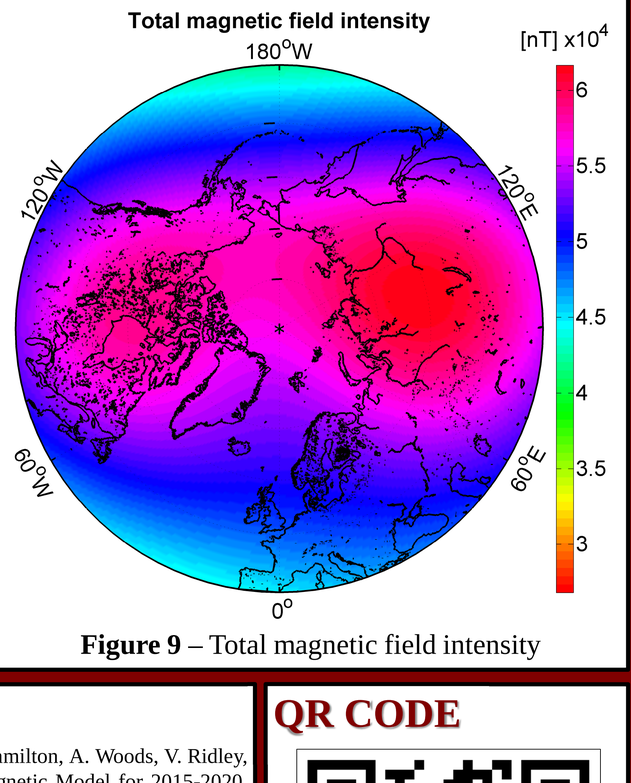

Figure 9 – Total magnetic field intensity

SUMMARY

Overall, the MAP-LAB software presented here provides a user-friendly environment, and is a fast and efficient tool for visualizing numerous types of data on the Earth's surface. MATLAB users that are not familiar with the *M_Map* toolbox , or MATLAB's mapping toolbox, are advised to use MAP-LAB instead. More extensive options of the *M_Map* toolbox will be included in future releases of MAP-LAB and in a more integrated environment. MAP-LAB is freely available for download at: http://www.dimitriospiretzidis.com/maplab_home.html . Along with the software, a detailed report in the form of a user guide has been prepared. The report provides general information about the *M_Map* toolbox and instructions on how to use MAP-LAB to produce high quality maps. MAP-LAB is designed using MATLAB R2010 and tested in later releases (e.g. R2012, R2014) in both 32- and 64-bit operating systems. Only MATLAB is required to run and use MAP-LAB. The CPU time that MAP-LAB requires to produce a map depends on the number of data imported into the software, the interpolation parameters (i.e., interpolation method and grid step), the resolution of the coastline and the extend of the area to be plotted. Users are encouraged to send their comments and suggestions for improving MAP-LAB either by sending and e-mail to the authors or by using the contact form available in MAP-LAB's website.

REFERENCES

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