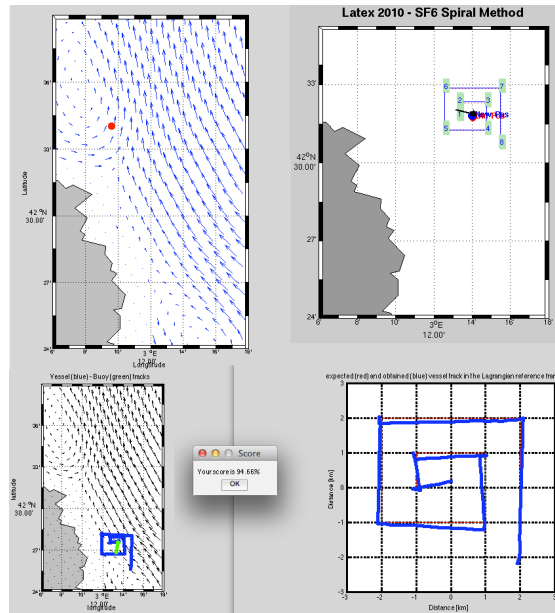# Users Guide for

LATEXtools

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The LATEXtools package is the result of a collaborative work of the LATEX team. In particular, it is based on the precious contribution by J.-L.Fuda, N.Grima, Z.Hu, M.Kersalé, F.Nencioli, A.Petrenko, G.Rougier.

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LATEX project web site : `http://www.com.univ-mrs.fr/LOPB/LATEX`.

LATEXtools download web site : `http://mio.pytheas.univ-amu.fr/~doglioli`. .

Contents

1   Introduction

This guide presents the LATEXtools package of Matlab routines, designed for planning and performing oceanographic cruises with a Lagrangian sampling strategy.

The importance of a Lagrangian sampling strategy for the analysis of tracer dispersion has been evidenced by in situ enrichment experiments, such as IronEx (Law et al., 1998; Stanton et al., 1998; Coale et al., 1998), PRIME (Law et al., 2001), SOIREE (Boyd and Law, 2001), CYCLOPS (Law et al., 2005), SEEDS (Tsumune et al., 2005), SERIES (Law et al., 2006) and SEEDS II (Tsumune et al., 2009). In fact, only the measurements collected in a Lagrangian reference frame moving with a tracer patch allow to correct the tracer budget for the effect due to water advection, and thus permit its accurate estimation.

LATEX project (LAgrangian Transport EXperiment, 2008-2010; `http://www.com.univ-mrs.fr/LOPB/LATEX`) was designed to study the influence of the coupled physical and biogeochemical dynamics at the meso- and submeso-scales on the transfers of matter and heat between the coastal zone and the open ocean. In order to reach this goal, the project was highly multidisciplinary, with a strategy based on a combined use of satellite data, numerical model results and in situ measurements from a series of four field campaigns. The main goal of the field experiment was to analyze transport patterns and dispersion rates of a mesoscale structure within the Lagrangian reference frame associated with it. Therefore, the experiment was designed to combine the release of SF6 with the deployment of an array of Lagrangian buoys.

To accomplish this task and to treat the data, we developed the software collected in the LATEXtools package. The software is equipped with a series of graphical and user-friendly accessories and the entire package for Matlab can be freely downloaded from `http://mio.pytheas.univ-amu.fr/~doglioli/latextools.htm`.

This is just a basic users guide; details of the Lagrangian method are described in Doglioli et al. (2013).

2   Installation

2.1   System and software requirements

This toolbox has been designed for Matlab. It needs at least 32 Mbites of disk space. It has been tested on several Matlab versions ranging from R2010a to R2011b. It has been mostly used on Linux workstations, but also on Windows (Vista) and Mac (MacBook Pro) personal computers.

The necessary Matlab toolbox m_map (vs 1.4, `http://www.eos.ubc.ca/~rich/map.html`) and other free programs are included.

Datasets from LATEX project are also included for running the tutorials described below.

2.2 Getting the files

The entire package LATEXtools can be freely downloaded from

`http://mio.pytheas.univ-amu.fr/~doglioli/latextools.htm`.

The package LATEXtool is a free software. It is distributed in the hope that it will be useful, but without any warranty. You can redistribute it and/or modify it under the terms of the GNU General Public License as published by the Free Software Foundation at `http://www.gnu.org/copyleft/gpl.html`.

2.3 Extracting the files

Uncompress and untar the file (gunzip and tar -xvf). You should obtain the following directory tree :

```
LATEXtools_0.0
    |- ADCP
    |- ARGOS
    |- AVHRR
    |- BATHYMETRY_NWMED
    |- Documentation
    |     |- Userguide
    |-figures
    |- FSLE
    |     |- MatFiles_*
    |- Log_Position
    |- m_map
    |     |- private
    |- other_stuffs
    |- SF6
    |- Tethys
    |- VESSEL
```

Definition of the different directories:

- `ADCP`: current velocity data measured during Latex10 cruise by the hull-mounted ADCP (Acoustic Current Meter Profiler) of the r/v Téthys II;

- `ARGOS`: Drifters' positions during Latex10 cruise;

- `AVHRR`: Sea Surface Temperature of the Gulf of Lion from Advanced Very High Resolution Radiometer (data from MétéoFrance);

- `BATHYMETRY_NWMED`: Isobaths of North-western Mediterranean;

- `Documentation`: LATEXtools Users Guide with its LaTeX source files;

- `Figures`: default folder for graphic outputs;

- `FSLE`: Finite Size Lyapunov Exposants calculated from satellite altimetry during Latex10 Cruise (for more infromation see Nencioli et al., 2011);

- `Log_Positions`: Boat and buoys positions during Latex10 cruise;

- `m_map`: m_map toolbox;

- `Other_stuffs`: potentially useful scripts. This software is distributed but not yet tested and/or commented in English;

- `SF6`: data from Sulfur Hexafluoride mapping during Latex10 cruise;

- `Tethys`: positions of the r/v Téthys II during Latex10 cruise.

The file `LATEXtools_param.m` contains the information about subdirectories paths for all the other scripts. It also sets the MATLAB paths for the session.

2.4   Future plans

We are working on multi-buoy marking of the water mass for i) a more precise positioning of the center of the Lagrangian reference frame and ii) an estimation of rotation and stirring effects of the investigated water mass.

Moreover it would be possible to take better advantage of the bidirectional Iridium communication, by implementing an automatic position query to the reference buoy when the vessel is nearby turn points.

2.5   Warnings

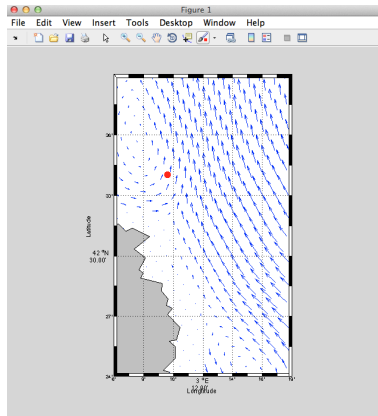At the moment no special warnings are known.

Figure 1: First figure of the demo. Current velocity vectors and the coastline of western part of the Gulf of Lion (Mediterranean Sea) are shown. The red dot represents the chosen location for the buoy release.

3   Tutorial: the Lagrangian Navigation DEMO

The Lagrangian navigation software developed during LATEX project has been adapted to perform a demo. Run `lagrangian_navigation_demo.m` to start it.

3.1   Functioning principles

For in situ experiments a buoy is released at the point of departure of the tracer release route to mark the center of the water mass. This buoy (hereinafter reference buoy) represents the moving origin of the Lagrangian reference frame. In order to simulate the drift of the reference buoy, a very simple random walk model has been added in the demo. The input velocity field for this model comes from a numerical simulation of the Northwestern Mediterranean (Symphonie model, Hu et al., 2009). The vessel displacement is also numerically simulated by assuming that the vessel follows the direction of the choosen target point with a fixed speed. Some pseudorandom perturbations are added for a more realistic demo.

For a real cruise you can replace the numerical model and the associated temporal cycle by two functions providing vessel and reference buoy positions by interfacing the Lagrangian navigation program and the onboard instruments. During Latex10 cruise we used the scripts `lecture_trame_fichier_bateau.m` for GPS-based vessel positioning and `lecture_trame_fichier_bouee.m` for Iridium-based buoy positioninig. These programs are also distributed (see in `other_stuffs` sub-directory).
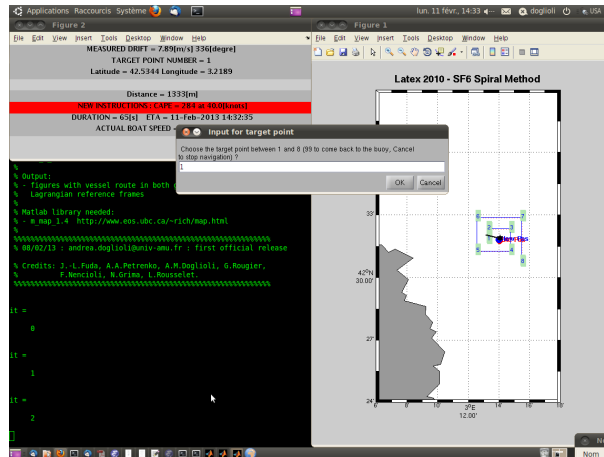
Figure 2: Lagrangian navigation screen. See text for explanation.

3.2 Running the demo

When the demo starts, the current velocity vectors and the coastline of a small portion of the Gulf of Lion are represented (Fig. 1).

You can choose the point where the reference buoy is released by clicking with the mouse on the map. For the first time, it is better to choose a point in the middle of the map in order to avoid that the reference buoy will exit of the map during the demo.

The following dialog box asks you to enter the number of the target point. You can chose between 1 and the maximum number of target points, that depends on the number of the spiral coils (8 is the default value). Moreover, the value -1 allows to know direction instructions to come back to the reference buoy. The "Cancel" button (or Tab+Enter) stops the demo. At first, chose the default value "1" and click "OK" button (or Ctrl+Enter). In the following, two MATLAB figures will open (Fig. 2). In the first one, are shown: i) the last and the next to the last positions of the reference buoy (blue and red dots, respectively); ii) the square spiral route, and the associated target points, positioned with respect to the last position of the reference buoy; iii) the vessel position (the black star); iv) the vessel direction vector (black line), as calculated to reach the chosen target point. In the second figure are reported the information about the reference buoy drift and the navigation instructions. Finally, a new dialog box open in order to chose the next target point.

The Lagrangian navigation continues until you press "Cancel" button. Then, two new MATLAB figures and a dialog box open (Fig. 3). These figures are prepared by the `lagrangian_reconstitution_demo.m` program. MATLAB figure 3 represents the vessel (blue) and spiral (green) trajectories in the geographical
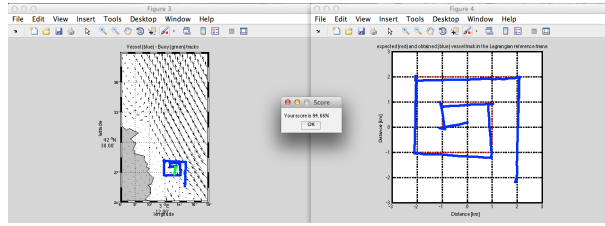
7

Figure 3: Final figures and dialog box. See text for explanation.

coordinates. MATLAB figure 4 represents the expected (red) and obtained (blue) vessel track in the Lagrangian reference frame. The dialog box reports your score as "Lagrangian Pilot". Such score is calculated on the basis of the length of the theorical square-spiral route and the length of the performed route. The score is equal to 100.00% if you have exactly performed the square spiral route. It is less if you have performed a shorter or longer route. If you stop the navigation before the last target point is reached, the score is not calculated. When you press the "OK" button on the dialog box the figure are saved in the figures' directory (the default directory is `LATEXtools_0.0/figures`).

The demo takes about 5-6 minutes, depending on your rapidity on answering the dialog boxes and on the performances of your computer.

Note that for the demo we optimized the positioning of the MATLAB windows. If you remove such an optimization, the program is faster.

3.3   Warnings

For a faster and more intuitive demo, some parameters have unrealistc default values:

- the square spiral has only 2 coils with a separation distance of 1000 m;

- the current field is accelerated;

- the vessel speed is fixed to 40 knots (during Latex10 cruise it was 3 knots and therefore the lagrangian navigation took 12 hours; too long for a demo!).

Of course, you can modify these values. All the parameter for the demo are regrouped in the first part of the script.

If the ballistic equation system has not solution, the program stops and a dialog box opens. The default values of the demo parameters have been chosen to avoid that.
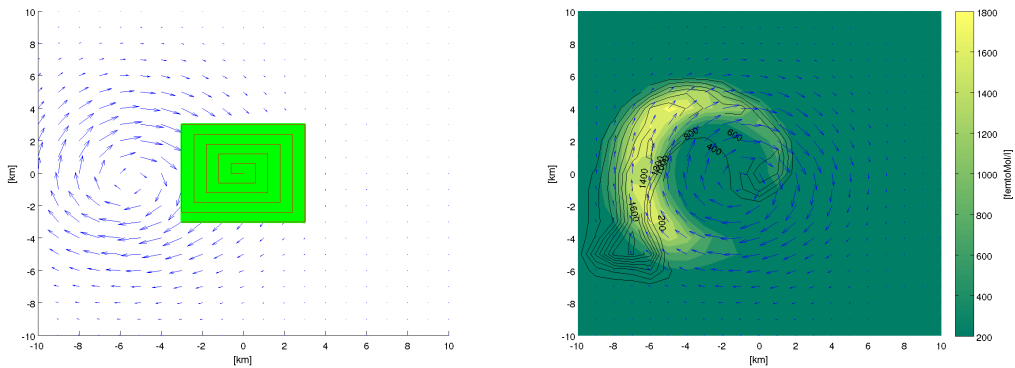
8

Figure 4: Simulation of a tracer release in a circular eddy. See text for explanation.

4 The other programs

4.1 Lagrangian Release Test

The program `lagrangian_release_test.m` simulates the release of a passive tracer by a simple random walk model. It can help in planning the tracer release providing the tracered area for a given tracer quantity released with a given flow along a given square-spiral route. Moreover, it perform sensitivity tests on impact of advection, stirring and rotation on the tracer dispersion. The code performs numerical experiment couples. Each couple consists of two experiments: one in which we release an instantaneous quadratic patch at time t_0 (this experiment includes effects of advection, stirring and rotation) and another in which at time t_0 we start to release from the center along a Lagrangian-corrected, expanding square-spiral, such as during Latex10 (this experiment includes only advection). In each experiment couple, all the other parameters, but the ones described above, have the same values. The sensitivity tests include the following types of flow: uniform, shear-driven (with different values of shear intensity), circular eddy flow (default, with different values of rotation intensity and eddy drift velocity). Fig. 4 shows the results for the numerical experiment in the case of a slow-moving but rapidly- rotating eddy. As shown on the left panel, the flow is characterized by the presence of a circular eddy with diameter of 10 km, maximum tangential velocity of 21 cm/s and drift velocity of 5 cm/s . The quadratic patch (green square) and the expanding square spiral route (red lines) have a side of 3 km and are centered on the right side of the eddy at a distance of 5 km from the eddy center (i.e. at the eddy perimeter). The release of 7000 liters of seawater saturated with SF6 (saturation concentration 1.77 10 -4 mol/l) is simulated with a release rate of 9 l/minute and a vessel speed of 3 knots. The horizontal mixing coefficient default
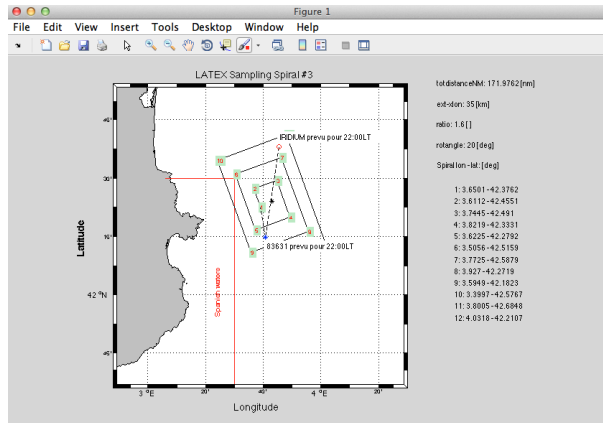
Figure 5: Planning of a sampling square-spiral route in the western part of the Gulf of Lion.

value is 2.5 m^2/s, as estimated during Latex10 cruise by Nencioli et al. (2013) and the mixed layer depth is 20 m. Finally, the numerical model has a grid mesh with 1 km x 1 km of resolution and 126 000 numerical particles. On the right panel are shown the SF6 concentrations (fmol/l) after 24 hours for both the instantaneous release (colors) and the expanding square spiral release (contour lines). 24 hours correspond to the first tracer mapping during the Latex10 cruise. These results confirms the validity of the 'no stirring and rotation' assumption made by Doglioli et al. (2013).

4.2 Lagrangian Sampling Spiral

The program `lagrangian_samplig_spiral.m` helps in planning sampling routes. When the program starts you can choose the position of the route starting point by mouse clicking. The default configuration is a square spiral route rotated 20 degree anticlockwise with respect the geographical North (Fig. 5).

4.3 Cruise data plotting

A set of programs named `load_*.m`, `plot_*.m` and `map_*.m` helps in plotting cruise data. Some data from Latex10 cruise are available for demo. For exemple, in Fig. 6 the program `map_ADCP` plots the current velocity field measured during Latex10 cruise.

4.4 Other utilities

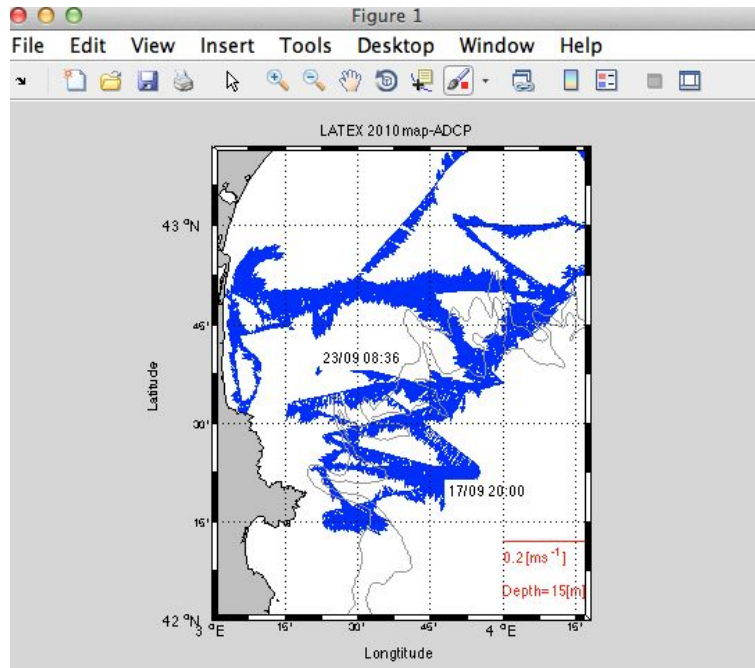Several other scripts are distributed:

Figure 6: ADCP map from `map_ADCP.m`.

- `make_route.m`: draws a route and calculate time between stations;

- `make_clean_ADCP.m`: helps in treating the ADCP row data, in particular in identifying the direction changes along the route and consequent useless parts of the transect;

- `clean_ADCP.m`: cuts ADCP transect on the basis of the information obtained with the above program;

- `regroup_ADCP.m`: matches data from different ADCP transects in a single .mat file;

- `decideg_to_degmin.m`: converts geographical coordinates from decimal degrees to (degrees,minutes);

- `degmin_to_decideg.m`: converts geographical coordinates from (degrees,minutes) to decimal degrees;

- `degminsec_to_decideg.m`: converts geographical coordinates from (degrees,minutes,secondes) to decimal degrees;

- `CenterOfEddy_finder.m` : finds the possible center of an eddy from an ADCP transect crossing it (for details about the method, see Nencioli et al., 2008; Hu et al., 2009);

- `Lagrangian_Reconstitution.m` and `reconstitution_2007.m`: old versions of the programs to reconstitue the route in a Lagrangian reference frame.

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