

# Tutorial 1

## Introduction to gLAB tool suite

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August 2022

# OVERVIEW

- Introduction
- The gLAB tool suite
- Examples of GNSS Positioning using gLAB
- Laboratory session organization



The figure shows the gLAB v5.1.0 software interface. On the left, there is a large panel for 'Modelling Options' containing numerous checkboxes for various correction types like Satellite Clock Offset Correction, Earth Rotation, and Relativistic Path Range Correction. In the center, there is a 'gLAB' panel with tabs for Input, Preprocess, Modeling, Filter, and Output. The 'Modeling' tab is active, showing settings for 'Precise Products Data Interpolation' (Interpolation Degree: 10, Orbit: 0, Clock: 0), 'Orbits' (Max Consecutive Gaps: 8, Total Gaps Allowed: 16), and 'Clocks' (Max Consecutive Gaps: 2, Total Gaps Allowed: 4). It also includes sections for 'Receiver Antenna Phase Centre Correction' and 'Receiver Antenna Reference Point Correction'. On the right, there are three plots: 'NEU positioning error [SPP]: Full model' showing errors over time (North, East, Up); 'Horizontal positioning error [SPP]' showing scatter plots of North vs. East errors for S/A=on (red dots) and S/A=off (blue dots); and '2c: Vertical positioning error [Kinem PPP]' showing Up error over time for 'Full model' (blue line) and 'No Solid Tides corr.' (red line).

# Introduction

- This practical lecture is devoted to analyze and assess different issues associated with Standard and Precise Point Positioning with GPS data.
- The laboratory exercises will be developed with actual GPS measurements, and processed with the ESA/UPC GNSS-Lab Tool suite (gLAB), which is an interactive software package for GNSS data processing and analysis.
- Some examples of gLAB capabilities and usage will be shown before starting the laboratory session.
- All software tools (including *gLAB*) and associated files for the laboratory session are included in the USB stick delivered to lecture attendants.

# OVERVIEW

- Introduction
- The gLAB tool suite
- Examples of GNSS Positioning using gLAB
- gLAB software installation



The figure shows a screenshot of the gLAB software interface. The main window is titled "gLAB v5.1.0" and features several tabs: Input, Preprocess, Modeling, Filter, and Output. The "Modeling" tab is active, displaying options for "Precise Products Data Interpolation" (Interpolation Option: Orbits, Clocks; Degree: 10, 0; Max Gaps Between Samples: 8, 2; Total Gaps Allowed: 16) and "Receiver Antenna Phase Centre Correction" (Specify Offset: Read Offset from ANTEX, Receiver Antenna Phase Centre Variation, Stop processing if Antenna's Radome is not found in ANTEX). To the right, there are sections for "Satellite Options" (Doppler Shift: 5 degrees, SIR Mask, Align carrier phase measurement with code, Devoid Satellites Under Eclipse Condition, Devoid Unhealthy Satellites (breakfast orbits)), "GRSS Satellite Selection" (GPS, Galileo, GLONASS, BeiDou, QZSS), and a grid of satellite icons. Below these are three plots: "NEU positioning error [SPP]: Full model" (error vs time in seconds), "Horizontal positioning error [SPP]" (error vs East error in meters), and "2c: Vertical positioning error [Kinem PPP]" (error vs Time in seconds).

# The gLAB Tool suite

- ▲ The GNSS-Lab Tool suite (gLAB) is an interactive multipurpose educational and professional package for GNSS Data Processing and Analysis.
- gLAB has been developed under the ESA contracts N. P1081434 and C4000113054.

## ▲ Main features:

- High Accuracy Positioning capability.
- Fully configurable.
- Easy to use.
- Access to internal computations.

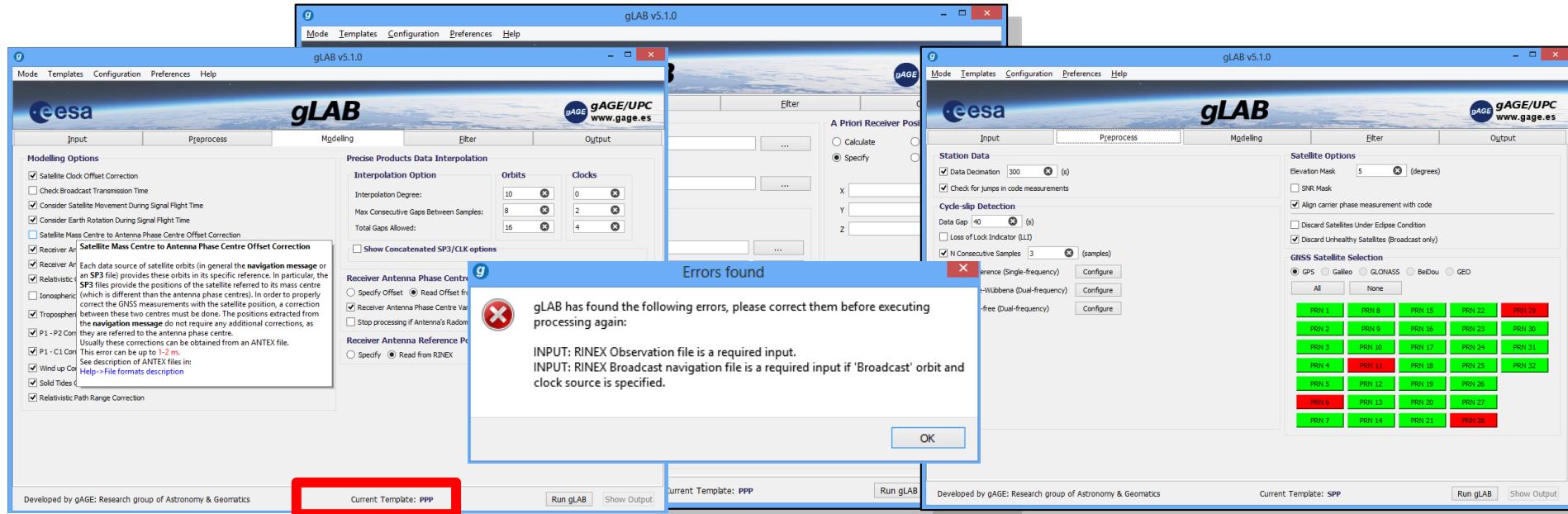


# The gLAB Tool suite

- gLAB has been designed to cope with the needs of two main target groups:
  - Students/Newcomers: User-friendly tool, with a lot of explanations and some guidelines.
  - Professionals/Experts: Powerful Data Processing and Analysis tool, fast to configure and use, and able to be included in massive batch processing.

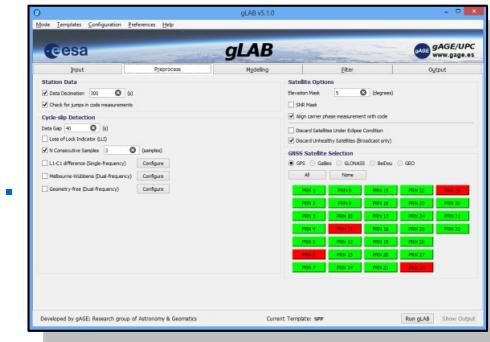
# The gLAB Tool suite

- Students/Newcomers:
  - Easiness of use: Intuitive GUI.
  - Explanations: Tooltips over the different options of the GUI.
  - Guidelines: Several error and warning messages. Templates for pre-configured processing.



# The gLAB Tool suite

- Students/Newcomers:
  - Easiness of use: Intuitive GUI.
  - Explanations: Tooltips over the different GUI options.
  - Guidelines: Several error and warning messages.
  - Templates for pre-configured processing.
- Professionals/Experts:
  - Powerful tool with High Accuracy Positioning capability.
  - Fast to configure and use: Templates and carefully chosen defaults.
  - Able to be executed in command-line and to be **included in batch processing**.



```
File Edit View Terminal Help
g4:~/workspace/edunav> ./gLAB_linux -input:obs test/madr2000.06o -input:sp3 test/igs13843.sp3 -input:ant test/igs05.atx
```

# The gLAB Tool suite

- In order to broad the tool availability, gLAB Software has been designed to work in Windows, Linux and Mac environments.



- The package contains:
  - Windows binaries (with an installable file).
  - Linux .tgz file.
  - Mac installable .dmg file.
  - Source code (to compile it in both Linux, Windows and Mac OS) under an Apache 2.0 and LGPL v3. licenses.
  - Example data files.
  - Software User Manual.
  - HTML files describing the standard formats.

# The gLAB Tool suite

## Read files capability:

- RINEX observation v2.11 & v3.00
- RINEX navigation message.
- SP3 precise satellite clocks and orbits files
- ANTEX Antenna information files.
- Constellation status.
- DCBs files.
- GPS\_Receiver\_Type files.
- SINEX position files.
- SBAS files: EMS, RINEX-B
- RTCM-v2x and RTCM-x3x

## Pre-processing module:

- Carrier-phase prealignment.
- Carrier-phase / pseudorange consistency check.
- Cycle-slip detection (customizable parameters)
  - Melbourne-Wübbena.
  - Geometry-free CP combination.
  - L1-C1 difference (single frequency).
- Pseudorange smoothing.
- Decimation capability.
- On demand satellite enable/disable.
- Elevation mask.
- Frequency selection.
- Discard eclipsed satellites.

## Modelling module:

- Fully configurable model.
- Satellite positions.
- Satellite clock error correction.
- Satellite movement during signal flight time.
- Earth rotation during signal flight time.
- Satellite phase center correction.
- Receiver phase center correction. (frequency dependent).
- Relativistic clock correction.
- Relativistic path range correction.
- Ionospheric correction (Klobuchar, NeQuick, IONEX).
- Tropospheric correction
  - Simple and Niell mappings.
  - Simple and UNB-3 nominals.
- Differential Code Bias corrections.
- Wind up correction.
- Solid tides correction (up to 2<sup>nd</sup> degree).
- SBAS Messages.
- RTCM messages.

# The gLAB Tool suite

## ➤ Filtering module:

- Able to chose different measurements to process (1 or more), with different weights. This design could be useful in future Galileo processing, where processing with different measurements may be desired.
- Fixed or elevation-dependant weights per observation.
- Troposphere estimation on/off.
- Carrier-Phase or Pseudorange positioning.
- Static/Kinematic positioning (full Q/Phi/P0 customization).
- Able to do a forward/backward processing.
- Able to compute trajectories (no need for a priori position).

## ➤ Output module:

- Cartesian / NEU coordinates.
- Configurable message output.

## ➤ Other functionalities:

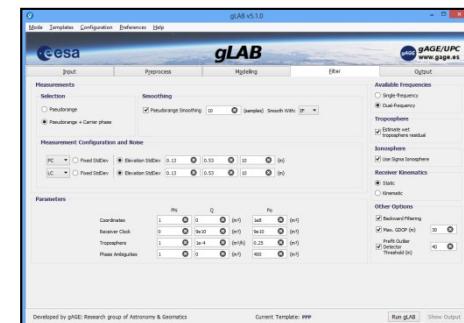
- Computation of satellite coordinates and clocks from RINEX and SP3 files.
- Satellite coordinates comparison mode. For instance RINEX navigation vs. SP3, or SP3 vs. SP3 (along-track, cross-track and radial orbit errors, clock errors, SISRE).
- Show input mode. No processing, only parsing RINEX observation files.

- Current version allows full GPS data processing, and partial handling of Galileo and GLONASS data.
- Future updates may include full GNSS data processing.

# GNSS learning material package

Includes three different parts, allowing to follow either a guided or a self-learning GNSS course:

- **GNSS Book:** Complete book with theory and algorithms (Volume 1), and with a Lab. course on GNSS Data Processing & Analysis (Volume 2).
- **gLAB tool suite:** Source code and binary software files, plus configuration files, allowing processing GNSS data from standard formats. The options are fully configurable through a GUI.



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The image shows the gLAB v5.1.0 software interface. On the left, there's a 'Modelling Options' panel with numerous checkboxes for GNSS corrections like Satellite Clock Offset Correction, Earth Rotation, and Ionospheric Corrections. In the center, there's a 'Precise Products Data Interpolation' panel with settings for Orbit and Clock interpolation degrees, and a 'Receiver Antenna Phase Centre Correction' section. To the right, there's a 'gLAB' panel with options for Satellite Selection (Orbits, Clocks, etc.) and a large 'gLAB' logo. Below these are three plots: 'NEU positioning error [SPP]: Full model' showing errors over time; 'Horizontal positioning error [SPP]' showing scatter plots of North, East, and Up errors; and '2c: Vertical positioning error [Kinem PPP]' showing vertical error over time.

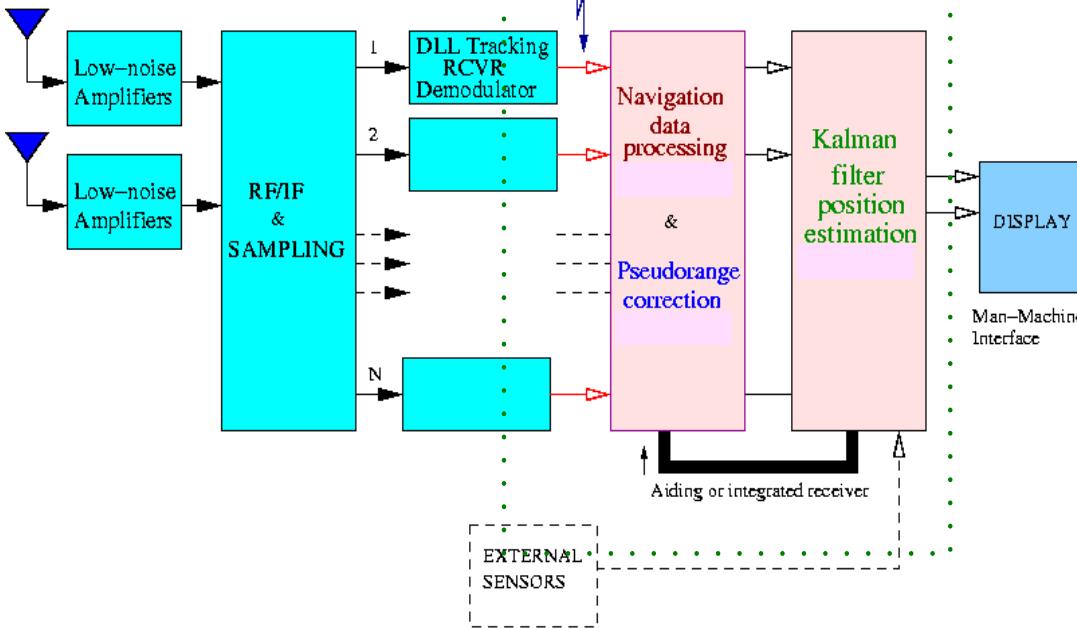
# Basic: Introductory Lab. Exercises

- Standard and Precise Point Positioning
  - To Illustrate how easy to process GNSS data using gLAB, a GPS receiver will be positioned in the next examples using:
    - Example 1: Broadcast orbits and clocks (**SPP**, kinematic).
    - Example 2: Precise Orbits and clocks (**PPP**, static).
    - Example 3: Precise Orbits and clocks (**PPP**, kinematic).
  - Solutions will be compared with an accurate reference value of receiver coordinates to asses the positioning error.

*Note: the receiver coordinates were keep fixed during the data collection.*

# We will work after the correlator: Our input data are code and carrier measurements and satellite orbits and clocks.

One or multiple antennas



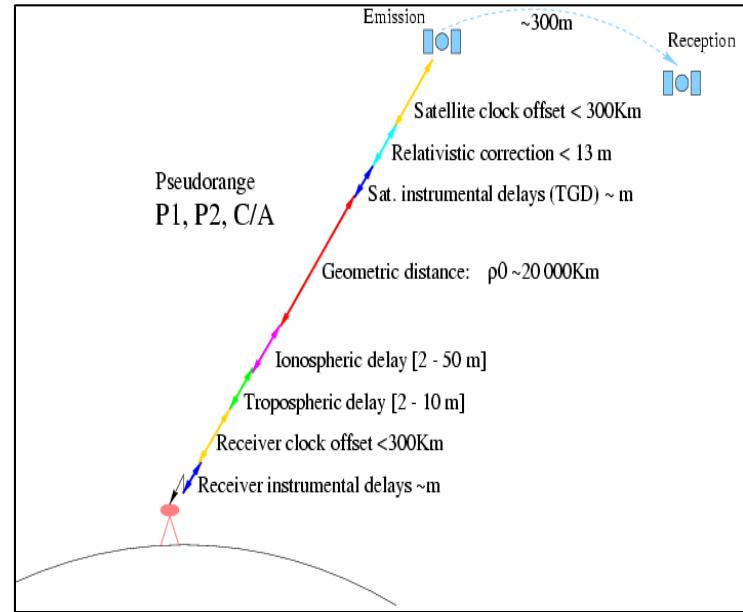
## RINEX FILES

- Pseudoranges (C/A, P1, P2),
- phase tracking (L1, L2)
- Navigation data (D(t))

**RINEX: observables**

```

2          OBSERVATION DATA   G (GPS)
RGRINEX0 V2.4.1 UX AUSLIG 10-JAN-97 10:19
Australian Regional GPS Network (ARGN) - COCOS ISLAND
BIT 2 OF LLI (+4) FLAGS DATA COLLECTED UNDER "AS" CONDITION
-0.000000000103      HARDWARE CALIBRATION (S)
-0.000000054663      CLOCK OFFSET (S)
COCO
AU18
mrh           auslig
126           ROGUE SNR-8100 93.05.25 / 2.8.33.2
327           DORNE MARGOLIN T
-741950.3241  6190961.9624 -1337769.9813
0.0040       0.0000     0.0000
1             1
5             C1   L1   L2   P2   P1
SNR is mapped to signal strength [0,1,4-9]
SNR: >600 >100 >50 >10 >5 bad n/a
sig: 9     8     7     6     5     4     1     0
30
1997        1     9     0     7     30.0000000
1997        1     9     23    59     30.0000000
97  1  9  0  7 30.0000000 0 7 1 25 9 5 23 17 6
22127685.105 -14268715.899 8 -11118481.28445 22127685.4014 <==== 1
22672158.746 -11810817.892 7 -8969469.30045 22672158.5184 <==== 25
22594902.367 -12949753.825 7 -10090708.53945 22594903.7394 <==== 9
22731128.796 -11621184.951 7 -9055464.16945 22731130.0094 <==== 5
24610920.702 -924108.174 6 -720085.67040 24610920.0404 <==== 23
20718775.074 -18605935.474 9 -14498133.97346 20718775.6074 <==== 17
20842713.610 -19083282.892 9 -14870090.55546 20842713.4814 <==== 6
  
```



# GNSS Format Descriptions

- GNSS data files follow a well defined set of standards formats: RINEX, ANTEX, SINEX...
- Understanding a format description is a tough task.
- These standards are explained in a very easy and friendly way through a set of html files.
- Described formats:
  - Observation RINEX
  - Navigation RINEX
  - RINEX CLOCKS
  - SP3 Version C
  - ANTEX

Open GNSS Formats

with Firefox internet browser

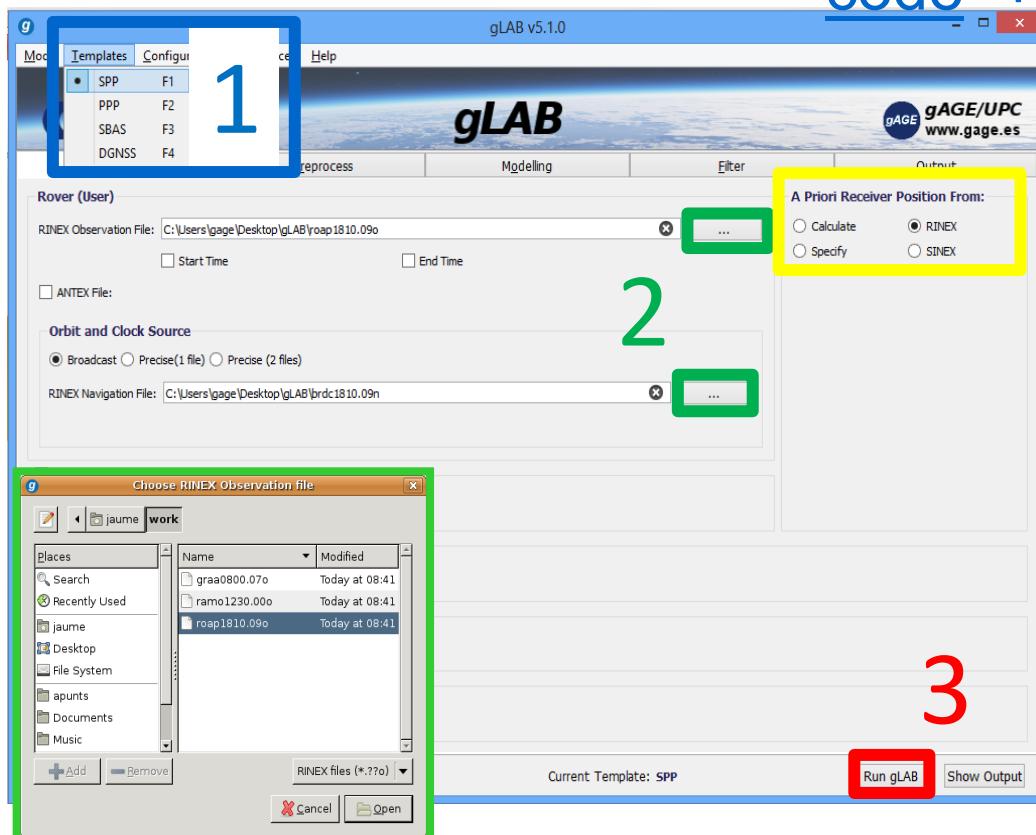
The screenshot shows a Firefox browser window with the URL <http://gage14.upc.es/gLAB/HTML/LaunchHTML.html>. The page title is "gAGE Learning Material - Mozilla Firefox". The main content area displays "GNSS Format Descriptions" and "Explained Formats" tables. A yellow circle highlights the "GNSS Formats" link in the sidebar navigation bar.

More details at: <http://www.gage.es/gLAB>

The image contains two screenshots of Internet Explorer browser windows. The top window shows the "Observation RINEX 2.11 Format" with a large amount of RINEX version 2.11 observation data. The bottom window shows the "CLOCK DATA FILE 3.00 Format" with a large amount of SP3 clock data.

# Example 1: Standard Point Positioning (SPP)

SPP Template: Kinematic positioning with single freq. C1 code + broadcast orbits and clocks.



1. Select the **SPP Template**

2. Upload the **RINEX files**:

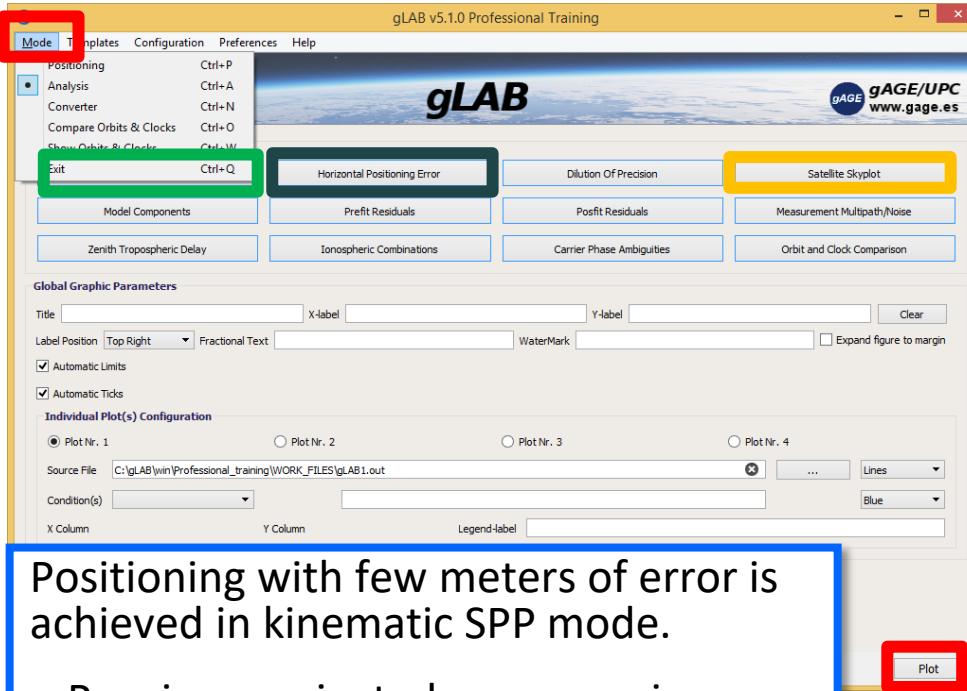
- Measurement: roap1810.09o
- Navigation: brdc1810.09n

3. **RUN gLAB**

Default output file:  
**gLAB.out**

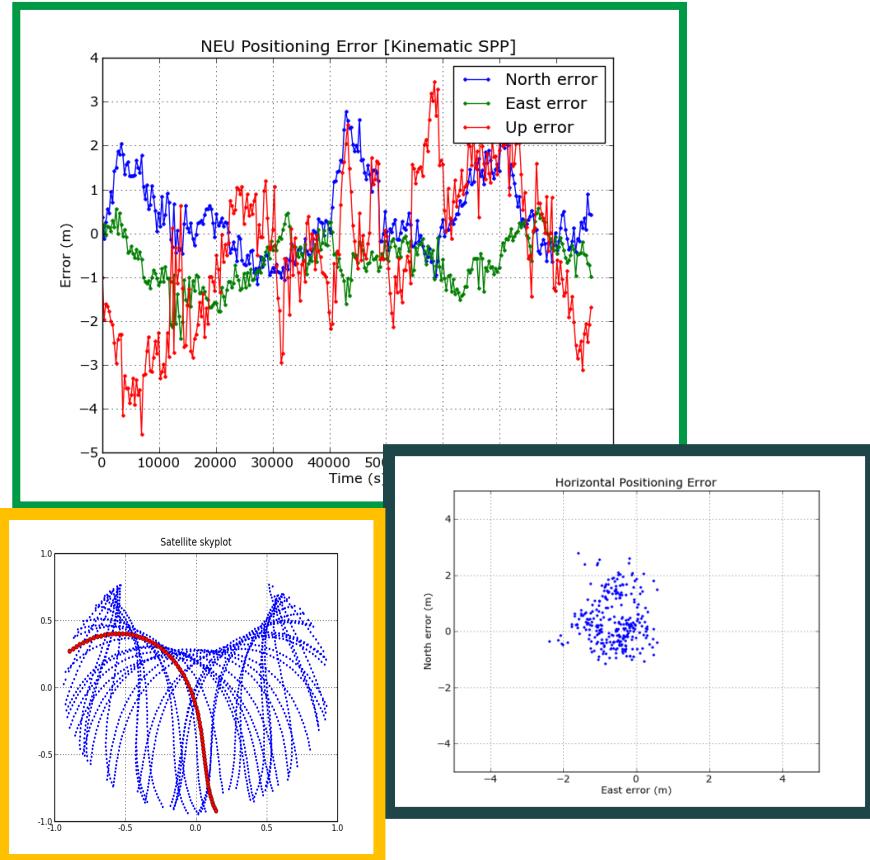
# Example 1: Standard Point Positioning (SPP)

- Plotting Results



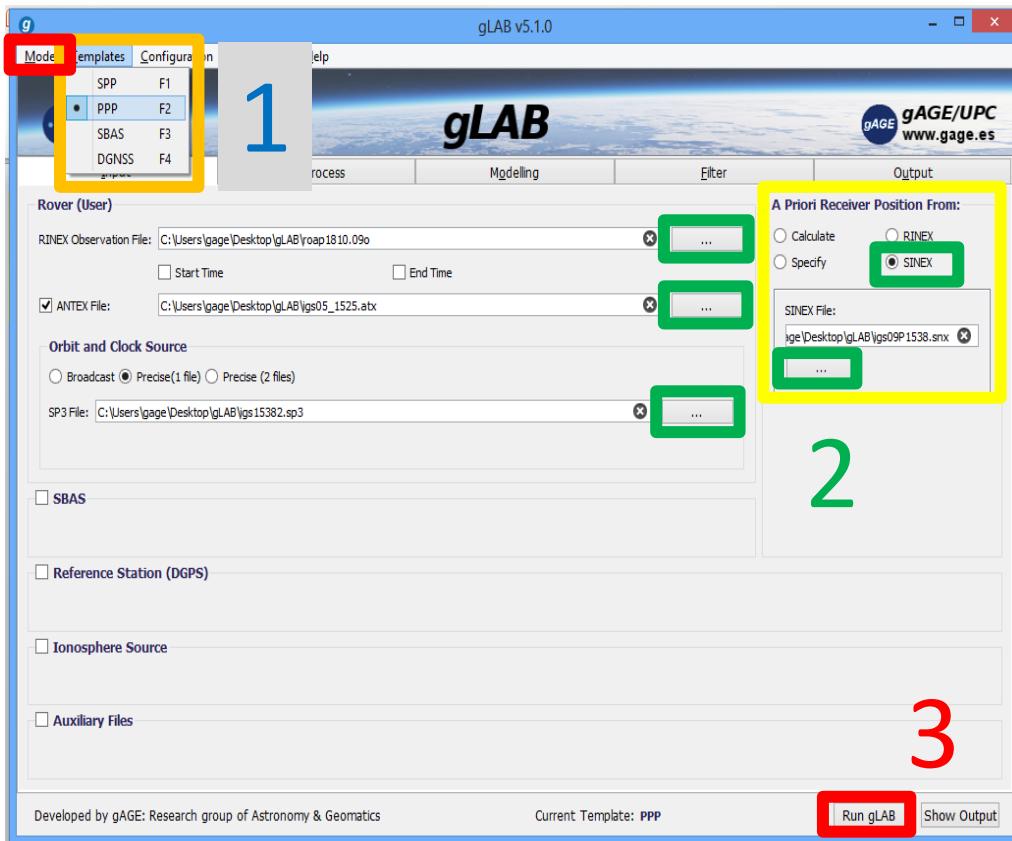
Positioning with few meters of error is achieved in kinematic SPP mode.

- Receiver navigated as a rover in pure kinematic mode.
- Single frequency C1 code is used.
- Broadcast orbits and clocks.



# Example 2: Static Precise Point Positioning (PPP)

PPP Template: Static positioning with dual freq. code & carrier (ionosphere-free combination PC,LC) + post-processed precise orbits & clocks.



1. Select the PPP Template

2. Upload data files:

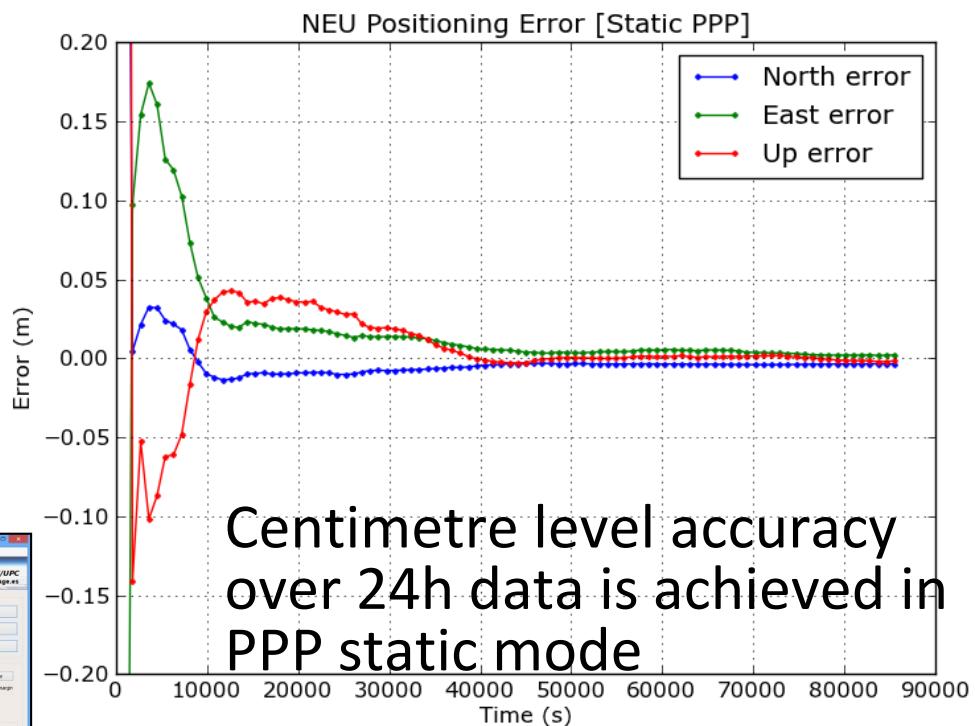
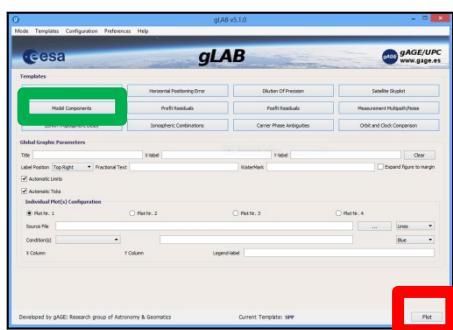
- Measurement: roap1810.09o
- ANTEX: igs05\_1525.atx
- Orbits & clocks: igs15382.sp3
- SINEX: igs09P1538.snx

3. RUN gLAB

Default output file:  
gLAB.out

# Example 2: Static Precise Point Positioning (PPP)

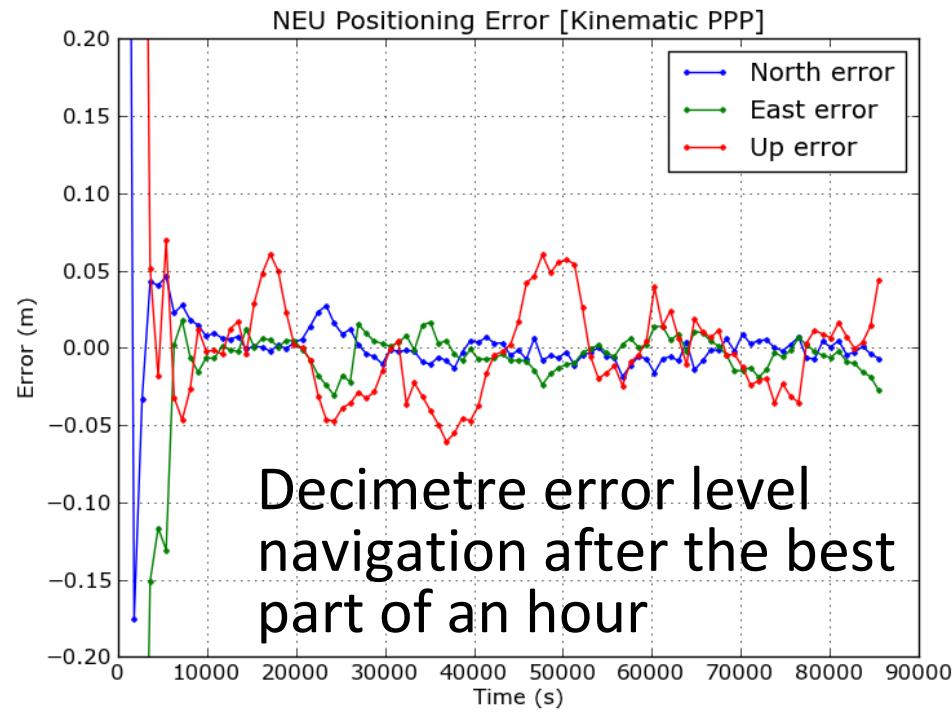
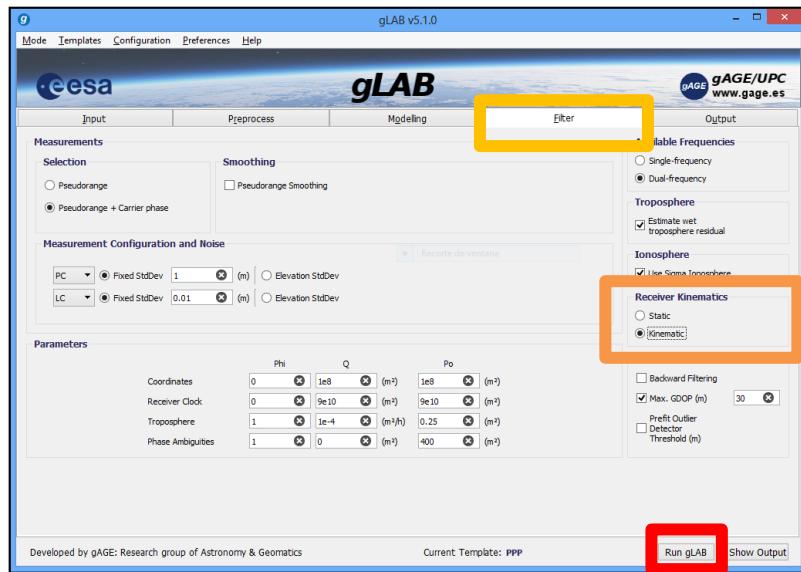
- Plotting Results
- Coordinates are taken as constants in nav. filter.
- Dual frequency Code and Carrier measurements.
- Precise orbits and clocks.
- Measurements modelling at the centimetre level.



# Example 3: Kinematic Precise Point Positioning

From default configuration of [PPP Template],

- Select **kinematics** in the [Filter] panel. Run *gLAB* and plot results.



Receiver navigated as a rover  
in a pure kinematic mode.

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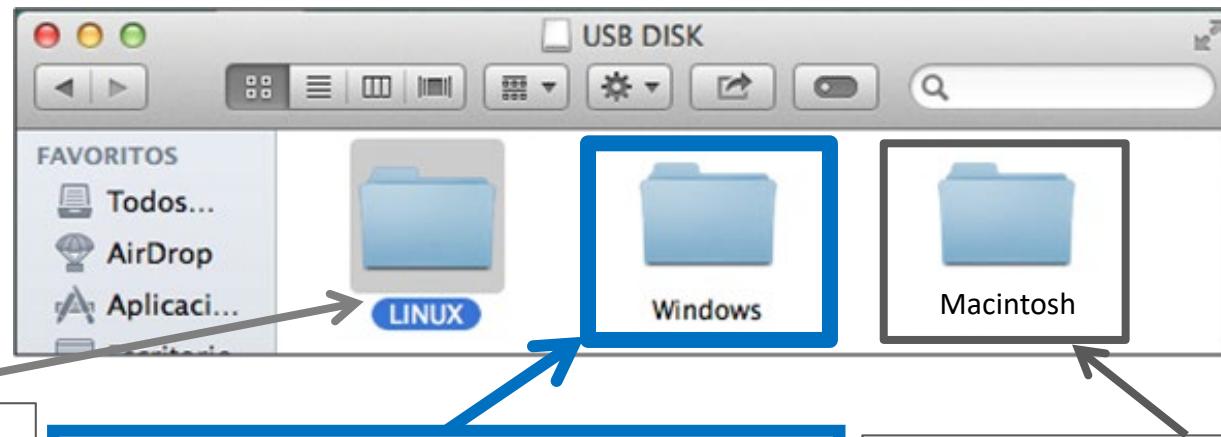


# Installing the software



This tutorial has been designed to be executed under **UNIX (Linux) Operative System (OS)**, which is a very powerful and robust environment.

Nevertheless, the necessary tools are provided for **Windows or Macintosh** users to install this software and to emulate a UNIX command line shell over Windows.



**Linux** users can install the **native version** of the software

**Windows** users can install the windows version of **gLAB** and the **Cygwin** emulator of a Linux command shell.

**Macintosh** users can install the software with the “**gLAB\_Install.pkg**” file.

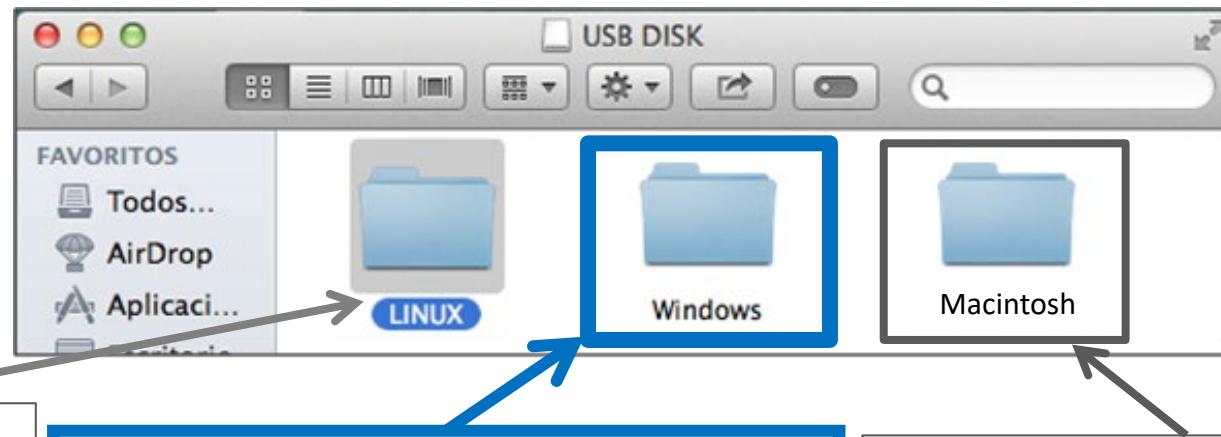


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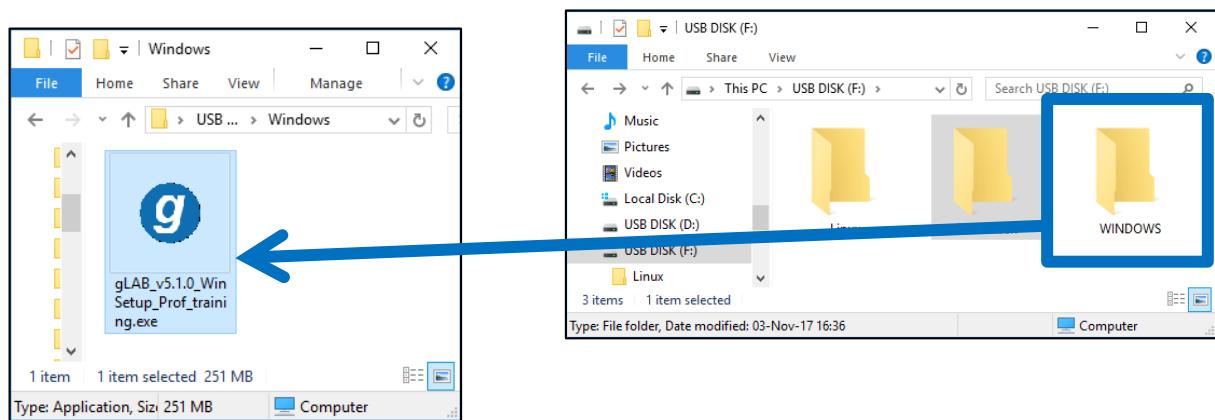


**Linux** users can install the **native version** of the software

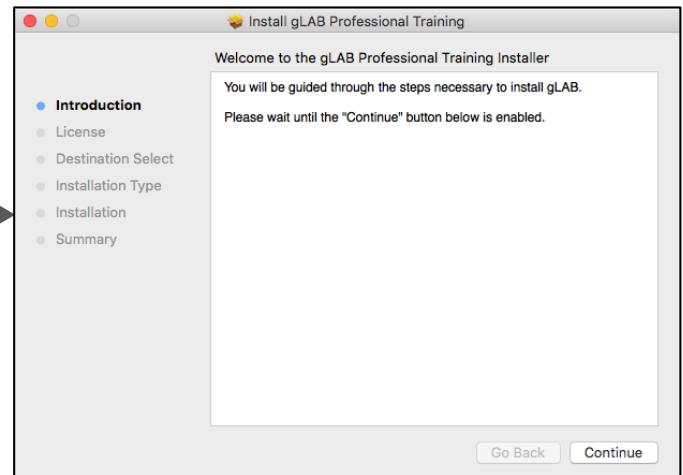
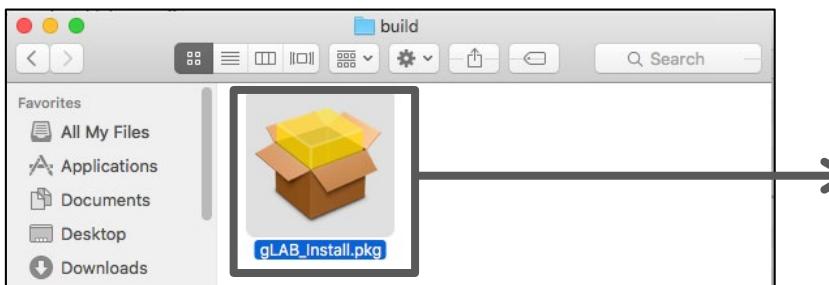
**Windows** users can install the windows version of **gLAB** and the **Cygwin** emulator of a Linux command shell.

**Macintosh** users can install the software with the “**gLAB\_Install.pkg**” file.

Inside the “Windows” folder, there is the installable ***gLAB program***. Follow the instructions of Software Installation file.



Inside the “Macintosh” folder, there is the dmg file. Double click on the “gLAB\_Install.pkg” file, and follow the instructions.





# Installing the software



Please install the software **before** the first laboratory class on Thursday.

If you need help, send an email to [glab.gage@upc.edu](mailto:glab.gage@upc.edu), so we have time to solve any installation issue offline.

Due to the large number of attendees, installation questions will not be answered during the laboratory sessions.

Thanks!!



# Installing the software

## Windows users



The Medium and Advanced exercises of this tutorial have been designed to be executed under **UNIX (Linux) Operative System (OS)**. Which is a very powerful and robust environment.

Nevertheless, **Windows OS** users can do the laboratory session by using **Cygwin**, which is a tool that allows to emulate a UNIX command line shell over Windows.

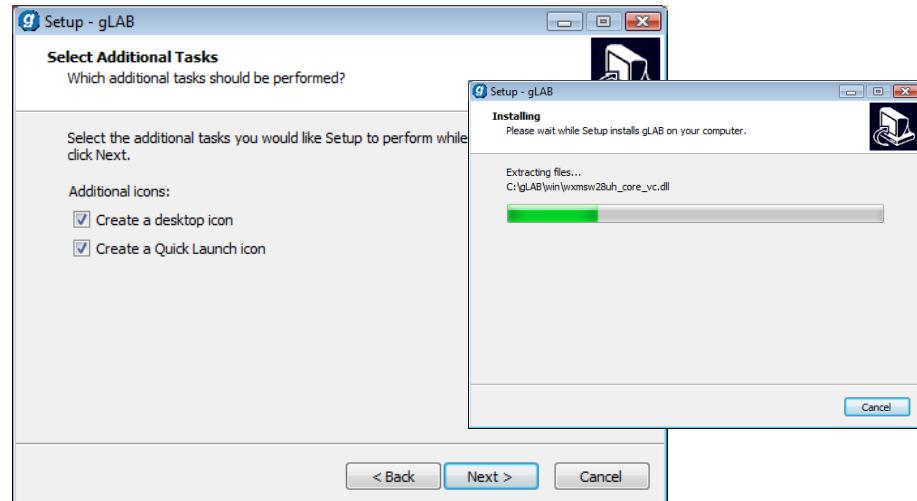
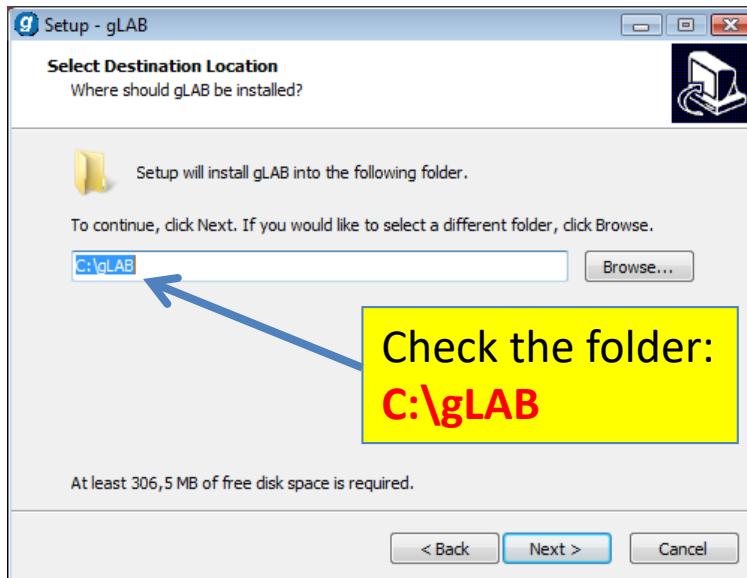
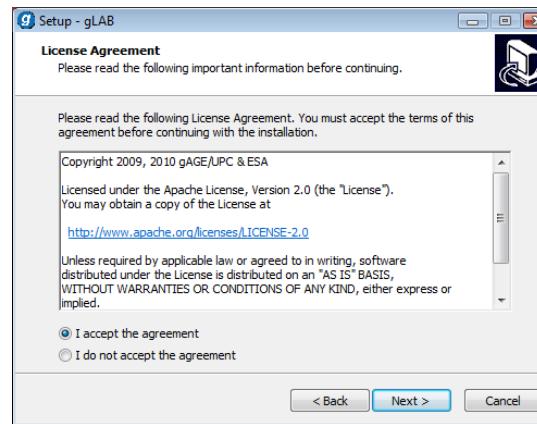
Indeed, after installing **Cygwin**, users can develop the laboratory session as if they were working on a UNIX system (as this tutorial was designed).



# Installing gLAB + Cygwin

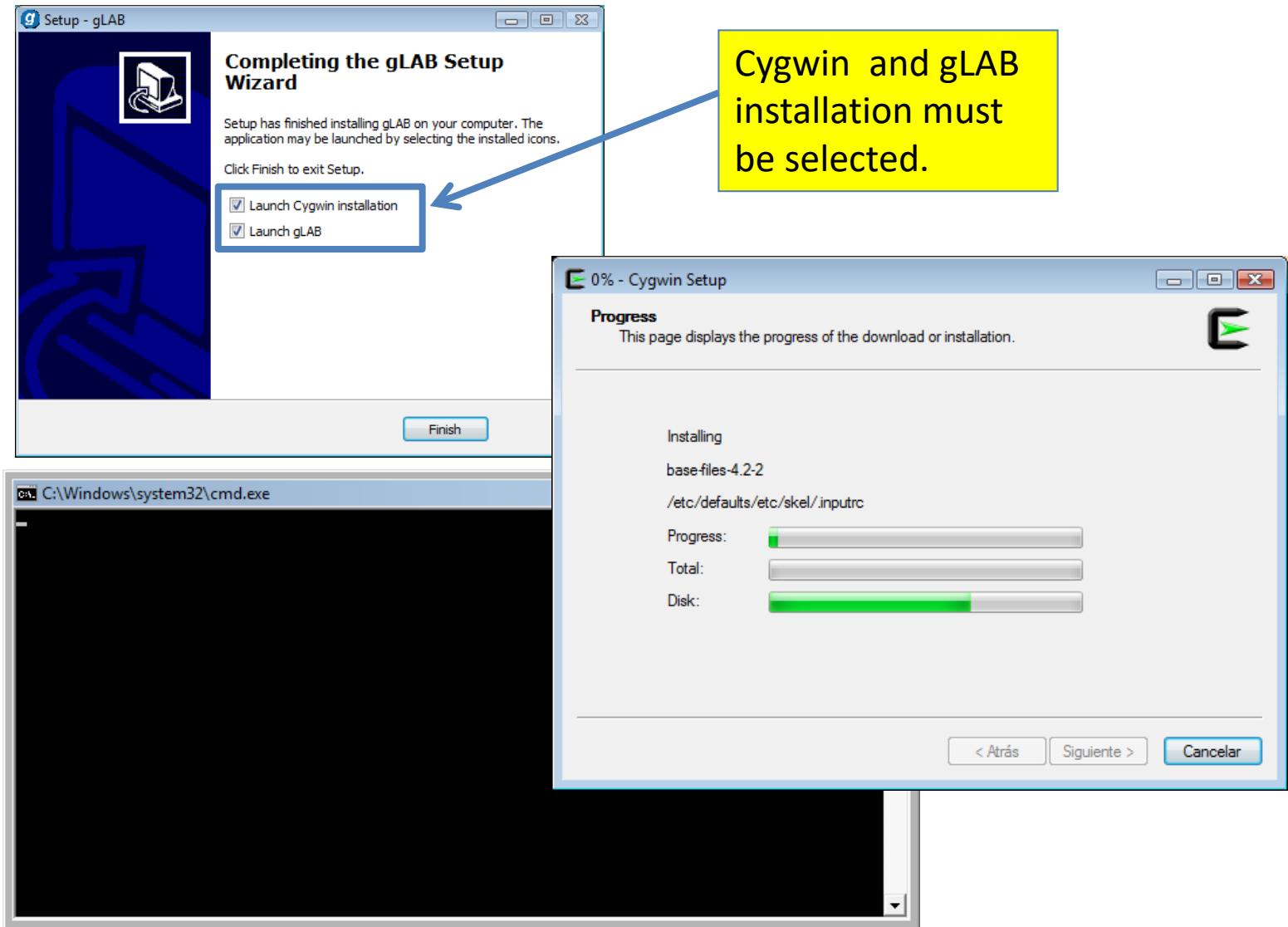
1.- First step: Click over the icon

g gLAB\_v5.1.0\_WinSetup\_Prof\_training.exe





## 2.- Second Step: Completing the gLAB Setup Wizard





Once the installation finish, the icons of **gLAB**, **Cygwin Terminal** and the **Professional training folder** will appear.

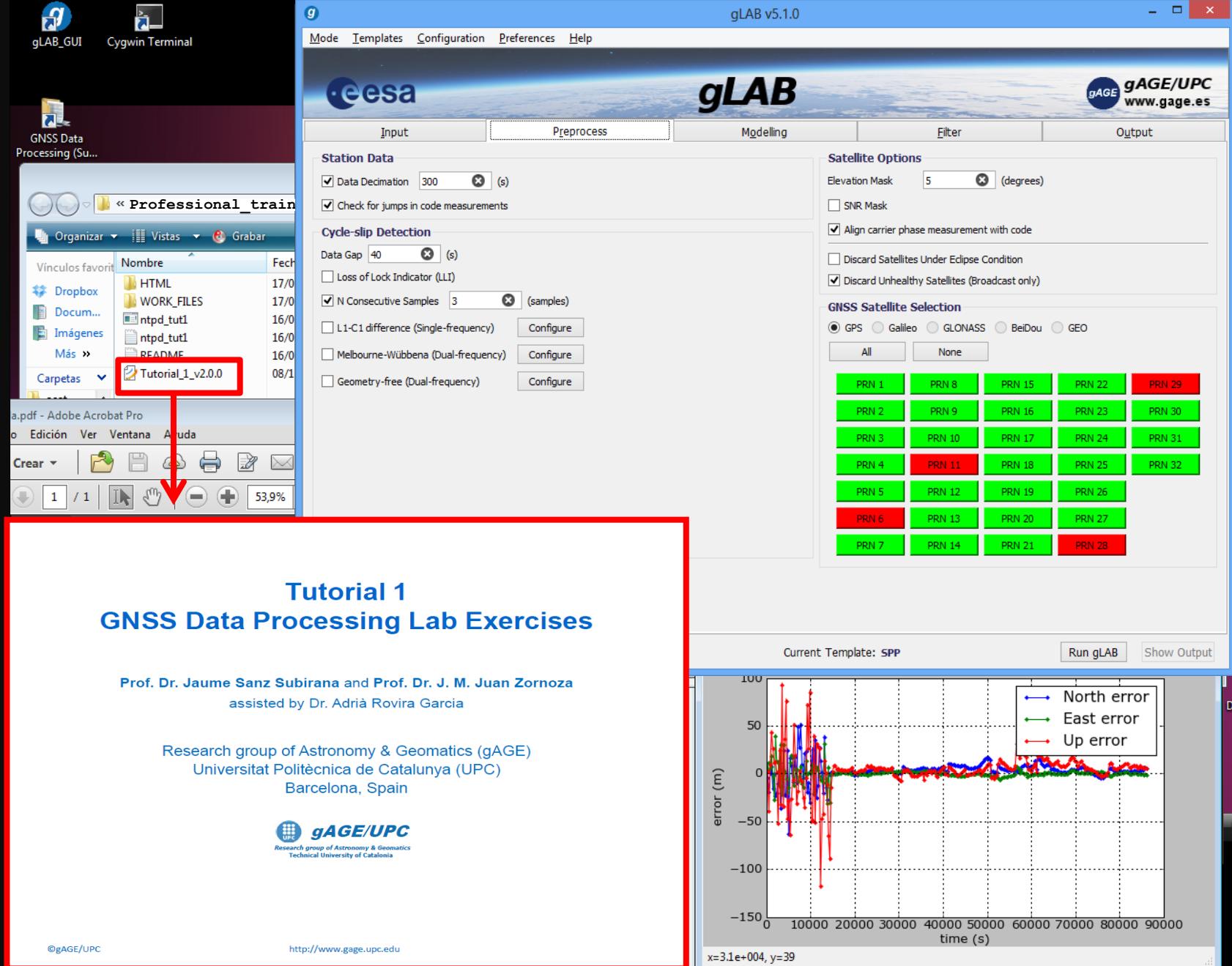
The screenshot shows a Windows desktop environment. On the left, there is a pinned folder named 'Professional\_training' containing several files and subfolders. One specific folder, 'Tutorial\_1\_v2.0.0', is highlighted with a red border. A cyan arrow points from this folder to a file browser window titled 'Organizar' (Organize) which displays the contents of this folder. In the top left corner of the desktop, there are three icons: 'gLAB GUI', 'Cygwin Terminal', and 'GNSS Data Processing (S...)'.

A yellow arrow points from the 'gLAB GUI' icon to the main gLAB application window. The gLAB window has a blue header bar with the text 'gLAB v5.1.0', 'Mode Templates Configuration Preferences Help', and the gAGE logo. The main interface features a large 'gLAB' title in purple, a background image of a satellite in space, and a status bar at the bottom with the text 'Developed by gAGE: Research group of Astronomy & Geomatics Technical University of Catalonia (UPC)', 'Current Template: SPP', and two buttons: 'Run gLAB' and 'Show Output'. The file browser window also shows the path 'gAGE@gage-PC:/cygdrive/c/gLAB/win/Professional\_training/WORK\_FILES |'.

**Tutorial slides**

**UNIX (Linux) console to execute “command line” sentences**

# Suggested desk configuration to start working



Thanks for your  
attention

Other Tutorials are available at  
<http://www.gage.upc.edu>

File Edit View History Bookmarks Tools Help

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www.gage.es/tutorials Bing

Personnel

- Permanent Staff
- Researchers
- Former Researchers

Publications

- Peer Reviewed Papers
- Meeting Proceedings
- Culture & Society
- PhD Dissertations

Learning Material

- Library
  - GNSS Books
  - GNSS Course and associated Tutorials
  - GNSS Format Descriptions
  - GNSS Webinars
- Software Tools

Projects

- gAGE/UPC
- gAGE-NAV, S.L.

Patents

- WARTK
- Fast-PPP
- Iono. Corrections
- Iono. Disturb. Mitig.
- Receiver orientation

GNSS Tutorials

- GNSS Course (associated to the [GNSS Data Processing Book](#))
- About the course
- GNSS Data Processing: Theory Slides (Full compendium)**
  - Lecture 0: Introduction
  - Lecture 1: GNSS measurements and their combinations
  - Lecture 2: Satellite orbits and clocks computation accuracy
  - Lecture 3: Position estimation with pseudoranges
  - Lecture 4: Introduction to DGNSS
  - Lecture 5: Precise positioning with carrier phase (PPP)
  - Lecture 6: Differential positioning with code pseudoranges
  - Lecture 7: Carrier based differential positioning. Ambiguity resolution techniques
- GNSS Data Processing: Laboratory Exercises (Full compendium)**
  - Tutorial 0: UNIX enviroment, tools and skills. GNSS standard file formats [Format files description]
  - Tutorial 1: GNSS data processing laboratory exercises
  - Tutorial 2: Measurement analysis and error budget
  - Tutorial 3: Differential positioning with code measurements
  - Tutorial 4: Carrier ambiguity fixing
  - Tutorial 5: Analysis of propagation effects from GNSS observables based on laboratory exercises
  - Tutorial 6: Differential positioning and carrier ambiguity fixing
- Associated Software and Data Files (Linux)
  - CDROM zipped tar file. How to install the CDROM [Linux]
  - CDROM ISO. How to install the CDROM [Linux]
- Associated Software and Data Files (Windows)
  - Instalable Toolkit ([gLAB + Cygwin](#))
  - Data Files
  - How to install the Software
- Bootable USB stick (Linux live)
  - [gAGE-GLUE](#) (to build-up a bootable USB stick). How to burn the gAGE-GLUE. [How to use the bootable USB stick.](#)
  - [How to start-up the laboratory session.](#)
- Useful tools for Windows: Windows users can install the next ports of Linux tools (instead of Cygwin) at [gnuwin32.sourceforge.net/packages.html](#):

The image shows two presentation slides for GNSS Data Processing. The left slide is titled 'GNSS Data Processing Theory Slides' and the right slide is titled 'GNSS Data Processing Laboratory Slides'. Both slides feature the gAGE logo and provide links to the respective resources.

About us

gAGE is a research group of the Technical University of Catalonia (UPC). UPC is a public university located in Barcelona, Spain.

gAGE Brochure

Shortcuts

- GNSS Data Processing Book
- GNSS Course and associated Tutorials**
- GNSS Webinars
- gLAB Tool Suite
- gAGE Products
- Useful GNSS links
- Master MAST (UPC)
- Master Of Science (ENAC)
- gAGE upload file facility

User login

Username: \* jaume.sanz

Password: \*

.....

Log in using OpenID

Request new password

Who's online

There are currently 0 users and 8 guests online.

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