Tutorial 1
Introduction to gLAB tool suite

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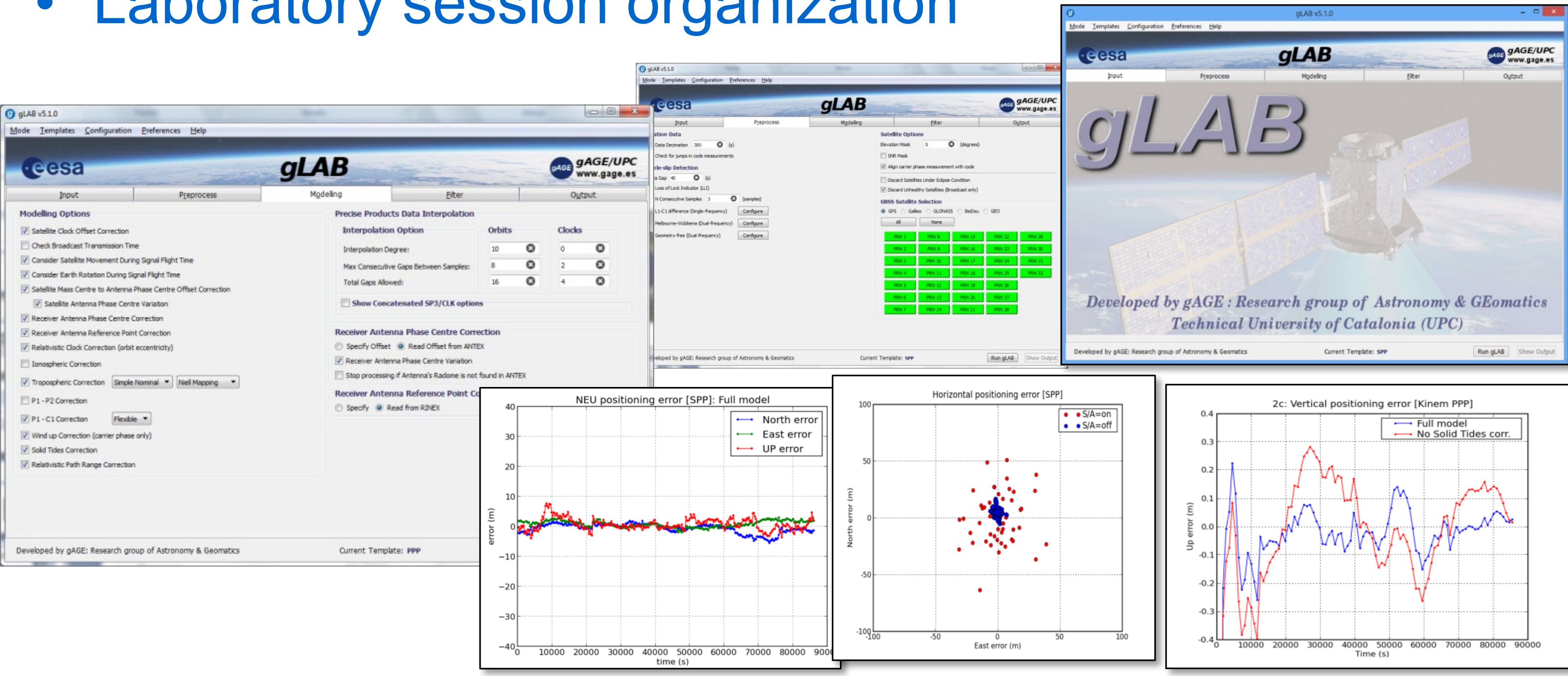
5th July 2021

OVERVIEW

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



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
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- Examples of GNSS Positioning using gLAB
- gLAB software installation

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.

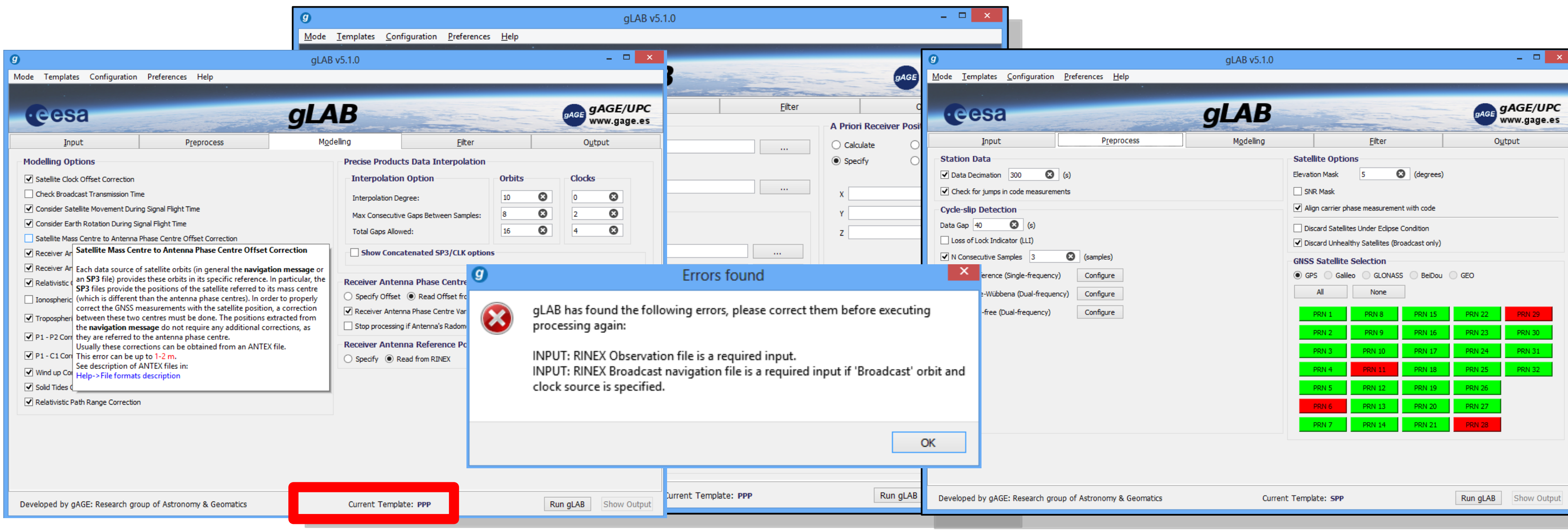
- Main features:
  - High Accuracy Positioning capability.
  - Fully configurable.
  - Easy to use.
  - Access to internal computations.

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.



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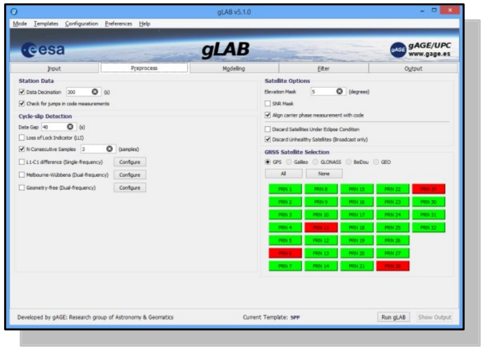
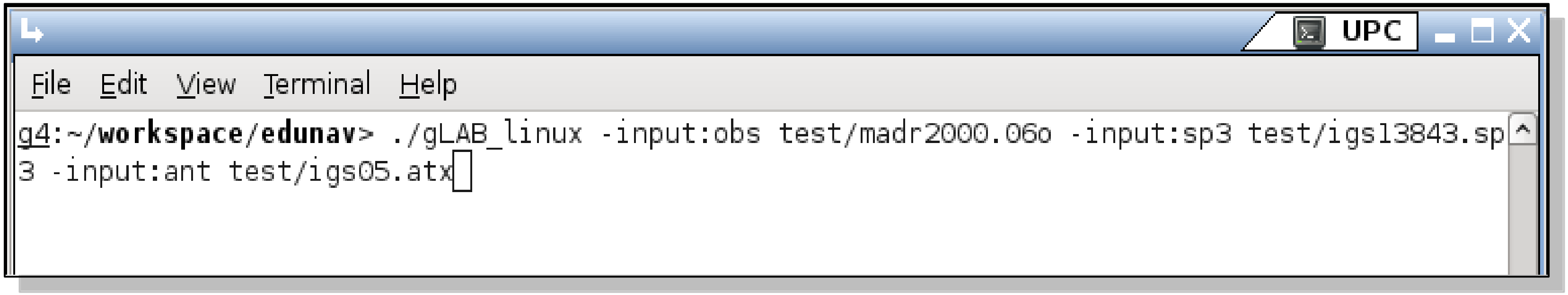


- Professionals/Experts:
  - Powerful tool with High Accuracy Positioning capability.
  - Fast to configure and use: Templates and carefully chosen defaults.
  - Able to be executed in command-line and to be **included in batch processing**.



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 2nd 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).

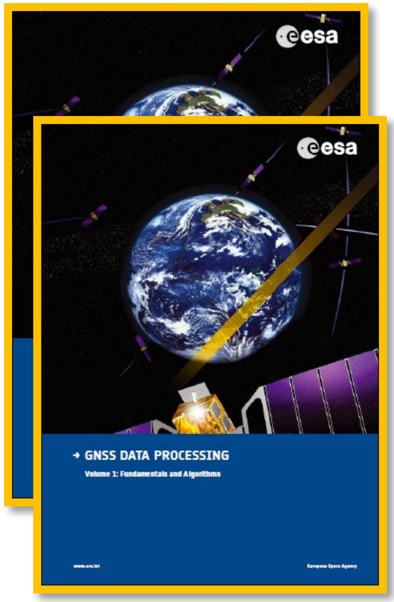
- Output module:
  - Cartesian / NEU coordinates.
  - Configurable message output.

- 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.

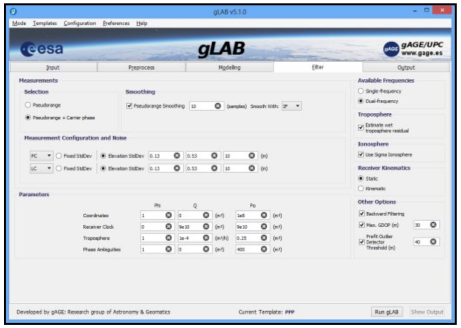
GNSS learning material package

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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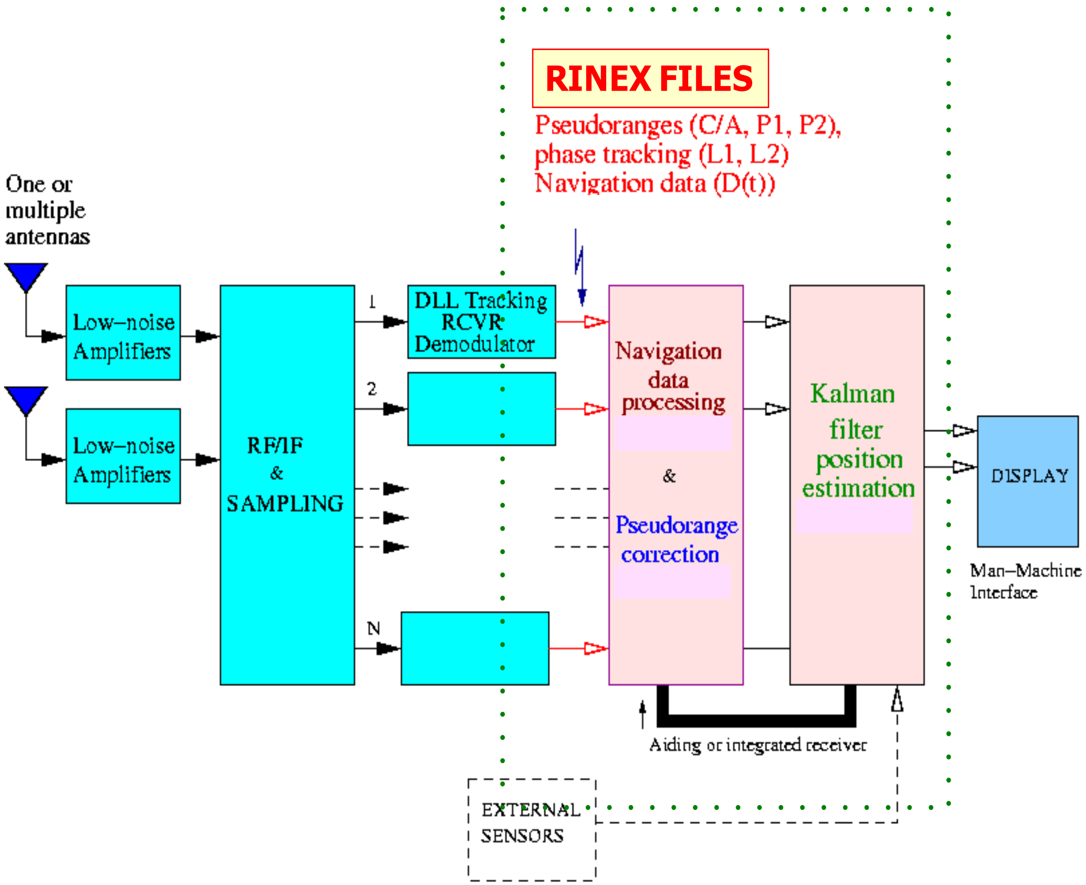
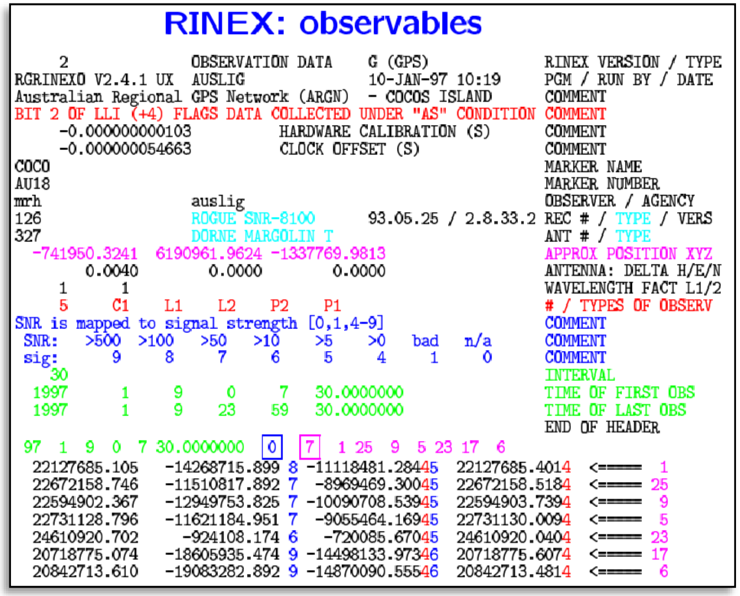
Basic: Introductory Lab. Exercises

- 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.

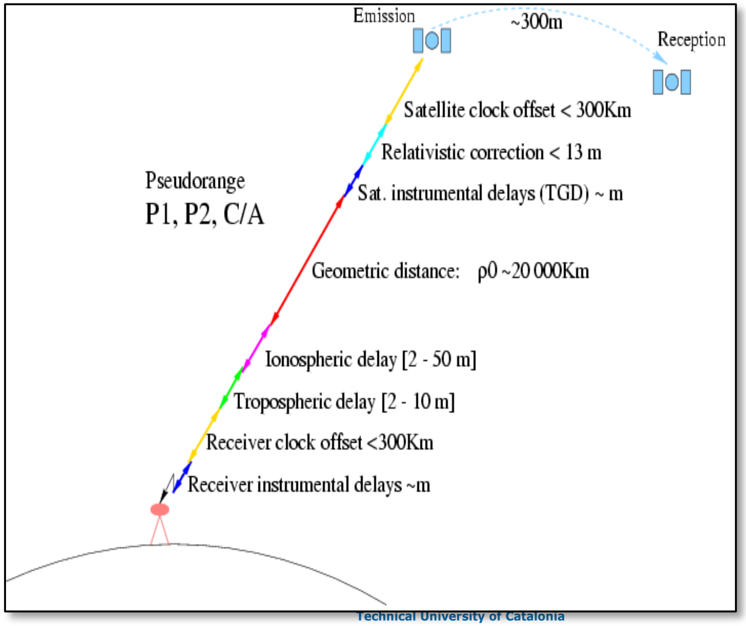
We will work after the correlator: Our input data are code and carrier measurements and satellite orbits and clocks.





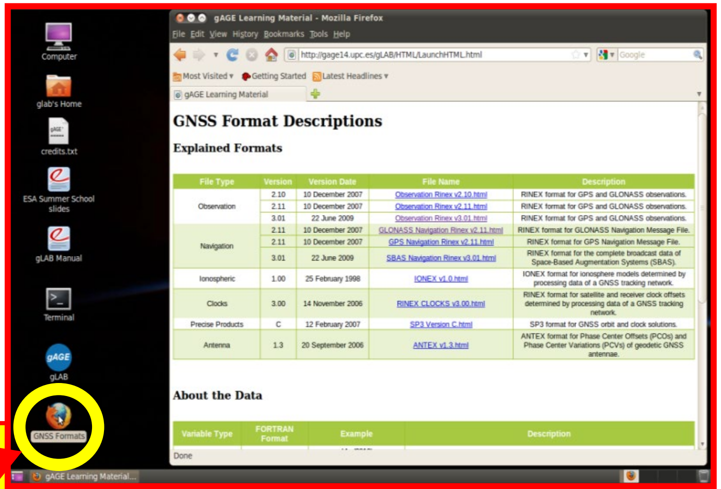
RINEX: observables

```
     2              OBSERVATION DATA    G (GPS)             RINEX VERSION / TYPE
RGRINEXO V2.4.1 UX  AUSLIG              10-JAN-97 10:19     PGM / RUN BY / DATE
Australian Regional GPS Network (ARGN)  - COCOS ISLAND      COMMENT
BIT 2 OF LLI (+4) FLAGS DATA COLLECTED UNDER "AS" CONDITION COMMENT
     -0.000000000103            HARDWARE CALIBRATION (S)    COMMENT
     -0.000000054663            CLOCK OFFSET (S)            COMMENT
COCO                                                        MARKER NAME
AU18                                                        MARKER NUMBER
mrh                 auslig                                  OBSERVER / AGENCY
126                 ROGUE SNR-8100      93.05.25 / 2.8.33.2 REC # / TYPE / VERS
327                 DORNE MARGOLIN T                        ANT # / TYPE
  -741950.3241  6190961.9624 -1337769.9813                  APPROX POSITION XYZ
        0.0040        0.0000        0.0000                  ANTENNA: DELTA H/E/N
     1     1                                                WAVELENGTH FACT L1/2
     5    C1    L1    L2    P2    P1                        # / TYPES OF OBSERV
SNR is mapped to signal strength [0,1,4-9]                  COMMENT
 SNR:   >500  >100   >50   >10    >5    >0   bad   n/a      COMMENT
 sig:      9     8     7     6     5     4     1     0      COMMENT
    30                                                      INTERVAL
  1997     1     9     0     7   30.0000000                 TIME OF FIRST OBS
  1997     1     9    23    59   30.0000000                 TIME OF LAST OBS
                                                            END OF HEADER
 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   -11510817.892 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    -720085.67045  24610920.0404  <==== 23
  20718775.074   -18605935.474 9 -14498133.97346  20718775.6074  <==== 17
  20842713.610   -19083282.892 9 -14870090.55546  20842713.4814  <==== 6
```



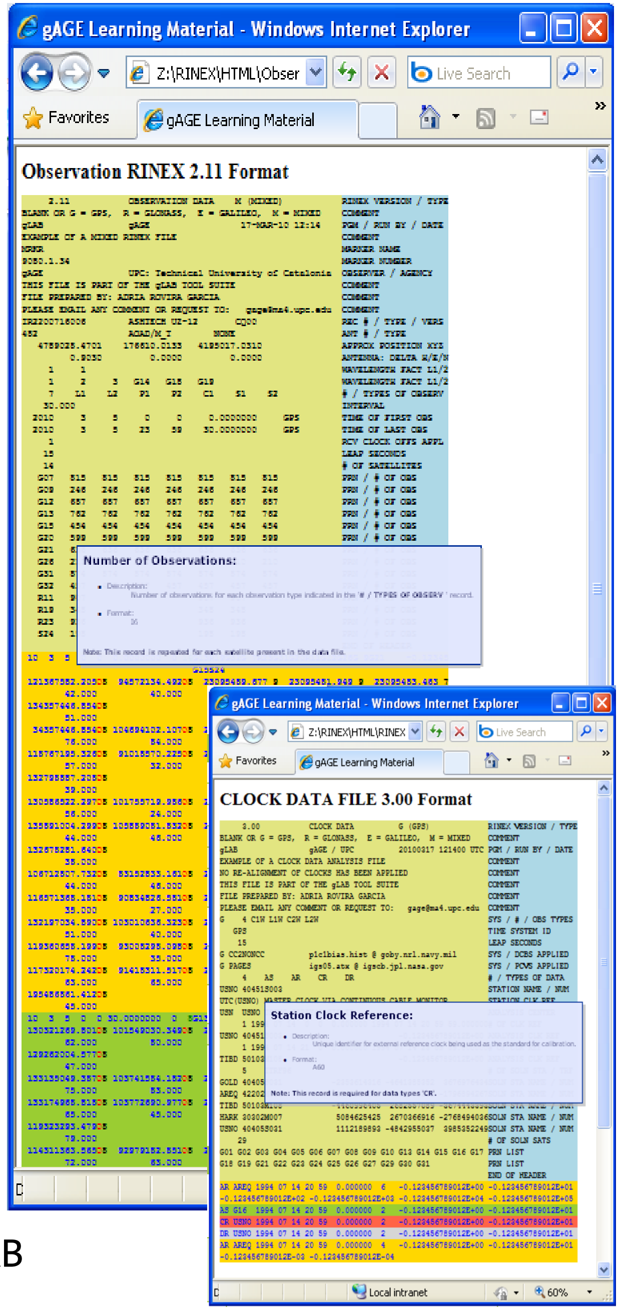
GNSS Format Descriptions

- 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

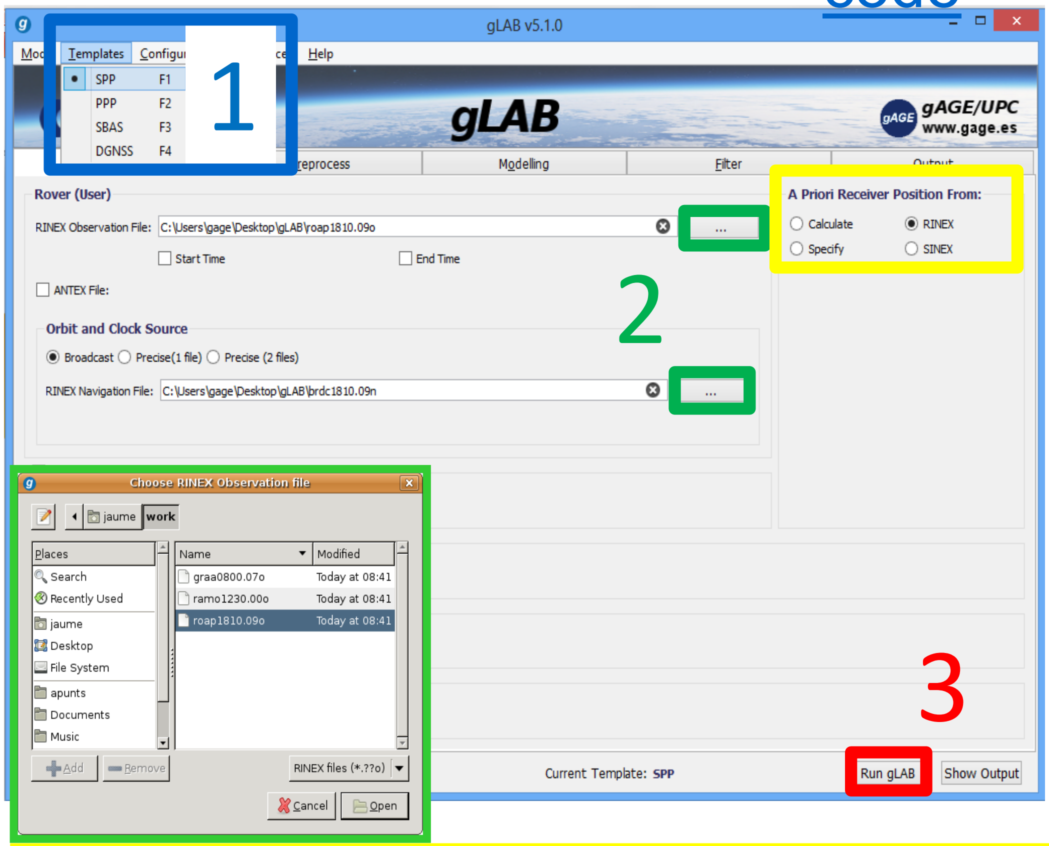
with **Firefox** internet browser



More details at: `http://www.gage.es/gLAB`

Example 1: Standard Point Positioning (SPP)

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



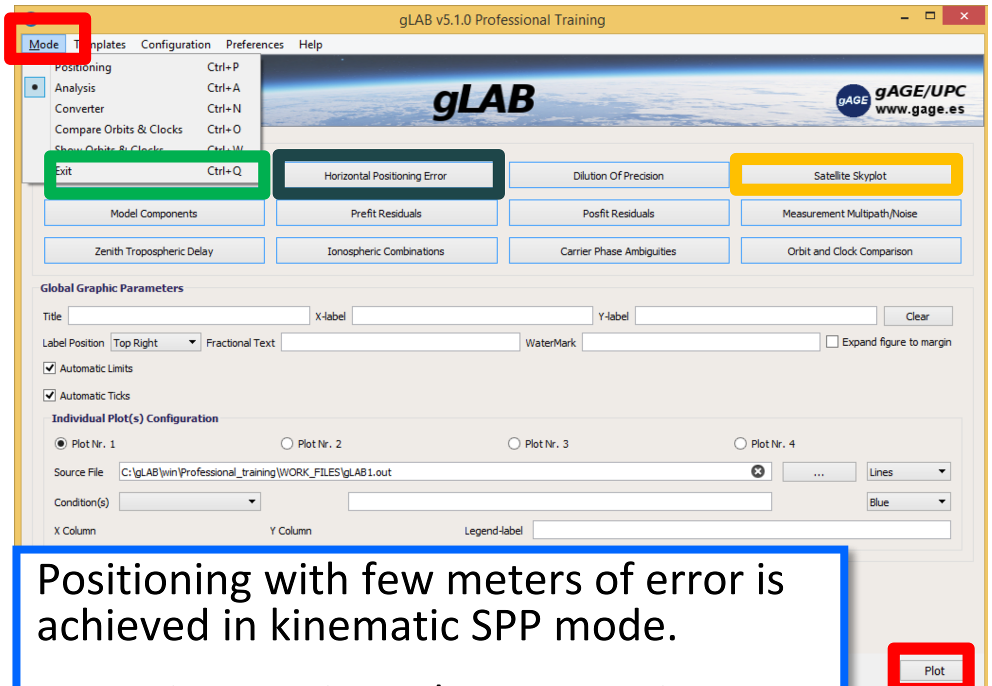
1. Select the **SPP Template**
2. **Upload the RINEX files:**
   - Measurement: roap1810.09o
   - Navigation: brdc1810.09n
3. **RUN** gLAB

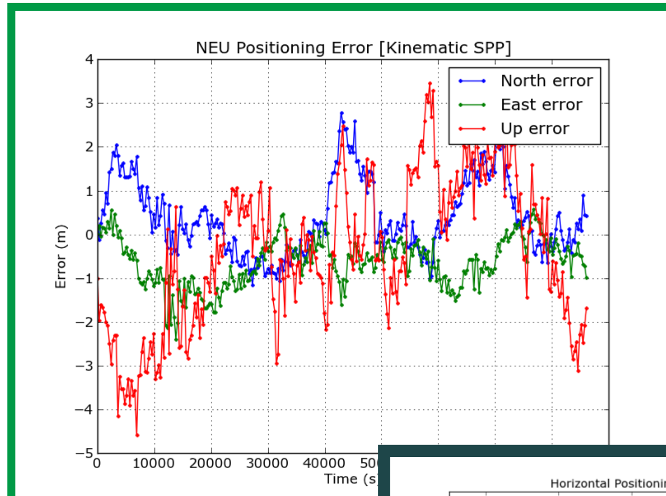
Default output file: gLAB.out

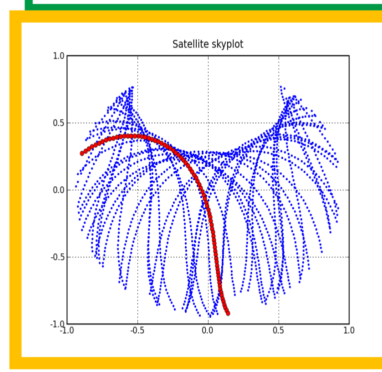
Note: Reference coordinates are from RINEX

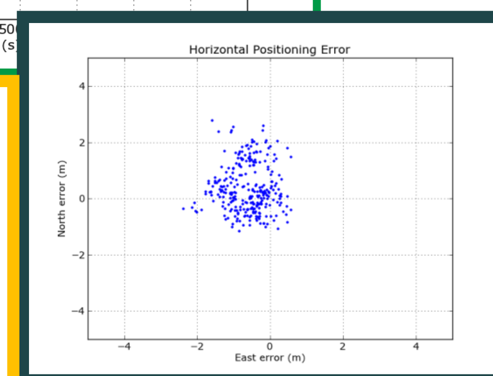
Example 1: Standard Point Positioning (SPP)

- Plotting Results







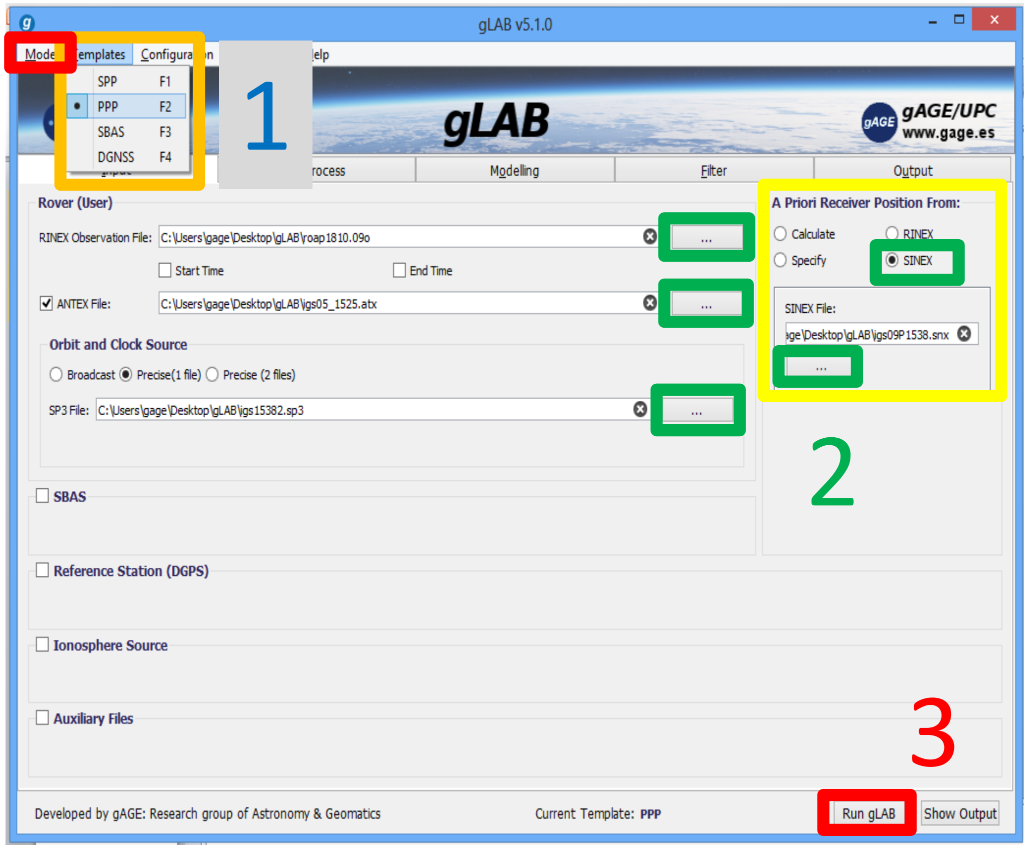


Positioning with few meters of error is achieved in kinematic SPP mode.

- 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.



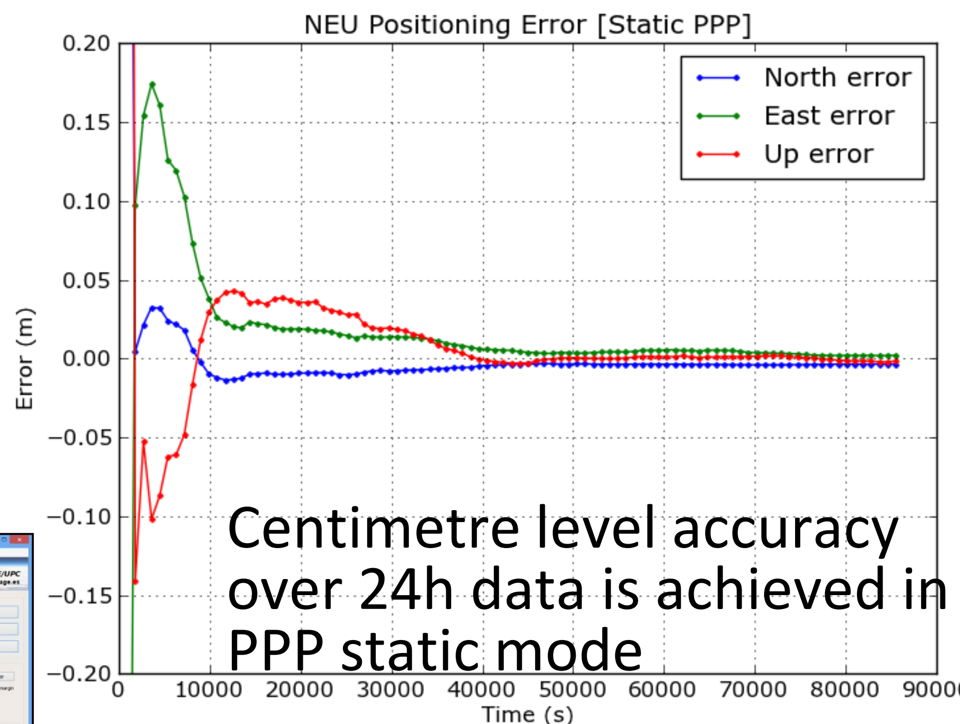
1. Select the **PPP Template**
2. **Upload data** files:
   - -Measurement: `roap1810.09o`
   - - ANTEX: `igs05_1525.atx`
   - - Orbits & clocks: `igs15382.sp3`
   - - SINEX: `igs09P1538.snx`
3. **RUN** gLAB

Default output file:
gLAB.out

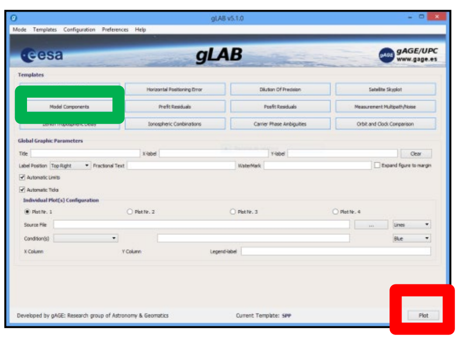
Example 2: Static Precise Point Positioning (PPP)

- 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.



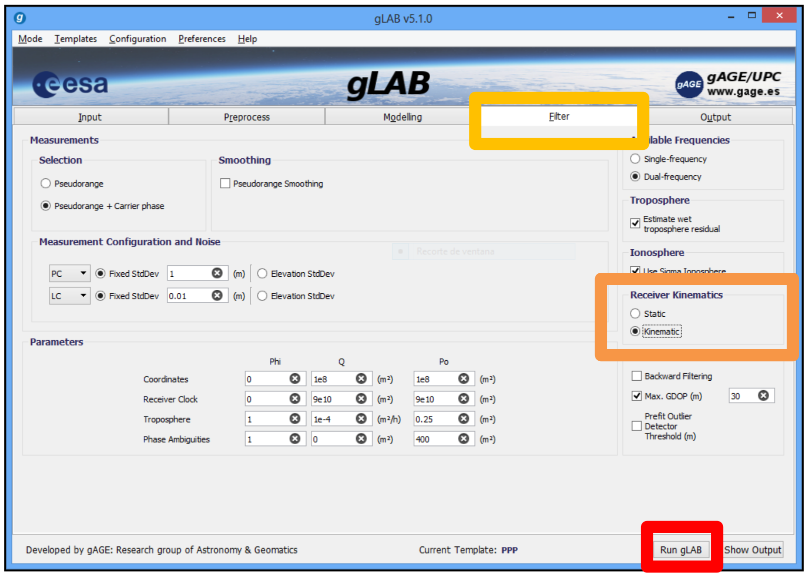
Centimetre level accuracy over 24h data is achieved in PPP static mode

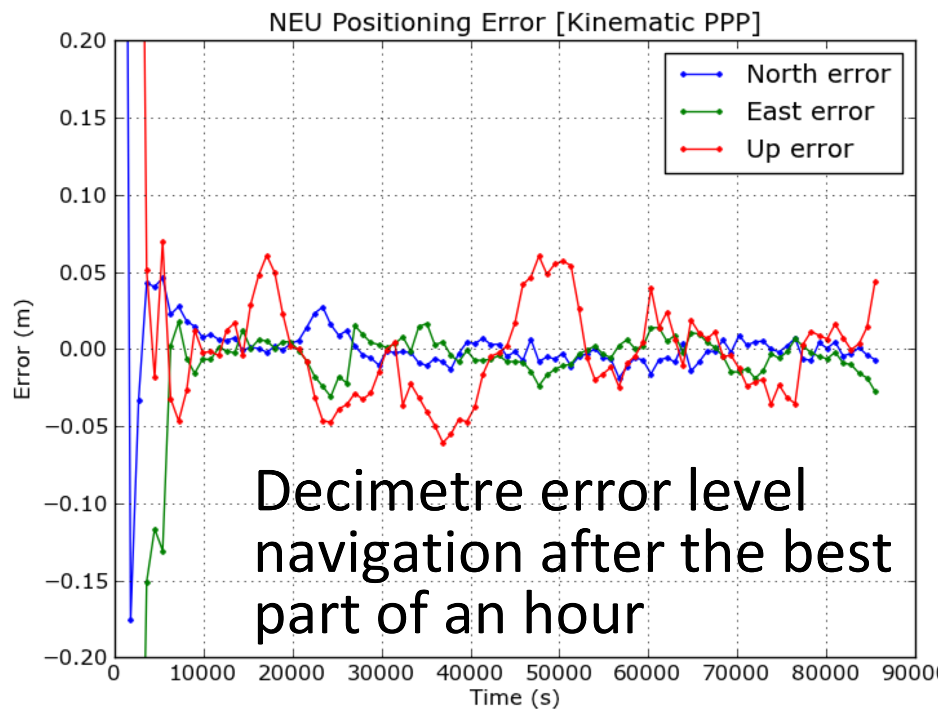


Example 3: Kinematic Precise Point Positioning

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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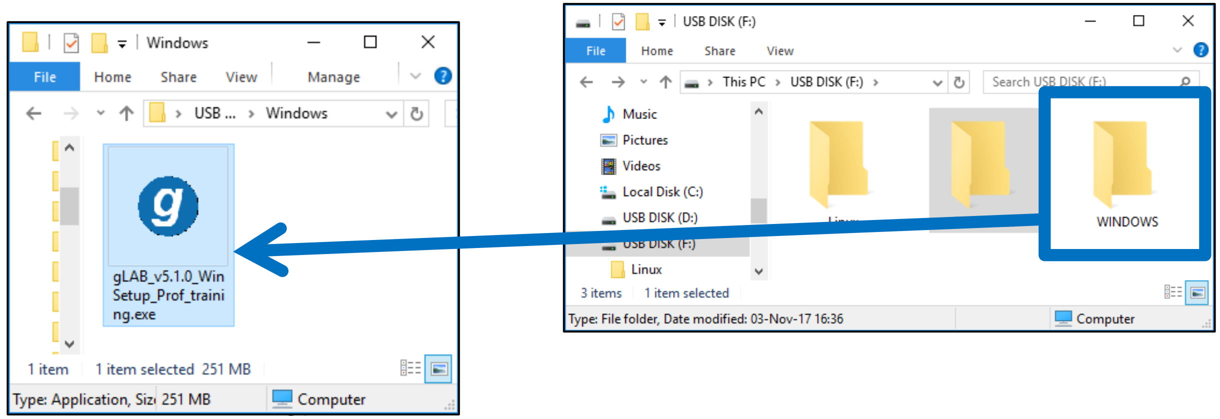
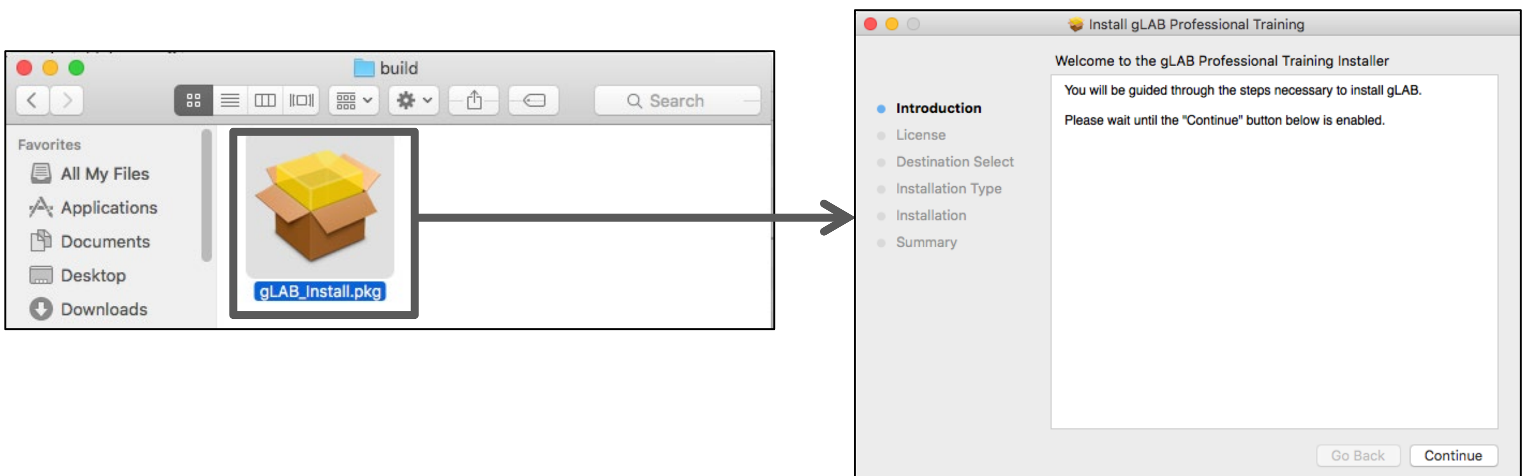
Macintosh users can install the software with the "gLAB_Install.pkg" file.

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**, 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

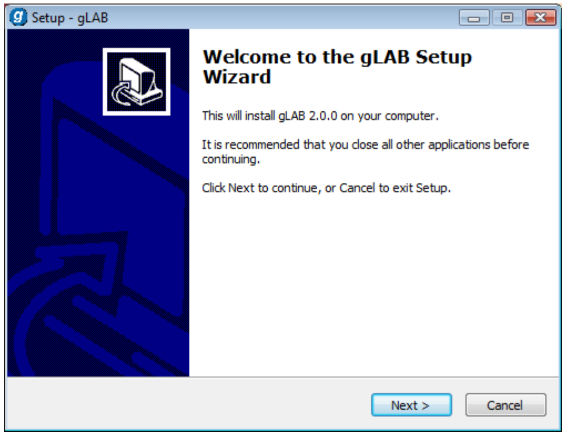
The Medium and Advanced exercises of this tutorial have been designed to be executed under **UNIX (Linux) Operative System** (OS). Which is a very powerful and robust environment.

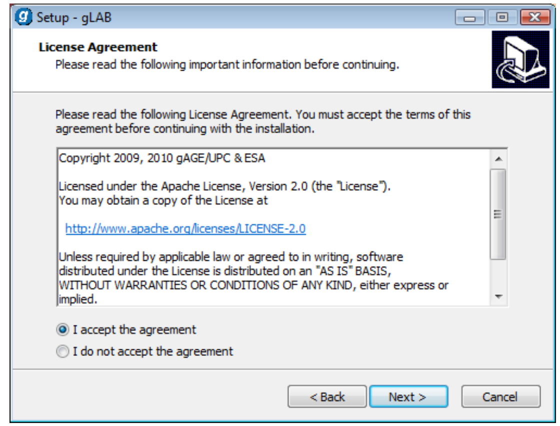
Nevertheless, **Windows OS** users can do the laboratory session by using **Cygwin**, which is a tool that allows to emulate a UNIX command line shell over Windows.

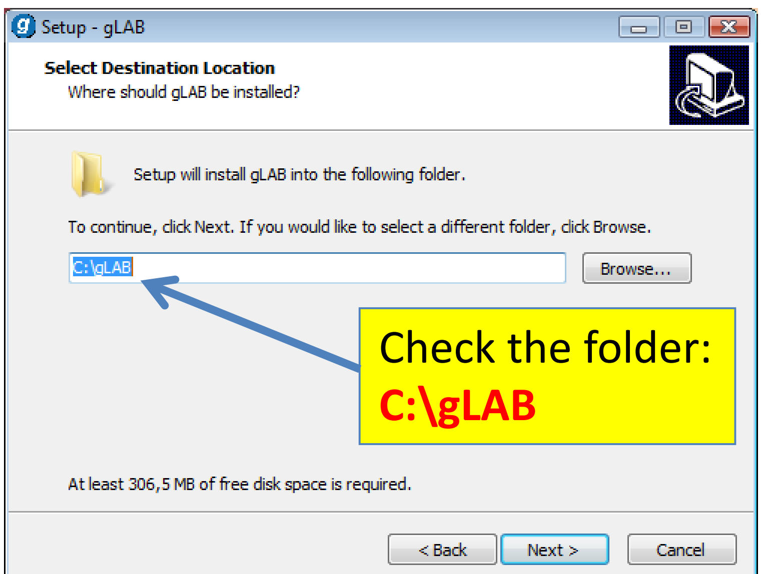
Indeed, after installing **Cygwin**, users can develop the laboratory session as if they were working on a UNIX system (as this tutorial was designed).

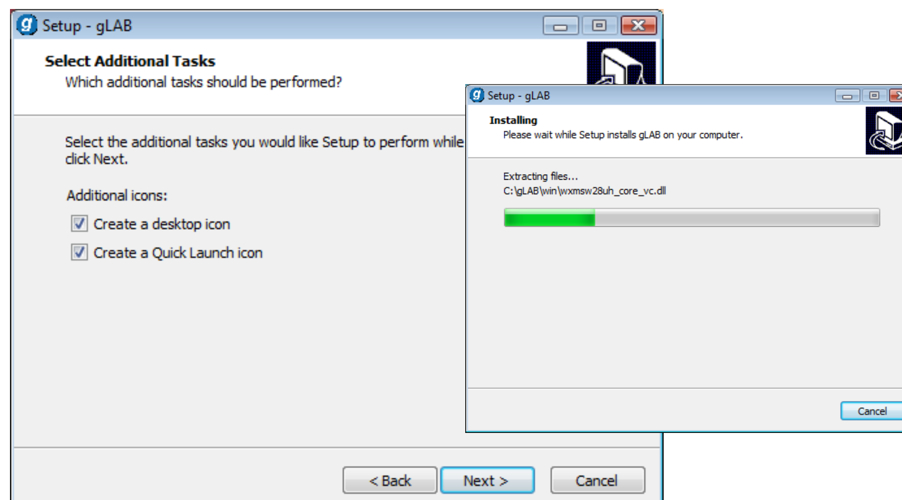
Installing gLAB + Cygwin

1.- First step: Click over the icon gLAB_v5.1.0_WinSetup_Prof_training.exe

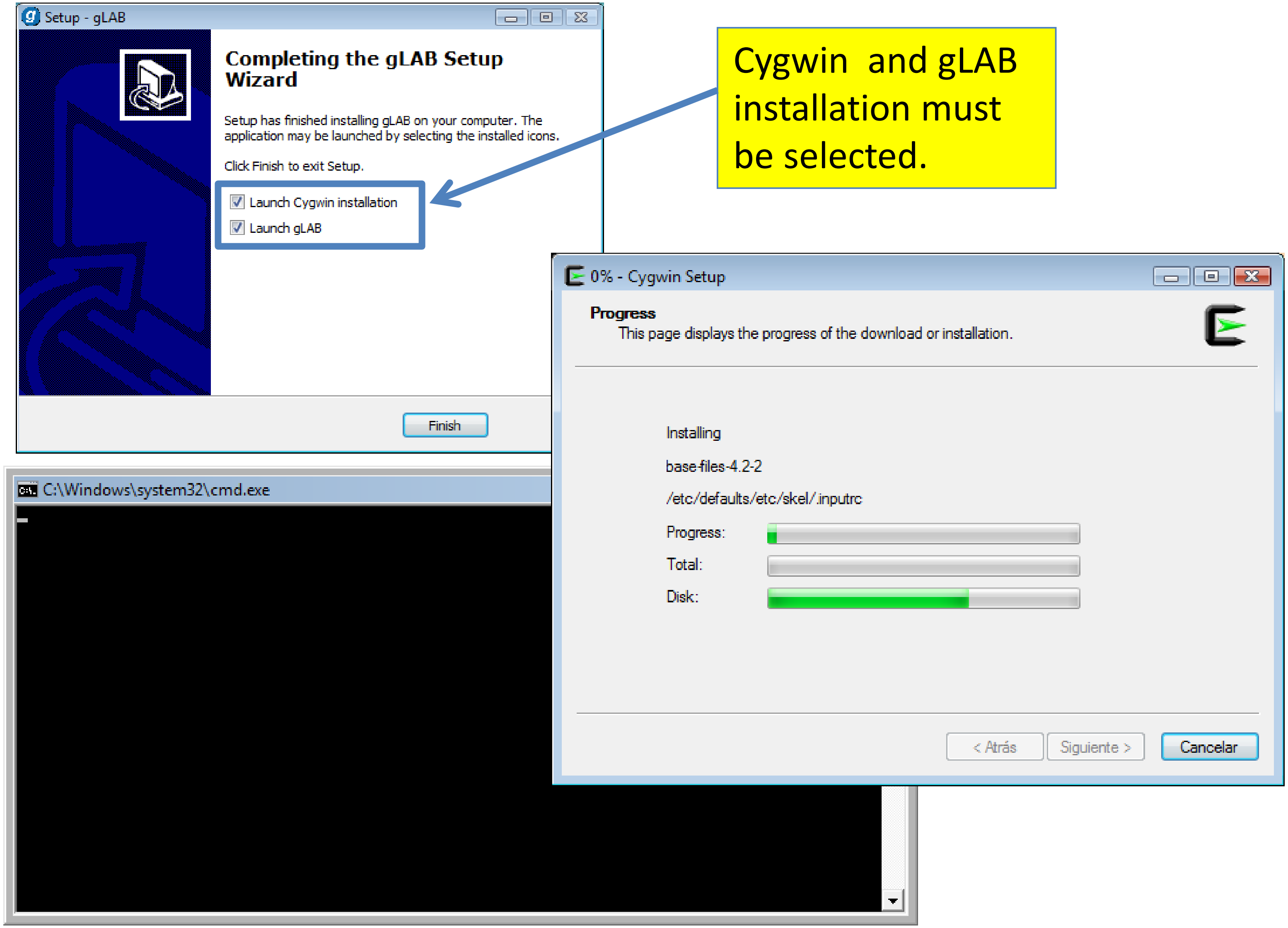






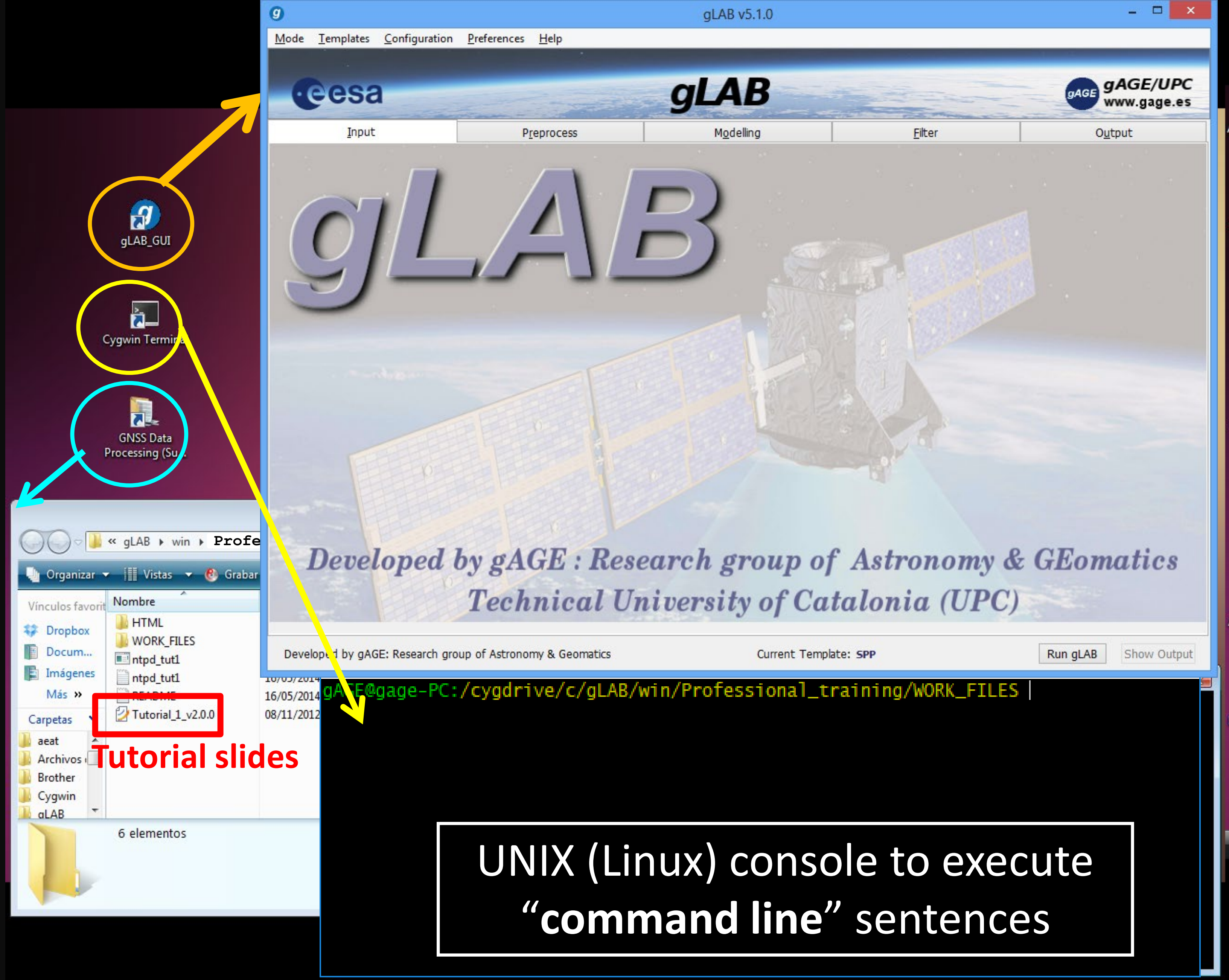


2.- Second Step: Completing the gLAB Setup Wizard

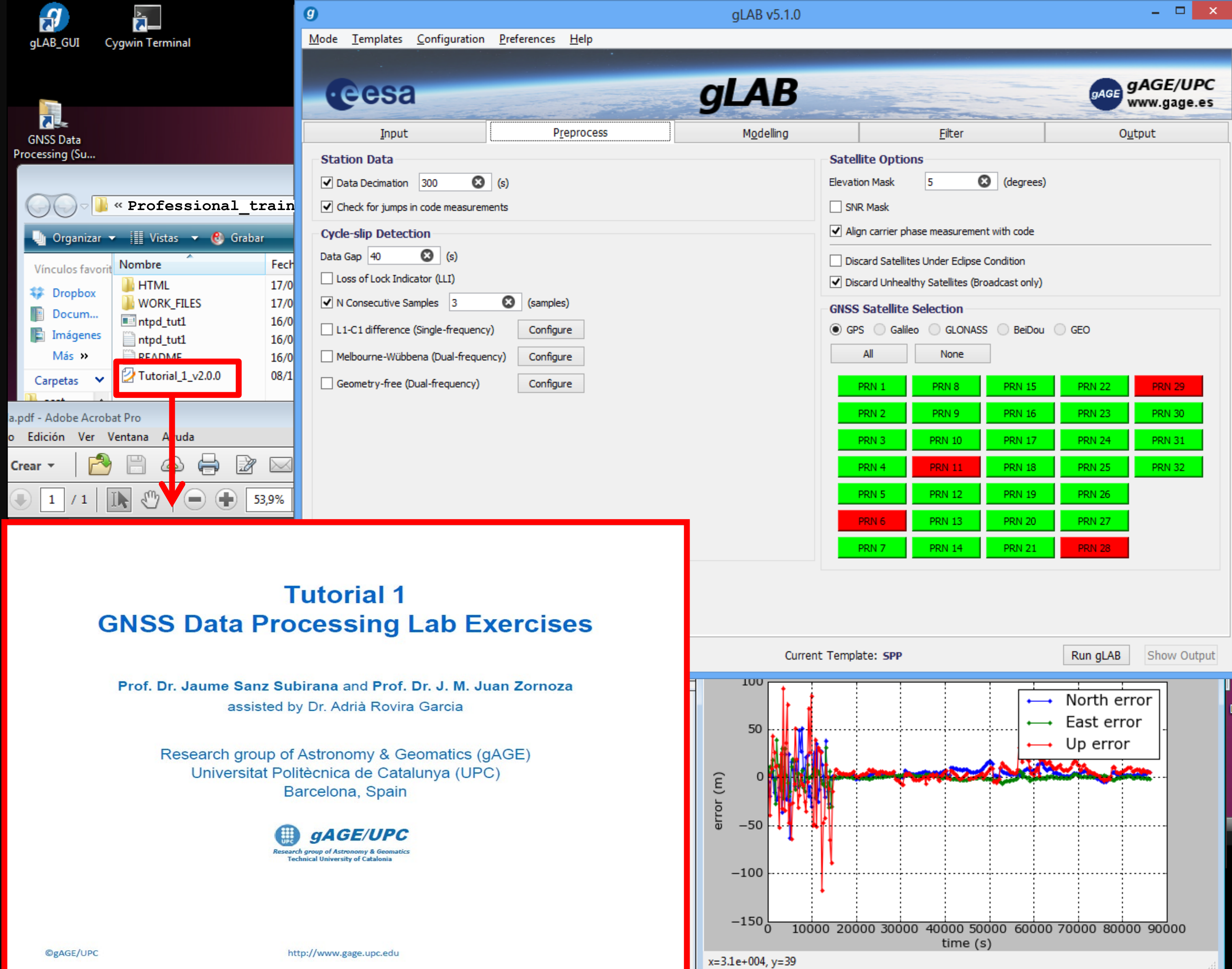


Cygwin and gLAB installation must be selected.

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



Suggested desk configuration to start working



Thanks for your attention

Other Tutorials are available at

http://www.gage.upc.edu

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Bing

Personnel

- Permanent Staff
- Researchers
- Former Researches

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

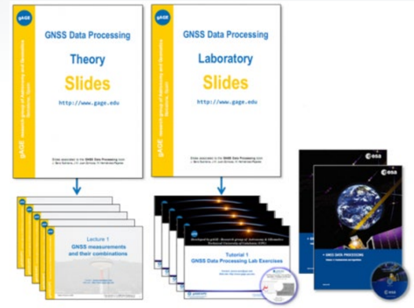
Projects

- 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 decription]
    - 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 buid-up a botable 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:

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

- Log in using OpenID
- Request new password

Who's online

There are currently *0 users* and *8 guests* online.

Acknowledgements

- The ESA/UPC GNSS-Lab Tool suit (gLAB) has been developed under the ESA Education Office contract N. P1081434.
- The data set of GRACE-A LEO satellite was obtained from the NASA Physical Oceanography Distributed Active Archive Center at the Jet Propulsion Laboratory, California Institute of Technology.
- The other data files used in this study were acquired as part of NASA's Earth Science Data Systems and archived and distributed by the Crustal Dynamics Data Information System (CDDIS).
- To Pere Ramos-Bosch for his fully and generous disposition to perform gLAB updates in his afterhours.
- To Adrià Rovira-Garcia for his contribution to the edition of this material and gLAB updating.
- To Deimos Ibáñez for his contribution to gLAB updating and making the Windows, Mac and LINUX installable versions for this tutorial.