Tutorial 0
Introduction to gLAB tool suite

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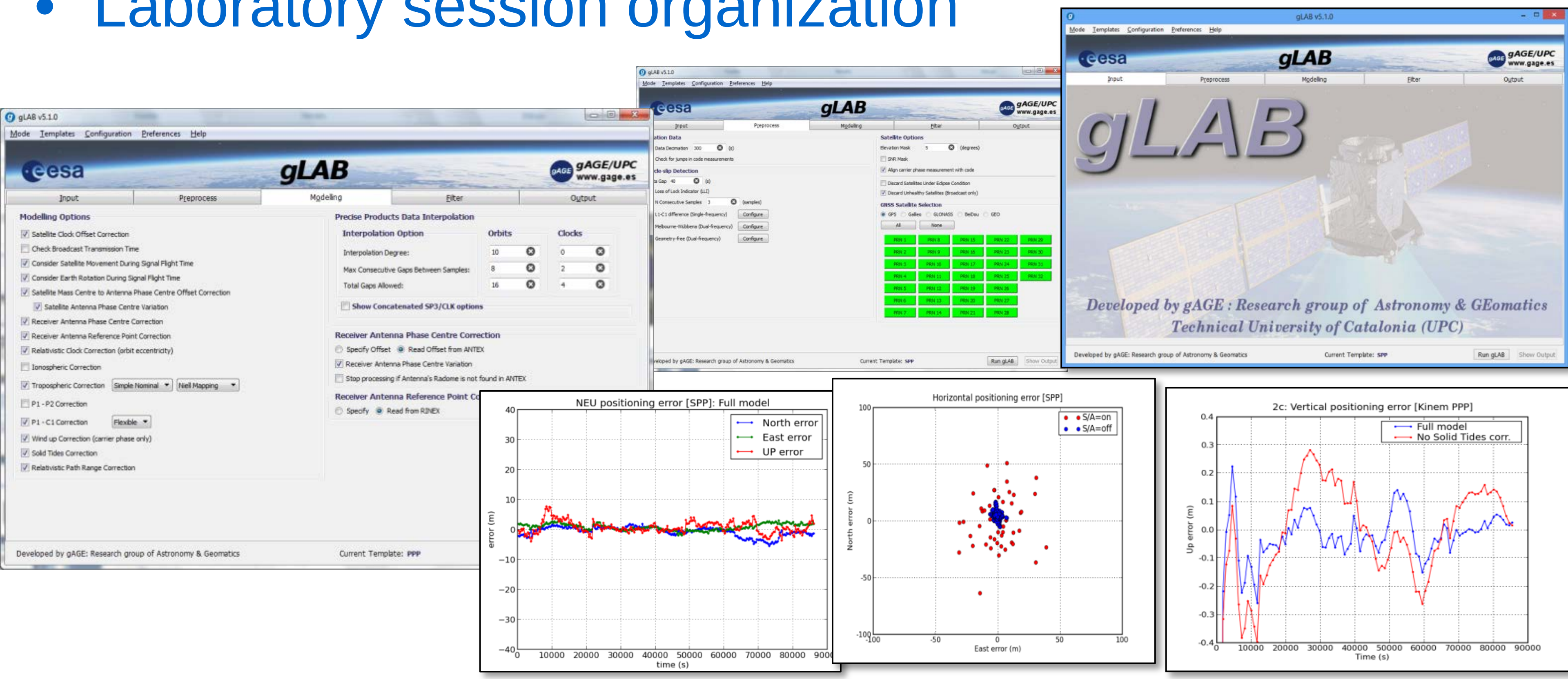
gAGE/UPC
Research group of Astronomy & Geomatics
Technical University of Catalonia

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.

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- Introduction
- The gLAB tool suite
- 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.

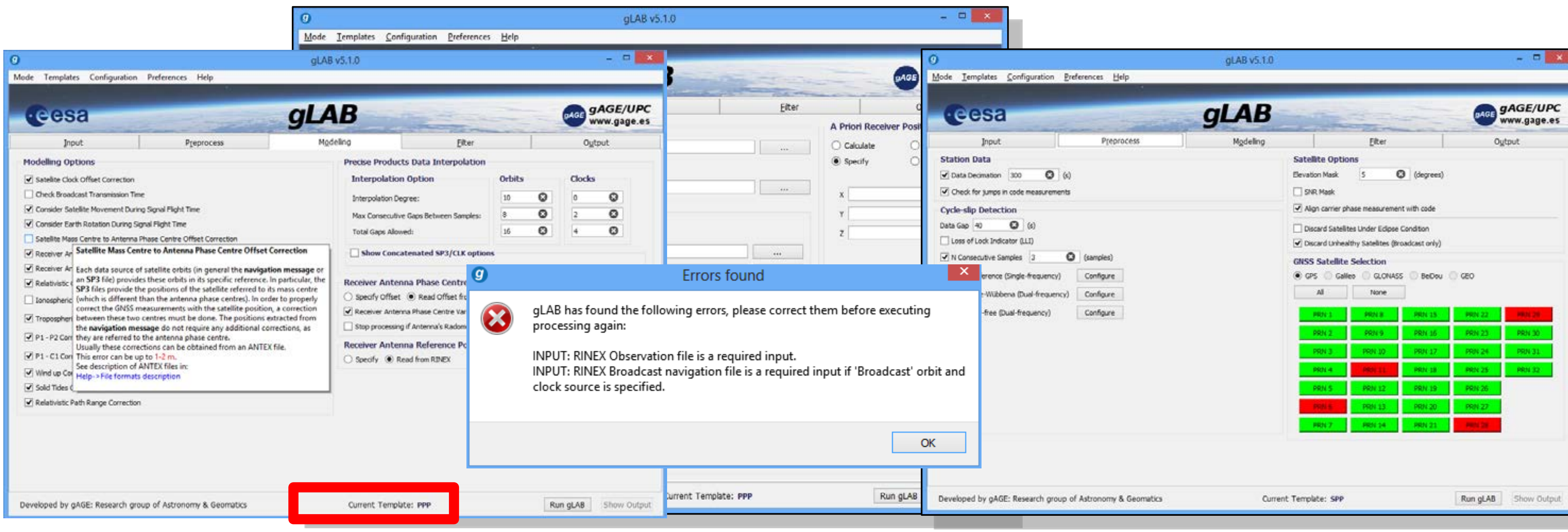
- Main features:
  - High Accuracy Positioning capability.
  - Fully configurable.
  - Easy to use.
  - Access to internal computations.

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

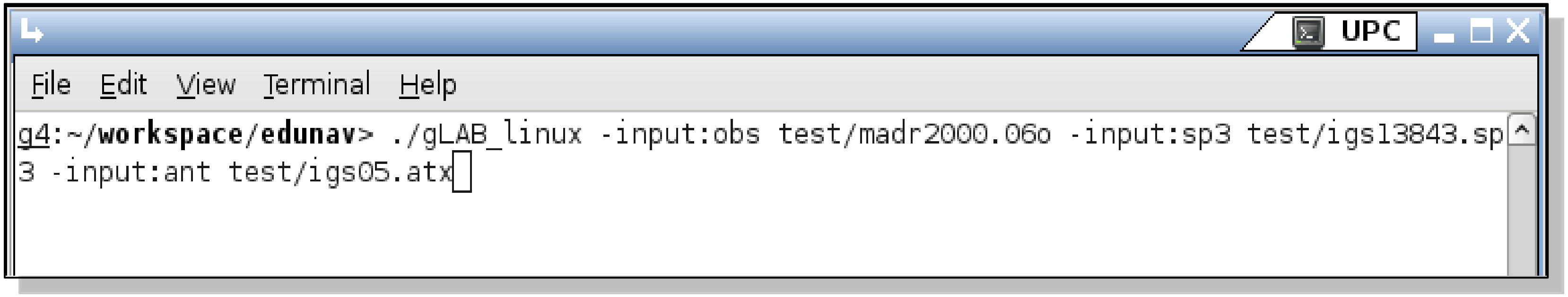
- Students/Newcomers:
  - Easiness of use: Intuitive GUI.
  - Explanations: Tooltips over the different options of the GUI.
  - Guidelines: Several error and warning messages. Templates for pre-configured processing.



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**.



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).

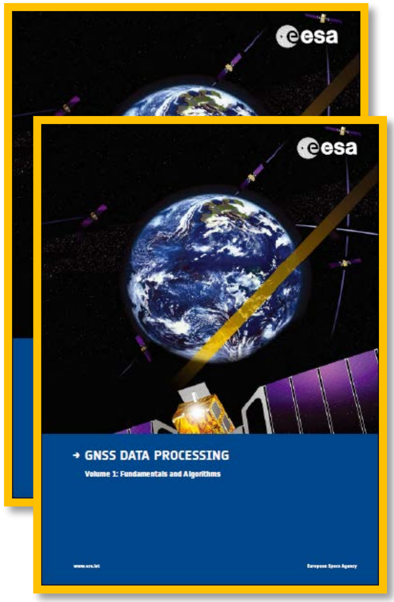
- Output module:
  - Cartesian / NEU coordinates.
  - Configurable message output.

- 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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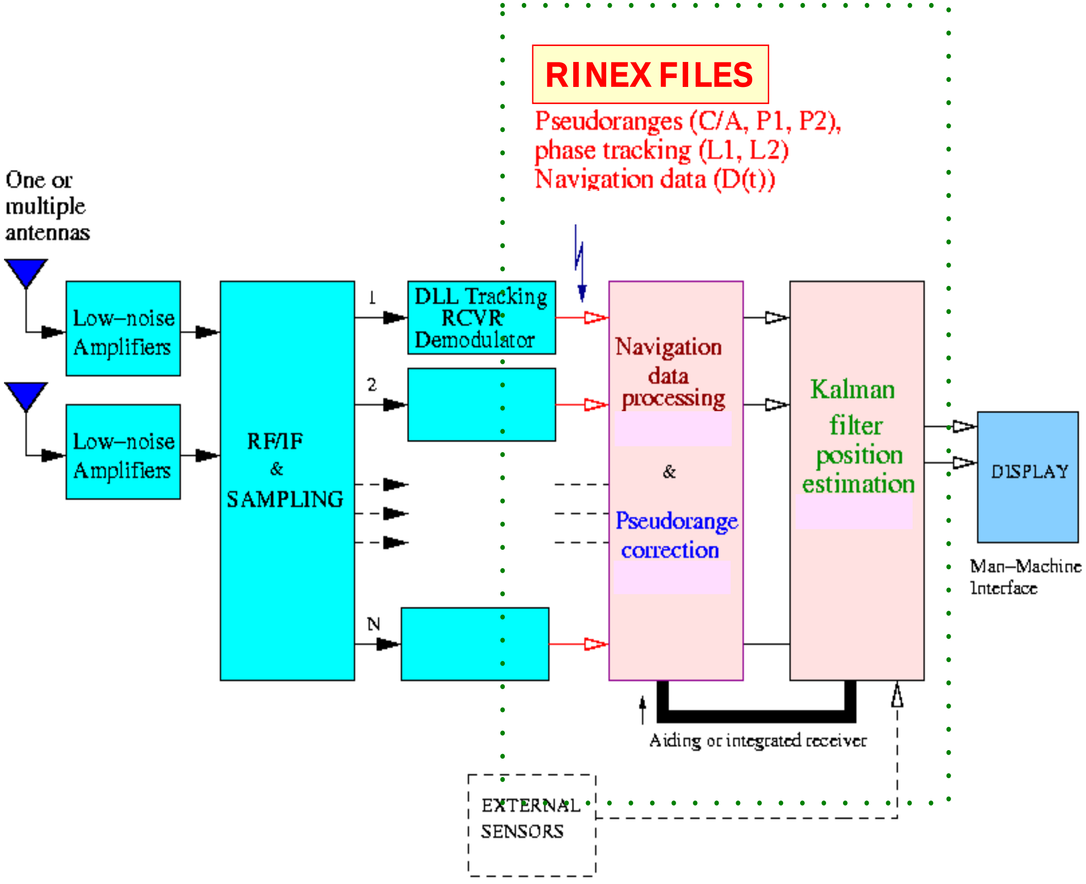
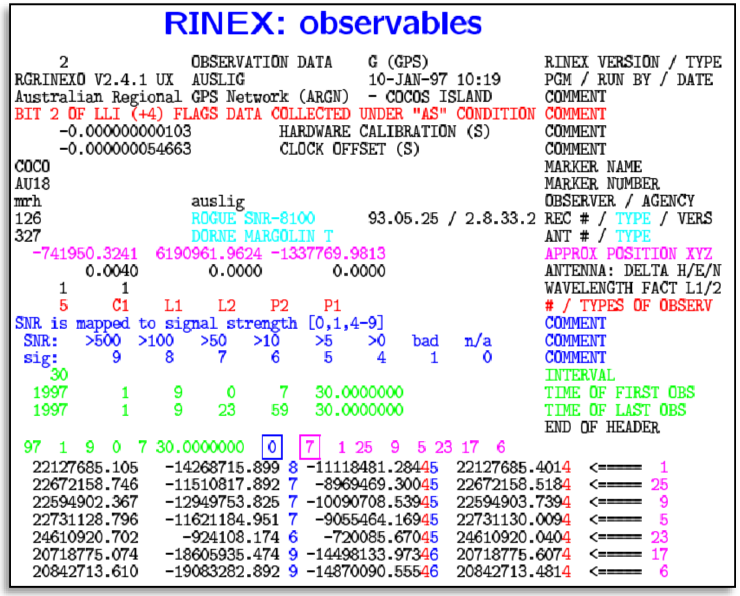
Basic: Introductory Lab. Exercises

- 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.

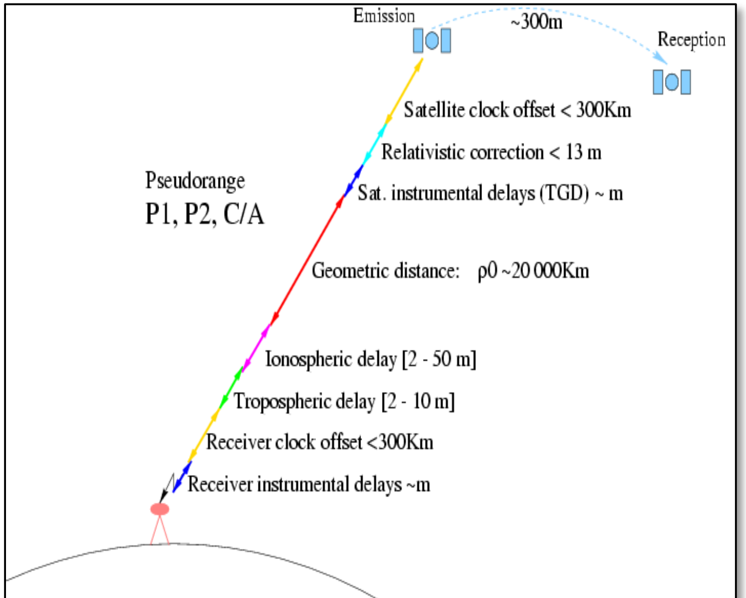
We will work after the correlator: Our input data are code and carrier measurements and satellite orbits and clocks.





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
```



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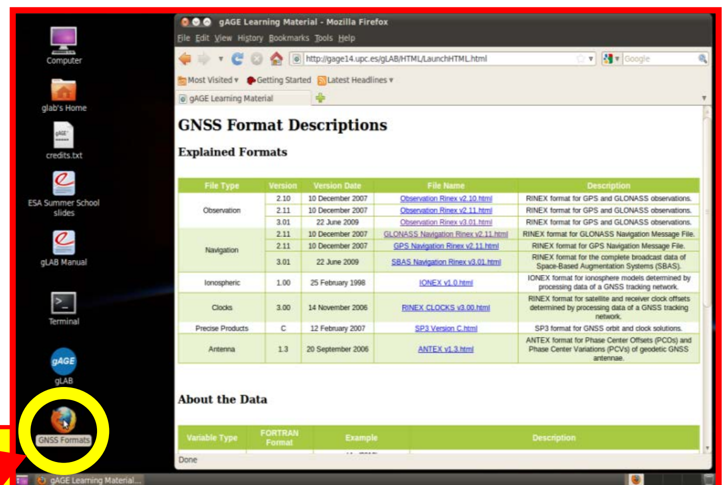
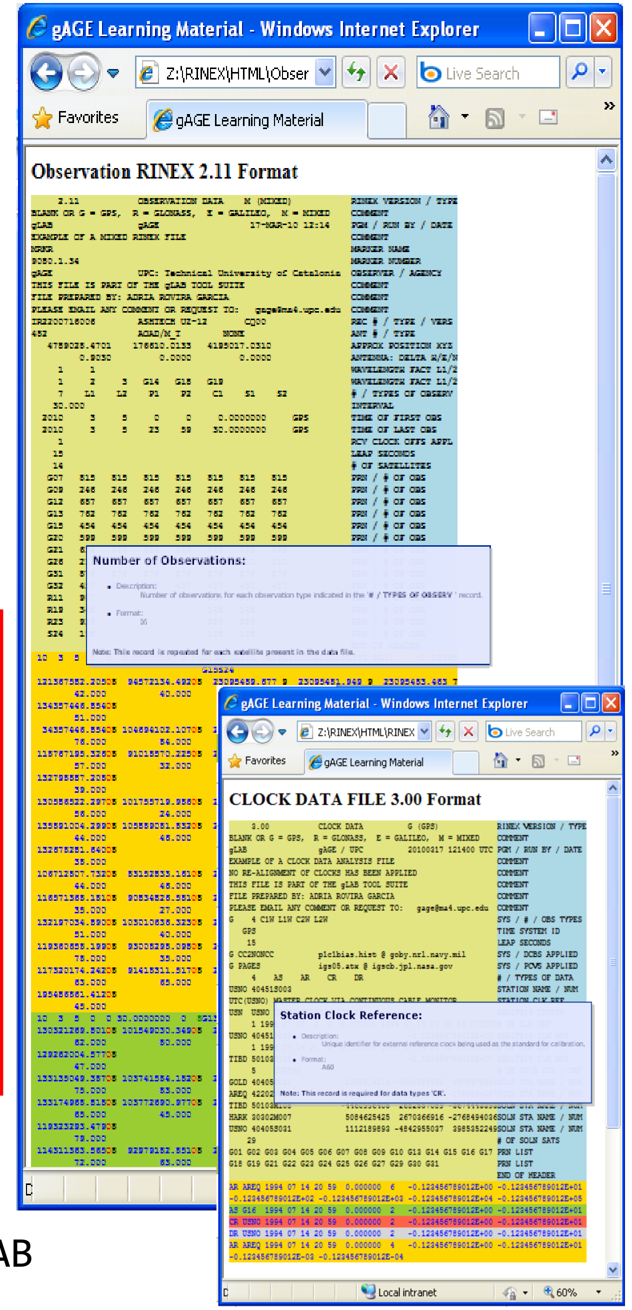
GNSS Format Descriptions

- 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

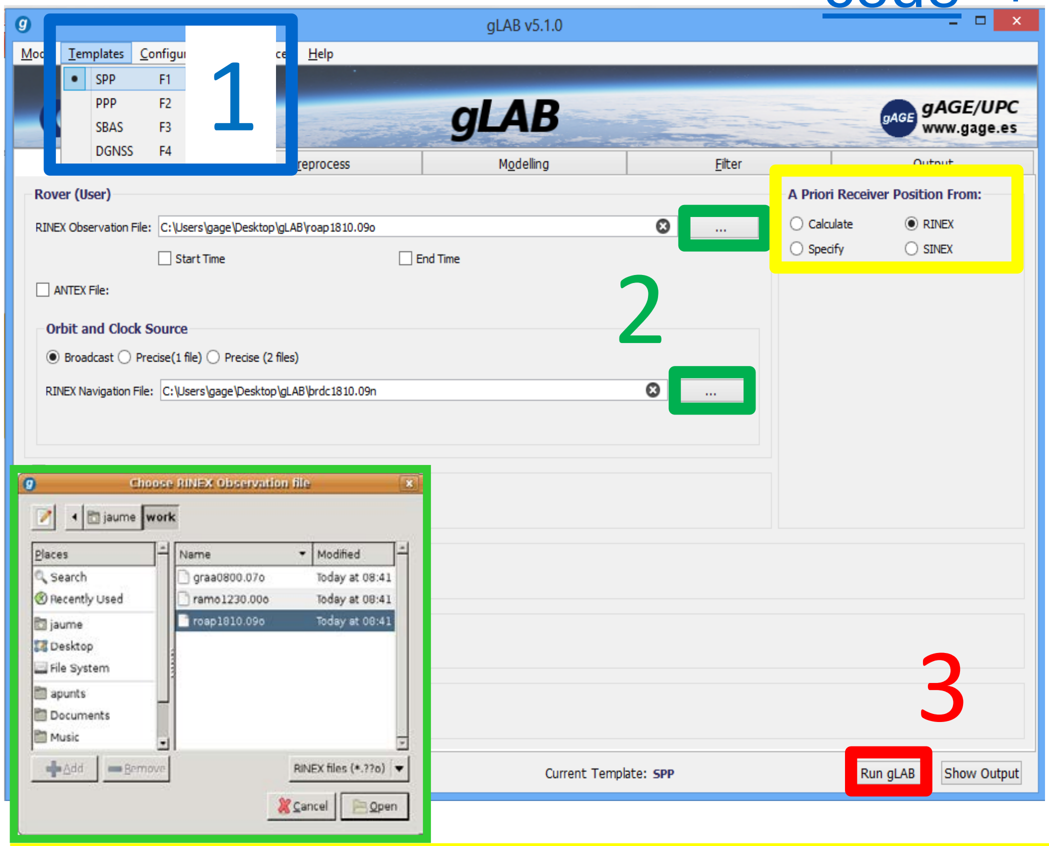
with **Firefox** internet browser



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.



Note: Reference coordinates are from RINEX

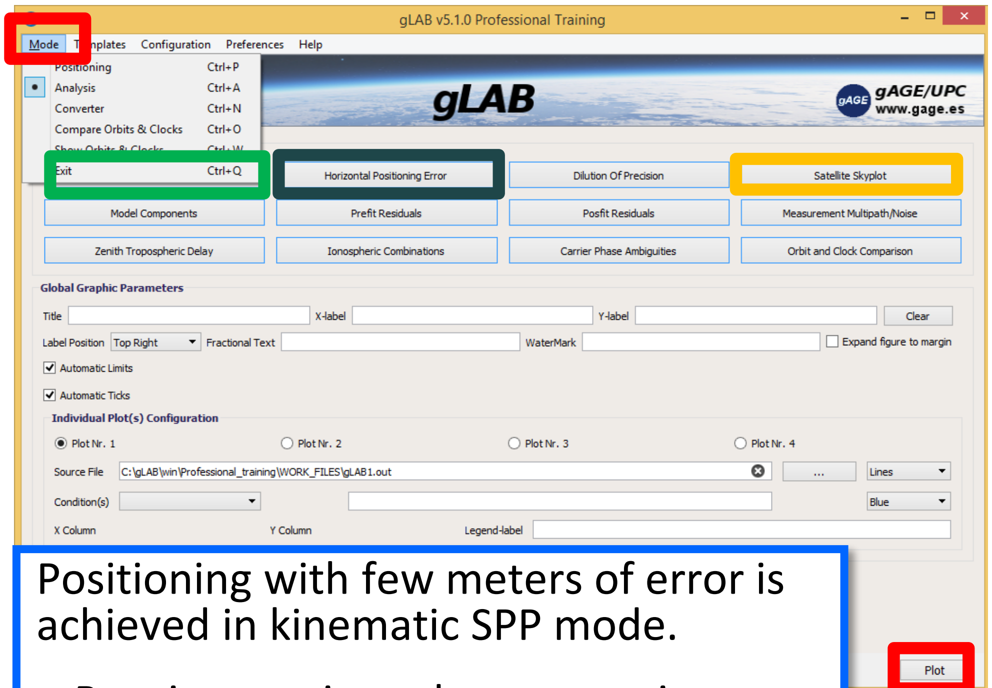
1. Select the **SPP Template**
2. **Upload the RINEX files:**
   - Measurement: `roap1810.09o`
   - Navigation: `brdc1810.09n`
3. **RUN** gLAB

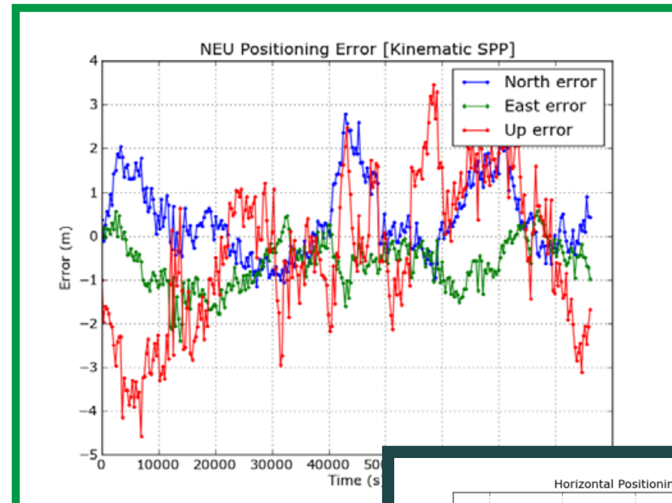
Default output file:

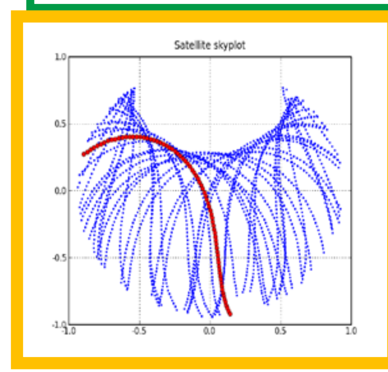
gLAB.out

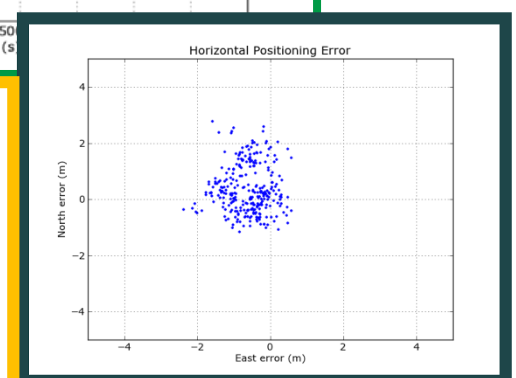
Example 1: Standard Point Positioning (SPP)

- Plotting Results







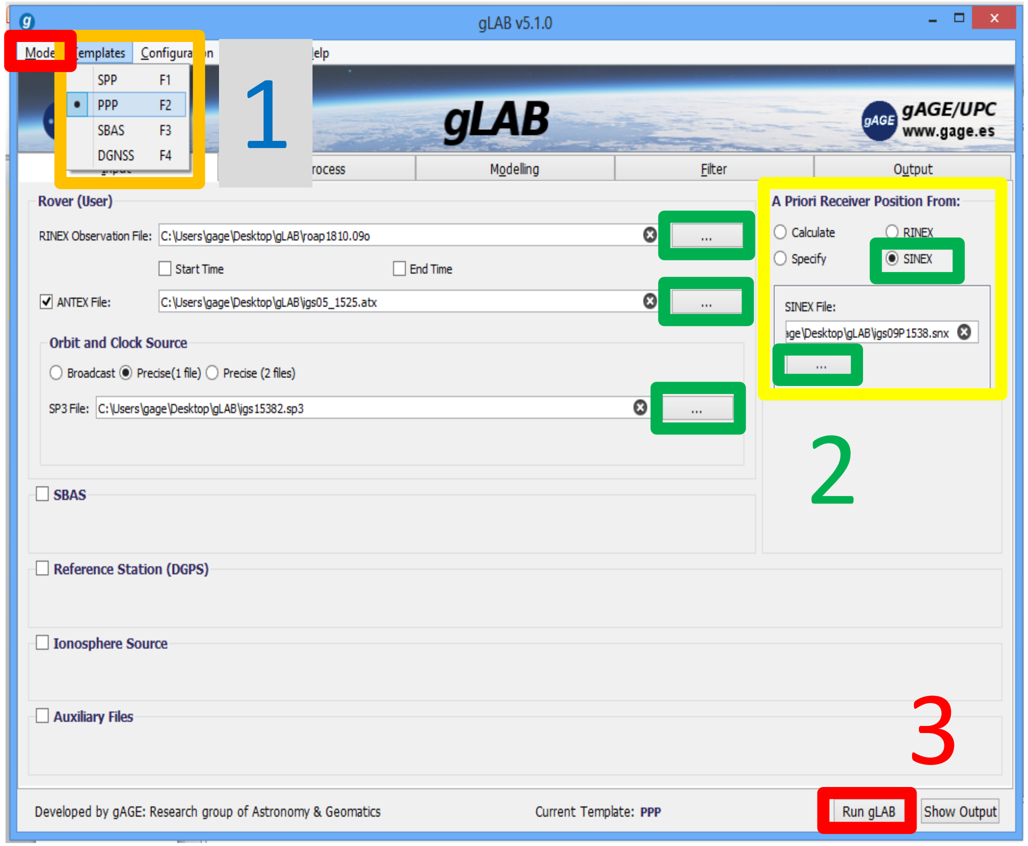


Positioning with few meters of error is achieved in kinematic SPP mode.

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

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

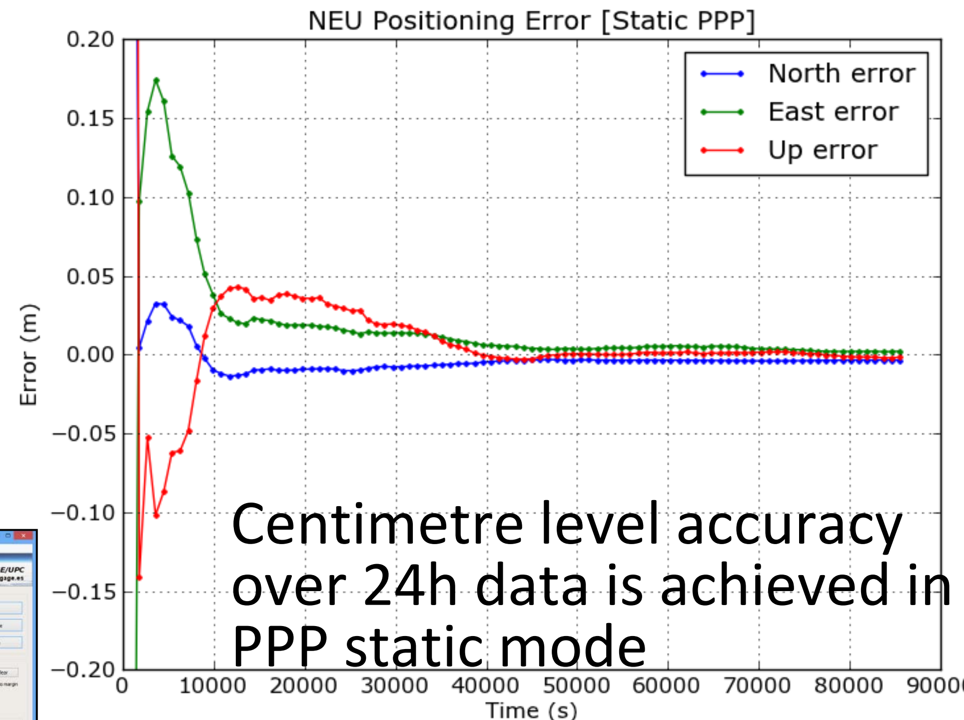
Default output file:

gLAB.out

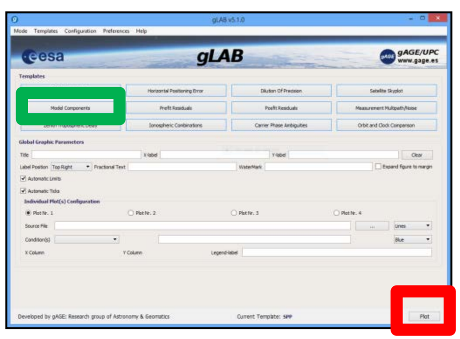
Example 2: Static Precise Point Positioning (PPP)

• 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.



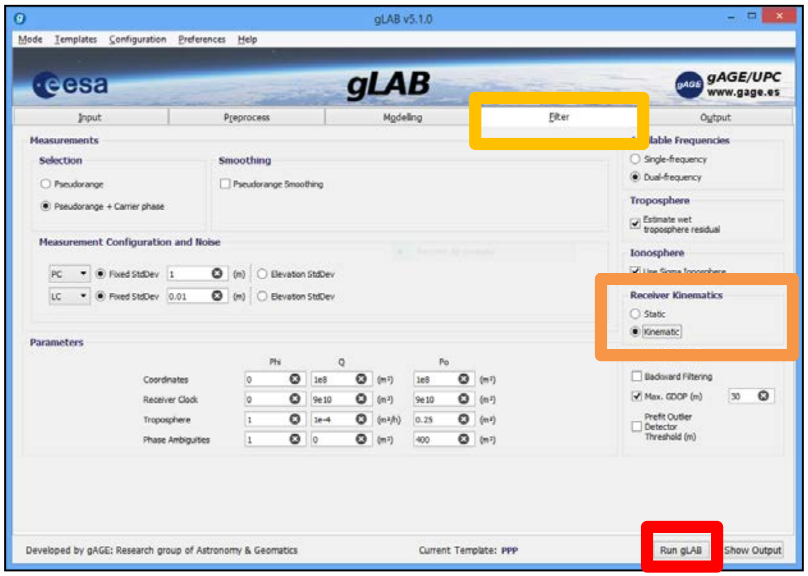
Centimetre level accuracy over 24h data is achieved in PPP static mode

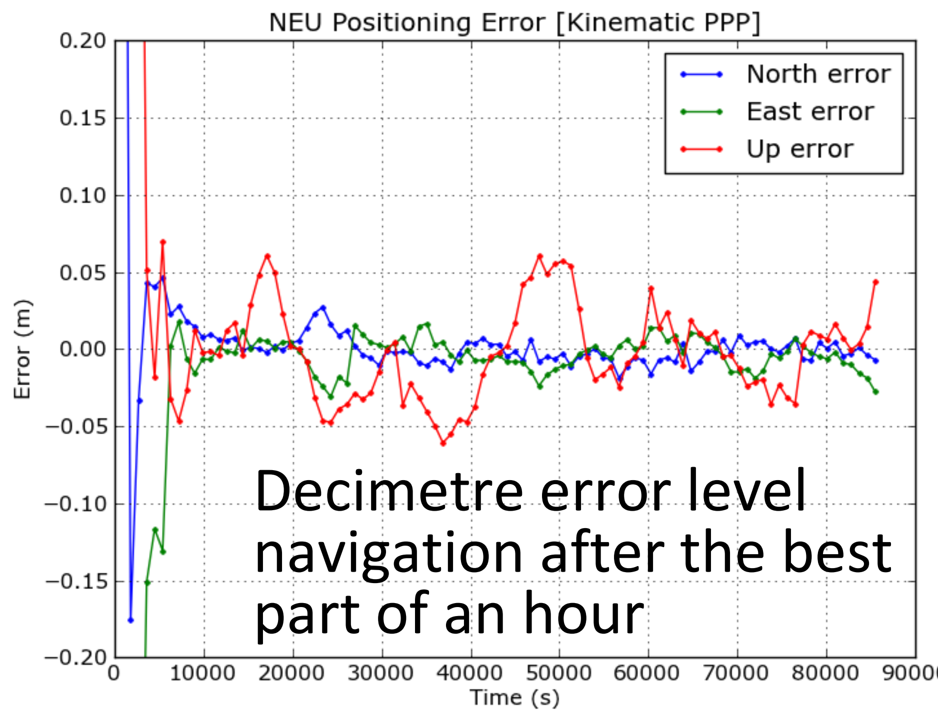


Example 3: Kinematic Precise Point Positioning

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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- Examples of GNSS Positioning using gLAB
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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.

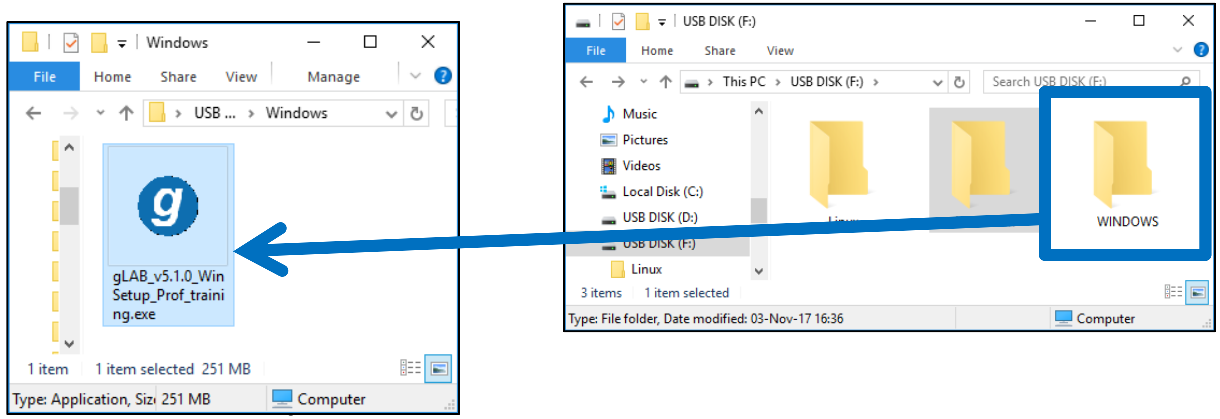
Nevertheless, the necessary tools are provided for **Windows or Macintosh** users to install this software and to emulate a UNIX command line shell over Windows.

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

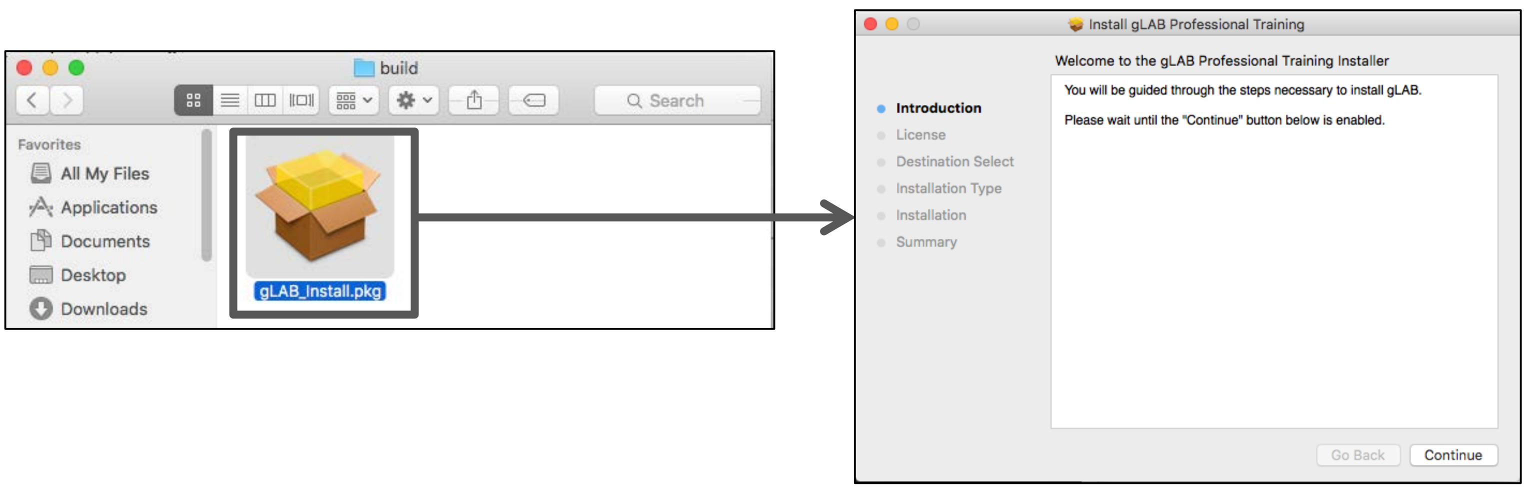
Windows users can install the windows version of **gLAB** and the **Cygwin** emulator of a Linux command shell.

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

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

Windows users

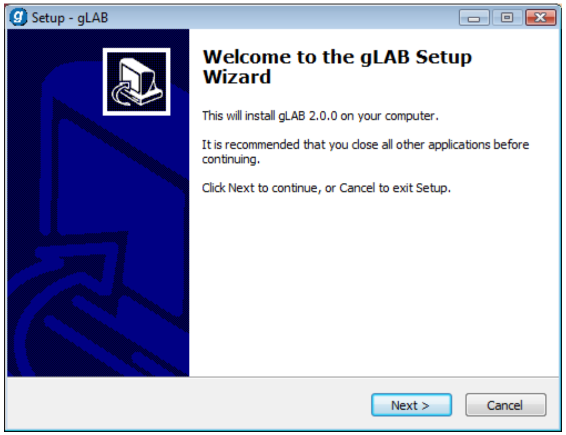
The Medium and Advanced exercises of this tutorial have been designed to be executed under **UNIX (Linux) Operative System** (OS). Which is a very powerful and robust environment.

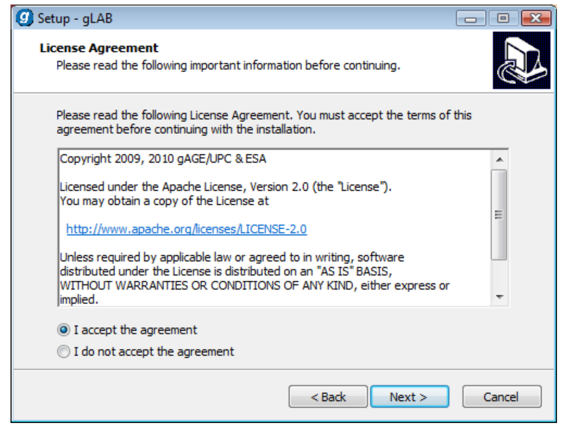
Nevertheless, **Windows OS** users can do the laboratory session by using **Cygwin**, which is a tool that allows to emulate a UNIX command line shell over Windows.

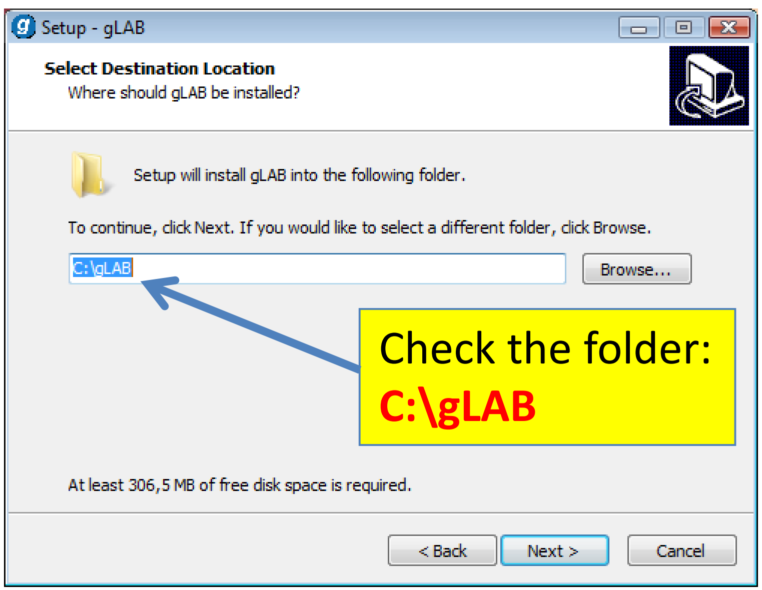
Indeed, after installing **Cygwin**, users can develop the laboratory session as if they were working on a UNIX system (as this tutorial was designed).

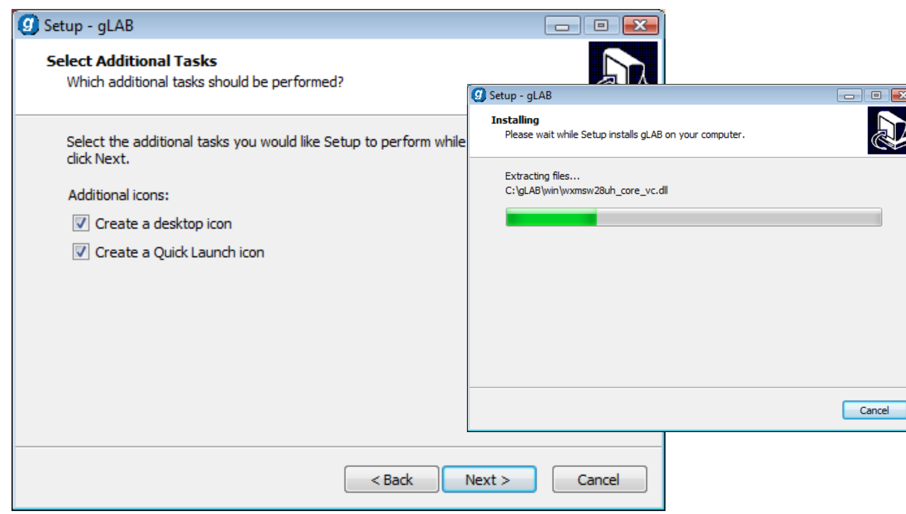
Installing **gLAB + Cygwin**

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

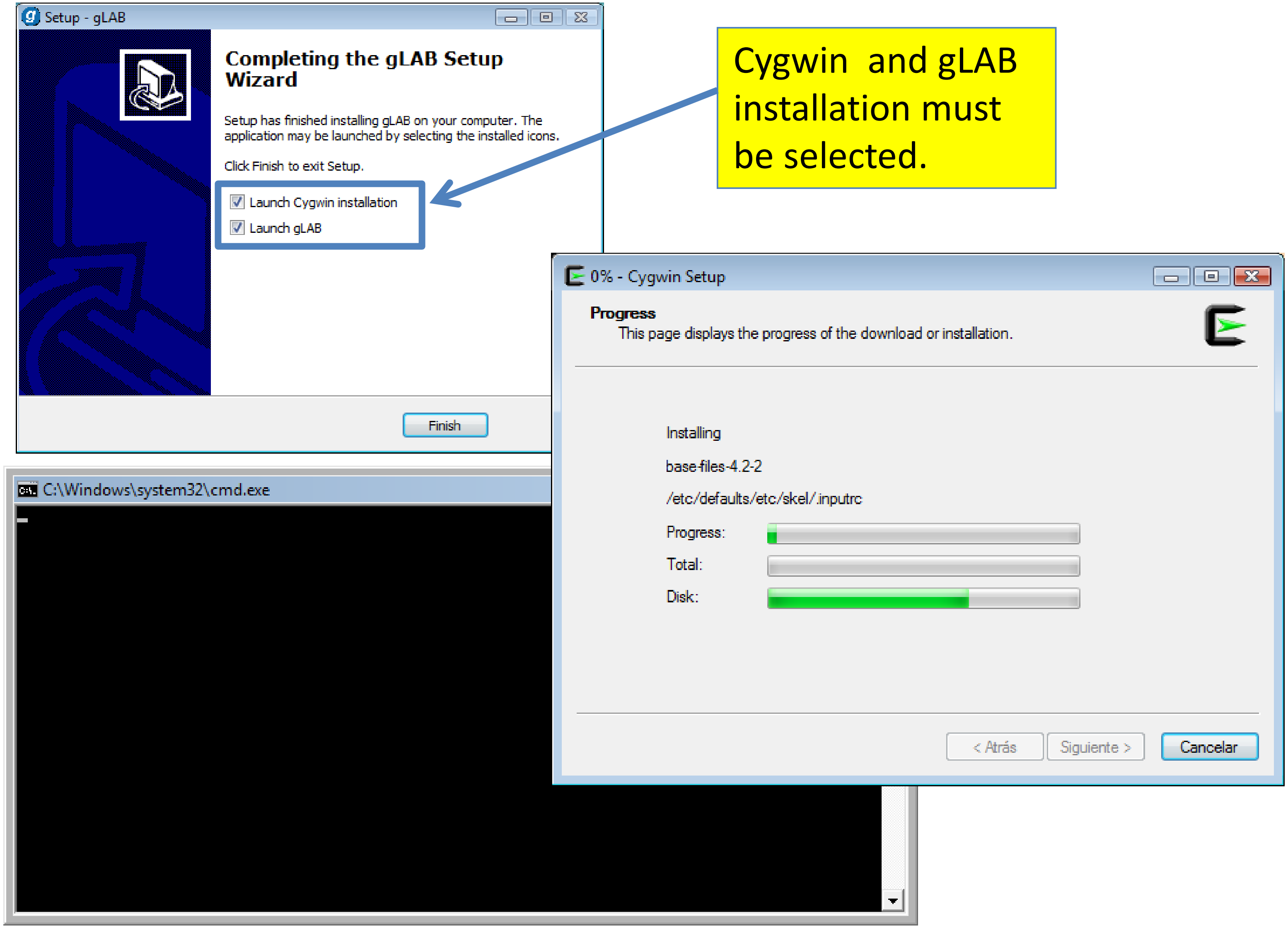








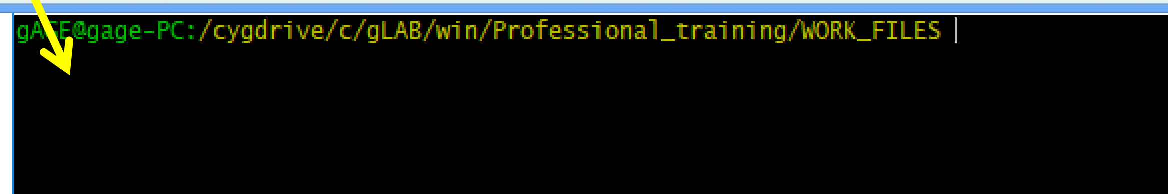
2.- Second Step: Completing the gLAB Setup Wizard



Cygwin and gLAB installation must be selected.

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

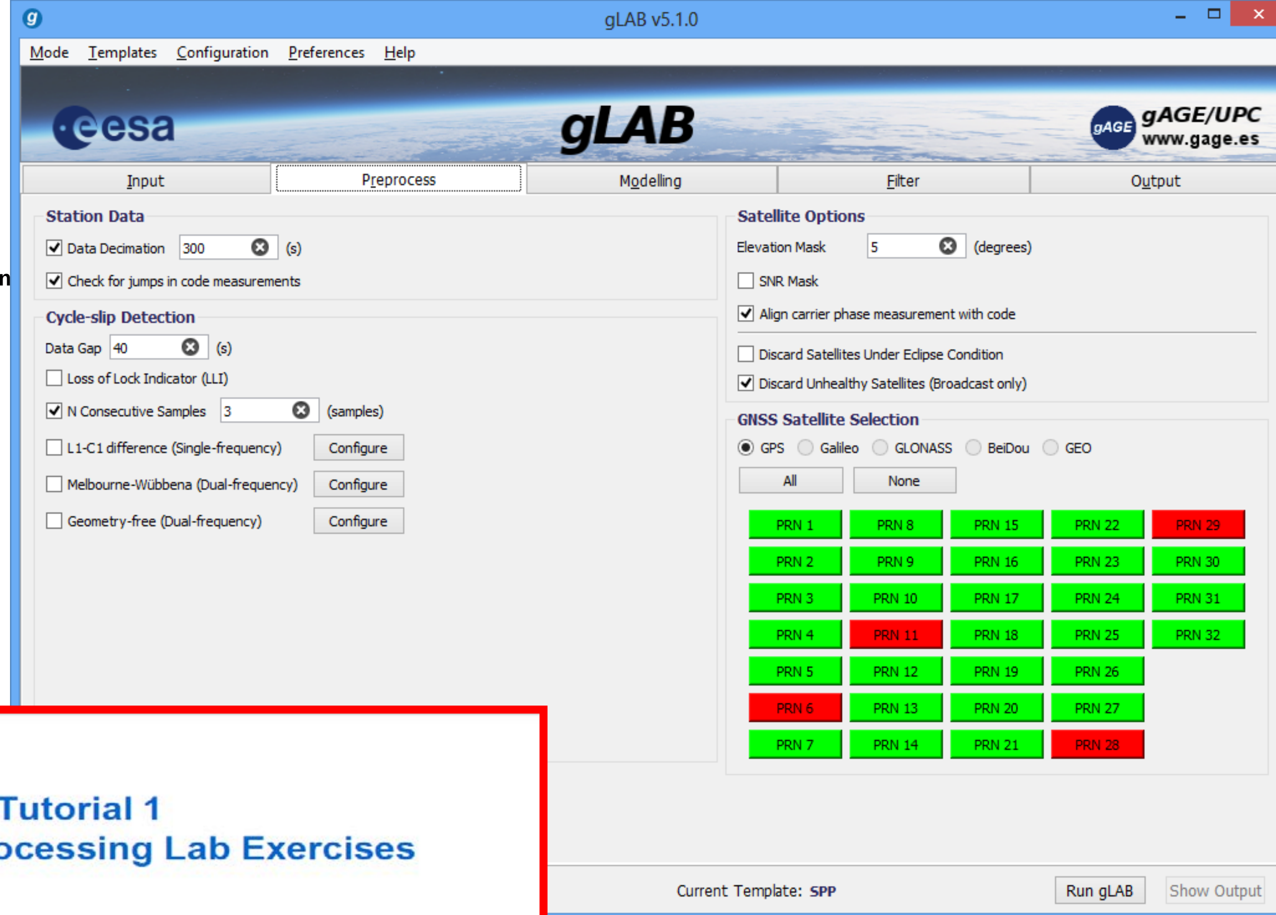
Tutorial slides

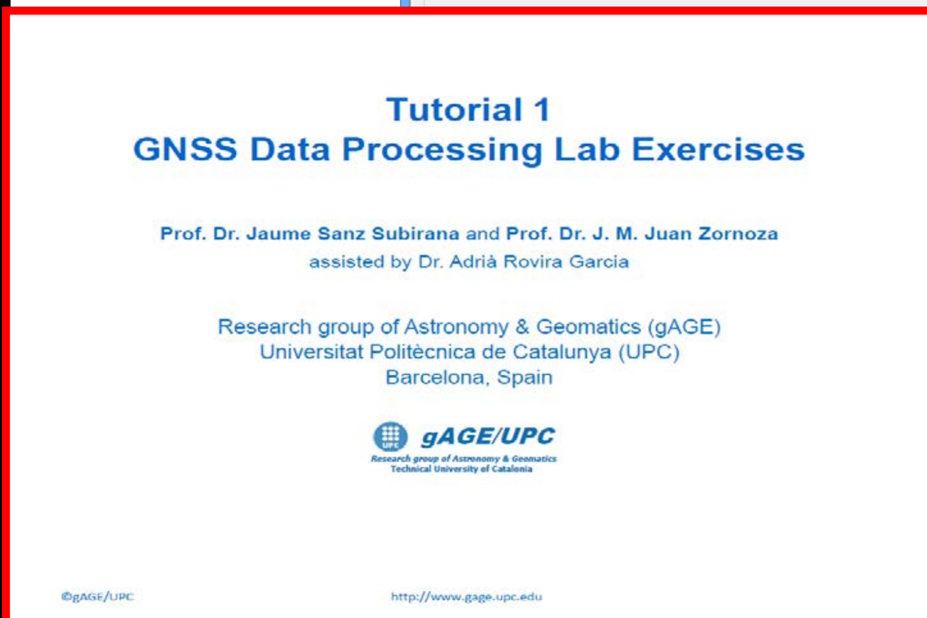


UNIX (Linux) console to execute "**command line**" sentences

Suggested desk configuration to start working

Professional_train

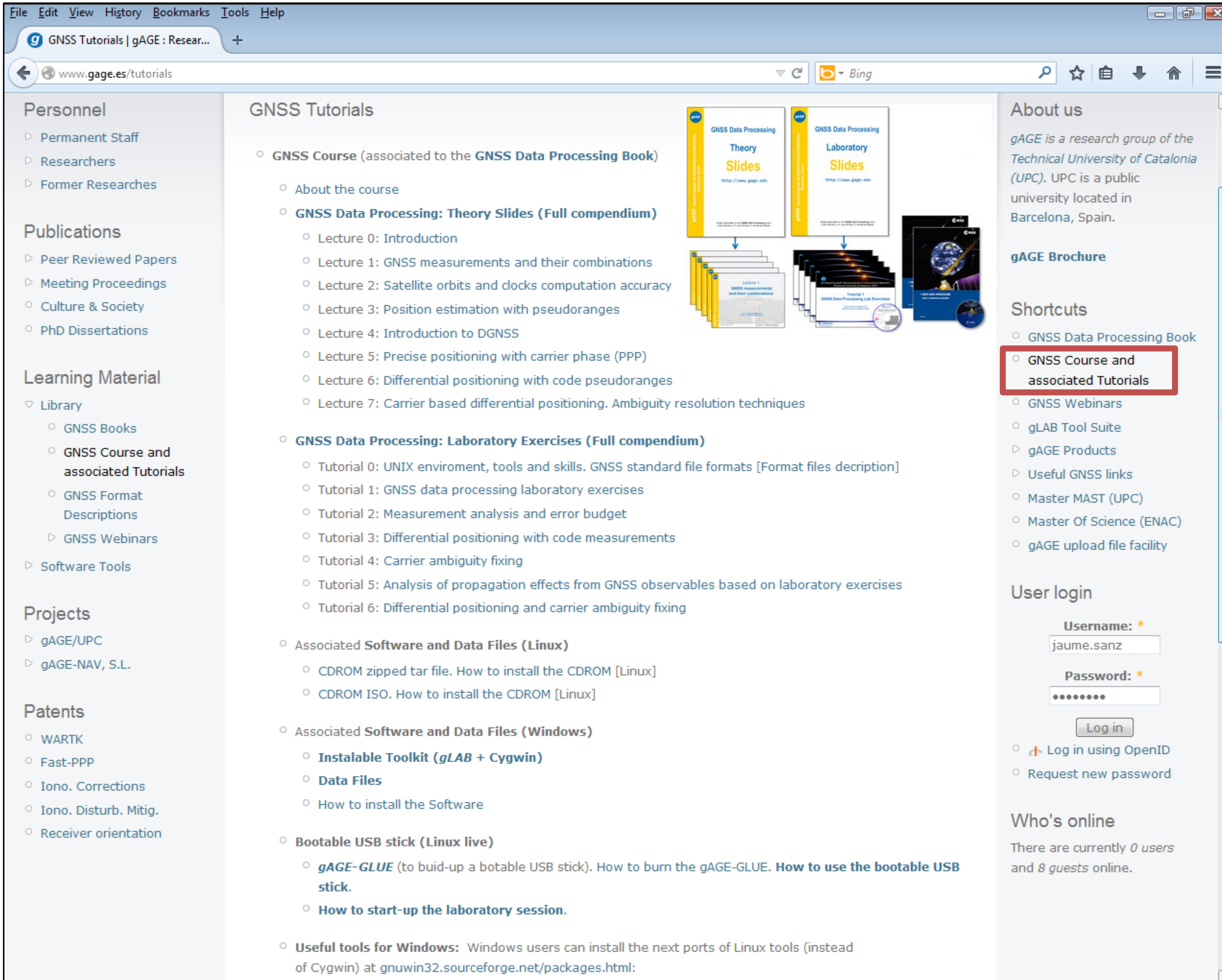




Thanks for your attention

Other Tutorials are available at

http://www.gage.upc.edu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www.gage.es/tutorials

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 installable version for this tutorial.