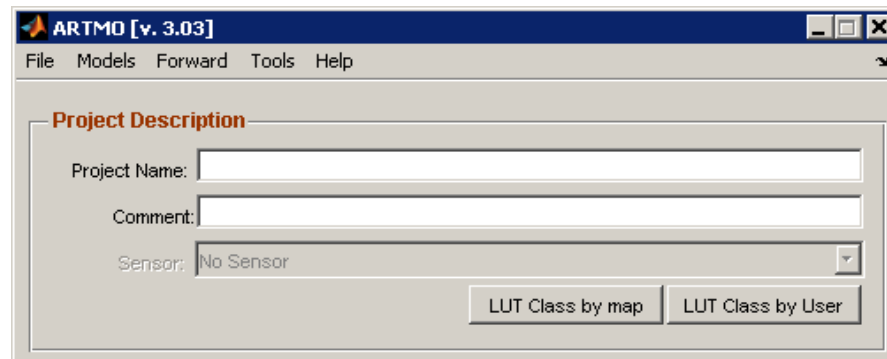


# Automated Radiative Transfer Models Operator (ARTMO)

## Tutorial: The ARTMO toolbox

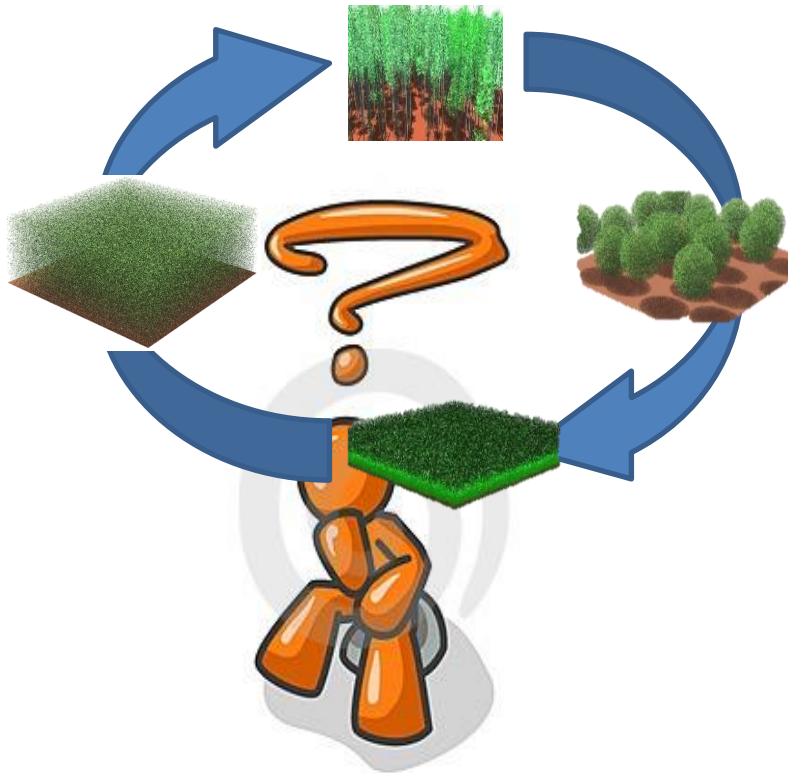


Jochem Verrelst

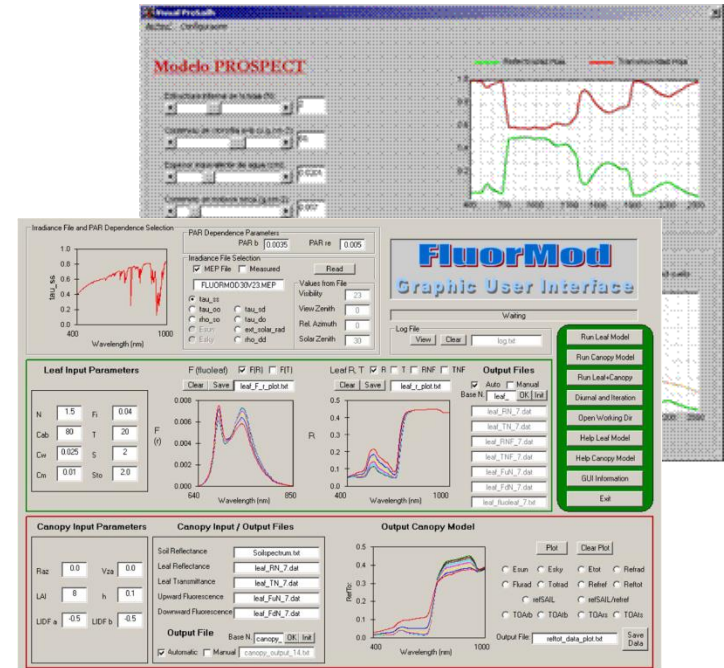
[Jochem.verrelst@uv.es](mailto:Jochem.verrelst@uv.es) - <http://ipl.uv.es/artmo/>

RTMs are important tools in EO research but for the broader community these models are perceived as complicated. Only very few of them offer a GUI.

Which RTM to choose?



Only very few of them offer a GUI



(Zarco-Tejada et al., 2006)

- No GUI exists that brings multiple RTMs together in one GUI
- None of existing GUIs provide retrieval strategies for biophysical parameters retrieval .

# To fill up this gap:

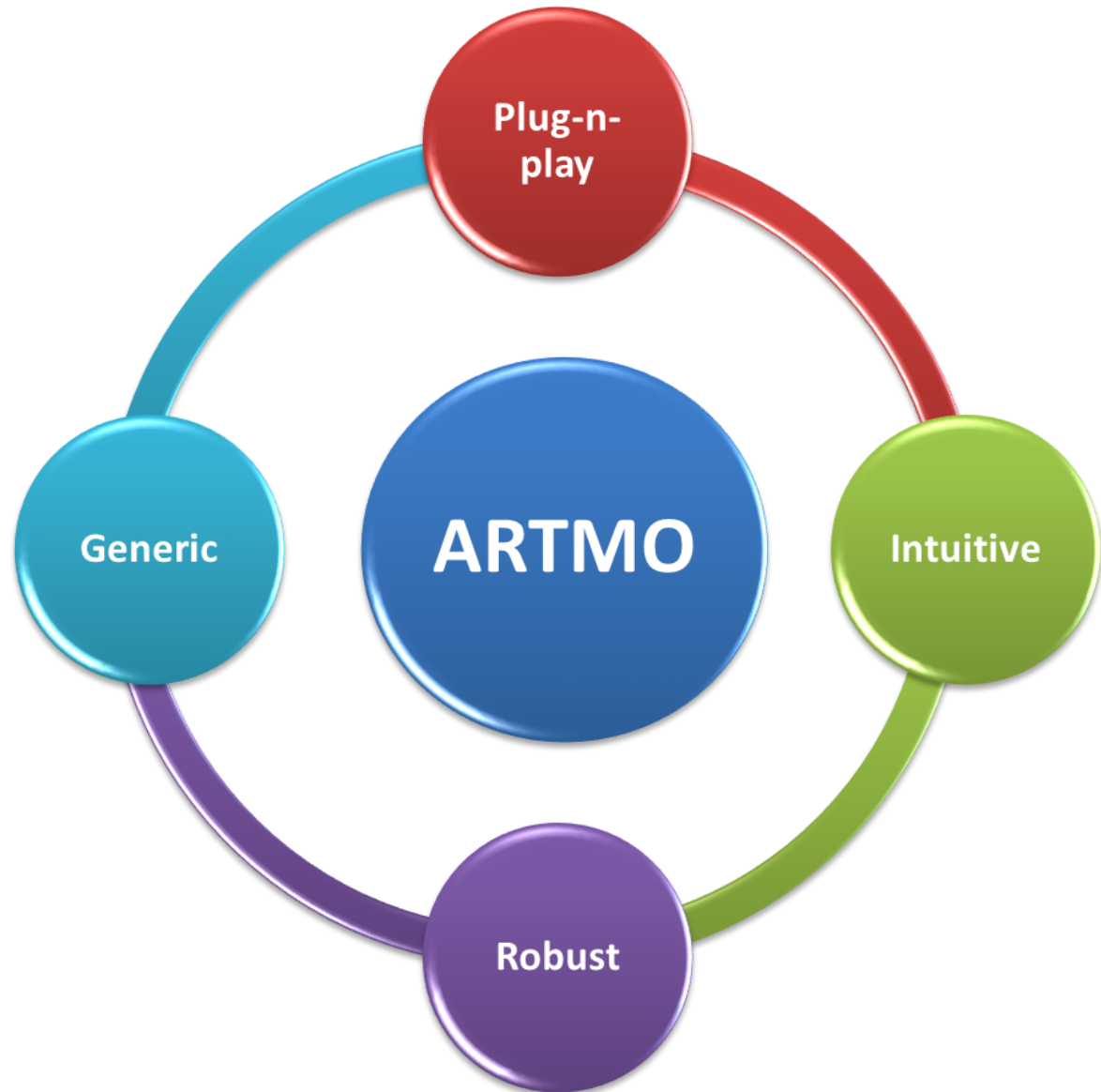
## ➤ To develop a GUI toolbox that:

- operates **various RTMs** in an intuitive interface
- provides a comprehensive **visualization** of model outputs
- works both for **multispectral and hyperspectral** data
- enables **to retrieve biophysical parameters** through various retrieval methods
- takes different **land cover classes** into account.

# Toolbox for EO applications:

## ARTMO:

Automated  
Radiative  
Transfer  
Models  
Operator





# ARTMO v3.03

**ARTMO [v. 3.03]**

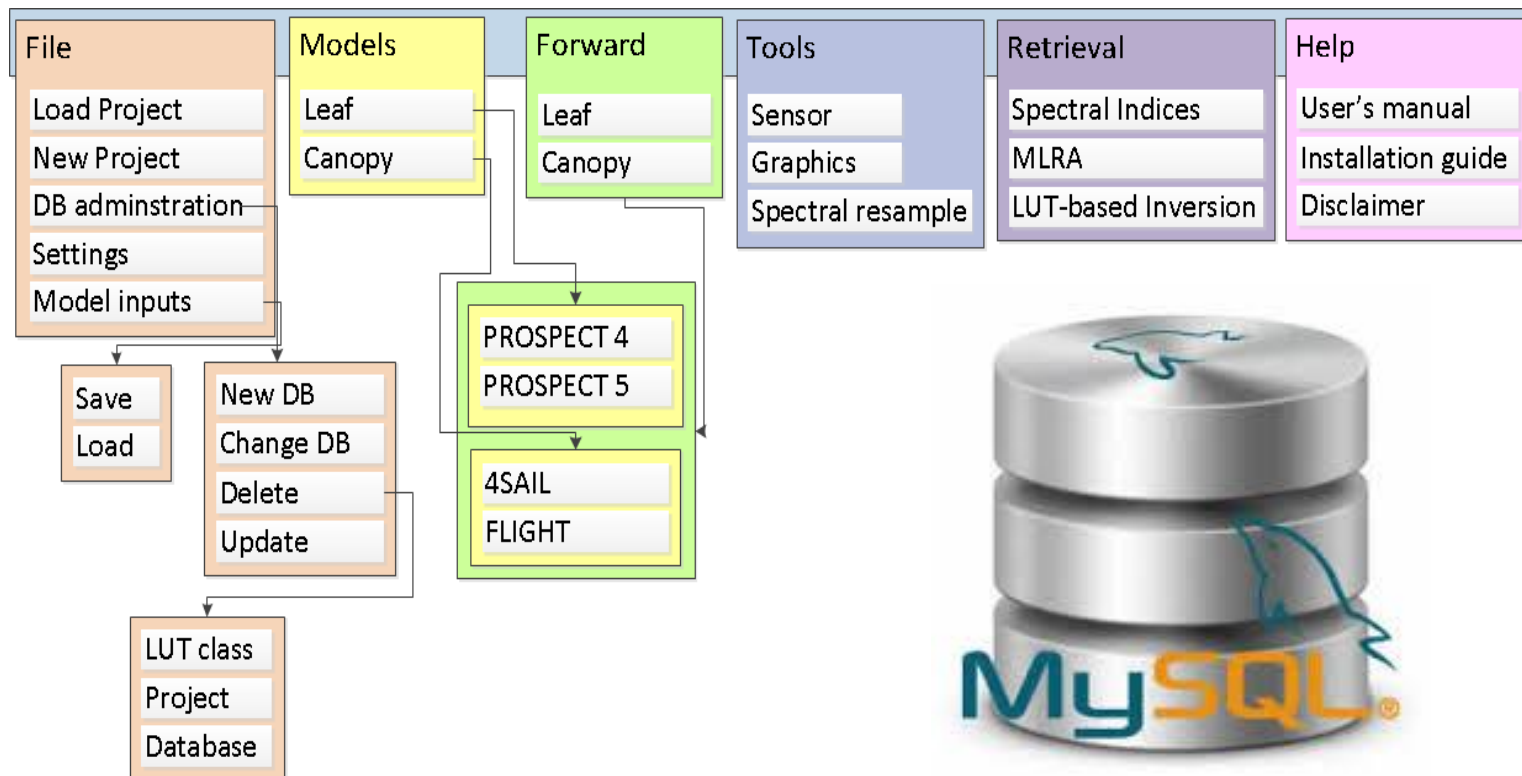
File Models Forward Tools Help

**Project Description**

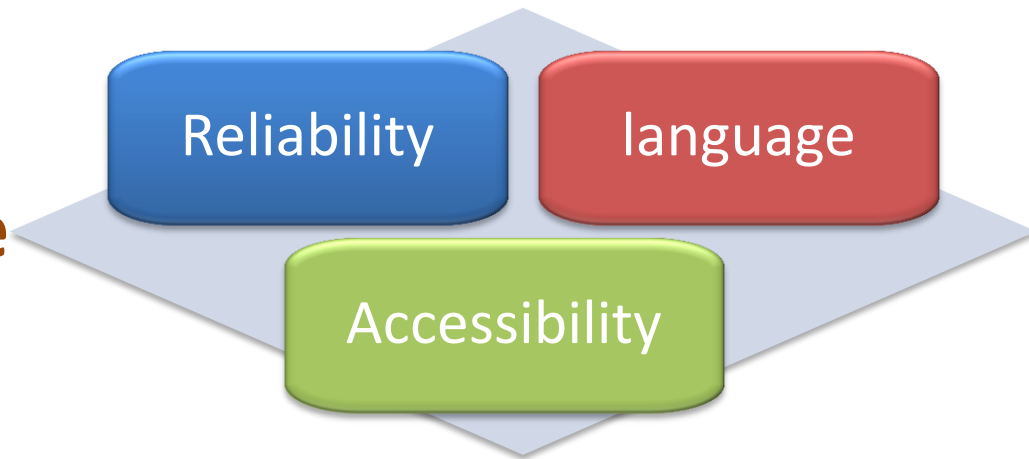
Project Name:

Comment:

Sensor:



# Selection RTMs & programming language

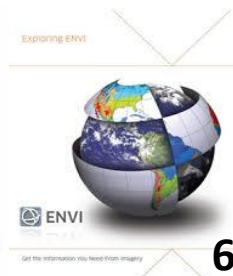


Model	Reference	Source code
PROSPECT-4	Feret et al., 2008	Matlab
PROSPECT-5	Feret et al., 2008	Matlab
DLM	Stuckens et al., 2009	Matlab
4SAIL	Verhoef et al., 2007	Matlab
FLIGHT	North, 1996	Executable file

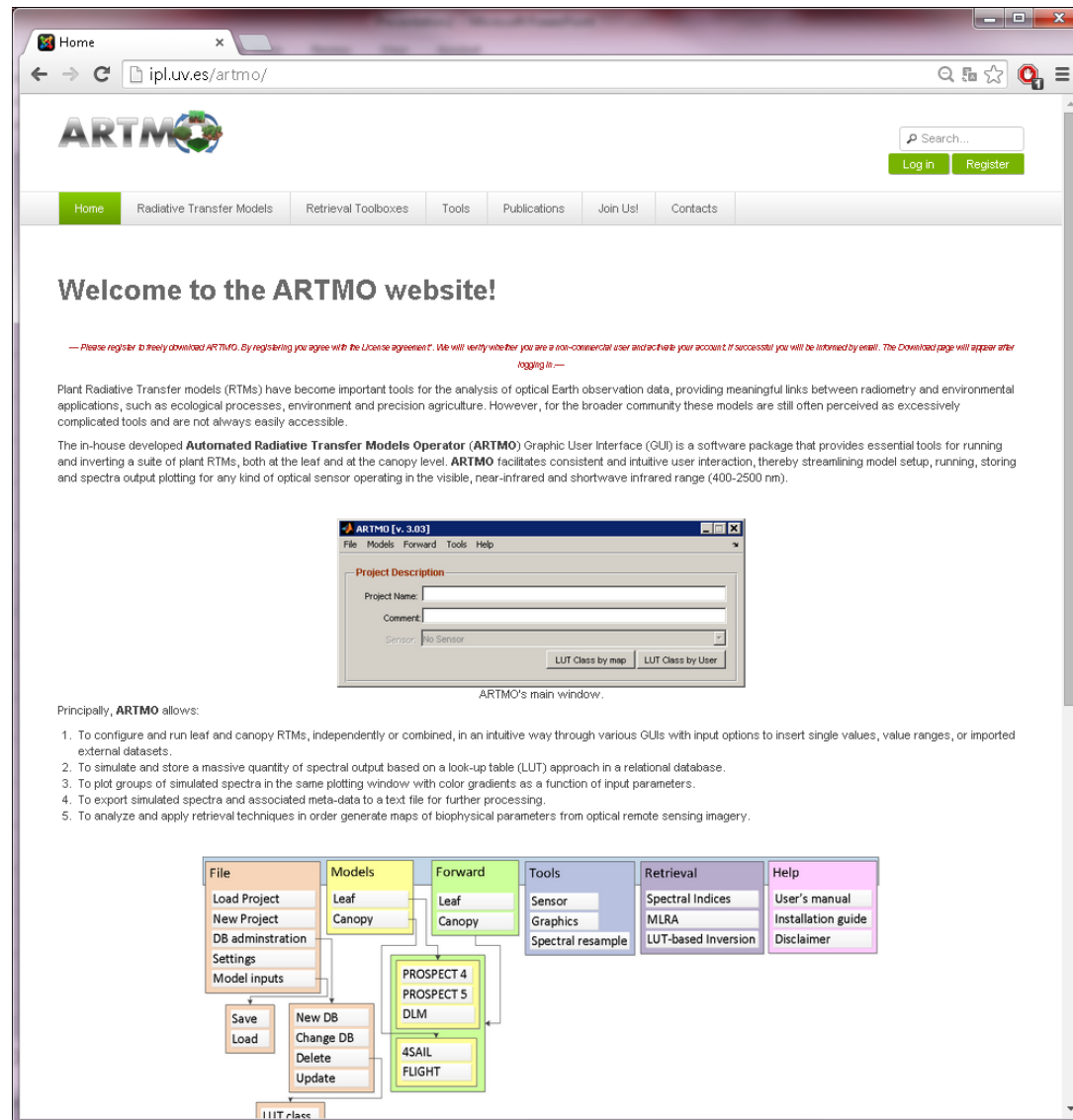
## Software packages:

Programming language: Matlab® (7.9.0.529)  
 Database: MySQL® (5.5.8)  
 Image processing software: ENVI® 4.5

**MATLAB**  
 The Language of Technical Computing



# Website: <http://ipl.uv.es/artmo/>



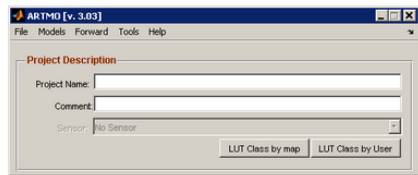
The screenshot shows the ARTMO website interface in a web browser. The browser address bar displays `ipl.uv.es/artmo/`. The website features a navigation menu with links: Home, Radiative Transfer Models, Retrieval Toolboxes, Tools, Publications, Join Us!, and Contacts. A search bar and 'Log in'/'Register' buttons are located in the top right. The main content area welcomes visitors and provides information about the ARTMO software, including a registration notice and a description of its capabilities. An inset image shows the ARTMO v. 3.093 main window, which includes a menu bar (File, Models, Forward, Tools, Help) and a 'Project Description' section with fields for Project Name, Comment, and Sensor. Below the main window, a list of five key features is provided, followed by a detailed menu structure diagram.

Welcome to the ARTMO website!

— Please register to freely download ARTMO. By registering you agree with the License agreement. We will verify whether you are a non-commercial user and activate your account. If successful you will be informed by email. The Download page will appear after logging in. —

Plant Radiative Transfer models (RTMs) have become important tools for the analysis of optical Earth observation data, providing meaningful links between radiometry and environmental applications, such as ecological processes, environment and precision agriculture. However, for the broader community these models are still often perceived as excessively complicated tools and are not always easily accessible.

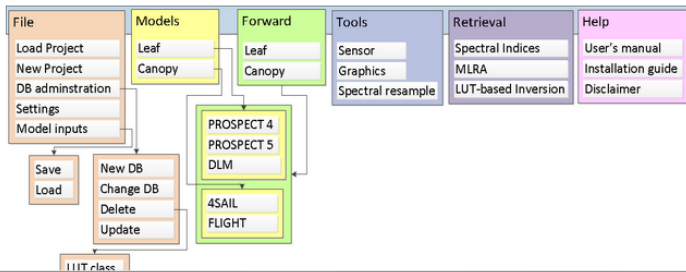
The in-house developed **Automated Radiative Transfer Models Operator (ARTMO)** Graphic User Interface (GUI) is a software package that provides essential tools for running and inverting a suite of plant RTMs, both at the leaf and at the canopy level. **ARTMO** facilitates consistent and intuitive user interaction, thereby streamlining model setup, running, storing and spectra output plotting for any kind of optical sensor operating in the visible, near-infrared and shortwave infrared range (400-2500 nm).



ARTMO's main window.

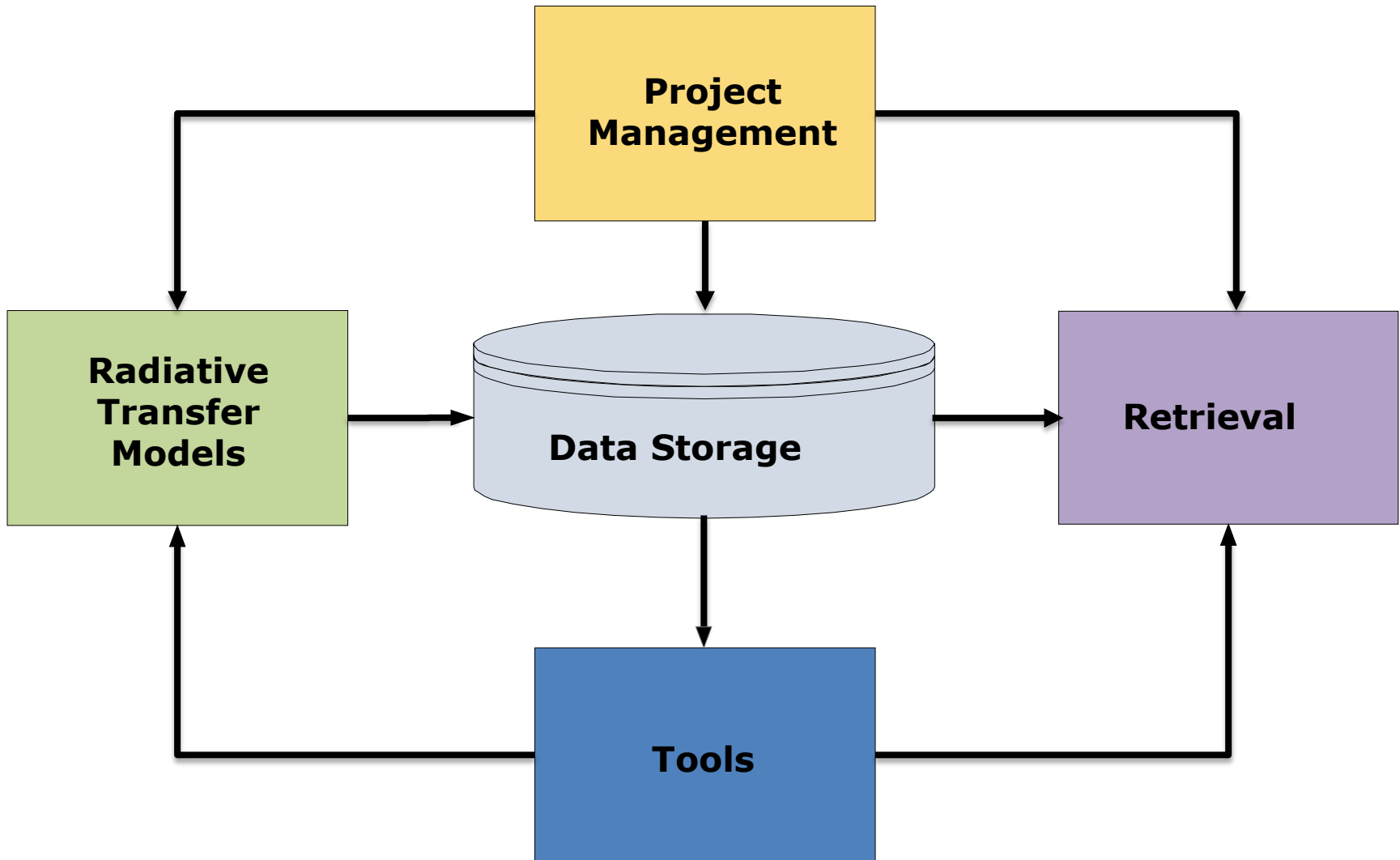
Principally, **ARTMO** allows:

1. To configure and run leaf and canopy RTMs, independently or combined, in an intuitive way through various GUIs with input options to insert single values, value ranges, or imported external datasets.
2. To simulate and store a massive quantity of spectral output based on a look-up table (LUT) approach in a relational database.
3. To plot groups of simulated spectra in the same plotting window with color gradients as a function of input parameters.
4. To export simulated spectra and associated meta-data to a text file for further processing.
5. To analyze and apply retrieval techniques in order generate maps of biophysical parameters from optical remote sensing imagery.



```
graph TD
    File[File] --> LoadProject[Load Project]
    File --> NewProject[New Project]
    File --> DBAdmin[DB administration]
    File --> Settings[Settings]
    File --> ModelInputs[Model inputs]
    Models[Models] --> Leaf[Leaf]
    Models --> Canopy[Canopy]
    Forward[Forward] --> LeafF[Leaf]
    Forward --> CanopyF[Canopy]
    Tools[Tools] --> Sensor[Sensor]
    Tools --> Graphics[Graphics]
    Tools --> Resample[Spectral resample]
    Retrieval[Retrieval] --> Indices[Spectral indices]
    Retrieval --> MLRA[MLRA]
    Retrieval --> Inversion[LUT-based Inversion]
    Help[Help] --> Manual[User's manual]
    Help --> Guide[Installation guide]
    Help --> Disclaimer[Disclaimer]
    ModelInputs --> Save[Save]
    ModelInputs --> Load[Load]
    ModelInputs --> NewDB[New DB]
    ModelInputs --> ChangeDB[Change DB]
    ModelInputs --> Delete[Delete]
    ModelInputs --> Update[Update]
    Save --> LUTclass[LUT class]
    Load --> LUTclass
    NewDB --> LUTclass
    ChangeDB --> LUTclass
    Delete --> LUTclass
    Update --> LUTclass
    LeafF --> PROSPECT4[PROSPECT 4]
    LeafF --> PROSPECT5[PROSPECT 5]
    LeafF --> DLM[DLM]
    CanopyF --> 4SAIL[4SAIL]
    CanopyF --> FLIGHT[FLIGHT]
```

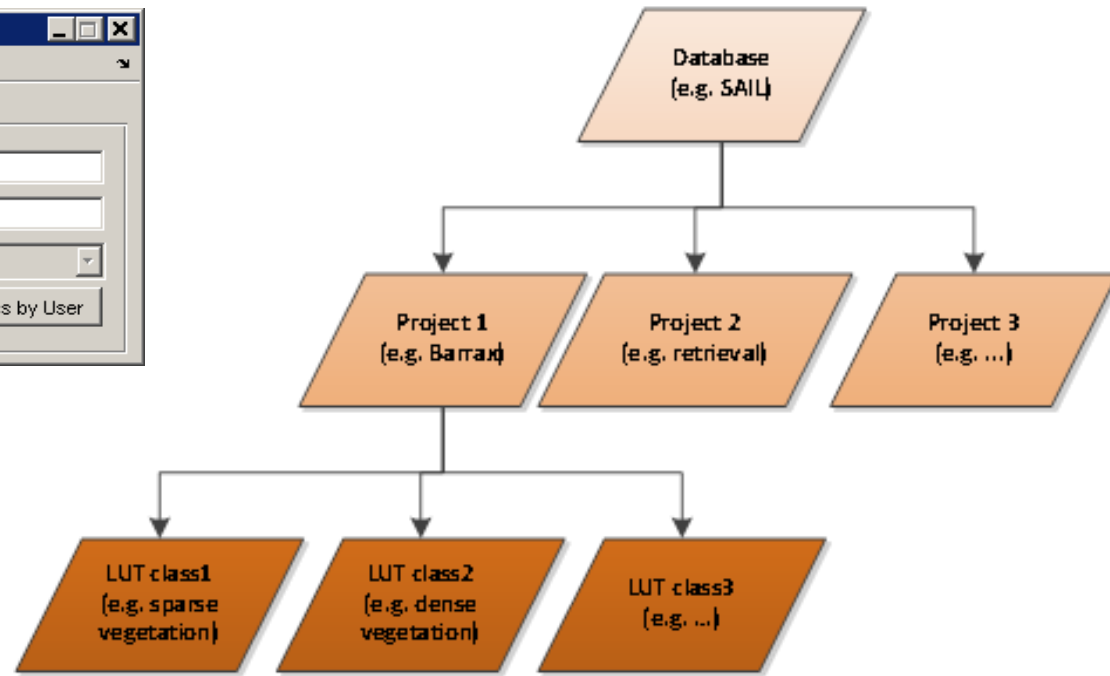
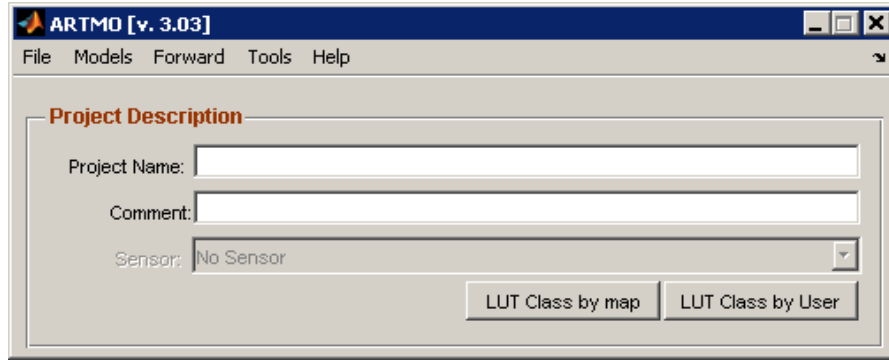
# Conceptual architecture ARTMO



Each individual blocks will be further explained in the following sections.

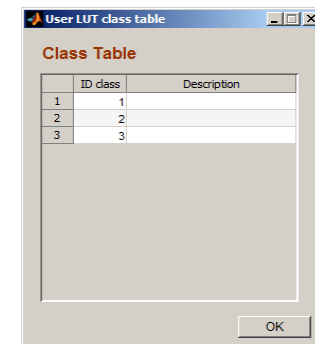
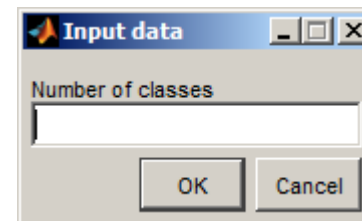
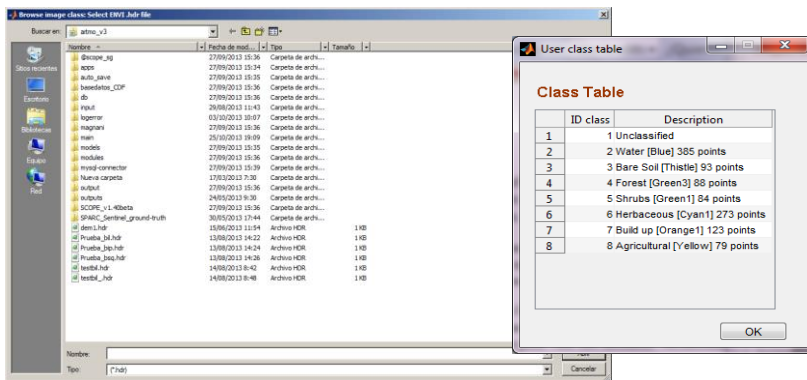


# ARTMO's hierarchical data storage

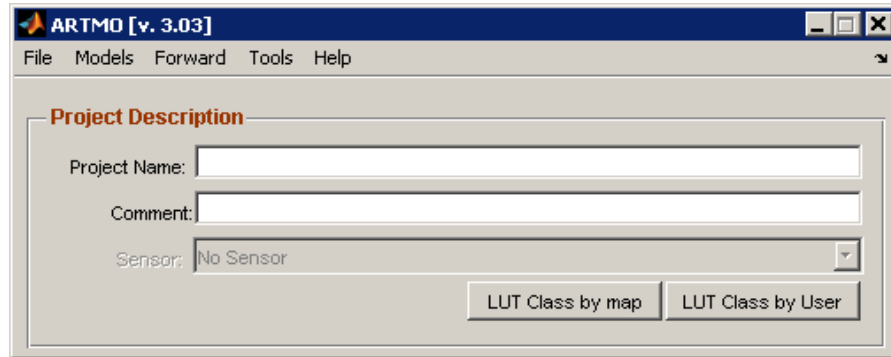


LUT class by map: ENVI .hdr file

LUT class by User

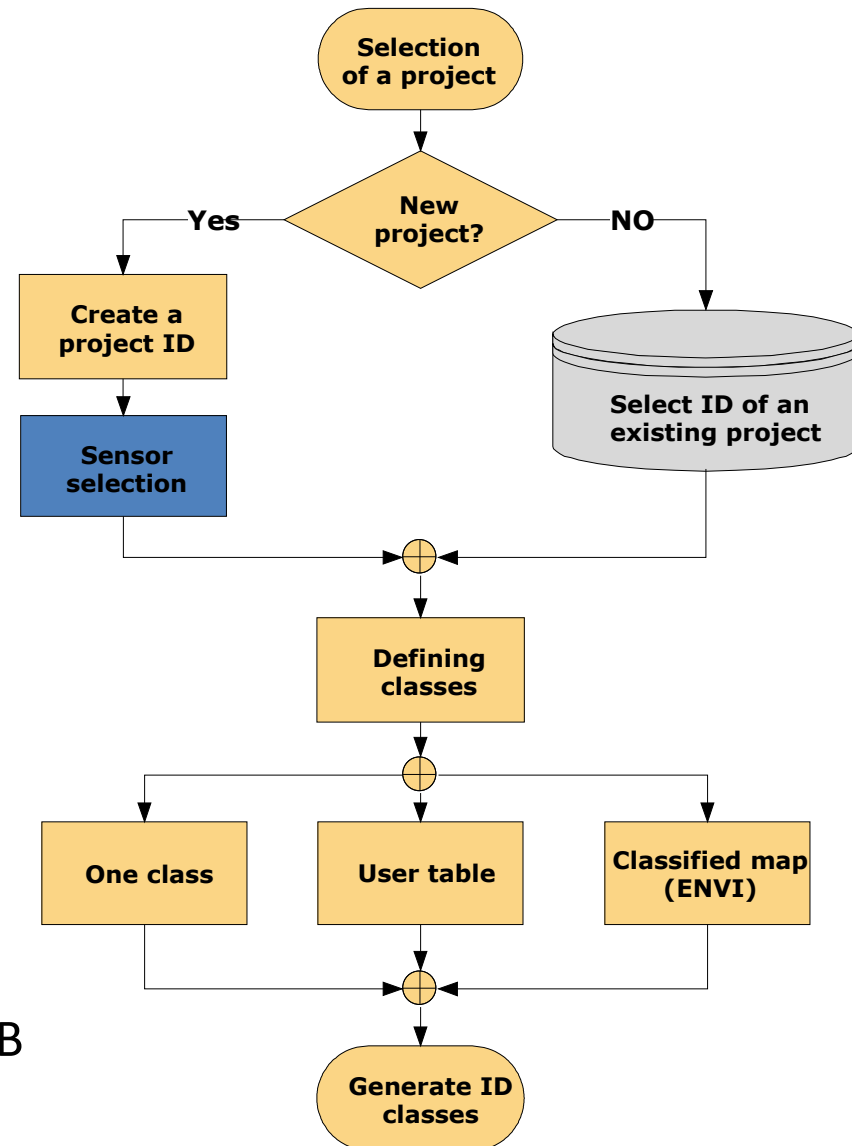


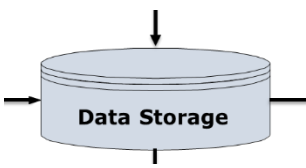
# Project management module



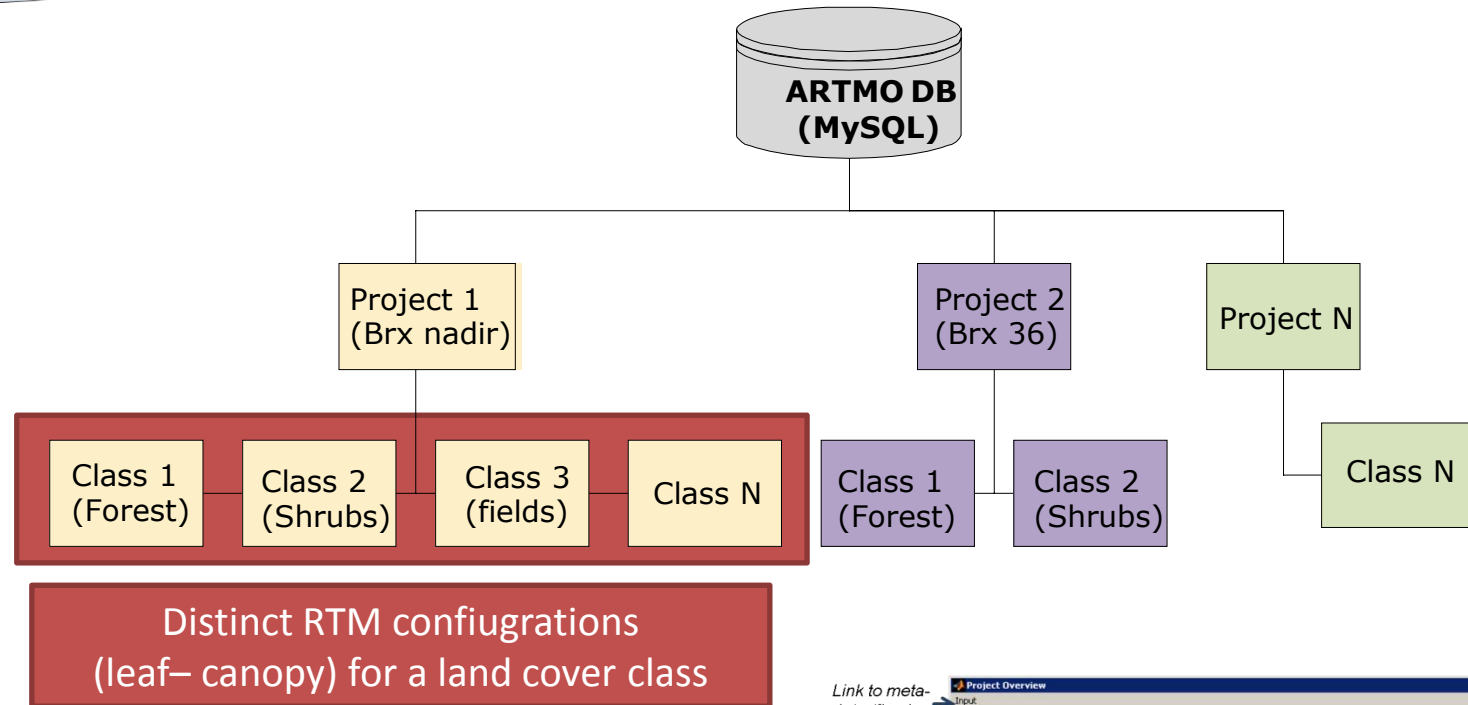
## Important features:

- ✓ Load an existing project or create a new one.
- ✓ Select a Sensor
- ✓ Choose whether a project should exist of LUT classes.
- ✓ Import/Export DBs, delete class/project/DB





# Underneath: MySQL data storage structure



## Important features:

- ✓ Input, output and metadata are stored in MySQL DB
- ✓ In 'Project Overview' metadata of all projects can be consulted.
- ✓ LUT casses can be accessed.
- ✓ All fixed input data and ranges of state parameters can be consulted.

Link to meta-data (fixed values)

The screenshot shows a window titled "Project Overview" with two tabs: "Input" and "Select Project". The "Select Project" tab is active, displaying a table with columns: ID\_PROJECT, NAME, DATE, SENSOR, # BANDS, # LUT..., and # SIM. The table has two rows of data. Below this is a section titled "LUT Classes" with a table showing DATE, #MODELS, LUT CLASS, and # SIM. The table has one row of data. Arrows point from the text labels to the corresponding parts of the screenshot.

Option to change DB

Overview of projects within selected DB

Overview of LUT-classes within selected DB

# RTM module

Radiative Transfer Models

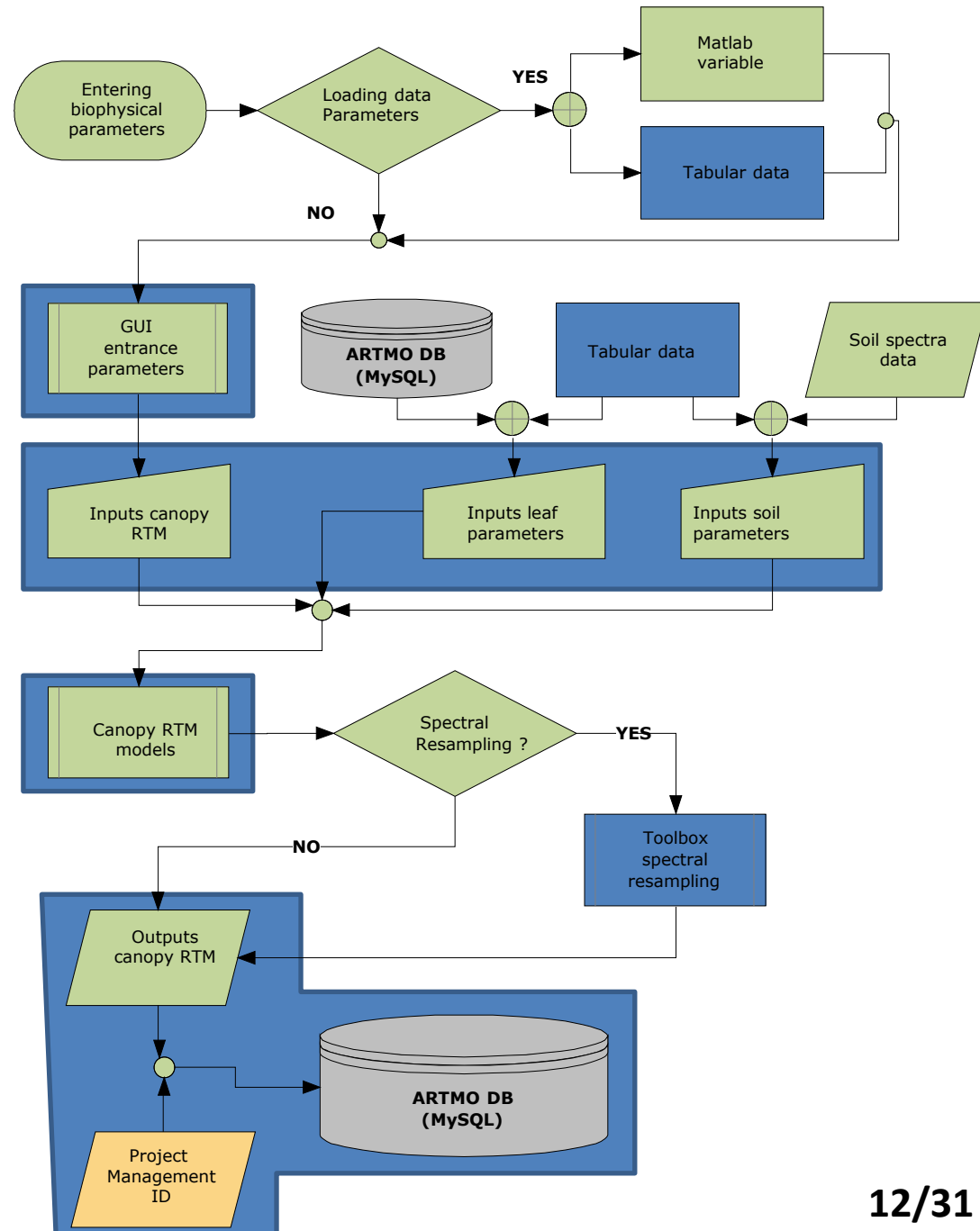
The screenshot shows the FLIGHT GUI with the following input parameters:

- Input Parameters:**
  - Dimension: 1D (selected), 3D
  - Number of bands: 8
  - Solar Angle: Zenith 24, Azimuth 162.8
  - Mode of operation: REVERSE (selected)
  - Number of photons: 10000
  - View Angle: Zenith 21.21, Azimuth 315.20
  - AOT @ 550 nm: AOT: 0.08
  - Soil roughness index: SRI: [0-1] 0
  - Leaf size: Size: [0-1] 0.01
  - LAI: Min: 1, Max: dense range: 5, Step: 0.5; Max: sparse range: 10, Step: 1
  - FVC: Min: 0.2, Max: 0.2, Step: 0
  - FGL: Min: 0.2, Step: 0
  - Constant Parameter: SEN (selected), BARK, Value: 0.8
  - LAD: [0-10]: 0.151, [20-30]: 0.192, [40-50]: 0.084, [60-70]: 0.048, [80-90]: 0.042; [10-20]: 0.256, [30-40]: 0.125, [50-60]: 0.061, [70-80]: 0.041
- Crown Shape:** Ellipsoid (selected), Cones, Field data
- Crown geo parameters:**
  - Crown radius: 0.880
  - Centre to top distance: 4.929
  - Height to first branch: Min: 4.1, Max: 9.9
  - Trunk DBH: 0.179

GUI of the model FLIGHT

## Important features:

- ✓ Insert a single value
- ✓ Insert user-defined input data
- ✓ Insert a range (stepwise or a distribution)
- ✓ Inset one or multiple spectra



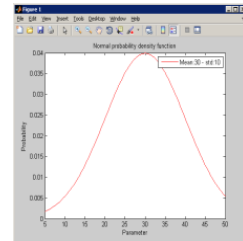
# Entering data: PROSPECT-4

Radiative Transfer Models

A single value

A range of values:  
1) steps

2) distribution: (uniform, normal, Poisson, extreme, Lognormal)



Recorded user data (e.g. field data)

3) Multiple input values

# Entering data: SAIL

When not coupled with a leaf reflectancemodel (e.g. PROSPECT) then leaf reflectance and transmittance data needs to be entered.

Option to select the Delimiter

Sample of the selected .txt file

On some models this panel will be activated so that a parameter can be assigned to data

OK to bring sample data to visualization panel

Browser for selecting .txt file

Visualization of selected input data

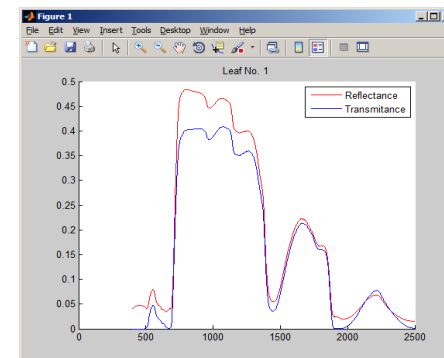
Line from where spectral data starts and conversion factor

Options to select Unit Wavelength

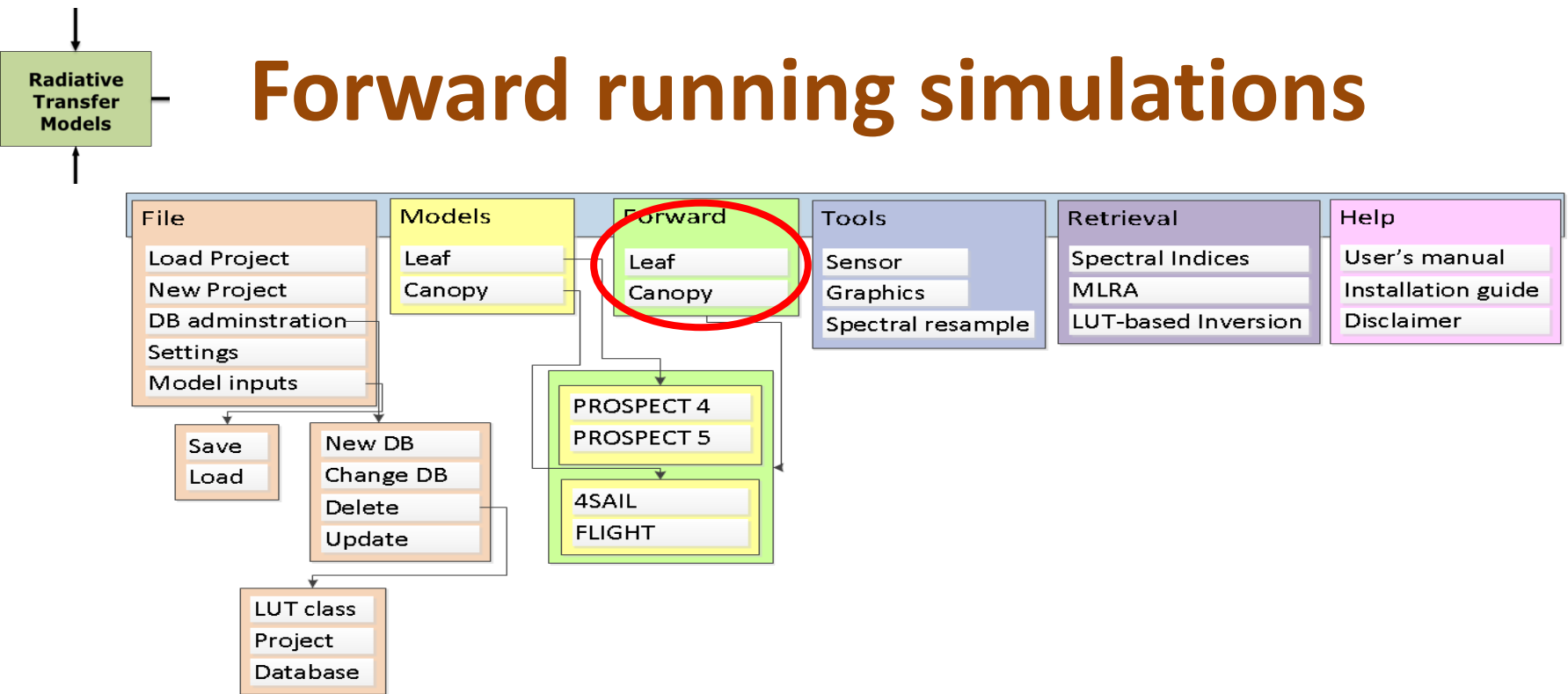
Options to select or deselect all spectra, and to deactivate plotting of spectra

## File

- **Save:** Save the input settings.
- **Load:** Load earlier saved input settings.



# Forward running simulations

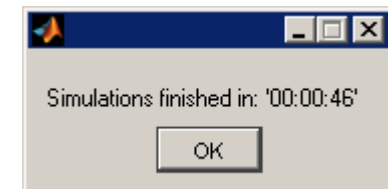
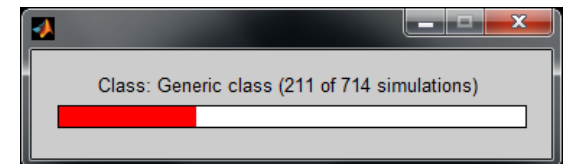


- In Forward the configured models can be selected, combined (in case of leaf + canopy) and run.
- Since all possible combinations are calculated, the LUT blows up exponentially. It is therefore possible to select a random subset.

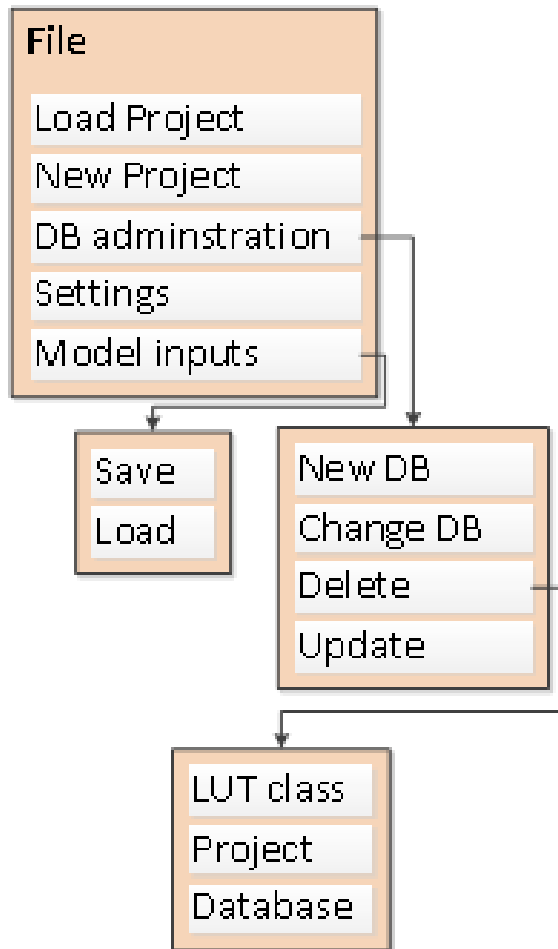
Master Simulations

	LUT Class	# Simulations	Subset
1	class1	2.0000e+09	10000

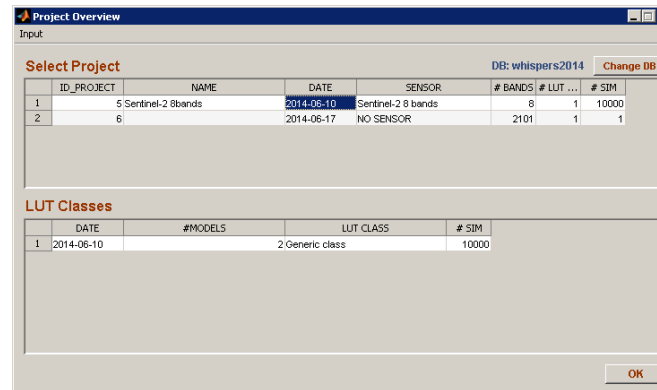
OK



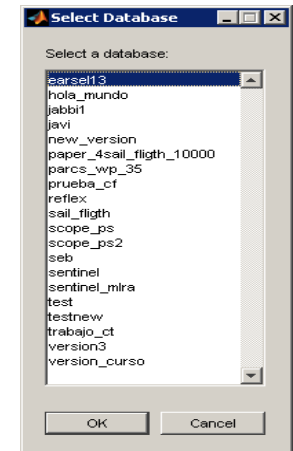
# ARTMO's file settings



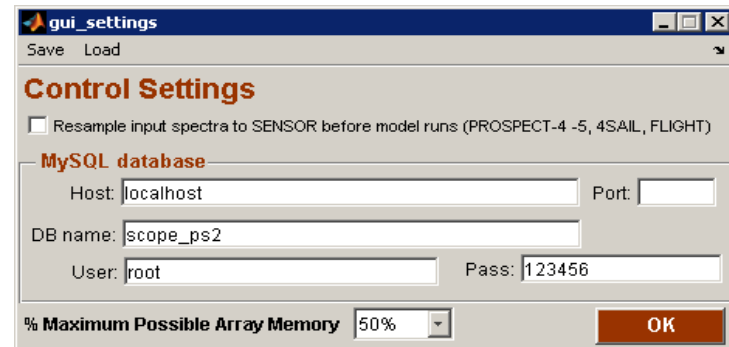
Delete a Project or a LUT-class



Delete a DB



Settings: manage connection with MySQL





# SENSOR TOOL

**Sensor Module [v. 1.00]**

Import Edit Spectral Filter Help

## Sensor Information

CHRIS Mode-3 ☐ Spectral filter

Unit wavelength

- Micrometers
- Nanometers**
- Wavenumber
- GHz
- MHz
- Index
- Unknown

Band details

	Band name	Min	Max	Center	FWHM
1	L1	438	447	442	9
2	L2	486	495	490	9
3	L3	526	534	530	9
4	L4	546	556	551	10
5	L5	566	573	570	8
6	L6	627	636	631	9
7	L7	656	666	661	11
8	L8	666	677	672	11
9	L9	694	700	697	6
10	L10	700	706	703	6
11	L11	706	712	709	6

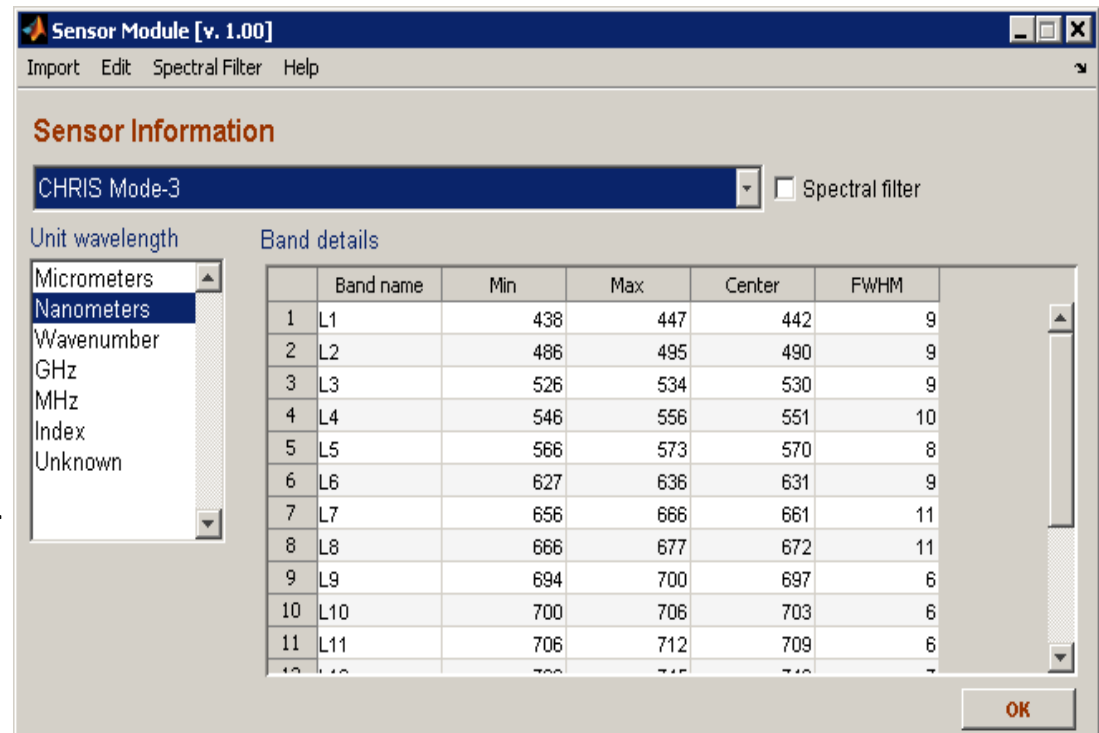
OK

# Sensor:

The **Sensor tool** enables configuring the band settings of a specific sensor. Once configured, radiative transfer models (RTMs) can then **generate outputs according to the band settings of a chosen sensor**.

The user can either **import sensor band settings or define its own sensor configurations**. In principle, any kind of band settings can be defined, but it is recommended to stay within the range that is covered by most models, i.e. 400-2400 nm.

- New sensor settings can be imported by clicking on the **'Import'** button in the top bar.
- Existing band settings can be modified or new ones can be added by clicking on the **'Edit'** button.
- Also a spectral filter of a sensor can be imported or viewed by clicking on the **'Spectral Filter'** button.



## Available sensors:

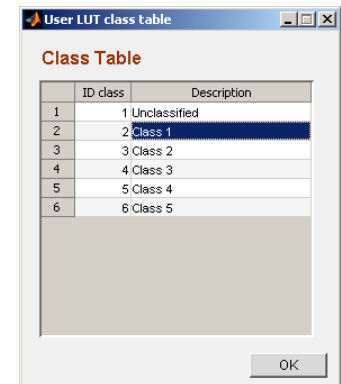
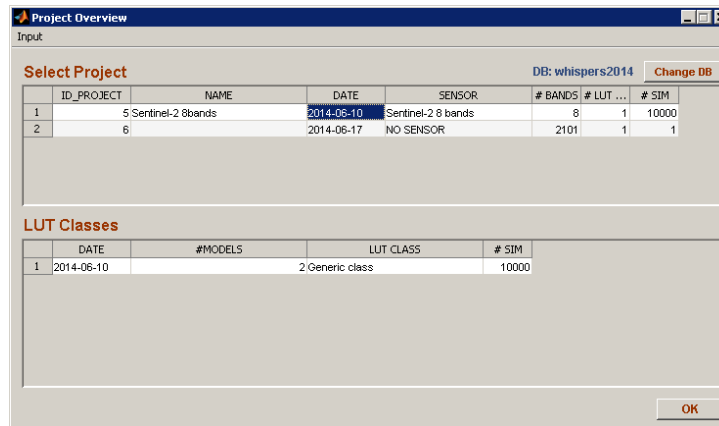
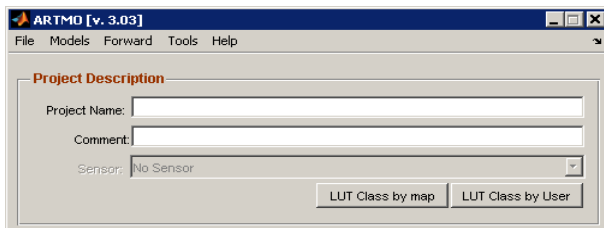
When having the Sensor tool implemented into ARTMO, then the following sensor band settings will be by default available when creating a new DB:

- Landsat 7 TM
- Landsat 7 ETM+
- SPOT-4 VMI
- SPOT-4 HRVIR
- CHRIS Mode-3
- MODIS
- MERIS
- Sentinel-2
- Sentinel-3 OLCI
- Sentinel-3 SLSTR



# Step 1 – Defining a project

1. In Matlab Command window type: **artmo**
2. Create a new project – check also ‘Load Project’
3. Select a sensor
4. Check the settings options
5. Check the ‘Class’ options



- ✓ Create a project (e.g. Barrax) with CHRIS 62 bands sensor
- ✓ Load a classified map to enable multiple LUT-classes:



# Step 2 – filling in the LUT

## Leaf model PROSPECT-4

- 3 ways to fill in the LUT
  1. A single value
  2. Selecting a range – multiple options:
    1. According to a step
    2. According to a distribution (uniform, normal, Poisson, extreme, Lognormal)

PROSPECT 4

File

**INPUT PROSPECT 4**

Select LUT Class: Generic class

Leaf Structure (N) [1-4]: 1.5 ☐ Range ☐ Table

Chlorophyll (Cab -  $\mu\text{g}/\text{cm}^2$ ) [0-100]: 30 ☐ Range ☐ Table

Water thickness (Cw - cm) [0-0.05]: 0.03 ☐ Range ☐ Table

Dry matter (Cm -  $\text{g}/\text{cm}^2$ ) [0-0.05]: 0.012 ☐ Range ☐ Table

OK

Probability density function

Parameter: Cab Range: [0-100]

Min: 0 Max: 100 Step: 5

Probability density functions: Uniform ☐ Par. A: Par. B:

Sample plot OK

Probability density function

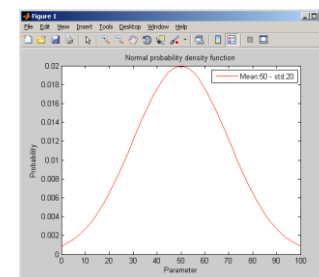
Parameter: Cab Range: [0-100]

Min: 0 Max: 40 # samples: 100

Probability density functions: Normal ☐ Mean: 20 std: 10

Normal ☒ Uniform ☐ Poisson ☐

OK



3. Inputting a range: File > Load Data Table  
(see next slide)

# Inputting user-defined data (e.g. coming from field data)

## 2 options to insert user data:

1. Combined multiple parameters: Multiple columns can be assigned to different parameters
2. Building up LUTs by combining multiple tables.

**PROSPECT 4 data table**

Text file: D:\Armo old\artmof\_ip\samples\Prospect 4 y 5\prospect.txt

Option text file: Delimiter character: Tab HeaderLines: 1

	1	2	3	4
1	31.498	0.020	0.006	
2	21.574	0.008	0.005	
3	11.809	0.013	0.004	
4	15.051	0.015	0.004	
5	26.619	0.013	0.005	
6	26.789	0.013	0.005	
7	30.466	0.013	0.006	
8	76.891	0.016	0.008	

Parameter: Cm: Leaf Dry Matter Content Column: Column 3 Convert factor: 1

Parameter	Column	Convert Fact...
1 Cab: Leaf Chlorophyll Content	Column 1	1
2 Cw: Leaf Water Content	Column 2	1
3 Cm: Leaf Dry Matter Content	Column 3	1

Import

**PROSPECT 4**

File

**INPUT PROSPECT 4**

Select LUT Class: Unclassified

Leaf Structure (N) [1-4]: 1.5 ☐ Range ☒ Table

Chlorophyll (Cab -  $\mu\text{g}/\text{cm}^2$ ) [0-100]: 30 ☐ Range ☒ Table

Water thickness (Cw - cm) [0-0.05]: 0.03 ☐ Range ☒ Table

Dry matter (Cm -  $\text{g}/\text{cm}^2$ ) [0-0.05]: 0.012 ☐ Range ☒ Table

OK

✓ Try out different input combinations

# Filling in a canopy model: 4SAIL

- Filling in 4SAIL: single or multiple values
- Soil spectra is required. Default spectra are provided or own spectra can be inserted.
- When not coupled with a leaf model then leaf spectra is required.

**4SAIL MODEL**

File Leaf Spectrum Dry Soil Spectrum Wet Soil Spectrum

**4SAIL MODEL**

Select LUT Class: Generic class

**LAI [0-10]**  
 ☐ Range ☐ Table

**Hot spot effect [0 - 1]**  
 ☐ Range ☐ Table

**Average leaf angle (°) [0 - 90]**  
 ☐ Range ☐ Table

**Solar zenith angle (°) [0 - 90]**  
 ☐ Range ☐ Table

**Diffuse/Direct radiation [0 - 100]**  
 ☐ Range ☐ Table

**Observer zenith angle (°) [-75 -75]**  
 ☐ Range ☐ Table

**Soil coefficient [0 - 1]**  
 ☐ Range ☐ Table

**Azimuth (°) [0 - 180]**  
 ☐ Range ☐ Table

**OK**

## Input leaf spectra (refl. & trans)

**Leaf Spectrum: Class=Unclassified**

Text file: C:\Users\1\Google Drive\REFLEX\_input\_support files\spectral library\Leaf\leaf.csv **Browse**

Option text file  
 Delimiter character: semicolon **HeaderLines** **OK**

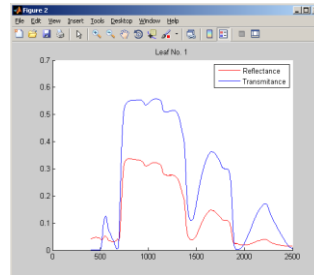
	1	2	3	4
1	400	0.041096571	1.10655E-05	0.04595813
2	401	0.041187413	1.04833E-05	0.04606716
3	402	0.04126012	9.83628E-06	0.04613785
4	403	0.041366639	9.14661E-06	0.04622413
5	404	0.041505728	8.58313E-06	0.04635361
6	405	0.041648831	8.20515E-06	0.04650820
7	406	0.041794653	8.02555E-06	0.04670393
8	407	0.041958843	7.93618E-06	0.04690904
9	408	0.042147977	7.82755E-06	0.04714477
10	409	0.042321863	7.69397E-06	0.04739436
11	410	0.042475835	7.72066E-06	0.04759331
12	411	0.042629235	7.59696E-06	0.04774734

First row spectral data: 1  
 Conversion factor: 1

Select Column  
 Select: ☒ Reflect: leaf 1 ☐ Trans: leaf 1  
 3 ☐ Reflect: leaf 2 ☐ Trans: leaf 2  
 4 ☐ Reflect: leaf 3 ☐ Trans: leaf 3  
 5 ☐ Reflect: leaf 4 ☐ Trans: leaf 4

Unit wavelength: Micrometers

**Import**



## Input soil spectra (refl.)

**Dry Soil Spectrum: Class=Unclassified**

Text file: C:\Users\1\Google Drive\REFLEX\_input\_support files\spectral library\4SAIL\dry\_soil **Browse**

Option text file  
 Delimiter character: comma **HeaderLines** **OK**

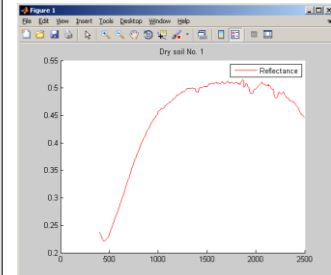
	1	2
1	400	0.2377
2	401	0.2373
3	402	0.2369
4	403	0.2365
5	404	0.236
6	405	0.2356
7	406	0.2352
8	407	0.2348
9	408	0.2344
10	409	0.234
11	410	0.2336
12	411	0.2332
13	412	0.2328

First row spectral data: 1  
 Conversion factor: 1

Select Column  
 Select: ☒ Soil No. 1

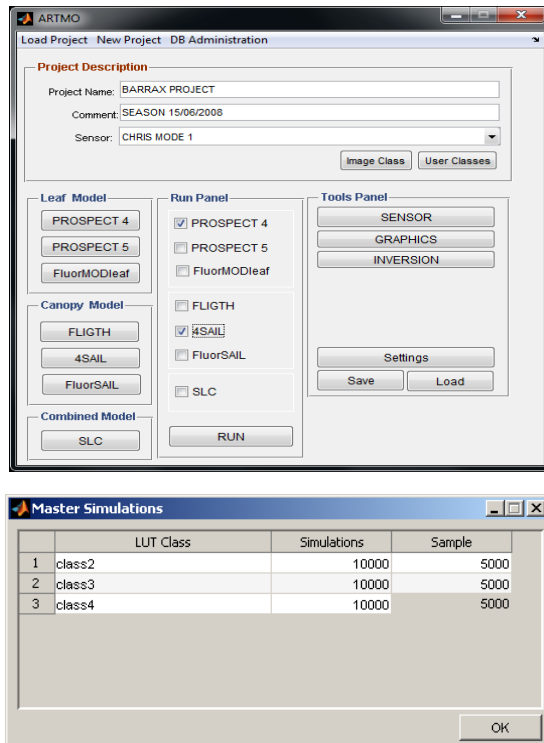
Unit wavelength: Micrometers

**Import**



# Filling in PROSPECT-4 + 4SAIL

When models are parameterized they turn active in the main window and can then be selected. By clicking on 'Run' a GUI appears where for each LUT class a random subselection can be defined.



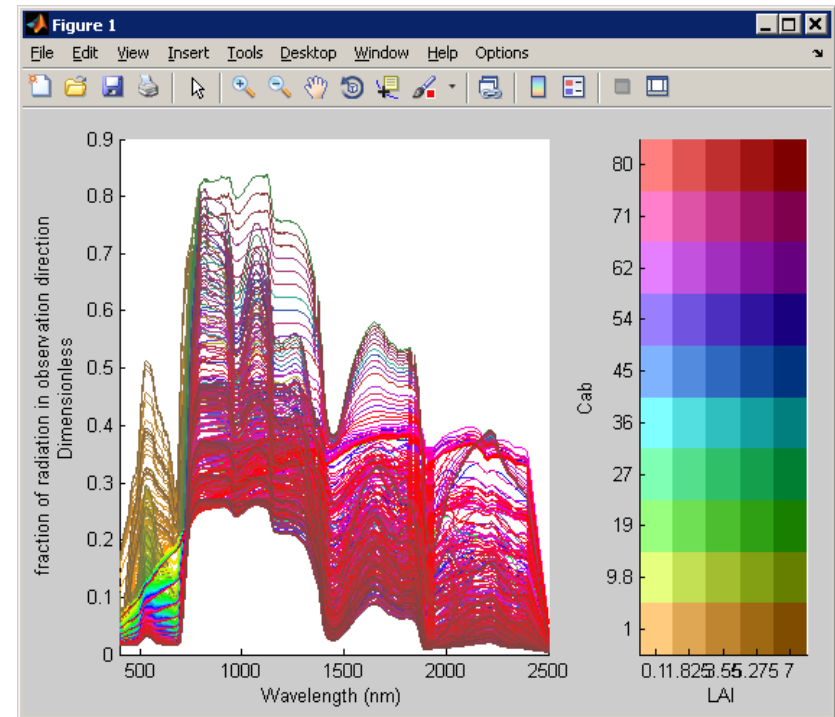
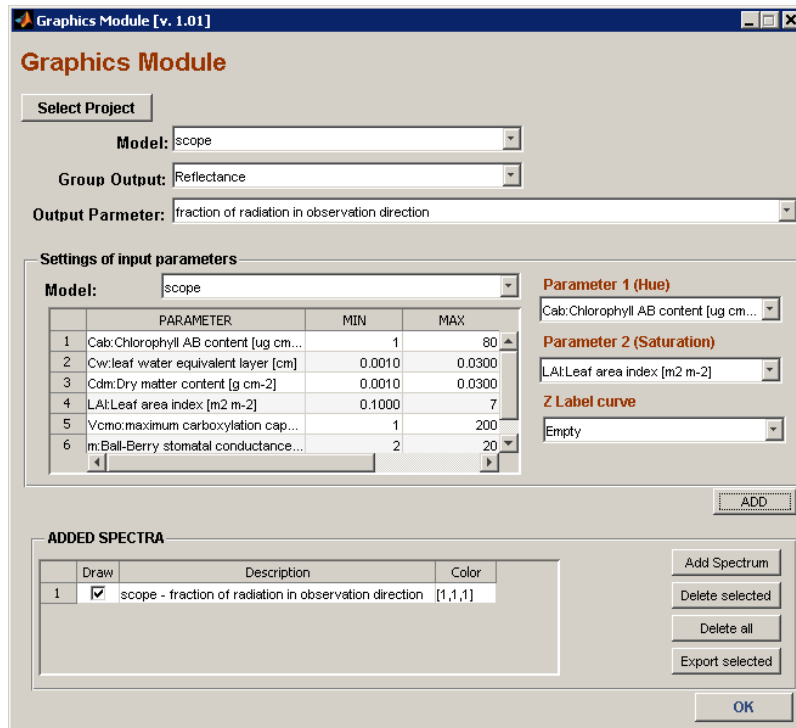
Model Parameters		Units	Range	Distribution
<i>Leaf parameters: PROSPECT-4</i>				
$N$	Leaf structure index	unitless	1.3-2.5	Uniform
$Chl$	Leaf chlorophyll content	$[\mu g/cm^2]$	5-75	Gaussian ( $\mu$ : 35, SD: 30)
$C_m$	Leaf dry matter content	$[g/cm^2]$	0.001-0.03	Uniform
$C_w$	Leaf water content	cm	0.002-0.05	Uniform
<i>Canopy variables: 4SAIL</i>				
LAI	Leaf area index	$[m^2/m^2]$	0.1-7	Gaussian ( $\mu$ : 3, SD: 2)
ALA	Average leaf angle	$[^\circ]$	40-70	Uniform
$\alpha_{soil}$	Soil scaling factor	unitless	0-1	Uniform
HotS	Hot spot parameter	$[m/m]$	0.05-0.5	Uniform
skyl	Diffuse incoming solar radiation	[fraction]	0.05	-
$\theta_s$	Sun zenith angle	$[^\circ]$	22.3	-
$\theta_v$	View zenith angle	$[^\circ]$	20.19	-
$\phi$	Sun-sensor azimuth angle	$[^\circ]$	0	-

- ✓ Fill in PROSPECT-4 and 4SAIL according to acceptable ranges. Make sure to have a broad range for Chl and LAI (e.g. Gaussian).
- ✓ Repeat parameterization for the different LUT classes.
- ✓ Click on 'Run' and select random subset of each LUT class, e.g. 5000 each.

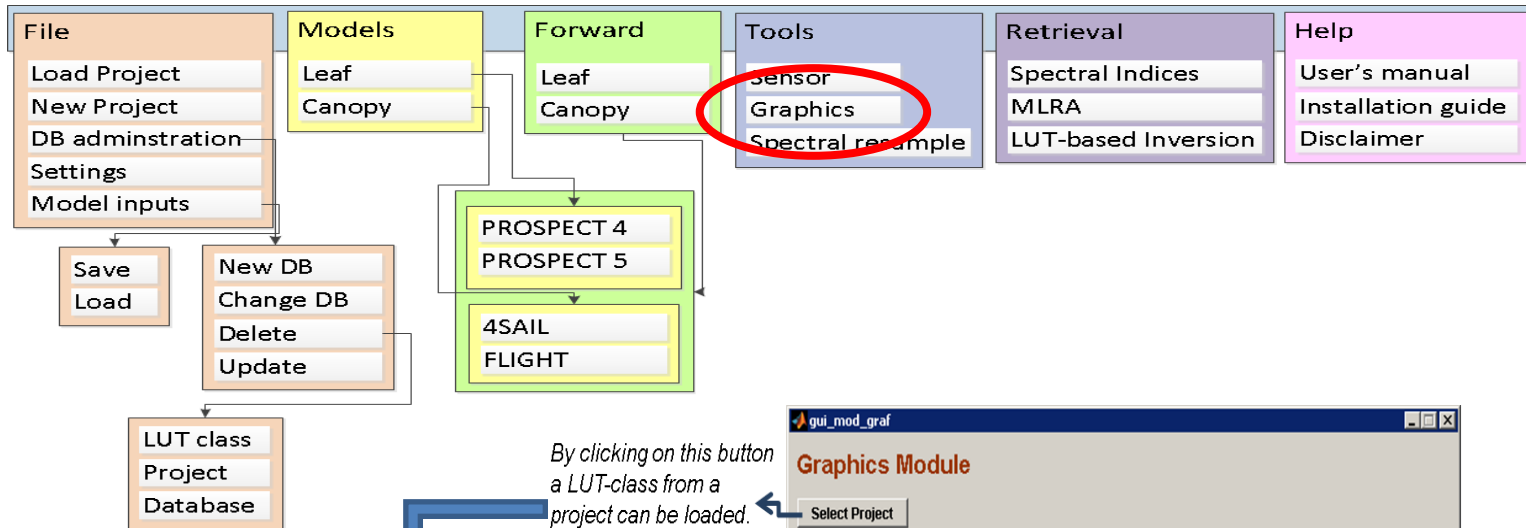


# Graphics v1.01 toolbox

## Tutorial



# Graphics



By clicking on this button a LUT-class from a project can be loaded.

Select the model, group output and output model.

Overview of range parameters of chosen model.

Overview of selected spectral groups.

Options to visualize the impact of parameters according to color gradients.

Add selected spectral group to plotting panel.

Options to add external spectrum, export and delete spectral groups.

**gui\_mod\_graf**

### Graphics Module

Select Project:

Model:

Group Output:

Output Parameter:

Settings of input parameters

Model:

	MIN	MAX	STEP	#
1	5	50	0	6
2	0.5000	5	6	6

Parameter 1 (Hue):

Parameter 2 (Saturation):

Z Label curve:

ADD

ADDED SPECTRA

Draw	Description	Color
<input checked="" type="checkbox"/>	scope - Fluorescence	[1,1,1]

Add Spectrum  
Delete selected  
Delete all  
Export selected

OK

**Project Overview**

Input

Select Project

ID_PROJECT	NAME	DATE	SENSOR	# BANDS	# LUT ...	# SIM
1	2 PROSAIL10000	2013-03-27	CHRIS MODE1	62	2	20000
2	3 PROSAIL_S210m	2013-04-03	Sentinel2-10m	4	2	20000
3	4 PROSAILmaria_S220m	2013-04-04	Sentinel2-20m	8	2	20000

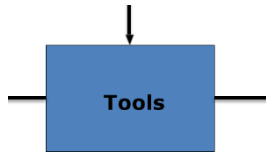
DB: earsel13 Change DB

Select Class Simulation

DATE	#MODELS	LUT CLASS	# SIM
1 2013-04-03		2 Generic class	10000

OK

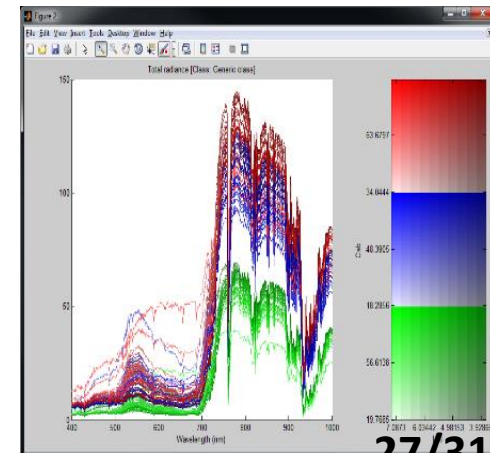
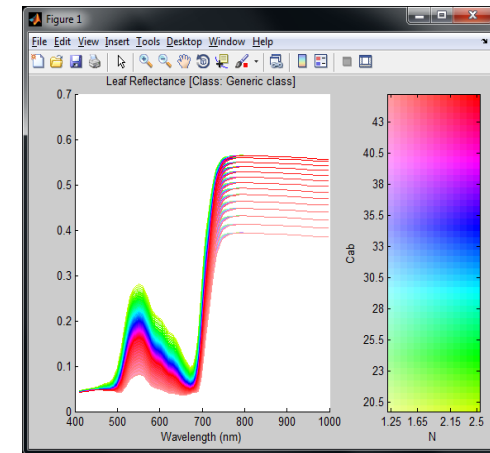
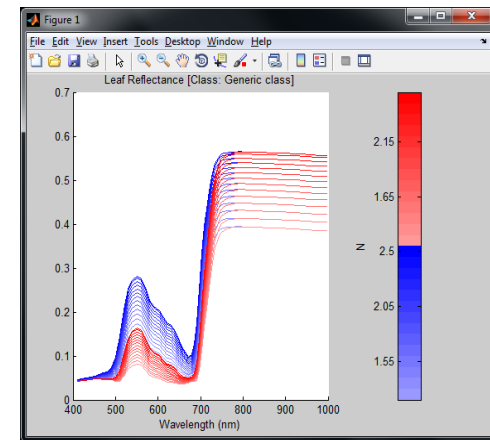
Only a LUT class can be selected, but spectral outputs of multiple LUT classes can be plotted within same plotting window.



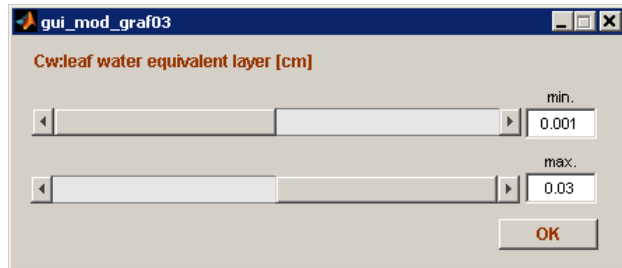
# Plotting examples

## Important features:

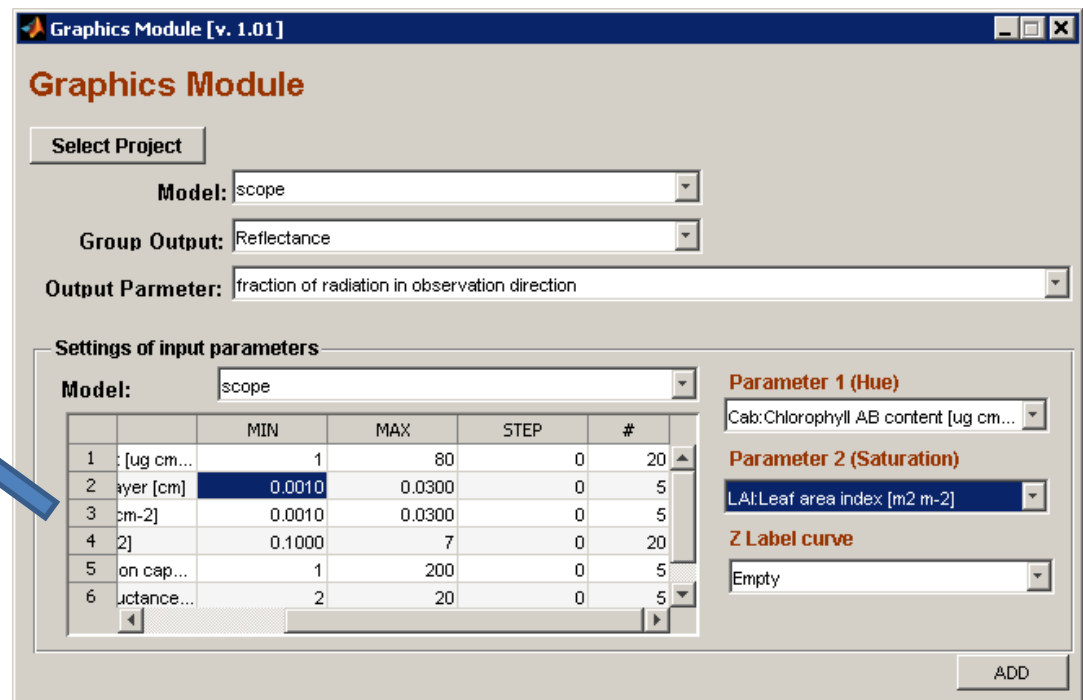
- ✓ A group of spectra can be plotted according to one color range related to 1 parameter.
- ✓ Multiple groups can be added to the same plotting panel.
- ✓ A group of spectra can also be added to 2 parameters, 1 as color hue and 1 as color saturation.
- ✓ External spectra can be added.
- ✓ The 'Graphics' module allows exporting spectra to a *.txt* file.



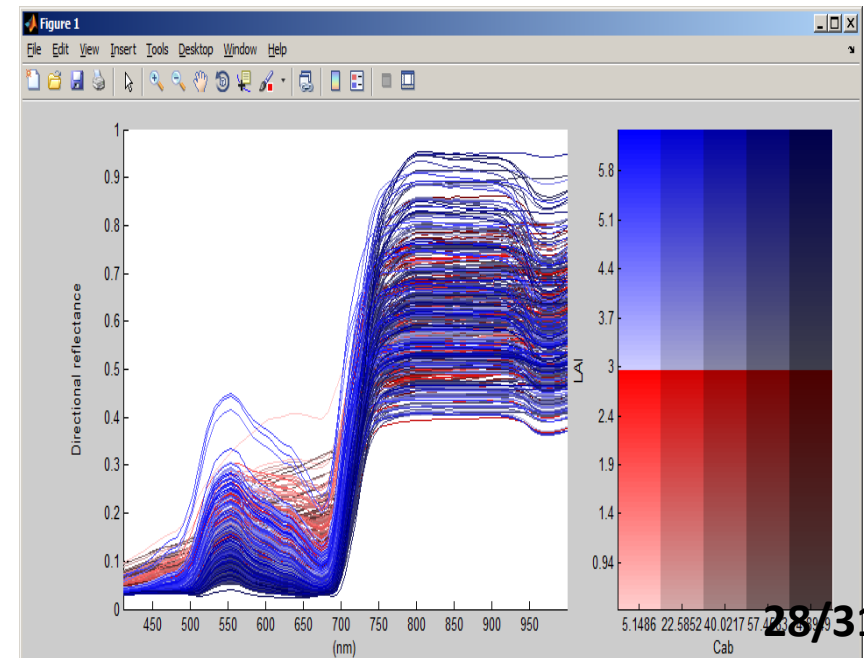
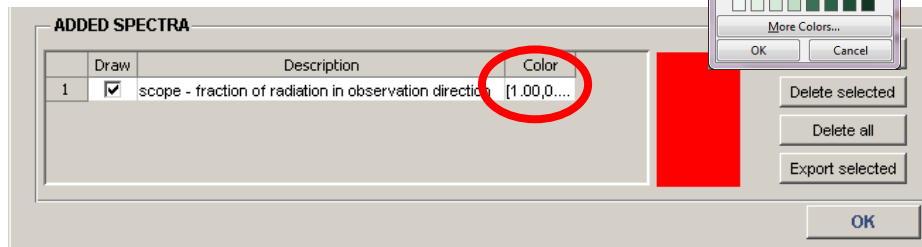
# Graphics



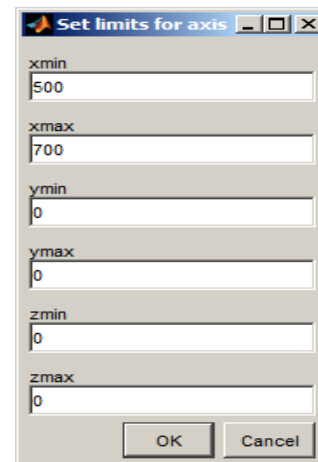
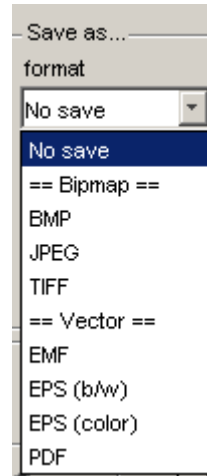
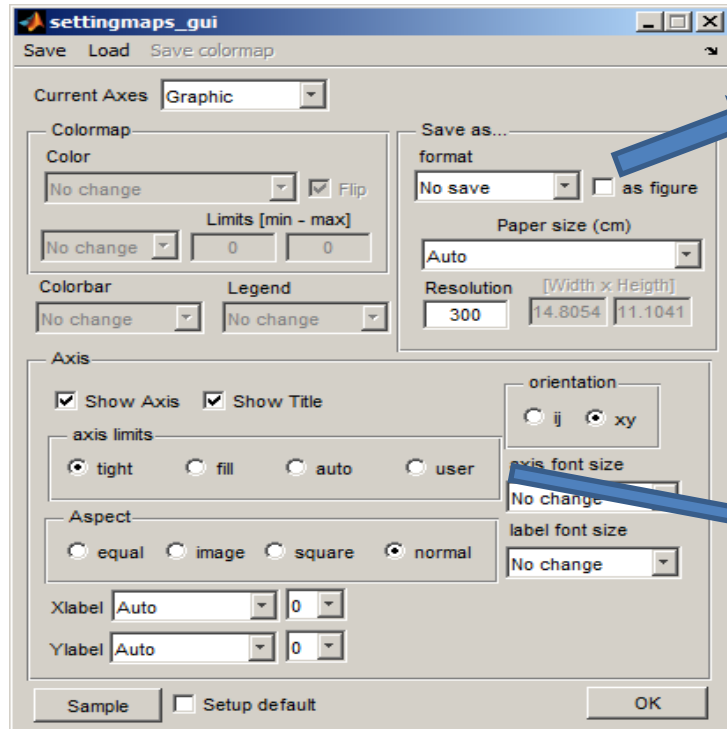
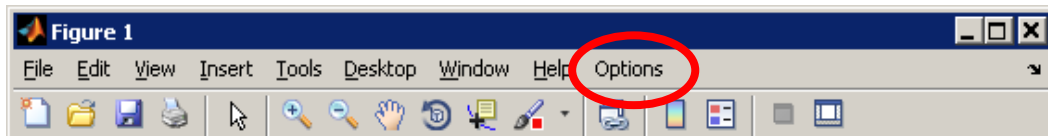
A subselection of the LUT can be plotted. Output spectra can be plotted as a function of color.



By default the full color scale is used. By clicking on color a specific color gradient can be selected.

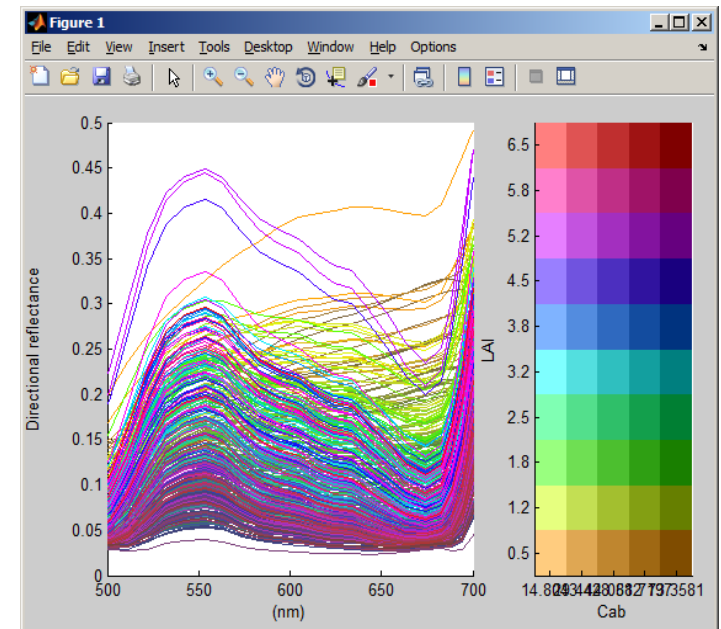


# Plotting options

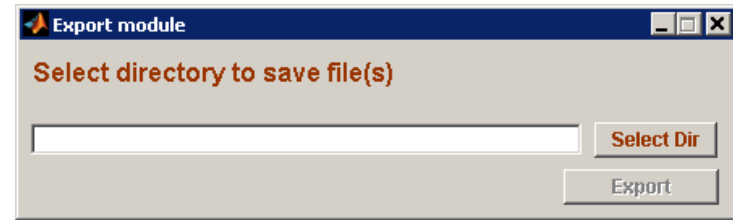
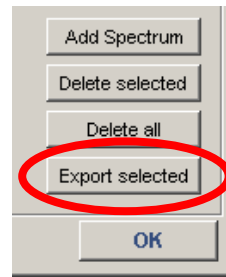


Graphs can be saved into various formats. As such, their space is optimized, i.e. with a minimum of white space around the graph.

By reducing the Axes a subselection of the spectral output can be visualized.



# Export graphics



The Graphics module enables exportation of selected simulations to a text file for further use.

Two files are created:

1. **Spectral data** including ranging variables on top of the spectral outputs
2. **Associated metadata** including a description of how data is organized and fixed variables

## Spectral data

A screenshot of the EditPad Lite 7 application window. The title bar shows the file path: [C:\Users\jochem\Desktop\Hemispherical\_reflectance.txt]. The menu bar includes File, Edit, Search, Go, Block, Extra, Convert, Options, View, and Help. The toolbar contains various editing icons. The main text area displays a large table of numerical data with multiple columns and rows. The status bar at the bottom shows '11:37', 'Insert', 'Unix', 'Windows 1252', and the copyright notice 'Copyright © 1996-2012 Jan Goyvaerts'.

## Associated metadata

A screenshot of the EditPad Lite 7 application window. The title bar shows the file path: [C:\Users\jochem\Desktop\Hemispherical\_reflectance\_meta.txt]. The menu bar includes File, Edit, Search, Go, Block, Extra, Convert, Options, View, and Help. The toolbar contains various editing icons. The main text area displays metadata information, including CLASS, PROJECT, COPIENT, DATE, SENSOR, # BANDS, and File created for ARTMO. It also lists fixed variables like Model, Model: Prospect 4, Model: 4SAI, skyl:Diffuse/direct light, tto:Solar Zenit Angle, tto:Observer Zenit Angle, psi:Azimuth Angle, and soil:Path for soil data. The status bar at the bottom shows '11:37', 'Insert', 'Unix', 'Windows 1252', and the copyright notice 'Copyright © 1996-2012 Jan Goyvaerts'.

# Exercise



- ✓ Make some plottings from earlier simulated LUT classes.
- ✓ Export your plotting to a text file.