System Modelling and Simulation with SCILAB

David Gonzalez – Valentín Cañas
DEIMOS

Brussels, 28 November 2019

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 737183.

Agenda

- Introduction
- Scilab
- Xcos
- Custom Toolbox
- Demo

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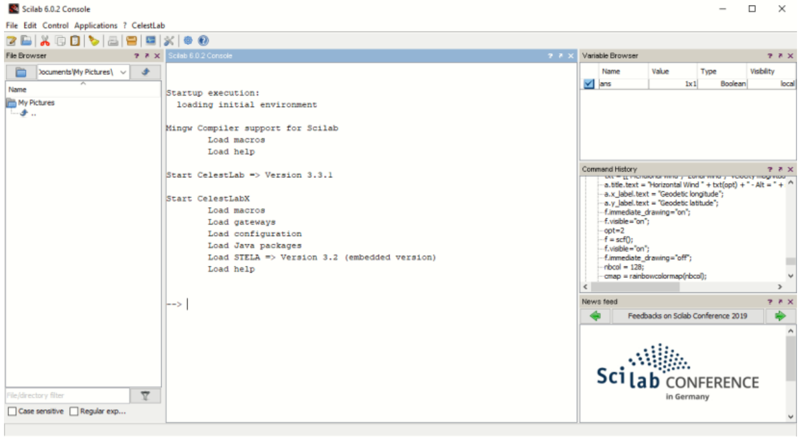
Introduction

- Numerical computation tool
- Graphical design (Xcos)
- Extendable
  - Toolbox
  - Integration with external tools
  - Programming
- Open source (GPL)

Available at http://www.scilab.org



```
Startup execution:
  loading initial environment

Mingw Compiler support for Scilab
        Load macros
        Load help

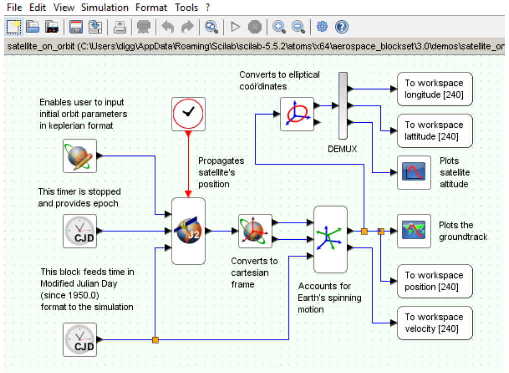
Start CelestLab => Version 3.3.1

Start CelestLabX
        Load macros
        Load gateways
        Load configuration
        Load Java packages
        Load STELA => Version 3.2 (embedded version)
        Load help


--> |
```

	Name	Value	Type	Visibility
☑	ans	1x1	Boolean	local

```
a.title.text = "Horizontal Wind " + txt(opt) + " - Alt = " +
a.x_label.text = "Geodetic longitude";
a.y_label.text = "Geodetic latitude";
f.immediate_drawing="on";
f.visible="on";
opt=2
f = scf();
f.visible="on";
f.immediate_drawing="off";
nbcol = 128;
cmap = rainbowcolormap(nbcol);
```


File Edit View Simulation Format Tools ?
satellite_on_orbit (C:\Users\digg\AppData\Roaming\Scilab\scilab-5.5.2\atoms\x64\aerospace_blockset\3.0\demos\satellite_or
Enables user to input initial orbit parameters in keplerian format
This timer is stopped and provides epoch
CJD
This block feeds time in Modified Julian Day (since 1950.0) format to the simulation
CJD
Propagates satellite's position
J2
Converts to cartesian frame
Converts to elliptical coördinates
DEMUX
Accounts for Earth's spinning motion
To workspace longitude [240]
To workspace lattitude [240]
Plots satellite altitude
Plots the groundtrack
To workspace position [240]
To workspace velocity [240]

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Introduction: Integration with other tools and hardware

- Extend Scilab with other languages:
  - Java, Python, Tcl Tk, Fortran or C, C++
- Use Scilab from different languages:
  - Java, Python or C, C++
- Integration with other programs:
  - Excel
  - Labview
  - OpenFoam
  - Etc.

More information in https://wiki.scilab.org/Interoperability

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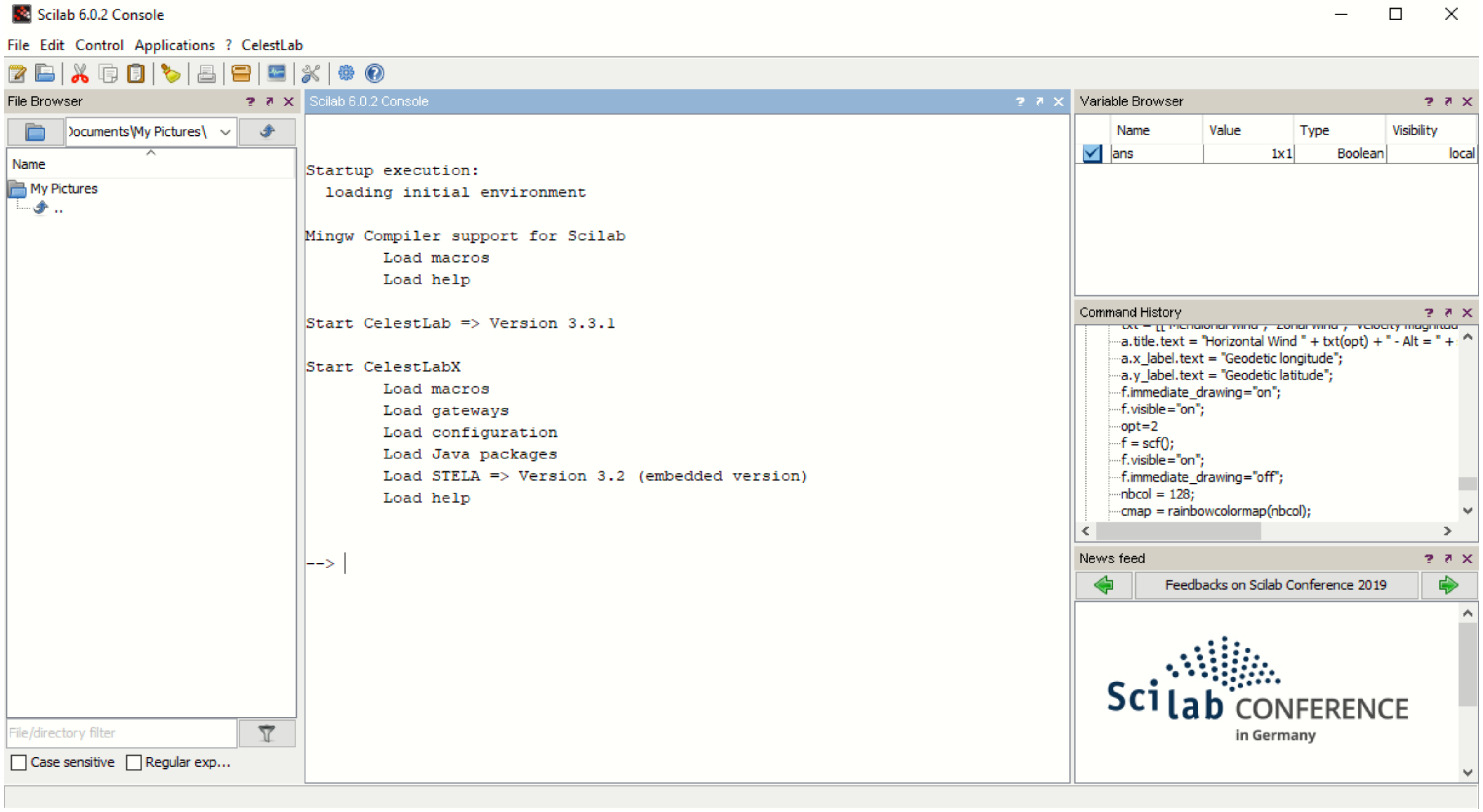
SCILAB



```
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        Load Java packages
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        Load help


-->
```

	Name	Value	Type	Visibility
☑	ans	1x1	Boolean	local

```
txt = [["Meridional wind"; "Zonal wind"; "Velocity magnitud
a.title.text = "Horizontal Wind " + txt(opt) + " - Alt = " +
a.x_label.text = "Geodetic longitude";
a.y_label.text = "Geodetic latitude";
f.immediate_drawing="on";
f.visible="on";
opt=2
f = scf();
f.visible="on";
f.immediate_drawing="off";
nbcol = 128;
cmap = rainbowcolormap(nbcol);
```

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Scilab: basic information

- Basic data element: **Matrix**
  - everything is a matrix. All real, complex, Boolean, integer, string, and polynomial variables are matrices.
- Variables names case sensitive and only 24 first characters are considered
- Protected variables: %i, %pi, etc.
- High-level interpreted language with variables, flow, functions, primitives.
- High-level functions for 2-D and 3-D data visualization

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Scilab: Useful commands

- **Help command**

--> help

--> help <name_of_command>

--> apropos(keyword)

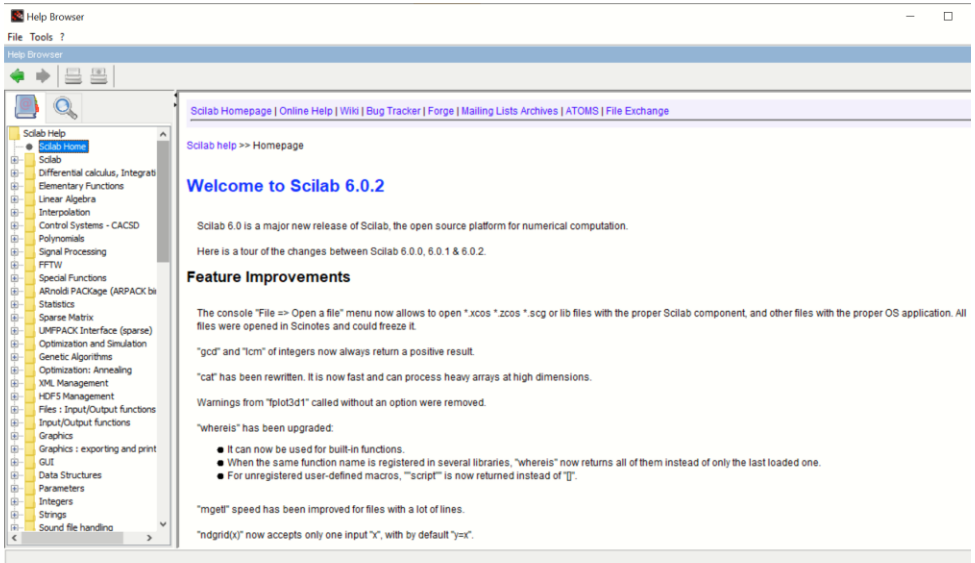
- **Workspace commands:**

--> clc: clear screen

--> what: show all the primitives

--> who/whos: show all the variables (with -name show variables starting with <>)

--> clear: delete all non protected variables



Welcome to Scilab 6.0.2

Scilab 6.0 is a major new release of Scilab, the open source platform for numerical computation.

Here is a tour of the changes between Scilab 6.0.0, 6.0.1 & 6.0.2.

Feature Improvements

The console "File => Open a file" menu now allows to open *.xcos *.zcos *.scg or lib files with the proper Scilab component, and other files with the proper OS application. All files were opened in Scinotes and could freeze it.

"gcd" and "lcm" of integers now always return a positive result.

"cat" has been rewritten. It is now fast and can process heavy arrays at high dimensions.

Warnings from "fplot3d1" called without an option were removed.

"whereis" has been upgraded:

- It can now be used for built-in functions.
- When the same function name is registered in several libraries, "whereis" now returns all of them instead of only the last loaded one.
- For unregistered user-defined macros, ""script"" is now returned instead of "[]".

"mgetl" speed has been improved for files with a lot of lines.

"ndgrid(x)" now accepts only one input "x", with by default "y=x".

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Scilab: Create functions

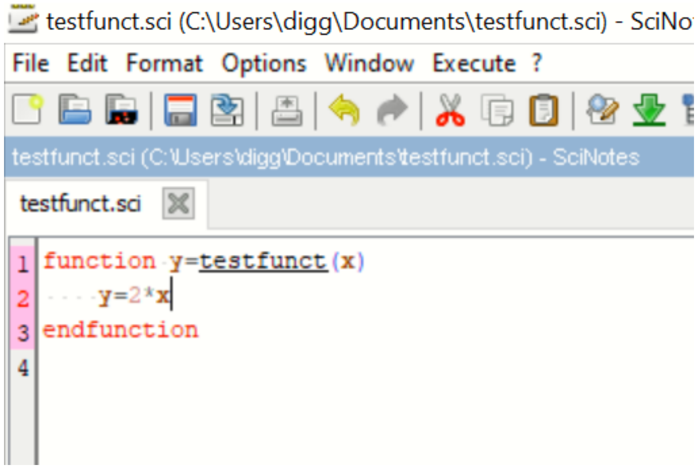
- Format:

function <lhs_arguments>=<function_name><rhs_arguments>

…

Endfunction

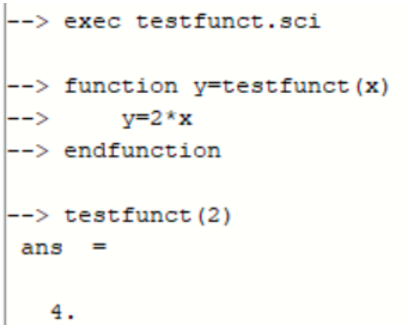
- Create the function with the editor
  - Save as *.sci file with the name of the function
- Load the function in the command line
  - exec filename.sci
- Genlib to build library from functions (sci files) in given directory



testfunct.sci (C:\Users\digg\Documents\testfunct.sci) - SciNo

File Edit Format Options Window Execute ?
testfunct.sci (C:\Users\digg\Documents\testfunct.sci) - SciNotes
testfunct.sci

```
function y=testfunct(x)
    y=2*x
endfunction
```



```
--> exec testfunct.sci

--> function y=testfunct(x)
-->     y=2*x
--> endfunction

--> testfunct(2)
 ans  =

   4.
```

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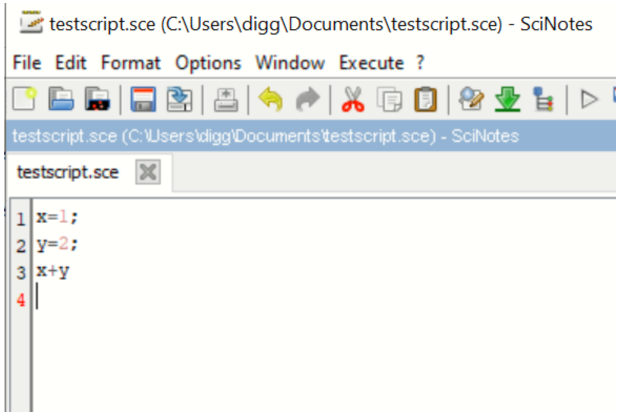
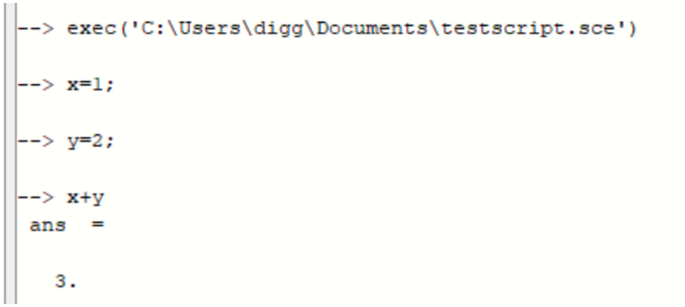
Scripting

- For long code scripts can be used:
  - Files with extension *.sce
  - Load: exec (‘filename.sce’)
  - Can include definition of functions


testscript.sce (C:\Users\digg\Documents\testscript.sce) - SciNotes
File Edit Format Options Window Execute ?
testscript.sce (C:\Users\digg\Documents\testscript.sce) - SciNotes
testscript.sce

```
x=1;
y=2;
x+y
```

- Edit with the editor (applications/SciNotes):
  - // for comments
  - F5 to evaluate the script



```
--> exec('C:\Users\digg\Documents\testscript.sce')

--> x=1;

--> y=2;

--> x+y
 ans  =

   3.
```

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Load/save data

Variables (environment) *sod

- Save and load commands
- Menu File/Save environment or Load environment

Graphics *.scg

- Any graphic figure can be saved:
  - save() through its identifier as a variable
  - xsave()
  - With figure's menu *File /Save*
- Load file ***.scg**: load(..) or xload()
- Several figures may be saved in the same file. Each restored figure gets a new incremented #id, so usually not the original one.

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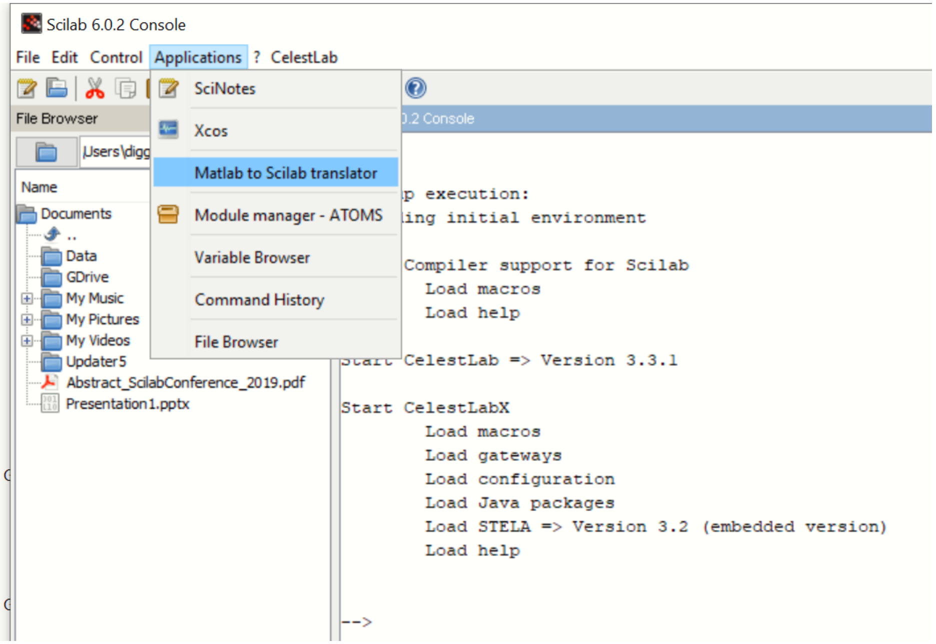
Scilab: Matlab

- 'Comparisons are odious‘
- https://wiki.scilab.org/MatlabToScilab
- Conversor available



```
p execution:
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-->
```

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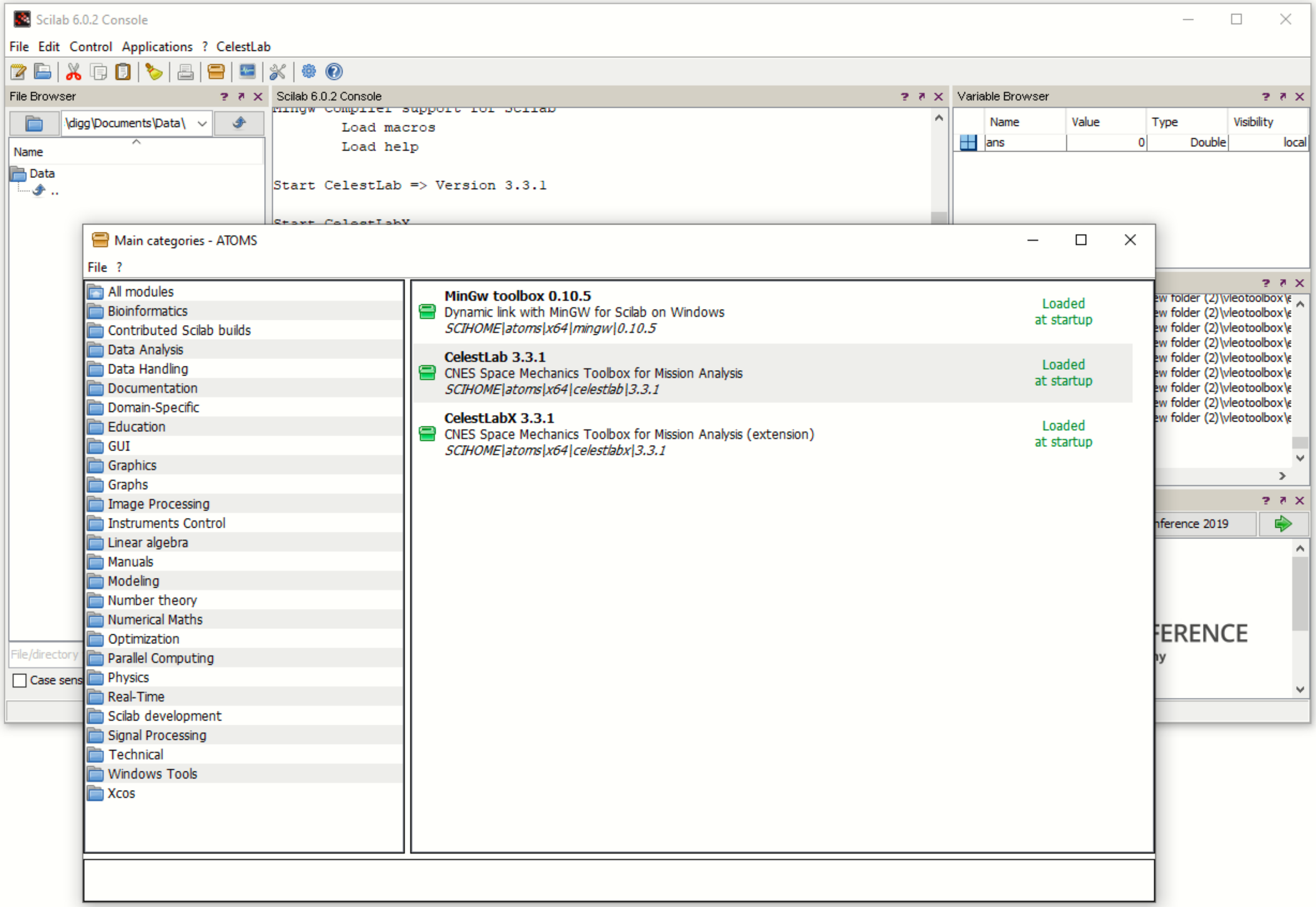
Scilab: ATOMS



```
MinGw Compiler support for Scilab
        Load macros
        Load help

Start CelestLab => Version 3.3.1

Start CelestLabX
```

Name	Value	Type	Visibility
ans	0	Double	local

MinGw toolbox 0.10.5
Dynamic link with MinGW for Scilab on Windows
SCIHOME|atoms|x64|mingw|0.10.5
Loaded at startup

CelestLab 3.3.1
CNES Space Mechanics Toolbox for Mission Analysis
SCIHOME|atoms|x64|celestlab|3.3.1
Loaded at startup

CelestLabX 3.3.1
CNES Space Mechanics Toolbox for Mission Analysis (extension)
SCIHOME|atoms|x64|celestlabx|3.3.1
Loaded at startup

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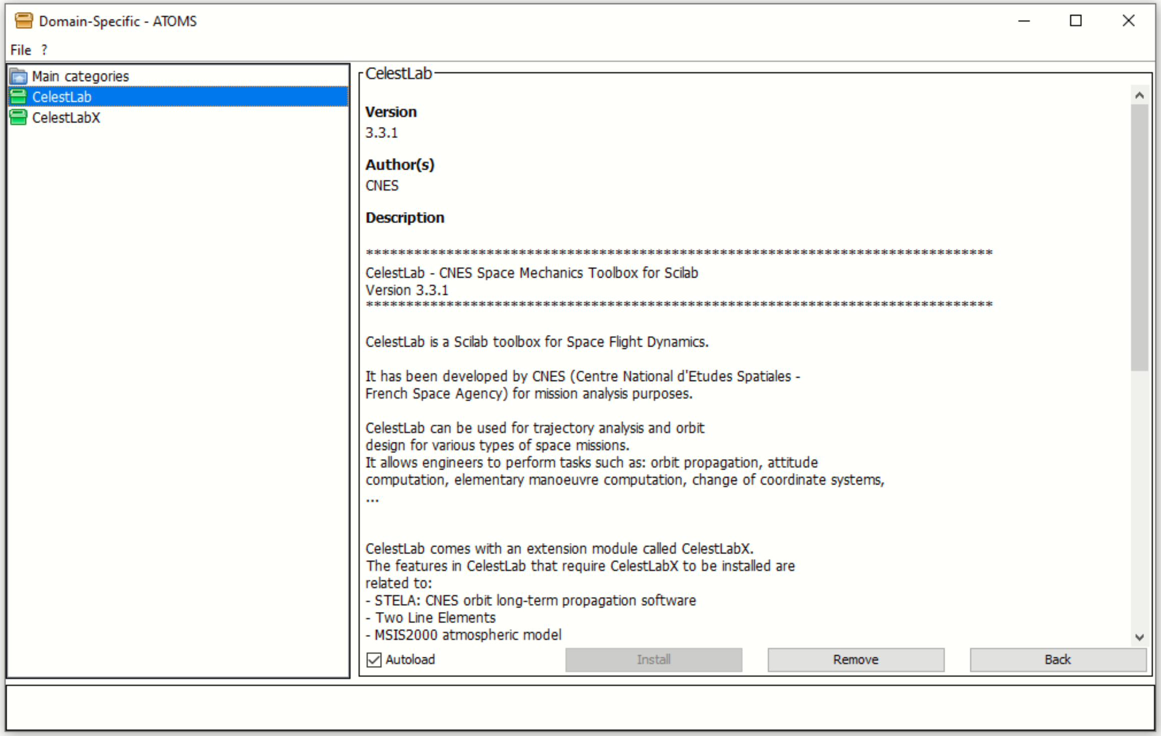
CelestLab/CelestLabX

- Atoms/Domain-specific/Celestlab



Version
3.3.1

Author(s)
CNES

Description

```
********************************************************************************
CelestLab - CNES Space Mechanics Toolbox for Scilab
Version 3.3.1
********************************************************************************

CelestLab is a Scilab toolbox for Space Flight Dynamics.

It has been developed by CNES (Centre National d'Etudes Spatiales -
French Space Agency) for mission analysis purposes.

CelestLab can be used for trajectory analysis and orbit
design for various types of space missions.
It allows engineers to perform tasks such as: orbit propagation, attitude
computation, elementary manoeuvre computation, change of coordinate systems,
...


CelestLab comes with an extension module called CelestLabX.
The features in CelestLab that require CelestLabX to be installed are
related to:
- STELA: CNES orbit long-term propagation software
- Two Line Elements
- MSIS2000 atmospheric model
```

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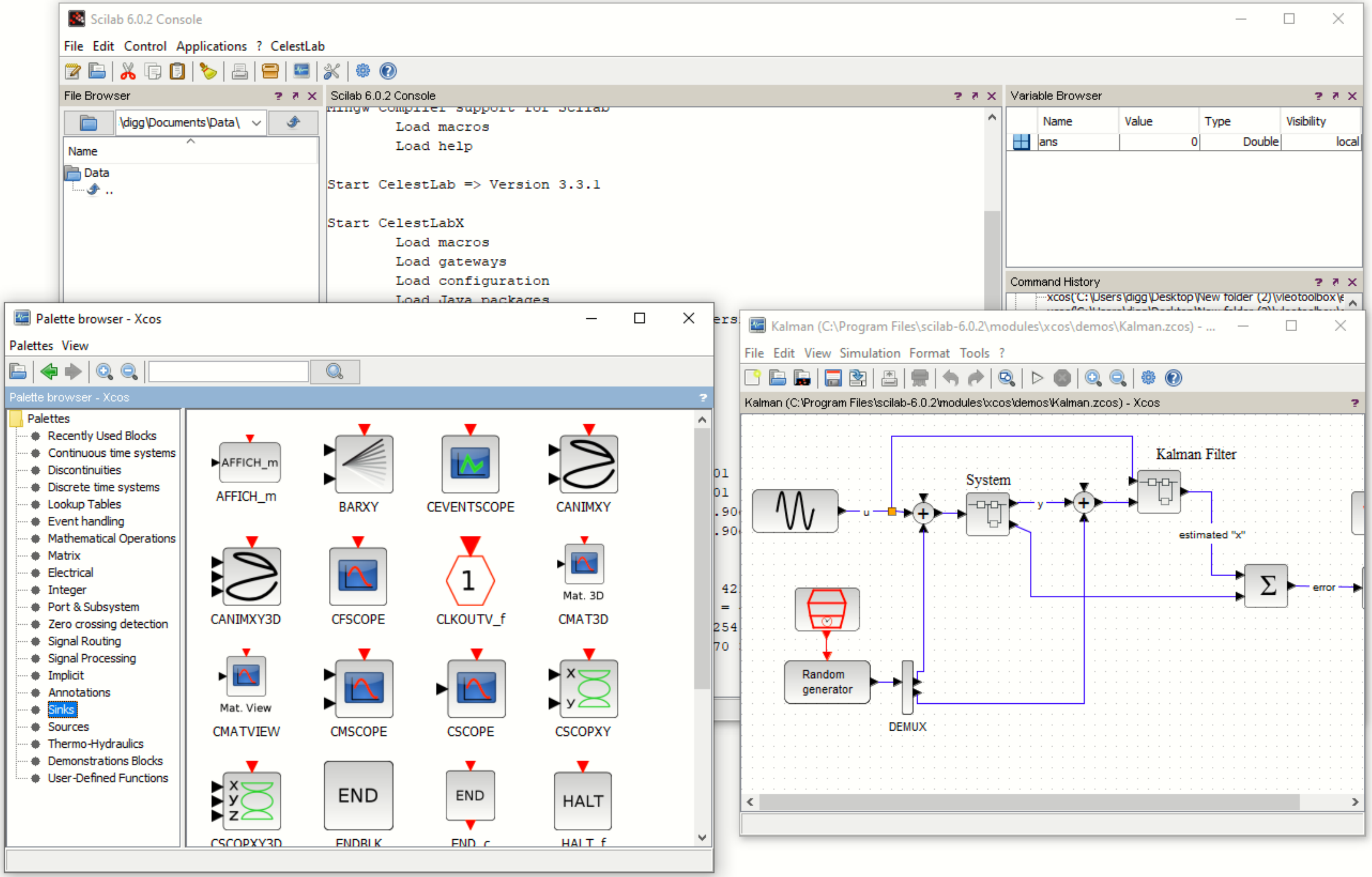
XCOS



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```

	Name	Value	Type	Visibility
▦	ans	0	Double	local

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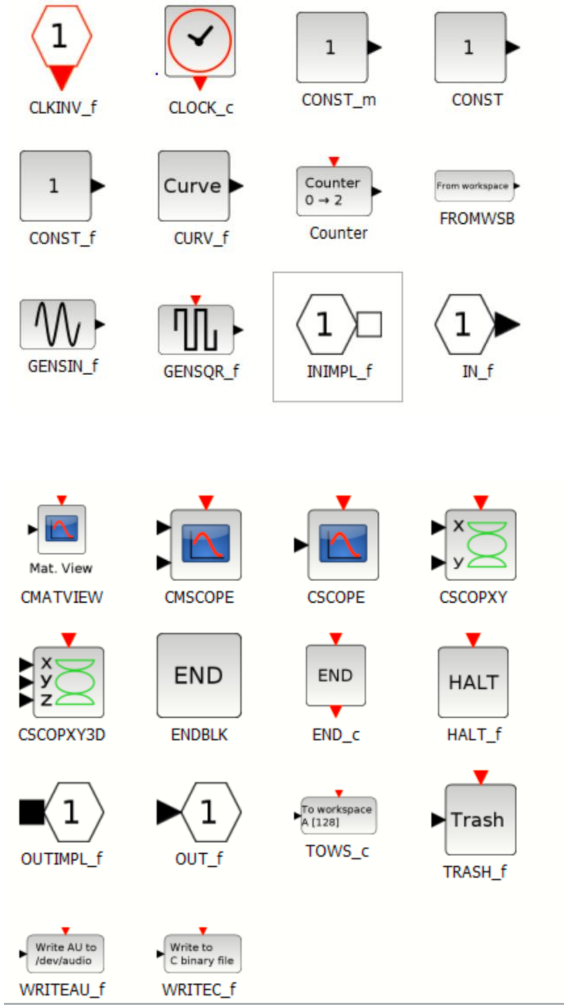
Xcos: Palette

- **Standard Palettes and Blocks**
  - Signal processing and signal routing
  - Thermo-hydraulic blocks
  - Mathematical operations, matrix, integer
  - Discrete and continuous system blocks
  - Electrical
  - User defined blocks
  - Annotations: text, LaTeX/MathML
  - Lookup tables
  - Event handling
  - Sinks and sources
  - Port and subsystem



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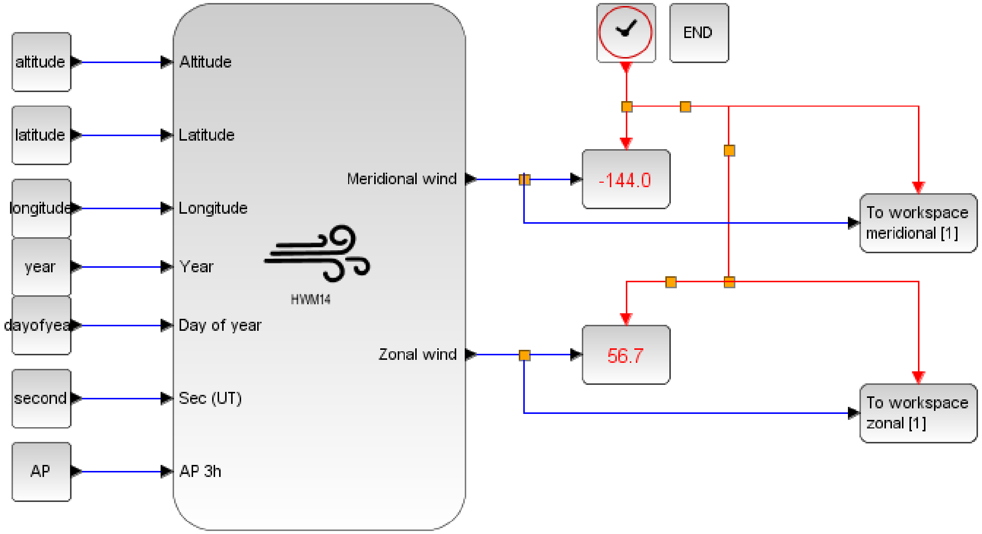
Model building and edition

- Blocks selection from existing palettes (drag and drop)
- Define inputs and connect blocks trough lines
- Superblocks management (Sub-diagram embedded in a single superblock for model reuse and simplification)
- All Scilab data types available for signal definition



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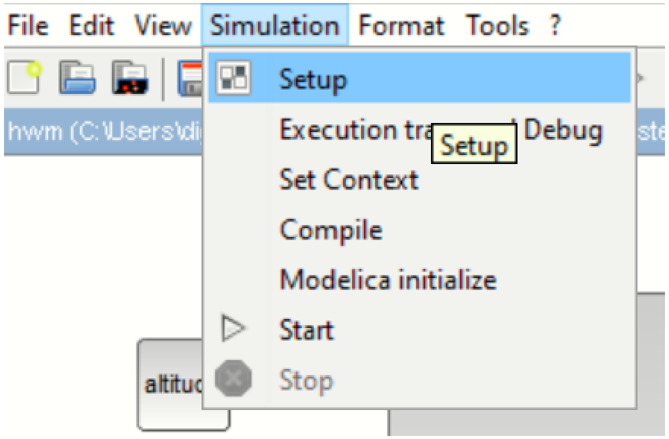
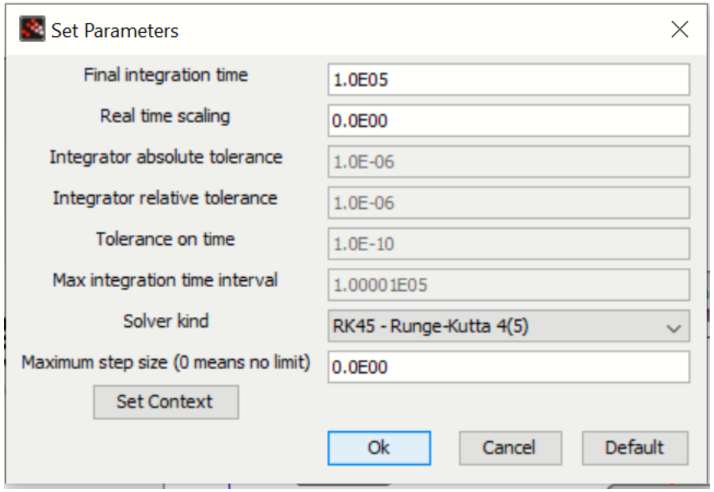
Model customization

- Simulation parameters definition (solver)




Set Parameters

Final integration time: 1.0E05

Real time scaling: 0.0E00

Integrator absolute tolerance: 1.0E-06

Integrator relative tolerance: 1.0E-06

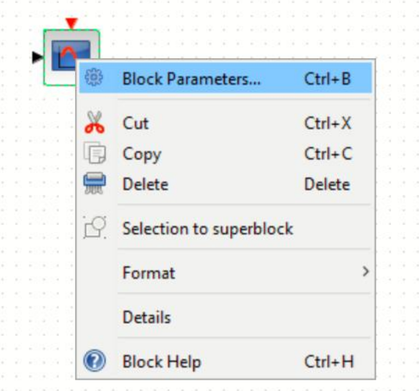
Tolerance on time: 1.0E-10

Max integration time interval: 1.00001E05

Solver kind: RK45 - Runge-Kutta 4(5)

Maximum step size (0 means no limit): 0.0E00

- Signals and blocks parameters adaptation



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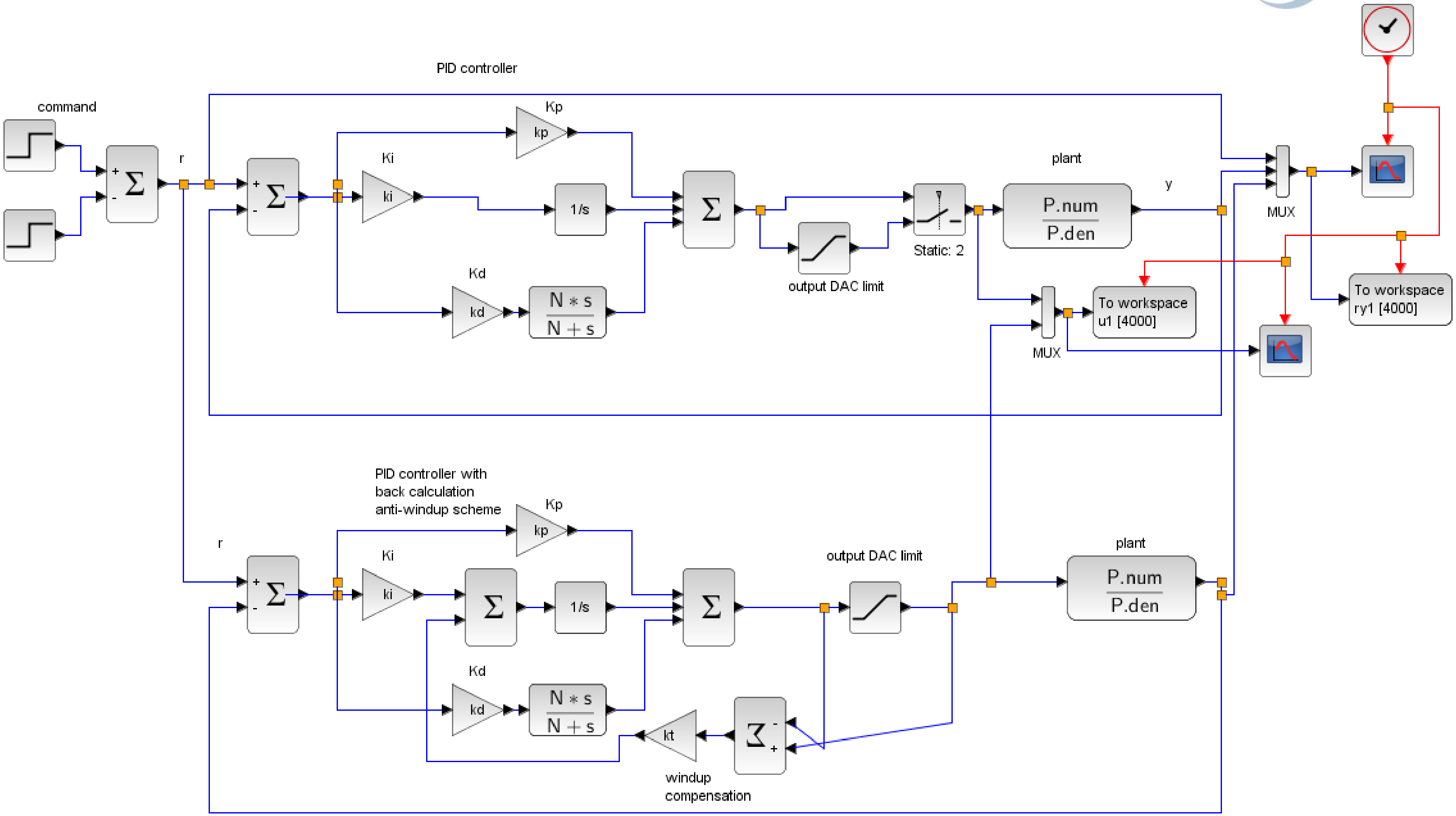
Example: AntiWindUp PID controller



Source: https://www.scilab.org/pid-anti-windup-schemes (Dew Toochinda, Scilab Ninja)

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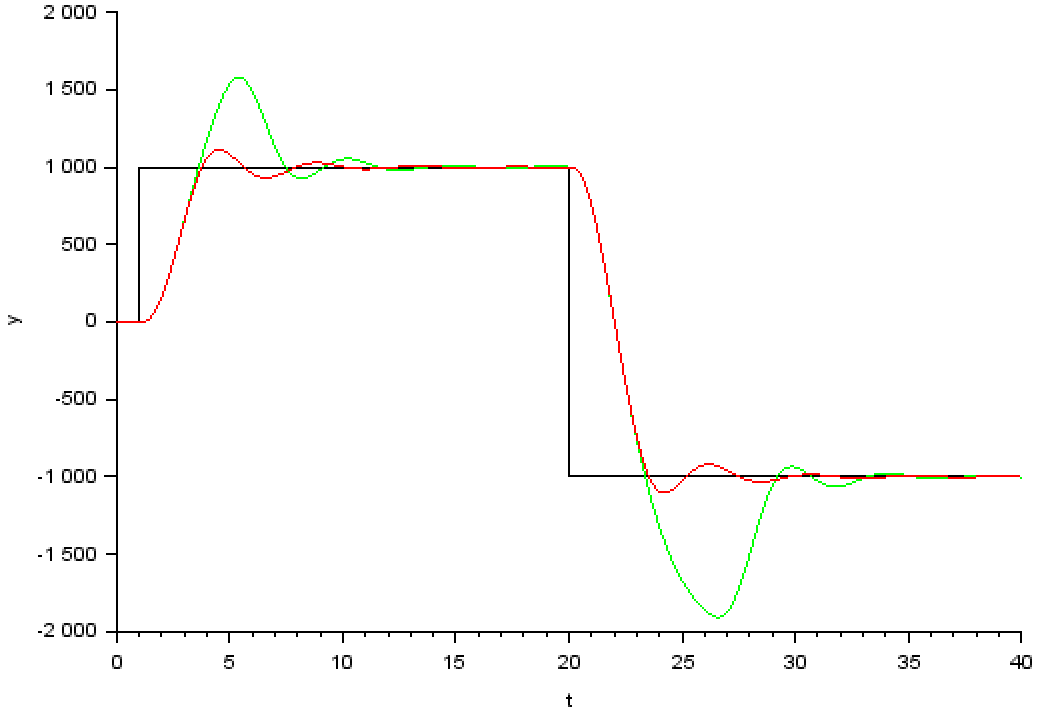
Example: AntiWindUp PID controller



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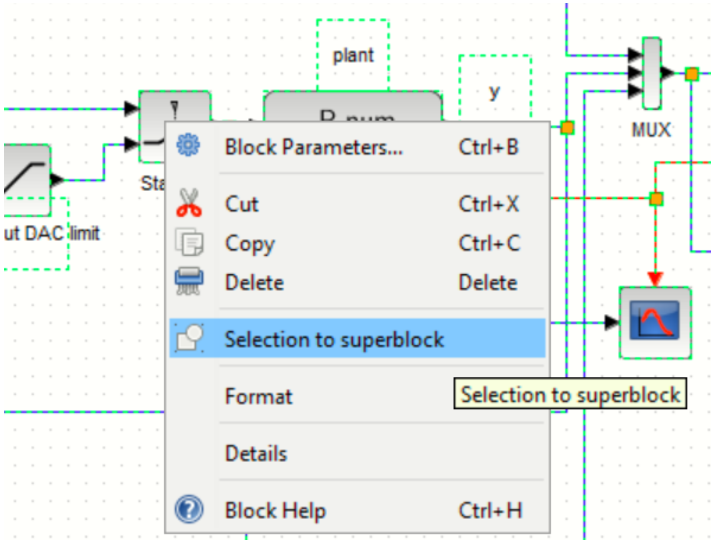
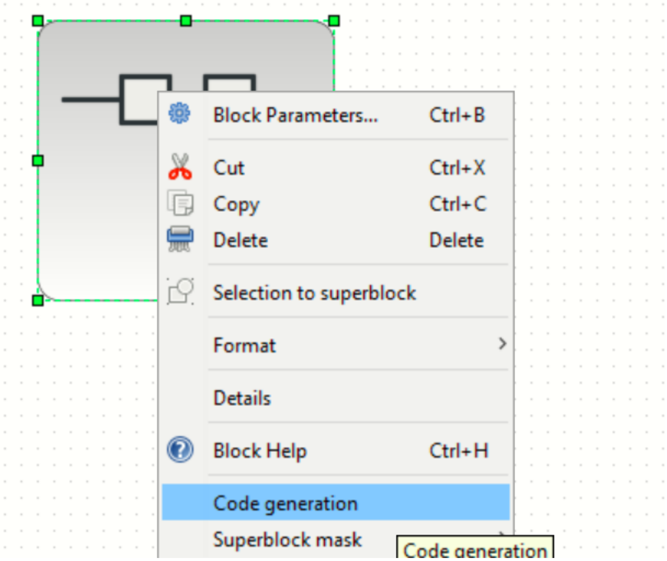
Code generation

Create Superblock



Generate code from superblock



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Xcos: Custom blocks

- External code (C, C++, Fortran)
- Xcos models (generate code)
- Scilab code

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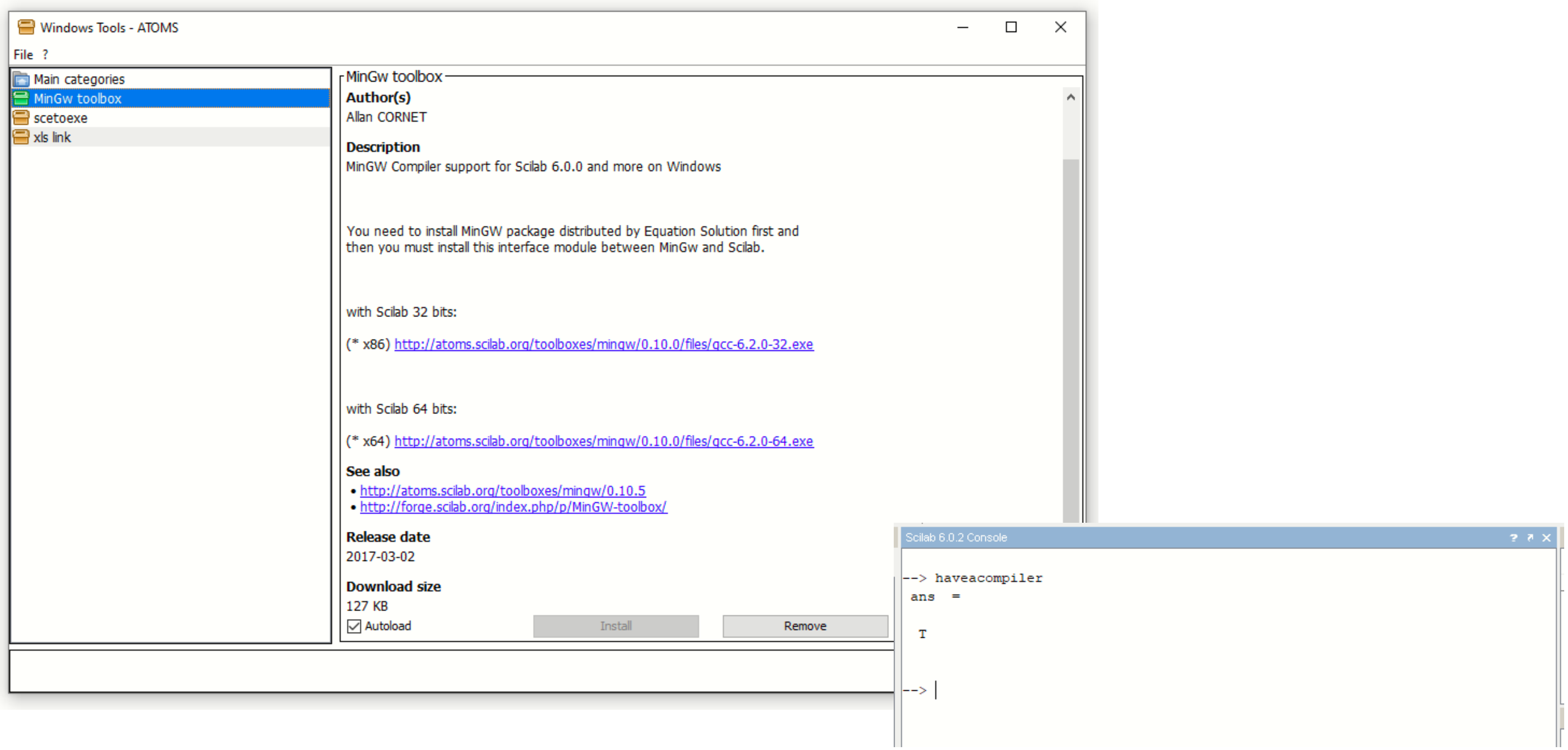
Xcos: Custom blocks

- Install MinGw and its toolbox to be able to compile code (C/C++, Fortran)
- Atoms/Windows Tools/MinGw toolbox



Author(s)
Allan CORNET

Description
MinGW Compiler support for Scilab 6.0.0 and more on Windows

You need to install MinGW package distributed by Equation Solution first and then you must install this interface module between MinGw and Scilab.

with Scilab 32 bits:

(* x86) http://atoms.scilab.org/toolboxes/mingw/0.10.0/files/gcc-6.2.0-32.exe

with Scilab 64 bits:

(* x64) http://atoms.scilab.org/toolboxes/mingw/0.10.0/files/gcc-6.2.0-64.exe

See also
- http://atoms.scilab.org/toolboxes/mingw/0.10.5
- http://forge.scilab.org/index.php/p/MinGW-toolbox/

Release date
2017-02-02

Download size
127 KB

☑ Autoload

```
--> haveacompiler
 ans  =

  T

-->
```

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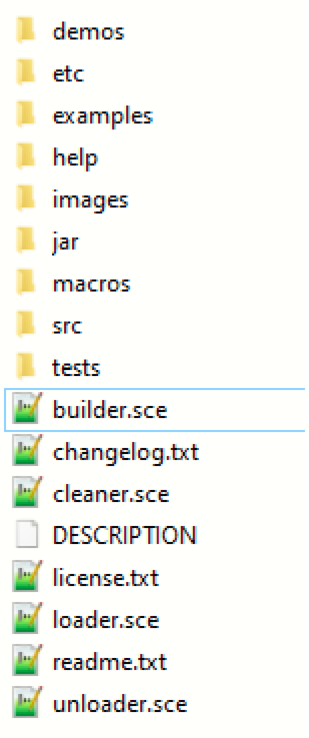
Xcos: Custom Toolbox



demos
etc
examples
help
images
jar
macros
src
tests
builder.sce
changelog.txt
cleaner.sce
DESCRIPTION
license.txt
loader.sce
readme.txt
unloader.sce

□Skeleton structure (contribs in Scilab source code):

- Etc
- Help
- Images
- Macros: Block definition and Scilab code,
- Src: Source code.
- Builder.sce: compilation script.
- Loader.sce: load toolbox.

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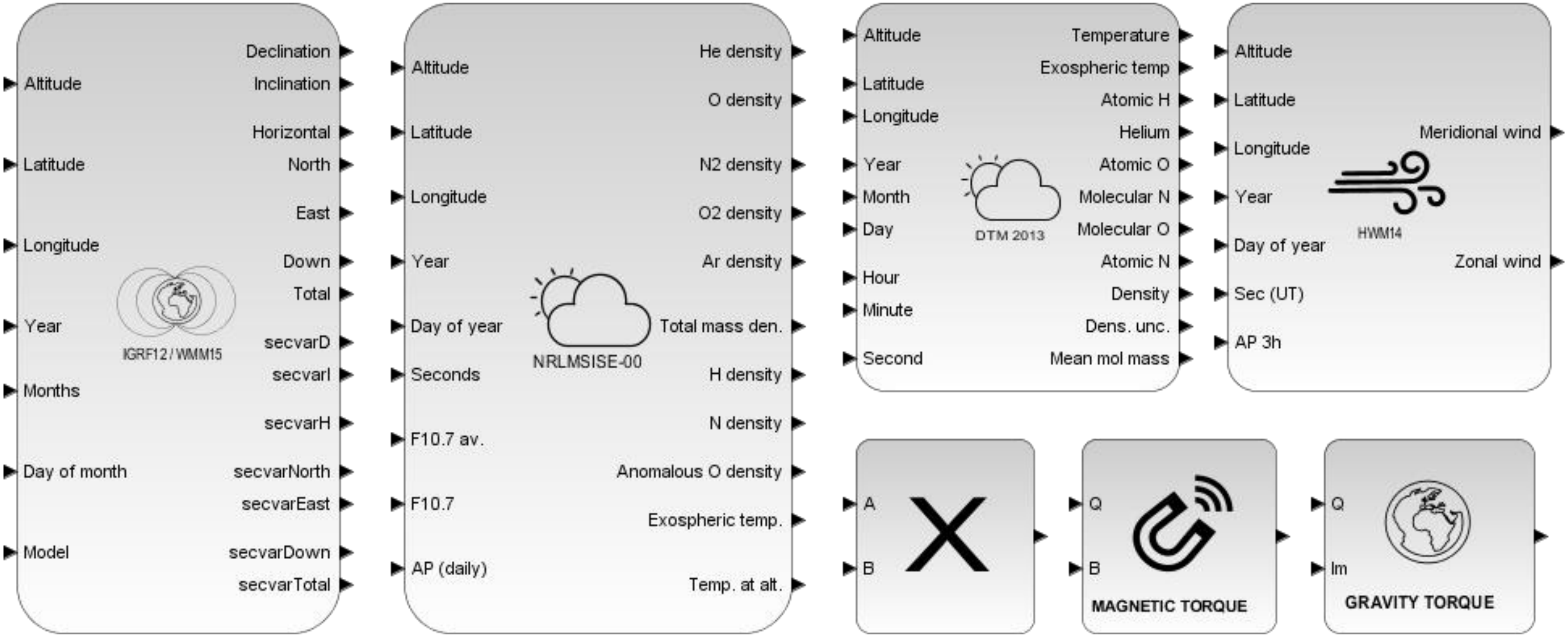
Xcos: Custom Toolbox



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Links

Links of interest		
⬇	Download	https://www.scilab.org/download/6.0.2
?	Tutorials	https://www.scilab.org/tutorials
W	Wiki	https://wiki.scilab.org/
✉	Mail lists	https://www.scilab.org/about/community/mailing-lists
💬	Forum	https://scilab.in/forum
📖	Books	https://www.scilab.org/about/community/books
?	Control Eng.	https://scilabdotninja.wordpress.com/scilab-control-engineering-basics/

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Demo

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