

HARMONIZATION AND COMPARISON OF ATMOSPHERIC RADIATIVE TRANSFER MODELS WITH THE ALG TOOLBOX

Jorge Vicent Servera (Magellium | Univ. of Valencia)
 Jochem Verrelst (Univ. of Valencia)
 Béatrice Berthelot (Magellium)
 Gustau Camps-Valls (Univ. of Valencia)
 jorge.vicent@uv.es | jorge.vicent-servera@magellium.fr

Atmospheric radiative transfer models (RTMs) are a critical tools in remote sensing applications, facilitating instrument design, data processing algorithms, and satellite Cal/Val activities. However, the diverse and complex nature of available RTMs presents a significant challenge to standardizing data processing schemes and harmonizing Cal/Val procedures.

LEARN MORE AT...

www.artmtoolbox.com
 J. Vicent et al.: Comparative analysis of atmospheric radiative transfer models using the Atmospheric Look-up table Generator (ALG) toolbox (version 2.0), Geosci. Model Dev., 13, 1945–1957
<https://doi.org/10.5194/gmd-13-1945-2020>, 2020.



OBJECTIVE

Our objective is to provide a **user-friendly software tool** that streamlines workflows and **standardizes RTM inputs and outputs**. Our tool seamlessly interfaces with external atmospheric data sources (CAM5, OPAC, Aeronet...) and is designed to be **modular and expandable** to integrate new atmospheric RTM. With our tool, users can effortlessly leverage a wide range of atmospheric RTMs while ensuring **harmonization of data sets** for remote sensing applications.

IMPLEMENTED MODELS

- MODTRAN modtran.spectral.com
- 6SV salsa.umd.edu/6spage.html
- libRadtran libradtran.org
- SBDART github.com/paulricchiazzi/SBDART
- ARTDECO icare.univ-lille.fr/artdeco/

and others in the pipeline (SCIATRAN, DISAMAR, pyDOME...)

CURRENT PROJECTS

- FLEX and CHIME end-to-end simulators | ESA/ESTEC
- Generic Simulator of Optical Satellites (GSOOS) | ESA/ESTEC
- FLEX Level-2 Study | ESA/ESTEC
- ACIX-III Land | ESA/NASA
- RAMI4ATM | EC
- SMAC | CNES
- VICALOPS | ESA/ESTEC

PLANNED UPDATES

- Satellite simulator tool: simulation of satellite data for testing & validation of atmospheric correction algorithms.
- HITRAN API interface for simulating transmittance spectra.
- Physics-aware emulation of atmospheric RTM data.

HARMONIZATION

Although all RTM solve the radiative transfer equation, their interfaces differ in content, definition and format. ALG serves as a wrapper to write RTM input files and read their outputs in a harmonized manner.

Inputs

Commonly used units, definitions (e.g. AOT vs visibility, optical properties) and conventions.

Outputs

Use of transfer functions (transmittance, path radiance, spherical albedo) for scene simulation and atmospheric correction, and TOA radiance spectra. Units are standardized.

Format

RTM native outputs are read and stored in a netcdf (.nc) file with intuitive and documented interfaces.

Dataset/ description	Format
LUT output data Stored LUT output data, consisting of atmospheric transfer functions as obtained by the executed RTM.	name="LUTdata" type=DOUBLE units=(various) dims=[n_funcs*n_wvl n_comb]
Solar Irradiance Extraterrestrial solar irradiance used in the simulation. Notice that I0 is the same for all the nodes in the LUT.	name="I0" type=DOUBLE units=mW-m-2-nm-1 dims=[n_wvl]
LUT header Matrix containing the values of the input variables at each combination in the LUT. The "units" attribute consists on a string of comma-separated units (e.g., 'unit1,unit2,...').	name="LUTheader" type=DOUBLE units=(various) dims=[n_param n_comb]
SZA Values of the Solar Zenith Angle for each of node in the LUT.	name="SZA" type=DOUBLE units=deg dims=[n_comb]
Wavelengths Values values at which the output atmospheric transfer functions are calculated.	name="wvl" type=DOUBLE units=nm dims=[n_wvl]
Static parameters Values of the fixed parameters in the LUT. Each parameter is stored in a subset with the corresponding variable name variable name.	name="static/varname" type=DOUBLE units=(various) dims=[1]

RTM COMPARISON

ALG was used to compare various atmospheric RTM. Overall, it was found that ALG facilitates the simulation of physically comparable datasets from a variety of RTM. Figures show global sensitivity analysis, hyperspectral model comparison, and preliminary RAMI4ATM results as illustrative examples.

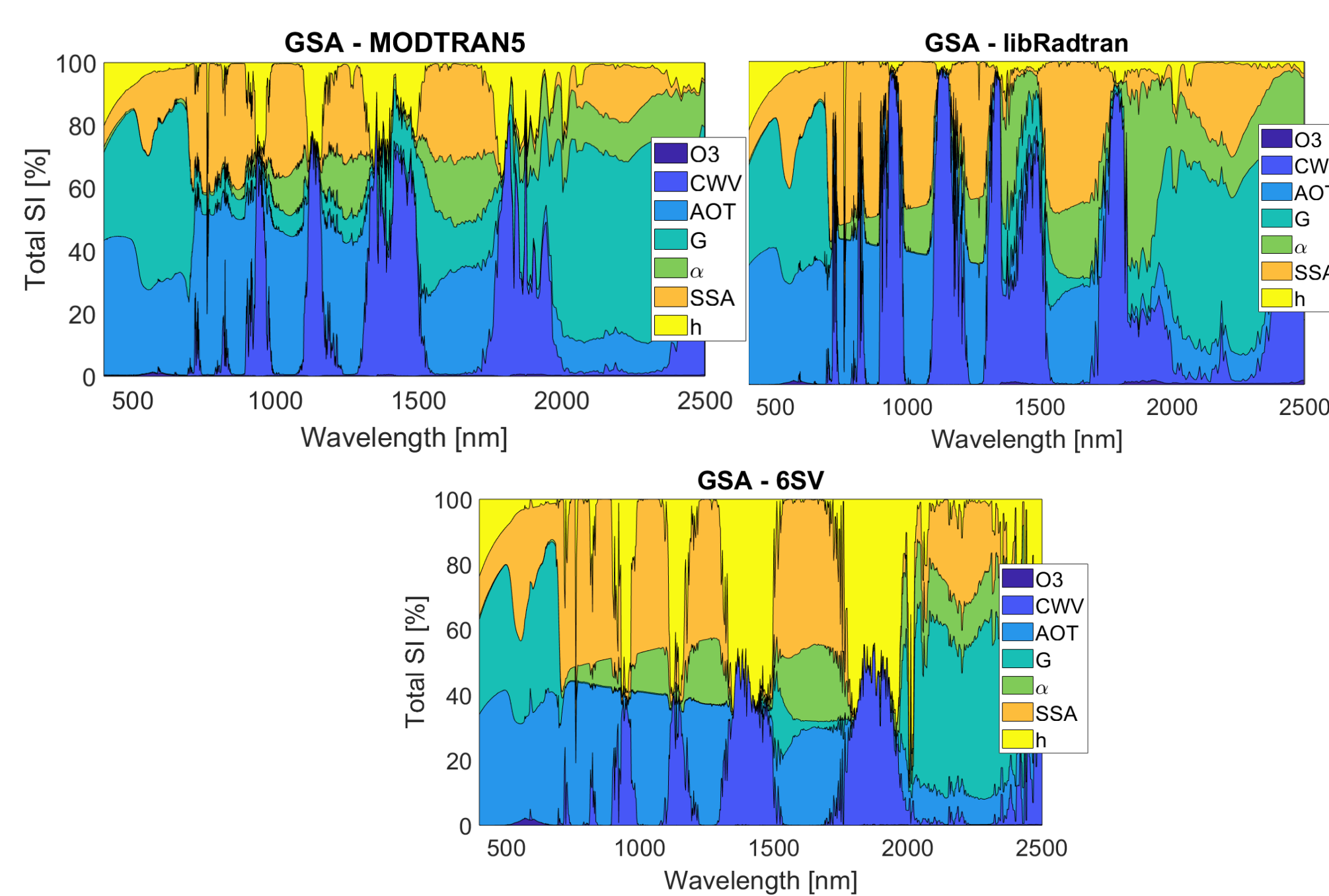


Fig 1. MODTRAN5, libRadtran, and 6SV Global Sensitivity Analysis (GSA) of main atmospheric properties at TOA radiance.

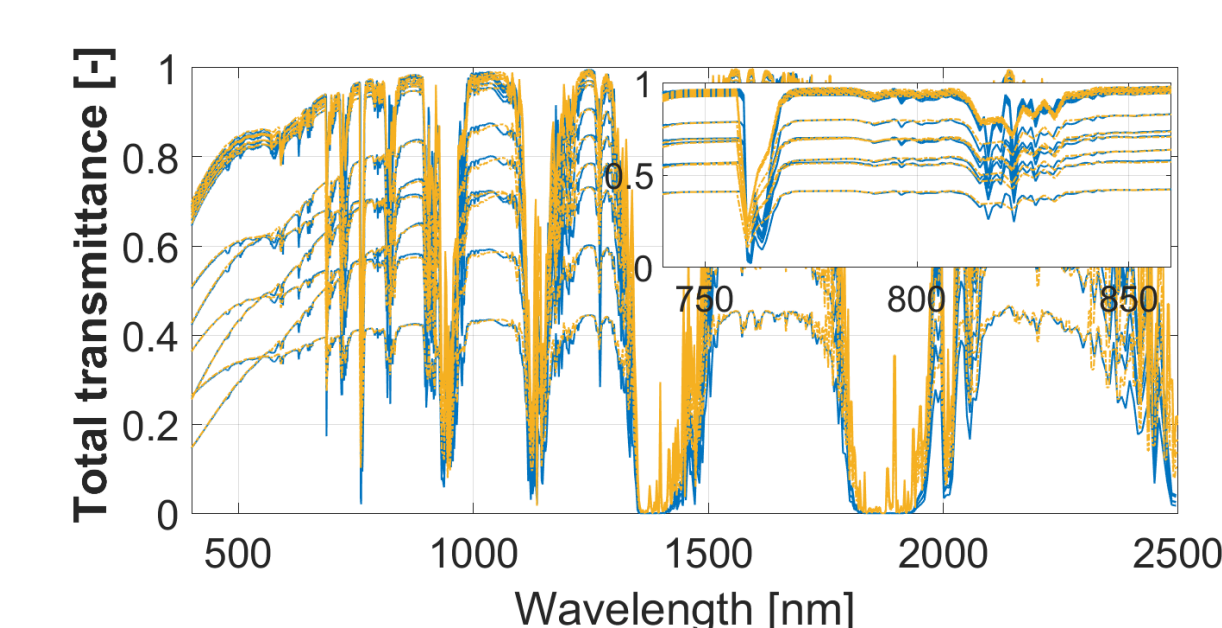


Fig 2. Comparison of MODTRAN5 and libRadtran total transmittance for various atmospheric and geometric conditions.

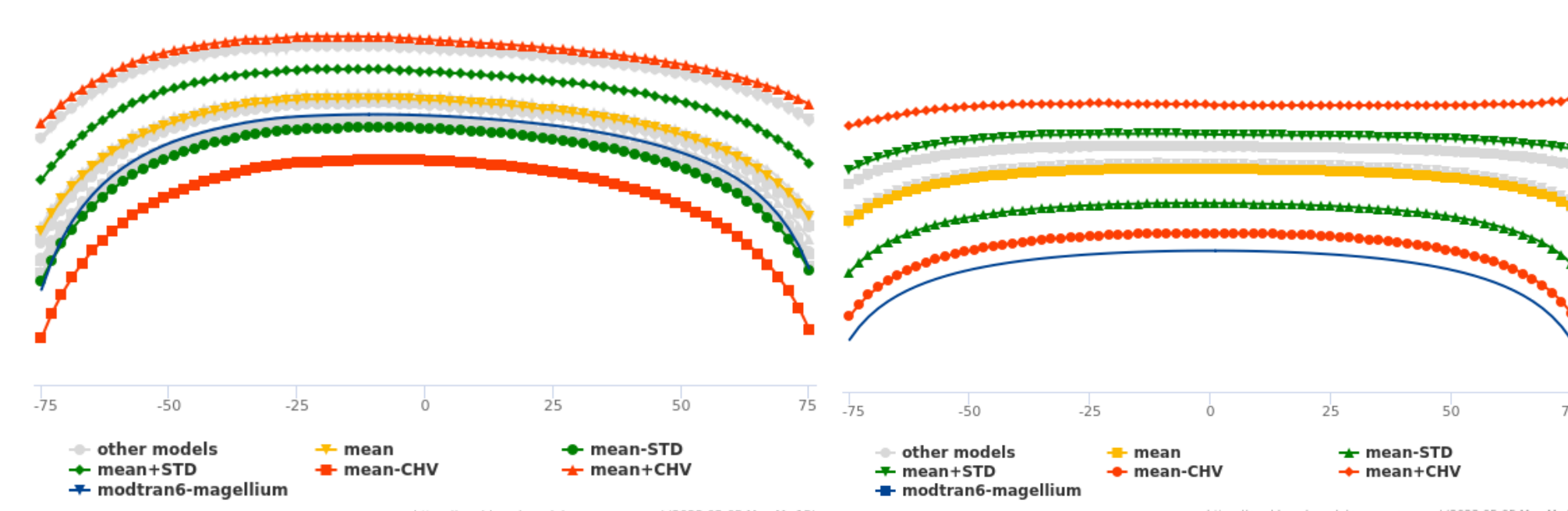
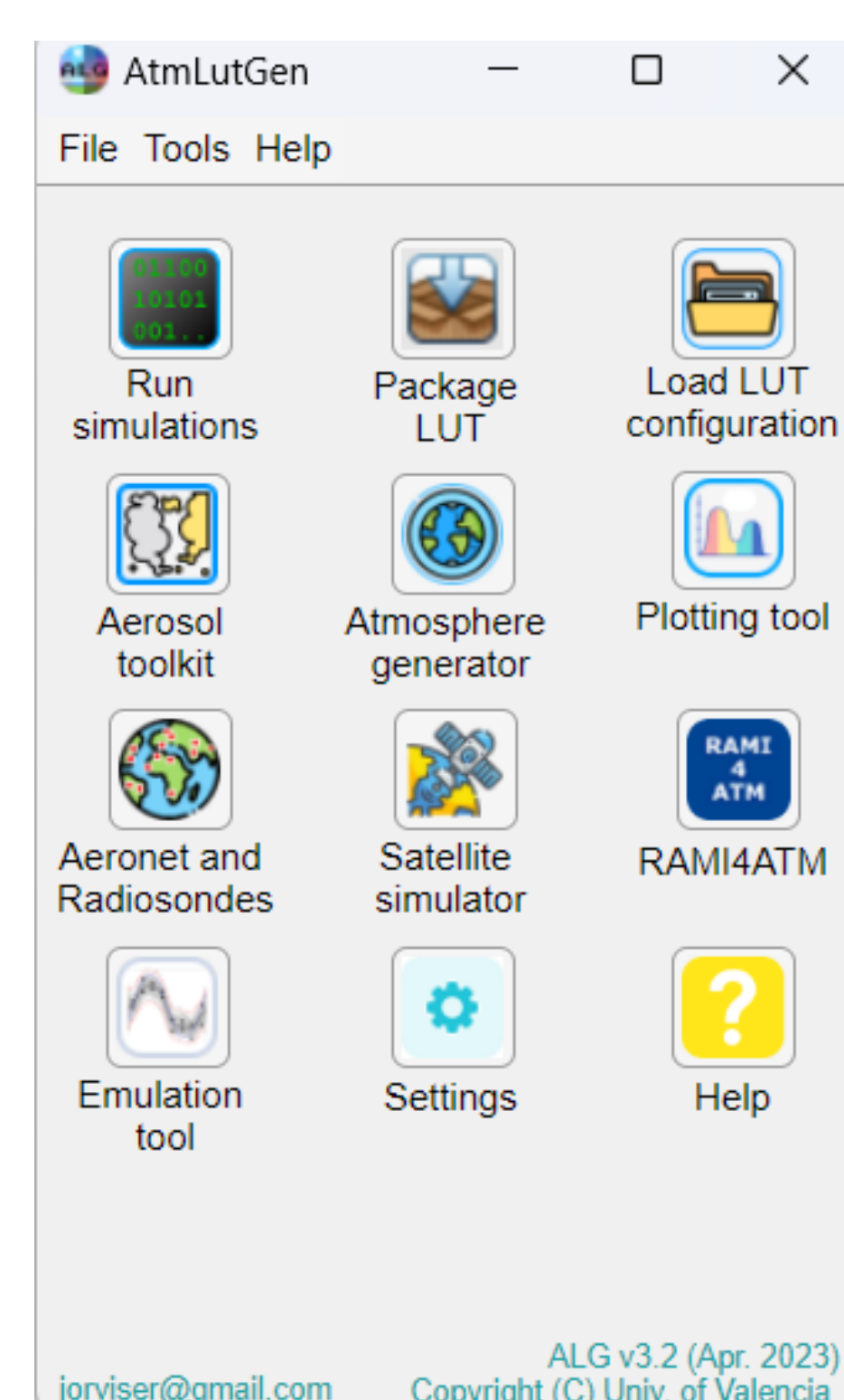
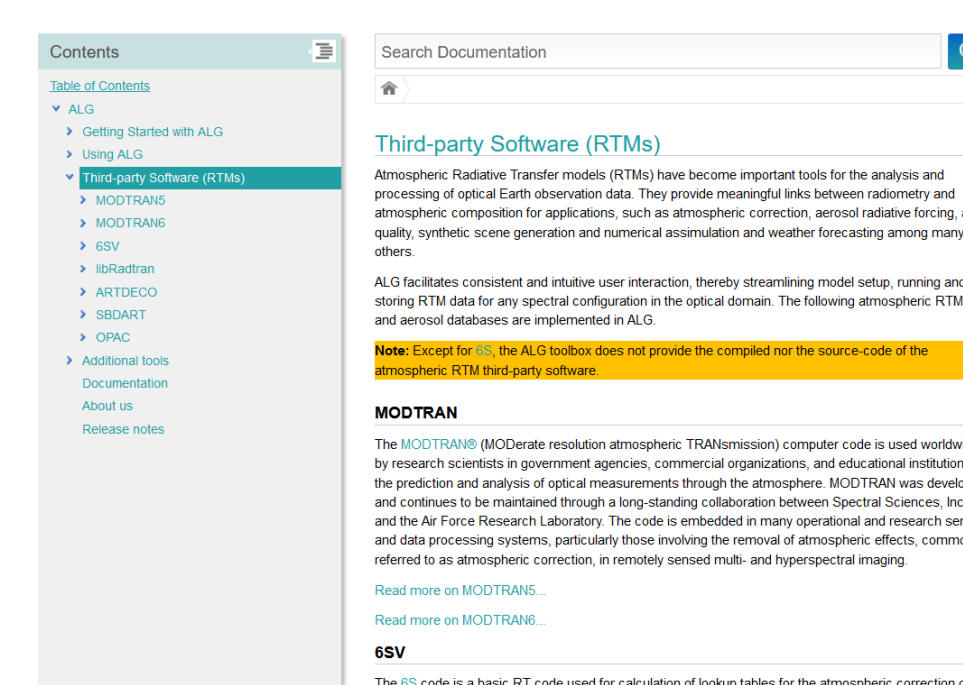


Fig 3. RAMI4ATM validation of MODTRAN6 TOA radiance simulations for complete scenario (E2CS, left) and absorption only scenario (A2CS, right). Absorption scenario indicates deviations since Rayleigh absorption was included in MODTRAN6 simulation.



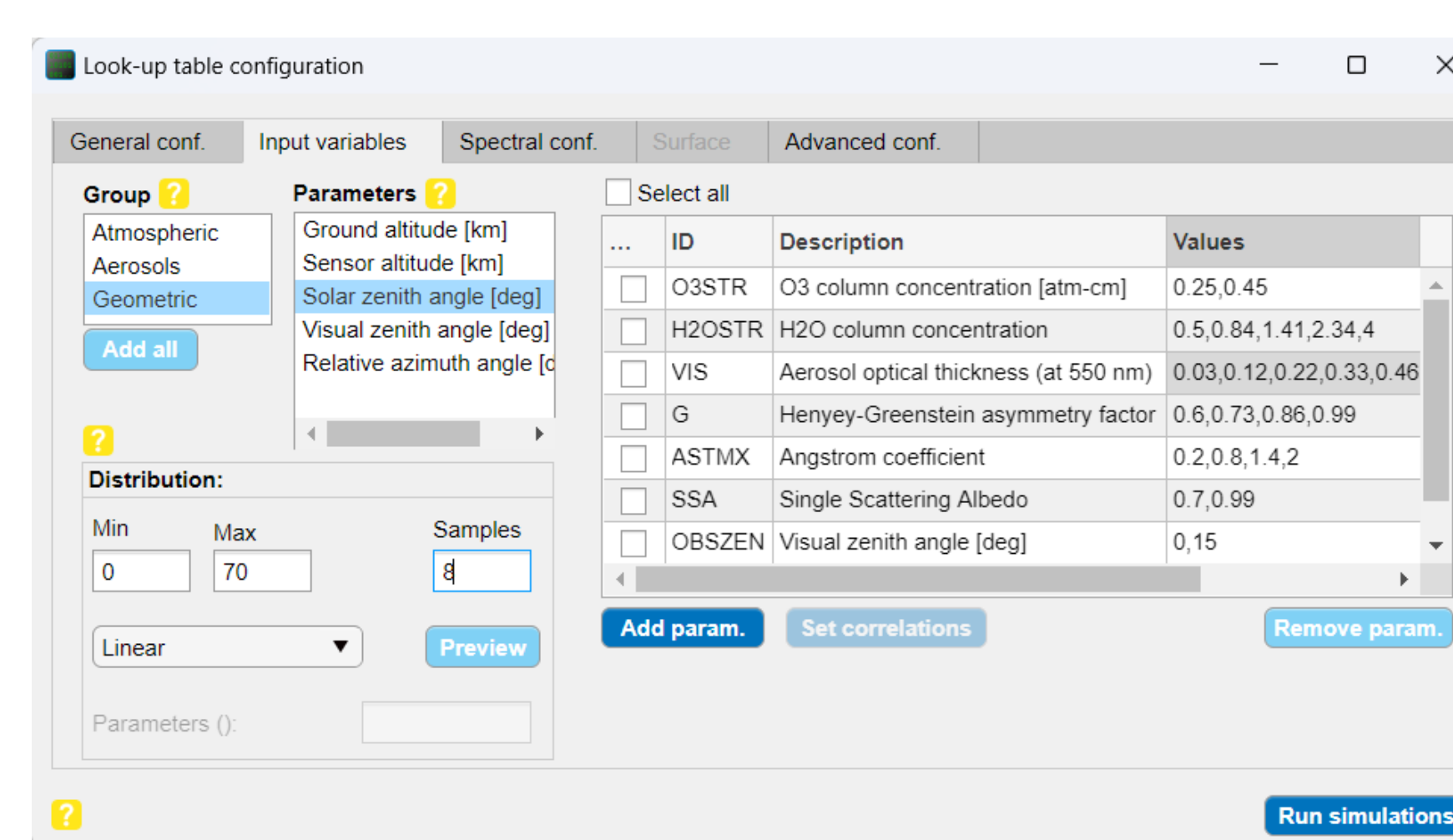
Main window

Access to the key tools within ALG (RTM simulation configuration, aerosols & atmospheric toolkit, Aeronet, emulation...)



User manual

Step-by-step procedures for using ALG software, with tutorials for practical examples. The user manual also gives support for RTM installation, description of the main RTM variables, and links to external scientific literature.

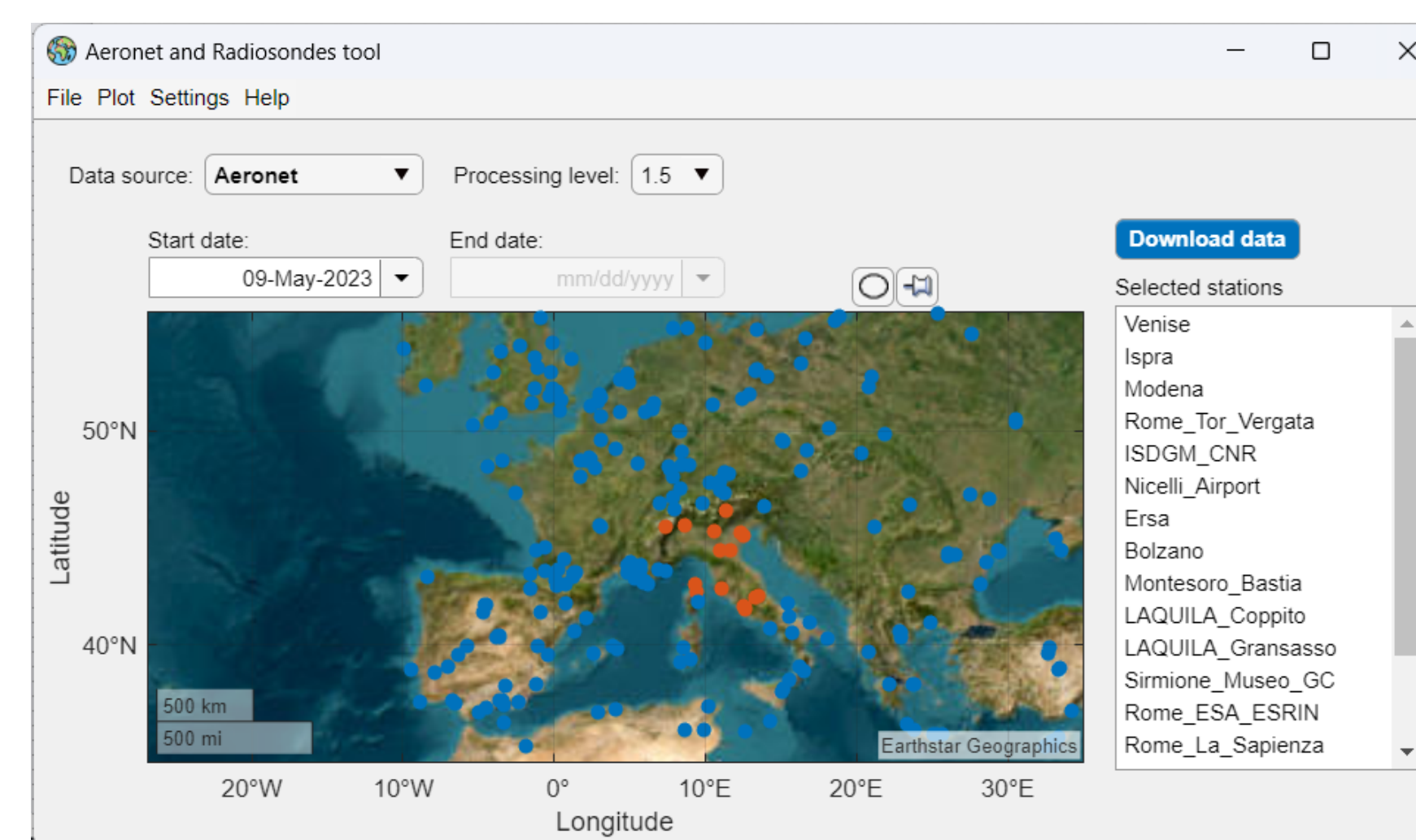
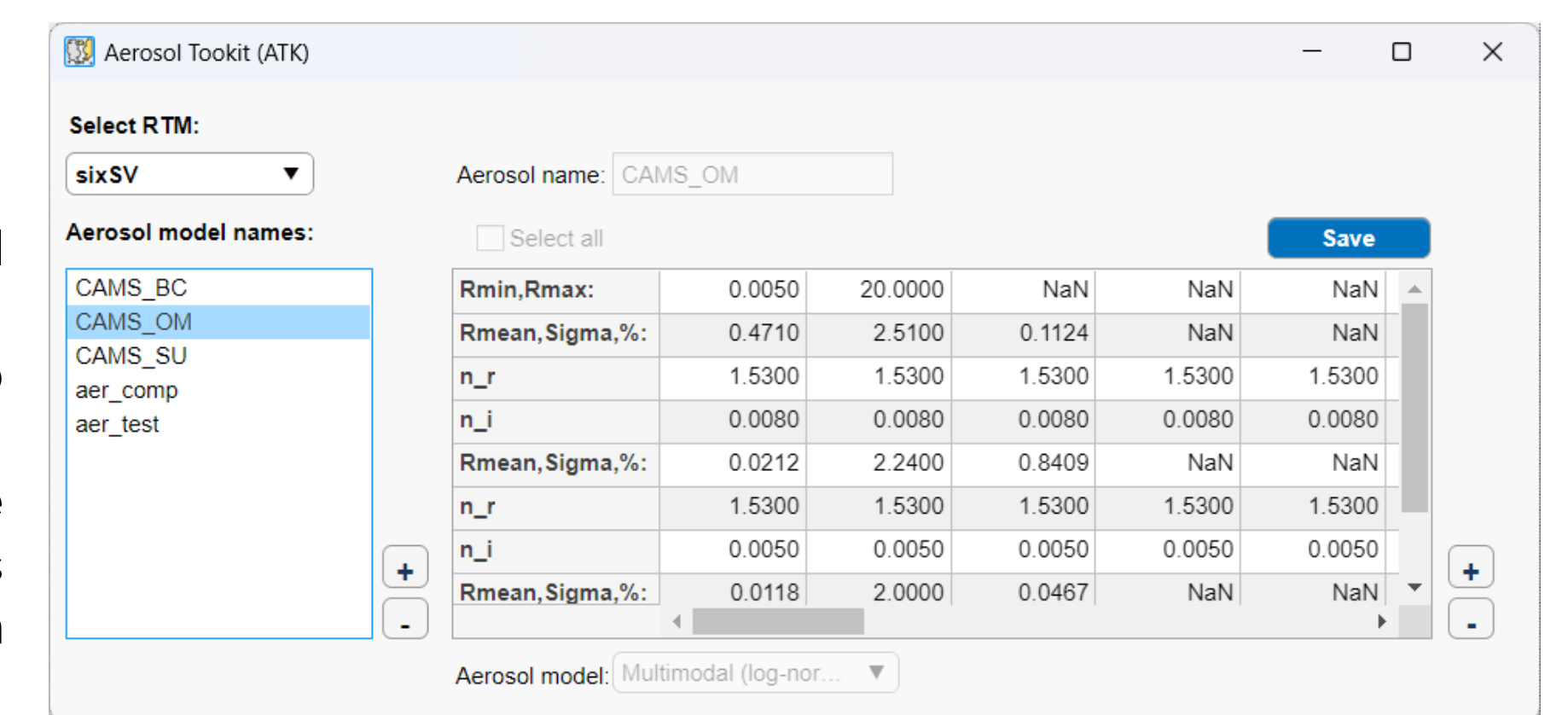


Aerosol toolkit and Atmosphere generator

User can define their own aerosol models based on micro-physics, optical properties or mixtures, allowing to interface aerosol databases (Aeronet, OPAC, CAMS). Similarly, the Atmosphere generator tool allows users to import and edit vertical profiles from repositories (CAM5, NCEP, NWP-SAF).

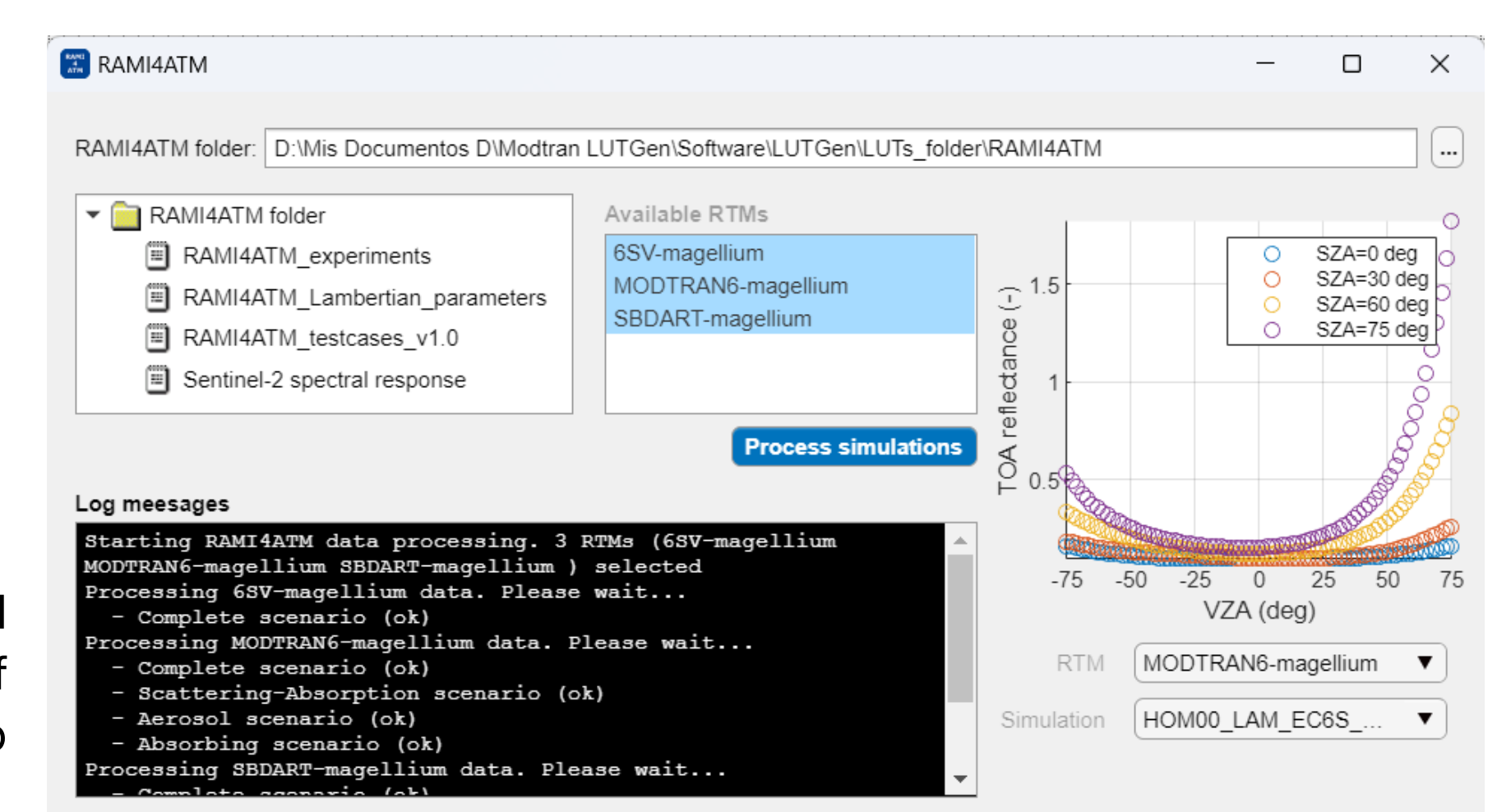
Simulations set-up window

Common interface to streamline model simulations. Selection of input variables values (and distribution), spectral configuration, surface conditions and advanced settings.



Aeronet and Radiosondes tool

Graphical access for downloading Aeronet and Wyoming radiosondes data from various stations and dates. Plotting tools and calculation of statistical information (probability distribution, correlations).



RAMI4ATM tool

Processor of RAMI4ATM simulated scenarios and automatic generation of output .mes files. Graphical tool to visualize simulations.