# The Radiation Transfer Model Intercomparison for Atmosphere: **RAMI4ATM** Initiative

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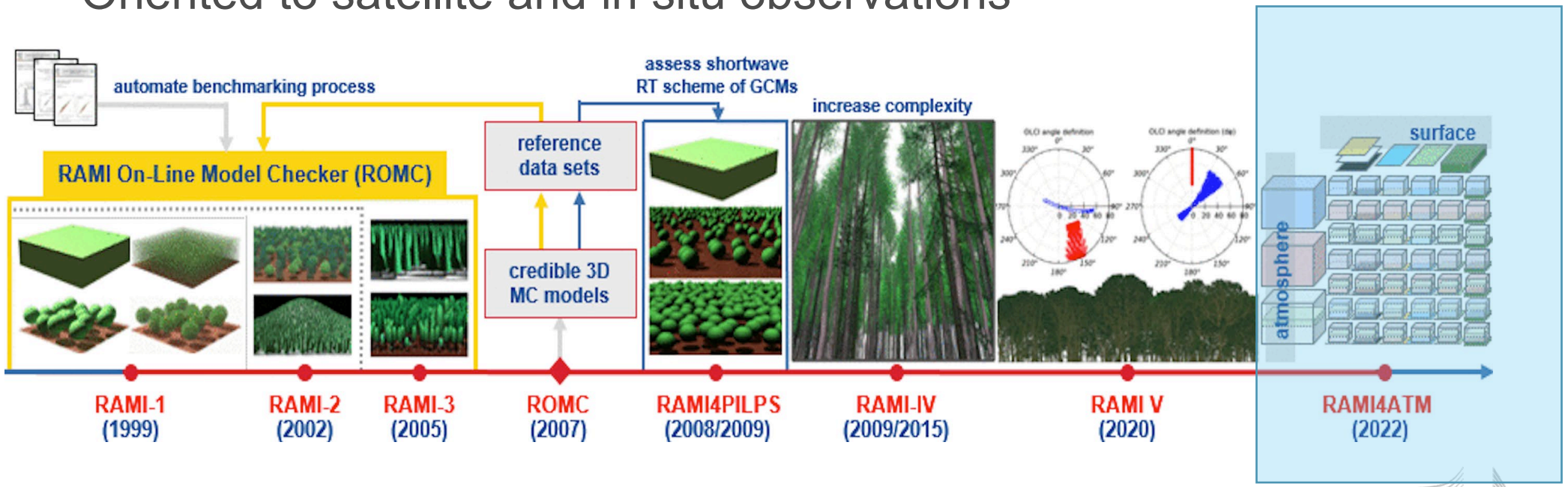
# Radiation Transfer Model Intercomparison exercise

- 3D Radiative Transfer model independent assessment
- 20+ years activities (five phases, ROMC and RAMI4PILS)
- Blind concept
- Increased complexity of scenarios and experiments
- Oriented to vegetated surfaces
- Oriented to satellite and in situ observations

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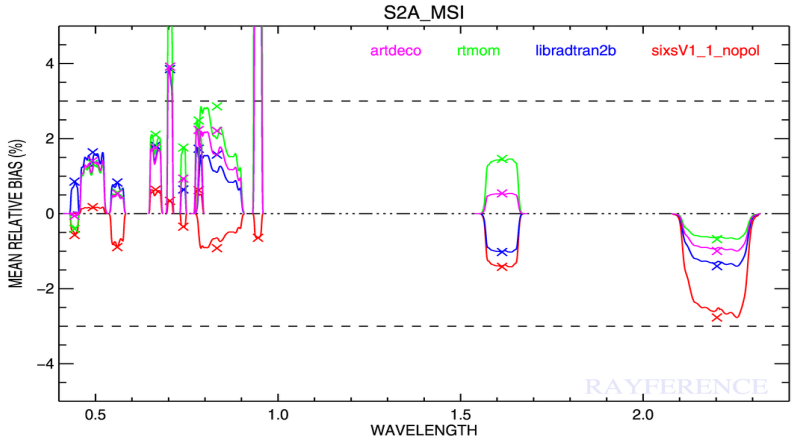
# Background

Many radiative transfer models have been developed and are widely used in Earth Observation:

- **Calibration**




- **Atmospheric correction** or **sensitivity analyses**

- The uncertainties of these models have **not** been clearly assessed in **realistic usage conditions** when supporting typical Earth Observation applications by remote sensing scientists.

RAMI4ATM is a **new** initiative dedicated to the benchmarking of **coupled surface-atmosphere** radiative transfer models. **It is primarily oriented to RTM users**.

April 2022 - September 2022 — **Active submission period**

January 2023 — **On-line results**

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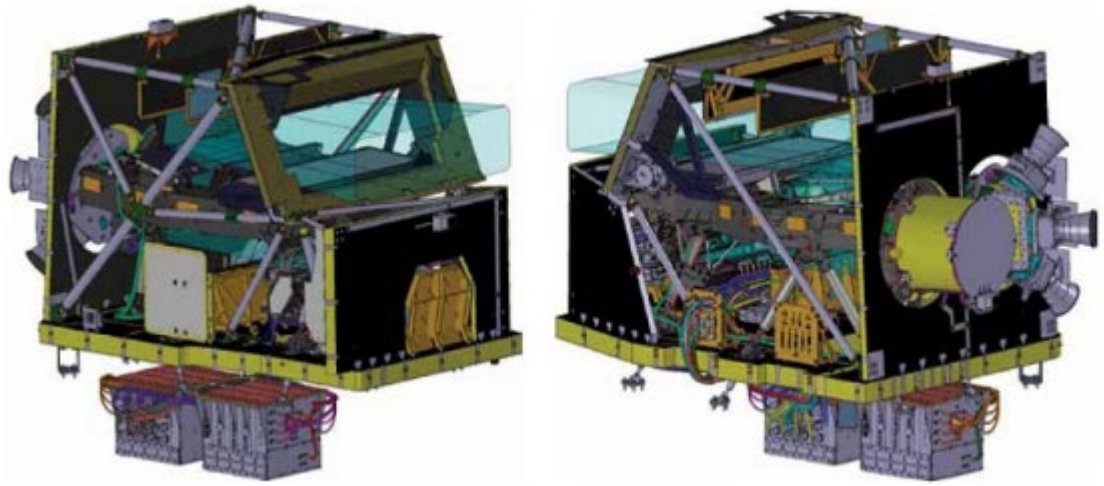
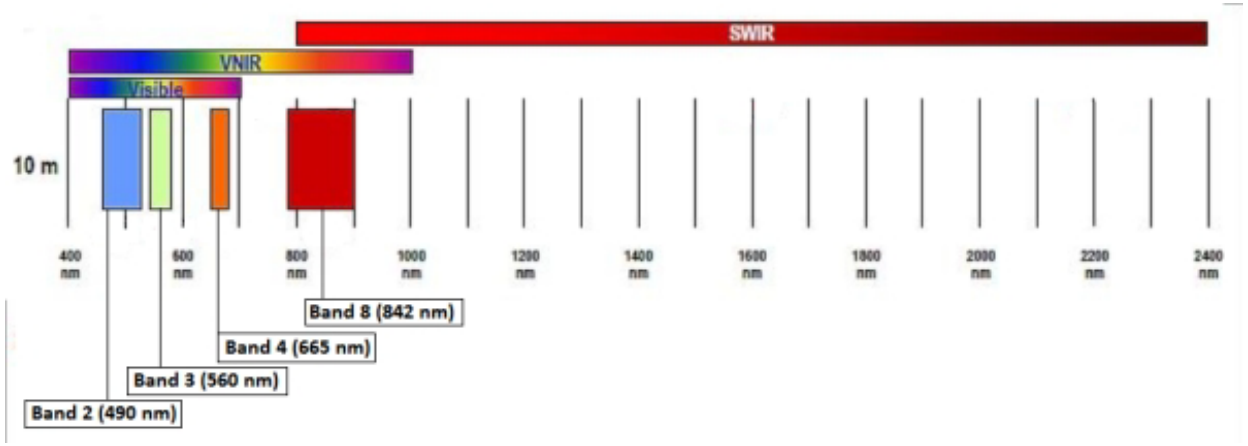
# Sentinel-2

| | Band | Centre | Width |
|---|---|---|---|
| Blue | MSI 2 | 492,4nm | 66nm |
| Green | MSI 3 | 559,8nm | 36nm |
| Red | MSI 4 | 664.6nm | 31nm |
| NIR | MSI 8a | 864,7nm | 21nm |
| 1,6µm | MSI 11 | 1613nm | 91nm |
| 2,1µm | MSI 12 | 2202nm | 175nm |

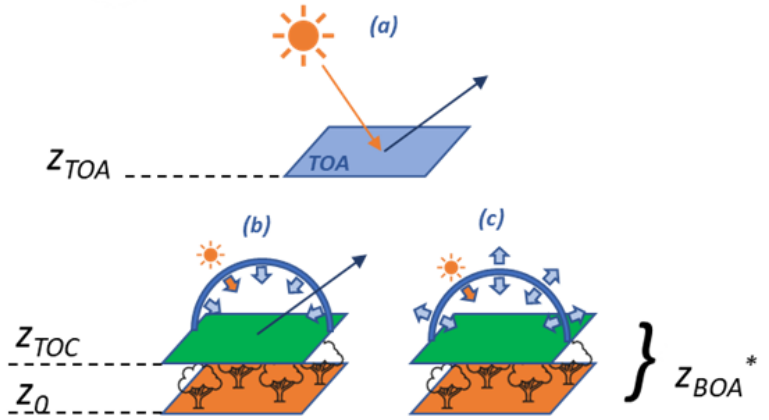


MultiSpectral Instrument (Airbus Defence and Space) source: [sentinels.copernicus.eu](sentinels.copernicus.eu)

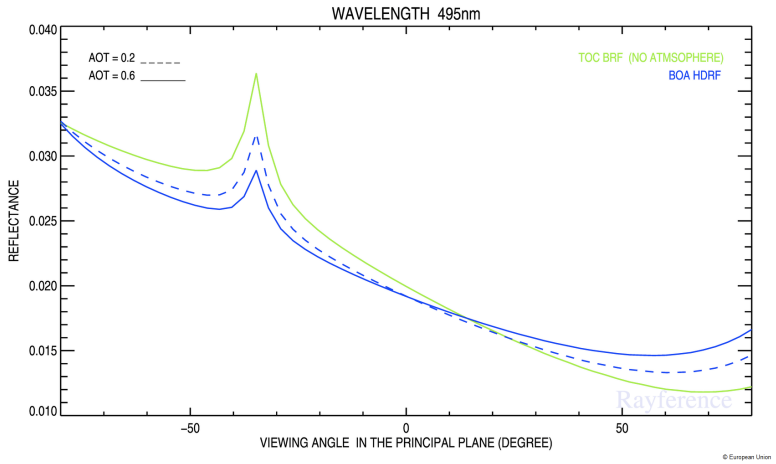


# Measurements

| <meas> Identifier tag | Link to Format file description | Level of the measurement |
|---|---|---|
| bhr | Bi-Hemispherical Reflectance | BOA |
| hdrfpp | Hemispherical Directional Reflectance Factor in the principal plane | BOA |
| hdrfop | Hemispherical Directional Reflectance Factor in the orthogonal plane | BOA |
| brfpp | Bi-directional Reflectance Factor in the principal plane | TOA |
| brfop | Bi-directional Reflectance Factor in the orthogonal Plane | TOA |



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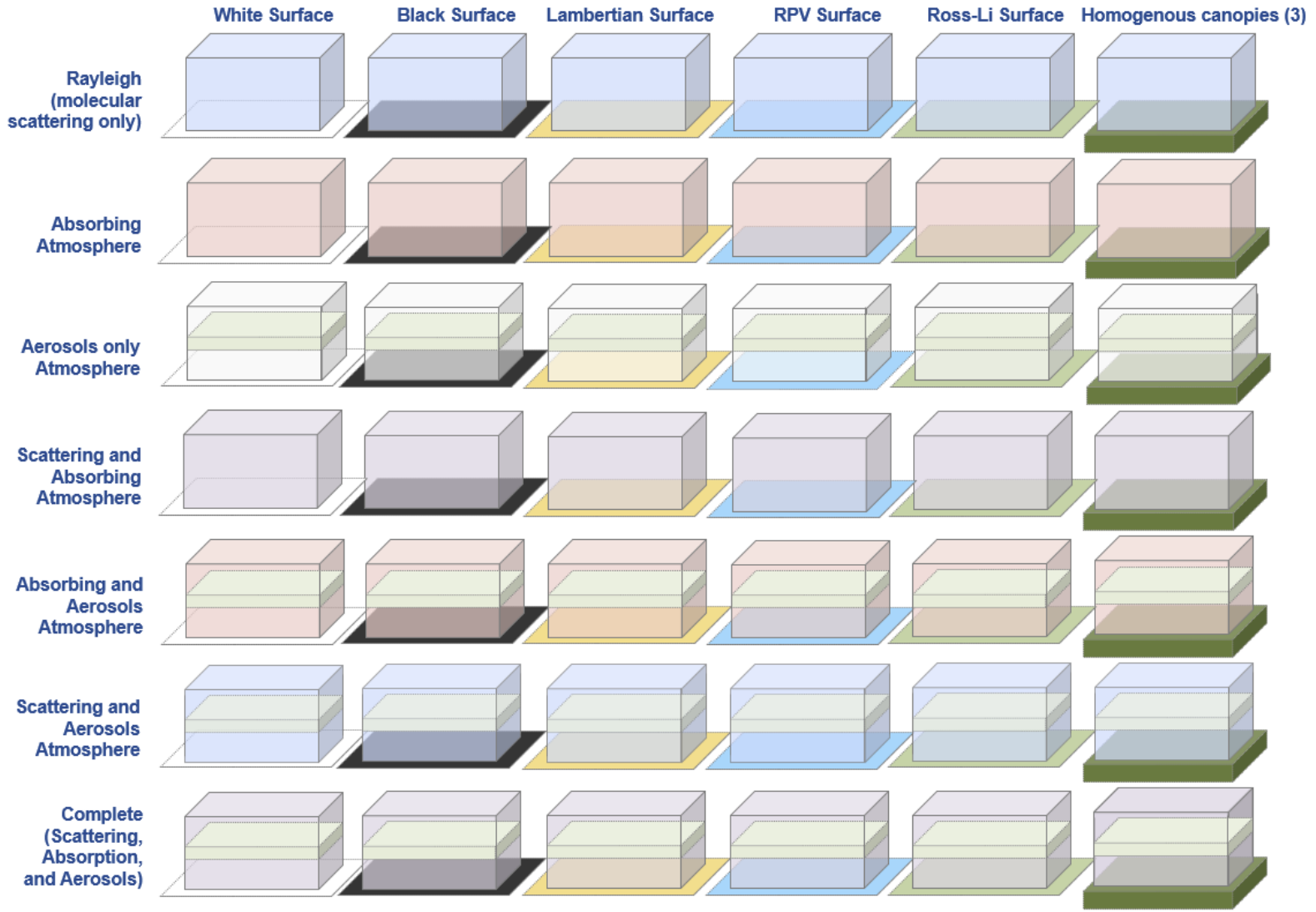
# Scenarios

7 Atmospheres families

## Surfaces: 5 parametric + 3 abstract canopies



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# Surfaces

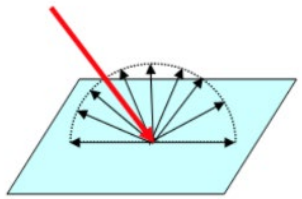
Lambertian

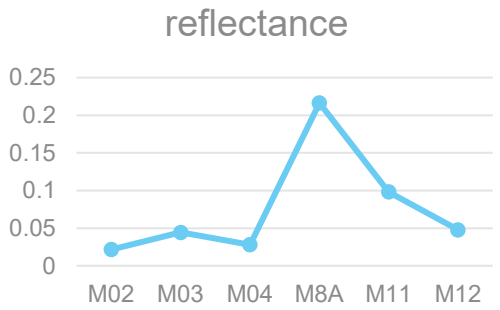
RPV

RLI

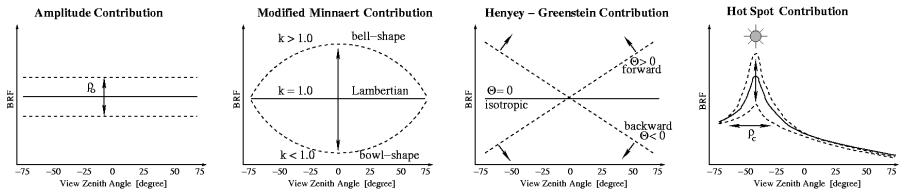
Purist corner $R = 0.0$

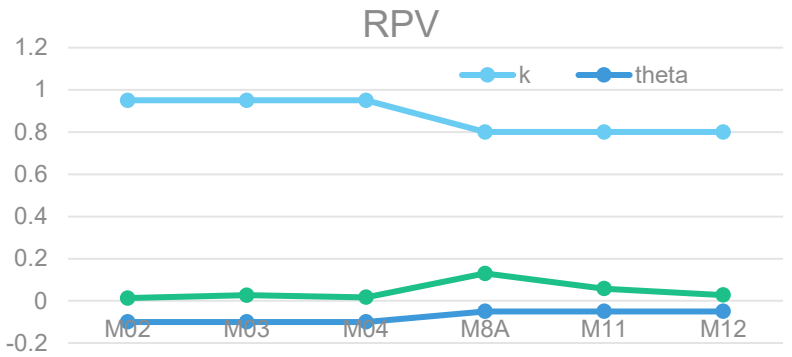
$R = 1.0$






RPV model with 3 parameters: $\rho_0, k, \theta$

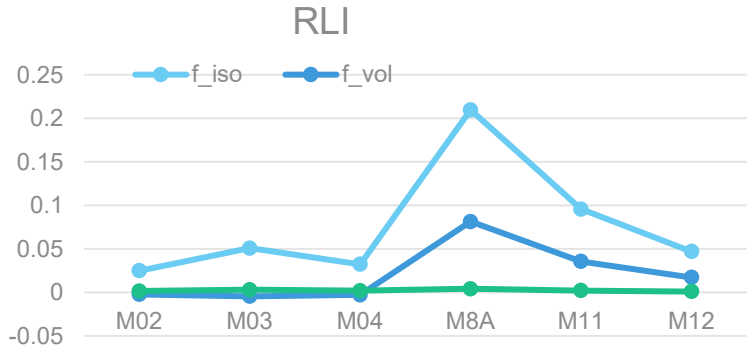



$$\rho(z_0, \mu_i, \mu_r, d\phi; \rho_0, \Theta, k, \rho_c) = \rho_0 \cdot M(k) \cdot F_{HG}(\Theta) \cdot H(\rho_c)$$

$$= \rho_0 \frac{(\mu_i \mu_r)^{k-1}}{(\mu_i + \mu_r)^{1-k}} \frac{1 - \Theta^2}{(1 + \Theta^2 + 2\Theta \cos g)^{1.5}} \left(1 + \frac{1 - \rho_c}{1 + G}\right)$$

Ross thick and Li sparse kernels combinations: $f_{iso}, f_{vol}, f_{geo}$




$$\rho(\theta_i, \theta_r, d\phi) = f_{iso}K_{iso} + f_{vol}K_{vol} + f_{geo}K_{geo}$$

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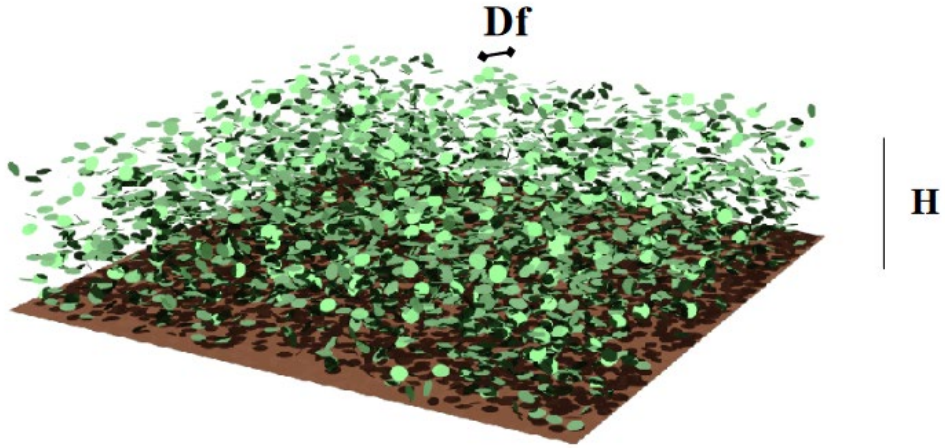
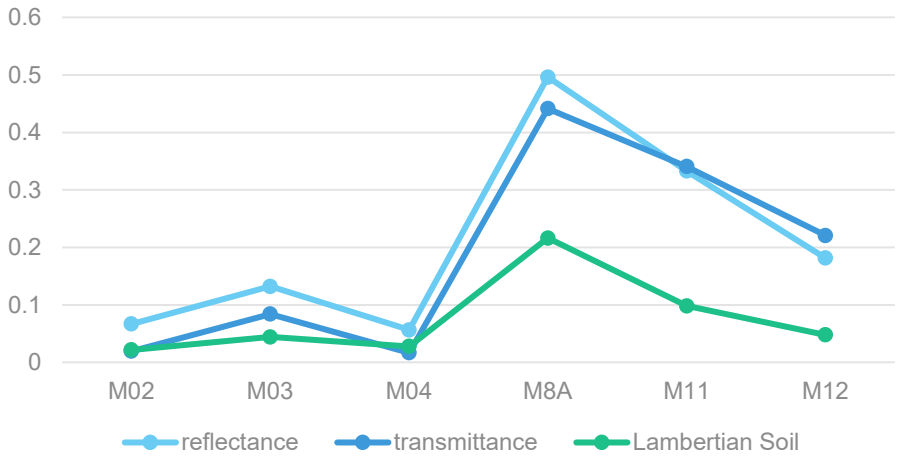
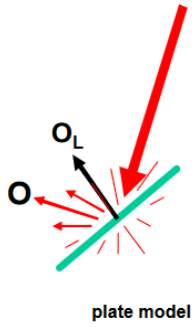
# Surfaces



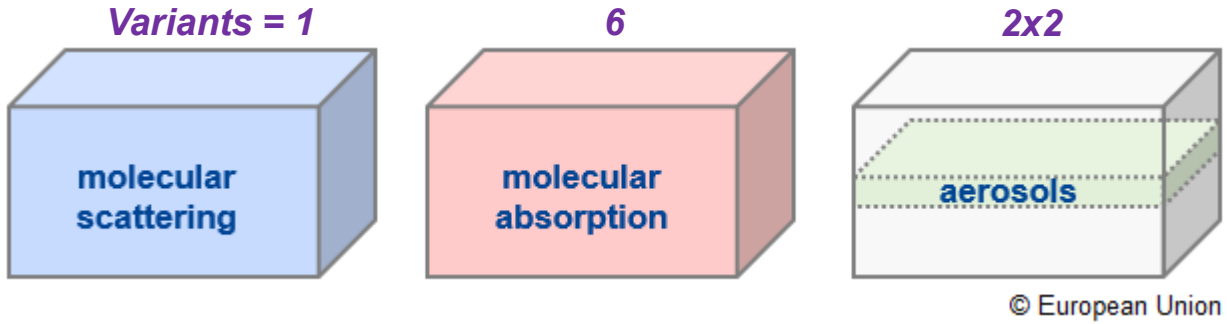

## 3 homogeneous abstract canopies

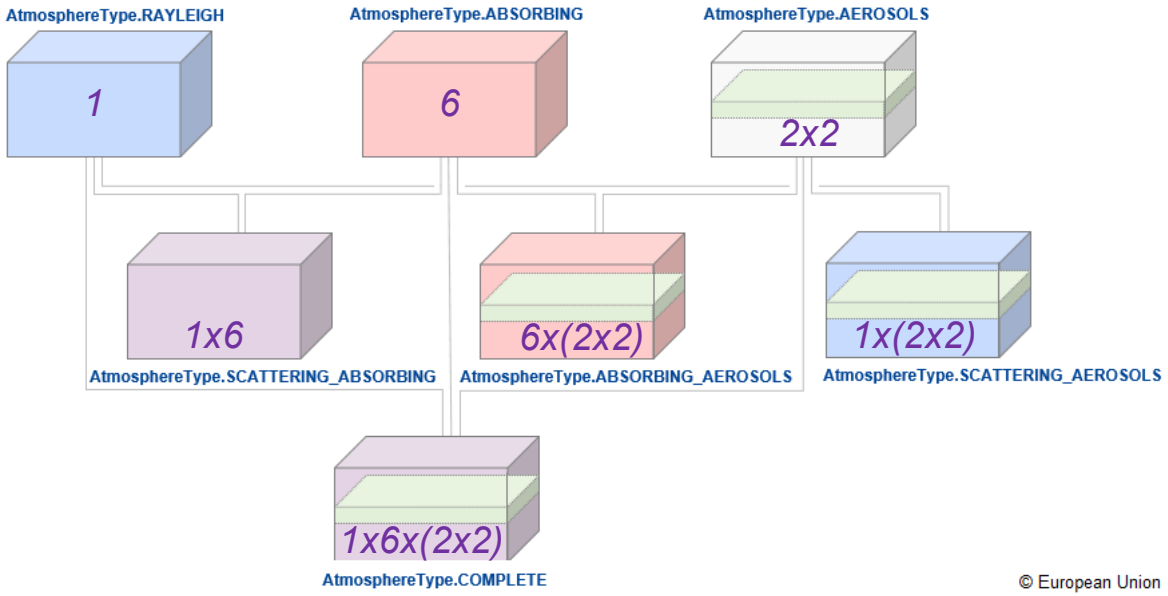
| | |
|---|---|
| Scene dimension | 25 x 25 x 2.1 m |
| Leaf center (Xmin, Ymin, Zmin) | -12.500, -12.500, 0.100 m |
| Leaf center (Xmax, Ymax, Zmax) | -12.500, -12.500, 2.100 m |
| Scatterer Radius | 0.05 m |
| Leaf area index | 3 $m^2/m^2$ |
| Height of canopy | 2 m |
| Number of leaves | 238732 |
| Planophile LAD (HOM25_LAM) | $\mu$=2.531 $\nu$=1.096 |
| Erectophile LAD (HOM35_LAM) | $\mu$=1.096 $\nu$=2.531 |
| Uniform LAD ( HOM45_LAM) | $\mu$=1.0 $\nu$=1.0 |

Common properties

# Atmospheres

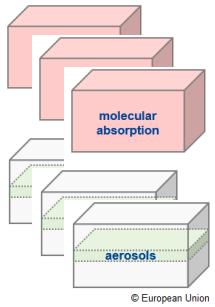
**Three main elements** are combined to create **seven** atmosphere families as shown in the diagram below




**As the three main elements are further characterized by specific properties such as:**

- 6 different combinations of the columnar concentrations of **water vapor** and **ozone**
- **Continental** and **Oceanic** aerosol models
- AOD550 low (0.2) and high (0.6)




**A total of 69 atm. variants are defined in RAMI4ATM.**
**Some of them are used only**

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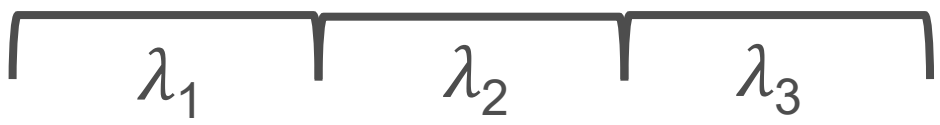
# Participation
# RTM users versus expert mode

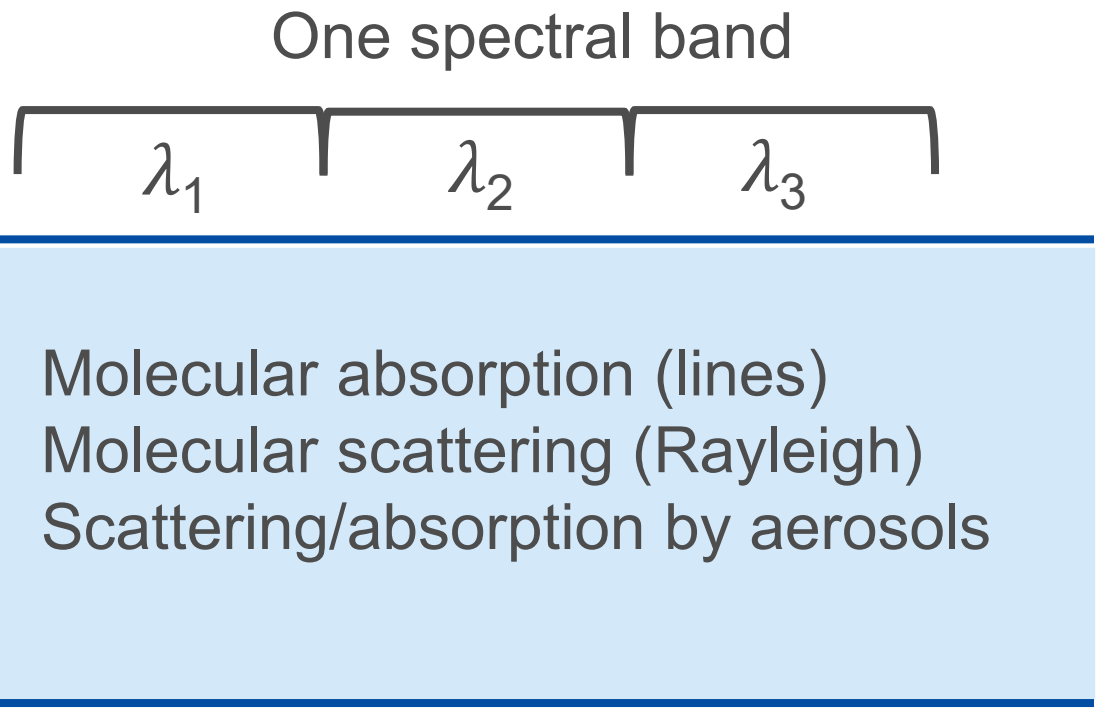



Radiative transfer equation (RTE) is strictly valid only for monochromatic intervals.

For practical reasons, RTE is solved in spectral intervals when simulating satellite bands.

One homogeneous atmospheric layer

# Participation
# RTM users versus expert mode

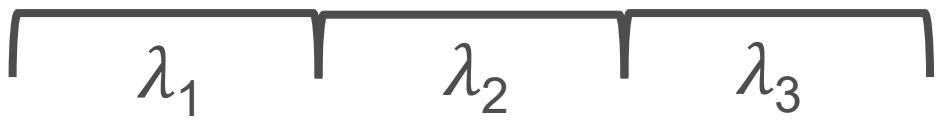



Advanced coupled surface-atmosphere RTMs combine all the radiative processes in each atmospheric layer and in each spectral interval for the **users**.

RAMI4ATM primarily targets these users.

# Participation
# RTM users versus expert mode

One spectral band




Molecular absorption (lines)
Molecular scattering (Rayleigh)
Scattering/absorption by aerosols

One homogeneous atmospheric layer

RTM developers can participate. Single scattering albedo and phase function of each layer and spectral interval is however not provided. Provided information is:

- Aerosol micro-physical properties
- Aerosol vertical concentration
- Molecular concentration

# Participation

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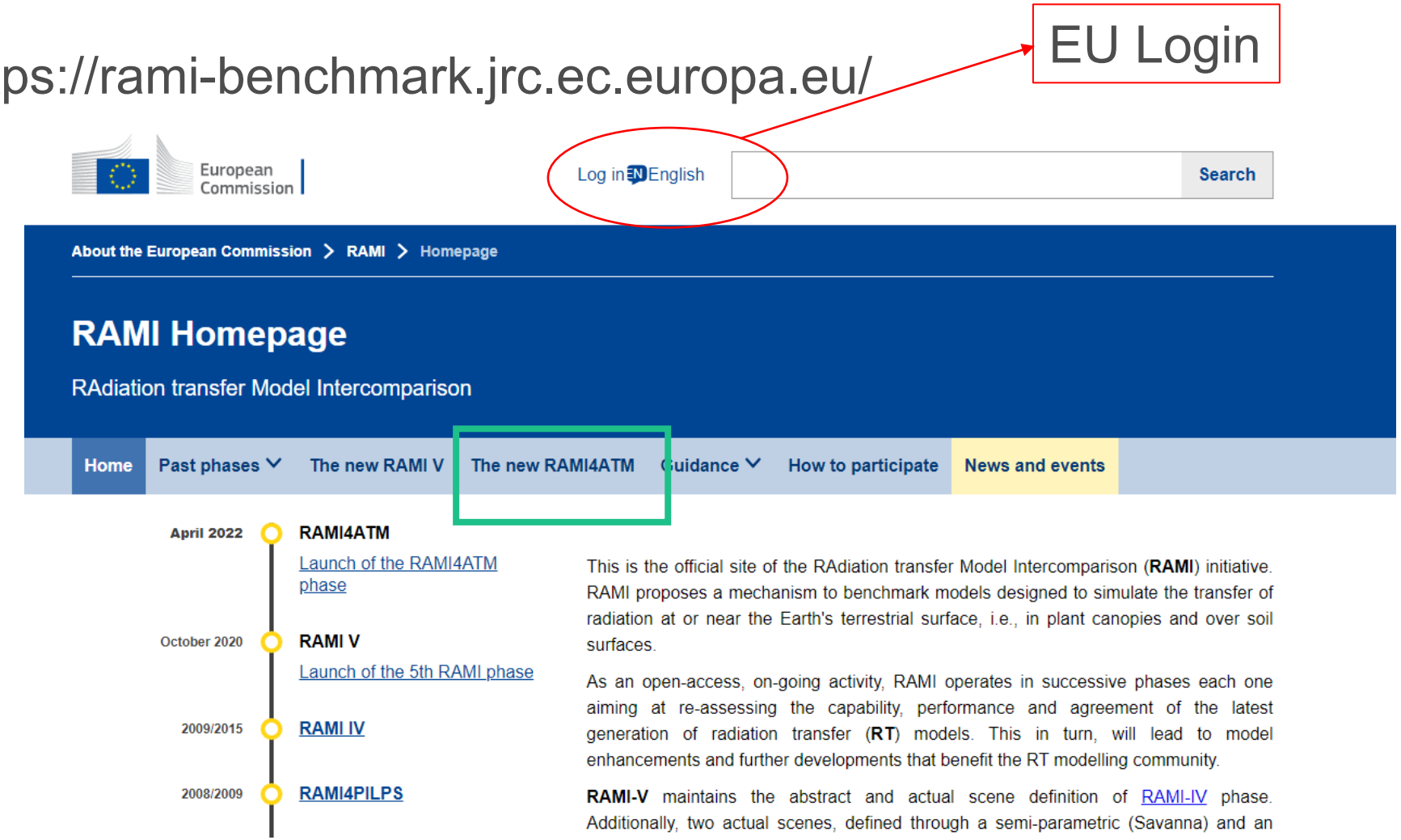
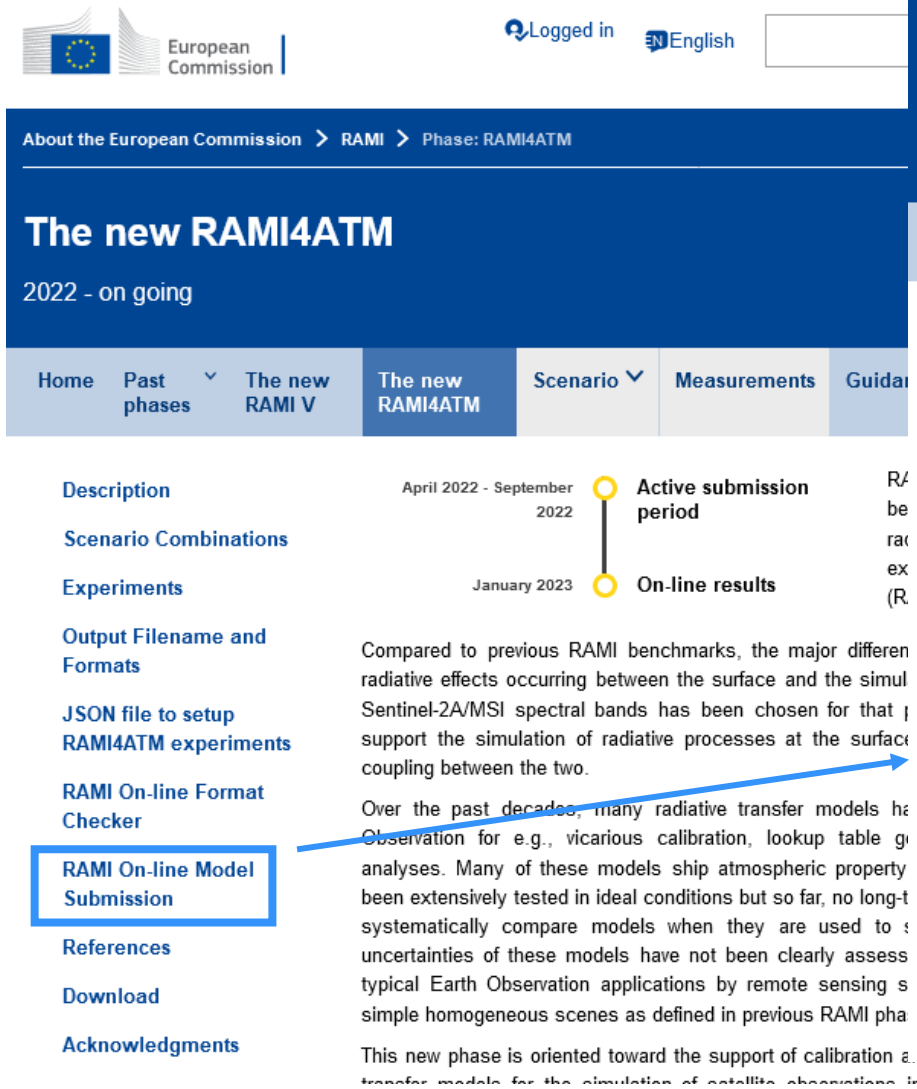
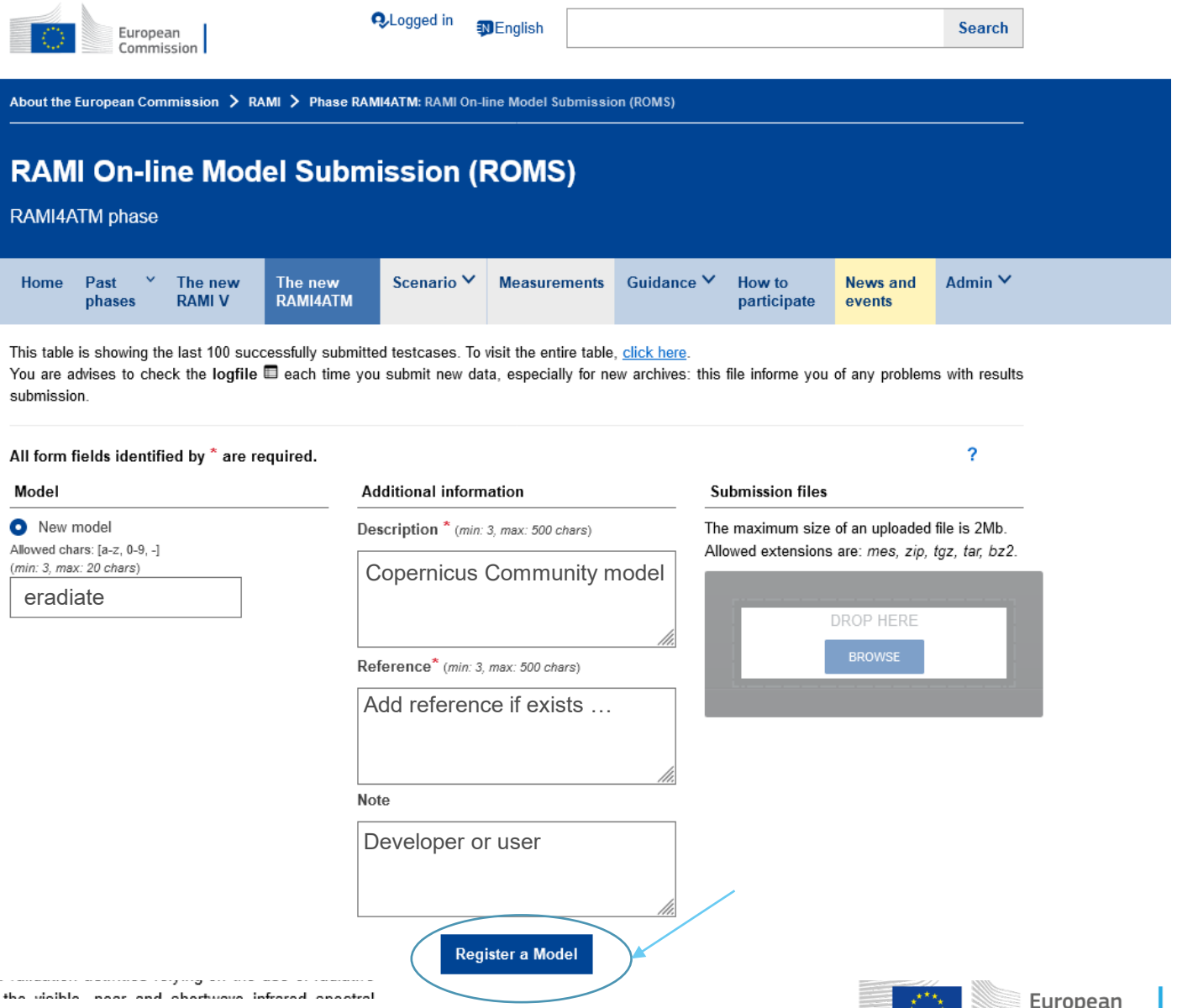
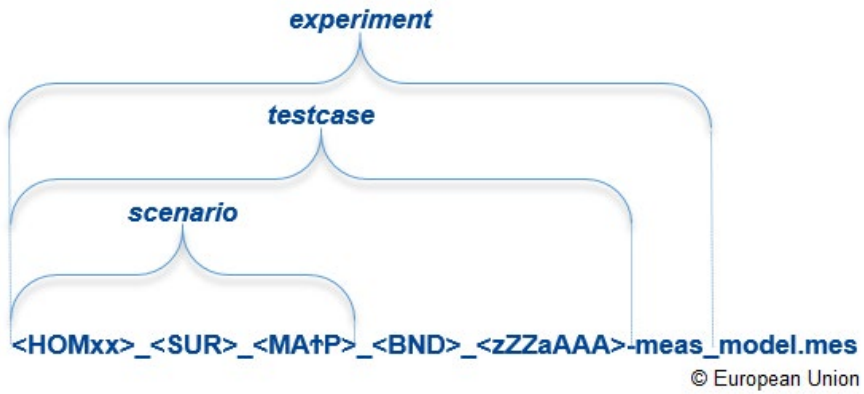


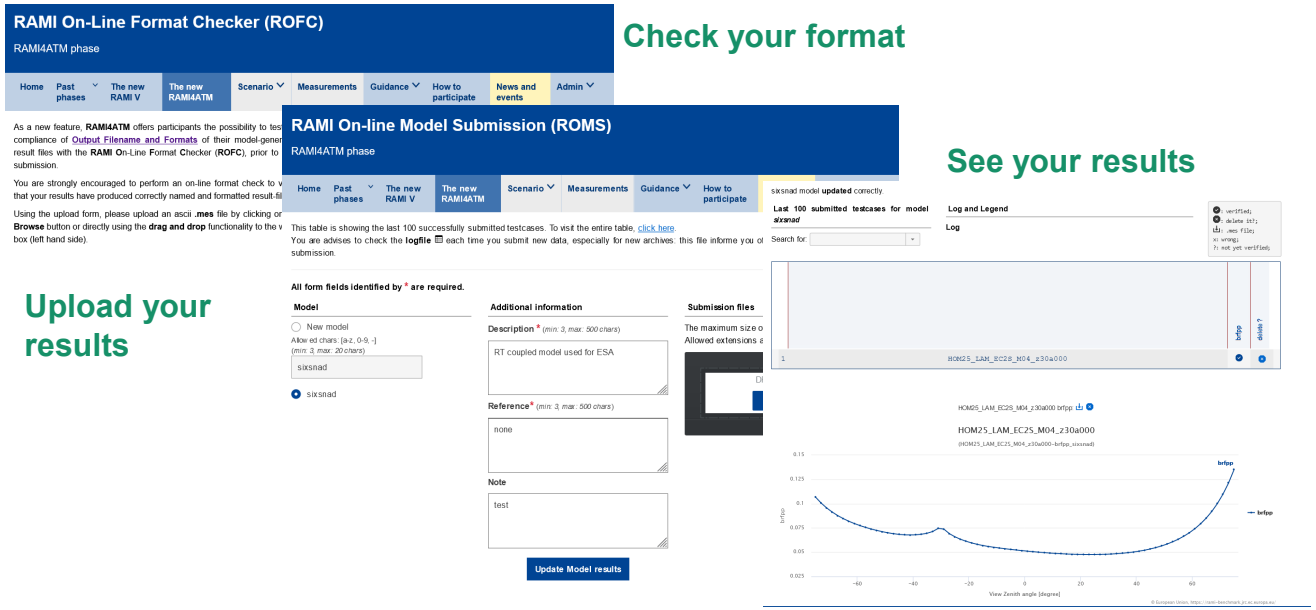
# Participation



# Practical Information

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## Download for RAMI4ATM

RAMI4ATM phase

- **Experiment list and setting section**

**RAMI4ATM experiments description JSON file**
**English** (603 KB - zip file) — Download

*A JSON file with all experiments available for RAMI4ATM phase.*

**RAMI4ATM experiments names**
**English** (152 KB - ASCII file) — Download

*An ascii file with the list of all experiments available for RAMI4ATM phase.*

- **Jupyter Notebook section (example)**

**Jupyter Notebook file for testcases**
**English** (238 KB - ipynb file) — Download

*An example of Jupyter Notebook used to illustrate how RAMI4ATM participants may load the **user mode** parameters for each scenario, perform their simulations and save their results.*

- **Surface section**

**RAMI4ATM lambertian spectral parameters**
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*An ascii file with spectral reflectances parameters of the Lambertian models.*

**RAMI4ATM RPV spectral parameters**
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*An ascii file with spectral parameters of the RPV model.*

**RAMI4ATM Ross-Li spectral parameters**
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# Thank you



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