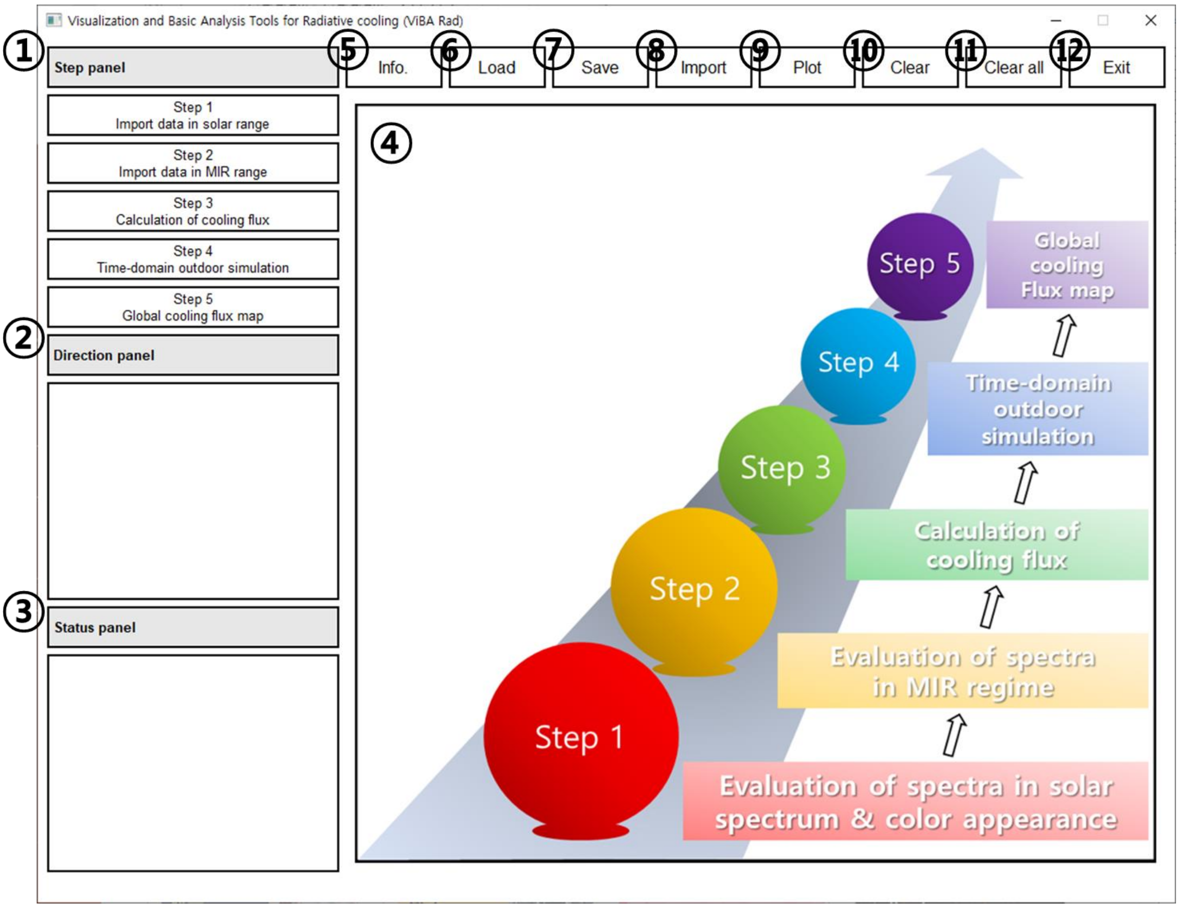
User guide

(ViBA Rad: Visualization and basic analysis tools for radiative cooling)

This tool allows the user to perform (1) basic cooling flux calculation of radiative cooling (RC), (2) time-domain outdoor simulation with external climate, and (3) representation of global cooling flux map.

Text files used in this user guide are provided in the "Example files" folder.

Software Interface



① <Step panel>:

The step panel includes five buttons, from which users can select each step of the process.

② <Direction panel>:

The direction panel provides specific instructions and information for each step, guiding users on how to proceed and the expected results.

③ <Status panel>:

The status panel displays users' action

④ <Main panel>:

The main panel includes input channels and display items where users can enter simulation parameters and settings and view the generated results.

⑤ <Info>:

Information about Visualization and Basic Analysis Tools for radiative cooling (ViBA Rad).

(Version, Description, Developer information, Support email.)

⑥ <Load>:

If users want to load previous inputs and settings (.txt), click the 'Load' button and find your txt file. Then, users can use the loaded data.

⑦ <Save>:

If users want to store their inputs and settings files, click the 'Save' button and select your saving folder.

⑧ <Import>:

Click this button and select the Solar Spectrum, Spectrum type, Atmospheric Transmittance, or Emissivity data type step by step. Then, you can bring in your corresponding data.

⑨ <Plot>:

Click this button to see the imported spectrum, cooling flux, temperature variation, and energy saving.

⑩ <Clear>:

Users can clear the input data and plot data on the current step page.

⑪ <Clear all>:

Users can clear all input data and plot data.

⑫ <Exit>:

Close the program.

Example of using ViBA Rad

- We provide two example data sets (Case 1: ideal RC and Case 2: visibly transparent RC) for Steps 1 and 2.

--- Step 1: Import of optical spectra in solar range ---------------------------------------

- Click 'Step 1 Import data in solar range' in the Step panel.
- Click the 'Import' button.
- Case 1) Ideal RC

  > In the "import window (step 1)", select "AM1.5 Direct" for the solar spectrum and "T/R/A" for the spectrum type, then click "Import" on the right side.

  (For the solar spectrum, "AM1.5 Direct", "AM1.5 Global", and "AM0" are provided. Users can also import other data as a text file.)

  (T/R/A represents transmissivity, reflectivity, and emissivity, respectively. Users can also select "Emissivity" for the spectrum type and import emissivity data instead of the full optical spectra.)

  > Select the "TRA.txt" file in the file dialog.

  > Click "OK" and "Done".

- Case 2) Practical RC

  > In the "import window (step 1)", select "AM1.5 Direct" for the solar spectrum and "T/R/A" for the spectrum type, then click "Import" on the right side.

> Select the "TRA_prac.txt" file in the file dialog.

> Change the "Wavelength unit" to "m".

> Click "OK" and "Done".

(When importing data, please adjust the units appropriately.)

- This will plot the solar spectrum of the RC.
- Next, to check the cooler's color, follow these steps:

> Select the source for color expression. As an example, select "Sunlight".

> Click "Plot".

- This will display the RC's color in the main window and a new window showing the CIE 1931 Chromaticity diagram.

(If the spectrum type is T/R/A, the transmitted color will be calculated. However, if only the emissivity is imported, the color corresponding to (1-emissivity) will be calculated.)

--- Step 2: Import of optical spectra in mid-infrared range -------------------------------

- Click 'Step 2 Import data in MIR range' in the Step panel.
- There are cases of normal/angled incidence, and users can follow the instructions for the normal incidence case below.
- Case 1) Ideal RC

> Click the "Import" button.

> In the "Import window (step 2)", select "AM1.5 PW 1mm" for atmospheric transmittance and "Normal incidence" for the emissivity data type.

(Other atmospheric transmittance data can also be imported by selecting "Import" for atmospheric transmittance.)

> Select "Normal.txt" in the file dialog.

> Click "Done".

- Case 2) Practical RC

  > Click the "Import" button.

  > In the "Import window (step 2)", select "AM1.5 PW 1mm" for atmospheric transmittance and "Normal incidence" for the emissivity data type.

  > Select "Normal_prac.txt" in the file dialog.

  > Change the "Wavelength unit" to "m", and click "Done".

- The case of angled incidence is as follows.
- Case 1) Ideal RC

  > Click the "Import" button.

  > In the "Import window (step 2)", select "AM1.5 PW 1mm" for atmospheric transmittance and "Angled incidence" for the emissivity data type.

  > Select "Angled.txt" in the file dialog.

  > Type "range(0,10,90)" in the "Incident angle" box, and click "Done".

  > Click "OK", and "Done".

- Case 2) Practical RC

  > Click the "Import" button.

  > In the "Import window (step 2)", select "AM1.5 PW 1mm" for atmospheric transmittance and "Angled incidence" for the emissivity data type.

  > Select "Angled_prac.txt" in the file dialog.

  > Change the "Wavelength unit" to "m" and type "range(0,10,80)" in the "Incident angle" box, and click "Done".

  > Click "OK", and "Done".

- This will plot the RC's MIR spectrum and its directional emissivity.

--- Step 3: Calculation of cooling flux --

- Click 'Step 3 Calculation of cooling flux' in the Step panel.
- In this step, you can calculate the cooling flux of the RC.
- In the Setting box,

  > Enter "298, 328, 1" on the first line.

  (These numbers represent the range of temperatures in Kelvin (K) that you want to consider for the calculation.)

  > Enter "303" on the second line.

  (This represents the ambient temperature in Kelvin.)

  > Enter "6" on the last line.

  (This represents the heat transfer coefficient (h_cc) between the RC and the ambient environment.)

- Click "Plot". Then, the cooling fluxes are calculated and plotted.

--- Step 4: Time-domain outdoor simulation ---

- Click 'Step 4 Time-domain outdoor simulation'
- In the first Setting box,

  > Enter "0, 24, 0.5" on the first line.

  (These numbers represent the time range of the simulation in hours.)

  >Enter "1e5" on the second line.

  (This represents the heat capacitance per unit area of the RC.)

  > On the third line, You can select the outdoor weather.

  > Select "Seoul (2021 Jul – Aug)" on the third line. This specifies the location and date of the outdoor weather.

  > Type "7" for "Month" and "15" for "Date" in the popup window, then click "Done".

  (If you want to use your weather data, select 'User input'. Then, you can select your weather data file, set the Temperature unit and Solar irradiance unit, and click the "OK" button.)

> On the fourth line, select "Ambient".

(If you want to set the initial temperature as another constant value, select the "User input" and enter the temperature.)

- In the second Setting box, select "Ambient temperature".

  (Users can also set a constant value or an offset value for the target temperature.)

- Click "Plot". This will display the time-evolution of the RC temperature and surplus cooling flux, along with the total energy saving per area.

--- Step 5: Global cooling flux map ---

- Click 'Step 5 Global cooling flux map'

- Click "Import" and select "global_July.txt" in the file dialog.
  (This file has been reduced to 1/4 of the original data points to reduce computation time)

- Select "K" for the "Temperature unit" in the pop-up window, and click "OK".

  (Check the temperature unit and solar irradiance unit if the user imports their data.)

- Then, temperature and solar irradiance (input) are plotted on a global map.

- Select "Ambient temperature" for the "RC temperature" and click "Plot".

  (Users can also set a constant value or an offset value for the RC temperature.)

- The global cooling flux is then plotted.

  > Users can change the color bar limits and colormap by clicking the "Tools" button. If users want to export data, they can click the "Export" button and save the calculated results as a text file.