KIPP & ZONEN
SINCE 1830


# Software Manual

## UV Radiometers • Correction Software

# Table of contents

# Important user information

Reading this entire manual is recommended for full understanding of the use of this product.

The exclamation mark within an equilateral triangle is intended to alert the user to the presence of important operating and maintenance instructions in the literature accompanying the instrument.

Should you have any comments on this manual we will be pleased to receive them at:


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Kipp & Zonen reserves the right to make changes to the specifications without prior notice.

**Warranty and liability**

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Manual version: 1111

# 1. Introduction

Welcome to UVIATOR UV irradiance correction software. UVIATOR is a user-friendly software program, developed by Kipp & Zonen. It is specifically intended for Kipp & Zonen UV radiometer users to correct UV irradiance using an atmosphere transmission model, radiometer calibration certificates and ozone column density data. A schematic overview of the UV irradiance correction process is depicted on the Processing Flow page.

UVIATOR features are:
• User-friendly, but also offers special functions for experts
• Handles multiple UV radiometer setups
• Configurable input data format
• Configurable output data columns, date/time format and interval
• Selection of ozone column density source
• Viewing output data graphs
• Supports radiometer re-calibration
• Night-time radiometer offset voltage correction
• Non-stability interpolation and radiometer not used periods
• Radiometer temperature monitoring
• Viewing digital instrument calibration certificates
• Viewing correction function graphs
• Saving correction functions to file
• Atmosphere transmission model selection
• Scheduling support by execution from command line

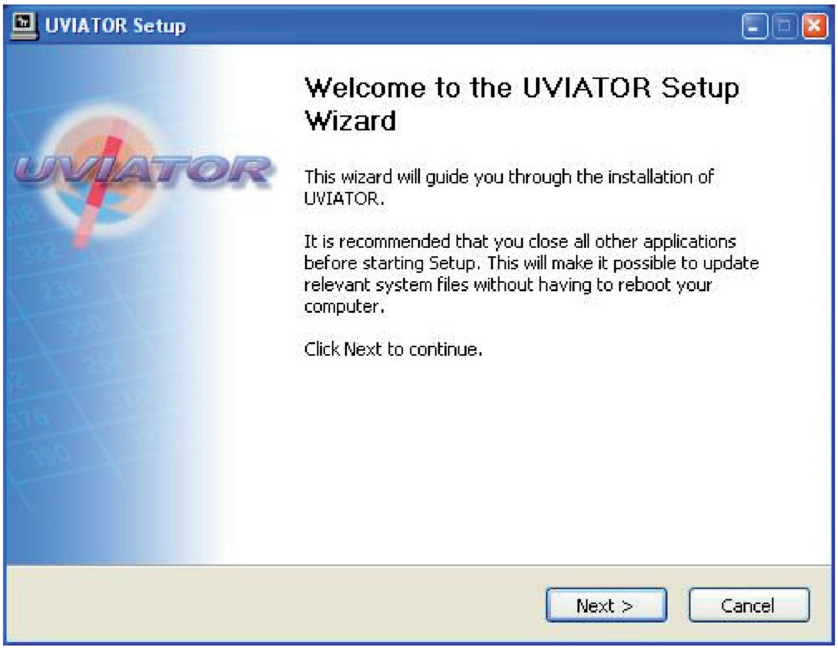
Kipp & Zonen related UV-Radiometers:
• UVS-A-T
• UVS-B T
• UVS-E-T
• UVS-AB-T

This program is developed by Kipp & Zonen B.V. Kipp & Zonen reserves the right to make changes to UVIATOR without prior notice. Should you have any comments on this software package we will be pleased to receive them at **info@kippzonen.com**

## 2. Installation

To be able to install UVIATOR, you must have administrative rights. If you do not have administrative rights, installation will be aborted. In case UVIATOR has been installed before, the installer will request to uninstall the current version. Un-installation of the current version is advised in order to clean it up properly. During un-installation data and configuration files remain preserved. However, modified files and UV model(s) that were installed by the installer, will be removed.

To start installation, insert the UVIATOR CD-ROM in your computer. In case the installation does not start automatically, invoke 'SETUP.EXE' on the UVIATOR CD-ROM.



# 3. System Requirements

The minimum computer hardware requirements for UVIATOR are a 300 MHz Pentium II or equivalent computer running Windows 95/98/ME/NT/2000/XP, 128 MB of RAM, 800x600 display resolution with 16 bits color depth (65535 colors), 20 MB of free hard-disk space (excluding data).

For proper operation Windows should have the following installed:

- Internet Explorer 5.x or later
- MS Sans Serif font (default Windows font)

# 4. Getting Started

This section explains how to configure and use the UVIATOR program. First, start UVIATOR from Start → Programs → UVIATOR.

In case UVIATOR does not have an active configuration, it will ask to start the **Configuration Wizard**. You can also start the **Configuration Wizard** from the **File** menu. After finishing the Configuration Wizard, UVIATOR is ready to process UV measurements.

Follow the steps described below to process UV measurements.
- Copy Input Files
- Processing Data
- Viewing Data
- Copy Output Files

It is also possible to configure UVIATOR without using the **Configuration Wizard** or modify an existing configuration. To do this, follow the steps described below. Reading these steps also help you getting acquainted with all features of UVIATOR. Afterwards, continue with the steps described above, in order to process UV measurements.
- Select Working Directory
- Configuration Settings

# 5. Select Working Directory

The working directory holds all specific information, such as configuration and measurement data, of a single measurement location of a specific radiometer. By creating more than one working directory, multiple measurement locations of radiometers can be managed. Both selecting and creating working directories is done by selecting **Select working directory** from the **File** menu. A working directory is also created and selected when using the Configuration Wizard. A working directory has the following subdirectories:

| | |
|---|---|
| **Input** | Holds all files containing UV measurement data.<br>Before processing/correcting UV measurements, files should be copied to this location |
| **Output** | Holds all files containing processed/corrected UV measurement data |
| **Config** | Holds configuration files of the measurement location and radiometer |
| **Certificate** | Holds digital instrument calibration certificates |

After selecting a working directory, the **View Output Files** page lists the files in the **output** subdirectory.

# 6. Configuration Settings

## 6.1 Radiometer

In this page details about the radiometer must be entered.

### 6.1.1 Digital Instrument Calibration Certificates

The digital instrument calibration certificate (DCC) should have been delivered with your radiometer. The DCC holds the relative radiometer response function and other radiometer calibration data. To use a DCC, import it by pressing **Import Certificate**. Importing makes a copy of the DCC file and puts it in the working directory. To remove a DCC, press **Remove Certificate**. This will delete the DCC file from the current working directory. When your radiometer is re-calibrated, you should import a new DCC. During processing of UV measurements, UVIATOR automatically uses the right DCC from the certificate list based on calibration dates. In the output file(s) you will be warned when expired certificates have been used. A DCC can be examined by double-clicking it in the certificate list.

### 6.1.2 View Correction Function

The correction function resulting from the atmosphere transmission model and a specific DCC can be examined and optionally be stored to file by pressing **View Correction** Function. You may lookup the value of the correction function for a specific solar zenith angle and ozone column density by filling in their values at **Graph Data Lookup**.

The wavelength bandwidth (lambda) used for calculating the correction function, originates from the DCC. In case the atmosphere transmission model does not cover the wavelength bandwidth of the DCC, the correction function cannot be calculated.

In order to make a comparison between corrected and uncorrected UV irradiance, the mean correction function is being calculated and displayed in the correction function graph. It is represented as a transparent surface that has a constant value for all solar zenith angles and ozone column densities. The mean correction function is the mean of all data points of the correction function. The mean correction function is used to calculate **UV Irradiance (without correction)**.

### 6.1.3 Night-time Offset Correction

Enabling **Night-time Offset Correction** will instruct the program to calculate the radiometer offset voltage at night. The following rules apply:

- The time used for offset calculation is localized by means of a correction based on longitude. This enables the program to determine the most suitable time frame for calculating the radiometer offset voltage.
- The time frame for calculating the radiometer voltage is from 1 hour before till 1 hour after midnight localized time.
- The solar zenith angle (SZA) must be bigger than the configured **Minimum SZA for Offset Correction**. The default value is 100°, which is 10° below horizon.
- The radiometer offset voltage will be calculated by averaging the radiometer voltages that meet the time frame and SZA rules.

The averaging weight of the radiometer offset voltage must be 3 or more.

When the calculated offset does not meet the rules above, the radiometer offset voltage as defined by the DCC will be used.

In order to monitor the radiometer offset voltage, enable the **Offset** column on the Output page.

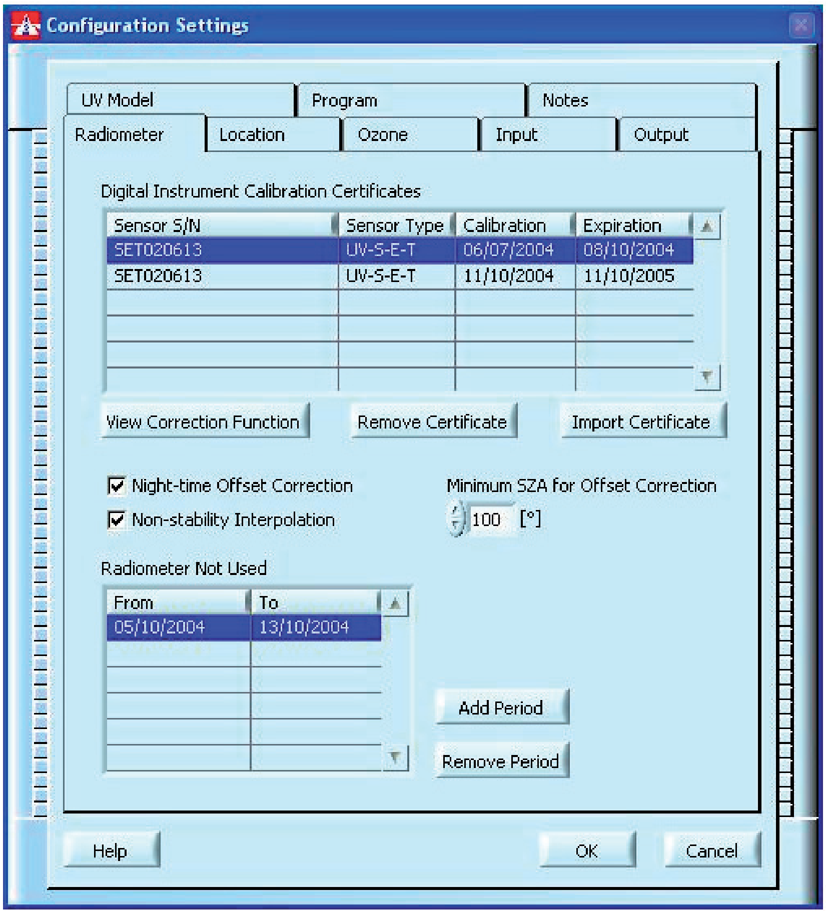
### 6.1.4 Non-stability Interpolation

Enabling **Non-stability Interpolation** will instruct the program to linear interpolate the non-stability factor (ρ) between each DCC instead of changing it abruptly between DCCs. Note that this feature is only useful for correcting UV measurements before the last re-calibration date.

When **Non-stability Interpolation** is enabled, you can also enter **Radiometer Not Used** periods. During such a period linear interpolation of the non-stability is stopped and remains constant, as the radiometer does not age when it is not used. A **Radiometer Not Used** period is defined is a radiometer that is not powered on and does not receive radiation. **Radiometer Not Used** periods can be added and removed by pressing the **Add and Remove Period** buttons. Editing is initiated by double-clicking.

In order to monitor the non-stability factor, enable the **Non-stability Factor** column on the Output page.

**Example**



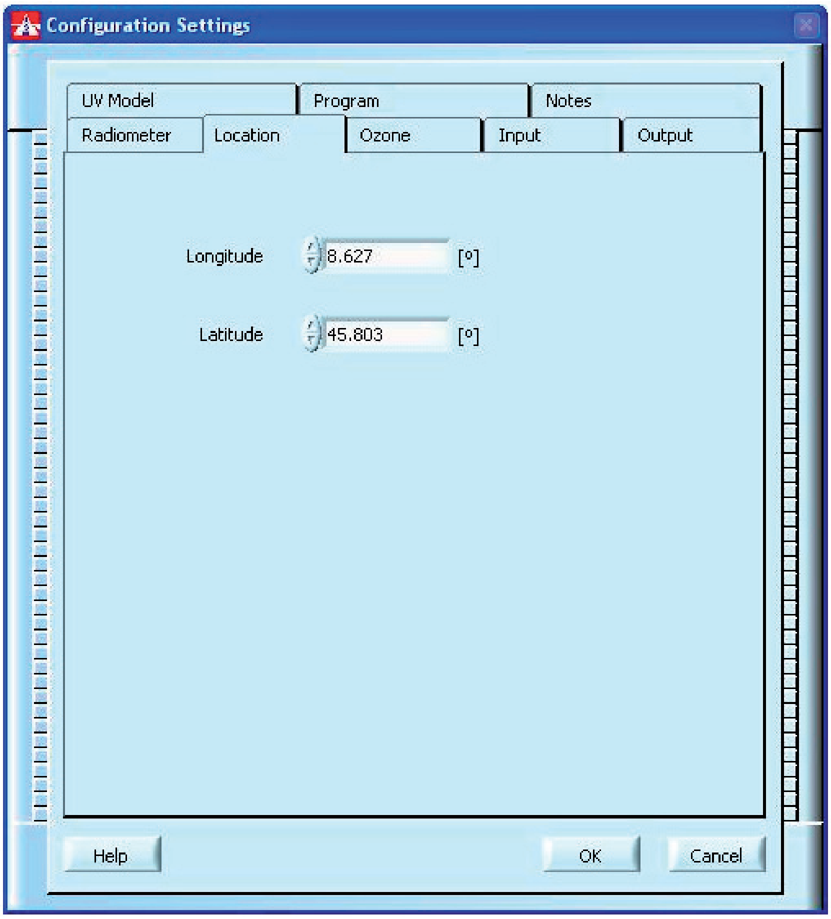
## 6.2 Location

In this page the location of the radiometer must be entered.

Positive longitude is eastern hemisphere and positive latitude is northern hemisphere.

Note that it is important that the location is accurate in order to get the right correction factor for the radiometer reading and to be able to make a good comparison with the atmospheric transmission model.

**Example**



### 6.3 Ozone

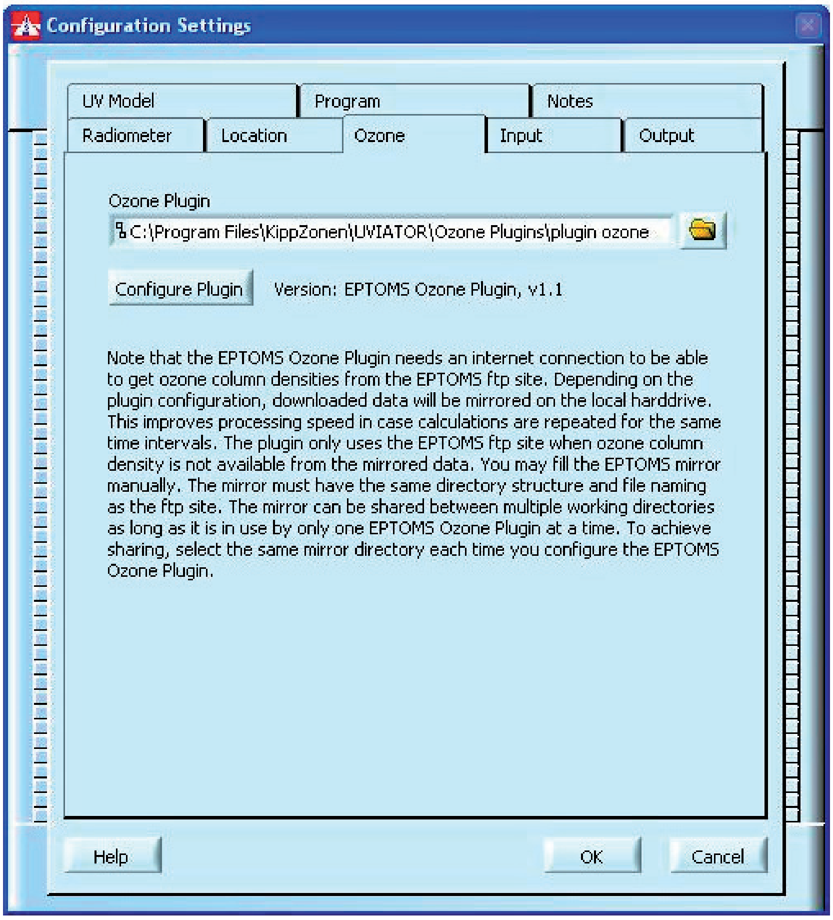
On this page the ozone plugin must be selected. Each plugin allows you to use ozone column density from a specific kind of source. When selecting a plugin, its version and general information will be displayed.

The standard ozone plugins delivered with the program are located in the program's installation ozone subdirectory, i.e. **'C:\Program Files\KippZonen\UVIATOR\Ozone Plugins'**. When you need to acquire ozone column density from a source that is not supported by the standard ozone plugins, please contact Kipp & Zonen for developing a custom ozone plugin.

By pressing the Configure button you open the plug-in configuration window. For configuration information about a specific plug-in, open its help file via the windows start menu or the plugin's configuration window.

Each plugin stores its configuration inside the working directory. Therefore a plugin's configuration is independent per working directory.

**Example**



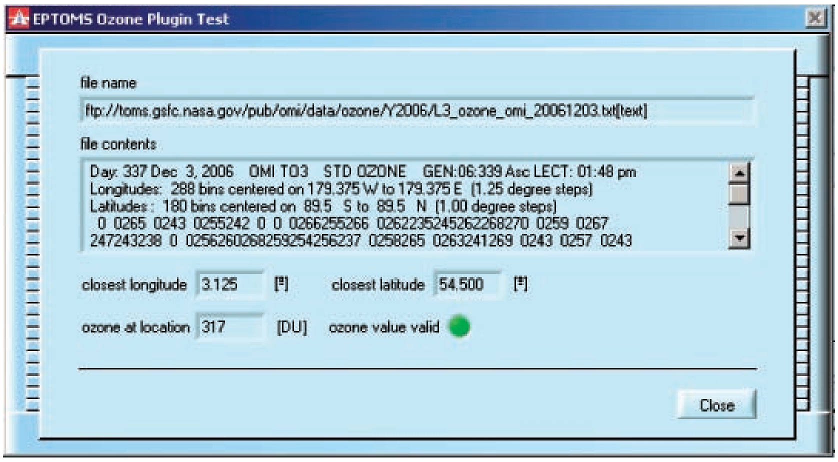
When configuring the plugin it is possible to do a quick test to see if the satellite data is online available (requires internet connection). If the light after ‘Ozone value valid’ stays red, connection to the satellite data could not be made. The data from the TOMS satellite is available until December 2006. After that data the satellite stopped providing data. The OMI satellite data is also available after that date.

The location of the OMI data on the internet is:

ftp://toms.gsfc.nasa.gov/pub/omi/data/ozone/ followed by the year and day string.

The default setting for the provided plug-in is for TOMS data. An example of the Ozone plug-in for OMI data is given below.

**Example**




## 6.4 Input

On this page the input data formatting configuration must be entered. The program can read UV data from many types of files. Characteristics of files that can be read are:

- It is a text file
- It has 0 or more header lines
- Data appears in columns
- It has date and time column(s)
- It has a UV Data column
- Optionally it has a Temperature Data column
- The date and time column(s) appear before the UV and Temperature Data columns
- Uses dot as decimal separator

### 6.4.1 Time Zone Offset

Time Zone Offset specifies in what time zone measurements have been recorded. It is important to enter a correct number for Time Zone Offset, so the program can calculate the right solar zenith angle and find the appropriate ozone value for each measurement. See Time Handling for more details about time.

### 6.4.2 Date Time Format

Date Time Format specifies how date and time are extracted from the measurement files. See Date and Time Pattern Matching Characters for characters that can be entered and what they mean.

### 6.4.3 Number of Header Lines

Number of Header Lines specifies how many header lines the measurement files have. These lines will be omitted when reading data.

### 6.4.4 UV Data Column

UV Data Column specifies from which column in the input files data is read. Data Column 1 is the first column after date and time. Date and time must always appear before Data Column 1, but may contain more than one column.

### 6.4.5 Temperature Data Column

Temperature Data Column specifies from which column in the input files radiometer temperature data is read. In case you do not have or do not want to process temperature data, set the column number to 0. Data Column 1 is the first column after date and time. Date and time must always appear before Data Column 1, but may contain more than one column.

### 6.4.6 Delimiter

Delimiter specifies the separator for data columns. See Pattern Matching Characters for space and non-displayable characters that can be entered here and what they mean.

### 6.4.7 Load

By pressing the load button, you can load an input data formatting configuration by means of a configuration file. The file may be a default configuration file (ex. input data formatting - default.ini), a previously saved configuration file or the configuration file of another working directory. In the latter case you must take care that the configuration file (ex. <working directory>\config\config.ini) belongs to a working directory that has set a suitable configuration for input data formatting. Note that loading a configuration file that does not have a setting for input data formatting results in no change to the input data formatting configuration.

### 6.4.8 Save

By pressing the save button, you can save the input data formatting configuration to a file. You can use this feature to store a default input data formatting configuration, to be used for configuring input data formatting in the future or share it with others.

### 6.4.9 Quick Test

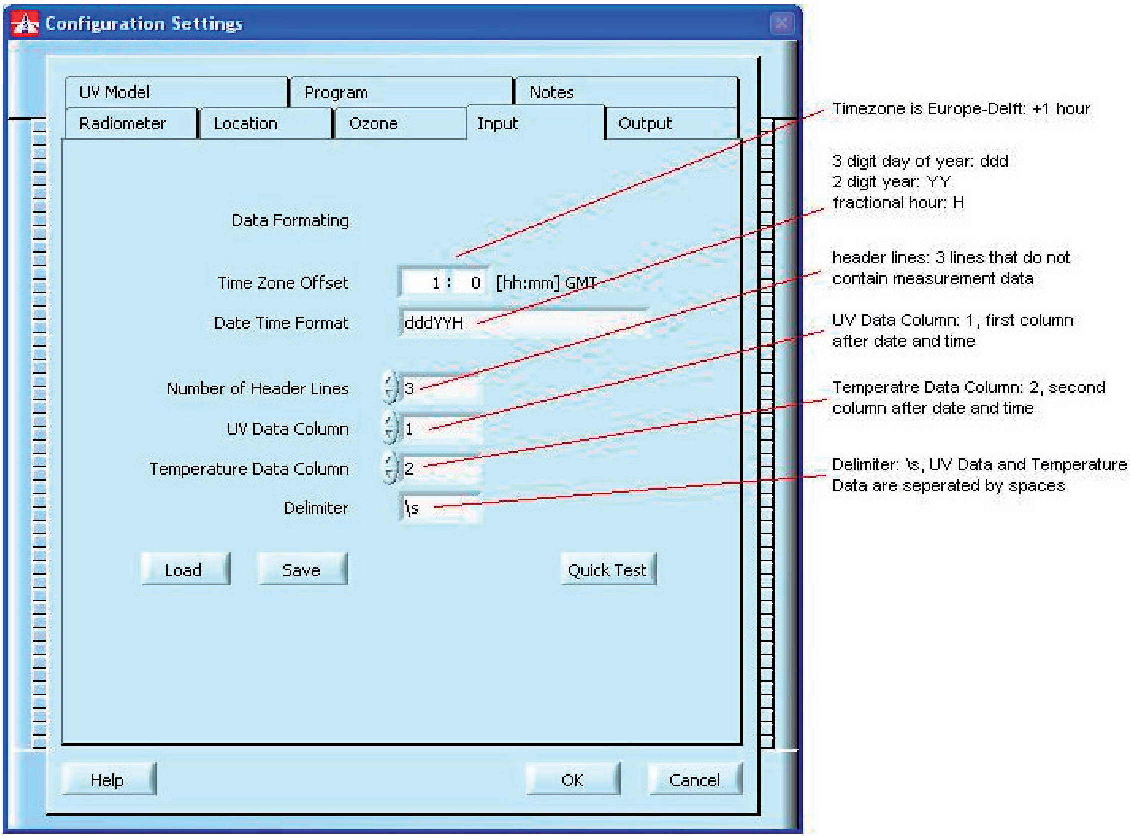
By pressing the quick test button, you can verify the configuration. You will be prompted to select an input file to test with. After selecting the test file, a window pops up, displaying the file using your input data formatting configuration. You must verify the displayed data with the originating data to assure the configuration matches your type of input files.

### 6.4.10 Example

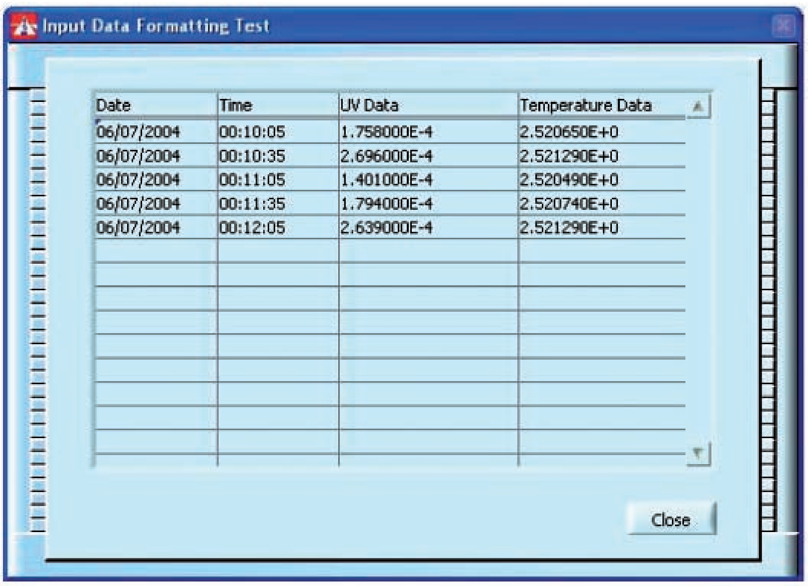
This example shows how to fill in the input data formatting for the following file:

```
Time zone information: Europe-Delft
Day        hour       uv data          temperature data
year
18804      0.167965   0.000175800      2.52065
18804      0.176299   0.000269600      2.52129
18804      0.184632   0.000140100      2.52049
18804      0.192966   0.000179400      2.52074
18804      0.201299   0.000263900      2.52129
```

The picture below shows what values have to be filled in:




The picture below shows the quick test window after selecting the file above. Note that the date and time formatting depend on the regional settings of your windows installation and therefore may differ from the picture below.




| Date | Time | UV Data | Temperature Data |
|---|---|---|---|
| 06/07/2004 | 00:10:05 | 1.758000E-4 | 2.520650E+0 |
| 06/07/2004 | 00:10:35 | 2.696000E-4 | 2.521290E+0 |
| 06/07/2004 | 00:11:05 | 1.401000E-4 | 2.520490E+0 |
| 06/07/2004 | 00:11:35 | 1.794000E-4 | 2.520740E+0 |
| 06/07/2004 | 00:12:05 | 2.639000E-4 | 2.521290E+0 |

## 6.5 Output

In this page you configure contents and format of output files. The output file layout specification describes the layout of output files.

### 6.5.1 Radiometer Data and Processed Data

Check the parameters that should appear as a column in the output file. When pointing the mouse to a parameter the name of the column in the output file will be displayed.

| Radiometer Data | Column Name | Unity |
|---|---|---|
| UV Data (raw) | UV (raw) | V |
| UV Data (without offset) | UV Data | V |
| Temperature (raw) | Temp (raw) | V |
| Temperature | Temp | K |
| Offset | Offset | V |
| Non-stability Factor | Rho | $V/(W/m^2)$ |

| Processed Data | Column Name | Unity |
|---|---|---|
| UV Irradiance | UV Irrad | $W/m^2$ |
| UV Irradiance (without correction) | UV Irr (avg) | $W/m^2$ |
| E-Scie | E-Scie | $W/m^2$ |
| UV Index | UV Index | - |
| UV Dose | UV Dose | MED |
| Solar Zenith Angle | SZA | ° |
| Ozone Column Density | Ozone | DU |
| Correction factor | Chi | $(W/m^2)/V$ |

Note that **UV Dose** values depend on the skin type selected. Skin type definitions are taken from **UV Index for the Public, ISBN 92-828-8142-3.**

### 6.5.2 Date and Time

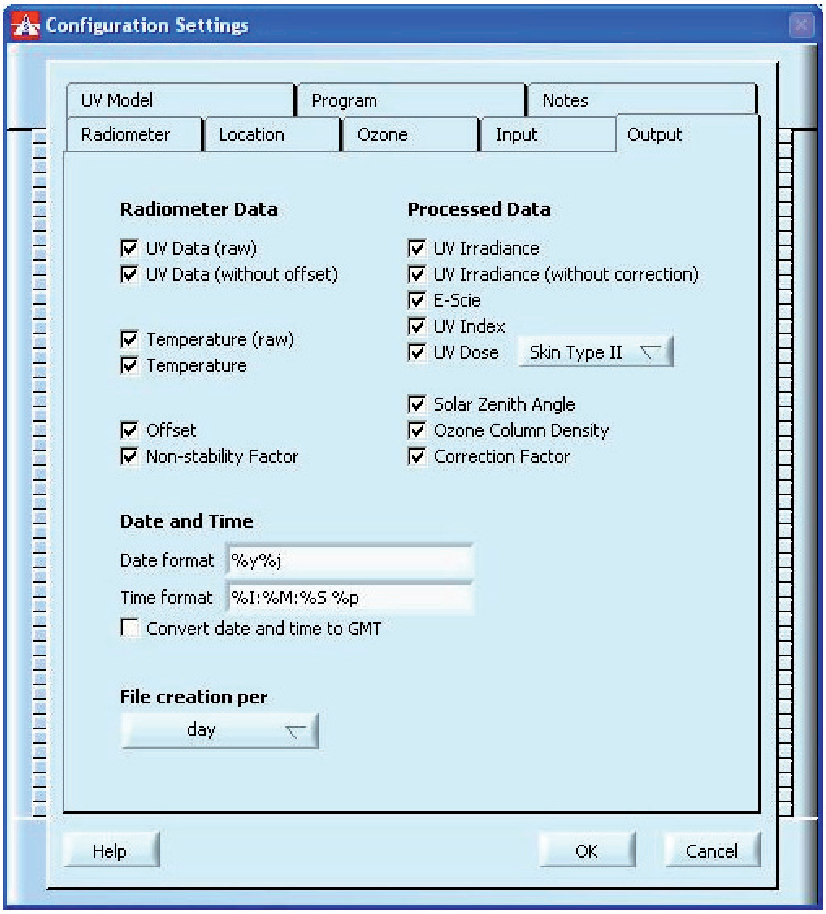
In order to change the default date and time format of output data, you should configure **Date format** and **Time format** using date and time format codes. Note that in case you do not specify enough formatting detail (for example only specify %y%d for date, only year and day of month), your output file may be useless.

Furthermore you can check **Convert date and time to GMT** to store data in GMT instead of UV Data time.

### 6.5.3 Select file creation interval

Select the time interval per output file. The start and end dates of processing data are restricted to the first and last date of a complete interval specified here. For example, when selecting month, processing data starts at day 1 of a month end ends at the last day of a month.

**Example**



## 6.6 UV Model

In this page an atmosphere transmission model must be selected.

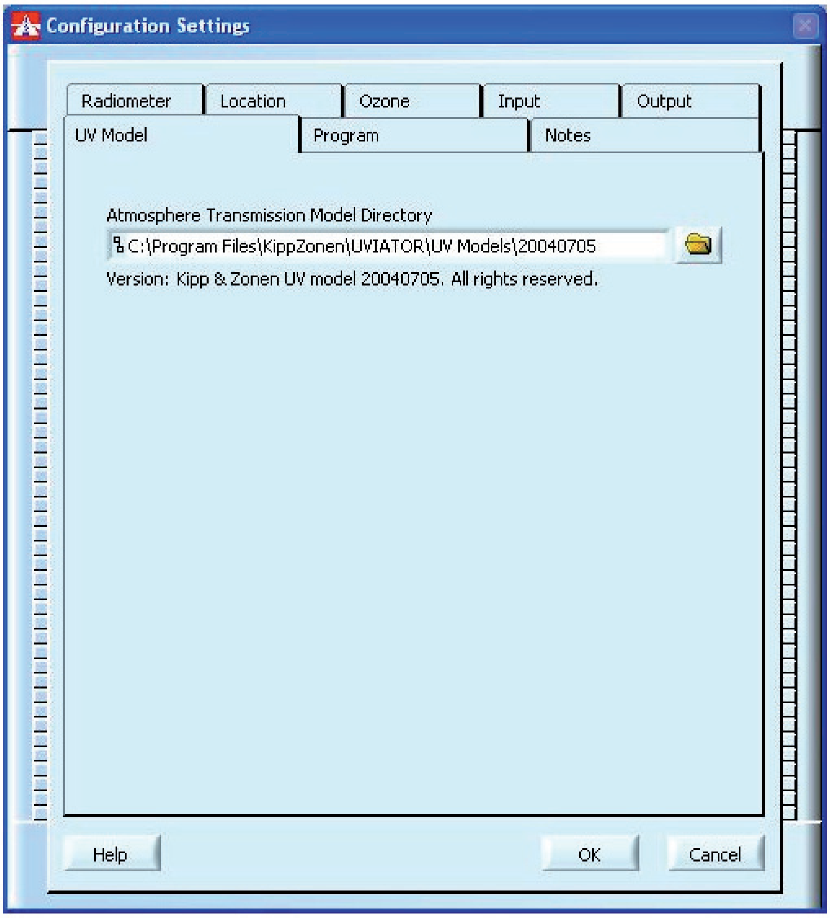
The atmosphere transmission model(s) provided by Kipp & Zonen reside in the program installation directory (ex. C:\Program Files\KippZonen\UVIATOR\UV Models).

You should only change this setting if:

- Kipp & Zonen has provided a new model
- You are an expert and have made your own model using exactly the same format as the default model
- You installed UVIATOR in a new directory, causing an existing configuration to point to a non-existing directory

Correction functions change when changing the atmosphere transmission model. They can be examined and optionally be stored to file by pressing **View Correction Function** on the Radiometer configuration page

**Example**



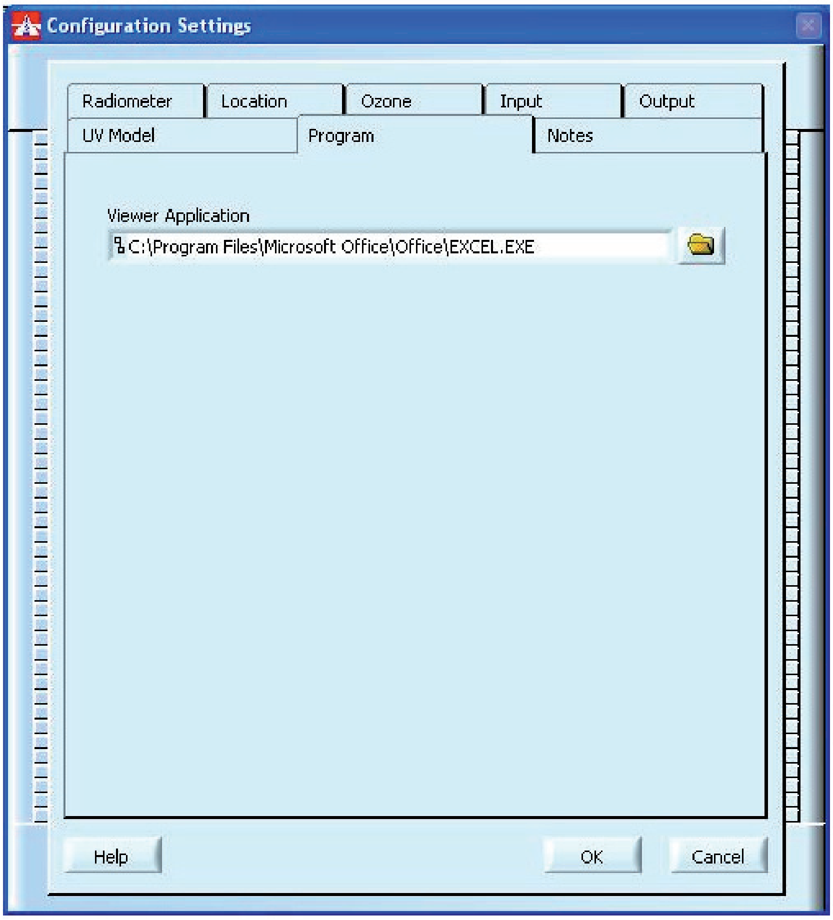
## 6.7 Program

This page holds the program settings. These settings are working directory independent.

### 6.7.1 Viewer Application

Sets the application that the program will use to open files for viewing. The application must be able to accept the name of a file as a parameter. Examples of such applications are:
'C:\Program Files\Microsoft Office\Office\EXCEL.EXE',
'C:\WINXP\system32\notepad.exe' or 'C:\emacs-21.3\bin\runemacs.exe'.

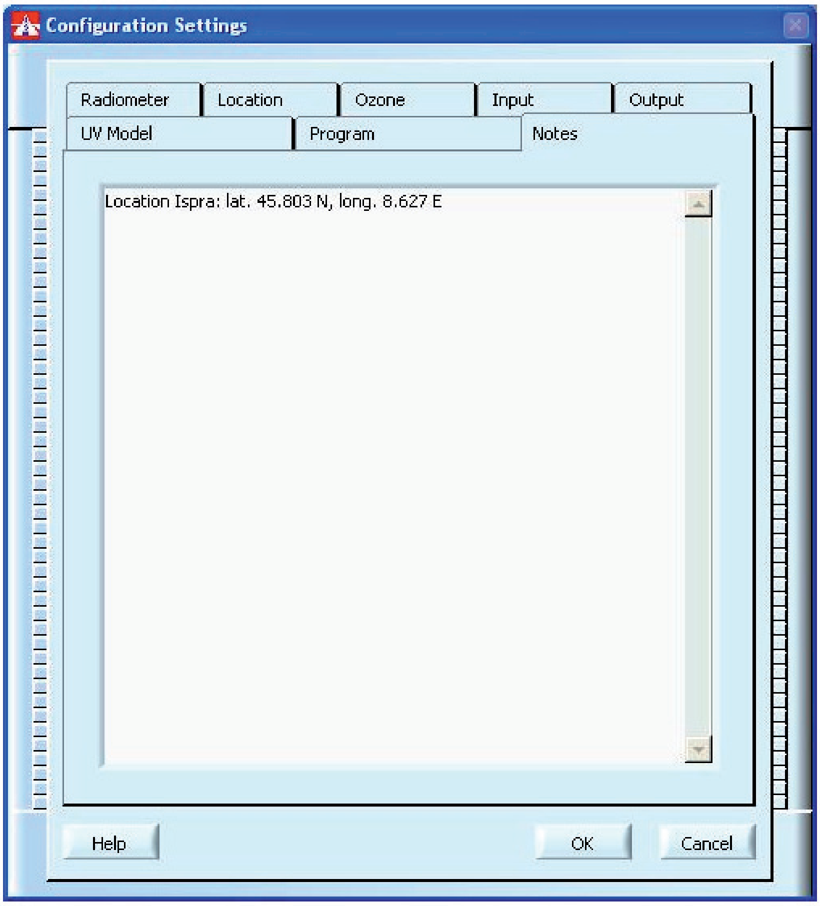
**Example**



### 6.8 Notes

This page has a textbox for making notes, for example about the location of the measurement system. The textbox may be left empty.

**Example**

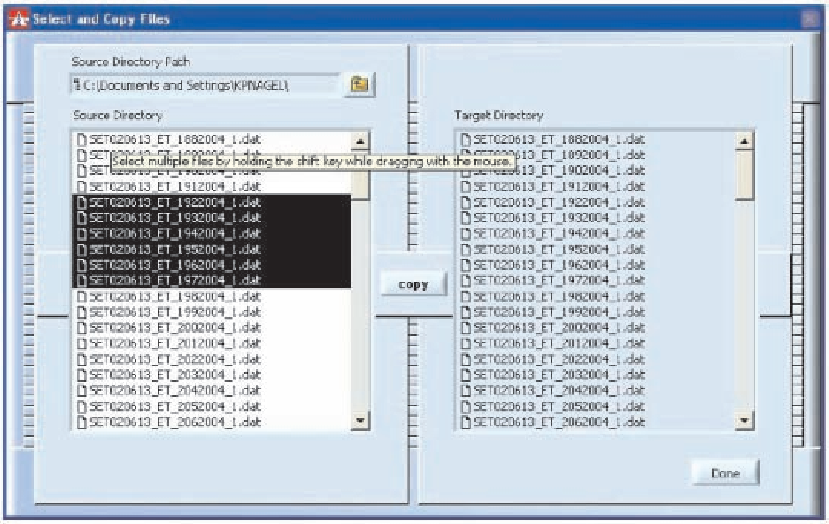


# 7. Copy Input Files

You may skip copying input files if you did this already at the Configuration Wizard.

Before the program can process UV data, files with the data must be copied to the input subdirectory. Copy files to the input subdirectory by selecting **Import Input Files** from the Tools menu. To select multiple files for copying to the input subdirectory, hold shift key while dragging with the mouse.

**Example**




It is also possible to fill the input subdirectory using an external application like Windows Explorer or another program.

Note that the input files do not need to have specific (sequential) names and do not need to start or end at a specific date and time. The program will sort the input files and their contents. However, it is not able to deal with UV data in the input directory that refers to the same date and time.

The formatting of the input files must be consistent in order to be able to read it using the **Input Data Formatting** configuration.

# 8. Process Data

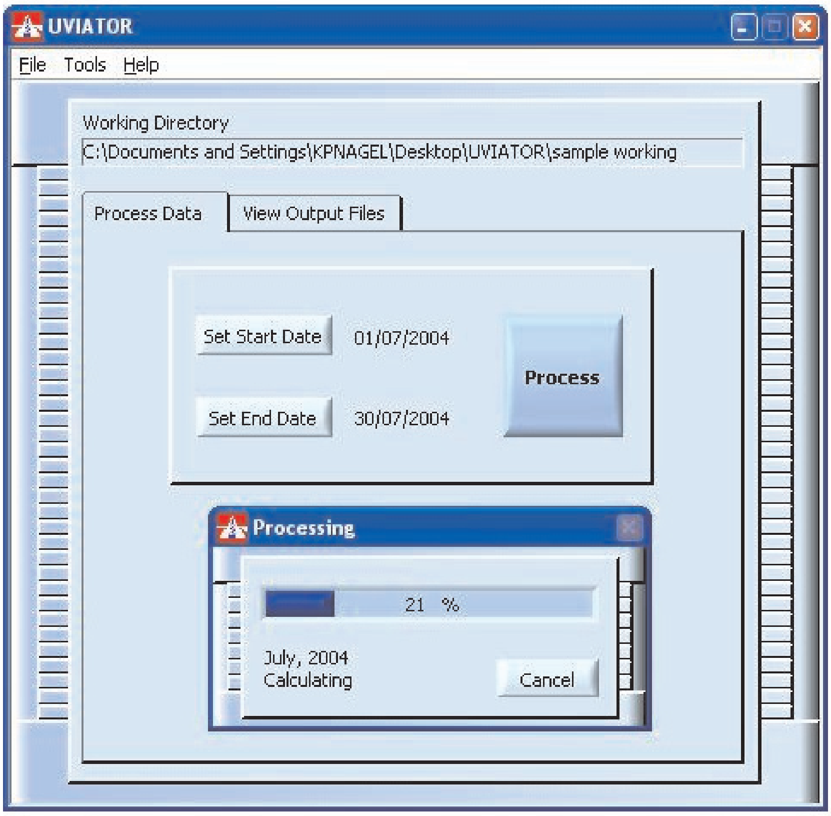
Before processing data, you should have:

- Selected a working directory
- Entered the configuration
- Copied input files to the input subdirectory
- Set the processing **Start Date**
- Set the processing **End Date**

Note that the granularity of **Start Date** and **End Date** is determined by the configuration of **File creation per**.

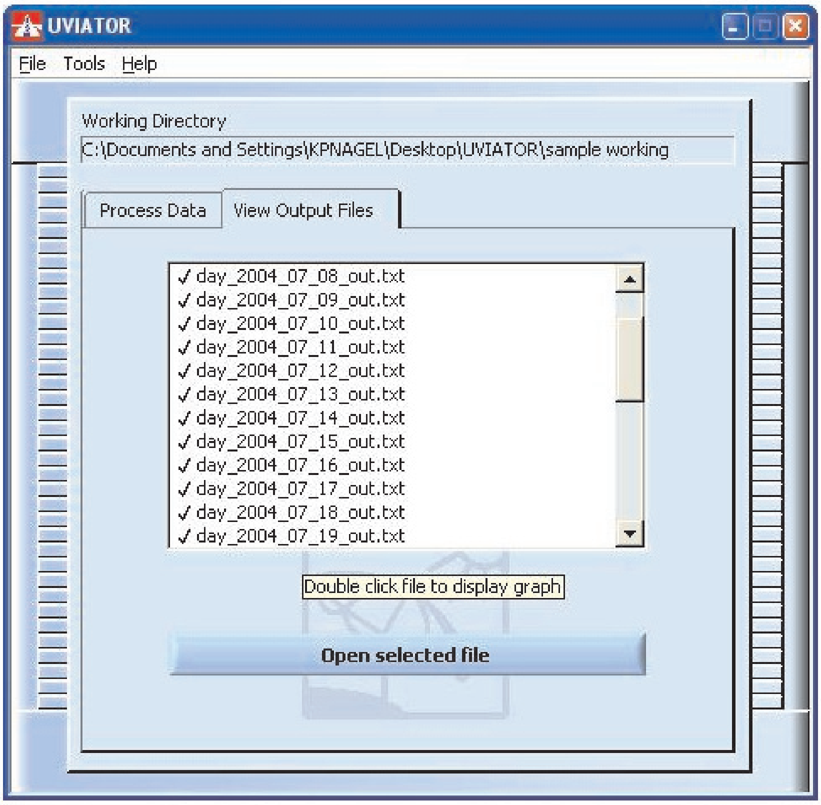
After **Start Date** and **End Date** have been set, the program is ready to process data. Start processing by clicking the **Process** button.

**Example**



When processing is finished, the **View Output Files** page is activated. The output files that have been created are indicated by a checkmark. The output files reside in the output subdirectory.

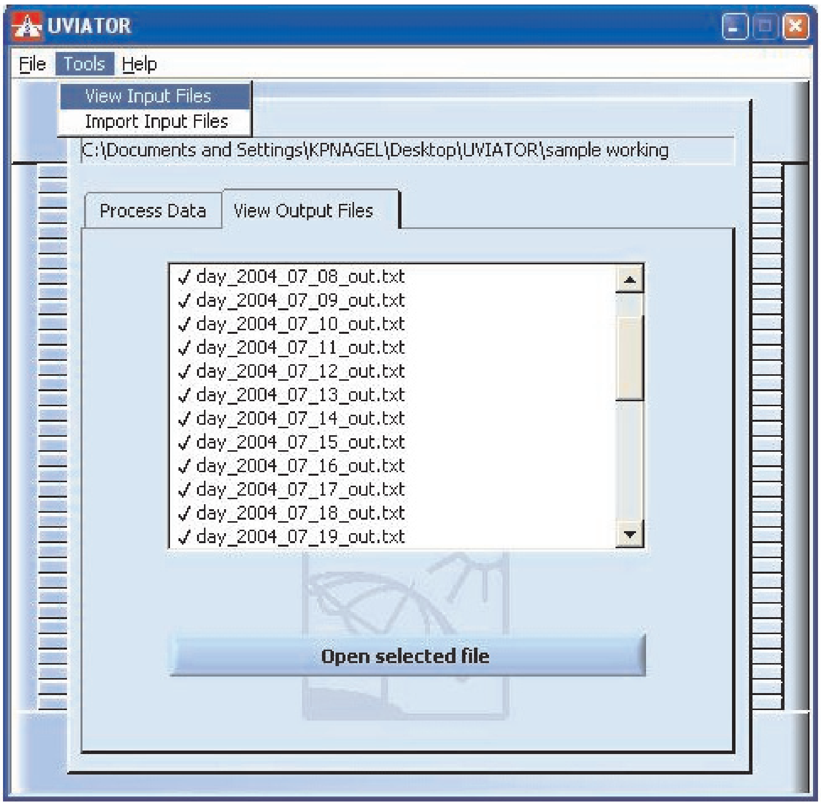
**Example**



# 9. View Input Files

Input files (measurement data) can be viewed by selecting **View Input Files** from the **Tools** menu. The configured viewer application will be used to open the selected file.

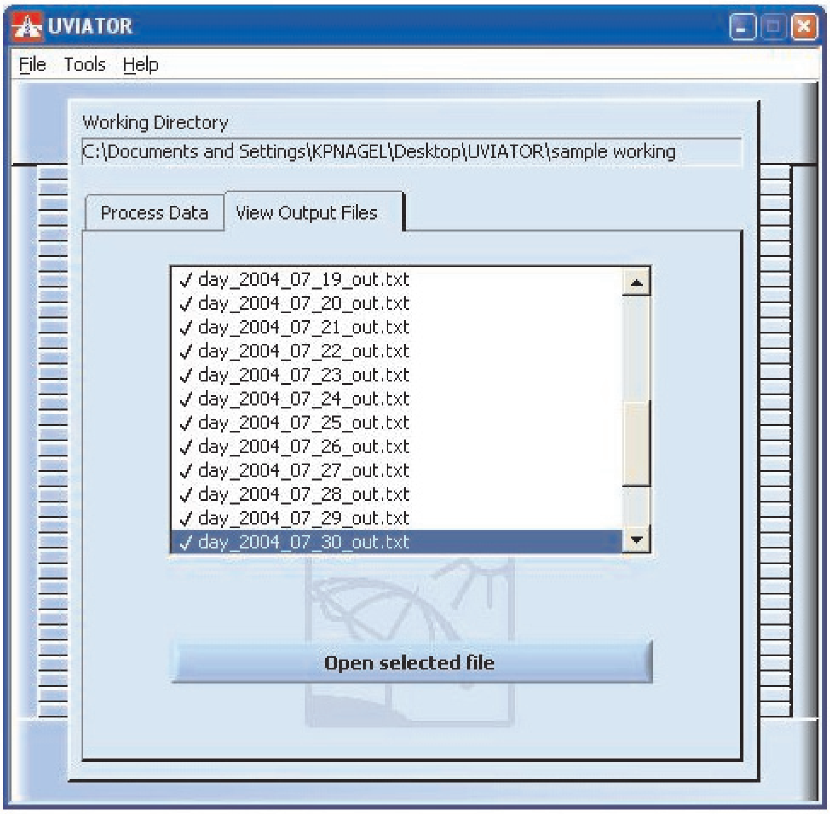
**Example**



# 10. View Output Files

To view an output file, select it and click on the **Open selected file** button. The configured viewer application will be used to open the file. Note that additional columns holding status flags are appended to the columns selected on the **output configuration window**. The meaning of status flags is explained here.

**Example**




To view the data of an output file as a graph, double-click the file. After zooming in on the **Date and Time** axis, click **Inspect** to be able to check correctness of the data, while automatically scrolling time. Use the **Reset Zoom** button to revert to the initial zoom level. The graph groups parameters of the file that have identical unities and only shows one group at a time. By selecting a parameter at the left of the graph, you select the whole group of identical unities. By de-selecting a parameter, it will be removed from the group being displayed. However, in case it was the last visible parameter of the group, the group will revert to displaying all its parameters. Invalid data points will be omitted in the graph. They can be detected by an interrupted plot line.

## 10.1 Copy Output Files

Output files generated by the program are located in the output subdirectory.

Copy files from the output subdirectory with Windows Explorer or another appropriate program. Output files follow the Output file format specification.

# 11. Command-line Parameters

UVIATOR can be called with command line parameters in order to start unattended processing of UV measurements. To do so, create a batch file that calls UVIATOR and call the batch file from a scheduler. Unattended processing requires that you specify a working directory and optionally a start date and end date. The working directory must be configured properly, so no user interaction is needed. Although called from the command line, the UVIATOR user interface will be visible during processing. See the table below for command line parameters accepted by UVIATOR.

| Parameter | Default | Description |
|---|---|---|
| /workdir=<workdir> | None | Sets the working directory |
| /startdate=<yyyymmdd> | Current date | Sets the start date of processing |
| /enddate=<yyyymmdd> | Current date | Sets the end date of processing |
| /action=process | None | Instructs UVIATOR to start processing |

Note that start date and end date will be rounded to the file creation per setting on the output configuration page. So for example, if file creation is per month and start date and end date are not specified, processing will be done for the current month.

See below and example of a batch file.

```
@rem example batch file, to be called from a scheduler
"C:\Program Files\KippZonen\UVIATOR\UVIATOR" "/workdir=C:\data\sample work dir" /startdate=20040730 /

enddate=20040730 /action=process

"C:\Program Files\KippZonen\UVIATOR\UVIATOR" "/workdir=C:\data\another work dir" /startdate=20041012 /

enddate=20041120 /action=process
```

# 12. Theory

This part shows the theoretical background of the UVIATOR software. Reading is only meant for those who are interested and not required for use of the UVIATOR software.

Atmospheric ultraviolet radiation measurements are difficult to perform due to the drastic decrease of UV-B irradiance towards shorter wavelengths, caused by the strong stratospheric ozone absorption. Besides the extinction of UV radiation due to ozone, Rayleigh scattering also affects the UV radiation, especially in the UV-B spectral region. As UV radiation represents a small portion of the solar spectrum only, broadband UV radiometers contain filters and use signal amplifiers to measure the UV irradiance in the appropriate spectral region. On top of the filters used to measure the UV irradiance in the entire UV-A or UV-B spectral region, dedicated weighting functions require to use additional filters which change the transmission function of the UV radiometer such that the spectral response function of the UV radiometer corresponds as much as possible to the theoretical weighting function. As none of these spectral response functions correspond exactly to the theoretical weighting functions, even not for the radiometers measuring only UV-A or UV-B irradiances, the measurements are affected by a systematic error.

The UV-S-X is suitable to measure UV irradiance according to the theoretically defined UV-B, E and A spectra. In general all broadband filter instruments have limited performance due to the intrinsic spectral mismatch of each sensor with respect to the theoretical definition of UV-B, -E and -A.

By knowing the spectral mismatch in detail one could compensate the instrument effects for different measurement conditions. Kipp & Zonen developed a software program for post processing and extensive analyses of UV data. The UVIATOR program performs automatically a number of UV measurement corrections and improves thereby the measurement quality significantly. The so-called spectral mismatch error correction is based on the correction method described in the WMO report No. 141 [2]. Further explanations and discussions of the spectral mismatch error are presented in a number of publications listed at the end of this section.

## 12.1 UV Radiometer Calibration and Correction Method

To achieve the most accurate measurement result with broadband UV radiometers, the raw signals must be transformed into UV irradiances using two calibration steps (A and B), and an adjustment step:

- Calibration step A: The raw signal of the instrument (in units of Volts) has to be transformed into an irradiance (in units of $W/m^2$). To achieve this transformation a so-called “radiometric calibration factor”, denoted as $\rho$ (in units of $V/W/m^2$), has to be determined.
- Calibration step B: The irradiances have to be corrected for the so-called spectral mismatch error with the “conversion factors”, denotes as $\gamma$ (no units). The conversion factors are determined using modelled UV irradiances as a function of various total ozone column densities and solar zenith angles.
- Adjustment step: The corrected and final UV measurements are obtained by multiplying the raw UV radiometer reading under outdoor measurement conditions with an appropriate adjustment factor, $\chi$, defined as $1/(\rho \cdot \gamma)$. The appropriate adjustment factor has to be chosen according to the measurement condition at the time of the UV radiometer reading.

The “adjustment step” which provides the final, spectral mismatch corrected, UV irradiance (in units of $W/m^2$), is carried out by the UVIATOR program for each individual UV radiometer reading. Before the broadband UV radiometer can be used in the field, however, it must be calibrated according to the “calibration steps” A and B, which provide the calibration and correction factors for a particular instrument.

The next two paragraphs describe the calibration steps A and B as they are performed at Kipp & Zonen. The final paragraph of this chapter describes the adjustment procedure as implemented in the UVIATOR program.

## 12.2 Calibration Step A: Determination of the Radiometric Calibration Factor

The calibration of the broadband UV radiometers is performed with a Xe-lamp system, a monochromator (ORIEL CornerStone MS257), and a calibrated Si-photodiode detector. The Si-photodiode detector and the broadband UV radiometers, mounted behind the exit slit of the monochromator, are exposed to spectral irradiances between 280 nm and 400 nm (step increments: 1 nm; slit width: 2 nm at FWHM). The spectral measurements are performed sequentially as the monochromator has one exit slit only. Nevertheless, identical monochromator output signals can be achieved for the Si-photodiode and the broadband UV radiometers by positioning the sensitive surfaces of both detectors at the same distance from the monochromator's exit slit(1).

A calibration factor is defined as the ratio between radiometer output and radiation input, i.e. the radiometer reading in Volts divided by the UV irradiance. To obtain the radiometric calibration factor, ρ, in the laboratory, the UV radiometer output and the UV irradiance input are determined using the monochromatic measurements. As only monochromatic measurements are performed the total UV radiometer output must be calculated according to $U_{UVS} = \int u_{UVS}(\lambda) \bullet d\lambda$, where $u_{UVS}(\lambda)$ are the spectrally measured UV radiometer readings. The index UVS denotes the variable of a broadband UV radiometer.

The radiometer-weighted irradiance, i.e. the UV irradiance input, has to be calculated similarly, according to

$$E_{UVS} = \frac{\int e_{Si}(\lambda) \bullet s_{UVS}(\lambda) \bullet d\lambda}{A_{eff}}$$

where $e_{Si}(\lambda)$ is the irradiance (in units of W/nm) of the monochromator output (measured with the Si-photodiode), $s_{UVS}(\lambda)$ is the normalized spectral response function of the broadband UV radiometer, i.e. $u_{UVS}(\lambda)/max\,(u_{UVS}(\lambda))$, and $A_{eff}$ is the effective surface area (in m²) of the broadband UV radiometer.

Finally, the radiometric calibration factor is obtained from the two monochromator based measurements ($U_{UVS}$ and $E_{UVS}$) according to ρ=$U_{UVS}$ /$E_{UVS}$. The units of ρ are V/(W/m²).

## 12.3 Calibration step B: Determination of the Conversion Factor Table

Without any measurement correction, the broadband UV radiometer can provide results that deviate by a factor of 2 or more from the true values. The magnitude of the deviation depends mainly on the extent of the spectral mismatch and the measurement condition.

The measurement conditions for which correction factors are calculated are obtained by varying the solar zenith angle, $\Theta_0$, and the total ozone column density, [$O_3$] in the radiative transfer model TUV [3]. Other atmospheric parameters affecting UV irradiances, such as extinction of UV radiation due to aerosols, are not explicitly included as they are assumed to be small compared to the effects that the solar zenith angle and the ozone column density have on the spectral distribution of UV radiation.

The modelled UV spectra are used to determine the conversion factors, $\gamma(\Theta_0, O_3)$, which are defined as $\gamma = T_{UVS} / T_{UVX}$, where $T_{UVS}$ and $T_{UVX}$ denote the normalized spectral response function-weighted irradiance and the 'true' irradiance, respectively:

$$T_{UVS}(\mathrm{O}_0, O_3) = \int e_{TUV}(\lambda, \Theta_0, O_3)\, s_{UVS}(\lambda)\, d\lambda \quad \text{and} \quad T_{UVX}(\Theta_0, O_3) = \int e_{TUV}(\lambda, \Theta_0, O_3)\, s_{UVX}(\lambda)\, d\lambda$$

where $e_{TUV}(\lambda, \Theta_0, O_3)$ denotes the TUV modelled irradiance as a function of the variable input parameters $\Theta_0$ and $O_3$. Note, that the 'true' irradiance, $T_{UVX}$, represents the modelled irradiance weighted with a theoretical spectral response function, $s_{UVX}(\lambda)$. Such a theoretical spectral response function could be the Erythema weighting function CIE-1987 [4]. The conversion factors calculated with the Erythema weighting function provide the corrections of the E-type UV radiometers.

(1) However, the exact distance between the exit slit and the sensitive surface is not very critical, as the spot of the exit slit is smaller than the sensitive surface of the detector, both detectors capture i.e. the entire radiant energy.

The solar zenith angles, $\Theta_0$, are varied between 0° and 85° (using steps of 5°) and the ozone column densities, $[O_3]$ are varied between 200 DU and 500 DU (using steps of 10 DU), yielding 18•31=558 conversion factors. If UV irradiances under exceptional conditions have to be measured with broadband UV radiometers, it is recommended to calculate new conversion factors using model parameters that are representative for the exceptional condition (e.g. snow covered land surface at a location which is mostly snow free).

## 12.4 Adjustment Step: UVIATOR correction method

To obtain the most accurate UV irradiances using broadband UV radiometers, the readings ("raw radiometer output") must be multiplied with the adjustment factor, $\chi$. The adjustment factor, $\chi$, is a combined correction factor, composed of the radiometric calibration factor, $\rho$, and the conversion factor, $\gamma$, i.e. $\chi=1/(\rho\bullet\gamma)$.

The UVIATOR program performs the required selection of the appropriate conversion factor automatically and corrects an instantaneous UV radiometer measurement according to the measurement condition at the time of the UV radiometer reading. For the selection of the conversion factor, the parameters $\Theta_0$ and $O_3$ have to be determined according to the measurement conditions at the time of the UV radiometer reading. The UVIATOR program calculates the solar zenith angle, $\Theta_0$, for each measurement as a function of the measurement location (latitude and longitude) and the GMT of the UV radiometer reading. The total ozone column density, $O_3$, is retrieved from the TOMS data archive(2). Note, that the TOMS retrieved ozone values are daily mean values only. However, the UVIATOR program offers so-called plug-ins, which allows using other ozone column observation methods for the correction, such as the Brewer-derived ozone column density measurements. Finally the UVIATOR program performs the UV measurement using the appropriate solar zenith angles and ozone column densities as obtained according to the available metadata of the UV radiometer readings (metadata: data about the measurement data).

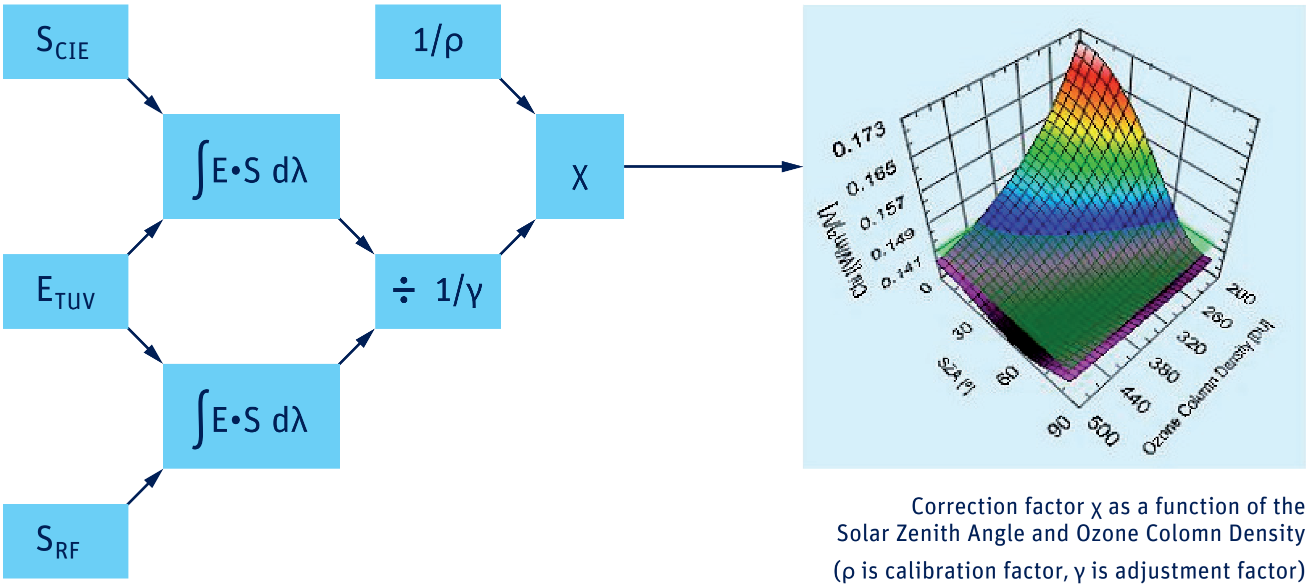
(2) See on http://toms.gsfc.nasa.gov/eptoms/ep.html

# 13. Technical Details

## 13.1 Processing Flow

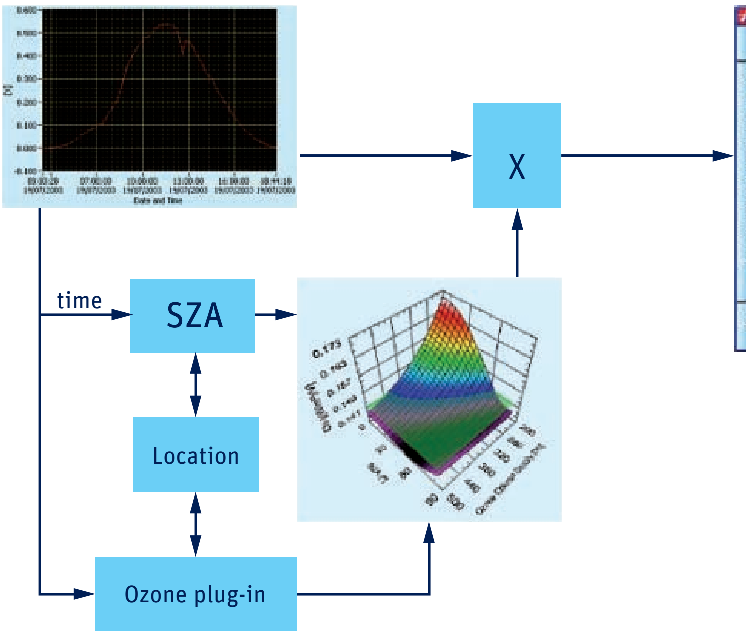
This page illustrates the processing flow from UV measurement to corrected UV irradiance.

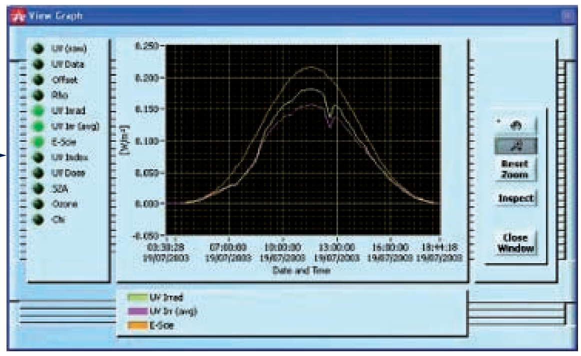
Before the program starts processing UV measurements, it calculates the correction factor χ from the atmosphere transmission model ($E_{TUV}$) and the ideal ($S_{CIE}$) and actual ($S_{RF}$) radiometer response function. The integration range of λ is set by the $S_{RF}$.




Correction factor χ as a function of the
Solar Zenith Angle and Ozone Colomn Density
(ρ is calibration factor, γ is adjustment factor)

For each UV measurement, the program calculates the solar zenith angle (using location and time) and gets the ozone column density (using the ozone plugin). Once the solar zenith angle and ozone column density are known, the correction factor value is calculated using spline interpolation. The correction factor value will be multiplied with the UV measurement, resulting in the corrected UV irradiance. Handling of trivial tasks, such as dealing with the offset voltage, are not depicted.




Calculate UV irradiance by multiplying the
radiometer measurement with the correction factor χ

# 14. Time Handling

## 14.1 Daylight Saving Time

The program cannot take daylight saving time into account. Therefore, make sure that measurements are not stored in daylight saving time.

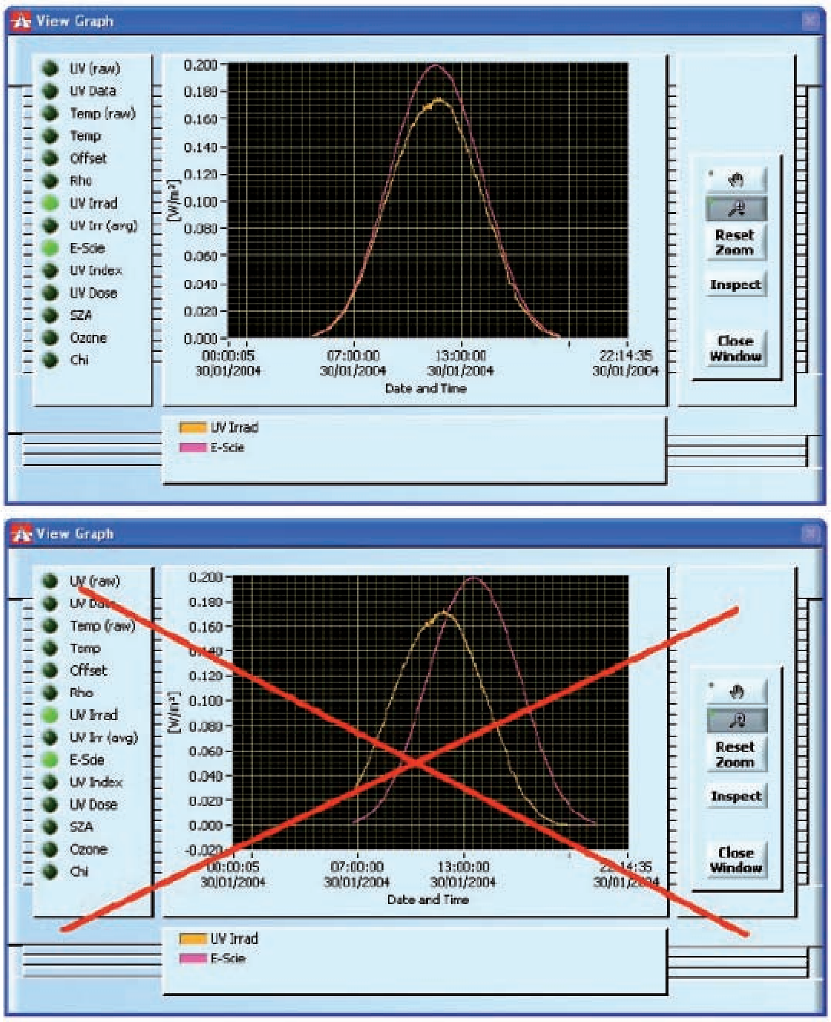
## 14.2 Time Zones and Location

It is important to configure the correct location and time zones for input data and the ozone plugin (if applicable). The program calculates the correction factor based on location, input data time, input data time zone and ozone plugin time zone. If these are not consistent, calculated corrections will be wrong.

A simple consistency for location, input data time and input data time zone is to compare the UV Irradiance graph of a sunny day with the atmosphere transmission model graph. In case these have an offset in time, there is a problem with one of them.

In order to verify the correct setting of the ozone plugin time zone, verify that ozone column densities change value as expected, for example at midnight.

**Example**




## 14.3 Date and Time Formatting

Date and time formatting in the user interface is according the regional settings of the operating system. Date and time formatting in output file headers is yyyymmdd, for example December 31st, 2004 is 20041231. Date and time formatting of data in output files is as configured in the Output configuration window.

# 15. File Naming

This section describes file naming. The location of files is explained here.

## 15.1 Input Files

Input files may have any name.

## 15.2 Output Files

| | |
|---|---|
| year | year_yyyy_out.txt |
| month | month_yyyy_mm_out.txt |
| week | week_yyyy_ww_out.txt |
| day | day_yyyy_mm_dd_out.txt |

| | | | |
|---|---|---|---|
| yyyy | = | 4 digit | year number |
| mm | = | 2 digit | month number |
| ww | = | 2 digit | week number |
| dd | = | 2 digit | day of month number |

# 16. Output File layout specification

The file below is marked with bold text. Bold text indicates data that is required for viewing the file as a graph. Three dots indicate that data may repeat an undefined number of times and that it has the same designation as the data above or left.

```
# header lines containing version and configuration information
# header lines start with a pound character.
# the number of header lines is variable.
# ...
# ...
# output date format: <date format codes>
# output time format: <time format codes>
# ...
# ...
# StartDate       StartTime       Name 1      Name 2      ...     Prog Flag   Cert
# [<Local|GMT>]   [<Local|GMT>]   [<unity>]   [<unity>]   ...
<date>            <time>          <value>     <value>     ...     <value>
...               ...             ...         ...         ...     ...         ...
...               ...             ...         ...         ...     ...         ...
```

Note that:

- Fields are separated by <TAB>
- Values have dot as decimal separator
- Dates in the header have format yyyymmdd (December 31st, 2004 appears as 20041231)
- The number of columns called 'Name <number>' may vary, depending on the parameters configured for output. Other columns are fixed
- Fixed columns are always present
- The meaning of columns called '<text> Flag' is described in the section "Output File Status Flags"

# 17. Date and Time Format Codes

The format codes can be used to generate a string with date and time. Any other characters will appear in the string without change.

| Format Code | Value |
|---|---|
| %% | a single percent character |
| %d | day of month (01 - 31) |
| %h | fractional hour (0.000000 – 23.999722), only available for formatting in output files |
| %H | hour (24-hour clock) (00 - 23) |
| %I | hour (12-hour clock) (01 - 12) |
| %j | day number of year (001 - 366) |
| %m | month number (01 - 12) |
| %M | minute (00 - 59) |
| %p | AM or PM flag |
| %S | seconds (00 - 59) |
| %y | year within century (00 - 99) |
| %Y | year, including the century (for example, 1997) |

The format codes always have leading zeros as necessary to ensure a constant field width. An optional # modifier before the format code letter removes the leading zeros from the following format codes: %#d, %#H, %#I, %#j, %#m, %#M, %#S, %#y, %#Y.

The # modifier does not modify the behaviour of any other format codes.

# 18. Date and Time Pattern Matching Characters

The characters listed below can be used to match a date or time field. Any other character will be scanned as is except when it is a regular pattern matching character.

| Character | Description |
|---|---|
| Y | Multiple digit year |
| YY | 2 digit year |
| YYYY | 4 digit year |
| M | Multiple digit month |
| MM | 2 digit month |
| D | Multiple digit day of month |
| DD | 2 digit day of month |
| d | Multiple digit day of year |
| ddd | 3 digit day of year |
| h | Multiple digit hour |
| hh | 2 digit hour |
| H | Fractional hour (sets hour, minute and second) |
| m | Multiple digit minute |
| mm | 2 digit minute |
| s | Multiple digit second |
| ss | 2 digit second |
| A | AM/PM |

## 18.1 Notes

• Make sure that no non-separator characters at the end of the date and time strings remain unmatched. These characters will be considered as measurement data

• Use fixed digit symbols in case date and/or time fields are glued together

• The last matched character contributing to a date or time field determines the value of that field. For example, in case H is followed by s, the second's time field filled by H will be overwritten by the value matched by s

## 18.2 Examples

| String | Suitable patterns |
|---|---|
| 2004139 6.5 | "YYYYdddH" or "YYYYddd H" |
| 2004139 6.5 | "YdH" or "Y d H" |
| 2004.00 139.000 6.5 | "Y.[0]+d.[0]+H" or "Y.00d000H" |
| 31/12/2004 23:12:10 | "D/M/Y h:m:s" or "DMYhms" |
| 31/12/2004 23:12:10.752 | "D/M/Y h:m:s.[0-9]+" or "DMYhms.[0-9]+" (no remaining non-separator characters at the end) |
| 31/7/2004 1:05 PM | "D/M/Y h:m A" or "DMYhmA" |

## 19. Pattern Matching Characters

| Character | Description |
|---|---|
| . | Matches any character |
| ? | Matches zero or one instances of the expression proceeding |
| \ | Cancels the interpretation of special characters (for example, \? matches a question mark).<br>You can also use the following constructions for the space and non-displayable characters:<br>\b backspace<br>\f form feed<br>\n newline<br>\s space<br>\r carriage return<br>\t tab<br>\xx any character, where xx is the hex code using 0 through 9 and upper case A through F |
| ^ | If ^ is the first character of regular expression, it anchors the match to the offset in string. The match fails unless regular expression matches that topic of string that begins with the character at offset. If ^ is not the first character, it is treated as a regular character. |
| [ ] | Encloses alternates. For example, [abc] matches a, b or c. The following character has special significance when used within the brackets in the following manner. |
| - (dash) | Indicates a range when used between digits, or lowercase or uppercase letters (for example, [0-5],[a-g],or [L-Q])<br>The following characters have significance only when they are the first character within the brackets. |
| ~ | Excludes the set of characters, including non-displayable characters. [~0-9] matches any character other than 0 through 9. |
| ^ | Excludes the set with respect to all the displayable characters (and the space characters). [^0-9] gives the space characters and all displayable characters except 0 through 9. |
| + | Matches the longest number of instances of the expression preceding +;<br>there must be at least one instance to constitute a match. |
| * | Matches the longest number of instances of the expression preceding * in regular expression,<br>including zero instances. |
| $ | If $ is the last character of regular expression, it anchors the match to the last element of string.<br>The match fails unless regular expression matches up to and including the last character in the string.<br>If $ is not last, it is treated as a regular character. |

# 20. Output File Status Flags

This section describes the status flags used in output files and their influence on irradiance calculation.

In general the following applies to status flags:

- a status flag value of 0 indicates **no error** or **successful**
- higher numbers indicate **increasing severity**
- a non-zero status flag does not always mean that calculations are stopped. For example, the **radiometer temperature status** flag is a warning and does not influence the calculation of irradiances.
- status flags that indicate no processing was done, such as **not calculated**, occur in case prerequisites were not successful. For example, when the sun is below the horizon, it does not make sense to calculate the correction factor and therefore determine the ozone value. In this case the **chi flag** and **ozone flag** will be set to **not calculated**.

### 20.1 Program Status Flag

The program status flag indicates general program status.

| Program Flag | Description | Irradiance Calculation |
|---|---|---|
| 0 | Successful | Yes |
| 9 | Failed to call ozone plugin | No |

### 20.2 Radiometer Offset Status Flag

The offset status flag indicates the status of the radiometer offset voltage calculation.

| Offset Flag | Description | Irradiance Calculation |
|---|---|---|
| 0 | Successful | Yes |
| 1 | Fallback to the radiometer offset voltage specified by the digital instrument calibration certificate (in case of a failed automatic offset calculation during the night). | Yes |
| 8 | Not calculated | No |

### 20.3 Radiometer Certificate Status Flag

The radiometer certificate status flag indicates the status of the digital instrument calibration certificate the program used for calculations.

| Certificate Flag | Description | Irradiance Calculation |
|---|---|---|
| 0 | Successful | Yes |
| 1 | Digital radiometer calibration certificate expired | Yes, but recalibrate radiometer |
| 9 | No valid digital instrument calibration certificate found | No |

## 20.4 Solar Zenith Angle Status Flag

The solar zenith angle status flag indicates the status of the solar zenith angle calculation.

| SZA Flag | Description | Irradiance Calculation |
|---|---|---|
| 0 | Successful | Yes |
| 1 | Sun below horizon | No |
| 8 | Not calculated | No |

## 20.5 Ozone Plugin Status Flag

The ozone plugin status flag indicates the status of determining the ozone column density using the configured ozone plugin.

| Ozone Flag | Description | Irradiance Calculation |
|---|---|---|
| 0 | Successful | Yes |
| 1 | Interpolated | Yes, but ozone column density was interpolated |
| 2 | Out of range [200, 500] [DU] | Yes, but only in case the out of range ozone column density is supported by the UV model |
| 8 | Not calculated | No |
| 9 | No ozone value found | No |

## 20.6 Correction Factor Status Flag

The correction factor status flag indicates the status of the process of finding the correction factor for the current solar zenith angle and ozone column density.

| Chi Flag | Description | Irradiance Calculation |
|---|---|---|
| 0 | Successful | Yes |
| 1 | E-Scie lookup failure | Yes |
| 2 | Chi lookup failure | No |
| 3 | Chi not found | No |
| 8 | Not calculated | No |

## 20.7 Radiometer Temperature Status Flag

The temperature status flag indicates the status of converting the temperature reading to actual radiometer temperature and verifying whether the temperature is in the range as specified by the digital instrument calibration certificate.

| Temperature Flag | Description | Irradiance Calculation |
|---|---|---|
| 0 | Successful | Yes |
| 1 | No temperature readings available | Yes, but uncertain whether the radiometer operated as specified |
| 2 | Temperature out of range | Yes, but the radiometer did not operate as specified |
| 9 | Temperature interpolation error (or temperature reading out of range) | Yes, but uncertain whether the radiometer operated as specified |

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