AWE-GEN

Advanced WEather GENerator

User Manual, version 1.0

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The purpose of this draft-note is only to help the user to run the weather generator code. A guide through possible different choices is also presented. The scientific documentation including a description of the parameters is provided in the Technical Reference.

1.Preliminary

→ Unzip the folder **AWE_GEN_PACKAGE** in a local directory.

2.Run the model

In matalb set the working directory to the folder containing the code ***GO_WG.m***.

To run the model just type **GO_WG** in the prompt of Matlab.

The code offers three main options that can be used sequentially within the same run or in different runs:

1. Parameters of the weather generator are estimated starting from observed time series of hydro-climatic variables.

2. New time series are generated starting from a set of weather generator parameters.

3. The results of weather generator saved from previous runs can be visualized and compared with observations.

The pop-up windows that allow one to make different choices are shown in the following:

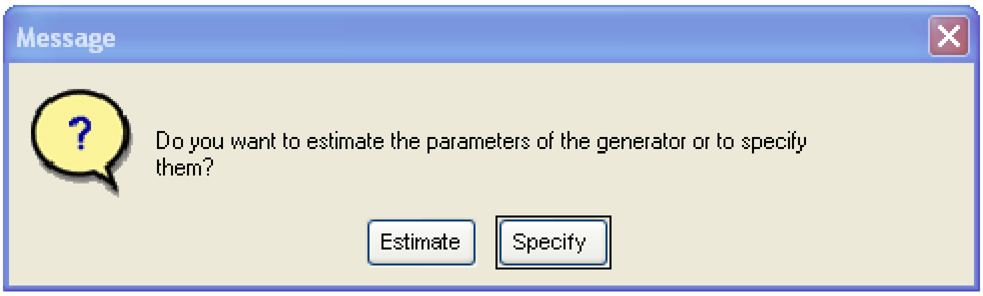

Fig.1. Option that allows one to specify a previous saved parameter file or to estimate the parameter file from observations.

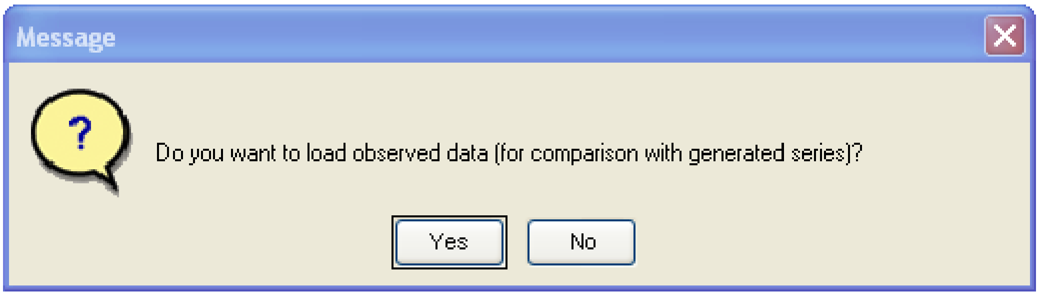

Fig.2 Option that allows one to load (or not) the observed time series for an automated graphical comparison.

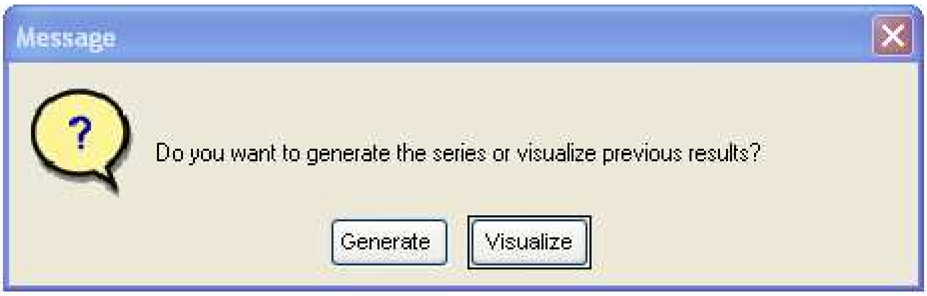

Fig.3. Option that allows one to generate new time series with the weather generator or simply load and compare previously saved results.

3.Data Input

A file of meteorological variables should be prepared in advance. The file must be a **.mat* with the time series of the variables below. Names and measurement units must correspond to the one specified below.

Pr--*Precipitation* [mm h^{-1}]
N--*Cloud cover* [0-1] discrete values with step 0.1;
Ta--*Air temperature* [°C]
Rsw--*Global shortwave solar radiation* [W m^{-2}]
U-- *Relative Humidity* [0-1]
Ws-- *Wind Speed* [m s^{-1}]
Pre--*Atmospheric Pressure* [mbar]

Rdir -- *Direct shortwave solar radiation* [W m^{-2}]→ optional
Rdif – *Diffuse shortwave solar radiation* [W m^{-2}] → optional
Pr_yr -- *Annual Precipitation* [mm] → optional
DT_fut – *Possible increase in temperature* [°C] → optional

The *Date* may be insert with five vectors or as a single vector **D** in matlab date format:

Yr [Years]
Mo [Months]
Da [Days]
Hr [Hours]
Mi [Minutes]

Or **D** [Matlab Date Format]

Pr_yr is the time series of annual precipitation that is an optional input. If it is not specified the code compute the annual precipitation statistics from **Pr.**

DT_fut is a vector [1x12] where for each month is specified the expected increase in temperature to apply into the model. It is an optional input and it is important for climate change studies. If it is not specified the code uses zero by default.

**Note

The integration interval for the solar variables and the solar radiation is a priori an unknown. It depends on the specific dataset. The code calculate the integration as [-1 0] hour. The user may change this interval modifying in the code "*SetSunVariable*" (lines 50-51) the limits of integration for the sun-variables, (***t_bef*** and ***t_aft***). The value assigned by default are: ***t_bef*** = 1 and ***t_aft*** = 0.

The variable ***phat*** that expresses an evaluation of the measurement error for annual precipitation is tentatively parameterized as 2.5%. The user may change this value in the code "GO_WG" (line 149 and line 200).

Pr and the ***Date*** are required fields. If other variables are not specified, the code requires to specify the correspondent parameters. For instance:

Fig.4. The code is requiring a parameter set for wind speed because it doesn't find such a variable among the inputs.

The code requires to specify also the geographic location, with the follow pop up window:

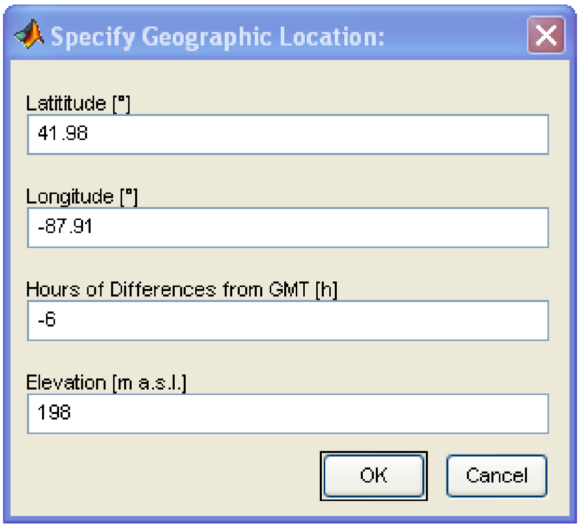

Fig.5. The code requires to specific the information about the geographical position of the station.

The code offers a summary of data consistency in terms of fraction of missing values (NaN) in the data:

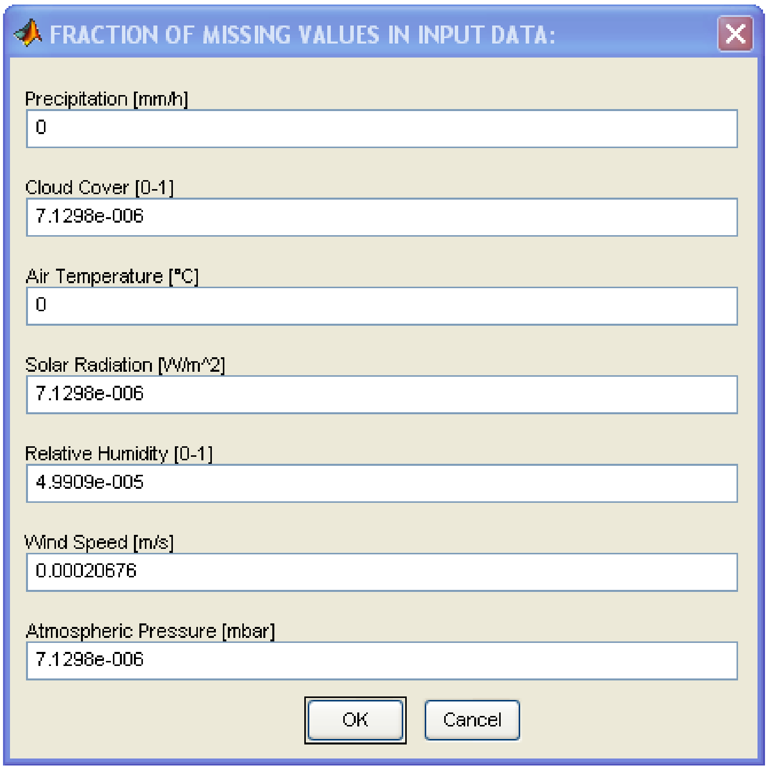

Fig.6. Summary of the fraction of missing values for each input variables. Note that elevated fractions of missing values may compromise significantly the performance of the weather generator

4.Parameter

In each AWE-GEN run the parameter set can be saved and used as input in successive simulations. The model simulates new time series also when the user has no data but provides a file containing the parameter set of the model. The format of the parameter set is described below.

File Paramters**:** The file should be a *.mat. The parameter file contains two matlab *structures* « Par » and « Par_yr » where each parameter "name" is Par.name or Par_yr.name

The parameters of the model [vector dimension] are specified in the following:

IN THE Par. STRUCTURE:

PRECIPITATION
lan: [1x12]
bet : [1x12]
muc: [1x12]

eta: [1x12]
alp: [1x12]
tet: [1x12]

CLOUD COVER
M0: [1x12]
sigmam: [1x12]
rhom: [1x12]
gam: [1x12]
acloud: [11x12]
bcloud: [11x12]
Tr: [1x12] (used only for graphical reasons)
EN1: [1x12]

AIR TEMPERATURE
bTemp: [12x5]
dTbar: [12x24]
rhodT: [1x12]
sigmadT: [12x24]
Ti: [1x12]
TR2: [1x12] (used only for graphical reasons)

SOLAR RADIATION
uo: [1]
un: [1]
alpha_A: [1]
omega_A1: [1]
omega_A2: [1]
rho_g: [1]
LWP_R: [1x12]
beta_A: [1x12]

VAPOR PRESSURE
aVap: [12x4]
dDem: [1x12]
rhodDe: [1x12]
sigmadDe: [1x12]

WIND SPEED
cWind: [5x1]
EdWs: [1]
rhodWs: [1]
sigmadWs: [1]
skedWs: [1]

ATMOSPHERIC PRESSURE
EPre: [1]
rhopre: [1]
sigmapre: [1]

IN THE Par_yr. STRUCTURE:

PRECIPITATION INTERANNUAL VARIABILITY
E: [1]
Cv: [1]
rho: [1]
skw:[1]

5.Results

The code allows the user to specify the length of the simulation period, specifically the start and end dates must be specified.

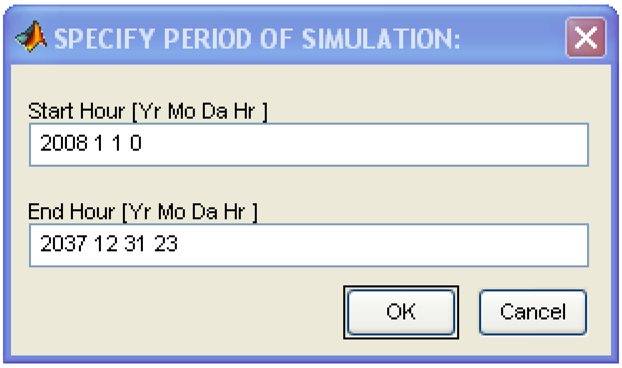

Fig.7. Specification of the simulation period. The dates are only used to define the length of the intervals. Obviously, there is no correspondence between the dates and the simulated time serirs, since the weather generator reproduce a stationary climate.

The code allows the user to enable and disable the interannual variability feature for the rainfall variable.

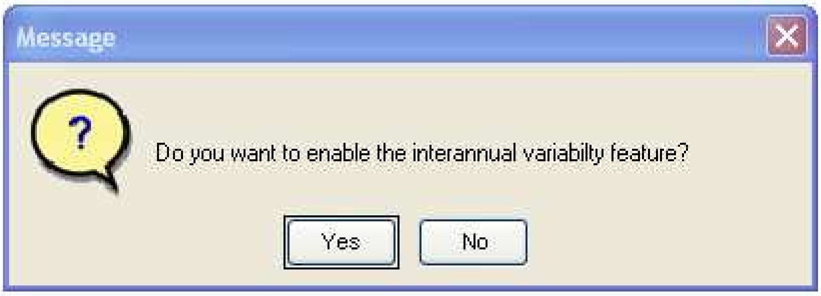

Fig.8. Option that allows one to enable (or disable) the interannual variability feature.

The output provided by AWE-GEN is a *.mat file containing (among the others) the following variables with the name and the measurement unit specified below.

Prs-- *Precipitation* [mm h^{-1}]
Ns --*Cloud cover* [0-1]
Tas --*Air temperature* [°C]

Rsws -- *Global solar radiation* [W m^{-2}]
Us -- *Relative Humidity* [0-1]
Wss -- *Wind Speed* [m s^{-1}]
Pres -- *Atmospheric Pressure* [mbar]
Rdirs -- *Direct solar radiation* [W m^{-2}]
Rdifs-- *Diffuse solar radiation* [W m^{-2}]
SAB1 -- *Direct solar radiation UV/VIS band* [W m^{-2}]
SAD1-- Diffuse solar radiation *UV/VIS band* [W m^{-2}]
SAB2-- *Direct solar radiation NIR band* [W m^{-2}]
SAD2-- *Diffuse solar radiation NIR band* [W m^{-2}]
PARB-- *Direct photosyntetically active solar radiation* [W m^{-2}]
PARD -- *Diffuse photosyntetically active solar radiation* [W m^{-2}]

The *date* is a four vectors **Yrs** [Years] **Mos** [Months] **Das** [Days] **Hrs** [Hours] and a single vector **DS** in matlab date format.

6. Graphical Comparison

A graphical function is used to compare the simulated weather generator results and the observational data. The captions of the generated figures are listed below:

Figure(101): A comparison between observed (red) and simulated (green) monthly precipitation. The vertical bars denote the standard deviations of the monthly values.

Figure(102): A comparison between observed (red) and simulated (green) monthly statistics of precipitation (mean, variance, lag-1 autocorrelation, skewness, frequency of nonprecipitation, transition probability wet-wet), for the aggregation period of 1 hour.

Figure(103): A comparison between observed (red) and simulated (green) monthly statistics of precipitation (mean, variance, lag-1 autocorrelation, skewness, frequency of nonprecipitation, transition probability wet-wet), for the aggregation period of 24 hours.

Figure(104): A comparison between observed (red) and simulated (green) monthly statistics of precipitation (mean, variance, lag-1 autocorrelation, skewness, frequency of nonprecipitation, transition probability wet-wet), for the aggregation period of 48 hours

Figure(105): A comparison between observed (red) and simulated (green) fractions of time with precipitation larger than a given threshold $[1-10-20 mm]$ at different aggregation periods (a). The same comparison for dry spell length distribution (b), i.e. consecutive days with precipitation depth lower than 1 $[mm]$ and for wet spell length distribution (c), i.e. consecutive days with precipitation depth larger than 1 $[mm]$. E_{obs} and σ_{obs} are the observed mean and standard deviation and E_{sim} and σ_{sim} are the simulated ones.

Figure(106): A comparison between the observed (red crosses) and simulated values of extreme precipitation (green crosses) at (a) 1-hour and (b) 24-hour aggregation periods; (c) extremes of dry and (d) wet spell durations. Dry/wet spell duration is the number of consecutive days with precipitation depth lower/larger than 1 $[mm]$.

Figure(108): The annual precipitation simulated with the *NSRP* model (red line) after the external selection based on the AR(1) precipitation series (magenta dots) has been carried out. The vertical bars denote the $\check{p}$ of the long-term average annual precipitation.

Figure(201): A comparison between the observed (cyan) and simulated (magenta) total cloud cover distribution, for every month. E_{obs} and σ_{obs} are the observed mean and standard deviation and E_{sim} and σ_{sim} are the simulated ones.

Figure(202): A comparison between the observed (cyan) and simulated (magenta) fair weather cloud cover distribution for every month. E_{obs} and σ_{obs} are the observed mean and standard deviation and E_{sim} and σ_{sim} are the simulated ones.

Figure(203): A comparison between observed (cyan) and simulated (magenta) total cloud cover distribution. E_{obs} and σ_{obs} are the observed mean and standard deviation and E_{sim} and σ_{sim} are the simulated ones.

Figure(301): A comparison between the observed (red) and simulated (green) average air temperature for every month, aggregation periods of 1 [*h*] (a) and 24 [*h*] (b). The vertical bars denote the standard deviations.

Figure(302): A comparison between the observed (red) and simulated (green) daily maximum (a) and minimum (b) air temperature for every month. The vertical bars denote the standard deviations.

Figure(304): A comparison between the observed (red) and simulated (green) air temperature distribution (a) and average daily cycle (b). The triangles are the standard deviations for every day hour, E_{obs} and σ_{obs} are the observed mean and standard deviation and E_{sim} and σ_{sim} are the simulated ones.

Figure(307): A comparison between the observed (red) and simulated (green) extremes of air temperature. a) Maxima of hourly temperature. b) Minima of hourly temperature. c) Maxima of daily temperature. d) Minima of daily temperature.

Figure(308): A comparison between the observed (red) and simulated (green) occurrence of heat (a) and cold (b) waves, i.e. consecutive days with temperature higher than the 90 percentile or lower than 10 percentile.

Figure(401): A comparison between the observed (red) and simulated (green) mean monthly shortwave radiation. a) Global radiation. b) Direct beam radiation. c) Diffuse radiation. The vertical bars denote the standard deviations of the monthly values.

Figure(404): A comparison between the observed (red) and simulated (blue) daily cycle of global (a), direct (b) and diffuse (c) shortwave radiation for all sky conditions.

Figure(406) A comparison between the observed (red) and simulated (green) annual cycle of global shortwave radiation for different local time hours. The global shortwave fluxes are expressed in $[W\,m^{-2}]$.

Figure(503): A comparison between the observed (red) and simulated (green) mean monthly relative humidity for aggregation periods of 1 hour (a) and 24 hours (b). The vertical bars denote the standard deviations of the monthly value.

Figure(504): A comparison between the observed (red) and simulated (green) mean monthly vapor pressure for 1 [h] (a) and 24 [h] (b) aggregation time periods. The vertical bars denote the standard deviations of the monthly values.

Figure(505): A comparison between the observed (red) and simulated (green) dew point temperature (a) and relative humidity (b) probability density functions. E_{obs} and σ_{obs} are the observed mean and standard deviation and E_{sim} and σ_{sim} are the simulated ones.

Figure(510): A comparison between the observed (red) and simulated (green) relative humidity daily cycle (a) and vapor pressure probability density function (b). The triangles in (a) represent the daily cycle of relative humidity standard deviation. E_{obs} and σ_{obs} are the observed mean and standard deviation and E_{sim} and σ_{sim} are the simulated ones.

Figure(601): A comparison between the observed (red) and simulated (green) wind speed probability density function (a) and daily cycle of wind speed (b). E_{obs} and σ_{obs} are the observed mean and standard deviation and E_{sim} and σ_{sim} are the simulated ones.

Figure(701): A comparison between the observed (red) and simulated (green) atmospheric pressure probability density function. E_{obs} and σ_{obs} are the observed mean and standard deviation and E_{sim} and σ_{sim} are the simulated ones.

Figure(802): A comparison between the observed (cyan) and simulated (black) monthly number of wet days (a) and cloud cover (b).

Figure (451): A comparison between the observed (red) and simulated (blue) daily cycle of global (a), direct (b) and diffuse (c) shortwave radiation for clear sky condition.