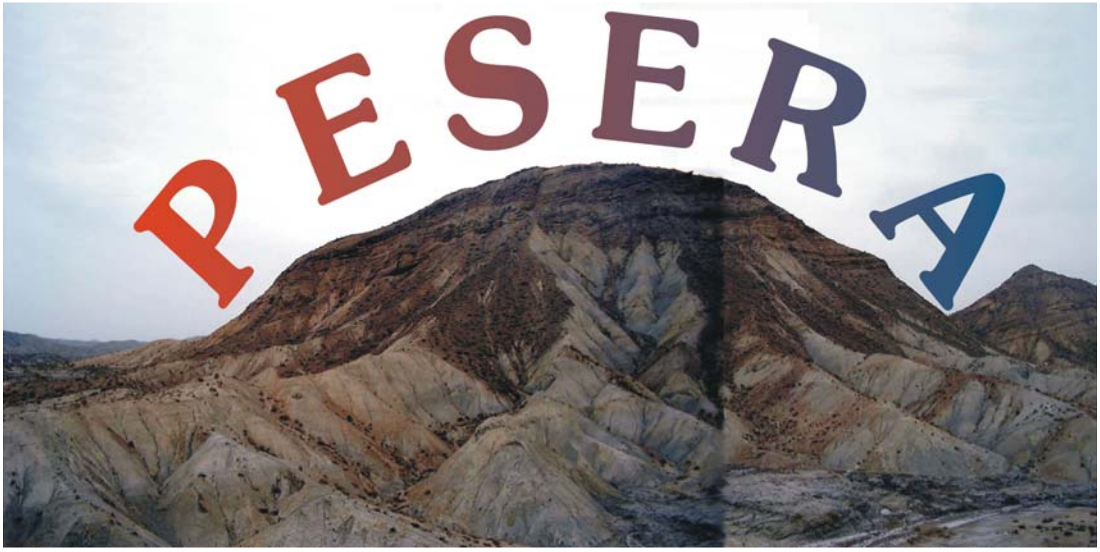

PAN-EUROPEAN SOIL EROSION RISK ASSESSMENT

Contract no. QLK5-CT-1999-01323

Key Action n° 1.1.1.-5.4.

DELIVERABLE 15: PESERA USER'S MANUAL

(1 APR '00 – 30 SEPT '03)

by Brian Irvine and Costas Cosmas

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CHAPTER 1 INTRODUCTION

The Pan-European Soil Erosion Risk Assessment model (PESERA) offers a methodology to assess regional soil erosion risk. The physical basis of the model, which distinguishes between soil erodibility and the hydraulic properties of soil, offers the potential to enhance land degradation predictions. Further, the model distinguishes between effects of land-use and climatic changes. As land-use and climate are explicit within the model, the sensitivity of changing environments can be explored.

The PESERA model expands from the concepts both of MEDALUS[1] and MODEM and offers an explicit theoretical response based on a simple and conservative erosion model, making use of land-use, topographic, soil and climatic data. Cell by cell hydrology and vegetation biomass are run to equilibrium. Runoff is estimated by integrating the incomplete gamma function which describes the distribution of daily rainfall. From the components, the model estimates water and sediment delivered to stream channels (Figure 1). The estimates are consistent with finer scale erosion models for flow strips, evaluated at the slope base; and are integrated across the frequency distribution of storm magnitudes. The model is based on a partition of daily precipitation into Hortonian and saturation overland flow, subsurface flow and evapo-transpiration. Hortonian overland flow, which is mainly responsible for soil erosion, is generated with respect to local soil and sub-surface moisture characteristics. Allowance is also made for snow accumulation and melting. The emphasis of the PESERA model is the prediction of hillslope erosion, and the delivery of erosion products to the base of each hillslope. Channel delivery processes and channel routing are explicitly not considered.

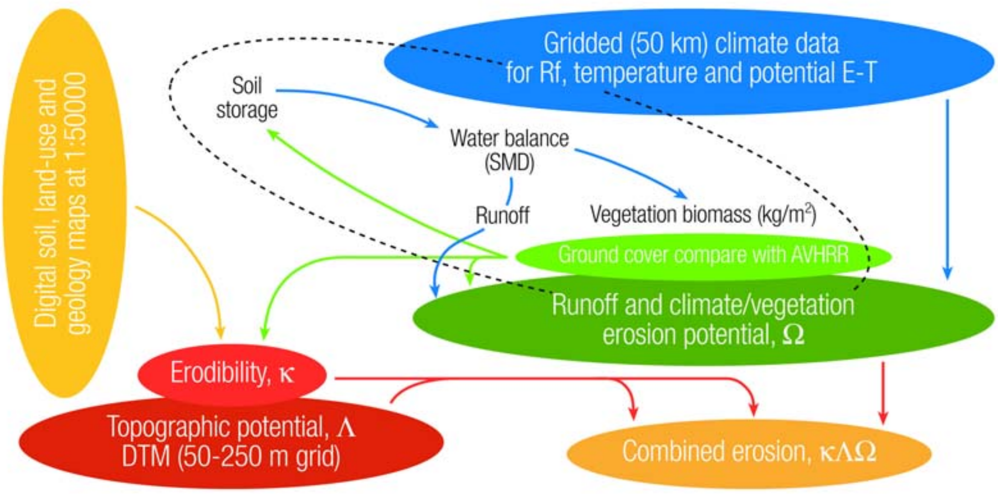

Figure 1: PESERA Model Schematic

This document describes the data requirements and execution of both versions of the model:

- PESERA_VBA (excel): point based code
- PESERA_GRID (Fortran90): grid based code

If the USER wishes to view and/ or critic PESERA_GRID predictions for soil erosion risk in Europe under current conditions then these predictions can be downloaded from the project website: http://pesera.jrc.it

Therefore, the USER need only prepare the data sets described if there is interested in:

- applying future climate data or land-use at the European scale or
- applying personal data to a local area

Alternatively, the USER may which to explore the regional effects of climate change on the web-interface: http://www.ccg.leeds.ac.uk/projects/pesera

The web-based interface aims to demonstrate the possibility of compiling European datasets which can be queried to run the PESERA_GRID erosion model at a regional scale and disseminate results. The provision/development of this facility allows the user to explore erosion risk with respect to climate at the regional level without licence constraint.

Current operating practicalities do not allow for land use scenarios to be considered in the web-interface, thus planting dates are applied based on a simplified look up table. Erosion estimates are presently derived from PESERA_GRID023 as such they are not directly comparable to the finalised erosion predictions. However, the interface demonstrates the possibility and value of future development.

All model output should be considered with reference to model validation documentation.

CHAPTER 2 PESERA_GRID

2.1. System Requirements

The code has been developed primarily in Fortran90 with Arc Micro Language (AML) modules to extract data and convert back to grid. The Fortran90 executables are compiled to run on PC. The following minimum hardware configurations are recommended:

- PENTIUM IV
- 1.6mHz
- 512 RAM
- 60GB Hard Drive Space (European Grid)

The following software has been used to extract data from grid to ascii and create output maps:

- ESRI ArcGIS (www.esri.com)

Model executables are currently distributed in PC format. The code will become available for compiling and use on UNIX.

2.2. Data Requirements (PESERA_GRID103)

This section assumes that the USER has an interest to compile the PESERA grids to apply land use or climate scenario and/or has access to local data. When preparing local data consideration should be given to:

- the projection and coordinates of data layers
- units, such that they are consistent with the description and
- the range of values in the data layers.

The datasets compiled to run PESERA_GRID at the European scale been resampled to 1km resolution utilising available data, providing INPUT model parameters for each grid cell. These European data layers have been derived from a number of sources as is described. Where local data is available at higher resolution this local data can be utilised at the users discretion The USER should be aware of the issues that surround the temporal and spatial quality of the European data sets and consider there applicability when applying the data at a regional scale as documented in the model validation. The USER should note that access restrictions apply to some of the European data sets and licences maybe required to access this data. USERS wishing to compile the European data are referred to the data source to determine licence requirements. Personal or local data may be compiled and applied in the manner described below. As data resolution is refined (< 100m grid resolution) assumptions applied in the development of the PESERA model may not hold.

A full set of 128 input data layers are required in arcGrid format to execute the model. DL17InputDatabase provides more details on how the grid input layers were created. The data layers required by the model are listed in Table 1.1. to Table 1.4. An Arc Macro Language (AML) module extracts local areas or complete areas to ascii format. The ascii files are combined into one data file on which the Pesera_GRID code operates. Final model output is written back to arcGRID format for visualisation Output grids of erosion estimates are considered the 'primary' output and are derived from ascii files as a series of monthly surfaces from which risk maps can be produced. Other significant outputs are the monthly runoff estimates and soil water deficits.

The majority of data grids are subject to licence agreement, details can be viewed on the project website. A comprehensive dictionary of the data grids can be viewed at (DL17: Databases on model input parameters): http://pesera.jrc.it

The 128 data layers required to run the model are summarised in the four tables set out below:

- Table 1.1: Climate data
- Table 1.2: Land-use, crops and planting dates
- Table 1.3: Soil data
- Table 1.4: Topography

Table 1.1 Monthly Climate Data (96 data layers)

Model Parameter	**Range of values**	**Units**	**Source**	**Description/Source**
meanrf130_	0-300	mm	***MARS***[2]	Mean monthly rainfall
meanrf2_	0-50	mm	***MARS***	Mean monthly rainfall per rain day
cvrf2_	1-10	-	***MARS***	Coefficienrt of variation of monthly rainfall per rain day.
mtmean_	-32.4 – 37.3	°C	***MARS***	Mean monthly temperature Corrected for altitude
mtrange_	2.4 – 18.4	°C	***MARS***	Monthly temperature range (max – min)
meanpet30_	0-300	mm	***MARS***	Mean monthly PET
newtemp_	-	°C	***HADLEY***[3]	Predicted future temperature (scenario lead)
newrf130_	-	mm	***HADLEY***	Predicted future rainfall (scenario lead)

Legal access constraints apply

Climate Data:
Description: virtual meteorological stations (cell centers) at 50 x 50 Km spacing.
Source: MARS 50 x 50 Km for 25 years of daily meteo parameters database - Space Application Institute - Joint Research Centre - Ispra (Italy)

Hadley Data:
Description: virtual meteorological stations (cell centers) at 50 x 50 Km spacing.
Source: www.cru.uea.ac.uk/link/HadRM3/HadRM3_home.html
If no climate scenarios are to be considered then a series of 'dummy' grids for newtemp_(12no') and newrf130_(12no') are required when compiling the data layers.

Table 1.2. Land-use, Crops and Planting dates (25 data layers)

Model Parameter	Range of values	Units	Source	Description/Source
use	-	-	***CORINE***[4]	Land cover type/management option
eu12crop1	-	-	***CORINE/FSS***	Dominant Arable Crop
maize_210c	-	-	***CORINE***	Maize Crop
eu12crop2	-	-	***CORINE/FSS***	2nd Dominant Arable Crop
itill_crop1	1-12	-	***FSS/PDD***	Planting month: Dominant Arable Crop
itill_maize	1-12	-	***FSS/PDD***	Planting month: maize
itill_crop2	1-12	-	***FSS/PDD***	Planting month: 2nd Dominant Arable Crop
mitill_1	0/1	-	***FSS/PDD***	Planting marker: Dominant Arable Crop
mitill_m	0/1	-	***FSS/PDD***	Planting marker: maize
mitill_2	0/1	-	***FSS/PDD***	Planting marker: 2nd Dominant Arable Crop
cov_	0-100	%	***CORINE***	Initial ground cover Cover is updated for arable crops with reference to planting date
rough0	0,5,10	mm	***CORINE***	Initial surface storage
rough_red	0,50	%	***CORINE***	Surface roughness reduction per month
rootdepth	10-1000	mm	***CORINE***	Rootdepth

Legal access constraints apply

FSS: *Farm Structure Survey (EuroStat);* PDD: Planting dates database (expanded and modified from Van Orshoven et al., 1999)

Grid USE:
Description: land cover classes.
Source: CORINE Land Cover, 250 m raster, MARS database, SAI/JRC Ispra.
Re-class CORINE land cover classification according to following table:

100 = Artificial land
210 = Arable land
221 = Vineyards
222 = Fruit trees and berry plantations
223 = Olive groves
231 = Pastures and grassland
240 = Heterogeneous agricultural land
310 = Forest
320 = Scrub
330 = Bare land
334 = Degraded natural land
400 = Water surfaces and wetland

Grid EU12CROP1:
Description: Dominant Arable Crop
1 = cereal (spring cereal)
2 = cereal (winter cereal)
3 = cereal (spring cereal)
4 = cereal (winter cereal)
6 = Maize
10 = Rootcrop
13 = Oilseed
18 = Forage
21 = Fallow

Grid MAIZE_210c
Description: arable land use (210) from CORINE, considered as the extent of maize cover for worst case scenario.

Grid EU12CROP2
Description: 2nd Dominant Arable Crop
1 = cereal (spring cereal)
2 = cereal (winter cereal)
3 = cereal (winter cereal)
4 = cereal (winter cereal)
5 = cereal (spring cereal)
6 = Maize
8 = cereal (spring cereal)
9 = Pulses
10 = Rootcrop
11 = Rootcrop
13 = Oilseed
14 = Vegetables/Flowers
18 = Forage
21 = Fallow

Grid ITILL_CROP1, ITILL_MAIZE, ITILL_CROP2
Description: tillage dates for crops under land use scenarios (1-3)

```
Grid MITILL_1, MITILL_M, MITILL_2
Description:  enhances planting date resolution if planting date falls
in the middle of month.  '0' if not applicable

Grid COV_
Description: % monthly canopy cover for individual land use codes and
annual arable crops
Source: cover model for Arable (see DL5: Modelling Strategy), expert
based for other land cover types.
```

Land Cover Type	Code	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Urban, Wetlands Wetlands	**100** **400**	100	100	100	100	100	100	100	100	100	100	100	100
Arable	**210**	Refer to crop groups: Table											
Vineyards	**221**	10	10	10	20	25	30	30	30	30	20	15	15
Fruit trees and berry plantations	**222**	10	10	10	20	25	30	30	30	30	20	15	15
Olive groves	**223**	10	10	10	20	25	30	30	30	30	20	15	15
Pastures and grassland	**231**	100	100	100	100	100	100	100	100	100	100	100	100
Heterogeneous agricultural land	**240**	50	50	50	60	70	80	90	90	60	50	45	45
Forest	**310**	100	100	100	100	100	100	100	100	100	100	100	100
Bare ground	**330**	0	0	0	0	0	0	0	0	0	0	0	0
Scrub Natural Degraded	**320** **334**	Natural vegetation allowed to grow: cover restricted to 30%											

CropGroup	**Month1**	**Month2**	**Month3**	**Month4**	**Month5**	**Month6**	**Month7**	**Month8**	**Month9**	**Month10**
Maize	17	61	94	94	43					
SpringCereal	9	46	88	94	37					
WinterCereal	8	27	47	67	78	87	96	98	86	32
Pulses	19	66	98	72						
RootCrops	11	68	99	94	86	36				
Oilseeds	13	68	95	94	45					
Veg&Flowers	18	64	98	91	45					
Forage	10	67	69	72	77	81	70	54		

Natural vegetation allowed growing in the inter-crop period

Water Use Efficiency

The ratio between actual and potential evapotranspiration is called the water use efficiency in the PESERA model. The wue-curve applied explicitly within the model is given below. Details are provided in DL5 (modelling strategy).

Crop	Month1	Month2	Month3	Month4	Month5	Month6	Month7	Month8	Month9	Month10
Maize	0.34	0.65	0.99	0.91	0.58					
SpringCereal	0.28	0.57	0.93	0.83	0.55					
WinterCereal	0.28	0.47	0.68	0.88	0.96	1.00	1.04	0.98	0.49	0.24
Pulses	0.44	0.73	1.04	0.76						
RootCrops	0.45	0.78	1.04	0.98	0.88	0.80				
Oilseeds	0.32	0.74	1.01	0.84	0.36					

Veg&Flowers	0.45	0.75	1.08	0.97	0.8			
Forage	0.39	0.84	0.79	0.82	0.87	0.91	0.80	0.65

Note: dormancy period necessary for winter cereal

Grid ROUGHO
Description: initial surface storage, defined for individual land cover

Grid ROUGH_RED
Description: surface roughness reduction per month, defined for individual land use

Grid ROOTDEPTH
Description: water available to ae per month, defined for individual land use

Land Cover Type	Code	Initial Roughness Storage (ROUGH0)	% Reduction after 1 month (ROUGH_RED)	Rooting depth (mm) (ROOTDEPTH)
Arable	**210**	10	50	200
Urban, Wetlands	**100/400**	0	0	10
Vineyards,	**221**	5	0	500
Fruit trees and berry plantations	**222**	5	0	500
Olive groves	**223**	5	0	500
Pastures and grassland	**231**	5	0	300
Heterogeneous agricultural land	**240**	5	0	300
Forest	**310**	5	0	1000
Scrub	**320**	5	0	600
Zero (Bare ground)	**330**	5	0	10
Natural Degraded	**334**	5	0	300

Table 1.3 . Soil Parameters (6 data layers)

Model Parameter	**Range of values**	**Units**	**Source**	**Description/Source**
crusting	1-5	mm	***SOIL DB***	Crust storage
erodibility	1-5	mm	***SOIL DB***	Sensitivity to erosion
swsc_eff_2	0-205	mm	***SOIL DB***	Effective soil water storage capacity
p1xswap1	0-90	mm	***SOIL DB***	Soil water available to plants in top 300mm
p2xswap2	0-154	mm	***SOIL DB***	Soil water available to plants : (300mm and 1000mm depth)
zm	5,10,15,20,30	mm	***SOIL DB***	Scale depth (TOPMODEL): f(texture)

Legal access constraints apply

```
Grid CRUSTING
Description: soil sensitivity to surface crusting.
Source: Soil Geographical Database of Eurasia at scale 1:1,000,000
version
   4.0 beta, European Soil Bureau, SAI/JRC Ispra[5].
   Derived from Pedotransfer Rules

Grid ERODIBILITY
Description: soil sensitivity to erodibility index.
Source: Soil Geographical Database of Eurasia at scale 1:1,000,000
version
   4.0 beta, European Soil Bureau, SAI/JRC Ispra.
   Derived from Pedotransfer Rules

Grid SWSC_EFF_2
Description:  Effective soil water storage capacity

swsc_eff_2 = (p1swap_top)(swap_top)  + 0.5 (po_tot_mmr)


Grid P1xSWAP1
Description:  Soil water available to plants in top 300mm.

p1xSWAP1 = (p1swap_top)(swap_top)

Grid p2xSWAP2
Description:  Soil water available to plants (300mm and 1000mm depth)


p2xswap2 = (p2swap_sub)(swap_sub_r)

Grid PO_TOT_MMR:
Description: drainable pore space in the top- and subsoil (0 - 100
cm) in mm
   including restriction of soil depth by depth to rock (Dr).
Source: Soil Geographical Database of Eurasia at scale 1:1,000,000
```

version
4.0 beta, European Soil Bureau, SAI/JRC Ispra.
Derived from Pedotransfer Rules.

Grid P1SWAP_TOP:
Description: proportion of the SWAP available for storing precipitation in
the topsoil (0 - 30 cm).
Source: Soil Geographical Database of Eurasia at scale 1:1,000,000 version
4.0 beta, European Soil Bureau, SAI/JRC Ispra.
Derived from Pedotransfer Rules.

Grid SWAP_TOP:
Description: Soil Water Available to Plants in the topsoil (0 - 30 cm) in mm.
Source: Soil Geographical Database of Eurasia at scale 1:1,000,000 version
4.0 beta, European Soil Bureau, SAI/JRC Ispra.
Derived from Pedotransfer Rules.

Grid P2SWAP_SUB:
Description: proportion of the SWAP available for storing precipitation in
the subsoil (30 - 100 cm).
Source: Soil Geographical Database of Eurasia at scale 1:1,000,000 version
4.0 beta, European Soil Bureau, SAI/JRC Ispra.
Derived from Pedotransfer Rules.

Grid SWAP_SUB_R:
Description: Soil Water Available to Plants in the subsoil (30 - 100 cm) in mm
including restriction of soil depth by depth to rock (Dr).
Source: Soil Geographical Database of Eurasia at scale 1:1,000,000 version
4.0 beta, European Soil Bureau, SAI/JRC Ispra.
Derived from Pedotransfer Rules.

Grid ZM
Description: Scale depth (TOPMODEL) derived from soil texture

Soil Texture		**zm (mm)**
Coarse	**C**	30
Fine	**F**	10
Medium	**M**	20
Medium Fine	**MF**	15
Organic Soils	**O**	10
Very Fine	**VF**	5

Grid TEXT:
Description: Soil Texture
Source: Soil Geographical Database of Eurasia at scale 1:1,000,000 version
4.0 beta, European Soil Bureau, SAI/JRC Ispra.

```
0    No information
9    No mineral texture (Peat soils)
1    Coarse (18% < clay and > 65% sand)
2    Medium (18% < clay < 35% and >= 15% sand,
     or 18% <clay and 15% < sand < 65%)
3    Medium fine (< 35% clay and < 15% sand)
4    Fine (35% < clay < 60%)
5    Very fine (clay > 60 %)
```

Table 1.4 Topographic data (1 data layer)

Model Parameter	**Range of values**	**Units**	**Source**	**Description/Source**
std_eudem2	-	m	***GTOPO30[6] / 250m DEM***	Standard deviation of elevation for all points within 1.5 km radius

Legal access constraints apply

```
Grid ALT:
Description: altitude (in meters).
Source: GTOPO30 30 arc seconds DEM (~1 Km), USGS HYDRO1K database,
   except France: 250 m DEM, Institut Géographique National,
   and Italy: 250 m DEM, source ???.

Grid STD_EUDEM2:
Description: 3x3 Km window relief index (in meters).
Source: computed from ALT.
```

The slope term in the sediment transport law equation of the model tends to H , relief, as the distance and gradient exponents are set at 2 and 1 respectively.

2.3. Scenario Analysis

Land use scenarios

The following three land use scenarios were suggested during the project as potential land use scenarios across Europe remain poorly defined:

1. Dominant Arable Crop (grid EU12CROP1: actual PESERA runs)
   Spatialised FSS layer (Dominant)
   Planting Dates Database

2. Worst case scenario: Maize (grid MAIZE_210c)
   CLC Arable assigned as only Maize
   Planting Dates for Maize

3. Scenarios of Changing Land Use: (grid EU12CROP2)
   Spatialised FSS layer (2^{nd} Dominant Arable Crop)
   Planting Dates Database

These land use layers may not reflect actual land use changes but will clearly demonstrate the effects of arable land use changes that may take place because of policy implementation. The necessary data layers have been distributed to the partners concerned and are to be combined with climate change scenarios.

Climate scenarios

Future climate prediction based on a range of scenarios can be accessed from the Hadley Centre via the Climatic Research Unit, University of East Anglia, UK:

www.cru.uea.ac.uk/link/HadRM3/HadRM3_home.html

Predictions of monthly mean temperature and rainfall are readily available. However, other climate parameters which drive the model are less readily available. Namely rain per rain day and the coefficient of rain per rain day. Estimates of these predictions remain with the user to explore.

2.4. Running the Model

The PESERA_GRID model reads data from ArcGRID files. To allow this, zipped ArcGRID input files should be extracted to or copied to the specified workspace (d:\meteo_grids)(128 grids). The required grids are summarised in Table 2.0. The executable files provided in release103.zip should be extracted to a new workspace (d:\temp_ascii). Once the grids and code are extracted there are 5 stages in operating the PESERA_GRID program.

Stage	Model code
GRID to ascii	**xgridascii103.aml**
PREPROCESSING	**ftn_input103.exe, ftn_combined_103.exe**
MODEL EXECUTION	**pesera_grid103.exe**
POST-PROCESSING	**to_grid_103.exe**
ascii to GRID.	**Xasciigrid103.aml**

When operating on large grids, large volumes of data are generated. (Allow 60GB to run the European grid)

The execution of each stage listed above is discussed below:

Extraction of GRID data and code.
Create a new workspace d:\meteo_grids and extract or copy the required grids (128no’) (Table 1)

Create a further workspace d:\temp_ascii and extract release103.zip to d:\temp_ascii.

Ensure salflibc.dll (from release103.zip) and 6 executables from ‘release103.zip’ are available at d:\temp_ascii

STAGE 1: GRID to ascii (AML)
The aml file xgridascii103.aml can be edited to extracted localised areas. Current default is to Europe.
This file extracts grid data to ascii. The extracted data is reformatted in the preprocessing stage.

To run xgridascii103.aml

open arc GRID, set workspace as d:\meteo_grids

ArcGIS > ArcInfo Workstations > Grid

At the GRID: prompt set workspace

GRID: arc w d:\meteo_grids

Run xgridascii103.aml

GRID: &run d:\temp_ascii\xgridascii103.aml

Ascii files will be extracted to d:\temp_ascii

STAGE 2: GRID DATA INPUT & PREPROCESSING
Grid data is written to ftn_input.dat. This file eliminates repetitive data entry. The file is generated by executing ftn_input103.exe. The following information is requested:

Variable requested	**Description**
Nrows	Number of rows in the analysis window
Ncols	Number of columns in the analysis window
Rfintrise	Predicted change in rainfall intensity
Cellsize	Grid resolution (m)
Xll	Lower left x-ordinate
Yll	Lower left y-ordinate
lu_scenario	Maize, eu12crop1 or eu12crop2 Enter '1','2' or '3' respectively.
Climatescenario	Future climate data is know required, to operate on this data enter '1'.

Changes in rainfall intensity can be entered as a percentage of the present rain per rain day, enter '0' for rfintrise if no scenario is being considered. (trise and rfrise are now read from GRID data)

Grid data (nrows, ncols,cellsize,xll,yll) can be verified from the header files of the extracted ascii files. Grids can be opened in excell or wordpad.
.
(Europe: 'nrows' = 2724 and 'ncols' = 3199)
(Currently 'nrow' max is 4000 and 'ncol' max is 3200)
(Europe: 'xll' = -1594713.25 and 'yll' = -1312168.125; 'cellsize' = 1000)

To run ftn_input103.exe

Double click on ftn_input103.exe. (Enter data requested, 'nrows', 'ncols', 'rfintrise', 'cellsize', 'xll', 'yll', 'lu_scenario' and 'climatescenario' . A file ftn_input.dat is generated.

The ascii data extracted from the 128no' grids is reformatted and combined to the file grid_data.dat when ftn_combined103.exe is executed.

To run ftn_combined_103.exe

Double click on ftn_combined_103.exe. (reformats data)
No data is requested,

(compiles data into grid_data.dat +**16GB**) **Do not delete 2use.dat nor 2swsc.dat, these files are used.** Program runs from 1 to 128 then 1 to ('nrows' x 'ncols')

STAGE 3: PESERA_GRID
This is the main model. To run a_pesera_grid103.exe

Double click pesera_grid103.exe. No data requested.
Program runs from 1 to ('nrows' x 'ncols')

STAGE 4: POST-PROCESSING
This procedure reassigns header and structure

Double click to_grid_103.exe. No data requested.
Program runs from 1 to ('nrows') then 1 to 12.

STAGE 5: OUTPUT GRIDS
Output ascii files are converted back to GRID

open arc GRID, set workspace as d:\temp_ascii

GRID: arc w d:\temp_ascii

Run xasciigrid103.aml

GRID: &run xasciigrid103.aml
sedi_jan to sedi_dec (12no) + (sedi_tot) can be viewed in ArcMap.
deficit_%m% (12no) and runoff_%m% (12no)

Ensure projection files are re-defined.

Table 2. Data GRIDS required

Annual data files (9 x 12 = 108 no')

Monthly data GRIDS (annual data derived from monthly data)	**Source**
cvrf21 to cvrf212	INRA data
meanpet301 to meanpet3012*	INRA data(x no' days in month)
Meanrf1301 to meanrf13012*	INRA data (x no' days in month)
Meanrf21 to meanrf212	INRA data
mtmean1 to mtmean12	INRA data
mtrange1 to mtrange12	INRA data
cov_jan to cov_dec	Land cover
Future temperature (jan-dec) (newtemp1 to newtemp12)	Hadley
Future monthly rainfall (jan-dec) (newrf1301 to newrf13012)	Hadley

Stationary data files (20 no')

data GRIDS	**Source**
crusting	INRA data
erodibility	INRA data
rootdepth (updated since release073)	Land cover
rough0	Land cover
rough_red	Land cover
swsc_eff_2	INRA/JRC
std_eudem2	INRA data
use	INRA data
zm	Texture
itill_maizei	Planting month
itill_crop1	Planting month
till_crop2	Planting month
mitill_m	Planting month
mitill_1	Planting month
mitill_2	Planting month
maize_210c	Crop
eu12crop1	Crop type
eu12crop2	Crop type
p1xswap1	SWAP
p2xswap2	SWAP

If no climate scenarios are to be considered then a series of 'dummy' grids for newtemp_(12no') and newrf130_(12no') are required when compiling the data layers.

The above data is for the current model, additional parameters maybe added.

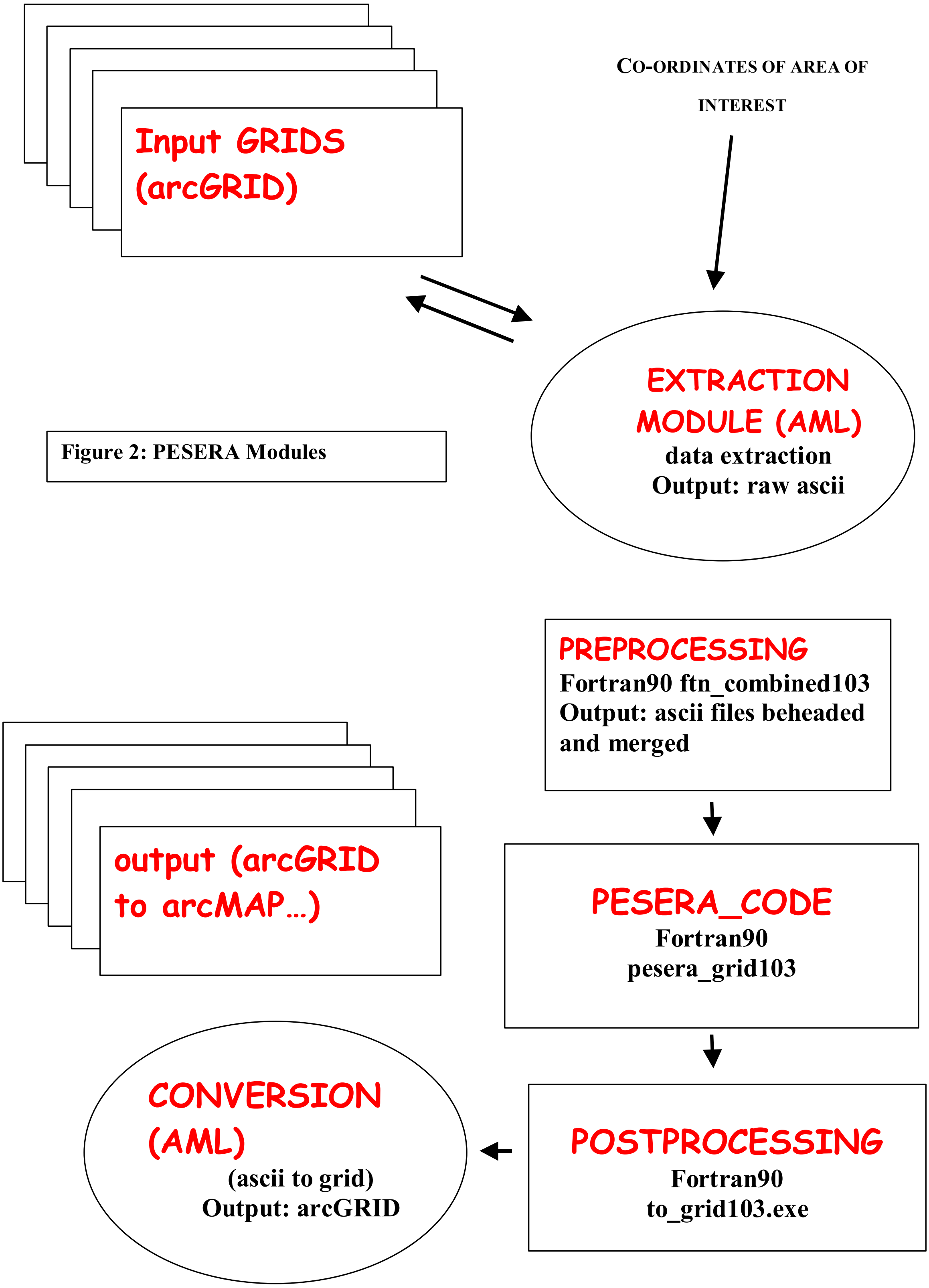

Figure 2: PESERA Modules

2.5. Output Grids

The principle product of the PESERA_GRID model is prediction of monthly and annual soil erosion risk described in tonnes per hectare per year. However, a number of significant output parameters may be of to the end-user. Current listed output is given in Table 3.0.

Table 3. PESERA_GRID output

Output Parameter	**Units**	**Sub-Routine**	**Description**
sedi_out	tonnes/ha	***erosion***	erosion
runoff	mm	***veggrowth***	runoff
deficit	mm	***veggrowth***	soil water deficit
xint	%	***veggrowth***	percentage interception
veg	(kg/m^2)	***veggrowth***	vegetation
hum	(kg/m^2)	***veggrowth***	hummus biomass

CHAPTER 3 PESERA_VBA(EXCEL) MODEL

The model runs from an Excel Spreadsheet. Most of the model computations are carried out by Visual Basic macro commands. If the macro-commands are activated, then the model is calculating the soil erosion for the study transect. The model speadsheet includes the following worksheets and charts:

- main
- erosion (chart)
- water (chart)
- vegetation (chart)
- cover table
- file data
- profile calculations

Worksheet 'main' is an interface to introduce the required data for running the model and view the output of data generated by the model. Predicted soil erosion, water balance, and vegetation characteristics generated by the model are presented in charts 'erosion', 'water', and 'vegetation', respectively. The worksheet 'cover table' includes data that the user can edit or apply as they are. This chart includes data on plant cover, soil roughness, rooting depth, soil erodibility, soil crusting, soil storage capacity, and hydraulic scale depth. The worksheet 'climate data' is used for creating a data base for various study sites. The chart 'profile calculations' includes data on slope profile characteristics determination adapted from hillslope hydrology.

To enter new data in the model worksheet, 'main', the user has to check/modify the values marked in the red boxes (Table 4). The information marked in blue font has already been set and should not be altered. Comments are included in many cells of the spreadsheet. These comments assist the user as they provide useful advice about the units of the parameters for the computations, appropriate values to enter, and how the model works. In certain cases it is pointed out in red font to ignore cell below as they are relevant only in specific cases such as an uncultivated natural vegetation or dry farmed cereal as well as others. Also parameters used by the model can be altered in the worksheet 'cover table'.

Table 4. Part of the model worksheet showing blocks in which data are introduced.

Select Land cover type	Enter Primary Cover		Enter Secondary Cover (or N)	
Chosen Land Cover >>>	W		N	50%
Uncultivated (Natural Veg'n)	X			
Cereal - Dry Farmed	C	3	9	
N. Hemisphere Arable		Runoff >Threshold	50	%
Winter Sown	W	Erodibility Class	High	10
Spring Sown	S	Erodibility for Vegetation		0.5
Both (in 1 year)	B	Crusting Class	High	2
Permanent Pasture	P	Root Depth (mm)	200	
Vineyards, Tree crops etc	V	Soil Storage (mm)	60	mm
Forest (Closed Canopy)	F	Roughness store	10	50

3.1. Input Model Parameters

When the PESERA model used, a message appears in the screen prompting the user to activate or deactivate the macro commands (Figure. 3). A third option appears which provides the used with more information about the model.

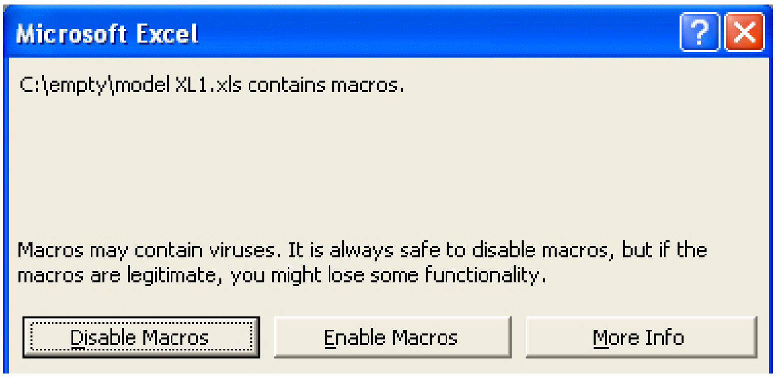

Figure 3. The starting point appearing in the screen for running the PESERA model.

The input data required by the model are introduced in the 'main' worksheet. Specifically the following data are required:

- Soil textural class
- Land cover type
- Percentage of runoff after storage threshold has exceeded (p)
- Slope profile type
- Slope relief (H)
- Slope length (L)
- % convexity
- Sediment transport law exponents (n, and m)

- Monthly rainfall (R)
- Mean rainfall per rain-day in the month (ro)
- Coefficient of variation (CV) for rainfall for all rain days in the month
- Monthly potential evapotranspiration (ETo)

Soil textural class corresponds to the texture of the surface horizon. Thickness of the surface horizon depends on soil, vegetation and management characteristics. The textural class of the surface horizon determines the following parameters used by the model: (a) soil erodibility (k), (b) crusting class, and (c) soil storage capacity in connection with soil depth. Soil textural class of the surface horizon is provided by regular survey reports. The user can select one of the soil textural classes included in Table 5.

Table 5. Soil textural class of the surface horizon used by the model.

Soil texture type	**Code**
Coarse	C
Fine	F
Medium	M
Medium Fine	MF
Organic Soils	O
Very Fine	VF

The values of the parameters soil erodibility, crusting class, and soil storage capacity related to textural class are listed in the worksheet 'cover table' (Table 6). The values can be edited if such data are available.

Table 6. Values for the parameters soil erodibility, crusting and soil storage capacity in relation to soil textural class of the surface horizon.

Soil Type		Erodibility Class	Value	Crusting Class	Value	Soil Storage (mm)	m (mm)
Coarse	C	High	6.52	Moderate	8.29	109	30
Fine	F	Low	0.85	Low	21.16	48	10
Medium	M	High	6.52	High	4.26	60	20
Medium Fine	MF	Moderate	2.80	High	4.26	24	15
Organic Soils	O	Nil	0.11	Nil	105.07	58	10
Very Fine	VF	Low	0.85	Low	21.16	47	5

Land cover type is related to the type of vegetation or type of land use which determines the percentage plant cover during a certain period, as well as initial roughness water storage and change with time, and plant root depth. The user can select in the excel worksheet one of the types of land use given in Table 7.

Table 7. Classification of the various types of land use with the corresponding codes used by the model.

Land cover type	Code
Uncultivated (Natural Vegetation)	**X**
Cereal - Dry Farmed	**C**
Mediteranean Autumn Sown Arable	**A**
Winter Sown	**W**
Spring Sown	**S**
BOTH (IN 1 YEAR)	**B**
Permanent Pasture	**P**
Vineyards, Tree crops etc.	**V**
Forest (Closed Canopy)	**F**
Heterogeneous (Tree crops, Pasture and Arable)	**H**
Natural Degraded	**D**
Rock, urban, wetlands etc	**R**
Zero (Bare Unvegetated)	**Z**

The initial soil surface roughness and therefore the initial surface runoff water storage is estimated by the model for each type of land use (Table 8). Also the changes of soil roughness with time is assessed by the model. Also rooting depth is related to the type of land use and therefore it is estimated by the model. Of course if such data are available, then the corresponding values can be introduced in the 'cover table'.

Table 8. Soil surface roughness storage and rooting depth corresponding to the various types of land use used by the model.

Code	Land Cover Type	Initial Roughness Storage (mm)	% Reduction after 1 month (mm)	Rooting depth (mm)
B	Both (in 1 year) Arable	10	50	200
C	Cereal- Dry Farmed	10	50	200
D	Natural Degraded	5	0	300
F	Forest (Closed canopy)	5	0	1000
H	Heterogeneous (Tree crops, Pasture and Arable)	5	0	300
P	Permanent Pasture	5	0	300
R	Rock, Urban, Wetlands etc	0	0	10
S	Spring Sown Arable	10	50	200
V	Vineyards, Tree crops etc	5	0	500

A	Autumn sown Mediterranean arable	10	50	200
W	Winter Sown Arable	10	50	200
X	Uncultivated (Natural Vegetation)	5	0	600
Z	Zero (Bare ground)	5	0	10

Percentage of runoff after storage threshold has exceeded (p) is related to the soil texture, soil depth, soil structure, hydraulic conductivity etc. This is a value estimating the percentage of excess water that will flow on the soil surface as runoff water. After soil storage capacity of the soil surface horizon has been exceeded, some of the rain water will flow through the soil macropores to the deeper soil layers and the rest will be temporally ponded on the soil surface and then surface runoff will be initiated. The percentage (p) of this runoff water is estimated and included in the worksheet of the model. Common range of this parameter is 0.3-0.85.

Topography is included in the model with the following parameters: (a) slope profile type, (b) slope relief (H), (c) slope length (L), and % convexity. Slope profile is related to the uniformity of the slope gradient. If the transect along which the model is applied has a uniform slope than the code U is used in the worksheet and then values for relief and slope length are given for the whole transect (Table 9). In the case that slope gradient changes along the study transect then the code F is used. For a full profile the user has to enter values for 10 equally spaced points constrained by total length and relief entered in the corresponding cells. In the case that a rough estimation of the slope gradient along the transect is used then the code S is added in the worksheet (Table 9).

Table 9. Slope profile type characteristics with the corresponding codes used by the model.

Profile type	**Code**
Full profile	F
Uniform profile	U
Summary profile	S

Slope relief and length are entered in meters (m) by the user (Table 10, red color). After defining the type of slope profile and assigned the values for relief and slope length, the model is calculating the mean slope gradient for the whole transect (blue color) and these values should not be altered in the excel file by the model user. An example for uniform and full slope profile is given in Table 10.

Table 10. Slope profile characteristics added by the user (red color) and calculated by the model (blue color).

Slope Profile	
Type	**U**
Relief (m)	**10**
Slope Length (m)	**100**
% Convexity	**0**

Slope Profile		**Dist (m)**	**Elev (m)**
Type	**F**	**0**	**10**
Relief (m)	**10**	**10**	
Slope	**100**	**20**	

Mean gradient	**10%**
Slope-base gradient	**10%**

Length (m)			
Ignore	**1**	**30**	
Mean gradient	**10%**	**40**	
Slope-base gradient	**0%**	**50**	
		60	
		70	
		80	
		90	
		100	**0**

Another important characteristic of the slope profile is the percentage of the slope which is convex or concave or linear. For the summary profile enter a value less than 100% for the % of slope length that is concave or convex. For uniform profile one can enter a value between +100% up to –100%, for zero slope at divide and for zero slope at base respectively. After introducing all the required data for slope profile, the model is generating the slope profile (Figure 4). The user has the ability to adjust the form of the slope profile by changing the input data for topography.

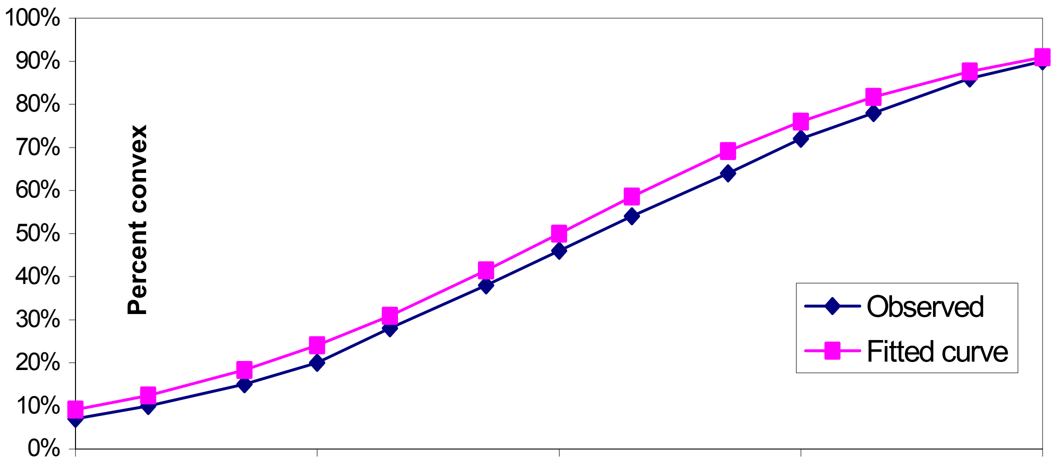

Figure 4. Example of observed and predicted by the model slope profile.

<u>The transport law exponents ‘m’ and ‘n’</u> used in the sediment transport equation are related to the climate and topography, respectively. The suggested values range from 1.5 to 3 and 1 to 3 for ‘m’ and ‘n’, respectively. The model user adds the values for the exponents ‘m’ and ‘n’ in the excel worksheet (Table 11). These exponents are calibrated using existing soil erosion data. If soil erosion data are not available then the values 2 and 1 can be introduced in the model for ‘m and ‘n’, respectively.

Table 11. Transport law exponents used in the sediment transport law equation of the model.

	Transport law exponents
Distance (m)	**2**
Gradient (n)	**1**

Climate characteristics used by the model are: mean monthly rainfall (R), mean rainfall per rain-day in the month (ro), coefficient of variation (CV) for rainfall for all rain days in the month, and monthly potential evapotranspiration (Pot E-T). Monthly rainfall is entered in mm in the worksheet (Table 12). The mean rainfall per day in each month is calculated by dividing the monthly rainfall by the number of rain-days and introduced in the worksheet for each month (Table 12). The user enters the coefficient of variation (CV of r0) for rainfall calculated for all rain days in the month. It is calculated by the equation CV = SD / mean, where SD is the standard deviation of daily rainfall in the month and mean is the mean daily rainfall in the month. These values are usually greater than 1.0 often varying between 1.2-1.8. The potential evapotranspiration rate (Pot E-T) is calculated by using existing meteorological data (daily data are preferable) and applying existing methods (e.g. Penman equation). The actual evapotranspiration (E-T) and the percent plant cover are calculated by the macro script 'Growveg'. Values can be also introduced in the reference table.

Table 12. Typical climate input data used by the model

MONTH	**Rainfall (mm)**	**r0= Mean Rain/Rain-Day**	**CV of r0 (SD/Mean)**	**Pot E-T**
January	70	5	1,27	20
February	50	5	1,27	30
March	60	5	1,27	50
April	50	5	1,27	70
May	60	6	1,27	85
June	60	7	1,27	100
July	60	7	1,27	120
August	50	8	1,27	130
September	75	6	1,27	100
October	95	5	1,27	70
November	100	5	1,27	40
December	90	5	1,27	30
ANNUAL	Total=820			**Total=845**

3.2. Model Output

After introducing the necessary parameters in the worksheet of the model, the model is running by pressing <control> and <g> to activate the macrocommands. If the model has finalized all the computation then in the screen appears the following message presented on Figure 5 stating also the number of years needed to reach equilibrium pops on screen. In order to view the final results the user must press OK. If the user desires to close the program, then the option ‘save as’ must be chosen. otherwise the output data will be overwritten to previous data and file.

Figure 5. Message appeared in the screen when the model has finalized all the computations.

If the input data were not introduced in the appropriate way, then the error message of Figure 6 appears in the screen. In such a case data for rainfall (R), mean rain per rain day (ro), or coefficient of variation (CV) are set to zero. For the model to run all computations a value 1 must be entered in the appropriate block.

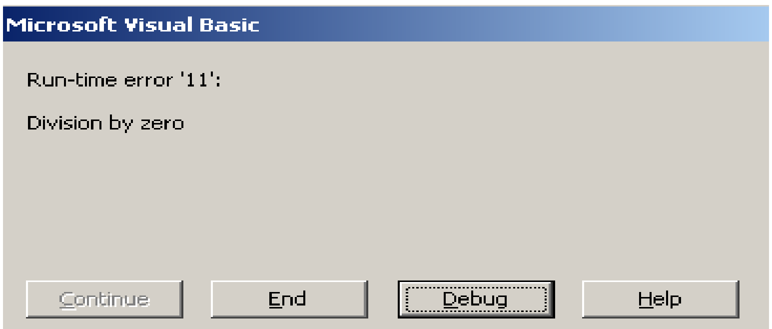

Figure 6. Error message appeared in the screen if no appropriate input values are introduced in the model.

If the macro-commands are activated, then the model is calculating the soil erosion for the study transect. The output data can be found in the worksheet: ‘main’ and charts ‘erosion’, ‘water’ and ‘vegetation. Specifically the user can find in the output of the model the following series of data on a monthly base:

- Actual evapotranspiration rate (mm)
- Plant cover (%)
- Water runoff (mm)
- Soil erosion rate (t/ha/month and t/ha/y)
- Soil erosion rate distribution along the slope profile (t/ha)
- Total water surface storage (mm)
- Vegetation biomass (kg/m^2)
- Humus biomass (kg/m^2)
- Rain interception (%)
- Climate senario and erosion rates

Actual evapotranspiration rate and plant cover change, on a monthly basis, are given in worksheet ‘main’ and chart ‘water’ (Table 13 and Figure 7). Climate scenario is also included in the calculations by the model. If any climate change has been entered in the worksheet ‘main’ as percentage of change in the existing rainfall then the model is calculating the corresponding changes in soil erosion, vegetation and actual evapotranpiration. Output data for the off-set climate scenario are calculated by the model only for plant cover in the cases of dry farming and uncultivated land use types. Effects by off-sets for climate scenarios are calculated for soil erosion and overland water runoff for all types of land uses.

Table 13. Data calculated by the model for plant cover and actual evapotrnapiration rate with and without change in climate (if any).

Actual E-T	Cover %
20	10%
29	20%
44	40%
51	60%
55	80%
57	100%
58	100%
50	50%
61	0%
58	0%
38	0%
29	10%
Total=550	Mean=39%

Offsets for climate scenario			
Offset r0 (mm)	**Offset Rainfall (mm)**	**Offset Pot E-T (mm)**	**Net Perc'n (mm)**
13,9	97	21	77,0
15,7	47	52	17,9
3,0	3	55	0,0
13,0	26	34	0,0
15,0	30	208	0,0
1,0	1	186	0,0
1,0	1	168	0,0
1,0	1	146	0,0
1,0	1	113	0,0
15,0	60	71	1,9
22,3	201	92	163,0
14,5	116	62	87,0
	584	**1207**	**346,8**

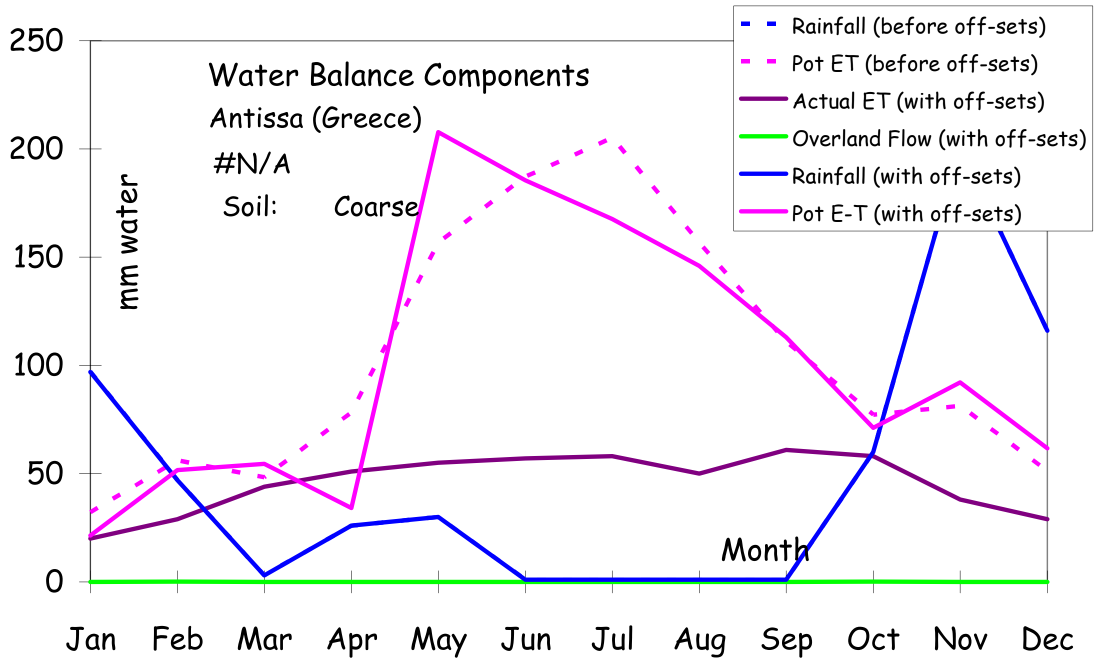

Figure 7. Change in evapotranspiration rate, rainfall, and overland flow with time including present climatic conditions and of-sets for climate change.

Overland water runoff is given in the worksheet 'main'. It is calculated on monthly and annual basis (Table 14). This parameter is given by the macro named Growveg (inside the PESERA model), and depends mainly on runoff coefficient (p), runoff threshold (h), and rainfall (daily runoff = p(r-h)), as well as on vegetation biomass and humus biomass.

Soil erosion rates and soil erosion distribution along the slope profile are given in worksheet 'main' and chart 'erosion'. Soil erosion (t. ha^{-1}) is estimated separately for each month for the whole study slope profile (Table 14), and for each segment of the slope profile if a whole profile (F) has been chosen (Table 15). The change of soil erosion and plant cover with time for the study slope profile is presented in Figure 8. (chart 'erosion'). Figure 8 shows, the highest erosion rates occur during the wet period when high amounts of rainfall occur and soil has low plant cover.

Table 14. Estimates for monthly water storage, erosion rate, vegetation and humus biomass, rainfall interception by plants, and overland water flow.

MONTH	Weighted Total Storage	Erosion Rate (T/Ha/y)	Veg'n Biomass (kg/sq.m)	Humus Biomass (kg/sq.m)	Inter-ception (%)	Runoff (mm)
January	34,7	0,000	4,87	0,65	62%	0,00
February	34,8	0,036	4,98	0,66	63%	0,06
March	34,8	0,000	5,03	0,67	63%	0,00
April	34,8	0,003	5,07	0,69	64%	0,01
May	34,8	0,000	4,92	0,65	63%	0,00
June	34,8	0,000	4,73	0,63	61%	0,00
July	34,8	0,000	4,57	0,61	60%	0,00
August	34,8	0,000	4,45	0,60	59%	0,00
September	34,8	0,000	4,37	0,61	58%	0,00
October	34,8	0,069	4,47	0,62	59%	0,11
November	34,8	0,005	4,68	0,62	61%	0,01
December	34,8	0,000	4,83	0,63	62%	0,00
ANNUAL	Mean = 35	Total = 00	Mean = 05	Mean = 01	Mean =61%	Total = 0

Table 15. Soil erosion rates (July to December) at the various segments of the slope profile calculated as total per year and for each month separately.

Slope Profile form		Erosion rates in Tonnes per Hectare						
Dist (m)	Elev (m)	Year	Jul	Aug	Sep	Oct	Nov	Dec
0	120,00	3,79	0,00	0,00	0,00	1,25	1,25	1,25
50	108,00	9,41	0,01	0,01	0,01	3,10	3,11	3,11
100	96,00	14,19	0,02	0,02	0,02	4,68	4,69	4,69
150	84,00	18,59	0,02	0,02	0,02	6,13	6,15	6,15
200	72,00	22,73	0,03	0,03	0,03	7,49	7,52	7,52
250	60,00	26,69	0,03	0,03	0,03	8,80	8,83	8,83
300	48,00	30,51	0,04	0,04	0,04	10,05	10,09	10,09
350	36,00	34,22	0,04	0,04	0,04	11,27	11,31	11,31
400	24,00	37,82	0,05	0,05	0,05	12,46	12,51	12,51
450	12,00	41,34	0,05	0,05	0,05	13,62	13,67	13,67
500	0,00	0,00						
		Slope Average	0,00	0,00	0,00	7,85	0,03	0,00

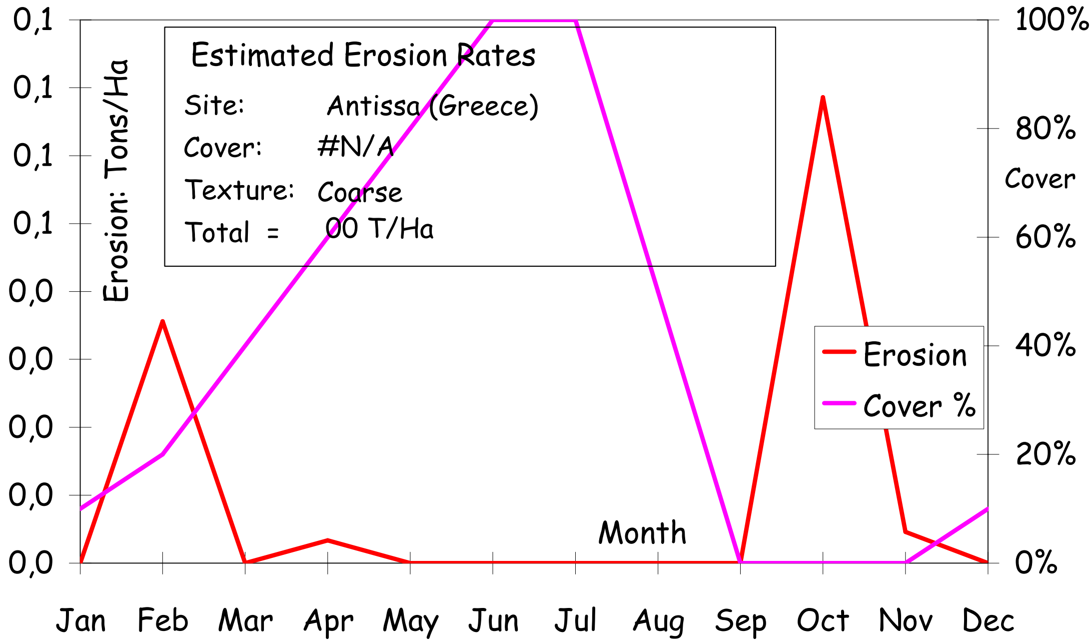

Figure 8. Changes in soil erosion rates and plant cover with time estimated by the model.

Soil erosion rate along the slope profile during a year is presented in Figure 8. The slope profile is computed by the model after introducing the appropriate values in the Table 10 (above). Then the model is estimating the erosion rate for each segment of the slope profile and the generated data are presented in a table (Table 15) and as a graph (Figure 9).

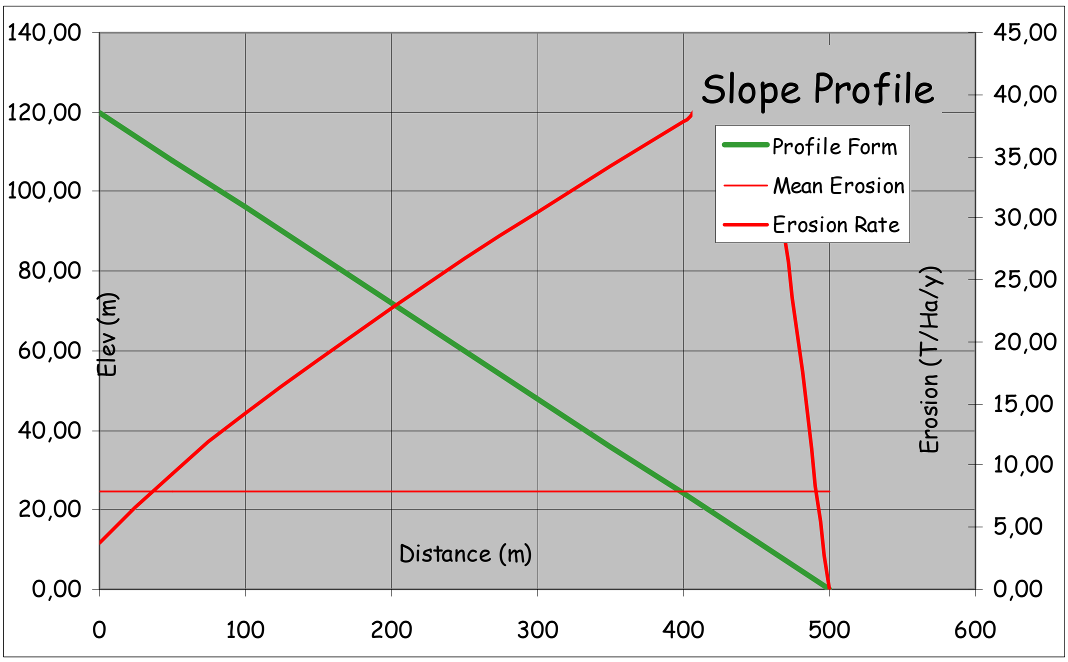

Figure 9. Slope profile characteristics and soil erosion rate change with distance along a study transect.

Total surface water storage is given in the worksheet 'main'. It is equal to roughness storage (mm) plus soil storage (mm). In fact, when the user defines the soil cover by selecting "land cover type" ('main'), the program uses the tables in the worksheet 'cover table' to calculate the soil storage and the roughness store (Table 14). It depends also on vegetation biomass and humus production.

Vegetation biomass, humus production and rain interception values are given in worksheet 'main' and chart 'vegetation'. Each one of these parameters is linked with the vegetation cover. Based on the selected type of land use the model generates vegetation biomass and humus production (Figure 10).

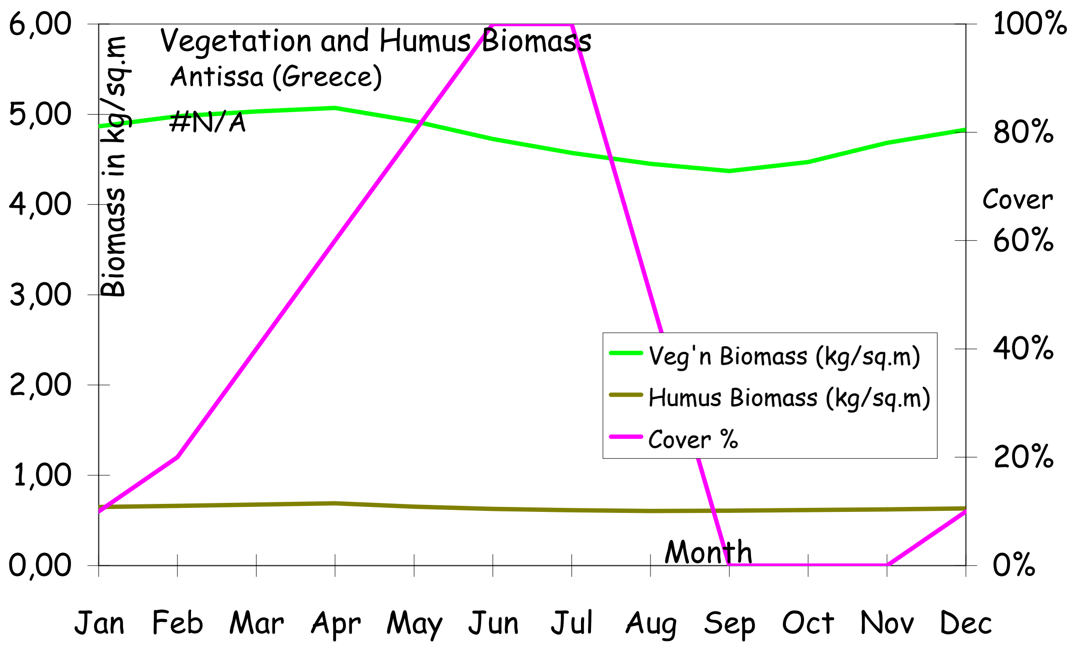

Figure 10. Changes in plant cover rates, vegetation biomass and humus biomass with time estimated by the model.

Climate senario and erosion rates can be estimated. The model provides the possibility to the user to assess climate changes on soil erosion under certain soil, vegetation and topographic characteristics. The model requires the parameters change in rainfall and rain intensity. Of course possible climate changes can be predicted by running climatic models such as the General Circulation Model.

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