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# **Livestock Grasshopper Documentation**

***Release 2018.03***

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Livestock is the name of the library of components that has been developed for this thesis. Livestock consists of a series of Grasshopper Python Script components and a underlying collection of Python scripts and a PyPI – Python Package Index - package. This is the documentation for the Grasshopper package.



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## Documentation for the Grasshopper Package:

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### 1.1 Livestock Grasshopper Components

#### 1.1.1 0 | Miscellaneous

##### Livestock Python Executor

###### Description

Path to python executor.

###### Inputs

**Name** PythonPath

**Description** Path to python.exe

**Data Access** Item

**Default Value**

None

###### Outputs

**Name** readMe!

###### Description

In case of any errors, it will be shown here.

**Name** BoundaryCondition

###### Description

Livestock Boundary Conditions.

##### Livestock SSH Connection

###### Description

Setup SSH connection.

Icon based on art from Arthur Shlain from the Noun Project.

#### Inputs

**Name** IP

**Description** IP Address for SSH connection.

**Data Access** Item

**Default Value**

None

**Name** Port

**Description** Port for SSH connection.

**Data Access** Item

**Default Value**

None

**Name** Username

**Description** Username for SSH connection.

**Data Access** Item

**Default Value**

None

**Name** Password

**Description** Password for SSH connection.

**Data Access** Item

**Default Value**

None

#### Outputs

**Name** readMe!

**Description**

In case of any errors, it will be shown here.

#### Livestock Hour To Date

**Description** Convert a hour of the year into a date on the format: DD MMM HH:mm.

#### Inputs

**Name** Hour

**Description** Hour of the year.

**Data Access** Item

**Default Value**

0

#### Outputs



**Name** readMe!

**Description**

In case of any errors, it will be shown here.

**Name** Date

**Description**

Converted Date.

### 1.1.2 1 | Geometry

#### Livestock Load Mesh

**Description** Loads a mesh.

##### Inputs

**Name** Filename

**Description** Directory and file name of mesh.

**Data Access** Item

**Default Value**

None

**Name** Load

**Description** Activates the component.

**Data Access** Item

**Default Value**

False

##### Outputs

**Name** readMe!

**Description**

In case of any errors, it will be shown here.

**Name** Mesh

**Description**

Loaded mesh.

**Name** MeshData

**Description**

Additional data if any.

#### Livestock Save Mesh

**Description** Saves a mesh and additional data

##### Inputs

**Name** Mesh

**Description** Mesh to save.

**Data Access** Item

**Default Value**

None

**Name** Data

**Description** Additional data if any.

**Data Access** Item

**Default Value**

None

**Name** Directory

**Description** File path to save mesh to.

**Data Access** Item

**Default Value**

None

**Name** Filename

**Description** File name.

**Data Access** Item

**Default Value**

None

**Name** Save

**Description** Activates the component.

**Data Access** Item

**Default Value**

False

## Outputs

**Name** readMe!

**Description**

In case of any errors, it will be shown here.

## 1.1.3 2 | CMF

### Livestock CMF Ground

#### Description

Generates CMF ground.

Icon art based created by Ben Davis from the Noun Project.

#### Inputs

**Name** Layers

**Description** Soil layers to add to the mesh in m.

**Data Access** List

**Default Value**

0

**Name** RetentionCurve

**Description** Livestock CMF Retention Curve.

**Data Access** Item

**Default Value**

None

**Name** VegetationProperties

**Description** Input from Livestock CMF Vegetation Properties.

**Data Access** Item

**Default Value**

None

**Name** SaturatedDepth

**Description** Initial saturated depth in m. It is depth where the groundwater is located.  
Default is set to 3m.

**Data Access** Item

**Default Value**

3

**Name** SurfaceWaterVolume

**Description** Initial surface water volume in m<sup>3</sup>. Default is set to 0 m<sup>3</sup>.

**Data Access** Item

**Default Value**

0

**Name** FaceIndices

**Description** List of face indices, on where the ground properties are applied.

**Data Access** List

**Default Value**

None

**Name** ETMethod

**Description**

Set method to calculate evapotranspiration.

0: No evapotranspiration.

1: Penman-Monteith.

2: Shuttleworth-Wallace.

Default is set to no evapotranspiration.

**Data Access** Item

**Default Value**

0

**Name** Manning

**Description** Set Manning roughness. If not set CMF calculates it from the above given values.

**Data Access** Item

**Default Value**

None

**Name** PuddleDepth

**Description** Set puddle depth. Puddle depth is the height were run-off begins.

**Data Access** Item

**Default Value**

0.01

**Name** SurfaceRunOffMethod

**Description**

Set the method for computing the surface run-off.

0: Kinematic Wave.

1: Diffusive Wave.

Default is set 0 - Kinematic Wave.

**Data Access** Item

**Default Value**

0

**Outputs**

**Name** readMe!

**Description** In case of any errors, it will be shown here.

**Name** Ground

**Description** Livestock Ground Data Class.

**Livestock CMF Weather**

**Description**

Generates CMF weather.

Icon art based created by Adrien Coquet from the Noun Project.

**Inputs**

**Name** Temperature

**Description** Temperature in C. Either a list or a tree where the number of branches is equal to the number of mesh faces.

**Data Access** Tree

**Default Value**

None

**Name** WindSpeed

**Description** Wind speed in m/s. Either a list or a tree where the number of branches is equal to the number of mesh faces.

**Data Access** Tree

**Default Value**

None

**Name** RelativeHumidity

**Description** Relative humidity in %. Either a list or a tree where the number of branches is equal to the number of mesh faces.

**Data Access** Tree

**Default Value**

None

**Name** CloudCover

**Description** Cloud cover, unitless between 0 and 1. Either a list or a tree where the number of branches is equal to the number of mesh faces.

**Data Access** Tree

**Default Value**

None

**Name** GlobalRadiation

**Description** Global Radiation in W/m<sup>2</sup>. Either a list or a tree where the number of branches is equal to the number of mesh faces.

**Data Access** Tree

**Default Value**

None

**Name** Rain

**Description** Horizontal precipitation in mm/h. Either a list or a tree where the number of branches is equal to the number of mesh faces.

**Data Access** Tree

**Default Value**

None

**Name** GroundTemperature

**Description** Ground temperature in C. Either a list or a tree where the number of branches is equal to the number of mesh faces.

**Data Access** Tree

**Default Value**

None

**Name** Location

**Description** A Ladybug Tools Locations.

**Data Access** Item

**Default Value**

None

**Name** MeshFaceCount

**Description** Number of faces in the ground mesh.

**Data Access** Item

**Default Value**

None

## Outputs

**Name** readMe!

**Description**

In case of any errors, it will be shown here.

**Name** Weather

**Description**

Livestock Weather Data Class.

## Livestock CMF Vegetation Properties

### Description

Generates CMF Vegetation Properties

Icon art based created by Ben Davis from the Noun Project.

### Inputs

**Name** Property

**Description** 0-1 grasses. 2-6 soils. Default is set to 0

**Data Access** Item

**Default Value**

0

### Outputs

**Name** readMe!

**Description**

In case of any errors, it will be shown here.

**Name** Units

**Description**

Shows the units of the surface values.

**Name** VegetationValues

**Description**

Chosen vegetation property values.

**Name** VegetationProperties

**Description**

Livestock Vegetation Property Data.

**Livestock CMF Synthetic Tree**

**Description**

Generates a synthetic tree

**Inputs**

**Name** FaceIndex

**Description** Mesh face index where tree is placed

**Data Access** Item

**Default Value**

None

**Name** TreeType

**Description** Tree types: 0 - Deciduous. Default is deciduous.

**Data Access** Item

**Default Value**

0

**Name** Height

**Description** Height of tree in meters. Default is set to 10m

**Data Access** Item

**Default Value**

10

**Outputs**

**Name** readMe!

**Description**

In case of any errors, it will be shown here.

**Name** Units

**Description**

Shows the units of the tree values.

**Name** TreeValues

**Description**

Chosen tree properties values.

**Name** TreeProperties

**Description**

Livestock tree properties data.

**Livestock CMF Retention Curve**

**Description** Generates a CMF retention curve.

## Inputs

**Name** SoilIndex

**Description** Index for choosing soil type. Index from 0-5. Default is set to 0, which is the default CMF retention curve.

**Data Access** Item

**Default Value**

0

**Name** K\_sat

**Description** Saturated conductivity in m/day.

**Data Access** Item

**Default Value**

None

**Name** Phi

**Description** Porosity in m<sup>3</sup>/m<sup>3</sup>.

**Data Access** Item

**Default Value**

None

**Name** Alpha

**Description** Inverse of water entry potential in 1/cm.

**Data Access** Item

**Default Value**

0

**Name** N

**Description** Pore size distribution parameter is unitless.

**Data Access** Item

**Default Value**

None

**Name** M

**Description** VanGenuchten m (if negative,  $1-1/n$  is used) is unitless.

**Data Access** Item

**Default Value**

None

**Name** L

**Description** Mualem tortoisivity is unitless.

**Data Access** Item

**Default Value**



None

## Outputs

**Name** readMe!

### Description

In case of any errors, it will be shown here.

**Name** Units

### Description

Shows the units of the curve values.

**Name** CurveValues

### Description

Chosen curve properties values.

**Name** RetentionCurve

### Description

Livestock Retention Curve.

## Livestock CMF Solve

### Description

Solves CMF Case.

Icon art based on Vectors Market from the Noun Project.

## Inputs

**Name** Mesh

**Description** Topography as a mesh.

**Data Access** Item

**Default Value**

None

**Name** Ground

**Description** Input from Livestock CMF Ground.

**Data Access** List

**Default Value**

None

**Name** Weather

**Description** Input from Livestock CMF Weather.

**Data Access** Item

**Default Value**

None

**Name** Trees

**Description** Input from Livestock CMF Tree.

**Data Access** List

**Default Value**

None

**Name** Stream

**Description** Input from Livestock CMF Stream. **Currently not working.**

**Data Access** Item

**Default Value**

None

**Name** BoundaryConditions

**Description** Input from Livestock CMF Boundary Condition.

**Data Access** List

**Default Value**

None

**Name** SolverSettings

**Description** Input from Livestock CMF Solver Settings.

**Data Access** Item

**Default Value**

None

**Name** Folder

**Description** Path to folder. Default is Desktop.

**Data Access** Item

**Default Value**

`os.path.join(os.environ["HOMEPATH"], "Desktop")`

**Name** CaseName

**Description** Case name as string. Default is CMF

**Data Access** Item

**Default Value**

CMF

**Name** Outputs

**Description** Connect Livestock Outputs.

**Data Access** Item

**Default Value**

None

**Name** Write

**Description** Boolean to write files.

**Data Access** Item

**Default Value**

False

**Name** Overwrite

**Description** If True excising case will be overwritten. Default is set to True.

**Data Access** Item

**Default Value**

True

**Name** Run

**Description**

Boolean to run analysis.

Analysis will be ran through SSH. Configure the connection with Livestock SSH.

**Data Access** Item

**Default Value**

False

**Outputs**

**Name** readMe!

**Description**

In case of any errors, it will be shown here.

**Name** ResultPath

**Description**

Path to result files.

**Livestock CMF Results**

**Description**

CMF Results

**Inputs**

**Name** ResultFolder

**Description** Path to result file. Accepts output from Livestock Solve.

**Data Access** Item

**Default Value**

None

**Name** FetchResult

**Description**

Choose which result should be loaded:

0 - Evapotranspiration

1 - Surface water volume

2 - Surface water flux

3 - Heat flux

4 - Aerodynamic resistance

5 - Soil layer water flux

6 - Soil layer potential

7 - Soil layer theta

8 - Soil layer volume

9 - Soil layer wetness

Default is set to 0.

**Data Access** Item

**Default Value**

0

**Name** SaveCSV

**Description** Save the values as a csv file - Default is set to False.

**Data Access** Item

**Default Value**

False

**Name** Run

**Description** Run component.

**Data Access** Item

**Default Value**

False

## Outputs

**Name** readMe!

**Description**

In case of any errors, it will be shown here.

**Name** Units

**Description**

Shows the units of the results.

**Name** Values

**Description**

List with chosen result values.

**Name** CSVPath

**Description**

Path to csv file.

## Livestock CMF Outputs

**Description** Specify the wanted outputs from the CMF simulation.

### Inputs

**Name** Evapotranspiration

**Description** Cell evaporation - default is set to True.

**Data Access** Item

**Default Value**

True

**Name** SurfaceWaterVolume

**Description** Cell surface water - default is set to False.

**Data Access** Item

**Default Value**

False

**Name** SurfaceWaterFlux

**Description** Cell surface water flux - default is set to False.

**Data Access** Item

**Default Value**

False

**Name** HeatFlux

**Description** Cell surface heat flux - default is set to False.

**Data Access** Item

**Default Value**

False

**Name** AerodynamicResistance

**Description** Cell surface water - default is set to False.

**Data Access** Item

**Default Value**

False

**Name** VolumetricFlux

**Description** Soil layer volumetric flux vectors - default is set to False.

**Data Access** Item

**Default Value**

False

**Name** Potential

**Description** Soil layer total potential ( $\Psi_{i_{tot}} = \Psi_{i_M} + \Psi_{i_G}$  - default is set to False.

**Data Access** Item

**Default Value**

False

**Name** Theta

**Description** Soil layer volumetric water content of the layer - default is set to False.

**Data Access** Item

**Default Value**

False

**Name** Volume

**Description** Soil layer volume of water in the layer - default is set to True.

**Data Access** Item

**Default Value**

True

**Name** Wetness

**Description** Soil layer wetness of the soil ( $V_{\text{volume}}/V_{\text{pores}}$ ) - default is set to False.

**Data Access** Item

**Default Value**

False

## Outputs

**Name** readMe!

**Description**

In case of any errors, it will be shown here.

**Name** ChosenOutputs

**Description**

Shows the chosen outputs.

**Name** Outputs

**Description**

Livestock Output Data.

## Livestock CMF Boundary Condition

**Description** CMF Boundary connection

### Inputs

**Name** InletOrOutlet

**Description** 0 is inlet. 1 is outlet - default is set to 0

**Data Access** Item

**Default Value**

0

**Name** ConnectedCell

**Description** Cell to connect to. Default is set to first cell.

**Data Access** Item

**Default Value**

0

**Name** ConnectedLayer

**Description** Layer of cell to connect to. 0 is surface water. 1 is first layer of cell and so on. Default is set to 0 - surface water.

**Data Access** Item

**Default Value**

0

**Name** InletFlux

**Description** If inlet, then set flux in m3/day.

**Data Access** List

**Default Value**

False

**Name** FlowWidth

**Description** Width of the connection from cell to outlet in meters.

**Data Access** Item

**Default Value**

None

**Name** OutletLocation

**Description** Location of the outlet in x, y and z coordinates.

**Data Access** List

**Default Value**

None

## Outputs

**Name** readMe!

**Description**

In case of any errors, it will be shown here.

**Name** BoundaryCondition

**Description**

Livestock Boundary Conditions.

## Livestock CMF Solver Settings

**Description** Sets the solver settings for CMF Solve

### Inputs

**Name** AnalysisLength

**Description** Total length of the simulation in hours - default is set to 24 hours.

**Data Access** Item

**Default Value**

24

**Name** TimeStep

**Description**

Size of each time step in hours - e.g. 1/60 equals time steps of 1 min and 24 is a time step of one day.

Default is 1 hour.

**Data Access** Item

**Default Value**

1

**Name** SolverTolerance

**Description** Solver tolerance - Default is 1e-8

**Data Access** Item

**Default Value**

10\*\*-8

**Name** Verbosity

**Description**

Sets the verbosity of the print statement during runtime - Default is 1.

0 - Prints only at start and end of simulation.

1 - Prints at every time step.

**Data Access** Item

**Default Value**

1

**Outputs**

**Name** readMe!

**Description**

In case of any errors, it will be shown here.

**Name** SolverSettings

**Description**

Livestock Solver Settings.

**Livestock CMF Surface Flux Result**

**Description** Extract the surface flux for a mesh.

**Inputs**

**Name** ResultFolder

**Description** Path to result file. Accepts output from Livestock Solve

**Data Access** Item

**Default Value**

None

**Name** Mesh



**Description** Mesh of the case

**Data Access** Item

**Default Value**

None

**Name** IncludeRunOff

**Description** Include surface run-off into the surface flux vector? Default is set to True.

**Data Access** Item

**Default Value**

True

**Name** IncludeRain

**Description** Include rain into the surface flux vector? Default is False.

**Data Access** Item

**Default Value**

False

**Name** IncludeEvapotranspiration

**Description** Include evapotranspiration into the surface flux vector? Default is set to False.

**Data Access** Item

**Default Value**

False

**Name** IncludeInfiltration

**Description** Include infiltration into the surface flux vector? Default is False.

**Data Access** Item

**Default Value**

False

**Name** SaveResult

**Description** Save the values as a text file - Default is set to False.

**Data Access** Item

**Default Value**

False

**Name** Run

**Description** Run component. Default is False.

**Data Access** Item

**Default Value**

False

## Outputs

**Name** readMe!

**Description**

In case of any errors, it will be shown here.

**Name** Unit

**Description**

Shows the units of the results.

**Name** SurfaceFluxVectors

**Description**

Tree with the surface flux vectors.

**Name** CSVPath

**Description**

Path to csv file.

**Livestock CMF Outlet**

**Description** Create a CMF Outlet.

**Inputs**

**Name** Location

**Description** Location of the outlet in x, y and z coordinates. Default is 0,0,0.

**Data Access** Item

**Default Value**

[0, 0, 0]

**Name** ConnectedCell

**Description** Cell to connect to. Default is set to first cell.

**Data Access** Item

**Default Value**

0

**Name** ConnectedLayer

**Description**

Layer of cell to connect to.

0 is surface water.

1 is first layer of cell and so on.

Default is set to 0 - surface water

**Data Access** Item

**Default Value**

0

**Name** OutletType

**Description**

Set type of outlet connection.

- 1: Richards.
- 2: Kinematic wave.
- 3: Technical Flux.

**Data Access** Item

**Default Value**

None

**Name** ConnectionParameter

**Description**

If Richards:

Potential - Sets the potential of the outlet. The difference in potential is what drives the flux.

If Kinematic wave:

Residence Time - Linear flow parameter of travel time in days.

If Technical Flux:

Maximum Flux - The maximum flux is in m<sup>3</sup>/day.

**Data Access** Item

**Default Value**

None

## Outputs

**Name** readMe!

**Description**

In case of any errors, it will be shown here.

**Name** BoundaryCondition

**Description**

Livestock Boundary Condition.

## 1.1.4 3 | Comfort

### Livestock New Air Conditions

**Description** Computes a new air temperature and relative humidity with the Atmosphere Model from the thesis of Christian Kongsgaard

#### Inputs

**Name** Mesh

**Description** Ground Mesh

**Data Access** Item

**Default Value**

None

**Name** Evapotranspiration

**Description** Evapotranspiration in m<sup>3</sup>/day. Each tree branch should represent one time unit, with all the cell values to that time.

**Data Access** Tree

**Default Value**

None

**Name** AirTemperature

**Description** Air temperature in C

**Data Access** List

**Default Value**

None

**Name** AirRelativeHumidity

**Description** Relative Humidity in -

**Data Access** List

**Default Value**

None

**Name** WindSpeed

**Description** Wind speed in m/s

**Data Access** List

**Default Value**

None

**Name** AirBoundaryHeight

**Description** Top of the air column in m. Default is set to 10m.

**Data Access** Item

**Default Value**

10

**Name** InvestigationHeight

**Description** Height at which the new air temperature and relative humidity should be calculated. Default is set to 1.1m.

**Data Access** Item

**Default Value**

1.1

**Name** CPUs

**Description** Number of CPUs to perform the computations on. Default is set to 2

**Data Access** Item

**Default Value**

2

**Name** ResultFolder

**Description** Folder where the result files should be saved

**Data Access** Item

**Default Value**

False

**Name** Run

**Description** Run the component

**Data Access** Item

**Default Value**

False

## Outputs

**Name** readMe!

**Description**

In case of any errors, it will be shown here.

**Name** NewTemperature

**Description**

New temperature in C.

**Name** NewRelativeHumidity

**Description**

New relative humidity in %.

**Name** LatentHeatFlux

**Description**

Computed latent heat flux in J/h.

**Name** UsedVapourFlux

**Description**

Vapour flux used to alter the temperature and relative humidity in kg/h.

## Livestock Load Air Results

**Description** A component class that computes a new air temperature and relative humidity with the Atmosphere Model from the thesis of Christian Kongsgaard

### Inputs

**Name** ResultFolder

**Description** Path to result folder.

**Data Access** Item

**Default Value**

False

**Name** LoadResult

**Description** Run the component

**Data Access** Item

**Default Value**

False

## Outputs

**Name** readMe!

**Description**

In case of any errors, it will be shown here.

**Name** NewTemperature

**Description**

New temperature in C.

**Name** NewRelativeHumidity

**Description**

New relative humidity in %.

**Name** LatentHeatFlux

**Description**

Computed latent heat flux in J/h.

**Name** UsedVapourFlux

**Description**

Vapour flux used to alter the temperature and relative humidity in kg/h.

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