Multi-Hazard Interactions
AIMS OF LISEM

- Systematic Integration of state-of-the-art numerical solutions for natural hazards
- Flexibility and customization
  - User makes most assumptions, not the model!
  - Model at fundamental level, larger behavior emerges
- Helping with dealing with uncertainties in complex simulations
- Making gathering and processing data easier
• Over 30 years of expert knowledge
  • Limburg Soil Erosion Model
• Integrated approach to modelling
  • Both spatially (multi-hazard) and temporally (feedbacks between events)

• Multi-Hazard simulations
  • Including interactions
• Implement fundamental rules
  • Larger behavior is emergent
LISEM Classic

Interface-based
Command line option

Processes:
- Hydrology
- Flow/Floods
- Erosion

Event/Continuous

LISEM (Hazard)

Scripting and Interface-based
Command line option

Processes:
- Hydrology
- Flow/Floods
- Erosion
- Slope failures
- Landslide/Debris flow
- Storm surging
- Tsunami
- Interactions with Seismic and Wind

Event/Continuous with scripting
Lisem Integrated Spatial Earth Modeller

What is LISEM?

Lisem (Lisem Integrated Spatial Earth Modeller) is a free and open-source software tool that allows users to manipulate geospatial data. Featuring both simple operations and advanced algorithms, complex models can be developed. The tool features an internal scripting environment designed for easy data manipulation, a geospatial data viewer, and the LISEM model, which aims at simulation of hydro-meteorological surface hazards. Additionally, the software comes with Python bindings that allow for interactions with other libraries and automation of code. Have a look at the documentation for more information on how to use and install LISEM.
Model Principles

• Data as sub-pixel fractions
• Multiple flow types (1D and 2D linked)
• Fully integrated erosion/hydrology
HYDROLOGY

• Hydrology from rainfall through groundwater towards catchment outflow

• Simulation of water flow base on Saint Venant equations

\[
\frac{\partial h}{\partial t} + \frac{\partial (uh)}{\partial x} + \frac{\partial (vh)}{\partial y} = R - I
\]

\[
\frac{\partial h}{\partial t} + \frac{\partial (uh^2)}{\partial x} + \frac{\partial huv}{\partial y} = S_x
\]

\[
\frac{\partial v}{\partial t} + \frac{\partial (vh)}{\partial x} + \frac{\partial (vh^2)}{\partial y} = S_y
\]

Gravity 9.81!

\[
S_{r,x} = -ghS_x
\]

\[
S_{r,y} = -ghS_y
\]

Pressure Reaction = Action!

\[
F_p = \int_0^h gh \, dh = \frac{gh^2}{2}
\]

Friction Manning was right

\[
S_f = \frac{g \frac{u^2}{n^2}}{h^3}
\]
Model setup

- Physically-based model customized for the relevant scale/areas of study; Efficient upscaling to maximize potential
LISEM Hazard

- Multi-hazard integrated simulation
  - Hydrology
  - Flow
  - Slope Stability
  - Landslides/Debris flows
  - Tsunami
  - Coastal

- Scripting
  - Custom models
  - Automatic Calibration
  - Data processing/visualization

- Raster editor (Paint for geo-data!)
Underlying principles

- Slope stability
- Two-phase flow equations
- Bussinesq equations for coastal

- Automatic calibration
  - Brute-force
  - Gradient descent
- Linking with real-time forecast data
Save/Load settings file for the model

Visualization of model dynamics

Process toggles

Additional settings

Model duration/steps/timestep

Input file directories

Output Options
- Toggle 3D View
- Add a new layer (Raster/Vector/Point cloud/Web/3D)
- Load and Save your current layout
- Drawing Options
- Render the map view to an image or video
- Select Coordinate Reference System for map view
Map name
Map full path
Minimum and maximum value. If both 0, the full range of the data is used
Color Scale
Opacity
Detailed Styling Options
Coordinate System
Edit (Raster or Vector)
Remove Layer
Elevation, shading and legend toggle
Info
Remove
Save As
Duplicate
Style
Copy Style
ZoomToExtent
Set CRS
Copy CRS
Set World CRS from Layer
Show Profile
Edit
• Often many layers required for simulating complex events
LISEM Hazard

• Scripting allows for easy preparation of data
  • Warping, interpolating, classification, simulation, filtering, projecting, analysis, derivatives, rasterizing and more

Slope.tif = Slope(dem.tif)

fixed.tif = InpaintNS(dem.tif)
SOFTWARE AVAILABILITY

• Written in c++
  • Qt for interface
  • GDAL for data in/output
  • OpenGL/OpenCL for visualization/compute
  • OpenMP for multi-core processing
  • Many more....

• Available on Github (GPL-3)
• Compiled windows binaries on Sourceforge
  • Compilation on linux possible but takes some extra work
• www.lisemmodel.com
SUPPORTING TECHNOLOGIES

- The resulting equations need to be solved Fast
- Program build in c++, data preparation and output using GDAL

Parallel computing (using your quadcore)