Introduction to Flow-R

- A distributed empirical model susceptibility assessment at the regional scale
- Based on topographic information (Digital Elevation Model-DEM)

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Flow-R, a model for susceptibility mapping of debris flows and other gravitational hazards at a regional scale

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Introduction to Flow-R

- Debris flows, snow avalanches, rock falls, flood propagation
- Mostly used for debris flows
- DEM resolution and accuracy are key elements for quality results
- DEM resolution: best results with 10x10 m cell size
- < 10x10 m: time consuming, over-precision
- 25x25 m: still usable result but with lower quality
- 50x50 m: too coarse, not-reliable results

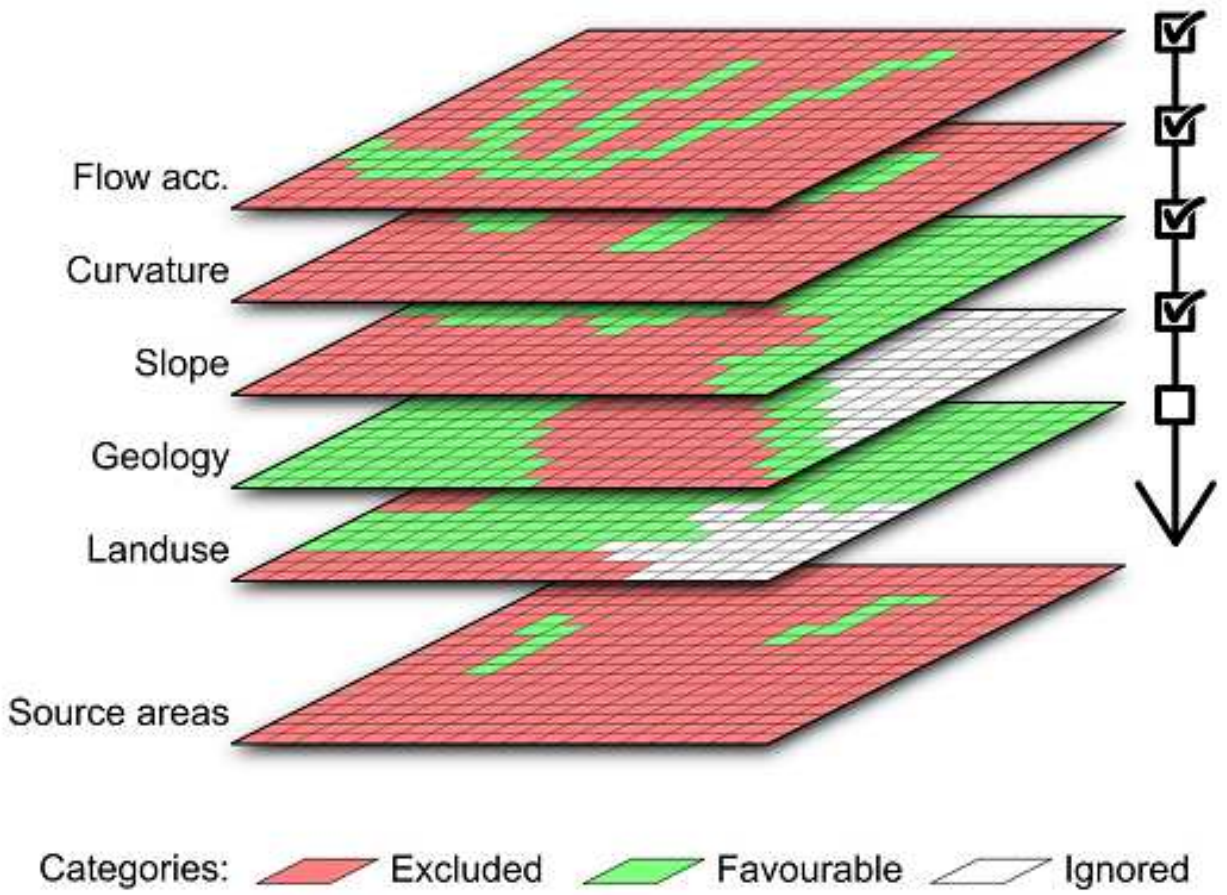
Computational process

- Two steps:
  - the source areas are first identified by means of morphological and user-defined criteria
  - debris flows are propagated from these sources on the basis of frictional laws and flow direction algorithms
- The debris flow volume and mass are not taken into account

Assessment of the source areas

- Grid cells of each input dataset are classified as *favourable*, when initiation is possible
- *excluded* when initiation is unlikely
- *ignored* when no decision can be taken on this parameter
- Datasets are combined according to the following rule: a cell is a source area if it was at least once selected as favourable, but never excluded.
- Alternatively, the user can directly import source areas which have been generated by another (GIS-based) approach.

Assessment of the source areas



Assessment of the propagation

Two types of algorithms are involved in the propagation assessment:

- Spreading algorithms controlling the path and the spreading of the debris flows

- Friction laws determining the runout distance

Flow direction algorithms

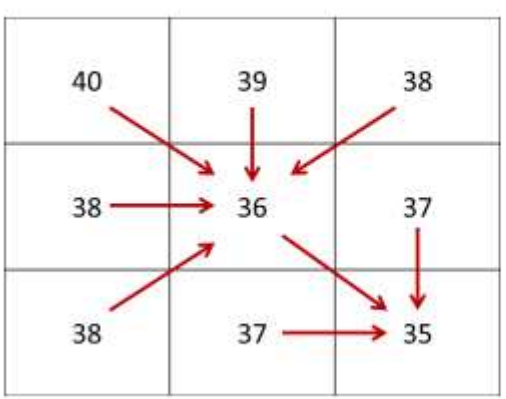
- Two most important algorithms for the propagation assessment of debris flows:

- Holmgren (1994), based on multiflow algorithm

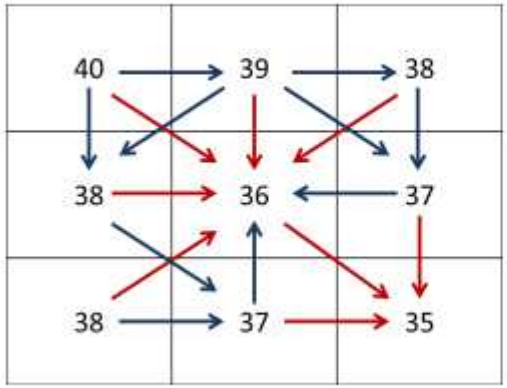
- Modified Holmgren (1994)

Flow direction algorithms

Single Flow Direction Illustration



Multi-Flow Direction Illustration



Flow direction algorithms

Holmgren (1994):

- adds a parameter to the multiple flow direction algorithm as an exponent "*x*" allowing control of the divergence
- For $x = 1$ the spreading is similar to the multiple flow direction
- When *x* increases, the divergence is reduced
- This parameter gives control over the spreading and thus allows the model to reproduce a wide range of flow accumulations
- Typical exponent value: 4

Flow direction algorithms

Modified Holmgren (1994):

- changes the height of the central cell by a factor *dh*, which will change the gradients values

- This allows smoothing of DEM roughness and production of more consistent spreading.

Inertial parameter

Inertial parameter (persistence function)

- The persistence function aims at reproducing the behaviour of inertia, and weights the flow direction based on the change in direction with respect to the previous direction

- In every persistence distribution, the cell opposed to the flow direction is nulled to avoid eventual backward propagation and to save computing time

Friction algorithms

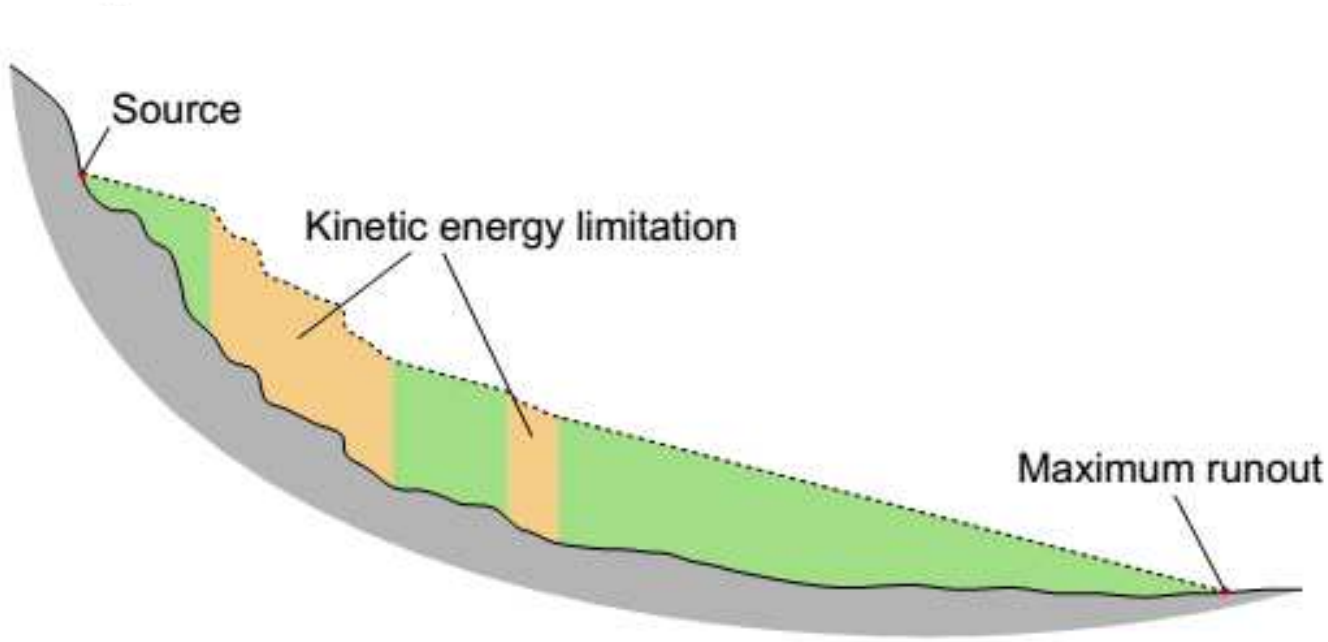
For debris flows:

- Perla et al. (1980): based on a non-linear friction law, which is the solution of the equation of movement, leading to the velocity *Vi* of the flow at the end of the segment *i*

- Simplified friction-limited model (SFLM): based on maximum possible runout distance, which is characterized by a minimum travel angle that is the angle of the line connecting the source area to the most distant point reached by the debris flow, along its path

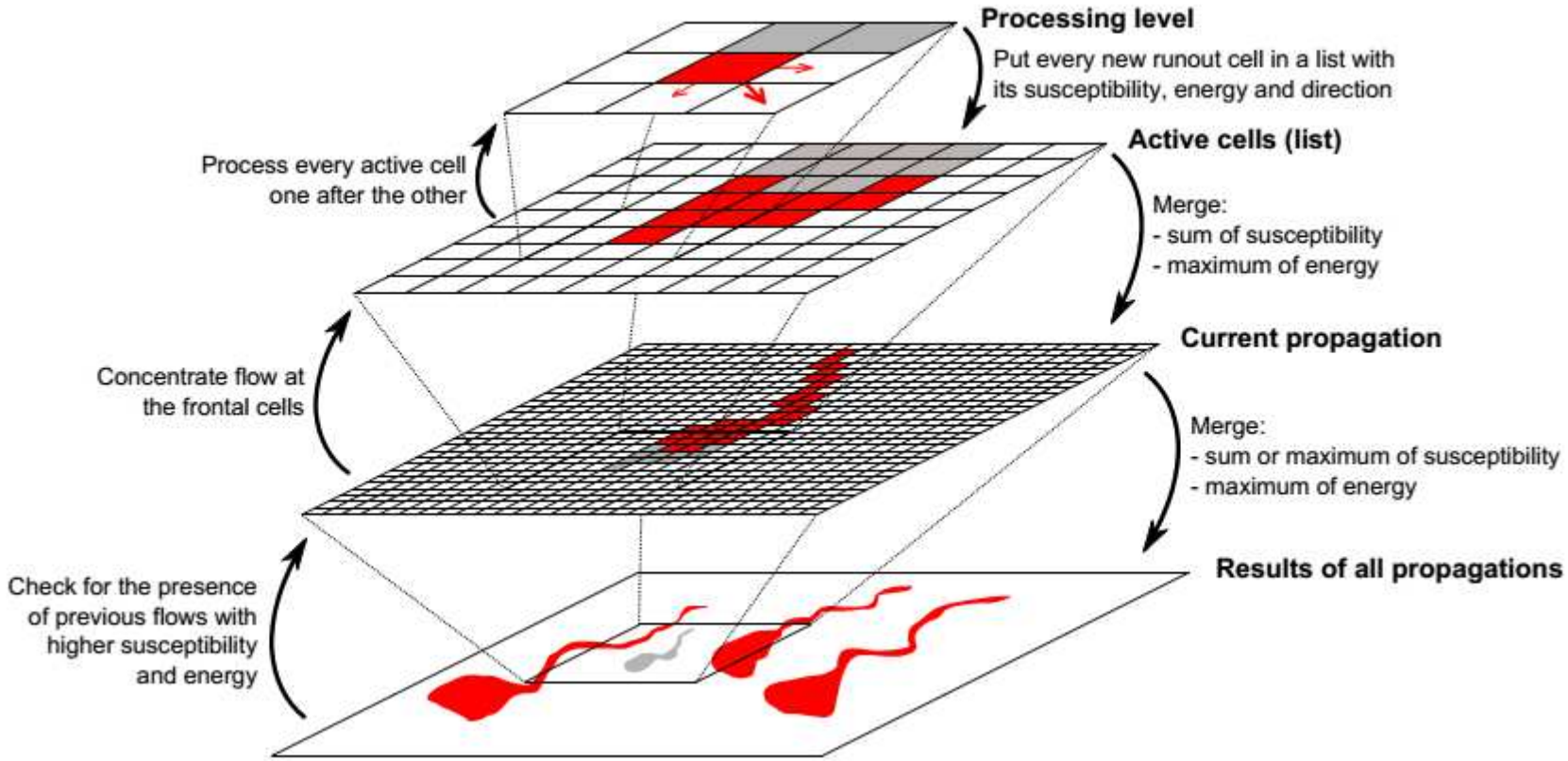
Friction algorithms: SFLM

Travel angle:

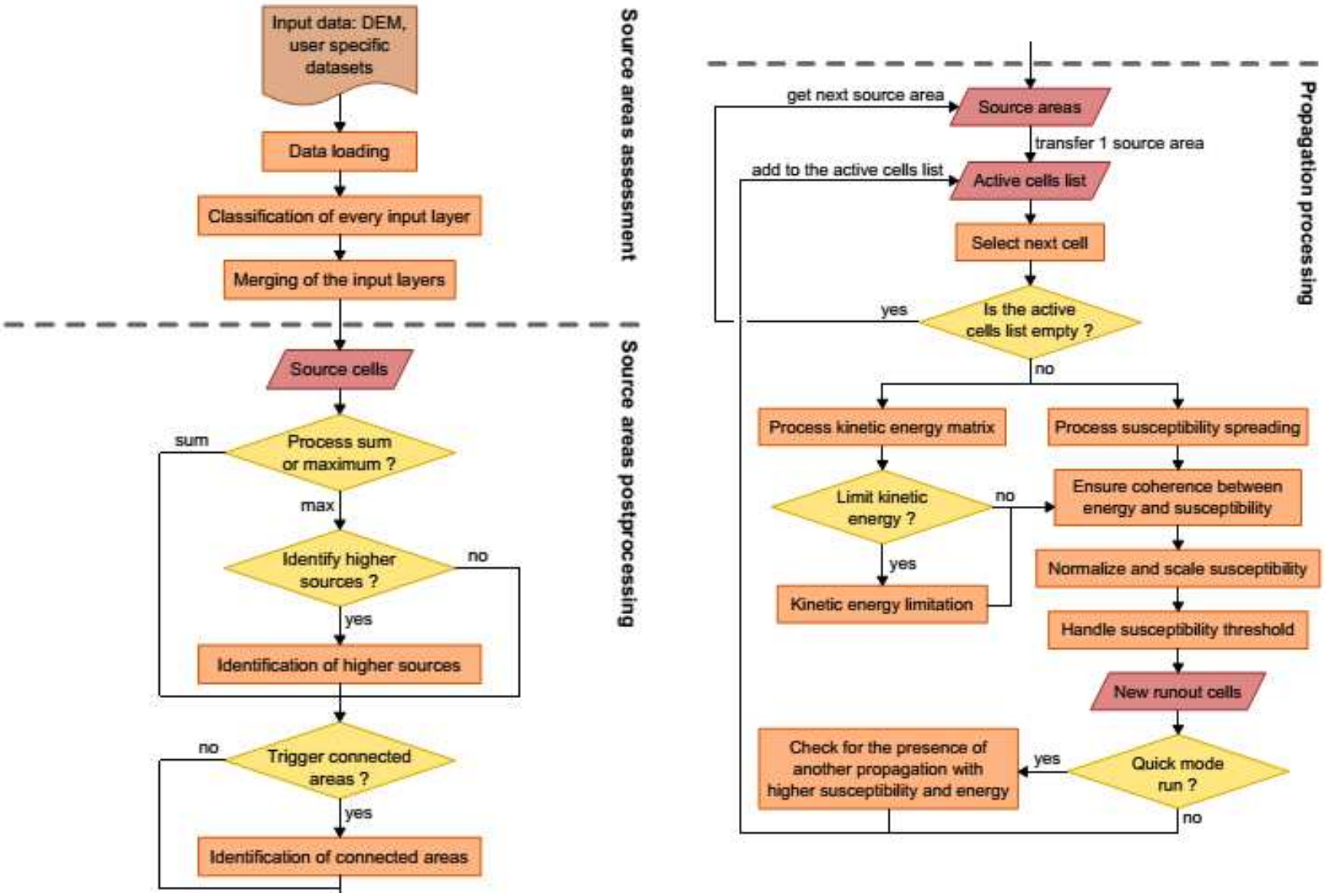


Propagation

The propagation routine considers one source area (a cell or a connected group of these) at a time and transfers it into the active cells list



Overall modelling process



Web site

www.flow-r.org