I/O-efficient Event Based Depression Flood Risk

Flash flood risk assessment
Our algorithm computes the areas of a terrain that are flooded in a given flash flood event by simulating how water flows on the terrain and fills up depressions.

Previous work only considered events where rain falls at a constant uniform rate on the entire terrain, whereas our algorithm allows different rainfall in each cell.

We assume that water only flows on the surface of the terrain. When a depression fills up, remaining water flows across a saddle cell of the terrain into a neighboring depression.

The merge tree represents how depressions are nested.

The topological complexity is \( X \), the number of sinks, which is the number of leaves of the merge tree.

The performance of our algorithm depends on the topological complexity of the terrain.

External Memory Model
We analyze our algorithms in the external memory model. The cost of an algorithm is the number of I/Os it performs.

\[
N = \# \text{ of items in input} \\
B = \# \text{ of items per disk block} \\
M = \# \text{ of items that fit in main memory} \\
\text{Scan}(N) = N / B, \text{ the cost of reading } N \text{ items sequentially} \\
\text{Sort}(N) = N / B \cdot \log_{2B} (N / B), \text{ the cost of sorting } N \text{ items}
\]

Event:

Terrain:

previous work has shown how to compute the [watersheds and merge tree](#) of the terrain in \( O(\text{Sort}(N)) \) I/Os.
This computation is independent of the flash flood event and only needs to be done once.

The key insight in the algorithm is that we in \( O(\text{Scan}(X)) \) I/Os can compute the excess volume of each depression, which is positive if it is full and negative if it has capacity for more rain.

Example in 1 Dimension
In the following example, the two elementary depressions have volumes 140 and 260, and they receive rain amounts 240 and 152 respectively.

First, our algorithm computes the excess volumes by subtracting the rain amounts (240 and 152) from the depression volumes (140 and 260).

Since the left depression has a positive excess of +100, and the right depression has a negative excess of −108, the flash flood event floods the left depression completely, and the right depression receives an extra 100 volume of rain.

In \( \text{Scan}(N) \) I/Os we then compute for each cell if it is flooded.