madalgo
CENTER FOR MASSIVE DATA ALGORITHMICS

Thomas Mølhave
University of Aarhus

Pankaj Agarwal, Duke University
Lars Arge, University of Aarhus
Andrew Danner, Swarthmore College
Ke Yi, HKUST

TerraSTREAM: Flow Modeling

Flow Modeling

Two of the most important concepts in terrain flow modeling are flow routing and flow accumulation

- **Flow routing** is the assignment of flow directions to every point in a terrain to globally model how water flows through it. This is done by selecting one or more downslope neighbors at each point.
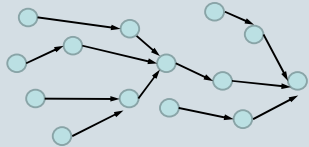
- **Flow accumulation** quantifies how much water flows through each point of the terrain if poured uniformly onto it. Water is routed along the flow paths computed by flow routing.

Hydrological Conditioning

Since flow models route water downstream, many small sinks impedes water flow along hydrological features.
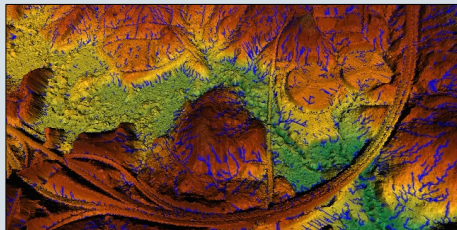

The figure above shows cells with high flow accumulation values in blue, these "rivers" are quite short and uninteresting. Furthermore, this terrain has a large sink defined by the highway bridge crossing the valley.
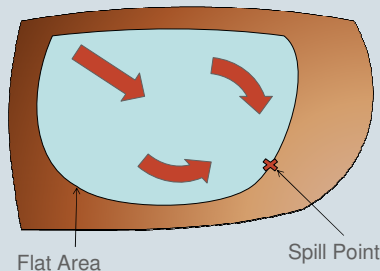
Flat Areas

By flooding insignificant sinks using a conditioning algorithm we get the following result
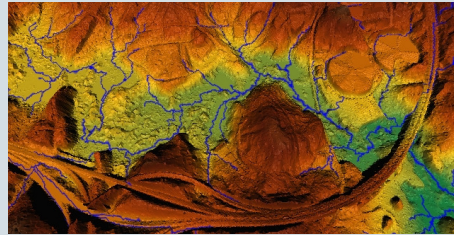
However, by flooding sinks we create flat areas and traditional flow routing models breaks down on such areas since they assume that at least one downslope neighbor exists for each terrain point.

× Spill points
☐ Flat areas produced by flooding
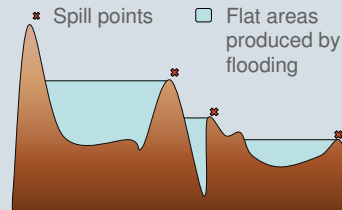
Flat area routing is the process of routing flow on a completely flat area, flow is routed from points with adjacent upslope neighbors to *spill points* with adjacent downslope neighbors.

Flat Area
Spill Point

Routing on Flat Areas

We support flow routing on flat areas using two different models.

- A traditional model that routes the flow at each point in the direction of the closest spill point (shown in white in the figure below).

- A more sophisticated model that makes the flow converge more naturally along the middle of the flat area (shown in blue on the figure).
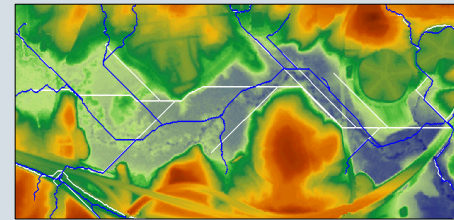
Performance Concerns

Standard non-flat routing is performed in a single scan of the input terrain.
Before flat routing can be performed the flat areas must be identified. We have developed an external memory batched union-find structure that can be used to compute connected components of flat cells. On grid terrains we can compute the connected components in a few scans of the grid. Flow accumulation is equivalent to sorting the input using an external-memory priority queue.
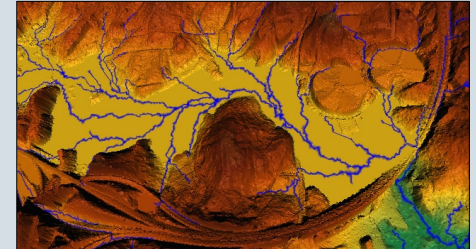
Flow Accumulation on the Neuse River Basin

This figure shows the Neuse river basin in North Carolina. We have performed flow routing on a digital model of the Neuse and colored all cells with a flow accumulation above a certain threshold (~20000) blue.