

Flood-risk Screening using Detailed and Massive Terrain Data



November 24, 2015

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madaLGO 
CENTER FOR MASSIVE DATA ALGORITHMICS

Flood-Risk Screening

- Important to screen extreme rain or sea-level rise flood risk
 - 50% of Danes worry about their homes being flooded (Userneeds)
 - 90% of Danes say high flood risk affect decision to buy house
 - Cost of 2011 Copenhagen flood over 6 billion kroner (Swiss Re)



Copenhagen 2011

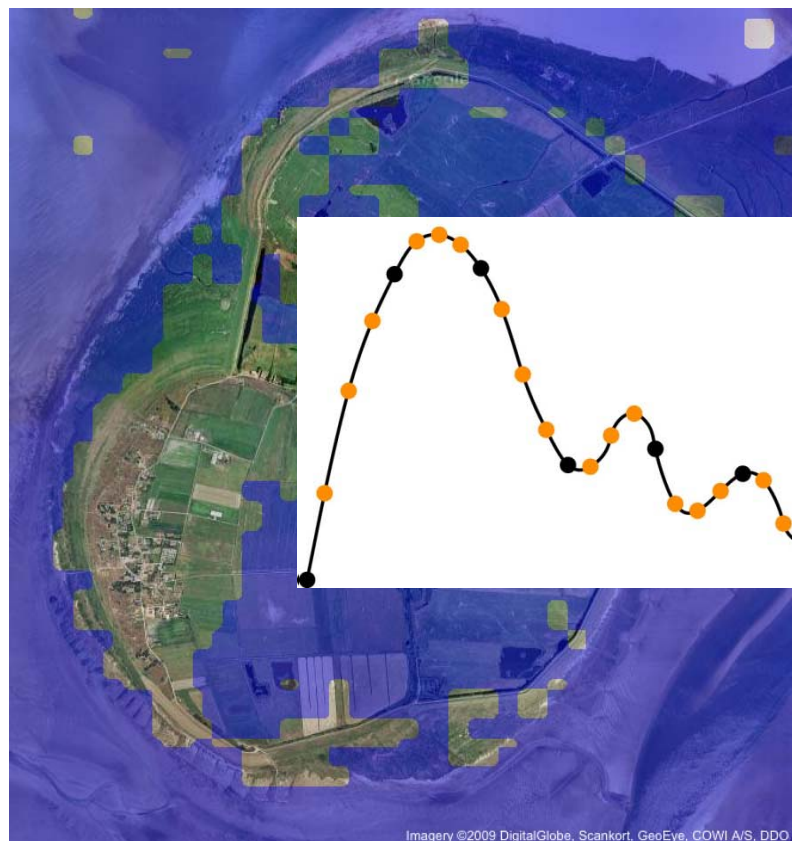


Aarhus 2012

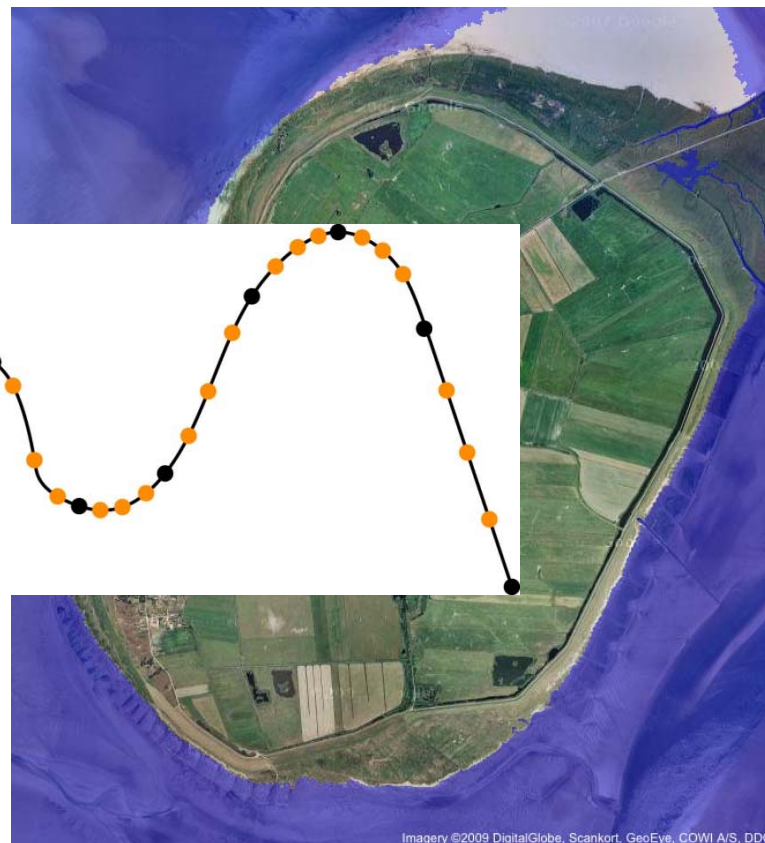
- Potential to do so using detailed national elevation model
 - Elevation for roughly every 2x2 meter and soon ½x½ meter
⇒ hundreds or even thousands of points in family home lot!

Detailed Terrain Data Essential

Sea-level rise (2 meter effect on Mandø)



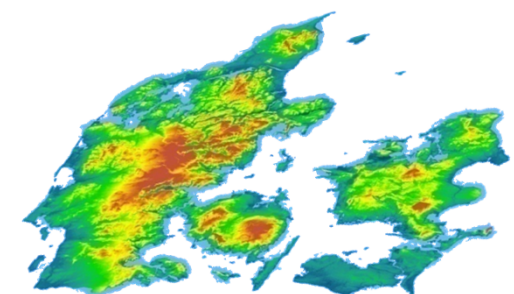
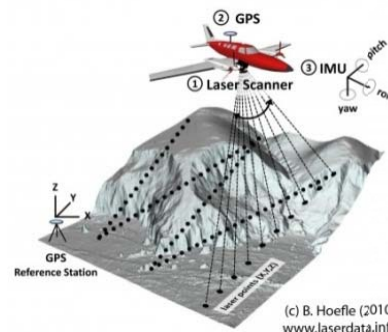
90 meter terrain model



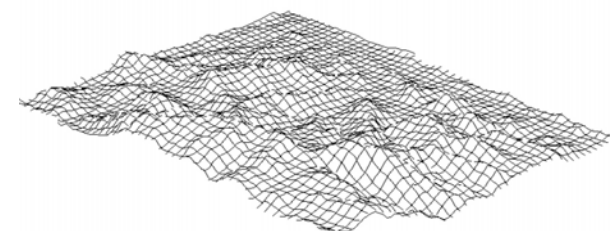
2 meter terrain model

Detailed Data Available and Massive

- Required detailed terrain models are huge, e.g. ½ meter LiDAR
 - Denmark ~168 billion points
 - Midtjylland ~52 billion points
 - Århus ~2 billion points



- Most systems cannot handle massive terrain datasets!
- Typical workarounds:
 - Tiling (difficult and cumbersome)
 - Data simplification (unreliable results)
 - Small areas (area identification, border conditions)



⇒ Hard to unleash potential of detailed national elevation model



MADALGO

- Established 2007 funded by “Danmarks Grundforskningsfond”
 - Renewed for additional 5 year in 2012
 - 10 year budget > \$25 million
 - International evaluation:
“*the world-leading center in area of massive dataset algorithmics*”



- I/O-efficient algorithms one of four main focus research areas
 - Lead to efficient processing of massive terrain data on desktop
 - Through collaboration with academic/industry GIS/LiDAR experts

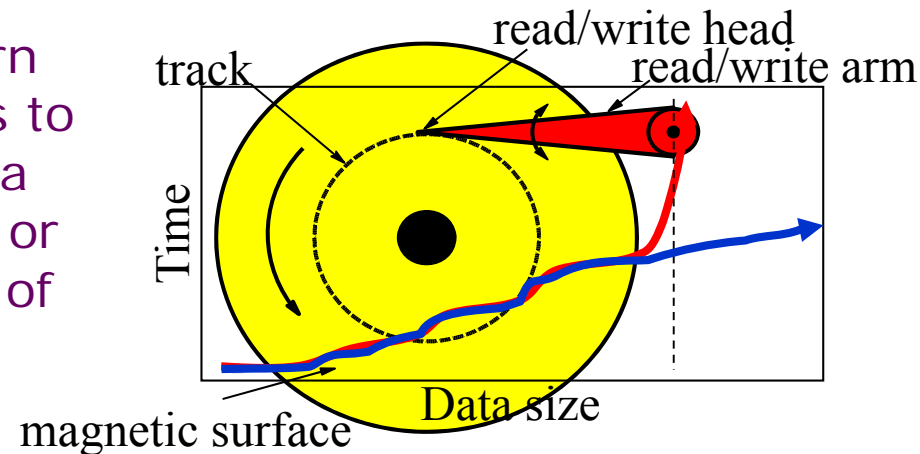


I/O-Efficient Algorithms

Disk often bottleneck when handling massive data

- Disk access is 10^6 times slower than main memory access

“The difference in speed between modern CPU and disk technologies is analogous to the difference in speed in sharpening a pencil using a sharpener on one’s desk or by taking an airplane to the other side of the world and using a sharpener on someone else’s desk.” (D. Comer)



- Large disk access time amortized by transferring large data blocks
→ Important to store/access data to take advantage of blocks

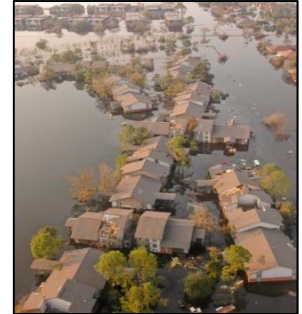
I/O-efficient algorithms:

- Move as few disk blocks as possible to solve given problem

I/O-Efficient Flood-Risk Screening

Flood-risk can be divided into risk from

- Rising sea-level
- Water rising in rivers
- Water collecting in depressions



Developed flood-risk tools/algorithms include

- Sea-level rise (path to sea)
- Bluespots (depression mapping)
- *Surface flow (flow accumulation/upstream area)*
- *Flash Flood Mapping (event based depression risk)*
- River rise (event based)



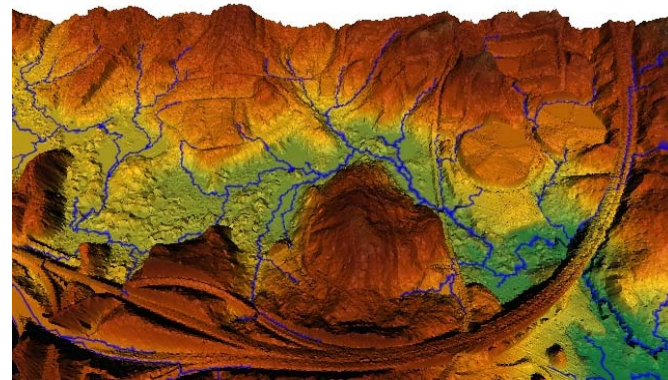
Commercialized by start-up SCALGO

SCALABLE
ALGORITHMIC

Surface Flow

Basic surface flow modeling primitives

- Flow direction: The direction water flows at each cell
- Flow accumulation: Amount of water flowing through each cell
 - Also upstream area
 - Drainage network = high flow accumulation



Most systems cannot handle even 2-meter Denmark model

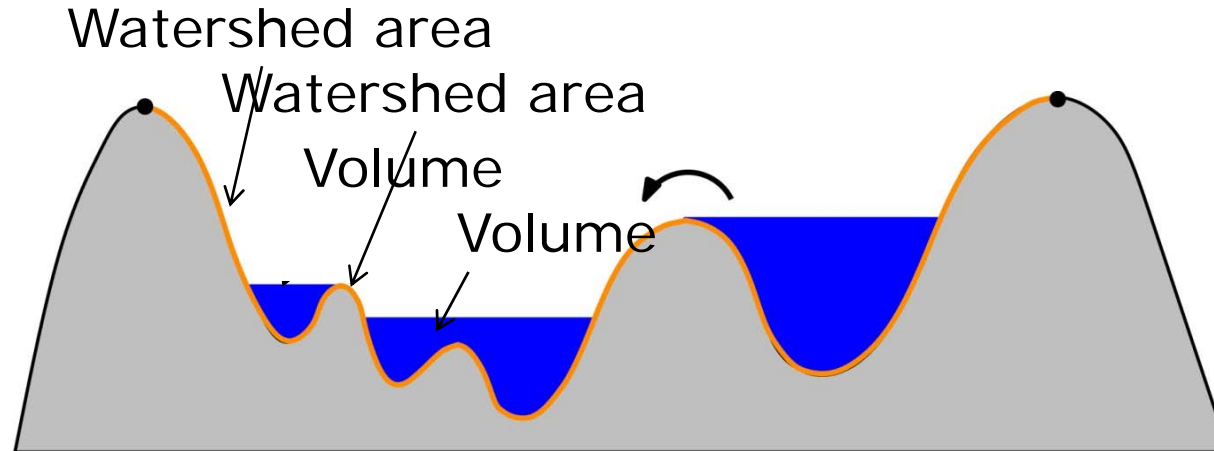
MADALGO/SCALGO algorithms handle in a day on 4GB machine

- No simplification
- No tiling

SCALGO Flash Flood Mapping

Models how surface water gathers in depressions as it rains

- Water from watershed of depression gathers in the depression
- Depressions fill, leading to (potentially dramatic) increase in neighbor depression watershed size



Flash Flood Mapping:

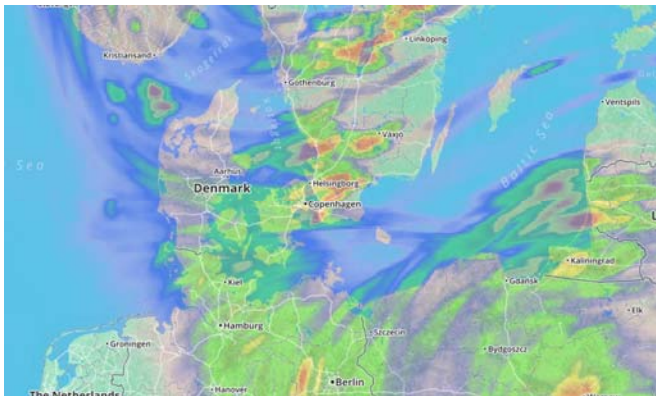
- Amount of rain before any given raster cell is below water

I/O-efficient MADALGO/SCALGO algorithm developed

Ongoing Flod-Risk Work

Ongoing work include

- Incorporation of infiltration and sewer-system
- Efficient (local) analysis update as data change
- Efficient scenario analysis
- Forecast based analysis



Online Demo

