

MapWindow and TauDEM V5

Chris George

WaterBase

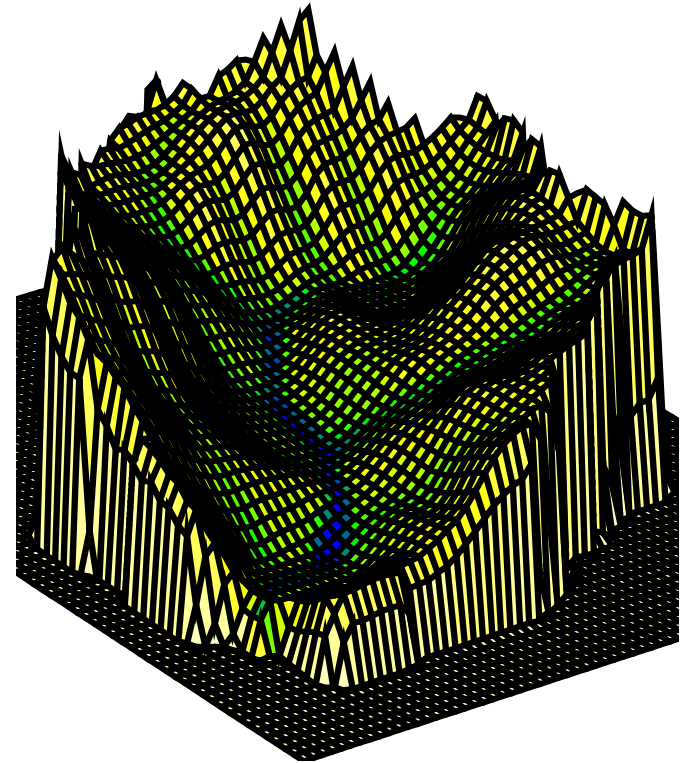
Terrain Analysis Using Digital Elevation Models (TauDEM)

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Deriving hydrologically useful information from Digital Elevation Models

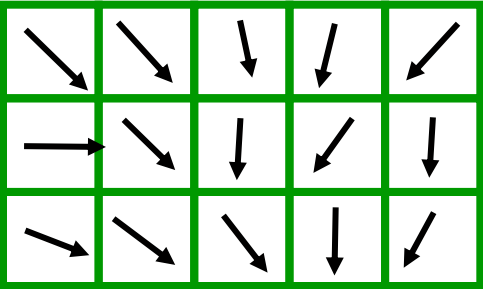
Raw DEM



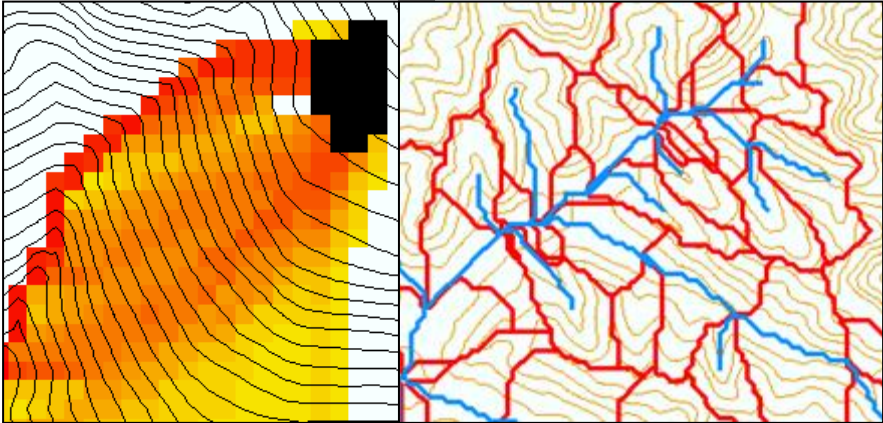
Pit Removal (Filling)



Flow Field



Flow Related Terrain Information



The challenge of increasing Digital Elevation Model (DEM) resolution

1980's DMA 90 m

10^2 cells/km²

1990's USGS DEM 30 m

10^3 cells/km²

2000's NED 10-30 m

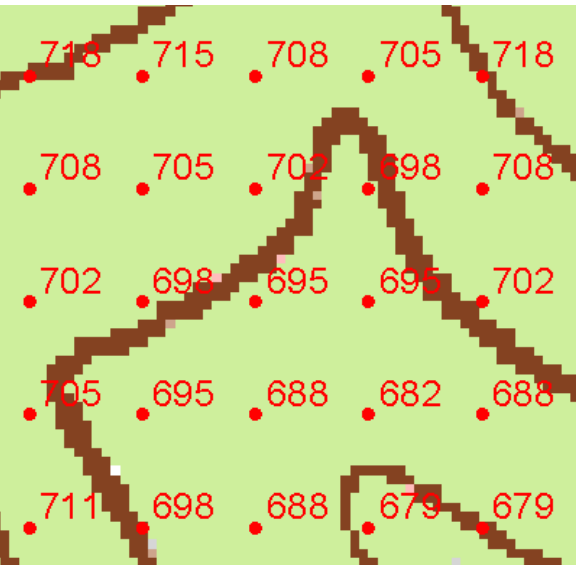
10^4 cells/km²

2010's LIDAR ~1 m

10^6 cells/km²



Grid Data Format Assumptions



- Input and output grids are uncompressed GeoTIFF
- Maximum size 4 GB
- GDAL Nodata tag preferred (if not present, a missing value is assumed)
- Grids are square ($\Delta x = \Delta y$)
- Grids are identical in extent, cell size and spatial reference
- Spatial reference information is not used (no projection on the fly)

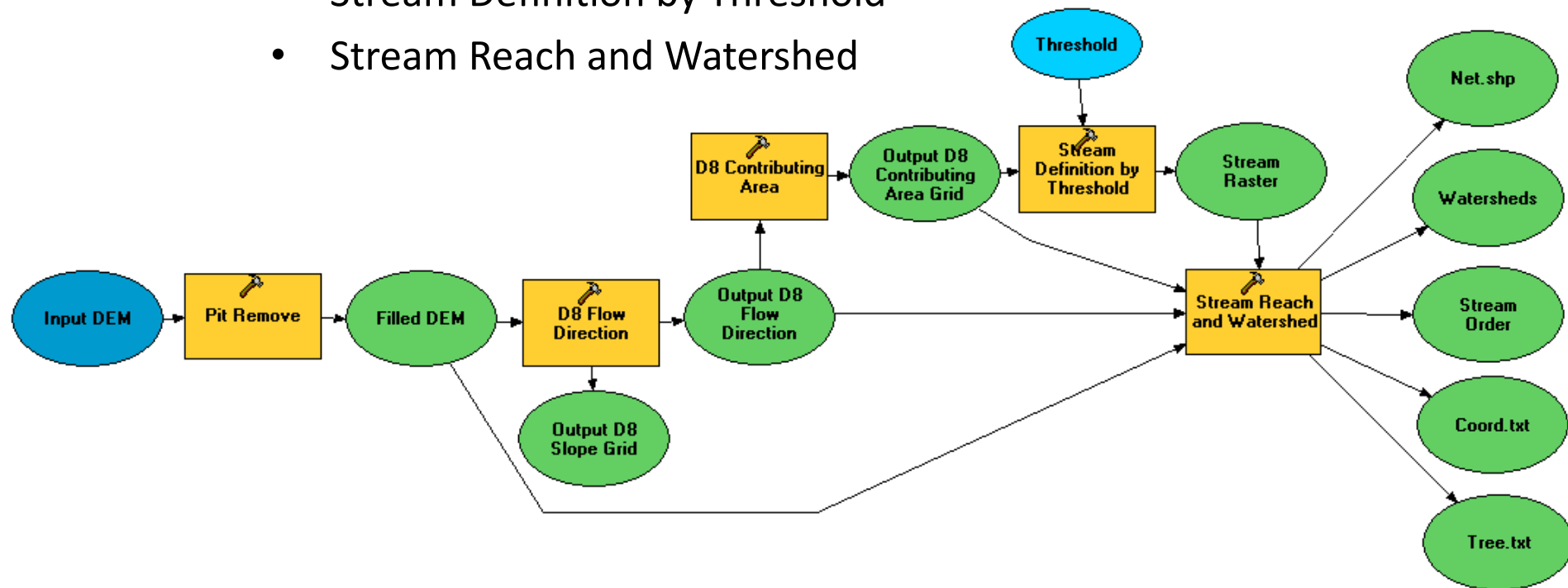
MapWindow port:

- Initial conversion to GeoTIFF if necessary
- Projection information is preserved

Illustrative Use Case: Delineation of channels and watersheds using a constant support area threshold

Steps

- Pit Remove
- D8 Flow Directions
- D8 Contributing Area
- Stream Definition by Threshold
- Stream Reach and Watershed



MapWindow AWD

Automatic Watershed Delineation

Setup and Preprocessing

Elevation Units: Meters | Base Elevation Data (DEM) Layer: Select a DEM Grid

Burn-in Existing Stream Polyline
Select a Stream Polyline Shapefile

Use a Focusing Mask

Use Current View Extents for Mask (Set Extents)

Use Grid or Shapefile for Mask
Select a Mask Grid or Polygon Shapefile or Use Extents

Draw Mask | Select Mask | 0 Selected

Use Existing Intermediate Files | Run

Network Delineation by Threshold Method

of Cells: | sq. mi

Use Existing Intermediate Files | Run

Custom Outlet/Inlet Definition and Delineation Completion

Use a Custom Outlets/Inlets Layer
Select a Point Shapefile, then Select or Draw Outlets/Inlets

Draw Outlets/Inlets | Select Outlets/Inlets | 0 Selected

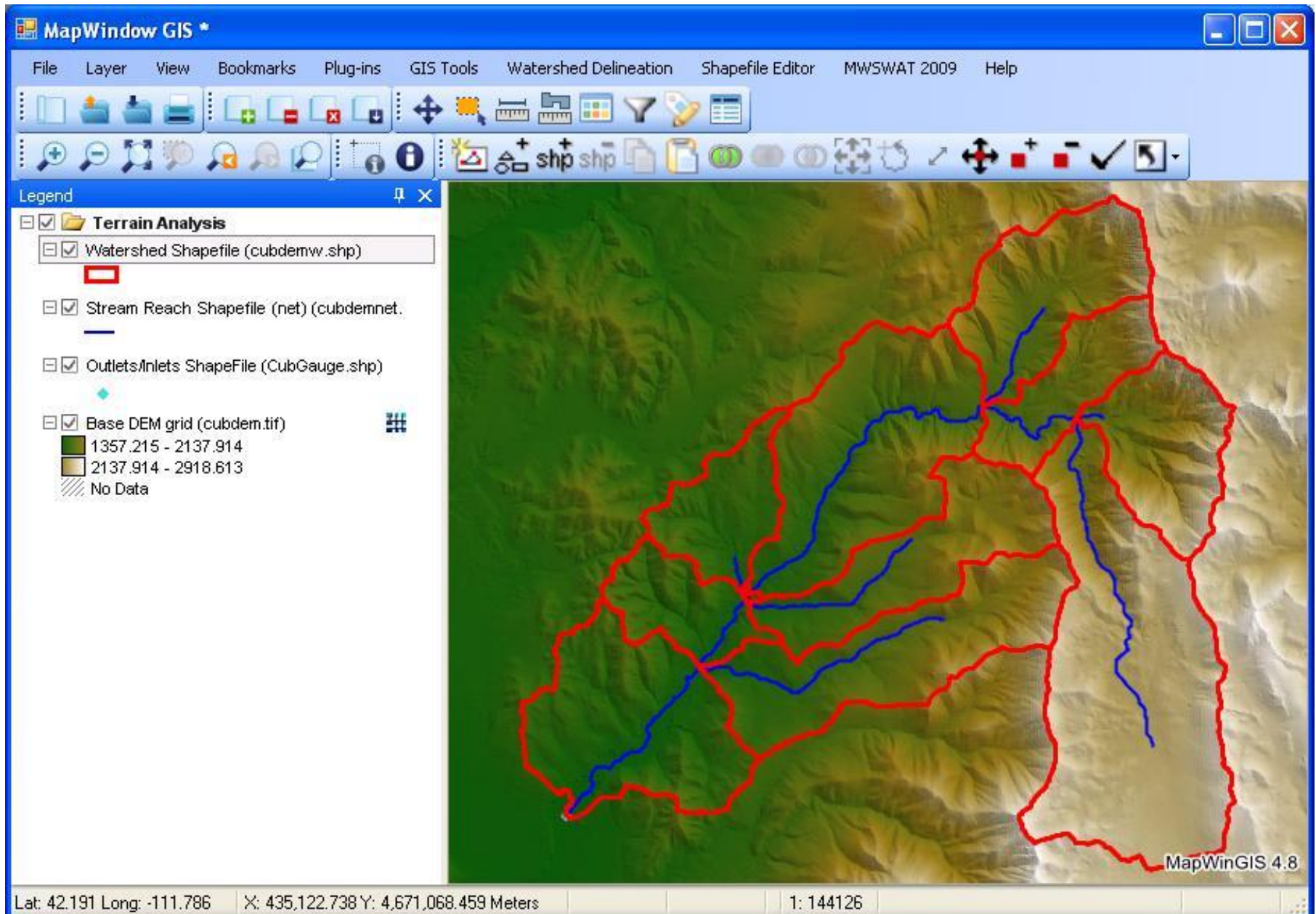
Snap Preview | Snap Threshold: 300 | Run

Number of processes: 8 | Show TauDEM output

Advanced Settings | Close | Run All

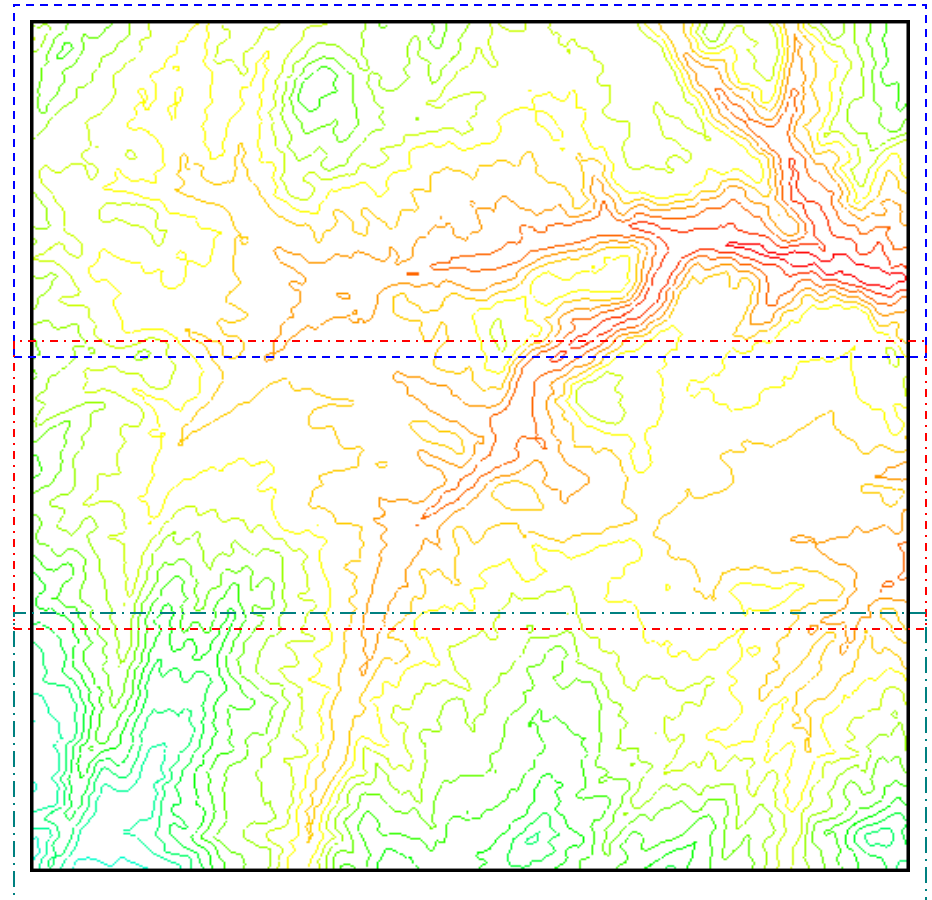
- Burn-in option
- Mask option
- Manual threshold (with suggestion based on DEM)
- Outlets option
- Plus inlets, point sources, reservoirs
- As previous foil, but also makes subbasin shapefile

AWD Result



Parallel Approach

- MPI, distributed memory paradigm
- Row oriented slices
- Each process includes one buffer row on either side
- Algorithm essentially compute, exchange buffer data, compute, until no change

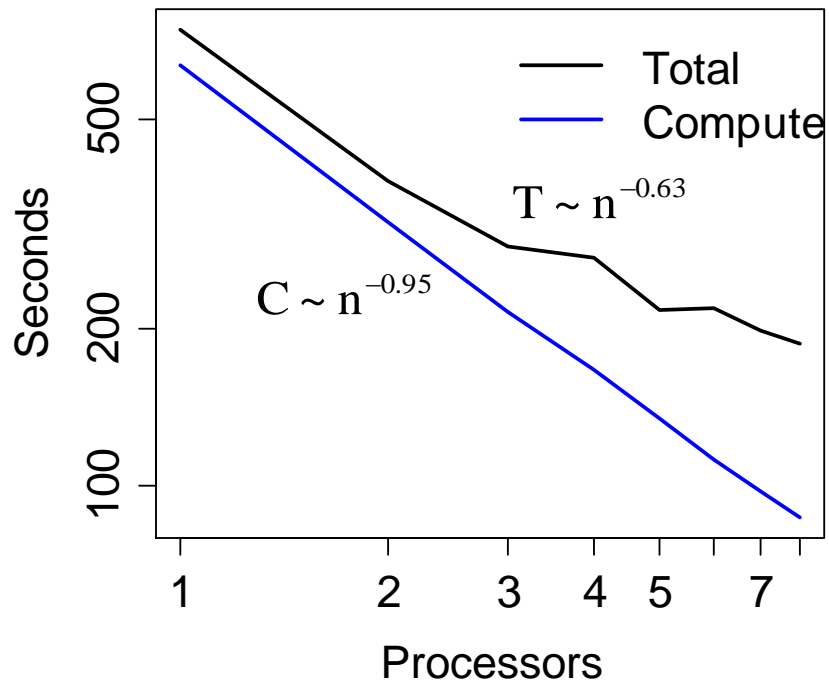


MPI implementation

- MPICH2 from Argonne National Laboratory
- Supports MPI-1 and MPI-2 standards
- Open source
- High performance, widely portable

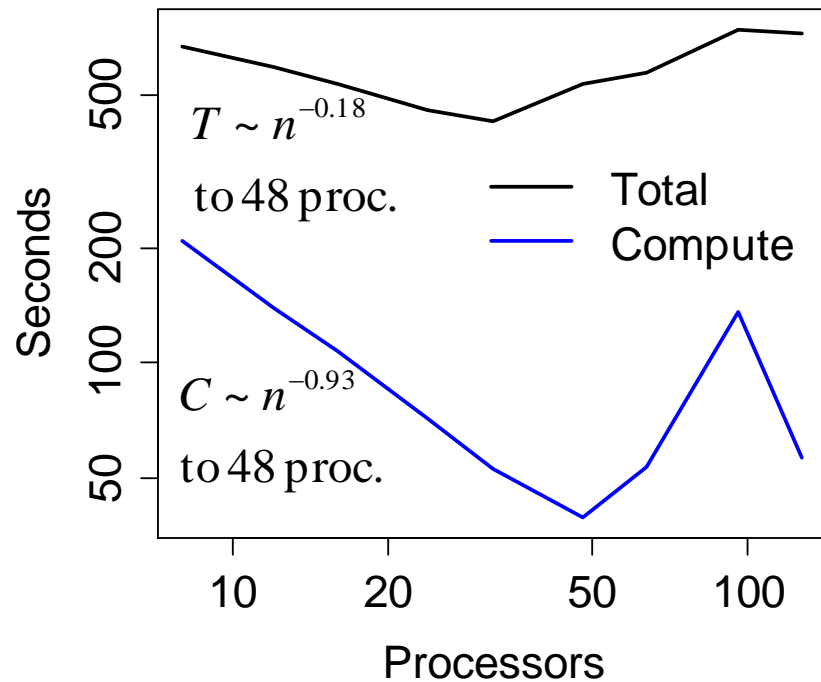
Improved runtime efficiency: Tarboton's results

Parallel D-Infinity Contributing Area Timing for Boise River dataset (24856 x 24000 cells ~ 2.4 GB)



8 processor PC

Dual quad-core Xeon E5405 2.0GHz PC with
16GB RAM



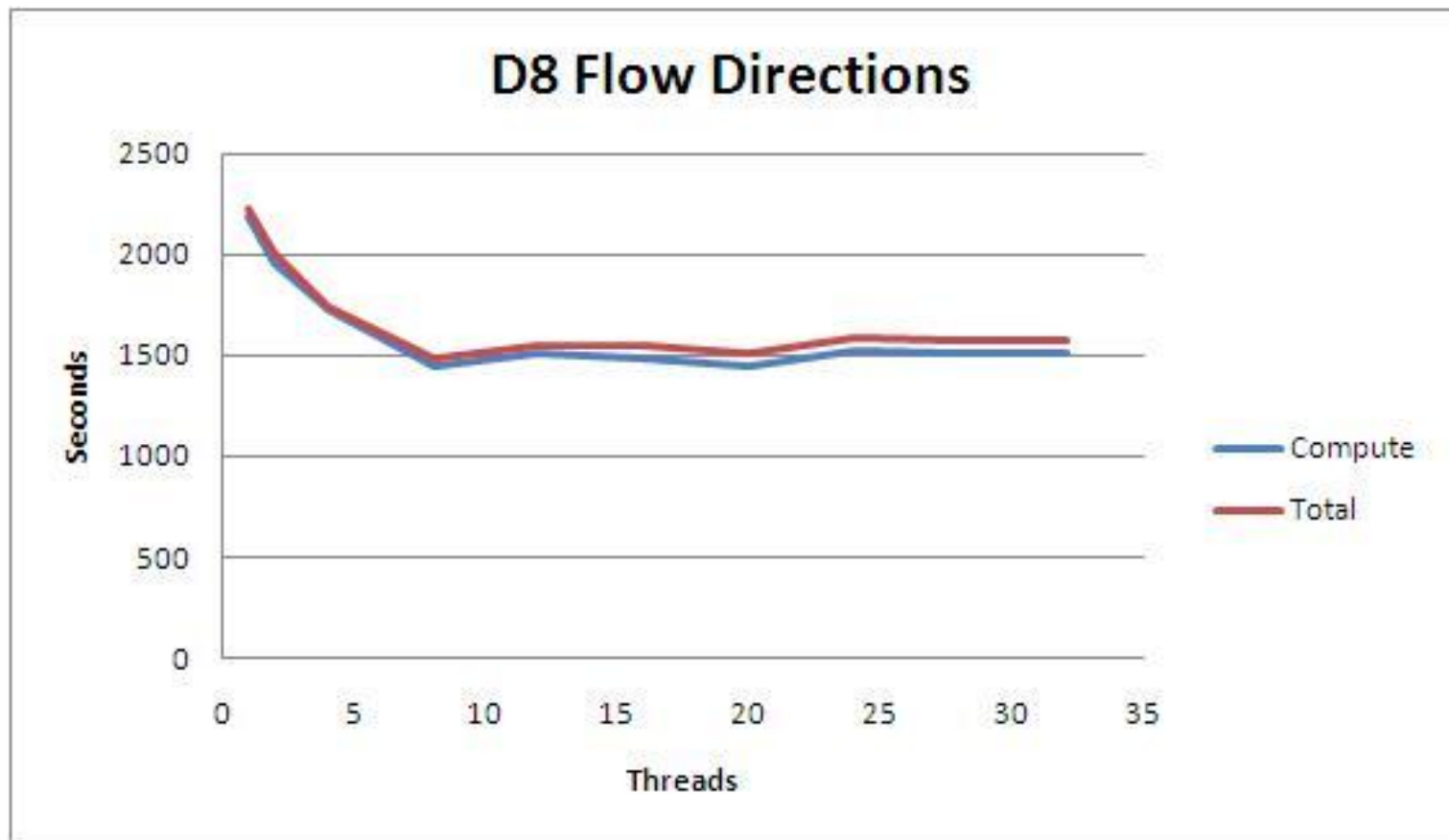
128 processor cluster

16 diskless Dell SC1435 compute nodes, each with 2.0GHz
dual quad-core AMD Opteron 2350 processors with 8GB RAM

On a More Typical Machine?

2 core CPU, 2.53 GHz, 2 GB Ram

6000 x 6000 SRTM 90m DEM



TauDEM Upgrade Objectives

- Same interface
- Easy installation
- Minimal maintenance

BUT

- TauDEM V5 comes as 25 separate executables
- MPICH2 needs administrator privileges
- Needs
 - Path to be set
 - User name and password to be set

although only local install needed

Approach used

- Basic install gives single processor use: MPICH2 used if program manager running
- MPICH2 can be installed (and upgraded) separately
- TauDEM executables run in minimised command window
- Output shown if requested or if error
- Requested output can be used to tune number of threads

Typical TauDEM Form

The image shows a screenshot of the 'D8 Flow Directions' dialog box in the TauDEM software. The dialog box has a blue title bar with the text 'D8 Flow Directions' and standard window control buttons (minimize, maximize, close). The main area is divided into 'Inputs' and 'Outputs' sections. Under 'Inputs', there is a field for 'Pit Filled Grid' with the path 'C:\Program Files\Taudem\CubRiver\Demo\cubdemfel.tif'. Under 'Outputs', there are two fields: 'D8 Flow Direction Grid' with the path 'C:\Program Files\Taudem\CubRiver\Demo\cubdemp.tif' and 'D8 Slope Grid' with the path 'C:\Program Files\Taudem\CubRiver\Demo\cubdemsd8.tif'. At the bottom, there is a 'Number of processes' field set to '8', a checked checkbox for 'Add layer(s) upon completion', and an unchecked checkbox for 'Show TauDEM output'. Three buttons are located at the bottom right: 'Help', 'Cancel', and 'Compute'.

D8 Flow Directions

Inputs

Pit Filled Grid C:\Program Files\Taudem\CubRiver\Demo\cubdemfel.tif

Outputs

D8 Flow Direction Grid C:\Program Files\Taudem\CubRiver\Demo\cubdemp.tif

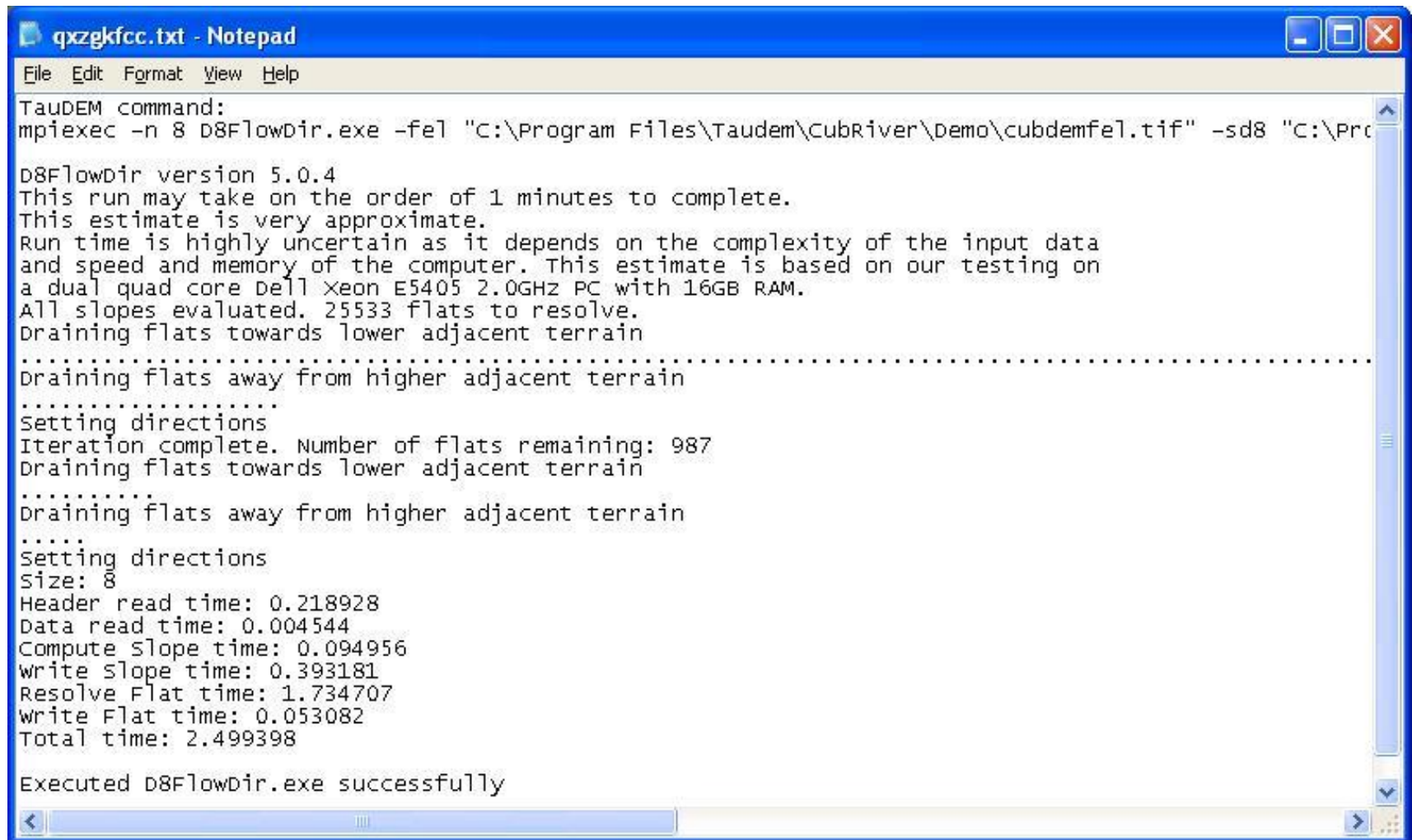
D8 Slope Grid C:\Program Files\Taudem\CubRiver\Demo\cubdemsd8.tif

8 Number of processes Add layer(s) upon completion Show TauDEM output

Help Cancel Compute

This is the default initial view: most file names preselected as defaults

TauDEM Output



```
qxzgfcc.txt - Notepad
File Edit Format View Help
TauDEM command:
mpirexec -n 8 D8FlowDir.exe -fel "C:\Program Files\Taudem\CubRiver\Demo\cubdemfel.tif" -sd8 "C:\Pro

D8FlowDir version 5.0.4
This run may take on the order of 1 minutes to complete.
This estimate is very approximate.
Run time is highly uncertain as it depends on the complexity of the input data
and speed and memory of the computer. This estimate is based on our testing on
a dual quad core Dell Xeon E5405 2.0GHZ PC with 16GB RAM.
All slopes evaluated. 25533 flats to resolve.
Draining flats towards lower adjacent terrain
.....
Draining flats away from higher adjacent terrain
.....
Setting directions
Iteration complete. Number of flats remaining: 987
Draining flats towards lower adjacent terrain
.....
Draining flats away from higher adjacent terrain
.....
Setting directions
Size: 8
Header read time: 0.218928
Data read time: 0.004544
Compute Slope time: 0.094956
Write Slope time: 0.393181
Resolve Flat time: 1.734707
Write Flat time: 0.053082
Total time: 2.499398

Executed D8FlowDir.exe successfully
```

Where else should MapWindow
be using multiple threads?