Workshop on:
Rainfall–Runoff Simulation Supporting with GIS and Satellite Data

Speaker:
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Watershed Modeling using HEC-GeoHMS
- Watershed boundary delineation
- Watershed parametrization

with the invention of Geospatial Information Systems (GIS) and computer models, the role of digital elevation model (DEM) has become very important and effective tools in flood inundation process. Flood simulation mapping and landslide susceptibility mapping are as examples that effectively employ the DEM and its derivatives as one of the important modeling inputs. On the other hand, satellite based DEMs have been growing rapidly in recent years.
Since Miller and Laflamme who coined the original term, other expressions such as DEM, Digital Height Models (DHM), Digital Surface Model (DSM), Digital Terrain Model (DTM), Digital Ground Models (DGM) and Digital Terrain Elevation Model (DTEM), have been used by Maidment, Djokic and Ye, Vieux and Li et al. According to Li et al. the word DEM is widely used in United States, DHM in Germany, DGM in the United Kingdom and DTEM was introduced and is used by United States Geological Survey (USGS).

Recommended DEM cell sizes and their range of applications (After Maidment)

<table>
<thead>
<tr>
<th>Cell Size</th>
<th>Watershed Area (km²)</th>
<th>Typical Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 m</td>
<td>5</td>
<td>Urban watersheds</td>
</tr>
<tr>
<td>90 m</td>
<td>40</td>
<td>Rural watersheds</td>
</tr>
<tr>
<td>460 m</td>
<td>1000</td>
<td>River basins</td>
</tr>
<tr>
<td>930 m</td>
<td>4000</td>
<td>Nations</td>
</tr>
<tr>
<td>5.6 km</td>
<td>150,000</td>
<td>Continents</td>
</tr>
<tr>
<td>9.3 km</td>
<td>400,000</td>
<td>Global</td>
</tr>
</tbody>
</table>

Different sources of free satellite-based DEMs:
Different sources of free satellite-based DEMs:

ASTER Satellite Sensor Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Launch Date</td>
<td>18 December 1999 at Vandenberg Air Force Base, California, USA</td>
</tr>
<tr>
<td>Equator Crossing</td>
<td>10:30 AM (north to south)</td>
</tr>
<tr>
<td>Orbit</td>
<td>705 km altitude, sun synchronous</td>
</tr>
<tr>
<td>Orbit Inclination</td>
<td>98.3 degrees from the equator</td>
</tr>
<tr>
<td>Orbit Period</td>
<td>98.88 minutes</td>
</tr>
<tr>
<td>Grounding Track Repeat Cycle</td>
<td>16 days</td>
</tr>
<tr>
<td>Resolution</td>
<td>15 to 90 meters</td>
</tr>
</tbody>
</table>

iSAR-DEM

<table>
<thead>
<tr>
<th>Product Deliverables</th>
<th>Pixel Size/Point Spacing</th>
<th>Accuracy (RMSE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1 Digital Surface Model (DSM)</td>
<td>5.5m</td>
<td>1.0m vertical, 2.0m horizontal</td>
</tr>
<tr>
<td>Topo Digital Terrain Model (DTM)</td>
<td>5.5m</td>
<td>1.0m vertical, 2.0m horizontal</td>
</tr>
<tr>
<td>Type 1 Orthorectified Pixel Image (ORI)</td>
<td>6.625m/1.25m</td>
<td>1.0m vertical, 2.0m horizontal</td>
</tr>
</tbody>
</table>
DEM Applications:

- Watershed delineation and rainfall runoff simulation

Integration with Landsat image for better visualization:
DEM Optimization
Hydrologically adjusted DEM or called Agree-DEM

Basic steps:
- Smoothing (using average filter)
- Majority filter (filling undefined pixels)
- Filling sinks
- Reconditioning

DEM creation results in artificial sinks in the landscape.
A sink is a set of one or more cells which has no downstream cells around it.
Unless these sinks are filled they will isolate portions of the watershed.
Filling sinks is the first step for processing a DEM for watershed delineation.

DEM reconditioning using attributes table of stream network

Schematic representation of DEM reconditioning
DEM optimization process

Problem with cartographic product

Watershed-layout in map index of topo sheets at scale of 1:25000
Filling void areas at sheet number 3757b (scale 1:25000) with topo sheets at scale 1:10000

Problem with cartographic product

Code consistency
**Edge matching**

![Edge matching diagram](image)

**Hydrologic Slope - Direction of Steepest Descent**

Slope: \( \frac{67 - 48}{30} = 0.45 \)

**Flow Direction Arrows Based on Direction of Steepest Descent**

![Flow direction arrows](image)
Eight Direction Pour Point Model

ArcGIS Flow Direction Encoding

GIS-based River Discharge Modeling Workshop

ArcGIS Flow Direction Raster Encoding

Flow Accumulation
Number of Cells Contributing Flow

Flow Direction

Flow Accumulation
Value = Number of Cells Flowing Into
Delineating Surface Water Drainage

Legend
- Waterbody
- Reservoir
- Irrigation

Primary delineated sub-basins boundary before batch point processing (left) and after batch point processing and merging and splitting sub-basins (right).
Observed and simulated flood hydrograph resultant from modified-CN for event 6 May at Sulaiman Bridge.
Exercise 2

- Open your ArcMap and activate your HEC-GeoHMS extension
- Generate Agree-DEM for raw DEM provided on d:/data
- Delineate watershed boundary for the Klang Gates Dam watershed
- Calculate the following watershed characteristics for each subbasin:
  (i) form factor,
  (ii) compactness coefficient,
  (iii) elongation ratio, and
  (iv) circularity ratio.

Thank you

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