Universiti Malaysia PAHANG

Workshop on:

Rainfall–Runoff Simulation Supporting with GIS and Satellite Data

Speaker:
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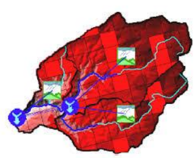
Venue: FKASA 5, Level 1, Faculty of Civil Engineering & Earth Resources University of Malaysia Pahang (UMP), 26300 Gambang, Kuantan, Malaysia

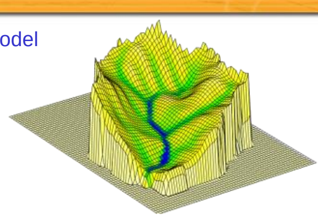
Watershed Modeling using HEC-GeoHMS

- Watershed boundary delineation

- Watershed parametrization



Digital Elevation Model (DEM)



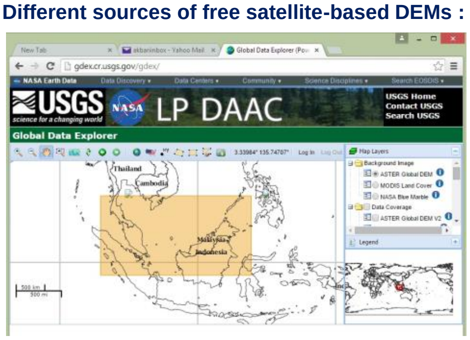
with the invention of Geospatial Information Systems (GIS) and computer models, the role of digital elevation model (DEM) has become very important and effective tools in, Flood inundation process. Flood simulation mapping and landslide susceptibility mapping are as examples that effectively employ the 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)

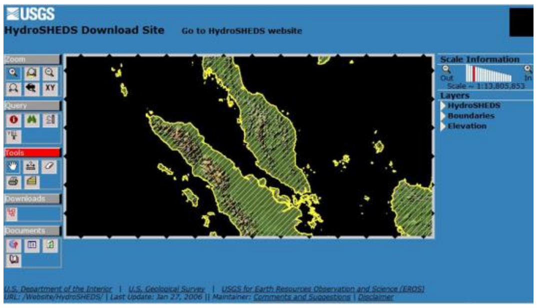
Recommended DEM cell sizes and their range of applications (After Maidment)

Cell Size	Watershed Area (km^2)	Typical Application
30 m	5	Urban watersheds
90 m	40	Rural watersheds
460 m	1000	River basins
930 m	4000	Nations
5.6 km	150,000	Continents
9.3 km	400,000	Global

Different sources of free satellite-based DEMs :



Different sources of free satellite-based DEMs :

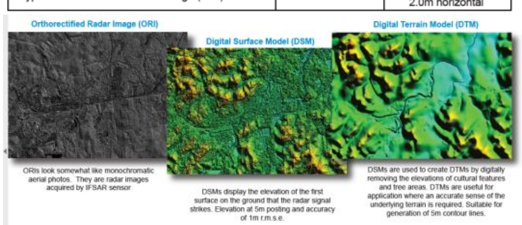


ASTER Satellite Sensor Specifications

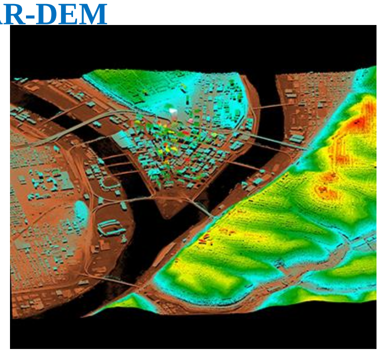
Launch Date	18 December 1999 at Vandenberg Air Force Base, California, USA
Equator Crossing	10:30 AM (north to south)
Orbit	705 km altitude, sun synchronous
Orbit Inclination	98.3 degrees from the equator
Orbit Period	98.88 minutes
Grounding Track Repeat Cycle	16 days
Resolution	15 to 90 meters

ifSAR-DEM

Product Deliverables	Pixel Size/Post Spacing	Accuracy (RMSE)
Type II Digital Surface Model (DSM)	5.0m	1.0m vertical 2.0m horizontal
Tropical Digital Terrain Model (DTM)	5.0m	1.0m vertical 2.0m horizontal
Type 1+ Orthorectified Radar Image (ORI)	0.625m/1.25m	1.0m vertical 2.0m horizontal



LiDAR-DEM



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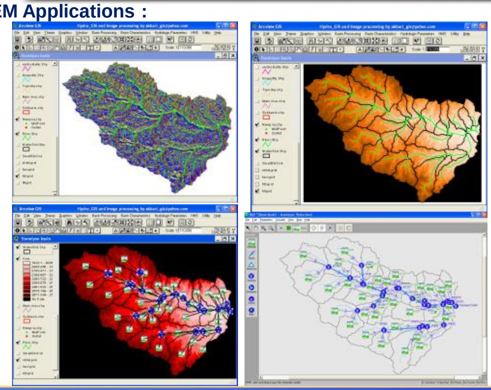
DEM Applications :



❖ Watershed delineation and rainfall runoff simulation

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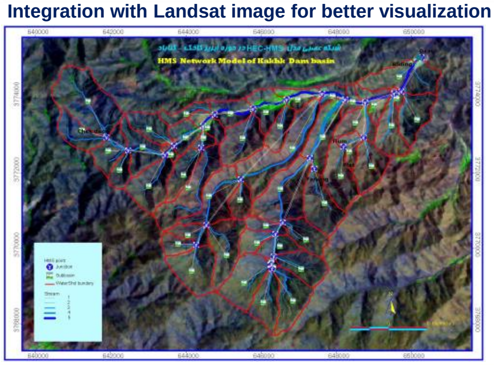
Integration with Landsat image for better visualization :



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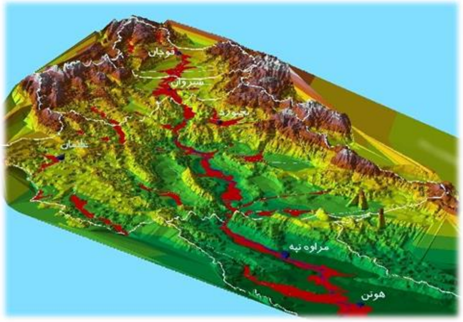
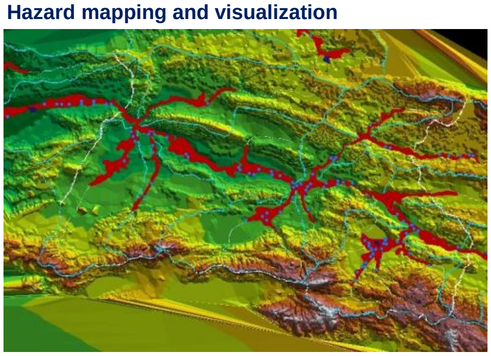
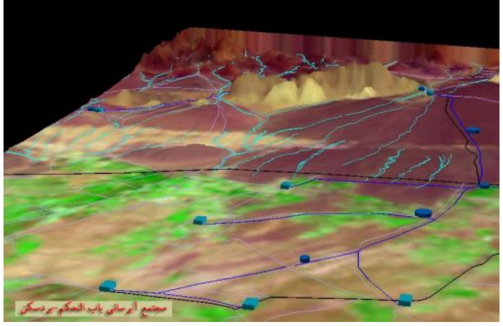
Flood inundation modeling and visualization



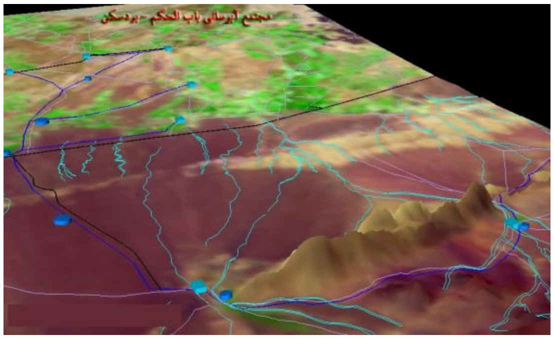
Hazard mapping and visualization



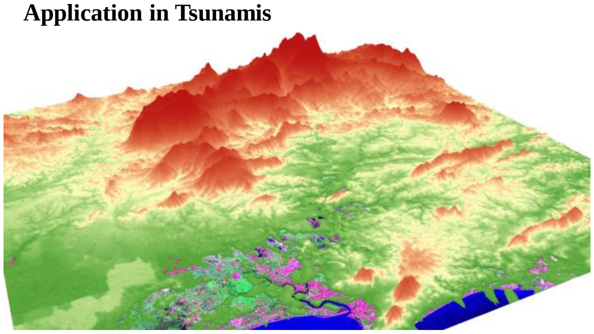
Design of water supply systems



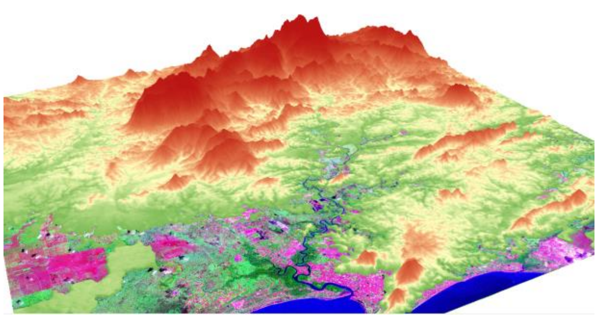
Water supply systems



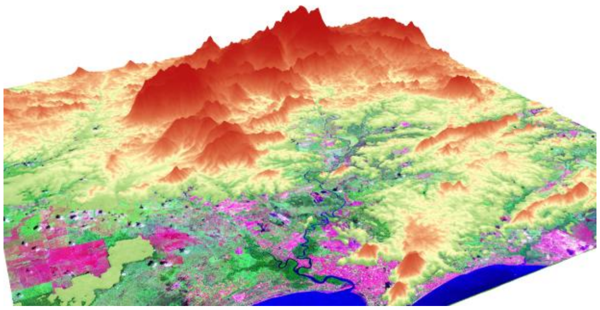
Application in Tsunamis



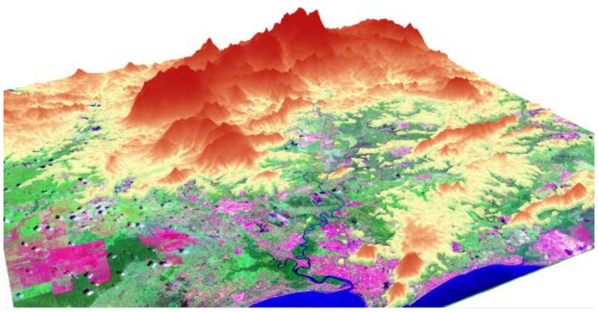
Tsunamis wave 10 m



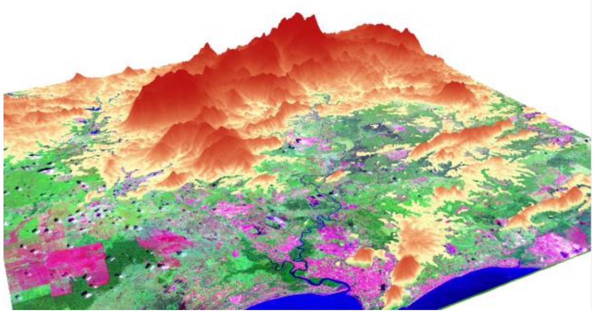
Tsunamis wave 20 m



Tsunamis wave 30 m



Tsunamis wave 40 m

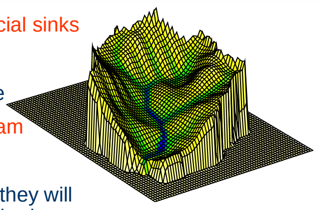


Tsunamis wave 50 m

DEM Optimization
Hydrologically adjusted DEM or called Agree-DEM

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

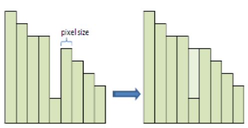
DEM creation results in artificial sinks in the landscape.



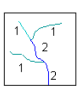
A sink is a set of one or more cells which has no downstream cells around it.

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.

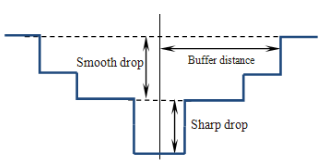


Profile view of sink in DEM (left) and filled depression of DEM (right)



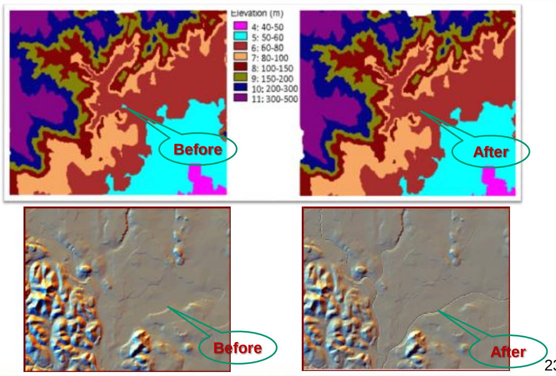
	Buffer_dist	Smooth_drop	Sharp_drop
2	40	2.0	2.0
1	20	1.0	1.0

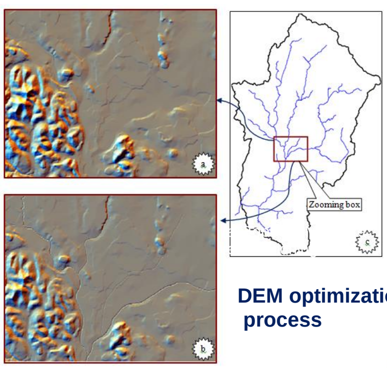
DEM reconditioning using attributes table of stream network



Schematic representation of DEM reconditioning

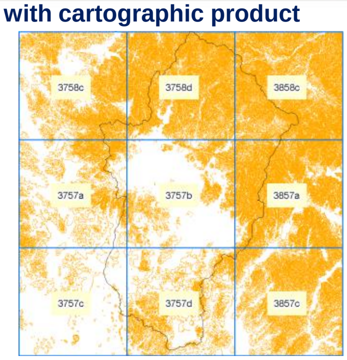
DEM optimization process





DEM optimization process

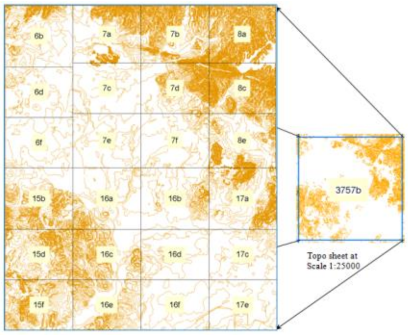
Problem with cartographic product



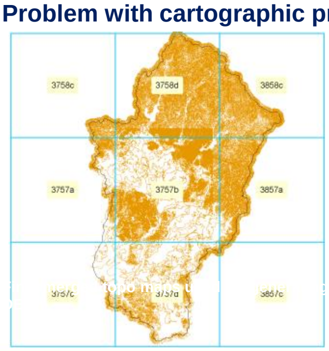
Watershed-layout in map index of topo sheets at scale of 1:25000

Problem with cartographic product

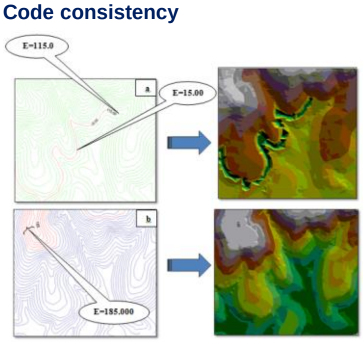
Filling void areas at sheet number 3757b (scale 1:25000) with topo sheets at scale 1:10000



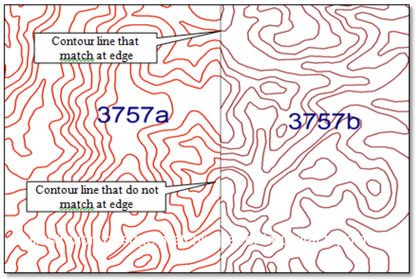
Problem with cartographic product



Code consistency



Edge matching



Hydrologic Slope
- Direction of Steepest Descent

← 30 →

67	56	49
52	48	37
58	55	22

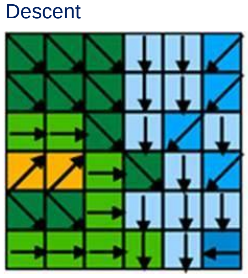
← 30 →

67	56	49
52	48	37
58	55	22

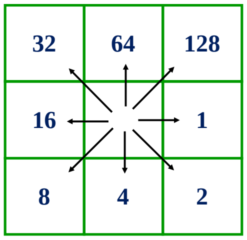
Slope: $\frac{67-48}{30\sqrt{2}} = 0.45$ $\frac{67-52}{30} = 0.50$

Flow Direction Arrows
Based on Direction of Steepest Descent

78	72	69	71	58	49
74	67	56	49	46	50
69	53	44	37	38	48
64	58	55	22	31	24
68	61	47	21	16	19
74	53	34	12	11	12



Eight Direction Pour Point Model



ArcGIS Flow Direction Encoding

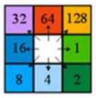
ArcGIS Flow Direction Raster Encoding

78	72	69	71	58	49
74	67	56	49	46	50
69	53	44	37	38	48
64	58	55	22	31	24
68	61	47	21	16	19
74	53	34	12	11	12

Elevation

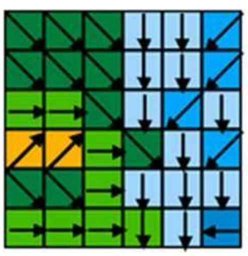
2	2	2	4	4	8
2	2	2	4	4	8
1	1	2	4	8	4
128	128	1	2	4	8
2	2	1	4	4	4
1	1	1	1	4	16

Flow Direction



Direction Coding

Flow Accumulation
Number of Cells Contributing Flow

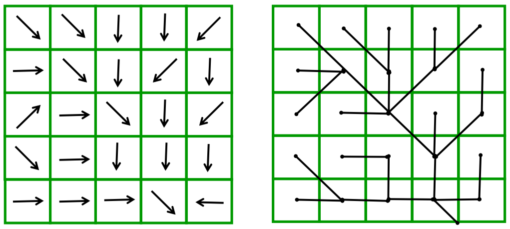


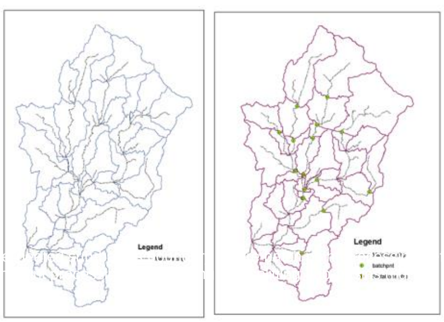
Flow Direction

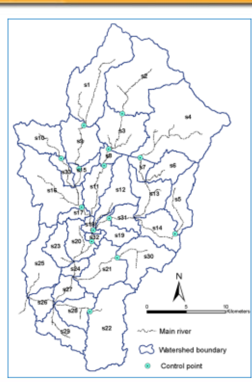
0	0	0	0	0	0
0	1	1	2	2	0
0	3	7	5	4	0
0	0	0	20	0	1
0	0	0	1	24	0
0	2	4	7	35	2

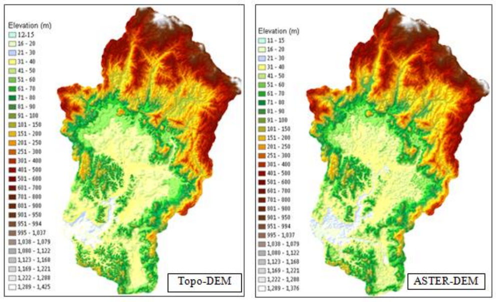
Flow Accumulation
Value = Number of Cells Flowing Into

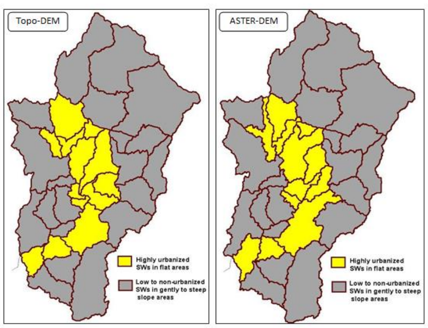
Delineating Surface Water Drainage

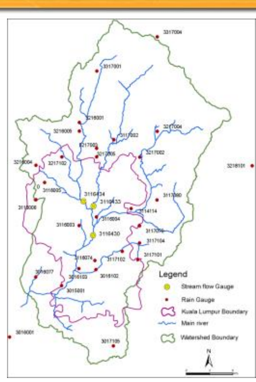


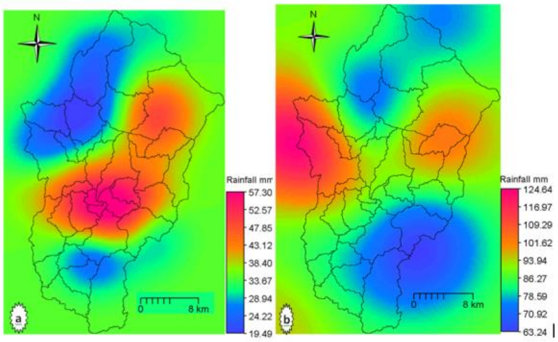


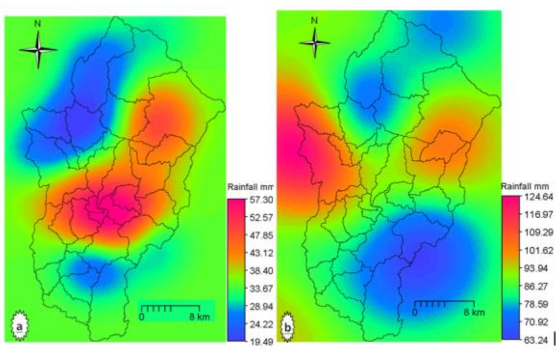


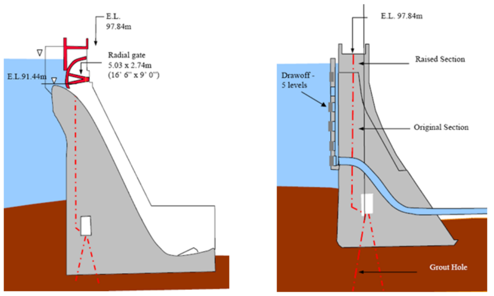

Elevation (m)
Topo-DEM
Elevation (m)
ASTER-DEM


Topo-DEM
Highly urbanized SWs in flat areas
Low to non-urbanized SWs in gently to steep slope areas
ASTER-DEM
Highly urbanized SWs in flat areas
Low to non-urbanized SWs in gently to steep slope areas

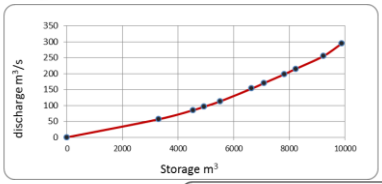

Legend
Stream flow Gauge
Rain Gauge
Kuala Lumpur Boundary
Main river
Watershed Boundary





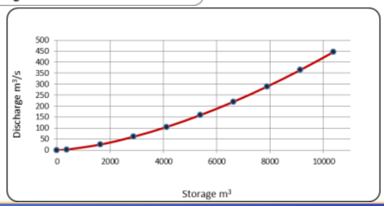


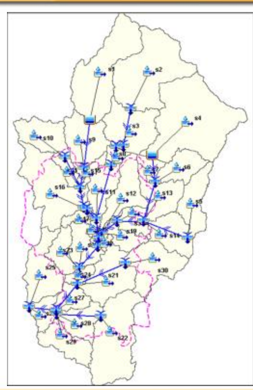
Cross section of Klang Gate Dam. Taken from Gibson and Dodge (1983)

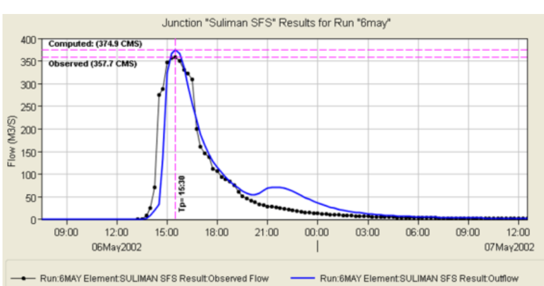


Storage-discharge relationship of Klang Gate Dam

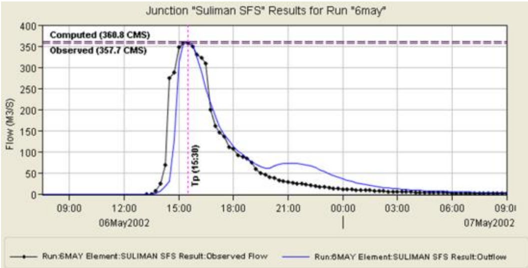
Storage-discharge relationship of Batu Dam







Observed and simulated flood hydrograph resultant from modified-CN for event 6-May at Sulaiman Bridge.



Observed and simulated flood hydrograph resultant from modified-CN for event 6-May at Sulaiman Bridge.

Exercise 2

- Open your ArcMap and active 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

akbariinbox@yahoo.com