OPTIMIZATION OF FLOOD INUNDATION SIMULATION USING MULTI-RESOLUTION DIGITAL ELEVATION MODEL

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by

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LIST OF SYMBOLS

%	Percentage
A_k	Area of face *k*
$A_k(H)$	Area of face *k* as a function of water elevation
C	Courant number
D	Depth
D_{bias}	Bias of data
D_h	Equivalent diameter (=4R_h, m)
E_u	Euler number
E_b	Fluid's bulk modulus
F_m	Froude number of the model
F_p	Froude number of the prototype
F_r	Froude number
G	Gravitational acceleration
g	Gravitational acceleration
H	Water Surface Elevation, Water depth, Height
L	Length
l_k	Length of the edge *k*
L_m	Length of the model
L_p	Length of the prototype
M	Mass
M_a	Sarrau-Mach number
N	Total number of sample
n_k	Unit normal vector at face *k*
No.	Number
P	Cell area

ΔP	Pressure difference
Q_{do}	Observation data
Q_{ds}	Simulation data
Q_m	Flow of the model
Q_o	Observation data
Q_p	Flow of the prototype
Q_s	Simulation data
R^2	Square for the Pearson correlation coefficient
R_e	Reynolds number
Re_m	Reynolds number of the hydraulic model
Re_o	Reynold number of the real system
S	Scale between prototype and model
s	Time step
S_f	Friction Slope
S_o	Bed Slope
T	Time
$t + \Delta t$	New time step
U	Mean velocity
v	Velocity of the flood wave (m/s)
V	Average water velocity (m/s)
V_k	Average velocity at face k
V_m	Velocity of the model
V_p	Velocity of the prototype
W	Width
W_e	Weber number
Δt	Time step
ΔT	The computational time step

ΔX	Average cell size (m)
λ_1	Gravitational forces
μ	Dynamic viscosity (=10^{-3} kg/sm)
ρ	Water density (=1000 kg/m^3)
Ω	Volume of a horizontally bounded region
σ	Surface tension

LIST OF ABBREVIATIONS

1D	One-Dimensional
1D/2D	One-Dimensional and Two-Dimensional
1D-2D	One-Dimensional and Two-Dimensional
2D	Two-Dimensional
3D	Three-Dimensional
ADI	Alternating Direction Implicit
ASTER	Advance Space Borne Thermal Emission and Reflection Radiometer
ASTER GDEM	Advance Space Borne Thermal Emission and Reflection Radiometer-Global Digital Elevation Model
Bappeda	Palembang City Regional Planning and Development Agency
CA Approach	Cellular Automata Approach
CESR	Center for Environmental System Research
CGIAR-CSI	Consultative Group for International Agriculture Research Consortium for Spatial Information
CIAT	International Centre for Tropical Agriculture
DEM	Digital Elevation Model
DGM	Digital Ground Model
DHM	Digital Height Model
DJI	Da-Jiang Innovations Science and Technology Co. Ltd.
DMA	Defence Mapping Agency
DSM	Digital Surface Model
DTEM	Digital Terrain Elevation Model
DTM	Digital Terrain Model
eATE	Enhanced Automatic Terrain Extraction
EU	European Union
FEM	Finite Element Method
FESWMS	Finite Element Surface Water Modelling Software

FESWMS-2DH	Finite Element Surface Water Modelling Software: Two-Dimensional Flow in a Horizontal Plane
GIS	Geographic Information System
GMTED	Global Multi-resolution Terrain Elevation Data
GMTED2010	Global Multi-resolution Terrain Elevation Data 2010
GPS	Global Positioning System
GTOPO30	Global Topography 30 arc second
GUFIM	GIS-based Urban Flood Inundation Model
HAND	Height Above the Nearest Drainage
HEC	Hydrological Engineering Center
HEC-HMS	Hydrological Engineering Center-Hydrologic Modeling System
HEC-RAS	Hydrological Engineering Center-River Analysis System
HydroSHEDS	Hydrological data and maps based on Shuttle Elevation Derivatives at Multiple Scales
IFAS	Integrated Flood Analysis System
IfSAR	Interferometric Synthetic Aperture Radar
InfoWorks RS	InfoWork River Simulation
JPS	Jabatan Pengairan dan Saliran Malaysia
LiDAR	Laser Induced Detection and Ranging
LP DAAC	Land Processes Distributed Active Archive Center
LPS	Leica Photogrammetry Suite
LULC	Land Use / Land Cover
MAE	Mean absolute error
METI	Ministry of Economy, Trade, and Industry
MLC	Maximum likehood classification
MODIS	Moderate Resolution Imaging Spectroradiometer
MRAE	Mean relative absolute error
NASA	National Aeronautics and Space Administration
NCFS	Near Channel Floodplain Storage

NGA	National Geospatial-Intelligence Agency
NIMA	National Imagery and Mapping Agency
No.	Number
Poly.	Polynomial
RANS	Reynolds Average Navier-Stokes
RFIM	Rapid Flood Inundation Model
RFSM	Rapid Flood Spreading Model
RISMO2D	River Simulation Model : 2-Dimensional
RMSE	Root Mean Square Error
RR	Rainfall-Runoff
RRI	Rainfall-Runoff-Inundation Model
SAR	Synthetic Aperture Radar
SfM	Structure from Motion
Sg.	Sungai
SIR-C	Dual Space Borne Imaging Radar
SRTM	Shuttle Radar Topography Mission
SWE	Shallow Water Equation
SWMM	Storm Water Management Model
TIN	Triangular Irregular Network
TNC	The Nature Conservancy
TVD	Total Variation Diminishing
UAV	Unmanned Aerial Vehicle
UK	United Kingdom
US	United States
USA	United States of America
USGS	United States Geological Survey
USISM	Urban Storm Inundation Simulation Method
VisualSFM	Visual Structure from Motion
VSAS3	Variable Source Area Simulator 3

WGS84	World Geodetic System 1984
WSE	Water Surface Elevation
WWF	World Wildlife Fund
X-SAR	Dual X-band Synthetic Aperture Radar

PENGOPTIMUMAN SIMULASI LIMPAHAN BANJIR MENGGUNAKAN KAEDAH MULTI-RESOLUSI MODEL KETINGGIAN DIGITAL

ABSTRAK

Beberapa kajian telah dilakukan untuk menambah baik simulasi limpahan banjir yang dihasilkan daripada Model Ketinggian Digital (DEM) kasar seperti penggunaan pengubahsuaian pengagihan ruang DEM dan pengubahsuaian keratan rentas sungai. Semua model ini memberi tumpuan kepada DEM. Sehingga kini, kajian pengoptimuman berkaitan hubungan di antara resolusi DEM dengan pengagihan limpahan banjir adalah terhad. Parameter ini adalah salah satu komponen utama di dalam fenomena banjir dan memerlukan ketepatan yang tinggi agar tindakan selanjutnya dapat dilakukan di dalam pengurusan risiko banjir. Di samping itu, nilai aliran masuk juga boleh digunakan untuk mengoptimumkan simulasi limpahan banjir tanpa mengganggu DEM kasar. Dalam kajian ini, hubungan di antara resolusi DEM dan ramalan limpahan banjir ditentukan dalam usaha untuk mencadangkan kaedah pengoptimuman baru bagi ramalan limpahan banjir. Kaedah ini dilakukan dengan menggabungkan nilai aliran masuk dengan hubungan di antara resolusi DEM dan limpahan banjir. Model hidraulik Sungai Bertam, Cameron Highland dibangunkan dengan skala 1:25 untuk menjalankan eksperimen dengan nilai aliran masuk yang berbeza. Hasilnya digunakan untuk mengesahkan model simulasi berangka 2D HEC-RAS. Kemudian, DEM beresolusi tinggi disampelkan kepada beberapa DEM beresolusi kasar untuk mensimulasikan semula limpahan banjir. Kedua-dua hasil DEM dan limpahan banjir (Ketinggian Permukaan Air (WSE), keluasan banjir, dan kelebaran banjir) digunakan untuk menentukan kesan

parameter aliran air masuk terhadap pengoptimuman simulasi limpahan banjir. Selain itu, pengoptimuman juga disahkan melalui eksperimen model hidraulik. Eksperimen model hidraulik menunjukkan geometri saluran air (bentuk and cerun) memainkan peranan penting dalam limpahan banjir dan nilai aliran masuk yang bersamaan dengan 64 l/s menghasilkan banjir besar di hilir sungai. Didapati bahawa persetujuan yang baik antara model hidraulik dan model HEC-RAS diperolehi kecuali pada aliran masuk yang rendah (25 m^3/s dan 50 m^3/s), halaju air (maksimum Purata Relatif Ralat Mutlak (MRAE) = 0.408) dan masa perjalanan aliran air (R^2 = 0.595). Hal ini disebabkan oleh algoritma “diffusive wave” yang terhad, permodelan 2-dimensi dan kesan konfigurasi grid. Hubungan antara resolusi DEM dan WSE memberikan hasil R^2 yang paling baik dengan nilai minimum R^2 = 0.9845 pada aliran masuk bersamaan 150 m^3/s. Peningkatan resolusi DEM juga meningkatkan indeks Purata Ralat Mutlak (MAE) dan MRAE. Pengoptimuman menggunakan hubungan antara resolusi DEM dan WSE serta beberapa nilai aliran air masuk memberikan peningkatan yang ketara sehingga 72 % daripada indeks MRAE untuk kelebaran banjir dan 131.53 % indeks MRAE untuk keluasan kawasan banjir. Pengesahan menggunakan eksperimen model hidraulik pada aliran masuk 200 m^3/s menunjukkan bahawa kaedah pengoptimuman ini meningkatkan indeks MRAE bagi WSE sebanyak 23 %. Kajian ini boleh disimpulkan bahawa simulasi limpahan banjir boleh di tambah baik dengan mengubahsuai parameter aliran masuk dan juga korelasi diantara resolusi DEM dan ramalan limpahan banjir.

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