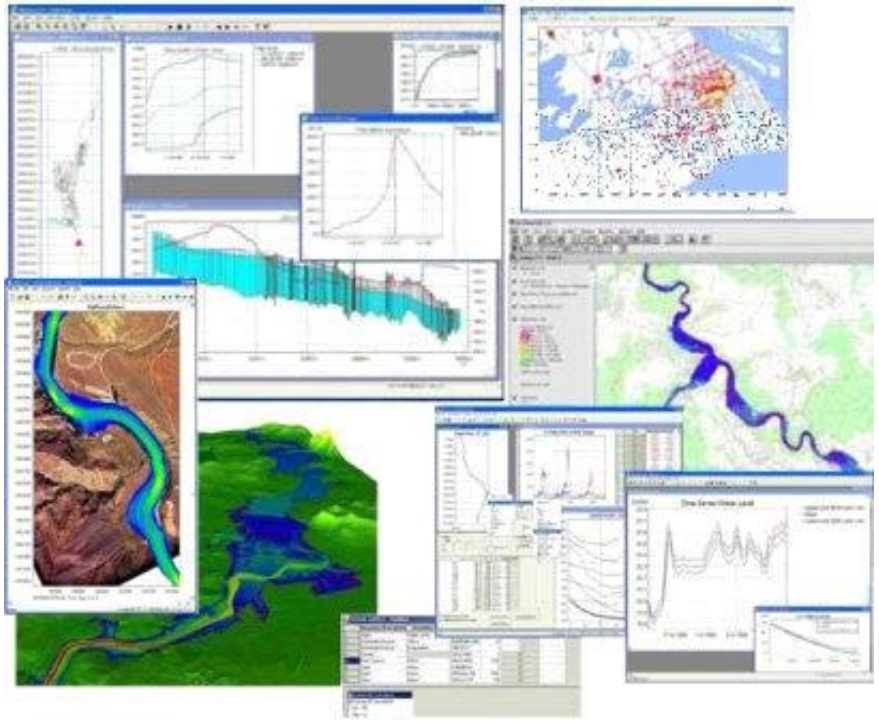
River Modelling



Assignment1: 1D Model Set-up

Steady Model

Modelling Process

Typical Modelling Steps

- data collection and pre-analysis and -processing
- **model set-up (steady model)**
- model calibration
- model validation
- model application
- data post-processing
- ….

Hydrodynamic Software Tools

Numerical Simulation

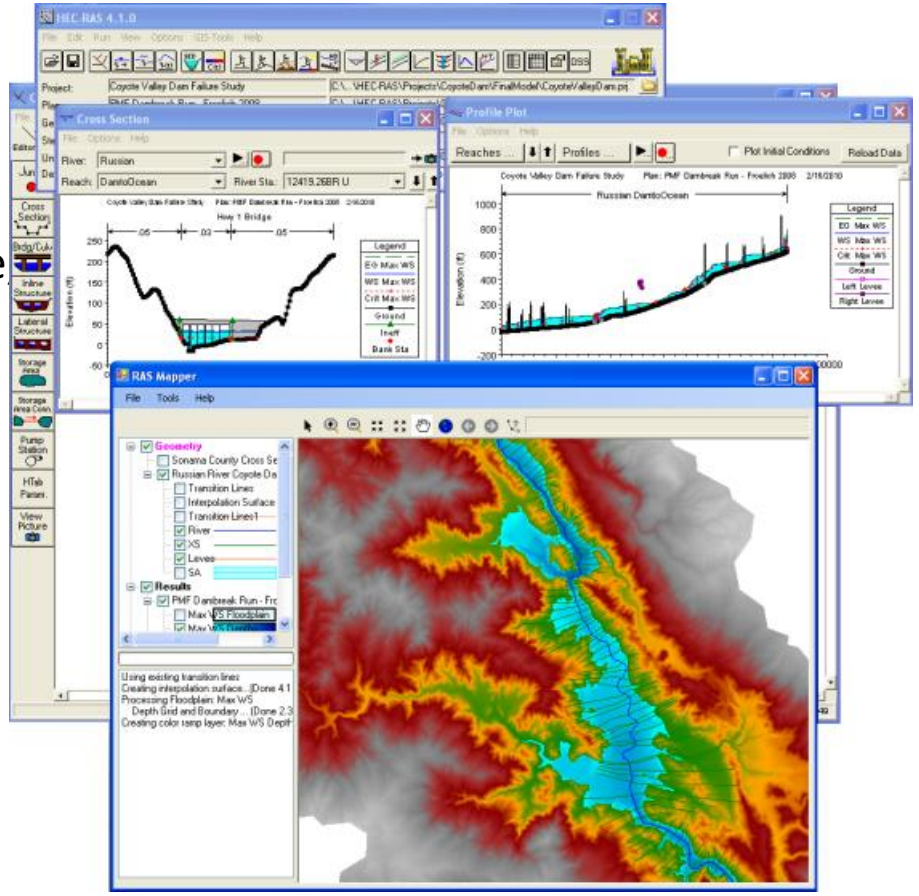
- physics: based on the Saint Venant Equations
- numerics: mainly Finite Difference Method
- examples:

Mike11	DHI (DK)
HEC-RAS	U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center (HEC)
ISIS1D	Halcrow/CH2MHill (UK)
SOBEK	Deltares (NL)
Kalypso1D	TU Hamburg-Harburg Björnsen Consulting Engineers (D)

HEC-RAS

Overview

- numerical simulation of
  1D hydraulic water flow in
  natural and artificial channels
  subcritical, supercritical, mixed flow regime
  bridges, culverts, weirs and structures
- simulation of:
  - steady flow
  - unsteady flow
  - sediment transport
  - mobile bed computations
  - water quality



HEC-RAS

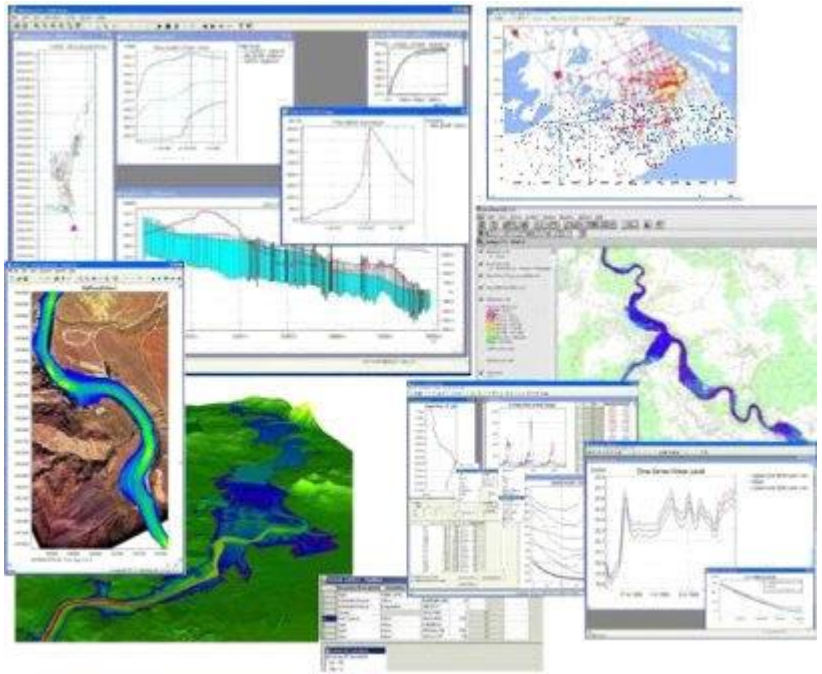
Overview

- provider: U.S. Army Corps of Engineers
  Hydrologic **E**ngineering **C**enter
- license: public release (see web page for details) since 1995
- version: 6.4.1 (2023)
- approach: unsteady flow: 1D Saint-Venant equation
  finite difference method
  Preissmann implicit scheme or 4-point Box scheme
- Web page: http://www.hec.usace.army.mil/software/hec-ras/

MIKE HYDRO River - Mike11

Overview

- steady and unsteady flow in branched and looped channel networks, and flood plains
- flow through a variety of standard and complex structures
- subcritical and supercritical flow
- additional modules:
  - advection-dispersion
  - water quality and ecology
  - sediment transport
  - rainfall-runoff
  - flood forecasting
  - real-time operations
  - dam break



MIKE HYDRO River - Mike11

Overview

- provider: DHI (DK)
- license: commercial and DEMO mode
- approach: unsteady flow: 1D Saint-Venant equation
  finite difference method
  Abbott-Ionescu implicit scheme (6-points)
- Web page: http://mikebydhi.com

1D Numerical River Modelling

River Model Components

- geometry — river location by points (geospatial location)
  cross section vertical to river branches / reaches
- topology — connection of branches / reaches -> channel network
- physics — parameter for physical descriptions
  of phenomena's such as gravitation, friction, …
- structures — description of different hydraulics structures,
  e.g. weir, culverts, bridges, pumps, …
- boundary cond. — physical state variables at spatial model boundary
- initial condition — physical state variables at begin of simulation period
- simulation — period, time step, spatial approximation,
  numerical parameter, stability criteria

1D Numerical River Modelling

River Model Components

- geometry — river location by points (geospatial location)
  cross section vertical to river branches / reaches
- topology — connection of branches / reaches -> channel network
- physics — parameter for physical descriptions
  of phenomena's such as gravitation, friction, …
- structures — ~~description of different hydraulics structures,~~
  ~~e.g. weir, culverts, bridges, pumps, …~~
- boundary cond. — physical state variables at spatial model boundary
- initial condition — physical state variables at begin of simulation period
- simulation — period, time step, spatial approximation,
  numerical parameter, stability criteria

1D Numerical River Modelling

Physics – Bed Resistance

- friction between river bed and water flow
- depends on bed type and slope
  -> less friction for smooth concrete
  -> typical friction for normal gravel
  -> high friction for rough stones/rocks and vegetation
- River Rhine ?

reference: GABonn, iksr

1D Numerical River Modelling

Model Set-Up (steady condition)

- selection of software product
- import of geometrical / bathymetry data
- estimation of roughness parameter
- boundary conditions for steady simulation
- review or parameter and assumptions
- ….
- as preparation of unsteady simulations

1D Numerical River Modelling

Model Set-Up (steady condition)

- selection of software product
  -> Mike11 or HEC-RAS
- import of geometrical / bathymetry data
  -> see prepared files on the server
- estimation of roughness parameter
  -> e.g. Strickler: 34
- boundary conditions for steady simulation
  -> Ruhrort: Q = 2260 m3/s
  Wesel: h = 14,96 m (3,74 + 11,22)

  (1st approach: rounded 20 years Ø values, Wesel gauge offset 11,22 m)

1D Numerical River Modelling

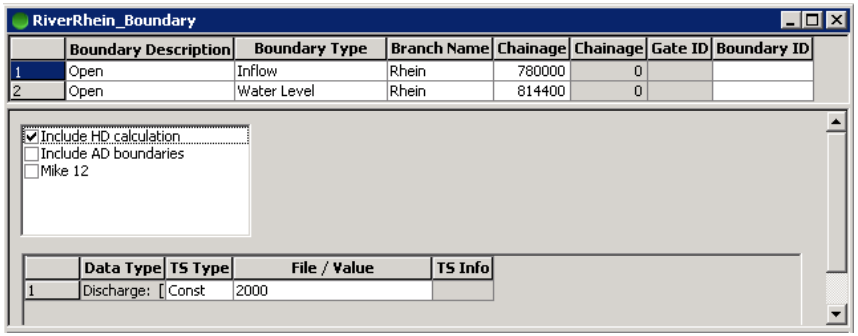
Model Analysis (steady condition in a unsteady simulation)

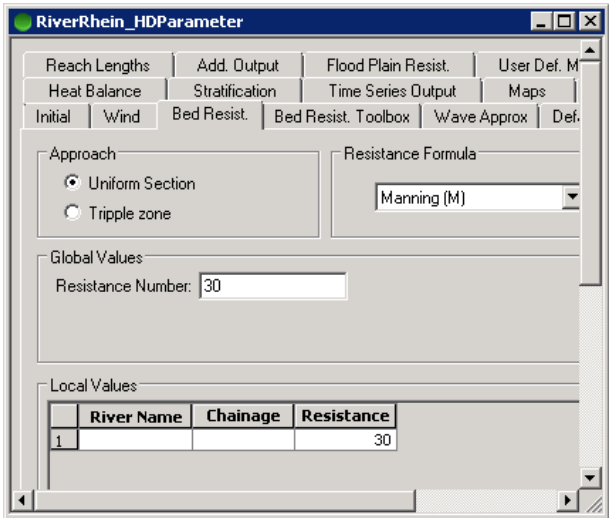
- simulation approach (steady / unsteady)
- review or parameter and assumptions
  -> required time step / number of cross sections
  -> Strickler value
  -> boundary conditions (water level -> rating curve)
  -> sensitivity analysis
- criteria (example Mike11)
  -> stability / oscillation of the solution
  -> convergence of the results

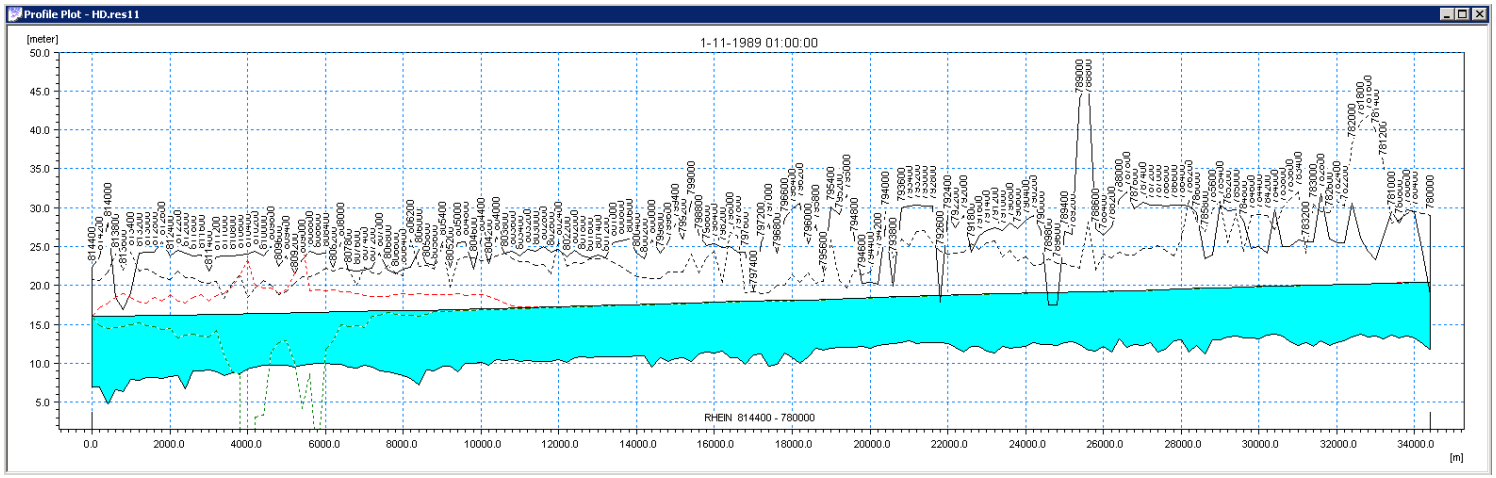
1D Numerical River Modelling

Model Set-Up Mike11

- steady condition as unsteady simulation







1D Numerical River Modelling

Model Set-Up HEC-RAS

- steady simulation
- steady condition as unsteady simulation
- boundary condition options
  normal depth, known WS, rating curve