Toward improving the hydraulic modelling for large-scale flood risk assessment

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Abstract

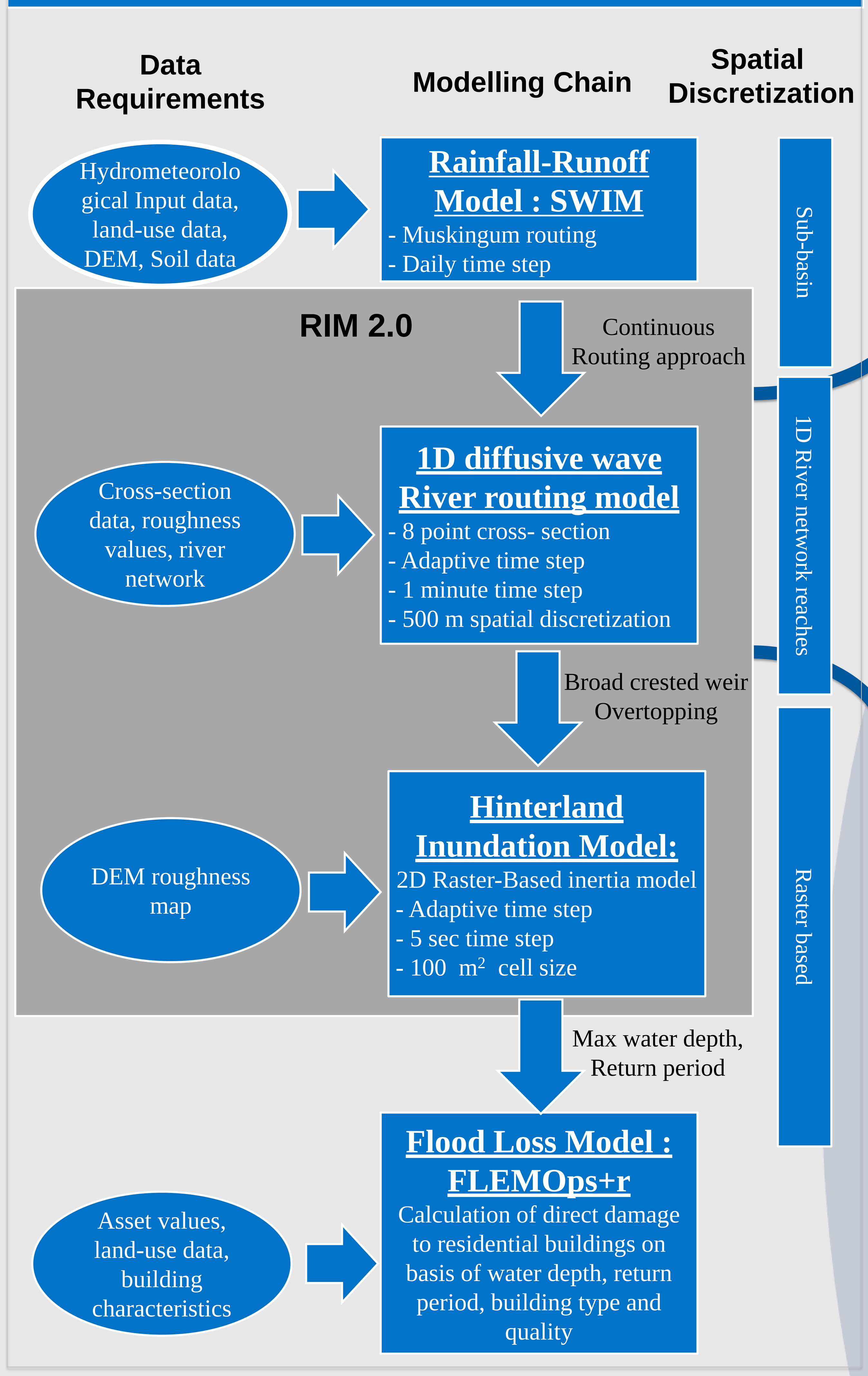
Large-scale flood risk assessment are needed for national policy developments, insurance industry, and large-scale disaster management planning however only few studies has addressed the large scale flood risk assessment.

- One of the approaches used for large scale flood hazard assessment is to include the whole simulation chain starting from the observed or synthetic climate data followed by rainfall runoff then the 1D hydrodynamic routing model coupled with a 2D hinterland inundation model and at the end of the chain comes a flood loss estimation model.

Objective

- In this research a new approach for coupling the rainfall runoff model with the 1D-2D models to accurately route the upstream and lateral flows following the river network and using the sub-basin discretized results from the rainfall runoff model. Second objective of the research is to better represent the river cross section shape using 8 points.

RFM (Regional Flood model)

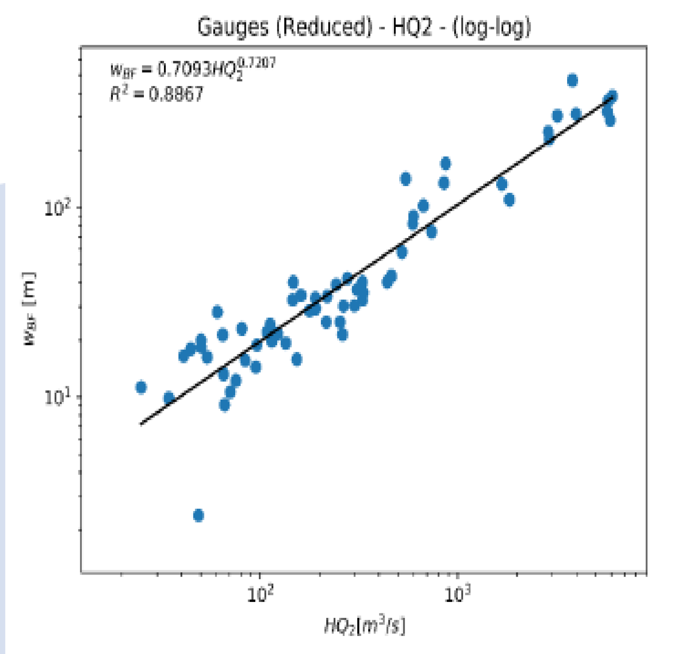


Methodology

The regional flood model (RFM) consists of four components, "SWIM" rainfall-runoff model, 1D river routing model, 2D raster based hinterland inundation model and flood loss estimation model.

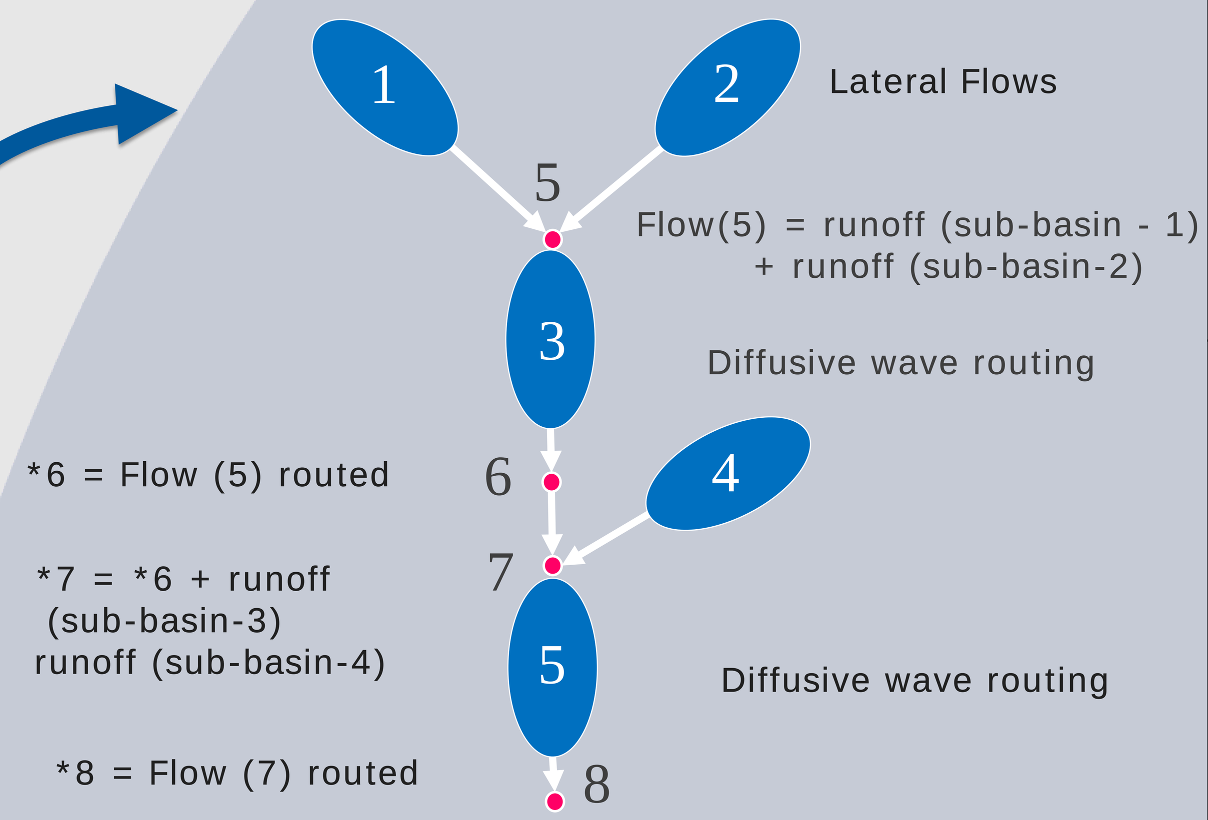
- **Numerical Solution**
  - I. Two separate conveyance systems (Main channel & Flood plain)
  - II. Explicit scheme with adaptive time step to maintain stability
  - III. Diffusive wave approximation following the approach by Bates et al. 2010
  - IV. Upstream Discharge is converted to water level boundary condition to allow for accumulation of lateral flow
- **River cross section data**
  - I. Flood plain : extracted from 10*10 m2 DEM and simplified to 6 point trapezoidal-like shape
  - II. Main Channel : or Bankfull area was derived statistically using the so called Hydraulic geometric

relationships (how hydraulic properties of river channels, i.e. depth, width and velocity, vary with discharge)

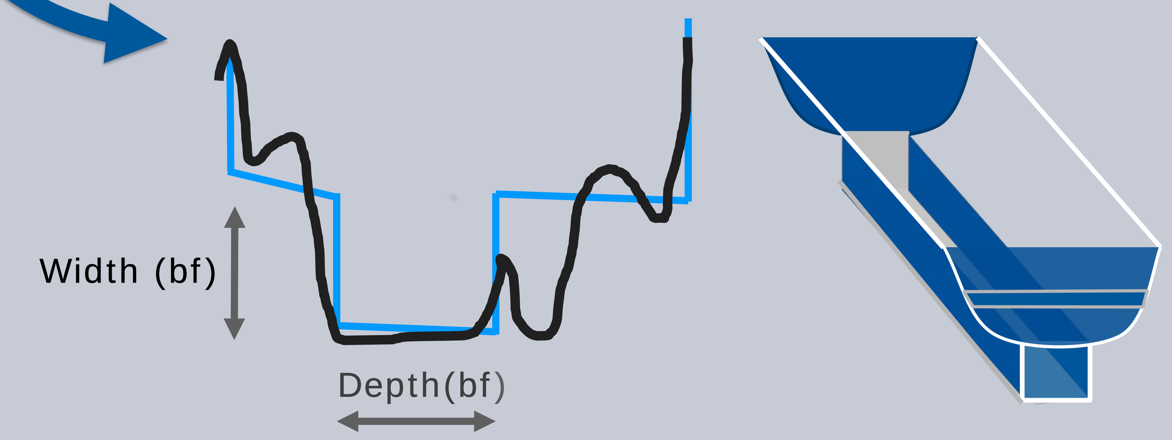


RIM 2.0

Continuous Routing Approach



8 Point cross section



8 point cross section

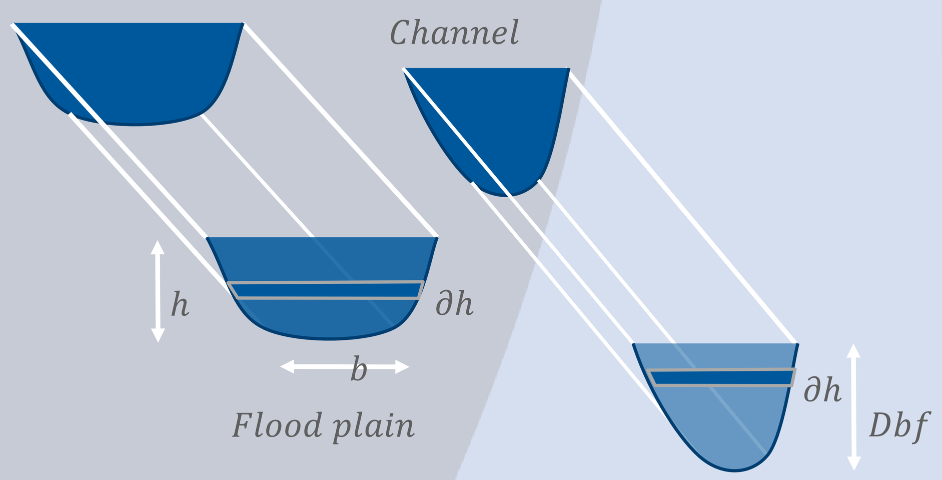
6 point XS derived from DEM (10m*10m)

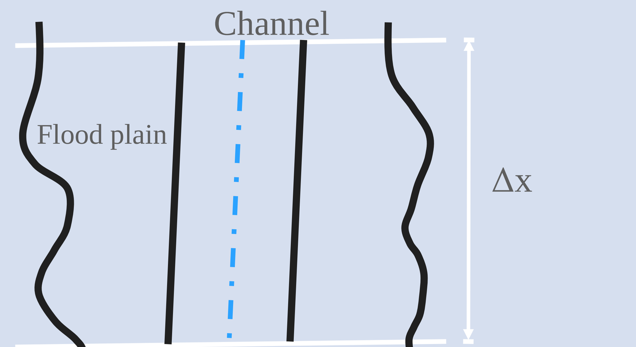
+ statistically derived Bankfull area {Width (bf) *Depth(bf)}

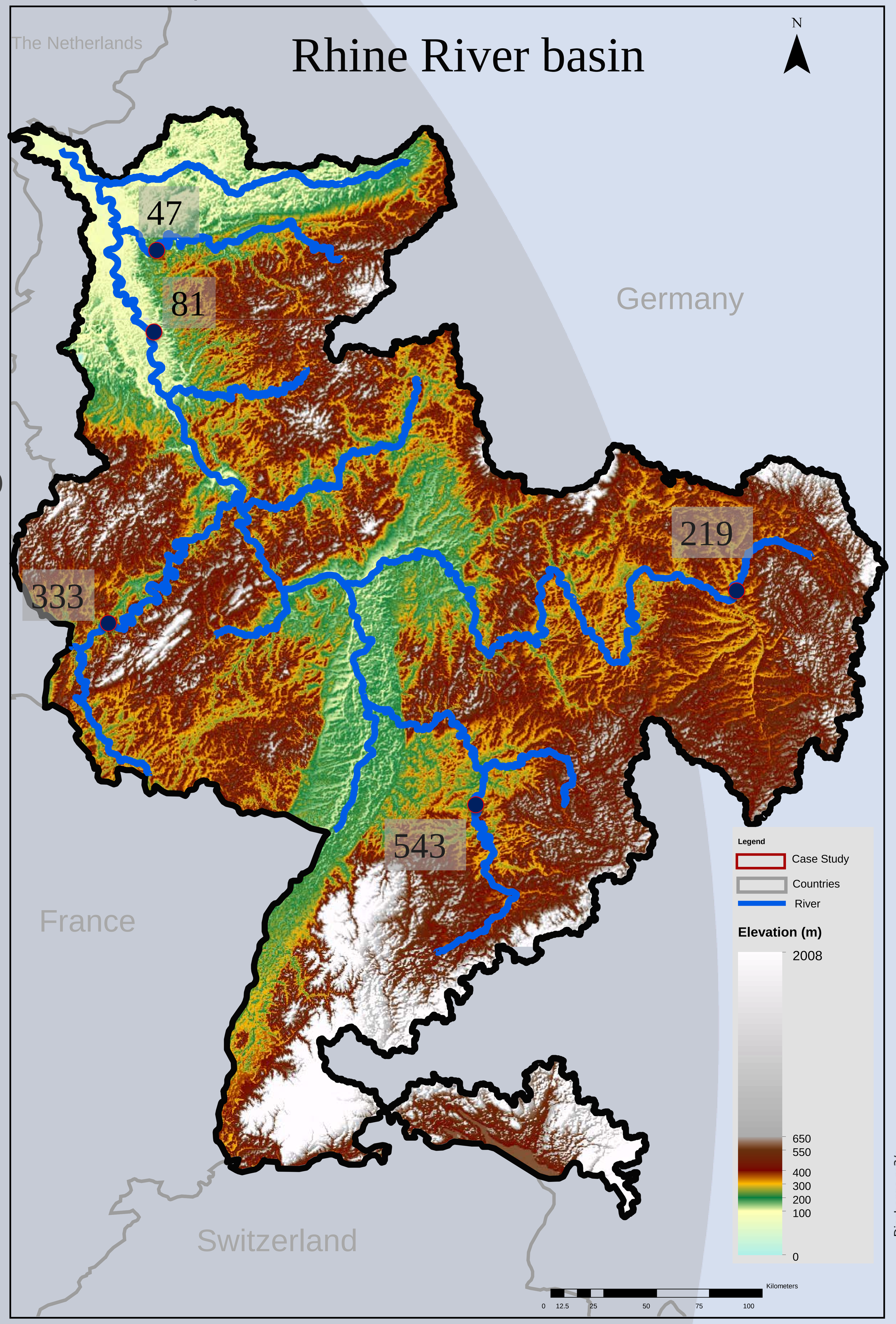
$$W_{BF} = a * HQ2^{b}$$

$$d_{BF} = c * HQ2^{f}$$

$$\frac{\partial Q_{bf}}{\partial x} + \frac{\partial A_{bf}}{\partial t} + \frac{\partial Q_{flood\,plain}}{\partial x} + \frac{\partial A_{flood\,plain}}{\partial t} = 0$$



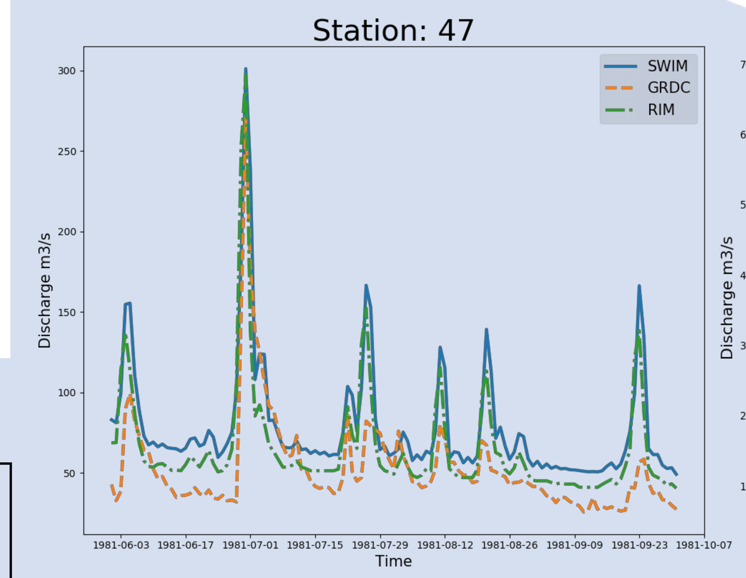




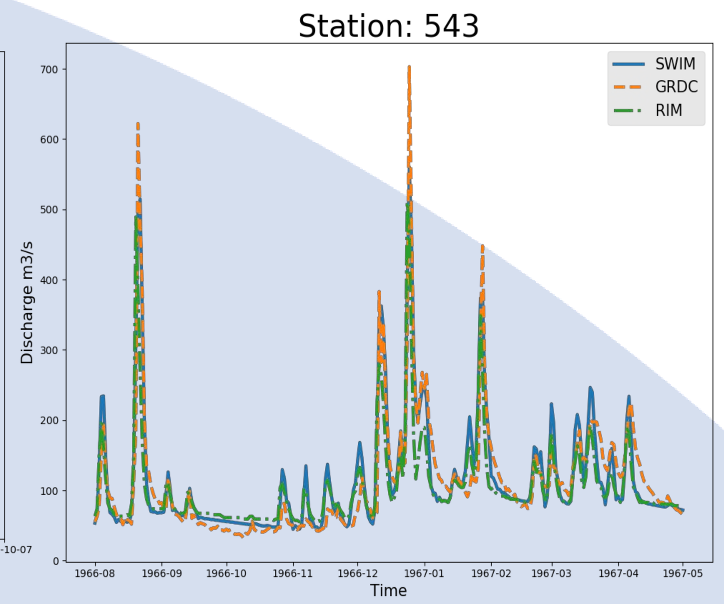
Case study

- The part of the river Rhine that is located in Germany with all tributaries flows to the rhine with a total length of 2390 km, and a total catchment area of 102,905 km2

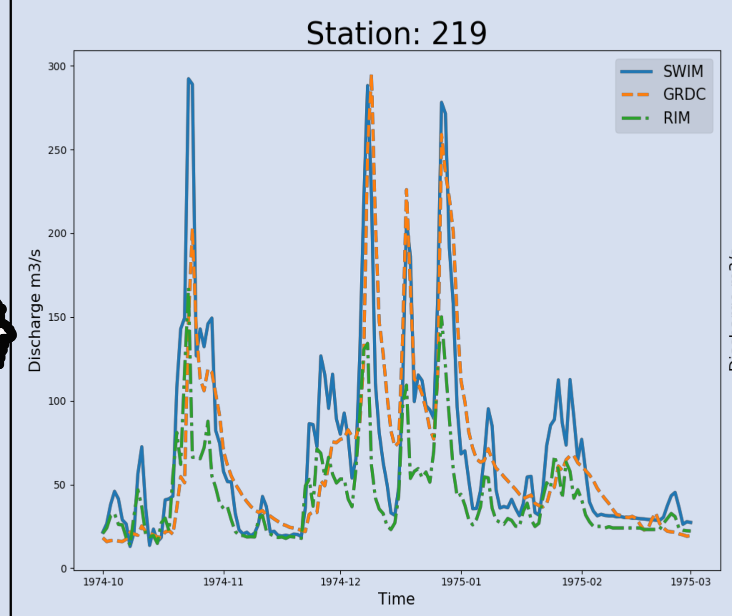
Calibration & Validation



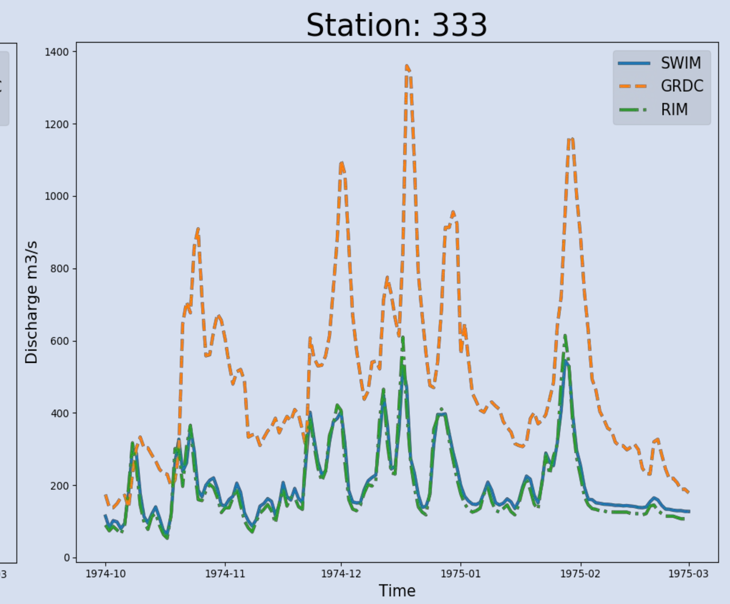
	RMSE	KGE	WB	NSE	NSE M
RIM-SWIM	20	0.81	85	0.85	0.87
SWIM-GRDC	47	0.6	82	0.64	0.74
RIM-GRDC	59	0.5	91	0.44	0.52



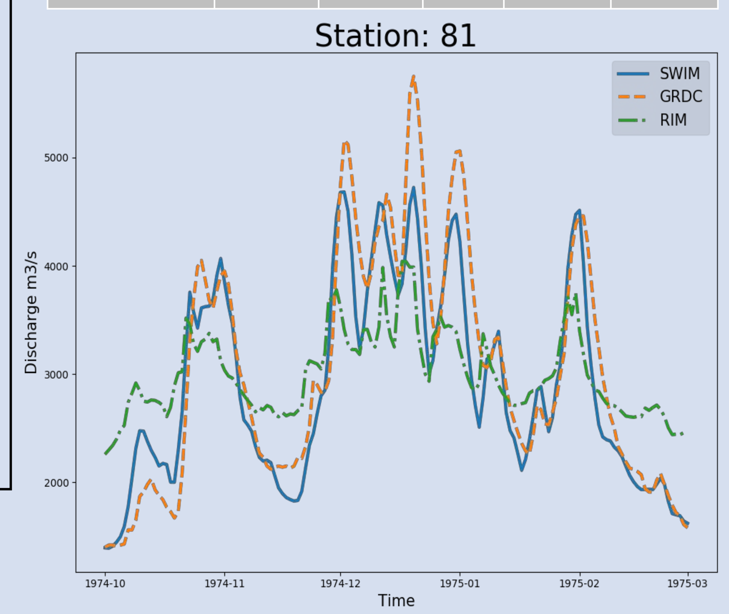
	RMSE	KGE	WB	NSE	NSE M
RIM-SWIM	28	0.73	99	0.84	0.83
SWIM-GRDC	35	0.85	97	0.82	0.86
RIM-GRDC	56	0.57	89	0.55	0.59



	RMSE	KGE	WB	NSE	NSE M
RIM-SWIM	22	0.48	77	0.64	0.63
SWIM-GRDC	22	0.79	93	0.61	0.82
RIM-GRDC	27	0.45	0.76	0.44	0.54



	RMSE	KGE	WB	NSE	NSE M
RIM-SWIM	19	0.88	89	0.95	0.97
SWIM-GRDC	294	0.09	43	0.16	0.16
RIM-GRDC	317	0.02	36	0.04	0.06



	RMSE	KGE	WB	NSE	NSE M
RIM-SWIM	684	0.54	70	0.31	0.60
SWIM-GRDC	564	0.73	89	0.75	0.75
RIM-GRDC	984	0.43	93	0.23	0.35

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