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Appropriate river basin modelling to assess the impact of climate change on river flooding

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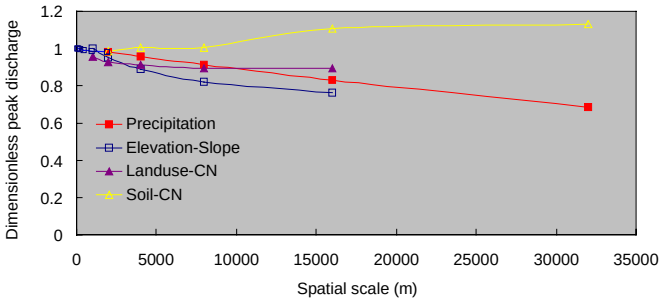
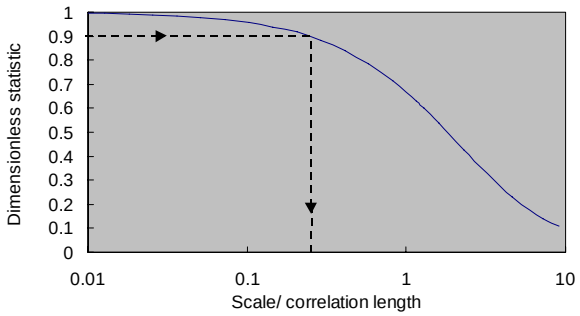
1. Introduction

How good should a river basin model be to assess the impact of climate change on river flooding for a specific geographical area? The determination of such an appropriate model should reveal which physical processes should be incorporated and which process formulations should be used at which appropriate spatial and temporal scale. It should be based on sensitivities and a right balance between uncertainties of inputs, parameters and process formulations resulting in an output uncertainty acceptable for the model user and feasible in view of data availability and computational possibilities. A model appropriateness procedure is described and applied to a river basin model for climate impact assessment.



2. Model appropriateness procedure



The appropriateness procedure roughly consists of the following steps:

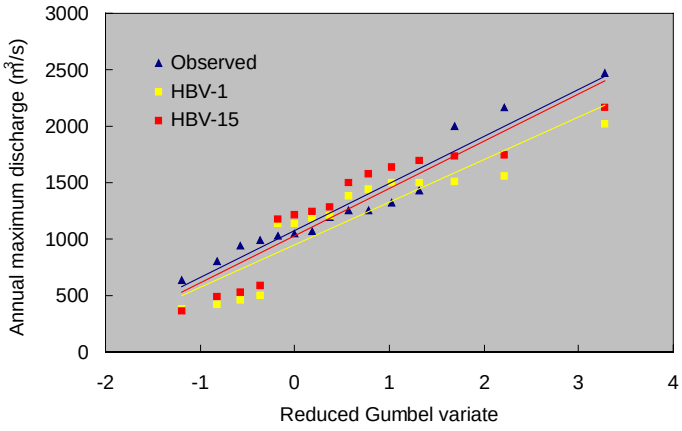
- selection of key processes (precipitation, infiltration and saturation excess overland flow, subsurface storm flow) and related variables
- determination of appropriate time scale (1 day)
- determination of appropriate spatial variable scales on the basis of relations between relevant statistics and scales:
  - precipitation 20 km
  - temperature 1000 km
  - elevation 0.1 km
  - land use 3.3 km
  - soil type 5.3 km
- integration to appropriate spatial model scale through relations between peak discharge and variable scales → ~10-13 km or 120-150 sub-basins for Meuse basin
- selection of appropriate process formulations

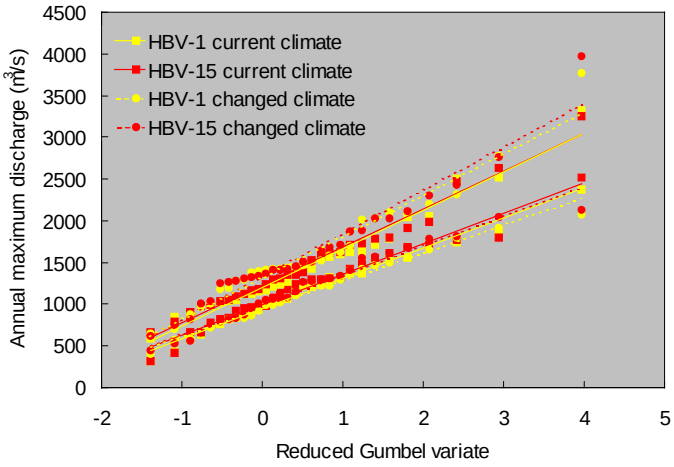
3. Application to river basin model for assessment of climate change impact on river flooding

The appropriate model concepts are integrated into an existing modelling framework, HBV (SMHI, Sweden), and applied to the river Meuse basin upstream of Borgharen (France, Belgium). The appropriate model has 118 sub-basins (HBV-118) and is compared with models with 1 and 15 sub-basins (HBV-1 and HBV-15) to assess the sensitivity of the model results to model complexity. In the calibration phase, criteria related to average discharge behaviour (R^2, volume error) and extreme behaviour (error in return values) are used for measured sub-basins. Relationships between HBV model parameters and river basin characteristics (slope, texture, land use) are employed for non-measured sub-basins.

The three models are calibrated and validated with measured rainfall data, discharges etc.. A stochastic rainfall model has been used for rainfall generation for current and changed climate conditions. This rainfall model has a temporal component based on a first-order 4-state Markov chain and a truncated gamma distribution and a spatial component based on discrete random cascades (Jothityangkoon *et al.*, 2000. *Water Resour. Res.*, **36**, 267-284). Multiple rainfall realisations with constant parameter values (derived from the average of GCMs and RCMs) and realisations with parameter values according to individual GCMs and RCMs are used.

4. Results and conclusions





- Appropriate spatial scale for precipitation is about 20 km
- Other appropriate scales vary between 100 m-1000 km
- Appropriate model scale is 10-13 km which means 120-150 sub-basins for the Meuse basin
- Rainfall model correctly simulates all relevant statistics of current and changed climate
- HBV-15 performs slightly better than HBV-1, sub-basins in HBV-15 are realistically simulated
- Differences between observed and simulated extreme discharges are small (< 10 %)
- First results with HBV-118 show small improvements
- Extreme discharges increase with climate change by 10 (±10) %