HYDROEUROPE
Hydroinformatics for water resources and water related hazards management in Europe

Design Storm analysis at the Ouseburn catchment using SHETRAN

Group 6

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Catchment and Software Overview

- **Ouseburn Catchment :** urban catchment (Newcastle Upon Tyne)
  - ⇒ flat region
  - ⇒ Moderate soil permeability
  - ⇒ Average rainfall: 600 to 700 mm/yr
- **SHETRAN:** Physically based distributed model
  - ⇒ Able to perform a detailed simulation of the catchment
  - ⇒ Advantage : Small modification can produce great difference in output.

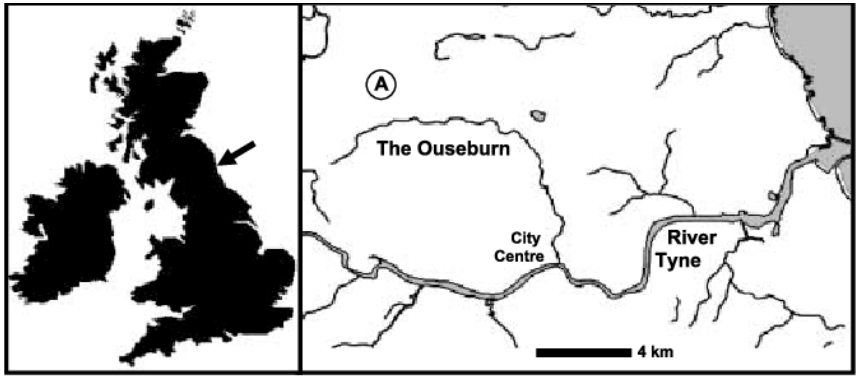
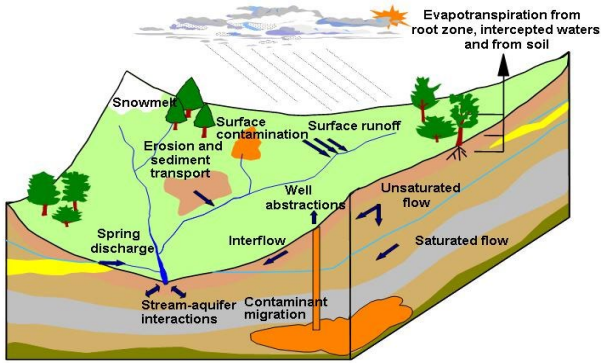
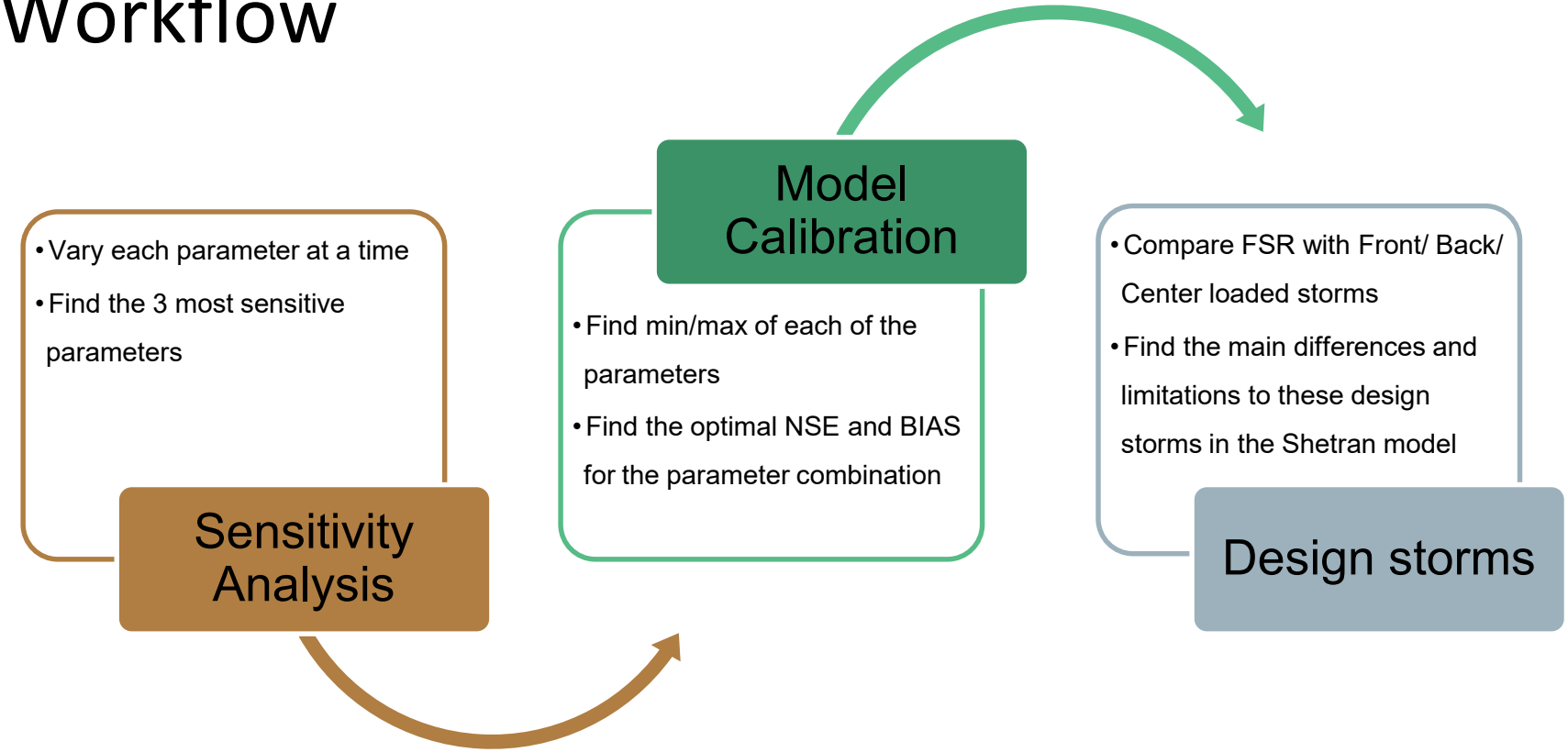


Fig. 1. Location map of the Ouseburn, NE England.



Workflow


Sensitivity Analysis
• Vary each parameter at a time
• Find the 3 most sensitive parameters
Model Calibration
• Find min/max of each of the parameters
• Find the optimal NSE and BIAS for the parameter combination
Design storms
• Compare FSR with Front/ Back/ Center loaded storms
• Find the main differences and limitations to these design storms in the Shetran model

Sensitivity Analysis

- 10 parameters were investigated
- NSE & BIAS are numerical criteria to test the sensitivity of each parameter
- Negative NSE implies that the model is fully irrelevant;

=> Hence the most sensitive parameters were selected to improve the simulation by calibrating the model

Investigated Parameters	Representation
SWC	Soil water content
SC	Saturated Conductivity (m/day)
RWC	Relative water content
ALPHA	Baseflow Factor
VANG-N	Soil moisture characteristic (1/cm)
CANOPY	Canopy Storage Capacity (mm)
LAI	Leaf Area Index
R DEPTH	Maximum Rooting Depth (m)
AE/PE at FC	Actual/Potential evapotranspiration at Field Capacity
Strickler coefficient	Surface Roughness

Pseudo Calibration

- Selecting 3 most sensitive parameters to perform the calibration with

  1. Strickler Overland flow coefficient

  2. AE/PE at Field Capacity

  3. Saturated Conductivity

- Picking 4 random values in the range and assess the best values for selected parameters regarding the optimal NSE and BIAS

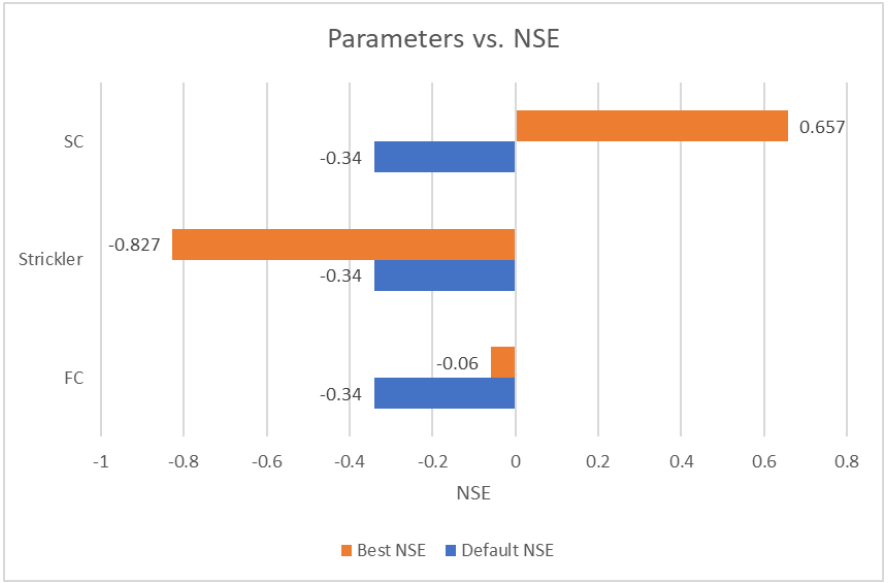
	AE/PE at Field Capacity			
Values	0.2	0.4	0.6	0.8
NSE	-0.709	-0.491	-0.261	-0.06
BIAS	104.852	96.764	87.772	77.658

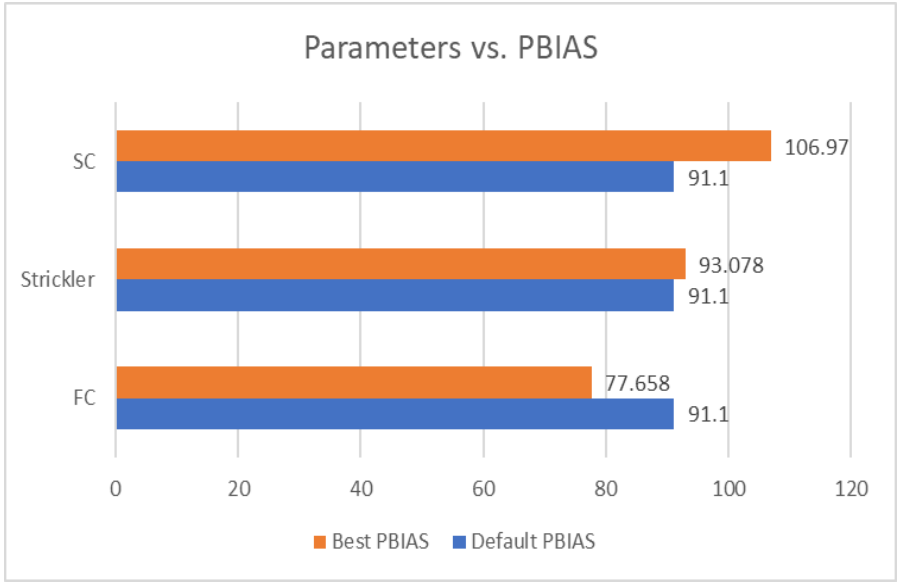
	Saturated Conductivity (m/day)			
Soil1	5	10	20	20
Soil2	1.00E-02	1.00E-03	1.00E-01	1.00E+00
Soil3	1.00E-04	1.00E-05	1.00E-03	1.00E-02
NSE	-0.340	-0.128	0.404	0.657
BIAS	91.098	91.437	93.854	106.969

Pseudo Calibration Results

Parameters in order of sensitivity	Range	Default Model	Best Value	Evaluation
Strickler Overland flow Coefficient	2 - 100	Vegetation : 2 Urban : 12	Vegetation: 2 Urban: 12	NSE: -0.827 BIAS: 93.087
AE/PE at Field Capacity	0 - 1	Vegetation: 0.53 Urban: 1.0	Vegetation: 0.8 Urban: 1.0	NSE: -0.06 BIAS: 77.658
Saturated Conductivity (m/day)	0.001 - 100	1st Layer: 5.8615 2nd Layer: 0.0141 3rd Layer: 0.0010	1st Layer: 20 2nd Layer: 1 3rd Layer: 0.01	**NSE: 0.657** BIAS: 106.969

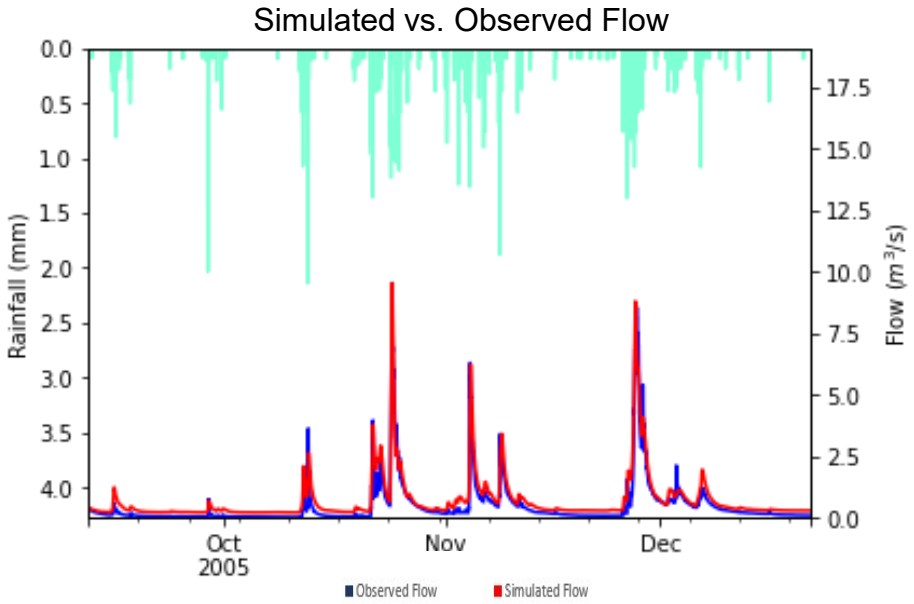
Pseudo-Calibrated Model vs. Initial Model





Model Calibration Result

- Simulation result improved significantly after running the model with the new values



Evaluation	Default Value	Calibrated Value
NSE	-0.34	0.690
BIAS	91.098	84.408

Design Storms

- Synthetic distribution of rainfall
- 100-year return period event
- FSR method is currently used which is based on 112 studied events to define the design storms used in the UK
  - 80 summer storms – used for urban areas FRAs
  - 32 winter storms – used for rural areas FRAs
- Three approaches for performing the design storm using 70000 events to create
  1. Front loaded
  2. Center loaded
  3. Back loaded

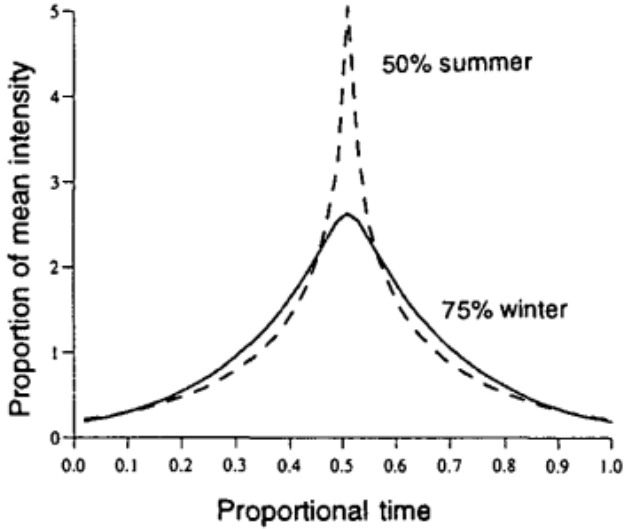
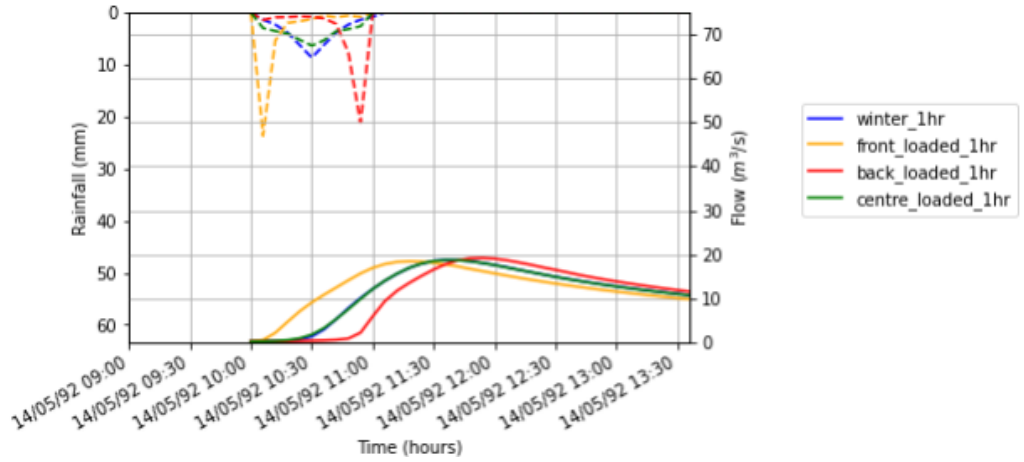


Figure: Design rainfall profiles for winter and summer, as normalized hyetographs (FEH)

⇒ **Is there a difference in the simulated flows with these new profiles? How will it compare to the currently used summer and winter profiles?**

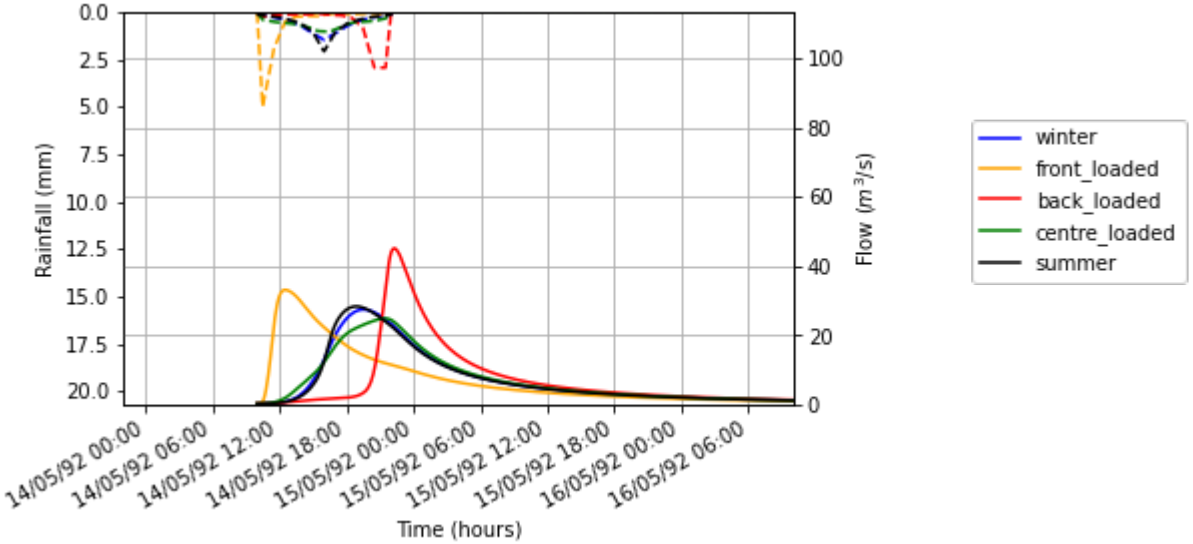
Result for 1-hour storm Duration

- 1 hour is not enough time to conclude a difference between FSR (winter/summer) and front/back/centre approaches
- The front/back/centre approaches doesn't show many differences in Peak discharge



		Maximum peak flow (m3/s)	Time to peak
Design Storm	Back loaded	19.183	1992-05-14 11:54:00
	Front Loaded	18.442	1992-05-14 11:18:00
	Center Loaded	18.732	1992-05-14 11:36:00
Industry Storm	Winter	18.745	1992-05-14 11:36:00
	Summer	18.758	1992-05-14 11:36:00

Result for 12-hour storm Duration



		Maximum peak flow (m3/s)	Time to peak
Design Storm	**Back loaded**	45.163	1992-05-14 22:18:00
	Front Loaded	33.168	1992-05-14 12:30:00
	Center Loaded	24.882	1992-05-14 21:30:00
Industry Storm	**Winter**	27.475	1992-05-14 19:30:00
	Summer	28.370	1992-05-14 18:54:00

Conclusions and Recommendations

- The model performance improved considerably after calibration; NSE from -0.34 to 0.690

  → Needs more detailed evaluation of all factors that controls the hydrological process

  For 1-hour storm duration the industry design storm can be used because of similar peak discharge between the FSR and back/centre/front approach (<1 m3/s)

  For 12-hour storm duration because of the significant difference of peak flow, the back/centre/front study needs to be implemented in order to have better flood prevention

- Creating more design storms and more profiles helps us to have more detailed view of catchment response to precipitation

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