Week 1 Presentation:

Investigate uncertainties in modelling the Skawa catchment, Poland using HEC-HMS

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Week 1 Timeline

**Tuesda
y**

Model creation

HEC-HMS model creation, set up and catchment familiarisation.

Wednesday

Calibration

Calibration of CN, Initial Abstraction, Lag Time in HEC-HMS

Thursday

Continuation and summary

Completion of the calibration.
Discussion of uncertainties.
Synthesis.

Friday

Today: The presentation!

GIS catchment characteristics

Calculation of the catchments surface

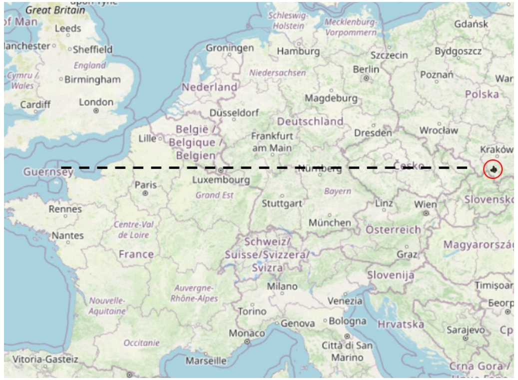


Figure 1. Parallel of the ROI, OSM

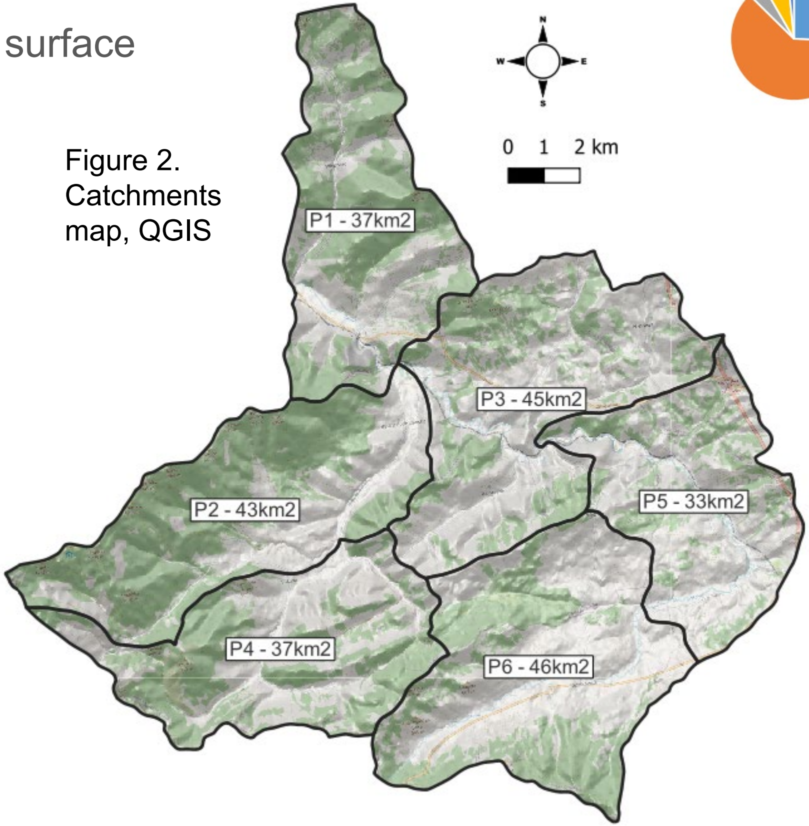


Figure 2. Catchments map, QGIS

Analysis of land covering

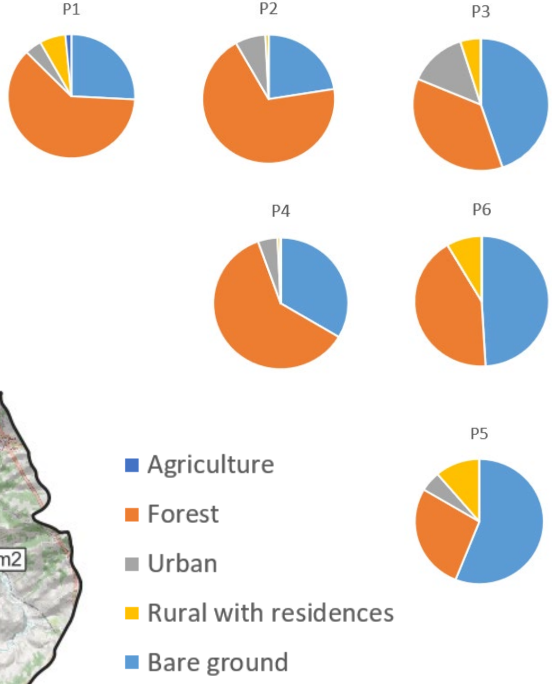
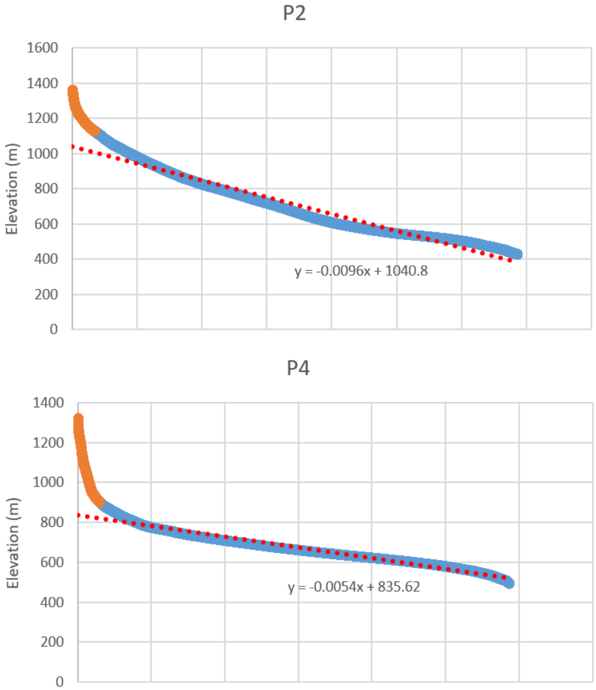


Figure 3. Distribution of land use, CLC Copernicus 2012

GIS catchment characteristics

Calculation of slope catchment



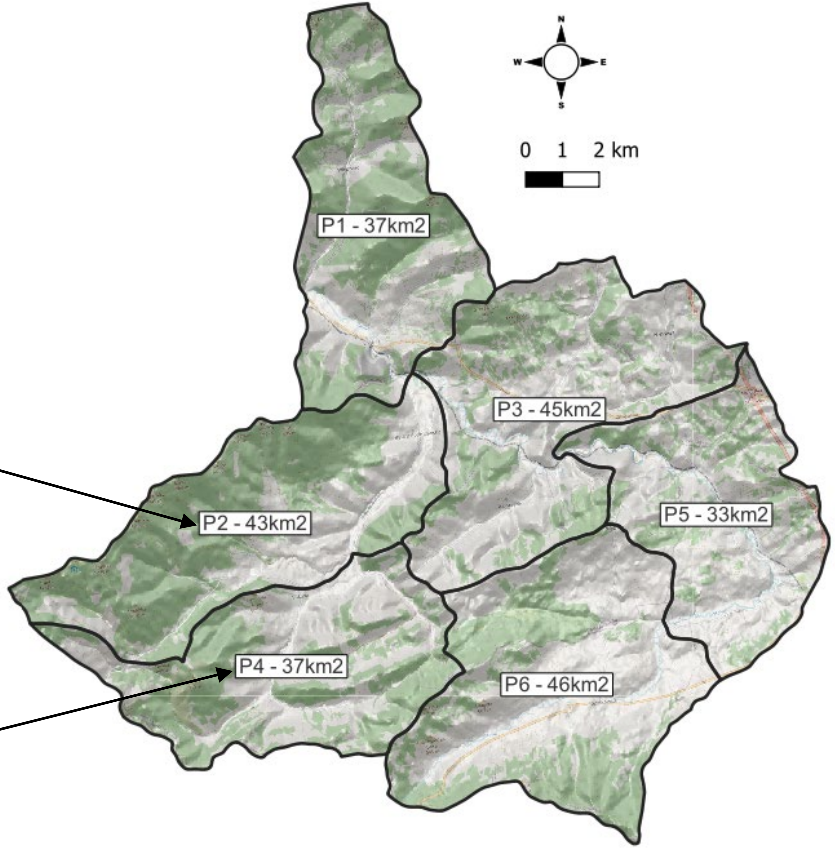


Figure 4.
Excel slope catchment analysis
DEM Copernicus 2020

HEC-HMS Model Overview

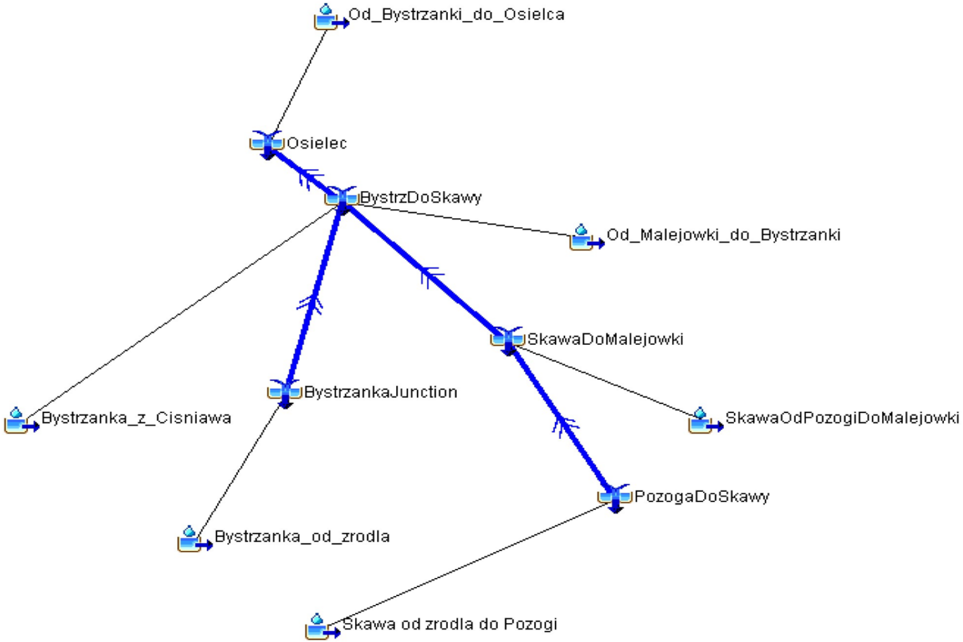


Figure 5. HEC-HMS Basin View, Skawa River Watershed from Osielec.

Semi-distributed Model with 6 Subcatchments

<u>Method Used:</u>
Loss Method - SCS Curve Number
Transform Method - Snyder Unit Hydrograph
Baseflow Method - Recession

<u>Data for Simulation :</u>
GPM precipitation data
Radar precipitation data

Radar data vs satellite data

Table 1. Summary of the difference between Radar and GPM data simulation

Radar	Satellite (GPM)
Obstruction - limited due to terrain complexity.	Almost global spatial coverage
Distance (100 km approx)	Covers larger area than radar data
Better spatial resolution: 1 km x 1 km grid size	Sparse spatial resolution: 12.5 km x 12.5 km grid size
Lower temporal resolution: 10 minutes	Higher temporal resolution: 30 minutes

Figure 5a: Radar Precipitation data

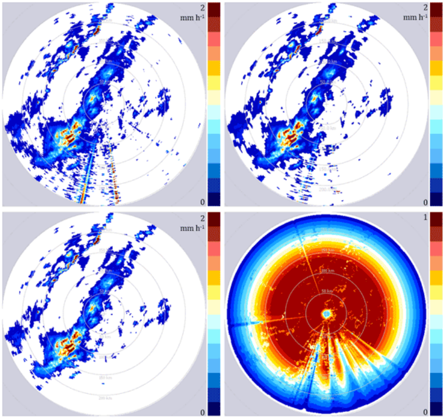
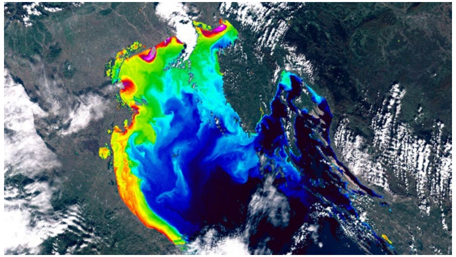


Figure 5b: Satellite precipitation data



The initial model based Satellite (GMP) and Radar precipitation data

Table 2. Summary statistics for the initial model run.

Parameter	Radar	Satelite
NSE	0.190	0.199
Observed peak discharge (m^3/s)	211.10	211.10
Simulated peak discharge (m^3/s)	79.20	62.00
Observed volume (mm)	80.13	80.13
Simulated volume (mm)	31.31	31.71
Difference in peak discharge (%)	62.48	70.63
Difference in volume (%)	60.93	60.43

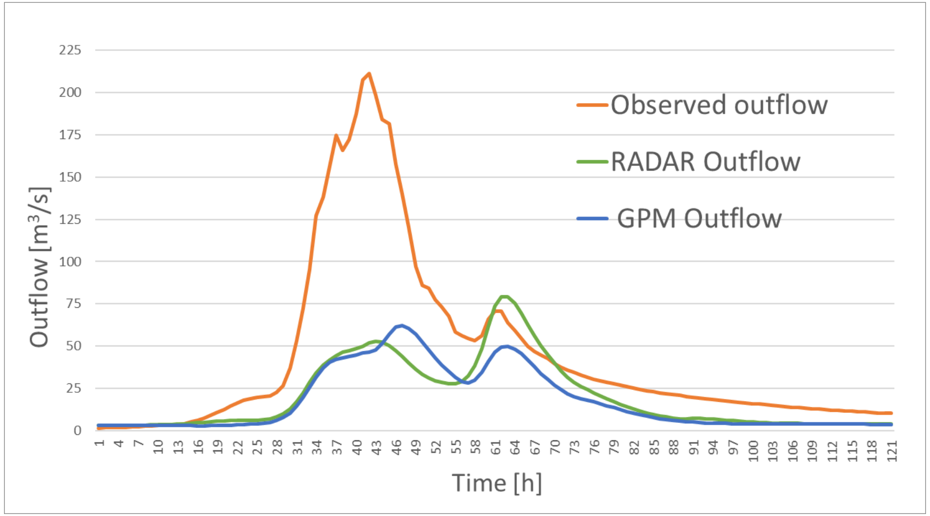


Figure 6. A plot of observed discharge vs simulated discharge using radar and satellite data for the Skawa catchment using the initial HEC-HMS model.

Initial calibration - strictly curve numbers

Curve number (CN) represents the potential for runoff from a given catchment, based on the relationship between the amount of rainfall and the amount of runoff that is generated. A curve number of 100 represents a completely impervious surface, water cannot pass through at all.

01 | calibration 1 - 50% increase on all curve numbers

02 | calibration 2 - increased the original curve numbers for each sub basin based on literature

03 | calibration 3 - increased the curve numbers by 50% + localised changes from the paper

Curve number calibration result - Satellite (GMP) and radar precipitation data

Table 3. Summary statistics for the curve number calibration.

Parameter	Radar	Satelite
NSE	0.669	0.759
Observed peak discharge (m^3/s)	211.11	211.11
Simulated peak discharge (m^3/s)	137.50	132.50
Observed volume (mm)	80.13	80.13
Simulated volume (mm)	66.89	61.28
Difference in peak discharge (%)	34.86	37.23
Difference in volume (%)	16.52	23.52

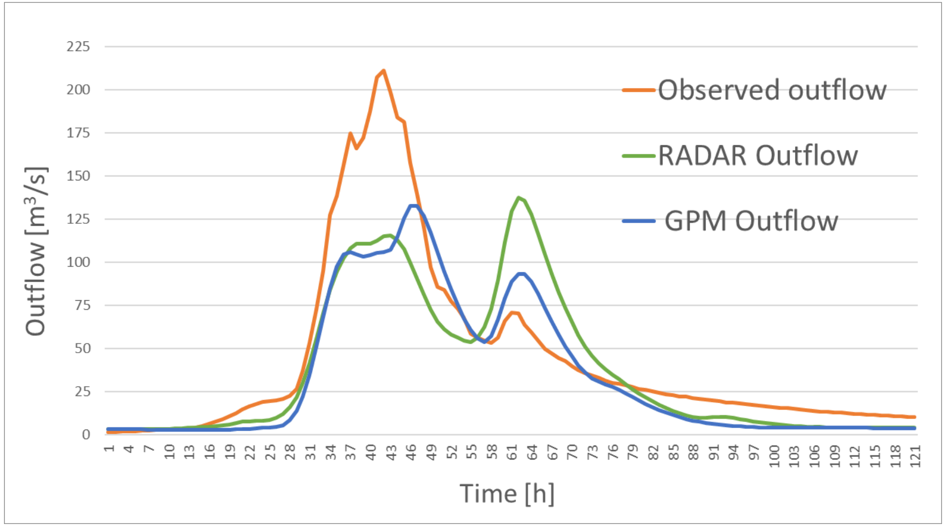


Figure 7. A plot of observed discharge vs simulated discharge using radar and satellite data for the Skawa catchment using the calibrated curve number HEC HMS model.

Calibration of multiple parameters

Initial Abstraction: the amount of water that must fall before saturation excess overland flow occurs. This is effected by interception and infiltration rates of the land cover and soil type.

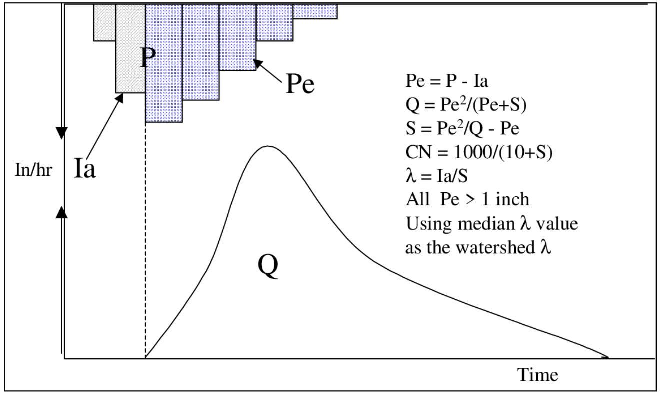


Figure 8. A hydrograph and hyetograph illustrating initial abstraction. Source: Woodward et al. (2003)

Lag Time: The amount of time between the centroid of precipitation mass and the peak of the flow in the hydrograph. Is calculated by subtracting the centroid of precipitation mass from the time to peak.

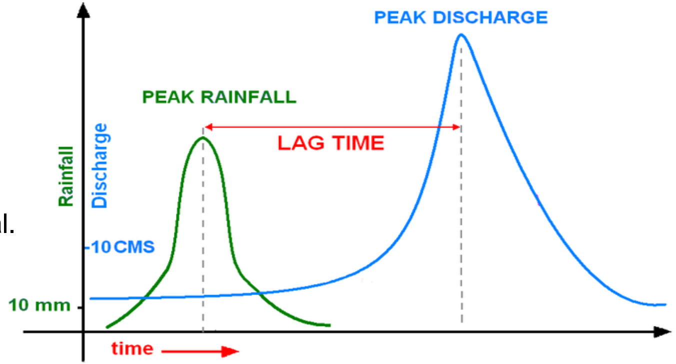


Figure 9. A diagram illustrating lag time. Source: Ancona et al. (2014)

*(Gilewski, Nawalany, 2018)

Observed data vs simulated data: % Difference

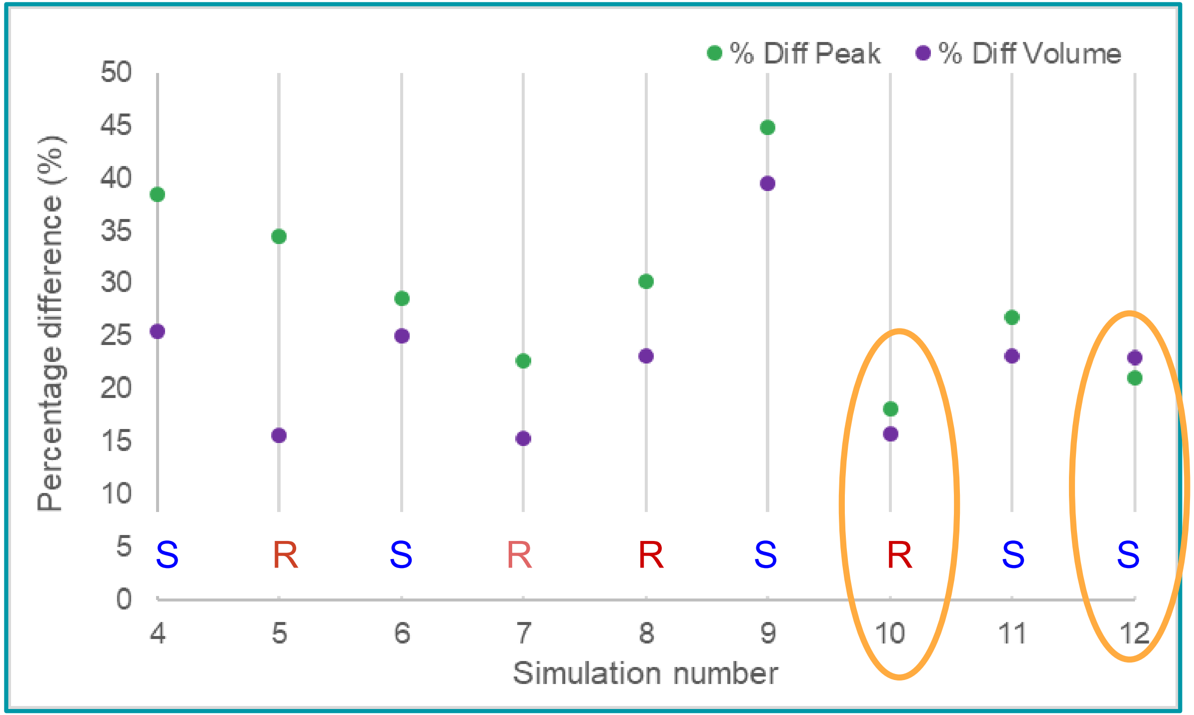


Figure 10.. A plot of the progression of our percentage difference in observed and simulated peak discharge and volume. 'S' indicates a run using satellite data and 'R' a run using radar data.

Table 4. Description of each run and the changes made.

Simulation number	Change
4 Satellite	Optimised CN, original lag, initial abstraction from paper*
5 Radar	As above
6 Satellite	Lag times from paper*
7 Radar	As above
8 Radar	All parameters from paper
9 Satellite	As above
10 Radar	Optimised CN and Initial abstraction based on land use of subcatchments
11 Satellite	As above
12 Satellite	Lag times based on land use for each subcatchment

Observed data vs simulated data: NSE

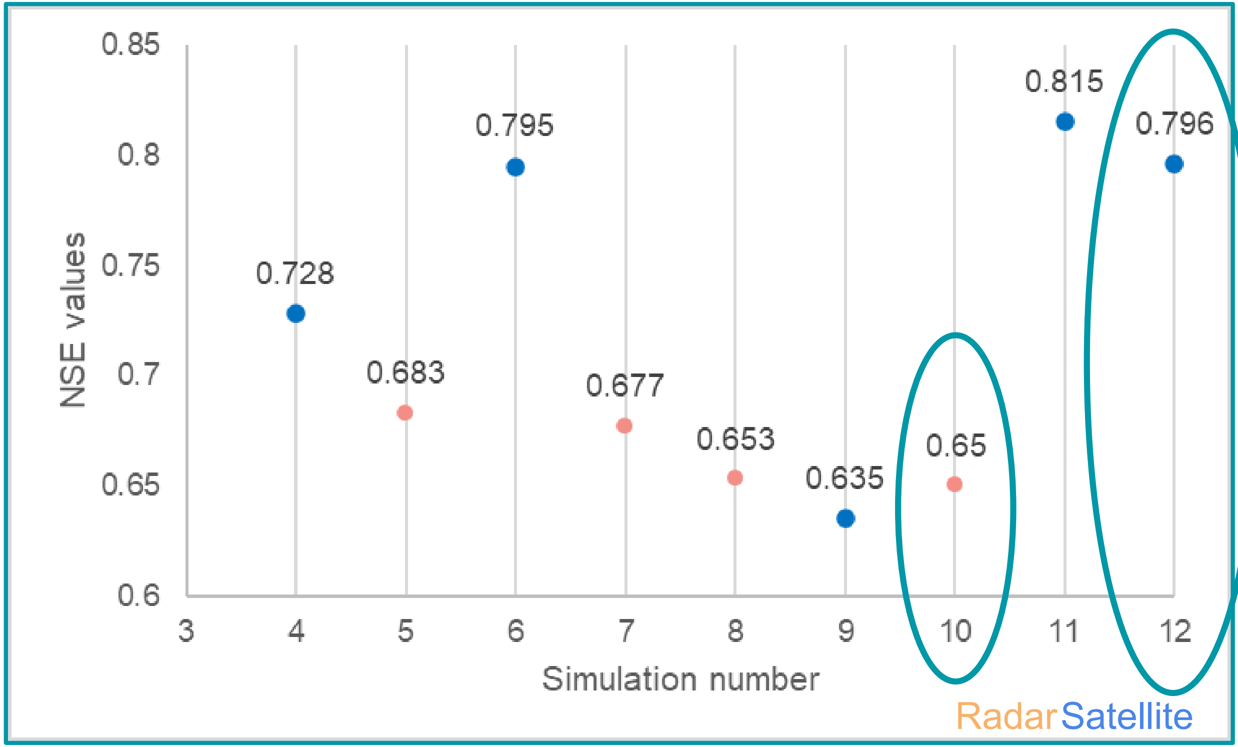


Figure 11. A plot of the progression of our NSE values over the multiple parameter calibration.

Table 5. Description of each run and the changes made.

Simulation number	Change
4 Satellite	Optimised CN, original lag, initial abstraction from paper*
5 Radar	As above
6 Satellite	Lag times from paper*
7 Radar	As above
8 Radar	All parameters from paper
9 Satellite	As above
10 Radar	Optimised CN and Initial abstraction based on land use of subcatchments
11 Satellite	As above
12 Satellite	Lag times based on land use for each subcatchment

The Best Multiple Parameter Calibration Result - satellite (GMP) and radar precipitation data

Table 6. Summary statistics for the multiple parameter calibration.

Parameter	Radar	Satelite
NSE	0.65	0.796
Observed peak discharge (m^3/s)	211.11	211.11
Simulated peak discharge (m^3/s)	173.00	166.60
Observed volume (mm)	80.13	80.13
Simulated volume (mm)	67.54	61.7
Difference in peak discharge (%)	18.05	21.8
Difference in volume (%)	15.71	23.00

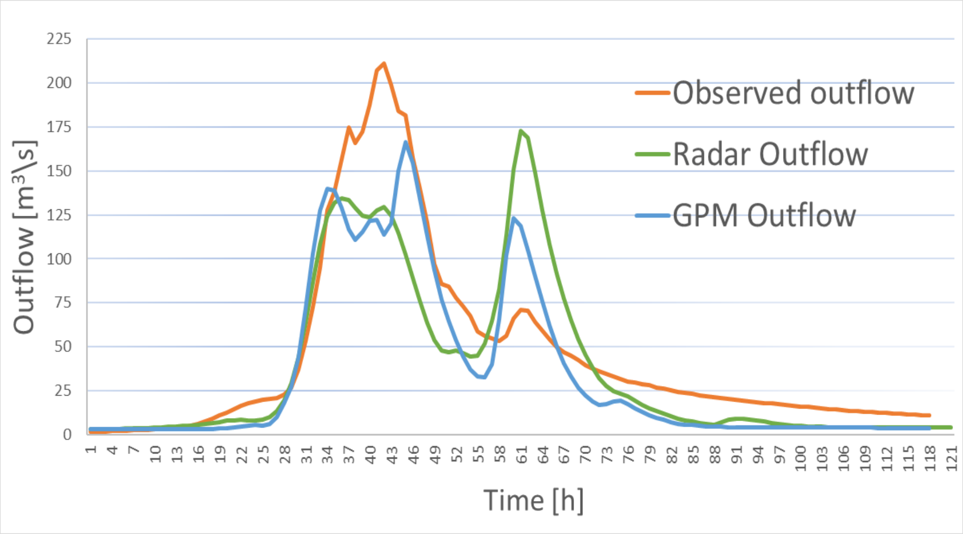


Figure 12. A plot of observed discharge vs simulated discharge using radar and satellite data for the Skawa catchment using the calibrated HEGHMS model.

Spatial and temporal resolutions (Radar and Satellite)

Observed discharge data measurement errors (can we trust the observed?)

Uncertainties with Input data

Accurate determination of catchment characteristics (i.e. vegetation and land use)

Radar obstruction

Uncertainties in Calibration of a Semi-Distributed Model

- Subbasin representation - semi distributed model
- Generalisation of lag time based on slope
- Generalisation of curve number based on land use
- CN introduces uncertainties in the model that aren’t necessarily physically based
- Generalisation of initial abstraction based on land use

Conclusions

1) Despite uncertainty (lower spatial and temporal) in satellite data, it can still provide more accurate representations of rainfall than radar data estimates.

1) CN creates the largest changes in model results, although its determination (NRCS charts) introduces uncertainty.

1) Uncertainties in input data, like Copernicus Land use 2012 while simultaneously using Radar data from 2014 are not temporally matched, and thus introduce uncertainty.

1) Calibration of a semi-distributed model has uncertainties, because each subbasin, channel, and junction lack direct physical connection, but instead are empirically related.

Thank you.

References:

Gilewski, P. and Nawalany, M., 2018. Inter-comparison of rain-gauge, radar, and satellite (IMERG GPM) precipitation estimates performance for rainfall-runoff modeling in a mountainous catchment in Poland. Water, 10(11), p.1665.

Ancona, M. et al. (2014) 'On the Design of an Intelligent Sensor Network for Flash Flood Monitoring, Diagnosis and Management in Urban Areas', Procedia Computer Science, 32, pp. 941-946. doi:10.1016/j.procs.2014.05.515.

Woodward, D. et al. (2003) 'Runoff Curve Number Method: Examination of the Initial Abstraction Ratio', *American Society of Civil Engineers*. doi:10.1061/40685(2003)308.