Improving the calibration strategy of a physically based model by using critical events

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Study area description

Site Name:	Pelorus, NZ	Minimum elevation:	35 m amsl
Catchment area:	377 km^2	Number of model grids:	43
Maximum elevation:	1756 m amsl	Average area per grid cell:	8.78 km^2

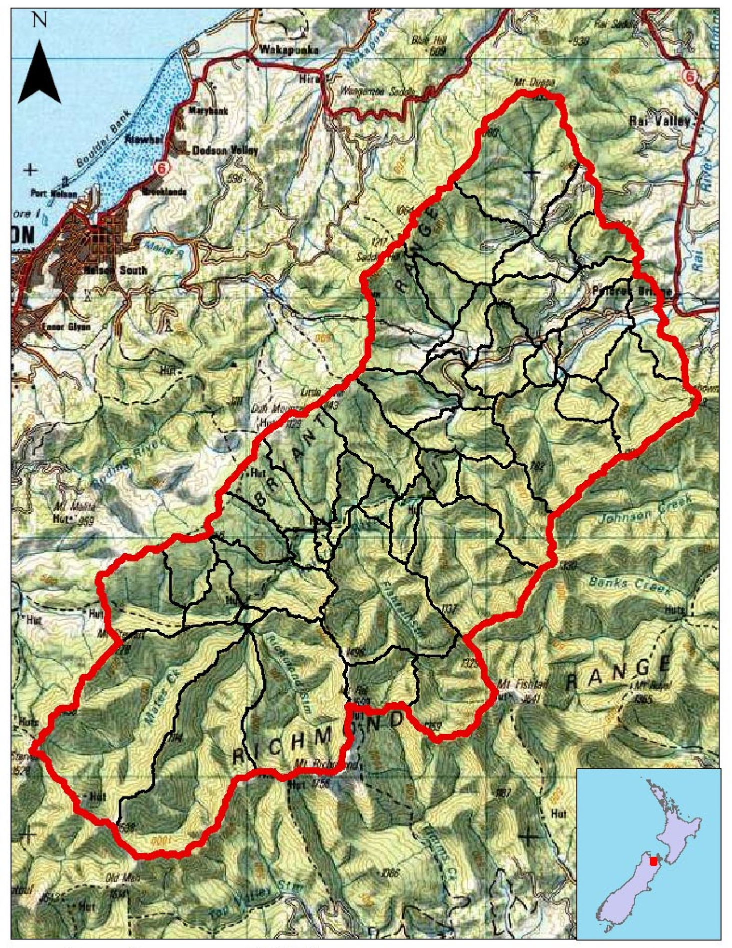

Figure 1: Site map.

Introduction

The use of physically complex models is limited due to the complexity in the measuring some of the parameters and calibrating others. The parameterisation of these models is a very difficult task. To run a complex model for a single simulation can take a few hours to a few days, depending on the simulation period and complexity of the model. The information contained in a time series is not uniformly distributed. The length of the observation period has a great influence on the identification of the model parameters.

So, if we can recognise the critical events which are important for identification of parameter, we can make parameterisation of complex models more efficient. In this study, the data depth function is used to identify the critical events. Low depth of any point in a multi variate set is an unusual combination in that cloud of points.

The methodology is demonstrated using the hydrological model TOPNET on the Pelorus catchment in New Zealand (Figure 1). Once the critical events were selected from a time series of precipitation or discharge, the model is calibrated using Robust Parameter Estimation (ROPE) algorithm (Bardossy & Singh, 2010). The result is compared with a standard model calibration, where the whole data set is being used. The results are very similar. Hence, model calibration using critical events may be very useful for the places where there is shortage of data or computational resources are limited.

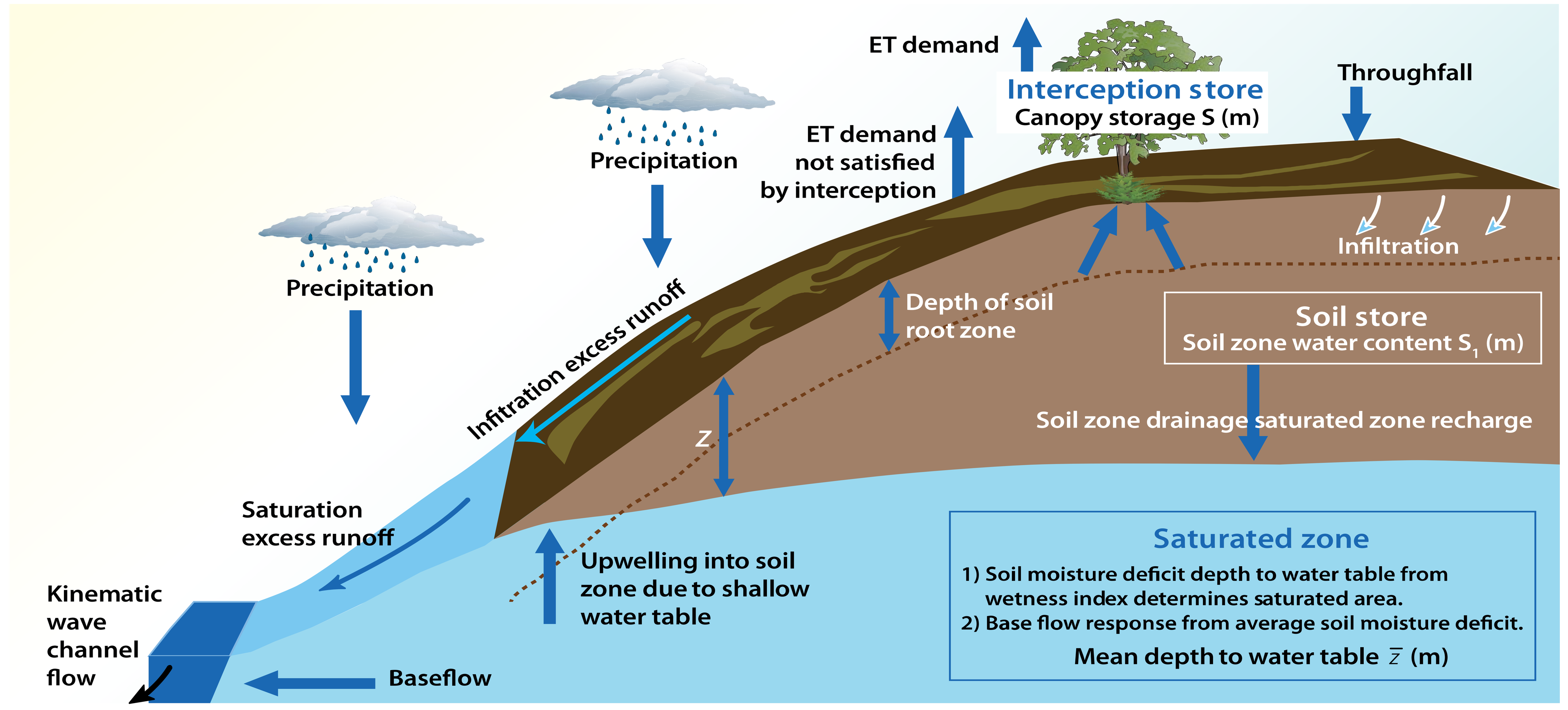

Figure 2: Schematic representation of the TOPNET modeling system (Bandaragoda et. al., 2004).

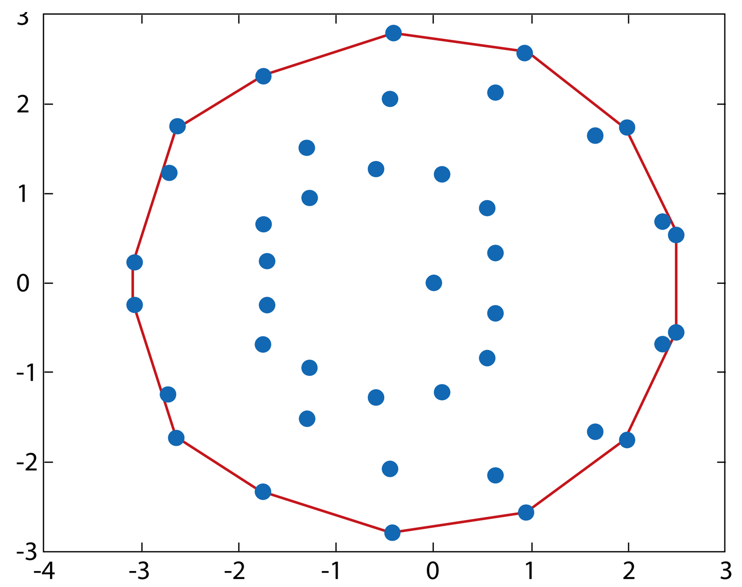

Figure 3: Convex hull.

Depth Function

Data depth is a quantitative measurement of how central a point is with respect to a data set or a distribution. This gives us the central outward ordering of multivariate data points.

$$D_X(p) = \min\left(\min\left(|\{x \in X\ (nh, x-p) > 0\}|\right), nh\ \left(|\{x \in X\ (nh, x-p) < 0\}|\right)\right)$$

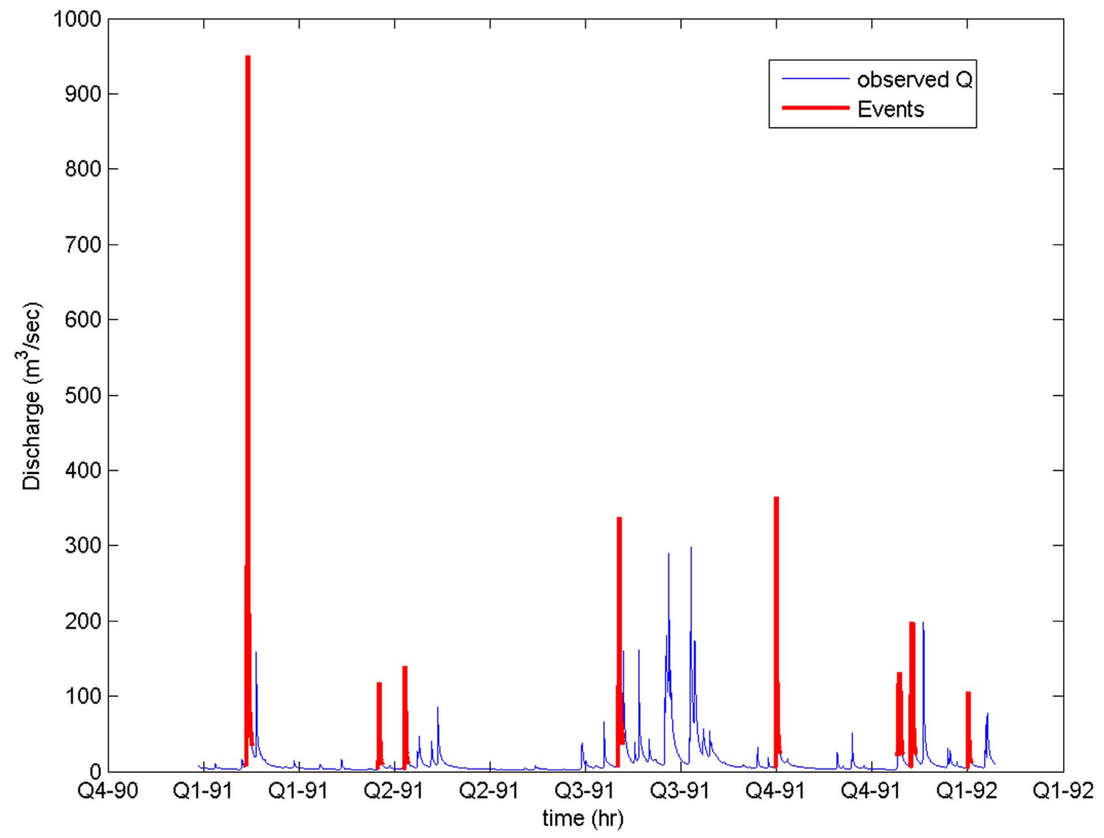

Figure 4: Unusual events selection

Using unusual events for parameter identification

Critical events correspond to higher information content. These events can be identified from the observations with the help of statistical depth function. Critical events are defined around the unusual (low depth) days.

	mean NS	max NS	min NS	std	% data used
Case 1	0.563	0.579	0.558	0.00589	100
Case 2	0.561	0.579	0.554	0.00700	5.7
Case 3	0.380	0.422	0.346	0.02598	5.7

Calibration result from all the three cases for time period 1990–1993 for Pelorus Catchment (statistics of best 10 parameter sets from ROPE).

Different Cases for Model Calibration

Case 1: Using whole series for given time period.

Case 2: Using only selected critical events for given time period (events selected by ICE algorithm (Singh & Bardossy, 2011).

Case 3: Using only selected (same number as in Case 2) random events for given time period.

	mean NS	max NS	min NS	std
Case 1	0.479	0.517	0.396	0.03223
Case 2	0.480	0.517	0.396	0.03156
Case 3	0.237	0.276	0.215	0.01976

Validation result from all the three cases for time period 1994–1996 for Pelorus Catchment (statistics of best 10 parameter sets from ROPE).

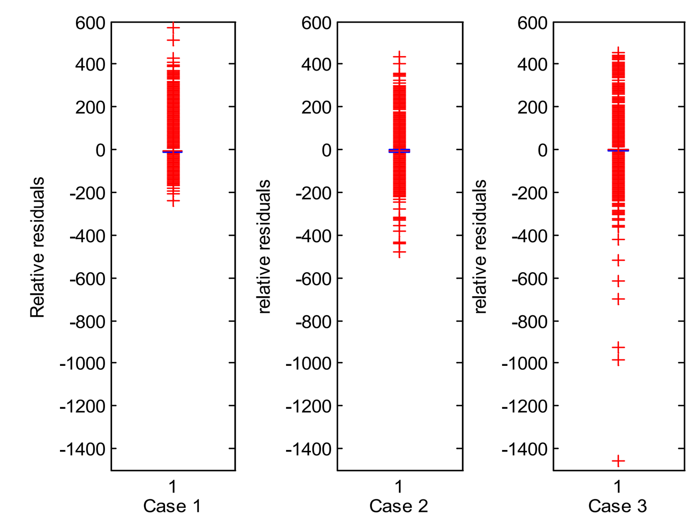

Figure 5: Boxplot of residual for calibration time period.

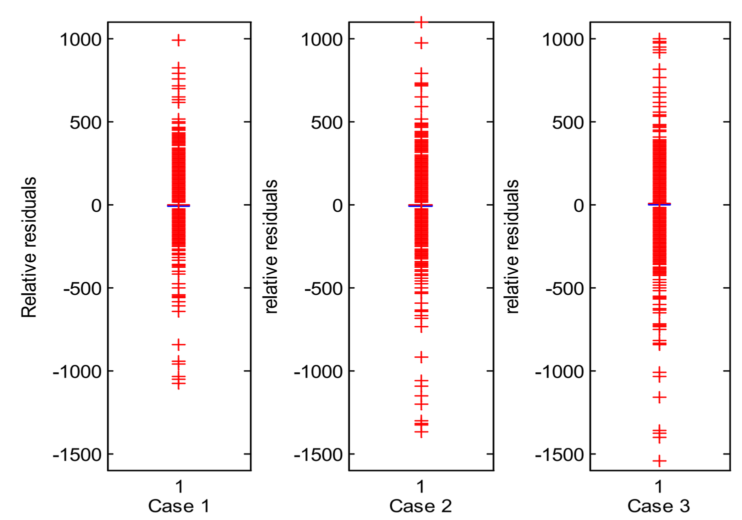

Figure 6: Boxplot of residual for validation time period.

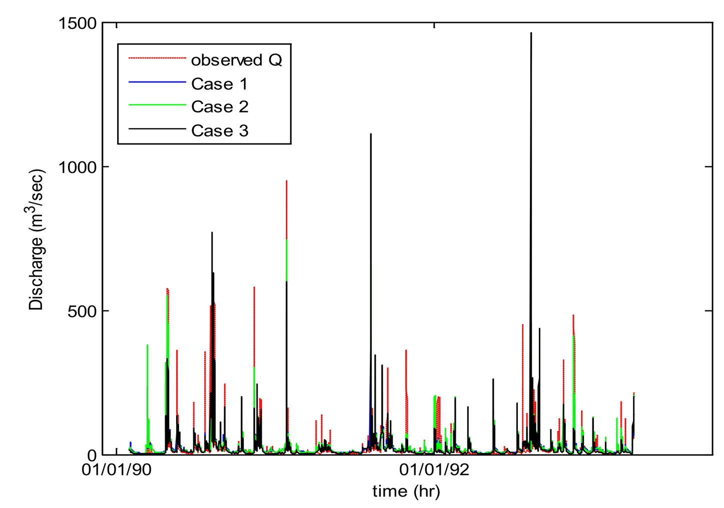

Figure 7: Hydrograph for all the cases for calibration time period.

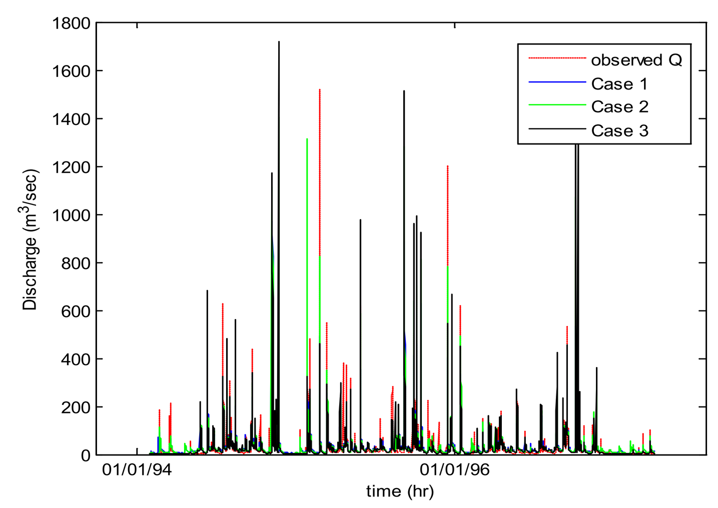

Figure 8: Hydrograph for all the cases for validation time period.

Conclusions

- Smartly selected and measured events are sufficient to identify the parameters of the model. Indeed, the prediction is as good as that arising from the calibration using the whole time period.
- Events selection by ICE algorithm is more robust than random selection of events.
- Critical event based calibration can be use for incomplete time series.
- Method has not only potential for discharge measurement but may also be useful for water quality measurements.

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