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Flood routing using models based on input and output data

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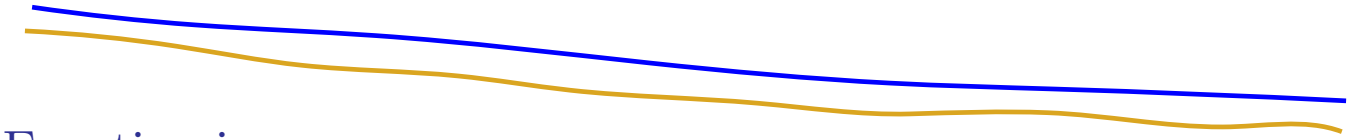
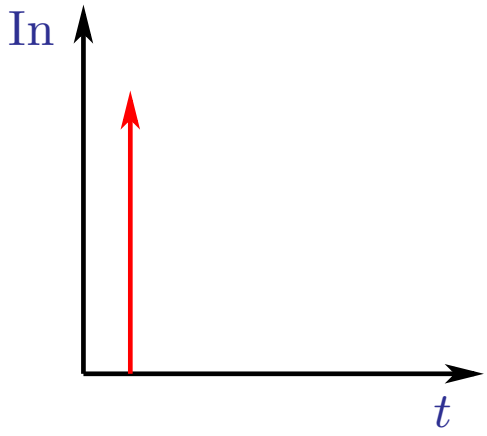
- Here, we use rather simpler optimising software than conventional deconvolution methods.

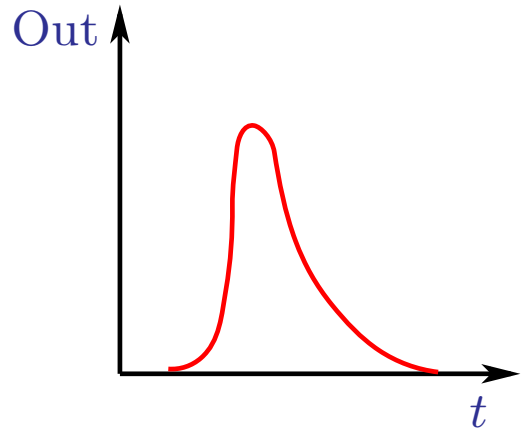
The Transfer Function and Convolution

Physical situation

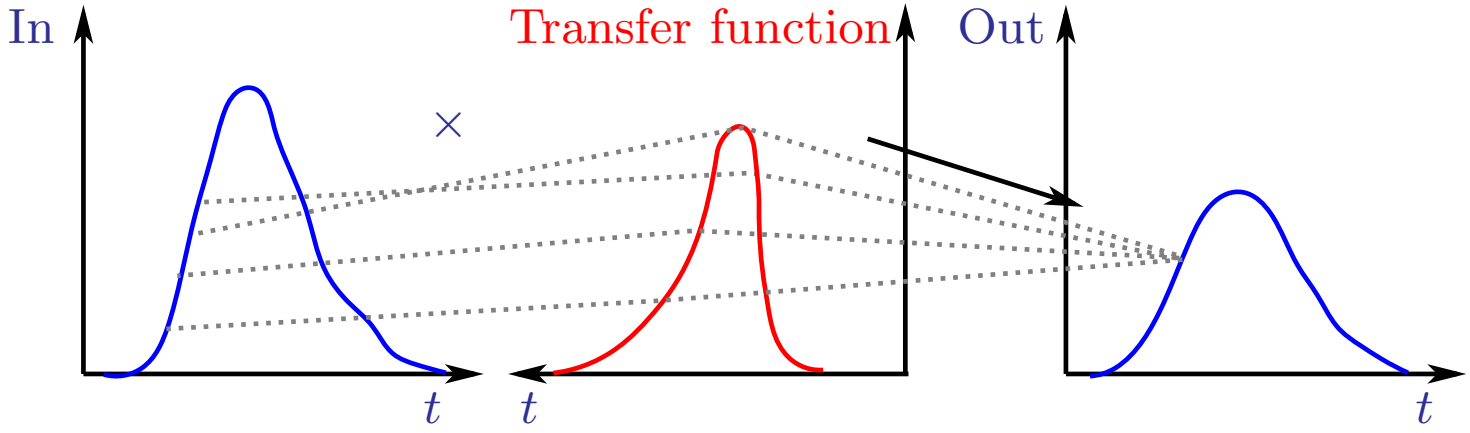


What the Transfer Function is





How it is obtained from how it works



What we measure

What we want to obtain - to use for future floods

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- Linear transfer function h_k, $k = 0, \ldots, K$, relating input to output
- Output O_n, whether river level or flow, is due to all the contributions I_m multiplied by their effect on the outflow with a time difference $n - m$:

$$O_n = \sum_{\substack{m=0, \\ m>n-K}}^{n \leqslant M} I_m h_{n-m}, \quad \text{for } n = 0, \ldots, N-1.$$

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- Such a summation is a discrete convolution. First, one takes the M input values and N output values and solves the system of linear equations for the h_k by standard methods. Then, the effects of any future flood can be predicted by performing the convolutions with the calculated h_k but with a new set of observed I_m.

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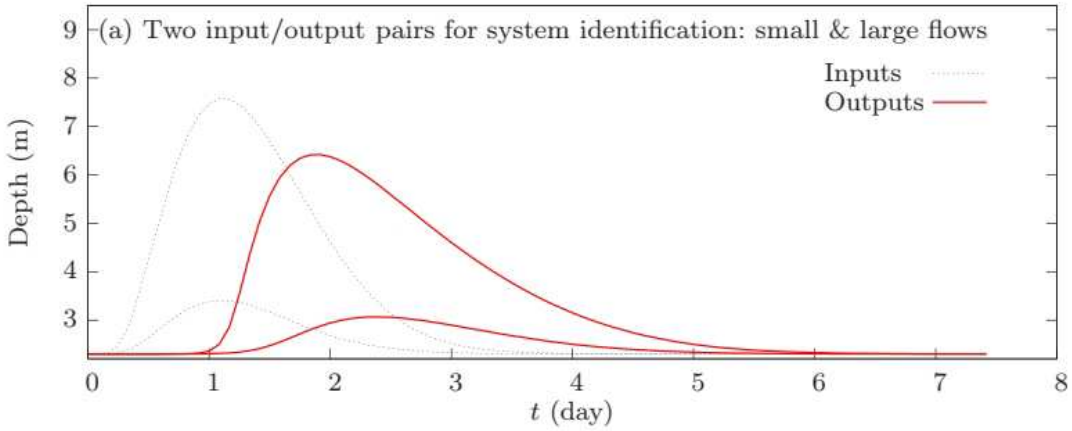
- The system of equations might be over-determined and might be poorly conditioned numerically.
- The use of optimising software overcomes some of these problems – *and would even allow nonlinear generalisations*. We seek to minimise the total sum of the squares of the errors e of the approximating convolutions over the N data points:

$$e = \sum_{n=0}^{N-1} \left(\sum_{\substack{m=0, \\ m>n-K}}^{n \leqslant M} I_m h_{n-m} - O_n \right)^2 .$$

A test of nonlinearity – large floods



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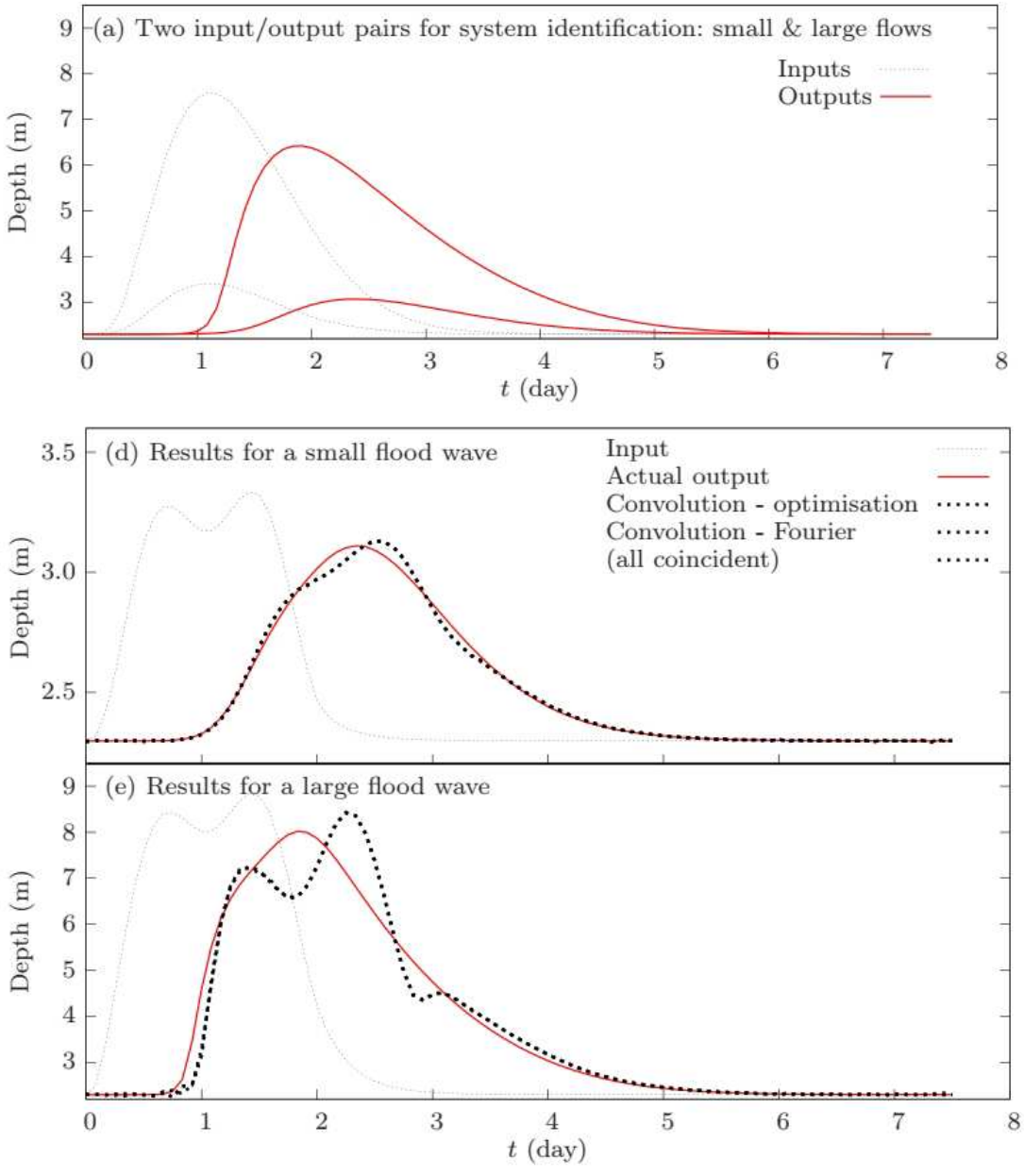

Field measurements – Chattahoochee River, Georgia, USA

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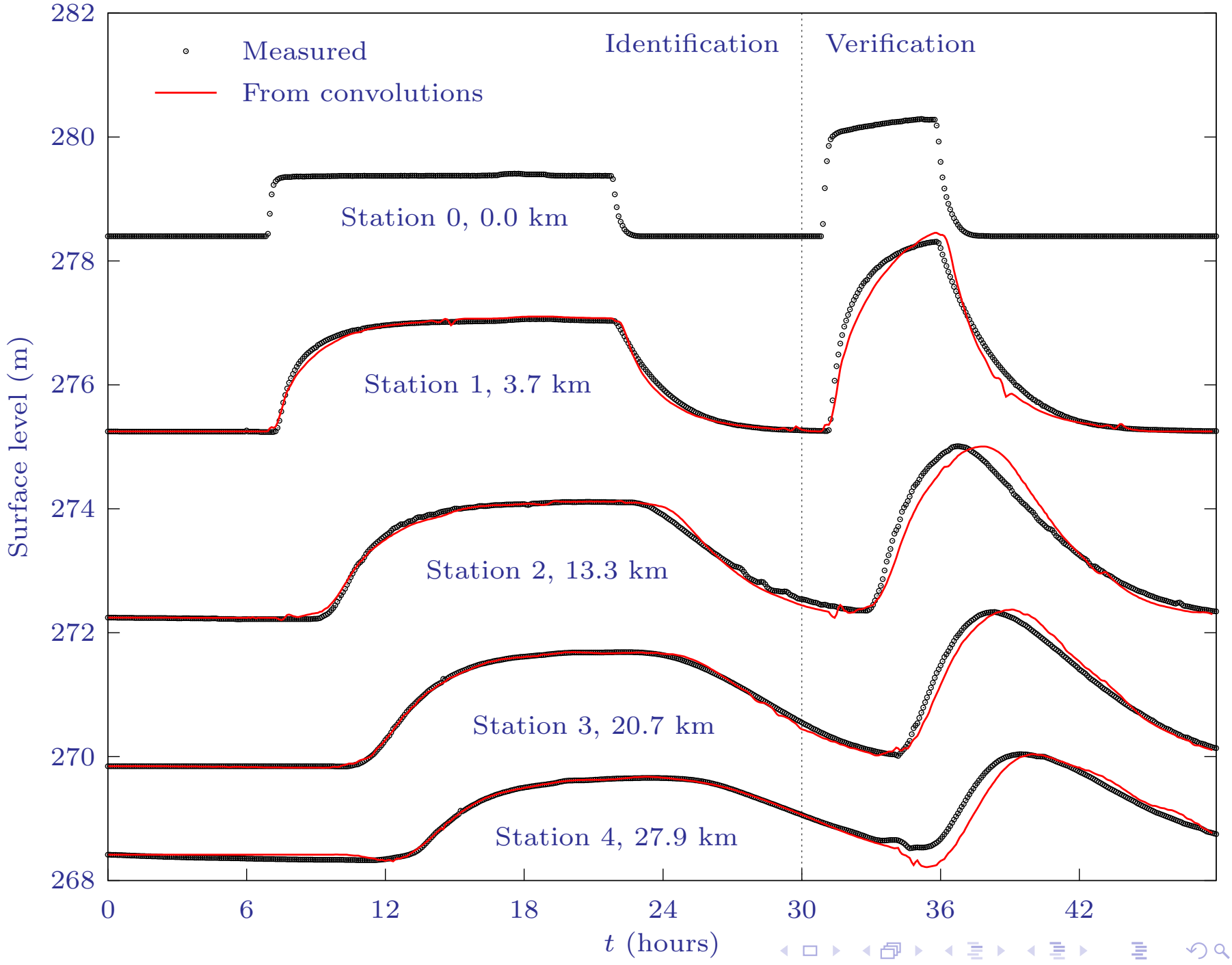
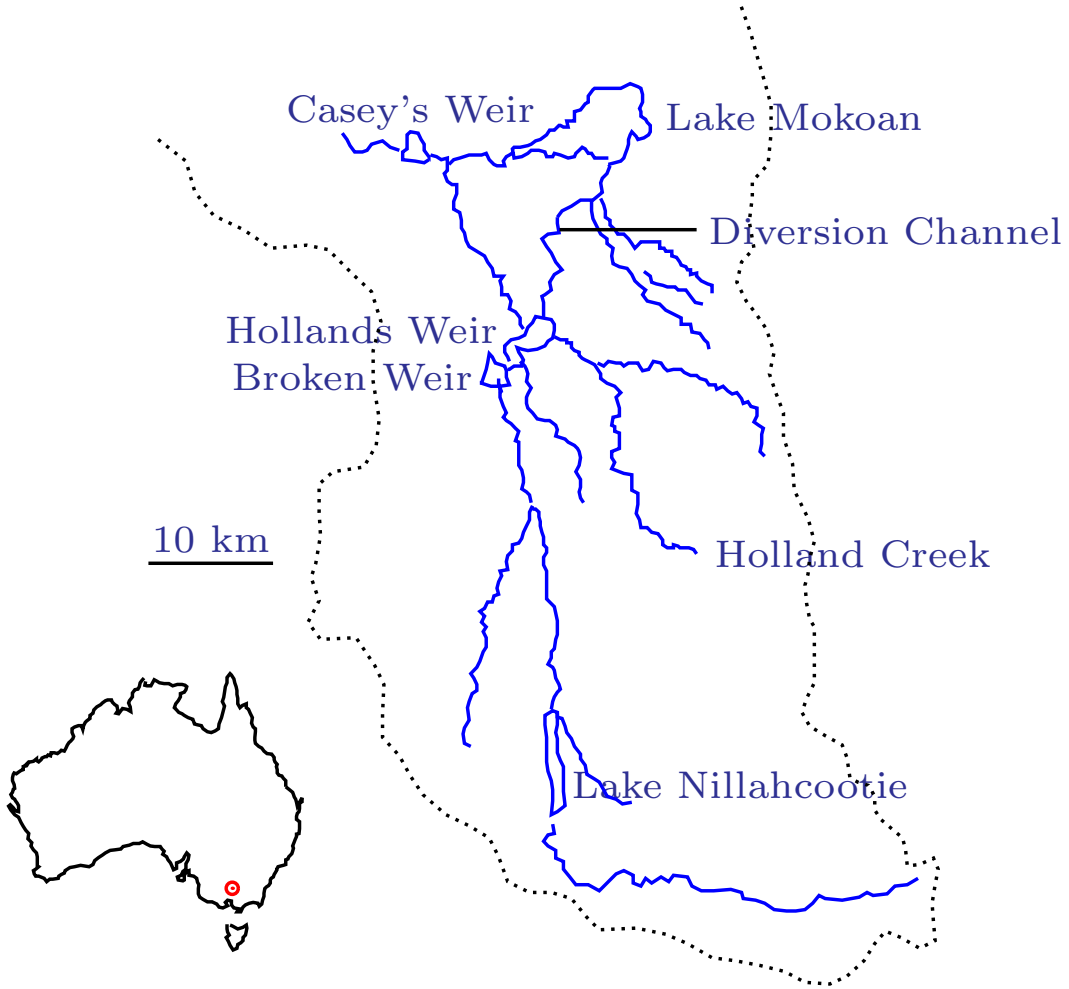
- Measurements of stage at a number of stations were made continuously.


Measured
From convolutions
Identification
Verification
Station 0, 0.0 km
Station 1, 3.7 km
Station 2, 13.3 km
Station 3, 20.7 km
Station 4, 27.9 km
Surface level (m)
t (hours)
282
280
278
276
274
272
270
268
0
6
12
18
24
30
36
42

A generalisation to multiple inputs

- Such a method was used in a study of flows in a complex set of interconnections in the Broken River Valley in south-eastern Australia



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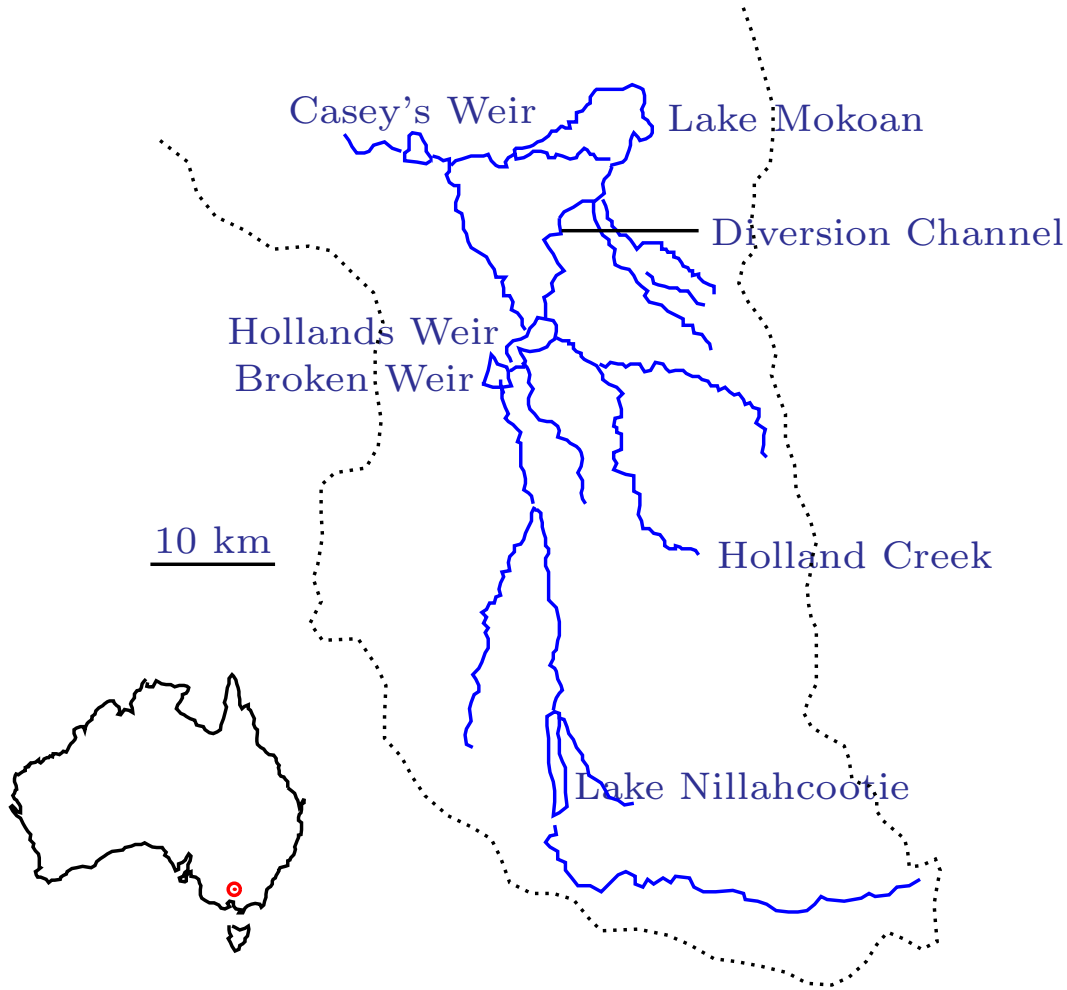
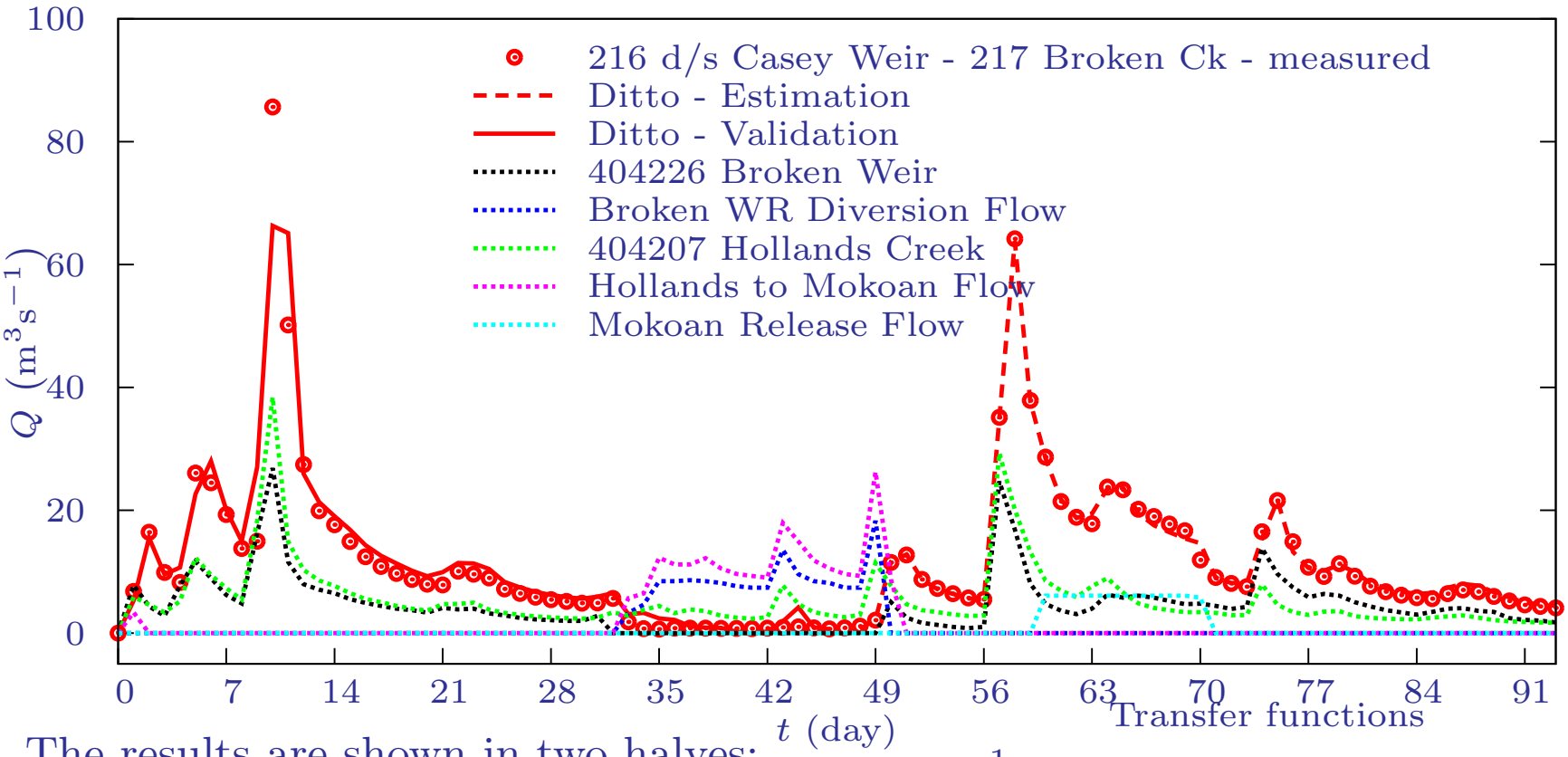
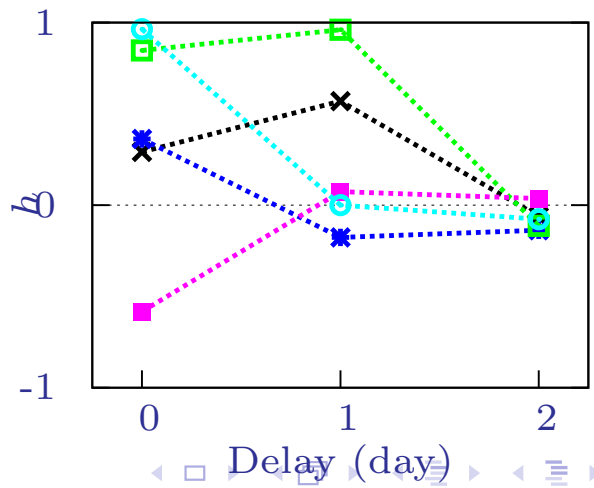
- The routing model was expressed as the simple combination of several transfer functions such as that shown previously.



Results



The results are shown in two halves: those for $t > 45$ d were used to estimate the transfer functions.



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- The method can be used with multiple inputs.