Evaluation of KRG2+4

Definitions

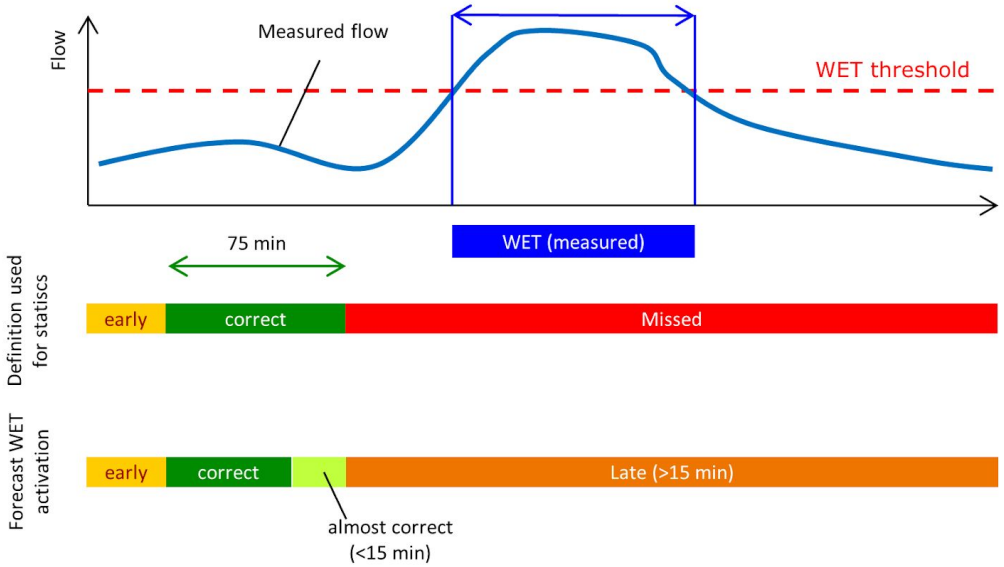
Flow forecasts

GB = new forecast model developed in WSC based on greybox model
WA= existing forecast model used on autocalibration of a Wateraspects model (only Damhusåen)

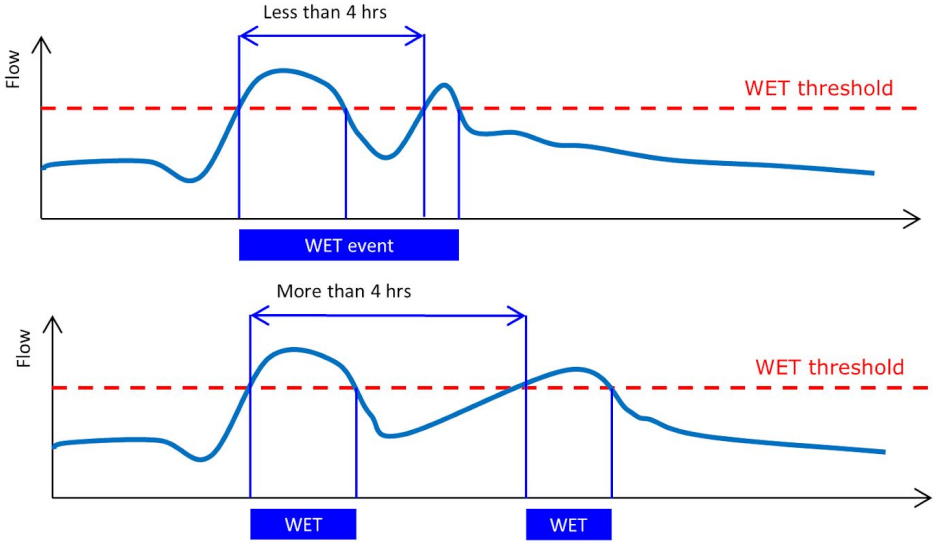
The analysis of the flow prediction is based on the definition of “WET event”, i.e. events exceeding a predefined threshold. In WET events, it is assumed that the WWTP will change its operations from dry-weather to wet-weather controls. For plants running the STAR/AQUAVISTA control, a WET event correspond to a simplified version of the ATS control (the actual ATS control is defined by several other factors than just the inlet flow, such as the capacity of the secondary clarifier or the biological processes, so this analysis provides an approximation of the actual performance with the ATS control).

WET event: if flow exceeded threshold.
Correct (Positive): if WET activation was predicted within a 75 min interval (from 60 min before measured flow exceeded threshold to 15 min after)
Missed: if WET activation was predicted more than 15 min after the measured flow exceeded the threshold or if no WET was predicted (False Negative)
Early: if WET activation was predicted earlier than 60 min before the measured flow exceeded the threshold

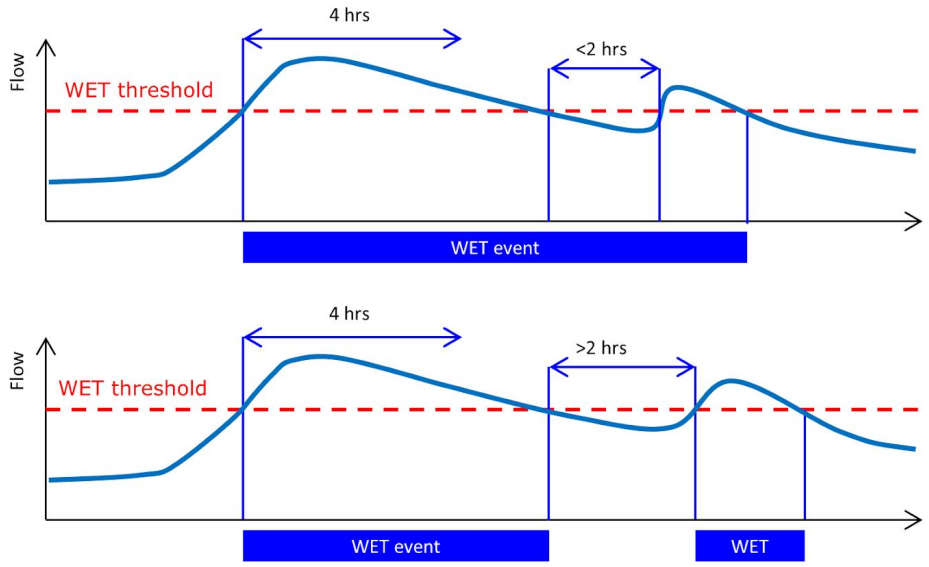
Down: no data are available for the specific time interval where WET event took place (i.e. it is not possible to evaluate the performance of the forecast)



WET activations taking place less than 4 hrs after the start of the WET event are counted in the same event

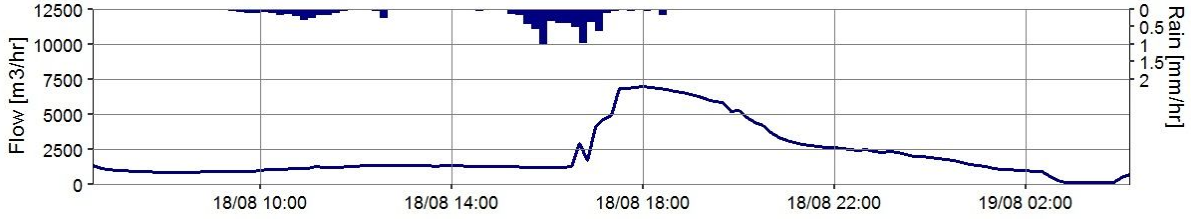


A new WET event activation is created if flow exceeds the threshold more than 2 hrs after the end of the previous WET event

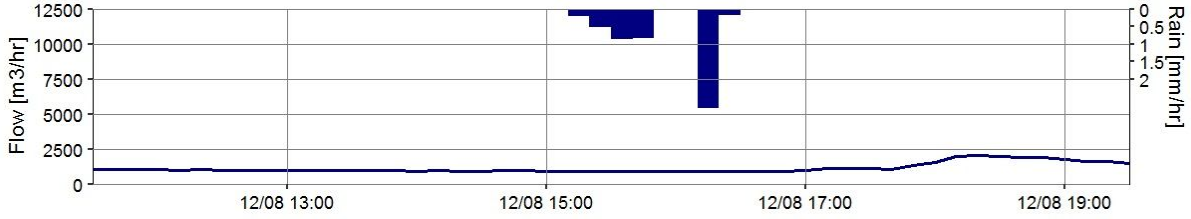


Rainfall forecasts

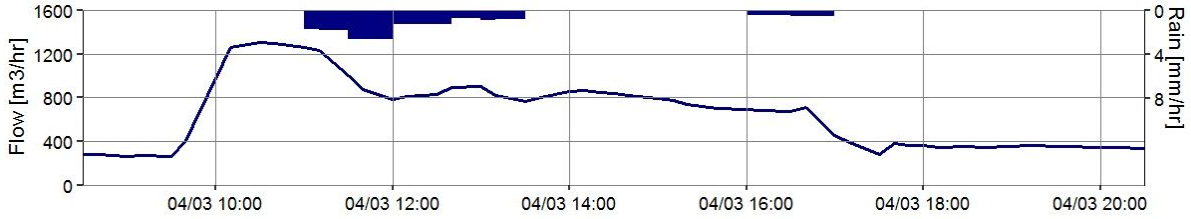
- Correct: rainfall was predicted, and measured flow exceeded threshold for WET activation. Underestimated rain are also classified as correct
- Early Rain: a series of rainfall events was predicted, and flow threshold was exceeded. However, the first rainfall intensities were overestimated, leading to flow below the threshold.



- False Alarm: Rainfall was predicted, but no increase in the flow was observed, or rainfall was overestimated, i.e. limited increase in the flow (still below the threshold for activation of WET) was observed.



- Missed/late rain: no rain in the forecast, but increase in flow, or forecasted rain is late compared to increase in flow (does not include underestimated rain)



Performance for volume forecasts

Bypassed volume: all volumes above WET threshold

Aarhus Vand - Forecast at inlet of Viby plant

Flow threshold for WET event: 600 m3/hr.

Results - Only measured WET events

The statistics in this section are based on the analysis only of events where the measured flow exceeded the threshold, i.e. false alarms are not included in these statistics. A total of 57 WET events were identified in the measurements in the period from 2019/02/21 to 2019/12/06.

Table 1: overview of analysed events

WET activation	Only measured	All (measured + forecasted)
120 min forecast	58	105
60 min forecast	58	88
30 min forecast	58	72

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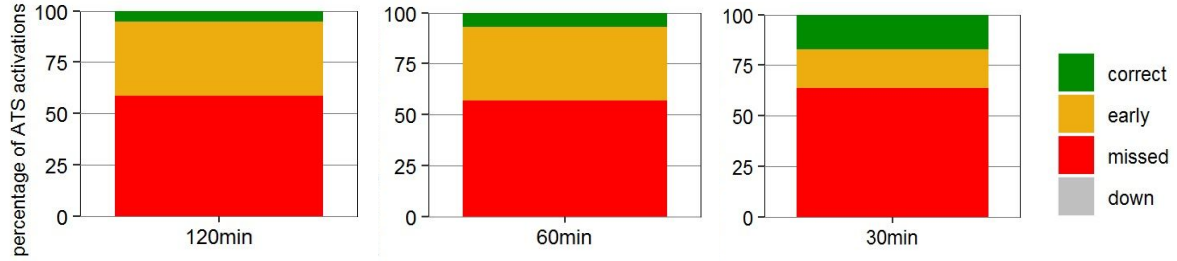


Table 2: Evaluation of performance for different forecast horizons

WET activation	120 min	60 min	30 min
Early	21	21	11
Correct	3	4	10
Missed	34	33	37

Results - Actual and forecasted WET events

The statistics in this section are based on the analysis of all the events where the measured flow exceeded the threshold, i.e. false alarms and correct negatives are also included in these statistics. The number of WET events in the period from 2019/02/21 to 2019/12/06 were 72 (30 min forecast) 88 (60 min forecast), 105 (120 min forecast).

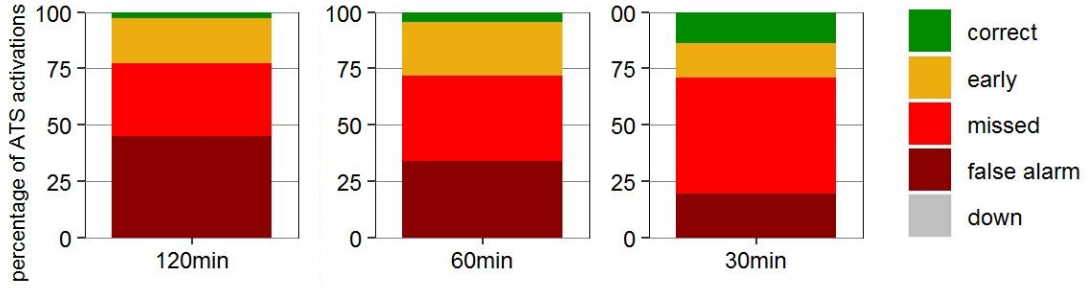


Table 4: Evaluation of performance for different forecast horizons

WET activation	120 min	60 min	30 min
Early	21 (24%)	21 (24%)	11 (13%)
Correct	3 (3%)	4 (5%)	10 (11%)
Missed	34 (39%)	33 (38%)	37 (42%)
False alarm	47 (53%)	30 (34%)	14 (16%)

Influence of forecast

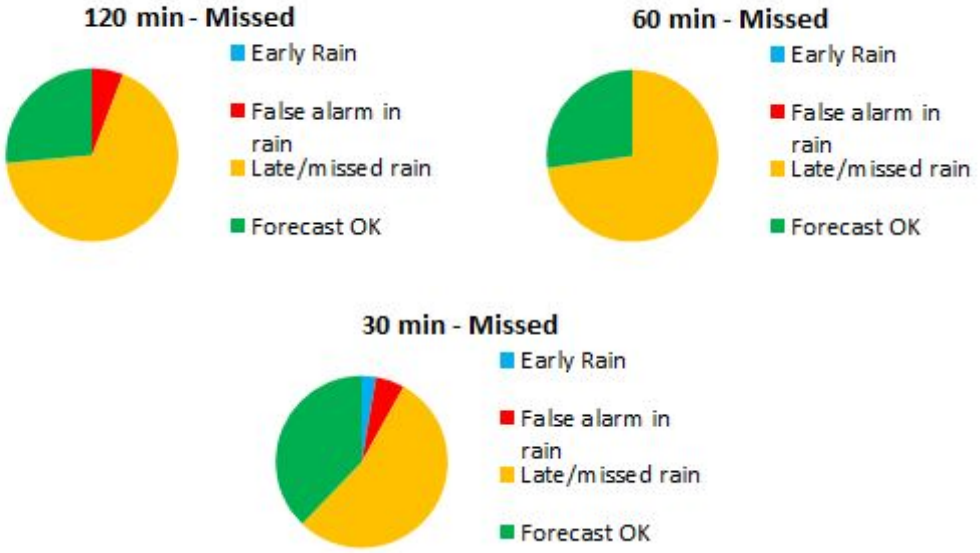
This section investigates the influence of the rainfall forecast on the performance of the flow forecast model

Table 6: Performance analysis of rainfall forecast

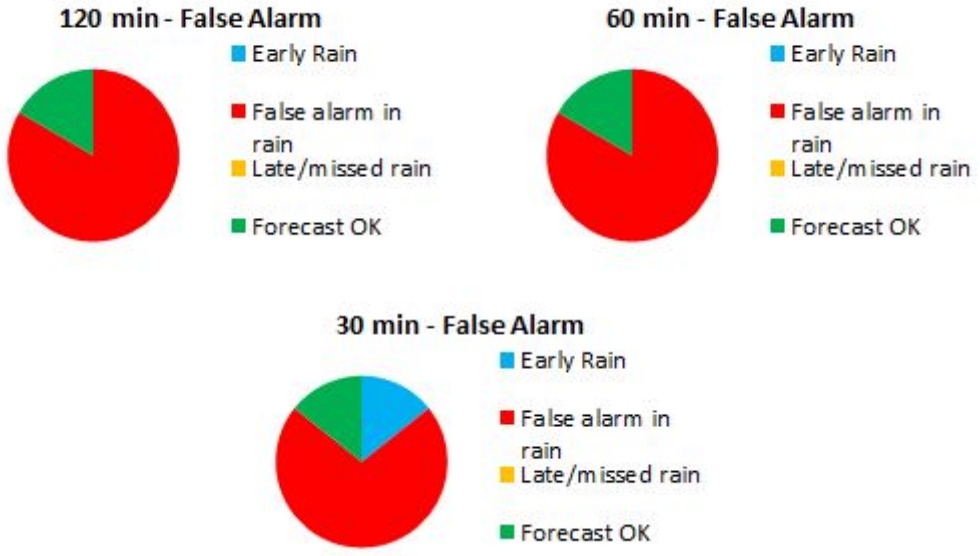
	Correct	Early Rain	False Alarm	Missed/late
120 min	20 (19%)	13 (12%)	45 (43%)	27 (26%)
60 min	19 (22%)	19 (22%)	26 (31%)	24 (28%)
30 min	29 (40%)	11 (15%)	12 (17%)	20 (28%)

Table 7: Overview of effect of rainfall quality on flow forecast performance

Rainfall	WET activation				
	Early	Correct	Correct negative	Missed	False alarm
	120 min				
Correct	11	2		9	11
Early Rain	9				
False Alarm	1			2	36
Missed/late		1		23	
	60 min				
Correct	5	3		9	5
Early Rain	16	1			
False Alarm					25
Missed/late				24	
	30 min				
Correct	3	10		14	2
Early Rain	8			1	2
False Alarm				2	10
Missed/late				20	

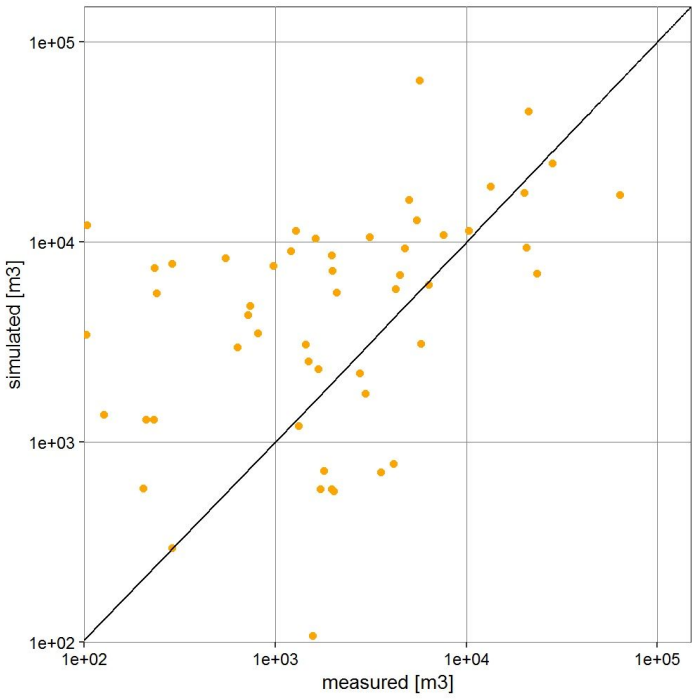


Relationship between "Missed" in flow forecasts and corresponding classification for rain forecast

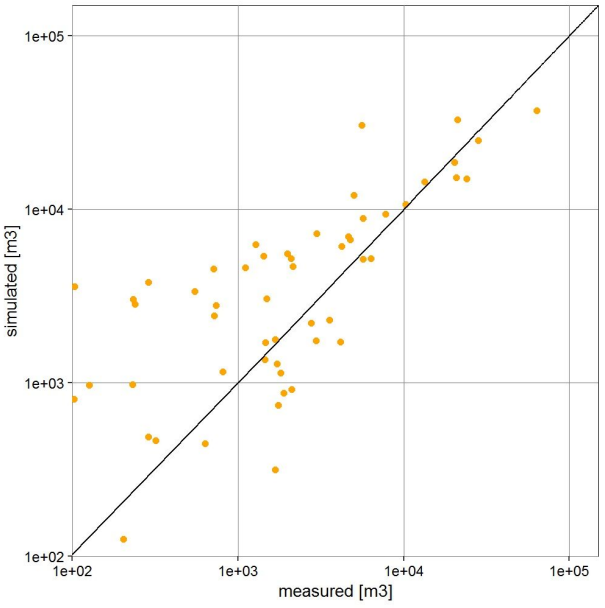


Relationship between "False Alarms" in flow forecasts and corresponding classification for rain forecast

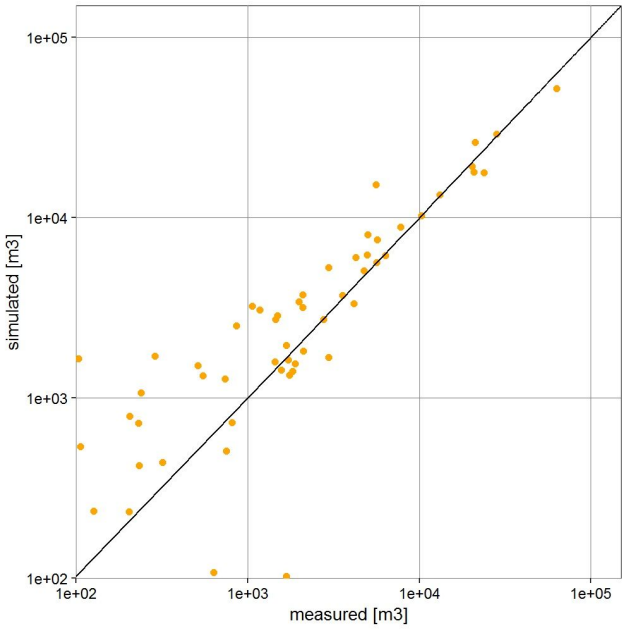
Performance for volume forecasts



120 min: OBS: simulated values equal to zero (missed events) are plotted on the 100 m3 line



60 min:OBS: simulated values equal to zero (missed events) are plotted on the 100 m3 line



30 min: OBS: simulated values equal to zero (missed events) are plotted on the 100 m3 line

Table 6: Comparison of volumes

	Median error on bypass volume	Average error on bypass volume
WET volume		
120 min	104%	624%
60 min	43%	226%
30 min	16%	89%

BIOFOS - Forecast at inlet of Damhusåen plant

Flow threshold for WET event: 5000 m3/hr.

Results - Only measured WET events

The statistics in this section are based on the analysis of only events where the measured flow exceeded the threshold, i.e. false alarms are not included in these statistics. A total of 57 WET events were identified in the period from 2018/01/14 to 2019/10/03

Table 1: overview of analysed events

WET activation	Measured	All (measured + forecasted)
60 min forecast	57	87
30 min forecast	57	85

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60 min forecast

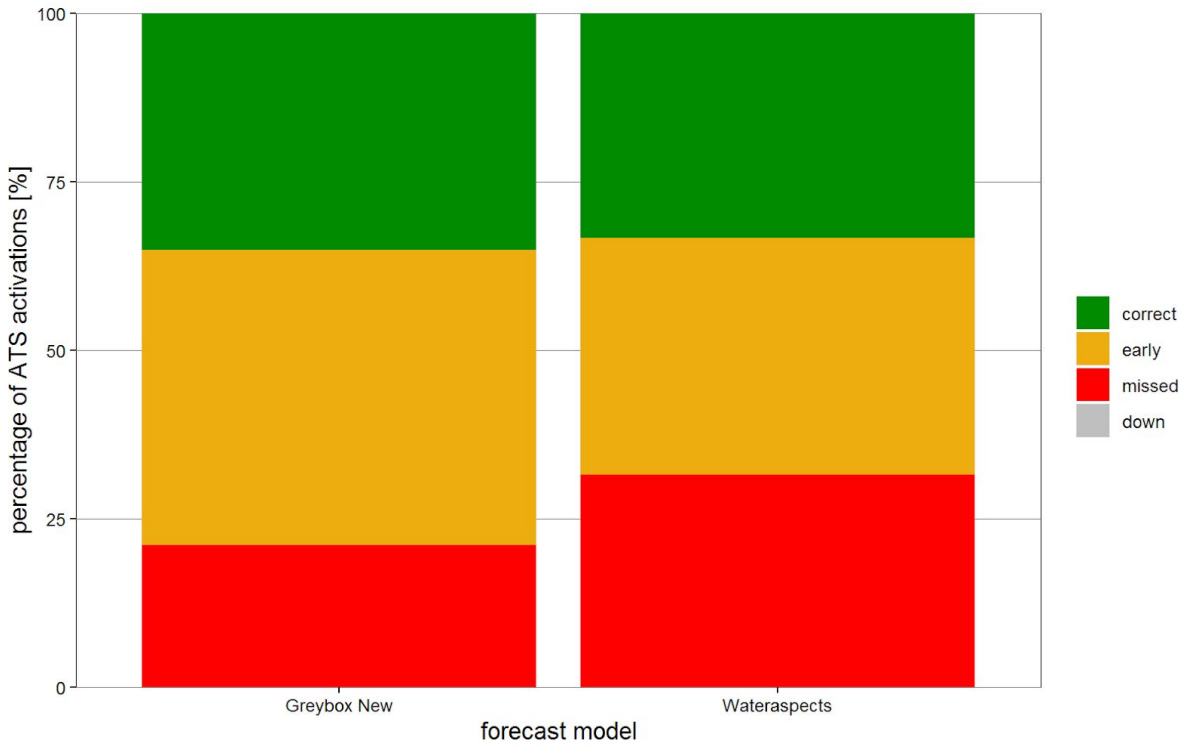


Table 2: Evaluation of performance for the 60 min forecast

WET activation	WA	GB	Variation [%]
Early	20 (35%)	25 (44%)	+25%
Correct	19 (33%)	20 (35%)	+5.3%
Missed	18 (32%)	12 (21%)	-33%

30 min forecast

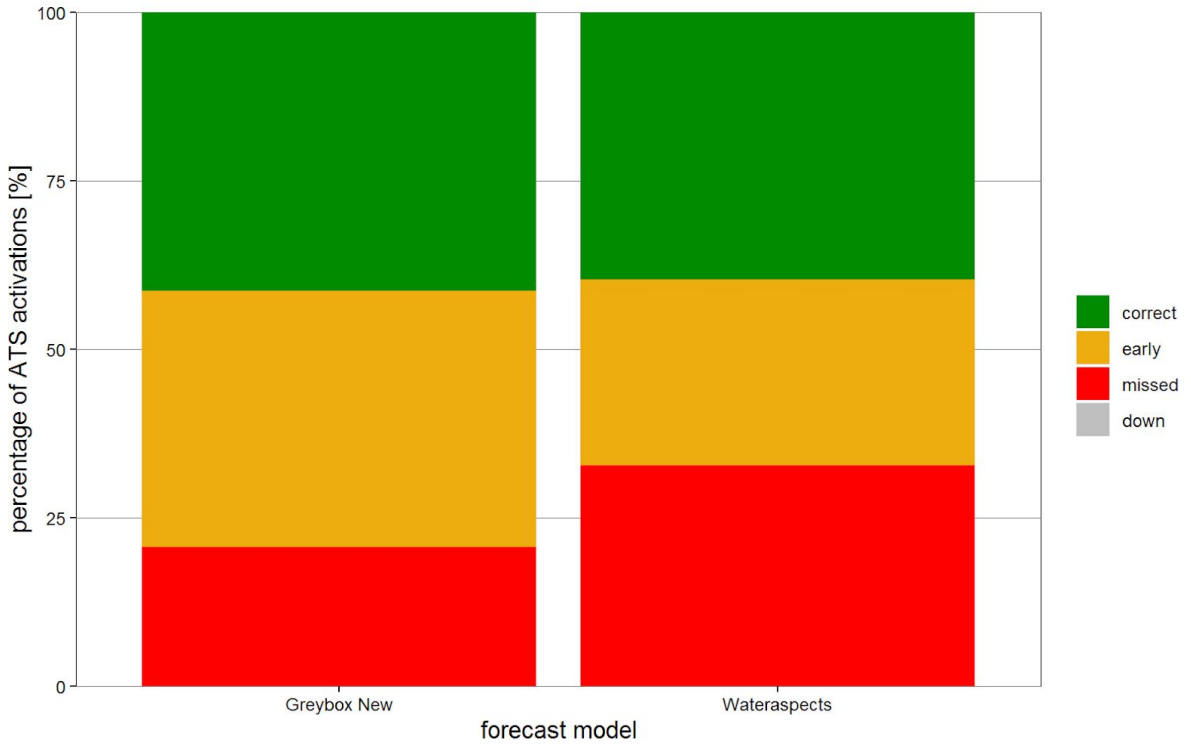


Table 3: Evaluation of performance for the 30 min forecast

WET activation	WA	GB	Variation [%]
Early	16 (28%)	22 (39%)	+38%
Correct	22 (29%)	23 (40%)	+5%
Missed	19 (33%)	12 (21%)	-37%

Results - Actual and forecasted WET events

The statistics in this section are based on the analysis of all the events where the measured flow exceeded the threshold, i.e. false alarms and correct negatives are also included in these statistics. The number of WET events in the period from 2018/01/14 to 2019/10/03 increased to 87 (60 min forecast) and 85 (30 min forecast).

60 min forecast

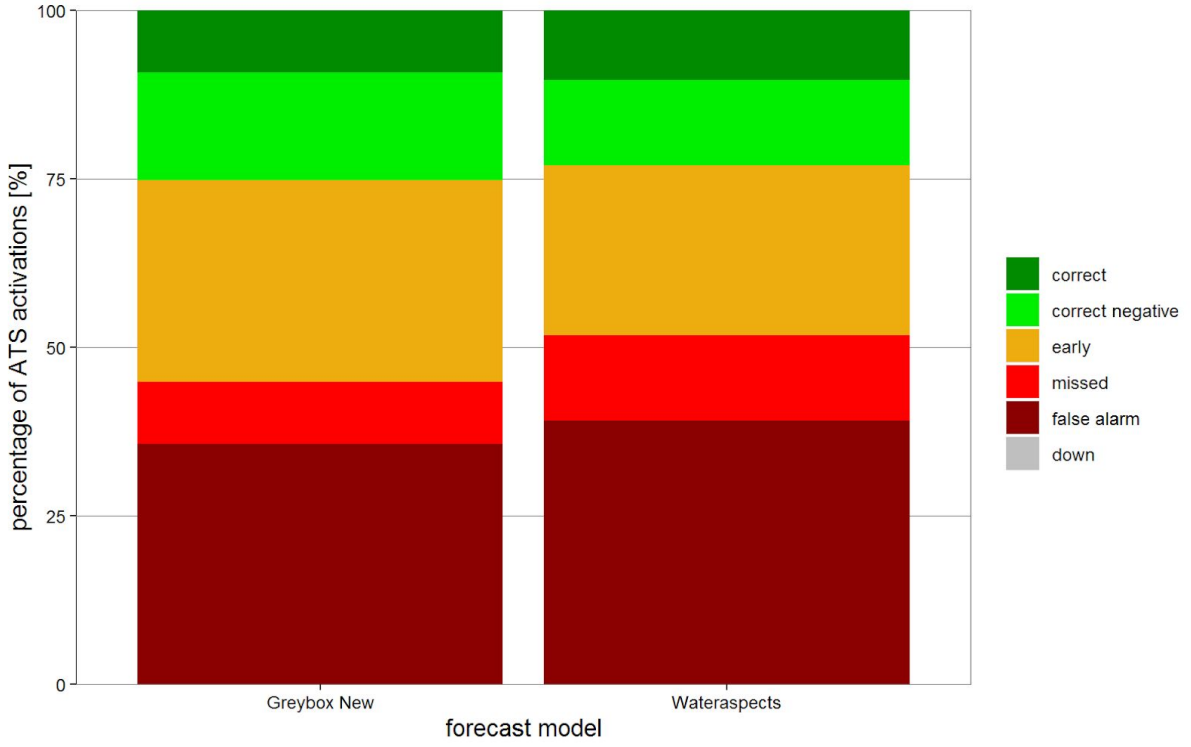


Table 4: Evaluation of performance for the 60 min forecast

WET activation	WA	GB	Variation [%]
Early	22 (25%)	26 (30%)	+18%
Correct	9 (10%)	8 (9%)	-11%
Correct negative	11 (13%)	14 (16%)	+27%
Missed	11 (13%)	8 (9%)	-27%
False alarm	34 (39%)	31 (36%)	-8%

30 min forecast

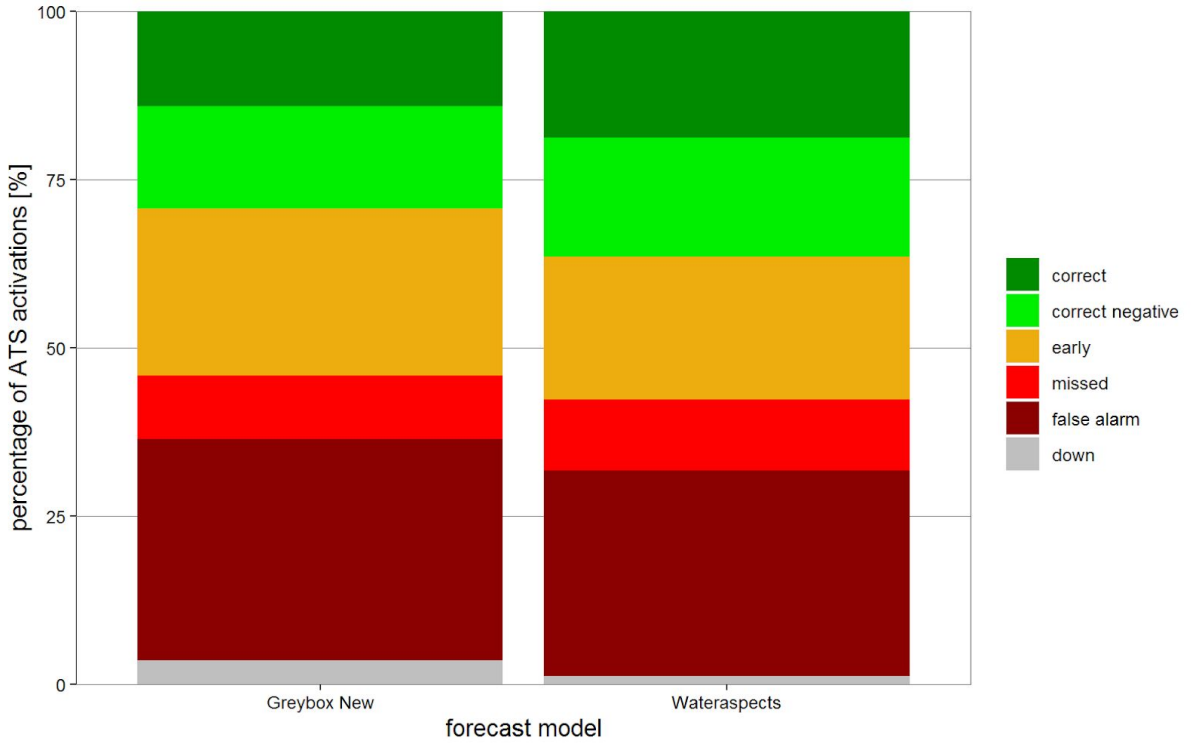


Table 5: Evaluation of performance for the 30 min forecast

WET activation	WA	GB	Variation [%]
Early	18 (22%)	21 (25%)	+17%
Correct	16 (19%)	12 (14%)	-25%
Correct negative	15 (18%)	13 (15%)	-13%
Missed	9 (10%)	8 (9%)	-11%
False alarm	26 (31%)	28 (33%)	+8%
Data not available	1 (1%)	3 (4%)	-

Influence of forecast

Table 5: Comparison between false alarms given by the different models

		False alarms (total)	False alarms given by both modes
30 min	WA	26	13 (50%)
	GB	28	13 (46%)
60 min	WA	34	20 (59%)
	GB	31	20 (65%)

Table 6: Performance analysis of rainfall forecast

	Correct	Early Rain	False Alarm
30 min	42 (49%)	13 (15%)	30 (35%)
60 min	51 (59%)	11 (13%)	25 (29%)

Table 7: Overview of effect of rainfall quality on flow forecast performance (30 min)

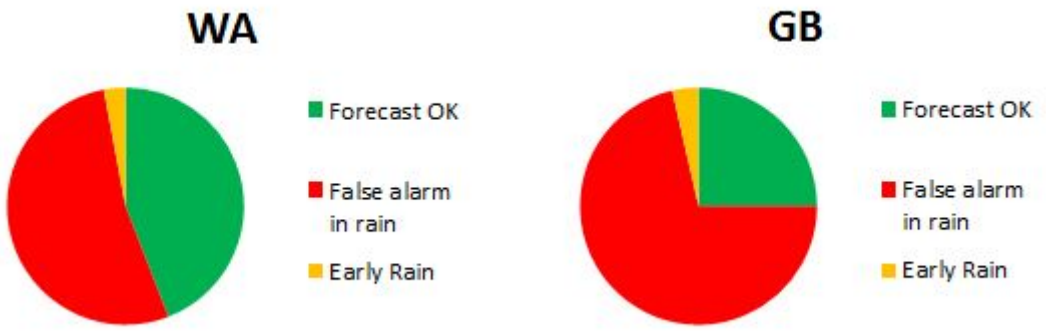
Rainfall	WET activation				
	Early	Correct	Correct negative	Missed	False alarm
	WA				
Correct	9	15	2	7	9
Early Rain	9	1		2	1
False Alarm			13		16
	GB				
Correct	11	10	8	8	3
Early Rain	10	2	1		
False Alarm			4		25

Table 8: Overview of effect of rainfall quality on flow forecast performance (60 min)

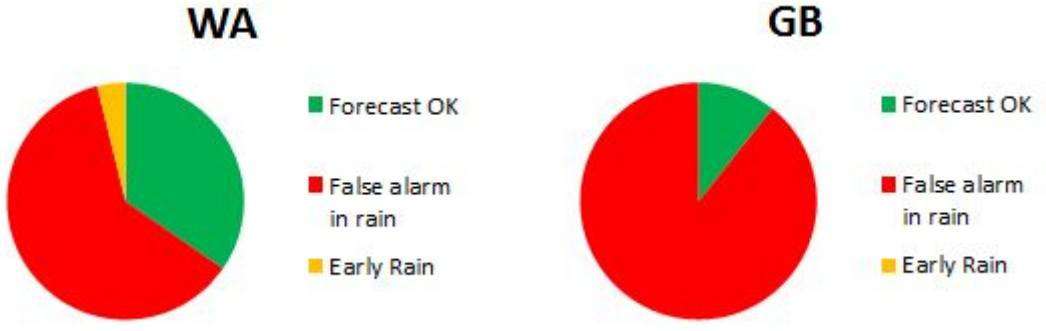
Rainfall	WET activation				
	Early	Correct	Correct negative	Missed	False alarm
	WA				
Correct	12	9	5	10	15
Early Rain	9			1	1
False Alarm			6		18
	GB				
Correct	15	8	12	7	7
Early Rain	10				1
False Alarm			3		20

Table 7 and 8 show that GB is more sensitive to false alarms in the forecasts, compared to WA (which provides more False Alarms with good forecasts). In fact, between 75% and 90% of the WET false alarms for GB were likely caused by false alarms in the forecast.

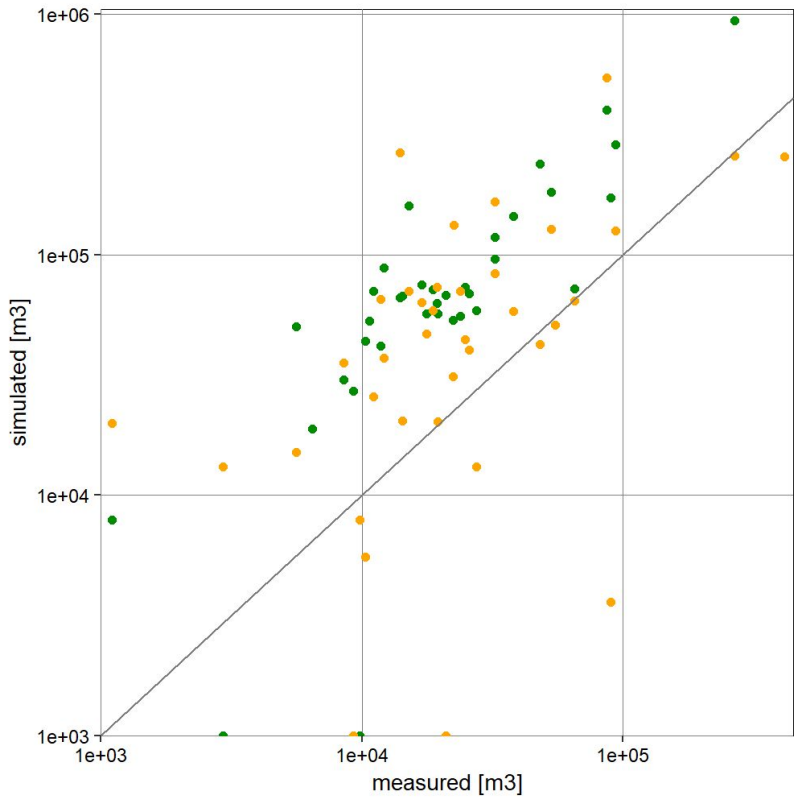
Relationship False Alarm in WET activations and rain forecast (60 min)



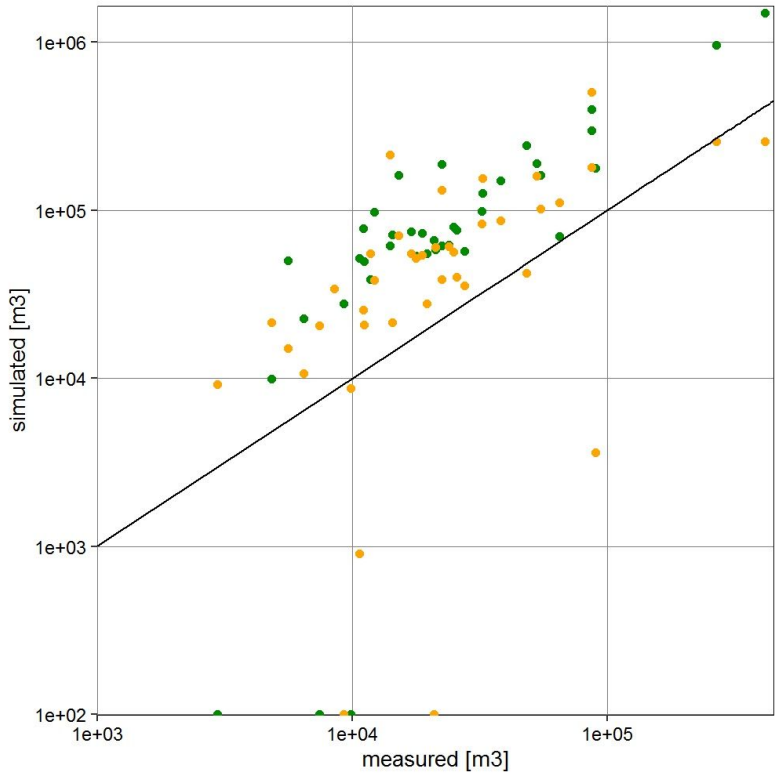
Relationship False Alarm in WET activations and rain forecast (30 min)



VOLUME



60 min OBS: simulated values equal to zero (missed events) are plotted on the 1,000 m3 line



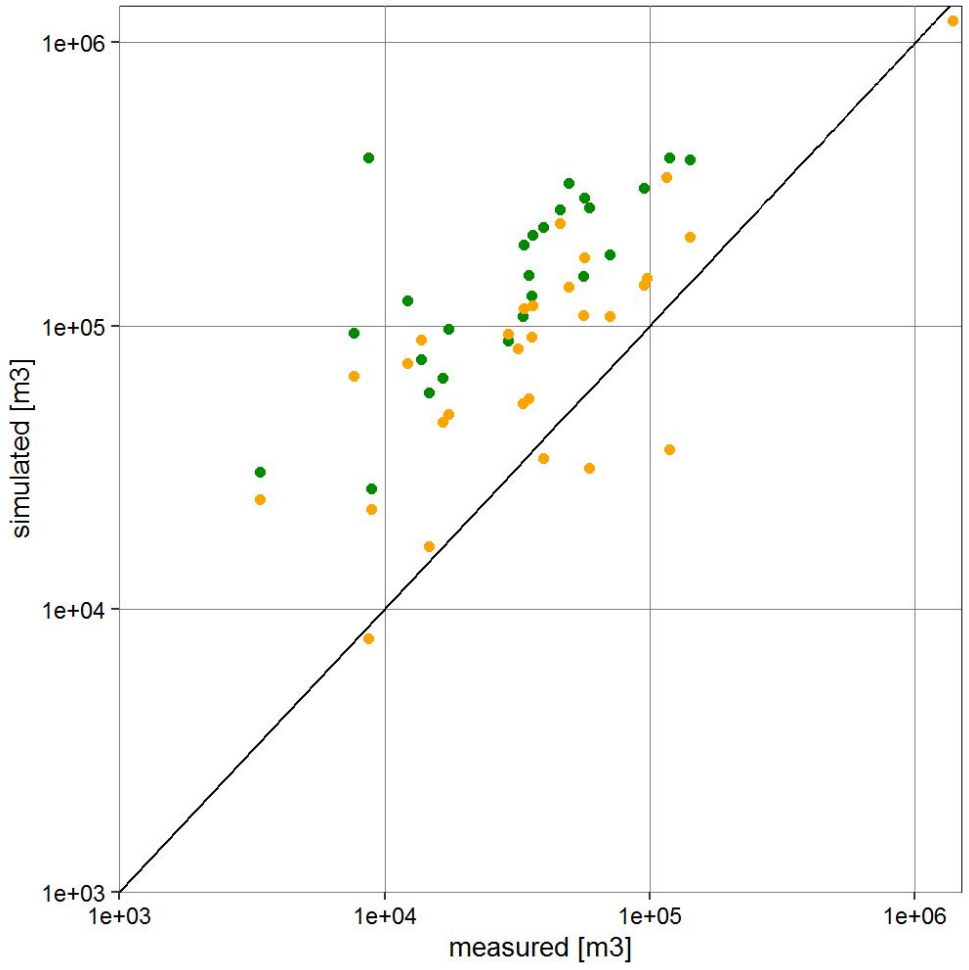
30 min OBS: simulated values equal to zero (missed events) are plotted on the 100 m3 line

Table 6: Comparison of volumes (for all events)

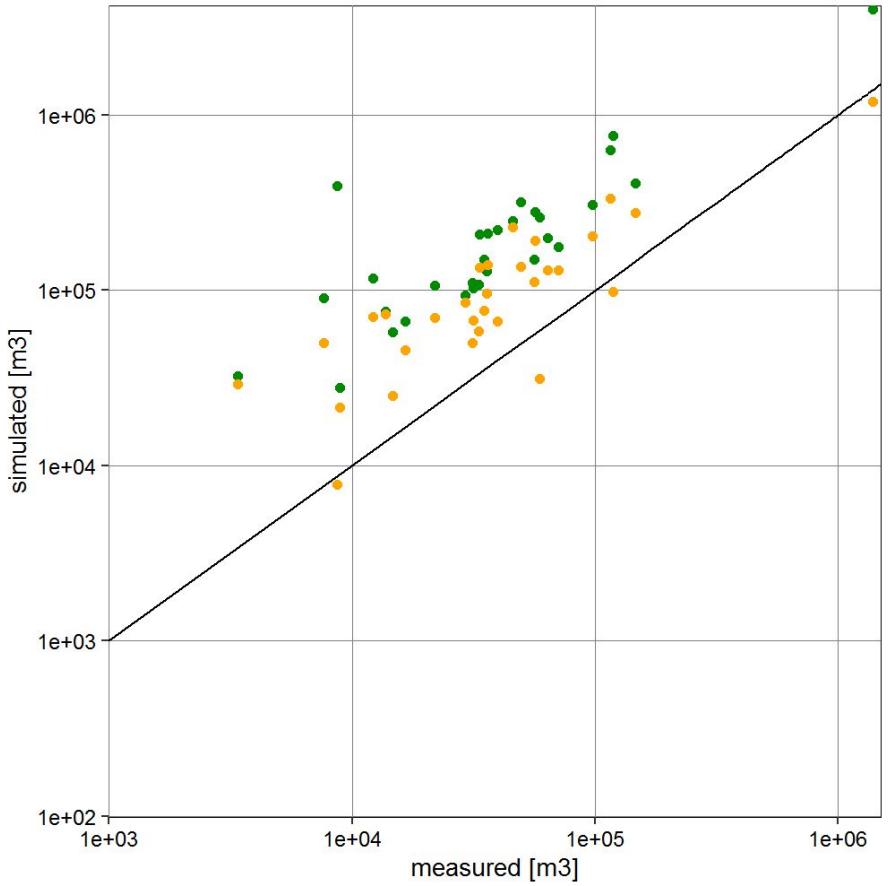
		Median error on bypass volume	Average error on bypass volume
WET volume			
60 min	WA	253%	295%
	GB	131%	221%
30 min	WA	257%	310%
	GB	155%	193%
Wet weather volume			
60 min	WA	342%	563%
	GB	153%	156%
30 min	WA	328%	520%
	GB	141%	187%

Performance for volume forecasts (small events)

Threshold lowered to 3,000 m3/hr (assumed as max value for DWF)



60 min



30 min: OBS: simulated values equal to zero (missed events) are plotted on the 100 m3 line