FURTHER REFINEMENT OF THE MFXP (MODIFIED FIXED PROPORTION) CMP

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SUMMARY

Results are reported for a refined MFXP CMP for tunings as specified at the September MSE meeting. The primary improvement compared to the previous version of this CMP is achieved by upweighting the contributions of the US_RR indices to the aggregated index used to calculate TACs for the West area. This leads to an improvement in conservation performance for the Western stock for OMs with a future regime shift, without any obvious associated disadvantages. The reason is that these indices detect the effect of such a regime shift earlier than the others available for the West area.

KEYWORDS

Management Strategy Evaluation, Candidate Management Procedure, Operating Model grid, Atlantic bluefin tuna, development tuning

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Introduction

This paper reports on further refinement of the MFXP (Modified Fixed Proportion) CMP, subsequent to that described in SCRS/2020/147 – Butterworth and Rademeyer (2020).

Description of FXP CMP

The CMP is empirical, based on inputs related to abundance indices which are first standardised for magnitude, then aggregated by way of a weighted average of all indices available for the East and the West areas, and finally smoothed over years to reduce observation error variability effects. TACs are then set based primarily on the concept of taking a fixed proportion of the abundance present, as indicated by these aggregated and smoothed abundance indices. The details are set out below.

Aggregate abundance indices

An aggregate abundance index is developed for each of the East and the West areas by first standardising each index available for that area to an average value of 1 over the past years for which the index appeared reasonably stable[2], and then taking a weighted average of the results for each index, where the weight is inversely proportional to the variance of the residuals used to generate future values of that index in the future modified to take into account the loss of information content as a result of autocorrelation. The mathematical details are as follows.

J_y is an average index over *n* series (*n*=5 for the East area and *n*=7 for the West area)[3]:

$$J_y = \frac{\sum_i^n w_i \times I_y^{i*}}{\sum_i^n w_i} \tag{1}$$

where

$$w_i = \frac{1}{(\sigma^i)^2}$$

and where the standardised index for each index series (*i*) is:

$$I_y^{i*} = I_y^i \Big/ Average\ of\ historical\ I_y^i$$

σ^i is computed as $\sigma^i = \frac{SD^i}{1-AC^i}$

where SD^i is the standard deviation of the residuals in log space and AC^i is their autocorrelation, averaged over the OMs, as used for generating future pseudo-data. Table 1 lists these values for σ^i.

The actual index used in the CMPs, J_{av}, is the average over the last three years for which data would be available at the time the MP would be applied, hence

$$J_{av,y} = \frac{1}{3}\left(J_y + J_{y-1} + J_{y-2}\right) \tag{2}$$

where the *J* applies either to the East or to the West area.

[2] These years are for the Eastern indices: 2014-2017 for FR_AER_SUV2, 2012-2016 for MED_LAR_SUV, 2015-2018 for GBYP_AER_SUV_BAR, 2012-2018 for MOR_POR_TRAP and 2012-2019 for JPN_LL_NEAtl2; and for the Western indices: 2006-2017 for GOM_LAR_SURV, 2006-2018 for all US_RR and US_GOM_PLL2 indices, 2010-2019 for JPN_LL_West2 and 2006-2017 for CAN_SWNS..

[3] For the aerial surveys, there is no value for 2013, 2018 and 2019 (French) and 2017-2019 (Mediterranean). For GBYP aerial survey there is no value for 2012, 2014, 2016 and 2019. For MOR_POR_TRAP survey, there is no value for 2019. These years were omitted from this averaging where relevant.

CMP specifications

The Fixed Proportion (FXP) CMPs tested set the TAC every **second** year [4]simply as a multiple of the J_{av} value for the area at the time (see Figure 1), but subject to the change in the TAC for each area being restricted to a maximum of 20% (up or down). The formulae are given below[5].

For the East area:

$$TAC_{E,y} = \begin{cases} \left(\frac{TAC_{E,2020}}{J_{E,2017}}\right) \cdot \alpha \cdot J^{E}_{av,y-2} & \text{if } J^{E}_{av,y} \geq T^{E} \\ \left(\frac{TAC_{E,2020}}{J_{E,2017}}\right) \cdot \alpha \cdot \left(\frac{J^{E}_{av,y-2}}{T^{E}}\right)^3 & \text{if } J^{E}_{av,y} < T^{E} \end{cases} \tag{3a}$$

If $TAC_{E,y} \geq 1.2 * TAC_{E,y-1}$ then $TAC_{E,y} = 1.2 * TAC_{E,y-1}$
If $TAC_{E,y} \leq 0.8 * TAC_{E,y-1}$ then $TAC_{E,y} = 0.8 * TAC_{E,y-1}$

For the West area:

$$TAC_{W,y} = \begin{cases} \left(\frac{TAC_{W,2020}}{J_{W,2017}}\right) \cdot \beta \cdot J^{W}_{av,y-2} & \text{if } J^{W}_{av,y} \geq T^{W} \\ \left(\frac{TAC_{W,2020}}{J_{W,2017}}\right) \cdot \beta \cdot \left(\frac{J^{W}_{av,y-2}}{T^{E}}\right)^3 & \text{if } J^{W}_{av,y} < T^{W} \end{cases} \tag{3b}$$

If $TAC_{W,y} \geq 1.2 * TAC_{W,y-1}$ then $TAC_{W,y} = 1.2 * TAC_{W,y-1}$
If $TAC_{W,y} \leq 0.8 * TAC_{W,y-1}$ then $TAC_{W,y} = 0.8 * TAC_{W,y-1}$

Note that in equation (3a), setting $\alpha = 1$ will amount to keeping the TAC the same as for 2020 until the abundance indices change. If α or $\beta > 1$ harvesting will be more intensive than at present, whereas for α or $\beta < 1$ it will be less intensive.

For the results presented here, the choices $T^E = 1$ and $T^W = 1$ have been made.

<u>Maximum extent of TAC decrease</u>

In the original FXP CMP, the maximum interannual increase or decrease in TAC is constraint to 20% (see equations 3a and 3b). This restriction can prove problematic if it prevents the TAC being reduced sufficiently, and sufficiently quickly, should abundance drop below some threshold. Accordingly, this restriction is modified to allow for further decrease if the average index falls below $J_{i,2017}$.

If $TAC_{i,y} \leq 0.8 * TAC_{i,y-1}$

then $TAC_{i,y} = (1 - maxdecr) * TAC_{i,y-1}$ (4)

where

[4] This has been changed from every third year, as implemented previously, given the decision to use second as a standard at the September MSE Technical Group meeting.
[5] The adjustment factor at low abundance has been changed from quadratic to cubic for a greater impact if abundance drops low.

$$maxdecr = \begin{cases} 0.2 & J^{i}_{av,y-2} \geq J_{i,2017} \\ \text{linear btw 0.2 and 0.5} & 0.5J_{i,2017} < J^{i}_{av,y-2} < J_{i,2017} \\ 0.5 & J^{i}_{av,y-2} \leq 0.5J_{i,2017} \end{cases} \tag{5}$$

CMPs

The CMPs presented here have been tuned based on the deterministic median Br30 for the Western stock, across the entire OM interim grid. For the Eastern stock, the α control parameter value has been fixed to 1.5 (unless otherwise noted), resulting in a deterministic median Br30 value of approximately 1.5. Results for the following CMPs are presented:

BR_1: Tuned to 1.0. Upweighting (3x) of the US_RR_66-114 and US_RR_115_144 indices used for the West area TAC determination. No cap on the maximum allowable catch.

BR_2: As BR_1, but tuned to 1.25.

BR_3: As BR_1, but tuned to 1.50.

BR_4: As BR_1, but with a 40 000t cap on the maximum allowable catch in the East.

BR_5: As BR_1, but with a 3 000t cap on the maximum allowable catch in the West.

BR_6: As BR_1, but without the upweighting of the US_RR indices.

BR_7: As BR_1, but with the α control parameter increased to 2.5 to result in a lower median Br30 value for the Eastern stock.

The control parameter values for each of the CMPs presented here are given in Table 2.

The key reasons for important modifications to the baseline CMP (BR_1), compared to the previous CMP version in SCRS/2020/147, are:

a) The α control parameter value was fixed to 1.5 even though this results in a median Br30 for the Eastern stock over the interim grid that is above 1 (i.e. above Bmsy); higher values of α can lead to extinction for some of the OMs, and this choice still leads to TAC values for the East area that are generally larger than awarded in the past.

b) The US_RR indices detect reduced abundance arising from a (negative) regime shift for the Eastern stock earlier than the other indices for the West area; upweighting these results in earlier TAC reduction for this area and hence somewhat improved conservation performance in circumstances where this regime shift occurs.

Results and Discussion

Table 2 gives the deterministic Br30 and AvC30 values (medians and 90%iles across the full interim grid of OMs), for each of the CMPs. Figure 2 is a visual representation of these results. Table 3 gives equivalent results, but for the stochastic runs, for BR_1 to BR_3.

The deterministic Br30 values under BR_1 (tuning of 1) and BR_3 (tuning of 1.5) for each of the 96 OMs of the interim grid are compared in Figure 3, while Figure 4 plots those values for the stochastic runs. Figure 5 compares deterministic with stochastic results for BR_1 to BR_3 in the same form as Figure 2.

A number of important features are immediately evident from these Figures:

- BR_1 – BR_3: Increasing the tuning target from 1 to 1.5: this leads to higher Br30 West values across the whole grid as to be expected, and in particular the worst OM conservation performance (OM9 = 3AII—L) improves from 0.01 to 0.09; however, this is at the expenses of a drop of about 1 kt in the median AvC30 for the West area.
- BR_4: Capping the catch in the East area: AvC30 for the East area decreases by about 10 kt, and after 30 years Bmsy (or higher) for the Eastern stock is achieved for most OMs; however, although AvC30 is larger by about 0.5 kt for the West area, the Western stock is more depleted. The reason is that with less catch in the East area, the Eastern stock becomes larger; this in turn leads to higher abundance in the West area with more Eastern bluefin there, most West area abundance indices increase, the West area TAC increases, so that more Western origin bluefin are caught. Overall then, the benefits of a cap on the east catch were considered to be outweighed the disadvantages (essentially the cubic control law adjustment and allowance for increased extents of TAC reduction at low abundance provide the same advantages that capping the TAC would do).
- BR_5: Capping the catch in the West area: The effects on performance statistics are negligible.
- BR_6: No upweighting of the US_RR indices: A wider range of AvC30 values for the West area, and a lower 5%ile for Br30 for the Western stock which drops from 0.35 to 0.23 (i.e. worse conservation performance).
- BR_7: A higher value of the α control parameter for the East area TAC: AvC30 better by about 12 kt for the East area but worse by more than 0.5kt for the West area; the conservation performance is worse for both stocks, which go either to or near to extinction for some OMs.

The comparison of deterministic and stochastic results in Figure 5 shows that the latter reflect distributions with somewhat lower medians and 5%ile values for Br30 for both stocks, and which are appreciably wider for AvC30 for the West but only slightly so for the East area.

The important advance made in this refinement of the MFXP CMP is that by upweighting the US_RR indices in the calculation of the TAC for the West area, an improvement in conservation performance for the Western stock is obtained for OMs with a future regime shift, without any obvious associated disadvantages.

Reference

Butterworth D.S., and Rademeyer R.A. 2020. Refining the FXP (fixed proportion) CMP. SCRS/2020/147.

Table 1: σ^i values used in weighting when averaging over the indices to provide composite indices for the East and the West areas (see equation 1). See the text for an explanation of where the upweighted values are used – note lower σ^i corresponds to higher weight.

EAST		WEST		
Index name	σ^i	Index name	σ^i	(upweighted)
FR_AER_SUV2	1.00	GOM_LAR_SUV	0.58	
MED_LAR_SUV	0.56	US_RR_66_114	1.47	(0.85)
GBYP_AER_SUV_BAR	0.56	US_RR_115_144	0.71	(0.41)
MOR_POR_TRAP	0.56	US_RR_177	1.29	
JPN_LL_NEAtl2	0.45	US_GOM_PLL2	1.29	
		JPN_LL_West2	0.62	
		CAN_SWNS	1.71	

Table 2: Control parameter values for each of the CMPs presented here. The tunings apply to deterministic results.

CMP name	Eastern CMP	Western CMP	α	β	Note
BR_1	BR_E1	BR_W100	1.500	0.600	Tuned to Br30=1.00
BR_2	BR_E1	BR_W125	1.500	0.410	Tuned to Br30=1.25
BR_3	BR_E1	BR_W150	1.500	0.210	Tuned to Br30=1.50
BR_4	BR_E2	BR_W100E2	1.500	0.768	40 000t cap in East
BR_5	BR_E1	BR_W100cap	1.500	0.610	3 000t cap in West
BR_6	BR_E1	BR_W100lw	1.500	0.690	no extra weight on US_RR
BR_7	BR_E3	BR_W100E3	2.500	0.400	Lower median East Br30

Table 3: Deterministic results (median and 90%iles) for different CMPs over the interim grid of OMs.

		Br30	AvC30
EAST			
Zero catch		3.41 (2.10; 4.13)	0.00 (0.00; 0.00)
BR_1	Tuned to Br30=1.00	1.52 (0.48; 2.14)	44.54 (9.85; 63.13)
BR_2	Tuned to Br30=1.25	1.53 (0.49; 2.14)	44.62 (9.85; 63.31)
BR_3	Tuned to Br30=1.50	1.54 (0.50; 2.14)	44.72 (9.85; 63.51)
BR_4	40 000t cap in East	1.81 (0.98; 2.85)	34.70 (9.30; 39.73)
BR_5	3 000t cap in West	1.52 (0.48; 2.14)	44.53 (9.85; 63.12)
BR_6	no extra weight on US_RR	1.53 (0.49; 2.14)	44.52 (9.85; 63.12)
BR_7	Lower median East Br30	1.18 (0.00; 1.83)	56.11 (9.85; 73.64)
WEST			
Zero catch		2.78 (1.49; 3.31)	0.00 (0.00; 0.00)
BR_1	Tuned to Br30=1.00	1.00 (0.35; 1.90)	1.74 (1.28; 2.59)
BR_2	Tuned to Br30=1.25	1.25 (0.51; 2.15)	1.27 (0.99; 1.93)
BR_3	Tuned to Br30=1.50	1.50 (0.72; 2.44)	0.76 (0.61; 1.15)
BR_4	40 000t cap in East	1.00 (0.30; 1.90)	2.25 (1.52; 3.30)
BR_5	3 000t cap in West	1.00 (0.34; 1.88)	1.76 (1.29; 2.62)
BR_6	no extra weight on US_RR	1.00 (0.23; 1.90)	1.70 (0.91; 2.83)
BR_7	Lower median East Br30	1.00 (0.08; 1.89)	1.17 (0.91; 1.82)

Table 4: Stochastic results (median and 90%iles) for BR_1 to BR_3 over the interim grid of OMs.

All OMs

		Br30	AvC30
EAST			
BR_1	Tuned to Br30=1.00	1.29 (0.26; 2.26)	45.50 (8.40; 67.39)
BR_2	Tuned to Br30=1.25	1.30 (0.28; 2.27)	44.99 (8.41; 67.41)
BR_3	Tuned to Br30=1.50	1.32 (0.30; 2.29)	44.95 (8.41; 67.28)
WEST			
BR_1	Tuned to Br30=1.00	0.88 (0.13; 1.77)	1.76 (0.70; 2.82)
BR_2	Tuned to Br30=1.25	1.10 (0.29; 2.04)	1.31 (0.57; 2.13)
BR_3	Tuned to Br30=1.50	1.37 (0.46; 2.39)	0.78 (0.39; 1.26)

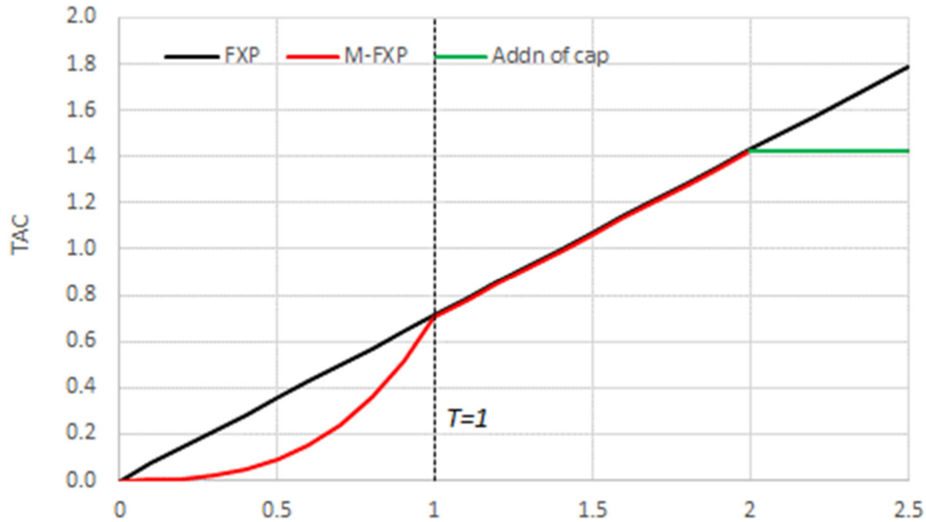


Figure 1. Illustrative relationship (the "catch control law") of TAC against $J_{av,y}$ for the original FXP and its modified form denoted here at M-FXP. The right side of the plot shows the modification to cap the TAC so as not to exceed some maximum value.

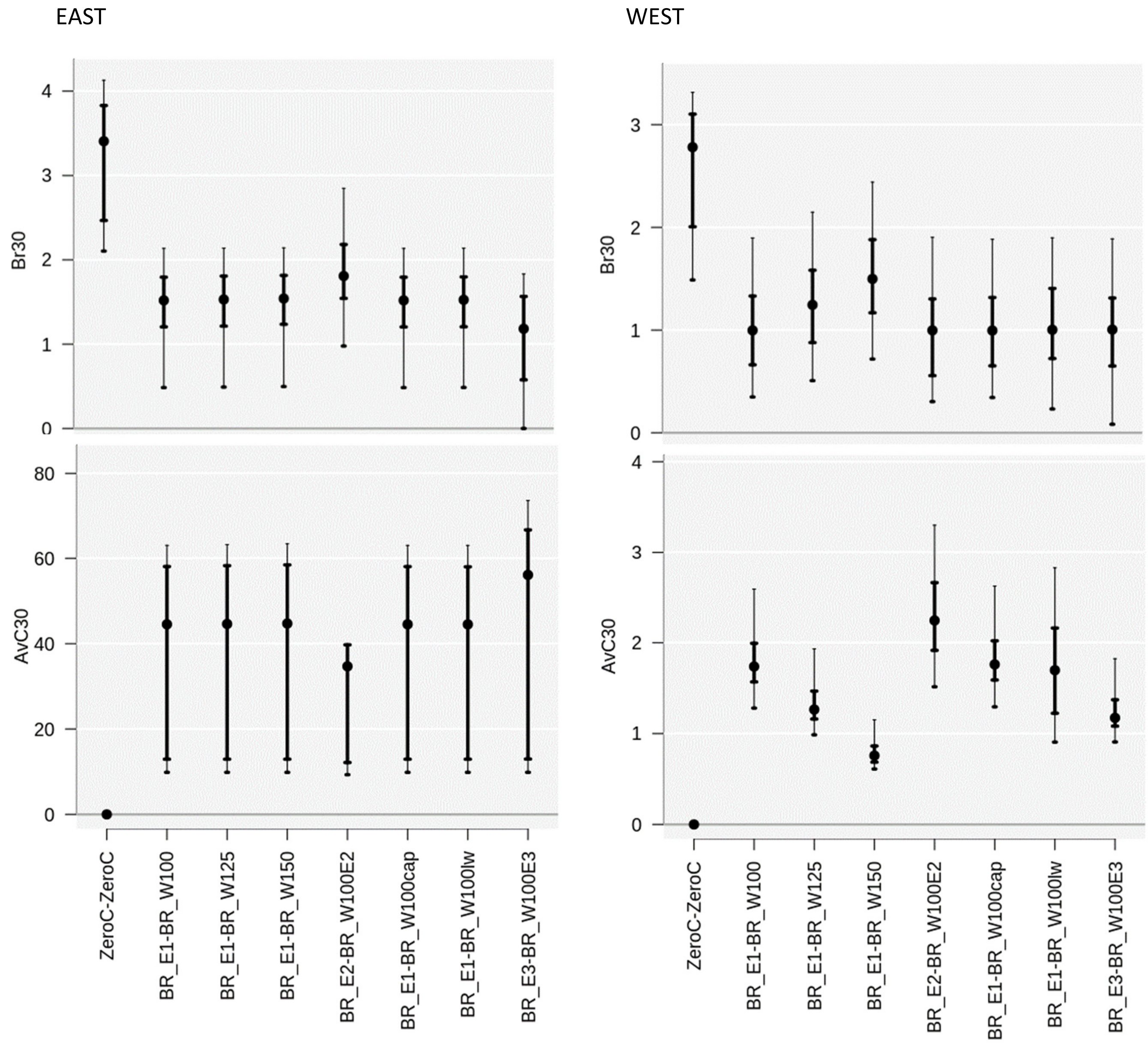
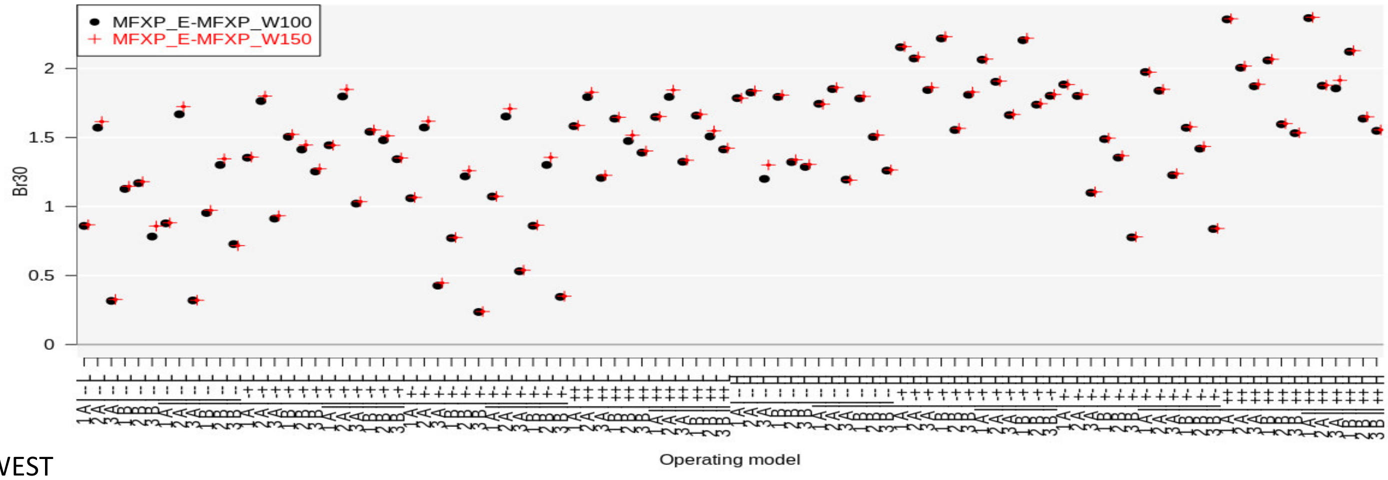


Figure 2: Deterministic Br30 and AvC30 values for all CMPs considered over the interim grid of OMs, showing median, interquartile and 90%-ile range.

EAST



WEST

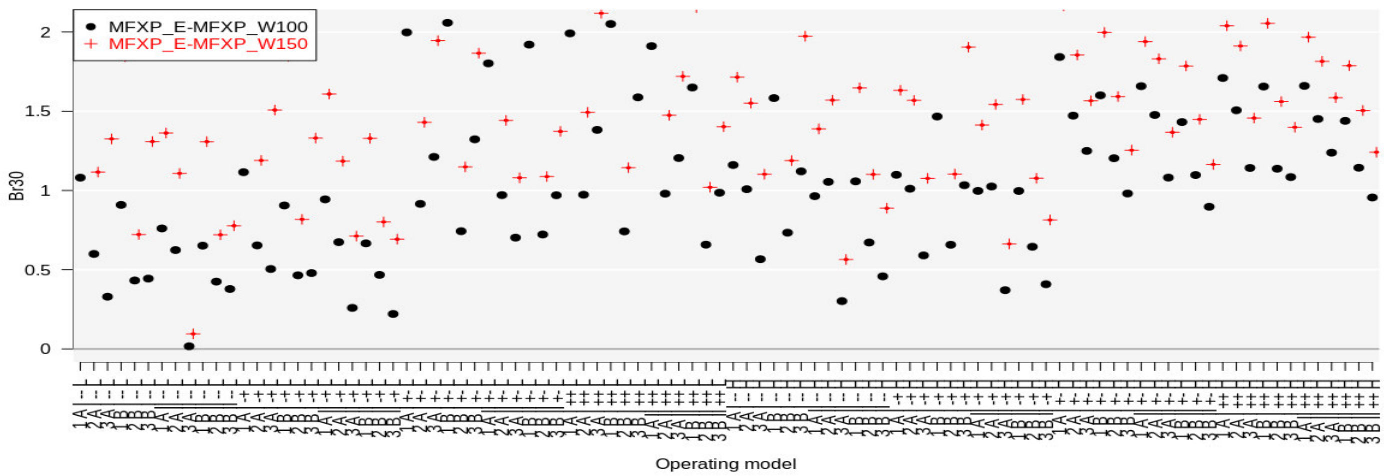
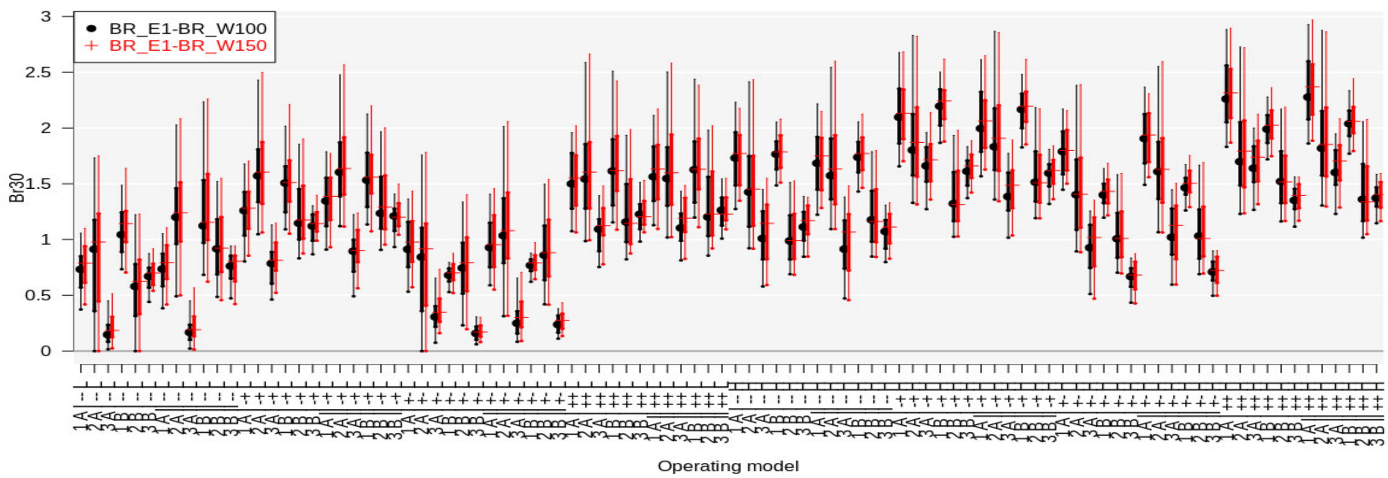


Figure 3: Deterministic Br30 results for BR_1 (1.0 tuning) and BR_3 (1.5 tuning).

EAST



WEST

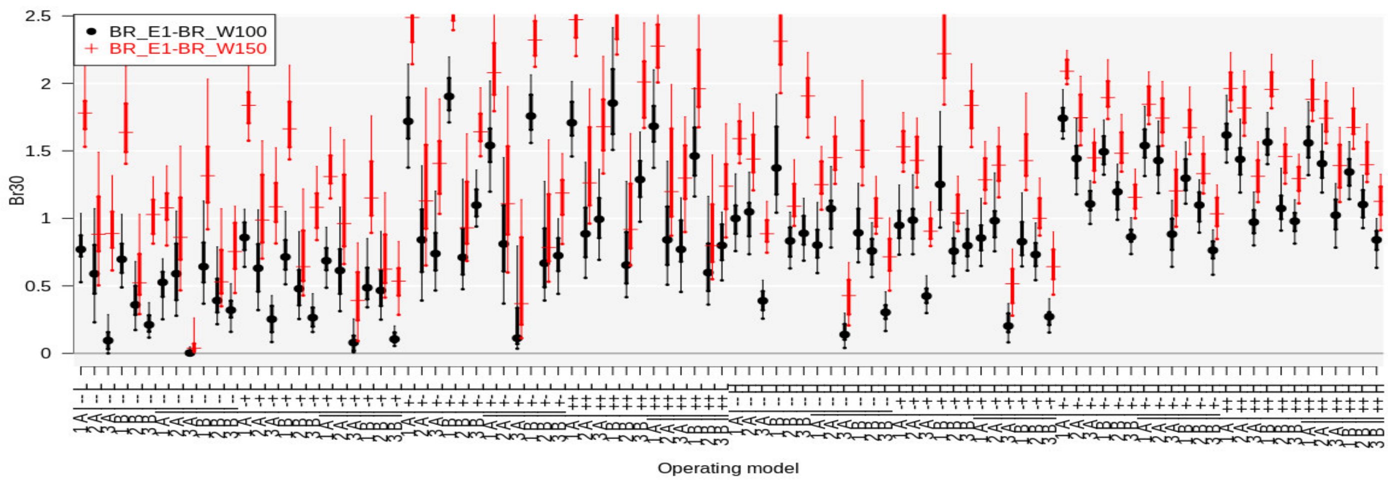


Figure 4: Stochastic Br30 results for BR_1 (1.0 tuning) and BR_3 (1.5 tuning). The plots show the median, interquartile and 90%-ile range.

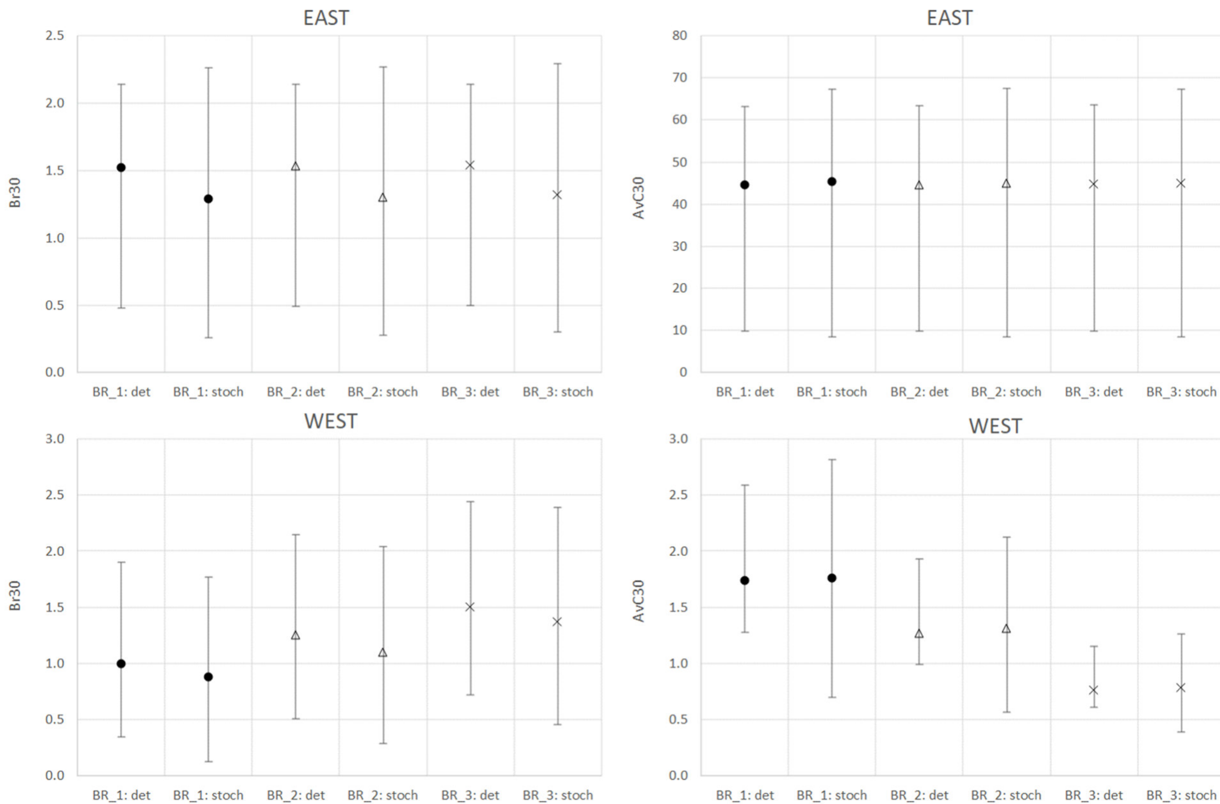


Figure 5: Deterministic and stochastic Br30 and AvC30 values for BR_1 to BR_3 considered over the interim grid of OMs, showing medians and 90%-ile ranges.