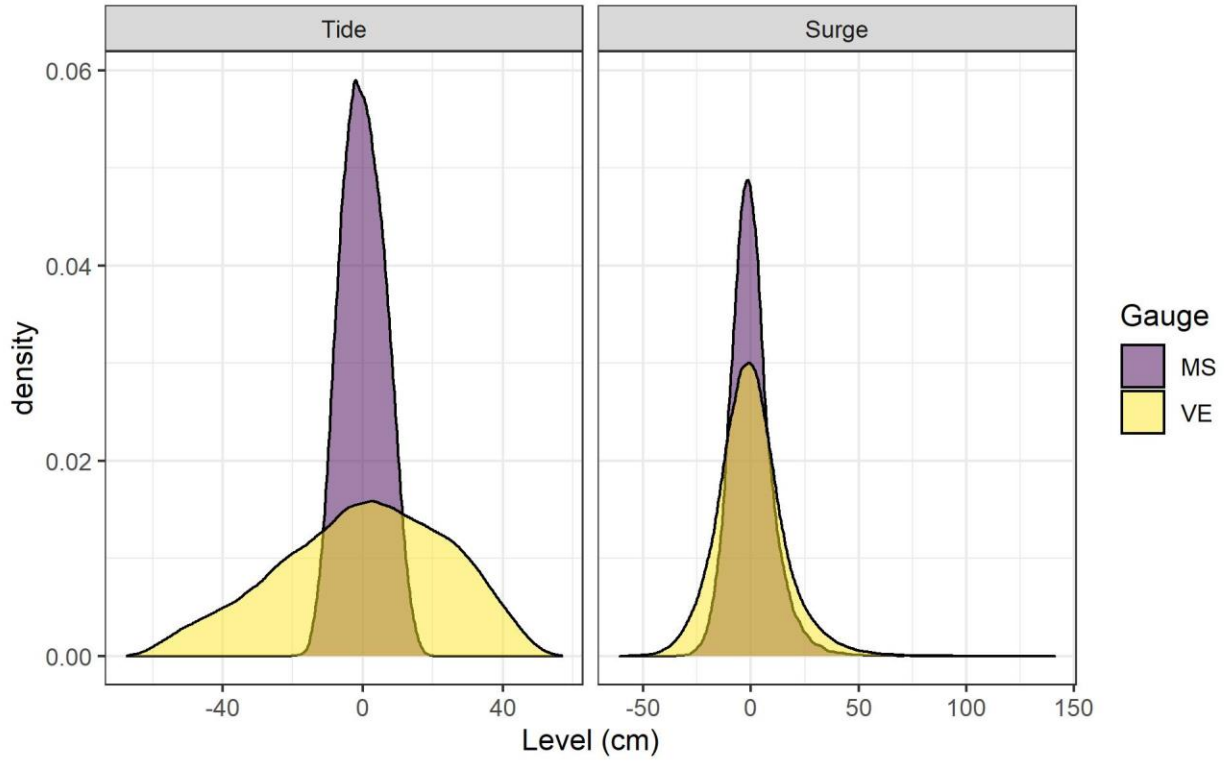


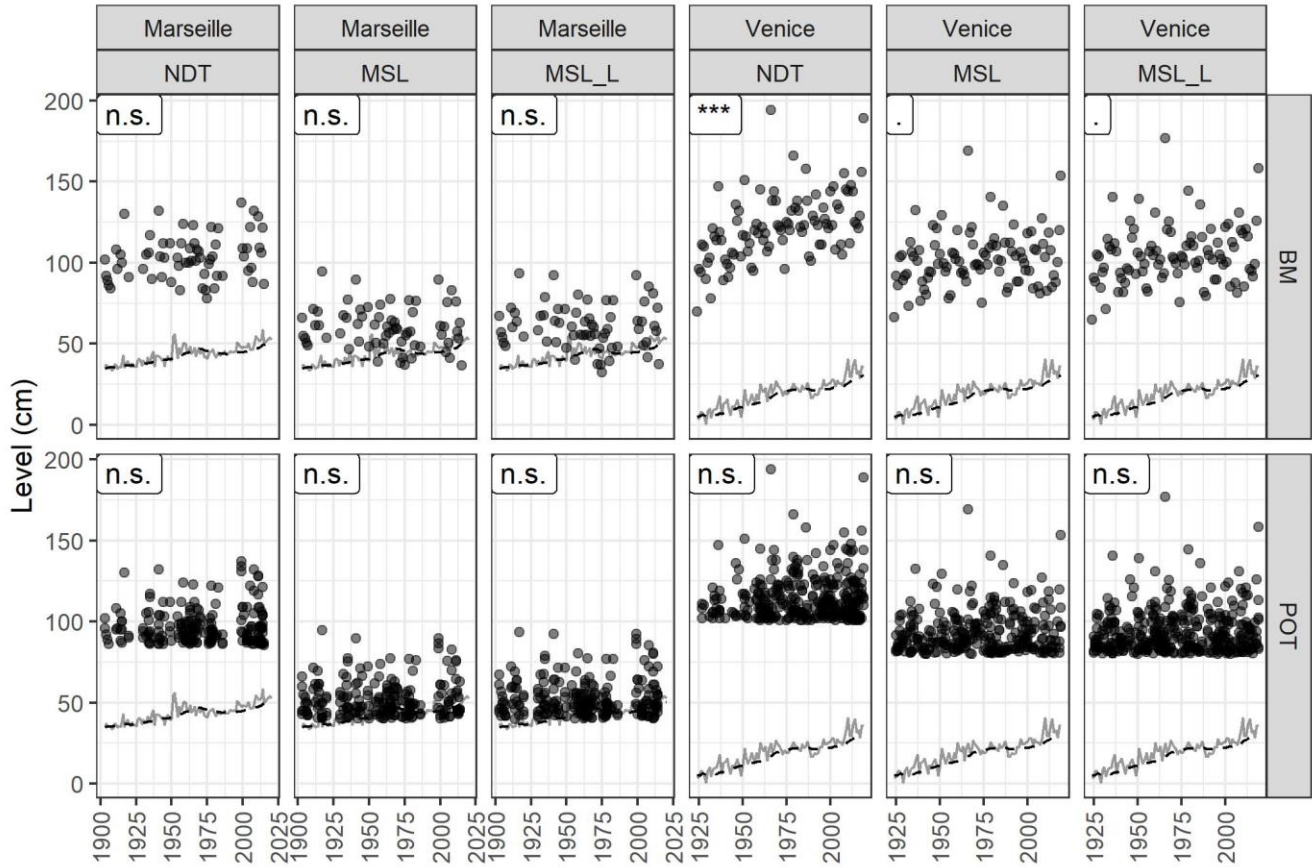
- 1 **Figure S1** – Tide and Surge distribution for Marseille and Venice. Both distributions are calculated from
- 2 data spanning 30 years.



3

4

5 **Figure S2** – Marseille data used to fit the models. Plots are grouped vertically according to the  
6 detrending method (MSL: mean sea level, MSL\_L: long term mean sea level, NDT: non detrended), and  
7 horizontally according to the maxima typology (BM: block maxima, POT: peak over threshold). The text  
8 in the label on the top-left corner of each plot shows the significance level of the Mann-Kendall trend  
9 test (n.s.: non significant; .:  $p < 0.1$ ; \*:  $p < 0.05$ ; \*\*:  $p < 0.01$ ; \*\*\*:  $p < 0.001$ ). The continuous line  
10 represents the mean sea level value; the dashed line represents the long-term mean sea level.

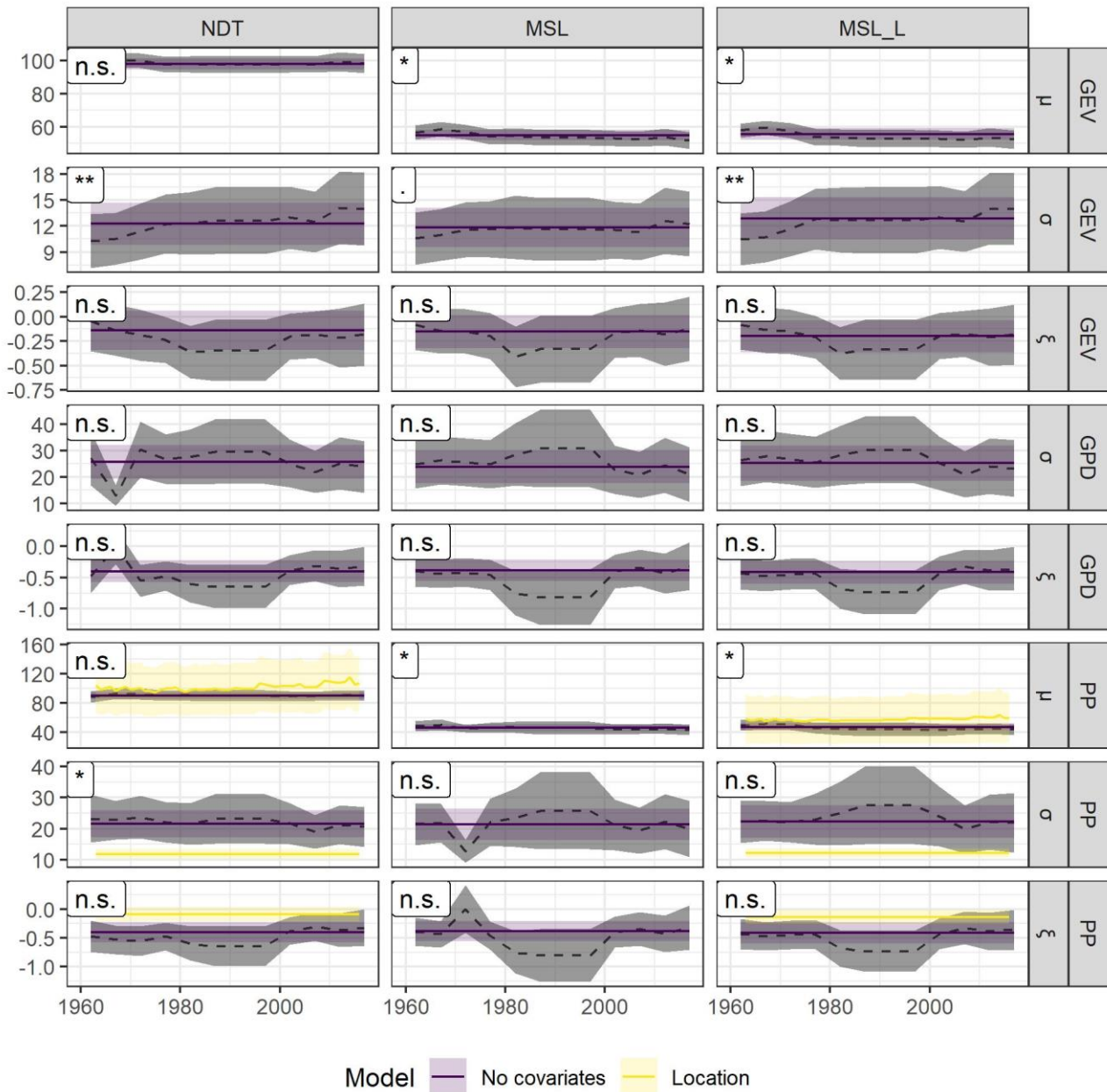


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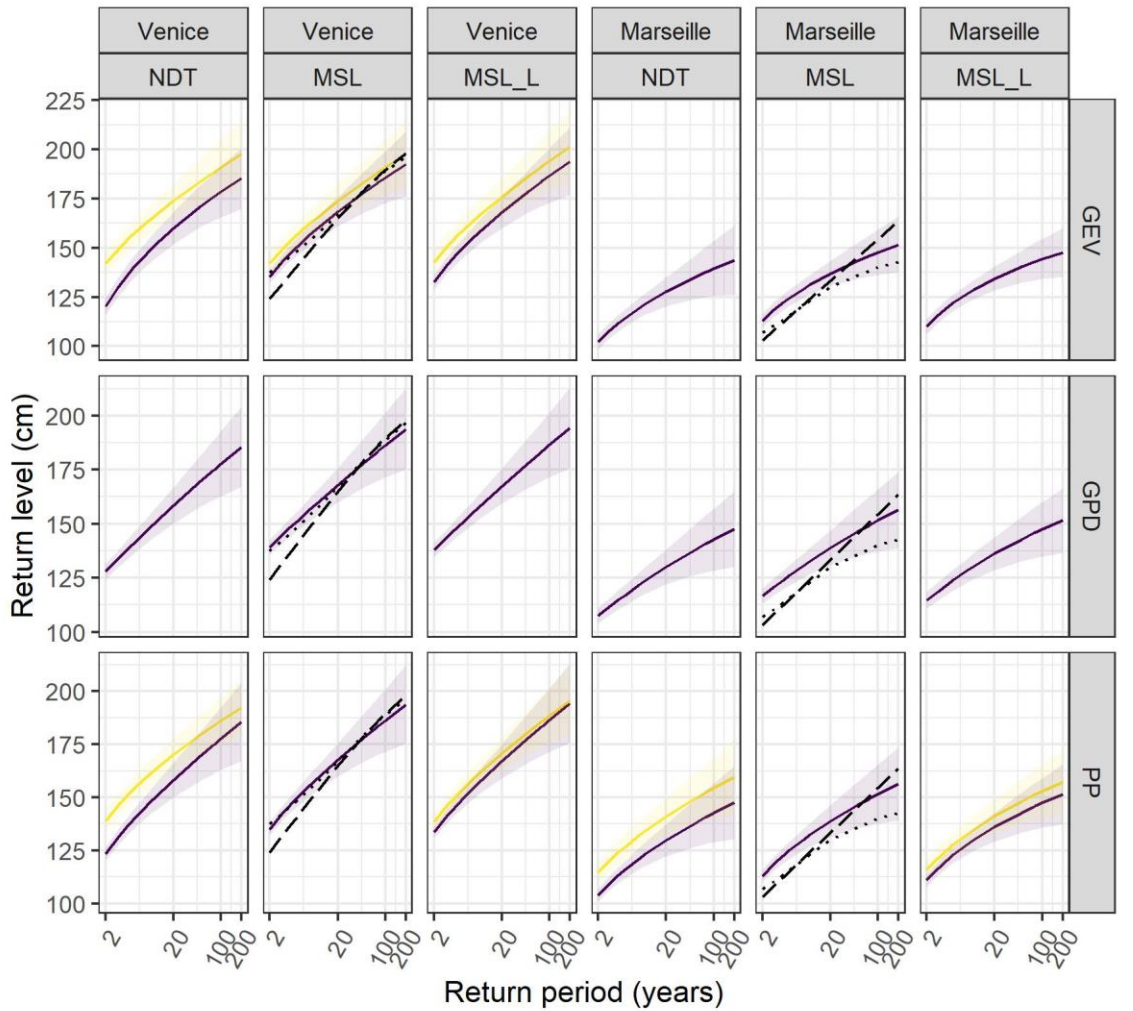
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14 **Figure S3** – Comparison between the parameters estimated in the time window analysis (dashed line;  
 15 the grey envelope represents the uncertainty of the parameters from the time window analysis) and  
 16 the parameters estimated by different models configurations over the full data length. Parameters from  
 17 all the configurations of GEV, GPD and PP that do not include covariates are shown. Parameters from  
 18 models with covariates are shown only if models improve significantly the fit (see Table 2 for the  
 19 likelihood test). The shape  $\xi$  is included in the figure, but no covariates dependence was tested for this  
 20 parameter. The horizontal axis represents the final year of the time window. Plots are grouped vertically  
 21 according to the detrending method, and horizontally according to the distribution function. The text  
 22 in the label on the top-left corner of each plot shows the significance level of the Mann-Kendall trend  
 23 test on the parameters from the time-window analysis



25 **Figure S4** – Return level plot actualized to 2019 for Venice and Marseille. Plots are grouped vertically  
 26 according to the detrending method (MSL: mean sea level, MSL\_L: long term mean sea level, NDT: non  
 27 detrended), and horizontally according to the distribution function (GEV: generalized extreme values,  
 28 GPD: generalized pareto, PP: point process). The dashed line is the empirical return level for the joint  
 29 probability method (JPM). Curves are color-coded based on the model configuration. Note: horizontal  
 30 axis is logarithmic. Return level curves for direct models with covariates are reported only if the addition  
 31 of the covariate improves the fit significantly ( $p < 0.01$ ; see Table 2).

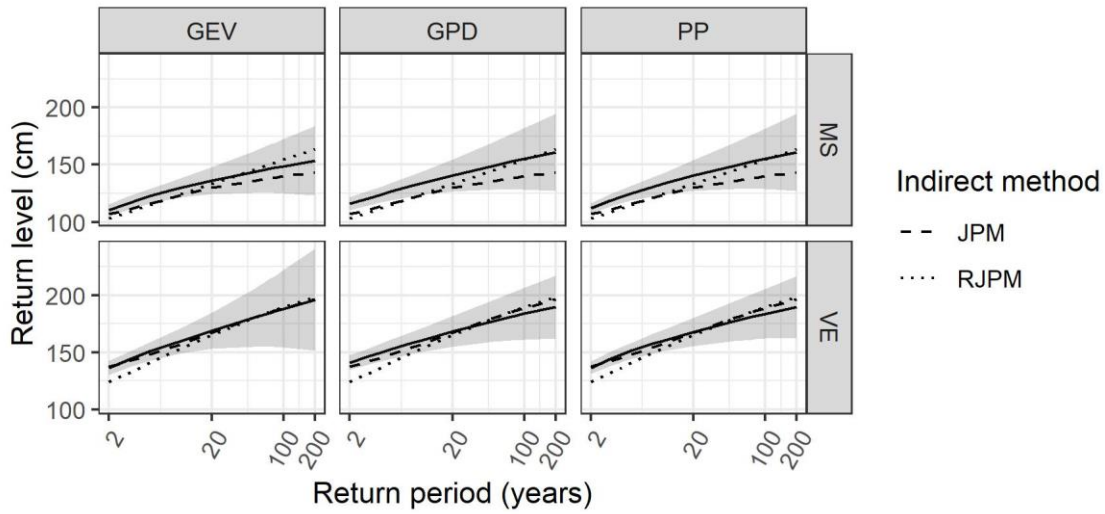


Direct method    — No covariates    — Location    Indirect method    ⋯ JPM    -- RJPM

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33

34 **Figure S5** – Comparison of direct and indirect methods fitted to data that are 30 years long (for VE,  
35 models are fitted for 1990-2019, for MS, models are fitted to 1968-2019). Only Models obtained from  
36 MSL detrending strategy without covariates are reported.



37

38

**Table S1** – Return level estimates for Venice data. Numbers in brackets are the standard estimates.

| Return period | Detrend | GEV           |              |              | GPD           |              | PP            |              |              | JPM | RJPM |
|---------------|---------|---------------|--------------|--------------|---------------|--------------|---------------|--------------|--------------|-----|------|
|               |         | No covariates | Location     | Scale        | No covariates | Scale        | No covariates | Location     | Scale        |     |      |
| 2-years       | MSL     | 136(132,139)  | 143(137,149) | 145(137,153) | 140(137,143)  | 146(141,151) | 136(133,138)  | 138(134,143) | 142(136,149) | 138 | 124  |
| 2-years       | MSL_L   | 134(130,137)  | 144(138,150) | 146(138,154) | 139(136,142)  | 146(141,152) | 134(132,137)  | 140(135,144) | 144(138,150) |     | -    |
| 2-years       | NDT     | 120(116,125)  | 143(137,149) | 145(137,153) | 128(125,131)  | 133(128,138) | 123(120,126)  | 139(134,145) | 142(136,148) |     | -    |
| 20-years      | MSL     | 169(161,176)  | 175(166,183) | 181(165,197) | 169(160,177)  | 182(165,199) | 168(160,176)  | 170(162,178) | 179(165,194) | 167 | 165  |
| 20-years      | MSL_L   | 169(161,177)  | 177(168,186) | 184(167,201) | 168(160,176)  | 184(165,202) | 168(160,176)  | 172(164,179) | 182(168,195) | -   | -    |
| 20-years      | NDT     | 160(152,168)  | 175(166,183) | 181(165,197) | 159(150,167)  | 169(155,184) | 158(150,166)  | 171(163,178) | 179(166,192) | -   | -    |
| 100-years     | MSL     | 186(173,200)  | 192(178,206) | 199(178,221) | 187(172,202)  | 205(171,238) | 187(172,202)  | 188(174,202) | 199(178,220) | 189 | 189  |
| 100-years     | MSL_L   | 187(174,201)  | 195(180,210) | 203(180,226) | 187(172,202)  | 208(173,243) | 187(172,202)  | 190(177,203) | 203(182,223) | -   | -    |
| 100-years     | NDT     | 179(166,191)  | 192(178,206) | 199(178,221) | 178(163,193)  | 192(165,219) | 178(163,193)  | 187(176,198) | 198(178,219) | -   | -    |
| 200-years     | MSL     | 193(177,210)  | 198(181,216) | 206(182,231) | 194(176,213)  | 214(172,256) | 194(176,213)  | 195(178,213) | 207(182,232) | 197 | 198  |
| 200-years     | MSL_L   | 195(178,212)  | 202(184,221) | 211(184,237) | 195(176,214)  | 218(174,262) | 195(176,214)  | 197(181,213) | 211(186,235) | -   | -    |
| 200-years     | NDT     | 185(170,201)  | 198(181,216) | 206(182,231) | 186(167,204)  | 201(167,235) | 186(167,204)  | 193(180,206) | 206(182,230) | -   | -    |

**Table S2** – Return level estimates for Marseille data. Numbers in brackets are the standard estimates.

| Return period | Detrend | GEV           |              |              | GPD           |              | PP            |              |              | JPM | RJPM |
|---------------|---------|---------------|--------------|--------------|---------------|--------------|---------------|--------------|--------------|-----|------|
|               |         | No covariates | Location     | Scale        | No covariates | Scale        | No covariates | Location     | Scale        |     |      |
| 2-years       | MSL     | 111(108,115)  | 110(103,116) | 110(103,116) | 115(111,119)  | 115(112,119) | 111(108,114)  | 112(108,116) | 112(107,117) | 107 | 103  |
| 2-years       | MSL_L   | 110(107,114)  | 111(104,118) | 111(104,118) | 115(111,119)  | 115(111,119) | 111(108,114)  | 115(111,120) | 114(109,119) | -   | -    |
| 2-years       | NDT     | 102( 99,106)  | 110(103,116) | 110(103,116) | 108(104,111)  | 108(104,112) | 104(101,107)  | 113(108,117) | 112(107,117) | -   | -    |
| 20-years      | MSL     | 135(129,142)  | 134(125,142) | 135(122,148) | 137(129,145)  | 138(129,146) | 137(130,145)  | 138(130,146) | 138(126,149) | 130 | 133  |
| 20-years      | MSL_L   | 135(129,141)  | 136(127,144) | 137(125,149) | 137(129,144)  | 137(129,145) | 136(130,143)  | 141(133,148) | 138(128,148) | -   | -    |
| 20-years      | NDT     | 128(120,135)  | 134(125,142) | 135(122,148) | 130(122,138)  | 132(122,141) | 130(122,137)  | 139(131,148) | 136(125,148) | -   | -    |
| 100-years     | MSL     | 146(135,158)  | 144(132,157) | 147(126,168) | 150(136,164)  | 150(136,165) | 150(136,164)  | 150(136,165) | 150(132,168) | 140 | 154  |
| 100-years     | MSL_L   | 145(134,155)  | 146(134,157) | 147(130,165) | 148(135,160)  | 148(135,161) | 148(136,160)  | 153(140,165) | 149(134,163) | -   | -    |
| 100-years     | NDT     | 139(125,153)  | 144(132,157) | 147(126,167) | 143(128,157)  | 145(128,161) | 143(129,157)  | 153(138,167) | 148(130,166) | -   | -    |
| 200-years     | MSL     | 150(136,164)  | 148(133,164) | 151(127,175) | 155(137,172)  | 155(137,173) | 155(137,172)  | 155(138,173) | 155(134,176) | 143 | 164  |
| 200-years     | MSL_L   | 148(136,160)  | 149(135,163) | 151(130,172) | 152(137,167)  | 152(137,168) | 152(138,166)  | 157(142,172) | 152(136,169) | -   | -    |
| 200-years     | NDT     | 144(126,161)  | 148(133,164) | 151(127,175) | 148(130,165)  | 150(129,170) | 147(130,165)  | 158(140,175) | 153(132,174) | -   | -    |