# Supplementary Information

## Validating a European-scale charcoal calibration dataset

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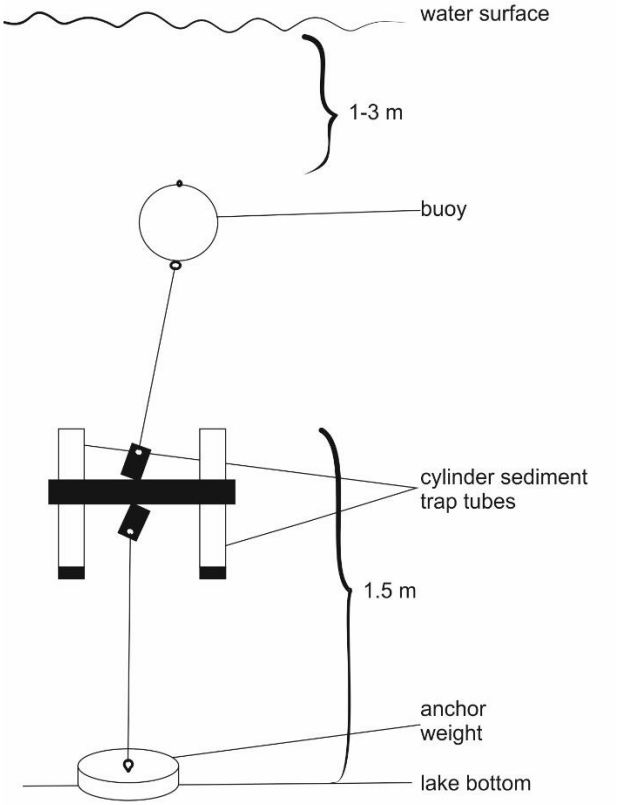
### Appendix 1: Model of cylinder sediment traps used in the study of Adolf et al. (2018).




*Appendix 1: Cylinder sediment trap. Figure modified after* (Hakanson & Jansson, 1983)

## Appendix 2: Data-Tables per lake

Tables showing sediment sample information along with the matching satellite-derived fire parameters for radii of 40 km around the lakes (FN and FRP) and 180 km around the lakes (BA). FN: Fire number, FRP: Fire radiative power, BA: burned area. FN and FRP derive from the Global Monthly Fire Location Product (MCD14ML, collection 5.1, Giglio, Descloitres, Justice, & Kaufman, 2003; Justice, Giglio, Boschetti, Roy, & Csiszar, 2006; Justice et al., 2002; Kaufman et al., 2003). For burned area, we used the shapefile version of the MODIS burned area product (MCD45monthly, collection 5.1, provided by the University of Maryland, D. Roy & Boschetti, 2008; D. P. Roy, Jin, Lewis, & Justice, 2005; D. P. Roy, Lewis, & Justice, 2002).

| Sarsjön | Charcoal type | Depth [cm] | Volume [$cm^3$] | Concentration sample (vol not stand.) [part. $cm^{-3}$] | Influx [part. $cm^{-2}$ $yr^{-1}$] | FN [# $yr^{-1}$] | FRP [$Wm^{-2}$] | BA [$km^2$] |
|---|---|---|---|---|---|---|---|---|
| SAR1 | MIC | 0.3 | 0.1 | 2116.5 | 2751.5 | 0.1 | 0.1 | 0.1 |
| SAR2 | MIC | 0.45 | 0.15 | 3878.7 | 3878.7 | 3 | 347.8 | 0.5 |
| SAR3 | MIC | 0.52 | 0.2 | 7135.9 | 2497.6 | 2 | 22.2 | 1.0 |
| SAR4 | MIC | 0.7 | 0.2 | 6414.8 | 5773.3 | 2 | 48.3 | 0.5 |
| SAR5 | MIC | 0.82 | 0.15 | 6583.6 | 5266.9 | 1 | 13.7 | 0.1 |
| SAR6 | MIC | 0.95 | 0.2 | 4830.6 | 3139.9 | 0.1 | 0.1 | 0.4 |
| SAR7 | MIC | 1.05 | 0.2 | 8723.6 | 4361.8 | 0.1 | 0.1 | 0.4 |
| SAR8 | MIC | 1.2 | 0.5 | 10981.0 | 3294.3 | 2 | 26.9 | 0.1 |
| SAR9 | MIC | 1.35 | 0.2 | 5333.2 | 3999.9 | 7 | 563.5 | 0.2 |
| SAR10 | MIC | 1.45 | 0.3 | 5541.9 | 1847.3 | 2 | 119 | 0.1 |
| SAR11 | MIC | 1.6 | 0.6 | 11727.0 | 2931.8 | 0.1 | 0.1 | 0.8 |
| SAR12 | MIC | 1.7 | 0.3 | 6765.2 | 2255.1 | 7 | 906.6 | 0.7 |

*Appendix 2a: Sarsjön*

| Jezioro Gościąż | Charcoal type | Depth [cm] | Volume [$cm^3$] | Concentration [part. $cm^{-3}$] | Influx [part. $cm^{-2}$ $yr^{-1}$] | FN [# $yr^{-1}$] | FRP [$Wm^{-2}$] | BA [$km^2$] |
|---|---|---|---|---|---|---|---|---|
| GOS1-5 | MIC | 2 | 1.25 | 33848.2 | 5469.6 | 0.1 | 0.1 | 7.7 |
| GOS1-5 | MIC | 2 | 1.25 | 33848.2 | 5469.6 | 4 | 181.3 | 3.1 |
| GOS1-5 | MIC | 2 | 1.25 | 33848.2 | 5469.6 | 1 | 17.6 | 0.7 |
| GOS1-5 | MIC | 2 | 1.25 | 33848.2 | 5469.6 | 1 | 15.4 | 0.7 |
| GOS1-5 | MIC | 2 | 1.25 | 33848.2 | 5469.6 | 3 | 72.1 | 0.7 |
| GOS6 | MIC | 4.25 | 2.7 | 56847.6 | 18025.5 | 0.1 | 0.1 | 1.1 |
| GOS7 | MIC | 5.75 | 1.5 | 44059.0 | 30567.9 | 2 | 177.3 | 3.1 |
| GOS8 | MIC | 7.25 | 2 | 41638.2 | 21666.2 | 11 | 436.3 | 5.3 |
| GOS9 | MIC | 8.75 | 2.75 | 78874.6 | 29848.7 | 3 | 70.3 | 1.0 |
| GOS1-5 | MAC | 2 | 1.5 | 0 | 0 | 0.1 | 0.1 | 7.7 |
| GOS1-5 | MAC | 2 | 1.5 | 0 | 0 | 4 | 181.3 | 3.1 |
| GOS1-5 | MAC | 2 | 1.5 | 0 | 0 | 1 | 17.6 | 0.7 |
| GOS1-5 | MAC | 2 | 1.5 | 0 | 0 | 1 | 15.4 | 0.7 |
| GOS1-5 | MAC | 2 | 1.5 | 0 | 0 | 3 | 72.1 | 0.7 |
| GOS6 | MAC | 4.25 | 4 | 7.00 | 5.99 | 0.1 | 0.1 | 1.1 |
| GOS7 | MAC | 5.75 | 4 | 4.25 | 4.42 | 2 | 177.3 | 3.1 |
| GOS8 | MAC | 7.25 | 4 | 5.00 | 5.20 | 11 | 436.3 | 5.3 |
| GOS9 | MAC | 8.75 | 4 | 6.00 | 6.24 | 3 | 70.3 | 1.0 |

*Appendix 2b: Jezioro Gościąż*

| Lago Piccolo d'Avigliana | Charcoal type | Depth [cm] | Volume [$cm^3$] | Concentration [part. $cm^{-3}$] | Influx [part. $cm^{-2}$ $yr^{-1}$] | FN [# $yr^{-1}$] | FRP [$Wm^{-2}$] | BA [$km^2$] |
|---|---|---|---|---|---|---|---|---|
| AVI1 | MIC | 0.7 | 0.5 | 5649.1 | 4330.8 | 19 | 221.4 | 2.2 |
| AVI2 | MIC | 1.2 | 1.2 | 15590.7 | 6757.2 | 39 | 635.8 | 3.1 |
| AVI3 | MIC | 1.5 | 0.6 | 3976.8 | 2290.4 | 24 | 385 | 0.7 |
| AVI4 | MIC | 1.9 | 1 | 9149.1 | 3609.1 | 30 | 495.1 | 0.5 |
| AVI5 | MIC | 2.3 | 0.9 | 3748.0 | 1560.6 | 24 | 356.4 | 32.3 |
| AVI6 | MIC | 2.6 | 0.6 | 6108.3 | 2867.8 | 47 | 1490.3 | 25.5 |
| AVI7 | MIC | 2.9 | 0.5 | 12804.3 | 6786.7 | 22 | 373.4 | 7.1 |
| AVI8 | MIC | 3.1 | 0.8 | 22137.6 | 7250.3 | 5 | 121.5 | 1.7 |
| AVI9 | MIC | 3.4 | 0.9 | 11727.0 | 3684.1 | 21 | 434.4 | 5.7 |
| AVI10 | MIC | 3.7 | 0.7 | 9149.1 | 3336.2 | 27 | 1336 | 34.0 |
| AVI11 | MIC | 3.9 | 0.9 | 17247.0 | 5418.2 | 11 | 147.8 | 19.9 |
| AVI12 | MIC | 4.3 | 2.1 | 25944.2 | 4799.3 | 5 | 66.3 | 26.5 |
| AVI1 | MAC | 0.7 | 1 | 1 | 0.38 | 19 | 221.4 | 2.2 |
| AVI2 | MAC | 1.2 | 1 | 1 | 0.52 | 39 | 635.8 | 3.1 |
| AVI3 | MAC | 1.5 | 1 | 0 | 0 | 24 | 385 | 0.7 |
| AVI4 | MAC | 1.9 | 1 | 0 | 0 | 30 | 495.1 | 0.5 |
| AVI5 | MAC | 2.3 | 1 | 11 | 4.12 | 24 | 356.4 | 32.3 |
| AVI6 | MAC | 2.6 | 1 | 10 | 2.82 | 47 | 1490.3 | 25.5 |
| AVI7 | MAC | 2.9 | 1 | 11 | 2.92 | 22 | 373.4 | 7.1 |
| AVI8 | MAC | 3.1 | 1 | 6 | 1.57 | 5 | 121.5 | 1.7 |
| AVI9 | MAC | 3.4 | 1 | 13 | 3.68 | 21 | 434.4 | 5.7 |
| AVI10 | MAC | 3.7 | 1 | 3 | 0.77 | 27 | 1336 | 34.0 |
| AVI11 | MAC | 3.9 | 1 | 4 | 1.13 | 11 | 147.8 | 19.9 |
| AVI12 | MAC | 4.3 | 1 | 2 | 0.78 | 5 | 66.3 | 26.5 |

*Appendix 2c: Lago Piccolo d'Avigliana*

| Lago Grande di Monticchio | Charcoal type | Depth [cm] | Volume [$cm^3$] | Concentration [part. $cm^{-3}$] | Influx [part. $cm^{-2}$ $yr^{-1}$] | FN [# $yr^{-1}$] | FRP [$Wm^{-2}$] | BA [$km^2$] |
|---|---|---|---|---|---|---|---|---|
| MONT1 | MIC | 3.5 | 0.13 | 11877.18 | 39590.6 | 102 | 2825.7 | 996.7 |
| MONT2 | MIC | 4.4 | 0.5 | 14466.12 | 26039.0 | 227 | 6562.7 | 853.4 |
| MONT3 | MIC | 5.6 | 1.6 | 22352.63 | 16764.5 | 124 | 3835.6 | 635.6 |
| MONT4 | MIC | 6.6 | 1.7 | 48544.8 | 28555.8 | 38 | 1046.2 | 300.3 |
| MONT5 | MIC | 7.5 | 2.25 | 56802.67 | 22721.1 | 138 | 4416 | 1853.1 |
| MONT6 | MIC | 8.5 | 0.7 | 22707.43 | 32439.2 | 284 | 11839.3 | 1530.7 |
| MONT7 | MIC | 8.9 | 1.5 | 40636.65 | 10836.4 | 72 | 1587.7 | 259.9 |
| MONT8 | MIC | 9.5 | 2.6 | 60474.46 | 13955.6 | 65 | 3218.2 | 836.6 |
| MONT9 | MIC | 10 | 1.2 | 22224.19 | 9260.1 | 195 | 5570.4 | 750.5 |
| MONT10 | MIC | 10.3 | 1 | 23256.54 | 6977.0 | 114 | 3535.4 | 817.5 |
| MONT11 | MIC | 10.6 | 2.1 | 39445.09 | 5635.0 | 89 | 3414.6 | 384.6 |
| MONT12 | MIC | 11.6 | 2.5 | 24126.34 | 9650.5 | 198 | 5957.4 | 1190.9 |
| MONT1 | MAC | 3.5 | 1 | 25 | 25 | 102 | 2825.7 | 996.7 |
| MONT2 | MAC | 4.4 | 1 | 22 | 19.8 | 227 | 6562.7 | 853.4 |
| MONT3 | MAC | 5.6 | 2 | 25.5 | 30.6 | 124 | 3835.6 | 635.6 |
| MONT4 | MAC | 6.6 | 2 | 20 | 20 | 38 | 1046.2 | 300.3 |
| MONT5 | MAC | 7.5 | 2 | 13 | 11.7 | 138 | 4416 | 1853.1 |
| MONT6 | MAC | 8.5 | 2 | 31 | 31 | 284 | 11839.3 | 1530.7 |
| MONT7 | MAC | 8.9 | 1 | 40 | 16 | 72 | 1587.7 | 259.9 |
| MONT8 | MAC | 9.5 | 2 | 32.5 | 19.5 | 65 | 3218.2 | 836.6 |
| MONT9 | MAC | 10 | 2 | 6 | 3 | 195 | 5570.4 | 750.5 |
| MONT10 | MAC | 10.3 | 1 | 19 | 5.7 | 114 | 3535.4 | 817.5 |
| MONT11 | MAC | 10.6 | 2 | 42 | 12.6 | 89 | 3414.6 | 384.6 |
| MONT12 | MAC | 11.6 | 2 | 4.5 | 4.5 | 198 | 5957.4 | 1190.9 |

*Appendix 2d: Lago Grande di Monticchio*

## Appendix 3: Chronology details per lake

Data for the isotope measurements, which in the cases of all but Jezioro Gosciaz were used only as supportive for the varve counting chronology. In the case of Sarsjön, light and thick layers in the core were associated to major floods in the regions (MSB, 2012).

| Jezioro Gościąż (GOS) | Depth [cm] | CRS-Model inferred calendar year | CRS-Model inferred Age [yrs] | Unsupported $^{210}$Pb Activity [Bq kg$^{-1}$] | $^{137}$Cs Activity [Bq kg$^{-1}$] |
|---|---|---|---|---|---|
| | 0.5 | 2011 | 2 ± 0.2 | 450 ± 263 | -5 ± 76 |
| | 1.5 | 2009 | 4 ± 1.3 | 335 ± 335 | -7 ± 9 |
| | 2.5 | 2008 | 5 ± 1.4 | 217 ± 42 | 9 ± 6 |
| | 10 | 2004 | 10 ± 1.4 | 151 ± 13 | 11 ± 1 |
| | 17 | 1998 | 15 ± 1.5 | 169 ± 19 | 7 ± 1 |
| | 24 | 1990 | 23 ± 1.6 | 147 ± 12 | 13 ± 1 |
| | 26.5 | 1988 | 25 ± 1.6 | 167 ± 24 | 15 ± 4 |

*Appendix 3a: Jezioro Gosciaz chronology data*

| Lago Piccolo d'Avigliana (AVI) | Depth [cm] | CRS-Model inferred calendar year | CRS-Model inferred Age [yrs] | Unsupported $^{210}$Pb Activity [Bq kg$^{-1}$] | $^{137}$Cs Activity [Bq kg$^{-1}$] |
|---|---|---|---|---|---|
| | 0.5 | 2010 | 3 ± 0.5 | 249 ± 42 | 61 ± 11 |
| | 8.5 | 1984 | 29 ± 2.4 | 165 ± 14 | 80 ± 5 |
| | 12.5 | 1973 | 40 ± 2.3 | 93 ± 9 | 48 ± 4 |
| | 16.5 | 1961 | 52 ± 3.0 | 72 ± 10 | 43 ± 2 |
| | 20.5 | 1946 | 68 ± 4 | 64 ± 7 | 4 ± 2 |
| | 25.5 | 1907 | 107 ± 11.2 | 26 ± 7 | - |

*Appendix 3b: Lago Piccolo d'Avigliana chronology data*

| Lago Grande di Monticchio (MONT) | Depth [cm] | CRS-Model inferred calendar year | CRS-Model inferred Age [yrs] | Unsupported $^{210}$Pb Activity [Bq kg$^{-1}$] | $^{137}$Cs Activity [Bq kg$^{-1}$] |
|---|---|---|---|---|---|
| | 2.3 | 2012 | 2 ± 0.2 | 329 ± 32 | 35 ± 5 |
| | 6.5 | 2007 | 7 ± 0.3 | 325 ± 47 | 41 ± 7 |
| | 9 | 2005 | 8 ± 0.8 | 355 ± 35 | 32 ± 3 |
| | 12 | 1999 | 15 ± 0.9 | 401 ± 46 | 31 ± 2 |
| | 17.5 | 1992 | 21 ± 1.1 | 288 ± 29 | 44 ± 2 |
| | 22.5 | 1987 | 26 ± 1.1 | 202 ± 19 | 61 ± 3 |
| | 27.5 | 1981 | 32 ± 1.1 | 207 ± 16 | 45 ± 2 |

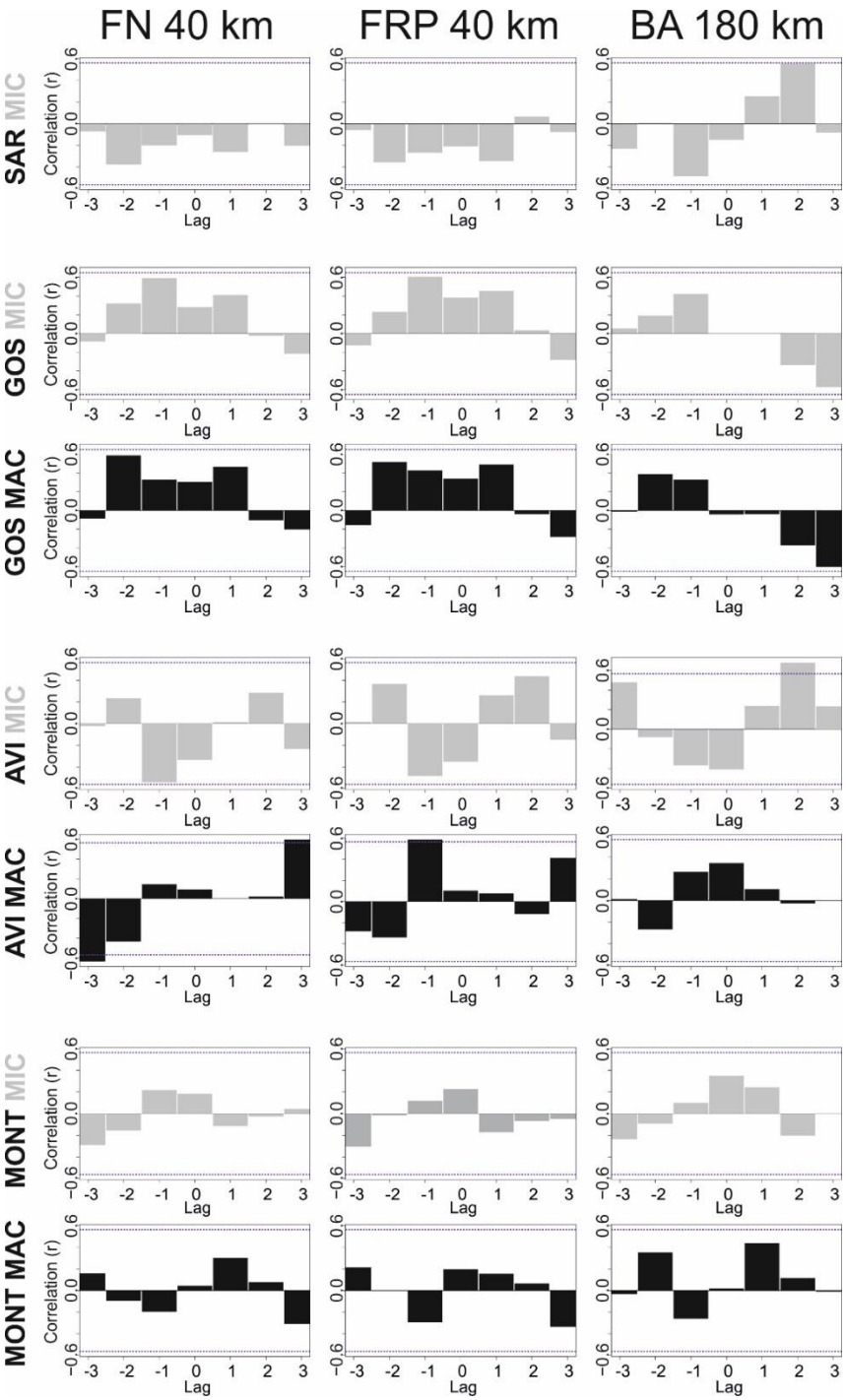
*Appendix 3c: Lago Grande di Monticchio chronology data*

| Sarsjön (SAR) | Depth [cm] | Varve-inferred calendar year | Varve-inferred age [yrs] | Regional, large flood events |
|---|---|---|---|---|
| | 0.3 | 2013 ± 1.33 | 1 ± 1.33 | |
| | 0.45 | 2012 ± 1.33 | 2 ± 1.33 | |
| | 0.52 | 2011 ± 1.33 | 3 ± 1.33 | |
| | 0.7 | 2010 ± 1.33 | 4 ± 1.33 | |
| | 0.82 | 2009 ± 1.33 | 5 ± 1.33 | |
| | 0.95 | 2008 ± 1.33 | 6 ± 1.33 | |
| | 1.05 | 2007 ± 1.33 | 7 ± 1.33 | |
| | 1.2 | 2006 ± 1.33 | 8 ± 1.33 | |
| | 1.35 | 2005 ± 1.33 | 9 ± 1.33 | |
| | 1.45 | 2004 ± 1.33 | 10 ± 1.33 | |
| | 1.6 | 2003 ± 1.33 | 11 ± 1.33 | |
| | 1.7 | 2002 ± 1.33 | 12 ± 1.33 | |
| | 2.4 | 1996 ± 1.33 | 17 ± 1.33 | Vännäsby and Vindeln (1995) |
| | 4.05 | 1981 ± 1.33 | 32 ± 1.33 | Umea (1986) |
| | 4.3 | 1979 ± 1.33 | 34 ± 1.33 | |
| | 5 | 1971 ± 1.33 | 42 ± 1.33 | Stornoorrfors (1971) |
| | 6.4 | 1958 ± 1.33 | 55 ± 1.33 | |
| | 8.45 | 1939 ± 1.33 | 74 ± 1.33 | Vännasby (1938) |
| | 9.1 | 1935 ± 1.33 | 78 ± 1.33 | |
| | 10.5 | 1926 ± 1.33 | 87 ± 1.33 | |
| | 10.6 | 1925 ± 1.33 | 88 ± 1.33 | |
| | 11.2 | 1921 ± 1.33 | 92 ± 1.33 | |

*Appendix 2d: Sarjön chronology data*

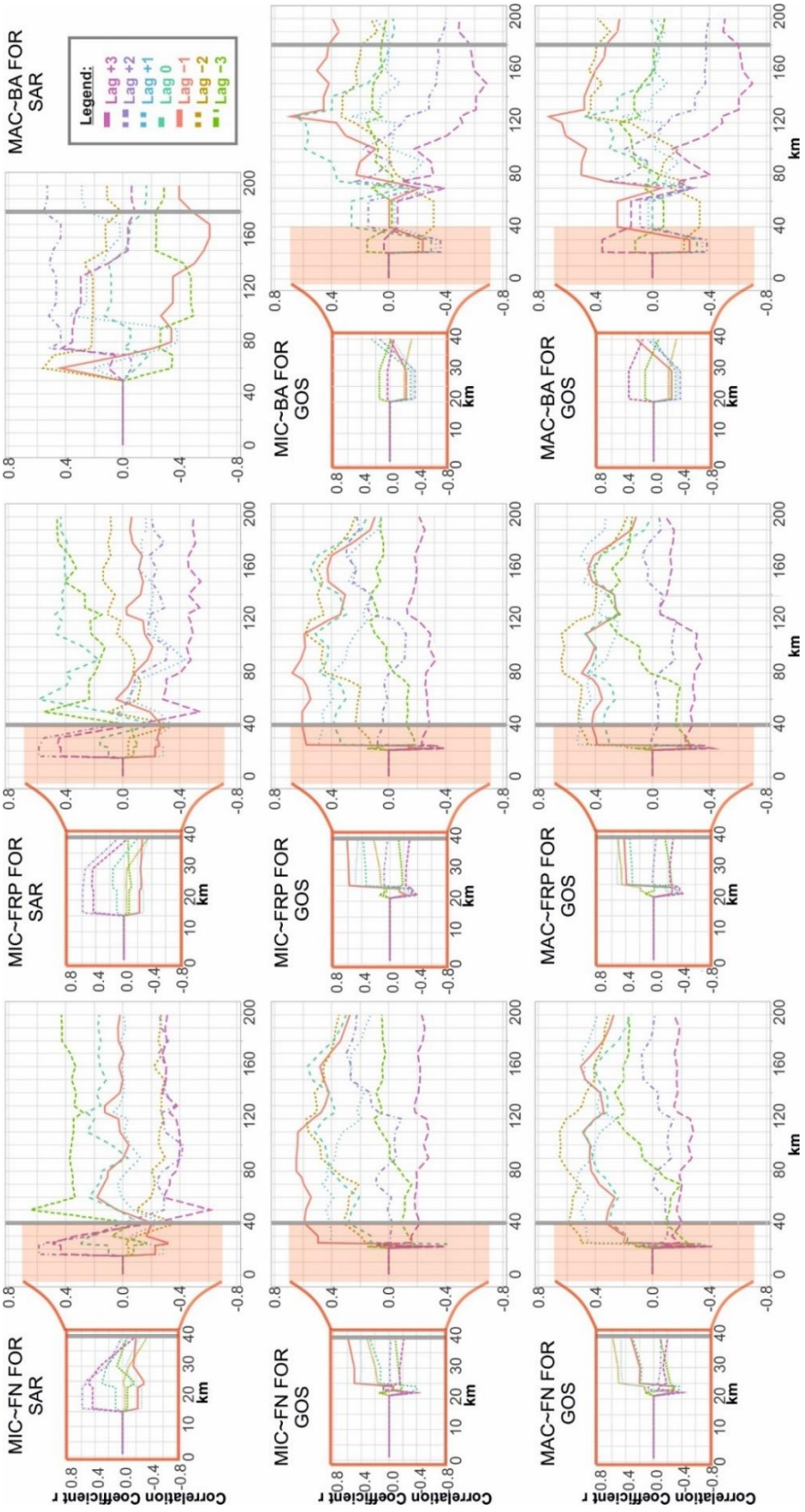
## Appendix 4: Cross-correlations at fixed radii of 40 and 180 km

Graphs are ordered by charcoal type (rows) and satellite-derived fire regime parameter (columns).

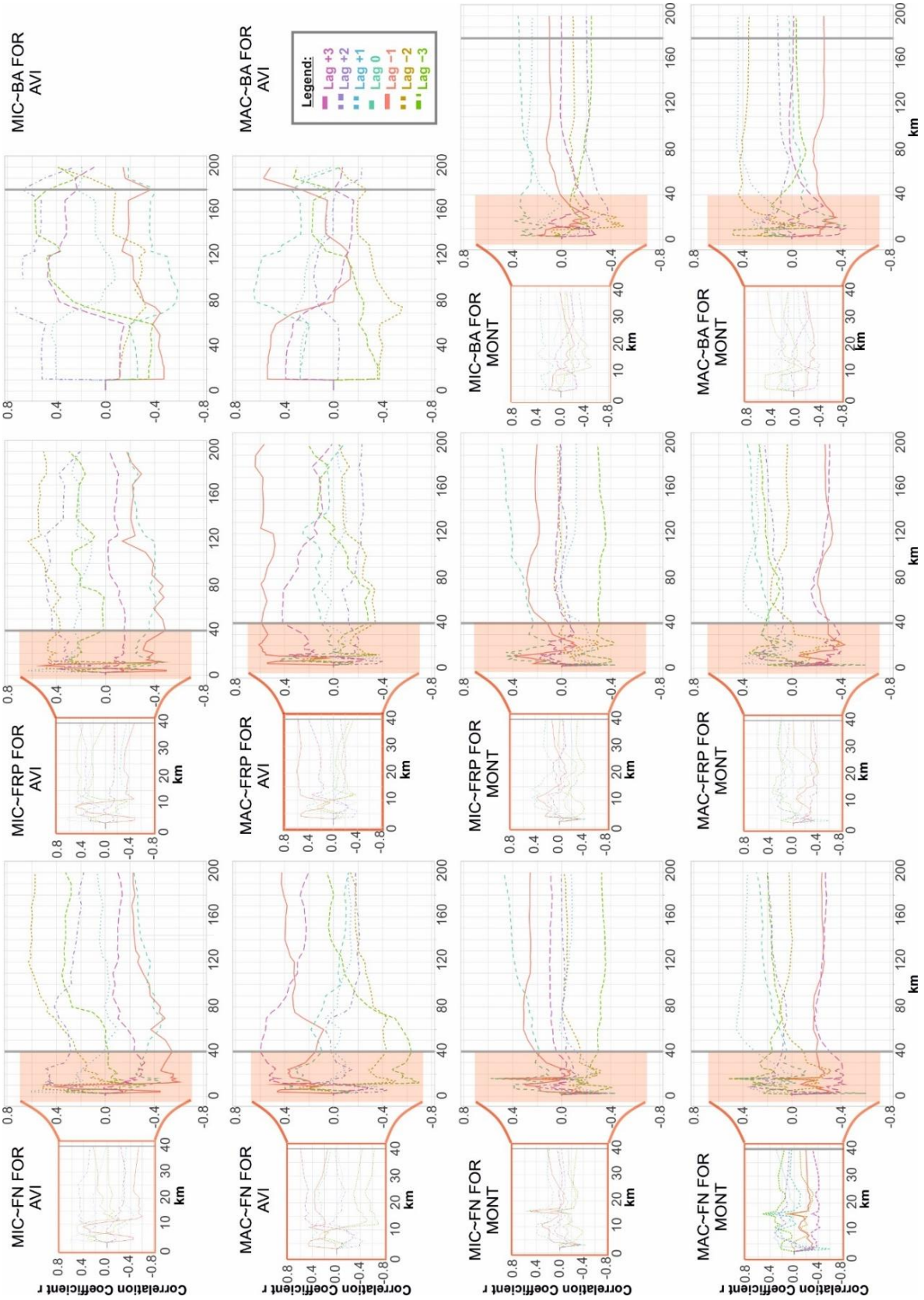



*Appendix 4: FN: Fire number, FRP: Fire radiative power, BA: burned area, SAR: Sarsjön, GOS: Jezioro Gosciaz, AVI: Lago Piccolo d'Avigliana, MONT: Lago Grande di Monticchio, MIC: microscopic charcoal, MAC: macroscopic charcoal.*

Appendix 5: Correlation coefficients for microscopic charcoal (MIC) and macroscopic charcoal (MAC) and satellite-derived fire parameters (fire number (FN), fire radiative power (FRP), burned area (BA)) in relation to increasing distance. Grey lines indicate source areas based on Adolf et al. (2018).




*Appendix 5a: Correlations coefficients for Lake Sarsjön and Jezioro Gosciaz*




*Appendix 5b: Correlation coefficients for Lago Piccolo d'Avigliana and Lago Grande di Monticchio*

Appendix 6: Comparison between mean predicted and observed values per site and per fire parameter (untransformed data).

| FIRE PARAMETER | | SARSJÖN | | JEZIORO GOŚCIĄŻ | | LAGO PICCOLO D'AVIGLIANA | | LAGO GRANDE DI MONTICCHIO | |
|---|---|---|---|---|---|---|---|---|---|
| | | Pred | Obs | Pred | Obs | Pred | Obs | Pred | Obs |
| **FN** | Mean MIC | 3.7 | 2.2 | 10.3 | 2.9 | 4.42 | 22.8 | 12.8 | 137.2 |
| | Mean MAC | - | - | 42.4 | | 16.3 | | 1,123.9 | |
| **FRP [W/M$^2$]** | Mean MIC | 62.2 | 170.7 | 229.6 | 107.8 | 77.0 | 505.3 | 297.4 | 4,484.1 |
| | Mean MAC | - | - | 2,372.8 | | 569.1 | | 248,483.4 | |
| **BA [KM$^2$]** | Mean MAC | - | - | 328.1 | 2.6 | 102.6 | 13.3 | 15,959.2 | 867.5 |

Appendix 6: Pred: Predicted values, Obs: Observed values, FN: Fire number, FRP: Fire radiative power [W m$^{-2}$], BA: Burned area [km$^2$], MIC: Microscopic charcoal, MAC: Macroscopic charcoal.

## Bibliography Supplementary Information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