**Supplementary Table 1**: Bulk sediment parameters in the thaw mounds (TM1, TM2), thaw slump floor (SF3) and Holocene terrace (HT1).

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Site | Depth [cm] | Lab ID | F14CIC ± 1σ | δ13CIC [‰]\*1 | F14COC ± 1σ | δ13COC [‰]\*1,2 | pH | IC [wt.%] | OC [wt.%] | N [wt.%] | OC/N |
| TM1 | 0-10 | COL5258 | - | -4.9 ± 0.1 | 0.215 ± 0.002 | -26.0 ± 0.1 | 7.9 | 0.2 ± 0.2 | 2.1 ± 0.2 | 0.16 ± 0.01 | 12.7 ± 1.4 |
|  | 10-20 | COL5259 | 0.050 ± 0.003 | -6.0 ± 0.1 | 0.042 ± 0.001 | -25.9 ± 0.2 | 8.2 | 0.4 ± 0.4 | 1.8 ± 0.1 | 0.19 ± 0.02 | 9.5 ± 1.2 |
|  | 20-30 | COL5260 | - | -7.2 ± 0.2 | 0.026 ± 0.001 | -26.1 ± 0.1 | 8.2 | 0.4 ± 0.2 | 1.9 ± 0.1 | 0.19 ± 0.02 | 10.0 ± 1.1 |
|  | 30-40 | COL5261 | - | -5.3 ± 0.2 | 0.035 ± 0.001 | -26.2 ± 0.2 | 8.1 | 0.2 ± 0.1 | 2.2 ± 0.1 | 0.20 ± 0.02 | 10.6 ± 1.2 |
|  | 40-50 | COL5262 | 0.043 ± 0.003 | -6.9 ± 0.1 | 0.030 ± 0.001 | -26.0 ± 0.1 | 7.9 | 0.3 ± 0.5 | 2.3 ± 0.2 | 0.22 ± 0.02 | 10.8 ± 1.6 |
|  | 50-60 | COL5263 | - | -7.0 ± 0.1 | 0.023 ± 0.001 | -26.0 ± 0.1 | 7.6 | 0.3 ± 0.3 | 2.6 ± 0.1 | 0.23 ± 0.01 | 11.4 ± 0.7 |
|  | 60-70 | COL5264 | - | -11.6 ± 0.1 | 0.016 ± 0.001 | -25.6 ± 0.3 | 7.9 | 0.2 ± 0.1 | 3.3 ± 0.1 | 0.31 ± 0.01 | 10.5 ± 0.2 |
|  | 70-80 | COL5265 | - | -19.1 ± 0.1 | 0.007 ± 0.001 | -26.1 ± 0.6 | 7.7 | 0.1 ± 0.1 | 3.3 ± 0.1 | 0.31 ± 0.01 | 10.7 ± 0.2 |
|  | 80-90 | COL5266 | - | -19.6 ± 0.1 | 0.007 ± 0.001 | -25.9 ± 0.2 | 6.8 | 0.0 ± 0.4 | 7.8 ± 0.4 | 0.58 ± 0.01 | 13.5 ± 0.7 |
| TM2 | 0-10 | COL5999 | 0.056 ± 0.001 | -5.3 ± 0.1 | 0.109 ± 0.001 | -25.3 | 7.6 | 0.7 ± 0.4 | 2.0 ± 0.1 | 0.19 ± 0.02 | 10.4 ± 1.1 |
|  | 10-20 | COL6000 | 0.055 ± 0.004 | -4.5 ± 0.1 | 0.029 ± 0.001 | -25.5 | 7.8 | 0.7 ± 0.3 | 1.5 ± 0.2 | 0.17 ± 0.02 | 8.9 ± 1.3 |
|  | 20-30 | COL6001 | 0.057 ± 0.004 | -7.0 ± 0.1 | 0.027 ± 0.001 | -30.8 | 7.3 | 0.5 ± 0.4 | 1.9 ± 0.1 | 0.18 ± 0.02 | 10.3 ± 1.3 |
|  | 30-40 | COL6002 | 0.044 ± 0.004 | -5.4 ± 0.1 | 0.023 ± 0.001 | -29.0 | 7.3 | 0.6 ± 0.2 | 1.0 ± 0.1 | 0.13 ± 0.00 | 7.8 ± 0.4 |
|  | 40-50 | COL6003 | 0.038 ± 0.004 | -4.6 ± 0.1 | 0.025 ± 0.001 | -25.7 | 7.3 | 0.8 ± 0.4 | 1.6 ± 0.3 | 0.17 ± 0.00 | 9.1 ± 1.5 |
|  | 50-60 | COL6004 | 0.019 ± 0.001 | -5.2 ± 0.1 | 0.025 ± 0.001 | -25.5 | 7.3 | 0.5 ± 0.2 | 1.4 ± 0.2 | 0.13 ± 0.00 | 11.0 ± 1.3 |
|  | 60-70 | COL6005 | 0.035 ± 0.004 | -5.2 ± 0.1 | 0.028 ± 0.001 | -26.1 | 6.4 | 0.8 ± 0.5 | 1.1 ± 0.0 | 0.12 ± 0.05 | 9.1 ± 1.5 |
| SF3 | 0-10 | COL6006 | 0.812 ± 0.009 | -12.8 ± 0.1 | 0.844 ± 0.012 | -28.5 | 5.8 | 1.9 ± 1.2 | 4.4 ± 0.6 | 0.31 ± 0.02 | 13.9 ± 2.1 |
|  | 10-20 | COL6007 | 0.668 ± 0.010 | -10.8 ± 0.1 | 0.664 ± 0.012 | -27.5 | 5.5 | 1.1 ± 0.8 | 4.2 ± 0.4 | 0.32 ± 0.03 | 12.9 ± 1.6 |
|  | 20-30 | COL6008 | 0.593 ± 0.008 | -9.1 ± 0.1 | 0.608 ± 0.012 | -28.0 | 5.1 | 0.2 ± 1.5 | 3.9 ± 1.3 | 0.22 ± 0.03 | 17.4 ± 6.2 |
|  | 30-40 | COL6009 | 0.179 ± 0.003 | -11.8 ± 0.1 | 0.829 ± 0.012 | -27.9 | 6.1 | 2.8 ± 0.5 | 5.5 ± 0.1 | 0.33 ± 0.03 | 16.6 ± 1.5 |
|  | 40-50 | COL6010 | 0.764 ± 0.010 | -10.2 ± 0.1 | 0.789 ± 0.012 | -27.7 | 5.5 | 2.2 ± 1.2 | 5.5 ± 0.1 | 0.37 ± 0.05 | 15.0 ± 2.1 |
|  | 50-60 | COL6011 | 0.609 ± 0.007 | -9.6 ± 0.1 | 0.607 ± 0.012 | -32.3 | 4.9 | 0.7 ± 0.4 | 4.3 ± 0.1 | 0.28 ± 0.02 | 15.4 ± 1.0 |
| HT1 | +8 | COL6014 | - | - | 1.149 ± 0.012 | -27.2 | 4.5 | - | 9.2 ± 6.0 | 0.44 ± 0.01 | 37.6 ± 0.4 |
|  | 0-11 | COL6012 | - | - | 0.946 ± 0.012 | -27.4 | 5.8 | - | 9.7 ± 0.4 | 0.70 ± 0.00 | 14.0 ± 0.6 |
|  | 11-17 | COL6013 | - | - | 0.597 ± 0.012 | -29.4 | 4.3 | - | 3.0 ± 0.1 | 0.17 ± 0.02 | 17.8 ± 2.1 |

**\*1 [‰ VPDB]; \*2 n = 1 for TM2, SF3, HT1**

**Supplementary Table 2**: Measured (s) and contamination corrected (c) δ13C, F14C values and conventional 14C ages of CO2 emissions and and atmospheric sample (Atm) as well as surface CO2 fluxes.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Site | Lab ID | F14Cs ± 1σ | F14Cc ± 1σ | Age (yrs BP) | δ13Cs [‰ VPDB] | δ13Cc [‰ VPDB] (n=1 per site) | Flux [g CO2 m-² d-1] |
| TM2 | COL5014 | 0.419 ± 0.004 | 0.242 ± 0.001 | 11400 ± 120 | -19.8 ± 0.1 |  | 12.3 |
|  | COL5015 | 0.234 ± 0.003 | 0.230 ± 0.001 | 11800 ± 170 | -23.1 ± 0.1 | -23.1 ± 0.6 | 6.7 |
|  | COL5016 | 0.583 ± 0.005 | 0.329 ± 0.002 | 8940 ± 90 | -17.7 ± 0.3 |  | 2.7 |
| SF3 | COL5011 | 0.829 ± 0.007 | 0.602 ± 0.004 | 4070 ± 40 | -14.9 ± 0.3 |  | 7.4 |
|  | COL5012 | 0.689 ± 0.006 | 0.547 ± 0.002 | 4850 ± 50 | -18.2 ± 0.1 | -22.5 ± 0.9 | 6.1 |
|  | COL5013 | 0.771 ± 0.006 | 0.716 ± 0.001 | 2690 ± 30 | -19.9 ± 0.3 |  | 11.6 |
| HT1 | COL5017 | 1.002 ± 0.007 | 0.985 ± 0.003 | 120 ± 5 | -18.4 ± 0.2 |  | 2.0 |
|  | COL5018 | 1.004 ± 0.008 | 0.967 ± 0.005 | 270 ± 5 | -14.2 ± 0.3 | -27.0 ± 1.7 | 0.8 |
|  | COL5019 | 1.010 ± 0.008 | 0.975 ± 0.006 | 210 ± 5 | -13.0 ± 0.1 |  | 0.9 |
| Atm | COL5025 | 1.021 ± 0.008 | - | present | -8.4 ± 0.3 | - | - |

**Supplementary Table 3**: 13C and 14C contents of CO2 with daily and normalized CO2 production during the incubation (means + std. dev).

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | 1st incubation period | 2nd incubation period |
| Site | **Depth [cm]** | **δ13C ± 1σ [‰ vs. VPDB]** | **F14C ± 1σ** | **µg CO2-C g dw-1 d-1** | **g CO2-C kg C-1 d-1** | **δ13C ± 1σ [‰ vs. VPDB]** | **F14C ± 1σ** | **µg CO2-C g dw-1 d-1** | **g CO2-C kg C-1 d-1** |
| TM2 | 0-10 | -23.4 ± 0.6 | 0.188 ± 0.131 | 0.41 ± 0.09 | 0.021 ± 0.001 | -21.6 ± 1.0 | 0.138 ± 0.088 | 0.28 ± 0.06 | 0.014 ± 0.002 |
|  | 10-20 | -22.0 ± 2.3 | 0.172 ± 0.023 | 0.48 ± 0.24 | 0.027 ± 0.009 | -21.1 ± 1.5 | 0.124 ± 0.010 | 0.36 ± 0.11 | 0.020 ± 0.006 |
|  | 20-40 | -22.8 ± 0.3 | 0.147 ± 0.012 | 0.76 ± 0.15 | 0.037 ± 0.006 | -22.9 ± 0.6 | 0.077 ± 0.009 | 0.55 ± 0.06 | 0.027 ± 0.003 |
|  | 40-70 | -23.9 ± 1.2 | 0.171 ± 0.017 | 0.51 ± 0.08 | 0.033 ± 0.003 | -21.9 ± 1.7 | 0.110 ± 0.064 | 0.39 ± 0.04 | 0.025 ± 0.002 |
| SF3 | 0-10 | -24.0 ± 2.2 | 0.717 ± 0.175 | 2.31 ± 1.47 | 0.047 ± 0.014 | -25.0 ± 2.9 | 0.741 ± 0.209 | 1.53 ± 0.70 | 0.031 ± 0.010 |
|  | 10-20 | -24.6 ± 2.0 | 0.718 ± 0.118 | 2.85 ± 1.09 | 0.052 ± 0.012 | -25.6 ± 2.4 | 0.762 ± 0.061 | 1.90 ± 0.61 | 0.035 ± 0.011 |
|  | 20-40 | -19.5 ± 1.4 | 0.702 ± 0.029 | 1.18 ± 0.92 | 0.027 ± 0.015 | -24.2 ± 2.0 | 0.701 ± 0.050 | 0.89 ± 0.55 | 0.020 ± 0.014 |
|  | 40-60 | -23.3 ± 1.9 | 0.585 ± 0.035 | 2.02 ± 0.10 | 0.052 ± 0.002 | -25.4 ± 1.7 | 0.652 ± 0.033 | 1.48 ± 0.20 | 0.038 ± 0.005 |
| HT1 | 0-11 | -27.0 ± 1.5 | 1.011 ± 0.003 | 7.54 ± 1.70 | 0.093 ± 0.009 | -27.3 ± 0.3 | 1.016 ± 0.003 | 6.68 ± 0.95 | 0.065 ± 0.009 |
|  | 11-17 | -26.3 ± 2.5 | 0.859 ± 0.027 | 0.55 ± 0.24 | 0.015 ± 0.002 | -28.5 ± 1.5 | 0.864 ± 0.011 | 0.51 ± 0.06 | 0.015 ± 0.001 |

**Supplementary Table 4**: Absolute C released (means + std. dev.) calculated from min. and max. distributions of the mass balance approach.

|  |  |  |  |
| --- | --- | --- | --- |
| Site | Depth [cm] | Minimum absolute produced CO2  | Maximum absolute produced CO2 |
| **OCa** | **OCy** | **IC** | **OCa** | **OCy** | **IC** |
|  | **175 days of incubation [g CO2-C kgC-1]** |
| TM2 | 0-10 | 2.14 ± 0.06 | 0.11 ± 0.01 | 0.87 ± 0.03 | 2.91 ± 0.09 | 0.84 ± 0.02 | 0.94 ± 0.03 |
|  | 10-20 | 2.75 ± 0.72 | 0.14 ± 0.04 | 1.12 ± 0.29 | 3.73 ± 0.97 | 1.07 ± 0.28 | 1.21 ± 0.32 |
|  | 20-40 | 3.85 ± 0.48 | 0.20 ± 0.02 | 1.57 ± 0.19 | 5.22 ± 0.65 | 1.50 ± 0.19 | 1.70 ± 0.21 |
|  | 40-70 | 3.46 ± 0.28 | 0.18 ± 0.01 | 1.41 ± 0.11 | 4.68 ± 0.38 | 1.35 ± 0.11 | 1.52 ± 0.12 |
| SF3 | 0-10 | 0 | 4.64 ± 1.12 | 1.99 ± 0.48 | 1.66 ± 0.40 | 6.14 ± 1.49 | 2.16 ± 0.52 |
|  | 10-20 | 0 | 5.14 ± 0.93 | 2.20 ± 0.40 | 1.84 ± 0.33 | 6.79 ± 1.23 | 2.39 ± 0.43 |
|  | 20-40 | 0 | 2.64 ± 1.23 | 1.13 ± 0.53 | 0.94 ± 0.44 | 3.49 ± 1.62 | 1.22 ± 0.57 |
|  | 40-60 | 0 | 5.14 ± 0.16 | 2.20 ± 0.07 | 1.84 ± 0.06 | 6.79 ± 0.22 | 2.39 ± 0.08 |
|  | **537 days of incubation [g CO2-C kgC-1]** |
| TM2 | 0-10 | 4.59 ± 0.40 | 0 | 1.66 ± 0.15 | 5.87 ± 0.51 | 1.28 ± 0.11 | 1.66 ± 0.15 |
|  | 10-20 | 6.58 ± 1.57 | 0 | 2.37 ± 0.57 | 8.41 ± 2.01 | 1.83 ± 0.44 | 2.37 ± 0.57 |
|  | 20-40 | 8.77 ± 0.89 | 0 | 3.16 ± 0.32 | 11.22 ± 1.13 | 2.45 ± 0.25 | 3.16 ± 0.32 |
|  | 40-70 | 8.31 ± 0.64 | 0 | 3.00 ± 0.23 | 10.63 ± 0.82 | 2.32 ± 0.18 | 3.00 ± 0.23 |
| SF3 | 0-10 | 1.00 ± 0.25 | 10.21 ± 2.59 | 1.67 ± 0.42 | 4.69 ± 1.19 | 13.56 ± 3.43 | 2.18 ± 0.55 |
|  | 10-20 | 1.13 ± 0.28 | 11.45 ± 2.84 | 1.88 ± 0.47 | 5.26 ± 1.30 | 15.21 ± 3.77 | 2.44 ± 0.60 |
|  | 20-40 | 0.66 ± 0.36 | 6.69 ± 3.63 | 1.10 ± 0.60 | 3.07 ± 1.67 | 8.88 ± 4.82 | 1.43 ± 0.77 |
|  | 40-60 | 1.24 ± 0.13 | 12.59 ± 1.30 | 2.06 ± 0.21 | 5.78 ± 0.60 | 16.72 ± 1.72 | 2.68 ± 028 |