Supplement of

A spectral approach to estimating the timescale-dependent uncertainty of paleoclimate records – Part 2: Application and interpretation

Andrew M. Dolman et al.

Correspondence to: Andrew M. Dolman (andrew.dolman@awi.de)

The copyright of individual parts of the supplement might differ from the article licence.
Radiocarbon dating was performed on 9 mono-specific samples of *Trilobatus sacculifer* consisting of approximately 50 specimens per sample from the 250-400 µm (Table S1). To determine the age-heterogeneity (σa) using the inter-individual standard deviation, 10 samples consisting of 10 specimens of *T. sacculifer* each from the same sediment depth (68-69 cm) were analysed (Dolman et al., 2020). All AMS-14C dates were analysed using a Mini Carbon Dating System (MICADAS) at the Alfred Wegener Institute, Bremerhaven, Germany (Wacker et al., 2010). Samples consisting of 50 specimens were analysed using a graphite target, samples consisting of 10 specimens using a gas target.

Stable oxygen isotope measurements were performed on *Globigerinoides ruber* (s.s.) from the 250-355 µm (250-400 µm when not enough specimens were available) size fraction (Table S2). For Rep1 5 specimens were analysed; for Rep2 30 specimens were crushed and mixed before enough material was taken from this mixed sample for analysis. Analyses were performed Thermo-Fisher Scientific 253plus gas isotope ratio mass spectrometer with Kiel IV automated carbonate preparation device at MARUM, University of Bremen. Isotopic results were calibrated relative to the Vienna Pee Dee belemnite (VPDB) using the NBS19 standard. The standard deviation of the laboratory standard was lower than 0.05‰ for the measuring period.

References.

Dolman, A. M., Groeneveld, J., Mollenhauer, G., Ho, S. L. and Laepple, T.: Estimating bioturbation from replicated small-sample radiocarbon ages., Earth and Space Science Open Archive, 19, doi:10.1002/essoar.10504501.2, 2020.

Wacker, L., Bonani, G., Friedrich, M., Hajdas, I., Kromer, B., Nemec, N., Ruff, M., Suter, M., Synal, H.-A. and Vockenhuber, C.: MICADAS: Routine and High-Precision Radiocarbon Dating, Radiocarbon, 52(2), 252–262, 2010.

Table S1. Down-core AMS-14C dates for GeoB 10054-4. Radiocarbon ages were calibrated with the Marine13 radiocarbon calibration curve.

| Analysis ID | Depth top (cm) | 14C age | σ 14C age | Calibrated age | No. foraminifera | Weight total (µg C) | Taxon                  |
|------------|---------------|---------|----------|----------------|------------------|---------------------|-----------------------|
| 1660.1.1   | 3             | 944     | 59       | 551            | 100              | 84.0                | *T. sacculifer* / *G. ruber* |
| 2662.1.1   | 13            | 1662    | 64       | 1214           | 43               | 110.0               | *T. sacculifer*         |
| 2663.1.1   | 28            | 1962    | 62       | 1514           | 50               | 136.0               | *T. sacculifer*         |
| 2664.1.1   | 48            | 3113    | 64       | 2895           | 50               | 143.0               | *T. sacculifer*         |
| 2665.1.1   | 88            | 4950    | 70       | 5282           | 50               | 169.0               | *T. sacculifer*         |
| 2666.1.1   | 108           | 5520    | 72       | 5902           | 50               | 164.0               | *T. sacculifer*         |
Table S2. Foraminiferal oxygen isotope measurements for core GeoB 10054-4. Radiocarbon ages were calibrated with the Marine13 radiocarbon calibration curve. Delta $^{18}\text{O}$ is given relative to the Vienna Pee Dee belemnite (VPDB) using the NBS19 standard.

| Core       | Record | Depth (cm) | No. foraminifera | d18O (VPDB) | Calibrated age |
|------------|--------|------------|------------------|-------------|----------------|
| GeoB 10054-4 Rep1 | 3.5   | 5          | -2.017           | 550.8117    |
| GeoB 10054-4 Rep1 | 4.5   | 5          | -2.42            | 617.1036    |
| GeoB 10054-4 Rep1 | 6     | 5          | -2.23            | 716.5413    |
| GeoB 10054-4 Rep1 | 8.5   | 5          | -2.868           | 882.2708    |
| GeoB 10054-4 Rep1 | 9     | 5          | -2.78            | 915.4167    |
| GeoB 10054-4 Rep1 | 10    | 5          | -2.29            | 981.7085    |
| GeoB 10054-4 Rep1 | 13.5  | 5          | -2.068           | 1213.73     |
| GeoB 10054-4 Rep1 | 14.5  | 5          | -2.58            | 1233.763    |
| GeoB 10054-4 Rep1 | 16    | 5          | -2.44            | 1263.812    |
| GeoB 10054-4 Rep1 | 18.5  | 5          | -2.533           | 1313.894    |
| GeoB 10054-4 Rep1 | 20    | 5          | -2.48            | 1343.943    |
| GeoB 10054-4 Rep1 | 21.5  | 5          | -2.58            | 1373.993    |
| GeoB 10054-4 Rep1 | 23.5  | 5          | -2.404           | 1414.058    |
| GeoB 10054-4 Rep1 | 25    | 5          | -2.34            | 1444.108    |
| GeoB 10054-4 Rep1 | 26.5  | 5          | -2.27            | 1474.157    |
| GeoB 10054-4 Rep1 | 28.5  | 5          | -2.209           | 1514.223    |
| GeoB 10054-4 Rep1 | 30    | 5          | -2.95            | 1617.801    |
| GeoB 10054-4 Rep1 | 31.5  | 5          | -2.47            | 1721.38     |
| GeoB 10054-4 Rep1 | 33.5  | 5          | -2.421           | 1859.485    |
| GeoB 10054-4 Rep1 | 34.5  | 5          | -2.09            | 1928.538    |
| GeoB 10054-4 Rep1 | 35.5  | 5          | -2.42            | 1997.591    |
| GeoB 10054-4 Rep1 | 38.5  | 5          | -2.282           | 2204.748    |
| GeoB 10054-4 Rep1 | 39    | 5          | -2.77            | 2239.275    |
| GeoB 10054-4 Rep1 | 40    | 5          | -2.41            | 2308.327    |
| GeoB 10054-4 Rep1 | 43    | 5          | -2.217           | 2515.485    |
| GeoB 10054-4 Rep1 | 44.5  | 5          | -2.28            | 2619.064    |
| GeoB 10054-4 Rep1 | 46.5  | 5          | -2.36            | 2757.169    |
| GeoB 10054-4 Rep1 | 48.5  | 5          | -2.439           | 2895.274    |
| GeoB 10054-4 Rep1 | 50    | 5          | -2.3             | 3004.843    |
| GeoB 10054-4 Rep1 | 51.5  | 5          | -2.25            | 3114.413    |
| GeoB 10054-4 | Rep1 | 53.5 | 5 | -2.263 | 3260.505 |
|---------------|------|------|---|---------|---------|
| GeoB 10054-4 | Rep1 | 54.5 | 5 | -2.63   | 3333.551|
| GeoB 10054-4 | Rep1 | 56   | 5 | -2.34   | 3443.121|
| GeoB 10054-4 | Rep1 | 58.5 | 5 | -2.159  | 3625.736|
| GeoB 10054-4 | Rep1 | 59.5 | 5 | -2.44   | 3698.783|
| GeoB 10054-4 | Rep1 | 61   | 5 | -2.65   | 3808.352|
| GeoB 10054-4 | Rep1 | 63.5 | 5 | -2.354  | 3990.968|
| GeoB 10054-4 | Rep1 | 64.5 | 5 | -2.12   | 4064.014|
| GeoB 10054-4 | Rep1 | 66   | 5 | -2.47   | 4173.583|
| GeoB 10054-4 | Rep1 | 68.5 | 5 | -1.742  | 4356.199|
| GeoB 10054-4 | Rep1 | 69.5 | 5 | -2.16   | 4402.47 |
| GeoB 10054-4 | Rep1 | 71   | 5 | -2.04   | 4471.876|
| GeoB 10054-4 | Rep1 | 73.5 | 5 | -2.342  | 4587.552|
| GeoB 10054-4 | Rep1 | 74.5 | 5 | -2.25   | 4633.823|
| GeoB 10054-4 | Rep1 | 76   | 5 | -2.45   | 4703.229|
| GeoB 10054-4 | Rep1 | 78.5 | 5 | -2.361  | 4818.906|
| GeoB 10054-4 | Rep1 | 79.5 | 5 | -2.28   | 4865.177|
| GeoB 10054-4 | Rep1 | 81   | 5 | -2.01   | 4934.583|
| GeoB 10054-4 | Rep1 | 83.5 | 5 | -2.31   | 5050.26 |
| GeoB 10054-4 | Rep1 | 84.5 | 5 | -2.52   | 5096.53 |
| GeoB 10054-4 | Rep1 | 86.5 | 5 | -2.31   | 5189.072|
| GeoB 10054-4 | Rep1 | 88.5 | 5 | -2.157  | 5281.613|
| GeoB 10054-4 | Rep1 | 89.5 | 5 | -2.34   | 5312.622|
| GeoB 10054-4 | Rep1 | 91   | 5 | -2.4    | 5359.136|
| GeoB 10054-4 | Rep1 | 93.5 | 5 | -2.053  | 5436.659|
| GeoB 10054-4 | Rep1 | 94.5 | 5 | -2.26   | 5467.668|
| GeoB 10054-4 | Rep1 | 96   | 5 | -2.45   | 5514.181|
| GeoB 10054-4 | Rep1 | 98   | 5 | -2.36   | 5576.2  |
| GeoB 10054-4 | Rep1 | 98.5 | 5 | -2.142  | 5591.704|
| GeoB 10054-4 | Rep1 | 99.5 | 5 | -2.02   | 5622.713|
| GeoB 10054-4 | Rep1 | 103.5| 5 | -1.908  | 5746.75 |
| GeoB 10054-4 | Rep1 | 104 | 5 | -2.26   | 5762.254|
| GeoB 10054-4 | Rep1 | 106 | 5 | -1.78   | 5824.272|
| GeoB 10054-4 | Rep1 | 108.5| 5 | -2.325  | 5901.795|
| GeoB 10054-4 | Rep1 | 109 | 5 | -2.27   | 5937.908|
| GeoB 10054-4 | Rep1 | 111 | 5 | -2.13   | 6082.359|
| GeoB 10054-4 | Rep1 | 113.5| 5 | -2.429  | 6262.923|
| GeoB 10054-4 | Rep1 | 114.5| 5 | -2.61   | 6335.149|
| GeoB 10054-4 | Rep1 | 116 | 5 | -1.83   | 6443.487|
| GeoB 10054-4 | Rep1 | 118.5| 5 | -2.102  | 6624.052|
| GeoB 10054-4 | Rep1 | 119 | 5 | -2.33   | 6660.164|
| GeoB 10054-4 | Rep1 | 120.5| 5 | -2.4    | 6768.503|
| GeoB 10054-4 | Rep1 | 123.5| 5 | -2.403  | 6985.18 |
| GeoB 10054-4 | Rep1 | 124 | 5 | -2.19   | 7021.293|
| GeoB 10054-4 | Rep1 | 125.5| 5 | -2.41   | 7129.631|
| GeoB 10054-4 | Rep1 | 128.5| 5 | -2.442  | 7346.308|
| GeoB 10054-4 | Rep1  | 129  | 5   | -1.76 | 7366.039 |
|--------------|-------|------|-----|-------|----------|
| GeoB 10054-4 | Rep1  | 130.5| 5   | -2.52 | 7425.233 |
| GeoB 10054-4 | Rep1  | 133.5| 5   | -2.082| 7543.621 |
| GeoB 10054-4 | Rep1  | 134  | 5   | -1.79 | 7563.352 |
| GeoB 10054-4 | Rep1  | 135.5| 5   | -2.73 | 7622.546 |
| GeoB 10054-4 | Rep1  | 138.5| 5   | -1.925| 7740.934 |
| GeoB 10054-4 | Rep1  | 138.5| 5   | -1.96 | 7740.934 |
| GeoB 10054-4 | Rep1  | 139.5| 5   | -2.49 | 7780.396 |
| GeoB 10054-4 | Rep1  | 143  | 5   | -2.06 | 7918.515 |
| GeoB 10054-4 | Rep1  | 144.5| 5   | -2.07 | 7977.709 |
| GeoB 10054-4 | Rep1  | 146.5| 5   | -2.4  | 8056.634 |
| GeoB 10054-4 | Rep1  | 148.5| 5   | -2.125| 8135.56  |
| GeoB 10054-4 | Rep1  | 150  | 5   | -1.83 | 8199.086 |
| GeoB 10054-4 | Rep1  | 151.5| 5   | -2.34 | 8262.612 |
| GeoB 10054-4 | Rep1  | 153.5| 5   | -2.351| 8347.314 |
| GeoB 10054-4 | Rep1  | 155  | 5   | -2.04 | 8410.84  |
| GeoB 10054-4 | Rep1  | 156.5| 5   | -2.68 | 8474.366 |
| GeoB 10054-4 | Rep1  | 158.5| 5   | -2.297| 8559.068 |
| GeoB 10054-4 | Rep1  | 160  | 5   | -1.98 | 8622.594 |
| GeoB 10054-4 | Rep1  | 161.5| 5   | -2.24 | 8686.12  |
| GeoB 10054-4 | Rep1  | 163.5| 5   | -1.977| 8770.822 |
| GeoB 10054-4 | Rep1  | 165  | 5   | -2.66 | 8834.348 |
| GeoB 10054-4 | Rep1  | 166.5| 5   | -2.04 | 8897.874 |
| GeoB 10054-4 | Rep1  | 168.5| 5   | -1.99 | 8982.576 |
| GeoB 10054-4 | Rep1  | 169.5| 5   | -2.16 | 9024.926 |
| GeoB 10054-4 | Rep1  | 170.5| 5   | -1.77 | 9067.277 |
| GeoB 10054-4 | Rep1  | 173.5| 5   | -2.05 | 9194.33  |
| GeoB 10054-4 | Rep1  | 174.5| 5   | -1.95 | 9240.985 |
| GeoB 10054-4 | Rep1  | 176.5| 5   | -2.28 | 9334.295 |
| GeoB 10054-4 | Rep1  | 178.5| 5   | -1.898| 9427.605 |
| GeoB 10054-4 | Rep1  | 180.5| 5   | -1.73 | 9520.915 |
| GeoB 10054-4 | Rep1  | 182  | 5   | -2.44 | 9590.897 |
| GeoB 10054-4 | Rep1  | 183.5| 5   | -2.279| 9660.879 |
| GeoB 10054-4 | Rep1  | 185  | 5   | -2.43 | 9730.862 |
| GeoB 10054-4 | Rep1  | 186.5| 5   | -1.75 | 9800.844 |
| GeoB 10054-4 | Rep1  | 188.5| 5   | -2.172| 9894.154 |
| GeoB 10054-4 | Rep1  | 190  | 5   | -1.9  | 9964.137 |
| GeoB 10054-4 | Rep2  | 3.5  | 30  | -2.333| 550.8117 |
| GeoB 10054-4 | Rep2  | 8.5  | 30  | -2.277| 882.2708 |
| GeoB 10054-4 | Rep2  | 13.5 | 30  | -2.496| 1213.73 |
| GeoB 10054-4 | Rep2  | 18.5 | 30  | -2.37 | 1313.894 |
| GeoB 10054-4 | Rep2  | 23.5 | 30  | -2.386| 1414.058 |
| GeoB 10054-4 | Rep2  | 28.5 | 30  | -2.363| 1514.223 |
| GeoB 10054-4 | Rep2  | 33.5 | 30  | -2.419| 1859.485 |
| GeoB 10054-4 | Rep2  | 38.5 | 30  | -2.511| 2204.748 |
| GeoB 10054-4 | Rep2  | 43   | 30  | -2.392| 2515.485 |
| GeoB 10054-4 | Rep2  | 48.5  | 30  | -2.244 | 2895.274 |
|-------------|-------|-------|-----|--------|----------|
| GeoB 10054-4| Rep2  | 53.5  | 30  | -2.331 | 3260.505 |
| GeoB 10054-4| Rep2  | 58.5  | 30  | -2.477 | 3625.736 |
| GeoB 10054-4| Rep2  | 63.5  | 30  | -2.475 | 3990.968 |
| GeoB 10054-4| Rep2  | 68.5  | 30  | -2.238 | 4356.199 |
| GeoB 10054-4| Rep2  | 73.5  | 30  | -2.275 | 4587.552 |
| GeoB 10054-4| Rep2  | 78.5  | 30  | -2.343 | 4818.906 |
| GeoB 10054-4| Rep2  | 83.5  | 30  | -2.337 | 5050.26  |
| GeoB 10054-4| Rep2  | 88.5  | 30  | -2.241 | 5281.613 |
| GeoB 10054-4| Rep2  | 93.5  | 30  | -2.258 | 5436.659 |
| GeoB 10054-4| Rep2  | 98.5  | 30  | -2.471 | 5591.704 |
| GeoB 10054-4| Rep2  | 103.5 | 30  | -2.252 | 5746.75  |
| GeoB 10054-4| Rep2  | 108.5 | 30  | -2.2   | 5901.795 |
| GeoB 10054-4| Rep2  | 113.5 | 30  | -2.154 | 6262.923 |
| GeoB 10054-4| Rep2  | 118.5 | 30  | -2.244 | 6624.052 |
| GeoB 10054-4| Rep2  | 123.5 | 30  | -2.509 | 6985.18  |
| GeoB 10054-4| Rep2  | 128.5 | 30  | -2.36  | 7346.308 |
| GeoB 10054-4| Rep2  | 133.5 | 30  | -2.167 | 7543.621 |
| GeoB 10054-4| Rep2  | 138.5 | 30  | -2.21  | 7740.934 |
| GeoB 10054-4| Rep2  | 143   | 30  | -2.29  | 7918.515 |
| GeoB 10054-4| Rep2  | 148.5 | 30  | -1.938 | 8135.56  |
| GeoB 10054-4| Rep2  | 153.5 | 30  | -2.208 | 8347.314 |
| GeoB 10054-4| Rep2  | 158.5 | 30  | -2.2   | 8559.068 |
| GeoB 10054-4| Rep2  | 163.5 | 30  | -1.889 | 8770.822 |
| GeoB 10054-4| Rep2  | 168.5 | 30  | -2.098 | 8982.576 |
| GeoB 10054-4| Rep2  | 173.5 | 30  | -2.172 | 9194.33  |
| GeoB 10054-4| Rep2  | 178.5 | 30  | -1.969 | 9427.605 |
| GeoB 10054-4| Rep2  | 183.5 | 30  | -2.195 | 9660.879 |
| GeoB 10054-4| Rep2  | 188.5 | 30  | -1.931 | 9894.154 |