Comparison of Dating Results achieved using Different Radiocarbon-AgeCalibration Curves and Data

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Manuscript History:

Document first established	22.Sep	2005	
First Update	4.Oct	2005	Results for CalPal-Online Program (CalPal_SFCP_2005 Online) included.
Second Update	22. Oct	2005	Authors & Citation (see above) added. Software versions more clearly specified.
Third Update	19. May	2007	Comparison with CalPal-Hulu-2007.
Fourth Update	21. Feb	2010	Comparison with INTCAL09.
Fifth Update	24.Oct	2013	Comparison with INTCAL13.
Sixth Update	19.Dec	2018	Construction of CalPal-Hulu-2018 (Hulu MSL & MSD).
Seventh Update	8.Dec	2019	Construction of CalPal-Hulu-2019 (minor update to include YD-data by Barbier & 2019)
	5.Jan	2020	Minior Refinement of CalPal-Hulu-2019 to include H82
Eighth Update	8.May	2020	Comparison with INTCAL20

The **primary focus** of the following study is to simultaneously evaluate (***test)*** the influence of the **shape** of the selected **calibration curve** on the calibrated output ages, as well as the **proper functioning** of **numeric algorithms**, over an **extended time-scale.** A **secondary focus** of this study is to evaluate the variability of calibrated ^{14}C-ages, as they may appear when using different **calibration curves** (selectable in **CalPal**) and - here (on 22nd Sep 2005) for the first time since 14 years - also using different **calibration software** (see below: **Fairbanks0805-OnLine-Version_Sep05, OxCal 3.1-download-version_Sep05, Calib 5.0-download-version_Sep05,** and **WinCal25 1.0-download_version_Sep05**).

The approach here is to apply **purely hypothetical standard errors** ± 1 ^{14}C-BP to the input ^{14}C-ages, in a **hypothetical age-window** 100 to max 52 ka ^{14}C-yrs (the maximum allowed radiocarbon input age varies according to software). By this measure we are undertaking efforts to evaluate the calibrated software under **extreme conditions** (i.e. we aim at testing - at least to a certain extent - the stability of the calibration algorithms). The overall aim of the study is to enhance any existing differences in the results of the software, calibration curves, numeric algorithms, rounding procedures, input/output procedures etc of the "candidates" under study (cf. Table below). The method is to produce - we hope - at least to a certain extent **maximised** (***worst-case***) calendric-scale errors - under as simple as possible input conditions. There may exist better test-approaches, but the following will suffice as a starting point for further studies. There is another point to be made: in the real world (e.g. in archaeological studies), we might expect that the numeric output (cal-scale) dating errors will always turn out larger than the input (^{14}C-scale) errors. This is invariably true, but there are exceptions (and these turn up quite clearly in the following table) namely that there exist cases, when the calendric output age has a smaller error than the radiocarbon input age. This may appear unnatural, but is to be expected, namely when the calibration curve has a slope > 45° and few (at least very closely spaced) reentry wiggles, over an extended time-window. Altogether the intention of the test is to evaluate the overall variability of calibrated ^{14}C-ages, that ***may*** turn up e.g. when using different age-calibration data sets, different derived calibration curves, as well as different calibration software (i.e. mathematical approaches). Although difficult to quantify - due to the variety and complexity of the variables under study - the sensitivity of the test is estimated to be in the (max) range of a few decades.

CONCLUSIONS (5. May 2007)

1. There are no discernible differences in the calendric ouput-ages (in the range of a few decades) between the test candidates (calibration programs & data sets) in the age range 0 to 11 ka ^{14}C-BP.
2. For input radiocarbon ages between 12 and 14 ka ^{14}C-BP all CalPal calibration curves give calendric ages c. 500-600 yrs older than INTCAL and Fairbanks 0508. This is due to the inclusion of the Cariaco-Hulu data set in Calcurve construction. In this age interval the alternative calcurves (INTCAL04, Fairbanks0805) are data-free extrapolations.
3. For input calibration ages between 15 and 16 ka ^{14}C-BP the calibration program WinCal25 gives output calendric ages that differ c. 300 yrs from the other candidates.
4. For input calibration ages between 17 and 19 ka ^{14}C-BP the calibration data set CalPal-2007-Hulu gives output calendric ages that differ by c. 300-400 yrs from other candidates. This is apparently (in part) due to the shape of the calibration spline (in the case of identical calibration data), and (in part) due to the choice of different calibration data.
5. For input calibration ages between 19 and 21 ka ^{14}C-BP the calibration program WinCal25 gives output calendric ages that differ by c. 300 yrs from all other candidates.
6. For input calibration ages c. 20 ka ^{14}C-BP the calibration program Fairbanks 0805 gives output calendric ages that differ by c. 1000 yrs from the other candidates. This is likely due to a combination of calibration data and chosen shape of the calibration curve.
7. We observe practically identical numeric output (often within single yrs) for the "internationally recommended" programs OxCal 3.1 and Calib 5.0 in the entire age range covered by the INTCAL04 data set (0 to 21 ka ^{14}C-BP). It is curious that the "internationally recommended" calibration program WinCal25 should often, for input > 14 ka ^{14}C-BP, give systematically different (c. 300 calyrs) output ages .
8. We observe practically identical numeric output (within quoted errors) for the software (programs/CalCurves) Fairbanks 0805 and CalPal (all versions) in their common age range i.e. back to 45 ka ^{14}C-BP.
9. For input calibration ages at 52 ka ^{14}C-BP the calibration program CalPal-Online gives output calendric ages that differ by c. 1200 yrs from the download version. This is likely due to a combination of

calibration data and chosen shape of the calibration curve, near the cut-off limits of the data table.

CONCLUSIONS (5th Jan 2019)

The new CalPal-2018-Hulu calibration curve (CC), constructed on 19th Dec 2018 based on N=404 U/Th-^{14}C-pairs (**Cheng & 2018)** for Hulu stalagmites MSD and MSL (together: 51.8-18.7 ka calBP) is now (5th Jan 2019) extended to cover the partly overlapping time window 27-10.7 ka calBP by including the data (N=248 U/Th-^{14}C-pairs) for Hulu stalagmite H82 (**Southon & 2012**). The now entirely Hulu-based Glacial CC includes, for the Holocene period (11.7-0.0 ka calBP), the corresponding tree-ring data from INTCAL13. This is convenient since, in the Holocene, with minor exceptions the tree-ring data sets underlying INTCAL04, CalPal-Hulu-2007, NTCAL09, and INTCAL13 are identical. The comparison results achieved with CalPal-2018-Hulu are shown in **Tab.2,** and **Fig.1.** As goes for the new 'Glacial' (better: non-tree) segment (51.8-10.7 ka calBP) the results achieved with CalPal-Hulu-2018, although statistically identical on a one-by-one basis, are systematically younger by 0-1 ka (max~2 ka at the end of the ^{14}C-scale) than with CalPal-2007-Hulu, depending on age (cf. **Fig.1**). The limits of ^{14}C-age calibration for application of CalPal-2018-Hulu have been set at 60 ka calBP and 55 ka BP (**Fig.2).** Further details of CalPal-2018-Hulu CC-construction, as well as literature references, are provided in CalPal-software (**version 2019.0**) in the **About->Documentation** menus.

Tab.1

To test the AD/BC scale-switch, CalAges-AD/BC are given negative (= calAD) or positive (calBC)

Blue= DataSet INTCAL04

Violett= DataSet Fairbanks

Green= DataSet CalPal_SFCP_2005

Black= ComputerProgram using this Dataset

[BP] [BP]

INTCAL04 CALPAL	CALPAL_SFCP 2005 CALPAL	CalPal_HULU 2007 CALPAL	CalPal_Hulu CALPAL ONLINE	Fairbanks ONLINE0805 (1)	INTCAL04 OXCAL 3.1 (2)	INTCAL04 CALIB 5.0 (3)	INTCAL04 WINCAL25 (4)
100 ± 1 -1790 ± 90	-1790 ± 90	-1800 ± 90	-1798 ± 90	-1799 ± 79	-1805 ± 115	-1807 ± 108	-1806 ± 106
200 ± 1 -1780 ± 120	-1790 ± 130	-1760 ± 100	-1728 ± 65	-1852 ± 100	-1875 ± 85	-1808 ± 2	-1866 ± 83
300 ± 1 -1570 ± 50	-1560 ± 50	-1560 ± 50	-1582 ± 52	-1579 ± 49	-1585 ± 65	-1585 ± 56	-1585 ± 57
400 ± 1 -1450 ± 20	-1450 ± 20	-1460 ± 30	-1455 ± 5	-1457 ± 4	-1460 ± 10	-1458 ± 7	-1457 ± 3
500 ± 1 -1420 ± 20	-1410 ± 20	-1410 ± 20	-1421 ± 4	-1425 ± 1	-1427 ± 8	-1426 ± 5	-1425 ± 8
600 ± 1 -1340 ± 30	-1330 ± 30	-1340 ± 40	-1350 ± 36	-1341 ± 22	-1355 ± 40	-1354 ± 40	-1356 ± 37
700 ± 1 -1280 ± 20	-1270 ± 20	-1270 ± 20	-1280 ± 2	-1285 ± 0	-1282 ± 8	-1283 ± 3	-1264 ± 5
800 ± 1 -1230 ± 20	-1230 ± 20	-1230 ± 20	-1235 ± 11	-1240 ± 11	-1237 ± 18	-1239 ± 6	-1241 ± 12
900 ± 1 -1100 ± 50	-1090 ± 50	-1100 ± 50	-1107 ± 47	-1123 ± 44	-1110 ± 60	-1108 ± 54	-1110 ± 50
1000 ± 1 -1010 ± 20	-1010 ± 20	-1010 ± 20	-1019 ± 3	-1024 ± 4	-1022 ± 8	-1022 ± 3	-1022 ± 8
2000 ± 1 0 ± 30	10 ± 30	10 ± 20	10 ± 17	2 ± 15	10 ± 30	8 ± 28	- 6 ± 5
3000 ± 1 1250 ± 30	1250 ± 30	1270 ± 20	1249 ± 22	1245 ± 22	1250 ± 40	1252 ± 38	1241 ± 22
4000 ± 1 2520 ± 40	2530 ± 30	2540 ± 30	2526 ± 32	2533 ± 25	2522 ± 43	2525 ± 39	2525 ± 36
5000 ± 1 3770 ± 30	3770 ± 30	3790 ± 20	3781 ± 8	3779 ± 8	3780 ± 15	3780 ± 12	3782 ± 4
6000 ± 1 4880 ± 30	4890 ± 30	4880 ± 30	4887 ± 26	4882 ± 21	4887 ± 42	4887 ± 40	4874 ± 26
7000 ± 1 5890 ± 20	5910 ± 40	5900 ± 30	5896 ± 7	5895 ± 21	5905 ± 65	5908 ± 59	5887 ± 3
8000 ± 1 6940 ± 90	6940 ± 80	6940 ± 80	6950 ± 87	6949 ± 78	6945 ± 105	6943 ± 99	6953 ± 87
9000 ± 1 8250 ± 20	8250 ± 20	8250 ± 20	8253 ± 5	8246 ± 6	8247 ± 15	8247 ± 9	8246 ± 4
10000 ± 1 9530 ± 100	9530 ± 100	9530 ± 100	9532 ± 121	9527 ± 85	9525 ± 125	9530 ± 121	9543 ± 97
11000 ± 1 10980 ± 30	10940 ± 50	10940 ± 60	10960 ± 94	10974 ± 81	10967 ± 23	10966 ± 18	10973 ± 9
12000 ± 1 11920 ± 60	11930 ± 60	11930 ± 60	12021 ± 190	11942 ± 72	11895 ± 45	11896 ± 43	11870 ± 7
13000 ± 1 13400 ± 90	13930 ± 310	13620 ± 40	13904 ± 386	13458 ± 94	13385 ± 135	13389 ± 130	13345 ± 27
14000 ± 1 14750 ± 110	15380 ± 30	15160 ± 30	15295 ± 206	14906 ± 108	14735 ± 195	14740 ± 190	14763 ± 26
15000 ± 1 16370 ± 180	16400 ± 150	16250 ± 230	16302 ± 233	16318 ± 117	16380 ± 200	16383 ± 192	16676 ± 18
16000 ± 1 17240 ± 110	17270 ± 120	17120 ± 70	17194 ± 212	17226 ± 93	17205 ± 85	17208 ± 78	17419 ± 19
17000 ± 1 18180 ± 100	18400 ± 50	18480 ± 50	18322 ± 298	18272 ± 22	18170 ± 90	18172 ± 83	18343 ± 23
18000 ± 1 19350 ± 130	19700 ± 50	19550 ± 40	19763 ± 338	19509 ± 55	19335 ± 165	19339 ± 159	19581 ± 28
19000 ± 1 20550 ± 70	20680 ± 100	20900 ± 80	20916 ± 289	20592 ± 58	20545 ± 65	20544 ± 56	20754 ± 22
20000 ± 1 22010 ± 80	21960 ± 140	21880 ± 70	21975 ± 307	21022 ± 63	22005 ± 105	22008 ± 99	22389 ± 22
21000 ± 1 23330 ± 180	23190 ± 170	22990 ± 50	23188 ± 352	23250 ± 46	23340 ± 220	23339 ± 213	23717 ± 20
22000 ± 1 24700 ± 90	24640 ± 340	24450 ± 190	24459 ± 318	24509 ± 66			
23000 ± 1 25700 ± 90	25880 ± 160	25970 ± 70	25635 ± 427	25565 ± 84			
24000 ± 1	26930 ± 260	26890 ± 280	26881 ± 369	26620 ± 83			
25000 ± 1	28080 ± 180	27950 ± 80	28038 ± 241	28041 ± 300			
26000 ± 1	28870 ± 130	28970 ± 250	29012 ± 324	29171 ± 64			
27000 ± 1	29340 ± 60	29820 ± 80	29823 ± 116	29974 ± 71			
28000 ± 1	30430 ± 490	30500 ± 210	30518 ± 270	30778 ± 80			
29000 ± 1	32300 ± 340	31550 ± 260	31565 ± 295	32111 ± 353			
30000 ± 1	33380 ± 190	32340 ± 140	32337 ± 132	33138 ± 61			
31000 ± 1	34190 ± 230	33060 ± 270	33088 ± 320	33942 ± 121			
32000 ± 1	34960 ± 200	33910 ± 250	34065 ± 228	34925 ± 53			
33000 ± 1	36220 ± 670	35330 ± 720	35555 ± 592	36161 ± 477			
34000 ± 1	38250 ± 850	37600 ± 970	37661 ± 940	37210 ± 76			
35000 ± 1	38760 ± 780	38200 ± 840	38135 ± 815	38687 ± 201			
36000 ± 1	39860 ± 200	39440 ± 270	39406 ± 223	39422 ± 74			
37000 ± 1	40230 ± 210	39950 ± 300	39904 ± 290	40010 ± 76			
38000 ± 1	40740 ± 300	40450 ± 320	40475 ± 306	40597 ± 83			
39000 ± 1	41390 ± 480	41010 ± 390	41306 ± 555	41402 ± 302			
40000 ± 1	41930 ± 430	41640 ± 460	41788 ± 574	42412 ± 62			
41000 ± 1	42680 ± 420	42350 ± 560	42603 ± 657	42802 ± 92			
42000 ± 1	43410 ± 590	43160 ± 710	43431 ± 729	43725 ± 176			
43000 ± 1	44210 ± 710	44030 ± 750	44682 ±1515	44596 ± 146			
44000 ± 1	45260 ± 960	45090 ± 960	45488 ±1519	45438 ± 237			
45000 ± 1	46170 ± 950	46150 ± 1080	46296 ±1524	46910 ± 482			
46000 ± 1	47080 ±1020	47170 ± 1130	47298 ±1732				
47000 ± 1	48500 ±1130	48390 ± 1400	48626 ±1798				
49000 ± 1	50560 ±1380	49700 ± 1540	49936 ±1726				
50000 ± 1	51330 ±1420	50900 ± 1810	51085 ±1872				
51000 ± 1	52360 ±1480	52060 ± 1900	52476 ±2145				
52000 ± 1	54500 ±2120	53280 ± 2040	49936 ±1726				

Methods:

Red = observable (possible) discrepancies

Green = OK (within - often large - errors)

Blue = maybe too small errors

(1) Fairbanks0805 On-Line PrograSep. 2005

(2) OxCal 3.1 Download ProgrSep 2005, using central value of 68.2% probability range.

(3) Calib 5.0 Download ProgrSep 2005, using central value of 68.2% probability range.

(4) WinCal25 1.0 Download ProgrSep 2005, using central value of 68.2% probability range, smallest error.

Tab.2

Comparison of different CalCurves and Programs **(all output calAD/BC-ages)**

BP-Input	INTCAL04 Calpal	CALPAL_SFCP 2005 Calpal	CalPal_HULU 2007 Calpal	CalPal_Hulu Calpal ONLINE	Fairbanks OnLine0805 (1)	INTCAL09 Calpal	INTCAL13 Calpal	CalPal Hulu 2018 CALPAL
100 ± 1	-1790 ± 90	-1790 ± 90	-1800 ± 90	-1798 ± 90	-1799 ± 79	-1800 ± 90	-1800 ± 90	-1800 ± 90
200 ± 1	-1780 ± 120	-1790 ± 130	-1760 ± 100	-1728 ± 65	-1852 ± 100	-1730 ± 70	-1720 ± 70	-1720 ± 70
300 ± 1	-1570 ± 50	-1560 ± 50	-1560 ± 50	-1582 ± 52	-1579 ± 49	-1550 ± 40	-1540 ± 30	-1540 ± 30
400 ± 1	-1450 ± 20	-1450 ± 20	-1460 ± 30	-1455 ± 5	-1457 ± 4	-1450 ± 20	-1450 ± 20	-1450 ± 20
500 ± 1	-1420 ± 20	-1410 ± 20	-1410 ± 20	-1421 ± 4	-1425 ± 1	-1420 ± 20	-1420 ± 20	-1420 ± 20
600 ± 1	-1340 ± 30	-1330 ± 30	-1340 ± 40	-1350 ± 36	-1341 ± 22	-1340 ± 30	-1340 ± 30	-1340 ± 30
700 ± 1	-1280 ± 20	-1270 ± 20	-1270 ± 20	-1280 ± 2	-1285 ± 0	-1270 ± 20	-1270 ± 20	-1270 ± 20
800 ± 1	-1230 ± 20	-1230 ± 20	-1230 ± 20	-1235 ± 11	-1240 ± 11	-1230 ± 20	-1230 ± 20	-1230 ± 20
900 ± 1	-1100 ± 50	-1090 ± 50	-1100 ± 50	-1107 ± 47	-1123 ± 44	-1100 ± 50	-1100 ± 50	-1100 ± 50
1000 ± 1	-1010 ± 20	-1010 ± 20	-1010 ± 20	-1019 ± 3	-1024 ± 4	-1010 ± 20	-1010 ± 20	-1010 ± 20
2000 ± 1	0 ± 30	10 ± 30	10 ± 20	10 ± 17	2 ± 15	10 ± 20	10 ± 20	10 ± 20
3000 ± 1	1250 ± 30	1250 ± 30	1270 ± 20	1249 ± 22	1245 ± 22	1240 ± 30	1230 ± 20	1230 ± 20
4000 ± 1	2520 ± 40	2530 ± 30	2540 ± 30	2526 ± 32	2533 ± 25	2530 ± 30	2530 ± 30	2530 ± 30
5000 ± 1	3770 ± 30	3770 ± 30	3790 ± 20	3781 ± 8	3779 ± 8	3760 ± 30	3750 ± 40	3750 ± 40
6000 ± 1	4880 ± 30	4890 ± 30	4880 ± 30	4887 ± 26	4882 ± 21	4880 ± 30	4880 ± 30	4880 ± 30
7000 ± 1	5890 ± 20	5910 ± 40	5900 ± 30	5896 ± 7	5895 ± 21	5920 ± 50	5920 ± 40	5920 ± 40
8000 ± 1	6940 ± 90	6940 ± 80	6940 ± 80	6950 ± 87	6949 ± 78	6930 ± 70	6930 ± 70	6930 ± 70
9000 ± 1	8250 ± 20	8250 ± 20	8250 ± 20	8253 ± 5	8246 ± 6	8250 ± 20	8250 ± 20	8250 ± 20
10000 ± 1	9530 ± 100	9530 ± 100	9530 ± 100	9532 ± 121	9527 ± 85	9520 ± 100	9530 ± 100	9530 ± 100
11000 ± 1	10980 ± 30	10940 ± 50	10940 ± 60	10960 ± 94	10974 ± 81	10910 ± 70	10900 ± 50	10930 ± 30
12000 ± 1	11920 ± 60	11930 ± 60	11930 ± 60	12021 ± 190	11942 ± 72	11910 ± 50	11900 ± 60	11910 ± 50
13000 ± 1	13400 ± 90	13930 ± 310	13620 ± 40	13904 ± 386	13458 ± 94	13610 ± 250	13610 ± 90	13580 ± 100
14000 ± 1	14750 ± 110	15380 ± 30	15160 ± 30	15295 ± 206	14906 ± 108	15090 ± 70	15060 ± 70	15040 ± 90
15000 ± 1	16370 ± 180	16400 ± 150	16250 ± 230	16302 ± 233	16318 ± 117	16320 ± 180	16280 ± 70	16230 ± 100
16000 ± 1	17240 ± 110	17270 ± 120	17120 ± 70	17194 ± 212	17226 ± 93	17210 ± 160	17370 ± 90	17380 ± 120
17000 ± 1	18180 ± 100	18400 ± 50	18480 ± 50	18322 ± 298	18272 ± 22	18240 ± 110	18560 ± 80	18590 ± 100
18000 ± 1	19350 ± 130	19700 ± 50	19550 ± 40	19763 ± 338	19509 ± 55	19530 ± 100	19850 ± 80	19980 ± 100
19000 ± 1	20550 ± 70	20680 ± 100	20900 ± 80	20916 ± 289	20592 ± 58	20720 ± 210	20920 ± 90	20960 ± 80
20000 ± 1	22010 ± 80	21960 ± 140	21880 ± 70	21975 ± 307	21022 ± 63	21970 ± 170	22120 ± 90	22120 ± 130
21000 ± 1	23330 ± 180	23190 ± 170	22990 ± 50	23188 ± 352	23250 ± 46	23110 ± 180	23410 ± 100	23410 ± 140
22000 ± 1	24700 ± 90	24640 ± 340	24450 ± 190	24459 ± 318	24509 ± 66	24480 ± 200	24250 ± 100	24300 ± 120
23000 ± 1	25700 ± 90	25880 ± 160	25970 ± 70	25635 ± 427	25565 ± 84	25910 ± 100	25380 ± 70	25310 ± 80
24000 ± 1		26930 ± 260	26890 ± 280	26881 ± 369	26620 ± 83	26890 ± 220	26070 ± 110	26240 ± 100
25000 ± 1		28080 ± 180	27950 ± 80	28038 ± 241	28041 ± 300	27920 ± 230	27080 ± 120	27230 ± 160
26000 ± 1		28870 ± 130	28970 ± 250	29012 ± 324	29171 ± 64	28820 ± 140	28360 ± 160	28330 ± 110
27000 ± 1		29340 ± 60	29820 ± 80	29823 ± 116	29974 ± 71	29350 ± 60	29110 ± 50	29200 ± 80
28000 ± 1		30430 ± 490	30500 ± 210	30518 ± 270	30778 ± 80	30210 ± 270	29730 ± 120	30010 ± 130
29000 ± 1		32300 ± 340	31550 ± 260	31565 ± 295	32111 ± 353	31680 ± 270	31280 ± 150	31510 ± 280
30000 ± 1		33380 ± 190	32340 ± 140	32337 ± 132	33138 ± 61	32740 ± 70	32100 ± 80	32530 ± 100
31000 ± 1		34190 ± 230	33060 ± 270	33088 ± 320	33942 ± 121	33690 ± 440	32930 ± 90	33480 ± 270
32000 ± 1		34960 ± 200	33910 ± 250	34065 ± 228	34925 ± 53	34610 ± 80	33970 ± 130	34490 ± 160
33000 ± 1		36220 ± 670	35330 ± 720	35555 ± 592	36161 ± 477	35730 ± 400	35100 ± 250	35500 ± 300
34000 ± 1		38250 ± 850	37600 ± 970	37661 ± 940	37210 ± 76	36920 ± 130	36570 ± 90	37060 ± 510
35000 ± 1		38760 ± 780	38200 ± 840	38135 ± 815	38687 ± 201	38160 ± 340	37590 ± 170	38390 ± 340
36000 ± 1		39860 ± 200	39440 ± 270	39406 ± 223	39422 ± 74	39260 ± 160	38700 ± 180	39200 ± 250
37000 ± 1		40230 ± 210	39950 ± 300	39904 ± 290	40010 ± 76	39920 ± 140	39630 ± 120	39750 ± 210
38000 ± 1		40740 ± 300	40450 ± 320	40475 ± 306	40597 ± 83	40560 ± 170	40280 ± 100	40200 ± 180
39000 ± 1		41390 ± 480	41010 ± 390	41306 ± 555	41402 ± 302	41250 ± 190	40890 ± 110	40650 ± 210
40000 ± 1		41930 ± 430	41640 ± 460	41788 ± 574	42412 ± 62	42040 ± 230	41640 ± 180	41270 ± 350
41000 ± 1		42680 ± 420	42350 ± 560	42603 ± 657	42802 ± 92	42760 ± 180	42590 ± 160	41960 ± 440
42000 ± 1		43410 ± 590	43160 ± 710	43431 ± 729	43725 ± 176	43410 ± 200	43390 ± 160	42800 ± 490
43000 ± 1		44210 ± 710	44030 ± 750	44682 ±1515	44596 ± 146	44060 ± 200	44200 ± 190	43590 ± 540
44000 ± 1		45260 ± 960	45090 ± 960	45488 ±1519	45438 ± 237	44950 ± 370	45220 ± 270	44600 ± 690
45000 ± 1		46170 ± 950	46150 ±1080	46296 ±1524	46910 ± 482	46280 ± 560	46420 ± 300	45580 ± 840
46000 ± 1		47080 ±1020	47170 ±1130	47298 ±1732		47500 ± 310	47570 ± 280	46710 ±1060
47000 ± 1		48500 ±1130	48390 ±1400	48626 ±1798				47780 ±1100
48000 ± 1		50560 ±1380	49700 ±1540	49936 ±1726				48850 ±1180
49000 ± 1		51330 ±1420	50900 ±1810	51085 ±1872				49960 ±1210
50000 ± 1		52360 ±1480	52060 ±1900	52476 ±2145				50990 ±1280
51000 ± 1		54500 ±2120	53280 ±2040	49936 ±1726				52000 ±1350
52000 ± 1								53010 ±1410
53000 ± 1								54030 ±1430
54000 ± 1								55130 ±1490
55000 ± 1								56290 ±1620
56000 ± 1								57320 ±1630
57000 ± 1								58160 ±1540
58000 ± 1								59220 ±1800
59000 ± 1								
60000 ± 1								

Note: In order to test the AD/BC scale-switch, CalAges are given on the CalAD/BC-scale

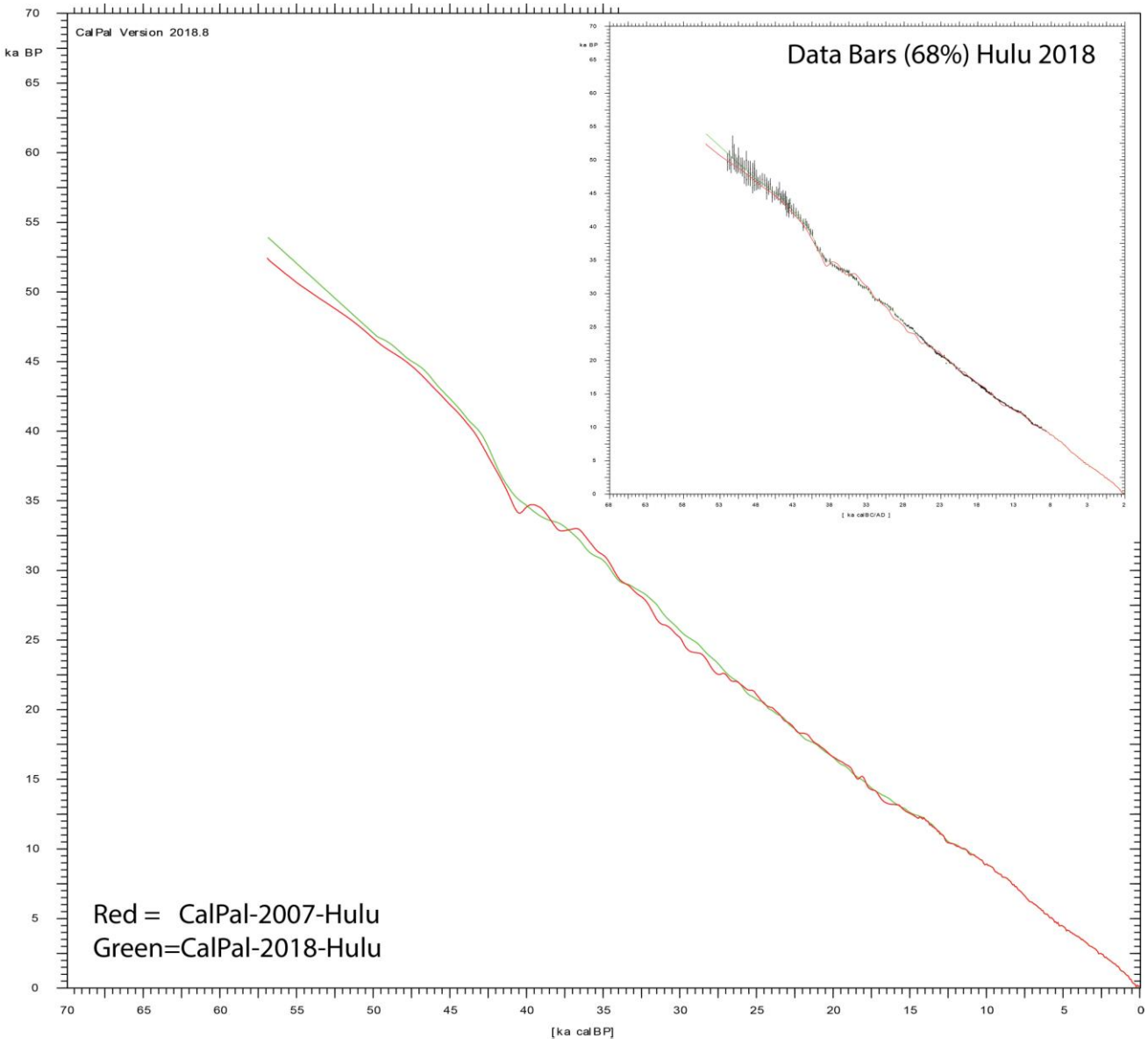

Fig.1 Comparison of ^{14}C-Age Calibration Curves CalPal-2007-Hulu (red) fand CalPal-2018-Hulu (green). The insert shows both calibration curves, with projection of the CalPal-Hulu-2018 databars for the three stalagmites (MSD, MSL, H82)

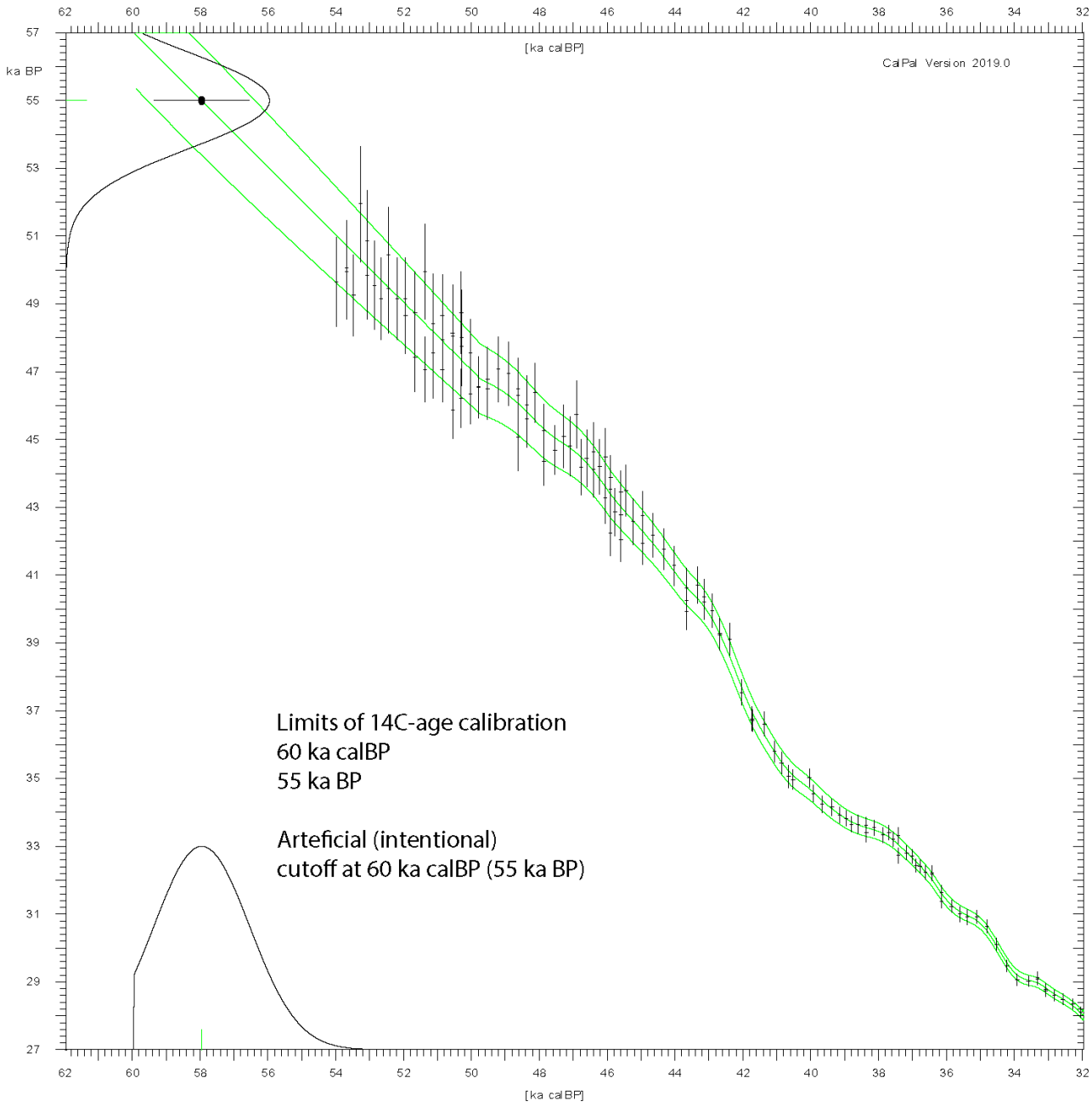

Fig.2 Illustration of the limits of ^{14}C-age calibration set at 60 ka calBP and 55 ka BP for application of CalPal-2018-Hulu.

CONCLUSIONS (8th Dec 2019)

The updated CalPal-2019-Hulu calibration curve (CC), constructed on 8th Dec 2019, includes some new (N=251) YD-^{14}C-ages recently published by Capano et al. (2019) [Reference: : Capano, M., Miramont, C., Shindo, L., Guibal, F., Marschal, C. Kromer, B., Tuna, T., and Bard, E., Younger Dryas recorded with ^{14}C at annual resolution in French subfossil trees. Radiocarbon, 2019].

According to Capano et al (2019), the floating tree-ring sequence from the French site of Barbier can be wiggle-matched with ^{14}C-data derived from kauri trees, to provide a preliminary sequence of atmospheric ^{14}C-ages for the interval 13008-12594 ± 10 calBP. **These calendric ages agree (very) well (± 4 yrs) with results based on wiggle matching the series with the CalPal-Hulu-2007 calibration curve, which has special focus on YD-length and the precise dating of LST (Laacher See Tephra).** As a corollary**,** as goes for the precise dating of the YD, the Barbier data do *not* agree well with the INTCAL-calibration. But this is not unexpected. To be precise, Wiggle matching of Barbier with CalPal-Hulu-2007 resulted in an endyear of 12601 ± 5 calBP (i.e 7 yrs older than for kauri comparisons). Note that kauri-comparisons require a more complex analysis, to allow for S-Hemispheric offsets. In consequence of the achieved good agreement between the Barbier data and the CalPal-2007-Hulu calibration curve, to some slightly lesser degree with CalPal-2018-Hulu, it was deemed useful for archaeological studies, in Late Interstadial I and YD, to provide a (minor) update of the (default) CalPal-calibration curve. This was achieved by insertion of the Barbier data into the CalPal-2018-Hulu curve. The insertion was undertaken in the (slightly: +7 yrs corrected) interval 13015-12601 calBP, in combination with some slight (manual) smoothening of the splined calcurve in the adjacent +100/-100 yrs. To achieve a monotonously increasing calendric time-scale, as required for application of CalPal IMSL-based B-splines), the combined new data set was annually binned, which required re-calculation of weighed averages for parts of the Barbier data set. The reduced data set contains a total number of N=209 ^{14}C-ages, in comparison to the original N=251 ^{14}C-ages. The (satisfactory) similarities and (minor) differences between the CalPal-2019-Hulu-Barbier update and previous calcurves can be studied in the following figure.

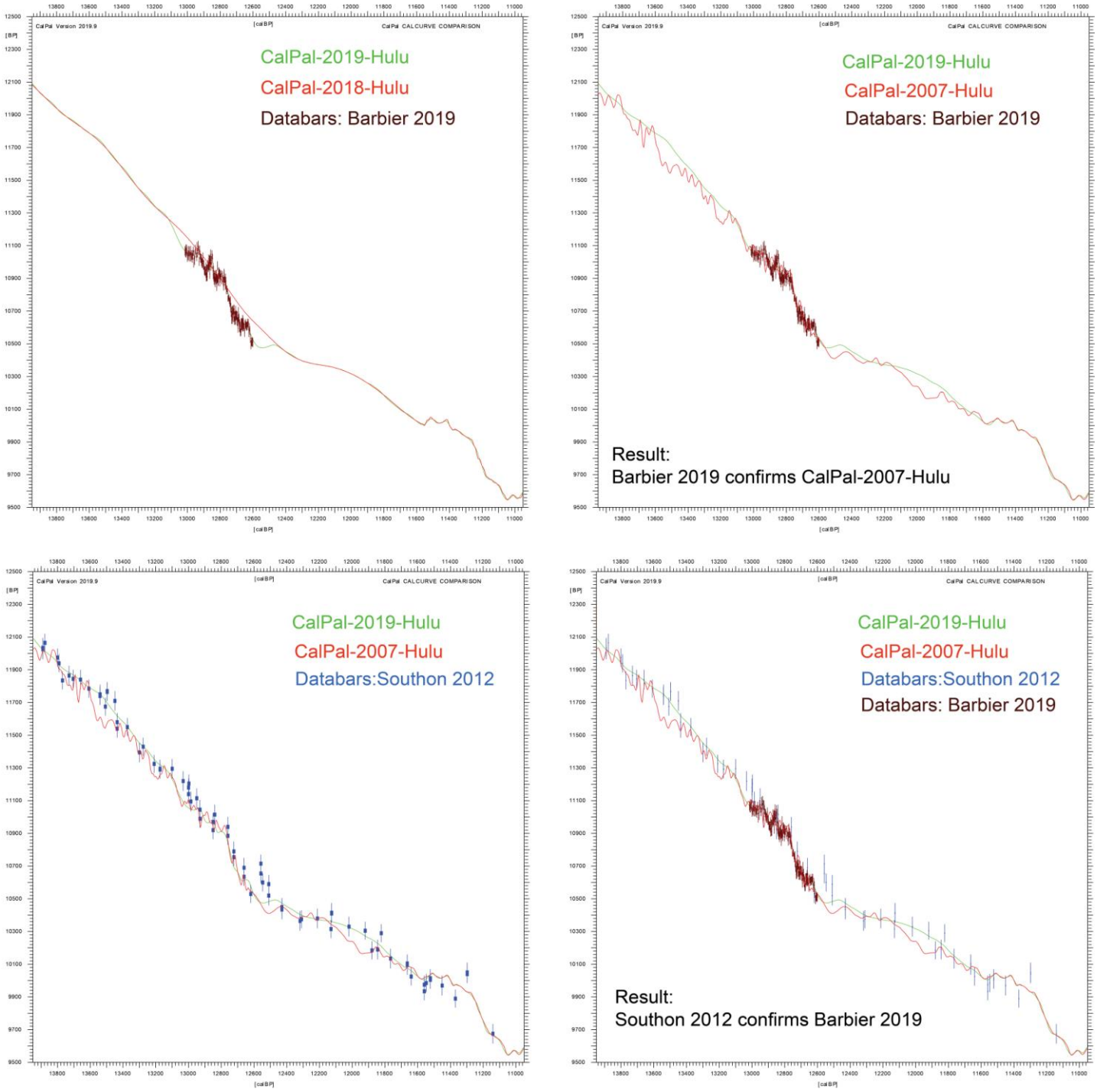

Fig.2 Comparison between CalPal-2019-Hulu and previous Calcurves in the time-window 11-14 ka calBP, showing the new Barbier data and the U/Th-^{14}C-data pairs published by Southon & 2012.

Tab.3 CalPal Dialog Comparison for Calibration Curve CalPal-2019-Hulu & INTCAL20

Comparison of different CalPal Dialogs and the same CalCurve (output: calAD/BC-ages, to test scale-switch)

BP-Input	Hulu 2018 CalTable	Hulu 2018 CalTable	Hulu 2019 CalKN	Hulu 2019 Multigroup	INTCAL20 [CalTable]	Hulu2019 minus INTCAL20 Difference [yrs]
100 ± 1	-1800 ± 90	-1790 ± 100	-1790 ± 100	-1790 ± 100	-1800 ± 90	-10
200 ± 1	-1720 ± 70	-1720 ± 70	-1720 ± 70	-1720 ± 70	-1730 ± 70	-10
300 ± 1	-1540 ± 30	-1540 ± 30	-1540 ± 20	-1540 ± 20	-1570 ± 50	-30
400 ± 1	-1450 ± 20	-1450 ± 20	-1450 ± 20	-1450 ± 20	-1460 ± 20	-10
500 ± 1	-1420 ± 20	-1420 ± 20	-1420 ± 20	-1420 ± 20	-1420 ± 20	0
600 ± 1	-1340 ± 30	-1340 ± 30	-1340 ± 30	-1340 ± 30	-1340 ± 30	0
700 ± 1	-1270 ± 20	-1270 ± 20	-1270 ± 20	-1270 ± 20	-1280 ± 20	-10
800 ± 1	-1230 ± 20	-1230 ± 20	-1230 ± 20	-1230 ± 20	-1240 ± 20	-10
900 ± 1	-1100 ± 50	-1100 ± 50	-1100 ± 50	-1100 ± 50	-1120 ± 60	-20
1000 ± 1	-1010 ± 20	-1010 ± 20	-1010 ± 20	-1010 ± 20	-1020 ± 20	-10
2000 ± 1	10 ± 20	10 ± 20	10 ± 20	10 ± 20	0 ± 30	10
3000 ± 1	1230 ± 20	1230 ± 20	1230 ± 20	1230 ± 20	1240 ± 20	-10
4000 ± 1	2530 ± 30	2530 ± 30	2530 ± 30	2530 ± 30	2520 ± 40	10
5000 ± 1	3750 ± 40	3750 ± 40	3750 ± 40	3750 ± 40	3760 ± 30	-10
6000 ± 1	4880 ± 30	4880 ± 30	4880 ± 30	4880 ± 30	4890 ± 40	-10
7000 ± 1	5920 ± 40	5920 ± 40	5920 ± 40	5920 ± 40	5900 ± 50	20
8000 ± 1	6930 ± 70	6930 ± 70	6920 ± 70	6920 ± 70	6930 ± 70	-10
9000 ± 1	8250 ± 20	8250 ± 20	8250 ± 20	8250 ± 20	8250 ± 20	0
10000 ± 1	9530 ± 100	9530 ± 100	9530 ± 100	9530 ± 100	9530 ± 00	0
11000 ± 1	**10930 ± 30**	**10930 ± 30**	**10960 ± 60**	10960 ± 60	10960 ± 60	10970 ± 60	-10
12000 ± 1	**11910 ± 50**	**11910 ± 50**	**11910 ± 40**	11910 ± 40	11910 ± 40	11950 ± 80	-40
13000 ± 1	13580 ± 100	13580 ± 100	13580 ± 110	13580 ± 110	13580 ± 110	13630 ± 40	-50
14000 ± 1	15040 ± 90	15040 ± 90	15040 ± 90	15040 ± 90	15040 ± 90	15080 ± 30	-40
15000 ± 1	16230 ± 100	16230 ± 100	16230 ± 90	16230 ± 90	**16230 ± 90**	**16310 ± 20**	**-80**
16000 ± 1	17380 ± 120	17380 ± 120	17390 ± 120	17390 ± 120	17390 ± 120	17370 ± 80	20
17000 ± 1	18590 ± 100	18590 ± 100	18580 ± 90	18580 ± 90	18580 ± 90	18570 ± 40	10
18000 ± 1	19980 ± 100	19980 ± 100	19980 ± 100	19980 ± 100	19980 ± 100	20000 ± 60	-20
19000 ± 1	20960 ± 80	20960 ± 80	20950 ± 80	20950 ± 80	20950 ± 80	21010 ± 30	-60
20000 ± 1	22120 ± 130	22120 ± 130	22130 ± 130	22130 ± 130	22130 ± 130	22050 ± 90	-80
21000 ± 1	23410 ± 140	23410 ± 140	23400 ± 130	23400 ± 130	23400 ± 130	23410 ±130	10
22000 ± 1	24300 ± 120	24300 ± 120	24300 ± 120	24300 ± 120	24300 ± 120	24250 ±120	50
23000 ± 1	25310 ± 80	25310 ± 80	25320 ± 80	25320 ± 80	25320 ± 80	25330 ± 40	-10
24000 ± 1	26240 ± 100	26240 ± 100	26250 ± 100	26250 ± 100	26250 ± 100	26150 ±140	100
25000 ± 1	27230 ± 160	27230 ± 160	27230 ± 160	27230 ± 160	27230 ± 160	27240 ± 40	-10
26000 ± 1	28330 ± 110	28330 ± 110	28330 ± 110	28330 ± 110	28330 ± 110	28250 ± 80	80
27000 ± 1	29200 ± 80	29200 ± 80	29200 ± 90	29200 ± 90	29200 ± 90	29180 ± 40	20
28000 ± 1	30010 ± 130	30010 ± 130	30010 ± 140	30010 ± 140	30010 ± 140	29940 ± 80	70
29000 ± 1	31510 ± 280	31510 ± 280	31520 ± 280	31520 ± 280	31520 ± 280	31560 ± 60	-40
30000 ± 1	32530 ± 100	32530 ± 100	32530 ± 90	32530 ± 90	32530 ± 90	32510 ± 70	20
31000 ± 1	33480 ± 270	33480 ± 270	33480 ± 270	33480 ± 270	33480 ± 270	33420 ± 80	60
32000 ± 1	34490 ± 160	34490 ± 160	34490 ± 160	34490 ± 160	34490 ± 160	34360 ± 80	130
33000 ± 1	35500 ± 300	35500 ± 300	35510 ± 300	35510 ± 300	35510 ± 300	35430 ±160	80
34000 ± 1	37060 ± 510	37060 ± 510	37060 ± 510	37060 ± 510	**37060 ± 510**	**37290 ± 90**	**-230**
35000 ± 1	38390 ± 340	38390 ± 340	38380 ± 340	38380 ± 340	38380 ± 340	38210 ± 80	170
36000 ± 1	39200 ± 250	39200 ± 250	39190 ± 250	39190 ± 250	39190 ± 250	39140 ±100	50
37000 ± 1	39750 ± 210	39750 ± 210	39750 ± 210	39750 ± 210	39750 ± 210	39900 ±100	-150
38000 ± 1	40200 ± 180	40200 ± 180	40200 ± 180	40200 ± 180	40200 ± 180	40330 ± 50	-130
39000 ± 1	40650 ± 210	40650 ± 210	40650 ± 210	40650 ± 210	40650 ± 210	40680 ± 80	-30
40000 ± 1	41270 ± 350	41270 ± 350	41260 ± 350	41260 ± 350	41260 ± 350	41120 ± 90	140
41000 ± 1	41960 ± 440	41960 ± 440	41960 ± 440	41960 ± 440	41960 ± 440	42160 ±170	-200
42000 ± 1	42800 ± 490	42800 ± 490	42800 ± 490	42800 ± 490	42800 ± 490	42750 ±100	50
43000 ± 1	43590 ± 540	43590 ± 540	43590 ± 540	43590 ± 540	43590 ± 540	43490 ±190	100
44000 ± 1	44600 ± 690	44600 ± 690	44600 ± 690	44600 ± 690	44600 ± 690	44350 ±240	250
45000 ± 1	45580 ± 840	45580 ± 840	45580 ± 840	45580 ± 840	45580 ± 840	45370 ±300	210
46000 ± 1	46710 ±1060	46710 ±1060	46710 ±1060	46710 ±1060	46710 ±1060	46350 ±250	360
47000 ± 1	47780 ±1100	47780 ±1100	47780 ±1100	47780 ±1100	47780 ±1100	47400 ±410	380
48000 ± 1	48850 ±1180	48850 ±1180	48850 ±1180	48850 ±1180	48850 ±1180	48900 ±650	50
49000 ± 1	49960 ±1210	49960 ±1210	49960 ±1210	49960 ±1210	49960 ±1210	49780 ±680	180
50000 ± 1	50990 ±1280	50990 ±1280	50990 ±1280	50990 ±1280	50990 ±1280	51090 ±530	100
51000 ± 1	52000 ±1350	52000 ±1350	52000 ±1350	52000 ±1350	52000 ±1350		
52000 ± 1	53010 ±1410	53000 ±1400	53000 ±1400	53000 ±1400	53000 ±1400		
53000 ± 1	54030 ±1430	54000 ±1400	54000 ±1400	54000 ±1400	54000 ±1400		
54000 ± 1	55130 ±1490	55000 ±1400	55000 ±1400	55000 ±1400	55000 ±1400		
55000 ± 1	56290 ±1620	56000 ±1400	56000 ±1400	56000 ±1400	56000 ±1400		
56000 ± 1	57320 ±1630	57000 ±1400	57000 ±1400	57000 ±1400	57000 ±1400		
57000 ± 1	58160 ±1540	58000 ±1400	58000 ±1400	58000 ±1400	58000 ±1400		
58000 ± 1	59220 ±1800	59000 ±1400	59000 ±1400	59000 ±1400	59000 ±1400		
59000 ± 1		60000 ±1400	60000 ±1400	60000 ±1400	60000 ±1400		

Conclusions:

· For identical ^{14}C-input, the CalPal dialogs produce identical cal-scale output

· The age-differences between INTCAL20 and CalPal-Hulu-2019 will be insignificant in most applications.

· The calculated errors for INTCAL20 are significantly larger than for CalPal-Hulu-2019 (all ages)