Supplementary information

Dendrochronological information

Series H

Series H consisted of 21 rings spanning AD 1730–1750 (220–200 cal BP) inclusive from a series of core samples taken from structural timbers in the dovecote, Breakspear House, Harefield, Greater London, England (51.60°N, 1.56°W), Great Bidlake Manor House, Bridestowe, Devon, England (50.68°N, 4.13°W), and Bretby Hall, Derbyshire, England (52.80°N, 1.56°W). The timber measured by each participating laboratory is indicated in Table 2.

All the samples were prepared previously for measurement and tree-ring analysis by polishing with a belt sander using progressively finer belts down to a fineness of 400 grit, and the annual growth rings were marked out. Dissection was undertaken by Alison Arnold and Robert Howard at the Nottingham Tree-Ring Dating Laboratory. Prior to sub-sampling, the cores were checked against the tree-ring width data to ensure that the sample contained the required rings. Once this was determined, the selected annual growth rings were split from the rest of the sample using a chisel or scalpel blade. Each sample consisted of a complete annual growth ring, including both earlywood and latewood. The sub-sample was then weighed and placed in a labelled bag.

The tree-ring dating of the roof of the dovecote at Breakspear House (HFD-) has been fully reported by Arnold and Howard (2011a). Core samples from 11 oak timbers were obtained from this roof, of which ten had sufficient (> 50) rings to proceed with analysis. These samples were prepared by sanding and polishing and their growth-ring widths were measured to a precision of 0.01 mm. The data of the measured samples were compared with each other using the Litton/Zainodin grouping procedure (Laxton *et al.* 1988; Litton and Zainodin 1991), allowing a single group of nine cross-matching ring-width series to be formed at a particularly high minimum value of t=8.0. The t-values following Baillie and Pilcher (1973) between these series are provided in Appendix Table S1; a t-value above 10 is indicative of potential same-tree derivation and, clearly, these timbers all derive from a single, discrete unit of woodland. These series were combined at their indicated offset positions to form HFDCSQ01, a site chronology with an overall length of 75 rings. The site

chronology is dated as spanning AD 1695–1769 (Appendix, Table S2). The raw ring-width data of all the measured samples from Breakspear House are provided by Arnold and Howard (2011a, 13–15).

The tree-ring dating of the manor house, stable, and threshing barn at Great Bidlake (GBD-) has been fully reported by Arnold and Howard (2011b). Core samples from 60 pine timbers and 59 oak timbers were obtained from the roofs, ceilings, and floors of these buildings, of which 50 pine samples and 43 oak samples had sufficient (> 50) rings for further analysis. These samples were prepared by sanding and polishing and their growth-ring widths were measured to a precision of 0.01 mm. The data of the 43 measured oak series were compared with each other using the Litton/Zainodin grouping procedure (Laxton *et al.* 1988; Litton and Zainodin 1991), resulting in 27 samples forming six groups at a minimum value of t=5.2. All the samples for radiocarbon dating were obtained from the second of these groups, site chronology GBDASQ02, which contains nine samples. The *t*-values following Baillie and Pilcher (1973) between these ring-width series are provided in Appendix, Table S3; a *t*-value above 10 is indicative of potential same-tree derivation. These series were combined at their indicated offset positions to form GBDASQ02, a site chronology with an overall length of 92 rings. The site chronology is dated as spanning AD 1681–1772 (Appendix, Table S4). The raw ring-width data of all the measured samples from Great Bidlake are provided by Arnold and Howard (2011b, 65–82).

The tree-ring dating of Bretby Hall has been fully reported by Howard *et al.* (1999). Core samples from 32 oak timbers were obtained from the building, all of which had sufficient (> 50) rings for further analysis. These samples were prepared by sanding and polishing and their growth-ring widths were measured to a precision of 0.01 mm. The data of the 32 measured series were compared with each other using the Litton/Zainodin grouping procedure (Laxton *et al.* 1988; Litton and Zainodin 1991), resulting in 30 samples forming four groups at a minimum value of t=4.5. All the samples for radiocarbon dating were obtained from the second of these groups, site chronology BRTASQ02, which contains eight samples. The *t*-values following Baillie and Pilcher (1973) between these ring-width series are provided in Appendix Table S5. A *t*-value above 10 is indicative of potential same-tree derivation and these timbers all derive from a single, discrete unit of woodland. These series were combined at their indicated offset positions to form BRTASQ02, a site chronology with

an overall length of 121 rings. The site chronology is dated as spanning AD 1685–1805 (Appendix, Table S6). The raw ring-width data of all the measured samples from Bretby Hall are provided by Howard *et al.* (2009).

Series A

Series A consisted of 21 rings spanning AD 280–300 (1670–1650 cal BP) inclusive from a single waterlogged oak (Q451) recovered from Allistragh, Co Armagh, Northern Ireland (54.23°N, 6.40°W).

Sample Q451 was prepared for both measurement and tree-ring analysis in the early 1970s by polishing with a rotary sander using progressively finer sanding paper down to a fineness of 600 grit, and each tenth ring had been marked. Dissection was undertaken by David Brown, Dendrochronology Laboratory, Queen's University Belfast. A 20mm x 40mm section of the required annual growth rings was removed from the bulk sample. This block was cleaned on both sides using a scalpel blade. The selected annual growth rings were marked on both sides to define the annual growth rings. The selected rings were removed from the rest of the sample using a cleaned Stanley knife blade and a scalpel blade. Each sample consisted of a complete annual growth ring, including both earlywood and latewood. The sub-sample was then weighed and placed in an Eppendorf tube and this was placed into a labelled bag.

The site master chronology consists of eight samples (Appendix, Table S*7*). These when matched and averaged produce the Allistragh Master Chronology which is 299 years long and dates from AD 39 to AD 337 (Appendix, Table S*8*). Baillie makes reference to the Allistragh site chronology before the absolute Belfast long chronology was constructed and dated (Baillie 1982, 179).

Timbers from Allistragh were originally waterlogged, but have subsequently been allowed to dry out naturally. The remainder of the sample is stored in the Dendrochronology Laboratory, School of Natural and Built Environment, Queen's University, Belfast. Ring-width data for all the measured samples from Allistragh can be found at http://www.chrono.qub.ac.uk/bennett/dendro_data/dendro.html.

Series R

Series R consists of 21 rings spanning Historical BC 5701 - 7681 (7650 – 7630 cal BP) from a single subfossil oak tree (Gaedheim Nr.5) found in a gravel pit near Gaedheim, at river Main, S-Germany (50.04°N, 10.31°E). The 161-years tree-ring series of the oak tree covers BC 5773 – 5613 (7722 – 7562 cal BP) and is securely crossdated on the German Holocene Oak Chronology (HOC) (Friedrich *et al.* 2004), both visually and statistically with *t*-value of 9.4 (Baillie and Pilcher 1973).

The subfossil oak wood was prepared for tree-ring width measurement using Hohenheim standard procedures as reported in Friedrich *et al.* (2004). Tree-ring width measurements on multiple radii resulted in a mean series that was used for crossdating on the HOC. For AMS samples a section of the disc was surfaced using razorblades. Tree ring-widths were measured to a precision of 0.01 mm and the sub-series was then compared to the mean series and crossdated to the HOC. Tree-rings were marked with respect to the absolute ages and consecutive rings were cut and split under the reflected-light microscope using a scalpel blade. Each sample consisted of a complete annual growth ring, including both earlywood and latewood. Sub-samples were then weighed and placed in Eppendorf tubes. Ring-width data of the series Gaedheim 5 is given in Appendix, Table S9.

Table S1. Matrix of t-values (Baillie and Pilcher 1973) for components of the site chronology.

	HFD-C01	HFD-C02	HFD-C03	HFD-C04	HFD-C06	HFD-C07	HFD-C08	HFD-C09	HFD-C10
Last measured ring (AD)	1769	1769	1764	1764	1769	1769	1764	1769	1769
HFD-C01		6.18	8.94	5.62	7.15	11.25	5.73	11.10	8.08
HFD-C02			5.65	5.31	5.55	7.89	9.16	5.22	10.07
HFD-C03				4.67	6.09	12.21	5.60	7.27	6.11
HFD-C04					6.54	5.66	7.32	6.51	7.27
HFD-C06						6.23	6.55	6.45	8.16
HFD-C07							7.16	9.13	8.88
HFD-C08								5.44	10.53
HFD-C09									8.90
HFD-C10									

Table S2. Results of the cross-matching of site sequence HFDCSQ01 and relevant reference chronologies when the first-ring date is AD 1695 and the last-ring date is AD 1769 (t-values after Baillie and Pilcher (1973)).

Reference chronology	**Span of chronology**	***t*-value**	**Reference**
Tilbury Fort, Thurrock, Essex	AD 1678–1777	7.9	Groves 1993
Winchester modern, Hampshire	AD 1635–1972	6.5	Barefoot 1975
Ely Cathedral, Ely, Cambridgeshire	AD 1678–1828	6.2	Esling *et al.* 1989
HMS Victory, Greenwich, London	AD 1640–1800	6.2	Barefoot 1975
Clothall Bury Farmhouse, Wallingford, Hertfordshire	AD 1636–1753	6.1	Arnold *et al.* 2003
Reading Abbey waterfront, Berkshire	AD 1708–1766	6.1	Groves *et al.* 1997
Skeleton Barn, Oakhouse Farm, Hampstead Norreys, Berkshire	AD 1722–1811	6.0	Miles 2001
White Tower, Tower of London, London	AD 1629–1782	5.9	Miles 2007

Table S3. Matrix of t-values (Baillie and Pilcher 1973) for components of the site chronology GBDASQ02 (- = t-values less than 3.00).

	GBD-A101	GBD-A102	GBD-A103	GBD-A104	GBD-A105	GBD-A106	GBD-A107	GBD-A108	GBD-A110
Last measured ring (AD)	1767	1772	1772	1768	1772	1772	1772	1760	1765
GBD-A101		11.51	3.45	3.76	3.40	5.89	5.71	3.16	5.65
GBD-A102			5.33	3.44	4.06	6.93	5.57	-	4.94
GBD-A103				-	4.28	9.31	4.56	-	5.11
GBD-A104					4.60	5.57	3.20	3.67	4.02
GBD-A105						6.28	5.61	4.00	3.63
GBD-A106							4.59	3.76	6.32
GBD-A107								9.66	6.82
GBD-A108									5.36
GBD-A110									

Table S4. Results of the cross-matching of site sequence GBDASQ01 and relevant reference chronologies when the first-ring date is AD 1695 and the last-ring date is AD 1769 (t-values after Baillie and Pilcher (1973)).

Reference chronology	**Span of chronology**	***t*-value**	**Reference**
St John the Baptist Chapel, Exeter Cathedral, Devon	AD 1698–1805	7.2	Arnold *et al.* 2006
Stoneleigh Abbey, Warwickshire	AD 1682–1753	6.0	Howard *et al.* 2000
Skeleton Barn, Oakhouse Farm, Hampstead Norreys, Berkshire	AD 1722–1811	5.8	Miles 2001
Holnicote barn, Selworthy, Somerset	AD 1632–1823	5.7	Miles *et al.* 2004
Warleigh House, Tamerton Foliot, Devon	AD 1671–1774	5.5	Howard *et al.* 2006
Clarendon House granary, Wiltshire	AD 1675–1764	5.5	Tyers 2001
Exeter Cathedral, Devon	AD 1659–1787	5.4	Mills 1988
South Coombeshead barn, Stoke Climsland, Cornwall	AD 1714–1833	5.1	Tyers and Groves 1999

Table S5. Matrix of t-values (Baillie and Pilcher 1973) for components of the site chronology BRTASQ02 (- = t-values less than 3.00).

	BRT-A17	BRT-A18	BRT-A19	BRT-A20	BRT-A21	BRT-A22	BRT-A23	BRT-A24
Last measured ring (AD)	1805	1796	1800	1799	1803	1801	1788	1789
BRT-A17		9.68	11.67	5.54	4.96	4.56	6.92	3.99
BRT-A18			12.66	9.50	4.03	4.07	7.48	4.25
BRT-A19				7.02	3.63	3.13	7.96	4.20
BRT-A20					-	-	-	3.03
BRT-A21						9.46	4.07	8.11
BRT-A22							4.28	7.43
BRT-A23								3.24
BRT-A24								

Table S6. Results of the cross-matching of site sequence BRTASQ02 and relevant reference chronologies when the first-ring date is AD 1695 and the last-ring date is AD 1769 (t-values after Baillie and Pilcher (1973)).

Reference chronology	Span of chronology	*t*-value	Reference
Avoncroft Museum	AD 1675–1754	7.2	Howard *et al.* 1994
Winchester modern, Hampshire	AD 1635–1972	6.3	Barefoot 1975
Great Barn, Old Basing, Hampshire	AD 1684–1788	6.2	Bridge 1996
St Firmin Church, Thurlby, Lincolnshire	AD 1599–1792	5.9	Arnold and Howard 2010
Reading Abbey waterfront, Berkshire	AD 1708–1766	5.6	Groves *et al.* 1997
Stone House Prebend, Derbyshire	AD 1640–1761	5.6	Arnold *et al.* 2014
Church of St Swithin, Kirklington, Notts	AD 1567–1757	5.5	Arnold *et al.* 2016
Stoneleigh Abbey, Warwickshire	AD 1646–1813	5.2	Howard *et al.* 2000
Granary, Old Basing, Hampshire	AD 1691–1790	5.1	Bridge 1996

Table S7. Matrix of t-values (Baillie and Pilcher 1973) for components of the site chronology Allistragh (- = t-values less than 3.00).

	Q449	Q450	Q451	Q452	Q453	Q454	Q455	Q456
Last measured ring (AD)	337	270	331	321	220	252	229	281
Q449		7.8	5.9	3.9	-	4.7	4.8	7.8
Q450			3.8	3.4	3.6	4.2	9.1	4.3
Q451				4.6	-	3.3	-	4.9
Q452					-	5.0	4.6	3.0
Q453						4.7	4.5	-
Q454							4.6	4.5
Q455								-
Q456								

*Table S8. Results of the cross-matching of Allistragh site chronology and relevant reference chronologies when the first-ring date is AD 39 and the last-ring date is AD 337 (t-values (Munro 1984): *** extremely significant match; ** very significant match; * significant match; nsm non-significant match).*

Reference chronology	**Span of chronology**	***t*-value**	**Reference**
Mill Lough, Co. Fermanagh	13 BC – AD 551	7.28***	Baillie 1982
Ballinderry, Co. Antrim	339 BC – AD 706	5.74***	Brown & Baillie 2012
Teeshan, Co. Antrim	AD 84 – AD 579	5.00***	Baillie 1982
Balloo, Co. Down	AD 17 – AD 312	4.88**	Baillie 1982
Moynagh Lough, Co. Meath	AD 209 – AD 593	4.11nsm	Bradley 1983
Oxford Island, Co. Armagh	AD 265 – AD 492	3.96*	Baillie 1982
Ross Lough, Co. Fermanagh	AD 209 – AD 538	3.72nsm	Baillie 1982

Table S9. Ring widths of the oak Gaedheim 5 (Germany, River Main, 50.04°N, 10.31°E); Subfossil Oak (Quercus sp.*),; 161 Rings, BC 5773–5613 (7722 – 7562 cal BP)*

Tree ring width [mm/100]

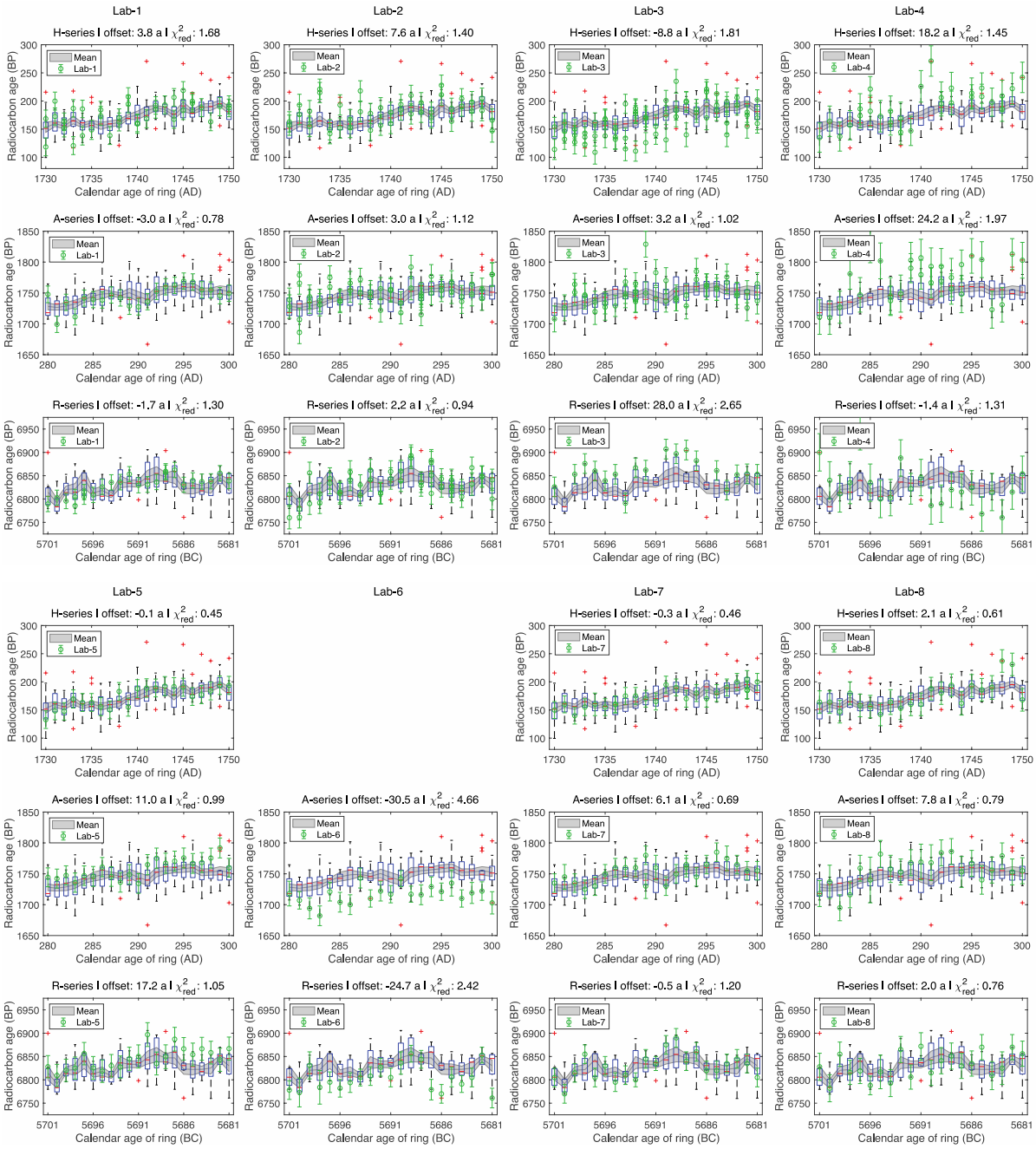
262	348	310	319	295	243	481	433	486	319
462	381	700	619	514	305	281	414	395	438
524	524	548	505	352	376	376	276	281	305
452	400	295	319	314	181	195	367	486	357
300	305	333	252	248	338	281	210	205	319
148	129	195	214	248	233	200	186	243	200
248	295	281	257	257	252	400	257	224	214
248	324	238	267	305	200	243	276	248	348
238	290	333	267	205	252	357	310	281	371
267	167	224	176	257	262	229	376	333	229
224	262	200	195	300	224	219	186	219	229
210	200	229	281	262	233	176	186	195	252

348	252	238	257	190	200	224	271	195	267
233	181	195	333	248	233	205	200	219	229
167	248	257	219	233	181	171	190	176	143
167	167	205	190	167	181	148	176	214	210

200

Radiocarbon measurements

Radiocarbon measurements of the individual laboratories are shown in Figure S1 on top of the box plots (see Figure 1).



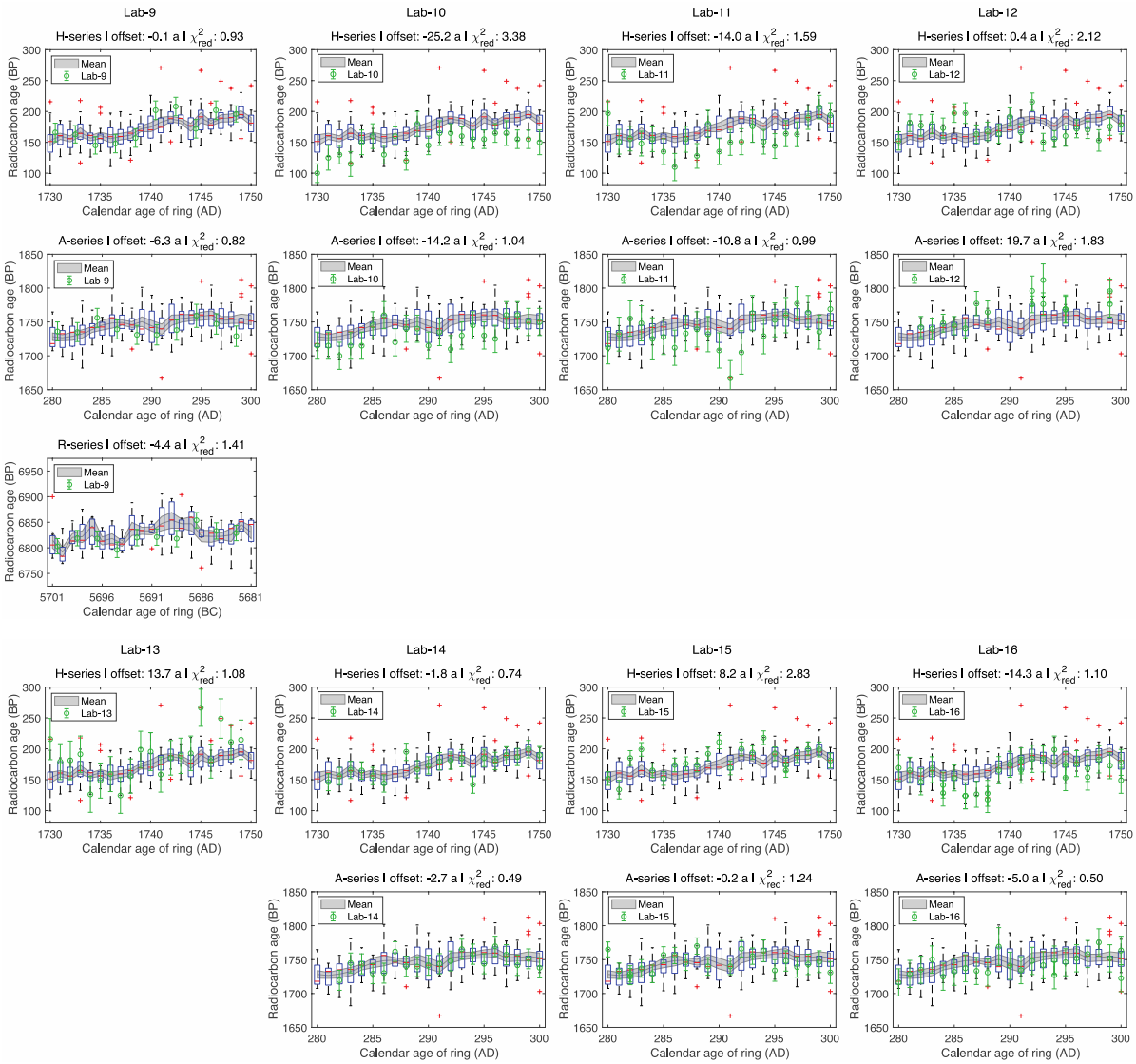


Figure S1: Measurements from the individual laboratories plotted over the box plot and the mean value (see also Figure 1).

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