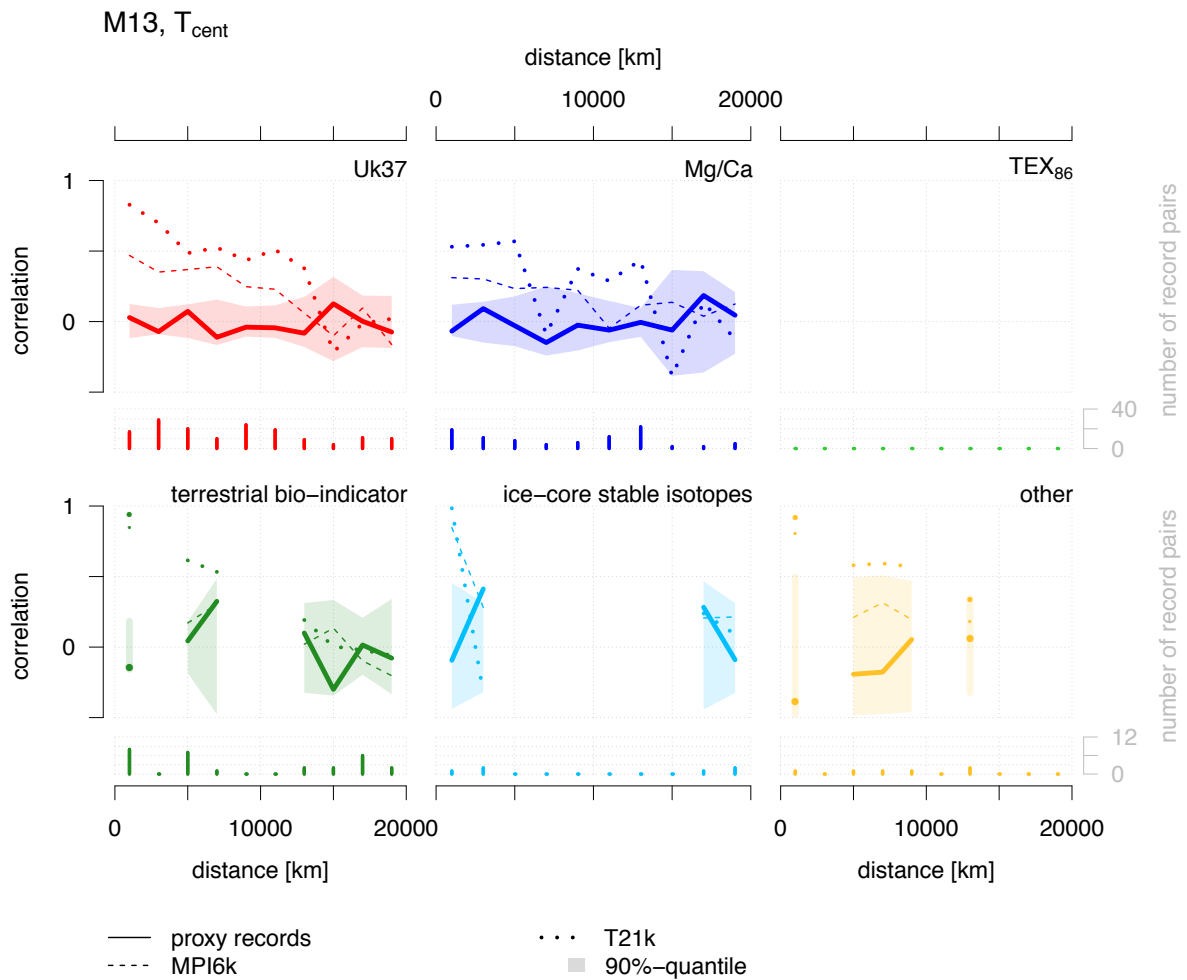
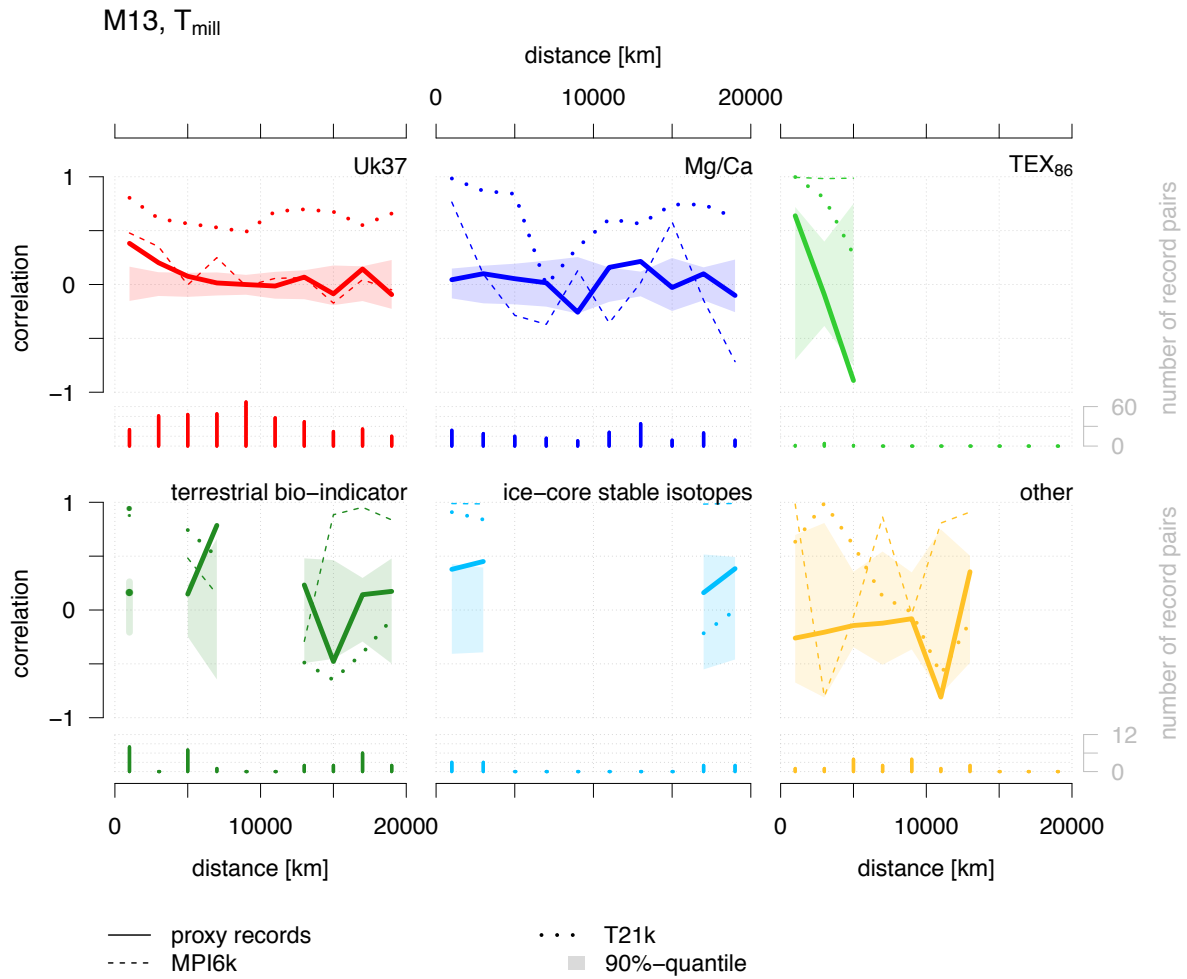


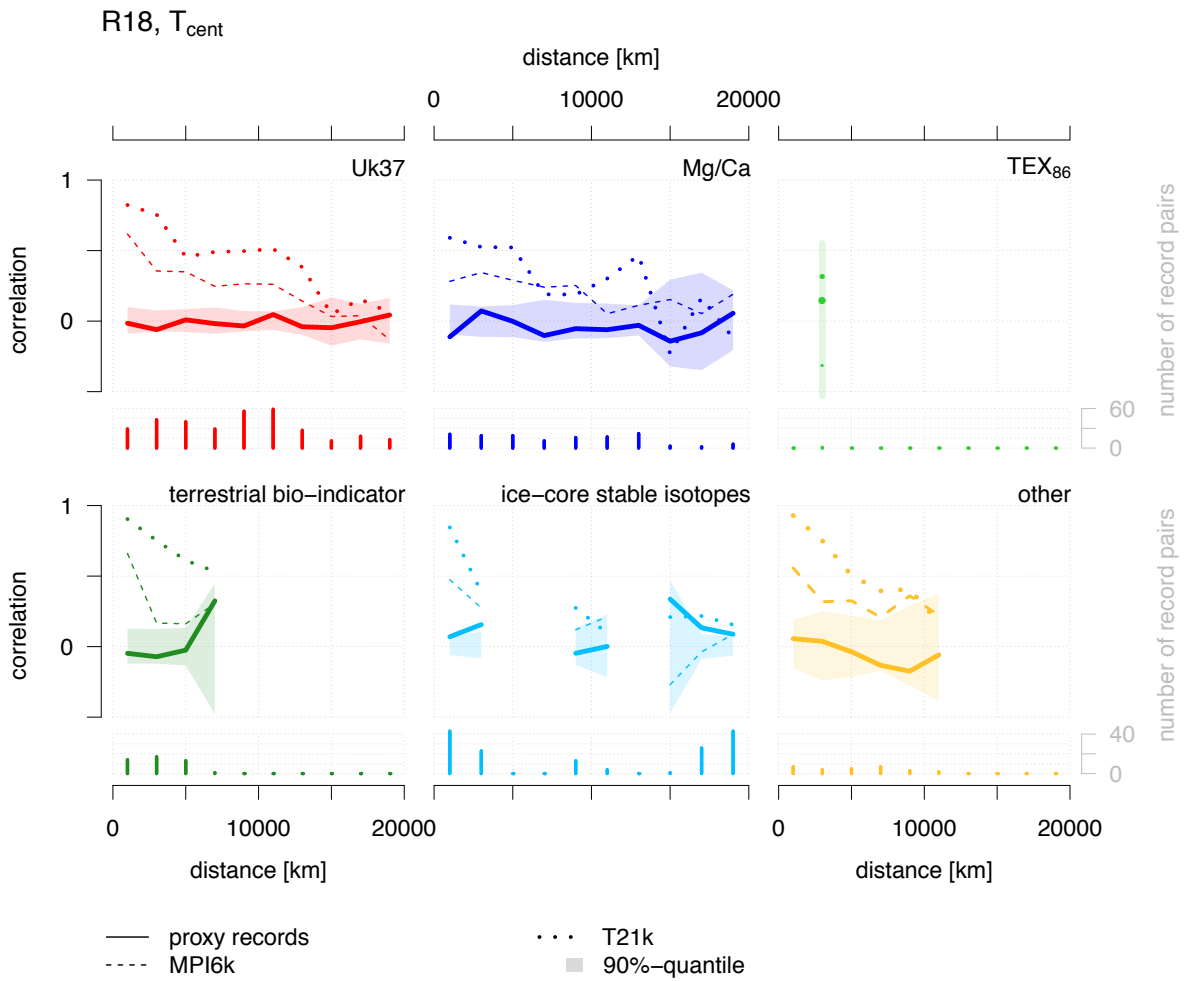
## Supplementary Figures



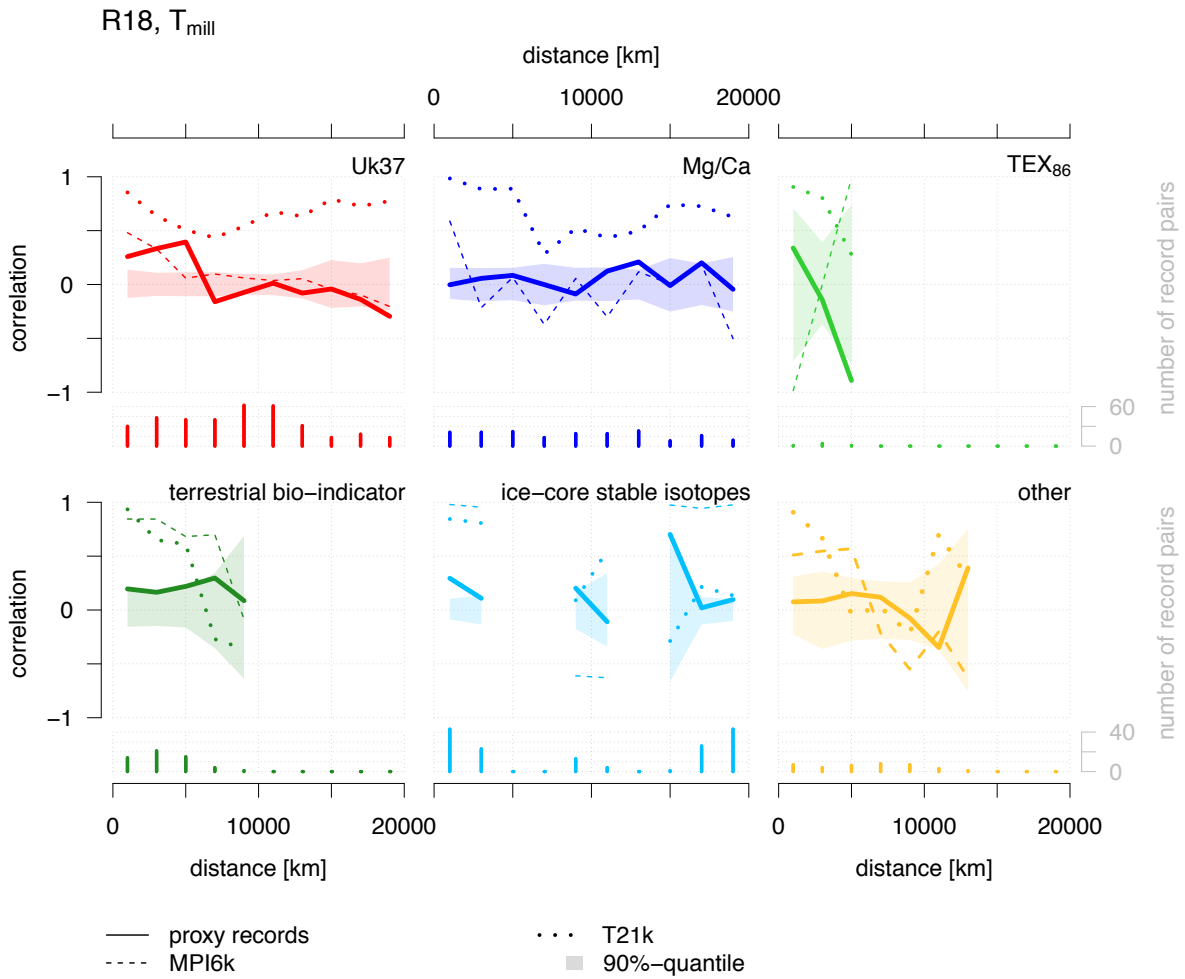
**Figure S1: Proxy-type-specific spatial correlation ( $T_{cent}$ ) of Holocene temperature proxy records and simulated surface air temperatures based on the M13 dataset.** The upper parts of the panels show mean correlations of 2000 km sized bins as a function of the separation distance between record pairs in model time series at proxy positions (dotted/dashed line) and proxy records (continuous line). Coloured polygons represent the 90%-quantile of mean correlations of uncorrelated surrogate time series with a power-law scaling of  $\beta = 1$ . The lower parts of the panels show the number of record pairs used for each estimate. Independent of the proxy type the spatial correlation of proxy records is not statistically significant. In contrast, model time series show a high correlation for close sites.



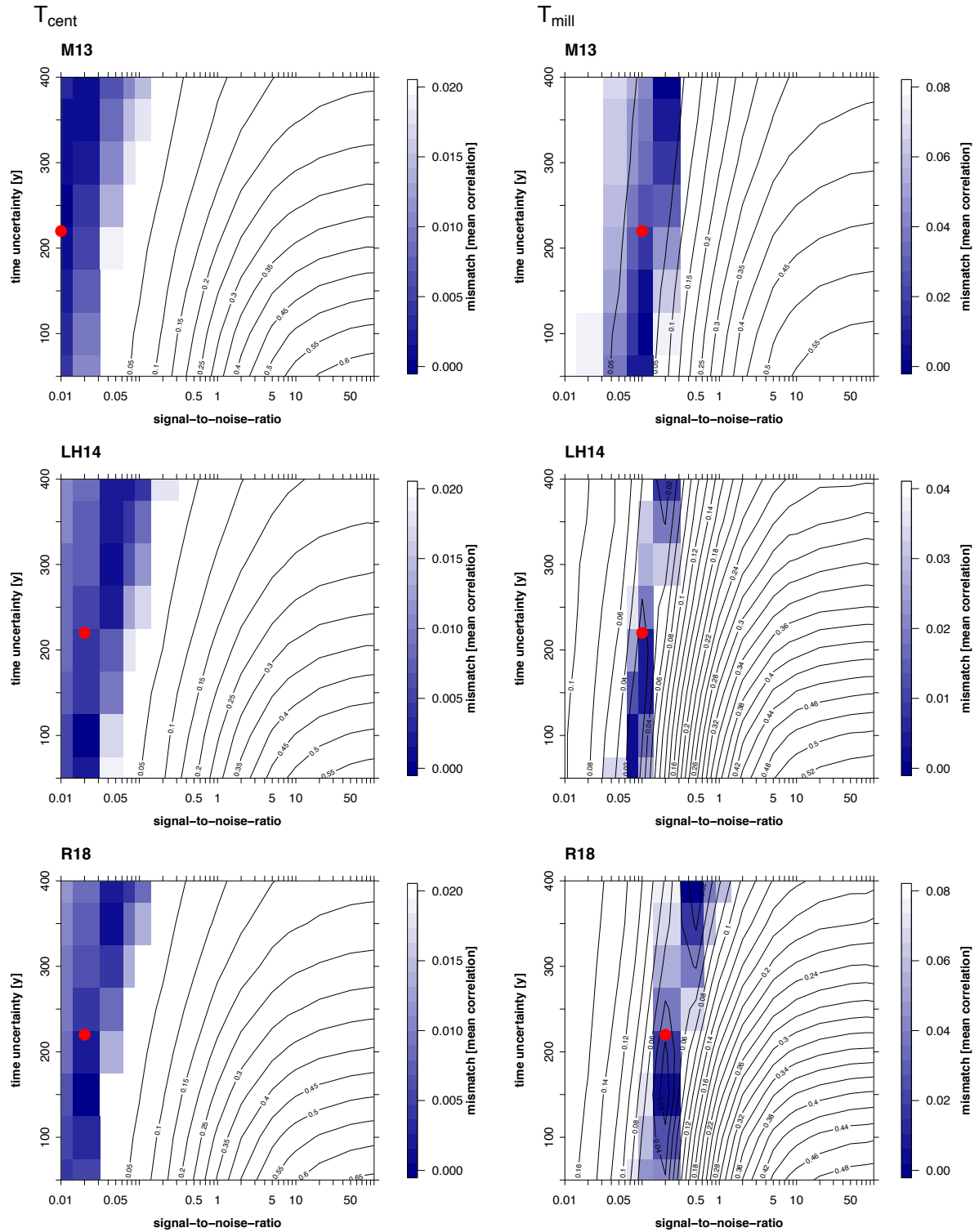
5 **Figure S2: Proxy-type-specific spatial correlation ( $T_{mill}$ ) of Holocene temperature proxy records and simulated surface air temperatures based on the M13 dataset.** The upper parts of the panels show mean correlations of 2000 km sized bins as a function of the separation distance between proxy record pairs (continuous line) and pairs of model time series extracted at proxy positions (dotted/dashed line). Coloured polygons show the 90%-quantile of mean correlations of uncorrelated surrogate time series with a power-law scaling of  $\beta = 1$ . The lower parts of the panels illustrate the number of time series pairs used for each estimate. Underrepresented proxy types such as  $TEX_{86}$ , terrestrial bio-indicators, ice-core stable isotopes and others show statistically not significant spatial correlations of proxy records. Despite of a higher number of proxy time series, Mg/Ca-based estimates are not and Uk37-based ones are only statistically significant for close sites (separation <6000 km).



5 **Figure S3: Proxy-type-specific spatial correlation ( $T_{cent}$ ) of Holocene temperature proxy records and simulated surface air temperatures based on the R18 dataset.** The upper parts of the panels illustrate mean correlations of 2000 km sized bins as a function of the separation distance between model time series at proxy positions (dotted/dashed line) and proxy datasets (continuous line). Coloured polygons mark the 90%-quantile of mean correlations of uncorrelated time series with a power-law scaling of  $\beta = 1$ . The lower parts of the panels show the number of record pairs used for each estimate. As in Figure S1, the proxy-type-specific spatial correlation based on proxy records is statistically not significant for all proxy types.

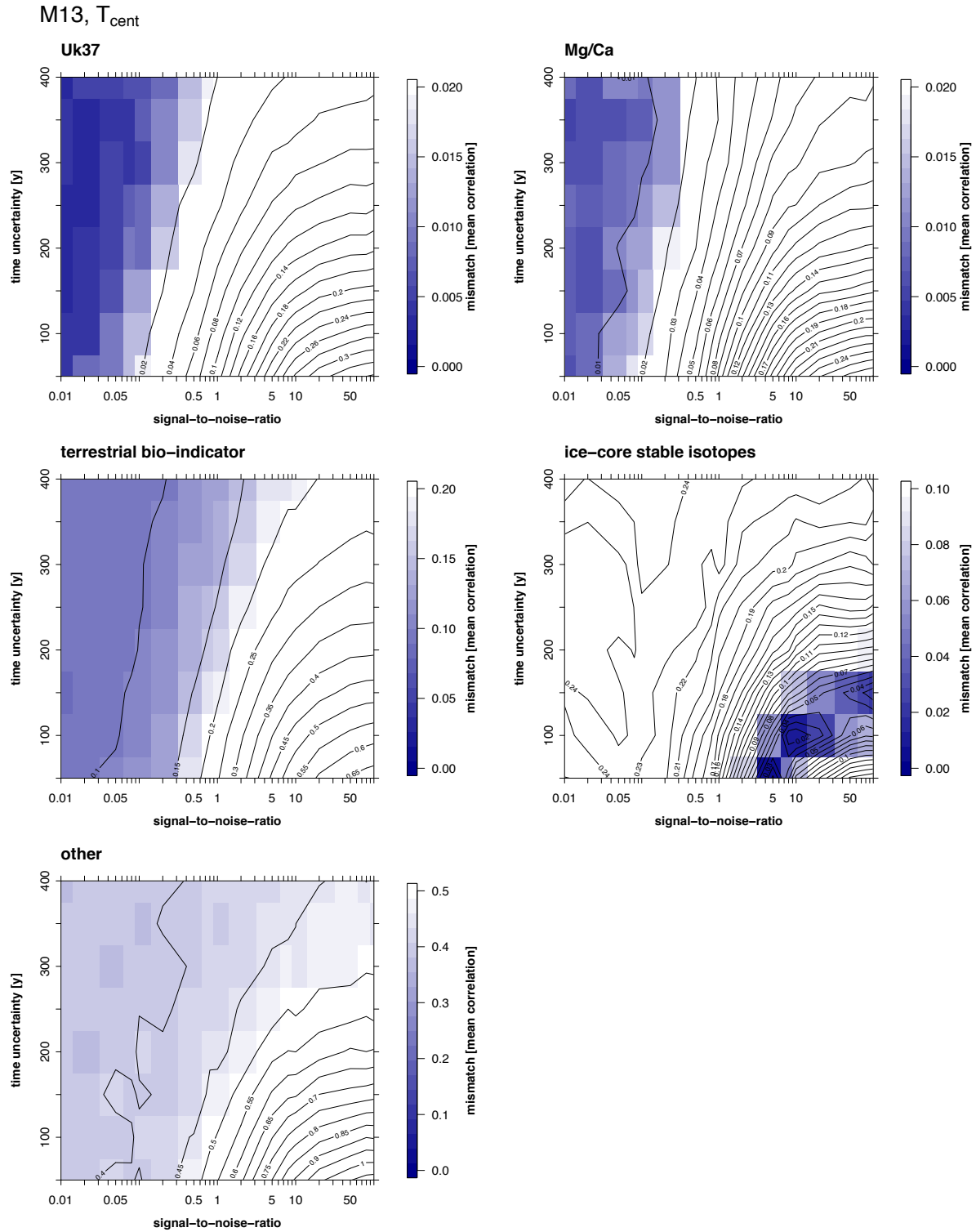


5 **Figure S4: Proxy-type-specific spatial correlation ( $T_{mill}$ ) of Holocene temperature proxy records and simulated surface air temperatures based on the R18 dataset.** The upper parts of the panels depict mean correlations of 2000 km sized bins as a function of the separation distance between proxy (continuous line) and model time series extracted at proxy positions (dotted/dashed line). The coloured polygons mark the 90%-quantile of mean correlations of uncorrelated surrogate time series with a power-law scaling of  $\beta = 1$ . The lower parts of the panels show the number of record pairs used for each estimate. As in Figure S2, only Uk37-based time series are statistically significant for close sites (separation  $< 6000$  km).



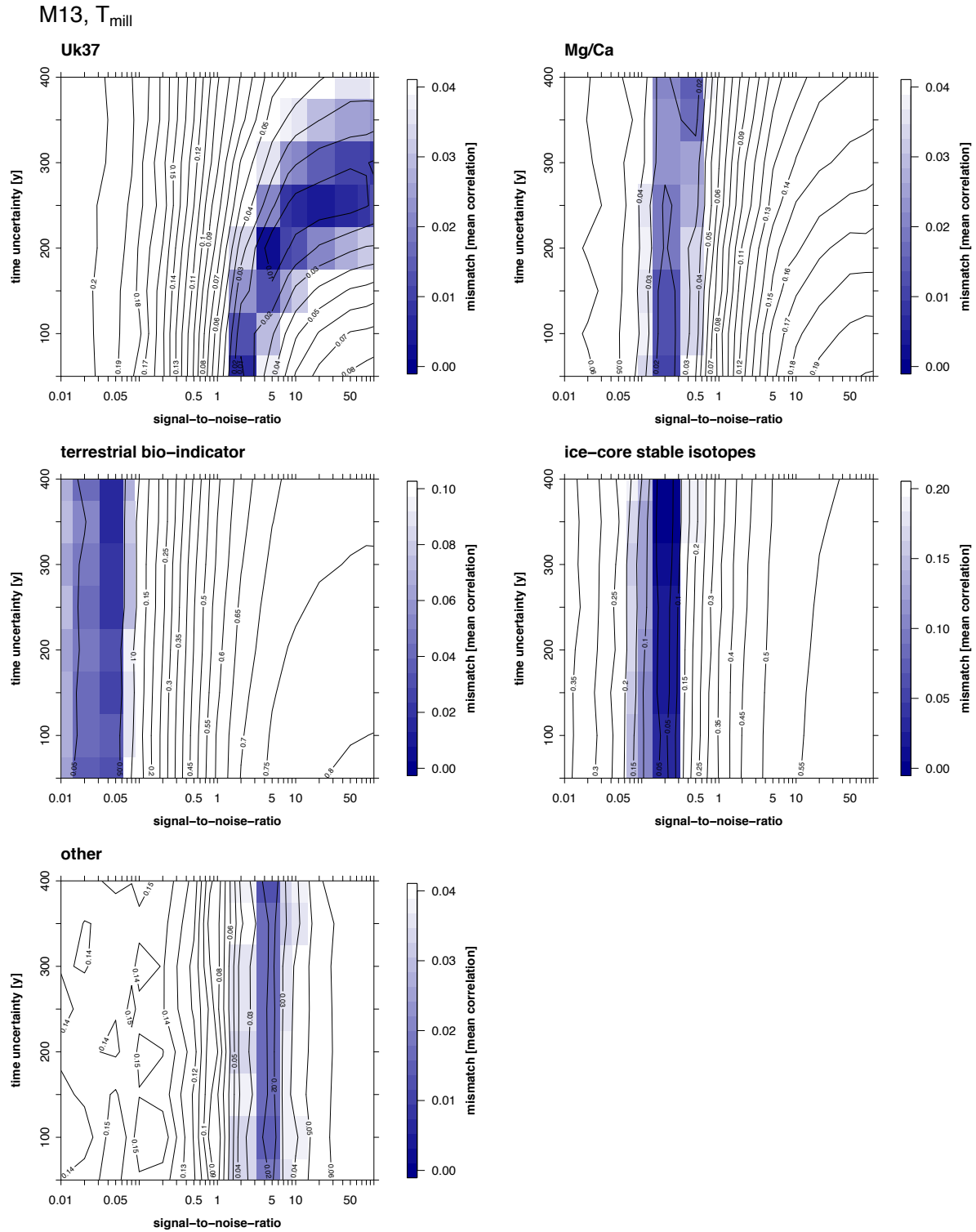
**Figure S5: SNR<sub>T21k</sub> estimates of Holocene temperature proxy records as a function of time uncertainty related to centennial  $T_{cent}$  and centennial to millennial time scales  $T_{mill}$ .** Each panel shows the mismatch between mean correlations of close-by (separation <5000 km) proxy records and model time series extracted at proxy locations from model T21k (TraCE-21ka model simulation) as a function of time uncertainty (vertical axis) and SNR (horizontal axis). Parts with the same mismatch are illustrated by contour lines with numbers. Coloured areas belong to the lowest mismatch and show suitable combinations of SNR<sub>T21k</sub> estimates and time uncertainties. The SNRs are consistent for all datasets and show smaller estimates on  $T_{cent}$  ( $SNR_{T21k,T_{cent}} < 0.05$ ) than on  $T_{mill}$  ( $0.05 < SNR_{T21k,T_{mill}} < 0.2$ ). The red dots illustrate SNRs for a time uncertainty of 220y which is the mean provided uncertainty in M13.

5



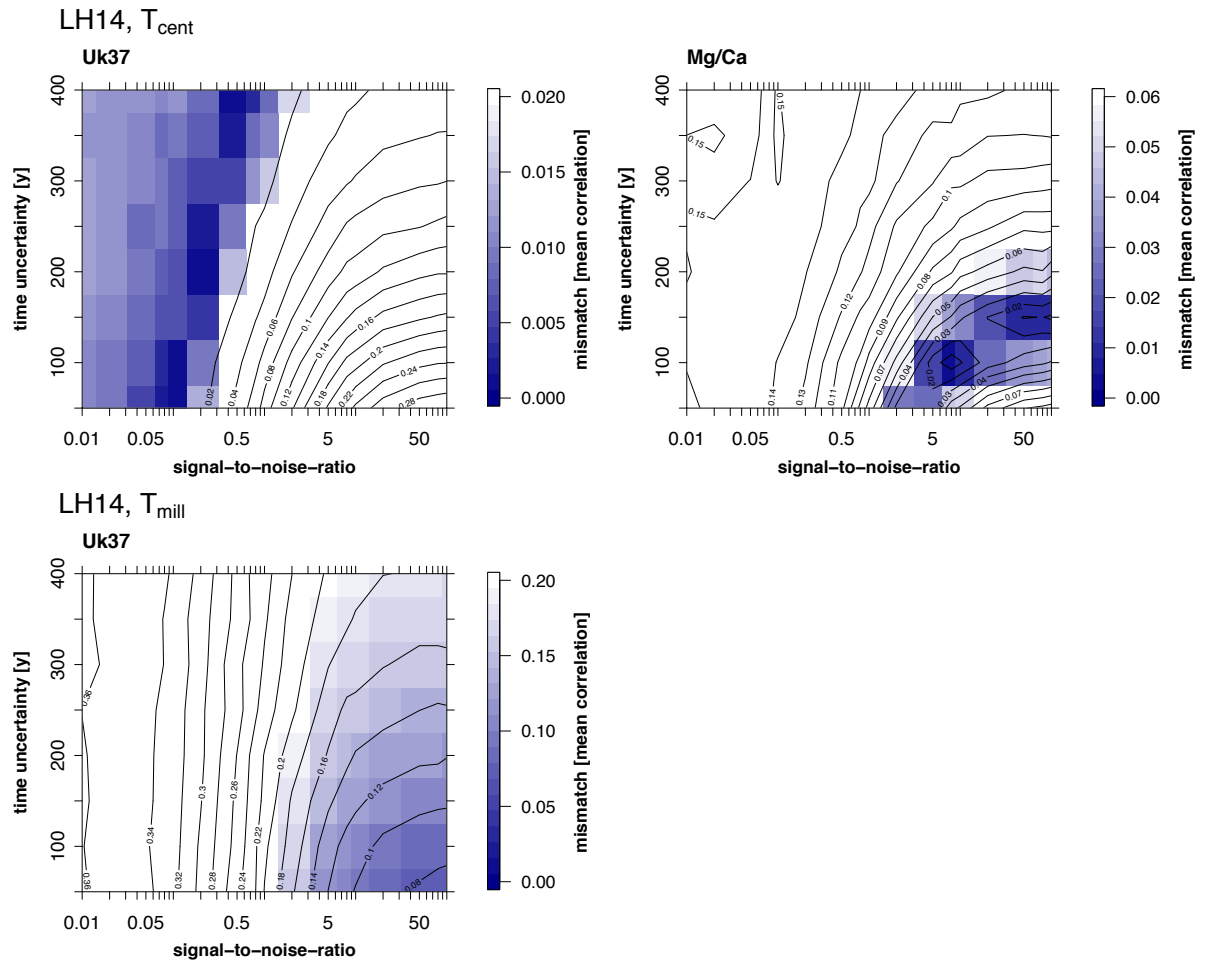
**Figure S6: Proxy-type-specific  $SNR_{MPI6k, T_{cent}}$  estimates of Holocene temperature proxy records as a function of time uncertainty based on the M13 dataset and related to centennial time scales  $T_{cent}$ .** The panels show the mismatch between mean correlations of close-by (separation  $<5000$  km) proxy records and model time series extracted at proxy locations from model MPI6k (ECHAM5/MPI-OM) as a function of time uncertainty (vertical axis) and SNR (horizontal axis). Contour lines with numbers illustrate areas with the same mismatch. Coloured parts of the panels mark suitable combinations of SNR estimates and time uncertainties (lowest mismatch). Except for ice-core stable isotopes, all proxy types are characterised by low  $SNR_{MPI6k, T_{cent}}$  estimates on  $T_{cent}$ .

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**Figure S7: Proxy-type-specific  $SNR_{MPI6k, T_{mill}}$  estimates of Holocene temperature proxy records as a function of time uncertainty based on the M13 dataset and related to centennial to millennial time scales  $T_{mill}$ .** Each panel illustrates the mismatch between mean correlations of close-by (separation  $<5000$  km) proxy records and model time series extracted at proxy locations from the model MPI6k (ECHAM5/MPI-OM) as a function of time uncertainty (vertical axis) and SNR (horizontal axis). Contour lines show parts with the same mismatch (numbers) and coloured areas (lowest mismatch) highlight suitable combinations of SNR estimates and time uncertainties. Most of the proxy-type-specific estimates indicate higher SNRs compared to  $T_{cent}$ . Except for Uk37, the estimated SNRs show a low dependence on time uncertainty.

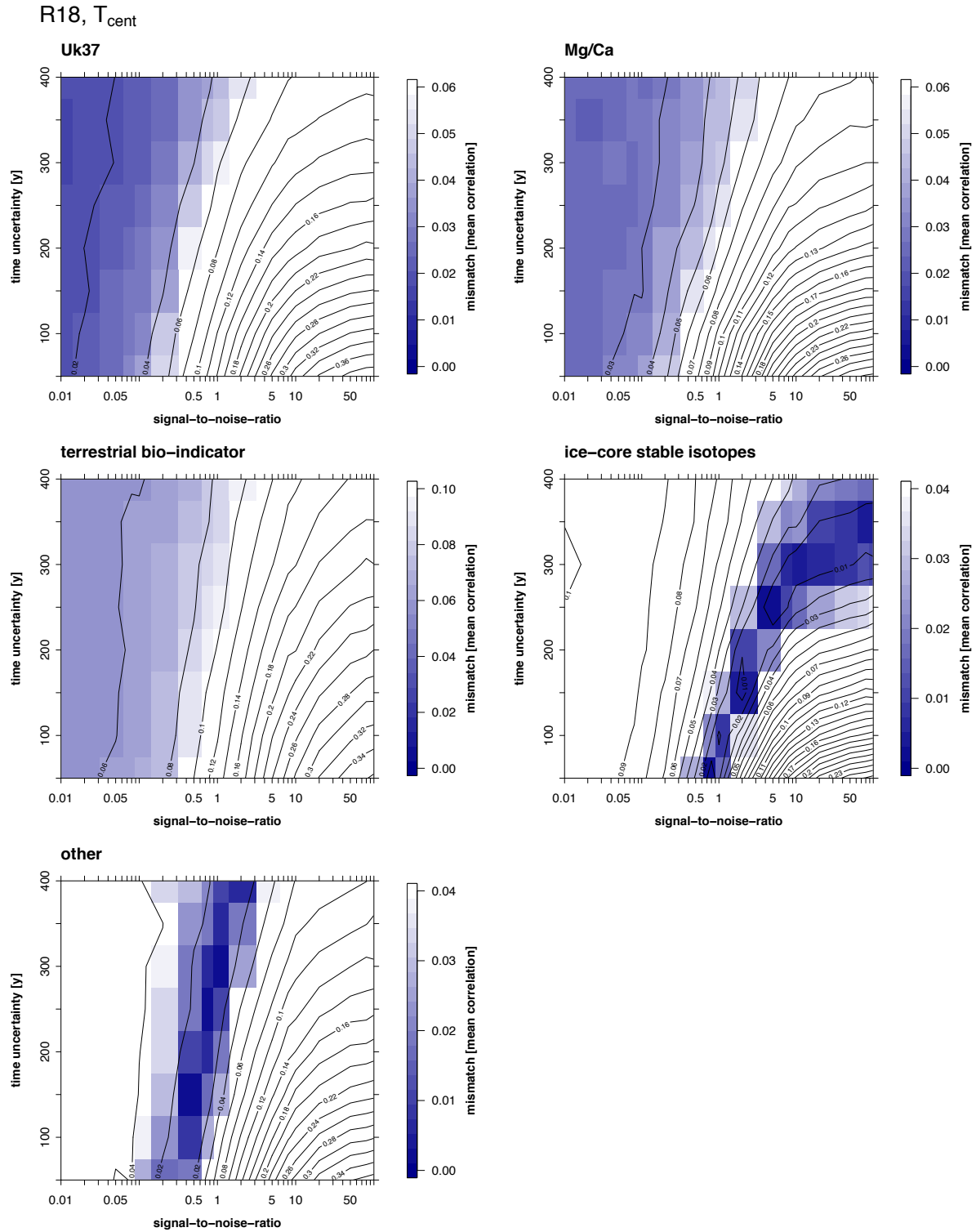
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**Figure S8: Proxy-type-specific SNR estimates of Holocene temperature proxy records as a function of time uncertainty based on the LH14 dataset and related to centennial  $T_{cent}$  and centennial to millennial time scales  $T_{mill}$ .** Panels show the mismatch between mean correlations of close-by (separation <5000 km) proxy records and model time series extracted from the model MPI6k (ECHAM5/MPI-OM) at proxy locations as a function of time uncertainty (vertical axis) and SNR (horizontal axis). Contour lines with numbers illustrate areas with the same mismatch. Coloured areas show the lowest mismatch and mark suitable combinations of SNR estimates and time uncertainties. On  $T_{cent}$ , Uk37-based estimates are low and Mg/Ca-based ones are high.  $T_{mill}$  related SNR estimates for Mg/Ca are not possible as the mean correlations of the proxy time series are higher than the mean correlations of the model time series.

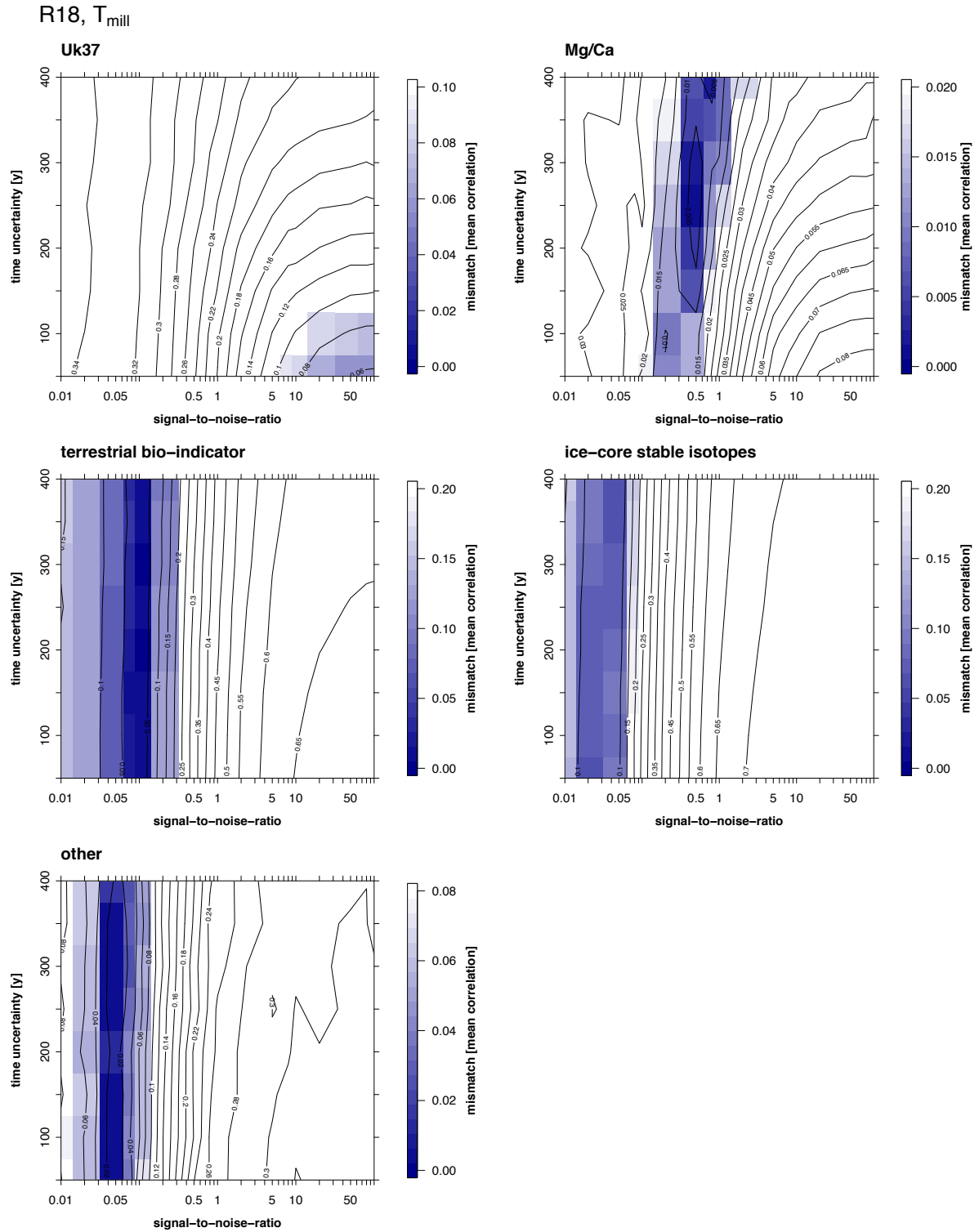
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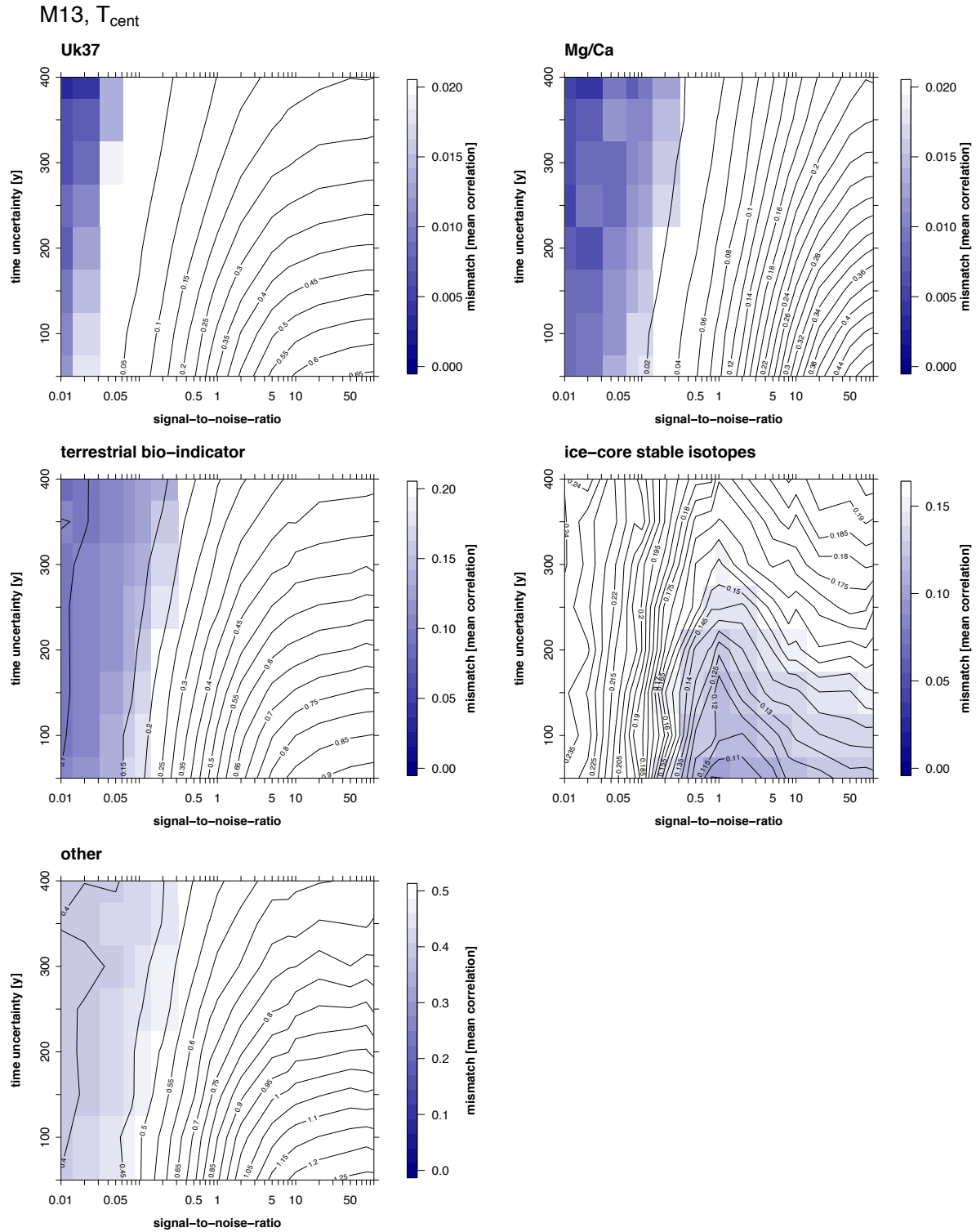
**Figure S9: Proxy-type-specific  $SNR_{MPI6k, T_{cent}}$  estimates of Holocene temperature proxy records as a function of time uncertainty based on the R18 dataset and related to centennial time scales  $T_{cent}$ .** Each panel illustrates the mismatch between mean correlations of close-by (separation <5000 km) proxy records and model time series extracted at proxy locations from model MPI6k (ECHAM5/MPI-OM) as a function of time uncertainty (vertical axis) and SNR (horizontal axis). Contour lines with numbers mark parts with the same mismatch. Coloured areas highlight suitable combinations of SNR estimates and time uncertainties (lowest mismatch). Except for ice-core stable isotopes, all proxy types have estimated  $SNR_{MPI6k, T_{cent}} < 1$ .

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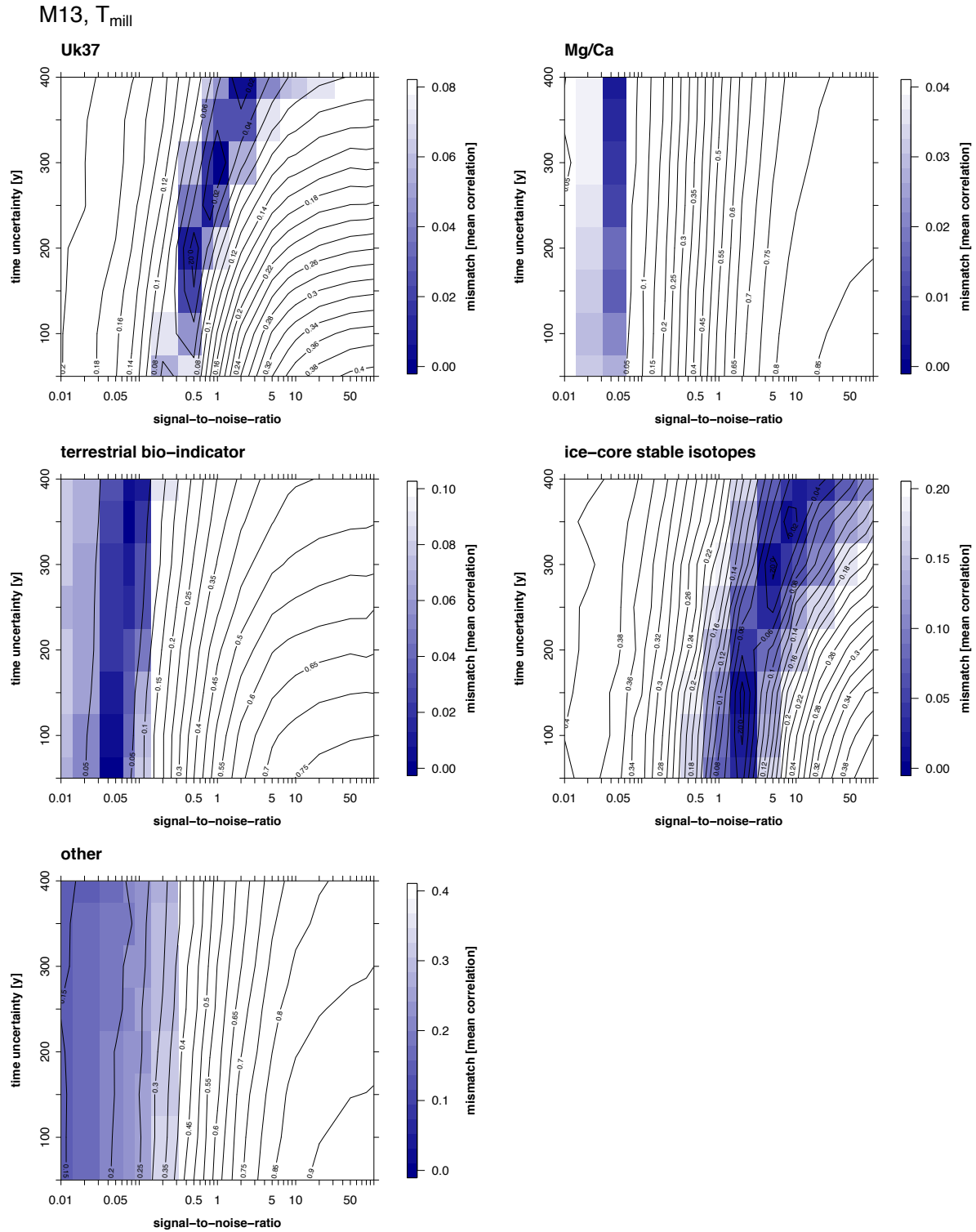
**Figure S10: Proxy-type-specific  $SNR_{MPI6k, T_{mill}}$  estimates of Holocene temperature proxy records as a function of time uncertainty based on the R18 dataset and related to centennial to millennial time scales  $T_{mill}$ .** The panels show the mismatch between mean correlations of close-by (separation  $<5000$  km) proxy records and model time series extracted at proxy locations from model MPI6k (ECHAM5/MPI-OM) as a function of time uncertainty (vertical axis) and SNR (horizontal axis). Contour lines mark parts with the same mismatch (numbers) and coloured areas (lowest mismatch) highlight suitable combinations of SNR estimates and time uncertainties. Most proxy-type-specific estimates indicate low SNRs. Very high SNR estimates are related to Uk37.

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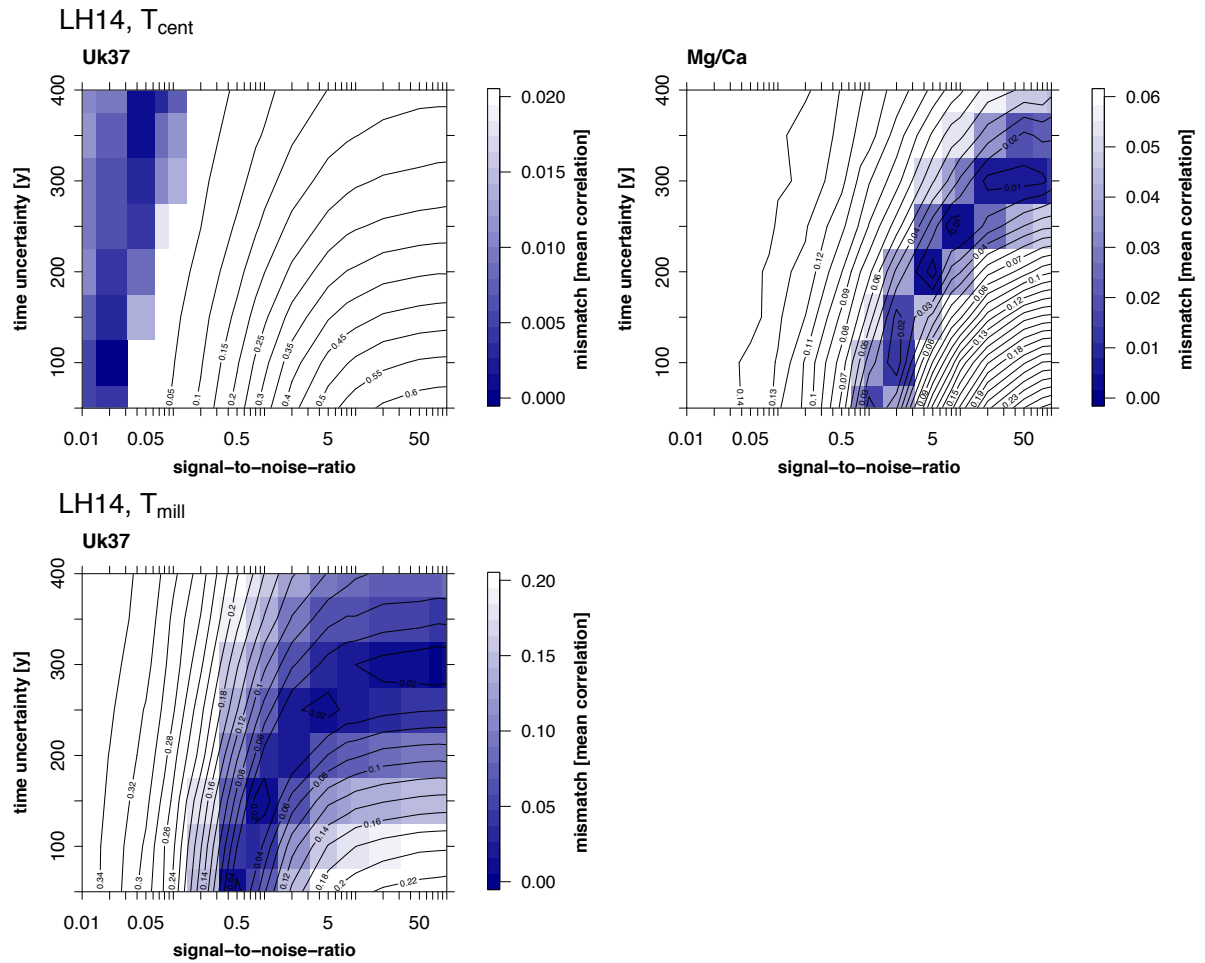
**Figure S11: Proxy-type-specific  $\text{SNR}_{T_{21k}, T_{\text{cent}}}$  estimates of Holocene temperature proxy records as a function of time uncertainty based on the M13 dataset and related to centennial time scales  $T_{\text{cent}}$ .** Each panel shows the mismatch between mean correlations of close-by (separation  $<5000$  km) proxy records and model time series extracted at proxy locations from model T21k (TraCE-21ka model simulation) as a function of time uncertainty (vertical axis) and SNR (horizontal axis). Contour lines with numbers illustrate areas with the same mismatch. Coloured parts of the panels mark suitable combinations of SNR estimates and time uncertainties (lowest mismatch). Most proxy types are characterised by very low  $\text{SNR}_{T_{21k}, T_{\text{cent}}}$  estimates. Ice-core stable isotopes show high SNRs combined with lower time uncertainties.

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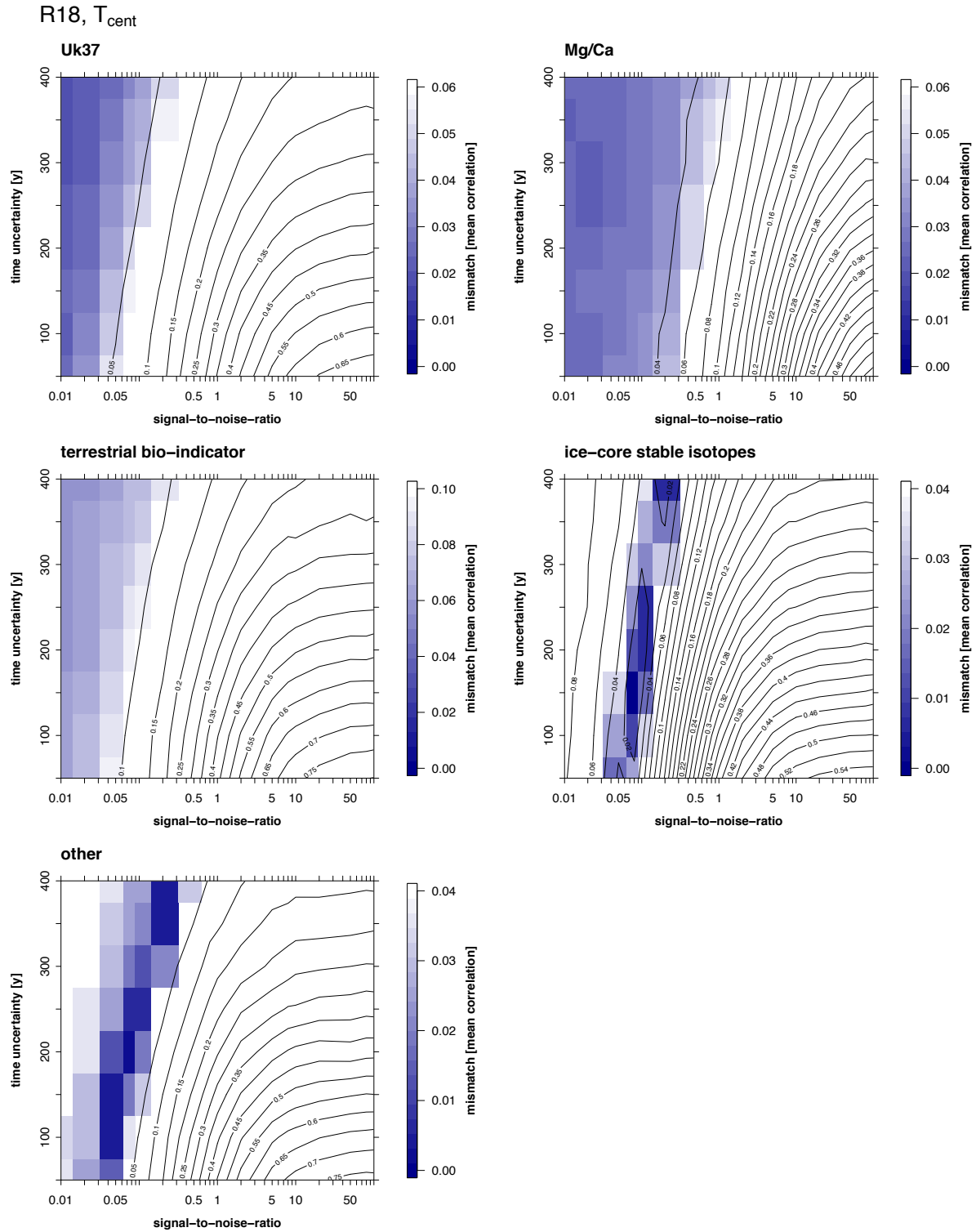
**Figure S12: Proxy-type-specific  $\text{SNR}_{T_{21k}, T_{\text{mill}}}$  estimates of Holocene temperature proxy records as a function of time uncertainty based on the M13 dataset and related to centennial to millennial time scales  $T_{\text{mill}}$ .** The panels illustrate the mismatch between mean correlations of close-by (separation  $< 5000$  km) proxy records and model time series extracted at proxy locations from model T21k (TraCE-21ka model simulation) as a function of time uncertainty (vertical axis) and SNR (horizontal axis). Contour lines show parts with the same mismatch (numbers) and coloured areas (lowest mismatch) highlight suitable combinations of SNR estimates and time uncertainties. All proxy-type-specific estimates indicate higher SNRs compared to  $T_{\text{cent}}$ . Except for Uk37 and ice-core stable isotopes, the estimated SNRs show a low dependence on time uncertainty.

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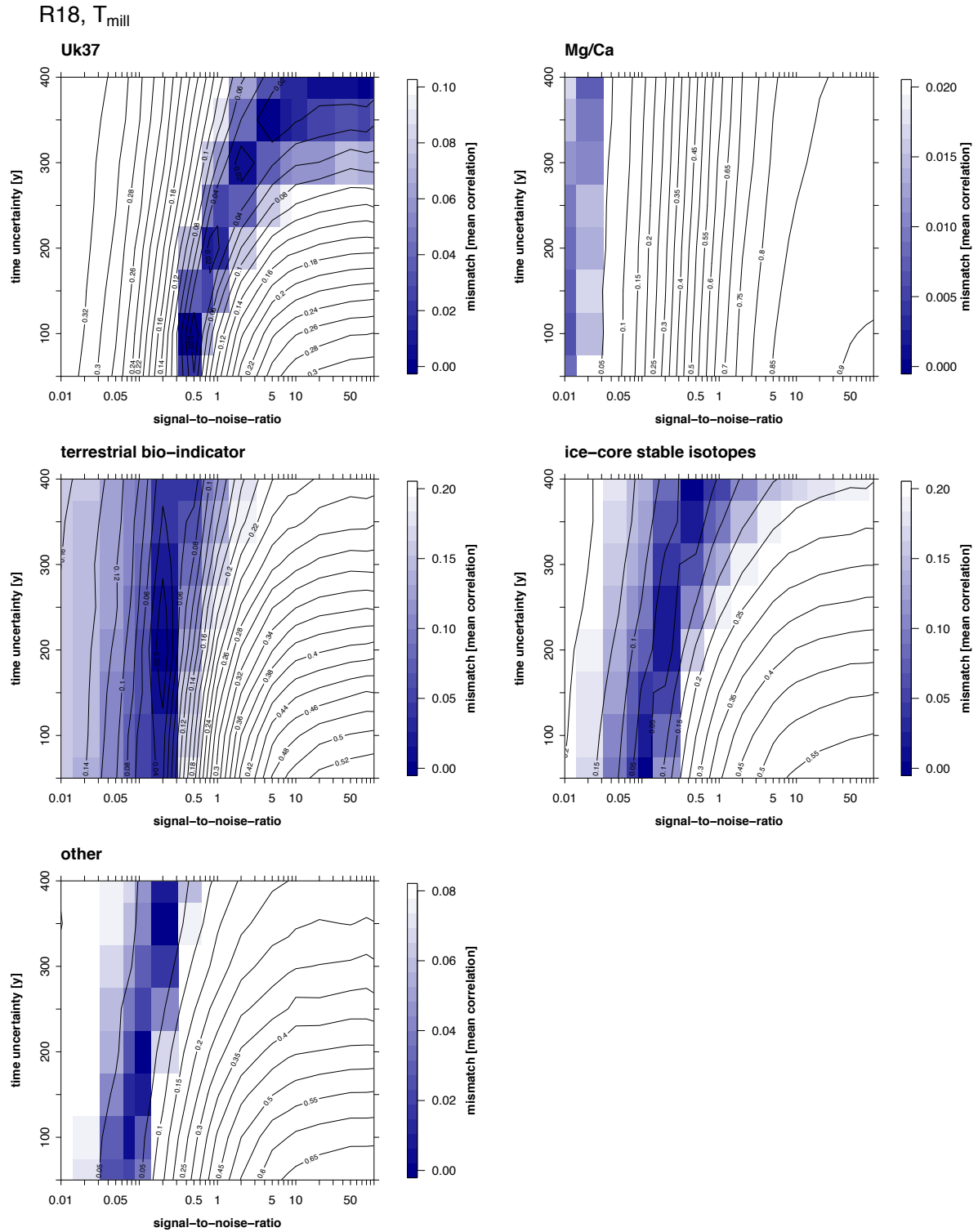
**Figure S13: Proxy-type-specific SNR estimates of Holocene temperature proxy records as a function of time uncertainty based on the LH14 dataset and related to centennial  $T_{cent}$  and centennial to millennial time scales  $T_{mill}$ .** Each panel shows the mismatch between mean correlations of close-by (separation <5000 km) proxy records and model time series extracted from model T21k (TraCE-21ka model simulation) at proxy locations as a function of time uncertainty (vertical axis) and SNR (horizontal axis). Contour lines with numbers illustrate areas with the same mismatch. Coloured areas show the lowest mismatch and mark suitable combinations of SNR estimates and time uncertainties. On  $T_{cent}$ , Uk37-based estimates are low and Mg/Ca-based ones are high.  $T_{mill}$  related SNR estimates for Mg/Ca are not possible as the mean correlations of the proxy time series are higher than the mean correlations of the model time series.

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**Figure S14: Proxy-type-specific  $SNR_{T_{21k}, T_{cent}}$  estimates of Holocene temperature proxy records as a function of time uncertainty based on the R18 dataset and related to centennial time scales  $T_{cent}$ .** The panels illustrate the mismatch between mean correlations of close-by (separation  $<5000$  km) proxy records and model time series extracted at proxy locations from model T21k (TraCE-21ka model simulation) as a function of time uncertainty (vertical axis) and SNR (horizontal axis). Contour lines with numbers mark parts with the same mismatch. Coloured areas highlight suitable combinations of SNR estimates and time uncertainties (lowest mismatch). All proxy types show (very) low  $SNR_{T_{21k}, T_{cent}}$  estimates.

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**Figure S15: Proxy-type-specific  $\text{SNR}_{T_{21k}, T_{\text{mill}}}$  estimates of Holocene temperature proxy records as a function of time uncertainty based on the R18 dataset and related to centennial to millennial time scales  $T_{\text{mill}}$ .** Each panel shows the mismatch between mean correlations of close-by (separation  $< 5000$  km) proxy records and model time series extracted at proxy locations from model T21k (TraCE-21ka model simulation) as a function of time uncertainty (vertical axis) and SNRs (horizontal axis). Contour lines mark parts with the same mismatch (numbers) and coloured areas (lowest mismatch) highlight suitable combinations of SNR estimates and time uncertainties. Most proxy-type-specific estimates show  $\text{SNR}_{T_{21k}, T_{\text{mill}}} < 0.5$ .

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## Supplementary Tables

**Table S1: List of records belonging to dataset M13.** The compilation is based on Marcott et al. (2013).

Name	Lat [°N]	Lon [°E]	Archive	Proxy type	Reference
17940	20.1	117.4	marine sediment	Uk37	Pelejero et al., 1999
18287-3	5.7	110.7	marine sediment	Uk37	Kienast et al., 2001
74KL	14.3	57.3	marine sediment	Uk37	Huguet et al., 2006
AD91-17	40.9	18.6	marine sediment	Uk37	Giunta et al., 2001
CH07-98-GGC19	36.9	-74.6	marine sediment	Uk37	Sachs, 2007
Composite: MD01-2421; KR02-06 St. A GC; KR02-06 St. A MC	36.0	141.8	marine sediment	Uk37	Isono et al., 2009
D13882	38.6	-9.5	marine sediment	Uk37	Rodrigues et al., 2009
GeoB 1023-5	-17.2	11.0	marine sediment	Uk37	Kim et al., 2002
GeoB 3313-1	-41.0	-74.5	marine sediment	Uk37	Lamy et al., 2002
GeoB 5844-2	27.7	34.7	marine sediment	Uk37	Arz et al., 2003
GeoB 5901-2	36.4	-7.1	marine sediment	Uk37	Kim et al., 2004
GeoB 6518-1	-5.6	11.2	marine sediment	Uk37	Schefuß et al., 2005
IOW 225514	57.8	8.7	marine sediment	Uk37	Emeis et al., 2003
IOW 225517	57.7	7.1	marine sediment	Uk37	Emeis et al., 2003
JR51-GC35	67.0	-18.0	marine sediment	Uk37	Bendle and Rosell-Melé, 2007
M25/4-KL11	36.7	17.7	marine sediment	Uk37	Emeis et al., 2003
M35003-4	12.1	-61.3	marine sediment	Uk37	Rühlemann et al., 1999
MD02-2529	8.2	-84.1	marine sediment	Uk37	Leduc et al., 2007
MD952011	67.0	7.6	marine sediment	Uk37	Calvo et al., 2002
MD952015	58.8	-26.0	marine sediment	Uk37	Marchal et al., 2002
MD 95-2043	36.1	-2.6	marine sediment	Uk37	Cacho et al., 2001
MD97-2120	-45.5	174.9	marine sediment	Uk37	Pahnke and Sachs, 2006
MD97-2121	-40.4	178.0	marine sediment	Uk37	Pahnke and Sachs, 2006
NIOP905	10.8	51.9	marine sediment	Uk37	Huguet et al., 2006
OCE326-GGC26	43.5	-54.9	marine sediment	Uk37	Sachs, 2007
OCE326-GGC30	43.9	-62.8	marine sediment	Uk37	Sachs, 2007
ODP Site 1019D	41.7	-124.9	marine sediment	Uk37	Barron et al., 2003
SO136-GC11	-43.4	167.9	marine sediment	Uk37	Barrows et al., 2007
A7	27.8	127.0	marine sediment	Mg/Ca	Sun et al., 2005
BJ8-03-13GGC	-7.4	115.2	marine sediment	Mg/Ca	Linsley et al., 2010
BJ8-03-70GGC	-3.6	119.4	marine sediment	Mg/Ca	Linsley et al., 2010
GeoB 10038-4	-5.9	103.3	marine sediment	Mg/Ca	Mohtadi et al., 2010
GeoB 3129	-4.6	-36.6	marine sediment	Mg/Ca	Weldeab et al., 2006
GeoB4905-4	2.5	9.4	marine sediment	Mg/Ca	Weldeab et al., 2005
KY07-04-01	31.6	128.9	marine sediment	Mg/Ca	Kubota et al., 2010
MD01-2378	-13.1	121.8	marine sediment	Mg/Ca	Xu et al., 2008
MD01-2390	6.6	113.4	marine sediment	Mg/Ca	Steinke et al., 2008
MD02-2575	29.0	-87.1	marine sediment	Mg/Ca	Ziegler et al., 2008
MD03-2707	2.5	9.4	marine sediment	Mg/Ca	Weldeab et al., 2007
MD98-2165	-9.6	118.3	marine sediment	Mg/Ca	Levi et al., 2007
MD98-2176	-5.0	133.4	marine sediment	Mg/Ca	Stott et al., 2007
MD98-2181	6.3	125.8	marine sediment	Mg/Ca	Stott et al., 2007
ME0005A-43JC	7.9	-83.6	marine sediment	Mg/Ca	Benway et al., 2006
ODP1084B	-25.5	13.0	marine sediment	Mg/Ca	Farmer et al., 2005
ODP 984	61.4	-24.1	marine sediment	Mg/Ca	Came et al., 2007
PL07-39PC	10.7	-64.9	marine sediment	Mg/Ca	Lea et al., 2003
RAPID-12-1K	62.1	-17.8	marine sediment	Mg/Ca	Thornalley et al., 2009



**Table S1:** (continued)

<b>Name</b>	<b>Lat [°N]</b>	<b>Lon [°E]</b>	<b>Archive</b>	<b>Proxy type</b>	<b>Reference</b>
74KL	14.3	57.3	marine sediment	TEX <sub>86</sub>	Huguet et al., 2006
GeoB 7702-3	31.7	34.1	marine sediment	TEX <sub>86</sub>	Castañeda et al., 2010
NIOP905	10.8	51.9	marine sediment	TEX <sub>86</sub>	Huguet et al., 2006
NP04-KH04-3A-1K, -4A-1K	-6.7	29.8	lacustrine sediment	TEX <sub>86</sub>	Tierney et al., 2008
Flarken Lake	58.6	13.7	lacustrine sediment	Pollen MAT	Seppä et al. 2005
Hanging Lake	68.4	-138.4	lacustrine sediment	Chironomid transfer function	Kurek et al., 2009
Homestead Scarp	-52.5	169.1	lacustrine sediment	Pollen MAT	McGlone et al., 2010
Lake 850	68.3	19.1	lacustrine sediment	Chironomid transfer function	Larocque and Hall., 2004
Lake Njulla	68.4	18.7	lacustrine sediment	Chironomid transfer function	Larocque and Hall., 2004
Moose Lake	61.4	-143.6	lacustrine sediment	Chironomid transfer function	Clegg et al., 2010
Mount Honey	-52.6	169.1	lacustrine sediment	Pollen MAT	McGlone et al., 2010
Tsuolbmajavri Lake	68.7	22.1	lacustrine sediment	Pollen MAT	Seppä and Birks, 2001
Agassiz & Renland	80.7/ 71.3	-73.1 / -26.7	ice core	$\delta^{18}\text{O}$ , borehole temp.	Vinther et al., 2009
Dome F, Antarctica	-77.3	39.7	ice core	$\delta^{18}\text{O}$ , $\delta\text{D}$	Kawamura et al., 2007
EPICA Dome C, Antarctica	-75.1	123.4	ice core	$\delta\text{D}$	Jouzel et al., 2007
EPICA DML	-75.0	0.1	ice core	$\delta^{18}\text{O}$	Stenni et al., 2010
Vostok, Antarctica	-78.0	106.0	ice core	$\delta\text{D}$	Petit et al., 1999
Composite: MD95-2011; HM79-4	67.0; 63.1	7.6; 2.6	marine sediment	Radiolaria transfer function	Dolven et al., 2002
GeoB 6518-1	-5.6	11.2	marine sediment	MBT	Weijers et al., 2007
GIK23258-2	75.0	14.0	marine sediment	Foram transfer function	Sarnthein et al., 2003
MD79-257	-20.4	36.3	marine sediment	Foram MAT	Levi et al., 2007
ODP 658C	20.8	-18.6	marine sediment	Foram transfer function	deMenocal et al., 2000
TN05-17	-50.0	6.0	marine sediment	Diatom MAT	Nielsen et al., 2004

**Table S2: List of records belonging to dataset LH14.** The compilation is based on Laepple and Huybers (2014).

Name	Lat [°N]	Lon [°E]	Archive	Proxy type	Reference
CH07-98-GGC19	36.9	-74.6	marine sediment	Uk37	Sachs, 2007
D13882	38.6	-9.5	marine sediment	Uk37	Rodrigues et al., 2009
GeoB 3313-1	-41.0	-74.5	marine sediment	Uk37	Lamy et al., 2002
GeoB 5901-2	36.4	-7.1	marine sediment	Uk37	Kim et al., 2007
GeoB 6007-2	30.9	-10.3	marine sediment	Uk37	Kim et al., 2007
IOW 225514	57.8	8.7	marine sediment	Uk37	Emeis et al., 2003
IOW 225517	57.7	7.1	marine sediment	Uk37	Emeis et al., 2003
JR51-GC35	67.0	-18.0	marine sediment	Uk37	Bendle and Rosell-Melé, 2007
KR02-06	36.0	141.8	marine sediment	Uk37	Isono et al., 2009
MD01-2412	44.5	145.0	marine sediment	Uk37	Harada et al., 2006
MD952011	67.0	7.6	marine sediment	Uk37	Calvo et al., 2002
MD952015	58.8	-26.0	marine sediment	Uk37	Marchal et al., 2002
MD 95-2043	36.1	-2.6	marine sediment	Uk37	Cacho et al., 2001
MD972151	8.7	109.9	marine sediment	Uk37	Zhao et al., 2006
OCE326-GGC26	43.5	-54.9	marine sediment	Uk37	Sachs, 2007
OCE326-GGC30	43.9	-62.8	marine sediment	Uk37	Sachs, 2007
ODP 658C	20.8	-18.6	marine sediment	Uk37	Zhao et al., 1995; deMenocal et al., 2000
ODP Site 1019C	41.7	-124.9	marine sediment	Uk37	Barron et al., 2003
SO139-74KL	-6.5	103.8	marine sediment	Uk37	Lückge et al., 2009
SO90-39KG/56KA	24.8	65.9	marine sediment	Uk37	Doose-Rolinski et al., 2001
SSDP-102	35.0	128.9	marine sediment	Uk37	Kim et al., 2004
A7	27.8	127.0	marine sediment	Mg/Ca	Sun et al., 2005
MD01-2378	-13.1	121.8	marine sediment	Mg/Ca	Xu et al., 2008
MD03-2707	2.5	9.4	marine sediment	Mg/Ca	Weldeab et al., 2007
MD98-2176	-5.0	133.4	marine sediment	Mg/Ca	Stott et al., 2004
MD98-2181	6.3	125.8	marine sediment	Mg/Ca	Stott et al., 2004
MD99-2251	57.4	-27.9	marine sediment	Mg/Ca	Farmer et al., 2008
MD99-2203	35.0	-75.2	marine sediment	Mg/Ca	Cléroux et al., 2012
MV99-GC41/PC14	25.2	-112.7	marine sediment	Mg/Ca	Marchitto et al., 2010
ODP1084B	-25.5	13.0	marine sediment	Mg/Ca	Farmer et al., 2005
RAPID-12-1K	62.1	-17.8	marine sediment	Mg/Ca	Thornalley et al., 2009

**Table S3: List of records belonging to dataset R18.** The compilation is based on Rehfeld et al. (2018).

Name	Lat [°N]	Lon [°E]	Archive	Proxy type	Reference
CH07-98-GGC19	36.9	-74.6	marine sediment	Uk37	Sachs, 2007
D13882	38.6	-9.5	marine sediment	Uk37	Rodrigues et al., 2010
GeoB 3313-1	-41.0	-74.5	marine sediment	Uk37	Lamy et al., 2002
GeoB 5901-2	36.4	-7.1	marine sediment	Uk37	Kim et al., 2004
GIK17940-2	20.1	117.4	marine sediment	Uk37	Pelejero et al., 1999
IOW225514	57.8	8.7	marine sediment	Uk37	Emeis et al., 2003
IOW225517	57.7	7.1	marine sediment	Uk37	Emeis et al., 2003
Isono2009-Composite	36.0	141.8	marine sediment	Uk37	Isono et al., 2009
JR51-GC35	67.0	-18.0	marine sediment	Uk37	Bendle and Rosell-Mel�, 2007
KNR195-5/ CDH 23	-3.7	-81.1	marine sediment	Uk37	Bova et al., 2015
MD01-2412	44.5	145.0	marine sediment	Uk37	Harada et al., 2006
MD01-2444	37.6	-10.1	marine sediment	Uk37	Martrat et al., 2007
MD03-2699	39.0	-10.7	marine sediment	Uk37	Rodrigues et al., 2010
MD952011	67.0	7.6	marine sediment	Uk37	Calvo et al., 2002
MD952015	58.8	-26.0	marine sediment	Uk37	Marchal et al., 2002
MD 952043	36.1	-2.6	marine sediment	Uk37	Cacho et al., 1999
MD97-2120	-45.5	174.9	marine sediment	Uk37	Pahnke and Sachs, 2006
MD97-2121	-40.4	178.0	marine sediment	Uk37	Pahnke and Sachs, 2006
MD982195	31.6	128.9	marine sediment	Uk37	Ijiri et al., 2005
NIOP905	10.8	51.9	marine sediment	Uk37	Huguet et al., 2006
OCE326-GGC26	43.5	-54.9	marine sediment	Uk37	Sachs, 2007
OCE326-GGC30	43.9	-62.8	marine sediment	Uk37	Sachs, 2007
ODP 658C	20.8	-18.6	marine sediment	Uk37	Zhao et al., 1995
ODP Site 1019C	41.7	-124.9	marine sediment	Uk37	Barron et al., 2003
P178-15P-uk37	12.0	44.3	marine sediment	Uk37	Tierney et al., 2016
PC6	40.4	143.5	marine sediment	Uk37	Minoshima et al., 2007
SO139-74KL	-6.5	103.8	marine sediment	Uk37	L�ckge et al., 2009
A7	27.8	127.0	marine sediment	Mg/Ca	Sun et al., 2005
BJ8-03-13GGC	-7.4	115.2	marine sediment	Mg/Ca	Linsley et al., 2010
BJ8-03-70GGC	-3.6	119.4	marine sediment	Mg/Ca	Linsley et al., 2010
GeoB 3129	-4.6	-36.6	marine sediment	Mg/Ca	Weldeab et al., 2006
KY07-04-01	31.6	128.9	marine sediment	Mg/Ca	Kubota et al., 2010
MD01-2378	-13.1	121.8	marine sediment	Mg/Ca	Xu et al., 2008
MD01-2390	6.6	113.4	marine sediment	Mg/Ca	Steinke et al., 2008
MD03-2707	2.5	9.4	marine sediment	Mg/Ca	Weldeab et al., 2007
MD98-2165	-9.6	118.3	marine sediment	Mg/Ca	Levi et al., 2007
MD98-2176	-5.0	133.4	marine sediment	Mg/Ca	Stott et al., 2007
MD98-2181	6.3	125.8	marine sediment	Mg/Ca	Stott et al., 2002
ODP1084B	-25.5	13.0	marine sediment	Mg/Ca	Farmer et al., 2005
ODP 1240	0.0	-86.5	marine sediment	Mg/Ca	Pena et al., 2008
ODP 984	61.4	-24.1	marine sediment	Mg/Ca	Came et al., 2007
P178-15P-mgca	12.0	44.3	marine sediment	Mg/Ca	Tierney et al., 2016
PL07-39PC	10.7	-64.9	marine sediment	Mg/Ca	Lea et al., 2003
RAPID-12-1K	62.1	-17.8	marine sediment	Mg/Ca	Thornalley et al., 2009
SK237-GC04	11.0	75.0	marine sediment	Mg/Ca	Saraswat et al., 2013
SO189-39KL	-0.8	99.9	marine sediment	Mg/Ca	Mohtadi et al., 2014

**Table S3:** (continued)

Name	Lat [°N]	Lon [°E]	Archive	Proxy type	Reference
GeoB 7702-3	31.7	34.1	marine sediment	TEX <sub>86</sub>	Castañeda et al., 2010
Lake Tanganyika	-6.7	29.8	lacustrine sediment	TEX <sub>86</sub>	Tierney et al., 2008
NIOP905	10.8	51.9	marine sediment	TEX <sub>86</sub>	Huguet et al., 2006
P178-15P-tex86	12.0	44.3	marine sediment	TEX <sub>86</sub>	Tierney et al., 2016
Dyer	66.6	-61.4	lacustrine sediment	Pollen Assemblage	Gajewski, 2015
Flarken Lake	58.6	13.7	lacustrine sediment	Pollen Assemblage	Seppä et al., 2005
Hanging Lake	68.4	-138.4	lacustrine sediment	Chironomid Assemblage	Kurek et al., 2009
JR01	69.9	-95.1	lacustrine sediment	Pollen Assemblage	Gajewski, 2015
KR02	71.3	-113.8	lacustrine sediment	Pollen Assemblage	Gajewski, 2015
Lake31	67.1	-50.5	lacustrine sediment	Pollen Assemblage	Gajewski, 2015
Lake 850	68.3	19.1	lacustrine sediment	Chironomid Assemblage	Larocque and Bigler, 2004
Lake Njulla	68.4	18.7	lacustrine sediment	Chironomid Assemblage	Bigler et al., 2003
Moose Lake	61.4	-143.6	lacustrine sediment	Chironomid Assemblage	Clegg et al., 2010
ODP 976-4	36.2	-4.3	marine sediment	Pollen Assemblage	Combourieu-Nebout et al., 2009
Tsuolbmajavri Lake	68.7	22.1	lacustrine sediment	Pollen Assemblage	Seppä and Birks, 2001
Agassiz 84/87	80.7	-73.1	ice core	$\delta^{18}\text{O}$	Koerner and Fisher, 1990; Vinther et al., 2009
Byrd	-80.0	-119.5	ice core	$\delta^{18}\text{O}$	Epstein et al., 1970; WAIS Divide Project Members, 2013
Camp Century	77.2	-61.1	ice core	$\delta^{18}\text{O}$	Dansgaard et al., 1969; Vinther et al., 2009
Dome C	-74.7	124.2	ice core	$\delta^{18}\text{O}$	Lorius et al., 1979
Dome F	-77.3	39.7	ice core	$\delta^{18}\text{O}$	Watanabe et al., 1999, 2003; Uemura et al., 2012
DYE 3	65.2	-43.8	ice core	$\delta^{18}\text{O}$	Dansgaard et al., 1982; Vinther et al., 2009
EPICA DML	-75.0	0.0	ice core	$\delta^{18}\text{O}$	EPICA Community Members, 2006; Veres et al., 2013
EPICA Dome C	-75.1	123.4	ice core	$\delta^2\text{H}$	EPICA Community Members, 2004; Jouzel et al., 2007; Veres et al., 2013
GISP2	72.6	-38.5	ice core	$\delta^{18}\text{O}$	Grootes et al., 1993; Grootes and Stuiver, 1997; Stuiver and Grootes, 2000; Seierstad et al., 2014
GRIP	72.6	-37.6	ice core	$\delta^{18}\text{O}$	Johnsen et al., 1992, 1997; Seierstad et al., 2014
Huascaran	-9.1	-77.6	ice core	$\delta^{18}\text{O}$	Thompson et al., 1995

**Table S3:** (continued)

<b>Name</b>	<b>Lat [°N]</b>	<b>Lon [°E]</b>	<b>Archive</b>	<b>Proxy type</b>	<b>Reference</b>
NGRIP	75.1	-42.3	ice core	$\delta^{18}\text{O}$	NGRIP Members, 2004; Veres et al., 2013
Penny Ice Cap	67.3	-65.8	ice core	$\delta^{18}\text{O}$	Fisher et al., 1998
Siple Dome	-81.7	-148.8	ice core	$\delta^{18}\text{O}$	Taylor et al., 2004; WAIS Divide Project Members, 2013
Talos Dome	-72.8	159.1	ice core	$\delta^{18}\text{O}$	Stenni et al., 2011; Veres et al., 2013
Taylor Dome	-77.8	158.7	ice core	$\delta^{18}\text{O}$	Steig et al., 2000
Vostok	-78.0	106.0	ice core	$\delta^2\text{H}$	Petit et al., 1999; Veres et al., 2013
WAIS Divide	-79.5	-112.1	ice core	$\delta^{18}\text{O}$	WAIS Divide Project Members, 2013
GeoB 6518-1	-5.6	11.2	marine sediment	MBT/CBT	Weijers et al., 2007
GreatBasin	38.0	-116.5	tree	ring width	Salzer et al., 2014
Kangerlussuaq-Stack	67.0	-50.7	lacustrine sediment	Uk37	D'Andrea et al., 2011
MD95-2011	67.0	7.6	marine sediment	Foraminiferal Assemblage	Risebrobakken et al., 2003
MD95-2011	67.0	7.6	marine sediment	Radiolarian Assemblage	Dolven et al., 2002
MD99-2275	66.6	-17.7	marine sediment	Diatom Assemblage	Jiang et al., 2015
NA 87-22	55.5	-14.7	marine sediment	Foraminiferal Assemblage	Waelbroeck et al., 2001
ODP 658C	20.8	-18.6	marine sediment	Foraminiferal Assemblage	deMenocal et al., 2000
Qinghai	36.8	100.1	lacustrine sediment	Uk37	Hou et al., 2016

**Table S4: Number of record pairs for different proxy types used for the SNR estimation (pairs of time series with separation distances <5000 km).** The number of records pairs is given in total (independent of proxy type) and separated per proxy type for each proxy compilation.  $T_{mill}$  refers to the number of pairs of time series with a mean inter-observation time step of  $\Delta t < 500y$  and  $T_{cent}$  counts pairs of time series with  $\Delta t < 200y$ .

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	<b>All proxy types</b>	<b>Uk37</b>	<b>Mg/Ca</b>	<b>TEX<sub>86</sub></b>	<b>Terrestrial bio-indicator</b>	<b>Ice-core stable isotopes</b>	<b>other</b>
M13 – $T_{mill}$	497	99	52	6	11	6	5
M13 – $T_{cent}$	312	59	37	-	11	3	1
LH14 – $T_{mill}$	141	75	11	-	-	-	-
LH14 – $T_{cent}$	141	75	11	-	-	-	-
R18 – $T_{mill}$	939	96	53	6	45	66	12
R18 – $T_{cent}$	862	95	51	1	39	66	11

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