

Supplement of Clim. Past, 14, 1669–1686, 2018
<https://doi.org/10.5194/cp-14-1669-2018-supplement>
© Author(s) 2018. This work is distributed under
the Creative Commons Attribution 4.0 License.



Supplement of

Neoglacial climate anomalies and the Harappan metamorphosis

Liviu Giosan et al.

Correspondence to: Liviu Giosan (lgiosan@whoi.edu)

The copyright of individual parts of the supplement might differ from the CC BY 4.0 License.

Supplementary Materials

1. Modern Climatology

Important limitations to modern climatological observations include their sparseness and short collection periods, which precludes investigations of multidecadal climate variability or longer (Abram et al. 2016). Even determining the stationarity and significance of interannual-to-decadal patterns of climate variability using instrumental records can be challenging. Nevertheless, the use of modern datasets allows us to look at climatic patterns at synoptic scales and establish their physical consistency for paleoclimate interpretation. Thus, in addition to exploring Holocene paleoclimate reconstructions from the eastern Northern Hemisphere and Tropics (see main text) we explored field correlations on interannual timescales (Thirumalai et al. 2018) to assess modern relationships between sea-surface temperatures in the Arabian Sea and winter monsoon rainfall over the region of interest, the upper Ghaggar-Hakra interfluvium.

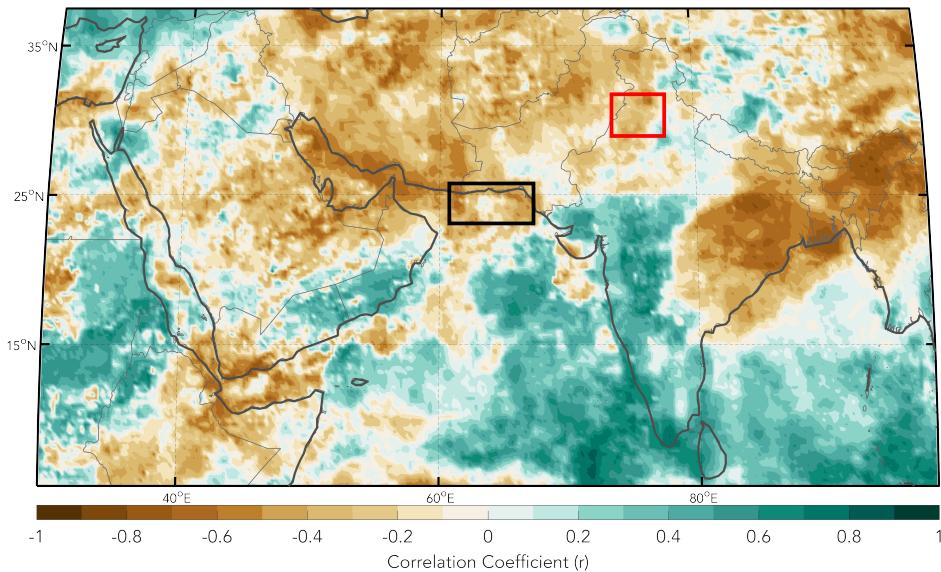


Fig. S1. Correlation map between modern DJF rainfall over the entire map domain and DJF SSTs in the northernmost coastal Arabian Sea (denoted by the black box). Data comes from the HadISST dataset (Rayner et al., 2003) for SST and TRMM for rainfall (Huffman et al. 2007). Red box encompasses the upper Ghaggar-Hakra interfluvium.

The TRMM dataset for rainfall (Huffman et al. 2007) and the HadISST dataset for SSTs (Rayner et al. 2003) were used over the 1998 to 2014 time domain. Wintertime SST averages (i.e., December, January, and February composites; hereafter DJF) and rainfall data were considered. The wintertime spatial pattern correlation between coastal SSTs in the northern Arabian Sea (i.e., red box along the Makran Coast) and regional rainfall amounts during DJF is shown in Supplementary Figure 1. Green colors indicate positive

correlations, i.e., more (or less) rainfall with warmer (cooler) SSTs whereas brown colors indicate areas of anticorrelation where higher rainfall occurs with cooler SSTs in the northern Arabian Sea.

This exercise indicates that a large zonal swath from the eastern Mediterranean to the western Himalayas is *negatively* correlated with wintertime coastal Arabian Sea SSTs. Although the short-term length of the rainfall dataset inhibits us from interpreting the magnitude of these correlations at face value and assessing significance (moreover, causation), the consistent and large spatial patterns of anticorrelation give us additional confidence in establishing a link between Arabian Sea SSTs and wintertime rainfall.

2. Age Model

The chronology for the Holocene section of the core was previously reported in Orsi et al. (2017) and is based on calibrated radiocarbon dates of five multi-specimen samples of planktic foram *Orbulina universa* and one mixed planktic foraminifer sample. The calibrated radiocarbon dates were used to derive a simple age model - a third order polynomial (Supplementary Figure 2) - that was used to interpolate ages (in years BP) for each sample depth (in cm):

$$\text{Age} = 0.0013*(\text{depth})^3 - 0.3631*(\text{depth})^2 + 56.906*(\text{depth}) + 164.08 \quad r^2 = 0.99999$$

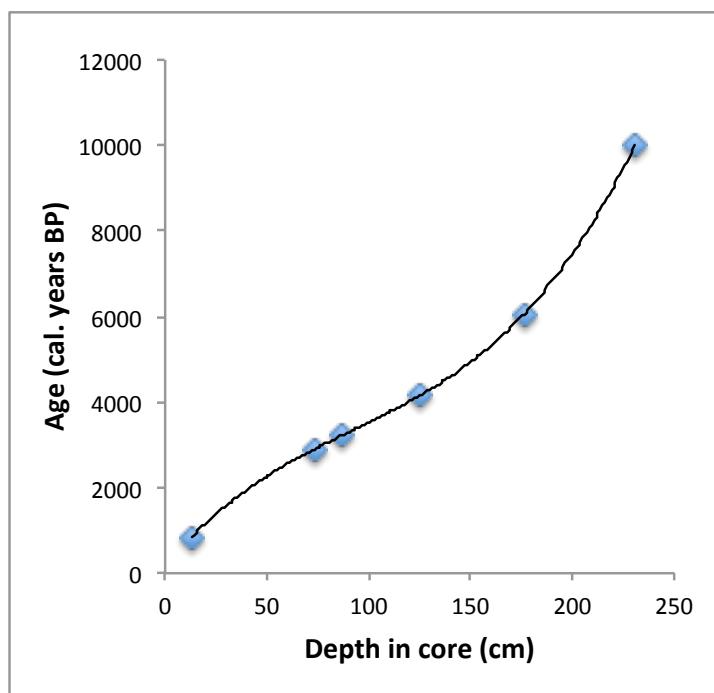


Fig. S2. Calibration curve for the Holocene sediments in core Indus 11C.

3. Archaeological Site Distributions in the Indus Domain

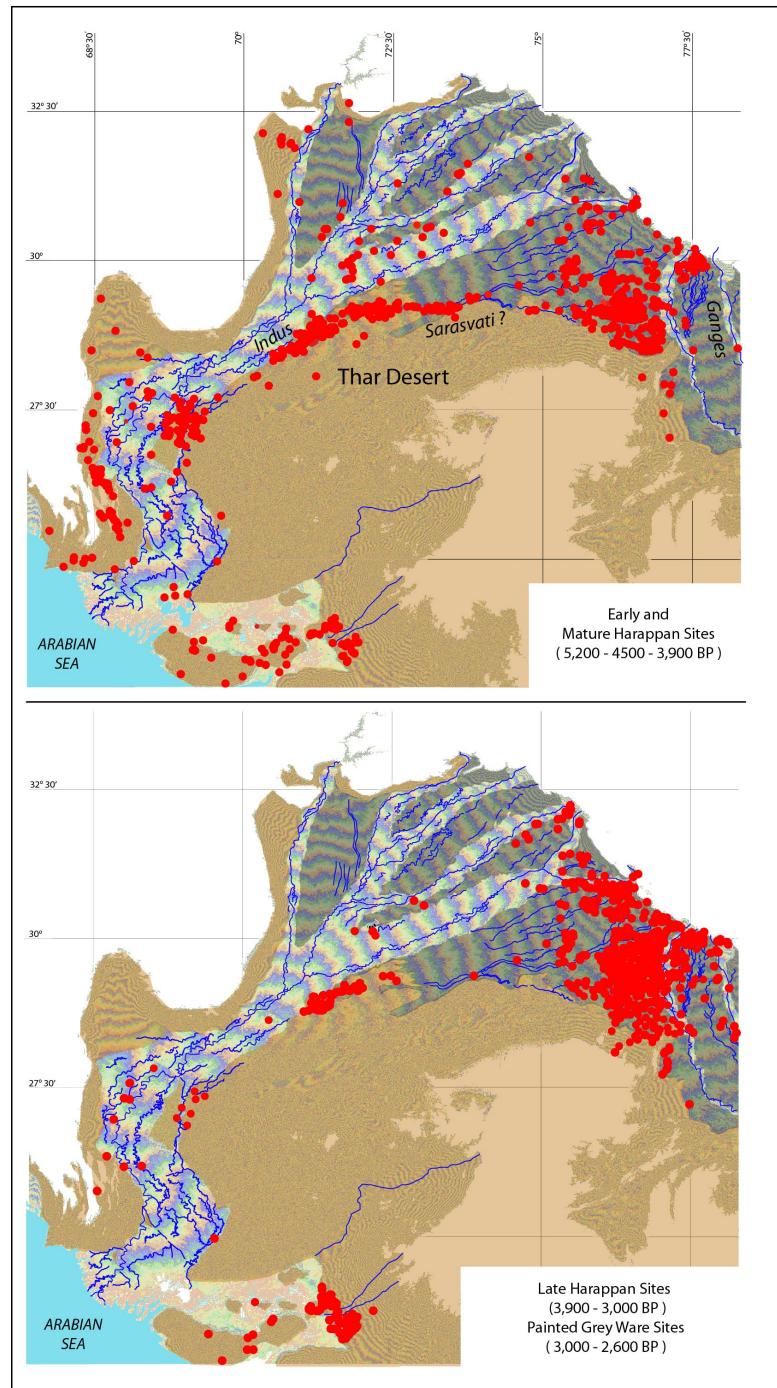


Fig. S3. Archaeological sites in the Indus domain for the Early and Mature Harappan periods (upper panel) and Late Harappan and Painted Gray Ware periods. The morphology of the region is highlighted by the color scheme: for altitudes, pattern of colors repeats every 10 m to 300 m in height; interfluves in gray mask and incised valleys with no mask); active and fossilized river channels are in blue.

Table S1. Depth distribution of paleo-DNA taxa (in %) from core Indus 11C that used for factor analysis.

Table S2. Relative abundances for chlorophyll biosynthesis proteins.

Depth (cm)	Age (years BP)	Chlorophyll biosynthesis proteins (%)
5.0	439.7	
10.0	698.1	0.000171910
32.0	1655.9	0.000431344
48.0	2202.8	
59.0	2524.6	
71.0	2839.3	
82.0	3105.7	0.000160414
88.0	3245.9	
96.4	3440.1	0.001164460
107.4	3698.0	0.005422218
118.4	3969.3	0.006170394
127.4	4208.7	0.007838955
138.4	4531.1	0.008094630
159.4	5274.2	0.006121696
175.4	5989.6	
191.4	6869.4	0.000222347
208.6	8034.9	
224.6	9357.5	
237.6	10624.0	

Table S3. Paleo-DNA factor analysis scores.

Paleo-DNA Taxa	Factor 1 Scores Variability Explained 20%	Factor 2 Scores Variability Explained 20%	Factor 3 Scores Variability Explained 20%
Eukaryota;Rhizaria;Polycystinea;Spumellaria;Sphaerozoidea;Raphidizozoum	0.3384	0.0691	0.0833
Eukaryota;Alveolata;Dinophyceae;environmental samples;uncultured dinoflagellate;Other	0.2046	0.2135	0.0345
Eukaryota;Alveolata;environmental samples;Uncultured marine alveolate Group I DH148-EKD22;Other;Other	0.0329	0.4261	0.04
Eukaryota;Rhizaria;environmental samples;uncultured rhizarian;Other;Other	0.0574	0.0842	0.2231
Eukaryota;Alveolata;environmental samples;uncultured marine alveolate;Other;Other	0.2011	0.1404	0.0684
Eukaryota;Rhizaria;Polycystinea;Nassellaria;Theoperidae;Pterocanum	0.2383	0.0921	0.008
Eukaryota;Rhizaria;Polycystinea;Spumellaria;Spongodiscidae;Euchitonina	0.1272	0.0637	0.1196
Eukaryota;Metazoa;Cnidaria;Anthozoa;Hexacoralla;Actiniaria	0.1099	0.1859	0.1265
Eukaryota;Fungi;Dikarya;Ascomycota;Pezizomycotina;Dothideomycetes	0.1063	0.2026	0.0636
Eukaryota;stramenopiles;environmental samples;uncultured stramenopile;Other;Other	0.19	0.0331	0.0279
Eukaryota;Alveolata;Ciliophora;Intramacronucleata;Colpoda;Cytolophosida	0.0329	0.0208	0.1603
Eukaryota;Alveolata;Dinophyceae;Blastodiniales;Blastodinium;Blastodinium nivalicula	0.0102	0.1391	0.0973
Eukaryota;Rhizaria;Cercozoa;Thecofilosea;Cryomonadida;Cryothecomonas	0.1115	0.2215	0.0585
Eukaryota;Viridiplantae;Chlorophyta;Prasinophyceae;environmental samples;uncultured Prasinophyceae	0.0158	0.0728	0.123
Eukaryota;Alveolata;Ciliophora;Intramacronucleata;Colpoda;Colpoda	0.0336	0.0294	0.2005
Eukaryota;Fungi;Dikarya;Ascomycota;mitosporic Ascomycota;Phoma	0.0443	0.1333	0.018
Eukaryota;Fungi;Dikarya;Basidiomycota;Ustilaginomycotina;Exobasidiomycetes	0.0206	0.0389	0.047
Eukaryota;Alveolata;Dinophyceae;Syndiniales;Amoeboophyceae;Amoeboophyra	0.0528	0.1292	0.0544
Eukaryota;Alveolata;Dinophyceae;Syndiniales;Syndiniaeae;Hematodinium	0.1538	0.1895	0.0804
Eukaryota;Metazoa;Cnidaria;Scyphozoa;Semeostomeae;Pelepidae	0.1638	0.0637	0.0015
Eukaryota;Alveolata;Apicomplexa;Coccidia;Eucoxidiorida;Eimeriorida	0.007	0.0161	0.1464
Eukaryota;Rhizaria;Polycystinea;Spumellaria;Eithmosphaeridae;Stytopsphaera	0.0255	0.0553	0.1322
Eukaryota;Rhizaria;Cercozoa;Silicofiliidae;Thaumatomonadidae;Thaumatomastigidae	0.0571	0.1671	0.0006
Eukaryota;Viridiplantae;Streptophytib;Embryophytib;Tracheophytib;Spermatophytib	0.0245	0.0785	0.0096
Eukaryota;Viridiplantae;Chlorophyta;environmental samples;uncultured Chlorophyta;Other	0.219	0.0483	0.1014
Eukaryota;Rhizaria;Cercozoa;environmental samples;uncultured cercozoan;Other	0.1266	0.0637	0.0106
Eukaryota;Alveolata;environmental samples;uncultured alveolate;Other;Other	0.0125	0.0629	0.0216
Eukaryota;Alveolata;Polycystinea;Spumellaria;Actinomycetidae;Hexactinidae	0.0398	0.0403	0.1196
Eukaryota;Alveolata;Dinophyceae;Gymnodiniales;Gymnodinaceae;Thalassiosirales	0.0166	0.0151	0.1764
Eukaryota;Viridiplantae;Chlorophyta;Prasinophyceae;Pseudochlorophyta;Thalassiosyraceae	0.3198	0.025	0.0527
Eukaryota;Metazoa;Artropoda;Crustacea;Copepoda;Copepida	0.0322	0.0367	0.1064
Eukaryota;Metazoa;Chordata;Tunicata;Appendicularia;Oikopleuridae	0.1016	0.0004	0.2343
Eukaryota;Alveolata;Ciliophora;intramacronucleata;Oligohymenophorea;Scuticociliatia	0.1266	0.0119	0.0427
Eukaryota;Alveolata;Dinophyceae;Stramenopiles;Lophodiniidae;Lophodiniaceae;Velozynska	0.0553	0.0484	0.0204
Eukaryota;Rhizophytib;environmental samples;uncultured rhizophyte;Other;Other	0.0067	0.1271	0.048
Eukaryota;Fungi;Dikarya;Basidiomycota;Agaricomycotina;Agricomycetes	0.025	0.1919	0.0815
Eukaryota;Rhizaria;Polycystinea;Spumellaria;Collospiraeridae;Collospiraera	0.015	0.0748	0.0277
Eukaryota;Viridiplantae;Chlorophyta;Chlorophyceae;Chlamydomonadales;environmental samples	0.0056	0.0221	0.1184
Eukaryota;Alveolata;Dinophyceae;Gymnodiniales;Gymnodinaceae;Karolimium	0.0276	0.0994	0.0145
Eukaryota;Fungi;Fungi;incertae sedis;Basal fungal lineages;Entomophthoromycotina;Entomophthorales	0.0038	0.0696	0.0789
Eukaryota;Metazoa;Chordata;Craniata;Vertebrata;Euteleostomi	0.0519	0.0292	0.0857
Eukaryota;Viridiplantae;Chlorophyta;Chlorophyceae;Pseudoscourfieldales;Pycnococcaceae	0.0769	0.09	0.0587
Eukaryota;Rhizaria;Acantharea;environmental samples;uncultured marine Acantharea;Other	0.2139	0.0081	0.0407
Eukaryota;stramenopiles;Comycetes;Myxocystisidae;Eurychasmataceae;Eurychasma	0.0231	0.165	0.0327
Eukaryota;Metazoa;Ctenophora;Typhocoeia;Platytenidae;Coelopoplidae	0.1912	0.0282	0.0252
Eukaryota;Metazoa;Cnidaria;Hydrozoa;Siphonophora;Cystonectae	0.1501	0.0201	0.0212
Eukaryota;Rhizaria;Cercozoa;Cercomonadidae;environmental samples	0.0172	0.0424	0.015
Eukaryota;Alveolata;Dinophyceae;Gymnodiniales;Gymnodinaceae;Gymnodinium	0.0323	0.0622	0.0278
Eukaryota;Haptophyceae;Reticulosphaerales;Reticulosphaera;Reticulosphaera socialis;Other	0.0251	0.1758	0.0422
Eukaryota;Rhizaria;Polycystinea;Nassellaria;Plerocorythidae;Plerocoryns	-0.096	0.0246	0.0537
Eukaryota;Rhizaria;Polycystinea;Spumellaria;Spongodiscidae;Stylocystida	0.0927	0.0359	0.0717
Eukaryota;Rhodophytib;Compsopogonophyceae;Compsopogonales;Compsopogonaceae;Compsopogonopsis	0.0153	0.0706	0.0197
Eukaryota;Fungi;Dikarya;Ascomycota;Pezizomycotina;Pneumocystidomycetes	0.0072	0.0688	0.154
Eukaryota;stramenopiles;Bacillariophyta;Coscinodiscophyceae;Rhizosoleniophycidae;Rhizosoleniales	0.0069	0.0181	0.1586
Eukaryota;stramenopiles;Bacillariophyta;Mediophyceae;Biddulphiophycidae;Hemialiales	0.0117	0.032	0.2417
Eukaryota;stramenopiles;Bacillariophyta;Bacillariophyceae;Bacillariophycidae;Naviculales	0.0311	0.0829	0.0182
Eukaryota;stramenopiles;Bacillariophyta;Chauanacanthida;Chauanacanthid 217;Other	0.0067	0.0329	0.2517
Eukaryota;Rhizaria;Polycystinea;Spumellaria;unclassified Spumellaria;Pseudopelmarian radiolarian 7017	0.2166	0.0687	0.0345
Eukaryota;Alveolata;Eubilobidae;Polychaeta;Colocida;Spinida	0.0263	0.0247	0.1051
Eukaryota;Fungi;Dikarya;Ascomycota;Taphrinomycotina;Pneumocystidomycetes	0.0015	0.1588	0.0413
Eukaryota;Alveolata;Ciliophora;Intramacronucleata;Oligohymenophorea;Peniculida	0.0183	0.0044	0.186
Eukaryota;Metazoa;Cnidaria;Hydrozoa;Hydroida;Leptomedusae	0.0373	0.1031	0.0273
Eukaryota;Alveolata;Dinophyceae;unclassified Dinophyceae;Naked dinoflagellate UDWSN0701;Other	0.0474	0.0409	0.0326
Eukaryota;Metazoa;Chordata;Cephalochordata;Branchiostomidae;Branchiostomi	0.019	0.1262	0.0315
Eukaryota;stramenopiles;Bacillariophyta;Bacillariophyceae;Bacillariophycidae;Bacillariales	0.0011	0.0594	0.0388
Eukaryota;Alveolata;unclassified Alveola;ichthyodinium;ichthyodinium chabardi;Other	0.0221	0.0249	0.2415
Eukaryota;Alveolata;Dinophyceae;Blastodiniales;Blastodinium;Blastodinium contortum	0.0337	0.0995	0.0081
Eukaryota;Metazoa;Arthropoda;Crustacea;Malacostraca;Eumalacostraca	0.0056	0.0043	0.0598
Eukaryota;Metazoa;Dinophyceae;Noctilucidae;Noctilucaceae;Noctiluca	0.0157	0.0382	0.1136
Eukaryota;stramenopiles;Glae;Phaeophyceae;Fucales;Sargassaceae	0.0246	0.1576	0.022
Eukaryota;Metazoa;Mesoza;Orthonida;Rhopalura;Rhopalura ophiocomae	0.0159	0.0998	0.0442
Eukaryota;Alveolata;Ciliophora;environmental samples;uncultured ciliate;Other	0.112	0.0556	0.0179
Eukaryota;stramenopiles;Bacillariophyta;Mediophyceae;Lithodesmophyidae;Lithodesmidae	0.0586	0.0863	0.0343
Eukaryota;Alveolata;Dinophyceae;unclassified Dinophyceae;Dinophyceae sp. Shepherd's Crook;Other	0.012	0.0164	0.0463
Eukaryota;Metazoa;Plathelminthes;Trematoda;Digenea;Strigeida	0.0944	0.0316	0.0066
Eukaryota;Cryptophyta;Pyrenomonadidae;Chroomonadaceae;Chroomonas;Chroomonas sp. M1312	0.0637	0.0339	0.027
Eukaryota;Metazoa;Annelida;Polychaeta;Scoleida;Orbiniidae	0.0305	0.0227	0.0503
Eukaryota;Cryptophyta;environmental samples;uncultured cryptophyte;Other;Other	0.0291	0.0254	0.1126
Eukaryota;Cryptophyta;Pyrenomonadidae;Geminieraceae;Guillardia;Guillardia theta	0.0051	0.0736	0.0095
Eukaryota;Chaoanflagellida;environmental samples;uncultured chaoanflagellate;Other;Other	0.0019	0.0307	0.0515
Eukaryota;stramenopiles;Bacillariophyta;environmental samples;uncultured heterokont;Other;Other	0.1421	0.0054	0.0401
Eukaryota;Alveolata;Ciliophora;Intramacronucleata;Spirotrichida;Choreotrichia	0.0815	0.0731	0.1742
Eukaryota;Metazoa;Plathelminthes;Trematoda;Digenea;Strigeida	0.0544	0.0347	0.003
Eukaryota;stramenopiles;Labyrinthulida;Thraustochytrida;Thraustochytrium kinnei	0.0478	0.1054	0.0109
Eukaryota;Alveolata;Dinophyceae;Prochlorophyceae;Prochlorothrix;Prochlorothrix	0.0244	0.0224	0.0024
Eukaryota;stramenopiles;Pseudopagriopina;Pseudopagriopina grossa;Other;Other	0.0036	0.0266	0.0202
Eukaryota;stramenopiles;Bacillariophyta;Coscinodiscophyceae;Chatocera;Chatoceratidae	0.0032	0.0268	0.1458
Eukaryota;Viridiplantae;Chlorophyta;Mamiellophyceae;Mamiellales;Micromonas	0.0083	0.0047	0.1229
Eukaryota;Alveolata;Ciliophora;Intramacronucleata;Spirotrichida;Hypotrichia	0.0159	0.0025	0.0887
Eukaryota;Rhizaria;Acantharea;Symphycanida;Amphilithiidae;Amphiblobine	0.0174	0.0269	0.0628
Eukaryota;stramenopiles;Bacillariophyta;Fragilarophyceae;Fragilarophycidae;Fragilariales	0.0029	0.018	0.0427
Eukaryota;Metazoa;Bryozoa;Gymnolaemata;Chelostomatida;Neochelostomatina	0.057	0.0331	0.0137
Eukaryota;Metazoa;Polycystinea;Nassellaria;Phagomyiae;Lithomelissa	0.1252	0.0391	0.0001
Eukaryota;Fungi;Dikarya;Ascomycota;Saccharomycotina;Saccharomyces	0.0568	0.0083	0.0166
Eukaryota;Metazoa;Cnidaria;Hydrozoa;Trachylina;Trachymedusae	0.0102	0.0084	0.0504
Eukaryota;Metazoa;Chordata;Tunicata;Thaliacea;Salpida	0.0069	0.0188	0.0623
Eukaryota;Alveolata;Ciliophora;Intramacronucleata;Protostomata;Prorodontida	0.0028	0.0017	0.0516
Eukaryota;Rhizaria;unclassified Rhizaria;Acantharian sp. 6201;Other;Other	0.0217	0.0757	0.0421
Eukaryota;stramenopiles;Comycetes;Peronopores;Phytophtora;Phytophtora infestans T30-4	0.073	0.0154	0.0188
Eukaryota;Metazoa;Nematoda;Chromadorea;Oxyurida;Oxyuroidea	0.0176	0.0186	0.1165
Eukaryota;Alveolata;environmental samples;Uncultured marine alveolate Group II DH145-EKD20;Other;Other	0.0004	0.0129	0.0543
Eukaryota;Metazoa;Annelida;Clitellata;Branchiobdellae;Branchiobdellida	0.0137	0.0284	0.0388
Eukaryota;Metazoa;Chordata;Tunicata;Thaliacea;Doliolida	0.0163	0.0839	0.0149
Eukaryota;Viridiplantae;Chlorophyta;Trebouxophyceae;Chlorella;Chlorella 'luteoviridis'	0.0741	0.015	0.0131
Eukaryota;Haptophyceae;Phaeocystidae;Phaeocystaceae;Phaeocysts;Phaeocysts globosa	0.1352	0.0536	0.0142
Eukaryota;Metazoa;Chordata;Tunicata;Thaliacea;Doliolida	0.0986	0.1271	0.2698
Eukaryota;Rhodophytib;Bangiophyceae;Bangiales;Bangiaceae;Porphyra	0.0105	0.0167	0.1411
Eukaryota;Rhizaria;Cercozoa;Cercomonadida;Cercomonadidae;Parcercomonas	0.0173	0.0061	0.0676
Eukaryota;Alveolata;Dinophyceae;Syndiniales;Syndiniaeae;Syndinum	0.0724	0.0219	0.0577
Eukaryota;stramenopiles;Ustigmatophyceae;Eustigmatales;Monodopsidae;Nannochloropsis	0.0753	0.0241	0.0047
Eukaryota;Alveolata;Dinophyceae;Gymnondiniales;Gymnondinaceae;Cochlodinium	0.0227	0.0502	0.0621
Eukaryota;Metazoa;Mollusca;Bivalvia;Periomorphia;Mytiloida	0.025	0.008	0.1149
Eukaryota;Metazoa;environmental samples;invertebrate environmental sample;Other;Other	0.0677	0.1378	0.015
Eukaryota;Metazoa;environmental samples;invertebrate environmental sample;Other;Other	0.0019	0.0232	0.0172
Eukaryota;Viridiplantae;Streptophytib;Embryophyta;Anthocerotophyta;Anthocerotopsida	0.0008	0.0338	0.0081

Table S4. Paleo-DNA factor analysis loadings.

Depth (cm)	Age (years BP)	Factor 1	Factor 2	Factor 3	Commonality Variability Explained
1	221	0.38	-0.04	0.30	0.24
5	440	0.62	0.17	0.24	0.48
10	698	0.78	0.12	0.15	0.65
16	987	0.64	0.32	0.18	0.55
21	1211	0.73	0.09	0.21	0.58
27	1461	0.43	0.29	0.19	0.30
32	1656	0.62	0.25	0.23	0.50
37	1838	0.60	0.39	0.06	0.51
43	2043	0.64	0.17	0.17	0.47
48	2203	0.69	0.20	0.12	0.53
54	2383	0.60	0.27	0.12	0.45
59	2525	0.58	0.37	0.24	0.54
66	2712	0.69	0.31	0.04	0.57
71	2839	0.59	0.34	0.25	0.52
76	2962	0.66	0.41	0.06	0.60
79	3034	0.47	0.55	0.06	0.52
82	3106	0.54	0.42	0.05	0.47
85	3176	0.44	0.44	0.18	0.42
88	3246	0.61	0.35	0.09	0.50
96.5	3442	0.18	0.41	0.37	0.34
101.5	3559	0.27	0.65	0.05	0.49
107.5	3700	0.23	0.42	0.16	0.25
111	3785	0.13	0.65	0.23	0.49
114.5	3871	0.23	0.51	0.11	0.32
118.5	3972	0.18	0.65	0.01	0.45
122.5	4076	0.28	0.59	0.17	0.45
127.5	4211	0.17	0.61	0.04	0.41
133.5	4383	0.17	0.67	0.18	0.51
138.5	4534	0.42	0.65	0.10	0.60
143.5	4695	0.34	0.58	0.21	0.50
148.5	4865	0.44	0.51	0.05	0.46
154.5	5083	0.42	0.53	0.14	0.48
159.5	5278	0.37	0.58	-0.04	0.47
164.5	5486	0.55	0.35	0.19	0.45
175.5	5995	0.39	0.47	0.13	0.39
183.5	6412	0.39	0.50	0.25	0.46
191.5	6875	0.22	0.43	0.14	0.25
197.5	7255	0.21	0.48	0.39	0.42
208.5	8027	-0.09	0.55	0.24	0.37
224.5	9348	0.21	0.33	0.54	0.44
237.5	10614	0.27	0.25	0.63	0.54
247.5	11715	0.14	0.14	0.79	0.67
257.5	12938	0.11	0.19	0.68	0.51
267.5	14288	0.16	0.09	0.78	0.64
278.5	15931	0.16	0.03	0.76	0.61

Table S5. Total planktonic foraminifer and *G. falconensis* counts.

Depth (cm)	Age (years BP)	Total planktonics (number specimens)	<i>G. falconensis</i> (%)
13.5	622	1135	22
25.5	1189	300	10
51.5	2156	412	7
62.5	2483	531	10
76.5	2852	412	35
82.5	2999	302	14
87	3106	539	43
92.5	3234	309	54
96	3315	341	43
108.5	3606	308	34
115.5	3773	371	32
121.5	3921	458	19
123.5	3972	407	39
125	4011	480	45
132.5	4211	303	26
143.5	4534	385	19
156	4954	574	6
165.5	5319	348	17
166.5	5360	400	3
176	5778	301	11
187.5	6358	429	4
202.5	7255	302	14

4. Supplementary References

Abram, N. J., H. V. McGregor, J. E. Tierney, M. N. Evans, N. P. McKay, D. S. Kaufman, K. Thirumalai, Pages2k Consortium (2016), Early onset of industrial-era warming across the oceans and continents, *Nature*, 536(7617), 411–418, doi:10.1038/nature19082.

Huffman, George J., et al. "The TRMM multisatellite precipitation analysis (TMPA): Quasi-global, multiyear, combined-sensor precipitation estimates at fine scales." *Journal of hydrometeorology* 8.1 (2007): 38-55.

Orsi, W.D., Coolen, M.J., Wuchter, C., He, L., More, K.D., Irigoien, X., Chust, G., Johnson, C., Hemingway, J.D., Lee, M., Galy, V., Giosan, L., 2017. Climate oscillations reflected within the microbiome of Arabian Sea sediments. *Scientific Reports*, 7(1), p.6040.

Rayner, N. A., D. E. Parker, E. B. Horton, C. K. Folland, L. V. Alexander, D. P. Rowell, E. C. Kent, and A. Kaplan (2003), Global analyses of sea surface temperature, sea ice, and night marine air temperature since the late nineteenth century, *J. Geophys. Res.*, 108(D14), 4407–37, doi:10.1029/2002JD002670.

Thirumalai, K., T. M. Quinn, Y. Okumura, J. N. Richey, J. W. Partin, R. Z. Poore, and E. Moreno-Chamarro (2018), Pronounced centennial-scale Atlantic Ocean climate variability correlated with Western Hemisphere hydroclimate, *Nature Commun.*, 1–11, doi:10.1038/s41467-018-02846-4.