PaleoJump database for research on rapid climate transitions

Witold Bagniewski[1], Denis-Didier Rousseau[2,3], Michael Ghil[1,4]

(1) École Normale Supérieure, PSL Univ., Laboratoire de Météorologie Dynamique, Paris, France
(2) Columbia Univ., Lamont Doherty Earth Observatory, New York, USA
(3) Univ. Montpellier, Géosciences, CNRS, Montpellier, France
(4) Univ. of California at Los Angeles, Dept. of Atmospheric and Oceanic Sci., Los Angeles, USA

Contact: wbagniewski@lmd.ipsl.fr

TIPPING POINTS IN THE EARTH SYSTEM

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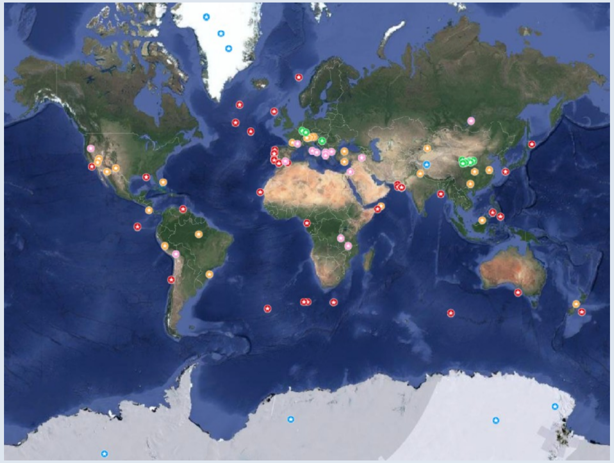
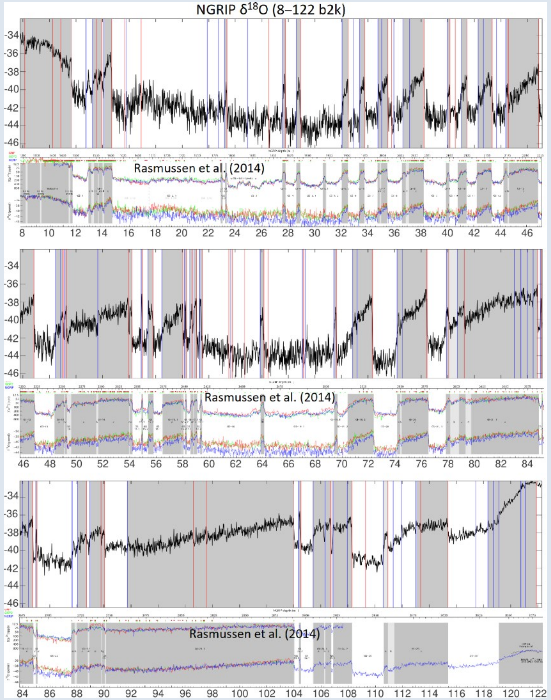


- Ice Cores
- Speleothems
- Lake Sediment Cores
- Loess Records
- Marine Sediment Cores

103 sites:
- 40 marine sediment cores
- 26 speleothems
- 14 loess records
- 14 lake sediment cores
- 9 ice cores

- PaleoJump: A database of carefully selected, high-quality paleoclimate records evidencing abrupt climate transitions in the past.
- Global coverage with records from all continents and ocean basins.
- Main focus on the Last Climate Cycle, with some records extending further back in time.
- Abrupt transitions in the records identified using a modified Kolmogorov-Smirnov test.
- Dates of these transitions, along with plots and other essential information about the records are provided in the database.
- A valuable, easy-to-use resource for researchers investigating tipping points in past climates.



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PaleoJump database for research on rapid climate transitions

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Motivation

- Records of past climate exhibit abrupt transitions, which may represent tipping points (TPs) in the Earth system's past.
- Paleoclimate proxy records provide valuable information for identifying critical TPs in current and future climate evolution
- TPs in paleoclimate records are often not properly identified. Furthermore, the data can be of variable quality and be based on different dating methods.
- Therefore, it is necessary to select high-quality records that give the best representation of past climate.
- Furthermore, as paleoclimate records vary in their origin, time spans, and periodicities, an objective, automated methodology is crucial for identifying and comparing TPs.

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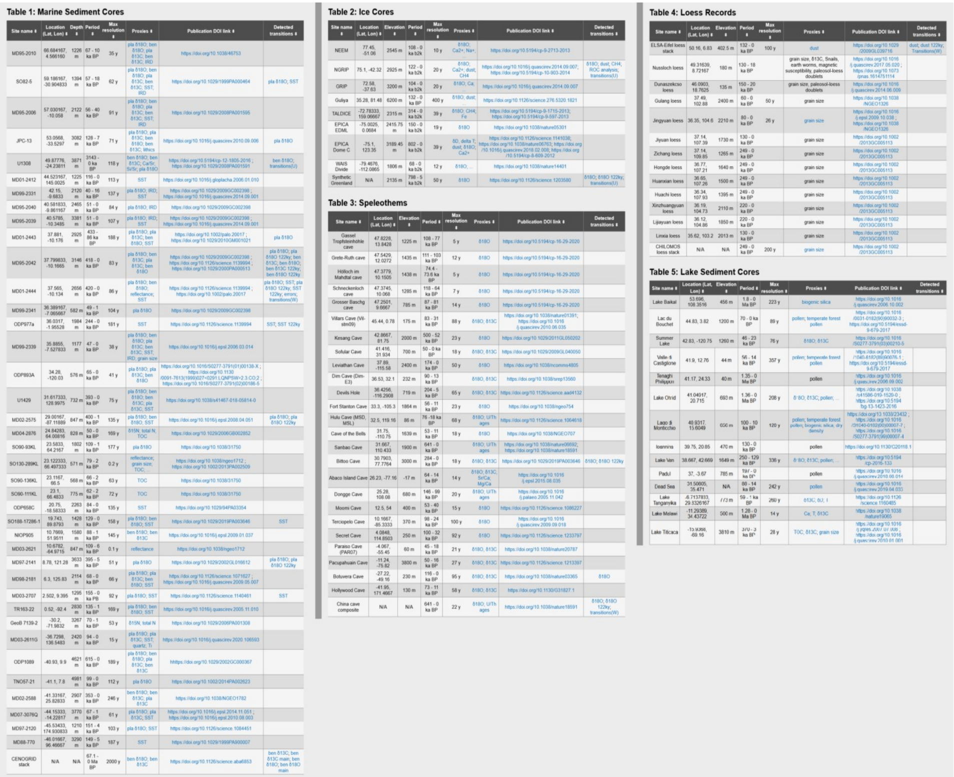
PaleoJump database

- The database contains proxy records selected for their quality, resolution, precision of the time scale, and representation of past climate variability, following extensive literature review and analysis of data obtainable from different repositories.
- 40 marine sediment cores, 26 speleothems, 14 loess records, 14 lake sediment cores, 9 ice cores.
- For each site, essential information is given in the tables: location, elevation, temporal range, maximum resolution, and available proxies. This information is accompanied with links to the original data and the associated publications.
- Temporal focus on the Last Climate Cycle, with some records including earlier glacial cycles of the Quaternary.
- Working version currently online (link available on request).



The list: 103 sites in total, most containing several proxies

PaleoJump database

Click on the markers for information about each site

Rows are sortable

Maximum resolution over any 10 ka interval (prior to the Holocene)

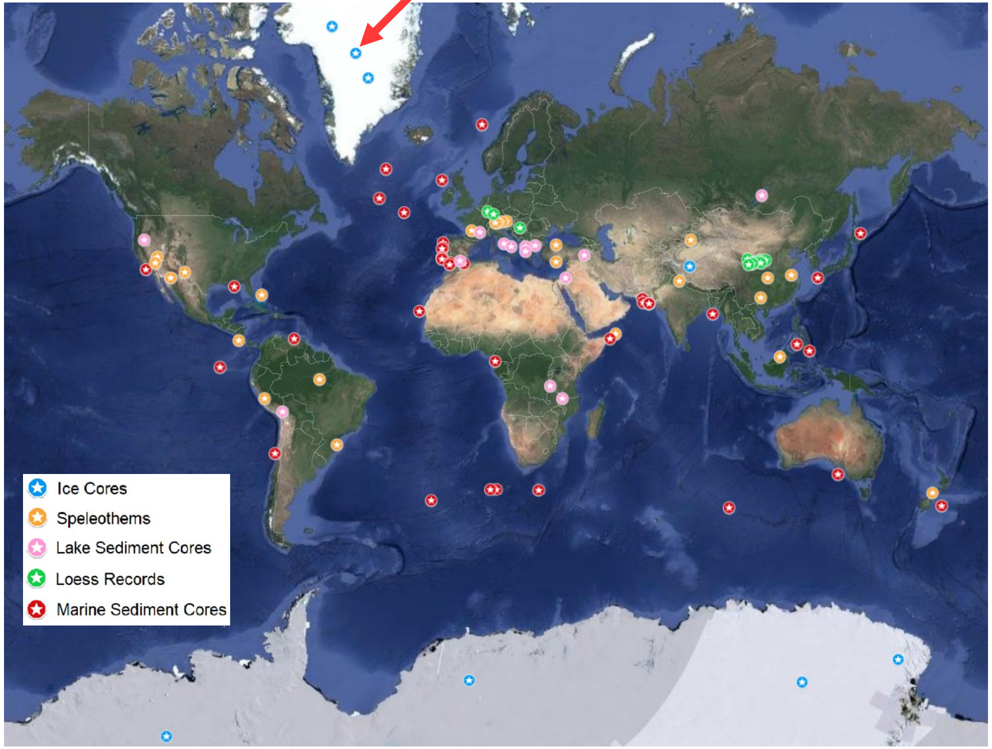


Table 1: Marine Sediment Cores

Site name ⇕	Location (Lat, Lon) ⇕	Depth ⇕	Period ⇕	Max resolution ⇕	Proxies ⇕	Publication DOI link ⇕	Detected transitions ⇕
MD95-2010	66.684167, 4.566160	1226 m	67 - 10 ka BP	35 y	pla δ18O; ben δ18O; pla δ13C; ben δ13C; IRD	https://doi.org/10.1038/46753	
SO82-5	59.186167, -30.904833	1394 m	57 - 18 ka BP	62 y	pla δ18O; ben δ18O; pla δ13C; ben δ13C; SST; IRD	https://doi.org/10.1029/1999PA000464	pla δ18O; SST
MD95-2006	57.030167, -10.058	2122 m	56 - 40 ka BP	91 y	pla δ18O; ben δ18O; pla δ13C; ben δ13C; SST; IRD	https://doi.org/10.1029/2008PA001595	
JPC-13	53.0568, -33.5297	3082 m	128 - 7 ka BP	71 y	pla δ18O; pla δ13C; ben δ18O; ben δ13C; lithics	https://doi.org/10.1016/j.quascirev.2010.09.006	pla δ18O
U1308	49.87776, -24.23811	3871 m	3143 - 0 ka BP	118 y	ben δ18O; ben δ13C; Ca/Sr; Si/Sr; pla δ18O	https://doi.org/10.5194/cp-12-1805-2016 ; https://doi.org/10.1029/2008PA001591	ben δ18O; transitions(U)
MD01-2412	44.523167, 145.0025	1225 m	116 - 0 ka BP	113 y	SST	https://doi.org/10.1016/j.gloplacha.2006.01.010	
MD99-2331	42.15, -9.6833	2120 m	40 - 16 ka BP	137 y	pla δ18O; IRD; SST	https://doi.org/10.1029/2009GC002398 ; https://doi.org/10.1016/j.quascirev.2014.09.001	
MD95-2040	40.581833, -9.861167	2465 m	51 - 0 ka BP	84 y	pla δ18O; IRD	https://doi.org/10.1029/2009GC002398	
MD95-2039	40.5785, -10.3485	3381 m	51 - 0 ka BP	107 y	pla δ18O; IRD; SST	https://doi.org/10.1029/2009GC002398 ; https://doi.org/10.1016/j.quascirev.2014.09.001	
MD01-2443	37.881, -10.176	2925 m	433 - 86 ka BP	188 y	pla δ18O; pla δ13C; ben δ18O; SST	https://doi.org/10.1002/palo.20017 ; https://doi.org/10.1029/2010GM001021	pla δ18O
MD95-2042	37.799833, -10.1665	3146 m	418 - 0 ka BP	83 y	pla δ18O; ben δ13C; pla δ13C; ben δ18O	https://doi.org/10.1029/2009GC002398 ; https://doi.org/10.1126/science.1139994 ; https://doi.org/10.1029/2000PA000513	pla δ18O; pla δ18O 122ky; ben δ13C; ben δ18O; ben δ13C 122ky; ben δ18O 122ky
					pla δ18O; ben		pla δ18O; SST; pla

PaleoJump database

Primary focus is on proxies that may be reliably compared with climate models:

- Oxygen isotopes: past temperatures, sea level, precipitation
- Carbon isotopes: past vegetation
- Aeolian deposits: past precipitation and atmospheric transport patterns
- Other proxy-based estimates of past temperatures

Links to the data files (hosted on PANGAEA, NCEI, etc.)

Transitions identified with the augmented KS test

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MD95-2006	57.030167, -10.058	2122 m	56 - 40 ka BP	91 y	pla δ^{18}O; ben δ^{18}O; pla δ^{13}C; ben δ^{13}C; SST; IRD	https://doi.org/10.1029/2008PA001595	
JPC-13	53.0568, -33.5297	3082 m	128 - 7 ka BP	71 y	pla δ^{18}O; pla δ^{13}C; ben δ^{18}O; ben δ^{13}C; lithics	https://doi.org/10.1016/j.quascirev.2010.09.006	pla δ^{18}O
U1308	49.87776, -24.23811	3871 m	3143 - 0 ka BP	118 y	ben δ^{18}O; ben δ^{13}C; Ca/Sr; Si/Sr; pla δ^{18}O	https://doi.org/10.5194/cp-12-1805-2016 ; https://doi.org/10.1029/2008PA001591	ben δ^{18}O; transitions(U)
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MD95-2042	37.799833, -10.1665	3146 m	418 - 0 ka BP	83 y	pla δ^{18}O; ben δ^{13}C; pla δ^{13}C; ben δ^{18}O	https://doi.org/10.1029/2009GC002398 ; https://doi.org/10.1126/science.1139994 ; https://doi.org/10.1029/2000PA000513	pla δ^{18}O; pla δ^{18}O 122ky; ben δ^{13}C; ben δ^{18}O; ben δ^{13}C 122ky; ben δ^{18}O 122ky
					pla δ^{18}O; ben		pla δ^{18}O; SST; pla

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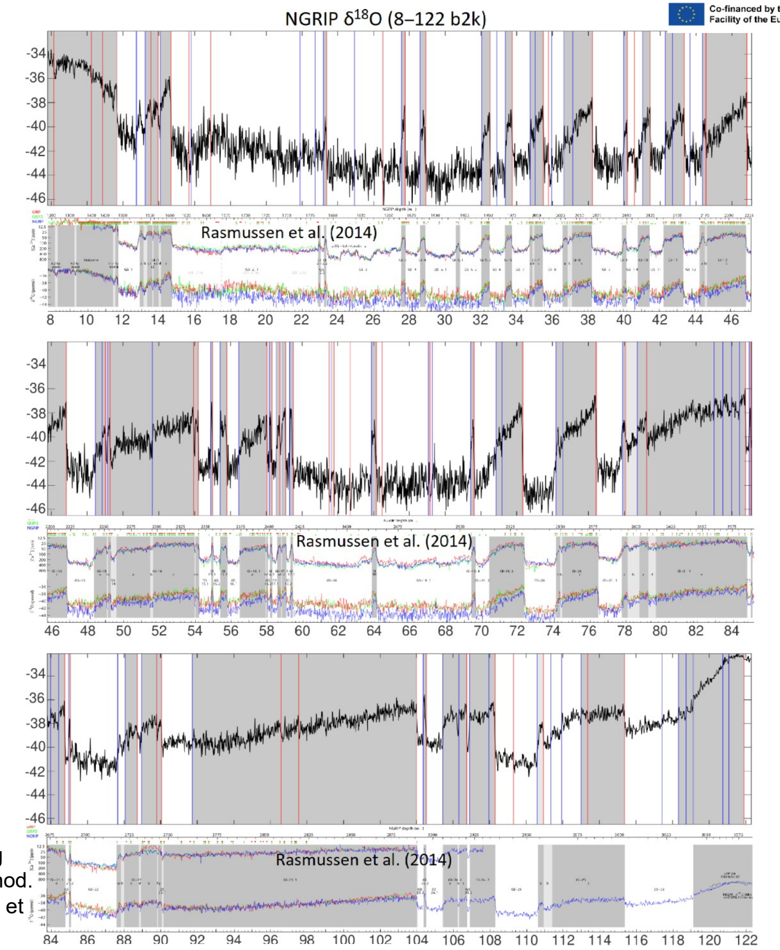
Abrupt transition detection

Our methodology is based on the nonparametric Kolmogorov-Smirnov (KS) test (e.g. Massey et al., 1951):

1. The KS test is applied to compare two samples drawn from a time series, before and after a potential jump.
2. The KS statistic quantifies the difference between the empirical distribution functions of the two samples to identify discontinuities.
3. We augment the KS test by other criteria: varying sample window size, minimum rate-of-change threshold.
4. Finally, long-term trends in maxima and minima are used to establish the main transitions, for example Stadial-Interstadial boundaries in Greenland ice cores.

We use the receiver operating characteristic (ROC) analysis to compare the diagnostic ability of different classifiers used in our methodology and to optimize the KS method's parameters.



NGRIP δ^{18}O ice core record including transitions detected with the KS method. Transitions described by Rasmussen et al. (2014) shown for comparison.

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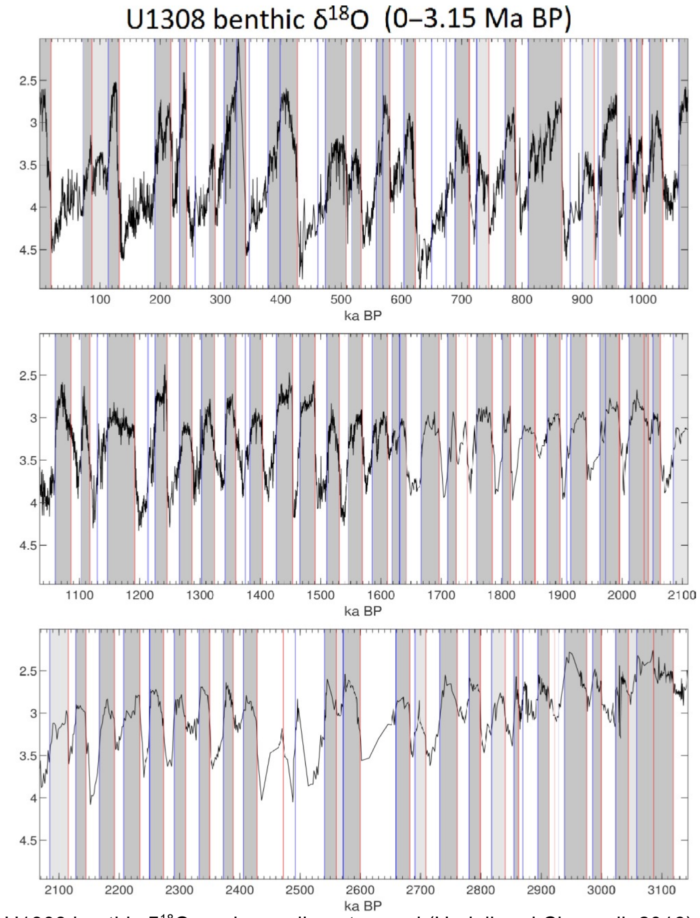
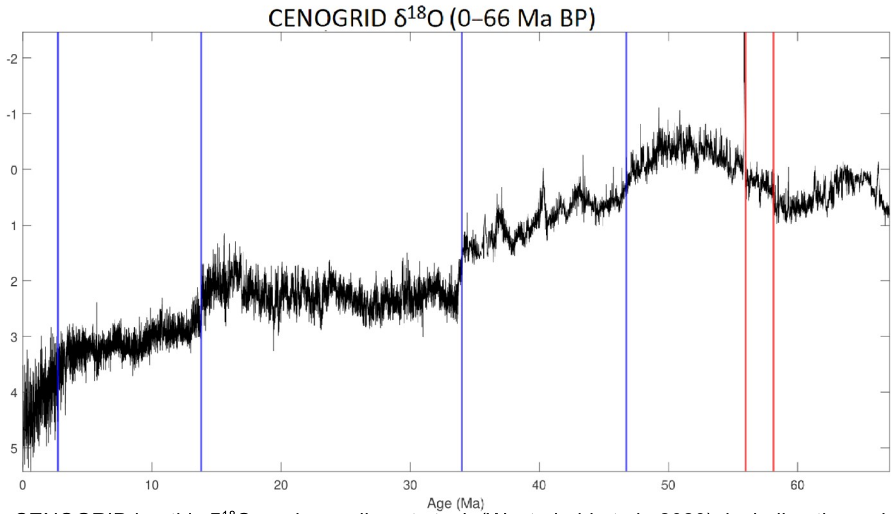
Abrupt transition detection



U1308 benthic $\delta^{18}O$ marine sediment record (Hodell and Channell, 2016), including detected transitions

- The method may be applied to records of different timescales, resolutions, and periodicities.
- Plots of the detected transitions, along with spreadsheets listing their dates are available on the PaleoJump database for selected records.



CENOGRID benthic $\delta^{18}O$ marine sediment stack (Westerhold et al., 2020), including the main transitions found with the KS method.

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Conclusions

- The PaleoJump database is an evolving, easy-to-use resource for researchers investigating tipping points in past climates and may simplify the process of finding the most relevant proxy records, including in model-data comparison studies.

- An objective, automated transition detection methodology is crucial for identifying and comparing TPs in paleoclimate records.

- The augmented KS test allows a robust detection of previously unrecognized transitions at every investigated time scale.

- The broad spatial coverage of the database facilitates research on different potential tipping elements in the Earth's climate, including the polar ice sheets, the AMOC, and the tropical rainforests and monsoon systems.

- The database is continuously expanded as more records are being added and information is being updated.

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