Ancient interglacials as analogues of the present: reconstructing the past variability for understanding and modelling the future climate

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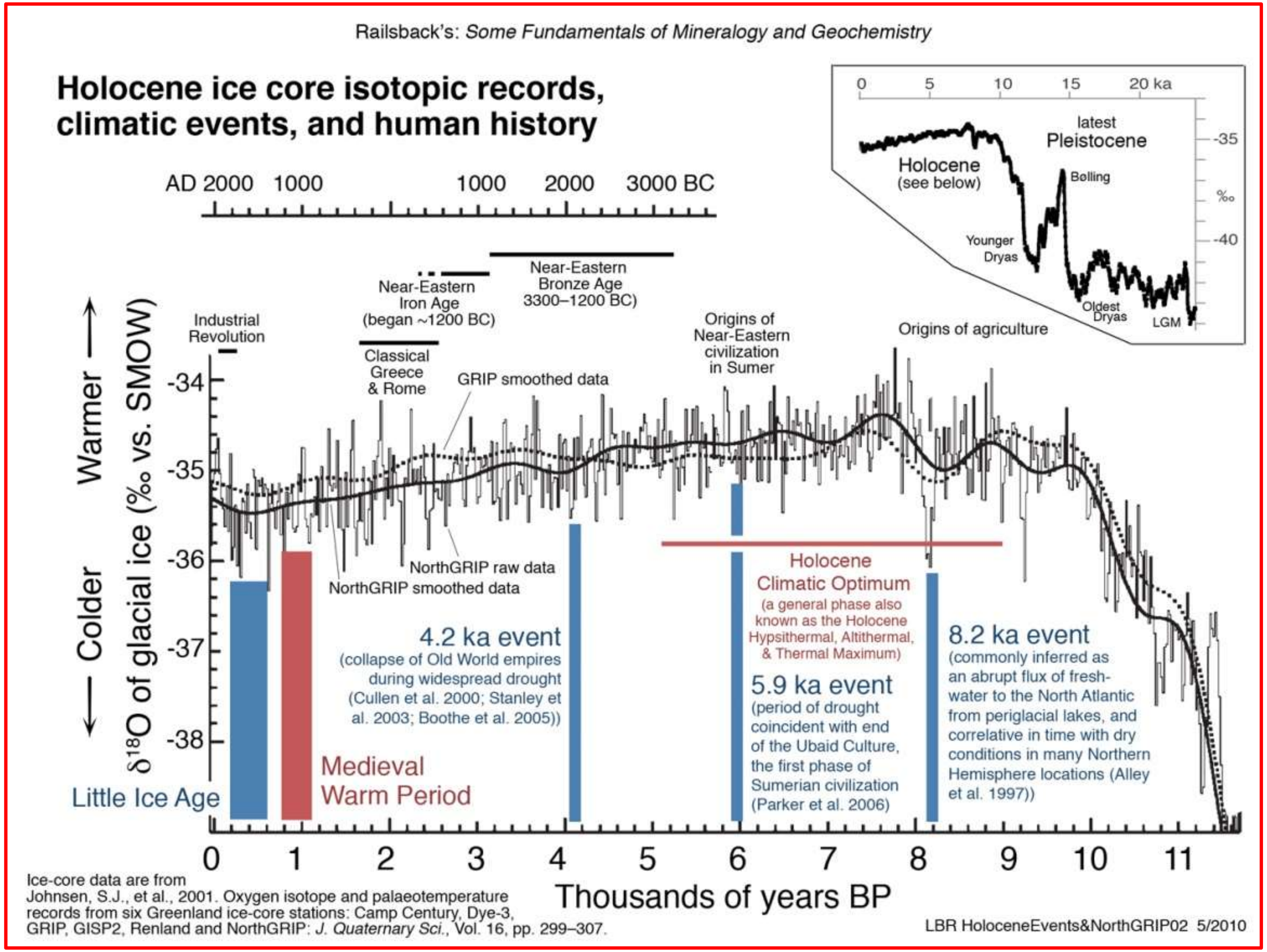
Centre for Climate Change Impact

Why past interglacials?



Holocene (MIS 1) 11.7 ka-?

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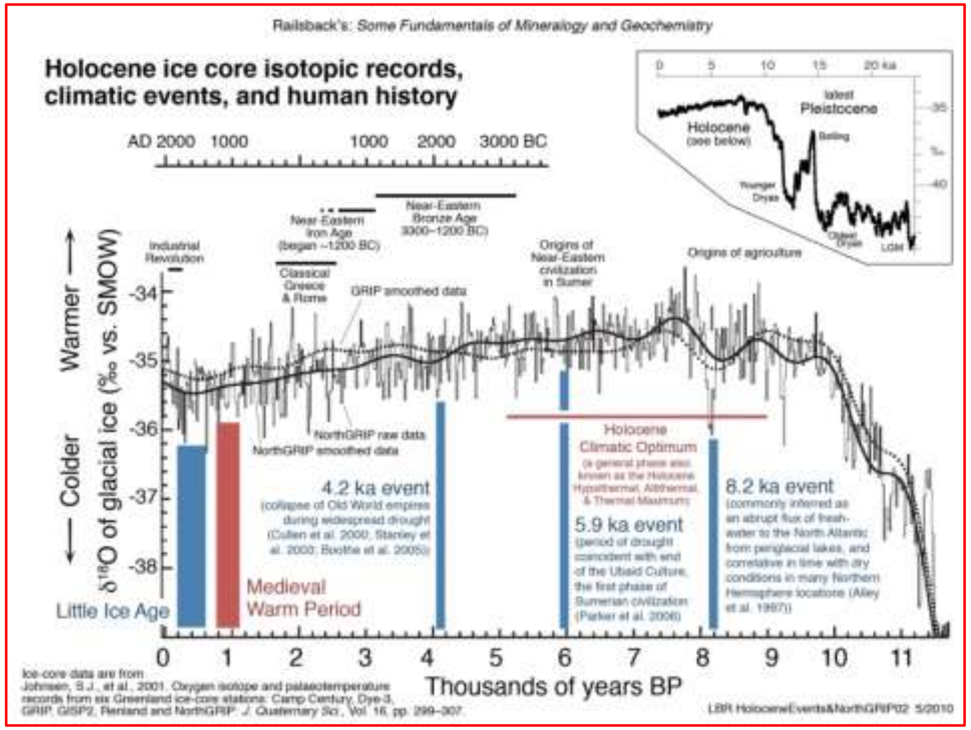

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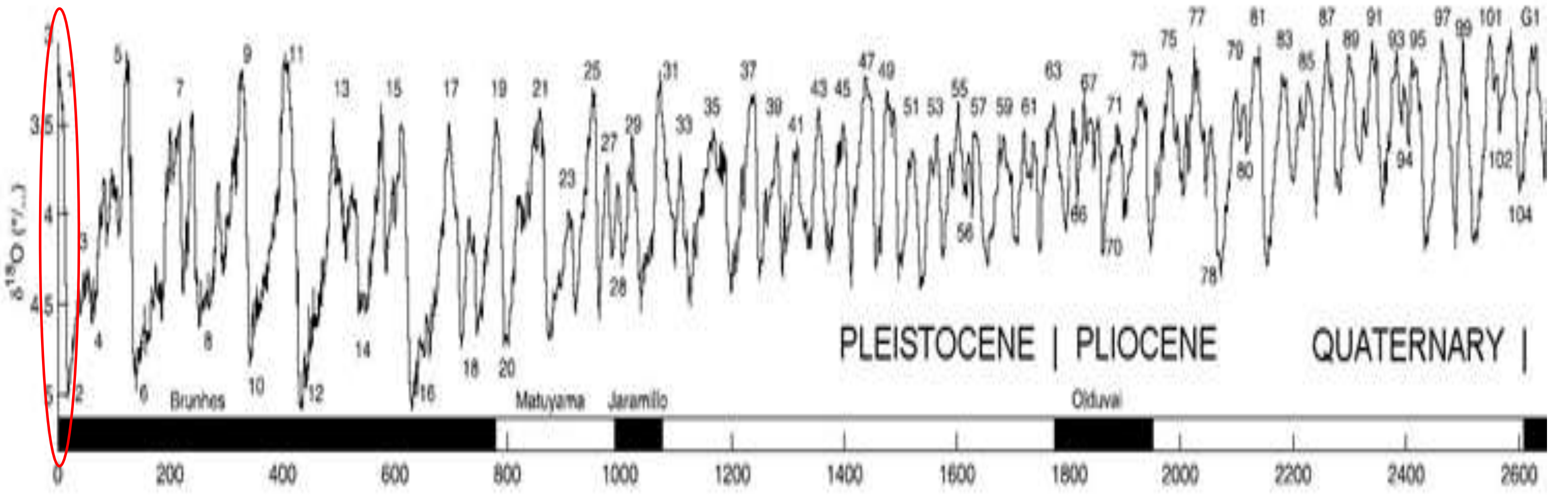

interglacial

glacial

Thousands of years

Lisieki and Raymo, 2005

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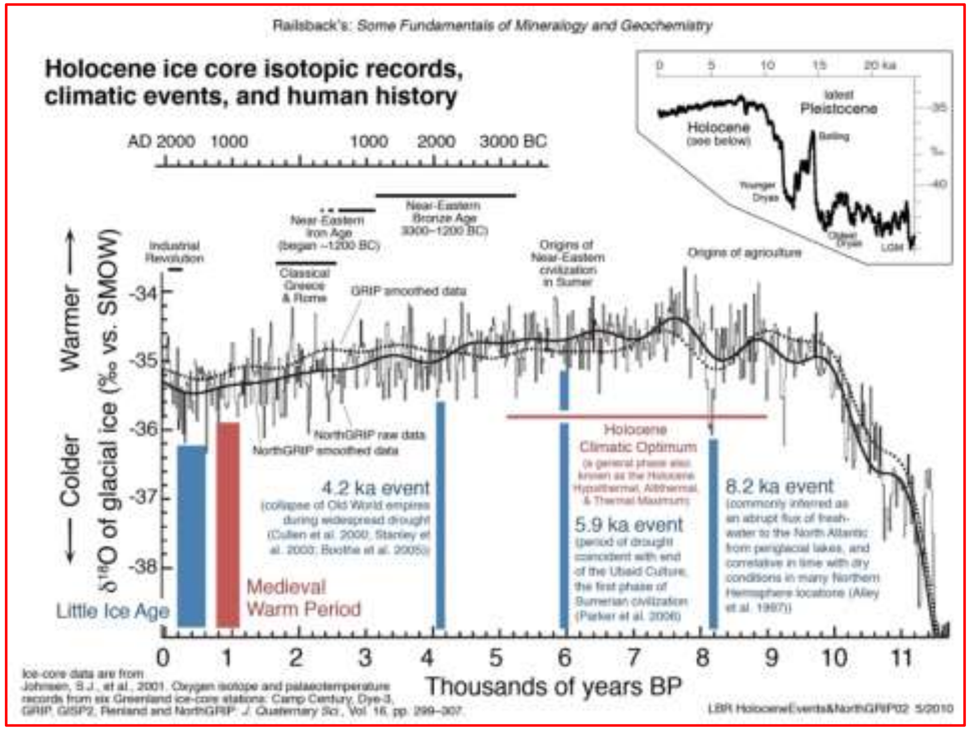

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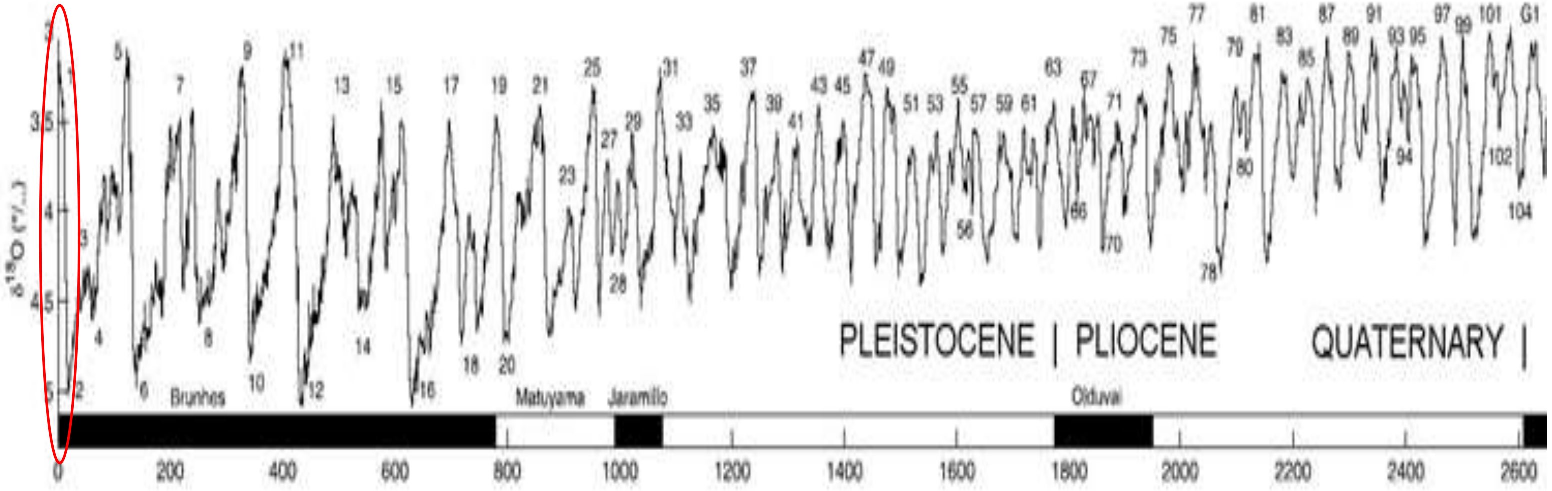

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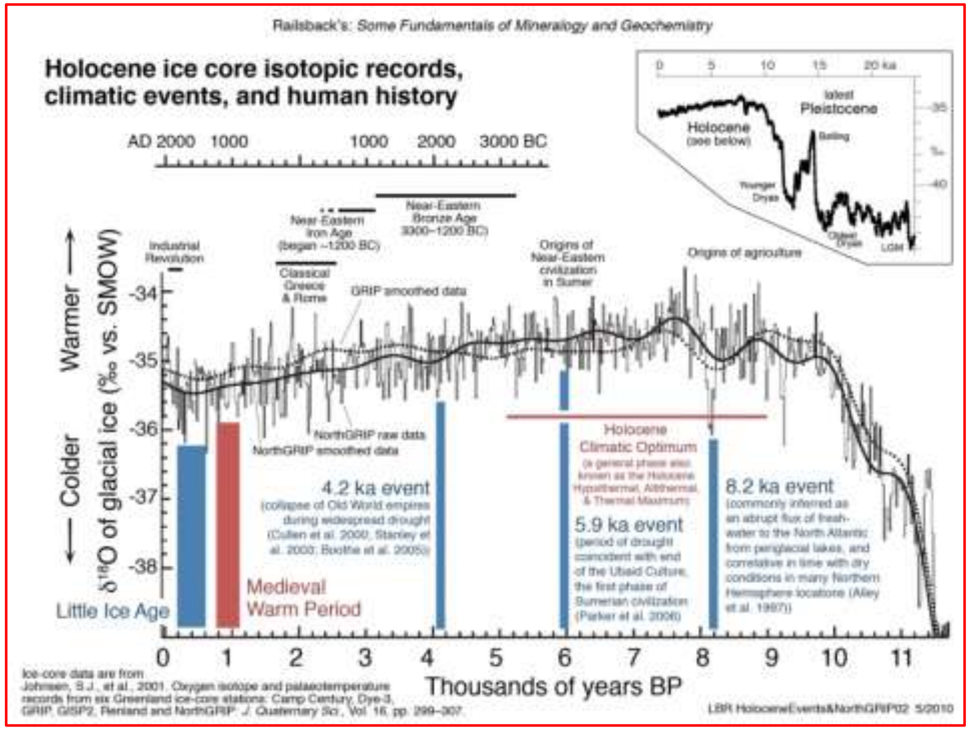

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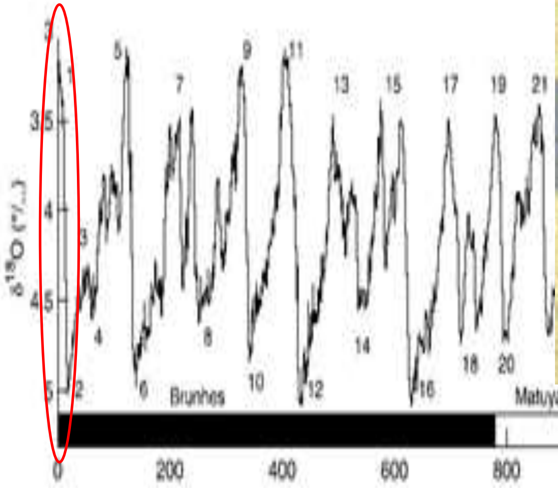

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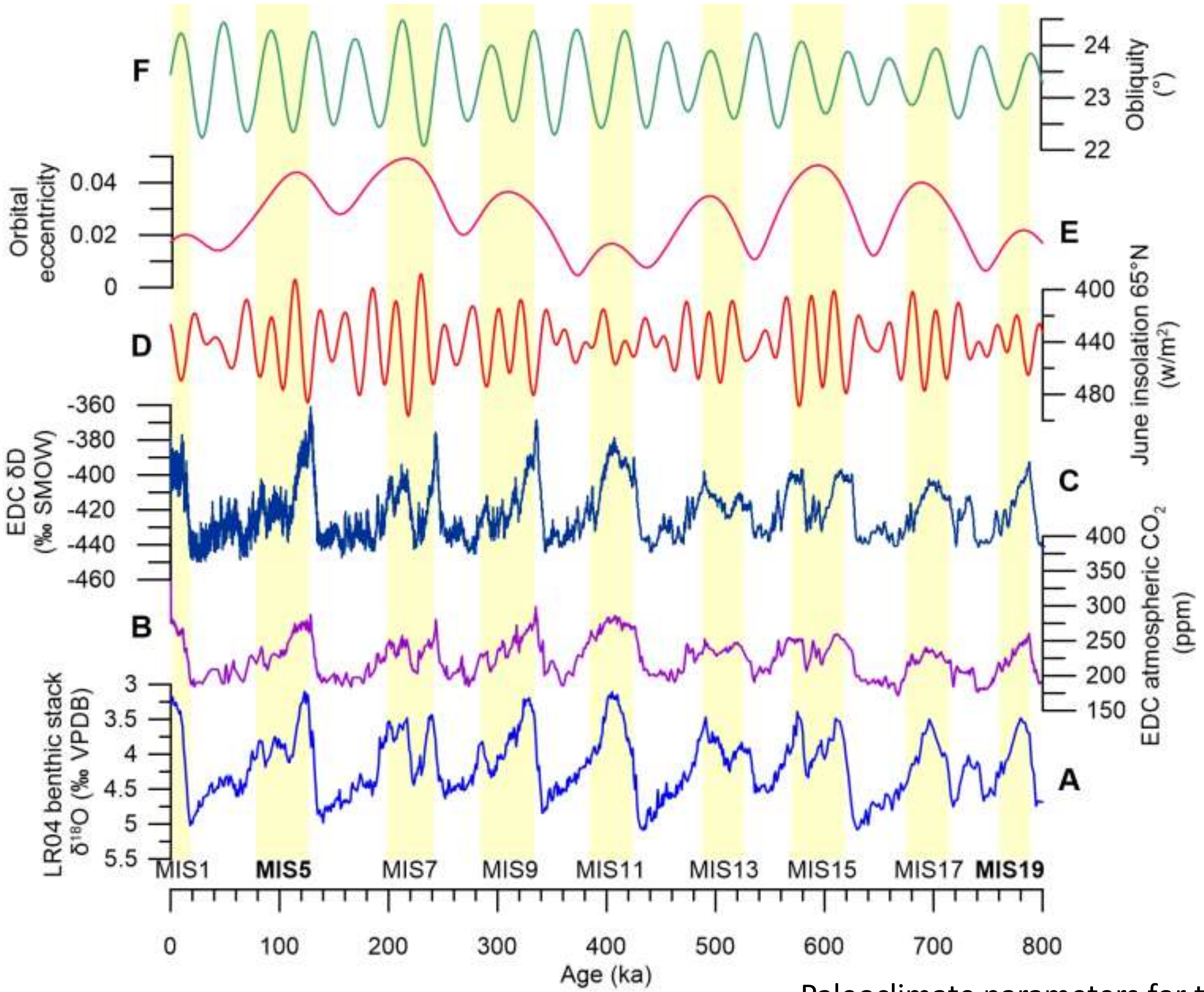


Past interglacials are "natural experiments", with different climate boundary conditions.

Insights into present and future climate

Paleoclimate parameters for the last 800 ka (modified from Tzedakis et al., 2009 Ngeo)

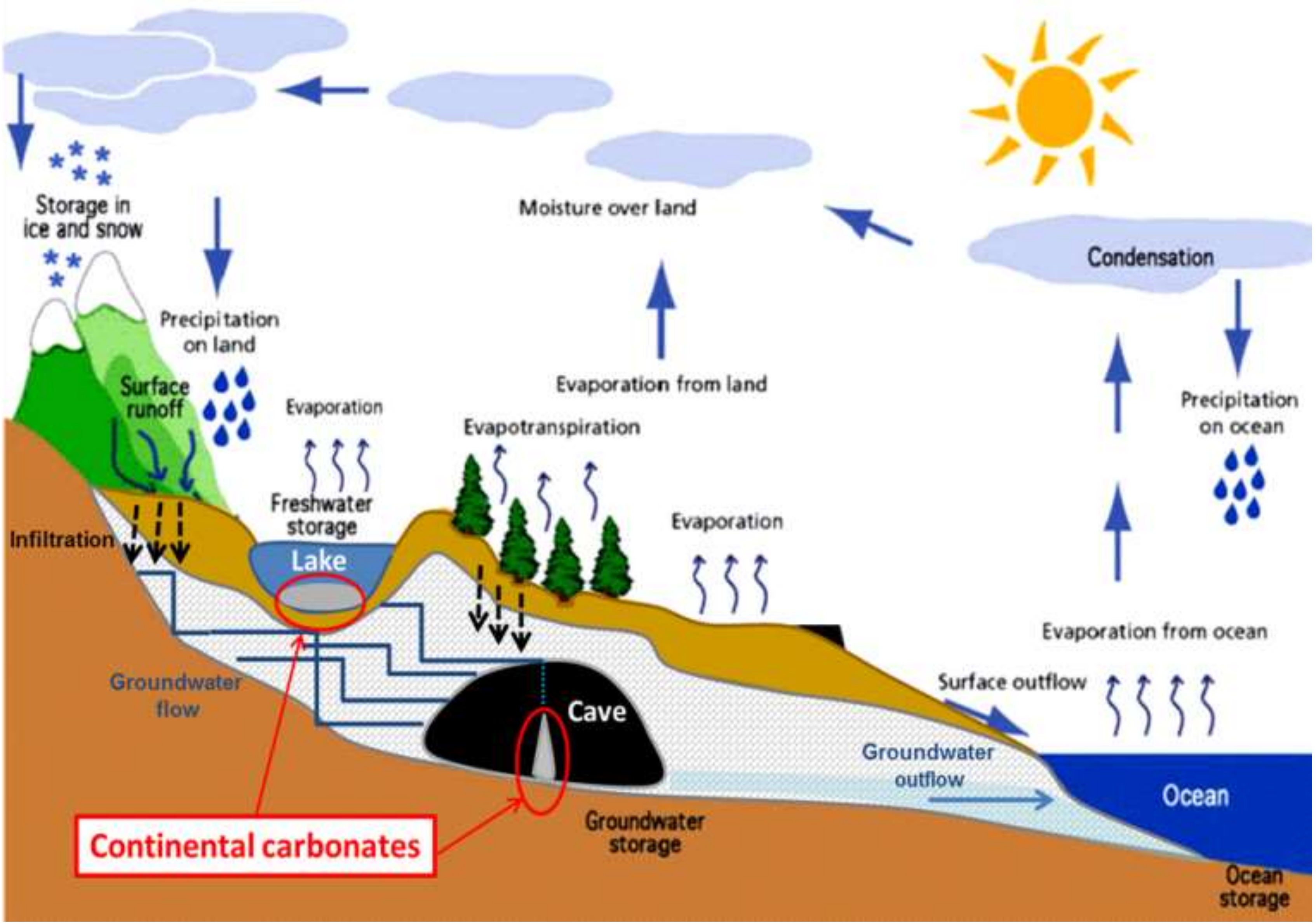
Why past interglacials?

Reconstruction of past interglacials variability

- Understand the sensitivity of the Earth system to different forcings
- Clarify where we are in the natural progression of events
- Explore the background of natural variability in which human-induced changes operate

High resolution, well dated and globally representative paleoclimatic records are required

Our case studies: high resolution, multiproxy records from caves and lakes of central Mediterranean sites covering past interglacial periods

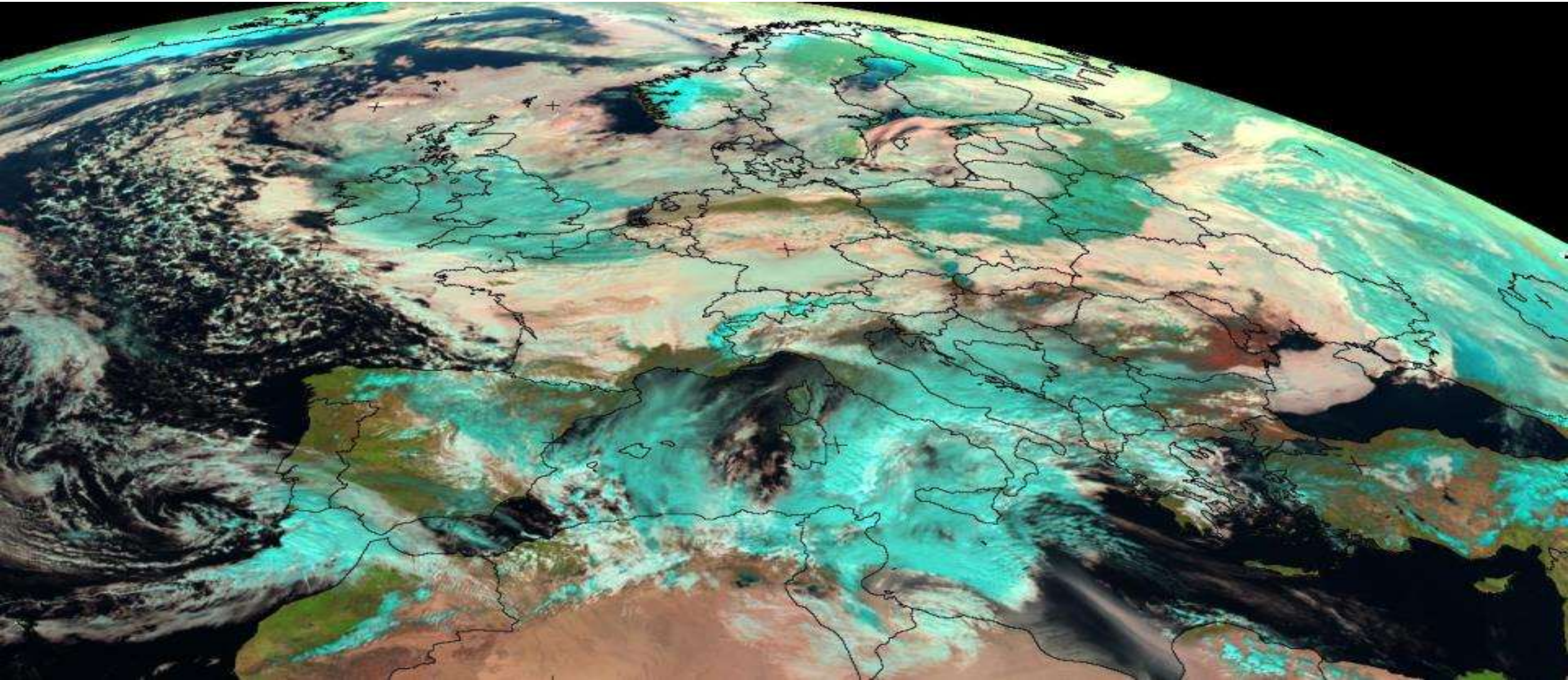


Speleothem: Cave chemical deposits

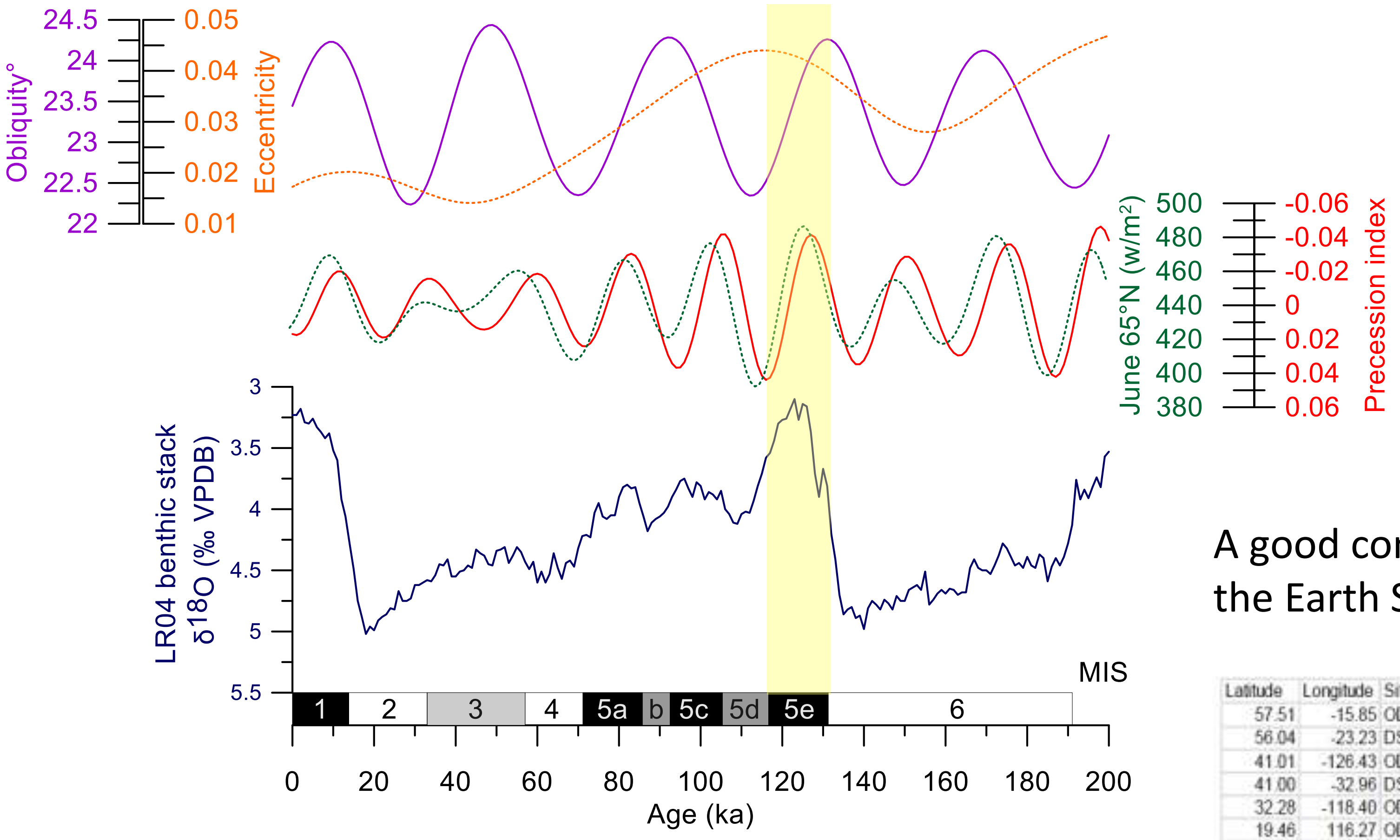
Marl lake deposits: Bio-mediated carbonates

Continental carbonates are powerful climatic archives.
Many properties sensitive to hydrological and environmental variability

Oxygen isotopes provide one of the best tracers of the Mediterranean hydrological cycle
Particularly sensitive to variations in the amount of rainfall



The Last Interglacial period (129-110 ka):



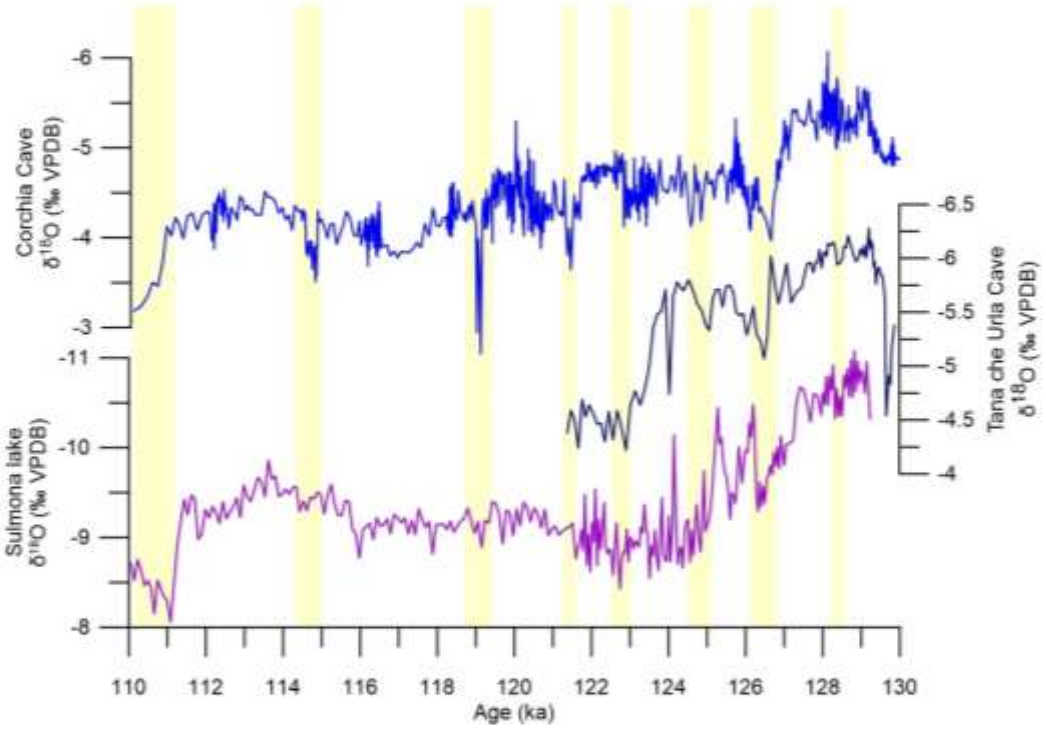
Global average warming of ~ 1 to 2°C relative to pre-industrial (2 to 4 °C in high northern latitudes)

A good context in which study the interactions occurring in the Earth System during warmer-than-present conditions.

Latitude	Longitude	Site		1	5e	7c	7e	9e	11c	13a	15a	15e	17c	19c	Ref
57.51	-15.85	ODP 982	A	15.0	16.2	15.0	14.5	15.8	15.0	13.7	14.1	14.4	14.2	14.1	l
56.04	-23.23	DSDP552s	A	15.0	15.1	17.3	14.7	14.2	16.4	12.4	14.7	16.0	18.3	14.7	m
41.01	-126.43	ODP 1020	P	11.1	14.1	12.2	11.7	12.8	14.0	10.2	12.5	11.5	13.6	12.1	n
41.00	-32.96	DSDP 607s	A	23.1	25.1	22.7	20.5	23.6	26.8	22.3	20.3	22.9	25.2	24.0	o
32.28	-118.40	ODP1012	P	16.8	19.5	18.9	17.7	19.7	19.1	17.5	18.3	19.4	19.3	18.0	p
19.46	116.27	ODP 1146	P	26.5	27.3	26.6	26.3	27.3	26.8	26.1	26.3	27.2	26.9	26.2	q
16.62	59.80	ODP 722	I	26.5	27.7	27.3	27.3	27.5	27.5	27.0	27.1	27.4	27.2	27.2	q
9.36	113.29	ODP1143	P	28.1	28.8	28.3	27.8	28.6	28.3	28.4	28.1	28.7	28.6	28.2	r
4.03	-95.05	HY04	P	26.5	27.2	26.9	26.6	26.7	26.3	26.5	26.2	26.0	26.4		s
2.04	141.76	MD97-2140	P	28.1	29.5	28.2	28.6	29.0	29.5	28.6	28.4	28.6	29.3	28.9	t
0.32	159.36	ODP 806B	P	29.2	29.6	29.1	29.2	28.8	30.2	28.2	29.4	28.7	29.0	29.4	u
-3.10	-90.82	ODP 846	P	23.2	25.1	23.9	24.0	23.8	24.0	23.6	23.7	23.5	23.7	23.7	v
-41.79	-171.50	ODP 1123	P	16.6	17.7	18.2	19.0	19.6	19.3	17.8	18.8	17.4	18.0	17.9	w
-42.91	8.90	ODP 1090	A	14.5	17.1	12.7	10.2	14.7	13.9	10.2	11.7	12.1	11.1	10.4	x
-43.45	167.90	MD06-2986	P	16.1	18.0	15.9	16.5	16.6	18.1	15.5	16.2	16.4	16.3	15.8	y
-45.52	174.95	DSDP594	P	14.2	18.3	14.0	7.1	9.5	17.5	10.0	11.7	11.5	12.1	9.7	z
-54.37	-80.08	PS75/034-2	P	8.8	10.3	7.6	8.7	8.6	8.8	6.5	7.8	8.6			aa
-75.10	123.35	Dome C δD		-392	-370	-402	-379	-371	-382	-403	-397	-398	-403	-393	ab

Paleoclimate records from the North Atlantic and the Mediterranean shows millennial-scale events of climate instability

The three records from central Italy show a coherent hydrological framework, and several drier events within the Last Interglacial



wetter

drier

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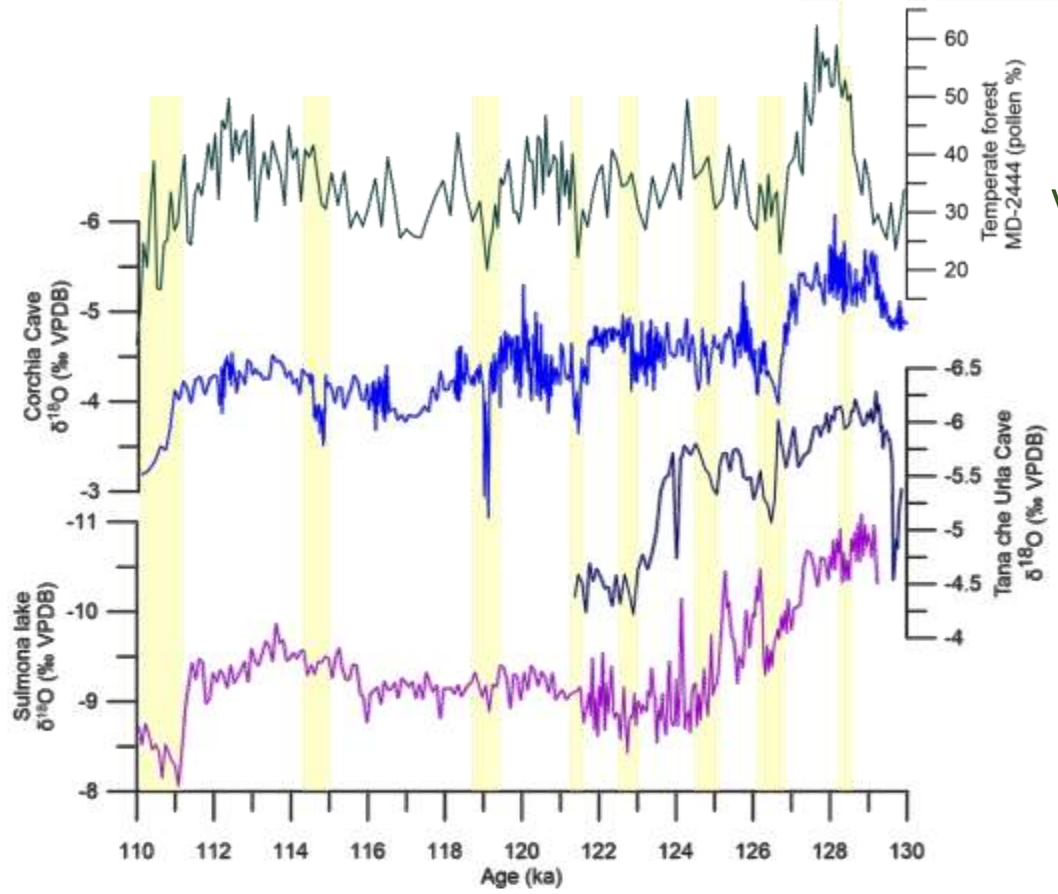
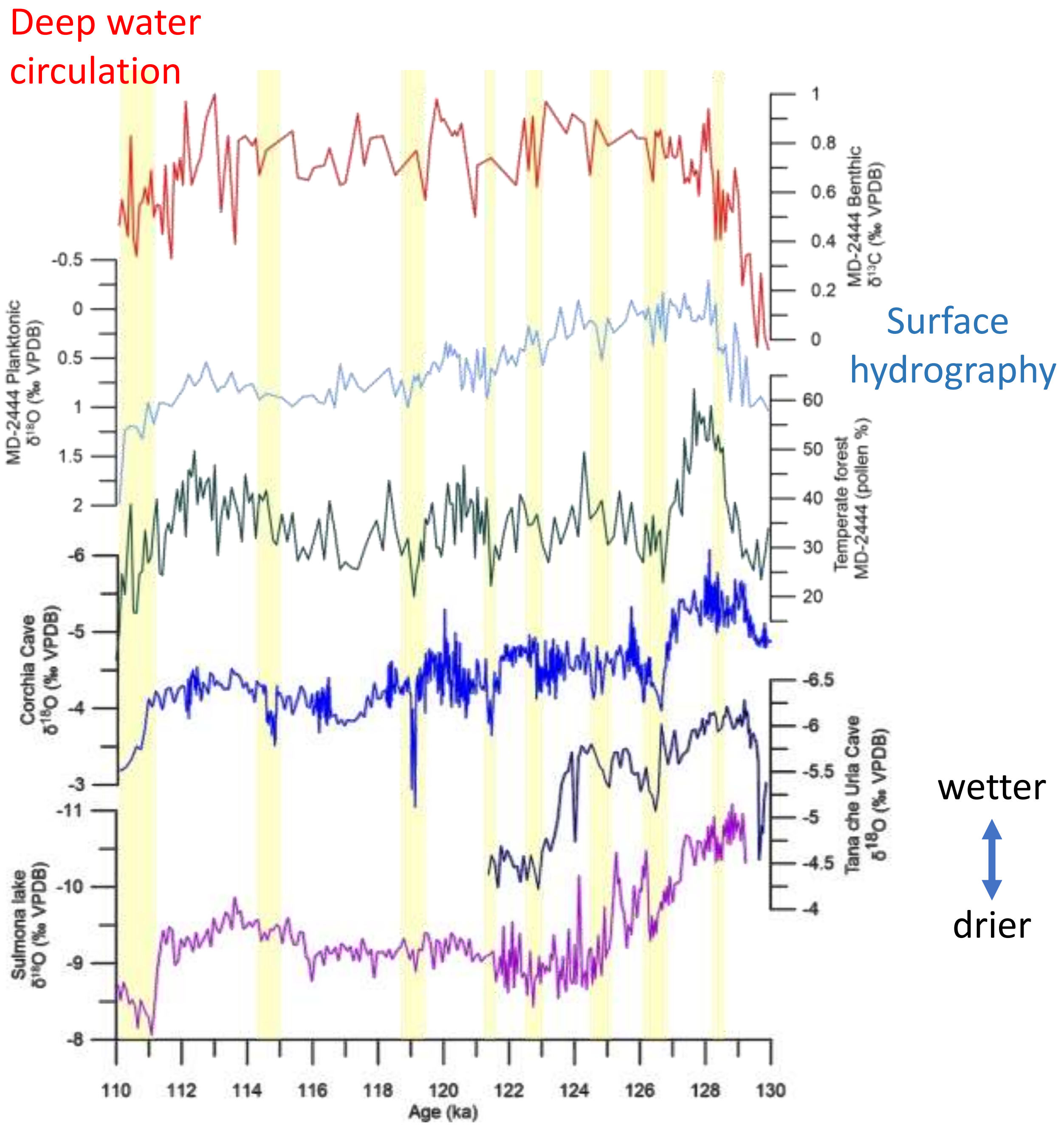
These drier events corresponds to reductions of arboreal vegetation in western Iberia, identified from pollen content in a marine core



Arboreal vegetation MD2444

wetter

drier



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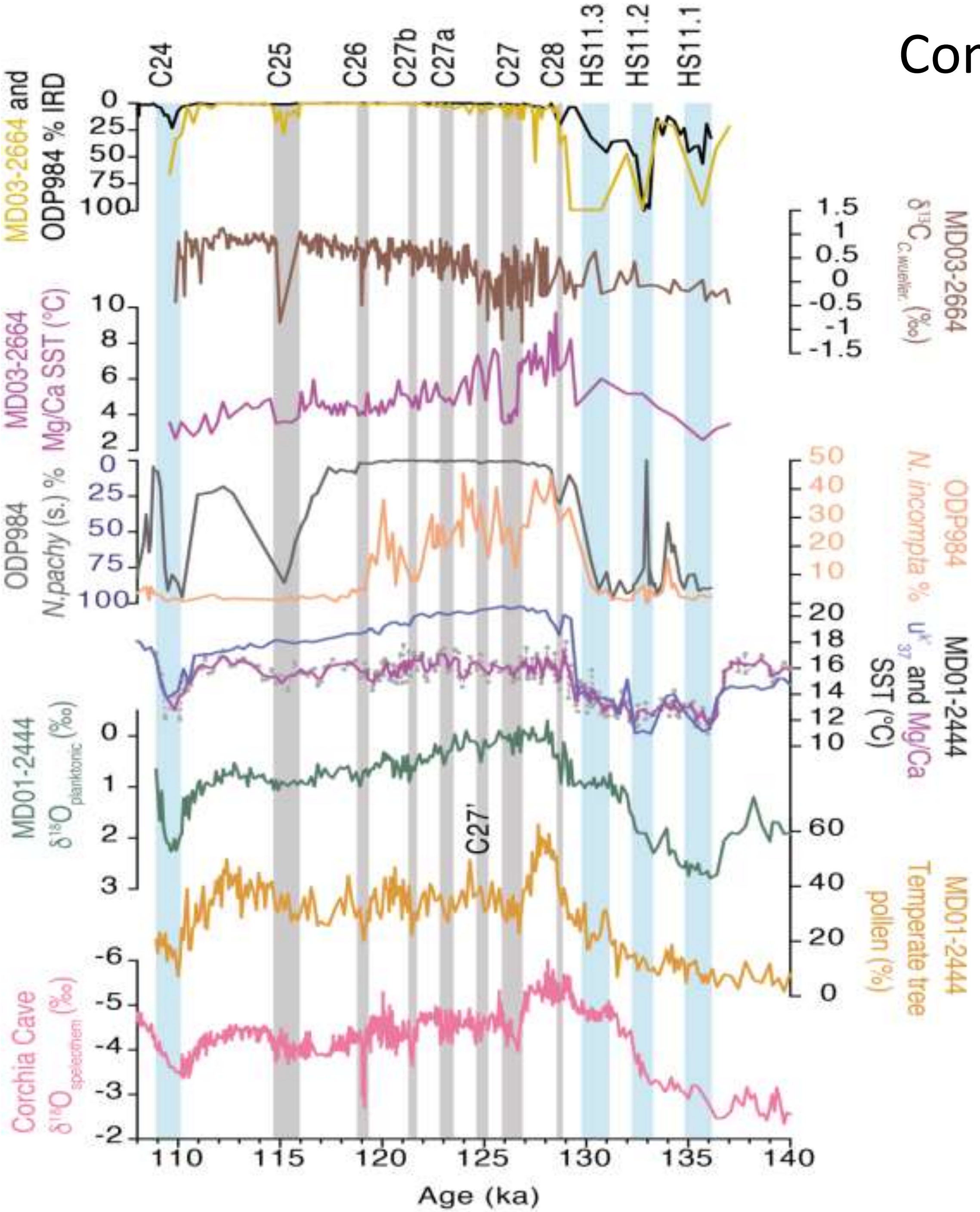
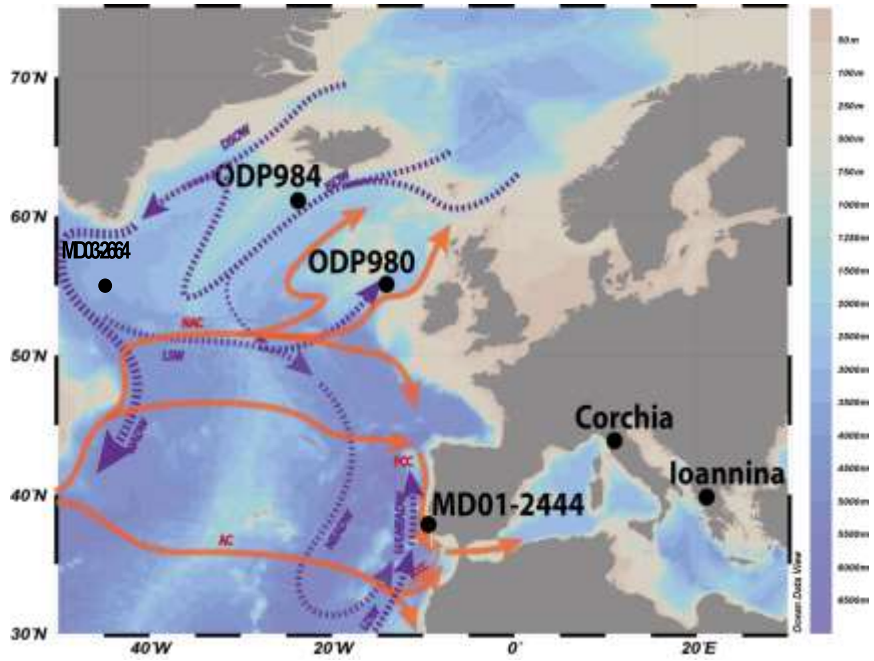
These events can be also tracked in marine proxies from the same core and appear to correspond to perturbations in surface hydrography and in deep water ventilation

Comparison with northern North Atlantic records



The same events are present also in marine records from the Northern North Atlantic

The multi-centennial mid-to-high latitude North Atlantic surface coolings point to significant reorganizations (weakening) of North Atlantic circulation (AMOC)



CONCLUSION:

Our records document a series of multi-centennial intra-interglacial arid events in southern Europe, coherent with cold water-mass expansions in the North Atlantic.

The spatial and temporal fingerprints of these changes indicate a reorganization of ocean surface circulation, consistent with low-intensity disruptions of AMOC

Climate numerical simulations suggest that episodic Greenland ice melt and runoff, as a result of excess warmth, may have contributed to short-term AMOC weakening and increased climate instability throughout the Last Interglacial

This implies that a high warming of the high latitudes increases the possibility of occurrence of abrupt climatic changes, with "chain" effects that propagate at the hemispheric level and can also affect precipitation in the Mediterranean area

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THANK YOU FOR YOUR ATTENTION