Plio-Pleistocene dust flux variability in the Subantarctic Atlantic

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DUSTSPEC WORKSHOP – LDEO May 2010

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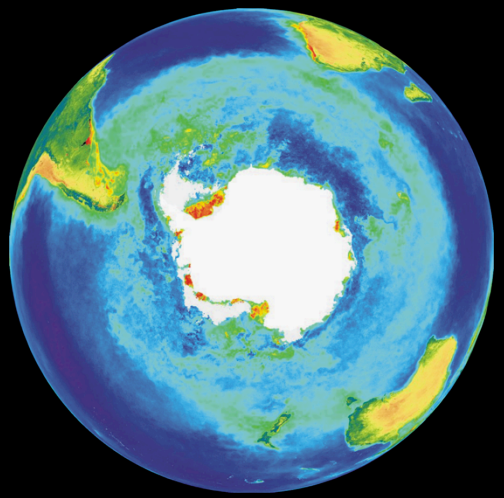
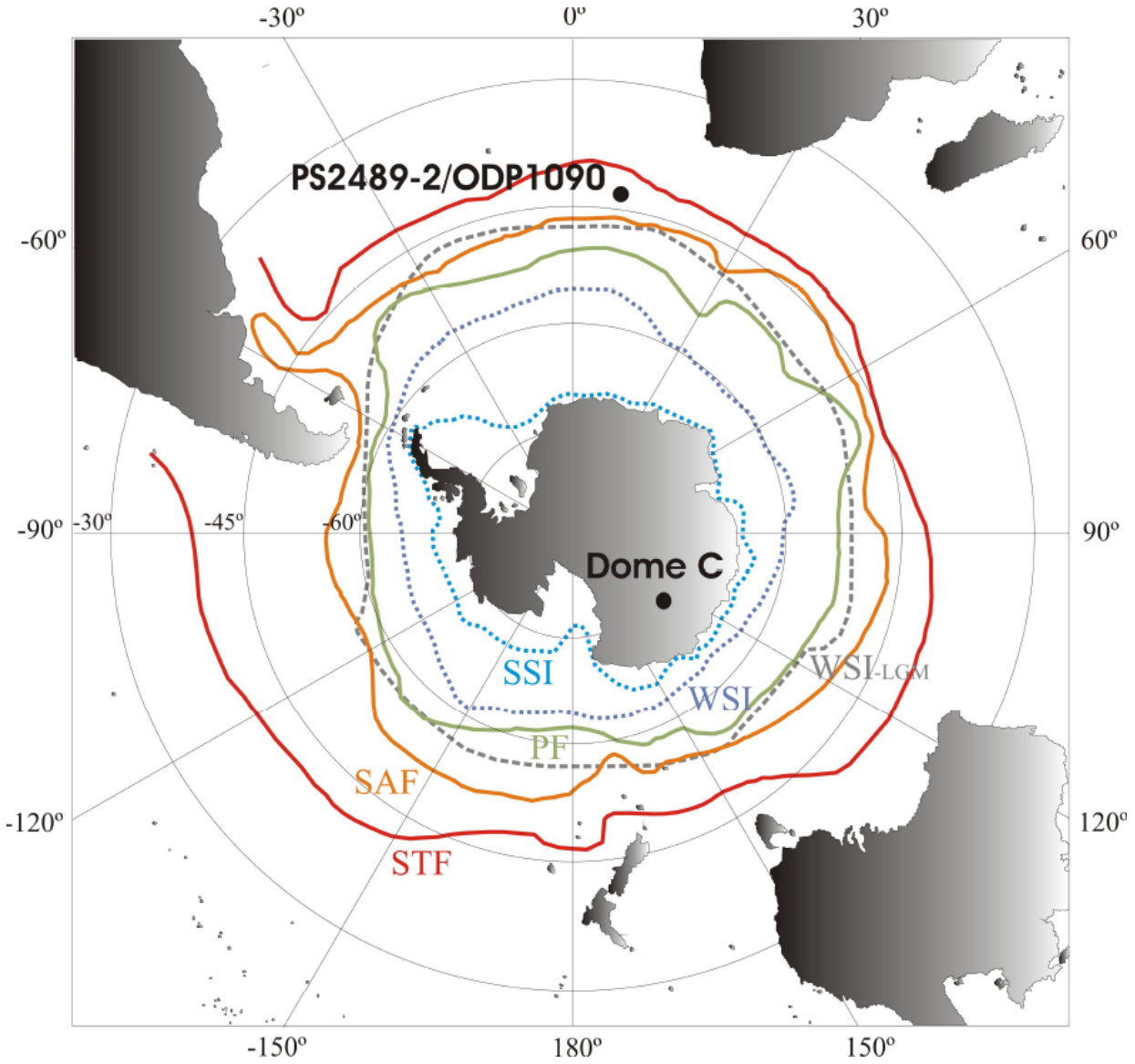
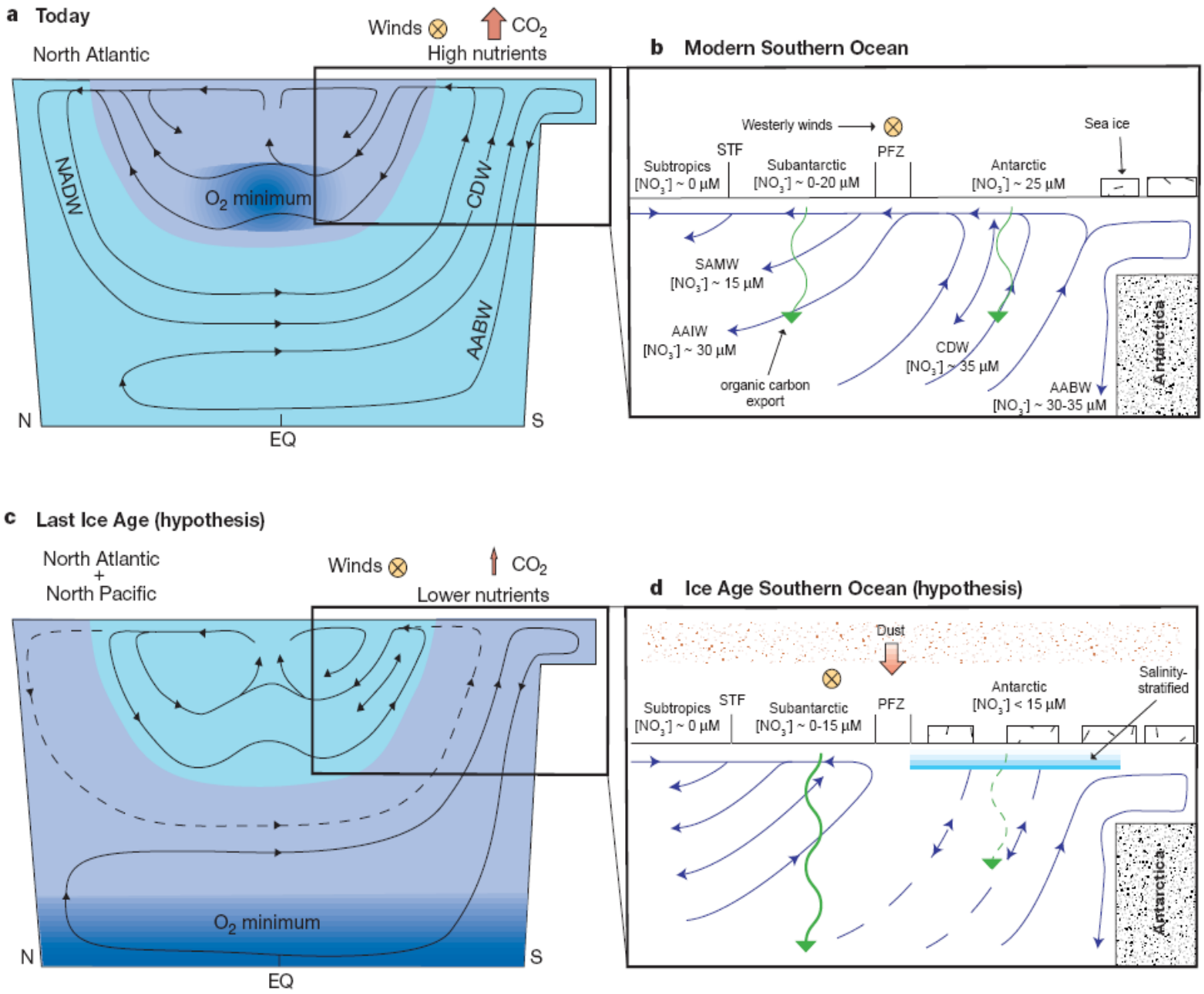


Site Location

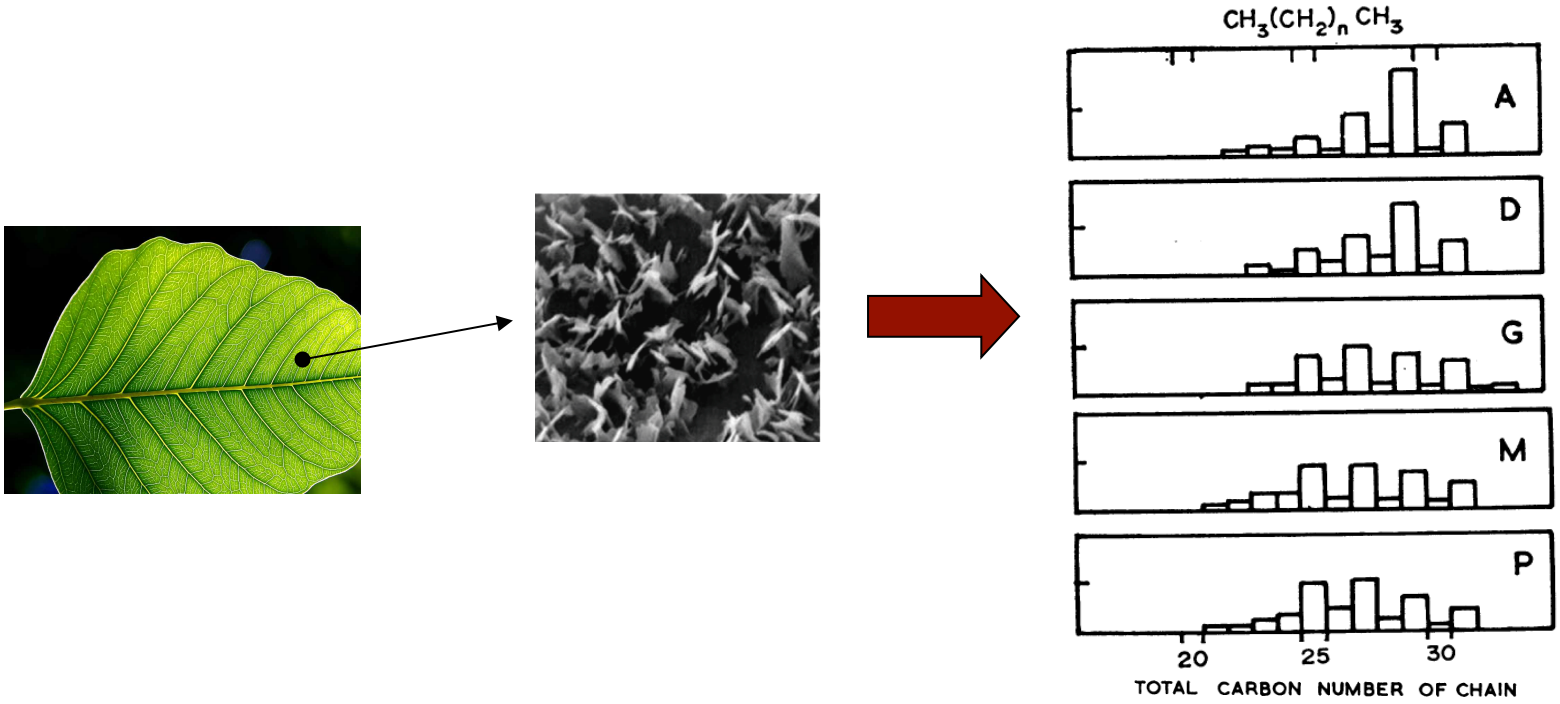




[*Sigman and Boyle, 2000, Nature*]

Dust Inputs

- Combined analysis of **long chain odd-carbon-numbered n-alkanes,** several inorganic tracers for lithogenic material (**Al**, **Fe** and **^{232}Th**), and **^{230}Th** as an **indicator of mass flux**.



[*Eglinton and Hamilton 1967, Science*]

Biogenic lipids in particulates from the lower atmosphere over the eastern Atlantic

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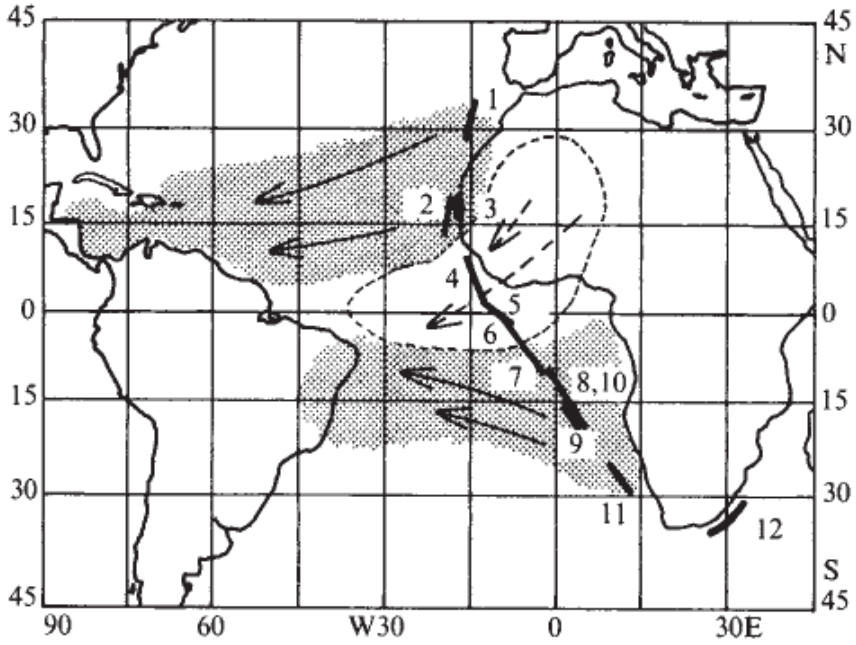
Abstract

Higher plant wax is demonstrated in aeolian dusts, showing the potential of aeolian transport in contributing significant amounts of terrestrial organic lipids to the marine environment over geological time periods.

Sample	Organic carbon (%)*	Total lipids (~μg per g of dust)	Total lipids (ng per m³ of air)	Approx. yield (μg g⁻¹)	*n*-Alkanes CPI†	*n*-Alkanes Max. at C no.‡
1	12	750	0.13	10	10.2	27
2	2	130	4.7	40	1.4	25, 29
3	2	460	10.0	400	7.5	27≃29
4	7	850	8.0	340	5.0	29
5	12	2,400	1.0	860	3.2	29
6	10	9,800	1.8	2,200	5.6	29
7	8	370	0.03	45	6.0	29≃
8	8	2,700	3.8	1,150	5.2	29≃31
9	8	270	0.08	120	6.5	29≃31
10	8	100	0.2	40	5.2	31
11	80	n.d.	n.d.	n.d.	—	hump
12	9	3,050	12.0	1,050	7.5	27



Nature **267**, 682-685 (1977)

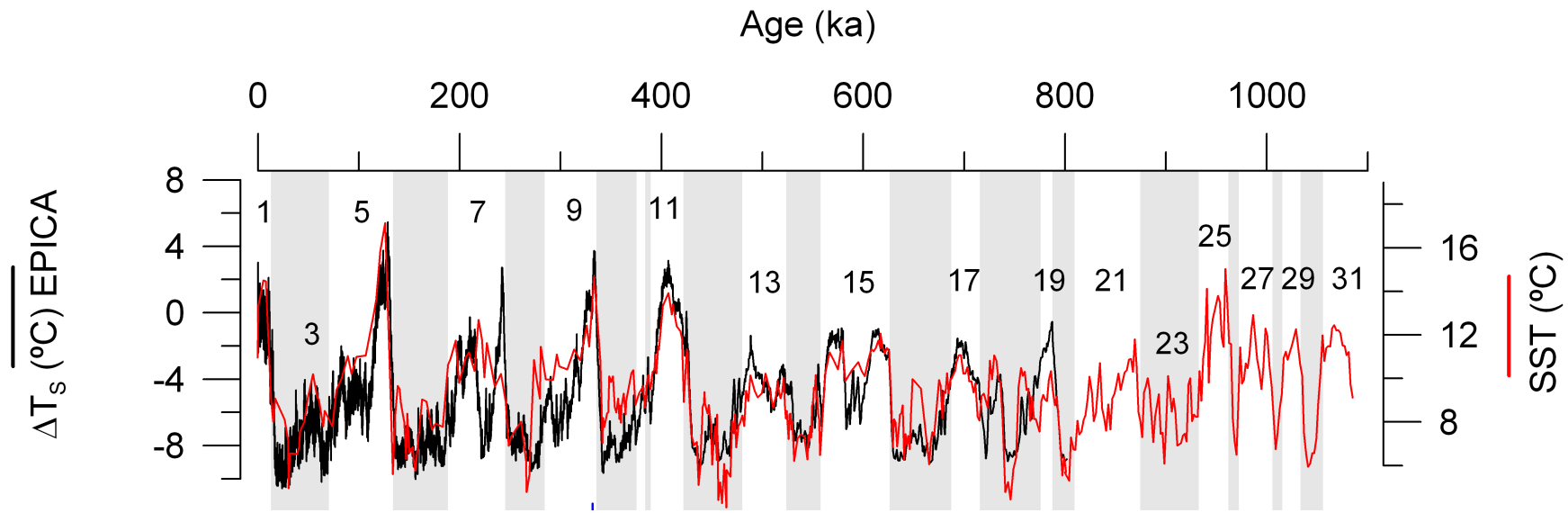
n-alkanes in marine sediments

- Chain length (expressed in C-atoms) indicative of origin
- CPI expresses odd over even dominance of chain length

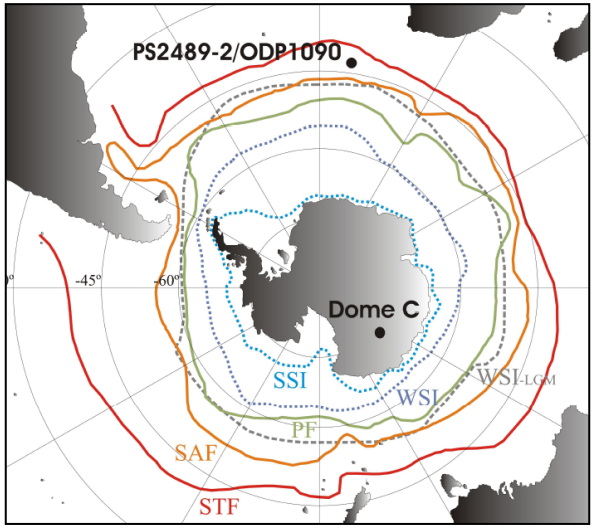
Organism	Environment	Dominant C	CPI	C range	Reference
Higher Plants	Terrestrial	C_{27}, C_{29} or C_{31}	High	15-57	[*Caldicott and Eglinton*, 1978]
Algae	Aquatic (pelagic)	C_{17}	High	15-19	[*Gelpi et al.*, 1970]
Blue-green algae	Aquatic (pelagic)	C_{17}	High	14-19	[*Blumer et al.*, 1971]
Brown algae	Aquatic (benthic)	C_{15}	Low	15-26	[*Youngblood and Blumer*, 1973]
Red algae	Aquatic (benthic)	C_{17}	Low	15-24	[*Youngblood et al.*, 1971]
Photo. bacteria	Aquatic (pelagic)	C_{17}, C_{26}	Low	14-29	[*Cranwell et al.*, 1987]
Non-photo bact.	Aquatic (benthic)	C_{17}-C_{20}	Low	15-29	[*Han and Calvin*, 1970]
Fungi	Terrestrial	C_{29}	-	25-29	[*Yen*, 1975]
Zooplankton	Aquatic(pelagic)	C_{17}, C_{18} & C_{24}	Low	18-54	[*Cranwell et al.*, 1987]
Rotifer Worms	Aquatic (benthic)	C_{24}	Low	20-52	[*Cranwell et al.*, 1987]
Insects	Terrestrial	-	High	21-55	[*Jackson and Blomquist*, 1976]

Martinez-Garcia, PhD Thesis

Marine vs Continental records - Temperature

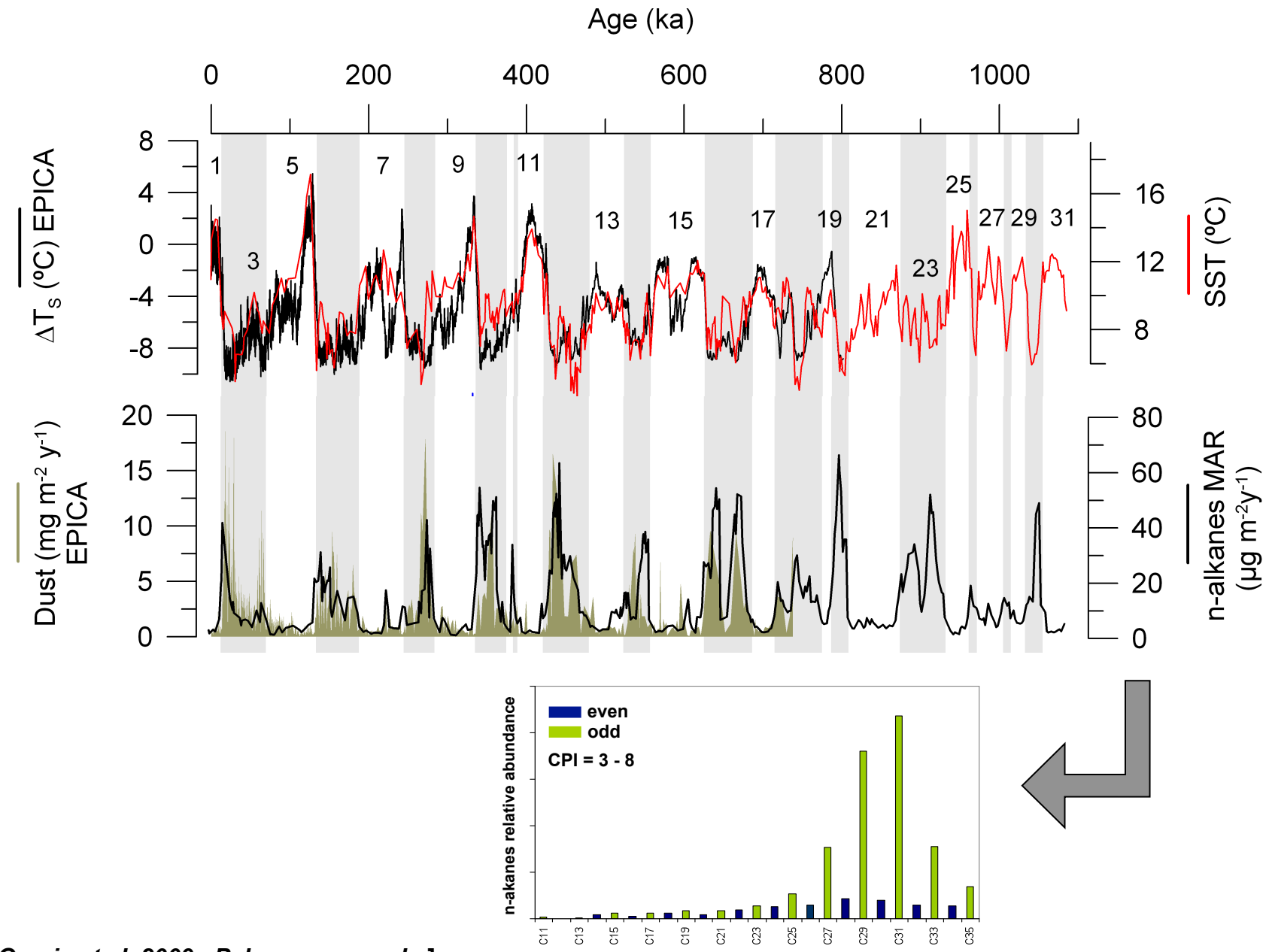


- **Atmospheric** and **Marine Temperatures** are closely **correlated** over the **last 800ky**



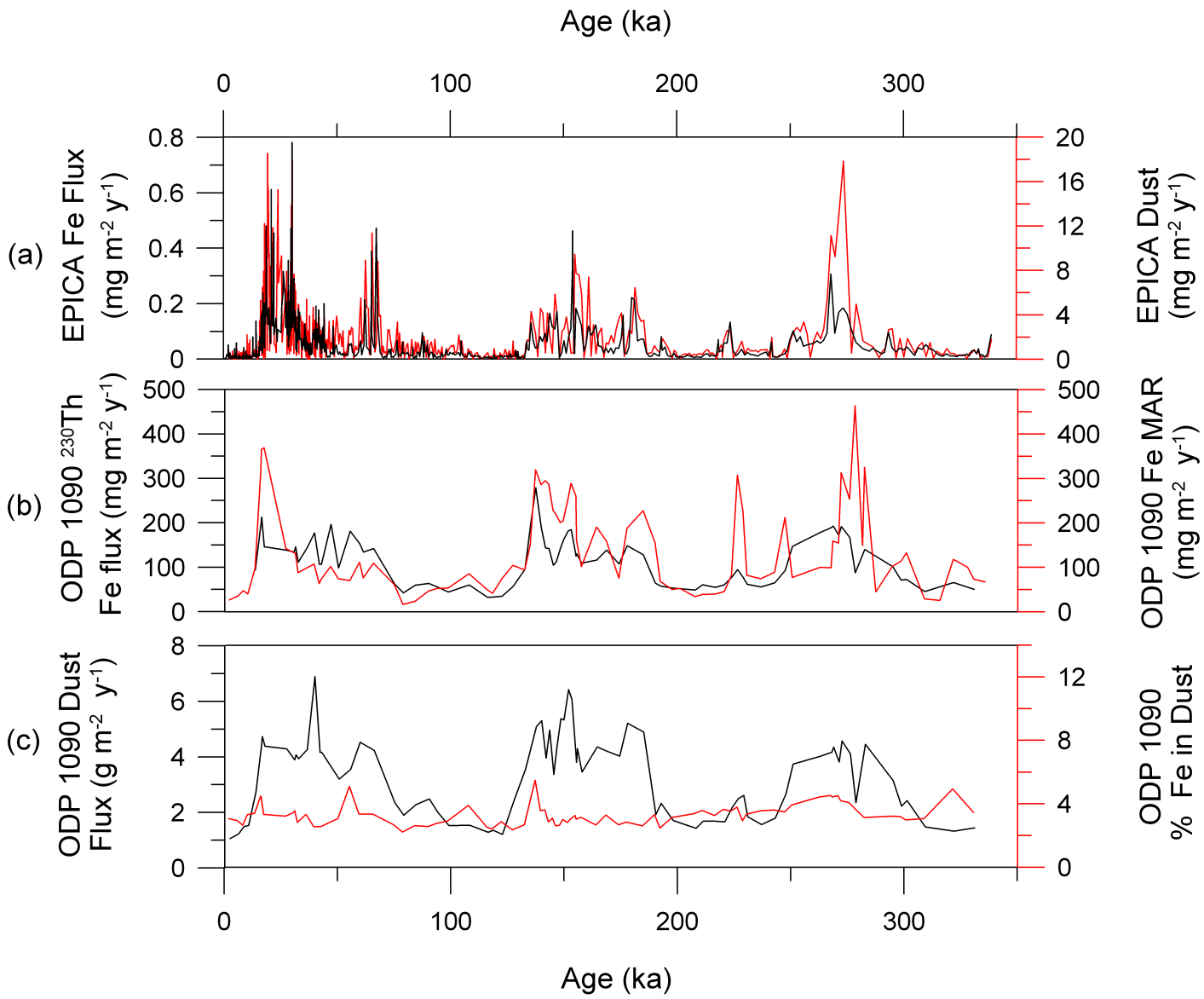
[*Martínez-Garcia et al, 2009 , Paleoceanography*]

Marine Vs Continental records – Dust fluxes



[*Martínez-Garcia et al, 2009 , Paleoceanography*]

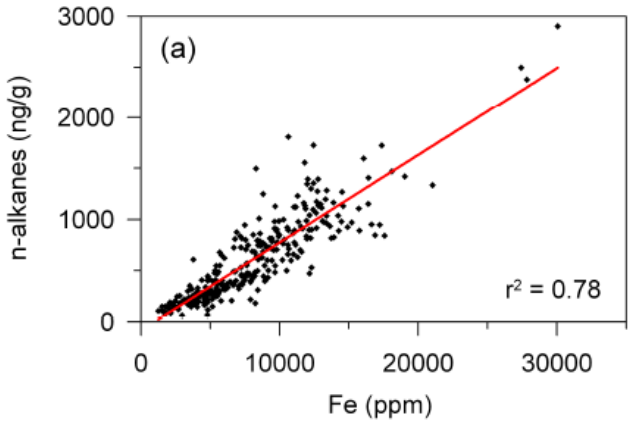
^{230}Th-normalized dust and Fe fluxes over the last 330 ka.

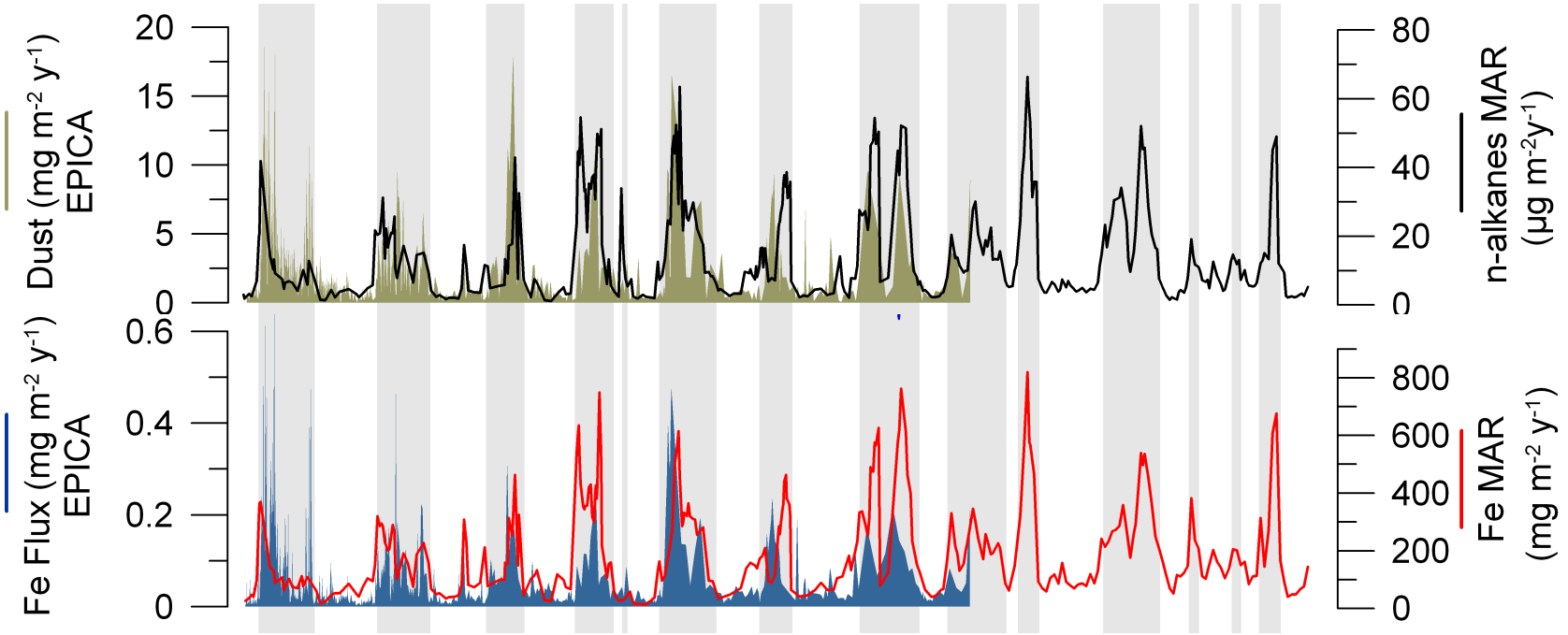


[*Martínez-Garcia et al, 2009 , Paleoceanography*]

Marine Vs Continental records – Dust & Fe fluxes

- **Dust** is the main source of **iron** to ODP Site 1090

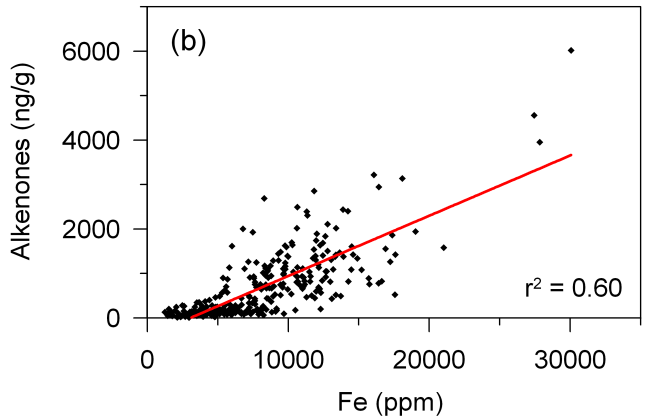


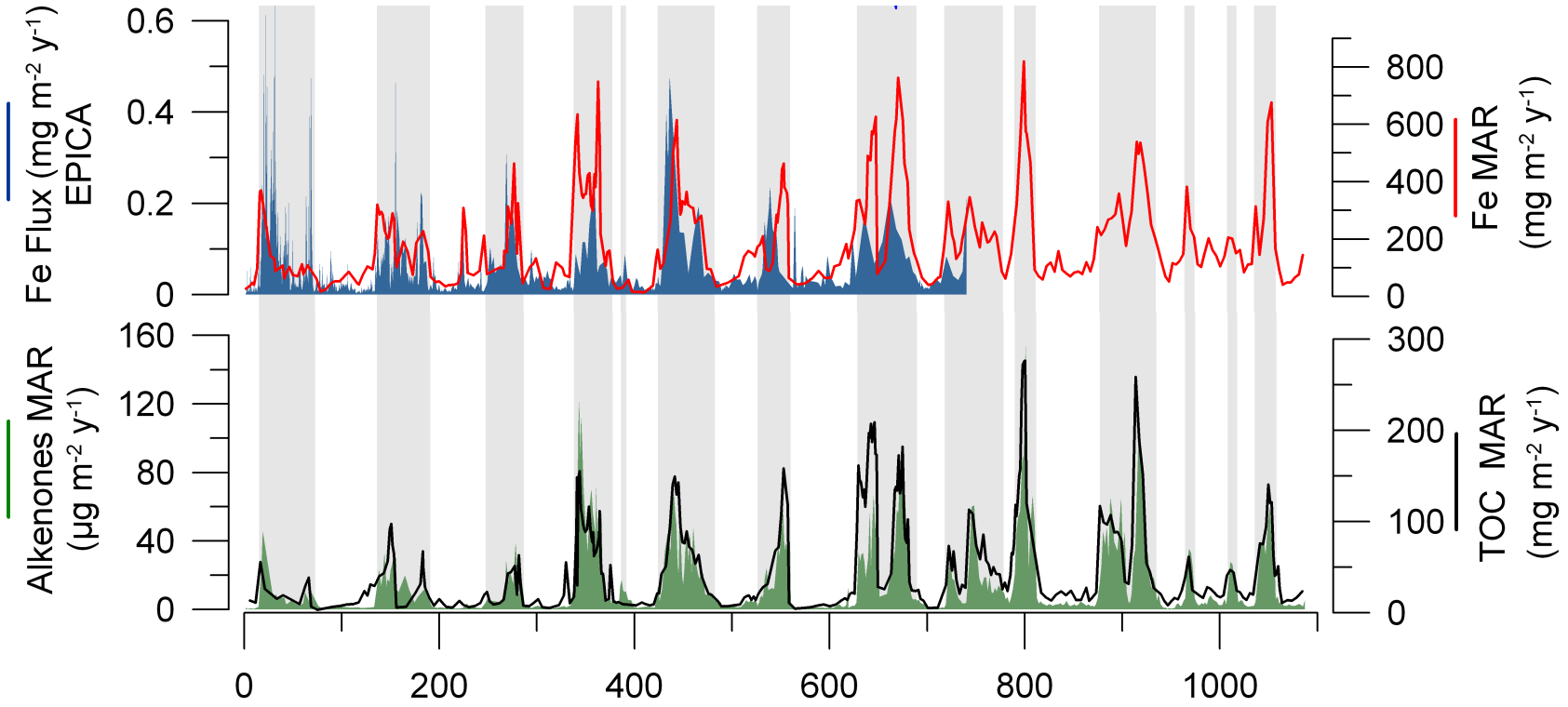


[*Martínez-Garcia et al, 2009 , Paleoceanography*]

Marine Vs Continental records – Dust & Fe fluxes

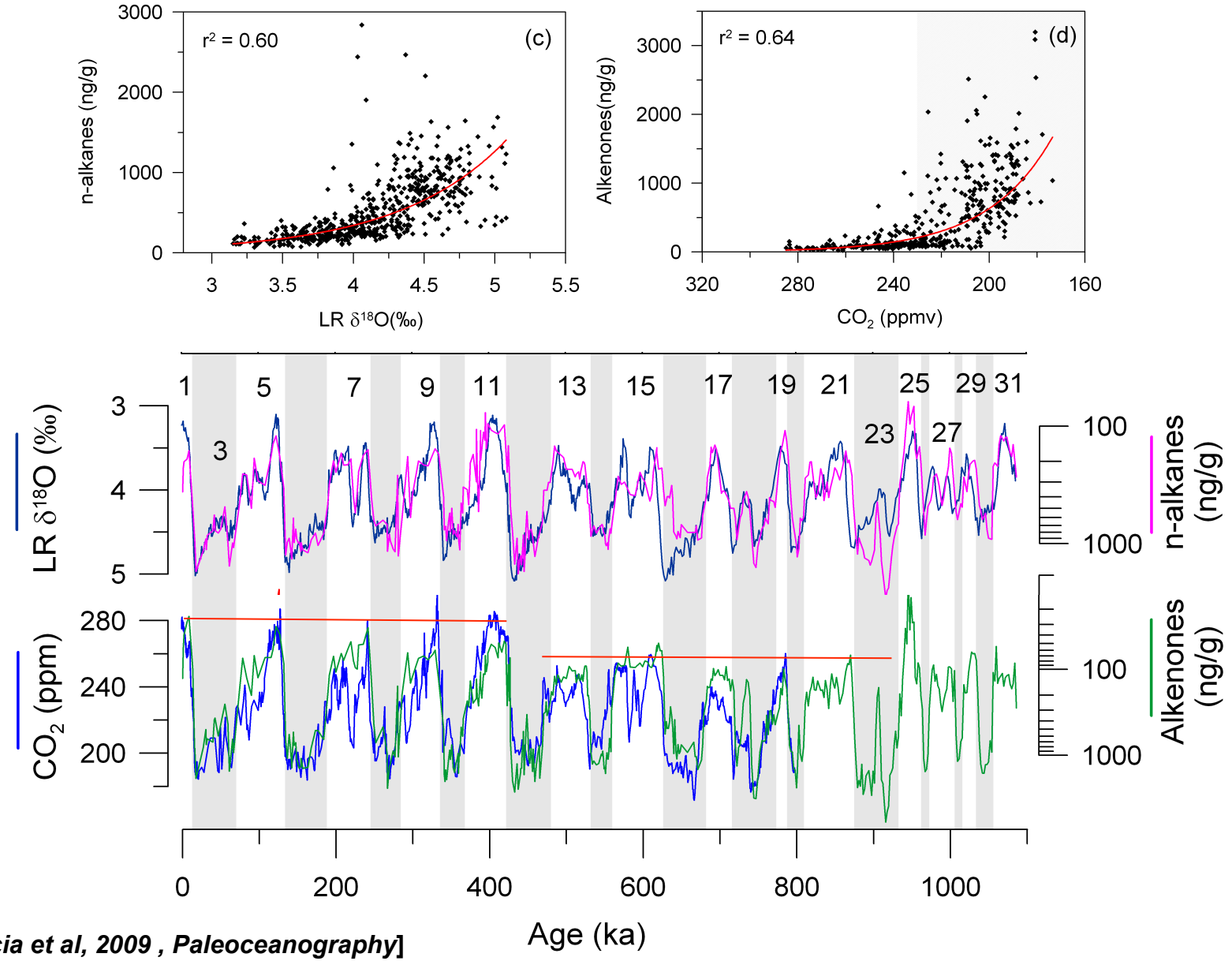
- The process of **iron fertilization** of **marine biota** has been a recurrent mechanism operating in the SAA in all the glacial stages of the last 1.1Ma





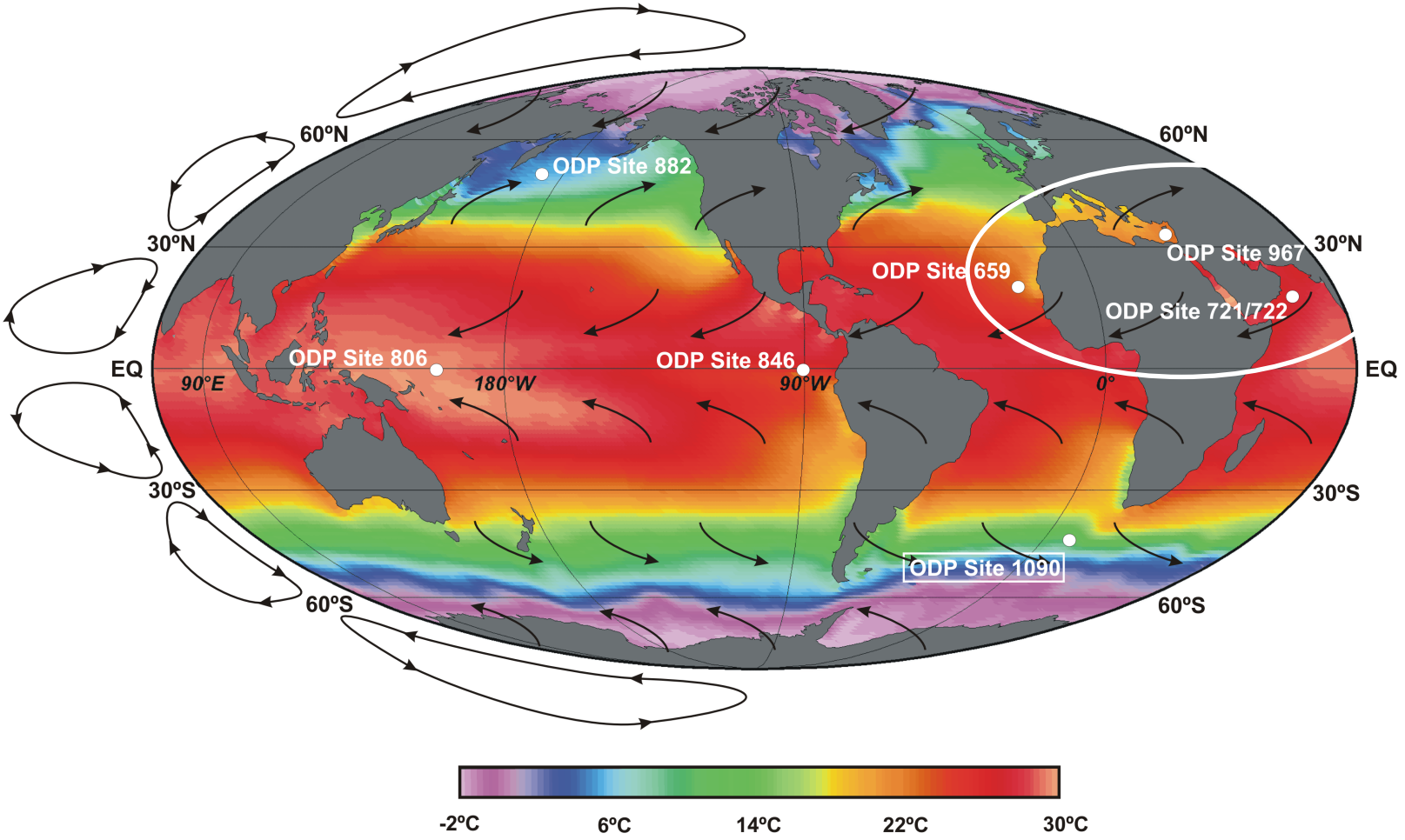
[*Martínez-Garcia et al, 2009 , Paleoceanography*]

- The relationship between **dust**, **export production** and **CO_2** is not linear, but exponential

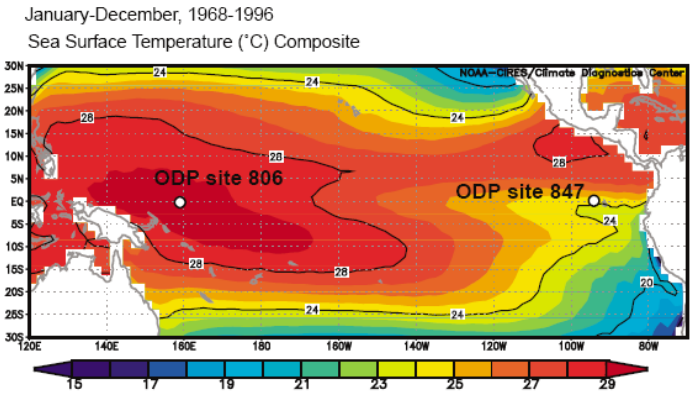


[*Martínez-Garcia et al, 2009 , Paleoceanography*]

SO Plio-Pleistocene dust-climate couplings

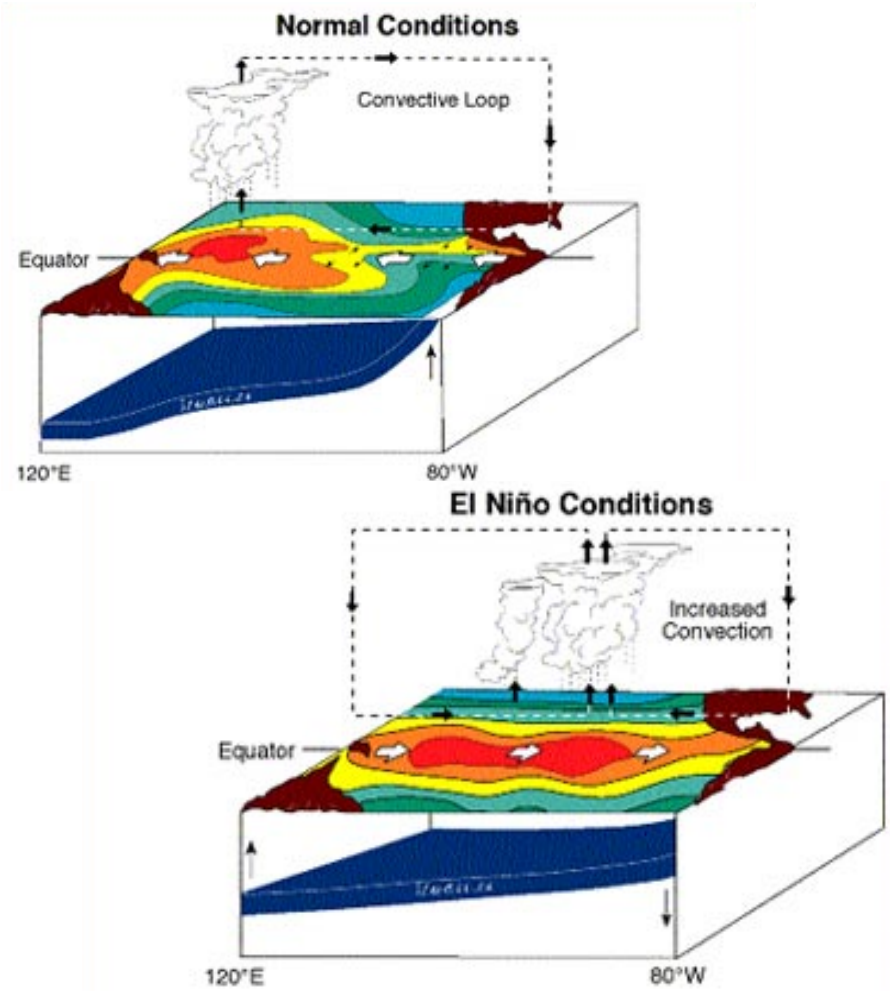


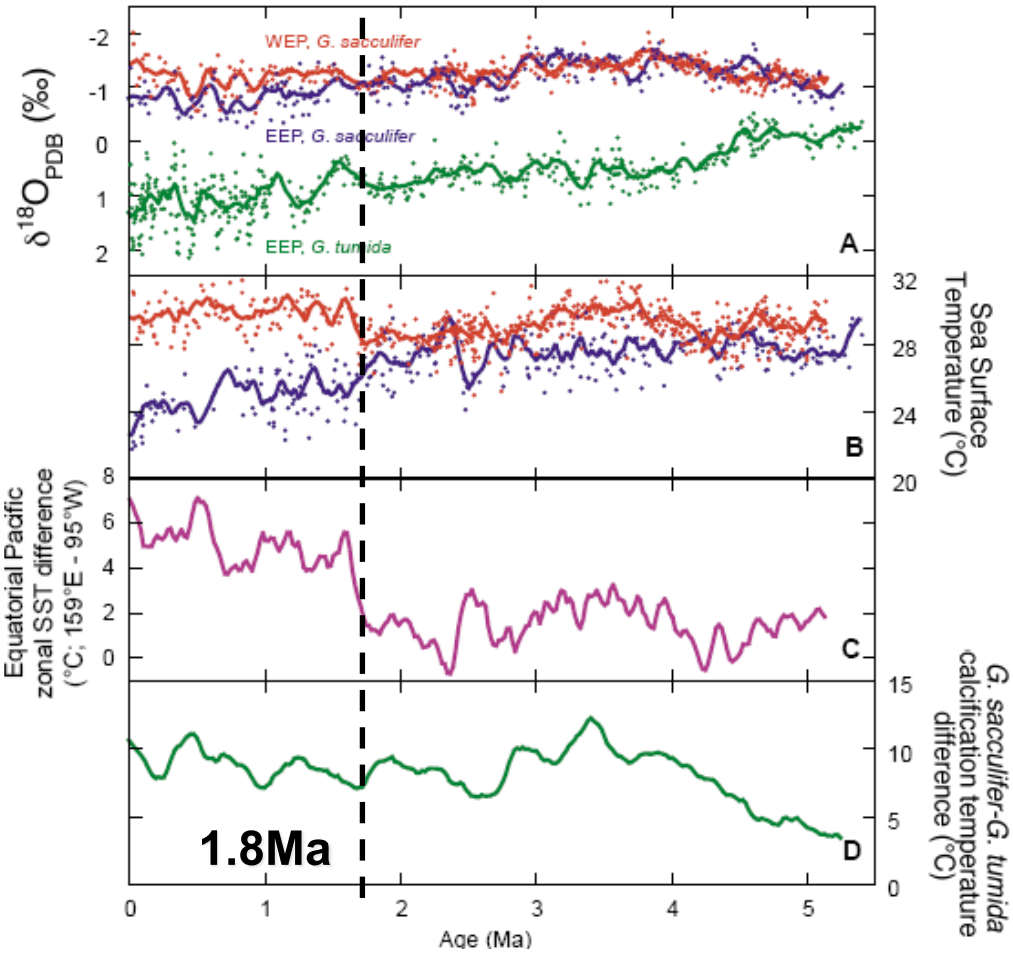
Plio-Pleistocene SO Dust



Permanent El Niño–Like Conditions During the Pliocene Warm Period

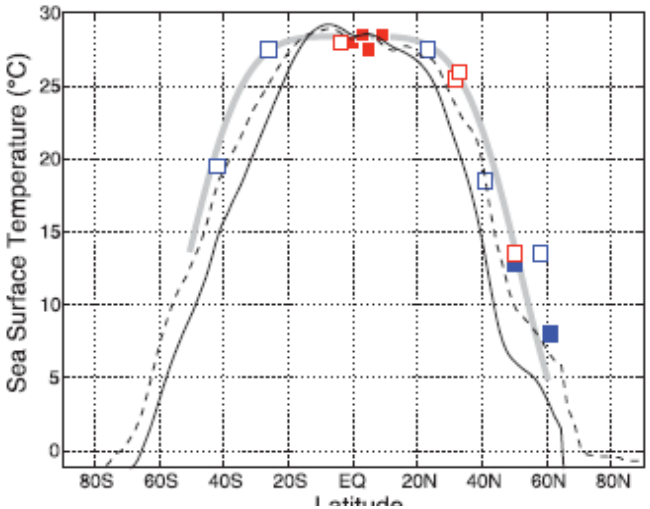
Michael W. Wara, Ana Christina Ravelo,* Margaret L. Delaney

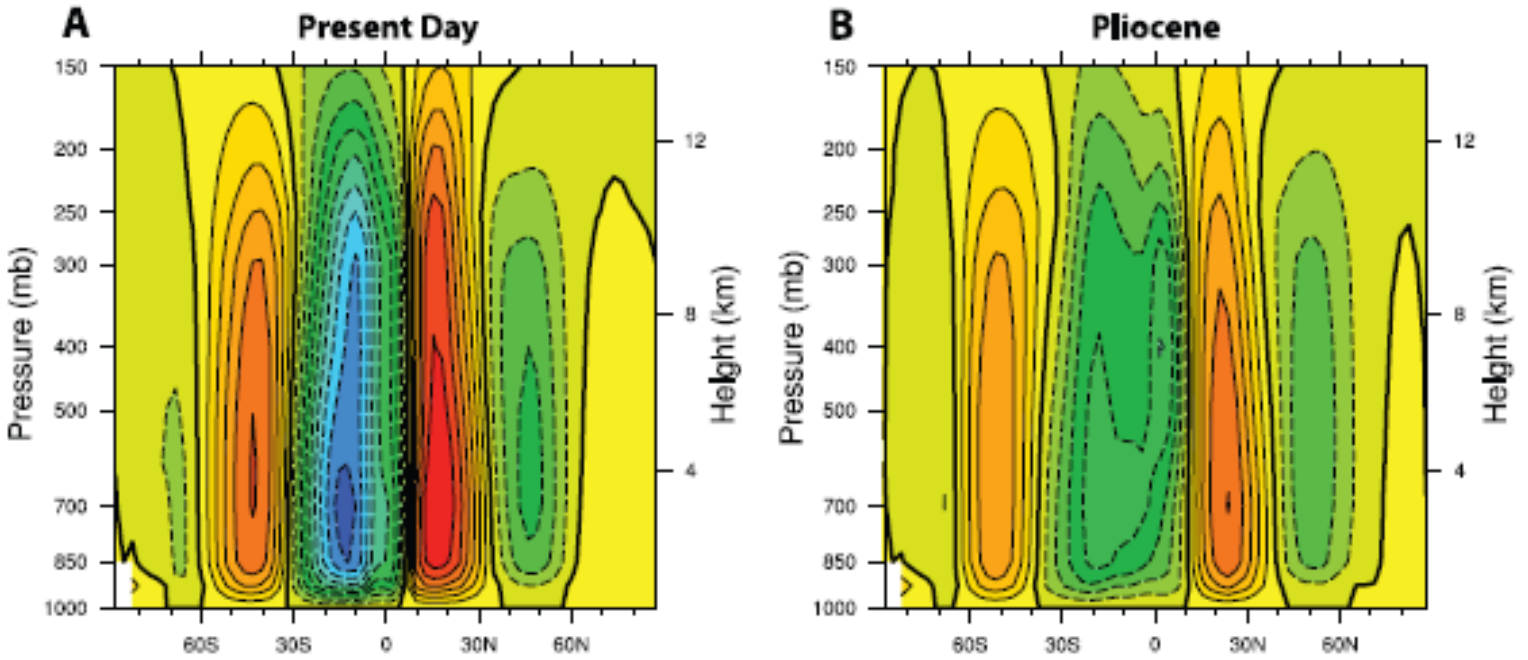


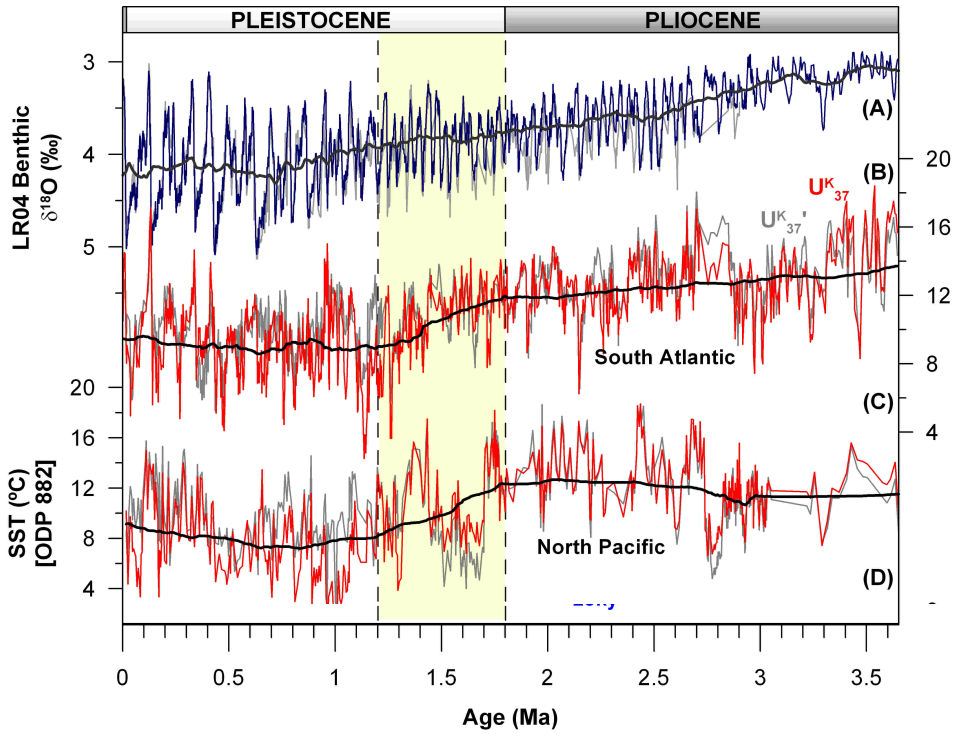


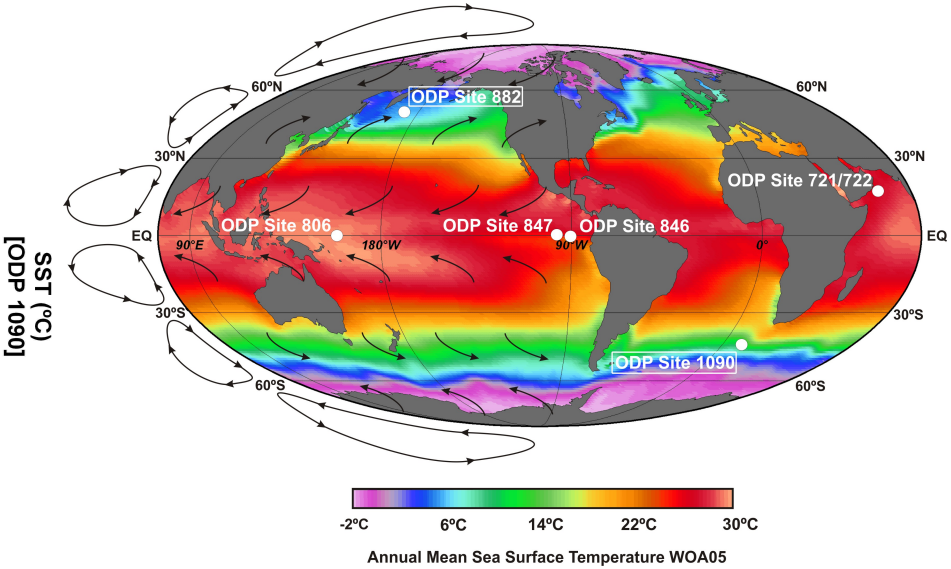
Greatly Expanded Tropical Warm Pool and Weakened Hadley Circulation in the Early Pliocene

Chris M. Brierley,[1]* Alexey V. Fedorov,[1]*† Zhonghui Liu,[2]* Timothy D. Herbert,[3] Kira T. Lawrence,[4] Jonathan P. LaRiviere[5]

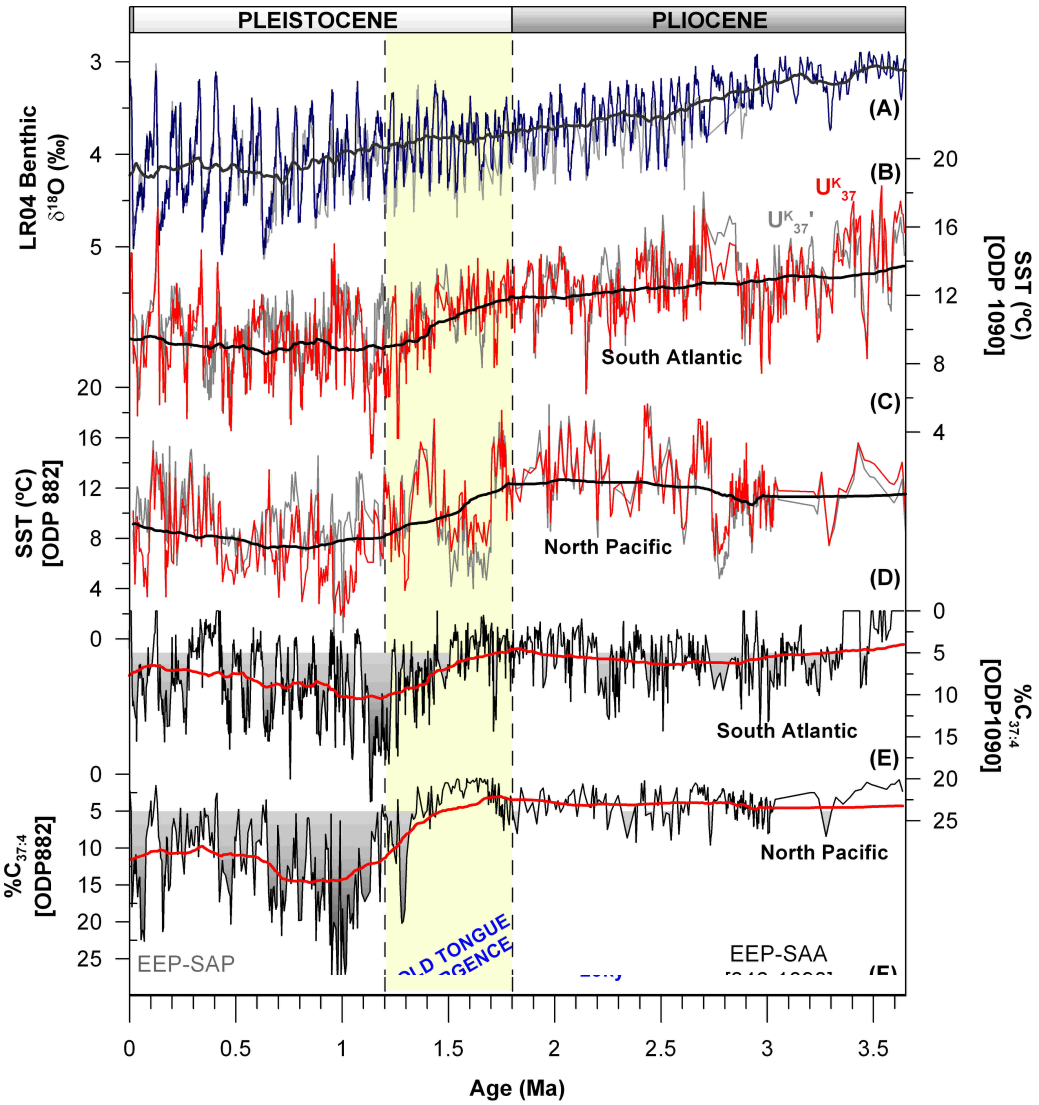




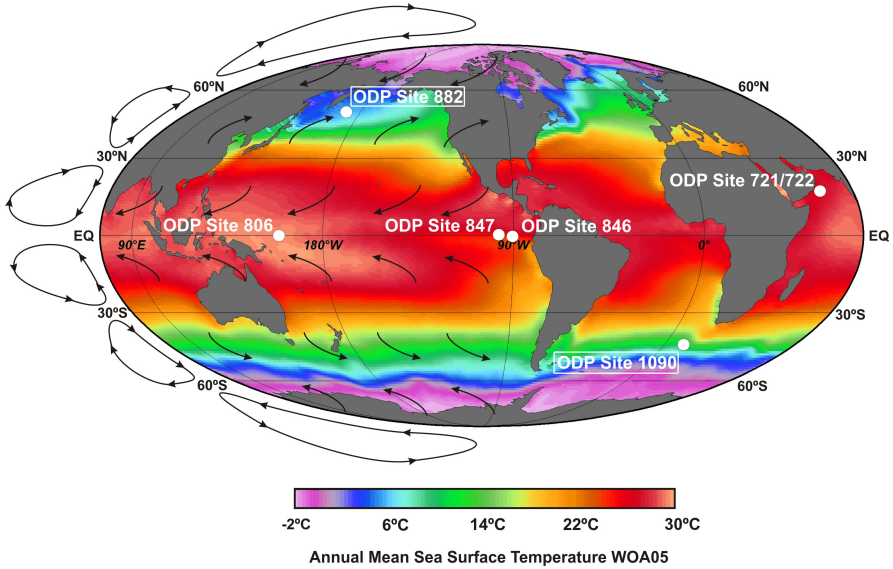


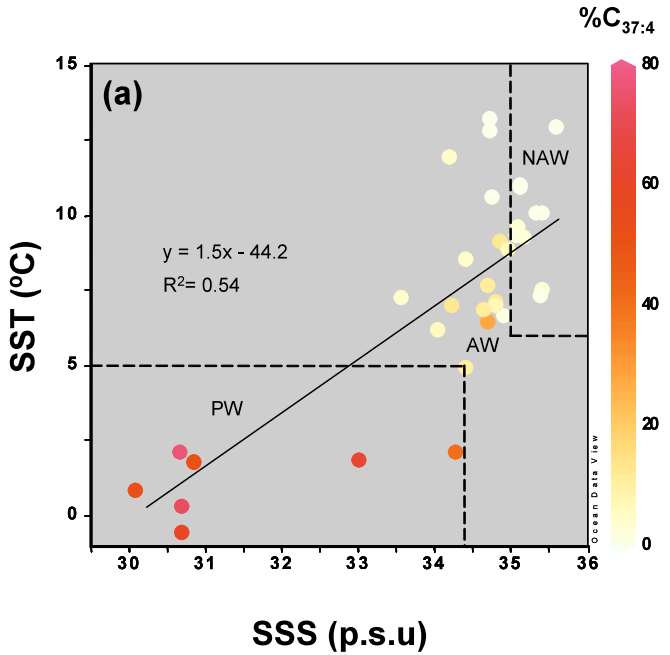


[*Martinez-Garcia et al, in press, Science*]

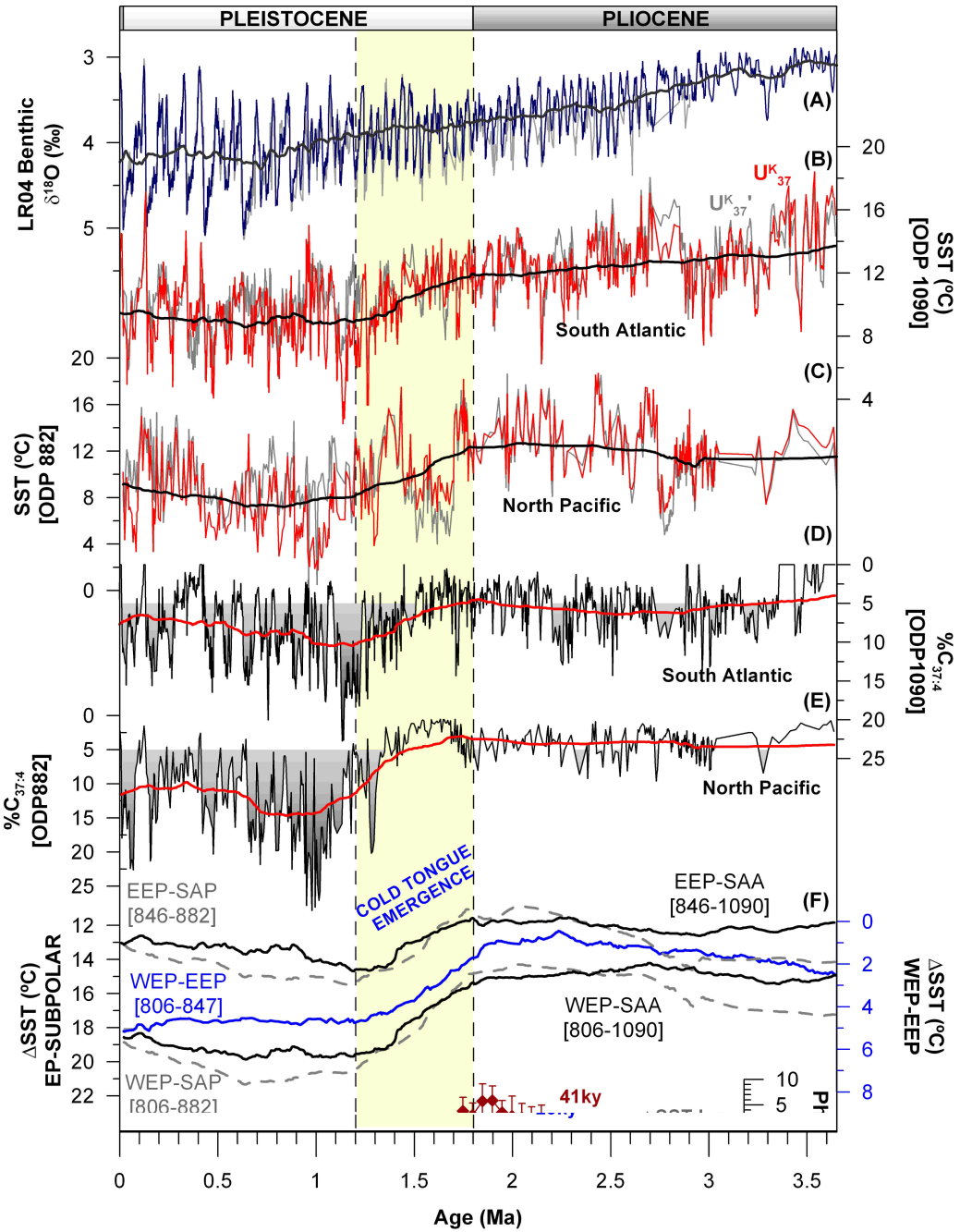


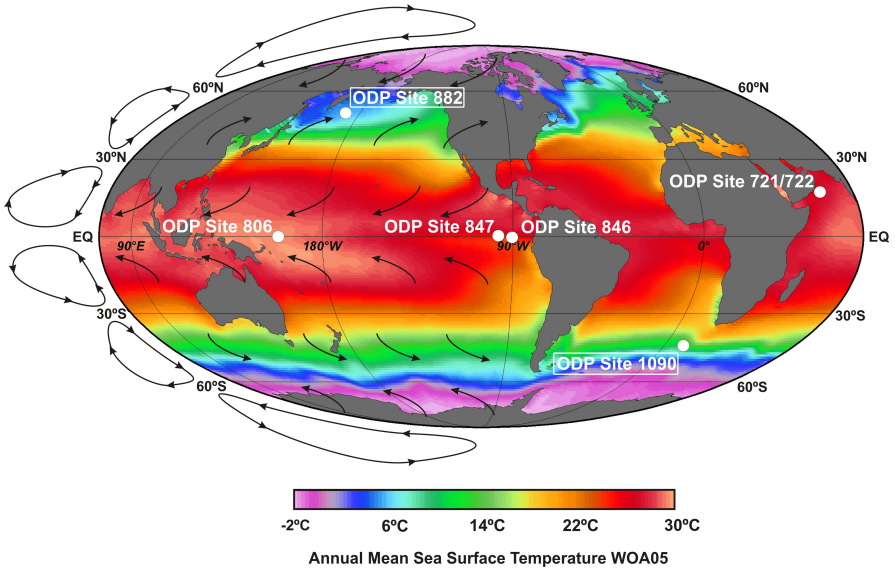
[*Martinez-Garcia et al, in press, Science*]





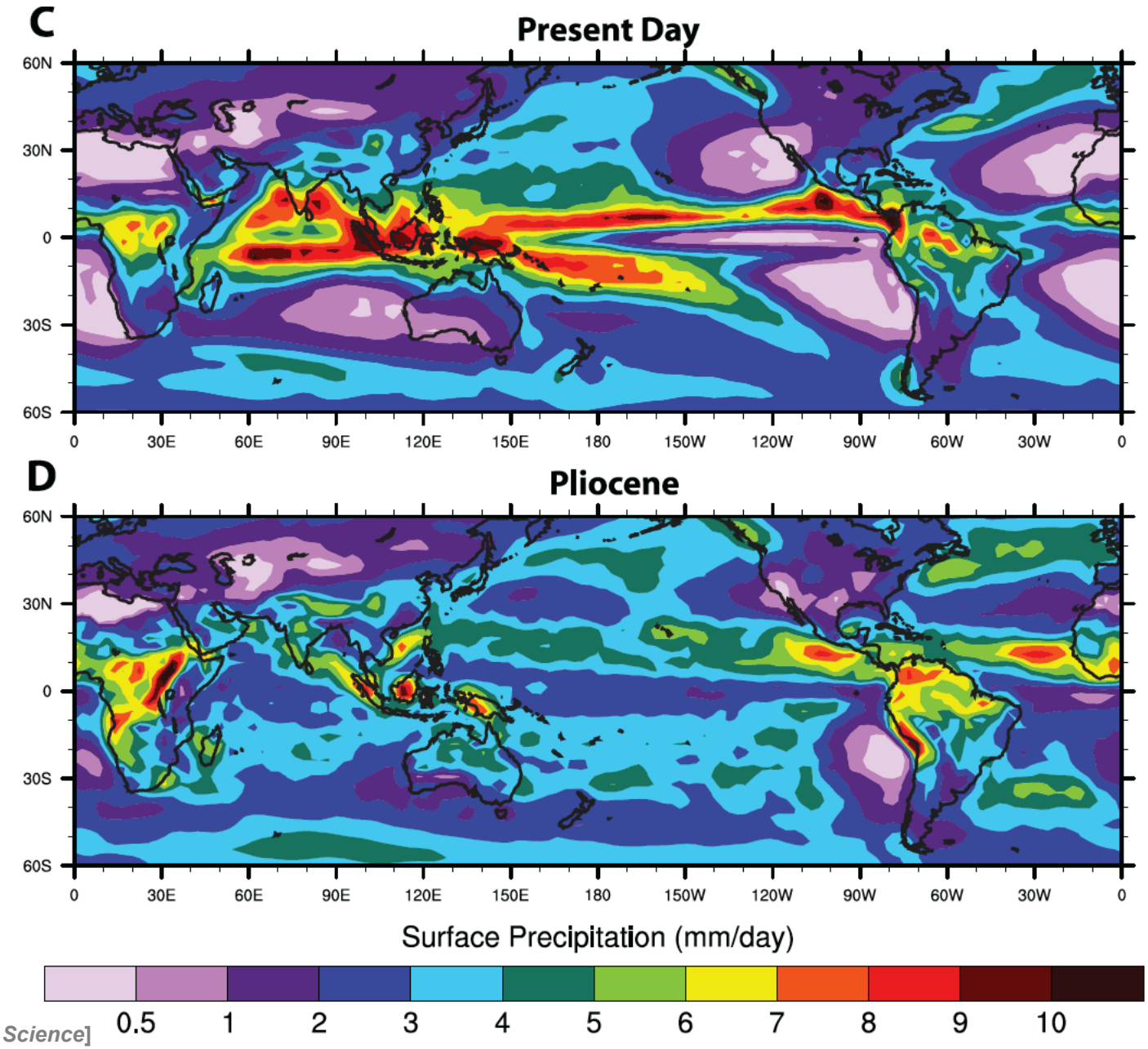
[*Bendle et al, 2005*]





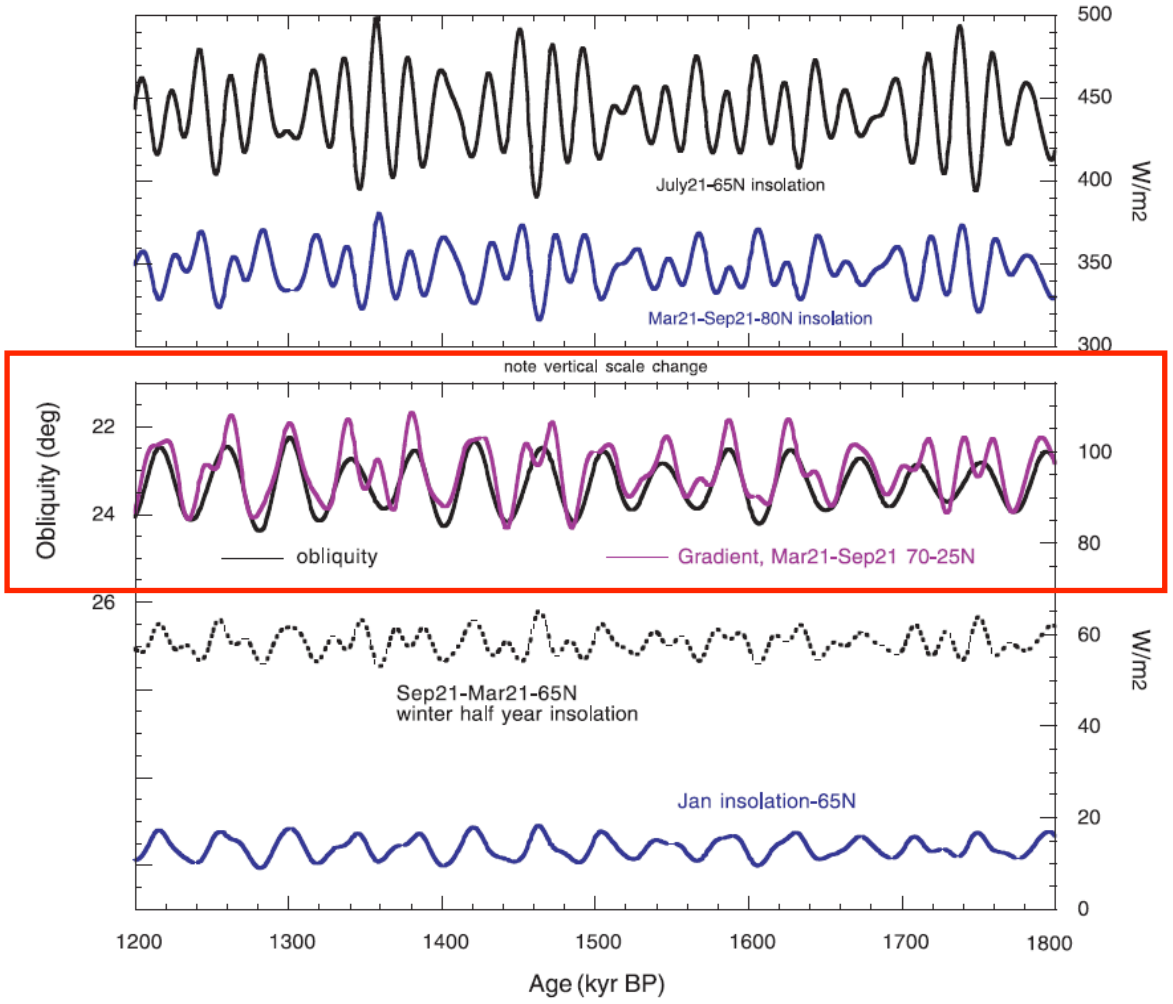
[*Martinez-Garcia et al, in press, Science*]

Plio-Pleistocene SO Dust



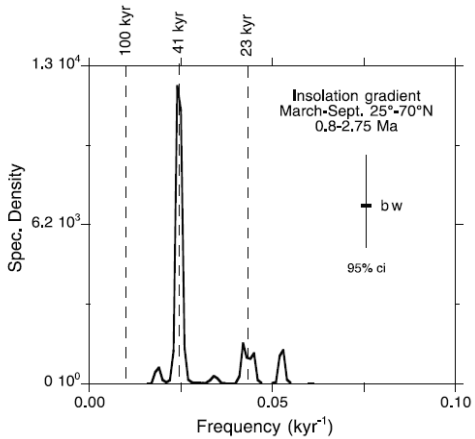
[*Brierley et al 2009, Science*]

SO Plio-Pleistocene dust-climate couplings



[*Raymo and Nisancioglu 2003, Paleoceanography*]

- **Insolation** driven variations in the **latitudinal temperature gradients** are paced by **obliquity** and precede ice-sheet growth



Conclusions

- We have identified an increase in dust deposition in the SAA during the glacial stages of the last 3 milion years. Dust is **exponentially linked to climate**.

- A **4- to 5-fold increase** in dust deposition is identified in the interval from **1.8 to 1.2 Ma**

- The extension of the SO dust record beyond the interval covered by the ice cores indicate that the strengthening of **the latitudinal temperature gradients** has been a key mechanism in **controlling dust deposition over the SO**

- Insolation driven variations in the **latitudinal temperature gradients** may also be involved in the **initiation of dust generation** during late Pleistocene **G-IG cycles**

- **SO dust** may have played a **more important** role in ocean biogeochemical cylces during the **last 1.2Ma** than during the warmer conditions of the late Pliocene and early pleistocene