ADOM1 2009

Atmospheric circulation Dynamics during the last glacial cycle: Observations and Modeling: *where does it come from, where are we, what can we expect?*

D.D. Rousseau

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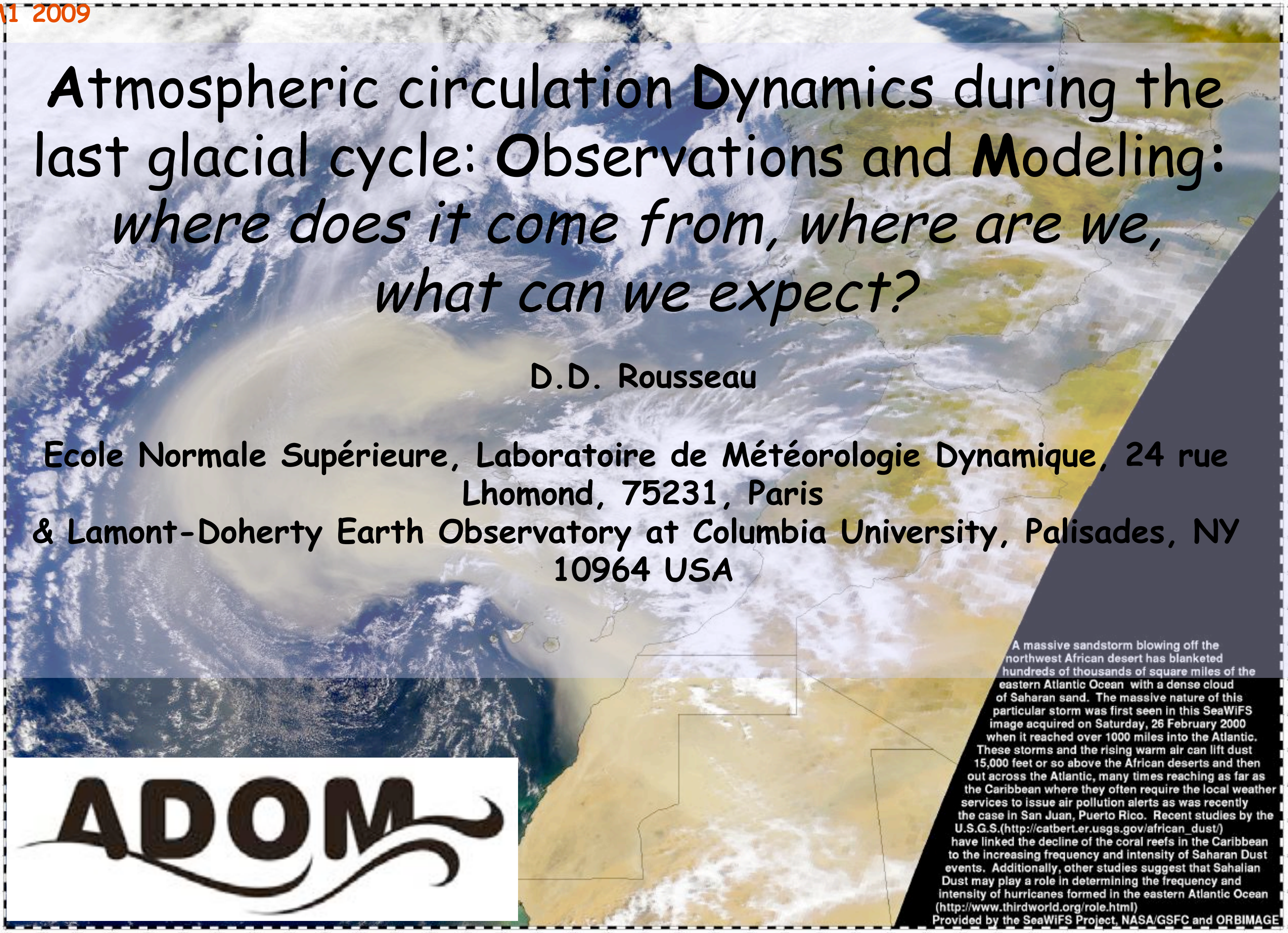

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LMD

INSU
Institut national des sciences de l'Univers

PAGES
PAST GLOBAL CHANGES

EUROPEAN ADOM

Outline:

- General introduction (back ground: where does it come from)
- Dust in ice cores (where are we)
- Asian loess sequences + link with marine cores
- European loess sequences
- North American loess sequences
- Present dust transport
- Program of the workshop (what can we expect)

What does it correspond to??

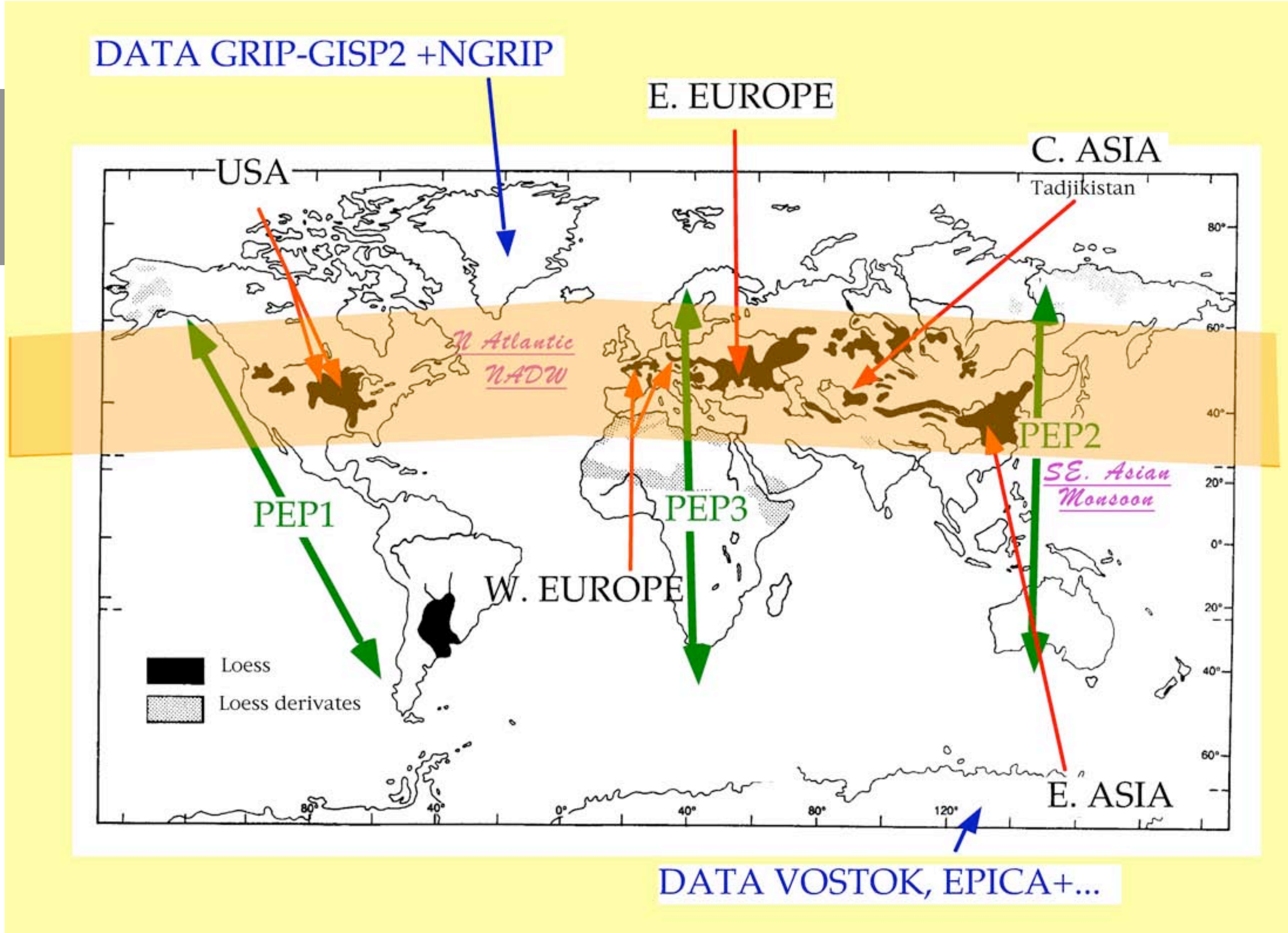
Studies on eolian deposits fit within the framework of PAGES (Past Global Changes) (Focus1: Global Paleoclimate & Environmental Variability)

■ Intervals studied:

- several cycles (10^5yrs)
- some thousand of years

Eolian records (mainly loess)

- •Complementary data to
  - lakes
  - peat bogs
- •"Continuous" in
  - time
  - space



M. Pecsi QI 1991

Multidisciplinary framework

Why a « loess/dust » initiative important now?

A global coordination of the activities is needed for the following reasons:

* High resolution studies have shown that European, and probably indirectly Asian, loess sequences recorded the abrupt climatic history described in both Greenland and N Atlantic

* Dust deposition occurred in Europe during time intervals different than in North America while the Asian records appear roughly continuous through the past 22 Myrs, involving different patterns, or at least climate boundary conditions

* Important link with the dust ice core records; comparison between the structure of the ice-core records and that of these long terrestrial records.

* Numerous excellent scientists working on such deposits share the same concern of providing high resolution records for modeling purpose.

* Development of new climate proxies and methods.

* Loess studies are funded investigations in Europe, Asia and North America with very active scientists.

* Knowing how dust deposited in the past combined with present dust deposition and transport must provide information on the dust cycle for future conditions, especially those associated to desertification

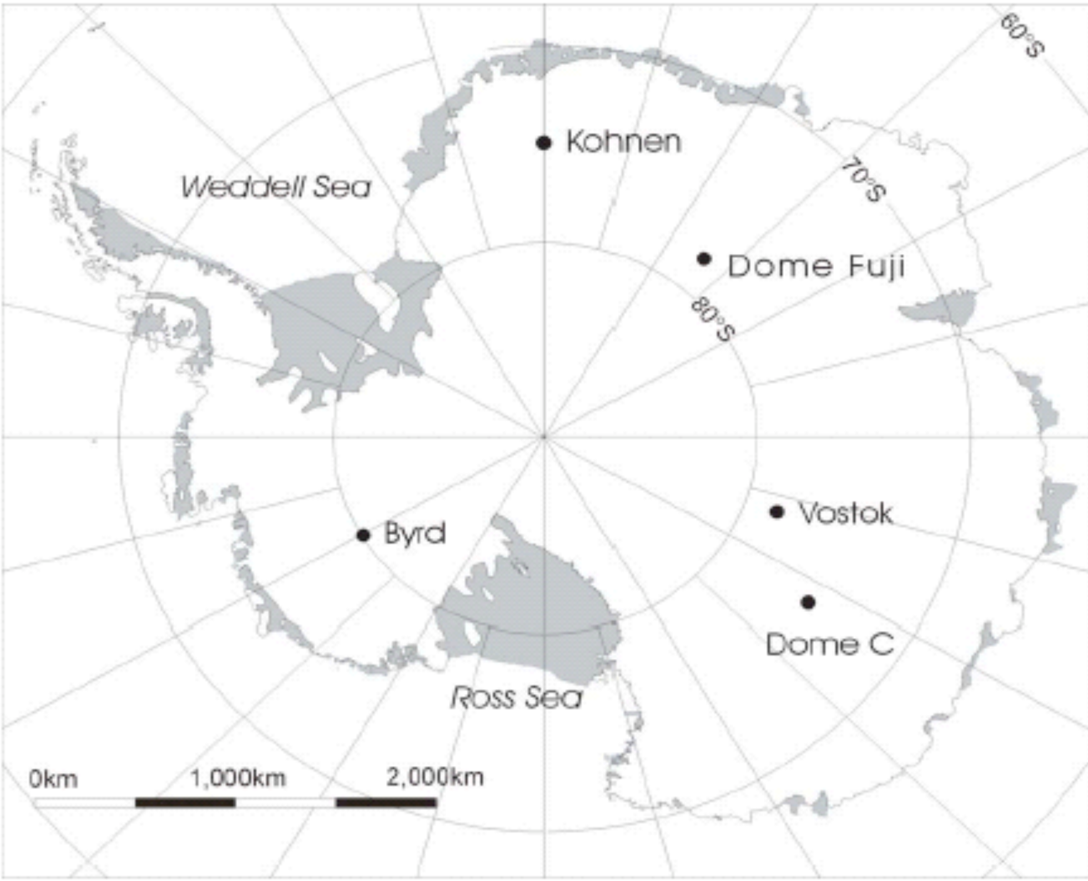
* Dust is an aerosol component and has a direct impact on the radiative budget

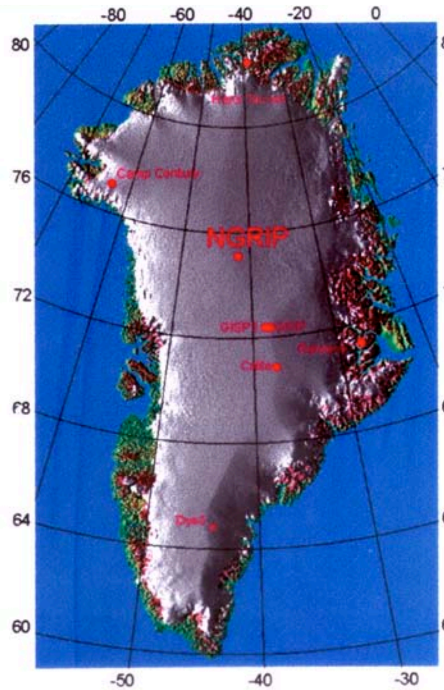
Carottes de glace profondes > 2 km :

Greenland : Camp Century, Dye 3, **GRIP**, GISP 2, **North GRIP**

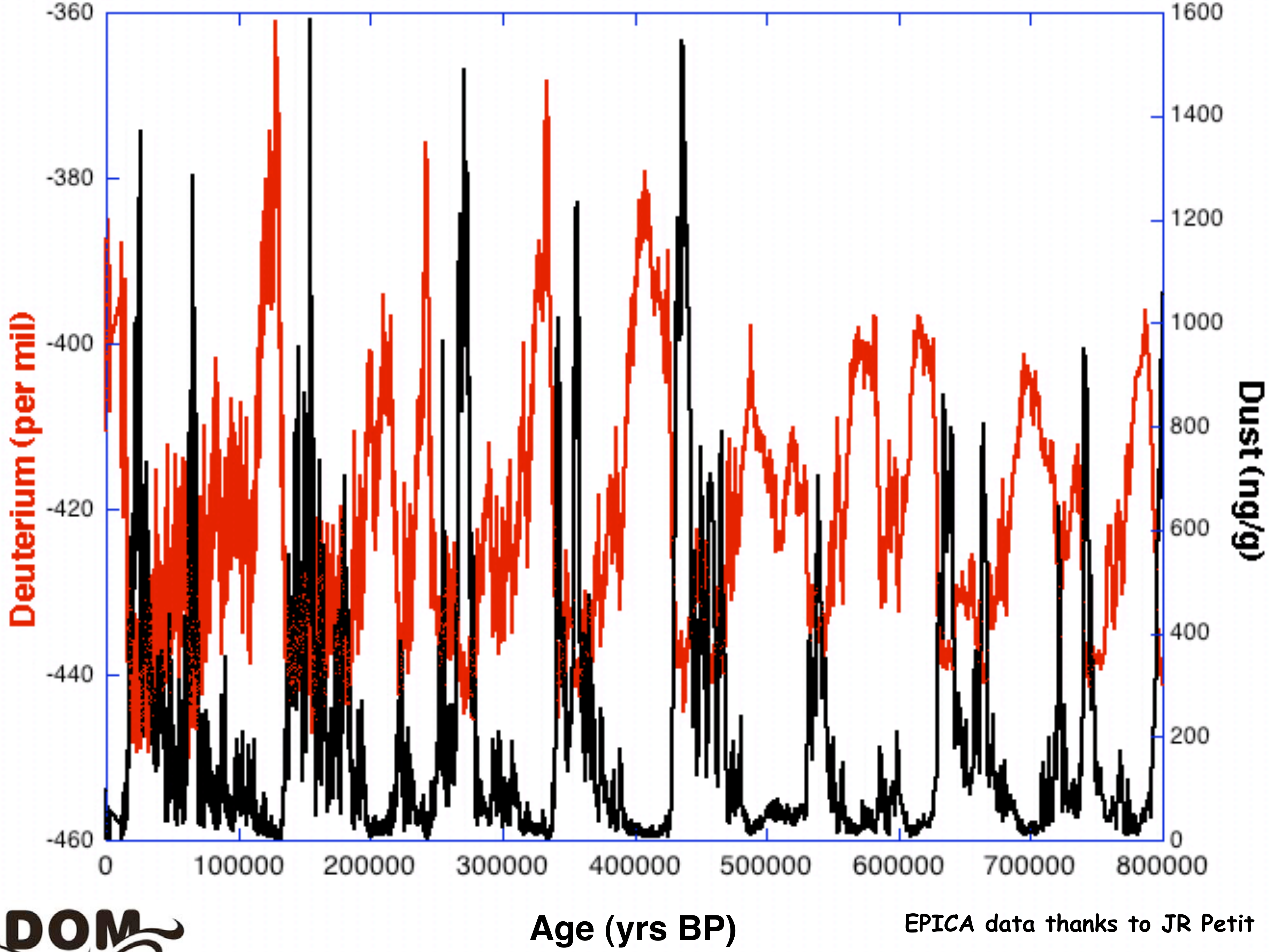
West Antarctica : Byrd

East Antarctica : **Vostok, Dome F, Dome C, Kohnen (DML)**





Antarctica dust record



EPICA data thanks to JR Petit

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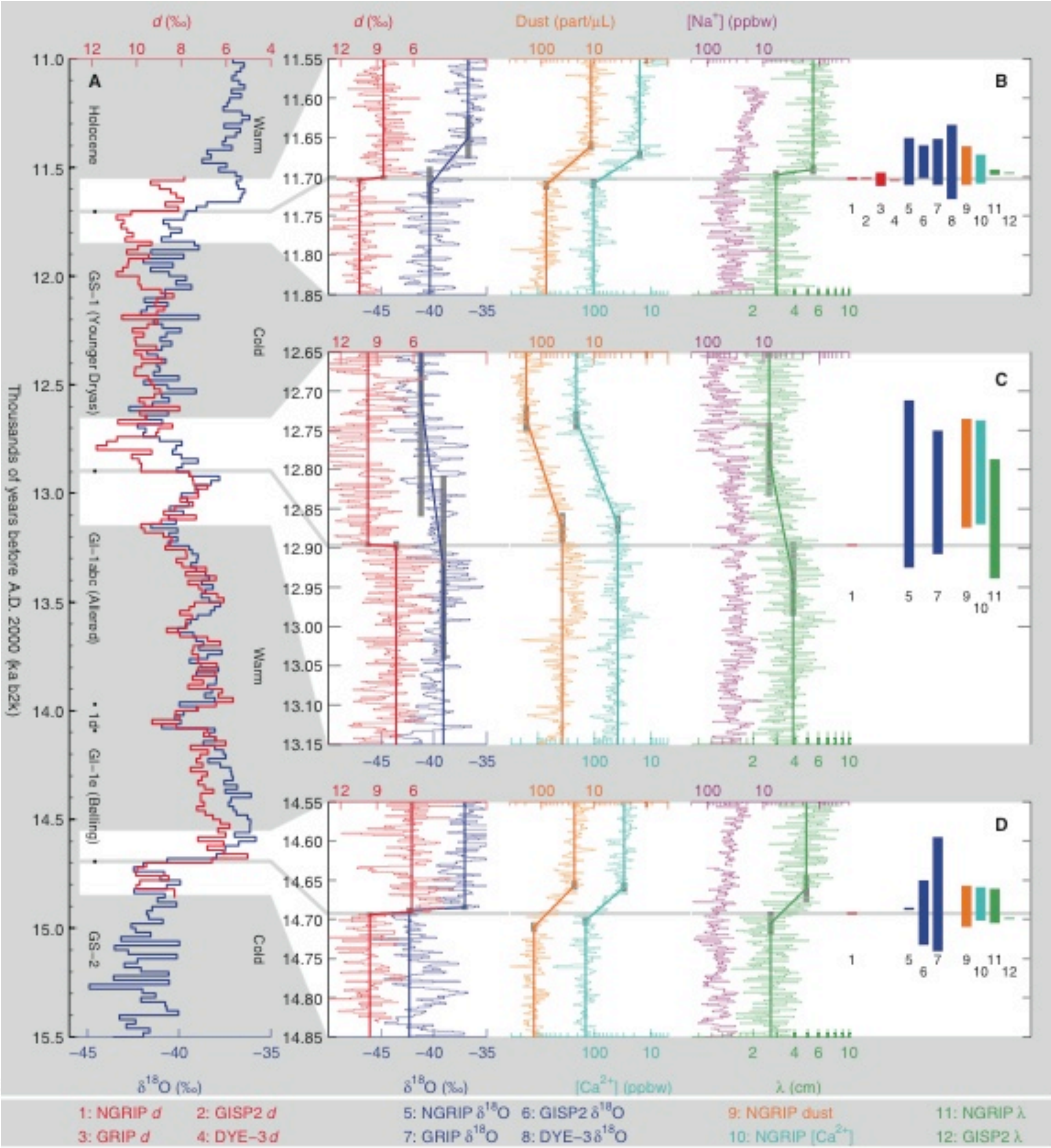
Greenland dust record



From Steffensen et al 2008

So why??

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New developments in

Pedology

Stratigraphy

Organic geochemistry

Rockmagnetic properties

Grain size

Paleomagnetism

Paleobiology

Geochemistry

Modeling

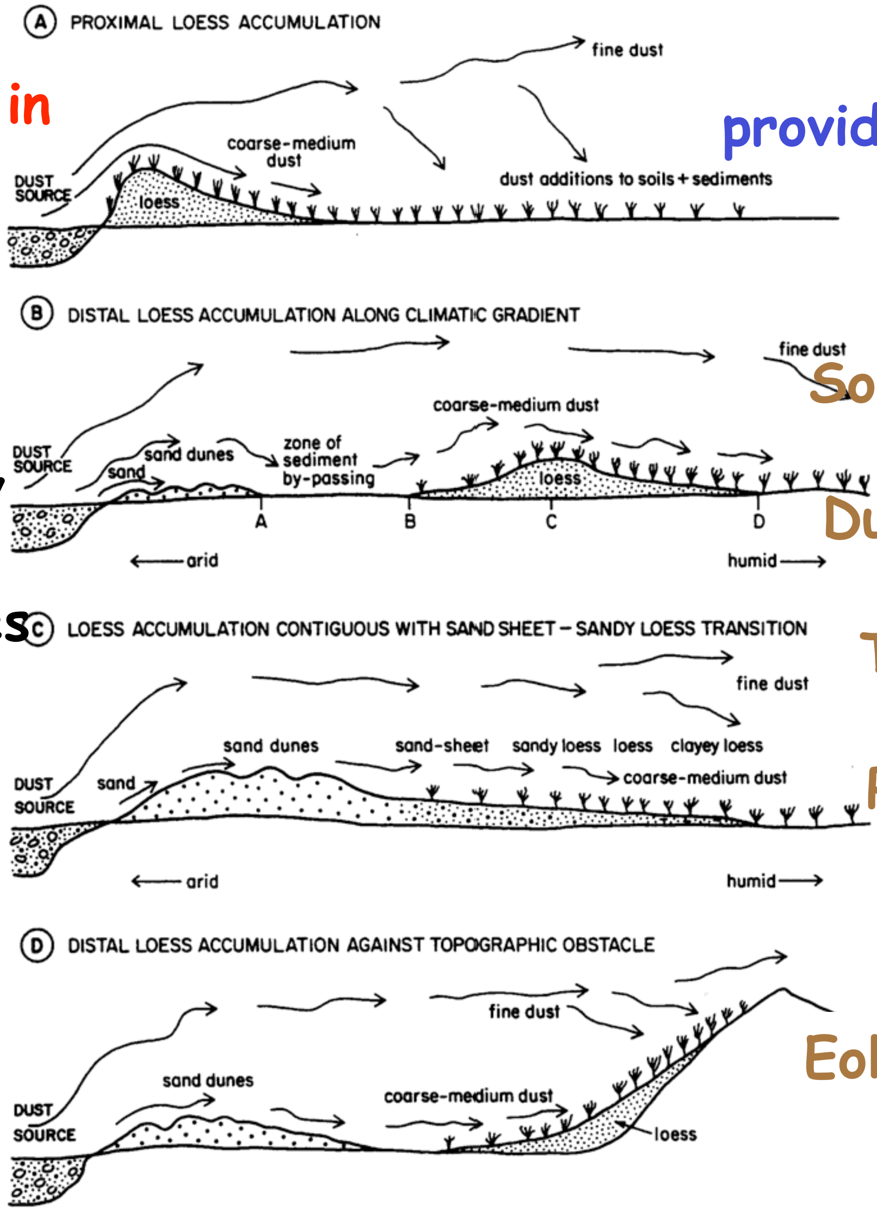

FIG. 11. Schematic models showing four conditions under which loess deposits may form: (A) accumulation of proximal loess on a well-vegetetated surface adjacent to a dust source; (B) formation of distal loess on the vegetated semi-arid margin of a desert, accompanied by formation of aeolian sand deposits proximal to the sediment source; (C) formation of loess which is joined to proximal sand dunes and sand sheets by a transitional sandy loess zone; (D) accumulation of distal loess deposit against a topographic barrier. See text for further explanation.

provide new proxies for

Seasonality

Source conditions

Dust transport

Temperature

Precipitation

Vegetation

Eolian Dynamics

K Pye QSR, 1995

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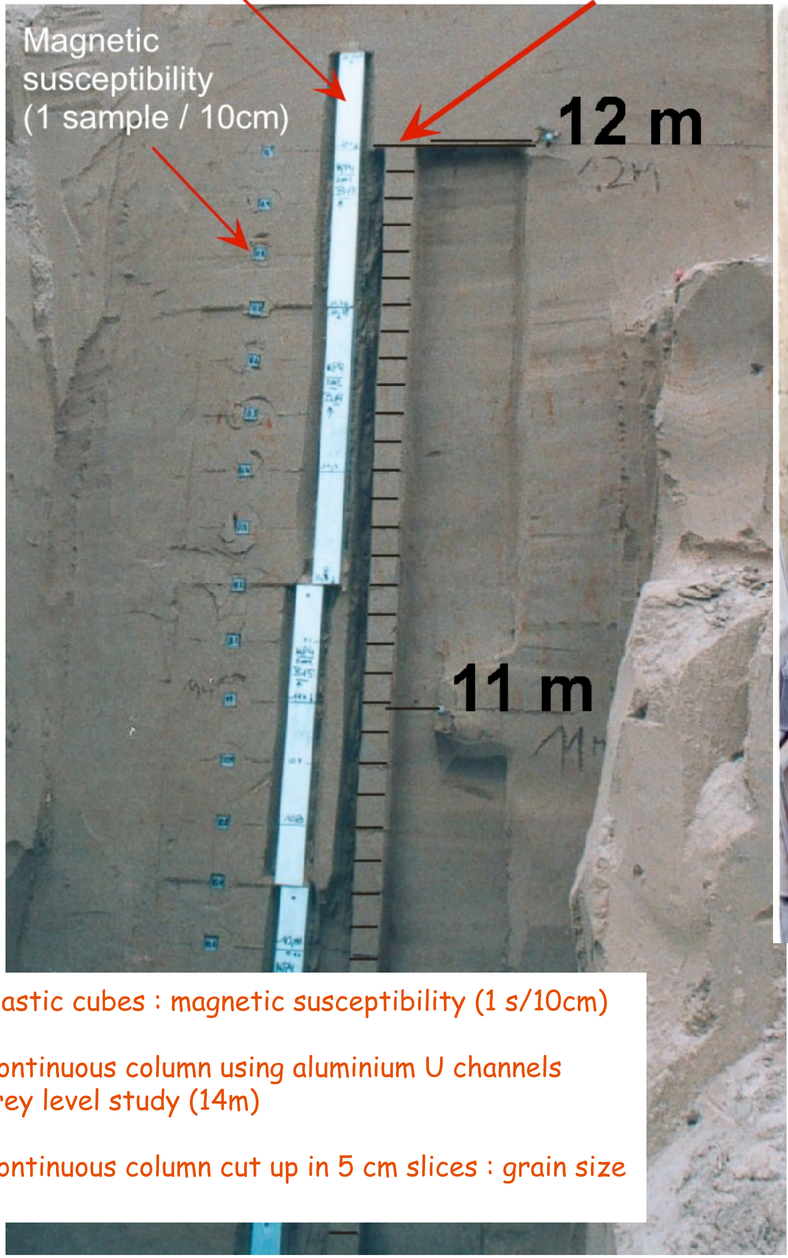
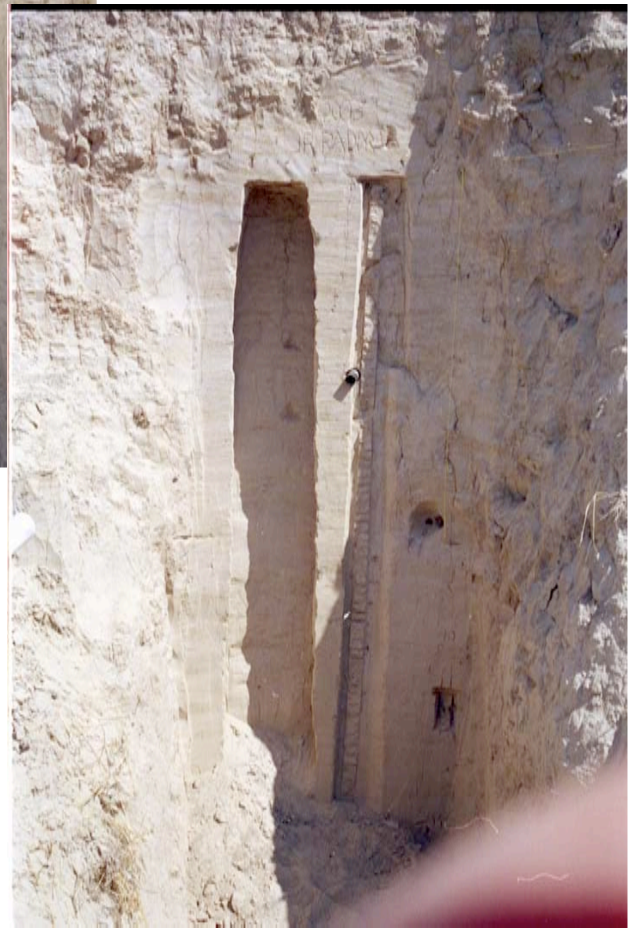
Undisturbed continuous
Sampling (aluminium U channels : 50 cm)

Grain size continuous sampling
Column (1 sample / 5 cm)





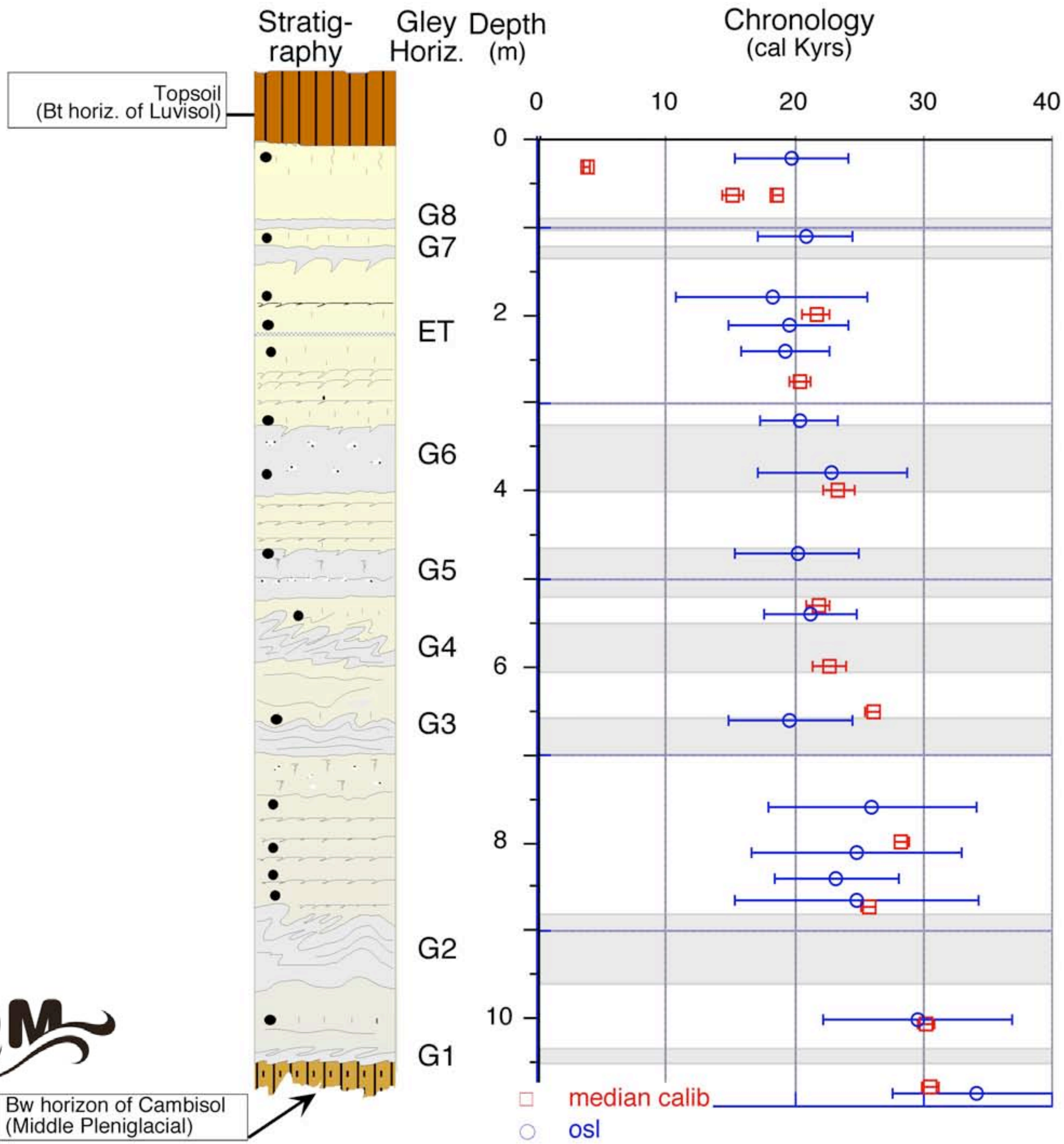
- Plastic cubes : magnetic susceptibility (1 s/10cm)

- Continuous column using aluminium U channels
: grey level study (14m)

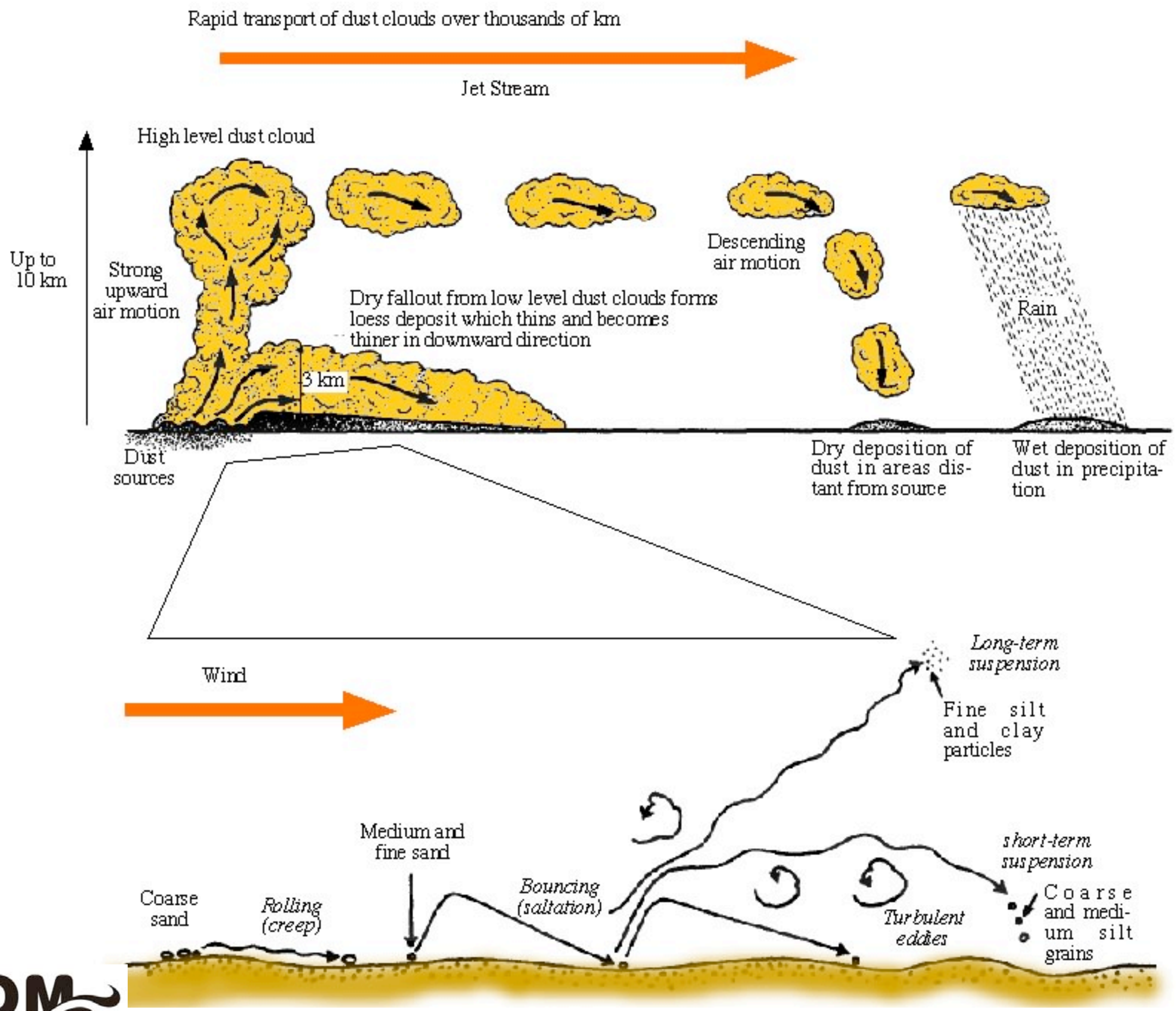
- Continuous column cut up in 5 cm slices : grain size

ADOM 10m

Upper Pleniglacial loess sequence Nussloch P2 40 and 15 ka

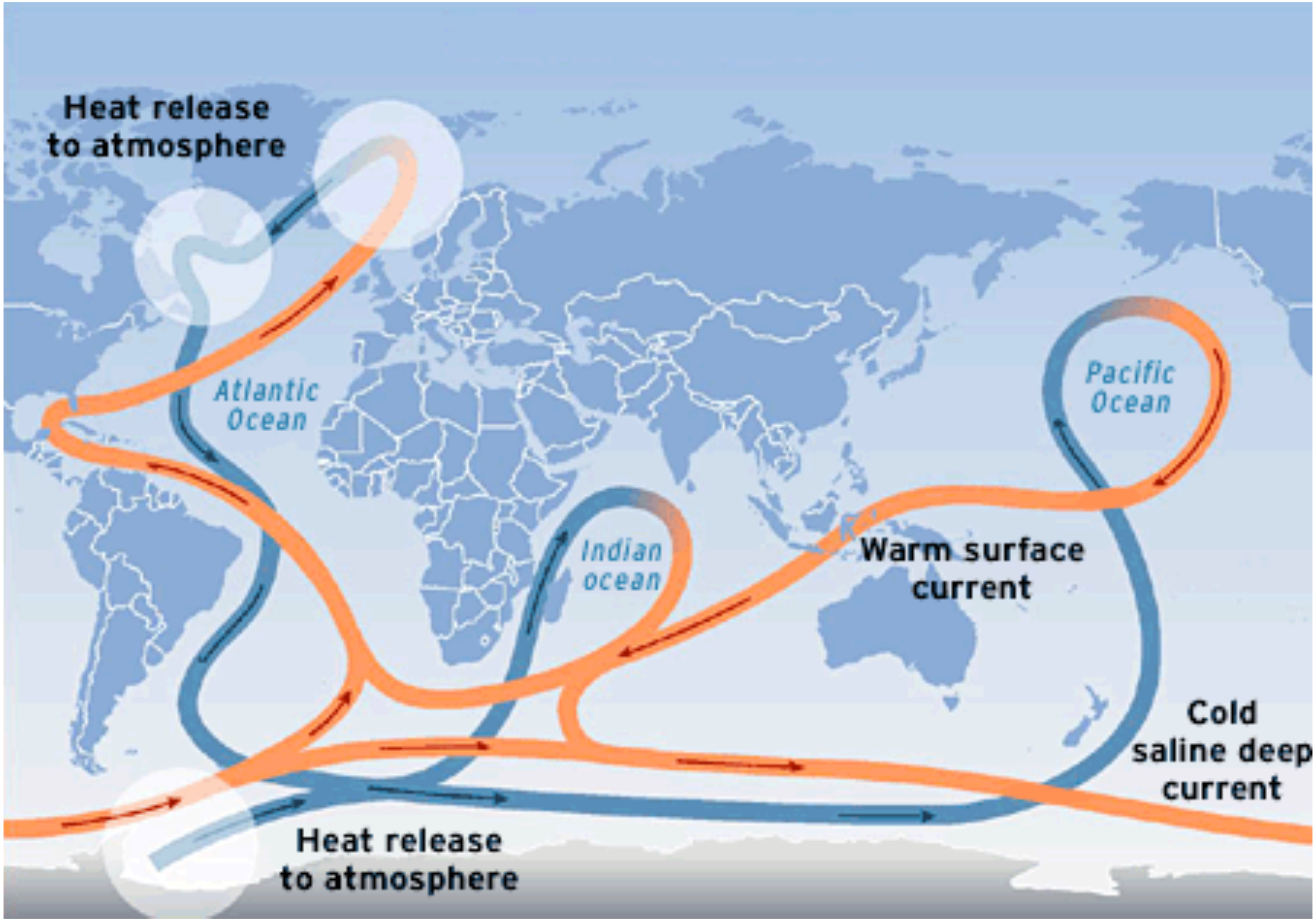


Antoine *et al.*, 2002 (modified)
Hatté et al. 2001 (modified)
Lang et al. 2003 (modified)
Rousseau et al 2002 (modified)



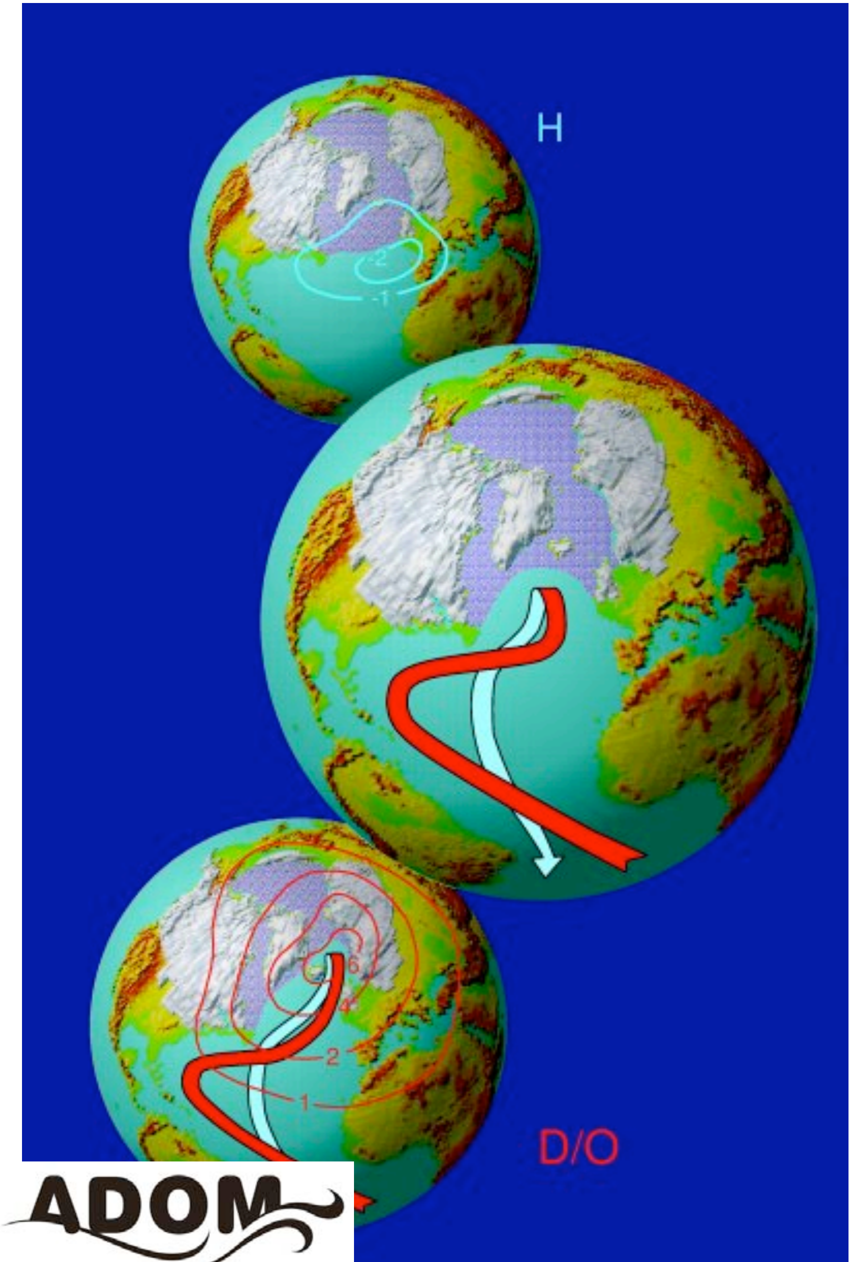
After Pye & Zhou 1989 modified

Simplified thermohaline Circulation



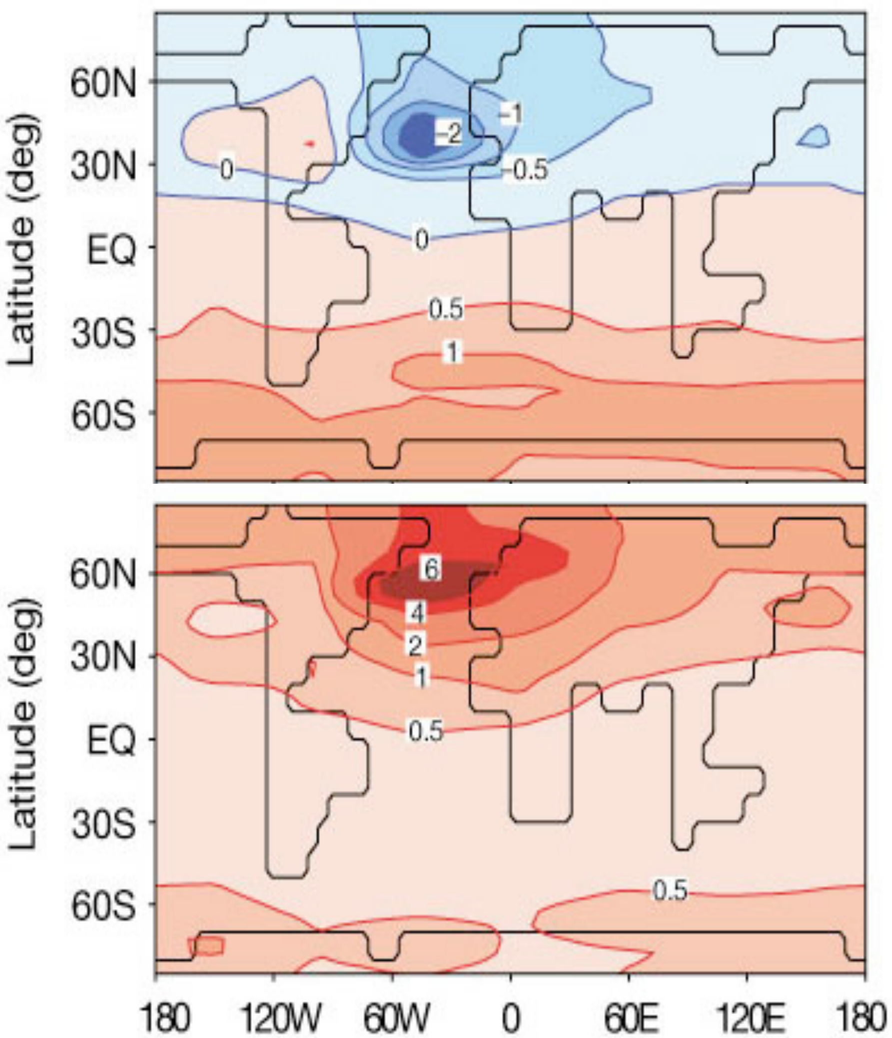
D'après illustration GIEC

Rapid changes of glacial climate simulated in a coupled climate model



Ganopolski, A. and S. Rahmstorf, 2001

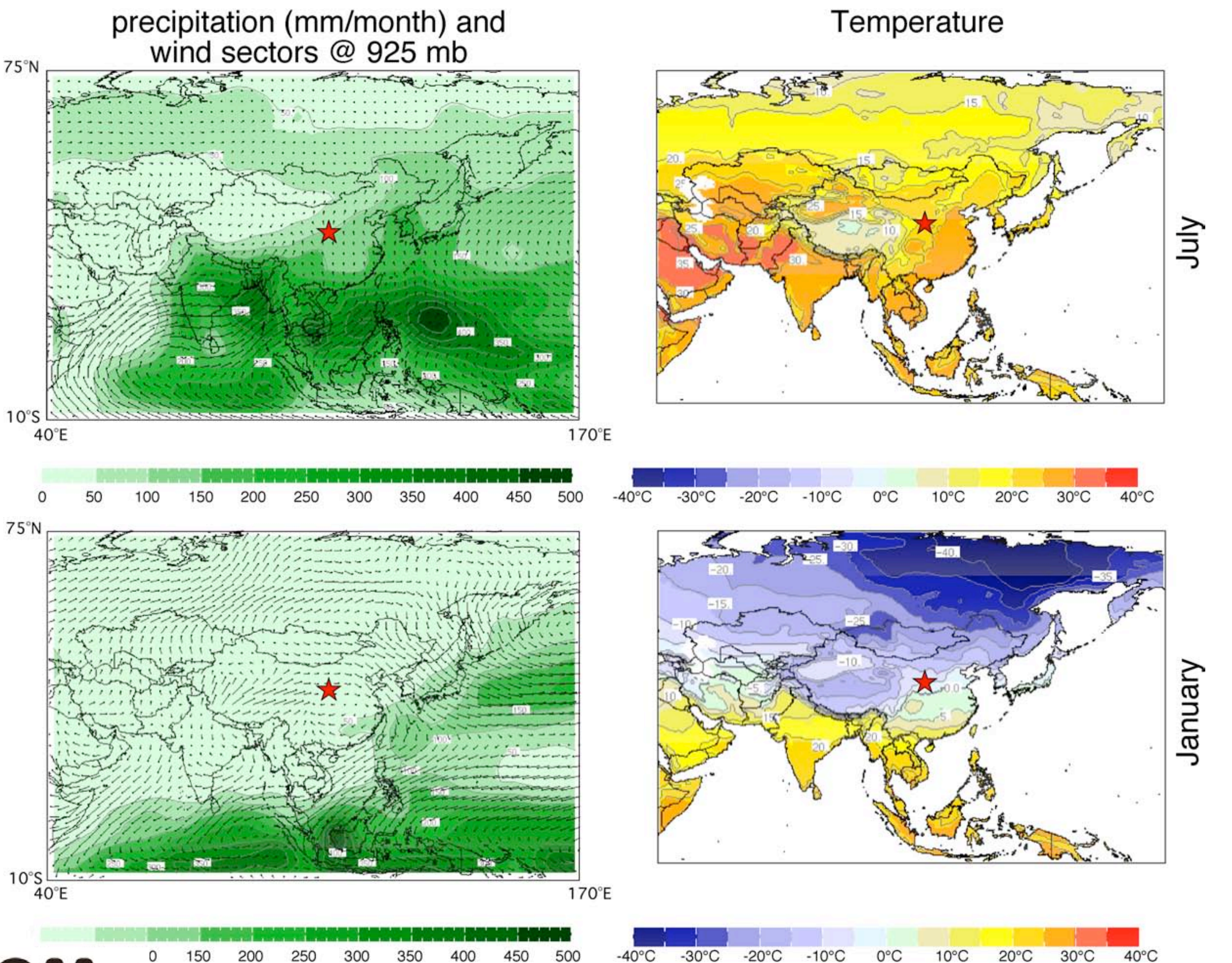
Conditions during a Heinrich event minus stadial mode



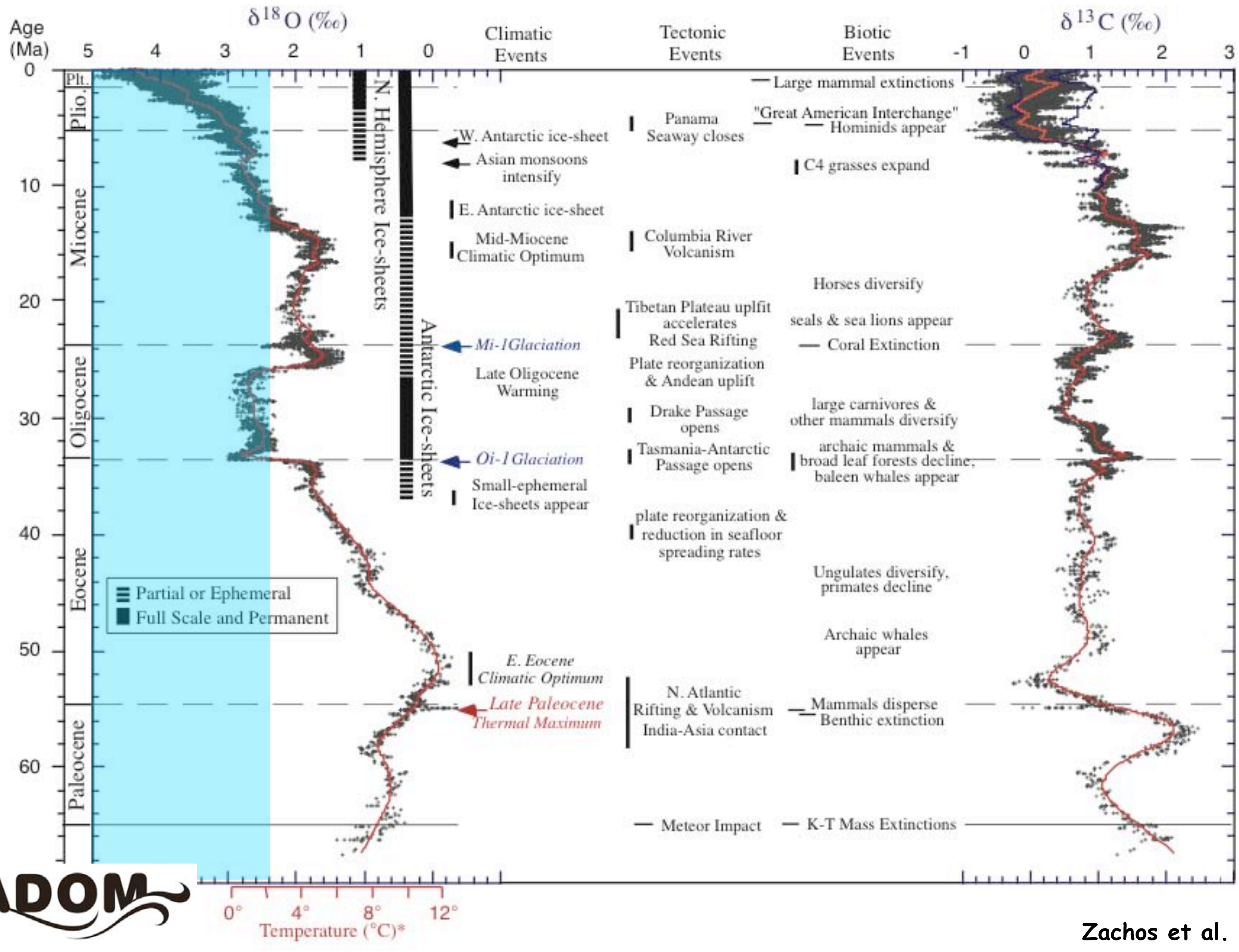
Warmest phase of a D/O cycle minus stadial phase

Differences in model-simulated annual mean surface air temperature (°C)

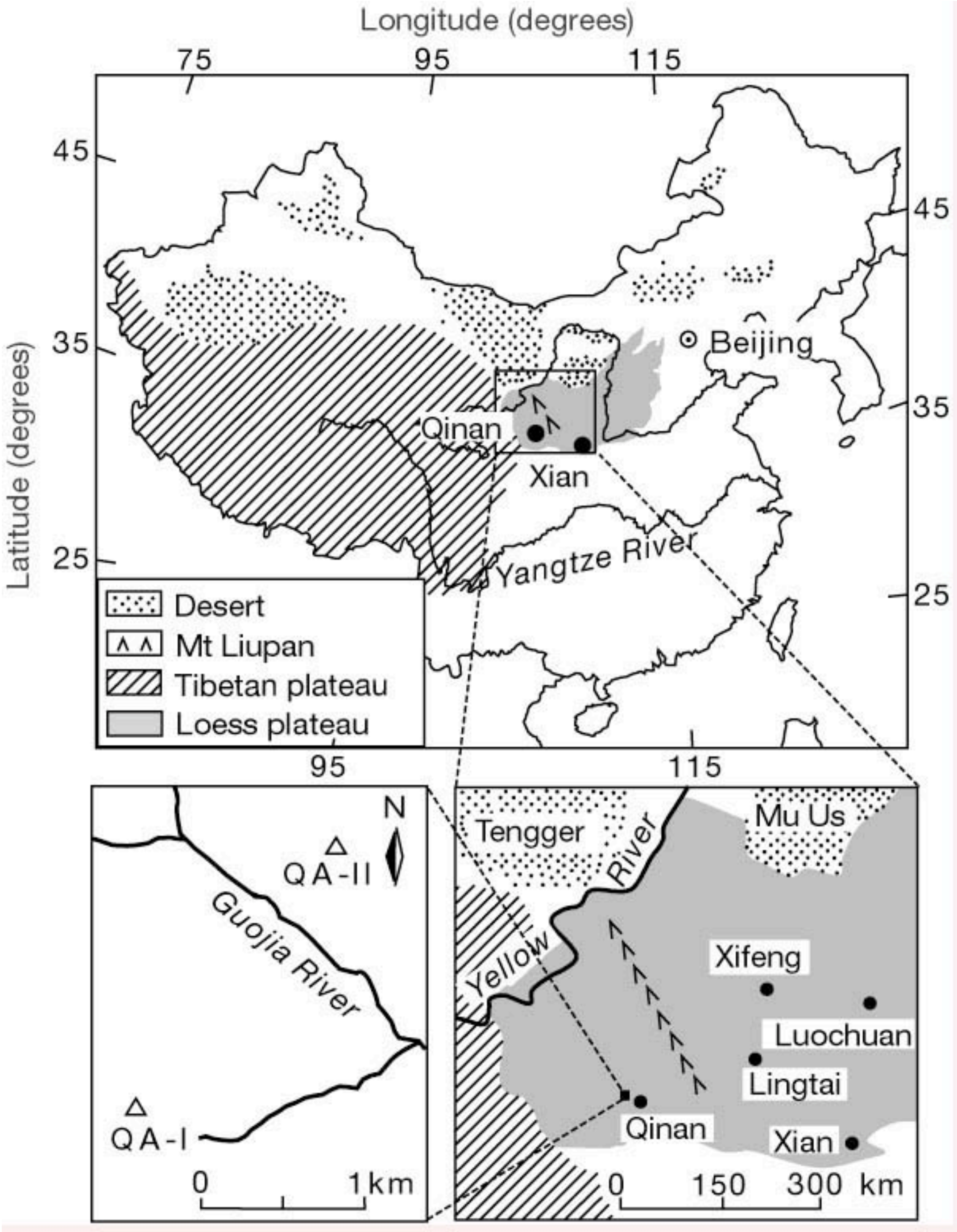

Asian loess sequences



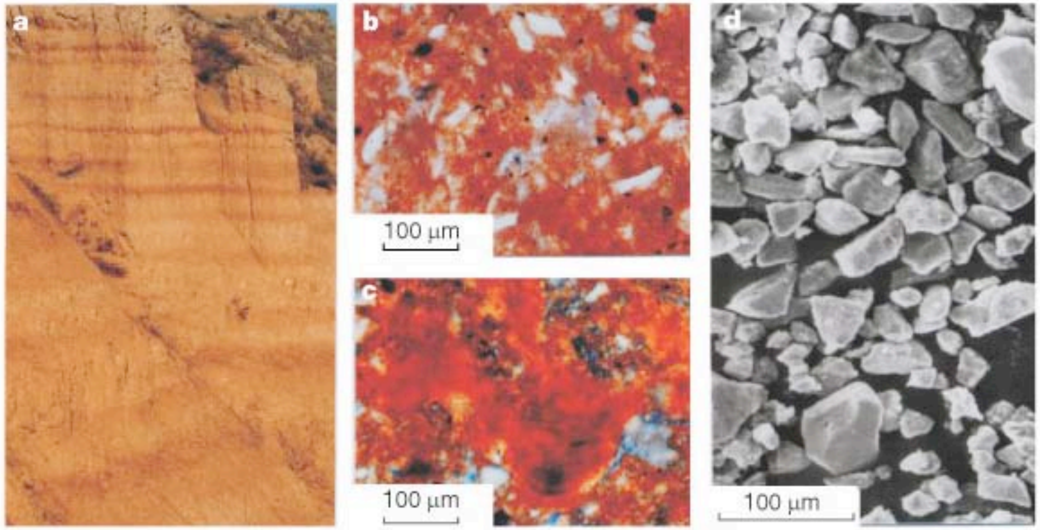
Rousseau et al. Clim. Past 2009



Zachos et al. 2001



Guo et al. 2002



Guo et al. 2002

Dongwan late Miocene-Pliocene loess sequence

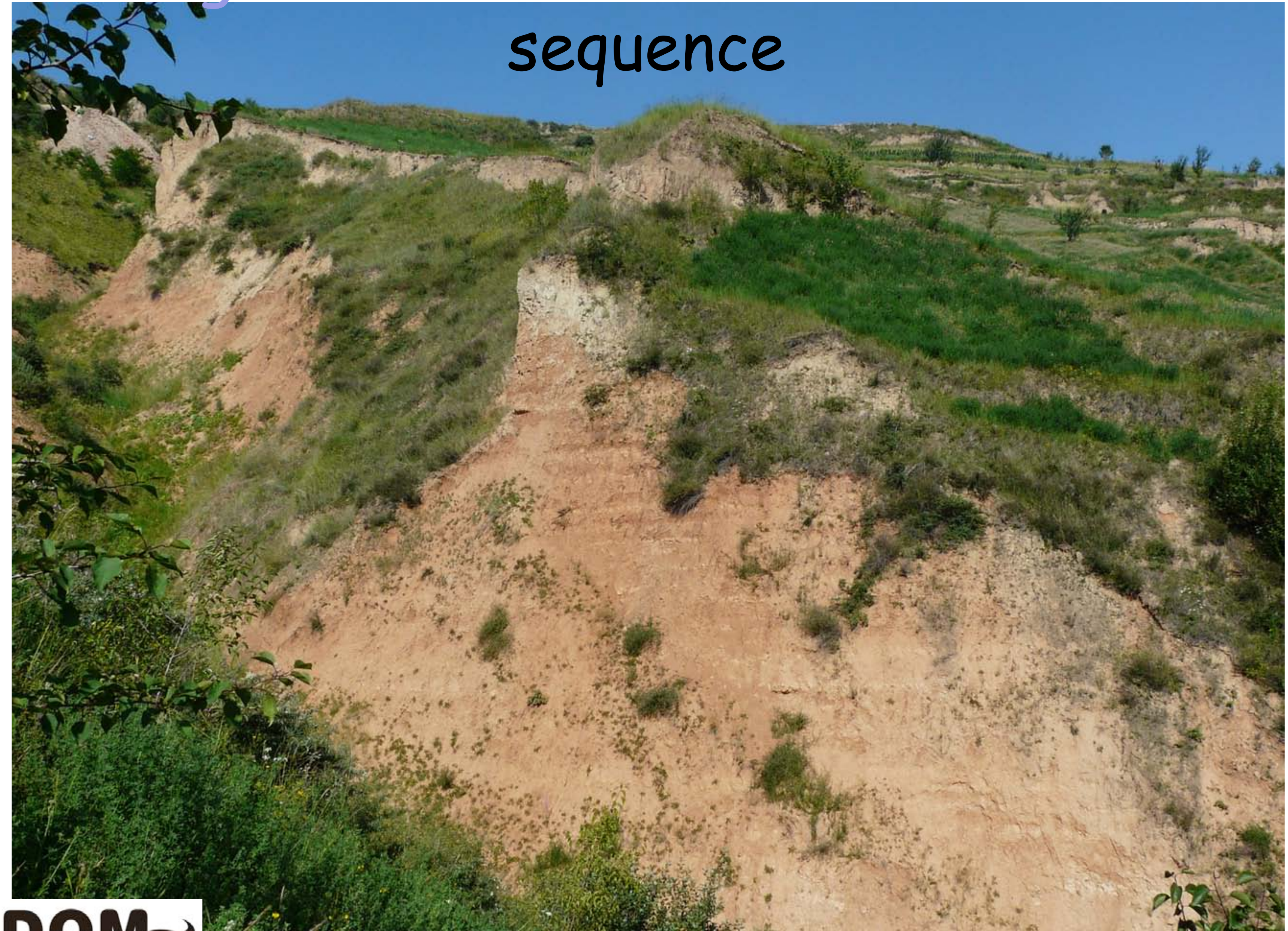
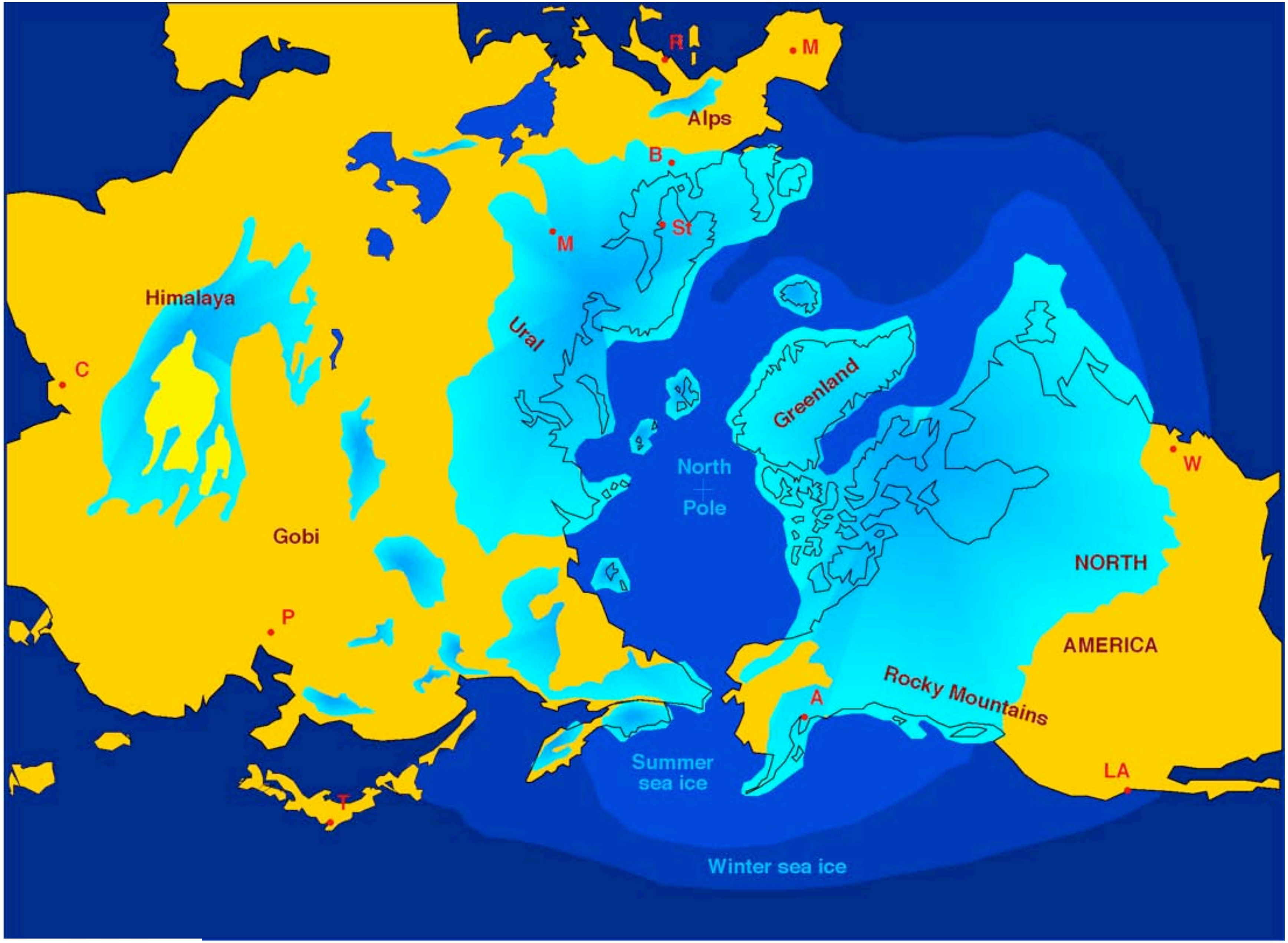
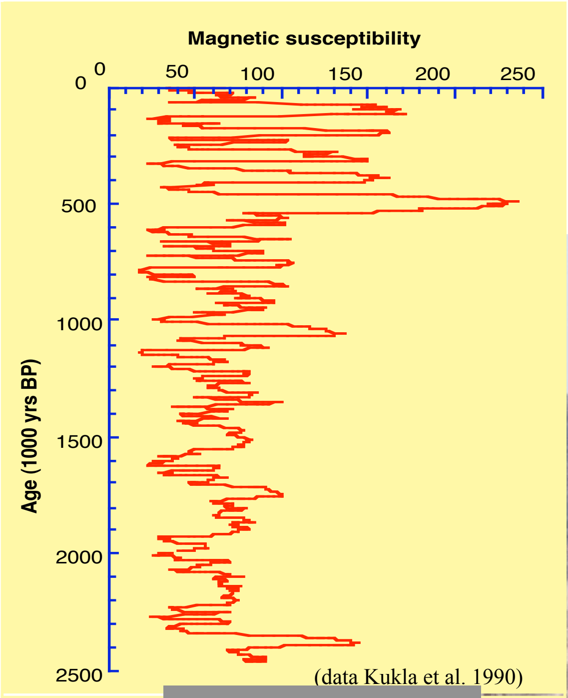


Photo Li Fengjiang, CAS Beijing

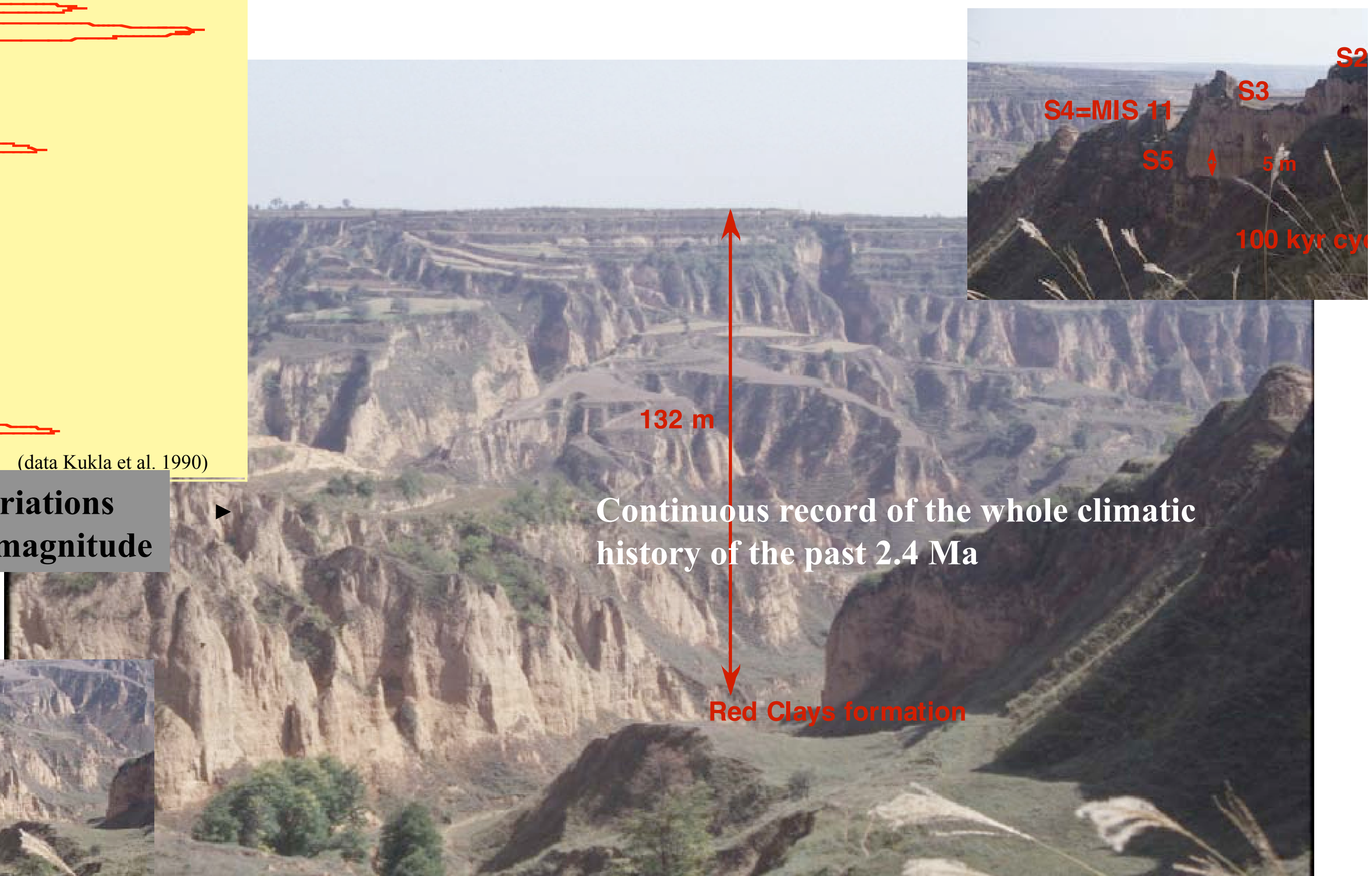


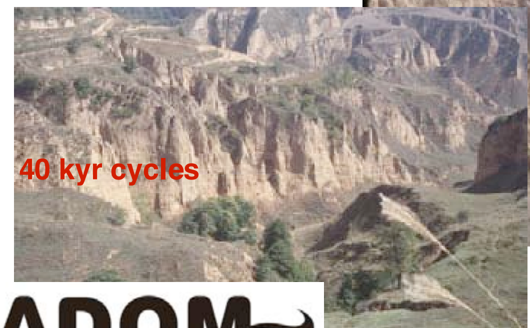
d'après Hannes Grobe, AWI

1 Variations in the cyclicity



2 Variations in the magnitude





3 Abrupt changes of the environment

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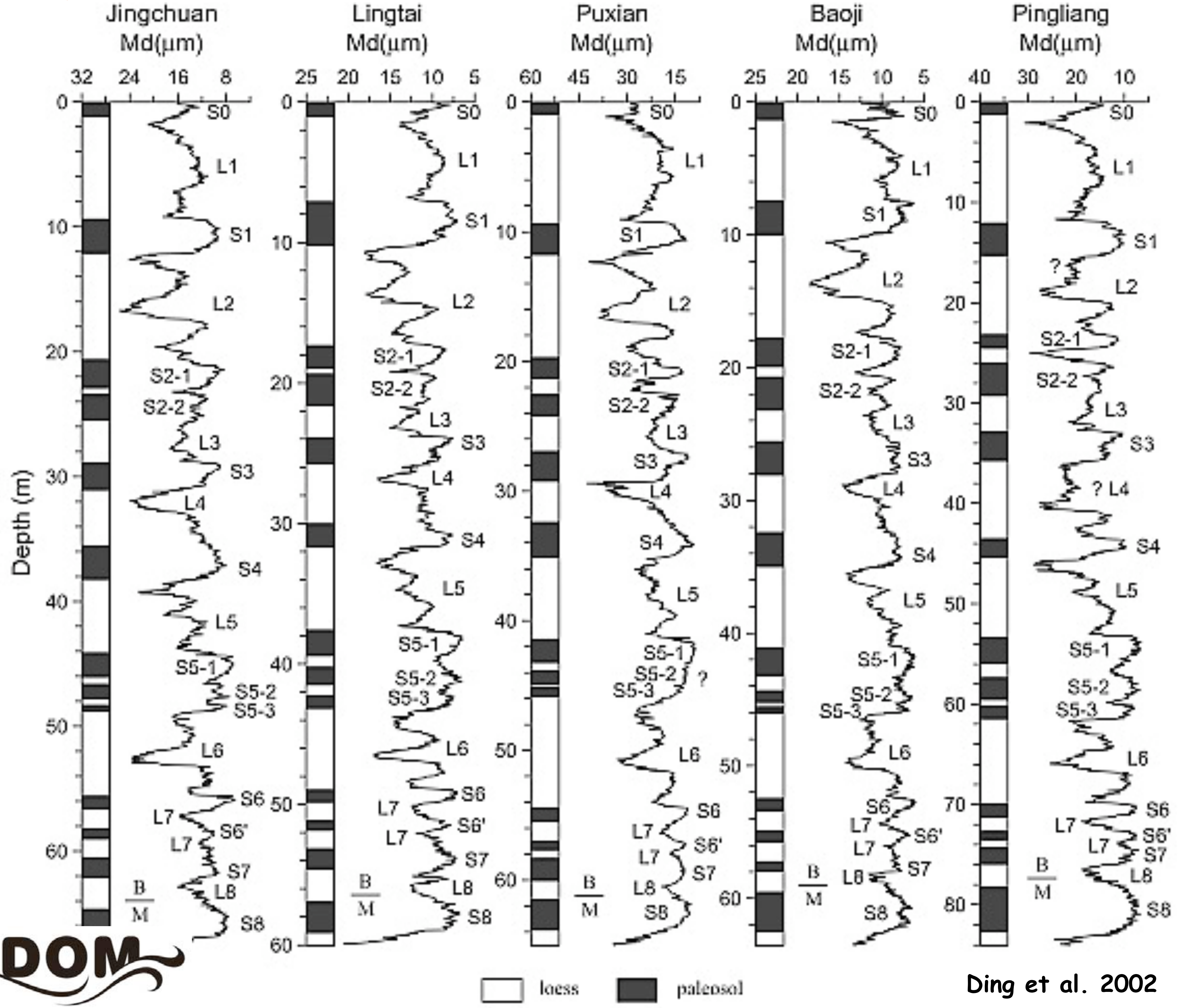
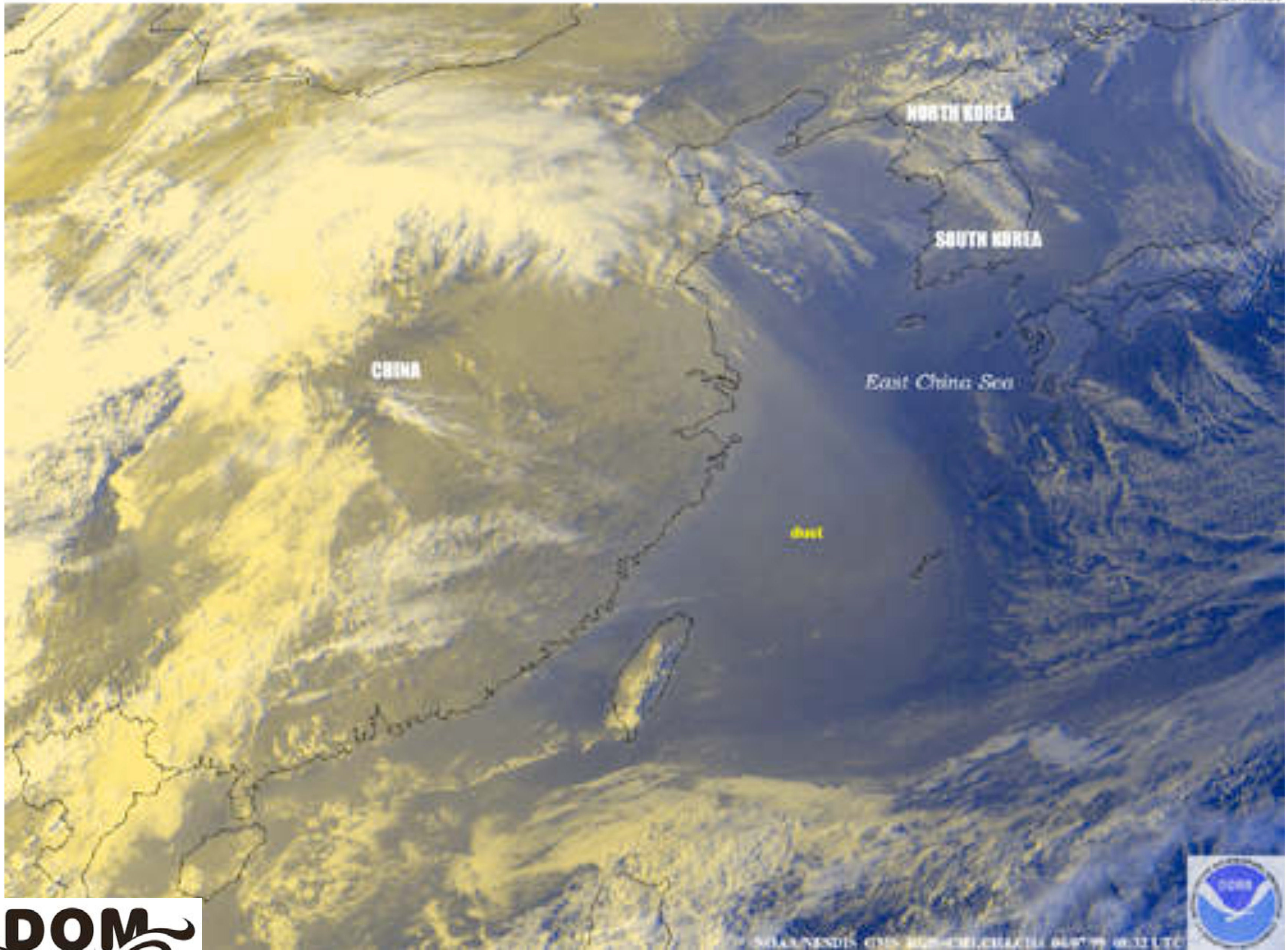
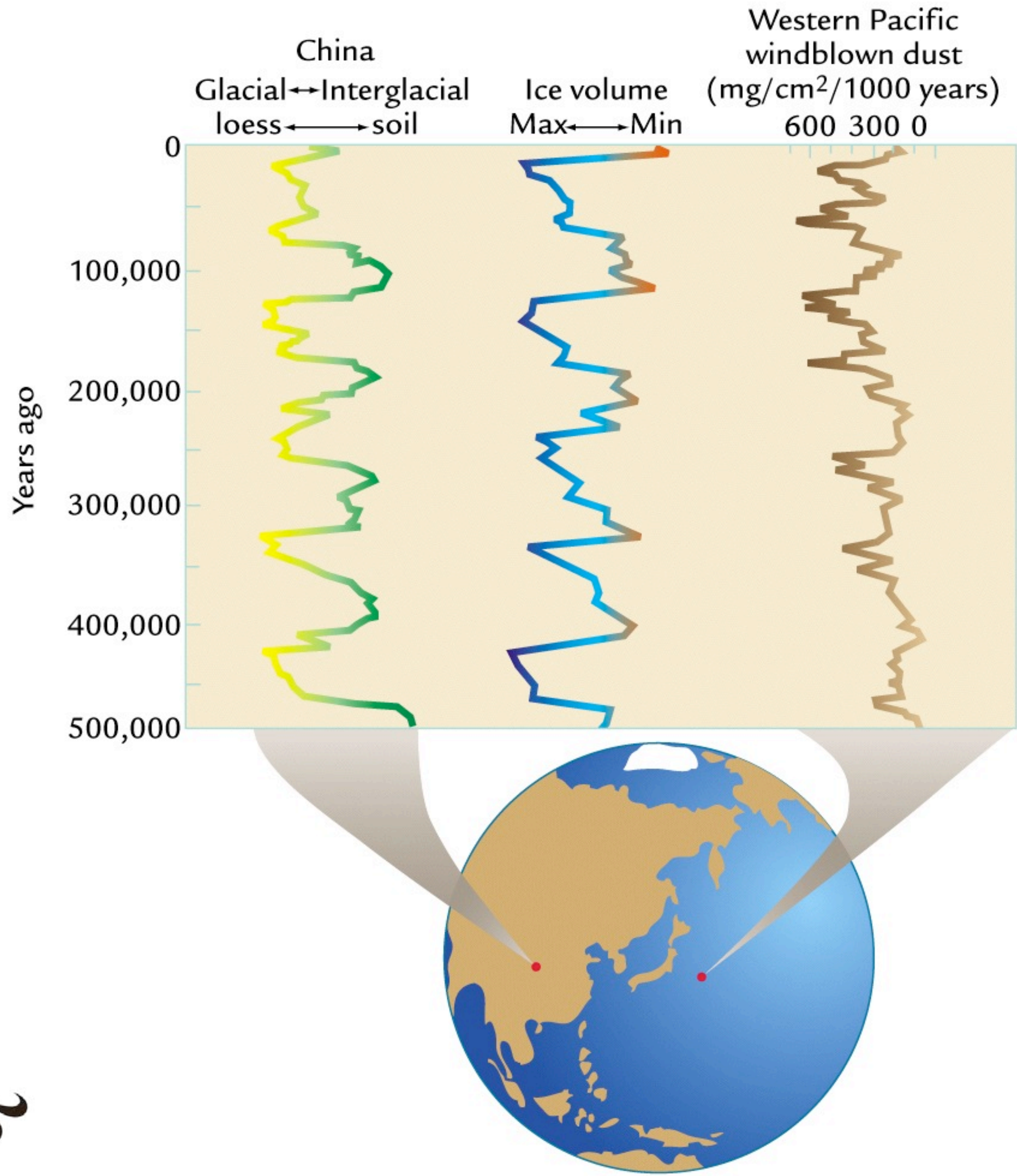


Ding et al. 2002

Airborne dust (light brown haze) streams off the coast of eastern China and over the East China Sea.

CREDIT: NOAA




China
Glacial↔Interglacial
loess ↔ soil
Ice volume
Max↔Min
Western Pacific
windblown dust
(mg/cm2/1000 years)
600 300 0
0
100,000
200,000
300,000
400,000
500,000
Years ago

Ruddiman

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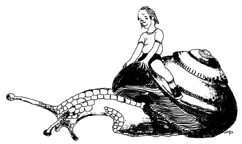
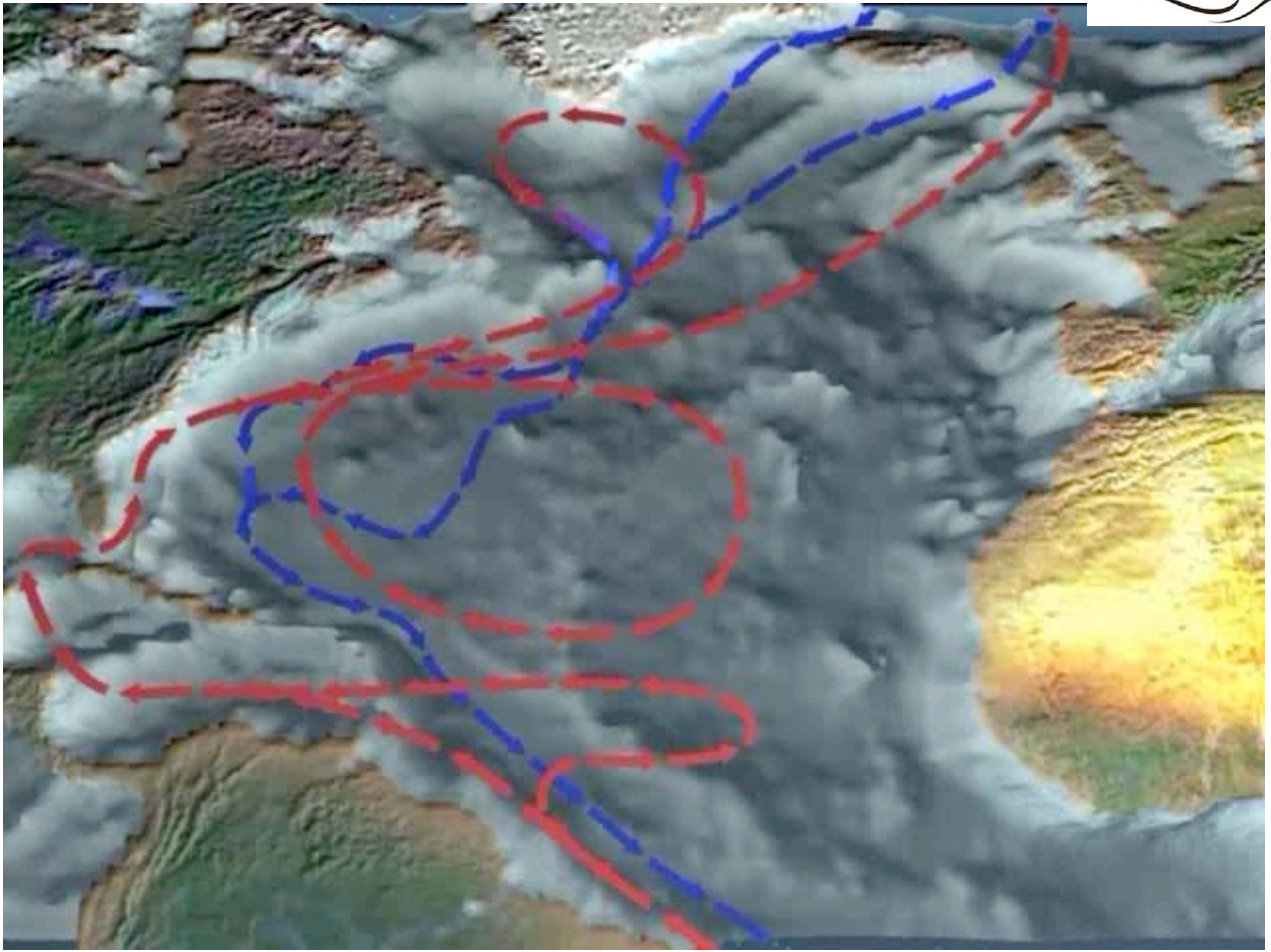
Eclipse
Environnement
et CLImat du
Passé:
hiStoire
et Evolution

Enregistrement des
Evénements
Eoliens dans
les séquences
Loessiques
Européennes

ADOM



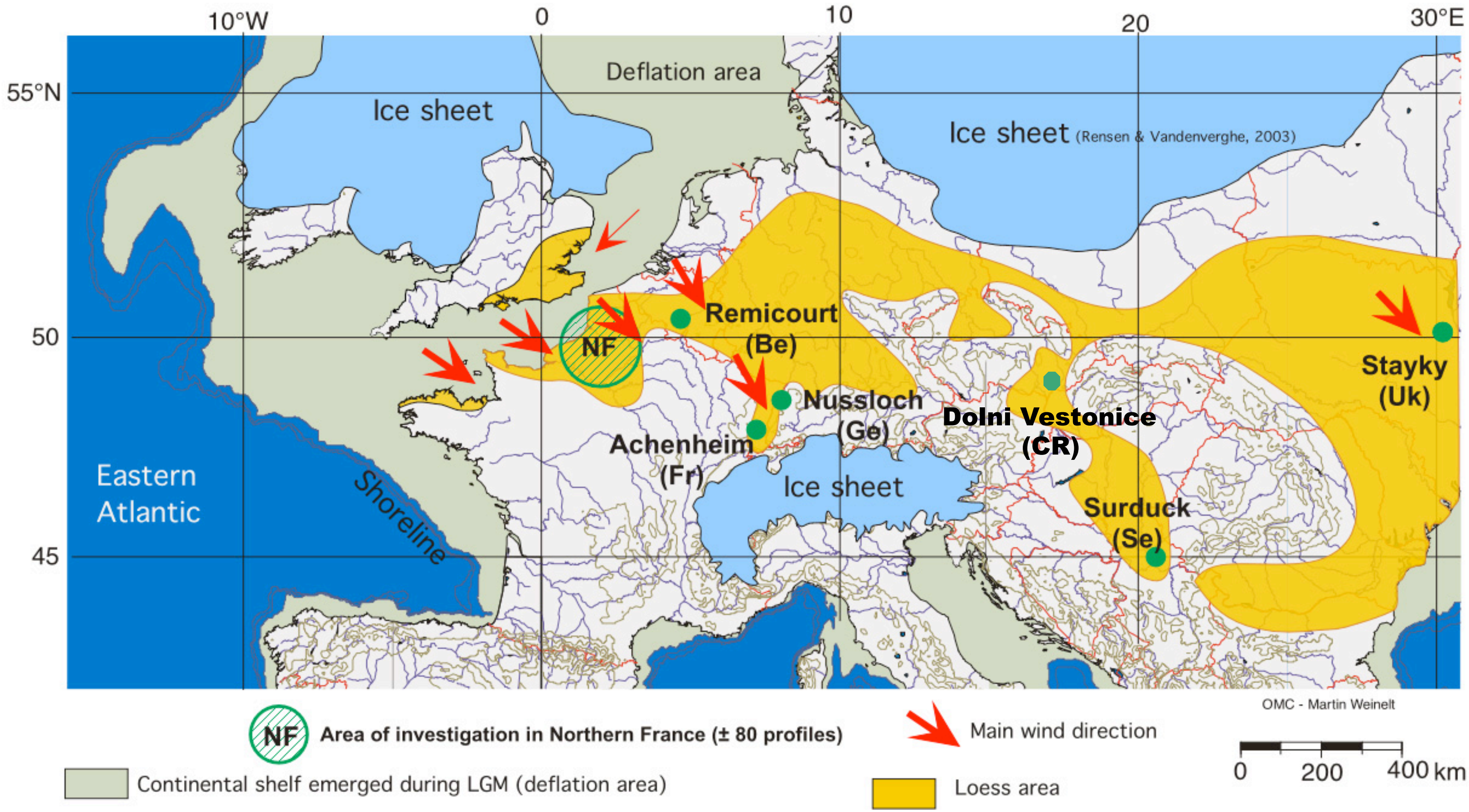
The simplified conveyor belt



Great Ocean Conveyor Belt (From the Intergovernmental Panel on Climate Change

Illustrations Jack Cook WHOI

European loess sequences



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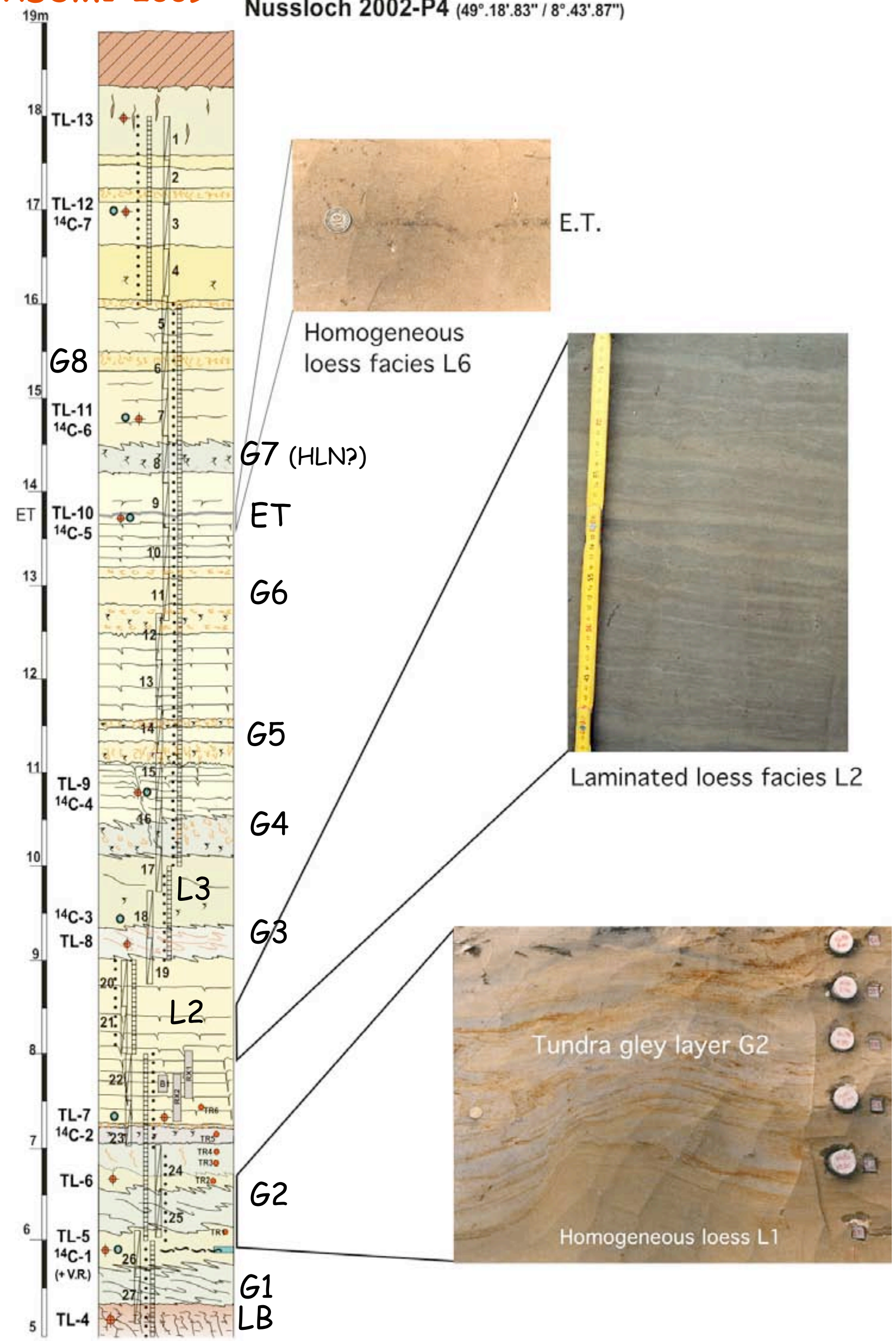

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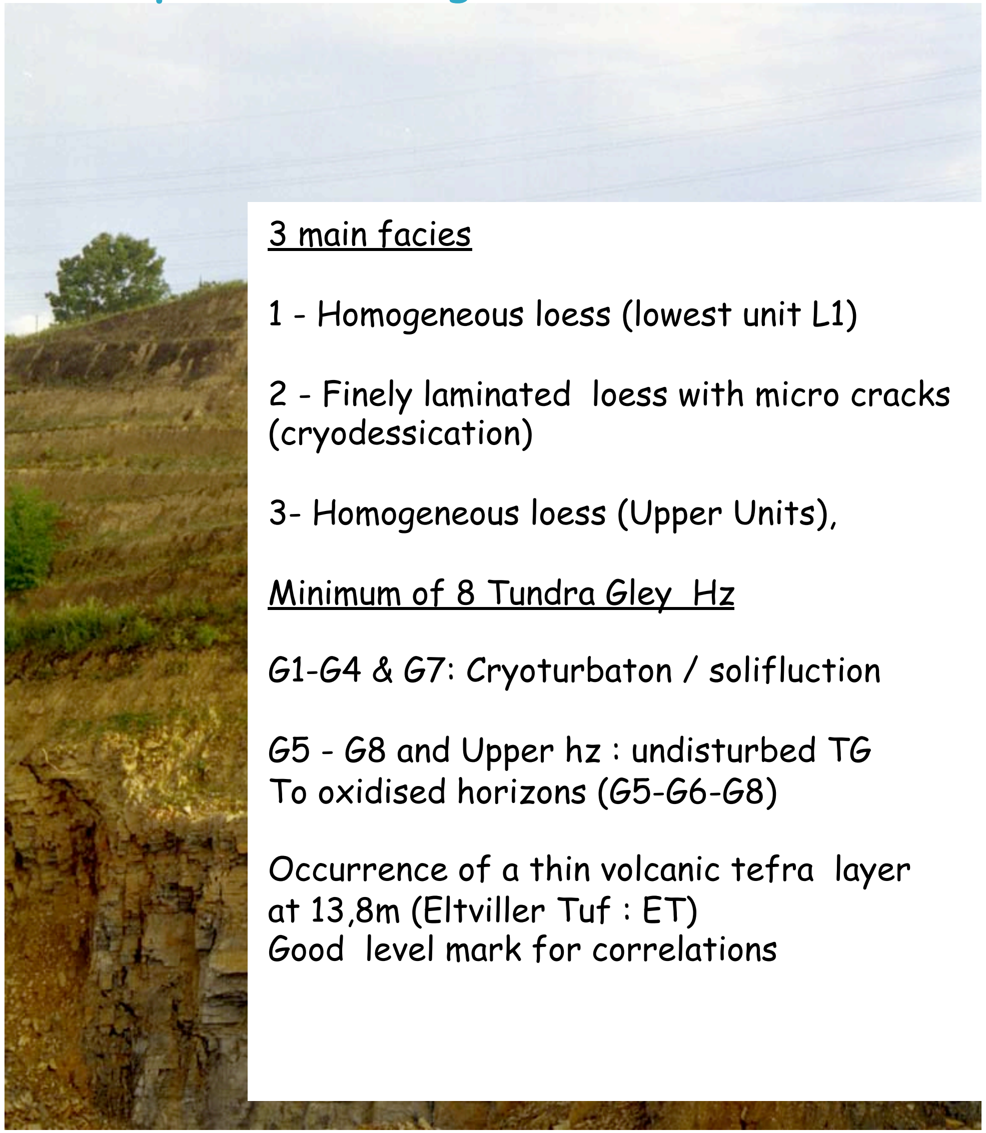
Last profile investigated: Nussloch P4



<u>3 main facies</u>

1 - Homogeneous loess (lowest unit L1)

2 - Finely laminated loess with micro cracks (cryodessication)

3- Homogeneous loess (Upper Units),

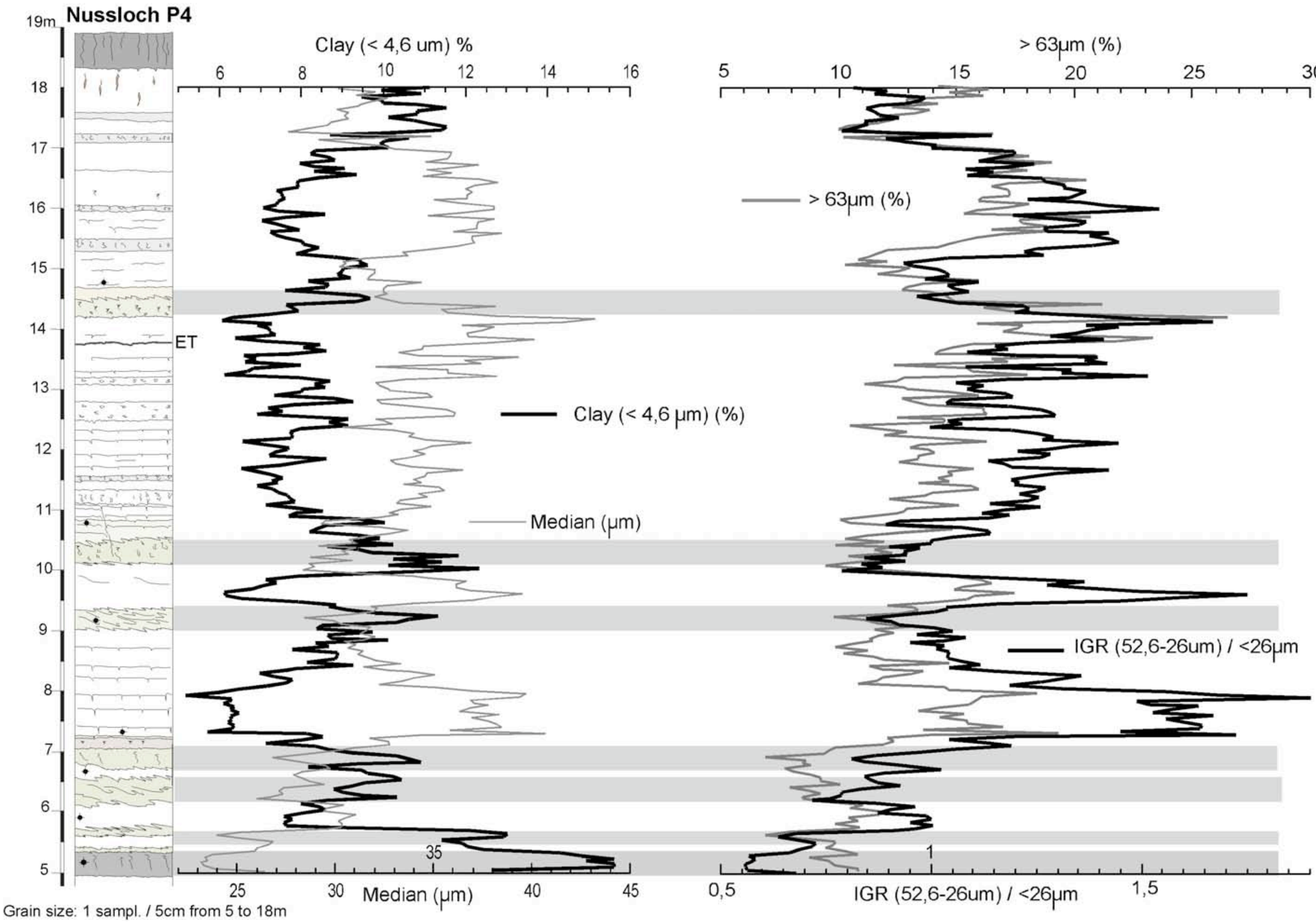
<u>Minimum of 8 Tundra Gley Hz</u>

G1-G4 & G7: Cryoturbaton / solifluction

G5 - G8 and Upper hz : undisturbed TG
To oxidised horizons (G5-G6-G8)

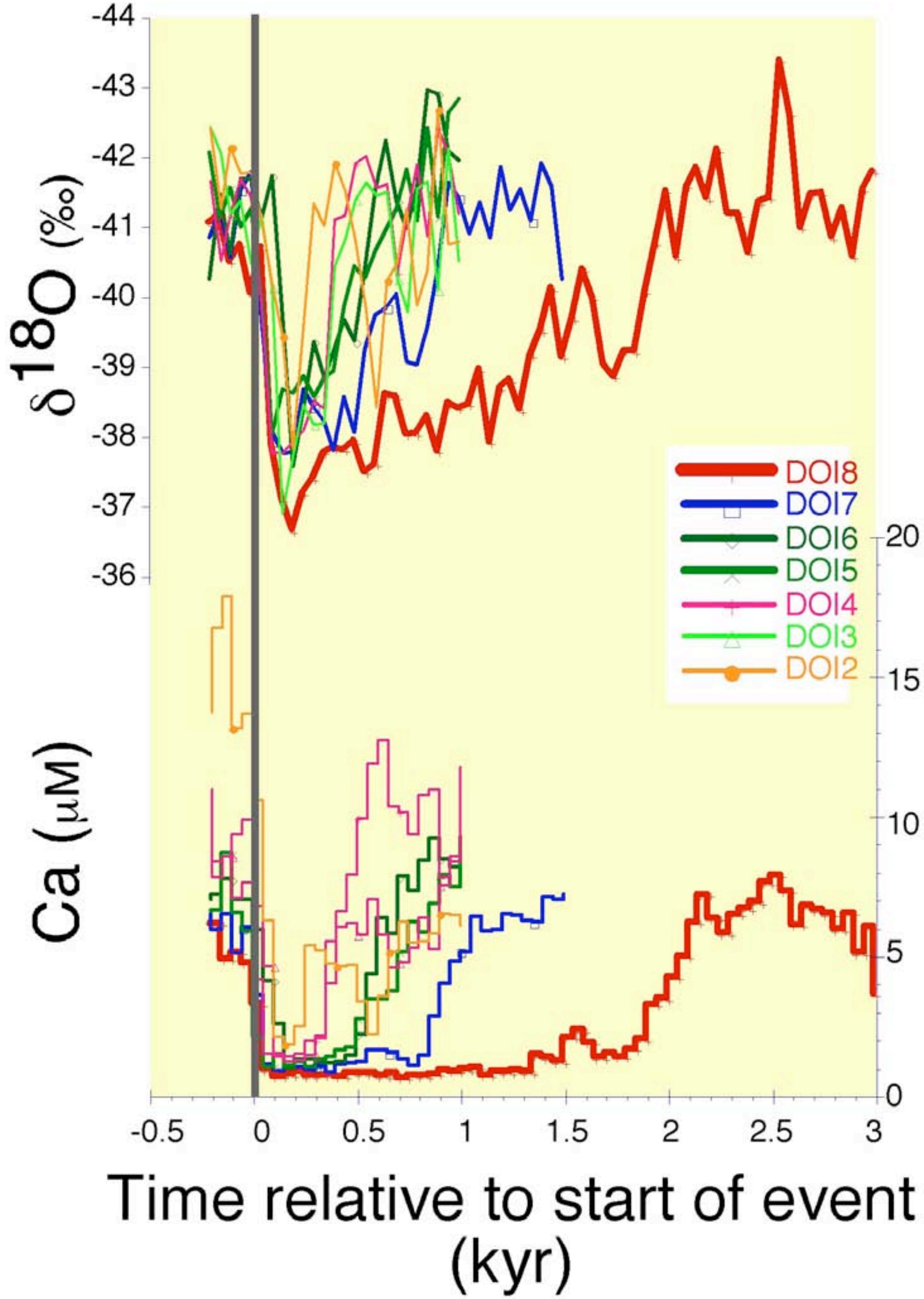
Occurrence of a thin volcanic tefra layer at 13,8m (Eltviller Tuf : ET)
Good level mark for correlations

Grain Size variations in the Upper Pleniglacial loess sequence Nussloch P4 40 and 15 ka



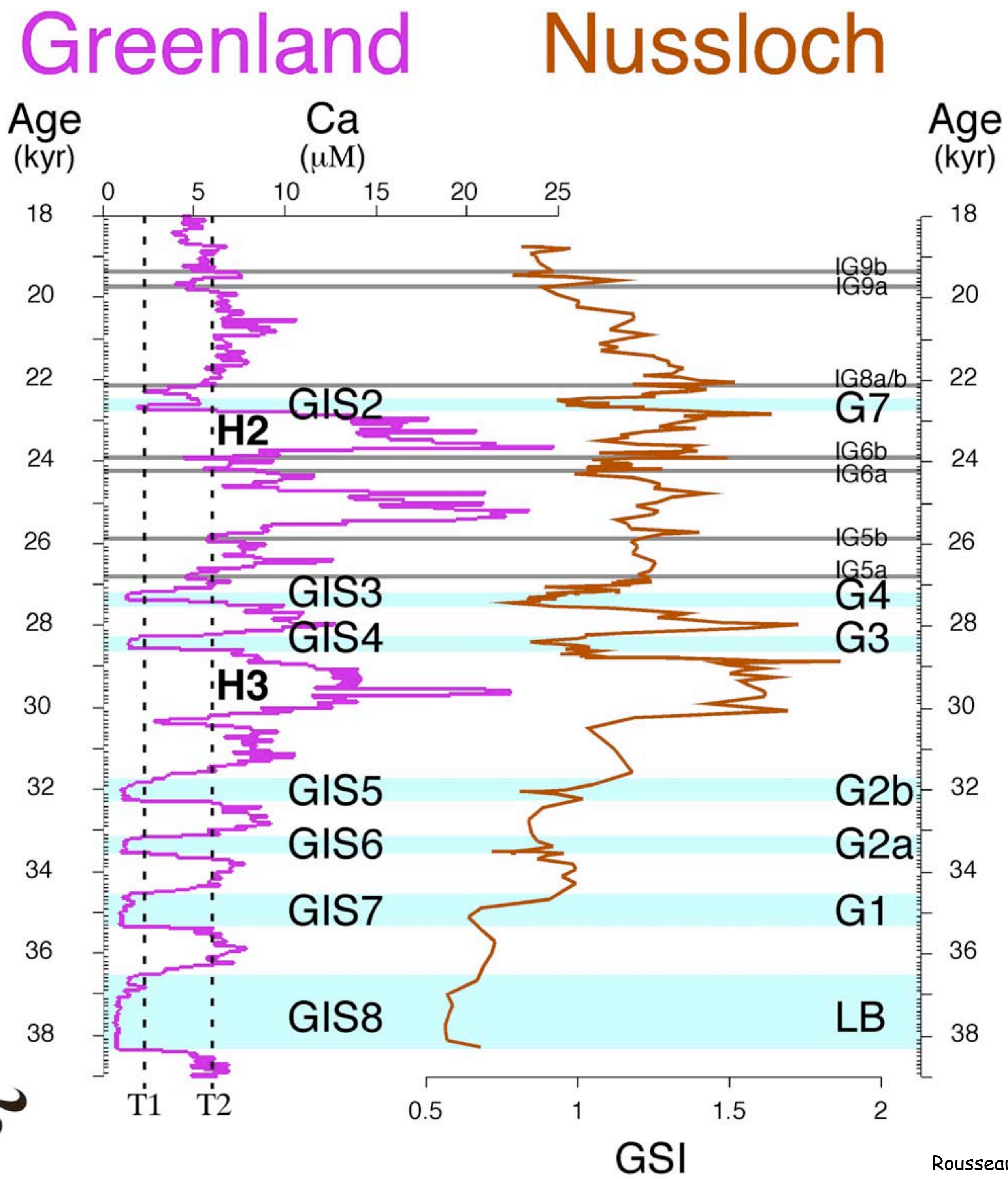
Antoine *et al.*, QSR (submitted)

DO expression in term of d18O and dust, the way to look at loess sequences



Rousseau *et al.* 2007 GRL (modified),

ADOM1 2009



Rousseau *et al.* 2007 GRL (modified),

US loess sequences

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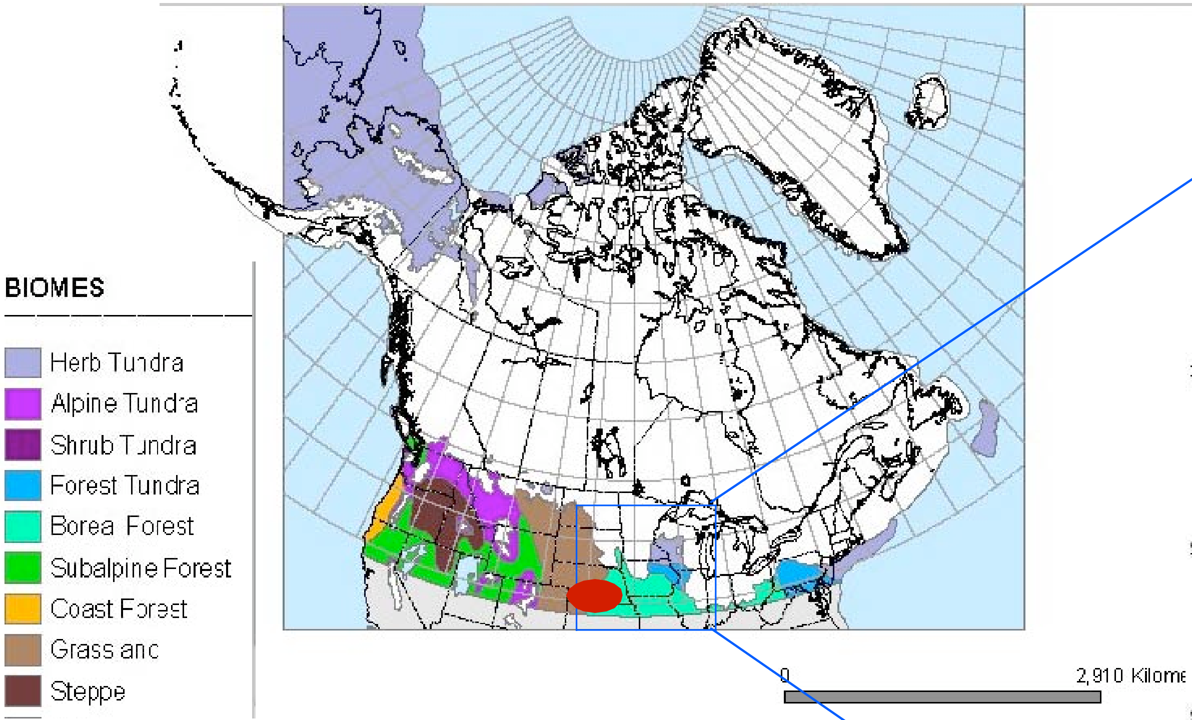
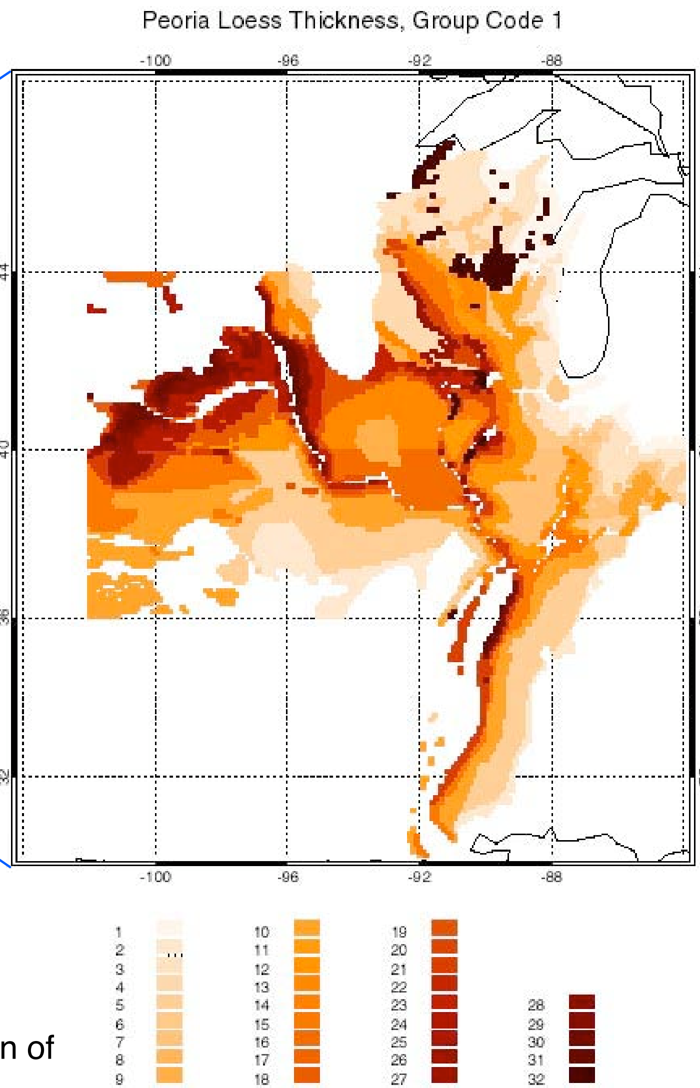
General context



Reconstruction of the maximum extent of the Laurentide ice sheet during the last glacial maximum, with indication of the reconstructed biomes. (from S.A. Wolfe 2004 @ http://sts.gsc.nrcan.gc.ca/mapviewers/paleo_18k_fr.asp?k=1)



Reconstructed thickness (in meters) geographic variation of the Peoria loess unit in mid-continent North America .
(from Kohfeld & Muhs 2001 @ http://www.ncdc.noaa.gov/paleo/loess/peoria/peoria.html)

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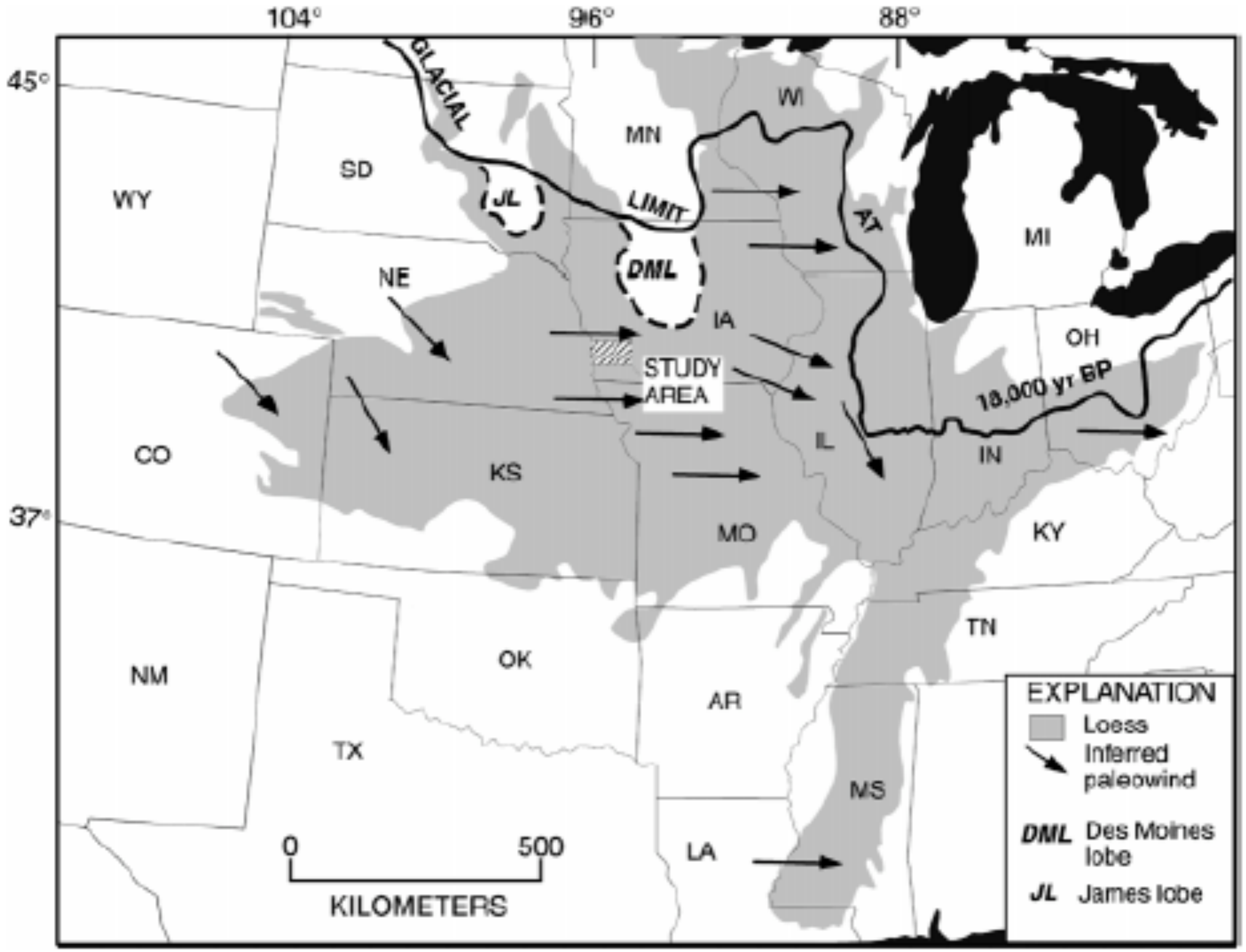
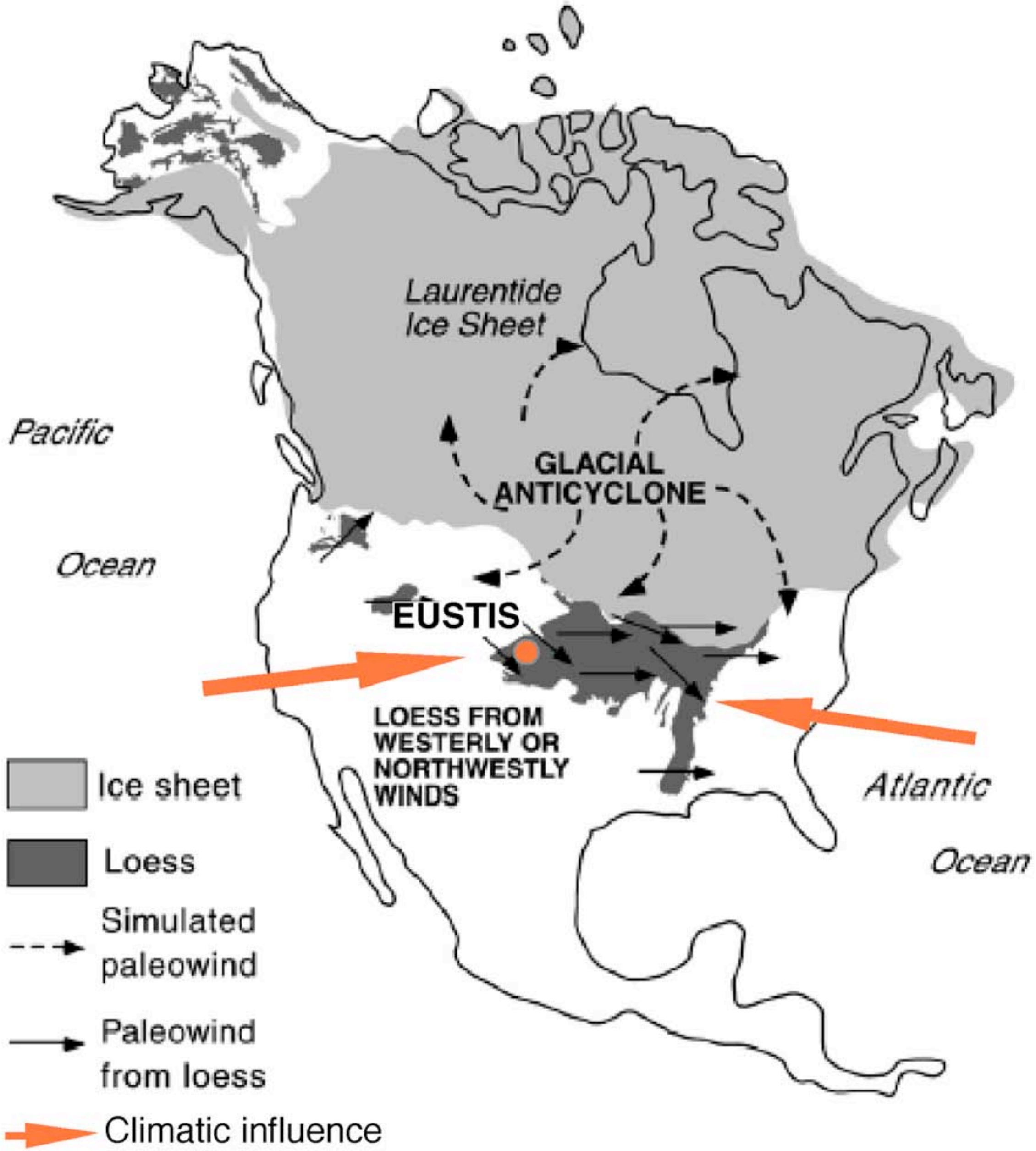
Rousseau *et al* . *EPSL 2007*

Wind directions deduced from proxies



Muhs & Bettis Geol. Soc. America Sp papers 2003



Map of North America with the extent of the Laurentide ice-sheet at the LGM with anticyclone wind patterns modeled from COHMAP and those derived from the loess thickness measured in the field (from Muhs and Bettis 2000).

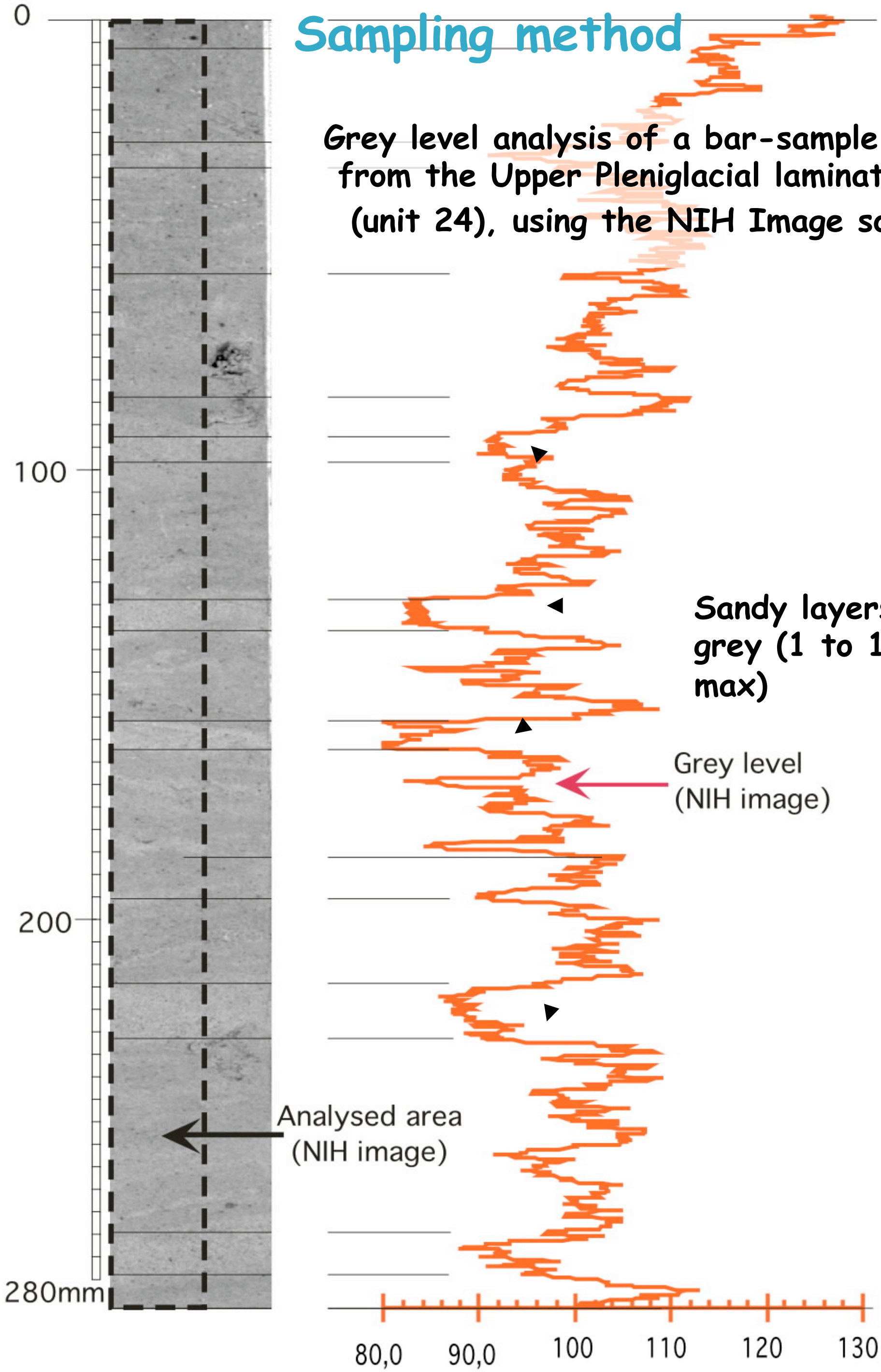
Rousseau *et al*. *EPSL 2007*

Fig. 6


Continuous or short event deposition?
Long or short distance transport?
How does it fit with modern dust?

Nussloch P4 2002 : Sampling method

Grey level analysis of a bar-sample (280mm) from the Upper Pleniglacial laminated loess (unit 24), using the NIH Image software.



Sandy layers: light grey (1 to 10 mm max)

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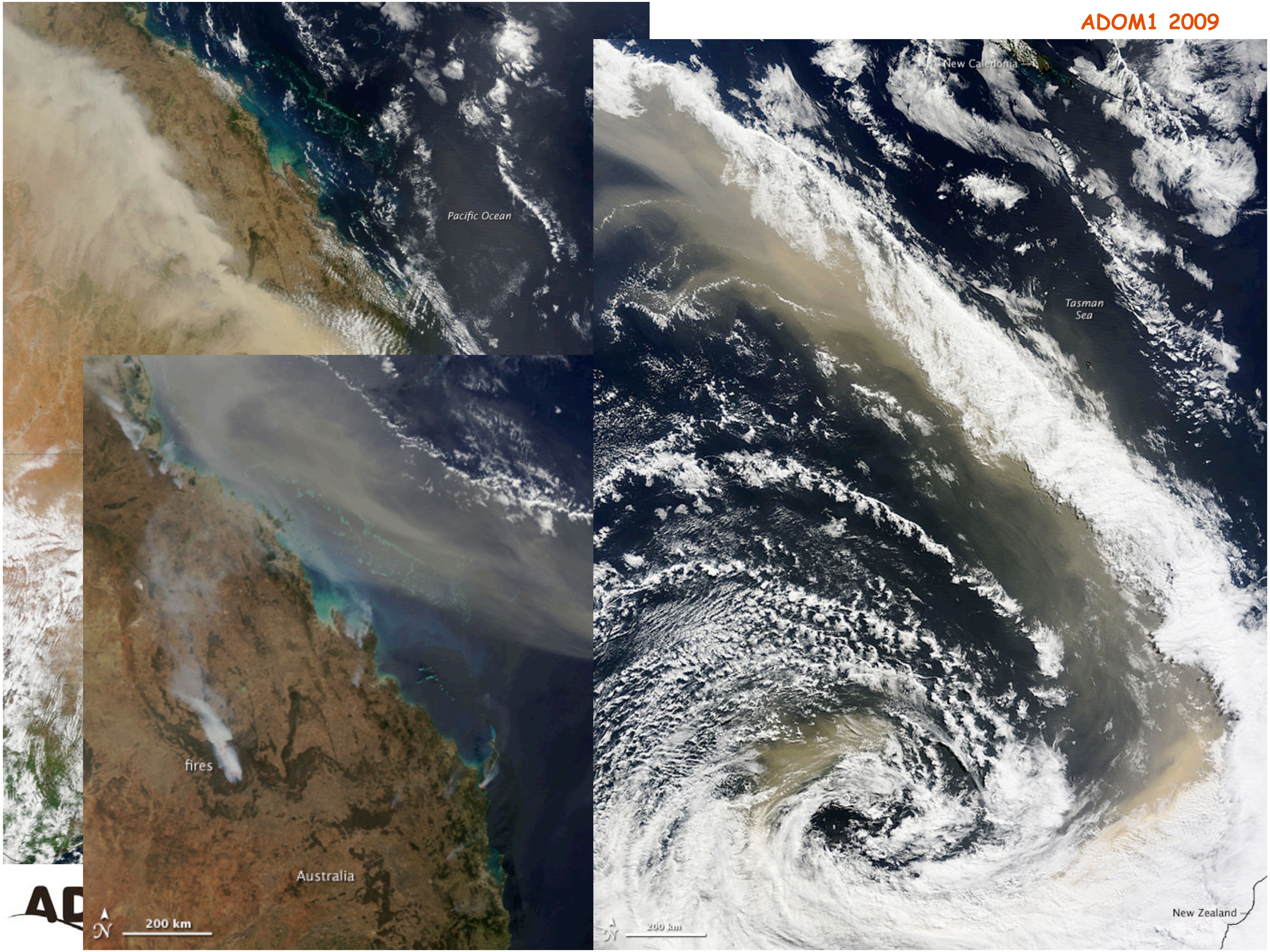


Pacific Ocean
fires
Australia
200 km
New Caledonia
Tasman Sea
New Zealand

Supplement to -

The 2001 Asian dust events

D. Jaffe, J. Snow and O. Cooper

submitted to EOS, May 2003

The following animation shows forward trajectory particles released from the desert regions of southern Mongolia and northern China that made a strong contribution to the Asian dust event of April 2001.

The particles were released from the lowest 2 km of the troposphere, spaced at 10 km intervals in the horizontal and 25 hPa in the vertical.

The yellow trajectory particles were released at 00 UTC April 6 ahead of a cold front and into the warm conveyor belt of a mid-latitude cyclone. The blue trajectory particles were released at 12 UTC April 6, behind the cold front of the same cyclone.

The trajectory particles advect across the North Pacific over the next 15 days and indicate the transport pathways of the Asian dust event. Note how the trajectory particles impact the North American west coast on April 16 and 17 and how other particles follow a polar route and subsequently impact the southeastern United States on April 19 and 20.

Ahead of a cold front (00 UTC April 6) **Behind the same cold front (12 UTC April 6)**

ADOM Specific Objectives

* Review datasets and model results relevant to atmospheric paleocirculation
* Define commonalities and differences between regions, archives and proxies
* Identify links between dust deposition and abrupt climatic and environmental change
* Summarize the current knowledge on past atmospheric dynamics
* Compare data records with modeling results
* Identify the critical gaps in knowledge and data for reconstructions and modeling
* Outline group papers

Workshop themes and questions

- Are the events described from the different records correlated within the dating uncertainties?
- What is the state-of-the-art on the interpretation of the different proxies used to characterize the millennial changes?
- Are changes in eolian deposition only related to wind activity or also to other climate-environment variables such as precipitation or to changes in dust sources?
- How is the dust deposition in Greenland related to the continental loess deposits, given that isotopic signatures indicate a similar source for both the loess in China and the dust in Greenland ice? What were the formation mechanisms of these deposits in the first place?
- Heinrich events 2 and 3 correspond to the highest dust concentration in Greenland ice, as well as to grain size maxima in European loess deposits.
- Were these anomalies causally linked? What environmental-climatic conditions did enable these extreme depositional events? Were these events of only regional extent or of hemisphere wide significance?

ADOM

*Sunday1*

* 9 -10 Welcome and ADOM introduction DDR were does it come from were we are and what one can expect.

Dust in ice cores (convener DDR)

* 10 - 11H. Ficher Ice core estimates of paleoclimatic changes in aeolian dust
* 11 - 12 K. Wolff High resolution dust measurements in the NGRIP ice core, Bølling-Allerød Interstadial
* 14 - 15 J.R. Petit The importance of the atmospheric cleansing for the long-range transport of the dust: the evidence from deep Antarctic ice cores records.
* 15 - 16 F. Thevenon Large-scale atmospheric circulation changes recorded by Saharan dust analysis in an Alpine ice core.
* 16 - 17 A. Wegner A Holocene dust concentration record from the new greenlandic NEEM ice core - Preliminary results
* 17- discussion

_*Monday 2*
_Continental records (convener Ina Tegen)

* 9 - 10 C. Hatte preliminary topic the chronological time scale: organic versus physiscs
* 10 - 11 R. Tada Provenance of eolian dust and reconstruction of millennial-scale atmospheric circulation changes in East Asia
 during the last glacial to the Holocene
* 11- 12 Z.T. Guo Chinese loess (presentation sent to LP Zhou) no title yet
* 14 - 15 L.P. Zhou A comparison of high-resolution dust records of last glacial period from polar ice cores and Asian loess fields
* 15 - 16 P. Antoine European loess records no title yet
* 16 - 17 A. Bettis (US loess records) ppt promised to be sent to DDR no title yet

Marine records

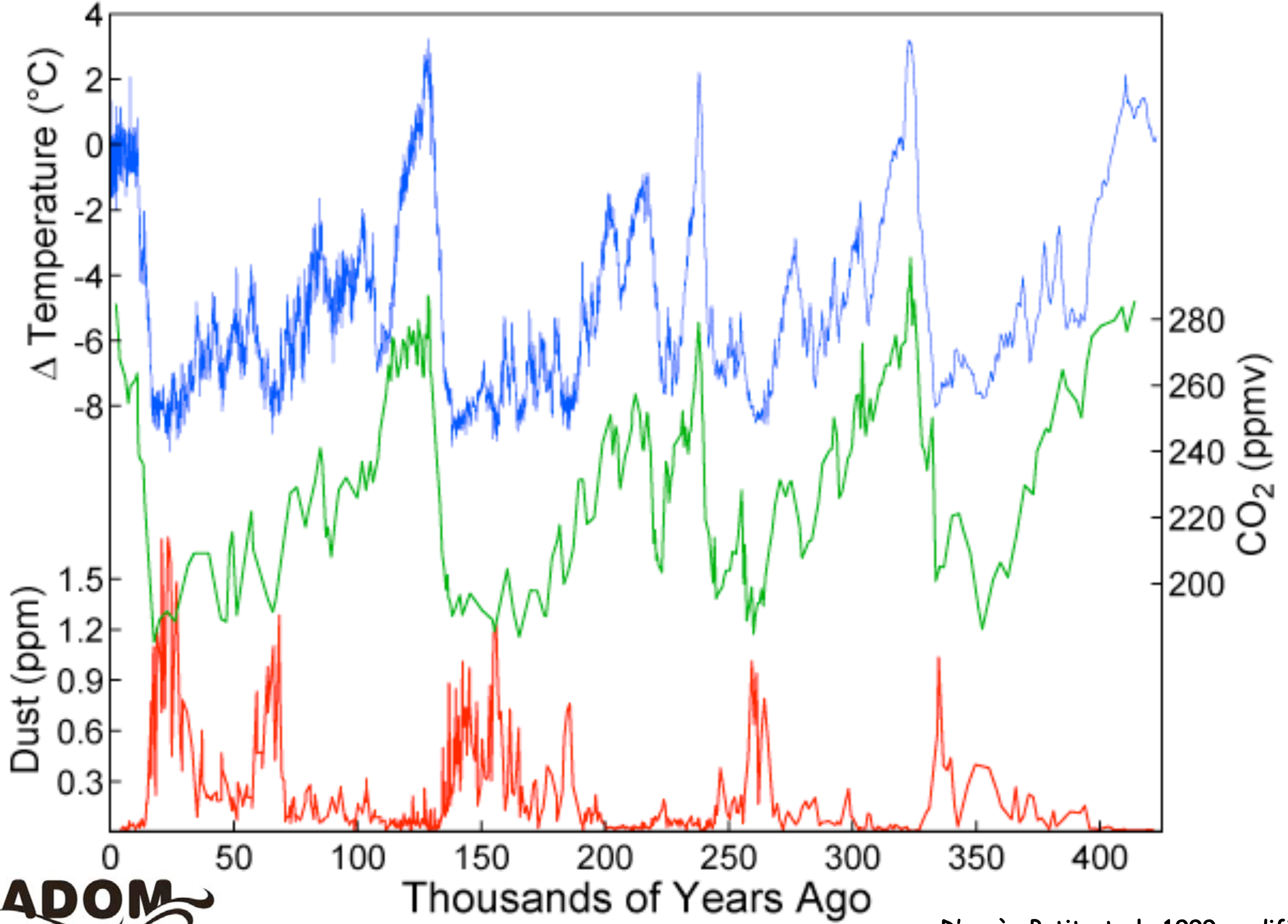
* 17 - 18 A. Rossell Mele Glacial/Interglacial variability in dust fluxes to the Subantarctic Atlantic during the Plio-Pleistocene
* 18 - 19 J. McManus Dust record in North Atlantic marine cores no title yet
* 19 - discussion

*Tuesday 3*
Dust cycle and modeling (convener Christine Hatté)

* 9 – 10 G. Bergametti Dust emissions: variability and modeling
* 10 – 11 I .Tegen Current issues in modeling modern dust
* 11 – 12 S.G. Boychenko About possible displacement of subtropical anticyclones on in a direction of mid latitudes and southern regions of Ukraine at the subsequent global warming + Use of Fokker-Plank equation for parameterization of turbulent diffusion of gas-aerosol pollution in atmosphere
* 14 – 15 A. Sima Imprint of North-Atlantic abrupt climate changes on European loess sediments during the last glaciation – a modeling study
* 15 – 16 U. Merkel Atmospheric dynamics and teleconnections during glacial climates
* 16 – 17 A. Ganopolski (sent his PPT to A Sima) Modelling of aeolian dust during glacial cycles
* 17 – 18 discussion

*Wednesday 4*

Wednesday morning
Data model comparison synthesis/ needs for modelers/ planning of the next meeting
Afternoon; departure or free visit of local islands.



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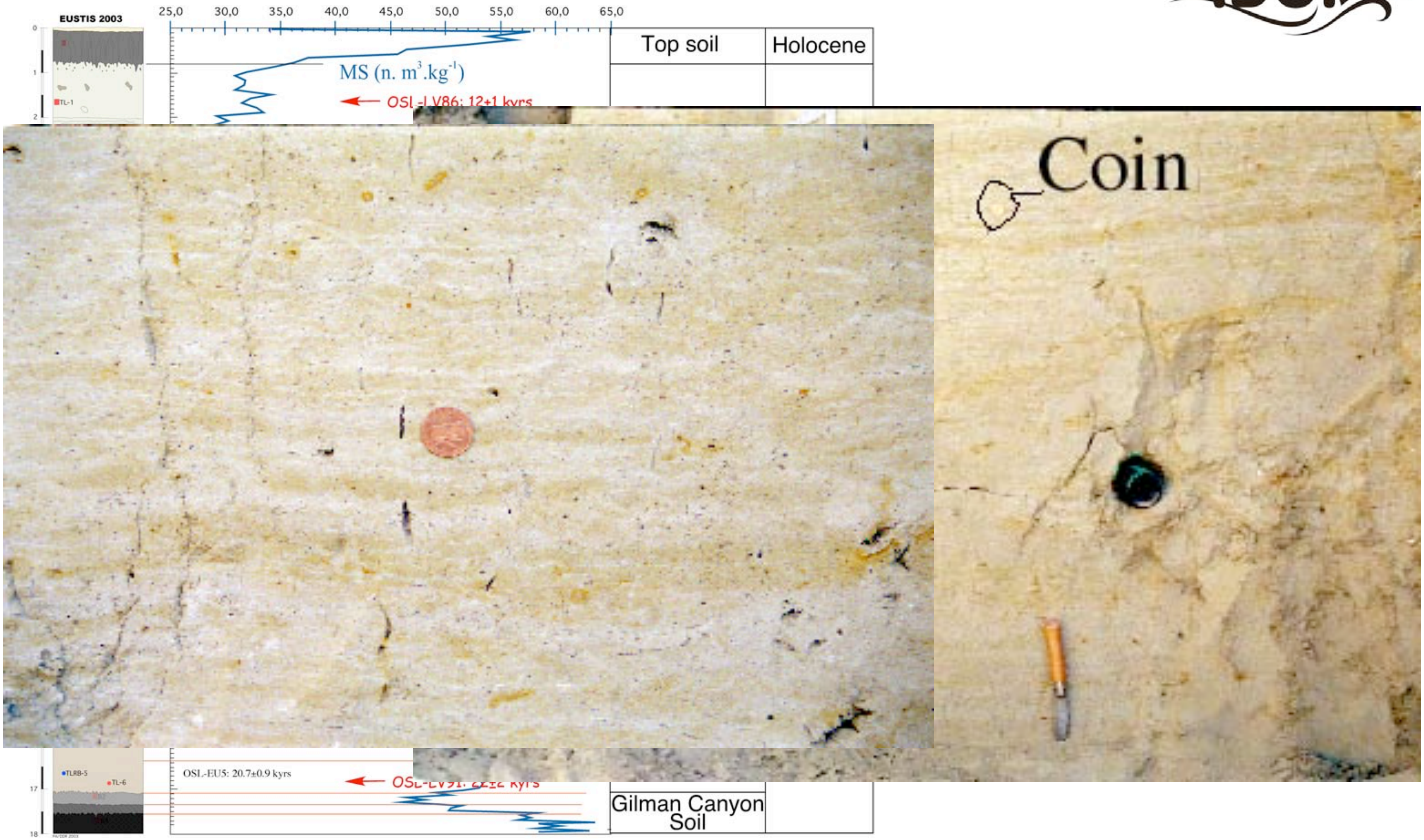
D'après Petit et al. 1999 modifié



Stratigraphy of the Peoria loess unit in the Eustis ash pit. Variation of the low field magnetic susceptibility and of the samples taken for luminescence dates. Location of the OSL dates obtained by H. Roberts (2003). The vertical arrows indicate cyclic pattern of deposition observed in the laminae-like horizons. This stratigraphy is in agreement with that described by Rousseau and Kukla (1994).

Rousseau *et al*. *EPSL 2007*

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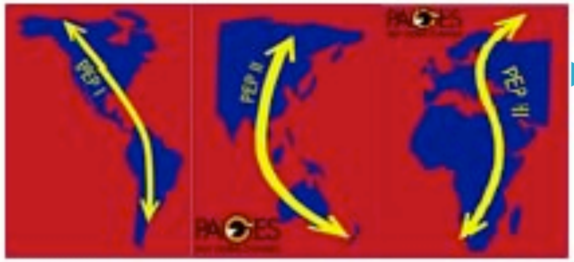
Focus 1: PANASH

Paleo-environments of the Northern and Southern Hemispheres

The goal of the Paleoclimate and Environments of the Northern and Southern Hemispheres (PANASH) Loess is to reconstruct paleoenvironments and paleoclimate along one west-east terrestrial transects, using a multiproxy data and modeling approach.

NH Loess



One of the major roles of Loess transects is to facilitate the development of west-east research partnerships and foster a unified sense purpose within the diverse international and interdisciplinary community addressing questions of past global change.

In addition to supporting Loess transects, PANASH as a whole stimulates exchange of information among marine, atmospheric, and terrestrial scientists, historical ecologists and environmental archaeologists globally.

PEP activities

The PEP transects have been extremely successful in achieving these goals as evidenced by the strong community interest in PEP activities (more than 300 people attended the PEP3 conference "Past Climate Variability Through Europe and Africa" in Aix-en-Provence, 27-31 August 2001), as well as the peer reviewed synthesis publications that have arisen from each transect (Markgraf 2001, Dodson and Guo in prep, Battarbee et al. in press).

Its primary tasks are to:

- document the amplitude, phase and geographic characteristics of climate change in the two hemispheres,
- determine the history of potentially important forcing factors,
- identify the important feedbacks that amplify or reduce the influence or effect of these forcings,
- identify the mechanisms of climatic coupling between the two hemispheres.

The basis of all PANASH activities is understanding the modes of climatic and environmental variability by answering problem-oriented questions, through the use of global, multiproxy based climate and environmental reconstruction.

What kind of information a « loess » initiative can/could provide?

* High resolution changes in areas where no other records are available

* Longitudinal investigations versus PEP latiduninaly oriented studies
  - Rapid climatic changes and their impact in NW Europe
  - Record of paleomonsoon regimes in Asia
  - Teleconnections between N Atlantic and Eastern Eurasia
  - Interactions between N pacific and N Atlantic changes in N America

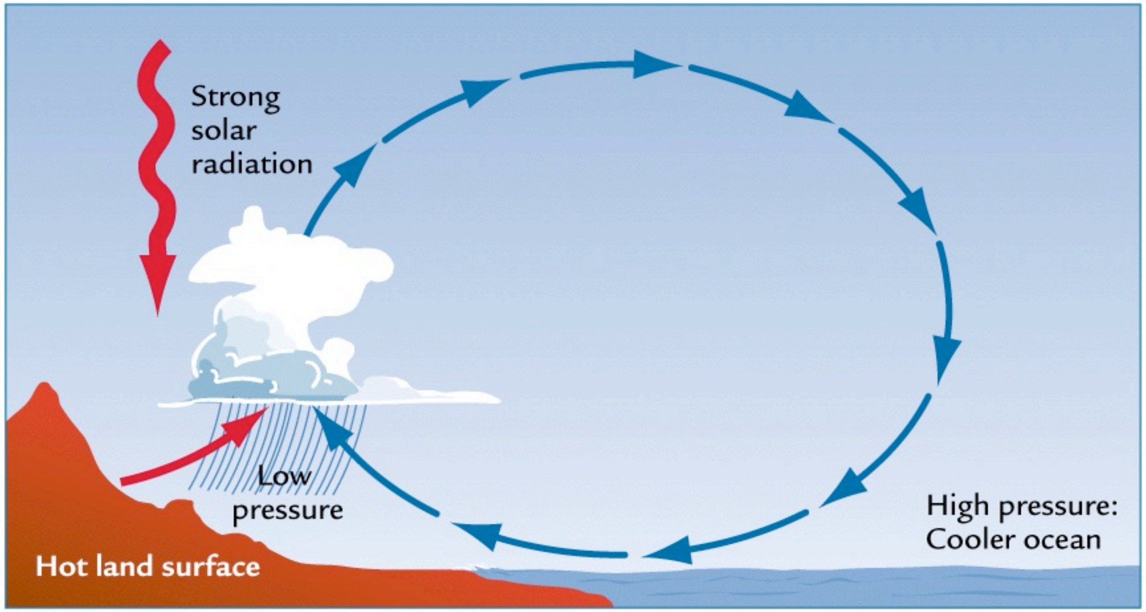
* Link with other PAGES projects

* Reliable and strong connection/correlations with marine and ice cores records

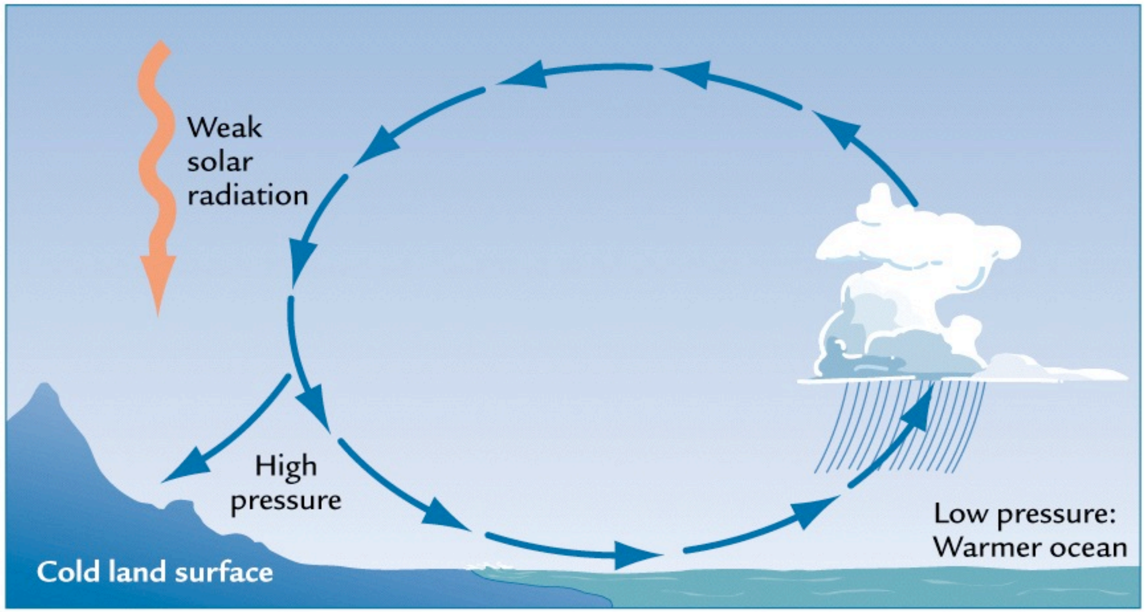
* Comparisons between typical loess and desert loess records

* Comparisons betwen present dust accumulation and past loess deposition

ADOM



A Summer monsoon



B Winter monsoon

Ruddiman


ADOM