Climate System II

(Winter 2023/2024)

11th lecture:

Regional and global changes

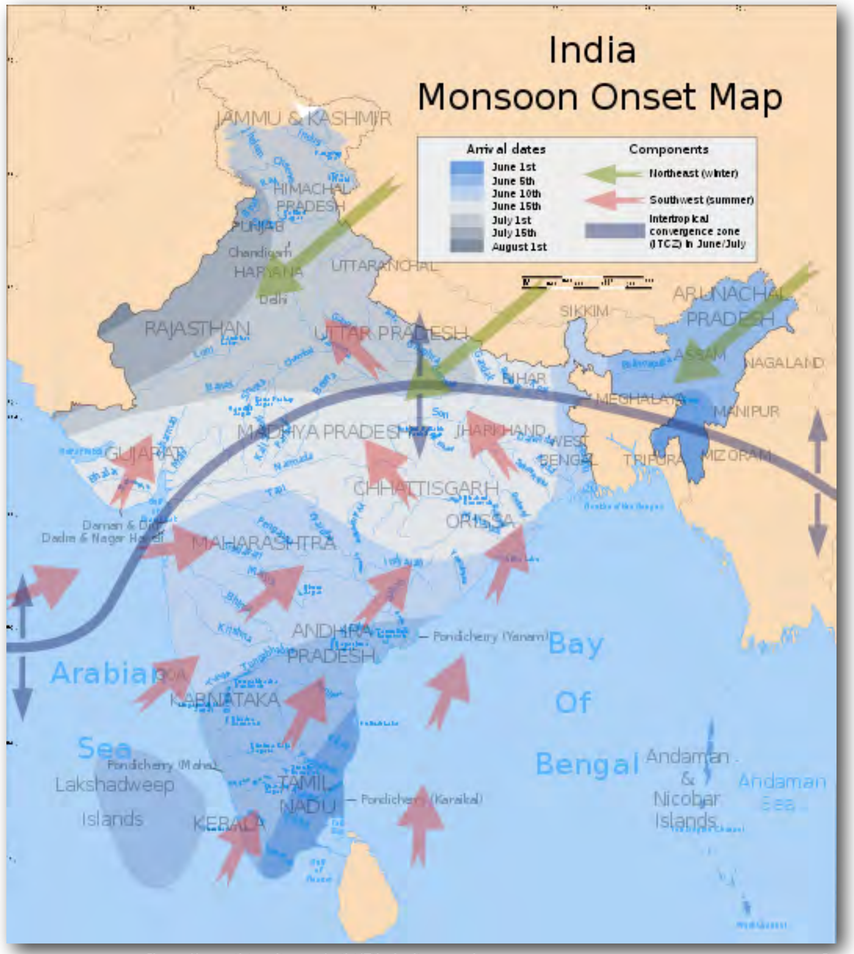
(Regional and global signals: Monsoons)

Gerrit Lohmann, Martin Werner

Tuesday, 10:15-11:45

https://paleodyn.uni-bremen.de/study/climate2023_24.html

Regional and global signals: Monsoons



[http://en.wikipedia.org/wiki/File:India_southwest_summer_monsoon_onset_map_en.svg]

[http://science.nationalgeographic.com/wallpaper/science/photos/climate/wind/]

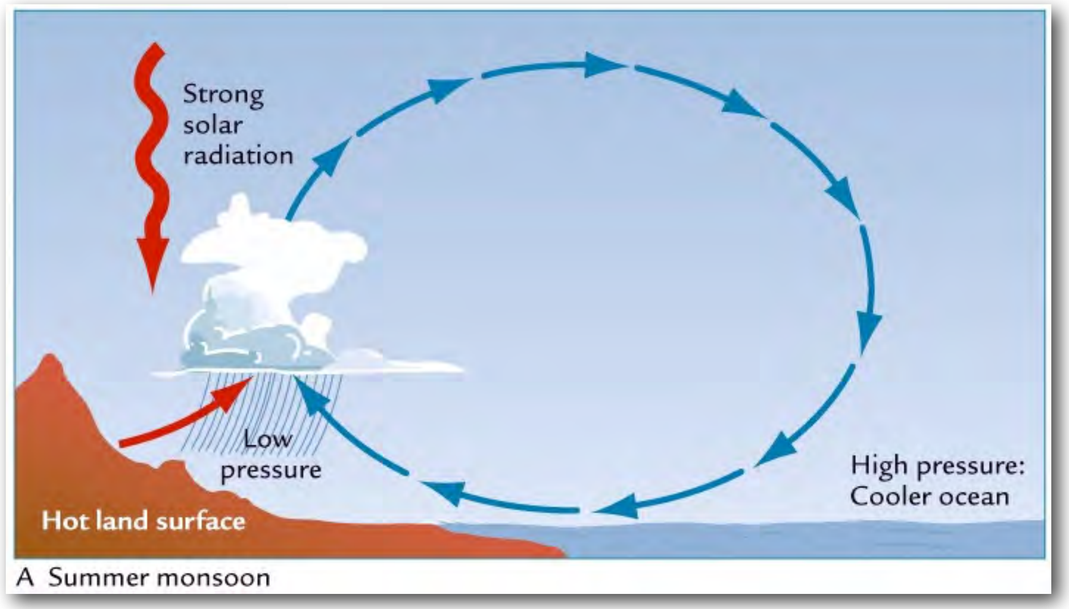
[http://mapurva.wordpress.com/2011/08/01/crazy-monsoon/]

The monsoon circulation

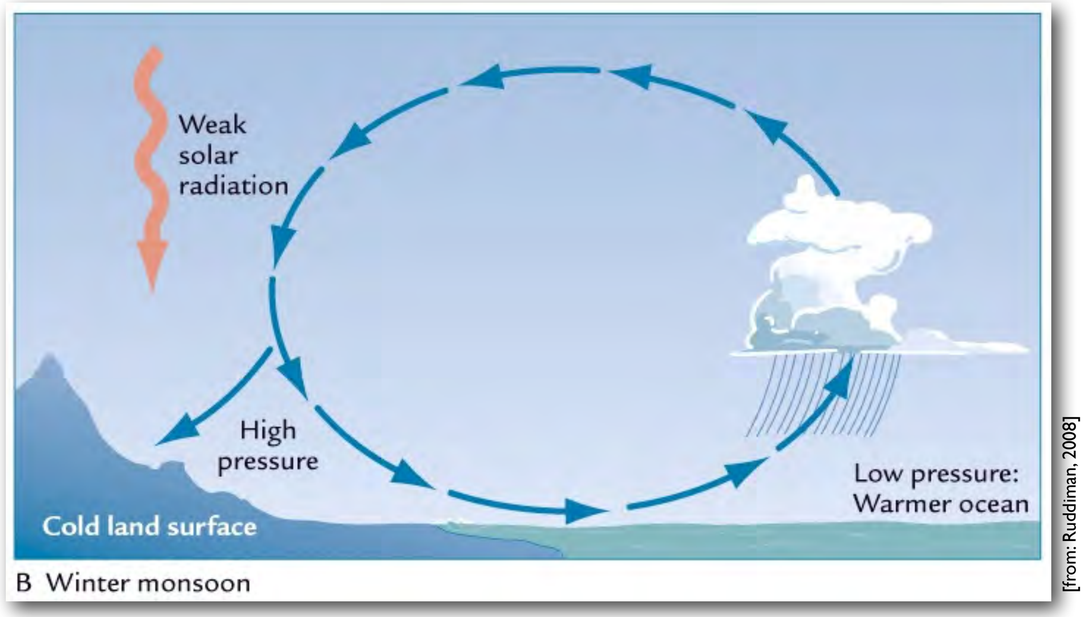
- monsoon circulation driven by
  large seasonal temperature gradient between
  land surface and adjacent ocean water

- summer monsoon bring heavy convective
  rainfall events, winter monsoon cold, dry air
  to the land surfaces

- most strong summer monsoons occur
  in the Northern Hemisphere
  (larger land masses, high Tibetan mountains)



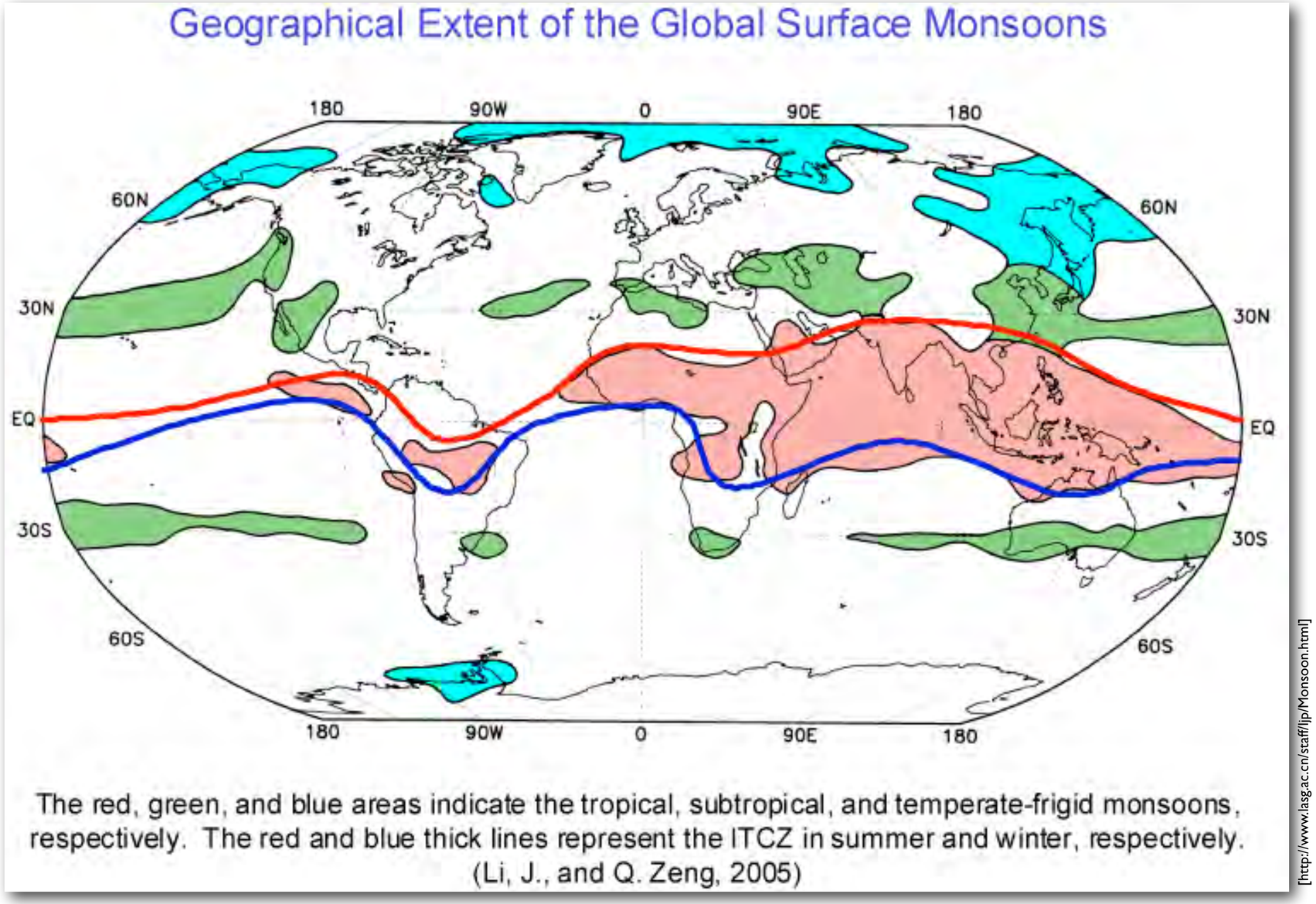
A Summer monsoon



B Winter monsoon

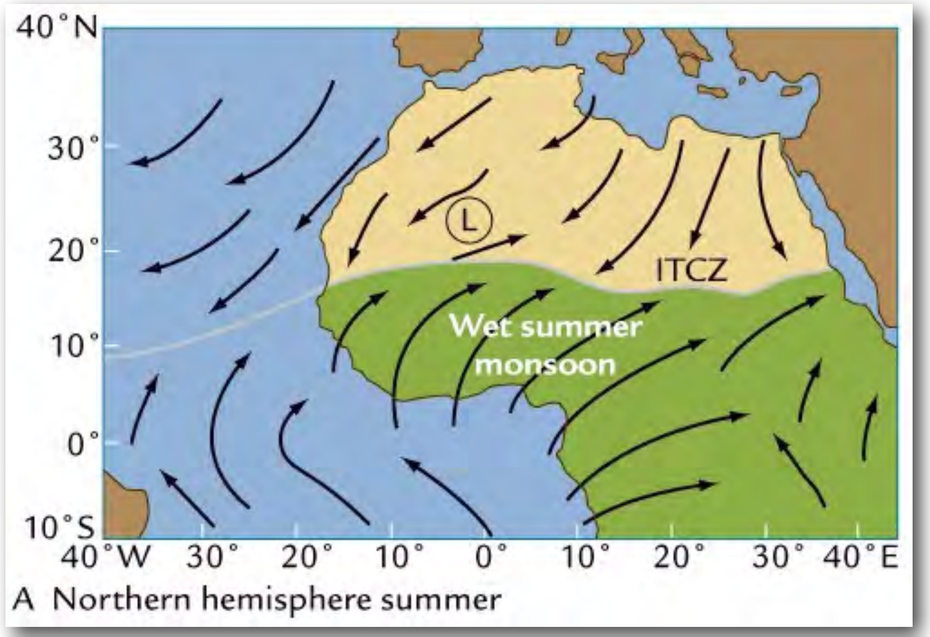
[from: Ruddiman, 2008]

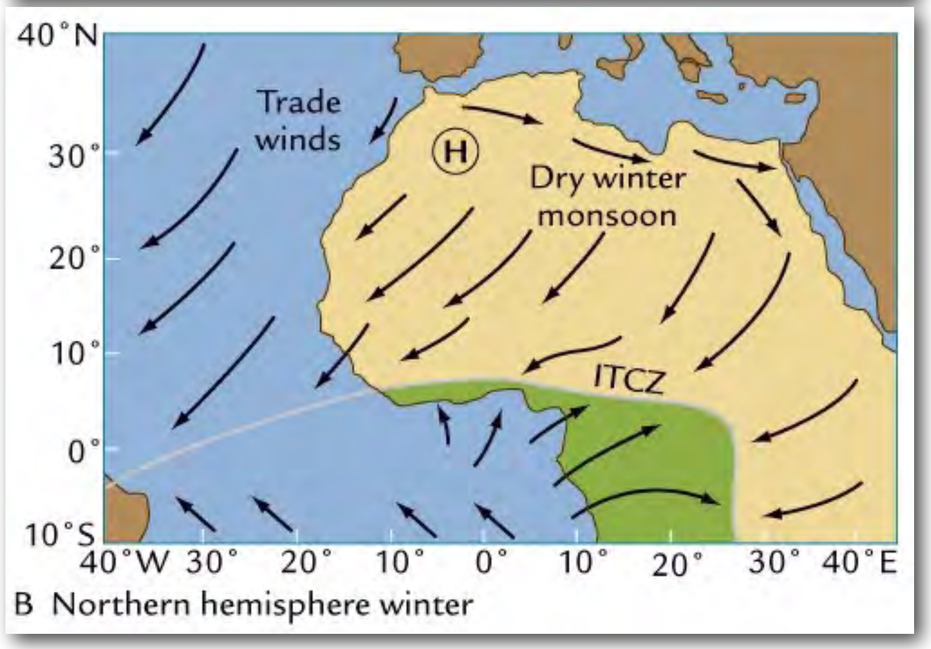
The global monsoon circulation

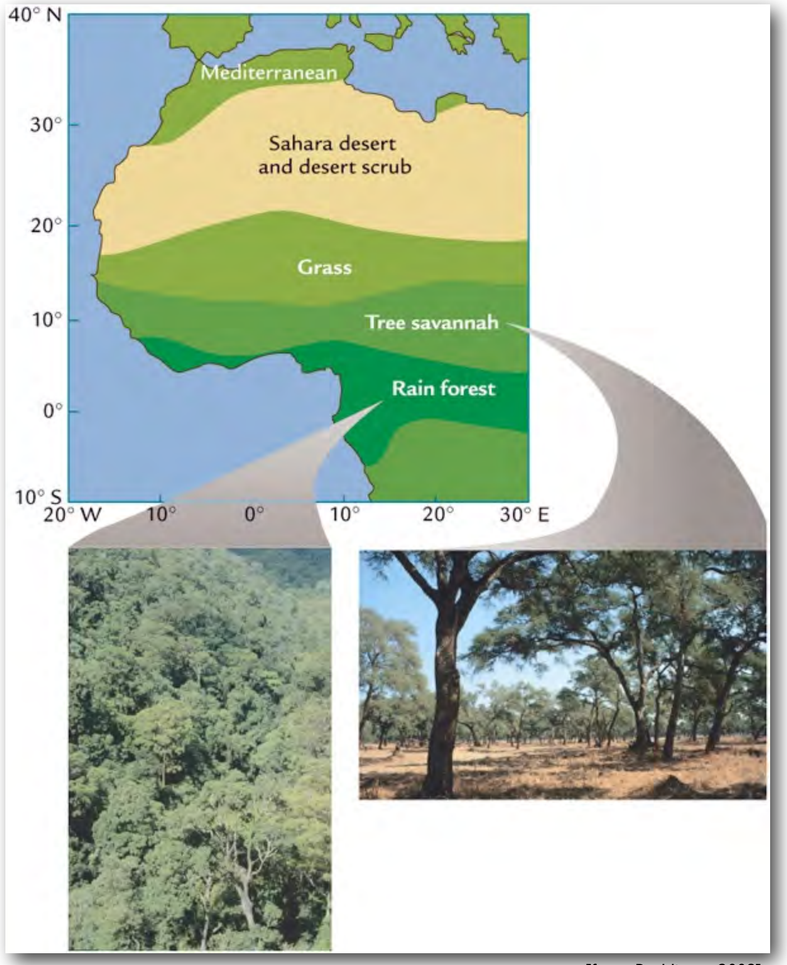


[http://www.lasg.ac.cn/staff/ljp/Monsoon.html]

The North African monsoon circulation





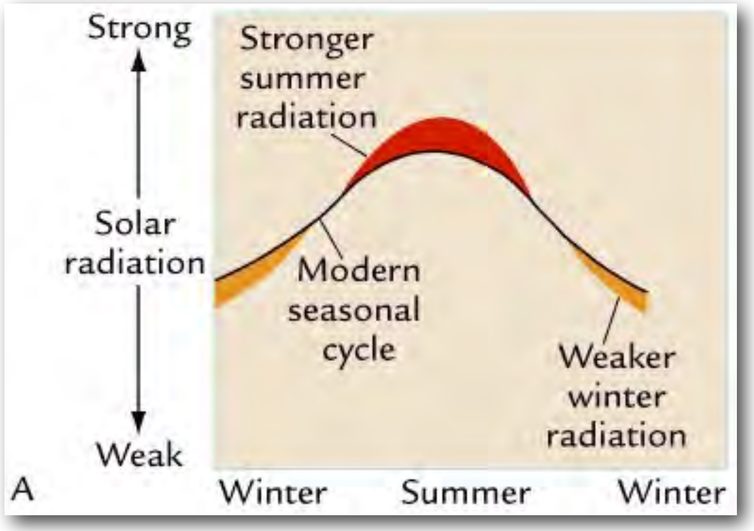


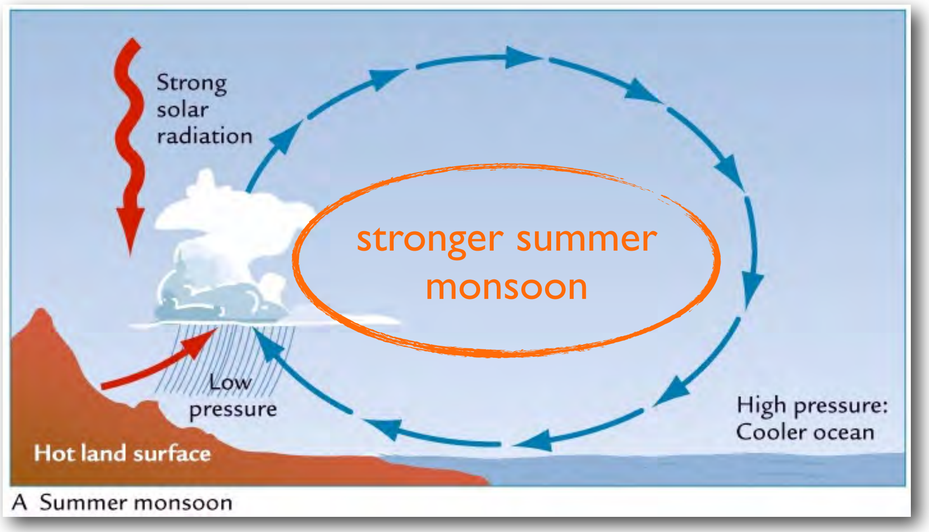
[from: Ruddiman, 2008]

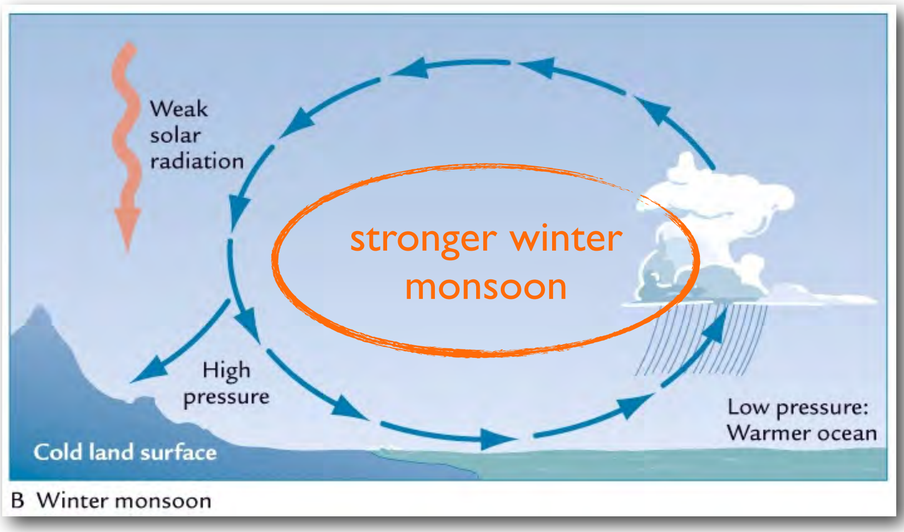
Orbital-scale control of monsoon circulation

Orbital monsoon hypothesis (J. Kutzbach, early 1980s)

- *stronger summer insolation caused by orbital changes should cause stronger summer monsoon*
- *vice versa for winter monsoon*
- *annual precipitation effects don't cancel each other out, as normal winter monsoon is often very dry, already*
  *=> **summer monsoon changes dominate annual signal***
  (nonlinear response of the climate system)

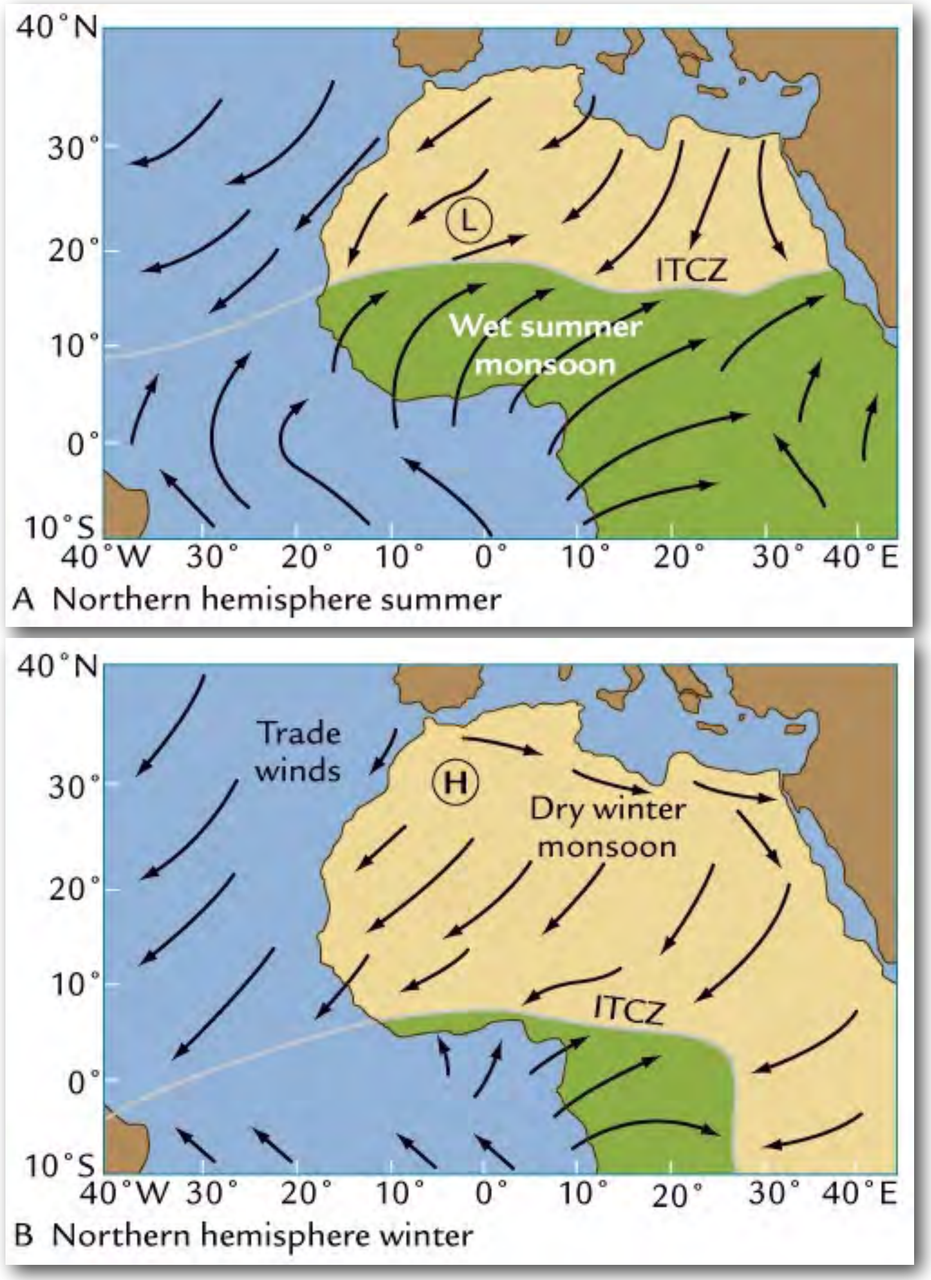






[from: Ruddiman, 2008]

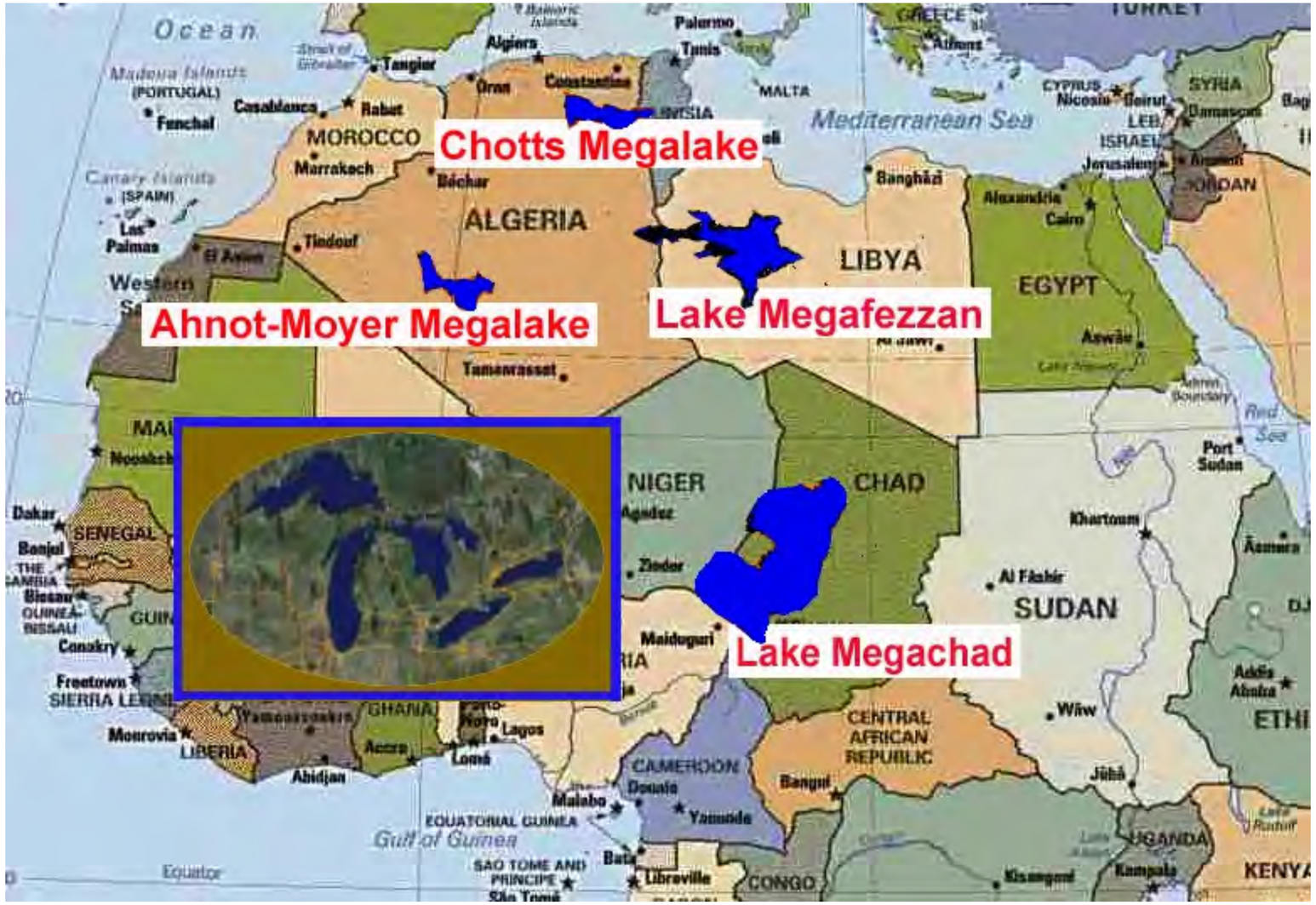
Orbital-scale control of North African monsoon circulation



[from: Ruddiman, 2008]

- <u>1st test of North African orbital monsoon hypothesis:</u>
  - *if summer monsoon brings more rain, there should have been more lakes in Northern Africa*
  - *old lake-beds should still be found*
  - *dating of lake sediments should be consistent with past times of high summer insolation values*

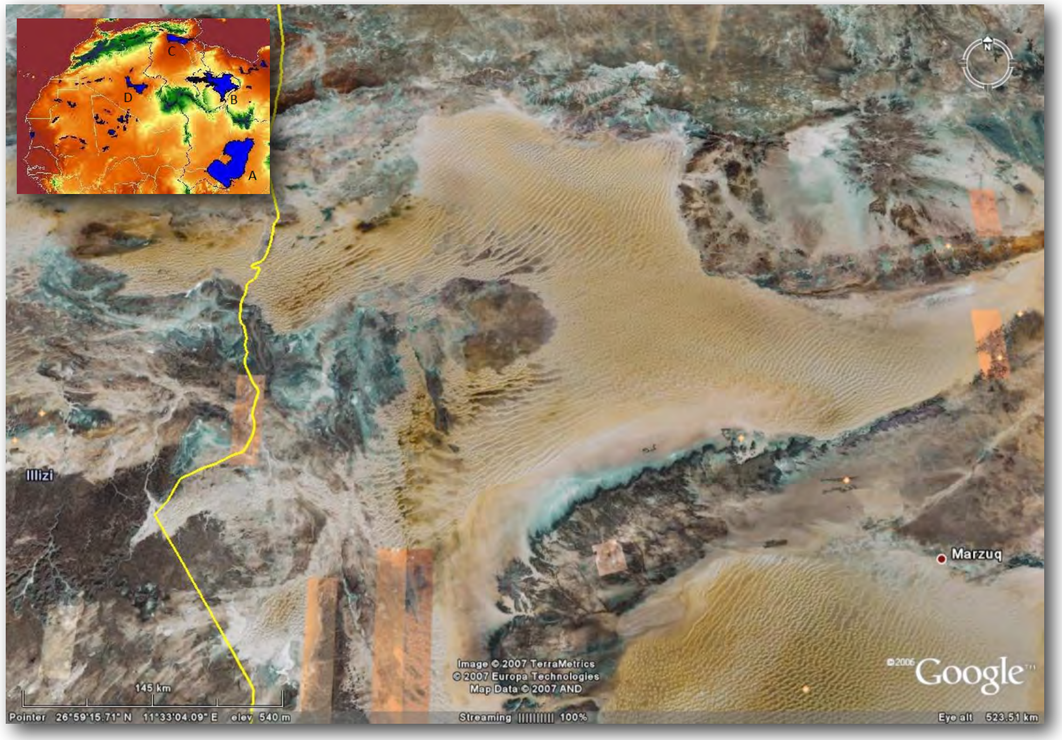
Orbital-scale control of North African monsoon circulation



The Megalakes of the Sahara region. These gigantic lakes have disappeared in recent millennia. Lake Chad is the only remaining trace of water from these giants. The inset shows the North American Great Lakes at the same scale (from Google Earth) for comparison purposes.)

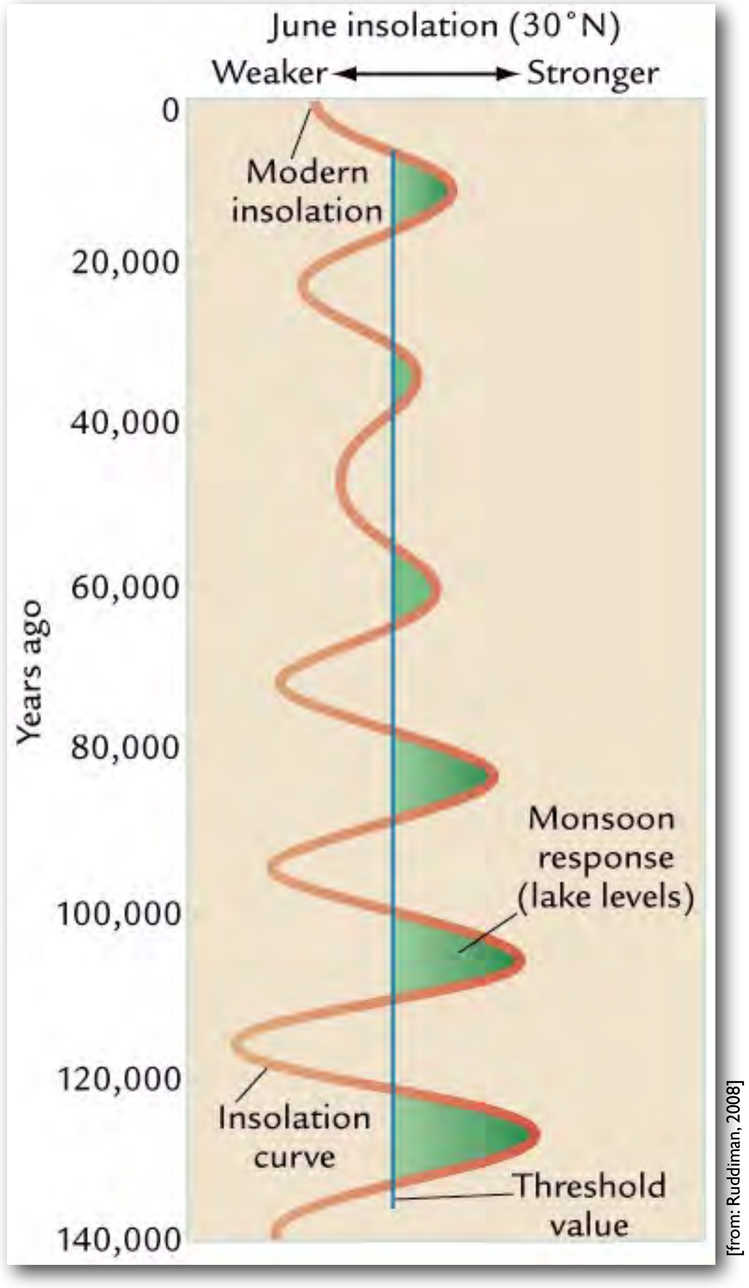
(from: http://climatesanity.wordpress.com/category/mega-lakes/)

Orbital-scale control of North African monsoon circulation



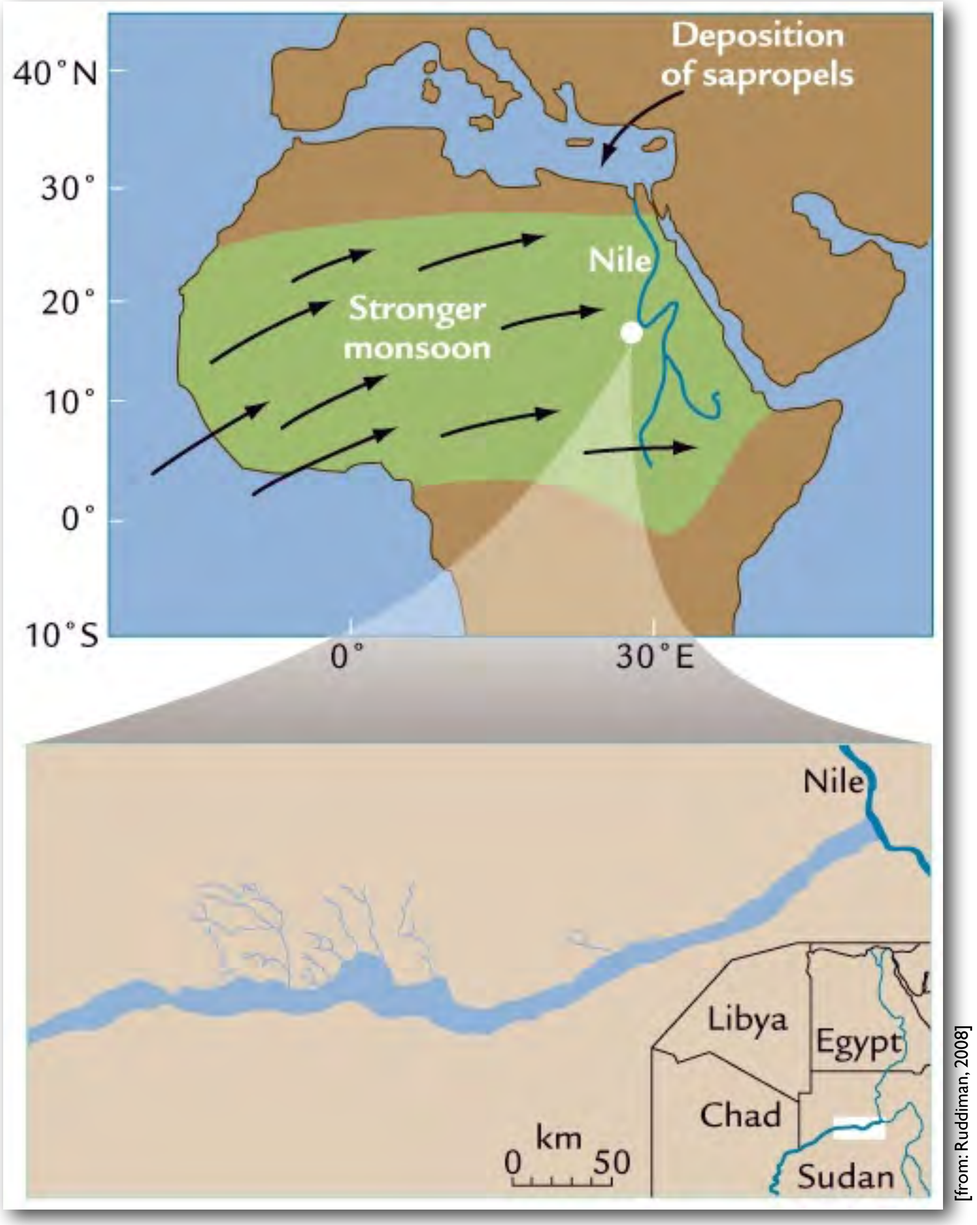
The site of Lake Megafezzan (B) as it appears today. All that remains is sand. (Image from Google Earth)

(from: http://climatesanity.wordpress.com/category/mega-lakes/)



[from: Ruddiman, 2008]

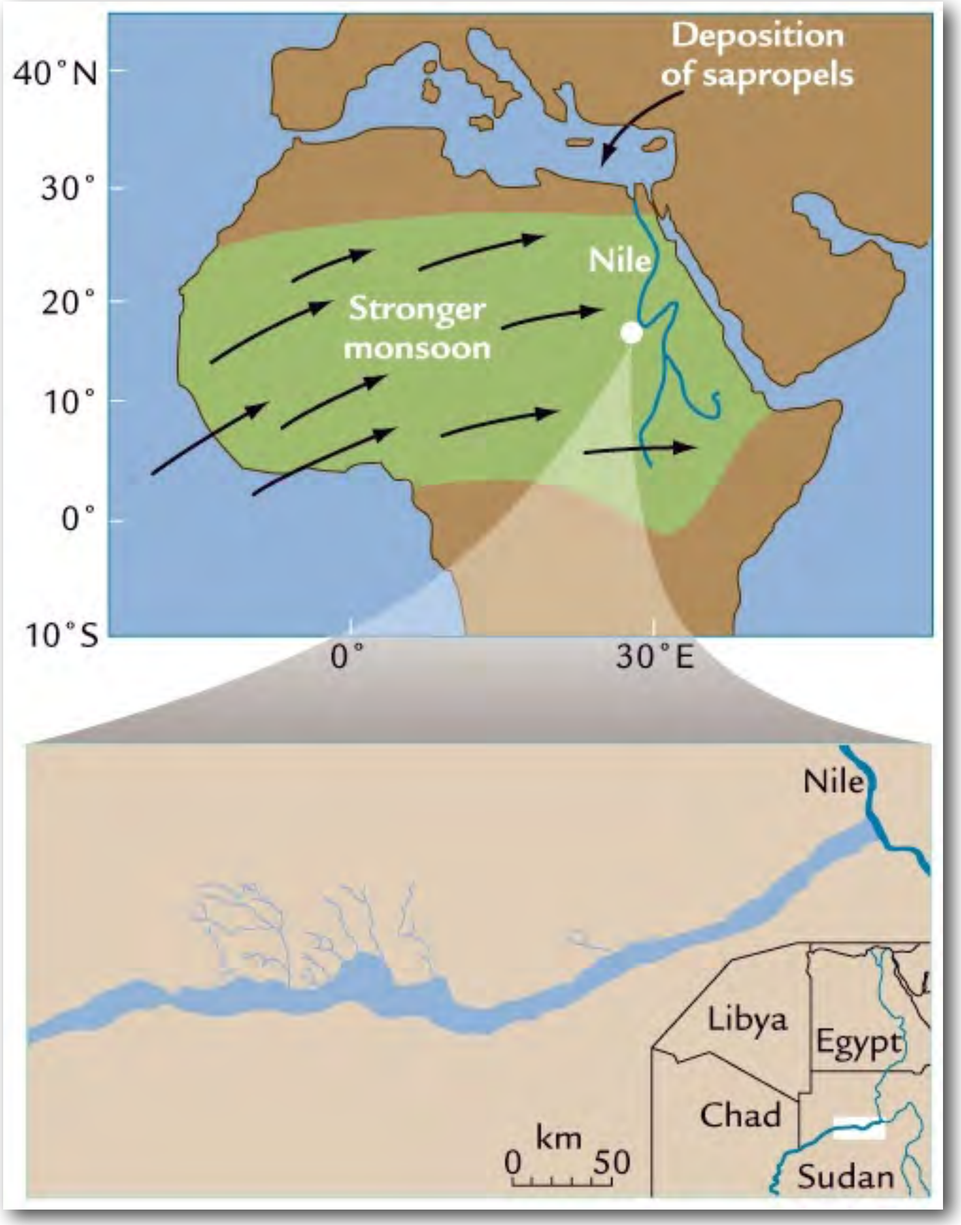
Orbital-scale control of North African monsoon circulation

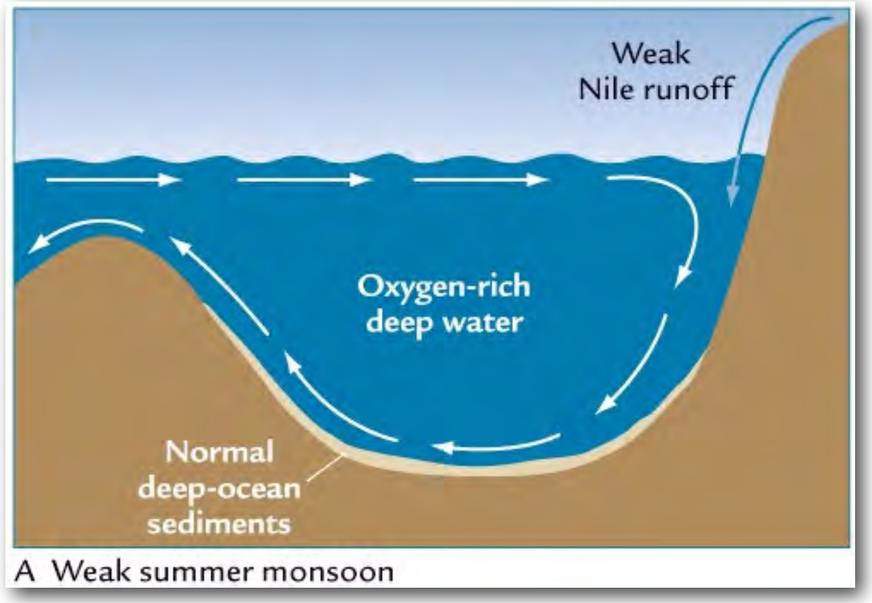


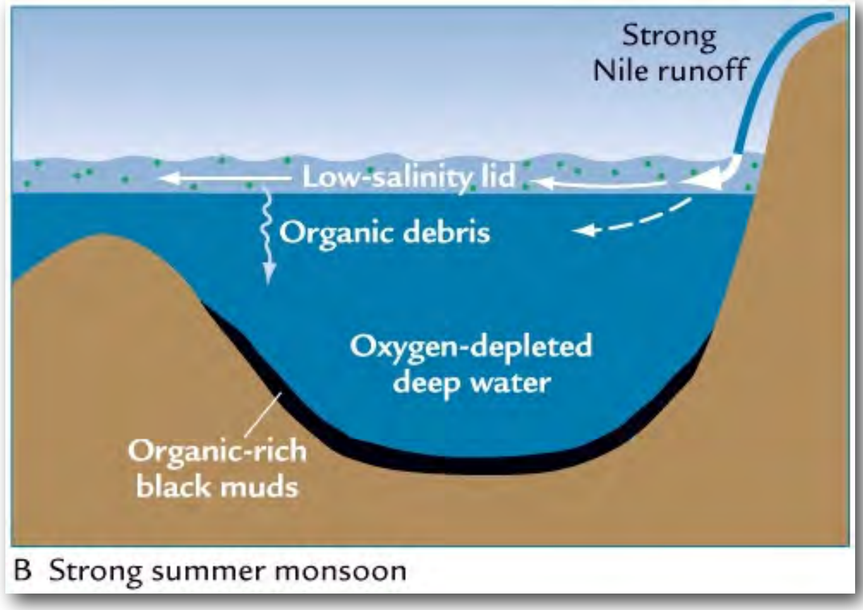
[from: Ruddiman, 2008]

- 2nd test of North African orbital monsoon hypothesis:
  - *if summer monsoon brings more rain, the Nile transports more fresh to the Mediterranean Sea*
  - *the circulation of the Eastern Mediterranean Sea should change*
  - *deeper water layers should loose oxygen*
  - *organic-rich black muds should be deposited (so-called sapropels)*

Orbital-scale control of North African monsoon circulation

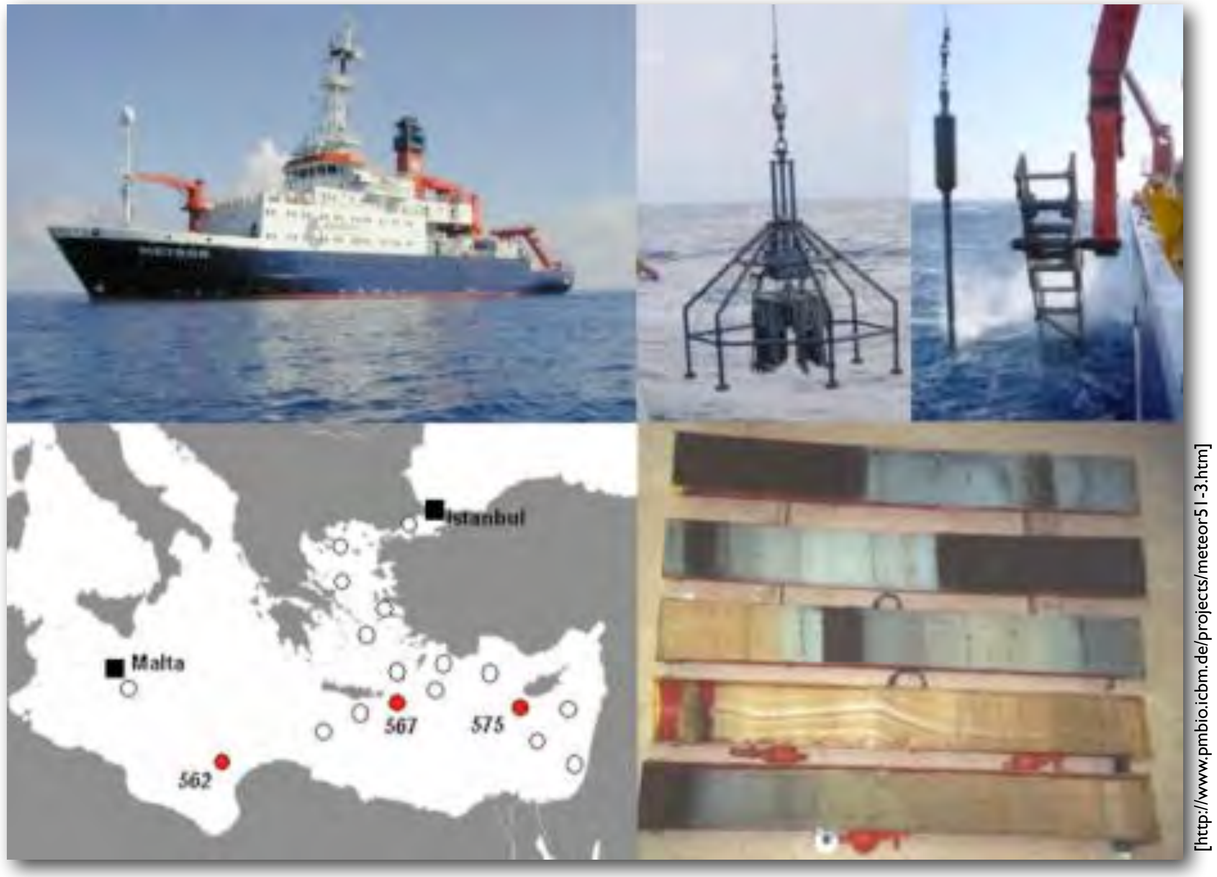






[from: Ruddiman, 2008]

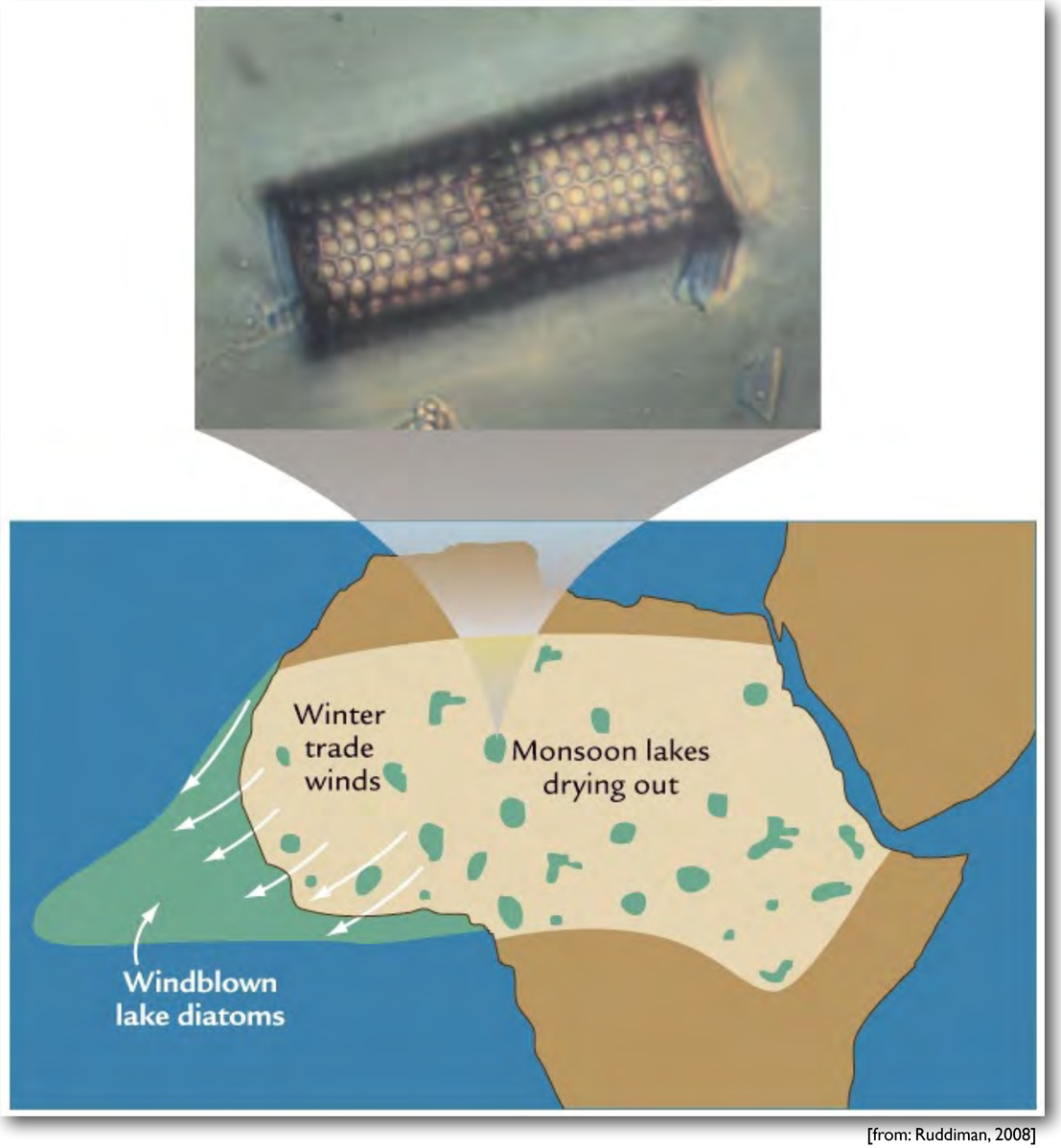
Orbital-scale control of North African monsoon circulation



[http://www.pmbio.icbm.de/projects/meteor51-3.htm]

- Sapropels are found in marine sediment cores from the Eastern Mediterranean Sea and their occurrence coincides with periods of strong summer insolation

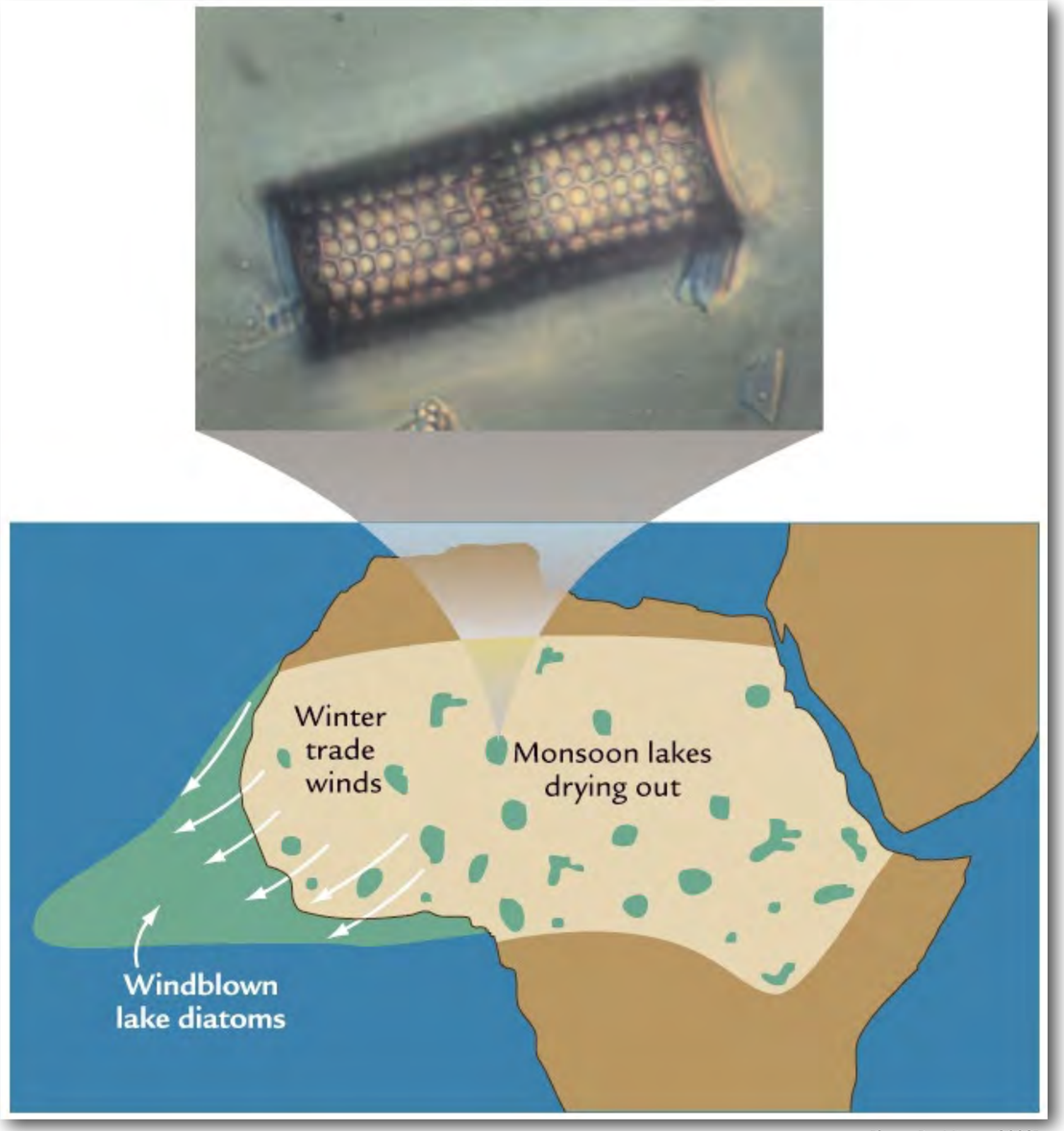
Orbital-scale control of North African monsoon circulation

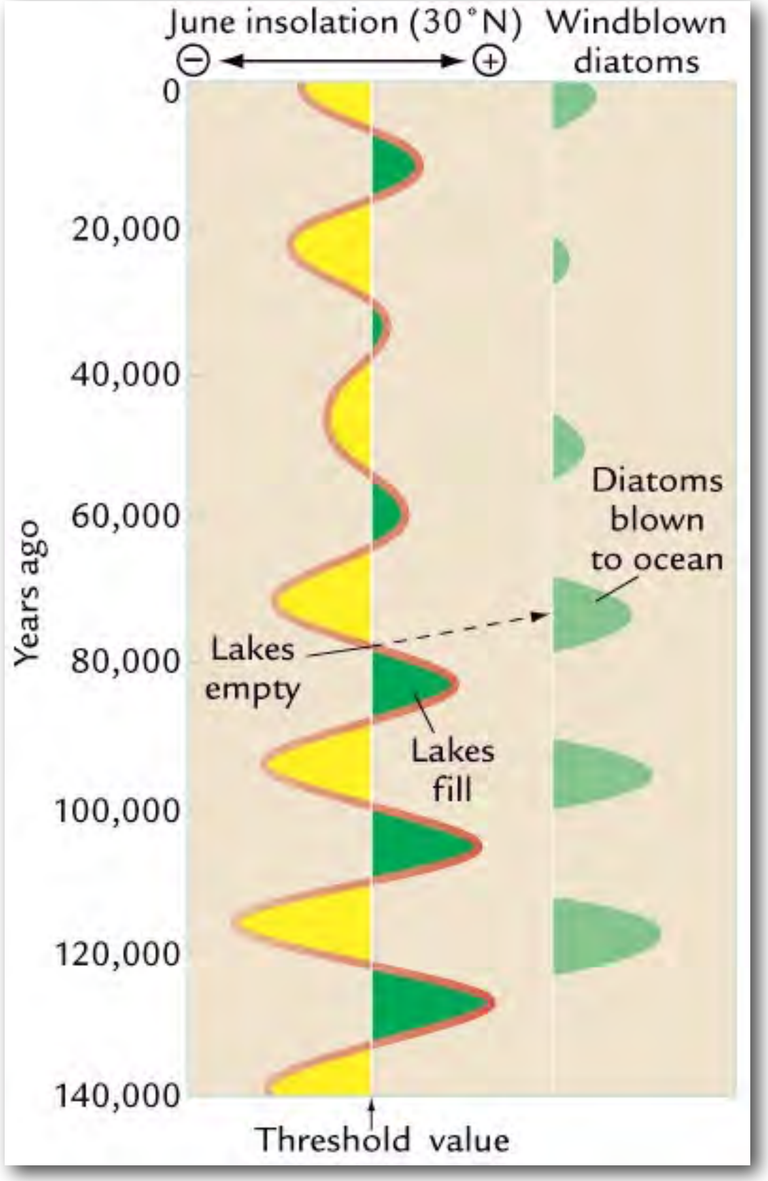


[from: Ruddiman, 2008]

- 3rd test of North African orbital monsoon hypothesis:
  - *if monsoon lakes dry out, the shells of fresh-water organisms (e.g., diatoms) are exposed to surface winds*
  - *small shells & shell particles are blown westwards into the Atlantic*
  - *marine sediments should contain these shells*
  - *the drying and sediment deposition should occur after the intervals of strongest monsoon activity*

Orbital-scale control of North African monsoon circulation





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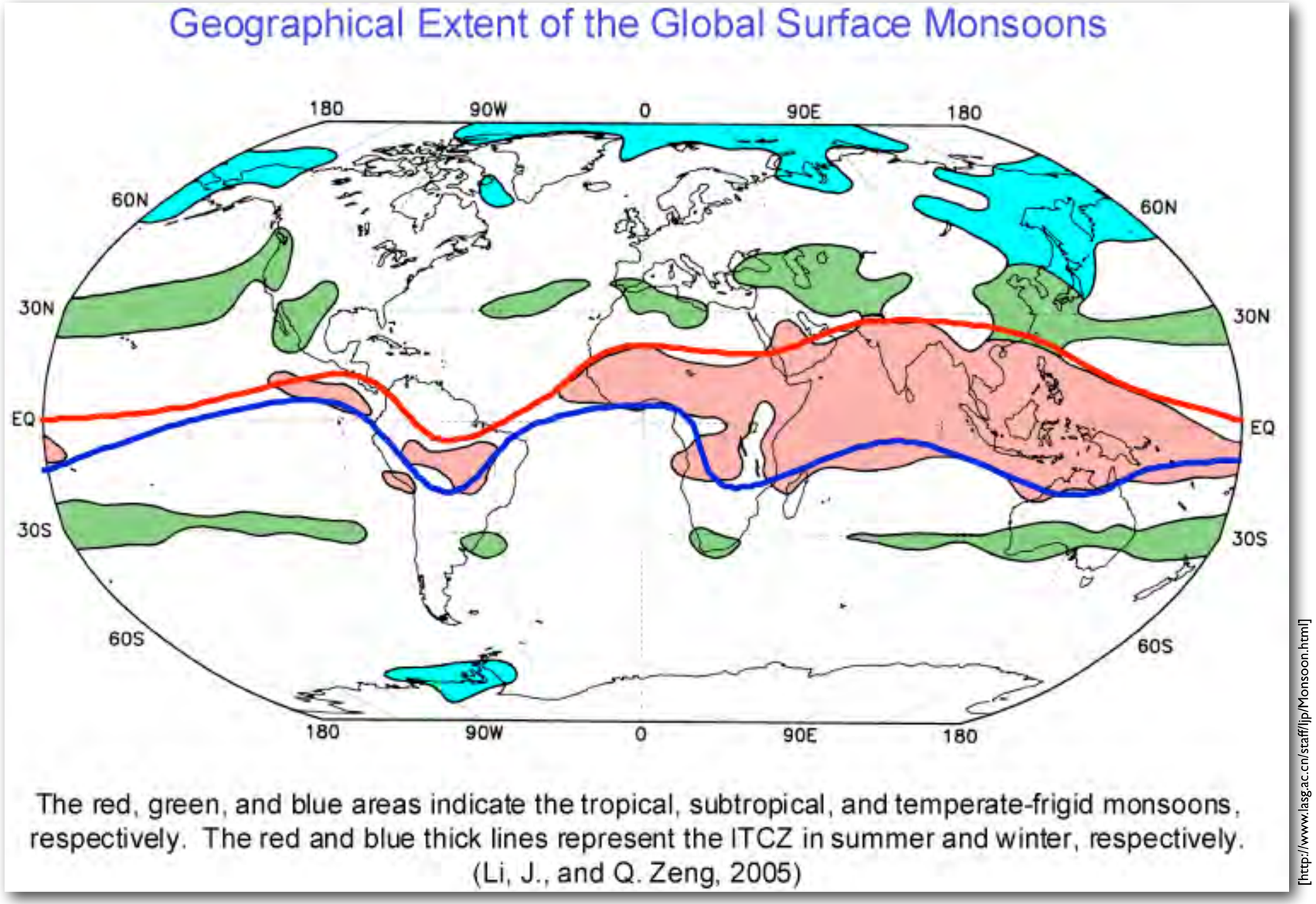
Orbital-scale control of monsoon circulation



[http://www.lasg.ac.cn/staff/ljp/Monsoon.html]

Speleothems: The Asian monsoon record

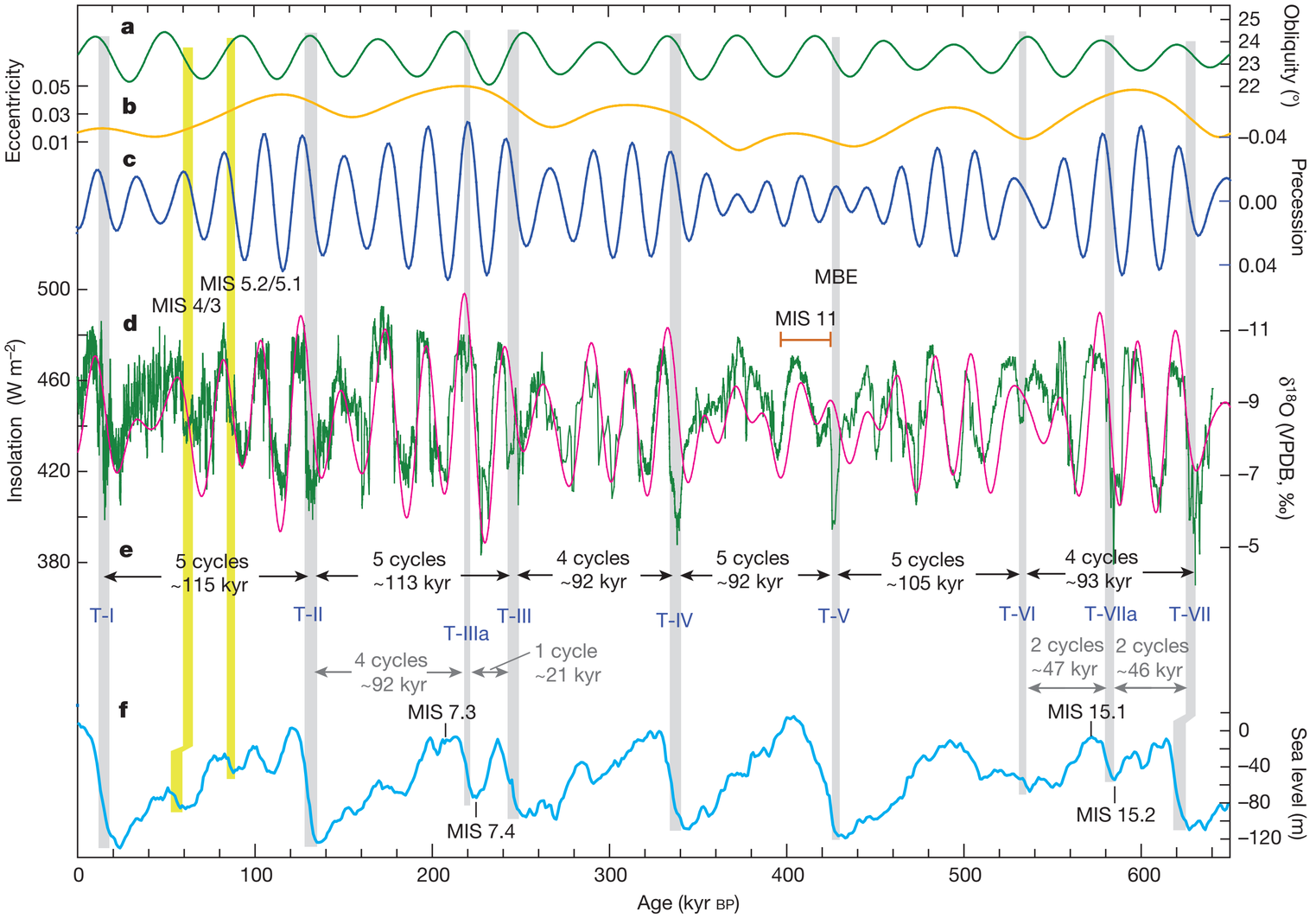


Figure 1 | Asian monsoon variations in the context of the Earth's orbital parameters. a–c, Changes in obliquity (**a**), eccentricity (**b**) and precession[45] (**c**). **d**, The composite AM $\delta^{18}O$ record (green; this study) and 21 July insolation at 65° N (ref. 45; pink). **e**, Termination pacing and duration. Vertical bars mark the timing of WMIs correlated to glacial terminations (grey) and two similar events (MIS 4/3 and 5.2/5.1 transitions) (yellow). The timing of T-IIIa-WMI in this study differs from the one described in ref. 4, although we consider the latter a plausible alternative (see main text and Extended Data Fig. 9). **f**, The composite sea level[17]. The timings of MBE, MIS 11, 7.3, 7.4, 15.1 and 15.2 are also depicted.

[Cheng et al., Nature, 2016]

Orbital-scale control of South American monsoon circulation

NATURE | VOL 434 | 3 MARCH 2005 |

Insolation-driven changes in atmospheric circulation over the past 116,000 years in subtropical Brazil

Francisco W. Cruz Jr[1,2], Stephen J. Burns[1], Ivo Karmann[2], Warren D. Sharp[3], Mathias Vuille[1], Andrea O. Cardoso[4], José A. Ferrari[5], Pedro L. Silva Dias[4] & Oduvaldo Viana Jr[2]

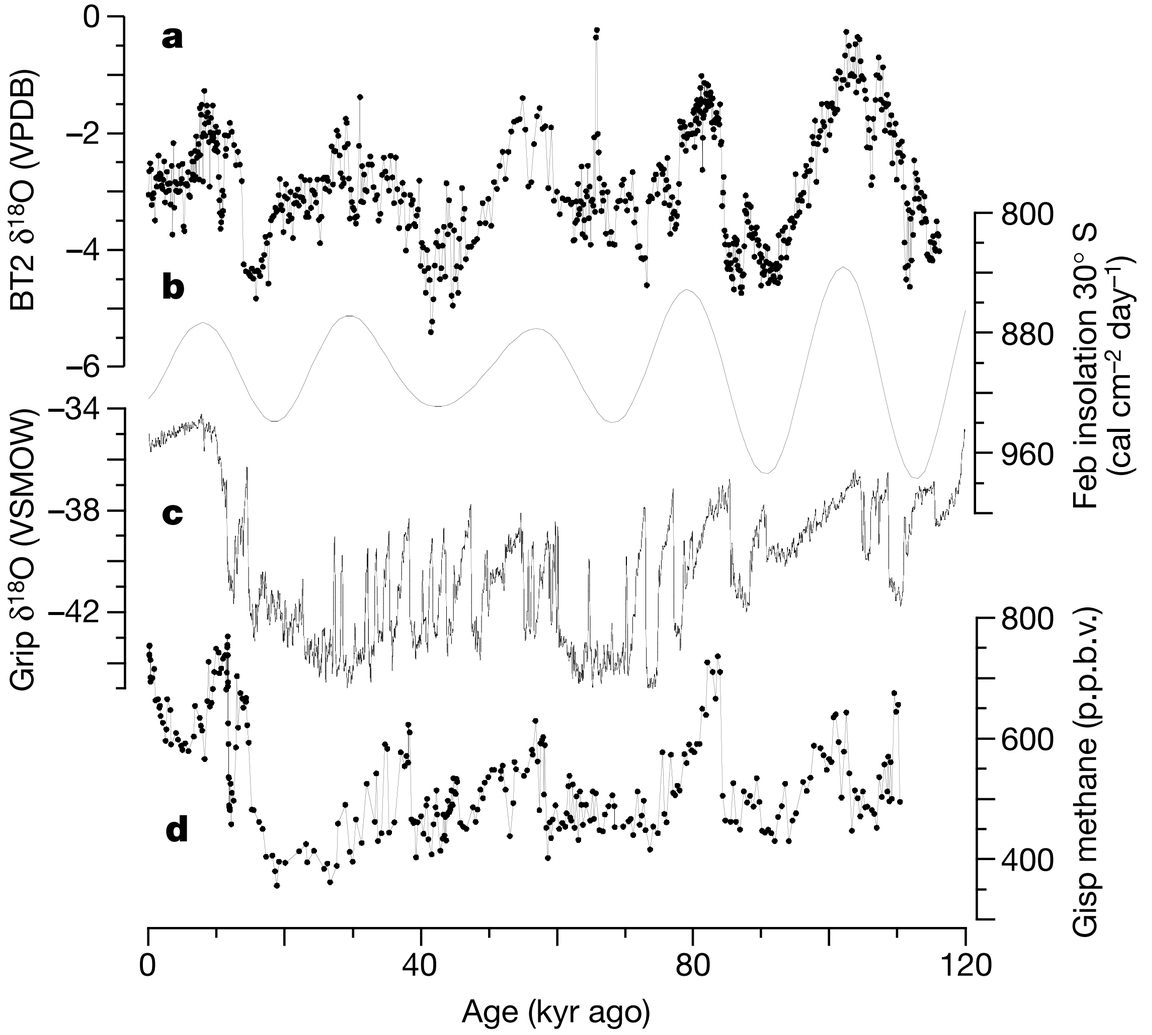


Figure 2 Stable oxygen isotope profile for stalagmite BT2. The BT2 profile (**a**) is compared with February solar insolation for 30° S (**b**), oxygen isotopes of the NGrip ice core from Greenland (**c**), and atmospheric methane concentrations from the Greenland ice core (**d**).

Climate System II

(Winter 2023/2024)

11th lecture:

Regional and global changes

(Regional and global signals: Monsoons)

End of lecture.

Slides available at:

https://paleodyn.uni-bremen.de/study/climate2023_24.html