中国科学院大气物理研究所
Institute of Atmospheric Physics, CAS

竺可桢—南森国际研究中心
Nansen-Zhu International Research Centre (NZC)

构造尺度古气候变化事实、驱动及启示意义

燕 青

中国科学院大气物理研究所

个人简介

2004/09 ~ 2008/06　兰州大学，获学士学位

2008/09 ~ 2013/06　中科院大气所，获博士学位

2016/03 ~ 至今　中科院大气所，副研究员

研究方向：地质时期多时间尺度热带气旋、冰盖/冰川和东亚气候模拟研究

汇报提纲

1. 地质时期地球气候变化事实
2. 新生代全球气候变化事实和机制
3. 中上新世气候变化事实和机制
4. 构造尺度气候变化的启示意义

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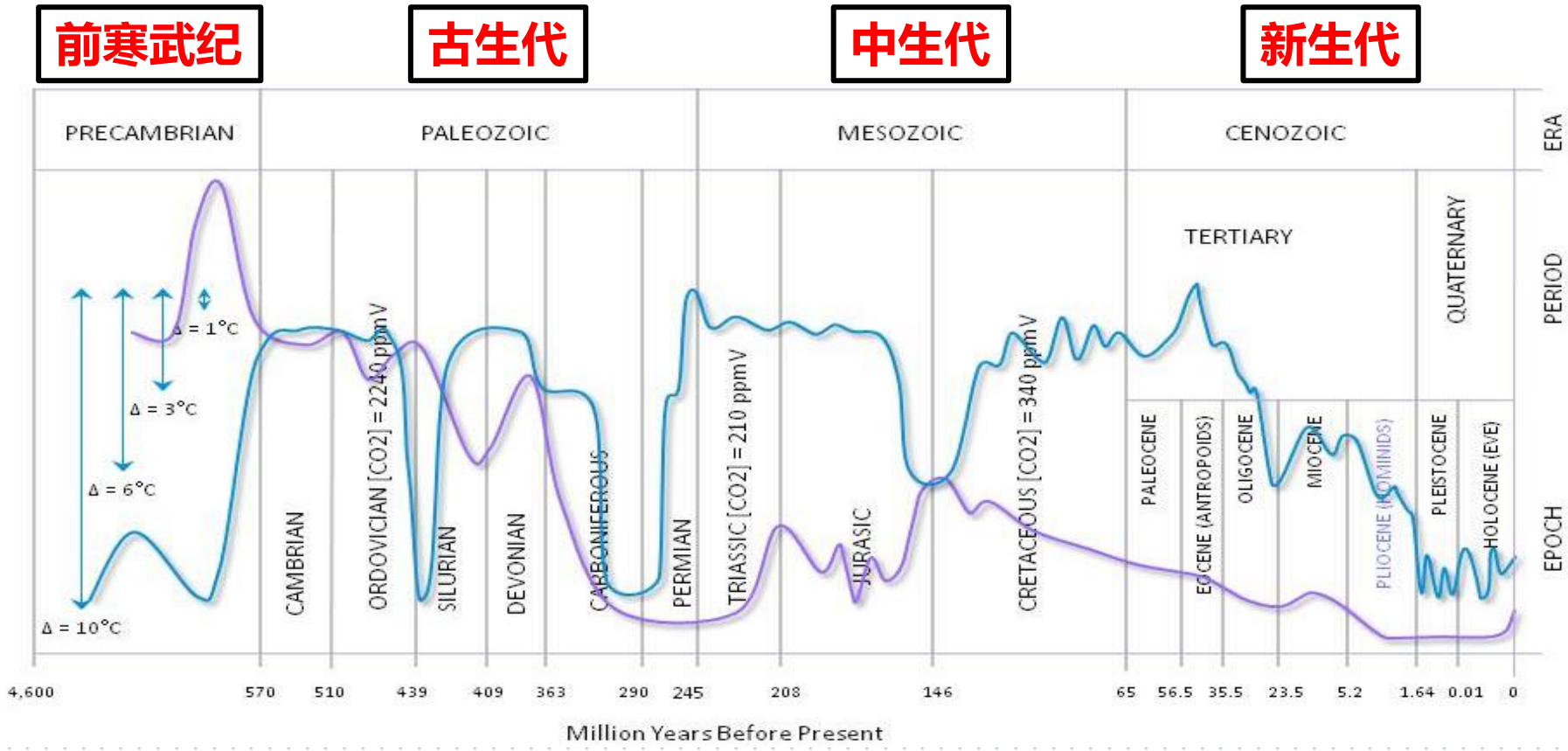
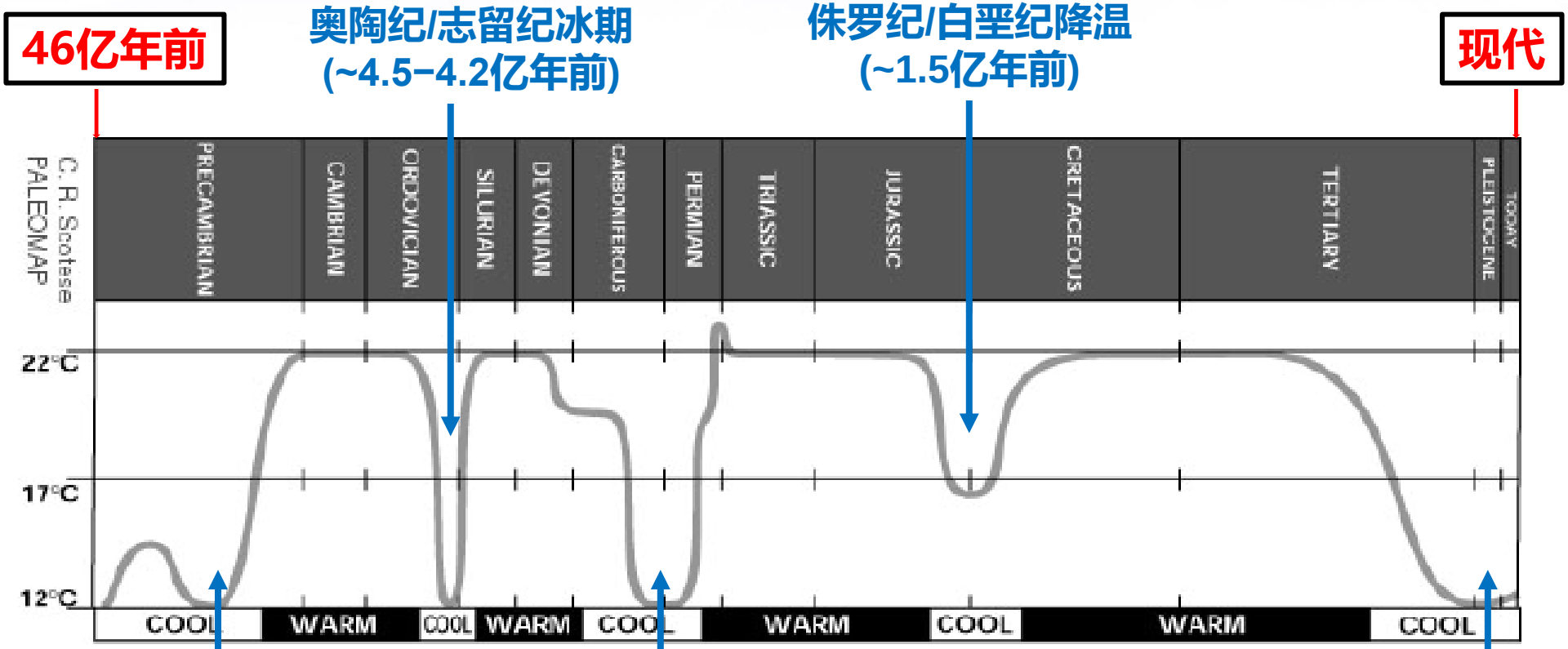
1. 地质时期地球气候变化事实

地球温度和CO_2演变



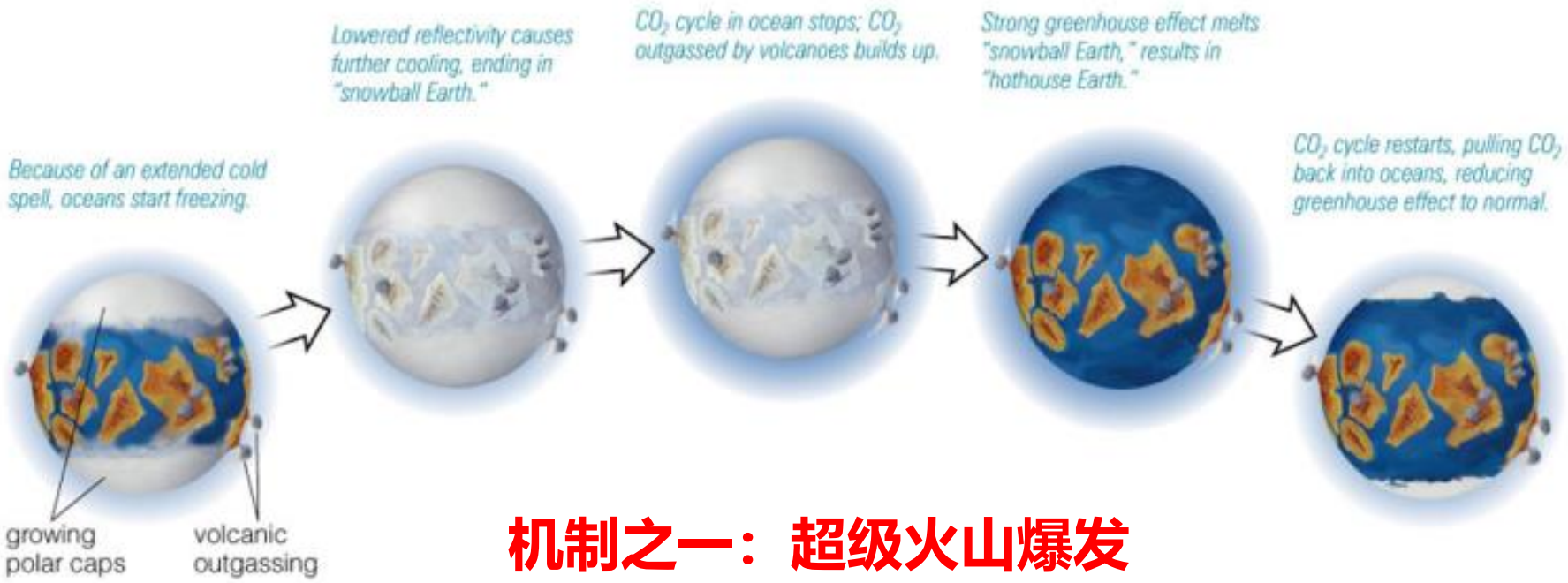
http://www.biocab.org/Carbon_Dioxide_Geological_Timescale.html

1. 地质时期地球气候变化事实



1. 地质时期地球气候变化事实

雪球地球 (~7.5–5.8亿年前)



机制之一：超级火山爆发

https://www.reddit.com/r/Frostpunk/comments/8gbml0/last_time_earth_might_have_been_covered_by_ice/

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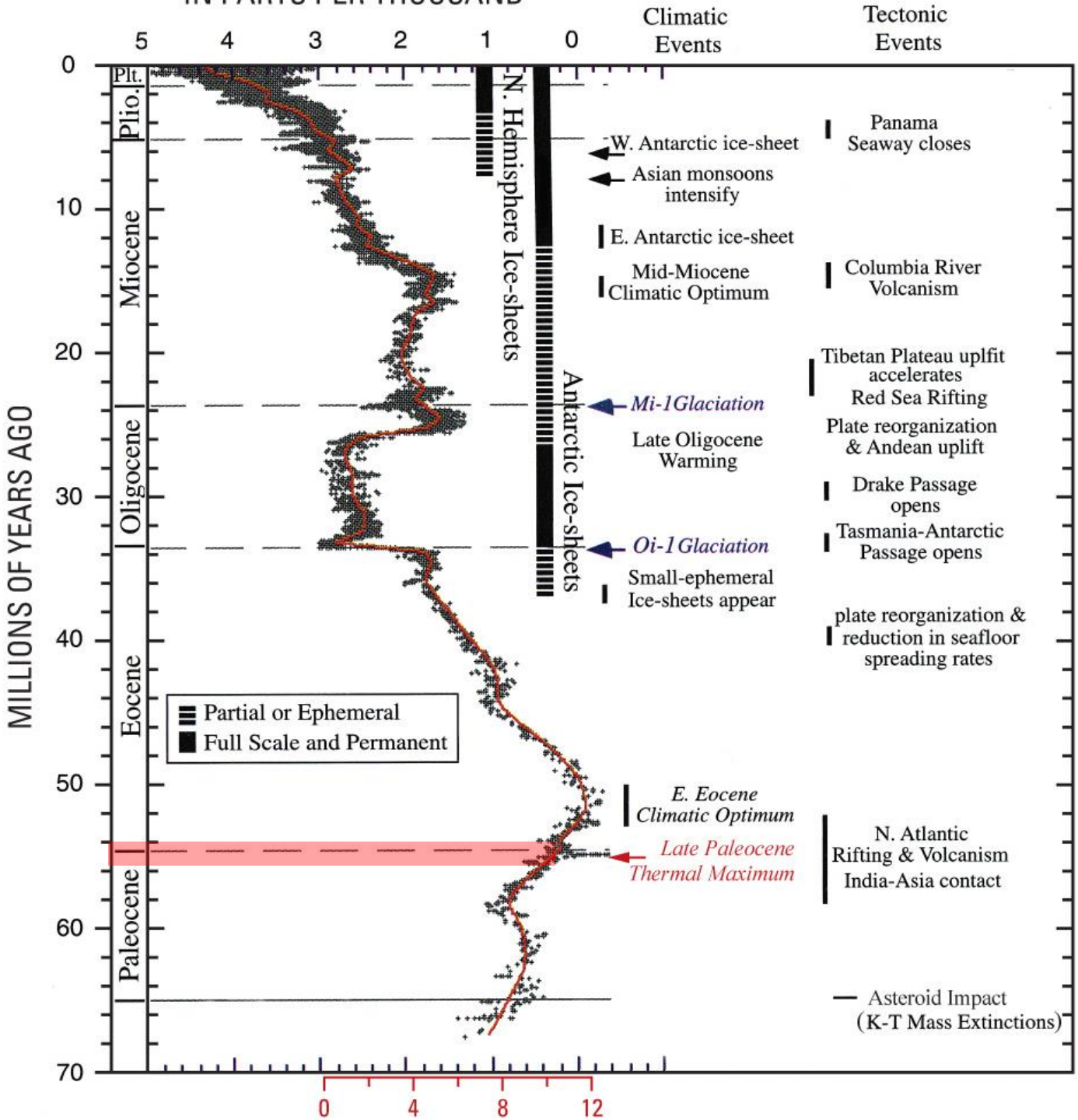
IN PARTS PER THOUSAND
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MILLIONS OF YEARS AGO
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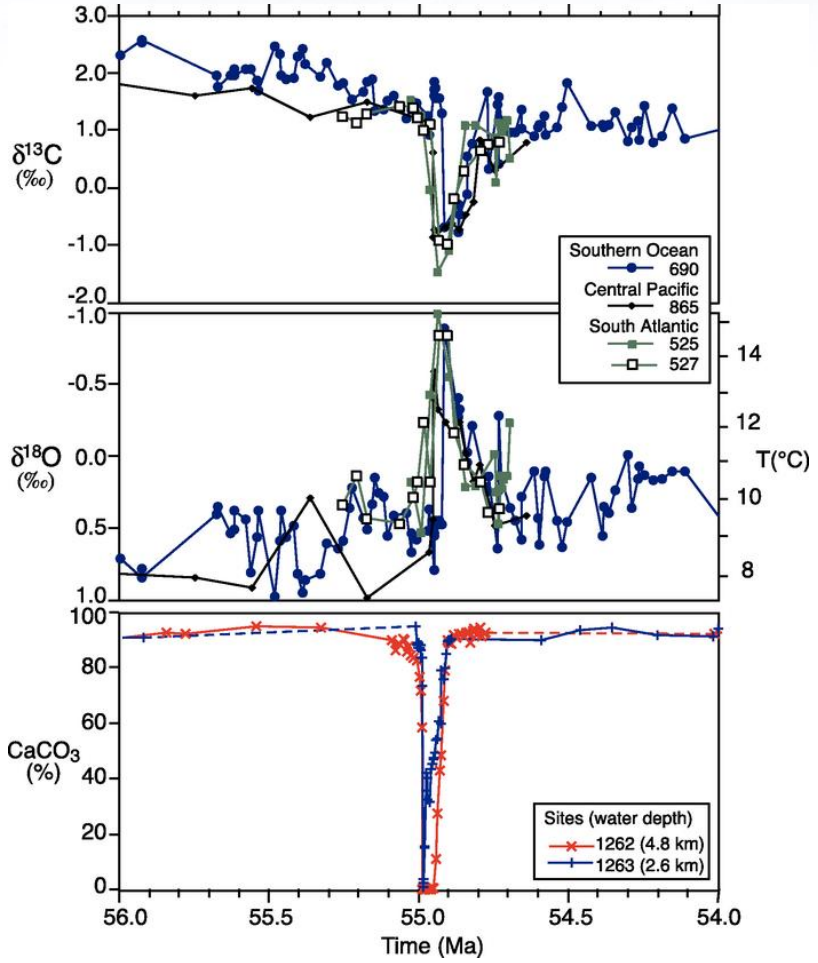
2. 新生代全球气候变化事实和机制

Palaeocene-Eocene Thermal Maximum

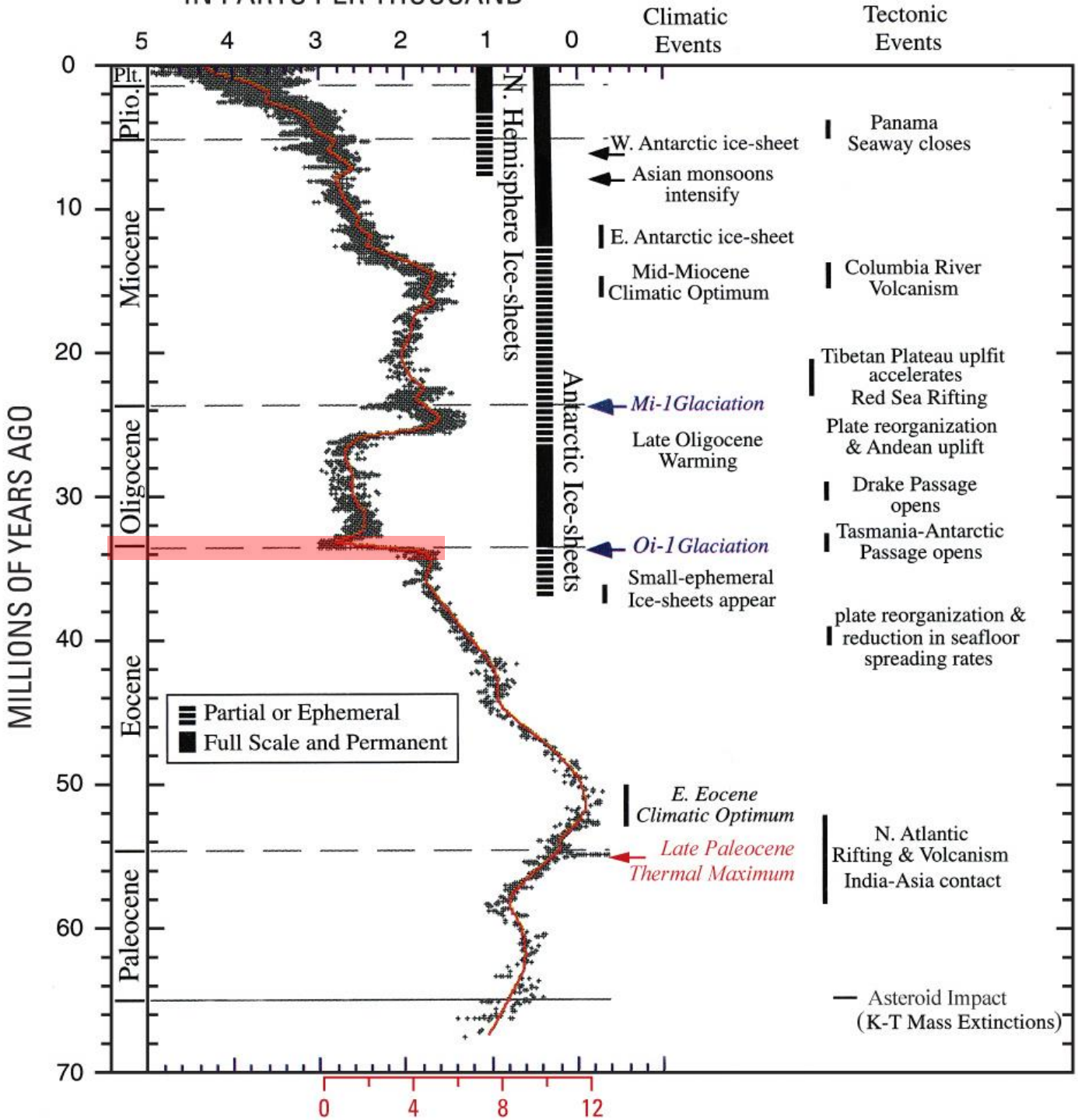


大气CO2和CH4增加

全球升温～5°C

碳酸盐溶解（海洋酸化）

IPCC， 2007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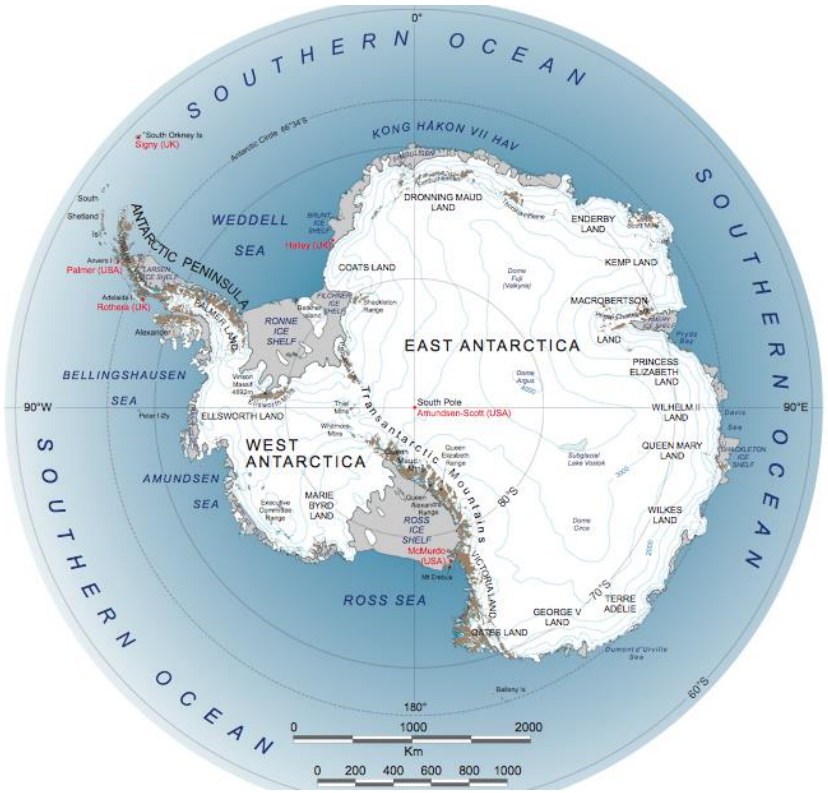
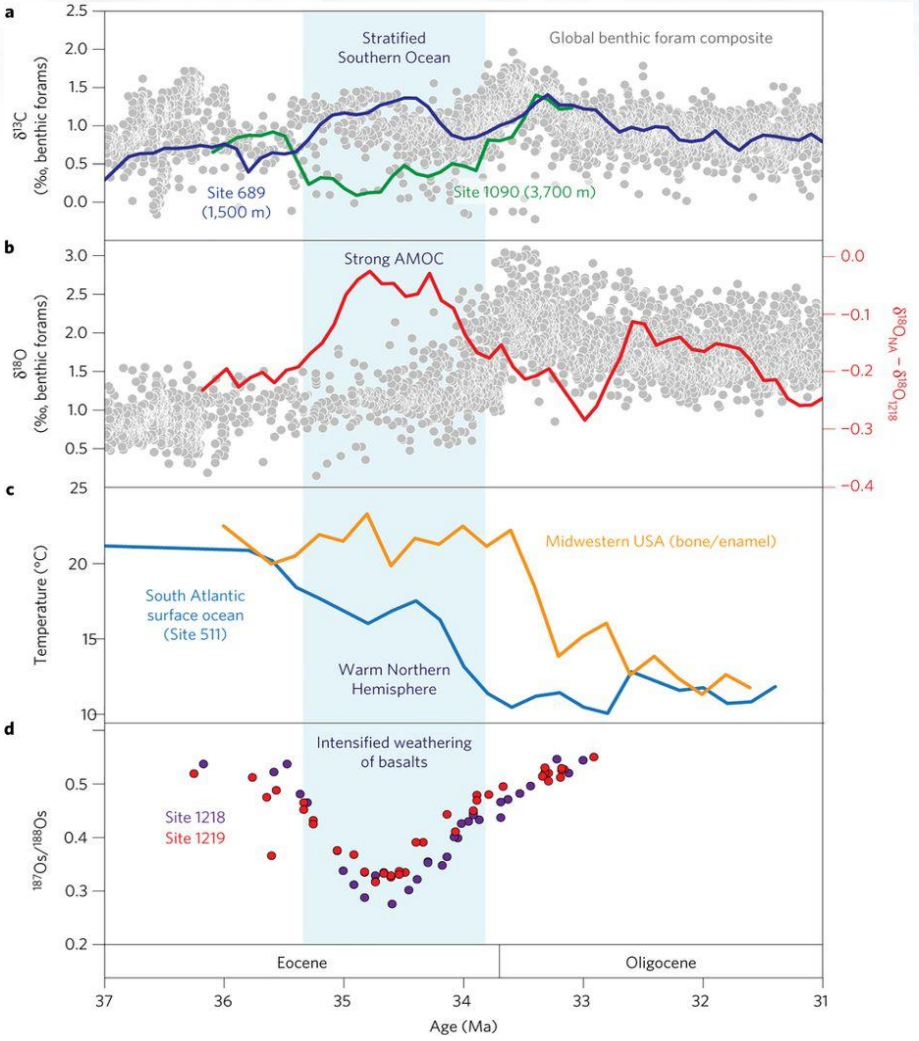
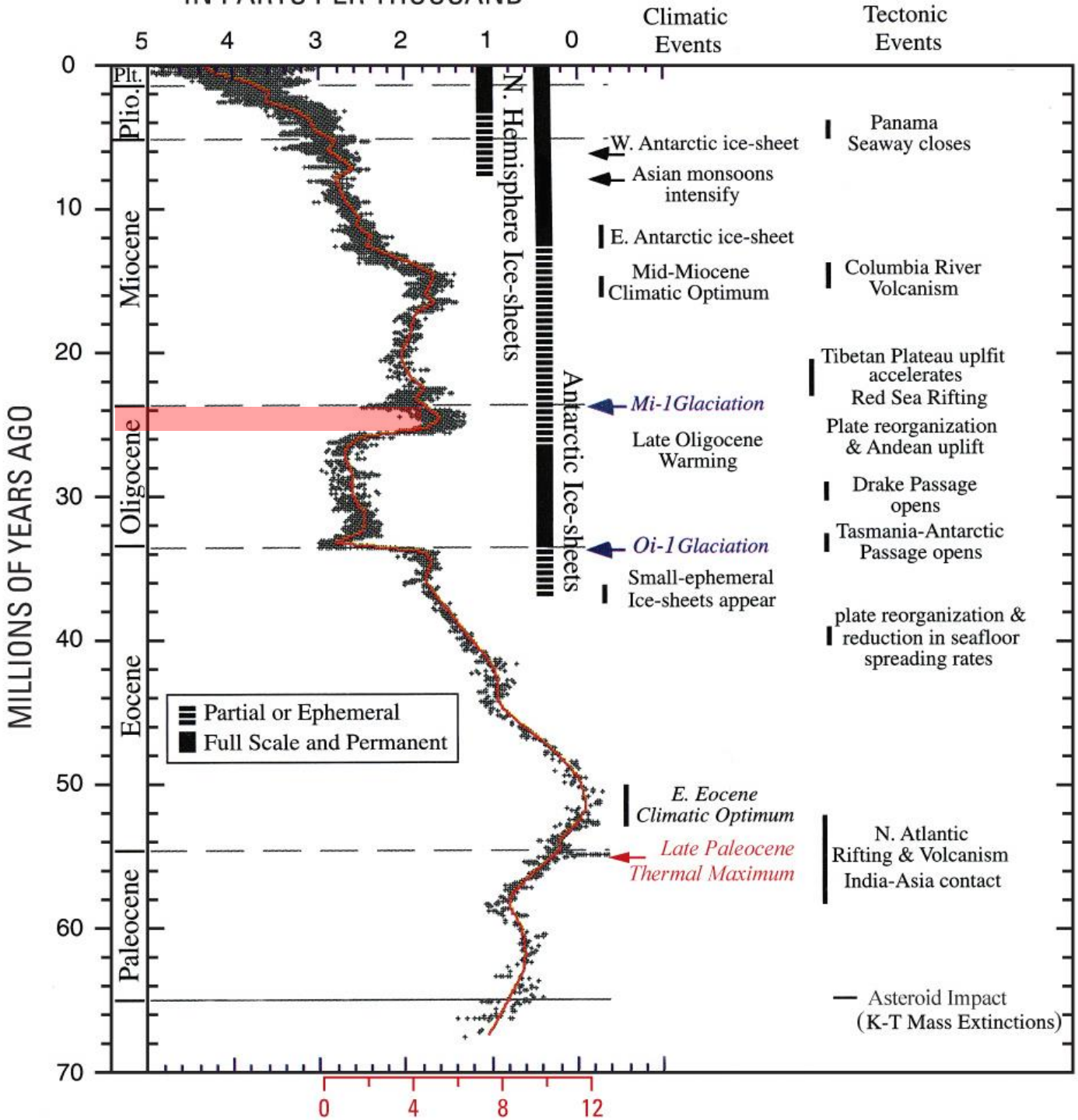
2. 新生代全球气候变化事实和机制

Formation of Antarctic ice sheet





Geneviève Elsworth, et al., 2017, Nature Geoscience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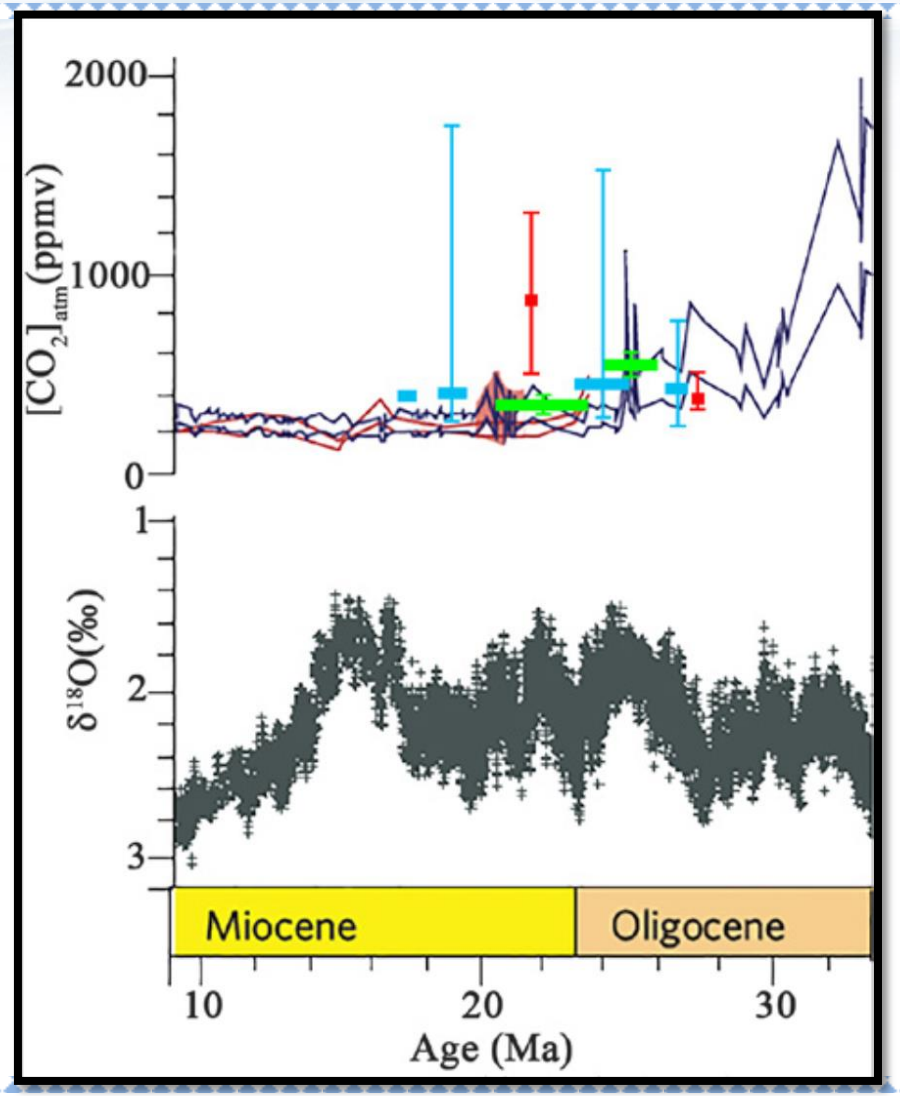
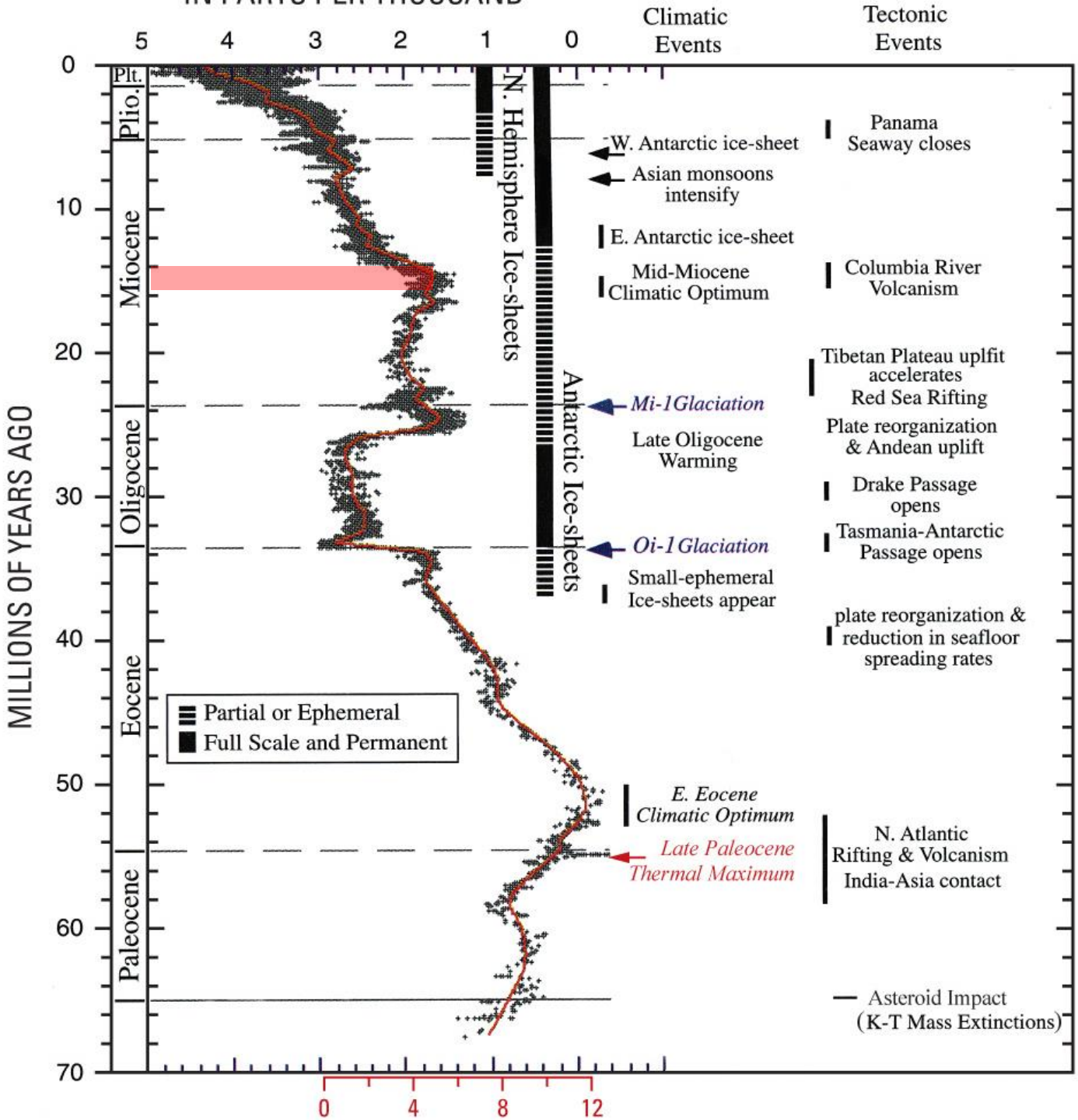


晚渐新世增温—CO2的作用?

Tekie Tesfamichael, et al., 2017, Geology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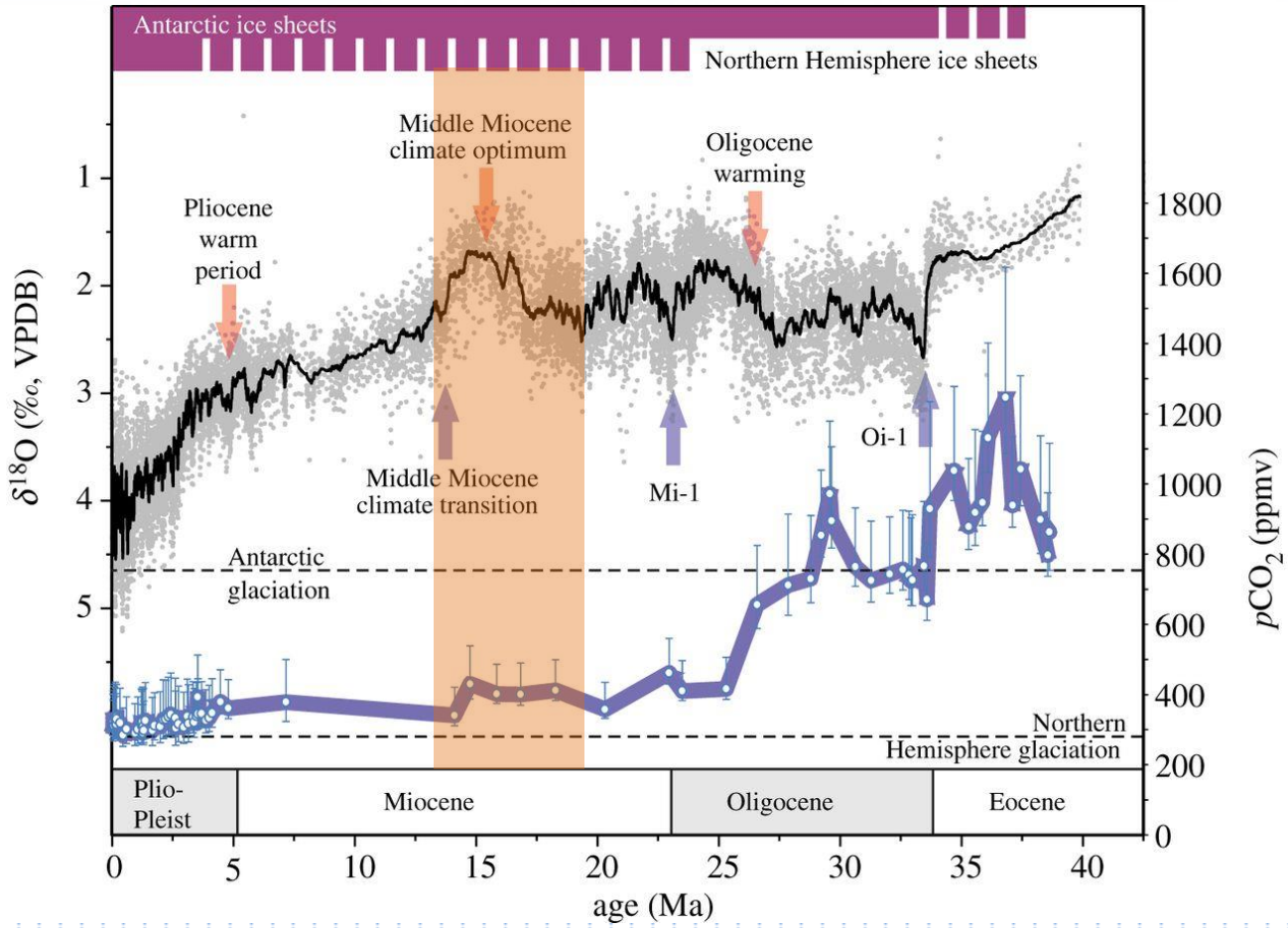
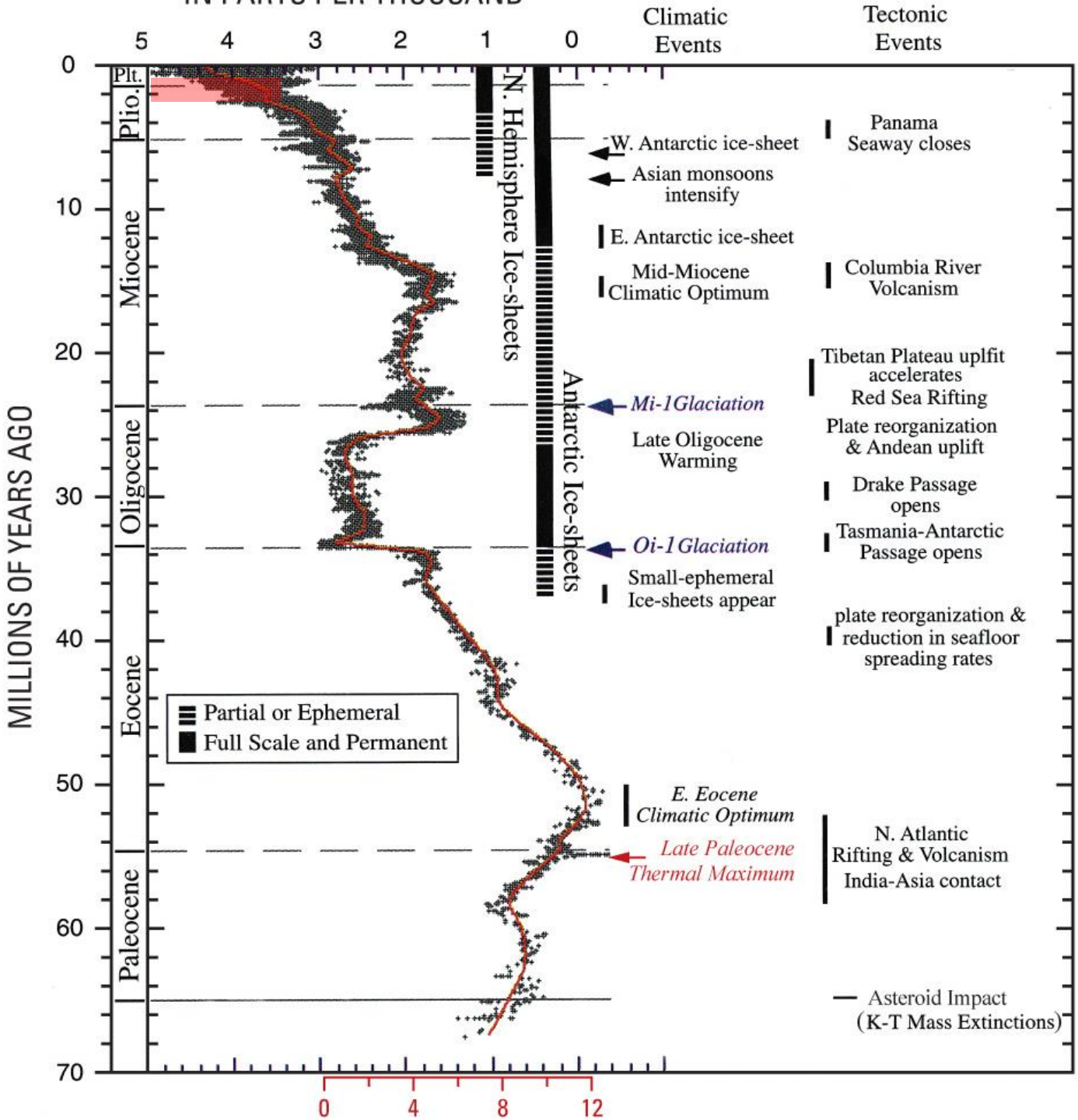
2. 新生代全球气候变化事实和机制

中新世增温—decoupling between CO2 and temperature?

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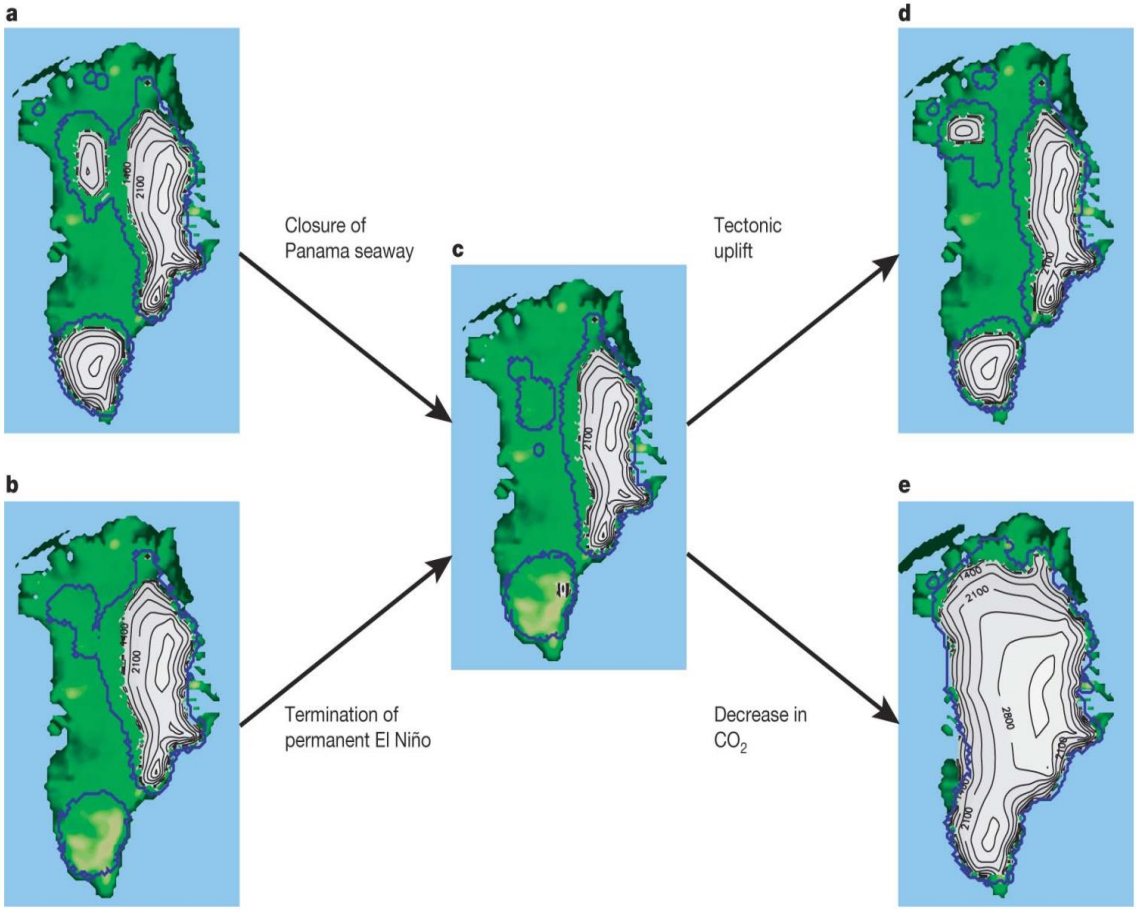
2. 新生代全球气候变化事实和机制

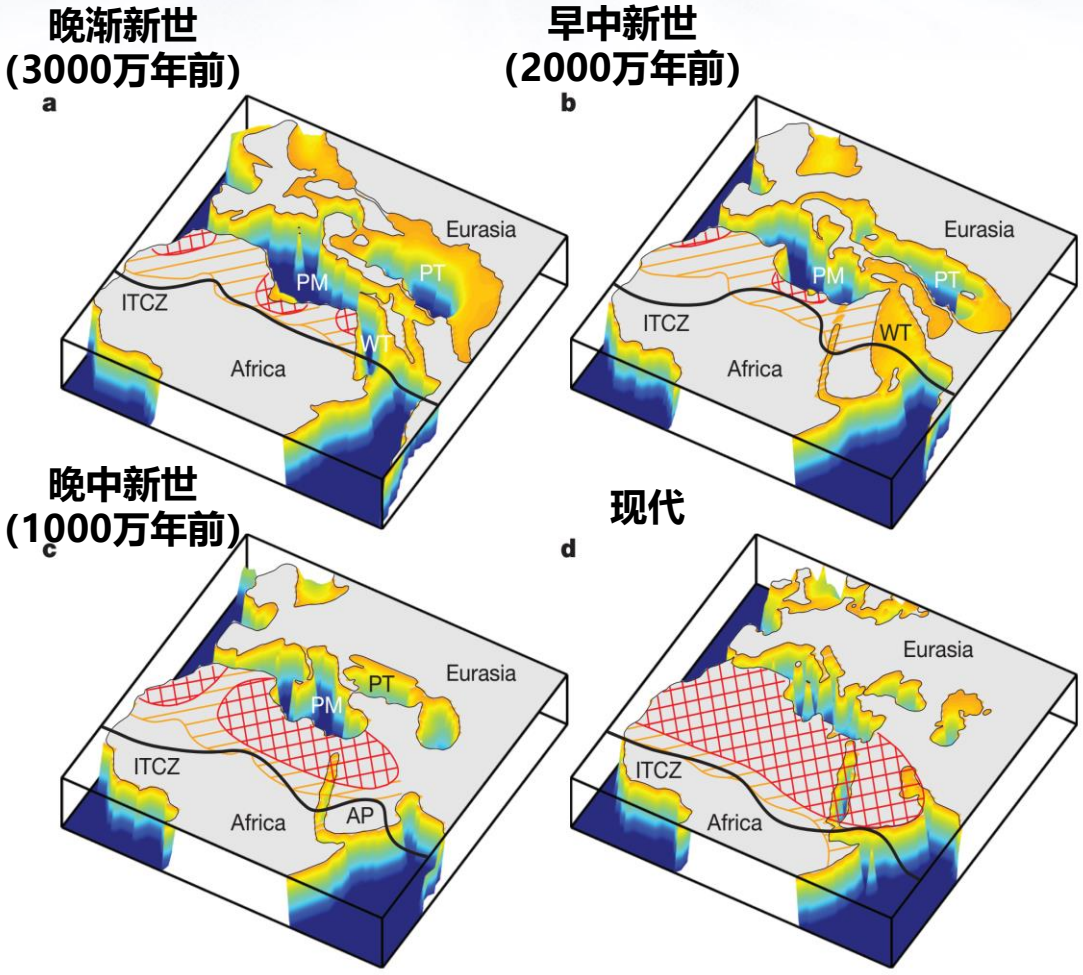
Formation of Greenland ice sheet



Dan Lunt, et al., 2008, Nature

2. 新生代全球气候变化事实和机制

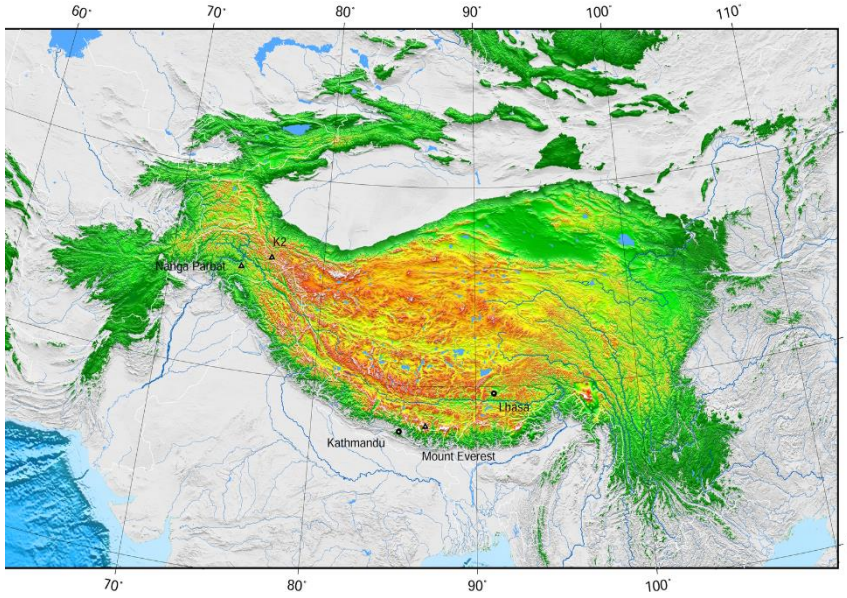
撒哈拉沙漠起源

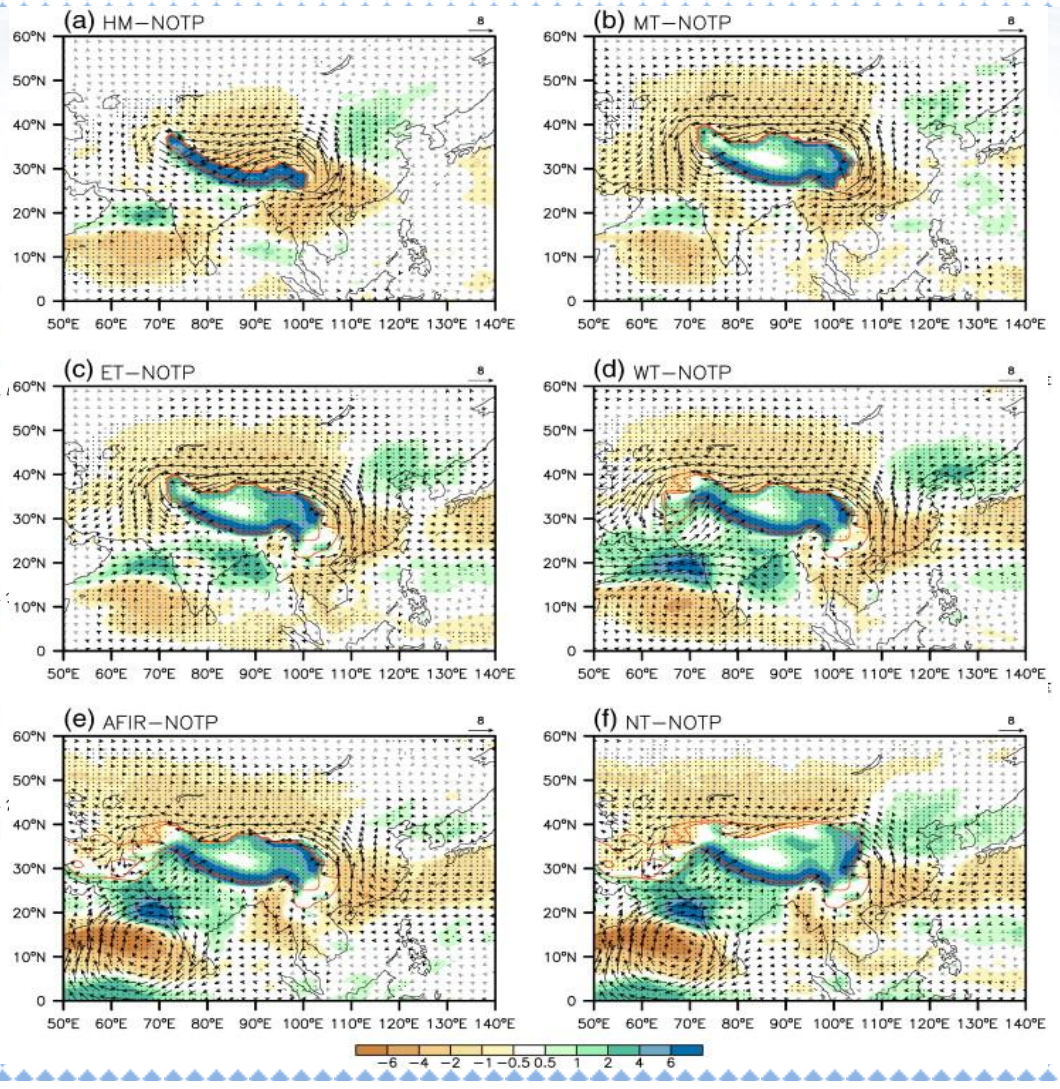


Zhang Zhongshi, et al., 2014, Nature

2. 新生代全球气候变化事实和机制

青藏高原隆升的气候效应





Zhang Ran, et al., 2015, 3P

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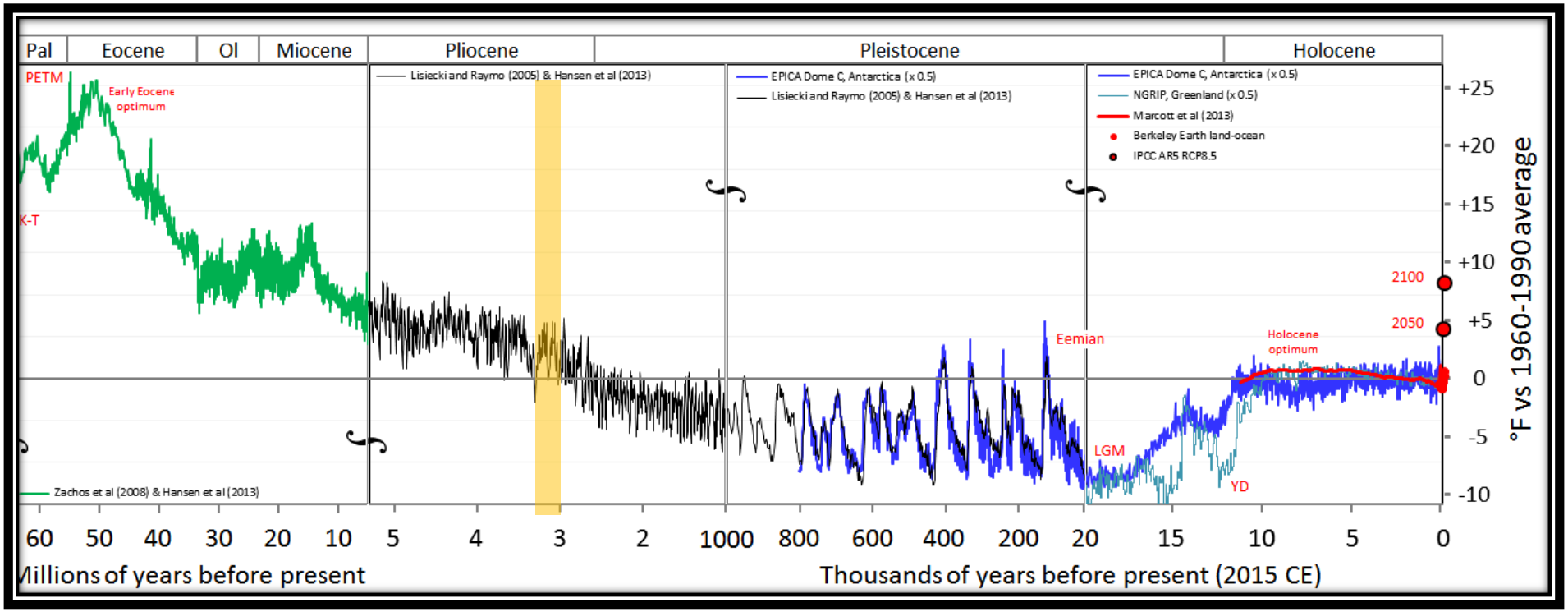
3. 中上新世气候变化事实和机制

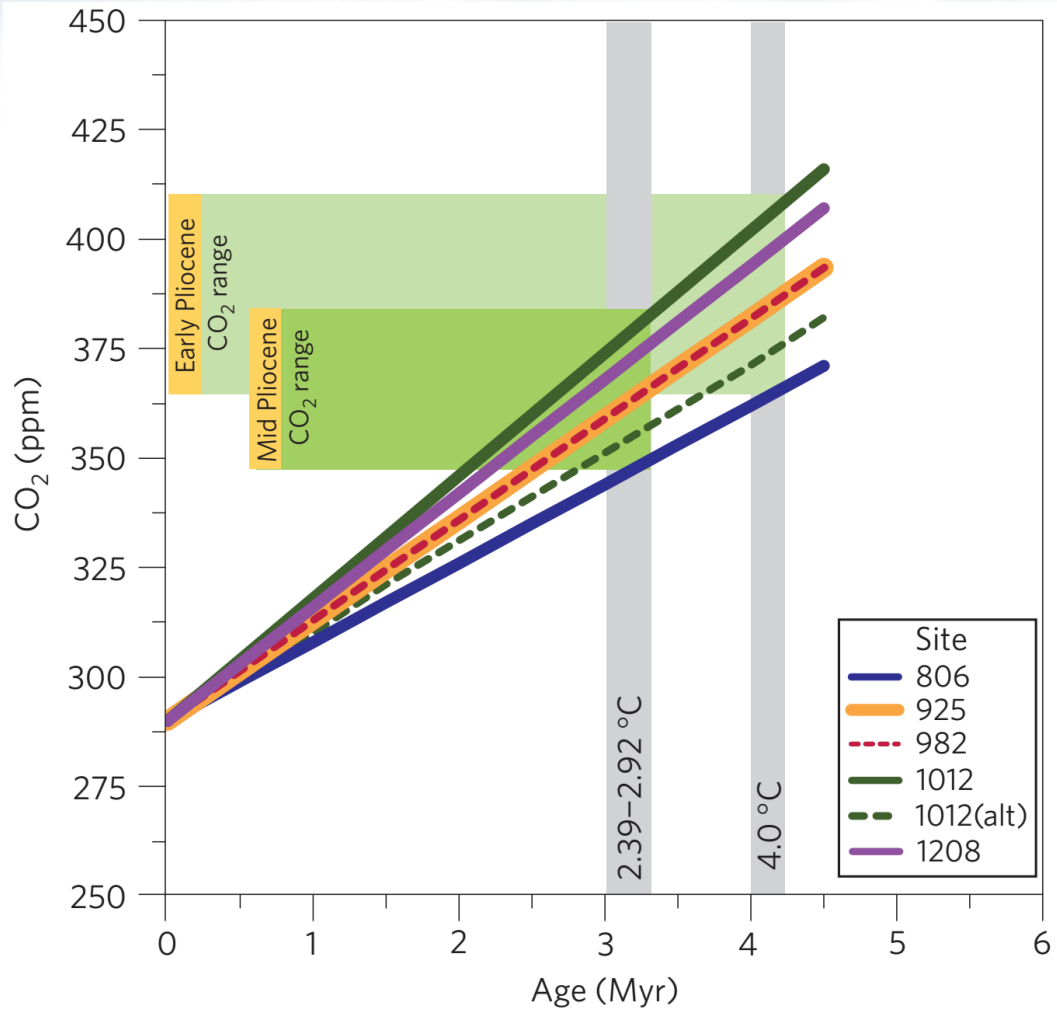
地球温度演变



中上新世地质时间尺度上距今最近的持续性暖期

https://upload.wikimedia.org/wikipedia/commons/f/f5/All_palaeotemps.png

3. 中上新世气候变化事实和机制



高地球系统敏感度

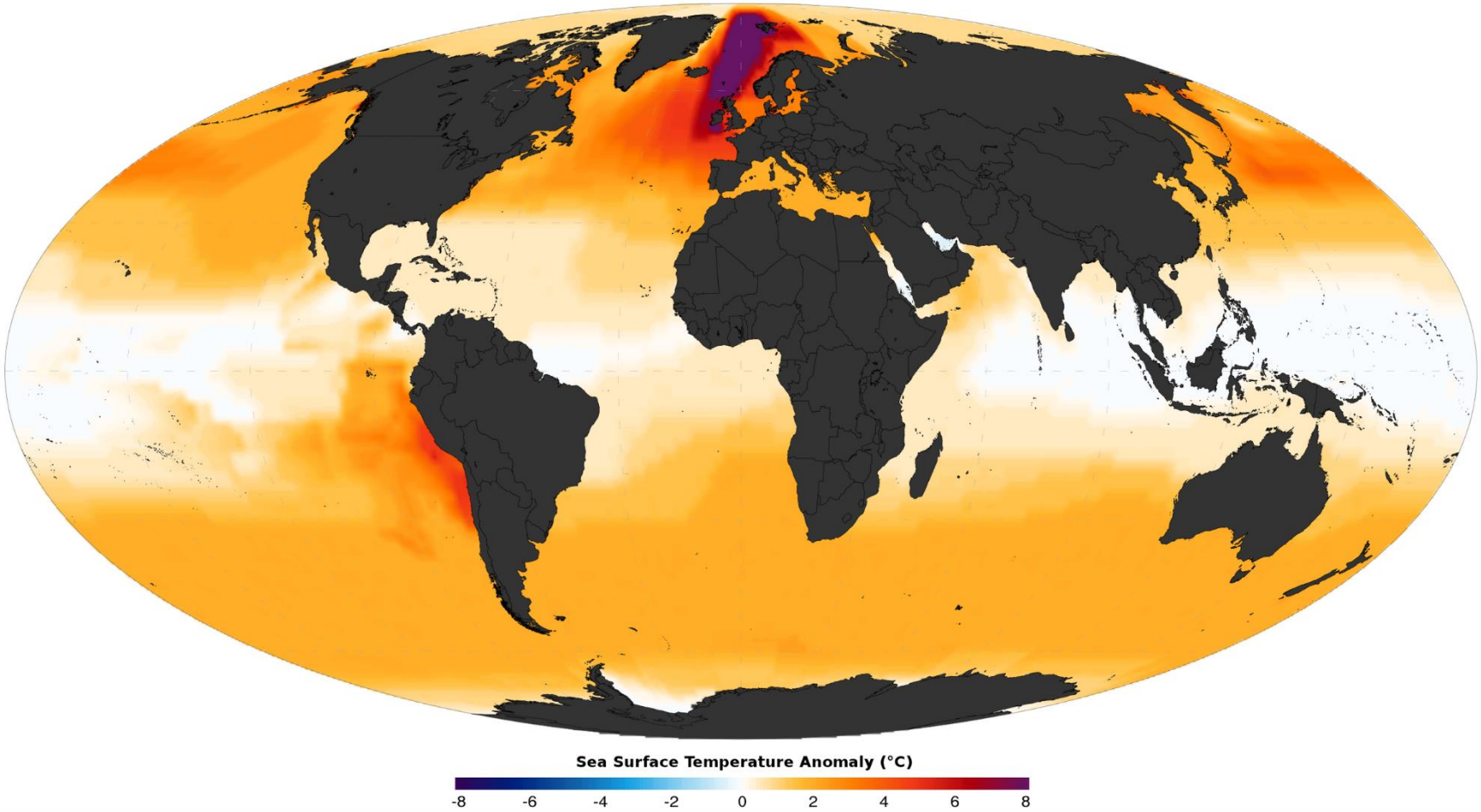
Earth-system climate sensitivity

7.1 ± 1.0 ◦C～8.7 ± 1.3 ◦C per 2xCO2

Pagani Mark, et al., 2009, Nature

3. 中上新世气候变化事实和机制

中上新世海温变化

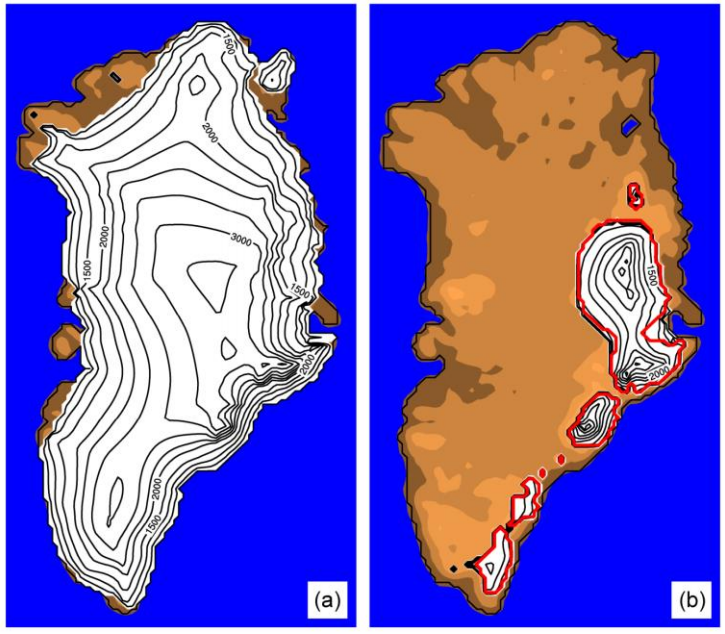


https://en.wikipedia.org/wiki/Pliocene_climate

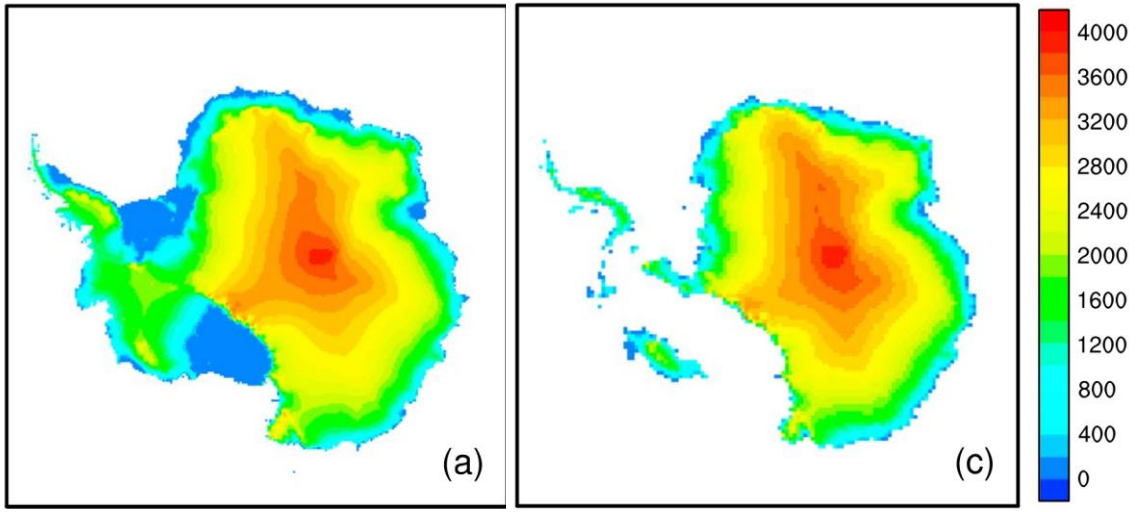
3. 中上新世气候变化事实和机制

极地冰盖显著退缩

格陵兰冰盖



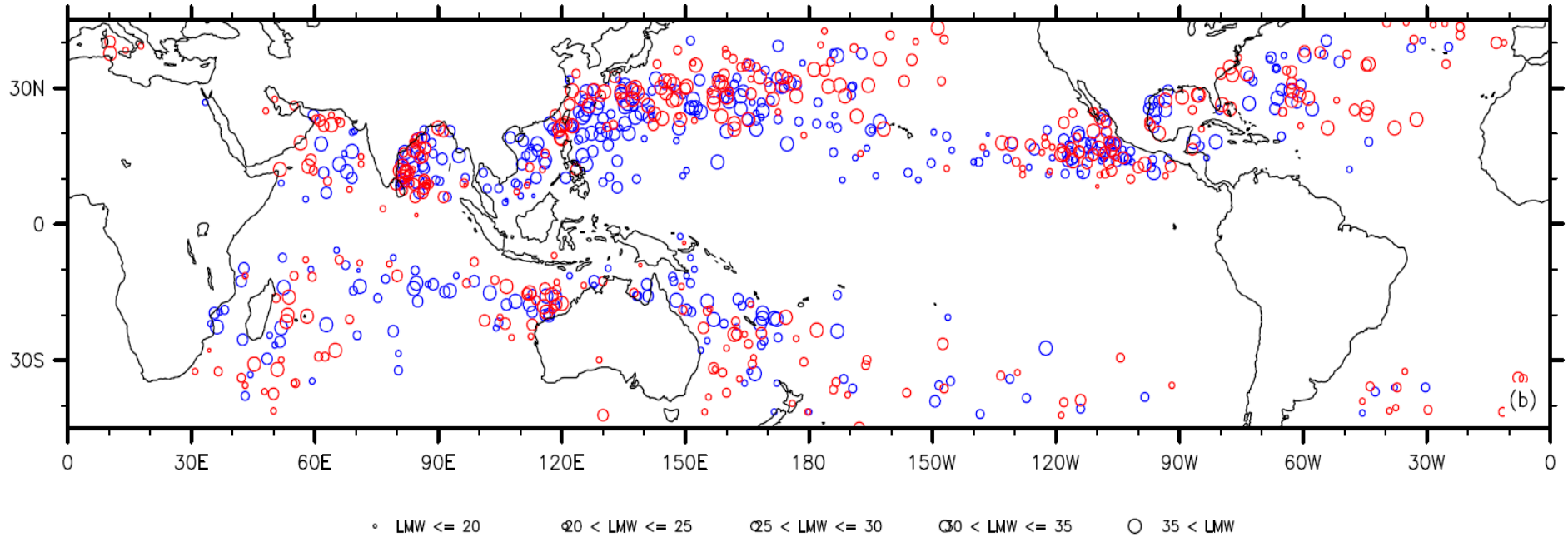
南极冰盖



Yan Qing, et al., 2016,

3. 中上新世气候变化事实和机制

热带气旋强度增加、并向极移动



mid-Pliocene　　pre-industrial

Yan Qing, et al., 2016, PNAS

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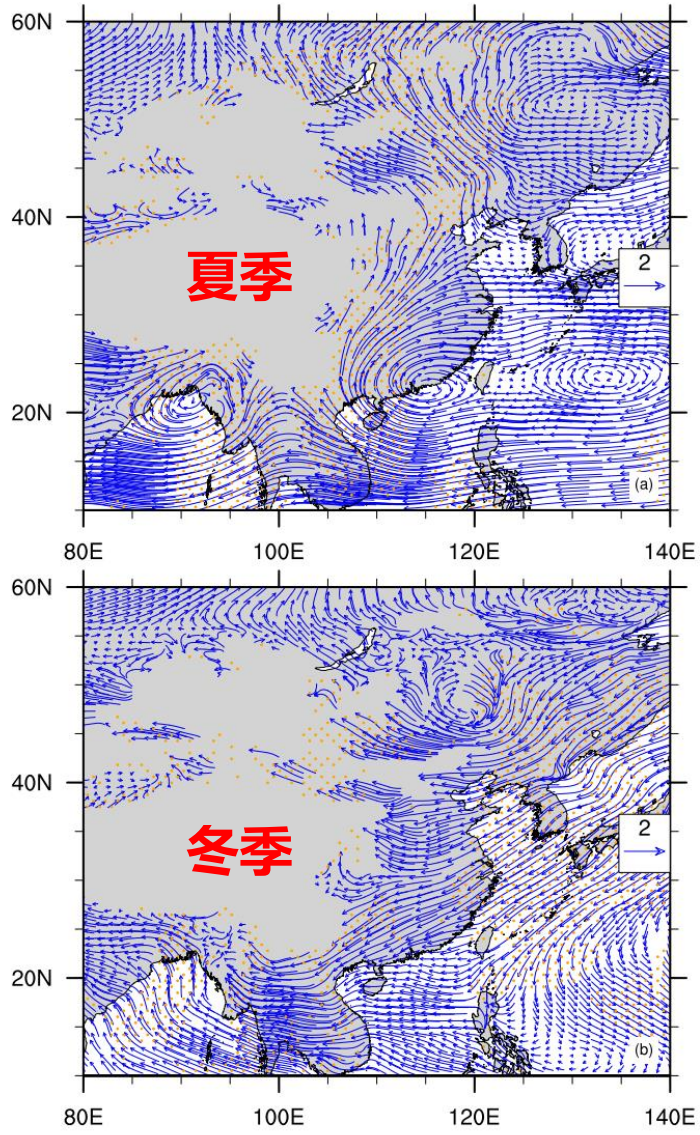
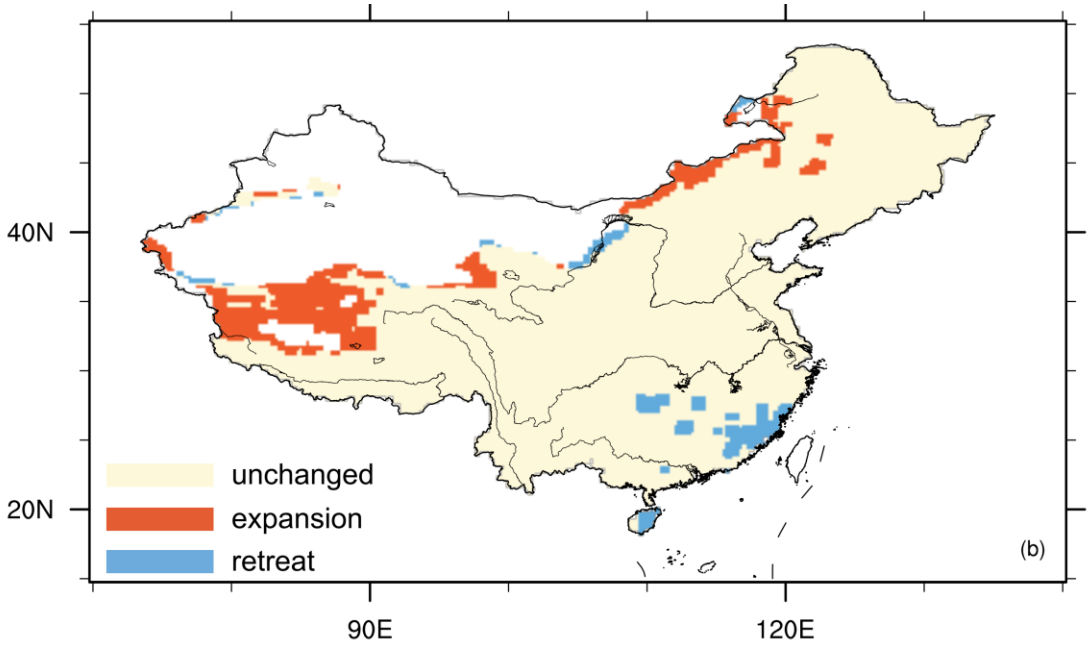


东亚夏季风加强、冬季风减弱；
季风边缘北进



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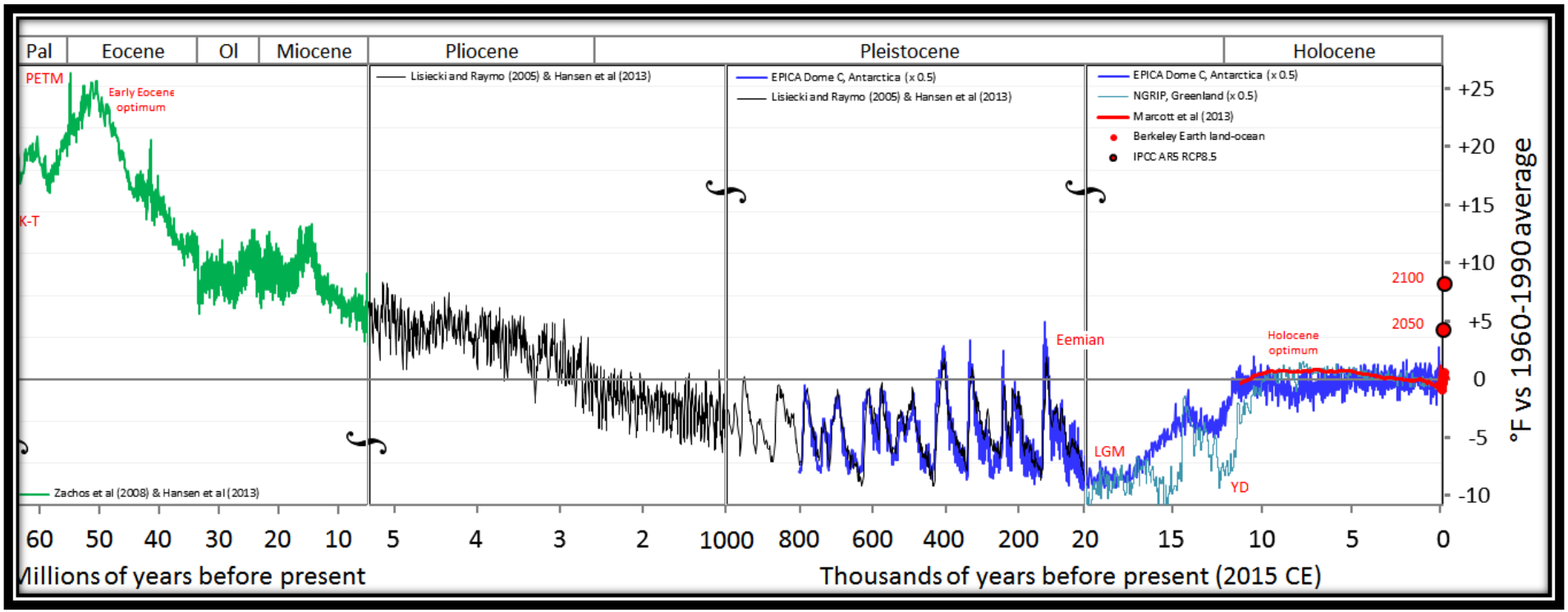
现代气候在始新世以来气候变化中的地位

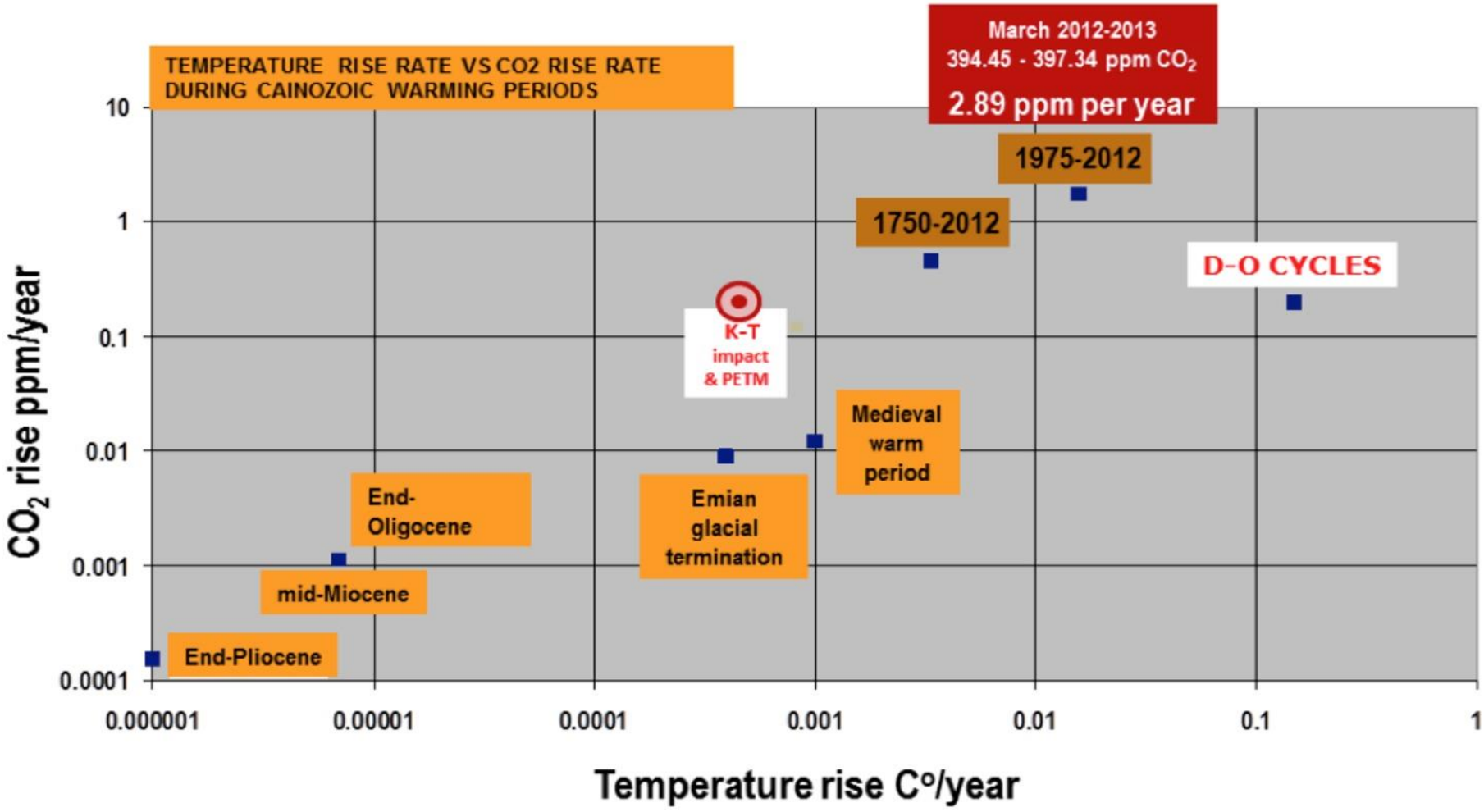
地球温度演变



构造尺度: 冷期　　**轨道尺度: 暖期**　　**百年尺度: 暖期**

https://upload.wikimedia.org/wikipedia/commons/f/f5/All_palaeotemps.png

现代气候在始新世以来气候变化中的地位



http://theconversation.com/existential-risks-to-our-planetary-life-support-systems-16896

4. 构造尺度气候变化的启示意义

- 阐明一系列关于“起源”的科学问题
- 给出可能的全球矿产资源分布
- 揭示高温室气体情景下可能的气候变化
- 揭示气候敏感度，用于约束现代气候模式

- ✓ 冰盖消融、海平面上升
- ✓ 植被带北移
- ✓ 热带气旋加强北移
- ✓ 东亚季风北进
- ✓ …

谢 谢!