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Permanent El Nino and IOD in Pliocene

Tomoki TOZUKA

University of Tokyo
Graduate School of Science
Dept. of Earth & Planetary Science

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Permanent El Niño and IOD in Pliocene

Tomoki Tozuka and Toshio Yamagata
(The University of Tokyo)

in collaboration with

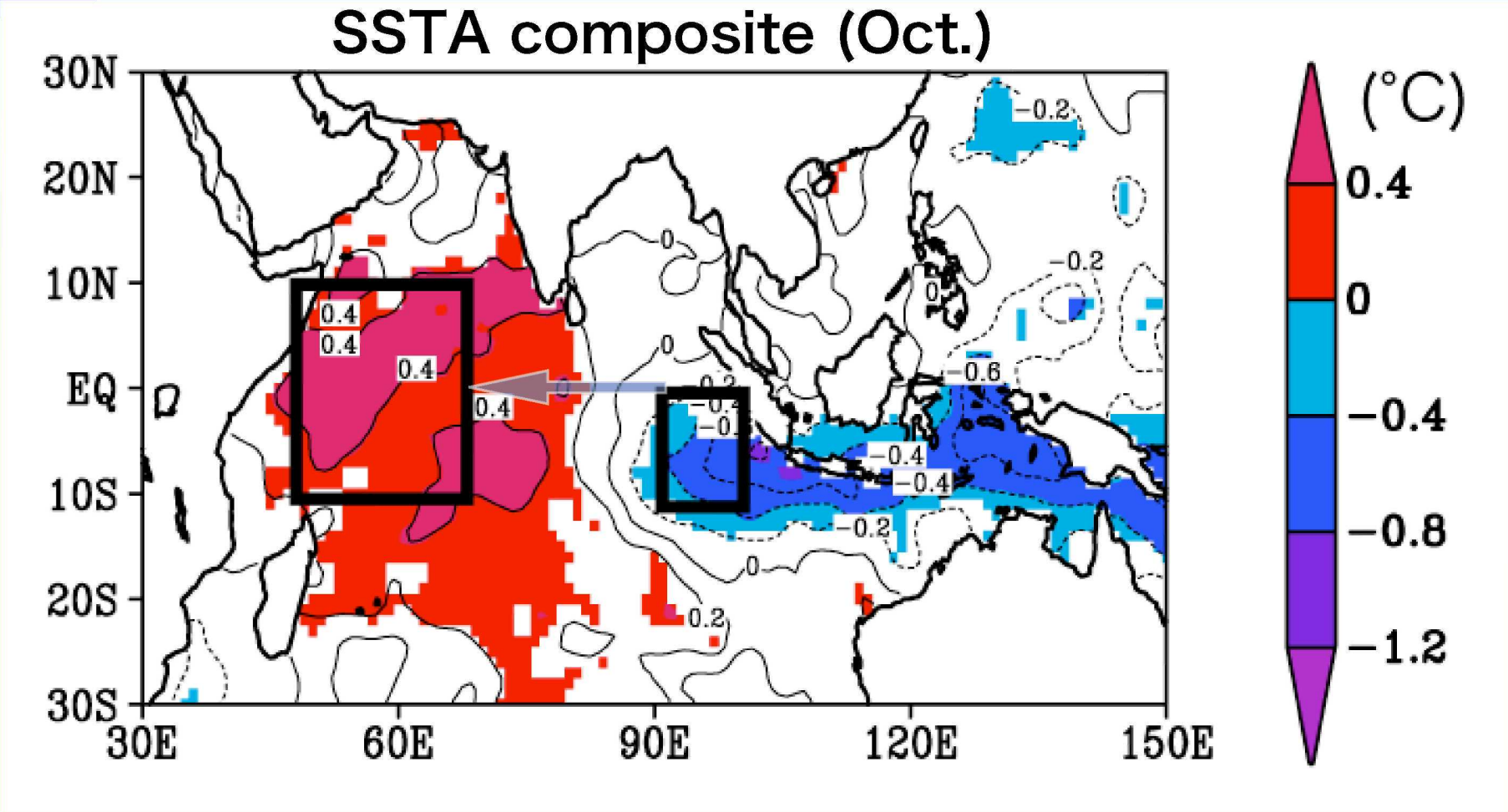
S. G. Philander and M. Barreiro

Permanent IOD-like condition

~ Warmer and wetter East Africa

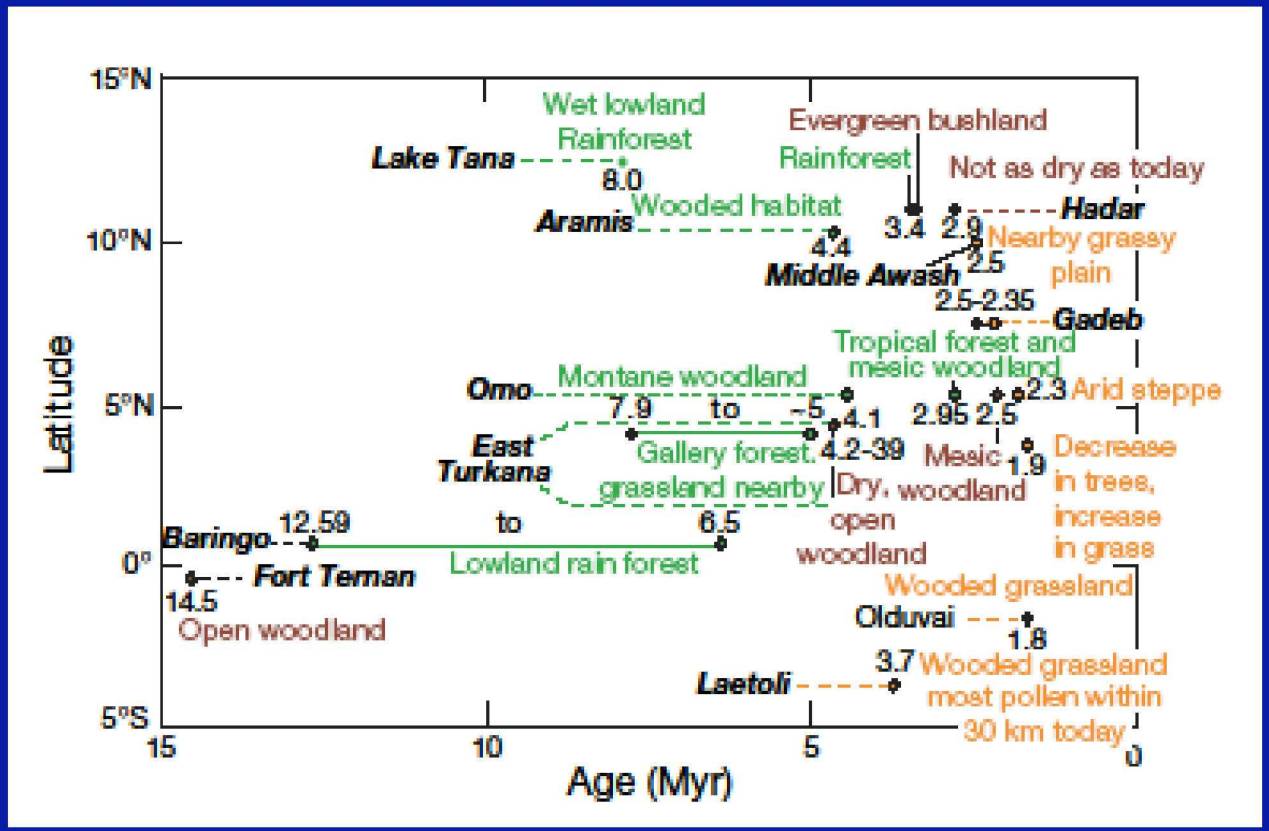
during Pliocene ~

Indian Ocean Dipole (Saji et al. 1999)



1961, 1967, 1972, 1982, 1994, 1997
(color : significant at 95%)

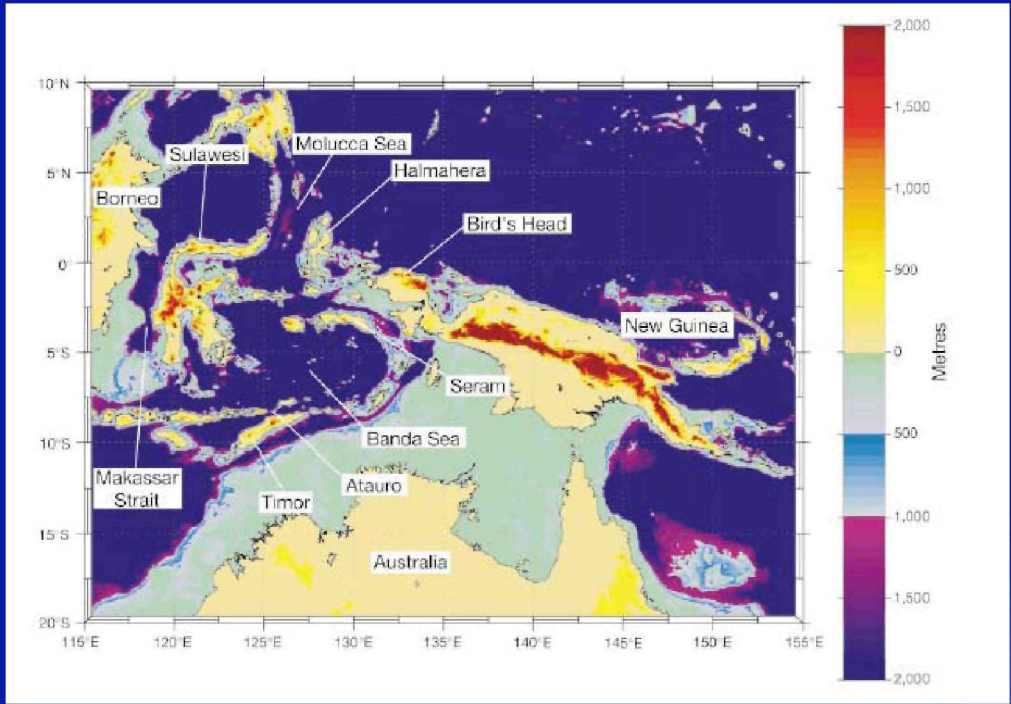
Paleo-environments in East Africa (Cane and Molnar 2000)



- Climate in East Africa has evolved from moist and warm to arid and slightly cooler over the past ~3-4 Myr.

Hypothesis for warmer and wetter East Africa (Cane and Molnar 2000)

New Guinea was located to the south and Halmahera Island was much smaller.



- Halmahera Island was much smaller.
- New Guinea was 2°-3° farther to the south.
- Mountains on the island were much lower.
- Timor was under water.
- 'Bird's Head' lay 250-400 km east of its present position with respect to Borneo.

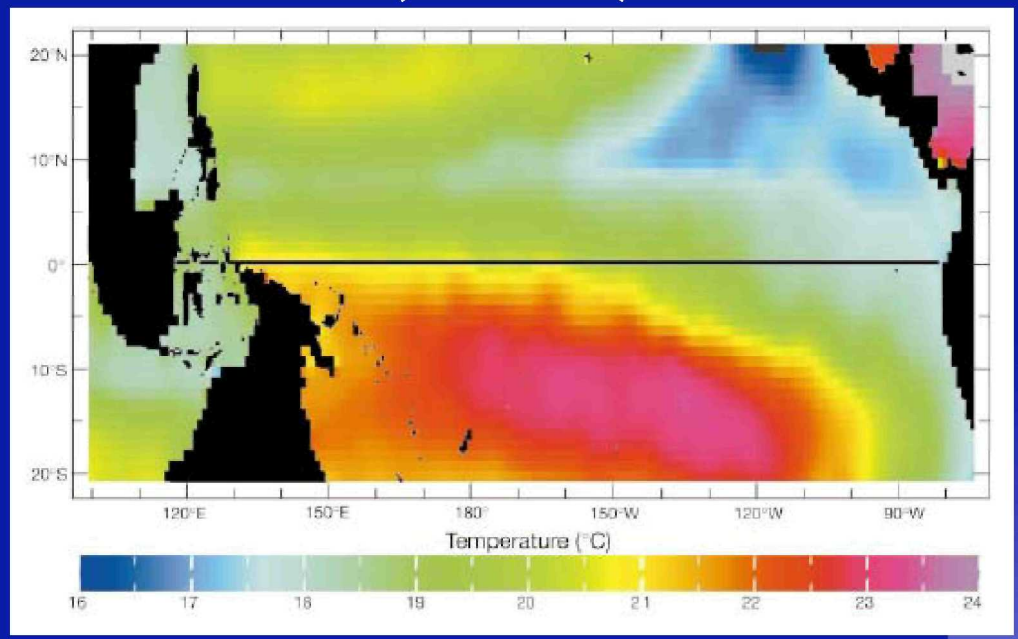
Hypothesis for warmer and wetter East Africa (Cane and Molnar 2000)

New Guinea was located to the south and Halmahera Island was much smaller.

▼

The Indonesian Throughflow water originated from the warmer South Pacific.

Temperature at σ=25.5 isopycnal (WOA94)



- The Indonesian Throughflow water currently originates from the Northern Hemisphere.

Hypothesis for warmer and wetter East Africa (Cane and Molnar 2000)

New Guinea was located to the south and Halmahera Island was much smaller.

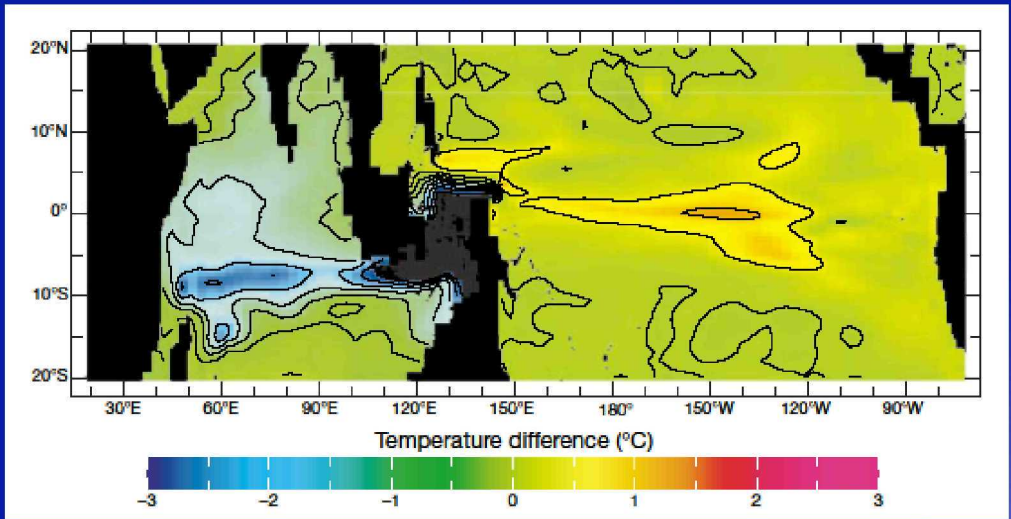
▼

The Indonesian Throughflow water originated from the warmer South Pacific.

▼

SSTs in the Indian Ocean was much warmer.

Difference in OGCM temperatures at 100m depth with the northern New Guinea at 2°N and 3°S (Rodgers et al. 2000): (2°N run)-(3°S run)



- Temperatures across the central Indian Ocean is 2°C warmer for the more southerly position.
- SSTs were warmer throughout the Indian Ocean, especially in upwelling regions, such as the Somali Current north of the Equator along the African coast.

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The Indonesian Throughflow water originated from the warmer South Pacific.

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SSTs in the Indian Ocean was much warmer.

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East Africa was much warmer and wetter.

Rodgers et al. (2000) assumed that wind stress was the same.

Alternate hypothesis for warmer and wetter East Africa

New Guinea was located to the south and Halmahera Island was much smaller.

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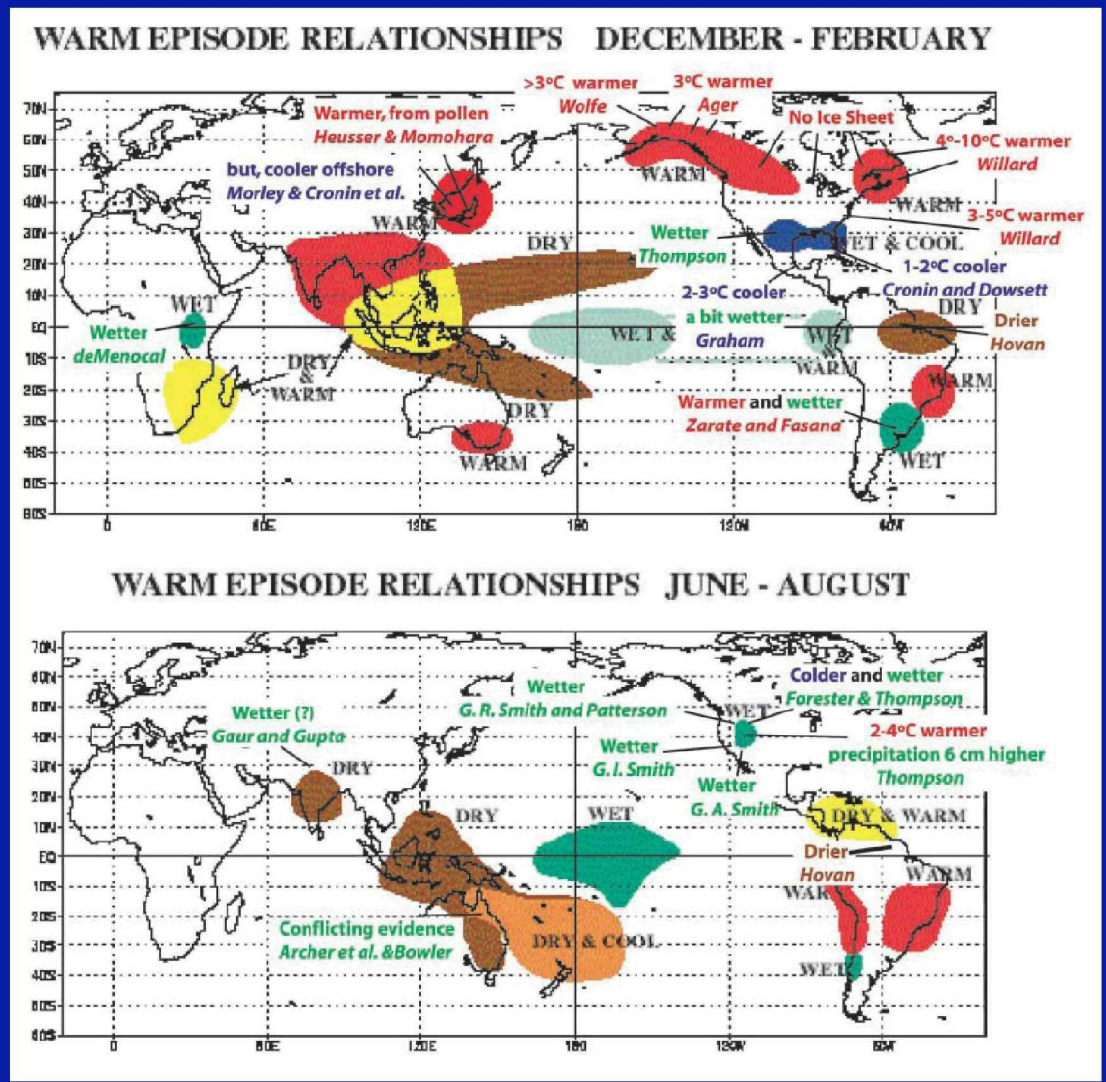
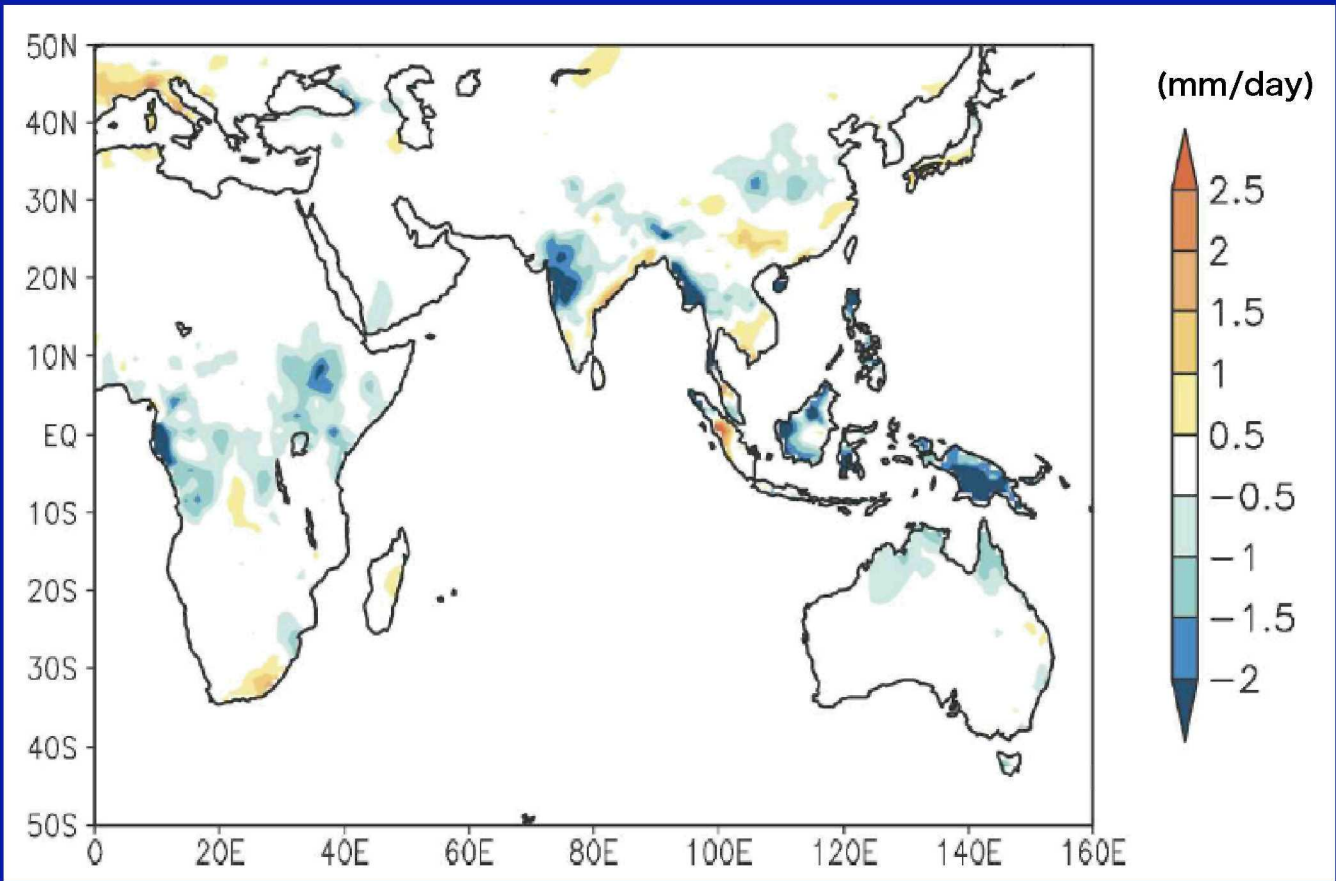
Permanent El Niño:
The zonal SST gradient was smaller and the Walker Circulation was weaker.

Teleconnection from the permanent El Niño?

Summer and Winter temperature/rainfall anomalies during El Niño with Pliocene paleoclimate data (Molnar and Cane 2002)



Pure El Niño composite of rainfall anomalies (Sep.-Nov.) (Behera et al. 2005)



East African rainfall decreases during pure El Niño events (El Niño that occurs without IOD).

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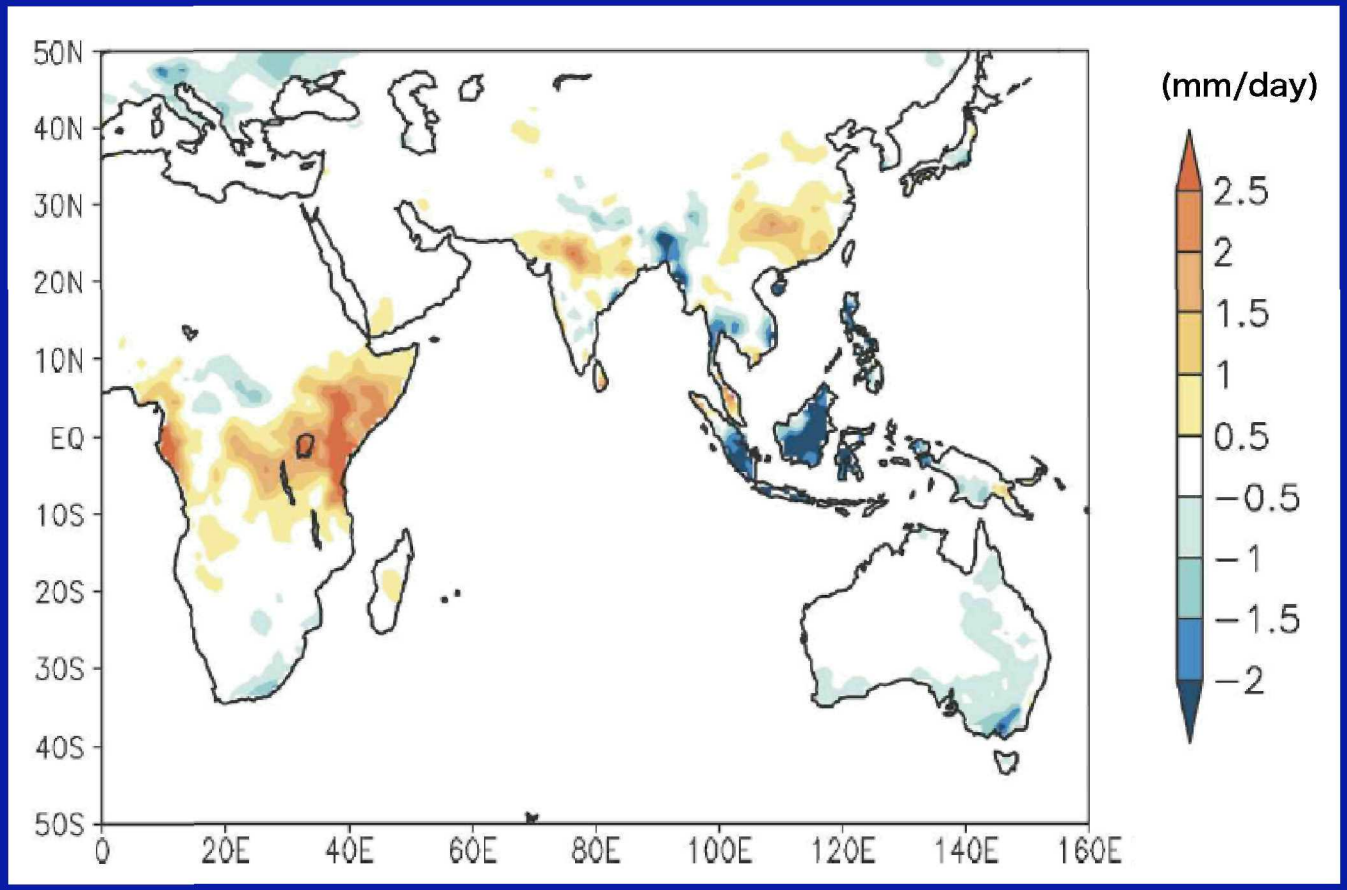
Permanent El Niño:
The zonal SST gradient was smaller and the Walker Circulation was weaker.

+

Permanent IOD:
The zonal SST gradient was smaller, zonal wind was more easterly, and the western IO was warmer.

Pure positive IOD composite of rainfall anomalies (Sep.-Nov.) (Behera et al. 2005)



East Africa receives more rainfall during pure positive IOD events (IOD that occurs without ENSO events).

Model description: FrAM1.1

- Upgraded version of FrAM1.0 (Guan et al. 2001)T42L28
- Cumulus convection: Kuo (1974)
- Cloud: Slingo and Slingo (1991)
- Gravity wave drag: Palmar et al. (1986)
- Land surface: Viterbo and Beljaars (1995)
- Radiation: Shibata and Aoki (1989), Shibata (1989), Lacis and Hansen (1974)

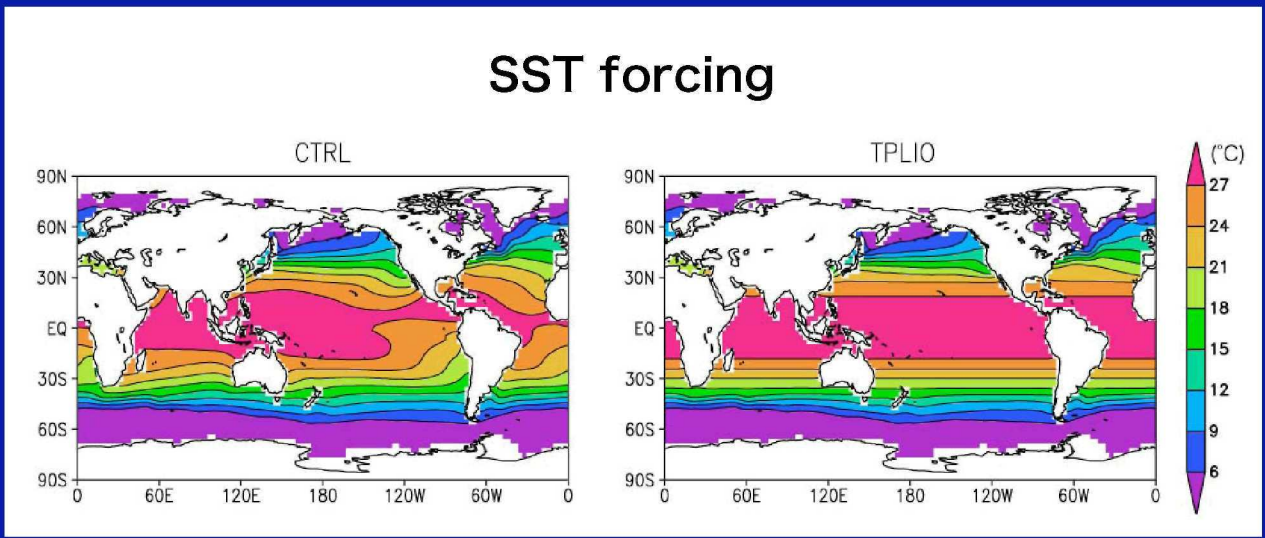
AGCM Experiments (similar to Barreiro et al. 2006)

- Sea ice is left at present values.
- CO2 is kept at a value of 356ppm.
- Topography is same as present.
- Experiments were run for 7 years and the last 4 years were used for analysis.

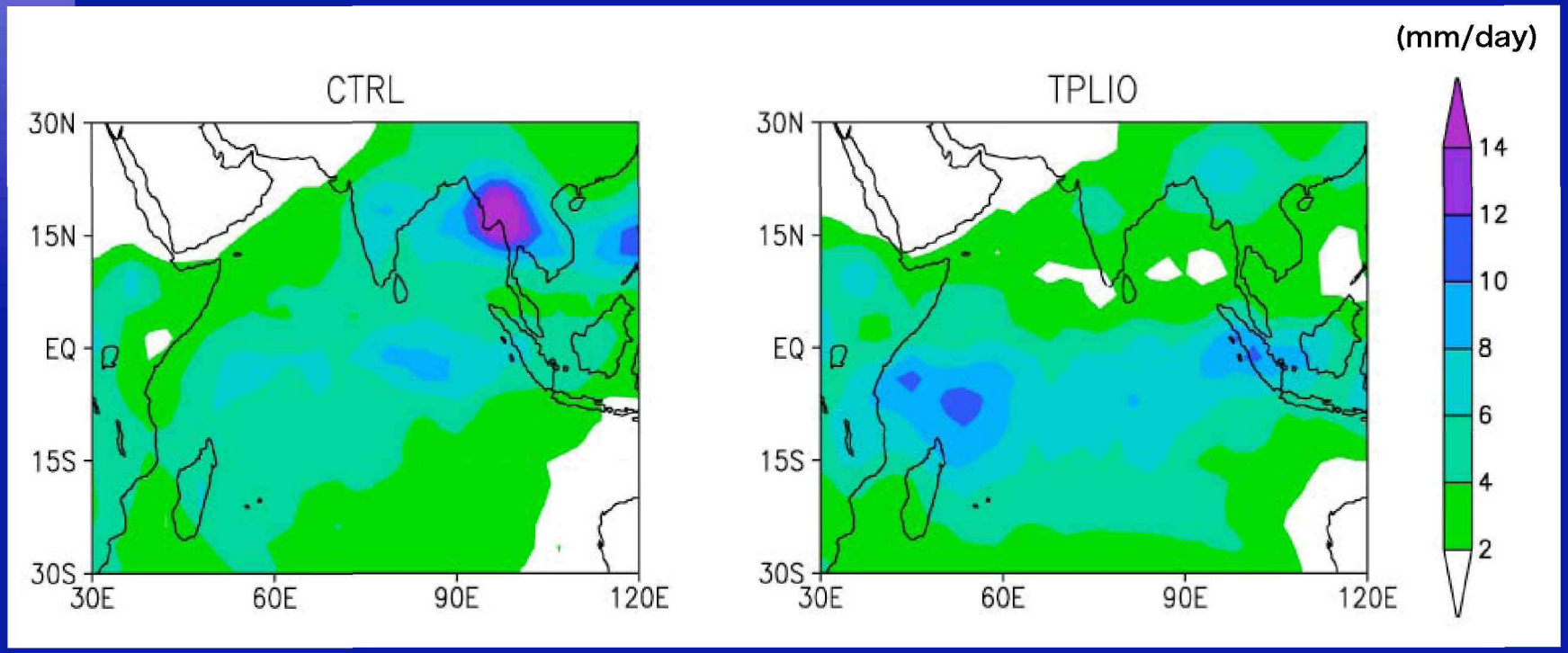
(The purpose of these simulations is not to reproduce Pliocene climate, but to investigate the role of the tropical SST without the zonal SST gradient on the atmospheric circulation.)

AGCM Experiments (similar with Barreiro et al. 2006)

- CTRL: Monthly climatology of the present day SST
- TPLIO: Seasonal variations of SST along the dateline today represent the seasonal cycle at all longitudes in the tropical oceans, and has present conditions elsewhere.

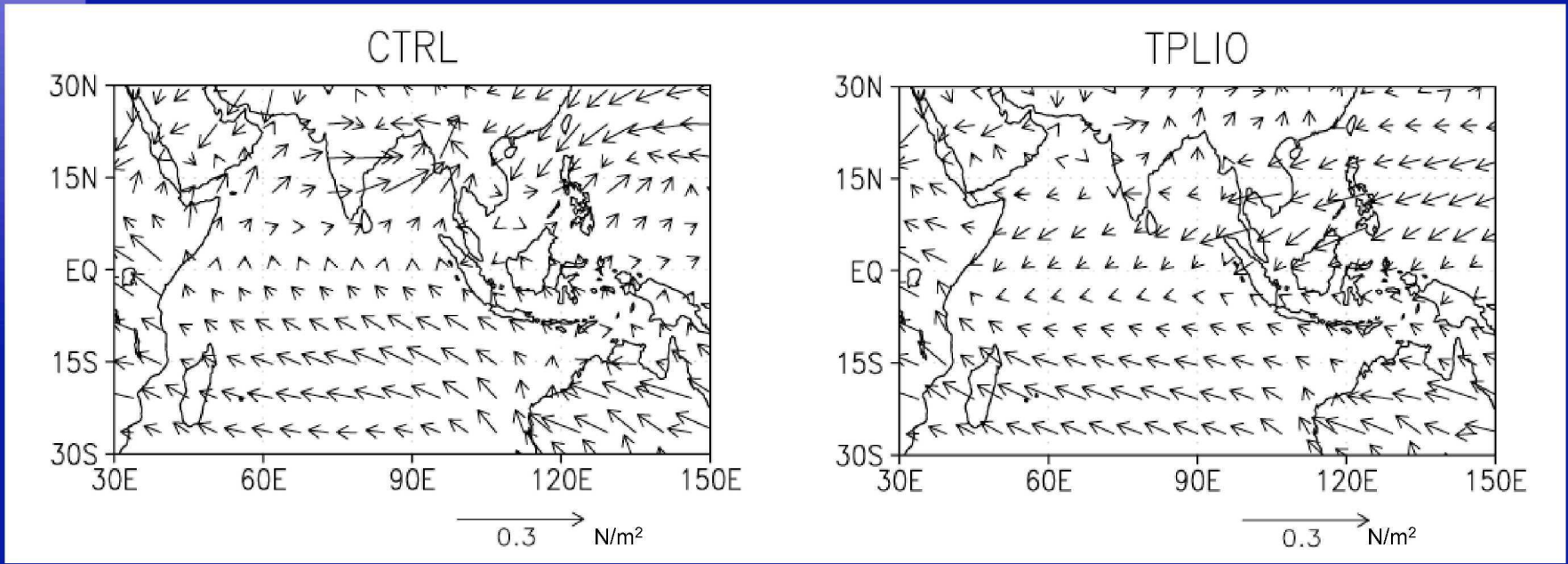


Annual mean rainfall in the Indian Ocean



- East Africa received more rainfall in TPLIO.

Annual mean wind stress in the Indian Ocean



- CTRL: slightly westerly wind over the equator.
- TPLIO: easterly wind over the equator.

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