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Vegetation cover in a warmer world simulated using a dynamic global vegetation model for the Mid-Pliocene

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Abstract

In this study we employ the TRIFFID (Top-down Representation of Interactive Flora and Foliage Including Dynamics) Dynamic Global Vegetation Model (DGVM) and the Hadley Centre Atmospheric General Circulation Model version 3 (HadAM3 GCM) to investigate vegetation distributions and climate–vegetation feedbacks during the Mid-Pliocene, and examine the implications of these results for the origins of hominid bipedalism. The TRIFFID model outputs support extant palaeoenvironmental reconstructions for the Mid-Pliocene provided by the PRISM Group (Pliocene Research Interpretations and Synoptic Mapping). Compared to the pre-industrial, TRIFFID simulates a significant increase in forest cover during the Mid-Pliocene, composed of needle leaf trees in the higher latitudes of the Northern Hemisphere and broad leaf trees in other regions. Needle leaf trees extend from the Arctic Coast into the northern mid latitudes. The fractional coverage of bare soil declines in North Africa, the Arabian Peninsula, Australia and southern South America, a pattern that is consistent with PRISM's assertion of less extensive arid deserts. A significant increase in the fractional coverage of both broad leaf trees in Africa and South America in the Mid-Pliocene scenario is not indicative of a major expansion of tropical rainforests. Rather, it represents an expansion of general woodland type habitats. The principal impact of using a DGVM on the GCM predicted climatology for the Mid-Pliocene is to reduce minimum and maximum temperature extremes, thus reducing the seasonality of temperature over wide regions. The predicted Pliocene expansion in broad leaf trees in Africa is difficult to reconcile with the 'savannah hypothesis' for the evolution of hominid bipedalism. Rather the results lend credence to an alternative hypothesis which suggests that bipedalism evolved in wooded to forested ecosystems and was, for several million years, linked to arborealism.

Keywords: Mid-Pliocene; Vegetation; General Circulation Model; Top-down Representation of Interactive Flora and Foliage Including Dynamics; Hominid; Bipedalism

1. Introduction

1.1. Vegetation during the Mid-Pliocene warm period

The Mid-Pliocene warm period (ca 3.29 to 2.97 Ma BP; Dowsett et al., 1999) represents one of the most intensively studied, scientifically challenging and controversial time periods in Cenozoic Earth history. For the last 15 years, the combined efforts of numerous individuals and research teams have been focussed on documenting the palaeoenvironmental and palaeoclimatic characteristics of the period (e.g., Dowsett et al., 1992, 1994, 1996; Thompson and Fleming, 1996; Poore and Sloan, 1996; Chandler et al., 1994; Sloan et al., 1996; Williams et al., 2005).

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Table 1
List and characterization of all terrestrial localities used within the PRISM2 vegetation reconstruction (Thompson and Fleming, 1996; Dowsett et al., 1999)

No.	Locality	Pliocene vegetation	References
1	Ocean Point	EVE, DEC	Nelson and Carter (1985)
2	Lost Chicken Mine	EVE	Ager (1994), Adam (1994)
3	Oak Grove Fork	EVE	Wolfe (1990)
4	Tulelake	EVE, GSS	Adam et al. (1989, 1990)
5	Sonoma Flora	EVE, DEC	Axelrod (1944), Evernden and James (1964)
6	Bruneau	EVE, GSS	Thompson (1992), Thompson (1996)
7	Fossil Gulch	EVE, GSS	Leopold and Wright (1985)
8	INEL	EVE, GSS	Thompson (1991)
9	Black Rock	EVE, GSS	Thompson et al. (1995)
10	DSDP Site 32	EVE	Fleming (1992, 1994)
11	DSDP Site 467	GSS, EVE, DEC	Heusser (1981), Ballog and Malloy (1981)
12	Meighen Island	EVE, TUN	Matthews (1987, 1990), Matthews and Ovenden (1990)
13	ODP 645b	EVE, TUN	De Vernal and Mudie (1989a)
14	ODP 646b	EVE, DEC	De Vernal and Mudie (1989b), Willard (1994)
15	Yorktown Formation	DEC, EVE	Litwin and Andrle (1992a), Willard (1994)
16	Duplin Formation	EVE, DEC	Litwin and Andrle (1992a), Willard (1994)
17	Raysor Formation	EVE, DEC	Groot (1991), Litwin and Andrle (1992a), Willard (1994)
18	Pinecrest Beds	EVE	Willard et al. (1993), Willard (1994)
19	Paraje Solo	DEC, EVE	Graham (1989, 1994)
20	Gatun Formation	RAI, DEC	Graham (1989, 1994)
21	Plain of Bogotá	DEC	Sarmiento (1991), Van der Hammen (1985), Wijninga and Kuhry (1990)
22	East-Central Pampas	GSS	Zarate and Fasana (1989)
23	Tjornes Section	EVE	Schwarzbach and Pflug (1957), Akhmetiev et al. (1978), Akhmetiev (1991), Willard (1992), Willard (1994)
24	ODP 642	EVE	Willard (1994)
25	Red and Walton Crags	EVE, DEC	Zalasiewicz et al. (1988), Hunt (1989)
26	Brunssum/Reuver	DEC	Suc and Zagwijn (1983), Zagwijn (1992)
27	Northwest Germany	DEC	Mohr (1986)
28	Bresse Basin	DEC	Rousseau et al. (1992)
29	Stirone River Section	EVE	Bertolani Marchetti et al. (1979), Gregor (1990)
30	Le Castella Section	EVE	Bertolani Marchetti (1975)
31	Garraf 1	EVE	Suc (1984)
32	Autan 1	EVE	Cravatte and Suc (1981), Suc and Zagwijn (1983)
33	Southern Poland	EVE, DEC	Stuchlik and Shatilova (1987)
34	Slovakia	EVE, DEC	Planderová (1974)
35	Kozani Basin	EVE	Van de Weerd (1983)
36	NW Black Sea Coast	DEC, EVE, GSS	Svetlitskaya (1994)
37	Russian Plain #1	EVE, DEC	Grichuk (1991)
38	Russian Plain #2	EVE, DEC	Grichuk (1991)
39	Russian Plain #3	EVE, DEC	Grichuk (1991), Borisova (1991, 1994)
40	Russian Plain #4	EVE, DEC	Grichuk (1991), Borisova (1991, 1994)
41	Russian Plain #5	EVE, DEC	Grichuk (1991), Borisova (1991, 1994)
42	DSDP 380	EVE	Traverse (1982)
43	Western Georgia	DEC, EVE	Shatilova (1980, 1986), Shatilova et al. (1991)
44	Azerbaijan	DEC, EVE	Mamedov (1991)
45	Hula Basin	EVE, DEC, GSS	Horowitz (1989), Horowitz and Horowitz (1985)
46	ODP 658	GSS	Leroy and Dupont (1994), Dupont and Leroy (1994)
47	Hadar	GSS	Bonnefille et al. (1987)
48	Turkana Basin	GSS	Williamson (1985)
49	East Africa	GSS	Cerling et al. (1988), Cerling (1992)
50	South Africa	GSS, DEC	Partridge et al. (in press), Scott and Partridge (1994)
51	West Siberia	EVE, DEC	Volkova (1991)
52	northern Pakistan	GSS	Quade et al. (1989)
53	Kathmandu Valley	EVE, DEC	Igarashi et al. (1988)
54	Yunnan and Xizang	DEC, EVE	Hsü (1983)
55	East China Sea	GSS?	Zhou et al. (1989)
56	Bugpyeong area	EVE	Choi and Bong (1986)

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