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Supplement of

Complex interplay of forcings drives Indian vegetation and summer monsoon variability during MIS 11

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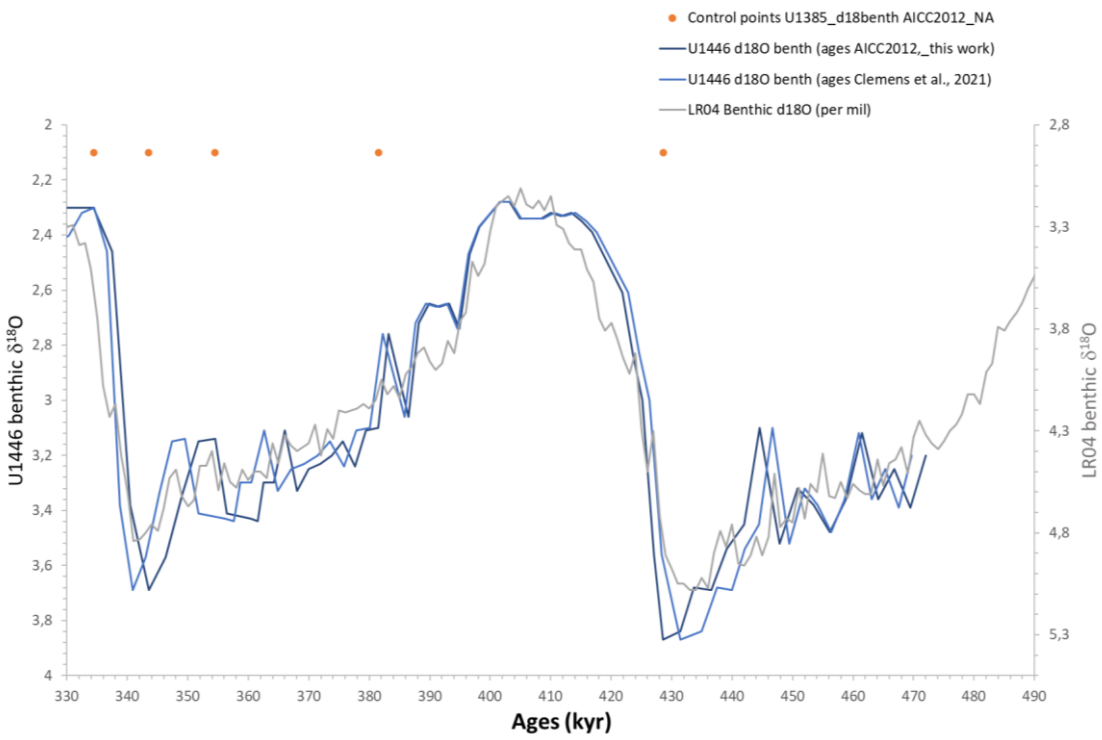

Fig. S1. Comparison between the original and revised age model for IODP Site U1446. The U1446 benthic $\delta^{18}O$ record is plotted using the original chronology of Clemens et al. (2021) and the revised AICC2012-based chronology developed in this study. The LR04 benthic $\delta^{18}O$ stack (Lisiecki and Raymo, 2005) is shown for reference, and orange circles mark the control points used to construct the revised age–depth model.

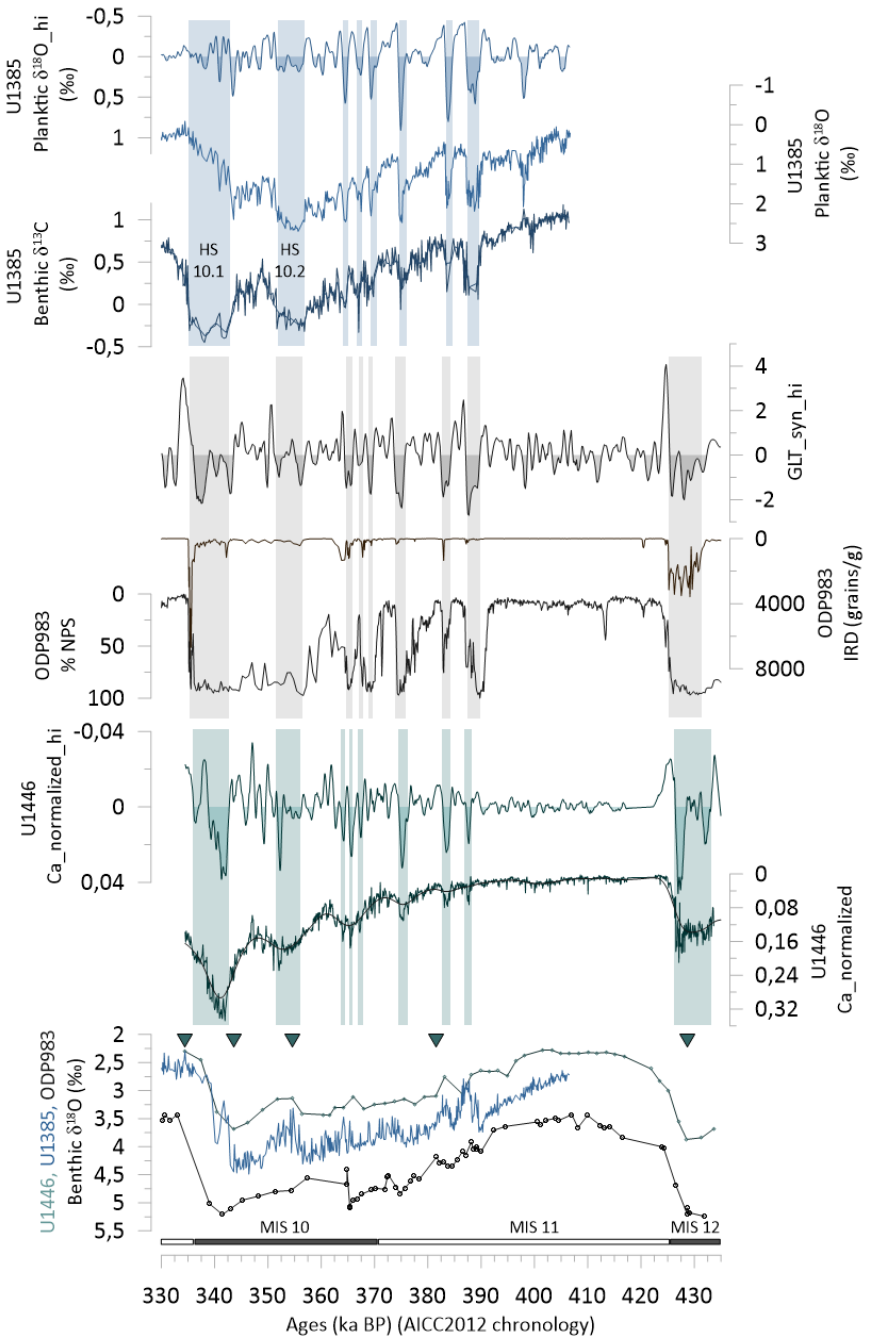

Fig. S2. Comparison of IODP Site U1446 records with selected North Atlantic records on the revised AICC2012-based chronology. From bottom to top: benthic $\delta^{18}O$ records from IODP Site U1446 (Clemens et al., 2021), IODP Site U1385 (Nehrbass-Ahles et al., 2020), and ODP Site 983 (Barker et al., 2019), with triangles marking the control points used to construct the revised U1446 age–depth model (this study); normalized and high-frequency XRF calcium signal (CaXRF) from Site U1446; ODP Site 983 ice-rafted debris (IRD) and %NPS records (Barker et al., 2019); GLT_syn data (Barker et al., 2019); and IODP Site U1385 planktonic $\delta^{18}O$ and benthic $\delta^{13}C$ records and their high-frequency components (Nehrbass-Ahles et al., 2020). The revised U1446 age–depth model was constructed by aligning the U1446 benthic $\delta^{18}O$ record with AICC2012-dated benthic $\delta^{18}O$ records from IODP Site U1385 and ODP Site 983. The age–depth model is based on linear interpolation between control points. Shaded bands indicate potential concurrent millennial-scale events.

IODP Site U1446
from late MIS 12 to early MIS 10

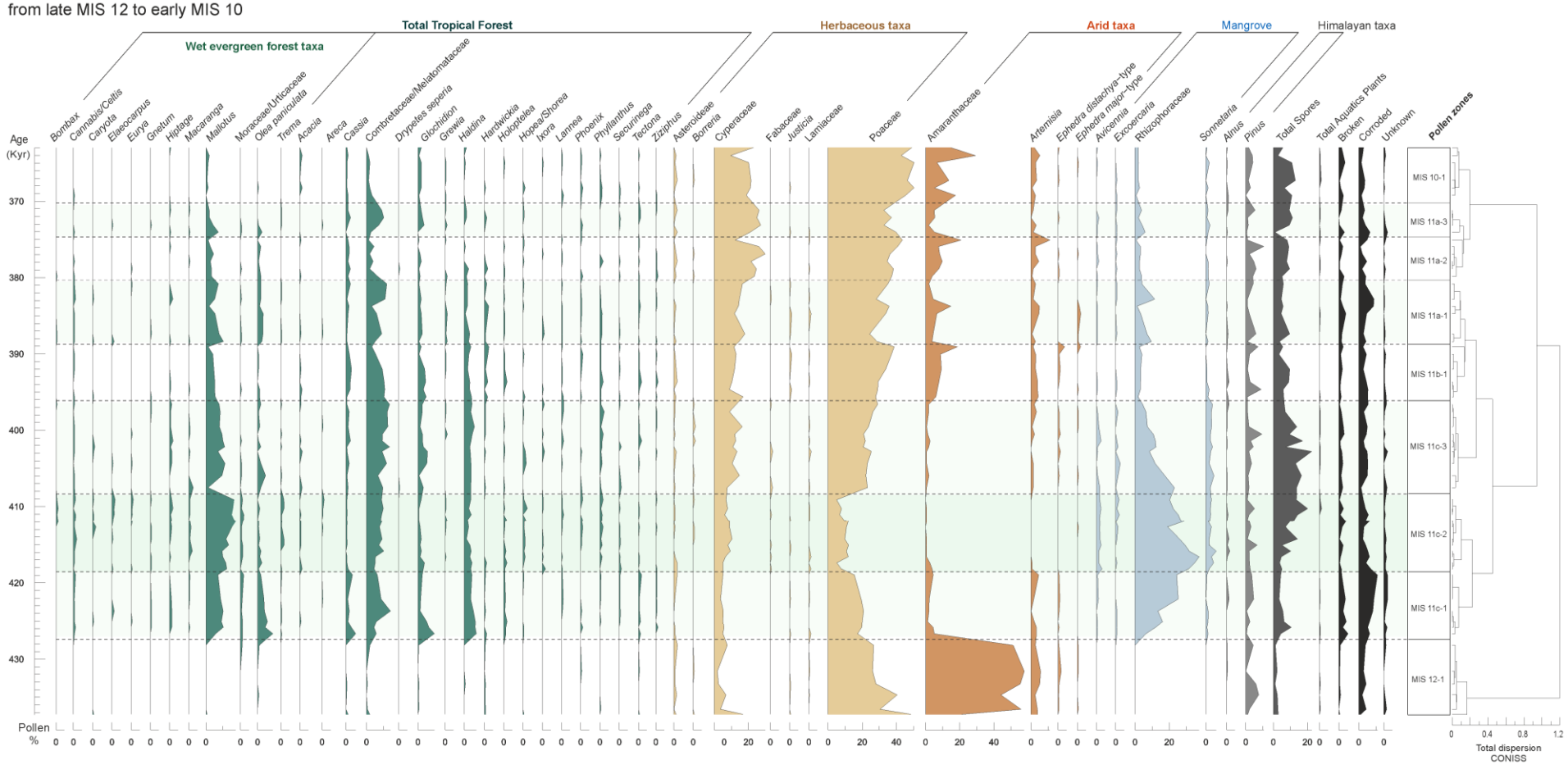

Fig. S3. Percentage pollen diagram of selected pollen morphotypes and ecological groups from Site U1446 in age (ka). The dendrogram from the cluster analysis and the pollen zones (labelled as MIS 11 substage - pollen zone number within each substage) are displayed on the right. Green bands indicate major expansions of the total tropical forest, mainly driven by the wet evergreen forest (zones MIS 11c-1 to 3, MIS 11a-1 and a-3), with the darkest green band representing their maximum expansion during MIS 11 (zone MIS 11c-2).

Table S1. IODP Site U1446 age-depth tie points.

	Site U1446 CCSF-A (m)	**Control points U1385_d18benth AICC2012_NA**	**Tx sed (cm kyr^{-1})**
Age on U1385 AICC2012_Nehrbass-Ahles (2020)	66.83	334.4	9.91
Age on U1385 AICC2012_Nehrbass-Ahles (2020)	67.732	343.5	10.8
Age on U1385 AICC2012_Nehrbass-Ahles (2020)	68.92	354.5	15.6
Age on U1385 AICC2012_Nehrbass-Ahles (2020) (MIS 11/10 transition)	73.14	381.5	17.9
Age on ODP 983 AICC2012 (MIS 12 end max)	81.59	428.6	11.4
Age on ODP 983 AICC2012 (MIS 13/12 transition)	86.52	472	

Table S2. Summary description of the pollen record of Site U1446 from late MIS 12 to early MIS 10 (this study). TF: Total tropical forest.

Pollen zones (basal age in ka)	**Pollen signature**
U1446-12-1 (433.3)	Dominance of xerophyte plants (Amaranthaceae, *Artemisia*, and Ephedraceae) with high values of herbaceous taxa, in particular of Cyperaceae and Poaceae. Very low frequencies of tree taxa (TF average < 4%) and mangrove. Maximum abundance of *Pinus*.
U1446-11c-1 (426.1)	High-amplitude drop of xerophyte plants and herbaceous taxa associated with a pronounced increase in TF taxa percentages (TF average ~ 49.6%), mostly composed of *Mallotus*, *Olea paniculata*, *Cassia*, *Moraceae/Urticaceae*, *Glochidion* and *Haldina*, which is followed by a decreasing trend. Highest abundances of tropical deciduous taxa (*Cassia*, *Hardwickia*, *Ziziphus*). Rising percentages of mangrove taxa, constituted mainly by Rhizophoraceae. Decline in Himalayan taxa, primarily due to *Pinus*, which remains very low but fluctuates throughout the remaining pollen zones.
U1446-11c-2 (416.8)	Marked decline in all xerophyte and herbaceous plants whereas TF taxa reach maximum percentages and pollen diversity (maximum of 58.2%) essentially due to wet evergreen taxa, specifically *Bombax*, *Celtis*/*Cannabis*, *Elaeocarpus*, *Gnetum*, *Hiptage*, *Macaranga*, *Mallotus*, *Moraceae*/*Urticaceae*, *Olea paniculata*, and *Trema*. Conversely, tropical deciduous taxa, including *Cassia*, *Hardwickia*, *Ziziphus*, fall to their minimums. Higher abundances of mangrove at the beginning, subsequently falling towards the top of the zone.
U1446-11c-3 (406.0)	Increasing percentages of herbaceous taxa (mostly Cyperaceae and Poaceae) and tropical deciduous taxa (primarily caused by *Cassia*). Decreasing frequencies of TF taxa (average of 41.6%, mainly attributed to *Mallotus*) and Rhizophoraceae.
U1446-11b-1 (394.1)	Significant drop in tropical forest taxa (TF minimum of 18.1%), especially in all wet evergreen taxa, which contrasts with higher abundances of tropical deciduous forest taxa (*Cassia*, *Hardwickia*, *Ziziphus*). Increasing percentages of Poaceae coinciding with a rise in xerophyte plants (Amaranthaceae, *Artemisia*, and Ephedraceae). Lower abundances of mangrove taxa (Rhizophoraceae and *Sonneratia*).
U1446-11a-1 (387.7)	Abrupt rise in TF taxa percentages (up to 42.3%), primarily owing to wet evergreen taxa (occurrences of *Bombax*, *Caryota*, *Elaeocarpus*, *Eurya*, *Gnetum*, *Hiptage*, *Moraceae*/*Urticaceae*, and *Trema* along with an increase in *Celtis*/*Cannabis*, *Mallotus*, and *Olea paniculata*) and Combretaceae/Melastomataceae. Decrease in tropical deciduous forest taxa, and in herbaceous and xerophyte plants (mostly Poaceae and Amaranthaceae, respectively). This pattern occurs twice due to a brief interruption in the middle of the zone forming an M-shape, where the trend reverses with a notable drop in TF taxa in favor of non-arboreal taxa.
U1446-11a-2 (380.3)	Decrease of TF taxa percentages (mainly attributed to wet evergreen taxa; TF minimum of 9.1%) while those of herbaceous plants (Cyperaceae, Poaceae) and Amaranthaceae return to higher abundances.
U1446-11a-3 (374.6)	TF taxa percentages increase (up to 26.7%), especially due to *Mallotus*, Combretaceae, and *Glochidium*, whilst herbaceous plants (Cyperaceae, Poaceae) and xerophyte plants decline. Slight increase in mangrove (Rhizophoraceae).
U1446-10-1 (370.2)	Fall in all TF frequencies (TF minimum of 5.9%), including the disappearance of wet evergreen taxa, except of *Mallotus* and single occurrences of *Celtis/Cannabis* and *Olea paniculata.* In contrast, Poaceae and xerophyte plants (particularly Amaranthaceae and *Artemisia*) increase significantly. Low and relatively stable mangrove percentages.

Table S3. Regression coefficients (R) of linear regression between simulated tree fraction and climate variables for the transient experiments with time-varying insolation and CO_2 concentration. The calculation was performed on the 1000-year running mean of the original simulated data.

	R
Annual mean temperature	0.349
Annual mean precipitation	0.996