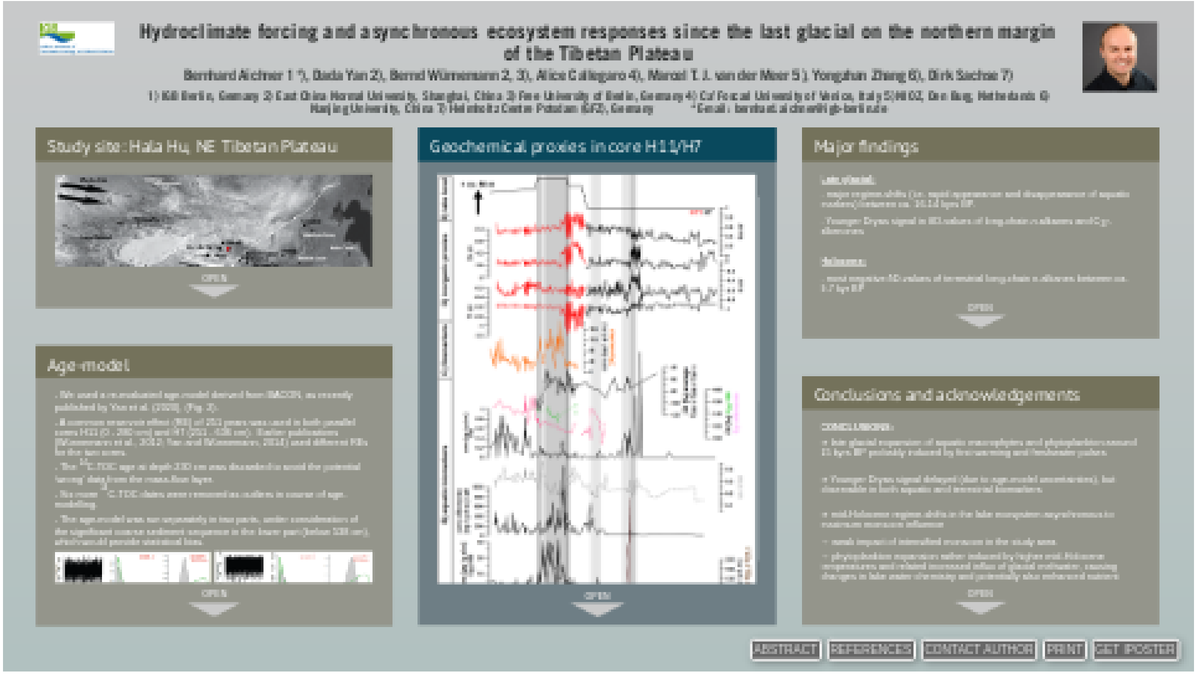
Hydroclimate forcing and asynchronous ecosystem responses since the last glacial on the northern margin of the Tibetan Plateau



Bernhard Aichner 1*), Dada Yan 2), Bernd Wünnemann 2, 3), Alice Callegaro 4), Marcel T. J. van der Meer 5), Yongzhan Zhang 6), Dirk Sachse 7)

1) IGB Berlin, Germany 2) East China Normal University, Shanghai, China 3) Free University of Berlin, Germany 4) Ca' Foscari University of Venice, Italy 5) NIOZ, Den Burg, Netherlands 6) Nanjing University, China 7) Helmholtz Centre Potsdam (GFZ), Germany *E-mail: bernhard.aichner@igb-berlin.de

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STUDY SITE: HALA HU, NE TIBETAN PLATEAU

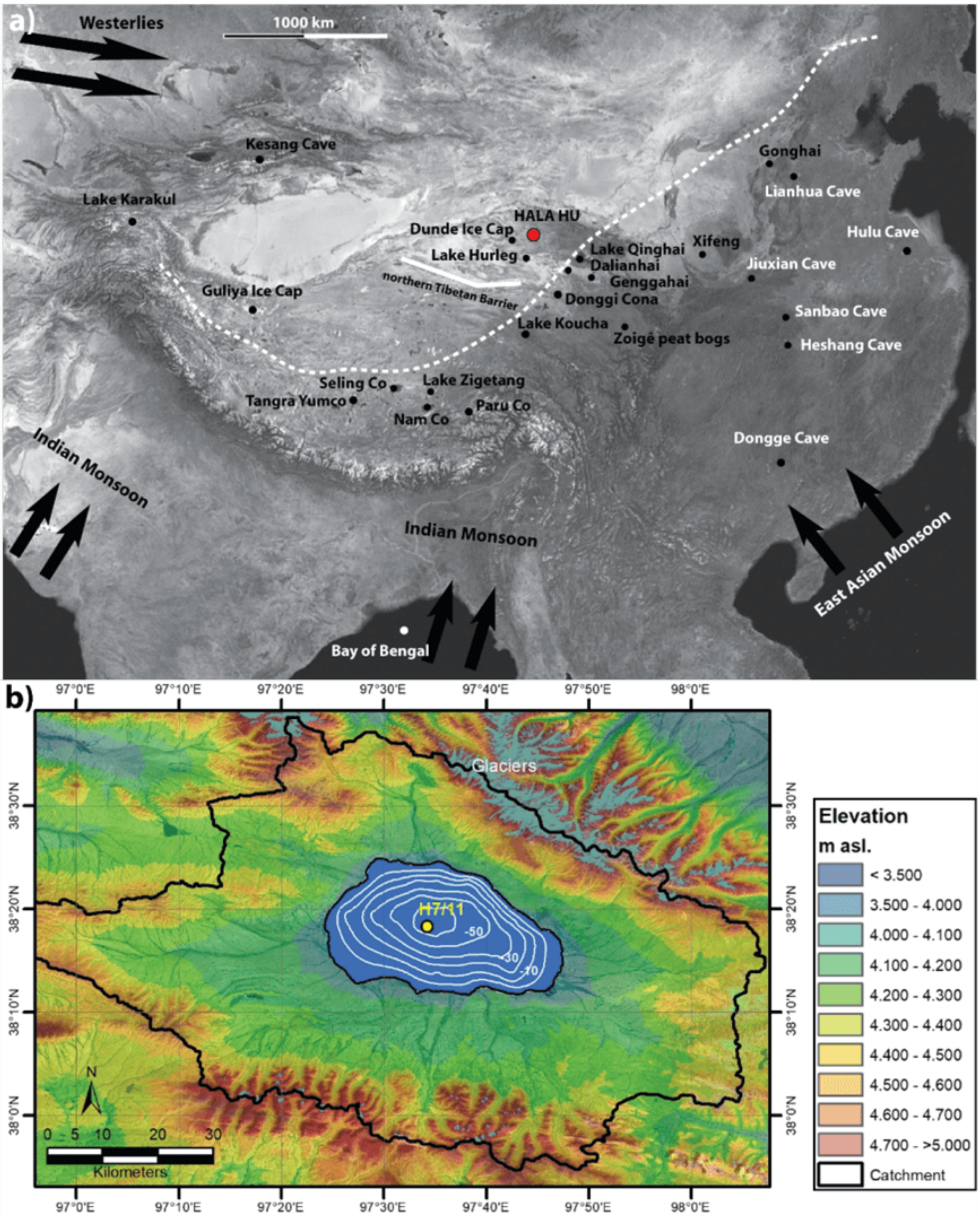

Fig. 1.: a) Location of Hala Hu and regional paleorecords. Dashed white line indicates approximate boundary zone of present day Asian Summer Monsoon (ASM). Northern Tibetan Barrier is the maximum extent of mid-Holocene monsoon influence as suggested by Ramisch et al. (2016). b) Hala Hu and catchment with coring location of H7 and H11 (Wünnemann et al., 2012).

Location parameters of Hala Hu:

- closed basin lake

- altitude: 4078m asl

- salinity: 17-19 psu

- MAT: -1.5°C

- MAP: ca. 230 mm

- potential evapotranspiration: > 1000 mm

- water supply at present: 60% precipitation, 40% glacial runoff

- coring depth: 65 m

AIM:

To investigate the impact of climatic changes since the last glacial maximum, upon a high-altitude lake ecosystem, located in the boundary zone of monsoonal influence.

AGE-MODEL

- We used a re-evaluated age-model derived from BACON, as recently published by Yan et al. (2020), (Fig. 2).

- A common reservoir effect (RE) of 251 years was used in both parallel cores H11 (0 - 280 cm) and H7 (251 - 636 cm). Earlier publications (Wünnemann et al., 2012; Yan and Wünnemann, 2014) used different REs for the two cores.

- The ^{14}C-TOC age at depth 230 cm was discarded to avoid the potential ‘wrong’ data from the mass-flow layer.

- Six more ^{14}C-TOC dates were removed as outliers in course of age-modelling.

- The age-model was run separately in two parts, under consideration of the significant coarse sediment sequence in the lower part (below 538 cm), which would provide statistical bias.

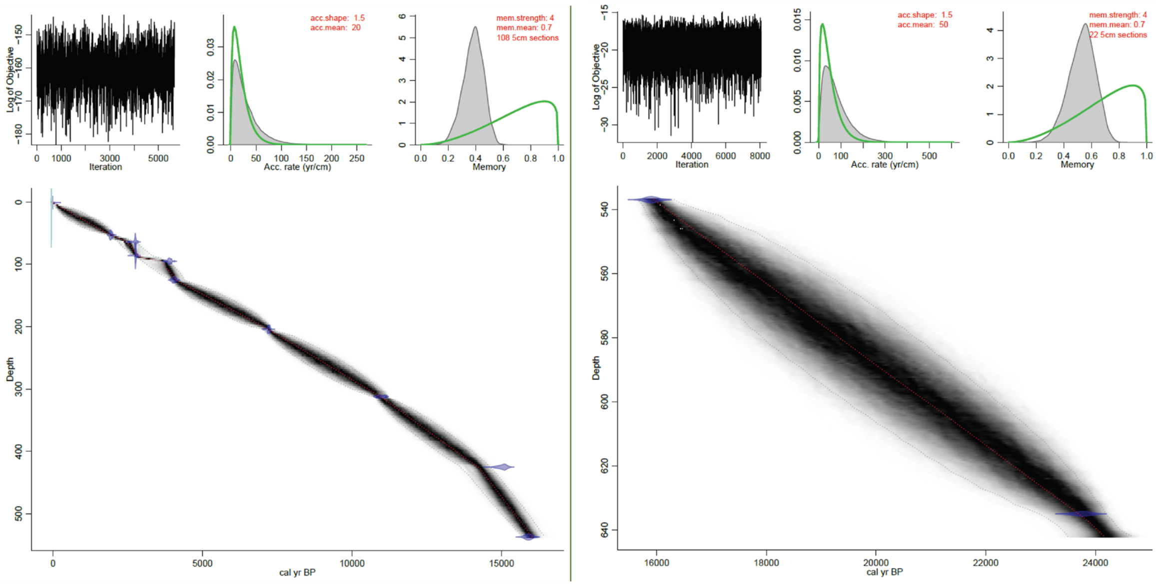

Fig. 2: BACON age-models from the upper (left) and lower (right) parts of the Hala Hu composite sediment cores H7/H11.

GEOCHEMICAL PROXIES IN CORE H11/H7

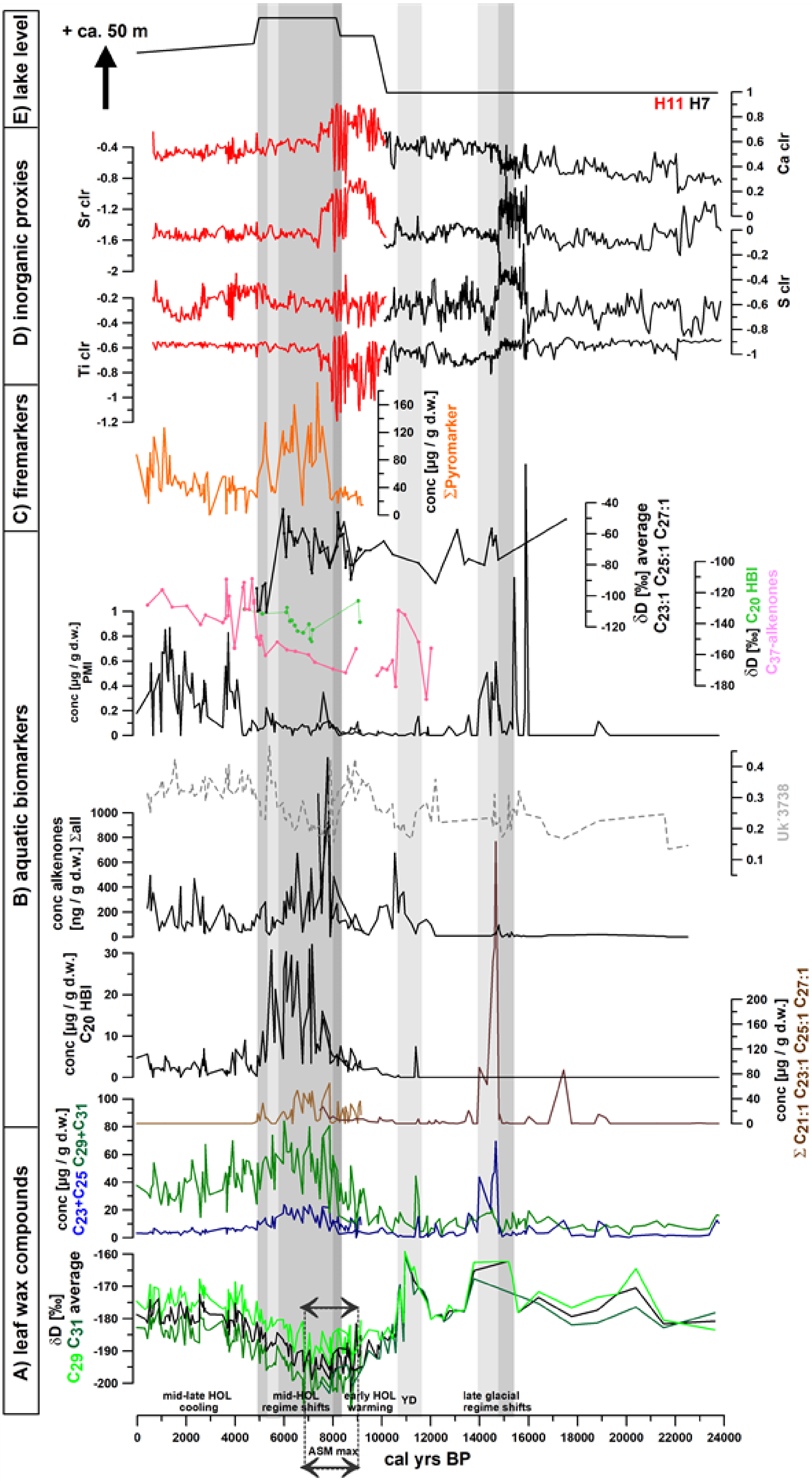

Fig. 3: Summary of measured proxy parameters in the cores H7 and H11 (overlap 7.4 – 9.1 kyrs BP): A) δD values and concentrations of mid- and long-chain *n*-alkanes. B) Concentrations and δD-values of aquatic biomarkers (C_{20}-HBI, C_{37}- and C_{38}-alkenones, $C_{23:1}$, $C_{25:1}$ and $C_{27:1}$ *n*-alkenes) and of microbial derived PMI; alkenone based index Uk'_{3738}. C) Concentrations of firemarkers, Σlevoglucosan, mannosan, and galactosan. D) Titanium, sulfur, strontium and calcium contents derived from XRF-scanning (Wünnemann et al., 2012; Yan and Wünnemann, 2014). E) Lake level inferred from ostracod assemblages (Yan et al., 2020). Dark shaded interval (8.4-8.0 kyrs BP) indicates mass flow layer. Light and medium grey shaded areas mark episodes of late glacial and mid-Holocene regime shifts within the aquatic ecosystem. Arrows indicate Asian summer monsoon (ASM) maximum inferred from most negative δD-values of long-chain *n*-alkanes.

MAJOR FINDINGS

Late glacial:

- major regime-shifts (i.e. rapid appearance and disappearance of aquatic markers) between ca. 16-14 kyrs BP.

- Younger Dryas signal in δD-values of long-chain *n*-alkanes and C_{37}-alkenones

Holocene:

- most negative δD-values of terrestrial long-chain *n*-alkanes between ca. 9-7 kyr BP

- pronounced regime-shifts within the aquatic ecosystem, and expansion of terrestrial vegetation, between 8-5 kyrs BP, synchronous to maximum concentrations of firemarkers

- major change of lake hydrology around 6-5 kyrs BP, indicated by shifts in δD-values of multiple aquatic compounds ($C_{23:1}$, $C_{25:1}$ and $C_{27:1}$ *n*-alkenes and C_{37}-alkenones)

CONCLUSIONS AND ACKNOWLEDGEMENTS

CONCLUSIONS:

⇒ late glacial expansion of aquatic macrophytes and phytoplankton around 15 kyrs BP probably induced by first warming and freshwater pulses

⇒ Younger Dryas signal delayed (due to age-model uncertainties), but observable in both aquatic and terrestrial biomarkers

⇒ mid-Holocene regime-shifts in the lake ecosystem asynchronous to maximum monsoon influence

→ weak impact of intensified monsoon in the study area

→ phytoplankton expansion rather induced by higher mid-Holocene temperatures and related increased influx of glacial meltwater, causing changes in lake water chemistry and potentially also enhanced nutrient supply.

Related publication:

The data on these poster are part of a manuscript Aichner et al. (in review).

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ABSTRACT

High altitude ecosystems react sensitively to climatic changes. To evaluate hydroclimate dynamics and ecosystem responses since the late glacial in a typical glacier influenced, high-altitude, lacustrine ecosystem, we analysed concentrations and hydrogen isotopic composition of different aquatic (alkenones, $nC_{23:1}$, HBIs) and terrestrial (nC_{31}) biomarker groups in Hala Hu. The lake is located on the northern margin of the Tibetan Plateau, i.e. in the transitioning zone between the East Asian summer monsoon (EASM) and westerlies influence. According to species association of ostracods, it experienced a lake level rise of ca. 45 m during the late glacial and early Holocene and reached its highest stand during early mid-Holocene (8 - 6.1 cal. kyr BP) followed by lake level decline.

The organic geochemical data reveal asynchronous responses of the aquatic and terrestrial ecosystem in Hala Hu and its catchment to hydroclimatic forcing. We interpret δD values of terrestrial biomarkers as indicative for δD of growing season precipitation, with a potential contribution of surface meltwater runoff. Hence, most negative values during 9 - 7 cal. kyr BP indicate changes in moisture source, possibly related to EASM intensification. In contrast, rapid appearance and disappearance of aquatic biomarkers and shifts in theirs δD values between ca. 8 – 5 kyr BP, revealed distinct mid-Holocene aquatic regime-shifts and changes in lake hydrology. Maxima of terrestrial biomarker concentrations also occurred between 8 - 5 cal. kyr BP, suggesting expansion of terrestrial grasses and eventually increased biomarker flux via surface runoff.

These results give evidence that neither shifts of vapour source nor increased precipitation amounts were the major triggers of ecosystem responses. Instead we hypothesize, that warmer temperatures during the Holocene climate optimum, receding glaciers and consequently increased meltwater discharge into the lake, caused the pronounced ecological changes. The rapid regime-shifts within phytoplankton communities in the mid-Holocene illustrate the sensitivity of high altitude mountain ecosystems within the marginal Asian monsoon region to climatic changes. This is of relevance in context with future changes as response to global warming.

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