Response to reviewers

Anonymous Referee #1

No suggestions for revision were given by the reviewer.

Anonymous Referee #3

Zhao et al. present a valuable effort to integrate marine and terrestrial records in order to reconstruct land–sea interactions from the LGM to the Holocene in the South China Sea. Their finding of an SST warming occurring ~1,300 years prior to terrestrial warming (i.e., tree expansion) is particularly interesting and highlights the potential influence of low-latitude ocean–atmosphere dynamics on regional climate. However, several issues remain regarding the definition, chronology, and description of the pollen and dinocyst zones. As a result, millennial-scale variability is not adequately addressed. In addition, inconsistencies exist between the zonation and climatic phases described in the text and those presented in both the main and supplementary figures. These issues should be resolved before the manuscript can be considered for publication.

Response: We thank the reviewer for the constructive comments and for recognizing the value of our multiproxy approach and the finding of early ocean warming. We have carefully addressed each issue as detailed below. All revisions are highlighted with track changes in the revised manuscript.

Specific comments are detailed below:

Major comments

Lines 308–316 – Why are pollen zones 3 and 4 not described separately? Their combined presentation reduces clarity.

Response: We agree with the reviewer that separate descriptions improve clarity. In the former submission, Zones 3 and 4 were grouped because CONISS analysis placed

the zone boundary at 14.5 ka (within the deglaciation) and both zones exhibited broadly similar trends in the key proxies. However, we acknowledge that distinct millennial-scale variability (including the Heinrich Stadial 1) exists within this interval. We have now separated the description of Zone 3 (17.0-14.5 ka) and Zone 4 (14.5-11.7 ka) in the revised manuscript (Sections 4.5.3 and 4.5.4) (lines 306-320).

Line 417 – The manuscript refers to four climatic phases, whereas the pollen and dinocyst records indicate five zones.

Response: The reviewer is correct. We originally defined four climatic phases (pre-LGM, LGM, last deglaciation, Holocene) based on broad glacial-interglacial transitions. However, the statistical zonation (CONISS) yielded five pollen/dinocyst zones, with the deglaciation subdivided into two sub-phases (17.0–14.5 ka and 14.5–11.7 ka). To resolve this inconsistency, we now explicitly state that the five statistical zones are grouped into four climatic phases in the revised manuscript (Section 5.2) (lines 419-428).

Lines 418–419; Line 499 – Only four phases are discussed. There appears to be a missing interval between 14.5 ka and 11.7 ka, which encompasses two well-known climatic phases: the Bølling–Allerød interstadial and the Younger Dryas.

Response: We thank the referee for raising this important point. We agree that the deglacial interval (17.0–11.7 ka) contains several well-known millennial-scale climate events. The Heinrich Stadial 1 (H1, 17.0–14.5 ka) is clearly expressed and has been discussed in our record, as evidenced by low SST, high $\delta^{18}O$, elevated herb pollen percentages, and high charcoal concentrations (Fig. 6). However, the Bølling-Allerød (B-A, 14.5–12.9 ka) and Younger Dryas (YD, 12.9–11.7 ka) are not clearly resolved in our proxies. Instead, our record shows a progressive trend toward warmer, wetter, and more forested conditions from 14.5 ka onward, without distinct reversals or plateaus. To make it clearer, we added a simple discussion in the revised manuscript (lines 499-501).

Furthermore, the age range assigned to the LGM should be consistent with that given

in the Introduction (26.5–19 ka); here, it is reported as 27.3–17.0 ka.

The time interval attributed to H1 (17–14.5 ka) is also inconsistent with established definitions of Heinrich Event 1 (17.5–14.5 ka; Broecker and Alley, 2006) and Heinrich Stadial 1 (18–15.6 ka; Sánchez Goñi and Harrison, 2010). In addition, the chronology of the yellow band in Figure 6 does not correspond to HS1.

Response: We thank the reviewer for this comment. The timing of both the LGM and Heinrich Stadial 1 (H1) is known to vary regionally due to differences in local forcing mechanisms, ocean-atmosphere interactions, and chronological uncertainties (Clark et al., 2009; Denton et al., 2006; Sánchez Goñi and Harrison, 2010). Global definitions represent broad averages, while individual proxy records commonly exhibit diachronous expressions of these events.

In the northern South China Sea, our multi-proxy record shows that the full glacial regime extends from 27.3 ka to 17.0 ka and the cold-dry interval associated with H1 spans 17.0 ka to 14.5 ka. Both intervals fall within or are consistent with the range of published chronology and with other marine records from the western Pacific marginal seas reflecting regionally sustained glacial conditions modulated by local oceanographic feedback (e.g., shelf exposure, winter monsoon intensification, and Kuroshio variability) (Sun et al., 2000a; Wang et al., 2009; Xu et al., 2013).

To avoid confusion, we have explicitly stated in the revised manuscript (lines 421-428 in Section 5.2 and lines 495-497 in Section 5.3) that these intervals represent the regional expressions of these events in the northern SCS.

Minor comments

Line 61 – Replace “South China Sea” with “SCS.”

Response: Done. We have checked and replaced “South China Sea” with “SCS” throughout the manuscript after the first full mention in line 31.

Lines 119–120 – Please clarify the statement: “The vegetation types occurring in southeast and southern China, as well as Taiwan Island, are the main pollen sources

of the northern SCS (Dai and Weng, 2011; Sun et al., 1999).” Is there a river mouth near the core location? Information about the main rivers influencing the site should be moved from the “Sedimentation rates” section to the “Vegetation” section.

Response: Thank you for this helpful suggestion. We have moved the information about riverine influence to the Vegetation section as requested. Specifically, we have:

(1) Deleted the original Section 2.4 (Sedimentation rates) and merged its relevant content into Section 2.3 (Vegetation).

(2) Added a clear statement that the Pearl River, located northeast of the core site, represents a particularly important pathway for transporting terrestrial palynomorphs (including pollen, spores and charcoal) from the adjacent continents to the deep basin (lines 117-126).

Line 231; Figure 2 – Replace “isotopes of” with “from.”

Response: Done.

Lines 420–423 – The terms “cooler and drier” and “higher productivity and sedimentation rates” should be specified relative to a clearly defined reference interval, which is currently lacking.

Response: We have added explicit reference intervals in the revised manuscript (lines 419-428) as:”The relatively cooler and drier glacial regime during 32.8-27.3 ka was defined as pre-LGM. The climatic condition became more pronounced during 27.3-17.0 ka, which was characterized by markedly higher sedimentation rates (Fig. 3a), cooler SST (by ca. 3.3°C on average, Figs. 6c and 6d), higher primary productivity (Figs. 6e and 6h), reduced humidity (Figs. 6f, 6j, 6l and 6m), a landscape dominated by herbaceous vegetation (Fig. 6j), and strengthened fire activity (Fig. 6k). We refer this interval to the LGM representing the regional expression of glacial conditions in the northern SCS, which is longer than the globally defined LGM (26.5-19.0 ka) (Clark et al., 2009), but consistent with other marine records from the western Pacific marginal seas (Sun et al., 2000a; Wang et al., 2009).”

Lines 438–439 – Please add an appropriate reference.

Response: We have added a reference in the revised manuscript (lines 449, 861-862): Zanzarini, V., Andersen, A. N., and Fidelis, A.: Flammability in tropical savannas: Variation among growth forms and seasons in Cerrado. Biotropica, 54(4), 979-987, doi: 10.1111/btp.13121, 2022.

We sincerely thank the reviewer again for the detailed and constructive review which has helped us to significantly improve the clarity and scientific rigor of our manuscript.