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Interactive comment on "A 22 570 yr record of vegetational and climatic change from Wenhai Lake in the Hengduan Mountains biodiversity hotspot, Yunnan, Southwest China" *by* Y. F. Yao et al.

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(1) Comments from Referee #2 General Comments The authors present results of a pollen core dating back to at least 20,000bp. I would congratulate the authors for their growing body of work in the region. The data they collect will surely be an important contribution to scientific discussion in the region. However, a major goal of the manuscript is to make inferences on past climate, based on their palynological findings. Regrettably, I found this aspect of the paper questionable, and generally poorly argued. The authors climate inferences are restricted to "cold", "warm", "humid", and

"dry", terms which are so open to personal interpretation that they are more likely to serve as a source of confusion than clarity. There seems to be no attempt to place these relative terms in context. For example, climatic inferences are not discussed in relation to well known climatic phenomena, such as the LGM, or even modern climate. Furthermore, climate inferences are based on few indicator taxa with questionable indicator value. The authors also do not adequately describe how modern vegetation and climate varies along mountain slopes, making at least this reader suspect the adequacy of the authors' ecological understanding of vegetation change along elevation gradients, and thus the ability to make climate inferences based on the vertical migrations of taxa on mountain slopes as determined by the pollen record. In general, while I deeply encourage the author's to get this information published, I cannot say that in its current form, the manuscript possesses the quantitative rigor that readers of BG might have come to expect.

Specific Comments Line 21-26 - Climate at _22,000 BP is initially inferred to be cool, presumably based on the dominance of broad-leaved taxa, and dry, based on the presence of Artemisia. At _20,000 BP, again based on the dominance of similar broad-leaved taxa, climate is inferred to be warm , and, (presumably) based on the presence of aquatic taxa, humid. I found the apparent capacity for broad-leaved taxa to indicate both cool and warm climates confusing and unrealistic. line 27 - Again, while the dominance of broad-leaved taxa is initially associated with cold conditions (line 21-23), in this line the dominance of broad-leaved taxa is associated to warm climate. In the methods section (line 110), broad-leaved taxa are described to "cloak" mountain sides at higher elevations, suggesting that dominance of broad-leaved taxa indicates cooler temperature. Thus, the author's climate inference does not seem to be consistent with their own descriptions of vegetation zonation along the elevation gradient. It also seems opposite to the expectation that conifers dominate at higher altitudes than broad-leaved trees. I'm a bit confused. line 32 - The term "coupled" suggests that broad-leaved and needle-leaved taxa coexist together rather than alternate in dominance with changing climate conditions, which seems to be the idea the authors are trying to indicate. line 35 - The strength of conviction the authors relate here concerning indications of human disturbance does not match the rather tentative mood in the discussion. line 38 - Based on the figure provided, I cannot visualize the marked decline in Quercus pollen in the first 30cm of the core. Rather, I see a trending decline in Quercus that began much earlier (around 60cm, or arguably around 230cm when Pinus becomes dominant). One interesting aspect of the first 30cm I do see is that the nearly perfect negative correlation between Pinus and Quercus seems to break down. The dramatic decrease in Pinus beginning around 20cm is not matched by an expected (based on the rest of the profile) increase in Quercus. At any rate, I think that if the authors wish to base arguments of human impact on the vegetation then these specific aspect of the profile should be made more visually apparent to the readers so that we are able assess the statements independently. line 52-53 - My initial reading of this sentence had me wondering why comparison between sites was predicated on altitudinal zonation of vegetation, as any two sites could be compared in theory. Maybe changing the word "and" ("compare between sites and build up....") to "in order to" or something equivalent might help. line 97 - One of main objectives of the paper is make past climate inferences. The ability to make inferences on past climates from the vertical migration of taxa along mountain slopes, as evident from the palynological record, is ultimately based on our knowledge of how the present vegetation is distributed along the elevation gradient. That said, I think the authors must do a better job of describing how present day vegetation changes with vertical ascent on these mountains. First, besides one citation at the beginning of the paragraph I notice that there are virtually no citations, especially to the botanical literature where vegetation zonation is likely to be well described. Second, the authors only describe the gradient from 3,100, where the study site is located, to 4000 masl. Considering that vertical migration can be up or down, a characterization of the type of forests below the site location seems critical. Third, based on the portion of the elevation gradient that has been described by the authors, it is very difficult for the reader to understand the main trends that are evident. For example, the distinction between broad-leaved and needle-leaved compositions

seems to be critical to the climate inferences the authors make at later points, suggesting that broad-leaved and needle leaved forests dominate at different elevations, and by extension, different climates. However, this is not evident in their descriptions. For example, begining line 97, "The study area is located within a vegetation “sub-domain” characterized by Pinus yunnanensis Franch. forest and Picea-Abies forest typical of northwestern-central Yunnan (WGYV, 1987). The local vegetation displays a distinct vertical zonation. On the mountains surrounding Wenhai Lake (3,100–3,500 m), the vegetation is dominated by oaks (Quercus pannosa Hand.-Mazz) and pines." Then...at line 109 "At higher elevations, between 3,500 and 3,800 m, the Jade Dragon Snow Mountain is cloaked in evergreen broad-leaved forest consisting of Quercus pannosa and Cyclobalanopsis glauca (Thunb.) Oerst, together with coniferous trees such as Abies delaveyi Franch., Picea likiangensis (Franch.) E. Pritz and Larix potanini Batalin." Resuming, the authors have described a situation where at low and high elevations forests are dominated by oaks (broad-leaves) and conifers (needle leaves). The major distinction between broad and needle leaves does not seem to capture any vertical zonation of vegetation communities along the elevation gradient, at least as the authors have described it. This is important because the broad/needle distinction later serves as one the main arguments for inferring climate change. And lastly, based on my reading of the authors description, I’m led to believe that dominance of broad-leaved taxa indicates higher elevations and, by inference, colder climates. This is opposite to my own expectations of needle-leaved taxa dominating at higher elevations. line - 148 - 151 - Were the groupings determined by the tilia software based on the groupings of taxa, or the taxa themselves? line 168 - 172 - The grouping described here is later used as a basis to make climate inferences, thus it stands to reason that the groups should be based on their climatic tolerance. While in most circumstances I would generally agree that a distinction between broad and needle-leaved taxa is ecologically important, the authors have failed completely to articulate this (see previous commentary). Also, it is not clear what the author’s inclusion criteria for the "broad-leaved" category was. For example, the inclusion, of herbaceous taxa such as Cyperaceae seems without foundation. It is also not clear whether the "broad-leaved" category was restricted to Quercus, Alnus, Artemisia, Cyperaceae, Ericaceae and Polygonaceae, or also included other angiosperms (Meliaceae, Flacaourts, Rosaceae, Rutaceae, Salix, etc). Also, it is not clear what the author's inclusion criteria for the aquatic category was. Mainly, I ask why not all aquatics are included, such as pediastrum? Also, it seems that grouping should be exclusive, in the sense that one taxa should not appear in different groups that are used to infer climate. Cyperaceae, for example, is grouped into the broad-leaved group, as well as the hygrophilous group. line 188-190 - "A greater diversity of palynomorphs was recovered from the core samples than from the surface samples, which might suggest that surface samples fail to capture the local vegetation completely." This seems a bit of a strange thing to say for two reasons. First, the core reflects 20,000 years of historical plant migrations up and down the slope as well as from other regions, while surface samples reflect only the most modern vegetation community. It seems intuitive that species should accumulate in the pollen record with time, thus the author's conclusion that it is due to the possibility that surface samples don't capture local vegetation pattern seems baseless. Second, palynological inference is ultimately based on the ability of surface samples, which are later fossilized under anoxic conditions, to capture trends in local vegetation pattern. If the authors contest that palynological samples adequately reflect local vegetation then they seem to have eroded the logical basis for their study. line 195 - The presence of Palmae is interesting as it is a clear warm climate indicator. I didn't see it in the figure of pollen profile. Why not? line 280-288 - The discussion opens with a paragraph where the authors outline what they believe to be indicator taxa for temperature and moisture. Generally, I found the section to be unconvincing. I am wary of any climate inferences based on the author's data for the following reasons. 1) Temperature and moisture covary in complex ways along the elevation gradient. The authors provide no description of how climate variables vary on the modern elevation gradient, thus it is impossible for the reader to understand how it has changed relative to modern conditions. How does precipitation vary along the elevation gradient in the authors's region? What are

conditions in the lowlands? The relative terms such as warm, cold, humid, and dry, that the authors used to describe the climate are generally not useful. They are open to so much personal interpretation that these terms are more likely to confuse, rather than contribute to further scientific inquiry. 2) On a physiological level, all land plants are faced with the competing demands of taking up CO_2 from the atmosphere while limiting water loss, thus, the assumption that plant species move vertically to remain within either their temperature or moisture tolerance independently does not account for these coupled environmental constraints on growth and survival (Crimmins et al 2011). Because ambient temperature and moisture availability both influence plant water-energy balance, distributional shifts of plant species apparent from the pollen record may not be adequately explained by considering changes in past temperature or moisture in isolation. By extension, the idea that vertical migration of few taxa could indicate change in either one or the other climate variable seems naive based on our understanding of modern plant physiology. Climate inferences should generally be based on many indicator species, not one or two. 3) The indicator taxa probably do not account for the entire extent of climate change experienced at the site. For example, two conifers, Abies and Picea, and Betula are considered to be indicators of cold climates, while Pinus is considered to indicate warm climate. The degree of temperature variation examined by considering only these taxa is relatively small compared to the taxa that are present in the core, such as Palmae, Meliaceae, Flacourtiaceae, etc, etc. Furthermore, Abies (author's indicator of cold) and Pinus (author's indicator of warm) visually tend to show positive correlation throughout the core (see Tilia figure), suggesting an overlapping response to environmental changes and thus are not likely to be able to distinguish between colder and warmer climates. 4) It is not clear whether the authors use the term hygrophilous to indicate plants that grow in and around the damp substrates surrounding the lake, or to indicate plants that are ecologically restricted to climates with high precipitation and/or low precipitation seasonality. Thus, it is unclear whether the authors view these taxa as indicators of the conditions of the immediate lake environment or regional precipitation. It is confusing because the authors have focused, until now, on regional climate inferences. The distinction is important because changes in abundance of aquatics and semi-aquatic taxa (hygrophilous) are likely to reflect changing local site conditions, rather than changes in regional climate (Bush 2004 provide a good discussion on this). For example, most of the taxa that the authors have chosen are predominantly comprised of species of fast growing low shrubs or small emergent herbs that occur in high light environments, such as forest edges surrounding lakes, rather than the forest understories. Thus, their increase and decline probably reflects shifting local processes in the lake rather than large scale change in precipitation. These taxa could only be used as indicators of regional precipitation if a positive correlation between their abundance and regional precipitation is expected. However, I don't see this as a likely scenario, as shifting abundances of these moisture indicators might even produce patterns opposite to what one might expect. For example, if decreasing precipitation lowers average lake levels it can increase suitable colonization sites for emergent hygrophilous taxa, whereas deeper lake levels that flood these colonization sites in response to high precipitation may decrease suitable habitat. In these examples, the amount of pollen of hygrophilous taxa is negatively correlated to regional precipitation. Patterns of hygrophilous taxa will depend as much on local topography of the lake bottoms and the nature of water inputs and outputs from the lake as regional climate. The point, is that once the ecology of hygrophilous taxa is taken into consideration, it is arguable that they are not likely to be good indicators of regional moisture. 5) The authors provide minimal support from the literature or distributional data that support the relevance of thier chosen indicator taxa to climate inference. Many taxa, such as Cyperaceae, Polygonaceae, and Poaceae are extremely diverse taxa and show high degrees of ecological differentiation. Artemisia, a taxa the authors suggest is an indicator for dry environments, for example, has been shown to have wide ecological amplitudes in nearby regions that limit its use for climate inference (Subally & Quezal 2002). Based on these observations, I am wary of the climate inferences the authors provide. line 292 - 295 - I fail to understand how, based on fossil pollen, the authors know that certain taxa occurred around the vicinity

of the lake and other taxa occurred at higher elevations. While pollen can certainly be transported downslope, it seems impossible to establish which pollen grains were produced at higher elevations and which were produced in situ, as least with the level of confidence that the authors suggest. line 296 - While I would generally agree that the herbs are probably growing in forest edge conditions around the lake, the authors contention that Artemisa, previously indicated as a taxa indicating dry environments, should prefer the wet conditions around the lake seems inconsistent. There seems to be some inconsistency in the environmental conditions that taxa indicate. Two other examples became apparent to me as well. 1) Cyperaceae is considered a broad-leave taxa, which the authors use to make inferences concerning temperature, as well as an indicator of moist conditions. 2) Polygonaceae is an indicator of moist conditions as well as human disturbance. Once again, the ecological diversity of these taxa likely make their utility in making good climate inference very difficult. line 299 - 300 - Cold and dry relative to what? How does this compare with other pollen studies and known climatic events (i.e. LGM). The authors do not provide a point of reference. The authors to not provide comparisons with other studies. The statement is thus not interpretable. Furthermore, it is not clear on what basis the authors have make their determination. What exactly makes the authors think this time period was cold and dry? line 301 - 307 - Again, warm and humid relative to what. This statement is not interpretable. Furthermore, it is not clear on what basis the authors have determined the climate to be warm and humid. I assume it is based on the increase in pollen of herbaceous and shrubby taxa that the authors have suggested as hygrophilous. See previous discussion on the ecology of these taxa. line 308 - 315 - On line 292 a dominance of broad-leaved taxa was associated with cold and dry conditions. Here, the decrease of broad-leaved taxa is associated with cold and dry conditions. I am thoroughly perplexed. line 331 - Again, cold humid and warm humid relative what? What indicates cold? What indicates warm?

(2) Author's response General Comments We accept the suggestions of Referee #2 and have made necessary corrections in the revised Ms. The major aim of the

manuscript is to make inferences on past climate based on principal palynomorphs from Wenhai Lake. Some indicator taxa may be questionable in indicator value like what Referee #2 said, but they have special ecological preferences in Southwest China. We have clarified in this regard and have given a detailed and clear statement on their climatic implication in the revised Ms. The climatic inferences have also been discussed in relation to the LGM and YD in the discussion section. Furthermore, we have adequately described how modern vegetation and climate varies along elevation gradients in the Jade Dragon Snow Mountain region.

Specific Comments Lines 21-26, 27: We agree with Referee #2 that it is impossible for broad-leaved taxa to indicate both cool and warm climates. It is really a bit confusing. Line 32: The term "coupled" suggests that broad-leaved and needle-leaved taxa coexist together. Line 35: We agree with Referee #2 that the strength of conviction concerning indications of human disturbance does not match the rather tentative mood in the discussion. Line 38: The marked decline in Quercus pollen in the first 30 cm of the core is compared with the early stage (around 60 cm). Line 52-53: We agree with Referee #2 that the word "in order to" is more suitable than “and”. Line 97: We agree with Referee # 2 that it is necessary to describe how the present day vegetation changes along the elevation gradients. Lines 148-151: The groupings were determined by the tilia software based on the groupings of taxa. Lines 168-172: The palynomorphs recovered from surface samples should be summed into trees and shrubs, herbs, pteridophytes, and aquatics, so that they are in agreement with the categories of palynomorphs from Wenhai core samples. The trees and shrubs include conifers and broad-leaved taxa (trees, shrubs). The aquatics comprise algae and Myriophyllum. Lines 188-190: We agree with Referee #2 that the palynological inference is based on the ability of surface samples. Line 195: Selected taxa with abundance of more than 1% in at least one sample were shown in Figure 2. However, Palmae pollen occurs in only three samples (with abundance of less than 1%), so we didn’t show it in the figure of pollen profile. Lines 280-288: We agree with Referee #2 that this section is unconvincing, because some taxa may be questionable in indicator value. More detailed information about the

indicator taxa is necessary. Lines 292 - 295: We agree with Referee #2 that it seems impossible to establish which pollen grains were produced at higher elevations and which were produced in situ. Line 296: It is true that the herbs are usually growing in forest edge conditions around the lake. Artemisia is taxon growing in temperate areas of mid to high latitudes of the Northern Hemisphere, in particular in arid or semi-arid environments (Valles and McArthur, 2001). The genus Artemisia is considered an indicator of steppe climate (Erdtman, 1952) and moderate precipitation (El-Moslimany, 1990). Cyperaceae is a cosmopolitan family, with many species commonly growing in wetlands and surrounding areas, adapted to an open and sunny condition. The high frequency of Cyperaceae pollen may indicate humid conditions (KIBCAS, 2003b; Sun et al. 2003). Most species of Polygonaceae family is in relation to moist conditions, but the occurrence of some species such as Rumex and Fagopyrum can be used as the indicator of human activity. Lines 299 - 300: The suggestions of Referee #2 are very good. We will provide comparisons with other studies and known climatic events. The genus Quercus is widely distributed in the fog zone (with higher humidity, at about 3,100 m) on the Jade Dragon Snow Mountain where it forms a montane needle- and broad-leaved mixed forest along with Tsuga and Picea. Betula is viewed as a cold- and drought-tolerant element. Based on the dominance of Quercus and Betula pollen, we may infer the climate condition was cold and dry followed by a cold and wet condition. Lines 301 - 307: Generally speaking, we can’t infer a warm and humid climate condition during this period, but we can infer a relatively cold and dry climate with several fluctuations in the humidity, based on a notable increase in Betula pollen and a dramatic decrease in Quercus pollen. Lines 308 - 315: The increase of Quercus pollen indicates a cold and wet condition, so the remarkable decrease of Quercus pollen together with Abies reaching its maximum extent during this period may reflect the climate changed to colder and drier compared to the last stage. Line 331: The statement of cold humid and warm humid possibly is not suitable. A significant decline of humidity from the early stage (early Holocene) to late stage (late Holocene) can be inferred based on the increase of Quercus pollen at the beginning and the decline after that.

(3) Author's changes in manuscript General Comments According to the suggestions of Referee #2, we have made a detailed statement on the climatic implication of major palynomorphs recovered from Wenhai Lake (Lines 434-469 in the revised Ms). The climatic inferences have been discussed in relation to the LGM and YD (Lines 471-645 in the revised Ms).How the modern vegetation and climate varies along elevation gradients in the Jade Dragon Snow Mountain region has been adequately described (Lines 141-151 in the revised Ms).

Specific Comments Lines 21-26, 27: Broad-leaved Quercus indicates cold and wet climate in the Jade Dragon Snow Mountain region. Broad-leaved Betula reflects cold and dry condition. We have made the necessary corrections (Lines 22-29 in the revised Ms). Line 32: We prefer to use the term "interspersed" instead of "coupled" (Line 50 in the revised Ms). Line 35: We have changed to "During this period, human activity likely increased in this region, with impacts on the vegetation which may be interpreted by the distinct decrease in Pinus and Quercus pollen and an increase in Polygonaceae pollen in the upper 30 cm of the core" (Lines 51-54 in the revised Ms). Line 38: The marked decline in Quercus pollen in the first 30 cm of the core is compared with the early stage (around 60 cm) (Lines 54-55 in the revised Ms). Line 52-53: We have changed the word "and" to "in order to" (Line 70 in the revised Ms). Line 97: The section of how the present day vegetation changes along the elevation gradients is described in lines 141-151 in the revised Ms. Lines 168-172: The palynomorphs recovered from surface samples were summed into trees and shrubs, herbs, pteridophytes, and aquatics (Lines 250-291 in the revised Ms). Lines 188-190: We have deleted "which might suggest that surface samples fail to capture the local vegetation completely" (Line 302 in the revised Ms). Line 195: Here we use a new figure 2 instead of the old one. In the new figure, all the palynomorphs were shown (Figure 2 in the revised Ms). Lines 280-288: The section of "Climatic implication of the principal palynomorphs from Wenhai Lake" was added to show the detailed information about the indicator taxa (Lines 434-469 in the revised Ms). Lines 292 - 295: We have changed to "the vegetation surrounding the lake catchment was dominated by broad-leaved forest (composed mainly of Quercus,

Betula and Castanopsis) and needle-leaved forest (mainly Pinus and Abies)." (Lines 475-477 in the revised Ms). Line 296: The herbaceous plants Artemisia, Labiatae, Compositae and Polygonaceae, and ferns Athyriaceae, Polypodiaceae, Gymnogrammaceae and Pteris, grew around the lake or under coniferous or broad-leaved trees (Lines 477-479 in the revised Ms). Lines 299 - 300, 301 - 307, 308 - 315, 331: The necessary corrections can be seen in the section "5.2 Vegetation and climate history at Wenhai" (Lines 471-645 in the revised Ms).

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