Clim. Past Discuss.,
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Climate of the Past
Discussions



# *Interactive comment on* "Middle Miocene climate of southwestern Anatolia from multiple botanical proxies" *by* Johannes M. Bouchal et al.

**Johannes M. Bouchal et al.**

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Referee comment 1: Bouchal et al. present a paleobotanic study from middle Miocene Anatolia using different approaches to reconstruct climate changes from existing data of the middle Miocene climate transition, ca. 15-13 Ma. The beauty of the study lies in the combination of three different reconstruction techniques, each with different underlying assumptions. The authors combine the results of two taxonomical approaches – one relying on the nearest-living-relative principle and the other on biogeography of floras - with leaf physiognomy, which does not rely on taxonomy. The authors conclude that the climate of middle Miocene Anatolia could not have been tropical but would have been fully humid warm temperate. This result is important in the discussion about global latitudinal temperature gradients. The study also reveals increase of herbal veg-



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etation in the mainly forested landscape of Anatolia during the global cooling after the mid-Miocene climate optimum. Moreover, the results of the study concerning vegetation structure are important in the discussion about the landscape of Anatolia in relation with fossil faunas. Thus, the paper presents an elegant study with interesting results for a wide research spectrum.

Author's response: Thank you very much.

Referee comment 2: I would like, however, to give some suggestions that may help reaching that broader audience. Primarily, the paper needs clear conclusions, which now are missing. I strongly urge the authors to provide them in a separate section.

Author's response: A concluding paragraph will be added in the revised manuscript.

Author's changes in manuscript: The following lines will be inserted in section "5. Conclusion" in Line 409.

5. Conclusion Here we used three proxies to infer climate, palaeoenvironments and biogeographic affinities of three middle Miocene floras of southwestern Anatolia. We showed that the palaeobotanical record resolves transitions from the warm MCO (16.8–14.7 Ma) into the MMCT (14.7–13.9 Ma), and a more pronounced cooling at 13.9–13.8 Ma, mainly expressed in the changing and fluctuating ratios between AP and NAP taxa. Using threshold percentages for main tree taxa, we further show that although NAP values significantly increased during the MMCT, AP taxa remained relatively abundant, signifying the coexistence of forested and open landscapes during this transition. In addition, the biogeographic analysis indicates mainly northern hemispheric biogeographic affinities of the middle Miocene flora of southwestern Anatolia and thus invalidates previous comparisons with tropical environments. Tropical climate conditions are also rejected by the Köppen signatures of the investigated floras and by the CLAMP analysis. Finally, the CLAMP data readily distinguish between strongly seasonal Cs and Cw and fully humid Cf climate types. More combined macrofossil and microfossil studies are needed for the Neogene of Turkey in order to establish a robust framework





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of terrestrial climate evolution in this important region.

Referee comment 3: Secondly, the explanation of the Köppen signatures unfortunately hides in the supplementary information. I suggest fitting S2 into a table in the main text.

Author's response: File S2 will be moved from the supplementary material to the main manuscript as Table 3.

Author's changes in manuscript: Table 3 and table caption will be included in the main text (see Figure 1 attached to this comment)

Table 3 captions: Description of Köppen-Geiger climate symbols and defining criteria (Kottek et al., 2006; Peel et al. 2007). MAP = mean annual precipitation, MAT = mean annual temperature, Thot = temperature of the hottest month, Tcold = temperature of the coldest month, Tmon10 = number of months where the temperature is above 10°C, Pdry = precipitation of the driest month, Psdry = precipitation of the driest month in summer, Pwdry = precipitation of the driest month in winter, Pswet = precipitation of the wettest month in summer, Pwwet = precipitation of the wettest month in winter, Pthreshold = varies according to the following rules (if 70% of MAP occurs in winter then Pthreshold = 2 x MAT, if 70% of MAP occurs in summer then Pthreshold = 2 x MAT + 28°, otherwise Pthreshold = 2 x MAT + 14). Summer (winter) is defined as the warmer (cooler) six months period of ONDJFM and AMJJAS.

Referee comment 4: Please, also summarize CLAMP protocols and leaf characteristics (lobbing and tooth form, leaf size, apex form, base form, length-to-width ratio and shape) instead of referring to the website, only.

Author's response: Additional text concerning this will be included in the final manuscript.

Author's changes in manuscript: The following lines concerning the CLAMP will be inserted in section "2.4 CLAMP", line 161.

2.4 CLAMP We inferred quantitative palaeoclimate parameters for the three Yatagan Basin floras using the Climate Leaf Analysis Multivariate Program (CLAMP) (Yang et al., 2011). CLAMP makes use of the relationship between leaf physiognomy of dicotyledonous flowering plants and climate and, hence, is a non-taxonomic approach to palaeoclimate inference (Spicer, 2008). CLAMP calibrates the numerical relations between leaf physiognomy of woody dicots and meteorological parameters in modern terrestrial environments. With this calibration, past climatic data can be determined from leaf fossil assemblages if the sampling of the fossil assemblage represents well the characteristics of the living source vegetation (http://clamp.ibcas.ac.cn). Modern and fossil leaf physiognomic data are positioned in multidimensional physiognomic space using canonical correspondence analysis (CANOCO; Ter Braak, 1986). CANOCO orders vegetation sites based on a set of attributes (leaf physiognomic characters). For modern sites, climate variables are known from long-term observations of climate stations or from high-resolution gridded climate data (New et al., 1999, 2002; Spicer et al., 2009). Vectors for each of the measured climate variables can be positioned in physiognomic space and calibrated. Palaeoclimate variables can then be quantified by scoring a fossil assemblage in the same manner as for the modern vegetation and positioning the fossil site in physiognomic space (http://clamp.ibcas.ac.cn). For the present study, 36 different leaf characters (including leaf shape and size, apex shape, base shape, and leaf margin characteristics) were scored for 61, 63, and 14 dicotyledonous leaf morphotypes from three localities, TÄśnaz, Eskihisar, and Salihpaşalar (see Supplementary Material S3 for scoring of morphotypes), following the CLAMP protocols (http://clamp.ibcas.ac.cn). At genus level, the floras of the Yatagan Basin show highest similarity with Eurasian extant woody angiosperms (Table 1), thus the PhysgAsia1 Calibration files dataset of CLAMP was used to position the fossil data.

Referee comment 5: I suggest plotting the CLAMP results of Tinaz and Eskihisar together in Figure 6. (The separate scores can be found in the supplementary material.)

Author's response: This will be done in the revised manuscript.

Author’s changes in manuscript: The following updated figure will be included in the final manuscript (see Figure 2 attached to this comment)

Referee comment 6: Please explain explicitly what you mean with the question marks to ‘marginal???’ (line 194) and ‘increased summer rainfall???’ (line 363).

Author’s response: These were old edits not removed before submission. We apologize for this.

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Table 3

| 1st | 2nd | 3rd | Description and criteria |
|---|---|---|---|
| **Descripton of Köppen-Geiger climate symbols and defining criteria** | | | |
| A | | | Equatorial / tropical ($T_{cold}$ ≥18°C) |
| | f | | Rainforest, fully humid ($P_{dry}$ ≥60mm) |
| | m | | Monsoonal (not Af & $P_{dry}$ ≥100-MAP/25) |
| | s | | Savannah with dry summer ($P_{sdry}$ <60 mm) |
| | w | | Savannah with dry winter($P_{wdry}$ <60 mm) |
| B | | | Arid (MAP <10 x $P_{threshold}$) |
| | W | | Desert (MAP <5 x $P_{threshold}$) |
| | S | | Steppe (MAP ≥5 x $P_{threshold}$) |
| | | h | Hot arid (MAT ≥18°C) |
| | | k | Cold arid (MAT <18°C) |
| C | | | Warm temperate/temperate ($T_{hot}$ >10°C & 0°C< $T_{cold}$ <18°C) |
| D | | | Snow / cold ($T_{hot}$ >10°C & $T_{cold}$ ≤0°C) |
| | s | | Summer dry ($P_{sdry}$ <40 & $P_{sdry}$ <$P_{wwet}$/3) |
| | w | | Winter dry ($P_{wdry}$ < $P_{swet}$/10) |
| | f | | Fully humid / without a dry season (not s or w) |
| | | a | Hot summer ($T_{hot}$ ≥22°C) |
| | | b | Warm summer (not a & 1≤ $T_{mon}$10 <4) |
| | | c | Cool / cold summer (not a or b & $T_{mon}$10 ≥4) |
| | | d | Extremely continental / very cold winter (not a or b & $T_{cold}$ <-38°C) |
| E | | | Polar ($T_{hot}$ <10°C) |
| | T | | Polar tundra ($T_{hot}$ ≤10°C) |

**Fig. 1.** Table 3 (former S3)



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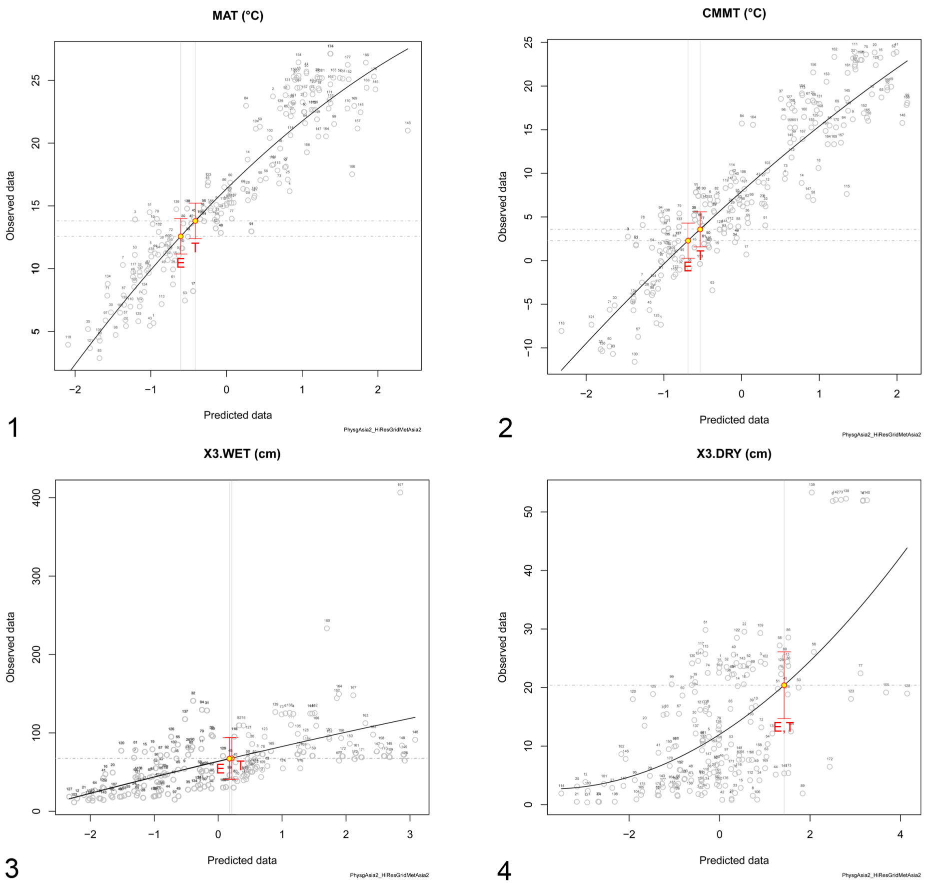


**Fig. 2.** updated Fig. 6