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Interactive comment on "Exploring a link between the Middle Eocene Climatic Optimum and Neotethys continental arc flare-up" *by* Annique van der Boon et al.

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We thank the two anonymous reviewers for their helpful comments on our manuscript, and provide a response to each of their comments below.

[Author reply to comment 1 of Reviewer 1]: The key point of our response to this comment is that there is no one single eruption around 40 Ma. This was perhaps not stated clearly enough in the manuscript, so we will rephrase this. We do not state that all these volcanic rocks have erupted in a single volcanic eruption as the reviewer seems to imply. Rather, we see a large increase in volcanic activity all around Iran in the middle Eocene, and this activity is observed in all different regions. Consequently, there

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must have been many volcanic eruptions that all together contributed to the thickness of (middle) Eocene volcanic units in Iran. We further emphasise that the thicknesses that we report are fully in line with the statement of Verdel et al. (2011): “Reported thicknesses of Paleogene volcanic and sedimentary rocks are âĹij3–9 km in the UrumiehâĂŘDokhtar belt (Figure 1) in central Iran and the Alborz Mountains in northern Iran [e.g., Förster et al., 1972; Annells et al., 1975; Hassanzadeh, 1993; Morley et al., 2009].” This is also clear from other literature on this topic. Berberian & King (1981) state that “Extensive volcanism, with a wide range of composition, started in the Eocene Period (50 Ma) and continued for the rest of the period with the climax in Middle Eocene time (about 47-42 Ma). Despite their great thickness (locally up to 6 and 12 km) and wide distribution, the volcanics and tuffs were formed within a relatively short time interval.” Stöcklin (1974) mentions Eocene volcanic rocks in the Alborz to have a thickness of 3-5 km. Allen et al. (2003) mention a thickness of 5 km for the Eocene Karaj Formation (which consists mostly of volcanic and volcaniclastic rocks) in the Alborz. Taking into account all these different estimates, we feel that the values of 3-9 km that we use in our calculations are reasonable and agree well with estimates from literature.

To clarify this issue in the text, we will add the above references to support the statement on the thickness of the volcanic deposits. Moreover, we will clarify that we do not intend to suggest that one eruption caused all these deposits but that they rather represent a phase of intensified volcanism.

[Author reply to comment 2 of Reviewer 1]: We fully agree with the reviewer that our estimates are likely underestimates. We deliberately chose a conservative approach. Therefore, we mention in line 139-140 that our assumption of a similar volume versus emission relationship as the Deccan traps results in a minimum estimate of CO2. We will put more emphasis on our estimates being minimum estimates, and the carbon contribution by Eocene volcanism in Iran could have been much larger (see also our response to the next comment).

We will add the following part to the discussion: "Erosion has affected the entire Iranian plateau, and could have eroded away significant volumes of Eocene volcanic rocks. Morley et al. (2009) and Ballato et al. (2011) note that clasts in the Lower and Upper Red formation (Oligocene-Miocene age), which in many places overlie Eocene volcanics, are for a large part made up of eroded Eocene volcanic rocks. Original thicknesses of Eocene volcanic rocks in Iran could thus have been larger, making our CO2 output estimate a minimum estimate."

[Author reply to comment 3 of Reviewer 1]: We agree with the reviewer that other volcanically active areas in the Tethyan region might have played a role during the MECO (Armenia, Georgia and Turkey) as we have mentioned in lines 46-48. In addition, we will add the following part to the discussion: "Our estimates of CO2 release due to middle Eocene volcanism in Iran are likely underestimates, as there is volcanism in other regions along the Neotethys subduction zone. Unfortunately, the lack of shapefiles of Eocene volcanic and intrusive rocks in Armenia and Azerbaijan, along the Lesser Caucasus Mountains (e.g. Allen and Armstrong, 2008), and plutons and volcanic rocks in Armenia (e.g. Moritz et al., 2016; Sahakyan et al., 2016), hampers calculations on additional CO2 emissions within these regions."

We have done a thorough literature study of other inferred causes of the MECO around the globe, such as increased mid-ocean ridge volcanism (Bohaty et al., 2009), increased metamorphic decarbonation associated with Himalayan uplift (Kerrick and Caldeira, 1999; Pearson, 2010), increased extrusive arc volcanism in the Pacific rim (Cambray and Cadet, 1996), increased carbonatite magmatism in the East African Rift (Bailey, 1992, 1993), or increased Cordilleran belt volcanism (Kerrick and Caldeira, 1998). However, we did not find confirming radiometric ages or other evidence that indicated that other regions showed a temporal link to the MECO event. We thus decided to focus on our own data, instead of discussing the absence of evidence from other regions.

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