Clim. Past Discuss.,
https://doi.org/10.5194/cp-2019-128-RC1, 2019

Climate of the Past
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Interactive comment on "The mechanism of sapropel formation in the Mediterranean Sea: Insight from long duration box-model experiments" *by* Jan Pieter Dirksen and Paul Th. Meijer

Anonymous Referee #1

Received and published: 21 November 2019

The authors explore key mechanisms of sapropel formation using a simplified transient model over a full precession cycle. This is the first time such an approach has been used and I find the results very interesting, notwithstanding model limitations and caveats. The study is thorough and nicely presented, and its findings will be of interest to those working on Mediterranean palaeoclimate. I was specifically asked to review the applicability of the work for future palaeo efforts in proxy-based studies, (in short: yes, it's applicable), but I also have some comments on the modelling and minor edits for the text.

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The study's applicability to future work is that it can help distinguish between the relative importance of different forcing mechanisms, and highlight where/how we could look for evidence of these processes. There are obviously many simplifications in the model (these are discussed), and these should be borne in mind when assessing the results. For instance, lack of seasonality and no separate boxes for the East and West basins (which each have different run-off, evaporation and ventilation regimes) means that the model could be missing important mechanisms for sapropel formation/preservation. The same goes for potential effects of meltwater pulses (from Atlantic and the EIS).I note (lines 233-235) the authors say that 'an arbitrary configuration (and number) of boxes' could be used, so why not use 6 boxes (Boxes 1-3 each for the east and west). The authors could also expound on the different DWF mechanisms (line 483), as these as significant for sapropel formation but they are not modelled here. Finally, in light of the limitations/caveats, I have an issue with the final 3 lines of the Conclusion - I don't think you can make such a strong conclusion about sapropel formation from this study.

However, on a positive note (and I do like this study), the strong agreement between the reference experiments and modern observations (eg deep water fluxes and O2 concentrations) suggests that the model is nonetheless capturing key processes for sapropel formation. The same goes for the agreement between geological proxy data and the modelled timing and duration of anoxia (and by inference, sapropel formation). I also like the investigation of switching the FW budget, both for the margins and open box, as it hints at what we could expect to see in the sediment record if such a switch occurred.

Model duration. The model is run over a full precession cycle, yet it is insolation – which includes an obliquity component – which seems to be the primary driver of long-term African monsoon variability over the Pio-Pleistocene. Modelling studies have demonstrated how obliquity forcing is significant for the African monsoon, and proxy data show the best match with local summer insolation and/or tropical insolation gradients (not all sapropels are associated with precession minima). I assume that going beyond one full

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precession cycle is beyond the scope of this study, and I appreciate that just to do one full precession cycle is an advance, but some comment on this is needed, especially as the authors state (line 117) that any sine wave could be used.

Lags/phasing. The study investigates the phase & duration of sapropels relative to precession as a function of the phase of evaporation, but I think it would be more useful to investigate sapropel timing/duration as a function of the phasing of run-off. The one study they cite re: variable phase of evaporation is for the Miocene, for which we have much less understanding about individual sapropels and their associated E-P, anoxia, etc. Yet many studies have shown links between the timing +/or intensity of palaeo-monsoons and ice-sheet & North Atlantic climate variability, and run-off appears to be the primary driver of sapropel formation.

Minor technical comments

Background: A map of the Med with its seas, basins etc may be useful for newcomers to the study of this region. The text mentions the Aegean, Levantine, Adriatic, etc Line 26 & throughout: 'relatively high latitude'. . .I think better to refer to the more northerly parts of the basin? I wouldn't say any of the basin is at a relatively 'high latitude. Line 36: West African summer monsoon (not East). Also some clarification here that the low density surface lid is not due to direct monsoon precipitation over the basin but via run-off Line 51: clarify sapropel mid-point Line 52: perform long runs Line 125: up to 8.8 times Line 145: an efficiency Line 237: Except for the lack of a flux Line 374: reaches Line 428: delete 'thousands' – the max midpoint phase is <1000. '. . .up to humdreds of years' would be more accurate. Line 458: as long as a sufficiently Line 471: as accurately as possible Line 514 influencing Line 550: deep eater in the open Line 551: by reversing the freshwater budget Line 556: of a hypothetical core Line 566: add Grimm et al 2015 Figures 3-6: a-e are not labelled Figures 7-8: font size too small; reorder 'left/right axis' in the caption (wrong way around). Figure A1: can't differentiate between blue & black lines

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