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A pause in the rise in upper ocean heat content: how unusual is it, and where does the heat go?

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Timeseries of upper ocean heat content (recently revised after several instrumental biases were discovered) display not only a substantial mean rise over the second half of the twentieth century, but also a pause in this rise over the past few years when upper ocean heat content (OHC) remained nearly constant [e.g.
, Levitus et al 2009].

This observation has raised two important questions: (1) can such a fluctuation in OHC be attributed to natural variability, as has been suggested, and (2) if the excess heat in the climate system due to greenhouse forcing did not get absorbed (partly) by the upper ocean in those recent years, then where did it go? Considering the large difference in heat capacity between the ocean and the atmosphere it a redistribution of the heat between these two components of the climate system seems unlikely. Alternatively, it has been suggested that the observed slow-down of the upper ocean warming may be explained by an additional increase in the deep OHC and/or an additional loss of heat at the top of the atmosphere.

In this study, we analyze the variability of upper OHC and its causes from a 17-member ensemble of climate model simulations. According to the model, a period of three or more years during which upper OHC remains nearly constant is not unusual (we found 20 occurrences in the 17 members between 1950 and 2000). For these cases without upper ocean warming, we construct a consistent heat budget of the various components of the climate system. We also address how subsampling in space and time affect the characteristics of OHC variability in the model ensemble as this is certainly an issue for the observational record,