within the glacial sequence, there were both cold and warm/humid intervals, which are commonly known as stadials and interstadials respectively. Likewise, in the interglacial sequences, e.g., in the Holocene, climate was warm during the medieval period but cold during the Little Ice Age, besides Younger Dryas and climatic optimum during the early Holocene[2,8].

The consequence of temperature changes over the temperate-polar regions of the North Atlantic has not only been noticed in the Arabian Sea, but also in different oceans, including the climate over Antarctica[9]. Some information is available with regard to the sub-orbital/millennial-scale variability in the climate inferred from the Arabian Sea sediments[10–13]. Though Das *et al.*[1] have cited some of these publications, they have ignored climatic oscillations at fine scales. In the light of current knowledge of climatic variability during the Quaternary mentioned above, Das *et al.*[1] have to reinterpret their results by identifying some of the sub-orbital climatic cycles and their significance for a better understanding of the monsoon fluctuations during the late Quaternary.

1. Das, S. S., Maurya, A. S., Pandey, A. C., Bhan, U. and Rai, A. K., *Curr. Sci.*, 2008, **95**, 1320–1326.
2. Bradley, R. S., *Paleoclimatology: Reconstructing Climates of the Quaternary*, Academic Press, San Diego, 1999.
3. Alley, R. B. and Clark, P. U., *Annu. Rev. Earth Planet. Sci.*, 1999, **27**, 149–182.
4. Broecker, W. S., *Nature*, 2002, **372**, 421–424.
5. Hemming, S. R., *Rev. Geophys.*, 2004, **42**, RG1005, DOI: 10.1029/2003RG-000128.
6. Schmittner, A., Galbraith, E. D., Hostetler, S. W., Pedersen, T. F. and Zhang, R., *Palaeoceanography*, 2007, **22**, PA3207, DOI: 10.1029/2006PA001384.
7. Sirocko, F., Garbe-Schonberg, D., McIntyre, A. and Molfino, B., *Science*, 1996, **272**, 526–529.
8. Mackenzie, F. T., *Our Changing Planet: An Introduction to Earth System Science and Global Environmental Change*, Prentice Hall, New Jersey, 1998, 2nd edn.
9. EPICA, *Nature*, 2006, **444**, 195–198.
10. Leuschner, D. C. and Sirocko, F., *Quat. Sci. Rev.*, 2000, **19**, 243–254.
11. Gupta, A. K., Anderson, D. M. and Overpeck, J. T., *Nature*, 2003, **421**, 354–357.
12. Altabet, M. A., Higginson, M. J. and Murray, D. W., *Nature*, 2002, **415**, 159–162.
13. Ivanochko, T. S., Ganeshram, R. S., Brummer, G.-J. A., Ganssen, G., Jung, S. J. A., Moreton, S. G. and Kroon, D., *Earth Planet. Sci. Lett.*, 2005, **235**, 302–314.

BUSNUR R. MANJUNATHA

Department of Marine Geology,
Mangalore University,
Mangalagangothri 574 199, India
e-mail: omsrbmanju@yahoo.com

Response:

We thank Manjunatha for his suggestions. The reply to his main concerns is given below:

The ratios of clay minerals, kaolinite/chlorite (K/C), kaolinite/illite (K/I) and kaolinite/palygorskite (K/P) considered indicative of humidity are used to discuss monsoonal variations during the late Quaternary. These indices clearly show characteristic monsoonal variations during the large glacial–interglacial cycles. The above ratios also showed few characteristic variations within a broad cycle. Some of them are correlated to the effect of stadial–interstadial cycles (within MIS 5) with support from the oxygen isotope data measured on foraminifers. A few more such peaks are shown by selective humidity index within other broad cycles. Such peaks are in part co-relatable to the stadial/interstadial cycles, but not well supported by all indices and/or by oxygen isotope data, and hence are not highlighted.

In the past, researchers have shown that the monsoon in the northwestern Arabian Sea was not only regulated by long-term glacial–interglacial cycles, but also by the short-term sub-orbital climatic cycles, such as Dansgaard–Oeschger cycles, Younger Dryas, etc.[1–4]. It has also been indicated that teleconnections between the subtropical monsoons and high-latitude climates exist during the last glaciation[5,6]. The Dansgaard–Oeschger events are globally synchronous[7] and occur quasi periodically, with the recurrence time[8] being a multiple of 1470 years. The transition from the last glacial period, which ended at around 16,000 years ago, to the present interglacial period, was punctured by a brief (approximately 1300 ± 70 yrs) and intense return to cold conditions[9] at ~11,000 yrs BP. This episode is now recognized as the Younger Dryas Event and is a prime example of dramatic and rapid climate oscillations. All these smaller-scale variabilities in climate are inferred based on high-resolution data analyses. The present study has been made on a relatively coarse sample interval. The age difference of two successive samples varies between 3000 and 4000 years or more. Moreover, the weathering mineral assemblages and erosional products may not respond immediately and directly to the climatic changes[10]. Sample data of very high resolution are needed to interpret the effect of climatic variability at sub-orbital scales, which is beyond the scope of the present work. However, the suggestions are encouraging to search for such climatic variability based on sub-orbital scale using clay mineralogy as proxy.

1. Leuschner, D. C. and Sirocko, F., *Quat. Sci. Rev.*, 2000, **19**, 243–254.
2. Altabet, M. A., Higginson, M. J. and Murray, D. W., *Nature*, 2002, **415**, 159–162.
3. Ivanochko, T. S., Ganeshram, R. S., Brummer, G.-J. A., Ganssen, G., Jung, S. J. A., Moreton, S. G. and Kroon, D., *Earth Planet. Sci. Lett.*, 2005, **235**, 302–314.
4. Anderson, D. M. and Prell, W. L., *Paleaoceanography*, 1993, **8**, 193–208.
5. Gupta, A. K., Anderson, D. M. and Overpeck, J. T., *Nature*, 2003, **421**, 354–357.
6. Sirocko, F., Garbe-Schonberg, D., McIntyre, A. and Molfino, B., *Science*, 1996, **272**, 526–529.
7. Voelker, A. H. L., *Quat. Sci. Rev.*, 2002, **21**, 1185–1212.
8. Rahmstorf, S., *Geophys. Res. Lett.*, 2003, **30**, 1510.
9. Berger, W. H., *Global Planet. Change*, 1990, **3**, 219–237.
10. Krissek, L. A. and Clemens, S. C., Proc. ODP, Sci. Res., Leg 117, 1991, pp. 197–213.

S. S. DAS[1,*]
A. S. MAURYA[1]
A. C. PANDEY[2]
UDAY BHAN[1]
A. K. RAI[1]

[1]*Department of Earth and Planetary Sciences,*
Nehru Science Centre, and
[2]*Department of Physics,*
University of Allahabad,
Allahabad 211 002, India
**e-mail: siddharthasankar_das@yahoo.co.in*