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From seasonal to orbital, the response of an idealised double hemisphere basin to variable buoyancy forcing

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The response of an idealised double hemisphere ocean basin to variable buoyancy forcing is examined. A general circulation model that employs a Gent-McWilliams mixing parameterisation is forced by a zonally constant restoring surface temperature profile, which varies with latitude and time over a period P. The set-up is such that the northern hemisphere always produces the densest waters. Two sets of experiments are conducted: set A where the forcings in either hemisphere have no lag and set B where the forcings have a lag of half a period. In each experiment, 17 different values of P are studied, ranging from 6 months to 32,000 years. The model's meridional overturning circulation (MOC) exhibits a very strong response on all timescales in both hemispheres, up to and including the longest forcing timescales examined for either set of experiments with the amplitude of the oscillations reaching up to 140% of the steady-state maximum MOC and exhibiting resonance-like behaviour, with a maximum at centennial to millennial forcing periods. This resonance like behaviour is identical to what has been observed in a single hemisphere and occurs for the same reasons. What is novel is that for set B, the amplitude of the response is substantially greater for large forcing periods (millennial and above), particularly in the subordinate (southern) hemisphere. This happens because for set B, the basin has in effect two sources of deep water. This leads to colder bottom waters and thus greater stratification, which in turn stabilises the water column and thus reduces the value of the minimum overturning. These results have some interesting palaeo implications and suggest an explanation for the half precessional time scale observed in the deep ocean temperature record.