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Did the Messinian Salinity Crisis affect global climate?

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Mediterranean Outflow Water (MOW) is thought to be one of the drivers currently contributing to the pattern and vigour of thermohaline circulation in the North Atlantic. However, no consensus has yet been reached over how MOW interacts with North Atlantic Deep Water formation and there is disagreement, even, over the direction of spread of MOW in the Atlantic today.

We examine the impact of MOW during the Messinian Salinity Crisis (6-5 Ma, approx.), when progressive tectonic activity dramatically modified the salinity and volume of MOW entering the North Atlantic. By combining the use of modelling and proxy data, we can determine the extent to which salinity and volumetric changes in MOW impacted Atlantic thermohaline circulation and global climate during the Messinian Salinity Crisis. Thus, our work achieves the dual target of assessing model sensitivity to changes in palaeo-circulations and improving our understanding of the climate system. To do this, we performed GCM simulations to determine:
1) The effect of gateway representation and model resolution on the spread of MOW in the North Atlantic.
2) The effect of volumetric changes in MOW on North Atlantic overturning circulation and global climate.

We explored the effect of model gateway representation by running eight simulations, each lasting 500-2000 years, using HadCM3 and HadCM3L (the UK Met Office's fully coupled atmosphere-ocean GCM) with dye-tracers, in which we varied the model's palaeo-bathymetry in the region of Mediterranean-Atlantic exchange. We compare simulations run using a 'closed gateway', where exchange occurs through a 'pipe' in the model, to simulations that use different 'open gateway' configurations. We find that the effect of gateway representation on the spread of MOW in the Atlantic Ocean is highly model-resolution dependent. This is especially true with the 'open gateway' configurations, where we observed very different patterns of MOW-spread in the Atlantic from the HadCM3 simulations compared to the lower-resolution HadCM3L simulations. A synthesis of our results suggests that the most faithful model representation of Mediterranean-Atlantic exchange and the spread of MOW in the Atlantic Ocean is achieved using a 'pipe' configuration, rather than an 'open gateway'. We advise that for palaeo-modelling research, GCMs should use and alter a gateway 'pipe', rather than attempting to resolve changes in the palaeo-bathymetry.

To determine the impact of MOW on North Atlantic overturning circulation and global climate, we have run a further ten HadCM3 and HadCM3L simulations (500-2000 years long) with dye-tracers, in which we varied the volume of MOW. Our results do not support previous findings that 'intensification' of MOW caused North Atlantic overturning circulation to strengthen and warmed the North-Atlantic/Greenland region (Bigg & Wadley, 2001; Rahmstorf, 1998; Johnson, 1997). Instead, we find that increasing the volume of MOW weakens North Atlantic overturning, resulting in cooling over the Norwegian and Greenland Seas.