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Estimates of volume, heat and freshwater budgets for the Arctic Mediterranean and North Atlantic in relation to the main physical processes: Insight from the EU-NACLIM observations

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The EU NACLIM (North Atlantic Climate) project aims to understand the forcing of the North Atlantic circulation and its importance for the climate of northwestern Europe. NACLIM comprises extensive modelling studies of the atmosphere, ocean and climate, but here mainly the oceanographic observations are presented. The core observation areas are the North Atlantic Subpolar Gyre and the Greenland-Scotland Ridge, separating the North Atlantic from the Arctic Mediterranean Sea. These are the areas, where the waters of the lower limb of the Meridional Overturning Circulation (MOC) are formed and sink into the deep North Atlantic to return southward, mainly in the Deep Western Boundary Current (DWBC). The exchanges across the Greenland-Scotland Ridge, both the northward flowing Atlantic and the returning dense waters, have been monitored over decades, as have the circulation in the Subpolar gyre and the convection and mode water formation in the Labrador Sea. These studies are extended southward to the RAPID array located in the Subtropical gyre at 26oN to capture the MOC further south, and northward into the Arctic Mediterranean Sea and the formation area of the densest water in the DWBC. In the Subtropical gyre the ocean circulation is mainly forced by the wind, while in the Subpolar gyre the atmospheric influence, in addition to wind forcing, also has a large thermodynamic component, changing the characteristics of the water masses and the density structure of the gyre. The importance of cooling and freshwater input increases in the Arctic Mediterranean Sea. Variability and a recent declining trend of the MOC strength have been observed in the Subtropical gyre at the RAPID array. By contrast, both the northward flow across the Greenland-Scotland Ridge and the overflows have remained steady during the observation periods. An increased atmospheric freshwater flux does not appear to affect the dense water formation in the Arctic Mediterranean, mainly because the low salinity upper layer is separated from the cooling area in the Norwegian Sea and the Barents Sea. A warmer climate could reduce the cooling and the density increase in the Atlantic water, unless it is compensated by higher initial salinity of the northward flowing Atlantic water. Ice drifting over and melting on the warm, saline Atlantic water might, however, create an upper layer that prevents further cooling of the Atlantic core below. The sea ice extent and volume are presently declining and such sea ice flux is not expect to happen, The possibility is rather that not enough ice is available to create the low salinity upper layer in the Nansen Basin. Should this upper layer disappear, it could actually lead to more overflow water being produced. Almost all of the atmospheric freshwater that is added to the North Atlantic flow south in the lower limb of the MOC. This implies that the freshwater is eventually mixed into and contributes to the mode waters that are formed in the Labrador Sea and the Irminger Sea and flow south in the DWBC.