Workshop 4: Effects of climate change on advective fluxes in high latitude regions

Background

Advective fluxes are very important in high latitude regions. In the Arctic, relatively warm subarctic waters reach into the Arctic Ocean transporting large quantities of heat. In the Atlantic sector, these northward flowing warm waters maintain an ice-free region in the southwestern Barents Sea during winter and higher temperatures well beyond its latitudinal average. They also allow boreal fauna and flora to flourish well beyond their typical northern limit, for example zooplankton species such as *Calanus finmarchicus* or fish such as cod, haddock or herring. Warm Atlantic waters also reach into the Arctic Basin through Fram Strait. As their density exceeds that of the surface Arctic waters there, they sink and flow into the Arctic Ocean as a subsurface current. In the Pacific, relatively warm subarctic waters flow through Bering Strait contributing to the heat content of the western Arctic Ocean. Significant quantities of freshwater are also carried northward and eventually into the Arctic by strong subarctic boundary currents such as the Norwegian Coastal Current and the Alaska Coastal Current. The outflow of cold, relatively fresh waters from the Arctic has an equally important role on the subarctic region. This includes the southern outflow through Fram Strait that is the origin of the East Greenland Current and the flows through the Arctic Archipelago that continue southward to the Labrador and beyond. The variability in these fluxes can generate strong effects such as the recent contribution to the large scale melting of the sea ice in the Arctic due to the heat carried through the Bering Strait or the flux of large amounts of freshwater from the Arctic into more southern regions along the eastern coast of North America.

In the Antarctic, the Antarctic Circumpolar Current (ACC) connects the major basins of the world's ocean generating some of the strongest current flows found anywhere on the planet. Circumpolar Deep Water (CDW) flows southward around the Southern Ocean, bringing warm, saline and high nutrient waters that upwell around the southern boundary of the ACC. These waters spread east and north in the ACC across the Southern Ocean to generate the high macronutrient concentrations that underpin production across the region. In turn, these waters spread out of the Southern Ocean affecting global patterns of nutrients and production. The upwelling of CDW also affects shelf waters and can change patterns of circulation, sea-ice distribution, biogeochemistry and plankton dynamics. Across the ACC, advection moves nutrients and biological material, underpinning the structure and function of regional and local food webs. In the Atlantic region, Antarctic krill (*Euphausia superba*) are moved northwards in association with colder waters from the south into areas on the edge of the ACC where their populations are not self-sustaining. In these areas krill are the major item in the diet of many land-based predators that congregate to breed each summer; so the biological advective fluxes are crucial. Such advective processes are also increasingly being recognized as important in maintaining population connectivity of a wide range of other species of zooplankton and fish throughout the Southern Ocean. These advective connections show marked interannual variability, associated with large scale variations in ocean and sea ice conditions. The rapid regional warming being observed in some areas, such as around the Antarctic Peninsula, is changing ecosystem structure and may also affect advective fluxes that underpin the ecological connectivity of ecosystems over a wide area of the Southern Ocean.