Dissertations

Atlantic Water in the Nordic Seas – properties, variability, climatic significance

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Post-doctoral (habilitation) thesis in the Earth Sciences.

In 2009 the Institute of Oceanology PAN (IO PAN) published a monograph by Waldemar Walczowski entitled 'Atlantic Water in the Nordic Seas – properties, variability and climatic significance'. This unique, 241-page long monograph (in Polish) describes the dynamics and transformation of Atlantic waters (AW) penetrating the cold seas of the European Arctic and supplying heat to the waters of the Arctic Ocean. The monograph was Dr Walczowski's post-doctoral thesis and was the basis for awarding him his second Ph. D. degree (habilitation) in 2010.

Let me first say a few words about the author of this monograph. Waldemar Walczowski was born in 1956. In 1980, he obtained his master's degree in Oceanography at the Faculty of Biology, Geography and Oceanography of the University of Gdańsk. He began his professional researches in oceanography at the Institute of Oceanology PAN in 1988. In the first years of his scientific career he worked on problems involving the hydrology of the Baltic Sea, but since 1993 his main field of interest has been the study of the dynamic processes of the transport and transformation of waters in the Nordic Seas. In 1993 Dr Walczowski became head of the Marine Hydrology Laboratory in the Department of Marine Dynamics at IO PAN, and in 2007 he took charge of the Ocean Circulation Laboratory in the same department. He wrote his Ph. D. thesis ('The transfrontal exchange of the mass and heat in the Arctic Front region') under the supervision of

Professor Jan Piechura and was awarded his doctorate in the Earth Sciences by the Scientific Council of IO PAN on 18 June 1998.

The post-doctoral thesis is an exceptionally valuable piece of work. This is because the level of knowledge of the transfer and exchange of mass and energy in the Nordic Seas is still far from satisfactory from the point of view of the needs of the numerical methods applied in the forecasting of climate changes in the Arctic with different time projections. The monograph was based mainly on a 15-year set of empirical data, regularly gathered each year in the study area in the West Spitsbergen Current region of the North Atlantic. This is the region where the most intensive transport of warmer AW to the cold regions of the Arctic takes place; it therefore plays a crucial part in the interaction between the ocean and the atmosphere. It is in this region that the 'deep convection' of AW takes place, which maintains the macroscale thermohaline circulation of the world ocean that warms or cools the lower layers of the atmosphere.

With several years' data from regular, annual records of the physical properties of AW in the same areas and seasons of the year at his disposal, Dr Walczowski was able to produce a synthesis presenting the influence of the dynamics and transformation of AW on the warming of the Nordic Seas and the Arctic Ocean. The full analysis of this dataset enabled him to obtain results, a spectacular example of which is graph No. 5.10 on page 107, illustrating the changes in temperature and salinity from 1996 to 2008, averaged over the whole vertical section of the flow field along latitude 76°30′N. This graph is highly instructive: the quasi-cyclic changes in temperature and salinity characterising the transport of heat carried by AW to the Arctic Seas always begin at a higher thermal level. The statistical mean of these changes provides incontrovertible evidence that AW is transporting more and more heat over a longer period of time to the areas of 'deep convection'.

The monograph consists of nine chapters discussing the identification of AW transport pathways, the mixing processes of these waters, and the transfer of the heat they carry. In the first group of original research results, the main processes of heat penetration from AW through the Fram Strait to the Arctic Ocean are discussed, and the pathways along which mass and heat are transported through the Nordic Seas are described. In the second group of problems, the main conclusion is that the scale of variability of the physical properties of AW is greater in the northern than in the southern areas of replenishment, and that the seven-year average exhibits a linear fall in temperature and salinity with increasing latitude. On the other hand, the temporal variability in the properties of AW entering the Nordic Sea area is due mainly to the variability in meteorological and hydrological conditions.

The results of this research show that in 2004–2006 there was a sudden rise in the temperature and heat content of AW, which in 2000–2003 had been much cooler. In 2004–2006 an intensive northward expansion of AW took place, leading to a change in the ocean climate in the Fram Strait region. In 2005–2006 large, mesoscale eddies appeared in the western branch of the study area, which played a substantial part in warming up the fjords of western Spitsbergen and in the transport of heat to the Arctic Ocean. The origin of these eddies is unknown, but the author's earlier studies, described in his Ph. D. thesis, indicate that mesoscale eddies are the result of frontolysis; it may be that the conservatism of eddies originating from the dissipation of some part of the Arctic Front is the reason for their appearance in the investigated regions of the Atlantic.

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