Available online at www.sciencedirect.com
ScienceDirect
Progress in Oceanography 73 (2007) 203–209
Progress in Oceanography
www.elsevier.com/locate/pocean

Changing freshwater content: Insights from the subpolar North Atlantic and new oceanographic challenges

Igor Yashayaev *

Ocean Circulation Section, Ocean Sciences Division, Bedford Institute of Oceanography, Fisheries and Oceans Canada, 1 Challenger Drive, P.O. Box 1006, Dartmouth, NS, Canada B2Y 4A2

Received 8 April 2007; received in revised form 17 April 2007; accepted 17 April 2007
Available online 4 May 2007

Abstract

Observations and analyses of oceanic inventories of heat and freshwater have recently provided convincing evidence of systematic global-scale changes. Some recent studies aimed at observing, modelling and understanding these changes are collected together in this special issue of Progress in Oceanography. This introductory article provides some background on the procedures used to define these changes and their importance to climate change, with special reference to the North Atlantic basin. In particular, we show that significant changes in the properties and distributions of the major intermediate and deep water masses occurred in the North Atlantic's subpolar gyre between the 1960s and 1990s. These changes are described using volumetric temperature-salinity censuses and other analyses based on compilations of observations from the warm salty 1964–1972 period and the cold fresh 1995–1997 period. This article and the others in this special issue are intended to provide an overview of recent advances in our knowledge of large-scale heat and freshwater changes in the ocean with the hope that some of the open questions will inspire future work.

Keywords: Hydrologic cycle; Freshwater budget; Subpolar North Atlantic; Climate variability; Labrador Sea Water; Denmark Strait Overflow; Northeast Atlantic Deep Water; Decadal change

1. Introduction

The global ocean is the largest planetary reservoir of freshwater and heat. While its salt content is approximately conserved, it is actively engaged in the meridional redistribution of heat and freshwater, moderating the Earth's climate and maintaining the planetary freshwater balance. Indeed, the net poleward atmospheric moisture flux is largely compensated by the net oceanic freshwater transport. Linkages between salinity variations and major components of the planetary climate system are insightful for understanding and predicting possible climate change. The rates of ocean mixing and water mass production are to some degree controlled by salinity stratification (via density stratification); on the other hand, such processes, as deep convection remove freshwater from the upper layer and spread it over a broader depth range, in their turn changing salinity and density stratification. This, in fact, may turn out to be the most vital feedback controlling not only

* Tel.: +1 902 426 2558; fax: +1 902 426 3711.
E-mail address: yashayaevi@mar.dfo-mpo.gc.ca

0079-6611/$ - see front matter Crown Copyright © 2007 Published by Elsevier Ltd. All rights reserved.
doi:10.1016/j.pocean.2007.04.014

water mass renewal and deep ocean ventilation, but meridional overturning circulation and, consequently, the global ocean conveyor (Haupt and Seidov, present issue).

Recent reports showing radical salinity changes over the Atlantic Ocean have provoked interest in ocean climate not only within research groups but also in the general public. Sustained wide-spread freshening since the 1970s in the deep subpolar basins (Dickson et al., 2002) stimulated discussions on magnitudes, sources, dynamics and consequences of this notable change in the ocean fresh water storage. Long-term salinity changes measured over the entire Atlantic domain produced a spatial pattern that looked quite intriguing – systematic freshening in both subpolar regions was opposed by increasing salinity in the upper waters of the tropics and subtropics (Curry et al., 2003). Such a tendency observed at the lower latitudes (which was also reported for other oceans worldwide) can be associated with increased evaporation from an anomalously warm sea surface – an anticipated footprint of global warming.

The unprecedented change in the freshwater content of the subpolar North Atlantic has been accompanied by a change in vertical stratification and density distribution. The diagrams shown in Figs. 2 and 3 and discussed below are symbolic – they had provoked the special session at the 2003 Fall AGU meeting which in turn led to this issue of Progress in Oceanography.

2. The subpolar North Atlantic experience

Although these observed salinity changes in the Atlantic Ocean imply an intensified hydrologic cycle, the recent literature suggests other contributing oceanic processes. These processes capable of adding, removing

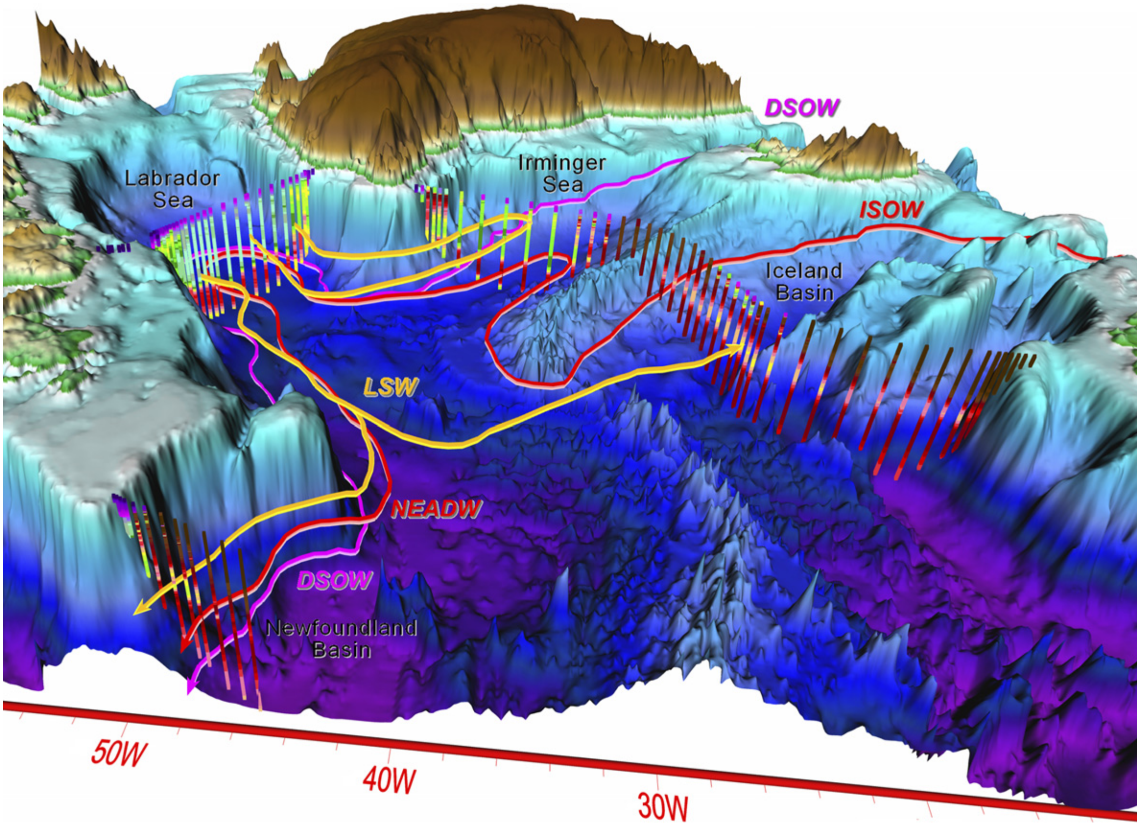

Fig. 1. The subpolar North Atlantic and the spreading pathways of its three major intermediate and deep water masses. LSW indicates the Labrador Sea Water produced in the Labrador Sea by deep winter convection, DSOW denotes the deep-basin coldest Denmark Strait Overflow Water and NEADW indicates the Northeast Atlantic Deep Water that originates from the Iceland–Scotland Overflow Water (ISOW) and is more saline than the other two waters. The 1994 AR7 hydrographic profiles (from Canadian and German oceanographic missions) are vertical lines colored by measured salinity (*low-to-high: magenta–blue–green–yellow–red–ruby*).