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The Indian Ocean HydroBase: A high-quality climatological dataset for the Indian Ocean

Taiyo Kobayashi [a,*], Toshio Suga [a,b]

[a] *Institute of Observational Research for Global Change, Japan Agency for Marine-Earth Science and Technology, 2-15, Natsushima-cho, Yokosuka-city Kanagawa 237-0061, Japan*
[b] *Department of Geophysics, Graduate School of Science, Tohoku University, Sendai, Japan*

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Abstract

The present study developed a high-quality climatological dataset for the Indian Ocean – the Indian Ocean HydroBase (IOHB) – from a combined dataset including the World Ocean Database 1998 version 2 (WOD98v2). Methods are similar to those used by previous studies for other oceans. Japanese data for the IOHB originated from the Japanese datasets MIRC (Marine Information Research Center) Ocean Dataset 2001 and Far Seas Collection; these datasets contain more Japanese observations than WOD98v2. Water mass properties in the IOHB climatology are consistent with previous studies. Seasonal patterns of properties near the sea surface are well reproduced, and deep-layer properties are consistent with the Reid-Mantyla climatology that is derived from high-quality observations. The isopycnal climatology of the IOHB differs from the World Ocean Atlas 2001 (WOA01) along the fronts associated with the Antarctic Circumpolar Current (ACC). The WOA01 shows a warm and saline intermediate water intrusion from South Africa to the east along the northern edge of the front. Such an intrusion is absent in IOHB where less saline intermediate water extends continuously northward from the southern ocean. The WOA01 shows a continuous belt of low potential vorticity along the ACC. This feature is less distinct in the IOHB climatology and in the Reid-Mantyla climatology. The IOHB consists of a $1° \times 1°$ gridded climatology and the datasets of raw and quality-controlled hydrographic stations. The latter is valuable for quality control of the Argo float salinity data as climatological reference. These datasets are available freely via the Internet.

Keywords: Indian Ocean; Climatological dataset; Water mass; Circulation; Quality control

* Corresponding author. Tel.: +81 46 867 9842; fax: +81 46 867 9835.
E-mail address: taiyok@jamstec.go.jp (T. Kobayashi).

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1. Introduction

Efforts to construct gridded climatological datasets from hydrographic data have been ongoing since 1980. Undoubtedly, the most famous climatological atlases are the series of World Ocean Atlases (WOAs; Levitus, 1982; National Oceanographic Data Center [NODC], 1994; Conkright et al., 1998; Conkright et al., 2002), which are produced from a huge number of historical data with objective interpolation on depth surfaces. They are widely used in climate and ocean modeling studies: as an "observed" ocean for comparison with model results and as restoring reference. Recently, a Special Analysis Center (SAC) in the World Ocean Circulation Experiment Hydrographic Program (WHP) produced another global ocean climatology (Gouretski & Jancke, 1998, 1999).

In addition to these global climatologies, "HydroBase" climatological datasets have been produced for the North Atlantic (Lozier, Owens, & Curry, 1995) and the North Pacific (Macdonald, Suga, & Curry, 2001). HydroBase climatologies have several advantages over the climatologies mentioned above. All hydrographic data are carefully quality checked by visual inspection at least once; visual checking screens suspicious data more strictly than automatic quality control procedures used in editing WOAs (e.g., Conkright et al., 2002) and SAC climatologies (e.g., Gouretski & Jancke, 1999). HydroBase climatologies are derived from averages along isopycnal surfaces. This averaging strategy precludes the formation of artificial water masses near frontal regions (Lozier et al., 1995; Macdonald et al., 2001). Note that the SAC climatology has also been constructed from averages along neutral surfaces. In addition to the gridded climatology the HydroBase includes the raw and quality-controlled station data. These are available for water mass analyses. Furthermore, custom-made gridded climatologies can be built from any subset of the station data with attached tools to produce, for example, a regional climatology on a mesh smaller than $1° \times 1°$. Curry, Dickson, and Yashayaev (2003) demonstrated sophisticated features of the HydroBase in an examination of the decadal-scale change in the freshwater balance of the Atlantic Ocean.

The present study describes a HydroBase climatology for the Indian Ocean: the Indian Ocean HydroBase (IOHB). The Indian Ocean is characterized by large seasonal variations driven by the monsoon winds (Schott & McCreary, 2001). Various researchers have also identified significant interannual variability in the Indian Ocean, such as Indian Ocean Dipole Mode (Saji, Goswami, Vinayachandran, & Yamagata, 1999; Webster, Moore, Loschnigg, & Leben, 1999). For the global thermohaline circulation, the Indian Ocean is a terminus for deep water (Mantyla & Reid, 1995), but also carries the return path of surface waters, part of the Warm Water Route (Gordon, 1986). The IOHB, with its gridded climatology and individual station data, is available for general ocean studies related to the above-mentioned features. Its quality-controlled salinity data enables a detailed examination of water masses such as Antarctic Intermediate Water (AAIW) and North Atlantic Deep Water (NADW). Also the seasonal and interannual changes of freshwater/salt budgets and associated transports and fluxes can be clarified by the IOHB more closely than the preceding study by Rao and Sivakumar (2003).

Many hydrographic variables are autonomously measured by profiling floats deployed in the world oceans under the Argo Project (The Argo Science Team, 2001). Because sensors drift in time it is important to evaluate the measurement quality in profiling float observations. Several such methods have been developed (Feng & Wijffels, 2001; Kobayashi et al., 2002; Wong, Johnson, & Owens, 2003), all using comparisons with local climatological datasets. The quality control depends crucially on a reference dataset (Kobayashi & Minato, 2005a) and float observations can therefore benefit from sophisticated datasets such as HydroBase. At present a reference dataset derived from the IOHB is used in the quality control operation of the Argo float data at the Japan Agency for Marine–Earth Science and Technology (JAMSTEC) from January 2005.

The purpose of this manuscript is twofold: to describe fundamental features of the IOHB, especially details in the quality control procedure and characteristics of the quality-controlled hydrographic data. And, to present climatological properties on isopycnal surfaces and to identify differences between the