

Ocean Heat and Freshwater Content Variability Estimates

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1. Abstract

This project supports the preparation of seasonal estimates of ocean heat content (OHC) and will lead to production of seasonal estimate for thermal expansion, and salinity anomalies. Such estimates are critical to understand earth’s climate system

2. Project Summary

The purpose of this project is to support the development and production of seasonal estimates of ocean heat content (OHC), salinity, and steric sea level every three months and make these estimates available online.

With prior NOAA funding the P.I. and his colleagues have pioneered in producing estimates of OHC for the post 1955 period. Numerous other groups are now studying OHC variability which is a key indicator of global warming since approximately 80% of the warming of earth’s climate system that has occurred in the past 50 years has occurred in the world ocean (Levitus *et al.*, 2001). The world ocean dominates earth’s heat budget.

Our previous estimates of OHC were produced for yearly time periods. With the acquisition of additional historical data to our archive and the advent of the Argo profiling float program we have begun producing seasonal (3-month) estimates of OHC and will extend our analysis to include similar estimates of the thermosteric component of sea level change. Thermal expansion (contraction) due to ocean warming (cooling) is an important term in the sea level budget of the world ocean and our papers on this subject have also stimulated a great deal of interest. We will also produce salinity anomalies for the Argo period (post-1994) on a seasonal basis. Our goal is to eventually extend our analyses to produce monthly analyses. These are not minor tasks

because both random and systematic errors with the data frequently arise. Resolving these quality control problems is a labor-intensive process.

The societal impact of our work is substantial. We have shown that it is the world ocean that dominates earth's heat budget. It is the amount of heat stored in the world ocean that will determine the response of earth's global average surface temperature to increasing carbon dioxide in earth's atmosphere.

The utility of our work is demonstrated by Table 1 which shows citations of our published papers. The Fourth IPCC Assessment has used our work on ocean heat content, salinity variability, and thermal expansion.

Table 1. Citation counts of papers relevant to this proposal.

| | Paper | # of Citations as of 01/21/10 |
|---|---|-------------------------------|
| 1 | Levitus, S., J. I. Antonov, T. P. Boyer, C. Stephens, 2000: Warming of the World Ocean. <i>Science</i> , 287, 2225-2229. | 436 |
| 2 | Levitus, S., J. Antonov, J. Wang, T. L. Delworth, K. W. Dixon, A. J. Broccoli, 2001: Anthropogenic warming of Earth's climate system. <i>Science</i> , 292, 267-270. | 207 |
| 3 | Levitus, S., J. I. Antonov, T. P. Boyer, 2005: Warming of the World Ocean, 1955-2003. <i>Geophys. Res. Lett.</i> , L02604, doi:10.1029/2004GL021592. | 253 |
| 4 | Antonov, J. I., S. Levitus, T. P. Boyer, 2002: Steric sea level variations during 1957-1994: Importance of salinity. <i>J. Geophys. Res.-Oceans</i> , 8013, doi:10.1029/2001JC000964. | 57 |
| 5 | Boyer, T.P., J. I. Antonov, S. Levitus, R. Locarnini, 2005: Linear trends of salinity for the world ocean, 1955-1998. <i>Geophys. Res. Lett.</i> , 32, L01604, doi:1029/2004GL021791. | 53 |
| 6 | Antonov, J. I., S. Levitus, T. P. Boyer, 2005: Thermosteric sea level rise, 1955-2003. <i>Geophys. Res. Lett.</i> , 32, L12602, doi:10.1029/2005GL023112. | 41 |

Figure 1 shows our latest ocean heat content results which are online at www.nodc.noaa.gov.

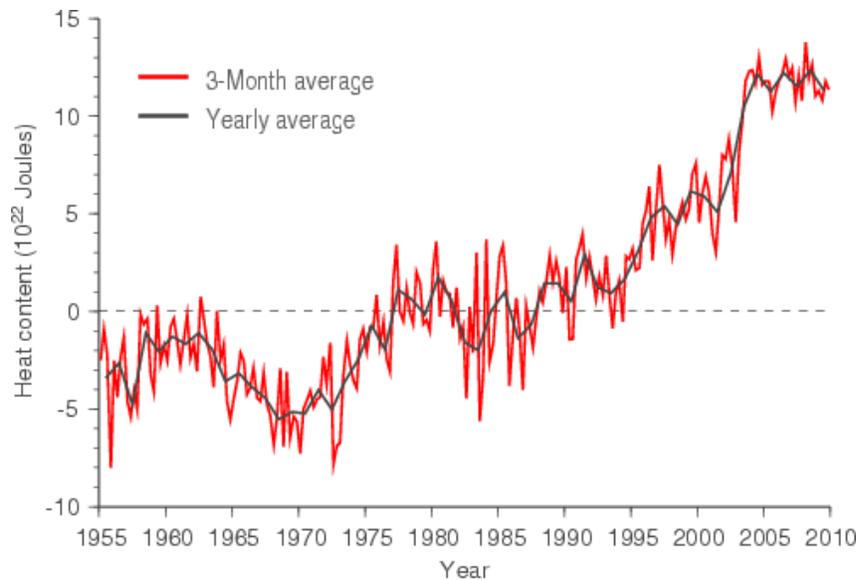


Fig. 1. Time series of seasonal and yearly Ocean heat content estimates through the end of 2009.

3. Scientific Accomplishments

This year we published (online) updated estimates of ocean heat content through 2009 for yearly and seasonal averaging periods.

(Levitus, S., J. I. Antonov, T. P. Boyer, H.E. Garcia, R.A. Locarnini, and A.V. Mishonov, H. E. Garcia, 2009: Global Ocean Heat Content 1955-2008 in light of recently revealed instrumentation problems. *Geophys. Res. Lett.*, 36, L07608, doi:10.1029/2008GL037155).

As a result of our work it is well-recognized that the world ocean plays a dominant role in earth's heat balance. The storage of heat in the ocean will be one of the main factors determining the response of earth's surface temperature (climate sensitivity). After a period of very a strong warming during 1993-2003 the ocean heat content in the 0-700 m layer has remained approximately constant. We will be updating our estimates through deeper depths to see if sub-700 m depths exhibit changing ocean heat content.

We now update the WOD every 3 months with newly acquired data and corrections to existing data.

A lack of funding prevents from acquiring even more additional historical and modern ocean profile and plankton data. We are aware of more data than we have time to process.

4. Education and Outreach

The P.I. and his colleagues are very active internationally in outreach efforts to acquire the oceanographic data needed by the ocean and climate research communities to study the role of the ocean as part of earth's climate system. In particular the P.I. is leader of the "Global

Oceanographic Data Archaeology and Rescue” and “World Ocean Database” projects for the Intergovernmental Oceanographic Commission.

The Ocean Climate Laboratory (OCL) responds to questions and c requests for information from the U.S. and international user community. OCL has hosted several undergraduate students as summer interns from the NOAA Educational Partnership Program (EPP) and Ernest F. Hollings (Hollings) scholarship program. These students typically get hands on experience using the NODC World Ocean Database and Atlas projects to examine various aspects of the earth’s climate system. OCL is expecting a new summer intern student in summer 2010 as part of the Hollings program. OCL also hosts temporary visits by US and international scientists to work with NODC staff on various aspects of database development. In addition, OCL initiated and hosts the “OneNOAA Science Discussion Seminar Series”. The OneNOAA Science Seminar Series is a joint effort by several seminar partners to pool seminars of common interest to help share science and management information and to promote constructive dialogue between scientists, educators, and resource managers.

5. Publications and Reports

5.1. Publications by Principal Investigators

Boyer, T. P., J. I. Antonov, O. K. Baranova, H. E. Garcia, D. R. Johnson, R. A. Locarnini, A. V. Mishonov, D. Seidov, I. V. Smolyar, M. M. Zweng, 2009: World Ocean Database 2009, Chapter 1: Introduction, NOAA Atlas NESDIS 66, Ed. S. Levitus, U.S. Gov. Printing Office, Wash., D.C. , 216 pp., DVD.

Levitus, S., Antonov, J. Wang, T. L. Delworth, K. W. Dixon, and A. J. Broccoli, 2001: Anthropogenic warming of earth's climate system. *Science*, 292, 267-270.

Levitus, S. *et al* (2009), Global ocean heat content 1955-2008 in light of recently revealed instrumentation problems. *Geophys. Res. Lett.* **36**, L07608, DOI: 10.1029/2008GL037155.

5.2. Other Relevant Publications

Peterson, T. C et al., 2009: State of the Climate in 2008. *Bull. Amer. Meteorol. Society*, 90, S13.