Data file:

The netCDF file ‘data_Purkey_Johnson_deep_heat_SLR.nc’ contains 8 three-dimensional data variables [longitude x latitude x depth] and 3 one-dimensional variables defining the axes of the data variables. The 8 data variables and the 3 axis variables are listed in the table below with units, dimensions, and a brief description of each. Please see the ‘Methods’ section below for an abbreviated description of how the fields in this file were calculated or see Purkey and Johnson (2010) for a full description of data collection, processing, and calculations.

Variable:	Units	Dim	Description
Longitude	Degrees of Longitude East-West	721x1	Degrees longitude run from 30 degrees E to 390 degrees E at half degree spacing.
Latitude	Degrees of Latitude North-South	361x1	Degrees latitude run from 90 degrees S to 90 degrees N at half degree spacing. Negative values indicate southern and positive northern hemispheres.
Depth	Meters	5x1	This is the ‘interface depth’ value as described below and in Purkey and Johnson (2010). Depths run from 2000 m to 6000 m at 1000 m intervals.
SLR	Millimeters per year	721x361x5	Mean rates of local sea level change over the area of each basin at the associated interface depth that result from the thermal expansion/contraction of water below that interface depth.
SLR_err	Millimeters per year	721x361x5	95% confidence limits associated with the mean values given in ‘SLR’. The means +/- these errors give the 95% confidence limits.
SLR_saf	Millimeters per year	721x361x5	Mean rates of local sea level change over the area at 1000 m south of the SubAntarctic Front (SAF) due to the thermal expansion/contraction of the water there between 1000 m and the associated interface depth.
SLR_saf_err	Millimeters per year	721x361x5	95% confidence limits associated with the mean values given in ‘SLR _saf’.
heat_flux	Watts per square meter	721x361x5	Mean local heat fluxes over the area of each basin at the associated interface depth required to account for the rate of warming/cooling of the water below that interface depth.
heat_flux_err	Watts per square meter	721x361x5	95% confidence limits associated with the mean values given in ‘heat_flux’.
heat_flux_saf	Watts per square meter	721x361x5	Mean heat fluxes over the area at 1000 m south of the SAF required to account for the warming/cooling of the water between 1000 m and the associated interface depth.
heat_flux_saf_err	Watts per square meter	721x361x5	95% confidence limits associated with the mean values given in ‘heat_flux_saf’.

Methods:

We divide the Global Ocean (excluding the Arctic Sea and some marginal seas) into 32 deep basins based on bottom topography and potential temperature. We estimate a rate of change in potential temperature with time (dθ/dt) at every depth for each basin using high-quality, full-depth, CTD data collected along oceanographic transect occupied two or more times between 1981 and 2010 either by the WOCE or the GOSHIP programs.

We use each dθ/dt to calculate a heat flux, Q, and Sea Level Rise (SLR) rate, F, below each of the five interface depths for each basin using:

$$Q_i = \frac{\int_{InterfaceDepth}^{bottom} \rho \cdot C_p \cdot d\theta/dt \cdot a\,dz}{a(InterfaceDepth)}, \quad F_i = \frac{\int_{InterfaceDepth}^{bottom} \alpha \cdot d\theta/dt \cdot a\,dz}{a(InterfaceDepth)}$$

where the density (ρ), heat capacity (C_p), and thermal expansion coefficient (α) are vertical profiles calculated from the mean climatological temperature, salinity and pressure data in each basin. Surface area (a) of each the basin is found at each depth. The integrals are summed from the bottom to the interface depth and then divided by the surface area at the interface depth to give a mean flux of heat (W m^{-2}) and mean rate of SLR (mm yr^{-1}) across the interface depth within that basin resulting from the volume-averaged rates of warming or cooling seen below the interface depth within that basin.

The 'heat_flux' and 'SLR' data matrices gives the value of the mean local heat flux value for each basin within the isobath of the interface depth for each basin. Outside of these regions values of 'NaN' are assigned. Deep basins without any data are assigned a heat flux and SLR rate of zero.

We define an additional basin in the Southern Ocean to study changes south of the SubAntarctic Front (SAF; as defined by Orsi et al. 1995) and calculate a vertical profile of dθ/dt using the available data in this region. The 'heat_flux_saf' and 'SLR_saf' values are calculated following the equations above except the integral runs from 1000 m to the interface depth and is divided by the area at 1000 m. Matrix values are assigned as described above but using the SAF instead of basin boundaries.

Each data matrix is associated with an error data matrix. The '*_err' matrices give the 95 percent confidence limits associated with each mean flux or SLR value given. To find the 95% confidence limits add/subtract the appropriate error matrix to/from the appropriate mean matrix.

The heat flux (or SLR) between 1000 m and the interface depth south of the SAF and below the interface depth globally can be added to give a total estimate of AABW's contribution to ocean warming following the arguments outlined in Purkey and Johnson (2010). However care must be taken to ensure that the same interface depth is used when adding these matrices. Also, NaNs must be considered carefully, because the values may be defined or missing in different areas.

Again, these are local basin-mean fluxes and SLR rates. For a full description of the data used, data processing and subsequent calculations (including global numbers) see Purkey and Johnson (2010).

Please contact purkeysg@u.washington.edu or gregory.c.johnson@noaa.gov with questions, comments, or suggestions. Also, if you use these data in a scientific study, we would appreciate receiving a brief e-mail from you about it.

References:

Orsi, A. H., T. Whitworth III, and W. D. Nowlin, Jr., 1995: On the meridional extent and fronts of the Antarctic Circumpolar Current. *Deep-Sea Res. I*, **42**, 641–673.

Purkey, S. G., and G. C. Johnson. 2010. Warming of global abyssal and deep Southern Ocean waters between the 1990s and 2000s: Contributions to global heat and sea level rise budgets. *J. Climate*, **23**, 6336-6351. doi:10.1175/2010JCLI3682.1.