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Sustained observations in the Weddell Sea spanning more than 20 years show gradual increase of the deep water heat content

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Beginning in 1989, Eberhard Fahrbach established and maintained until his premature death an observational programme in the Weddell Sea, which outstandingly contributed to alleviate the grave problem of undersampling of the Southern Ocean. Continuation of his legacy by the Alfred-Wegener-Institut has yielded a time series that now extends into 2013, hence covers almost 24 years.

Here we analyse this data set for long-term changes of the heat content in the deep Weddell Sea. We exclusively evaluate the calibrated temperature records obtained with ship-lowered CTD (conductivity-temperature-depth sonde) casts at repeated hydrographic stations and along repeated sections. Using this approach we avoid introducing potential temperature offsets that can result from combination of different measurement technologies and potential biases resultant from differences in geographic positions.

Our results show that the deep water masses below 700 m gradually warmed over the past two decades by 0.001 – 0.004 K a^{-1}. Superimposed inter-annual to multi-annual variations appear as largely uncorrelated horizontally across the Weddell Gyre. The long-term (21 – 24 years) trends of increasing temperatures in different depth layers below 700 m at all stations and sections can be approximated by linear regression that explains between 27 and 91 % of the variance, where the coefficients of correlation tend to increase with depth. No significant trends are found in the top 700 m.

The heating rate of the water masses below 700 m is estimated to 0.79 ± 0.14 W m^{-2}, which is more than twice as high as determined for the global deep ocean in general. Our results hence corroborate the view that Southern Ocean processes make an above-average contribution to the deep ocean warming, and so add to bring global estimates of the deep ocean heating rate and of the net energy flux into the Earth's climate system at the top of the atmosphere of 0.5 - 1 W m^{-2} closer in line with each other. Thus they help to resolve the problem of the 'missing heat' or 'missing energy', respectively, terms coined to grasp the observation that surface temperatures of planet Earth have stalled rising since about 15 years while radiation-affecting atmospheric CO_2 concentrations continued to increase. Our results support the finding that excess energy which results from changes in the Earth' radiation balance is transferred into heating of the deep ocean, where it does not contribute to an increase of surface temperatures but inevitably enhances thermosteric sea level rise.