South Adriatic Recipes: Estimating the Vertical Mixing in the Deep Pit

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The available historical oxygen data show that the deepest part of the South Adriatic Pit remains well-ventilated despite the winter convection reaching only the upper 700 m depth. Here, we show that the evolution of the vertical temperature structure in the deep South Adriatic Pit (dSAP) below the Otranto Strait sill depth (780 m) is described well by continuous diffusion, a continuous forcing by heat fluxes at the upper boundary (Otranto Strait sill depth) and an intermittent forcing by rare (several per decade) deep convective and gravity-current events. The analysis is based on two types of data: (i) 13-year observational data time series (2006–2019) at 750, 900, 1,000, and 1,200 m depths of the temperature from the E2M3A Observatory and (ii) 55 vertical profiles (1985–2019) in the dSAP. The analytical solution of the gravest mode of the heat equation compares well to the temperature profiles, and the numerical integration of the resulting forced heat equation compares favorably to the temporal evolution of the time-series data. The vertical mixing coefficient is obtained with three independent methods. The first is based on a best fit of the long-term evolution by the numerical diffusion-injection model to the 13-year temperature time series in the dSAP. The second is obtained by short-time (daily) turbulent fluctuations and a Prandtl mixing length approximation. The third is based on the zero and first modes of an Empirical Orthogonal Function (EOF) analysis of the time series between 2014 and 2019. All three methods are compared, and a diffusivity of approximately $\kappa = 5 \cdot 10^{-4} \text{m}^2 \text{s}^{-1}$ is obtained. The eigenmodes of the homogeneous heat equation subject to the present boundary conditions are sine functions. It is shown that the gravest mode typically explains 99.5% of the vertical temperature variability (the first three modes typically explain 99.85%) of the vertical temperature profiles at 1 m resolution. The longest time scale of the dissipative dynamics in the dSAP, associated with the gravest mode, is found to be approximately 5 years. The first mode of the EOF analysis (85%) represents constant heating over the entire depth, and the zero mode is close to the parabolic profile predicted by the heat equation for such forcing. It is shown that the temperature structure is governed by continuous warming at the sill depth and deep convection and gravity current events play less important roles. The simple model presented here allows evaluation of the response of the temperature in the dSAP to different forcings derived from climate change scenarios, as well as feedback on the dynamics in the Adriatic and the Mediterranean Sea.
