SENSITIVITY OF THE GULF STREAM MIXED-LAYER HEAT BUDGET TO ATMOSPHERIC FORCING IN AN EDDY-PERMITTING SIMULATION

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The distribution and variability of the upper heat content are key parameters since they impact the air-sea fluxes as well as the subsurface water masses properties via subduction. The respective roles of the different mechanisms that rule the mixed-layer (hereafter ML) heat budget, such as advection or vertical mixing, are not fully understood. Numerical modeling allows quantitative estimates of these terms but model errors, especially uncertainties in atmospheric forcing, are suspected to influence significantly these estimates. Here, we investigate the impact of two atmospheric products (ERA40 reanalysis and CORE product) on the temperature budget during the ML deepening season. We use the NEMO model in the 'NATL4' configuration (North Atlantic, 1/4°) from the DRAKKAR project. We focus on the Gulf Stream region over the period Sep 1994 – Mar 1995. This work complements a previous one on the model response to atmospheric perturbations (Lucas et al., 2008).

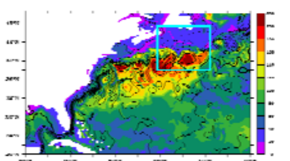

Fig. 1: ML depth (in m) and sea surface height (contours) on Jan 13rd 1995

The study is based on 3 simulations: the 'Reference' and 'CORE' runs start on Jan 1st 1987 from the same climatological conditions and are forced by ERA40 and CORE fields respectively. The 'Mixed' run starts on Sep 1st 1994 from the Reference run and is forced by CORE fields. We first analyze the ML temperature budget by averaging each term over the GS region (in blue on Fig 1). As expected, the ML temperature is mainly driven by the atmospheric heat fluxes. Horizontal advection has a significant impact: on average, the meridional component is cooling the ML while the zonal one is warming it. This antisymmetry is mainly due to the southward Ekman transport of cold slope water and to the eastward advection of warm waters by the GS. The spatial distribution evidences another mechanism: the effect of meanders that produce zonal and meridional advection terms of opposite signs. The third dominant term is the vertical diffusion. From November, this term warms the ML; this process is intensified just north of the main jet, in areas of shallow ML, where surface cold and fresh water masses overlay saltier and warmer ones.

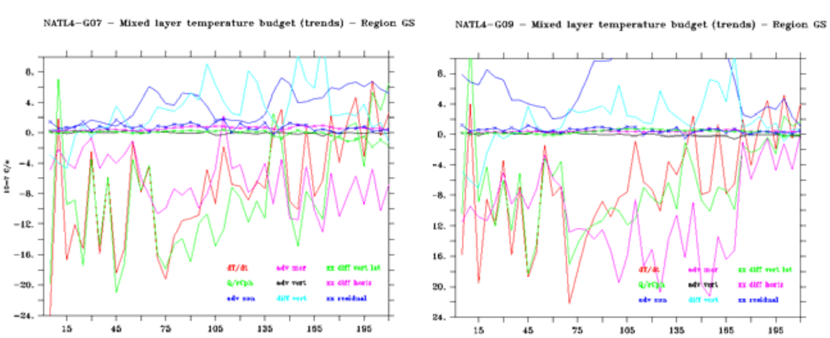

Fig. 2: Time variations of the ML heat budget terms averaged in the GS area for the Reference (left) and CORE (right) runs: temperature trend (red), atmospheric forcing (green), zonal advection (dark blue), meridional advection (magenta), vertical advection (black), vertical diffusion (light blue), vertical lateral diffusion (green + crosses), horizontal diffusion (magenta + crosses) and residual (blue + crosses). Units are °C.s^{-1}.

The CORE simulation exhibits a more intense and energetic Gulf Stream, leading to larger horizontal advection terms. The warming by the vertical diffusion term is smaller than in the Reference run. However the atmospheric cooling term in both runs is similar despite significant local differences in the turbulent components. As a result, the temperature trends in the 3 runs are not substantially different. Comparisons with the Mixed run corroborates the dominant role of the atmospheric fluxes with respect to the dynamics on the seasonal time scale.

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