wavelength$/2\pi$). The corresponding variability subspace is thus estimated for the domain of main interest (sampled region on Fig. 4). The details of the algorithm are in Section A.1. Briefly, the eigendecomposition of the variability covariance matrix of the observed variables (here T/S) is first specified based on the initial data (Section 3.1.1). The dominant covariance matrix of the complete PE variability is then estimated by cross-covariances (Section 3.1.2): the initial fields $\hat{\psi}_0$ are perturbed based on the dominant T/S variability and the corresponding flow variability is build using an ensemble of nonlinear adjustment PE integrations (Section 2.3). The resulting PE variability from $\hat{\psi}_0$ is decomposed by SVD and scaled for adequate initial error variances.

3.1.1. Dominant eigendecomposition of the three-dimensional tracer error covariance matrix

The initial tracer variability covariance function is assumed separable in the horizontal and vertical. The covariance matrix is then amenable to exact eigendecomposition using Kronecker product properties (Graham, 1981). In the horizontal, the correlation function used (Section 2.3) has isotropic decorrelation scales set to 25 km and zero-crossings to 50 km. The eigendecomposition is simply carried out. In the vertical, the decomposition of the covariance matrix is estimated from the EOFs of the differences between the profiles available on Sept. 15 (Fig. 4a) and the initial tracer fields.

Fig. 6 illustrates the results of the vertical multivariate EOF decomposition. The normalized cumulative variance and four dominant EOFs are shown. These four EOFs explain 81% of the variance of the data residuals from the initial tracers (Fig. 5). The first EOF (32% of the variance) is surface-intensified. It mainly represents the temperature variability within the surface thermocline. The non-dimensional S in that first EOF is 4 times smaller in amplitude, but extends deeper, than T and has a secondary maximum around 200–400 m, locations of the MLIW. The second EOF accounts for 30% of the variance. It is mainly a salinity EOF. The signature in S is also deeper than that in T of EOF 1. Since the MAW is almost always found above 200 m depth, this signature in S is mainly related to Tunisian shelf and Ionian waters found in the eastern and southern part of the domain (Fig. 5). Hence, EOFs 1 and 2 likely correspond to two different water masses. The EOF 3 (12% of the variance) represents thermocline and halocline variabilities. Both T and S are mid-depth intensified, with one significant zero-crossing. The amplitudes in the surface layers are vertically uniform and about three times smaller than the mid-depths maxima. The T peak is within 20 to 100 m (thermocline depths) while the S peak is within 70 to 400 m (mainly halocline depths). Comparing the non-dimensional amplitudes of T and S, that of S is twice as large. During the months considered, the salinity variability associated with the MLIW and with the Tunisian shelf and Ionian waters is important for determining the local halocline/thermocline depths. Finally, the fourth EOF explains 7% of the variance. It has a structure opposite to that of EOF 3. However, the T/S amplitude ratio of EOF 4 is larger than the S/T ratio of EOF 3. The EOF 4 could thus be mainly temperature-driven processes, with no physical relation to EOF 3.

Combining the vertical and horizontal (not shown) decompositions (Section A.1, Eqs. (A5), (A6), (A7), (A8), (A9), (A10) and (A11)), the dominant eigendecomposition of the