bounds. This is due to the different error weights, which during RR96 often yield to OI fields smoother than the ESSE ones. Outside of the assimilated data regions (Fig. 4b–c), the data corrections are advected downstream of the dominant features, e.g., along the AIS meanders and Ionian slope fronts. The Ionian slope region is in fact where the two fields differ the most. Since there is no in situ verification data at these locations, the SST image on Sept. 23 (Fig. 20c) is used for qualitative evaluations. Describing the estimates southward along the Ionian slope, the present estimate (Fig. 20a) is closer to the SST image than the OI one for each of the following features: the southward AIS meander off the coast of Calabria; the U-shaped pattern of warm Ionian water towards the eastern Sicilian coast; the 16E intrusion of Ionian water off Syracuse (36°N to 37°N); the adjacent MAW extrusion along the slope from 37°N to 35.3°N, suggesting an AIS bifurcation; the 25.5–26C, 70 km radius anticyclonic eddy centered around (35.7°N, 16.1°E); the two cold, 20 km radius mesoscale eddies at (35.2°N, 15.2°E) and (35.3°N, 16.5°E); and finally the IBV and its southwestward tongue entrained in the MCC.

The quantitative evaluation of the present field estimates is carried out using the in situ data. On average, within the new data regions (Fig. 4c–d), the level by level RMS of the forecast-data misfits at data-points give an ESSE forecast 10 to 20% better than the OI one, depending on the depth considered. Fig. 21 summarizes these results, plotting the Sept. 15–24 evolution of the surface-averaged (top 5 levels) data misfits at data-points. The OI is in red, the adaptive ESSE in blue. Both curves are the same up to Sept. 18. The measurement RMS error given by ESSE (Section 2.4.1) is shown in green, again on average for the top 5 levels: it increases for T, but decrease for S, in accord with the average variability tendencies (Panels a–b). All melded estimates have a RMS error below that measurement RMS error. Nonetheless, the present surface forecasts are on average about 20% better than the OI ones, even though the melded OI fields have smaller data misfits. For example, the Sept. 24 ESSE data-forecast misfit at data-points is for T, 21% better, and for S, 16% better, than the OI one. This is encouraging since the sampling of Sept. 24 (Fig. 4d) revisits the IBV domain already measured on Sept. 22 (Fig. 4c). The large temperature RMS error increase for both schemes on Sept. 24 is due to their slightly off-positioned forecasts of the IBV front. Considering salinities (Panel b), even though the OI/ESSE salinity RMS misfits decrease steadily, the salinity forecast errors grow rapidly. This may indicate that the estimation of the AXBT salinities (Section 2.3) could be improved. Finally, looking at the SST on Fig. 20c, the evaluation based on localized data (Fig. 4b–d) may underestimate the performance. The overall improvements could be higher than 20%.

4. Summary and conclusions

In the foregoing paper, the ESSE approach was applied in real-time for a period of ten days during the NATO operation RR96, considering mesoscale variability in the Strait of Sicily. Combining the intensive RR96 data survey with the primitive equation model of HOPS (e.g., Robinson, 1996), the estimation and study of the physical fields and their dominant variability and error covariances were carried out. The four-dimen-