sional adaptive estimation methodology was illustrated and evaluated. The corresponding technological achievements and scientific progress were presented and studied.

Technology-wise, this experiment and similar studies in several regions of the world's ocean (Robinson et al., 1998c) demonstrate that the ESSE system is a portable and comprehensive nonlinear assimilation scheme for realistic mesoscale to large-scale ocean studies, capable of providing real-time estimates of ocean fields and associated error and variability covariances. Presently, its main components involve the PE model of HOPS, the initialization and parallel ensemble forecast of the error subspace, the sequential assimilation, the dynamic measurement model, the adaptive learning of the dominant errors and the verification modules. The system confirmed that the dominant error eigenvalues have a decay faster than exponential and the ES convergence criterion employed showed that an ES dimension of order 300 sufficed for the considered RR96 experiment. The present nonlinear scheme is thus here about $299{,}052/300 \sim 10^3$ times cheaper than classic, full-covariance and linear methods (e.g., Robinson et al., 1998a). For identical computer power, such methods would need more than 8 years for the ten days of estimation. Yet, sensitivity studies on the size of the ES and improvements of the parallel forecast networking suggest that the present elapsed-time could be further reduced by half. Considering sub-optimal schemes for rapid operations, one could also keep the ES constant for some time, hence using a piece-wise stationary ES. Other simplifications only perturb regions in which future data are known to be gathered or use simple models for the error eigenvalue growth, keeping the eigenvectors fixed. Such considerations are first steps towards rapid, nested and multiscale assimilation systems in multiple regions.

The estimated fields were evaluated by intercomparisons with OI fields, clear SST images and available in situ data. Qualitative comparisons with the OI fields clearly showed the advantage of the present error weights (covariances) which are multivariate, multiscale, anisotropic and commonly non-uniform in space and time, in accord with the evolving data and dynamics. Quantitatively, the forecast-data misfits at the in situ observation points around the Ionian Shelf Break Vortex region implied that the present forecasts were, on average, 20% better than the OI ones. Qualitative comparisons with SST images over the complete model domain suggested much higher improvement factors. Note that the OI is nonetheless a robust scheme and a useful assimilation quality benchmark. It is cheaper than the present scheme by a factor approximately equal to the size of the ES divided by the number of CPUs used in parallel. In this study, 12 to 16 Sun Sparc 20 CPUs were employed, depending on availability. Improving the OI scheme from analyses of the present error weights is thus useful, especially for large-domain, rapid assimilations. In general, ESSE simulations can be used for comparison and refinement of cheaper assimilation techniques.

Several scientific results were also obtained. The dominant decomposition of the initial PE variability covariance matrix has determined several of the features associated with the dominant variability in the Strait of Sicily during August–September 1996. Five coupled features emerged: the Adventure Bank Vortex (ABV), the Maltese Channel Crest (MCC), the Ionian Shelf Break Vortex (IBV), the intermittent Strait of Messina Vortex (SMV) and the subbasin-scale temperature and salinity fronts of the Ionian slope and their corresponding wave patterns. The first three of these features were also