4.2 MERGING OF OBSERVATIONS AND MODELS

Ocean models have become increasingly useful as new processes have been incorporated and parameterized in formulations. Also, numerical techniques improved, and more powerful computing capabilities have allowed increased spatial and temporal resolution and range as well as greater numbers of variables and balance equations. As more data have been collected, analyzed, and interpreted, and as computer model simulations have demonstrated more realistic results, observationalists and modelers have become more cognizant of and dependent upon each other for making scientific advances. The culmination of this cultural change is epitomized by two methodologies: inverse methods and data assimilation. Here we briefly outline some of the salient features of these, especially in regard to time series observations of biogeochemical studies.

The "ocean circulation inverse problem" has been defined by Wunsch (1996) as a problem of inferring the ocean circulation, understanding it dynamically, and forecasting it by quantitatively combining theory and observations. He defines "inverse methods" as techniques used for solving problems or systems of equations that are mathematically underdetermined. Most physical, and certainly all interdisciplinary, oceanographic problems lie within this "underdetermined" category. Again, we are almost always seriously limited in our studies by undersampling and aliasing. Hence, there is growing interest in application of inverse methods to many oceanographic problems. Inverse methods are often used in the context of data assimilative models as well.

The term data assimilation is defined by and Hofmann and Friedrichs (2001) as "the systematic use of data to constrain a mathematical model." In reference to data assimilation, they comment that: 1) it is assumed that dynamics responsible for processes and distributions of properties are inherent in the data, 2) by inputting data into a specific model, the model will produce a more accurate model simulation, and 3) hindcasts, nowcasts, and forecasts are improved through data assimilation. We can consider data assimilation to broadly comprise parameter estimation and setting/resetting of state variables. A thorough mathematical formulation of the biological (and chemical) data assimilation problem is presented in Robinson and Lermusiaux (2002) and Matear (this volume) discusses data assimilation methods and biogeochemical signatures of climate change.

The application of data assimilation methods to interdisciplinary oceanographic problems is non-trivial (e.g., Robinson et al., 1998, and Friedrichs, 2001, 2002; Robinson and Lermusiaux, 2001, 2002; Dickey, 2002; Matear, this volume). In particular, broad ranges of time and space scales need resolution to depict relevant processes for interdisciplinary