example, remote sensing of many physical and biogeochemical variables is most attractive for reasons described earlier. Unfortunately, many of the more important biological and chemical variables cannot be measured from space, even at the surface at present, and cloudy conditions negate ocean color (and temperature) data retrievals sporadically and regionally. In addition, measurements and models of the ocean at depth are vital because of the considerable vertical structure and variability, which cannot be inferred directly from remote sensing. This point was illustrated with the eddy studies described earlier. Another methodological problem concerns sampling of episodic events, some of which may contribute substantially if not dominantly to variance in physical and biogeochemical properties. Fortunately, more platforms and sensors will likely be available in the future to provide for high temporal and spatial resolution data at representative ocean sites; data obtained from these locations will be valuable for data assimilation systems. Data assimilative modeling using data collected from all of the available platforms (Figures 4a and 13) will be needed to characterize, quantify, and model the processes depicted in Figures 1, 2, and 3

5. FINAL COMMENTS

This chapter has concentrated largely on recent progress in quantifying and understanding global biogeochemical variability on a broad range of time scales. However, it is useful to take a look back and to consider some of the outstanding issues for future research. Interestingly, prior to the JGOFS-era, several elements and processes were yet to be identified or, at minimum, demonstrated to be important for biogeochemical cycling. These include the microbial loop/food web (and many heretofore unknown or undescribed forms of plankton), plankton community size and trophic structure, predators such as zooplankton (some with important diel migration behaviors), dissolved organic matter and dissolved organic carbon cycling, N_2 fixation, trace element (e.g., iron) and multi-nutrient limitation, episodic events and mesoscale eddies as they may affect primary production and carbon flux to the deep sea, particle transport and remineralization in the "twilight zone" (100-1500m depths), and the non-Redfield ratio nature of the sea's elemental stoichiometry (these are all discussed in papers in this volume and in papers Oceanography, 14(4), and several JGOFS Deep-Sea Research II volumes). Many of these were discovered through the intensive regional process and time series studies described above, yet it must be admitted that much remains to be learned and quantification is essential. Besides the obvious lack of data, one of the problems has been that different methodologies,