biased performance through over-fitting. In principle, dynamic models should be responsive to changes in the background state (changes on decadal and longer timescales) because the physical laws and parameterizations are representative of the climate system and responsive to systematic forcing. The major negative attribute of dynamic models is the enormous infrastructure necessary to support such systems. More detail on the status of climate prediction techniques is given in the Appendix.

The performance of many coupled ocean-atmosphere climate models (where outputs were made available as research or experimental products) during the 1997–98 El Niño event has been assessed. Many were predicting during 1996 that warming of the central equatorial Pacific Ocean (i.e. an El Niño event) would take place during 1997. However, the strength of the evolution was handled well only after the event was under way.

Two examples of El Niño forecasts are given to indicate the level of skill achieved during the 1997–98 event. The forecasts are from full climate models, where an atmospheric general circulation model is coupled to a dynamical ocean general circulation model. The results represent the ability of climate models to simulate the changing sea surface temperature of the equatorial Pacific Ocean.

The National Centers for Environmental Prediction (NCEP) of the United States produce an ensemble of predictions for each month. Each prediction is for 11 months in advance. The "plume" diagrams in Figure III.1 represent the evolution of sea surface temperature from the ensembles for the NIÑO 3.4 region of the equatorial Pacific Ocean. Warming was predicted by the NCEP model from November 1996, although the magnitude was underestimated prior to April 1998. Forecasts were then excellent until May 1998.

The European Centre for Medium-range Weather Forecasting (ECMWF) has made available predictions for the NIÑO 3 region of the eastern equatorial Pacific Ocean. The ECMWF produces 13 ensemble members for each forecast of six months in advance and a sample is shown in Figure III.2. The ECMWF model identified modest warming in November 1996, but in February 1997 the model prediction was levelling off in May whereas the event continued to develop. The August 1997 prediction was too warm although the commencement of the anomaly decay in January 1998 was correct.

The skill of prediction is improving with the evolution of scientifically more complex and technically more advanced dynamic climate models. The evolution is carried forward both by the outcomes of scientific research and the development of more advanced computing platforms. Future analysis of the 1997–98 El Niño event is expected to contribute further to the development of predictive skill. As known processes are examined with new data and processes previously not recognized through lack of data are discovered, their place in the dynamics of the climate system will become established.

In addition to the skill of the sea surface temperature forecasts it will be necessary to verify how well the models predicted weather regimes around the globe. It is the characteristics of the weather regimes, including precipitation, temperature and winds, that determine the socio-economic impacts such as flooding, erosion, drought,

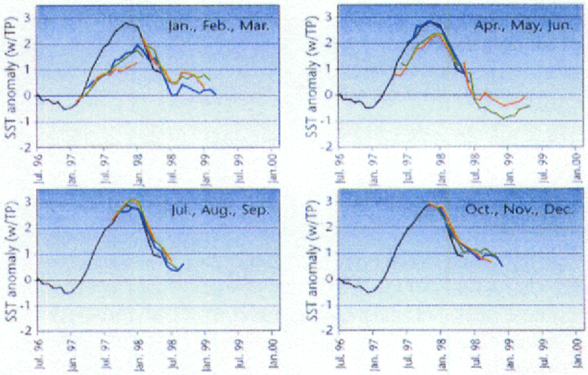

Figure III.1
Plume diagrams of the evolution of forecasts of sea surface temperature anomalies predicted by NOAA/NCEP in the equatorial Pacific region NIÑO 3.4 (long 170°W to 120°W, lat 5°N to 5°S). The black line is the observed anomaly and the coloured lines are the forecasts initiated in the months indicated in the upper right corner.
(Trenberth, 1998)

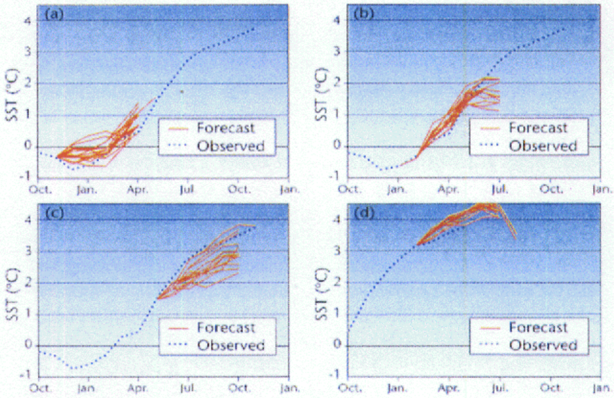

Figure III.2
Plume of sea surface temperature anomalies predicted by ECMWF for the eastern equatorial Pacific Ocean NIÑO 3 (long 150°W to 90°W, lat 5°N to 5°S). Forecasts were initiated in a) November 1996; b) February 1997; c) May 1997; and d) August 1997. The heavy line shows the observed values.
(Trenberth, 1998)