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Modes of Variability of the coupled atmosphere-ocean system: Redundancy analysis of global sea surface temperature and air pressure

F. Bakalian (1), H. Ritchie (1), K. R. Thompson (1), and W. J. Merryfield (2)

(1) Department of Oceanography, Dalhousie University, Halifax, Nova Scotia, Canada, (2) Canadian Centre for Climate Modelling and Analysis, Victoria, British Columbia, Canada (bakalian@phys.ocean.dal.ca)

In preparation for the development of a coupled atmosphere-ocean model and assimilation system for long-range forecasting, an exploratory statistical analysis of the covariance structure of joint atmosphere-ocean variables is performed on global scales. The ultimate goal is to better describe the background error covariance structure needed for the joint assimilation of atmosphere and ocean observations into the coupled system. Two main statistical tools have been used: Principal Component Analysis (PCA) and Redundancy Analysis (RA). The data sets are joint global fields of sea surface temperature and sea level pressure from (i) an NCEP reanalysis and (ii) coupled model output of the Canadian Centre for Climate Modeling and Analysis. Propagating components of the ENSO SST signal are identified in the global PCA of observations and model output and suggest a teleconnection between ENSO and the Arctic Oscillation. Time-lagged EOF analysis is most effective (i.e. the proportion of variance accounted for by the leading modes is maximized) when the global pressure leads the SST by about 1 month. The limitations of PCA in terms of identifying causal relationships is discussed and it is argued that more informative results may be obtained from RA. Several RAs are undertaken to explore the effect of sea surface temperature from specific geographic regions on the global atmospheric circulation and vice versa. It is shown that the Redundancy Index, a measure of the strength of the linear relationship between large-scale patterns in forcing and response, is particularly informative when calculated as a function of lag. The implications of these statistical relationships for

modeling of background error covariance, and ultimately prediction of the coupled atmosphere-ocean system using a data assimilative model, is discussed.