STUDIES IN REGIONAL CLIMATE SENSITIVITY,
PREDICTABILITY, AND TEMPORAL RESPONSE

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TECHNICAL PROGRESS REPORT

The main theme of this research project is to explore the behavior of a class of climate models by use of classical statistical estimation techniques and to examine the broader applicability of the techniques themselves. In particular, we study a class of energy balance climate models including a crude representation of the deep ocean and with stochastic forcing at the surface. These models include an explicit representation of the land-sea geography so that regional products are generated (although crude at best). We view the exercise as preliminary to the same techniques being applied to coupled ocean/atmosphere general circulation models and the solutions we generate can be thought of as benchmarks against which the more detailed simulations can be compared.

To date we have written five papers on this project (see appendix). In our first year we published a paper (Kim et al., 1992) describing the behavior of the coupled EBM under ramp-like increases in the radiative forcing (e.g., temporally exponential CO₂ increases). While crude these simulations do have some interesting properties. They are capable of reproducing the 0.5°C increase over the last century, projecting a 1.5°C increase in the next 50 years. The land leads the ocean surface in the warming. The mid-Asia versus mid-Pacific differential is as much as 0.15°C. This result is in good agreement with the coupled

ocean/atmosphere GCM runs reported by GFDL and Hamburg. At the same time we feel that our vertical adjustment process in the simple model is unrealistic and its study may help us in pinpointing how sensitive the transient problem is to the way the upper ocean is treated in all models.

We have also learned how to solve the above model with stochastic forcing (Kim and North, 1992). The model (with deep upwelling-diffusion ocean and land-sea geography) has been successfully tuned to fit the seasonal cycle (it fits better [nontrivially] than the old mixed-layer-only model) and the fluctuation properties of its surface temperature field have been compared to 40 years of data. The variance field and the spatial correlation properties are in good qualitative agreement with the data. Key to advancing the estimation problem is the enumeration of the frequency-dependent empirical orthogonal functions (fdEOFs) for these models (Kim and North, 1993). This is important since these functions form the natural basis set for many applications such as detection of signals embedded in natural variability (North and Kim, 1993; North et al., 1993). We have found (Kim and North, 1993) these fdEOFs for the noise forced model and have already applied them in the detection problem (North and Kim, 1993; North et al., 1993). In finding the fdEOFs we have been able to learn much about the difficulties in estimating these functions and their eigenvalues for finite records.

PLANS FOR THE COMING YEAR

We are continuing our exploration of the solutions of the simple models, but we realize the importance of this work lies more in the development of the statistical techniques. For this reason we are beginning to apply the technique to some long existing runs of GCMs. For example, we have obtained a 100 year run of the CCMO from Dr. Robert Chervin (NCAR) and are analyzing the fdEOFs for the model-produced surface temperature field. Dr. Klaus Hasselmann of the Max Planck Institute has just agreed to allow us to perform these analyses on his 100 year run of the Hamburg coupled ocean-atmosphere GCM. We will intercompare the estimation results based upon the simple and not-so-simple models to see about the sensitivity to the estimated fdEOFs. (We think the results will be insensitive). Besides these analysis problems we have some theoretical problems that need solving. These include the problem of regional prediction and predictability based on the optimal linear statistical prediction methods. Based on our work in related estimation problems we are certain that we will be able to exploit our fdEOF basis set in this application. One year from now we should have a good idea about this possibility.

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