albedo caused by excessive amounts of low cloud cover in the control simulation. Such an increase may provide a better overall representation of the present climate, but it has not been demonstrated that it will not also contribute to summertime overheating and drying of the continents. The model also does not yet treat meridional or vertical heat transport in the oceans and so may not adequately represent interannual variability or the effects of perturbed oceanic conditions.

The scope of the examination of the results of the various models for a doubling of CO_2 is also still limited. While reported results indicate that monthly average temperatures increase, there are not yet definitive indications of whether this means each hour of each day would warm an equal amount, whether daytime temperatures would stay about the same and nighttime temperatures increase sharply (or vice versa), or whether there would be fewer cool, cloudy days and more warm, clear days. With regard to investigation of potential increases in summer dryness, Manabe and Wetherald (*5*) are conducting a thorough analysis of the mechanisms by which this change occurs in their model. Reconciliation of their results with those of other investigators requires similar analyses by all the groups of questions concerning the seasonal water balance and how well it is being treated.

The CO_2 issue is of global importance and of high visibility. It is essential that scientists state clearly and in a forthright manner what we do and do not know so that efforts to assess and respond to the potential climatic changes are effective and soundly based.

MICHAEL C. MACCRACKEN
Lawrence Livermore National Laboratory, Livermore, CA 94550
MICHAEL E. SCHLESINGER
Oregon State University, Corvallis, OR 97331
MICHAEL R. RICHES
Carbon Dioxide Research Division, Department of Energy, Washington, DC 20545

REFERENCES AND NOTES

1. J. R. Trabalka, Ed., *Atmospheric Carbon Dioxide and the Global Carbon Cycle* (DOE/ER 0239, Department of Energy, Washington, DC, 1985); B. R. Strain and J. D. Cure, Eds., *Direct Effects of Increasing Carbon Dioxide* (DOE/ER 0238, Department of Energy, Washington, DC, 1985); M. C. MacCracken and F. M. Luther, Eds., *Detecting the Climatic Effects of Increasing Carbon Dioxide* (DOE/ER 0235, Department of Energy, Washington, DC, 1985).
2. M. C. MacCracken and F. M. Luther, Eds., *Projecting the Climatic Effects of Increasing Carbon Dioxide* (DOE/ER 0237, Department of Energy, Washington, DC, 1985).
3. M. E. Schlesinger and J. F. B. Mitchell, in (*2*), pp. 81–147.
4. S. Manabe, R. T. Wetherald, and R. J. Stouffer [*Clim. Change* **3**, 347 (1981)] and S. Manabe and R. T. Wetherald [*Adv. Geophys.* **28** (part A), 131 (1985)] describe the model of Manabe and Wetherald and related experiments done at the Geophysical Fluid Dynamics Laboratory; W. M. Washington and G. A. Meehl [*J. Geophys. Res.* **89**, 9475 (1984)] describe recent experiments with a model in use at the National Center for Atmospheric Research; J. E. Hansen *et al.* [in *Climate Processes and Climate Sensitivity*, J. E. Hansen and T. Takahashi, Eds. (Maurice Ewing Series No. 5, American Geophysical Union, Washington, DC, 1984), pp. 130–163] describe the model in use at the NASA Goddard Institute for Space Studies.
5. S. Manabe and R. T. Wetherald, in preparation.
6. Frederick M. Luther, Lawrence Livermore National Laboratory, who died on 13 September 1986, also contributed to this letter.

Response: We did not discuss the results from (*1*) because a detailed analysis of the surface water budget and its seasonal variation is not yet available from either study. Without this information, it is difficult to assess these studies in comparison with our own investigations. However, a brief mention of these works would have given the readers a better perspective.

We should have also mentioned the study of Mitchell and Lupton (*2*), who explored the same issue by a somewhat different approach. Their general circulation model has a high computational resolution and thus represents the field of precipitation better than the models presented in (*1*). In the control integration of Mitchell and Lupton, the observed distribution of sea surface temperature is prescribed. In the doubled CO_2 experiment, the change of sea surface temperature is determined in such a way that the ocean as a whole is in approximate thermal equilibrium. In qualitative agreement with our report and (*3, 4*), this study indicates a summer reduction of soil moisture over an extensive, mid-continental region of both the North American and Eurasian continents. More recently, Mitchell (*5*) performed a similar experiment by using a model with predicted cloud cover. He found that the summer reduction of soil moisture is further enhanced by the incorporation of the feedback process involving cloud cover and radiation, which is also in agreement with our results.

MacCracken *et al.* speculate that the absence of diurnal variation of insolation in our model may reduce the convective precipitation that supplies moisture to the continental surface. Because the total daily insolation is unaltered by this averaging process, it is not obvious that this reduction should occur. Also, MacCracken *et al.* are concerned that the solar constant of our present global model is artificially increased by 5% above the measured value. This artificial increase is counterbalanced by the bias of the model toward excessively low cloud cover. Accordingly, the solar radiation actually reaching the model surface is not excessive.

One should also note that our earlier model with a realistic solar constant and prescribed cloud cover (*3*) yields a summer reduction of soil moisture similar to that described in our report. More recently, we have constructed yet another model in which the oceanic heat flux at the bottom of the mixed layer is prescribed in such a way that the distribution of both sea surface temperature and sea ice are realistic in the control integration. This procedure (*6*) reduces the error of a climate sensitivity study attributable to an unrealistic simulation of sea surface temperatures. The results from this study also indicate a similar reduction of soil moisture during summer. In addition to these numerical investigations, we have made a major effort to elucidate the physical mechanisms responsible for this phenomenon on the basis of a detailed analysis of the surface water budget (*3, 7*). We look forward to comparing critically our results with those from the other studies when the surface water budgets in those experiments become available.

SYUKURO MANABE
RICHARD T. WETHERALD
Geophysical Fluid Dynamics Laboratory/ National Oceanic and Atmospheric Administration Princeton University, Princeton, NJ 08542

REFERENCES

1. J. E. Hansen *et al.*, in *Climate Processes and Climate Sensitivity*, J. E. Hansen and T. Takahashi, Eds. (Maurice Ewing Series No. 5, American Geophysical Union, Washington, DC, 1984), pp. 130–163; W. M. Washington and G. A. Meehl, *J. Geophys. Res.* **89**, 9475 (1984).
2. J. F. B. Mitchell and G. Lupton, *Prog. Biometeorol.* **3**, 353 (1984).
3. S. Manabe, R. T. Wetherald, R. J. Stouffer, *Clim. Change* **3**, 347 (1981).
4. S. Manabe and R. T. Wetherald, *Adv. Geophys.* **28** (part A), 131 (1985).
5. J. F. B. Mitchell, *Dynam. Climatol. Tech. Note 39* (Meteorological Office, Bracknell, Berkshire, England, 1986).
6. L. H. Druyan, J. R. Miller, G. L. Russell, *Atmos. Ocean* **21**, 94 (1983).
7. S. Manabe and R. T. Wetherald, in preparation.

Artist Identified

Lynn Rathbun is the "unidentified artist" with the initials L. R. who prepared the drawings praised by Malcolm C. McKenna in his review (5 Sept., p. 1102) of *The Evolution and Ecology of Armadillos, Sloths, and Vermilinguas*.

KATHERINE RALLS
Department of Zoological Research, National Zoological Park, Smithsonian Institution, Washington, DC 20008
ROBERT L. BROWNELL, JR.
Piedras Blancas Field Station, U.S. Fish and Wildlife Service, San Simeon, CA 93452