Reply (Evaluation of Land-Surface Parameterization Schemes Using Observations)

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Robock et al. (1995a) tested a 15-cm bucket model (Manabe 1969) and the Simplified Simple Biosphere (SSiB) model (Xue et al. 1991) by forcing them with observed meteorological and actinometric data and comparing the results with observed soil moisture, albedo, snow depth, and net radiation. Xue et al. (1997) show that it is possible to improve SSiB in response to errors in the simulations by fixing the snowmelt partitioning and adjusting the soil properties to produce a higher effective field capacity. We agree with their conclusion that using real data to test models is a good idea, and this was one of the major conclusions of Robock et al. (1995a).

Xue et al. (1997) claim that they demonstrate that the fundamental structure of their model is sound and that it just needs tuning by adjusting parameter values. However, while the bucket model did not have any problem with snowmelt partitioning in the Robock et al. (1995a) experiments, which involved six stations for 6 yr in the former Soviet Union, for some stations the 15-cm field capacity was clearly too low. Schlosser (1995) demonstrated that major improvements are also possible in bucket model simulations for particular stations by taking into account actual conditions at the station. Figure 1, for example, shows a dramatic improvement in the Kostroma simulations by using the actual field capacity of 28 cm of plant-available water in the top 1 m of soil rather than the standard 15 cm used in the GCM version of the bucket model. Not only are the winter soil moisture values accurately simulated, but the summer drying is accurately modeled in wet and dry summers. In fact, this improved simulation of soil moisture for Kostroma, produced by changing only one parameter in the bucket model, the field capacity, appears to be superior to the simulation by SSiB, as shown by Xue et al. (1997) in their Fig. 1b. Using the observed field capacity also produces improvements for the simulations with the bucket model of the other five Russian stations.

The bucket model can also be improved in other ways, such as in its method of calculating potential evaporation. Schlosser (1995) showed that by taking into account the suggestion of Milly (1992) that the temperature of a saturated surface rather than the simulated temperature be used, bucket model simulations are also improved. Similarly, he suggested methods for improving the simple bucket runoff scheme.

The design of an optimal land-surface scheme, which correctly simulates sensible and latent heat flux, soil moisture, and runoff, remains an active research goal. This model would be applicable globally and require a minimum number of parameters, all of which could be observed to the required accuracy at each grid point. If SSiB can be tuned at individual locations to more accurately simulate the observed seasonal cycle, but if the required parameters cannot be determined for locations for which we do not currently have validation data, then the question remains open as to whether another approach might be superior.

While Xue et al. (1997) demonstrate an improved mean seasonal cycle in SSiB simulations, the serious problem of timescale in SSiB is not addressed. Both Schlosser (1995) and Robock et al. (1995b) found that SSiB and its related models (dubbed SiBlings by Robock et al. 1995b) exhibited multiyear timescales in their temporal autocorrelation, which differ from the observed timescales (Vinnikov et al. 1996) of 2–4 months for this climate. The problem appears to be in the slow exchange of moisture into and out of the bottom (third) layer of the SiBling models, and this again demonstrates the potential of comparing parameterizations with actual observations to point to paths that could improve those parameterizations.

The philosophy of testing land-surface schemes by

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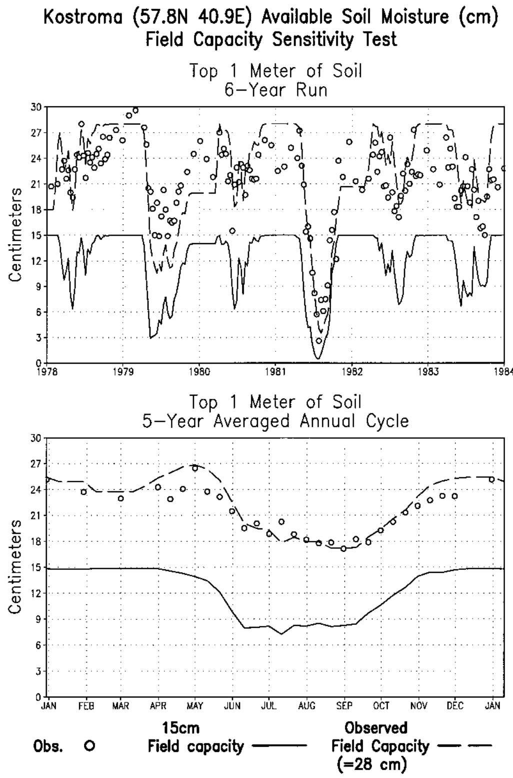

FIG. 1. Soil moisture simulations with the bucket model for Kostroma showing dramatic improvements in the simulations simply by using the correct field capacity of 28 cm (Fig. 3.1 from Schlosser 1995).

forcing them with observed meteorological and actinometric data, and then comparing the soil moisture and fluxes generated by the schemes with observations, has also been embraced by phase 2 of the Program for Intercomparison of Land-Surface Parameterization Schemes (PILPS; Henderson-Sellers et al. 1993, 1995), which is comparing 27 different land-surface schemes. Unfortunately, the first such test, using 1 yr of data from Cabauw in the Netherlands (PILPS phase 2a; Chen et al. 1997) did not have soil moisture data available for validation and only had 1 yr of data for the tests. As shown by Robock et al. (1995a,b), spinup problems can invalidate the first part of the simulations, making interpretation of the results difficult. An attempt was made to deal with this problem by having the modelers run their models with the same 1 yr over and over until it reached equilibrium, but this will completely solve the problem only if all the years before the one simulated are identical. As seen in Fig. 1, there is large interannual variability of soil moisture, and multiple-year tests would be much better. Fortunately, another PILPS phase 2 test is now beginning using 18 yr of data from Valdai, Russia (Schlosser 1995; Vinnikov et al. 1996), which will allow the spinup problem and interannual variations to be examined. Yang et al. (1996) also used the six Russian stations described by Robock et al. (1995a) to test the Biosphere–Atmosphere Transfer Scheme land-surface scheme (Dickinson et al. 1986), in particular the snow parameterization.

All of the experiments described above have been limited to the Russian stations that we have developed so far, which are all in relatively high latitude locations. To remedy this situation, we are now conducting the same experiments for about 50 stations in Russia, which will give us a much larger range of climate and model response. In addition, we are now in the process of developing a dataset of 102 stations from China, which have data starting in 1981 and cover a much larger range of climate regimes including the Asian monsoon climate in southern China, and a 40 station dataset from Mongolia. Furthermore, we are using satellite measurements of microwave brightness and of vegetation index to develop a global soil moisture dataset, which will serve as ground truth for global model simulations of soil moisture.

One of the fundamental results of Robock et al. (1995a), which is well illustrated in Fig. 1 and in the results of Xue et al. (1997), is that the most important parameter for conducting global simulations of soil moisture is the field capacity, which can vary greatly for different soil and vegetation types. We are now working on this problem by combining actual observations of field capacity with satellite observations, global soil and vegetation databases, and theoretical considerations.

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