INTERCOMPARISONS OF SELECTED LAND SURFACE PARAMETERIZATION SCHEMES USING RUNOFF DATA

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Introduction: The GEWEX Continental-Scale International Project (GCIP) is designed to take full advantage of operational mesoscale atmospheric models such as the Eta model of the National Weather Service National Center for Environmental Prediction (NCEP). One of the key components of the Eta model is its land surface parameterization. The original operational version of the Eta model used a one-parameter Manabe bucket scheme. Because of many apparent weaknesses in the bucket scheme, NCEP is upgrading it with a more sophisticated land surface parameterization scheme. A modified version of the soil hydrology model developed at the Oregon State University (hereafter referred as the OSU model) has replaced the bucket scheme to represent the land surface parameterization in the operational Eta model since October of 1995 (Mahrt and Pan, 1984). The OSU model represents both water and energy processes. This model is considered to be "physically based" because the model is based on theoretical principles governing vertical movement of water and energy in a vertical column of soil at a point location. This type model is in contrast to "conceptual" type models which represent spatially averaged water processes over a "large" area. The operational Sacramento (SAC) model (Burnash et al., 1973) and the experimental Simple Water Balance (SWB) model (Schaake et al., 1995), both of which are part of the National Weather Service River Forecast System (NWSRFS) belong to conceptual type. Past research has indicated that a proper representation of runoff processes in the land surface parameterization is critical in modeling land surface/atmosphere interactions. Therefore, an offline experimental study of a few selected land surface parameterization schemes, including the modified OSU model, the Manabe bucket, the SAC model, and the SWB model, was conducted to evaluate the ability of different models to simulate runoff processes.

Study Strategy: This study focused on water movement processes in the land surface, while the energy flux exchanges were not investigated. Because runoff processes were the key in this study, the modeling domain was basin-based instead of soil column based. In the initial pilot study, three basins representing respectively dry, moderate and wet hydrologic regimes were chosen. For each basin, historical hydrologic data were collected for many years (> 7 years). The historical data were divided into two independent parts to allow split sampling study. The first part was used to calibrate model parameters, while the second part was used to validate the calibrated parameters. A global optimization search method - the Shuffled Complex Evolution (SCE-UA) method - was employed to calibrate the models (Duan et al., 1992). Three different objective functions measuring the difference between simulated runoff and observed runoff were used to evaluate the performance of the different models. These objective functions were: Daily Root Mean Square (DRMS) error; Monthly Volume Root Mean Square (MVRMS) error; and Coefficient of Efficiency (E).

Preliminary Results: Table 1 displays the preliminary test results of this study. It can be seen clearly that the ability of the Manabe bucket scheme to simulate runoff was much inferior to that of other schemes. In general, the performance of the OSU model in Bird Creek and Leaf River basins was comparable to that of the SAC or the SWB model. But in the French Broad River basin where the climate condition was wet and sub-surface runoff was abundant, the OSU model did much worse than either the SWB or the SAC model. This result indicated that the sub-surface representation of OSU model might be inadequate in wet conditions.

Further Research: Further research is planned to enhance the land surface parameterization scheme of the Eta model. A retrospective/historical hydrologic time series data base is being assembled to allow more extensive testing of different land surface parameterization schemes in various hydrologic regimes. This data base will also be used to develop regional parameter estimation procedures that are necessary for successful large scale application of atmospheric/hydrologic models. Model structural modifications to the OSU model are made or contemplated to improve the representations of surface and subsurface runoff processes. A frozen ground component will also be added to the OSU model to account for the seasonal effect of the frozen soil. The modified OSU model will be part of the Project for Intercomparison of Land Surface Parameterization Schemes Phase 2d (PILPS 2d) whose major objective is to evaluate the ability of the current generation of land surface schemes used in climate and numerical weather prediction models to reproduce measured energy and water fluxes at both the regional and basin scales.

References:

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Table 1. Summary of the Calibration and Verification Results

Objective Function	Model	Bird Creek		Leaf River		French Broad	
		Calibration period 56-60	Validation period 61-62	Claibration period 52-60	Validation period 61-69	Calibration period 54-59	Validation period 60-64
DRMS	OSU[1]	24.71	34.25	23.07	24.44	2.25	2.59
	SWB	21.17	31.46	18.79	27.66	1.40	1.65
cms	SAC	18.64	31.45	16.04	21.05	1.31	1.34
	Manabe	124.51	96.04	120.23	154.37	70.14	88.70
MVRMS	OSU	10.76	14.66	17.03	18.25	22.49	22.98
	SWB	8.38	12.10	12.10	17.93	10.65	11.98
mm	SAC	6.07	11.13	10.12	14.09	9.54	9.86
	Manabe	16.11	18.90	25.33	31.96	53.04	58.37
E	OSU	0.90	0.71	0.72	0.88	0.82	0.79
	SWB	0.93	0.76	0.81	0.84	0.91	0.92
	SAC	0.94	0.75	0.88	0.88	0.92	0.94
	Manabe	-1.57	-1.28	-6.68	-3.89	-12.81	-14.57