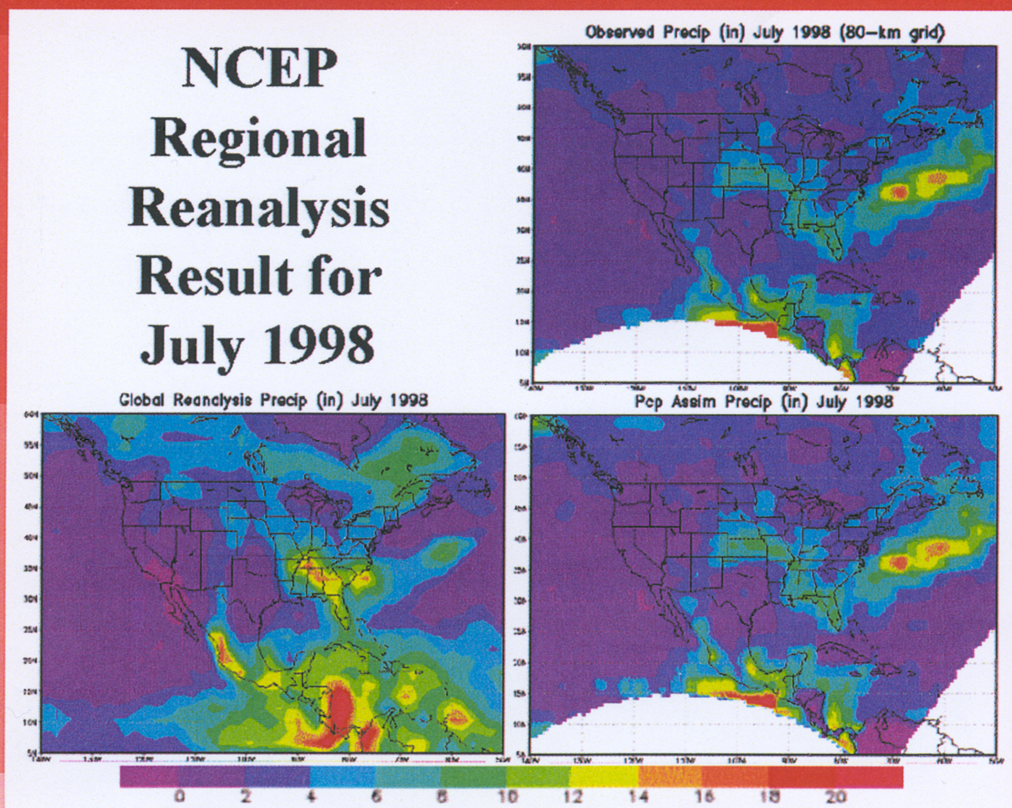
16th Conference on Hydrology

13–17 January 2002
Orlando, Florida



AMERICAN METEOROLOGICAL SOCIETY

J4.4 THE EFFECTS OF IMPLEMENTING TOPMODEL CONCEPTS IN THE NOAH MODEL

C. D. Peters-Lidard*[1]
Hydrological Sciences Branch, Code 974
NASA/Goddard Space Flight Center
Greenbelt, MD 20771

1. INTRODUCTION

Topographic effects on runoff generation have been documented observationally (e.g., Dunne and Black, 1970) and are the subject of the physically based rainfall-runoff model TOPMODEL (Beven and Kirkby, 1979; Beven, 1986a;b) and its extensions, which incorporate variable soil transmissivity effects (Sivapalan et al, 1987, Wood et al., 1988; 1990). These effects have been shown to exert significant control over the spatial distribution of runoff, soil moisture and evapotranspiration, and by extension, the latent and sensible heat fluxes (Famiglietti et al., 1992; Famiglietti and Wood, 1994a; b; Peters-Lidard et al, 1999).

The objective of this research is to investigate and demonstrate the impact of topographic control of runoff production and lateral soil water redistribution on the water and energy balance as simulated by the NCEP NOAH land surface model (Mahrt and Ek, 1984; Mahrt and Pan, 1984; Pan and Mahrt, 1987; Chen et al., 1996; Schaake et al, 1996; Chen et al., 1997; Mitchell, 1999). Currently, the NOAH model solves the Richards equation for 1-D vertical soil water transport in each land surface model grid, which corresponds to the atmospheric model horizontal grid. There is no provision for lateral soil water redistribution or for explicit subgrid soil moisture heterogeneity. Several modifications to NOAH have been incorporated which parameterize the effects of subgrid variability in topography and/or soil moisture, including:

- infiltration/runoff generation parameter "REFKDT" (Schaake et al., 1996). REFKDT is a tuneable parameter that significantly impacts surface infiltration and hence the partitioning of total runoff into surface and subsurface runoff. Increasing REFKDT decreases surface runoff.
- non-linear soil moisture stress function for stomatal resistance (Chen et al., 1996). The non-linearity in this function represents the ability of wetter portions of the grid to transpire even when the grid-averaged soil moisture is near the wilting point, as well as the dryer portions of the grid which may be stressed when the grid-averaged soil moisture is near field capacity.
- drainage parameter "SLOPE" (Schaake et al., 1996). SLOPE is a coefficient between 0.1-1.0 that modifies the drainage out the bottom of the bottom soil layer. A larger surface slope implies larger drainage.

TOPMODEL provides a physically-based approach to represent subgrid topography and soil effects on the runoff production, the soil moisture distribution and drainage, via a drainage index which can be estimated directly from digital topographic and soils data. In the current project, the three parameterizations above are being replaced with a subgrid distribution of the TOPMODEL drainage index to explicitly represent the subgrid distribution of water table depth and soil moisture. The effect of this subgrid distribution on lateral soil water redistribution, runoff generation and surface fluxes will be modeled statistically in the manner of Famiglietti and Wood (1994a) and Peters-Lidard et al. (1997). We are demonstrating the NOAH model in both its original and new forms in the Arkansas-Red River basin using all other input parameters as specified in the LDAS project. By incorporating topographic effects into the existing NOAH model while all other processes remain the same, the effects of this representation on runoff, soil moisture and energy fluxes can be isolated. All simulations are being run off-line and in a retrospective mode for this test period.

4. CONCLUSIONS

The work to date suggests the following three conclusions:

1. The baseflow predicted by the TOPMODEL equation seems to behave more smoothly and realistically than the original formulation, which has a peak in the summertime.
2. The baseflow predictions, as with other aspects of TOPMODEL, are highly sensitive to parameters related to the Topographic index distribution and the decay of saturated hydraulic conductivity with depth.
3. In order to be useful as an LDAS model, the TOPMODEL parameters must be available for the CONUS and beyond, and therefore, an understanding of the effects of DEM resolution on the parameter estimation is essential.

More results and detailed discussion will be presented at the conference.