Applying Two Binned Methods to the Simple Biosphere Model (SiB) for Improving the Representation of Spatially Varying Precipitation and Soil Wetness

I-WATER
Integrated Water, Atmosphere, Ecosystems Education and Research

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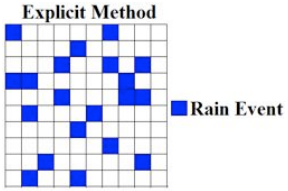
Introduction

Representing subgrid-scale variability is a continuing challenge for modelers, but is crucial for accurately calculating the exchanges of energy, moisture, and momentum between the land surface and atmospheric boundary layer. Soil wetness is highly spatially variable and difficult to resolve at grid length scales (~100 km) used in General Circulation Models (GCMs). Currently, GCMs use an area average precipitation rate that results in a single soil wetness value for the entire grid area, and due to the nonlinear relationship between soil wetness and evapotranspiration, significant inaccuracies arise in the calculation of the grid area latent heat (LH) flux. Using a finer GCM resolution will not solve this problem completely and other methods of modeling need to be considered.

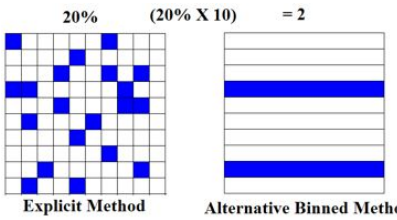
Methods

Explicit Method:
-An arbitrary grid area was normalized to an area of unity
-Grid area:
-Divided into 100 cells of equal area
-Fractional areas remained constant
-Randomly initialized with a Gaussian distribution of total plant available water (PawTot)
-Each cell was represented by a SiB Model
-Daily precipitation events fell uniformly on randomly selected cells



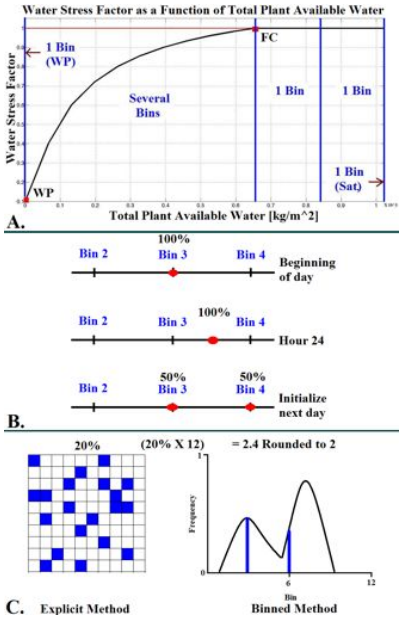
Bulk Method:
-Grid Area:
-Single SiB model and PawTot value
-Area averaged meteorology

Alternative Binned Method:
-Variation of explicit method
-Bin number of SiB models
-Fractional areas remained constant
-Based on percentage of cells that received precipitation in the explicit method

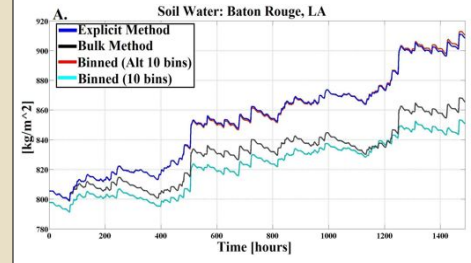


Methods Continued

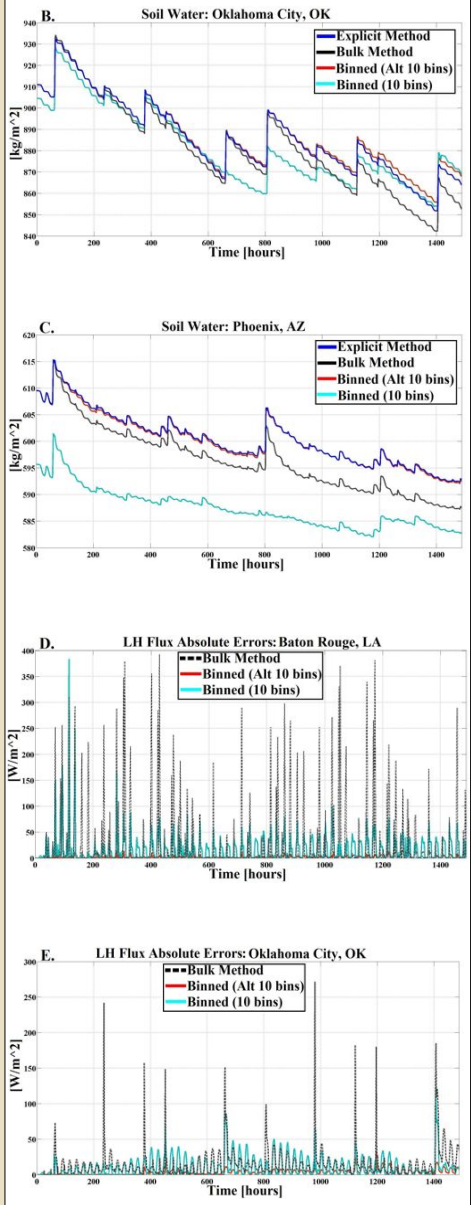
Binned Method:
-Bins represented by interval midpoint values (see A. below)
-Initial Gaussian distribution was binned
-Fractional areas were assigned to each bin
-Grid area was represented by bin number of SiB models
-Daily Change in the distribution was reflected in the fractional areas (see B. below)
-Daily precipitation events fell uniformly on randomly selected bins (see C. below)
-Based on percentage of cells that received precipitation in the explicit method
-Method conserves water exactly



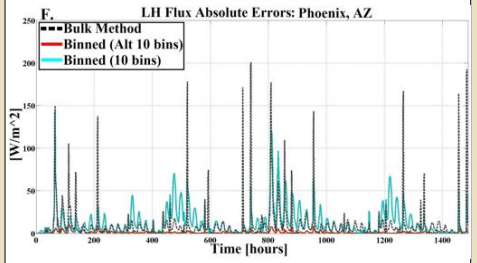
Results



Results



Results

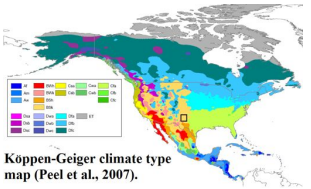


Figures A, B and C: Time series of the grid area column integrated soil water mass for Baton Rouge, LA (A), Oklahoma City, OK (B) and Phoenix, AZ (C), for the various methods. Figures D, E and F: Time series of absolute errors (defined here as the absolute value of the difference between an explicit method grid value and the equivalent grid value for the other methods) for the LH flux for the bulk and binned methods, for Baton Rouge, LA (D), Oklahoma City, OK (E) and Phoenix, AZ (F).

Conclusions/Future Work

Conclusions:
-Alternative binned method results were in closer agreement with explicit method results
-10 bins was sufficient
-Little additional computational cost to the bulk method

Future Work:
-Implications of climate change on water resources in the semiarid South Plains region (see map below)
-Compare current climate of the South Plains region to future simulations from:
1. Colorado State University (CSU) Multiscale Modeling Framework (MMF) General Circulation Model (GCM) (Khairoutdinov et al., 2007)
2. Conventional GCM
-Assess possible future hydrologic changes, atmospheric feedbacks and the hydrologic response to those feedbacks



Köppen-Geiger climate type map (Peel et al., 2007).

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