"A physically based, variable contributing area model of basin hydrology"

K.J. Beven and M.J. Kirkby in Hydrological Sciences Bulletin, 1979

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Introduction

- There is a need for:
  - simple physically-based model for medium sized basins
  - model with parameters that are directly measurable for a given basin.

- Issue
  - Basins are complex open systems with processes and variables that may change rapidly over space and time.

- This paper presents a model for humid temperate areas
  - attempts to combine advantages of simple lumped parameter models with the important distributed effects of variable contributing areas and flow routing through the channel network, while retaining the possibility of deriving parameters by direct measurement within the basin

Variable Contributing Area Concepts:

Four major ways runoff can occur in a uniform basin

A. Rainfall intensity exceeds infiltration or storage capacity resulting in overland flow all over the basin
B. Rainfall intensity exceeds infiltration or storage capacity on a variable area of near-saturated soils
C. Rain falling on stream channels and completely saturated soils.
D. Downslope lateral flow of saturated or unsaturated soil water.

Modeling Concepts

- Structure of the model:
  - Reflect the types of hydrological characteristics that are quick, convenient and economic to measure
    - Examples: topographic structure, infiltration rates, overland and channel flow velocities, discharge measurements and soil hydrological characteristics.

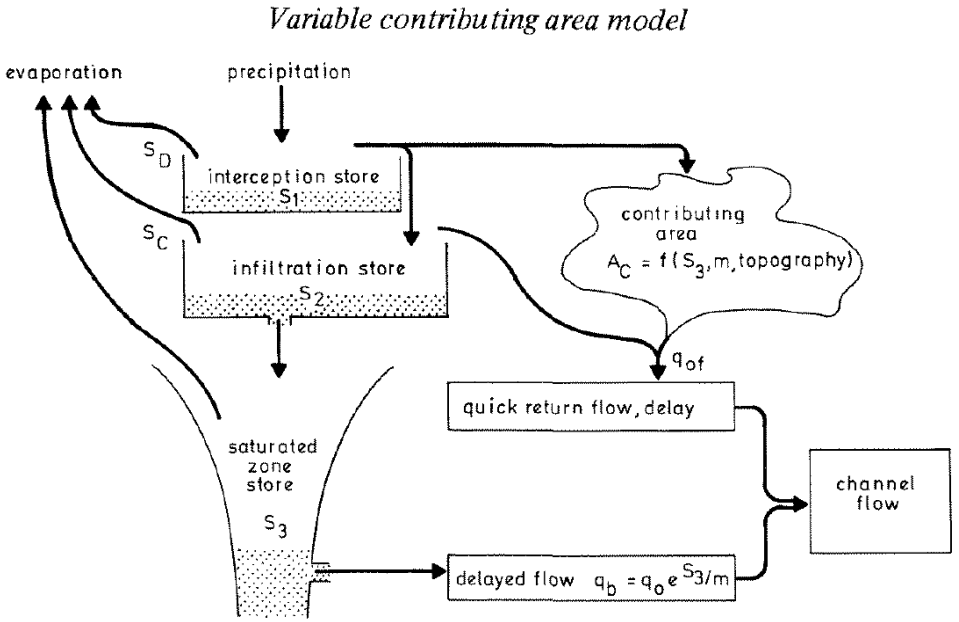

FIG. 1. A schematic representation of the sub-basin model.

Modeling Concepts

- In the previous figure, the sequence of storage elements is assumed to represent the average response of the soil water in a homogeneous sub-basin unit.

- Each sub-basin is treated as a lumped system

Application of Model

- Crimple Beck Basin
  - known soil characteristics
  - known vegetation & landuse
- Divide it into 23 homogenous sub-basins based on channel networks and patterns of soil and landuse

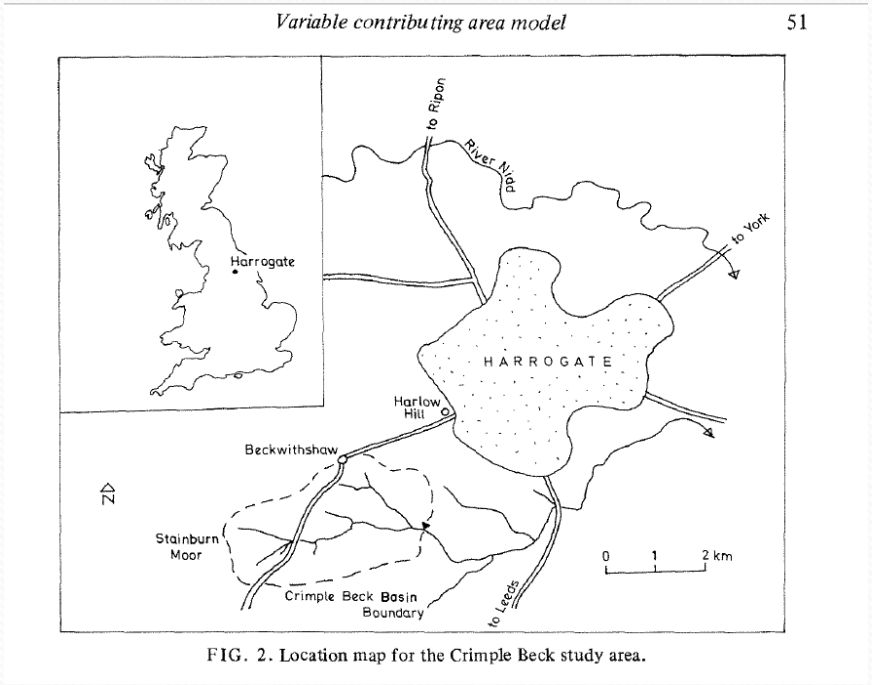

FIG. 2. Location map for the Crimple Beck study area.

Model Calibration

- First, derive the value of λ and the distribution of $\ln(a/\tan\beta)$ with area for each sub-basin.
- Spatial distribution of slope values must be obtained and the pattern of subsurface flowlines in the horizontal plane must be inferred for the subcatchment

- Topographic Moisture Index $= \ln(a/\tan\beta)$
  - Where a is the upslope contributing area per unit contour length and tanβ is the local slope

Model Calibration

- Overland flow, interception and infiltration parameters
- Subsurface storage parameters
- Channel routing parameters

Model Simulation

- Crimple Beck Basin Results
  - The model can provide reasonable reproduction of the hydrological response of small & very flashy areas
  - Simulations were much better for the winter
    - Model predictions of evapotranspiration losses need improvement
- Simulation for whole Crimple Beck Basin
  - Believe results justify further application & development of the model.

Discussion

- Models are simplifications of our perceptions of reality
- This model provides reasonable representation of basin behavior using measured & estimated parameter values
- Further development and testing of the model is needed