

# Native water supply scenarios for the South Platte Basin

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## Introduction

Over the next few years, one of the primary activities of the Vulnerability, Policy and Planning Group of the CIRES Western Water Assessment is to develop an integrated model of the water supply and demand system in the South Platte River Basin. This model will provide a tool to assess the impacts on the allocation of water resources of variability and trends in climate, changes in water demand that result from population growth, and the changing balance of agricultural, industrial and commercial activities in the basin, as well as changes in water management policy and water law. This poster describes one approach that will be employed to develop scenarios of river flows.

## The Un-Natural Water Cycle of the South Platte Basin

The South Platte Basin is semi-arid. The water supply system relies heavily on contributions of runoff from melting seasonal snowpacks in headwater basins on both the east and west slopes of the continental divide. The volume of water that is accumulated in seasonal snowpacks and ultimately becomes available for downstream use depends not only on the amount of solid precipitation that falls in winter and spring (Serreze et al 1999) but also the volume of water lost directly from snowpacks to the atmosphere by evaporation and sublimation. In summer, semi-arid conditions in the basin mean that large amounts of water are required to irrigate crops and to meet the demand for water by municipalities.

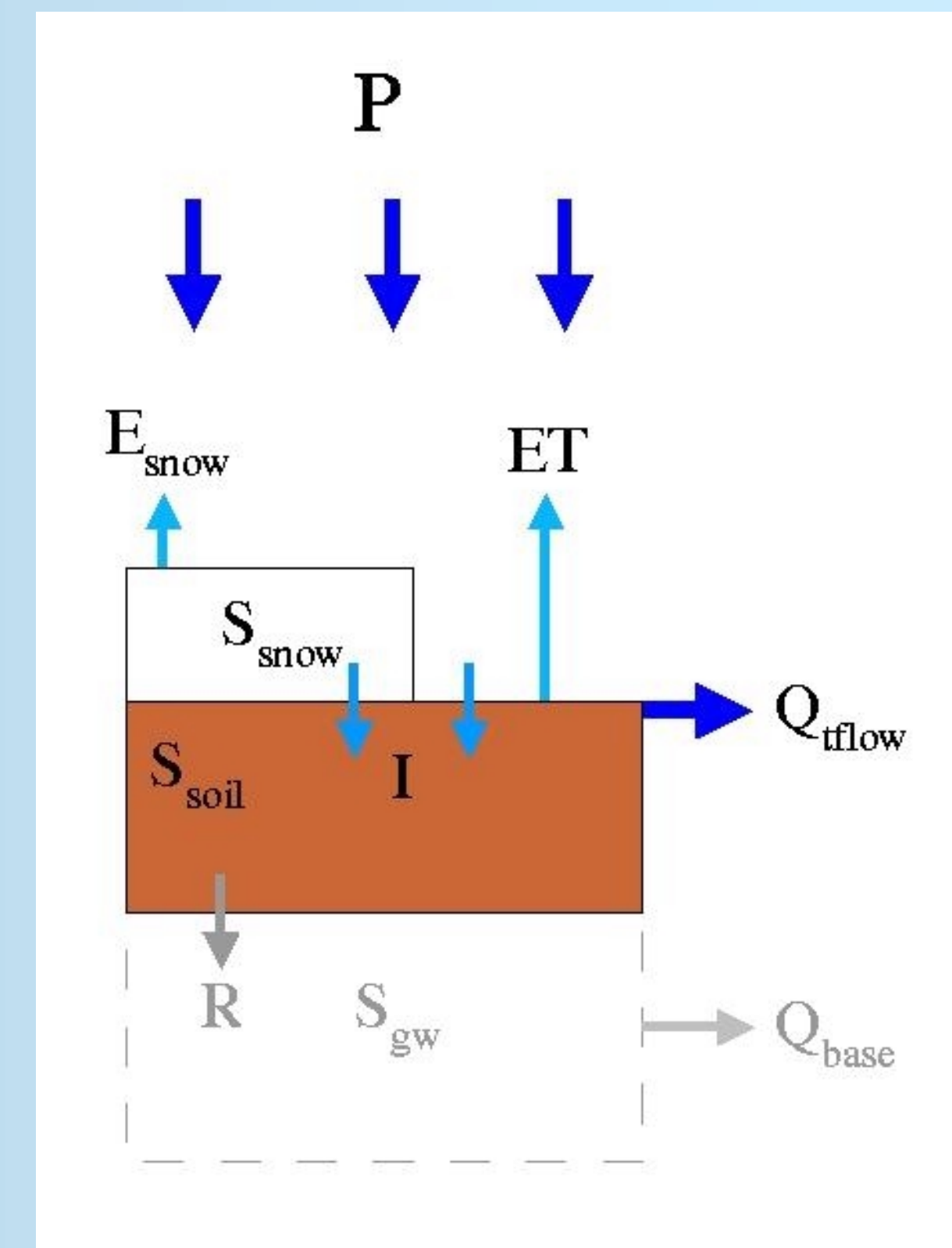


Figure 2. A simple water balance model.

## A Simple Water Balance Model

A simple water balance model (Figure 2) is well suited to the time step (1 month) chosen for the integrative water model. The water balance model used in this study characterizes the climatic demand (Evapotranspiration) and supply (liquid and solid precipitation  $P$ ) of water in a single drainage basin. Individual models are calibrated for sub-basins in the South Platte. Monthly total precipitation ( $P$ ) and monthly mean air temperature ( $T$ ) drive the model. In this study the model has been implemented with snow and soil moisture reservoirs ( $S_{\text{snow}}$  and  $S_{\text{soil}}$  respectively).

## Characterizing model uncertainty

All predictions and simulations made using hydrologic models are subject to some degree of uncertainty. This uncertainty occurs because no model can fully characterize the hydrologic processes in a drainage basin (Beven 2001). It is unlikely that an optimal model can be found for a given basin. Instead, an ensemble of equally acceptable models can be found (Beven and Binley 1992). This approach both improves simulation of runoff and provides a measure of model uncertainty

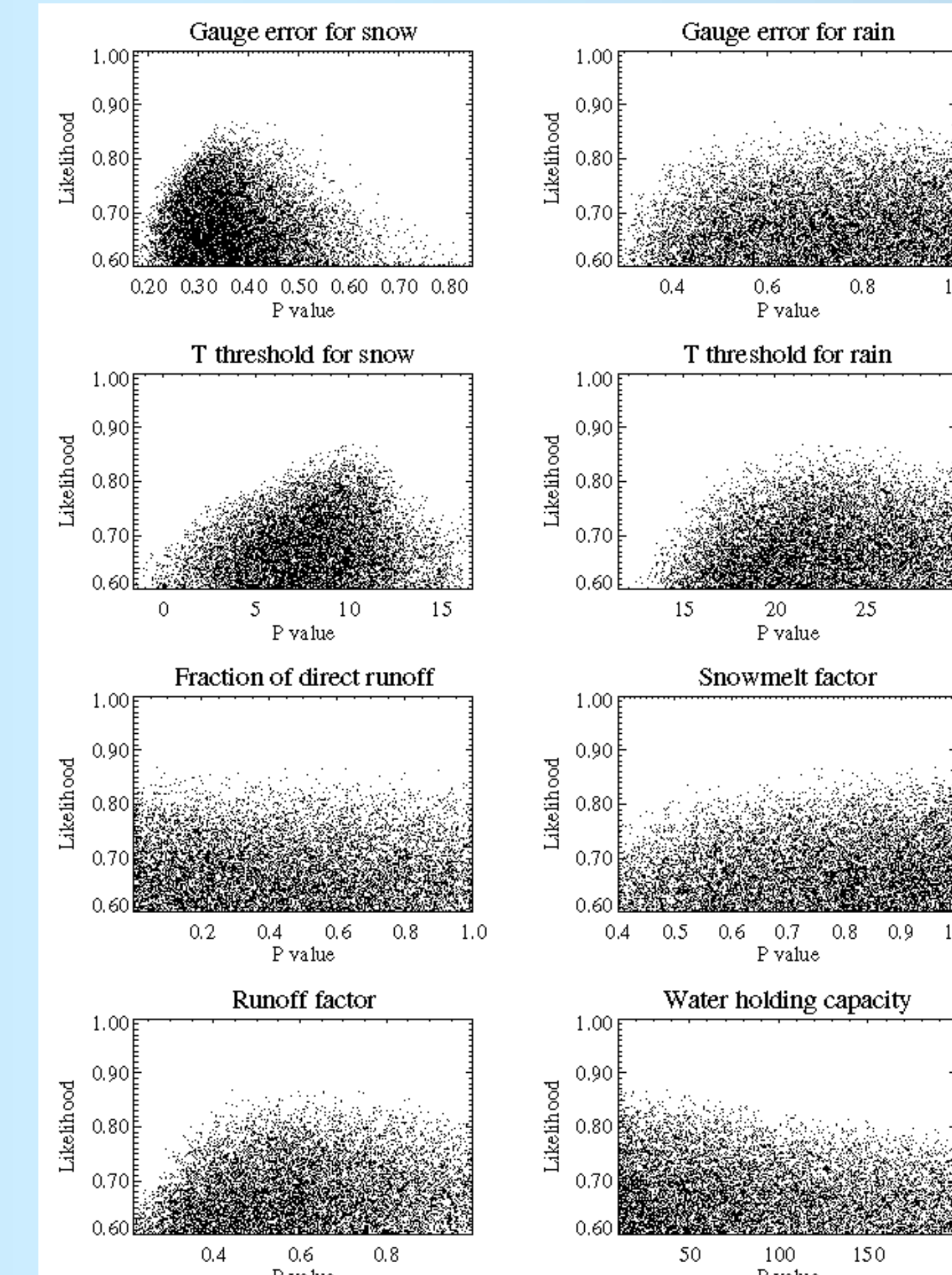


Figure 3. 'Dotty plots' showing the large number of acceptable models.

Parameter sets were selected using Monte Carlo sampling of parameter hyper-space to generate multiple models. Model performance was assessed for two calibration periods using the Nash-Sutcliffe efficiency criterion. Models with Nash-Sutcliffe scores greater than 0.6 for both calibration periods were deemed acceptable. Figure 3 shows 'dotty plots' of Nash-Sutcliffe values for each parameter for acceptable models. Each dot represents one model run. The performance of a model is a function of the parameter set as a whole and not one individual parameter.

## Model Validation

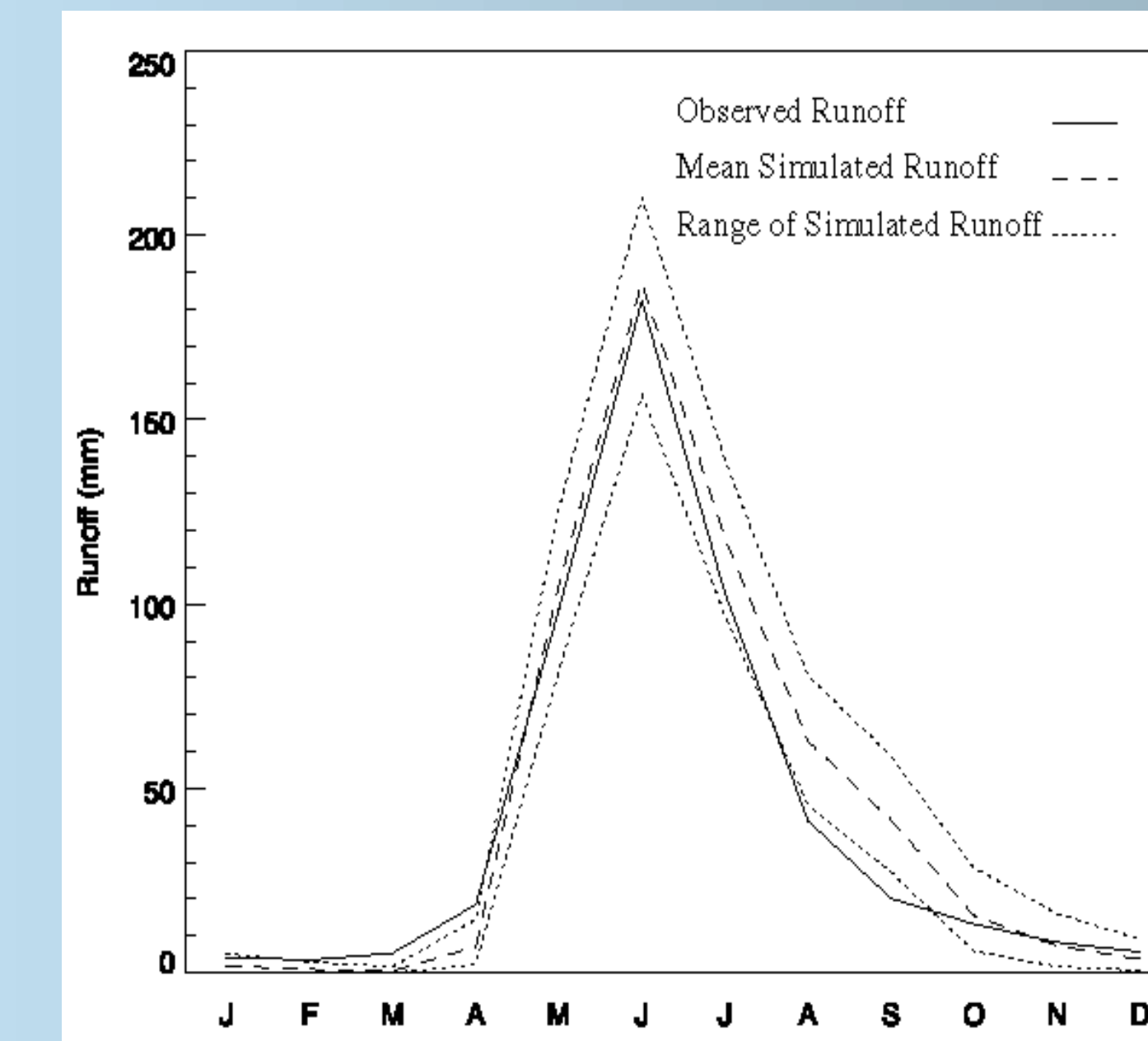


Figure 4. Mean observed and simulated hydrographs for Middle Boulder Creek at Nederland (20 miles west of Boulder). Mean simulated hydrographs are generated from an ensemble of simulated hydrographs produced by a subset of acceptable models (represented by dots in figure 3) and weighted by the normalized Nash-Sutcliffe score obtained for the calibration periods to produce a weighted mean runoff value. The normalized Nash-Sutcliffe score is an index of the degree of belief placed in each model.

## Runoff Scenarios

As an initial step, runoff scenarios were generated for simple perturbations of historical climate records. Although hydrographs shown in figure 5 are weighted means of an ensemble of hydrographs, the intention is to use individual ensemble members to drive the South Platte Basin model to produce an ensemble of water resource allocation scenarios.

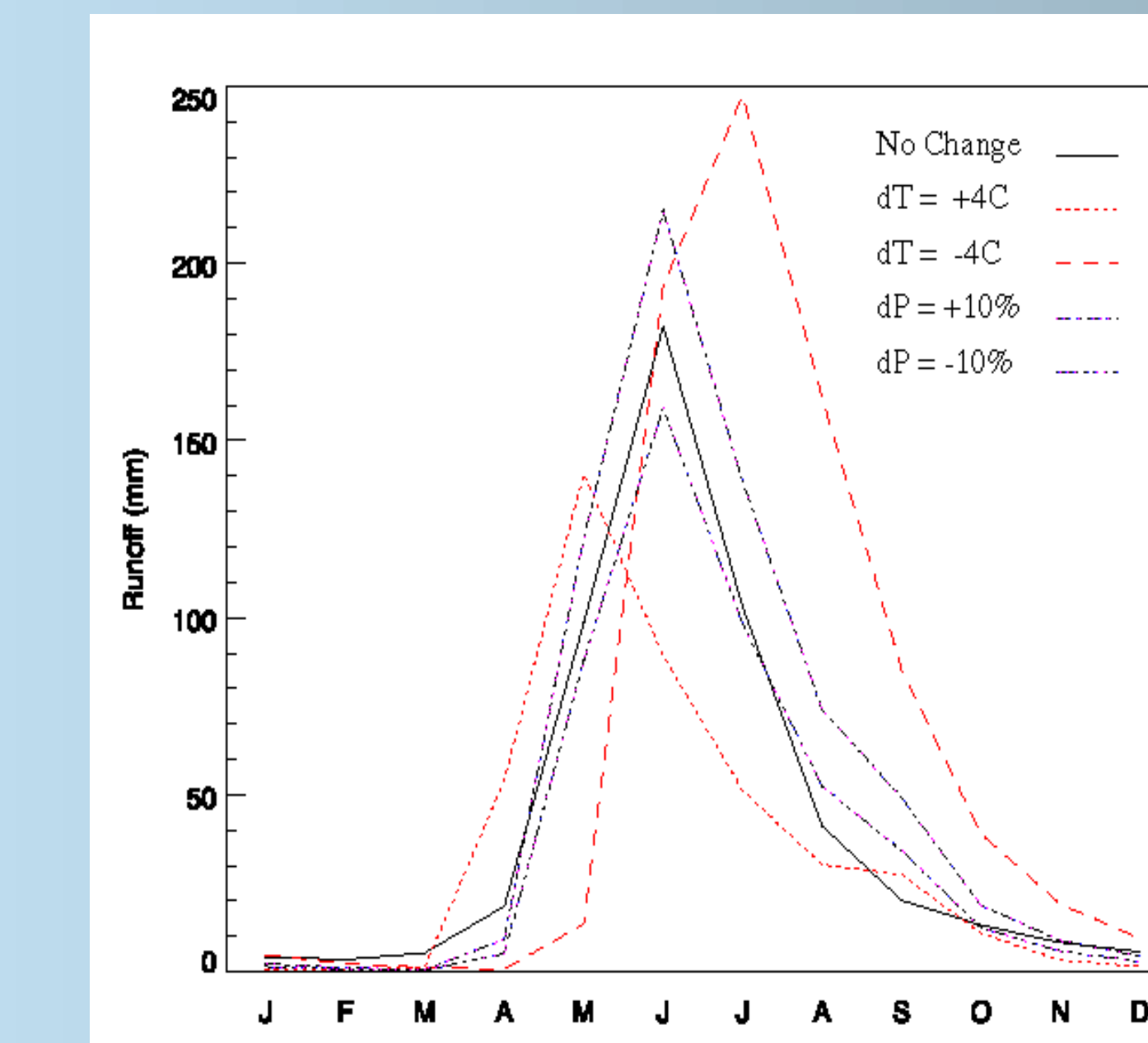


Figure 5. Mean hydrographs for changes in air temperature and precipitation of  $\pm 4^\circ\text{C}$  and  $\pm 10\%$  respectively. Runoff scenarios mimic scenarios generated by other workers for snowmelt dominated basins.

## Summary and Outlook

A simple water balance model has been used successfully to simulate historical hydrographs and to generate ensembles of runoff scenarios for alternative climates in a sub-basin of the South Platte. An integrative water model for the South Platte water system has already been developed. Ensembles of runoff scenarios will be used to investigate the relative importance of climate in this system with respect to changes in population growth, agricultural practices and water policy and law.

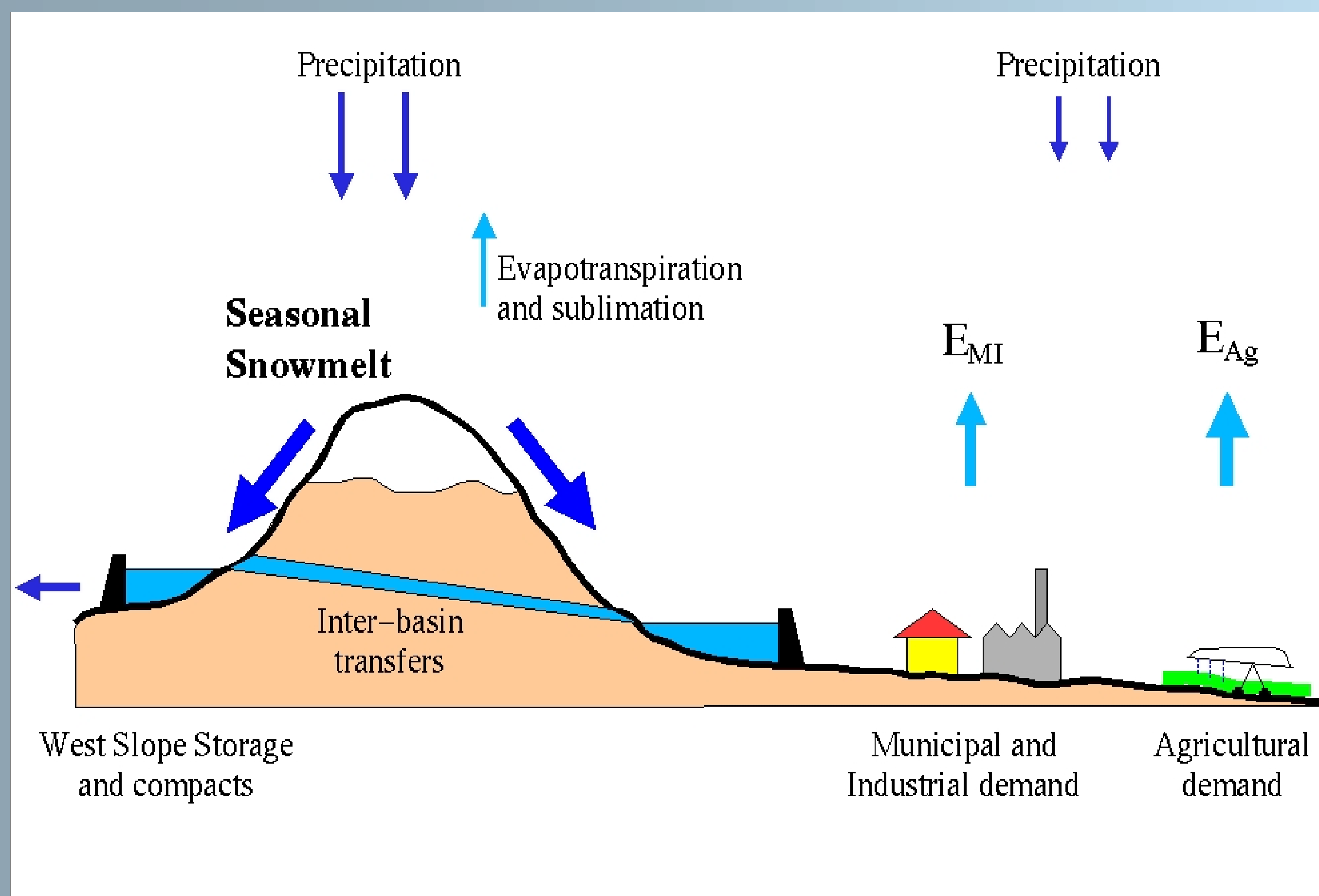


Figure 1. The 'Un-natural' Water Cycle. Climate driven supply and demand in the South Platte Drainage Basin