REAL-TIME WATER RESOURCE MANAGEMENT SYSTEM IN MEKONG RIVER SYSTEM

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ABSTRACT

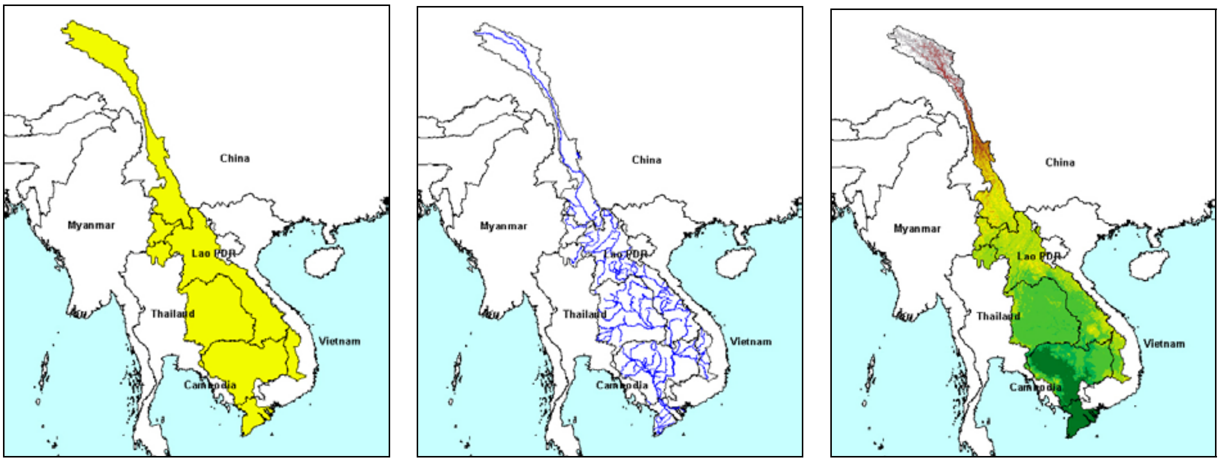
Flood, drought and water qualities are consequences of changing in hydrological cycles of the region. This change has been due mainly to climate change (especially precipitation, temperature and wind pattern changes) as well as land cover change (especially vegetation cover, evapotranspiration, soil-water property and flow routing property) and irrigation/water management activity in the basin. The flood forecasting and watershed simulation system for Mekong River Basin developed by the Southeast Asia START Regional Center (SEA START RC) based on Variable Infiltration Capacity model which is regional hydrology model for simulated hydrological issue.

The model simulates runoff using precipitation, potential evaporation, and temperature as input. The forecasting system divided into 3 parts, archive real-time data from satellite and telemetry station, update watershed model, forecast the climate then simulate the flood risk area. Forecasts are usually made daily or weekly during flood period depend on the nature of each watershed. For watershed with short response, simulate will be made daily and watershed with long response, the simulation will be made every 2 day or twice per week.

INTRODUCTION

The Mekong River flows from China's Yunnan Province through Myanmar, Thailand, Laos and Cambodia, reaching the South China Sea in Vietnam. The riparian people, plants and animals depend on the river's annual cycle of flood and drought. The Mekong River is the world's 12th longest river system, with a total length of 4,800 km, a drainage area of 795,000 km2 and an average annual runoff of 475,000 million m3. It posses the regional 's largest potential water resources. The Mekong Basin has experienced several major floods within this century. Flooding of the Mekong River is a recurrent event and causes each year in varying degree damage to agriculture, rural infrastructure and human activities, which reach disastrous damage with serious losses in food production and human lives. The 1996 flood as well as 2000 was exceptionally serious in many part of the basins. In the past, flood in 1961 and 1996 were similarly large events by an analysis of the flood levels of the Mekong River over the 30-40 years. Figure 1 shows location, stream network and elevation of Mekong basins. A preliminary analysis of flood in the Mekong delta in 1999 reveals that although the average rainfall over the whole catchments was not higher than the long-term average, more rainfall was concentrated in the Northeastern Thailand where deforestation was maximum. This could show some transboundary linkages between upstream landcover change and downstream flood in this international basin.

Heavy monsoon rains in July 2000 triggered severe flooding along the Mekong River, which cuts through Lao PDR, Thailand, Cambodia and Vietnam. An estimated 6.5 million people have been affected, especially in the southern delta regions of Cambodia and Vietnam. In Vietnam, 45,000 families have been displaced, many to cramped makeshift shelters atop crumbling earth dikes or alongside highways. Others have remained in their flooded homes, their possessions stacked on bamboo platforms inches above the water. In the worst hit provinces of Dong Thap, An Giang and Long An, acres of lush rice paddies have been swallowed by muddy brown waters that have swamped low-lying rural roads. Water levels have peaked but will not recede until mid-November, assuming that there are no more heavy storms (Anonymous, 2000).



a. Location b. Stream Network c. Elevation

Figure 1 Coverage Area of Mekong River Basin

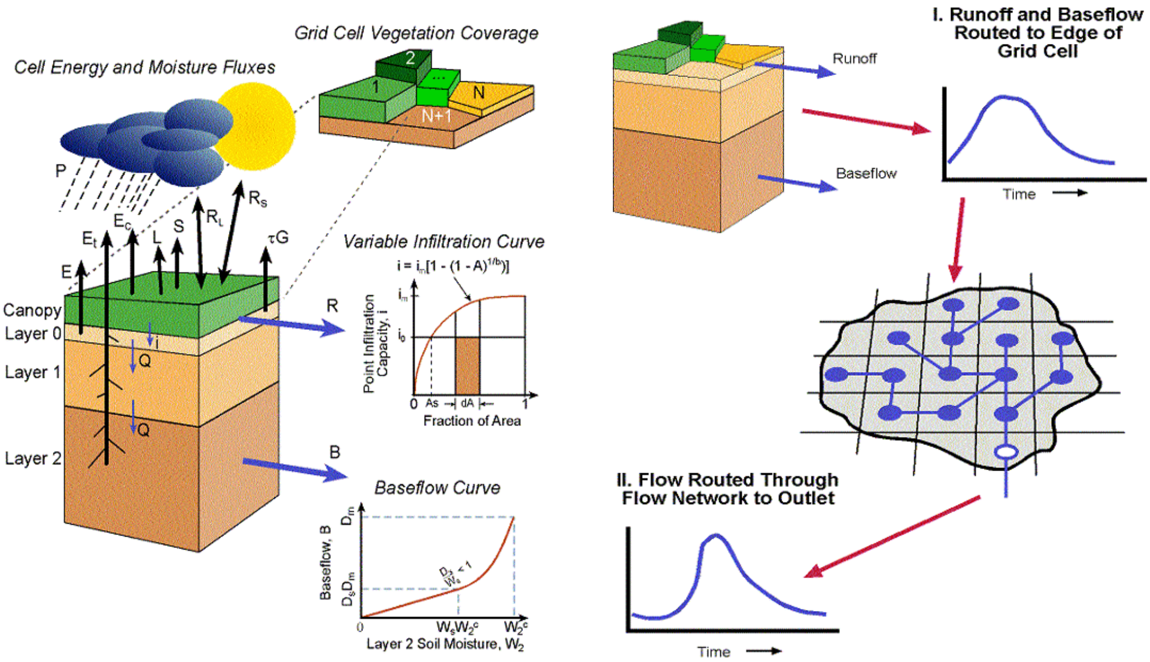
Southeast Asia Integrated Regional Model of Drainage Basin Input to Coastal Zone (SEA-BASINS) project is a regional research and development project for an integrated and systematic system to quantify the effect of global environmental changes on the hydrology, chemistry and greenhouse gas source/sink function of surface and subsurface waters. SEA-BASINS has adopted the Variable Infiltration Capacity (VIC) Model as a tool to simulate the regional hydrology situation e.g. flood forecasting, water quality modeling.

WATERSHED SIMULATION MODEL

The Watershed simulation model of flood forecasting system based on the variable Infiltration Capacity (VIC) hydrology model developed at the University of Washington, Princeton University and Southeast Asia START Regional Center. The overall model consists of two independent parts, a runoff production and evapotranspiration model and a horizontal transport model. The basic component of a VIC model is a conceptual hydrological model, which simulates runoff using precipitation, potential evaporation, and temperature as input. VIC model is a semi-distributed grid-based hydrological model that parameterizes the dominant hydro meteorological processes taking place at the land surface - atmosphere interface. A mosaic representation of land surface cover, and sub-grid parameterizations for infiltration and the spatial variability of precipitation, account for sub-grid scale heterogeneities in key hydrological processes. From figure 2, the VIC model uses three soil layers and one vegetation layer with energy and moisture fluxes exchanged between the layers. Recent additions to the model include addition of an energy balance snow accumulation and ablation model, and a frozen soil algorithm. The VIC model has been widely used for simulation of regional-scale watershed in North America and Europe (Liang et al., 1994; 1996; 1998).

The main parts of the VIC model are precipitation, snow, soil moisture, evapotranspiration, subsurface, and groundwater models. For Flooding simulation system the Mekong Basin were divided into 45-50 watersheds using elevation and stream network to distribute the watershed model and increase the accuracy in the watershed simulation. The basic hydrological model is then calibrated more or less specifically for all the sub-basins in the watershed depending on the available data. The runoff from different sub-basins is the connected with river routing models. The combination of hydrological runoff models, stream routing model forms the Watershed simulation model. A grid network version of the two-layer variable infiltration capacity (VIC) macro scale hydrologic model is described. VIC model is a hydrologically based soil-vegetation-atmosphere transfer scheme designed to represent the land surface in numerical weather prediction and climate model (Nijssen et al., 1997).

Vegetation and soil characteristics associated with each grid cell are reflected in sets of vegetation and soil parameters. Parameters for vegetation types are specified in a user defined library of vegetation classes, while their distribution over the gridded land surface area is specified in a vegetation parameter file. Soil characteristics (e.g., sand and clay percents, bulk density) can be represented for a user-defined number of vertical soil layers - usually two or three, divided into a thin upper layer and a secondary set of layers that extend several meters into the soil column.



a. Schematic of VIC vertical (water and energy balance) **b.** Schematic of VIC horizontal (river routing)

Figure 2 Overview of the Suited of Linked Models used to investigate the Climate /Hydrology/Water Resources System

GENERAL DESCRIPTION OF THE SYSTEM

The main operating part of the watershed simulation and forecasting system (WSFS) consists of 45-50 watershed models, which simulated the hydrological cycle using standard meteorological data. The new watershed models are fully automatic (in development process), whereas some of the older ones are run interactively.

The components and stage of forecasting system describe in figure 3. The operational use of a watershed model consist of weather and watershed data collection from weather data which transfer in real-time from 4 sources of data, 1) Satellite-based imageries (e.g. TRMM, SSM/I), 2) Ground data from participants (e.g. Mekong River Committee, etc), 3) Regional weather station, 4) Water level and discharge data from observation station from participants (e.g. Mekong River Committee: MRC) which 1 day or more delayed.

The data source for the simulation model divided into 2 type, static layer and dynamic layer. The static layers are elevation, stream network and soil property data. These data require for the basin delineation and initiate the VIC model input parameters. The dynamic layers are landcover, atmospheric forcing and soil moisture data. These data are acquire from the Satellite sensor from various type of satellite e.g. precipitation data from TRMM and GPCP data, Soil moisture from the Special Sensor Microwave/Imager (SSM/I).

The interpretation of satellite and gridding the atmospheric data by climate modeling model using CSIRO DARLAM climate model use as the forecast and simulation model for climate prediction.

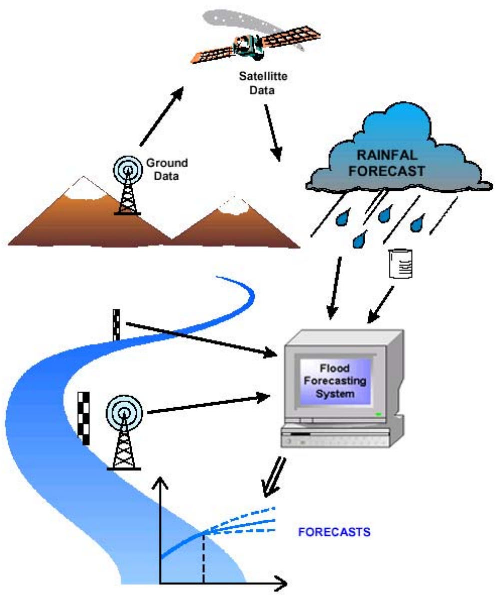


Figure 3 Computational elements in real-time flood simulation network

Then simulated output with basic simulation run, updating of model according to observations data, runs with different regulation rules for regulated lakes, the forecasting run with weather forecast and different weather statistics and the distribution of forecasts through the data network of the SEA START RC (Intranet, Internet-WWW) to the participants and public or distribution of Warning Message to Flood Management Organization for flood action plan Owing to the large number of forecasts done, the entire operating system has been developed into a fully automatic system.

CONCLUSION AND RECOMMENDATION

The operation of a watershed simulation model consist of meteorological and hydrological data collection, basic simulation run, updating of model accuracy according to observations, model runs with different regulation rules for regulated lakes, forecasting run with weather forecast and weather statistic and the delivery of forecast to Regional Responsibility Center, other users and Internet. Owing to the large number of forecasts done, the entire operating system has been developed into a fully automatic form. Forecast and simulation results are presented as graphs of discharge, graphs of water level or map-based user interface to makes its possible to examine on a map.

Assimilation of Dynamic and Higher Resolution Spatial Information, to provide the forecasting system capabilities, the land cover/land use data layer must be made dynamic, to represent changes in the basin over time (for retrospective analyses, current conditions, and for future scenarios). This needs to be done at two scales. The first is basin wide. Through the new MODIS (Moderate Resolution Imaging Spectroradiometer) improved and easier to access products are becoming available.

The two variables essential for describing the daily to interannual dynamics of a river basin are precipitation, and daily temperature (minimum and maximum). Ideally, gridded (in a GIS) data fields (for input to the spatial models) would be derived directly from observations at weather stations with sufficient frequency and resolution to be incorporated directly. Unfortunately, this does not happen - stations are sparse, recording can be sporadic, and take a considerable time to become available. Newer technologies, however, make it feasible to derive the necessary climatology much more rapidly. The Tropical Rainfall Measuring Mission (TRMM, the "flying rain gauge") produces daily data with a spatial extent of about 100 km and available within about 72 hours of collection.

The forecasting systems still under development, many parameters will be collected from ground to increase forecasting accuracy and update the watershed model e.g. soil data, we use the soil property data from the Global Soil Data Task, coordinated by the Data and Information System (DIS) of the International Geosphere-Biosphere Programme which is specific purpose derived data-sets for major class of global soils. This datasets contains two layers of soil depth 0-30 cm and 30-100 cm but in real world soil layer in Southeast Asia are very complex.

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