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Importance and necessity of integrated river basin management

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Abstract

It is obvious that water resources management has been an important issue in this century under the specified situation of climate change, regional development and population increase. Moreover, the modern life has become vulnerable to water environment effected with climate change. New water-related technologies may create the additional water consumption or drastic water saving. Freshwater withdrawals by human activities have increased dramatically over the years. Already, at the beginning of the 21st century, one-sixth of the world's population was without access to improved water supply while two-fifths lacked access to improved sanitation. Problems of water resources have also become much discussed issues in international conferences and multi-national organizations.

Keywords: Water resources management; Climate change; Whole river basin; Environment assessment

1. Introduction

It can be seen that the water demand is relatively stable, and the corresponding rate of development of water resources has slowed down when compared with that of past years. However, it is clear that problems associated with environmental issues and coordination between conflicting demands of upper and lower stream users in various river basins continue to increase. Furthermore, it can be seen that the earth's water is in a state of crisis, and accordingly a strategy is needed for the creation of an environment where sustainable water resources use is achievable. So, we have to propose the long-term forecasting procedure with high accuracy and the effective countermeasures against severe drought. The long-term forecasting of river discharge must be imperative to mitigate the water resources disaster. There are several important issues on future water resources such as (i) spatial and temporal distribution of water resources under the climate change, (ii) impacts assessment of rainfall and runoff distribution on vegetation and ecosystem, (iii) water resources dynamics of water circulation linking with water use and social activities, and (iv) establishment of water resources assessment in the whole river basin. Concretely, those issues are summarized as follows:

- Impacts of global warming on water circulation, vegetation, and land use.
- Global water dynamics with economical activities under the climate change.
- Regional water circulation processes with water quantity, quality, and ecosystem.
- Whole river basin planning and management with multipurpose and multi-factor.

2. Water resources potential with pattern classification

Fig. 1 shows the classified pattern sequences of atmosphere temperature under the conditions of total amount and whole feature. It presents that same patterns had occurred up to 1954 and the peculiar one happened frequently. Especially typical three patterns have occurs in these ten years. Consequently, the atmosphere temperature is changing from both viewpoints of average and frequency. Though the precipitation did not show the clear results, the dispersion around average has been bigger.

On the other hands, the regional precipitation is affected by global climate such as the change of air pressure

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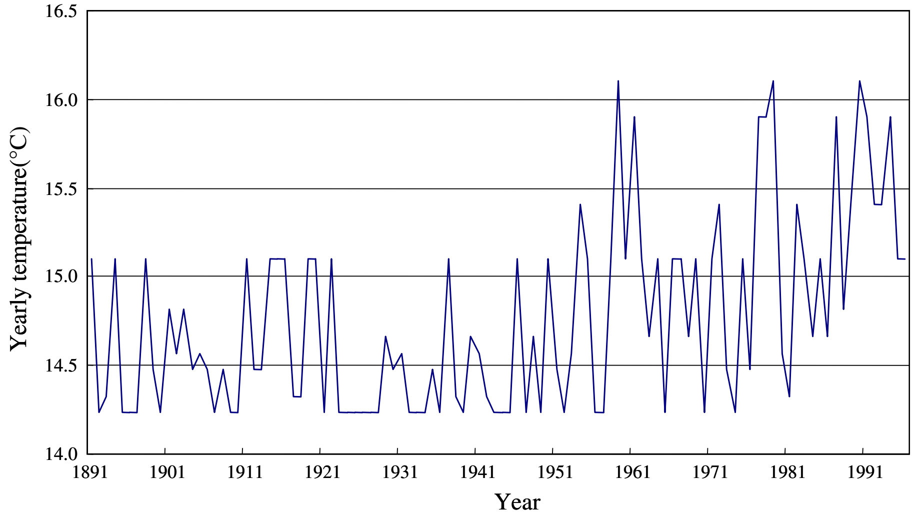

Fig. 1. Classified pattern sequence of atmosphere temperature.

distribution, El-Nino or La-Nina because the precipitation is produced through the relation between solar radiation and moisture behaviors in atmosphere and marine zones. The high temperature situation on equator generates many and strong typhoons with much rainfall. The Japan and Chishima ocean currents decide the location of rain front providing high atmosphere and low temperature in Japan, respectively.

New technologies of not only numerical analysis but also artificial technologies are requested to estimate the detailed climate change in meteorological and hydrological aspects and take down scaling into the designated area.

3. River basin simulation with distributed runoff model

The river basin is modeled with multi-mesh and multi-layer-typed runoff model combined with GIS data. As the whole river basin must be considered, the basic mesh consists of squares and only one and straight channel exists in a mesh according to the digital elevation map. The mountain, paddy field, urbanized zones are decided with their occupation ratios under the classified infiltration rate. Regarding to the paddy field, the intake discharge volume from river, the distribution procedures and storage (or overflow) process are formulated through the linear storage method concept. Secondly, the concentrations of water qualities in the river channel are calculated through diffusion and emission processes. As the water temperature is also one of the most important factors for creatures in rivers, it is analyzed by considering the heat balance of air temperature, soil temperature and heat conductivity between atmosphere, groundwater and soil in the ground. Finally, the impact of global warming on water resources is estimated under the assumption of global warming scenarios.

Fig. 2 shows the proposed mesh-typed multi-layer runoff model in river basin. For water quantity, the heat balance method is introduced to calculate the evaporation and snowmelt at each mesh and at each day. On the runoff process, the runoff model is applied with the kinematic wave method for surface and the linear storage method for ground water of first to forth layer (Kojiri et al., 1998; Kojiri and Kobayashi, 2003).

For water quality, the water temperature and water pollutant are analyzed from an environmental viewpoint. The water quality is assumed that the sewerage water from the factories or houses flows down into the river through individual treatment tank, combined treatment tank, or sewerage network for agriculture. The inflow concentration of waste water to the river is calculated according to pollutant load per unit activity. The waste water from non-point source is also obtained through weighted mean interpolation at each land use as follows (Kunimatsu and Muraoka, 1990):

$$L_{\mathrm{np}} = \frac{\sum L_{\mathrm{npu}} A_{\mathrm{u}}}{A} \tag{1}$$

where L_{npu} is the released load unit of non-point pollutant for land use u (mg/m^2/day), A_{u} is area of land use u (m^2). The traction load of piled material from non-point source is represented in proportion to the square of runoff height as follows:

$$L_{\mathrm{swp}} = k_{\mathrm{wnp}} P_{\mathrm{np}} Q_{\mathrm{h}}^2 A \tag{2}$$

where Q_{h} is the horizontal runoff height (m/h), k_{wnp} is traction coefficient due to non-point source (h/m^2), P_{np} piled pollutant load (mg/m^2) (Kunimatsu and Muraoka, 1990). The outflow and inflow load (mg/h) are formulated as follows:

$$-\text{outflowload} - L_{\mathrm{vout}} = \sum C_{vi} Q_{\mathrm{out}} A \tag{3}$$

$$-\text{inflowload} - L_{\mathrm{viin}} = \sum (C_{\mathrm{w}} Q_{\mathrm{in}} A + L_{\mathrm{swpw}}) \tag{4}$$