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YRiS Yellow River Studies

News Letter Vol.1

September 1, 2003

(1) Preface

Since we have learned that the Yellow River dried frequently up in 1990's, Professor Changming Liu, Chinese Academy of Sciences, and myself talked about this situation in the scientific committee of IGBP/BAHC held in once a year under the leadership of Professor Pavel Kabat. As we lived in Asian region, we should tell the community not only scientific results, but also a process of our activities involving relevant community much more. We are also sure that such an activity will contribute people who are suffering from water shortage.

As a kick-off meeting, we have held an International Workshop of the Yellow River Studies in Kyoto on January 27-29, 2003, with

Fig.1-1 The Yellow River Basin

colleagues more than forty including twelve guests from overseas. The reason why we have written "Studies" is that Professor Changming Liu is now conducting Chinese National project named as No. 973 which is planned to analyze modern Yellow River problems, as a leader, and I have two different research funds for the implementation of the Yellow River issues. One is a project of RIHN itself which consists of field observations and analysis in the research fields of atmosphere-land interaction, land-ocean interaction, and the evaluation of human activity to water circulation, starting from 2002 to 2007. Other is a project of modeling development of water use and water resources issues in the Yellow

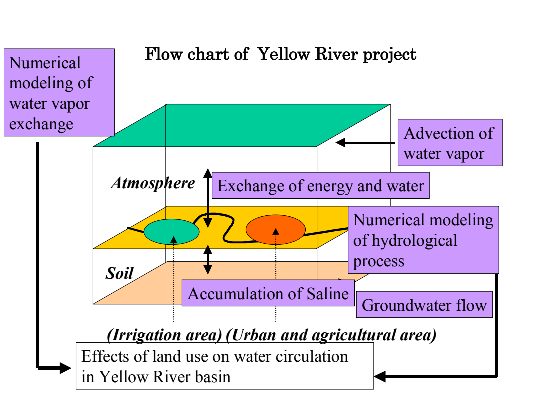

Fig.1-2 Overall research framework

River domain, as a part of Revolutionary Research Project funded by MEXT, during five years from 2002. I was very excited and pleased to hear many expectations from all of participants of the workshop. As a representative, I have promised to publish News Letter by internet. I'm very glad that a brochure of our study plan has published on July.2003, and News Letter No.1 is now ready by efforts of Professor Makoto Taniguchi, RIHN. I'm eager that those publications are useful for information exchange and something to get and to be close to our study target, each other.

(Yoshihiro Fukushima, RIHN)

(2) The Study Regarding Water Cycle Mechanism in the Yellow River Basin - News from China's Yellow River Studies

The Yellow River Basin is located between 96°－119°E and 32°－42°N, 1,900 km from west to east, 1,100 km from north to south and covers an area of 752,443km^2. The Yellow River, being the second largest river in China, is supplying water for 15% cultivation land and feeding 12% population of the whole China with only 2% of the total runoff of all rivers in China. Lying mostly in arid and semi-arid area and affected by human activities and unfavorable climate, the Yellow River Basin is characterized with draught and brittle ecological environment.

To harness the Yellow River has been a great issue for China, scientists have make progress in sediment, flood control and water resources development. With the ongoing of the project of Maintaining Renewable Capacity of Water Resources in Yellow River Basin (one of "973" PROJECT 19990436-01), it gives a precise and in-depth analysis of the formative factors of the water crisis in the basin. Research on water cycle mechanism and its influence elements was carried out by means of indoor simulation, distributed hydrologic model and remote sensing analyses in three levels of small, mid and large scale at different patterns in time and space, the research provided effective theory and technical methods to study water resources problems in the Yellow River.

2-1. Experimental Study on the Mechanism of Runoff Generation and Routing in Laboratory

The condition of sloping runoff in the Yellow River was simulated to carry out experiment on precipitation and runoff mechanism, 400 experiments on precipitation and runoff were carried out in the lab of the Institute of Geographic Sciences and Natural resources Research, new knowledge about non-linear theory of runoff were achieved:(1) The time that precipitation lasts had obvious non-linear effects on the runoff process. (2) The non-linear function existed at a critical point or zone. Experiment observed that the critical point was runoff concentration time of the whole basin. When the precipitation time was shorter than the runoff concentration time of the whole basin, the non-linear function exists and was evident, contrarily, the runoff generation system turned to be a linear system, and the nonlinear system changes into a linear system.

2-2. Study on the Distributed Hydrologic Model in the Yellow River Basin

The Xiaolangdi in the Yellow River to Huayuankou (Xiaohuajian), the upper reaches of Luohe River, was chosen to develop Distributed Hydrologic Model due to runoff generation and routing characteristics. Based on the 1971-1996 experiment datum, Distributed hydrologic model was established at day and hour scale. The main results were as follows:

(1) Distributed hydrologic model was established to the study area coupled with DEM and GIS. (2) Distributed hydrologic model based on day runoff process was set up to water resources management purposes. (3) A Distributed hydrologic model system based on module structure（MDHMS）was established which includes four parts, database, data pretreatment hydrological model and data

treatment.

2-3. Study on Remote Sensing of Water Cycle in the Yellow River Basin

Based on remote sensing data and ground observation data, remote sensing analyses research was carried out in water cycle elements, such as evaporation, precipitation, soil moisture, land cover, and vegetation cover etc. advances in the study were as follows:

(1) Based on remote sensing and monitoring datum during 1982-2000, soil moisture (0-20cm) was estimated in the Yellow River. Evaporation at spatial distribution and dynamic time change of evaporation and evapotranspiration were also estimated. (2) Based on NDVI, evaporation was estimated for last 20 years in the whole Yellow River Basin. (3) Based on the AVHRR pathfinder datum, precipitation in the mouth of the Yellow River was estimated by means of remote sensing calculation method, and 1hour, 3hours, and 5hours precipitation were observed respectively. (4) Information including 1982-1998 AVHRR pathfinder datum, soil moisture datum of 29 agricultural weather stations during 1982-1998, precipitation and evaporation datum of 263 weather stations were employed to retrieve soil moisture (0-1m) during 1982-1998 of the whole basin. (5) Ground Humidity Calculation Model was established and validated. The ground humidity condition was estimated in the area of the middle reaches of the Yellow River.

(Notice: There are 8 subprojects undertaking concurrently. The above information is from first subproject only.)

(Changming Liu)

(3) Bohai Sea Study Project

Variability of the river discharge from the Yellow River is very large, that is, between 5,000 m^3/sec in early 1960 and 0 m^3/sec in late 1990, but the effect of such large variability to the marine environment in the Bohai Sea has not been clarified yet. The objective of this project is to elucidate the effect of variability of Yellow River discharge to the marine environment such as water temperature, salinity, current and lower trophic level ecosystem in the Bohai Sea.

The participants of this project are T. Yanagi (Kyushu Univ.), X. Guo (Ehime Univ.) and M.Hayashi (Kobe Univ.) from Japan and Prof. Gao and other staffs of the Ocean University of China.

The methodology is 1) to conduct intensive field observations two times in the Bohai Sea, 2) to develop a numerical hydrodynamical model of the Bohai Sea, 3) to develop a numerical ecosystem model of the Bohai Sea, 4) to gather visible and infrared satellite images during 1 year in the Bohai Sea, and 5) to synthesize the results of 1) - 4). The expected results are the difference of marine environment such as temperature, salinity, current and lower trophic level ecosystem in the Bohai Sea between high river discharge and low river discharge from the Yellow River. In the fiscal year 2003, we will develop numerical hydrodynamical and ecosystem models of the Bohai Sea and to gather visible and infrared satellite images of the Bohai Sea. In the fiscal year 2004 and 2005, we will conduct intensive field observation in September 2004 and in

March 2005 in the Bohai Sea. In the fiscal year 2006, we will reproduce the results of field observations by the numerical hydrodynamical and ecosystem models and to compare the reuslts of field observations with satellite images. In the fiscal year 2007, we will synthesize the results.

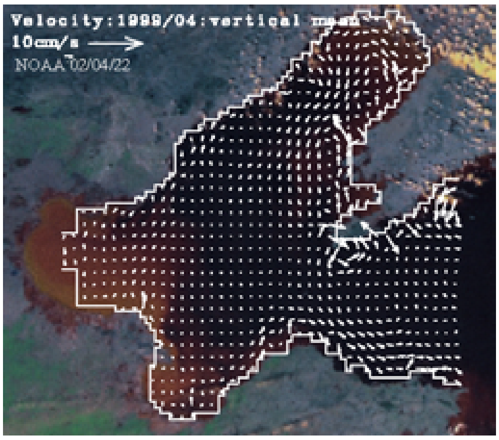

Fig.3-1 Velocity in Bohai sea

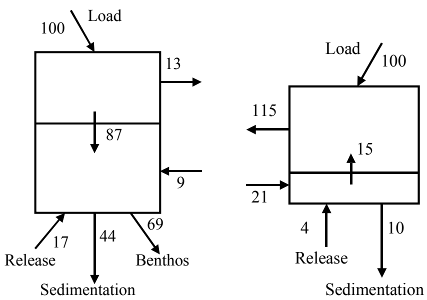

Fig. 3-2 Ecological models for weak or strong circulation

(Testuo Yanagi, Kyushu University)

(4) Interactions between groundwater, river water and seawater in the Yellow River delta

The Yellow River does not reach often to the Bo-Hai Sea since 1970's because of huge amount of water uses for irrigation at midstream. Shortage of river water induces water pollution, decrease in groundwater level, and decrease of nutrient transports to the Bo-Hai Sea. The purposes of this study are; (1) to evaluate groundwater and river water discharges and their dissolved material transports into the Bo-Hai Sea, (2) to evaluate the effect of recent Yellow River cut-off due to changes in land utilization and water management on groundwater and Bo-Hai Sea, and then (3) to evaluate the interactions between Yellow River, groundwater, and Bo-Hai Sea in the delta. Studies on land-ocean interaction in the Yellow River Delta are planed from 2003 to 2006 though; (a) measurements of chemical components of water in the Yellow River, and (b) investigations of the groundwater and coastal water in the Yellow River Delta. River water will be collected at Lijin for chemical analyses (DIN(NO_3, NO_2, NH_4), DIP, DON, DOP, TN, TP, Si, DO, pH, SPN) to evaluate the transports of dissolved materials to the Bo-Hai Sea through Yellow River. Interactions between groundwater and seawater in the Yellow River Delta will be evaluated using 10 automated seepage meters, CTD in 10 boreholes, resistivity cables, and fiber thermo-radars. Chemical analyses of submarine groundwater seepaged into Bo-Hai Sea will be made for isotope components (O-18, Deutrium, C-14, N-15), and dissolved components. Feasibility study in the Yellow River Delta had been made on August 2002. Groundwater and water of the Yellow River in the delta were analyzed for isotope components and dissolved components.

The participants of this project are M. Taniguchi (RIHN), J. Chen (RIHN), S. Onodera (Hiroshima Univ.), K. Miyaoka (Mie Univ.), T. Tokunaga (Univ. Tokyo), W.C. Burnett (Florida State Univ.) and Prof. Gao, Prof. Liu, Prof. Mi and other staffs of the Ocean University of China.

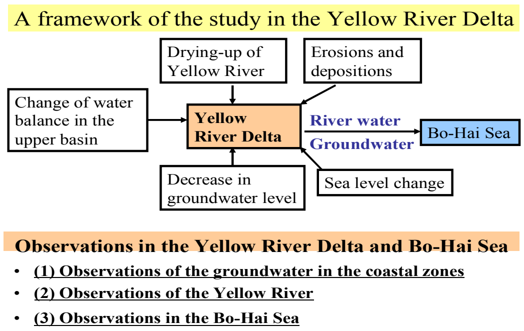

Fig. 4-1 Framework of the studies in the Yellow River Delta

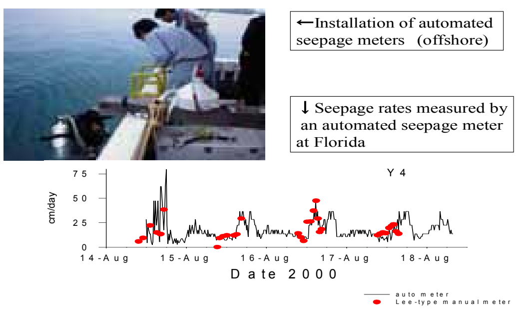

Fig. 4-2 Seepage meter measurements

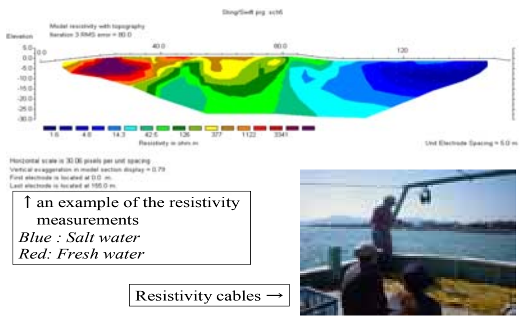

Fig.4-3 Resistivity measurements

(Makoto Taniguchi, RIHN)

(5) Socio-Economic Transition and the Future Water Resource Demand and Supply in the Yellow River Basin: Natural and Human-Induced Water Cycles and Sustainable Development

5-1. Scarcity of Water Resources and Sustainability

The future water supply and demand in the Yellow River Basin will be determined by the balance between constraints on supply and the pressures of growing demand. If one is thinking on a long-term scale of 30 to 50 years, the impacts of global climate change may also become apparent. With the recent trends in northern China toward greater aridity and desertification, there is a concern about serious desertification and reductions in rainfall in the catchment area at the source of the upper Yellow River. It is feared that in the long-term the existing shortage of water resources in the Yellow River Basin will even worsen. There is little likelihood that the Basin will find fundamental solutions to the supply constraints in the absence of large-scale water diversion projects such as the South-to-North Water Transfer Project. This means that the need for demand control will increase. These will require a drastic efficiency improvement of water utilization through water conservation and recycling, and there are concerns that these requirements could become bottlenecks for economic growth.

When all is said and done, the future sustainability of economic growth and water supply and demand comes back to the question of how much water use efficiency can be improved. More specifically, to what extent water consumption per unit of production (unit consumption) can be reduced in the agricultural, industrial, and urban domestic sectors. If a shortage of water occurs, agricultural and industrial production will be obstructed, and this will also suppress urban population growth. In such a situation, the issue of which region and which sectors should be allocated the limited water resources becomes an important topic for China's regional developmental policies.

5-2. Conflicts among Agricultural, Industrial and Domestic Water Demands

Until now, industry and urban lifestyles were given high priority in water allocation, and the agricultural sector was expected to accept severe water restrictions. This dynamic was possible because of the belief that industrial expansion was absolutely necessary for economic growth. It was also grounded in the presumption that the agricultural sector had not yet rationalized and boosted water-use efficiency to the extent possible, and that if more thorough efforts were made to save water so that it was only provided when absolutely needed for crop growth, there was still considerable potential to limit the use of water. However, there is a physical limit to the water conservation, and that might give greater constraints on food production. Besides the above, water is needed to maintain natural ecosystems, in terms of "environmental water". If humans were to use every drop of rainwater that falls, it would be impossible for forests and grasslands to sustain themselves. Dams also need a certain amount of water discharge in order to let sediment flow through.

5-3. Conflicts among Upper, Middle and Lower Reaches

The lower reaches of the river have the severest water scarcity. Here, water shortages are chronic as a result of heavy water consumption upstream and midstream, but the same areas also face the threat of flooding during abnormally heavy rains. In contrast, the areas with the highest population density are in the chain of midstream provinces (Shanxi, Shannxi, Gansu), which include tributaries such as the Weihe and Fenhe rivers. Development is relatively delayed in this region, and its people look forward to industrialization and urbanization as a result of the China West Development Strategy policies. Awareness today in this region about water scarcity is not as high as those in the downstream area, but if industrialization and urbanization proceed as quickly as it is hoped, water demand here will increase, leading to strained agricultural water supplies here. Clearly, growing water demand in the midstream region will worsen water scarcity downstream. In addition, sedimentary runoff occurs greatest from the midstream region. Thus, in the context of the Yellow River's water supply and demand issues, one could say that the midstream area is the most important region.

5-4. Study Framework

Based on the above considerations, this study focuses on the midstream area of the Yellow River, or Weihe river basin including Xian City and its suburbs, in particular, and analyses the water resource demand and supply balance in the context of changing socio-economic conditions in the region. It will try to establish a model to predict the changes in activity levels and unit consumption, based on given assumptions about the macro-level frame of social and economic transformation in the region and China as a whole. For demand, future predictions are needed for both activity levels and unit consumption, but in reality both are in a mutual feedback relationship. For example, if industrial production increases, water demand increases; however, at the same time, the industrial sector also modernizes, so unit consumption declines due to technological progress. Also, due to growth in the industrial sector, investments to make agriculture more modernized become possible, and unit consumption in the agricultural sector thus declines. The model will take into account these multiple feed back systems.

The objective of this study and its methodology are demonstrated in the Fig.5-1 and Fig.5-2, respectively.

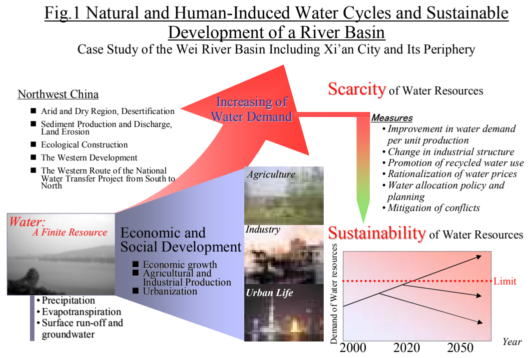

Fig. 5-1 Natural and Human-Induced Water Cycles and Sustainable Development

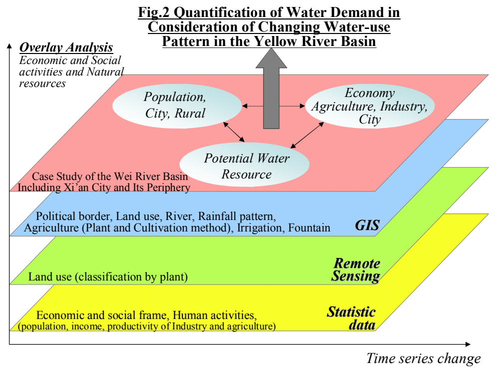

Fig. 5-2 Quantification of Water Demand in Consideration of Changing Water-use Pattern

(Hidefumi Imura, Nagoya University)

(6) Research Group on "Land-Surface & Atmospheric Boundary-Layer Processes"

The purpose of our research group is re-evaluation of water cycle system in the Yellow River Basin by means of atmospheric boundary layer (ABL) observations over "Loess Plateau". In order to achieve the purpose, we will analyze processes in development of convective boundary layer and generation of cumulus clouds by using cloud resolving models on the basis of the ABL observation data. We will also analyze satellite remote sensing data to diagnose the land surface conditions around the target region. The improvements of parameterizations schemes in the processes of ABL, cloud physics, and precipitation systems over a dry-and-high altitude region will be our final goals.

The ABL measurements will be employed at the meteorological field of the "*Changwu* Agro-Ecological Experiment Station on Loess Plateau, Chinese Academy of Sciences" locating at N35° 12′ , E107° 40′ . The measurements include the surface flux observations of momentum, sensible heat, latent heat, and carbon dioxide. We will establish a 10-m height flux tower on the center of the research field (Fig.6-1), on which three sets of ultra-sonic anemometer-thermometers and infrared H_2O/CO_2 gas analyzers will be installed. Also included in the ABL observations are the profile measurements of three-dimensional wind speed components, air temperature, and absolute humidity in and around 30 minutes' intervals. Those data will be obtained by a wind profiler radar and a microwave water vapor radiometer. In addition, fine resolution (both in time and in spectral) radiation measurement system will be installed at the same station. This system will be used for the improvement of local surface characteristics of optical satellite measurements. The observations will be carried out continuously from 2004 to 2007 (more than two years).

As one of the product of our research group, we can obtain plenty of data sets on the ABL measurements over the "Loess Plateau". Flux data set will be opened for the FluxNet community. These obtained data sets can be used for the re-evaluation of parameters on ABL turbulence, entrainment process, and cloud physics in cloud-layers, using a cloud resolving models (CRMs). Improved parameterization schemes can be added to regional climate models (RCMs) and re-evaluation of water cycle system in the Yellow River Basin can be achieved. These new parameterizations are possible to apply hopefully for the re-evaluation of water cycle system in the Yellow River Basin.

Fig. 6-1 Establishment site proposed for the flux and radiation observation tower and wind profiler radar at *Changwu* Experiment Station.

(Tetsuya Hiyama, Nagoya University)

(7) Clouds, precipitation, radiation and land use

Precipitation, radiation and land use data are quite important for understanding change in water cycle in Yellow River basin for the past few decades. These data are archived by using satellite and ground-based observations. 0.1°x0.1° high resolution daily data set will be obtained from the analyses of collected data, and will be used to investigate the relationship between changes of human activities and natural environment. Also those data will be used as input data to model studies.

Precipitation data are archived mainly from the rain gauge measurements on the ground surface. High resolution data set will be obtained by interpolating the original data which are spatially inhomogeneous. The quality of interpolated data is checked by comparing with satellite data such as GPCP and objective analysis data. Precipitation data are also compared with cloud and water vapor distributions as obtained from satellite observation such as ISCCP or from objective analysis data such as ECMWF data.

Shortwave and longwave radiation budgets are important for evaluating the sensible and latent heat fluxes on the earth's surface. Utilization of satellite data, particularly of cloud data, is indispensable for this purpose. Satellite data are suitable for the project because some of those data are available for the last two decades. For example, ISCCP data since 1982 are available, from which surface radiation budgets have been already estimated with 1°x1° resolution although the archived period is limited. However, some new improvements are needed for 0.1°x0.1° spatial resolution even if the radiative transfer technique is applied to cloud and other atmospheric data for estimating surface radiation budgets. On the other hand, direct measurements of radiation on the ground surface are quite poor to cover the whole Yellow River basin so that those measurements are used to validate results estimated from satellite remote sensing. Most of shortwave radiation measurements are sunshine duration in China. Statistical approach may be useful to merge these ground-based measurements and satellite data.

In addition to precipitation and radiation, land use map is obtained by using satellite data such as NOAA/AVHRR and LANDSAT. Land use change for the past few decades will be analyzed from the viewpoint of human activity such as agriculture. Since the atmosphere and climate are closely related to land use change, comprehensive studies will be carried out with the results of precipitation and radiation analyses.

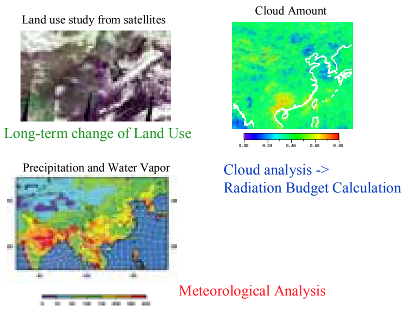

Fig. 7 Meteorological analyses

(Tadahiro Hayasaka, RIHN)

(8) Development of Agricultural Land and Water Management Model for the Yellow River Studies

Agricultural sector uses much water resources in the Yellow River Basin for as well as other basins in the world. Much water is diverted from the main stream of Yellow River to the irrigation scheme, and most of it does not return to the main river, while much water is consumed in the irrigated fields by evapotranspiration and deep percolation to groundwater. Land and water management in the agricultural production regions, especially in the larger irrigation districts, determines amount of withdrawals of water from the main stream and return flow to it, and definitely affects the hydrological regime of the river. To improve the basin management of Yellow River, it is essential to assess the water management and water balance of irrigation schemes.

On the other hand, from agricultural points of view, assessment of water management in irrigation district is also required to increase water use efficiency and to save irrigation cost, simultaneously with land and cropping management evaluation, which is inseparably connected with water management. Especially in arid areas, since irrigated land might suffer from soil salinity problem, appropriate soil and water management is crucial issue.

For example, the Hetao Irrigation District in the Inner Mongolian Autonomous Region, which is the largest irrigation scheme in the Yellow River Basin, diverts about 5 billion m^3 of the Yellow River water to its irrigated fields of about 600 thousand hector annually. It is considerably a big amount, compared with the annual discharge of the Yellow River at the diversion points, which is around 35 to 40 billion m^3. While water use in this region affects water use in the downstream regions, the water balance of this district is not clear. In this irrigation district, agricultural production has been suffering from soil salinization problem. According to the continued field reclamation program with field measurement and analysis on soil and water movement from soil hydrological aspect, the soil salinity problem has been gradually alleviated. The most effective measure to control salinity problem is to leach out the accumulated salt with much water application to field. The salt balance of the whole district, however, is also not clear as well as water balance. To save water resources in the basin, the diversion amount allocated to this district is to be reduced from 5 billion m^3 of the previous to 3.8 billion m^3 of the future per year. The question is how can the reduction be realized and what will happen in the future.

In the research module for development land and water management model in the Yellow River Studies, based on diagnostic studies review of the previous research results on land and water use in agricultural production areas, especially in the larger irrigation schemes, land and water use models are to be developed or modified to evaluate water balance of several extents of agricultural production area; plot, farm, irrigation district, and agricultural production region. These models are to be connected with GIS platform, and to be combined to the land and water management model, which is set up in the basin hydrology model. The land and water management model could assess the vulnerability of land and water use, predict the future changes of water balance with changes of land and water management policies and practices, and also could identify effective measures for wise use of the resources.

This research sub-module is being implemented in the collaboration with the Agriculture Sub-Group of the CREST Yellow River Research Project funded by JST, both of which sub-group head is Dr. Tsugihiro Watanabe of RIHN.

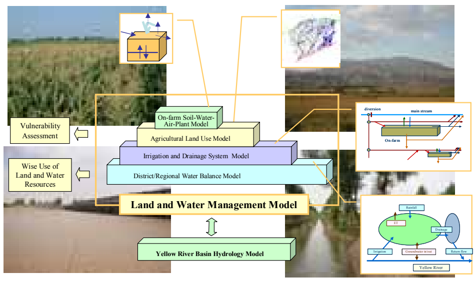

Fig. 8 Development of land and water management medel

(Tsugihiro Watanabe, RIHN)

(9) A Study Plan of Modeling Group

The Yellow River basin which is situated in a dry climate region has a high population density with agricultural development in the downstream. The drying-up of the Yellow River in 1990's has surprised people because it is the second largest river in China and one of historically recorded river in the world . Is it an effect of the decrease of precipitation amount due to global warming or an effect of the overuse of river water to agriculture? The answer is not so simple because both causes have affected in the same time. Understanding of the processes which are occurred in the Yellow River might give us a knowledge on agricultural and environmental issues in contemporary and future for countries which have similar climate condition and suffer from instability in water use.

Not only process studies are required to evaluate the relationships between causes and results from investigation and analysis, but also macro-scale water budget studies for the whole Yellow River basin are needed. Modeling works may be classified in two components. The first one is a modeling work on/under land surface, and the second one is a modeling work of the circulation of water vapor in atmosphere. The former is used to be called as hydrological model but we are keen to develop a "water resources model" from a hydrological model already developed and validated in Siberian Lena River basin, because it should combine with the practical water uses like control of river water in reservoir system, irrigation and so on. Groundwater is also an important factor because it changes each other from surface water as a natural system and it's amount decreases usually by pumping water up from wells in agricultural field like Northern China Plain. A water resources model is to be validated by using twenty years daily data from 1981 to 2000 with the resolution of 0.1 degree grid including the changes of land use. The latter, a model of atmospheric circulation is also a principal component because recycling process of water vapor induces re-precipitation. In particular, we don't know enough a cloud-precipitation process in the Yellow River domain as a dry region. Both models should be combined as a synthetic energy and water circulation model. As a final result, effects on water circulation considering changes of land use are to be discussed on the model based upon different scenarios of land use.

Although Yellow River Studies are executed by using different two funds, the modeling group is established for a cross-over role between both funds.

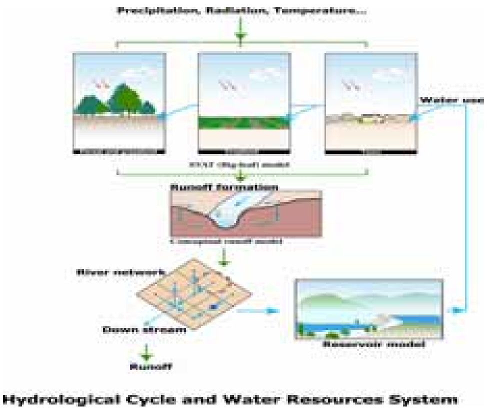

Fig. 9 Integrated model for hydrology and water resources

(Yoshihiro Fukushima, RIHN)

(10) Research activities at Uppsala University related to "Recent rapid changes of water circulation in the Yellow River and its effects on the environment"

Climate-change research has gradually been related to questions of water resources, population growth and biodiversity. These interrelated questions are all central to the development in the Yellow-River basin. Global-change research in Uppsala addresses two fields that have not been in international focus but that are relevant to the Yellow River: Hydrological modeling and downscaling of GCM scenarios that work in cold regions and in regions where data availability is not as good as in parts of the U.S.A. and Europe where many models and methods originate. The Uppsala group is working on a global hydrological model and intends to test a regional version of it on the Baltic-Sea and the Yellow-River continental-scale basins. For this reason we suggest the following two subprojects as contributions to the joint international Yellow-River project. We name them Upp-1 and Upp-2 for the sake of future correspondence.

The Uppsala group is open for collaboration and we are looking forward to establish contacts with hydrologists, climatologists, and meteorologists working both in the Baltic-Sea and the Yellow-River regions for data exchange and model comparison/development.

10-1. Upp-1: Effects of climate change in wintertime, at high latitudes and in data-sparse marginal areas. Macro-scale hydrological modeling.

This newly-started project intends to explore continental-scale hydrological models for streamflow simulation. Emphasis will be on parameter-value estimation since extra care must be taken when parameter values are transferred over regions and scales.

Our global hydrological model, WASMOD-M (Water and Snow balance Modeling system at Macro-scale) is a further development of the catchment-scale WASMOD (Xu, 2002). WASMOD was taken as our starting point since it works with a flexible time step (from day to month), has been proven to give good results at different spatial scales (small to medium-size catchments), and can accept input data of different quality depending on the availability and climatic boundary conditions (Xu, 2002). It has few parameters, all of which can be related to physical catchment characteristics at different spatial scales. It has been successfully applied to ungauged catchments (Xu, 1999, Müller-Wohlfeil *et al.*, 2003). WASMOD-M will first be run on the global scale. In a second stage, we will develop it with higher spatial resolution for application on continental-scale catchments such as the Yellow-River and the Baltic-Sea basins. The first global-scale results are expected in the second half of 2003.

10-2. Upp-2: Modeling extreme values of precipitation with statistical downscaling

Output data from general-circulation models (GCMs), run in climate or weather-forecast modes, are not directly applicable to hydrological modeling. GCM climate scenarios produce large-scale circulation patterns that can hopefully be trusted. Local- and regional-scale hydrological models require GCM-generated circulation patterns to be transformed to hydrologically relevant variables, specifically precipitation, at the local scale. Statistical downscaling is a tool for doing this that is computationally cheap and can be performed by small research groups, whereas dynamical downscaling requires large resources and can only be performed at major climate-research institutes.

In Upp-2, we compare and evaluate 4 statistical downscaling methods:

- Multiobjective fuzzy-rule-based classification (MOFRBC, Stehlik & Bardossy, 2002)
- Nonhomogenous hidden Markov model (NHMM, Hughes *et al.*, 1999)
- Statistical downscaling model (SDSM, Wilby *et al.*, 2002)
- The analogue method (Zorita *et al.*, 1995)

The analogue method will be used as a benchmark for the other, more sophisticated methods (Wetterhall *et al.*, 2003). Tentative results have already been achieved for the upper parts of the Yellow-River catchment on the basis of MOFRBC method (Fig. 1). These, as well as similar results from central Sweden, indicate that the spatial variability of extreme values is captured both by the analogue method and MOFRBC.

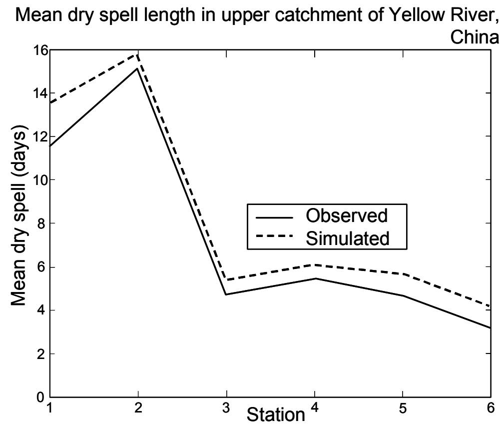

Fig.10 Mean dry-spell length for 6 stations in the upper part of the Yellow-River basin during the years 1961-1965. Observed (NCEP/NCAR reanalysis data; solid) and modelled with MOFRBC (dotted).

(Halldin, S., Xu, C-Y., Wetterhall, F. & Widén, E., Uppsala University)

(11)Groundwater Inputs in the Yellow River – Bohai Sea System: Natural Isotopic Tracers

The reduced discharge of the Yellow River over the past several years because of agricultural demands is well known. However, the role that groundwater inputs play in delivering fresh water and nutrients to the nearshore waters is not clear. The Research Institute for Humanity and Nature (RIHN) research project, "Recent Rapid Change in Water Circulation of the Yellow River and Its Effect on the Environment" has several objectives, one of which is to clarify the role that groundwater plays in the water/nutrient balance of the coastal waters of the Yellow River. Groundwater is now known to be an important source of biogeochemically important constituents to some coastal waters. Are nutrient fluxes from groundwater important in the Yellow River – BoHai Sea system? How do groundwater inputs respond to decreasing river discharges? These are some of the questions we will set out to answer using natural decay-series isotopes as tracers of groundwater-seawater interactions.

We will use two approaches that are both based on measurement of natural decay-series nuclides (radon and radium) as indicates of groundwater inputs. We will attempt to evaluate the magnitude of groundwater flow by continuous measurements of ^{222}Rn, naturally enriched in groundwater relative to seawater. Using a mass balance approach, we calculate radon fluxes from the seabed from the change in measured inventories over time. Once the radon fluxes are established, we can estimate groundwater fluxes by dividing the radon fluxes by the concentration of radon in the discharging groundwater (Fig. 11-1).

In order to quantify the exchange between the coastal zone (with components from both river and groundwater discharge) and the Bo-Hai Sea, we plan to use natural radium isotopes, especially ^{223}Ra and ^{224}Ra that have half-lives (3.66 d and 11.4 d, respectively) on the same time scale as mixing rates in many near-shore environments. This approach works because there are inputs of these isotopes in the near-shore waters from the river and from groundwater and there should be almost none in the open sea away from these sources (Fig. 11-2).

A residence time (average length of time since the water acquired these tracers) may be calculated if the initial isotopic composition is known and assumed to be constant. In practice, the sampling usually consists of a transect or a series of transects extending from the coastline out to sea to cover the entire mixing profile. Because of the highly seasonal discharge of the Yellow River, the length of such a transect will vary tremendously. Once the samples are collected and the measurements made, a residence time can be estimated from the following equation:

$$^{224}Ra_{obs} = {}^{223}Ra_{obs}\left(\frac{^{224}Ra}{^{223}Ra}\right)_i \bullet \frac{e^{-\lambda_{224}T}}{e^{-\lambda_{223}T}}$$

where T is the residence time in days, $(^{224}Ra/^{223}Ra)_i$ is the initial isotopic ratio, and λ_{224} and λ_{223} are the decay constants of the respective isotopes of radium.

Groundwater discharge into the coastal environment has been an overlooked process that may have several connections to real-world coastal problems (nutrient loading, harmful algal blooms, etc.). It is not an easy process to study and should be approached in a systematic, concentrated manner. Such studies should be integrated with land use and other coastal investigations to discern the most important linkages (Fig. 11-3). The upcoming Yellow River project represents a unique opportunity for such an approach.

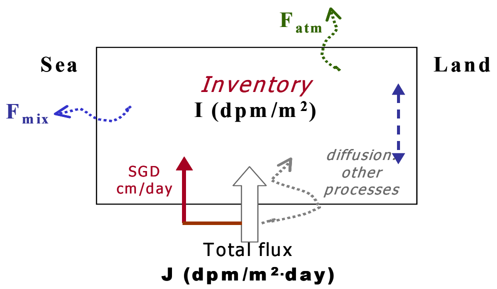

Fig.11-1 Conceptual model illustrating the mass balance approach for estimating seabed radon fluxes in a well-mixed coastal system.

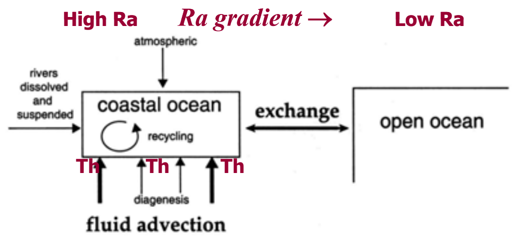

Fig. 11-2 Diagrammatic view of how natural short-lived Ra isotopes (daughters of Th isotopes in sediment) can be used to quantify mixing between coastal and offshore waters. Figure modified from Moore (2000)

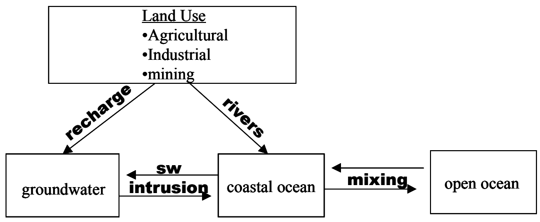

Fig.11-3 Linkages between land use, coastal aquifers, and the ocean. Effects measured in the ocean may be consequence of activities in the interior with a groundwater pathway

(W. C. Burnnet, Florida State University)

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