# A Study of Water Cycle and Water Resources Security Using Isotopic and Remote Sensing Technologies in North China Plain

Xianfang Song, Jun Xia and Jingjie Yu

Key Lab. of Water Cycle & Related Land Surface Processes,
Institute of Geographic Sciences & Natural Resources Research,
Chinese Academy of Sciences (CAS), 100101, Beijing, China

## Introduction

Since 1980's, dramatic increases in water and unplanned groundwater development along with rapid growth in urban population have caused some critical water and eco-environmental problems such as both the water resource and runoff in the mountain areas have substantially decreased, drying-up of river system, large water level depression by over pumping, subsequent increase in potentials of land subsidence, lake & wetland degradation, and water pollution in plain area etc. It was shown in the case of Haihe River Basin that among the total rivers of 10,000 km, the rivers of 4,000 km have been turned to be seasonal rivers. Comparing with the beginning of 1950s, the wetland area within the Basin decreased from 10,000 $km^2$ to 1,000 $km^2$ at present. Over-extraction of groundwater, this area covers nearly 90,000 $km^2$, 70% of the plain areas. Comparing with that of the end of 1950s, the accumulated over-extracted groundwater is 90 billion $m^3$. Water and soil loss area in mountainous region□110,000 km2, rating two thirds of the mountainous area. The sandstorms induced by desertification endangering Beijing and other cities. Thus, the problems of water shortage and related eco-environmental issues in North China have become the most significant issue to impact sustainable development in this very important region that are political, cultural and economic center of China.

To study these urgent issue in North China, Chinese Academy of Science (CAS) has supported a Key Project, namely Water Cycle and Water Resources Scurety in North China, with total budget of 110 million USD from 2002-2005, leading by Prof. Xia Jun, Director General, Key Laborotoary of Water Cycle & Related Surface Processes, CAS.

## Objectives

By cooperation of the key project founding by Chinese Academy of Science and the facilities from Key Laborotoary of Water Cycle & Related Surface Processes, CAS, and other international cooperation preojects, we try to focus on Integrating Watershed and Aquifer Dynamics to understand interaction between groundwater and surfacewater, and provide recover ways for urgent groundwater degredation due to over exploiation.

## Methods

Two research lines are selected: one is the most important area, where is the capital area of China, from Yanshan Mountain to Bohai Sea; another one is farm area, where is most important food area, from Taihang Mountain to Bohai Sea. A scheme of research is following (Fig. ). The first step is hydrological field investigation by using environmental tracers, remote sensing and GIS. The environmental iostopes are defined as those isotope, which are either naturally present or artificially produced and released, and become distribued in the environment by natrual processes and are thansported with water through the hydrological cycle. Environmental isotopes, and water quality either natural or pullted could be used, according to field experience in different topogaraphies in Japan, Indonesia and Sri Lanka, as effective trcers for groudwater flow investigation.

## Environmental tracers

### Radioactive isotopes

Tritium and Carbon-14 are very usful tracers. Tritium is a radioactive isotopic specics of hydrogen with half life of 12.43 yr. Th natural source of tritium is in the stratosphere and the tritium is supplied from the stratosphere to the troposphere through the tropopause in the higher latitude zone. Therefore the natural level of tritium concentration in precipitation is high in the polar zone and low in the tropics,. The same is stratosphere in the northern hemisphere. The high tritium concentration in precipitation hasbeen used as a tracer for water cycle mostly in the middle and high latitude zones in the northern hemisphere. Carbon-14 is a radioactive isotopic specics with half life of 5730 yr, it is exyebsively applied in hydrogeology and date groundwater. Natrural production in upper atmosphere is balanced by decey and burial to maintain a steady-state atmosperic $^{14}CO_2$ activity of about 13.56 disibtegrations per minute (dpm) per gram of C or about 1 $^{14}C$ atom per 1012 stable C atoms. However, the high neutron fluxes associated with the explosion of nuclear devices also produced large quantities of radiocarbon so that by 1964 the atmosphere concentrations in the northern hemisphere had almost doulbed. This readiocarbon has now been almost "washed out"but can be found both in plant materials and the oceans□

### Stable isotpoes

The deuterium and oxygen-18 are most commonly used environemntal istopoes in hydrology□ The stable isotope species will show circulation pattern closely related those of the bulk water in the hydrological cycle□ HDO and $H_2{}^{18}O$ will show systematic devation from the circulation patern of $H_2{}^{16}O$ because evaporation and condensation cause slight fraction of the isotopic species□These deviation would be predictable if one knew in detail the pattern of water circulation in nature□ Stable isotpoe techniques have mostly been appled in hydrology to trace a single arc of the hydrological cycle such as the vapor tranport in the atmosphere or groundwaetr comtribution to runoff□ The principle processes which cause to fractionate stable isotpoic composition of water in nature are evaporation and condensation □ Resulatant fraction effects are recognized as

temperature effect□ altitude effect□ inland effect□ and amount effect□The present research aimed at more detailed process study□ that includes whole water cycle starting from sea water to atmospheric vapor□ precipitation□ soil awter retourn to atmosphereic vapor from soil water□ lake water□ groudwater□ spring water□ river water□ and return to atmospheric vapor from irrigation water□ We tried to elucidate vatious hydrological processes occuring in Norch China Plain□ through the changes in isotopic composition in waters sampled in field□

## Remote Sensing and GIS

There is a national key laborotry of remote sensing and GIS in our institute□The NOAA□MODIS and TM data□and GIS data are usful□

The second step is predication (Diagnosis) by using model, which is distributed model including surface water and subsurface water, water quantity and water quality.

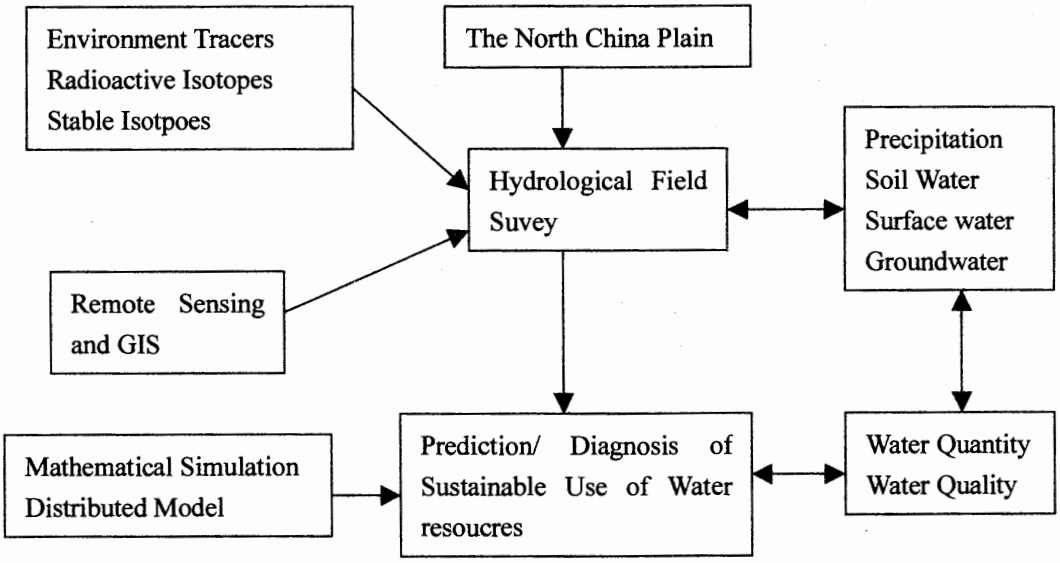


Fig. 1 Methods of Scientific understanding of hydrological cycle

## Acknowledgements

This research was supported by the following research grants: the knowledge Innovation Key Project (KZCX-SW-317/CX10G-E01-08), Chinese Academy of Sciences and the director's grant of Institute of Geographical Sciences & Natural Resources Research, Chinese Academy of Sciences.

## REFERENCES

Chen, J. Q. & Xia, J. (1999) Facing the challenge: barriers to sustainable water resources development in China. Hydrol. Sci. J. 44(4), 507–516.

Huang, G.H., and J.Xia (2001), Barriers to sustainable water quality management, J. of Environmental

Management, 61(1), 1-23.

International Atomic Energy Agency(1981): Stable isotope hydrology. Deuterium and oxygen-18 in the water cycle, Technical Reports Series No.210, IAEA, Vienna, 273p.

Kayane, I. (1992): Water cycle and water use in Bali island. Institute of Geoscience, University of Tsukuba. 320p.

Liu Changming and Yu Jingjie (2001), Groundwater Exploitation and Its Impact on the Environment in the North China Plain, Water International, 26(2),pp.265-272;

Plate, E. J. (1993) Sustainable development of water resources: A challenge to science and engineering. Water International, 18(2), 84-93.

Song, X. Kayane, I. Tanaka, T. & Shimada, J.(1999)□ A study of groundwater cycle using stable isotope in Sri Lanka. Hydrological Processes. Vol. 13(10), 1479-1496.

WMO & UNESCO (1988) Water resources assessment. Handbook for review of national capabilities, WMO, Geneva.

Xia Jun, & David Chen, (2001), Water problems and opportunities in hydrological Sciences in China, Hydrological Science Journal , 46(6), 907-922 .