



Consequences of Human Interventions on Groundwater Resources: *Can China Cope With Its Water Crisis?*

Chunmiao Zheng, Guoliang Cao, Jie Liu



北京大學
PEKING UNIVERSITY



THE UNIVERSITY OF
ALABAMA

Water: China's Greatest Crisis?

- China's State Council (Cabinet) warned in 2007 that even after taking into full account water-saving, by 2030 China's water use will reach or approach the total volume of exploitable water resources.
- China is expected to use 700-800 billion m³ of water per year by 2030, out of an estimated total of 800-900 billion m³ available.



MONDAY, March 22

2010

Desert storm

blatant
of M

Is expanding
the severe
and Hu

T

China Daily, March 22, 2010

“The sky across North China



for the
ed a
t of

GLOBAL TIMES

環球時報

DISCOVER CHINA, DISCOVER THE WORLD

► InDepth
Big cat's last legs
12-13



► Life & Art
The call of nature
17



www.globaltimes.cn

VOLUME 1 • NO. 235 • WEDNES

Millions struggle for drinking water as drought continues

March 24

By Liang Chen in Yunnan and Song Shengxia in Beijing

Tens of millions of villagers such as Qian Guoqiao face a very real threat this year, to their lives and ability to support their families.

Widespread drought, particularly across southwest China, has ravaged the land, making drinking water scarce and putting the coming season's crops at risk of never even being planted.

"It is time to plant rice seedlings, but without water, we may miss the time to plant rice," Qian, who lives in Shuige village, in the prefecture of Qujing in Yunnan Province, told the Global Times yesterday.

Yunnan has been one of the worst hit areas in southwest China.

Qian said that he and his wife haven't bathed for a month, and they have bathed just three times in the past seven months.

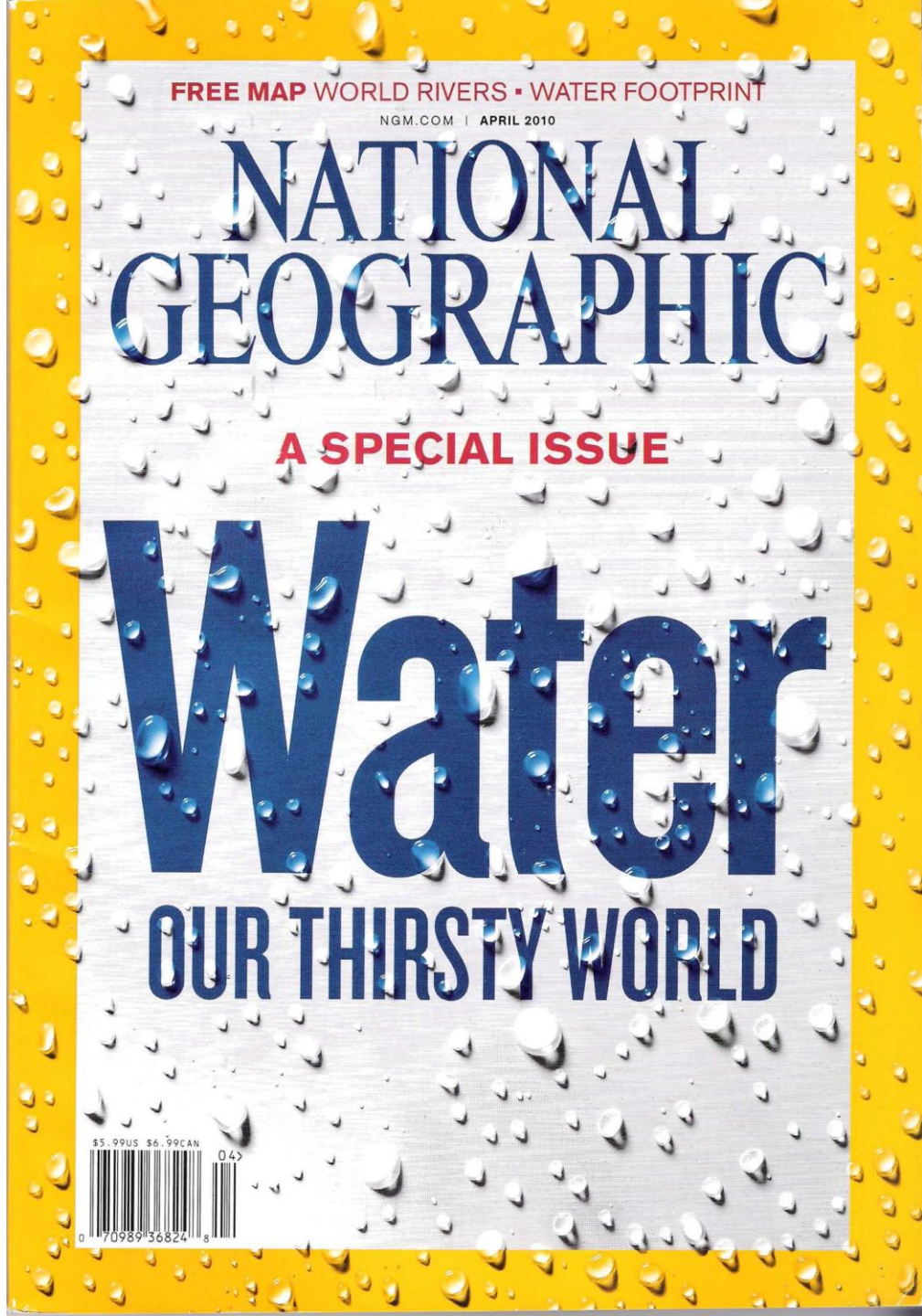
► 2
Food



A boy squeezes the last drop from a mineral water bottle in Wulong county, Chongqing, Saturday. The area is suffering from one of the severest droughts in history.

CHEN CHENG / XINHUA

April 2010



FREE MAP WORLD RIVERS • WATER FOOTPRINT

NGM.COM | APRIL 2010

NATIONAL GEOGRAPHIC

A SPECIAL ISSUE

Water

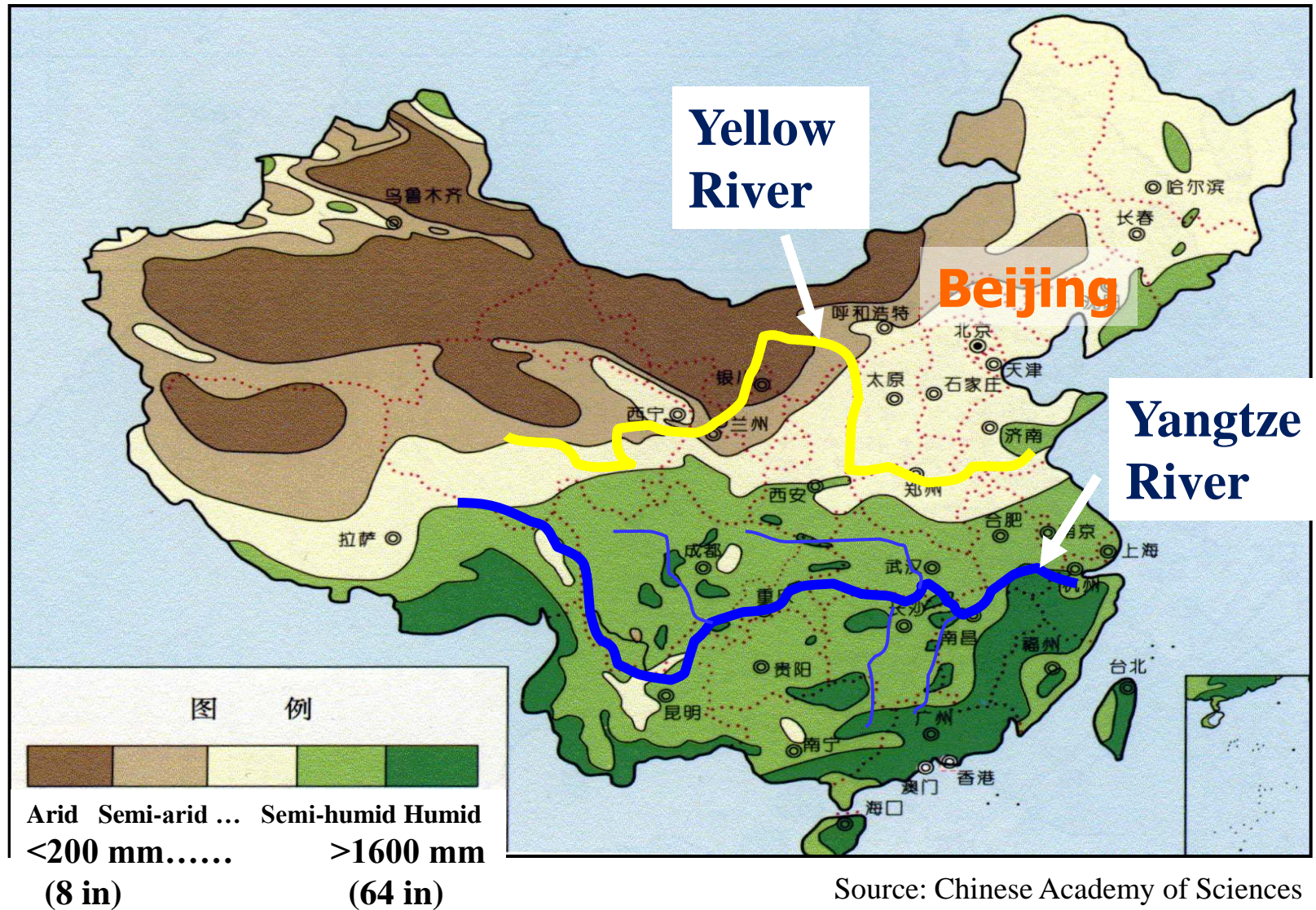
OUR THIRSTY WORLD

\$5.99US \$6.99CAN 043

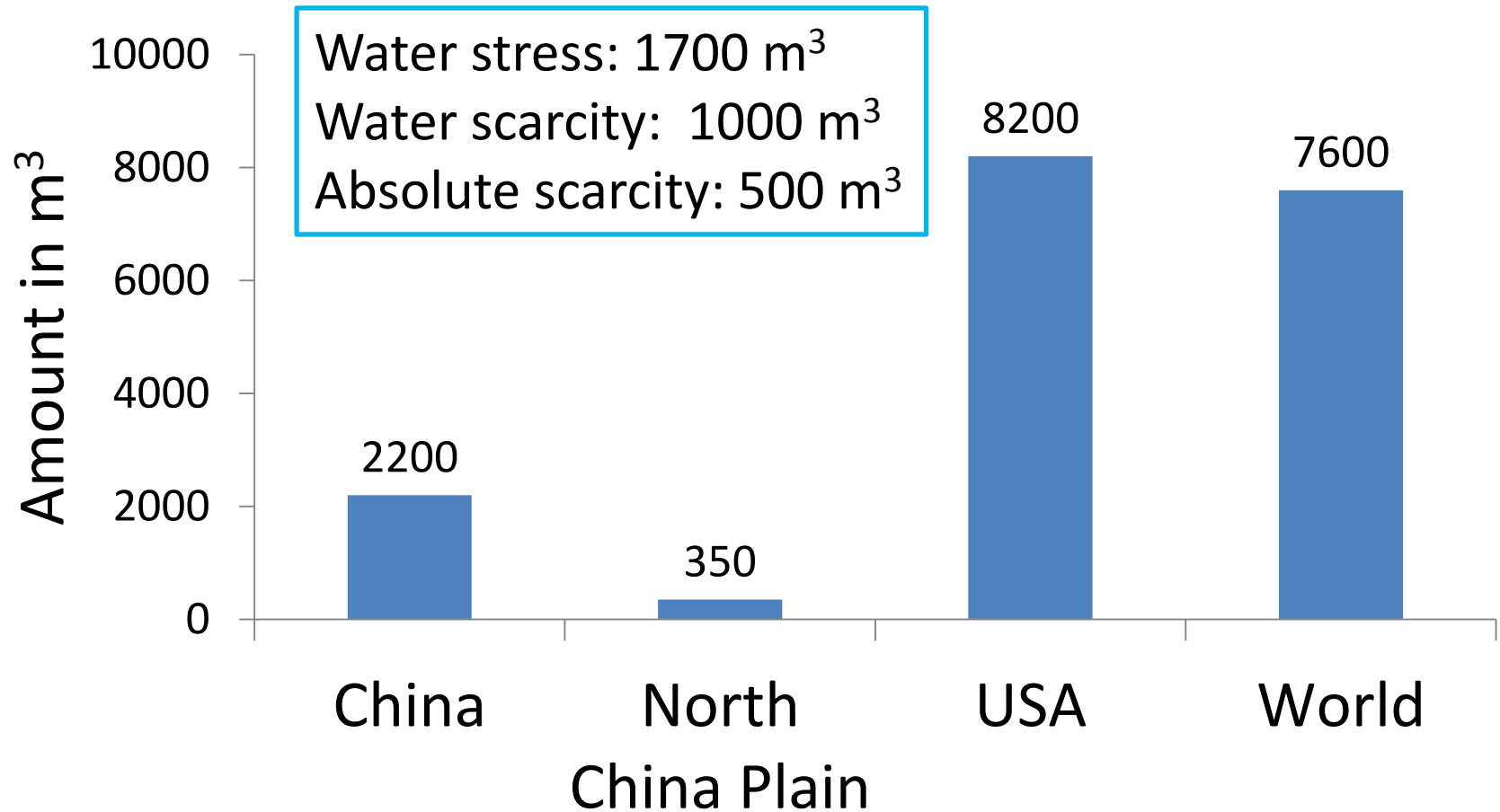


0 70989 36824 8

China, A Tale of Two Halves



Comparison of Exploitable Water Resources Per Capita



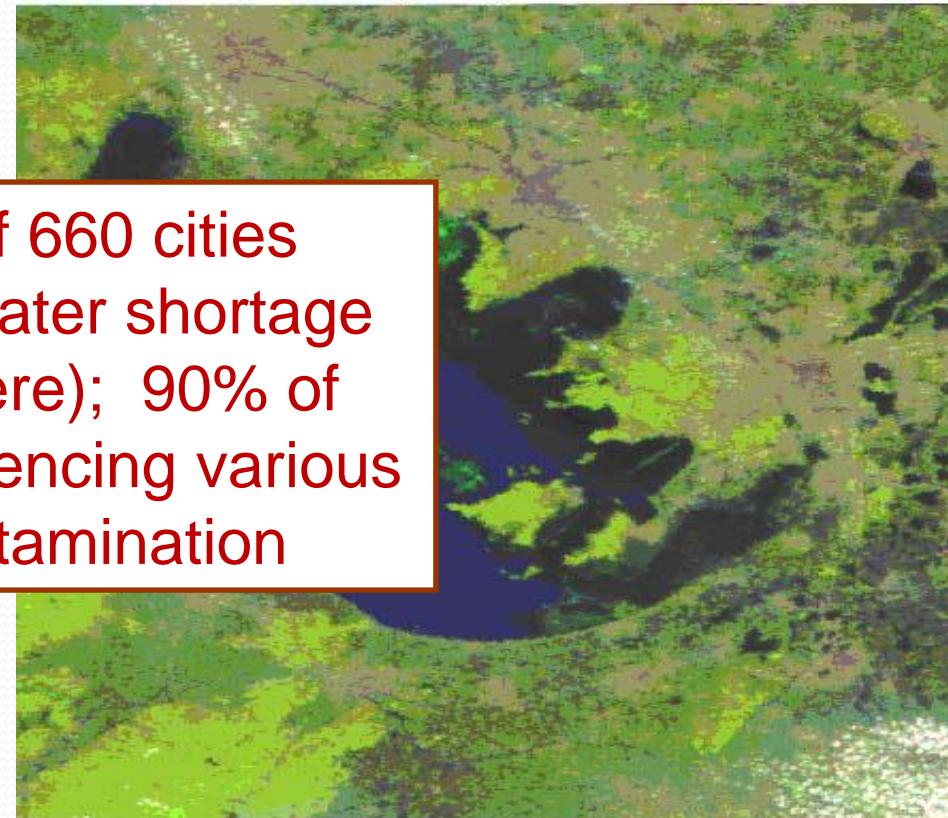
Sources: Gleick (2003) & Shiklomanov (1997)

Scarcity and Pollution: Double Whammy



2010 Drought in SW China

气象卫星太湖水体监测图
(2008年6月29日10时)



2008 Lake Taihu algae bloom

Over 400 out of 660 cities experiencing water shortage (110 cities severe); 90% of aquifers experiencing various degrees of contamination

"Geographically" North China Plain (~300,000 km²)

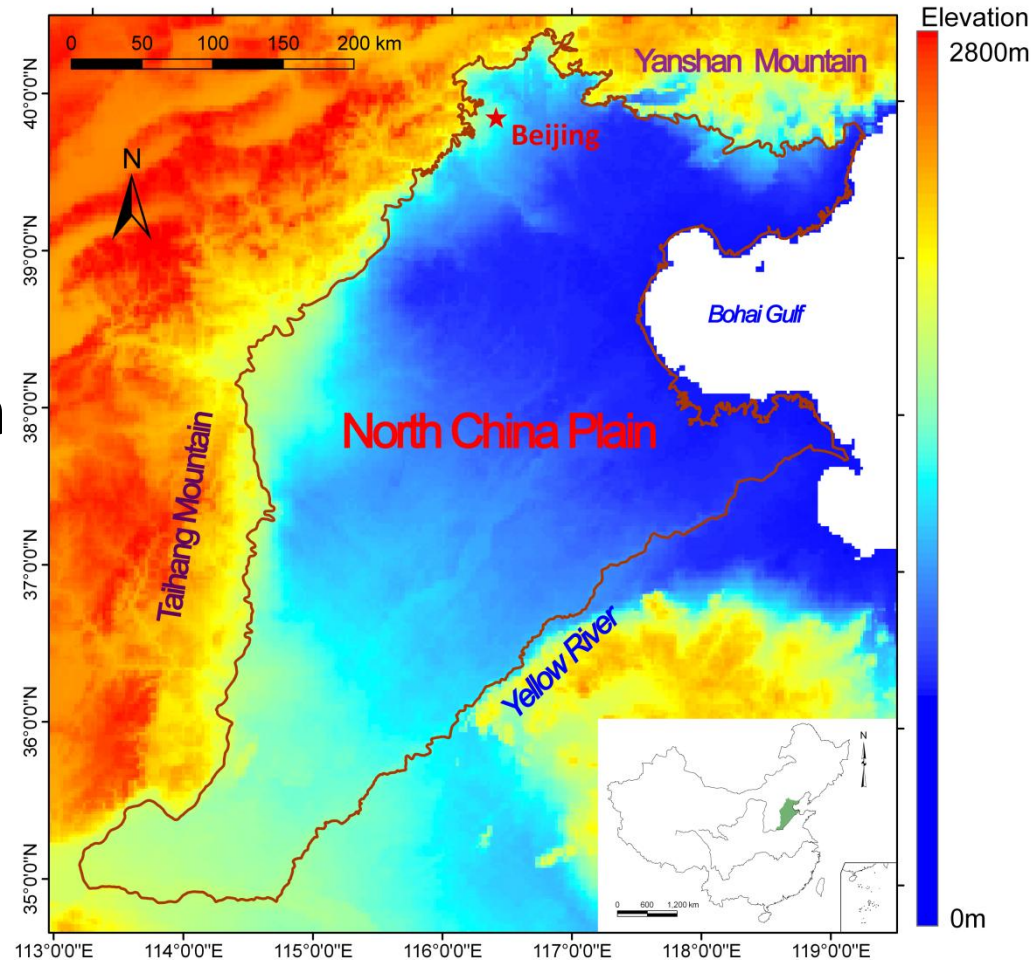


**N
o
r
t
h
C
h
i
n
a
P
l
a
i
n**

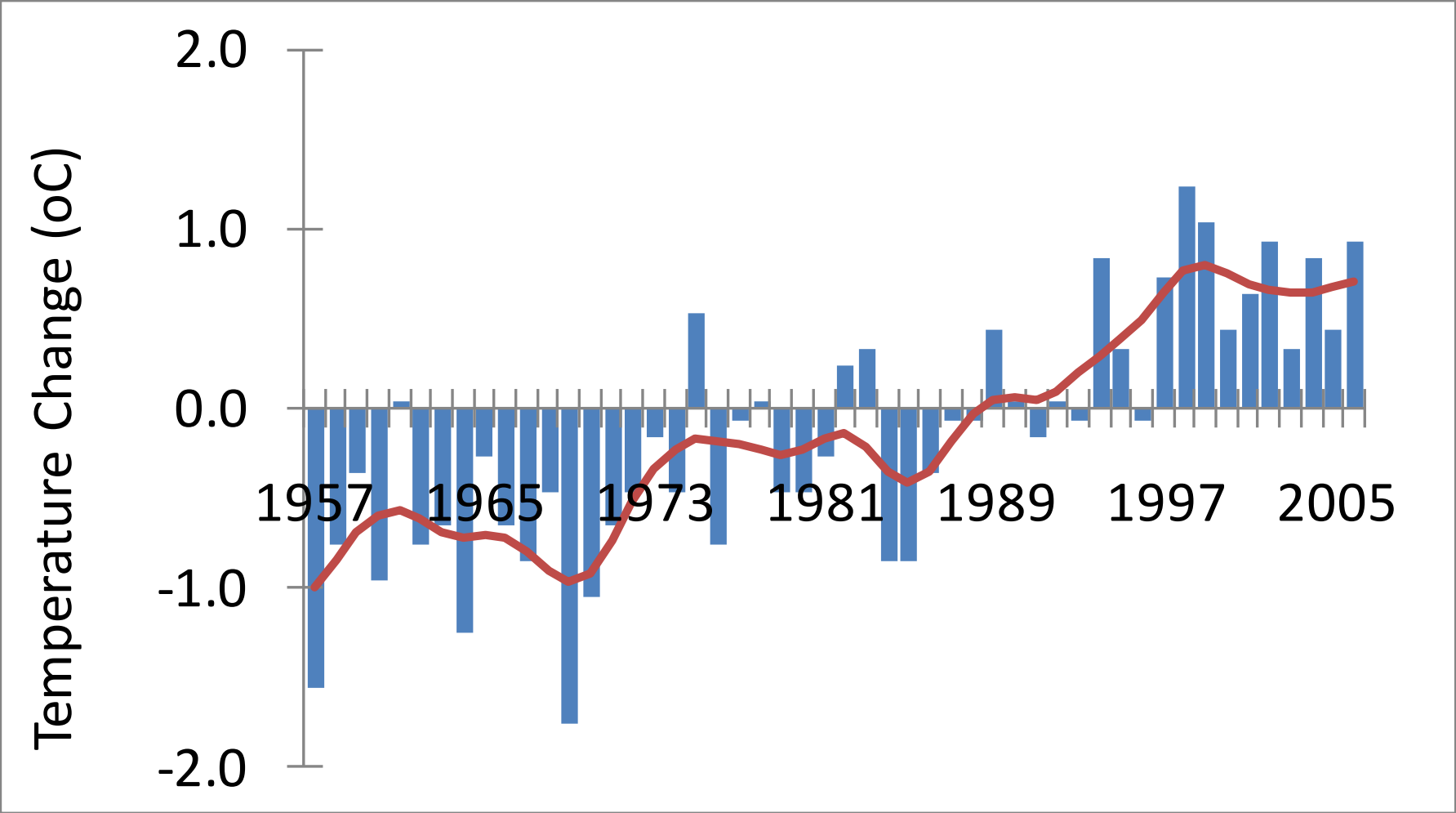


“Hydrogeologically” North China Plain

- China’s key cultural, political, economic center
- Total area: 140,000 km²
- Population: ~130 million
- 12% of China’s GDP
- 10% of China’s total grain production
- Precipitation: 535 mm

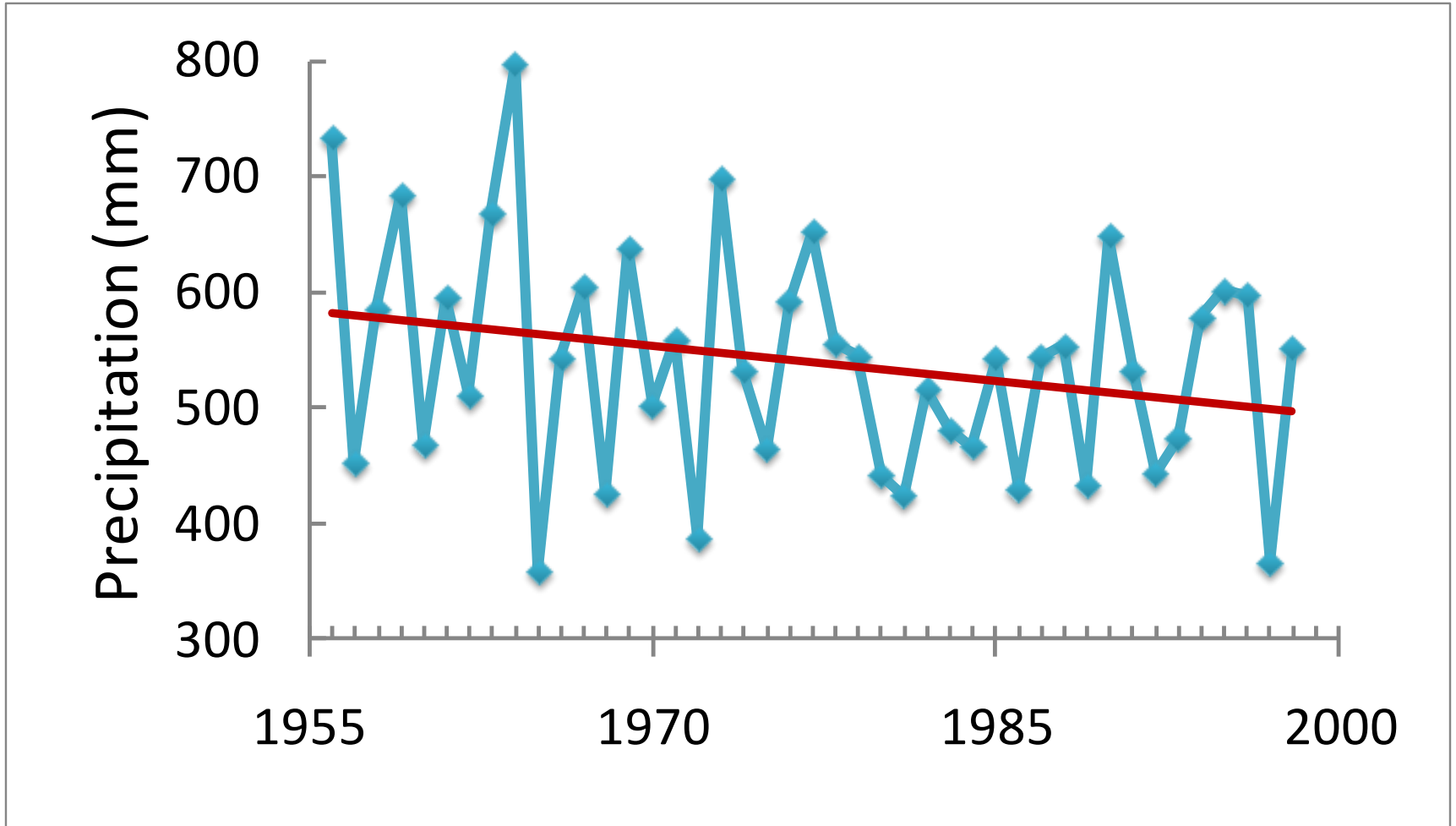


Annual Temperature Change for NCP



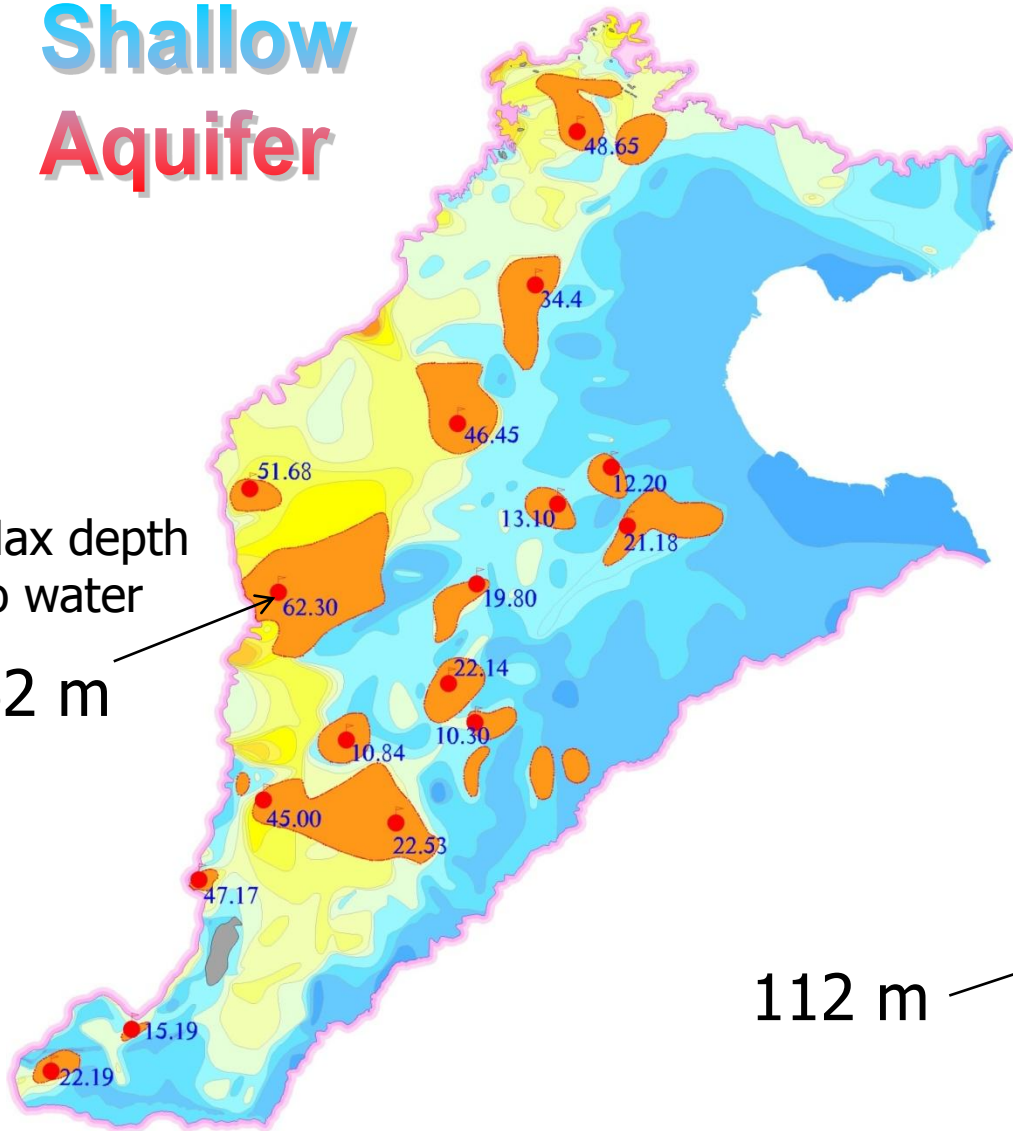
Source: Hebei Climate Center (2008)

Annual Precipitation Trend for NCP



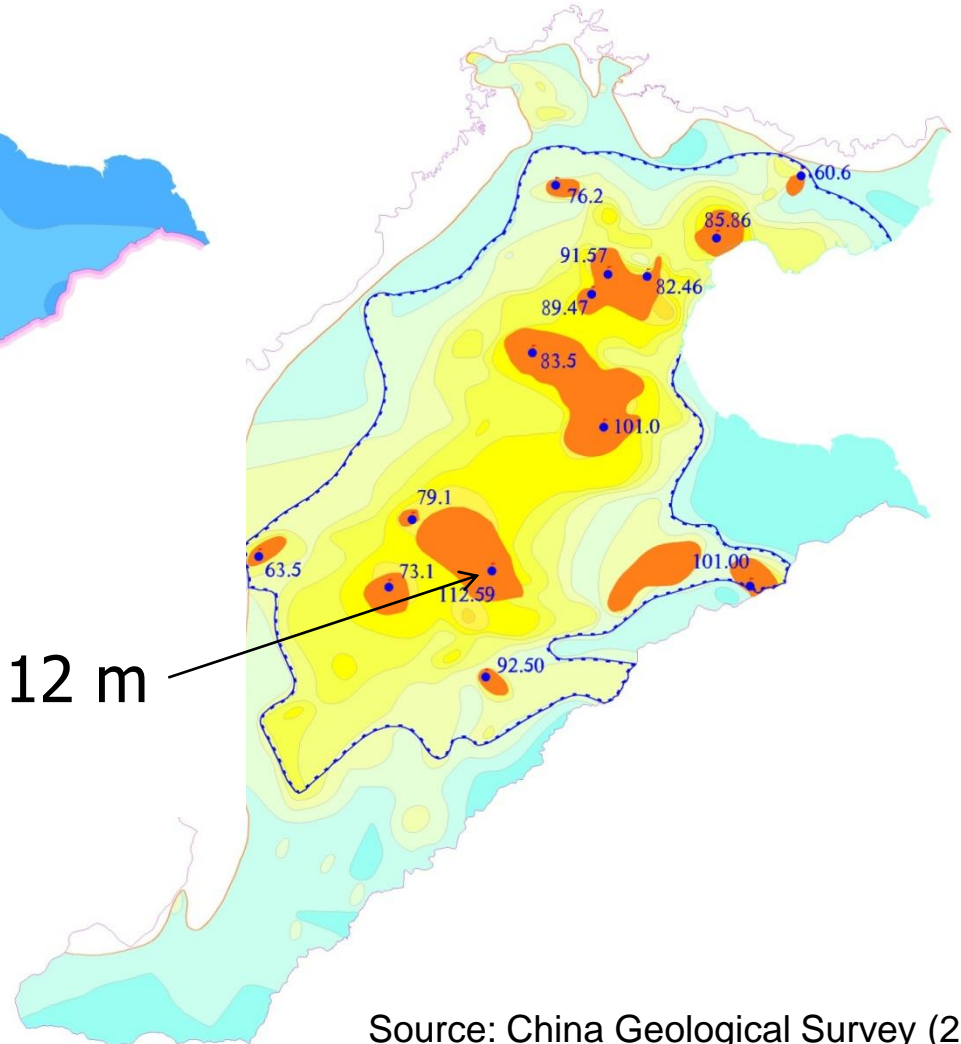
Shallow Aquifer

Max depth to water
62 m



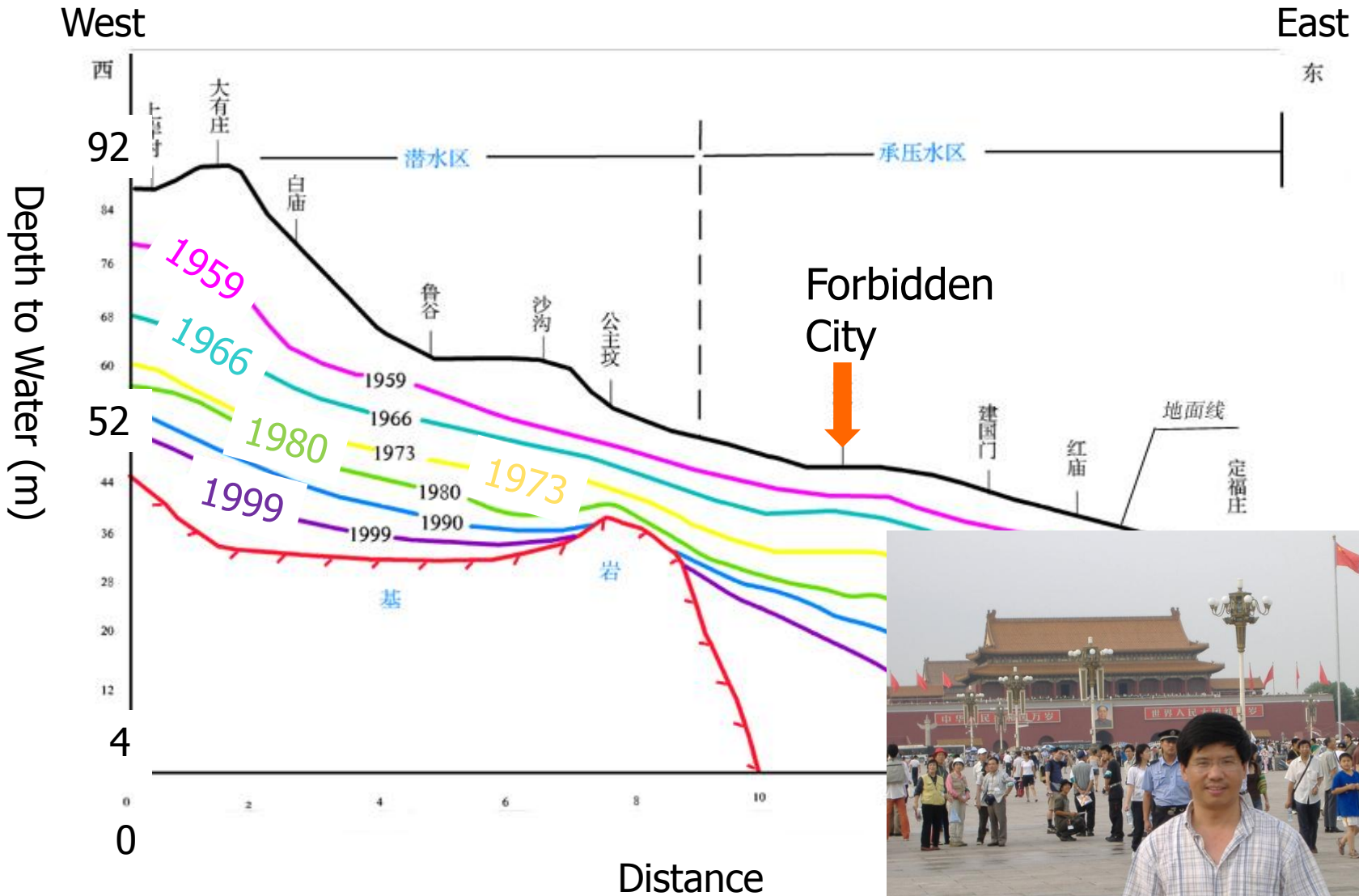
Deeper Aquifer

112 m



“Cones of Depression”

Water Table Declines in Beijing 1959-1999





Where Have Rivers Gone?



Disappearing
Wetlands



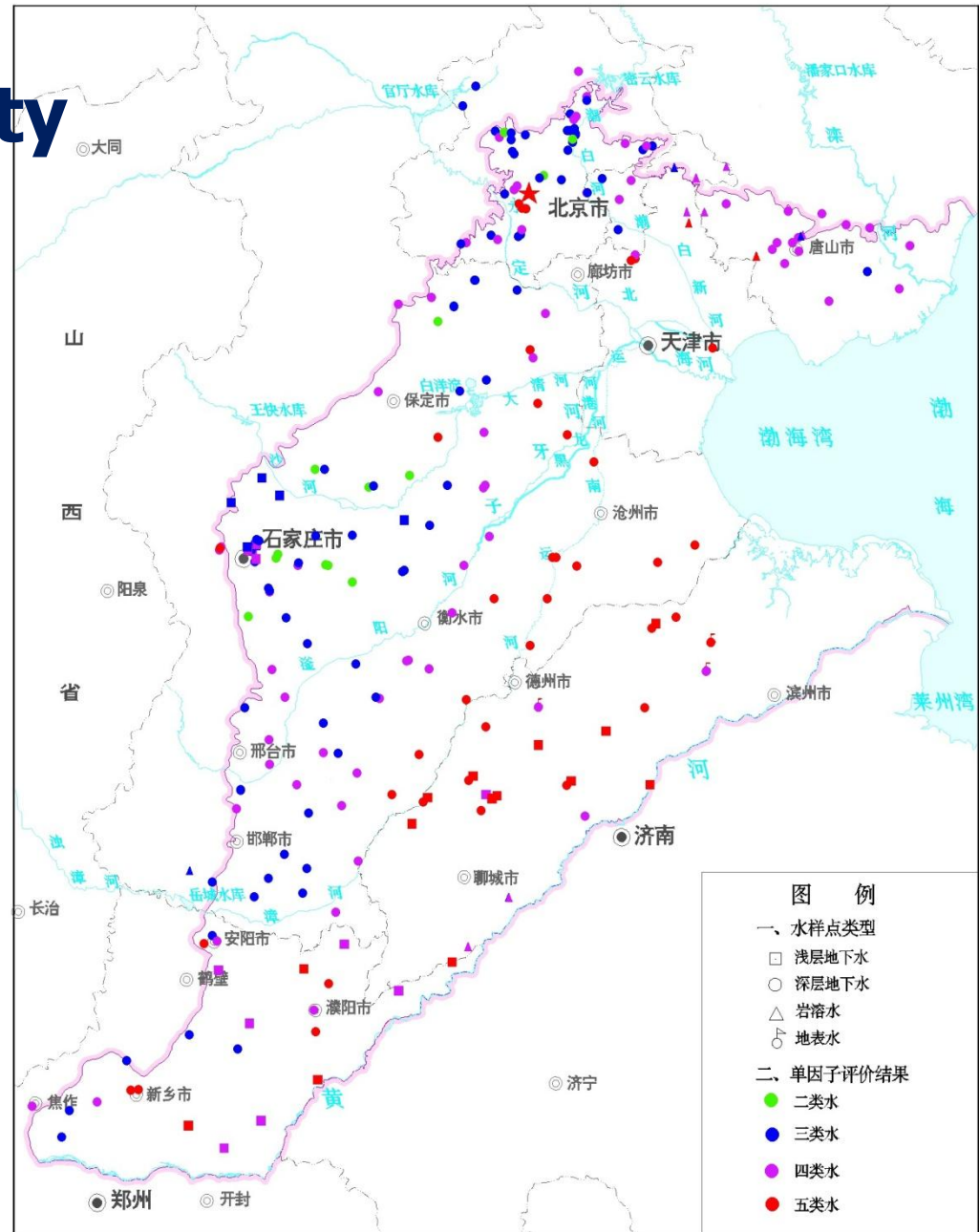
Wastewater
Discharge

Groundwater Quality

- Shallow aquifer
- Deeper aquifer
- Category-2 water
- Category 3
- Category 4
- Category 5

Poor quality

58% of 243 samples



Source: China Geological Survey (2008)

0 50 100km 100 km

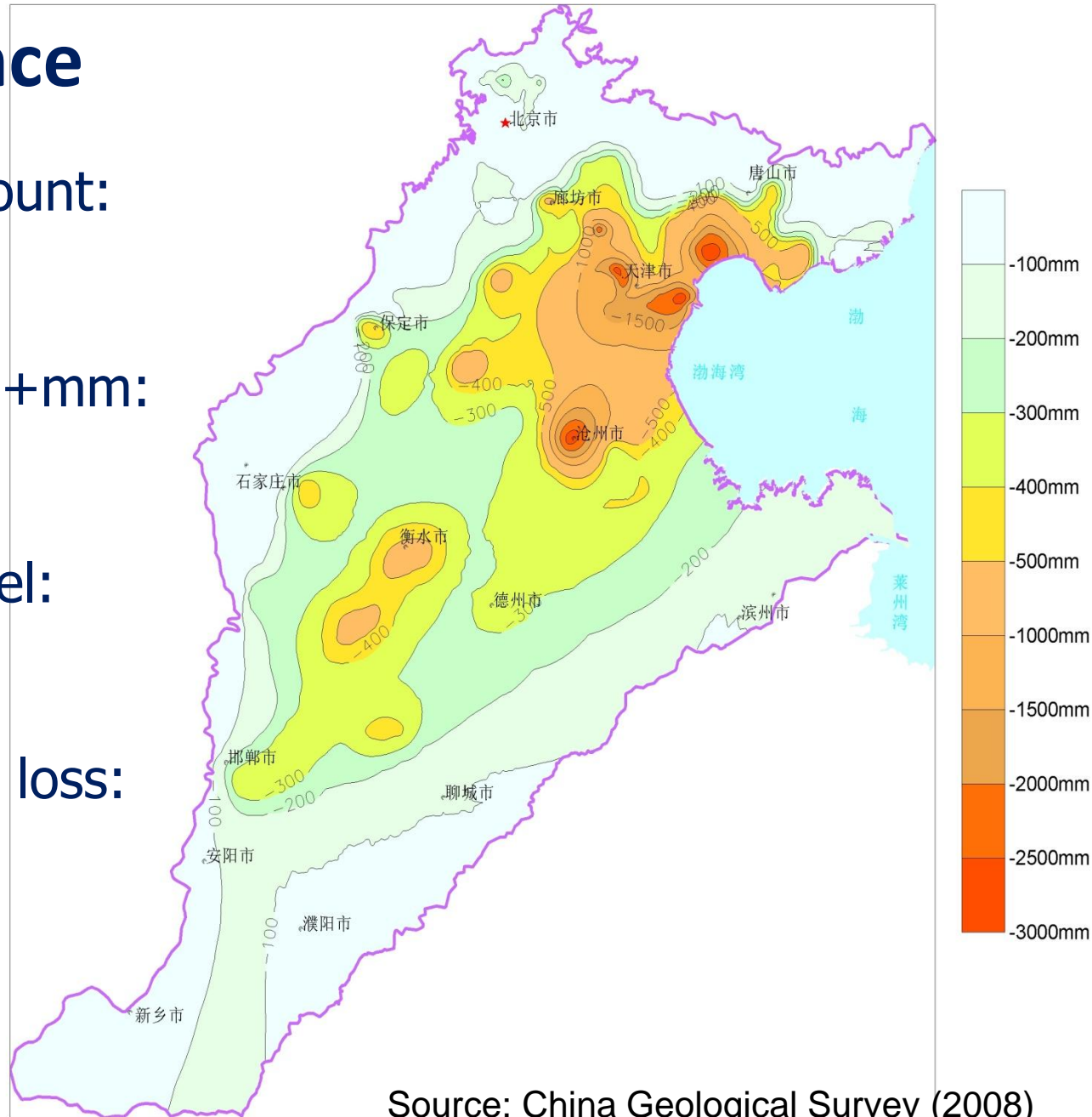
Land Subsidence

Max cumulative amount:
~3.25 m

Areas subsiding 200+mm:
60,000 km²

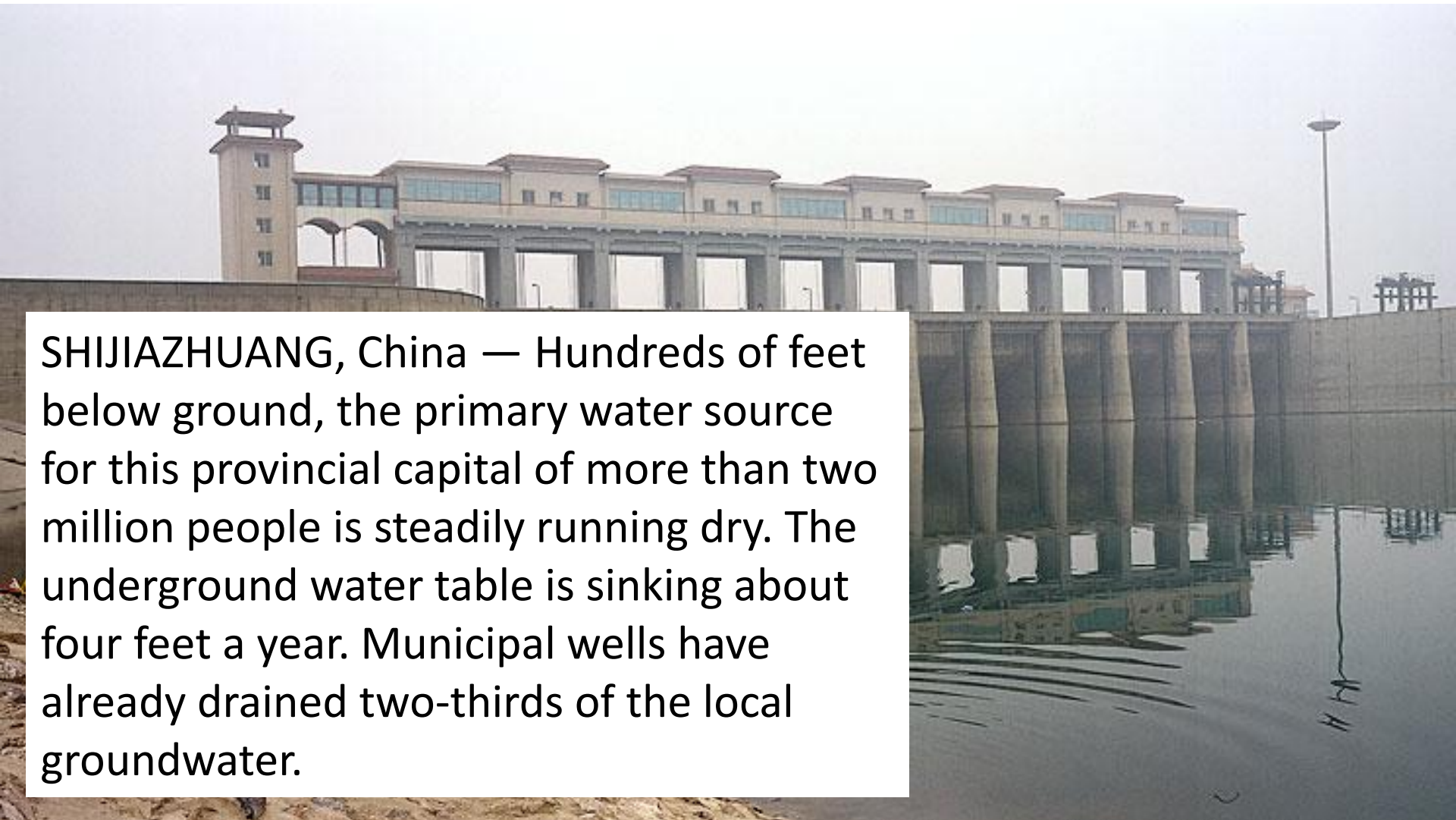
Areas below sea level:
118,000 km²

Estimated economic loss:
330 billion RMB



Source: China Geological Survey (2008)

“Beneath Booming Cities, China’s Future Is Drying Up”

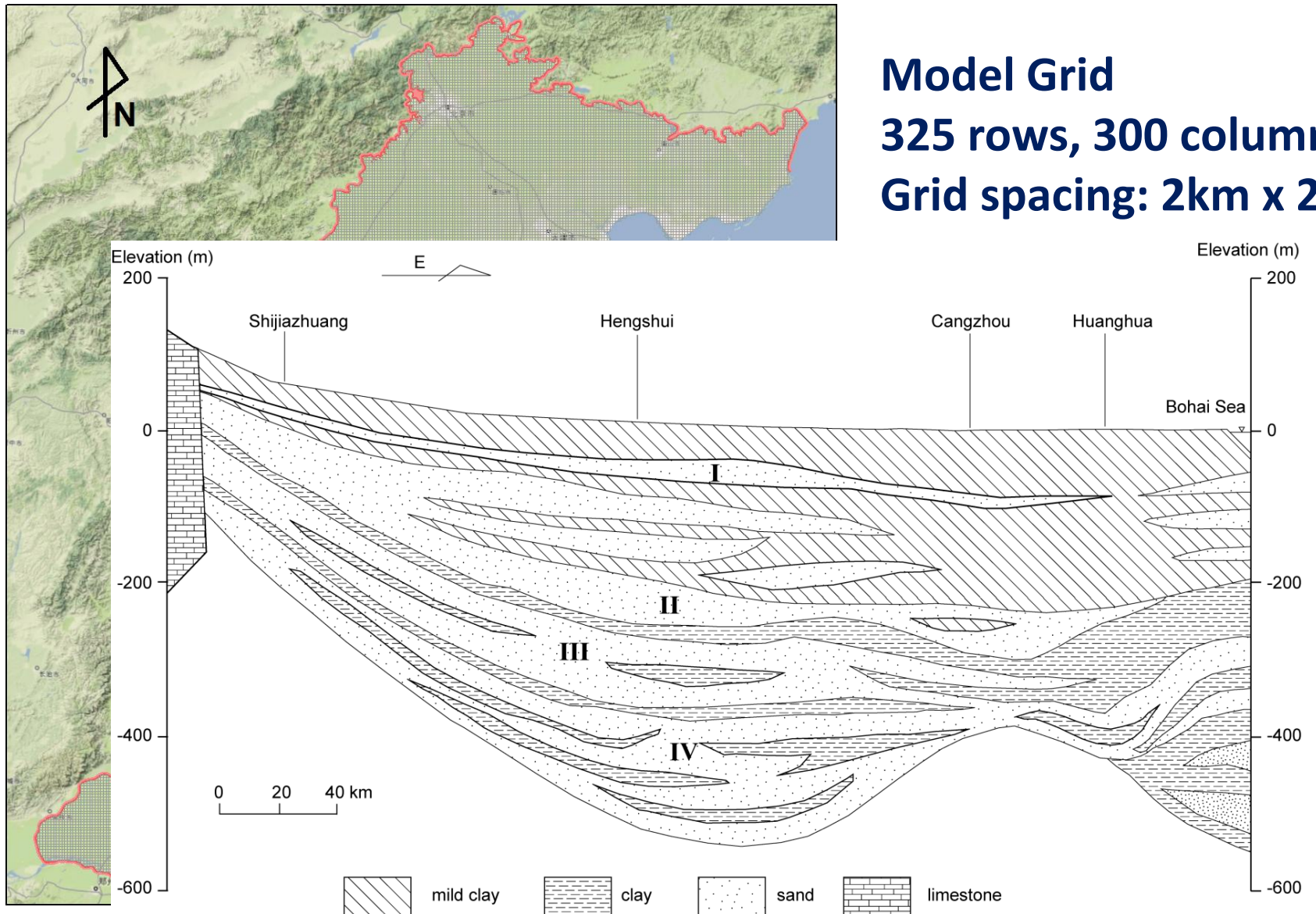


SHIJIAZHUANG, China — Hundreds of feet below ground, the primary water source for this provincial capital of more than two million people is steadily running dry. The underground water table is sinking about four feet a year. Municipal wells have already drained two-thirds of the local groundwater.

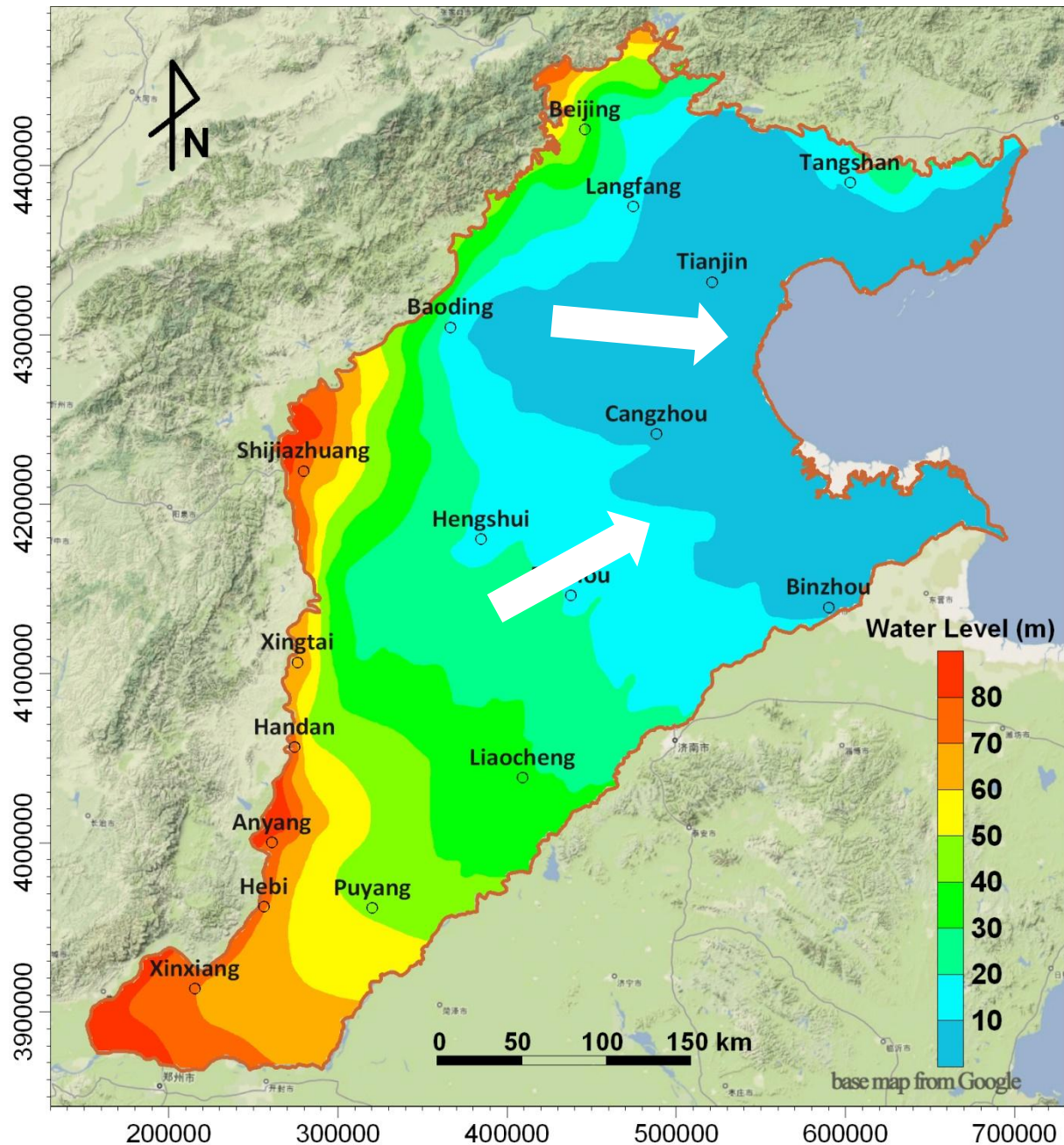
(New York *Times*, September 28, 2007)

Basin-Scale Groundwater Modeling

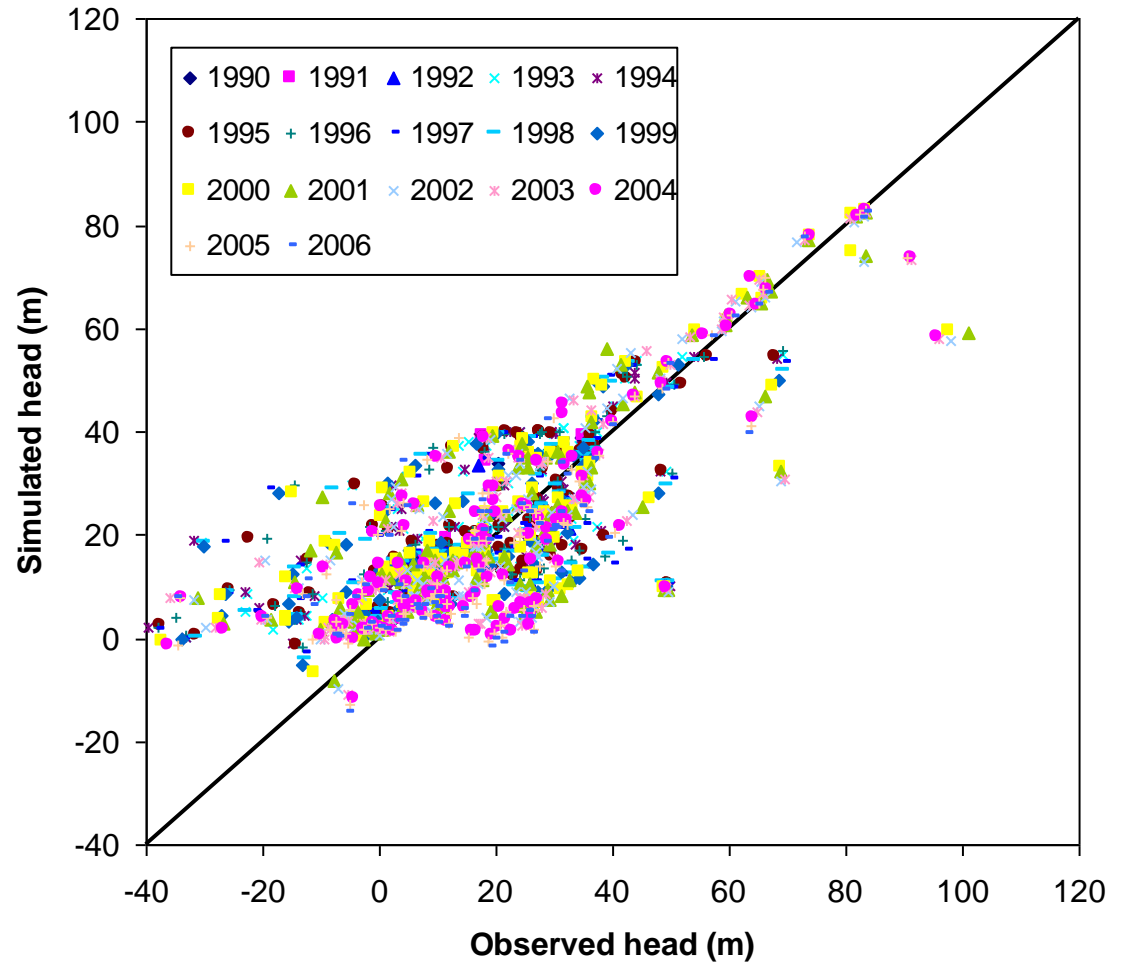
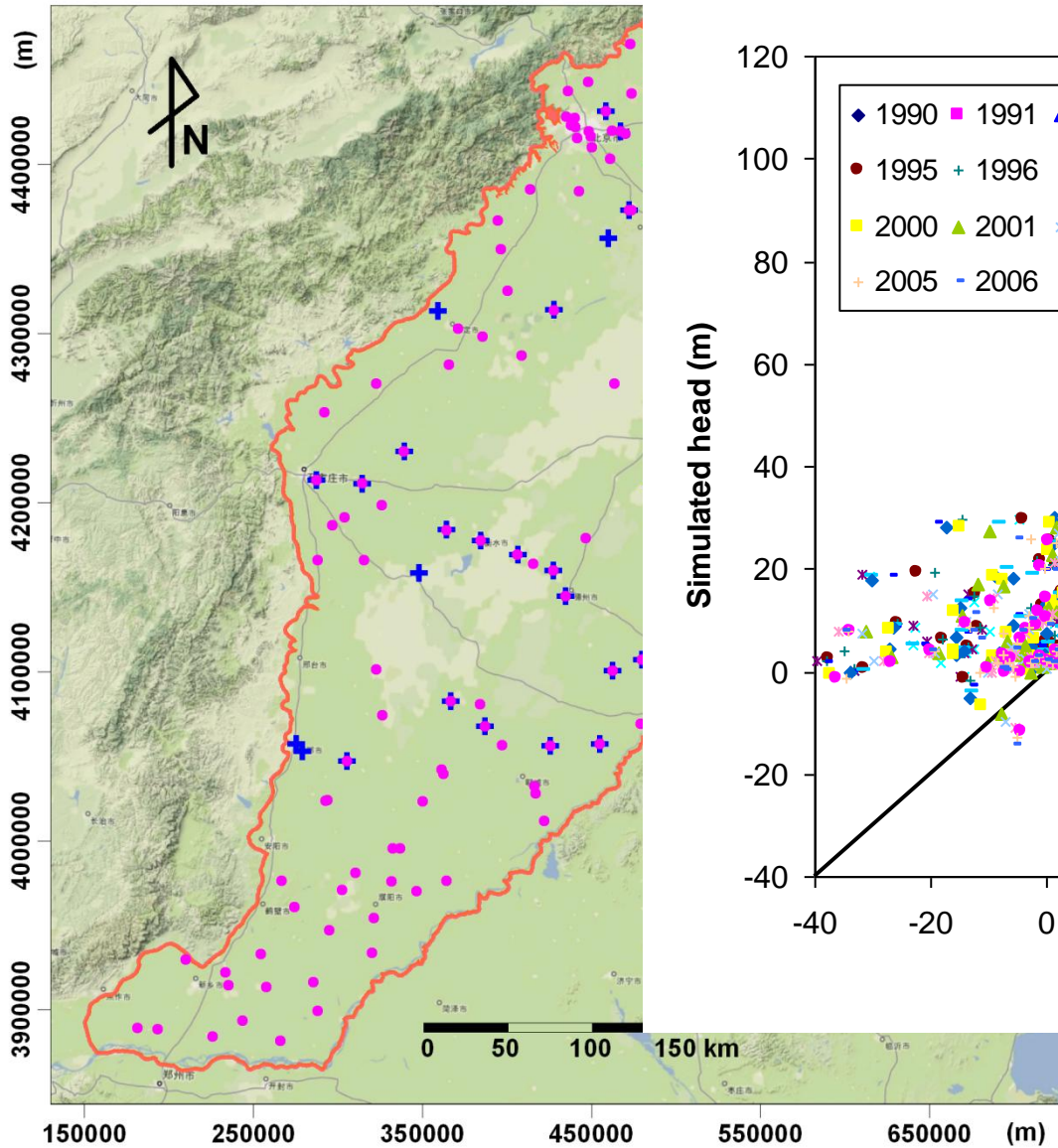
Model Grid
325 rows, 300 columns
Grid spacing: 2km x 2km



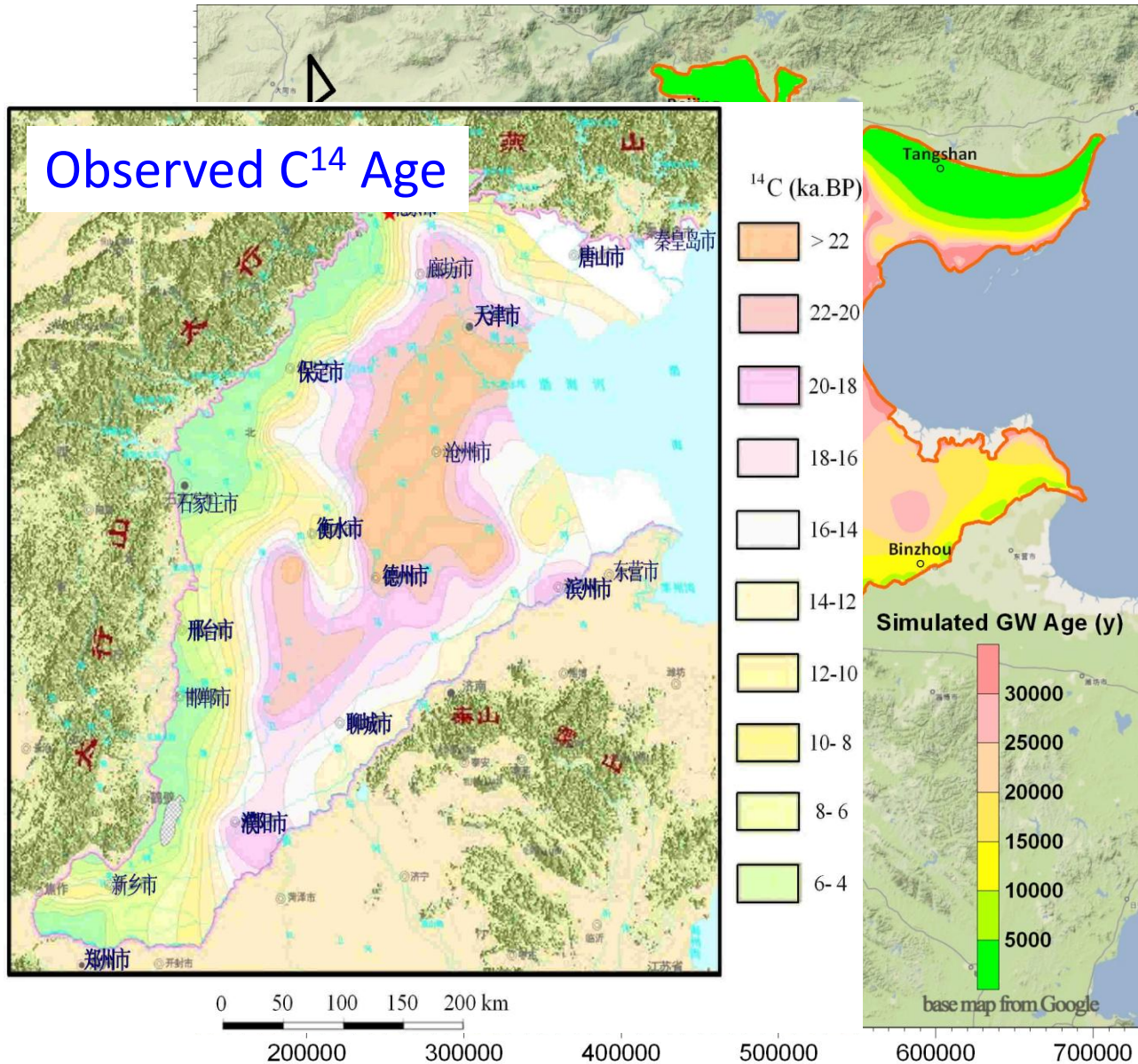
Distribution of steady-state water levels in shallow aquifer in 1959 as the *initial condition* for transient flow model 1959-2009



Flow Model Calibration

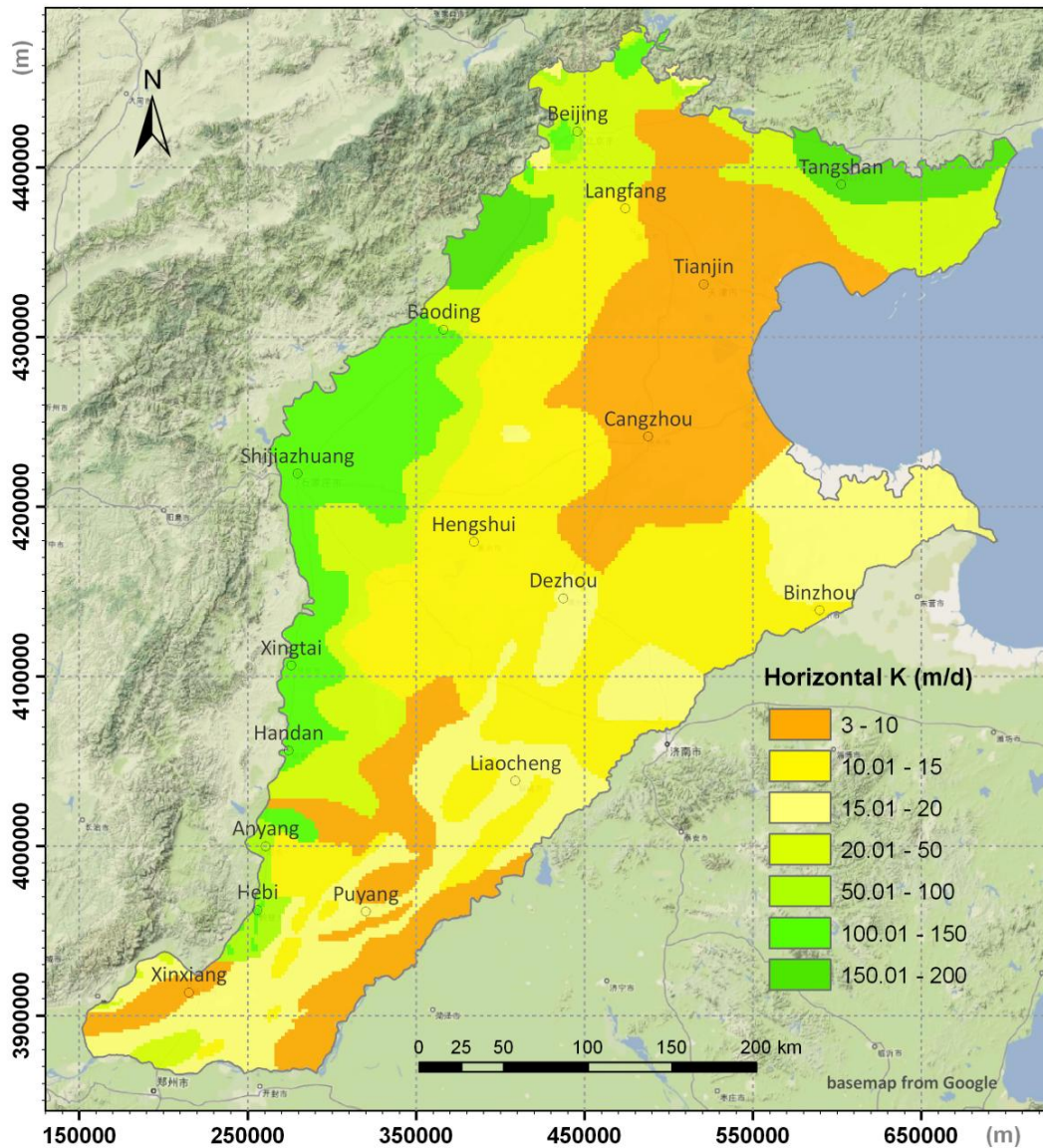


Groundwater Age as Model Constraint

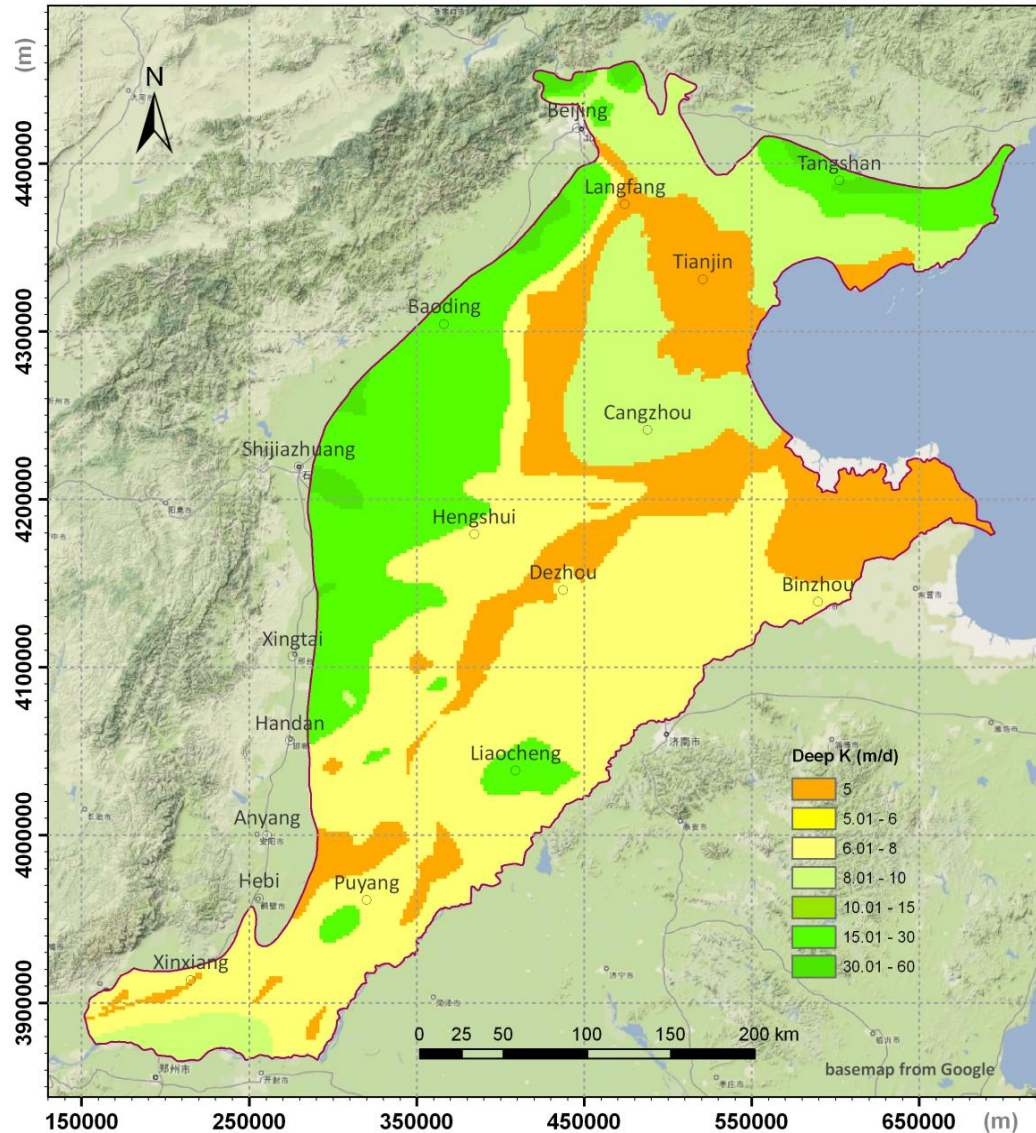


Simulated
Mean
Groundwater
Age in Deep
Aquifer

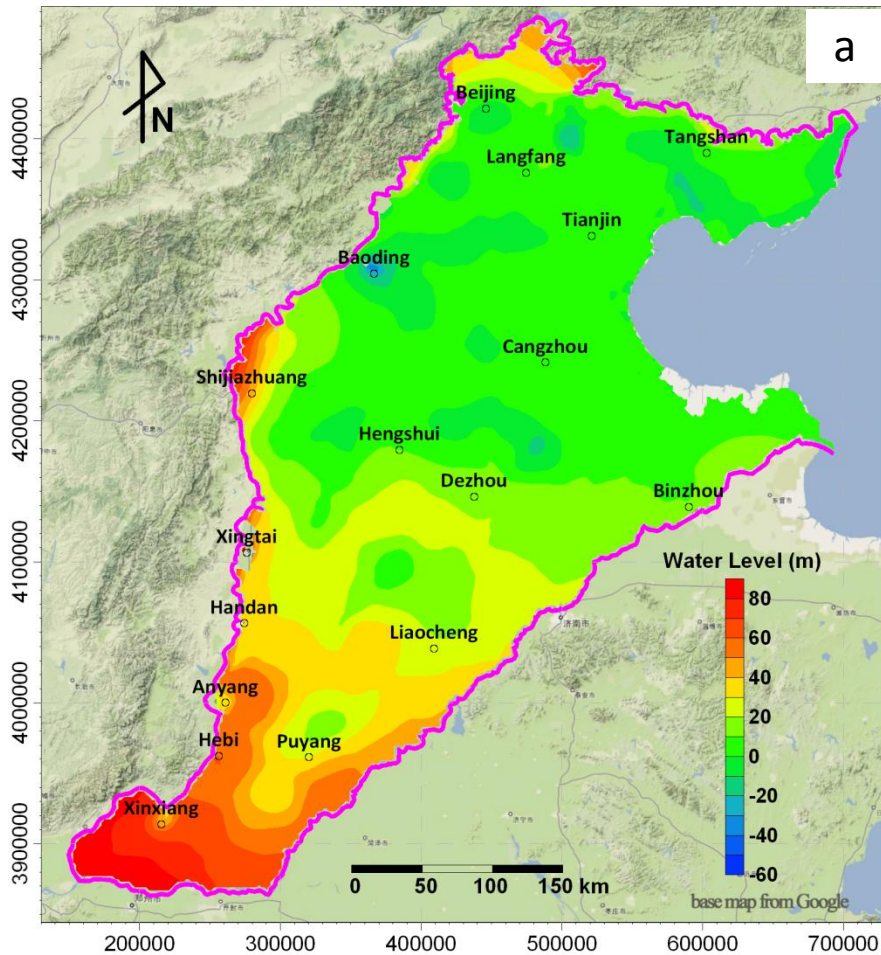
Calibrated K Distribution in Shallow Aquifer



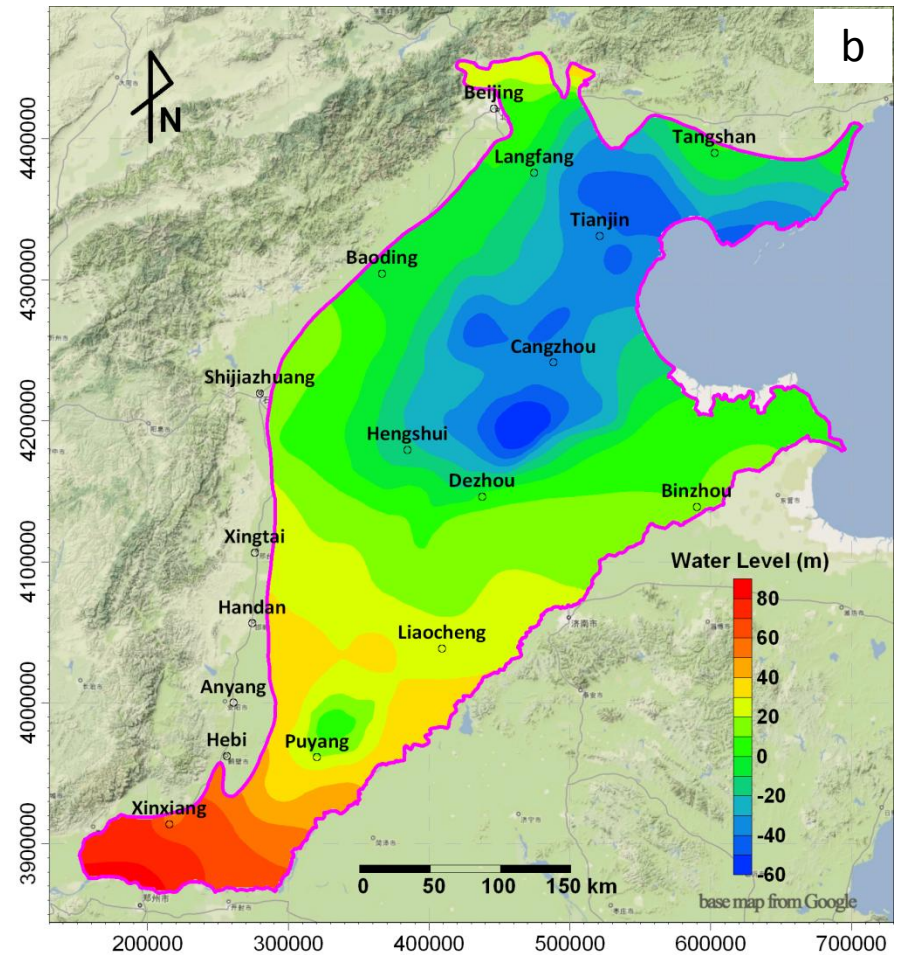
Calibrated K Distribution in Deep Aquifer



Simulated Head Distribution in 208

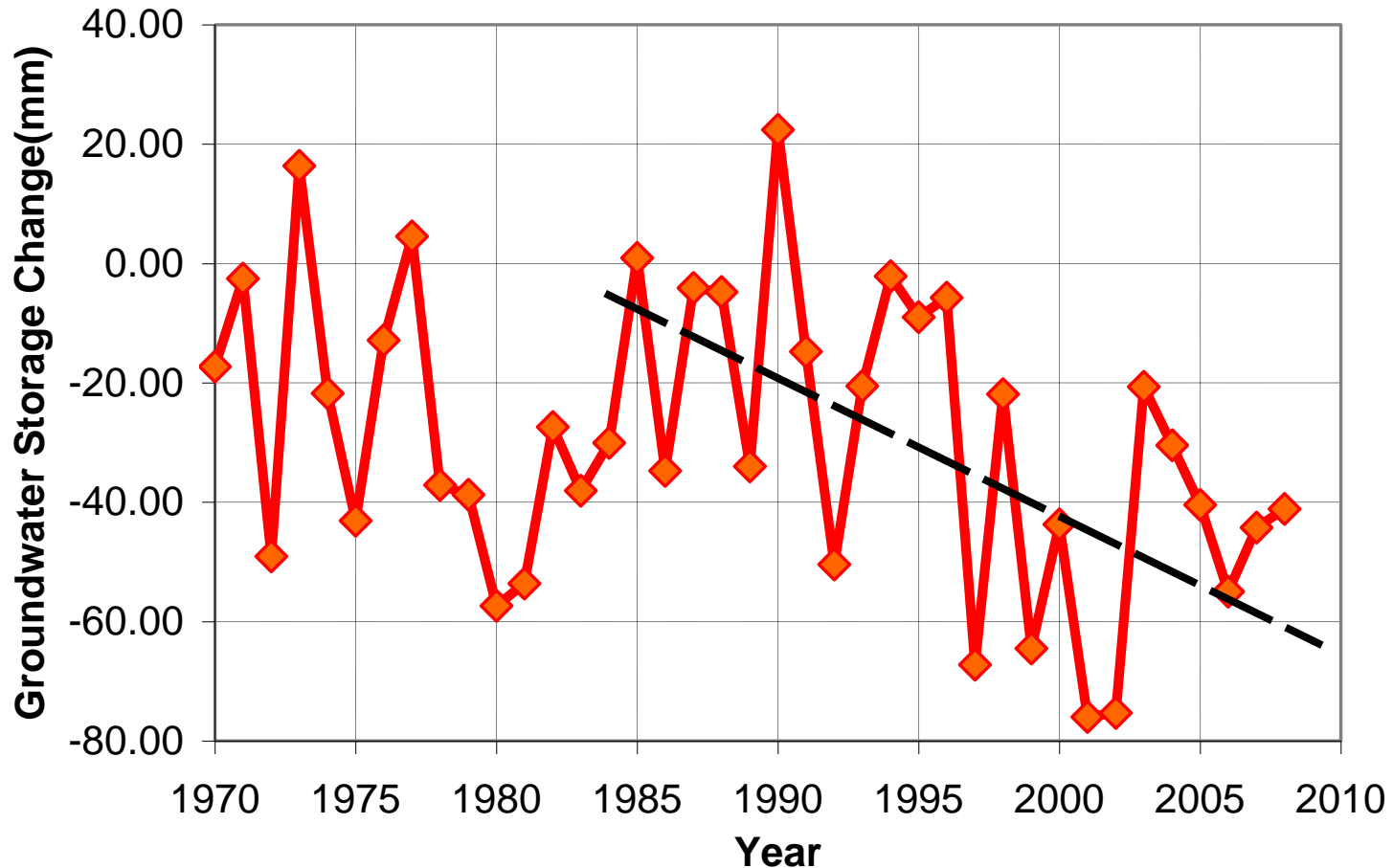


(a) shallow Aquifer



(b) deep aquifer

Simulated Groundwater Storage Depletion



1985-2008 annual storage depletion: **~4 billion m³**

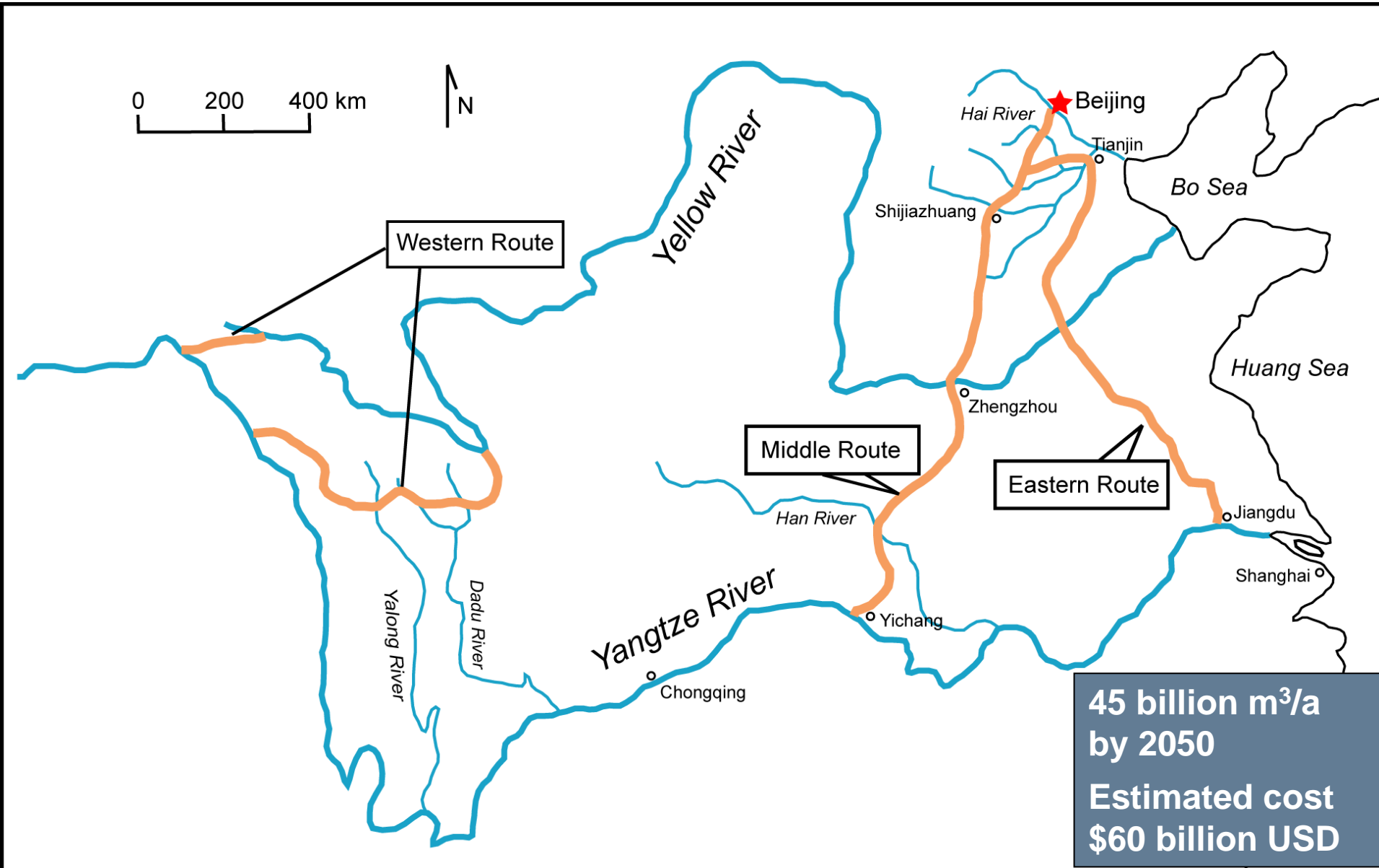
Copying with Water Scarcity

- Water saving – higher efficiency
- Changes to agricultural practice
- Rainwater harvesting
- Desalination
- Price reform
- **Water transfer**



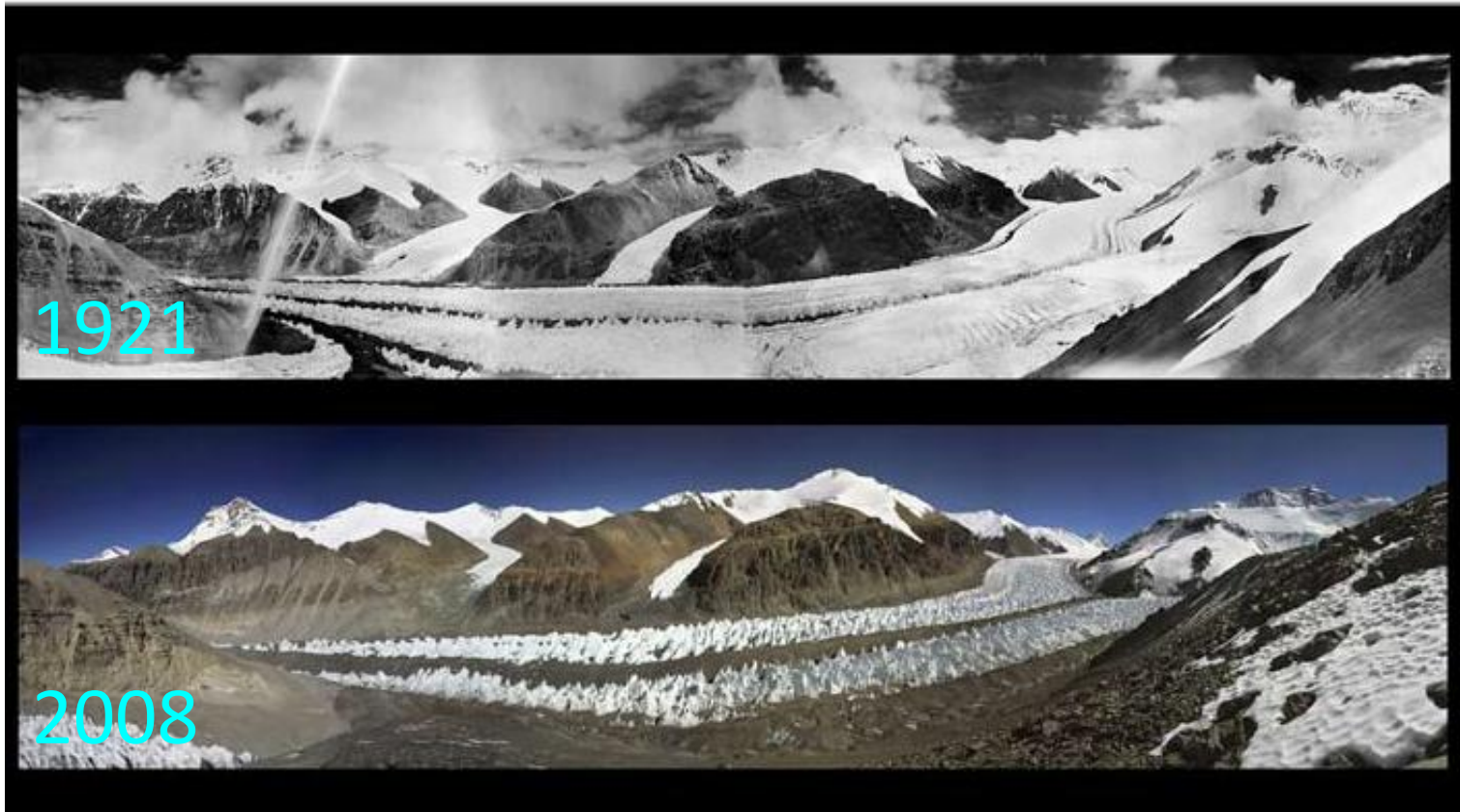
Any comprehensive solution requires consideration of social, political, economic, and institutional factors

South-To-North Water Transfer Project



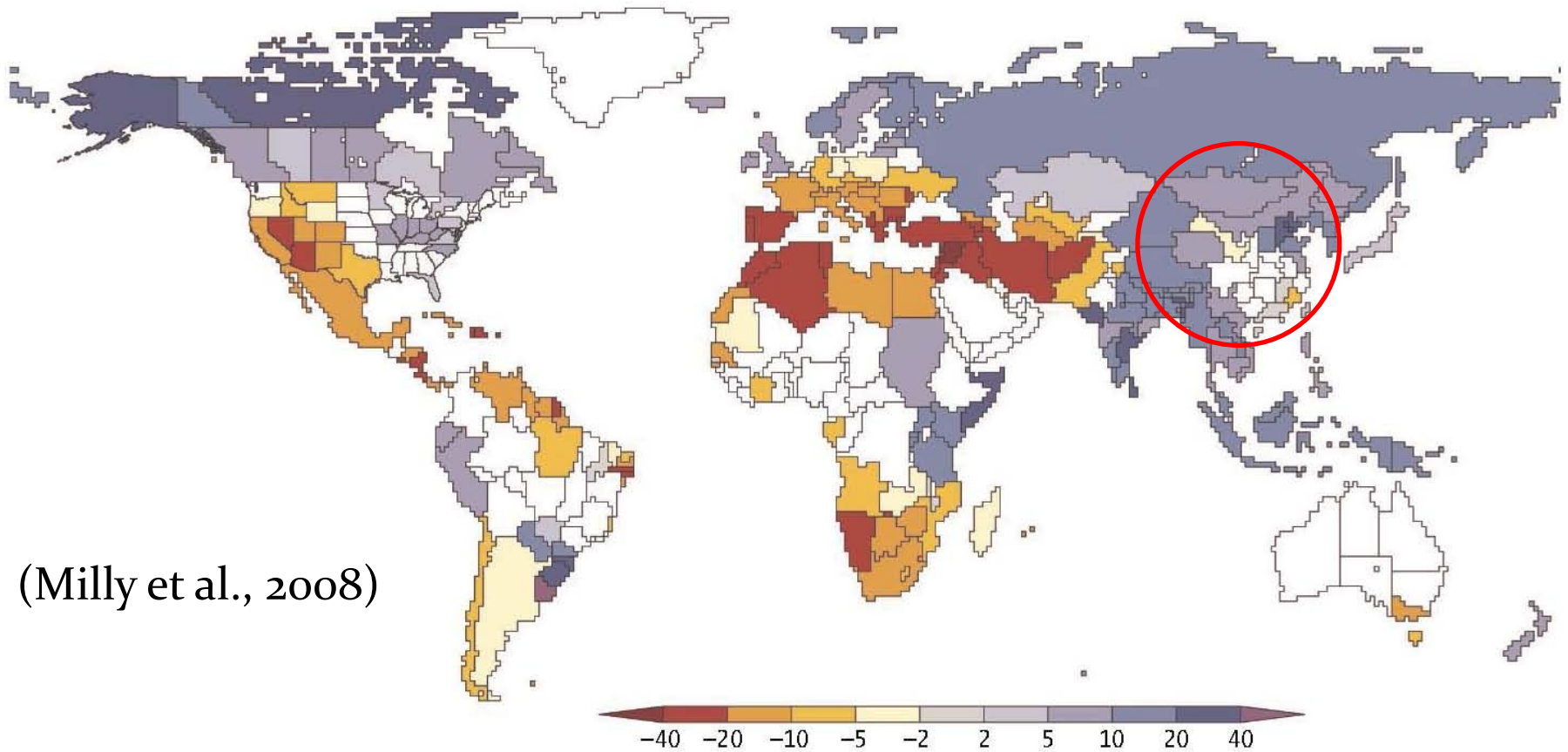
Consequences of SNWTP

- Impact of climate changes on flows of Yangtze River
- Polluted inflows and return flows
- Environmental and ecosystem issues
- Energy consumption
- Social impact on displaced people
- Institutional controls



Mount Everest's East Rongbuk Glacier lost ~350 vertical feet of ice between 1921 and 2008
© National Geographic 2010

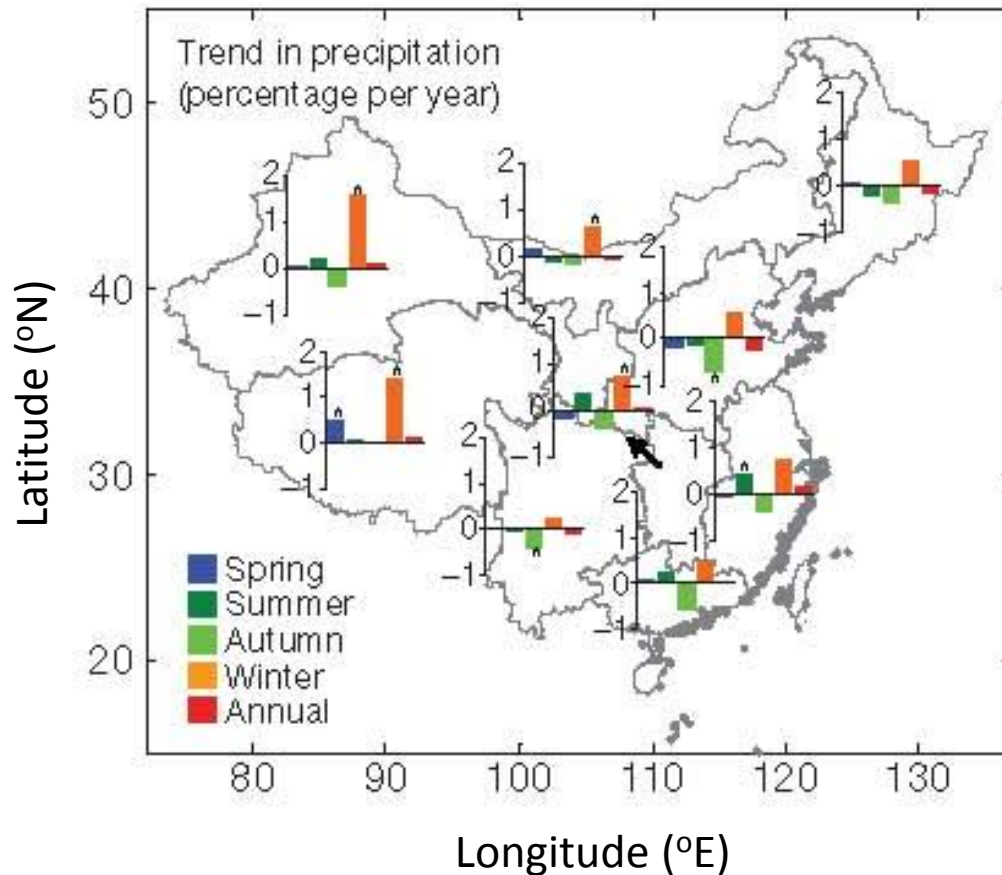
Wetter or Drier?



(Milly et al., 2008)

Projected change in runoff volume by mid-21st century relative to 1900-70

Trend in Precipitation as Percentage Per Year Based on Data from 1960 to 2006



(Piao et al., 2010; NATURE)

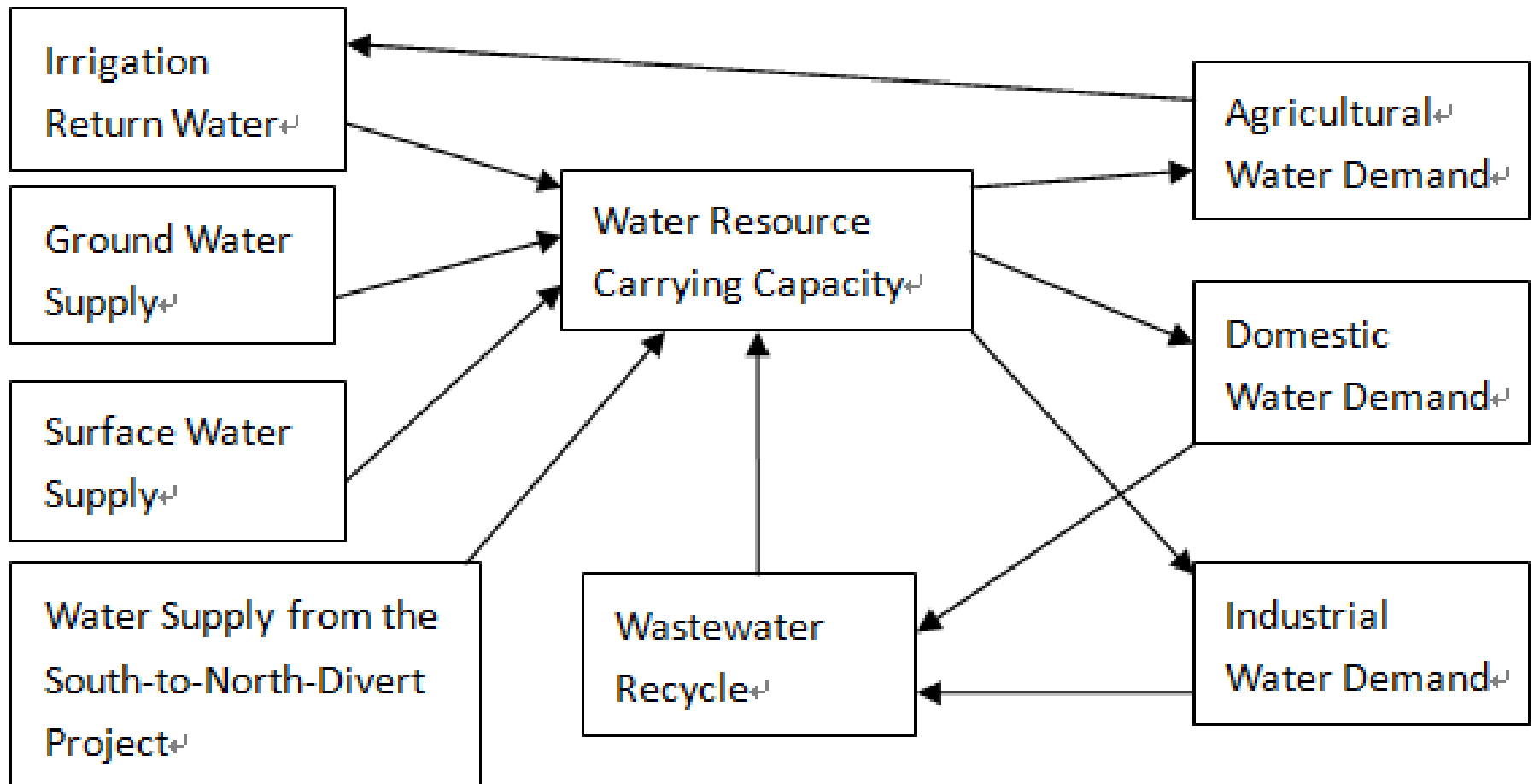
Challenges and Opportunities

- Water and energy were designated top two national priorities by Chinese government for the 2006-2020 “medium- to long-term planning period”
- Substantial increases in governmental funding for water and environmental research, assessment, and data gathering
- Total investment for the water services market over next 5 years (2009-2014) is expected to top 1 trillion RMB (\$150 billion USD)

Thank you!

Lake Tianchi (Heavenly Lake)
Xinjiang, October 2008

System Dynamics Analysis of Water Supply and Demand for NCP



Projection of Water Deficit 2010-2030

