Monitoring and modeling hydrological change in Hai River Basin, China

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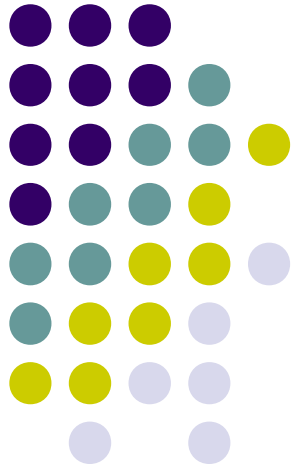


Outline

- About our institute
- Hai River Basin (HRB) and hydrological changes
- Agricultural water issue
- Future plan

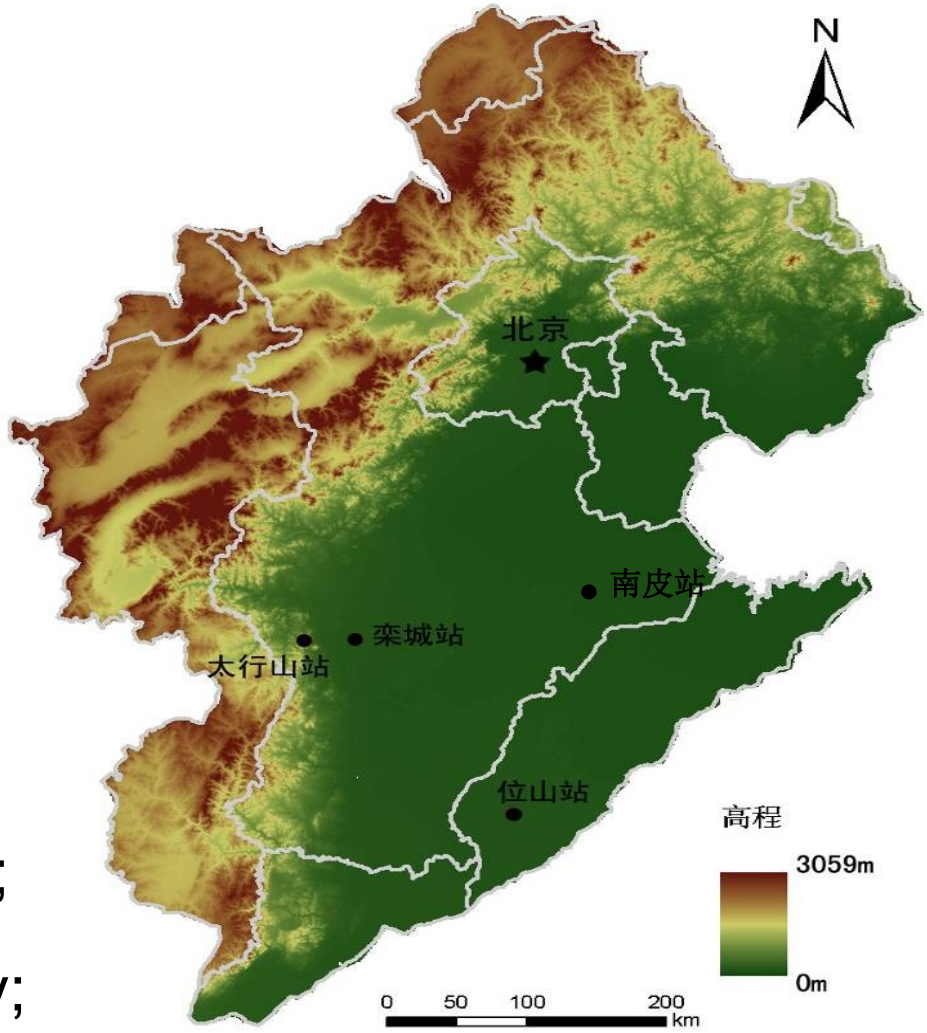
About our Cent

Center for Agricultural Resources Research

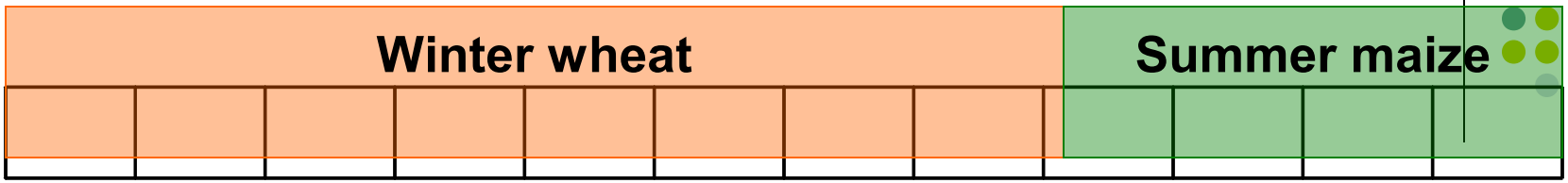
- 12 research teams
- 110 research staffs
- 80 graduate student
- 3 field sites

Hai River Basin (HRB) and its hydrological changes

- A basin under human exploitation for thousands of years;
- Area: 318, 000 km^2;
- Population: ～100 million;
- 15% of China's industrial production;
- 30% of China's grain production;
- Pr = 500~700 mm; Ta = 14 C;
- water resource ~300 m^3/cap/y;

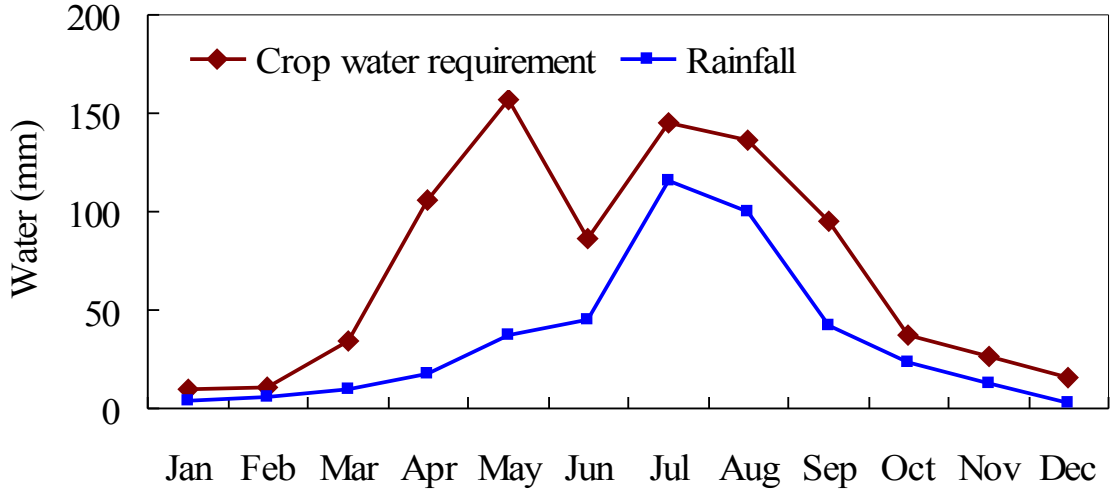


The typical cropping mode of NCR

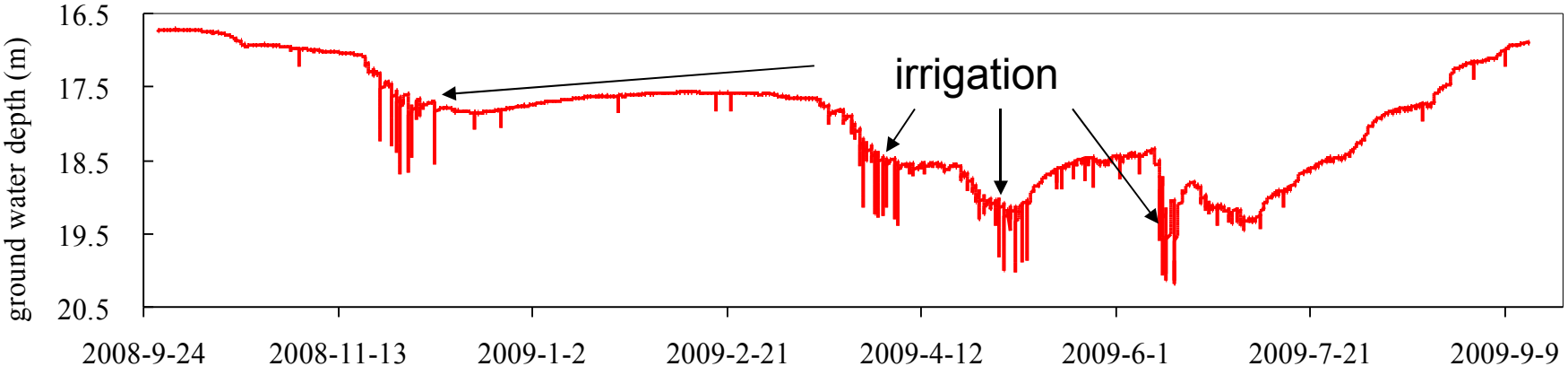


Winter wheat	Summer maize
Grain yield:	
5.3t/ha (irrigation)	**7.4t/ha (irrigation)**
3.6t/ha (rain-fed)	**4.7t/ha (rain-fed)**
Precipitation:	
127.7mm	**288.6mm**
Crop water requirement:	
429.4mm	**433.1mm**
Irrigation requirement:	
301.7mm	**144.5mm**

Data source: Luancheng agro-ecosystem station (sun et al, 2007)

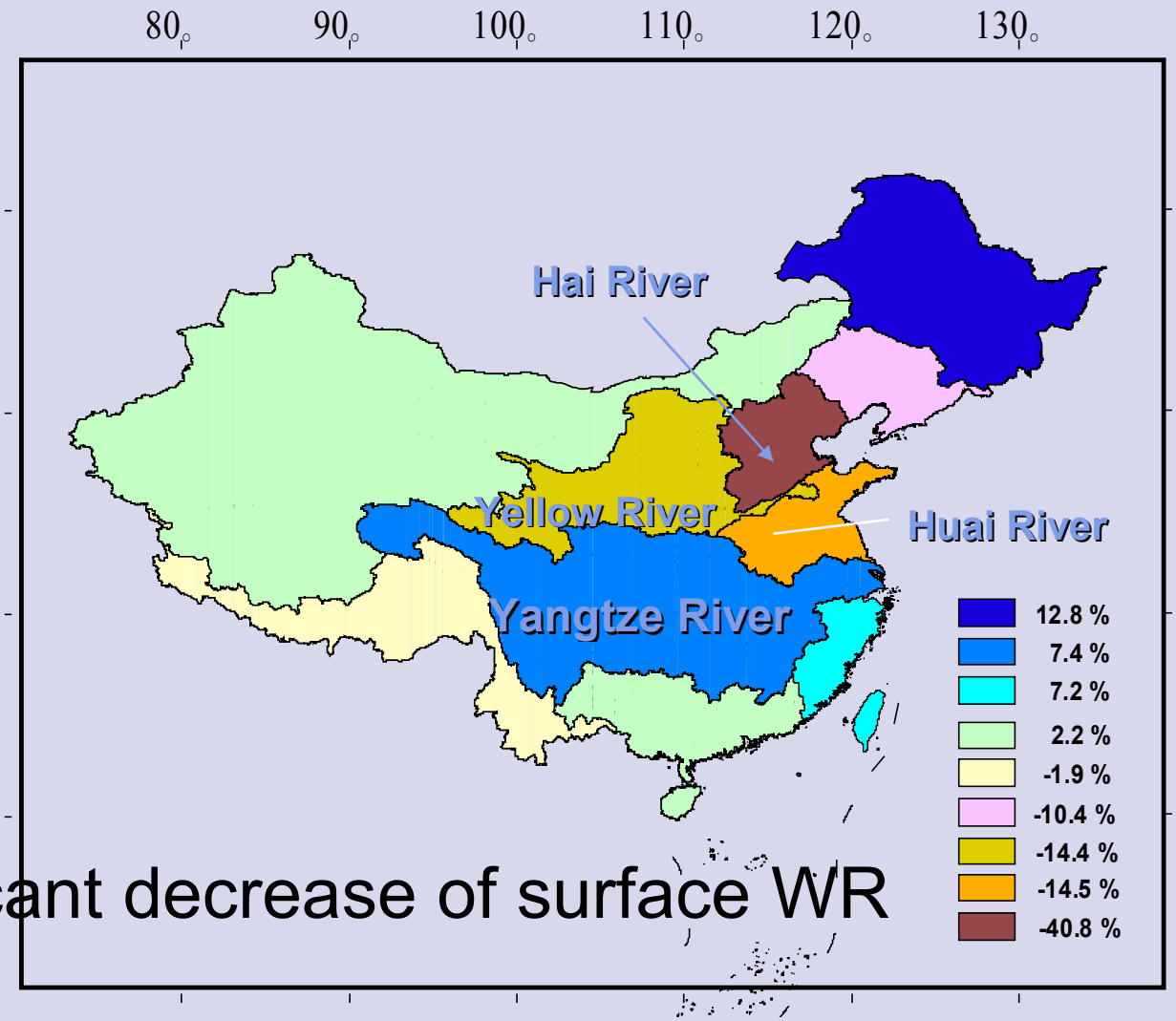


Average monthly crop water requirement , rainfall of Luancheng from 1984 to 2005



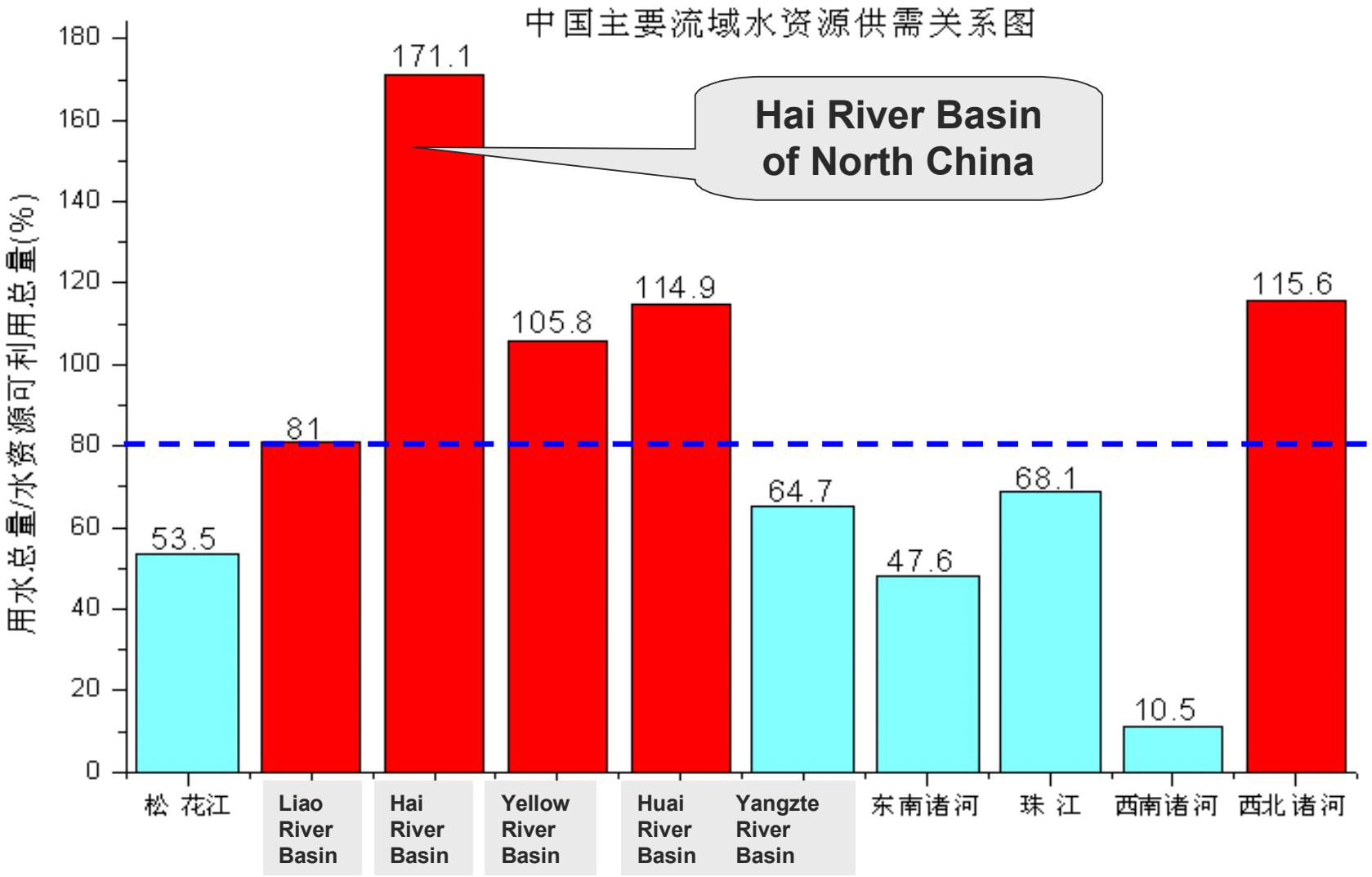
Annual change of groundwater depth, Pengjiazhuang (Luancheng)

Runoff variation by comparison of 1980-2000 with 1956-1979

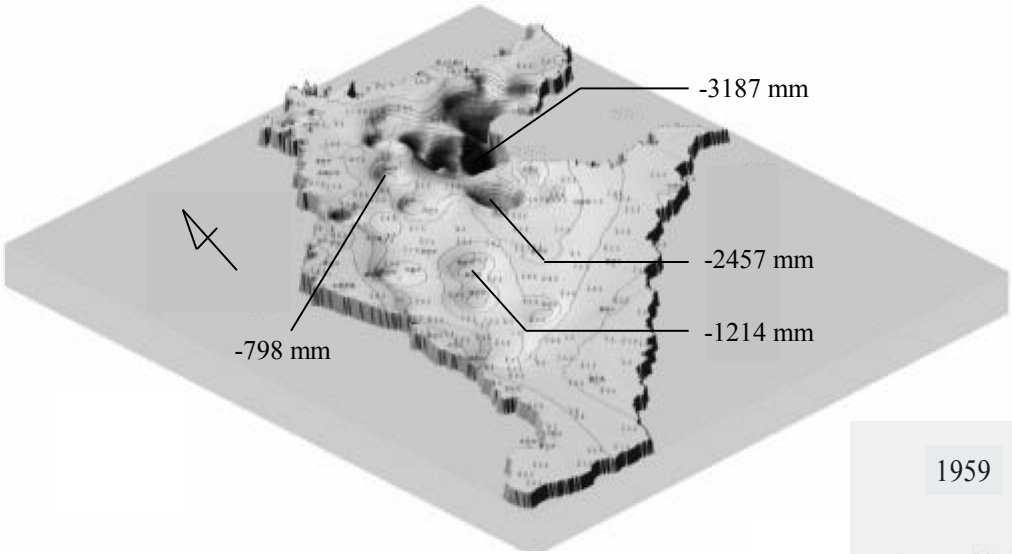


Significant decrease of surface WR

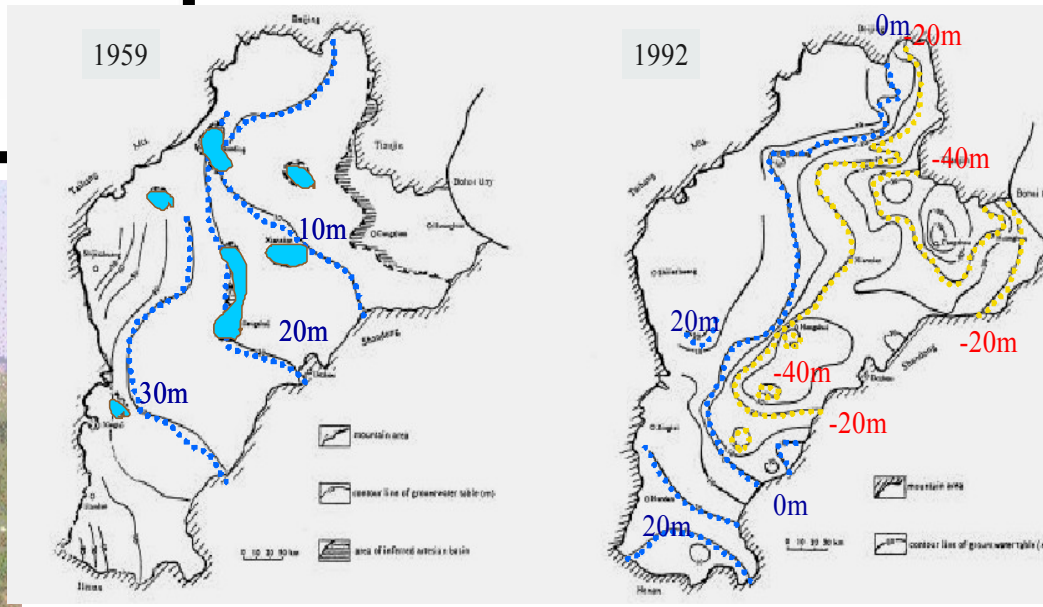
Total water use / usable water resources in China

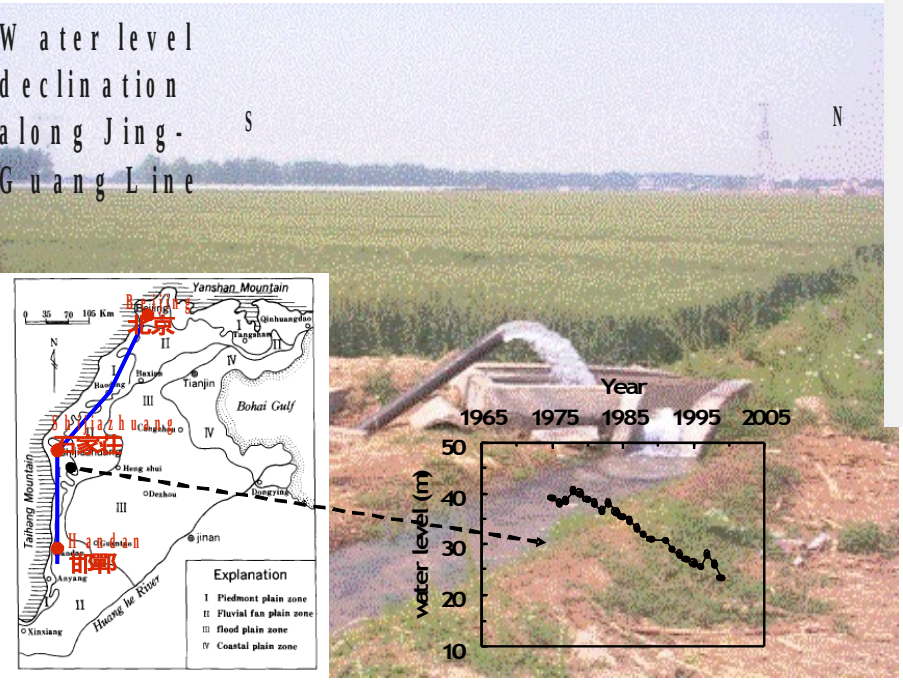


Schematic Map of Land Subsidence in North China Plain (1986-2004)



Depletion of groundwater





Agricultural sector shares more than 70% of total water use.

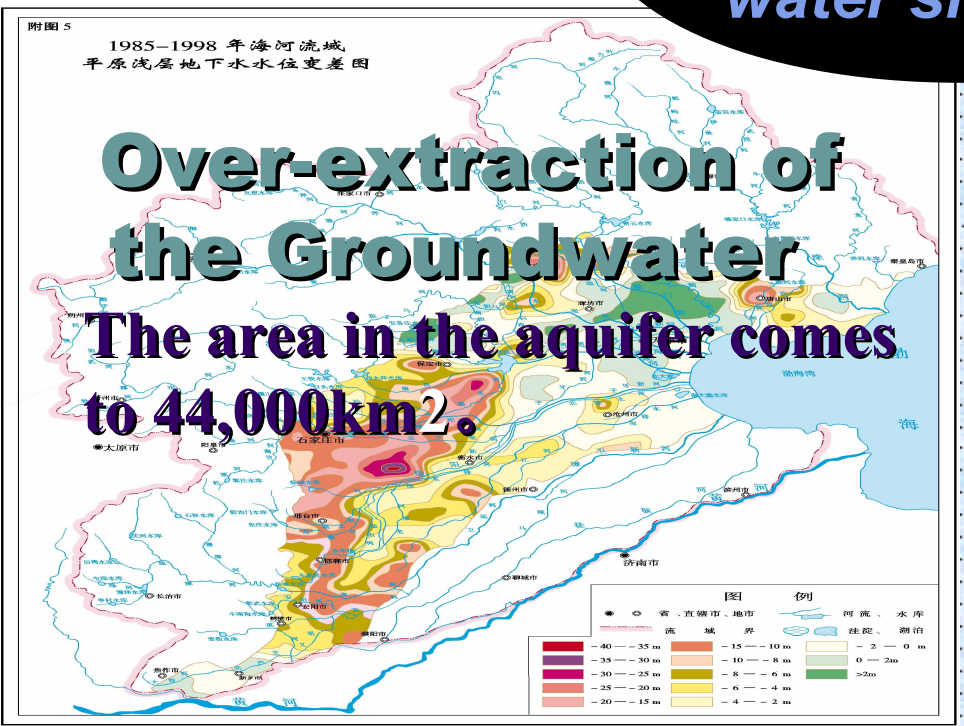
Drying-up of Rivers

40% of the total rivers was changed to be seasonal rivers

Wetland degradation

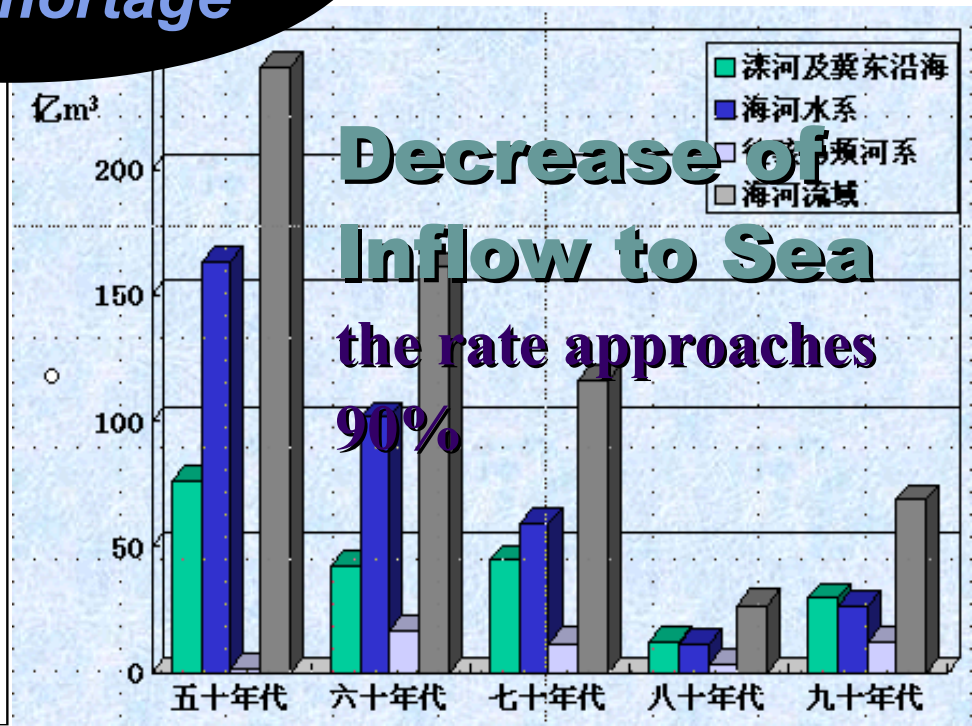
the rate reaches 90%

Ecosystem degradation due to water shortage



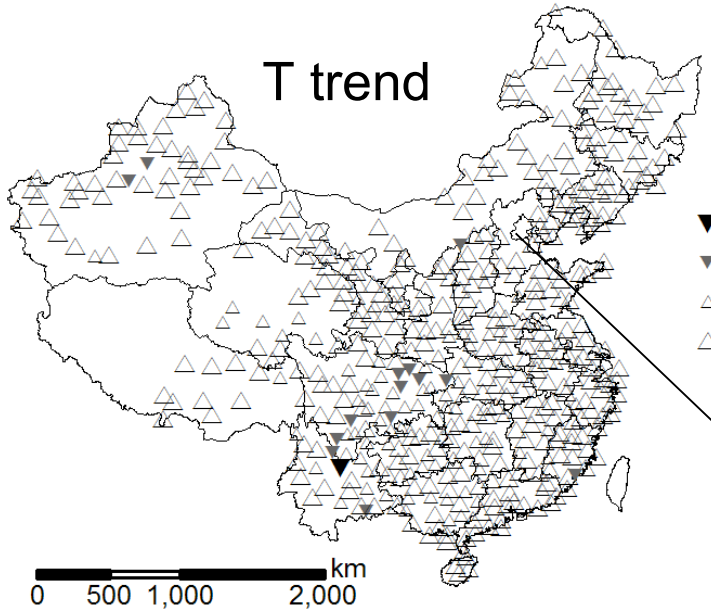
Over-extraction of the Groundwater

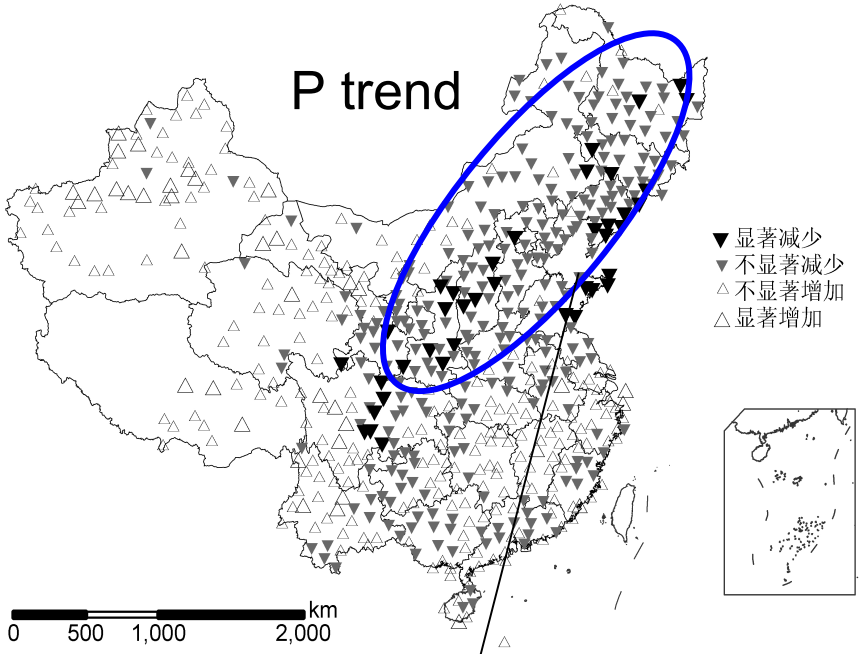
The area in the aquifer comes to 44,000km^2。

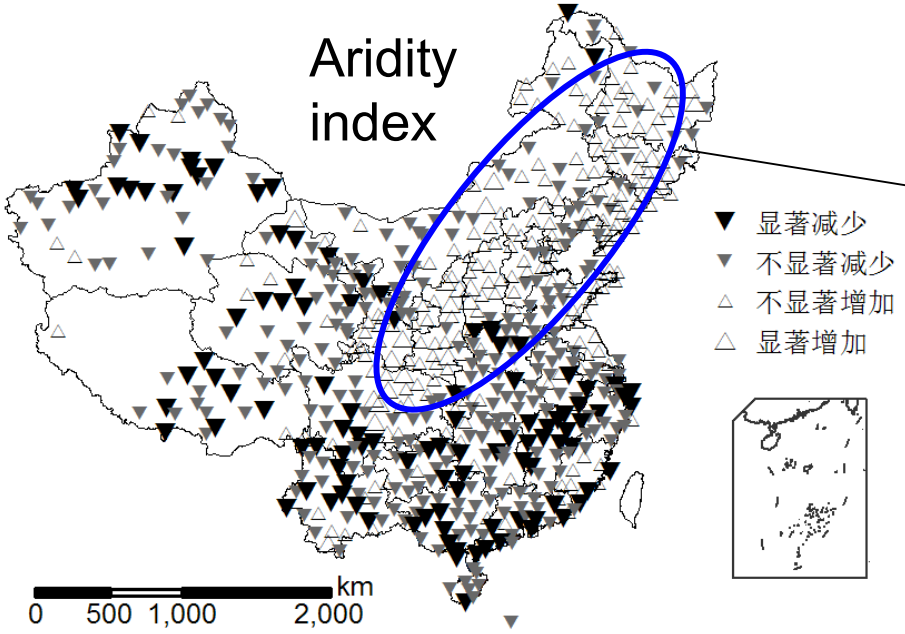


Decrease of Inflow to Sea

the rate approaches 90%



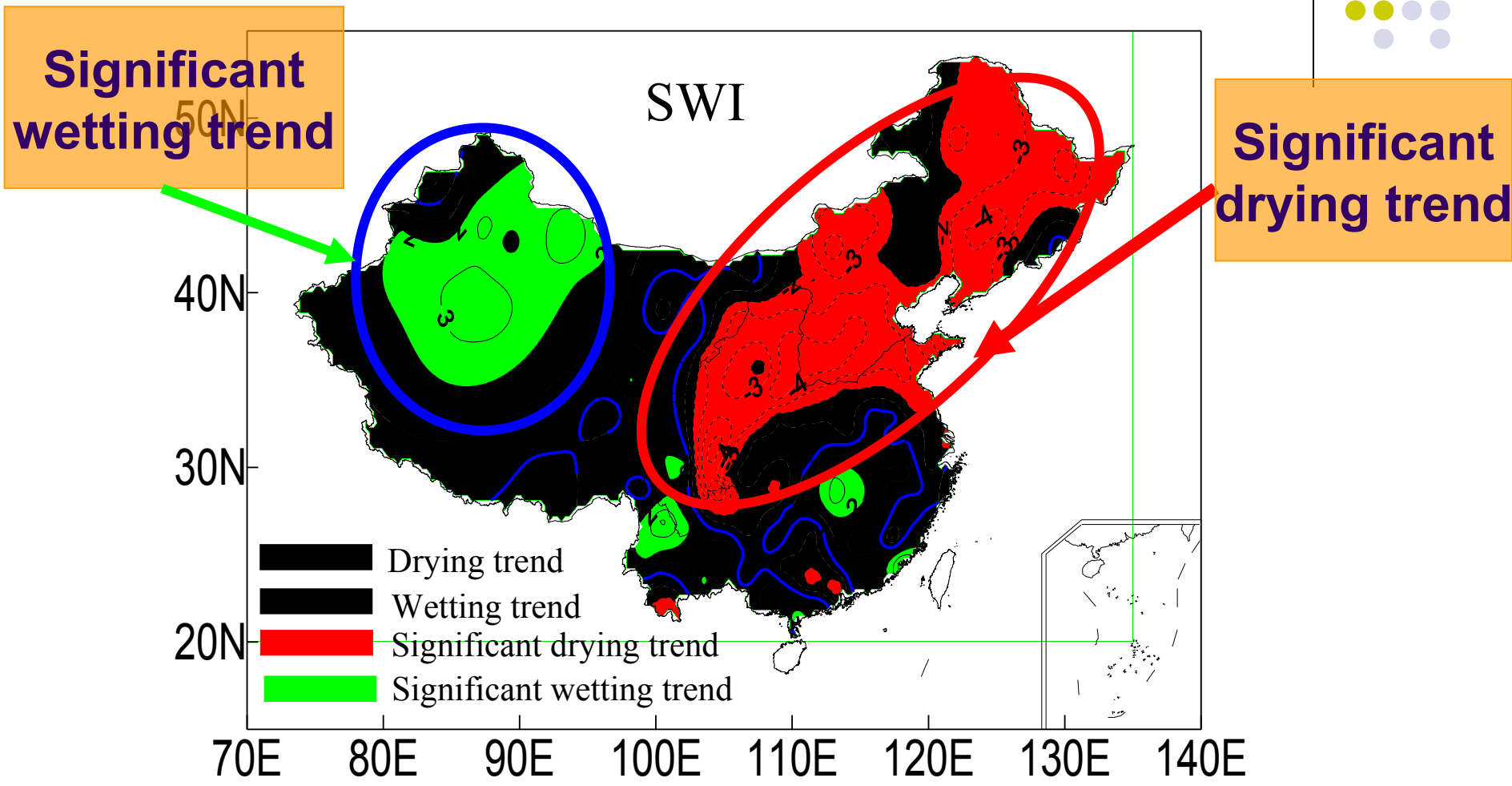




Significant drying and warming trend in past 50 years!

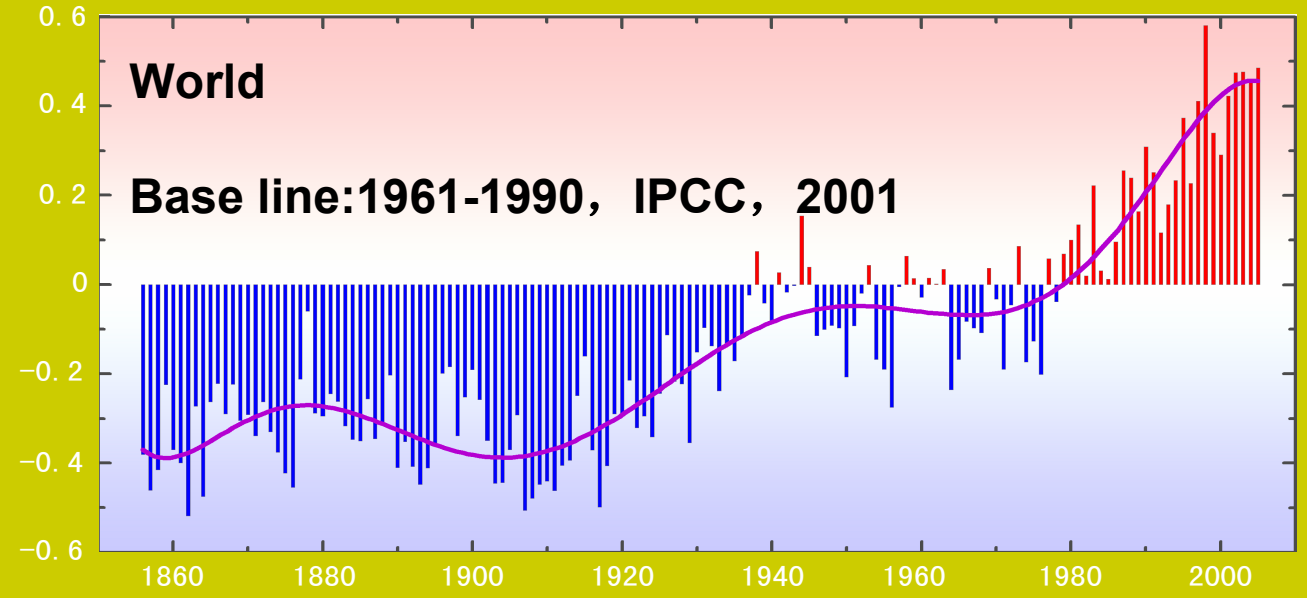
(Liu et al. 2009)

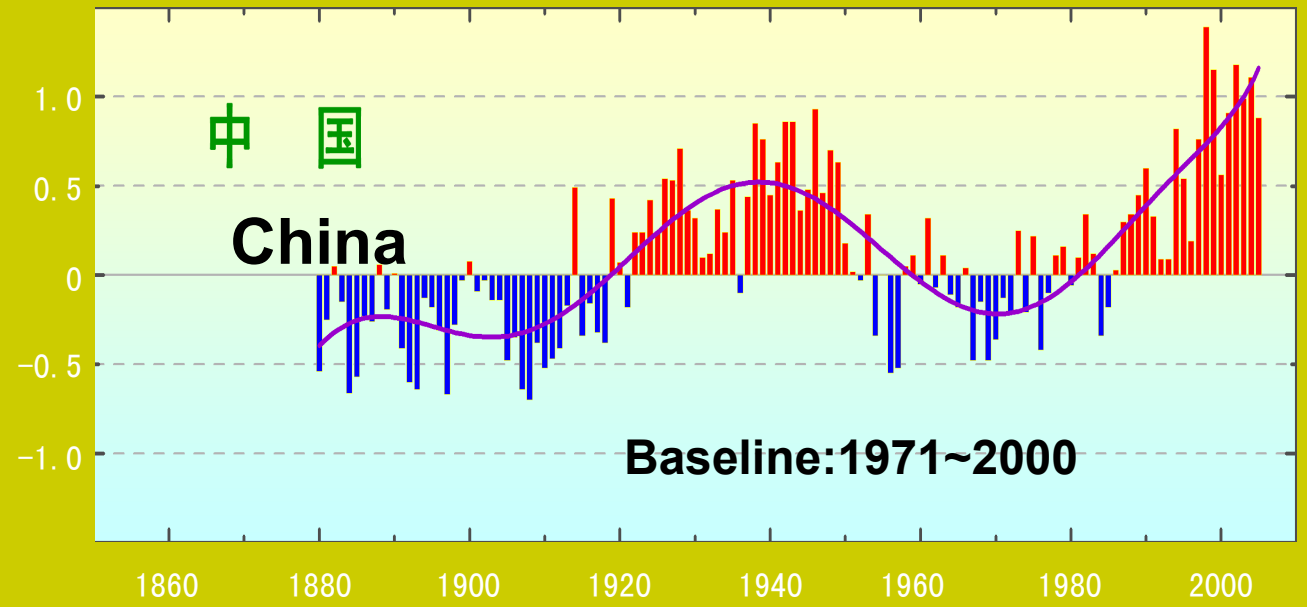
The Trend of Surface Wetness Index in China from 1951 to 2006 (Z G Ma)



The significant drying trend is mainly in semi-arid area in China

Warming is accelerating



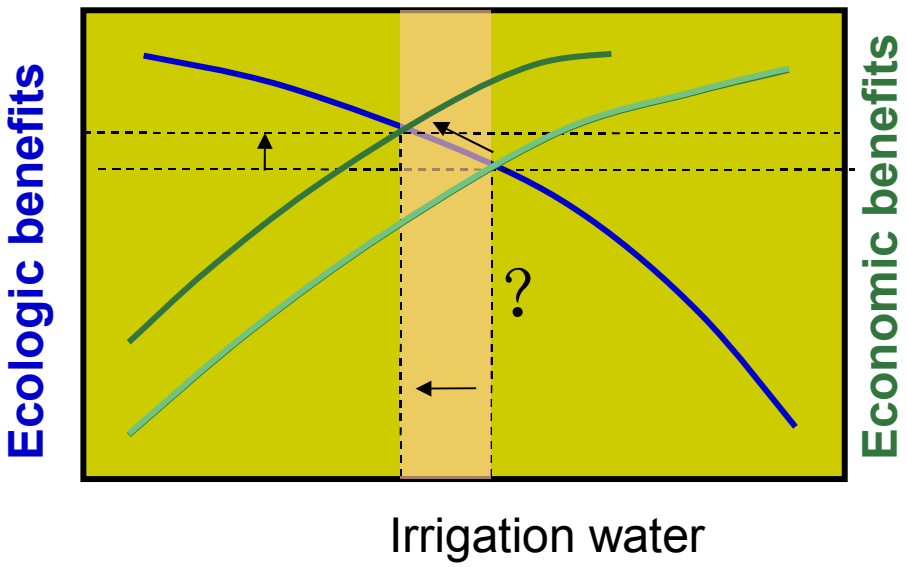


Future
???

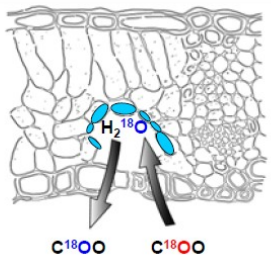
Agricultural water resources

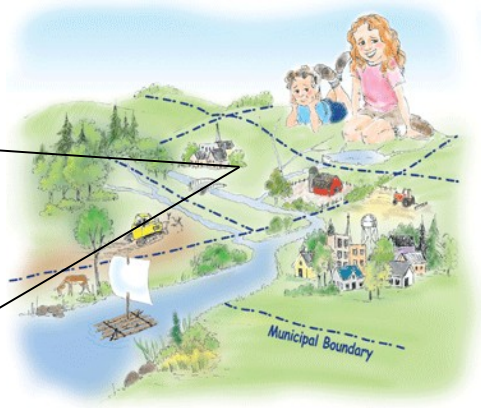
- Agriculture is the largest water use sector (> 70%)
- Irrigation development contributes most to yield increasing
- Irrigation alters hydrological cycle
- Agricultural water use closely relates to regional energy and water budgets, and affects regional climate

Questions…

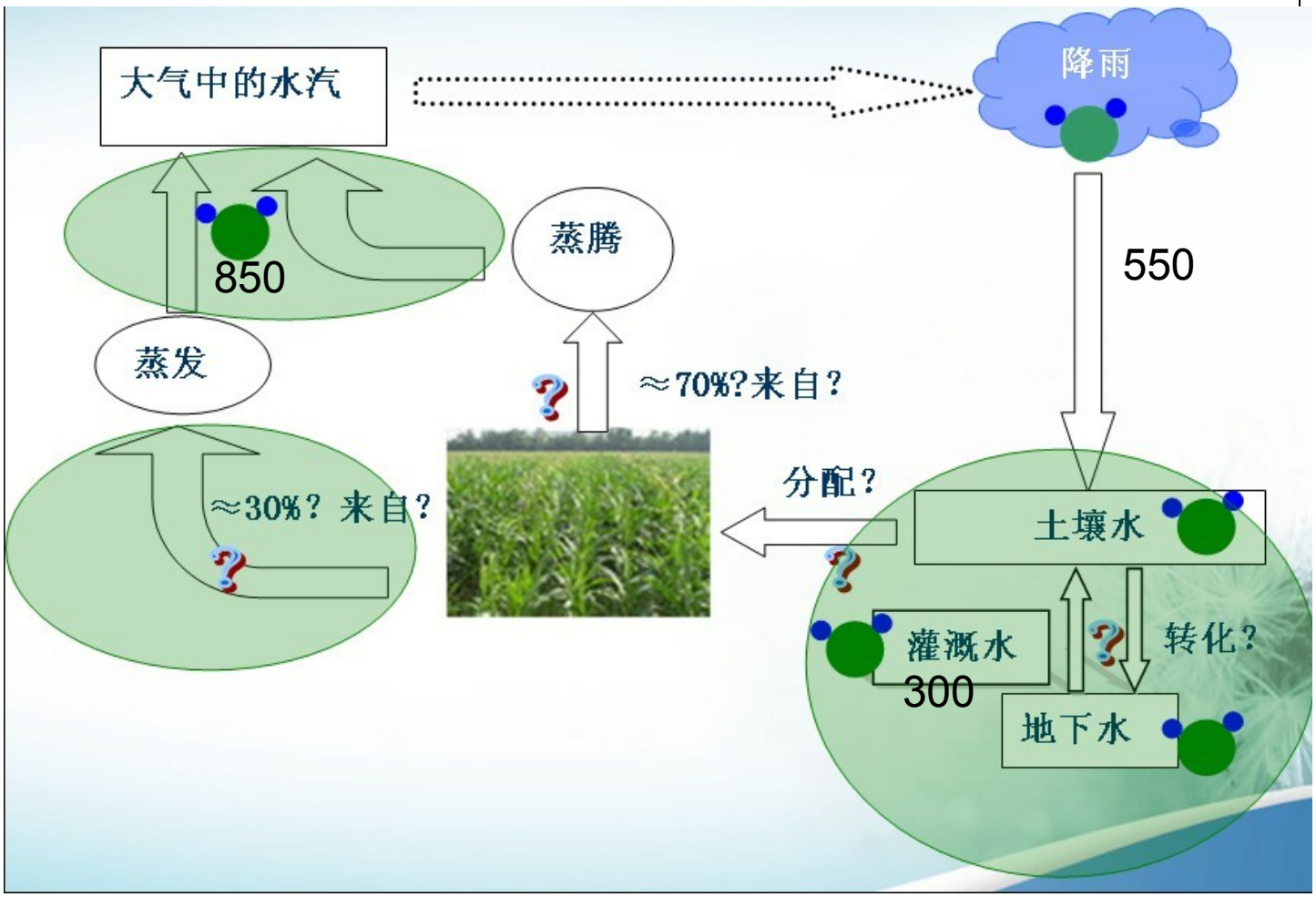


- Energy partitioning process?
- Crop water demand/consumption, WUE?
- Nonproductive water consumption?
- Transformation of irrigation water?
- Agricultural water consumption and water saving at regional scale?

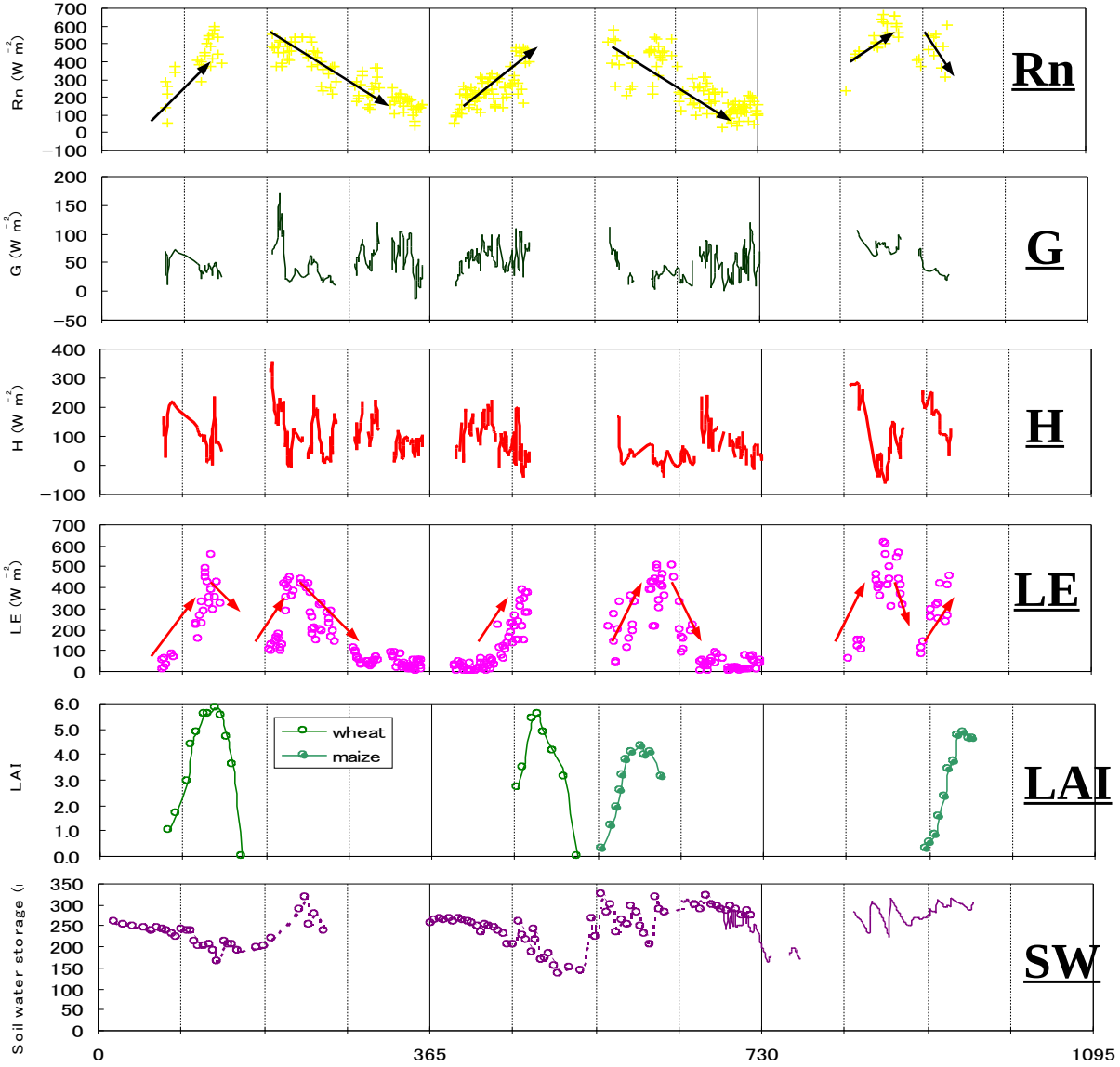




农田水分循环与转化示意图



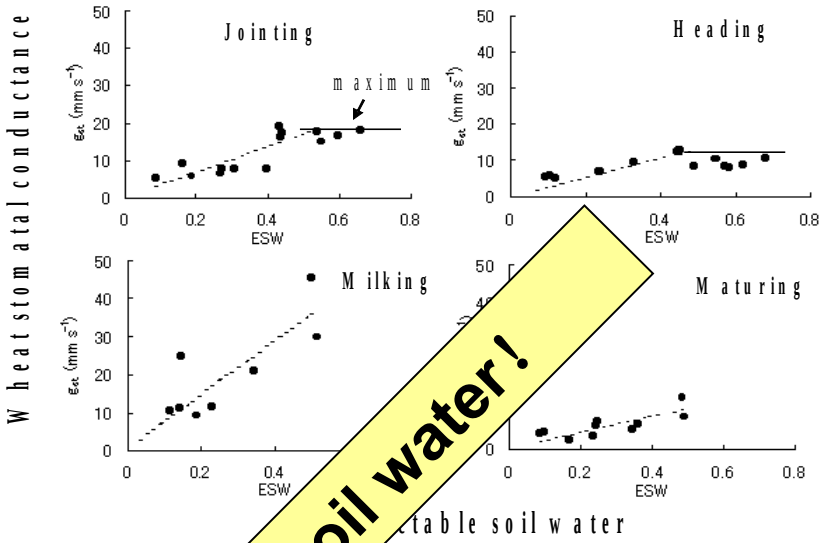
So, at farm scale…..



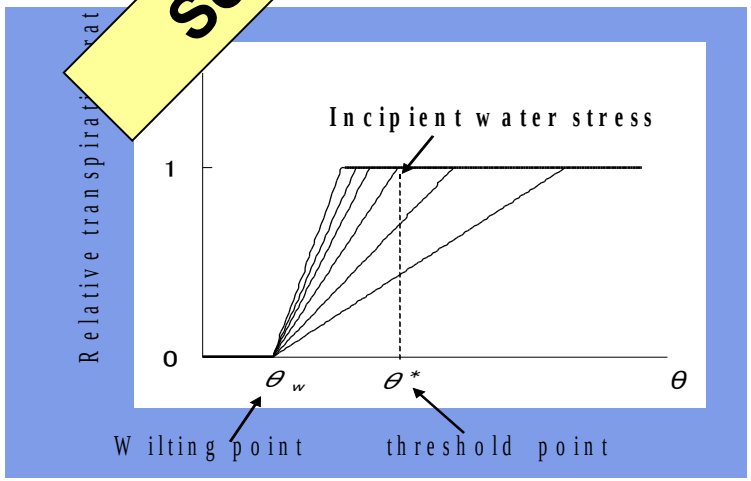
Days from 1999/01/01

(Shen et al., Hydr. Procs. 2004)

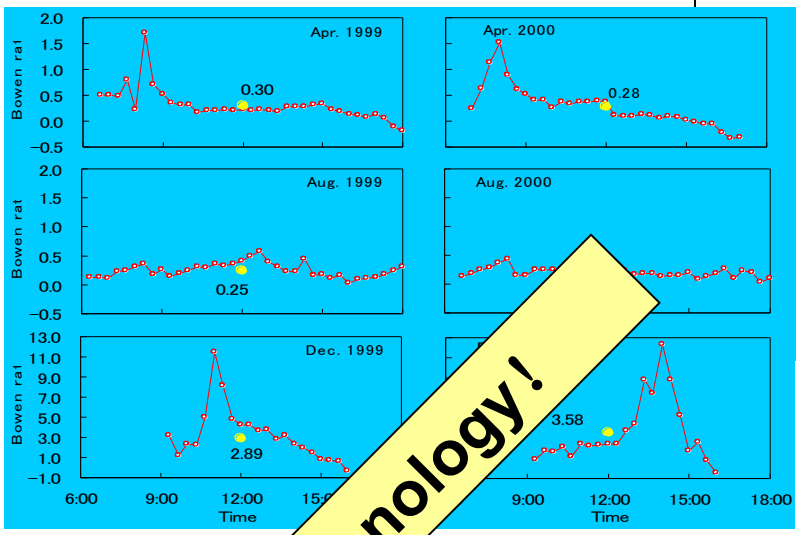
Energy and water balances as influenced by moisture and phenology

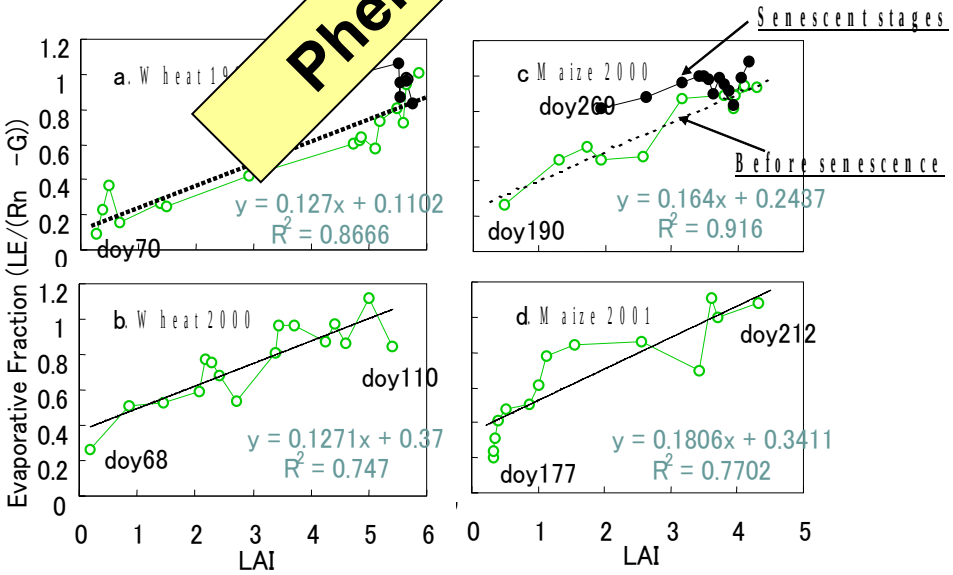


Soil water!



Phenology!

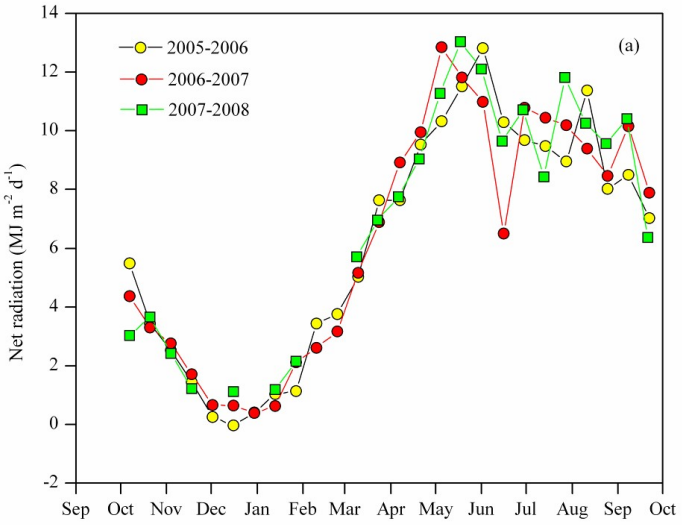


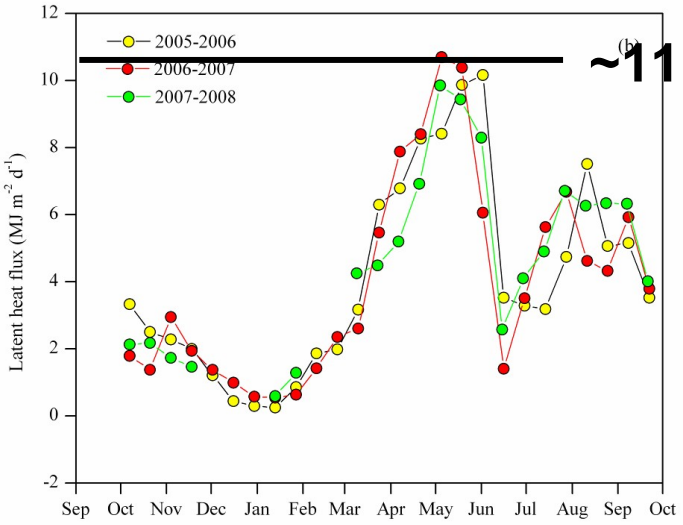


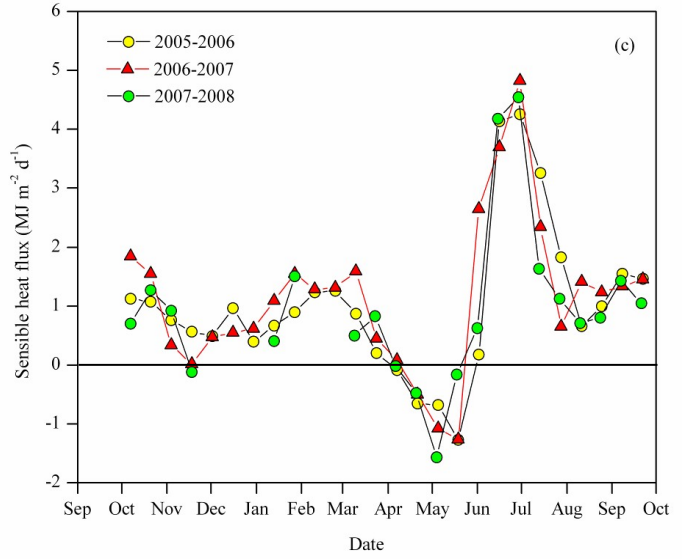
(Shen et al., Hydr. Process., 2002)

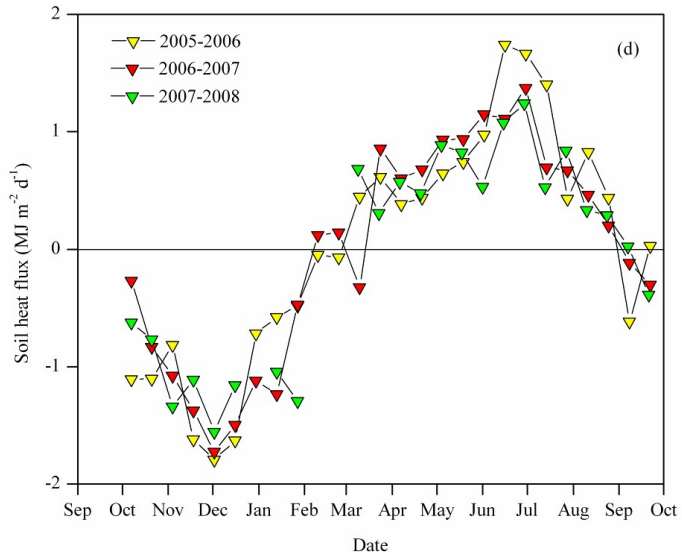
(Shen et al., Hydr. Process., 2004)

Energy balance at Liaocheng



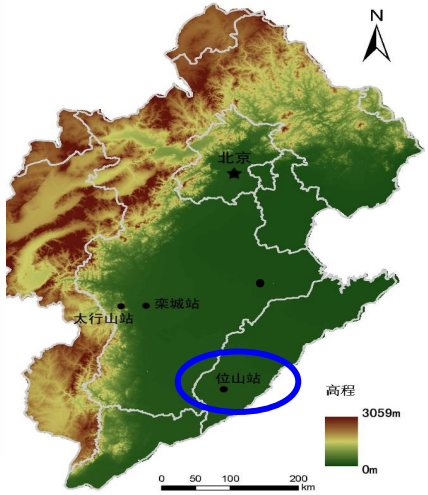




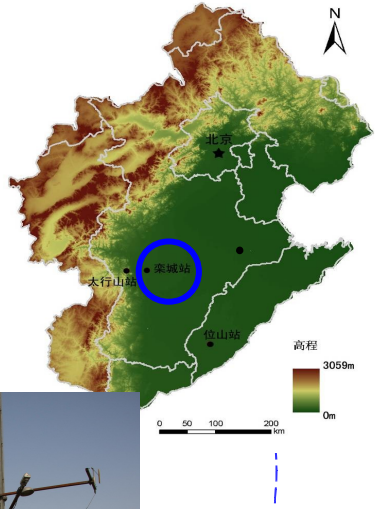


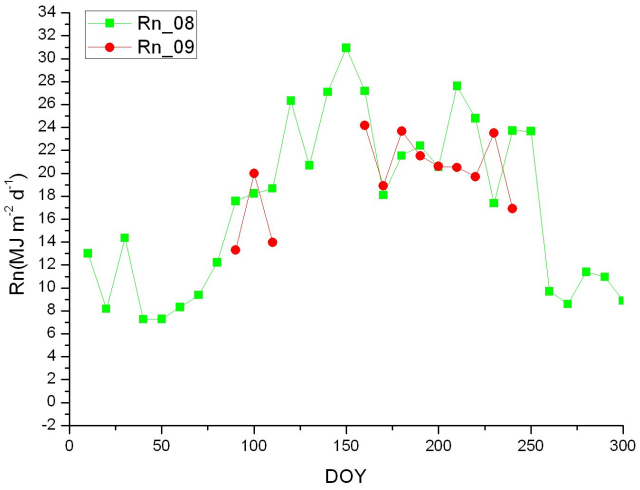
Yellow R irrigated

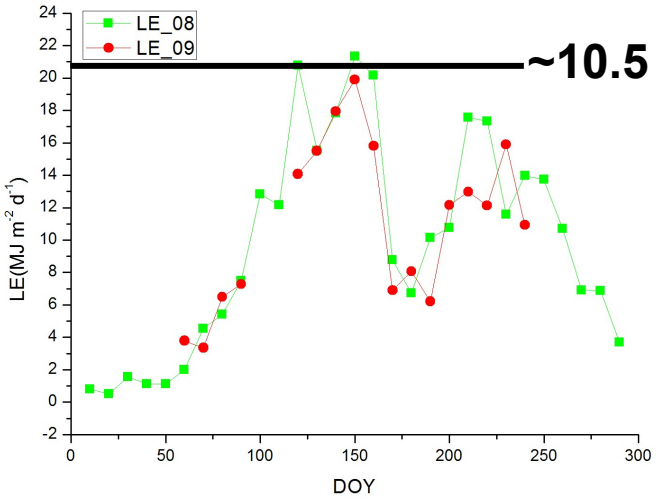
Groundwater depth < 2m

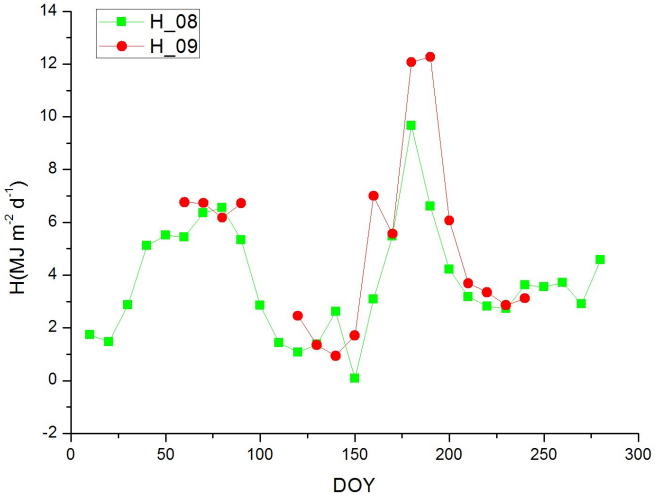


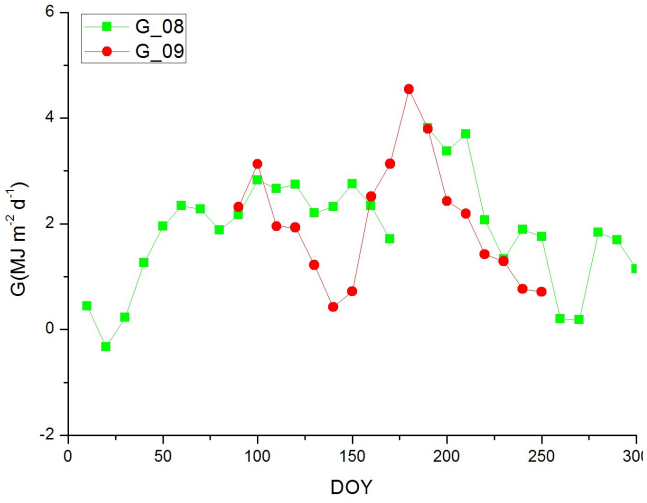
Energy balance at Luancheng

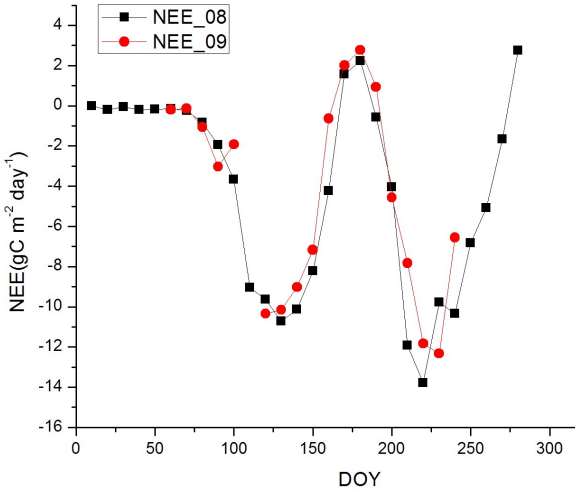






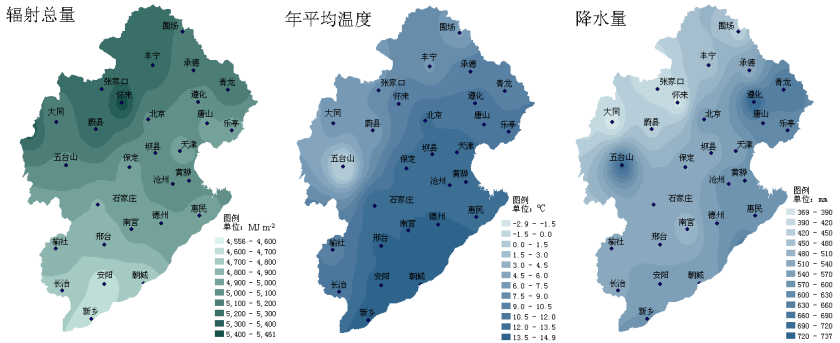




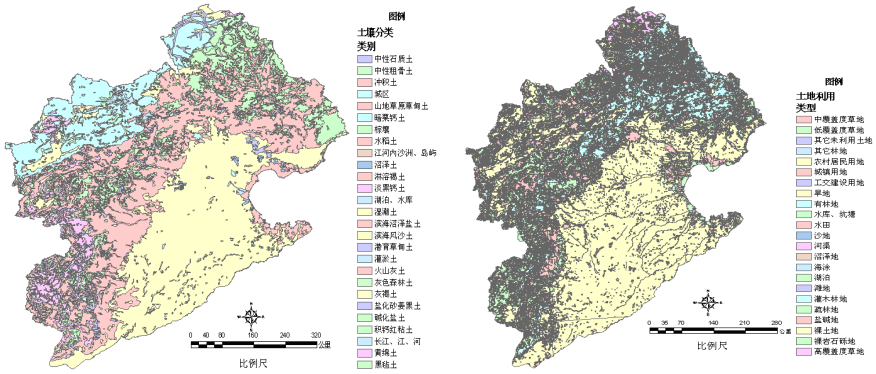


Groundwater depth > 35m

At regional scale, remote sensing+modeling

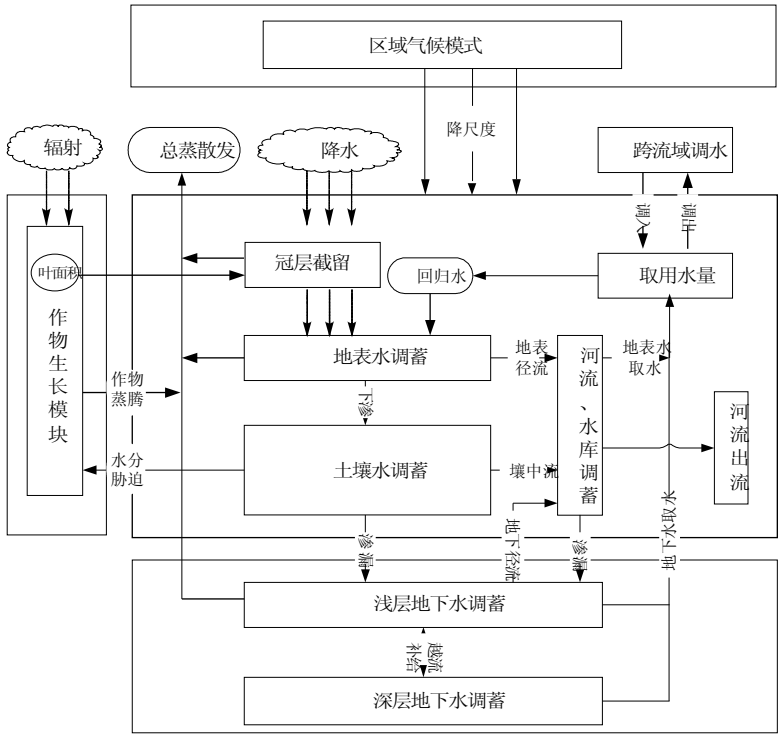


2000年海河流域的辐射、温度与降水量
radiation、temperature and precipitation in Hai River Baisn(2000)



海河流域2000年土壤分类和2004年土地利用图

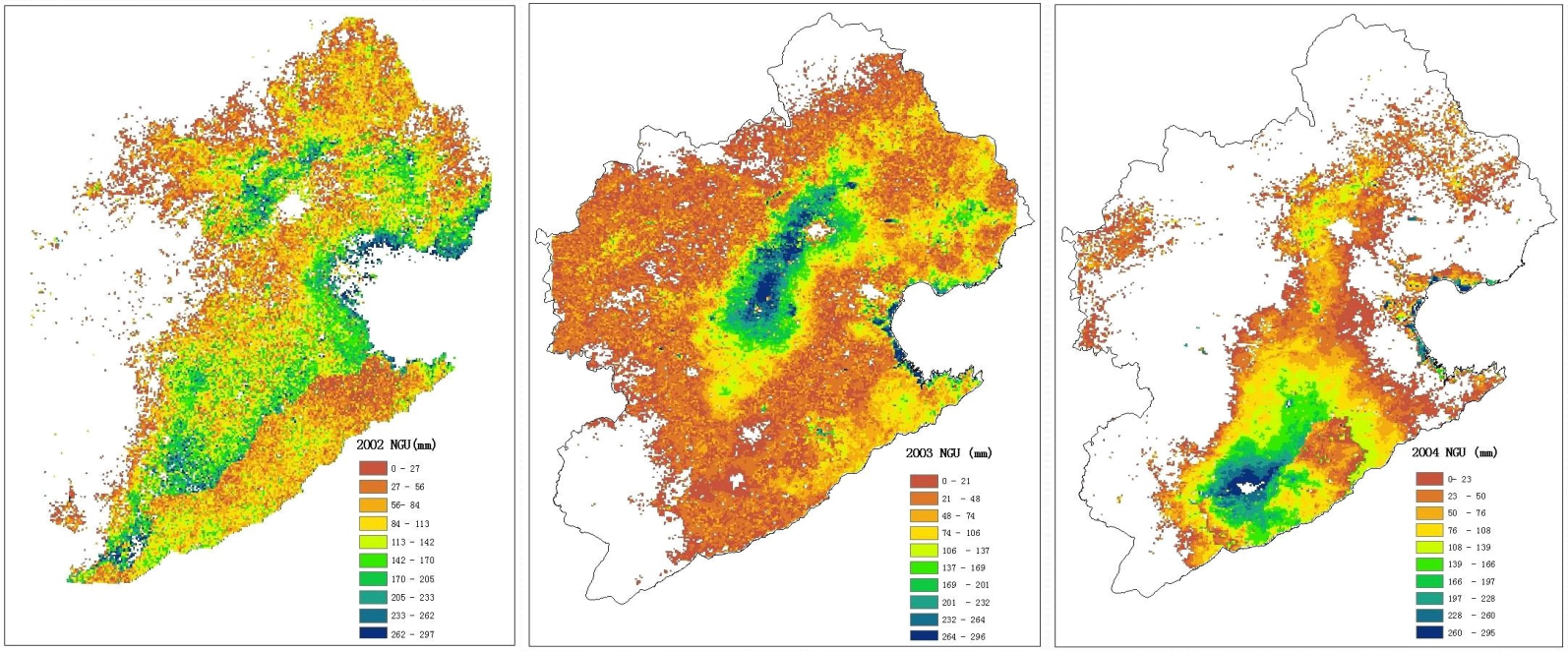
跨流域的区域分布式水循环模型框图
Across-basin Large-scale DTVGM distributed hydrological model



Groundwater management based on ET in Hai river basin, North China

Net Groundwater Use（NGU）

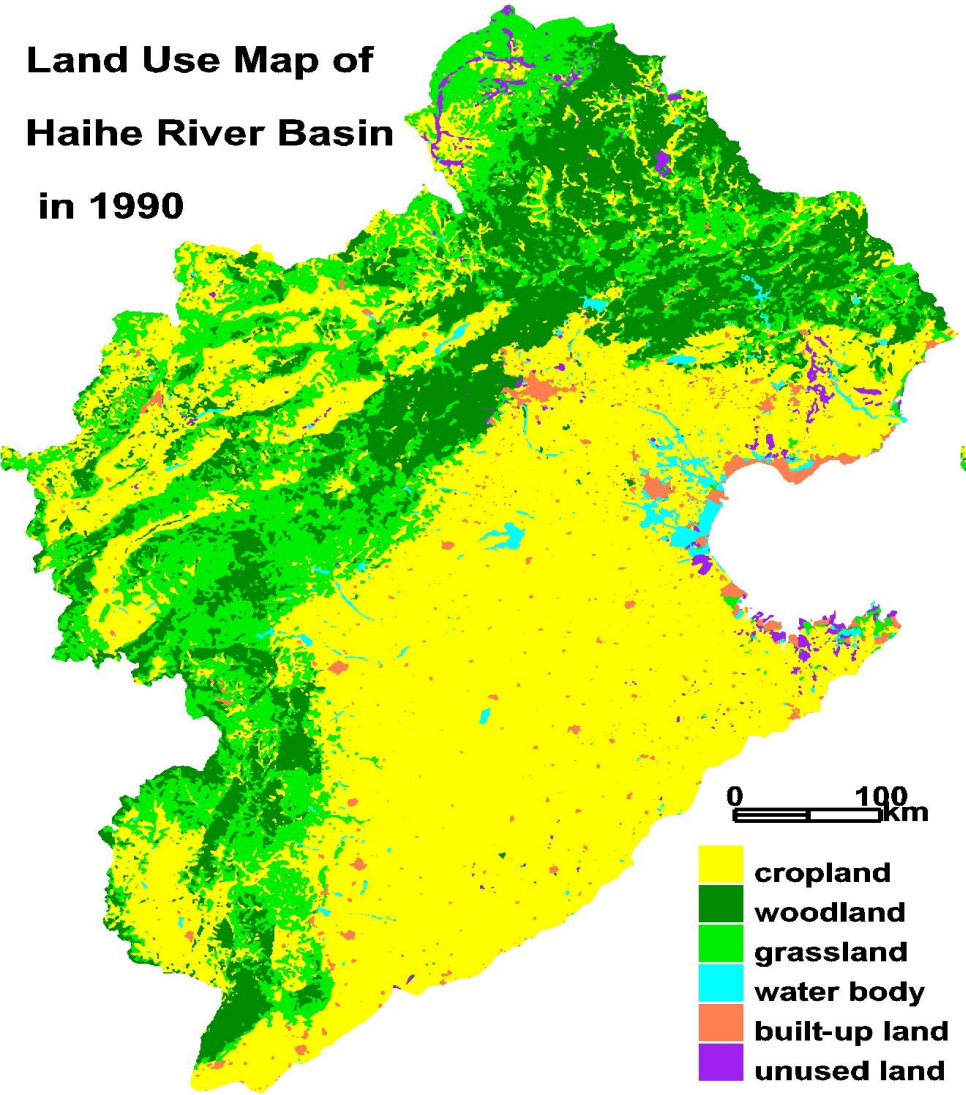
$NGU = ET_{RS} - P$

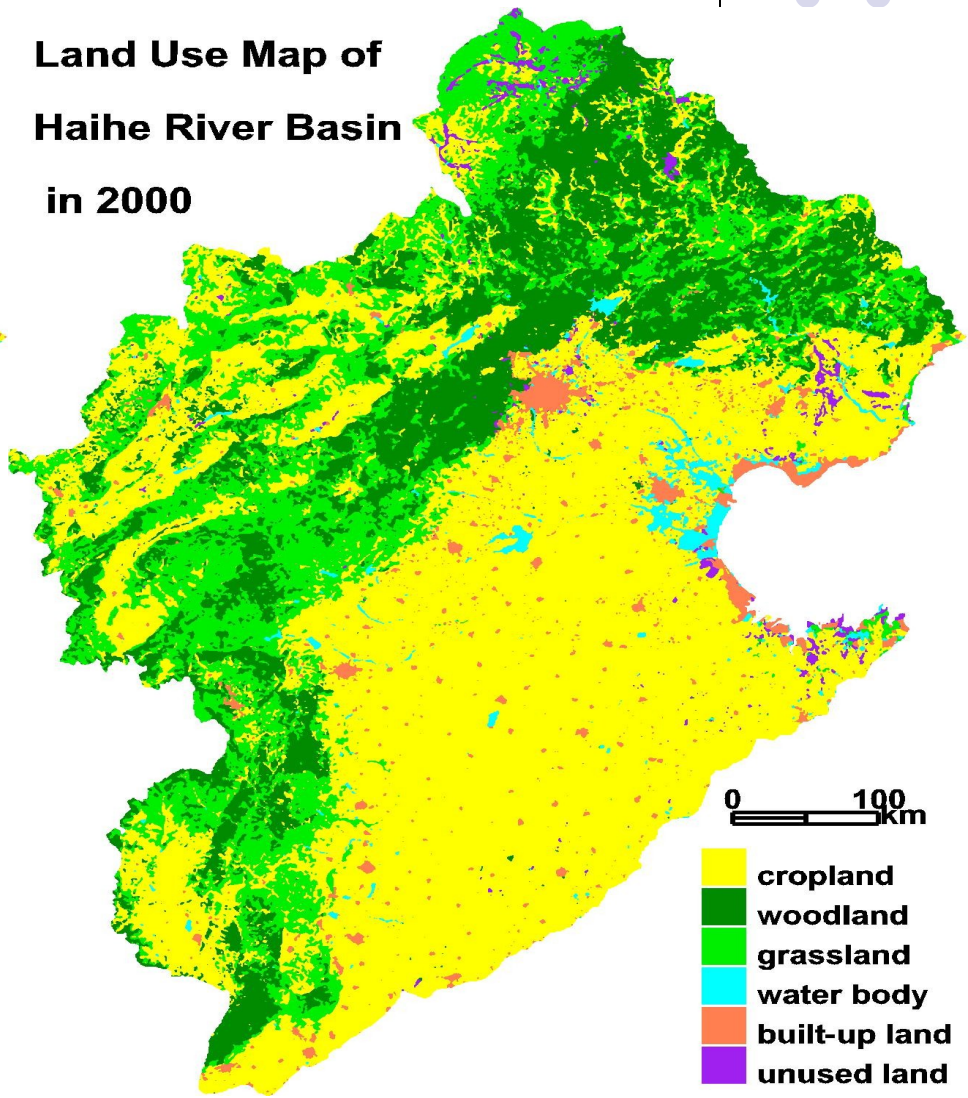


NGU Spatial Distribution Map from 2002 to 2004 in the Hai Basin

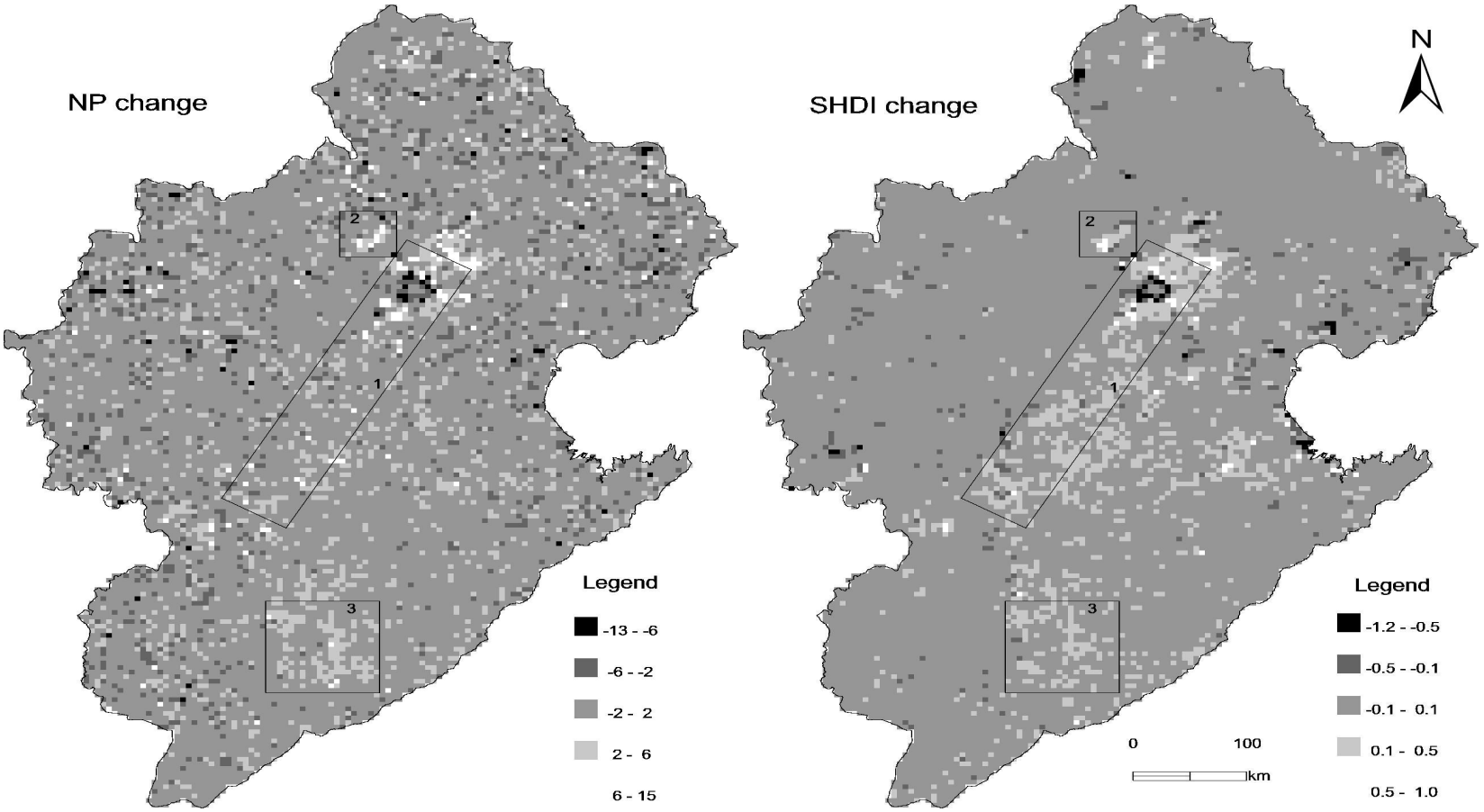
Wu et al. 2008

Quantifying human activity intensity: a perspective of land use





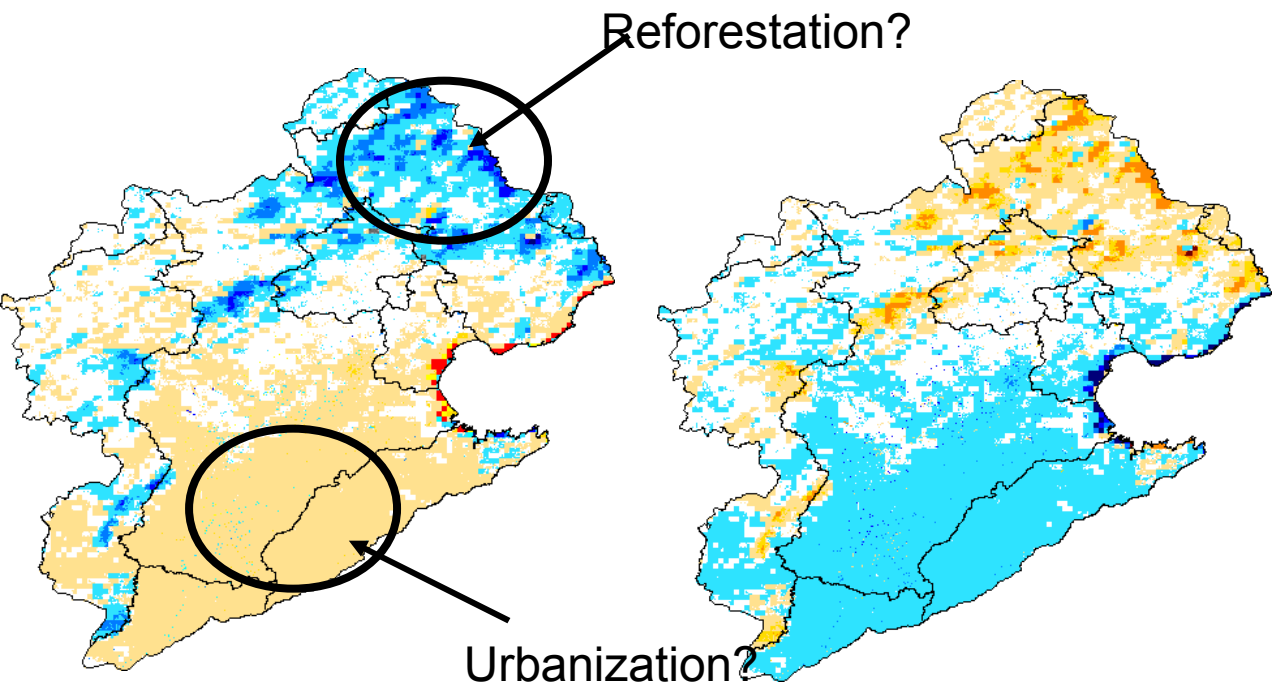
Spatial distribution of human activity intensity between 1990 and 2000

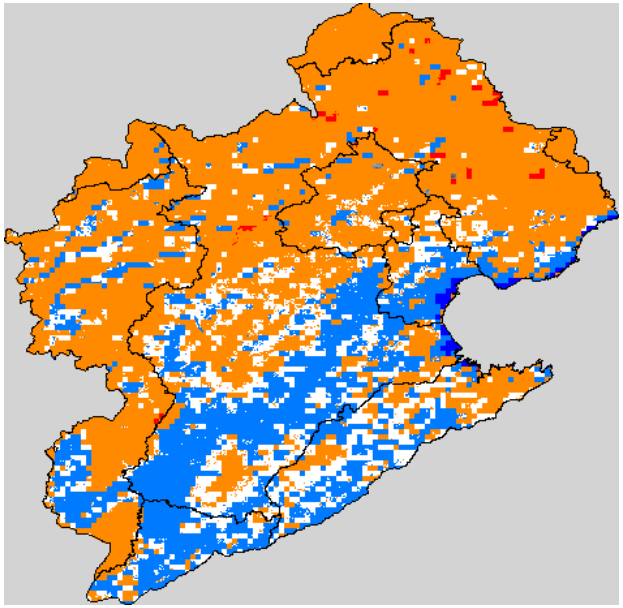


Shi Yusheng, Master thesis, 2009

Impacts of land use change

ET change | **Ro change** | **Change in aridity index**





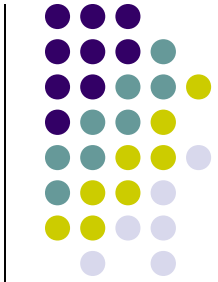
-300 -100 -50 -5 5 50 150 360 (Unit: mm/year)

Relative change (%)

-100 -50 -1 1 50 300

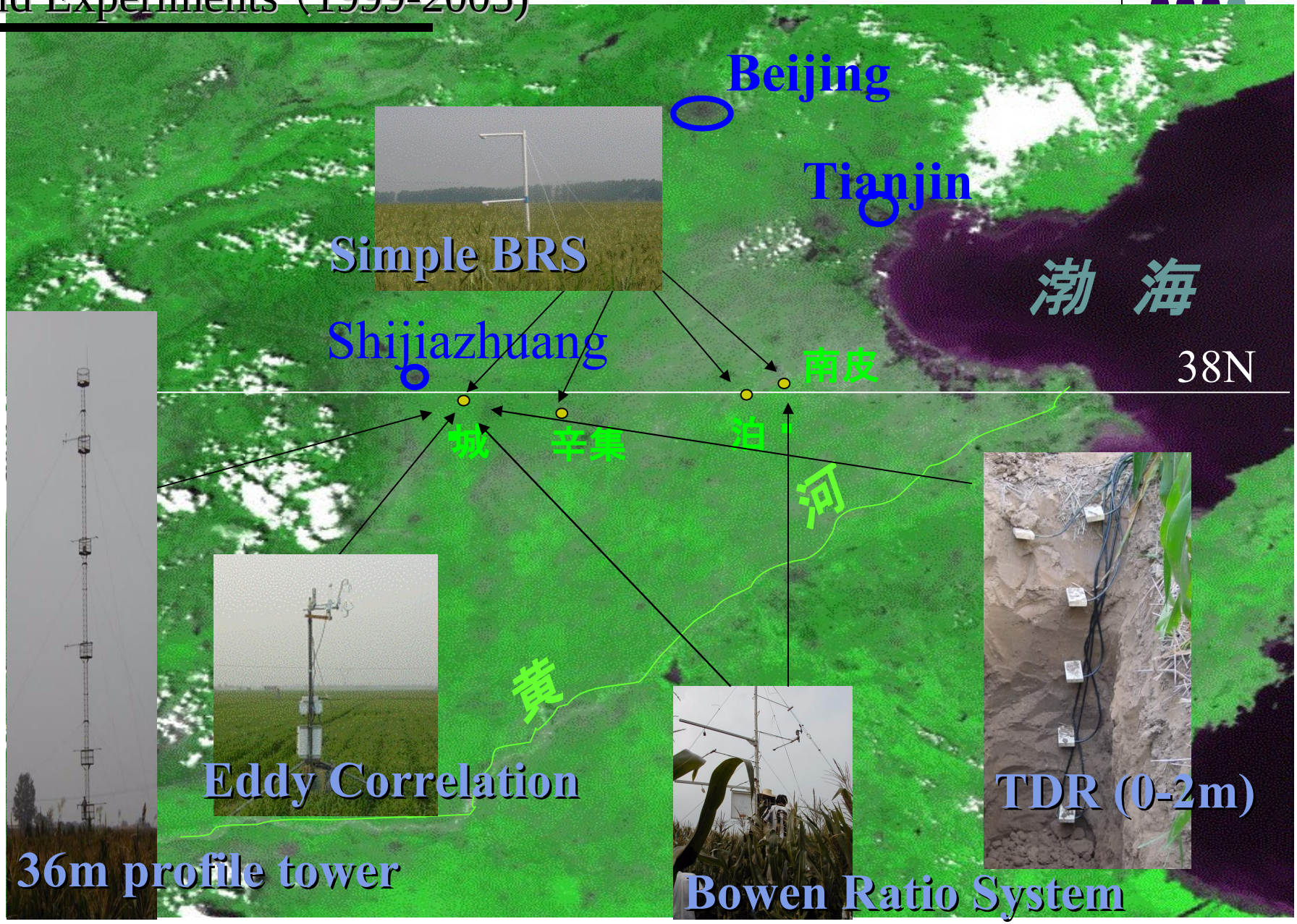
Shi Yusheng, Master thesis, 2009

Main efforts in near future



- Monitoring and modeling hydrological cycle at multi-scales

Field Experiments（1999-2005）



*: NOAA/AVHRR image of NCP.

Field Experiments（2007-2010 ）

Luancheng: GW irrigation

GW depth >30 m

Liaocheng: YR irrigation

GW depth 1~10m

Crops: wheat + maize

New observing systems launched from 2007

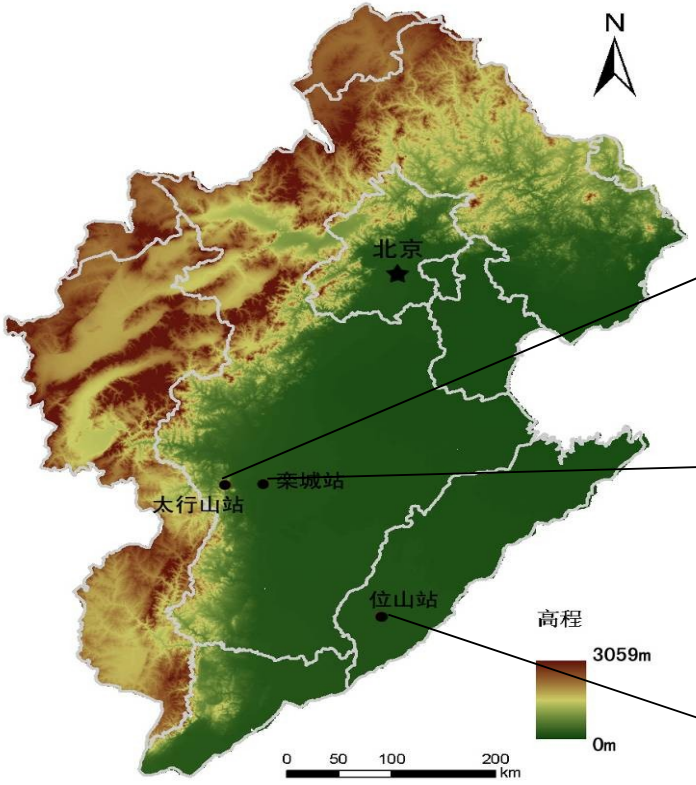
- new site at yellow river irrigated region (Liaocheng, SD)
- Observations at the 2 stations
  - Eddy correlation systems (H, LE, Fco2, etc.)
  - Large Aperture Scintillometer (path length: 0.9km & 2.3 km)
  - Isotopic monitoring (rainw, soilw, plantw, gw, vapor)

Eddy Correlation

*: NOAA/AVHRR image of NCP.

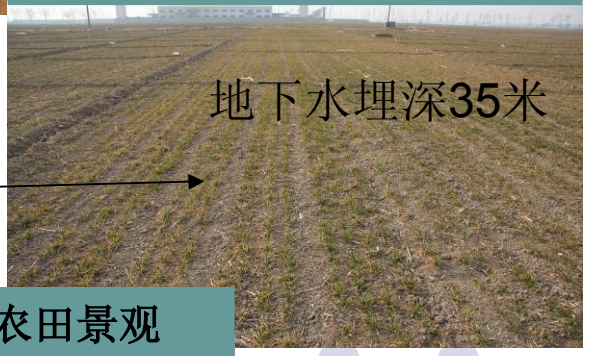
典型农田系统水热和CO2过程的监测

典型农田景观



太行山区雨养旱作农田景观

栾城地下水灌区农田景观



聊城引黄灌区农田景观

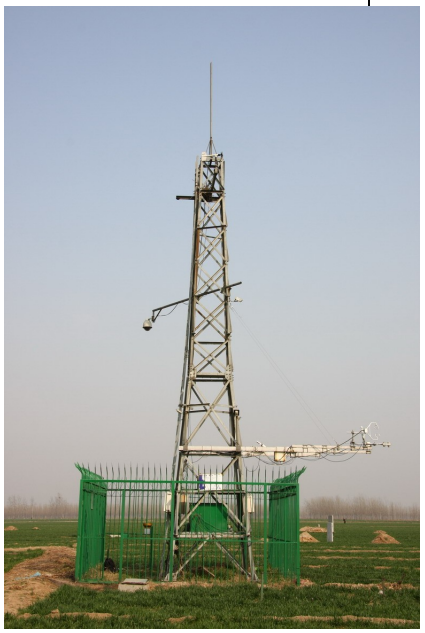
- 各▪站点▪▪施

栾城站涡度相关与小气候观测系统

地下水35m

太行山站微气象要素观测系统

无潜水面



位山站水热通量涡度相关观测系统

地下水2m

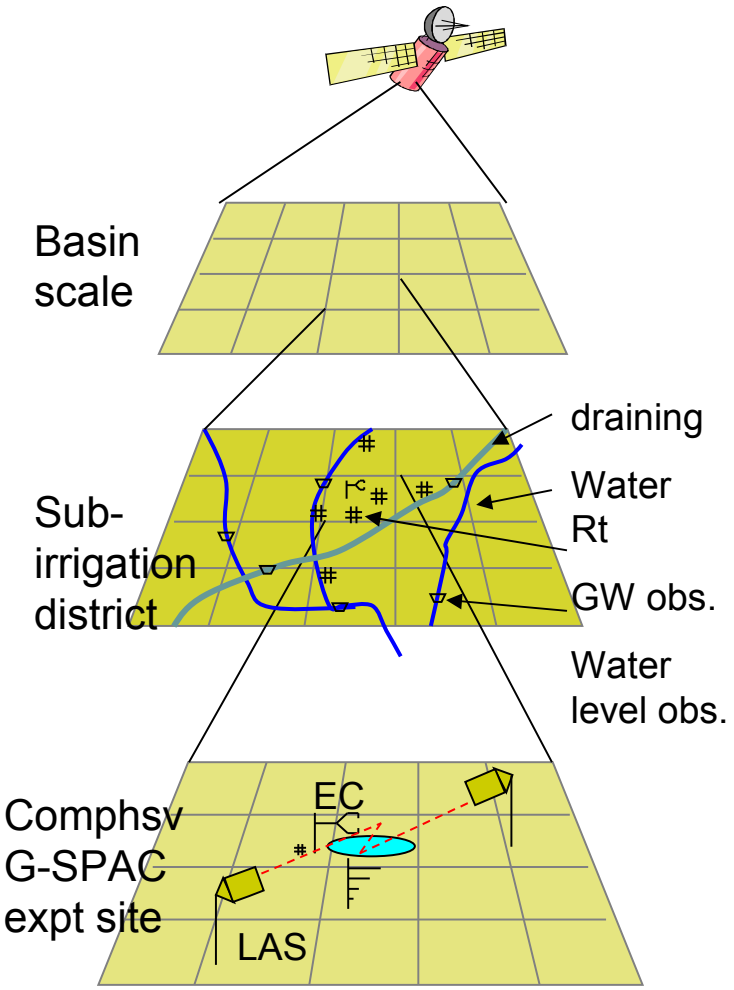
- 太行山站地区 ▪▪

旱作流域尺度的农业用水调查和水平衡计算

- 雨量、储水池水量观测
- 产量调查

太行山站的大致位置

Monitoring and modeling water balances at multi-scale



Scaling-up to large area using RS and LSM

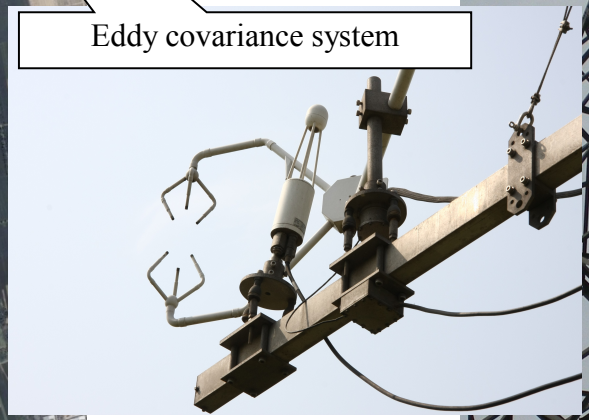
Soil water, veg, gw, survey

Quality and quantity

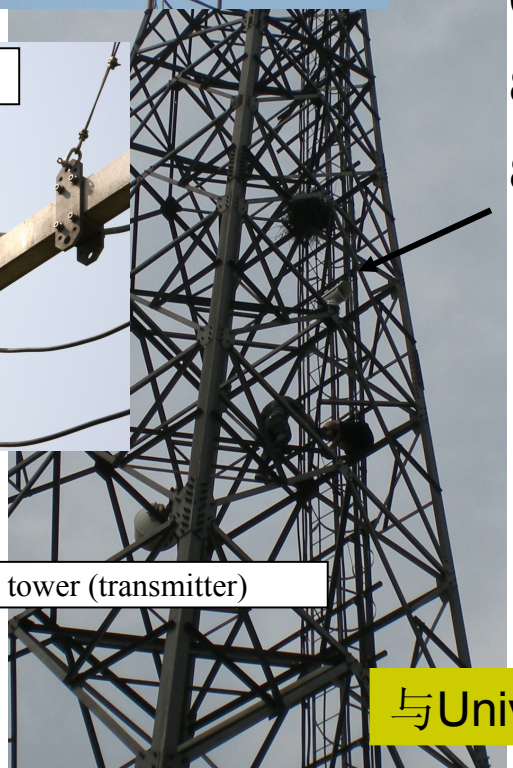
1D micro-meteor, eco-phys, soil phys & chem, groundwater expt.

LAS observation at Luancheng

36m tower at our field station (receiver)



Eddy covariance system



China Mobile tower (transmitter)

Path length: 2300 m

Path height of receiver: 16.5 m

Path height of transmitter: 16.5 m

Averaging period: 10 min

Reference wavelength for C_n^2: 880 nm

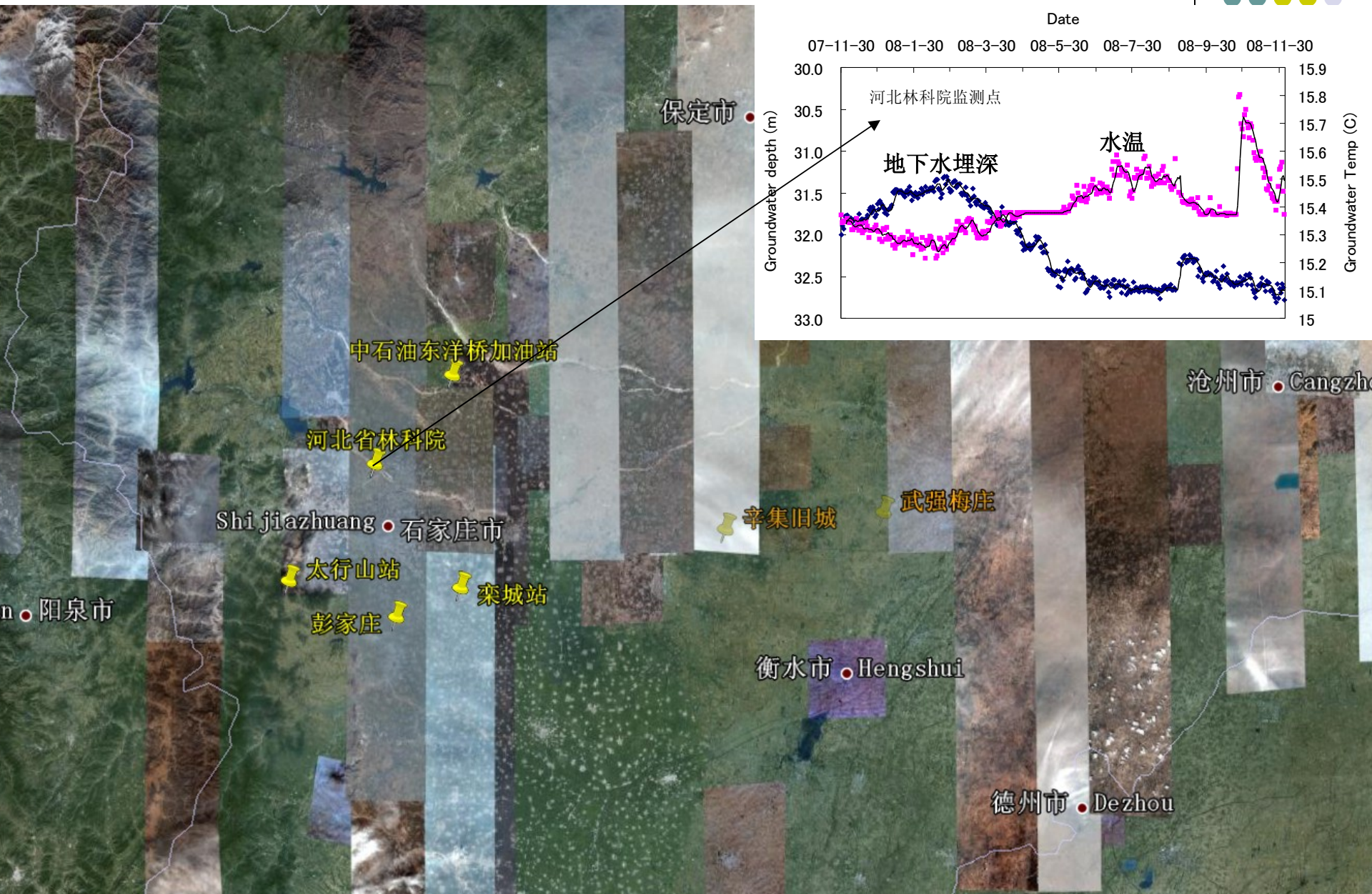
6月27日安装；

8月20日开始运行；

8月27日受暴风雨袭击。

与Univ. Texas at Austin合作

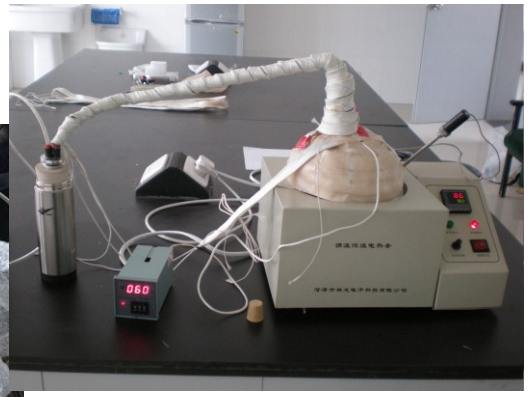
Monitoring groundwater table

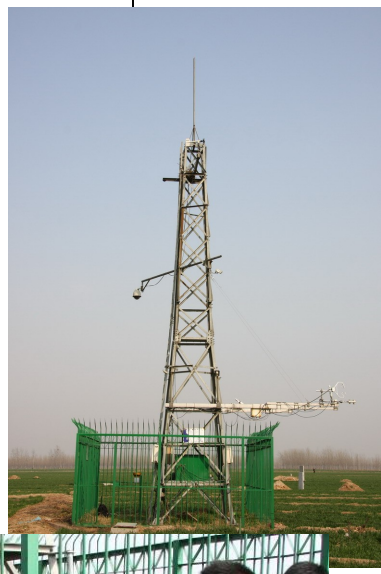


Isotope water sampling at 2 sites

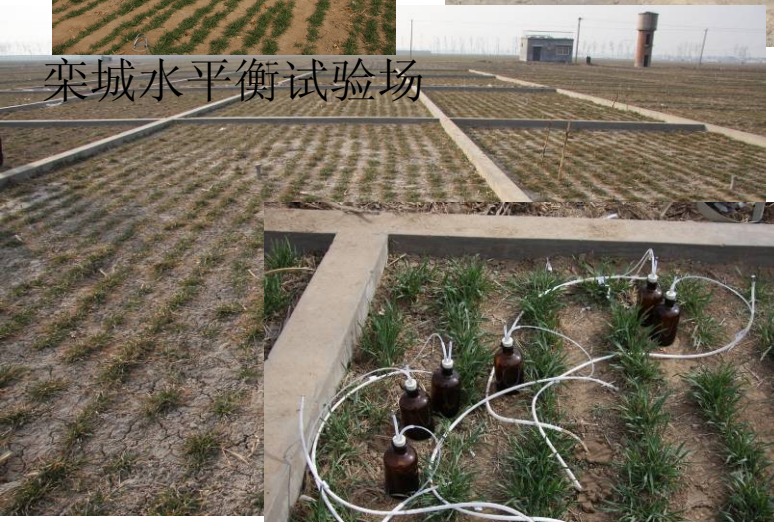
Vapor

Plant water





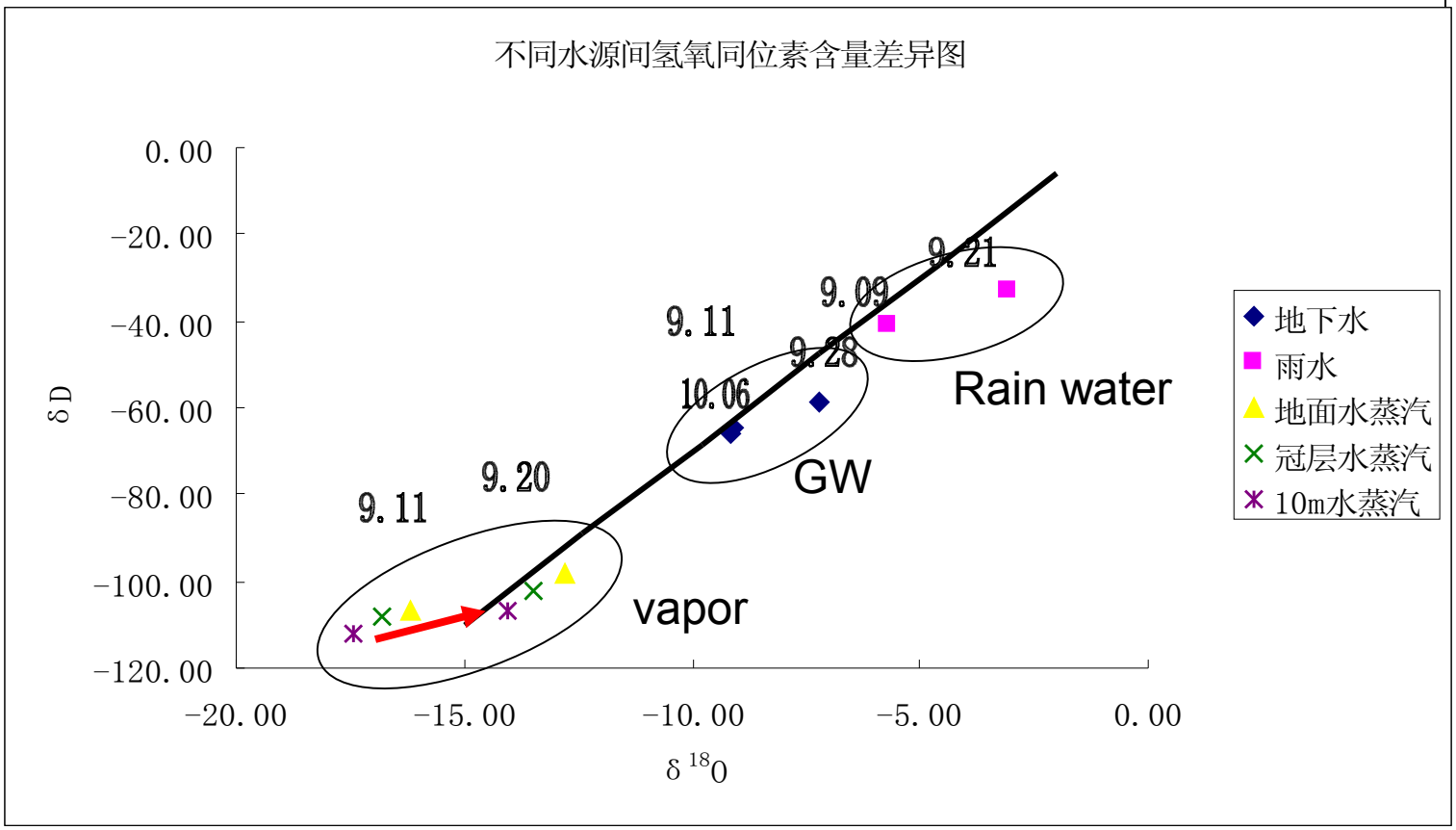
栾城水平衡试验场

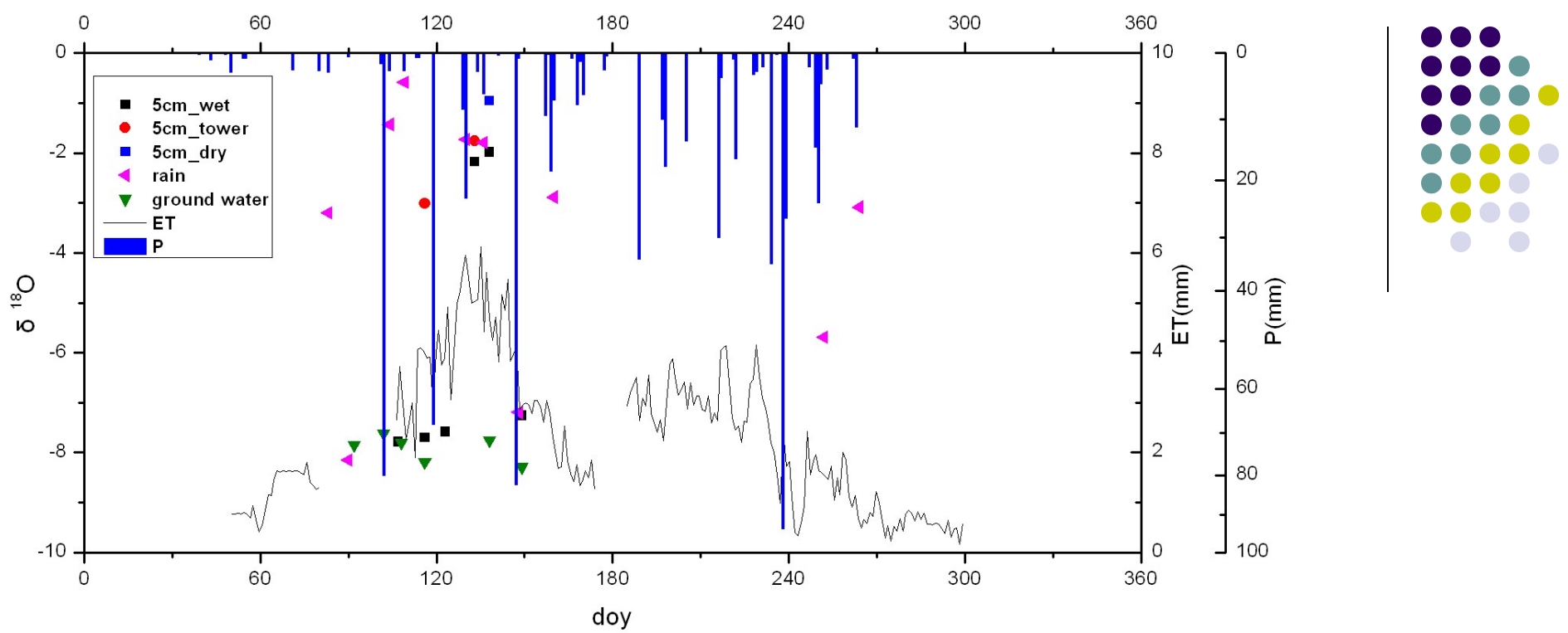


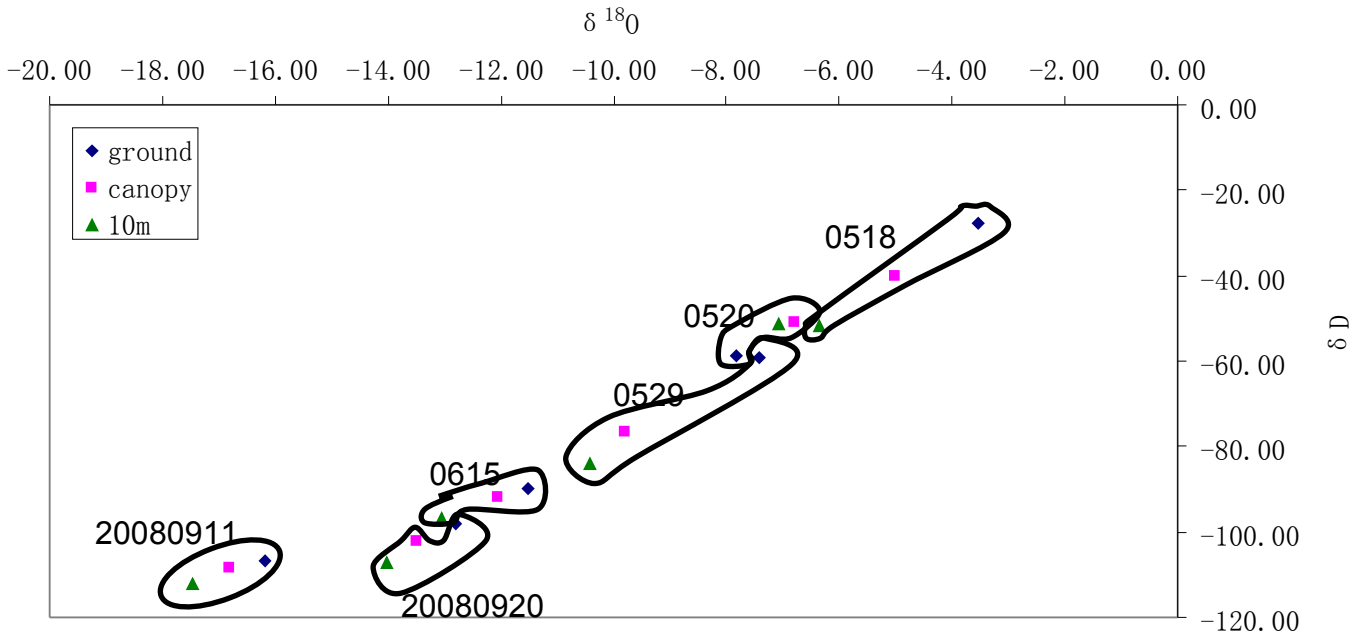
Soil water

Rain water

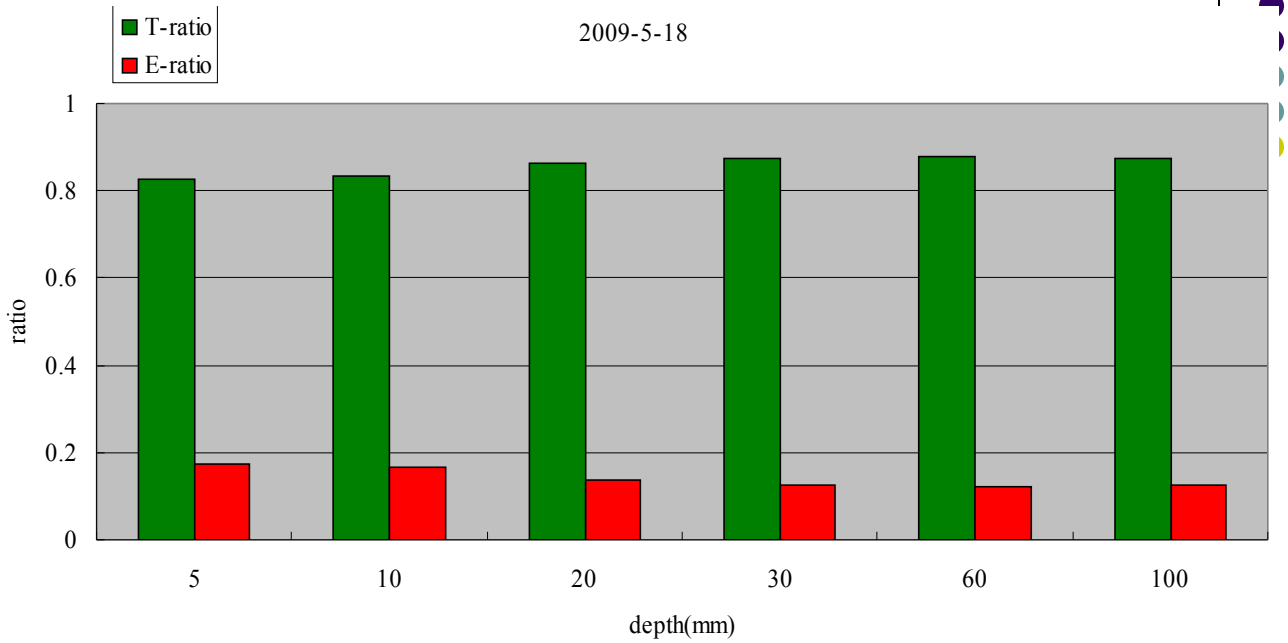
Initial isotopic results

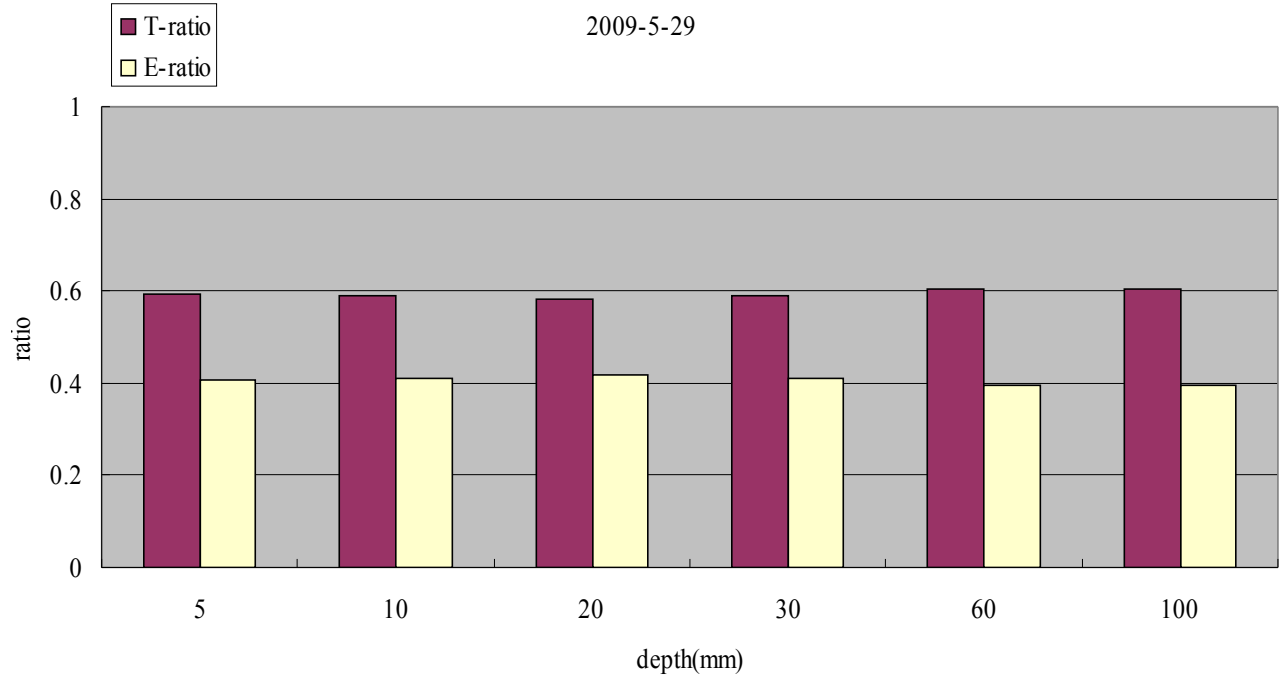



5cm_wet
5cm_tower
5cm_dry
rain
ground water
ET
P
δ 18O
ET(mm)
P(mm)
doy


δ 18O
ground
canopy
10m
0518
0520
0529
0615
20080911
20080920
δ D

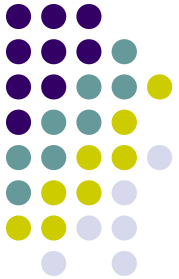
Separation of E and T





Acknowledgements

- National Scientific Foundation of China
- Chinese Academy of Sciences
- Prof. A. Kondoh, CEReS, Chiba U
- Prof. T. Oki, IIS, U Tokyo



Thank you!
ありがとうございました！
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