Institute of Remote Sensing and Digital Earth
Chinese Academy of Sciences

*Measuring water from Sky:*

# ETWatch and its Application

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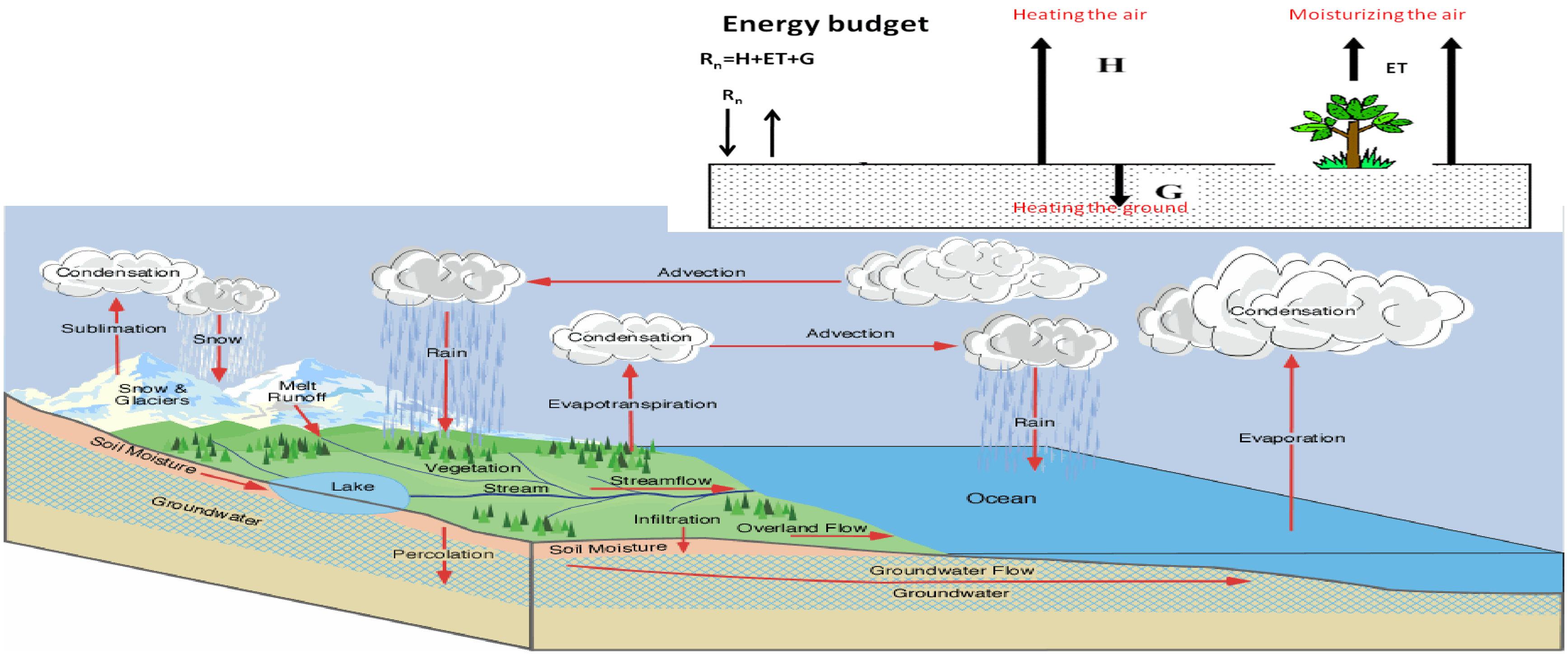
# ET

**Evapotranspiration:** the canopy transpiration and soil evaporation

- ET is the actual water consumption.
- ET is the important segment of water circulation.
- ET is equally important to precipitation, hydrological observation.



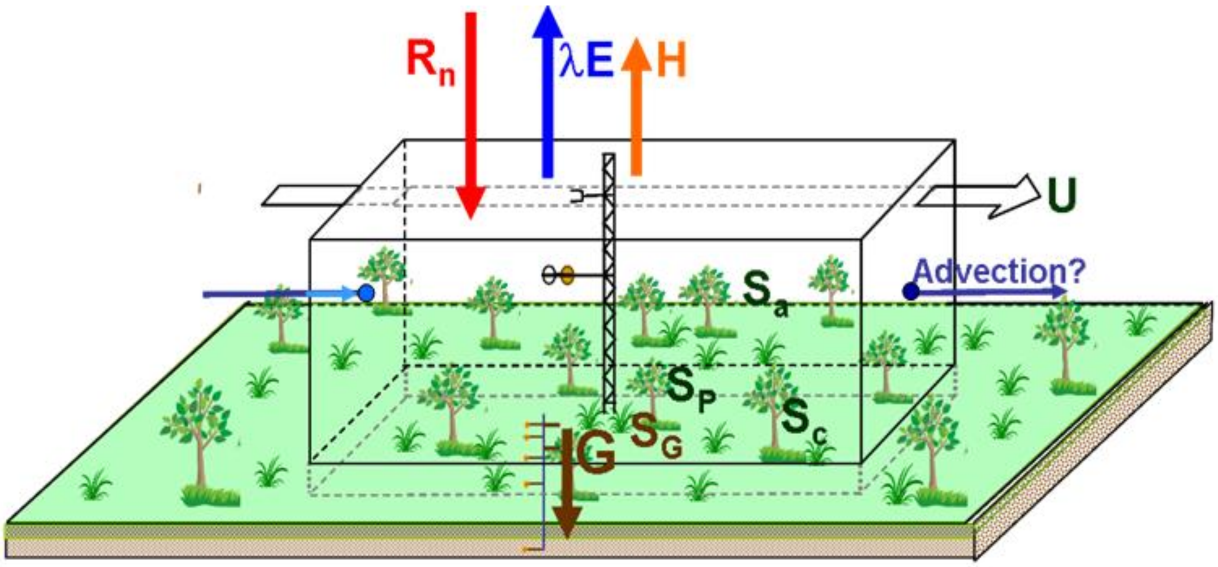
# ETWATCH

# ETWatch – operational ET remote sensing system

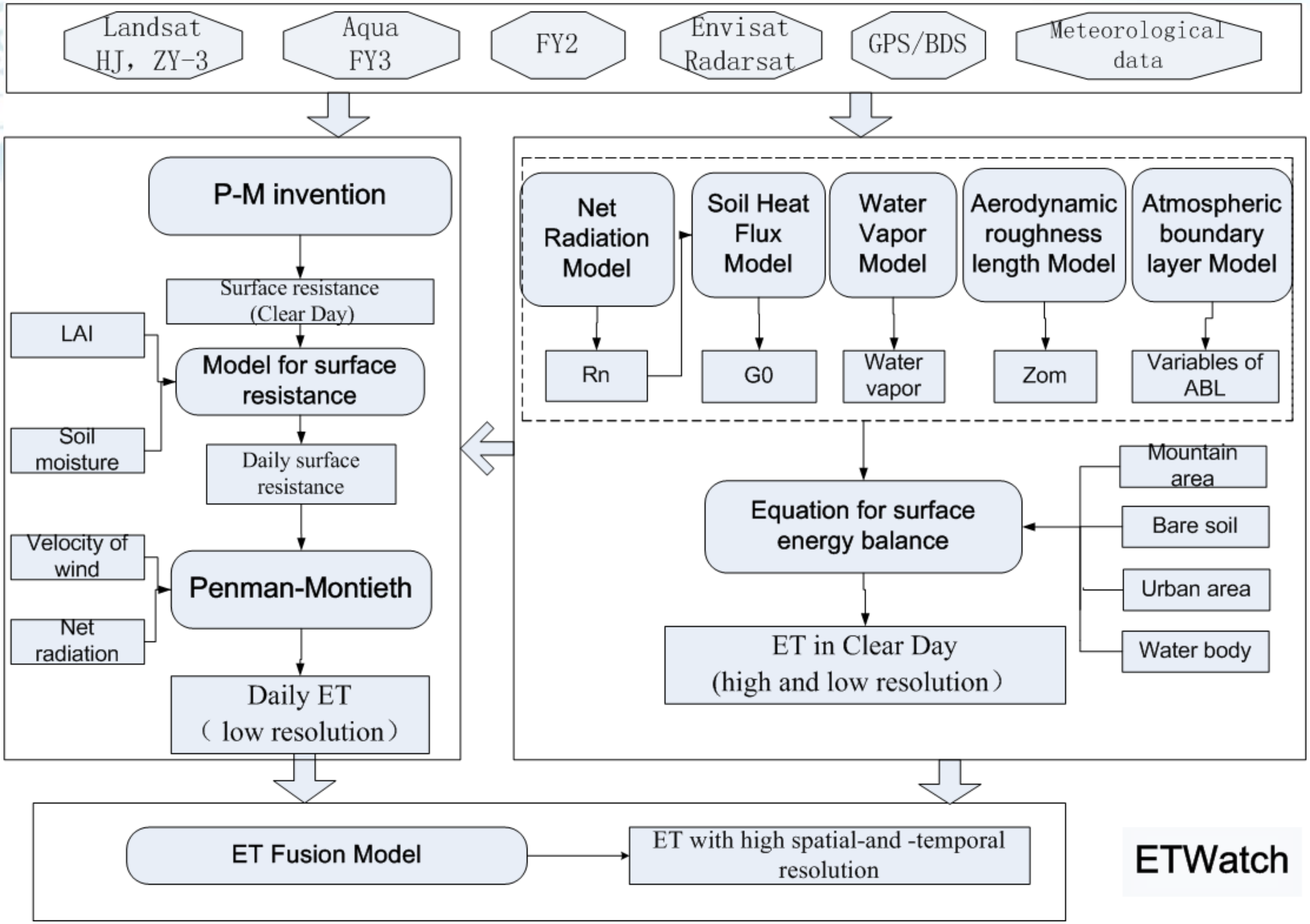

- Validation of ETWatch using field measurements at diverse landscapes: A case study in Hai Basin of China, Journal of Hydrology,436–437 (2012)
- ETWatch: Models and Methods. Journal of Remote Sensing, 2011, 15(2)
- ETWatch: Methods of Calibration. Journal of Remote Sensing, 2011, 15(2)
- ETWatch: A Method of Multi-resolution ET Data Fusion. Journal of Remote Sensing, 2011, 15(2)
- Estimation and validation of land surface evaporation using remote sensing in North China. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing. Conference special issue. 2010, 3(3)
- A Method of Water Consumption Balance and Application. Journal of Remote Sensing, 2011, 15(2)
- Estimation of Agricultural Water Productivity and Application. Journal of Remote Sensing, 2011, 15(2)

# New Models in ETWatch

- Elements in surface energy balance:
  - Net-radiance model
  - Soil heat flux model
  - Aerodynamic roughness
  - Atmospheric Boundary Layer
  - Daily Surface resistance (Rs)



# ETWatch – operational remote sensing model

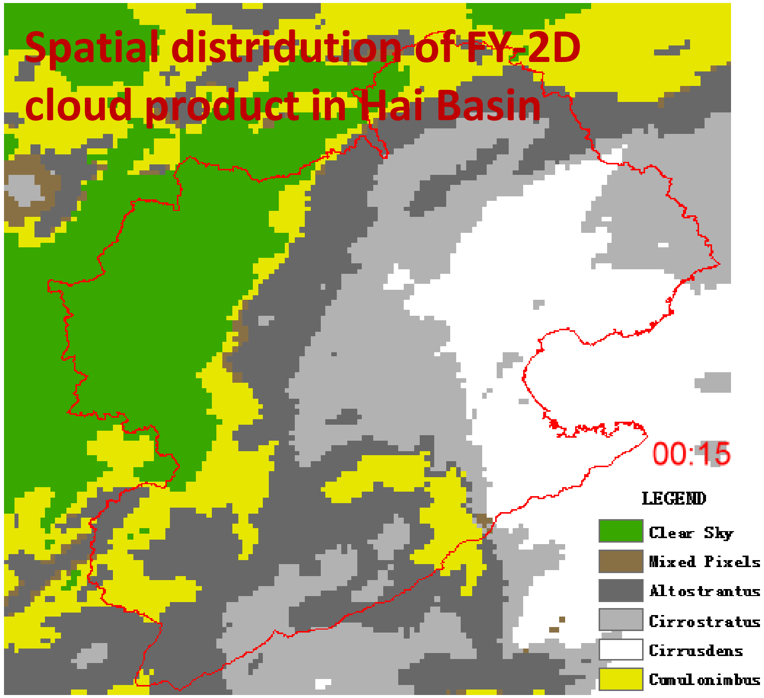



ETWatch

| Parameter | Description | Source | Clear day | Cloud day |
|---|---|---|---|---|
| **Rn** | net radiation | RS+Meteo | O | O |
| **G** | soil heat flux | RS | O | × |
| **rs** | land surface resistance | RS+Meteo | O | ○ With Surface Resistance model |
| **es** | Saturated vapour pressure | Meteo | O | O |
| **ea** | Actual vapour pressure | Meteo | O | O |
| **ra** | air dynamic resistance | Meteo | O | O |
| **Z0m** | aerodynamic roughness length | RS | O | × |
| **NDVI** | Normalized Difference Vegetation Index | RS | O | ○ With S-G model |
| **LST** | Land surface temperature | RS | O | × |
| **Albedo** | Surface reflectivity of solar radiation | RS | O | ○ With Filter method |
| **LAI** | Leaf Area Index | RS | O | ○ With LAI-NDVI |
| **Meteo parameters** | Relative Humidity，Wind Velovity，Sun Shine Hours，Air Presure, Air Temperature | Meteo | O | O |
| **ABL** | Air temperature, Wind Velovity , Air Presurre and Humidity of Boudary Layers | RS | O | O |

# ETWatch Input data

# Method of daily net radiation estimation



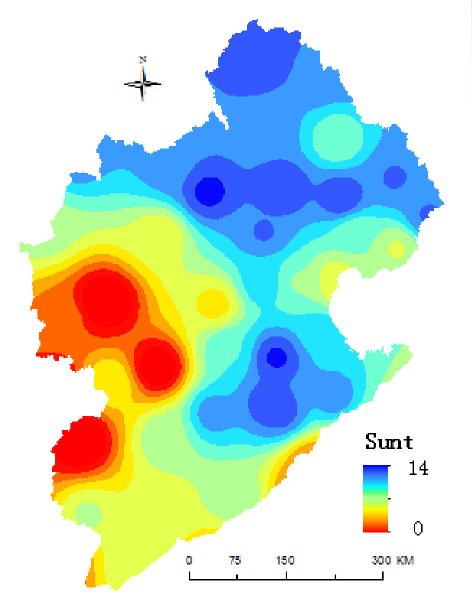

Sunshine Factor (SF) base on cloud product

| Value | Classification | SF |
|---|---|---|
| 0/1 | Clear Sky | 1 |
| 11 | Mixed Pixels | 0.5 |
| 12 | Altostrantus or nimbostratus | 0.6 |
| 13 | Cirrostratus | 0.8 |
| 14 | Cirrusdens | 0.6 |
| 15 | Cumulonimbus | 0.2 |
| 21 | Stratocumulus or altocumulus | 0.4 |

- Traditionally , sunshine hours from meteorological station are used to calculate surface net radiation
- Now, The surface sunshine hours can be replaced by cloud information from geostational meteorology satellite. It indicates more precise spatial distribution of surface net radiation
- The FY-2 cloud product was used to detect the sunshine changes every hour based on Sunshine Factor .

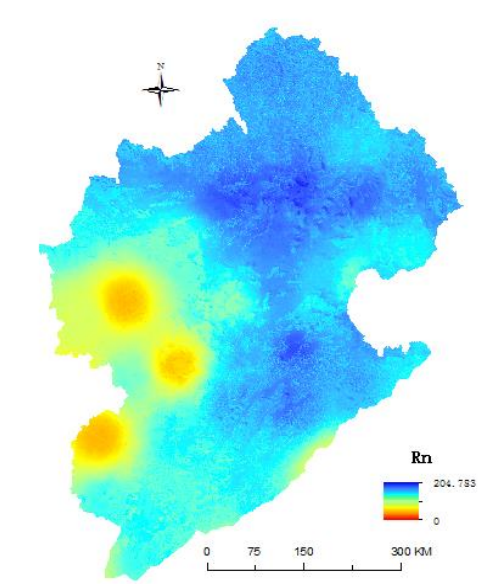
# Comparison between Rn Estimated and Observed

2008/08/15



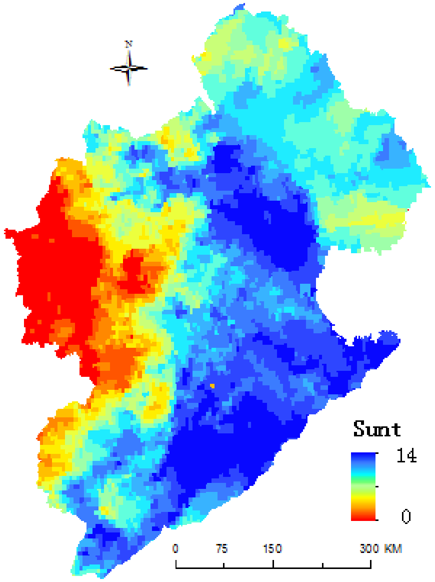

Sunshine Hour from Observation

2008/08/15



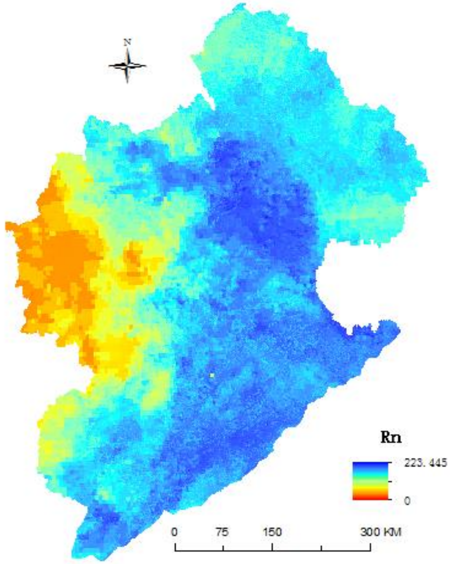

Surface Net radiation

2008/08/15




Sunshine Hour from FY-2D

2008/08/15




Surface Net radiation

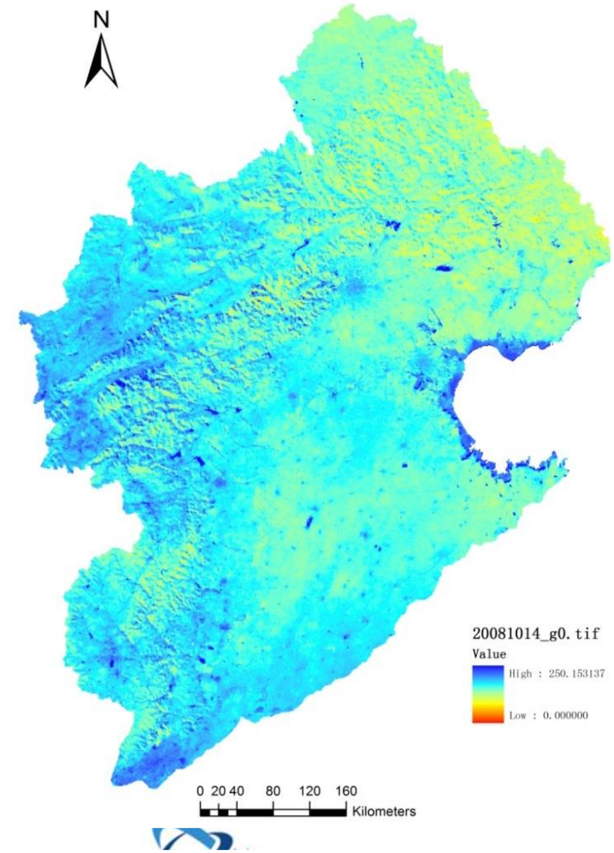
# Soil heat flux parameterization method

$$\frac{G}{Rn}=\frac{Ts}{15}(0.013RVI^2-0.121RVI+0.396)(0.48b3+0.76b4+0.35)e^{\frac{1}{10}sm+0.05-\frac{0.25}{\cos(soz)}}$$

- G : Instantaneous soil heat flux
- Rn : Net radiation
- Ts : Surface tempreture (unit: K)
- RVI: Ratio vegetation index

($RVI=\rho_{nir}/\rho_r$)

- b3, b4 : Shortwave infrared reflectance
- sm : Soil moisture
- soz : Solar zenith angle




October 14,2008,pm.instantaneous soil heat flux

# Modelling of aerodynamic roughness length

**Aerodynamic Roughness**

**Vegetation**
（NDVI）

**Thermal Factor**
Surface Temperature

**Dynamic factor**
Doppler Wind profile

**Topography factor**
ASTER GDEM-30

**Surface roughness**
SAR

Source Area: Topography, Vegetation, Surface Elements

Wind velocity: Dynamic factor

Temperature gradient: Thermal Factor

Dynamic factor + Thermal Factor → Dynamic overlap

Source Area → Geometric roughness at pixel

Dynamic overlap → Geometric roughness at pixel

Geometric roughness at pixel → Aerodynamic Roughness

Ground measurement → Aerodynamic Roughness

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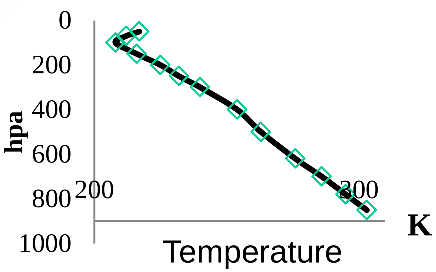
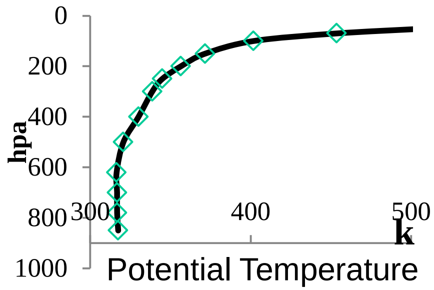
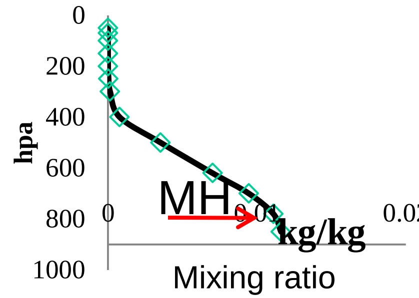
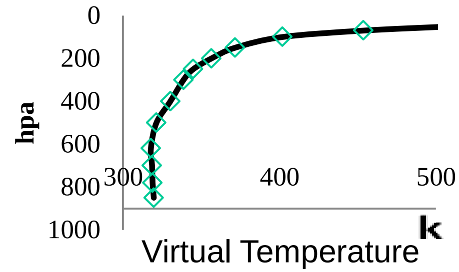
# Model of ABL (Atmospheric Boundary Layer)

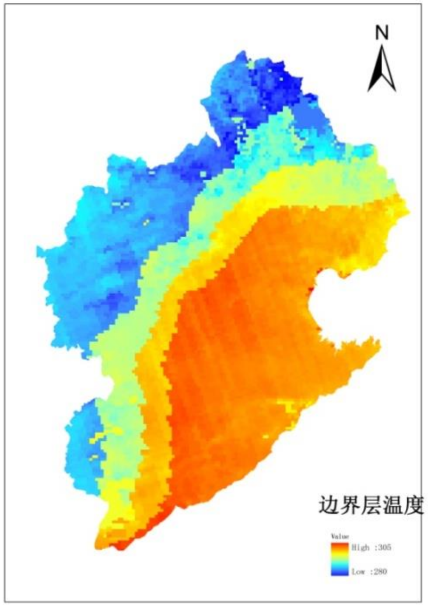
- With this method， we can reduce the sensitivity of ETwatch to the thermal character of ground. Using the atmospheric profile data derived from remote sensing， we can estimate the spatial distributing of MH,then improve the accuracy of ET model .

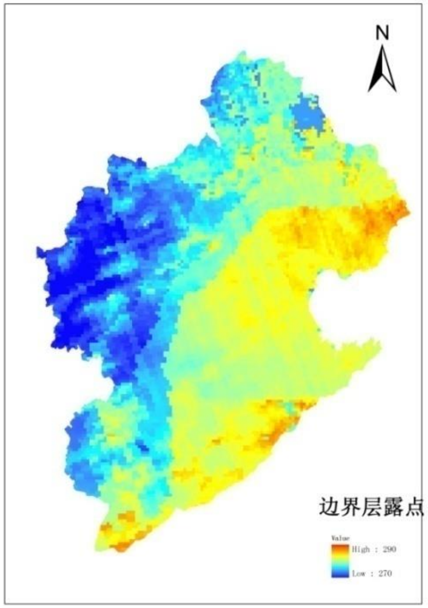


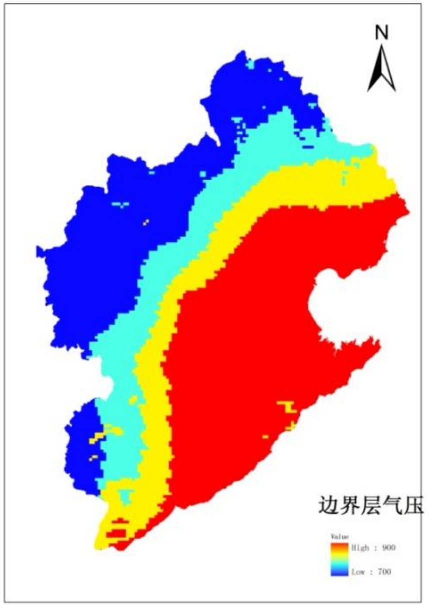



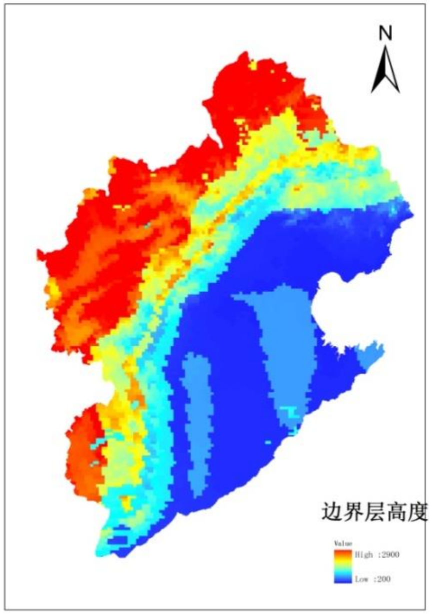



# Surface resistance Model

$$r_{s,daily} = \frac{r_{s,clear} \times LAI_{clear} \times \boxed{Rn_{clear}} \times SM_{clear} \times \boxed{U_{clear}}}{\boxed{Rn_{daily}} \times SM_{daily} \times \boxed{U_{daily}} \times LAI_{daily}}$$

LAI is used as a scalar to relate surface resistance with environmental constraints such as air temperature and vapour pressure deficit (VPD).

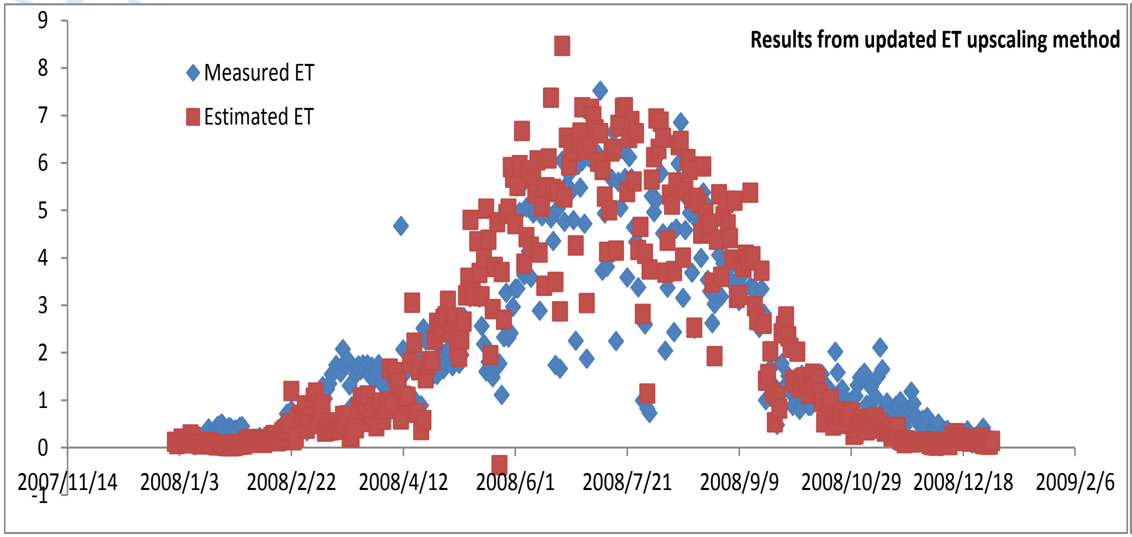
$r_{s,\,clear}$ is surface resistance on clear day inverted by P-M equation.

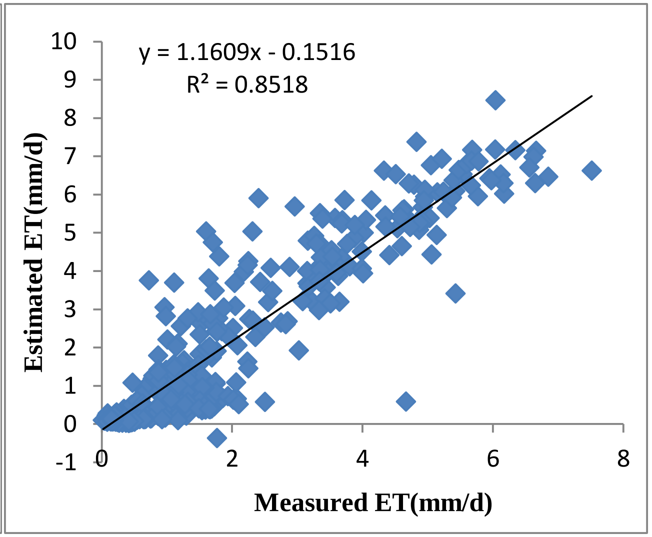
SM is soil moisture inverted by remote sensing data

U is wind speed

$R_n$ is surface net radiation

# Surface resistance Model




Comparison of measured ET and Estimated ET

The estimated ET based on model had significant linear relationship with measured ET .

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# Validation of ETWatch

- Different regions and different surface conditions
- Five Flux stations. EC、LAS (2007-)
- Eight mountain flows stations (2001-)
- Two basins：Hai basin and Turpan


| Spatial scale | Technique | Daily (%) | Season (%) | Annual (%) |
|---|---|---|---|---|
| Field scale | Soil moisture | N/A | 13.6 | N/A |
| Field scale | Lysimeter | N/A | 11.3 | 9.0 |
| Field scale | Eddy covariance | 7.6 | N/A | 3.0 |
| Village scale | Soil moisture | N/A | 3.9 | N/A |
| County scale | Soil moisture | N/A | 3.7 | N/A |
| Sub-basin scale | Water balance | N/A | N/A | 3.8 |
| Basin scale | Water balance | N/A | N/A | 1.8 |

Bingfang Wu, et. al, Validation of ETWatch using field measurements at diverse landscapes: A case study in Hai Basin of China
Journal of Hydrology 436–437 (2012) 67–80

The memorandum of World Bank GEF assessment mission in 2008:

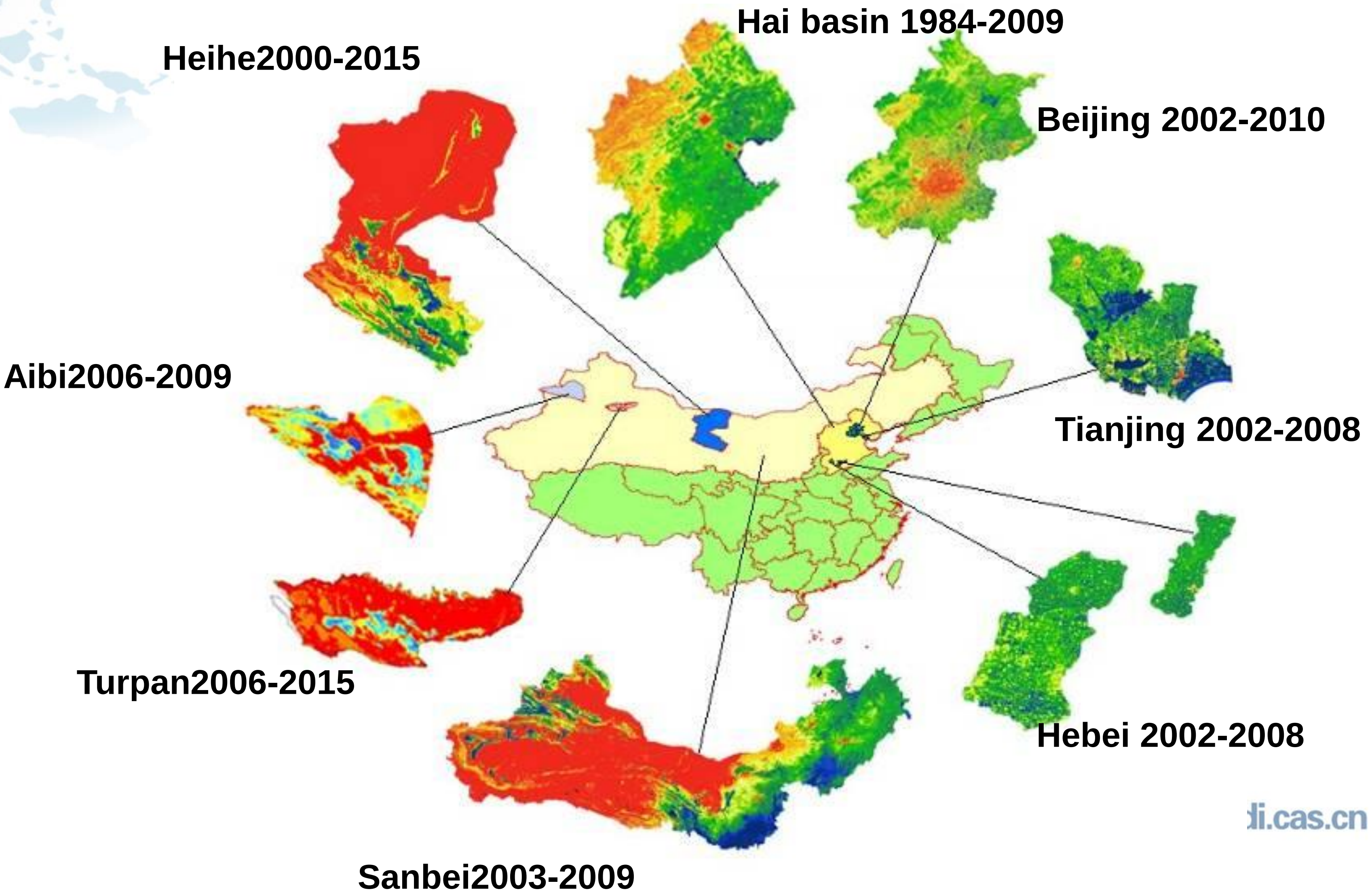
ET data using ETWatch was developed for 2002-2005 for the Hai Basin with 1 km pixels and for 13 counties with 30 m pixels. ET data was also produced using SEBAL for 2002-2005. All PMOs agreed that the ETWatch data was better and opted to use this data.

# ETWatch Features

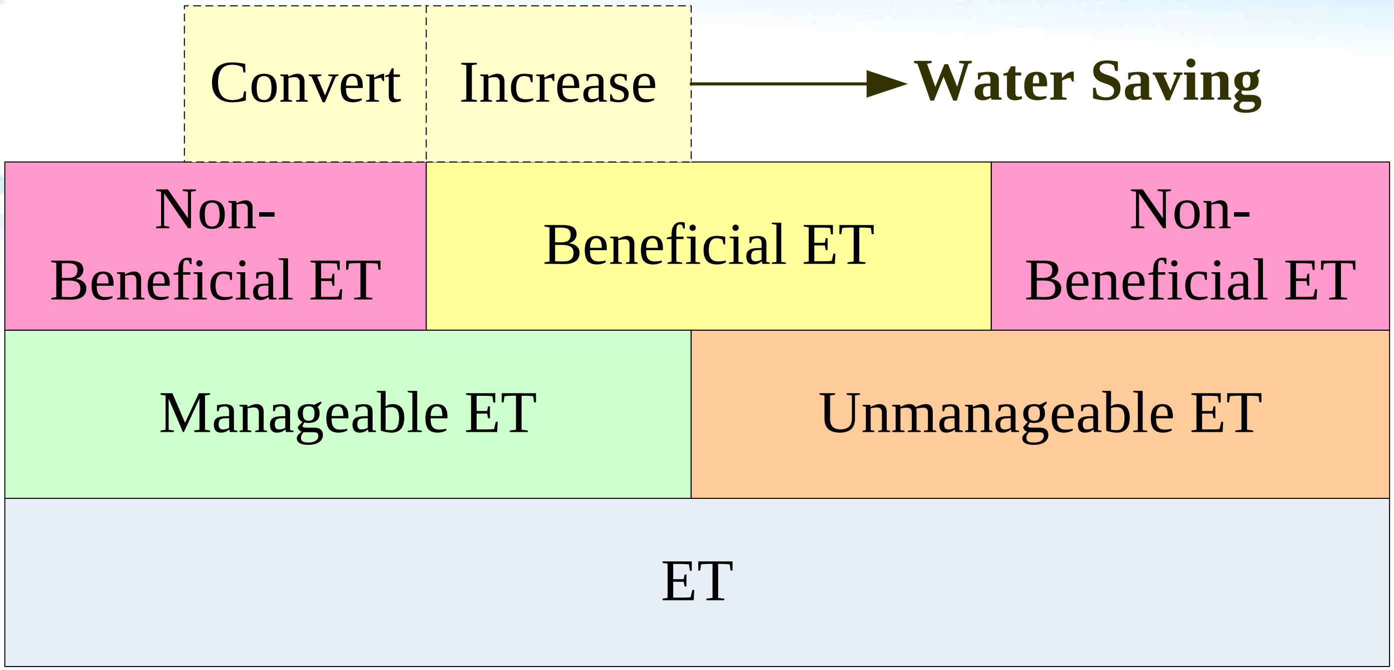
- Basin scale, daily products
- Systematic
- Pre-processing of all data used
- New models and methods embedded
- Internal calibration
- Quality Control in process

# Application

# Application: ETWatch in China

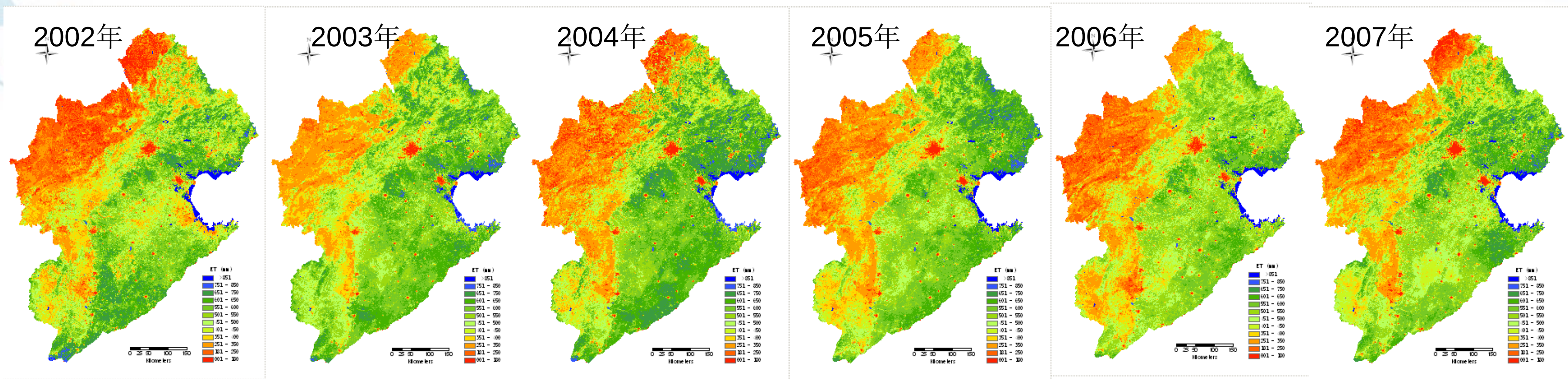


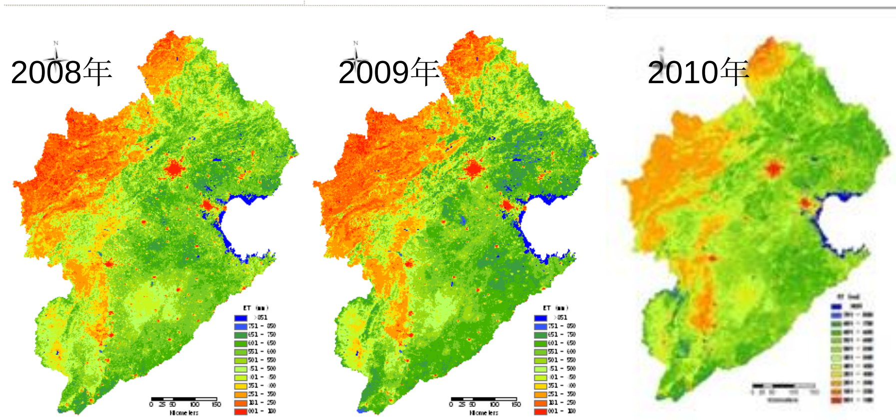
# Approach of ET Management

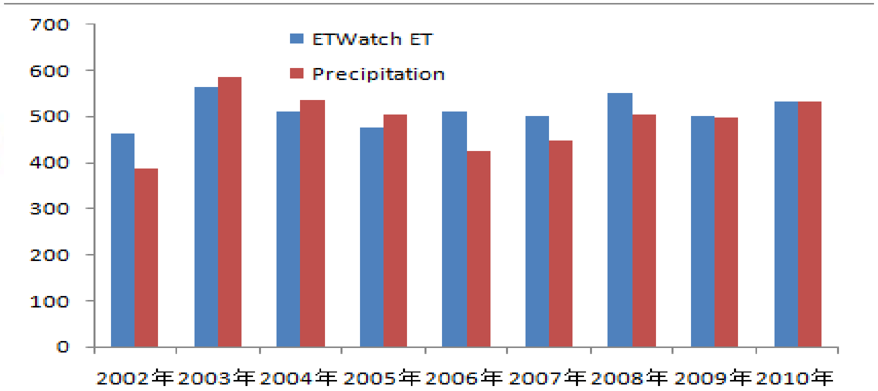



- ET Management has three elements: (1) reducing non-beneficial ET (2) converting non-beneficial ET to beneficial ET or (3) Increasing productivity of beneficial ET
- Increasing ET productivity will reduce water competition for irrigation from other sectors and improve social well-being by allowing water to be moved into higher value sectors.

# Hai basin 1km ET dataset

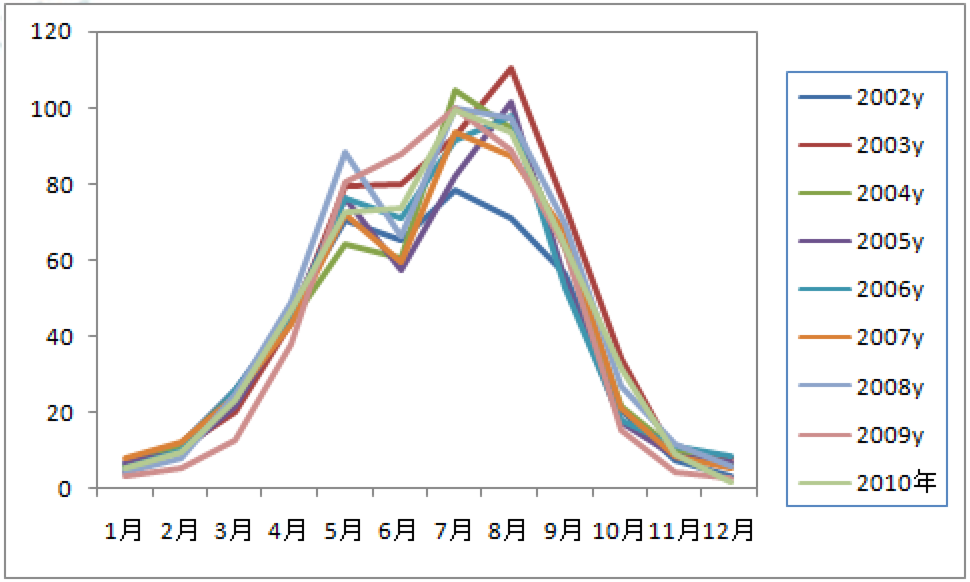



| | 2002y | 2003y | 2004y | 2005y | 2006y | 2007y | 2008y | 2009y | 2010y |
|---|---|---|---|---|---|---|---|---|---|
| ETWatch ET | 463.923 | 564.983 | 509.915 | 474.826 | 511.298 | 501.052 | 551.562 | 502.148 | 531.587 |
| Precipitation | 387.00 | 587.28 | 535.11 | 504.87 | 426.75 | 448.04 | 504.17 | 499.15 | 531.84 |

# Monthly 1km ET dataset on Hai basin, 2002-2010



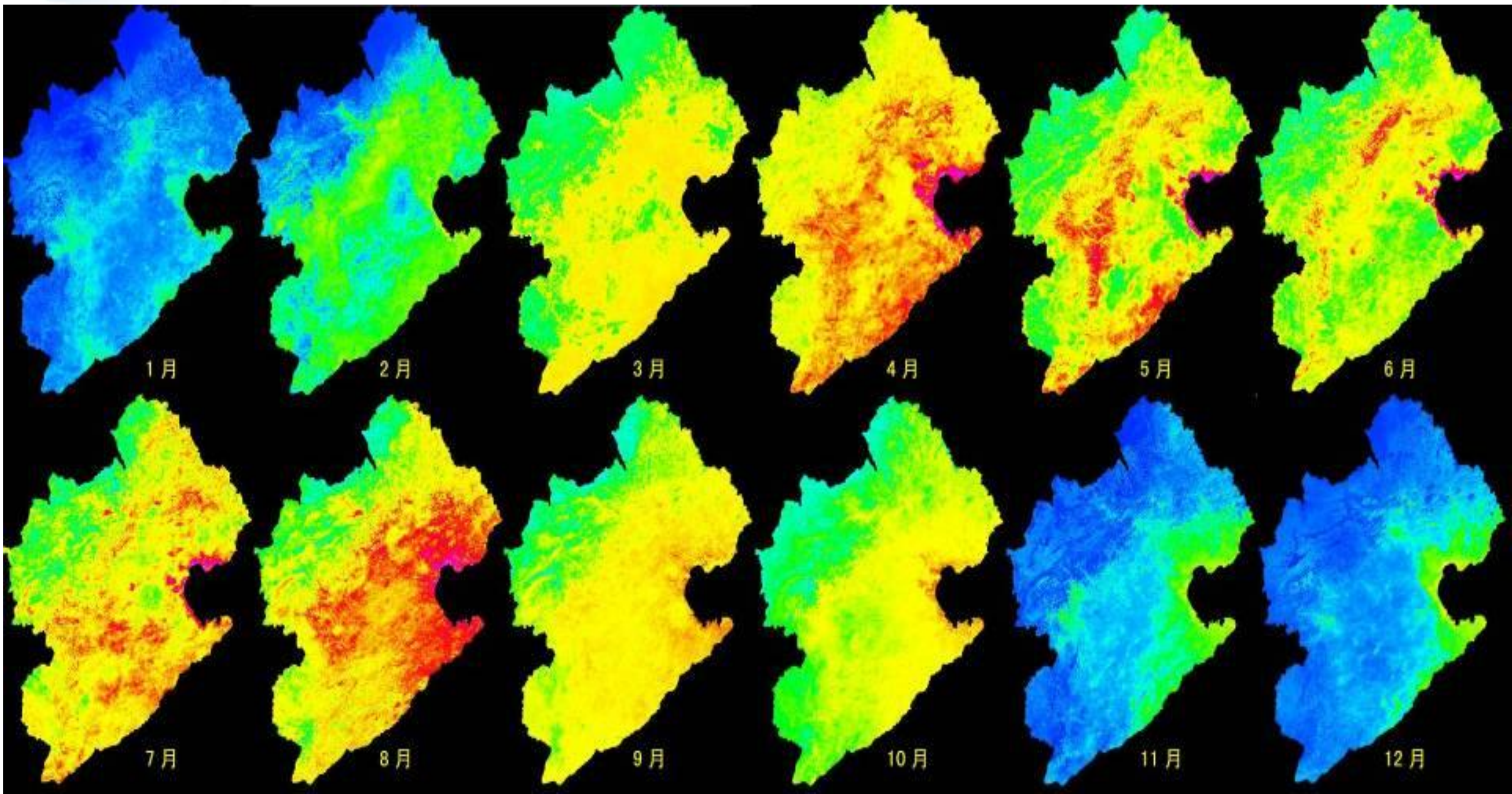

2002-2010逐月ET

| 海河 | 2002年 | 2003年 | 2004年 | 2005年 | 2006年 | 2007年 | 2008年 | 2009年 | 2010年 |
|---|---|---|---|---|---|---|---|---|---|
| 1月 | 6.54 | 4.14 | 5.96 | 7.1 | 5.26 | 7.79 | 4.36 | 3.17 | 5.28 |
| 2月 | 11.64 | 10.33 | 11.25 | 9.8 | 9.91 | 12.1 | 7.78 | 5.47 | 9.92 |
| 3月 | 25.86 | 19.81 | 25.37 | 21.92 | 25.57 | 24 | 24.94 | 12.41 | 23.34 |
| 4月 | 46.58 | 43.63 | 43.54 | 46.05 | 44.56 | 43.18 | 48.98 | 38.19 | 47.16 |
| 5月 | 70.74 | 79.18 | 64.08 | 76.52 | 75.87 | 71.87 | 88.23 | 80.6 | 72.49 |
| 6月 | 65.31 | 80.01 | 60.24 | 57.27 | 71.13 | 59.53 | 66.26 | 88.11 | 73.9 |
| 7月 | 78.39 | 92.76 | 104.55 | 81.99 | 91.43 | 93.66 | 100.01 | 100.18 | 99.44 |
| 8月 | 70.79 | 110.38 | 94.39 | 101.54 | 97.64 | 87.55 | 97.58 | 89.27 | 93.48 |
| 9月 | 56.35 | 74 | 62.9 | 54.78 | 52.63 | 67.55 | 69.45 | 63.37 | 63.84 |
| 10月 | 20.83 | 34.33 | 21.47 | 17.58 | 18.04 | 20.68 | 26.97 | 15.37 | 31.75 |
| 11月 | 7.72 | 8.61 | 9.96 | 8.38 | 10.91 | 8.25 | 11.46 | 4.06 | 9.17 |
| 12月 | 3.33 | 7.96 | 6.36 | 6.97 | 8.5 | 5.05 | 5.71 | 2.59 | 1.8 |

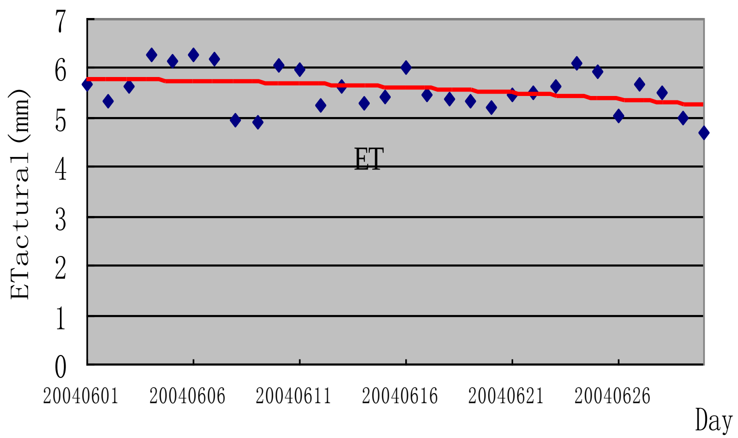
# Monthly ET in Hai Basin, 2003

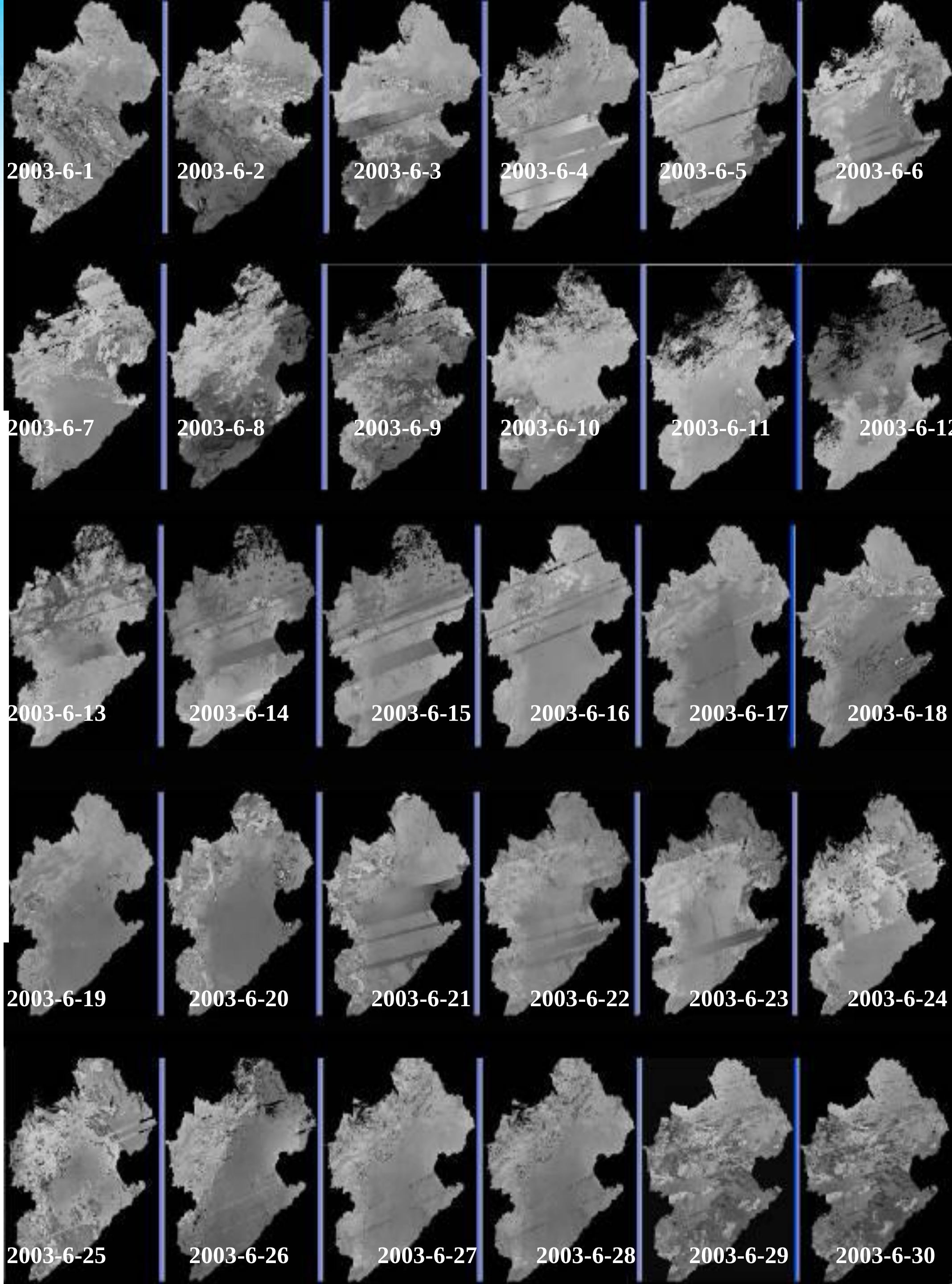
Legend

0 - 10 mm
10 - 25 mm
25 - 40 mm
40 - 55 mm
55 - 70 mm
70 - 85 mm
85 - 100 mm



# Daily ET June 2003



# ET is main water consumption at basin level

- Three energy sources for water consumption
- Water consumption from solar energy (i.e. ET) accounts for 98%.

The water consumption from different energy sources, Hai Basin, 2002-2008 ($10^8 m^3$)

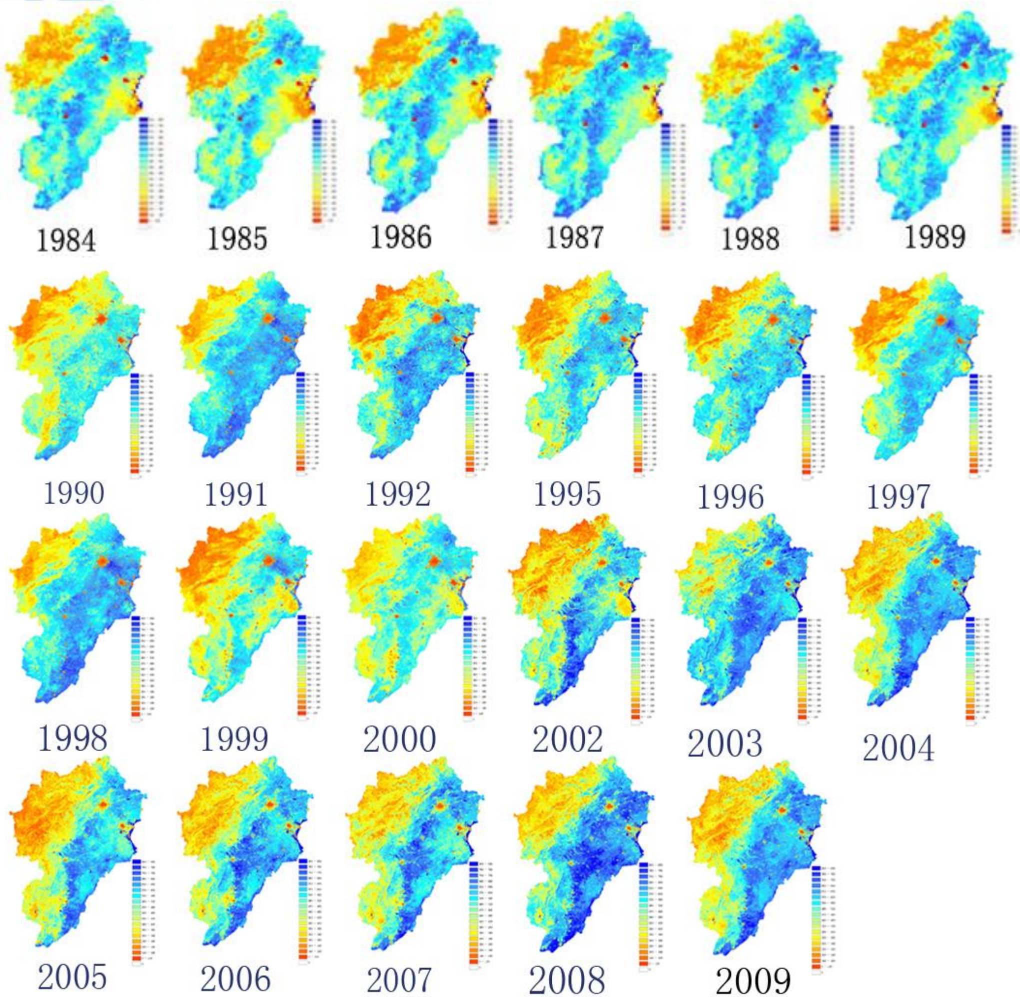
| Item | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | Average |
|---|---|---|---|---|---|---|---|---|
| ET from solar energy | 1480.9 | 1804.7 | 1627.3 | 1516.1 | 1632.4 | 1599.4 | 1760.3 | 1631.6 |
| Water consumption from mineral energy | 30.9 | 30.6 | 34.9 | 40.9 | 40.9 | 40.9 | 40.9 | 37.1 |
| Water consumption from biological energy | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| Total water consumption | 1512.6 | 1836.1 | 1663.0 | 1557.8 | 1674.1 | 1641.1 | 1802.0 | 1669.5 |

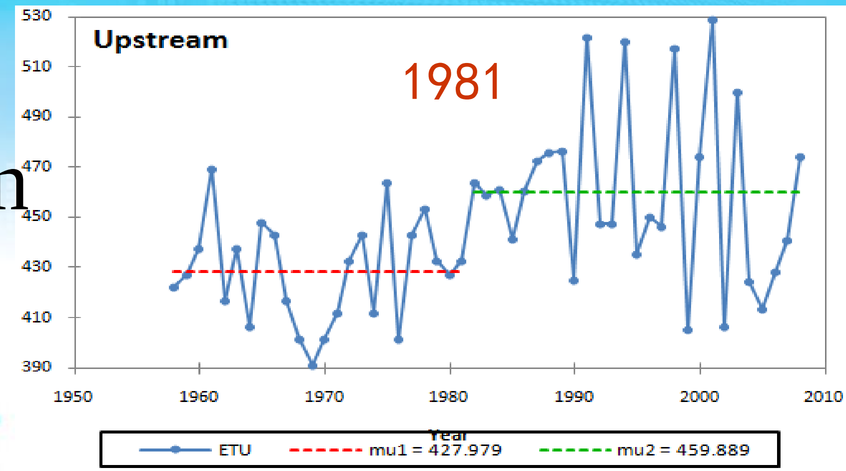
# Water balance based on water consumption in Hai Basin

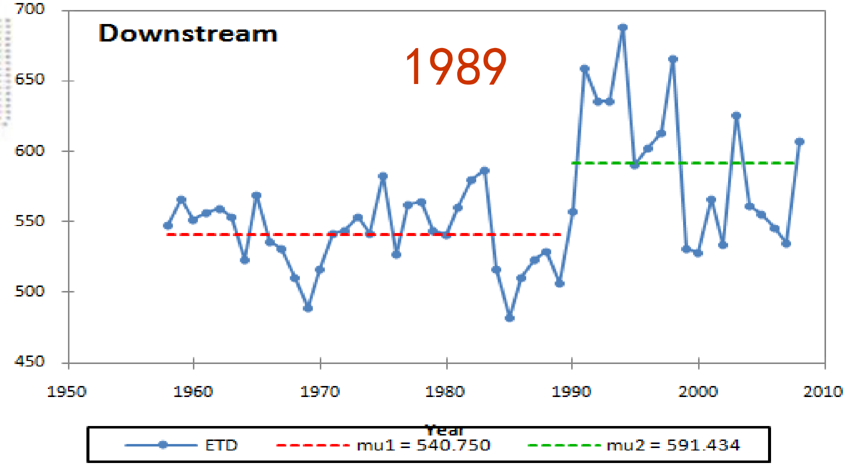
| Item ($10^8 m^3$) | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | Average | % |
|---|---|---|---|---|---|---|---|---|
| **Water Resource(I+P)** | 1320.2 | 1899.0 | 1764.8 | 1595.8 | 1448.8 | 1590.4 | 1603.1 | 100.00% |
| Inflow | 46.4 | 36.1 | 42.3 | 37.3 | 46.3 | 42.8 | 41.9 | 2.60% |
| Precipitation | 1273.8 | 1862.9 | 1722.4 | 1558.5 | 1402.5 | 1547.5 | 1561.3 | 97.40% |
| **Outflow** | 1.8 | 21.8 | 37.1 | 24.9 | 13.9 | 17.1 | 19.4 | |
| **Actual Water Consumption** | 1511.5 | 1833.8 | 1661.8 | 1556.6 | 1672.7 | 1639.8 | 1646 | 100.00% |
| Agri ET | 842.2 | 970.0 | 919.6 | 843.8 | 902.3 | 889.9 | 894.6 | 54.30% |
| Eco-environ ET | 637.5 | 832.4 | 706.6 | 671.0 | 728.7 | 708.2 | 714.1 | 43.40% |
| Living water consumption | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.10% |
| Industrial water consumption | 30.9 | 30.6 | 34.9 | 40.9 | 40.9 | 40.9 | 36.5 | 2.20% |
| **Water Storage Change** ⊿s | -193.1 | 43.4 | 65.9 | 14.4 | -237.8 | -66.5 | -62.3 | |

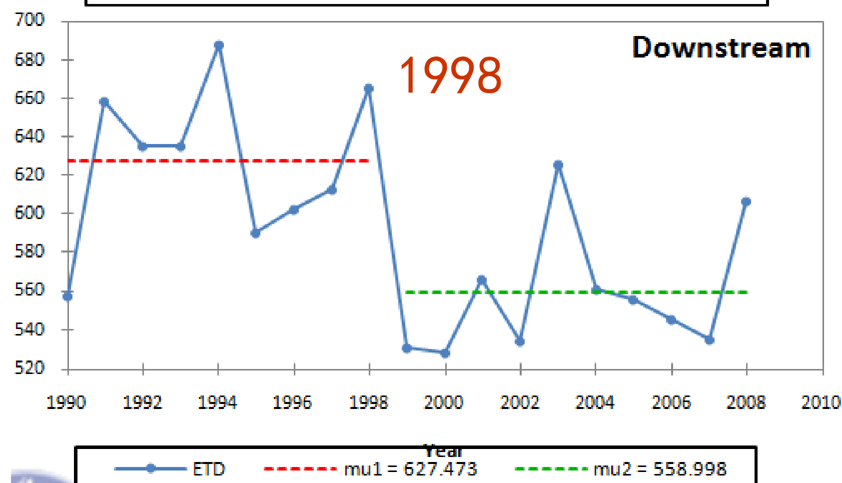
- The average water storage change is 6.23 billion $m^3$
- The Agricultural ET accounted 54.3% of the total water consumption

# Spatio-temporal variation of Evapotranspiration in Hai basin from 1984-2009

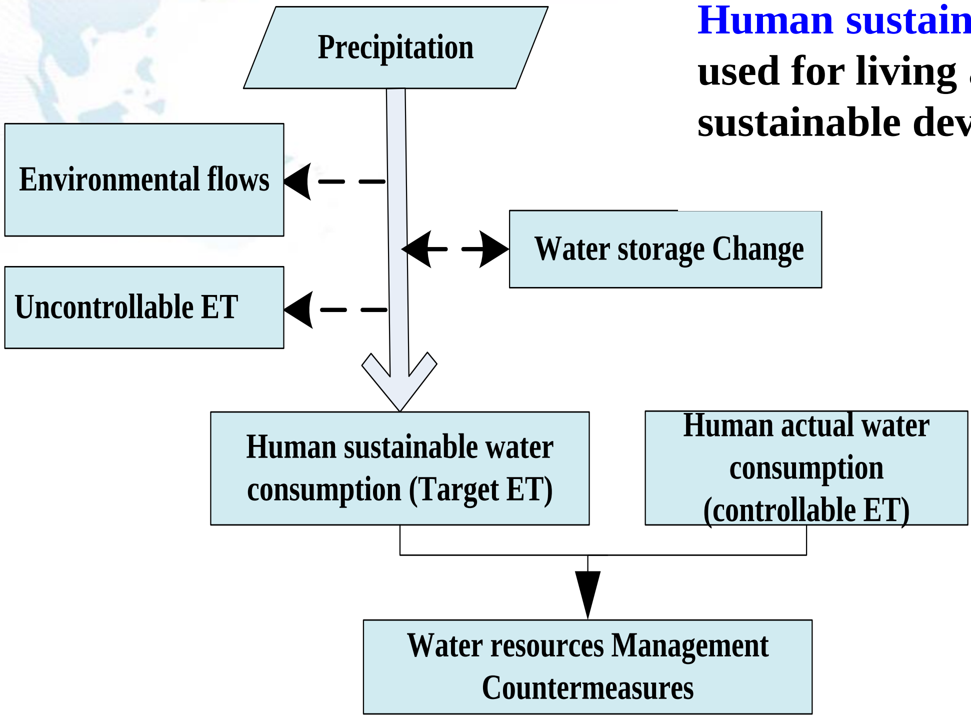


# Watershed water consumption balance model




**Human sustainable consumable water:** **the consumable water used for living and production while maintaining the sustainable development of ecological environment.**

**Three conditions:**

- **Groundwater is not over-exploited**
- **Natural ecosystems are not destroyed**
- **Ensure that river channels have the ecological flow for the dilution of pollutants in order to maintain shipping and ecological diversity**

$$SCW = P - ET_{env\_uc} - ET_{hum\_uc} - R_{env}$$

**SCW -- human sustainable consumable water**

**P --the precipitation,**

**$R_{env}$ -- ecological flow**

**$ET_{env\_uc}$ --uncontrollable ET of natural ecosystems**

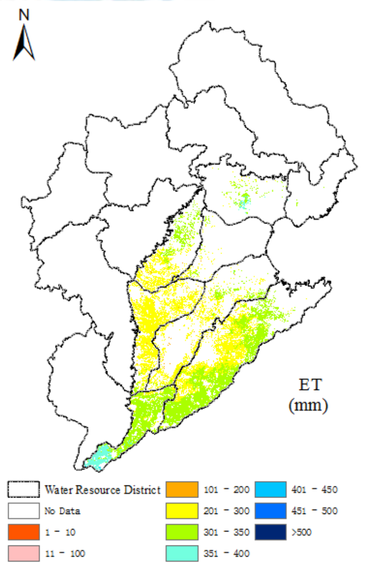
**$ET_{hum\_uc}$ --uncontrollable ET of artificial ecosystems.**

# Human sustainable water consumption and controllable ET

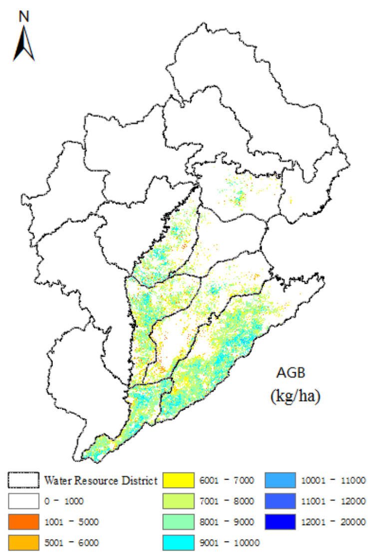
| Third Grade | Precipitation | Uncontrollable ET | Environmental flows | **Human sustainable water consumption** | Solar controllable ET | | | | Bioenerge ET | Mineral energe ET | **Total human controllable** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Habitation sites | | | Farmland | | | |
| | | | | | Town | Rural area | Total | | | | |
| Beisan river mountainous | 109.86 | 101.58 | 5.24 | 3.04 | 1.21 | 0.47 | 1.68 | 8.44 | 0.01 | 0.30 | 10.43 |
| The upstream of the Yongding River Cetian Reservoir | 66.25 | 50.58 | 1.46 | 14.21 | 0.49 | 0.83 | 1.32 | 5.99 | 0.02 | 1.34 | 8.67 |
| From the Yongding River Cetian Reservoir to Sanjiadian | 108.38 | 86.21 | 2.06 | 20.11 | 0.87 | 1.07 | 1.94 | 9.58 | 0.03 | 1.04 | 12.59 |
| Beisi river plain | 82.35 | 45.25 | 2.86 | 35.24 | 8.90 | 1.57 | 10.47 | 35.15 | 0.10 | 3.03 | 48.75 |
| Daqing river mountainous | 92.11 | 79.10 | 5.44 | 7.57 | 0.54 | 0.41 | 0.95 | 7.20 | 0.01 | 0.48 | 8.64 |
| Daqing river west plains | 61.83 | 35.45 | 0.43 | 25.95 | 7.51 | 1.32 | 8.83 | 36.85 | 0.06 | 1.68 | 47.42 |
| Daqing river east plains | 68.99 | 41.82 | 1.68 | 25.49 | 6.42 | 0.76 | 7.18 | 26.71 | 0.07 | 1.60 | 35.56 |
| Ziya river mountainous | 158.00 | 111.25 | 6.52 | 40.23 | 1.50 | 0.88 | 2.38 | 16.91 | 0.04 | 2.62 | 21.95 |
| Ziya river plains | 76.34 | 42.15 | 0.26 | 33.93 | 8.27 | 1.77 | 10.04 | 46.34 | 0.07 | 2.64 | 59.09 |
| Zhangwei river mountainous | 148.27 | 100.72 | 5.85 | 41.70 | 1.17 | 1.34 | 2.51 | 20.00 | 0.04 | 2.24 | 24.79 |
| Zhangwei river plains | 52.69 | 26.41 | 1.41 | 24.87 | 3.52 | 1.32 | 4.84 | 32.32 | 0.05 | 1.36 | 38.57 |
| Heilonggangyundong plains | 119.73 | 67.43 | 1.35 | 50.95 | 8.60 | 1.24 | 9.84 | 62.94 | 0.06 | 1.36 | 74.20 |
| Hai River system | 1145.82 | 787.95 | 34.55 | 323.32 | 48.99 | 12.99 | 61.98 | 308.43 | 0.58 | 19.69 | 390.68 |
| The proportion of the total controllable | | | | | 13% | 3% | 16% | 79% | 0% | 5% | 100% |

# Crop Water Productivity(CWP) estimation in Hai Basin

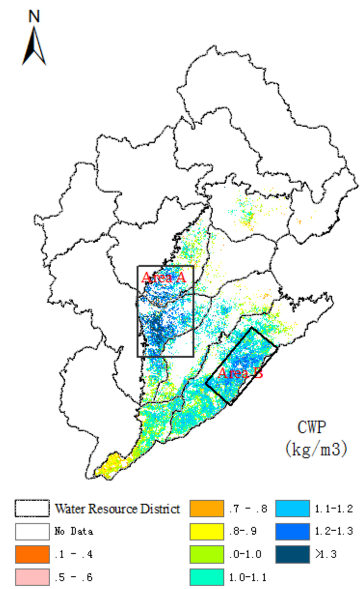
## Methods and results




Averge ET of winter wheat(mm)



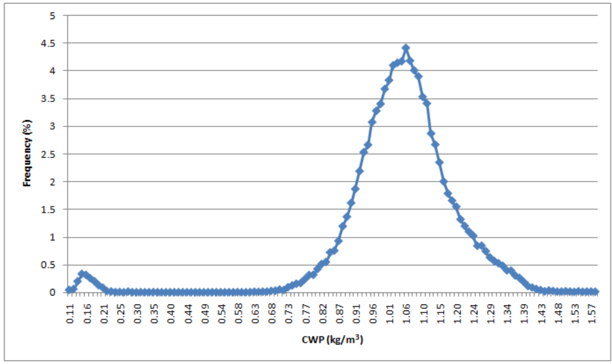

Biomass(kg/ha)




crop water productivity of winter wheat (kg/m$^3$)

$$CWP = \frac{Yi}{\sum_{ts}^{te} ET};$$

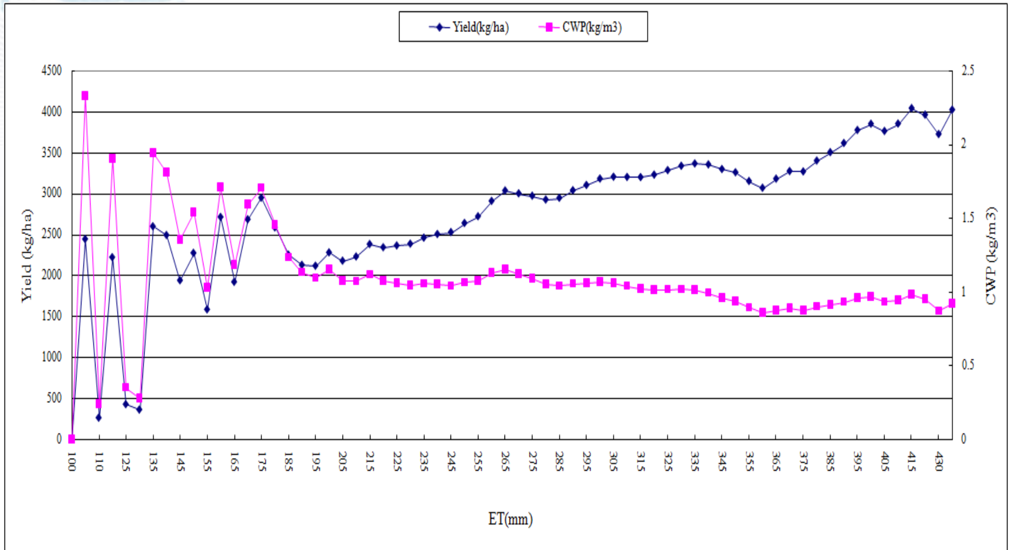
$$Yi = Hi \times \sum_{ts}^{te} DM$$

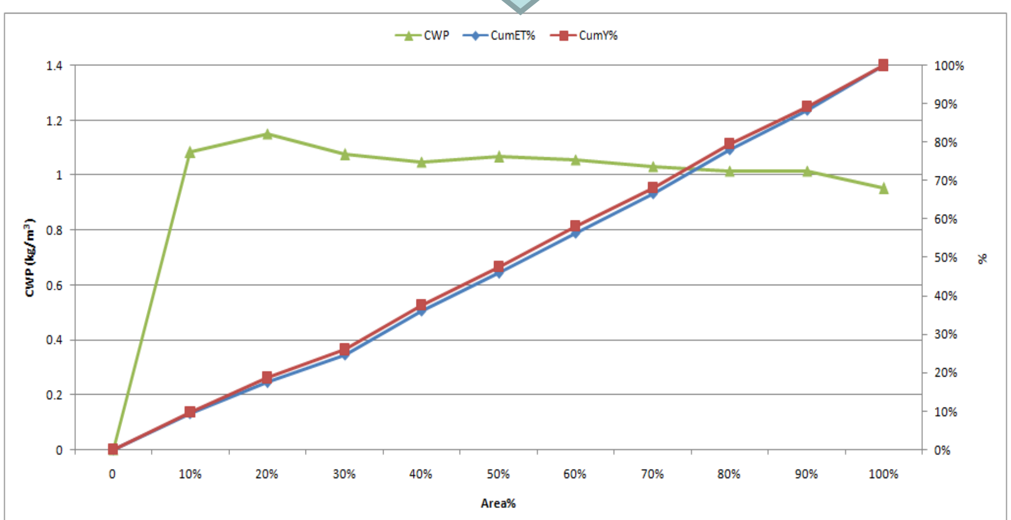



- Average CWP of winter wheat from 2003 to 2009 is 1.05kg/m$^3$ (Western Europe>1.2, FAO).
- CWP can reach 1.2kg/m$^3$ with ET reduction of 36.5mm for winter wheat under the premise that yield dose not change.

# Crop Water Productivity(CWP) estimation in Hai Basin

## Spatio-temporal integration analysis




**The relations among ET, Yelid and CWP at the regional scale :**

- **The relation between yield and ET is significant, and correlation coefficient is** 0.93
- **With increasing ET, Yield increases significantly, while CWP values are relatively stable.**
- It can be concluded that water saving does not necessarily mean the improvement of water productivity

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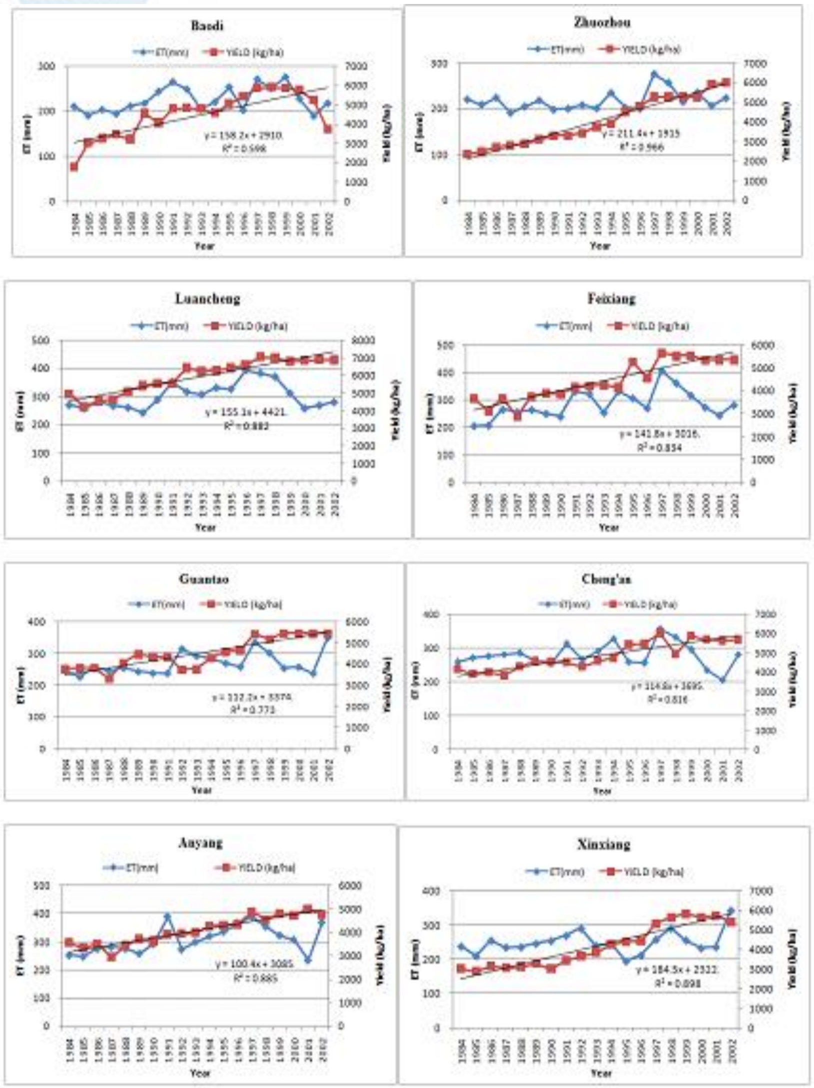
# Crop Water Productivity(CWP) estimation in Hai Basin

## Spatio-temporal integration analysis




The temporal change relation among yield CWP, and ET:

**□The significant linear increase trends of winter wheat yield were found at all stations from 1982 to 2002, without corresponding increase in ET.** The increase in CWP depends on an increase in yield rather than on a reduction in ET.

**□The effects of irrigation engineering measures on the improvement of CWP, have been confirmed by the field experiments. The increase in CWP depends only on water saving would be very difficult.**

The existing viewpoints of “Increasing yield through increasing ET” and “Increasing CWP through water saving measures implements ” are not appropriate for Hai River Basin.

# Water saving analysis in Hai Basin

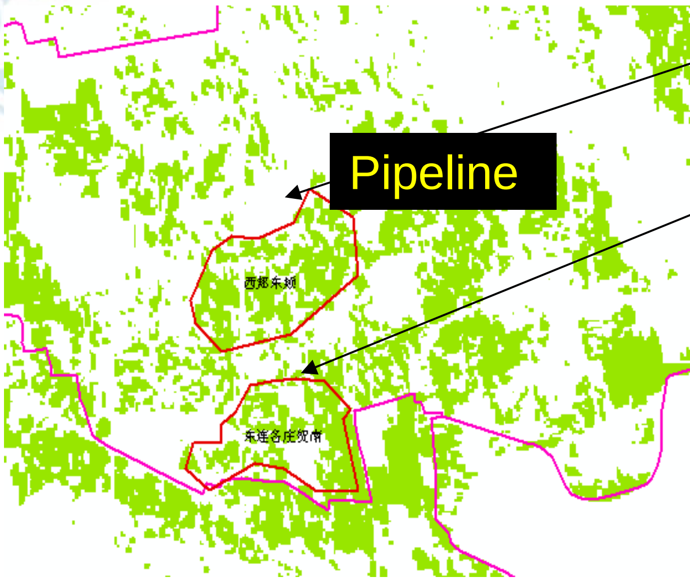
## Based on water productivity

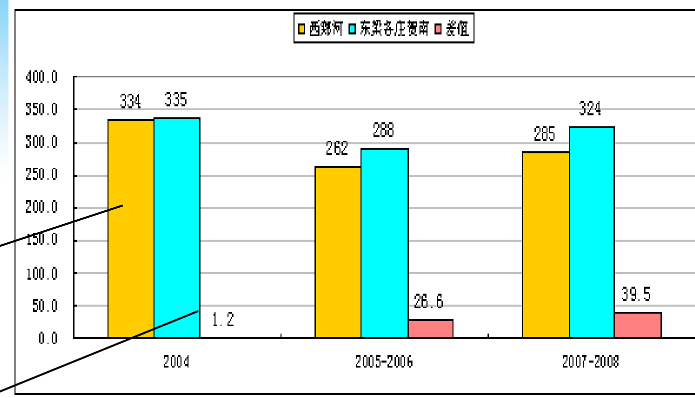
### Water saving potential in the farmland of Hai Basin from 2003 to 2009

| Third Grade District | CWP threshold | ET reduction | Area | Water saving potential in the farmland $10^8 m^3$ |
|---|---|---|---|---|
| Beisan river mountainous | 1.14 | 74.1 | 3153 | 2.34 |
| From the Yongding River Cetian Reservoir to Sanjiadian | 1.11 | 72.7 | 11826 | 8.60 |
| The upstream of the Yongding River Cetian Reservoir | 0.88 | 73.1 | 11126 | 8.13 |
| Beisi river plain | 1.13 | 65.2 | 11583 | 7.55 |
| Daqing river mountainous | 1.15 | 55.8 | 3807 | 2.13 |
| Daqing river west plains | 1.18 | 48.8 | 10053 | 4.90 |
| Daqing river east plains | 1.17 | 49.8 | 9403 | 4.68 |
| Ziya river mountainous | 1.16 | 55.1 | 11584 | 6.39 |
| Heilonggangyundong plains | 1.31 | 32.1 | 18217 | 5.84 |
| Ziya river plains | 1.22 | 31.8 | 11803 | 3.75 |
| Zhangwei river mountainous | 1.02 | 40.7 | 11140 | 4.54 |
| Zhangwei river plains | 1.17 | 26.3 | 7370 | 1.94 |
| Total | | | | 60.79 |

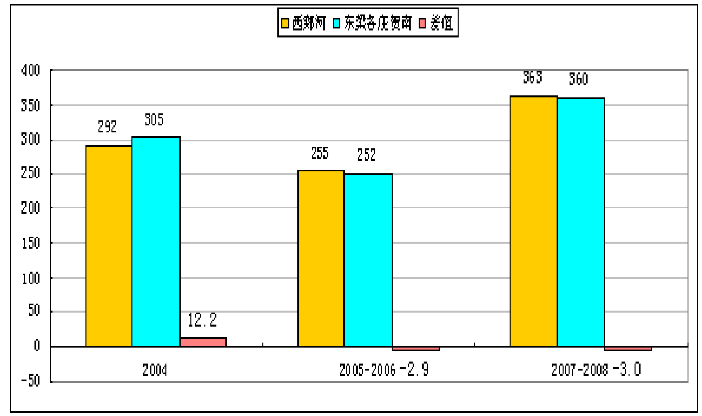
- The total water saving potential of Hai Basin is 60.79 $*10^8 m^3$.

# Water Saving



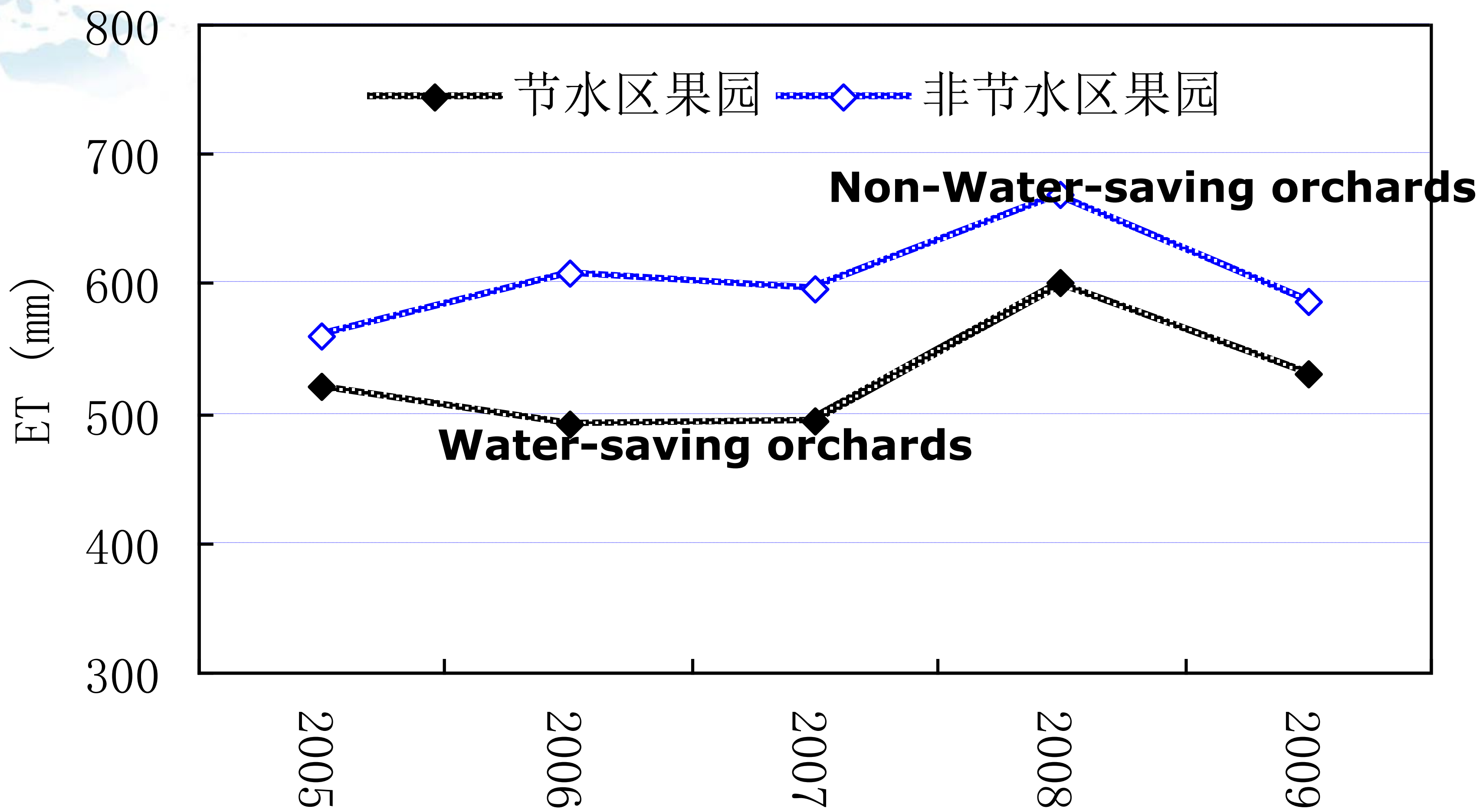

Wheat



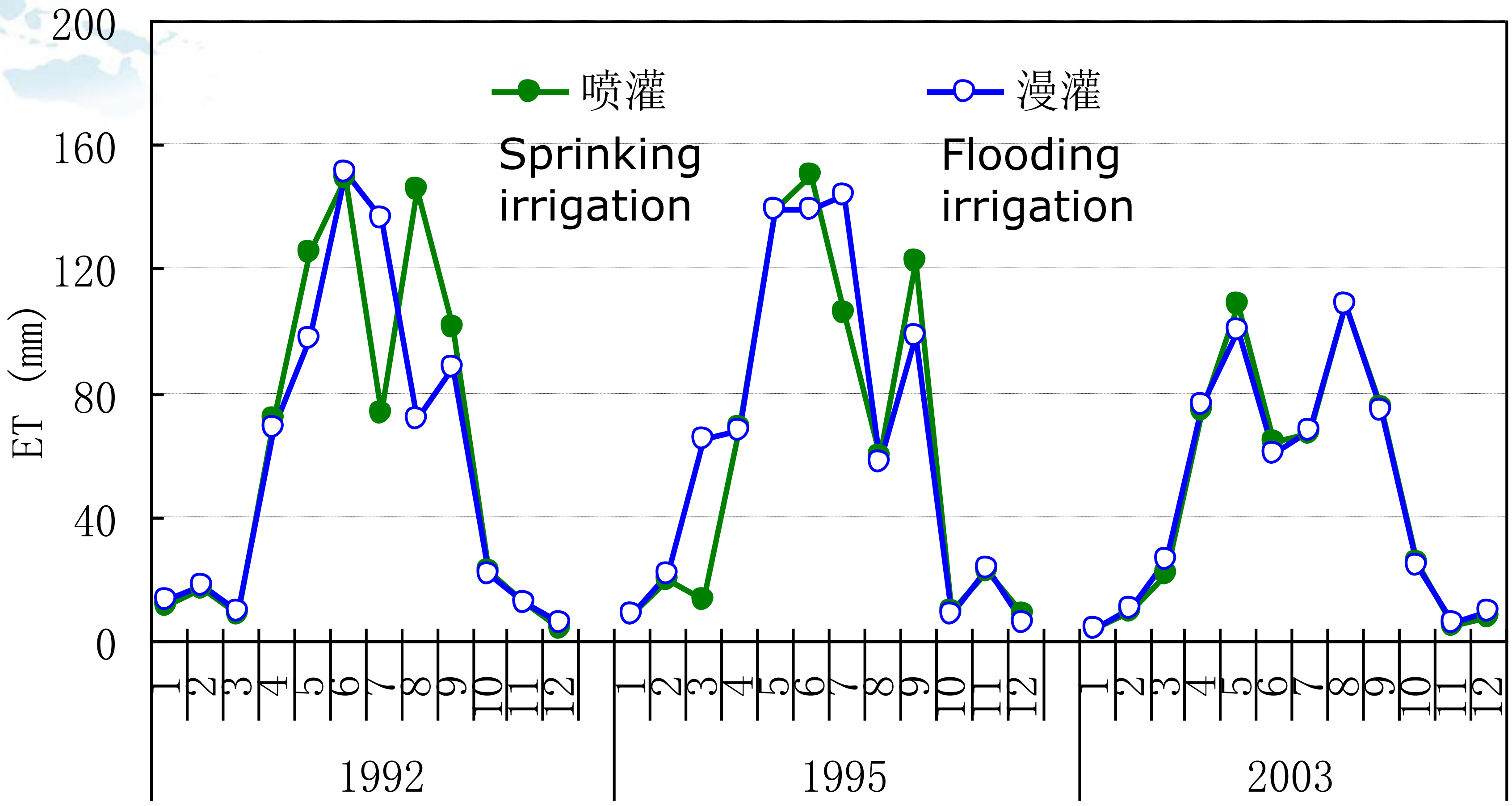

Maize

- Water saving measure: Xijiahe, pipeline irrigation since 2005
- Since 2005, ET in Xijiahe is lower than Donliangezhuang in wheat growth season; But there is little difference in maize

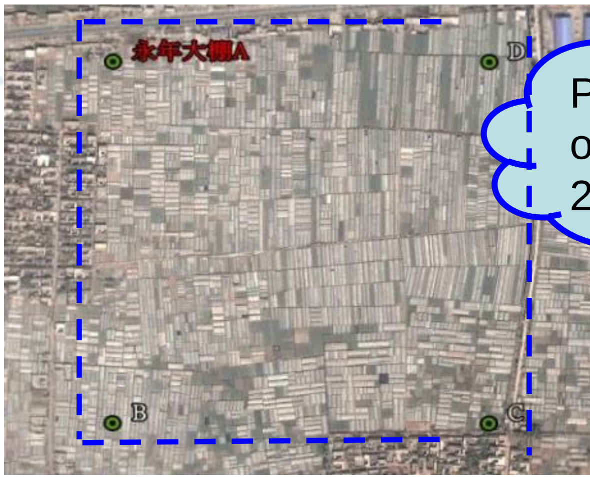
# The water-saving effect of orchards drip irrigation in Neiqiu county



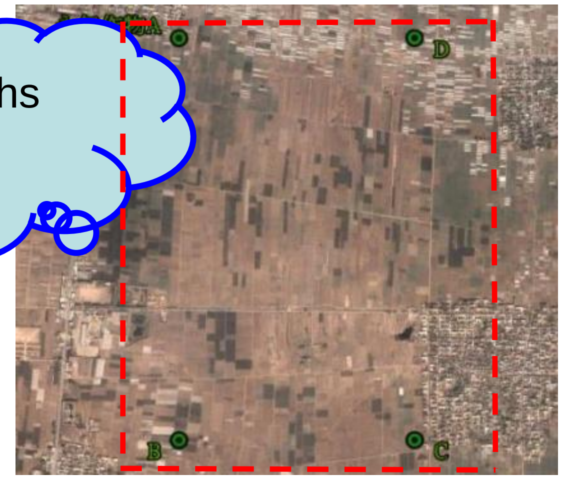
# Crop ET distribution of different irrigation modes in typical year (Dacaozhuang farms)



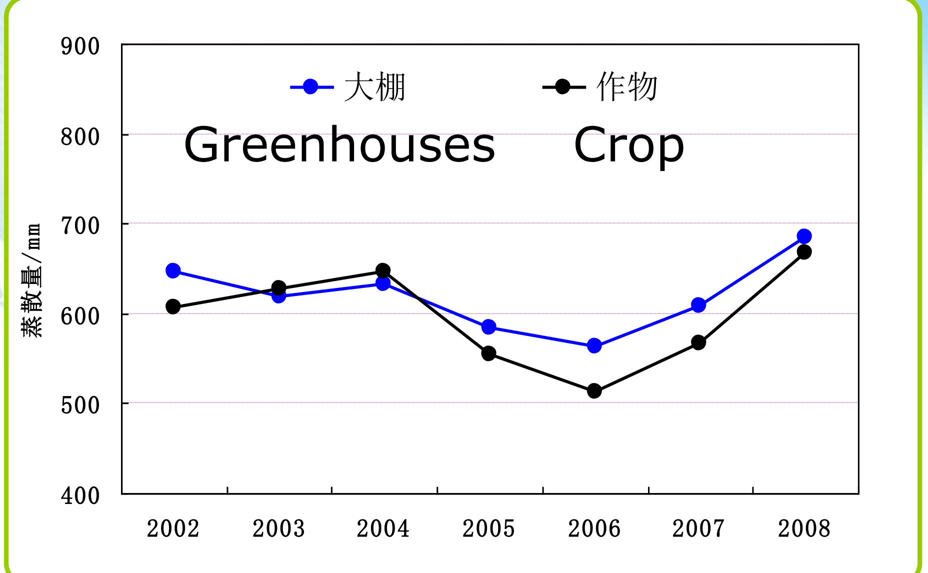
# Comparison of water consumption between vegetable greenhouses and crop in Yongnian county

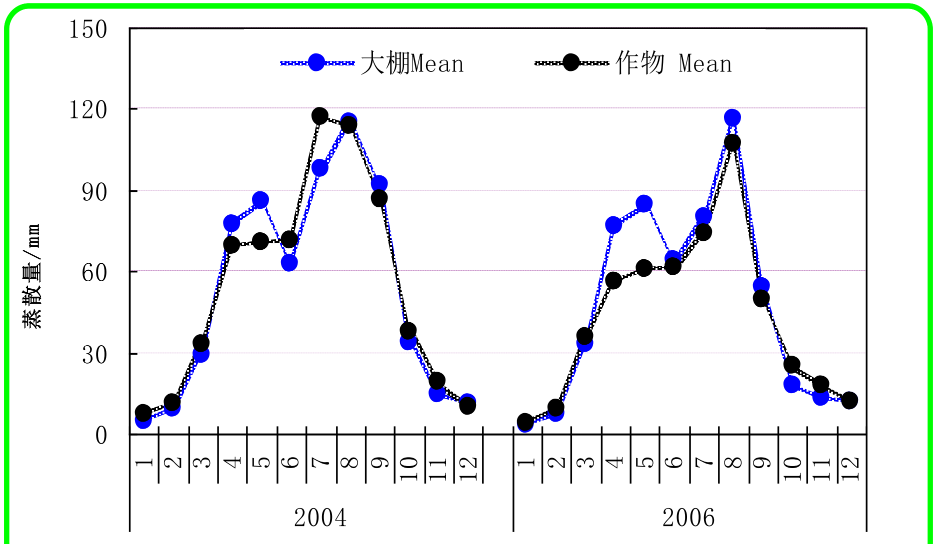



Photographs of time 2008/4/6

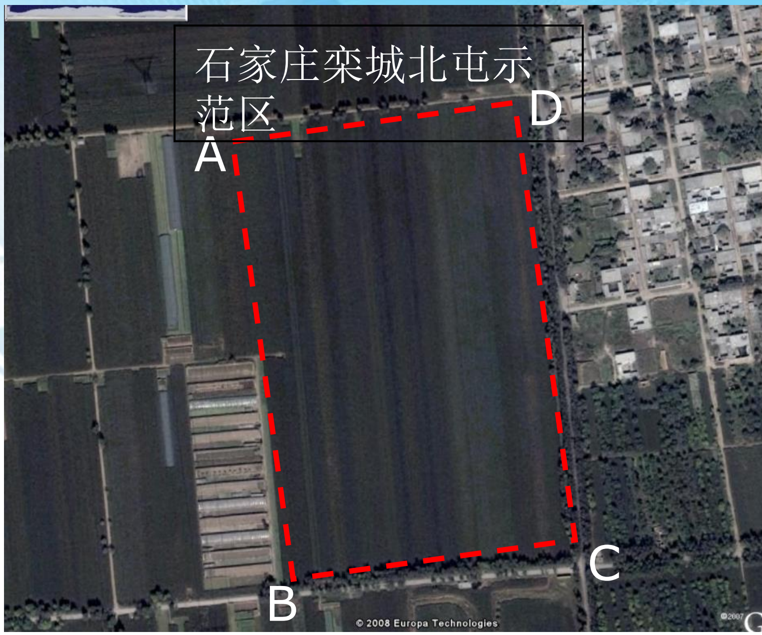







- The change trend of ET is basically consistency between field crops and Greenhouses from 2002 to 2008,and the average water consumption are 598mm and 620mm respectively. The average water consumption of vegetable greenhouses is more than field crops from 22mm to 50mm.
- The change trend of ET is basically consistency between field crops and Greenhouses during the year. The greenhouse ET was significantly higher than field crops from April to may because of rising temperatures, and the greenhouse need to be opened. At the same time vegetables are in the growing period and the water consumption was significantly higher than the water requirement of crops. The water consumption of vegetables was decreased in June , because the new vegetables is in the seeding stage



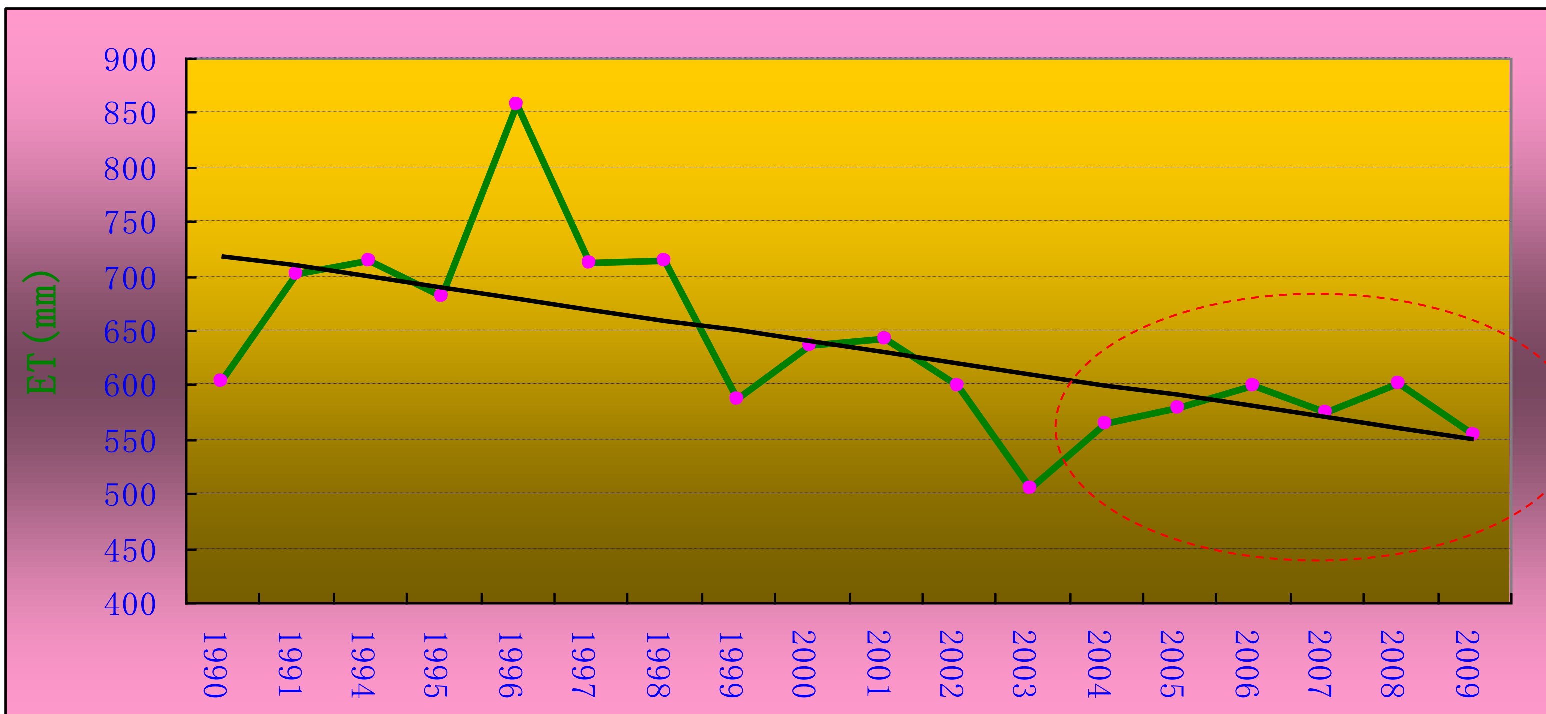

# Beitun demonstrative district

The first year of straw cover: 2003

The average ET from 1990 to 2002 is 676mm

The average ET from 2003 to 2009 is 576mm

Average water- saving: 100mm

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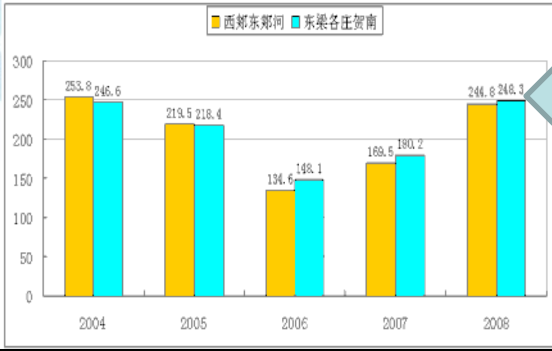
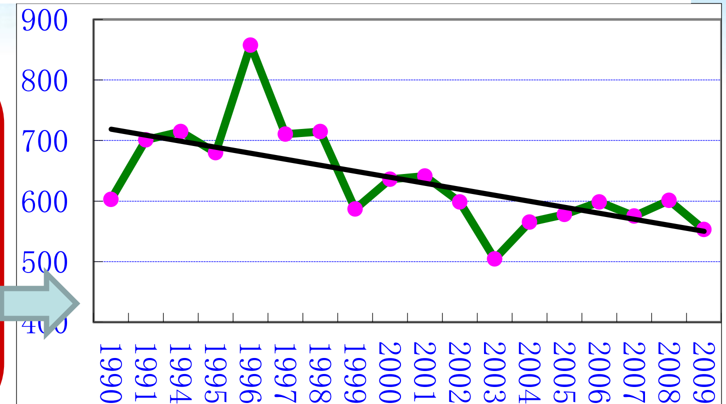
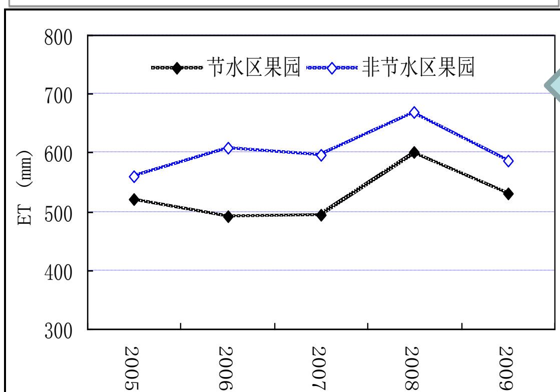
# Water saving analysisl in Hai Basin

## The effect of agricultural water saving management measures

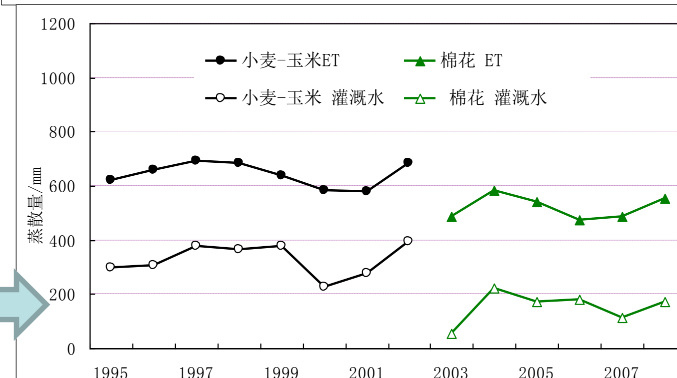


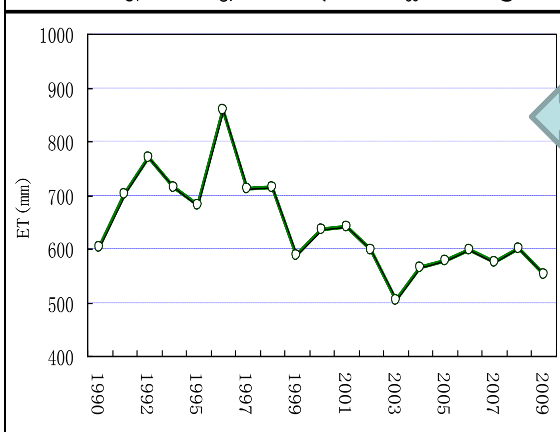

The average water saving of wheat is 16.5mm with Tube feeding in Daxing.
The average water saving is 49.6mm with straw cover in Beitun demonstrative district



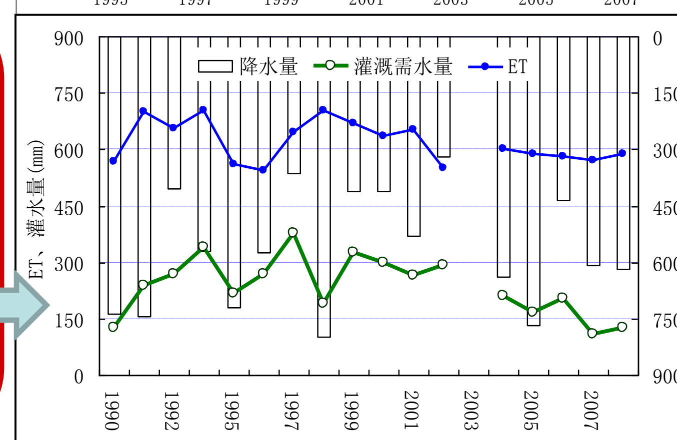




The average water saving of orchard is 77mm with drip irrigationin Neiqiu.
The average water saving is 82mm with planting structure adjustment in Zhou county




The average water saving is 76mm combination with agronomic, engineering and scientific irrigation in Beitun demonstrative district.
The average water saving is 47mm with engineering measures in Dacaozhuang county demonstrative district



# Water saving analysisl in Hai Basin

## Water  saving potential of different measures

| | Coverage of anniversary stalks (wheat-corn) | The row spacing adjustment (wheat-corn) | Optimization of irrigation system(wheat) | Water saving and high yielding(wheat) | planting structure adjustment | Integrated water saving of wheat and corn |
|---|---|---|---|---|---|---|
| Area /$10^4$km$^2$ | 4.3 | 4.3 | 4.3 | 4.3 | 4.3 | 4.3 |
| Water saving amount /mm | 37.9 | 20-30 | 40-50 | 25-40 | 82 | 30-45 |
| Water saving total amount /$10^8$m$^3$ | 16.3 | 8.6-13 | 17.2-21.5 | 10.8-17.2 | 35.3 | 13-19.4 |
| Recharge /$10^8$m$^3$ | 46.0 | 49.4-53.7 | 40.8-45.1 | 45.1-51.6 | 27.0 | 48.0-54.4 |
| Scene 1 | | | Scene 2 | | | |
| Wheat growing season controllable ET/mm | | 187.9 | Farmland controllable ET/mm | | | 331.2 |
| Wheat fallow area /$10^4$km$^2$ | | 2.6 | Farmland fallow area /$10^4$km$^2$ | | | 1.5 |
| Proportion /% | | 24.8% | Proportion/% | | | 14.1% |

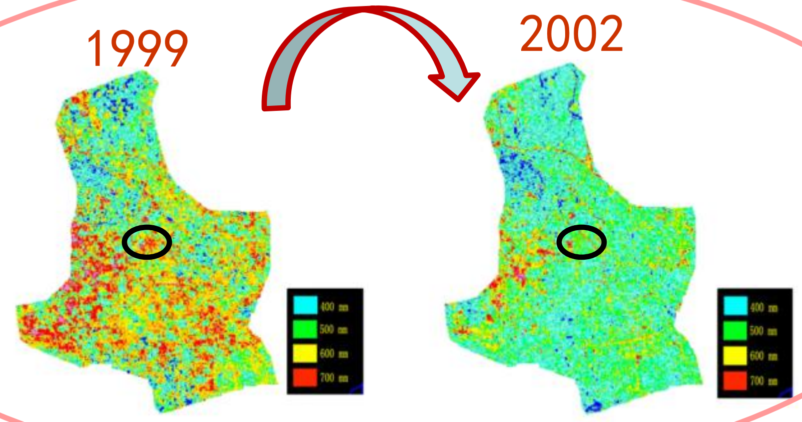
- The water deficit was 67.4 *$10^8$m$^3$ from 2002 to 2009 in Hai basin; The total water saving of integrated water saving measures was up to 19.4 *$10^8$m$^3$; Becase the total water saving amount is still unable to meet the sustainable development of the basin water resources,  14.8% (24.8%) of cultivated land (wheat) need to be fallow.
- The South-to-North Water Diversion project will provide about 90~140 *$10^8$m$^3$ of water every year, which is an important act plan to solve the deficit of water resources in the Hai basin and to gradually improve the ecological environment.

# Monitoring and evaluation of water consumption

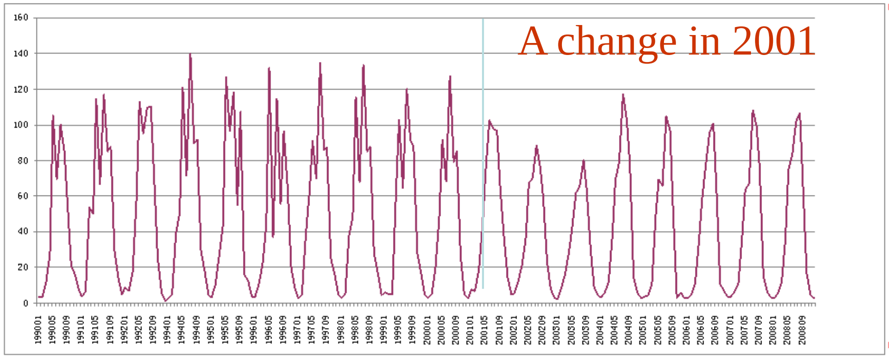
## Agricultural engineering

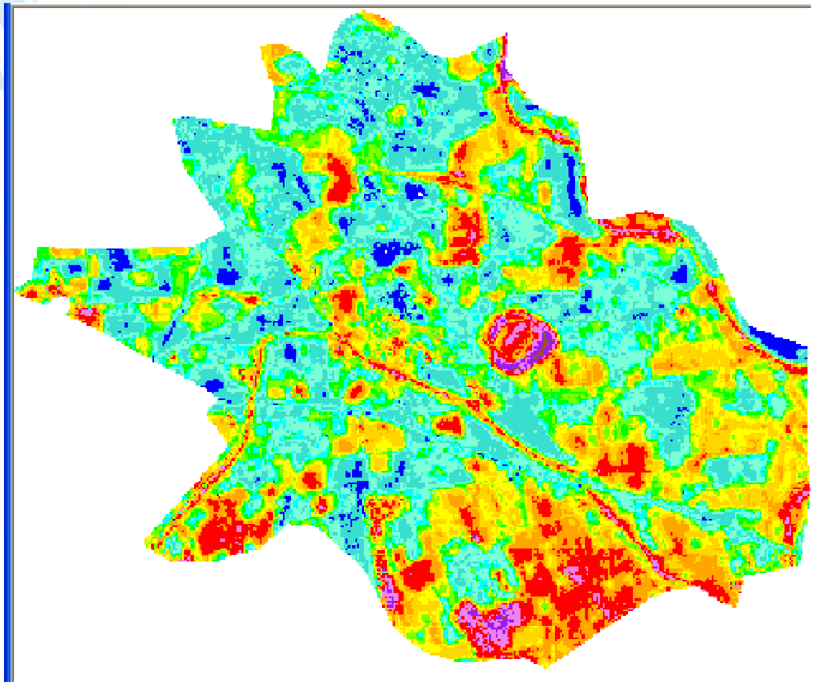
Water saving effect supervision after crop pattern adjustment

Water saving measures implement in Tongzhou




Planting structure adjustment in the downstream of Miyun reservoir

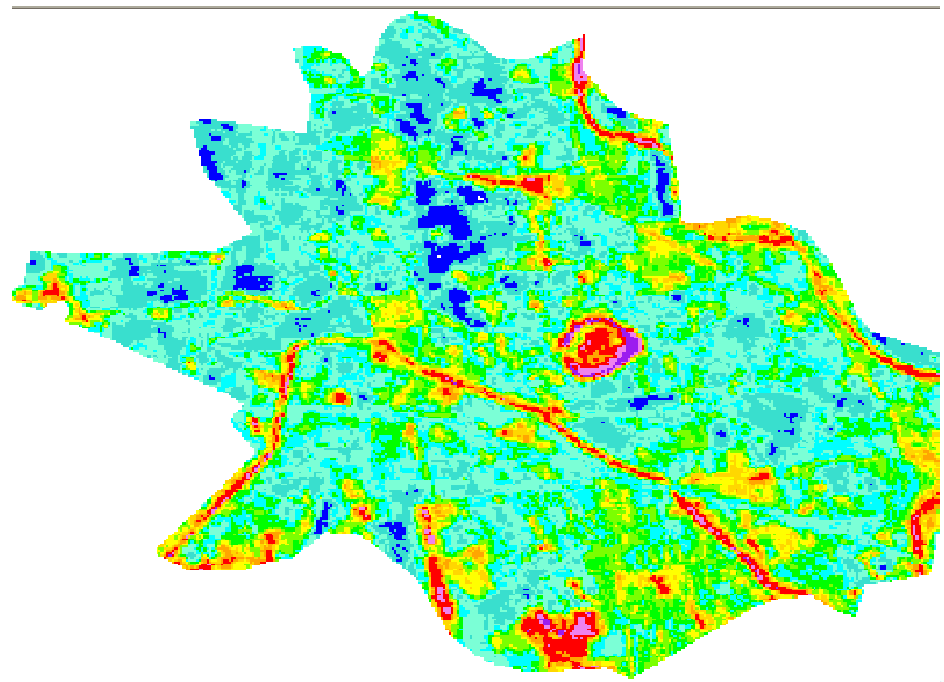




Before Project

Legend(unit:mm)

- 0-200
- 200-300
- 300-400
- 400-500
- 500-600
- 600-700
- 700-800
- 800-900
- 900-



After Project

# Remarks

- **ET Technology: basin-wide and irrigation district measurement with same accuracy as prep/runoff**
  - ET accuracy from ETWatch model is more than 95% on the watershed scale, more than 90% on a field scale.
- **ET management**
  - **simplifies WRM - wide range and future direction**
  - **consumption balance is key to sustainable water resources development**
  - **promotion and training needed to convince more people in water sector**
  - **stimulus governance model, behaviour and awareness change on water consumption control**

# Develop water consumption saving society

What happen today?

Man-made Lawn


Man-made waterbody

Man-made ski slopes

Carwash uses groundwater

Cooling tower

Grass to forest

Canal seepage control projects

## What we should do?

- Strengthen remote sensing ET monitoring
- Monitoring water consumption from industry and mining
- Water consumption management regulations (fees, water rights, laws and so on)
- Raise awareness on water consumption

melon in gravel-mulched field

# Thanks!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