Research and application of spatial information technology in disease control and prevention field in China

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Outline

1. Application of spatial information technology (SIT) in public health field
2. Monitoring and prevention of schistosomiasis

Application of SIT in public health field

New requirements for the development of SIT

Health Field

- Prevention and control of major infectious diseases is faced with severe situation
- High health risks regionals are heavily polluted
- Emergent public health events never come to an end

3S can meet the requirements from data acquisition, analysis and evaluation to decision support.

3S

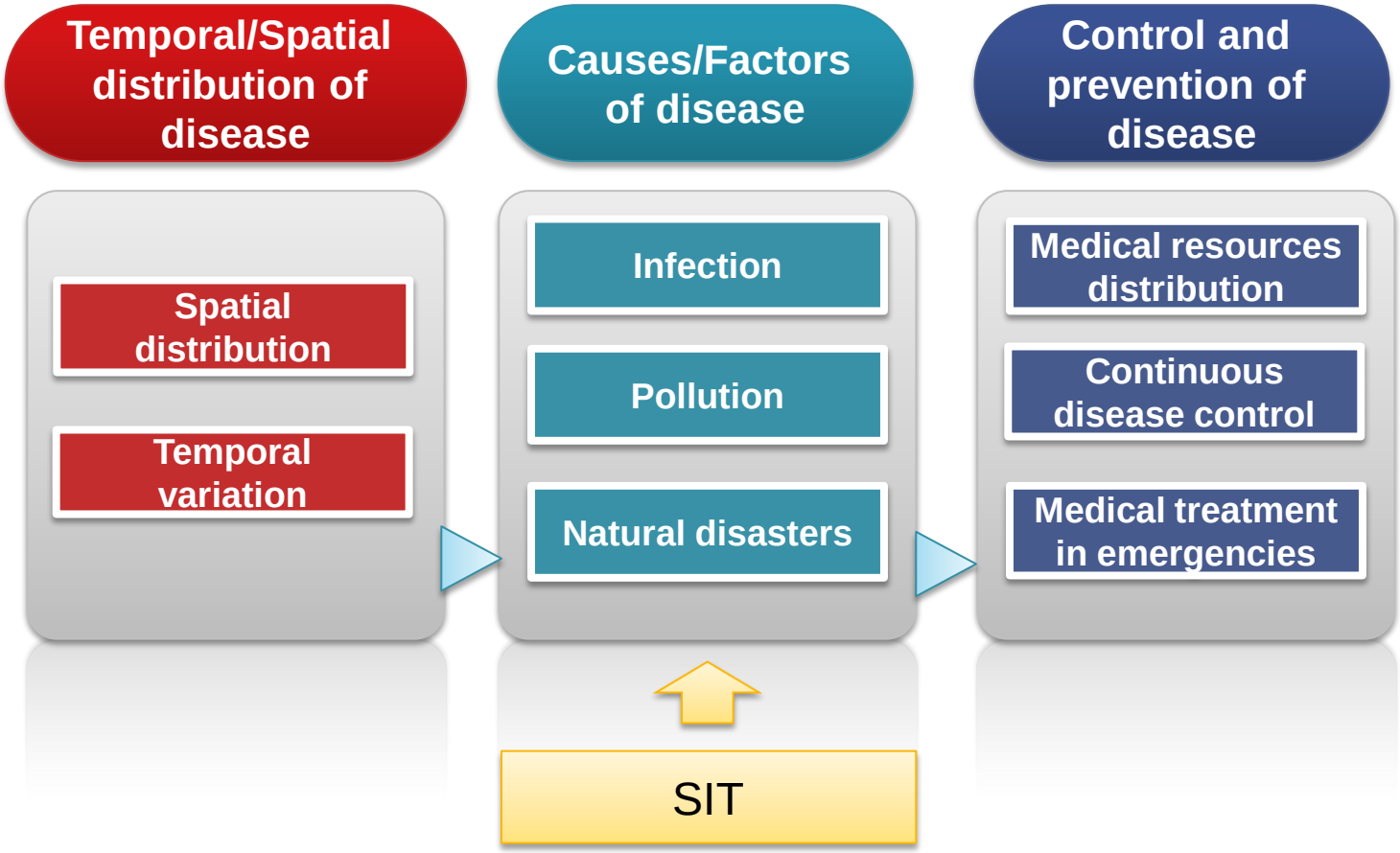
- GIS: spatial analysis tool — **Analyze space-time distribution of environment and disease, and their correlation, causality**
- GPS: spatial positioning tool — **Sample collection**
- RS: main data source — **Extracting the information of water, land and atmosphere.**

Application of SIT in public health field

- In 2003, the "Center for Applied Research on Spatial Information Technology in the Field of Public Health " was jointly established by Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, Institute of Microbiology and Epidemiology, Academy of Military Medical Sciences and Remote Sensing and GIS Research Center, Beijing Normal University.
- In 2012, the sub-center of "Center for Applied Research on Spatial Information Technology in the Field of Public Health" was established in Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences.

- In December 2012, approved by the China Institute of health information, health geographic information Specialized Committee was formally established , for the wide application of spatial information technology in the field of health.

Application of SIT in public health field



Application of SIT in public health field

Project name: High resolution satellite remote sensing information service system for disease prevention and control

Mission Unit:
China National Space administration

- Statistical Information Center of National Health and Family Planning Commission
- Institute of Geographical Sciences and Natural Resource Research, Chinese Academy of Sciences
- Chinese Centre for Disease Control and Prevention
- Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences
- Shanghai Center for Disease Control and Prevention
- Institute for Parasitic Disease control and Prevention, Chinese Centre for Disease Control and Prevention
- Institute for Infectious Disease control and Prevention, Chinese Centre for Disease Control and Prevention

The total project time: 2012-2020

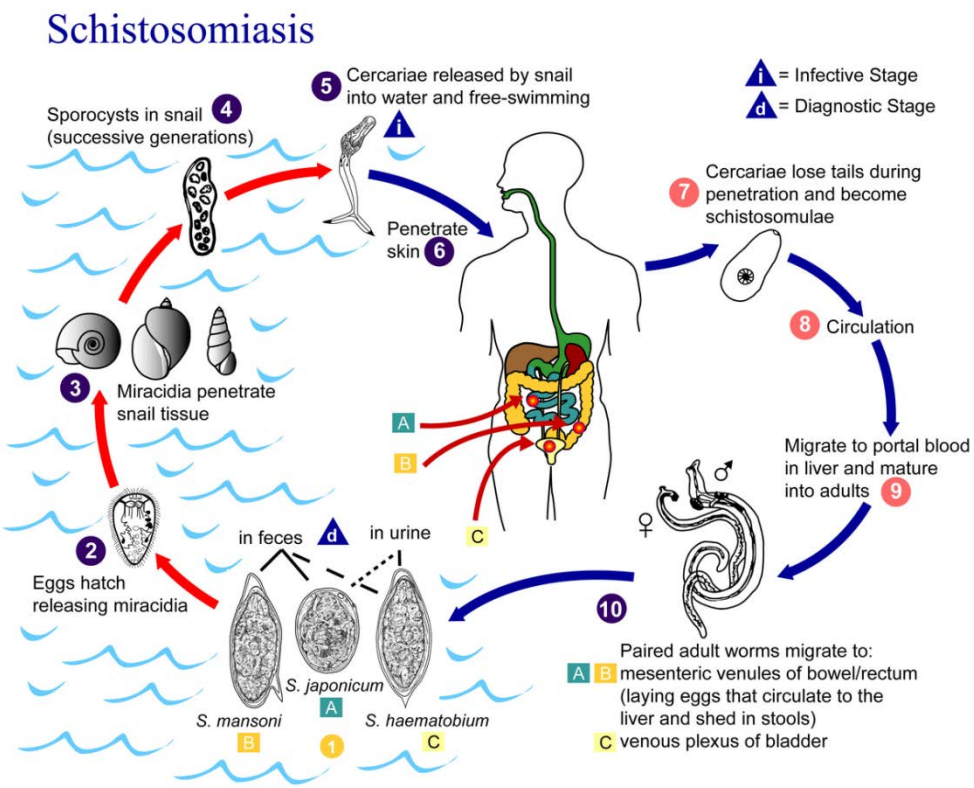
- Advance research (2012-2014)
- Phase I (2014-2017)
- Phase II (2017-2020)
- **Project budget**: 5,810,322 $ (40 million RMB)

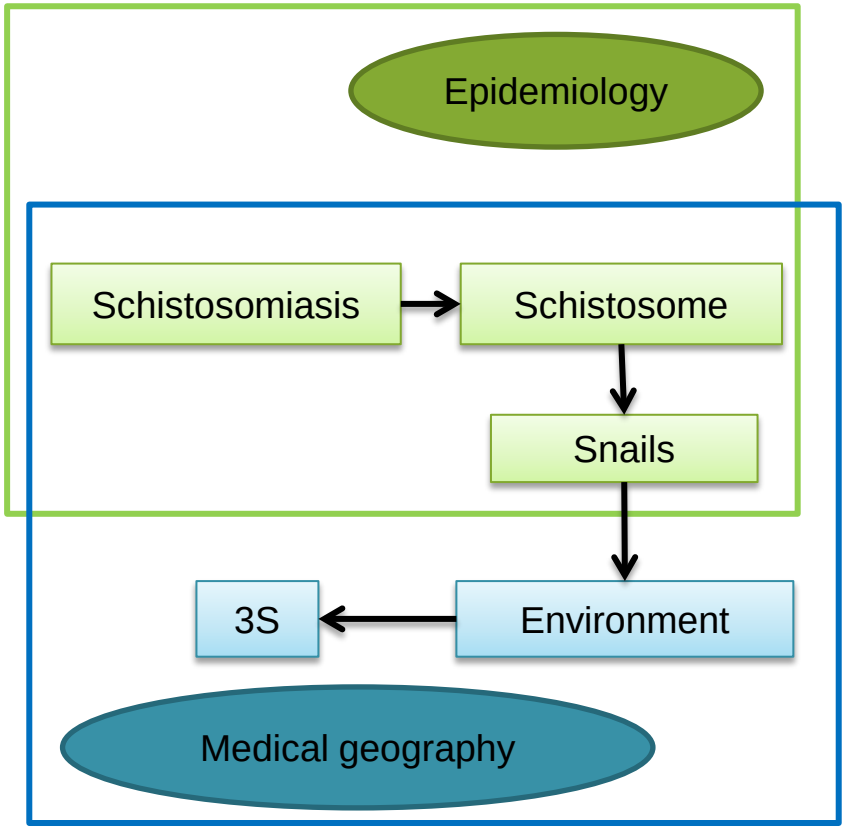
Main research contents:

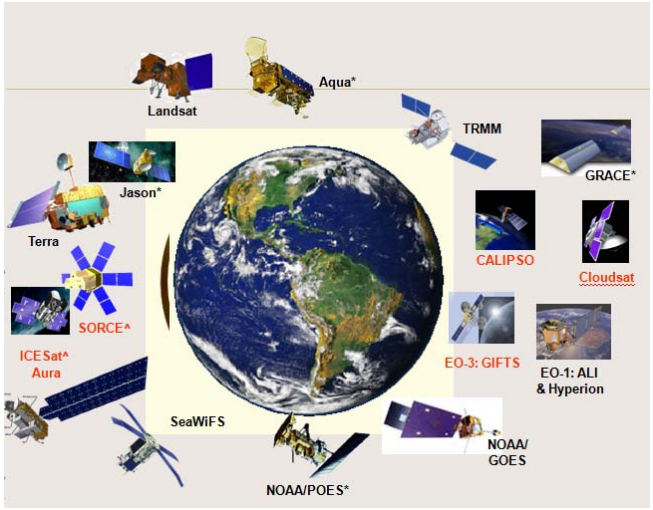
- Monitoring and evaluation of infectious diseases (schistosomiasis, dengue fever, plague, kala-azar, hemorrhagic fever);
- Monitoring and evaluation of residents' health risks in polluted areas (highways, mines, large chemical plants);
- Abrupt public health event emergen (earthquake, flood, landslide / debris flow)

Monitoring and prevention of schistosomiasis

- Schistosomiasis is a disease caused by parasitic worms of the Schistosome.
- The disease is spread by contact with water that contains the parasites (寄生虫).These parasites are released from freshwater snails that have been infected.






Aqua*
Landsat
TRMM
GRACE*
Jason*
Terra
CALIPSO
Cloudsat
SORCE^
ICESat^
Aura
EO-3: GIFTS
EO-1: ALI
& Hyperion
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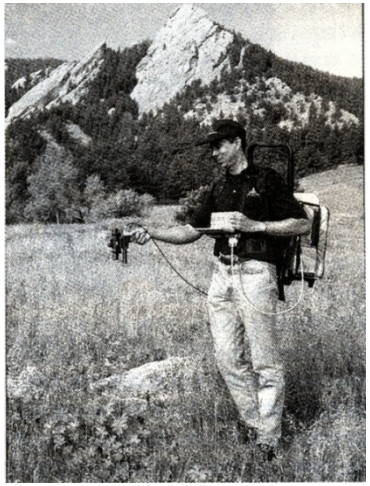
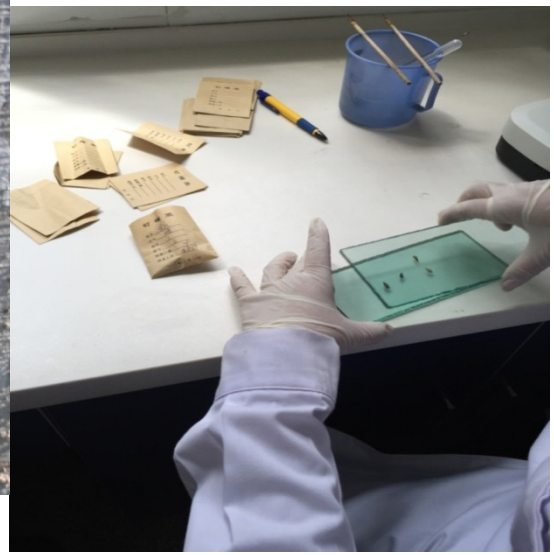
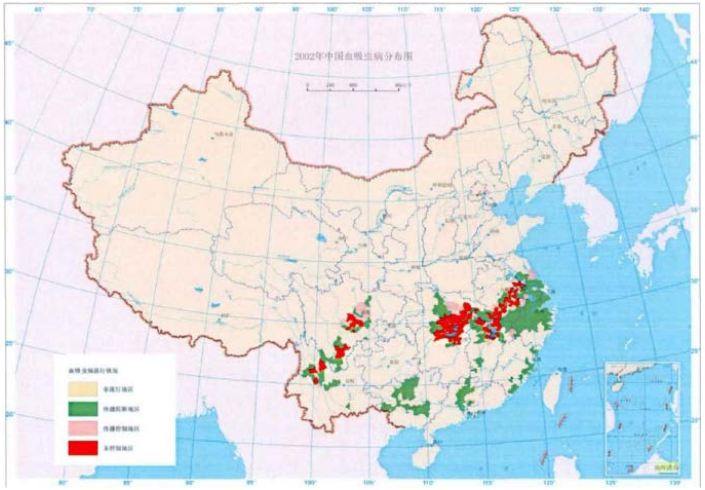




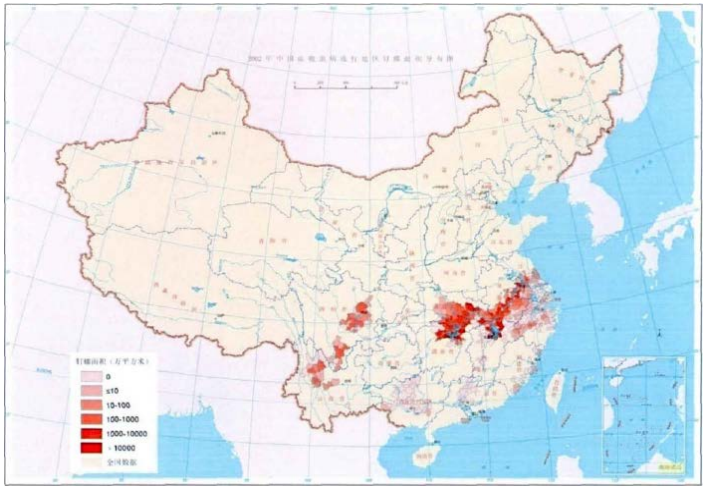
Monitoring and prevention of schistosomiasis

Distribution

- Mainly distributed in the Yangtze River Basin and 12 provinces and municipalities south of the Yangtze River.
- In 2015, 77194 patients were calculated.



Spatial distribution of schistosomiasis



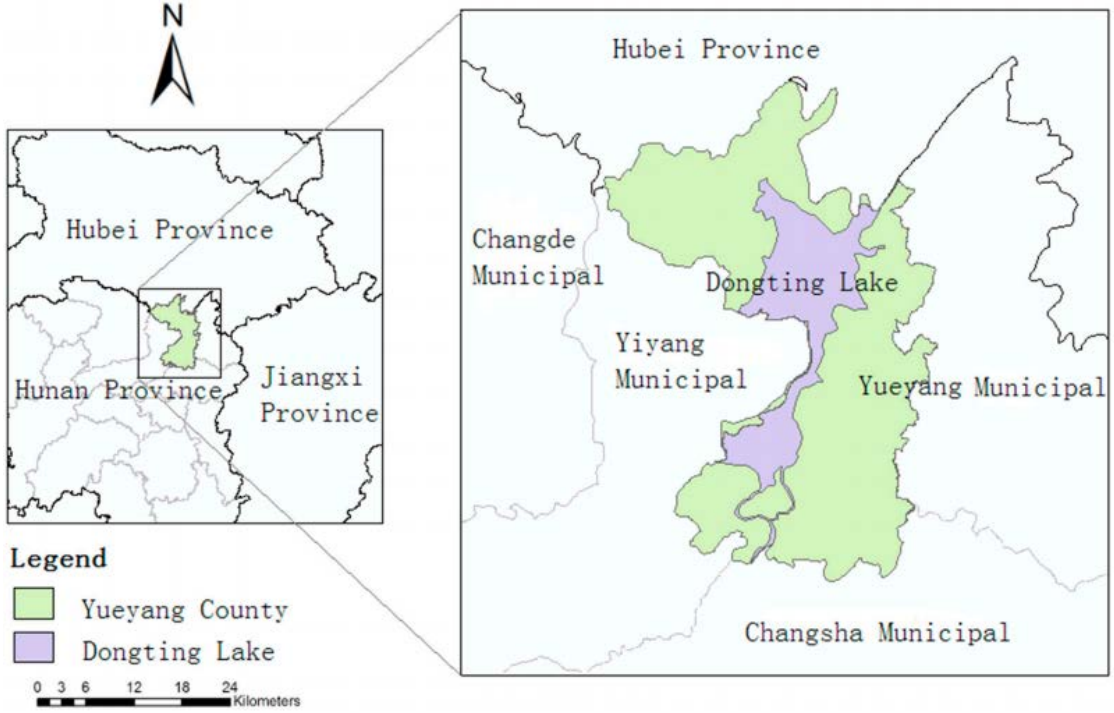
Spatial distribution of oncomelania hupensis

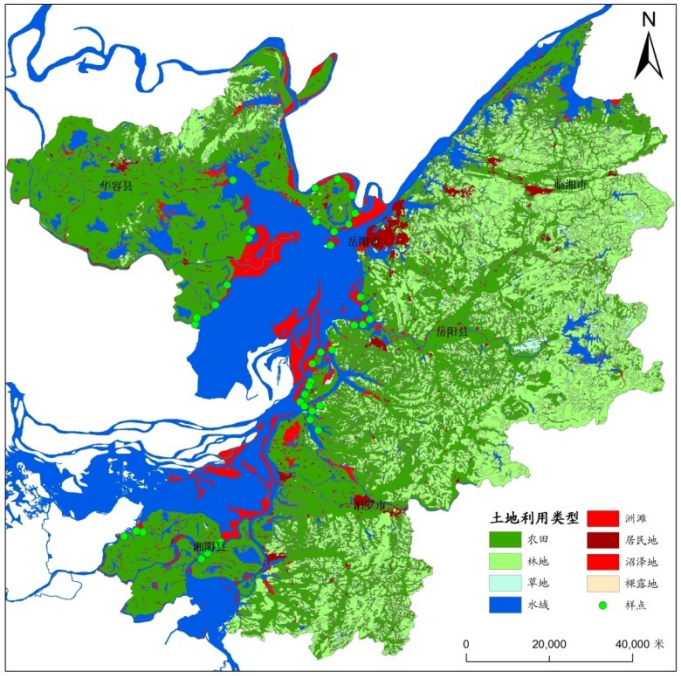
Monitoring and prevention of schistosomiasis

- 3S
  - GIS
    - Establishment of schistosomiasis database
    - Spatial analysis and visualization
  - GPS
    - Sample location
    - Length and area measurement
  - RS
    - Basic geographic data (topography, geomorphology, soil, hydrology, etc.) ← High Spatial Resolution Remote Sensing
    - Extraction of environmental factors (NDVI, temperature, humidity, vegetation) ← Multi/ hyperspectral remote sensing
    - Periodic and continuous monitoring of the factors influencing the epidemic situation ← Multi - temporal remote sensing

Monitoring and prevention of schistosomiasis

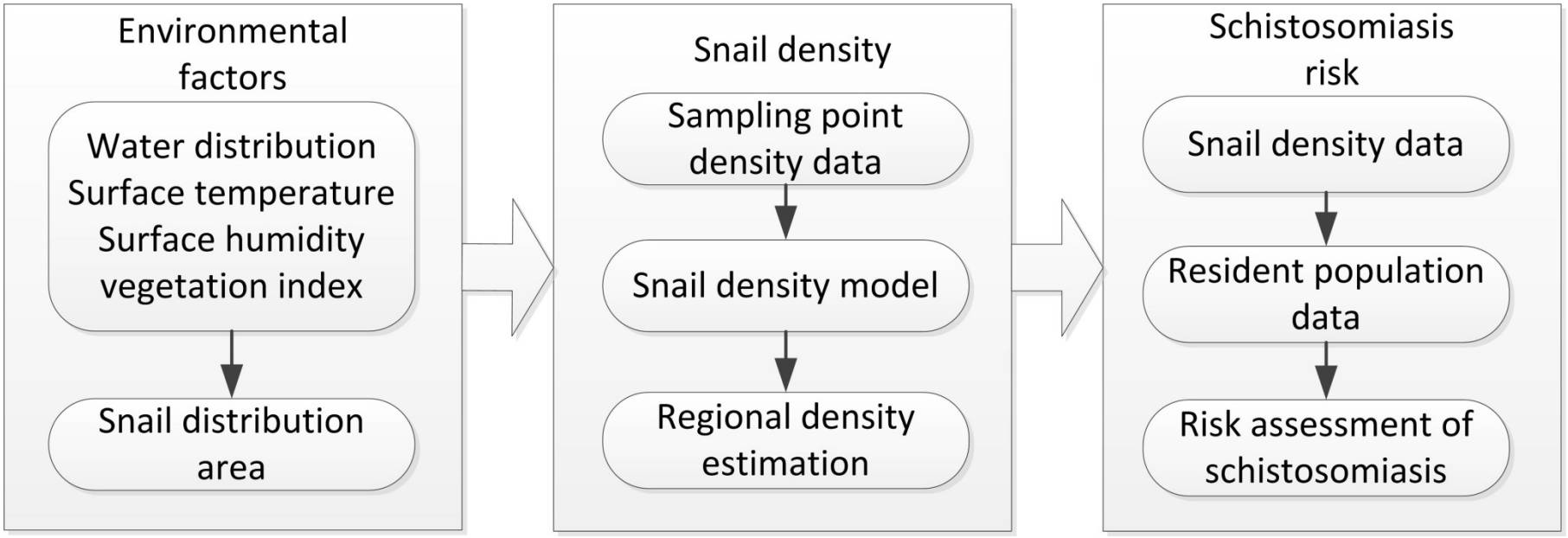
A case study : Rapid monitoring and evaluation method of schistosomiasis based on SIT





Study area

Monitoring and prevention of schistosomiasis



Technical flow chart

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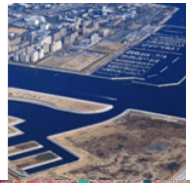
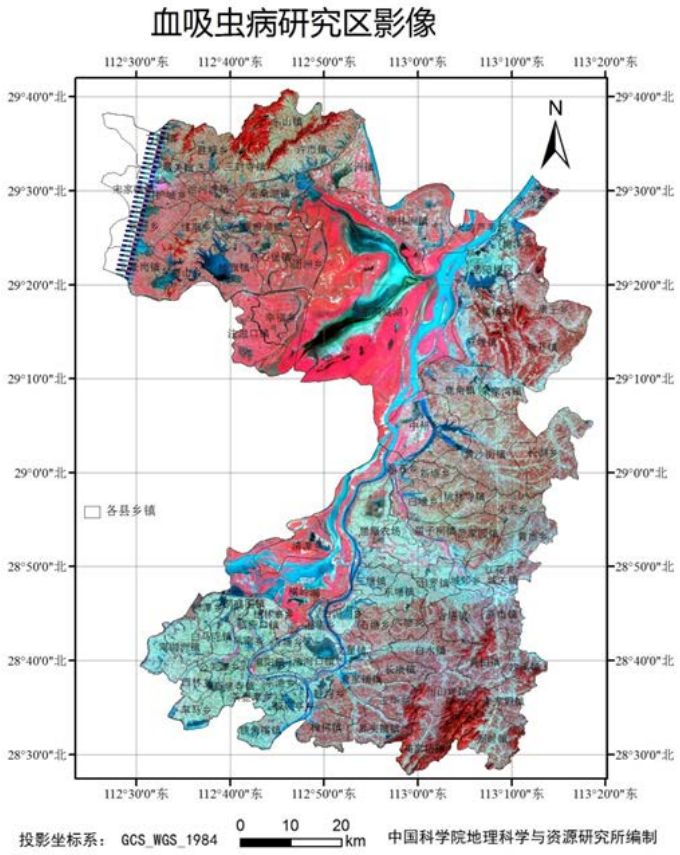
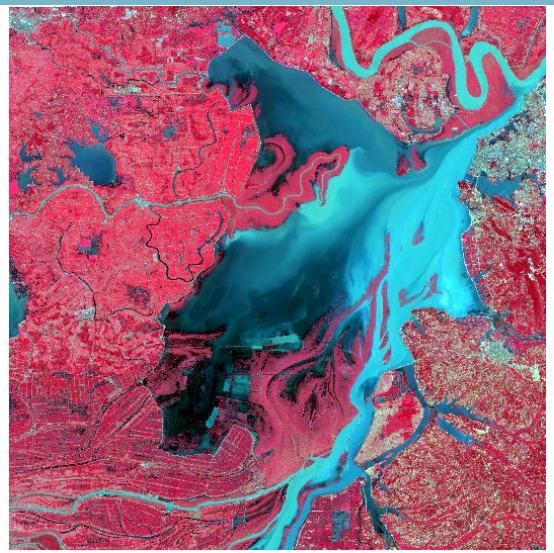
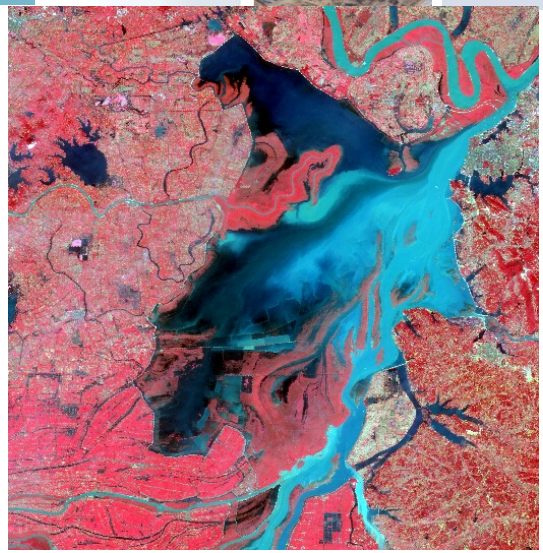




TM image



GF-1 RS image in May 2013



GF-1 RS image in May 2014

GF-1 RS image in May 2015

GF-2 RS image in August 2016

Monitoring and prevention of schistosomiasis

Field sampling

Using 1M * 1M quadrat

Snail information sampling points

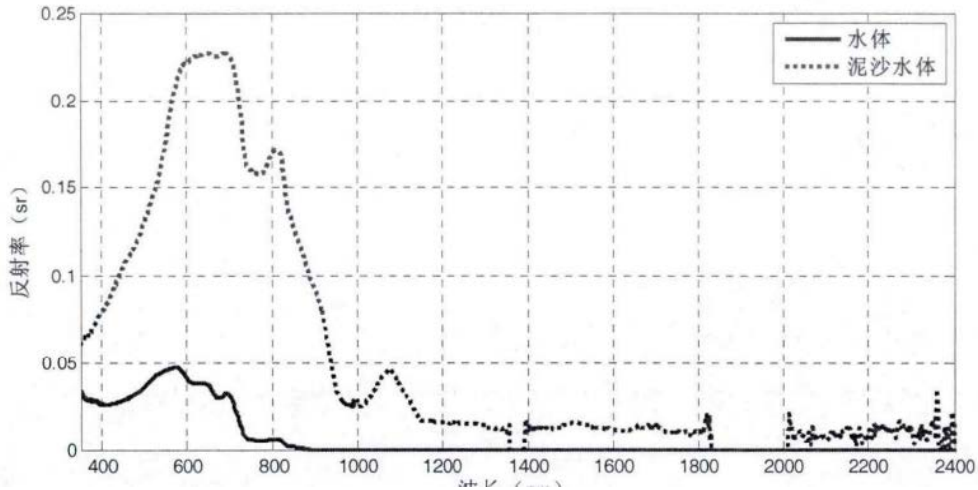
Monitoring and prevention of schistosomiasis

Remote sensing inversion of environmental factors——water body

In visible band, the reflectance of water is above 2.5%, in the near-infrared band, the reflectance is almost 0.

Method for extracting water information based on spectral characteristics:

- Band threshold method
  (Bnir>a)
- Spectrum-photometric method
  (TM2+TM3>TM4+TM5)
- Water body Identification method
  (NDWI=(G-NIR)/(G+NIR))



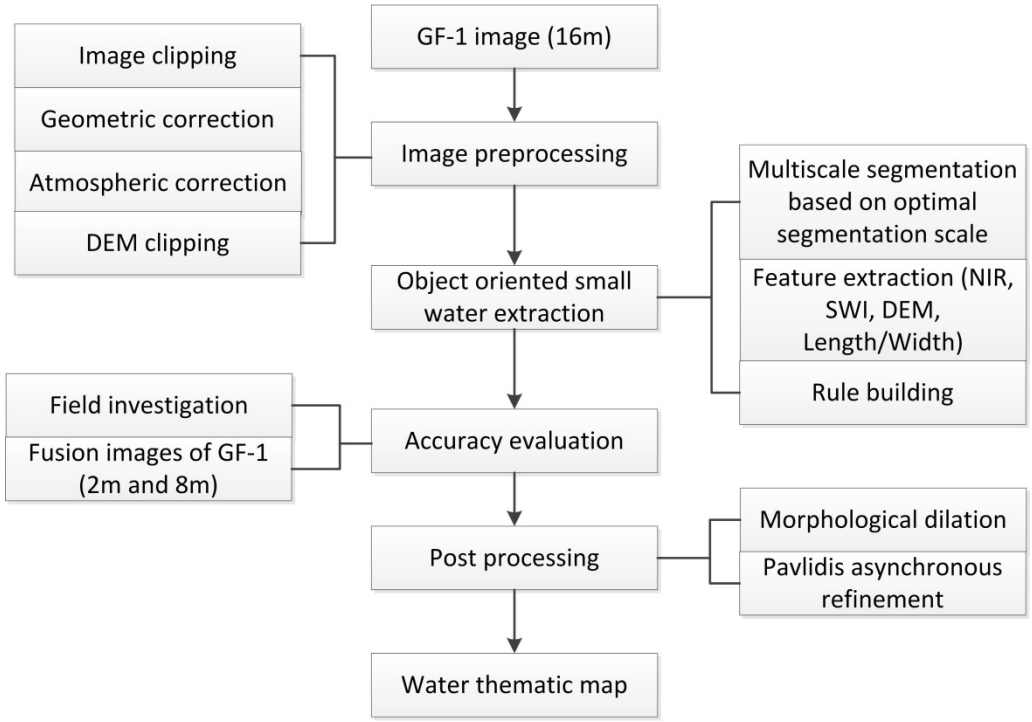
Reflectance curves of purified water and water with sediment

Only based on the spectral characteristics, for the extraction of small rivers, there will be edge loss, river disconnection and some other problems.

Monitoring and prevention of schistosomiasis

Remote sensing inversion of environmental factors——water body

Based on the high spatial resolution image, the object-oriented method was used to extract the small water bodies such as ditches, river networks and ponds.



- Multi-scale segmentation
  Based on the principle of minimum heterogeneity
- Spectral characteristics analysis
  eg: Using NIR band threshold to distinguish between dark objects and bright features; Establishing thresholds of DEM or Length / Width to remove mountain shadows.
- Post-processing
  For broken lines, etc.

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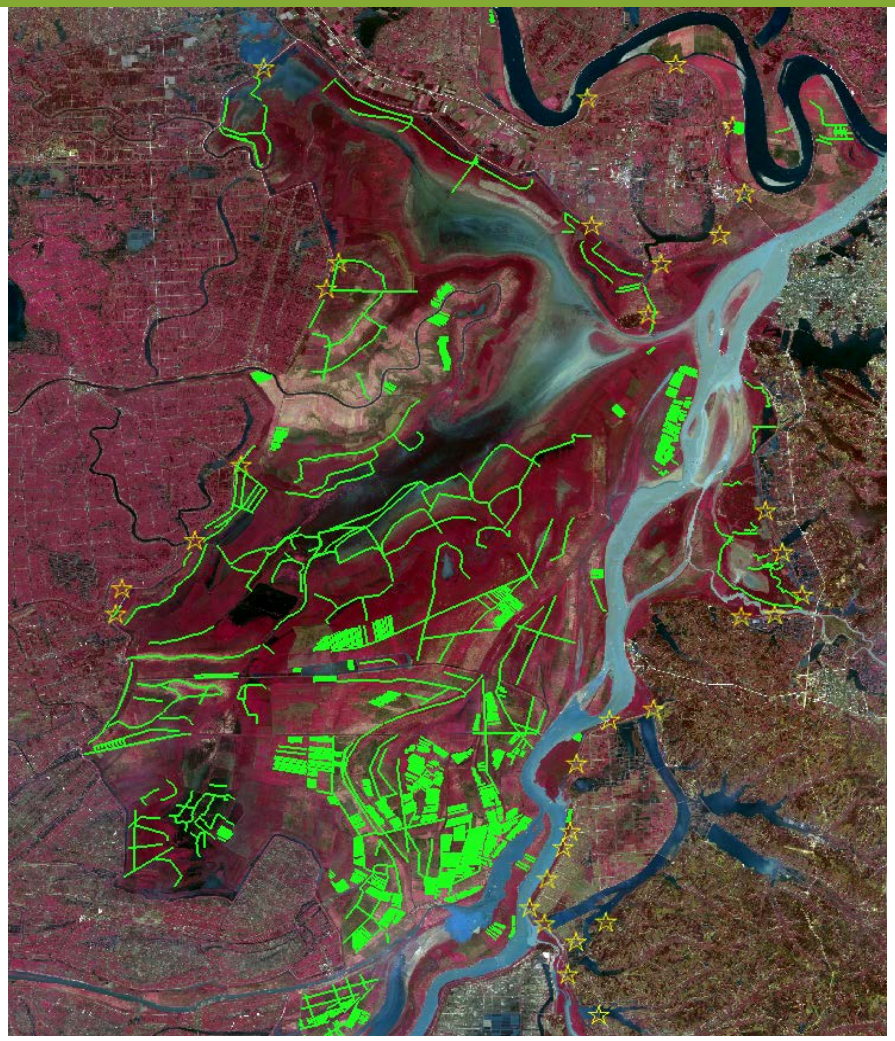
Remote sensing inversion of environmental factors——water body



Ditch information extracted from GF-1 image

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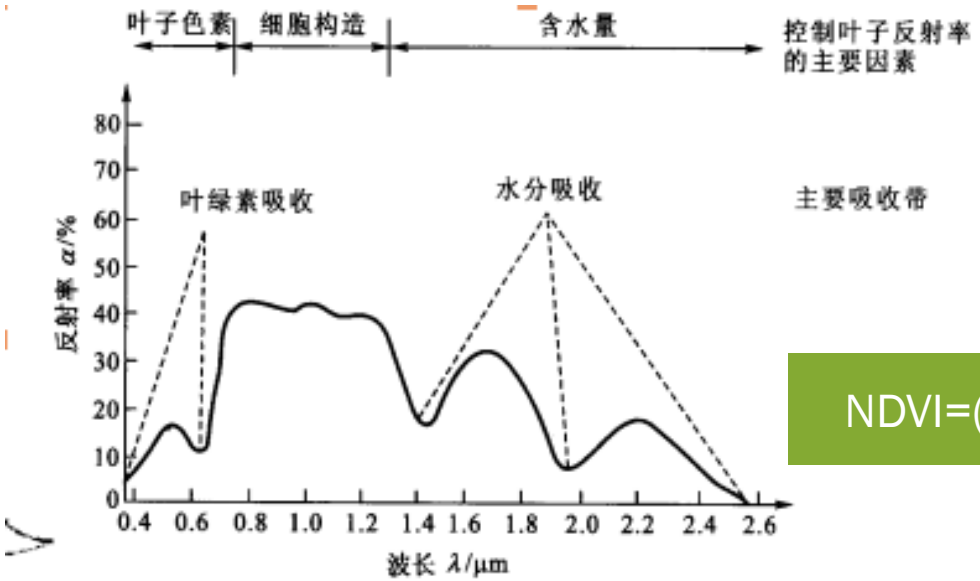
Remote sensing inversion of environmental factors——vegetation

- In the blue band (470nm) and red band (670nm), the spectral reflectance of vegetation is low;
- Near the green band (500nm), there is a small reflection peak;
- In the near-infrared band, the spectral reflectance is the highest.



Green vegetation spectral curve

$$NDVI=(B_{nir}-B_{red})/(B_{nir}+B_{red})$$

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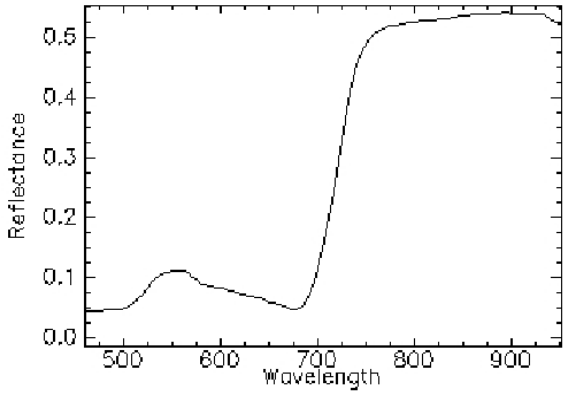
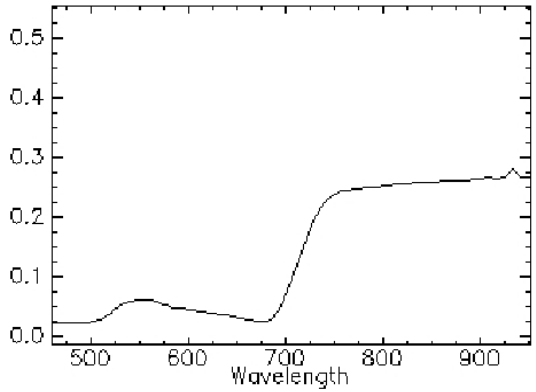
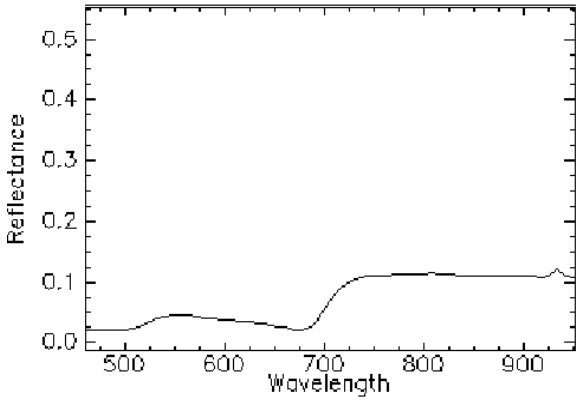
Remote sensing inversion of environmental factors——vegetation



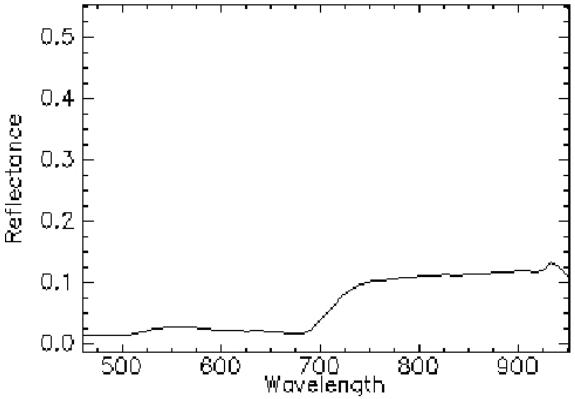
杂草类草甸 Weed meadow



水田 Paddy field



芦苇 reed



沉水植被 Submerged vegetation

Two distinct reflection peaks and two obvious absorption valleys

Measured spectral curves of different types of vegetation in snail breeding environment

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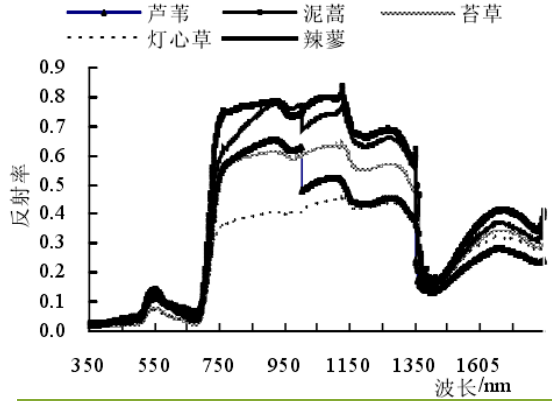
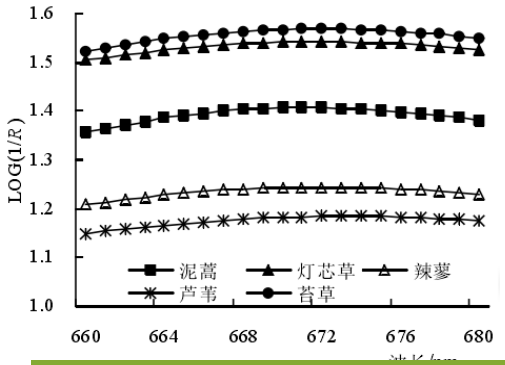
Remote sensing inversion of environmental factors——vegetation

For 5 kinds of vegetation: Artemisia, rushes, Polygonum, reeds, Carex in Dongting Lake area.



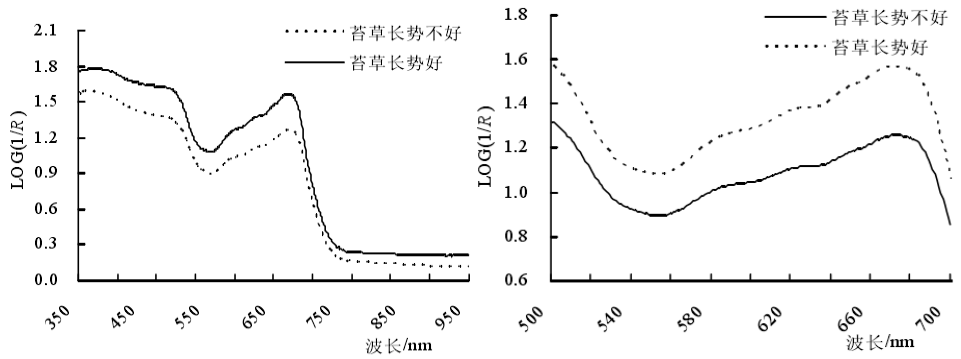
Original Spectrum of Vegetation

- There are significant differences in the band range 610-680 nm, 810-880 nm, 1030-1100 nm, 1170-1240 nm, 1635-1705 nm.
- In the band range 1030-1100 nm, the spectral difference is the largest.



The logarithm of the reciprocal of spectral reflectance

After LOG (1/ R) transformation, five vegetation types could be distinguished from band range 660-680 nm.



Comparison of vegetation spectra of different growth conditions

The growth of Carex can be clearly distinguished from 500-700 nm.

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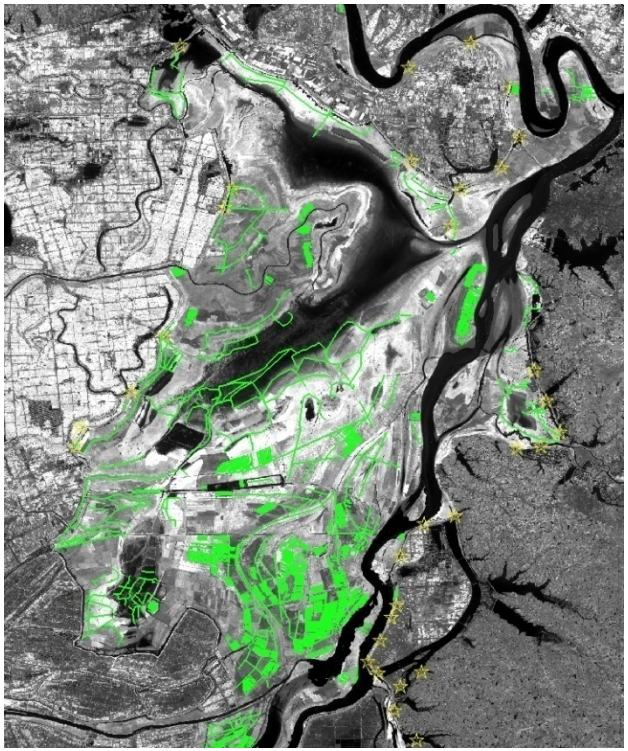
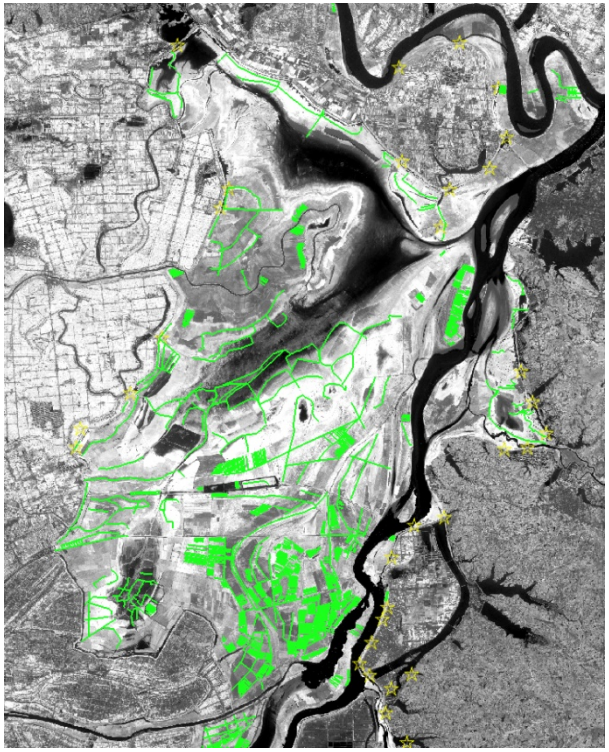
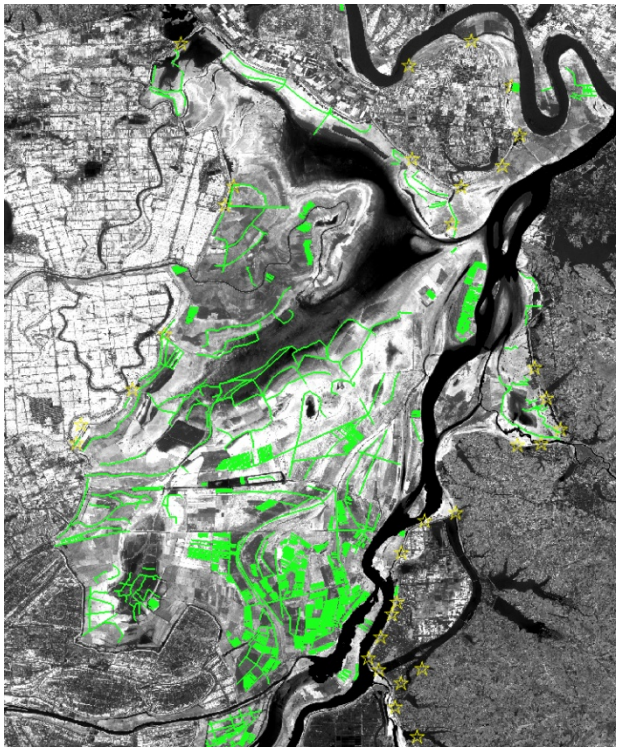
Remote sensing inversion of environmental factors——vegetation



RVI



NDVI



DVI

Monitoring and prevention of schistosomiasis

Remote sensing inversion of environmental factors——Surface temperature

Thermal infrared surface temperature inversion

- The main algorithms of LST inversion based on Landsat TM/ETM+ thermal infrared band data include: radiative transfer equation method, single window algorithm and single channel algorithm.
- based on the data characteristics, single window algorithm was selected:

$$LST = \frac{1}{C}[a(1-C-D) + (b(1-C-D) + C + D)T_{sensor} - DT_a]$$

Where a and b are constants, C and D are intermediate variables, the formula is: $C=\varepsilon\tau$, $D=(1-\tau)[1 + (1-\varepsilon)\tau]$, Tsensor is the thermal infrared band, ε is the surface emissivity in the Tsensor range, τ is the atmospheric transmittance in the Tsensor range, Ta is the average atmospheric temperature.

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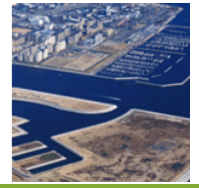

Remote sensing inversion of environmental factors——Surface temperature

Multichannel inversion method based on mid infrared band and thermal infrared band.

Split window algorithm

$$T_s = C + (A_1 + A_2\frac{1-\varepsilon}{\varepsilon} + A_3\frac{\Delta\varepsilon}{\varepsilon^2})\frac{T_4+T_5}{2} + (B_1 + B_2\frac{1-\varepsilon}{\varepsilon} + B_3\frac{\Delta\varepsilon}{\varepsilon^2})\frac{T_4-T_5}{2}$$

Where T_4 and T_5 are atmospheric top brightness temperature corresponding to AVHRR/3 sensors Ch_4, Ch_5, ε is the mean of two adjacent channel emissivity (ε=（$\varepsilon_4+\varepsilon_5$）/2), Δε is the difference between the emissivity of two adjacent channels ($\Delta\varepsilon=\varepsilon_4-\varepsilon_5$) , C, A_1, A_2, A_3, B_1, B_2, B_3 are the coefficients of the windowing algorithm.

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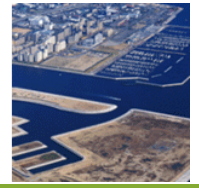


Remote sensing inversion of environmental factors——Surface temperature

Microwave remote sensing surface temperature inversion

- The radiation of the shallow surface temperature is mainly reflected in the high frequency channel, and the vertical polarization brightness temperature of 37 GHz is better related to the surface temperature.
- Many statistical regression models have been developed based on this feature and other channels (T22V, T19H, T85V)

Monitoring and prevention of schistosomiasis

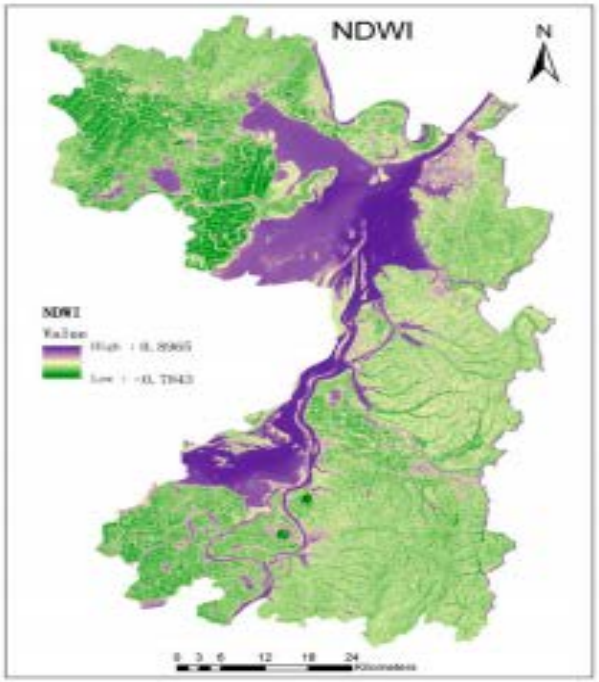
Remote sensing inversion of environmental factors——Soil moisture

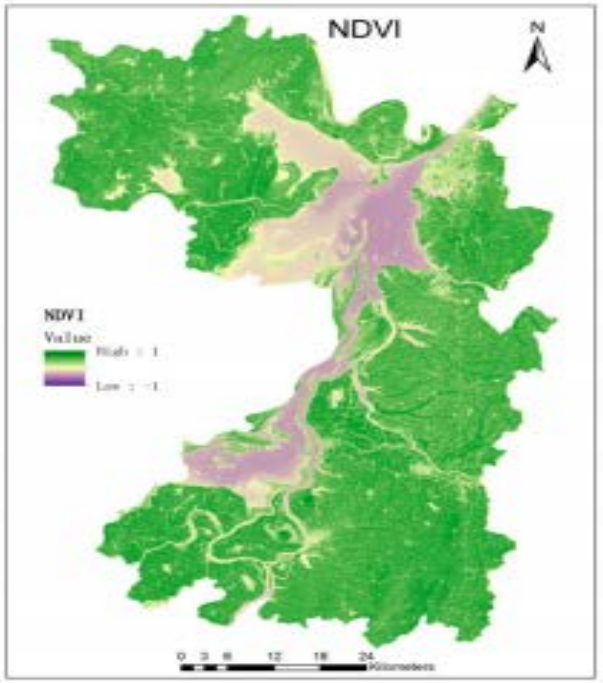
In optical remote sensing, the spectral reflectance of soil moisture is mainly in the thermal infrared band. Soil surface reflectance, soil surface emissivity or surface temperature are used to estimate soil moisture.

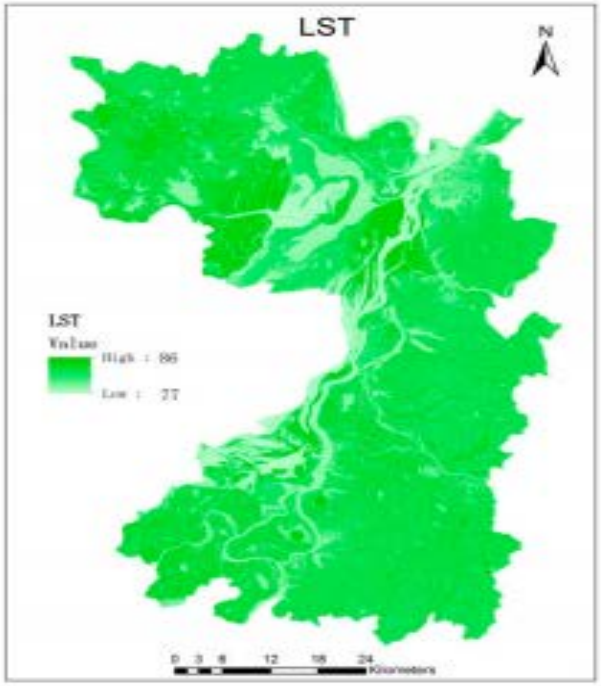
The inversion formula of this study is as follows ：

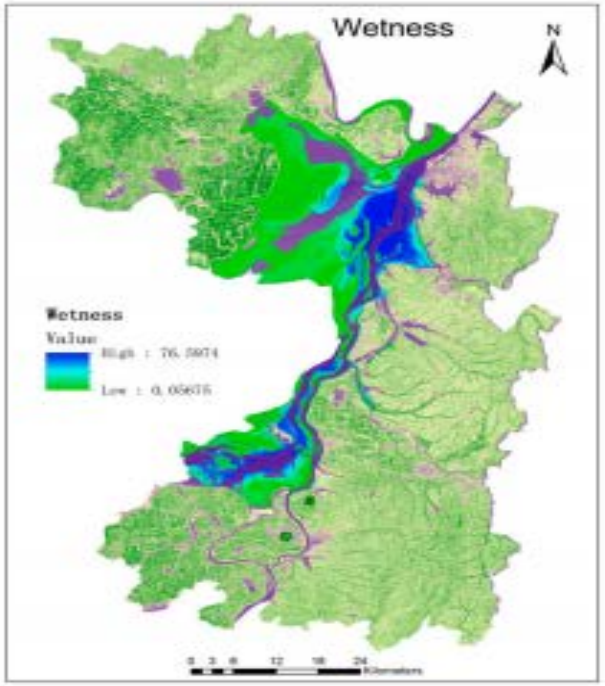
Wetness = 0.2325CH1 + 0.207CH2 + 0.087CH3 + 0.079CH4 - 0.638CH5 - 0.497CH7 ,

Where CH1-CH7 represent 1-7 bands of TM image, respectively


NDWI
N
NDWI
Value
0 3 6 12 18 24


NDVI
N
NDVI
Value
0 3 6 12 18 24

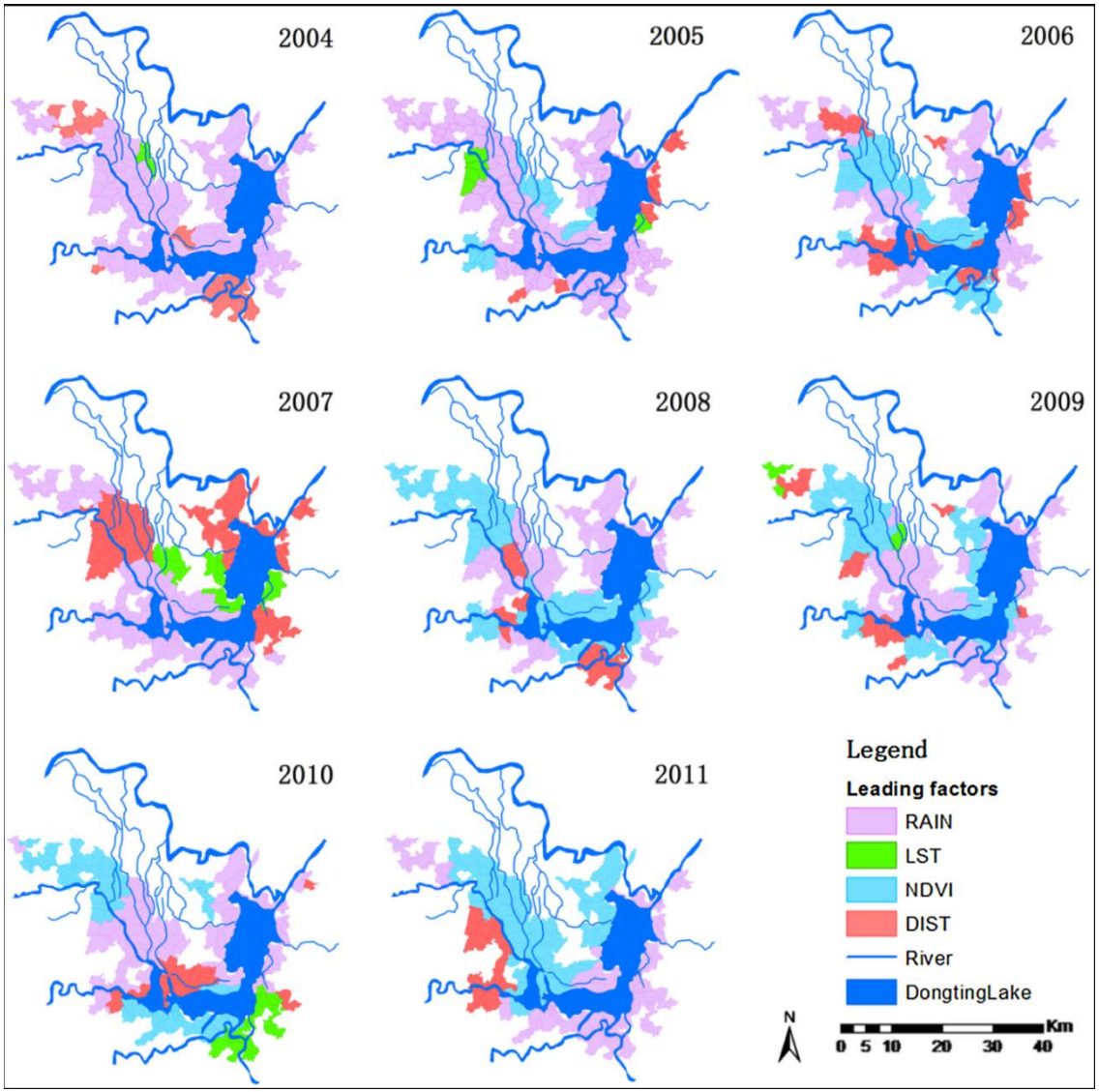

LST
N
LST
Value
High : 86
Low : 27
0 3 6 12 18 24


Wetness
N
Wetness
Value
0 3 6 12 18 24

Monitoring and prevention of schistosomiasis

Leading factors in the spatio-temporal distribution of Oncomelania (钉螺)

- Vegetation, light, temperature, moisture and soil will affect the snails, then affect the geographical distribution of Schistosomiasis.
- The environment conditions could be monitored and analyzed by SIT.



Monitoring and prevention of schistosomiasis

Snail density estimation model

- extracting the environmental factors related to the survival of Oncomelania: water distribution, surface temperature, surface humidity, vegetation index, land use types.
- construct the regression model of snail distribution using these environmental factors.

$$D=g^{-1}(\eta)=g^{-1}(NDVI\ x^{\beta_1}+LSTx^{\beta_2}+Wetnessx\ ^{\beta_3}+Distance\ x^{\beta_4}+Z\gamma)+\varepsilon$$

Where D is the density of snails, $g^{-1}()$ is the inverse function of the monotone differentiable continuous function g (), β is the estimated parameter of the observed variable, NDVI is the vegetation index, LST is the surface temperature, Wetness is the surface humidity, Distance represents the distance to the water body, Z represents the random variable, γ is the estimated parameter of the corresponding random variable, ε is the random error.

Monitoring and prevention of schistosomiasis

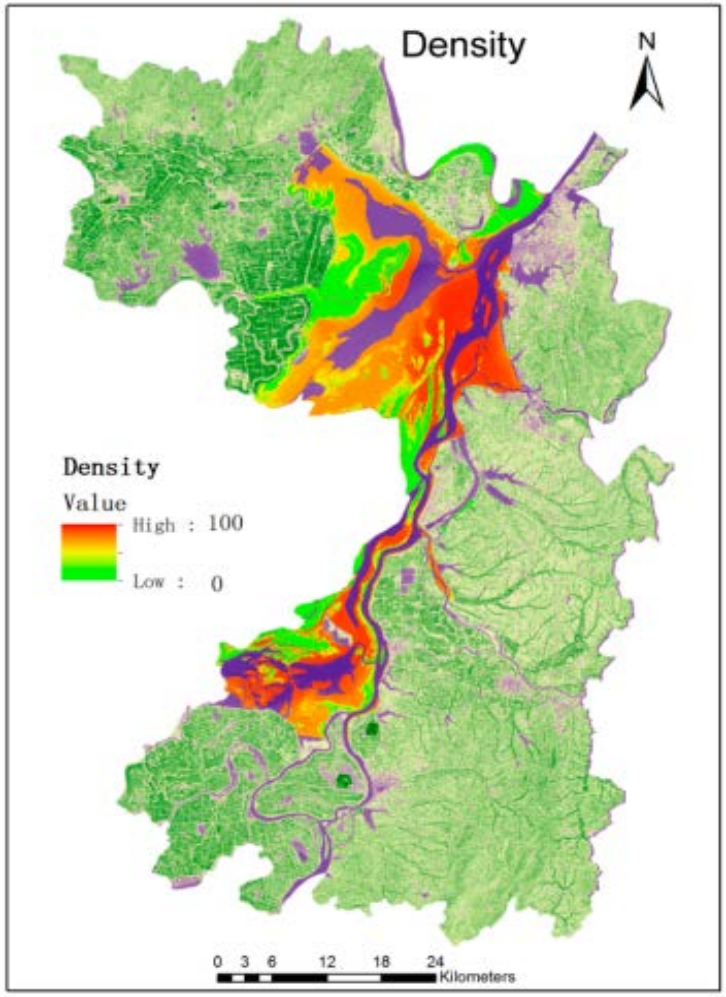
Snail density estimation model

$$Y1=-0.006407d-0.1846t+1.925m+0.1168b-0.995v+15.689$$

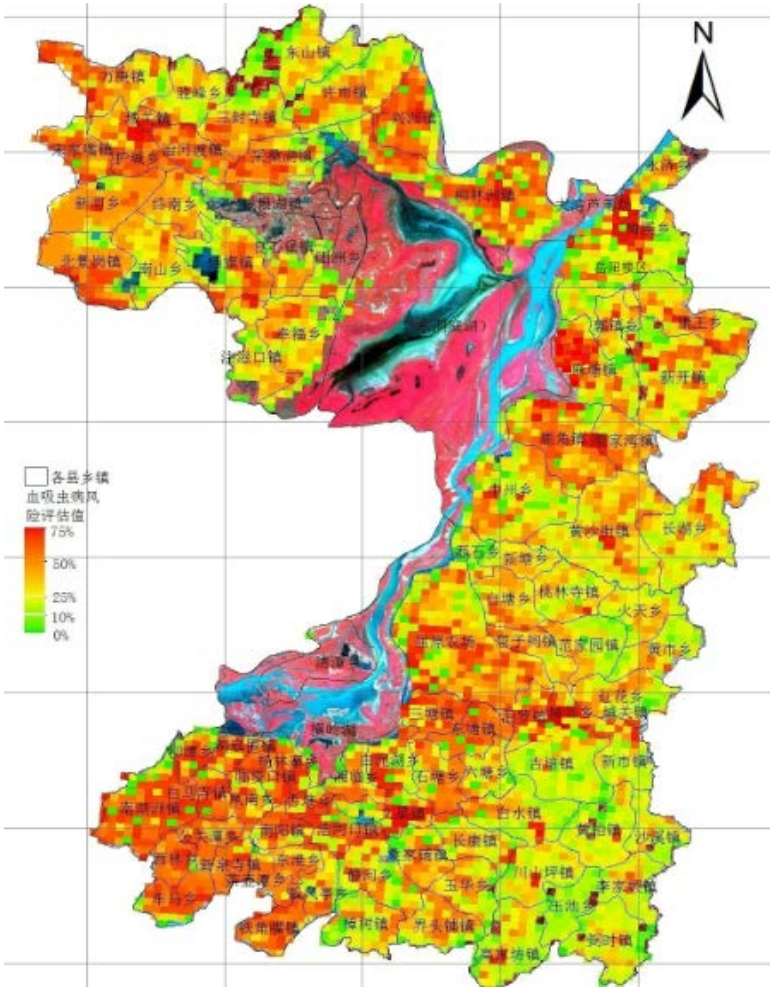
$$Y2=0.0644d+0.1957t+0.08948m+0.407b-0.4411v-4.476$$

where Y1 and Y2 are the snail density in spring and autumn in Dongting Lake area, respectively, d is the distance between the observation point and the water body, t is the surface temperature (LST), m is the surface humidity (Wetness), b represents the brightness component of the hat conversion (Brightness), v is the vegetation index (NDVI).

Monitoring and prevention of schistosomiasis



snail density Distribution



Schistosomiasis risk distribution

Thank you!

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