ESA - MOST Dragon 2 Programme

2011 DRAGON 2 SYMPOSIUM

中国科技部-欧洲空间局合作 "龙计划"二期

"龙计划"二期2011年学术研讨会

Environmental Analysis on Transmission Risk of Schistosomiasis in Dongting Lake Area

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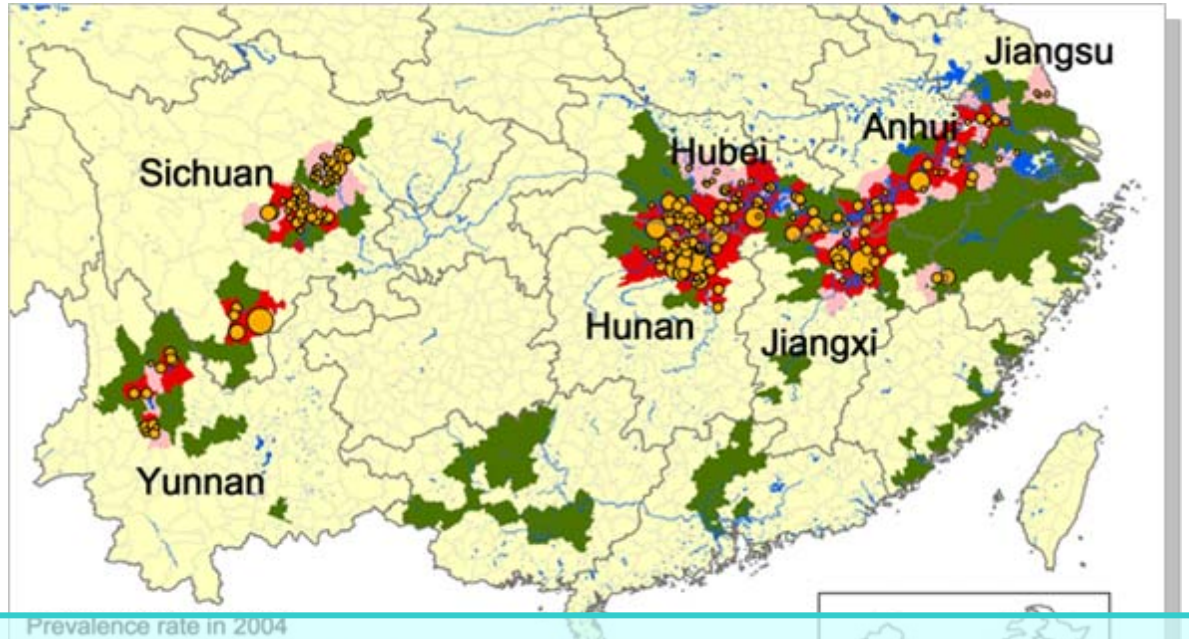
2011.06

OUTLINE

- Background
- Object
- Project description
- Future works
- Acknowledgement

Background

Schistosoma japonicum -- Status in China



- Mid 1950s: 434 counties endemic in 12 provinces
- End of 2003: Transmission interrupted: 262 counties (60.4%)
  Transmission controlled: 63 counties (14.5%)
  Transmission ongoing: 109 counties (25.1%)
- Now: Situation is still worrying…

Epidemiology of Schistosomiasis in the People's Republic of China, 2004 *(Zhou et al.,2004)*

Schistosoma japonicum -- Life cycle

The prevalence and distribution of schistosomiasis are closely related to its intermediate host snail.

Monitoring and controlling the number of snails is an important way to reduce the transmission risk of schistosomiasis.

Cercariae

Adult worms

Definitive hosts

Sporocyst

Intermediate host
Snail

Miracidium

Egg

Background

Schistosoma japonicum -- Monitoring methods

Monitoring characteristics of snails' spatial/temporal distribution is of vital importance to the schistosomiasis prevention and control.

Remote sensing technology provides promising ways for snail monitoring and control.

The traditional snail survey methods based on field detection are difficult to meet the demand of monitoring in large scale.

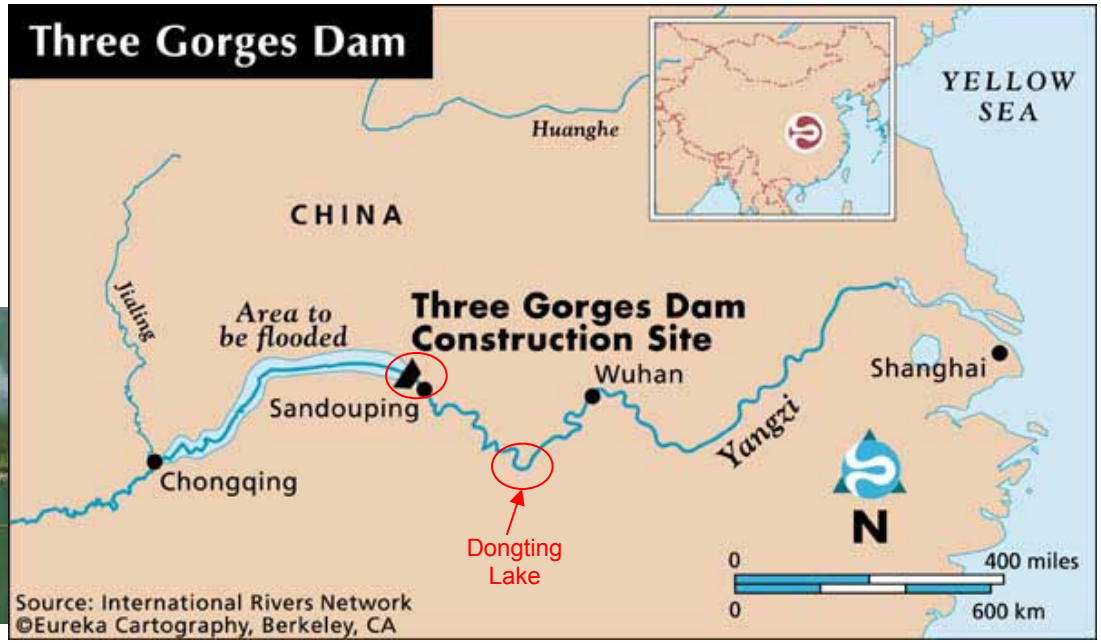
Three Gorges Dam (TGD) project -- General situation

- TGD was established in 2006. As the world's largest hydroelectric dam, it is located in the Three Gorges region in the upper reaches of the Yangtze River (the world's third-longest river, 6211 km long)

Impoundment Level

2003——135.00m
2006——156.00m
2009——185.00m

(D.P. McManus, 2010)



Three Gorges Dam (TGD) project -- Concern

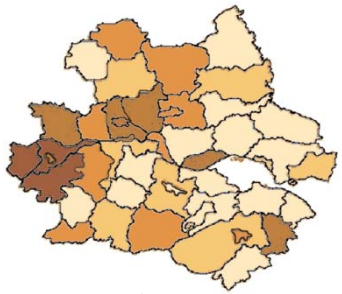
How will it affect the ecological environment of surrounding and downstream areas, including lake water level, temperature, soil moisture, etc.?

These environmental elements may impact on the survival environment of snail, then indirectly influencing the spread of Schistosomaiasis japonicum.

There have been several efforts devoted to analyze the influence of TGD on schistosomiasis transmission occurred in the Yangtze river basin *(D.P. McManus et al, 2010; Zhu et al, 2010).* **However, these studies are usually based on field snail surveys.**

Few references can be found to employ RS and GIS techniques to identify habitats of snail, and accordingly derive the impacts of TGD on the spread of schistosomiasis.

Working flow



Data collection

Survey data

Remote sensing data

Landsat-TM

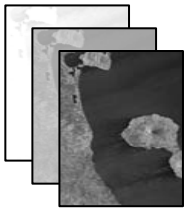
Envisat

Vis, FVC

LST

MIs

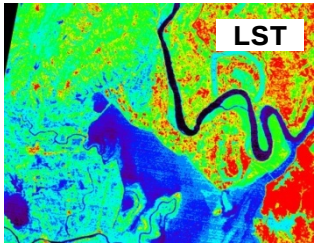
… …



$$P_{it} = f(VIs, LST, FVC, MIs, ...)$$

Model establishment

GIS analysis & mapping



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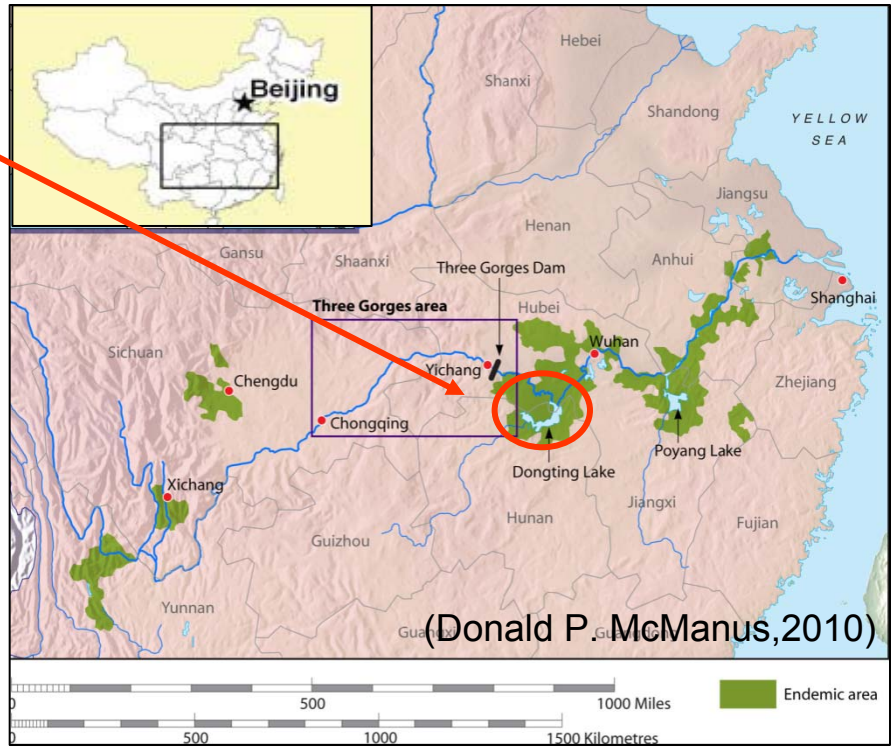
Object

- To quantitatively extract environmental factors related to *Oncomelania* snail distribution based on the combination of optical and microwave remote sensing data.
- To establish regression model of schistosomiasis prevalent high-risk areas based on the retrieved environmental factors and snail surveys.
- To analyze the spatial and temporal variations of *Oncomelania* snail affected by the TGD project, based on the temporally different data.

Study area

- Dongting Lake is located within 28°30′–30°20′N and 111°40′–113°40′E, in the northeast part of Hunan Province and covers a water surface area of about 2,681 km^2
- Archaeological studies have shown that schistosomiasis japonica has been endemic in the Dongting Lake region for thousands of years
- Nearly 20% buffaloes were infected, and about 200,000 human cases were reported in 2003

(Incited by Zhou, 2005)

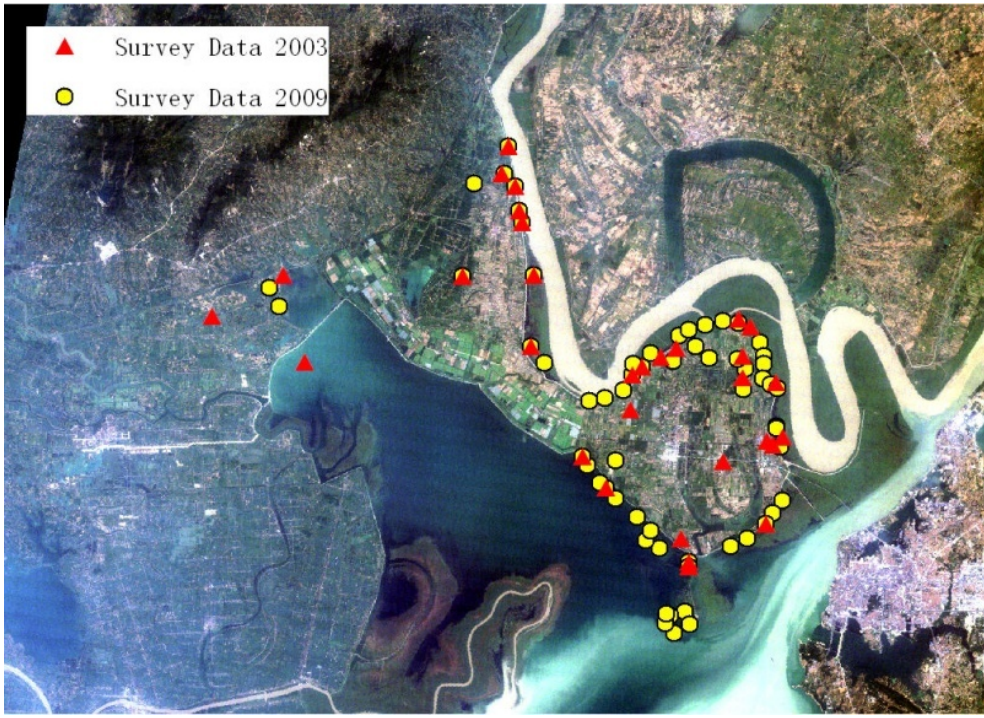


Map of schistosomiasis epidemic regions and TGD

Data -- Snail surveys

Snail survey results of spring 2003 and spring 2009 are used, representing conditions before and after the set up of TGD, respectively. Survey data are collected around the Jun mountain, nearby the Dongting Lake.

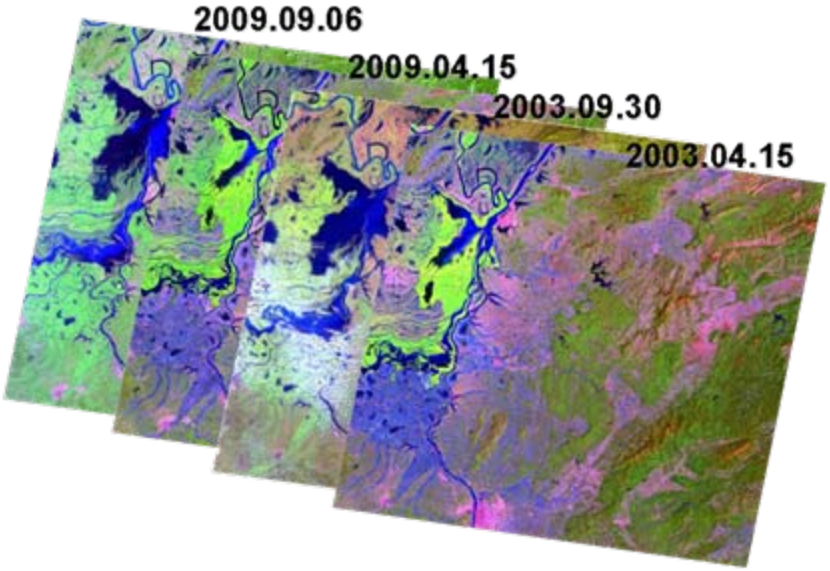
- 2003 spring: 31 sites
- 2009 spring: 62 sites
- Survey Parameters:
  1. Survey area
  2. Snail area
  3. positive snail area
  4. No. of survey frame
  5. No. of frame with living snail
  6. No. of living snail
  7. No. of frame with snail-infected
  8. No. of snail-infected



Data -- RS data

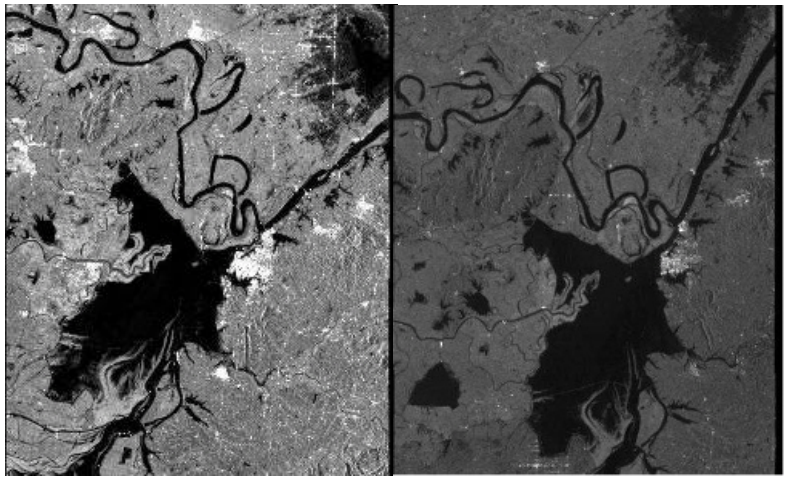
- Landsat - TM/ETM images :

-- to retrieve environmental factors including vegetation index, vegetation fraction, surface temperature, etc.



- Envisat-ASAR images :

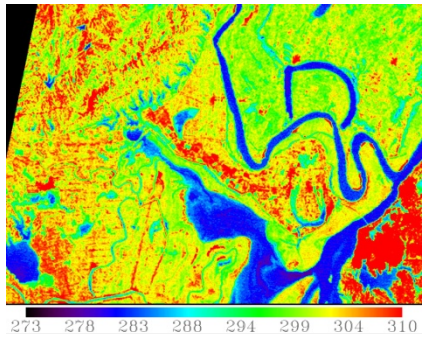
-- to extract water area and soil moisture, so as to distinguish vegetation area with water underneath from the land area. The results are complementary to optical images.

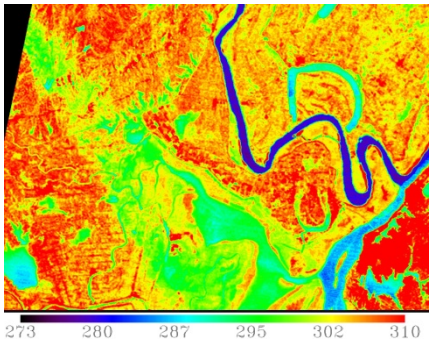


2010.07.10 HH　　2004.07.23 HH

Project Description

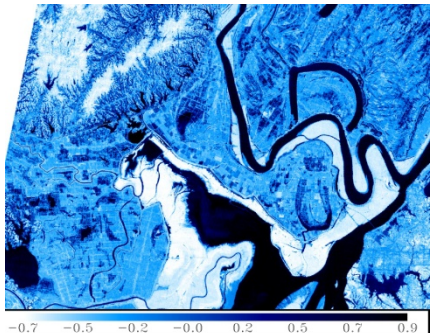
Environmental factors retrieval -- From Landsat-TM/ETM images

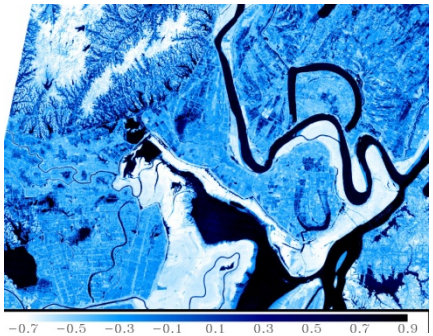




2003.04.15 2009.04.15

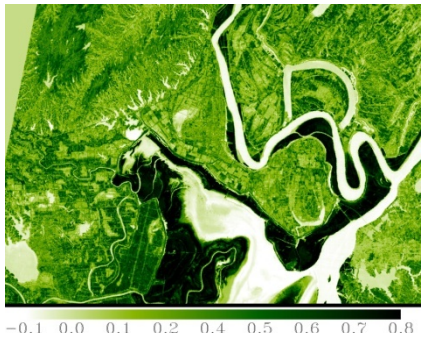
LST (Land Surface Temperature)

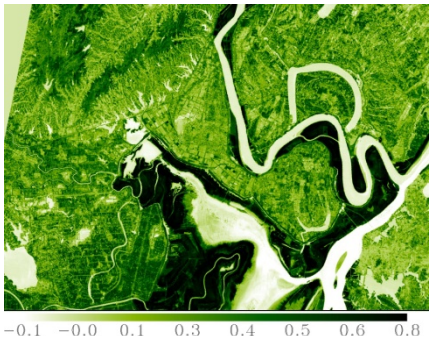




2003.04.15 2009.04.15

NDMI (Normalized difference moisture index)





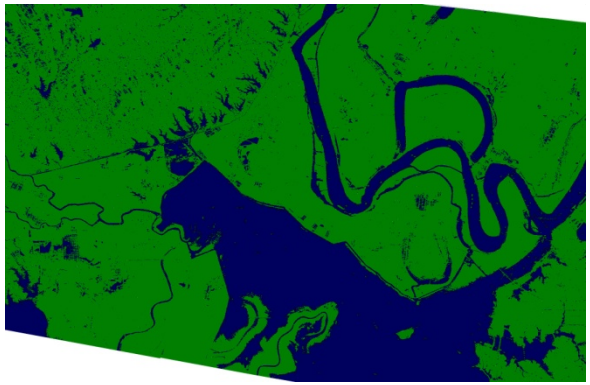
2003.04.15 2009.04.15

MSAVI (Modified Soil-Adjusted Vegetation Index)

2003.04.15 2009.04.15

FVC (Fractional *Vegetation* Cover)

Environmental factors retrieval -- From Envisat-ASAR images



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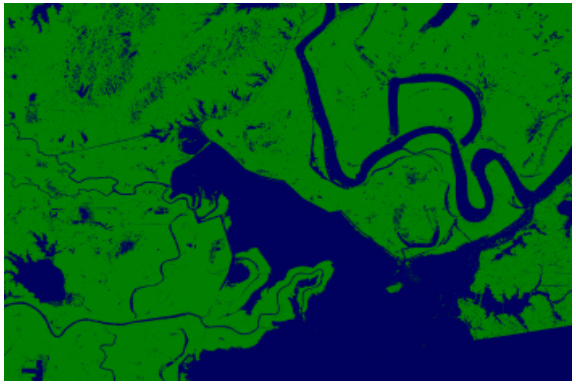
Water region



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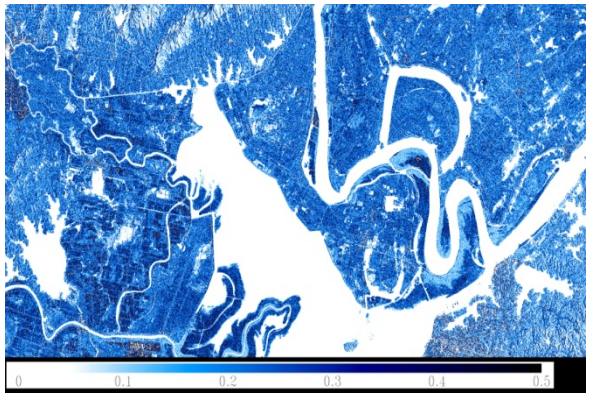

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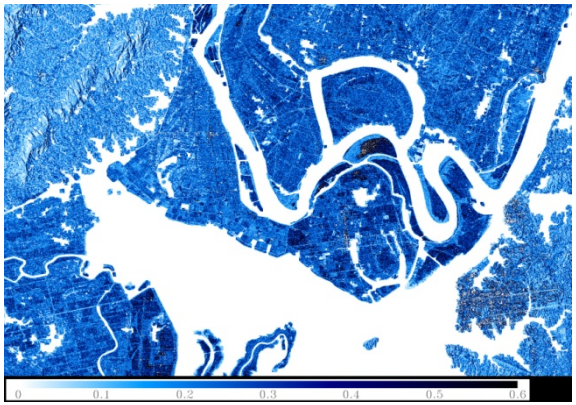
Soil moisture



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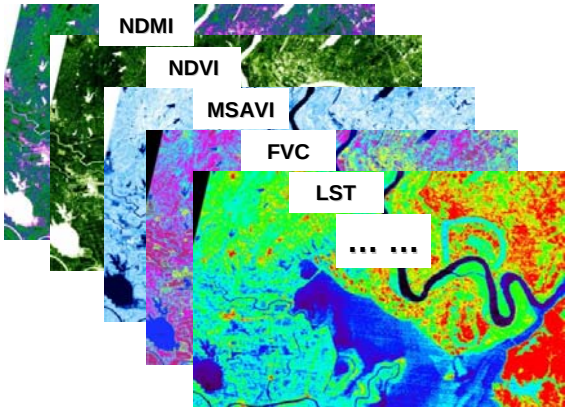
Prediction Model -- Based on GIS techniques



Retrieval environmental factors images

survey data of living snail density

Regression Model:

$$Y' = -0.02 + 1.44MSAVI - 0.713NDMI$$

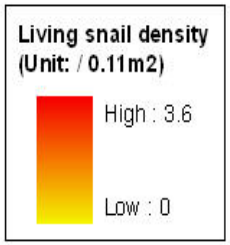
Residual model :

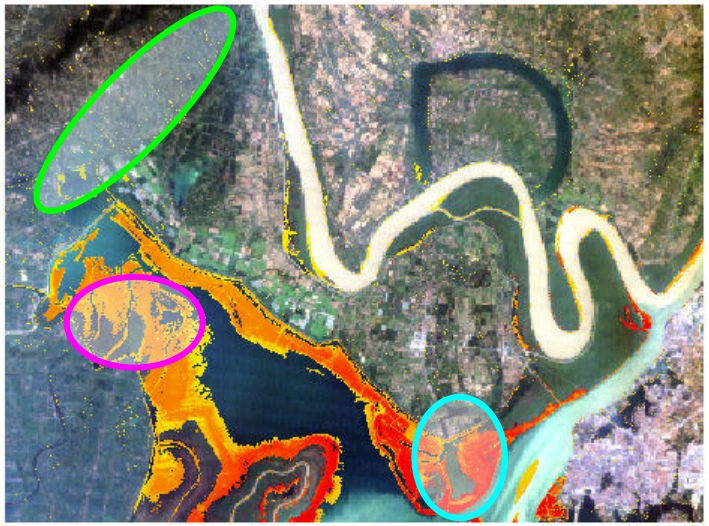
$$R(h) = 0.11231 + 0.10711[1 - \exp(-3h/22283.7)]$$

Prediction model of living snail density

$$Y = [Y' + R(h)]^2$$

Results & analysis -- Potential snail habitats before and after TGD





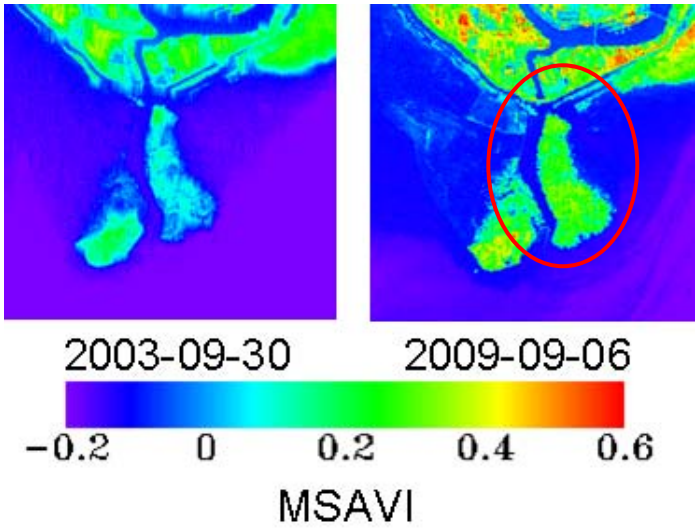
Before the TGD (2003)
Predicted potential area : 146.45 km^2

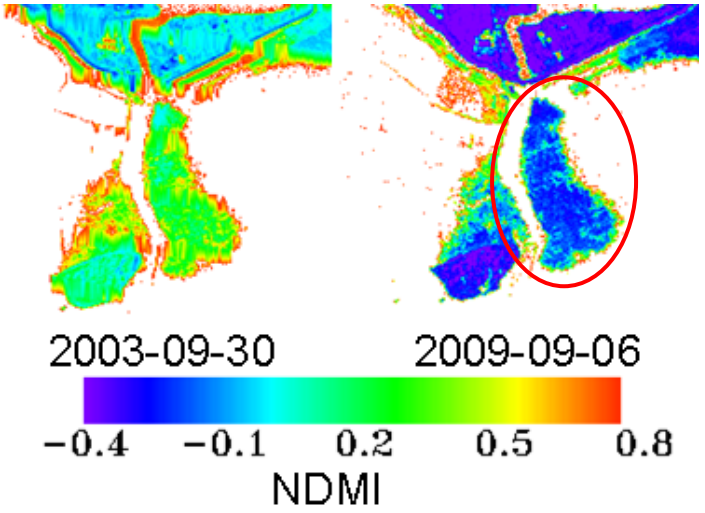
After TGD (2009)
Predicted potential area : 138.84 km^2

- **The living snail density is increasing trend from north to south, and from west to east.**
- **The potential snail habitats area in 2009 is smaller than 2003.**

Results & analysis -- Factors analysis

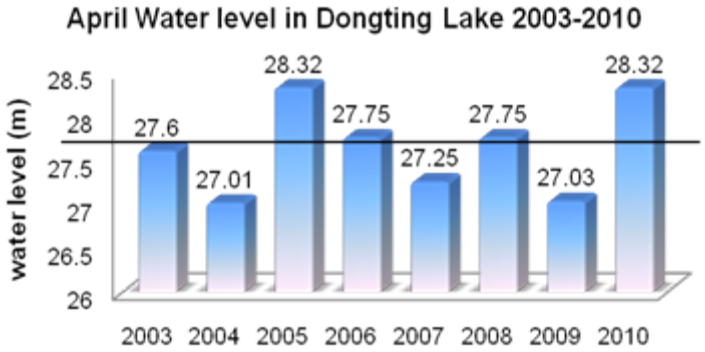
- **MSAVI and NDMI are the most sensitive factors for the snail density, which reflect the conditions of vegetation and soil moisture, respectively. MSAVI shows positive correlation to snail density, while NDMI is negatively correlated.**





Results & analysis -- Factors analysis

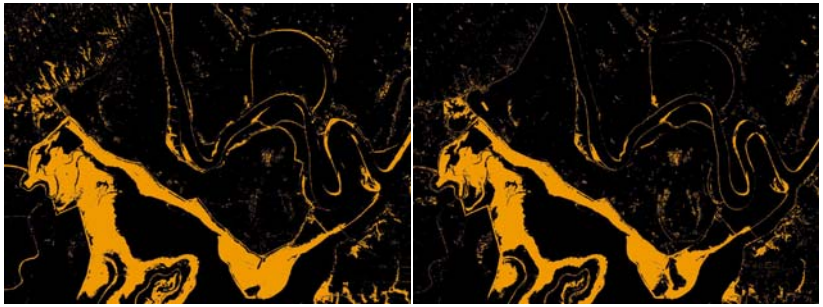
- Snail breeding activity mainly occurred in April, and their breeding environment possess the characteristic of “winter-land, summer-water”.



- Due to the TGD project, water levels in April decreased in 2005-2009, and hence the snail habitats in marshland area shrank.

(Zhu, 2010)

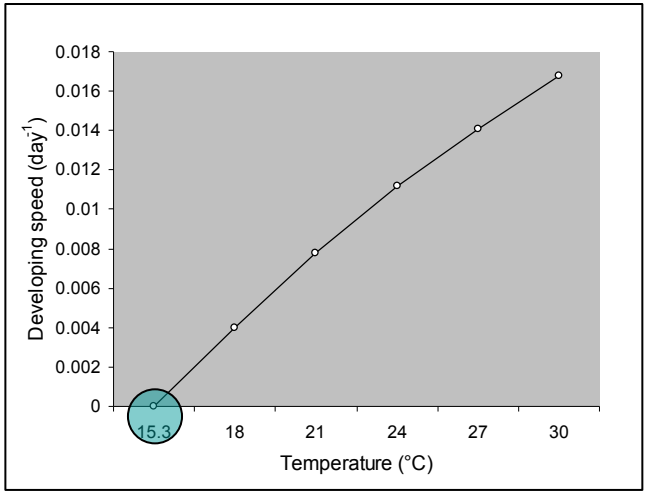
- The region of “winter-land, summer-water” in 2009 is reduced, and some areas will not fit the breeding of snail.
- The TGD project is the possible reasons of the change of the snail habitats.



2003 2009

The region with “winter-land, summer-water”

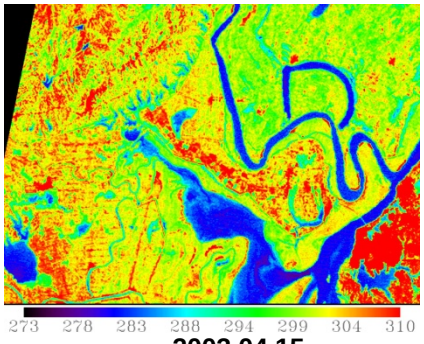
Results & analysis -- Factors analysis



- **The snail infested areas are the regions where the January mean temperature is higher than 0℃.**
- **There is a positive linear relationship between temperature and the development of S. larvae harboured in snail. In snail kept at 15.3 degree, larvae tend to halt their development, or we call it lowest developing temperature.**

(Yang etal, 2007)

- **LST shows the region in Dongting Lake area belongs to the snail infested area. However LST is not sensitive for snail density.**



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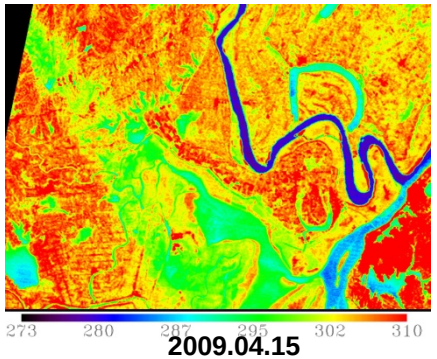
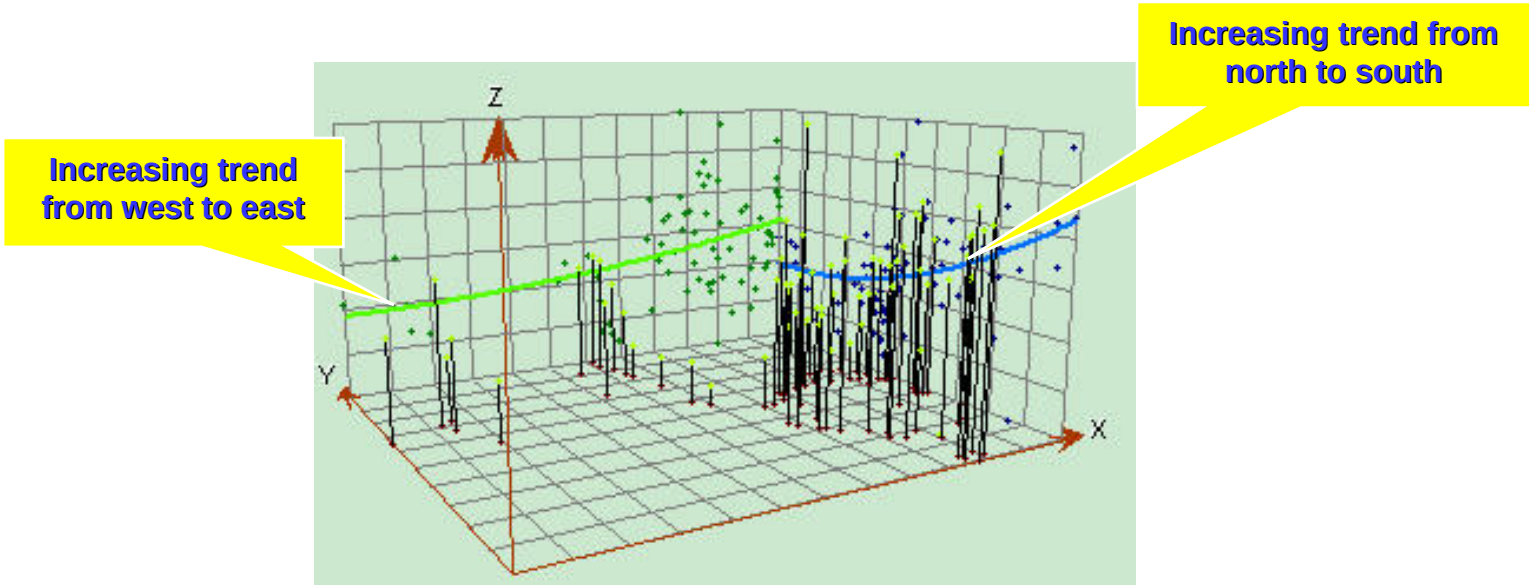


2009.04.15

Results & analysis – Model analysis



- **Trend analysis of estimation residuals of the regression model indicates that the uncertainty of the regression model exhibits the following differences: east larger than west, and south larger than north.**

Results & analysis -- Summary

- Potential range of the intermediate host snail area becomes smaller after the TGD project through the comparison of 2003 and 2009 results.
- The change of marshland to land caused by the decrease of water area might be the main reason for the reduction of snail breeding area in Dongting Lake area.
- Vegetation cover and LST are also the main factors affecting snail distribution. However LST is not related with snail density directly.
- The potential snail habitats can be predicted by extracting the environment factors from RS data. And the quantitative information of snail should be predicted by combining with survey data to reduce the uncertainty.

Future works

- Based on those achievements in monitoring schistosomiasis transmission risk under the framework of Dragon project, long time-series, multi-source remote sensing data will be employed to assess the effect of Three Gorges Project on snail breeding environment and schistosomiasis transmission risk in areas like Dongting Lake, Poyang Lake, etc.

- Work together with Chinese Center for Disease Control and Prevention to establish monitoring and warning platform for the temporal-spatial variation characteristics of snail, and further extend it to other parasitic diseases which are sensitive to environmental changes so as to optimize control strategies for policy-makers.

Acknowledgements

- Particular thanks to Prof. *Zhou Xiaonong* (National Institute of Parasitic Diseases, China CDC) for his generous provision of field survey data and helps in developing the analysis.
- Thanks to Dr. *Yang Guojing* (Jiangsu Institute of Parasitic Diseases, China JIPD), who provided essential materials.
- *ESA-MOST DRAGON project* provided Envisat-ASAR images.
- *Center for Earth Observation and Digital Earth, Chinese Academy of Sciences*, provided Landsat-TM images.

Thanks