Space observatory for climate change and response in China

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OpenGCS (Geological CO2 Storage) Monitoring Platform

- **Motivation**

  CO2 Capture and Storage (CCS) technology captures the CO2 emissions from large point sources and transports and stores them in relatively geological structures or oceans for a long time. It is one of the effective technologies to **significantly reduce global emissions to the climate system.**

- **Geological Carbon Storage (GCS) is usually stored in saline aquifers, depleted oil and gas reservoirs, and unmined coal beds.**

- Once the **CO2 leaks** to the surface through faults, fractures, or oil and gas wells and other channels, it will form a gas cloud heavier than air near the surface, which **is harmful to human health, life safety, and the ecological environment.**
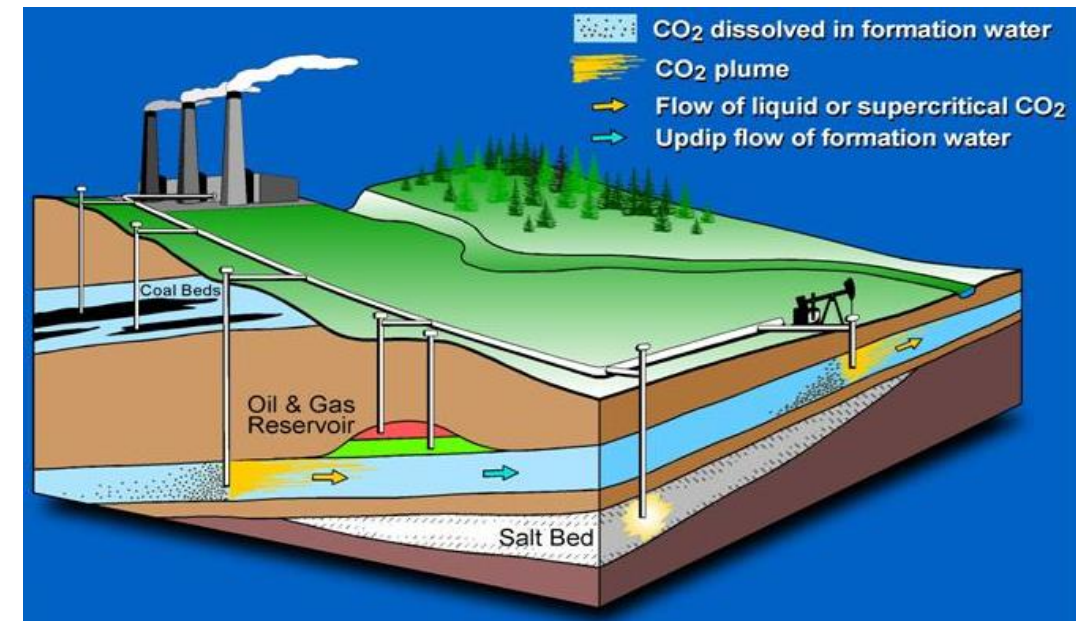
Pilot Test of CO2 Injection and GCS

- China's GCS projects started late, and there are few typical CO_2 geological storage demonstration projects in operation at this stage.

- Since 2011, the pilot test of CO2 injection in Shizhuang North Block in Southern Qinshui Basin has been carried out.

- The goal is to provide free and open access to real-time monitoring data and long-term observations of GCS.

- **Qinshui Basin is located in Qinshui County, Jincheng City, Southeast of Shanxi Province. Qinshui Basin is an important coalbed methane exploration area in China which is a compound syncline.**
- **In order to assure project performance , monitoring techniques need to be deployed to track CO_2 plume migration, assess leakage risk, and guard against environmental hazards.**
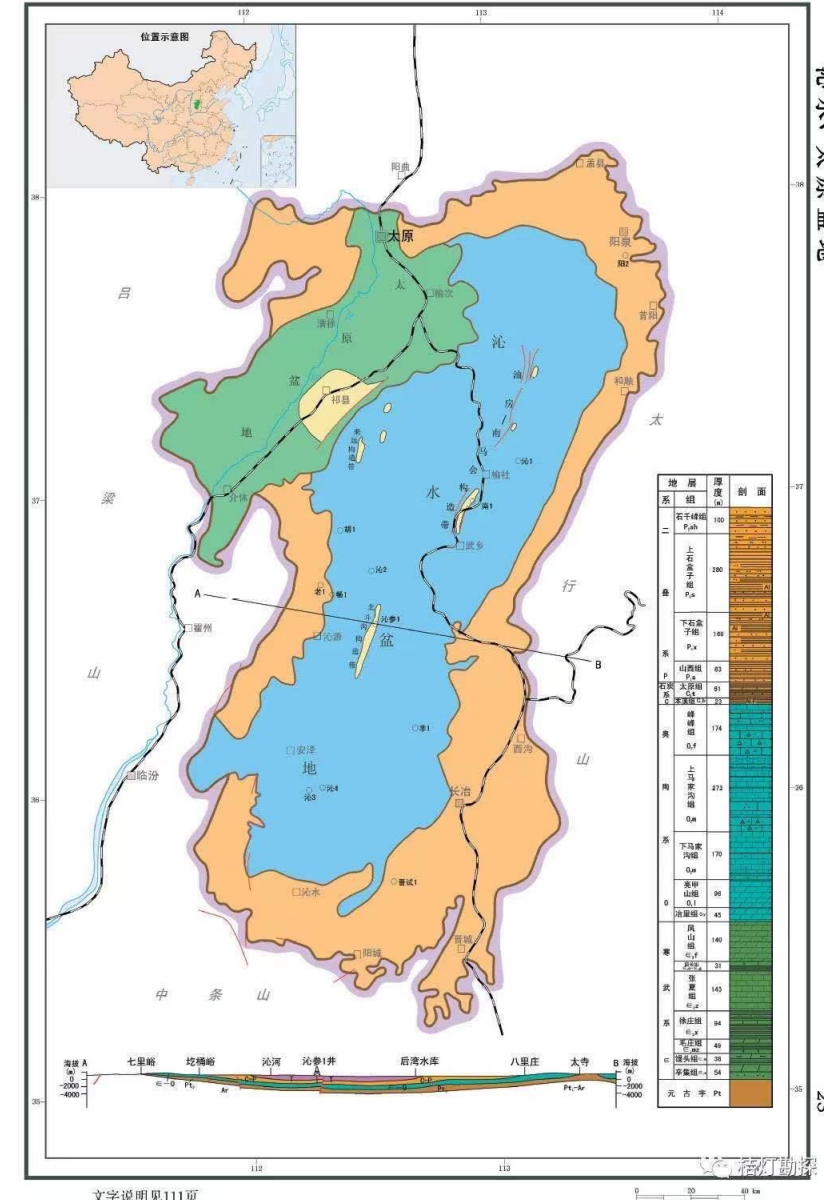
Key Technologies of Open Geological Carbon Storage

❶ Local Monitoring

Surface environmental information monitoring

Develop CO_2 monitoring instrument based on WSN

- To develop a remote real-time online surface environmental information monitoring instrument for surface CO2 concentrations based on the Internet of Things technology.
- To design and develop a visual monitoring platform for GCS leakage based on cloud computing.
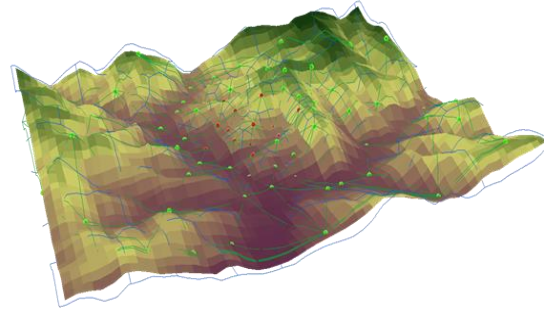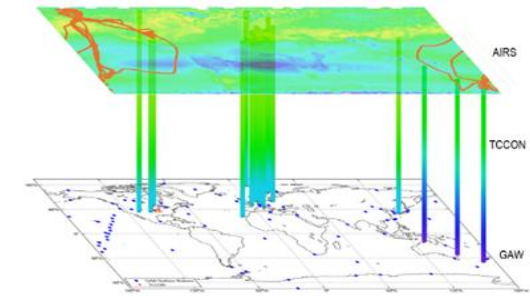

❷ Reginal Monitoring

Optimization design of near-surface monitoring network

Optimizing Sensor Network Node Location in Geological CO2 Storage Area

- To analyze geological, geographical and meteorological data in GSC area.
- To design different coverage control schemes of monitoring sensor network nodes.
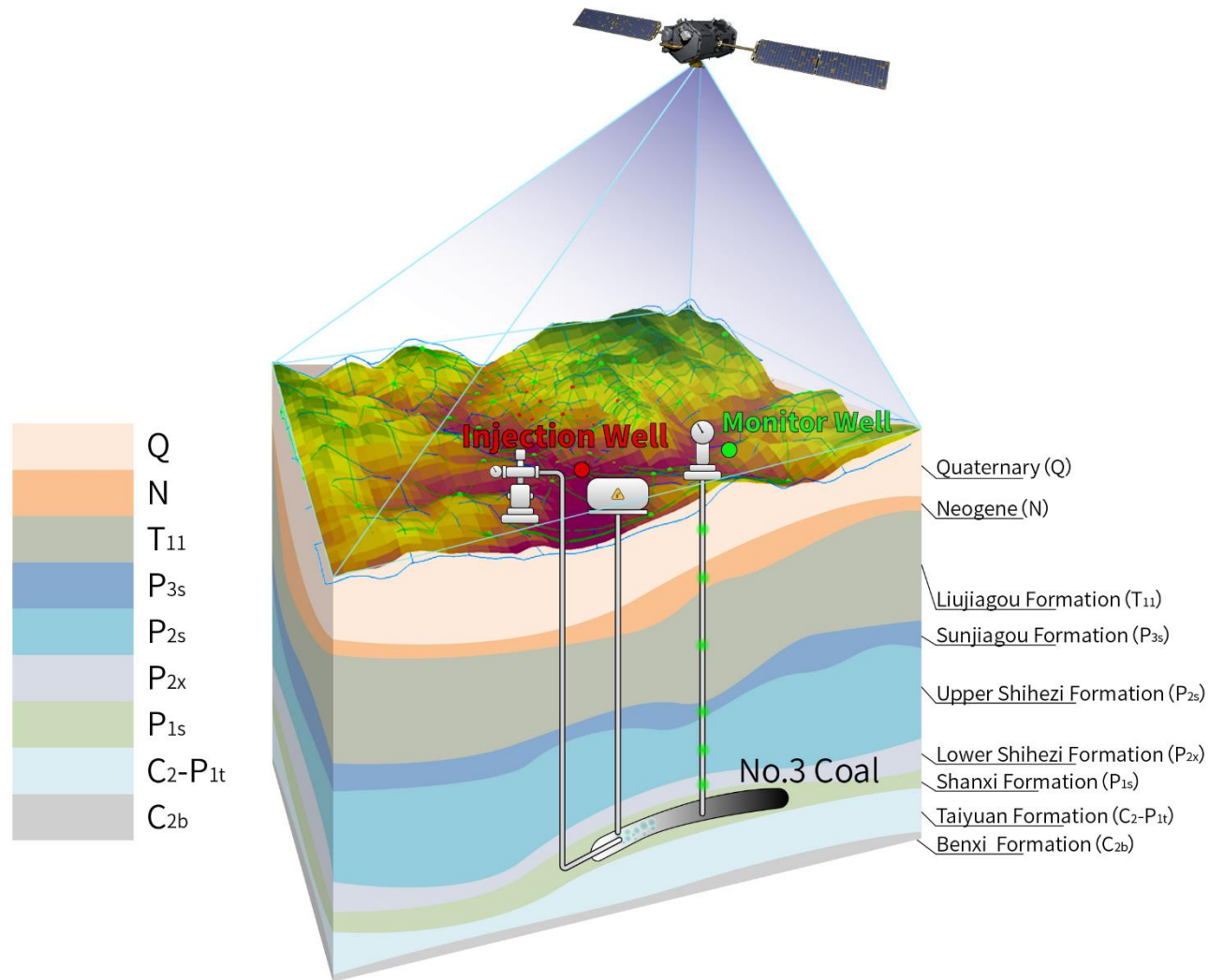- To intensively or sparsely arrange sensor nodes based on Delaunay triangulation.

❸ Global Monitoring

Temporal and spatial distribution of CO_2 concentrations

Online aggregation of real-time monitoring data and diffusion migration model

- To study the potential of the combination of high-resolution in situ surface and aircraft measurements for validating AIRS observations.
- To inter-compare with GAW, HIPPO, with reference to the TCCON from near surface level to mid-to-high troposphere.
- To analyze the spatial distribution, rising trend and seasonal variation using monthly averaged AIRS observations.

Open Geological Carbon Storage Monitoring

Q
N
T₁₁
P₃s
P₂s
P₂x
P₁s
C₂-P₁t
C₂b

Injection Well   Monitor Well

Quaternary (Q)
Neogene (N)

Liujiagou Formation (T₁₁)
Sunjiagou Formation (P₃s)

Upper Shihezi Formation (P₂s)

Lower Shihezi Formation (P₂x)
Shanxi Formation (P₁s)
Taiyuan Formation (C₂-P₁t)
Benxi Formation (C₂b)

No.3 Coal

WSN network online monitoring data

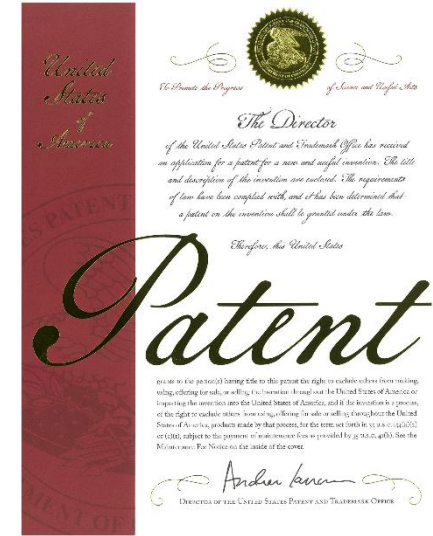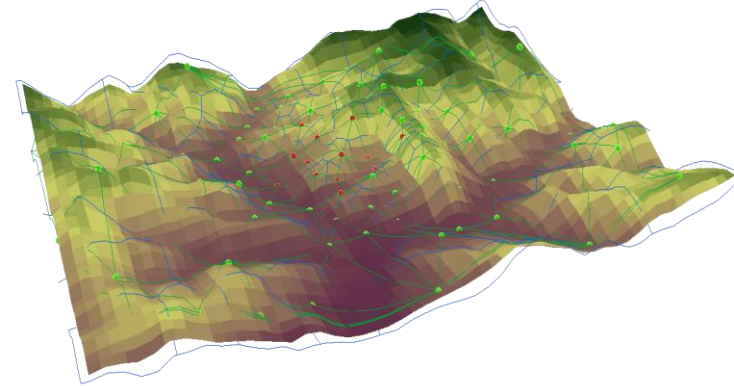The spatial distribution map of the CO2 and CH4 in the geological storage area

Time (monthly, annual) changes of CO2 and CH4 in the geological storage area

Analysis results of the impact of the observed changes on the environment

Achievements of OpenGCS

- **National patents of the Online Monitoring of Geological CO2 Storage and Leakage based on Wireless Sensor Networks**

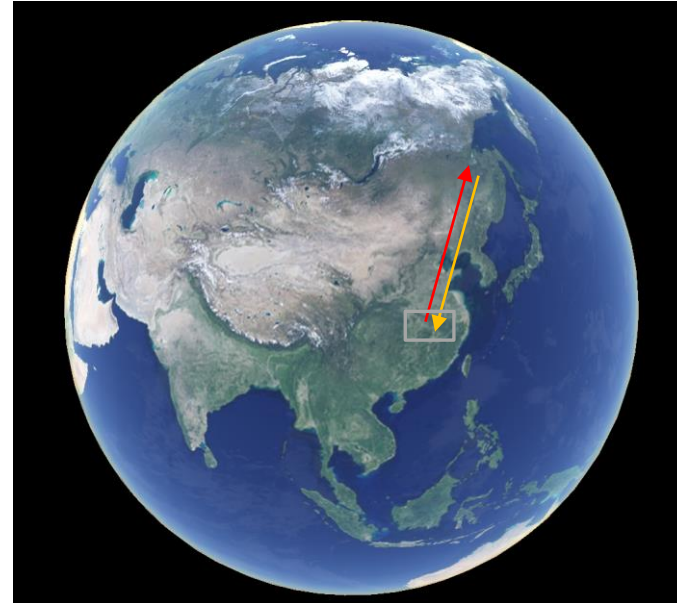- **International patents of Optimizing Location of Sensor Nodes in Geological CO2 Storage Area**

HABITAT Yangtze

■ **Wetland and migratory waterbirds**

The wetland across the middle and lower Yangtze River basin is the wintering habitat for a variety of migratory waterbirds.


Ciconia boyciana

■ **Climate change and human activities constantly change the habitat condition and thus then influence the lives of these birds. The migration and habitation behavior of these birds have been changing gradually but constantly, which climate change is believed to be one of the leading causes.**

Traditional Methodology and its Limitation

- Environmental attributes have been collected, the birds have been observed, the well-being of wetlands through field surveys has been monitored and manually remote sensing interpretation has been used during the last 20 years.

- The spatial-temporal resolution of the data acquired by the previously mentioned methods is relatively low, and the field studies could not simultaneously observe all the wetlands across the middle and lower Yangtze River basin. This prevents a clear understanding of the impact of climate change on the wetland.

Key Technologies of HABITAT Yangtze
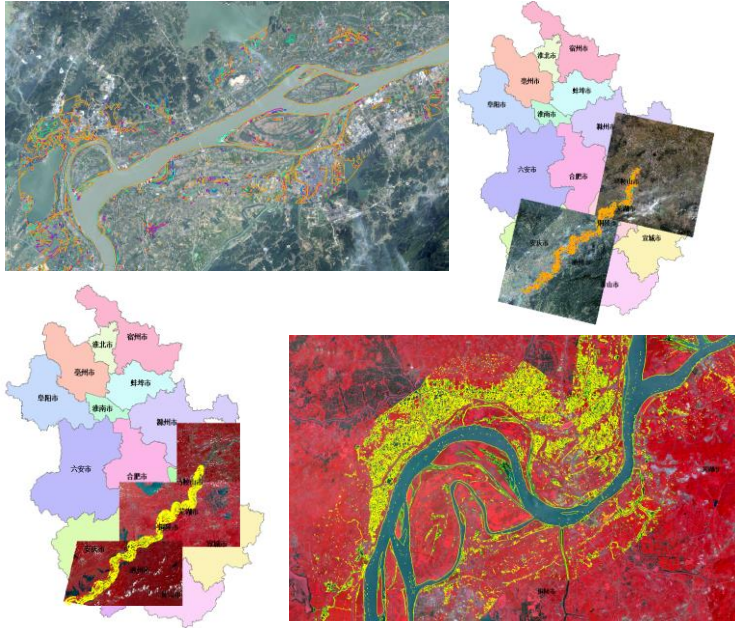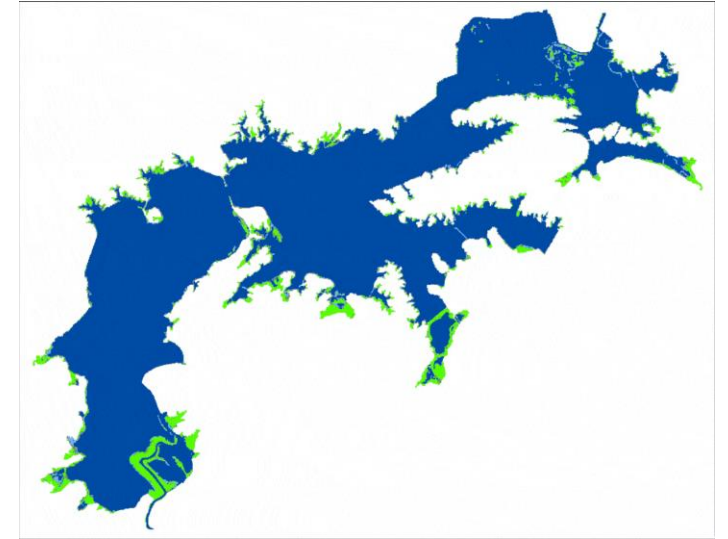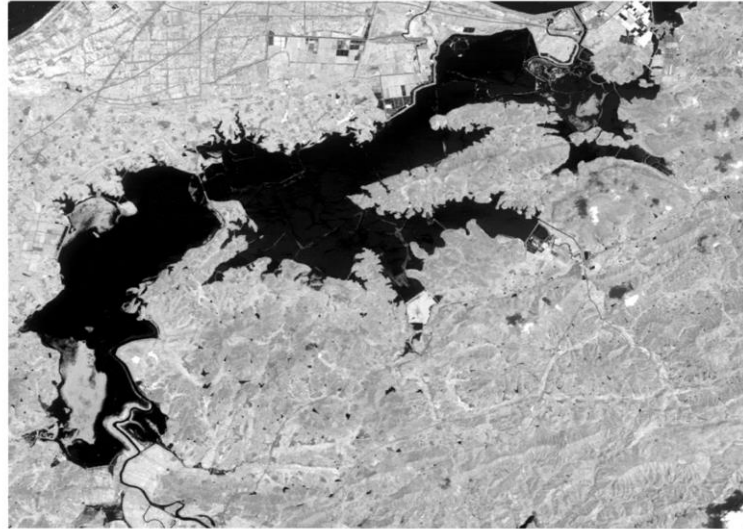

Object detection: water body

Object detection: road

Change detection: water body

The pillars of this project are a series of **deep learning models and corresponding automatic mapping algorithms**, automatically identifying and mapping **water bodies, land cover types in wetlands, roads, and buildings, extracting their boundaries, and detecting the temporal changes** from remote sensing imageries with very **high accuracy** (95% pixel precision and 98% area precision) in multiple test areas.
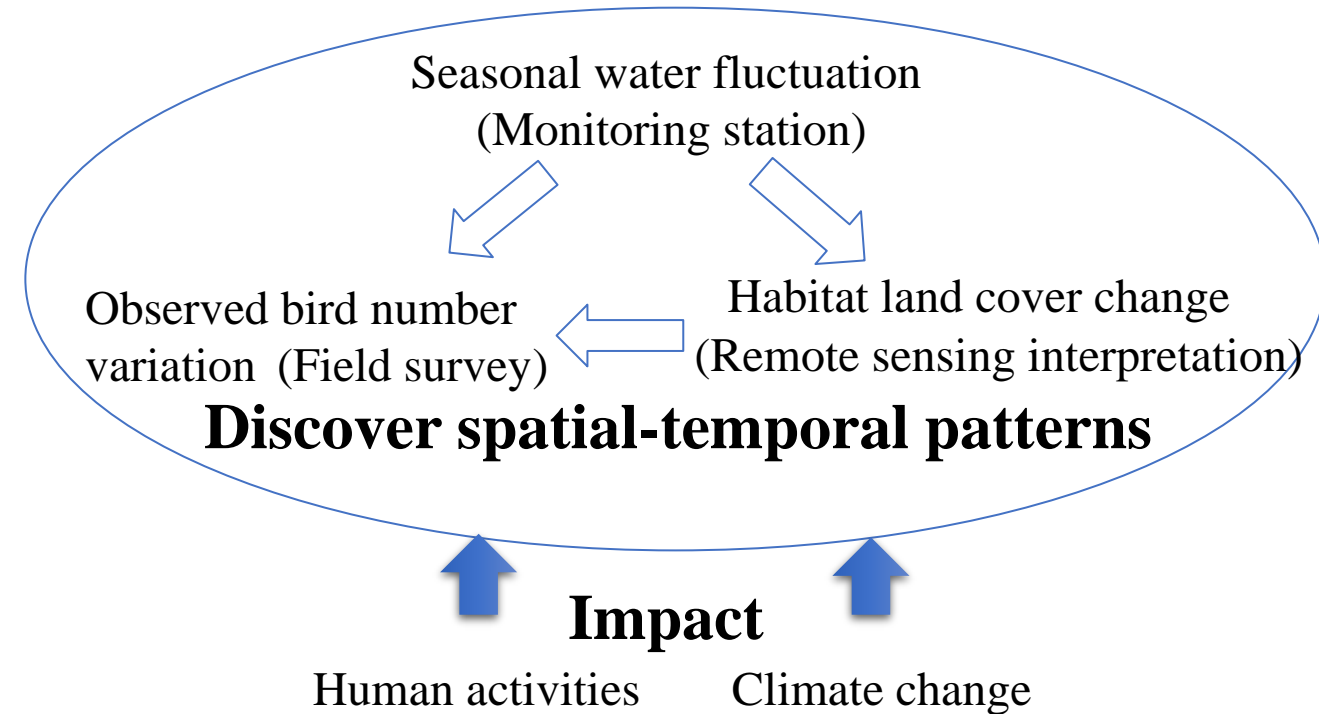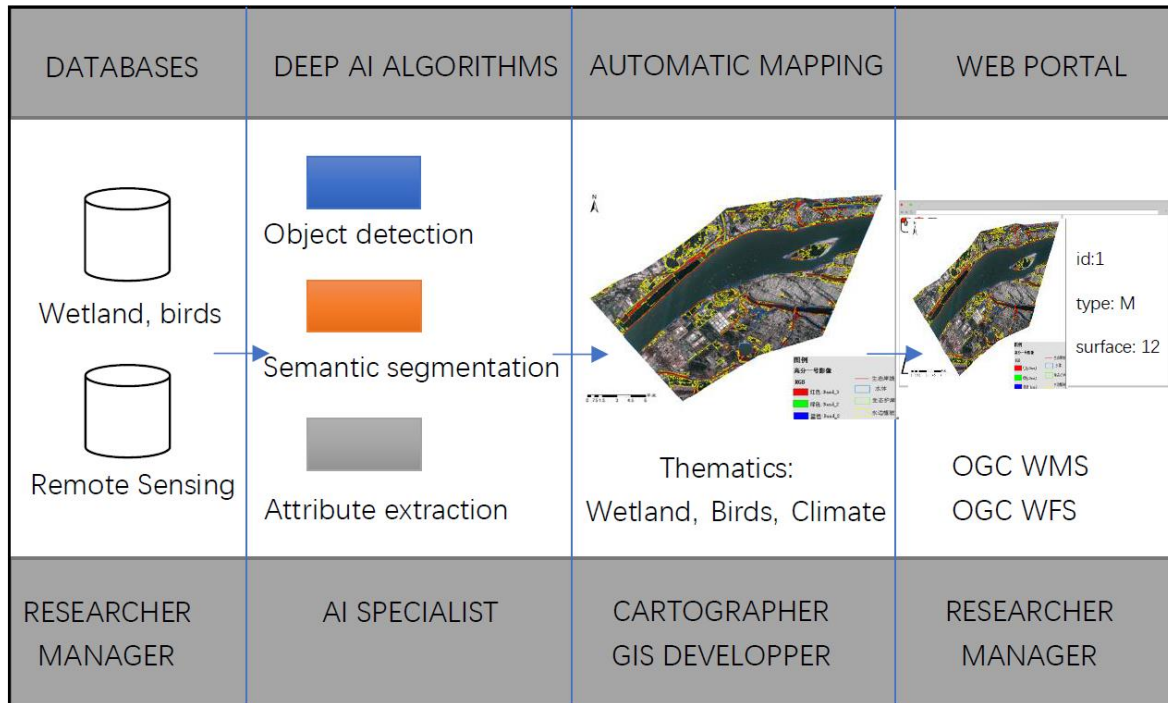
The algorithms have already demonstrated their capability to be scaled up to different regions and to a longer period.
Constant deep AI land cover interpretation and automatic mapping by HABITAT Yangtze. Deep blue: deep water, light blue: shallow water, green: grassland, grey: mudflat at Shengjin Lake

Structure of HABITAT Yangtze

The objective is to provide a rich-feature, large-scale, high spatial-temporal resolution, quick response, and remotely accessible database and corresponding map service of the middle and lower Yangtze-river basin wetlands to the local, national, and international birds' researcher, protector, the wetland manager, and the climate change researcher.

Achievements of HABITAT Yangtze
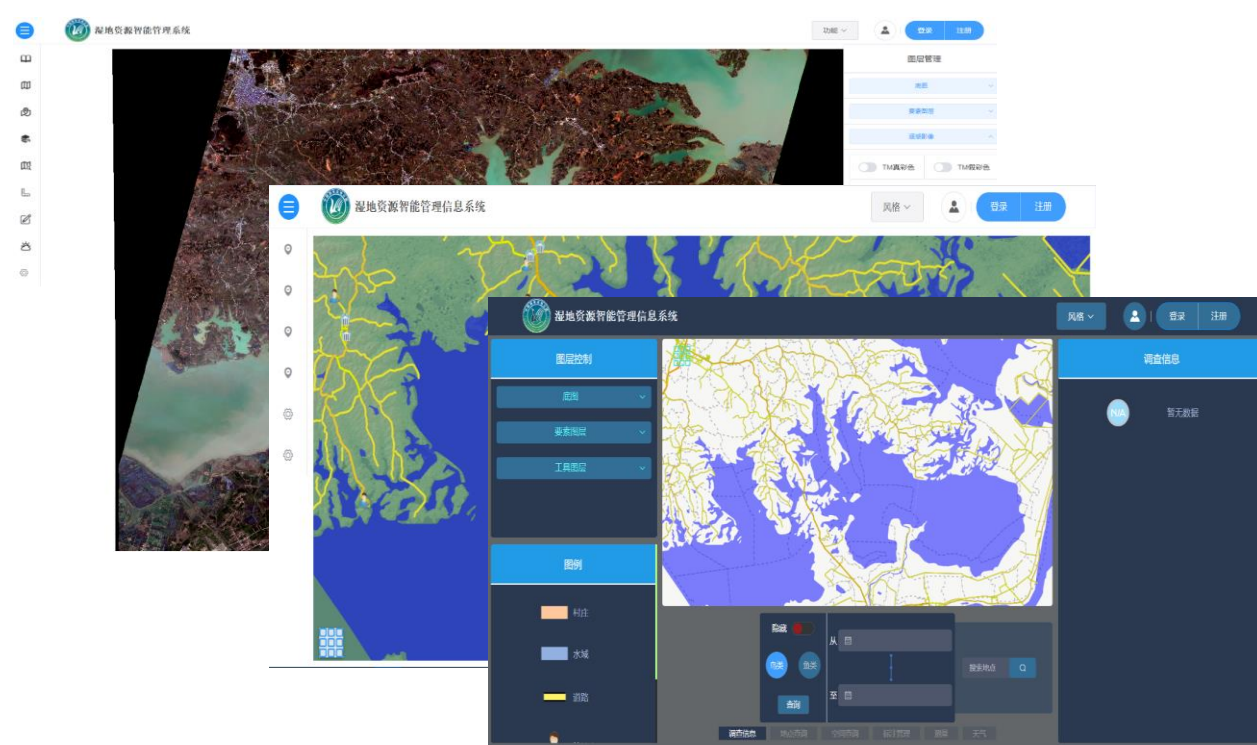
HABITAT Yangtze's web portal:

- Remote sensing image browsing

- Field survey data query

- Multiple layouts for different user groups
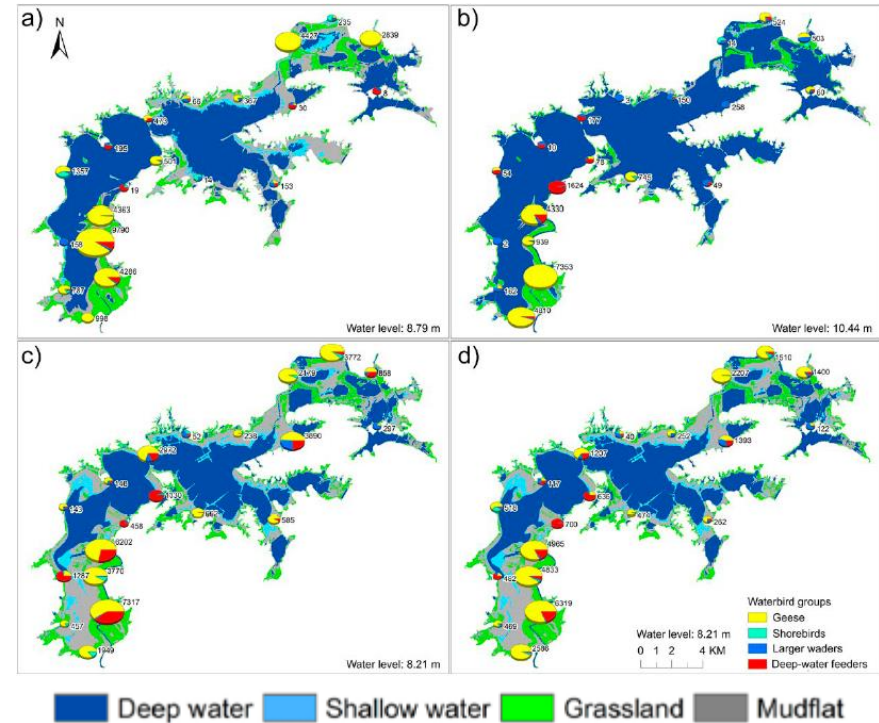
Case study:

- Spatial distribution of different groups of waterbirds (Geese, shorebirds, lager waders, and deep-water feeders) at Shengjin Lake;

- Land cover segmentation