6th Asia-Oceania Group on Earth Observations (AOGEO) Workshop

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Integrated remote sensing monitoring of ecosystem over Asia-Oceania hot areas

Jing Li

Aerospace Information Research Institute,

Chinese Academy of Sciences

AO GEO

Earth Observations for Asia-Oceania

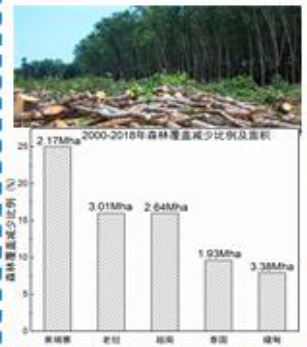
https://aogeo-workshop-2022.casconf.cn/

Email：aogeo_china@aircas.ac.cn

Background

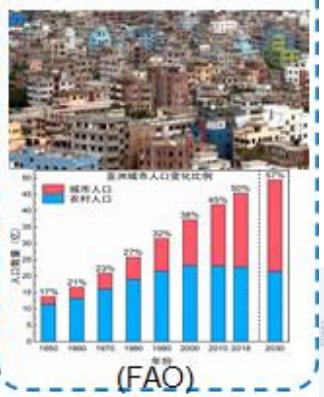
Ecological and environmental problems in Asia-Oceania are becoming serious

Deforestation



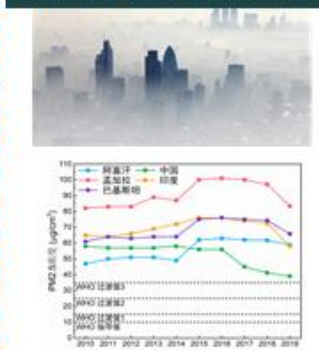
(Global Forest Watch)

Urban Expansion



(FAO)

Air Pollution



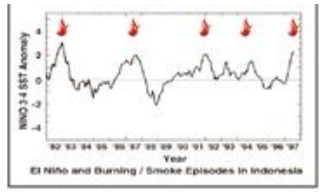
(State of Global Air & QAir)

AOGEO three priority research areas

- Lancang-Mekong River Basin
- Tibet Plateau
- Small island countries

Forest Fires

ENSO and Indonesia Fires



(Global Fire Monitoring Center)

Background

Facing on **two major goals**, this project establish **three framework** and gain **five abilities** to realize ecosystem monitoring, evaluation and service sharing over AO countries.

Sustainable Development in Asia-Oceania | **Chinese Aerospace Serve Globally**

Breakthrough of technology framework

- Thematic products generation technology
- Monitoring and evaluation technology

Establish monitoring application framework

- Integrated monitoring system
- Hot areas monitoring and evaluation

Establish cooperation framework in AO countries

- Cross-border experiment
- Information joint releasing

Product Development | **Monitoring** | **Oversea validation** | **Service sharing** | **Decision support**

Research Content

1. **Integrated ecosystem monitoring** over Asia and Oceania and the software development

2. Analysis of ecosystem change **under ENSO event** and its driving mechanism in China and Australia

3. Dynamic monitoring of **forest ecosystem** over Lancang-Mekong River Basin and analysis of its driving mechanism

4. Monitoring of **urban** changes over Lancang-Mekong River Basin based on multi-scale high-resolution satellite data

5. Dynamic monitoring of the **air quality** over Lancang-Mekong River Basin and analysis of ecosystem response and its driving mechanism

Technique Flowchart

Specifications of integrated remote sensing monitoring index system and technical procedure

❶ Products

Thematic product algorithm research

FY3、MODIS、GF1/2/5/6、CBERS04、

Inversion algorithm research

Thematic product generation

- ◆Integrated monitoring
- ◆Grassland monitoring
- ◆Forest monitoring
- ◆Urban expansion
- ◆Air quality monitoring

Thematic product validation (International cooperation)

❷ Monitoring

Integrated monitoring analysis method (International cooperation)

- Integrated ecosystem analysis over Asia-Oceania hot areas
- Analysis of the grassland change and its driving mechanism in China and Australia
- Analysis of the forest cover change and its driving mechanism over Lancang-Mekong River Basin
- Analysis of urban ecosystem changes over Lancang-Mekong River Basin
- Analysis of the atmospheric quality and ecosystem response over Lancang-Mekong River Basin

Monitoring results verification (International cooperation)

❸ Platform & Application

Integrated monitoring and analysis platform for typical ecosystem over Asia-Oceania

Monitoring information release and sharing (International cooperation)

AOGEO TG12 Information sharing platform

Asia-Oceania countries

❶ Developed 16 thematic products over Asia-Oceania

List of 16 thematic products

Range	Parameters	Spatial Resolution	Temporal Resolution	Time Span
Asia-Oceania	Annual mean LAI	5km	1 year	1982-2000
		1km		2001-2022
	Anomaly of LAI	5km	1 year	1982-2000
		1km		2001-2022
	Annual accumulated GPP	1km	1 year	2001-2022
	Anomaly of GPP	1km	1 year	2001-2022
	Intensity by ENSO	5km	ENSO event	1982-2000
		1km		2001-2022
	Sensitivity area by ENSO	5km	ENSO event	1982-2000
		1km		2001-2022
	Annual maximal FVC	250m	1 year	2015-2022
	Annual mean LAI	250m	1 year	2015-2022

Range	Parameters	Spatial Resolution	Temporal Resolution	Time Span	Accuracy	
Lancang-Mekong River	Forest Change	30m	1年	2015-2022	≥85%	
	Impervious surface	10m	1年	2015-2022	≥80%	
	Forest Mapping	30m	1年	2015, 2020	≥85%	
	Atmospheric fine particle AOD	3.3km	1年	2019-2022	±(0.05+AOD×15%)	GF5/DPC
	PM2.5	10km	1年	2015-2018	r≥0.88	
		3.3km	1年	2019-2022	r≥0.88	
Cambodia	Impervious surface	5m	2年	2017-2018, 2021-2022	≥80%	CBERS 04
	Forest biomass	16m	1年	2015, 2020	≥80%	GF 1/6
	Forest carbon storage	16m	1年	2015, 2020	≥80%	

- **New products**: to monitor the vegetation anomaly by ENSO events
- **Temporal spatial continuous time series**
- **Generated from Chinese satellites**
- **Higher spatial resolution**

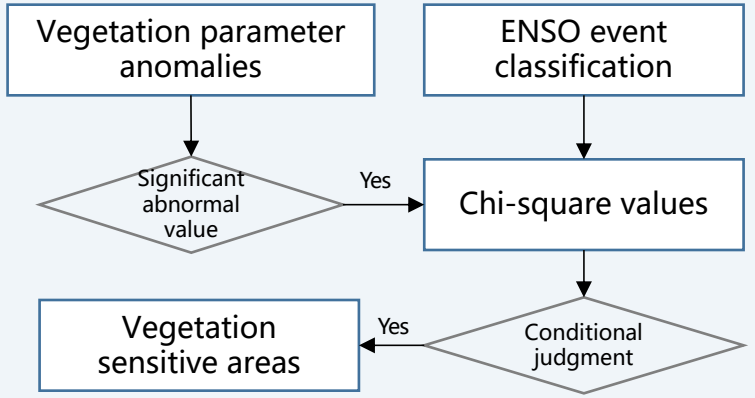
Intensity and area in response to ENSO

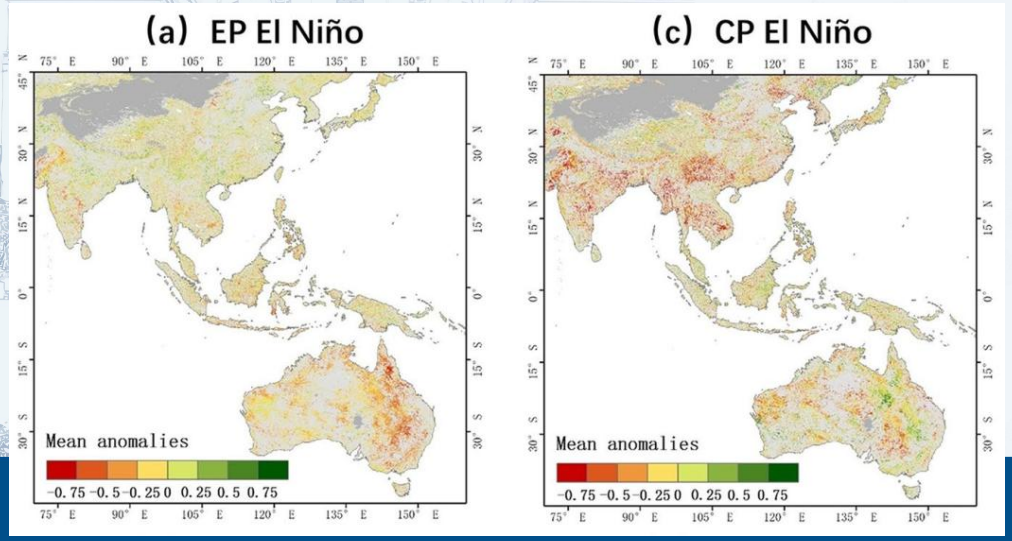
◆ We constructed the method to extract vegetation anomaly intensity and sensitive areas under each ENSO events (El Niño and La Niña) based on long time series of LAI/NDVI products. (Wang C., et.al, 2022, GRL)

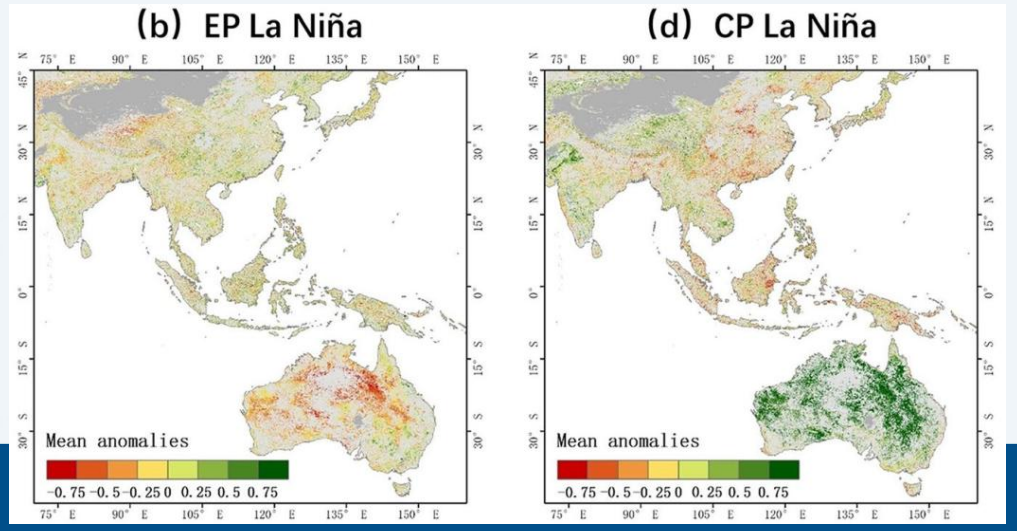
Improved Pearson's chi-square test:

$$\chi^2 = \frac{(m - n \cdot p_b)^2}{n \cdot p_b \cdot (1 - p_b)}$$

- ✓ Exclude the impacts of non-ENSO periods
- ✓ Identify El Niño and La Niña sensitive areas separately
- ✓ Consider the uncertainty of vegetation anomaly response



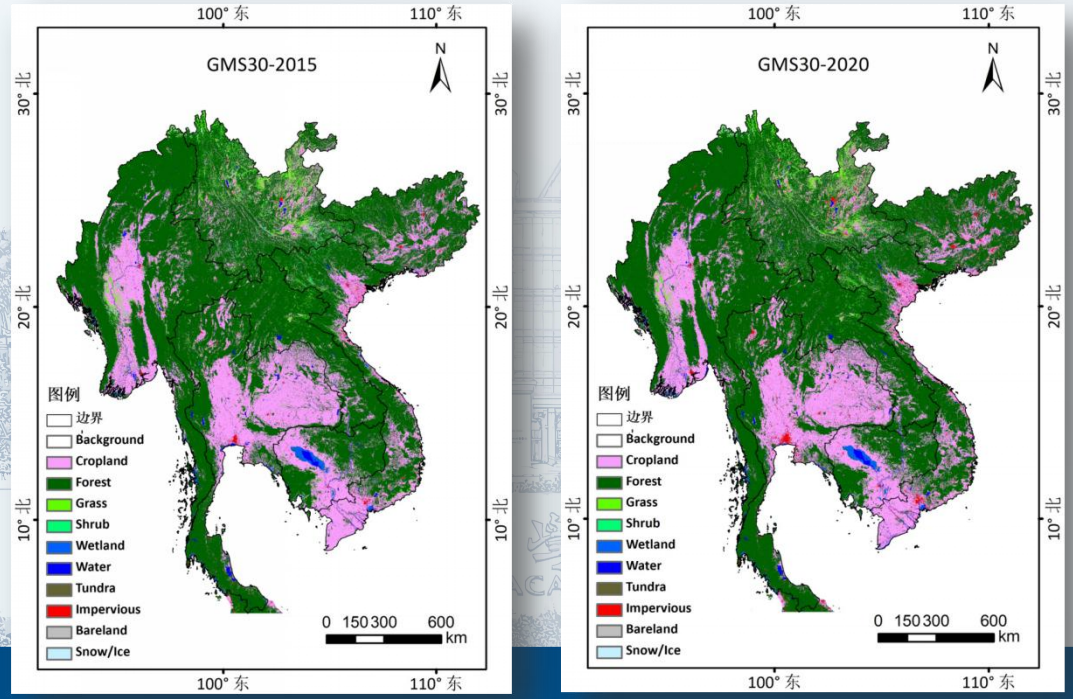




Spatio-temporal Continuous forest cover

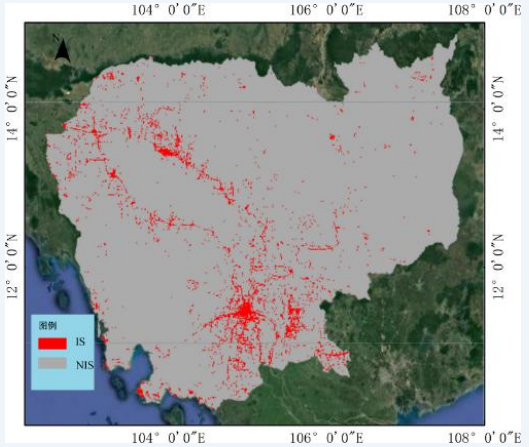
- Spatio-temporal continuous time series in rainy Lancang-Mekong River basin were generated with proposed WAP method (Meng S.L., et.al, 2023) .
- 30m forest cover product in Lancang-Mekong river Basin were generated (Meng S.L., et.al, 2023)

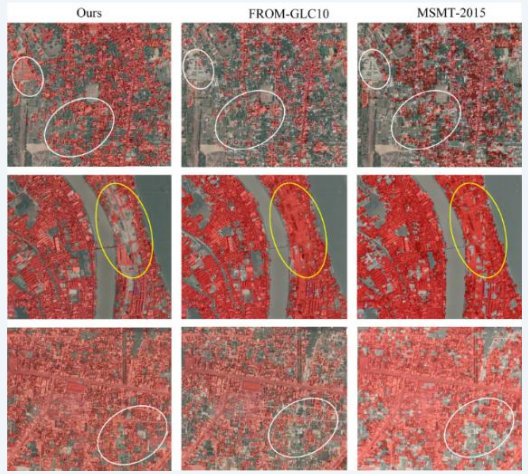
Forest cover in 2015 and 2022 (30m)



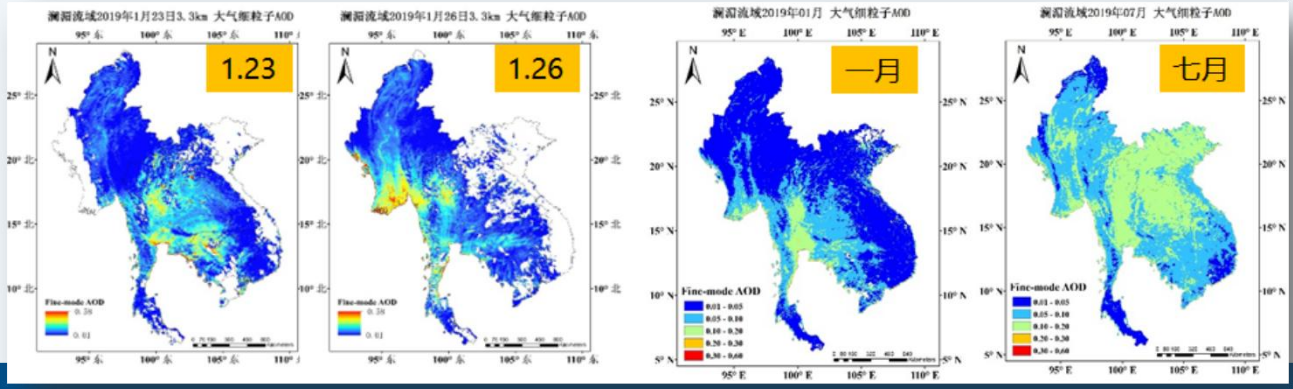
Higher spatial resolution from Chinese satellites

- 5m impervious surface product in Cambodian with CBERS04 (Sun G.Y., et.al, 2022, ISPRS)



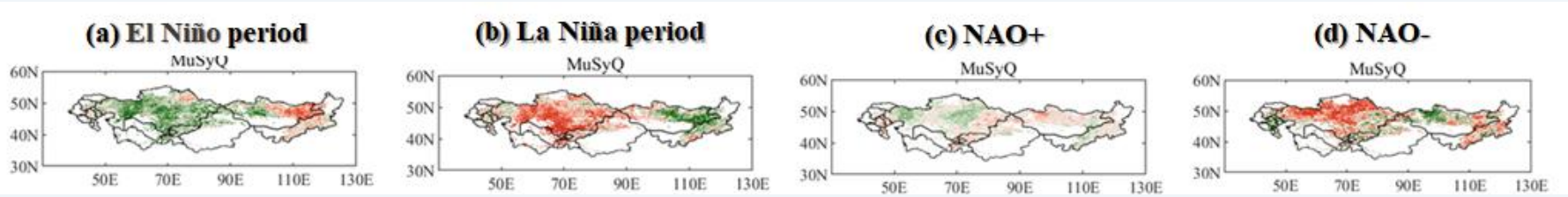


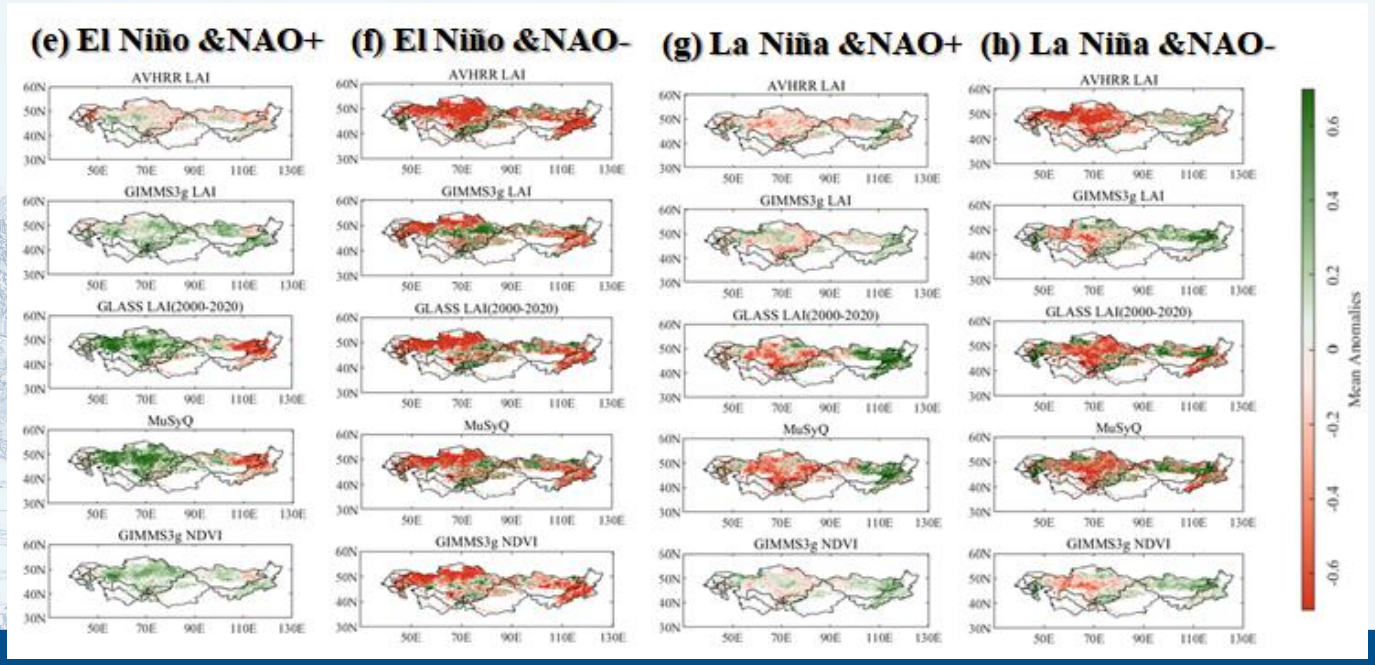
- 3.3km PM2.5 concentration were estimation based on GF5/DPC (Bao F.W., et.al, 2022, IEEE TGRS)



❷ Integrated monitoring & Reports

- We explored the combined influence of ENSO and North Atlantic Oscillation (NAO) on Eurasian Steppe during 1982 – 2020 using **five long-term LAI/NDVI products** (Liu C., et.al, Science of the Total Environment, 2nd review)





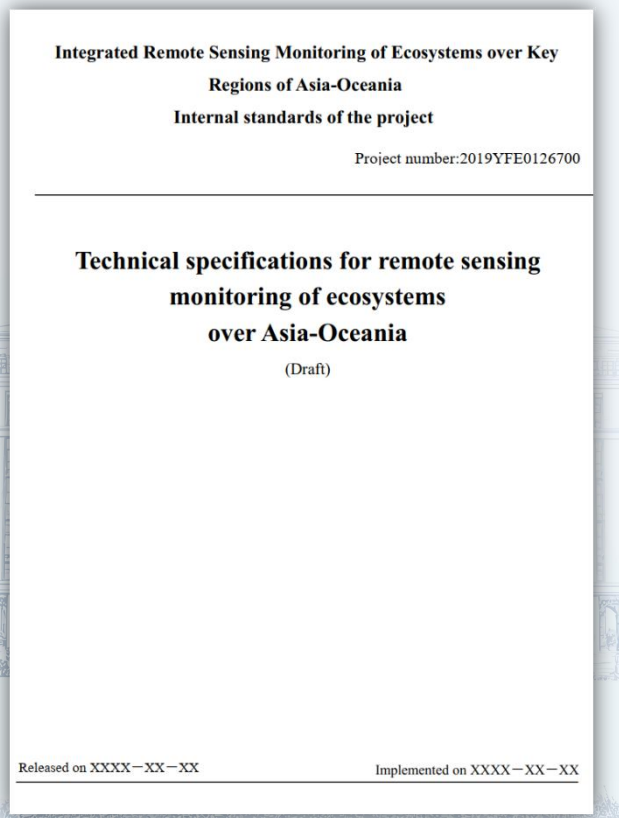
- ✓ El Niño and NAO+, accompanied by the increased temperature and slightly more precipitation, improved the grassland growth in the western EA.
- ✓ La Niña and NAO- with a cooling effect over the whole EAS and uneven precipitation decrease, deteriorated the EAS grassland.

- ✓ The combination of warm ENSO and NAO+ (approximately 1982, 1993, and 2016) events with a **more severe warming effect** caused more significant grassland greening.

- ✓ The repeated occurrence of ENSO and NAO events in recent decades shaped the EAS grassland change characteristics. However, the climate oscillations tended to cause a short-term anomaly in the background of the continuous increase in temperature in the EAS

❷ Integrated monitoring & Reports

- We wrote technical specification to standardize the technical process of **product generation**, **monitoring procedures**, **monitoring report template** for ecosystem quality monitoring, vegetation response to ENSO, forest change, urban expansion, and air quality monitoring.



Integrated Remote Sensing Monitoring of Ecosystems over Key Regions of Asia-Oceania

Internal standards of the project

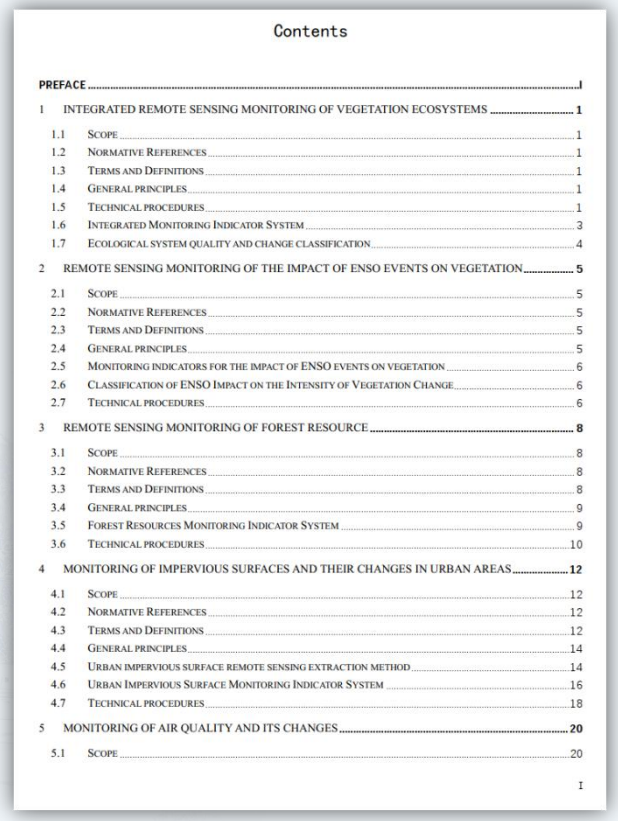
Project number:2019YFE0126700

Technical specifications for remote sensing monitoring of ecosystems over Asia-Oceania

(Draft)

Released on XXXX－XX－XX

Implemented on XXXX－XX－XX



Contents

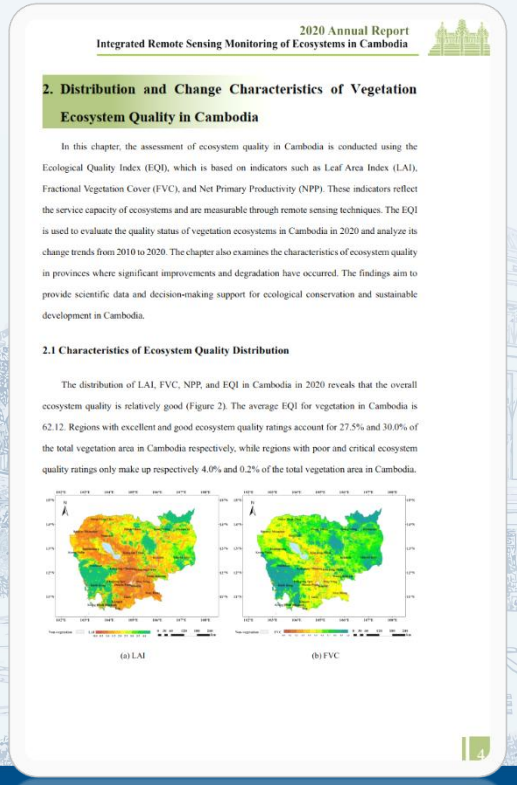
I

Peer reviewed
Panel meeting

❷ Integrated monitoring & Reports

- The **2020 annual report** on integrated remote sensing monitoring of ecosystems **in Cambodia** was generated. The report analyzes and assesses the **distribution in 2020 and change characteristics** of **ecosystem quality**, **forest resources**, **urban expantion**, **air quality** and **the influence of ENSO events on ecosystems** in Cambodia in recent decade.

Ecosystem Quality


2020 Annual Report
Integrated Remote Sensing Monitoring of Ecosystems in Cambodia

2. Distribution and Change Characteristics of Vegetation Ecosystem Quality in Cambodia

In this chapter, the assessment of ecosystem quality in Cambodia is conducted using the Ecological Quality Index (EQI), which is based on indicators such as Leaf Area Index (LAI), Fractional Vegetation Cover (FVC), and Net Primary Productivity (NPP). These indicators reflect the service capacity of ecosystems and are measurable through remote sensing techniques. The EQI is used to evaluate the quality status of vegetation ecosystems in Cambodia in 2020 and analyze its change trends from 2010 to 2020. The chapter also examines the characteristics of ecosystem quality in provinces where significant improvements and degradation have occurred. The findings aim to provide scientific data and decision-making support for ecological conservation and sustainable development in Cambodia.

2.1 Characteristics of Ecosystem Quality Distribution

The distribution of LAI, FVC, NPP, and EQI in Cambodia in 2020 reveals that the overall ecosystem quality is relatively good (Figure 2). The average EQI for vegetation in Cambodia is 62.12. Regions with excellent and good ecosystem quality ratings account for 27.5% and 30.0% of the total vegetation area in Cambodia respectively, while regions with poor and critical ecosystem quality ratings only make up respectively 4.0% and 0.2% of the total vegetation area in Cambodia.

(a) LAI (b) FVC

ENSO Influence


2020 Annual Report
Integrated Remote Sensing Monitoring of Ecosystems in Cambodia

3. Monitoring the Impact of ENSO Events on Ecosystems in Cambodia

In the context of global changes, frequent occurrences of extreme climate events have led to a growing interest in accurately understanding and assessing their impacts on vegetation growth. The El Niño-Southern Oscillation (ENSO) phenomenon refers to the sustained anomalous warming or cooling of sea surface temperatures in the central and eastern Equatorial Pacific region, coupled with interactions between the atmosphere and ocean circulation. It is a significant influencing factor driving global extreme climate events. Specifically, El Niño and La Niña events represent warm and cold phases of the ENSO cycle, respectively, reflected in sea surface temperature anomalies. ENSO events alter the atmospheric conditions in certain regions globally, such as reducing rainfall in tropical oceanic rainy areas due to changes in atmospheric pressure gradients and affecting monsoon rain areas. Therefore, the frequent occurrences of El Niño/La Niña events in recent decades have directly resulted in disastrous extreme weather phenomena, including droughts and heavy rainfall, in the tropical Pacific and its adjacent regions, while indirectly influencing global climate and triggering meteorological disasters elsewhere. Between 1982 and 2020, a total of 20 ENSO events were recorded, including 11 El Niño events and 9 La Niña events (Figure 17). Based on detrended global LAI products, a Vegetation Anomaly Index (VAI) was constructed as an indicator of vegetation anomalies to assess the impacts of ENSO events on vegetation growth conditions.

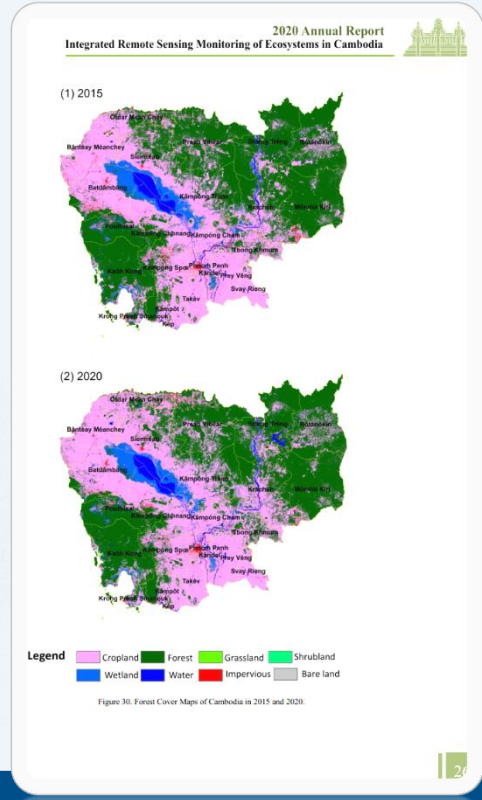
Nino3.4 Elnino EP Elnino CP Lanina EP Lanina CP

Figure 17. ENSO events occurrence timeline from 1982 to 2020.

3.1 ENSO-correlated Regions

The correlation analysis between the VAI and ENSO (Nino3.4 index) in Cambodia reveals spatial variations in the regions correlated with ENSO. Overall, during the period from 1982 to 2020,

Forest Resources


2020 Annual Report
Integrated Remote Sensing Monitoring of Ecosystems in Cambodia

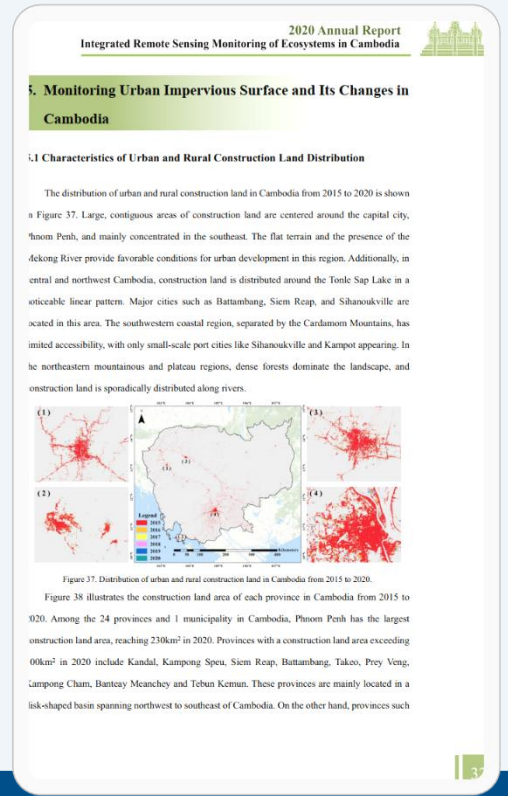
(1) 2015

(2) 2020

Legend Cropland Forest Grassland Shrubland Wetland Water Impervious Bare land

Figure 30. Forest Cover Maps of Cambodia in 2015 and 2020.

Urban Imperious


2020 Annual Report
Integrated Remote Sensing Monitoring of Ecosystems in Cambodia

5. Monitoring Urban Impervious Surface and Its Changes in Cambodia

5.1 Characteristics of Urban and Rural Construction Land Distribution

The distribution of urban and rural construction land in Cambodia from 2015 to 2020 is shown in Figure 37. Large, contiguous areas of construction land are centered around the capital city, Phnom Penh, and mainly concentrated in the southeast. The flat terrain and the presence of the Mekong River provide favorable conditions for urban development in this region. Additionally, in central and northwest Cambodia, construction land is distributed around the Tonle Sap Lake in a noticeable linear pattern. Major cities such as Battambang, Siem Reap, and Sihanoukville are located in this area. The southwestern coastal region, separated by the Cardamom Mountains, has limited accessibility, with only small-scale port cities like Sihanoukville and Kampot appearing. In the northeastern mountainous and plateau regions, dense forests dominate the landscape, and construction land is sporadically distributed along rivers.

Figure 37. Distribution of urban and rural construction land in Cambodia from 2015 to 2020.

Figure 38 illustrates the construction land area of each province in Cambodia from 2015 to 2020. Among the 24 provinces and 1 municipality in Cambodia, Phnom Penh has the largest construction land area, reaching 230km² in 2020. Provinces with a construction land area exceeding 100km² in 2020 include Kandal, Kampong Speu, Siem Reap, Battambang, Takeo, Prey Veng, Kampong Cham, Banteay Meanchey and Tebun Kemun. These provinces are mainly located in a fish-shaped basin spanning northwest to southeast of Cambodia. On the other hand, provinces such

Air Quality

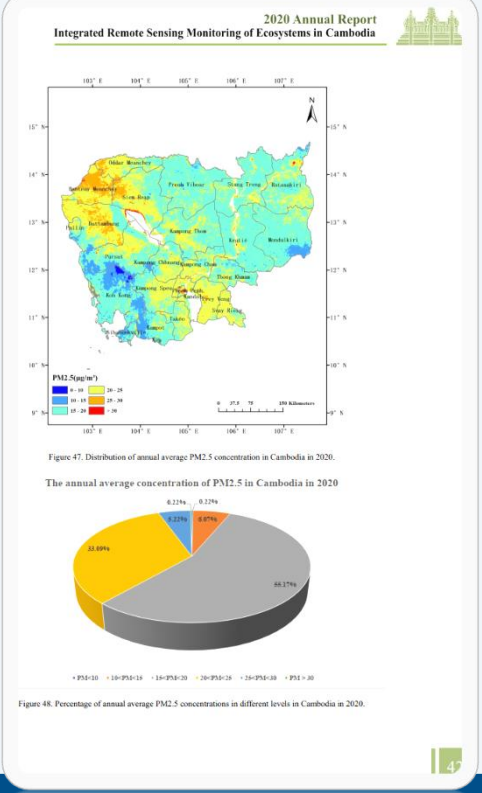

2020 Annual Report
Integrated Remote Sensing Monitoring of Ecosystems in Cambodia

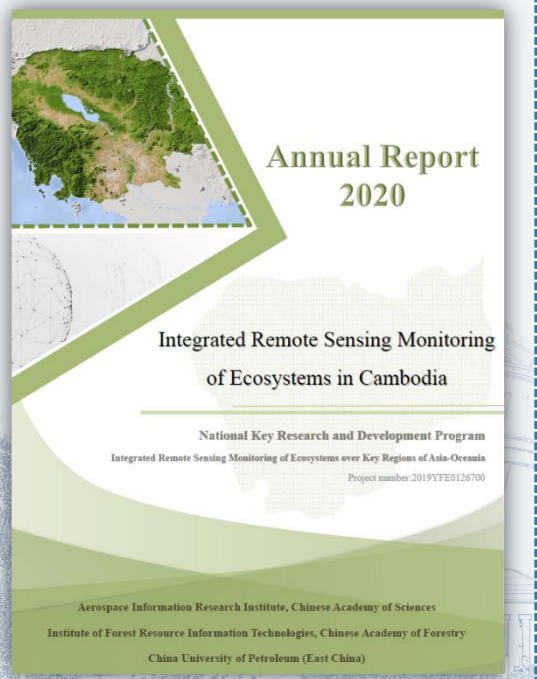
Figure 47. Distribution of annual average PM2.5 concentration in Cambodia in 2020.

The annual average concentration of PM2.5 in Cambodia in 2020

Figure 48. Percentage of annual average PM2.5 concentrations in different levels in Cambodia in 2020.

Integrated Remote Sensing Monitoring of Ecosystems in Cambodia (2020)

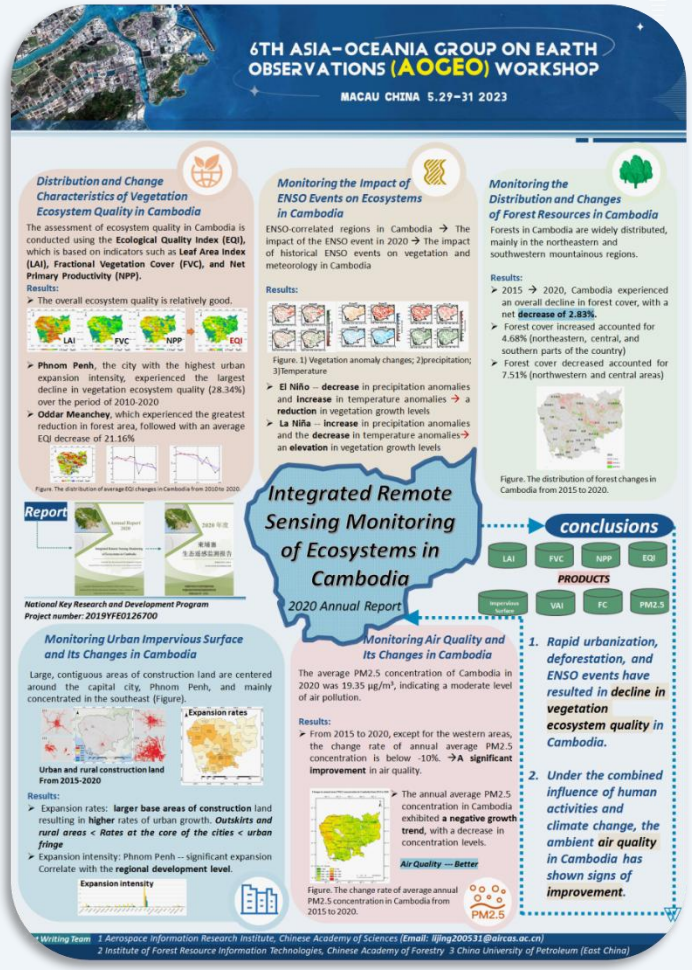
Cover



1. *Rapid urbanization, deforestation, and ENSO influence resulted in **decline of ecosystem quality** in Cambodia. The average Ecological Quality Index decreased by 7.50% over the period of 2010-2020.*

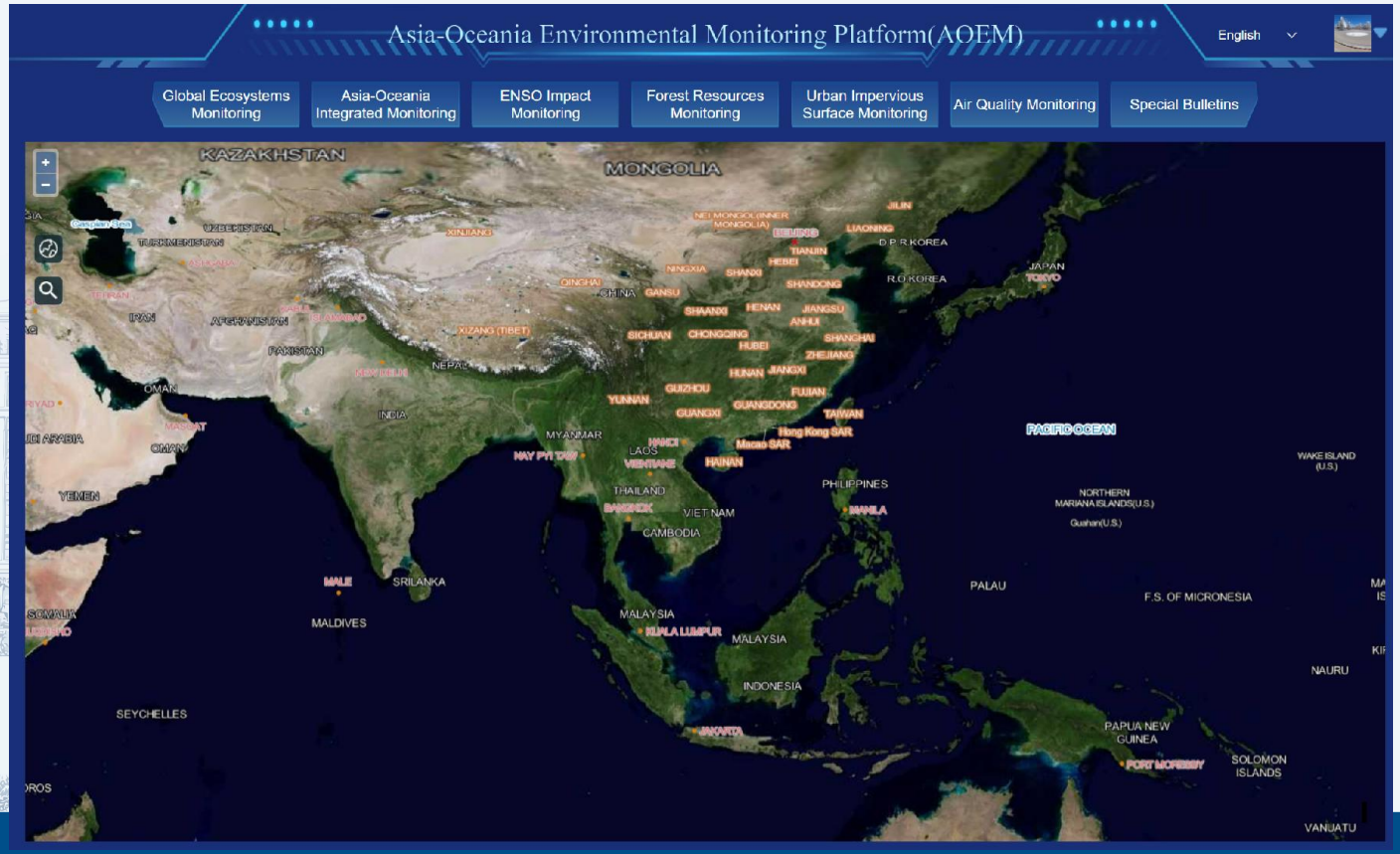
2. *The ambient **air quality** in Cambodia has shown an improvement tendency, with an average decrease of 7.88% in PM2.5 concentrations over the period of 2015-2020.*

Poster



❸ Platform & Application

- To promote the international sharing and provide convenient information services in Asia-Oceania region, we developed **Asia-Oceania Environmental Monitoring Platform** (AOEM). It showed the **monitoring results** of ecological quality, forest resources, unban expansion and air quality in AO regions, and also **release** the monitoring **reports** and **products**.



Please visit:

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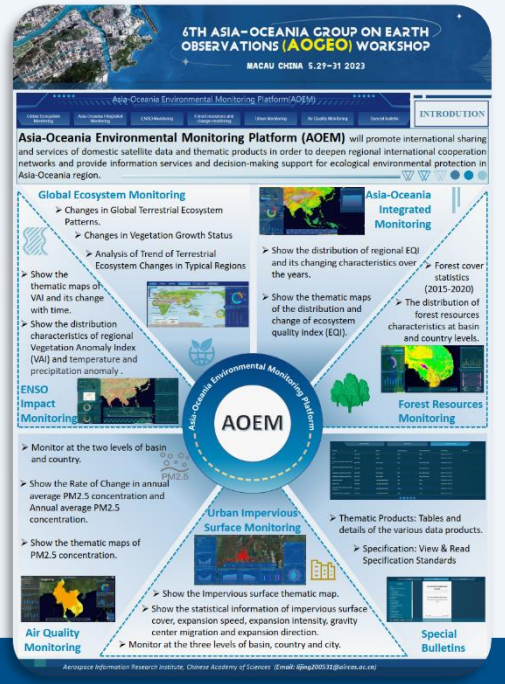
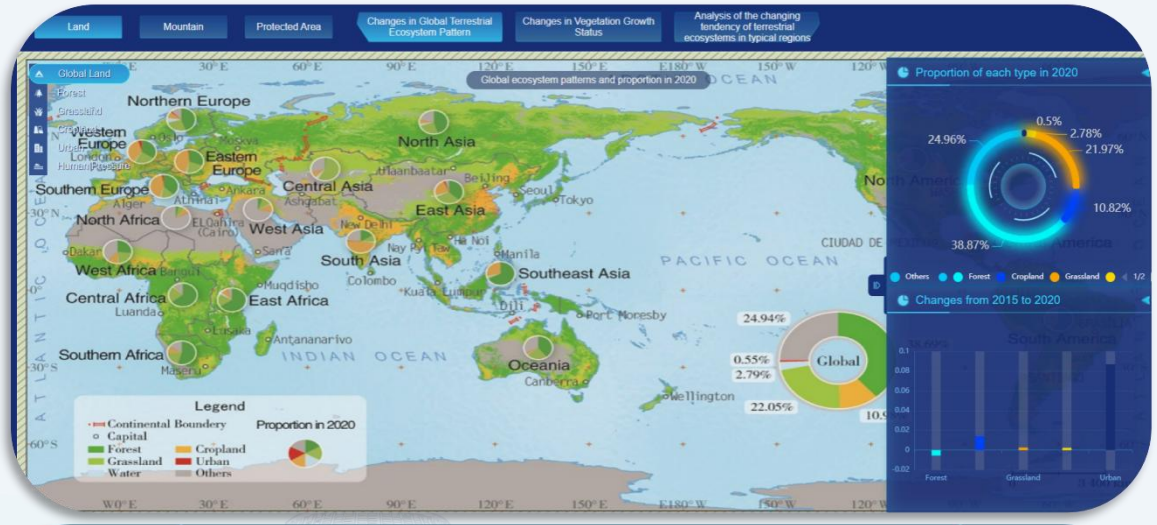
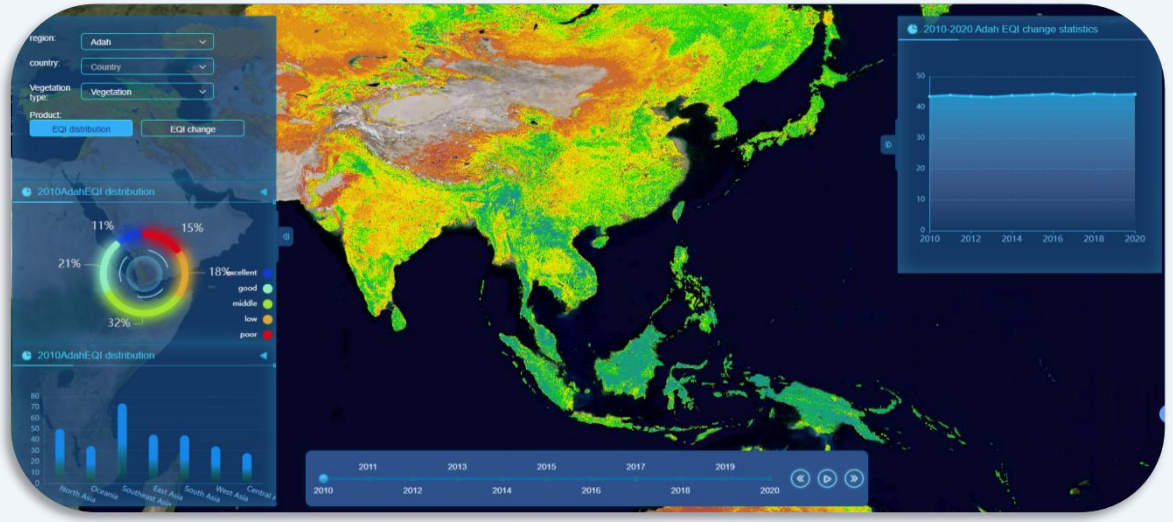


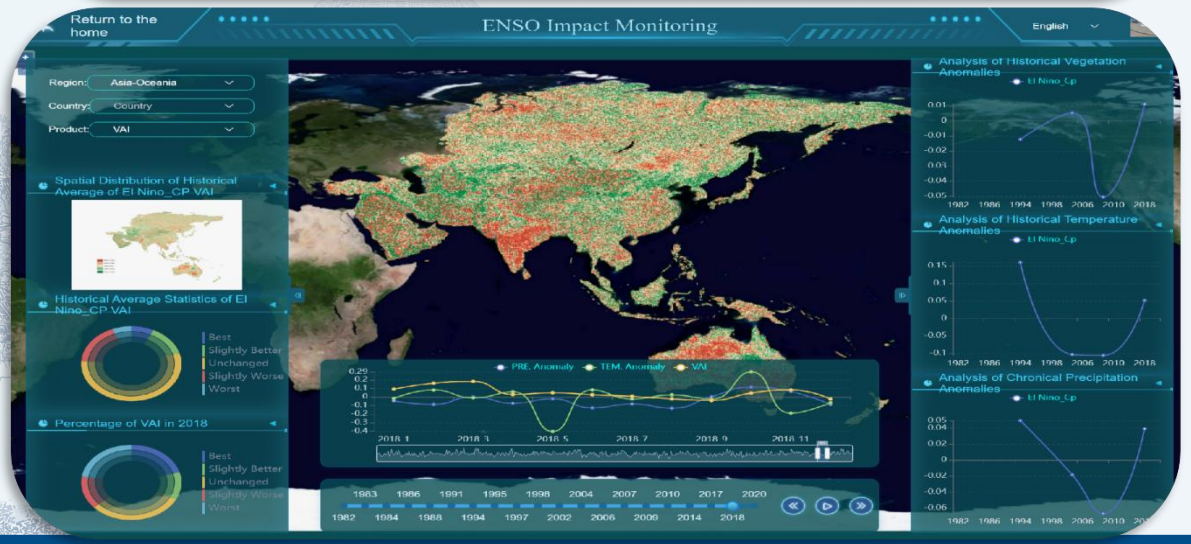
Asia-Oceania Environmental Monitoring Platform (AOEM)

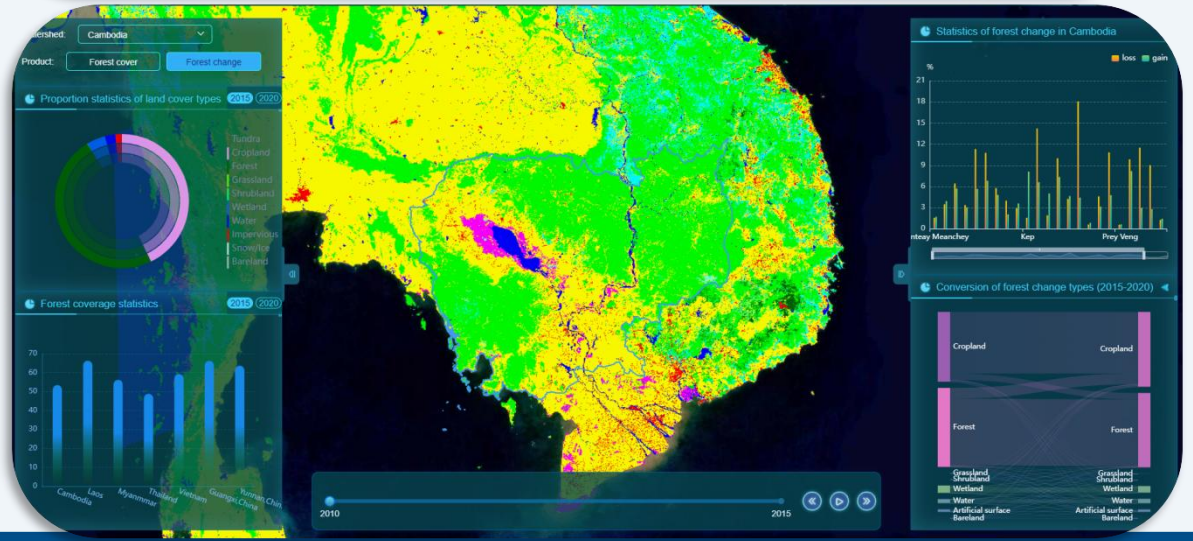
Global Ecological quality



AO Ecological quality





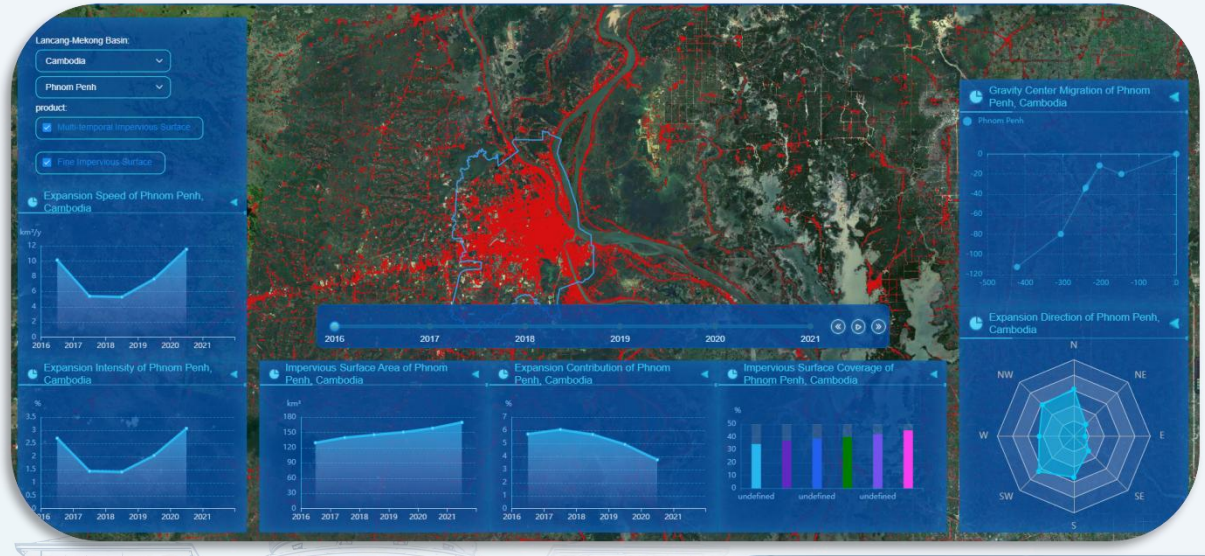


ENSO Influence

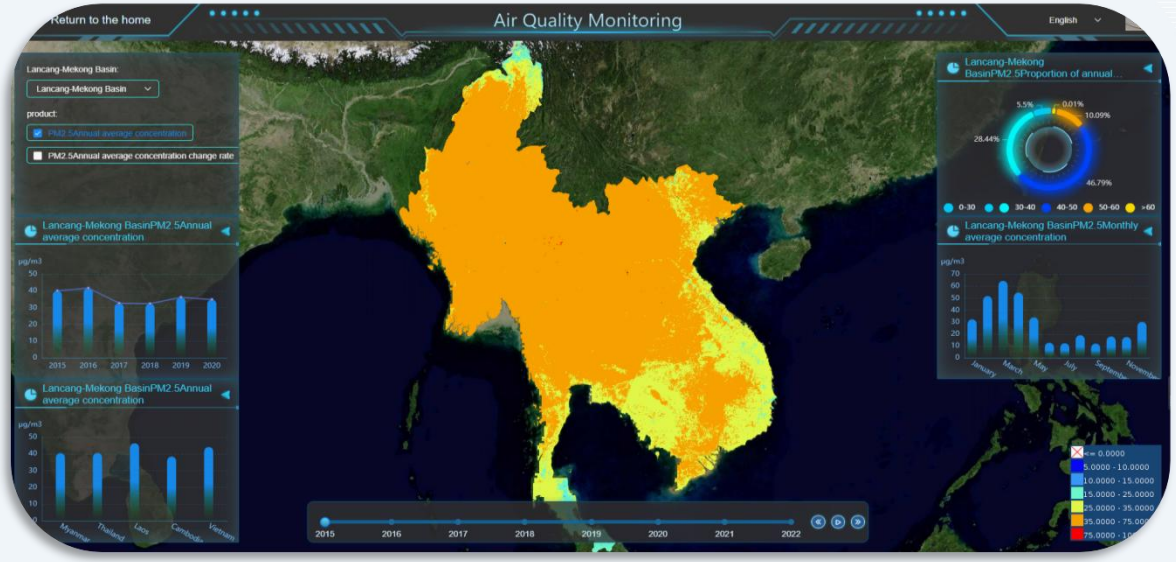
Forest resource

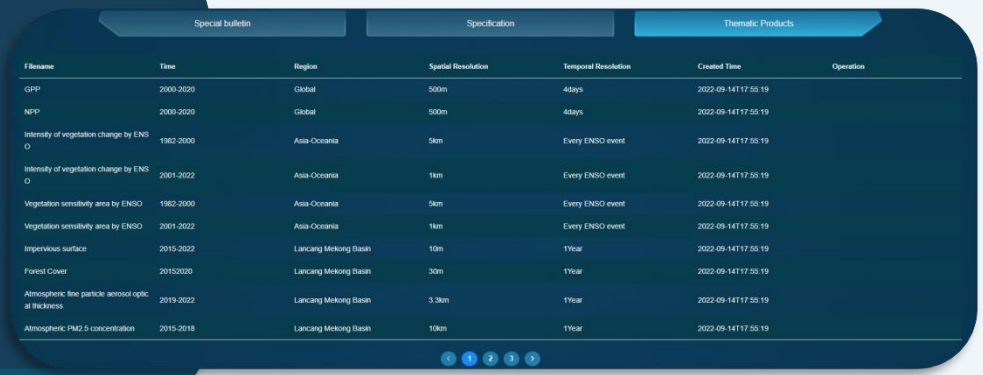
Asia-Oceania Environmental Monitoring Platform (AOEM)

Urban impervious



Air quality





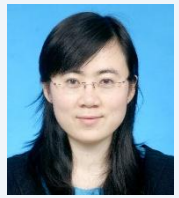
Report downloading

Specification browsing

Dateset downloading

Research Team -- Chinese Teams

The project is hosted by AIRCAS, and joint by 5 domestic units



Leader

AIRCAS
Li Jing

Institute of Forest Resource Information Techniques, Chinese Academy of Forestry
Meng Shili

- Task1: Construct standard technical process of product generation, change analysis
- Task2: Analyze grassland ecosystem change and its driving mechanism in the sensitive areas of climate change over China and Australia
- Task5: Remote sensing monitoring of atmospheric environmental quality and analysis of ecosystem response in Lancang-Mekong river basin

China Centre For Resource Satellite Data and Application
Luo Yiping

- Task3: Dynamic forest ecosystem monitoring based on remote sensing data and the analysis of its driving mechanism in the Lancang-Mekong River Basin.

China University of Petroleum (East China)
Sun Genyun

- Task4: Provide 5m panchromatic and 10m multispectral images of CBERS-04 in ASEAN region and 2m panchromatic and 8m multispectral images of GF-1 and GF-6 satellites

Shandong University of Science and Technology
Sun Lin

- Task4: Urban ecosystem dynamic monitoring of in the Lancang-Mekong River Basin based on multi-scale high-resolution satellite data.

Huazhong Agricultural University
Xu Baodong

- Task4: Develop preprocessing technologies such as cloud and cloud shadow detection, atmospheric correction for high-resolution satellite data

- Task1: Produce integrated monitoring products over Asia-Oceania region and analyze the spatial characteristics of ecosystem changes over Asia-Oceania region in the past 40 years

Research Team -- Overseas Teams

Co-leader

UTS, Australia
Alfredo Huete

- **Task5**: Evaluate the contribution of fires to urban ambient air, and estimate the daily exposure risk of population weighted average
- **Task2**: Analyze the temporal and spatial characteristics of the influence of ENSO events on grassland and the driving mechanism of ENSO events

UNSW, Australia
Xiuping Jia

- **Task4**: Construction of multi-scale impervious surface extraction technology system integrating multi-level feature learning and integrated classification
- Carry out the joint validation of ecosystem monitoring products of urban ecosystem change.

CSIRO, Australia
Tapas K Biswas

- **Task1**: Promote the sharing and application of vegetation parameter products and integrated ecosystem monitoring platform in the world
- Carry out the joint validation of ecosystem monitoring products based on the ground observation of CSIRO

GDEKI, Ministry of Environment, Cambodia
Chiven LENG

- **Task3 & 4**: Carry out ground observation and investigation
- Promote the sharing of remote sensing monitoring products and monitoring demonstration of forest change and carbon storage, unban expansion, etc.

We are looking for the cooperative partners in Asia-Oceania countries to jointly make the monitoring, release the national report, and apply the platform!

THANKS

lijing200531@aircas.ac.cn

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Email：aogeo_china@aircas.ac.cn