AOMSUC-15 2025 FYSUC
THE 15TH ASIA-OCEANIA METEOROLOGICAL SATELLITE USERS' CONFERENCE (AOMSUC-15)
2025 FENGYUN SATELLITE USER CONFERENCE (2025 FYSUC)

Application of Multi-source Remote Sensing Data in Sugarcane Production of Guangxi

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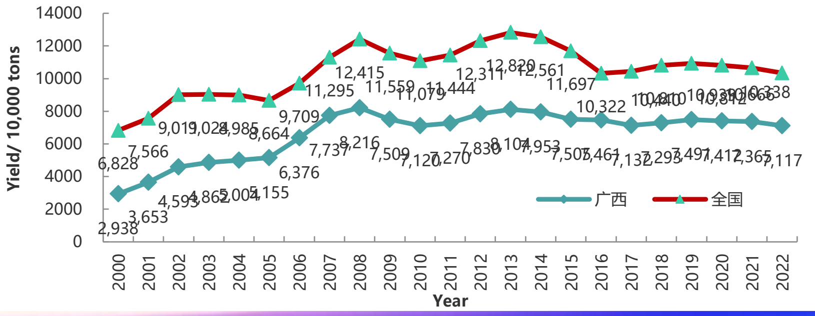
Outline

- ☐ Background
- ☐ Main applications
- ☐ Some thoughts

1. Background - Importance of Location

Sugarcane is the primary source of sugar in China and holds a significant position in the agricultural economy.

- **Over 50% of the world's sugar comes from sugarcane, with China ranking fourth globally in production and output value.**
- **Guangxi is the largest sugarcane production base in China, accounting for over 60% of the national total.**



1. Background - National Planning

In China, National plans include the construction of "double-high" sugarcane bases and digital agriculture.

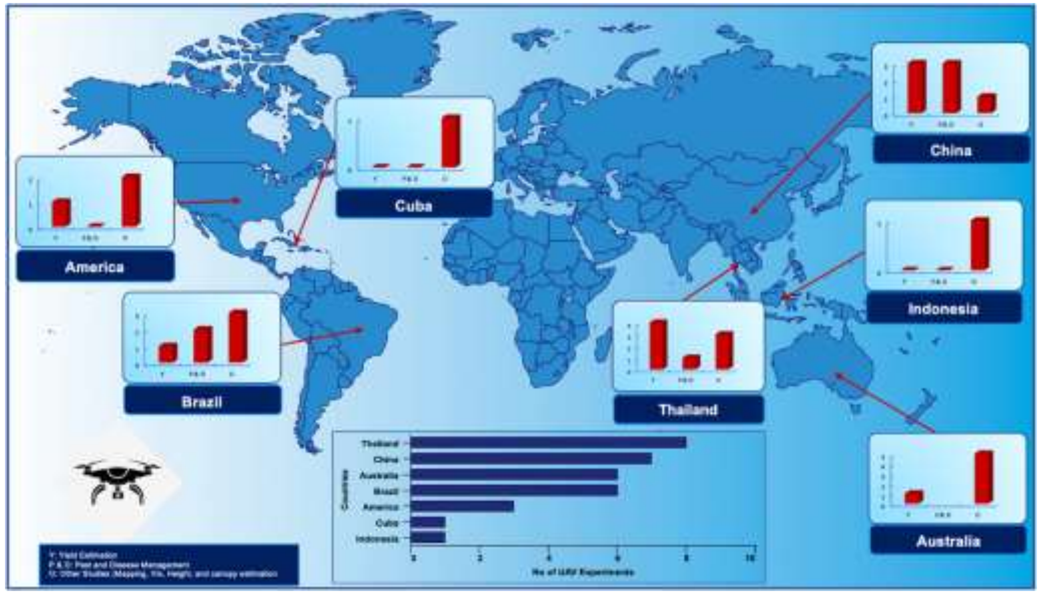
Its goal is to produce sugarcane with high yield and high sugar content.

- “Pilot Implementation Plan for the Construction of High Quality, High Yield, and High Sugar Sugarcane Demonstration Base in Guangxi”: Actively promote the construction of sugar cane double-high base
- “Digital Agriculture and Rural Development Plan (2019-2025)”: Developing an integrated space-air-ground observation system for agriculture and rural areas

1. Background - Industry Prospects

Remote sensing technology shows great advantages and potential for innovating service models in the sugarcane industry.

- **Smart agriculture has become a strategic development line for modern agriculture, and remote sensing technology is inseparable from smart agriculture.**
- **Remote sensing technology has been increasingly applied in sugarcane production and demonstrates distinct advantages in crop quality monitoring.**



Global distribution diagram of sugarcane remote sensing technology applications

Remote sensing for high-throughput crop phenotyping

Outline

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- ☐ **Main applications**
- ☐ Some thoughts

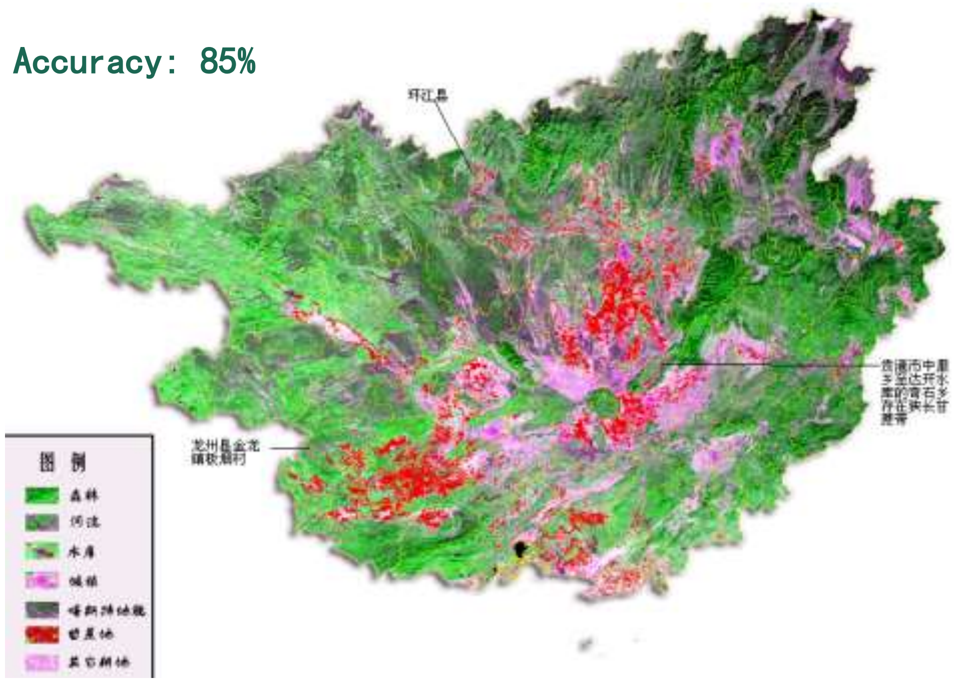
2. Application of Remote Sensing Technology - Area Extraction

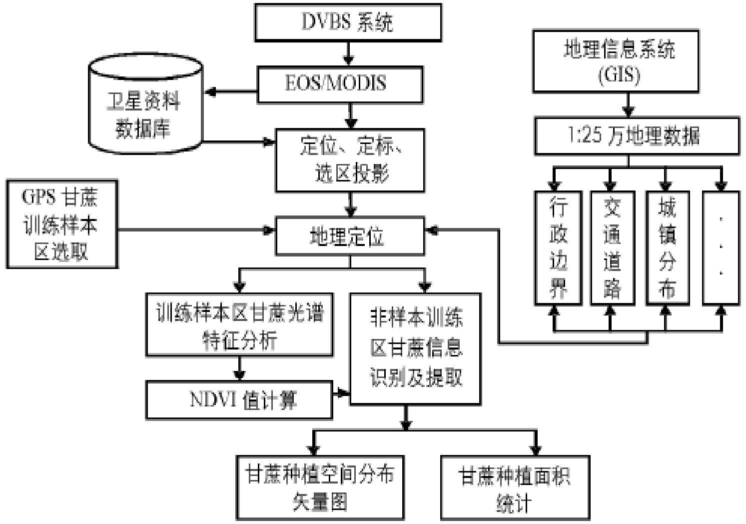
◻ Area Extraction（MODIS，250m）

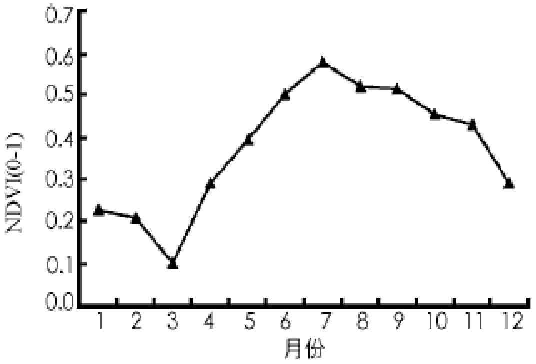
NDVI → Phenological division → Supervised classification → Multi- temporal exclusion

Complex topography and dispersed nature of the sugarcane plots resulted in unsatisfactory extraction accuracy

Accuracy: 85%







NDVI variation curve of sugarcane in training areas of Guangxi from 2001 to 2006

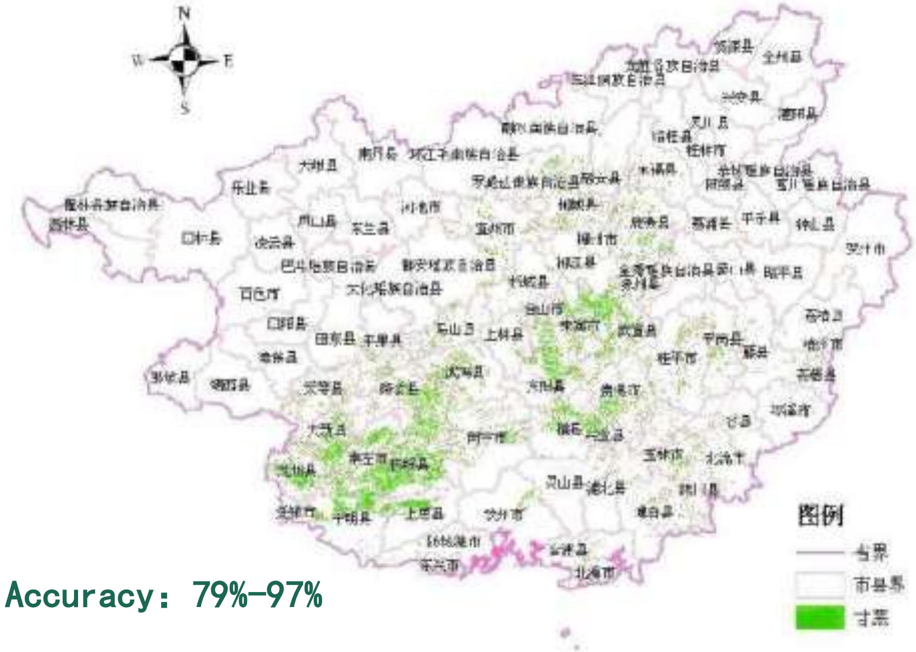
(Ding et al, Journal of Southwest University, 2008)

2. Application of Remote Sensing Technology - Area Extraction

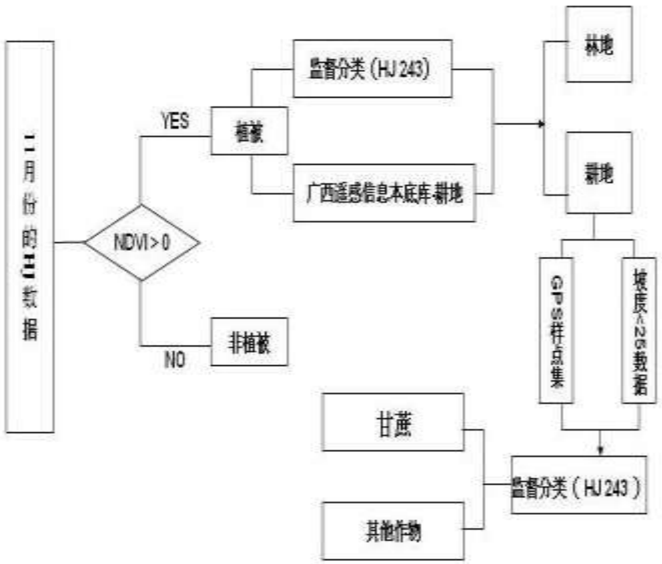
□ Area Extraction（HJ CCD，30m）

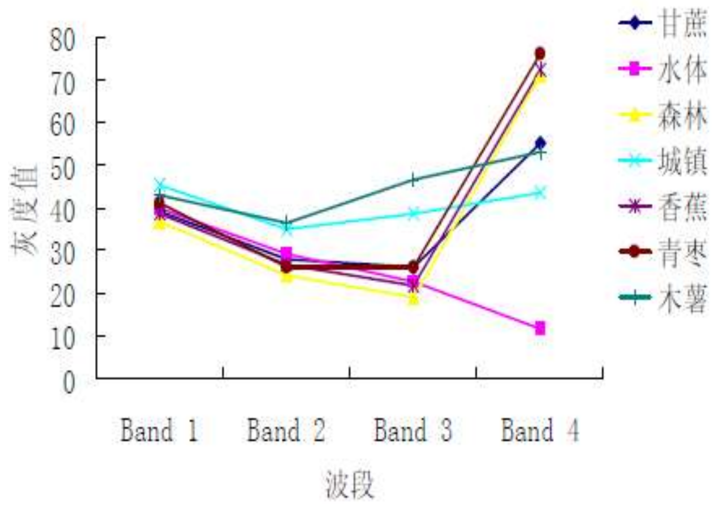
Decision tree classification ➕ Supervised classification

Limited availability of clear-sky data poses a challenge,and accuracy between plains and mountainous areas show significant difference



Accuracy：79%–97%





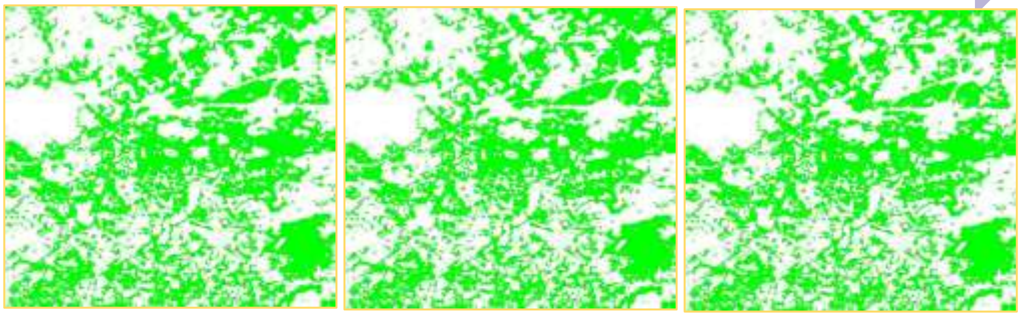
Spectral characteristics analysis of typical land features such as sugarcane

（Li et al.， *International Conference on Remote Sensing，2010*）

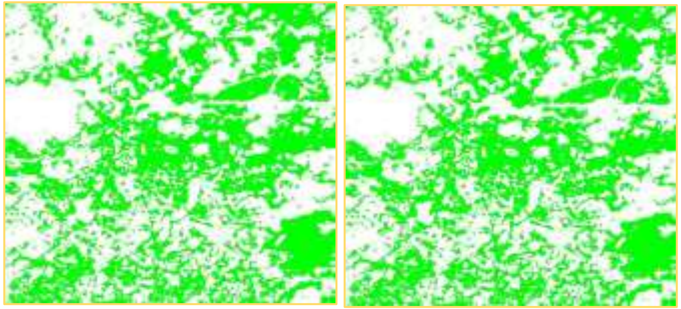
2. Application of Remote Sensing Technology - Area Extraction

□ Area Extraction（MODIS/FY3+HJ fusion）

Remote sensing data → Spectral feature → Identification model → Sugarcane identification



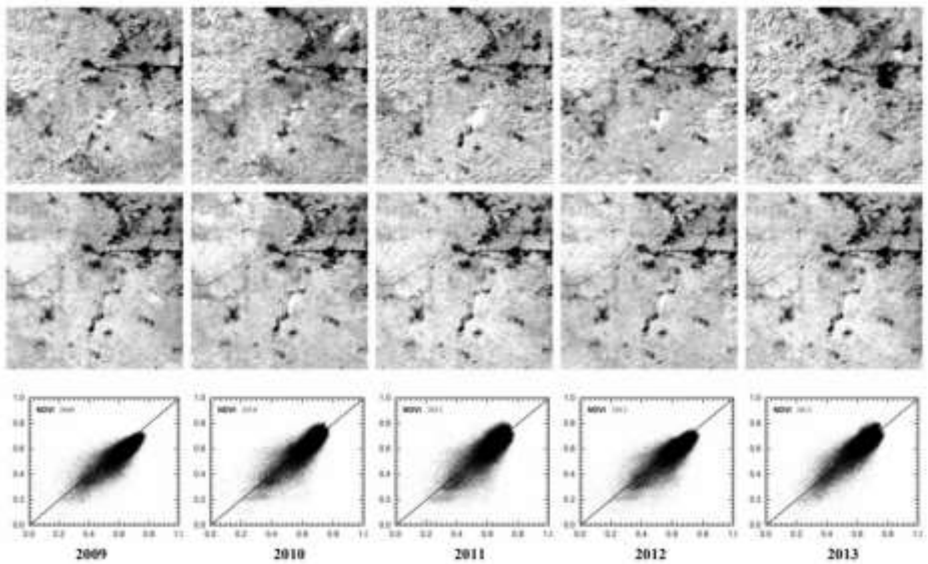
97-113d 97-129d 97-145d

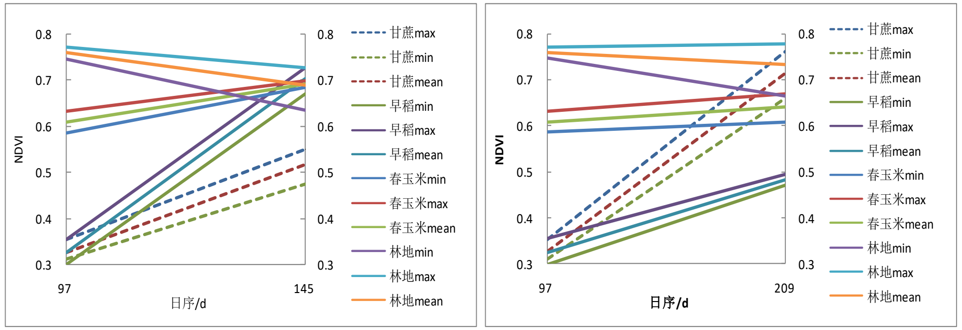


97-193d 97-209d

Accuracy: ＞ 90%

（Chen et al., Journal of the Indian Society of Remote Sensing,2020）

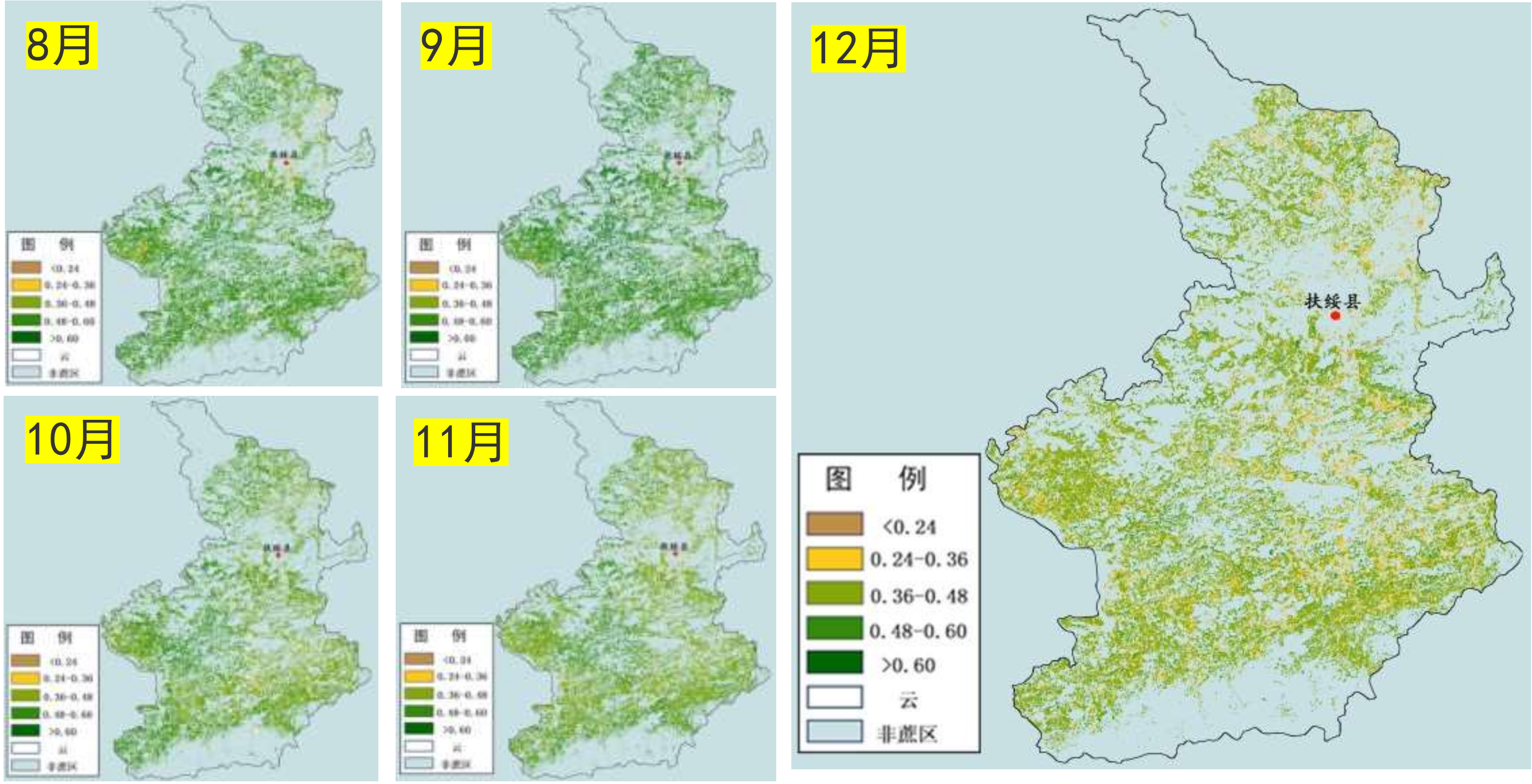




NDVI change rate $V = \dfrac{NDVI_t - NDVI_s}{D}$

2. Application of Remote Sensing Technology - Growth Assessment

□ First generation product



- ✓ weak indicator
- ✓ weak correlation with yield
- ✓ subjective rating system

2. Application of Remote Sensing Technology - Growth Assessment

- □ Update product

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QX

中华人民共和国气象行业标准

QX/T 284—2015

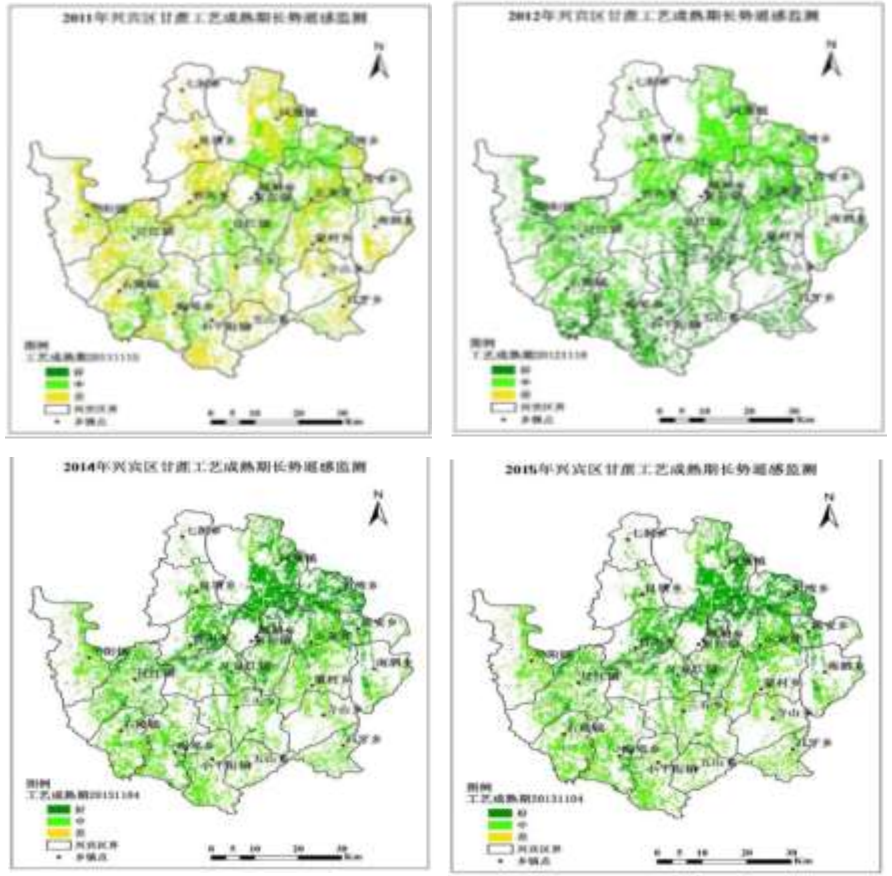
甘蔗长势卫星遥感评估技术规范

Technical specifications for evaluation on sugarcane growth status by satellite remote sensing

2015-07-21 发布 2015-12-01 实施

中国气象局 发布

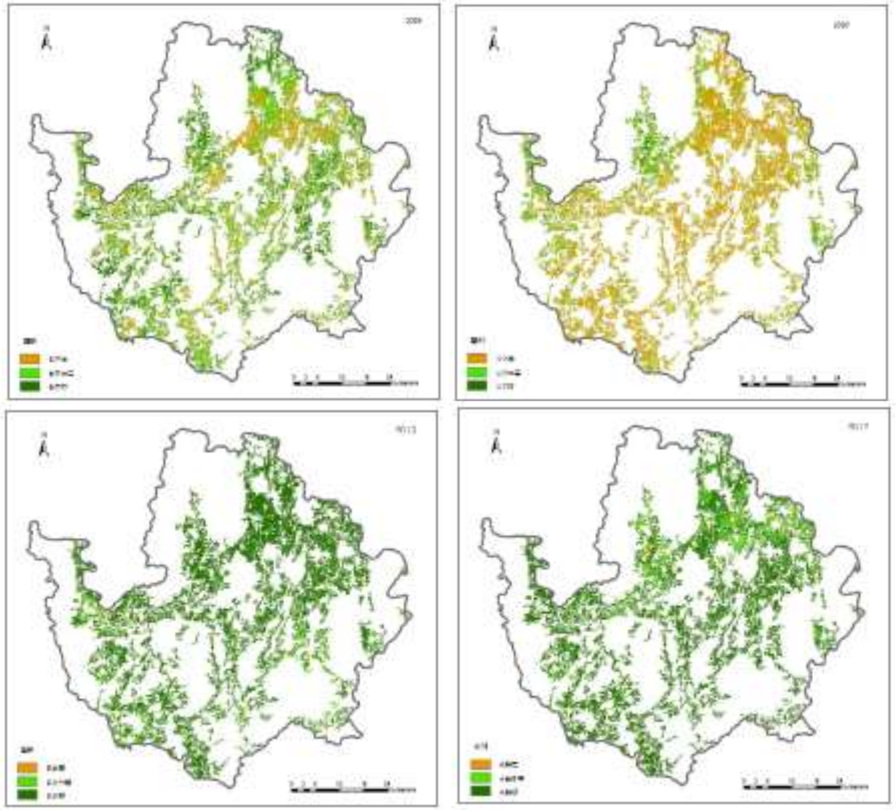
（Ding et al., Industry standard，2015）



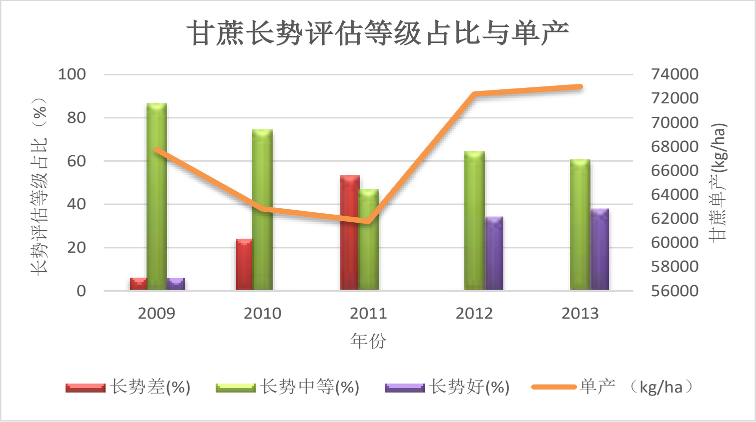
- ✓ 3-level system: good, medium, poor
- ✓ tied directly to yield: Good (High yield), Medium (medium yield), Poor (low yield)
- ✓ allowed for year-to-year comparison
- ✓ released an industry standard in 2015

2. Application of Remote Sensing Technology - Growth Assessment

Remote sensing data fusion → Relationship between Crops and NDVI → Construction of growth model → Growth assessment

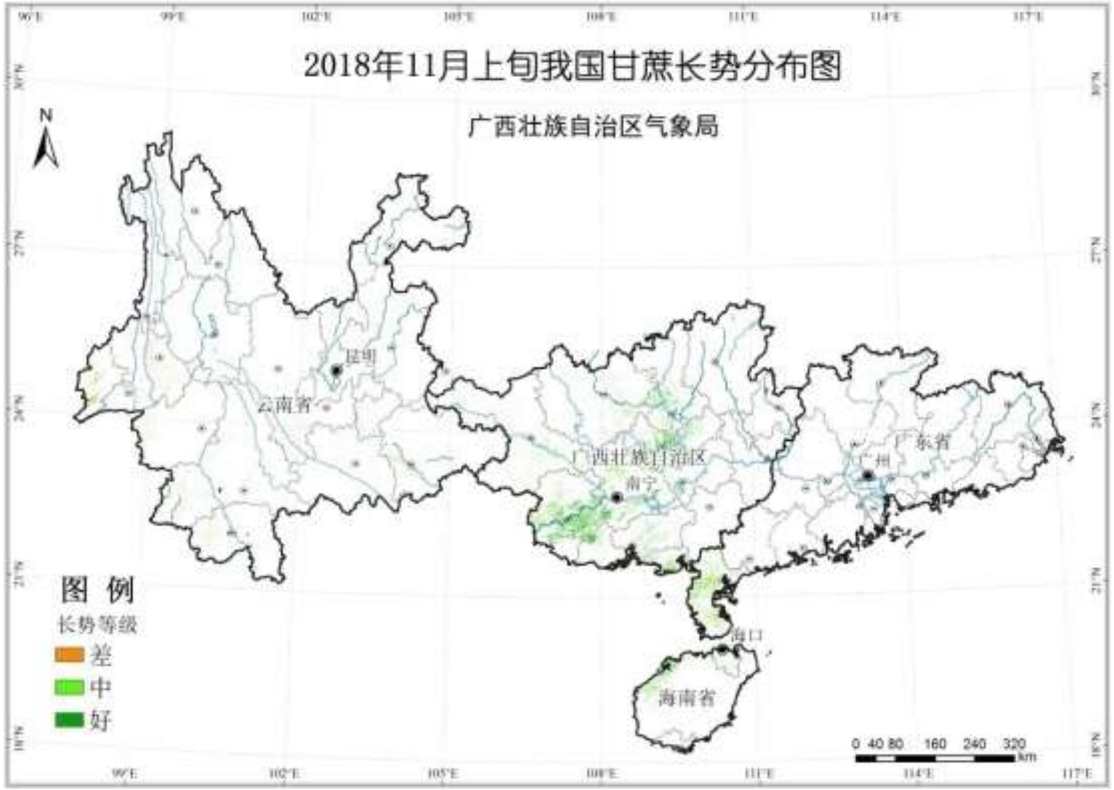


Crops	Models	Leaf Area Index	NDVI
Good	$Y=0.146x^{0.524}$	11	>0.51
Medium		8～11	0.43–0.51
Poor		8	<0.43

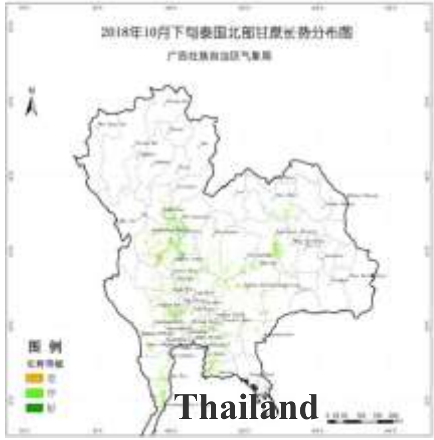


- ✓ better growth, higher yield per unit
- ✓ growth assessment product is a strong predictor of the final yield.

2. Application of Remote Sensing Technology - Growth Assessment



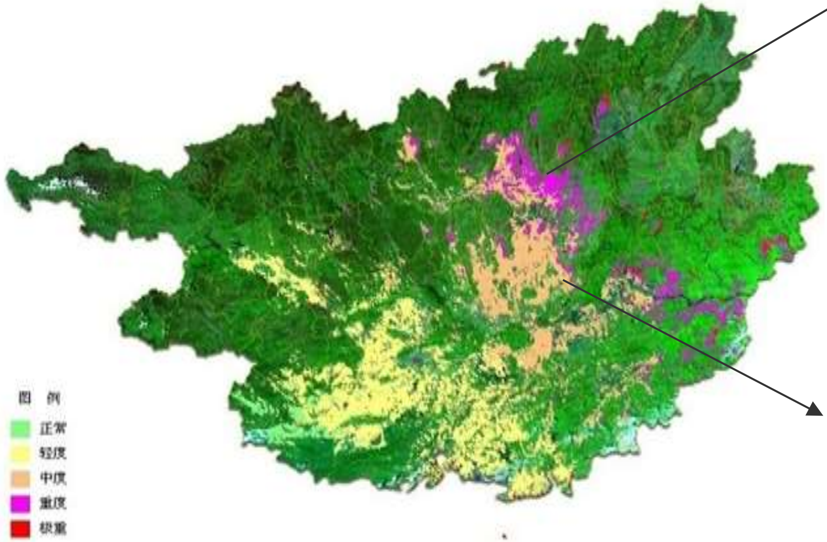
Guangxi Eco-Meteorological Remote Sensing Annual Report



2. Application of remote sensing technology - Frost Damage

Sugarcane frost damage model that integrates real-time weather, forecasts, and GIS. This allows us to quantify freeze damage losses accurately.

(Kuang et al., Journal of Applied Meteorology, 2009; Tan et al., Meteorology, 2010)

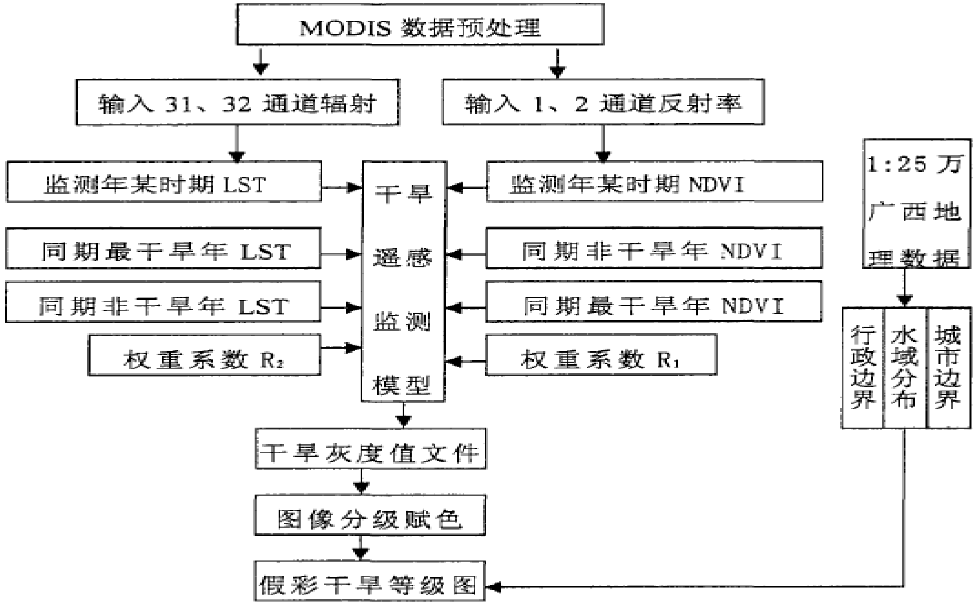


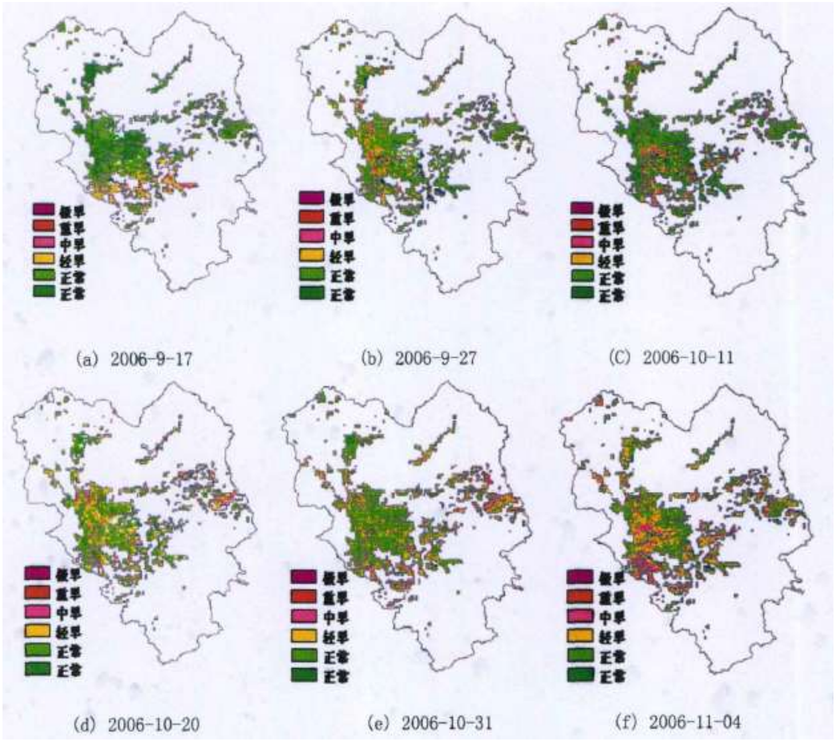
Serious and extremely severe damage 13.6%

Moderate damage 37.5%

2. Application of Remote Sensing Technology - Drought

A drought monitoring model (DI) for sugarcane was developed using the Vegetation Condition Index (VCI) and the Temperature Condition Index (TCI). Practical validation has confirmed its applicability for monitoring drought conditions in sugarcane.

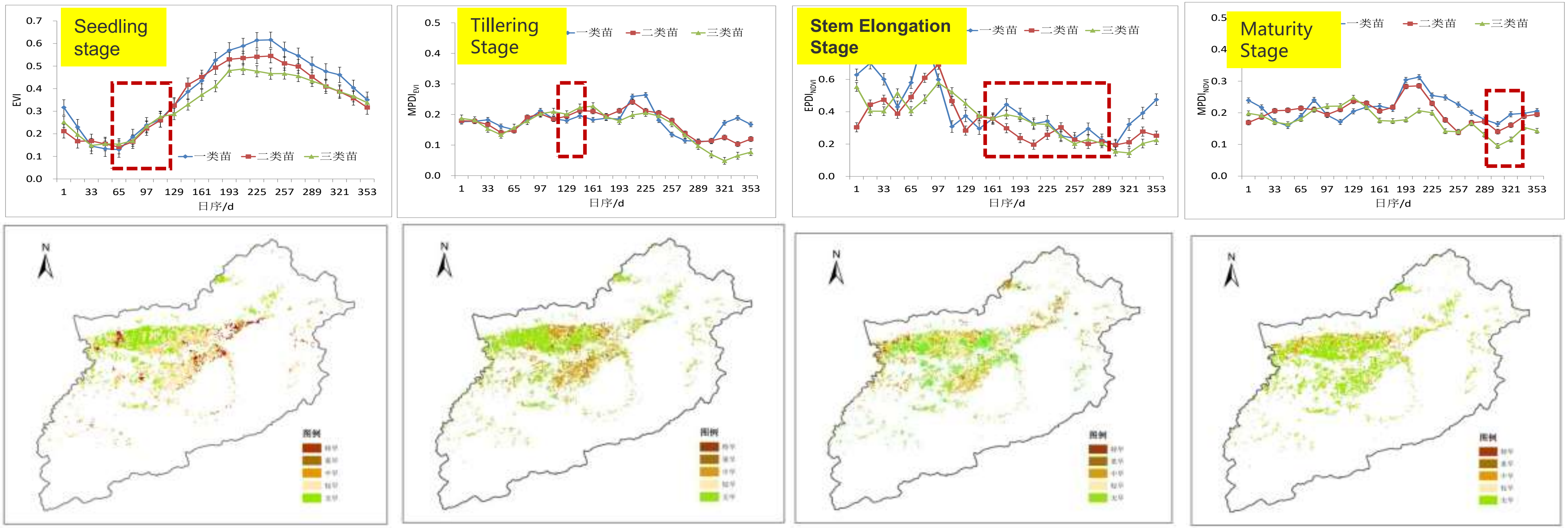




(Kuang et al., Chinese Agricultural Meteorology, 2007)

2. Application of Remote Sensing Technology - Drought

A single drought index doesn't work well for the entire sugarcane season. Best drought indexes for monitoring sugarcane at each growth stage varies: Seedling Stage: EVI; Tillering Stage: $MPDI_{EVI}$; Stem Elongation Stage: $EPDI_{NDVI}$; Technical Maturity Stage: $MPDI_{NDVI}$



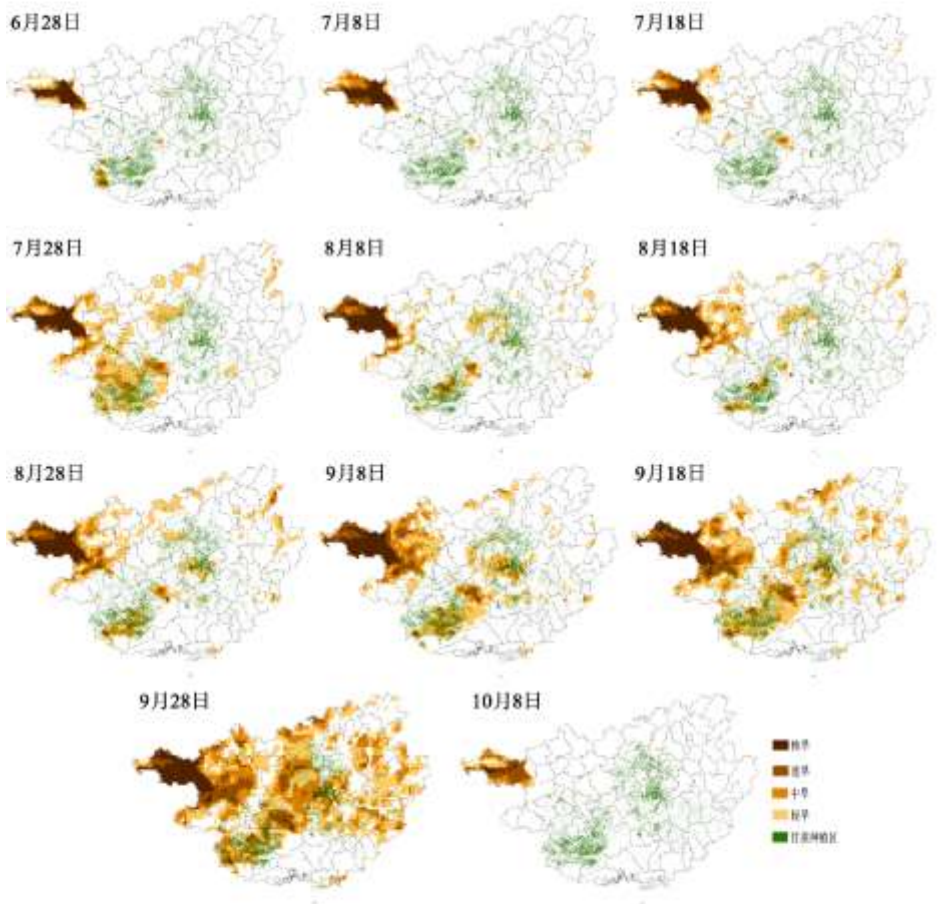
(Chen et al., CAU paper, 2020)

2. Remote Sensing Technology Application - Drought

CLDAS data works well for drought monitoring. By combining CLDAS with HWSD, we created a new drought index. Its error is below 8%.

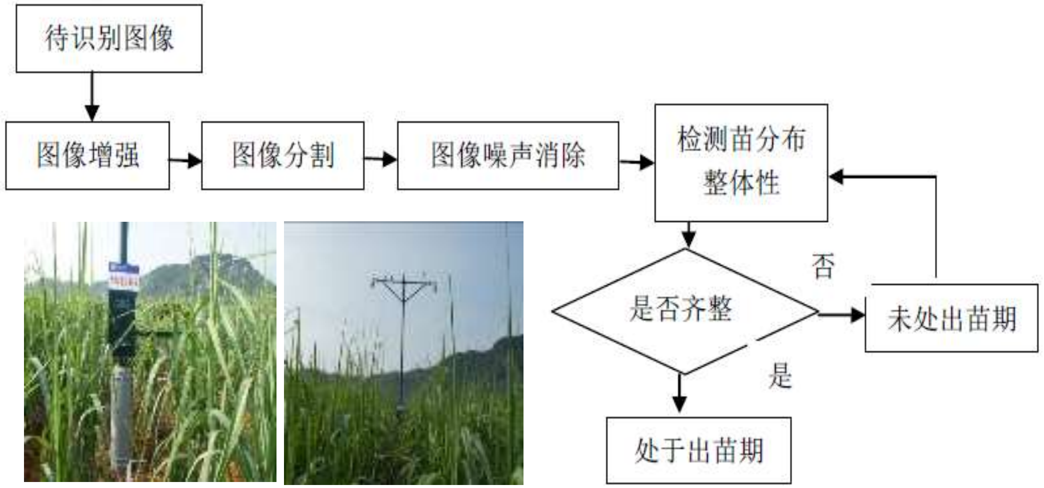
Levels	Agricultural drought level	Sugar cane drought disaster level	CLDAS sugarcane drought index
Non-drought	$R_{sm}>60$	$R_{sm}\geq70$	$R_{sm}\geq75$
Light drought	$50<R_{sm}\leq60$	$65\leq R_{sm}<70$	$70\leq R_{sm}<75$
Medium drought	$40<R_{sm}\leq50$	$60\leq R_{sm}<65$	$65\leq R_{sm}<70$
Severe drought	$30<R_{sm}\leq40$	$50\leq R_{sm}<60$	$55\leq R_{sm}<65$
Extrem drought	$R_{sm}<30$	$R_{sm}<50$	$R_{sm}<55$

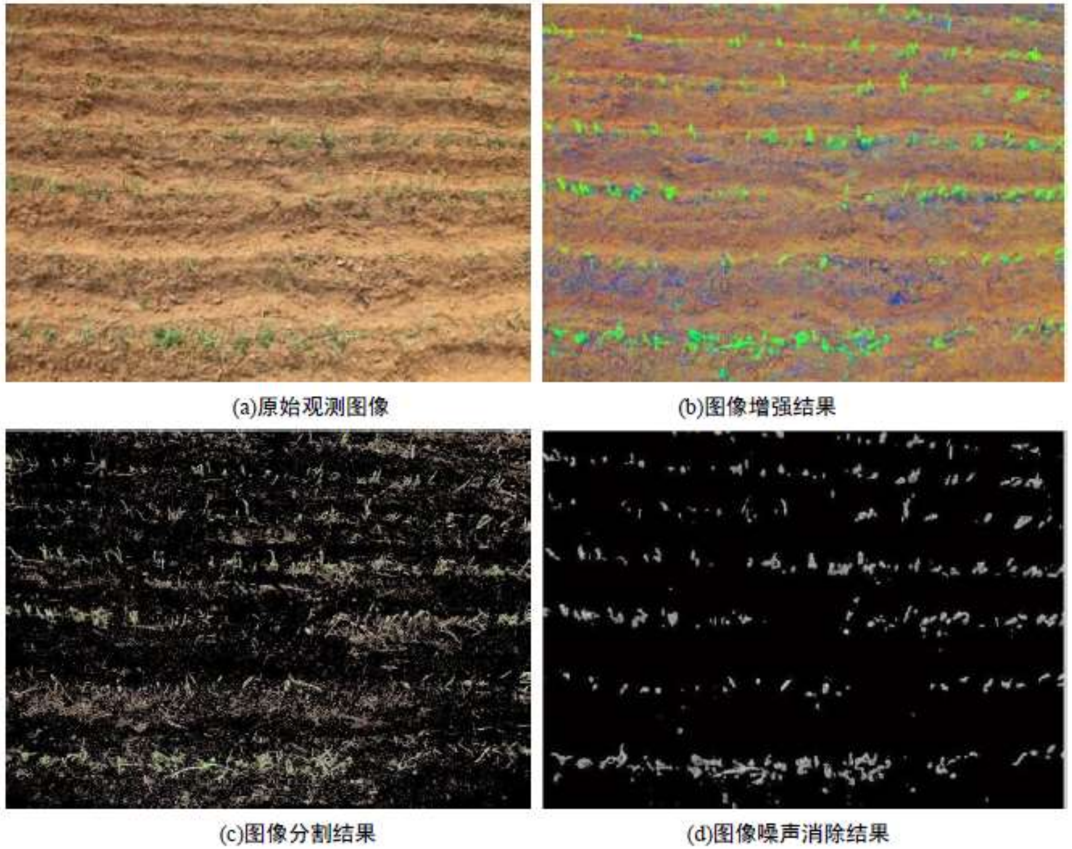
(Chen Yanli et al., Arid Meteorology, 2020)



2. Application of Remote Sensing Technology - Seedling Detection

Images from our automated agri-weather stations can identify sugarcane emergence.Compared to manual observations, the difference is less than 6 days. The overall identification result is quite satisfactory.





(Liu et al., Sugarcane Sugar Industry, 2020)

2. Application of Remote Sensing Technology - Yield Estimation

Yield estimation models for key growth stages and full-season were established. The full-season model performed better.

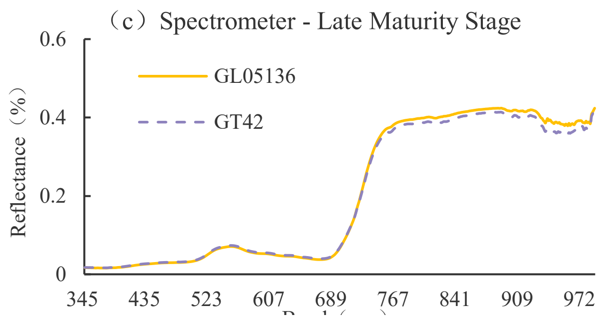
模型类型	模型方程	R^2	F	Sig.
多元线性方程	$Y=8.779EVI_{s1}-0.999EVI_{s2}+1.523NDVI_{s3}-1.548$	0.746	5.518	0.009

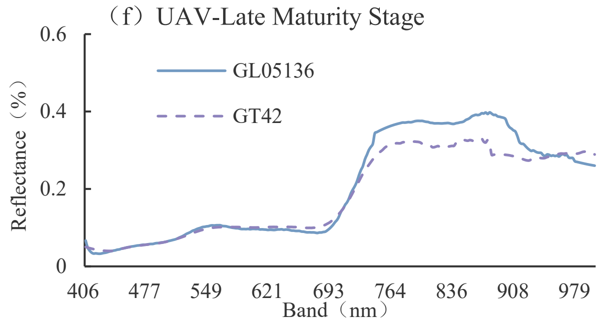
Accuracy analysis of sugarcane yield estimation model

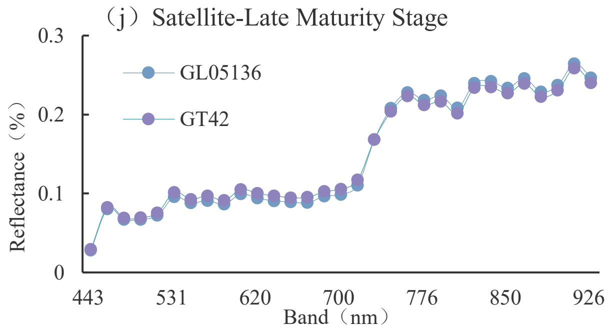
生育期	模型方程	误差分析	高安乡	侨巩乡	陶邓乡	蒙村乡
工艺成熟期	线性方程	实际单产（吨/亩）	4.42	4.34	4.59	4.65
		估测单产（吨/亩）	4.56	4.48	4.73	4.57
		相对误差（%）	3.13	3.22	3.14	-1.64
糖分积累期	线性方程	估测单产（吨/亩）	4.58	4.45	4.61	4.60
		相对误差（%）	3.66	2.50	0.41	-1.12
	对数方程	估测单产（吨/亩）	4.58	4.45	4.61	4.60
		相对误差（%）	3.72	2.47	0.47	-1.06
茎伸长中期	一元二次方程	估测单产（吨/亩）	4.49	4.46	4.49	4.57
		相对误差（%）	1.51	2.81	-2.13	-1.76
	线性方程	估测单产（吨/亩）	4.54	4.43	4.55	4.64
		相对误差（%）	2.66	2.09	-0.92	-0.22
全生育期	多元线性方程	估测单产（吨/亩）	4.52	4.41	4.58	4.63
		相对误差（%）	2.33	1.64	-0.24	-0.45

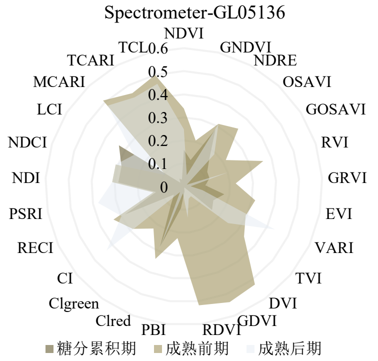
2. Application of Remote Sensing Technology - Sugar Content

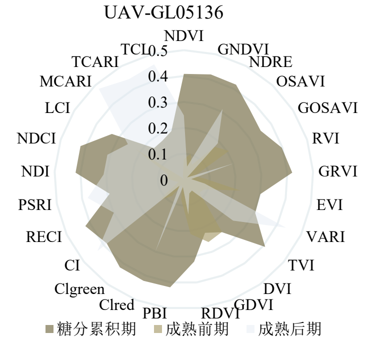
Hyperspectral data works for estimating sugar levels. And drones really stand out here.Their accuracy beats both handheld hyperspectral sensors and satellites.

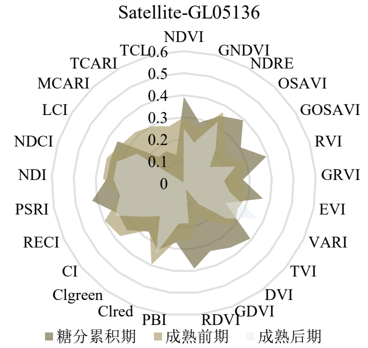






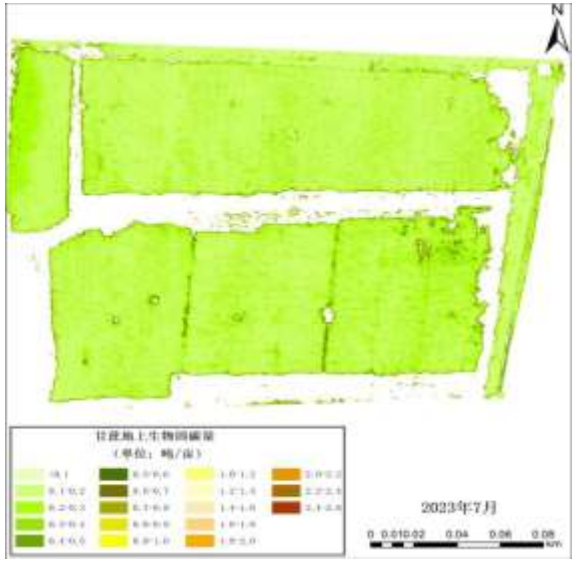


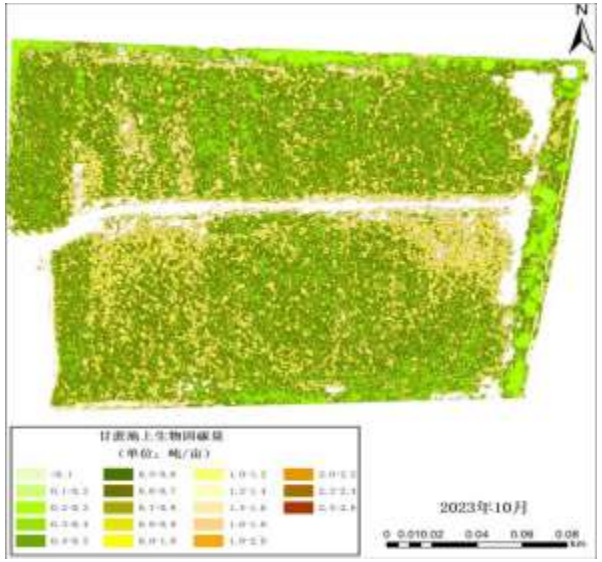


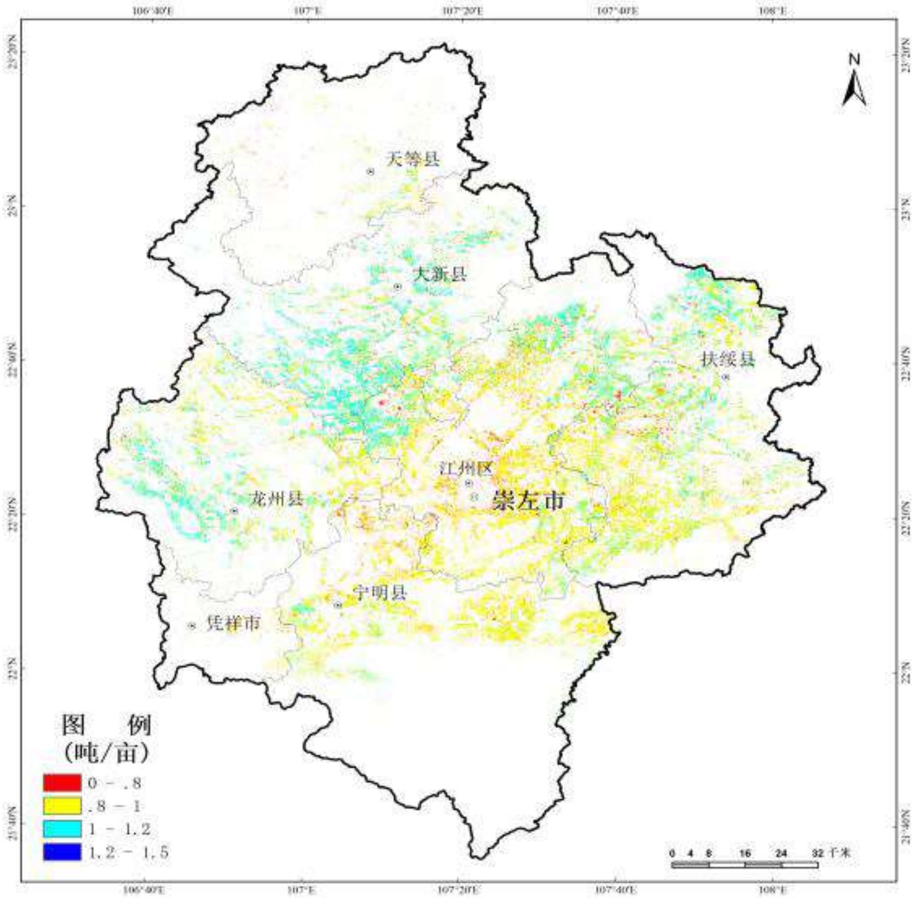


2. Application of Remote Sensing Technology - Carbon Sequestration Calculation

Remote sensing can also monitor carbon sequestration in sugarcane. By fusing ground data with drone multispectral indices, we can now track sugarcane carbon sinks dynamically.







(Guangxi Ecological Meteorological Remote Sensing Annual Report, 2024)

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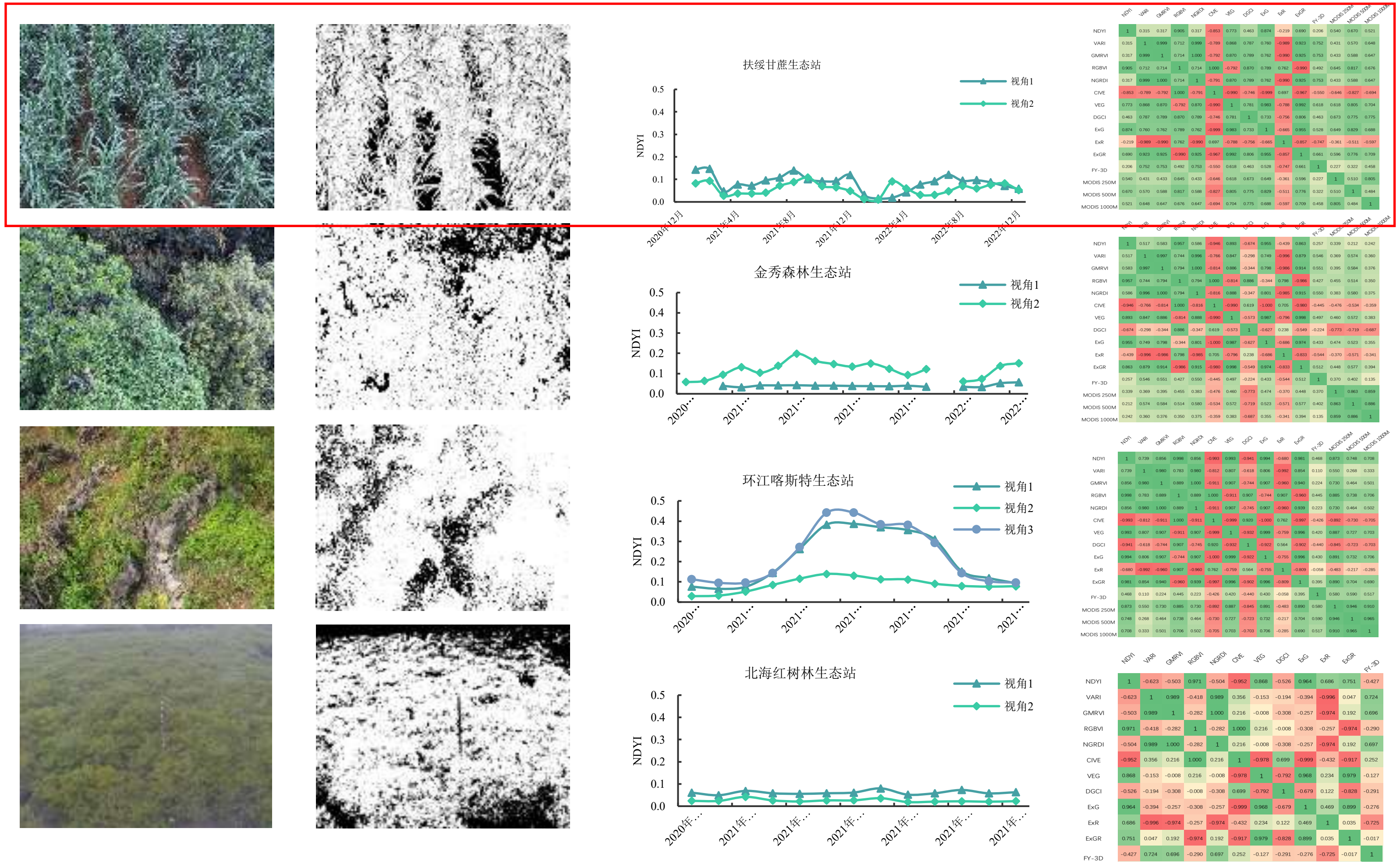
3. Some thoughts

Ground-based remote sensing has great potential in sugarcane production. It enables early pest detection and disaster verification.However, process-based models for weather impacts on sugarcane need more research.



Thanks