Integration and application of key technologies in precision agriculture

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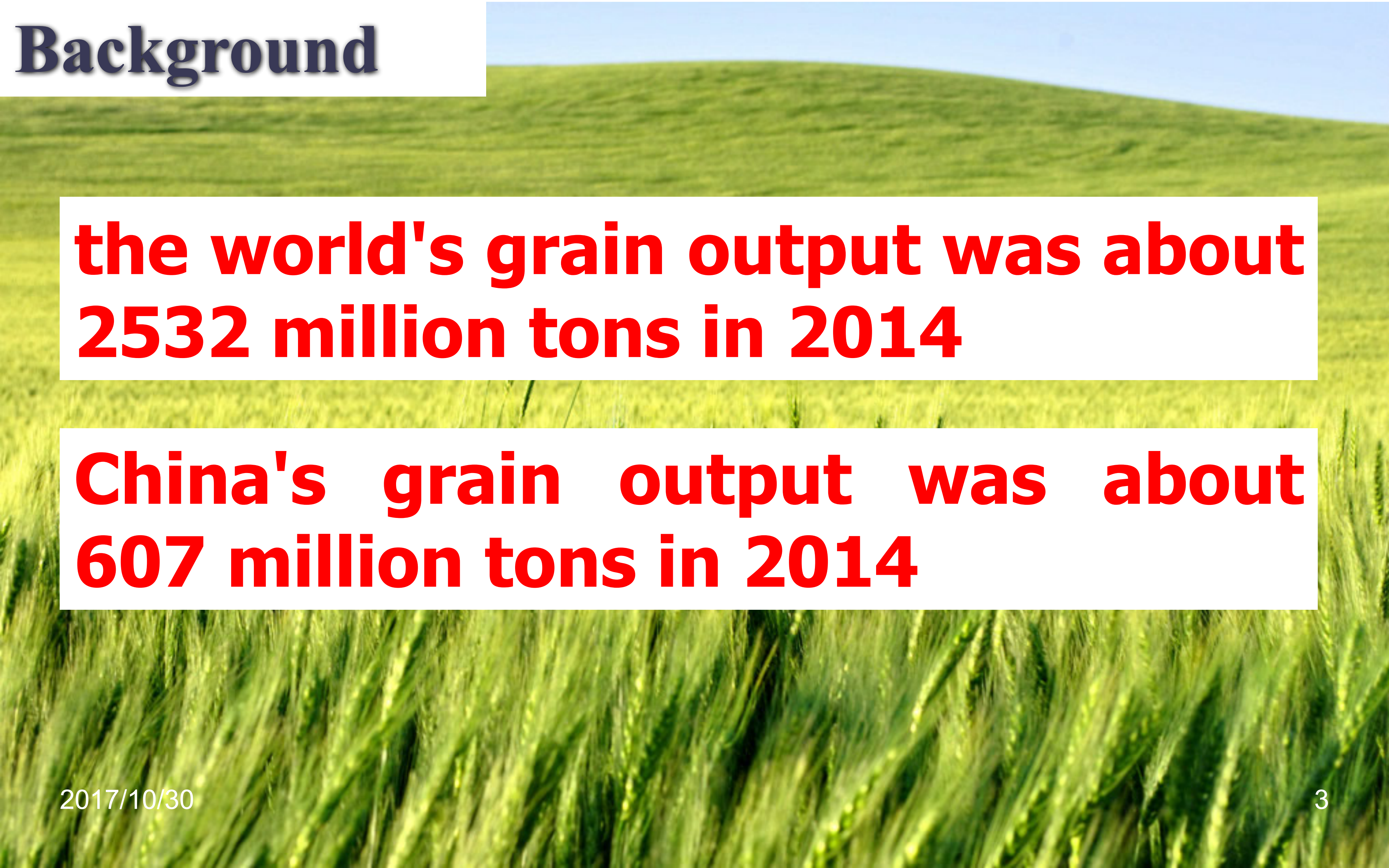
1. Overview of precision agriculture
2. The supporting techniques of precision agriculture
3. Research status of key technology of precision agriculture
4. Integration and application of precision agriculture key technology

1 Overview of precision agriculture



Background

the world's grain output was about 2532 million tons in 2014

China's grain output was about 607 million tons in 2014

1 Overview of precision agriculture

Background

1 Overview of precision agriculture

Background

Problems in agriculture:

Energy consumption is high,

environmental pollution is serious,

market competition is fierce

To realize the harmony between human and nature

Sustainable agriculture

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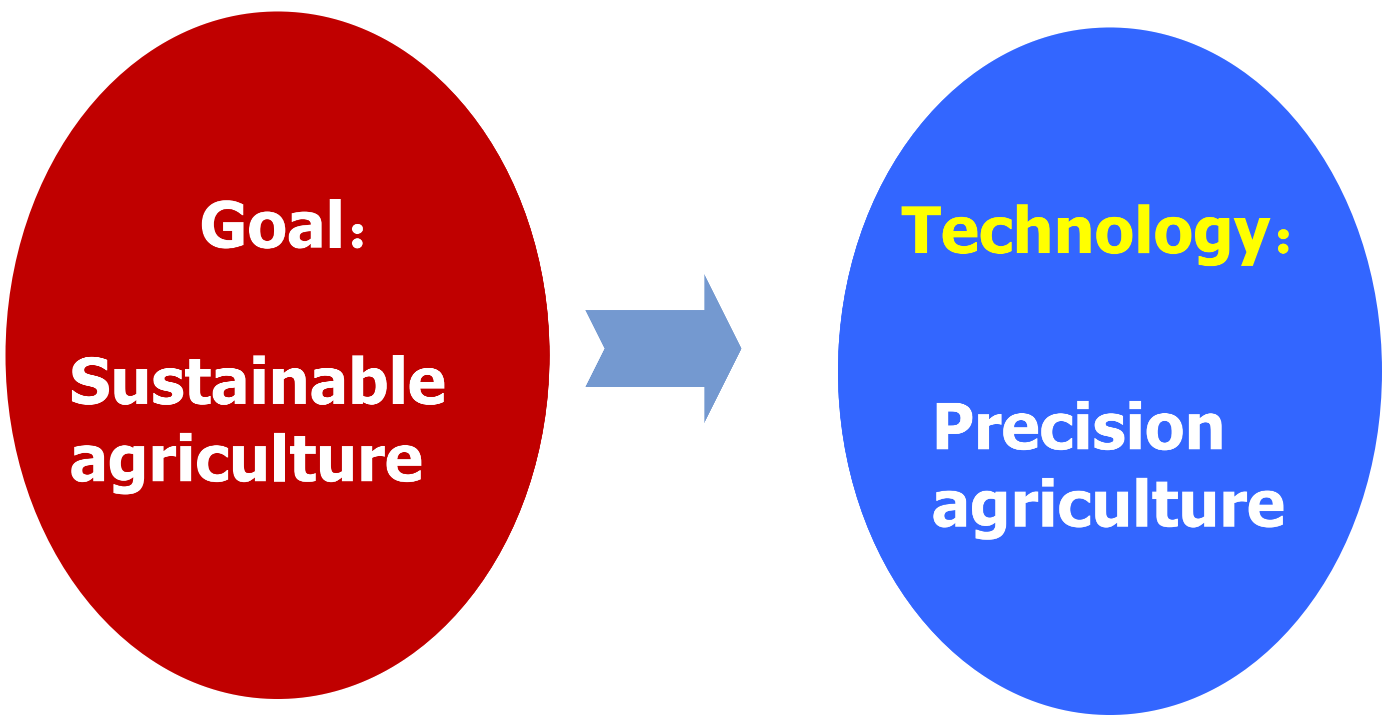
Background



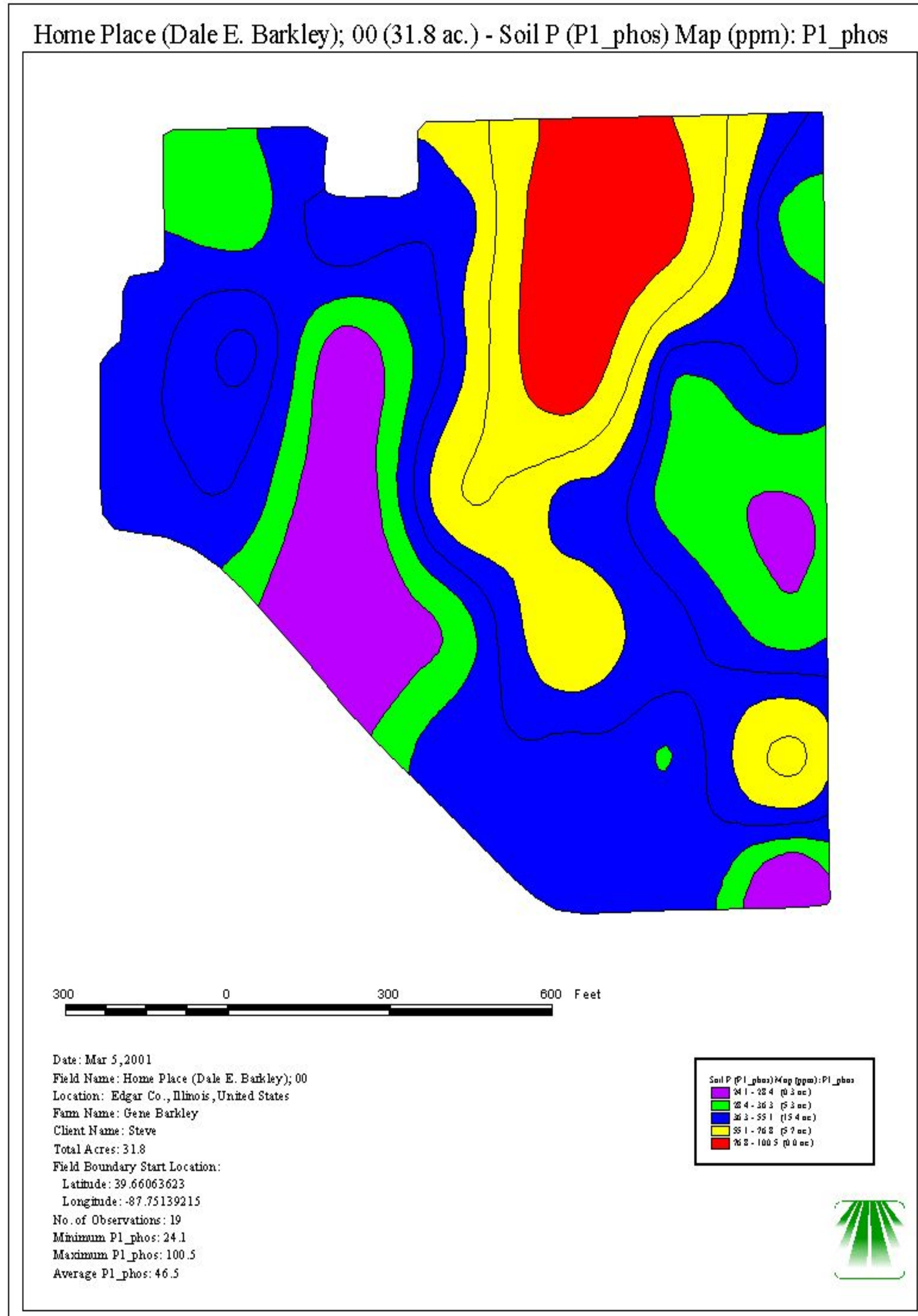
1 Overview of precision agriculture

Background

Spatial and temporal variability of cropland

1 Overview of precision agriculture

Background



spatial distribution of phosphate fertilizer content in a Farmland

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Background

Spatial and temporal variability of cropland

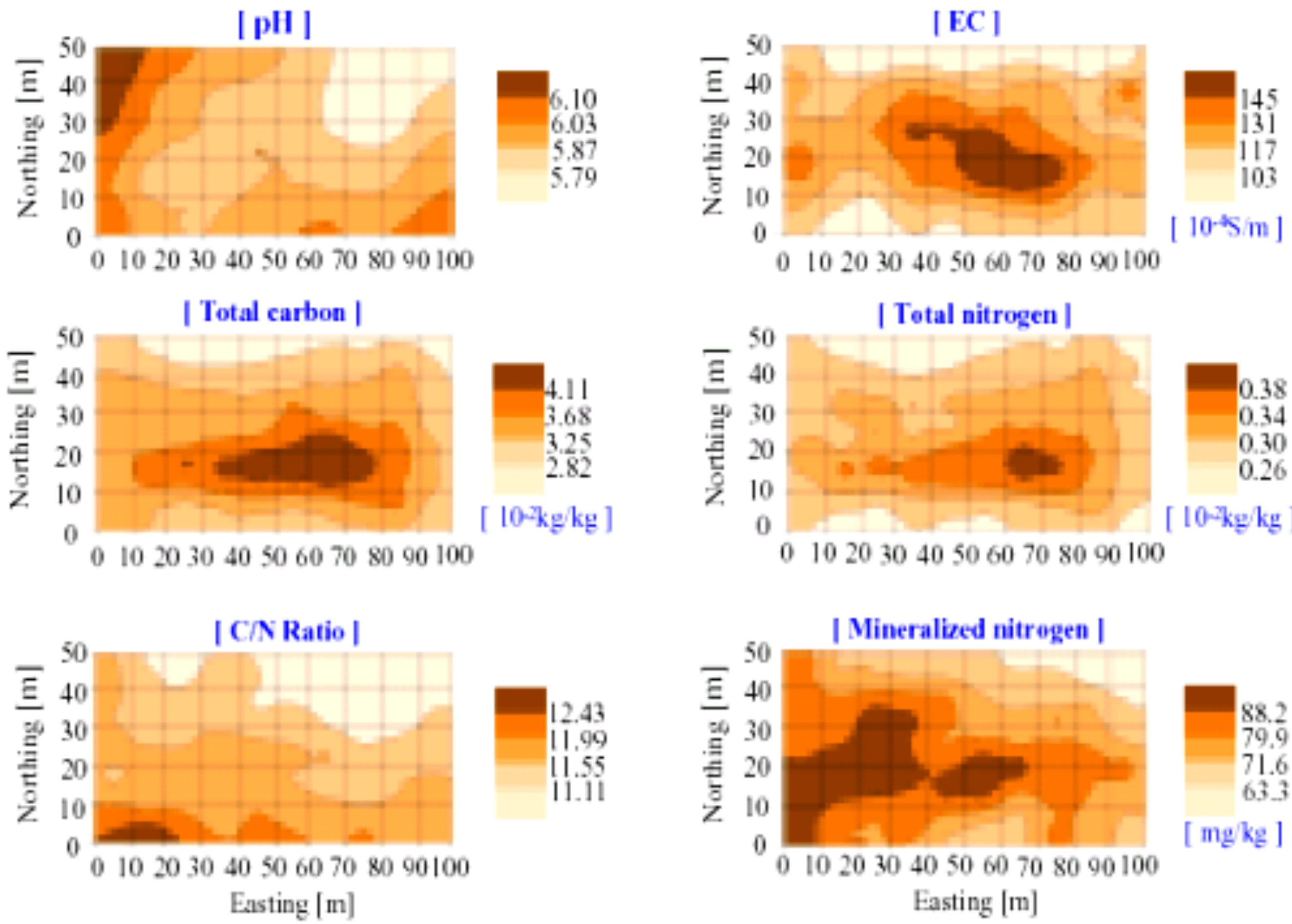

Fig. 11 Soil chemical property map in 2000

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Background

Spraying(Farming) Uniformly

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Basic Conception

traditional farming → **Uniform operation, ignoring variation**

↓

New farming → **Field management based on variation**

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Basic idea on farming:

intensive and meticulous farming

A traditional Chinese painting on farming and harvesting

the Southern Song Dynasty (1127-1279）

1 Overview of precision agriculture

Basic idea on farming:

intensive and meticulous farming

1 Overview of precision agriculture

Concept of Precision Agriculture

Precision agriculture(PA), also known as **precision farming(PF)**, is a broad term commonly used to describe particular farm management concepts, sometimes referred to as **site specific crop management (SSCM)**. The term first came into popular use with the introduction of **GPS** (global positioning satellites) and **GNSS** (global navigation satellite systems) as well as other methods of **remote sensing** which allowed farm operators to create precision maps of their fields that provide detailed information on their exact **location** while in-field. Advancements in technology have enabled the practice of precision agriculture to expand, providing even greater advantages for farmers and agricultural **operations**, including yield monitoring and crop scouting.

where？ when？ how？

1 Overview of precision agriculture

Terms：

Prescription farming

Site specific crop management　SSCM

Precision farming

Precision agriculture

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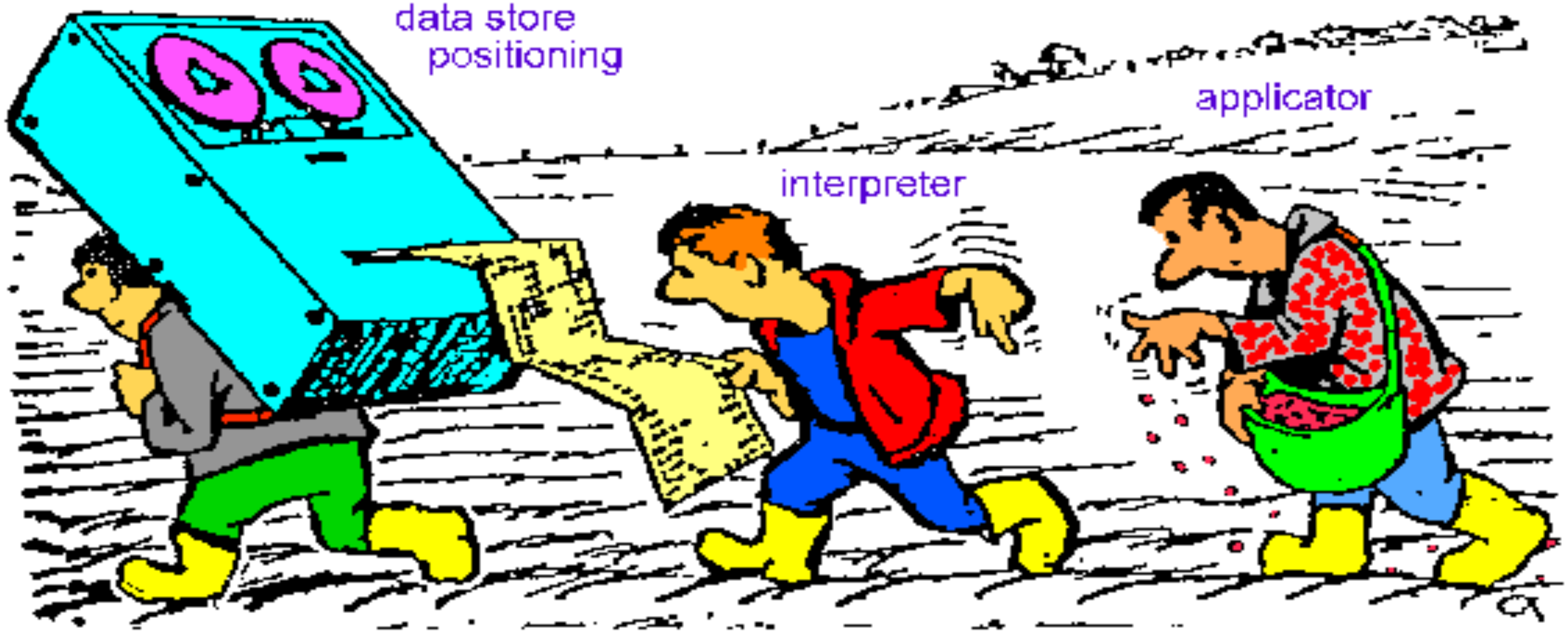
Process of PA



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Step 1：

grasp farmland variation Correctly

Soil

field operations

plant information

information acquisition technique and Sensors

Crop yield information

weather information

material used for agriculture

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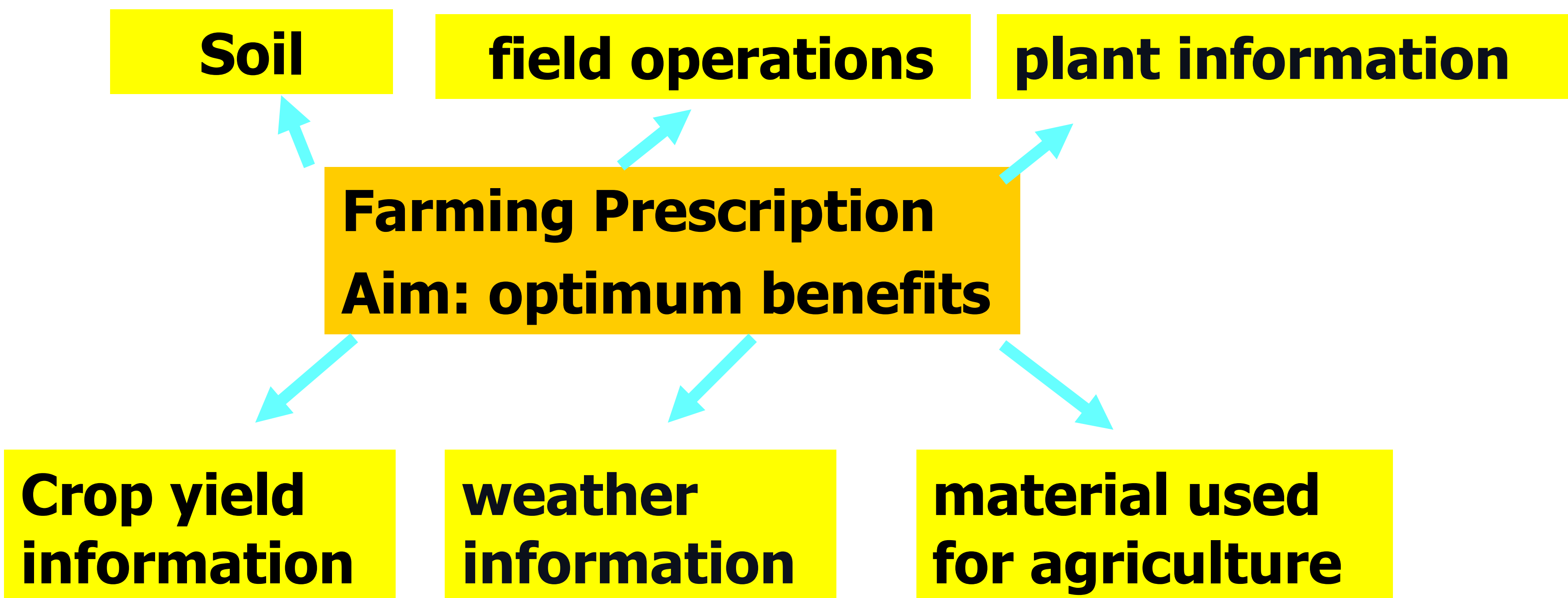
Step 2:

Modeling of agricultural production processes



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Step 2:

Realization – variable rate farming

Aim: optimum benefits

Precision Feitilization

Precision Seeding

Precision Irrigation

Precision Weeding

Pricision Deinsectization

Pricision Harvest

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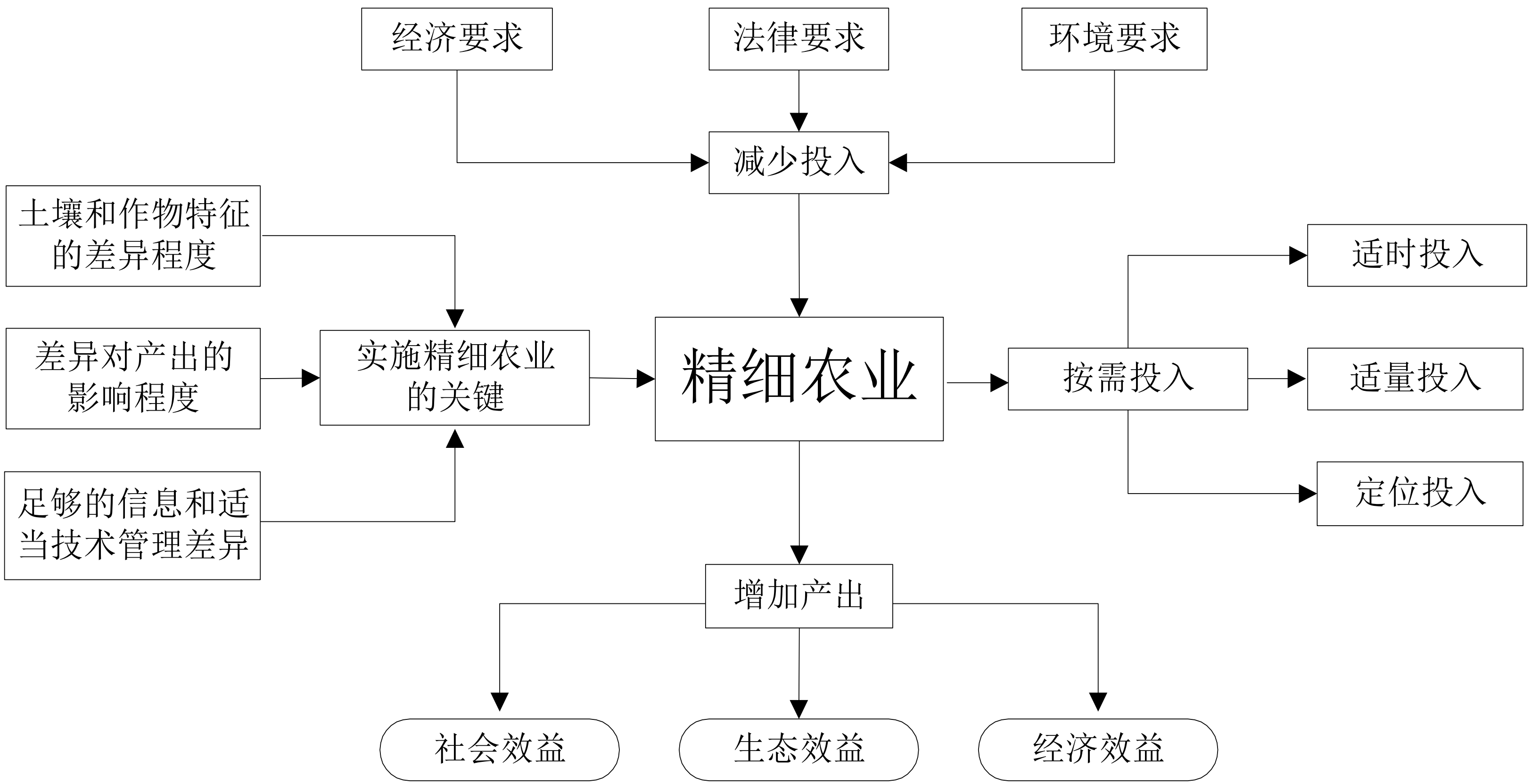

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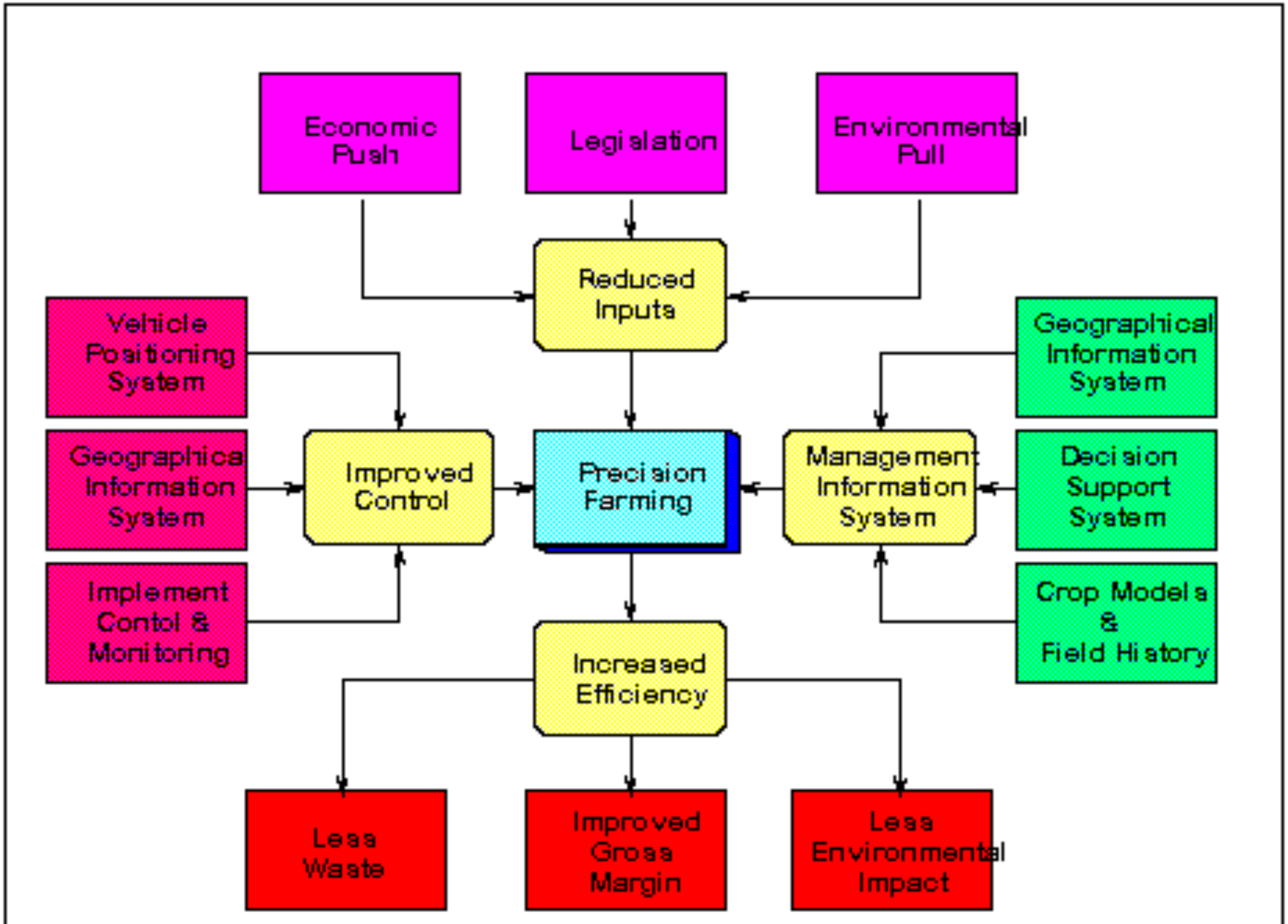

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Benefits of Precision Agriculture

- Increase productivity and net profit
- Better decision making ability
- Improve soil productivity
- Improve water quality
- Improve wildlife habitat
- Sustains natural resources for future generations.

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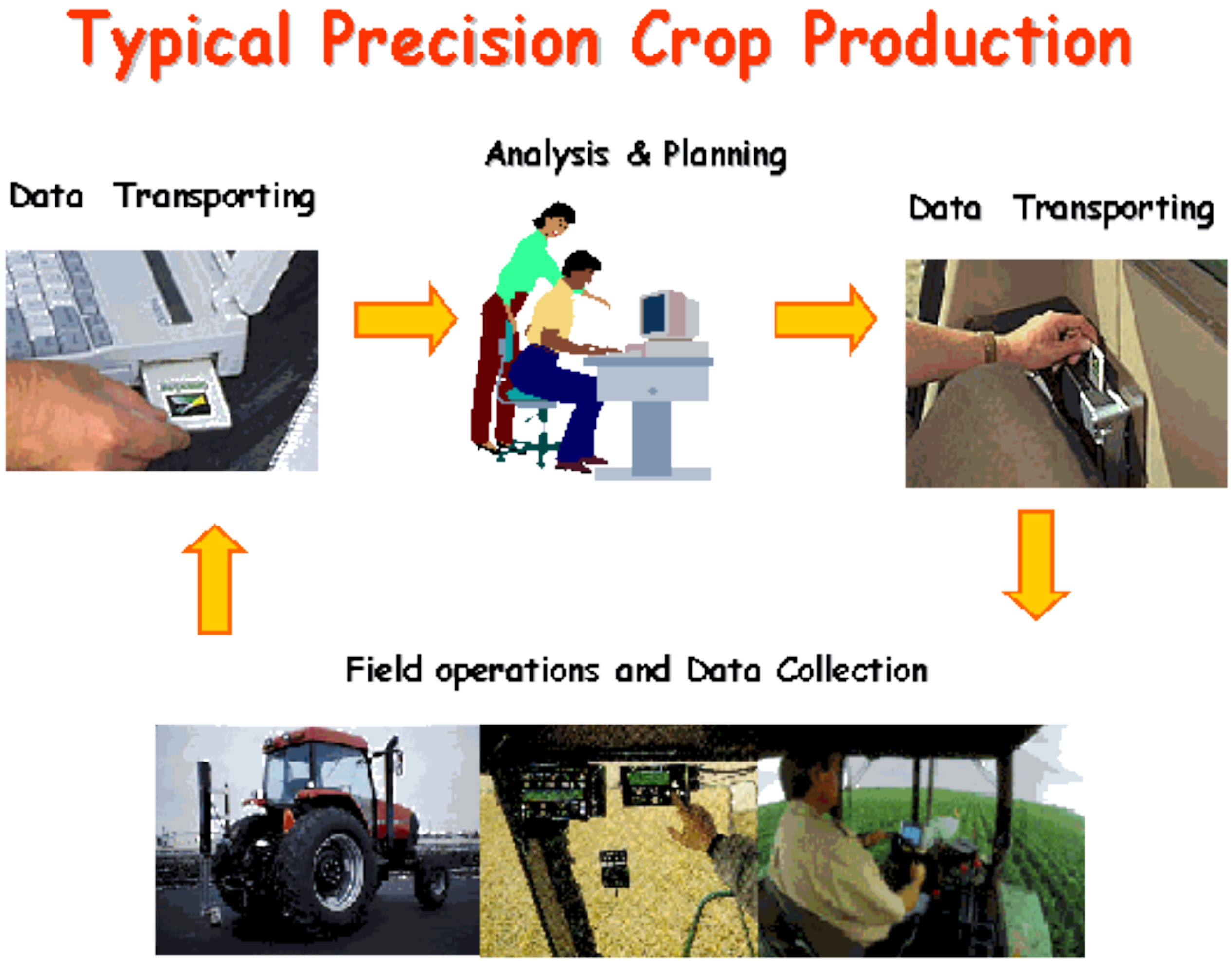

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Information Acquisition:

soil information

- Soil fertility
- Moisture content
- Soil texture
- Topography
- Pest population
- pH

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Soil Information

<u>Fast changers:</u>

- nitrate level
- moisture content
- pest population

<u>Slow changers:</u>

- topography
- texture
- pH

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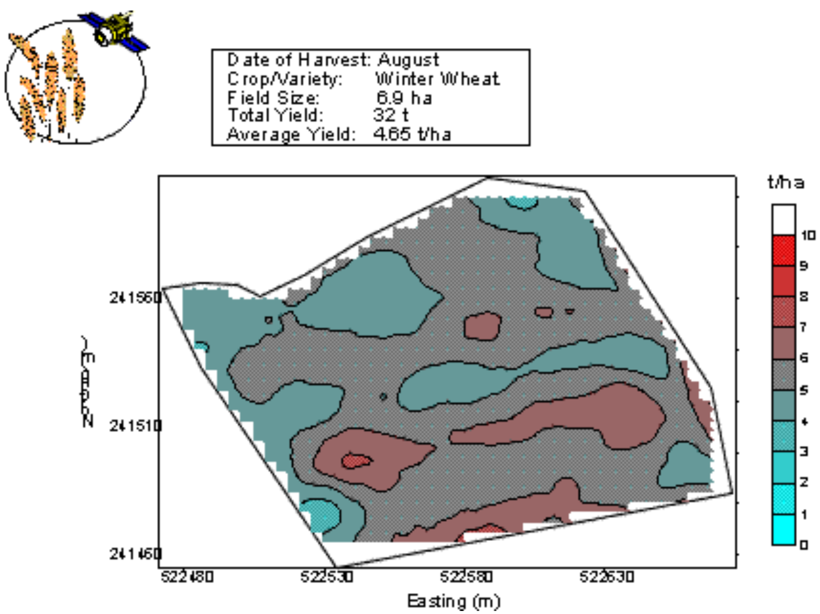
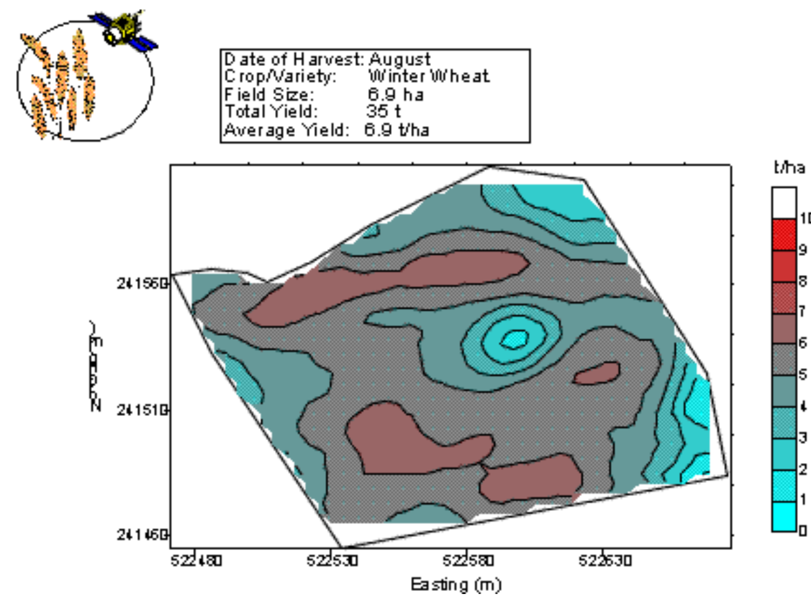
Information Acquisition: Yield Map

Yield Map

- Find the yield map
- Why the difference in the maps?





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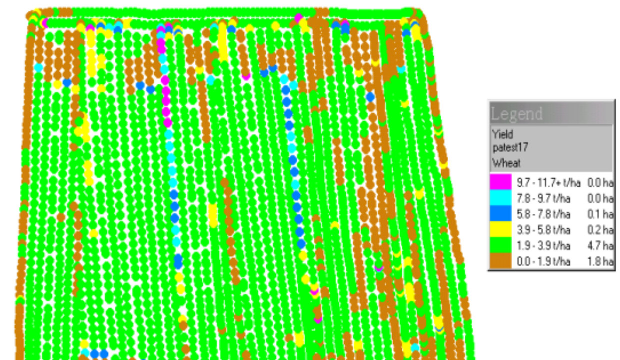
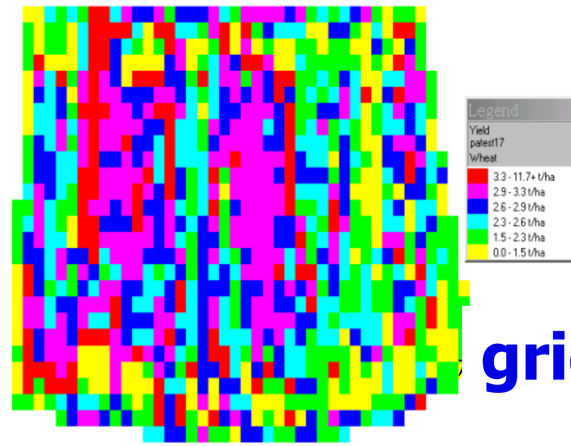
Information Acquisition: Yield Map

raw data

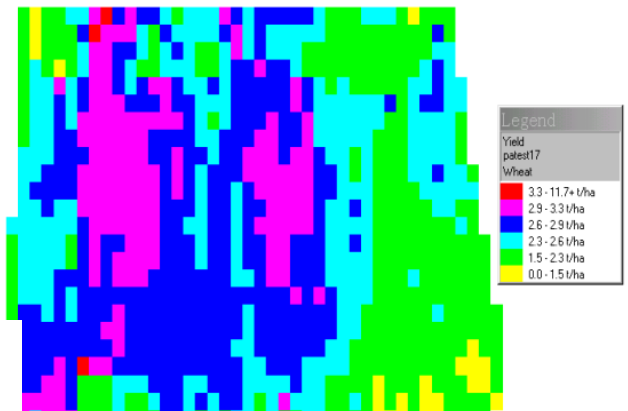


原始数据图

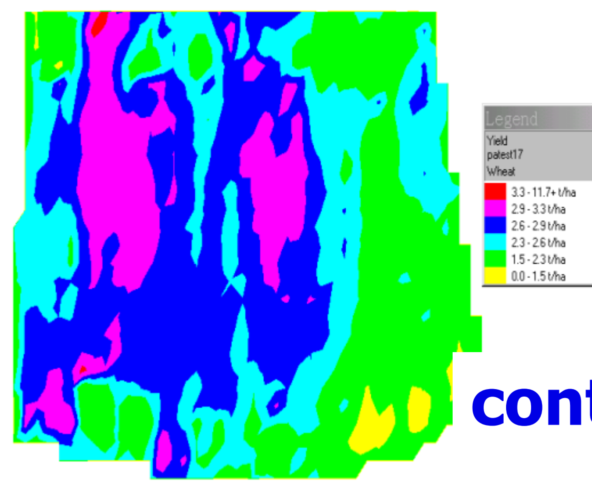


grid map

Smoothing map



平滑处理图



contour map

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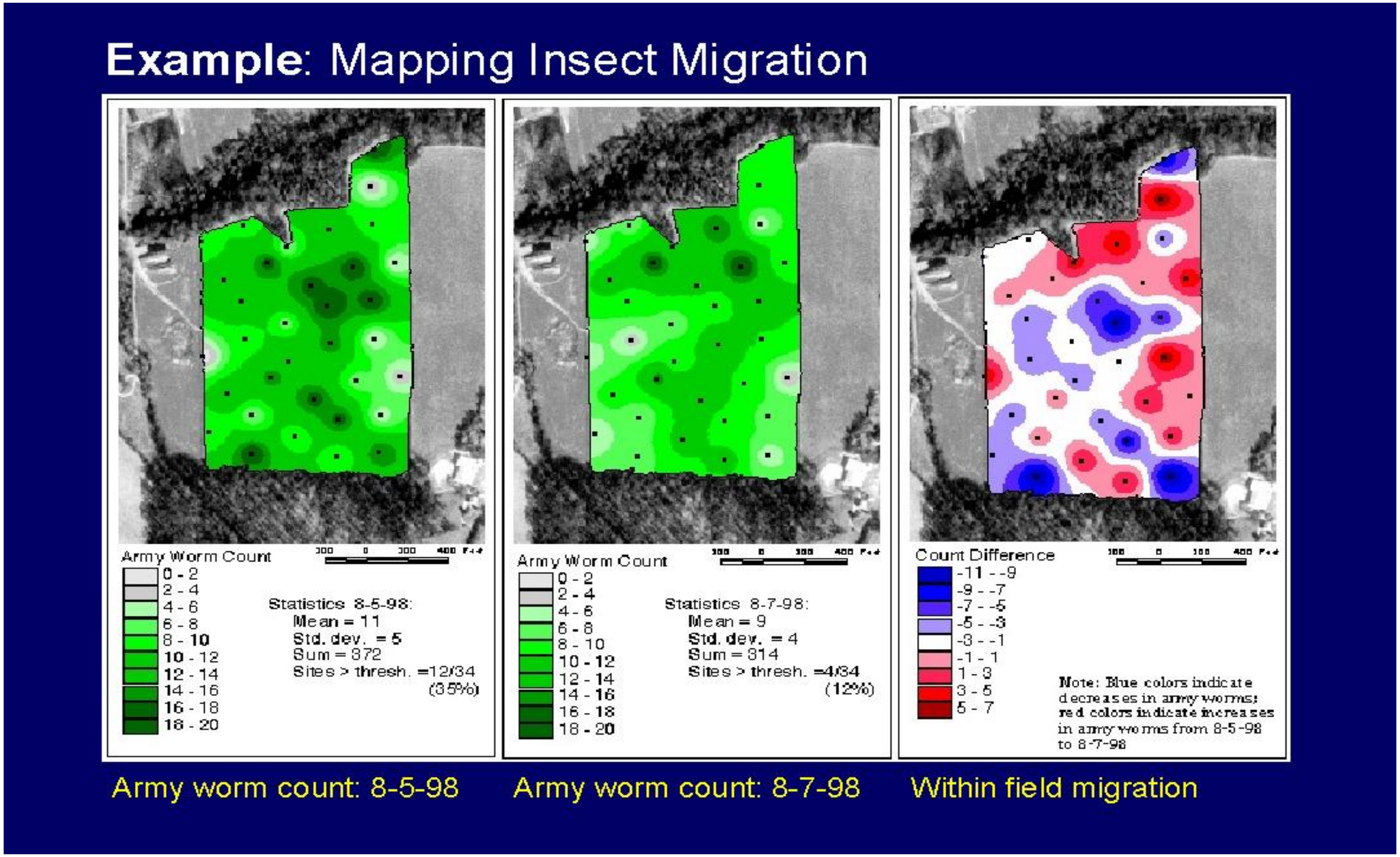
Other Maps



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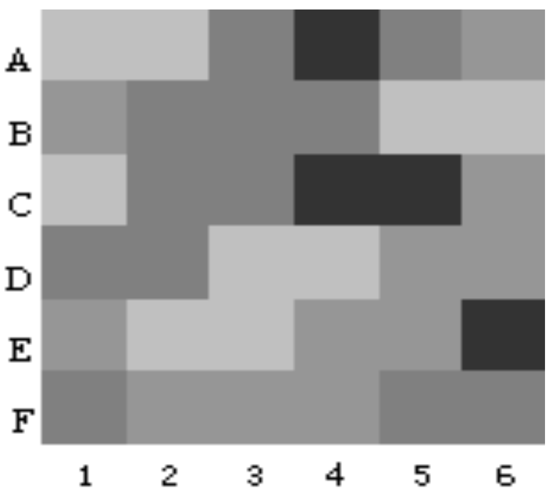
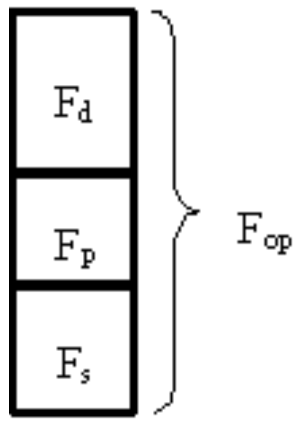
Making a prescription map





$$F_a = \frac{F_d}{j} = \left(F_{op} - F_p - F_s\right)/j$$

F_a: fertilizing amount

j: fertilizer utilization factor

F_d: replenished amount of fertilizer

F_{op}: amount of required fertilizer

F_s: Soil fertility potential

$\boldsymbol{F_p}$: absorbed fertilizer by plants

(a) Precision fertilizer prescription maps

(b) formula for calculating the amount of fertilizer applied

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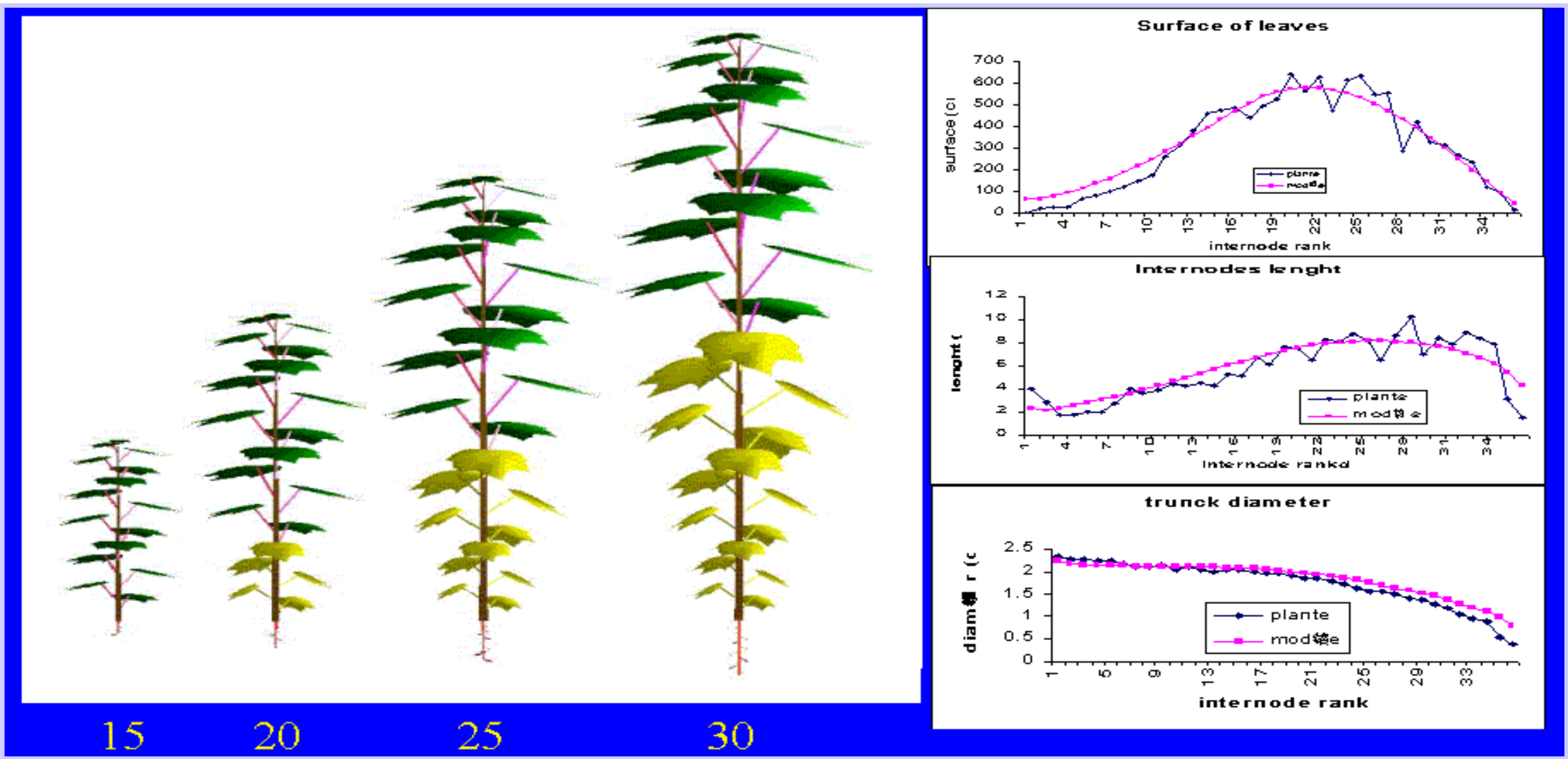
Making a prescription map

crop modeling



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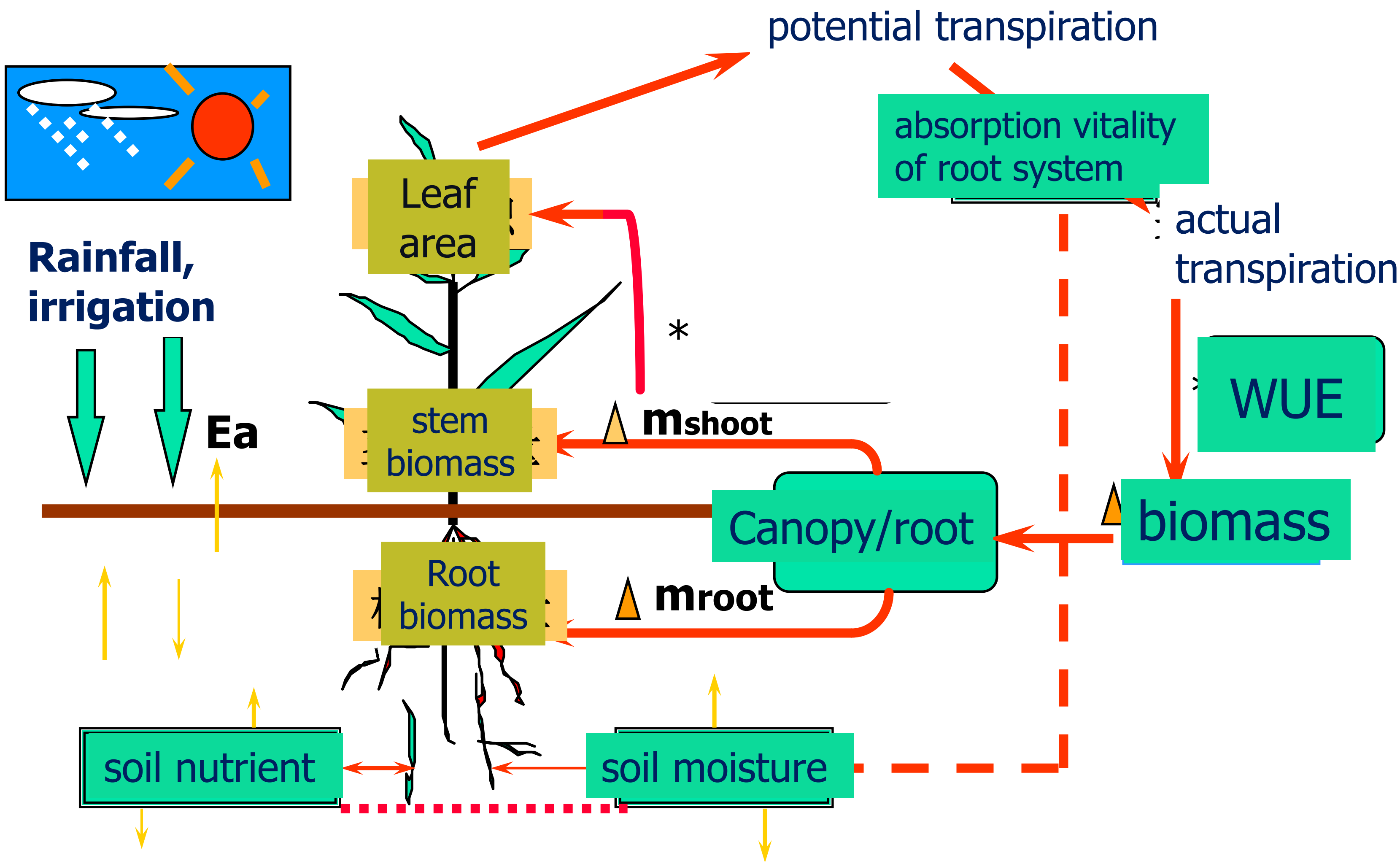
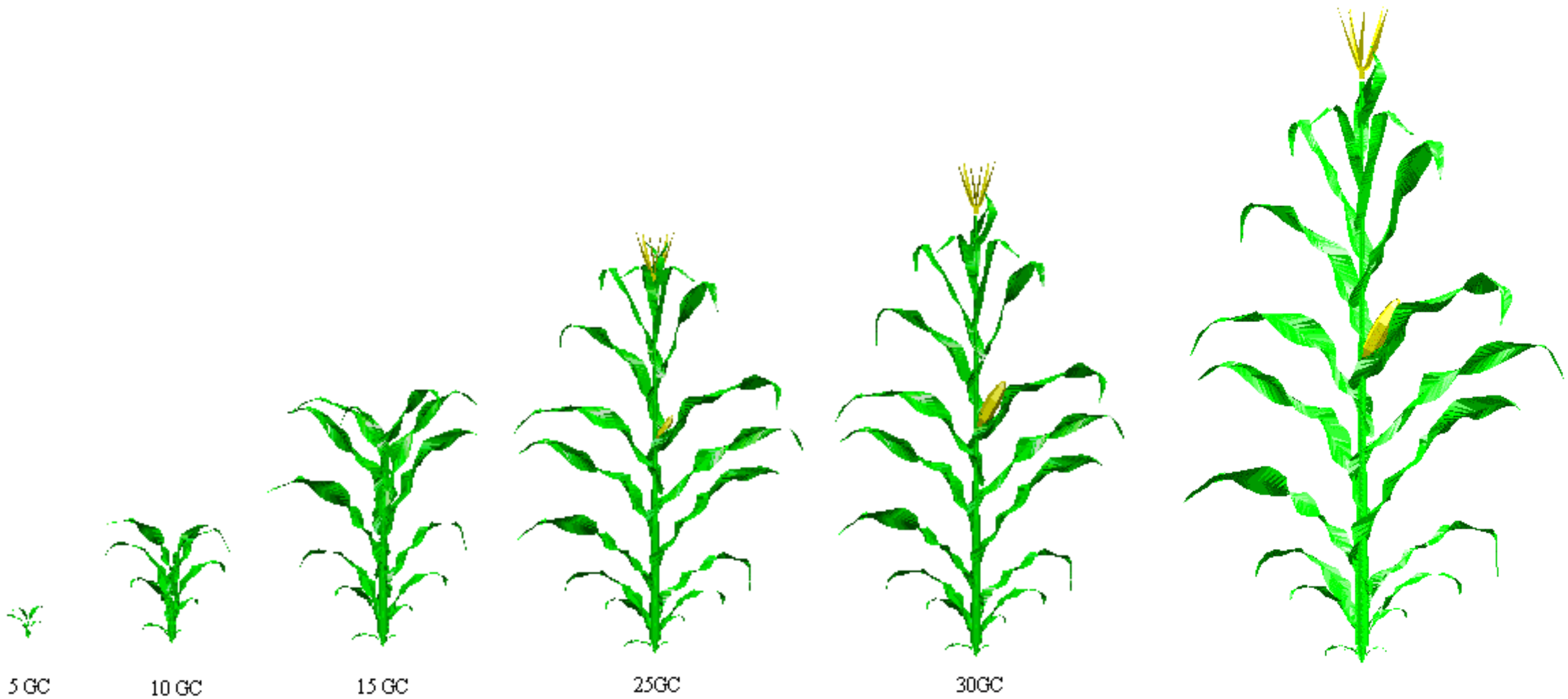
Making a prescription map crop modeling



1 精细农业概述

Making a prescription map crop modeling



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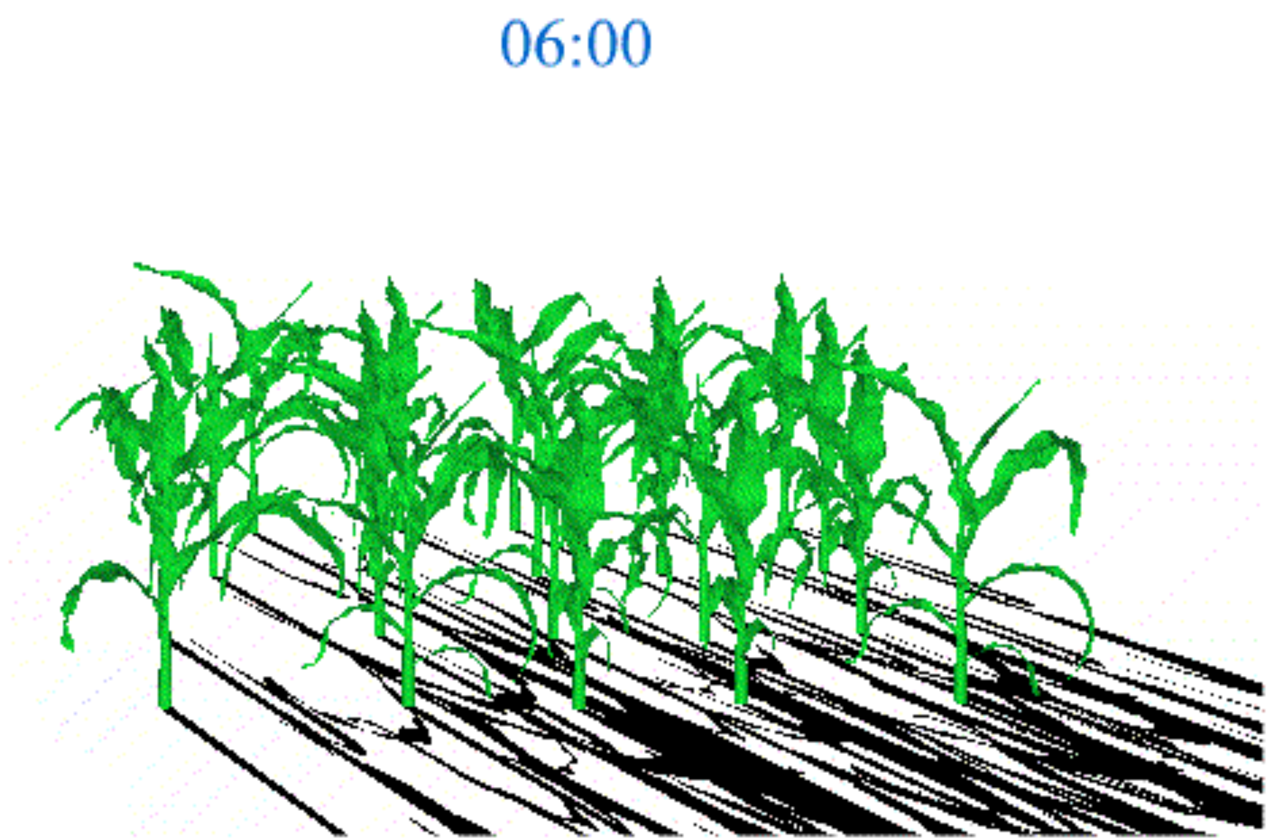

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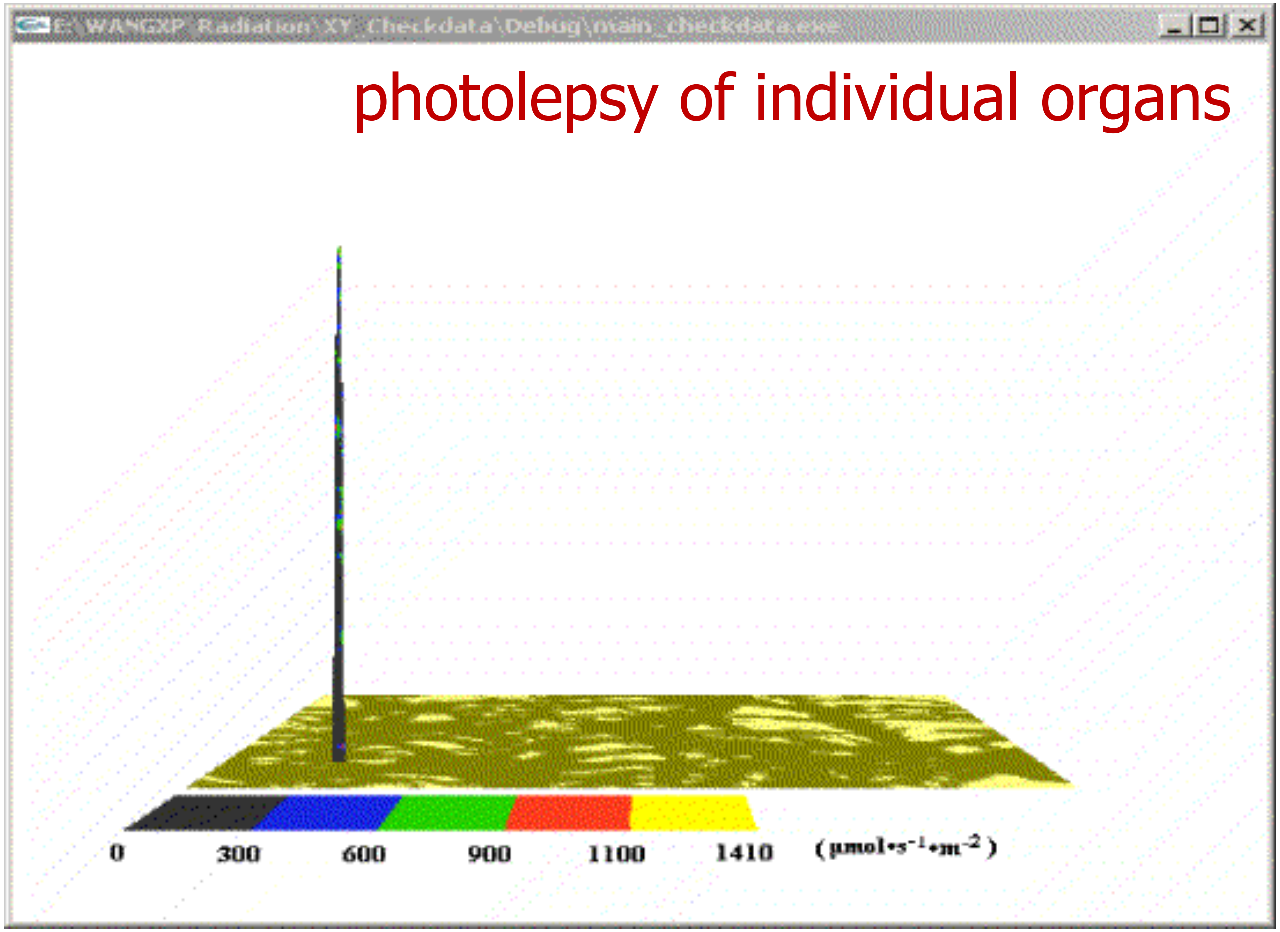

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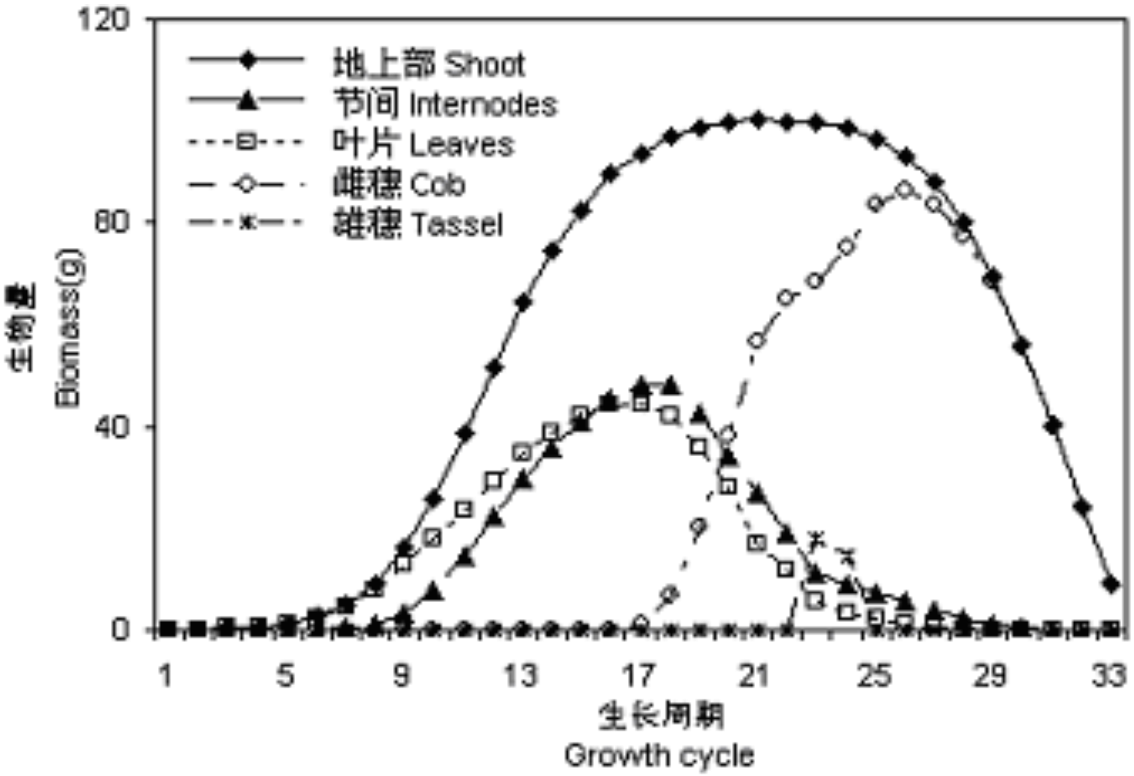
Making a prescription map crop modeling



(Annals of Botany, 2007, 99: 61- 73)

Dynamic growth of individual maize based on functional-structural GREENLAB model

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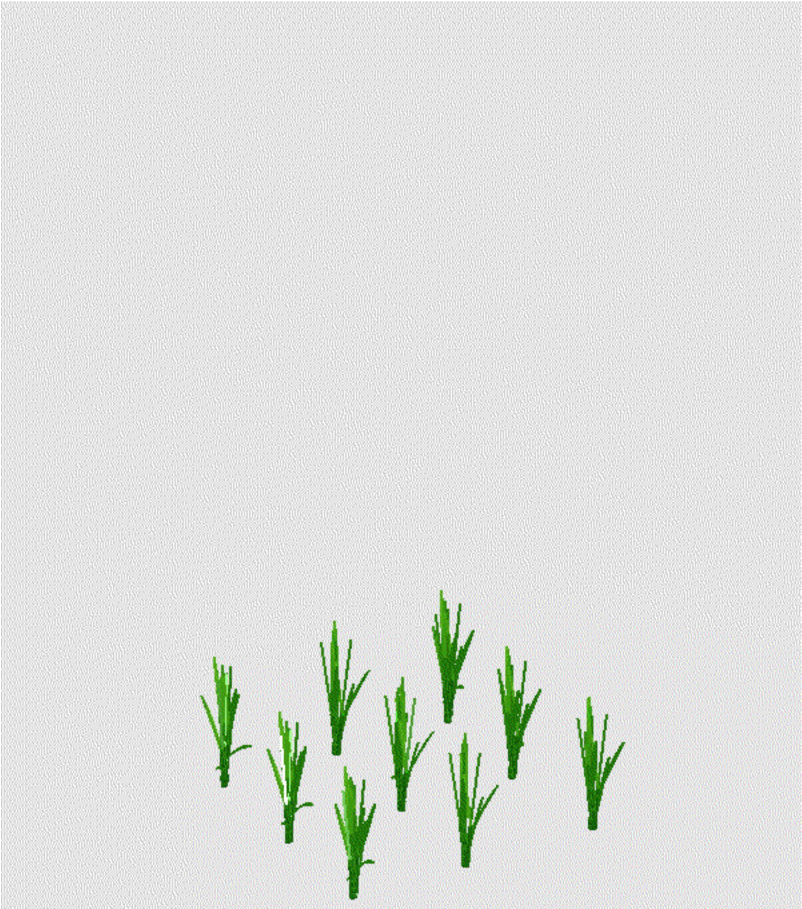
Making a prescription map crop modeling



1 Overview of precision agriculture

integration and application

1 Overview of precision agriculture

integration and application

Precision Farming applied to Tea in Tanzania

1 Overview of precision agriculture

Precision Farming applied to sugar cane in Austrilia, brazil and Mauritius

- Fields
  - Highly structured small blocks
- Yield mapping
  - Hand cutting moving to mechanical harvesters
- Fertilizer application
  - By hand, using maps, increasingly mechanized
- Technology
  - Medium support
- Special considerations
  - Reducing the cost of production, Mechanization, De-rocking, no burning after 2006 in Brazil.

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Coconut trees

- Fields
  - Well established groves (each tree numbered)
- Yield mapping
  - Record harvest from each tree
- Fertilizer
  - Applied by hand, according to treatment maps
- Technology
  - Low support
- Special considerations
  - Labour shortages
  - Operator safety (15m trees!)

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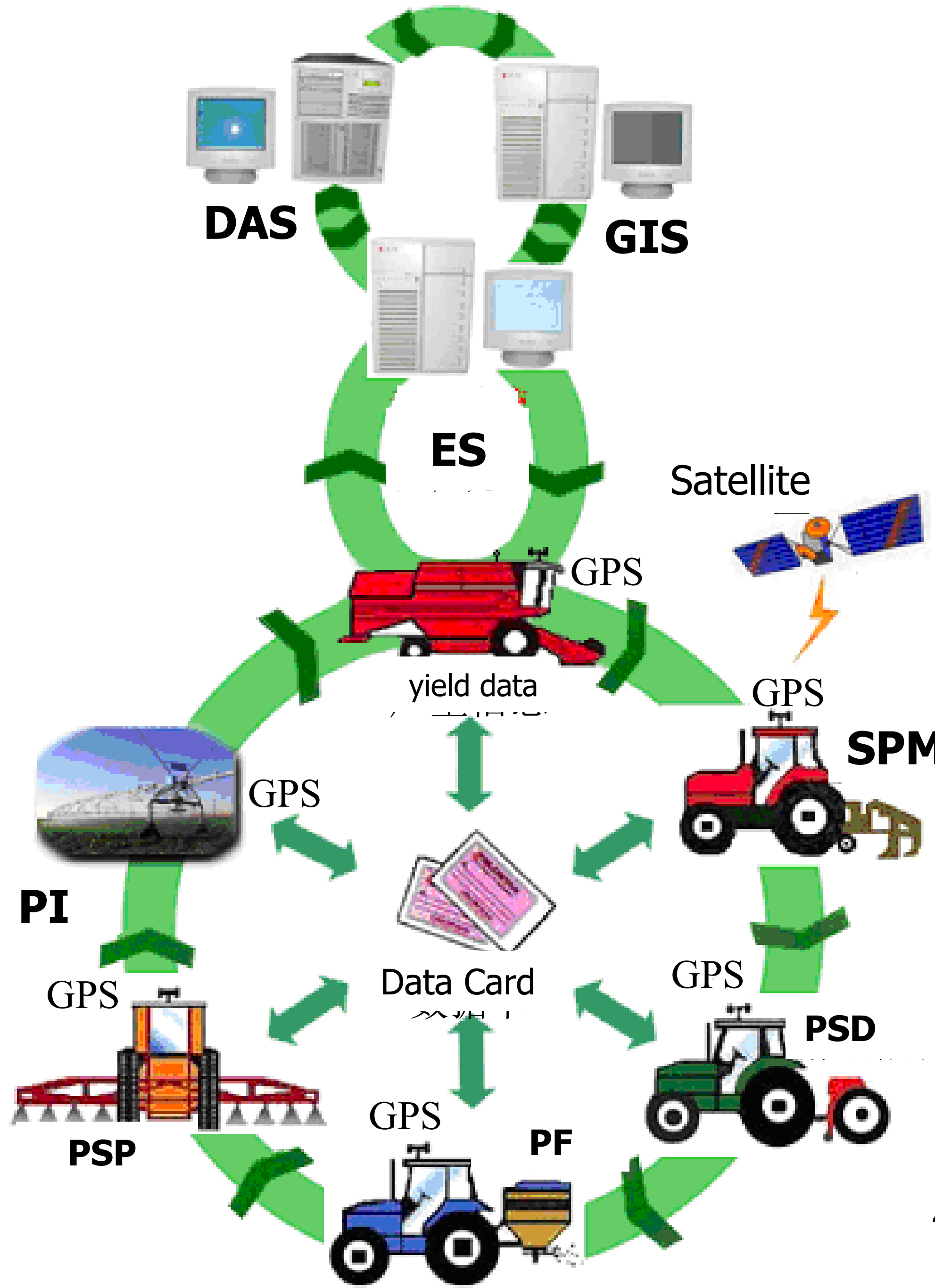
- Picked by hand
- Weighed by block
- Quality graded on farm

1 Overview of precision agriculture

integration and application



1 Overview of precision agriculture

expand PA to other area

Variable management based on spatial and temporal variation

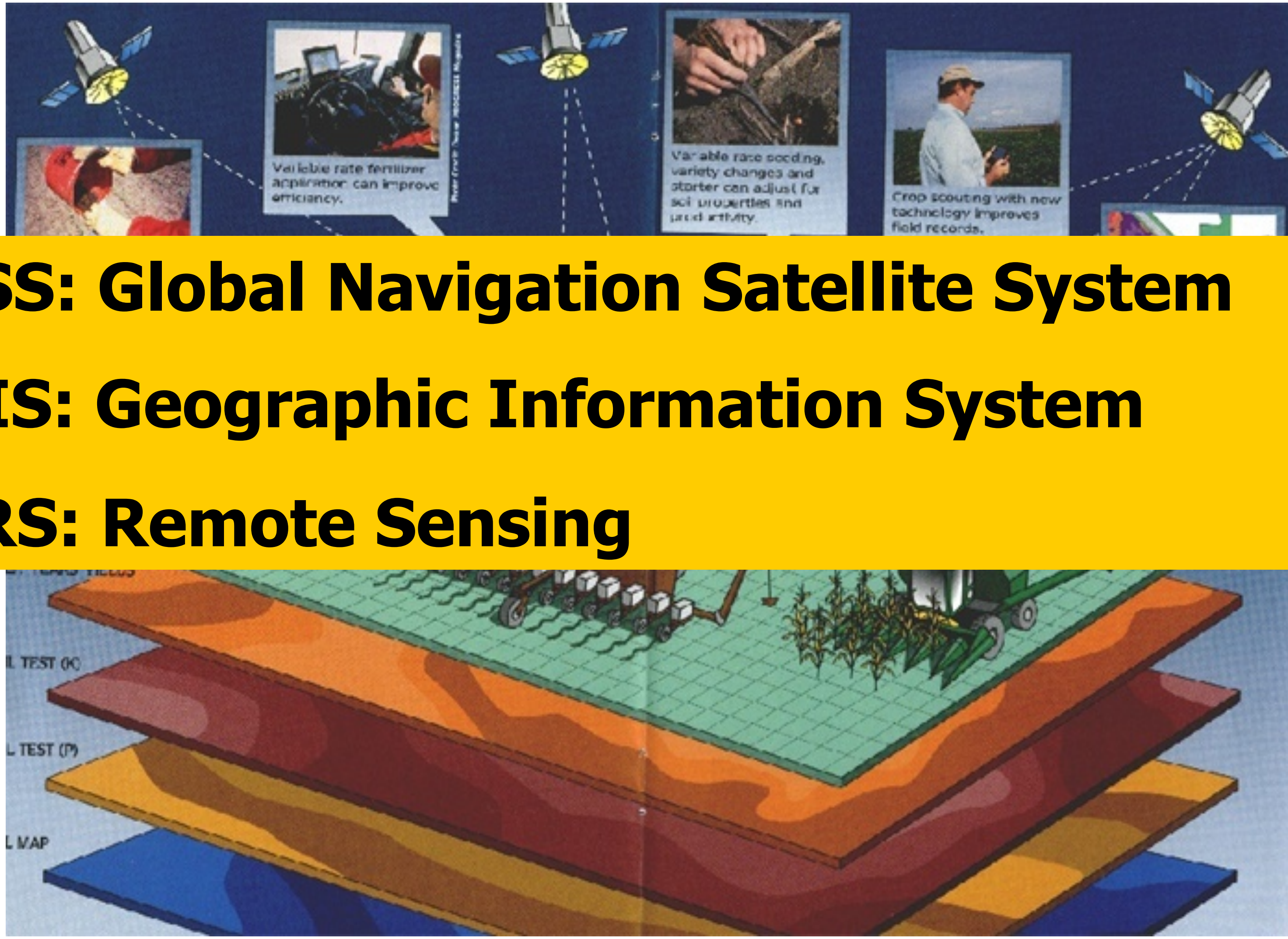
Precision Forestry

Precision Agrotechny

Precision Livestock and poultry breeding

Precision Horticulture

2. Supporting Technologies of PA



GNSS: Global Navigation Satellite System

GIS: Geographic Information System

RS: Remote Sensing

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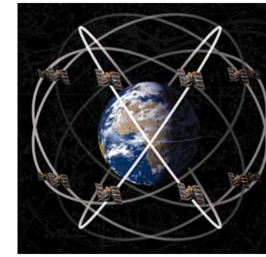


GNSS:

GPS: Global Positioning System . The United States

GLONASS: GLObal NAvigation Satellite System. The formerly Soviet, and now Russian

BeiDou-2: (or BDS, formerly known as COMPASS), second generation Beidou Navigation Satellite System. China.

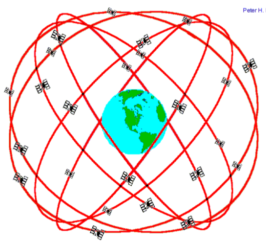
Galileo: Galileo positioning system. The European Union and European Space Agency

RNSS(**Regional navigation satellite systems**) :

NAVIC (NAVigation with Indian Constellation): developed by Indian Space Research Organisation (ISRO). throughout India and within a region extending approximately 1,500 km around it.

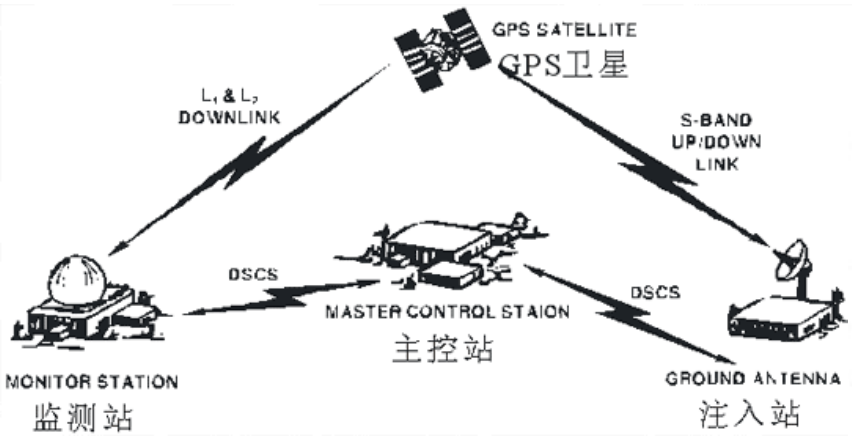
QZSS: Quasi-Zenith Satellite System , is a proposed three-satellite regional time transfer system and enhancement for GPS covering Japan.

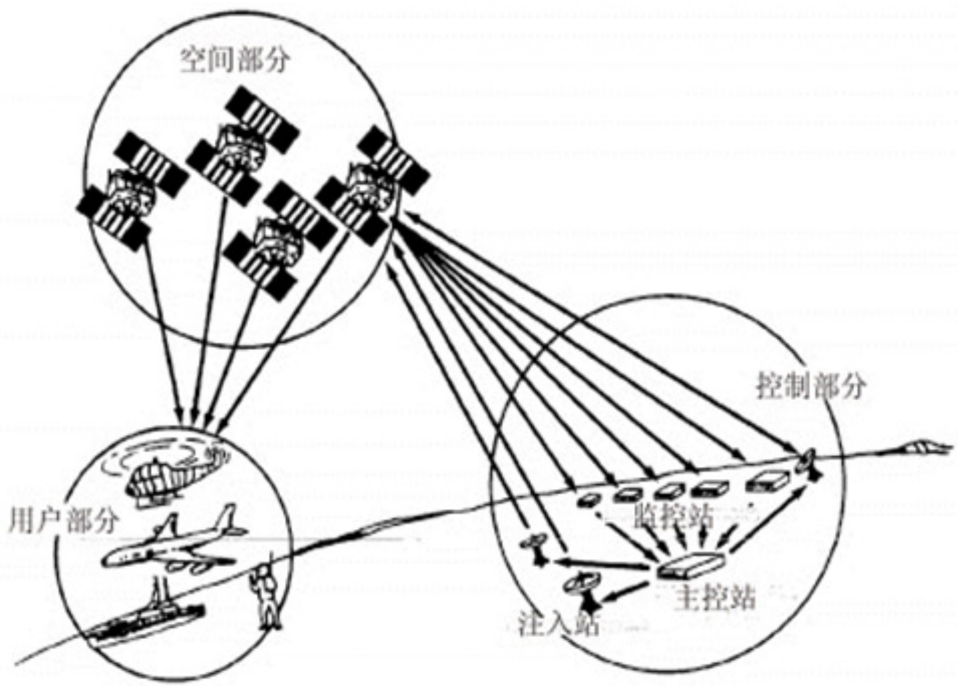
2. Supporting Technologies of PA



GPS

GPS Nominal Constellation
24 Satellites in 6 Orbital Planes
4 Satellites in each Plane
20,200 km Altitudes, 55 Degree Inclination



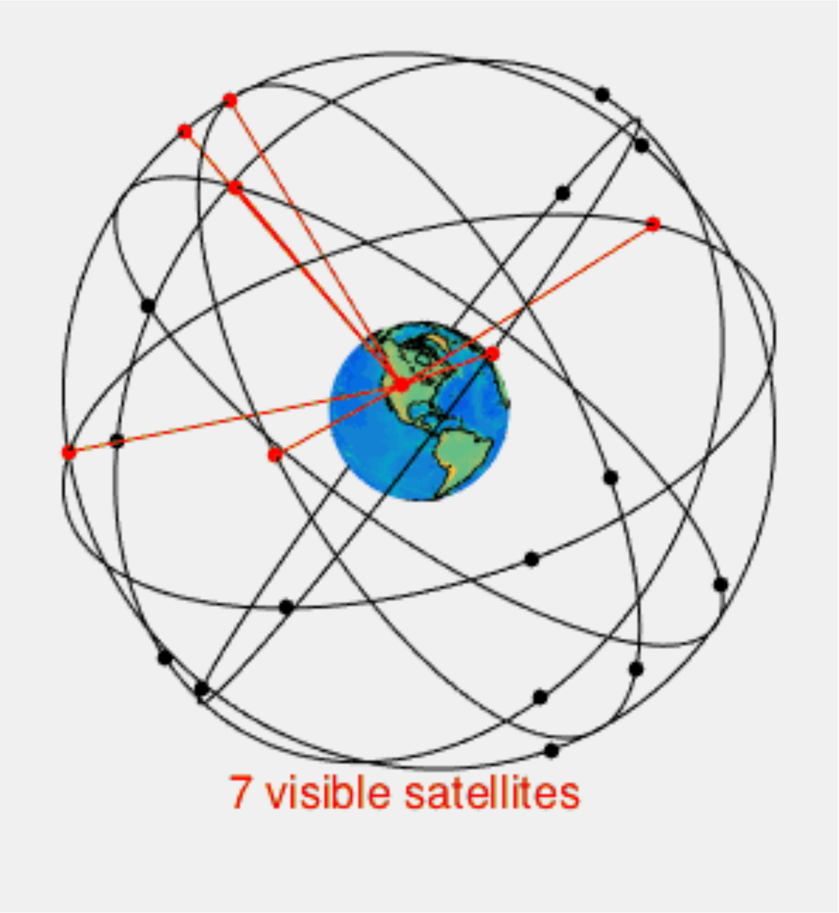


GPS consists of three major segments. These are the space segment(SS), a control segment(CS), and a user segment(US)

2. Supporting Technologies of PA

space segment (SS)

SS is composed of the 24 orbiting GPS satellites in GPS parlance, six orbital planes with four satellites each. The orbital period is about one-half a day, so that the satellites pass over the same locations or almost the same locations every day. The orbits are arranged so that at least six satellites are always within line of sight from almost everywhere on the Earth's surface.



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The control segment(CS)

CS is composed of:

A master control station (MCS), an alternate master control station, four dedicated ground antennas, and six dedicated monitor stations.

It provides the operational capability that supports GPS users and keeps the GPS system operational and performing within specification.

Ground monitor station used from 1984 to 2007, on display at the Air Force Space & Missile Museum at Cape Canaveral in Brevard County, Florida, United States

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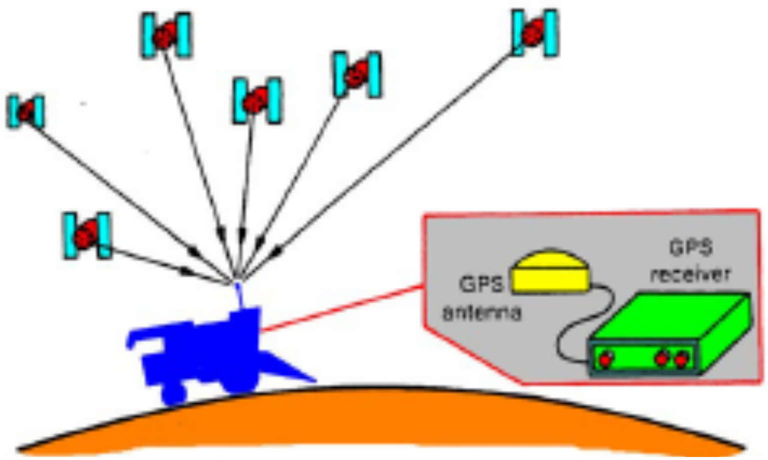
The user segment (US)

US is composed of hundreds of thousands of U.S. and allied military users of the secure GPS Precise Positioning Service, and tens of millions of civil, commercial and scientific users of the Standard Positioning Service

GPS receivers are In general composed of an antenna, tuned to the frequencies transmitted by the satellites, receiver-processors, and a highly stable clock (often a crystal oscillator). They may also include a display for providing location and speed information to the user.

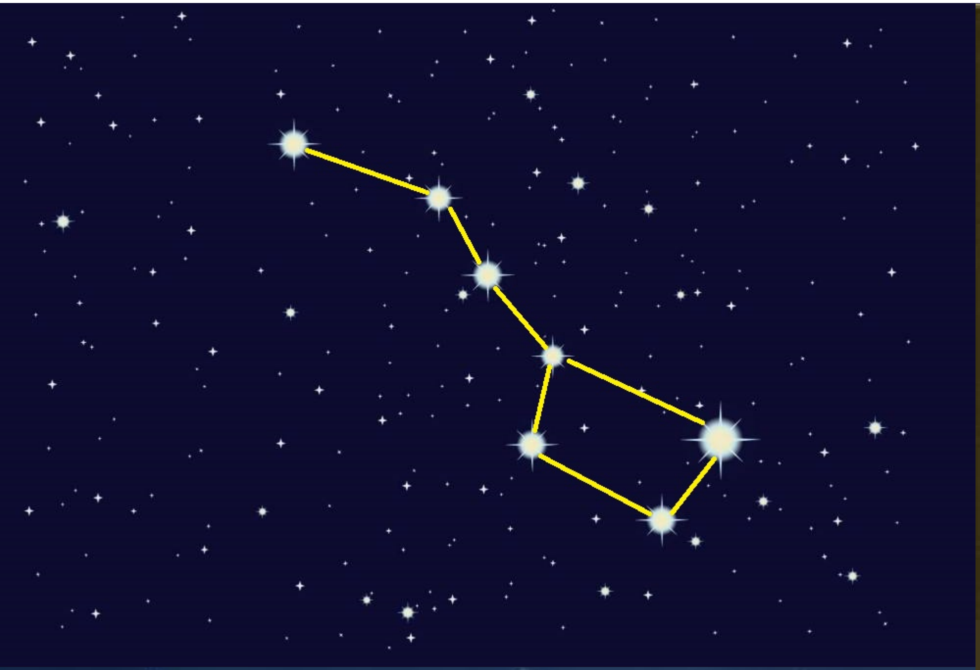


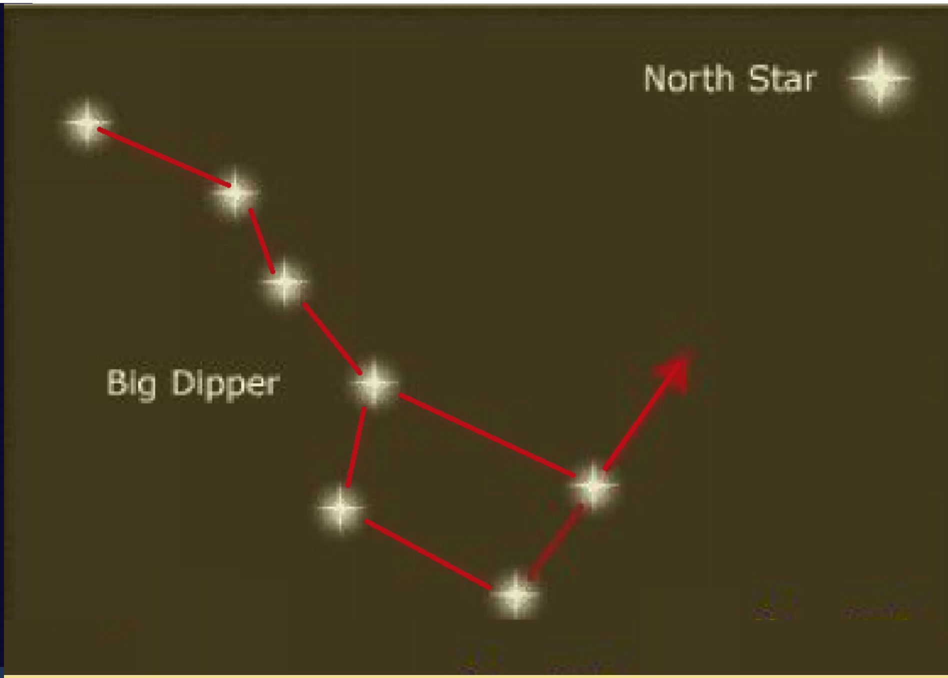
GPS RECEIVER MEASURES DISTANCE FROM MULTIPLE SATELLITES

2. Supporting Technologies of PA

GPS RECEIVERS

Beidou and Compass





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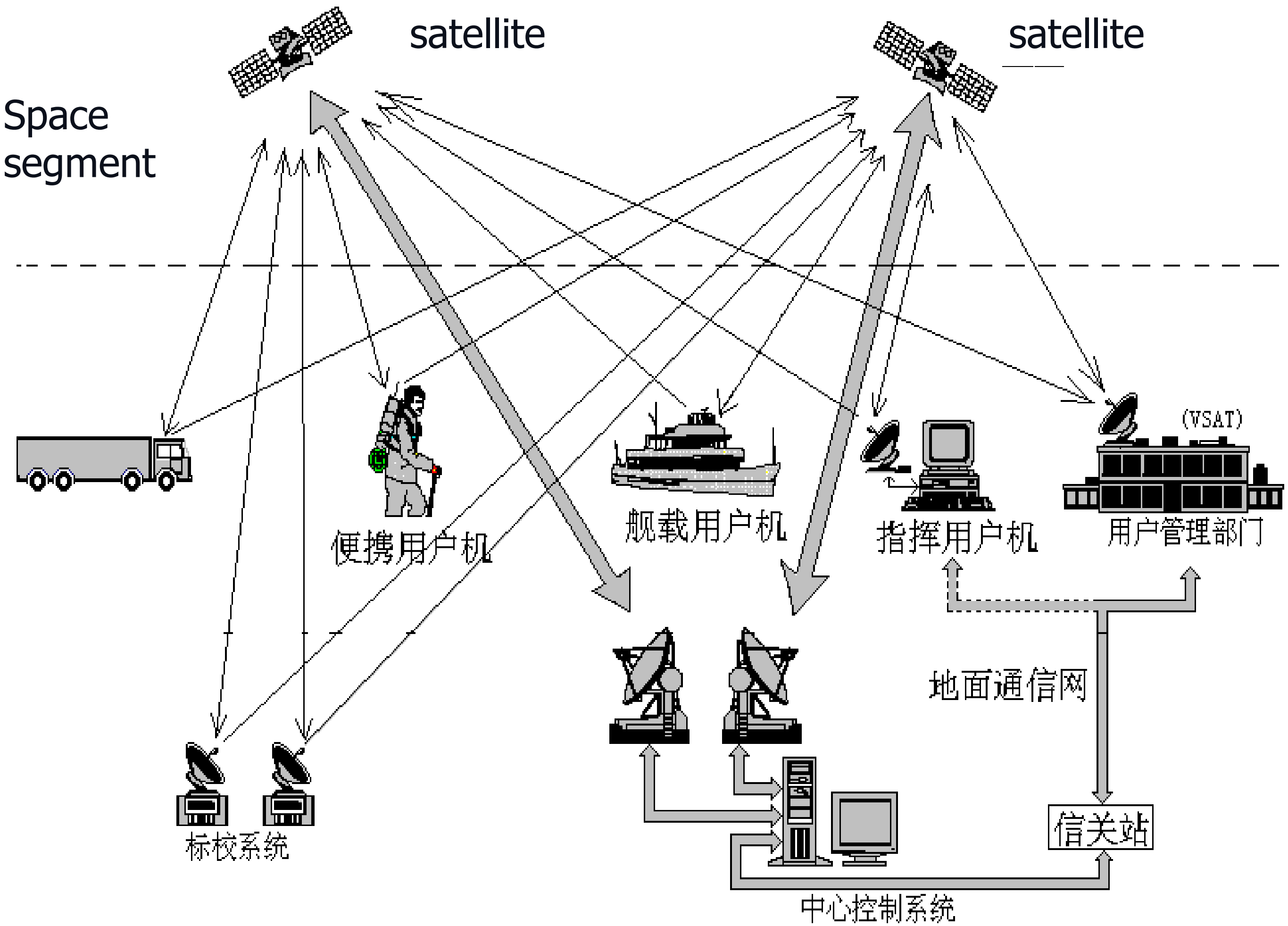
BDS



Schematic diagram of BDS

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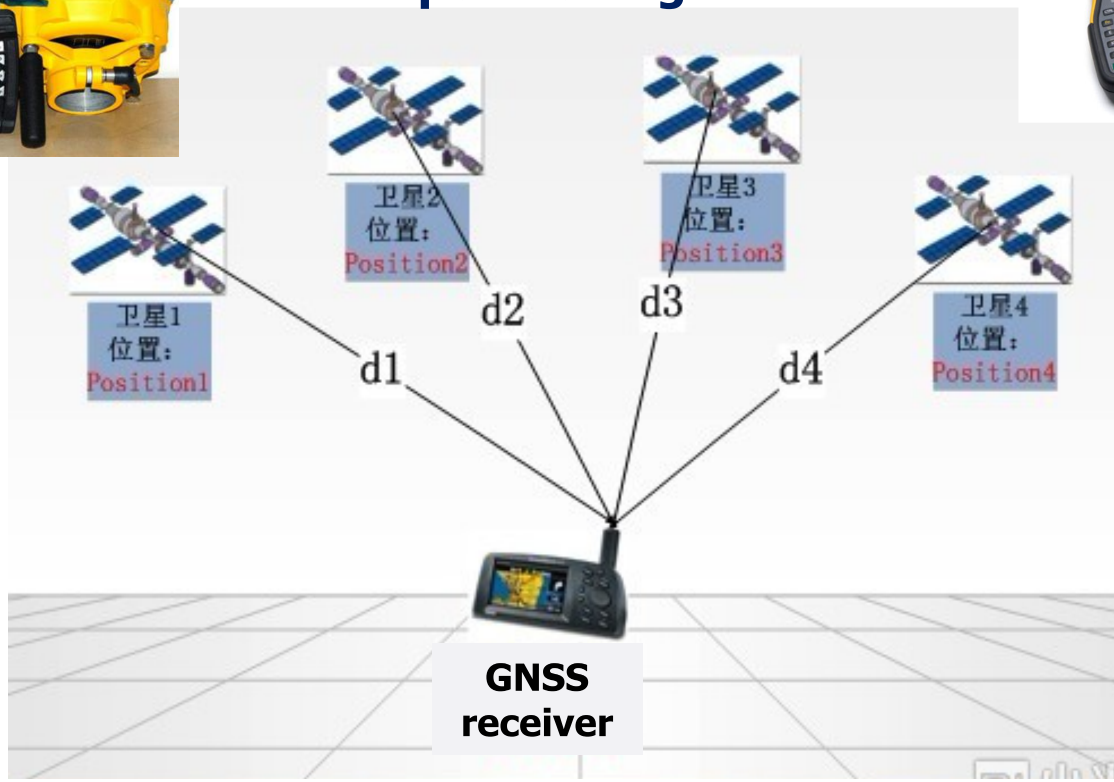
GNSS single-point positioning



Correction signal

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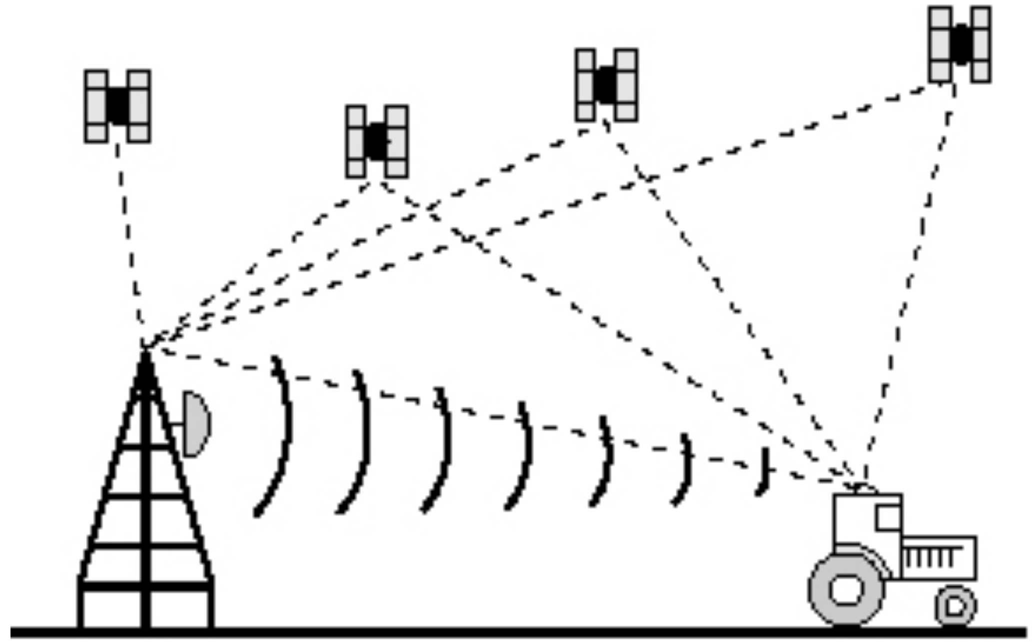
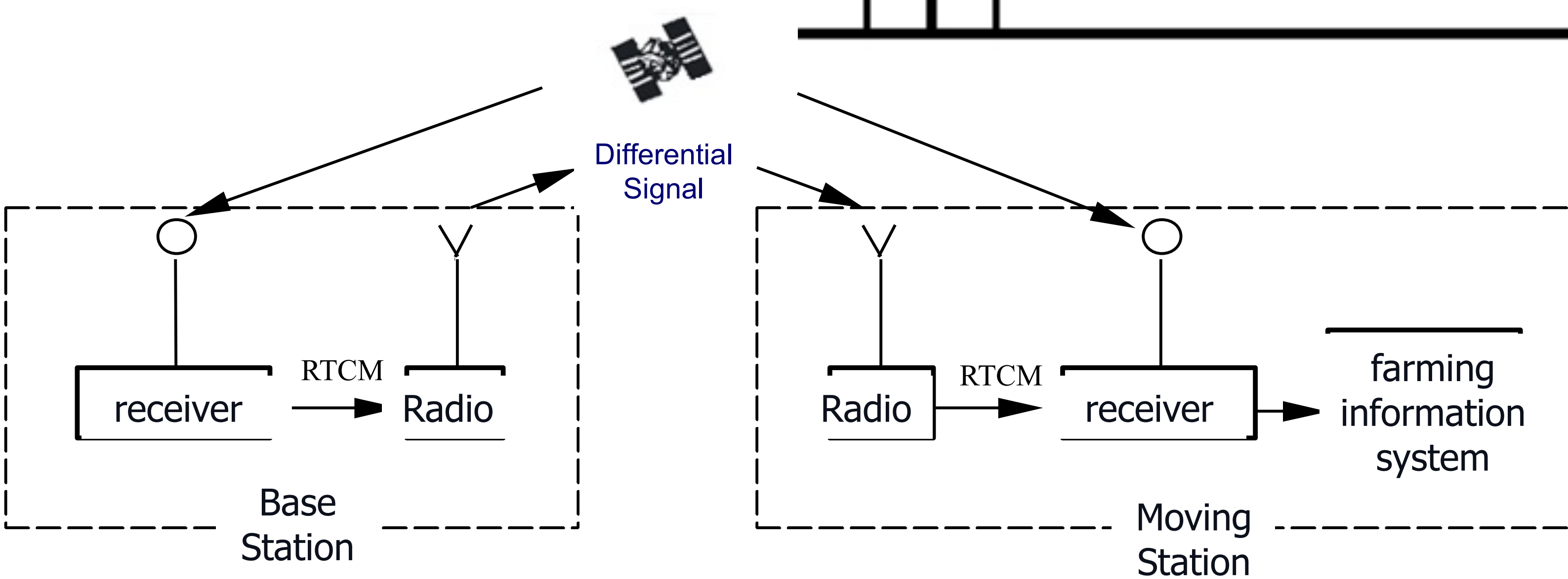
DGNSS:
Differential GNSS System





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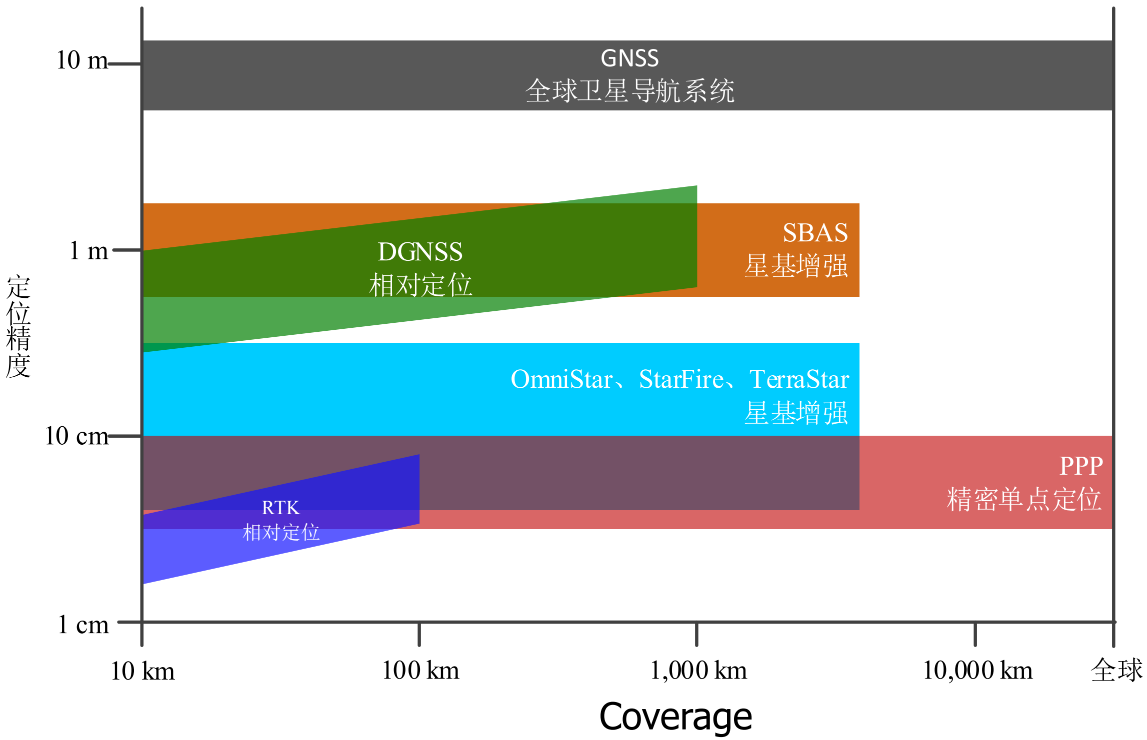
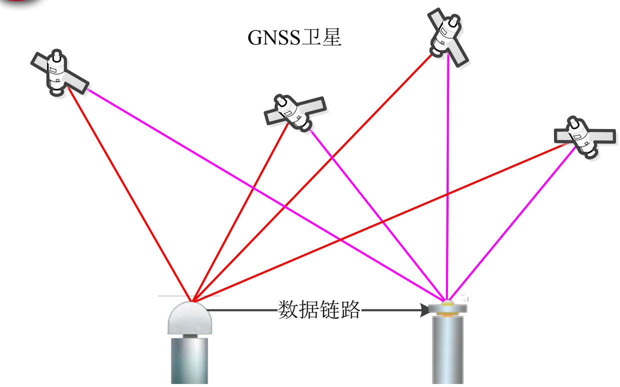
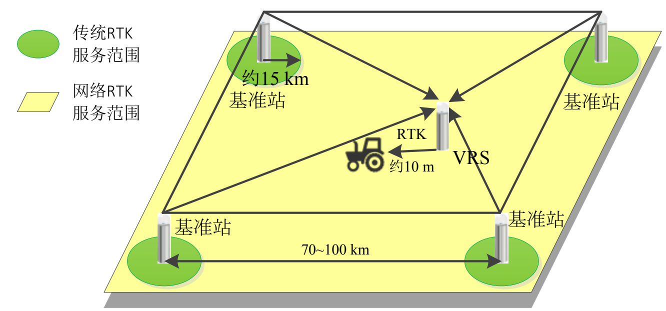
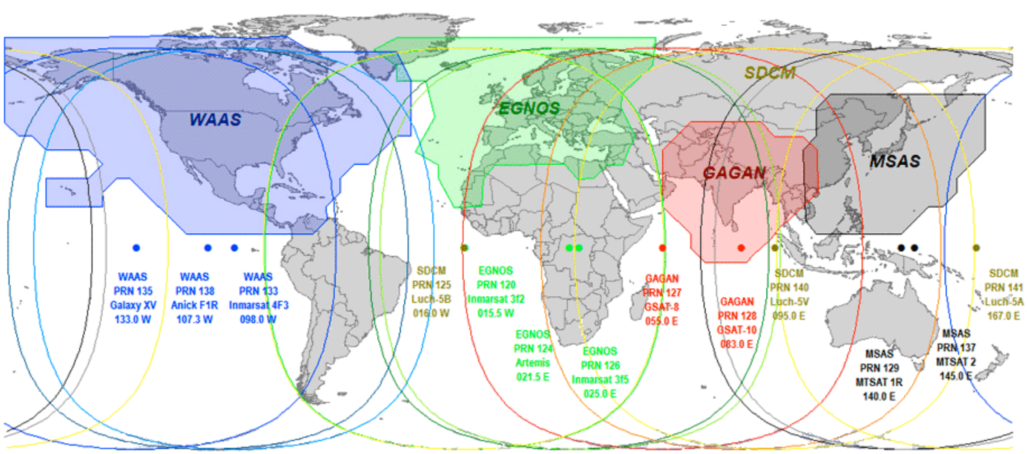




RTK: Real-time Kinematic



CORS: Continuous operational reference system



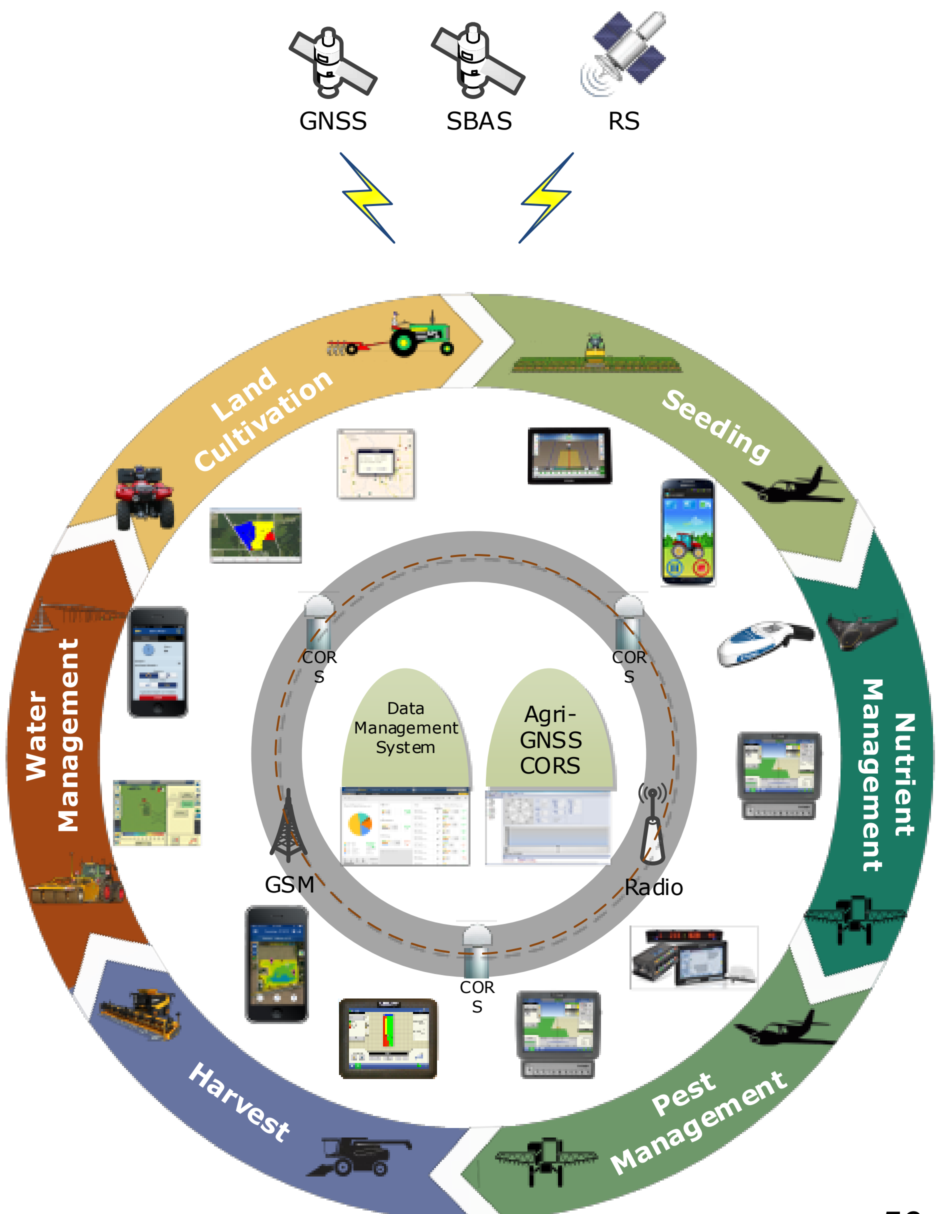
SBAS:
Satellite
Augmentation
System

GNSS: Key technology of PA

GNSS：key technology of Precision Agriculture（PA）

- Agri-GNSS CORS CORS for Agriculture
- Data Management System: LBS for Agriculture

Accuracy	Performance	Application
cm level (horizontal)	±2.5 cm	Auto-steering
cm level (vertical)	±3 cm	Land levelling, deep tillage, ……
dm level	±1 dm	Information collecting ……
m level		Fleet management ……



GNSS Application in Precision Agriculture

- **GNSS is the basis of precision agriculture, and is the core support of precision operations and fine management.**

◆ GNSS是精准农业的核心支撑，是实现精准作业和精细管理的核心

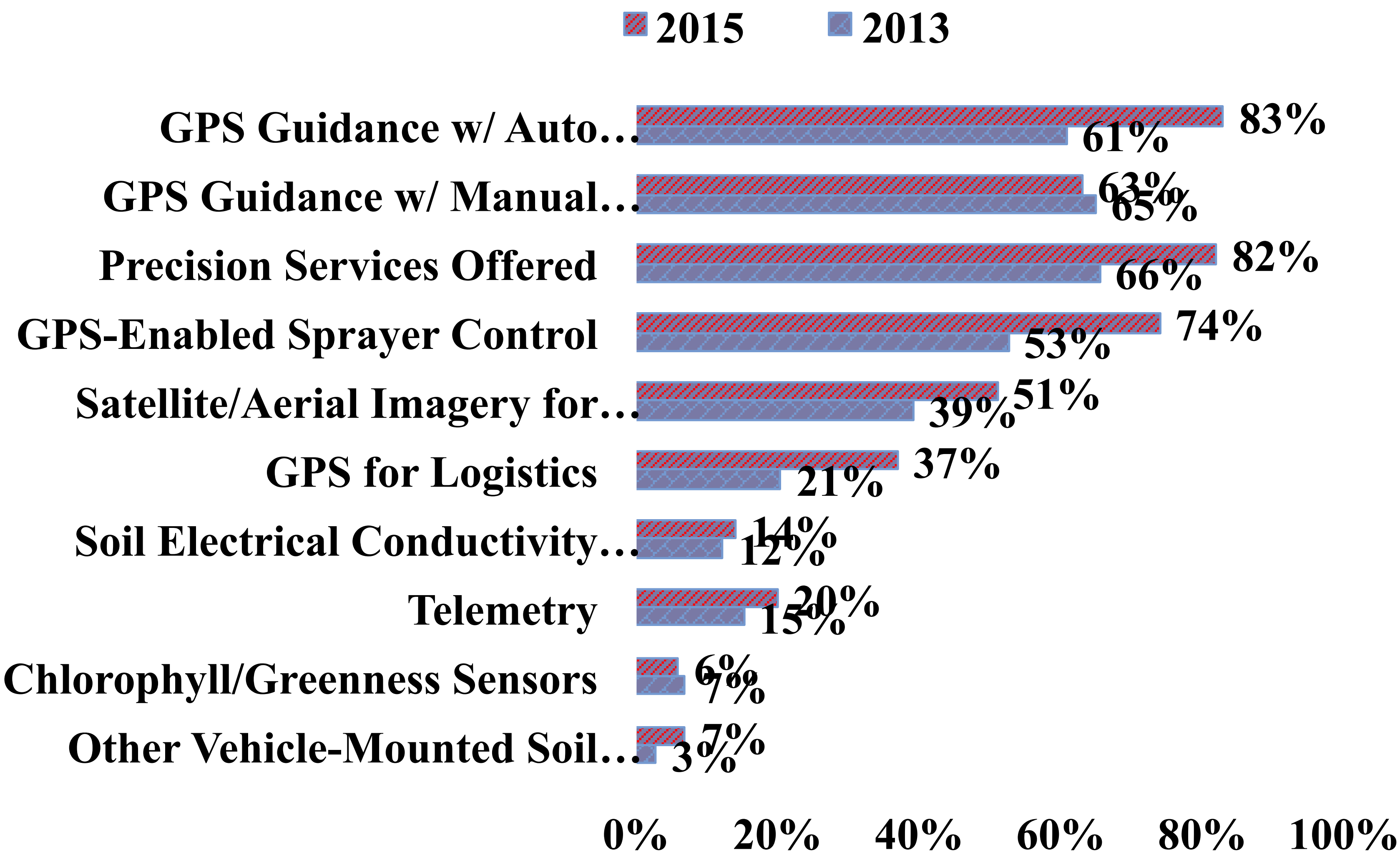
- **GSA: 500,000 Auto-steer GNSS terminals were used, most of them used in US, Canada, and Australia.**

◆ 欧空局（GSA）调查认为50万台套GNSS自动驾驶已使用，主要用在美国、加拿大、澳大利亚

European GNSS Agency (GSA), 2015. GNSS Market Report 2015 (Issue 4).

GNSS Application in Precision Agriculture

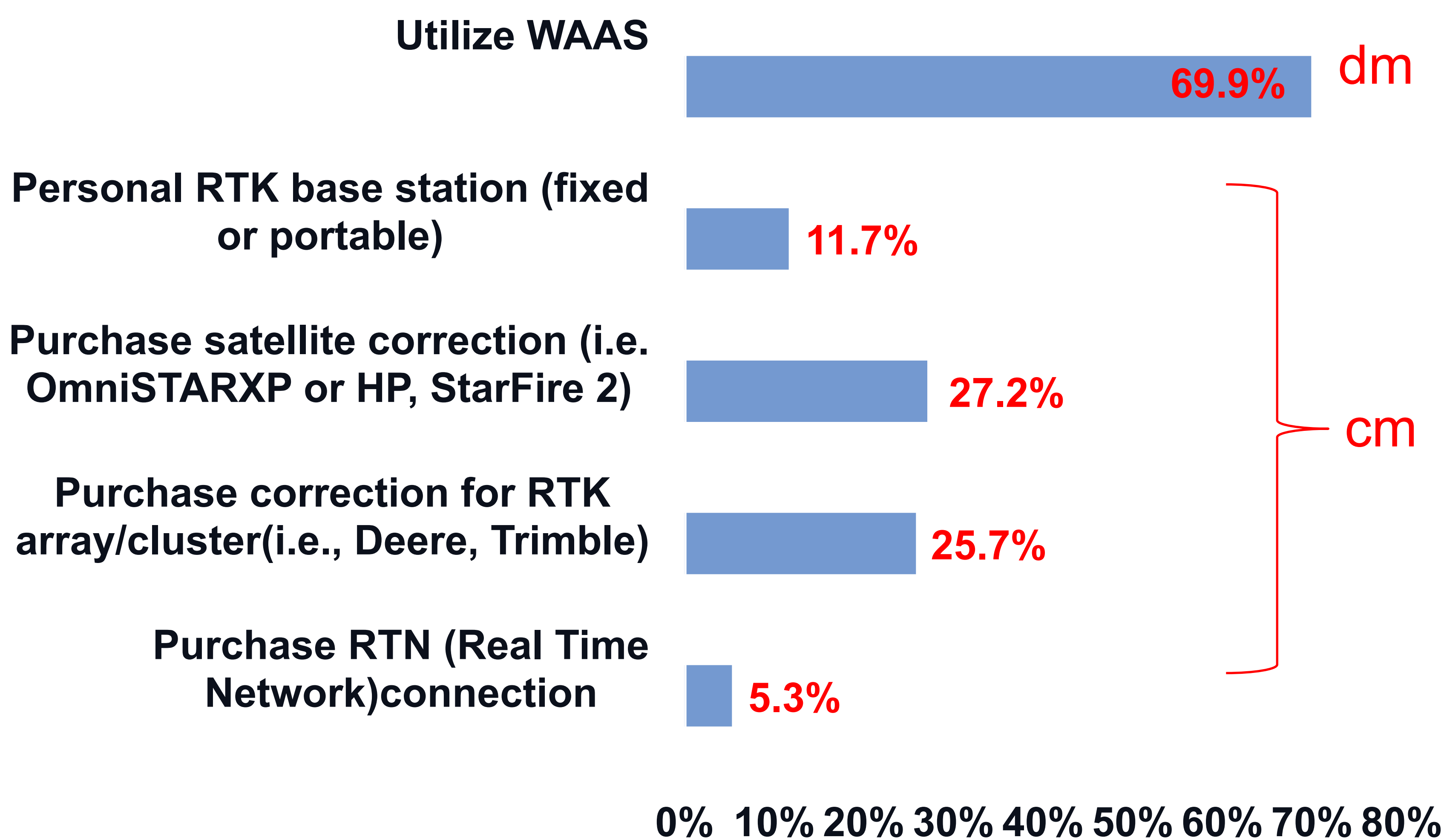
Use of Precision Technology in US



Bruce Erickson, David A. Widmar. 2015 Precision Agricultural Services Dealership Survey Results.

GNSS Application in Precision Agriculture

2015 Types of GPS Correction Used in US



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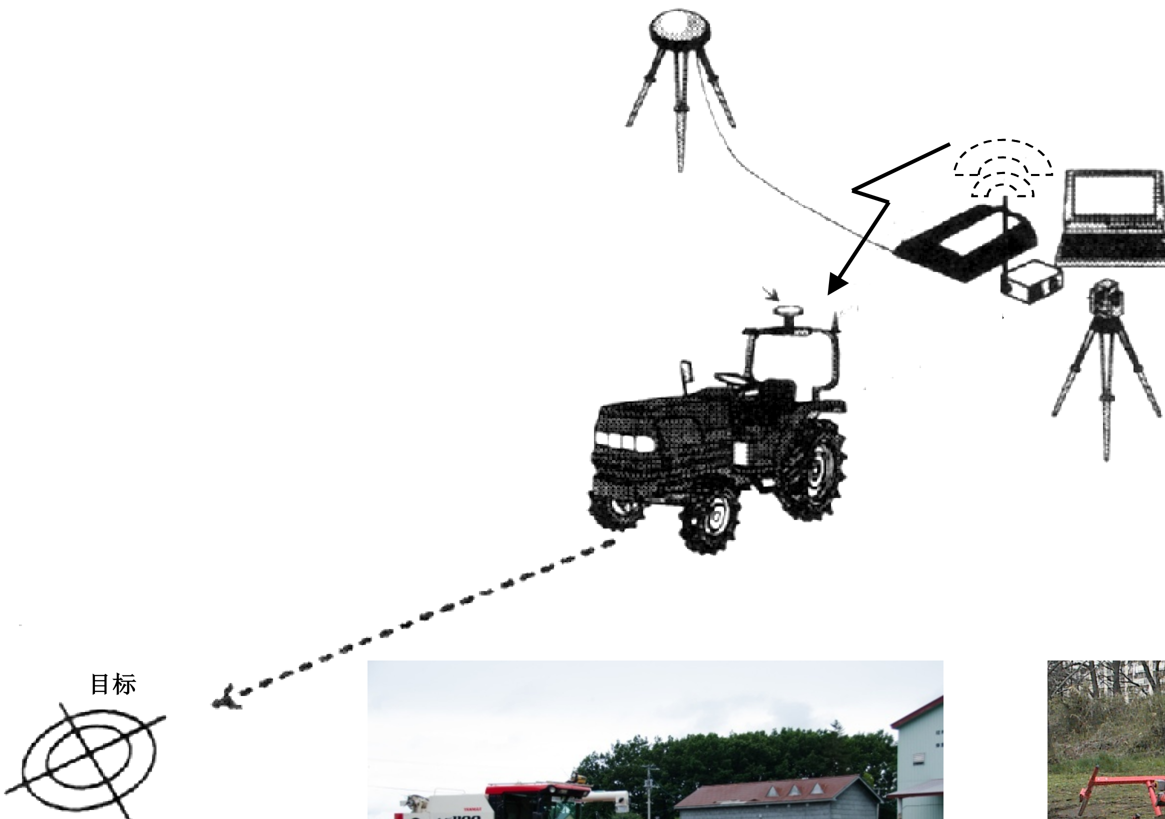
2. Supporting Technologies of PA

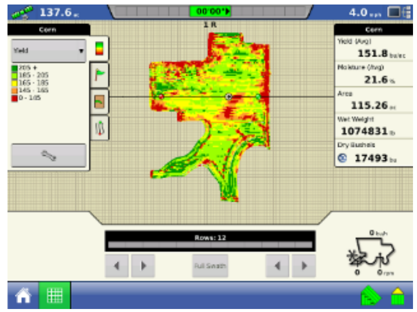
DGNSS Applications

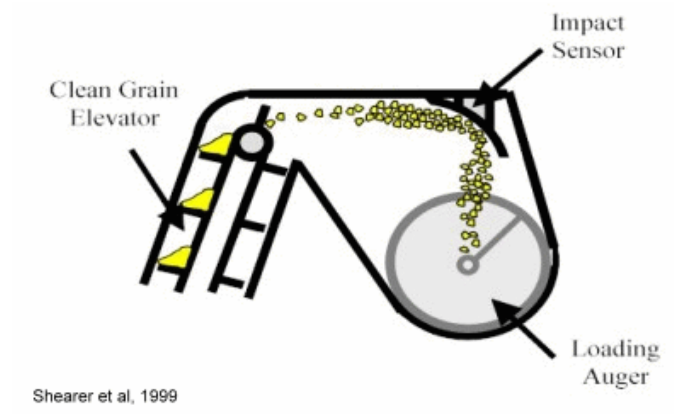
Agricultural machinery automatic navigation



Auto guidance system made in US

Yield Monitoring, Variable Rate Application

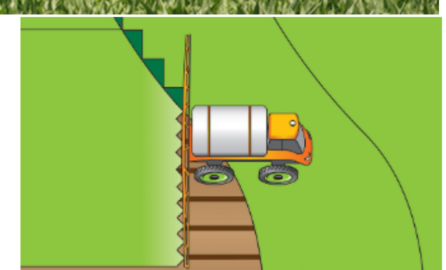




AgLeader Cotton Yield Monitor

John Deere crop input
control system

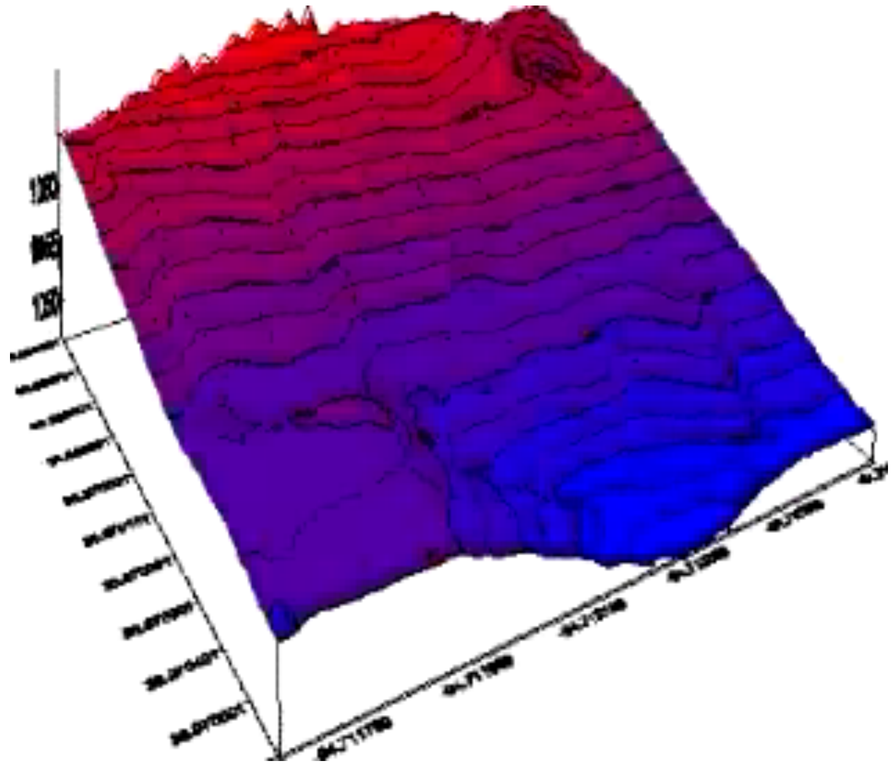
AutoSwath



2. Supporting Technologies of PA

DGNSS Applications

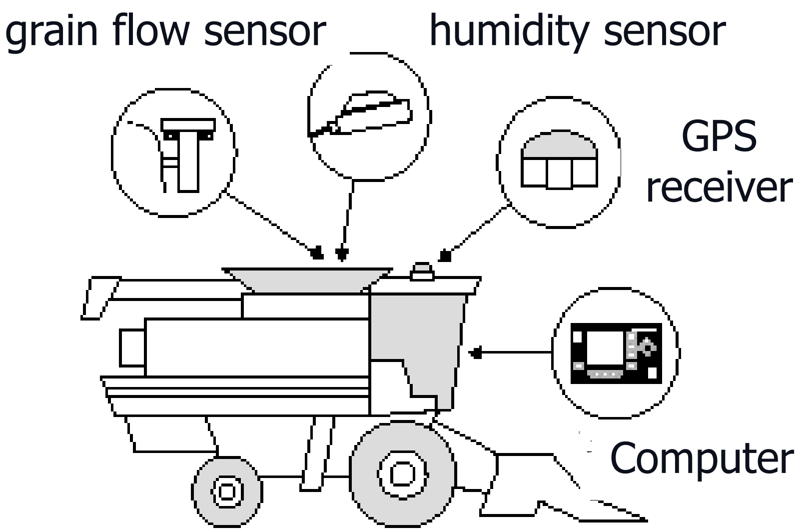
Obtaining its boundary by driving with a GNSS receiver around a farmland



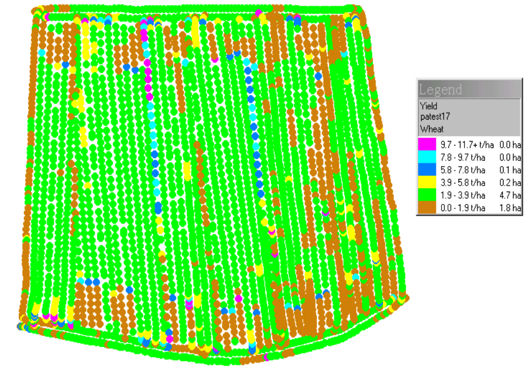
topography of a farmland

2. Supporting Technologies of PA

DGNSS Applications



Components of yield measure system for combine harvester



2. Supporting Technologies of PA

DGNSS Applications

Vehicle navigation equipment,
AgLeader Co.

Easy and affordable, the EZ-Guide® Plus lightbar guidance system from Trimble, represents a breakthrough in simple vehicle guidance.

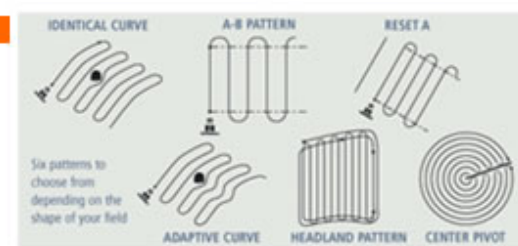
Accurate GPS position output (via NMEA) for yield monitors, planters, variable rate controllers, and field computers

Bright LED lights and clear display to keep you driving on line in dust, fog, or even in the dark

Integrated GPS with the standard EZ-Guide Plus lightbar or your choice of higher performance receivers—we have the accuracy and corrections that best suit your operation

Simple displays, including overhead and perspective view show you where you need to be

Choose from multiple guidance patterns and between plan and 3D perspective views to see where you are and what you've been doing



2. Supporting Technologies of PA

BDS Application in Precision Agriculture in China

- BDS for marine fisheries: universal application
- GNSS for area measure: widely used
- Auto-steer guidance for tractor: increase quickly
- GNSS for operation monitoring: increase quickly
- GBAS for agriculture: used in some areas
- Other areas: being explored

中国北斗精准农业应用：

- 海洋渔业：基本普及
- 面积测量：广泛使用
- 自动驾驶：增长迅速
- 作业监管：增强迅速
- 地基增强：部分应用
- 其他应用：正在探索

BDS for marine fisheries 海洋渔业应用

China's mainland coastline measures approximately 18,000 km, with a total maritime area of 4.73 million sq km, with a total fishing boat of 1.2 million, about 310,000 marine fishing vessels and 8 million people engaged in fishing..

The Beidou navigation satellite system will help establish a security system to protect fishermen.

BDS mainly provides instant alarms and unique short messaging services.

- guide vessel to destination
- report emergencies to fishery departments
- weather forecasting service

The government pays for most of the cost of the client terminals. More than 50,000 fishing vessels in China had been equipped with BDS terminals

GNSS for area measure 面积测量应用

The owner of farm machinery usually provides social service for the farmers without machinery. The driver should calculate the operation area for each field.

tape measure

measuring wheel

The harvester installs a navigation terminal similar to the taxi meter

GNSS measurement

History of Tractor Auto Guidance 自动驾驶发展

Age	Technology	Content
1920-	Mechanic & Electronic	Requirement
1990-	Mechatronics & hydraulics integration	
2000-	GPS (L1)	Demonstration of assisted steering （US）
2010-	GNSS (L1 L2)+INS	Popularization of auto guidance (US) Import and demonstration (China)
2013-		Subsidy for BDS terminal (China)
2016-		Popularization of auto guidance (US) Regional popularization of auto guidance (China) Half of GNSS terminal made in China (China)

提出需求

机电液一体化

美国示范

美国推广

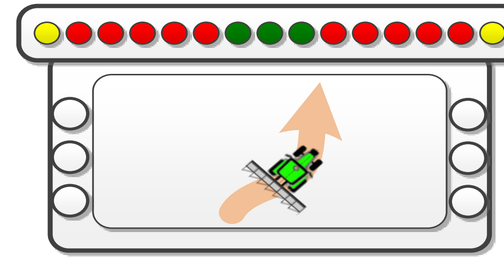
中国引进

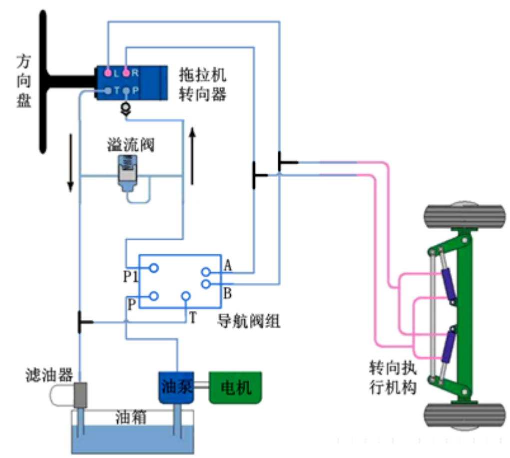
中国补贴

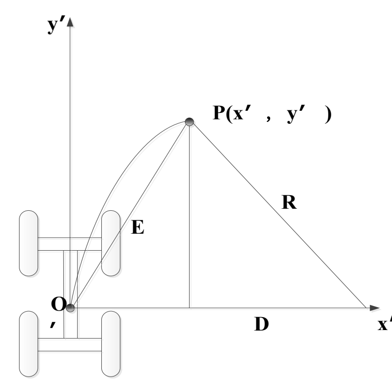
美国普及

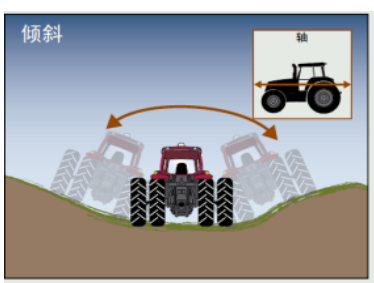
中国推广

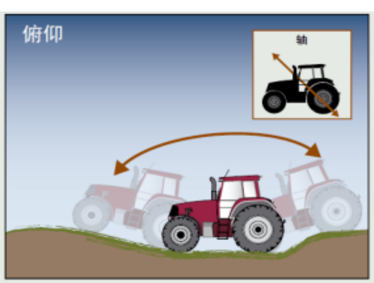
国产半数

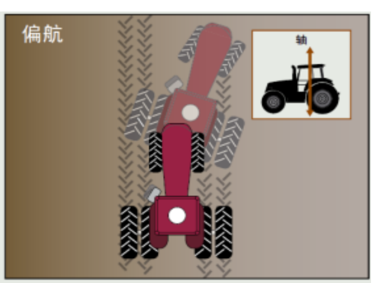








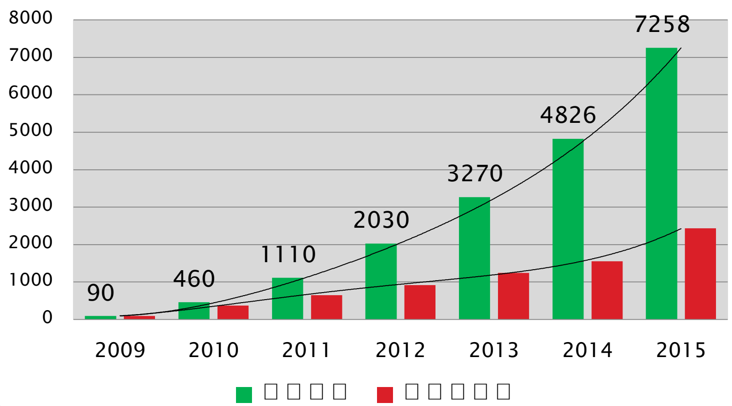




Auto guidance system made in China 中国自动驾驶

Auto guidance system made in China

The amount of tractor automatic driving system in China



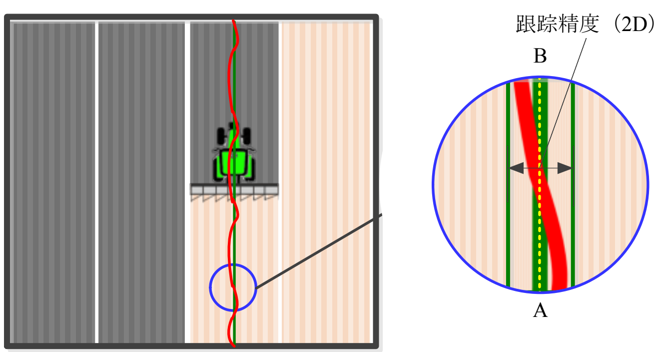
Regional distribution of tractor automatic driving market in China

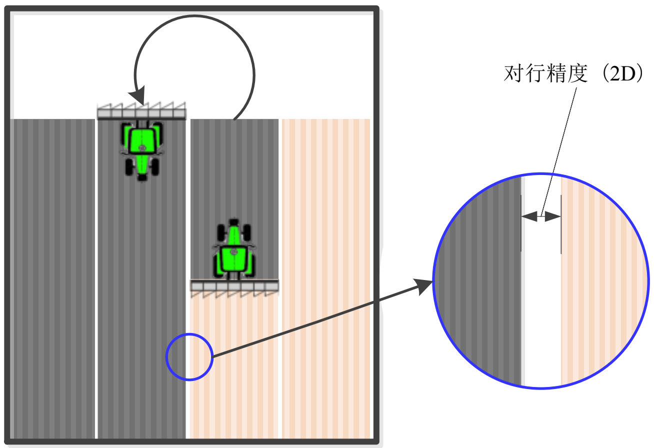
数据、图片来源：赵延平，我国北斗农机自动化应用现状，“金桥产业技术创新会议”第十三次会议，2016.3

Function of Auto Guidance 自动驾驶作用

- Improve operation quality
- 提高作业质量
- Increase yields
- 增加作物产量
- Improve work efficiency
- 提高工作效率
- Extend operation time
- 延长作业时间
- Increase the area of land
- 提高土地利用率

- Reduce skill requirements
- 减少技能要求
- Reduce labor load
- 减少雇工成本
- Reduce harvesting loss
- 减少产量损失
- Reduce fertilizer & chemical application
- 减少化肥农药施用

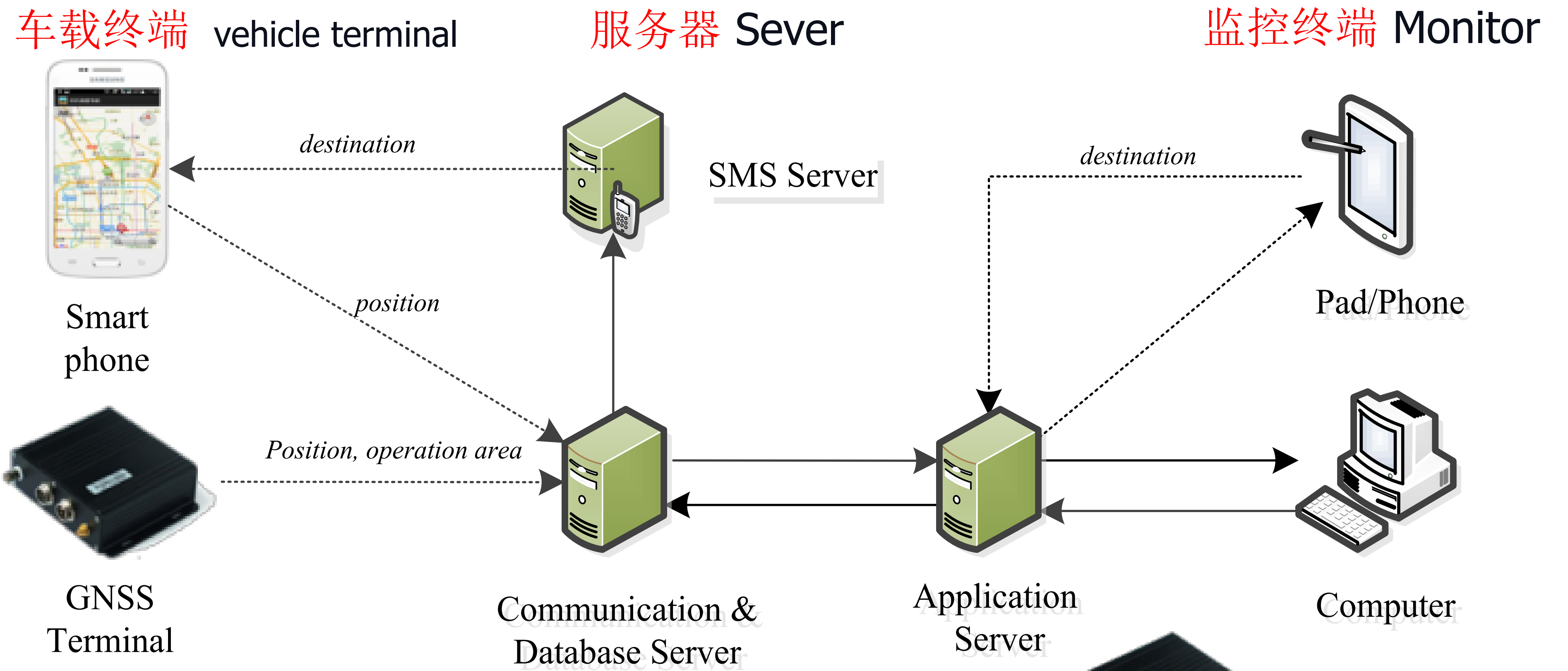




GNSS for operation monitoring 作业监管应用

- Farm machinery service organization 农机合作社
  - Fields
  - Personnel
  - Tractors
  - implements
  - ……

GNSS for operation monitoring 作业监管

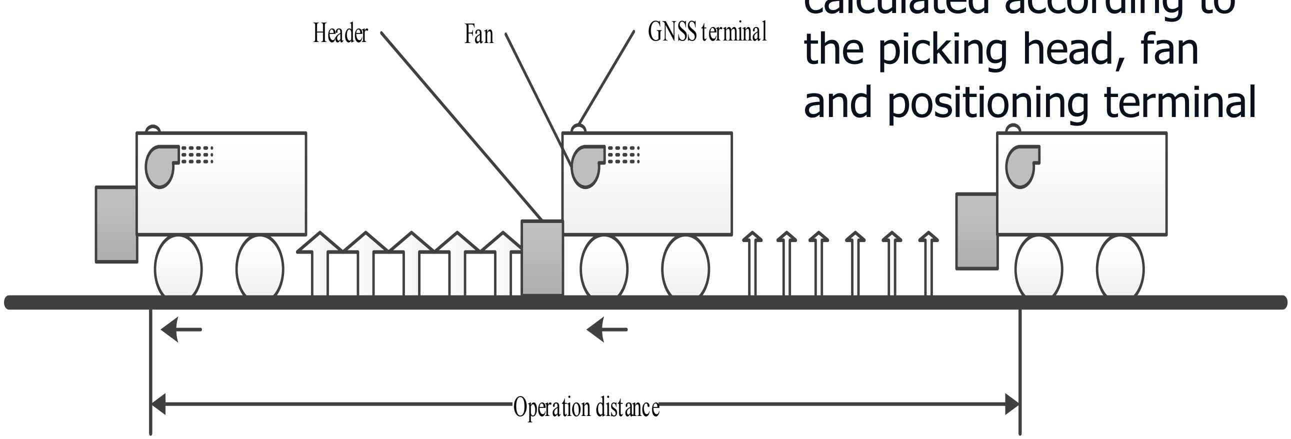


作业监管系统包括：车载终端、服务器、平台和监控终端

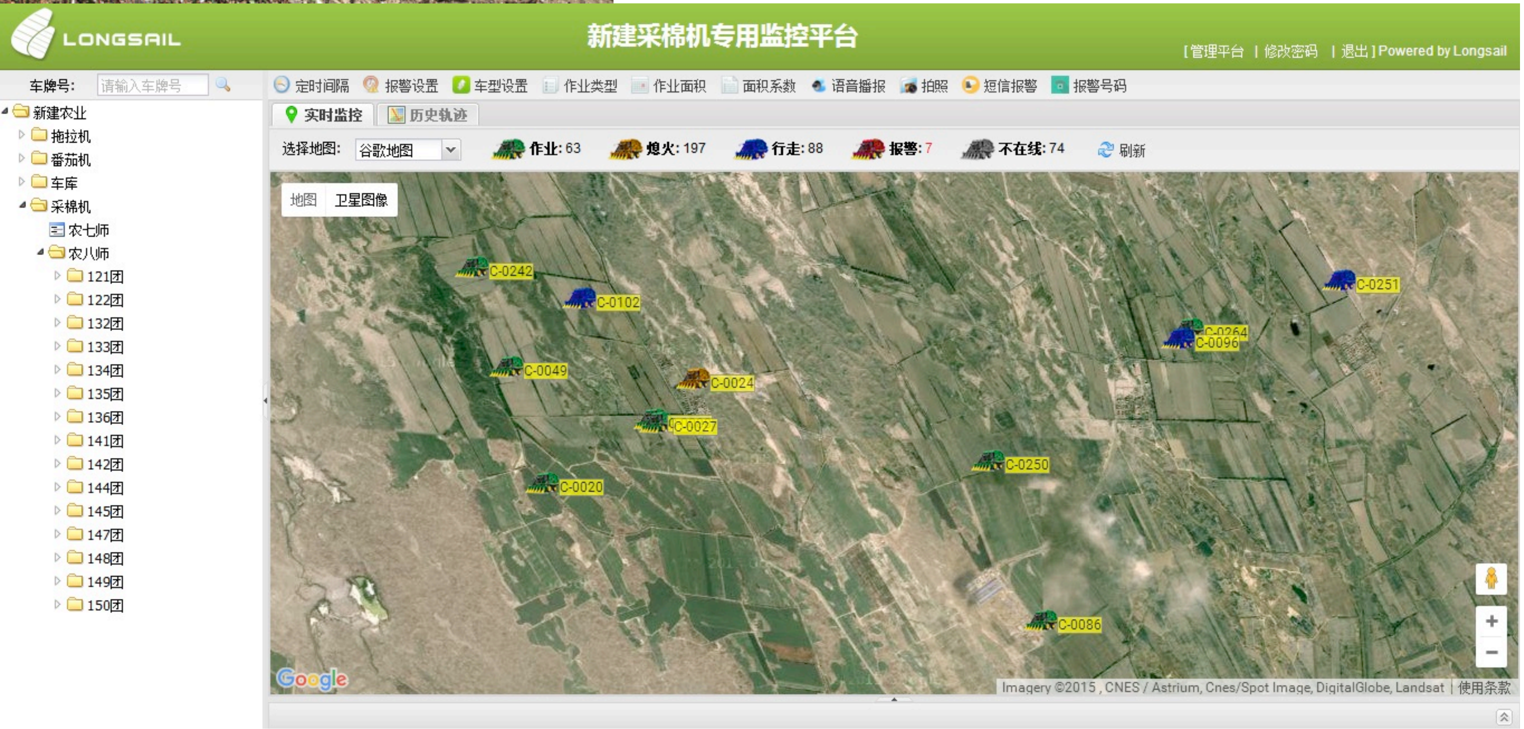
The operating supervision system includes: vehicle terminal, server, platform and monitoring terminal

采棉机监控终端 Monitoring terminal of cotton picking machine

GNSS for operation monitoring 作业监管



The working area is calculated according to the picking head, fan and positioning terminal

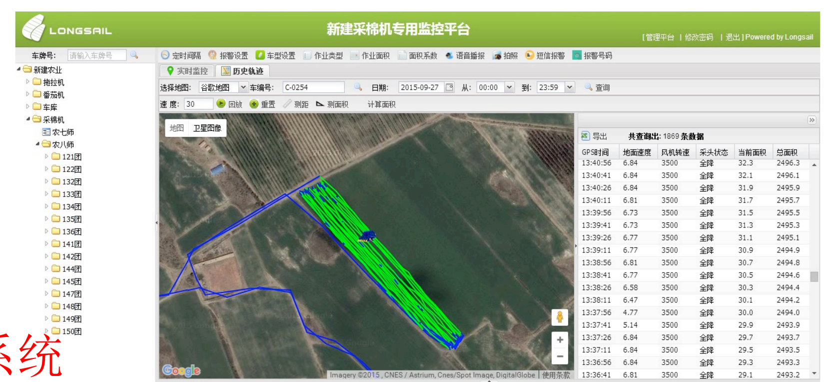


采棉机监控平台 Monitoring platform of cotton picking machine

Software

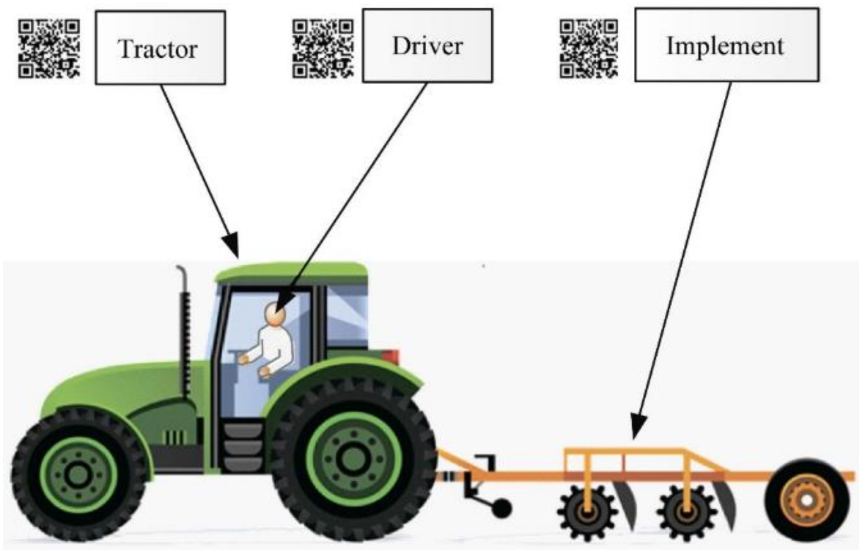
Operation Scheduling 作业调度

调度系统



调度系统

Smartphone based precise monitoring 精细监测



3G/4G status	GNSS status	Working status	Illustrations
normal	normal	normal	Data transferred to server in real-time
abnormal	normal	normal	Data transferred to server when GPRS/3G/4G connected
normal	abnormal	abnormal	Not working
abnormal	abnormal	abnormal	Not working

Give the tractor, driver and agricultural machinery QR codes, the driver scan the QR code before working, will be helpful on operation management

a. Fertilizer spreading

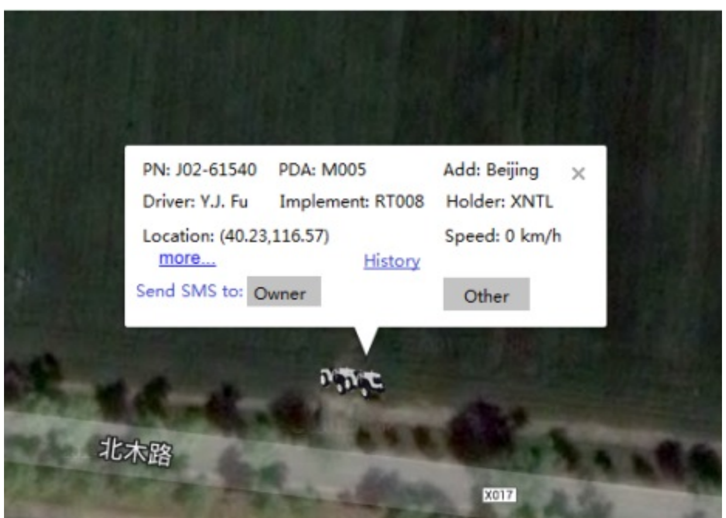
b. Disc harrowing

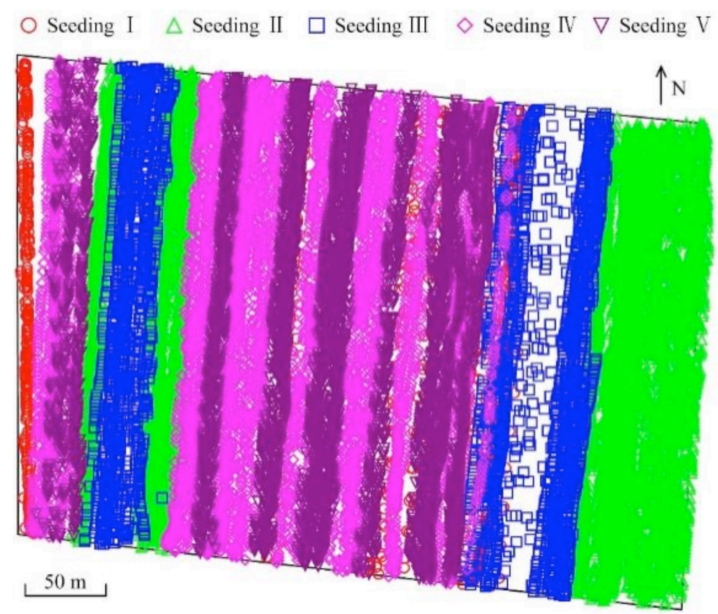
c. Plowing

d. Rotary hoeing

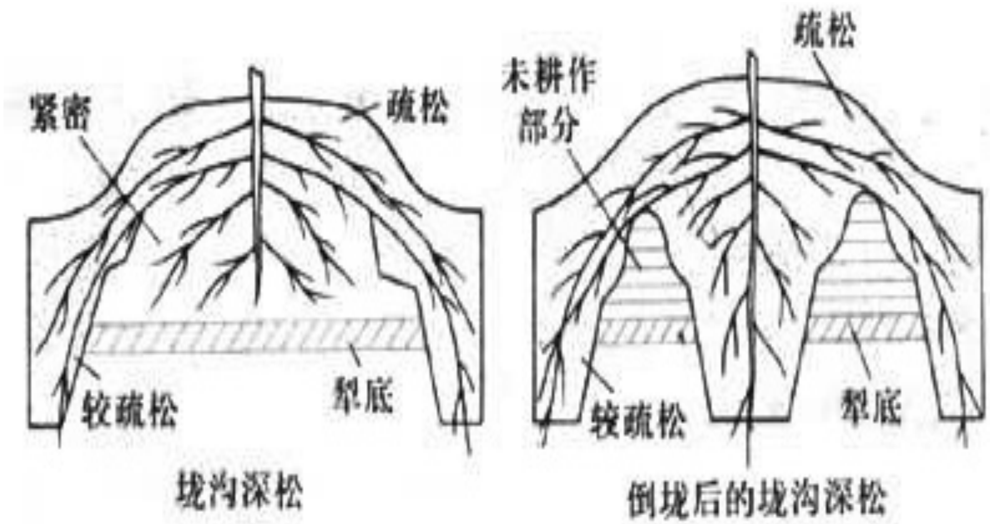
e. Seeding

f. Driver scaned QR codes before working





GNSS for operation monitoring: deep scarification

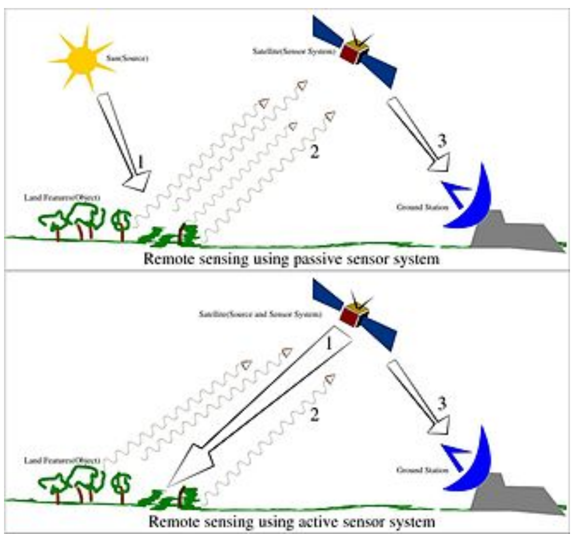


深松机

深松监测传感器

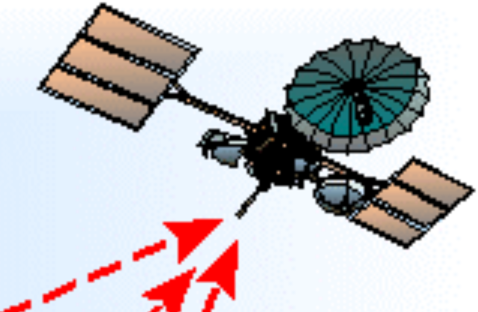
深松监测平台

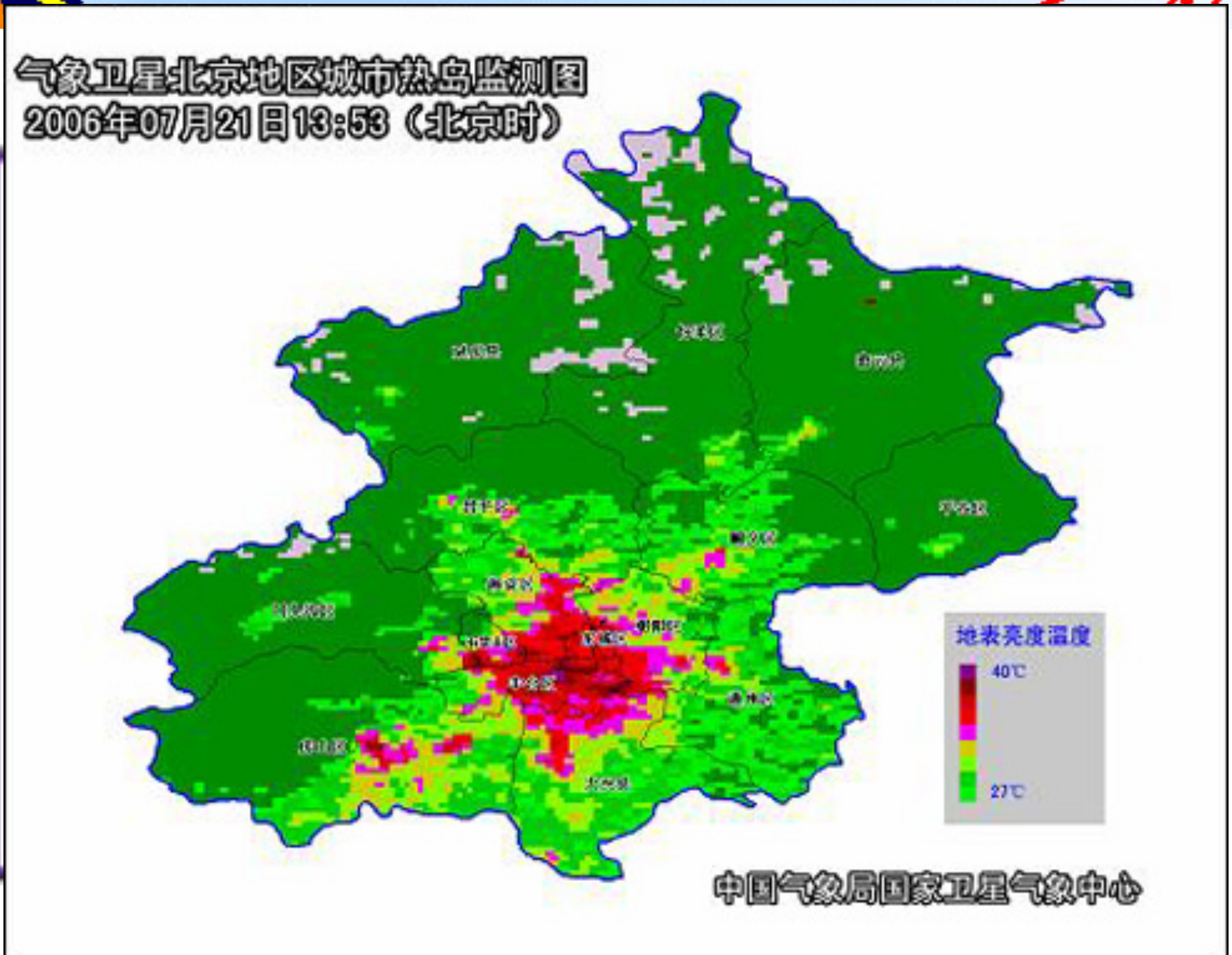
2. Supporting Technologies of PA



Remote sensing(RS)

RS is the acquisition of information about an object or phenomenon without making physical contact with the object and thus in contrast to on-site observation. In current usage, the term "remote sensing" generally refers to the use of satellite- or aircraft-based sensor technologies to detect and classify objects on Earth. It may be split into "active" remote sensing (i.e., when a signal is emitted by a satellite or aircraft and its reflection by the object is detected by the sensor) and "passive" remote sensing (i.e., when the reflection of sunlight is detected by the sensor). Examples of passive remote sensors include film photography, infrared, charge-coupled devices, and radiometers.





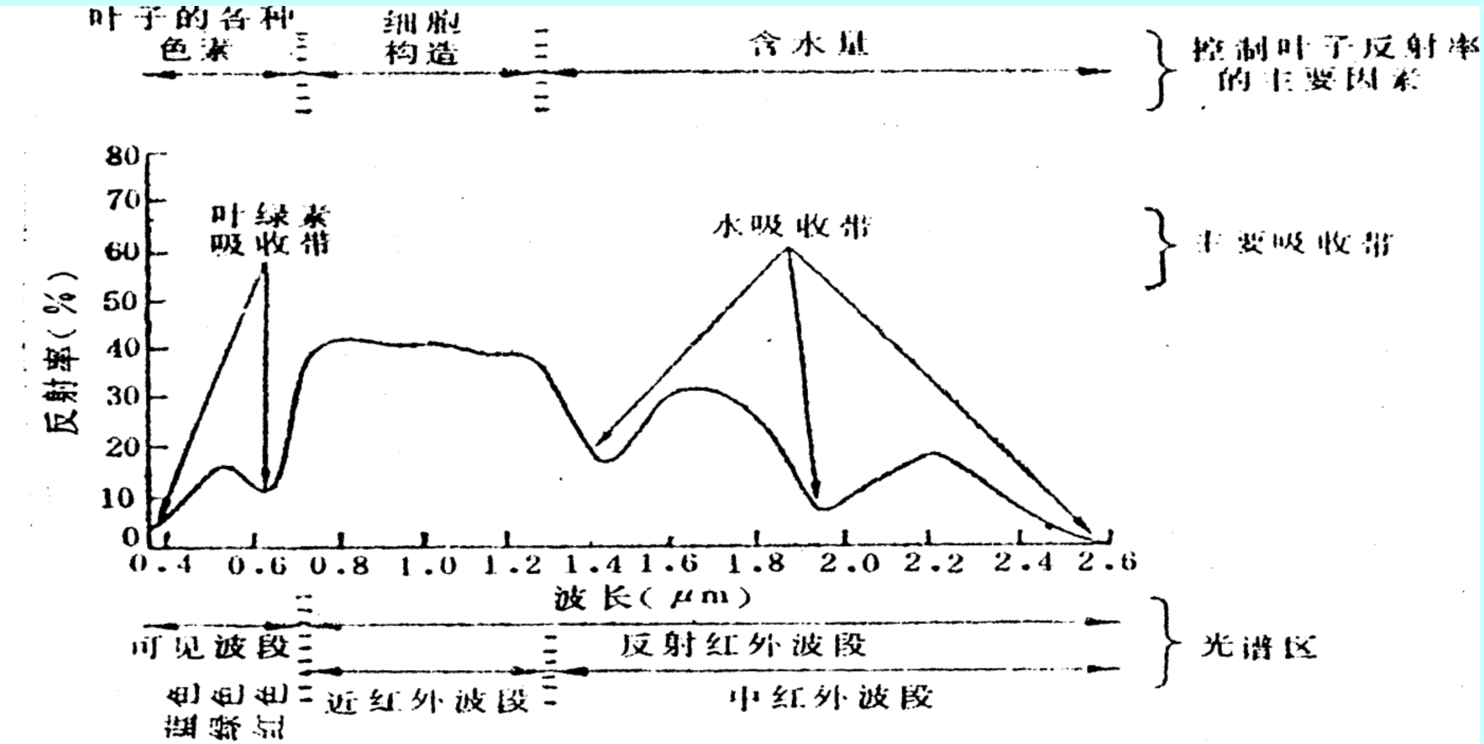
g EMR

d EMR

EMR

2. Supporting Technologies of PA

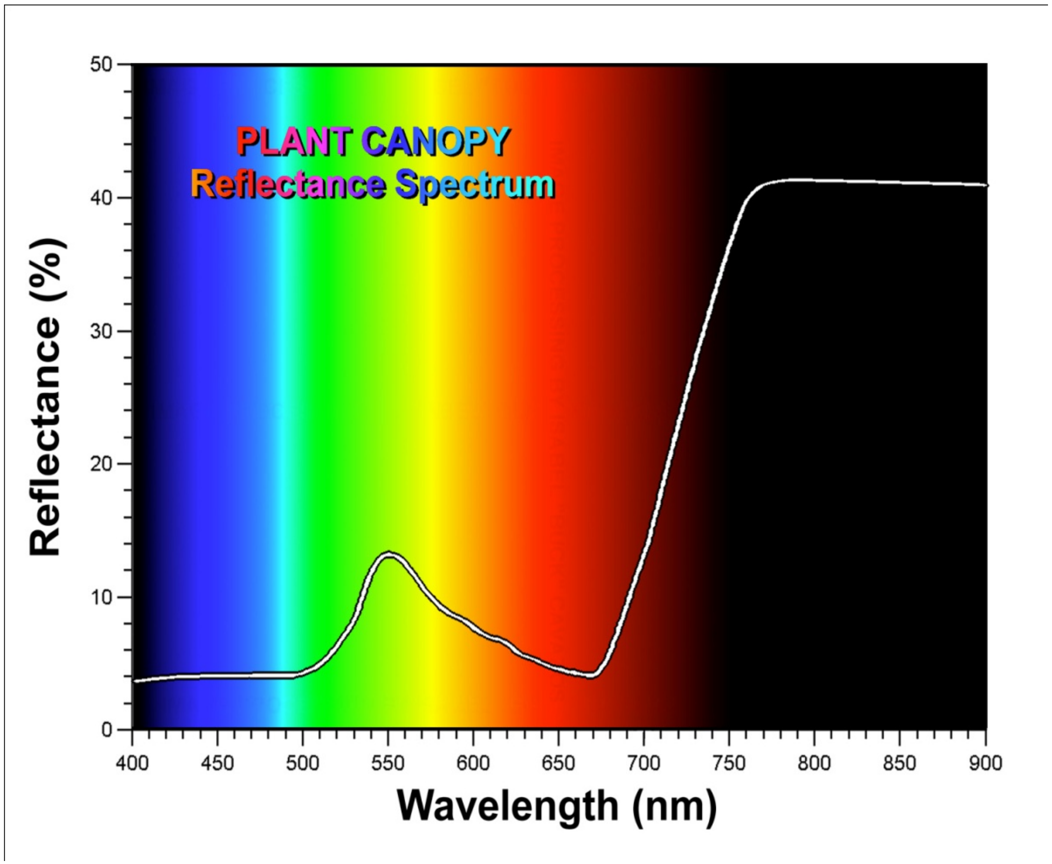
The main spectral response characteristics of green plants



绿色植物的主要光谱响应特性

2. Supporting Technologies of PA

The main spectral response characteristics of green plants



$$RVI = \frac{R_{ir}}{R_r}$$

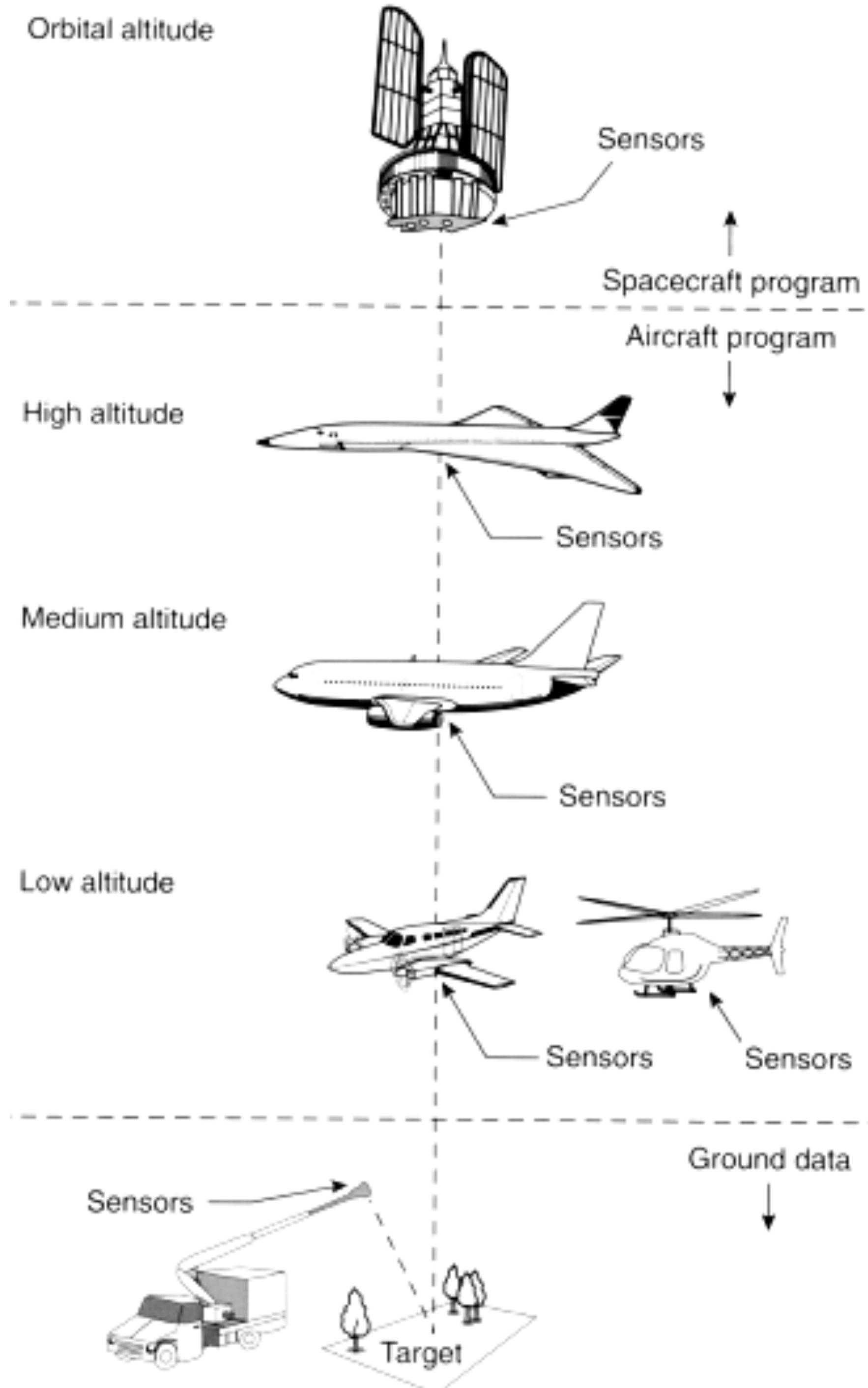
$$NDVI = \frac{R_{ir} \quad R_r}{R_{ir} + R_r}$$

2. Supporting Technologies of PA

The main spectral response characteristics of green plants

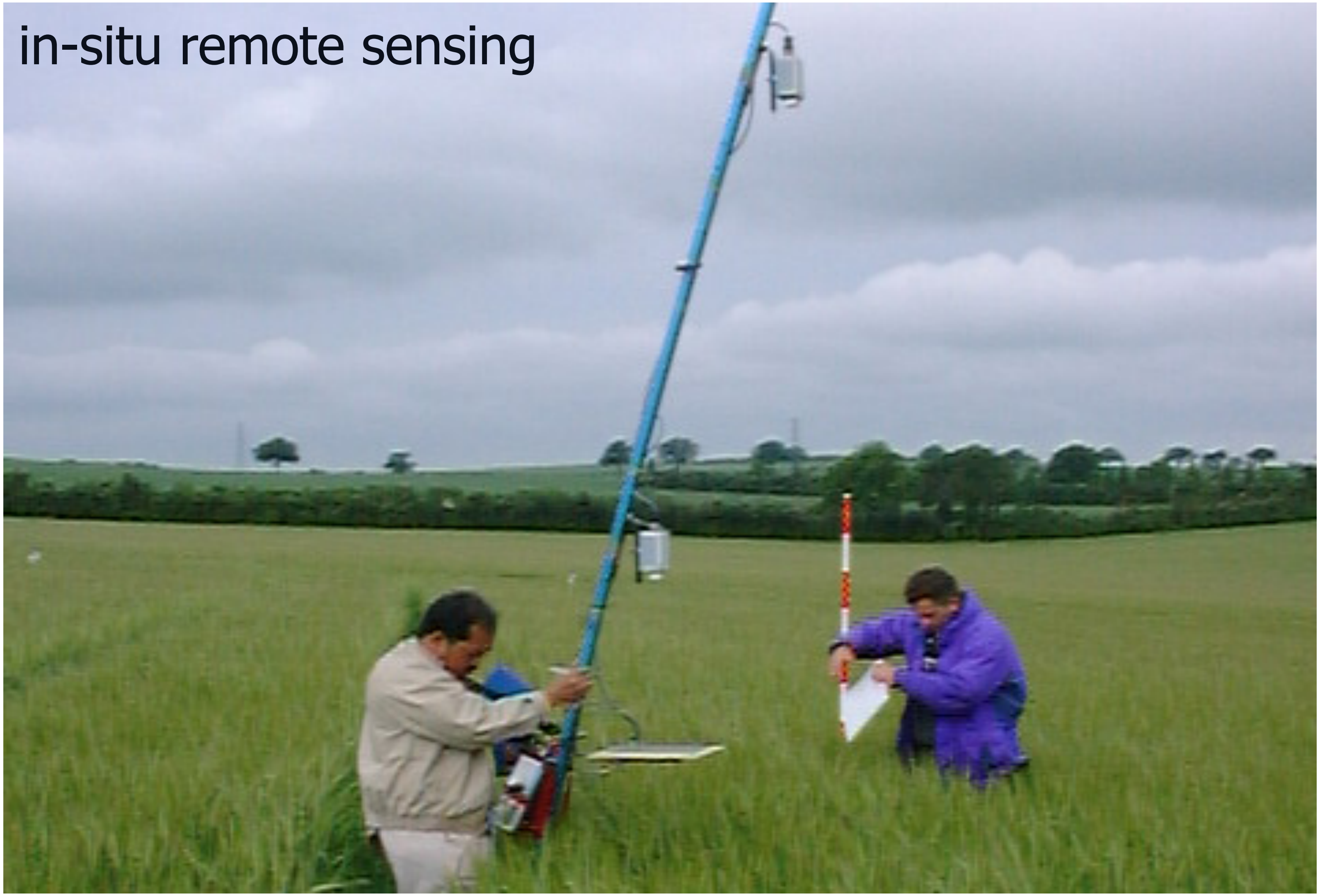
2. Supporting Technologies of PA

remote sensing platform



2. Supporting Technologies of PA

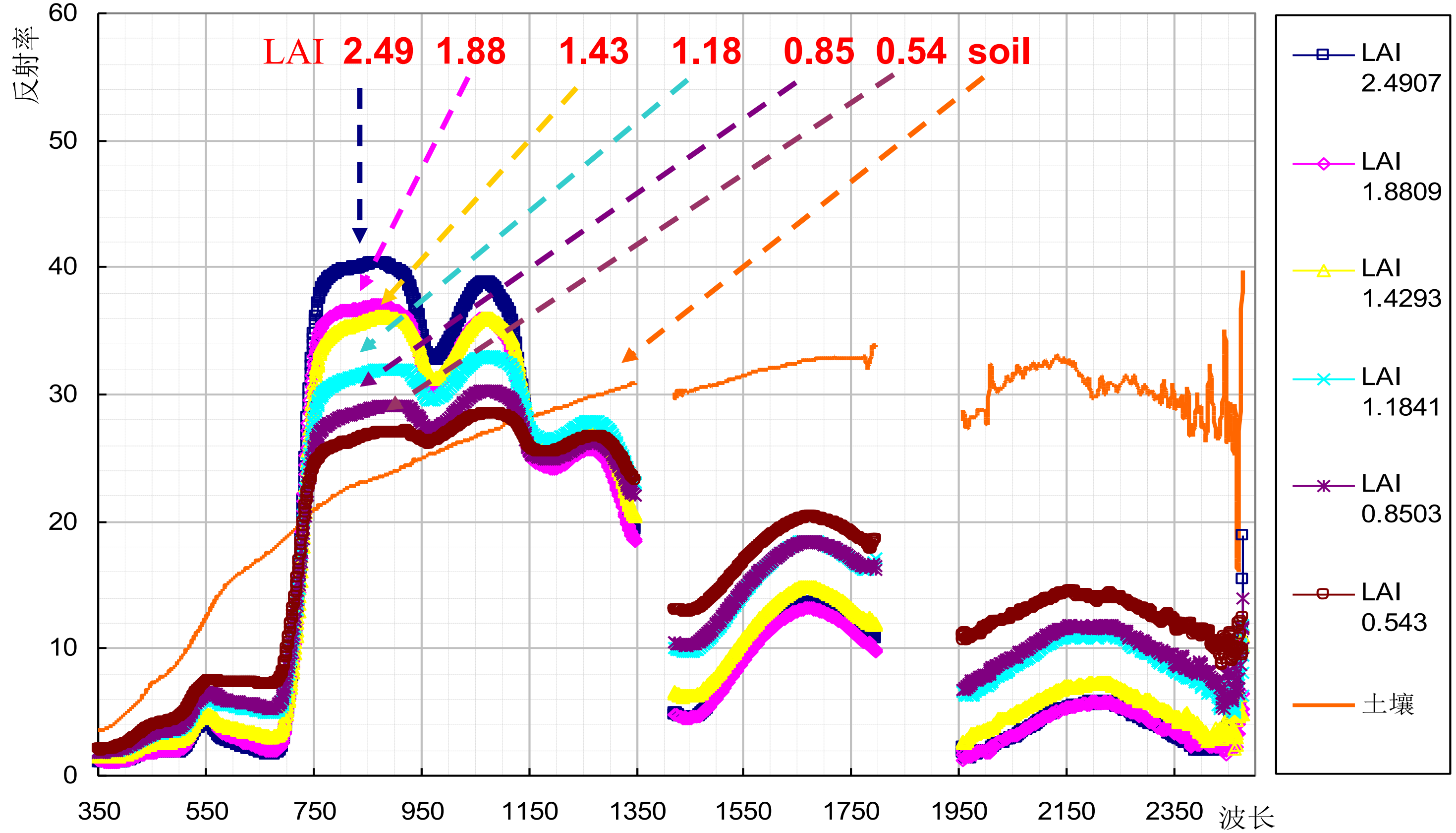
2. Supporting Technologies of PA



2. Supporting Technologies of PA

in-situ remote sensing

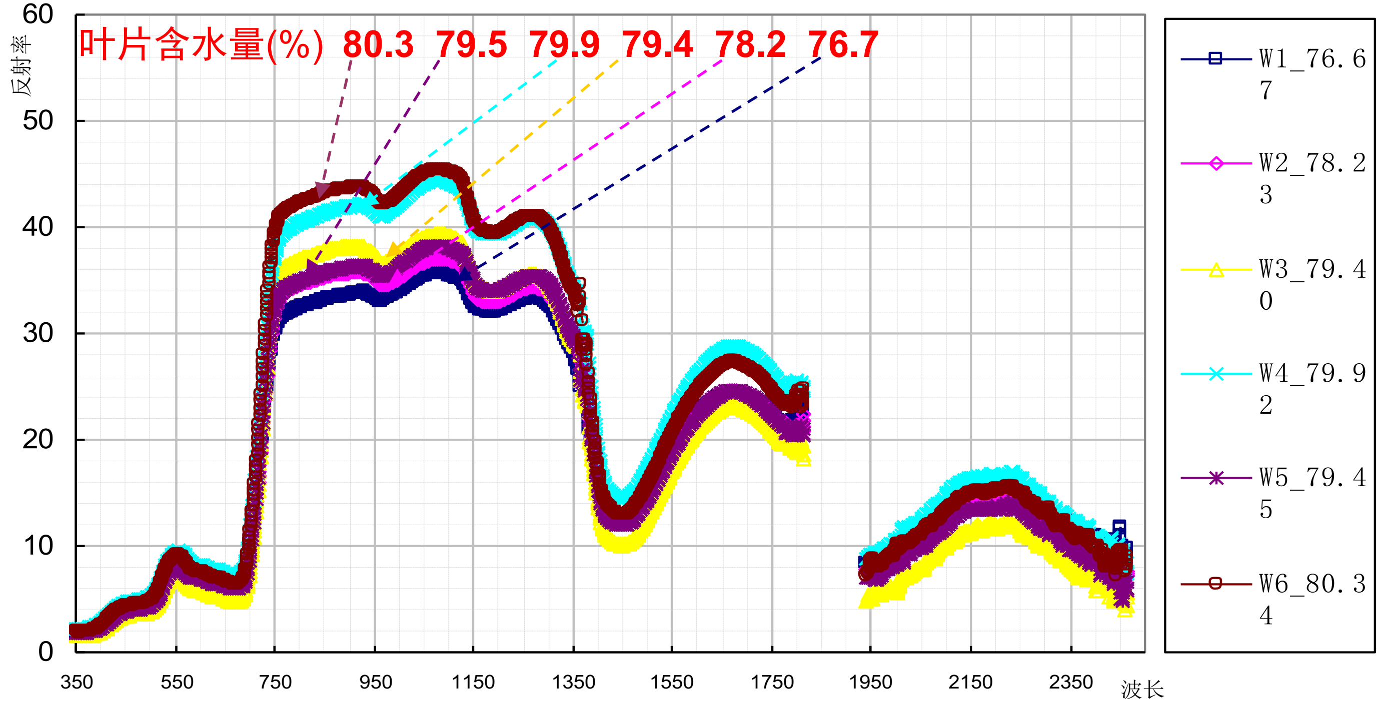
Spectral characterization of different leaf area index



2. Supporting Technologies of PA

in-situ remote sensing

Spectral characterization of water content in leaves

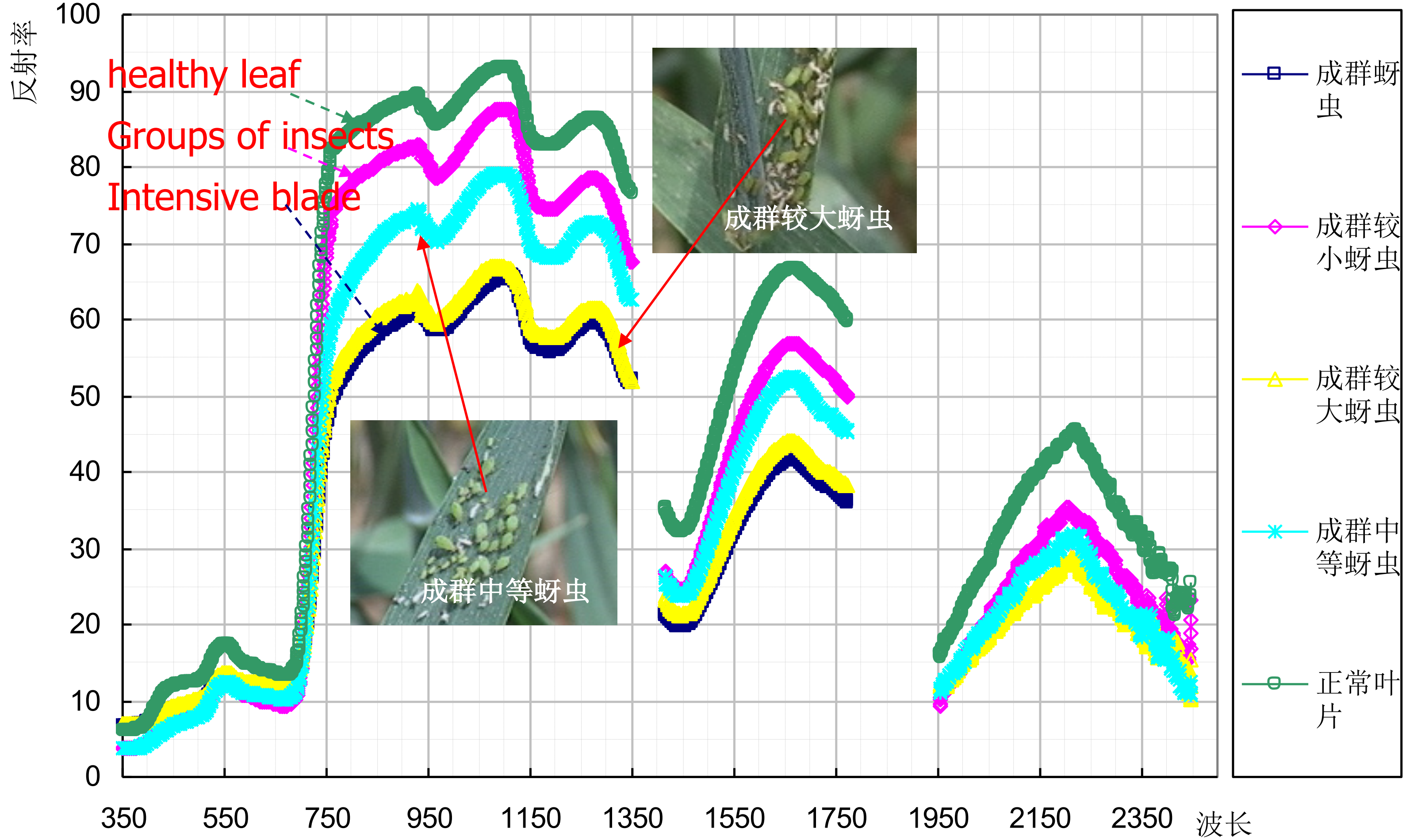


叶片含水量	76.67	78.23	79.40	79.92	79.45	80.34
叶面积指数	1.1994	1.124	0.944	0.956	0.884	1.146

2. Supporting Technologies of PA

in-situ remote sensing

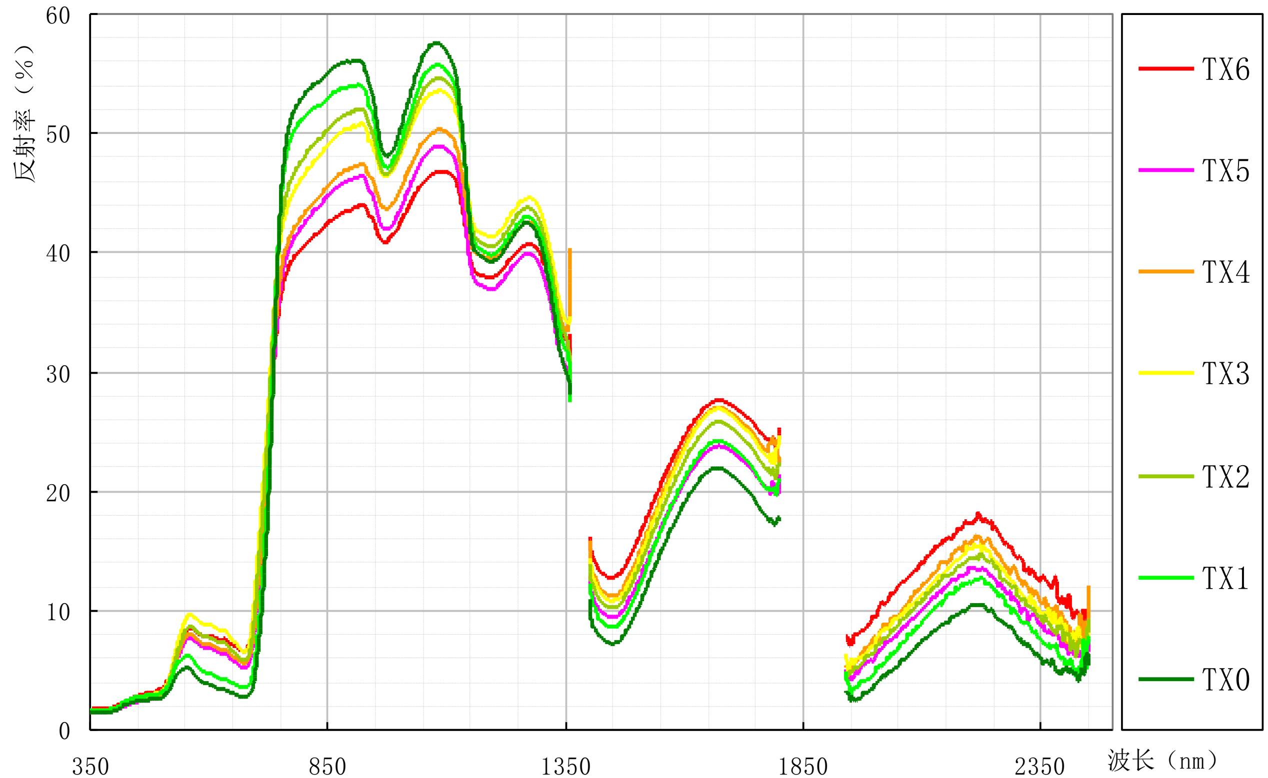
The spectral characterization of aphids in wheat

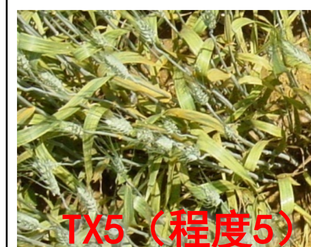


2. Supporting Technologies of PA

in-situ remote sensing

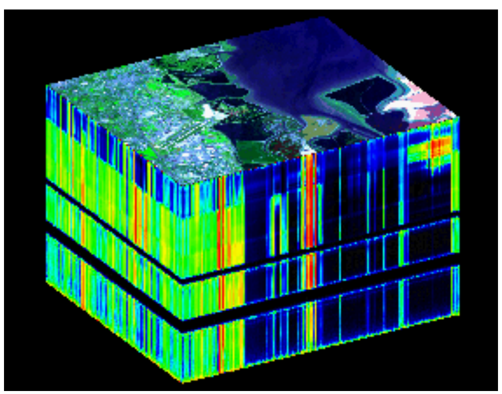
wheat rust and its spectral characterization





2. Supporting Technologies of PA

aerial remote sensing

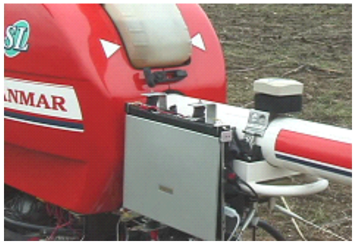


2. Supporting Technologies of PA

aerial remote sensing

2. Supporting Technologies of PA

Computer



GPS antenna

RTK-GPS

System overview

INS and GDS

Adjustable pan-head

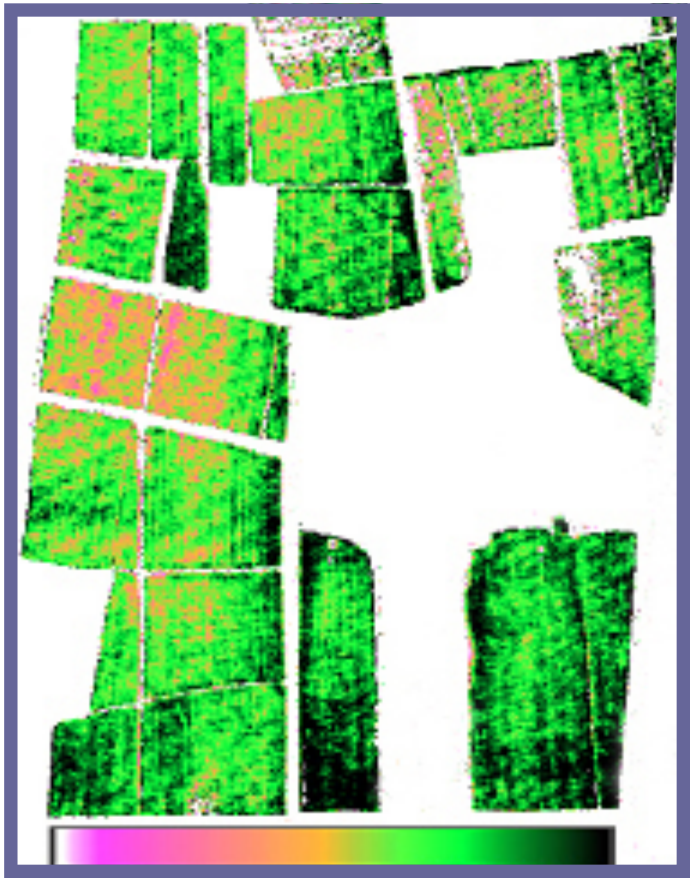
Laser range finder

Multi-spectral imaging sensor

2. Supporting Technologies of PA

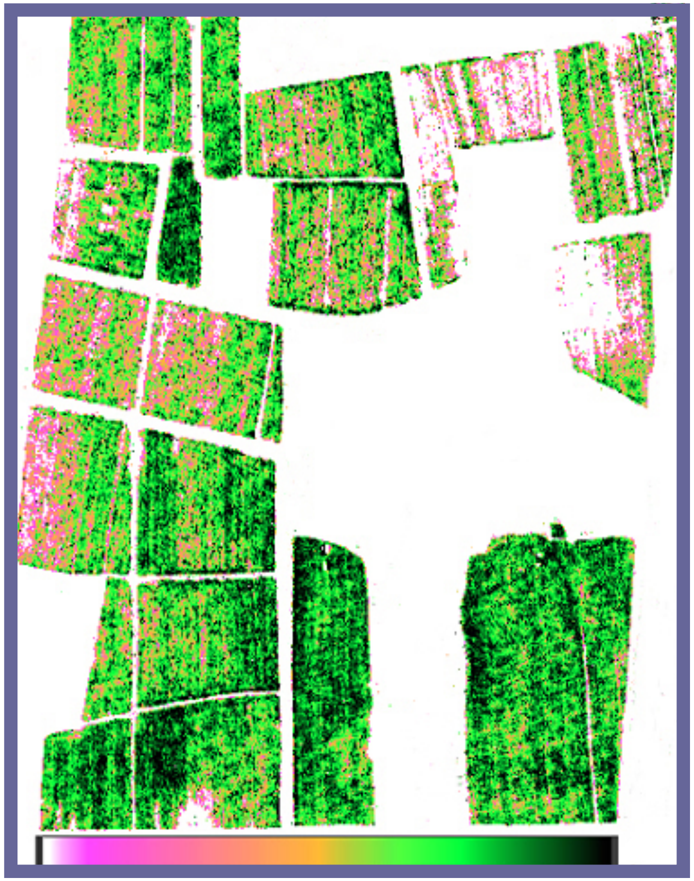
aerial remote sensing

Inversion of physical parameters using spectral data



60 70 80 90

canopy water content(%)



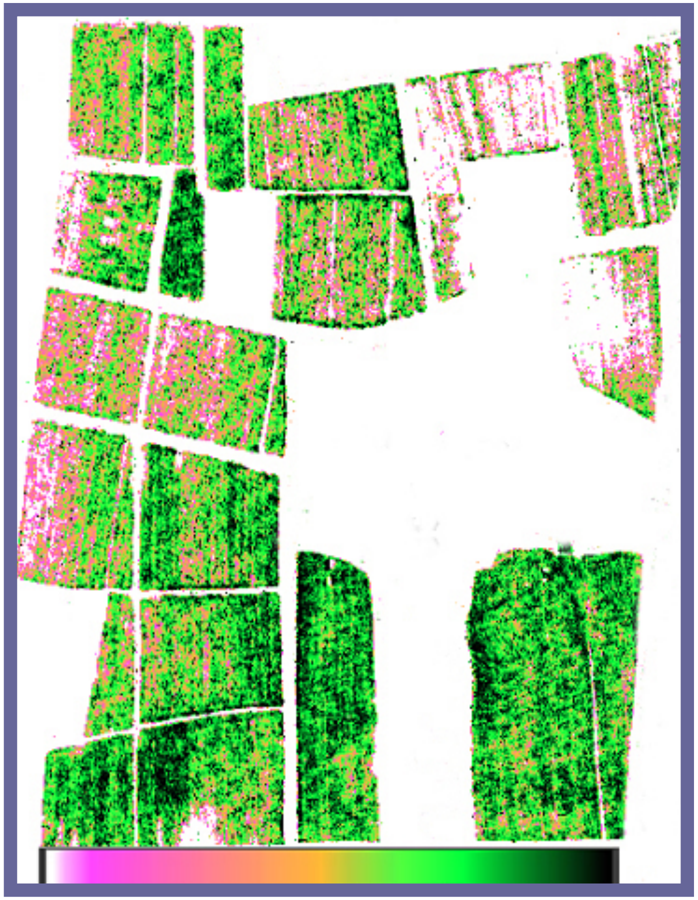
1 2 3 4 5

Chlorophyll AB concentration in canopy (mg/g)

2. Supporting Technologies of PA

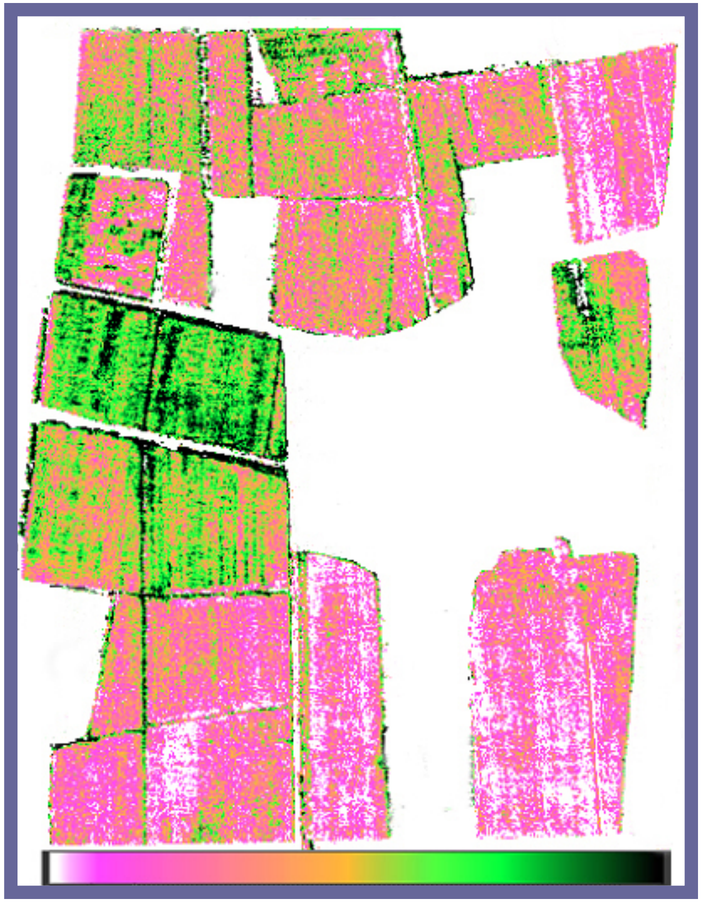
aerial remote sensing

Inversion of physical parameters using spectral data



1 2 3 4 5 6 7

Canopy total nitrogen content (%)



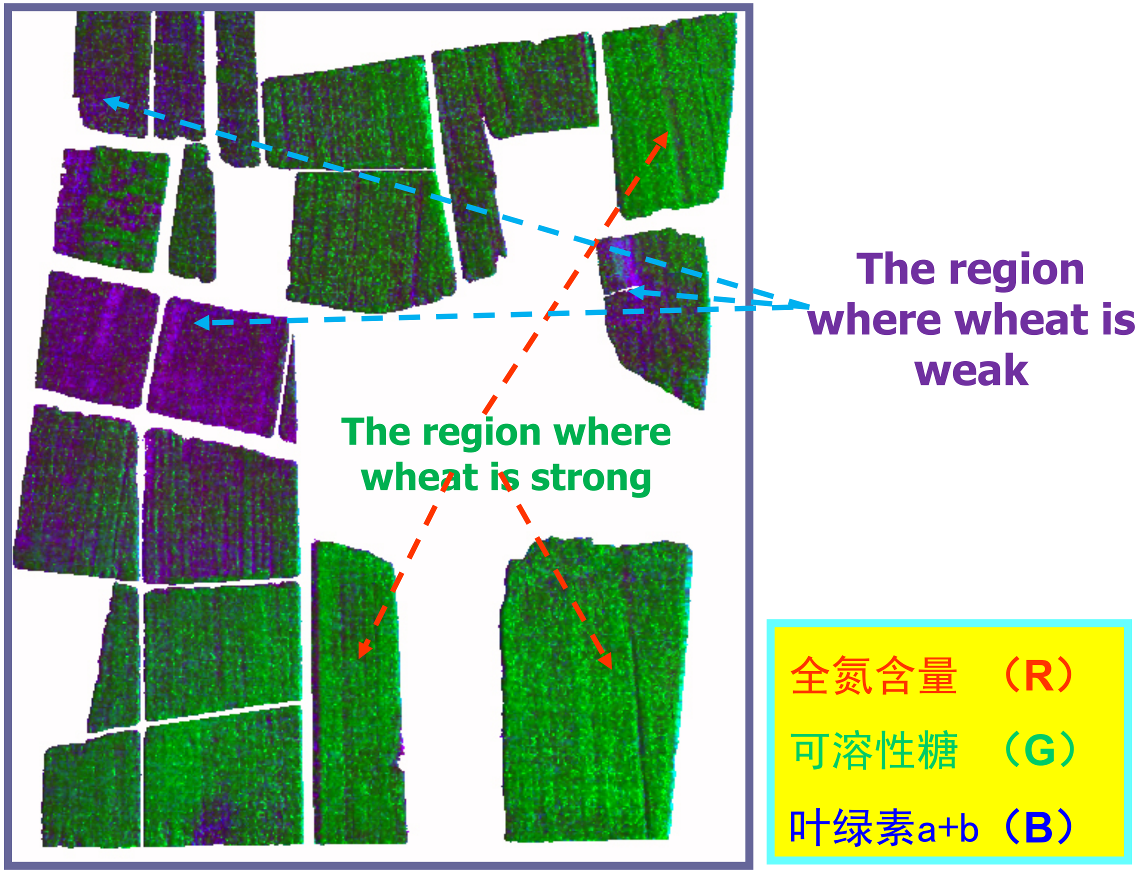
0 10 15 20 30

Canopy soluble sugar content (%)

2. Supporting Technologies of PA

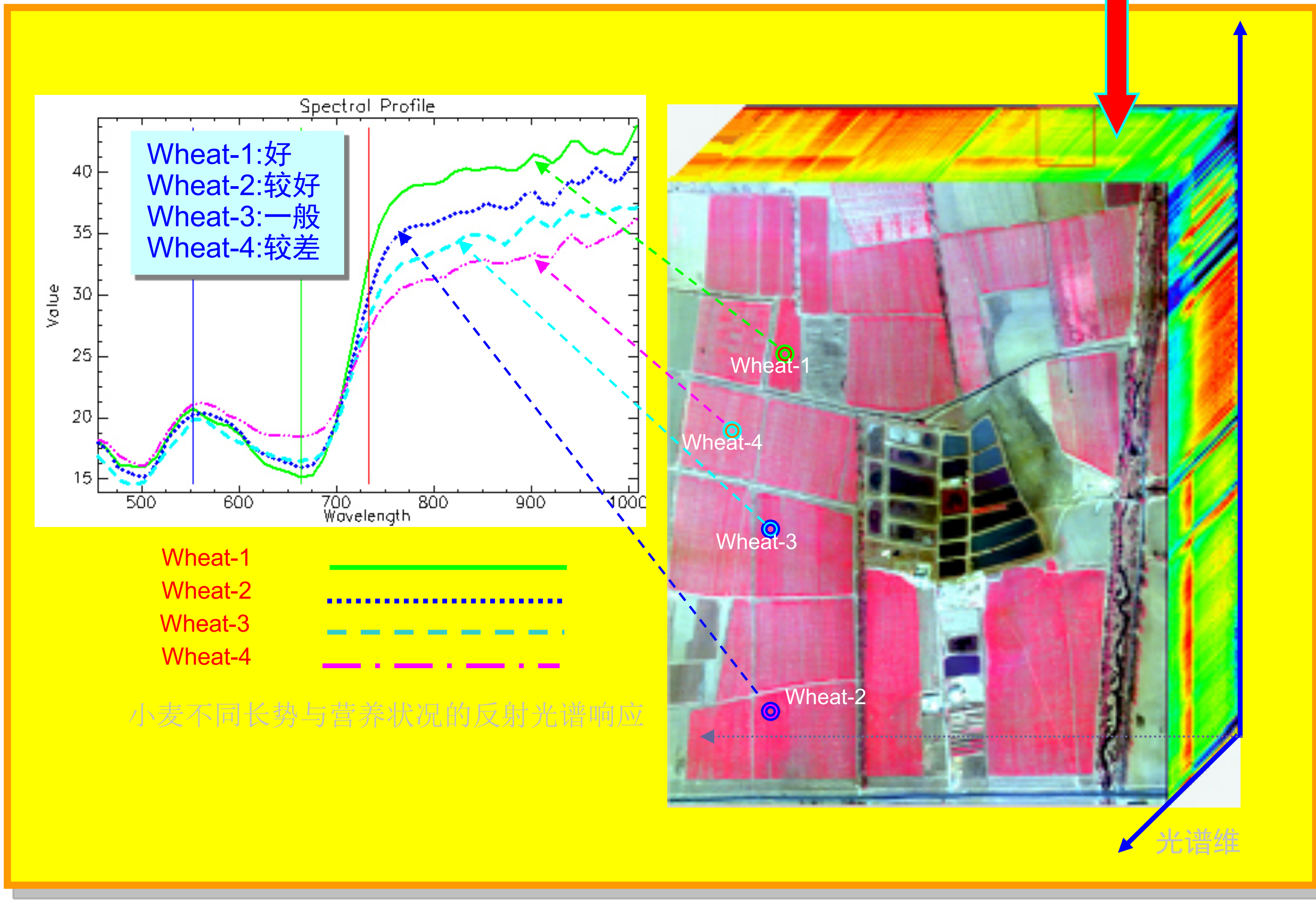
aerial remote sensing

New application:
To Combine remote sensing with agronomy. The ecological and physiological significance of physicochemical parameter image processing and analysis.



2. Supporting Technologies of PA

Aerial remote sensing



Inversion of wheat canopy stratification parameters based on reconstructed reflectance spectra

3 advances in key technologies of PA

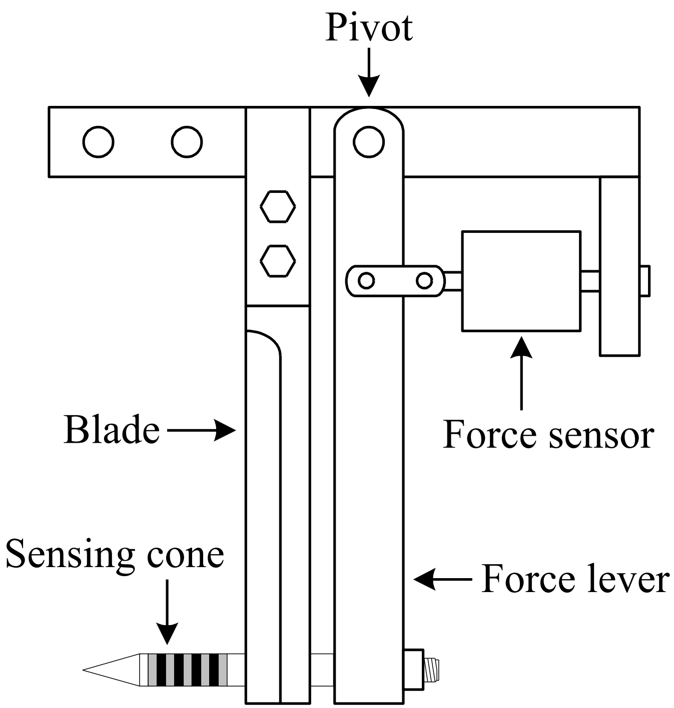
Research progress of sensing and detection technology

Research progress of intelligent equipment technology

Research progress of wireless sensor network technology

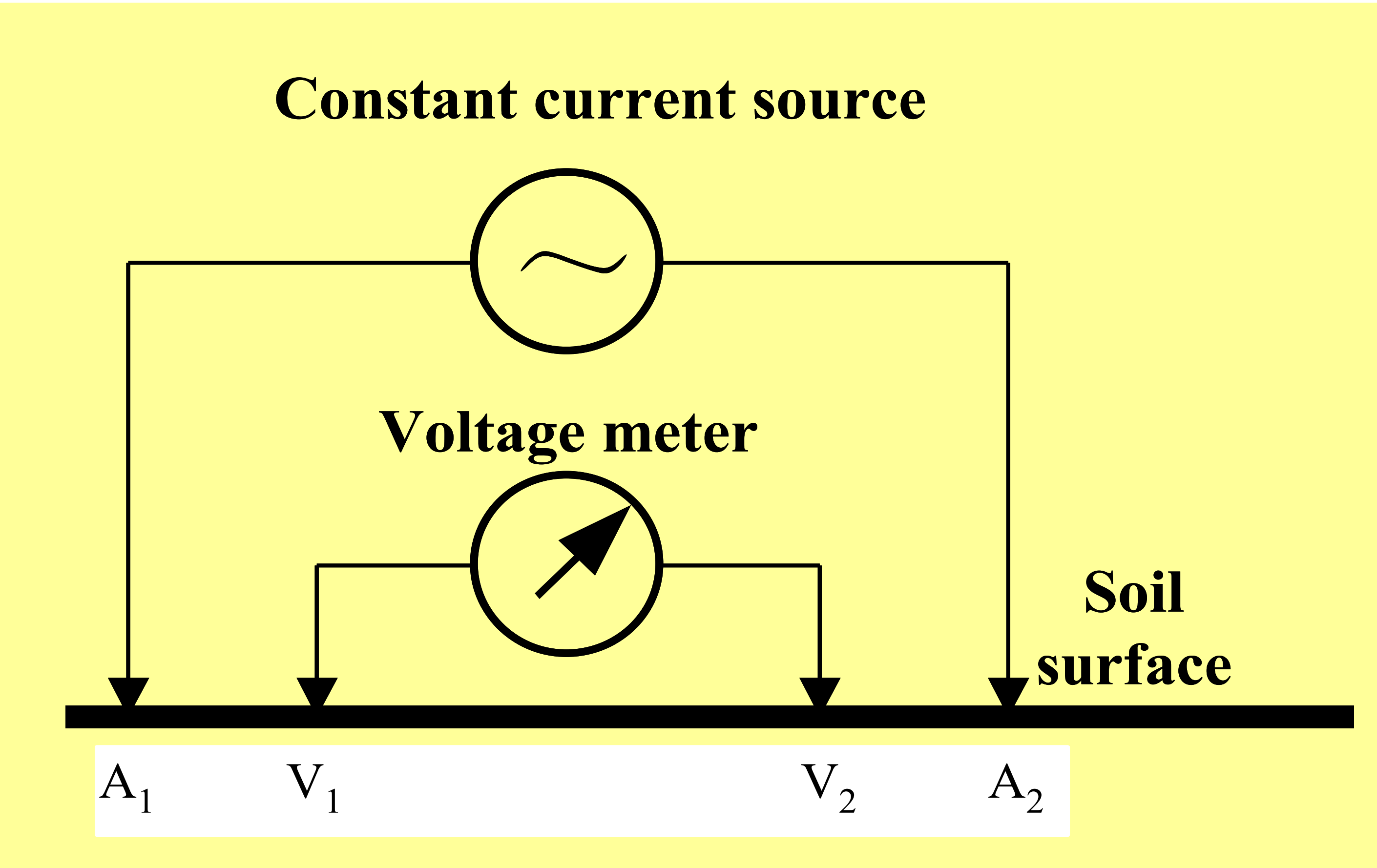
3 advances in key technologies of PA

Sensor of soil moisture



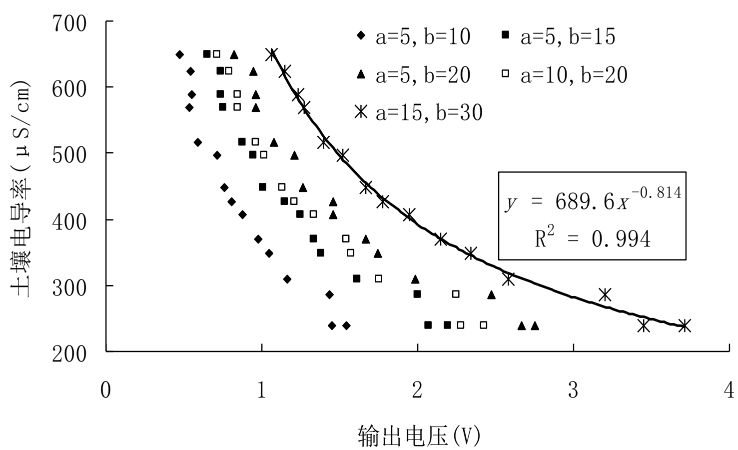
3 advances in key technologies of PA

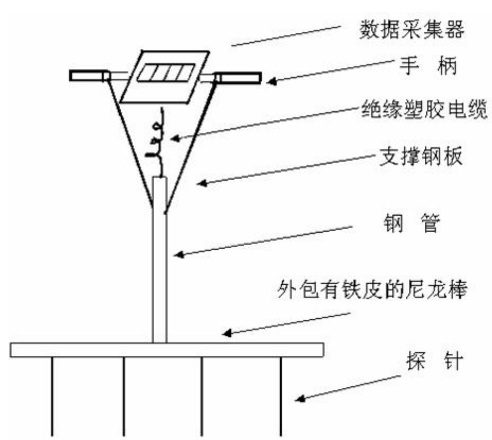
Sensor of soil electrical conductivity



3 advances in key technologies of PA

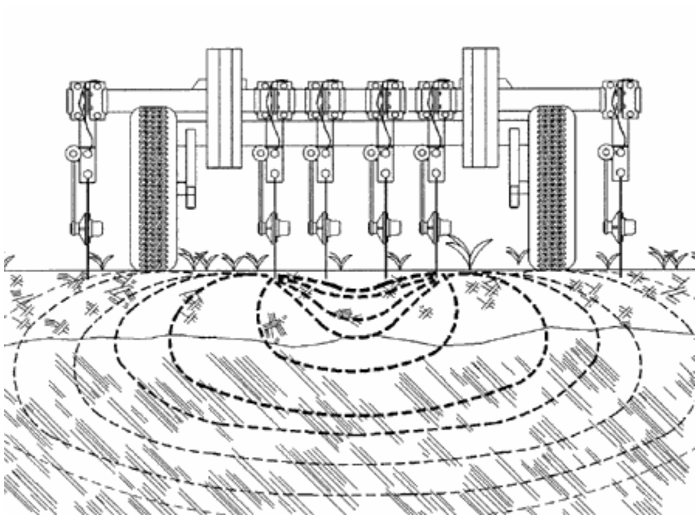
Sensor of soil EC





3 advances in key technologies of PA

Sensor of soil EC



3 advances in key technologies of PA

Automatic acquisition of soil EC information

Soil EC is an inherent property to measure soil conduction current capacity. The results show that the sand has low EC, the surface soil has medium EC and clay has high EC.

Attribute of soil EC:

1. water retention capacity / water leakage
2. cation exchange capacity (CEC)
3. depth of clay layer (texture)
4. capacityorganic compounds
5. salinity
6. pH

3 advances in key technologies of PA

Automatic acquisition of soil EC information

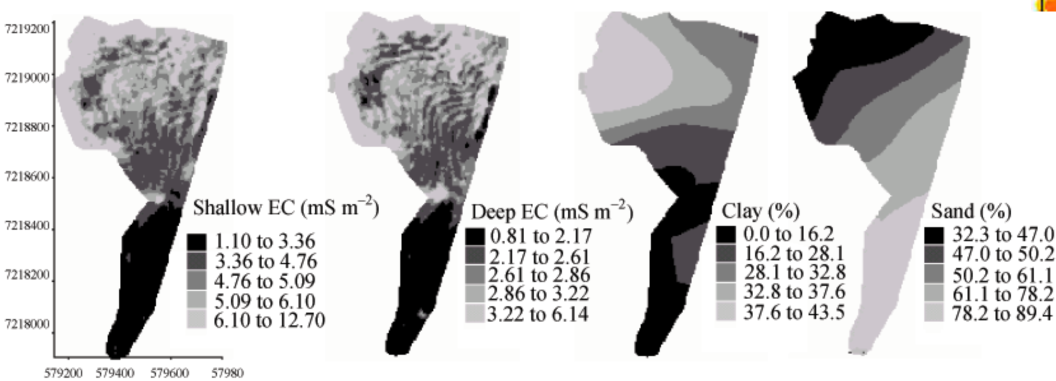
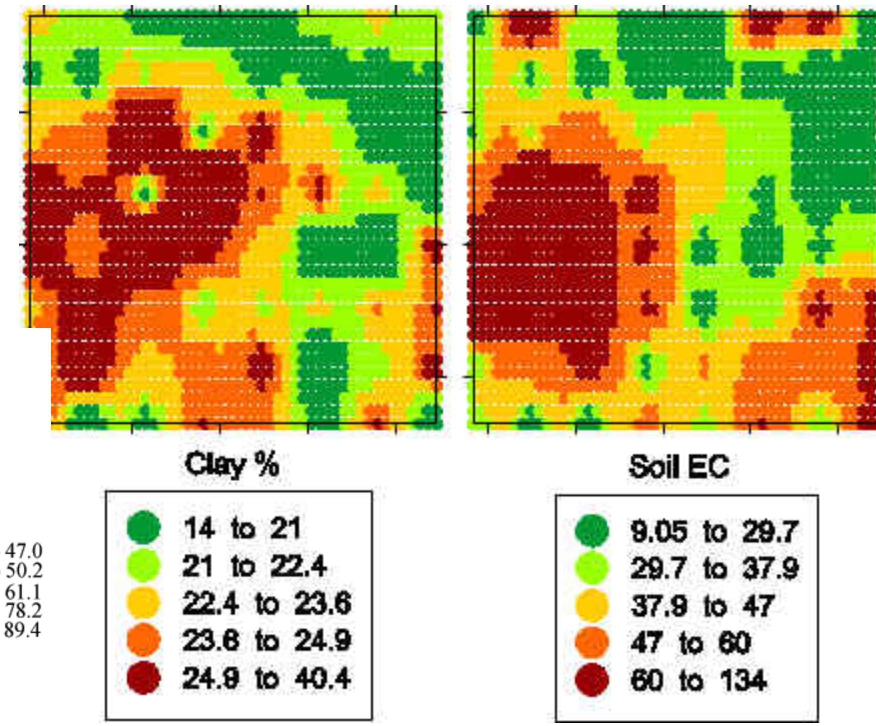
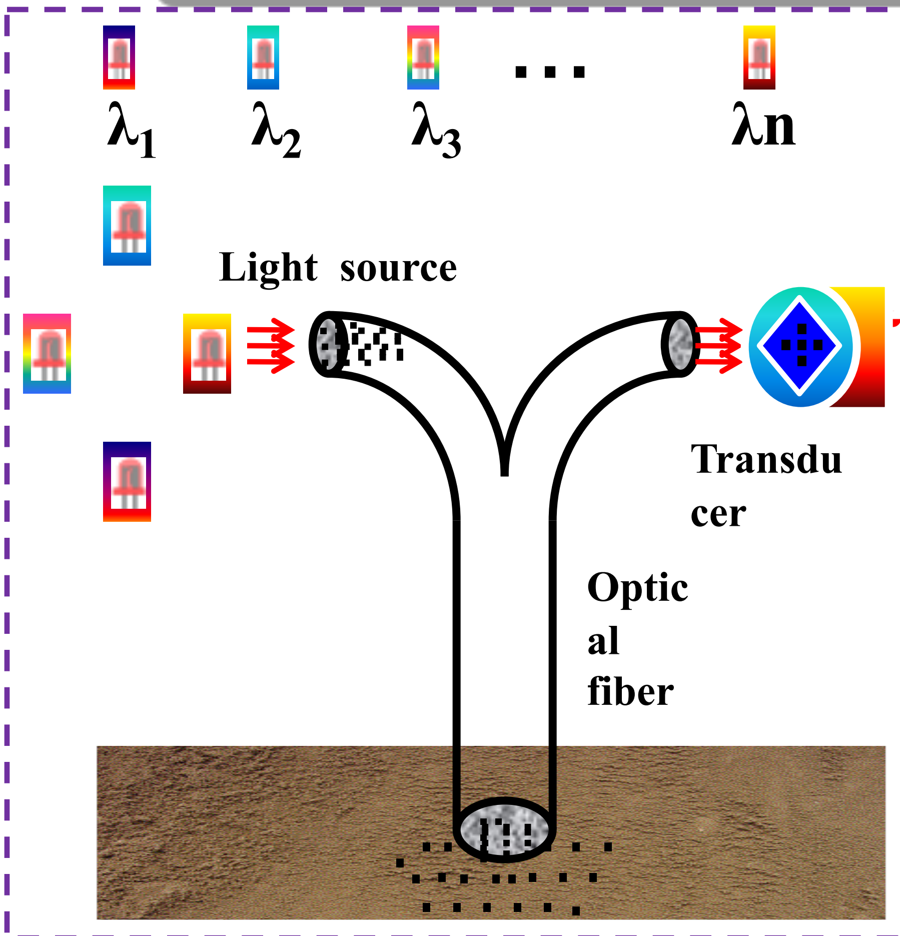


Figure 1 - Shallow (0 – 0.3 m) and deep-reading (0 – 0.9 m) soil EC maps, and soil clay and sand content maps.

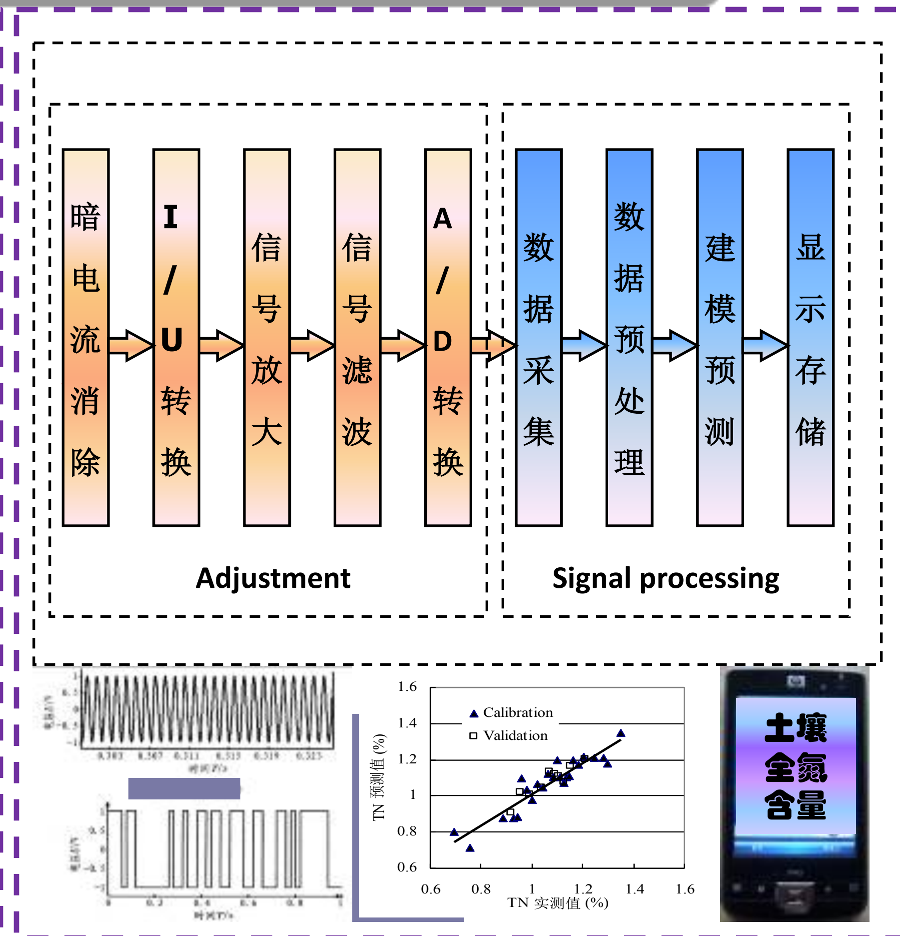


3 advances in key technologies of PA

Sensor of soil nutrient content



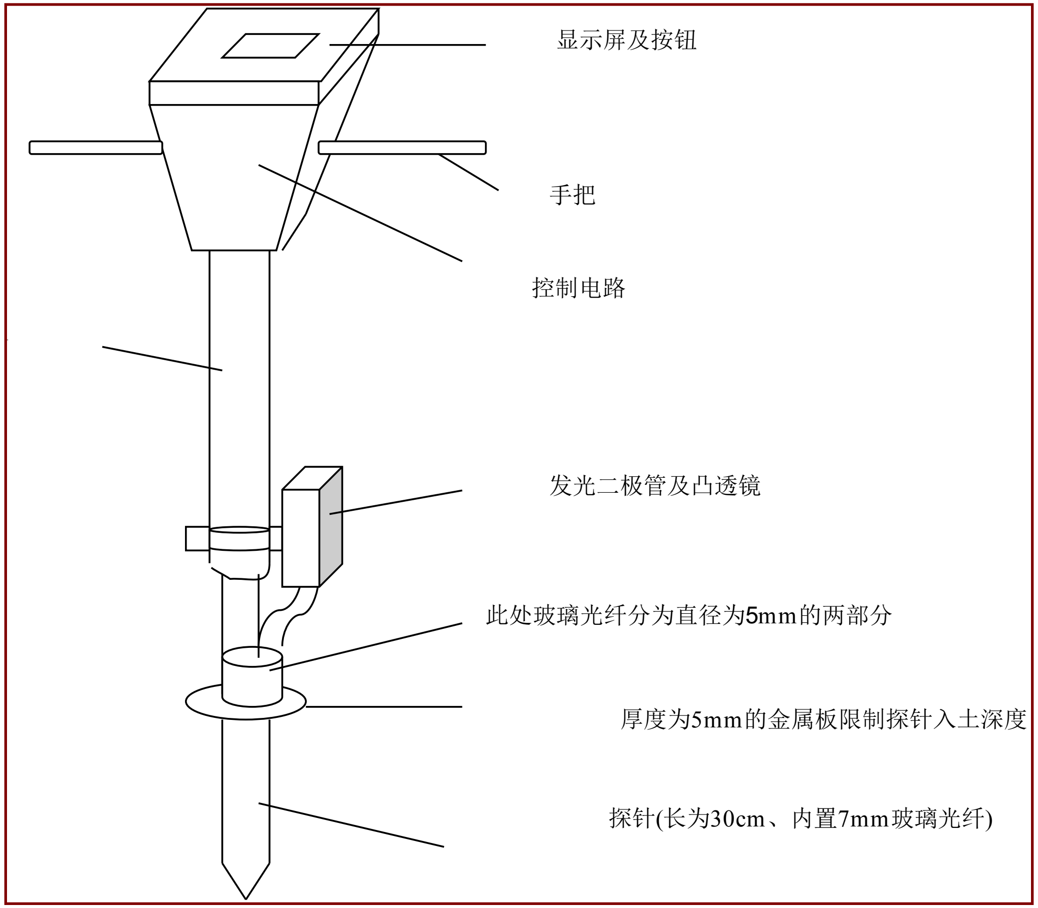
Sensor unit



Instrument

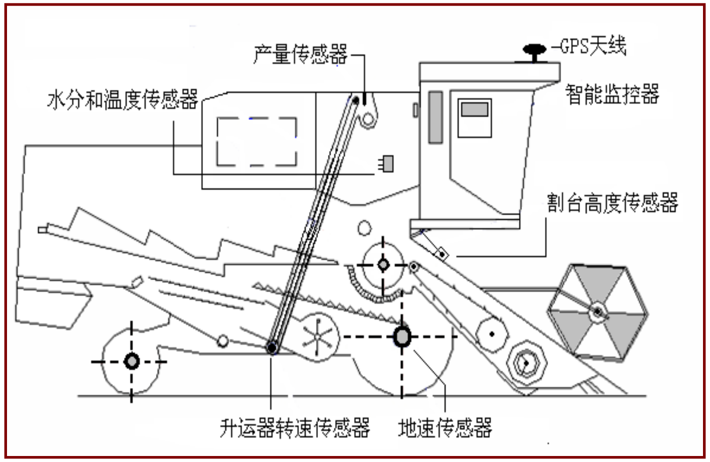
3 advances in key technologies of PA

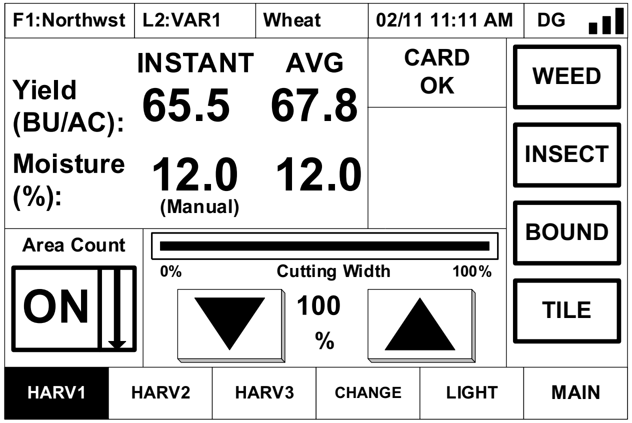
Sensor of soil nutrient content

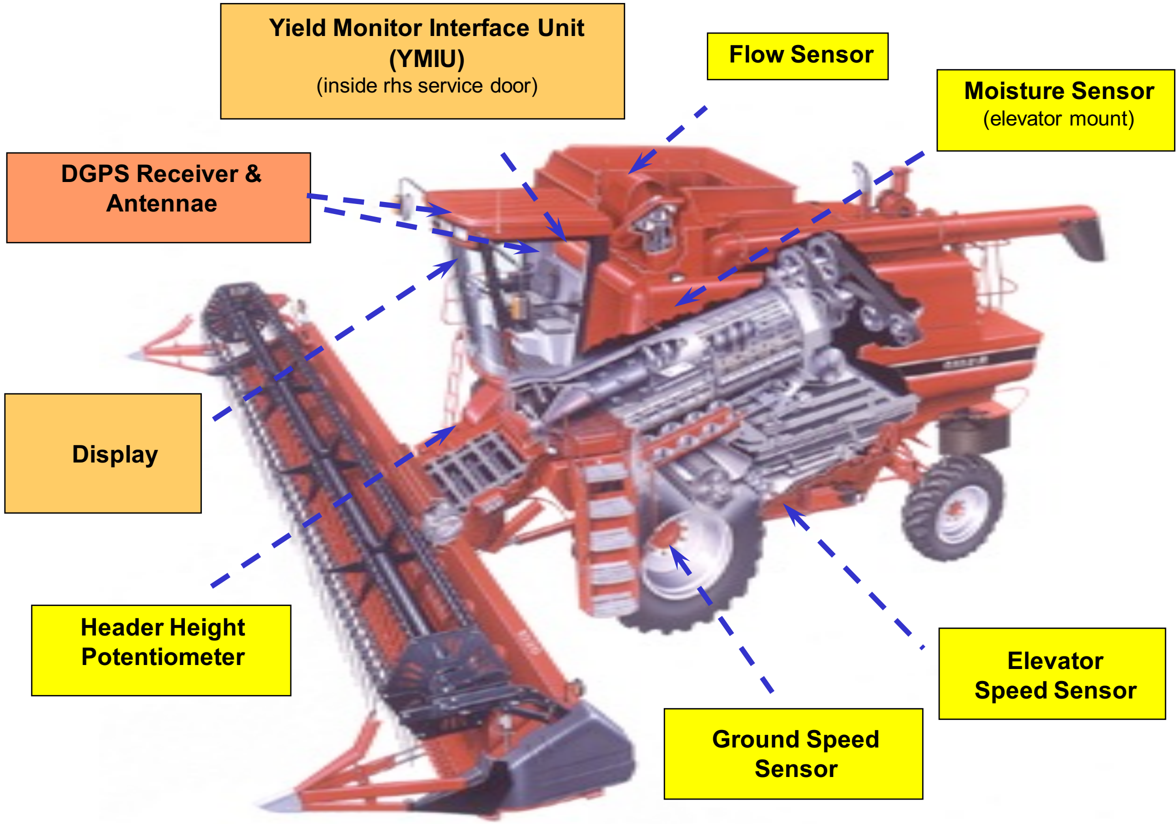


3 advances in key technologies of PA

Sensor of yield monitor

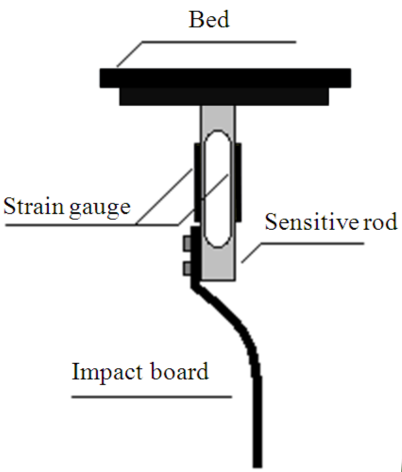


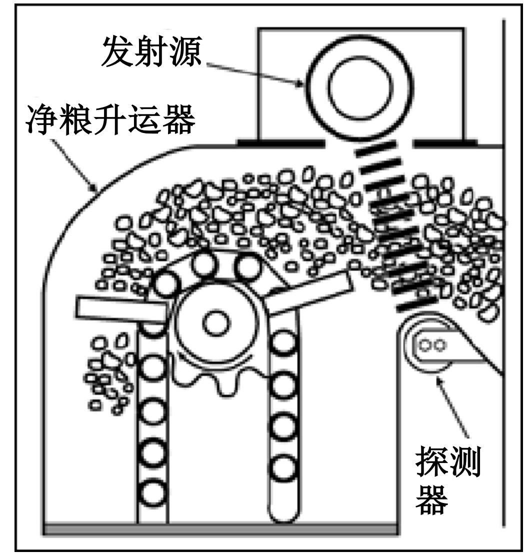


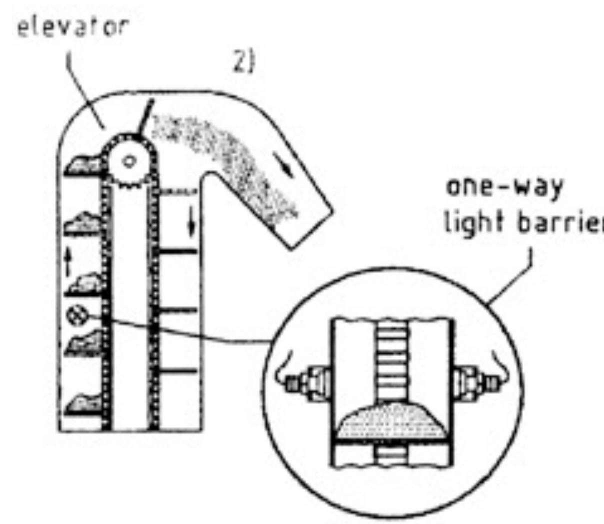


3 advances in key technologies of PA

Sensor of yield monitor







A combine with a AFS system

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Sensor of yield monitor

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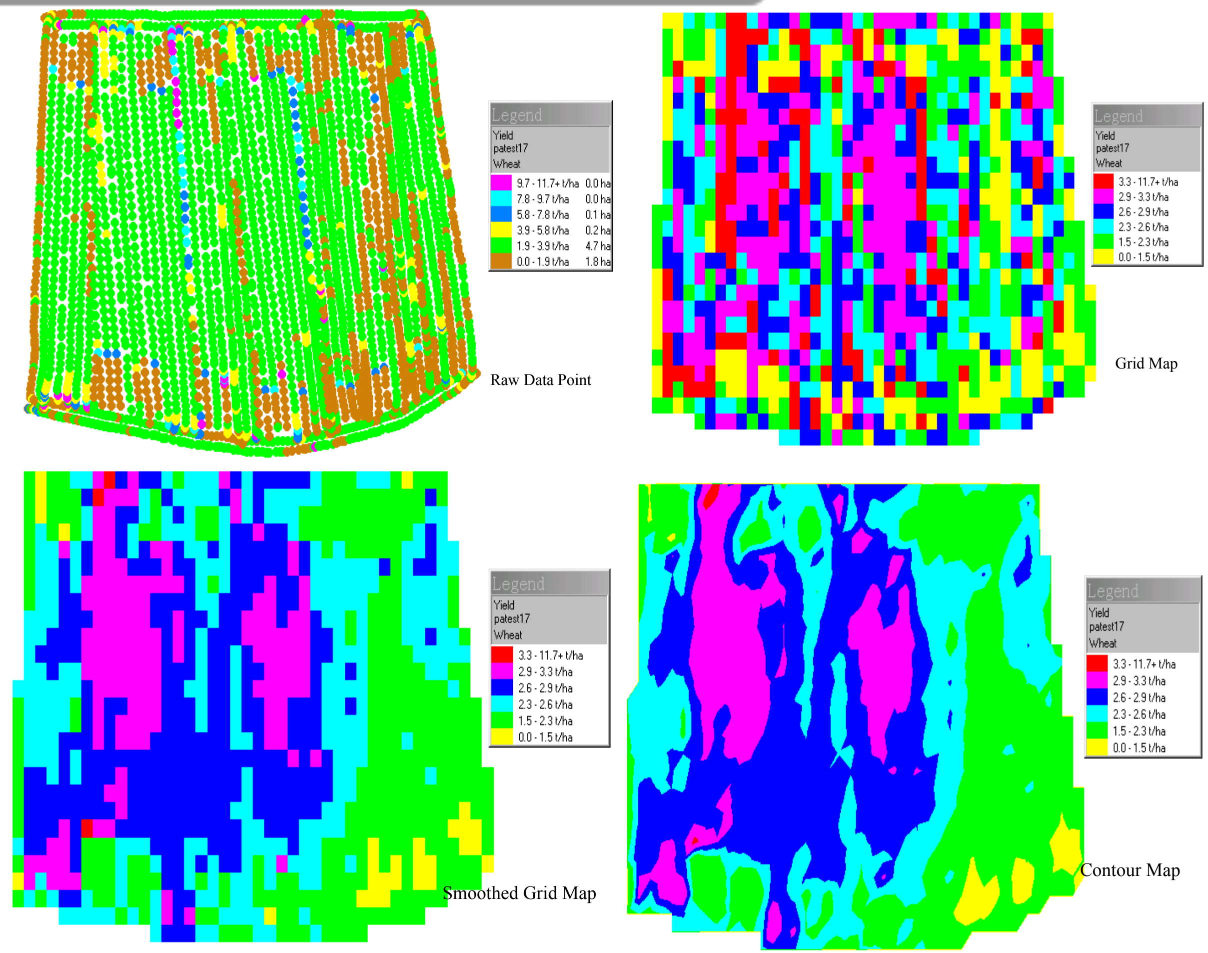

图5.1 划分为六个等级的产量图

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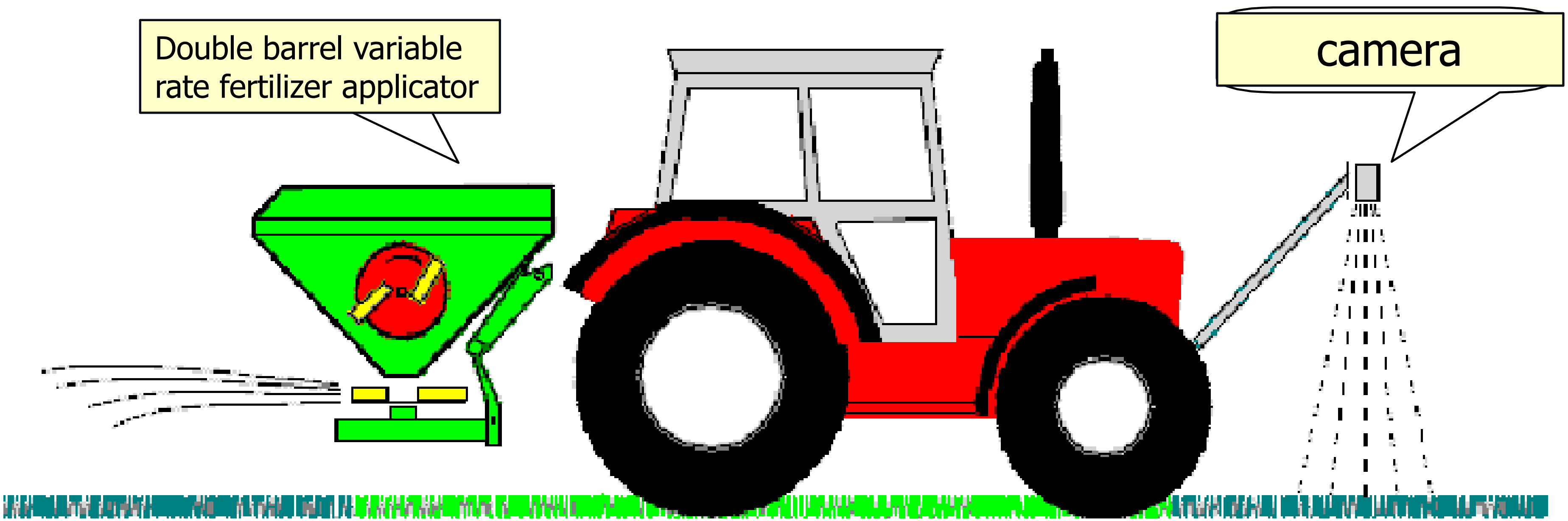
On-demand fertilization(Precision fertilization)



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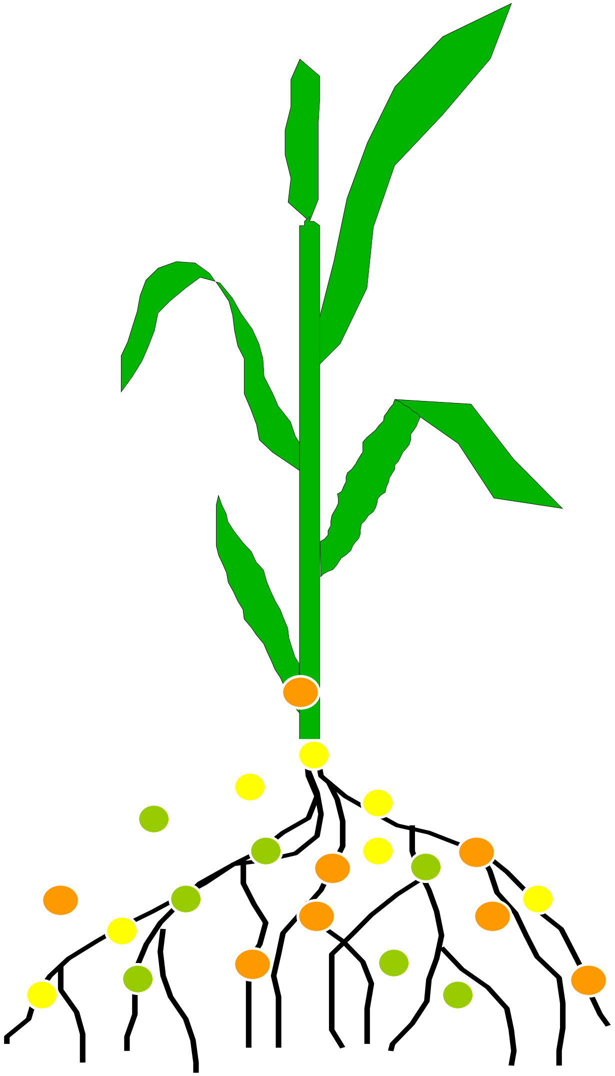
Crops absorb nutrients from the soil



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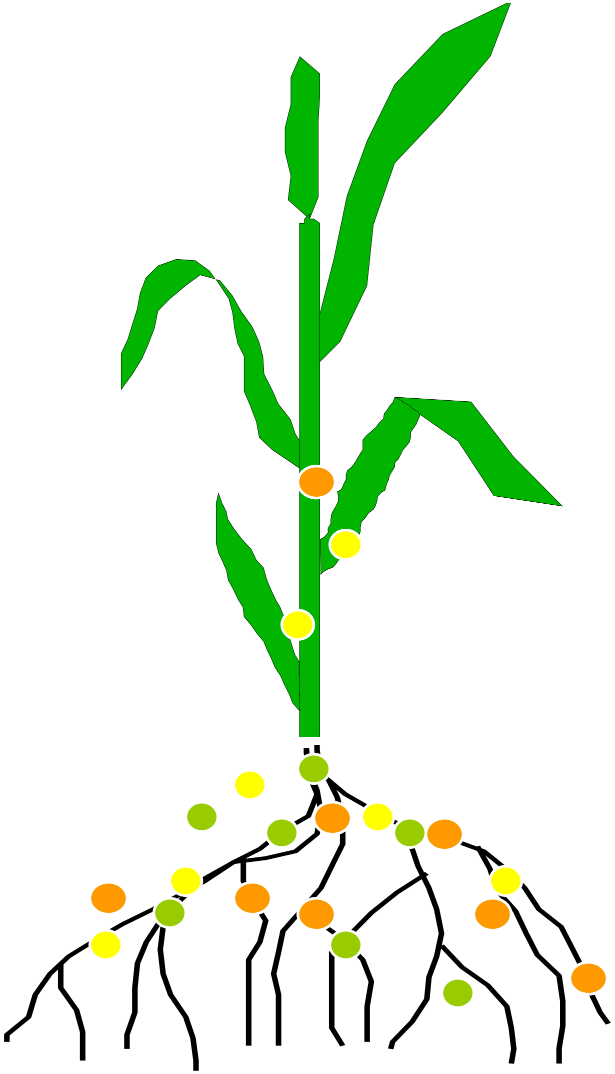
Crops absorb nutrients from the soil



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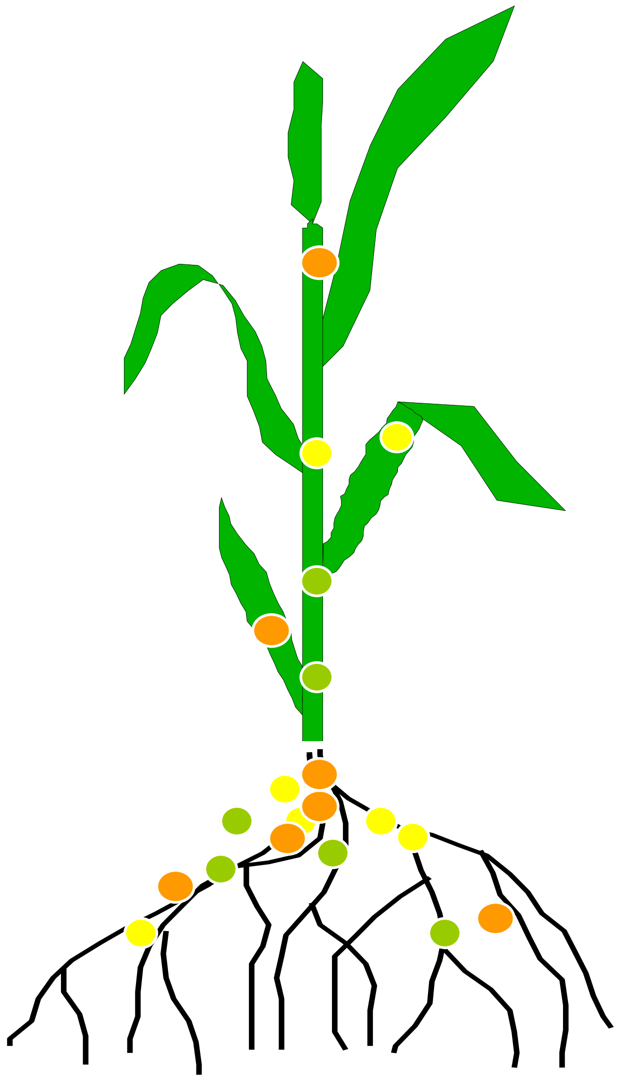
Crops absorb nutrients from the soil



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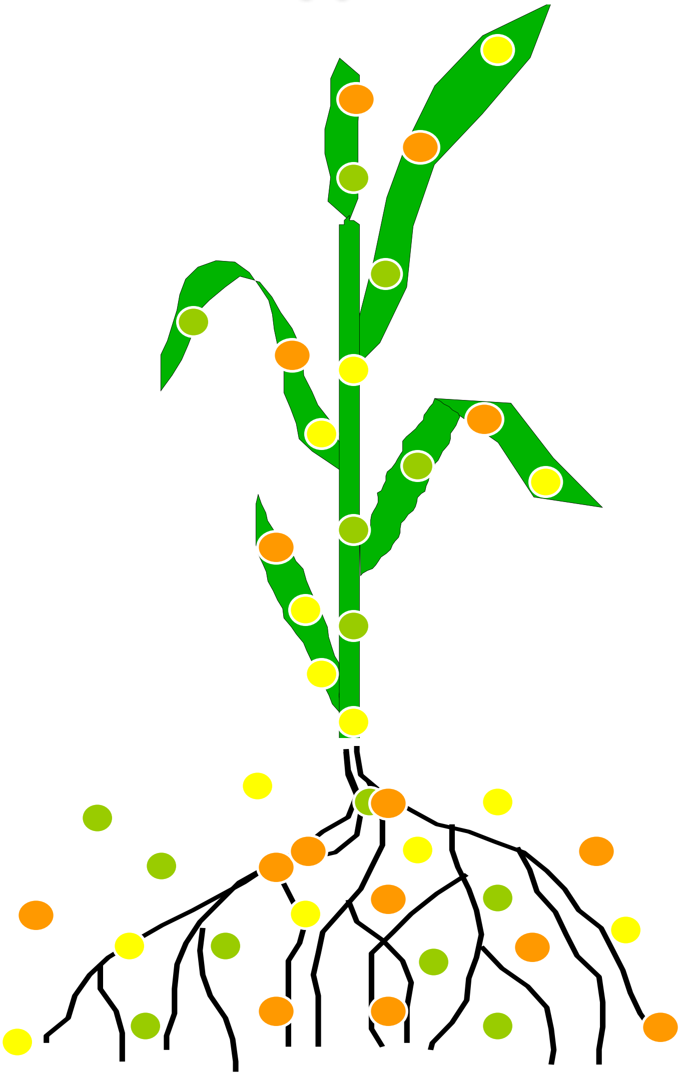
Fertilization to supplement soil nutrients



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Crop nutrient inconsistency

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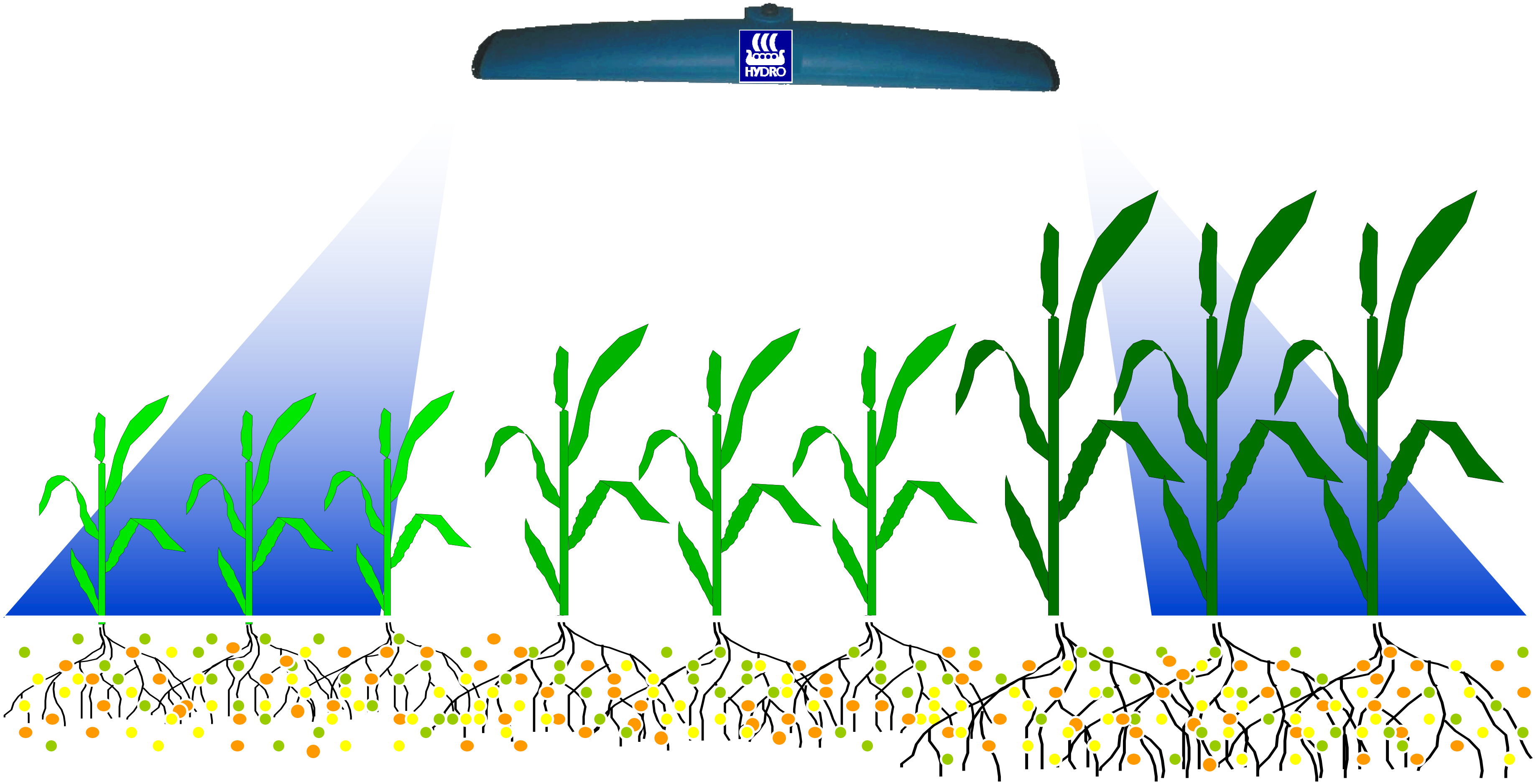
...and adjusts the amount of fertilizer.



„high“ **„medium“** **„low“**

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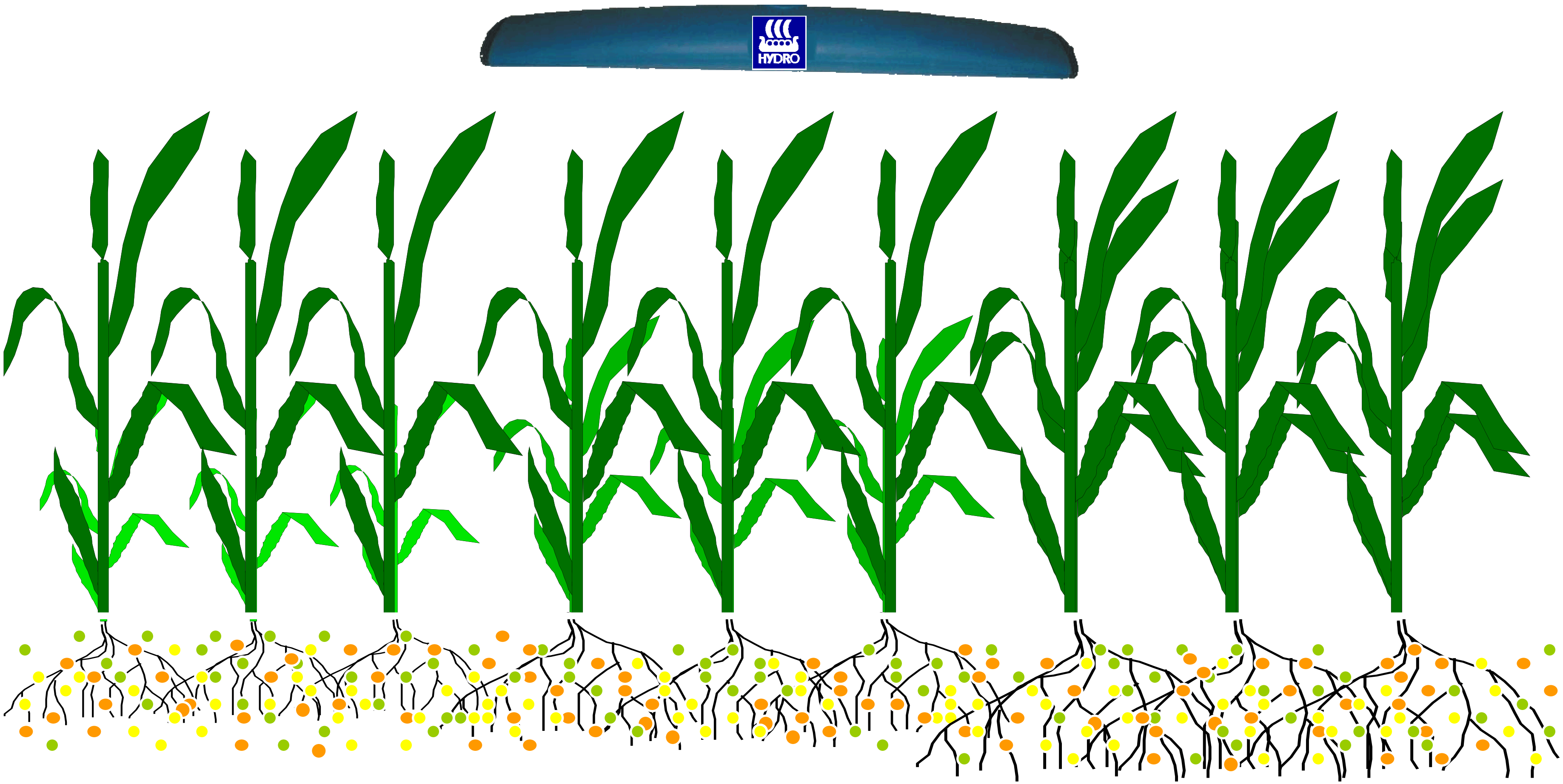
Hence all plants develop optimal.



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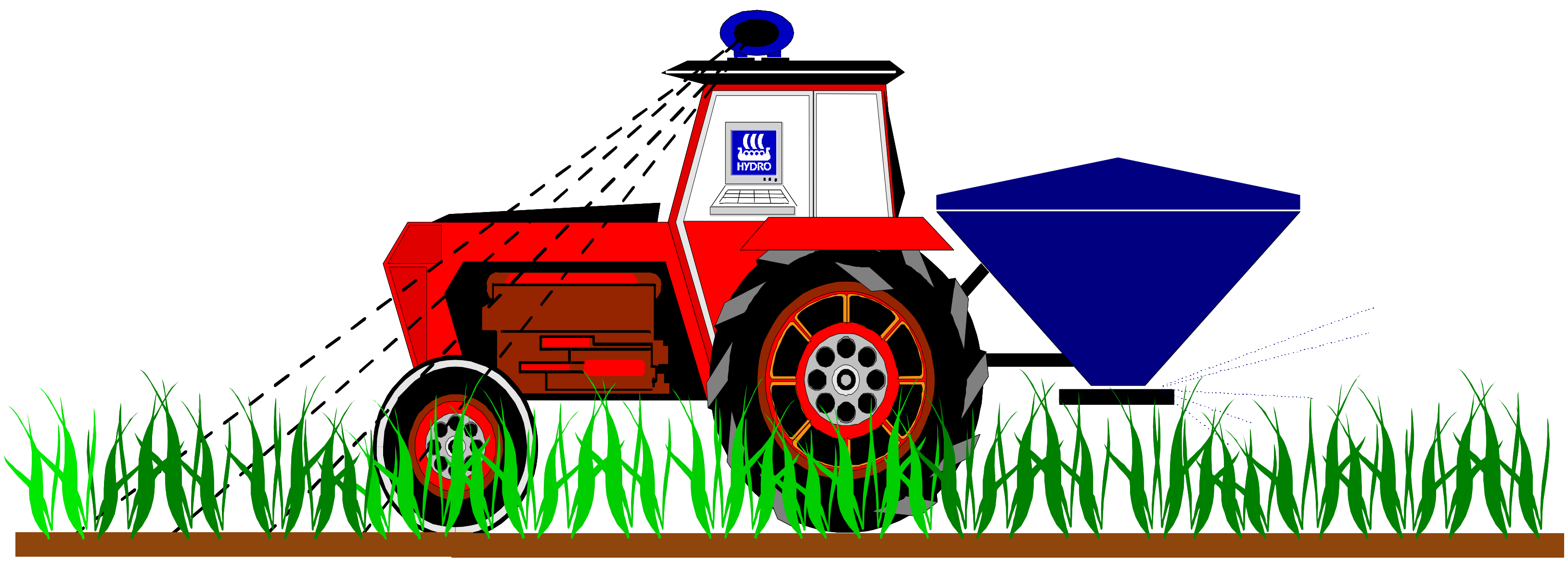
On-demand fertilization(Precision fertilization)

Measurement → **Calculation of N fertilizer demand** → **N application**



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On-demand fertilization(Precision fertilization)

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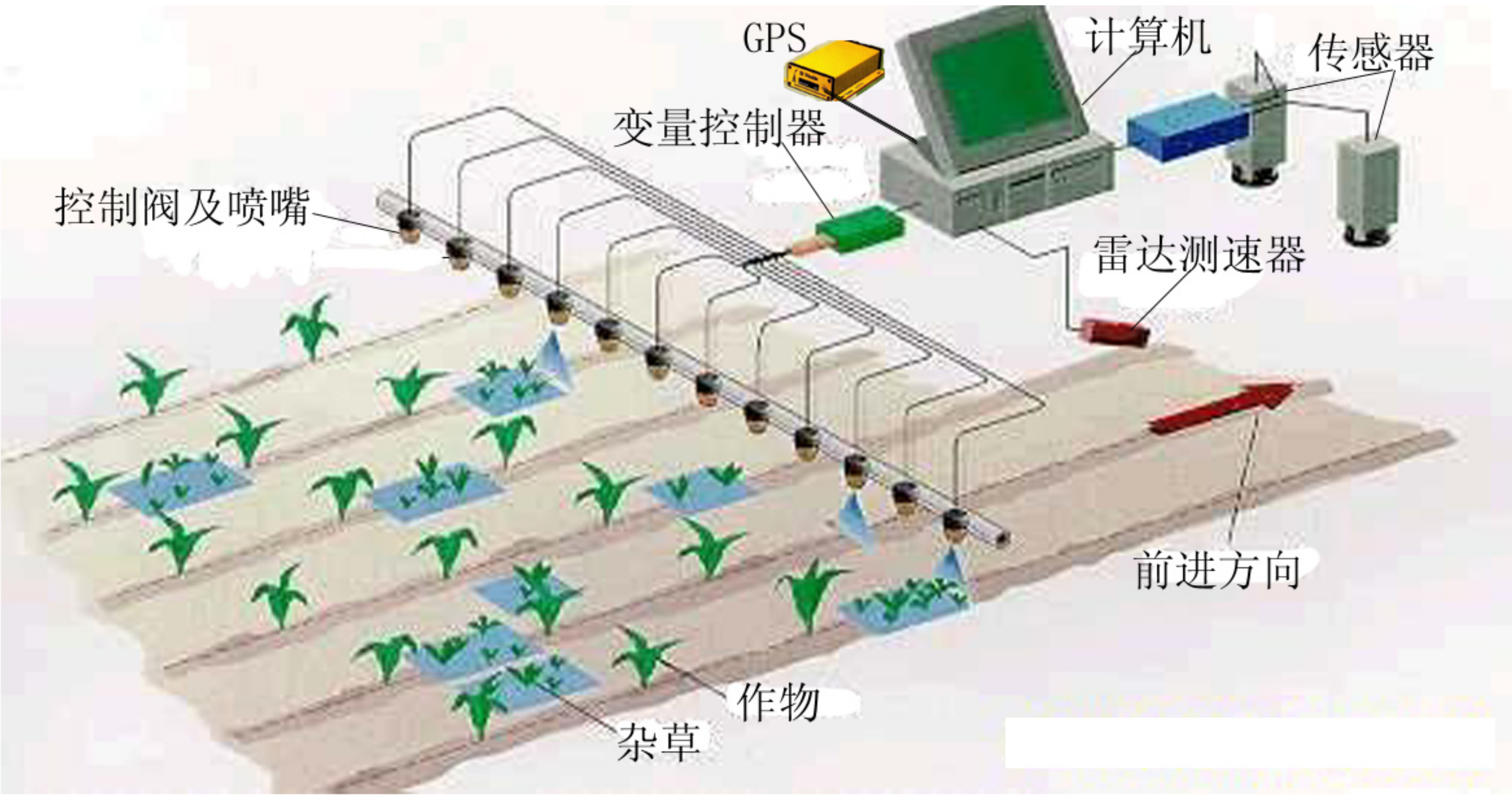
Precision weeding



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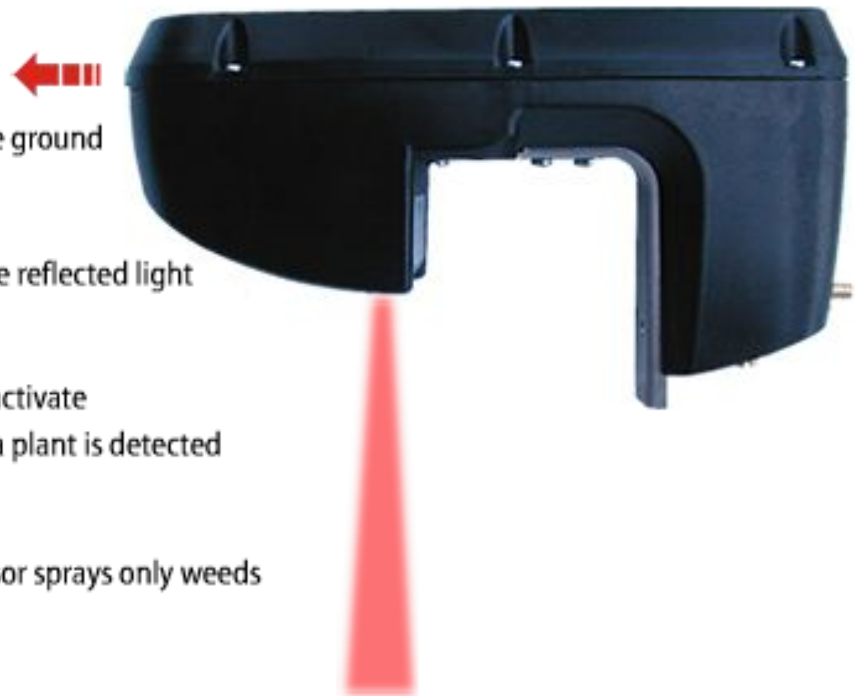
Precision weeding



1. LEDs emit light on the ground
2. The detector reads the reflected light
3. Onboard electronics activate the valve cartridge if a plant is detected
4. The WeedSeeker Sensor sprays only weeds not bare ground!

<< Back to previous page

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Precision weeding

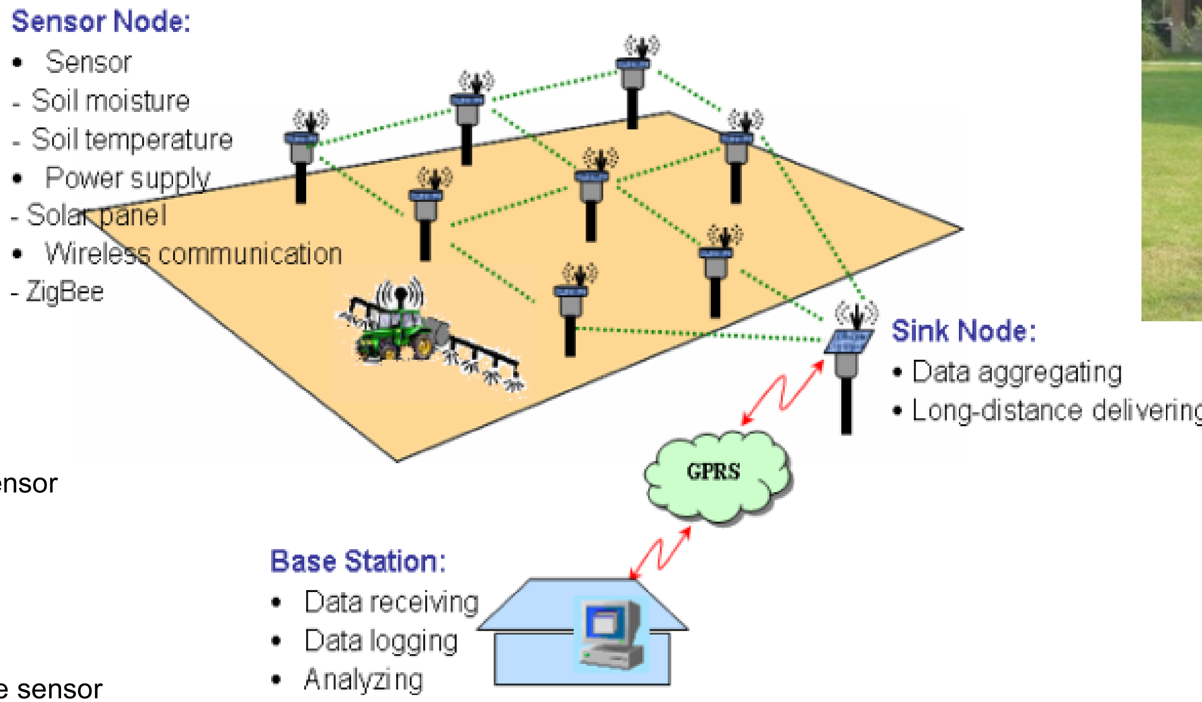
3 advances in key technologies of PA

Application of WSN in Agriculture

Environmental Monitoring on Croplands

Soil moisture sensor

Soil temperature sensor



3 advances in key technologies of PA

Internet of Things

Processing, computing, decision

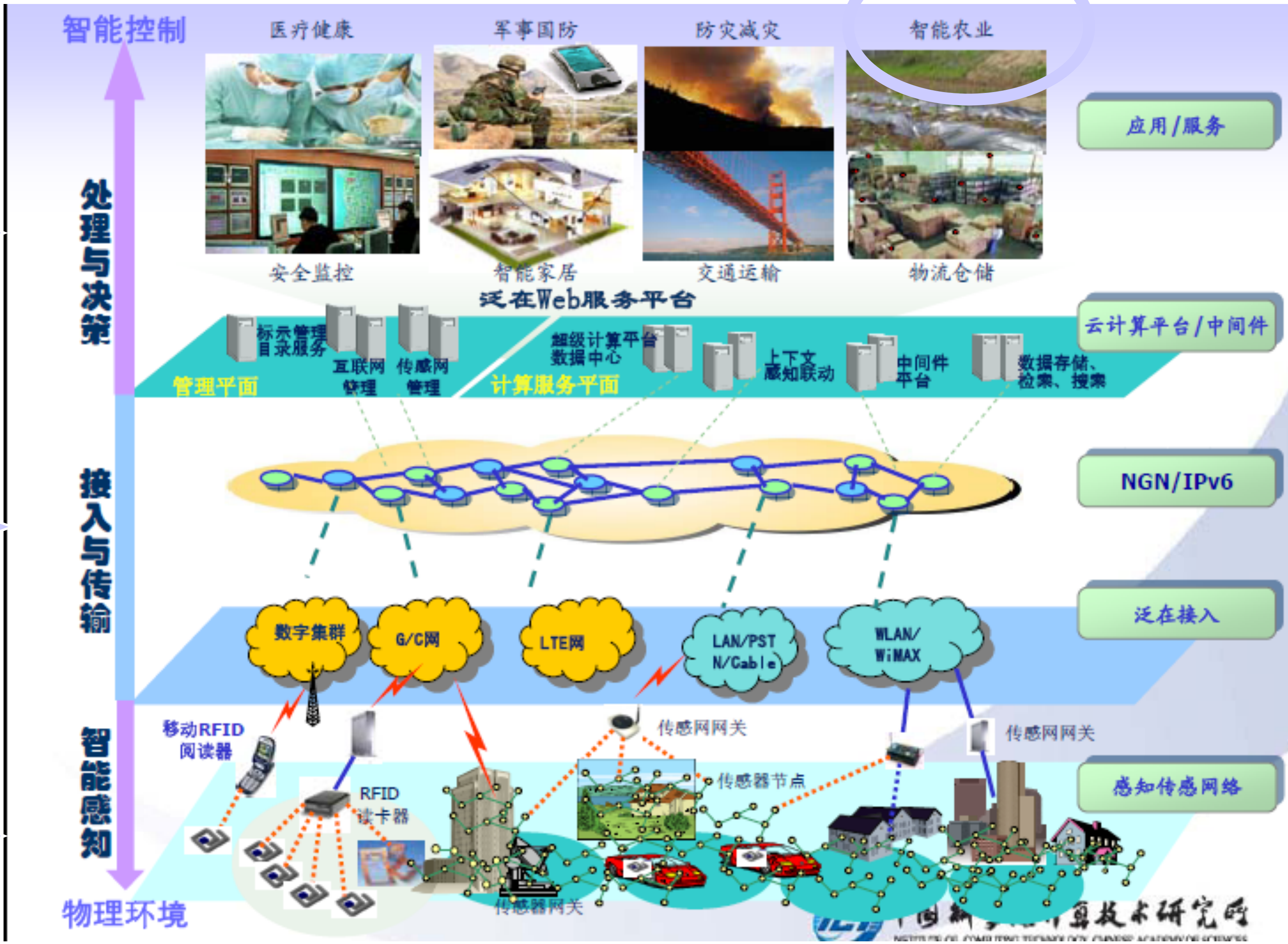
Application layer

Access and Transmission

Network layer

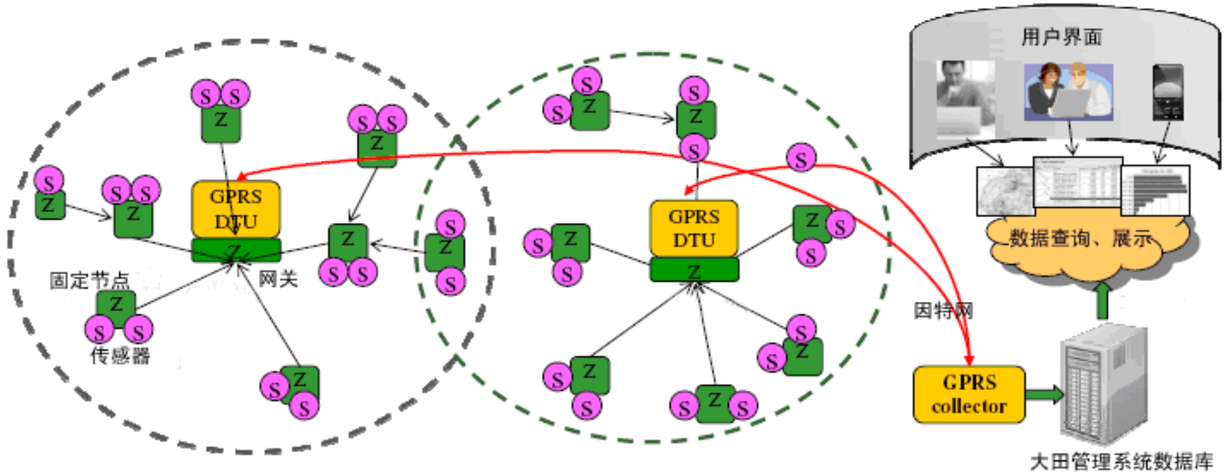
Sensor, Sensor Network

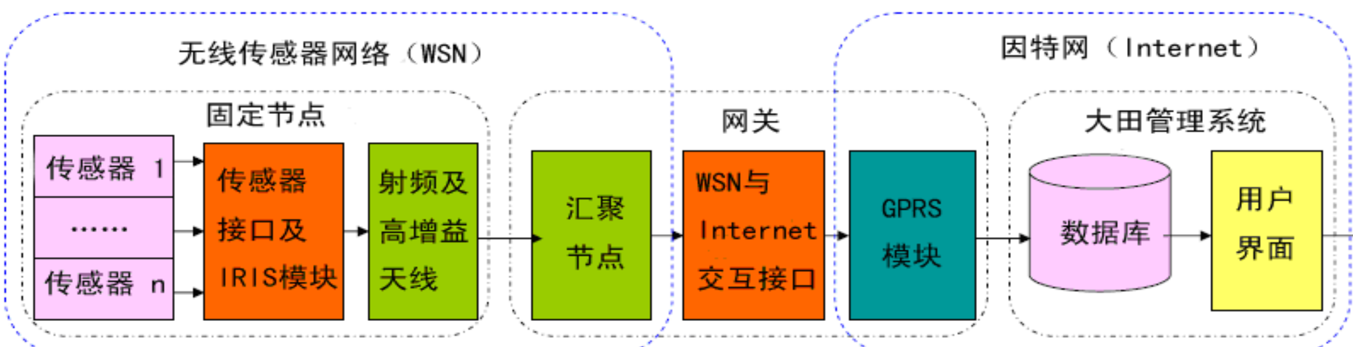
Sensing Layer



3 advances in key technologies of PA

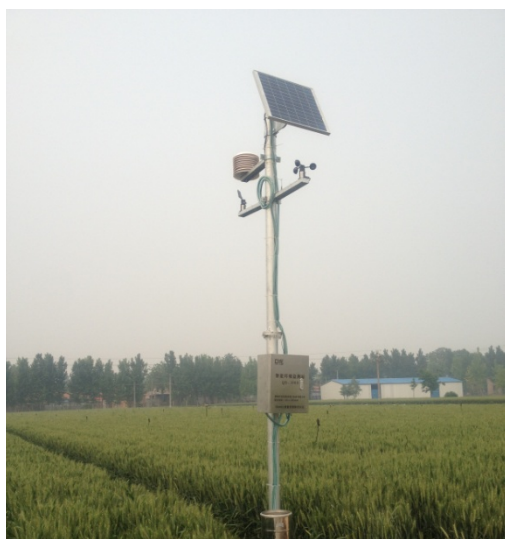
Application of WSN in Soil Sensing





3 advances in key technologies of PA

Application of WSN in Soil Sensing



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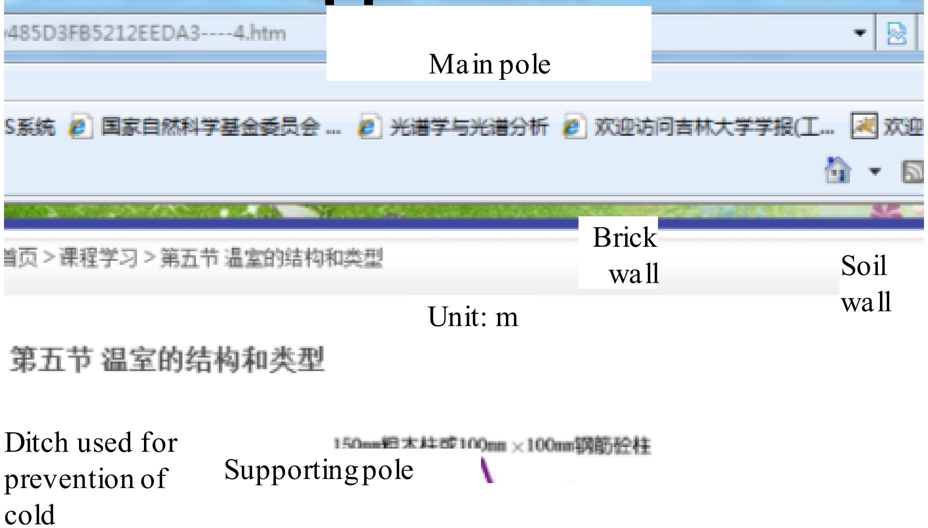
Application of WSN in Soil Sensing

序号	监测项目	监测点	时间	监测值	评价	管理建议
1	土壤湿度	9	2011-9-18 2:39:27	21.61	偏高	正常
2	土壤湿度	1	2011-9-18 2:34:16	19.41	适宜	正常
3	土壤湿度	9	2011-9-18 2:07:51	21.61	偏高	正常
4	土壤湿度	10	2011-9-18 2:05:56	20.74	偏高	正常
5	土壤湿度	3	2011-9-18 1:45:14	19.96	适宜	正常
6	土壤湿度	8	2011-9-18 1:33:40	20.30	偏高	正常
7	土壤湿度	9	2011-9-18 1:33:29	21.61	偏高	正常
8	土壤湿度	10	2011-9-18 1:32:27	21.23	偏高	正常
9	土壤湿度	6	2011-9-18 1:16:17	19.86	适宜	正常
10	土壤湿度	3	2011-9-18 1:13:45	19.94	适宜	正常
11	土壤湿度	9	2011-9-18 1:04:30	21.61	偏高	正常
12	土壤湿度	12	2011-9-18 0:56:15	21.27	偏高	正常
13	土壤湿度	1	2011-9-18 0:29:52	19.56	适宜	正常
14	土壤湿度	6	2011-9-18 0:16:31	19.94	适宜	正常
15	土壤湿度	[illegible]	2011-9-18 0:15:14	20.36	偏高	正常

3 advances in key technologies of PA

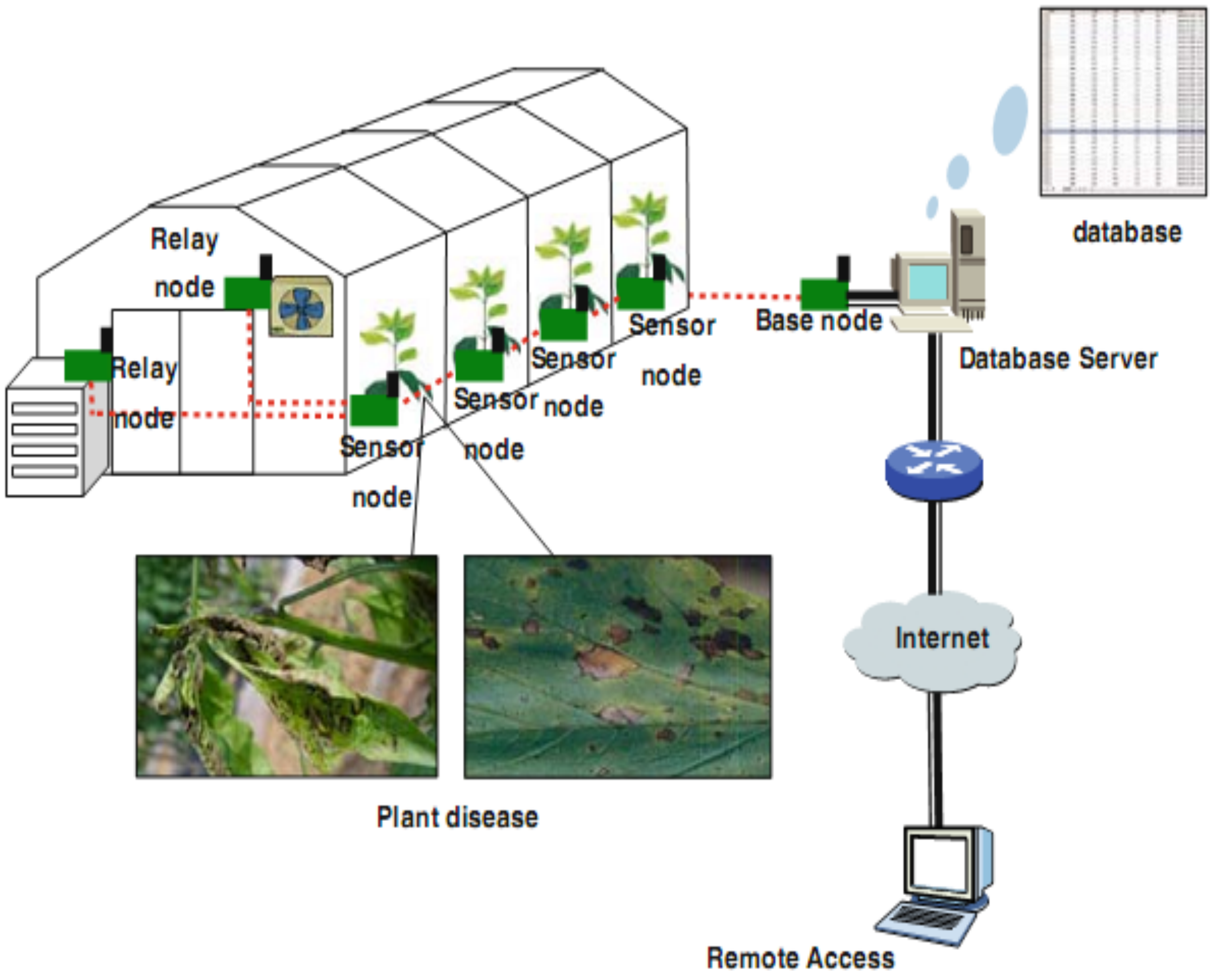
Application of WSN in Solar Greenhouse



- It mainly uses solar energy so that it can reduce energy consumption.
- It consists of three parts, thermal insulation walls, movable thermal insulation covers made by cotton, straw, and so on, and fixed cover.

3 advances in key technologies of PA

Wireless sensor network in greenhouse

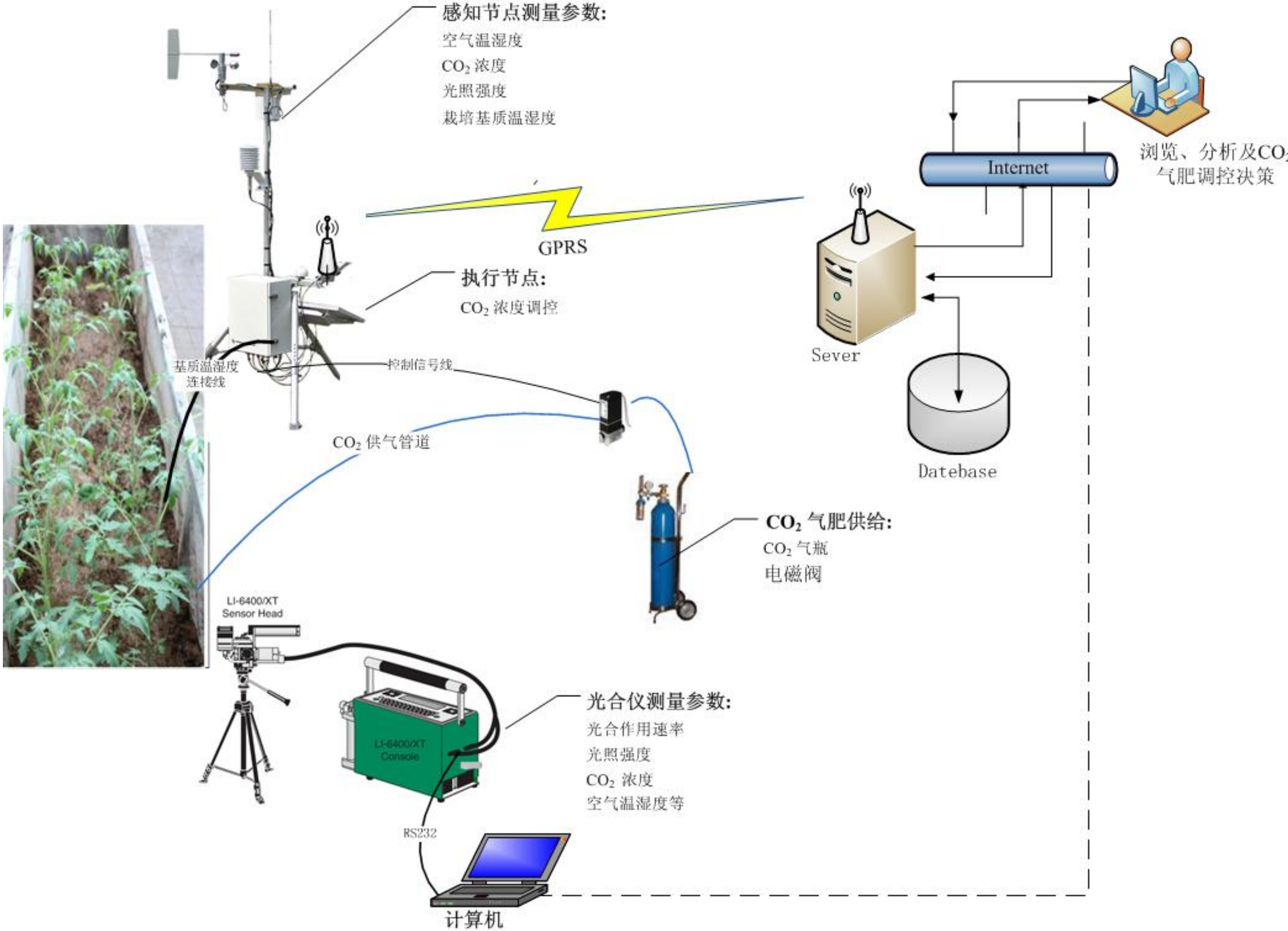


3 advances in key technologies of PA

Application of WSN in Solar Greenhouse

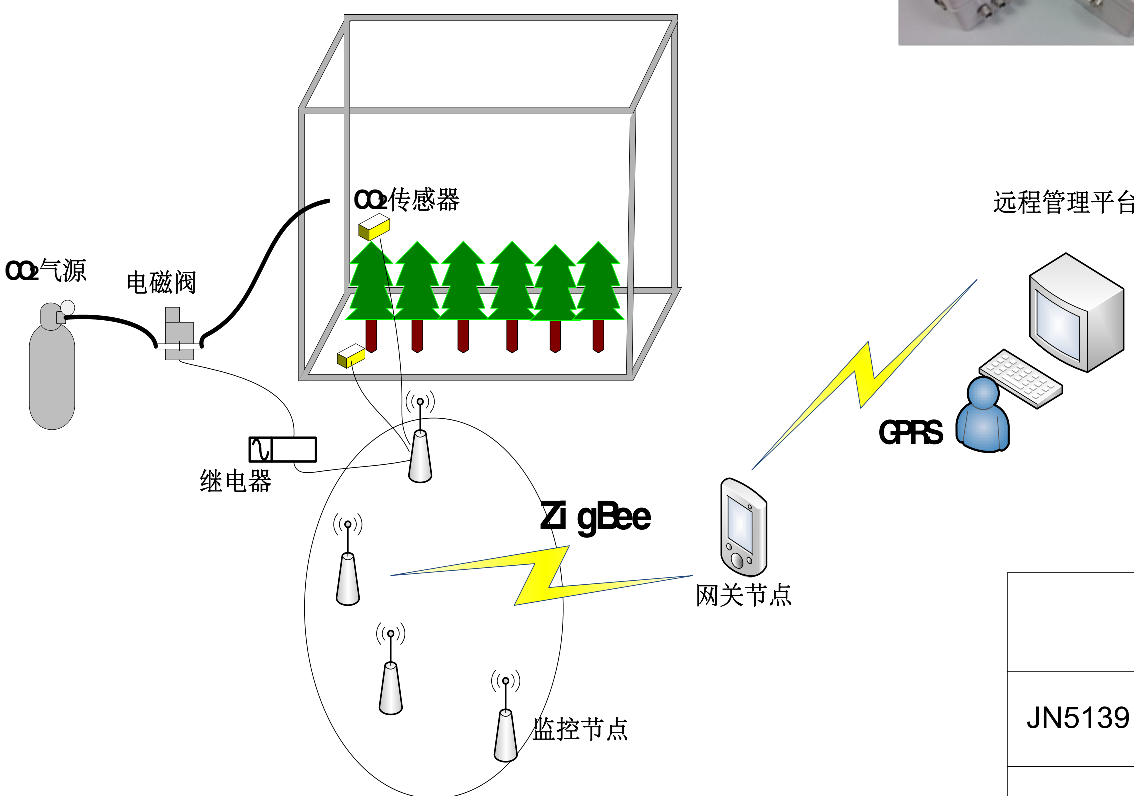
3 advances in key technologies of PA

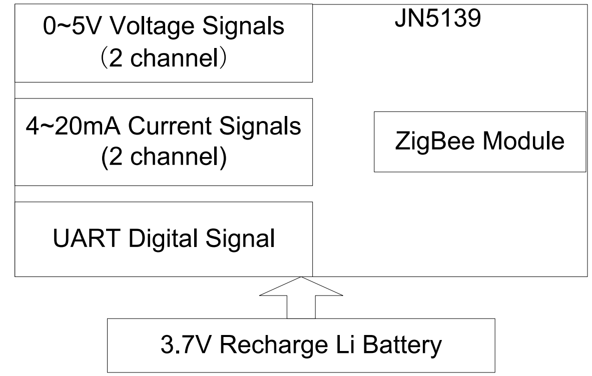
Application of WSN in Solar Greenhouse

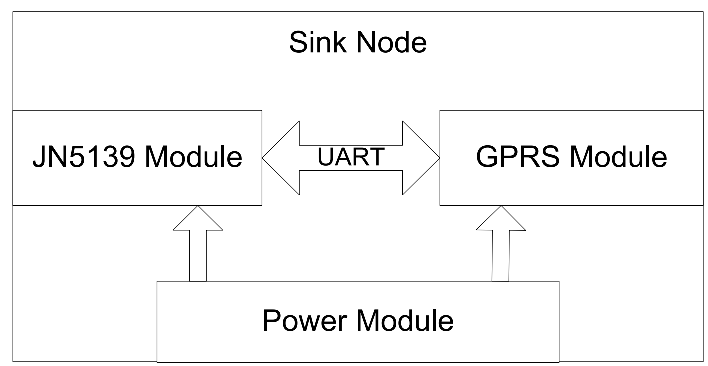


感知节点测量参数:
空气温湿度
CO_2 浓度
光照强度
栽培基质温湿度
GPRS
Internet
浏览、分析及CO_2
气肥调控决策
执行节点:
CO_2 浓度调控
Sever
基质温湿度
连接线
控制信号线
Datebase
CO_2 供气管道
CO_2 气肥供给:
CO_2 气瓶
电磁阀
LI-6400/XT
Sensor Head
LI-6400/XT
Console
光合仪测量参数:
光合作用速率
光照强度
CO_2 浓度
空气温湿度等
RS232
计算机

3 advances in key technologies of PA







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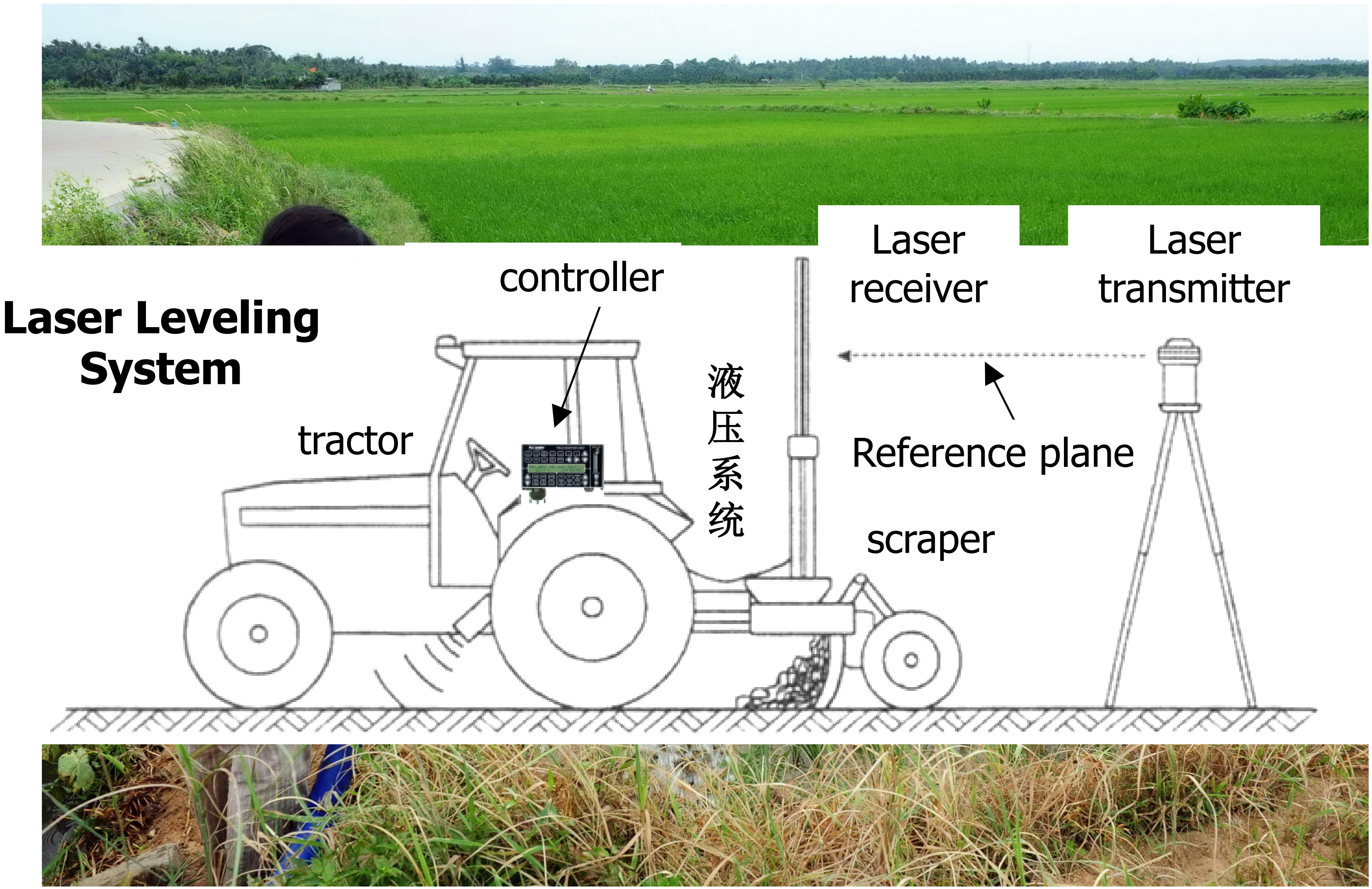
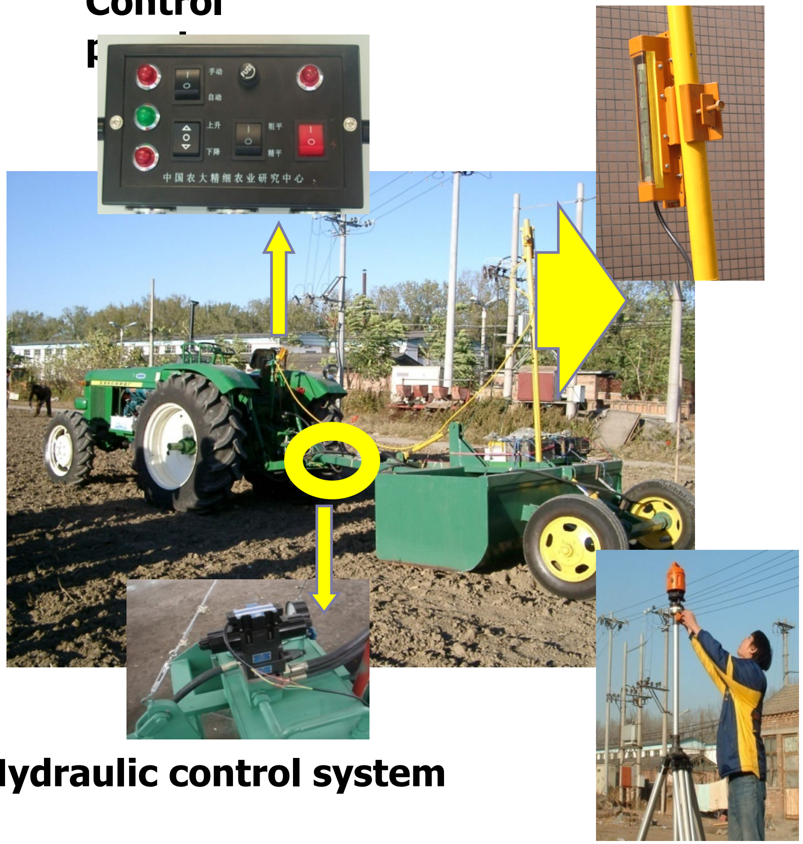


3 advances in key technologies of PA

Laser Leveling System

Control

Laser Receiver



Hydraulic control system

Laser Transmitter

Paddy-fields

Dry-fields


THANK YOU ！