Quantitative remote sensing for precise forest management

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2.Why quantitative remote sensing?

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Forest Ecosystems Journal

1.Remote sensing position in FM

You can't manage what you don't measure

— Peter F. Drucker

- Forest management
- Forest Measurement (sampling)
- Remote sensing

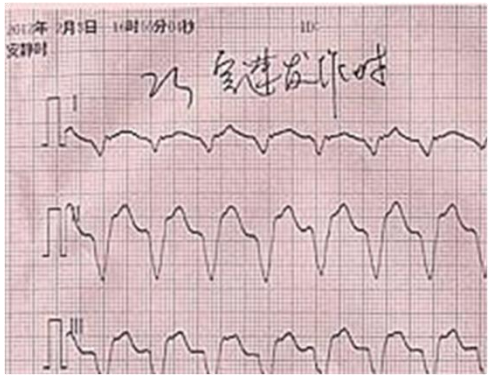
1.1 Challenges and revolution

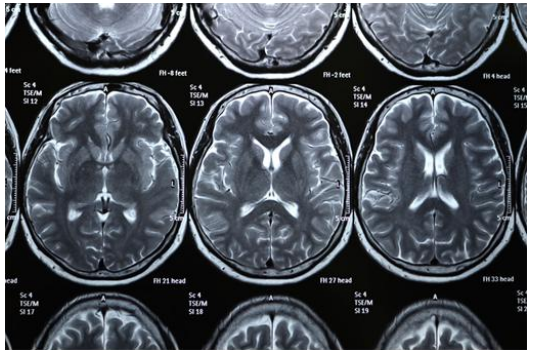
- **Just a tool: work for others**
- **Too simple applications:segmentation and NDVI**
- **Too universal: everybody know RS, such as silvicuture, soil conservation, wildlife...**

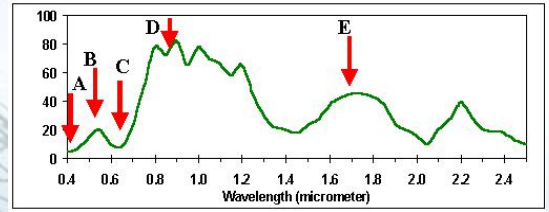
- **What is our special contribution?**
  - in time and operational (annual report on whole China)
  - high accuracy (breakthrough the bottleneck)

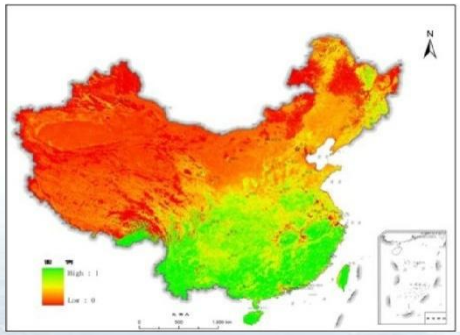
1.2 Remote sensing Position

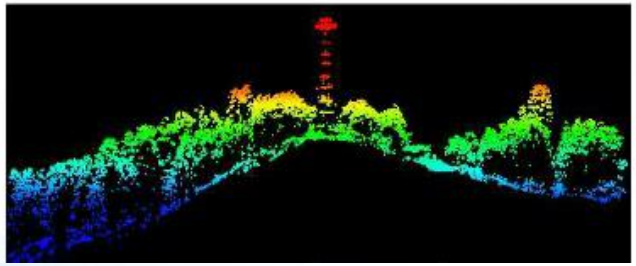
- **Remote sensing is an important tool: like the CT and B-mode ultrasonography in hospital**
- **Invetigation and diagnosis： earlier,better**











1.3 Mission

- **Support the forest quality improvement**
  - **Remote Measure for management**
  - **Improve old metrics:precise and pratical**
    - **Volume,biomass, classification and area**
  - **Discover new things:**
    - **new metrics, new algorithms,new sensors**

2.Why quantitative RS?

- **lower maturity comparing to other industories**
  - Meteorological: operational predication (FY-4)
  - Land resources: high resolution
  - Agricultural: HOM, easier measurement, money
  - Forest: HET,cloud, rain, hard, less money
- **Two inherent problems:**
  - **Low accuracy（70-90%）**
  - **Insufficient operational satellites**

2. .Why quantitative RS?

- **Deep into mechanism to explain more and improve accuracy**
- **Develop simulation models for quatitative inversion**
- **pre-research to explore frontier and pave the way of prosepctive layout**

2. Why quantitative RS?

2.1 Deep into mechnism

- **Complex land surface： terrain、mixture pixel**
- **Saturation： high biomass**
- **ill-pose inversion： underdetermined equation**
- **Multi-angular： BRDF effect**
- **Scale effect： inconsistency**
- **Data fusion： optical and microwave**

2.Why quantitative RS?

2.2 Simulatin models

- **high-spectral simulation：Clarify the best bands, resolution, and potential for tree spicies classification**
- **Optical imaging：clarify errors from terrain, mixture pixe; scale correction**
- **TIR imaging：drought, pest effect**
- **Lidar：Clarify footprint size, angle, multple scattering on tree height**
- **BRDF：extract tree height**
- **Microwave imaging：improve data fusion**

2.Why quantitative RS?

2.3 Pre-research for leading edge

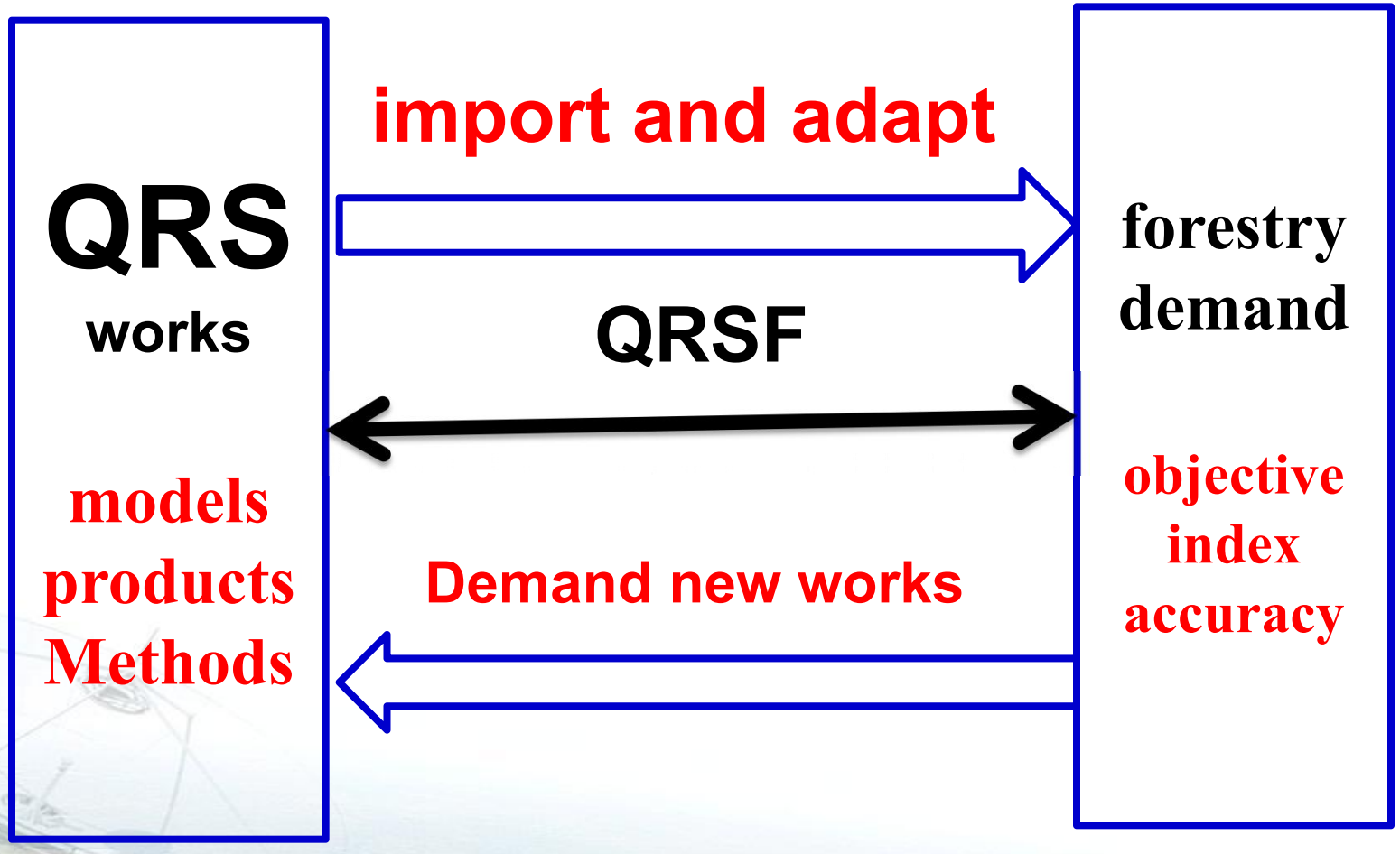
- **What new sensors are required?**
  - **High penetration：microwave INSAR**
  - **Vertical structure：Space-borne Lidar**
  - **Tree species：two highs (spatial and spectral)（e.g. GF-5）**
  - **Single tree：Lacking data in forested area**
- **How to mine current data potential?**
  - **What is limit of information contribution?**
  - **How to better fuse?How to better remove noise?**

3. Framework

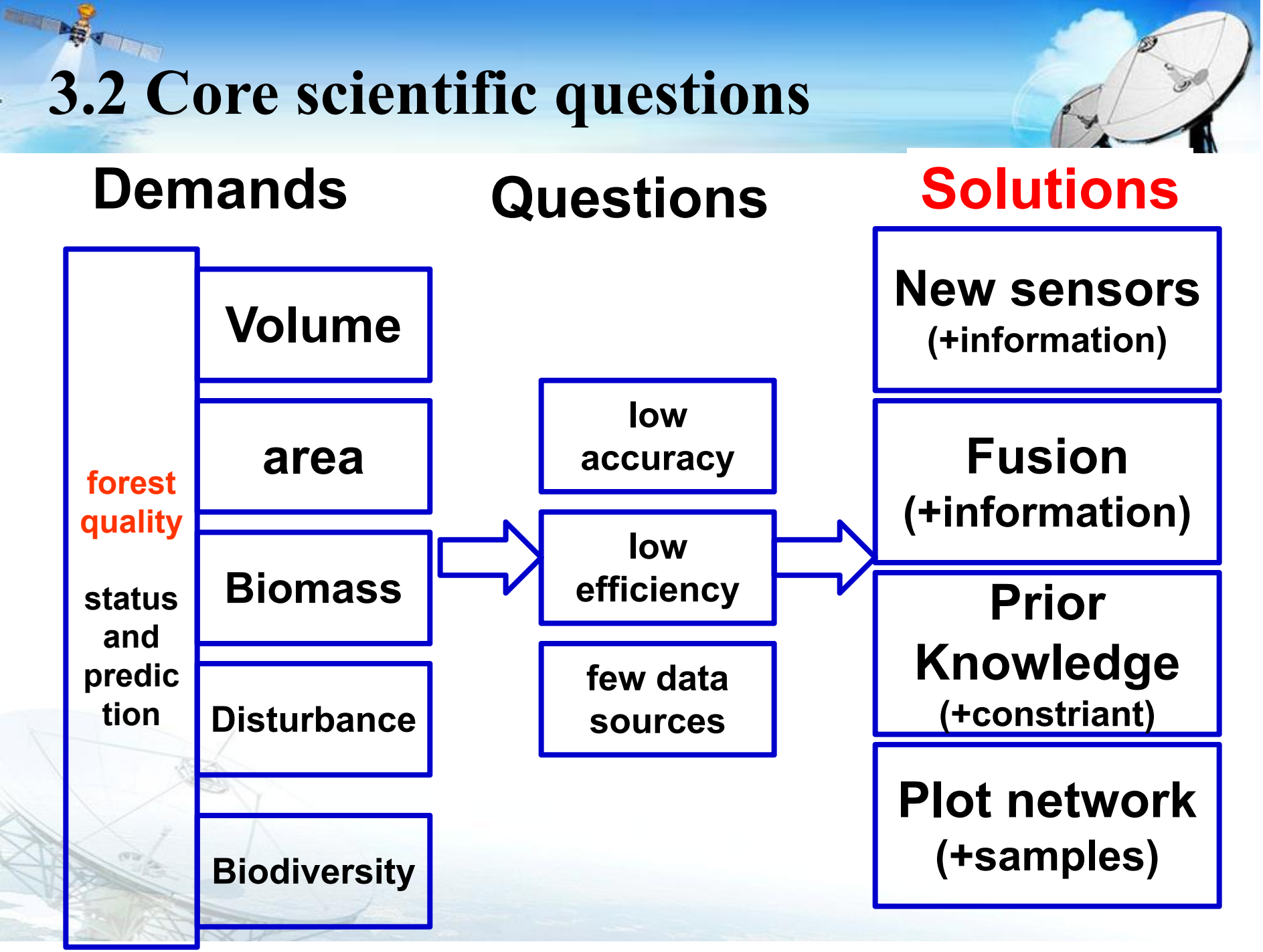
- **Basic framwork： QRS+application**
- **Propose scientific questions： demand-oriented**
- **Makse use of current resources**

3. Framework

3.1 **Basic** Framework



3.2 Core scientific questions

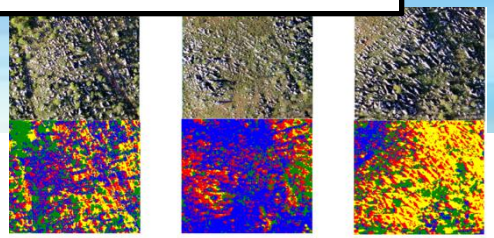


Solutions	Scientific questions
New sensors (+information)	What sensors?
	Contribution ratio?
Fusion (+information)	How fusion?
	unify scale?
Prior Knowledge (+constriant)	Can we improve?
	Error transfer?
	how to add prior?
Plot network (+samples)	Best smapling?
	Improve efficiency?
	Automatically?

3.3 Mine current rich data sources

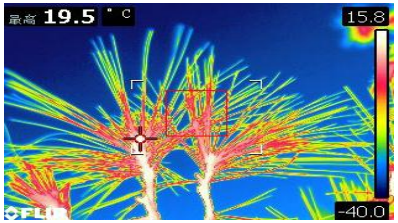
云南虫害图像
无人机2 cm

顺义共青林场林木定位
无人机1cm

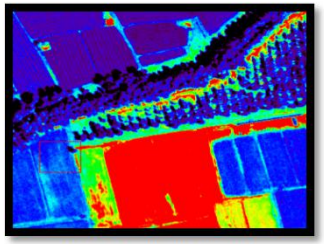


云南石林石漠化制图
无人机1cm

黑河青海云杉分布
航空相片0.1米

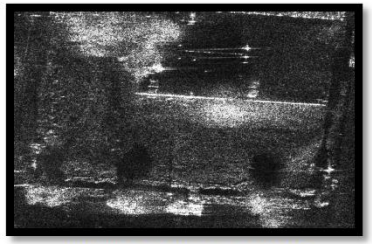


云南松针叶
（地面 FLIR热温度图像）

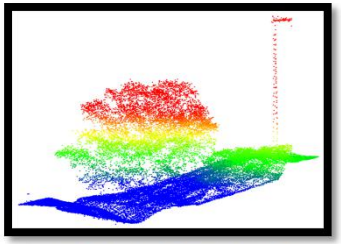


甘肃农田防护林
（ 机载热红外温度图像）

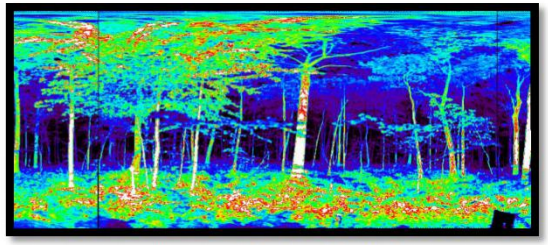
河北侧柏林
（ 塔吊热红外温度图像）



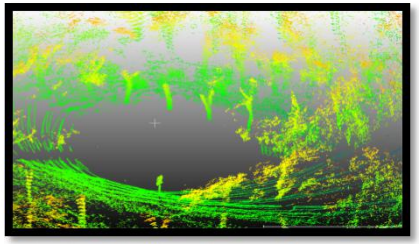
某地X波段雷达图像
（ 0.1 m SAR）



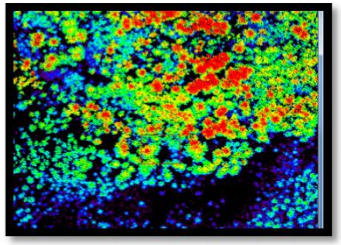
某城区单木和电线杆
（机载激光雷达点云）



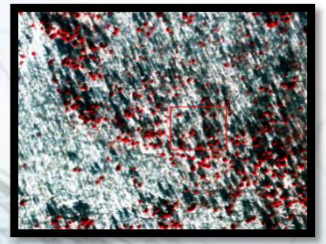
哈佛大学林场森林样地
（地基 激光雷达点云）



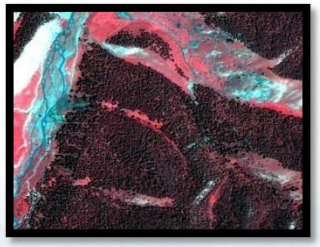
北京林业大学主楼前
(VLP-16 激光雷达点云）



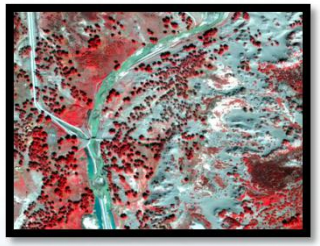
根河落叶松林
（ 激光雷达提取的树高）



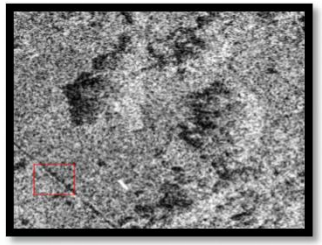
蛟河红松分布
RapidEye卫星5米



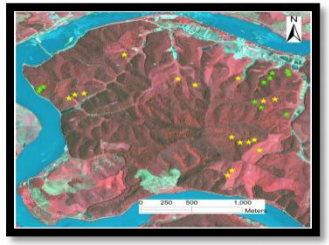
黑河青海云杉分布
Quickbird卫星0.6米



额济纳胡杨林
（quickbird 2 m)



夏威夷雷达图像
（ TerraSAR 2 m）



浙江将乐林场图像
（ Worldview-2 0.5m）

3.3 Make use of current QRS models

PROSAIL = PROSPECT + SAIL
http://teledetection.ipgp.jussieu.fr/prosail/

ARTMO platform:
http://ipl.uv.es/artmo/

GOMS: Geometrical-optics

GORT: Geometrical-optics and radiative transfer

DART: 3D models

3.3 Make use of rich QRS products

- **Structural： tree height,forest cover,LAI，LAD**
- **Biochemical： chlorophill、water、fluorescence、evaportraspiration**

http://earthexplorer.usgs.gov/

https://scihub.copernicus.eu/dhus/#/home

http://www.eorc.jaxa.jp/ALOS/en/aw3d30/

http://landcover.org/

http://glass-product.bnu.edu.cn/

4. Our practices

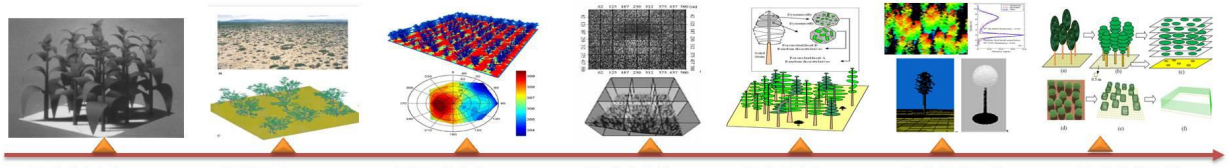
- **4.1 3D model RAPID:**
  - **Top level、full band、Chinese brand**
- **4.2 Ground observation:**
  - **LAI-Mobile for fast LAI**
  - **Line scanning lidar for fast forest strcuture**
- **4.3 Inversion:**
  - **Chl、LAI、Rocky desertification**

4.1 RAPID (**Top level、full band、Chinese brand**)

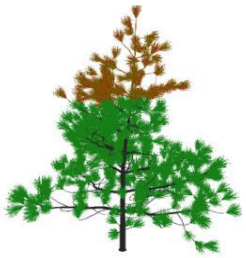
Support VNIR, TIR, microwave, Lidar

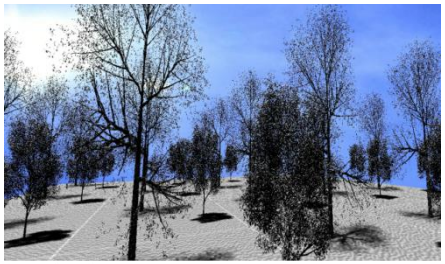
http://www.3dforest.cn/

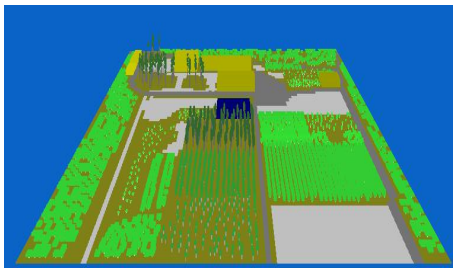
3D simulation model on remote sensing signals (RAPID)

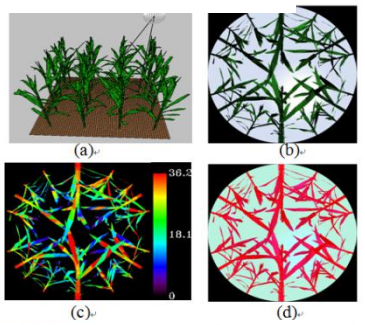


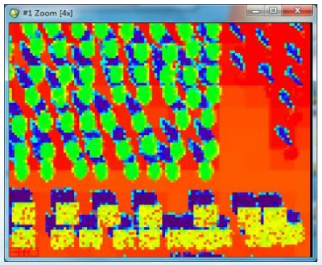
@Remote sensing of forest group











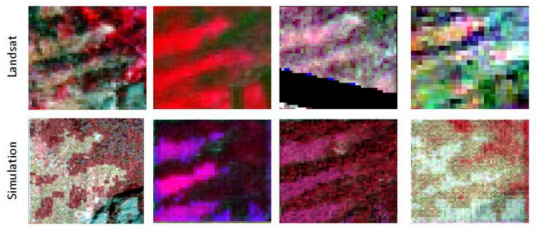
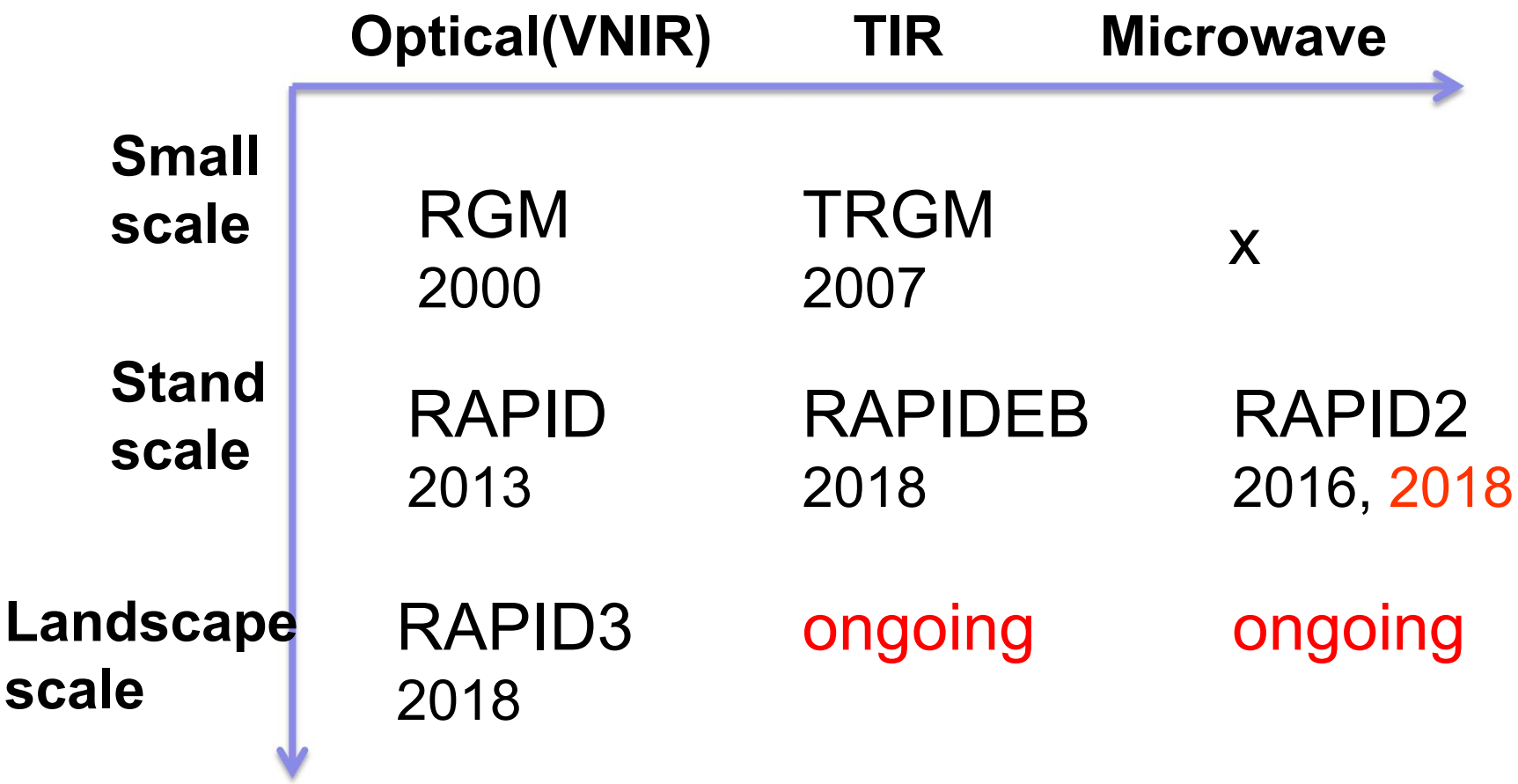


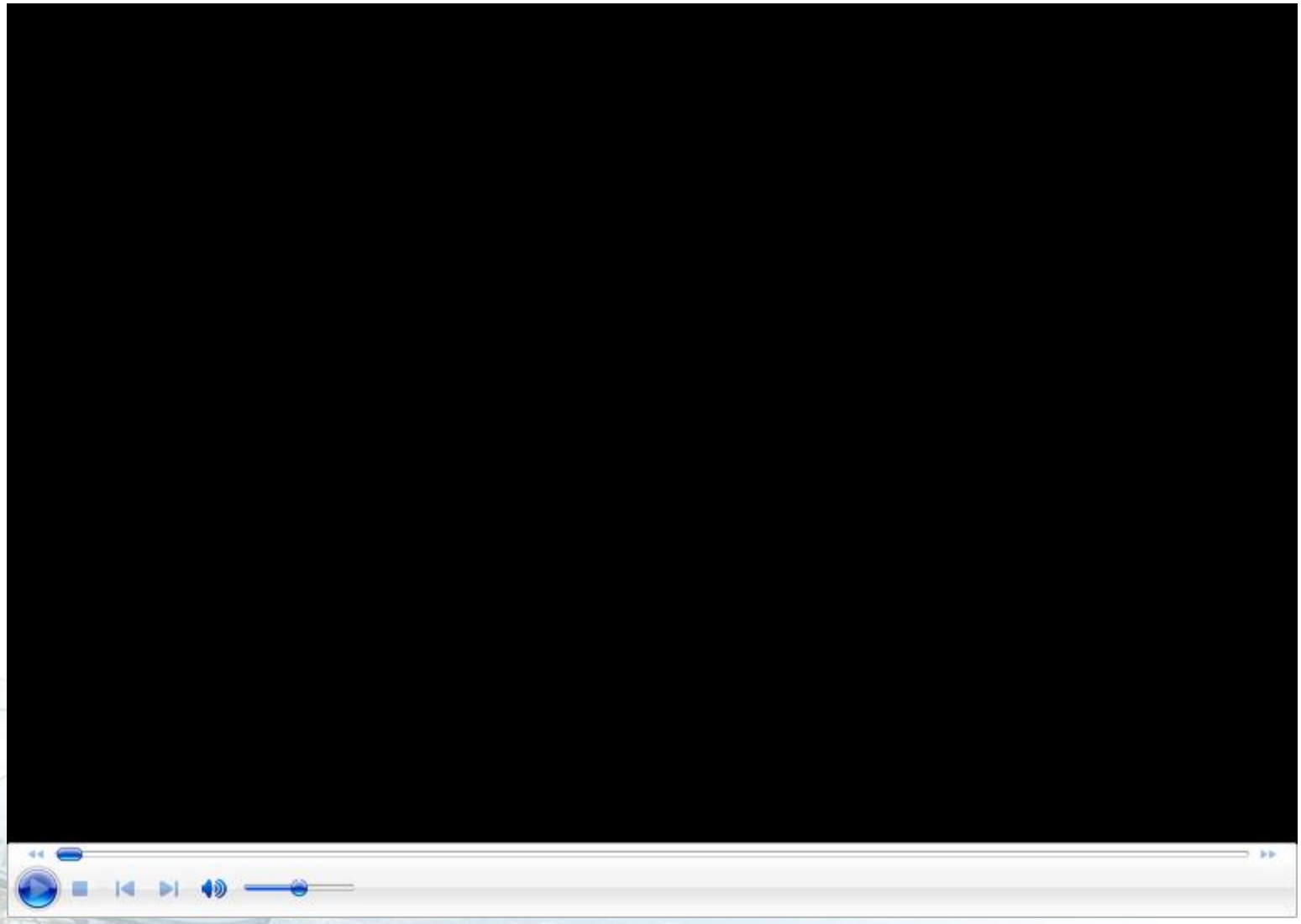
Fig. 11 Comparison between simulated and Landsat images with false color composition



RAPID3 (RS, 2018) can run a 500 m scane in 13 minutes on a notebook

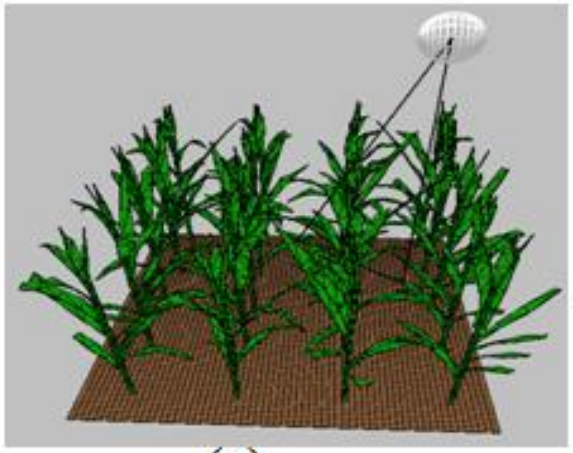

1.map - RAPID
File (F)
DTM (E)
x:128 m, y:45 m

RAPID demo Video



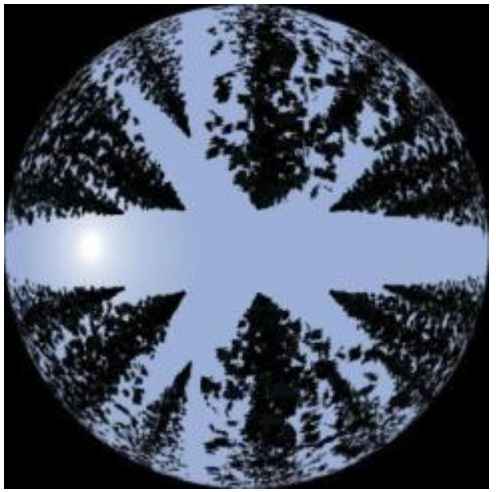
Multi-sensors

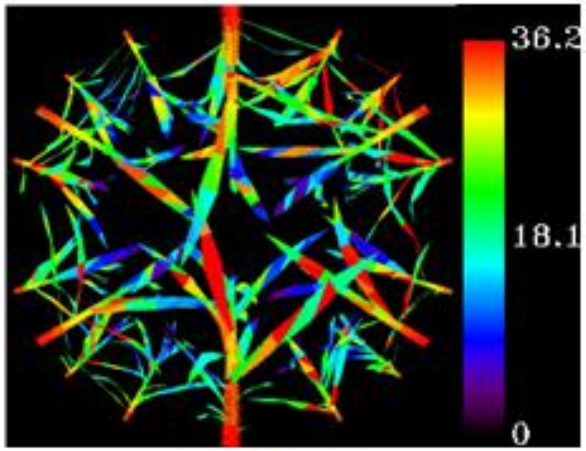
Simulating fish-eye images in RGB, NIR, and TIR



(a)

(b) RGB

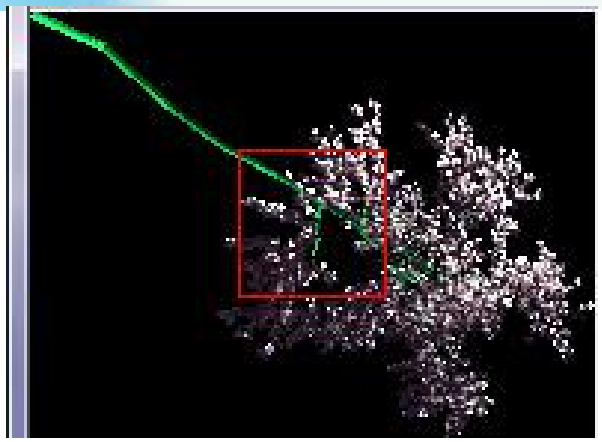




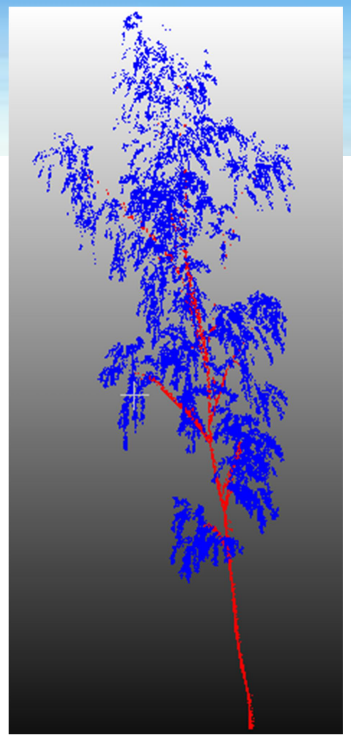
(c) TIR

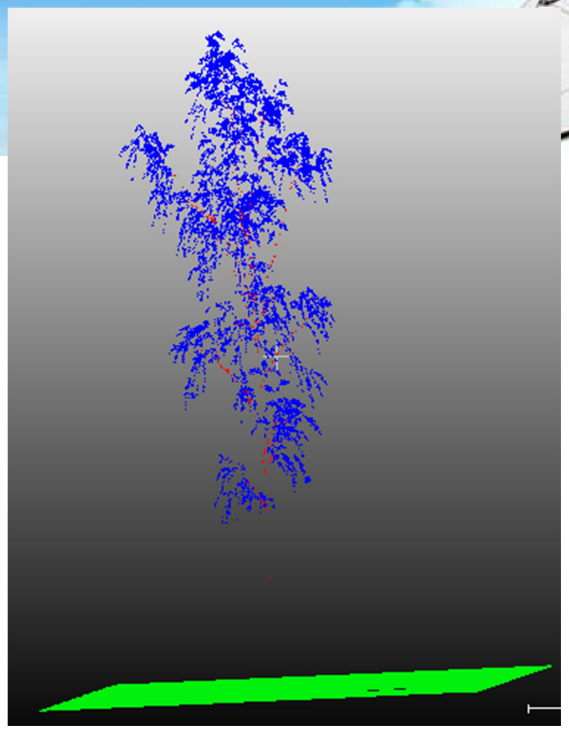
(d) NIR

Ground vs Air-borne

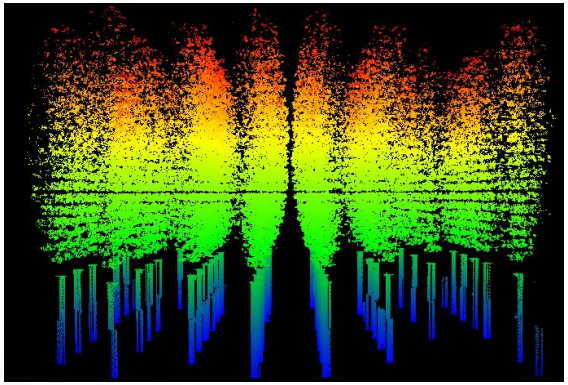


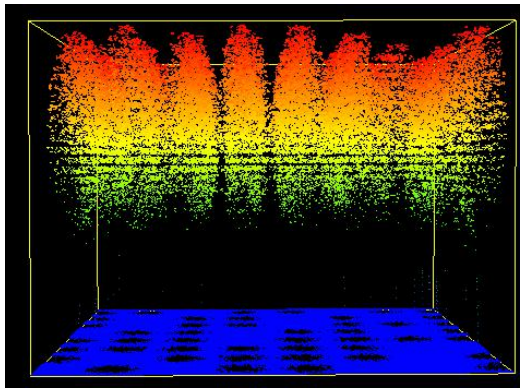
TLS—one tree





TLS--forest



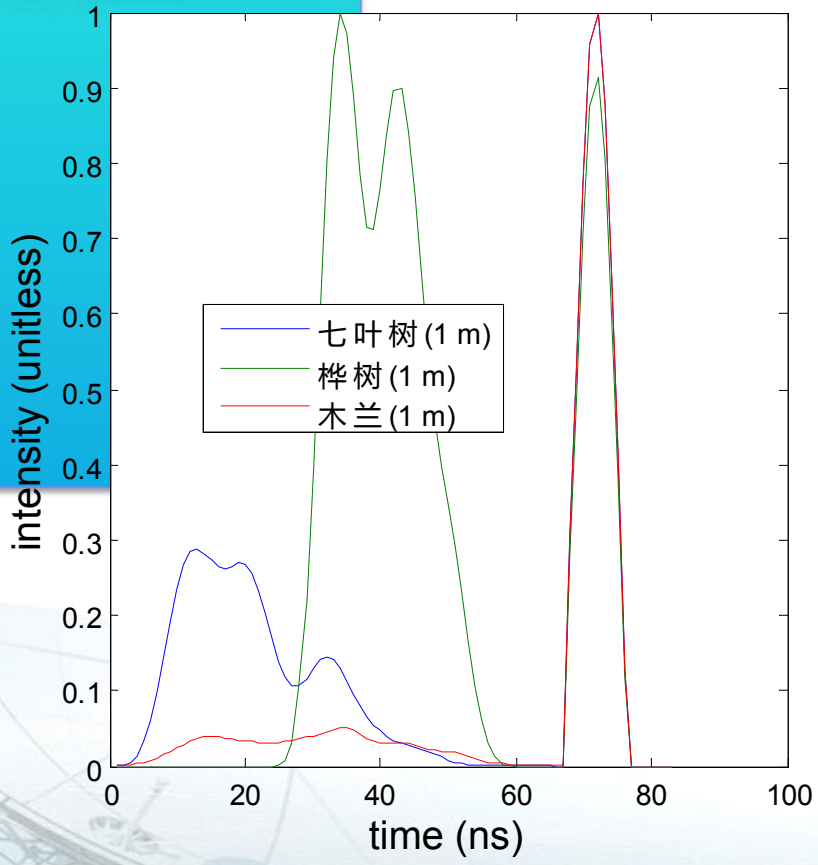


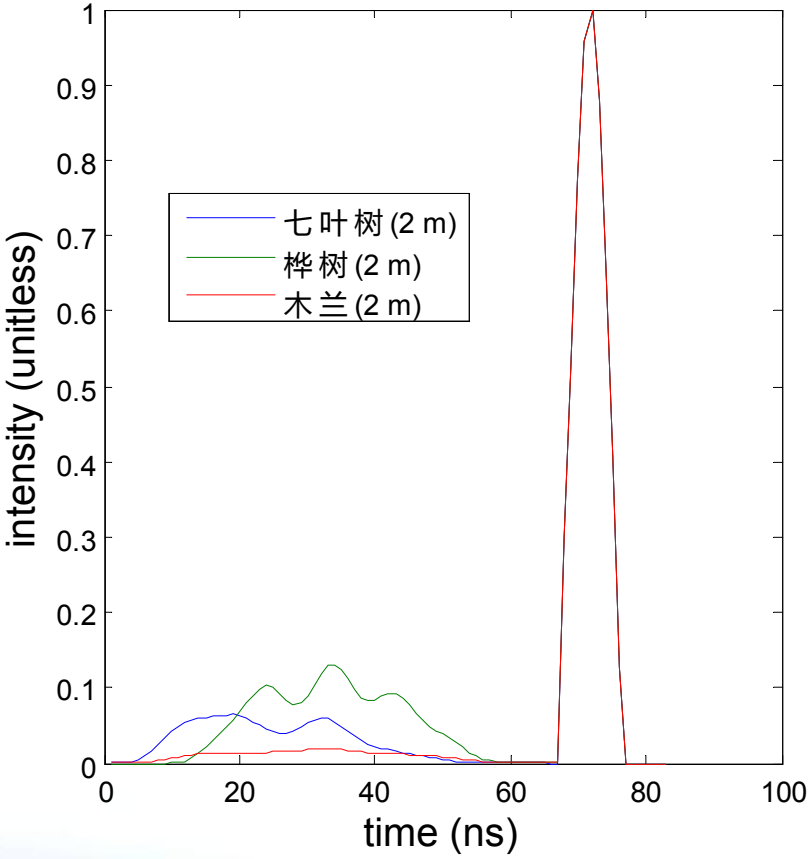
TLS vs. ALS

Aesculus

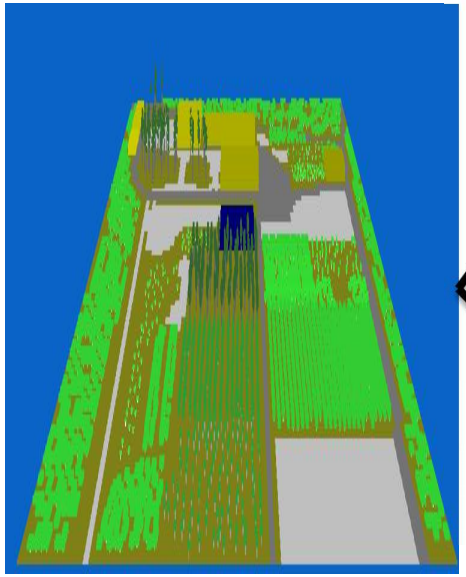
Birch

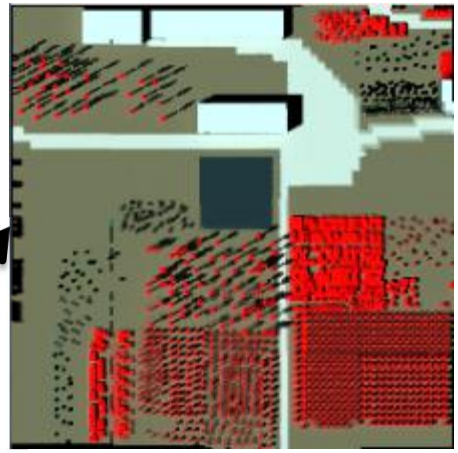
Magnolia





Small footprint waveform

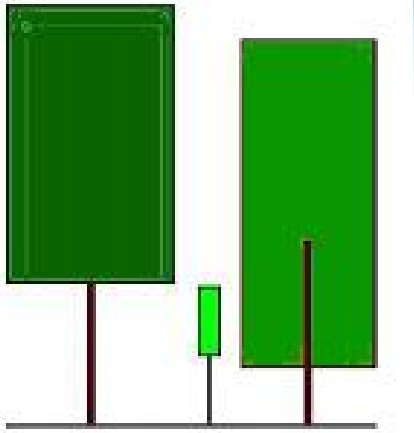




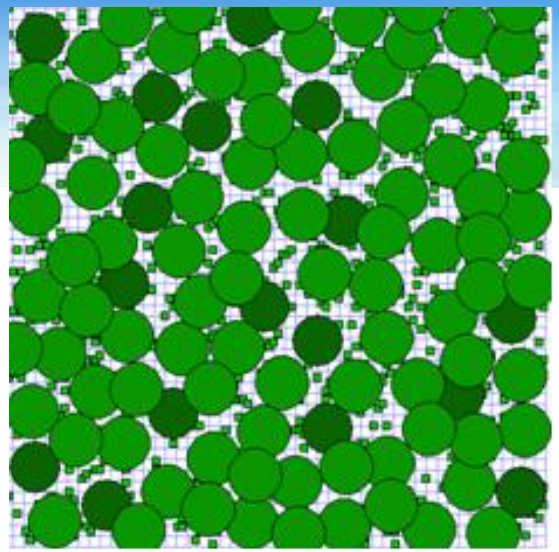
（a）VNIR (NIR,R,G)

（b）TIR image

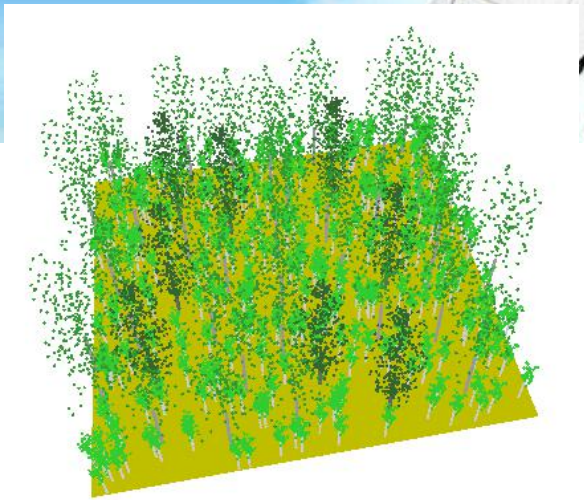
100m by 300m



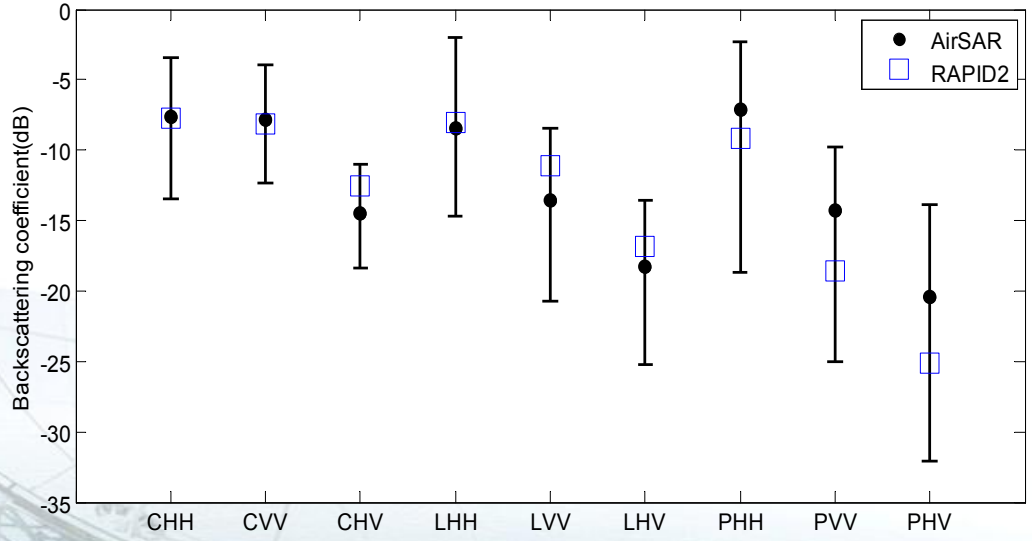
Relative tree size



2D scenes of RAPID2



3D scenes of RAPID2



microwave

accepted in RSE

Annaul Landsat image simulation

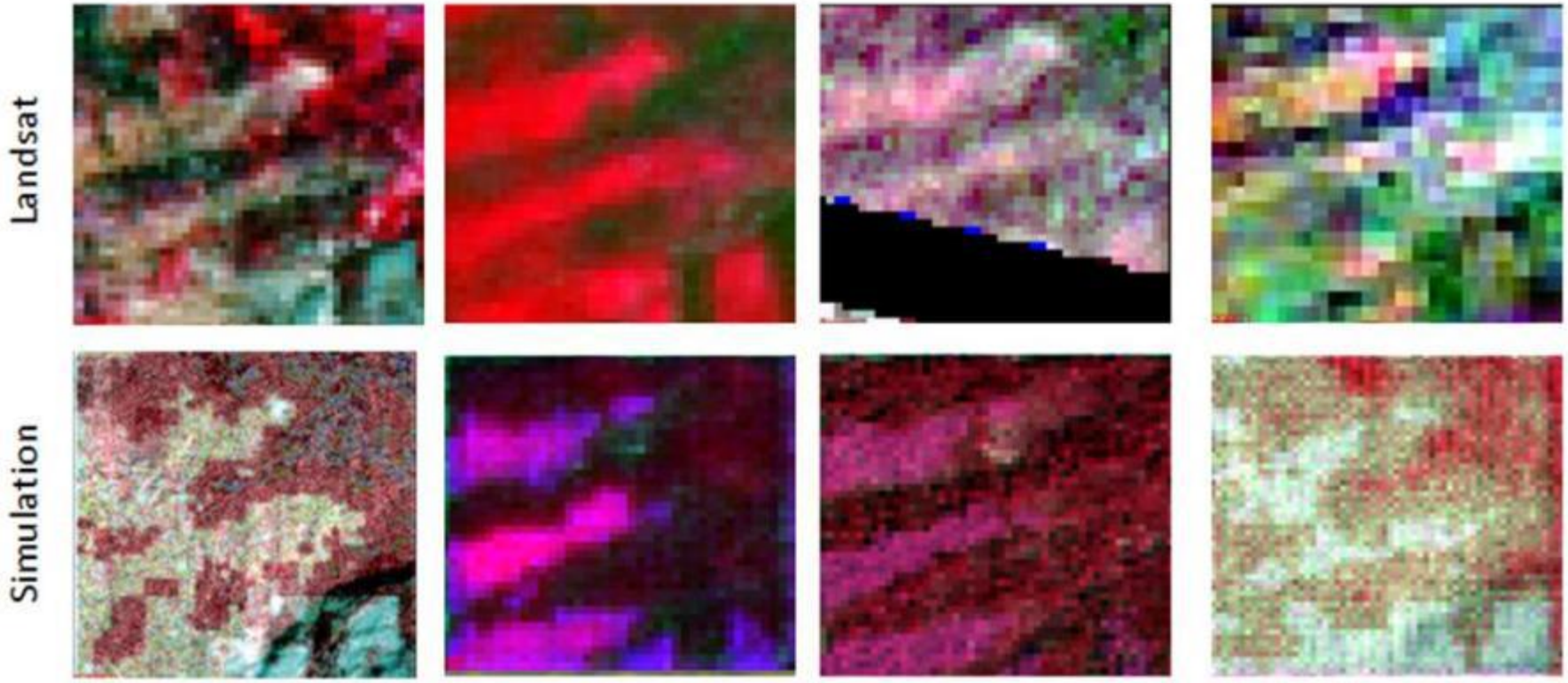
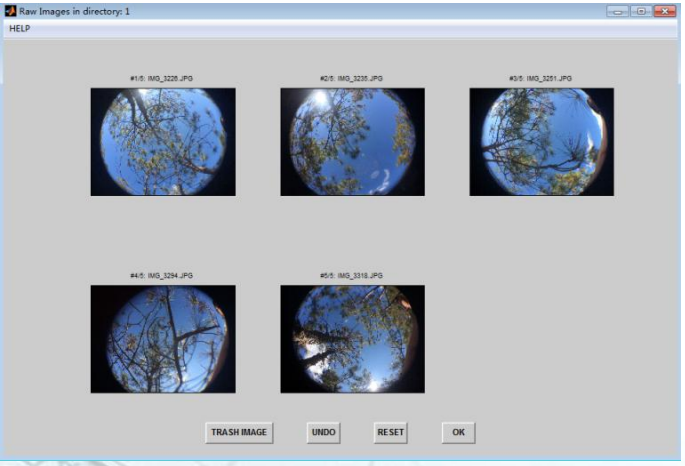


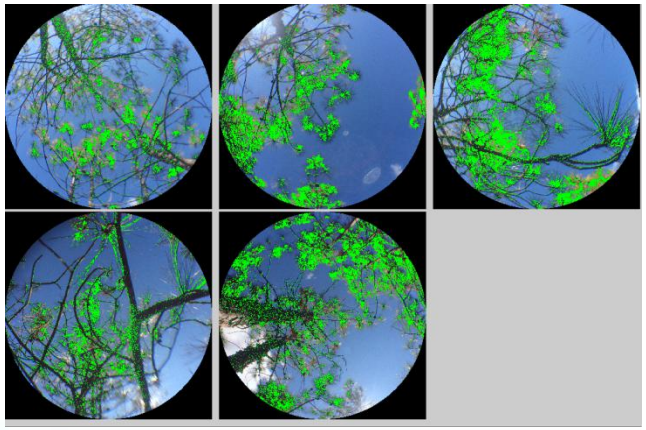
Fig. 11 Comparison between simulated and Landsat images with false color composition

Huang and Lian, 2015, Forest Ecosystems

4.2 Ground observation

LAI-Mobile for fast LAI obvervations

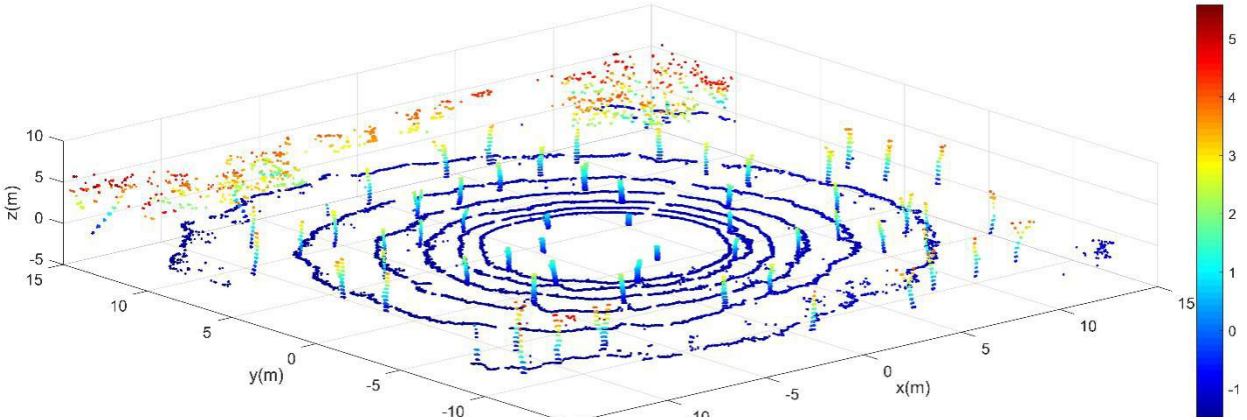


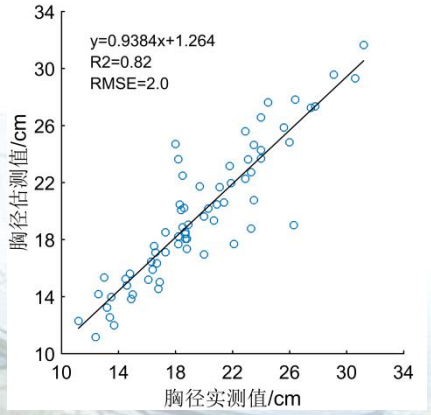


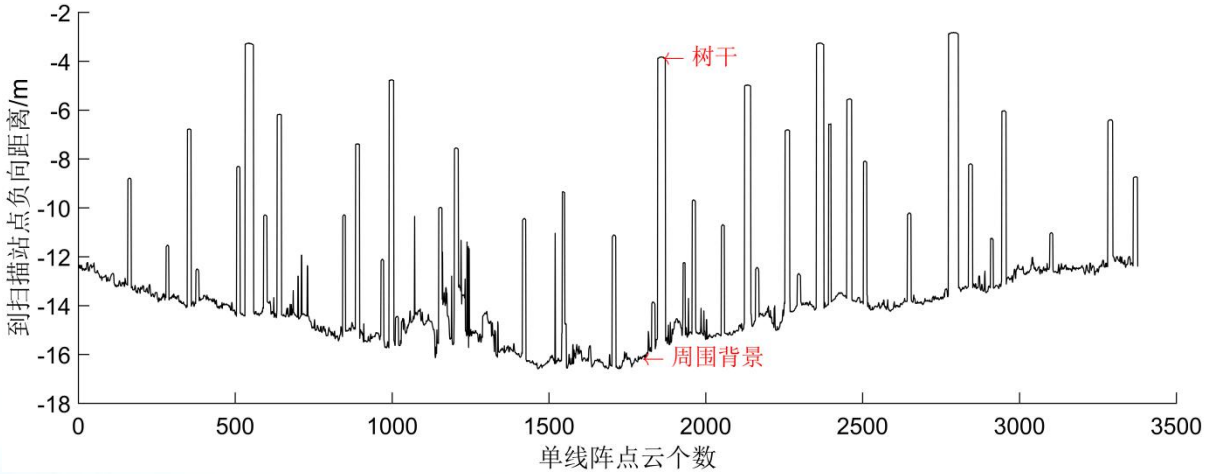
Wang et al., 2018, Remote Sensing Letters

4.2 Ground observation

VLP-16 for forest volume estimation



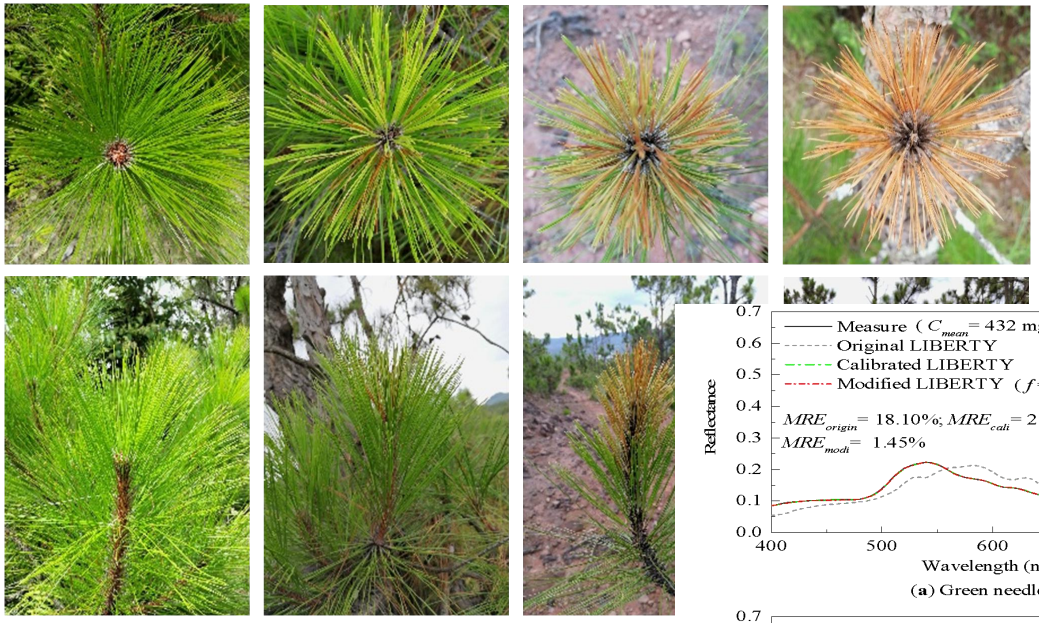




Ma et al., 2018, Journal of Beijing Forestry University

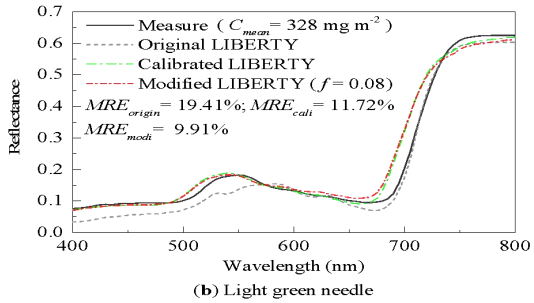
4.3 Inversion

Chl, Modifying LIBERTY model to consider pest

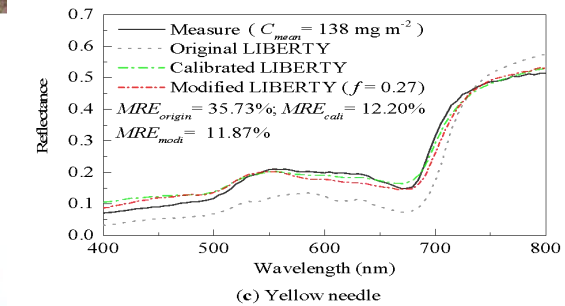


A new yellow index

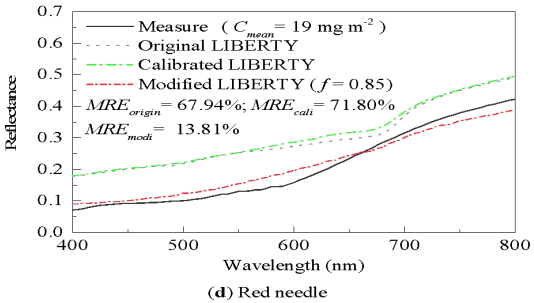
(a) Green needle



(b) Light green needle



(c) Yellow needle

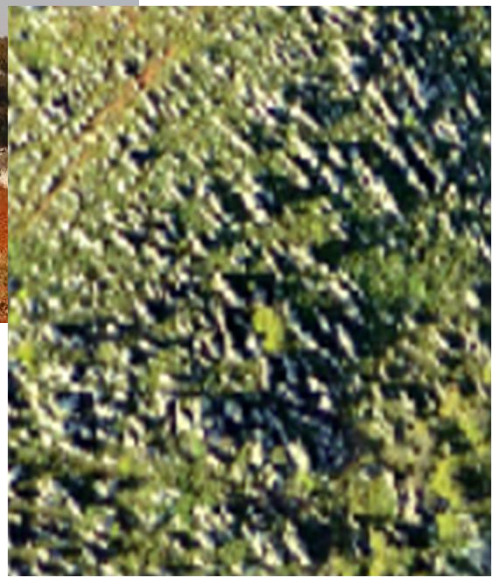


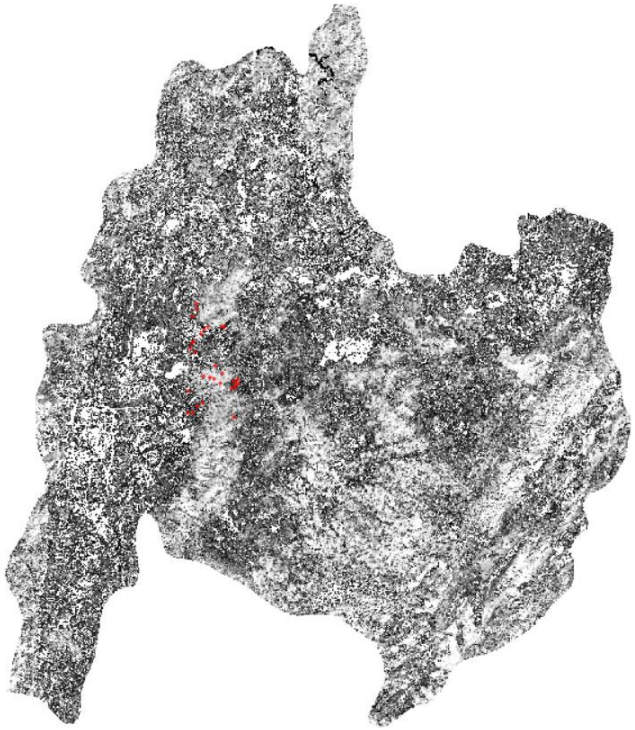
(d) Red needle

(Lin et al., 2018, Remote Sensing)

4.3 Inversion

Rocky desertification using GO idea



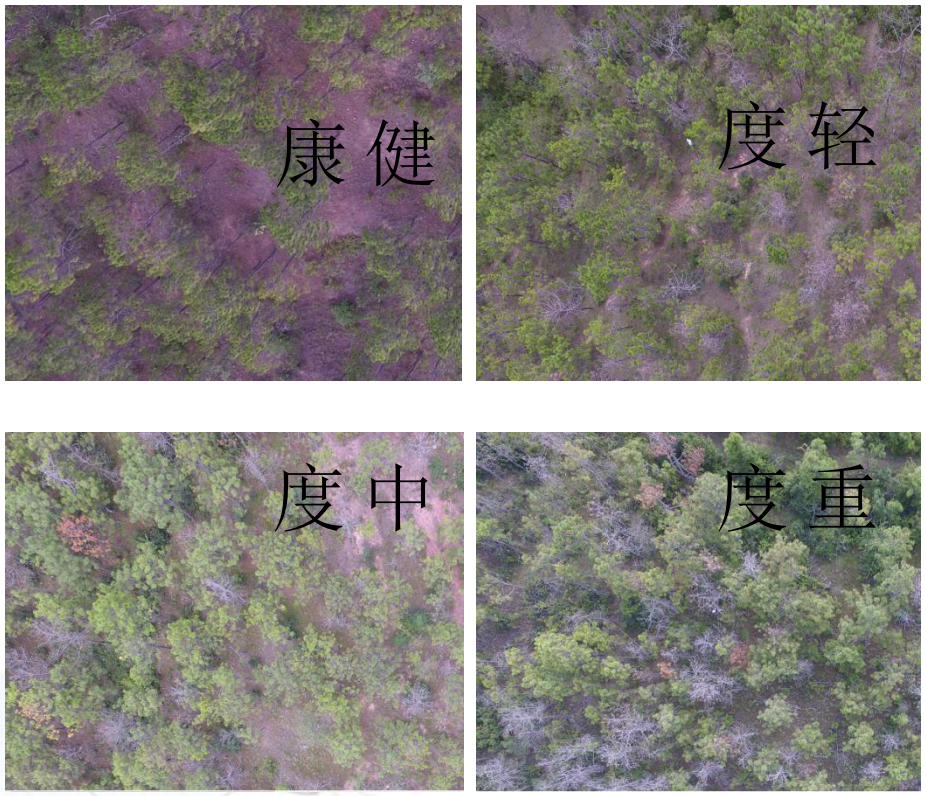


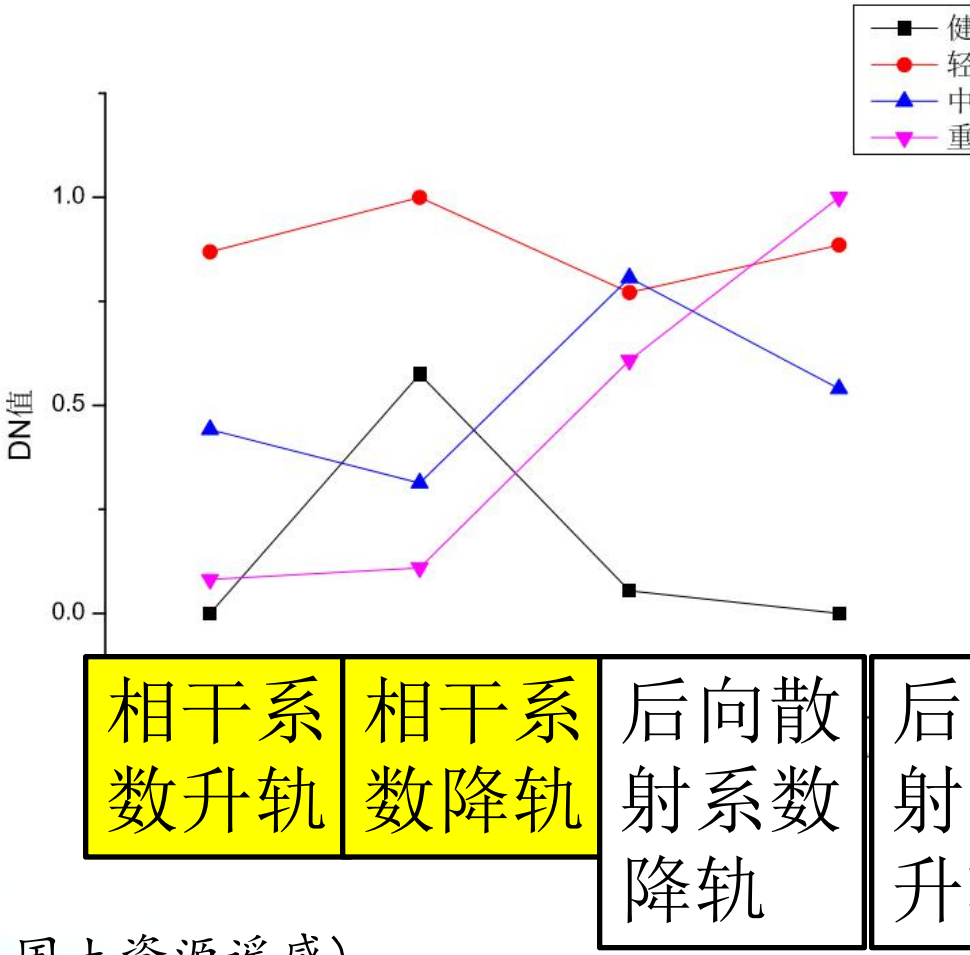
four components：rock、veg、soil、shadow

(Meng, 2017, Master Thesis)

4.3 Inversion

Microwave InSAR detect forest pest

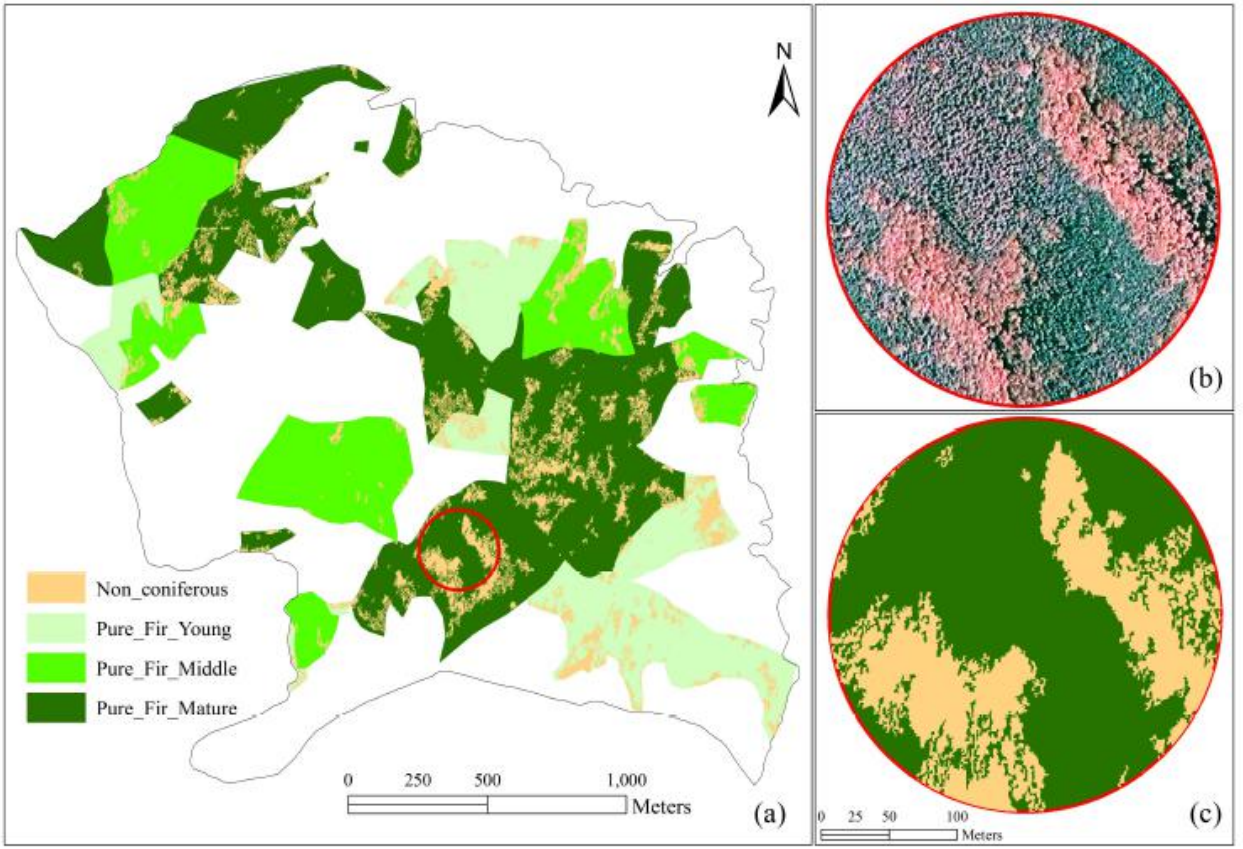




(Xue et a., 2018, 国土资源遥感)

4.3 Inversion

Machine learning to classify tree species



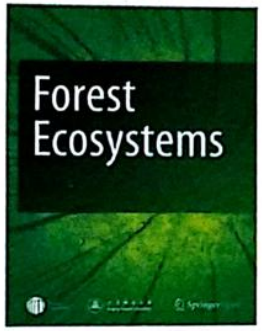
(Chen et al., accepted, IEEE-JSTARS)

5. Future

- Foundation of Smart forestry
- Big data plus QRS
- Operational use of Chinese satellites
- Data fusion of all sensors
- General cooperation

Forest Ecosystems

《森林生态系统》英文



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本刊目前由国际知名出版集团 Springer Nature 以“开放获取”模式出版。主编由北京林业大学尹伟伦院士及德国哥廷根大学 Klaus von Gadow 教授共同担任。

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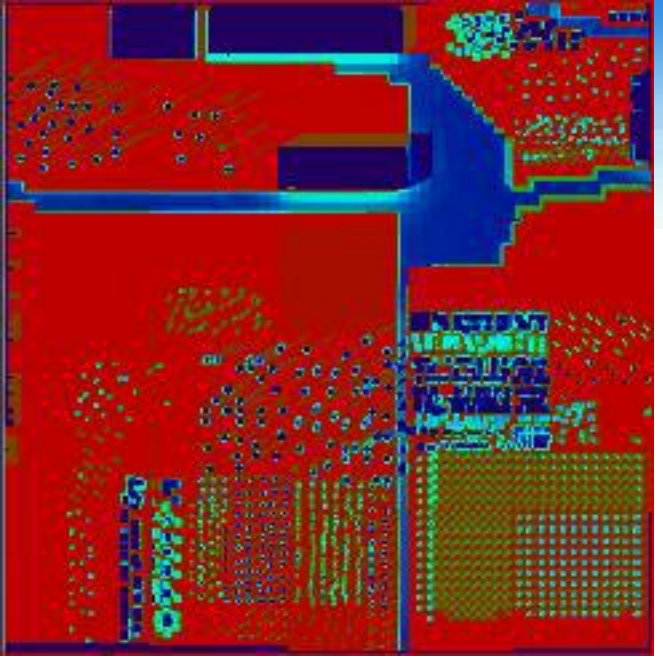

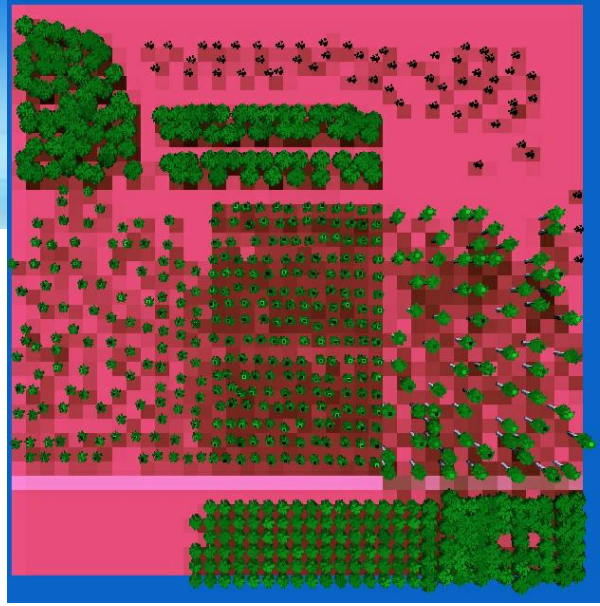

Thanks!

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