UAV-HiRAP:

(Unmanned Aerial Vehicles - High Resolution imagery Analysis Platform)

A novel method to improve landscape-level vegetation classification

and coverage fraction estimation with unmanned aerial vehicle platform

Haozhou WANG[1], Feng WANG[1*], Xueling YAO[1], Yue MU[1], Yongfei Bai[2*], Qi LU[1*]

12th international Congress of Ecology

2017-08-22

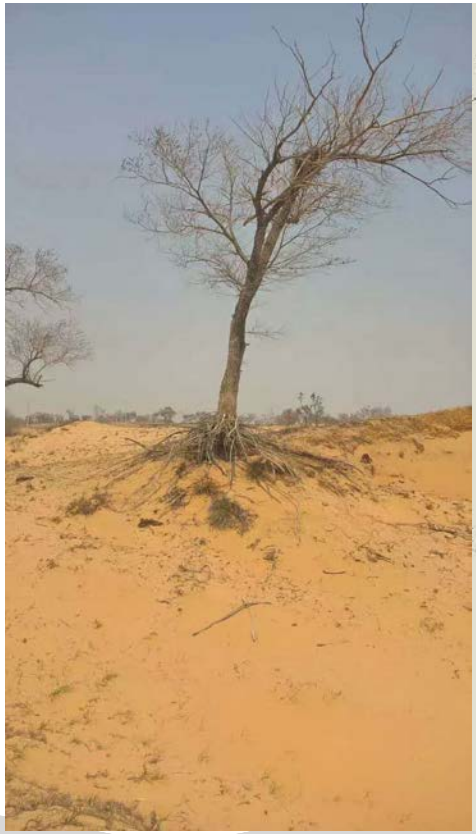
[1]Institute of Desertification Studies, Chinese Academy of Forestry, Beijing 100091, China
[2]State Key Laboratory of Vegetation and Environmental Change, Institute of Botany, The Chinese Academy of Sciences, Beijing, 100093, China

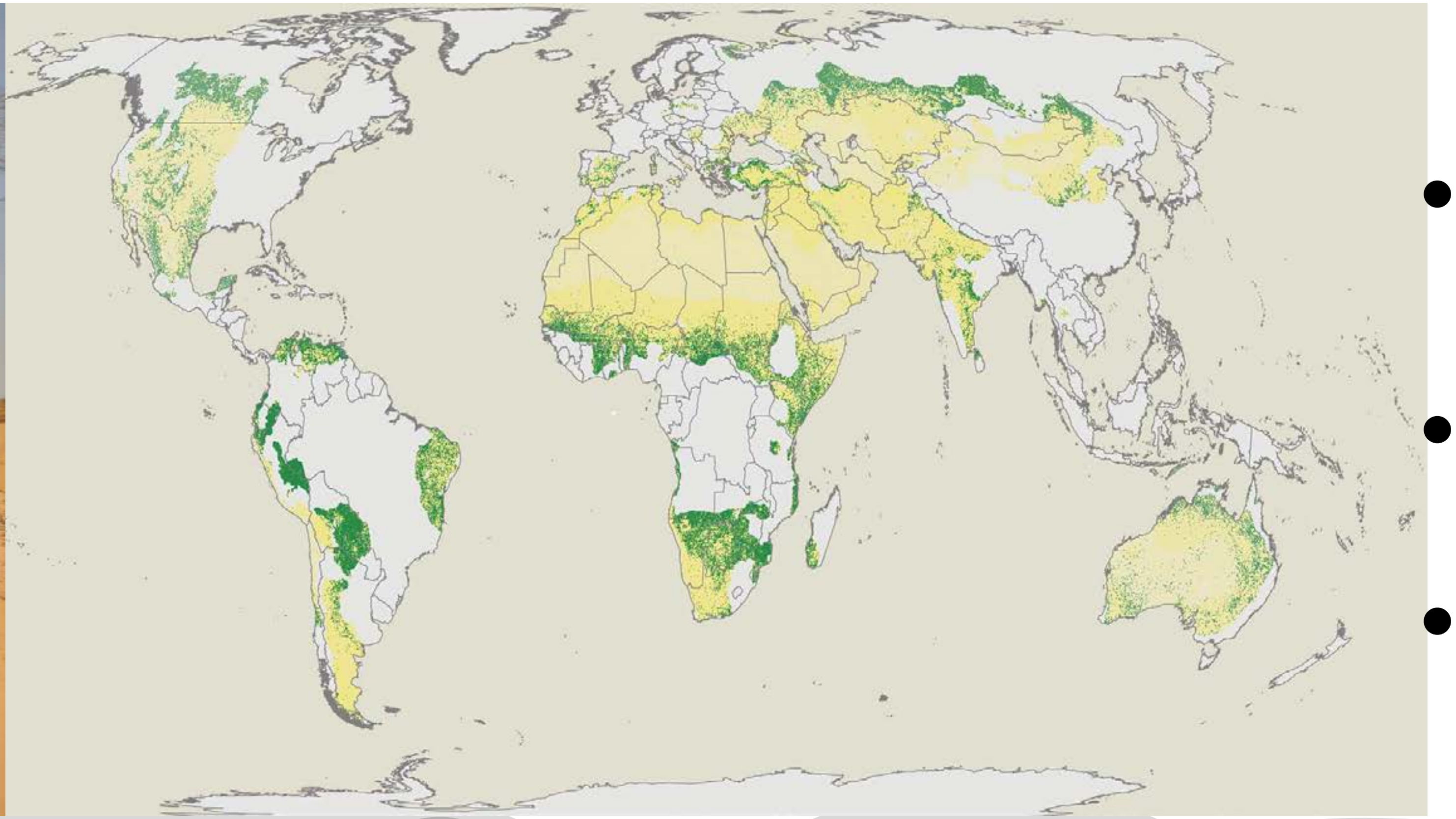
CONTENTS

01

Background

What is dryland?

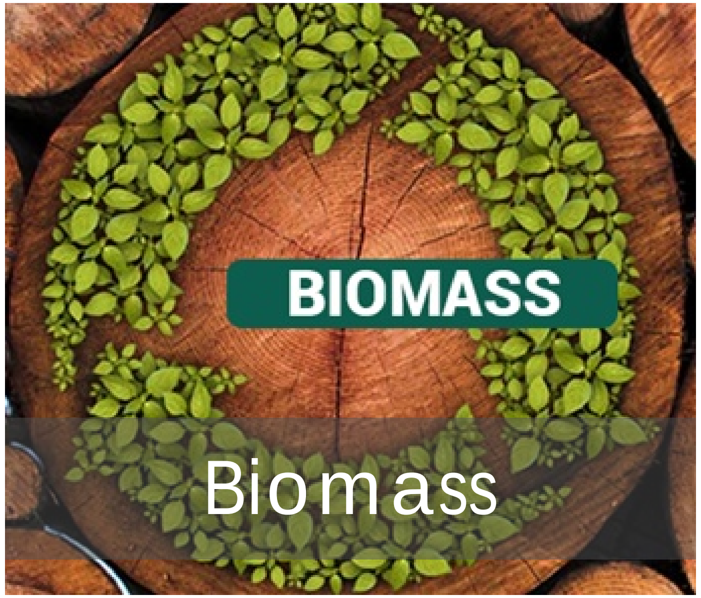




(Bastin et al., Science, 2017)

- Largest ecosystem (45%)
  (Schimel, Science, 2010)
- Support 2.4 billion people
- Fewer study

What do we measure?

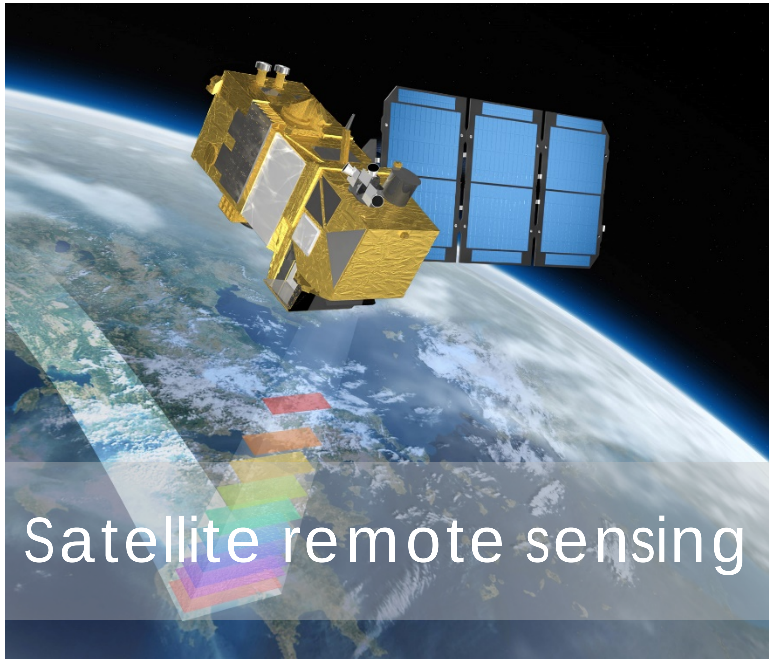


Biomass

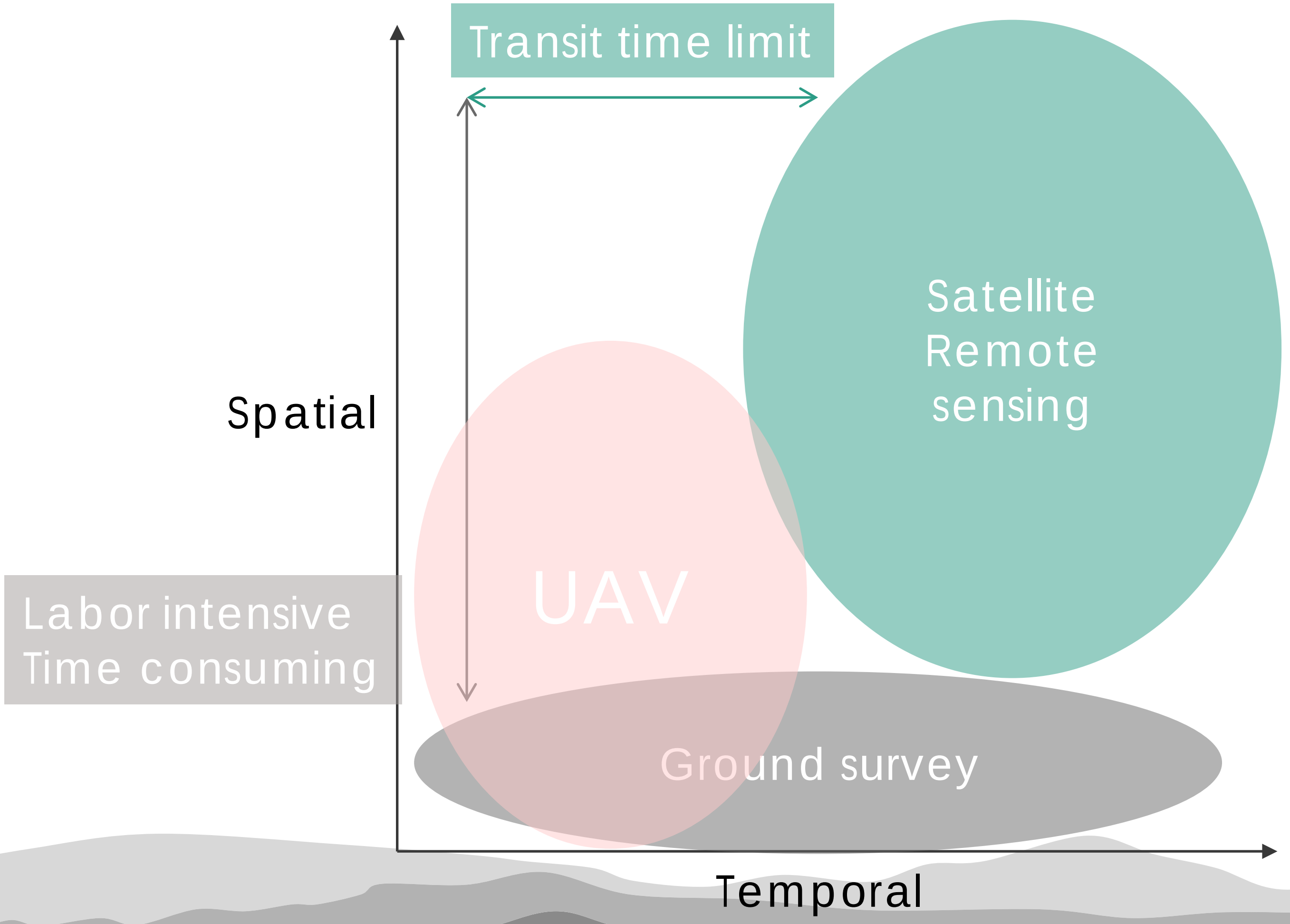
Diversity

Growth condition

How we measure commonly?



How we measure commonly?



01 Background

Image acquisition work

www.dji.com

——Satellite RS

- Ultrahigh resolution (0.5-10 cm/pixel)
- Time flexibility

——Ground survey

- Landscape scale
  (Faye et al., Methods in Ecology and Evolution, 2016)
- Labor save

Image processing work

1GB – 100GB

(Wallace et al., Forests, 2016)

——Difficulties

- Too large file size
- Too more human participation (common GIS methods)

Batch processing
Heavy image work

——Solution

- Combine with Artificial intelligence
  (Wang., Science, 2017)

Our work

- Establish UAV + AI platform -> landscape plant fraction coverage calculation
- Validate UAV results by ground survey data
- Develop a simple model for optimizing the workload of ground vegetation survey.

02

Materials and Methods

2.1 Study Area Overview

1) Location
2) Landscape

2.2 Data sources

1) Aerial photograph
2) Investigation data

2.3 Process flow

1) Classification
2) Validation
3) Application

02 Materials and methods

Location

Otingdag Sandland, inner-Mongolia, China

Plot size

1km×1km (1km^2)

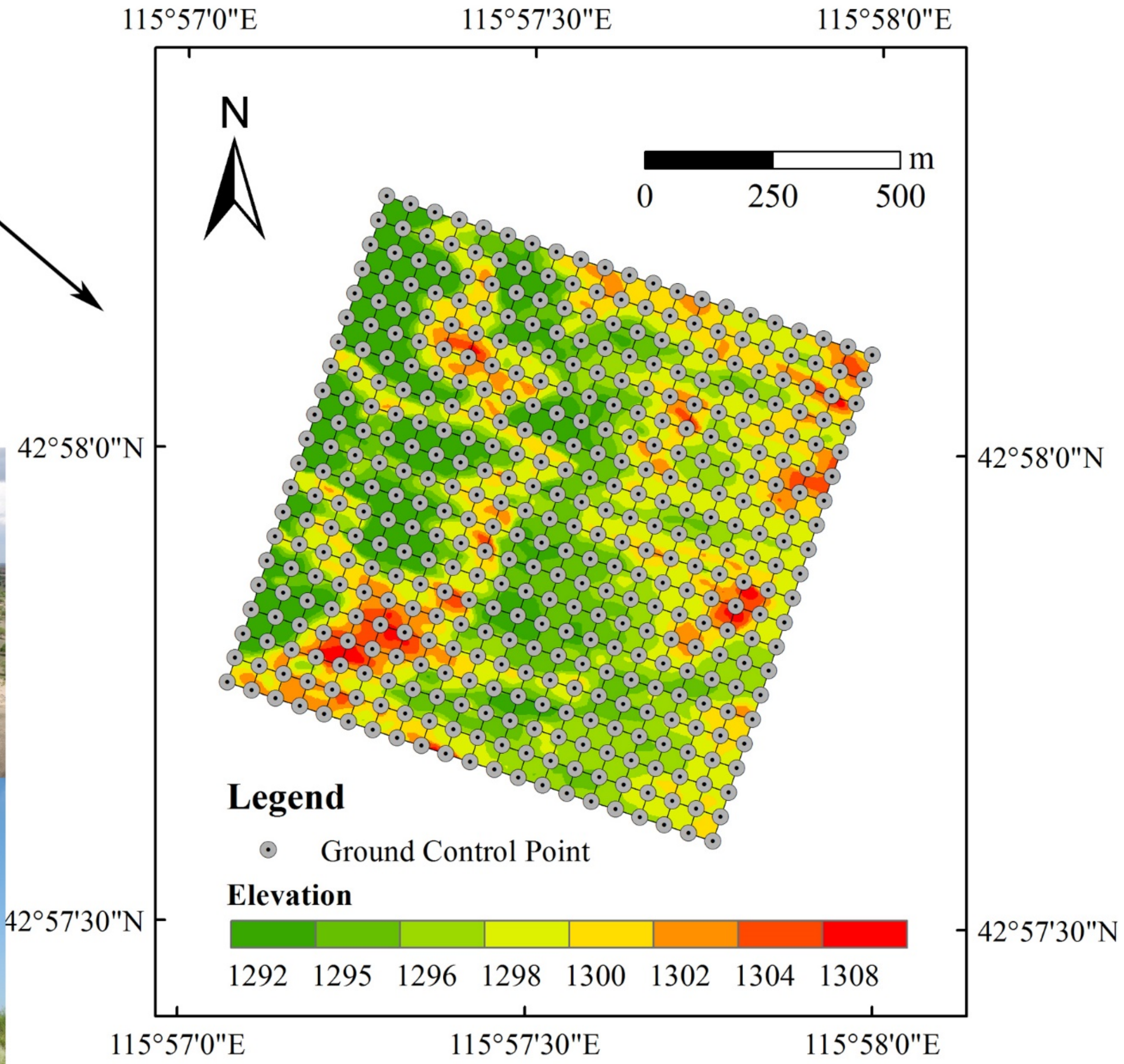
Survey time

The UAV images

2013-06-09

The ground survey

2013-07 – 2013-08



02 Materials and methods

2.1 Study Area Overview

1) Location
2) Landscape

2.2 Data sources

1) Aerial photograph
2) Investigation data

2.3 Process flow

1) Classification
2) Validation
3) Application

Equipment

- LTBT- “Mapping Eagle” fixed wing UAV
- Canon 5D Mark II

Photo parameters

- Resolution: 0.1 m/pixel

Investigation data

- Number: 3953 Elm , 879 shrub-like Elm , 18798 shrubs.
- Parameters: X,Y grid, Height, DBH, crown diameter

2.1 Study Area Overview

1) Location
2) Landscape

2.2 Data sources

1) Aerial photograph
2) Investigation data

2.3 Process flow

1) Classification
2) Validation
3) Application

2.1 Study Area Overview

1) Location
2) Landscape

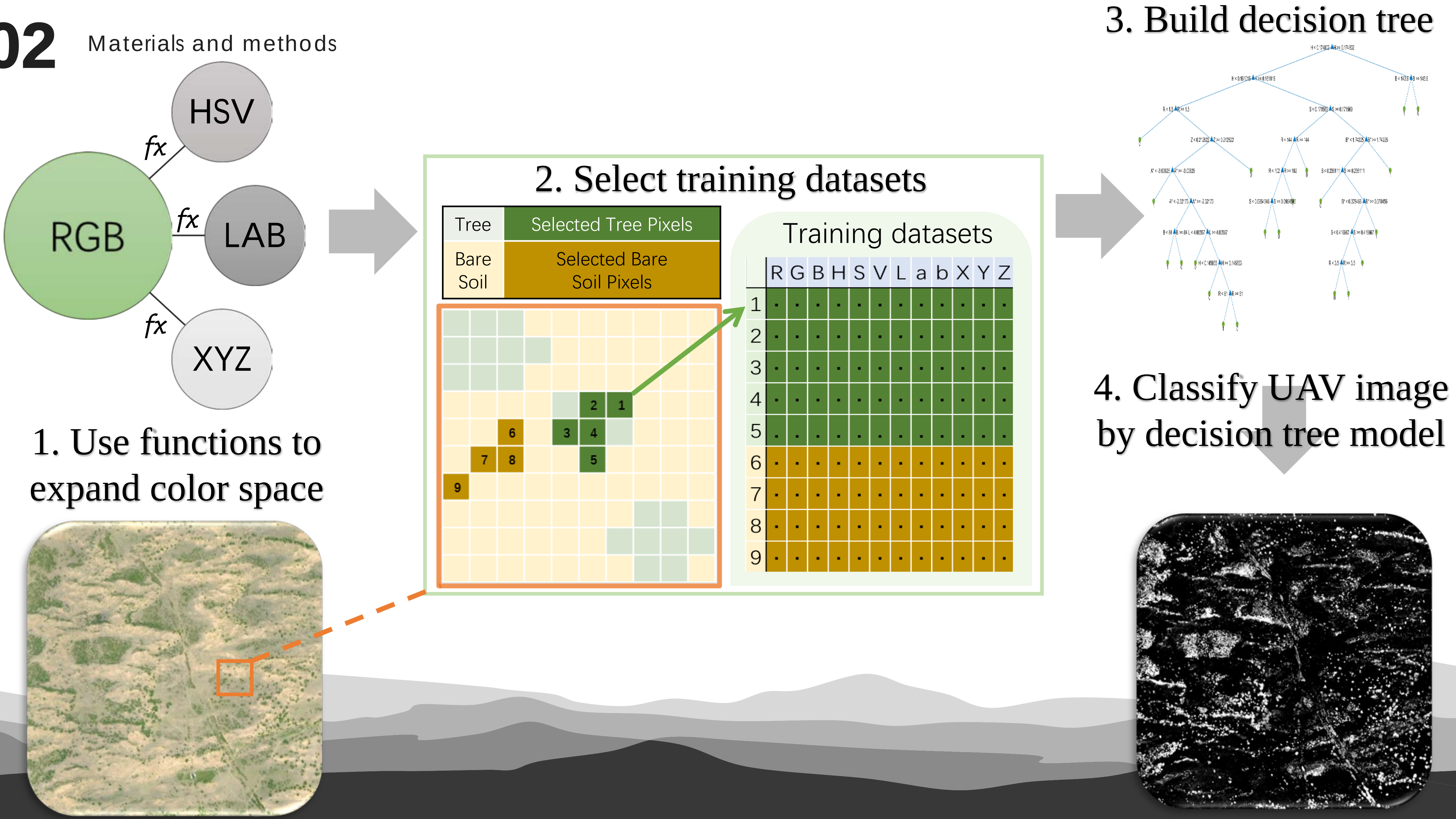
2.2 Data sources

1) Aerial photograph
2) Investigation data

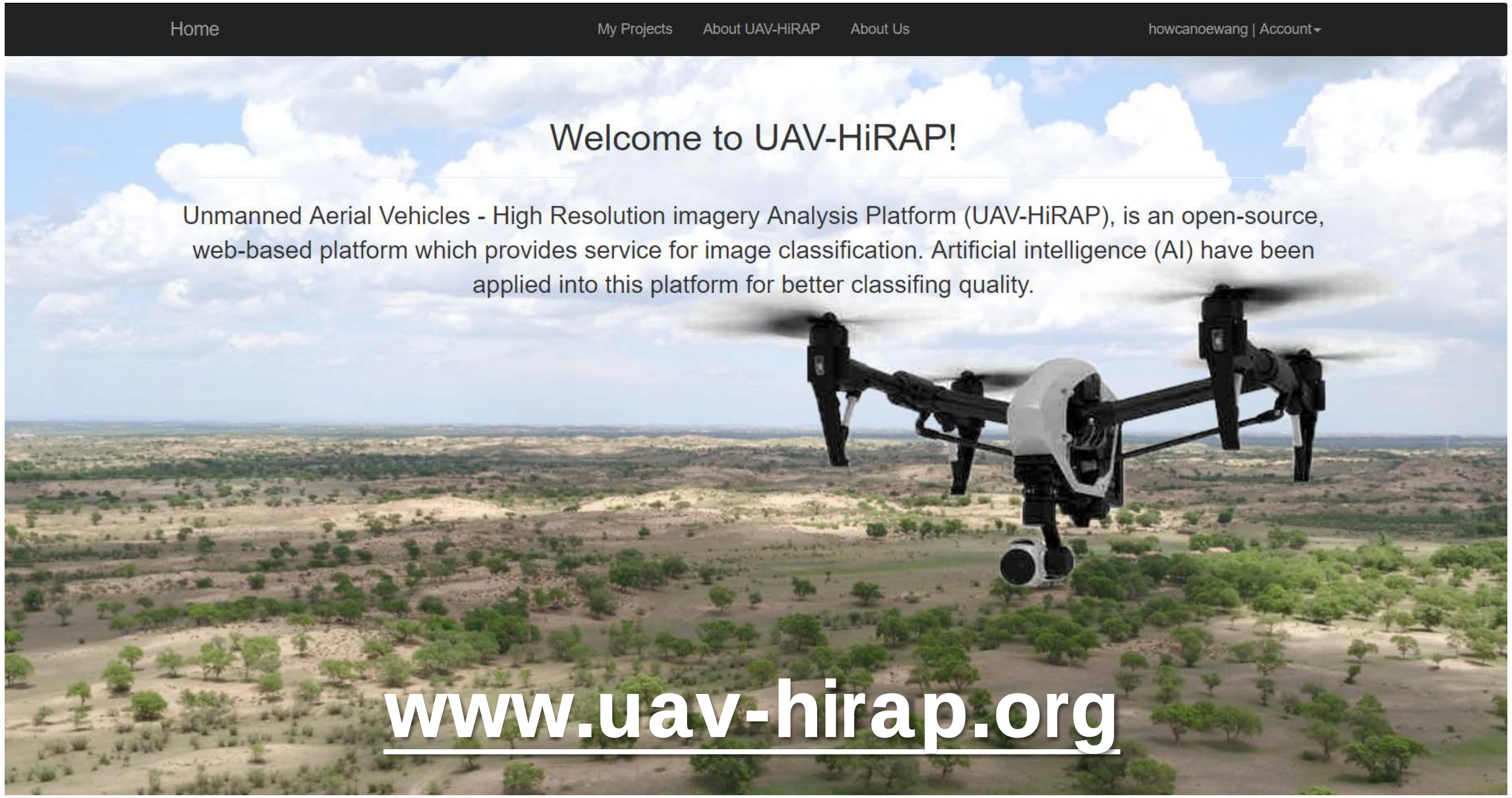
2.3 Process flow

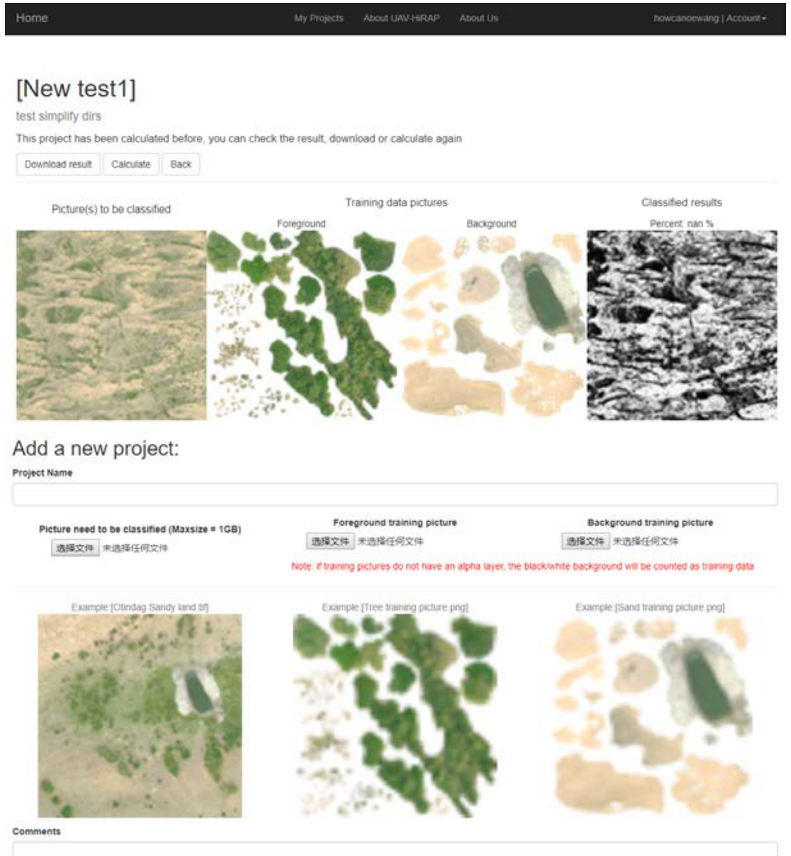
1) Classification
2) Validation
3) Application

02 Materials and methods



02 Materials and methods





02 Materials and methods

2.1 Study Area Overview

1) Location
2) Landscape

2.2 Data sources

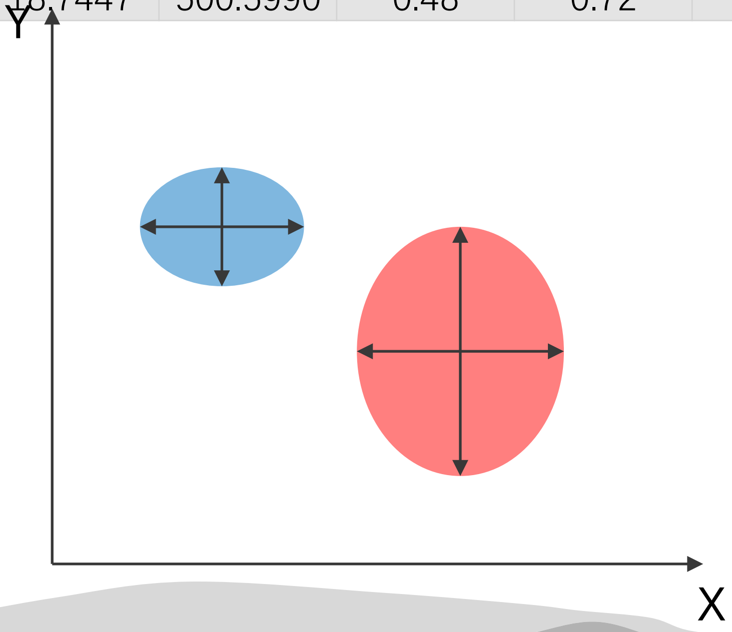
1) Aerial photograph
2) Investigation data

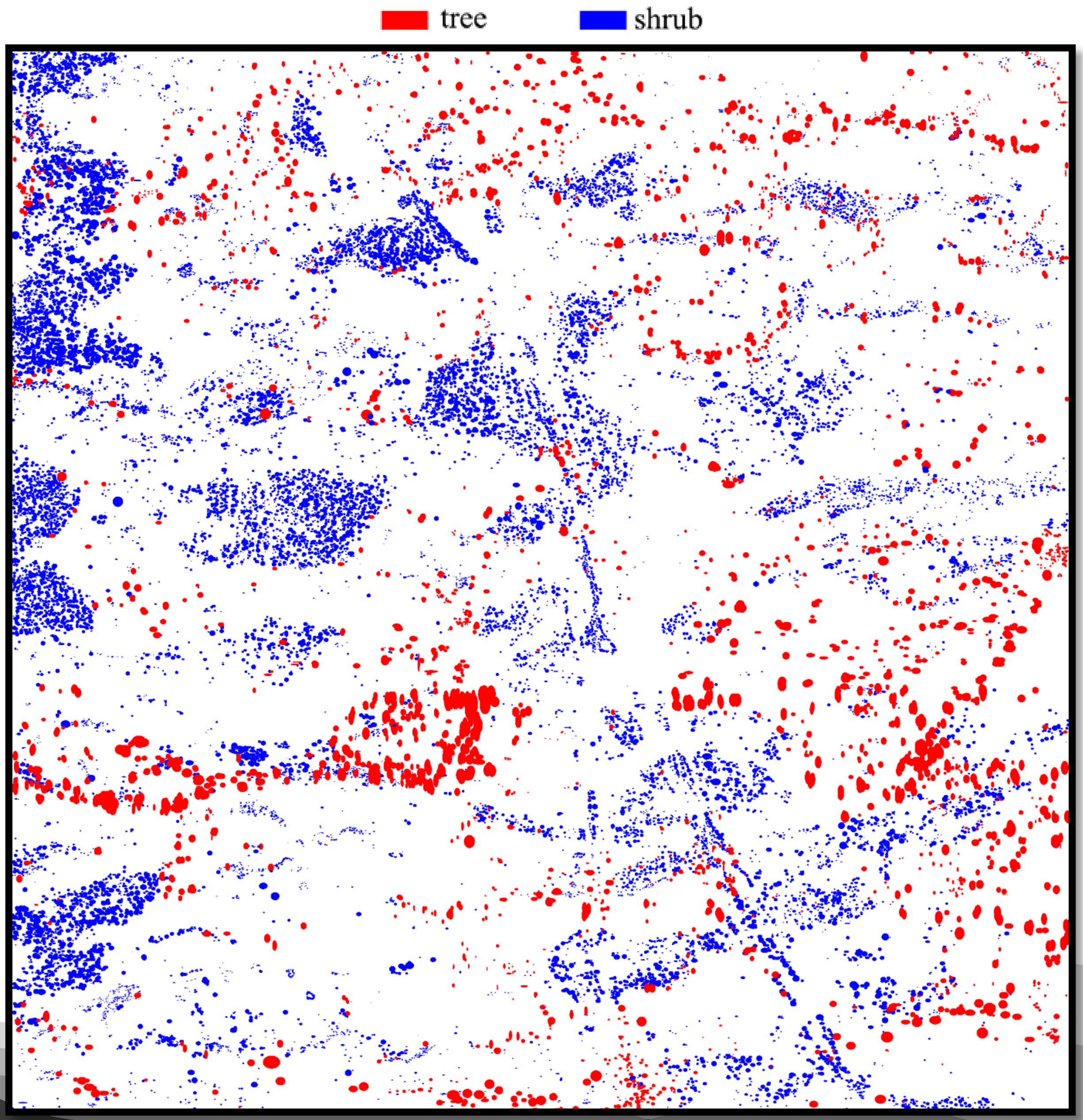
2.3 Process flow

1) Classification
2) Validation
3) Application

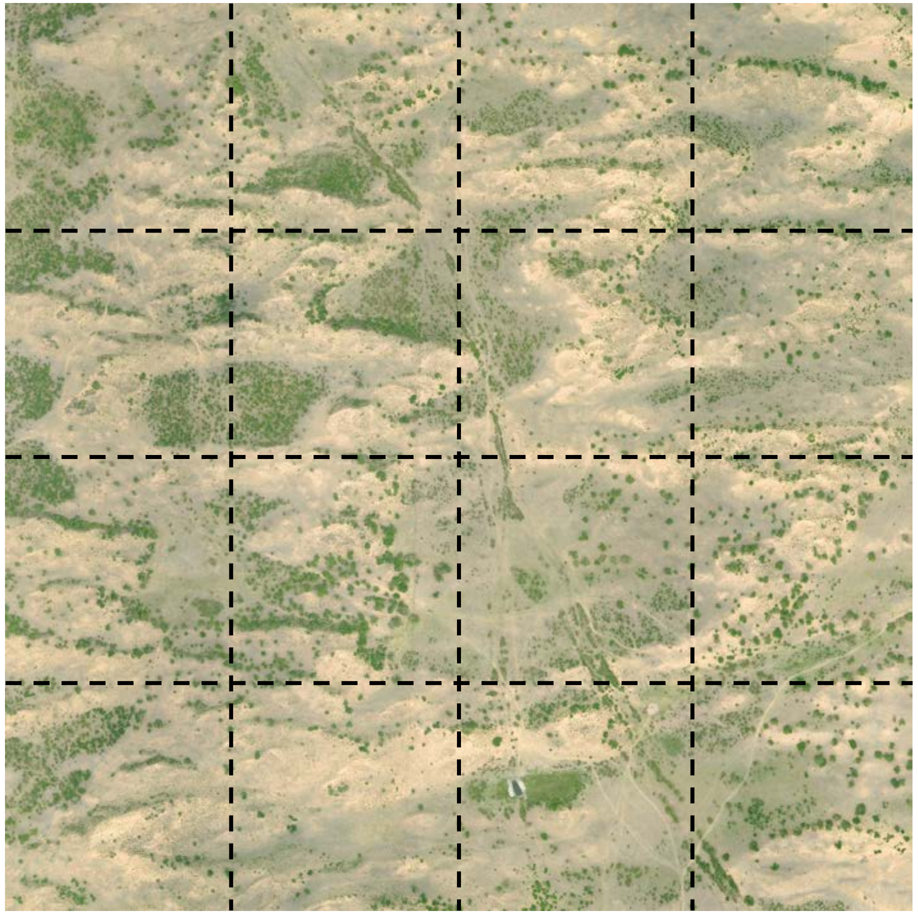
02 Materials and methods

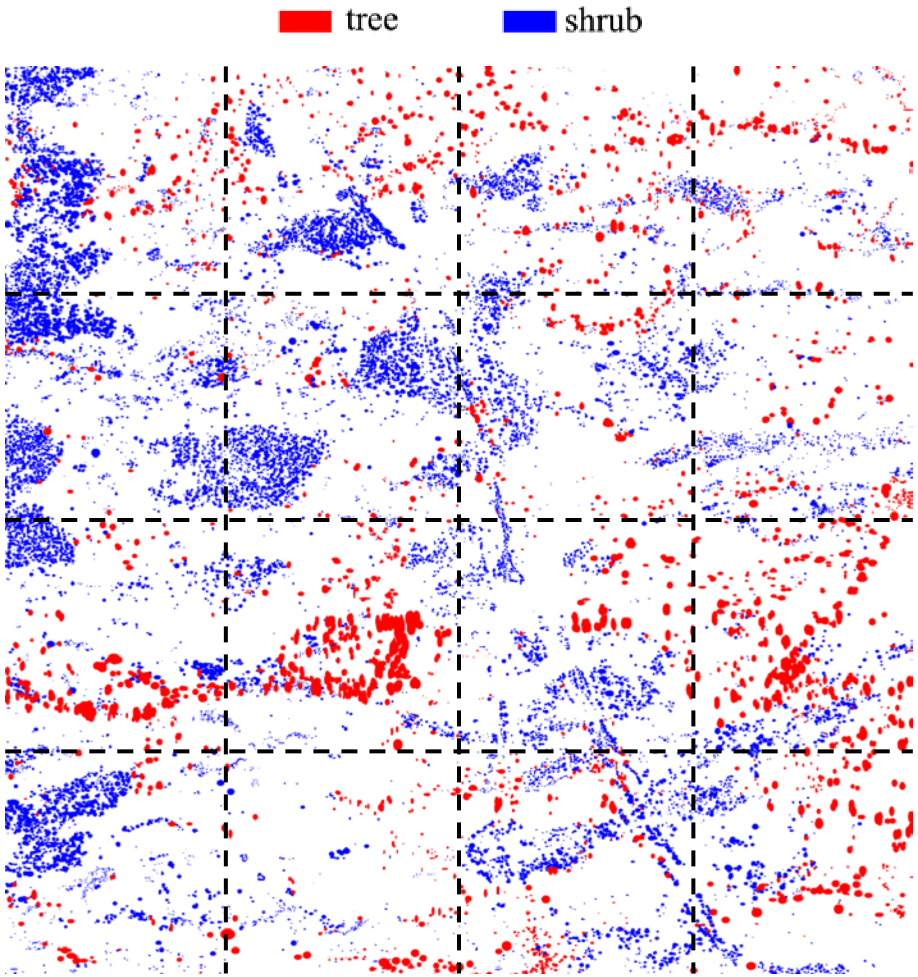
Ground survey data					
No.	X	Y	Long axis (m)	Short axis (m)	Kinds
1	735.6471	579.4423	3	1.76	Tree
2	736.2334	575.1919	3.23	2.3	Tree
…	…	…	…	…	…
4833	729.3089	555.5778	1.77	0.9	Shrub
…	…	…	…	…	…
23630	18.7447	500.5990	0.48	0.72	Shrub





02 Materials and methods





02 Materials and methods

2.1 Study Area Overview

1) Location
2) Landscape

2.2 Data sources

1) Aerial photograph
2) Investigation data

2.3 Process flow

1) Classification
2) Validation
3) Application

02 Materials and methods

(Vegetation coverage fraction, VCF)

VCF_{UAV} = 14.07% (as true value)

e.g. 10 × square subplots (size: 10m × 10m)

1m ×1m
2m × 2m
…
100m × 100m

×100

$VCF_{Estimate}$ = average(10 subplots VCF)

$VCF_{Deviation}$ = abs($VCF_{Estimate}$ – VCF_{UAV})

	$VCF_{Deviation}$				
Times	Num=10	Num=20	Num=30	Num=40	…
1	10.1%	?	?	?	…
2	13.8%	?	?	?	…
…	…	…	…	…	…
96	7.8%	?	?	?	…
97	15.9%	?	?	?	…
98	16.9%	?	?	?	…
99	9.6%	?	?	?	…
100	16.7%	?	?	?	…

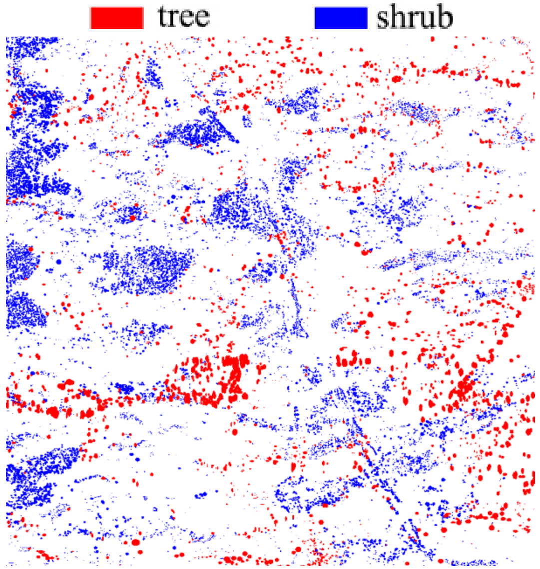
03

Results and Discussion

03 Results and discussion

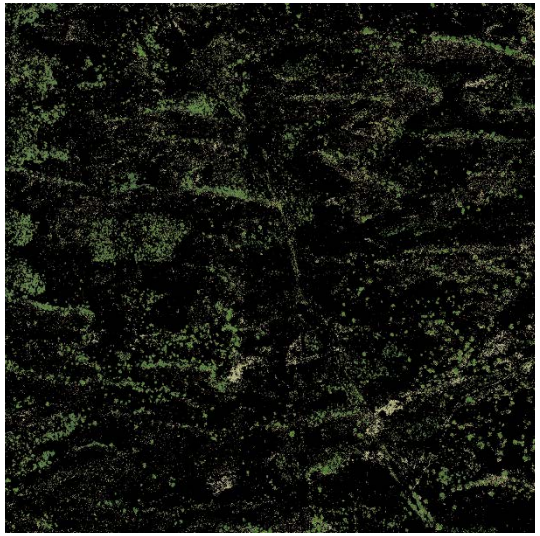
Classification results → Partial evaluation → Application results

03 Results and discussion

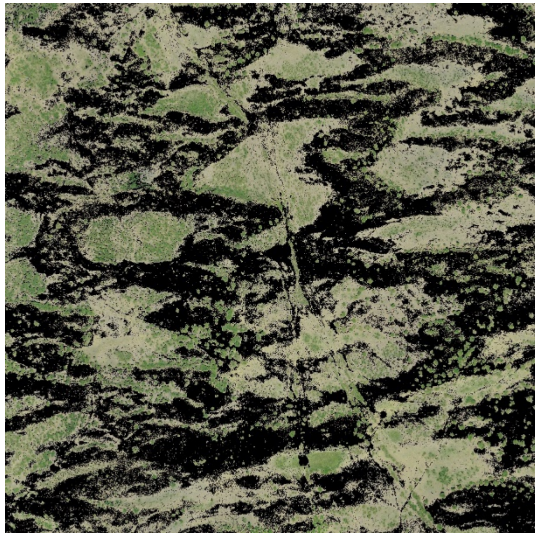


Plant map(from ground survey)

UAV image



UAV_tree + shrub

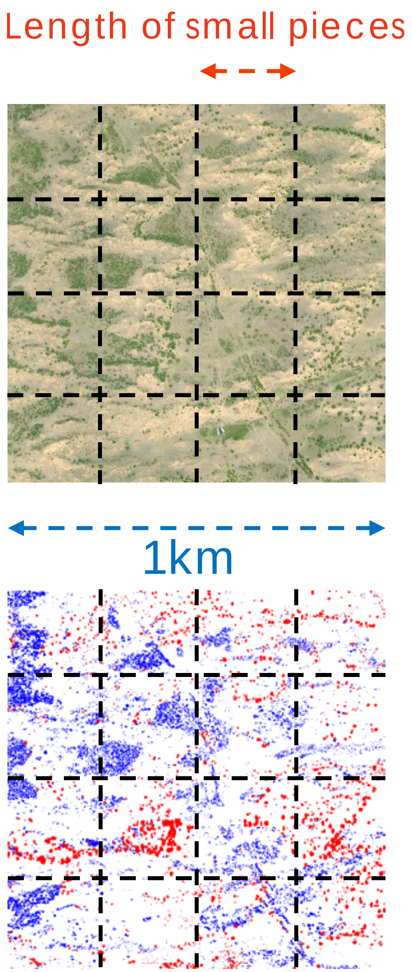


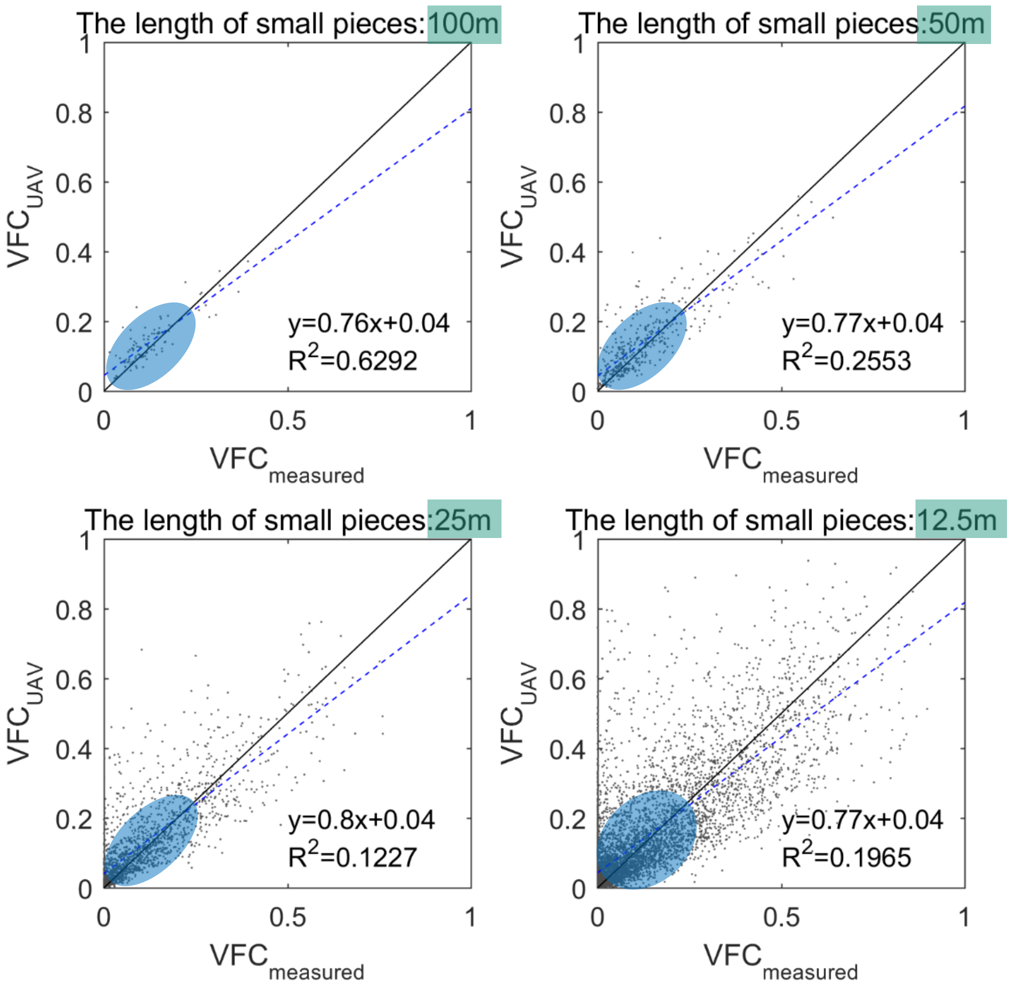
UAV_tree + shrub + grass

<table>
<tr><th></th><th>Tree</th><th>Shrub</th><th>Grass</th></tr>
<tr><td rowspan="2">VCF_{ground}</td><td>4.87%</td><td>7.67%</td><td rowspan="2">-</td></tr>
<tr><td colspan="2">12.54%</td></tr>
<tr><td rowspan="2">VCF_{UAV}</td><td colspan="2">14.07%</td><td>46.12%</td></tr>
<tr><td colspan="3">60.19%</td></tr>
</table>

Classification results → Partial evaluation → Application results

03 Results and discuss

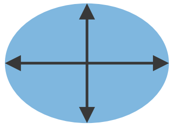




y=0.78x+0.04

Length of small pieces decrease cause Scatters more discrete

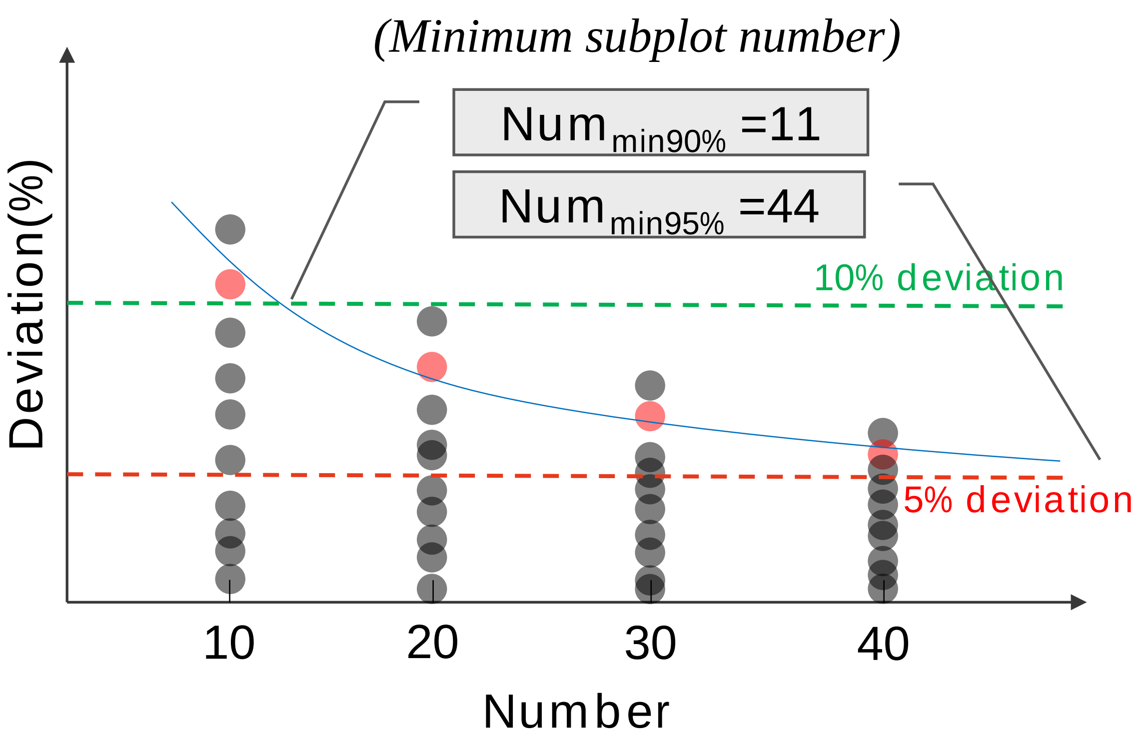
- Ground survey results are not exactly same to UAV results **in details**.

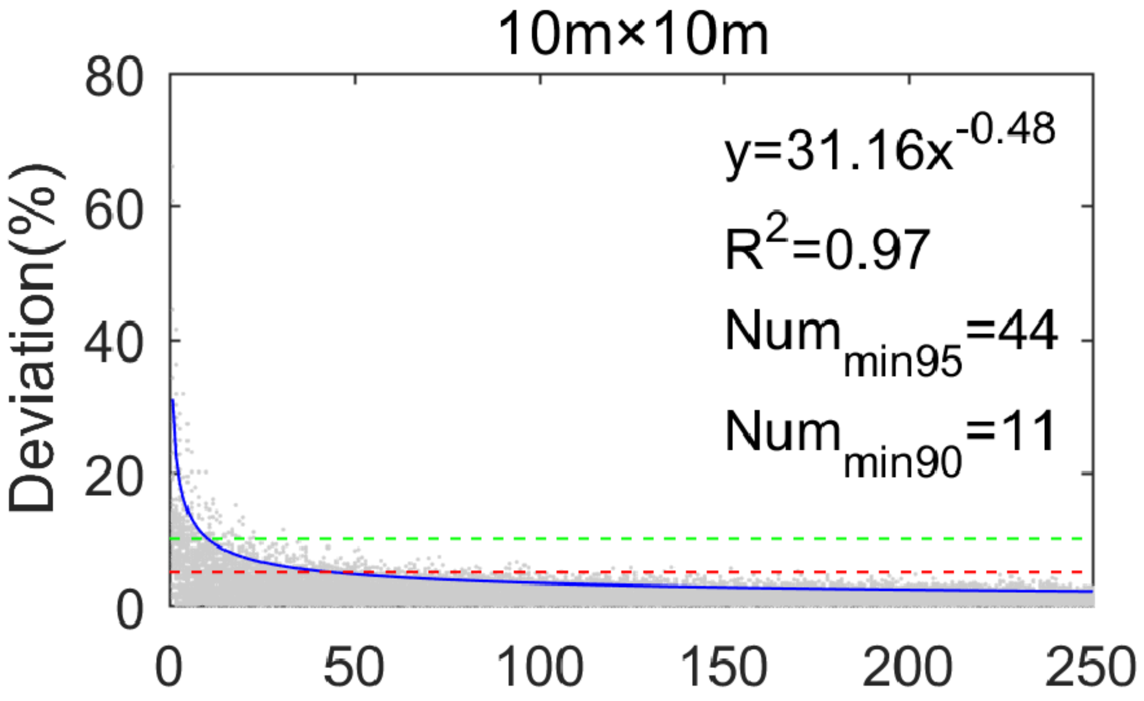


Scatters gathered most below 25%

- Partial VCFs are closed to global VCF (12-14%).
- Most sparse distribution fewer high-density cluster.

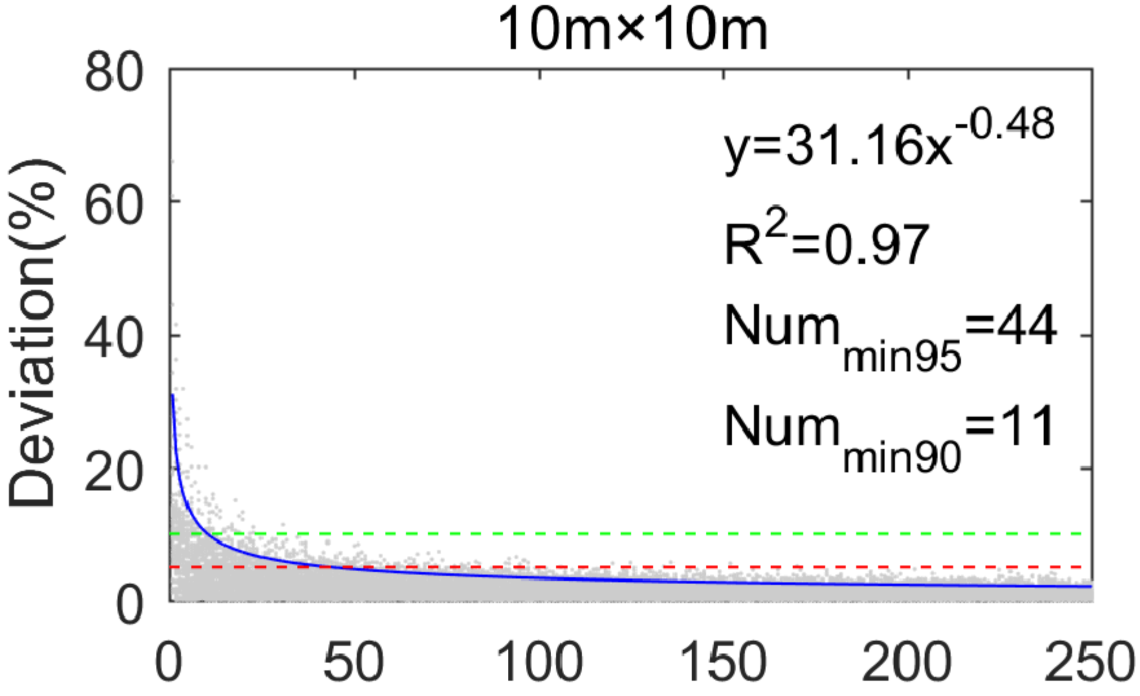
Classification results → Partial evaluation → Application results


(Minimum subplot number)
Num min90% =11
Num min95% =44
10% deviation
5% deviation
Deviation(%)
10
20
30
40
Number

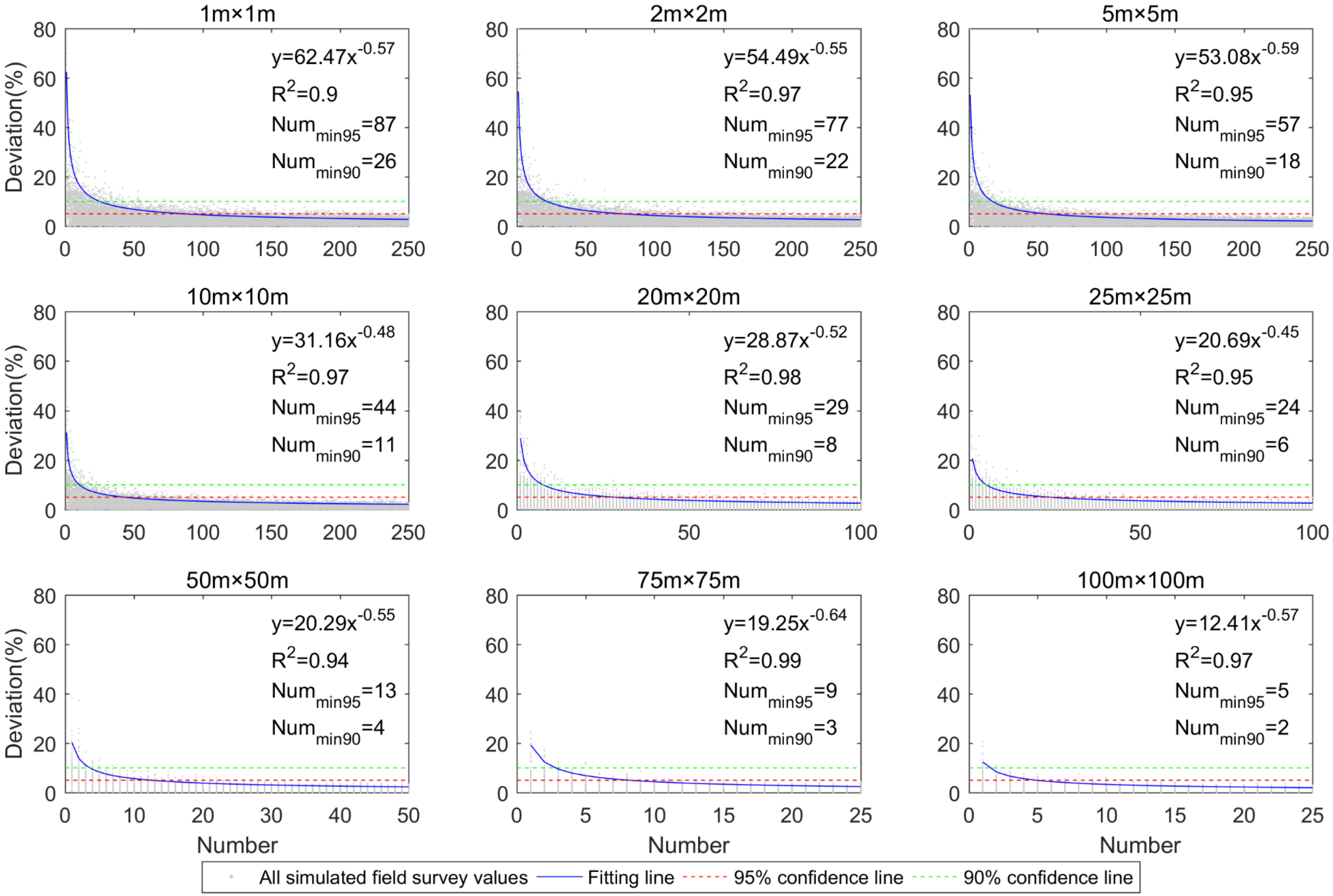

10m×10m
y=31.16x-0.48
R2=0.97
Num min95=44
Num min90=11
Deviation(%)
80
60
40
20
0
0
50
100
150
200
250

1) With subplot **quantity increasing**, the **deviation** drops **down** quickly

2) If we **decrease** the **confidence** from **95%** to **90%,** the quantity of subplots decrease greatly.



03 Results and discussion

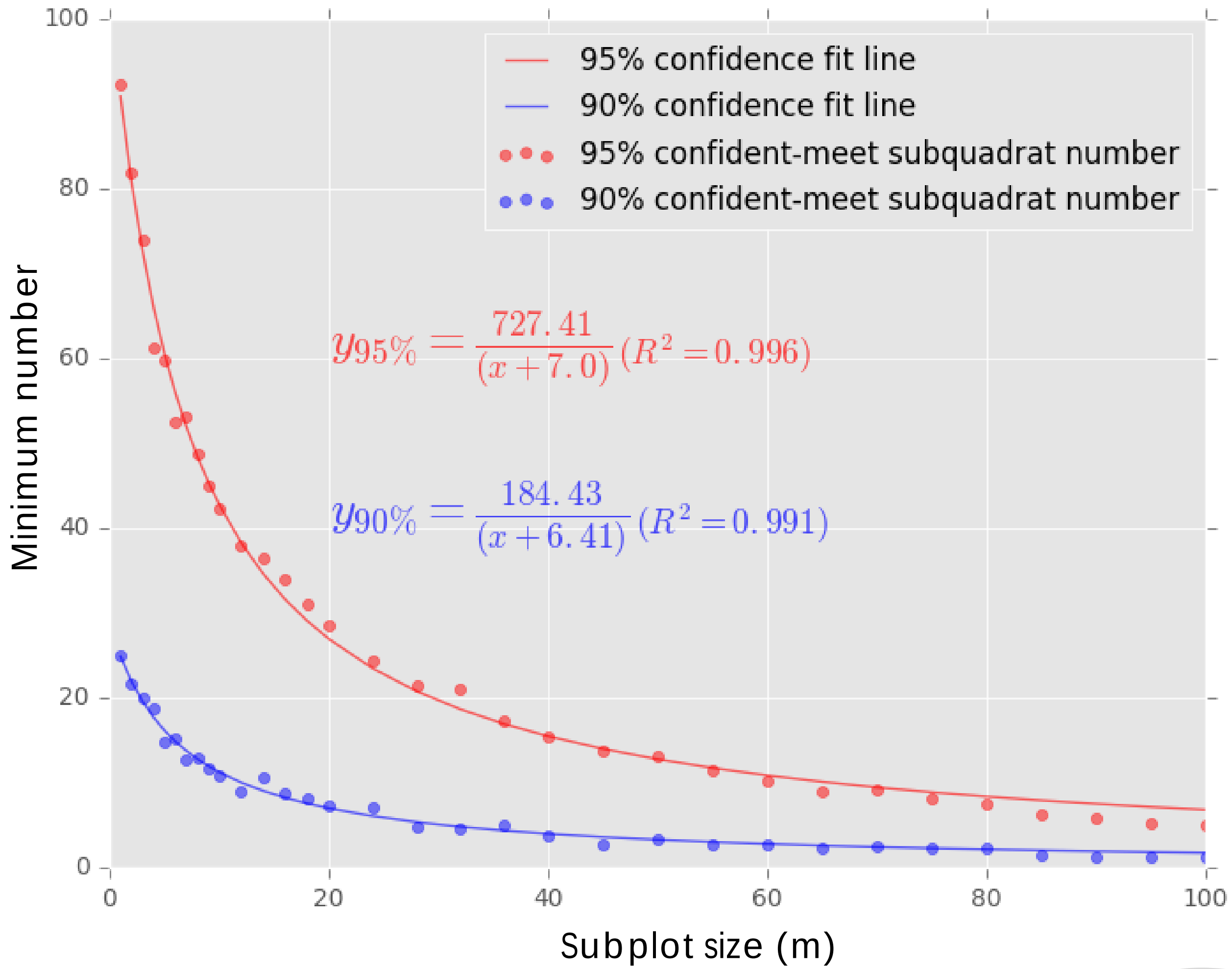


With subplot **size increasing**, the minimum subplot **quantity decrease**.

03 Results and discussion

1) Total survey area ($A_{95\%}$) = subplot size × number = $x^2 \times y_{95\%} = x^2 \times \frac{k}{x+b} = \frac{kx^2}{(x+b)}$ (k, b>0), $A_{95\%} = \frac{kx^2}{(x+b)}$ (k, b>0).

2) This means that to achieve the same accuracy,
small-size subplots with high quantity
V
large-size subplots with low quantity.



04

Conclusion

04 Conclusion

Classification

We establish a high-resolution image analysis platform (UAV-HiRAP) to classify vegetation types and estimate coverage fraction at landscape-level with UAV by machine learning algorithm and parallel computing

Validation

The accuracy of new method has been validated by detailed ground-based data in elm sparse forest grassland

Application

A simple model for optimizing the workload of vegetation survey has been generated.

05

Acknowledgement

05 Acknowledgement

Thanks a lot for Institute of Desertification Studies, Chinese Academy of Forestry provides the internship opportunity for me.

The field survey data could not be acquired without the assistance of all volunteers from The second phase of Chinese Grassland Hiking(华夏草原行)

Thanks for your attention