Half-Gaussian Fitting Method for Estimating Fractional Vegetation Cover from UAV Images.

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LAND AND WATER
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Summary

- Increasing height of flight reduces spatial resolution and increases the fraction of mixed pixels in LARS images in LARS images.
- Existing methods for estimating fractional vegetation cover (FVC) from proximal images don’t work well on LARS images.
- Selecting only ‘pure’ pixels to derive the Gaussian distributions reduces the influence of ‘mixed’ pixels on image analysis.
- Half-Gaussian fitting to decompose a Gaussian mixture model provides a more robust and accurate estimate of fractional vegetation cover of crops from LARS images.
- LARS images may require customized image processing and analysis methods.

Background

•Fractional vegetation cover (FVC) plays a key role in land surface processes.

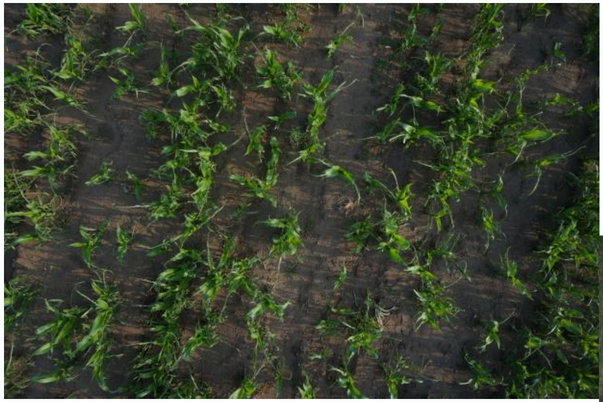
•Low-altitude remote-sensing (LARS) has advantages over both proximal and satellite remote-sensing platforms: flexible timing, inexpensive, large spatial coverage…

•Unmanned aerial vehicles (UAVs) are flown at a wide range of heights, often with the same camera and lens, and acquired images have a wide range of spatial resolution.

•Image analysis methods developed for proximal and satellite remote-sensing imagery are poorly suited to LARS owing to many mixed pixels.

Decreasing spatial resolution →

Proximal



Pixel classification

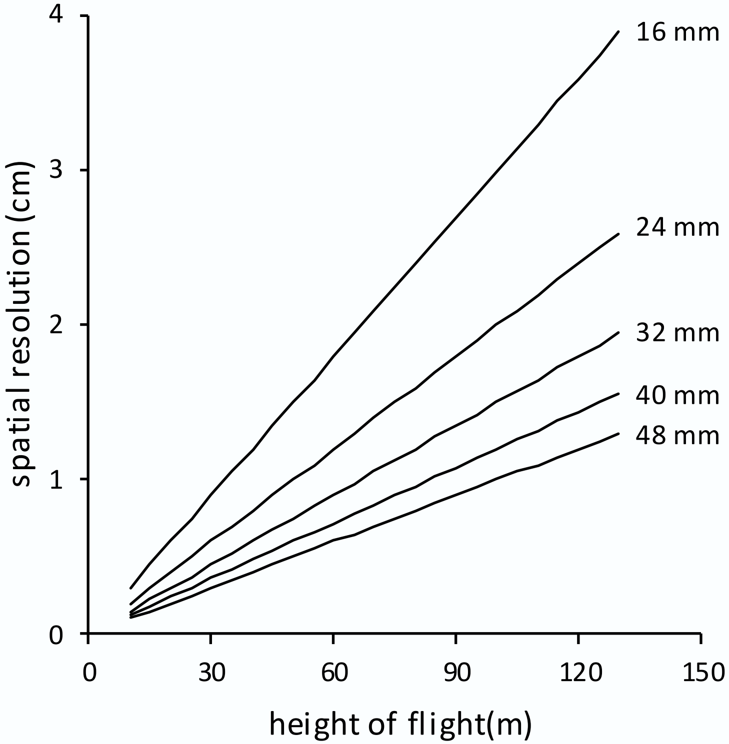
LARS

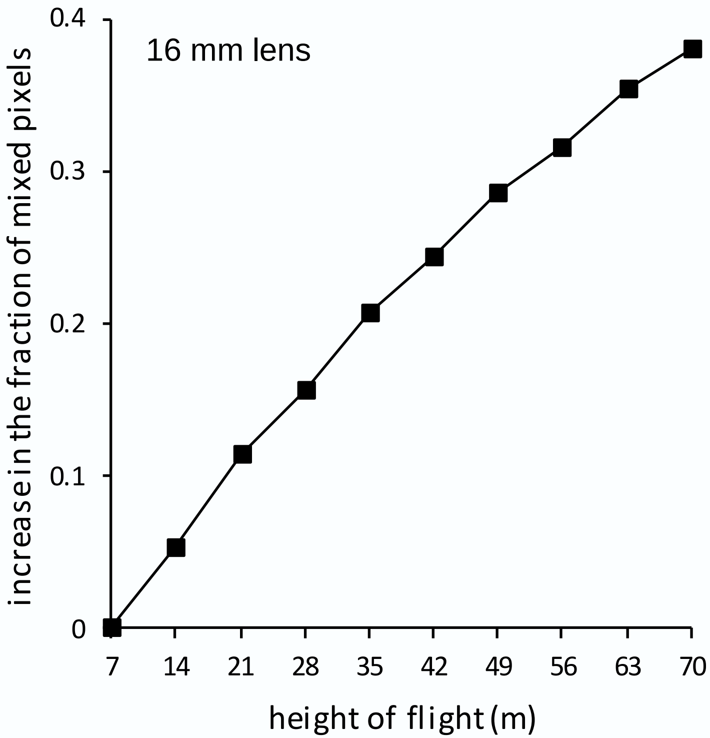
?

Satellite

Vegetation indices

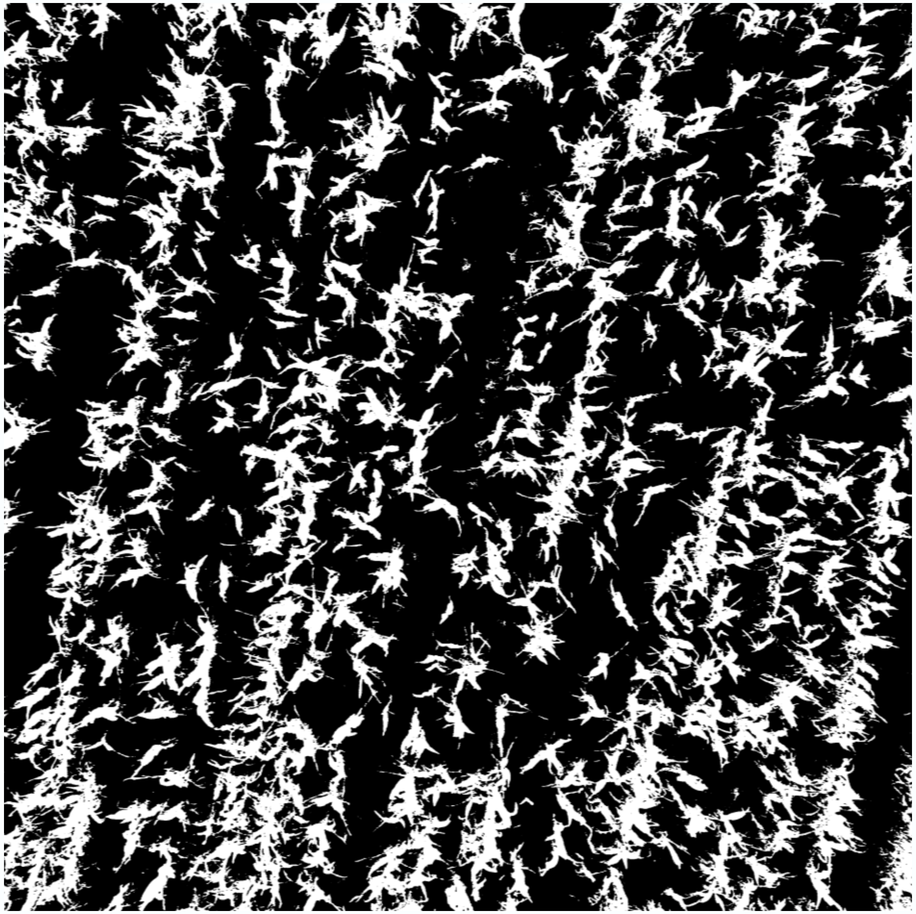
Spatial resolution versus height of flight



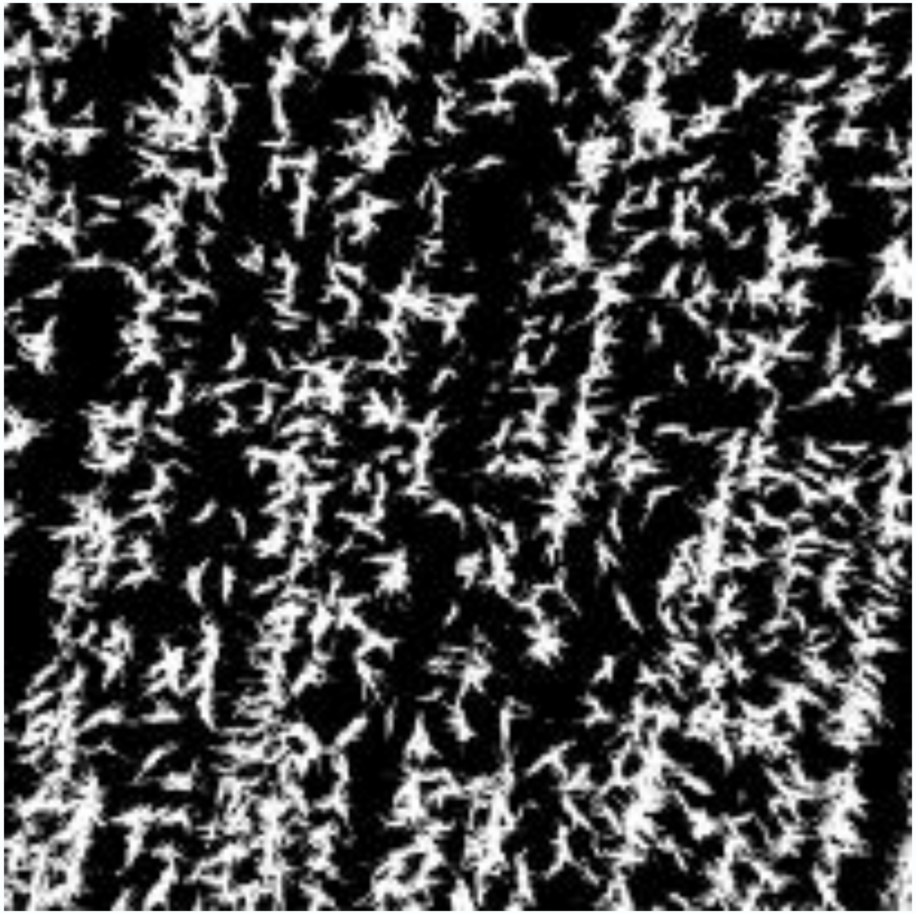


More mixed pixels as height increases

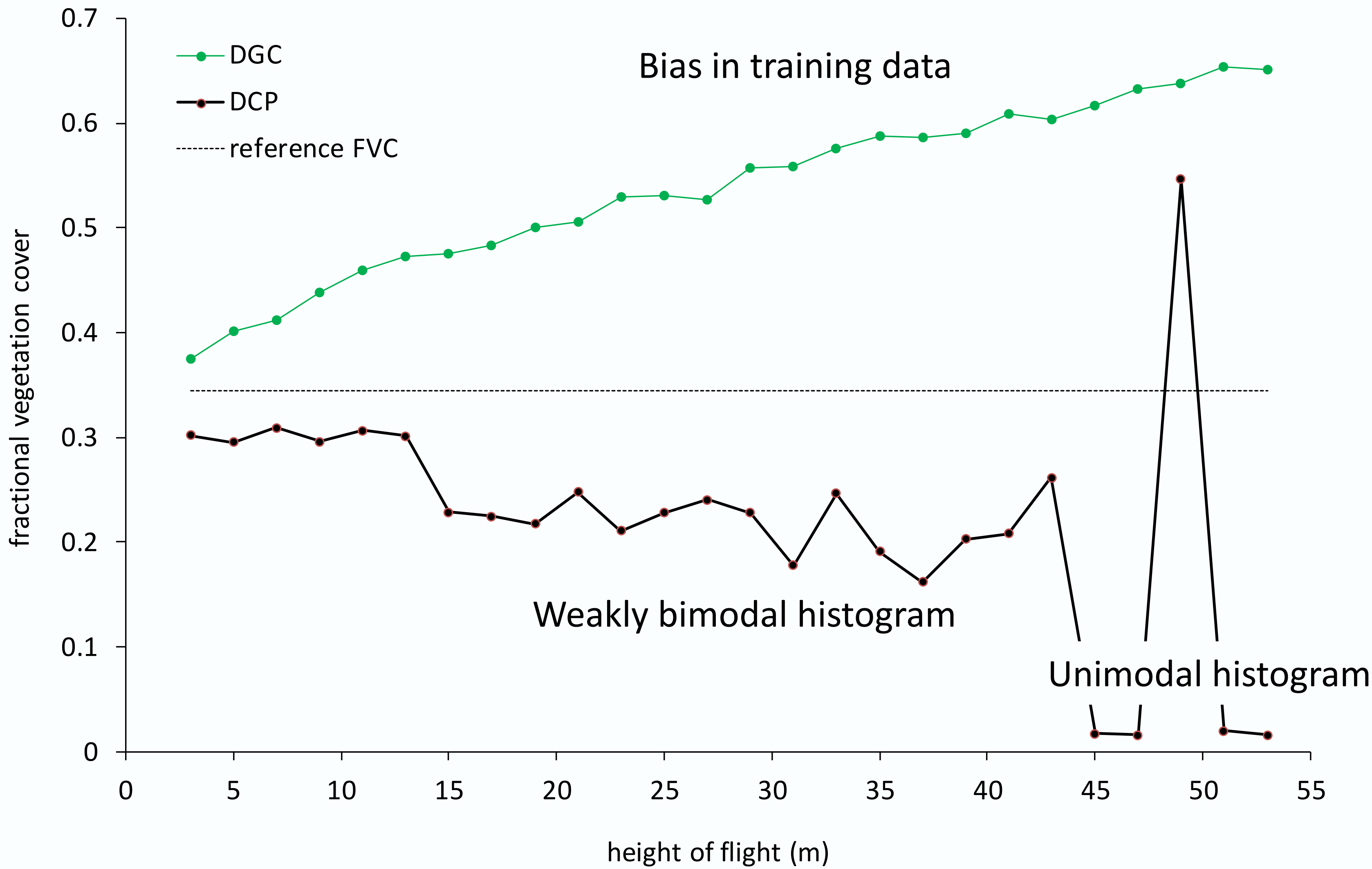
Proximal (7 m)



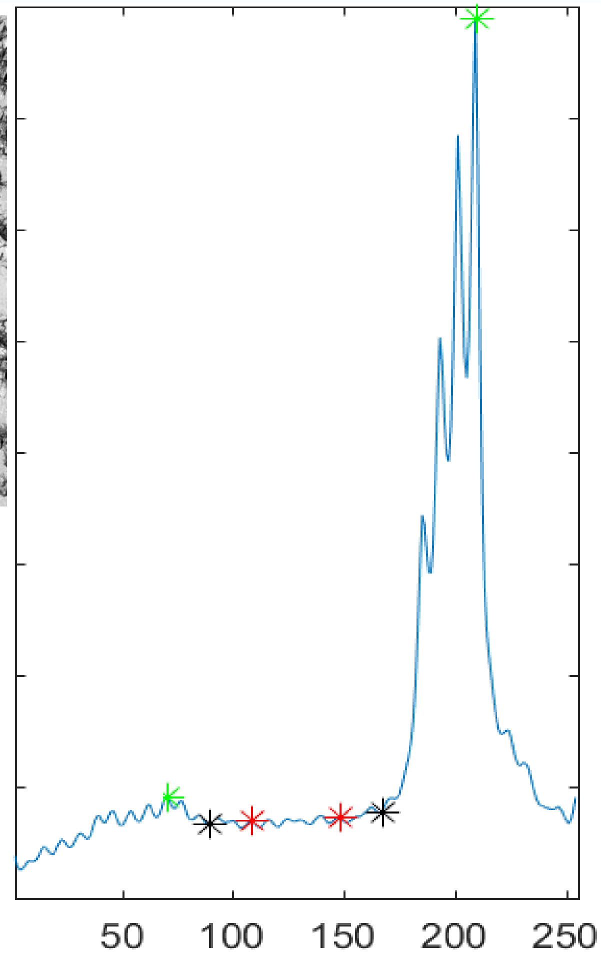
LARS (70 m)

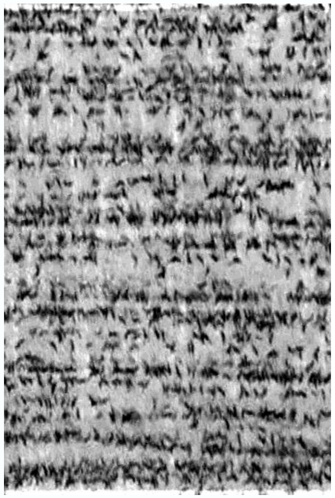


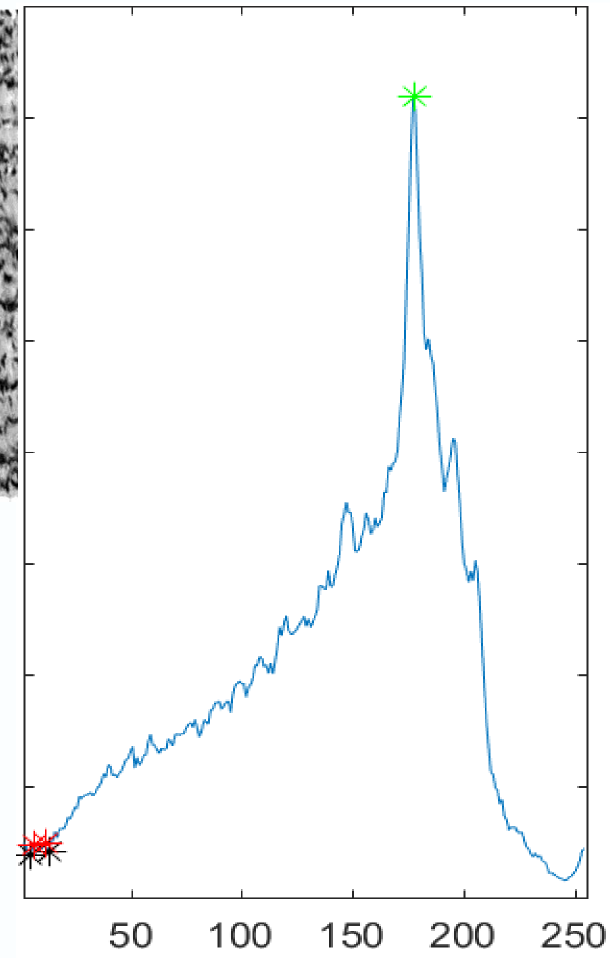
The proximal approach



Histograms with many mixed pixels



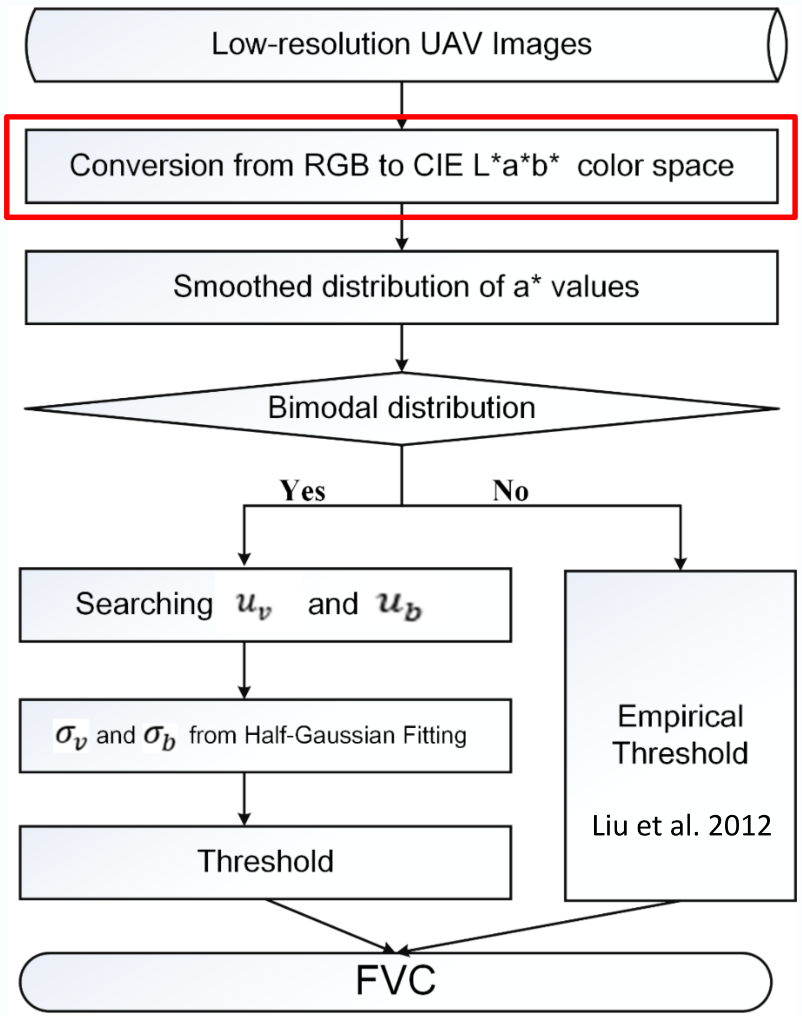


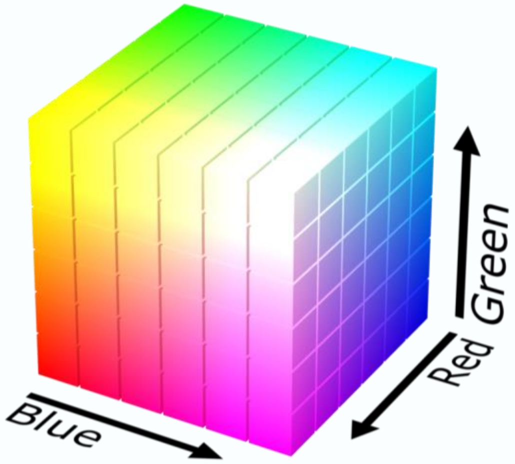


Aim

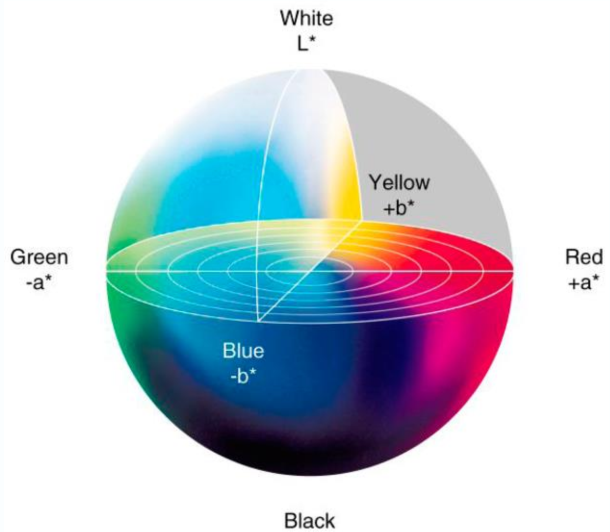
- To compare existing image analysis methods for estimating FVC from RGB images, with a new method that:
    - allows for many mixed pixels and weakly bimodal histograms
    - yields a value of FVC that is independent of height of flight
- Comparison methods:
    - LAB2 (Macfarlane and Ogden 2012)
    - SHAR-LABFVC (Song et al. 2015)
- New method:
    - fits half-Gaussian distributions to pure foreground (vegetation) and background pixels in the CIE L*a*b* color space
    - decomposes a Gaussian mixture model using the full Gaussian distributions

HAGFVC



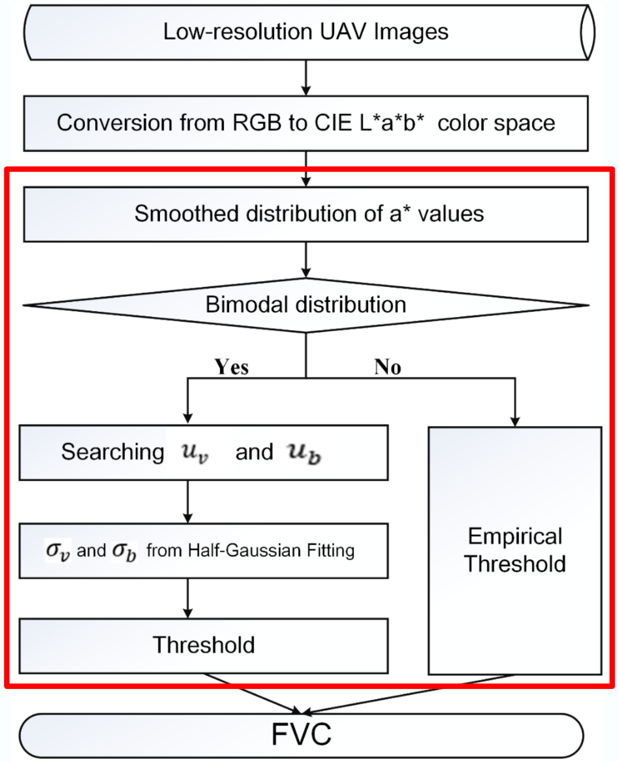


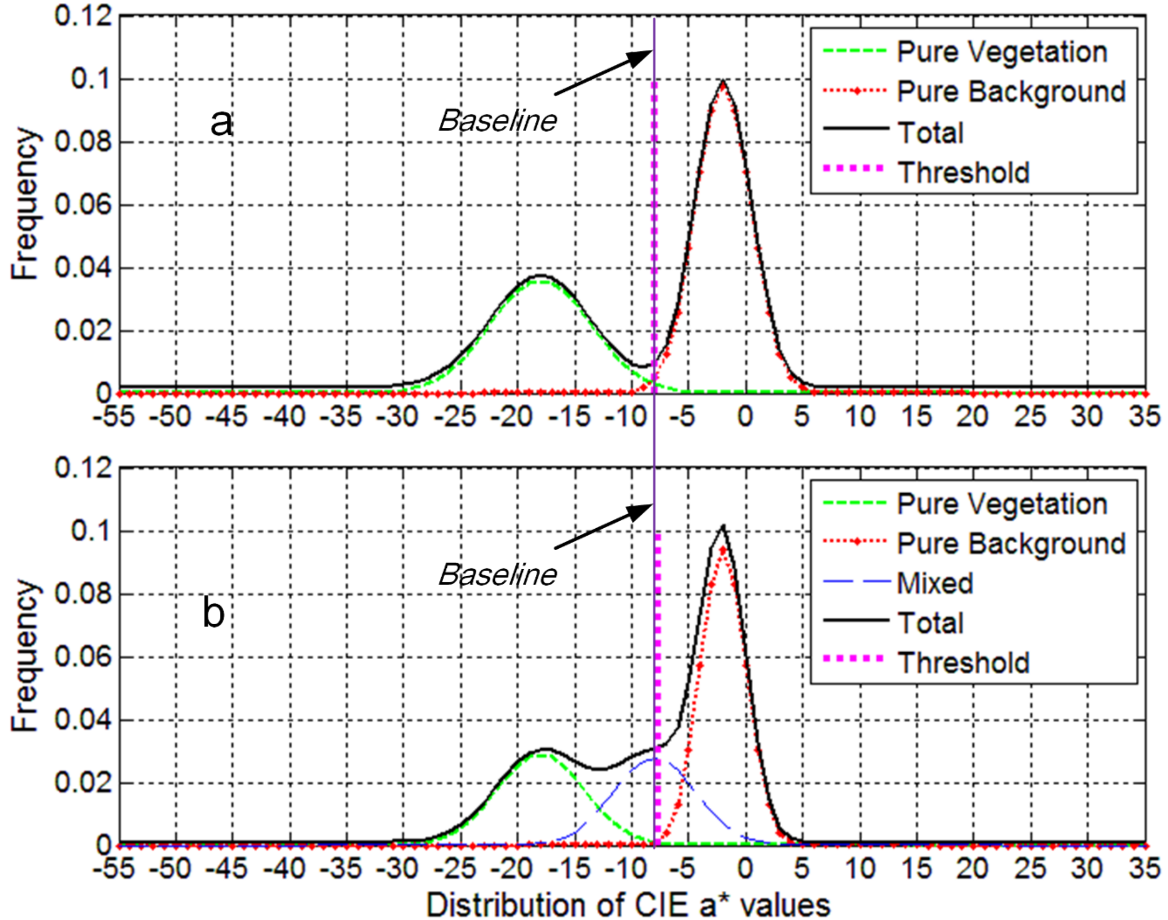
RGB color space. By SharkD - Own work, GFDL, https://commons.wikimedia.org/w/index.php?curid=3375025



CIE L*a*b* color space

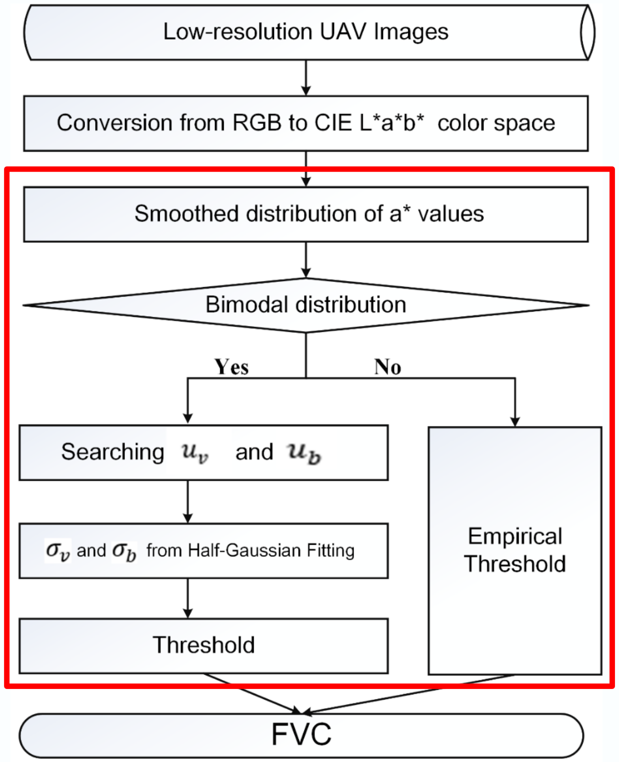
HAGFVC

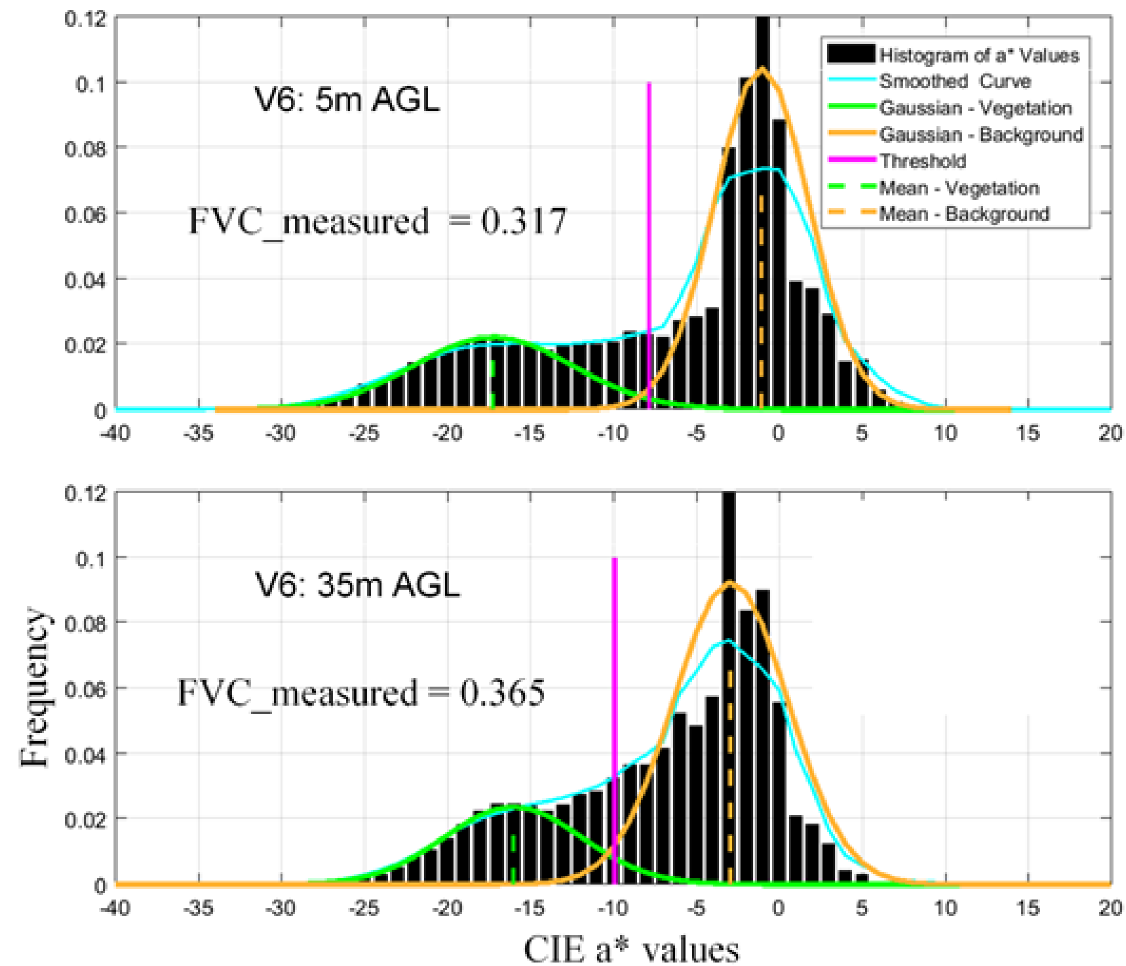




$$w_{iv} \cdot erfc\left(\frac{x-u_{iv}}{\sqrt{2}\cdot\sigma_{iv}}\right) = w_{ib} \cdot erfc\left(\frac{x-u_{ib}}{\sqrt{2}\cdot\sigma_{ib}}\right)$$

HAGFVC

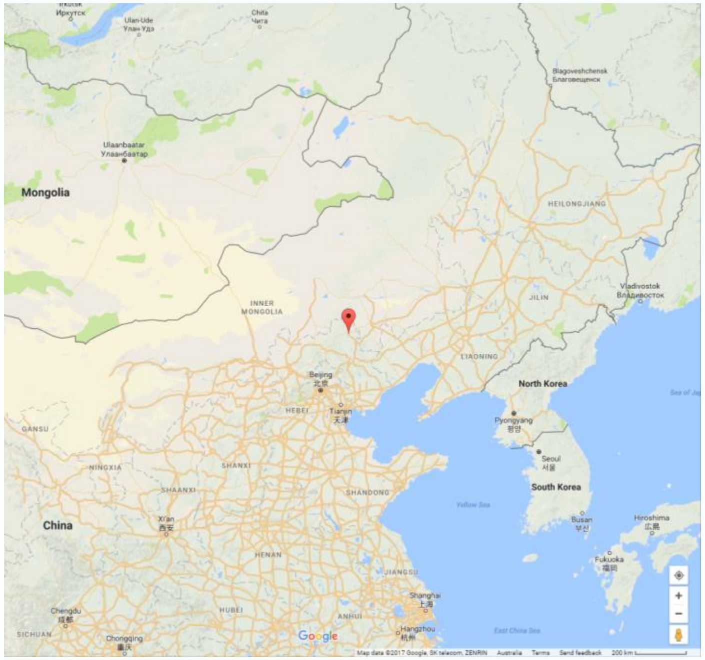


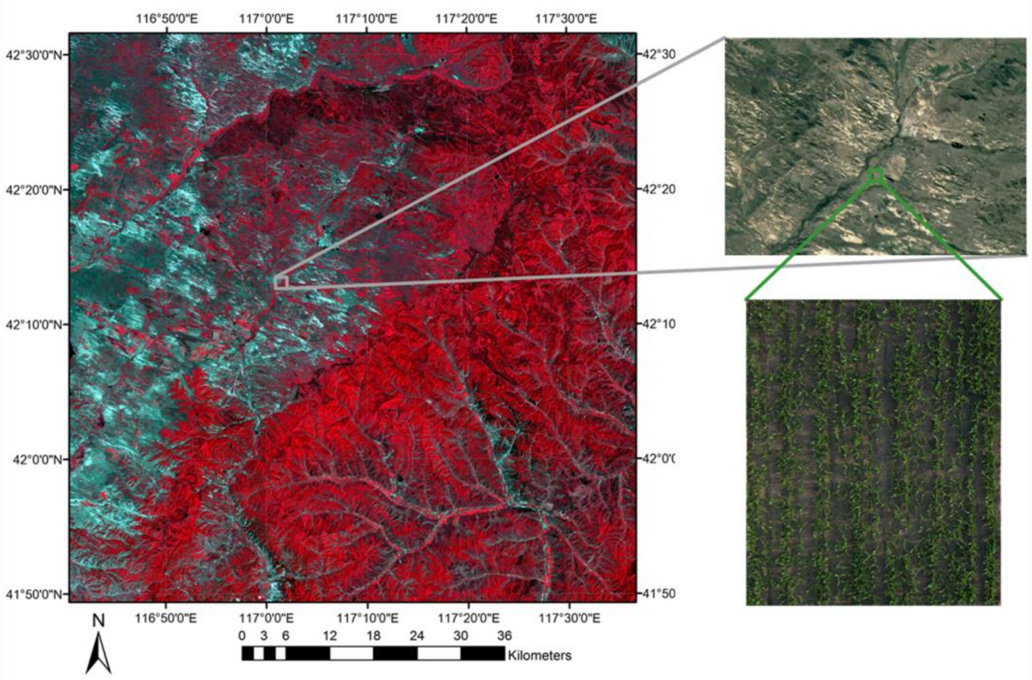


$$w_{iv}\cdot erfc\left(\frac{x-u_{iv}}{\sqrt{2}\cdot\sigma_{iv}}\right)=w_{ib}\cdot erfc\left(\frac{x-u_{ib}}{\sqrt{2}\cdot\sigma_{ib}}\right)$$

Experimental site

- Weichang County, Hebei Province, China.
- 10 m × 8 m plot located in a cornfield (bottom-right frame).
- Images captured at three stages of growth in 2015, with FVC 0.2-0.8.



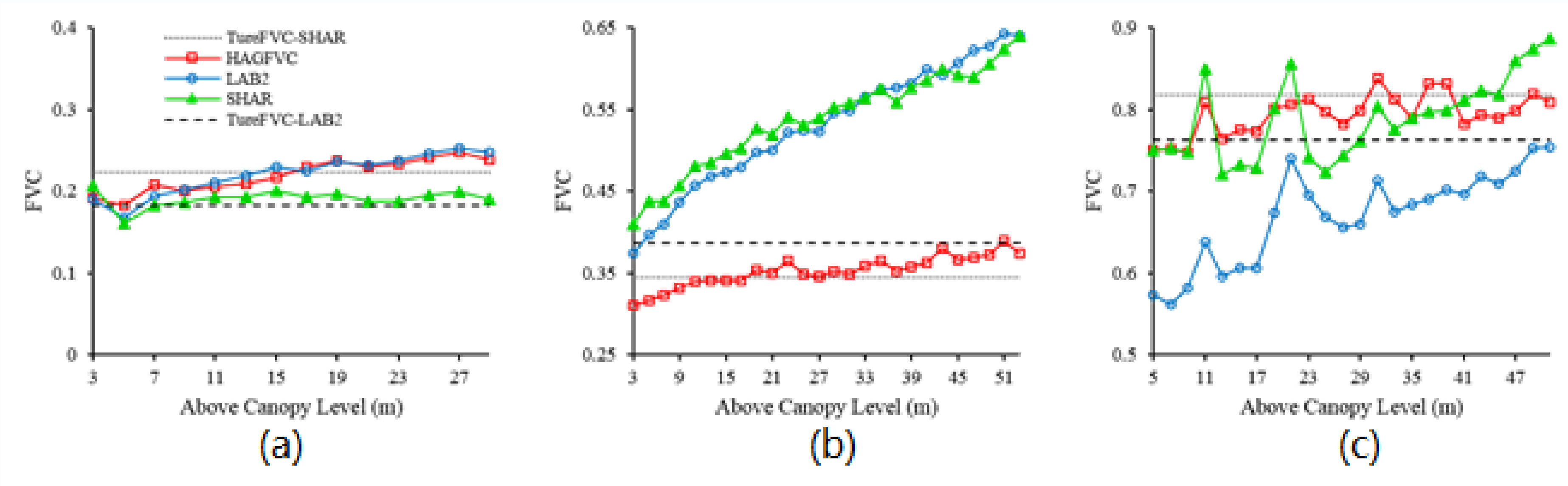


Materials and methods

- Model X-601 hexacopter (Chaoyi Corporation, Beijing, China)
- Sony Nex-5R 16MP mirrorless digital camera, focal length 16mm.
- Various heights of flight.

Date	Time	Growth Stage	Mean Leaf Width (cm)	Number of Images	Flight Height (m)	Reference FVC	Illumination
28/06	11:30 am	V4	2.7	14	3 - 29 (step=2 m)	0.223	diffuse light (cloudy day)
11/07	06:30 pm	V6	4.1	26	3 – 53 (step=2 m)	0.345	direct light (large sun zenith)
31/07	05:45 pm	V8	8.8	24	7- 53 (step=2 m)	0.817	diffuse light (cloudy day)

Method comparison



FVC comparison among the three methods in three vegetative growth stages, i.e., (a) V4, (b) V6 and (c) V8. Vn indicates n leaves with collars visible. The TrueValue-SHAR and TrueValue-LAB2 respectively represent the FVC derived by using the SHAR-LABFVC and LAB2 methods in field measurements

Caveats

- Method only formally tested in one crop with strong contrast between foreground and background. Application to non-agricultural landscapes is uncertain.
- Note that method doesn’t ‘correctly classify’ all pixels because mixed pixels have no correct classification.

Conclusions

- Increasing height of flight reduces spatial resolution and increases the fraction of mixed pixels in LARS images.
- Selecting only ‘pure’ pixels to derive the Gaussian distributions reduces the influence of ‘mixed’ pixels on image analysis.
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- LARS images may require customized image processing and analysis methods.
- Adjusting camera focal length as flight height is increased may increase robustness of FVC estimates.

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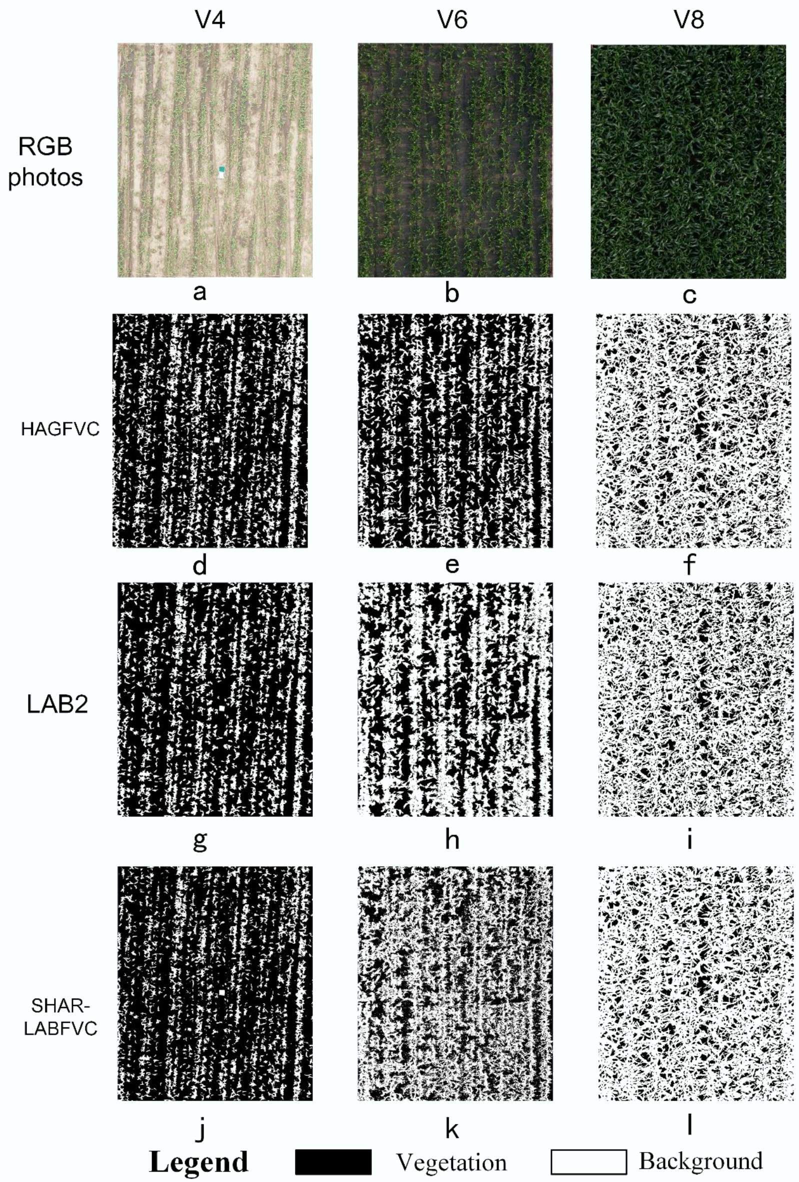
Don’t fly too close to the sun.

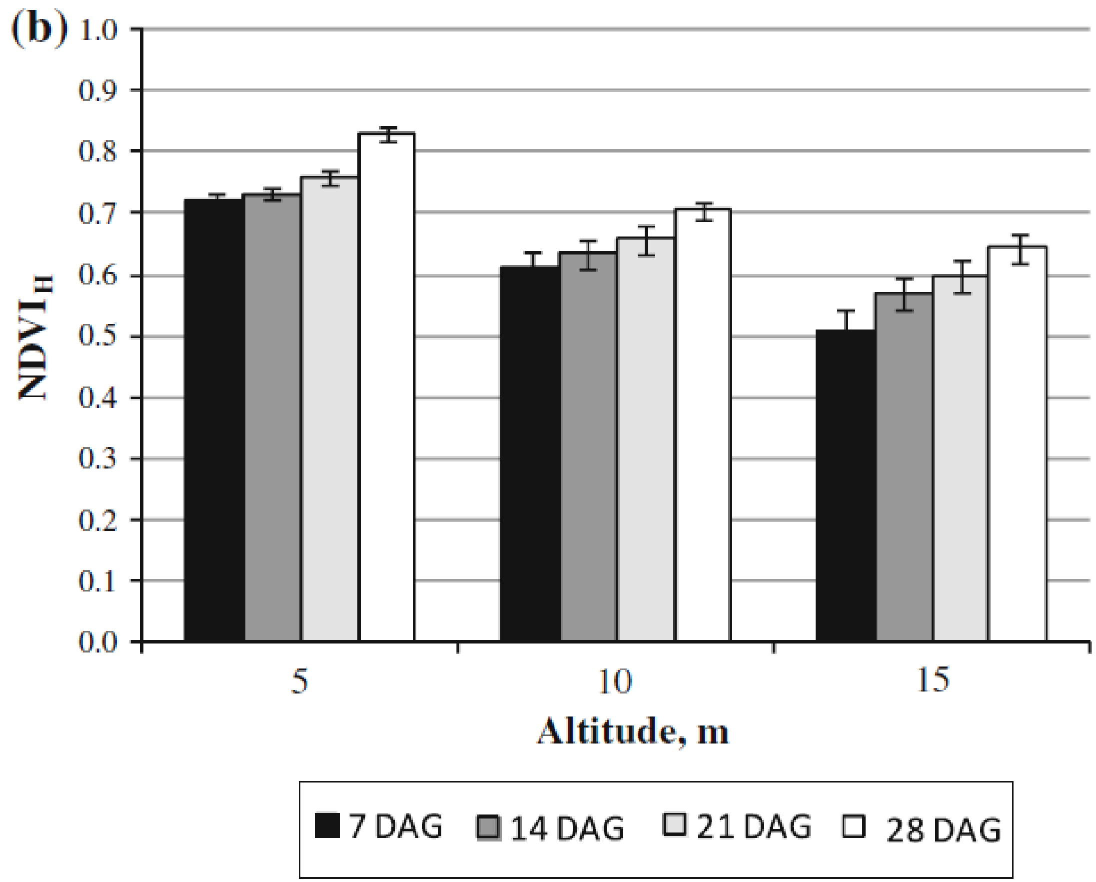
X-601 Specifications

Flight mode: artificial remote control, autonomous hover, autonomous route;
No load off weight: 3.5Kg;
Maximum takeoff weight: 7.5Kg;
Maximum mission load: 4Kg;
Maximum life time: 40 minutes;
Cruising speed: 3 ~ 50Km / h;
Flight height: ≤1000 m (relative height);
Maximum ceiling: 5,000 meters
Effective control radius: 2Km (expandable to 5Km);
Navigation: GPS navigation / Beidou navigation / GPS and Beidou integrated navigation
Horizontal navigation error: ≤2.5 m;
Normal landing wind speed: ≤ 6;
Can set the maximum flight radius and the maximum flight height, beyond the border automatically enter the default mode;
After the data link is interrupted, it will automatically return or continue the route task (can be set);


V4
V6
V8
RGB photos
a
b
c
HAGFVC
d
e
f
LAB2
g
h
i
SHAR-LABFVC
j
k
l
Legend
Vegetation
Background

The remote-sensing approach

Fig. 9 Variation of reflectance indices with altitude: **b** helicopter-mounted



Samseemoung et al. (2012) Application of low altitude remote sensing (LARS) platform for monitoring crop growth and weed infestation in a soybean plantation. Precision Agriculture. 13:611-27.