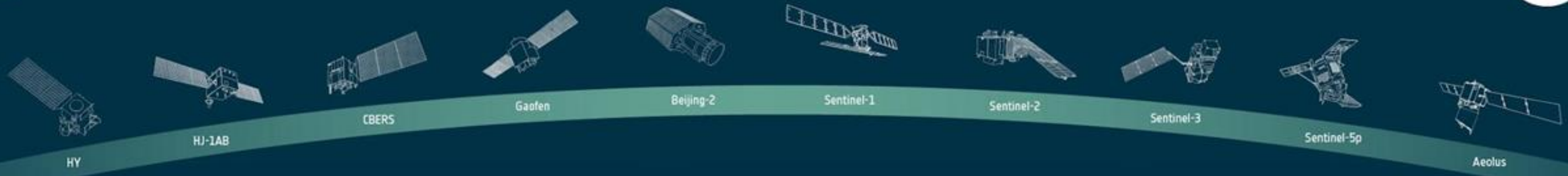


2022 DRAGON 5 SYMPOSIUM

MID-TERM RESULTS REPORTING

17-21 OCTOBER 2022

[PROJECT ID. 58817]

[UAVS 4 HIGH-RES. OPTICAL SATS.]

THURSDAY 20/10/2022
ID. 58817

PROJECT TITLE: EXPLOITING UAVS FOR VALIDATING DECAMETRIC EARTH OBSERVATION DATA FROM SENTINEL-2 AND GAOFEN-6(UVA4VAL)

PRINCIPAL INVESTIGATORS: PROF YONGJUN ZHANG AND PROF JADU DASH

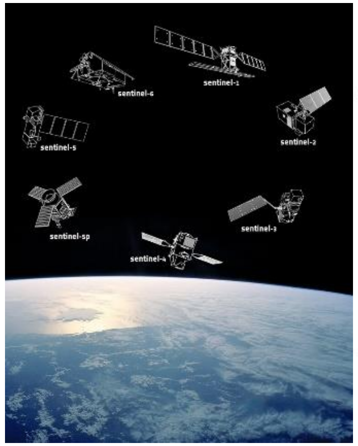
CO-AUTHORS:

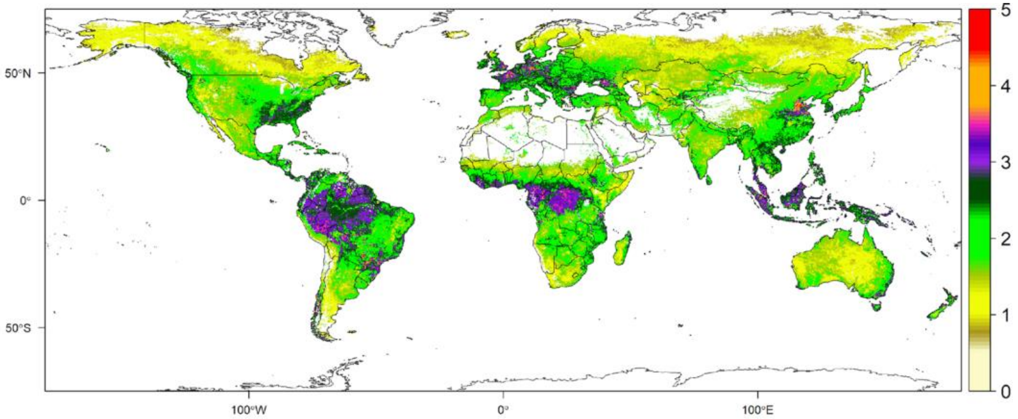
PRESENTED BY: PROF JADU DASH

UNIVERSITY OF Southampton

Project background

- Vegetation biophysical variables such as Leaf Area Index (LAI), Canopy Chlorophyll content (CCC), Fraction of absorbed Photosynthetic Radiation (fAPAR) are important plant and ecosystem status indicators.
- Advances in sensing and retrieval techniques -> suitability in operational use
- Validation is crucial to ensure fit-for-purpose
- Field campaigns are logistically challenging and resource intensive
- Automated measurement the way forward



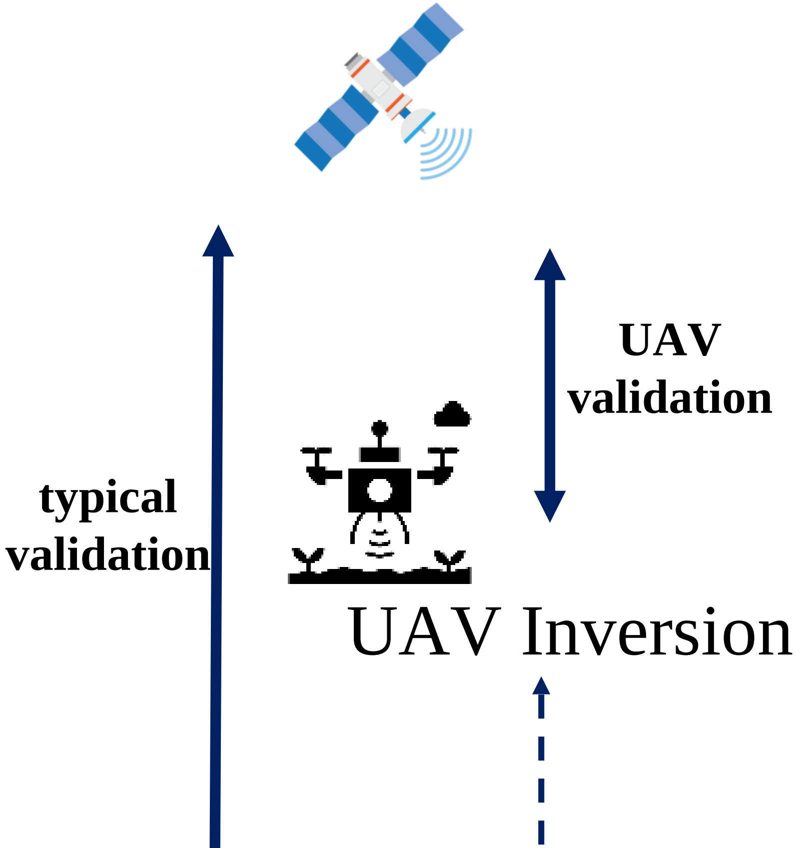


Project objective: UAV4VAL

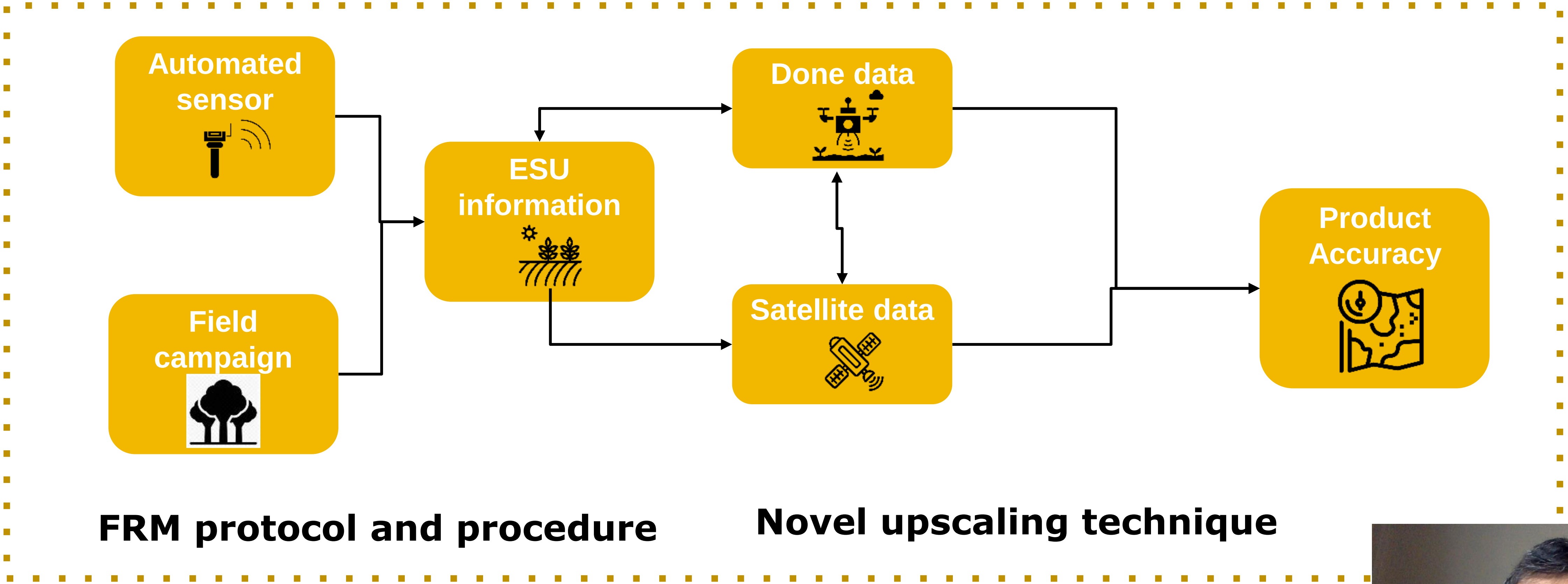
- Evaluate the capability of UAVs as a source of reference data for validating decametric surface reflectance and vegetation products, (specific focus on Sentinel-2 and GF-6)

- Transfer knowledge gained from existing ESA-funded projects on fiducial reference measurements (FRM), which focus on traceability and uncertainty evaluation in earth observation validation efforts

- Achieved through collection, processing, and analysis of ground measurements over European and Chinese sites, coinciding with UAV acquisitions



Project objective: UAV4VAL



NRSCC

Project team

esa

Dr Jadu Dash

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Dr Yan Gong

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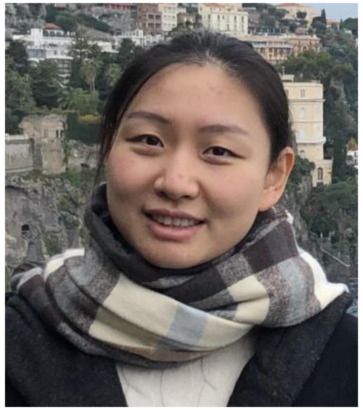
Niall Origo

Rosalinda Morrone



Xuerui Guo

Luke Brown

UNIVERSITY OF Southampton

WUHAN UNIVERSIT

NPL

National Physical Laborato

Timeline

Protocols, procedures, training and calibration

Field Campaign in UK and China

Campaign data processing and delivery

Dissemination and outreach

ECR exchange and training

Year 1 | Year 2 | Year 3 | Year 4

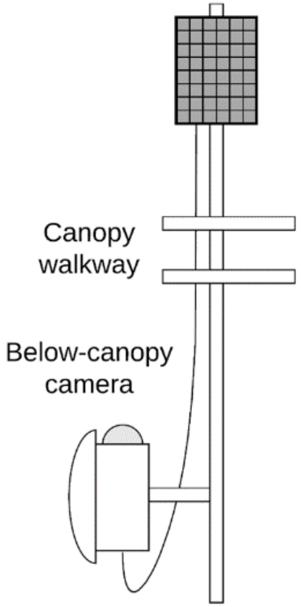
In-situ data measurements–second round

Overview: 2^{nd} Round of fieldwork

Campaign	Period	Parameters and equipment	Contribution
Taizi Mountain, China (112°48′E-113°03′E, 30°48′N-31°02′N)	02-06-2021	LAI-2200C for LAI collection ASD spectrometer for Spectral data collection DJI Phantom 4 for UAV images collection	Wuhan university
Wytham Woods, UK (51.769265N, 1.329185W)	19-07-2021	SPAD for LCC collection Digital hemispherical photography(DHP)	University of Southampton, National Physical Laboratory (NPL)

Wytham Woods, Oxford, UK (1)

- Deciduous broadleaf forest
  - (Oak, Ash, Beech, Hazel, Sycamore)
- Managed research forest with ~75 years of ecological monitoring
- Canopy walkway, Flux tower
- > 200 RS papers at site



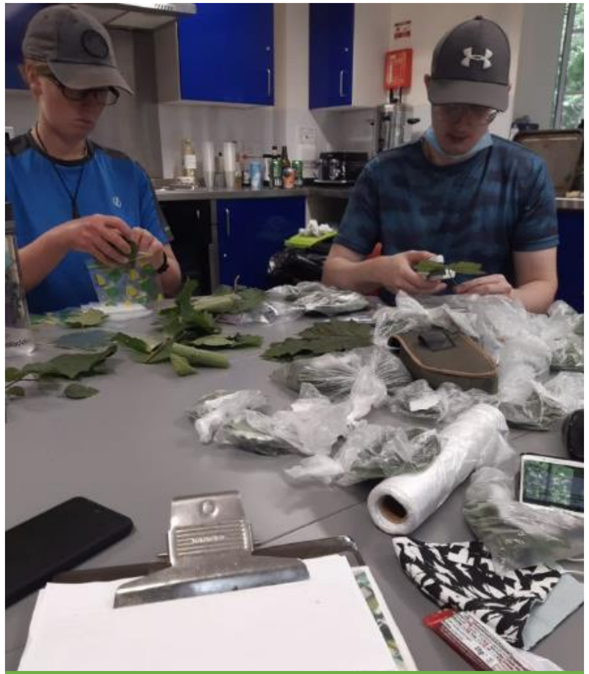
In-situ data measurements and requirements

Wytham Woods, Oxford, UK

- leaf sampling and chlorophyll measure
- DHP measure
- CCC = LCC x LAI

Licor LAI-2200

Digital hemispherical photography



SPAD Chlorophyll meter

Field sites

Taizi Mountain Hubei Province, China

- Deciduous broadleaf forest
  - (Oak and Maple)
- Designated a national park
- Validation of SPOT 6 and GF2 at site
- > 35 remote sensing papers at site

DJI Phantom 4

LAI-2200C

ASD spectrometer

In-situ data measurements and requirements

Taizi Mountain Hubei Province, China

- Surface reflectance and drone images
  - Ground Hyperspectral measurements (350 – 2500 nm)
  - DJI Phantom 4 for drone image collection
  - In-suit data collection

ASD Fieldspec 4

Spectralon panel

DJI Phantom 4

Method: Overview

Taizi Mountain Hubei Province, China

Step 1

Acquisition and processing of UAV imagery and in-suit biophysical measurements.

Step 2

LAI Inversion from UAV imagery through Vegetation Indices (VIs) regression model.

Sentinel-2 retrieved LAI product from ESA SNAP software.

Step 3

VIs sensitivity test on a Radiative Transfer Model (RTM)-simulated dataset.

Step 4

Sentinel-2 LAI product validated by the UAV based LAI product.

Method: LAI inversion from UAV imagery

Parametric regression through Vegetation indices(VIs)

Formulas of the four VIs and the evaluation metrics for LAI-VI relationship modelling.

$$NDVI = \frac{\rho_{NIR} - \rho_{Red}}{\rho_{NIR} + \rho_{Red}}$$

$$SAVI = \frac{\rho_{NIR} - \rho_{Red}}{\rho_{NIR} + \rho_{Red} + 0.5} \times 1.5$$

$$ARVI = \frac{\rho_{NIR} - (2\rho_{Red} - \rho_{Blue})}{\rho_{NIR} + (2\rho_{Red} - \rho_{Blue})}$$

$$EVI = \frac{\rho_{NIR} - \rho_{Red}}{\rho_{NIR} + 6\rho_{Red} - 7.5\rho_{Blue} + 1} \times 2.5$$

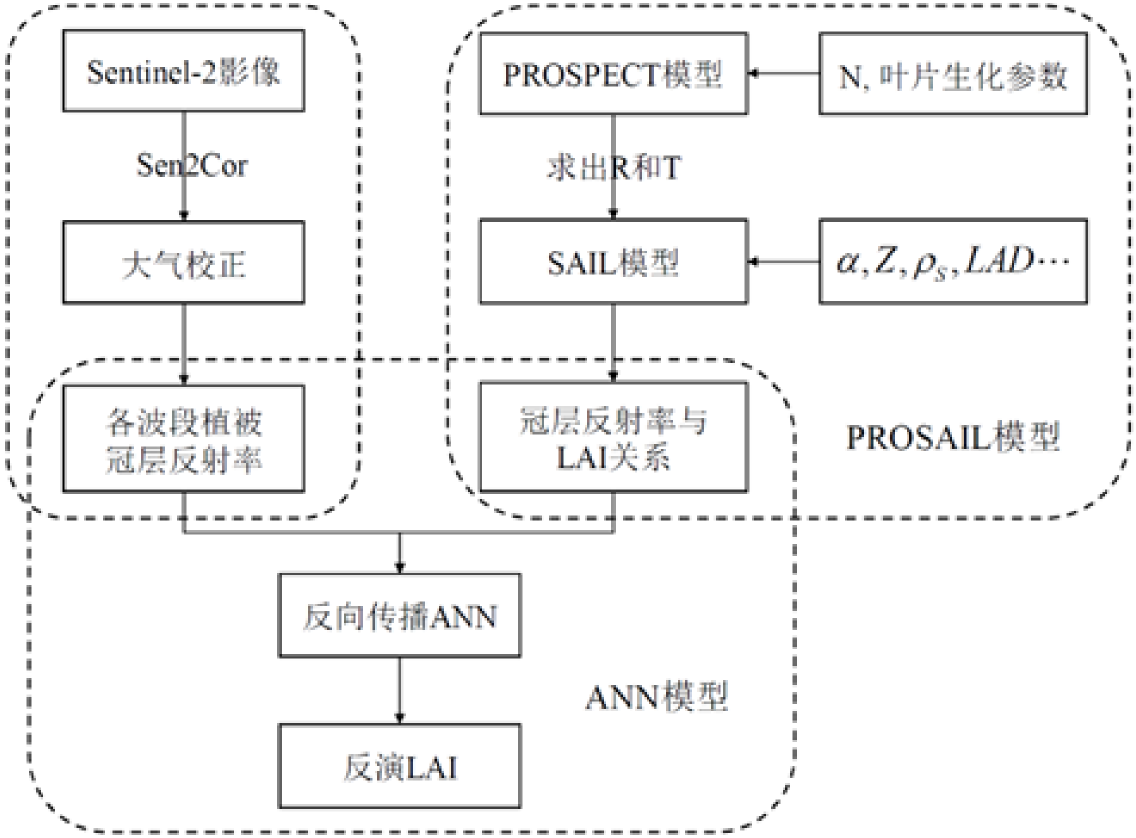
$$R^2 = 1 - \frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{\sum_{i=1}^{n}(\hat{y}_i - \bar{y})^2}$$

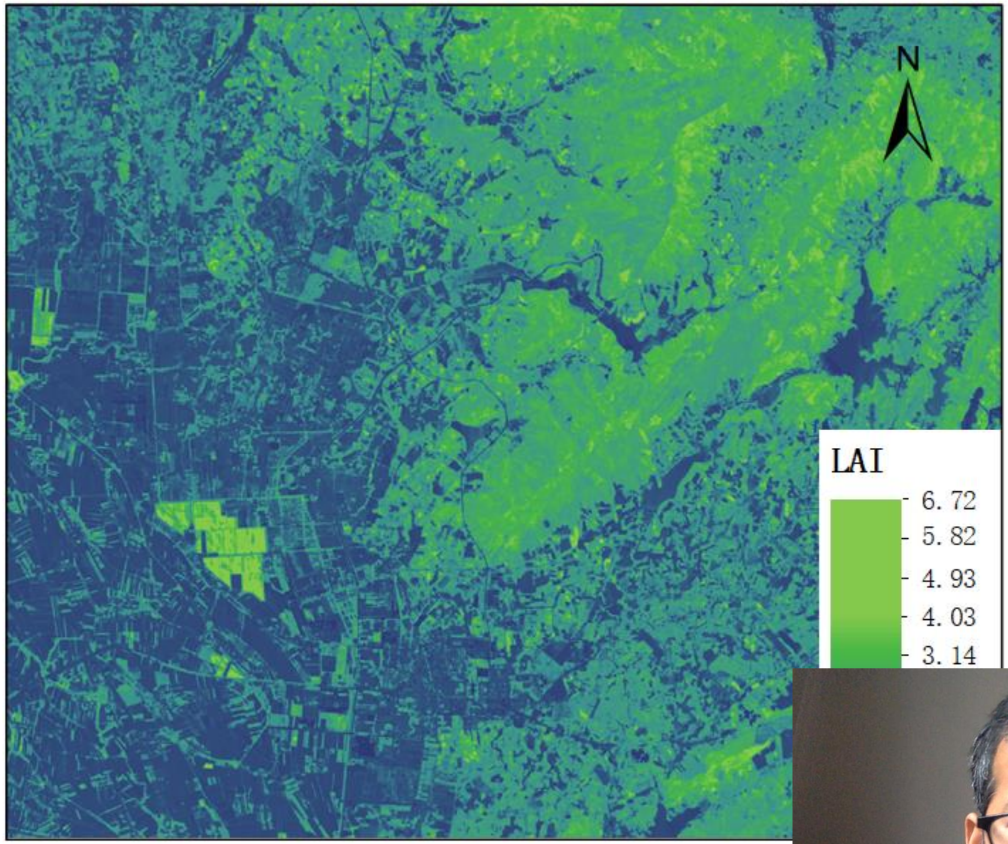
$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{n - p}}$$

$$MAE = \sum_{i=1}^{n}\left|\frac{y_i - \hat{y}_i}{n}\right|$$

$$ME = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{y_i - \hat{y}_i}{y_i}\right) \times 100$$

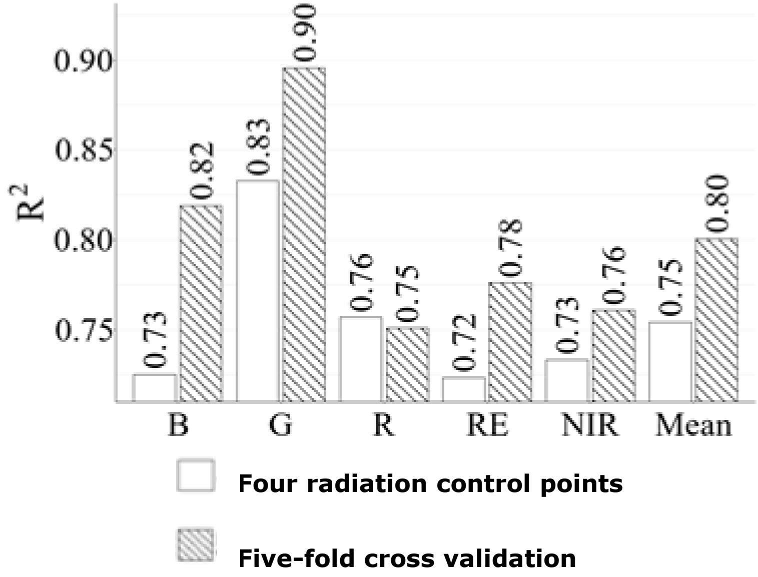
Method: LAI inversion from Sentinel-2 imagery

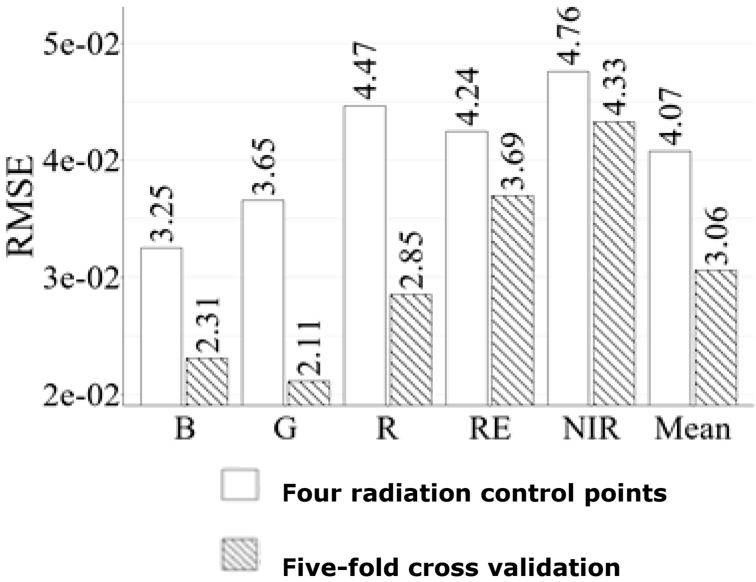


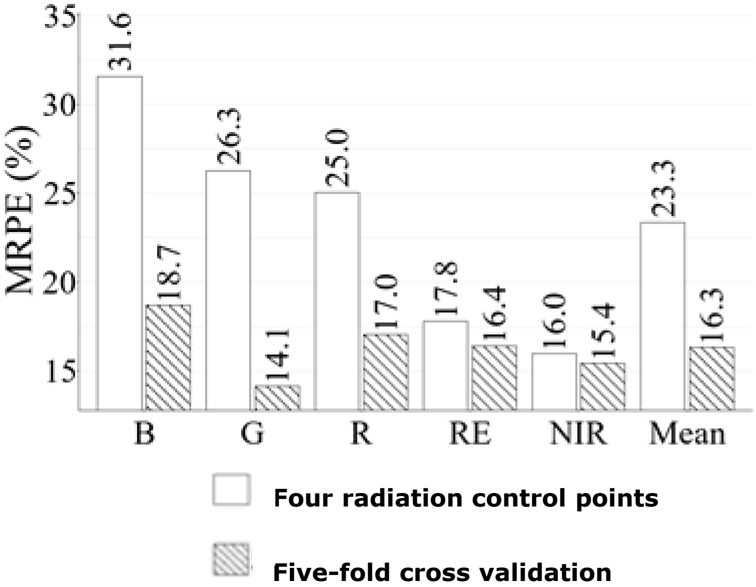


Results: UAV Radiometric calibration

UAV images Radiometric calibration







Adding certain number of the radiation control points can effectively control the acc

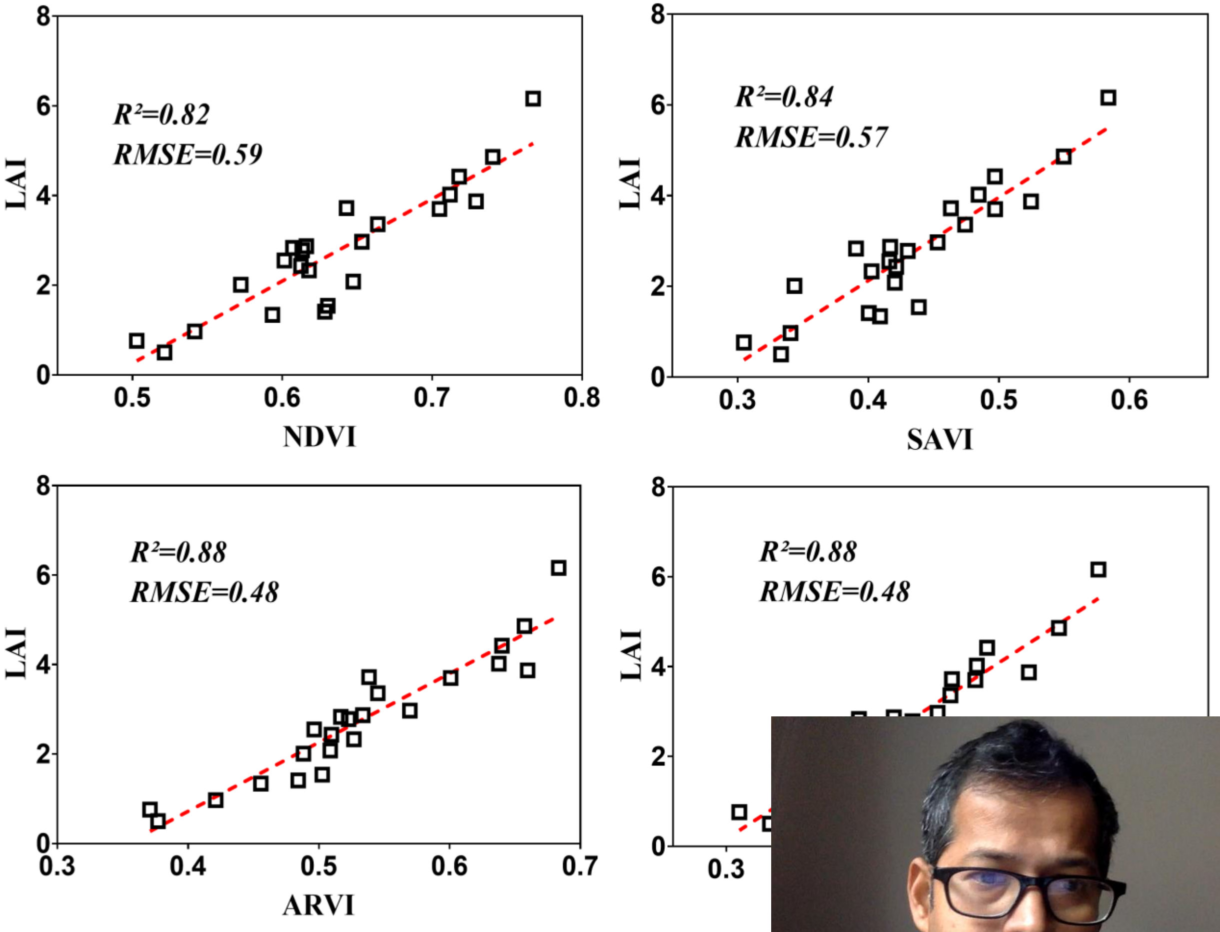
and propagation of errors and improve the accuracy of radiation correction.

Result: UVA-LAI inversion from VIs regression

UAV-LAI inversion model

- **All R^2 >0.8**
- **The correlation between LAI and VI is good**
- **ARVI and EVI perform well**

VI	Model Evaluation Metrics	
	R^2	RMSE
NDVI	0.8242	0.5985
SAVI	0.8401	0.5706
ARVI	0.8869	0.4801
EVI	0.8798	0.4947

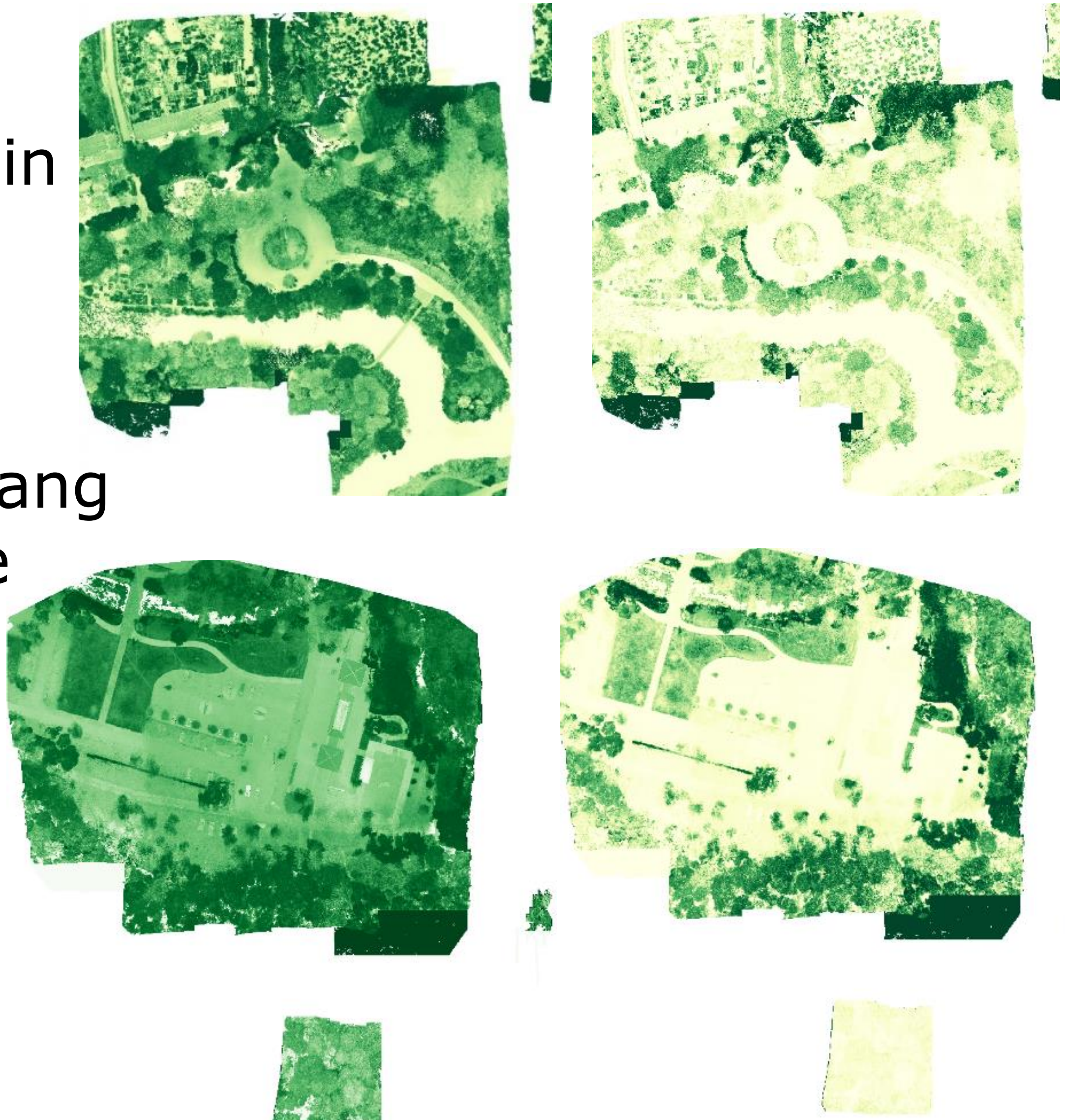


Result: UVA-LAI inversion from VIs regression

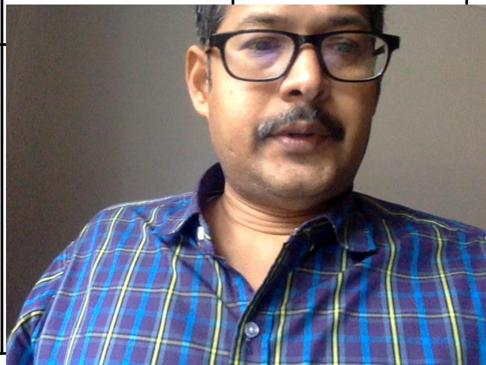
ARVI NDVI

Taizi Mountain

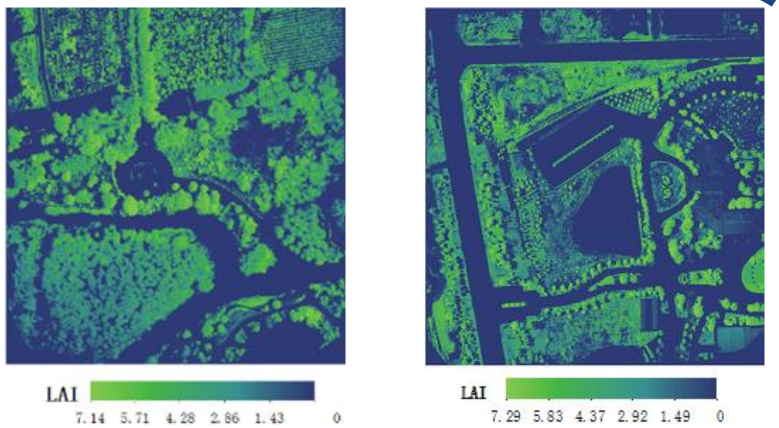
Wangmang Cave



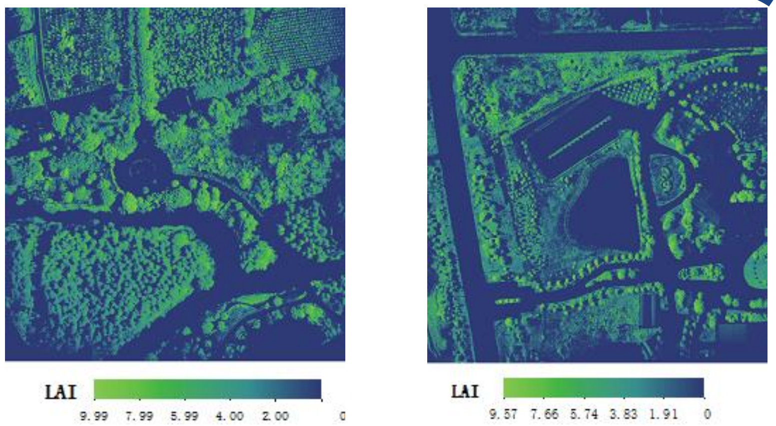
Validation method	Evaluation index		
	MAE	ME	RMSE
Based on Ground LAI	1.613	-2.032	2.167
Based on UAV LAI products inverted by ARVI	1.228	-1.677	1.566
Based on UAV LAI products inverted by NDVI	1.238		



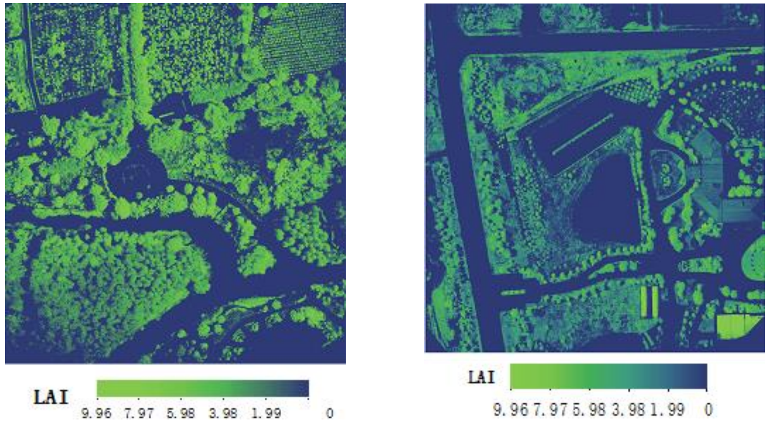
UAV LAI products



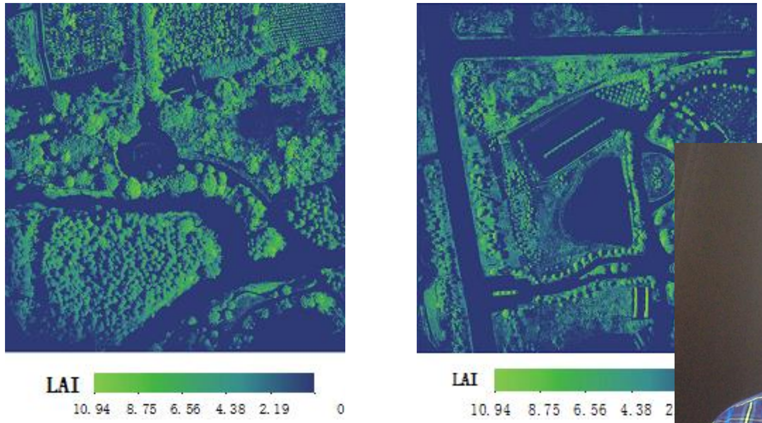
NDVI-LAI



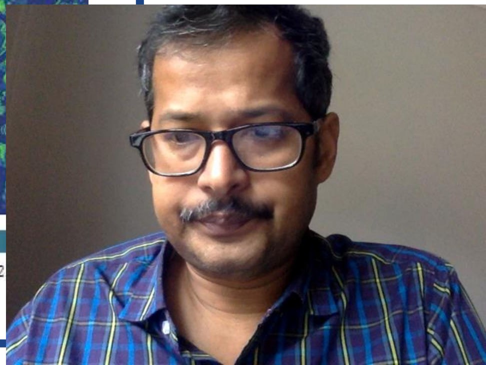
SAVI-LAI



ARVI-LAI

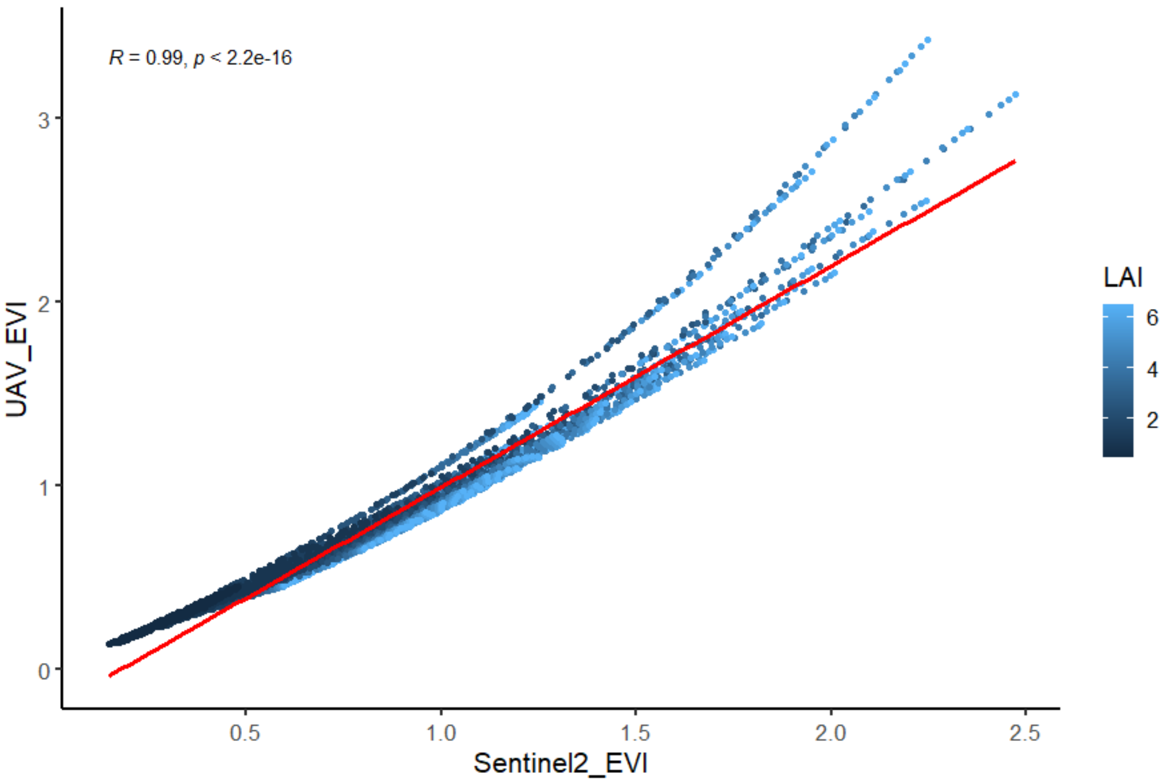


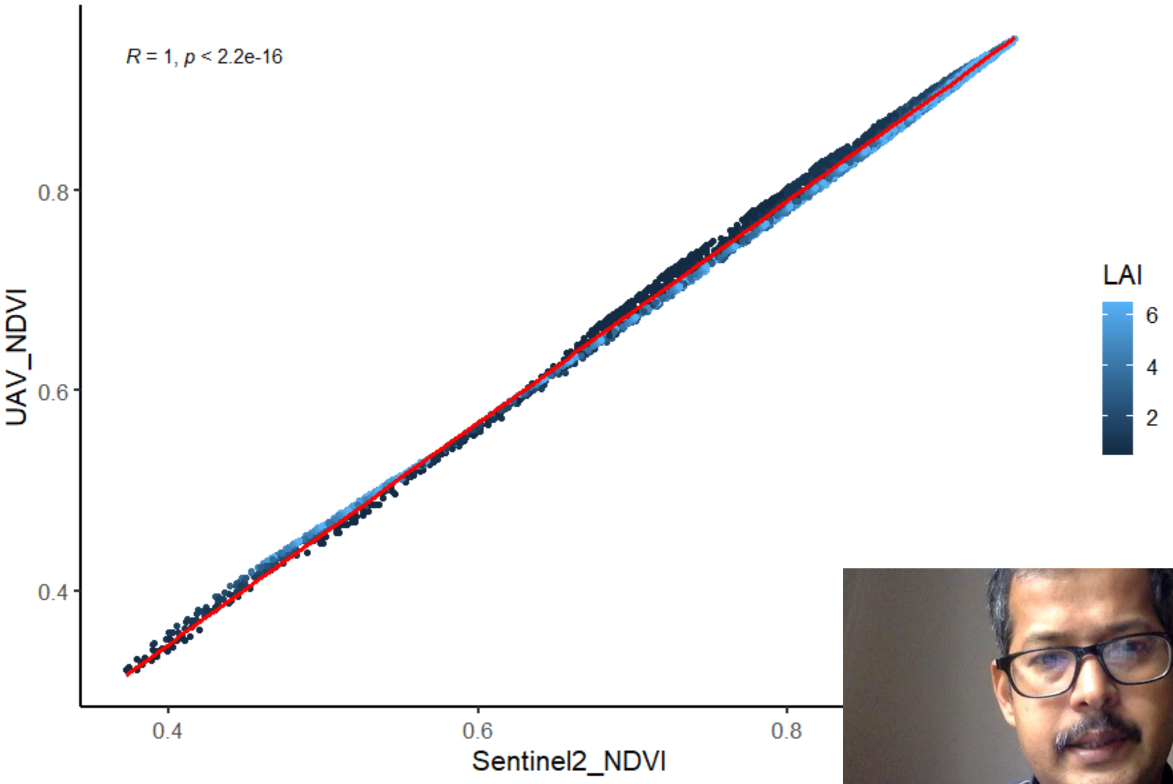
EVI-LAI



Result: VI sensitivity test

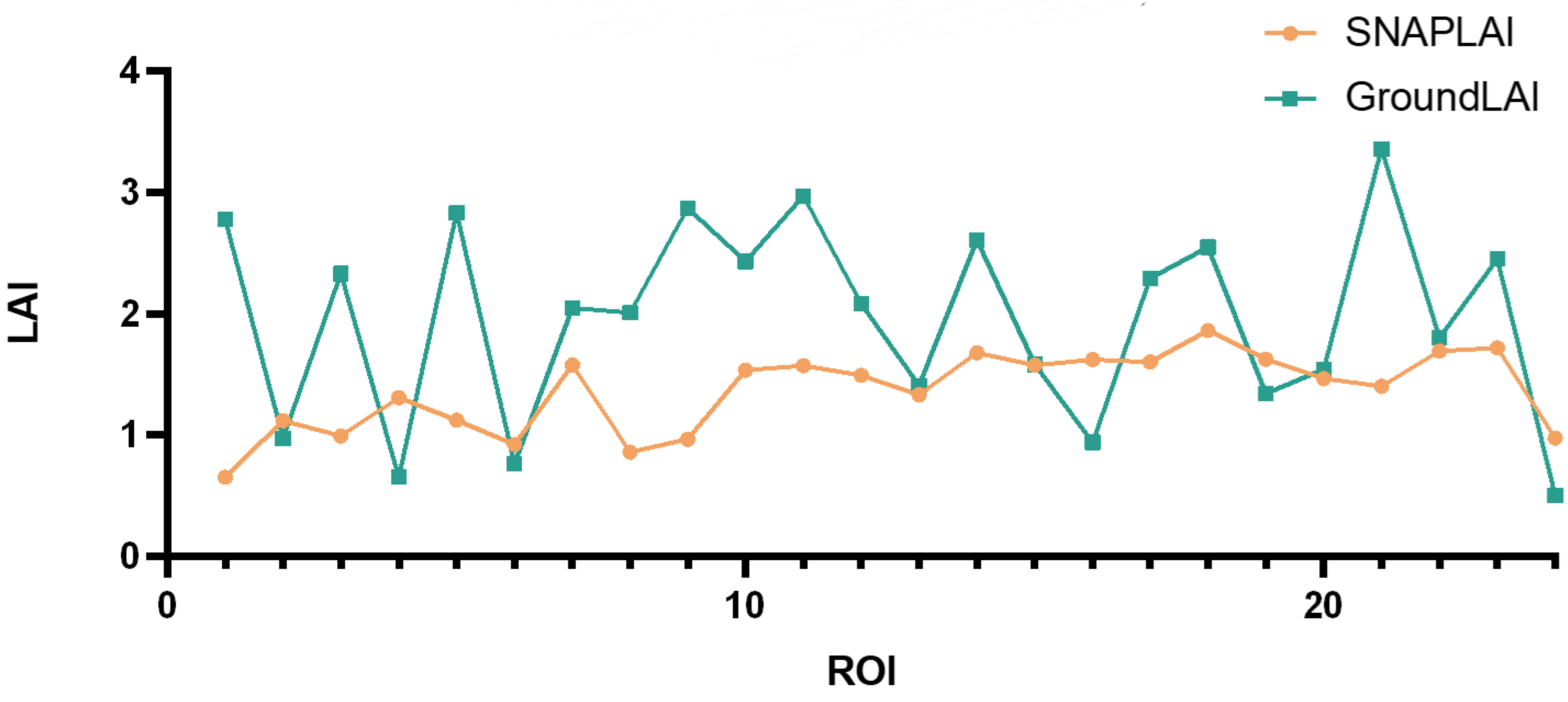
- **VI-LAI relationships are stable for both UAV and Sentinel-2 sensors**
- **The large EVI bias was found for high dense vegetation**



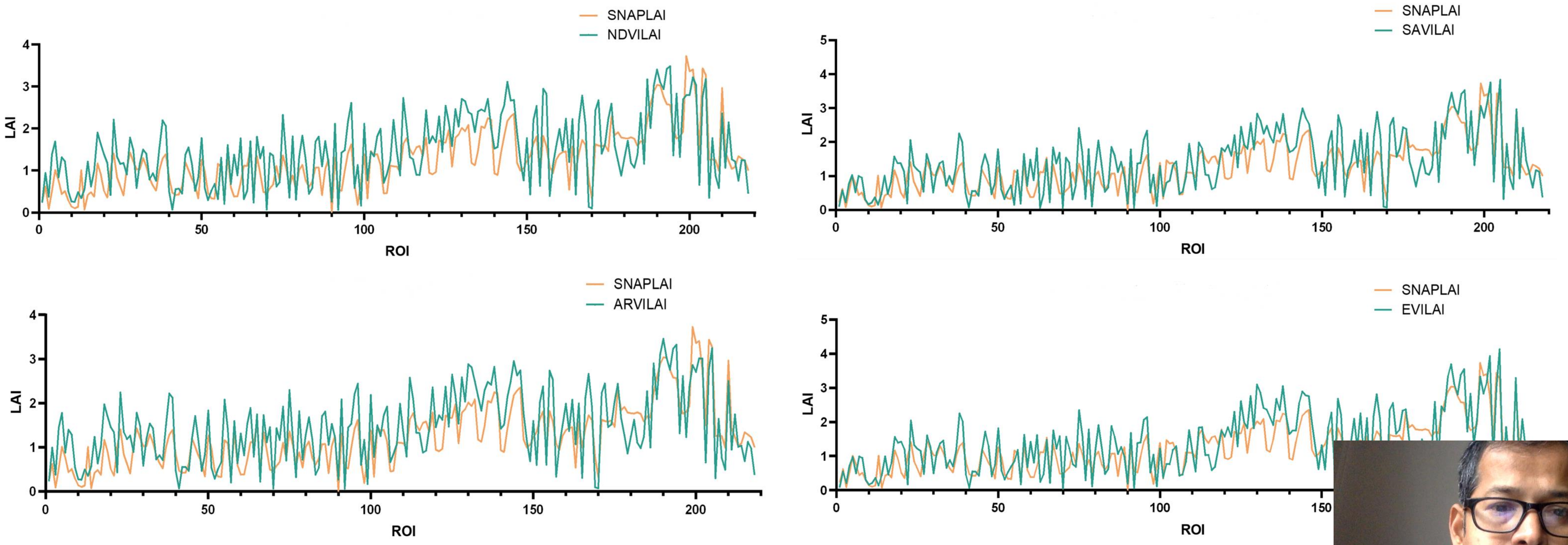


Result: Sentinel-2 LAI product validation

Validation method based on LAI measured on the ground



Validation method based on UAV LAI product



Result: LAI inversion from Sentinel-2 imagery

Validation method based on LAI measured on the ground

Validation method	Validation index		
	MAE	ME	RMSE
Based on Ground-LAI	0.802	0.853	1.020
Based on NDVI-LAI UAV product	0.504	0.548	0.586
Based on SAVI-LAI UAV product	0.486	0.731	0.580
Based on ARVI-LAI UAV product	0.483	0.554	0.558
Based on EVI-LAI UAV product	0.472	0.672	[illegible]

Future plan

- **More physical-based inversion methods like Look-up Table(LUT) and Non-parametric regression with machine learning algorithms could be explored in UAV based biophysical parameters retrieval.**

- **The further acquisition of multispectral and even hyperspectral data from the UAV platform is expected.**

- **More fieldwork and communication in person from the collaborate institutes are planned.**

EO Data Delivery

Data access (list all missions and issues if any). NB. in the tables please insert cumulative figures (since July 2020) for no. of scenes of high bit rate data (e.g. S1 100 scenes). If data delivery is low bit rate by ftp, insert "ftp"

ESA Third Party Missions	No. Scenes
1.	
2.	
3.	
4.	
5.	
6.	
Total:	
Issues:	

ESA Third Party Missions	No. Scenes
1. Sentinel 2 MSI	10
2. Sentinel 3 OLCI	10
3.	
4.	
5.	
6.	
Total:	
Issues:	

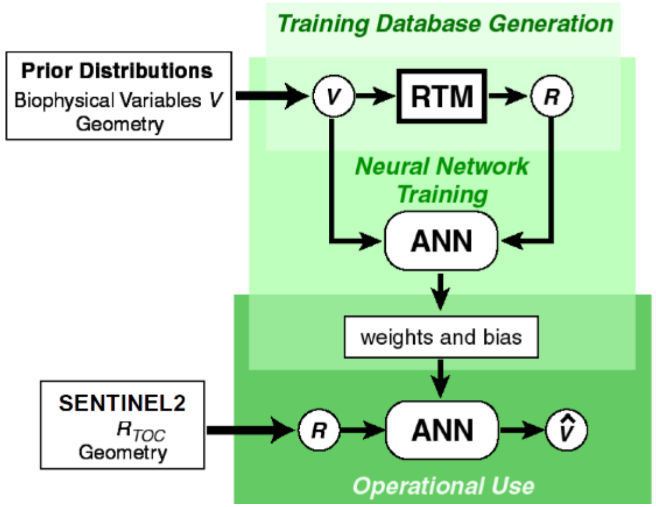
Chinese EO data	No. Scenes
1.GF-6	4
2.GF-6	4
3.	
4.	
5.	
6.	
Total:	
Issues: ftp (for oversea users), colleagues at Wuhan University are helpful.	

European Young scientists contributions in Dragon 5

Name	Institution	Poster title	Contribution
Xuerui Guo	University of Southampton	Vegetation Index Sensitivity Test Based on PROSPECT+SAIL Model – a Preliminary Test Under the UAV4VAL Project	
Harry Morris	University of Southampton	Using A Wireless Quantum Sensor Network To Monitor The Temporal Dynamics Of Vegetation Biophysical Parameters In A Mediterranean Vineyard	

Conclusion

- Project team in-depth communication and regular progress meetings
- Return fieldwork at both Chinese and UK sites, data sharing
- GF6 data processing and biophysical variable extraction
- UAV based LAI retrieval method and validation on Sentinel-2 LAI product



Thank you
J.Dash@soton.ac.uk