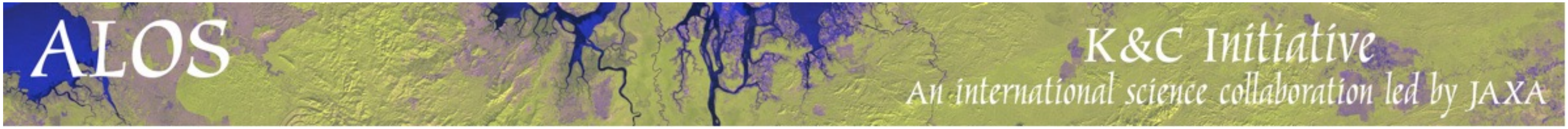

KC#27 Project Report

Assessing multi-sensor Earth observation time-series data for enhancing the credibility and integrity of nature-based climate solutions in Southeast Asia

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K&C Science Team meeting #27
Tokyo, Japan, September 9-10, 2023

The data I want!

The data I have!

Project outline and objectives

Component 1: Estimation of aboveground forest carbon stocks and flows in tropical SEA using of multi-sensor time-series satellite data

Component 2: Detecting deforestation and forest degradation.

Three K&C thematic drivers (**C**arbon cycle science, **C**limate Change, and Environmental **C**onservation)

PALSAR/PALSAR-2 data access

- Requested and obtained ALOS PALSAR Fine Beam Dual (FBD) for Palawan and S. Leyte in the Philippines

Background

- **<u>Multi-sensor remote sensing data</u>** may improve the estimation of aboveground forest carbon stocks.

- **<u>Scarcity of forest inventories in tropical forests</u>**, compels us to use the pre-existing forest inventory datasets to calibrate remote sensing data. However, these forest inventories were likely executed with **different objectives and sampling designs**.

Knowledge gap

- Little information exists about the **<u>accuracy of above-ground carbon estimates from combined datasets</u>** across various forest types and geographies, particularly in the tropical forests of Southeast Asia (Dupuis et al., 2020; Miettinen et al., 2014).

What we did!

- We **pooled forest inventory datasets** from GIZ REDD+ field inventory plots from three study sites in the Philippines

- Used **Multiple Linear Regression** to model AGB from forest inventory data and satellite data, specifically **L-band SAR and Landsat**.

Two research objectives!

- Assess if **<u>individual sensor vs combined sensor</u>** data produces accurate AGB estimates.
- Assess if a **<u>'global' model developed from pooled forest plot data</u>** accurately estimates forest carbon **compared to site-specific models**.

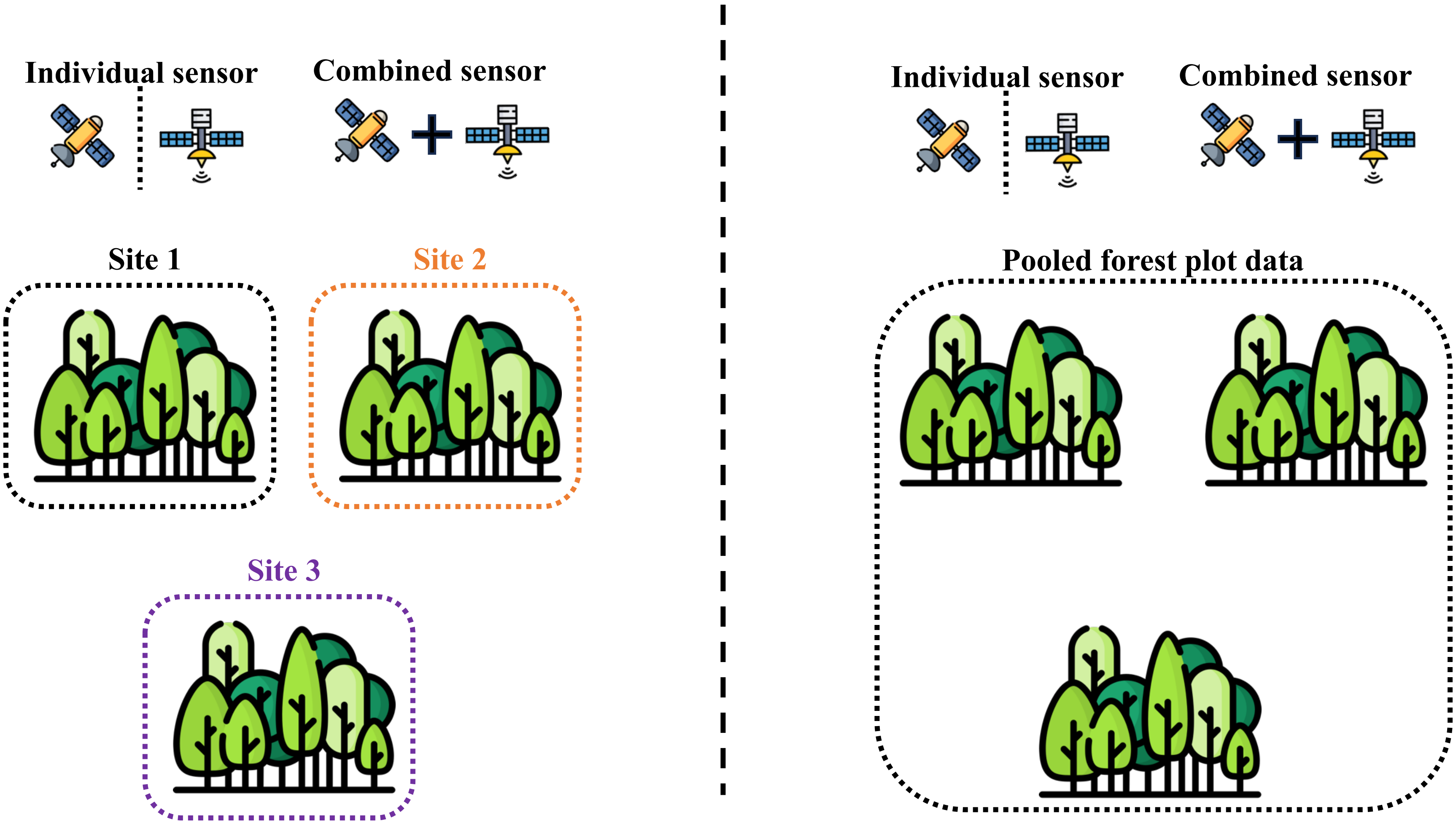
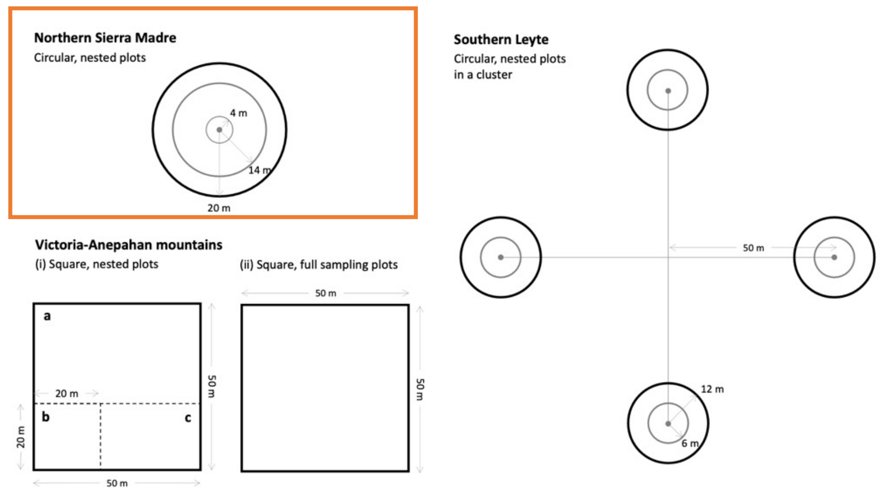


Table 1. Summary of forest plot design and characteristics for each study site.

Plot information	Study sites			
	NSM	**SLY**	**VAM**	
Sampling design	Stratified systematic grid	Stratified systematic grid	Random design	
Plot dimension	Circular (4 m, 14 m, and 20 m)	Circular (6 m and 12 m)	Square (50x50 m, 50x20 m, and 20x20 m)	Square (50x50 m)
Plot area	0.126 ha	0.045 ha	0.250 ha	0.250 ha
Tree sampling method	Nested	Nested	Nested	Full
Total number of plots	122	382	45	20
Year of data collection	2014	2011–2012	2013	



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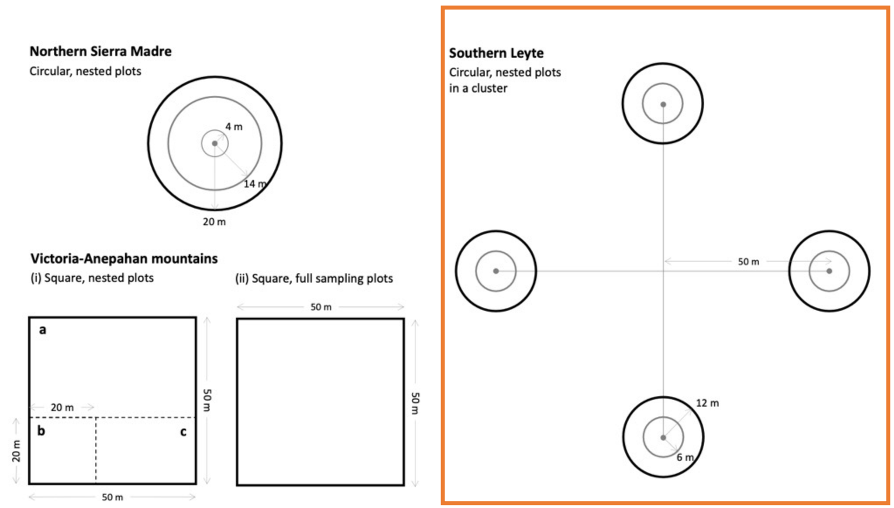

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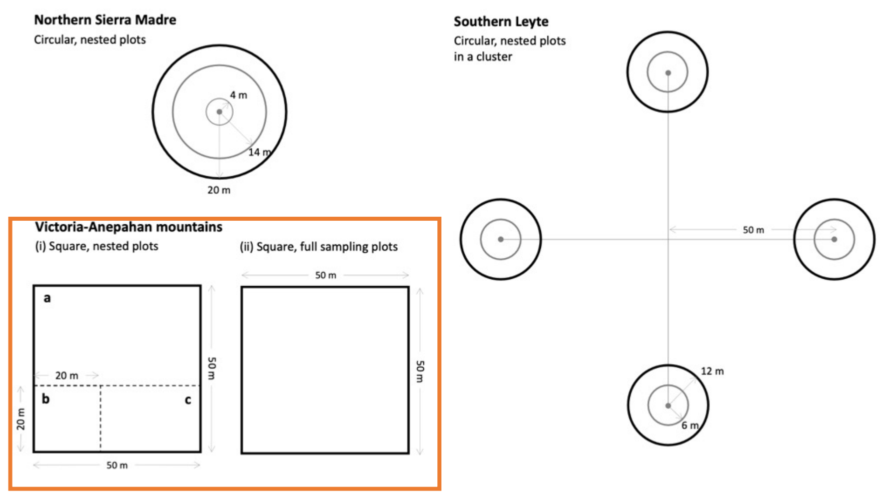
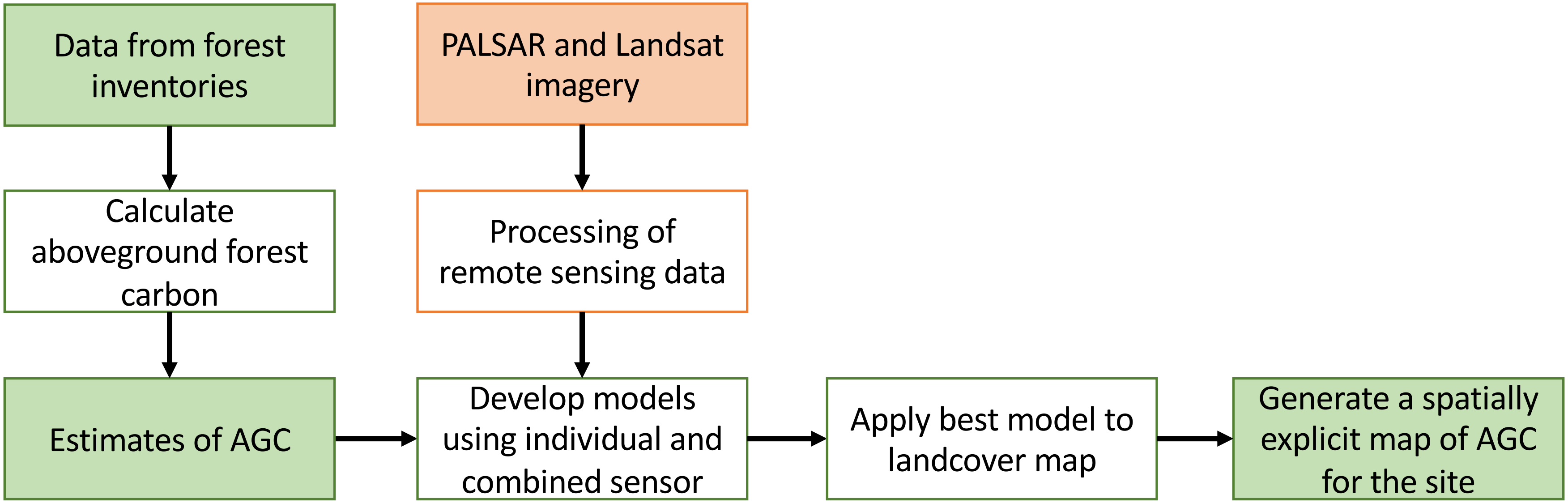
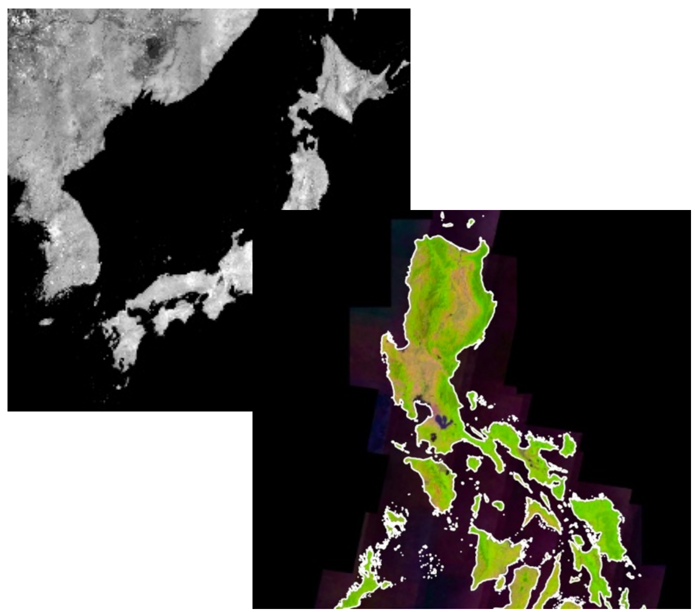


Workflow


Data from forest inventories
PALSAR and Landsat imagery
Calculate aboveground forest carbon
Processing of remote sensing data
Estimates of AGC
Develop models using individual and combined sensor
Apply best model to landcover map
Generate a spatially explicit map of AGC for the site

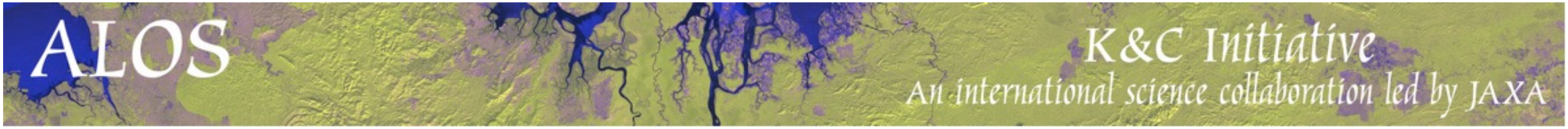



Sulu Sea
Sandakan

REDD+ Forest inventory data

	SLY		VAM	NSM	
2010	2011	2012	2013	2014	2015
SLY & VAM PALSAR1					NSM PALSAR2

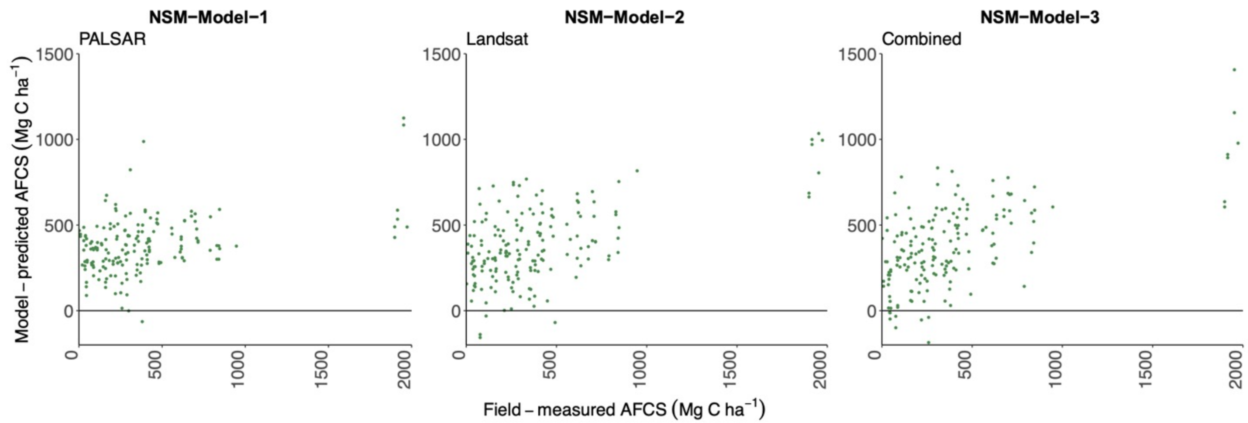
PALSAR data

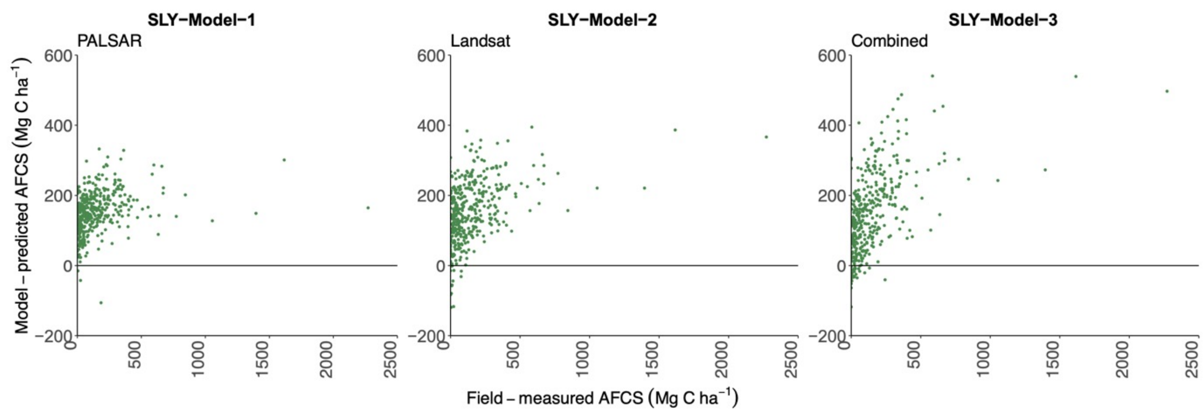


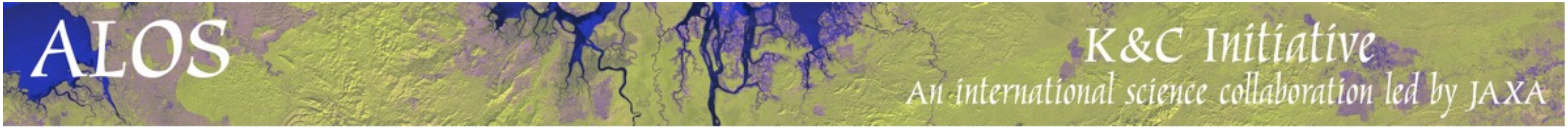
Results – Site Specific Models

1. The **combined sensor models performed better** than individual PALSAR-only or Landsat-only models for all study sites. 🤓

2. **But even the best models for NSM and SLY**, had **low R^2 and high RMSE values.** 😔







Results – Site Specific Models

Combined	VAM-Model-3	–15768.63 + 1.91**B7_K11_VAR** + 0.10**HV_K11_AVG** + 135.72**B4_K3_IDM** + 5030.31**HH_K5_ENT** + 1782.07**B5_K11_IDM** + 0.15**HH_K7_DIS** – 0.0002**HV_K11_CON** + 0.35**B6_K11_VAR** – 132.85**B2_K3_COR** + 466.37**B6_K3_IDM** – 0.05**DIF** + 224.85**B6_K5_COR** – 1133.08**B6_K9_IDM** – 119.39**B5_K5_COR** + 0.33**HH_K11_DIS** + 0.50**B2_K7_CON** + 2447.94**B3_K11_ASM**	0.82	42.92
VAM (Full; 0.25 ha)				
PALSAR	VAM-Model-4	–465.33 + 0.11**AVE** + 343004.07**HV_K3_IDM** + 1160.78**HV_K9_COR** – 859.76**HH_K9_COR**	0.57	66.97
Landsat	VAM-Model-5	1995.67 – 309.62**B2_K3_IDM** - 56960.03**B6_K5_ASM** + 347.79**B5_K9_COR** – 235.83**B7_K11_COR**	0.58	66.04
Combined	VAM-Model-6	3267.79 + 0.03**AVE** + 369350.37**HV_K3_IDM** – 597.09**B7_K11_COR** – 59248.92**B6_K5_ASM** + 28513.65**HV_K5_IDM** – 776.84**HH_K11_COR** – 298.02**B3_K3_ENT** – 114.38**B7_K3_COR** + 286.63**B5_K7_COR** – 628.06**SATVI** – 3757.41**B4_K7_ASM**	0.93	27.20

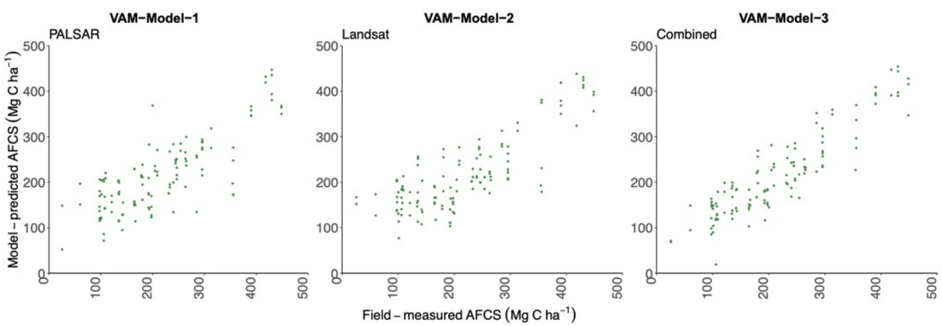


Fig. 6. Comparison of field-measured vs model-predicted aboveground forest carbon stocks from models of different sensor data types in VAM (nested sampling plots).

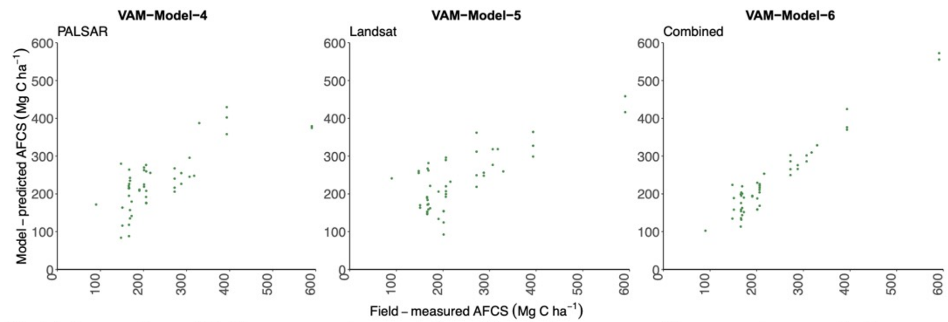
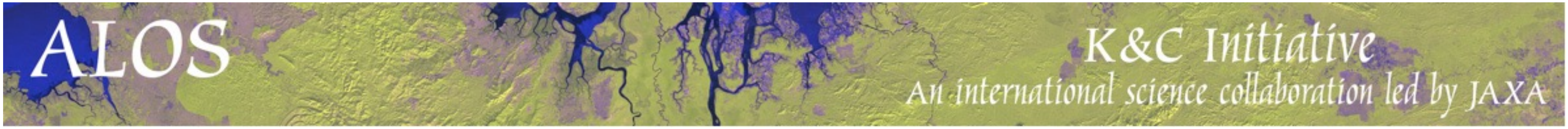


Fig. 7. Comparison of field-measured vs model-predicted aboveground forest carbon stocks from models of different sensor data types in VAM (full sampling plots).



Results – Global Models

Sensor Type	Model	Model Equation	R^2	RMSE (Mg C ha⁻¹)
Across all study sites				
PALSAR	Global-Model-1	–98993.44 + 0.03**HV_K11_AVG** – 136.44**HV_K3_COR** + 9141.20**HH_K5_IDM** – 16846.50**HVoHH** + 3295.85**HHoHV** – 0.37**HH_K11_DIS** + 0.00002**HV_K9_VAR** + 21194.62**HH_K11_ENT** – 34274.23**NDI** + 0.15**HH_K7_DIS**	0.13	245.71
Landsat	Global-Model-2	797.62 – 22.11**B6_K11_DIS** + 9.36**B5_K7_DIS** – 186.61**B2_K11_ENT** – 790.29**NDTI** + 164.64**B2_K3_ENT** – 207.41**B7_K11_COR** + 528.88**B2_K11_COR** –309.72**B2_K9_COR** + 561.77**LSWI** + 13.24**B2_K11_DIS**	0.19	237.13
Combined	Global-Model-3	–75859.24 – 27.12**B6_K11_DIS** + 10.47**B5_K7_DIS** – 131.16**B2_K11_ENT** – 734.06**NDTI** + 110.06**B2_K3_ENT** – 142.04**HV_K3_COR** + 13290.14**HH_K5_IDM** + 14979.35**HH_K11_ENT** – 3912.62**HH_K3_IDM** – 27249.85**HV_K3_ASM** + 297.23**B2_K11_COR** – 219.31**B4_K7_COR** + 26.81**HVg0** – 0.04**DIF** – 179.36**B3_K3_IDM**	0.24	230.61

The combined sensors model performed better than individual PALSAR-only or Landsat-only global models, but overall it was poor compared to all of the site-specific models using combined sensors. ☒

Results – AGC estimate using site specific model for VAM

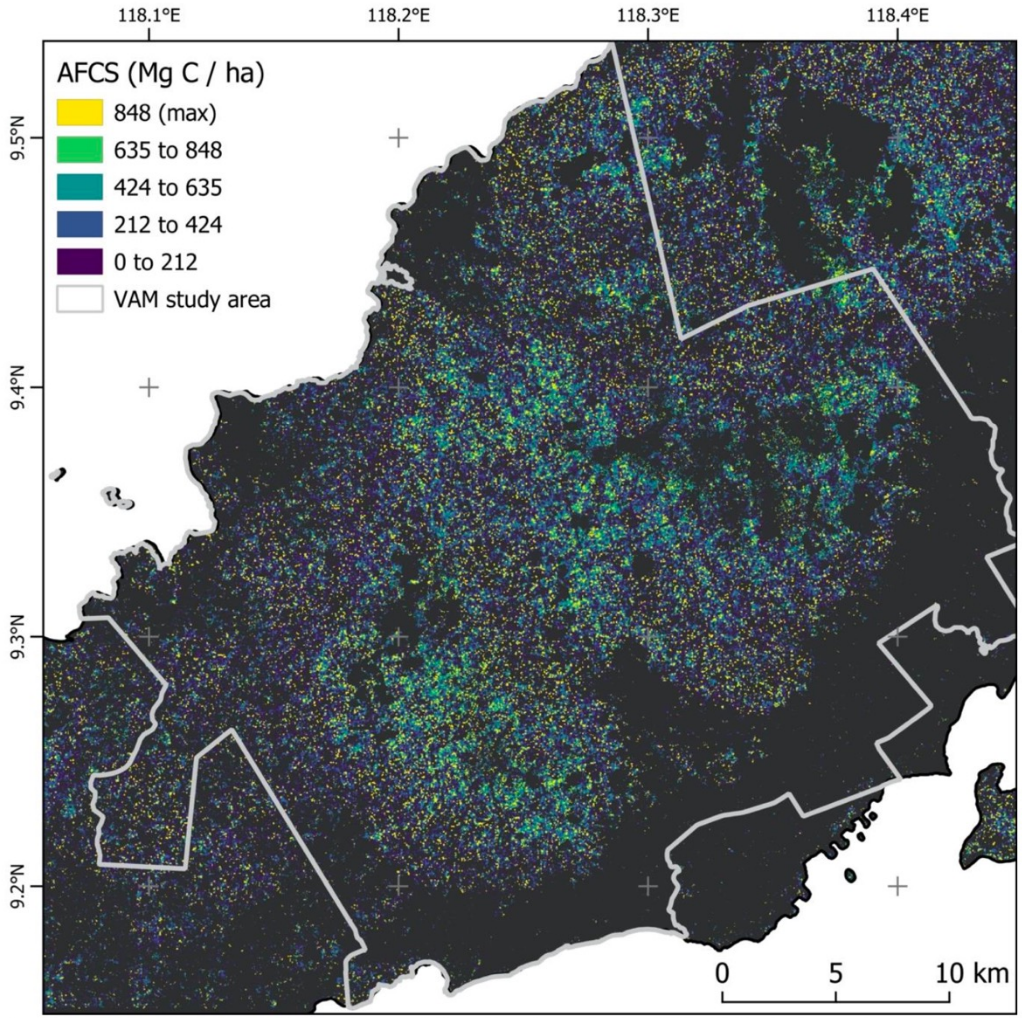


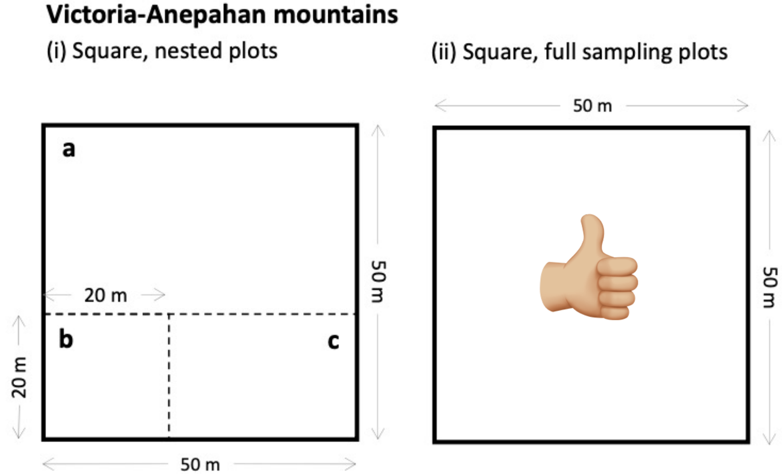
Fig. 9. Spatial distribution of aboveground forest carbon stock within Victoria-Anepahan mountain range (VAM), using the combined sensor model calibrated with full sampling plots (VAM-Model-6).

Discussion and suggestions!

1. **Using pooled datasets from various forest inventories will likely generate unreliable model estimates** and predictions of aboveground forest carbon over larger scales (i.e., country or regional scales), even with combined sensor data, **if forest characteristics vary substantially between and across forest landscapes.**

2. The **larger 0.25-ha VAM plots generated better model-predicted estimates.** We suggest using **larger forest inventory plot sizes** when combined with remote sensing data than smaller plot sizes. Moreover, better carbon estimates were achieved in **VAM despite having a fewer number of large plots** (i.e., 45 nested and 20 full sampling plots).

3. Between **nested and full tree sampling** of large plots in VAM, the **fully sampled plots produced better estimates**.



Deliverables and other output

Project deliverables

Component 1:

- Estimates of aboveground forest carbon
- Models developed using single and combined sensor data
- Accurate and spatially explicit maps of aboveground forest carbon stocks and flows

Component 2:

- Accuracy assessments of mapping forest cover and change
- Accurate forest cover, deforestation, and forest degradation maps

- Peer-reviewed publications – brewing!
- Non-peer-reviewed publications (conference papers, reports etc.)

  ⇨ 42^{nd} Asian Conference on Remote Sensing (22-24 Nov 2021)

Thank you JAXA for your support!

Arigato gozaimasu!