

國立中山大學  
National Sun Yat-sen University



# Georeference

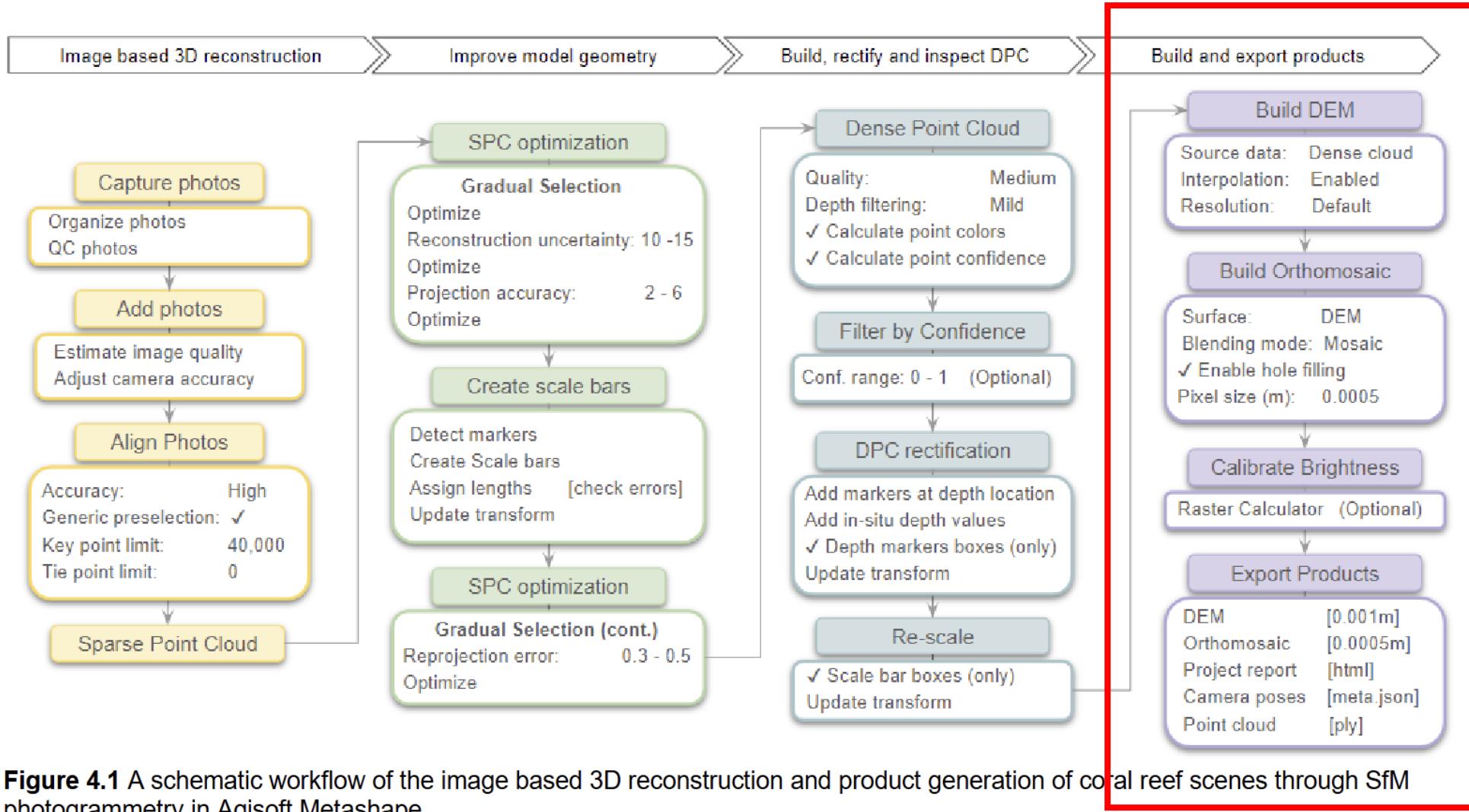
Guan-Yan Chen 陳冠言

Ph.D. candidate, Hawaii Institute of Marine Biology



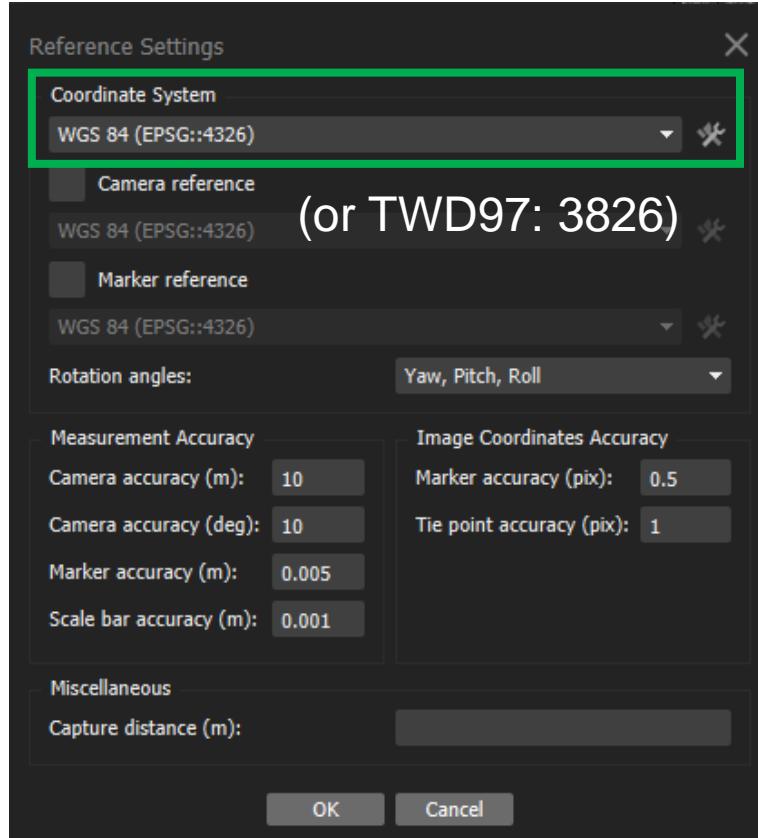
Jun 05 2025  
At National Sun-Yet  
Sen University





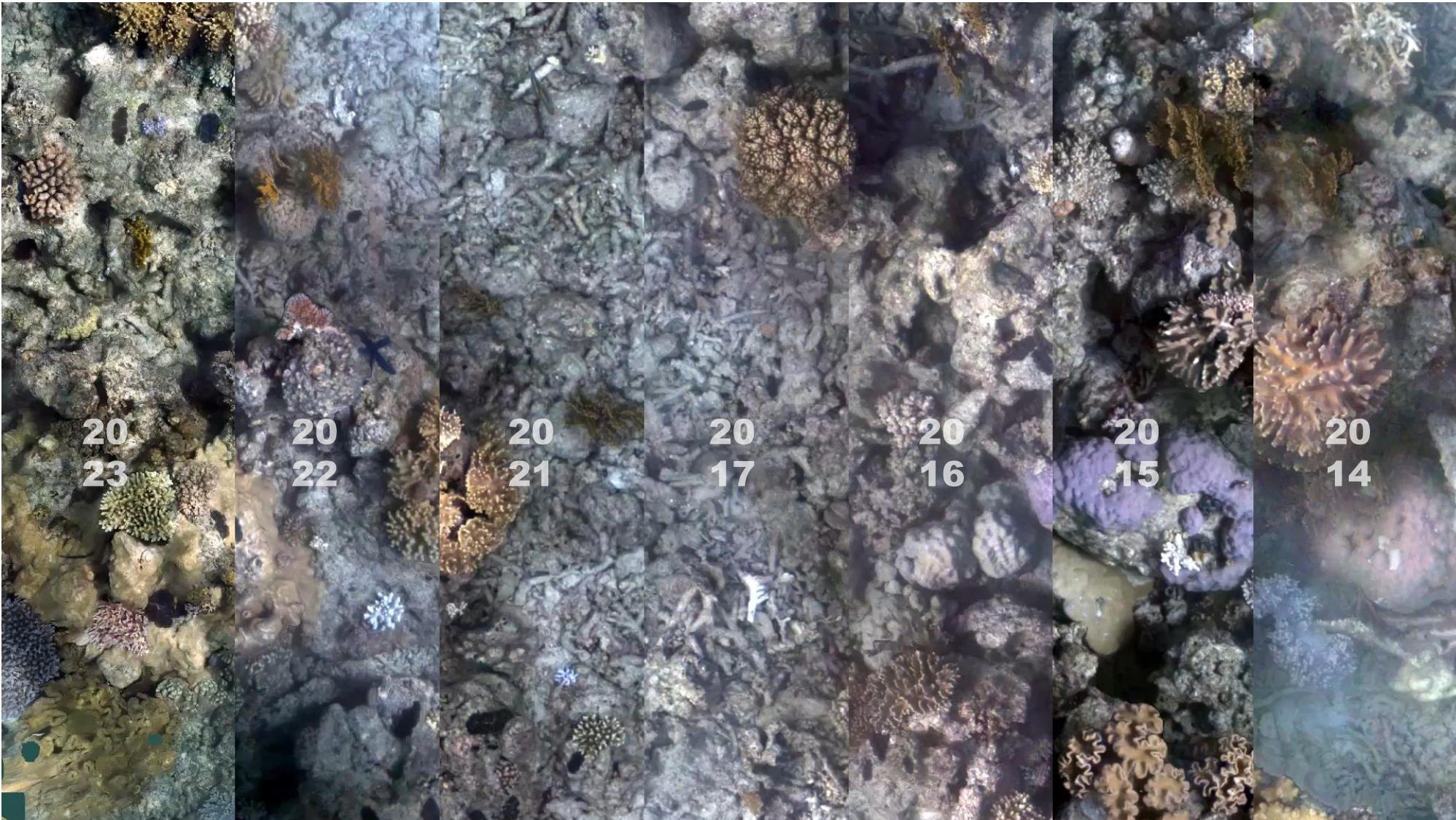
**Figure 4.1** A schematic workflow of the image based 3D reconstruction and product generation of coral reef scenes through SfM photogrammetry in Agisoft Metashape.

# 掌握坐標之力 建立更精準的3D模型!



Coordinate power make your life better

# Georeference for historical data comparison



# Get coordinate info





## Garmin Descent™ G1 Solar, Rugged Dive Computer with Solar Charging Capabilities, Multiple Dive Modes, Activity Tracking, Black

Visit the Garmin Store  
4.5 ★★★★★ 52 ratings | Search this page

Amazon's Choice

-15% \$549<sup>99</sup>

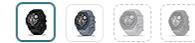
List Price: \$649.99 ⓘ

Or \$110.00/mo (5 mo). Select from 2 plans

✓prime

Get a \$100 Gift Card: Pay \$449.99 \$549.99 upon approval for Prime Visa. No annual fee.

Color: Black



Style: Descent G1 Solar

Descent G1 Solar

Descent G1

Roll over image to zoom in

Operating System Android & iOS

Memory Storage Capacity 32 GB

Special Feature Bluetooth

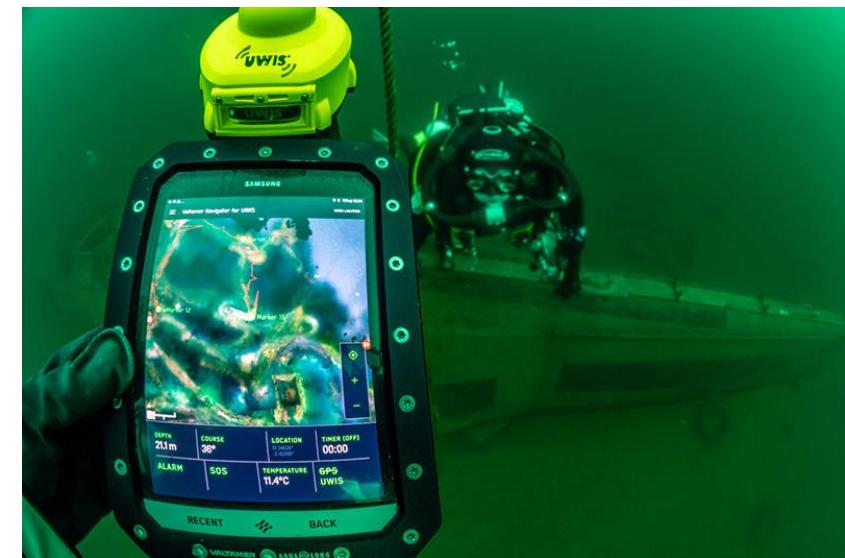
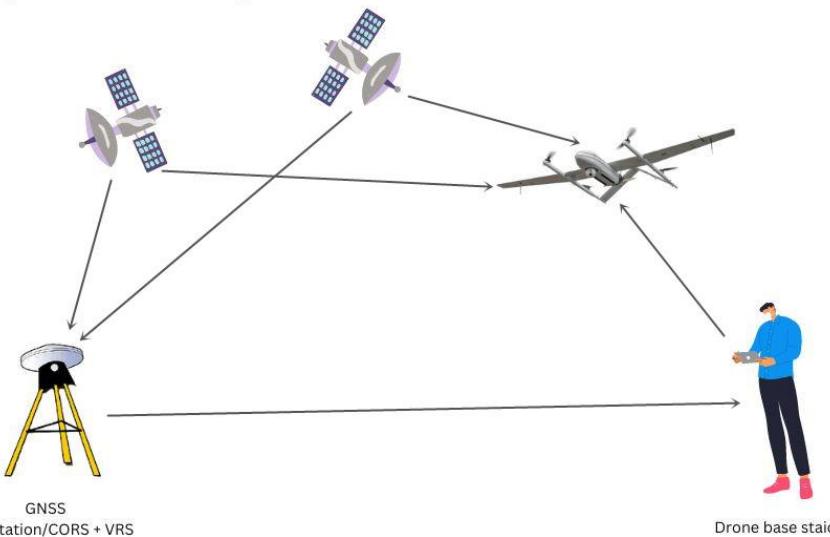
Battery Capacity 4 Milliamp Hours

Connectivity Technology Bluetooth, Wi-Fi, USB

Wireless Communication Bluetooth



## RTK (Real Time Kinematics)



IL\_P2\_2205.psx — Agisoft Metashape Professional

File Edit View Workflow Model Photo Ortho Tools Help AddTools

Reference

Cameras Longitude Latitude Altitude (m) Accuracy (m)

P5040...

P5040...

P5040...

P5040...

P5040...

P5040...

P5040...

P5040...

Markers

	Longitude	Latitude	Altitude (m)	Accuracy (m)
✓ target 34	120.753850	21.954808	-0.721203	0.005000
✓ target 42				
✓ target 43				
✓ target 45	120.753897	21.954764	-2.822943	0.005000
✓ target 46				
✓ target 49	120.753909	21.954812	-3.892194	0.005000
✓ target 51				
✓ target 52				
✓ target 55				
✓ target 52				

Scale Bars

	Distance (m)	Accuracy (m)	Error (m)
✓ target 34_target 42	0.299000	0.001000	-0.000118
✓ target 43_target 51	0.304000	0.001000	-0.001929
✓ target 45_target 46	0.305000	0.001000	-0.000206
✓ target 52_target 55	0.301000	0.001000	0.001362

Total Error

Control scale bars 0.001187

Check scale bars

Workspace Reference

Animation

Photos

Speed (%) X Y Z Yaw

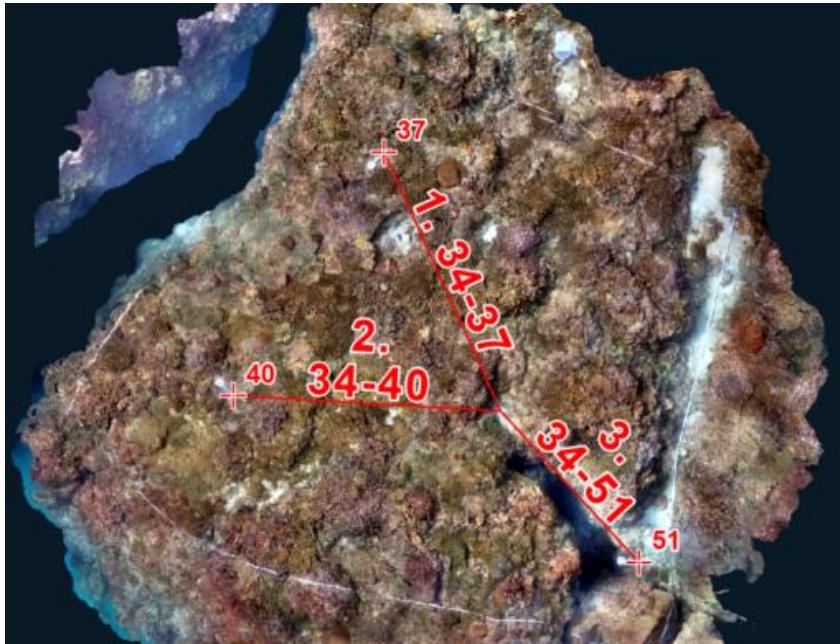
WGS 84 (EPSG:4326) 21°57'17.20" N 120°45'14.27" E 28.086 m

• At least 3 points GPS and depth info needed

• 至少要得知三個Markers的經緯度資訊與對應的深度

(using diver watch to get 3 points gps is not accurate)

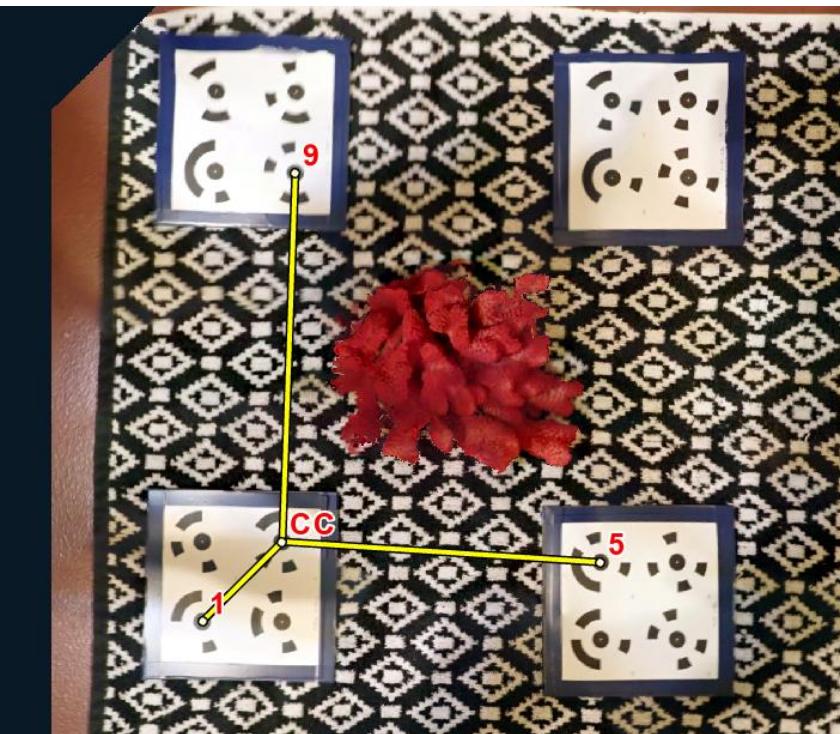
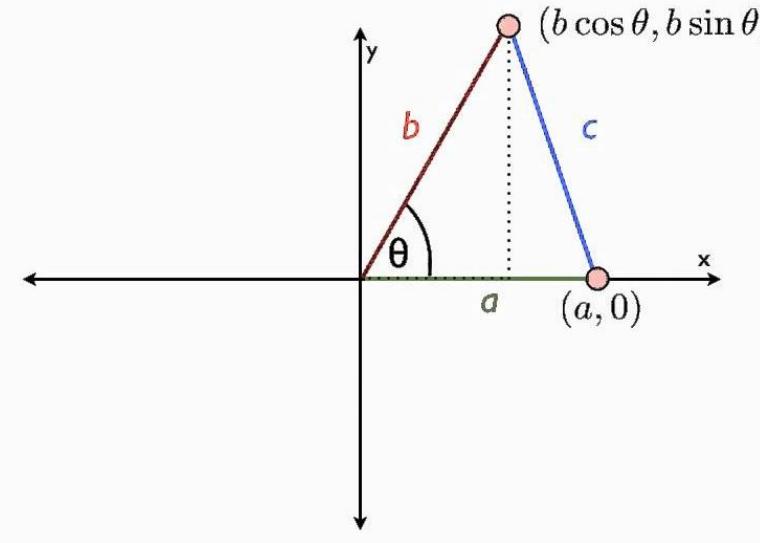
(直接用錶量是不準的，需要進行一些數學運算)



Get 1 center point GPS, then use triangulation to infer the other points' coordinate

Try to make the points distributed evenly and in various depth

The Law of Cosines: An identity that describes the relationship between an angle ( $\theta$ ) of a triangle and its adjacent sides ( $a, b$ )

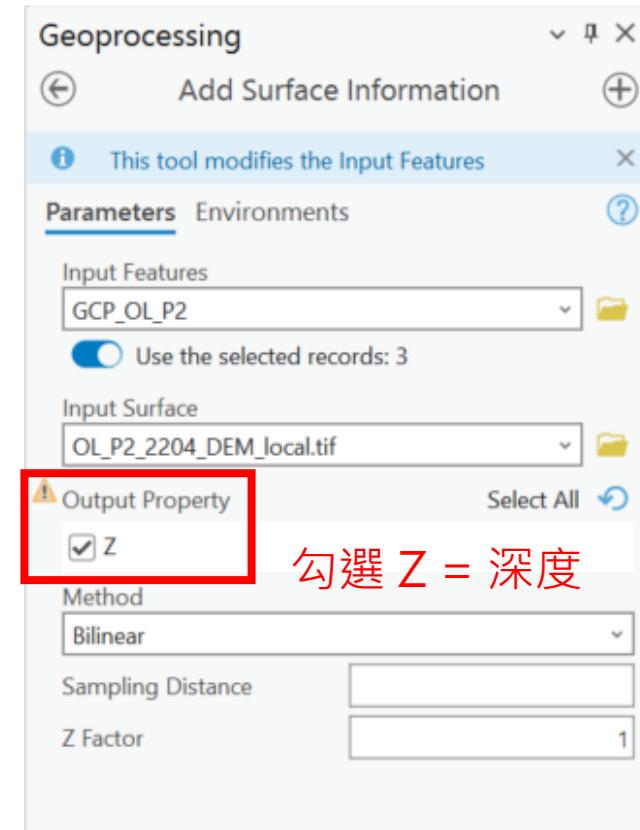
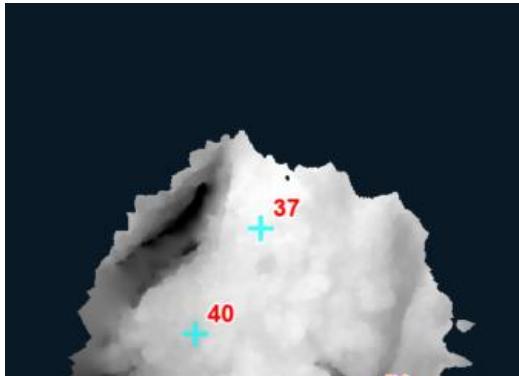


A diagram showing a triangle in a 2D Cartesian coordinate system. The horizontal axis is labeled 'x' and the vertical axis is labeled 'y'. The origin is at '(a, 0)'. A point on the y-axis is labeled '(b cos \theta, b sin \theta)'. A dashed line extends from this point to the x-axis, forming a right-angled triangle with the x-axis. The hypotenuse of this triangle is labeled 'b'. The angle between the x-axis and the hypotenuse is labeled '\theta'. The adjacent side to the angle \theta is labeled 'a'.

$$\cos(\theta) = \frac{x}{b} \implies x = b \cos(\theta)$$
$$\sin \theta = \frac{y}{b}$$
$$\implies y = b \sin \theta$$

# More accurate measurement by GIS

使用DEM進行深度計算，  
需要確認DEM有和  
Orthomosaic確實重疊



使用Add surface information  
工具，取得三點對應在DEM上  
的深度值

完成計算後的Attribute table如下

Field:	Add	Calculate	Selection:	Select By Attributes	Zoom To
OBJECTID *	SHAPE *	ID	x	y	z
1	Point Z	Center_34	120.745267	21.931657	<Null>
2	Point Z	40	<Null>	<Null>	-2.626412
3	Point Z	37	<Null>	<Null>	-1.859628
4	Point Z	51	<Null>	<Null>	-4.05752

中心點取經緯度  
周圍三點取深度

Field:	Add	Calculate	Selection:	Select By Attributes
OBJECTID *	SHAPE *	Shape_Length	Direction	ID
1	Polyline Z	4.695211	335.687235	1. 34-37
2	Polyline Z	4.440098	273.307886	2. 34-40
3	Polyline Z	3.388021	137.587413	3. 34-51

線取長度與角度

Input distance and bearing between the center and 3 points

將上述計算結果，輸入以下Excel轉換表，只需輸入綠色與紅色字體的部分，其他部分的表格都不用動

	A	B	C	D	E	F	G	H	I	J	K	L	
1		ID	Site	x (deg)	y (deg)	Mag (deg)	Mag (rad)						
2		0	SITE	120.7452672	21.93165747	-4.08	-0.071209433						
3	1	2	3	4	5	6	7	9	10	12	14	15	
4			record	rad	rad	dd	dd	(m)	(km)	(m) -neg	(deg)	(rad)	
5			ID	date	X (long)	Y (lat)	X (long)	Y (lat)	dist_record	dist	depth_record	fwd_brng	fwd_brng
6	center	34		2.10740247	0.38277963	120.74526723	21.93165747			0			
7	1	37		2.10740209	0.38278028	120.74524558	21.93169462	4.695211	0.0046952	-2.626412367	335.6872352	5.7876	
8	2	40		2.10740172	0.38277962	120.74522419	21.93165693	4.440098	0.0044401	-1.859627694	273.3078859	4.6989	
9	3	51		2.10740289	0.38277927	120.74529105	21.93163649	3.388021	0.003388	-4.057520465	137.5874128	2.3301	

深度不影響計算結果，但可一並輸入方便後續閱讀

Record **depth** for the calculation later

## 輸入中心點經緯度

**輸入進行潛水調查  
的時間(年月即可)**

NOAA > NESDIS > NCEI (formerly NGDC) > Geomagnetism

# Magnetic Field Calculators

Declination    U.S. Historic Declination    Magnetic Field    Magnetic Field Component Grid    Correct My Compass    Registration

## Magnetic Declination Estimated Value i

Declination is calculated using the most recent [World Magnetic Model \(WMM\)](#), [IGRF](#) model. For 1590 to 1900 the calculator is imposed from 1890 to 1900. The [Enhanced Magnetic Model \(EMM\)](#) is a research surveys which attempts to include crustal variations in the magnetic field too fine accurate to 30 minutes of arc, but environmental factors can cause magnetic field changes. Data is available in [HTML](#), [XML](#), [CSV](#), or [JSON](#) programmatically (API). **Registration** is required to use the API.

**Calculate Declination**

Latitude: 22.629969  S  N  
Longitude: 120.262656  W  E

Model:  WMM (2024-2029)  IGRF (1590-2029)  
 EMM (2000-2019)  WMMHR (2024-2029)

Date: Year: 2025 Month: 5 Day: 1

Result format:  HTML  XML  CSV  JSON  PDF

**Declination**

Model Used:	WMM-2025
Latitude:	22.629969° N
Longitude:	120.262656° E
Date	Declination
2025-05-01	4.30° W = 0.30° changing by 0.03° W per year

**該地磁偏角** (This place's magnetic declination angle)



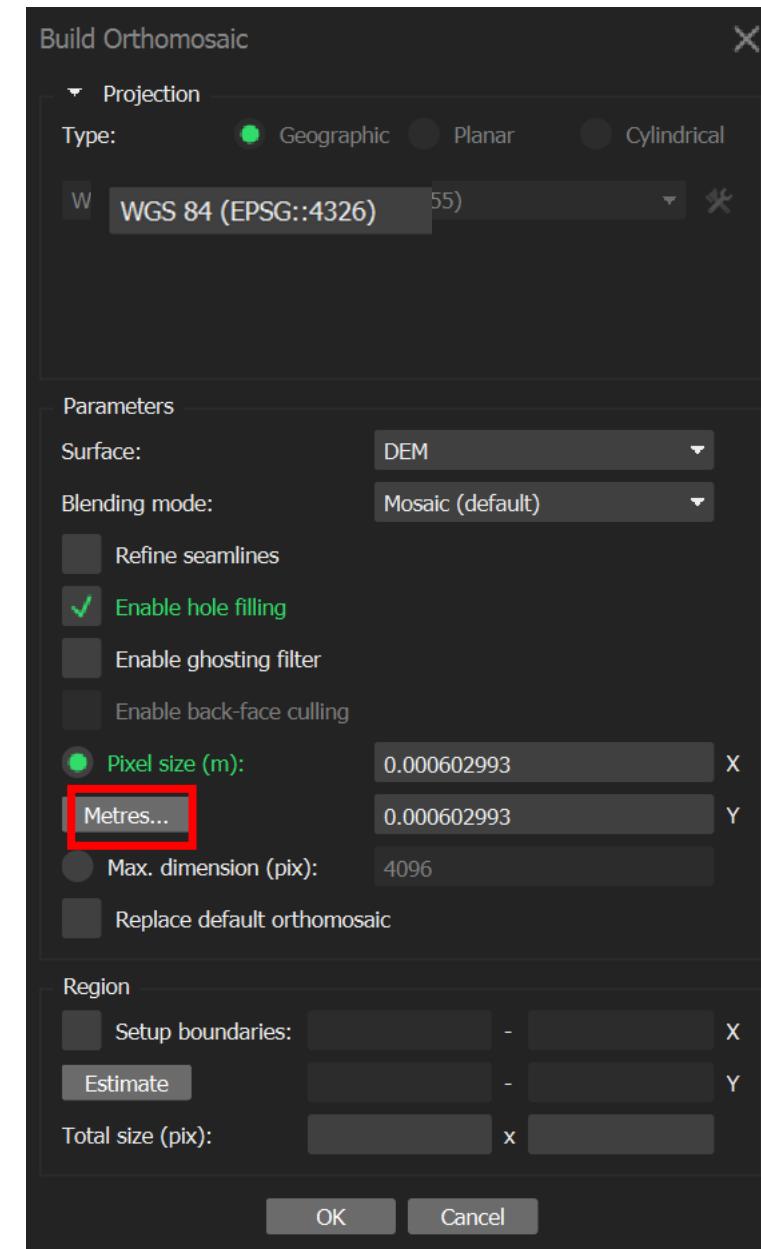
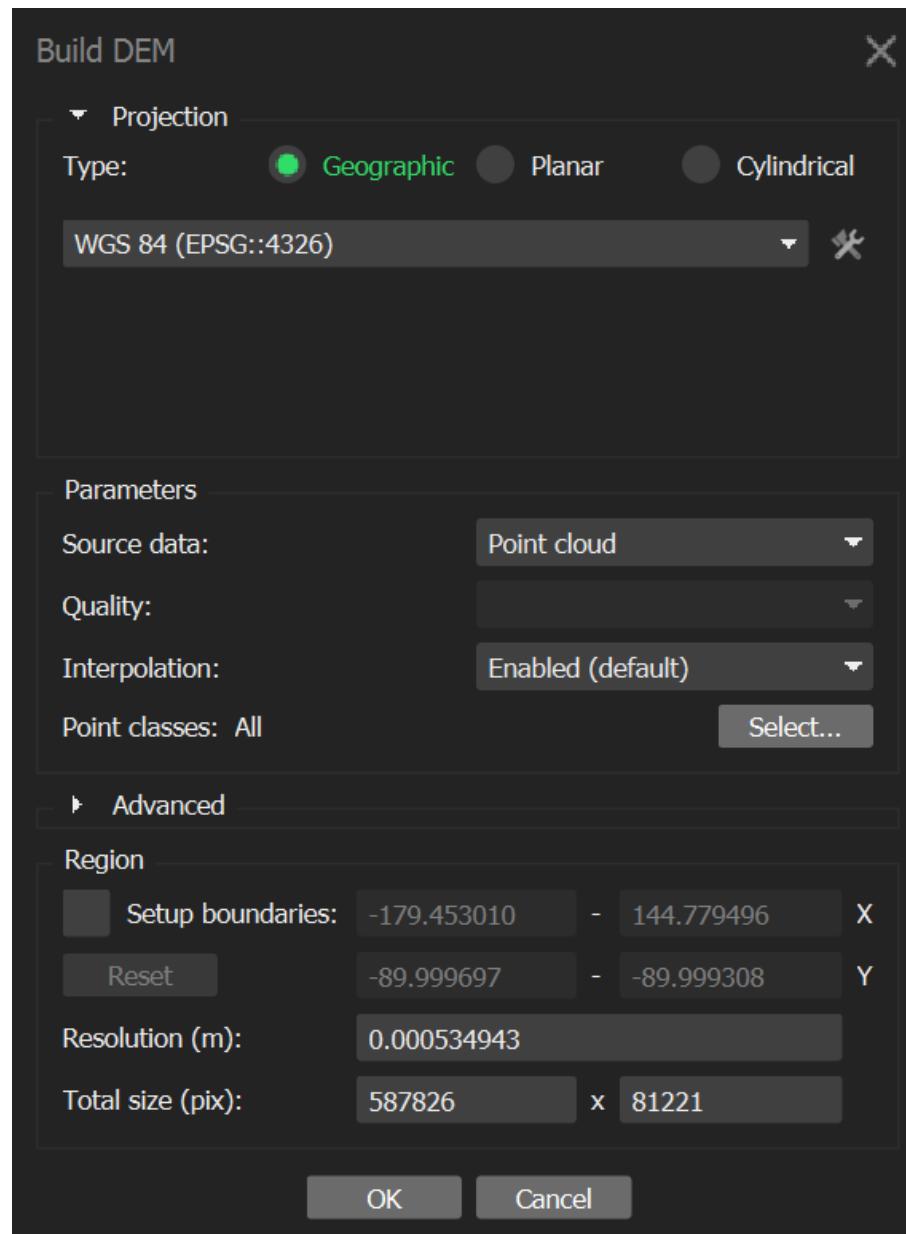
Esri, HERE, Garmin, NGA, ... esri

- 地理指北位置與地磁偏角的關係，地磁場會在不同地點造成不同的偏角，這就是地磁偏角。

## 磁偏角查詢網站連結

<https://www.ngdc.noaa.gov/geomag/calculators/magcalc.shtml>

偏東邊(E)是正 East -> +  
偏西邊(W)要加負號 West -> -



# 使用WGS 84模型在Agisoft的結果顯示

確認坐標轉換結果無誤之後，即可重新輸出使用WGS84做為Reference的Orthomosaic與DEM，有別於使用在地坐標系，其結果能顯示於實際的地理位置



The screenshot shows the Agisoft Metashape Professional interface with a focus on orthorectification. A red box highlights the 'Ortho' button in the top toolbar.

**Reference** panel:

- Cameras: PC020141, PC020142, PC020143, PC020144, PC020145, PC020146, ...
- Markers: target 56, target 9, target 1, target 2, target 3, target 4
- Scale Bars: target 9\_target 10, target 49\_target 50, target 55\_target 56

**Model** panel (Perspective 30° view):

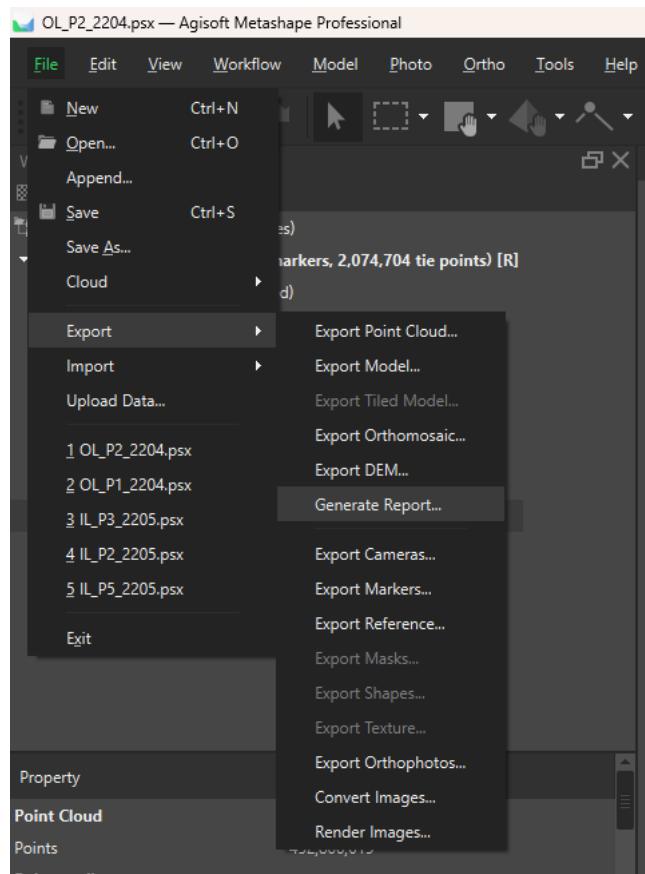
- 1,673,787 points
- Basemap: (C) OpenStreetMap contributors (C) Mapzen

**Photos** panel:

- PC020138, PC020139, PC020140, PC020141, PC020142

# Generate report and check quality

更新完坐標系，重新產生DEM與  
Orthomosaic之前，先輸出report，  
檢查比例尺誤差是否有達到**標準**



若是沒有達到標準，檢查GIS中的測量，  
或是表格中的數值是否輸入有誤，或是  
Target的擺放是否有誤

## Scale Bars

Label	Distance (m)	Error (m)
target 32_target 37	0.299155	-0.000844576
target 40_target 54	0.303696	0.00369649
target 32_target 37	0.299155	-0.000844576
target 34_target 42	0.297274	-0.00272583
<b>Total</b>		<b>0.00237281</b>

Table 7. Control scale bars.

比例尺總誤差需小於0.003 (m)  
= 相對誤差小於1% (0.3/30 cm)

# 在Agisoft中使用WGS 84模型的優點

能產生歷年模型變化比較影片



使用Agisoft內建的Animation功能，利用經緯度座標建立動畫取景軌跡，即可在不同年份調查的模型中產生比較動畫

OL\_P2\_2204.psx\* — Agisoft Metashape Professional

File Edit View Workflow Model Photo

Workspace

Chunk 1 (1) Workspace 74,704

Image Composition Markers Scale Tie Points Depth 3D Model Point Cloud DEM Ortho Camera Track

Animation Properties 取景 資存路徑

Speed (%) X Y Z Yaw

	Speed (%)	X	Y	Z	Yaw
T	100	120.745202	21.931579	4.680285	347.068
D	100	120.745299	21.931637	5.485097	358.676
O	100	120.745349	21.931690	6.416711	279.897

File name: IL\_P3\_camera\_path  
Save as type: Camera Path (\*.path)