# Drones pt2

GEOG 457 657
Feb 1, 2024

# Structure from motion

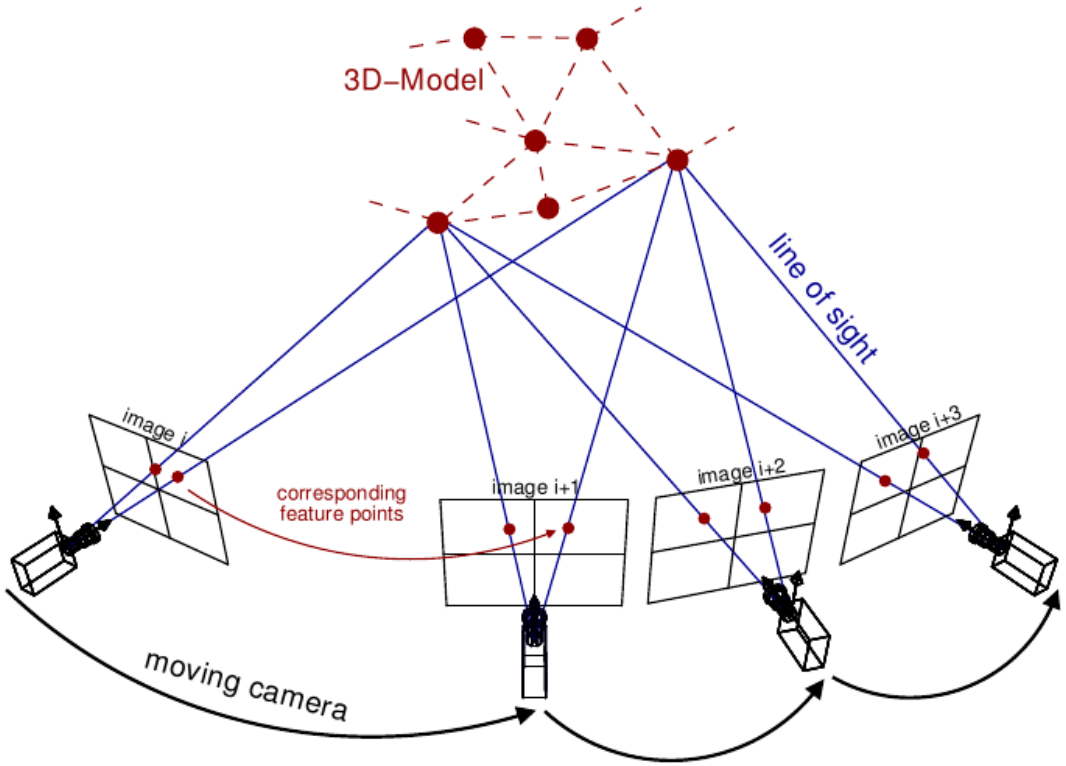
**Photogrammetry:**

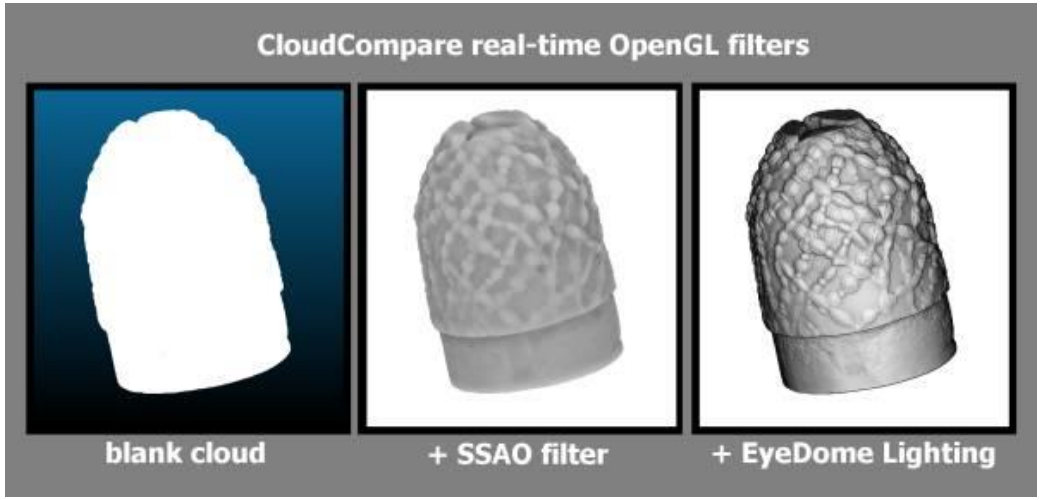
1. Extract geometric information from 2D images to reconstruct the 3D structures
2. Widely used in various fields, including surveying, mapping, architecture, archaeology, and 3D modeling.

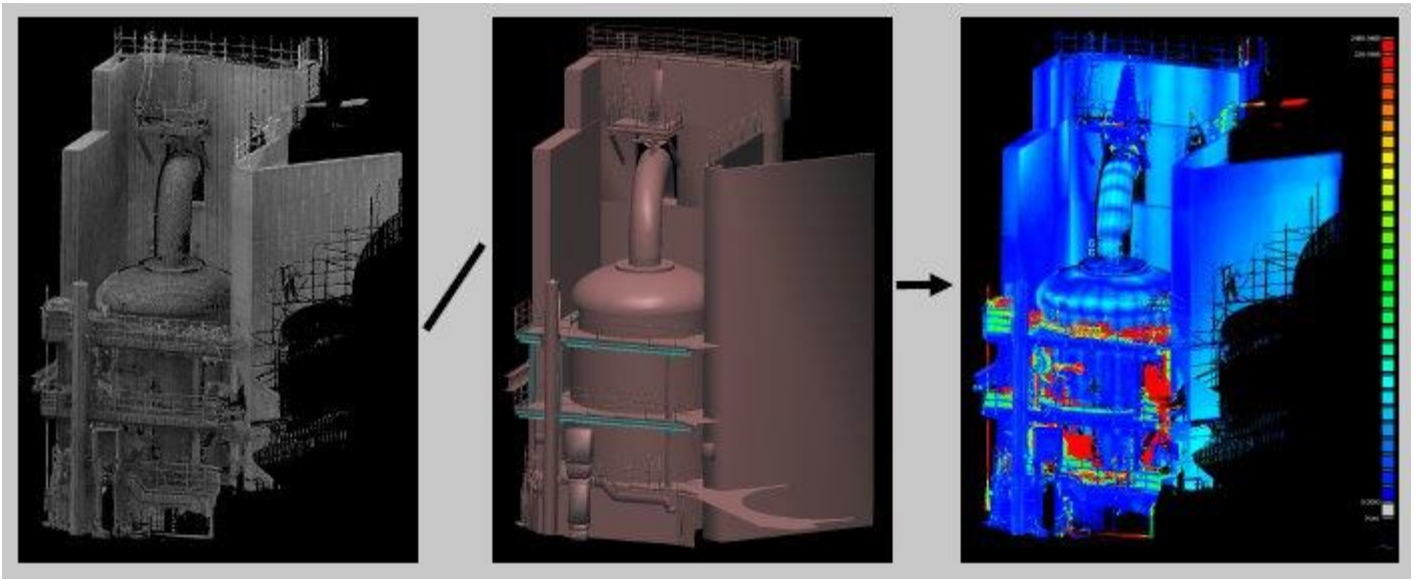
**Structure from Motion (SfM):**

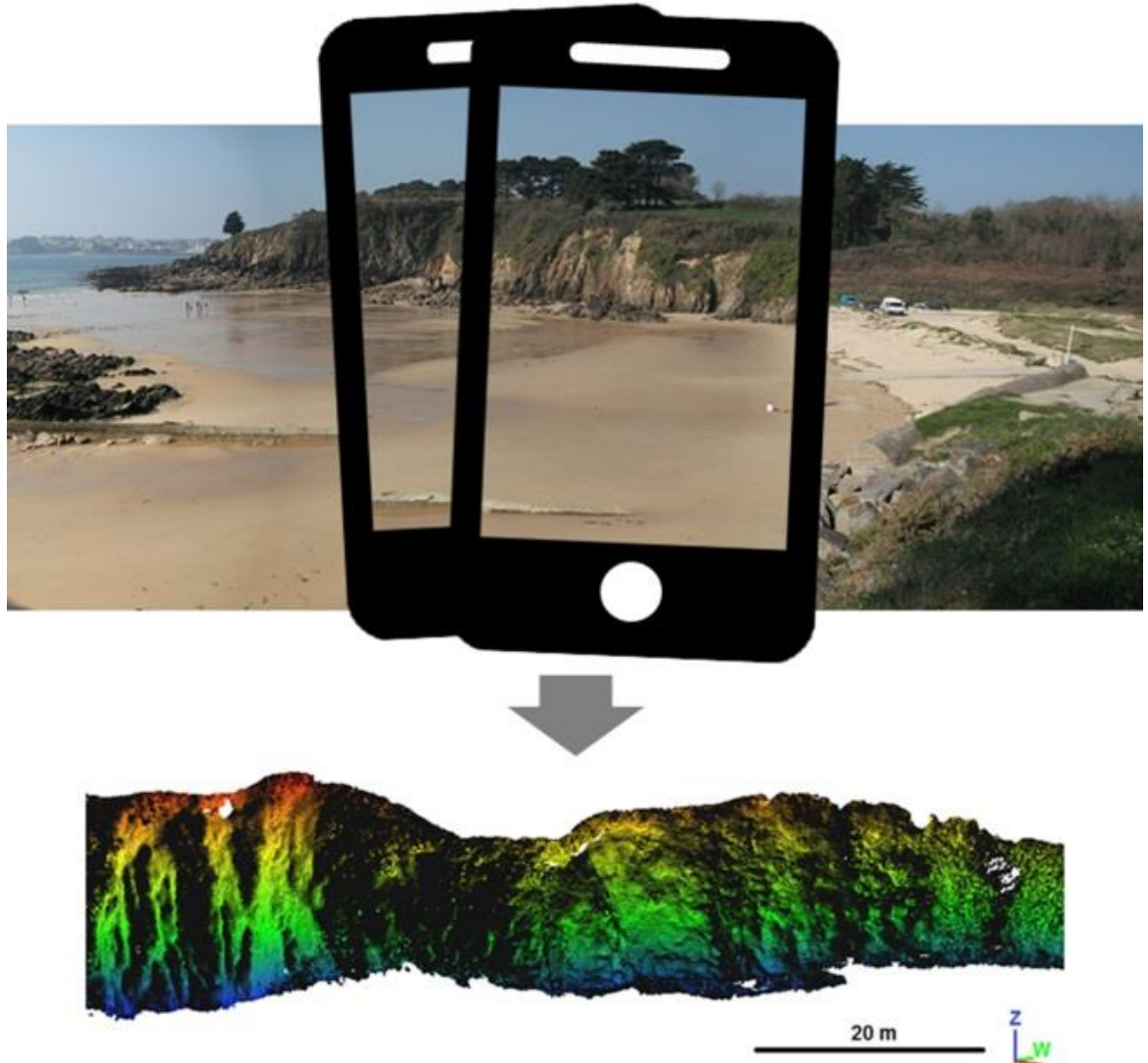
1. SfM is a photogrammetric technique that focuses on the reconstruction of 3D structures and camera poses from a **sequence** of 2D images.
2. Commonly used in creating 3D models from photographs, reconstructing scenes from video footage, and in robotics for navigation and mapping.

# Not just for drones!






Potential of Smartphone SfM Photogrammetry to Measure Coastal Morphodynamics (Jaud et al. 2019)

Google Arts & Culture

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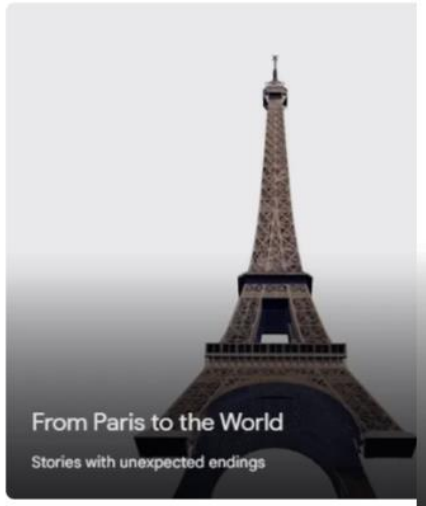
# 3D Models

Get a new perspective

## Travel the world in three dimensions

See Paris, Tokyo, and more from a new point of view

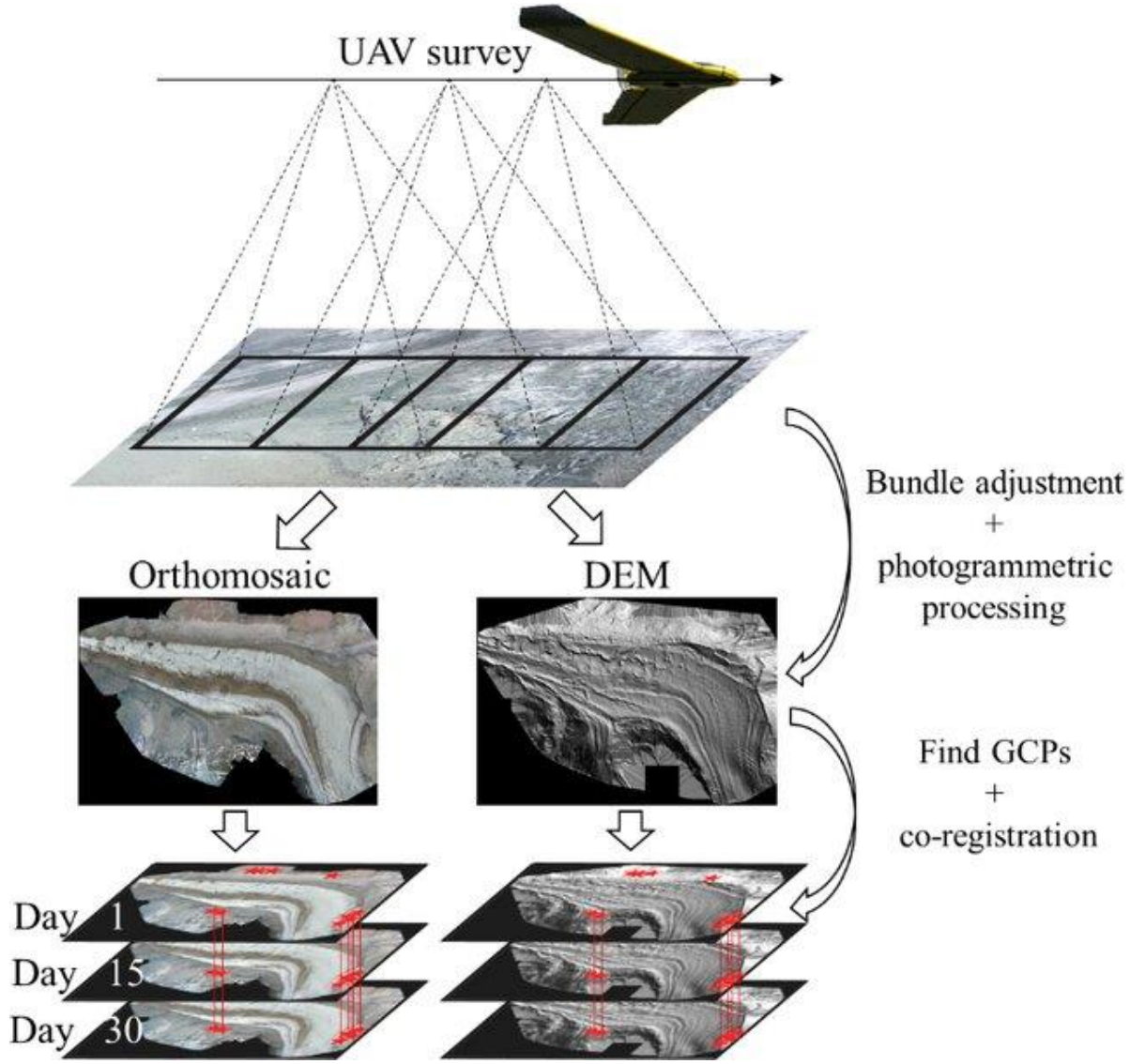




# Co-registration

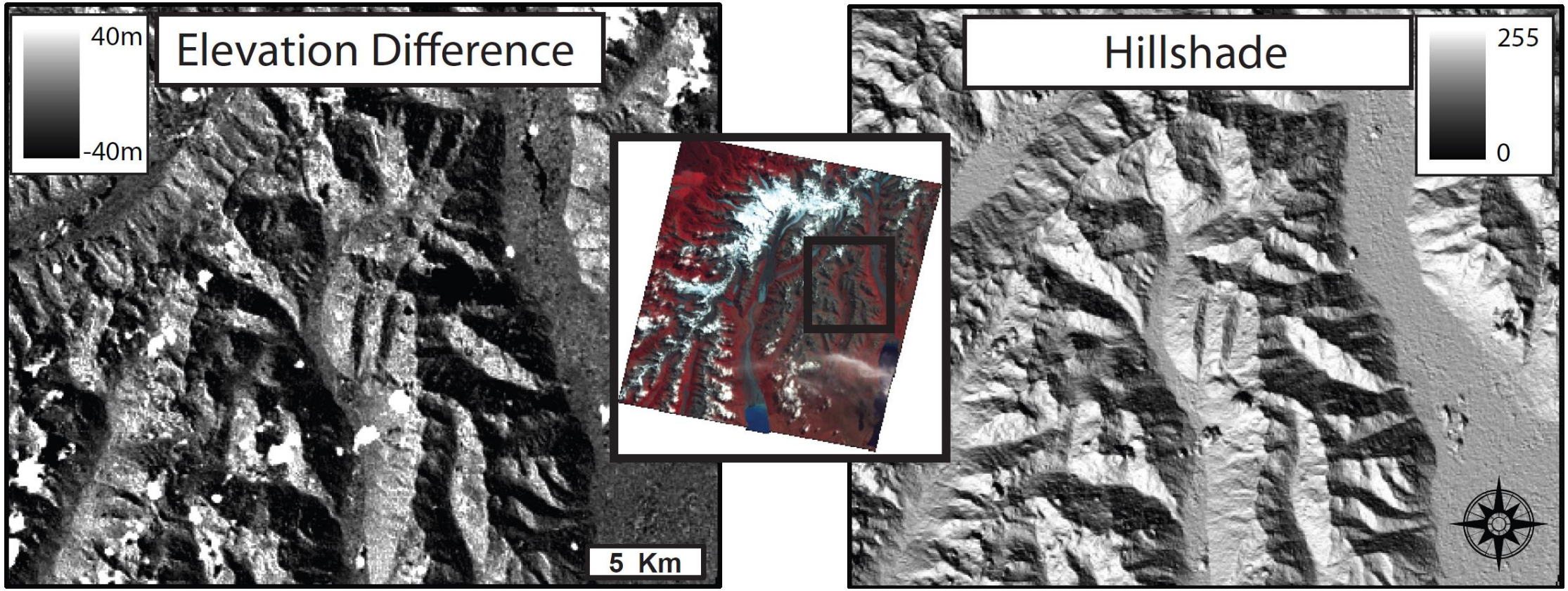
Co-registering drone products is essential when working with multiple datasets.

It is an essential process, and also time consuming!



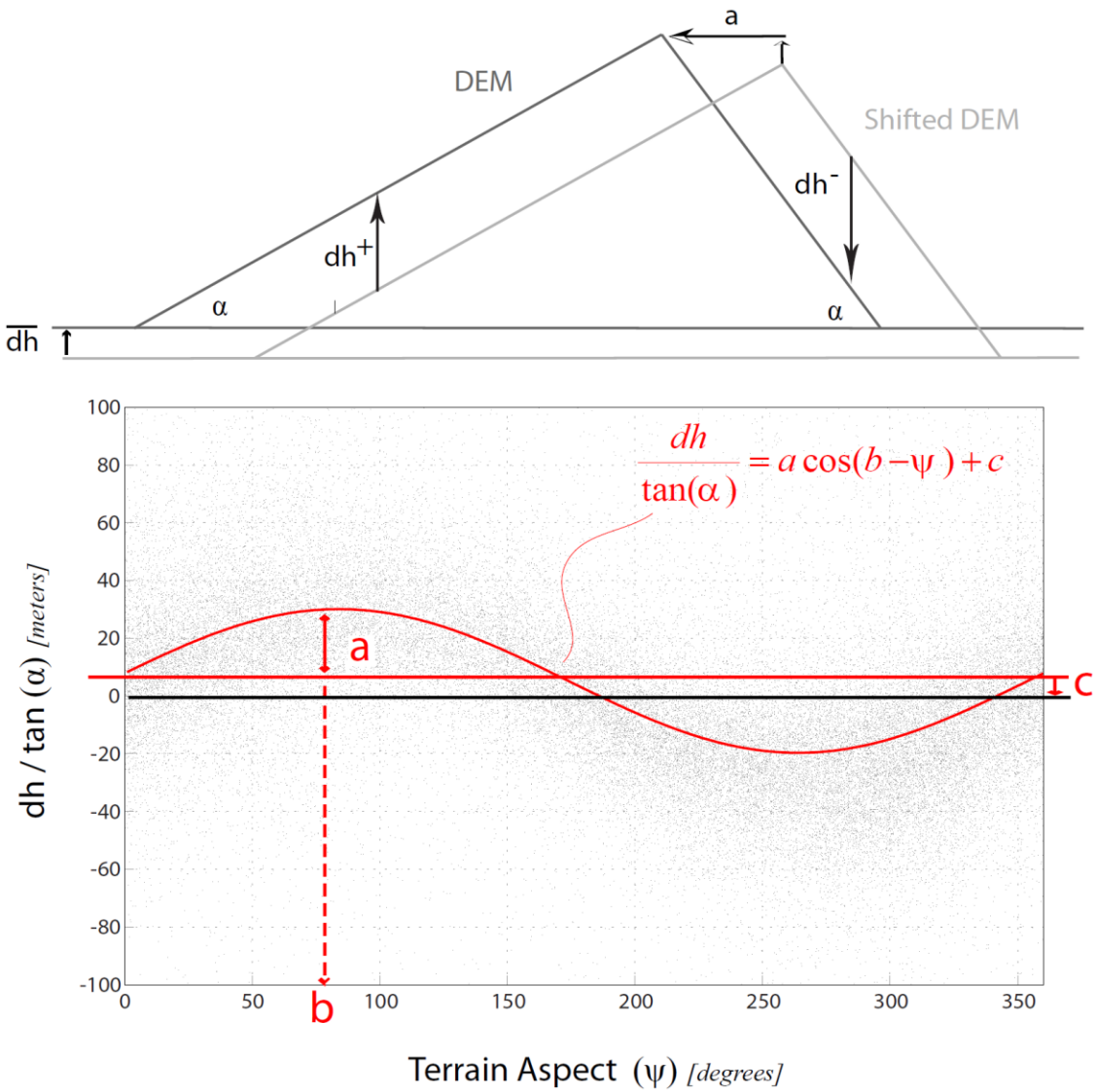

Benoit et al. 2019

# Automatic DEM co-registration




Nuth et al. 2011 -- **Fig. 1.** The elevation differences before co-registration (left) between ASTER DEMs in 2006 and 2002 from New Zealand (described in Sect. 5.2 and shown in Fig. 5) are remarkably similar to the hillshade of the DEMs (right). The location of the subsetted region is depicted in the 2006 ASTER image (center).

**Fig. 2.** Top: 2-D scheme of elevation differences induced by a DEM shift. Bottom: The scatter of elevation differences between 2 DEMs showing the relationship between the vertical deviations normalized by the slope tangent (y-axis) and terrain aspect (x-axis). The example is the DEM differences between the 2002 and 2003 DEM shown in Sect. 5. The equation for the solved sinusoidal curve fit is shown along with the three unknown solution parameters, a, b and c.



master 4 Branches 3 Tags Go to file t Add file Code

dshean dem_align: add check for projected CRS 8a49067 · 5 months ago 301 Commits

| | | |
|---|---|---|
| demcoreg | dem_align: add check for projected CRS | 5 months ago |
| docs | Update beginners_doc.md (#38) | 2 years ago |
| .gitignore | add docs | 8 years ago |
| LICENSE | Initial commit | 8 years ago |
| MANIFEST.in | Add MANIFEST.in | 8 years ago |
| README.md | Update README.md | 4 years ago |
| setup.py | setup.py update to version 0.5.0 | 5 years ago |

README License

DOI 10.5281/zenodo.7730376

# demcoreg

Python and shell scripts for co-registration of rasters, specifically horizontal and vertical alignment of digital elevation models (DEMs).

## Overview

All DEMs have some horizontal and vertical geolocation error. It is important to remove relative offsets when differencing DEMs for elevation change analyses. These tools offer several options to solve this problem. Most solve for the sub-pixel horizontal shift and vertical offset required to minimize errors over "static" control surfaces. The ASP `pc_align` tool can also solve for more complex transformations with rotations and scaling.

### About

Utilities for DEM and point cloud co-registration

Readme
MIT license
Activity
98 stars
16 watching
36 forks
Report repository

### Releases 3

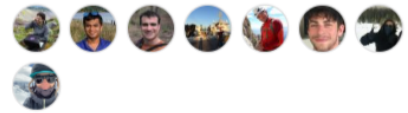
v1.1.1 Compatibility and doc imp... Latest
on Mar 13, 2023

+ 2 releases

### Packages

No packages published

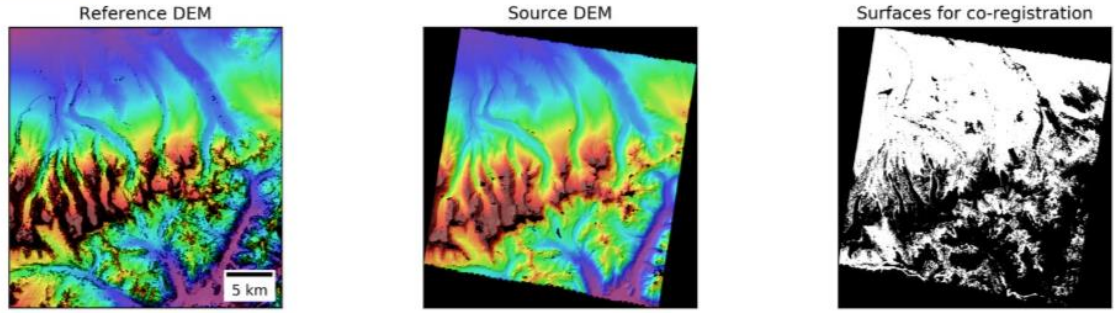
### Contributors 8

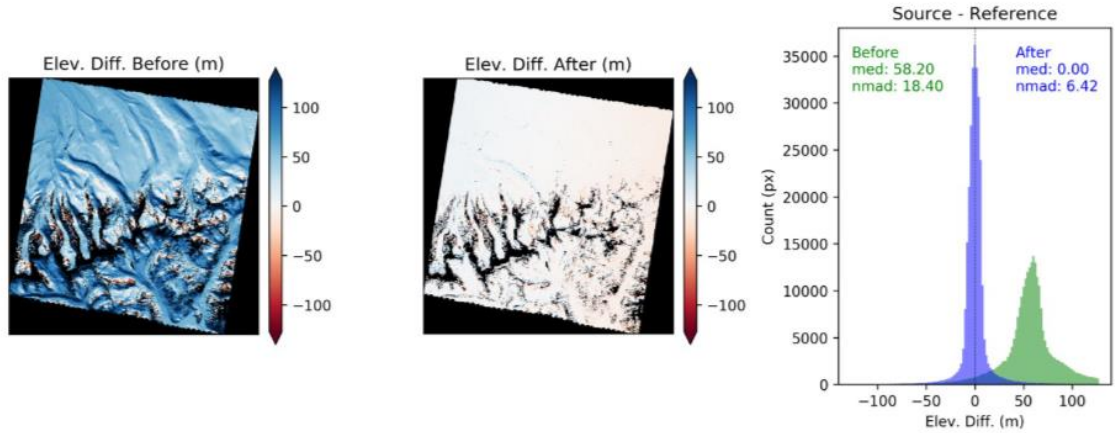


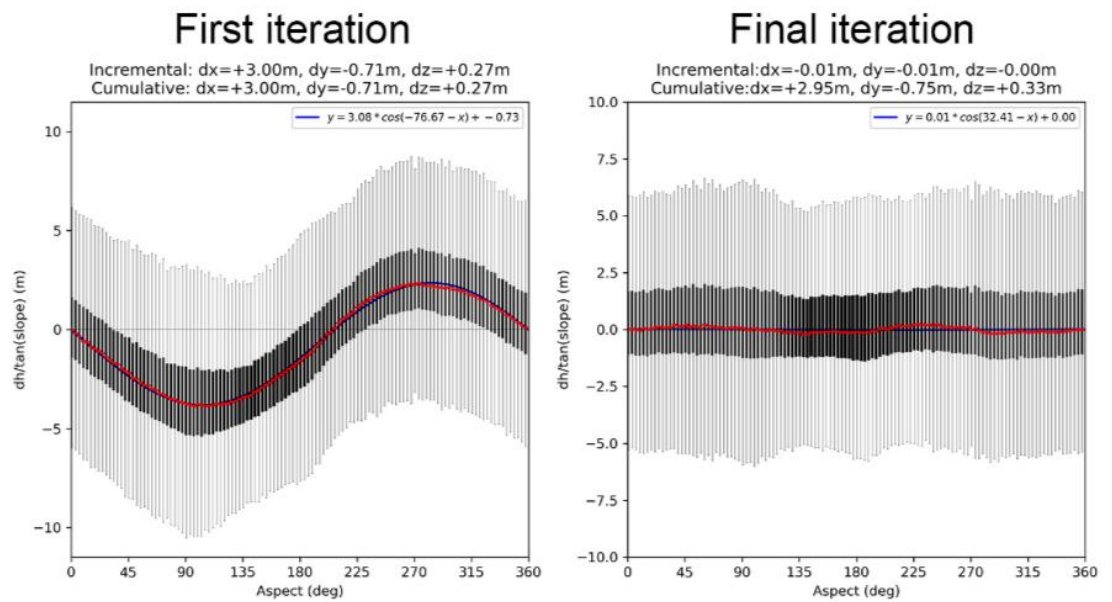
### Languages



Jupyter Notebook 70.3% Python 25.2%
Shell 4.5%

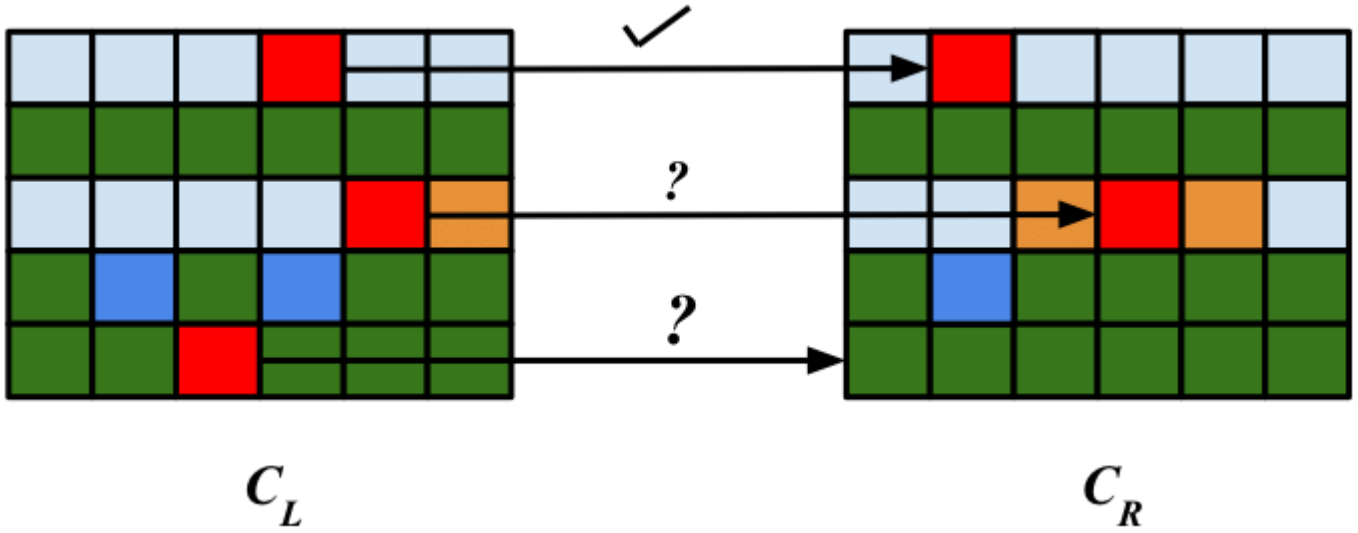

Reference DEM
5 km
Source DEM
Surfaces for co-registration


Elev. Diff. Before (m)
100
50
0
−50
−100
Elev. Diff. After (m)
100
50
0
−50
−100
Source - Reference
Before
med: 58.20
nmad: 18.40
After
med: 0.00
nmad: 6.42
Count (px)
35000
30000
25000
20000
15000
10000
5000
0
−100
−50
0
50
100
Elev. Diff. (m)


First iteration
Incremental: dx=+3.00m, dy=-0.71m, dz=+0.27m
Cumulative: dx=+3.00m, dy=-0.71m, dz=+0.27m
y = 3.08 * cos(−76.67 − x) + −0.73
dh/tan(slope) (m)
10
5
0
−5
−10
0
45
90
135
180
225
270
315
360
Aspect (deg)
Final iteration
Incremental:dx=-0.01m, dy=-0.01m, dz=-0.00m
Cumulative:dx=+2.95m, dy=-0.75m, dz=+0.33m
y = 0.01 * cos(32.41 − x) + 0.00
dh/tan(slope) (m)
10.0
7.5
5.0
2.5
0.0
−2.5
−5.0
−7.5
−10.0
0
45
90
135
180
225
270
315
360
Aspect (deg)

# Pixel matching

- Using patterns, we can match a given pixel between images.
- This is one of the basic principles behind photogrammetry.
- We can also match pixels over time.



# Image velocimetry

- Pixel tracking is increasingly used in hydrology to measure the surface velocity of rivers from video.
- The 3D geometry is complex and many assumptions need to be made.

- Rectification of Image Velocity Results (RIVeR): A simple and user-friendly toolbox for large scale water surface Particle Image Velocimetry (PIV) and Particle Tracking Velocimetry (PTV). Patalano et al. 2017

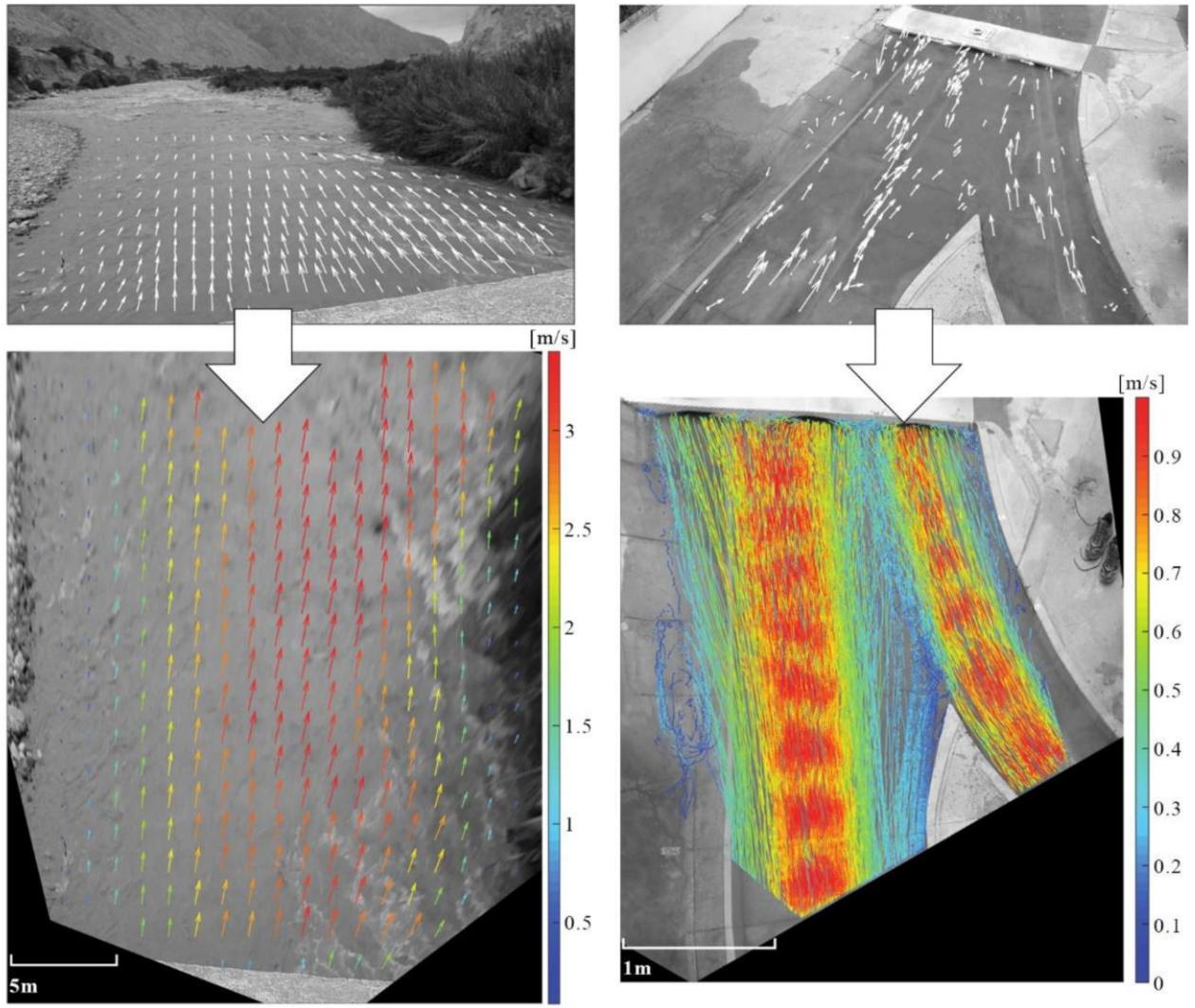
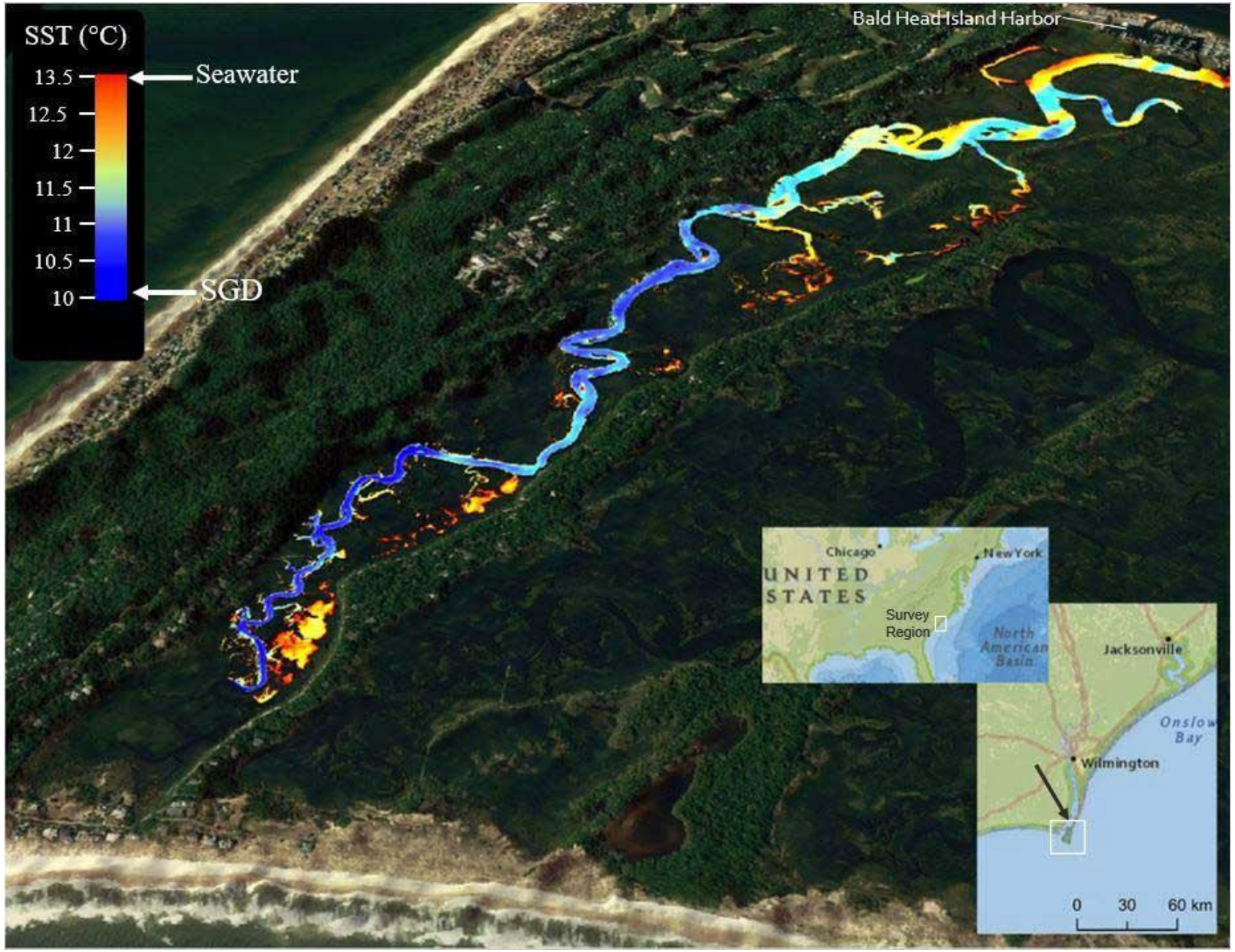
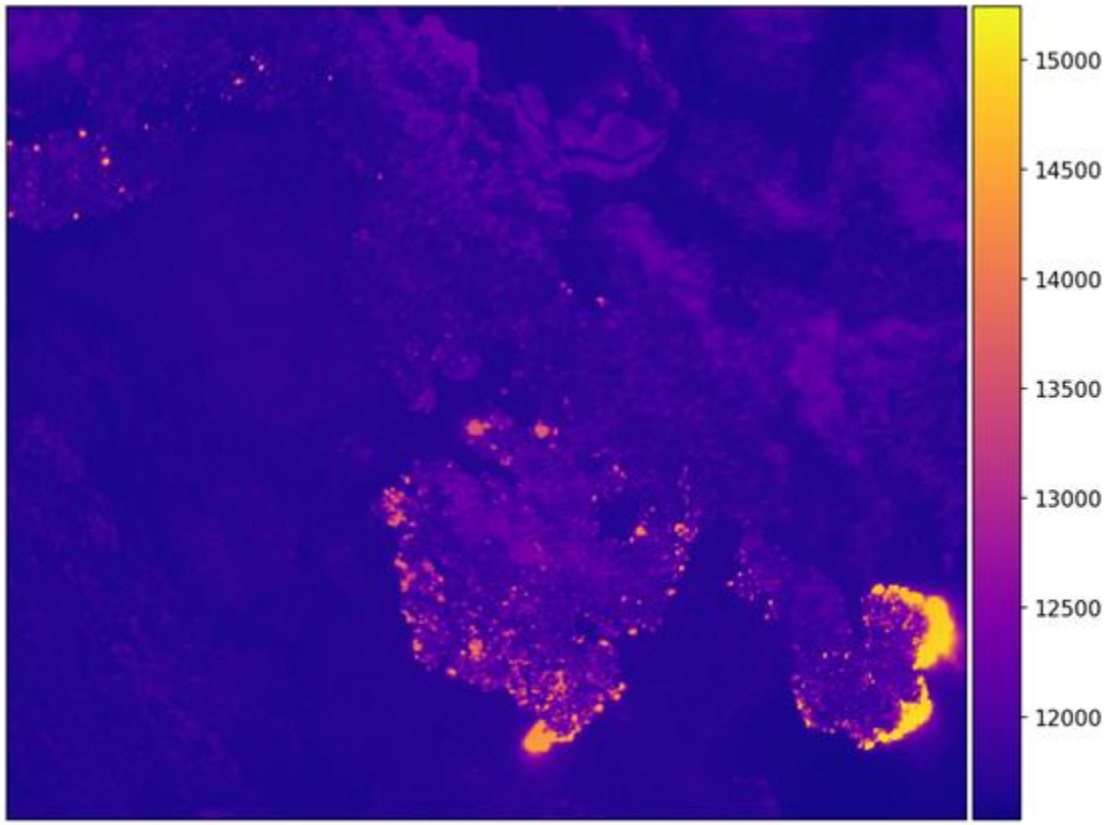



Fig. 5. Rectification results from LSPIV and LSPTV analysis using RIVeR. On the left-hand side: LSPIV, images

# Thermal drones

- ‘Skin’ temperatures, influenced by air temperature between the sensor and the target
- Many Industrial applications
- Search and rescue
- Useful for hydrology ☺

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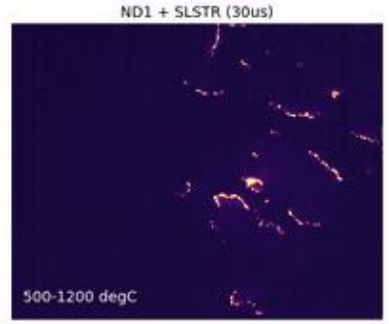
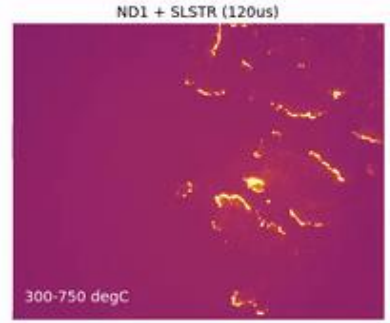
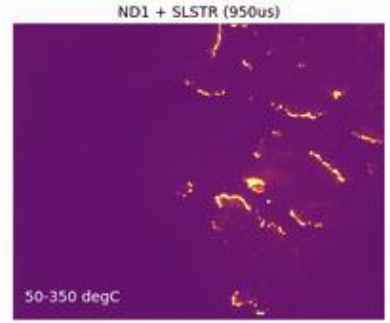
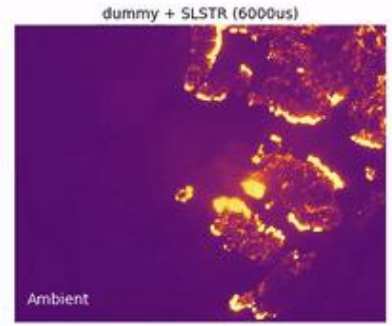
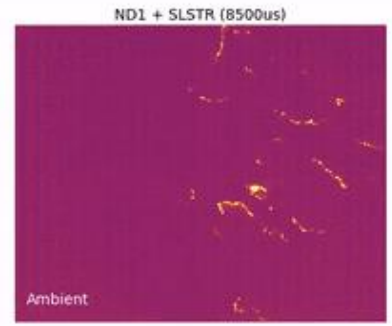
14500
14000
13500
13000
12500
12000


ND1 + SLSTR (30us)
500-1200 degC


ND1 + SLSTR (120us)
300-750 degC


ND1 + SLSTR (950us)
50-350 degC


dummy + SLSTR (6000us)
Ambient


ND1 + SLSTR (8500us)
Ambient

# Object Detection

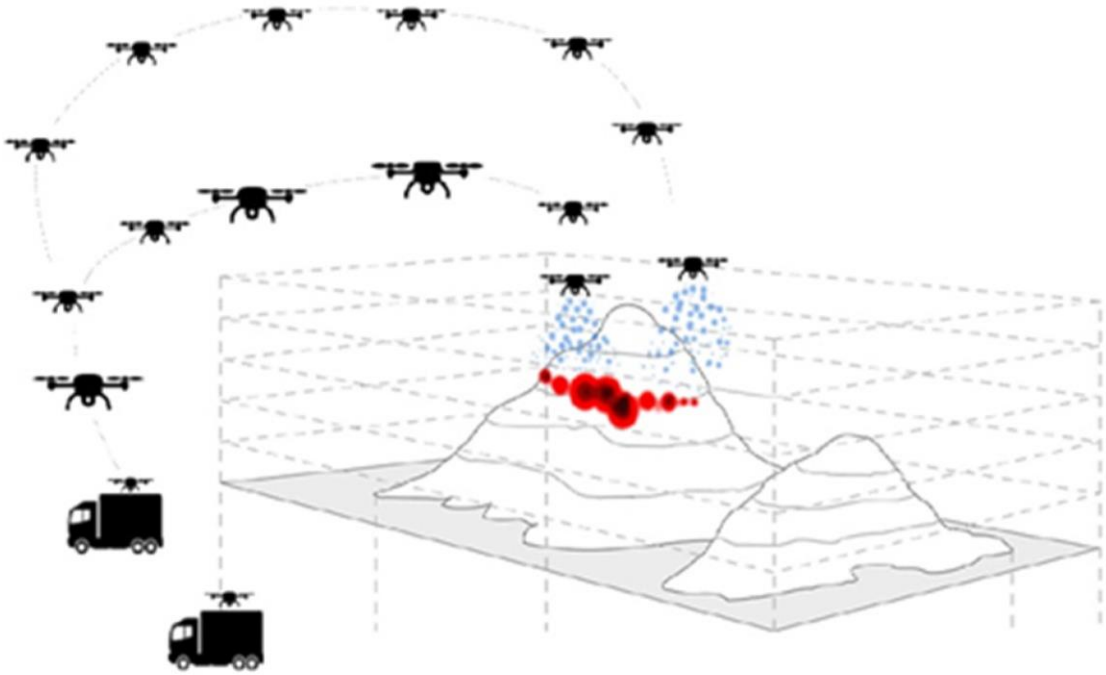
**Deep Drone: Object Detection and Tracking for Smart Drones on Embedded System**

Song Han, William Shen, Zuozhen Liu
*Stanford University*

Figure 3. Yolo detector performs not as well as Faster RCNN. When the target person is small, the detector fails.

# Drone Swarms

(a)



(b)

Drone Swarms in Fire Suppression Activities: A Conceptual Framework (Ausonio et al. 2021)

# The US Military Is Getting Smaller, Cheaper and Smarter

A new drone-swarm initiative called Replicator will use low-cost technology to counter China's massive arms buildup.

September 1, 2023 at 4:00 AM PDT

**By James Stavridis**

James Stavridis is a Bloomberg Opinion columnist, a retired US Navy admiral, former supreme allied commander of NATO, and dean emeritus of the Fletcher School of Law and Diplomacy at Tufts University.

South Korea has its own drone swarms. *Photographer: Yelim Lee/AFP/Getty Images*

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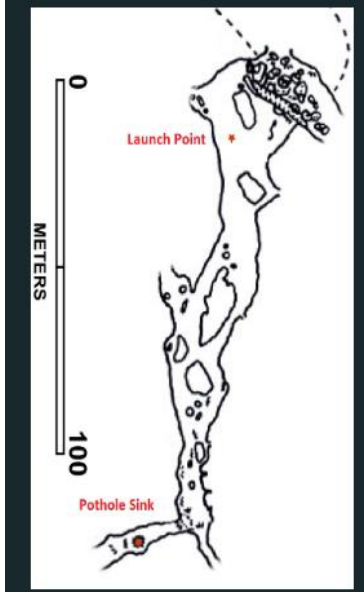
Tools

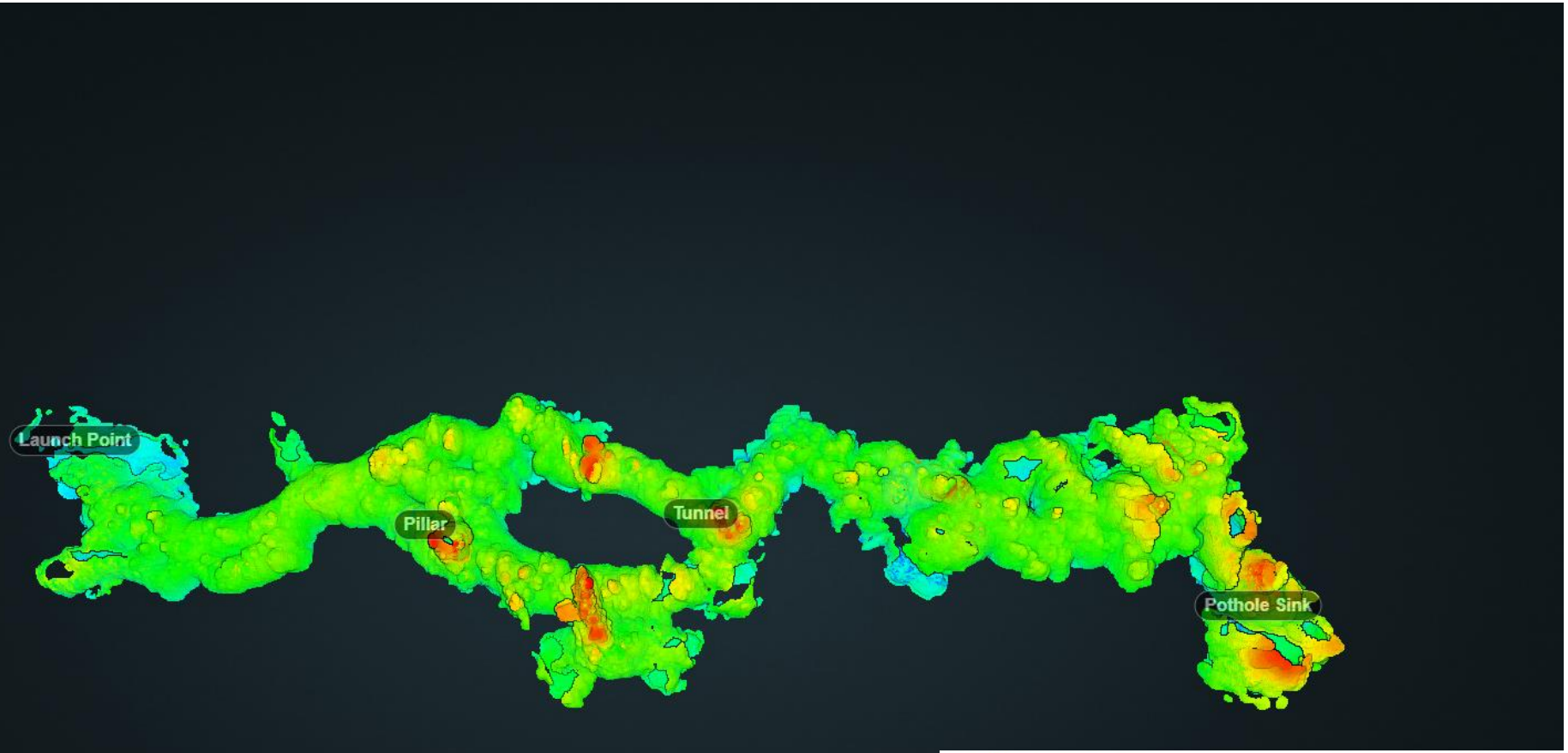
Scene

2-Dimensional Map




Marker Images

Launch Point





Inside the world's deepest caves

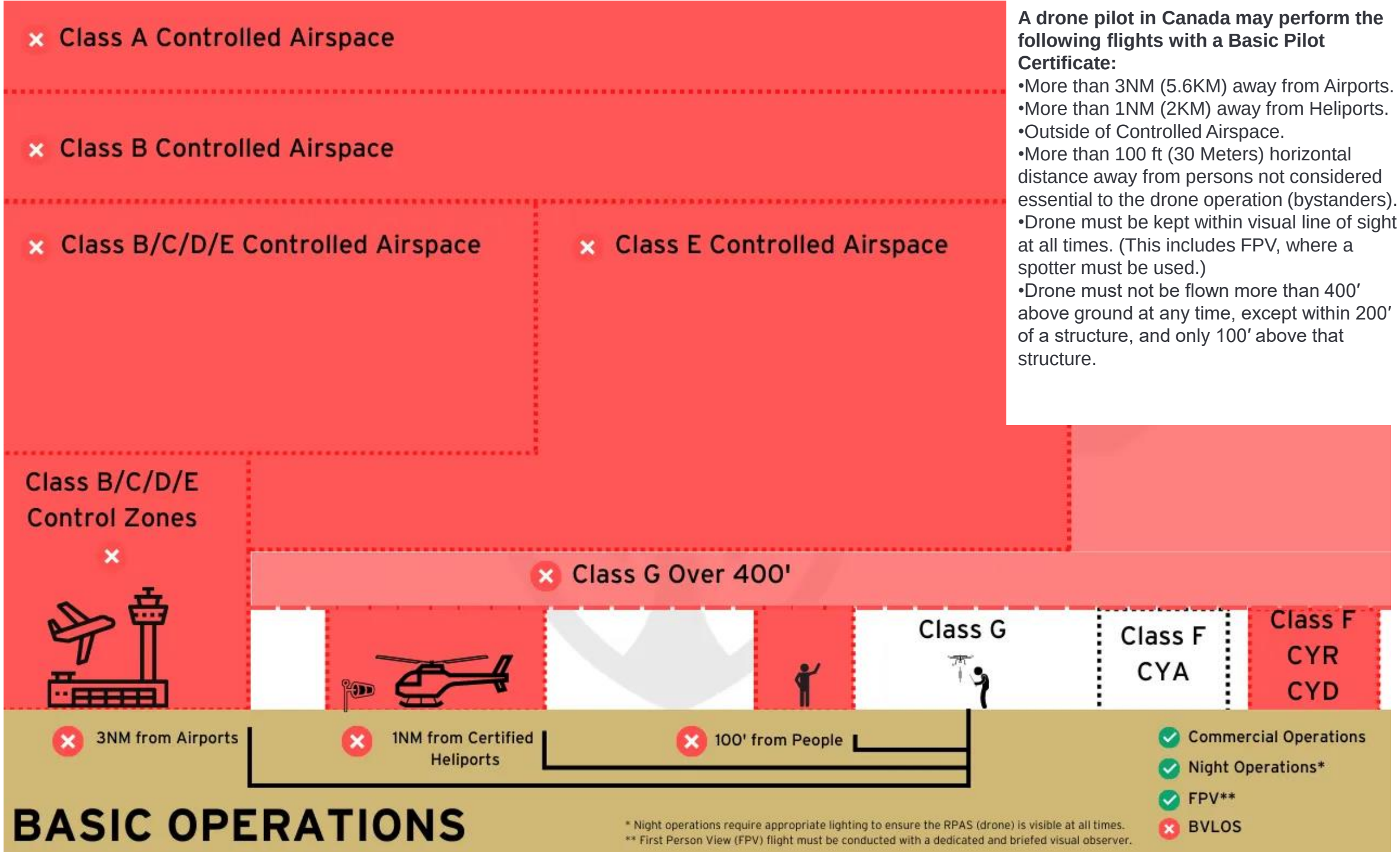
2,271,896 views | Bill Stone | TED2007 • March 2007

https://www.ted.com/talks/bill_stone_inside_the_world_s_deepest_caves
https://explore.stoneaerospace.com/interfaces/peacocksprings/peacocksprings.html

# Twig Sampling Method in BC by Unmanned Aerial Vehicle -UAV

# Planning

- *Airspace Awareness*: Understanding the regulatory environment.
- *NOTAMS*: Notices to Airmen for airspace information.
- *Log Book*: Recording flight details.
- *KP Index*: Solar activity affecting GPS accuracy.
- Pre-flight procedures
  - Airspace
  - NOTAMS
  - Log book
  - KP index




**A drone pilot in Canada may perform the following flights with a Basic Pilot Certificate:**

- More than 3NM (5.6KM) away from Airports.
- More than 1NM (2KM) away from Heliports.
- Outside of Controlled Airspace.
- More than 100 ft (30 Meters) horizontal distance away from persons not considered essential to the drone operation (bystanders).
- Drone must be kept within visual line of sight at all times. (This includes FPV, where a spotter must be used.)
- Drone must not be flown more than 400′ above ground at any time, except within 200′ of a structure, and only 100′ above that structure.

## Class A Controlled Airspace

*FL180 (18,000') and up, really, come on, why are you up here?*

## Class B Controlled Airspace

*12,500' to 17,999', why are you up here?*

## Class B/C/D/E Controlled Airspace

*Permission from NAVDrone not Required*
*Exercise extreme caution, CARS 900.06*

## Class E Controlled Airspace

*No-Contact, Typically 700' and up,*
*Exercise extreme caution, CARS 900.06*

## Class B/C/D/E Control Zones

*Permission from NAVDrone not Required, CARS 900.06*

*Above 400', CARS 900.06, but not recommended.*

Class G - Uncontrolled Airspace

Class F CYA

Class F CYR CYD

- 3NM from Airports
- 1NM from Certified Heliports
- Over People
- 16.5' from People
- 100' from People

- Commercial Operations
- Night Operations*
- FPV**
- BVLOS

# MICRO DRONES

Over-People operations must exercise caution.
* Night operations still require appropriate lighting to ensure the RPAS (drone) is visible at all times.
**** First Person View (FPV) flight should be conducted with a dedicated and briefed visual observer.**

## Class A Controlled Airspace

*FL180 (18,000') and up, SFOC Required*

## Class B Controlled Airspace

*12,500' to 17,999', SFOC Required*

## Class B/C/D/E Controlled Airspace

*Permission from NAVDrone Required*

## Class E Controlled Airspace

*No-Contact, Typically 700' and up, SFOC Required*

## Class B/C/D/E Control Zones

*Permission from NAVDrone Required*

*Above 400', SFOC Required*

## Class G - Uncontrolled Airspace

## Class F CYA

## Class F CYR CYD

3NM from Airports

1NM from Certified Heliports

Over People

16.5' from People

100' from People

- Commercial Operations
- Night Operations*
- FPV**
- BVLOS

# ADVANCED OPERATIONS

Over-People operations requires a sufficient manufacturer's safety declaration.

* Night operations require appropriate lighting to ensure the RPAS (drone) is visible at all times.

** First Person View (FPV) flight must be conducted with a dedicated and briefed visual observer.