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Cliff change detection using Siamese KPConv deep network on 3D point clouds

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1. Motivations

Context:

- Cliffs cover **52%** of the world's coastline [1]
- Cliff **erosion likely to increase** with sea level rise [2]
- Endangering** nearby populations and infrastructures

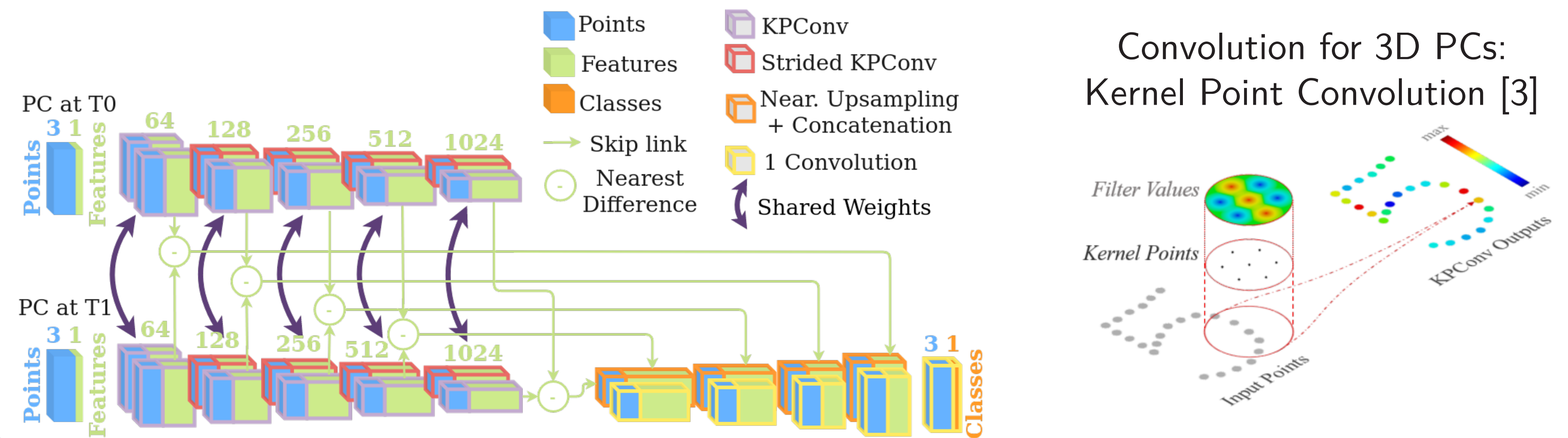
Challenges:

- Working **directly on raw 3D point clouds** to avoid the loss of information when rasterizing the vertical cliffs
- Randomness of natural cliffs** (unlike buildings in urban areas)
- Being able to **study vertical** or very steep **cliffs**

2. Objectives

Explore the efficiency of **Siamese KPConv deep learning** algorithm over raw 3D point clouds (PCs) for **change detection** and categorization on **coastal cliff faces**.

3. Siamese Kernel Point Convolution Network [4]



4. Study area



Petit Ailly cliffs are rocky limestone cliffs in Varengeville-sur-Mer (Normandy, France), 40 m high and monitored since 2010 every 4-5 months. Figure modified from [5]

5. Data

5 different 3D point clouds derived from 2 methods...

Terrestrial Laser Scanning (TLS):

Riegl® VZ-400

- Accuracy: 5 mm
- Precision: 3 mm (at a range of 100 m)

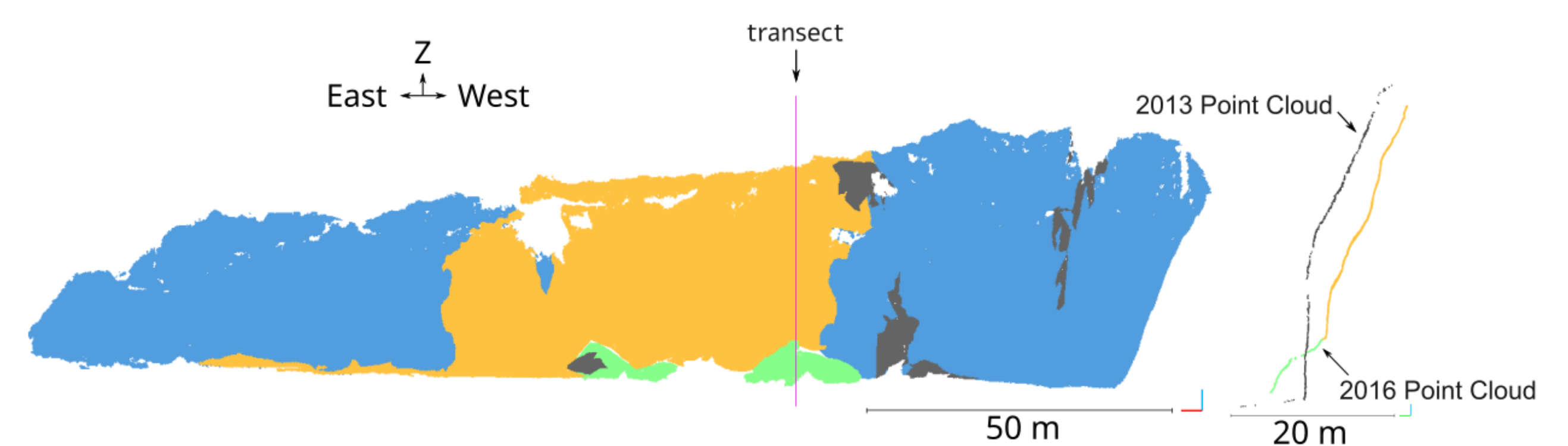
Terrestrial Photogrammetry (TP):

Nikon D800 reflex camera

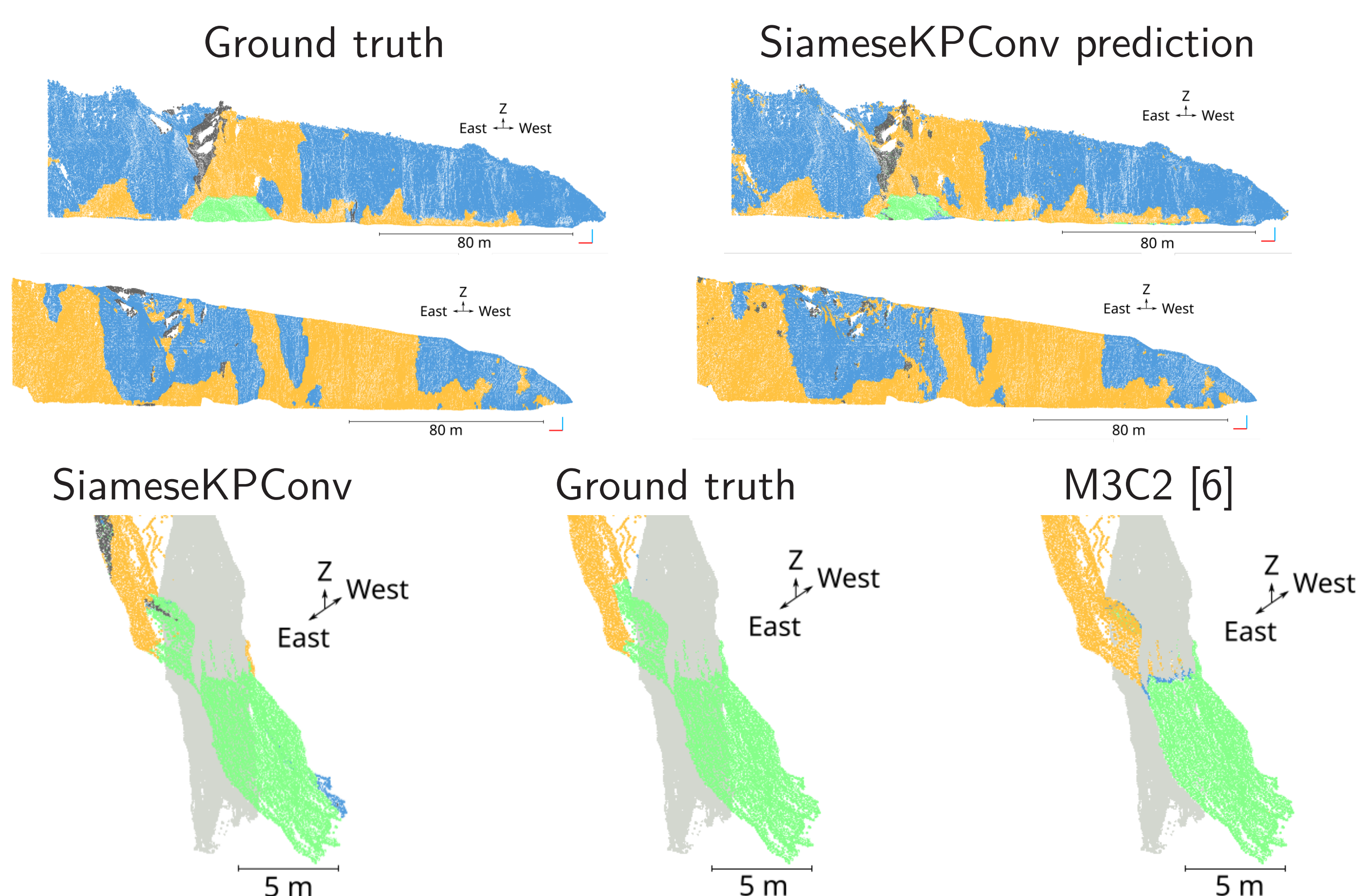
- 35 mm focal length
- Overlap > 60%
- Camera positions close to each other and > 20 m from cliff face

... Forming **4 pairs** of PCs, **manually annotated** by 3 experts.

- Unchanged
- Erosion
- Accumulation
- No data to compare



6. Results



● Older point cloud

	Per class IoU(%)			mIoU _{int}
	Unchanged	Erosion	Accum.	
Siamese KPConv	91.94	83.86	70.28	82.03
M3C2 + threshold	95.06	87.23	48.20	68.12

7. Conclusion

- First study** experimenting a **deep learning** method on **vertical cliffs** without rasterization of PCs for **3D change detection**
 - 82.03%** of mIoU over 3 classes of interest (unchanged area, erosion and accumulation)
- ⇒ **Experimenting** with the Siamese KPConv algorithm on 3D point clouds **from satellite stereo-restitution with lower density** (~ 2.7 pts/m² with Pléiades images)
- ⇒ **Automation of the monitoring of coastal changes**, advocated by governments and coastal observatories in order to improve the management of the associated risks

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