



HAL
open science

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

Iris de Gélis, Zoé Bessin, Pauline Letortu, Marion Jaud, Christophe Delacourt, Stéphane Costa, Olivier Maquaire, Robert Davidson, Thomas Corpetti, Sébastien Lefèvre

► To cite this version:

Iris de Gélis, Zoé Bessin, Pauline Letortu, Marion Jaud, Christophe Delacourt, et al.. Cliff Change detection using Siamese KPConv deep network on 3D point clouds. ISPRS Congress, Jun 2022, Nice, France. , 55, pp.457 - 476, 2022. hal-03707448

HAL Id: hal-03707448

<https://hal.science/hal-03707448v1>

Submitted on 29 Jun 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

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

I. de Gélis^{1,2*}, Z. Bessin^{3,4*}, P. Letortu⁴, M. Jaud^{5,3}, C. Delacourt³, S. Costa⁶, O. Maquaire⁶, R. Davidson⁶, T. Corpetti⁷ and S. Lefèvre²

¹ Magellium, F-31000 Toulouse, France

² IRISA UMR 6074, Université Bretagne Sud, F-56000 Vannes, France - iris.de-gelis@irisa.fr

³ Geo-Ocean - UMR 6538, Univ Brest, CNRS, F-29280 Plouzané, France - zoe.bessin@univ-brest.fr

⁴ LETG - UMR 6554, Univ Brest, CNRS, F-29280 Plouzané, France

⁵ European Institute for Marine Studies (IUEM) - UMS 3113, Univ Brest, CNRS, F-29280 Plouzané, France

⁶ IDEES - UMR 6266, Normandie Univ, UNICAEN, CNRS, F-14000 Caen, France

⁷ CNRS, LETG UMR 6554, F-35000 Rennes, France



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

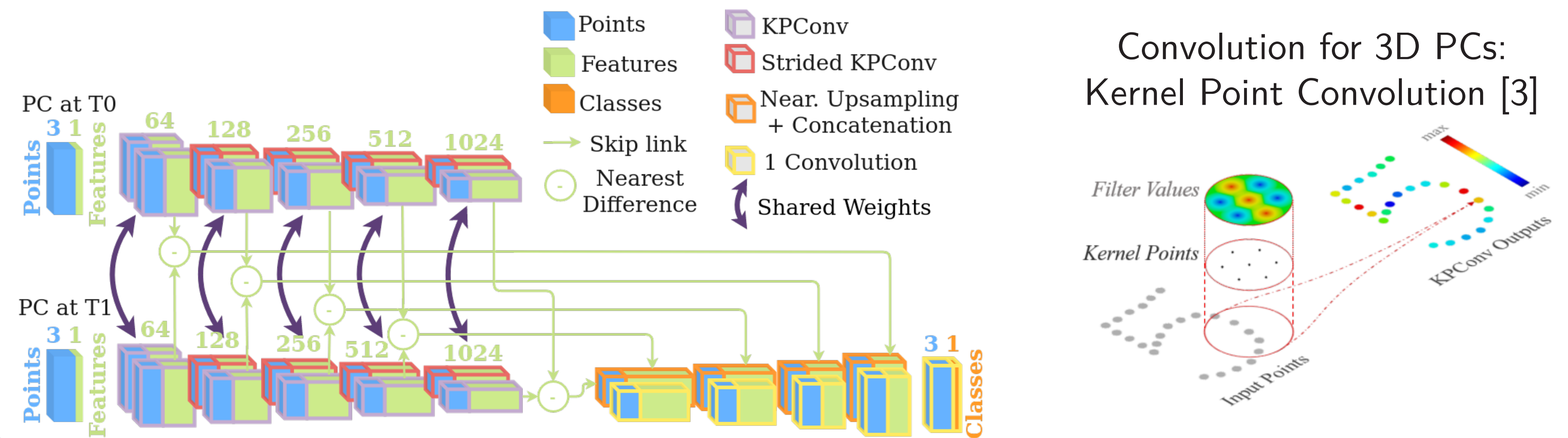
Challenges:

- 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)

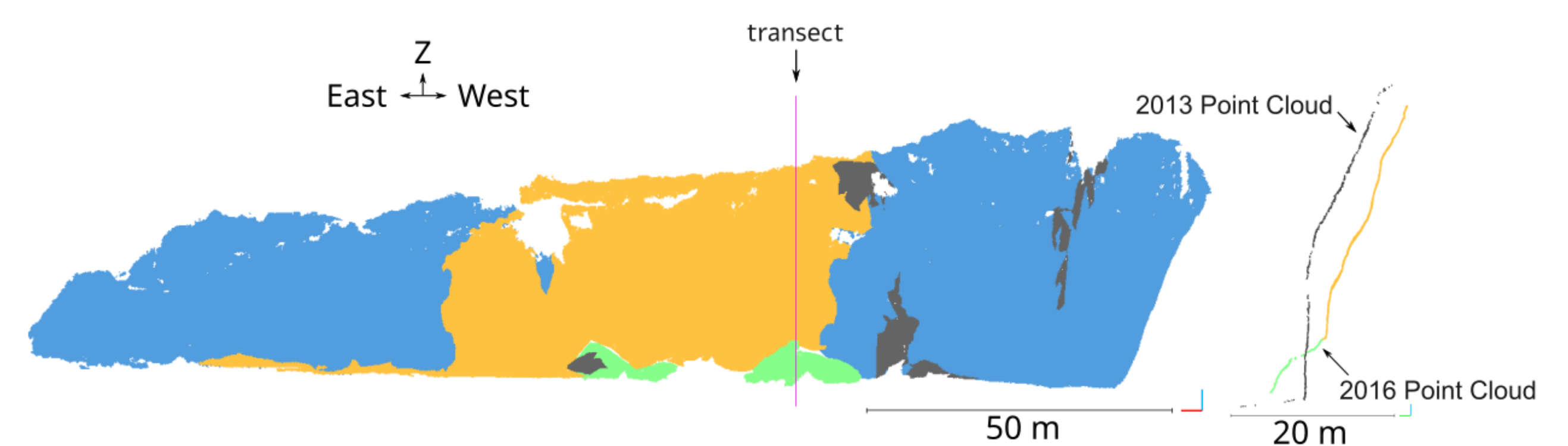
Terrestrial Photogrammetry (TP):

Nikon D800 reflex camera

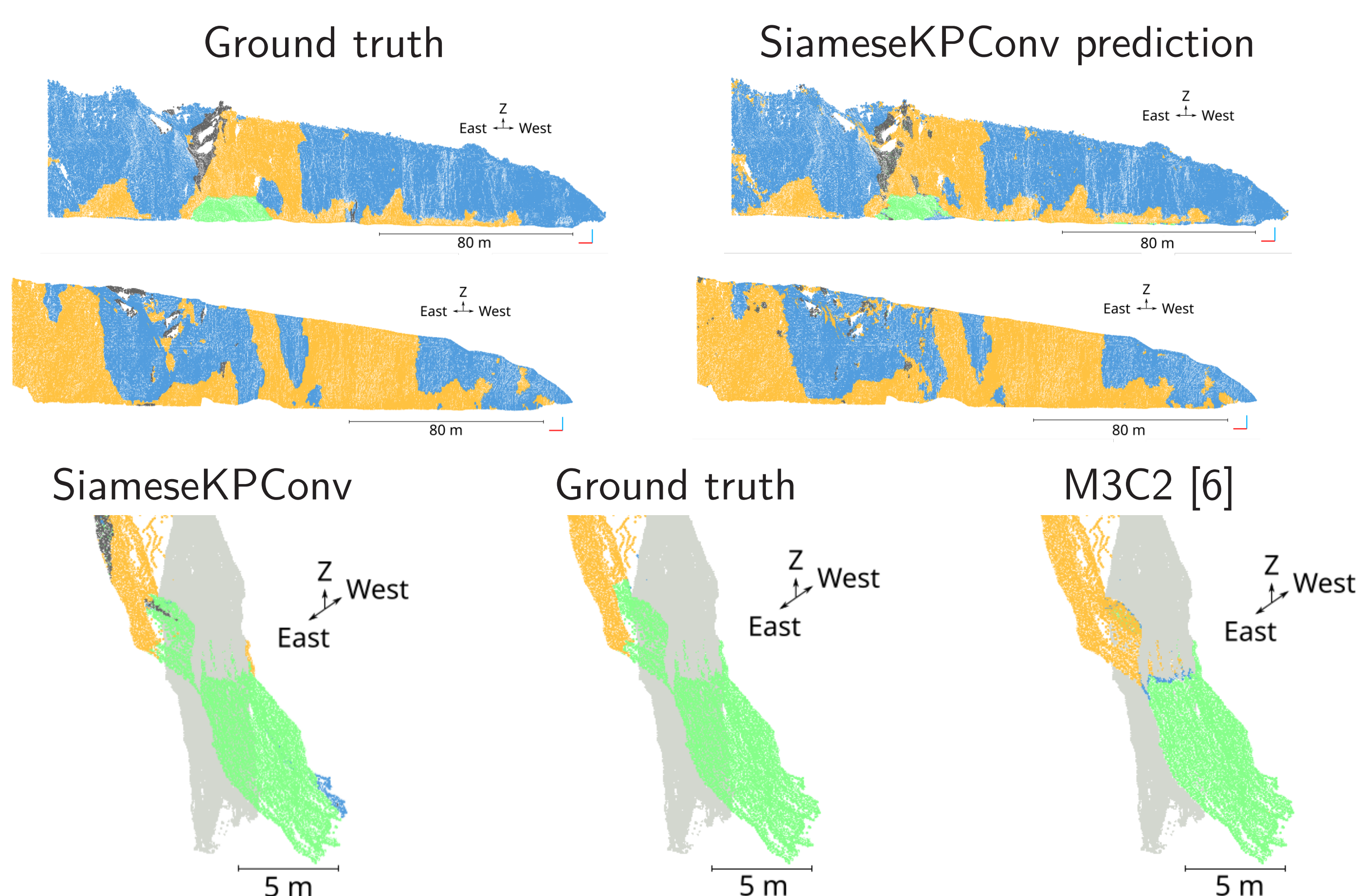
- 35 mm focal length
- Overlap > 60%
- Camera positions close to each other and > 20 m from cliff face

... 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

References

- [1] Adam P Young and Jessica E Carilli. Global distribution of coastal cliffs. *Earth Surface Processes and Landforms*, 44(6):1309–1316, 2019.
- [2] Richard P Allan, Ed Hawkins, Nicolas Bellouin, and Bill Collins. *Ipcc, 2021: Summary for policymakers*, 2021.
- [3] Hugues Thomas, Charles R Qi, Jean-Emmanuel Deschaud, Beatriz Marcotequi, François Goulette, and Leonidas J Guibas. Kpconv: Flexible and deformable convolution for point clouds. In *Proceedings of the IEEE/CVF International Conference on Computer Vision*, pages 6411–6420, 2019.
- [4] Iris de Gélis, Sébastien Lefèvre, and Thomas Corpetti. 3d urban change detection with point cloud siamese networks. *ISPRS-International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 43: 879–886, 2021.
- [5] Pauline Letortu, Marion Jaud, Philippe Grandjean, Jerome Ammann, Stephane Costa, Olivier Maquaire, Robert Davidson, Nicolas Le Dantec, and Christophe Delacourt. Examining high-resolution survey methods for monitoring cliff erosion at an operational scale. *Gi-science & Remote Sensing*, 55(4):457–476, 2018. ISSN 1548-1603. doi: 10.1080/15481603.2017.1408931.
- [6] D. Lague, N. Brodu, and J. Leroux. Accurate 3D comparison of complex topography with terrestrial laser scanner: Application to the rangitikei canyon (NZ). *ISPRS Journal of Photogrammetry and Remote Sensing*, 82:10–26, 2013.

ISPRS Congress – Nice – June 6-11th, 2022