Update to Scientific Applications of Unmanned Vehicles in Svalbard (UAV Svalbard Update)

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1. Introduction

This report is an update to a previous chapter focussing on the scientific application of unmanned vehicles in Svalbard, published in the 3rd SESS report for 2020 (Hann et al. 2021). This chapter serves two main purposes. The first is to give an updated overview of the scientific literature that utilises unmanned vehicles in Svalbard. Even though only one year has passed since our previous report, a substantial number of relevant articles have been published. A total of 15 new articles published between August 2020 and 2021 are added in this update to the original literature database, which contained 49 entries. The high number of recent publications in this field highlights the great importance and large potential of unmanned systems for scientific applications in Svalbard.

The second objective of this chapter is to examine the new drone regulations and their application in Svalbard. The new EU-wide drone regulations have been gradually introduced throughout 2021 and will completely replace the existing Norwegian drone laws from 2022 onwards. This chapter describes the main rules applying to scientific unmanned aerial vehicle (UAV)[1] missions in Svalbard and givs practical information on how to operate drones in Svalbard according to the new rules. The information is intended for Norwegian and non-Norwegian operators.

2. Method

The literature review follows the same method used for the original chapter (Hann et al. 2021). Relevant publications were identified in Google Scholar by using a combination of the following keywords: Svalbard, Spitsbergen, UAV, UAS, RPAS, drone, unmanned, vessel, ASV, ROV, AUV. This literature review identified 15 new articles which were published after the cut-off date for the previous literature review in August 2020. In addition, two older articles were discovered that had been missed in the original literature view. All publications were categorised according same identifiers as in the 3rd SESS report (Hann et al. 2021).

3. Database update

Appendix 1 shows all publications that have been included in the database, along with a few selected characteristics. The updated full database with additional characteristics is available as literature list (SESS UAV Database, 2021) and as searchable database[2]. Of the 15 publications, only three used unmanned marine vehicles. For this reason, the emphasis in the following section will be on aerial systems.

3.1. Publication dates

The original literature review identified 49 publications in the period from 2007-2020. During one year, from August 2020 till August 2021, a total of 13 publications using UAVs in Svalbard have been published. Two additional publications from 2015 and 2017, that were missed in the original report, were also added. Figure 1 shows the number of publications over the total review period. The large number of publications in 2021 has to be seen in the context of the COVID-19

1 *Note: Following the terminology of the original chapter, the terms "UAV" and "drone" are used synonymously. Other common terms are remotely piloted aircraft system (RPAS), unmanned aerial system (UAS), unoccupied aerial vehicle, or uncrewed aerial vehicle.*
2 https://sios-svalbard.org/UAV_Svalbard

pandemic which prevented many field activities in that year (Jawak et al. 2021). Indeed, the work published in 2021 typically uses data that has been collected in the last 2-3 years. A sensible hypothesis could be that many scientists used the pandemic effectively to publish older datasets. The full effects of the pandemic on fieldwork in Svalbard, especially with respect to long-term monitoring, are not fully captured yet.

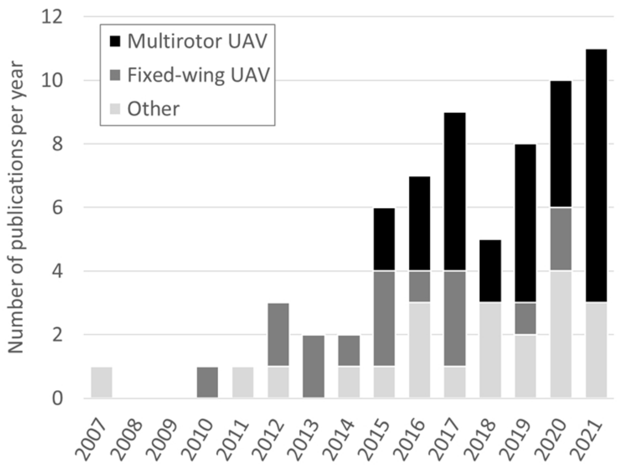

Figure 1: Overview of the number of publications using UAVs in the updated dataset. Other systems referring to unmanned marine systems.

3.2. Type of operation

The data in Figure 1 also show that the use of multirotor UAVs has been high since 2015, while fixed-wing UAVs are used substantially less. Indeed, all publications in 2021 involved use of multirotor UAVs. Of these, all were commercially available drones, most belonging to the Phantom or Mavic series from DJI. This underlines one of the main conclusions of the chapter in the previous SESS report about basic drone operations being an increasingly important research method in Svalbard (Hann et al. 2021). These basic operations use off-the-shelf multirotor systems that can be purchased at a relatively low cost. Drones provide a birds-eye perspective to capture visual images that are mostly processed using photogrammetric methods (structure from motion) to generate digital elevation models (DEMs) and orthomosaic maps. Such products are useful for a wide range of scientific applications, such as geomorphology, ecology, atmospheric sciences, oceanography, glaciology, and more.

Another observation in the updated dataset was that several publications included contained inadequate descriptions of the methods used, and that key information was often omitted. This ranged from missing information about the exact UAV system, to lack of detail about post-processing software. As outlined in the previous SESS report, it is important to include sufficient information about the method in order to ensure scientific quality (transparent and reproducible method). This situation highlights the importance of having an active discussion in the scientific community and developing a standardised way to report drone-based results.

3.3. Map

Figure 2 shows the updated map of the sites in Svalbard where unmanned systems have been used to gather data that were subsequently subjected to peer reviewed publications. Most of the studies published within the last year focus on the existing clusters around Longyearbyen/Adventdalen, Pyramiden/Billefjorden, and Ny-Ålesund/Kongsfjorden. This confirms the trends already seen in the last report. The large number of studies that are co-located and possibly cover overlapping study areas opens up a substantial potential for establishing long-term monitoring. This potential was identified in the previous report, where recommendations were formulated intending to increase collaboration within the community. The recent publications reaffirm this opportunity and emphasise the need for more discussions and cooperation.

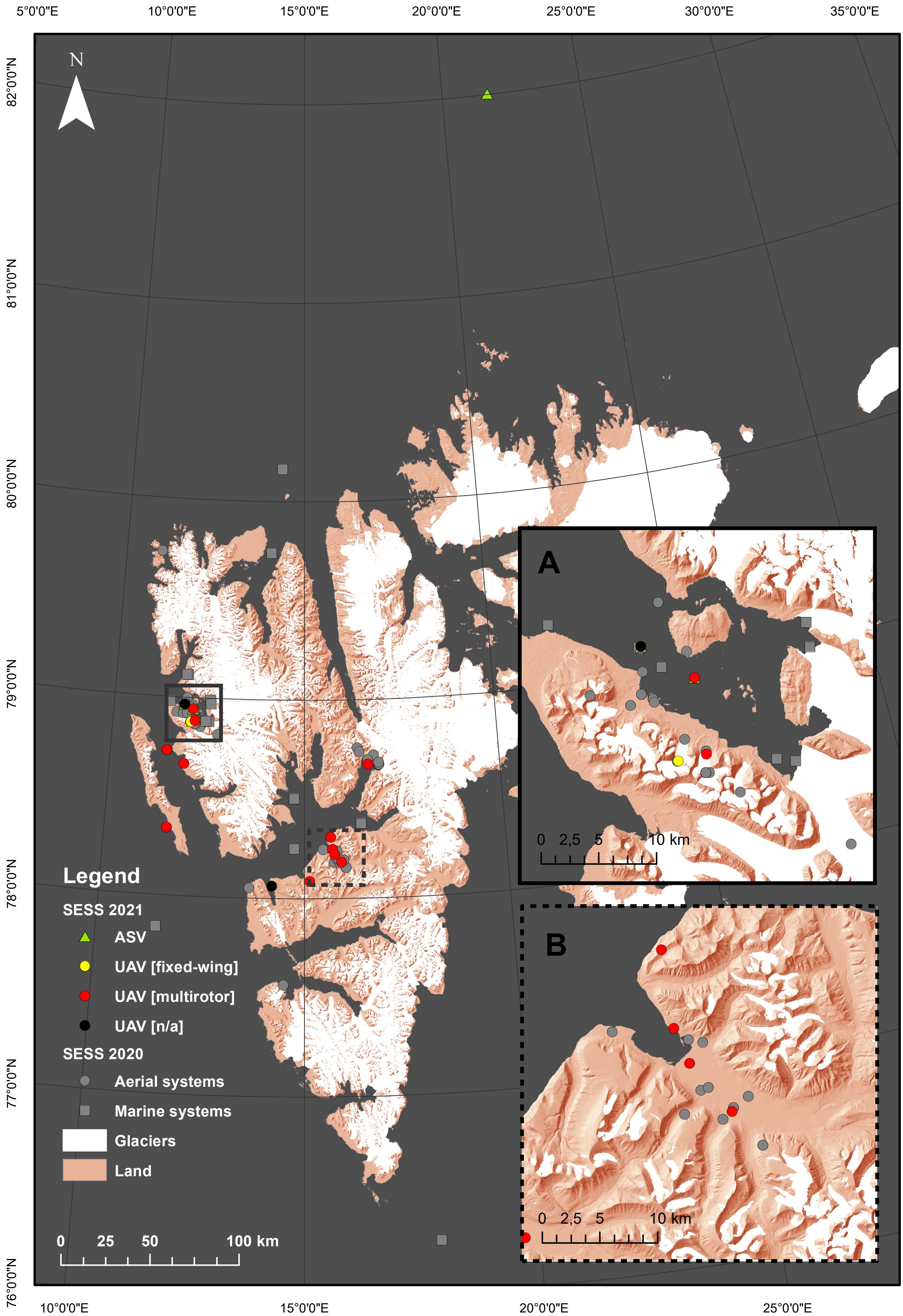

Figure 2: Location of study sites: A: Kongsfjorden region; B: Adventdalen region; ASV - Autonomous Surface Vehicle, UAV - Unmanned Aerial Vehicle.

4. New EU regulations

Until 2020, drone operations in Svalbard were regulated by the Norwegian Civil Aviation Authority (CAA, Norwegian: Luftfartstilsynet). Starting in 2021, new regulations from the European Union Aviation Safety Agency (EASA) were implemented EU-wide. These also apply in Norway and Svalbard. The old Norwegian rules are gradually being replaced with the new EU regulations during a transition period from 1 January 2021 to 31 December 2021. From 2022 onwards, the new EU drone regulations apply in full force in Svalbard.

There are several significant differences between the old rules and the new EU regulations that affect drone operations in Svalbard. The following section is intended to give an outline of how the new regulations affect basic drone operations in Svalbard. Note that it is each drone operator's responsibility to follow the correct regulations and this text is intended as guidance only. For further reading, we recommend the following online resources: www.luftfartstilsynet.no/en/drones, www.flydrone.no, and www.easa.europa.eu/domains/civil-drones-rpas.

4.1. EU regulation framework

The new rules are specified in EU Regulation 2019/947 and EU Regulation 2019/945. Drone operations are classified into 'open', 'specific', and 'certified' categories, see Appendix 2. Differences are mainly related to drone type, maximum altitude, and proximity to uninvolved persons. For scientific operations in Svalbard, the most important categories are 'open' and 'specific'. The old operations types (RO1, RO2, and RO3) are transitioning into these categories. A new rule is that drones will be required to have a CE marking ('Conformité Européenne'). Drones will be assigned a CE-marking with a number between 0 and 6 (C1, C2, ..., C6), depending on their weight and technical equipment. For certain missions or operation categories, drones may require a specific CE-marking. The exact regulations around the CE-markings are still under development but are expected to be implemented by 1 January 2023.

4.2. Rules for basic drone operations

Basic drone operations are mostly covered within the open category; there are several subcategories in open, which are shown in Appendix 3. In simple terms, the categories can be translated into:

- A1: Small drones under 250 g
- A2: Fly drones close to people
- A3: Fly drones far from people

The majority of drone operations in Svalbard are basic flights with commercial off-the-shelf rotary drones and within visual line of sight (VLOS) conditions in remote areas far from people (Hann et al. 2021). Under the new EU regulations, these types of operations will be covered within the A3 category. The following limitations are important for this type of operation:

- Pilots need to be registered and have a valid EASA certificate of competency and have read the user manual.
- The maximum drone weight is 25 kg.
- The operator must have valid liability insurance for the drone in accordance with Regulation (EC) No 758/2004, covering at least 9.2 million NOK.
- The drone must be marked with the operator registration number.
- No uninvolved persons[3] are allowed in the area of flight operations.
- Generally, the 1:1 rule should be followed, i.e. the horisontal distance between the drone and uninvolved persons should be at least the same as its altitude (e.g. if the drone flies at 50 m altitude, it should keep a horisontal distance of 50 m to uninvolved persons).
- A distance of 150 m to residential, commercial, industrial, or recreational areas must be maintained.
- Operations must be conducted only with continuous and unaided visual contact, i.e.

3 *An uninvolved person is a person who is not participating in the drone operation or who is not aware of the instructions and safety precautions given by the drone operator.*

VLOS. The drone and surrounding airspace must be visible at all times and may not be obstructed by fog, clouds, terrain, smoke, buildings, etc. A remote observer situated alongside the pilot may assist in this task.
- The maximum altitude is 120 m from the closest point of the earth.
- No-fly zones must be respected. In Svalbard, the most important no-fly zones are within a 5 km-distance from the airports in Longyearbyen and Svea and within a 20 km distance around the settlement of Ny-Ålesund (radio silence). Operations in these areas are forbidden but may be authorized upon request.
- Drones must not carry dangerous payloads or drop items.
- It is forbidden to disturb wildlife.
- Operations must be discontinued if a risk to other aircraft, people, wildlife, environment or property arises.
- Operations at night are possible if the drone is visible (VLOS). This requires lights on the drone. From 1 July 2022 drones will be required to have a green flashing light when flying at night.
- Drones do not need to be labelled with a CE-marking.
- Drone operations involving several pilots are required to have an operation manual that includes operation procedures and a list of all personnel and their responsibilities. Persons acting as operators and pilots do not require an operation manual.
- Automatic operations, where the drone follows pre-determined flight paths, are allowed. For these missions, the remote pilot needs to be able to take control of the drone at any moment in case of unforeseen events.
- Note that a proposed amendment to the Svalbard Environmental Protection Act may introducee strict drone access rules in protected areas in Svalbard (Miljødirektorat 2021).

For drone operations that require closer distance to uninvolved persons, the subcategory A2 is required. Within this subcategory, drones can approach uninvolved persons to a minimum horizontal distance of 30 m. Drones with a low-speed function (max. speed 3 m/s) can fly as close as 5 m. The A2 subcategory allows a maximum drone weight of 2 kg. Drones need to be marked with a CE-marking, issued by the producer. After 31 December 2022, all drones without CE-marking will be considered as 'legacy'-class. Unmarked legacy-class drones can only be operated in subcategory A3 from 2023 onward.

The largest difference between the old rules and the new EU regulations is the dropped distinction between private and commercial operations and the added requirement of EASA-competency certification. Furthermore, the definition of altitude has changed and now encompasses the distance measured from the closest point of the earth (e.g. this can be a vertical cliff). In addition, there are changes in the minimum distances to uninvolved persons.

4.3. Norwegian drone operators

The following rules apply to all drone operators from Norway. Pilots who have previously been certified under RO1/RO2/RO3 must fulfill the same requirements as new operators. In other words, after 1 January 2022, all previous certification is obsolete and all drone operators must fulfill the following:
- All operators and pilots must register online (www.flydrone.no), even if they have previously been certified RO operators. Annual fee 180 NOK for private persons and 2 000 NOK for companies.
- Online training courses for A1/A3 must be completed. These are free of charge.
- A basic online exam must be taken for A1/A3. A passing grade is valid for five years. Free of charge.
- Operators must have liability insurance and drones must be marked with operator registration numbers.
- A2 operations require first passing a theoretical exam for A2. In Norway, the exam can be taken at and costs 1,400 Driver and Vehicle Licensing Offices for 1 400 NOK (2021). The old 'drone exam' for RO2/RO3 is no longer sufficient. In addition, practical self-training must be completed. The operator needs to declare that they can perform basic flight manoeuvers (take-off, landing, etc.).

4.4. Non-Norwegian drone operators

For operators that are not registered as such in Norway and want to fly drones in Svalbard the following regulations apply. Citizens of EASA member states[4], must be registered as drone operators in their home country with a valid EASA A1/A3 or A2 certificate of competency. The process of obtaining this certificate of competency is typically the same as in Norway (see above). For operators that are registered in an EASA member country, it is not necessary to register in Norway in order to fly in the open category. In short, all pilots that are allowed to fly open category in an EASA member state can fly open category in Svalbard.

Citizens of non-EASA-member states and people who are not registered as drone operators in an EASA member state, must register in Norway (flydrone.no) and follow the same rules as Norwegian drone operators (see above). Online courses, practical self-training, and exams are all available in English.

Note that insurance requirements may vary within EASA member countries. In Norway, all drones (except CE-marked toys) must have third-party liability insurance according to Regulation (EC) No 758/2004. Other countries may not require insurance for lighter drones.

4.5. Rules for advanced drone operations

Advanced drone operations in Svalbard, typically involving flight above 120 m altitude and beyond visual line of sight (BVLOS), are covered under the 'specific' category. Operations in this category entail higher risk and operators require approval from the Norwegian CAA. Approval can be granted via four different processes:

- Standard Scenario (STS): EASA has defined (currently only two) standard scenarios of operations. Operators who use STS can declare this to the Norwegian CAA for approval. STS-01 covers VLOS flights below 120 m in populated areas. STS-02 covers BVLOS flights over sparsely populated areas with special class C6 UAVs (e.g. C6 class UAVs may require an emergency landing system such as a parachute).
- Specific Operation Risk Assessment (SORA): Operators have to conduct a risk assessment that identifies all possible operational risks and proposes measures for risk mitigation and submit this to the Norwegian CAA for approval.
- Predefined Risk Assessment (PDRA): This is a simplified risk assessment for the typical operations that have been identified by EASA. Instead of conducting a full risk assessment, the operator fills out a form and submits it to the Norwegian CAA for approval.
- Light Unmanned Aerial System Operator (LUC): Operators can become certified as LUC by the Norwegian CAA which grants them the privilege of self-assessing the risks of the operation and authorising it themselves.

5. Recommendations for the future

Our previous SESS chapter developed four recommendations, which are still valid. In addition, four more recommendations were developed in the scope of this update.

The results from the literature review clearly show that basic drone operations are a very valuable tool for many scientific applications in Svalbard. The new EU drone regulations are expected to have a

4 *EASA member countries: AUT, BEL BGR CHE CYP CZE DEU DNK ESP EST FIN FRA GRC HRV HUN IRL ISL ITA LIE LTU LUX LVA MLT NLD NOR POL PRT ROU SVK SVN SWE*

double-edged impact on drone operators. On the one hand, it makes it easier for non-Norwegian pilots and scientists to operate in Svalbard. Flying in the open category A3 is easy and lowers the barrier for scientists to implement UAVs into their research. On the other hand, the new regulations introduce higher barriers to more advanced operations, such as extended VLOS or flight at altitudes higher than 120 m.

Recommendation 1: Develop national standard operational scenarios (NSTS) for Svalbard.

Most areas in Svalbard are remote and uninhabited. This means that drone missions have lower risks compared to operations on the mainland. This offers the potential for extending the operational envelope, especially for basic type operations. Similar NSTS have already been developed in other countries, for example in Poland, and SIOS should discuss this with the Norwegian CAA. In Svalbard two main scenarios are desirable for scientific applications:

- Extended VLOS operations (with observer) with drones below 2.5 kg and altitude below 120 m. Such operations are relevant for mapping activities.
- VLOS operations near take-off point with drones below 2.5 kg and altitudes below 400 m. Such operations are relevant for meteorological or geomorphological measurements.

Recommendation 2: Disseminate information about the new EU drone regulations.

The information about the new EU drone regulations in this chapter should be distributed to potential scientific drone users in Svalbard beyond the scope of this report, for example online as dedicated blog posts, posters, brochures, and similar.

Recommendation 3: Establish an interdisciplinary communication platform.

Expanding on our findings and recommendations presented in the 2020 SESS report, our literature review reveals that a wide range of science fields use unmanned systems. This diversity means that there is a need for an interdisciplinary platform where researchers with different backgrounds can come together to discuss, share experiences, develop best practices, etc. This would benefit experience transfer, development of standards, and help to build a knowledge base. Such a platform could also be combined with education and training activities. Especially for basic applications of UAVs, there is a large number of very diverse users who could learn from each other and develop common standards for data reporting or establishing long-term monitoring datasets. We suggest that the Svalbard Science Forum or the SIOS Polar Night Week could be used for this purpose.

6. Acknowledgements

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Drone fieldwork at Tunabreen (Photo: Cristophe Castagne).

Appendix 1

An overview of all the new literature that has been added to the database in the scope of this update

Title	Discipline	Fieldwork location(s)	Unmanned system	Publication type	Reference
High resolution mapping of supra-glacial drainage pathways reveals link between micro-channel drainage density, surface roughness and surface reflectance	Glaciology	Midtre Lovénbreen	UAV/fixed wing	Article	Rippin et al 2015
Spatial variability of CO2 uptake in polygonal tundra: Assessing low-frequency disturbances in eddy covariance flux estimates	Atmosphere	Adventdalen	UAV/rotary wing	Article	Pirk et al 2017
Monitoring of Sea-Ice-Atmosphere Interface in the Proximity of Arctic Tidewater Glaciers: The Contribution of Marine Robotics	Glaciology	Kronebreen, Blomstrandbreen glacier front, Ny-Alesund Harbour, Kongsbreen, Conwaybreen	ASV, UAV/ rotary wing	Article	Bruzzone et al 2020
Using ship-deployed high-endurance unmanned aerial vehicles for the study of ocean surface and atmospheric boundary layer processes	Meteorology, Oceanography	Kongsfjorden	UAV/fixed wing	Article	Zappa et al 2020
Analysis of the paraglacial landscape in the Ny-Ålesund area and Blomstrandøya (Kongsfjorden, Svalbard, Norway)	Geomorphology	Kongsfjorden	not specified	Article	Berthling et al 2020
New Cost-Effective Technologies Applied to the Study of the Glacier Melting Influence on Physical and Biological Processes in Kongsfjorden Area (Svalbard)	Glaciology, Oceanography	Kongsfjorden	ASV	Article	Pasculli et al 2020
Applications of unmanned aerial vehicle (UAV) surveys and Structure from Motion photogrammetry in glacial and periglacial geomorphology	Geomorphology	n/a	n/a	Review article	Śledź et al 2021
Drones and marine mammals in Svalbard, Norway	Biology	Midtøya, Sarstangen, Nordenskiöldbreen, Deltaneset, Tempelfjorden, Grønfjorden	UAV/rotary wing	Article	Palomino-González et al 2021
Moving out of town? The status of alien plants in high-Arctic Svalbard, and a method for monitoring of alien flora in high-risk, polar environments	Biology	Barentsburg	not specified	Article	Bartlett et al 2021

Coastal Erosion of Arctic Cultural Heritage in Danger: A Case Study from Svalbard, Norway	Cultural Preservation	Hiorthhamn	UAV/rotary wing	Article	Nicu et al 2021
Seeing beyond the outcrop: Integration of ground-penetrating radar with digital outcrop models of a paleokarst system	Geomorphology	Rudmosepynten	UAV/rotary wing	Article	Janocha et al 2021
Where will widening occur in an outwash braidplain? A new approach to detecting controls on fluvial lateral erosion in a glacierized catchment (north-western Spitsbergen, Svalbard)	Geomorphology	Kaffiøyra	UAV/rotary wing	Article	Weckwerth et al 2021
3D modelling and interpretation of depositional elements in the Aspelintoppen Formation, Spitsbergen, Svalbard, a facies analysis	Geology	Colesdalen	UAV/rotary wing	Thesis	Bøgh 2021
Back analysis of a coastal cliff failure along the Forkastningsfjellet coastline, Svalbard: Implications for controlling and triggering factors	Geomorphology	Forkastningsfjellet	UAV/rotary wing	Article	Kuhn et al 2021
Multiscale mapping of plant functional groups and plant traits in the High Arctic using field spectroscopy, UAV imagery and Sentinel-2A data	Biology	Adventdalen	UAV/rotary wing	Article	Thomson et al 2021
Snowcover Survey over an Arctic Glacier Forefield: Contribution of Photogrammetry to Identify "Icing" Variability and Processes	Glaciology	Austre Lovénbreen	UAV/rotary wing	Article	Bernard et al 2021
Adaptive Sampling of Surface Fronts in the Arctic Using an Autonomous Underwater Vehicle	Oceanography	North of Svalbard	ASV	Article	Fossum et al 2021

Appendix 2

An overview of the open, specific, and certified categories in the new EU drone regulations

OPEN	SPECIFIC	CERTIFIED
Pilots must register on flydrone.no and pass an online exam.	Operators need approval based on specific risk assessments, standard scenarios or pre-defined risk assessments.	Same risks as manned aviation. Requires EASA-certification of aircraft, operator, pilot.
Under 25 kg	Above 25 kg	Flight with passengers
VLOS	BVLOS	Flight over inhabited areas
Under 120 m altitude	Over 120 m	Urban operations
Basic drone operations	Advanced drone operations	Highest risk operations

Appendix 3

An overview of the requirements of the open category in the new EU drone regulations

Category	Limitations / Requirements	CE-Marking / Weight	Competence
all	• Max altitude 120 m • VLOS • No dropping of objects • No dangerous payloads		• Register at flydrone.no
A1	• Avoid flying over uninvolved persons • No flying over assemblies of persons	• C0 marked or • Unmarked* • Under 250 g & max speed 19 m/s	• Read user manual • Register only if camera onboard
	• No flying over uninvolved persons • No flying over assemblies of persons	• C1 marked or • Unmarked* • Under 500 g	• Read user manual • A1/A3 course and exam
A2	• Min 30 m from uninvolved persons • Min 5 m from uninvolved persons in low-speed mode	• C2 marked	• Read user manual • A1/A3 course and exam • A2 course and exam • Practical self-training
	• Minimum 50 m from uninvolved persons	• Unmarked* • Under 2 kg	
A3	• Min 150 m from residential, commercial, industrial, or recreational areas • No uninvolved persons in the area of operation	• C3 or C4 marked or • Unmarked drones after 1. Jan 2023 • Under 20 kg	• Read user manual • A1/A3 course and exam

*Unmarked drones only valid until 01 January 2023. Thereafter considered legacy drone in A3.