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FROM DRONES TO SATELLITES: THE USE OF REMOTE SENSING IN ANTARCTIC ECOLOGY AND CONSERVATION

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Using RPAS in assessing Southern giant petrel Macronectes giganteus nests on King George Island - Antarctica during the Southern summer 2020.

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The importance of using remotely piloted aircraft systems (RPAS) in conservation as a tool for the wildlife study in places of restricted accessibility is highlighted. During the southern summer 2020, in the framework of the Peruvian Antarctic Campaign ANTAR XXVII, the mapping of a Southern giant petrel colony located on King George Island was carried out using RPAS. The use of this tecnology allowed georeferencing each nest, counting and categorizing individuals and determining densities in that locality, as well as the geographic features related to their habitat. This method also provides the possibility of repeating the count and recording of the above mentioned parameters, even by different evaluators, without causing an impact on individuals, which constitutes an important tool for the study of this species and its conservation in the area.

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Whales from space in the Antarctic: Opportunities and challenges

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Understanding spatial and temporal presence of whales on the West Antarctic Peninsula (WAP) is necessary to aid marine conservation and management. However, traditional surveys, either by planes or boats, are frequently too expensive, and as a consequence such surveys are often infrequent. Very High Resolution (VHR) satellite imagery offers a means of gathering data more frequently than traditional in situ methods. Previous research has detected whales in imagery, both at-sea and on the coast and when stranding events occur. However, further investigation into the application of this technique are needed. Here we use five WorldView-3 (31cm) images of Wilhelmina Bay, WAP, captured over the austral summer of 2018/19, covering the known humpback whale season (December to March). Systematic manual scanning of these images by three trained observers revealed whale-features, such as long white flippers, bubble nets, and blows. Detection of whale-like features on each image was congruent between observers, with the number of definite features recorded by observers typically being within 2.54±2.42 of each other. Differences in classifications emerged between observers when features were harder to distinguish from surface conditions. Densities estimated from these manual surveys increased throughout the season, peaking in early March (2.99 ±1.68 whales per km2). However, detection was also influenced by levels of sea ice and increasing darkness late in the season, with surface wind and swell also influencing detectability. These observations demonstrate the growing potential of VHR as a platform to monitor whales on the WAP.

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Using drone technology for improved Antarctic Specially Protected Area (ASPA) management in Antarctica

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For the first time, we demonstrated the use of remotely piloted aircraft (RPA) technology in directly informing Antarctic Specially Protected Area (ASPA) management. Our work provides the means for undertaking rapid and low-impact ASPA surveys that are cost effective and highly repeatable. The repeatability of these surveys is of particular value to environmental managers and policy makers. RPA surveys provide quantifiable information on human impact within ASPAs as well as changes that occur from natural variability or climate such as the change in vegetation cover and species distribution.

In this study, we used a custom-built multirotor RPA to conduct systematic autonomous aerial surveys over Botany Bay ASPA 154 in January 2018. The RPA system was customised for high altitudes, sub-zero temperatures and high wind conditions with specialised multispectral and hyperspectral sensors. GNSS surveys were conducted to provide ground control points to improve the accuracy and precision of the models and vegetation maps produced. The resultant vegetation maps provided a much higher level of accuracy and a far greater degree of confidence in the spatial coverage of the vegetation that is being protected in the ASPA. The revised management plan for ASPA 154, including the new vegetation maps, was submitted to the 42nd ATCM and was adopted unanimously by the Parties (ATCM Measure 6, 2019).

The approach we used is highly relevant to monitoring change at Antarctic sites, ensuring the values being protected remain intact and that management actions remain relevant in light of any observed change at the site.

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Frontiers and challenges at the intersection of cetacean populations, deep learning, and high-resolution imagery in the Antarctic

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The ongoing recovery of Antarctic cetacean species is a process of interest to management, conservation, and ecological forecasting, yet highly mobile and wide-ranging predators such as these are challenging to study in this environment. Research efforts local to permanent stations provide high temporal resolution information at the expense of spatial extent, whereas occasional at-sea and aerial surveys provide information over larger areas, but at a coarse temporal grain. Meanwhile many areas of predator habitat remain virtually unsurveyed. We demonstrate the potential for very high-resolution satellite imagery analysis to supplement more traditional survey methods in the Southern Ocean. Using deep learning methods, we describe an aerial imagery-trained model to detect large cetaceans in satellite imagery, finding 100% of whales in our test imagery, and misclassifying only 10% of images of open water as whales. Numerous challenges remain to wide-scale implementation broadly, and specific challenges remain to successful implementation as a survey method in the Antarctic.

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Faster, greener, and more competitive? Quantified vegetation change over 55 years in continental Antarctica

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The unique Antarctic terrestrial vegetation may serve as a sensitive early warning system in understanding ecosystem responses to climate change. In situ data have revealed distribution shifts, and many species have expanded their ranges in a warming Antarctic. In the terrestrial realm, suitable habitat availability is predicted to increase by ~25% in the next century and along the Antarctic Peninsula, warmer temperatures boost terrestrial ecosystem productivity as shown for lichens, mosses and vascular vegetation.
Any such information cannot easily be translated to continental sites, where water availability and microclimate dictates ecosystem productivity. There is a need to assess changes in vegetation cover, composition and distribution shifts in continental Antarctica if we aim to improve our understanding of Antarctica's terrestrial biosphere in the context of global carbon cycles and ecosystem resilience. This unique study compares detailed vegetation survey data from 1962 and 2004 at Cape Hallett, Victoria Land with manual field surveys and high-end hyperspectral imagery taken in 2018 representing the longest available time period for assessing vegetation change in Antarctica. We evaluate changes in the expansion of vegetation cover by applying a random forest model to a hyperspectral data cube to create a high-resolution map of the local vegetation and assess its resilience by combining remote sensing and physiological measurements testing the physiological acclimation capacity of the local moss species. Our results indicate a drastic increase in moss cover indicating a higher water availability with unknown consequences for the productivity, associated ecosystem services and ecosystem functioning in this fragile habitat.

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Optimizing ocean colour remote sensing measurements in the West Antarctic Peninsula

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Ocean colour remote sensing (OCRS) has long been used to study phytoplankton in coastal and oceanic regions. As OCRS enables the acquisition of continuous data with good spatiotemporal coverage, it is considered a vital tool towards studying remote ecosystems, where in-situ data is scarce. In the Antarctic Peninsula, however, two main limitations have prevented a definite implementation of OCRS: common ice and cloud coverage. Plus, ocean colour algorithms have been seen to consistently underestimate chlorophyll a concentrations in Antarctic waters. This work will seek to use two synchronous 10-year in-situ and OCRS datasets to evaluate and improve the performance of ocean colour remote sensing as a tool for evaluating phytoplankton biomass off the Antarctic Peninsula. On the one hand, the Ocean Colour – Climate Change Initiative chlorophyll a product will be used, since it offers multi-sensor, mid-long-term data with good spatiotemporal resolution. Plus, this product is error-characterised and its algorithm takes into account the seawater bio-optical properties of a given pixel. On the other one, yearly in-situ campaigns comprising of biological, physical and bio-optical data will be used to validate and finetune OCRS data. Specific validation exercises will be performed, considering regions, cruises, dominant water class and dominant phytoplankton groups. Solutions to increase performance will be tested using novel methods and its results presented. Results are expected to pave the way towards more accurate OCRS measurements in the Antarctic Peninsula, contributing to the establishment of OCRS as a definite tool for studying phytoplankton in Antarctic waters.

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Aerial surveys for penguin populations on the Antarctic Peninsula

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There are 18 species of penguin, six of which breed regularly on the Antarctic Peninsula and across the Scotia Sea. Populations in this region have been changing over the past century, with reported declines for Adélie and chinstrap penguins, but increases for gentoos. However, considerable spatial heterogeneity exists in penguin population trends across long-term study sites.

The most up-to-date and most comprehensive population data for Antarctic penguins comes from the MAPPPD project (Humphries et al. 2017). This database includes all published data on Antarctic penguin populations.

Colony counts in MAPPPD for Adélie penguin breeding sites show that 98.5% of the regional population has been surveyed since 2004. In contrast, for chinstrap penguins, only 10.2% of the population has been surveyed since 2004, and that most of the population has not been counted in over 30 years. Counts for gentoos are intermediate, with 83.4% of the population having been surveyed since 2004, but with most of the remainder being older than 30 years.

Up-to-date data are vital for management purposes, including managing the fishery for Antarctic krill, understanding the regional impacts of climate change, and understanding how ecosystems change, given the ongoing recovery of marine mammals. New tools are needed if managers are to adequately understand penguin population trajectories. The British Antarctic Survey has therefore initiated an aerial photographic survey programme to update colony estimates for more than 50 of the larger colonies. In this poster we report initial findings and explore some of the challenges for updating penguin population estimates.

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Discovery of new colonies reveals good and bad news for emperor penguins

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The distribution of emperor penguins is circumpolar, with 54 colony locations currently reported of which 50 are currently extant. Here we report on eight newly discovered colonies and confirm the re-discovery of three breeding sites, only previously reported in the era before Very High Resolution satellite imagery was available. This represents an increase of ~20% in the number of breeding sites, but, as most of the colonies are small, these sites only increase the total population by around 5-10%. The discoveries have been facilitated by the use of Sentinel2 satellite imagery, which has a higher resolution and more efficient search mechanism than the Landsat data previously used to search for remote colonies. Some of the colonies are very small, indicating that considerations of reproductive output in relation to metabolic rate during huddling, is likely to be of interest. Some of the colonies exist in offshore habitats, something not previously reported for emperor penguins. Comparison with recent modelling results show that the geographic locations of all the newly found colonies are in areas likely to be highly vulnerable under business-as-usual greenhouse gas emissions scenarios, suggesting that population decreases for the species will be greater than previously thought.

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Seals from Space: the monitoring of ice seals and sea ice habitats by remote sensing

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Antarctic pack-ice seals (APIS) are long-lived, upper trophic level predators and amongst the largest consumers of Antarctic krill. Therefore, the monitoring of APIS populations can indicate changes in the Antarctic ecosystem. However, APIS inhabit the inaccessible sea ice zone, making traditional surveys (i.e., ship/aerial) logistically difficult. Because of these challenges, reliable population estimates and habitat information for ice seals are lacking. To overcome these limitations, very high-resolution (VHR) satellite and unmanned aerial vehicle (UAV) imagery will be used to discriminate ice seals for counts at local scales and identify habitat hotspots. This involves identifying species classification parameters; extracting sea ice characteristics; constructing habitat models to explain population dynamics and predict responses to environmental change.

Here, we present details of two approaches for sea ice habitat classification for seals i) a citizen-science based manual approach and ii) an automated computer vision approach resulting in the first VHR sea ice classification tool. We also discuss the analysis of in-situ and satellite seal surveys. The outputs from the sea ice classification and seal counts are combined into an ecological model to explain seal distribution in terms of social behavior and environmental variables. Resulting insights into the habitat preference and distribution of seal colonies will enable us to better predict future responses to climate change. Given that sea ice volume is predicted to decline significantly by the end of the century, the efficient monitoring of APIS and their habitat is pivotal to polar marine conservation.

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Green Antarctica - remote sensing reveals snow algae as important terrestrial carbon sink

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In the limited terrestrial ecosystems of Antarctica, all photosynthetic organisms will make a significant contribution to the ecology of their habitat. Blooms of snow algae are known to occur annually in Antarctica but, until now, neither their scale nor contribution have been quantified. We present the first estimate of the green snow algae community biomass and distribution along the Antarctic Peninsula. Using Sentinel-2 satellite imagery from 2017-2019 and field data collected over the same period, we identified 1679 blooms covering approximately 1.95km² of snow in a season. Field measurements enabled us to calculate that this represents a dry biomass of 1327 tonnes (479 tonnes of carbon). Spatial analysis suggests that snow algal range is limited to areas with average positive degree days in the austral summer, and that their distribution is strongly influenced by nutrient inputs from the ocean via marine vertebrates, with 60% of the blooms identified found within 5 km of penguin colonies. Our findings suggest a warming Antarctic Peninsula will likely to lose a majority green snow algae blooms, as 62% of these were on small islands with no high ground for upward range expansion. However, as bloom area and elevation were observed to increase towards the north of the Peninsula, we suggest a parallel expansion of blooms on larger landmasses, close to bird or seal colonies. This increase is predicted to outweigh significantly the biomass lost from small coastal blooms and result in a net increase in snow algae extent and biomass as the Peninsula warms.

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Fine-scale seasonal trends in abundance and distribution of pinnipeds in the Palmer Archipelago

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Unoccupied aircraft systems (UASs) enable rapid, on-demand remote sensing of environments and their fauna with less disturbance than on-the-ground surveys. In mid–late austral summer 2020, UAS surveys were conducted near Palmer Station, Antarctica, over known terrestrial haul-out locations of southern elephant seals (Mirounga leonina) and Antarctic fur seals (Arctocephalus gazella). Flight plans were implemented to (1) map the substrate and topography of coastal environments and (2) count and locate pinnipeds every 5–10 days. Mapping and pinniped surveys collected high resolution photo-sets with ground sampling distances ranging from 1.5–4 cm. Orthomosaic products and digital surface models were produced using standard 'structure from motion' workflows. Natural ground control points were collected with a survey-grade GPS at select sites to (1) estimate the error of unreferenced photogrammetric products and (2) produce georeferenced map products. Analysts visually detected and identified M. leonina and A. gazella by pelage and morphology across a range of substrates, alongside sporadic occurrences of pagophilic seals (Lobodon carcinophaga and Leptonychotes weddellii). Sequential surveys revealed fluctuating but persistent occupancy of M. leonina through mid–late summer and a precipitous arrival of A. gazella in late summer. All species exhibited distinct spatial affinities, with M. leonina aggregating at beaches and wallow sites, A. gazella dispersing throughout coastal landscapes, and pagophilic seals hauling out exclusively at low-lying beaches and snowbanks. These surveys, conducted as part of the Palmer Station Long-term Ecological Research Program (LTER) represent the first efforts to comprehensively study pinniped abundance and distribution in the Palmer Archipelago.

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Detection and community-level identification of microbial mats in the McMurdo Dry Valleys using drone-based hyperspectral reflectance imaging

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The reflectance spectroscopic characteristics of cyanobacteria-dominated microbial mats in the McMurdo Dry Valleys (MDV) were measured using hyperspectral point and line-scan spectrometers aboard unmanned aerial systems (UAS; RPAS, UAV, or drone) to determine whether mat presence, type, and activity could be mapped at a spatial scale sufficient to characterise inter-annual change. Mats near Howard Glacier and Canada Glacier (ASPA 131) were mapped, and mat samples were collected for DNA-based microbiome analysis. Although a common broad-band spectral parameter (pNDVI) identified mats, it missed mats in comparatively deep (>10 cm) water or on bouldery surfaces where mats occupied fringing moats. A hyperspectral parameter (B6) did not have these shortcomings and recorded a larger dynamic range at both sites. When linked with colour orthomosaic data, B6 band strength is shown to be capable of characterising the presence, type, and activity of cyanobacteria-dominated mats in and around MDV streams. When we applied B6 band analysis to line-scan hyperspectral imagery, we were able to map the extent and activity of distinct mat types at decimeter resolution over more than five hectares. Microbiome analysis of the mat samples revealed that dominant cyanobacterial taxa differed between spectrally distinguishable mats, indicating that spectral differences likely reflect underlying biological distinctiveness. Our findings demonstrate that combined rapid-repeat hyperspectral measurements can be applied to monitor the distribution and activity of sentinel microbial ecosystems, which are expected to respond rapidly to change in meltwater availability associated with warming.

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A convolutional neural network architecture designed for the automated survey of seabird colonies

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Satellite imagery is now well established as a method of finding and estimating the abundance of Antarctic penguin colonies. However, the delineation and classification of penguin colonies in sub-meter satellite imagery has required the use of expert observers and is highly labor intensive, precluding regular censuses at the pan-Antarctic scale. Here we present the first fully automated pipeline for the segmentation and classification of high-resolution satellite imagery. Our method leverages site-fidelity by using images from previous years to improve classification performance but is robust to georegistration artifacts imposed by mis-alignment between sensors or terrain correction. We use a segmentation network with an additional branch that extracts the useful information from the prior mask of the input image. This prior branch provides the main model information on the location and size of guano in a prior annotation yet automatically learns to compensate for potential misalignment between the prior mask and the input image being classified, leading to a 44% improvement (mean IoU increasing from 0.34 to 0.48) over previous approaches. While trained for the classification of Adélie penguin colonies, this method can be adapted for other ecological applications where the dynamics of landscape change are slow relative to the repeat frequency of available imagery and prior information may be available to aid with image annotation.

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Combining Underwater Hyperspectral Imaging and Structure-from-Motion digital photogrammetry to improve benthic habitat assessments

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Advancements in Underwater Hyperspectral Imaging (UHI) and Structure-from-Motion digital photogrammetry (SfM) are rapidly improving benthic studies, this research investigates its usefulness for increasing our knowledge of Antarctic benthic ecosystems. Hyperspectral imaging collects data across hundreds of bands of light detecting subtle differences in the way benthic objects absorb and reflect light conferring them a unique 'spectral signature'. Furthermore, UHI can achieve mm/pixel spatial resolution providing researchers enough information to identify organisms based on more than what is visible to the naked eye and can enhance automated methods for benthic habitat mapping. SfM complements the high-resolution data of UHI by creating 3-D structure models of benthic organisms and habitats providing additional taxonomic features and structural complexity metrics of the benthos. Currently, there are no studies applying UHI in tandem with SfM for Antarctic benthic organism identification. By collecting in situ benthic specimens and through the additional development of a controlled lightning-laboratory setup, this study will explore the potential of UHI spectral signatures with 3-D metrics for organism identification. We hypothesize that efforts in bringing these two technologies together will enhance biodiversity studies and improve our ability to detect changes in benthic habitats. Results will provide the basis to further upscale these imaging techniques onto underwater platforms for improved and automated Antarctic benthic habitat assessments.

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Remote Sensing of Southern Ocean Phytoplankton in a Warming World

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Marine phytoplankton play an essential role in the structure and functioning of the Southern Ocean (SO). Being short-lived and fast growing, phytoplankton can respond rapidly to changes in sea surface temperature (SST). Concurrent with long-term small increases in average SST, the more dramatic increases in short-term warming events, that is marine heatwaves (MHWs), are very likely to be attributable to global warming (IPCC 2019). Little is known about how oceanic warming coupled with MHWs will affect SO phytoplankton. This research aims to address this research gap by quantifying the effects of MHWs on chlorophyll-a (chl-a) concentrations, a proxy for phytoplankton biomass, using satellite measurements of ocean colour.

All extreme summertime MHW events across the SO were identified from 2002-2018. These short-term anomalies were correlated with chl-a using a 'control vs. impact' experimental design. A MHW identification procedure based on Hobday et al. (2016) was used, defining MHWs as anomalously warm events during which temperatures exceed the 90th percentile and persist for >5 days. Based on Anova and correlation analyses, I found that these extreme summer MHWs increased chl-a in the SO, and that this increase was stronger in regions with lower average SST and higher ice cover.

The results suggest that a focus on average changes over long periods and wide areas could overlook ecologically important short-term changes associated with MHWs. These events, superimposed on long-term climate change, may eventually reach a tipping point in the SO with large-scale shifts to entire communities at the base of the food web.

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Mapping emperor penguins by drone

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The Southern Ocean is increasingly influenced by humans. Climate change and fisheries are changing its ecosystem and are at the same time influenced by its condition. However, data on the state of this ecosystem are difficult to obtain. Penguins are among the few of its elements visible on the surface, particularly emperor penguins, which breed on seasonal sea ice. This and their function as predators in the food web makes them an important indicator of the state of the Southern Ocean ecosystem.
This species does not only breed in difficult to access places, it also has a high mobility during the breeding period, making data on the size of penguin colonies difficult to acquire. The use of drones offers the possibility to collect data even from large colonies in a relatively short period of time.
From November to January 2019/20 we mapped the emperor penguin colony in Atka Bay, Dronning Maud Land at three different times during the season with a quadrocopter drone. The main colony is located on the sea ice at the western edge of Atka Bay. Since emperor penguins, unlike other penguin species, do not build nests, they constantly change their position and separation into different subcolonies depending on current weather conditions is common. By using a drone, it was also possible to locate and record a relatively mobile and remote subcolony on the ice shelf.
We present mapping results and share our experience on the use of drones under the harsh climatic conditions of continental Antarctica.

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Obtaining reliable centimetre-resolution predictions of biologically relevant temperature variation in the canopy of moss turfs

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The majority of Antarctica's terrestrial biodiversity exists no more than a few centimetres above the ground- this being the approximate canopy height of moss beds which harbour much of the continent's floral, fungal, invertebrate and microbial diversity. For this reason, surface conditions are disproportionately important for Antarctic ecology. Automated weather stations (AWSs) in Antarctica record the conditions of weather at heights upwards of 1.5-m above the surface, and are often strongly misrepresentative of surface conditions, which can vary substantially across very small spatial scales due to surface micro-topography. Despite this, observations from AWSs are often used as predictors or explanatory variables in ecological studies, as long-term observations at the surface don't exist. Applying previously described biophysical formulae and UAV LiDAR, this study presents a physical downscaling approach for coarse-resolution satellite-derived radiation data, and a physically parameterised energy balance equation driven by AWS observations for remotely and reliably predicting canopy temperatures of moss beds, both spatially and temporally, at a centimetre resolution. Observations of moss canopy temperatures were obtained in situ from the Coppermine Peninsula Antarctic Specially Protected Area (ASPA No. 112) in the Maritime Antarctic. Validated against these observations, the model predicts canopy temperatures largely in agreement with measured temperatures and has a RMSE of 2.1°C. Modelled and measured temperatures correlate with an R2 of 0.71 across 956 corresponding data points. This study presents a promising method for obtaining biologically relevant spatially explicit information from point sources in Antarctica, and can potentially be applied in a range of ecological studies.

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The behavioural responses of emperor penguins to drones

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The increasing usage of UAVs by researchers, TV- and movie production teams and private persons which has been reported during the last years is even reaching remote Antarctic regions with pristine ecosystems. Until now, there is no information on whether and how species living in such environments, like the emperor penguin, are impacted by the application of this technology. In consequence, it is almost impossible for national competent authorities to assess the possible environmental impacts of the UAV usage in the proximity of wildlife.
To investigate the behavioural response of emperor penguins and their chicks to UAVs, we conducted horizontal overflights in different altitudes ranging from 20 to 150 m above the animals as well as direct vertical approaches. We used two UAV types - one quadrocopter and one fixed wing UAV. During all flights, three separated groups of penguins within the colony were video recorded from the shelf ice at a distance of about 100 to 300 m. We also conducted experiments on the response to humans on foot to compare both kinds of disturbances. All experiments were accomplished from November 2019 to January 2020 at the emperor penguin colony at Atka Bay, Dronning Maud Land.
The recorded data are currently being analysed and the results will be presented. Preliminary insights into the data hint towards a strong reaction to direct human contact, while UAV flights cause less reaction. Within those, vertical approaches seemingly cause a stronger response than horizontal flights, which induce few reactions even at low altitudes.

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UAS-based micro-scale photogrammetric modelling of topographic abiotic factors for microbial communities. A case study of the Sør Rondane Mountains, East Antarctica.

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The Antarctic ice-free areas are among the most extreme environments on Earth. Yet, their soils harbor diverse microbial communities, varying significantly between regions and micro-climatic conditions. Some of these, such as biological soil crusts (biocrusts) provide multiple ecosystem services by increasing soil fertility and stability, thus influencing biogeochemistry and erosion. Previous studies showed topographical factors influencing the community structure of soils, like orientation, elevation or the daily received solar energy. Nevertheless, the factors responsible for driving the microbial diversity and structure of inland nunataks of East Antarctica are still poorly understood. This study aims to determine topographical parameters through very-high-resolution 3D modelling of micro-community habitats. Following the sampling of soils (from barren bedrock to substrates covered by biofilms and biocrusts), we deployed uncrewed aerial systems to survey several nunataks with structure-from-motion (SfM) near-surface remote sensing. While SfM is known for its limitations in homogeneous, low-contrast environments such as snow and ice, the chosen nunatak's rocky slopes provide ample structure for high resolution modelling.

The resulting point clouds and derived digital elevation models facilitate an in-depth characterization of soil habitats in regard to e.g. slope, roughness and exposure, as well as parameters derived from these. This will help to identify and understand potential topographic limiting factors for these communities. To our knowledge, this is the first two-centimeter-resolution model of a nunatak in continental Antarctica, promoting the application of this technology to other harsh environments and allowing for a detailed comparison of near-surface and satellite-based remote sensing in this structurally diverse environment.

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Exploring Applications of ICESat-2 to investigate Gentoo Penguin Range Expansion

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Gentoo penguins (Pygoscelis papua) are commonly considered 'climate change winners', as their populations have undergone rapid growth along the Western Antarctic Peninsula (WAP) since the early 2000s. Coincident with increasing regional population sizes, gentoo penguins have also established several new breeding colonies that have expanded their current home range further south along the WAP.

The advances in remote sensing have enabled the polar research community to use satellite technology to detect and estimate penguin colony size, as well as monitor suitable penguin habitat with respect to regional climate conditions and sea ice concentration. With the recent deployment of ICESat and ICESat-2 laser altimetry systems, researchers have a unique opportunity to detect and explore winter sea ice conditions using novel sensor platforms. Here we detail efforts to explore fine-sale changes in winter sea-ice conditions with respect to range expansion of marine predators such as gentoo penguins.

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Detailed site and contaminant characterisation using drones and ground based soil gas surveys across a perennial Antarctic snowpack and a legacy catchment at Casey station, Australian Antarctic Territory.

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UAV imagery and RTK GNSS data was used to create high resolution digital surface models and orthophotomosaics of two diesel contaminated sites at Casey station, East Antarctica, using Structure from Motion (SfM) techniques.

The presence of a thick cover of wind-blown snow and an underlying perennial snow-pack (> 4m depth) at one of the sites limited the ability of the field team to assess the extent of the diesel contamination through traditional techniques (such as the use of photo ionisation detectors and soil samples). The second site studied was from a well-studied legacy diesel spill near Old Casey station. Data from traditionally obtained soil and water samples, and from two high resolution passive soil gas investigations was combined with the detailed site survey data to identify specific sub-surface hydrocarbon contaminant migration pathways at Australia's Casey Station in Antarctica.

Contaminant surfaces were generated in ArcGIS Spatial Analyst using data from passive soil gas samplers to visualise hydrocarbon intensity within the context of a three dimensional model of surface snow and ground surface conditions. This helps reveal the dominant fuel migration pathways, how they relate to observed changes in surface snow and melt conditions and ground topography to better inform environmental risk and site management.

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