
DREAM2
DRone tEchnology for wAter resources and hydrologic hazards Monitoring

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Team composition

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Pietro Lorenzetti

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Tommaso Francalanci

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Tasks and Skills

Luke Addati – Developed the model for 2016 using photoscan by outputting the relevant files such as Digital Surface Models & Orthophotos. He worked on the data using QGIS to evaluate the data trend patterns on the glacier due to global warming. He also kept control of all the finances by organizing the budget, assisted the team with report writing the methods & conclusion section and attended both campaigns for data capture.

Pietro Lorenzetti – Pietro work on developing the model for 2016 by evaluating each individual photo and finding the relevant alignment points. He also assisted with data evaluation. He controlled and coordinated the report writing amongst the team members, writing an extensive amount himself, assisted with drone construction, attended the first campaign and coordinated the final presentation development.

Tommaso Francalanci – Investigated the state of the art drone technologies, organized a list of components, purchased and built the drone with the assistance of other team members. He attended both main campaigns and also assisted with smaller campaigns when more data was required. The Monographic points were tabulated by Tommaso for use within the model. He attended the SIFET conference in Sicily where he presented the DREAM project, where the project was chosen as the best at the conference.

Angelo Falleta – Worked on the hydrological analysis for evaluation of the Degree Day Factor between 2015-2016 and compared the results to the previous year's findings. The analysis was also compared to our results and traditional approaches to determine whether drone technology had viable results. He worked on the velocity map evaluation within the model development, assisted in the first campaign, wrote an extensive amount of the report theory & the hydrological analysis section.

Costanza Parisi – Supported the first campaign & worked on the monographic points for use within the model. She assisted in construction of the drone and report writing the section regarding the campaigns & the work that was performed in the area.

Project description

Nowadays, expected effects of climate change at local, regional and global scales endanger hydrologic budgets of Alpine regions. An example is the massive shrinkage of mountain glaciers, with the consequent problem of water resources reduction for civil population and ecosystems. Therefore, it is very important to monitor glaciers' evolution, in order to allow an estimation of glaciers' reduction and possible effects on the hydrologic cycle. This project aims at investigating new technologies and tools, especially Unmanned Aerial Vehicle (UAVs) for evaluating water resources at different scales. The eastern slopes of Monte Rosa and its glacier tongue (Belvedere glacier) has been used as test site. Research method analysis mainly followed three steps. Usually, glacier's thickness, area evolution, and glacial motion are monitored using time-consuming field activities, e.g. analysis based on point stratigraphy and mass balances or radar sounding, which do not allow to obtain a continuous-time, detailed and accurate information about surface and volume evolution at fine spatial resolutions. In the first step, we have used a fixed-wing UAV to acquire RGB images, in order to generate a dense DSM (Digital Surface Model). The acquisition was carried out with a field campaign in October 2016. Data have been elaborated with different photogrammetric software in order to investigate the ratio quality of the product/time consumption, with respect to hydrological purposes. The DSM obtained has been compared with the one realized in 2015 to estimate the volumes' variations, and the glacial motion in the period October 2015- October 2016. In the second step, we have designed, assembled and tested a quadcopter drone. In the third step, we have used the assembled drone in an ad-hoc field campaign realized in March 2017 together with commercial drones in order to check the validity and potentiality of the assembled drone. Finally, we have been compared the obtained results with the existent literature in alpine areas.

Abstract

As climate change continues to be of serious concern to the planet, countless hours of research are being invested to better understand this phenomena and to improve data acquisition. Due to the complexity of the problem, it is very difficult to understand what is going on with current technologies. Scientists are still trying to develop proper models but require additional data to assist in the development. The project continues to focus on the ambitious goal of investigating innovative technologies for data collection, while attempting to keep costs low and allow for good usability.

The first DREAM project successfully proved that it was possible to monitor and evaluate the glacier at Belvedere using Drone technology. The drone was fitted with a camera capable of taking high resolution images that could be utilized in photogrammetry to develop digital models for analysis. DREAM 2 further investigated this concept by continuing the same analysis and also developed a low cost drone for the Universities to use on the glacier. We successfully built and utilized our drone for the second campaign and were able to extract the data acquired to use for analysis. We utilized two sports action cameras, one with a regular filter and one with an Infra-red filter and were able to evaluate the differences in photo quality. In addition, we were able to use to the data obtained from the developed models to estimate glacier melting and compared it to actual data. As an extra evaluation compared to our predecessors, we were able to develop a velocity map, where we were able to compare various objects and evaluate their movement over the years. We can confirm that drones are a valid technology for investigating climate change at glacier locations, which are low cost, extremely versatile and with excellent usability.

Understanding the Problem

Significant development has occurred in drone technology, mainly due to the cost of components dropping significantly, allowing anyone to be able to build a drone themselves at a very good price. Due to its expansion into many fields such as agriculture, transportation, search and rescue and even hobby use shows that it has a broad use spectrum. The previous DREAM project proved the concept and set the foundation for DREAM2 to pick up the reins and to continue the great work being performed. We were tasked with continuing the work as per DREAM one with the extension of developing our own low cost drone for use on the glacier. The focus of the drone had to be on cost and usability, due to the budget constraints and the fact that the area where the drone would be deployed had harsh conditions.

UAV technology was investigated with the following key points;

- Investigating existing drone structures such as rotor or fixed wing topologies. Understand their benefits and drawbacks and select the right one for use on the glacier.
- Understand the conditions where the drone will work. Environmental conditions have adverse effects such as cold temperatures to batteries.
- Evaluate costs for each drone specification and find the lowest cost that meets our requirements.
- Review different sensor technologies and apply the best one onto the drone.

Like our predecessors, the test site was at the eastern slopes of Monte Rosa and its long glacier tongue (Belvedere Glacier). The valley lies at the base of the east side of Monte Rosa and stretches from its peak of 2200km to 1800km. The area is particularly interesting as the glacier is not retreating but is moving down the valley. The drone technology was required to gather data from the area to assist scientists in understanding and hopefully explaining its movements.

Exploring the Opportunities

By proving that a low cost drone can be used to evaluate an area such as the Belvedere Glacier, it has a huge impact for scientists and researchers who could investigate and implement the same technology in other environments. Opportunities could arise for the following areas;

Civil Protection – More morphological information can improve the understanding of critical phenomena and lower the risks for people being in an area during avalanches or landslides.

Valley Inhabitants – The glacier is one of the most important natural elements influencing the climate in the valley, its evolution may produce significant changes to the environment with direct consequences for the whole population, both from and individual and economic standpoint.

Regione Piemonte – Being responsible for the management of the territory, such an institution is interested in the matter of studying and knowing the dynamics of the Belvedere glacier. An increased knowledge of the area may result in an optimization of the plans for the development of local communities as well as an improved offer for tourism.

Agricultural Industries – Estimating the quantity of water they can rely on thanks to the snow is an actual need for them, especially in terms of forecast and water supply management. In addition, the planning and construction of agricultural infrastructures like dykes, dams or channels also rely on the knowledge of both accumulation and dispersion of the water resource.

Hydroelectric Companies – The glacier is a hydrological resource so that any increase in the knowledge of the belvedere area may actually interest such companies. Not only the Snow Water Equivalent (SWE) provides information about the size of the water resource, but also forecasting and information related to the timing of peak discharge can help hydropower plant operators maximizing the power production.

Drone and Sensor Manufacturers – New applications of drones for research purposes and area monitoring could lead to new developments in the drone industry. Furthermore, since this field if application is absolutely recent, where it's potential has yet to be fully discovered. There may be significant economic opportunities for using this cutting edge technology.

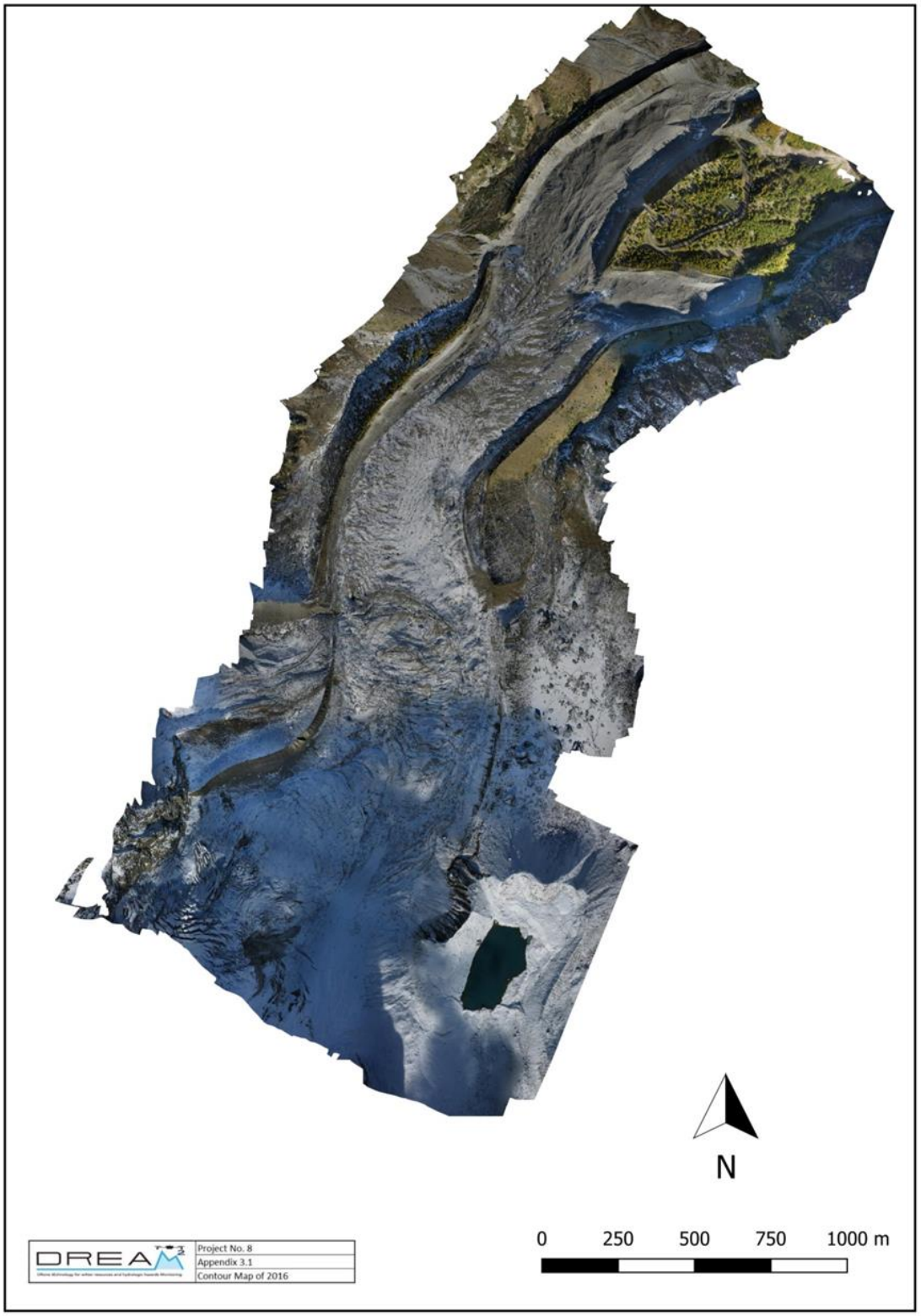
Generating a Solution

The project was separated into unique steps and phases which lasted for various time frames. We initially started with training sessions in Turin and Milan to understand the project and expectations better. The first campaign was performed in October 2016, where the team ventured to the glacier to gather data using an already built drone, the eBee SenseFly. As we were using indirect photogrammetry, Geo-Referenced markers were required to be positioned on the glacier, placed by us students and the professors which would be used in constructing the models from the drone images. The Geo-Referencing was performed using highly precise GPS equipment which provided us the exact positioning of the point on the glacier.

Once the data had been captured, we began post-processing of the data using photoscan and evaluating our models using QGIS. As an output, we obtained a Digital Surface Model (DSM) which would be used to obtain relevant information such as volume and contours, and also an orthophoto, which is a high resolution final image of all the images merged together. In parallel, the team also began investigating and developing the drone concept. Requirements for the drone were developed and agreed upon and finally the components were purchased. When the components arrived, the drone was constructed in Milan with necessary team members arriving to assist.

The drone choice was a rotary drone with 4 propellers to keep the cost low and sports action cameras were used to obtain the necessary image quality of the glacier. The drone was flown on the second campaign, where only a small section of the glacier was evaluated for the level of snow that had fallen. The flights proved extremely successful with only a few minor problems occurring which were resolved in the field. We were able to construct a fully functional drone which was low cost and highly capable of being used on the glacier.

The models from the first campaign were analysed and a difference in volume was found between the 2015 and 2016 models. The data was shown to be trending, where we could see similar patterns forming to where the volume was displacing. The models also allowed us to calculate the Degree Day Factor (DDF), a performance criteria used to determine the melting speed of the glacier. The results showed once again that the glacier is losing volume due to global warming, with the difference between 2015 and 2016 being the greatest loss in volume with respect to all other measurements so far. We also compared our data to traditional methods and found similar results in the melting speed.



DREAM	Project No. 8
	Appendix 3.1
	Contour Map of 2016