Glacier Noir and Glacier Blanc fieldwork (Summer 2014)

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Context of the fieldwork

Debris-covered glaciers represent approximately 20% of all mountain glaciers worldwide, and are an important component of the alpine environment. Studies have concluded that debris-covered glaciers evolve more slowly than clean-ice glaciers, with delayed responses to climate change, because the debris layer thermally isolates the ice. One of the main objectives of my PhD is to directly compare the response to climate change of a debris-covered glacier and a clean-ice glacier.

To achieve this objective, I organized and conducted one month of fieldwork in the French Alps between the 15 August 2014 and the 15 September 2014. My field site was Glacier Noir (debris-covered glacier not systematically studied) and Glacier Blanc (clean-ice glacier largely studied) situated in “Les Ecrins” National Park. The two types of glacier are within a radius of 3 km (Figure 1) so they experience similar climatic conditions. This particular situation allows the direct comparison.

Measurements

During this month of fieldwork, my field assistants and I conducted at various locations on both glaciers (Figure 2) the following measurements (in no particular order):

- Dye (rhodamine) tracing on Glacier Noir and Glacier Blanc was undertaken to measure the transit time and mixing of the meltwater at different locations on the glacier’s surface (Figure 3).
- Debris-thickness measurements (Figure 4) at on Glacier Noir by digging through the debris layer to the ice surface, and using a measuring tape to record the distance. These measurements are important to map debris layer which is the main characteristic and control of the glacier.
- Direct ablation measurements on both glaciers using ablation stakes (Figure 5 and Figure 6). This will allow the calculation the mass balance of the glaciers during fieldwork period. The mass balance will be confirmed with the water discharge measurement (see below).
- Surface velocity measurements using differential GNSS (Global Navigation Satellite System) techniques at multiple locations on Glacier Noir (Figure 7). This will help to determine the dynamic of the glacier.
- Temperature measurement (Figure 8) using a string of 4 thermistors. These thermistors measured the air temperature, and the temperature on the surface, in the middle, and at the bottom of the debris layer. Temperature transmission through the debris layer is one of the major axe of research in many studies.
- Water quality measurements on Glacier Noir (Figure 9) including electrical conductivity (EC), suspended sediment concentration (SSC) and water level. The measurements allow the evaluation of the mass balance (via the water discharge and, therefore, the water level) of the glacier, erosion and transportation of sediment (via the SSC combined with the water discharge) resulting from its movements and the dynamics (via the EC, SSC and dye tracing) of the drainage system of the glacier. A similar water gauging station was installed on a Glacier Blanc stream, but one day later was washed away by a torrential flow and therefore no automatic data were collected but manual water level and EC data were for the equivalent of 2 days.
- A large number of ground-based pictures were on both glacier taken in order to create a Digital Elevation Model (DEM) using the Structure-from-Motion technique.

Initial results and data analysis

Despite various difficulties during the fieldwork (for example, the loss of a water gauging station during torrential rain event) the initial results are very encouraging and will give a better definition to my PhD project.

The analysis of the water quality measurements is in progress but already it shows interesting features, such as a small not-explain delay between the EC, SSC and water level daily cycle (Figure 10). These results will be combined with the water transit time (derived from the dye tracing) of 30-60 minutes depending on the side of Glacier Noir. This will be compared with Glacier Blanc. In addition, the characteristics of the torrential flow for Glacier Noir were recorded.

The dGNSS measurements reveal a displacement of the surface of Glacier Noir of between 20 and 45 cm in 20 days (1-2.25 cm/day). This result is lower than expected, but confirms that Glacier Noir is a stagnant glacier.

The ablation stakes and the temperature station behaved exactly as expected. The ablation rate on Glacier Noir is 2-3 times lower than that on Glacier Blanc. A finer analysis is necessary to evaluate the correlation with temperature. The temperature (Figure 11) shows the expected delay reflecting the insulation effect of the surface debris layer on Glacier Noir. Here again, a finer analysis is necessary to precisely evaluate the reasons for this delay as well as the influence of rain on the propagation of the heat through a debris layer of 40 cm.

The ground-based images for the DEM are not processed yet and some additional remote sensing and historical data are needed to determine the evolution of the geometry of Glacier Noir and Glacier Blanc.

An evaluation of the distribution of debris on the surface of Glacier Noir revealed a much thicker debris layer than historical observations suggested.

Potential outcomes

The initial results of this summer fieldwork 2014 are interesting and full of promise. The potential outcomes are 3-4 scientific articles involving field data and remote sensing analysis, 1-2 presentation/posters during glaciological or geographical conferences, and multiple outreach posts on my scientific blog (http://icenrock.org/) describing my fieldwork experience and the process to analyse the data. In addition, this report will be sent to “Les Ecrins” National Park documentation centre and will be available to the public.

Conclusion and acknowledgements

This fieldwork season could be considered successful despite the loss of one gauging station that will prevent me from establishing a full direct comparison between Glacier Noir and Glacier Blanc. All the data collected during this month will be very useful for my PhD project.

I wish to thank the BSG and the DGES for the funding that allowed me to conduct this fieldwork. Thank you to “Les Ecrins” National Park staff in the headquarters and on site for their help. And of course thank you to my supervisors Neil Glasser, Tom Holt and Bryn Hubbard for their help and support during the preparation and the execution of this fieldwork.

Appendix 1: Expenditure breakdown

BSG		DGES PDRF	
Item/s	**Expenditure (£)**	**Item/s**	**Expenditure (£)**
Accommodation	352.31	Toll charge	196.36
Petrol part a	328.99	Petrol part b	29.51
Various field Equipment	320.53	Internet Access	76.65
		Hotel in/outward	86.38
		Transport to cross the English Channel	120
Total	**1001.83**	**Total**	**508.9**
Award	**1000**	**Award**	**500**

Appendix 2: Figures

Figure 1: Position of Glacier Noir and Glacier Blanc in the valley of "Pré de Madame Carle"

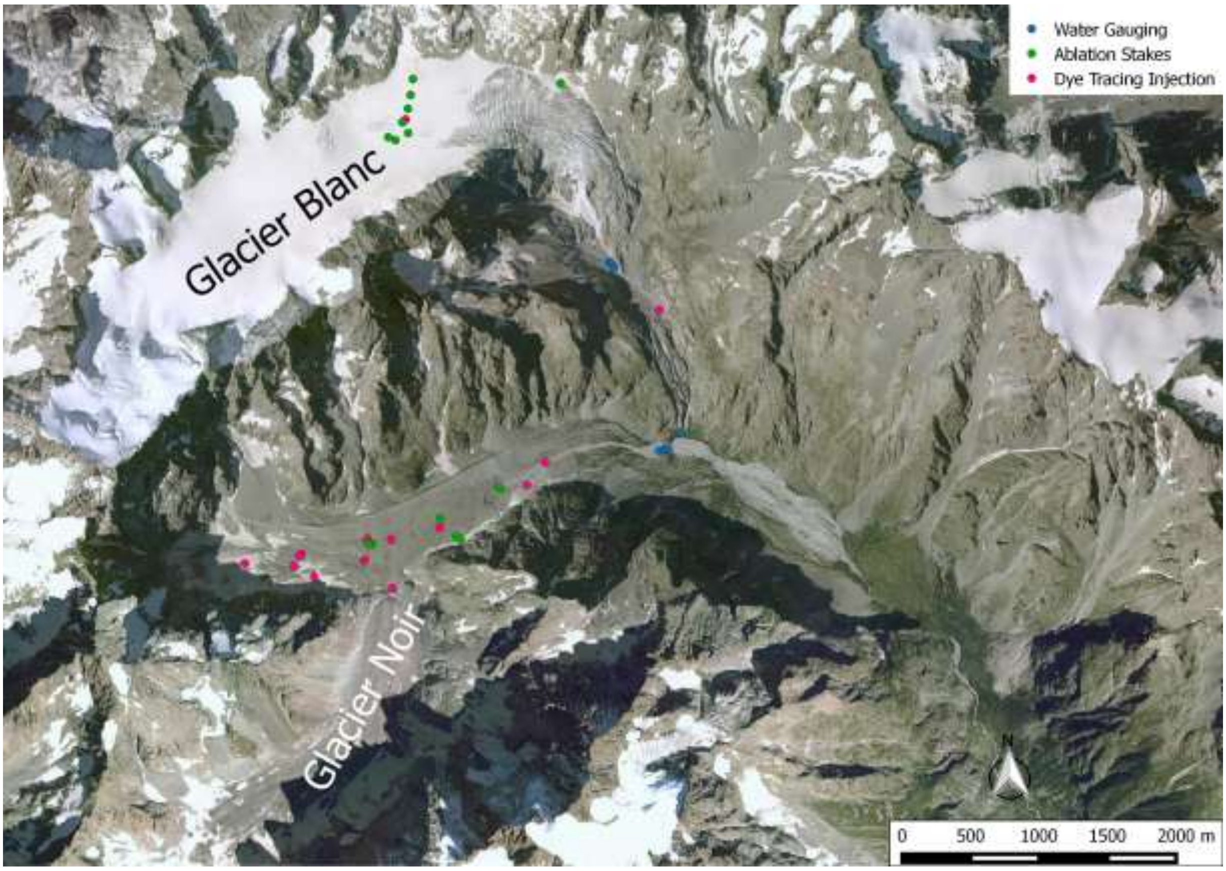

Figure 2: Location of the different types of measurements conducted

Figure 3: Dye injection on Glacier Blanc

Figure 4: Debris thickness measurement

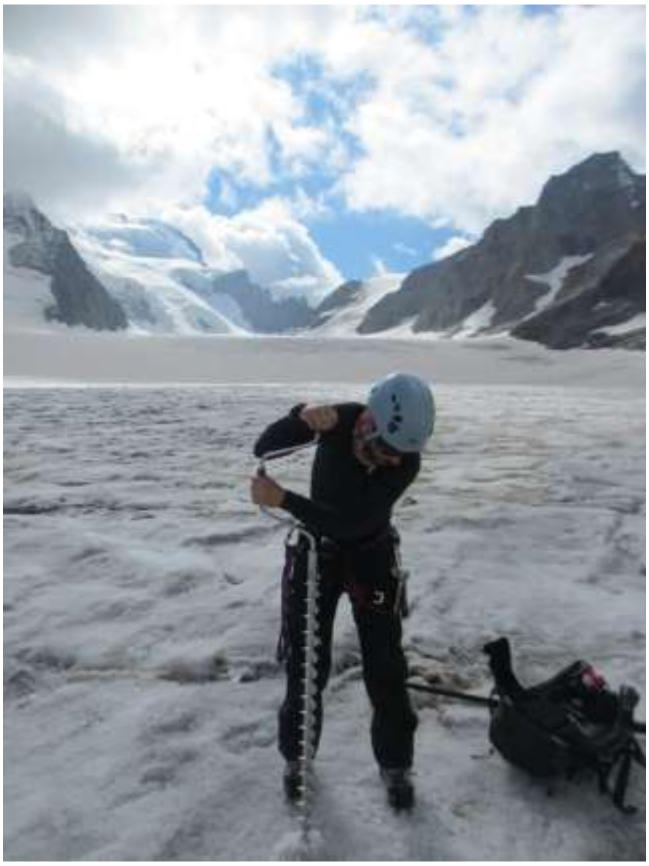

Figure 5: Hand drilling for ablation stakes on Glacier Blanc


Figure 6: One of the 6 ablation stakes of Glacier Noir


Figure 7: The base station for dGNSS measurements was installed on the top of house-size boulder

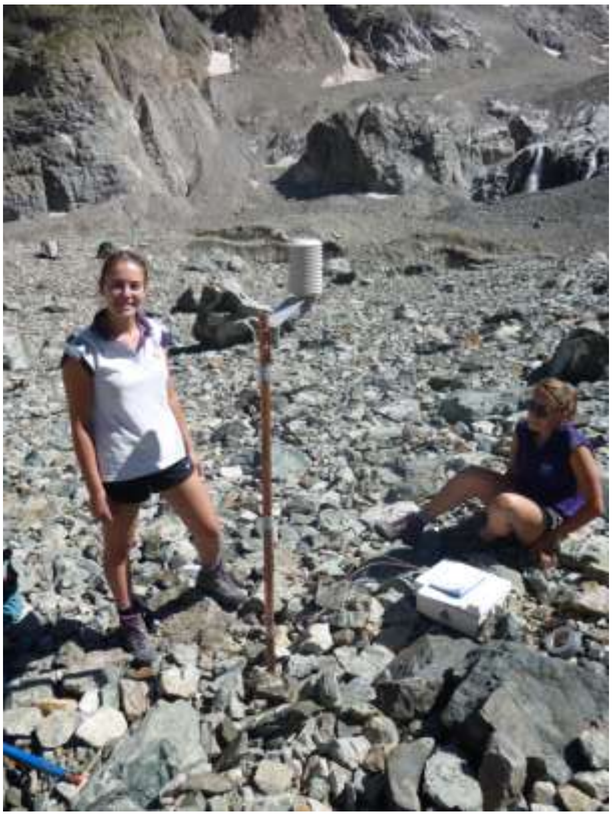

Figure 8: The temperature station freshly installed

Figure 9: The water gauging station was set up under the bridge of Glacier Noir Stream

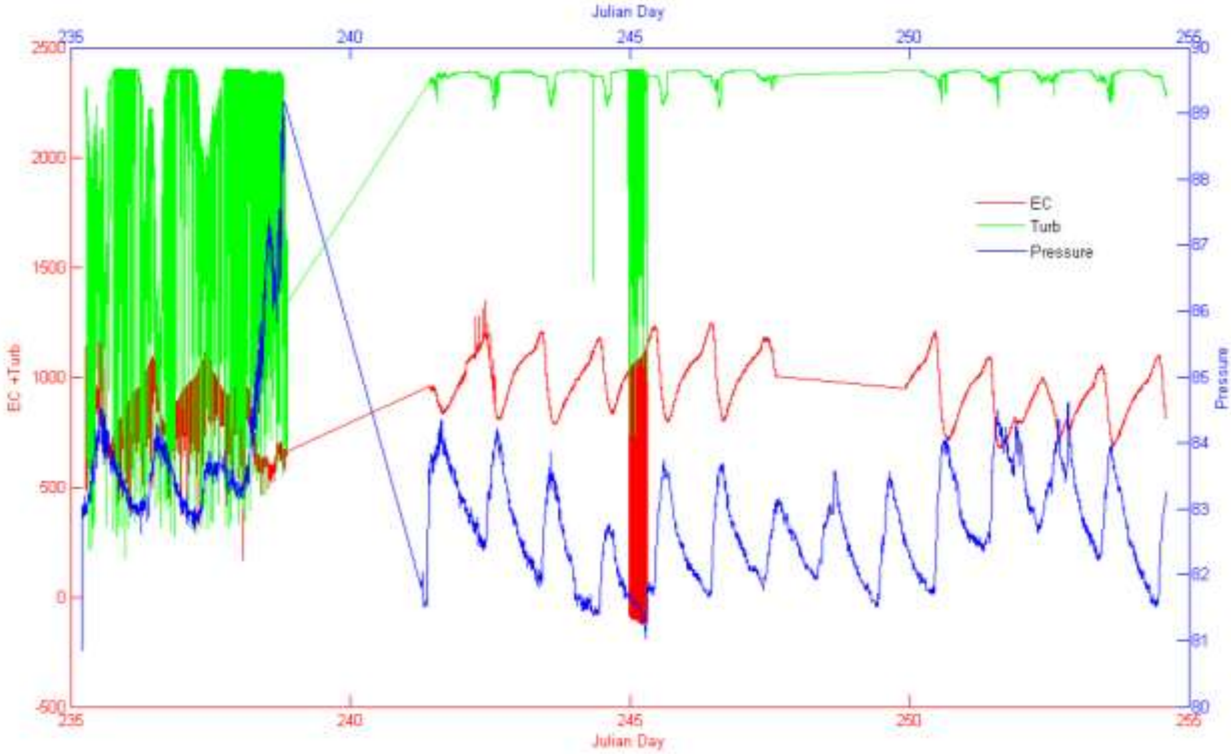

Figure 10: The raw readings of the water quality station. In green, the Suspended Sediment Concentration labelled "Turb". In red, the Electrical Conductivity (EC). In blue, the pressure indicating the water level. Around day 240, there is missing data due the torrential flow. Around day 245, the noise in the EC and SSC comes from a very low level water that exposed the probes to the air. Just before day 250, the flat line is due a malfunction of the data logger.

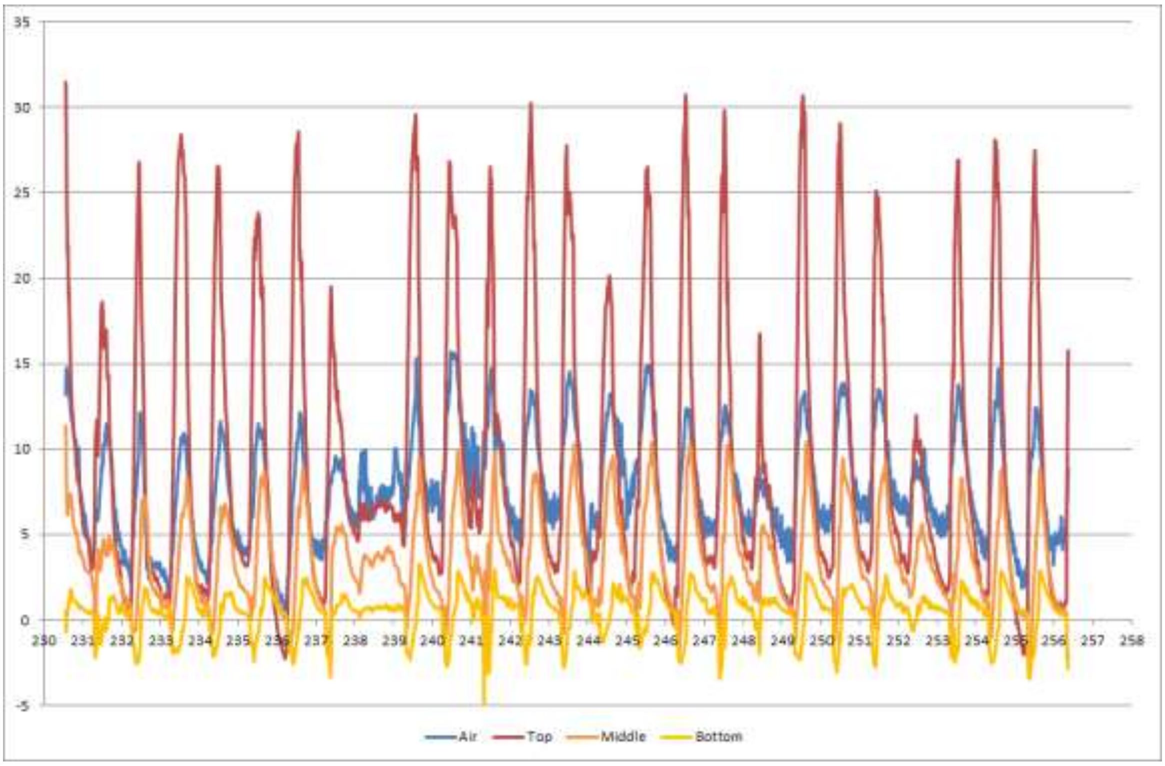

Figure 11: Variation of the temperature of the air and the top, the middle, the bottom of the debris layer on Glacier Noir