ウェブサイト公開用

（様式 10）
（海外特別研究員事業）
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海 外 特 別 研 究 員 最 終 報 告 書

独立行政法人日本学術振興会 理事長　殿

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（氏名は必ず自署すること）

海外特別研究員としての派遣期間を終了しましたので、下記のとおり報告いたします。
なお、下記及び別紙記載の内容については相違ありません。

記

1. 用務地（派遣先国名）用務地：アウストラル・デ・チリ大学　（国名：　チリ共和国　）

2. 研究課題名（和文）※研究課題名は申請時のものと違わないように記載すること。
パタゴニアにおけるカービング氷河の末端消耗

3. 派遣期間：平成 30 年 5 月 21 日　～　令和 2 年 3 月 31 日

4. 受入機関名及び部局名
アウストラル・デ・チリ大学

5. 所期の目的の遂行状況及び成果…書式任意　**書式任意（A4 判相当 3 ページ以上、英語で記入も可）**
（研究・調査実施状況及びその成果の発表・関係学会への参加状況等）
（注）「6. 研究発表」以降については様式 10－別紙 1～4 に記入の上、併せて提出すること。

1. Introduction of the project

The Patagonia icefields are characterized by outlet glaciers terminating in lakes and the ocean (Fig. 1). These glaciers are called "Calving Glacier", and some of them are rapidly thinning and retreating over the last decades. The recession of outlet glaciers plays a crucial role in recent mass loss of the icefield. Changes in calving glaciers are often more rapid than land-terminating glaciers because they are affected by processes occurring at the ice-water boundary as well as the surface mass balance. Frontal ablation, composed of calving and melting at the glacier front, is important to understand the rapid change of calving glaciers, but these processes and quantity are poorly understood in Patagonia. Therefore, I processed satellite images and field data to better understand frontal ablation. In addition to the data analysis, I have carried out six fieldwork in Patagonia with the host researcher and international collaborators in course of two years of the project. In this report, I would like to describe the overview of my activities of the project over the two years.

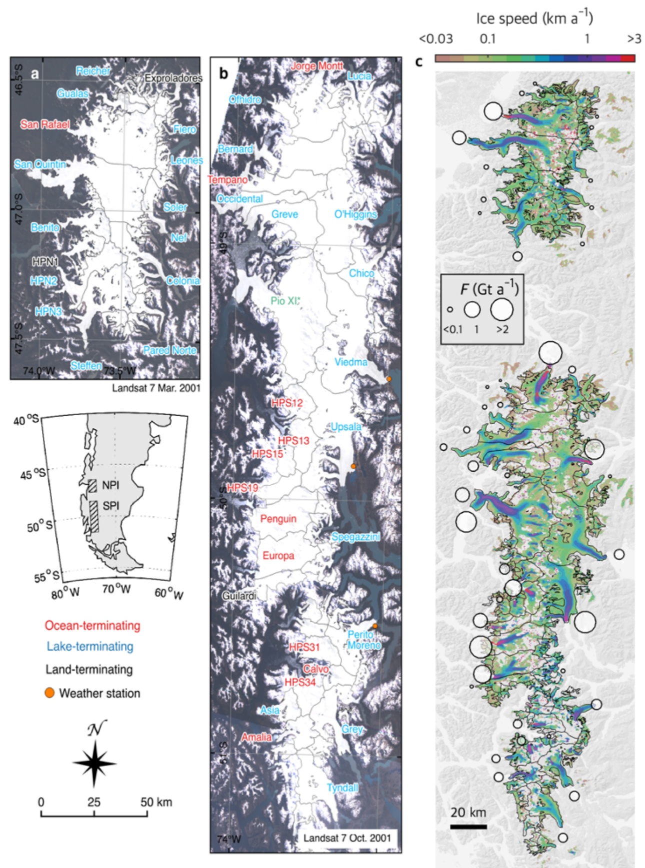

Figure 1. Satellite image of the (a) northern and (b) southern Patagonia Icefields. Name of the target glaciers is indicated on the image. (c) Area of white circles indicate mean frontal ablation between 2000 and 2019.

2. Frontal ablation of Patagonia Icefields

I have processed more than 1800 of optical satellite images for ice-front position, surface speed and surface elevation of 44 outlet glaciers in Patagonia between 1970s and 2019 (Fig. 1a & b). Those datasets were used to calculate frontal ablation for those 44 glaciers (Fig. 1c). This is one of the first direct quantification of frontal ablation for all major glaciers in Patagonia. We demonstrated that the rapid ice moss loss of the

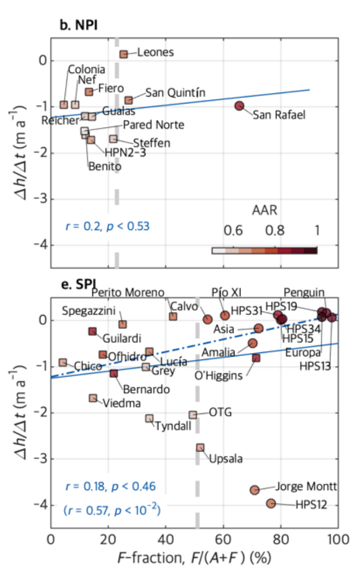

Figure 2. Relationship between frontal ablation fraction and ice-surface elevation change.

southern Patagonia Icefield is dominated by an increase of frontal ablation at several glaciers (Fig. 2). A manuscript which resuming these findings, is now under revewing in Nature geoscience [1]. Furthermore, I am processing satellite images and field datasets in details to understand factors controlling frontal ablation. Several field campaigns have been carried out to collect water depth, water properties and calving activity at several glaciers in Patagonia, which is described in the next section. The study is planning to be submitted to an international journal within this year.

3. Field activities

I have done several fieldwork at ten different glaciers in the southern Patagonia icefield over two years (Fig. 3).

One of the best achievements of the fieldwork was measuring water depth in front of nine calving glaciers. Some of the measurements were for the first time. Because the water depth is expected to be the most important factor controlling frontal ablation, the observed data will improve our understanding of glacier variation in Patagonia. Some of the water depth measurements were performed in very remote places with difficult access. For these glaciers (HPS12, Tyndall and O'Higgins), it was possible to do bathymetry measurement in this project We also realized many more possibilities of other measurements in the near future.

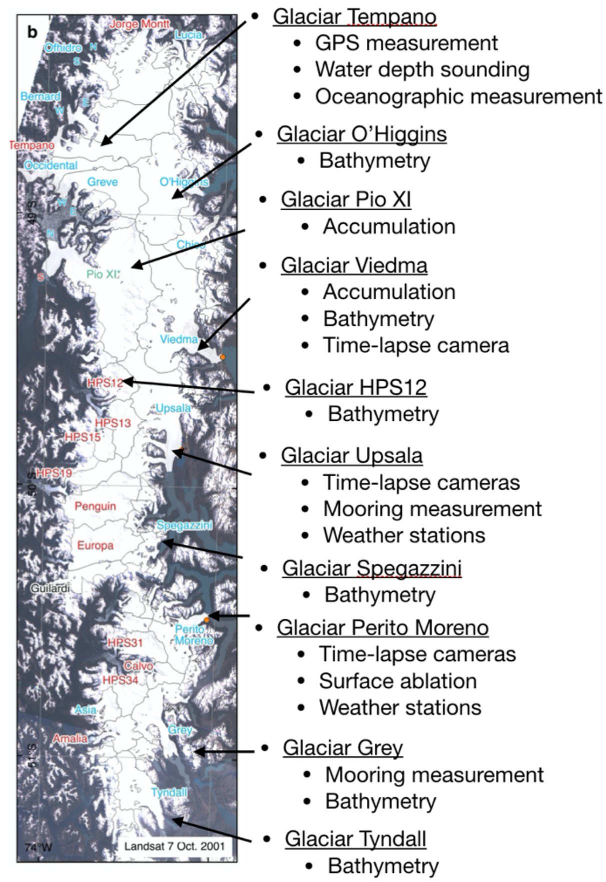

Figure 3. Summary of the field activities during the project.

Secondly, lake water properties were measured with a mooring system installed in front of Glaciar Grey and Upsala. Water temperature and current have measured every minute at several depths. For those glaciers, we also monitored ice-front advance/retreat, calving and ice speed by time-lapse cameras, which took pictures every hour. Combining these datasets, I am going to investigate the controlling mechanisms of frontal ablation. These measurements were performed in collaboration other researcher from Hokkaido University, Japan and University of Alaska, USA.

Thirdly, we made a glaciological traverse between Viedma and Pio XI glaciers to understand snow accumulation of the glaciers (Fig. 2). The field report was published in Bulletin of Glaciological Research [2]. We observed surface elevation change of the glacier by accurate GPS measurement which was useful to validate our remote sensing dataset. Also, we sampled snow and measured snow layers by an ice radar to reconstruct snow accumulation. The measurements indicated the presence of a strong reflector at a distance of 30–40 m from the surface, which we interpret as an aquifer at the firn-ice transition. We could also show that we manage to work in such harsh environment and we are planning more activities in this direction in the next research project.

4. Other works

One of unique point of my study is that I am trying to use tsunami waves to monitor glacier calving. The method is developed by the author in Patagonia and now I have a collaborative project in Greenland with colleagues at Hokkaido University. In the study, we found that we could estimate calving flux from the tsunami waves. The study was published on Earth Planetary Science Letters (Minowa *et al*., 2019) [5].

There is another collaborative study in Antarctica for ice dynamics and mass balance of an ice shelf with colleagues located at Hokkaido University. I am in charge of ice dynamics and basal melting of the ice shelf to study. I presented the study in an international workshop at France on September 2018 [13]. For the ice dynamics, we deployed GPSs and passive seismic sensors to understand how glacier fracture and lose their mass at the glacier front. We found that the ocean tide has the strongest influence on the ice fracture at the ice shelf and the study was published on Annals of Glaciology (Minowa et al., 2019) [4]. For the basal melting, I calculated the basal melting rate and preparing a manuscript which is about to submit.

5. Summary

Overall, as I described above, with the help from the host researcher and other collaborators, I could carry out the project as mostly in the way I had planned it before. By combining the results from satellite data analyses, I could calculate frontal ablation for the major glaciers in Patagonia for the first time. I have done many fieldwork to collect datasets to explain controlling mechanisms of frontal ablation. Some of the field activities I experienced were physically and logistically very challenging. These experiences were very helpful to realize and open new study field in the near future.