Historically Unprecedented Retreat Of The Viedma Glacier: Challenges And Opportunities

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Viedma Glacier low basin (Credit: Andrés Lo Vecchio)

Fresh water is a scarce yet strategic resource. Its availability and accessibility have a great impact not only on human lives, as it is a source of social and economic development, but also on all living organisms on Earth. This is indeed the case in the south of Argentina, in the forests and steppes of Southern Patagonia, where numerous socio-economic activities (including the use of water for human consumption, tourism, agricultural, industrial and agroindustrial activities, and hydroelectric production, among others) depend directly or indirectly on the availability of water from glacier and snow resources.

And it is here, in the southernmost tip of South America, straddling the boundary between Argentina and Chile, where the Southern Patagonian Icefield (SPI), one of the largest and most dynamic glacial icefields on Earth, is located. Unlike Greenland, Antarctica, and the glaciers of Alaska and Canada, which deliver water directly to seas and oceans, many glaciers in the SPI contribute water to vast proglacial lakes. These lakes have given origin to numerous large rivers that contribute to the development of complex lake and terrestrial ecosystems that are exploited for human activities.

The rivers formed by the SPI have great strategic importance for Argentina. Among these stands the Santa Cruz River, the largest Patagonian stream, with a

Viedma Glacier, the largest in Argentina and one of the largest in the SPI.

Between the years 1984 and 2010, the Viedma Glacier reported a retreat rate of 84 my^{-1} (meters per year). However, between 2010 and 2016, the retreat rate tripled to 281 my^{-1}. These figures are comparable to those of the Uppsala (270 my^{-1}) and Montt (240 my^{-1}) glaciers, which were considered to be the ones displaying the highest retreat rates in the SPI (Sakakibara and Sugiyama, 2014).

Glaciers are highly sensitive to climate fluctuations and are considered to be indicators of climate change. Nevertheless, the recent generalized retreat of SPI glaciers has shown to be unrelated to climate variables. Rather to the contrary, it is determined by calving, a glacial ablation process. Calving is not a single process, so understanding calving necessarily involves addressing other long-standing problems in glaciology, such as subglacial hydrology, basal motion, ice fracture, and energy exchanges (Benn and Evans, 2010). Note that calving causes the greatest mass loss from the ice shelves of Antarctica, Greenland, and numerous glaciers in Alaska, Patagonia, and other regions.

Due to the marked increase in the retreat rate of the Viedma glacier, a multicausal study was carried out on the factors intervening in its dynamics by means of remote sensing. Geospatial data acquisition methods for Earth observation and monitoring applications have seen great technological advancements in recent years, as the performance potential of the sensors, in terms of spatial, spectral, and temporal resolutions has significantly expanded to study complex physical processes in the glaciology field. Thus, considering the immensity and the unaffordable nature of glacial environments, remote sensing may be the only effective low-cost tool to study glaciers comprehensively, and the most practical way to obtain a continuous spatial measurement.

In this study, we related surface speeds, surface temperatures and glacier front fluctuations to gain greater insights into its physical behavior. As a result, we may say that its surface speed is modulated by internal deformation and basal sliding (1); and changes in length are related to flotation (2) or otherwise of the glacier terminus in contact with Lake Viedma.

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Credit: Andrés Lo Vecchio & M. Gabriela Lenzano

Between October 2015 and March 2016, the glacier reported maximum surface speeds of 3 ± 0.3 md^{-1} in the terminus and 2 ± 0.3 md^{-1} in the middle basin. According to reports by Lo Vecchio et al. (2018), 90% of the surface speeds could be attributed to (1) basal sliding and the remainder to internal deformation displacement. It should be noted that in basal sliding, the increase in ice temperature may raise the melting rate and provide a higher meltwater flow to the englacial and subglacial systems. In this sense, water plays an important role in modulating frictional drag. In turn, the sliding due to internal ice deformation is closely related to ice temperature, so that ice deforms much more readily as it warms towards its pressure melting point.

On the other hand, the glacier's front is in contact with Lake Viedma, which is deep enough (with a maximum depth of more than 500 m) for the terminus to be, occasionally, floating (2) and exposed to a strong calving of the terminus. This leads to a great loss of glacial mass, which translates into gigantic icebergs going adrift. Indeed, the combination of high flow speeds and the terminus floating are leading to a sudden loss of ice.

Bearing in mind the importance of basal sliding in the Viedma Glacier, future increases or declines in the fusion rates could involve changes in flow speed. These changes would immediately affect calving rates. The changes observed in the calving rate will impact the flow rates in Santa Cruz River, which currently contributes all of its flow to the Atlantic Ocean.

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Ice-melange and Viedma front (Credit: Andrés Lo Vecchio)

In such context, it is crucially important to more deeply study glacier dynamics and water management from a social perspective. The millions of liters of water that are poured into the ocean every second represent an important source of fresh water for the planet. Yet, the use of water resources needs to be carefully planned. Changes in the levels of proglacial lakes could accelerate glacier retreat. Two new hydroelectric dams are currently under construction on Santa Cruz River, and one of the main arguments of their detractors relates to the impact these may have on lake levels.

These findings are described in the article entitled **Estimation of surface flow speed and ice surface temperature from optical satellite imagery at Viedma glacier, Argentina**, recently published in the journal ***Global and Planetary Change***. This work was conducted by Lo Vecchio, A., Lenzano, M.G., Durand, M., Lannutti, E., Bruce, R., and Lenzano, L. from **CONICET-MENDOZA**.

References:

1 Sakakibara, D., and Sugiyama, S. (2014). Ice-front variations and speed changes of calving glaciers in the Southern Patagonia Icefield from 1984 to 2011. Journal of geophysical research: earth surface, 119(11): 2541-2554.

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