The Count Paolo Ballada de Saint Robert and his *Receding of the Glaciers*

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Abstract. The Count Paolo Ballada de Saint Robert (1815–1888) was an Italian scientist mainly busy in mechanics and thermodynamics. This paper describes the conclusions of Saint Robert concerning the retreat of glaciers and tries to explain his theory through modern knowledge.

Key words: Adhémar, Alps, History of climate change, Glaciers, Marsh, Milankovitch

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1 A Short Introduction

An increase of scientific studies on glaciers started only in the middle of XIXth century. The interest was great and for the Italian Alps of Piedmont were involved scientists, geologists and glaciers scholars. In Italy the scientific approach to the glaciers observation was driven by the rise of Italian alpinism where many of these scholars belonged (Malaroda 1995). In 1927 Federico Sacco (1864–1948), President of the Committee of Glaciology, collected and ordered all the main glaciology studies, where next to important scholars it's mentioned the note of Saint Robert[1] defined as a *bearer of good observations on glaciology* (Sacco 1927). In 1930 the Saint Robert's note was listed in the bibliography of the Bulletin of the Italian Glaciological Committee that brings together all the major scientific studies on glaciers (Capello 1930).

[1] The count Paolo Ballada di Saint Robert was born in Verzuolo, Italy on the 10th June 1815. For biographical sketch see Pisano 2013 (and, Medici and Maffioli in this book). He was a member of the *Reale Accademia delle Scienze* of Turin, the *Reale Accademia dei Lincei* of Rome and of the *Società (Academy) Italiana called XL* (forty). His life was dedicated to technical-scientific studies: Ballistics, Artillery, Mechanic, Hypsometry, Thermodynamic and natural studies. His studies of Thermodynamic was very important: he was the first in Italy to write about Sadi Carnot and his work *Principes de Thermodynamique* (1865 et editions) was adopted as text book in the most important Universities in Europe. Raffaele Pisano describes Saint Robert as an important promoter of scientific culture, scholar of military technology among the most distinguished of his time, he succeeded in combining pure and applied science, art and social interests into one of the most elevated synthesis (Pisano 2013; Gillispie and Pisano 2013; Pisano 2007). As a passionate mountaineer, he did many alpine excursions and he was the main promoter and organizer of the first Italian ascent to mount Monviso in 1863 with his friend Quintino Sella, and contributed to the foundation of the Italian Alpine Club in the same year; he was also Honorary Member of the *Alpine Club of London* and intimate friend with William Mathews, John Ball and Francis Fox Tuckett. He retired in Castagnole delle Lanze in 1878 until 1884. He died in Turin in 1888.

2 Why Saint Robert Wrote this Note

In the paper presented at the Royal Academy of Lincei on 2nd December 1883, published also in the Alpine Journal[2], Saint Robert submitted observations to the Note entitled *On the temperature corresponding to the glacial period* (Blaserna 1883–1884a, 1883–1884b, 1882–1883) presented by Pietro Blaserna (1836–1918). In a letter[3], dated 20 November 1883, Saint Robert manifested to his friend Quintino Sella (1827–1884), President of the Royal Academy of Lincei of Rome, the intention to submit a paper about glaciers to integrate the theories exposed by professor Blaserna. This caused some discontent in Blaserna who soon answered in two papers published at the Royal Academy of Lincei (*Ivi*). It didn't follow an official response from Saint Robert probably because he was already sick and tired. The interest of Saint Robert for a subject far to his expertise is due to his work as scientist mountaineer who led him directly to practice and study glaciers. For example, during the ascent to Mount Ciamarella he wrote: "Being the technical alpine language yet to be formed, I make bold to propose the word *rima* to indicate the cracks formed in glaciers, to which the french people give the name *crevasses* [...]" (Saint Robert 1867, p 247). It's probable that Saint Robert, in the formulation of his theory, was influenced by George Perkins Marsh (1801–1882), U.S.A. ambassador in Turin in the early years of Kingdom of Italy and *ante litteram* ecologist, author of the book "Man and nature" translated also into Italian[4] (Perkins Marsh 1870).

2.1 Blaserna's Theory

In extreme synthesis: Pietro Blaserna, through his mathematical studies and the collection and processing of weather data, concluded that the maximum development of european glaciers corresponded to a temperature higher than current one (Blaserna 1882) and agreeing with the theories of Auguste Arthur de la Rive (1801–1873), John Tyndall (1820–

[2] Alpine Journal, n. 85, vol. XII, August 1884, pp. 134–136.

[3] Fondo Carte Quintino Sella, letter n. 885, Sella Foundation, Biella.

[4] We know for sure that this book was part of his personal library, as found in the list of Saint Robert's books donated to Biblioteca Civica di Torino.

1893) and Antonio Stoppani (1824–1891), he said that the temperature of Europe during the Ice Age was higher than current (De Marchi 1911).

2.2 Saint Robert's Theory

In the first observation to Blaserna's theory, Saint Robert indicates that Blaserna does not consider the decrease of temperature to explain ice age (Saint Robert 1883–1884). Saint Robert points out that there are evident traces of glaciers in places where currently there are no more, as for example to the Gran Sasso of Italy. It is impossible, as Blaserna instead supposed, that the increase of temperature could make possible the return of these glaciers, because in this conditions the perennial snowline rises and the condensing surface disappears. The traces of past glaciers show that, in the ice age, the perennial snowline was much lower than actual and this was possible only thanks to a lower temperature or at least to a lower summer temperature. Saint Robert concludes that atmospheric temperature was lower in the ice age and not higher, as Blaserna supposed.

The second observation it's about the significant retreat of glaciers during the XIXth century. According to the theory of prof. Blaserna such receding corresponded to a decrease in temperature. Saint Robert explains how, not only the average annual temperature has not changed much in recent years, but remains mostly constant from 33 centuries. *What is the mistake of Blaserna's theory?*

Saint Robert says that Blaserna did not consider the ablation of a glacier. When the extension of a glacier is constant, annual ablation is exactly equal to the amount of snow falling at the top every year. A glacier, increases or decreases from one year to another depending on whether the ablation is less than or greater than the amount of snow fall. But what is the cause of receding of glaciers? Saint Robert says that the main cause is the progressive decrease of precipitation during the cold season and the increase of summer temperature. The condensed water vapour at the top during the hot season, does not contributes to the formation of glaciers. The water vapour condensed during the cold season remains on the mountains in a state of snow and feeds the glaciers. At the same time, higher summer temperatures contribute to glacier retreat, increasing the ablation's erosion work. The weather observations in Turin, Geneva, Paris and San Bernardo, show, compared to 50/60 years earlier, a significant decrease in rainfall during the cold season and an increase of summer temperatures. These two conditions were caused, as Saint Robert

says, by continuous deforestation of mountains and plains, and by the drainage works of rivers, marshes and ponds. All these actions, operated by man, reduced the evaporating surface and the important water vapour effect on mitigating summer temperatures and winter solar irradiation.

The theory of Saint Robert, to explain the Ice Age, is that in prehistoric period the evaporating surface was greater than the current. As a consequence, the huge quantity of atmospheric water vapour reduced the temperature difference between the cold and the hot season, lowering the level of perennial snow. During the Ice Age the temperature of Europe, or at least the summer temperature, was lower than the current and that the cause of the receding of glaciers is not attributed to astronomical causes, as some scholars believed at that time, but simply caused by climate change, in part caused by human activities on the earth's surface.

2.3 Saint Robert's Theory Today

Luca Mercalli, contemporary glaciologist, climatologist and meteorologist, supports that Saint Robert is certainly more acute than Blaserna when he excludes categorically that a glaciation can be the result of an increase of temperature, identifying correctly glacial conditions as the result of a decrease of temperature (today we know 6–10°C lower than the current). It's absolutely correct the interpretation of the glacial dynamics (today we call it *mass balance*) that is the balance between incoming snowfall on the glacier and ablation of ice during the summer. Saint Robert incurs, however, in a series of inevitable mistakes due to the lack of systematic studies and of a complete database that would have allowed him a correct analysis. He makes a mistake when he doesn't consider the astronomical causes for the decrease of temperature. Joseph Alphonse Adhémar (1797–1862), an eminent French mathematician, was the first to propose in 1842 a rigorous scheme of astronomical forces that control the Earth's orbit and the glacial cycles. Adhémar theory was implemented in 1875 by James Croll (1821–1890). In the theory, still relevant today, exposed in 1941 by Milutin Milankovitch (1879–1958) it's demonstrated how some orbital parameters, as for example the eccentricity of Earth's orbit around the sun, the tilt of the Earth and the procession of equinoxes change periodically, influencing the amount of incoming solar radiation on Earth and therefore changing the climate. Saint Robert's theory also does not consider the general atmospheric circulation and its synoptic variations to explain the decrease of winter precipitation. The cause of this decrease isn't due to

local deforestation (as suggested by Saint Robert) because the true evaporating surface is not local, but rather represented by the Atlantic Ocean and the Mediterranean Sea. Saint Robert didn't have enough data to identify the mechanisms that lead European and alpine climatology and that control the advection of moisture in the Alps. The provisions of the atmospheric currents, on hemispheric scale, govern the alpine rainfall/snowfall by random or cyclic fluctuations, linked to oceanic currents or to changing in atmospheric pressure. Human activity was also a negligible cause on the climate change, because during XIXth century the global population was only 2 billions (while today is 7 billions) and the use of fossil fuels was limited. The only consequences of deforestation operated by man, was hydrogeological instability in mountain regions. The retreat of glaciers, observed at the end of 1800 is not due to human activities but to the end of the Little Ice Age (1300–1850), caused both by a partial decrease in solar activity (Maunder's Minimum) and to a particular frequency of volcanic explosions that projected into the atmosphere large quantities of dust, decreasing solar radiation, temperature and increasing precipitations (Mercalli 2009).

3 Conclusion

It's important to remember that the Italian Glaciological Committee (the first scientific approach to glaciology in Italy) was founded in 1895 twelve years later than Saint Robert's theory. The Count tried, with more than a century in advance and despite the limited knowledge of its historical period, to outline problems that would have prevailed only in more recent times. We think that it is useful to propose this note to better understand the scientific approach, the intellectual honesty and promotion of scientific culture of this great character, mostly forgotten in the history's folds.

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