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THE EVOLUTION OF THE MER DE GLACE GLACIER

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The evolution of the Mer de Glace glacier

Eugen Lucian Casparian

L'evolution de Mer de Glace. Au moitie du 19eme siecle les glaciers du Mont Blanc massif ont été cartographiés et étudiés pour la premiere fois. Au cours du temps géologiques on peut estimer la localisation, le volume,les retraites et les avances du glacier.Mer de glace est du temps anciennes un repère pour la population du vallée de l'Arve, et aujourd'hui un indicateur précieux pour l'evaluation du fenomen de réchauffement climatique. Les ages de glace passes influencaient la répartition des glaciers et façonné le paysage du Mont Blanc massif et de la vallée de l'Arve. On peut constaté que le taux de fusion est de plus en plus plus accélére dans la seconde moitié du XXe siècle et vraiment accelere apres 1980. En utilissant les différents modèles 3D et les données climatiques recueillies pour la station météo de Chamonix Mont-Blanc, nous savons que le passé, nous pouvons confirmer cela, et faire les prédictions sur l'évolution future du glacier.

Mots-clés: glacier, la fonte, le réchauffement climatique, l'évolution, le retrait.

Evoluţia gheţarului Mer de Glace. Începand cu mijllocul secololului al XIX-lea gheţarii masivului Mont Blanc au fost cartografiaţi şi studiaţi pentru prima dată. De-a lungul timpului geologic putem estima amplasarea, volumul, retragerea si avansarea gheţarului Mer de Glace. El a reprezentat din cele mai vechi timpuri, un reper pentru populaţia din valea râului Arve, pentru ca în zilele noastre să reprezinte un indicator preţios pentru evaluarea fenomenului de încalzire globală. Glaciaţiunile trecute au influentat repartiţia gheţarilor şi au modelat relieful masivului Mont Blanc şi a văii Arve. Se constată că ritmul topirii este din ce în ce mai accelerat în a doua jumatate a secolului al XX-lea şi de-a dreptul galopant dupa 1980. Utilizând diferite modele tridimensionale şi datele climatice prelevate pentru Staţia meteorologică Chamonix Mont-Blanc, putem cunoaşte trecutul, confirma prezentul şi putem face predicţii asupra evoluţiei viitoare a gheţarului.

Cuvinte cheie: gheţar, topire, încalzire globală, evoluţie, retragere.

1. INTRODUCTION

This paper argues that the Mer de Glace glacier (figure 1) has varied in size since the first ice age and right now it's on a decending curve.

As Samuel Nussbaumer proved [1], the Mer de Glace had an oscilating evolution with it's maximum extent during the litle Ice age in the year 1644. Because the litle ice age was a period of climatic abnormality wich causes are not knowned, we can just assume that this period is the peak for the extension of the Mer de glace in the time frame studied. It is widely accepted that from then on, following a multitude of supposed factors as the industrial revolution or the nuclear age, the climate has goten gradually warmer. As John Tyndall first observed [2], that alpine glaciers have a certain dynamics,slightly different from fluid dynamics, and more close from the point of its plasticity to solids bodies [3].

Figure 1. Mer de Glace General view from Montevers
Photo: Casparian 2011

As Grecu said [4], the Mer de Glace is a glacier that was formedinto an alpine valley in the Wurm ice age and it's northward orientation gives this glacier ideal climatic conditions to keep his ice mass. If the glacier is melting at an alarming pace, then we can

asses that the climate is warming and that is what causes the srinking of the ice mass [5]. We can observe the reduction of ice mass from the analisis of climatic data,but most uniquely we can see first hand the damage done by global warming by looking at engravings,paintings [6] and photographs [7]. If we take in acount that we are talking about the 3rd largest glacier in the Alps after the Aletsch [8] and the Gornergrat, both in Switzerland, and both situated at much higher altitudes.,then we can say that Mer de Glace is the ideal case study for the srinking of Alpine glaciers.In the next chapters I should try to highlight the turning points,the highs and lows of the glacier's history and also pinpoint the causes of this fenomenon.

What is a glacier?

Of course we must ask ourselfs before we go deeper in the study of the evolution of a glacier,what is a glacier?

A glacier is a mass of solid water (snow, ice) wich for the untrained eye is motionless. In fact it moves quite a lot,renewing itself constantly by obeing the laws of dynamics of plasticity. It is a combination between two factors:the acummulation (snow, blizards, avalanches) and ablation (melting). There is a constant cyclical mouvement between the upper part (acummulation zone) and the lower part(ablation zone), having the solid flow at a maximum level where the balance (accumulatio/ablation) is 0 [12].

2. IMPORTANT FEATURES OF THE MER DE GLACE

The Mer de Glace is situated in the Savoyard Alps,having the following coordonates: - 45°54'10” northern latitudine si 6°56'40” eastern longitudine [4].

The surface of the Mer de Glace is 33,1 km^2, and the tongue of the glacier descends to 1470 m, giving the glacier a total length of 12,3 km. The echilibrium line is situated at 2920 m of altitude and the maximum altitude is 4240m [8]. It has a slope inclination of 25% and that gives it a flowing speed of 90m/year [5].

It is a valley glacier that is situated perpendicular on the valley below(Vallee de l'Arve) and today gives birth to a litle stream called Arveyron,that did not exist in the 19th century because the glacier reached all the way to the valley floor.

Mer de Glace it is a glacier wich is formed as a result of the junction of 3 glaciers: Tacul, Lescheaux, Talefre.

It has an average thickness of 200 m.

It is the largest glacier of the French Alps, if we take in account the surface as criteria [8].

3. THE ICE AGES THAT AFECTED THE MER DE GLACE

After the Mont Blanc massif was formed,it was afected by multiple ice ages and it's still situated in a mild glacier period, technically speaking. The efects of Wurm and "the little ice age" (XVIIth to XIXth century are still visible today and they give us the oportunity of reconstructing diferent stages of ice coverage of the Mont Blanc and the valleys below. [9]

In the time of the Wurm ice age, the alpine glaciers descend all the way to the plains and the Rhone valley. In fact, all the alpine region was covered with thick ice and snow, leaving only the highest summits uncovered. The Chamonix Valley is covered by a thick lair of ice, 1000 to 1300m thick (figure 2).

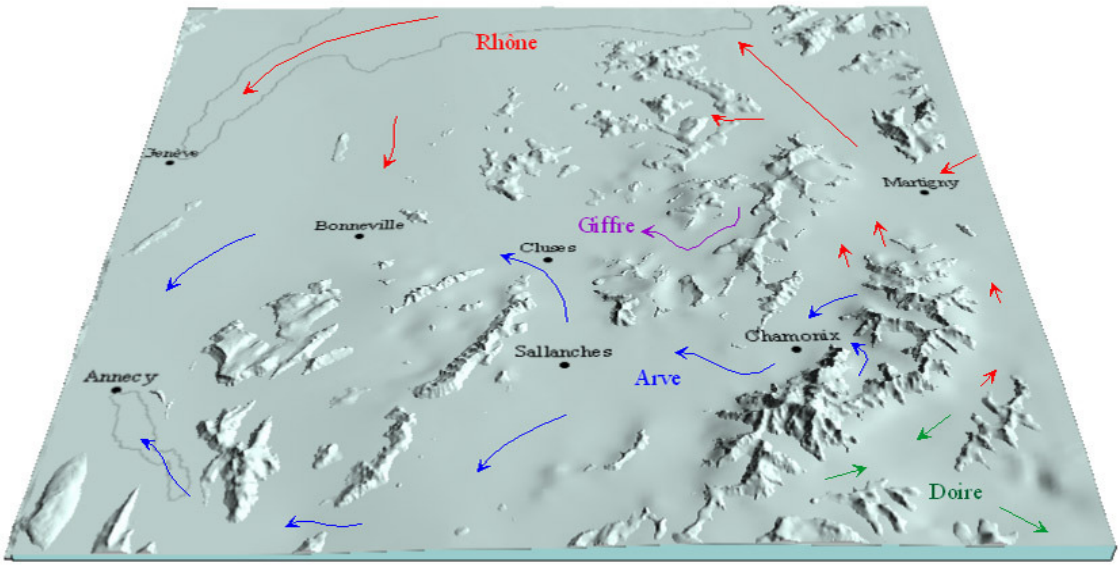


Figure 2. 3D Modelisation of the Haute Savoie region at the maximum extent of the Wurm glaciar period. The Modelisation was done by S.Coutterand, Institut Geographique de Laussane source:http://www.geologie-montblanc.fr/glaciations.html [9].

In the ice age called Dryas, to be more specific,recent Dryass,the glacier is still in the valley and now it reached Lavancher (in the Chamonix Valley) (figure 3).

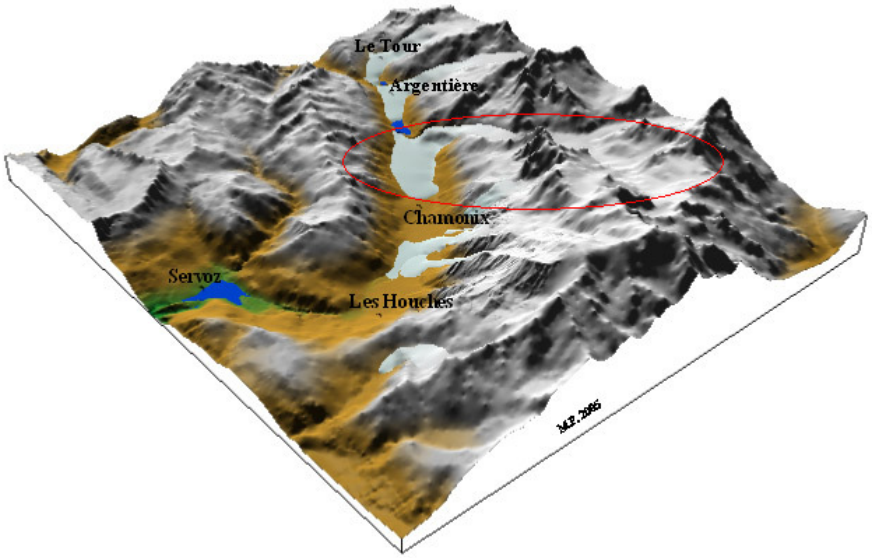


Figure 3. 3D Model of the Mont Blanc massif and the valee Blanche
Source: http://www.geologie-montblanc.fr/glaciations.html [9]

In the time of "the litle ice age", meaning XVII th to XIX th century, because of a temporary cooling up of the climat (it's not clear wich are the causes), the glacier advances. The Mer de Glace reaches the botom of the valley in the exact spots called les Bois and Tines (figure 4), forming the morenaic complex "Cote du Piget"[12].

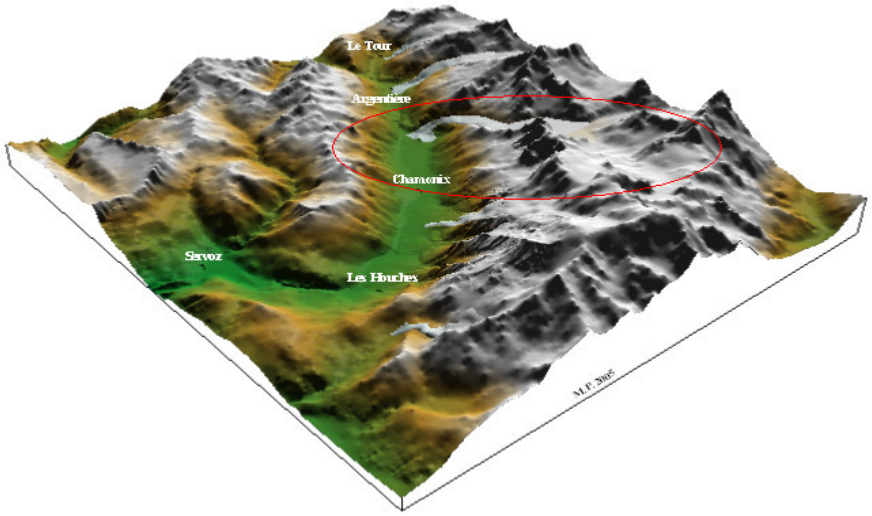


Figure 4. 3DModel of the Mont Blanc massif at the time of the "Little ice age" 1644
Source:http://www.geologie-montblanc.fr/glaciations.html [9].

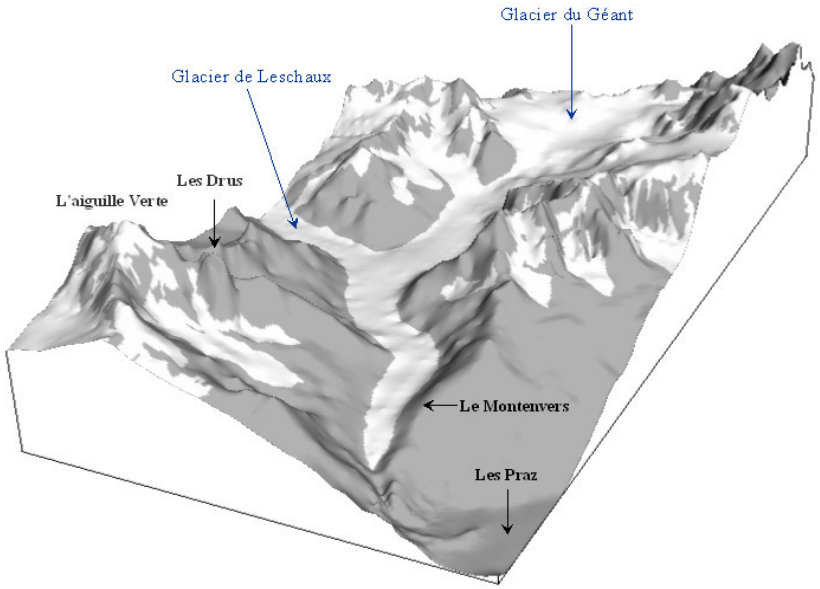


Figure 5. 3D Model of the glacier in the present
Source:http://www.geologie-montblanc.fr/glaciations.html [9].

In the present (figure 5), the glacier retains a lot of it's ice mass, but if we compare it with the 19th century or with the little Ice age, it's clear that it has withdrawn substantially, because in the bottom part of the glaciar's valley we can observe traces of the glacier reaching Les Praz and Les Bois, thus the glacier's name in the 19th century: "Glacier des Bois".

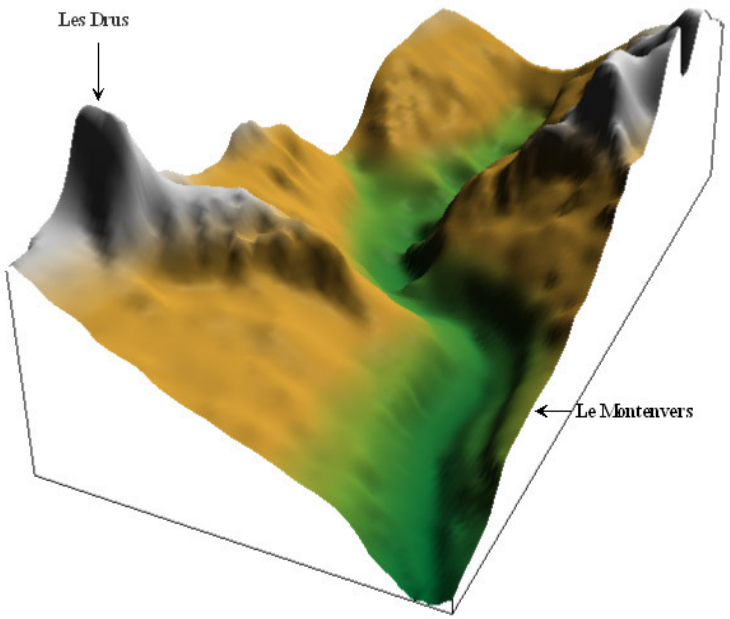


Figure 6. 3D Model of the region whithout ice
Source:http://www.geologie-montblanc.fr/glaciations.html [9].

The scenario in which Mer de Glace looses all its ice becomes plausible if the climatic tendencies manifested in the last 200 years are following the same patern. The Mer de Glace lost 150 m of thicknes from mid XIX century till the present day. It is very possible that the smaller glaciers in the Mont Blanc massif will dissapear completely (figure 6) and that larger ones like Mer de Glace will withdraw up their valley till very high altitudes. [9]

4. THE CLIMATIC PARAMETERS THAT INFLUENCE THE EVOLUTION OF MER DE GLACE

To explain the oscilations of the Mer de Glace glacier we must observe some climatic parameters such as: precipitations (figure 7), temperature (figure 8).

Using the climatic data from the meteorologic post Chamonix Mont Blanc and

analising the data supplied by "Universite de Bourgogne" laboratoire C.R.C. climatology laboratory, we can see that the Mer de Glace oscilates in strict connexion with precipitations and temperature.

As far as the precipitations are concerned, if we calculate the data of every months precipitation from every year of the period (1934-2010), we end up with an oscilating graphic (figure 7), that has a couple of obvious minimums and maximums,but not a clear trajectory of descent.

If we observe the amount of precipitation during the winter months [11], we will see that precipitation has decreased. If we put the precipitation in relation with the temperature in those months we can also see that winter minimums are higher recently and the winters have a tendecy to become shorter. Thus the forming of ice becomes more dificult and cannot keep up with the melting of the ice in summer months witch guides us to the conclusion that we are dealing with a negative balance between the ice acumulated and the ice melted [1].

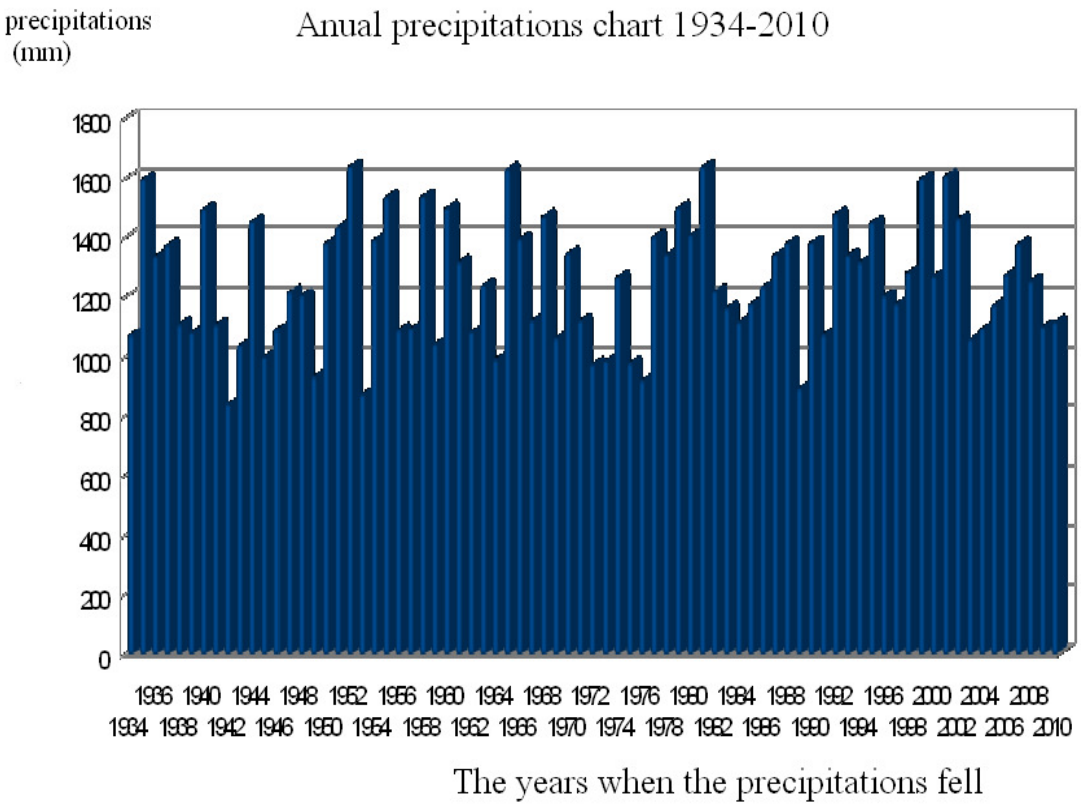


Figure 7. Annual preciptation chart realised for the period 1934-2010

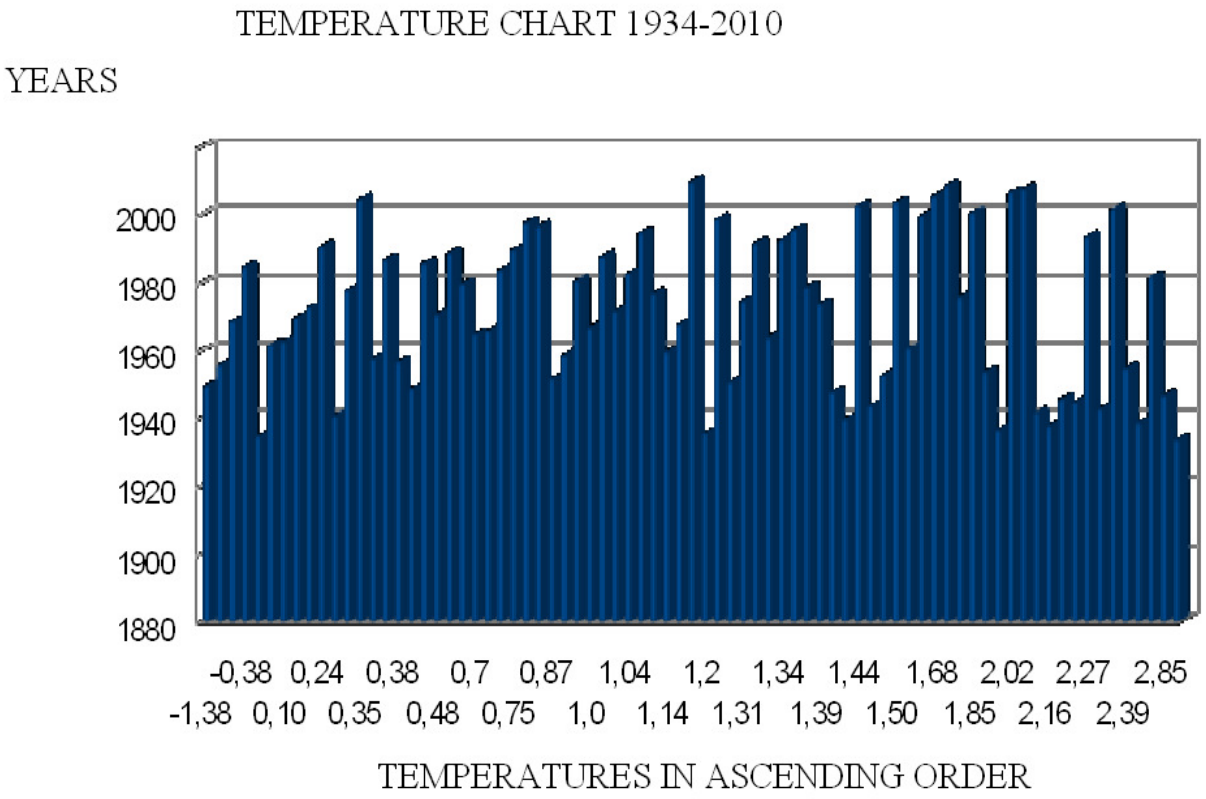


Figure 8. The minimum annual averages in an ascending order reported to the time period when they where registred

The grafic points out the fact that the minimum annual averages were lower in the 40's, 50's and 60's and higher near the present (figure 8), (table 1). Although the difference may seem small, it is decisive for the glacier's evolution.

Table 1. Minimum annual averages T (°C)

Source: Casparian researches, data supplied(monthly averages) by CRC Climatology laboratory of "Universite de Bourgogne", Dijon, France

Year	temperature	Year	temperature
1934	3	1973	0.24
1935	-0.38	1974	1.39
1936	1.2	1975	1.31

1937	1.98	1976	1.85
1938	2.16	1977	1.05
1939	2.54	1978	0.32
1940	1.44	1979	1.37
1941	0.32	1980	0.61
1942	2.15	1981	0.94
1943	2.33	1982	2.77
1944	1.45	1983	1.04
1945	2.18	1984	1.71
1946	2.16	1985	-0.38
1947	2.85	1986	0.42
1948	1.41	1987	0.37
1949	0.42	1988	1
1950	-1.38	1989	0.5
1951	1.25	1990	0.75
1952	0.87	1991	0.24
1953	1.5	1992	1.31
1954	1.95	1993	1.34
1955	2.39	1994	2.27
1956	-0.79	1995	1.04
1957	0.38	1996	1.34
1958	0.36	1997	0.83
1959	0.94	1998	0.81
1960	1.14	1999	1.24
1961	1.51	2000	1.52
1962	-0.24	2001	1.85
1963	0.1	2002	2.33
1964	1.33	2003	1.44
1965	0.7	2004	1.5
1966	0.7	2005	0.35
1967	1	2006	1.68
1968	1.15	2007	2.02
1969	-0.66	2008	2.05
1970	0.22	2009	1.73
1971	0.48	2010	1.18
1972	1.04		

5. THE FLUCTUATIONS OF THE MER DU GLACE

Starting with the 1820's, the Mer de Glace started to withdraw constantly until the limit we know today. We can see in the image above (figure 10). The maximum extension of the glacier (the green line) was reached in the year 1644 (the peak of "the litle ice age"). After that maximum there was a slight withdrawl in the next 177 years until 1821, when the glacier reached the level represented by the red line. Between 1821 and 1895, a much more spectacular withdrawal has taken place. As we can see on the image above, the orange line marks te limit on which the frontal moreine stood on. On this constant line of melting in the last 190 years there were a couple of rebounds that the glacier performed, such as the ones in 1890, 1920, the decade 1940-1950 (figure 11), which in Europe was a decade with very cold winters, and also a short spell of cold winters between 1979-1982 wich made the glacier to advance about 100 m [12, 13].

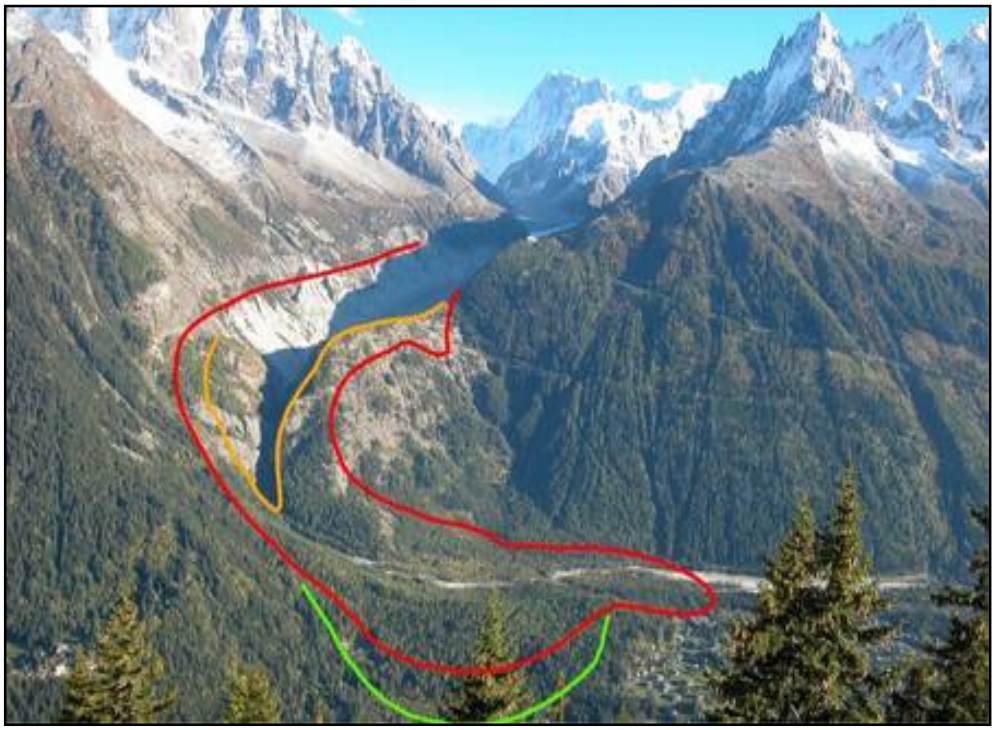
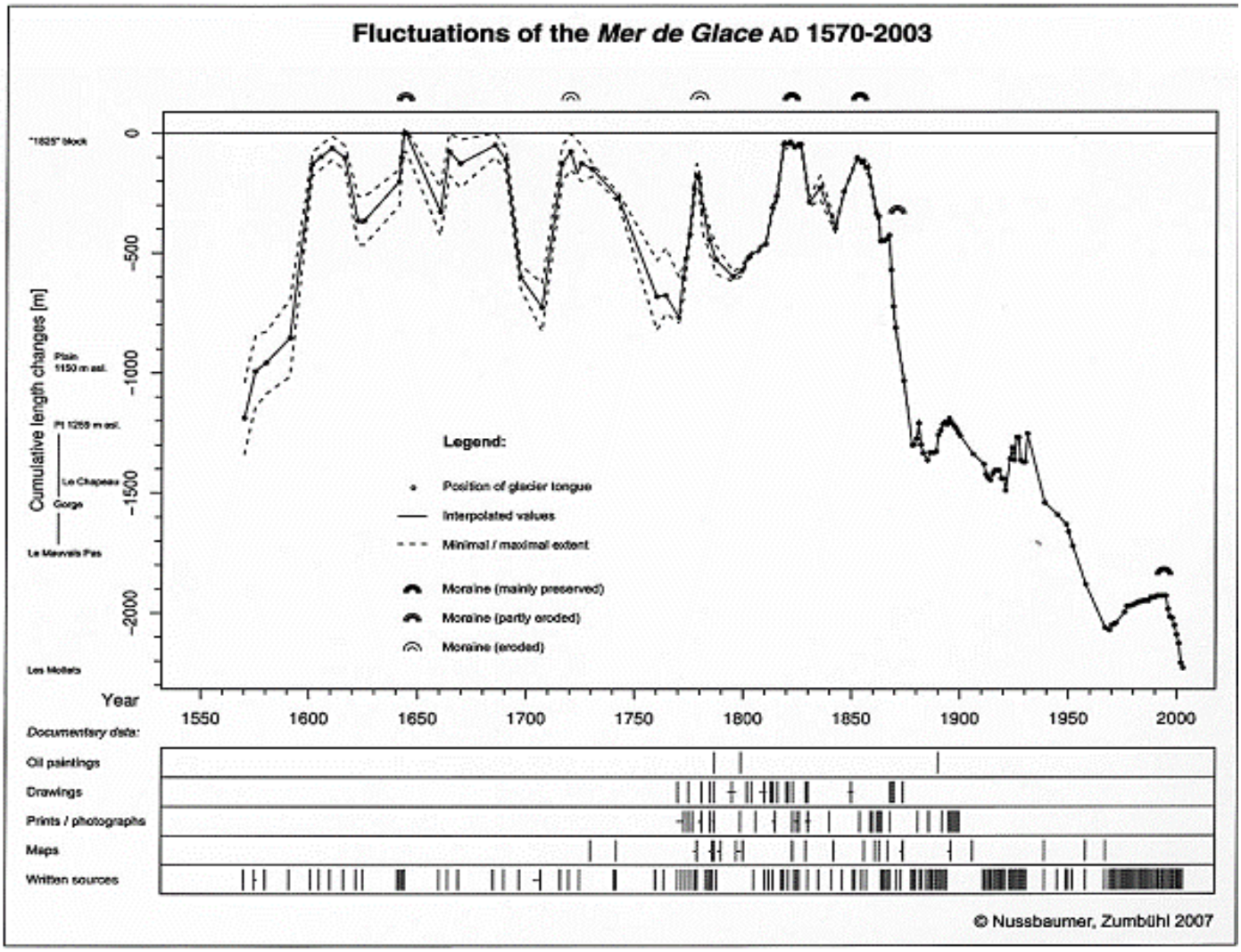


Figure 10. The extension of the Mer de Glace glacier since 1644
Source: Samuel Nussbaumer/FNS [1], University of Bern

Finally, the cause o variations in the ice mass of the Mer de Glace is determined by the delicate balance between the alimentation with snow in winter and the summer meltdow. In the accumulation zone, the gainning of mass is obteined by the ading of a snow colomn at the end of the year, if the year balance was positive. Lower on, in the ablation

zone, the quantity of ice lost is mesured with the aid of depth drilling with a vapor jet drill that aids us to leave markers,which help the measurement (10 and 15 m depth measurements). These markers travel with the glacier and show us the variation between levels in diferent seasons. This helps in calculating the aftermath of a year (if we have acumulation or loss of mass). That is expressed in cubic meters of water gained or lost. This kind of measurement permits us to explain the caracteristics and variations of the length of the glacier.

After the calculations the conclusion is that the winter precipitations, although important in the oscilations,are not decisive and in fact the summer temeratures, wich can be sometimes very high (summer of 2003 heat wave) are decisive in the oscilation of length and mass in Mer de Glace.



↑ Figure 11. The chart of the fluctuation of the Mer de Glace
Source: Samuel Nussbaumer/FNS [1]

6. CONCLUSIONS

- The fact that Mer de Glace is retreating is undeniable and can be seened using field observation that show a modification in the shape of the glacier. Starting with the 17th century onwards, the lenght of the glacier is decreasing constantly, in the 20th century this speed increases considerably and after 1990, the situation becomes alarming [1].
- The fact that the glacier is situated in western Europe, at a median latitude and with a northern exposure makes the glacier an ideal subject for studying the efects of global warming over glacier dynamics.
- Although afected by rising temperatures in the frontal area of the glacier, we can observe that higher up its thickness remains unafected.
- Following the evolution of the glaciers along a great period of time and using tridimensional computer modeling,we can conclude that the melting will continue in a more accelerated rhythm [9].
- The decisive factor in ice melting is the summer heatwaves.Although they can be decisive for the lower part of the glacier,its upper part remains allmost impervious to the fenomenon.
- The graphic sources, like sketches and paintings are usefull for a more objective view of the modifications in the glacier and also to make ones self an ideea of the scale of the landscape [6], [7]. As a consequence of this,we can construct unique case studyies, besides comparing the evolution not only at the basis of climate data. .

We can reconstruct, using this method: the history of the glacier, we can cuantify the variation of the glacier.

- Mer de Glace was the glacier on which most of the thories of glaciology were first enounciated [2].
- Although glaciology takes its roots back to the 18th century,a lot of things are not realy knowned,especially about the flow of the glacier as a plastic body,rather then a fluid [2].
- It is absolutely necessary to observe the glacier for a long period of time in a very minute and meticulous way. This kind of observation reveals the changes in ice mass and the impact of climate change on ice. It also gives us the model from wich we can make predictions for the future [12].

7. ACKNOWLEDGEMENTS

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