Ukichiro Nakaya's Sense of Snow

by Peder Anker and Sverker Sörlin

Imagine this: you have just been appointed professor of physics at the Hokkaido University in northern Japan with the expectation of carrying out path-breaking research, but you have minimal financial resources, hardly any equipment, and not much of a laboratory. Having just finished your graduate studies at King's College London, you have set high research standards for yourself and you are committed to being part of the international scientific community. Yet it is entirely unclear to you how you are supposed to continue your investigations into those long-wavelength x-rays you carried out in London. This is pretty much the situation Ukichiro Nakaya found himself in when he settled down in Sapporo in 1930. On the plus side: he had plenty of snow.

In deciding to study snow, Nakaya turned his difficulties into an opportunity. He started spending the winters taking photos of snow crystals in his laboratory, and subsequently continued his photography at the dormitory of the forest guards at nearby Mount Toachi, more than a thousand metres above the sea. He spent three winters there taking pictures of snow, and he would also spend two winters in a mountain hut on the slope of Mount Asari near Sapporo. As a consequence, he and his assistants suffered 'under the terrible chill' and the results were disappointing: 'We could not as yet begin to explain the simplest and most primary problem, why snow crystals show such a complicated variation in form and structure.'[1]

Nakaya had approached snow from the point of view of natural history, by collecting and recording snow in the field. This was perhaps useful as part of a larger scientific effort of trying to understand weather patterns, but not very helpful to the issue Nakaya tried to

1 Ukichiro Nakaya, *Snow Crystals: Natural and Artificial* (Cambridge: Harvard University Press, 1954), vi, iix.

solve, namely the variations of the structure of snow. He took over 3,000 photomicrographs in the process, and used them to lay out the general classification of snow crystals as they appear in nature.

In 1936, the Low Temperature Laboratory in Hokkaido opened, which allowed Nakaya to start experimenting with the artificial construction of snow under controlled circumstances. He lowered a drop of water on the point of a thin rabbit hair into the chamber and was able to observe and photograph the water turning into a snow crystal. This experiment was, most likely, the first artificial scientific production of snow. By varying the amount of water and the growing condition for these artificial snow crystals, Nakaya created an elaborate diagram of snow types. His hope was that it could help meteorologists determine the atmospheric conditions that shaped the snowflakes they found on the ground.

Nakaya shared his challenges with a few, rare colleagues around the world, who, like him, pioneered the scientific discovery of this eternal element—snow—that only now was properly studied. In the past, snow did not attract much scientific interest, and it was commonly understood that the characteristics of snow were similar to those of soil. The new research in the interwar period would prove this an unjustified simplification, and a whole new understanding would soon emerge.

This research on snow and ice was driven by many sources and impulses, ranging from climatic nationalism, to military needs, and even the Titanic disaster.[1] A key area of concern was the growth of infrastructure and activities, not least winter tourism, in alpine areas. Avalanches were common, and it was necessary to improve protection from this danger for forests, villages, and the growing network of railroads, roads, power lines, and other infrastructure. In Switzerland, railway and electricity companies and the forestry service funded the emerging avalanche research. Later on, when useful results were showing, the government and the military also stepped in along with the insurance industry.[2] Just like Nakaya in Japan, Swiss

1 Trevor Levere, *Science and the Canadian Arctic: A Century of Exploration*, 1818–1918 (Cambridge: Cambridge University Press, 1993), 426. Mads P. Claudi, 'Forlisning, forvirring og folkeopplysning: Naturvitenskap og teknologi i fortolkningen av *Titanic-ulykken*,' in *Sann opplysning?: Naturvitenskap i nordiske offentligheter gjennom fire århundrer*, eds. Johan Tönnesson and Merethe Roos (Oslo: Cappelen Damm, 2017), 307–334.

2 Dania Ackermann, 'Snow and Avalanche Research as Patriotic Duty?: The Institutionalization of a Scientific Discipline in Switzerland,' in *Snow and Ice in the Cold War—Histories of Extreme Climatic Environments*, eds. Julia Herzberg, Christian Kehrt and Franziska Torma (New York & Oxford: Berghahn Books, 2018) 49–68.

scientists working on the issue soon came to the conclusion that field studies of snow and avalanches were very difficult and did not provide all the necessary answers. Instead, they also moved indoors. A first laboratory, built entirely of snow, was set up in the winter of 1935 in Davos. It worked to satisfaction and the following year a permanent construction was built at high altitude in Weissfluhjoch, near a railway station for access.

One of the Swiss scientists was Henri Bader who engaged in groundbreaking studies of the properties and formation of snow crystals at the same time as Nakaya was working in Hokkaido. Bader, just as Nakaya, used the microscope.[3] After the Second World War, Bader left for the United States where he became the head of the Snow, Ice and Permafrost Research Establishment (SIPRE) under the US Army Corps of Engineers. The US military had a strong interest in snow, primarily as construction material in the Arctic, which they saw as a potential theatre of future warfare.[4] Research on snow and ice engaged scientists elsewhere as well, further encouraged by speculations about climate change—still mostly thought to be non-anthropogenic. There were also some elements of landscape nationalism: glaciers were spectacular and added to alluring imagery, and even climate and weather, and thereby snow could be turned into national assets. In Switzerland there were also moral and military properties, with the Alps and snow serving as natural barriers against enemies. In addition, Switzerland could count a venerable tradition of scientific study of snow back to the publication of physician, physicist, and alpinist Johann Jakob Scheuchzer's *Beschreibung der Natur-Geschichten des Schweizerlands* [Description of the Natural History of the Swiss country] (1706–1708).

There were national styles and nuances to the rising flair for snow. Glaciology, rather than research on snow crystals, became a stronghold in the Scandinavian countries.[5] In Russia, there was a focus on

3 Henri Bader, *Der Schnee und seine Metamorphose: Erste Ergebnisse und Anwendungen einer systematischen Untersuchung der alpinen Winterschneedecke* (Bern: Kümmerly & Frey, 1939).

4 Janet Martin-Nielsen, '"An Orgy of Hypothesizing": The Construction of Glaciological Knowledge in Cold War America,' in *Snow and Ice in the Cold War—Histories of Extreme Climatic Environments*, eds. Julia Herzberg, Christian Kehrt and Franziska Torma (New York & Oxford: Berghahn Books, 2018), 69–88.

5 Sverker Sörlin, 'The Global Warming That Did Not Happen: Historicizing Glaciology and Climate Change,' in *Nature's End: History and the Environment*, eds. Sverker Sörlin & Paul Warde (London: Palgrave MacMillan, 2009), 93–114; Sörlin, 'Do Glaciers Speak?: The political aesthetics of vo/ice', in *Methodological Challenges in Nature-Culture and Environmental History Research*, eds. Stephanie Rutherford, L. Anders Sandberg and Jocelyn Thorpe (New York: Routledge, 2017), 13-30.

permafrost, glaciers and sea ice, but also work on snow.[1] In the UK, the famous crystallographer Max Perutz, who won the Nobel Prize in 1962, engaged in the study of ice crystals.[2] Geographer Gerald Seligman wrote a massive volume, *Snow Structure and Ski Fields* (1936), which summarized the knowledge up until then, as Seligman saw it.[3] Already in 1923, Polish geoscientist Antoni Dobrowolski had collected and written up his massive research of many years in a 900 page tome in Polish, *A Natural History of Ice*, a view quite different from the one that Seligman saw. In particular, they disagreed on the concept of 'the cryosphere' that Dobrowolski coined but Seligman vehemently opposed.[4]

This was the international context in which Nakaya worked, albeit still largely within a Japanese context. With the onslaught of war in December 1941, Nakaya worked on atmospheric icing, the artificial dissipation of fog, and other meteorological research that could be helpful in the war effort, while also finishing his book about snow. When the book was under production, the printing office with the copper types was bombed and burned, and he gave up hope of ever seeing his research published. It was not until the spring of 1949 that he was asked by the American Academy of Arts and Sciences to rewrite the book for an English-speaking audience. It was part of a larger war reconciliation effort, and the funding enabled the book to appear with Harvard University Press in 1954.

It is a remarkable 500-page tour de force through the natural and artificial worlds of snow. The observation of snow, the classification of snow, the physical properties of snow, the artificial production of snow, and the investigation and comparisons of snow, are all explained in a text supported by diagrams and the most breathtaking

1 Christine Bichsel, 'White spots on rivers of gold: Imperial glaciers in Russian Central Asia', in *Ice Humanities: Materiality, Ontology, and Representation*, eds. Klaus Dodds and Sverker Sörlin (Manchester: Manchester University Press, 2021; in press). Pey-Yi Chu, 'Mapping Permafrost Country: Creating an Environmental Object in the Soviet Union, 1920s–1940s.' *Environmental History* 20, no. 3 (July 1, 2015): 396–421. Julia Lajus and Sverker Sörlin, 'An Ice Free Arctic Sea?: The Science of Sea Ice and Its Interests,' in *Media and Arctic Climate Politics: Breaking the Ice*, eds. Miyase Christensen, Annika E. Nilsson and Nina Wormbs (New York: Palgrave MacMillan, 2013), 70-92.

2 Max F. Perutz and Gerald Seligman, 'A Crystallographic Investigation of Glacier Structure and the Mechanism of Glacier Flow,' *Proceedings of the Royal Society of London*, series A, *Mathematical and Physical Sciences* 172, no. 950 (August 1939): 339–40.

3 Gerald Seligman, *Snow Structure and Ski Fields: Being an Account of Snow and Ice Forms Met With in Nature, and a Study on Avalanches and Snowcraft* (London: Macmillan, 1936).

4 Roger G. Barry, Jacek Jania, and Krzysztof Birkenmajer. 'A. B. Dobrowolski—the First Cryospheric Scientist—and the Subsequent Development of Cryospheric Science.' *History of Geo- and Space Sciences* 2 (April 2011): 75–79.

photos. It is a cosmopolitan text that uses the language of snow to build bridges between cultures and communities shattered by war, years of hostility, and racial prejudices. Nakaya begins his book, for example, by giving credit not only to fellow Japanese scientists, but also to German and English-speaking scientists.

The book was widely promoted with ads in major science magazines emphasizing that 'many a layman will value this authoritative and beautifully illustrated book.'[5] Book reviewers typically praised 'the exciting beauty and astonishing variety of snow crystals'[6] in the volume and argued that the 'pictures unquestionably are the finest ever made.'[7] Yet the purpose of the photos was not aesthetic or ornamental. They served as documentation in support of Nakaya's scientific order of snow, which he hoped could be helpful for the field of meteorology. Bringing the formation of symmetrical snow forms into the laboratory was the book's chief achievement. As one reviewer acknowledges: 'One of the most satisfying rewards of the workers in Nakaya's group must have been the artificial production of crystal types that had never been found in natural snow and the subsequent search in which these types were eventually observed.'[8]

While the photos of the snow crystals served as facts for the scientists, they had a larger meaning for the general public. 'Snow crystals are the hieroglyphs sent from the sky,' is a much-quoted saying of Nakaya. In Japan, he was a much-appreciated teacher and educator, reaching out to an audience way beyond the field of physics; and is also known as the author of some thirty non-fiction books of high literary quality.[9] It is thus reasonable to give his snow photography a larger meaning than just viewing them as being objective facts serving a narrow argument about the formation of snow in the atmosphere.

After the war, his ideas started to travel, as interest in snow and ice grew, especially as a feature of the US Cold War effort. The US scientists were fully aware of the fact that American glaciology was much less developed compared to other parts of the world, such as Europe—and also Japan. In the grand designs for a US research program, Henri Bader, chief scientist, along with SIPRE's director, geoscientist Albert Lincoln Washburn, turned to their colleagues around the world,

5 Harvard University Press' ad in *Scientific American* 190:4 (April, 1954), 93.

6 Kirtley F. Mather, 'Snow Crystals' (review), *American Scientist* 42: 3 (July, 1954), 508.

7 Jesse L. Greenstein, 'Snow Crystals' (review), *Scientific American* 191:3 (Sept., 1954), 162–163.

8 K. L. S. Gunn, 'Snow Crystals' (review), *The Scientific Monthly* 80:1 (Jan., 1955), 59. Similarly in Herbert B. Nichols, 'Snow Crystals' (review), *Science* 120:3123 (Nov. 5, 1954), 755.

9 James A. Bender, 'Obituary: Ukichiro Nakaya,' *Arctic* 15:3 (Sep., 1962), 242–243.

including Japan, and notably to Ukichiro Nakaya. Thus, after working in separation in the Swiss Alps and in Hokkaido, the two traditions of research into snow crystals came together on the Greenland ice sheet. Where, throughout the 1950s, the Americans conducted their research into aspects of snow and ice, such as density, structure, and thermal and electrical properties; all of which was synthesized into a volume, *Physics and Mechanics of Snow as a Material* (1962) by Bader and another Japanese snow scientist, Daisuke Kuroiwa.[1]

In 1957, Nakaya himself visited Greenland where he was researching snow and ice as part of the International Geophysical Year. In studying what he assumed to be a pristine environment, he was surprised to find 'polluted atmospheres' with particles from the industrial society.[2] At the time, climatologists and meteorologists were contemplating in a hypothetical manner whether such pollution could impact climate, with the world's large emissions of carbon dioxide—CO2—into the atmosphere being of particular interest.[3] Nakaya picked up these early speculations and saw their policy relevance:

> *Because of the global increase in atmospheric temperature since the beginning of the 20th century, glaciers in many places in the world are shrinking or retreating. The cause for this is an increase of CO_2 due to the automobile-dominated society and cutting down of forests. Warming of climate will melt the ice in Antarctic and Greenland leading to a sea-level rise, and lowlands all over the world will be in danger of being submerged.*[4]

This may well have been the first of such warnings coming from a Japanese scientist expressing concerns about what warmer climates caused by humans may entail, especially for a nation like Japan with large populations living in coastal cities.

1 Martin-Nielsen, '"An Orgy of Hypothesizing",' 77. Henri Bader and Daisuke Kuroiwa. *Physics and Mechanics of Snow as a Material* (Hanover, NH: US Cold Regions Research and Engineering Laboratory, 1962).

2 Ukichirō Nakaya, (Abstract) in *Meteorological Abstracts and Bibliography* 9:4 (1958), 31–35.

3 Spencer R. Weart, *The Discovery of Global Warming* (Cambridge: Harvard University Press, 2003). James Rodger Fleming, *The Callendar Effect* (Boston: American Meteorological Society, 2007).

4 Ukichiro Nakaya, 'Moon World in White,' 1957. Not seen by the authors. Quoted in Oslo Kunstforening, Ultima Academy Seminar, Sept. 9, 2017. http://en.oslokunstforening.no/letters-sent-from-heaven.

In 1959, Nakaya joined American and Canadian scientists occupying the T-3 iceberg in the North Pole.[5] The huge iceberg was discovered back in 1947 and had since the early 1950s been an outpost for research of military and civil interests. Here Nakaya would study polar winds, ice, and ocean currents, research that became a point of reference for current understandings of the melting of polar ice in view of climatic change.

Nakaya died in Tokyo in 1962, right at the time when his daughter Fujiko had her first solo exhibition of paintings in the Tokyo Gallery. She had graduated with a Bachelor of Arts from Northwestern University in 1957, and continued her studies in painting in Paris and Madrid until 1959. Her early career as an artist must have been to the liking of her father, who over the years had become a proficient *sumi-e* artist (the art of using single brush strokes and black ink). After her father's passing, Fujiko would turn to fog as her chief artistic medium, beginning with her famous fog installation at the Pepsi Pavilion at Expo '70 in Osaka. Yet there is a closer connection to her father than a shared interest in art. Her fog installations also draw deeply on his research on atmospheric snow, as well as his worldly outlook and care for the human condition.

5 Anonymous, 'Japanese Join Iceberg Study,' *New York Times*, March 13, 1959, 2.