My Career as a Researcher, Supported by Kakenhi

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I believe it would have been almost impossible to conduct my research and make a number of important findings without the assistance of the Grants-in-Aid for Scientific Research (Kakenhi) program. I am currently investigating the effect of aerosol on climate in the Arctic from a new perspective under the Grant-in-Aid for Scientific Research (A) program. I consider that my studies were made in four different phases.

I served the first phase in my career as a research associate at Nagoya University, where I began studying the destruction of stratospheric ozone. Stratospheric ozone protects life on Earth by absorbing harmful ultraviolet solar radiation. This stratospheric ozone is destroyed by nitrogen oxides, and the increase in ultraviolet radiation due to the destruction of the ozone layer is known to have potentially harmful effects on Earth's organisms. The aim of my research was to investigate the distribution of nitrogen oxides in the atmosphere in order to determine the extent of ozone destruction. To this end, I started to develop an instrument that could measure the concentrations of nitrogen oxides with high precision. Looking back, the technological hurdles involved in the development of this instrument were extremely challenging. Over a three-year period, I received an annual grant of approximately 1 million yen under the Encouragement for Young Scientists program. As I needed to make a number of new trials, tests, and changes of the prototype instrument, I was particularly grateful for the support of this Kakenhi grant, which came with relative freedom to spend as I required. The notice from the university office stating that my Kakenhi application had been accepted came at a time when my experiments for the development required new ideas, and I remember how this news boosted my spirits and served as a major encouragement to forge ahead with my research. Although it took me three years to complete development of the measurement instrument, thanks to the Kakenhi grant I was able to conduct several phases of experimental attempts and consolidate the experimental foundation required for observational research.

In the second phase of my research career, which lasted over a period of close to 10 years I was able to use the instrument I had developed to conduct balloon-borne experiments abroad in countries such as France and Sweden. At a time when I was in my mid-to-late 30s and transitioning into a fully fledged research career, I was fortunate to receive continued support from the Kakenhi program under categories including General Scientific Research (B) and (A) as well as International Scientific Research. This enabled me to obtain a wealth of data from the balloon experiments in Europe, thereby gaining statistically reliable information. I believe it was because of the foundation I laid under the Encouragement for Young Scientists program, and the recognition of the papers I published based on the results of these early-phase studies, that I was able to receive subsequent Kakenhi funding when it was most needed. The publication of a number of papers based on my research opened up access to a greater amount of Kakenhi funding, which in turn allowed me to generate further findings.

A third phase in my research career subsequently developed, partially overlapping with the second phase. Whereas stratospheric ozone plays a role in absorbing ultraviolet radiation, ozone in the troposphere at altitude up to 10 kilometers is linked to global warming, and negatively impacts human health and the growth of vegetation due to its properties as a powerful oxidant. Although the production of tropospheric ozone sensitively depends on the concentrations of nitrogen oxides (NO_x), the distributions of NO_x were poorly understood. In the 1990s, the amount of nitrogen oxides emitted into the atmosphere in Asia was rising rapidly due to industrial growth. Realizing the importance of this chemical process, I developed an instrument that could be fitted to aircraft to measure the concentration of nitrogen oxides and began conducting research on this topic. Precisely around this time, NASA was planning a mission using large aircraft to study the rapidly changing atmospheric environment in Asia. My research caught the attention of the project supervisor at NASA, and I could participate in the mission. The concentrations of nitrogen oxides in the wider Pacific Ocean area are generally much lower than those in the stratosphere. We had to not only further increase the sensitivity of the instrument, but also be able to measure the concentrations of sum of nitrogen oxides (NO_y), for improved understanding of the chemistry of tropospheric ozone. Although the measurement of NO_y was critically important to investigate the oxidation processes of NO_x, there were no reliable measurements of NO_y at that time.

Again, much of the development costs for this new measurement instrument were covered by Kakenhi grants. In addition to the cost of constructing the instrument, a significant financial outlay was required to participate in the mission, including the cost of transporting equipment and overseas travel expenses. At the time I expressed my intention to join the mission, there was no guarantee that my Kakenhi application would be approved—in effect, I jumped the gun. Fortunately, however, my application was granted, and we succeeded in obtaining highly accurate nitrogen oxides measurements, thereby making a significant contribution to the understanding of the chemical process by which ozone is generated in Asia. By this stage in my career, I was not concerned about what I would do if my Kakenhi application was not approved. Instead, my experience of the Kakenhi program encouraged me to take on the new challenge, confident that the grant would be provided.

The fourth phase of my research career was not a simple extension of my previous work. I had realized the importance of understanding aerosol which has significant impacts on Earth's energy balance due to the fact that it reflects or absorbs solar radiation. It was then—after reaching 50 years of age—that I set aerosol as my primary research topic. In order to obtain a quantitative understanding of aerosol's impact on climate, which was unclear at the time, I felt that it was necessary to develop a new measurement technology capable of distinguishing between particulate matters which absorb sunlight, such as black carbon, and particles which scatter sunlight, such as ammonium sulfate. It was also important to be able to measure the diameters of individual particles with high precision. I focused on the characteristics of black carbon to strongly absorb light, and established a high-precision measurement method based on the absorption and scattering of laser light. Using this method to conduct airborne and ground-based observations led to significant advances in understanding of the behaviors of black carbon. I have conducted the airborne measurements of the altitude distribution of black carbon in Asia and the Arctic for the first time, and elucidated the effect aerosol has on the radiation balance. This research was accepted for a Grant-in-Aid for Scientific Research (S) on two occasions, and I was able to obtain internationally acknowledged research findings over a 10-year period by developing a high-precision measurement instrument and using this to conduct field observations. During this phase, I considered it critically important to develop the creativity and the capability of innovation of postgraduate students, postdoctoral students, and young researchers in this new research topic wherever possible, with the aim of fostering the next generation of researchers. I devoted a significant portion of the Kakenhi grant to this purpose, and as a result, many

outstanding researchers have emerged in this field.

Conducting advanced research requires a significant financial outlay, and for researchers, the task of obtaining the necessary funding is a very real hurdle that cannot be overcome by ideals alone. When making plans with new research concepts, researchers need to have a realistic expectation that steady funding can be secured. Looking back over my research career, it was critically needed to obtain consecutive Kakenhi grants when I was just starting out, and obtaining those grants allowed me to establish a foundation for my later work. It is due to this experience that I believe in order to develop the next generation of researchers, the budget allocated to support young researchers must be increased. Funding categories that offer support to young researchers have recently been established. However, we must make improvements to and further enhance these programs to create a fairer and more effective system for allocation of research funding, especially to encourage the next generation of researchers, who will make substantial contributions in the future.

One of the aims of the Grant-in-Aid for Scientific Research (S) and other large-size grants is to extend the capabilities of young researchers to their full potential, in particular by allocating funding to purchase equipment and travel overseas, or hiring them as researchers. In order for Japan’s scientific research to flourish and prosper going forward, I believe we must support promising young researchers in the period immediately after they have completed their doctoral programs.

I also feel strongly that I should contribute to the research community and society at large, through the experiences and knowledge I have obtained with the support of the Kakenhi program. Accordingly, over the past several years I have worked to publish books that may be useful as foundations for the next generation to pursue further advances in earth science.