Japan Academy Prize to:

Yutaka Kondo
Research Professor,
National Institute of Polar Research

for “Science of Global Atmospheric Environment”

Outline of the work:

In recent years, there is growing evidence that changes in atmospheric composition by human activities are causing significant effects on climate and air quality, which are critically important for human lives. Because of this importance, studies to understand how atmospheric composition has changed and the processes that control these changes have rapidly advanced. Prof. Yutaka Kondo has made important contributions to the development of the new research field “Science of Global Atmospheric Environment”. He clearly recognized the essential importance of high accuracy measurements in atmospheric observations that he undertook for his studies. He played key roles in international and Japanese cooperative research projects conducted in many parts of the world by deploying his own sampling instruments developed for balloon, aircraft, and ground-based observations. Based on these observations, he made detailed studies on the effects of airborne particles (aerosols), especially carbonaceous particles, on climate. He also made important contributions to the systematic understanding of the mechanisms of the destruction of stratospheric ozone and the chemical processes that produce tropospheric ozone. Specifically, he made profound achievements in the three important research areas of the Science of Global Atmospheric Environment.

Studies on the effects of black carbon (BC) on climate

Black carbon (BC) particles emitted by incomplete combustion of carbon-based fuels strongly absorb solar radiation and thus contribute significantly to global warming. The climate effects of BC particles depend on their masses and the state of coating by non-BC compounds. However, there used to be no techniques to measure accurately the mass of BC and the coating thickness, leading to large uncertainties in the estimates of the effect of BC on climate. Prof. Kondo is a pioneer in the development and scientific use of new instruments that measure the BC content of individual particles using the laser induced incandescence (LII) technique. Prof. Kondo showed that the detection of BC-containing particles by LII is uninfluenced by the coating of BC, and provided a firm basis for the determination of BC mass separately from its coating, leading to the unambiguous definition of BC mass. He also developed a method to measure the coating thickness of a BC-containing particle, which enhances the climate influence of these particles in the atmosphere. His work has enabled the quantitative estimates of the macroscopic properties of aerosols by the measurements of their microphysical properties. In addition, he developed a commercial instrument to measure BC mass concentration continuously with the highest accuracy, based on photo-absorption of BC. He demonstrated the consistency of different atmospheric BC measurement techniques used in the international community and established an operational definition of BC, terminating the confusion of the definition of BC that had existed for more than two decades. Prof. Kondo obtained spatial distributions of BC by making the first aircraft measurements in Asia and the Arctic using the LII instrument. Using ground-based measurements, he discovered that the size and coating thickness of BC increase during the transport of emissions from China.

Through these observations, he systematically elucidated the physical and chemical processes of BC starting from its emission and including its transport, coating, and removal by precipitation.

Studies on the destruction of stratospheric ozone

Ozone in the stratosphere (10-50 km altitude) absorbs harmful solar ultraviolet radiation, protecting life on earth. Ozone over the Antarctic is destroyed rapidly in spring by anthropogenic species that contain chlorine and bromine, forming the Antarctic ozone hole. Nitrogen oxides ($NO + NO_2 = NO_x$) from natural and anthropogenic sources also destroy ozone catalytically. On the other hand they suppress the catalytic ozone destruction by chlorine radicals by converting them into a more stable species. Therefore, accurate measurement of reactive nitrogen is a key for the understanding of the chemical processes that control ozone. Prof. Kondo developed a highly sensitive NO and total reactive nitrogen (NO_y) chemiluminescence instruments for balloon-borne measurements in order to investigate the processes of oxidation and the budget of NO_y. He first participated in an international balloon campaign at the age of 32, and measured the NO profile up to 32 km in the stratosphere with the highest accuracy. Further, he succeeded in the simultaneous measurements of NO and NO_y and showed that heterogeneous reactions on sulfate aerosols greatly influence the partitioning of NO_y species.

Stratospheric ozone destruction was also found to occur in the Arctic. In order to understand the special chemical conditions in the Arctic, Prof. Kondo participated in several international Arctic balloon campaigns and conducted a satellite validation balloon campaign in Sweden. He found that NO_y largely decreased in the mid-stratosphere in the cold Arctic winter, when ice particles formed. The decrease was due to the absorption of NO_y on ice particles, which underwent gravitational sedimentation. As a result, the rate of sequestering of chlorine radicals by NO_x decreased, leading to a formation of a small-scale ozone hole. These studies greatly improved quantitative understanding of the ozone decrease in the Arctic, which occurs under conditions different from those in the Antarctic.

Studies on tropospheric ozone

Ozone in the troposphere (0-10 km altitude) has a significant greenhouse effect, influences the oxidizing capacity of the atmosphere, and is harmful to humans and other life forms near the surface at concentrations above natural levels. The production rate of ozone is strongly controlled by NO_x concentrations, which are enhanced by human activities. Prof. Kondo participated in several NASA aircraft missions by conducting airborne observations using the very sensitive reactive nitrogen instrument he developed. With these first-time observations, he greatly improved quantitative understanding of the processes of oxidation of NO_x and irreversible loss of NO_y. He assessed the chemical and transport schemes used for 3 dimensional atmospheric models through the comparison of the observed and model-calculated values, and demonstrated the validity of the model estimates of the effects of ozone on climate.

Because of these achievements, Prof. Kondo received 6 awards from 4 science societies in Japan. He also received the Medal with Purple Ribbon and the Science and Technology Prize from Toray Science Foundation, and was elected as a Fellow of the American Geophysical Union.

List of Publication

(1) Studies on the effects of black carbon (BC) on climate

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(2) Studies on the destruction of stratospheric ozone

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