Prof. Dr. H. R. Pruppacher

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Professor Dr. Hans Rudolf Pruppacher was a towering figure in the international cloud physics community. He was a researcher, teacher, and mentor, and had immense impact on both experimental and theoretical developments in the field in atmospheric science. His pioneering work is gaining even more importance as recent climate studies have underlined the fundamental uncertainties resulting from clouds.

Hans was born in Zurich, Switzerland in 1930. Since a young age he was interested to understand environmental phenomena and his passion for meteorology increased during his studies of natural sciences with majors in experimental physics and physical chemistry at the ETH in Zürich. There, he met his mentor and promoter Prof. Dr. Raymund Sänger of the Institute of Physics. Under the supervision of Sänger, Hans earned his diploma in theoretical physics, experimental physics and physical chemistry, as well as geophysics, and was the first to do his diploma work on cloud physics. For his diploma work, Hans started a laboratory of cloud physics within the institute for Physics.

Hans presented his diploma research results in 1955 in the meeting of the Swiss Physical Society and surprised the international cloud physics community as he showed experimentally that current knowledge of formation processes of snow crystals in atmospheric clouds needed profound revision. The director of the ETH recognized the importance of cloud physics in Switzerland, as Swiss agriculture suffered heavy damage due to hail every year, and wanted to lay down the foundation of an atmospheric physics section in the department of geophysics. Obviously Hans would play an important role in the new section and was sent to UCLA in 1956 to obtain a full education of meteorology under the scholarship of the Swiss National Science Foundation.

The Department of Meteorology at UCLA (now the Department of Atmospheric and Oceanic Sciences) was, at the time, a relatively young department, which was founded in 1940 by Jacob Bjerknes with another Bergen school meteorologist Jørgen Holmboe and others. There, Hans received a M.S. degree in 1958 and a Ph.D. degree in 1962, both in meteorology. His Ph.D. work was on the effect of electrolytes and external electric fields on the supercooling of water drops, which was a successful application of his sound background in physical chemistry and his research experience developed in ETH to a cloud physics problem.

While Hans's original plan was to return to ETH after the completion of his study, fate had it that he would stay in the U.S. for a longer time. During his study in the U.S., Prof. Sänger passed away which put the establishment of an institute of atmospheric physics in ETH on hold.

However, also in the US, Hans's cloud physics talent did not go unnoticed. He stayed at UCLA to become a faculty member in 1964 and set up one of the best-equipped cloud physics laboratories in the world, of which the UCLA Cloud Tunnel was undoubtedly the centre piece.

Clouds are condensed water substances (water drops and ice particles) freely floating in air supported by updrafts, and their development is strongly influenced by the air current passing by these condensed particles. Most of experimental cloud physics studies previous to this time were performed under static conditions where the formation and growth of hydrometeors were studied without relative motion with respect to air. To more realistically study the cloud formation and development in the atmosphere, therefore, one needs to create a controlled environment that simulates the free atmosphere condition of the cloud environment. A vertical wind tunnel, which produces updrafts to support freely floating hydrometeors and whose temperature and humidity can be controlled, would be ideal for such a study, and thus the cloud tunnel was born.

Experiments performed on the UCLA Cloud Tunnel soon produced many results of fundamental importance to cloud physics. The first to be published was the experimentally measured terminal velocities and drag of small water drops carried out by Kenneth Beard who later became an atmospheric science professor at the University of Illinois— Champaign Urbana. This was followed by work on evaporation, growth and hydrodynamics of both water drops (large and small) and ice particles, performed by subsequent graduate students. At the time of its operation, the UCLA Cloud Tunnel was the best-controlled enclosed (as opposed to open-ended) vertical wind tunnel in the world.

Cloud tunnel experiments were usually recorded as movies that gave the viewer direct understanding of the complicated processes occurring during experiments. These movies became a great hit at every cloud physics conference whenever they were shown. Who would not be impressed looking at freely floating water drops or ice crystals performing their magic oscillation, spinning, tumbling, or simply hanging there quietly? These are things that would occur in clouds but normally cannot be observed directly. Soon, one would hear everywhere in the conference of discussions about the cloud tunnel experimental movies shown by “the Pruppacher Mafia.” Probably created by jealous colleges, this expression was rapidly adopted by the group of students and colleges working with Hans as an honorary expression for the closed sworn community of the addicts of cloud process studies.

Aside from the Cloud Tunnel, there was another facility — a 100 ft long rain shaft that extended from the roof of the Mathematical Sciences Building to its basement. The long distance was needed for large raindrops to reach terminal velocities. Hans and his students used this facility to perform experimental measurements of the acceleration behaviour of raindrops and the scavenging efficiency of aerosol particles and SO_2 by simulated raindrops.

Hans received the prestigious Alexander-von-Humboldt- Award of Germany in 1977 in recognition of his great contributions to cloud physics. In 1982, he received the highly distinguished Second Half Century Award from the American Meteorological Society, which

cited that the award was given “for his outstanding research in experimental cloud physics, which has provided fundamental data on a wide range of microphysical phenomena essential to the quantitative understanding of clouds and precipitation.”

Experimental studies were not the only kind of contribution performed by Hans and his students. Theoretical studies performed by them, especially numerical models, also contributed significantly to the field of cloud physics. Hans has collaborated with Archie Hamielec, a chemical engineering professor of McMaster University in Hamilton, Canada, to investigate the flow fields around falling hydrometeors. Fluid mechanics and transport phenomena figure prominently in both chemical engineering and cloud physics, so cross-fertilization is very natural. The collaboration bore fruitful results, beginning with the numerical study of flow around falling ice plates performed by Richard Pitter and extending to the flow around columnar ice crystals and small drops, and to the collision growth rates by subsequent students.

Precipitation scavenging, the process by which air pollutants are removed by cloud and precipitation process, is by far the most efficient cleansing mechanism of the atmosphere. This is an area of natural extension to cloud physicists. As mentioned above, Hans Pruppacher and his students had done experimental measurements of this process, but his group also contributed significantly in the numerical modelling of it. They constructed two complementary models – a trajectory model and a flux model – for determining the collection efficiencies of aerosol particles by water drops and ice crystals. This combined approach was quite successful and provided one of the earliest quantitative data sets for scavenging rates of aerosol particles by individual hydrometeors.

In 1982, Hans accepted a full professor position at the University of Mainz, Germany, after 18 years of distinguished work in the U.S. Fully aware of the air pollution and acid rain problems in Europe and the close relation between clouds and air pollutants, he immediately engaged in the study of how cloud and precipitation systems interact with aerosol particles and trace gases.

With the support of German Science Foundation, he and his colleagues in Mainz built another vertical wind tunnel more advanced than the one at UCLA. The new tunnel not only included better computerized control of the air flow, but was also constructed with chemical corrosion resistance in mind. The tunnel turned out to be another complete success as it has produced much experimental data of fundamental importance to cloud-chemical interaction. Over the years this installation was complemented by further developments and connecting devices like a walk-in cold chamber.

In connection with this, Hans Pruppacher was one of the first to understand that in order to put all this fundamental knowledge into work, one needs a cloud dynamic model. Only a 3-D numerical model is capable of generalizing the specific experimental results and the theoretical formulation of the scavenging of aerosol articles and trace gases into cloud drops and snow crystals, and the subsequent chemical transformation inside and at the surface of the hydrometeors, and thus can lead to an enhanced understanding of acid rain and forest decline.

Already in the US he had recognized that the simple cloud models and their highly parameterized approaches were far from reality, as they did not consider the individual cloud microphysics and chemical processes inside isolated drops and crystals.

Just arrived in Mainz, Hans Pruppacher, together with Andrea Flossmann, currently professor at the University in Clermont-Ferrand, France, founded at the institute a working group on cloud modelling. In the 80th and 90th, in collaboration with NCAR in Colorado parcel models were developed, as well as 1D, 2D and 3D cloud models with a detailed bin resolved microphysics and bin resolved chemical processes, tested during two major field experiments at the “Kleiner Feldberg” near Frankfurt and above the North Sea.

Together with the wind tunnel facilities, the models represent part of his scientific heritage, still state of the art and still exploited by his former students and collaborators.

From 1985 to 1992 Hans Pruppacher became the director of the Mainz Meteorological Institute and from 1994 to 1996 he was directing the Special Research Section 233 of the German Science Foundation “Dynamics and Chemistry of Hydrometeors”. After his retirement, he was made honorary member of the ICCP/IAMAS executive commission in 1996.

The publication of the book Microphysics of Clouds and Precipitation, co-authored with James D. Klett in 1978, was an important event in cloud physics community. This book compiled extensive materials, especially those related to the hydrodynamic behaviour of hydrometeors, an area that Hans's group had contributed heavily in both experimental and theoretical aspects. The 1978 edition was enlarged in 1997 (and reprinted with corrections in 2000 and 2010) to include cloud chemistry and cloud electricity. The book remains the most comprehensive book in cloud microphysics to date.

To his students, Hans was a demanding supervisor — he only wanted work of the highest possible quality. Yet the students worked hard not due to verbal demand but because of the example set by their advisor — Hans himself worked harder! It is this example that resulted in such a high productivity of his research group. Anyone who reads Microphysics of Clouds and Precipitation will easily understand that such a comprehensive book packed with so many original research results couldn't be worked on in a sedentary fashion.

Hard working and demanding at the workplace, Hans was very kind to his students in personal relations. Many students will remember the many warm social occasions hosted by Hans and his wife Monica in their houses in Los Angeles and Mainz.

Hans Pruppacher passed away after a short and violent fight against a brain tumour and is survived by his wife Monica and his son Lucas.