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In Memoriam

Arnt Eliassen, 1915–2000

Arnt Eliassen died in his home in Oslo on 22 April 2000. Together with a few others, he pioneered the era of numerical weather prediction (NWP), and was a major contributor to the development of modern dynamic meteorology.

Arnt Eliassen was born in 1915, and grew up in Oslo where he also went to university. He was about to specialize in astrophysics when he was diverted into meteorology by the seminars of Vilhelm Bjerknes and his assistant Einar Høiland. After some years as a research student and assistant under Professor Halvor Solberg, he became a forecaster at the Norwegian Meteorological Institute. There he soon started to develop his own research ideas. He discovered the benefits of formulating the basic equations in pressure co-ordinates, and he developed the geostrophic momentum approximation that has later been named semi-geostrophy. This approximation was less restrictive but harder to apply in early NWP-experiments than the quasi-geostrophic equations of Jule Charney. Based on an exceptional intuition and mathematical understanding, he demonstrated a strong ability to manipulate equations into more useful forms, and to unveil their secrets about the physical world. This ability is seen throughout his scientific contribution.

The principles for the development of numerical weather prediction were founded by Vilhelm Bjerknes in 1904, but neither he, Lewis Fry Richardson nor anyone else had successfully applied these principles in practice until it was done in the late 1940s with Arnt Eliassen as an important contributor.

At the Institute of Advanced Study in Princeton, USA, the mathematician John von Neumann supervised the construction of an electronic computer. Von Neumann realized that weather forecasting could become an important application, but he needed help of meteorologists with a strong background in mathematics and physics. On the initiative of Jule Charney, who had already joined the project, Eliassen was invited to participate in 1948–49. Since the computer was not ready, the two scientists made forecasting experiments with a simple one-dimensional analytical model. This resulted in the famous paper that demonstrated the effect of large mountain-chains on planetary waves. Furthermore, the quasi-linear damping of tropospheric relative vorticity by Ekman-pumping was developed. Eliassen had to leave Princeton before any real numerical forecast could be made, but was replaced by his colleague from Oslo, Ragnar Fjørtoft, who took part in the final break-through.

The time in Princeton helped him to establish a very extensive network of contacts with leading American scientists. Another important factor in his scientific development was a group of young scientists led by his close friend Einar Høiland, which functioned as a strong research school in theoretical fluid-dynamics throughout much of the fifties.

After a short period at Rossby's International Meteorological Institute in Stockholm he became a lecturer (1953) and later a Professor (1958) at the University of Oslo. Here, he led the build-up of the Department of Geophysics, which was his working place for the rest of his career.

Throughout his life, he made a number of contributions with impact on the development of dynamic meteorology. Several of his papers belong to the classics of the field. One of his main themes was the secondary circulations of balanced flows. This included global-scale meridional circulations, as well as meso-scale circulations in fronts and tropical cyclones. Another major topic was the propagation of energy and momentum in mountain waves on all scales. Together with Enok Palm, he clarified the upper boundary condition for these waves, which is now widely made use of in gravity wave-drag parameterizations in atmospheric models. They were also responsible for the Eliassen-Palm flux, which came into use some 20 years later. In the field of numerical prediction, he suggested methods for statistical interpolation of observation data, and for numerical integration of prognostic equations. In particular, he initiated modelling in isentropic surfaces. This idea has not become popular in atmospheric modelling, but the oceanic counterpart, isopycnic ocean modelling, is used by several groups today.

Eliassen had a strong influence as a teacher of meteorology. His ability to present complicated subjects in a clear and concise manner was highly recognized. Furthermore, he never relaxed a strong requirement for quality and independence among his students. At the University of Oslo, he developed a curriculum in dynamic meteorology with lecture notes that had the status of a "bible". Unfortunately these notes were never published in English, but internationally his review article together with E. Kleinschmidt in *Handbuch der Physik* was much used as teaching material. His international fame drew many visitors to the department, and this was of great benefit for the students.

He received a large number of awards and honorary memberships of scientific societies and academies. The perhaps most prestigious award was the Swiss-Italian "Premio E. Balzan" presented by the Italian president in 1996 for his lifetime contribution to meteorology.

In spite of all his achievements, Eliassen was a modest person. He was always quick to point out that some of his discoveries had also been made independently by others, and he often mentioned how lucky he had been to enter a rapidly developing field where his talent could be made full use of. Among his many interests outside of science, it should be mentioned that he played the viola in an amateur string quartet. From the repertoire, one realizes that few tasks would be too challenging for him. His many friends will remember him not only as an outstanding scientist, but also as a warm, playful and stimulating human being.

Arne Bratseth and *Trond Iversen*
Department of Geophysics
University of Oslo
Norway