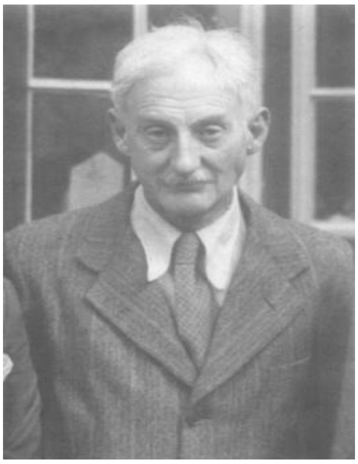
Charles Kenneth Mackinnon Douglas, OBE, AFC, MA, meteorologist



Charles Kenneth Mackinnon Douglas was to many the greatest synoptic forecaster of this century. He was born in Edinburgh on 29 May 1893, the elder son of Dr K. M. Douglas and his interest in meteorology was kindled as an 11-year-old schoolboy. He was educated at Edinburgh Academy, where he twice gained awards for being top pupil, and at King's College, Cambridge, where he read mathematics.

In the Great War, Douglas received his commission in the Royal Scots, as did his brother, but was soon transferred to the Royal Flying Corps in which he was involved in a serious crash during combat training as a fighter pilot. Whilst on flying duties between May and July 1916, Douglas, then a lieutenant, had many favourable opportunities to photograph and study clouds and weather phenomena, and in these operations he showed considerable flair. The changing patterns of the clouds provided him with an insight into the physical processes of the atmosphere, and their value in forecasting work.

The majority of his observations were confined to heights up to 8,000ft (2438m) but a few were obtained at altitudes of IO,OOOft (3048 m). The aneroids and thermometers could not be relied upon for complete accuracy, but the latter were fully exposed to the wind and were sensitive to changes in temperature. Using both altimeter and aneroid readings, Douglas was able to measure wind speeds above the boundary layer. He noted the deviation between surface and upper winds, and he recognised that a knowledge of the temperature profile with regard to instability would prove a useful aid to the forecaster. Forecasts based on the pressure distribution alone sometimes mentioned the probability of thunder when the temperature gradient showed stability and the chances of thunder were very remote. Douglas felt that a marked degree of instability would have to exist before thunderstorms could be predicted with certainty. Thus Douglas had begun to diagnose atmospheric states to study the changes of the three-dimensional atmospheric conditions from day to day, to comprehend the laws of atmospheric change and to test prognostic methods.

Whilst on active service, Douglas was wounded five times, awarded the Air Force Cross, and rose to the rank of captain. He published papers which gained the interest of the Officer Commanding the British Meteorological Service in France, Lt. Col. E. Gold, DSO, FRS. In 1918 Gold requested and secured the services of Douglas for his newly created Meteorological Flight.

The steady increase in the availability of upper-air observations before the Great War precipitated statistical investigations correlating temperature patterns in the upper air with patterns near the surface, and during the War previously unexplored weather phenomena and rarely experienced forecasting problems confronted meteorologists. The necessity of studying the meteorology of the upper air was paramount, and from May 1918 to May 1919 Douglas made a considerable number of observations by aeroplane of upper-air temperatures and humidity in north-east France. During this period, he also selected examples from kite and balloon ascents by Gold to investigate the distribution of these same parameters relative to the centres of depressions.

These studies were aimed at finding not only a means of identifying the boundaries of airmasses, but also the source of the air current which caused variations of the upper-air temperature, as well as the relationship of these variations to weather changes. Douglas analysed the lapse rate of temperature, which gave an idea of the general thermal structure of the atmosphere, and observed upper-cloud drift from which he deduced the origins of upper-air flows, noting the past history of airmasses and their modification by the underlying surfaces.

The work of Shaw and Lempfert on trajectories and their emphasis on currents of air paved the way for this. However, this provided only general qualitative indications of an airmass; Douglas acknowledged that quantitative measurement of the vertical temperature profiles would be necessary to forecast detailed meteorological conditions within airmasses, and the need to define criteria for classifying and identifying them. In his initial studies of depressions, Douglas found the sloping surface of discontinuity between polar and equatorial air was observed at various heights up to 14,0OOfi (4,267m) - almost as high as aeroplanes of that period could fly - and observations of clouds and upper winds supplied evidence that the discontinuity extended much higher.

The term ‘thermal wind’ was first used by Gold in 1917 in the prediction of upper winds from surface charts for determining the course of Zeppelins during the Great War; and Douglas, like Ley nearly 50 years earlier, found from his observations of cirrus clouds that the upper-air currents in a cyclone deviate from those at the centre, indicating the presence of the thermal wind. In a baroclinic zone, Douglas found that if the correlation between temperature and pressure is disturbed, important developments (i.e. cyclogenesis) would take place. He pointed out that both troughs of low pressure and wedges of high pressure normally lie funher west in the upper air than at the surface - factors which emerge from modern diagnostic analysis.

During the summer of 1920, Vilhelm Bjerknes, a pioneer of dynamic meteorology, invited Shaw to visit Bergen to discuss the new ideas of the Norwegian meteorologists, and amongst those who accompanied him were A. H. R. Goldie, L. F. Richardson and Douglas. Douglas showed slides of cloud photographs and records of temperature fluctuations made in Scotland which had a bearing on fronts and associated clouds, and described some typical altostratus-nimbostratus cloud structures together with complex multilayer types.

In retrospect some 30 years later, Douglas felt that, although the underlying ideas of the Bergen school were three-dimensional, the widespread adoption of the Norwegian techniques relating to Polar front meteorology was due to their suitability for surface charts, which were the only ones available.

The emphasis on rainfall and the occlusion process meant that the ascent of air was fundamental, and subsidence and dynamical warming were soon brought into the picture.

Douglas realised that the frontal discontinuity was often smoother in the upper air than it is near the ground, a feature not considered important at the time. He believed that the Norwegians would have done better to have paid less attention to surfaces of discontinuity and more to the generalised problem of divergence and vorticity. It could not have influenced practical developments, since vorticity could not be applied to the main three-dimensional problem until upper-air data were available.

The precise status of the surface of discontinuity was still in doubt. Some young depressions had such a surface extending to the tropopause, though with complexities, but others had not, and there was no obvious difference in behaviour. This is the main reason for the modern preference for the baroclinic zone.

Friedman describes how in November 1919 neither Bergeron nor his Bergen colleagues considered any significance in his hypothetical explanation of the occlusion process; they could not define the precise nature of this phenomenon, if indeed it existed. But during 1920 the Bergen meteorologists came to accept this process; by the following year the subject was frequently discussed among them, and it did provide them with the key for arriving at a model for cyclone evolution. It appears that Douglas at first shared that scepticism concerning the occlusion on account of the lack of sdlicient empirical evidence, but by 1925 he had become more persuaded of the process.

At the Meteorological Office Having previously been a member of the Scottish Meteorological Society, which was absorbed by the Royal Meteorological Society in 1921, Douglas was elected a Fellow of the latter Society on 19 November 19 19. He received the Buchan Prize at the Royal Meteorological Society's Annual General Meeting held on 19 January 1927, partly for his contribution to the understanding of the causes of rain. He accepted the award with modesty, and considered that the ground covered by his earlier papers on the problem of rainfall was small compared to the complexity of problems still to be faced. Nevertheless, he was optimistic for the future.

In 1925 Douglas began his long career as a forecaster at the Meteorological Office. Two of his papers (Douglas 1929, 1934) gave what was probably the first full account of the development of showers and thunderstorms into areas of continuous rain. In the first of these Douglas discussed some characteristics of fronts, whilst at the same time acknowledging their intrinsic importance in synoptic meteorology and also their complexity. In earlier papers, he had lamented the lack of adequate upper-air observations in the proximity of fronts, but clouds and rain prevented the recording of observations of pilot balloons and made aircraft flights difficult ~ although the RAF had successfully undertaken meteorological flights during continuous precipitation.

Douglas expressed the view that the primary cause of fronts was to be sought in horizontal air movements associated with large depressions and anticyclones, which brought together masses of air of widely different origins and characteristics. Transitions between areas of uniformity may be greatly contrasted or almost non-existent. Thus the properties of frontal zones may extend into flanking areas, or alternatively may be narrowly restricted. Modifications which occurred during transport and the effects of local weather factors in the lower atmosphere made it necessary to examine conditions in the upper layers of an airmass to ensure accurate identification.

Douglas recognised the fact that depressions are often characterised by systematic and complex cloud patterns aligned along fronts, which marked the warm edges of concentrated horizontal gradients of temperature. From surface observations Douglas found that the characteristics of fronts are sometimes altered considerably as they cross the British Isles, and he noted that one cause of a front becoming sharp occurred when air in the frontal zone is displaced upwards, which involved convergence and precipitation. On the other hand, when there is divergence and subsidence, the front becomes smoothed out. Further insight into this matter is evident in a paper by Brunt and Douglas (1 928) in which it is shown that convergence at a front occurs when changes in pressure distribution are such that the vector difference of the geostrophic wind between locations on different sides of the front is increasing. Brunt and Douglas demonstrated that pressure changes, vertical motion and rain cannot be explained in terms of the geostrophic winds alone. They pointed out that the geostrophic departure is important, and emphasised the relationship of this ageostrophic component to the acceleration of the air. In addition, they showed that the ageostrophic wind could be estimated from the pressure field and its changes. The study of the departure of the wind field from geostrophic values, and the closely related acceleration of motion, was of great importance in synoptic analysis and forecasting.

Following Bergeron’s ideas, Douglas considered that surface friction was also an important factor in determining the sharpness of a front, for it reduced not only the wind speed but also the vorticity in the boundary layer, and therefore could work either cyclolytically or anticyclolytically, depending upon circumstances. In addition, Douglas perceived that this friction also influences the layers of air above it; it causes ascending motion at the top of the boundary layer in areas with cyclonic vorticity.

He found that such friction normally caused some convergence and rainfall along a front, but large amounts of rain could occur only when there was convergence extending up to several thousands of feet, which resulted in the warm current rising en mane up the sloping frontal surface. This heavier precipitation was, in Douglas's view, related to development, a subject followed up by Sutcliffe in 1939. From his observations at coastal stations, Douglas also noted cases of frictional convergence, where the angular deviation of the wind from the isobars increased with the roughness of the underlying surface. Douglas's approach to the study of the life history of cyclones was unusual, for he had selected individual cyclones and attempted to find out all he could about them.

Douglas's stature as a forecaster was established during the years between two world wars, when there was little more than the sequence of surface synoptic charts to guide the forecaster. Individual forecasters would learn through their own experience and that of their predecessors how each structure moved and developed. In British practice, the forecaster would initially construct a prebaratic chart, which would be a subjective appraisal of the appearance of the next day's weather map, and he would use the chart to infer the coming weather conditions. Douglas was forced to rely on methods which, however primitive they may seem today, gave unlimited scope for his individual skill and judgement allied to a prodigious memory that enabled him to recognise a synoptic situation and place it alongside an analogous scenario from the past.

Meteorological events preceding and during the D-Day landings in France in June 1944 have been documented in Group Captain J. M. Stagg's book, Forecast for Overlord, and an account by Douglas himself was published in the Meteorological Magazine (1952).

In 1943, Stagg was appointed Chief Meteorological Adviser to the Supreme Allied Expeditionary Force, and as such he became responsible for the forecast for the D-Day landings. Stagg's job was to give a comprehensive meteorological briefing as far ahead as possible, and he had to fuse together into a compatible report the frequently diverging perceptions of the leading British and American forecasters of the day (Ratcliffe 1994a). Also in 1943, Sverre Petterssen, the talented Norwegian meteorologist, was placed in charge of the upper-air unit at Dunstable, where Douglas himself became the senior forecaster in 1944.

Vital information was regularly disseminated throughout the meteorological services of the British and American military formations, and Douglas's observations were rated highly over the years when Bomber Command's operations called for telephone conferences among responsible forecasting centres. Sverre Petterssen was to forecast five days ahead in general terms, using mainly information from the upper-air unit. Douglas, however, held the view that trying to forecast more than 3648 hours ahead, using the methods then available, constituted conjecture except in rare circumstances.

The Americans, on the other hand, were already endeavouring to forecast six days ahead, largely by recourse to historical analogues. Stagg was faced with the unenviable task of presenting agreed meteorological forecasts between the American and British teams without bias, yet nevertheless from his own experience believing Douglas's views to be the most sound.

The intense moment came with the forecasts leading up to the military landings on the Continent, which Ratcliffe (1994b) so aptly describes as "a meteorologic epic". Stagg exercised tact and meteorological expertise of a high level, and he carried out his task in a highly commendable manner. But it was Douglas who was the key figure - the mastermind - behind the D-Day forecasts; ably supported by Petterssen, Douglas led the British team, and it was for this that he was awarded the OBE. The forecasters had displayed an international and inter-service approach which led to the success of the forecasts, and which was then considered the most important in the history of the world.

Douglas's very demanding responsibilities during World War I1 caused him to behave sometimes in an odd manner, for Berson (1991) records that he would suddenly run twice around a double row of desks whilst on duty. Berson suggests that this could have been caused not only by stress, but also by memories of his aeroplane crash in the Royal Flying Corps. Berson also recalls Douglas's phenomenal memory of synoptic situations, citing as an example during early 1944 a secondary depression that had transferred from the north-west to the Bay of Biscay and which appeared to pose little threat to the weather of the British Isles. But Douglas had forecast snow in Northern Ireland and sleet in southern Britain, based upon a similar situation in November 1935, and he was shown to be completely correct when the synoptic situation was analysed the following day.

After the War, Douglas returned to the problem of instability, and he and J. Harding were coauthors of a paper wherein they considered that the thunderstorm of 14/15 July 1945 was the most severe storm to affect England since the night of 9/10 July 1923.

On 14 July the heaviest rainfall occurred in parts of Sussex in particular, London and the other Home Counties, and the east Midlands, but the storms were generally widespread. Douglas and Harding noted that, as with other storms of this type, there was a strong horizontal temperature gradient over France, and a cold airmass with its associated upper trough of low pressure to westward towards Biscay and Iberia.

They observed that the typical thundery front develops over Biscay or western France when the temperature in the upper air decreases westward, often ahead of an Atlantic front. In relation to this storm, Douglas and Harding's observations contain a pre-science of the phenomenon known as the 'Spanish plume'.

In his earlier years Douglas gained a reputation as a mountaineer, and in his obituary Sutcliffe recalls a situation when Douglas and his companion were caught near the top of the Schreckhorn in a heavy thunderstorm, and they were fortunate to survive. A reserved man and quietly spoken, Douglas was, nevertheless, dedicated to his work as a meteorologist and possessed considerable perception into the problems that confronted the science. He was awarded the Royal Meteorological Society's Hugh Robert Mill Medal and Prize for 1954 "for his outstanding contributions to the science of meteorology with particular reference to rainfall", became a VicePresident of the Society in 1955, and was elected an Honorary Fellow in 1960. Douglas was married with a son and daughter. In 1954, he retired from the Meteorological Office, and lived quietly in Devon until he died on 19 February 1982.