The Role of Weather Flights in the History of Meteorology

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Introduction

Weather flights made by manned balloons, gliders and aircraft have played a leading role in the history of meteorology by providing research vehicles to extend our knowledge of the upper air.

Balloon ascents

Following the historic flight by aeronauts in a hot-air Montgolfière balloon at Paris on 21 November 1783, the first meteorological ascent was made by the French physicist, Jacques Charles, on 1 December 1783 in a hydrogen balloon equipped with a barometer and thermometer. During his flight, Charles recorded a fall of temperature with height and was the first to determine an atmospheric lapse rate value. A more ambitious weather ascent was made in England on 30 November 1784 by the American physician, John Jeffries, and the French balloonist, Jean-Pierre Blanchard, in a hydrogen balloon on a 29 km (18 mi) long track from London to Dartford. During their 1_-hour flight, Jeffries, like Charles, observed that the temperature decreased with height, recording 11° C on the surface and – 2° C at 2.7 km (9,000 ft). While he recorded a steady decrease in pressure, Jeffries noted that there was an appreciable variation of humidity with height.

Further balloon ascents for meteorological purposes were made in the following century, for example, in 1804 Jean Baptiste Biot and Louis-Joseph Gay-Lussac reached 7.0 km (23,000 ft) and between 1862 and 1866 James Glaisher made a series of ascents for the British Association with the aeronaut Coxwell. These flights included a sounding in which Glaisher claimed to have reached 8.8 km (29,000 ft) to record a pressure of 330 mbar (9.75 inches) before fainting due to a lack of oxygen (Fig. 1).

However, the readings made on such ascents were not wholly reliable and an investigation began into more effective ways of obtaining temperature values when, for example, the thermometer was liable to be exposed to the sun. Furthermore, the soundings were not being made frequently or widespread enough for use with the synoptic weather forecasting methods that were developing in the late nineteenth century.

In 1887 Assmann invented the aspirated psychrometer for obtaining more representative temperature and humidity values and was followed by Hugo Hergesell who designed the Bosch-Hergesell meteorograph to allow pressure as well as temperature and humidity to be more reliably recorded. In 1894 Assmann organised simultaneous balloon ascents in Berlin, St Petersburg and Göteborg to set up the first upper-air station network. Two years later Léon Teisserenc de Bort founded the Trappes Observatory near Versailles for the study of the upper air with unmanned balloons that led to the discovery of the stratosphere. At about the same time, a special department of the Royal Prussian Meteorological Institute under Assmann was devoted to upper-air research and in due course an aerological observatory was set up as a separate institute at Lindenberg. This establishment became a notable centre for

the study of the upper air, the development of instruments for kite and balloon soundings, and later aircraft ascents.

Gliders

In 1926 Walter Georgii, Professor of Flight Meteorology, Darmstadt Technical University, organised research flights with gliders to investigate standing waves, thermals and cumulonimbus clouds. Dr Ursula Vieweg-Pielsticker was one of the first weather pilots to obtain quantitative data about thermals on cross-country flights initially using meteorographs but later employing more sophisticated recording equipment such as the Askania-Vierfach-Schreiber (four-component recording instrument). At the 1929 Wasserkuppe Competition, the Austrian pilot, Robert Kronfeld, in his glider, *Wien,* equipped with a meteorograph, flew along a storm-front associated with a cumulonimbus and achieved a new world distance record of 143 km (89 mi) (Fig. 2). Other meteorological research glider flights showed, for the first time, that speeds of up to 30 m/sec (67mph) could occur in upcurrents and between 15 to 20 m/sec (34 to 45mph) in down draughts within thunderstorm clouds.

Experience gained at the Wasserkuppe Competitions led Georgii to request the construction of a larger sailplane to carry out more extensive meteorological research for the Rhön-Rossitten Gesellschaft. As a result, Lippisch and his team designed a purpose-built glider, *Obs*, which, in addition to the pilot, could carry an observer equipped with an array of aerological and meteorological instruments. *Obs* first appeared at the 1932 Wasserkuppe Competition and was extensively used for research flights at Darmstadt the following year. In 1934 *Obs* was taken to Munich where a Meteorological Conference on Soaring was being held.

Gliders are a relatively simple and inexpensive means of investigating atmospheric dynamics. Free from engine disturbance, they have proved to be superior in some ways to the aeroplane as a vehicle for upper-air investigations. However, the powered plane should not be excluded from this field. One of the more successful applications of a sailplane as a research vehicle has occurred in combination with an aeroplane, the latter helping the former to ascend and launching the glider at a specified height for free-flight observations.

Another notable development in recent years is with highly sophisticated sailplanes being equipped with small retractable-powered engines. This enables gliders to be self-starting as well as allowing pilots to reach safe landing areas at the end of their missions. Furthermore, instrumental equipment using the Global Positioning System with meteorological sensors for pressure, temperature, humidity and other aeronautical parameters, allows the analysis of atmospheric conditions to be completely reconstructed along glider flight paths.

Aircraft ascents

As the design and performance of heavier-than-air machines improved during the early 20th century Assmann proposed using aircraft for upper-air soundings and in 1911 motivated the aircraft designer, August Euler, to modify one of his machines for that purpose. The following year a meteorograph was installed in an Euler monoplane and *Lt* von Hiddessen made the first aircraft ascent from Frankfurt am Main recording pressure and temperature up to 1,100 m (3,600 ft). Although the instrumental readings were rather unsteadily traced, due to engine vibration, Assmann considered the trial worthwhile and the procedure justified if a more stable means of mounting the instruments could be developed. Hergesell, like Assmann, soon recognised the

potential of aircraft for aerological research and in 1913 arranged for Kurt Wegener to be trained as a pilot for this purpose.

Although the First World War delayed the development of aerological research certain advances were made on both sides. For example, in 1916 Captain C.K.M. Douglas, anticipating future aircraft ascents, recorded upper-air temperatures, and observed and photographed clouds whilst serving in France as a pilot in the Royal Flying Corps. The following year, Albert Wigand, Professor of Atmospheric Physics at Halle University, began equipping military reconnaissance aircraft with meteorographs. This was to convince the German Army Met service about the value of making weather flights.

In 1919 the aircraft designer, Hugo Junkers, built the first all-metal passenger aircraft, the Ju F 13, at Dessau. Wigand then succeeded in raising Junkers' interest with the idea of aircraft ascents and the first weather flights were made with Junker planes the following year. Also, during 1921 a few disarmed wartime aircraft were released for making weather flights. In Britain the first RAF Met Flight was formed at about the same time and during the 1920s over 200 aircraft ascents were being flown annually from bases such as Andover, Duxford and Farnborough

Daily schedules of weather flights were established at the Aerological Observatory, Lindenberg under Hergesell, with Wegener and Schneider as pilots, and the Deutsche Seewarte, Hamburg with Robert Förster flying from Fuhlsbüttel Airport. This latter base became the first Wetterflugstelle (WeFlugSt), regional Met Flight station, in Germany. By 1929 four WeFlugSt, namely, Hamburg, Darmstadt, Königsberg and Munich, were functioning. Further stations including Berlin, Breslau, Cologne and Frankfurt joined the network during the early 1930s. Aircraft at these WeFlugSt, equipped with meteorographs, were flown to maintain, as far as possible, a daily schedule of ascents (TEMPs) up to at least 5,000 m (16,400 ft). Data derived from such flights and other aerological reports, direct and indirect, allowed Richard Scherhag to construct circulation patterns up to 500 mbar (5,400 m/18,000 ft) at the Frankfurt School of Meteorology during the mid 1930s. This pioneer work in upper-air analysis led to major advances in synoptic meteorology, including a better knowledge and understanding of the yet to be named jet streams.

During the inter-war period, daily reports were received on an international basis from surface and upper-air stations for synoptic weather analysis. As many of these observations would not be available under wartime conditions, alternative sources of data were under consideration in Germany during the late 1930s. For instance, the Reichsluftfahrtministerium ordered the formation of a Großraum-Wettererkundungs-Staffel (long-range meteorological reconnaissance squadron) at Berlin-Gatow in 1938. The operational training of the Großraum-Wettererkundungs-Staffel resulted in several new procedures being introduced such as the Sägezahn-Flugprofil (saw-tooth flight profile). On this type of flight, the altitude was changed several times to obtain TEMPs, in addition to horizontal weather conditions along the track, together with 'surface' reports (OBS).

Due to the deteriorating political situation, preparations were made for the formation of further meteorological reconnaissance (Met Recce) units. Within the new Luftwaffen-Wetterdienst, the Großraum-Wettererkundungs-Staffel became the nucleus for all Met Recce developments, providing the new units with experienced and trained personnel at Staffel level, as well as specially equipped aircraft. These new Wettererkundungs-Staffeln, abbreviated Wekusta or Westa, were assigned to the newly formed Luftflottenkommandos (Air Fleet Commands). All the weather units were equipped with modified twin-engine bombers, Do 17 and He 111, as

reconnaissance aircraft. Some older types, such as the Fw 58 *Weihe*, and the Ju W 34 and Ju 52 were also utilised for training and liaison flights. In June 1940, following the fall of France and reports that the Luftwaffe units were making weather sorties over the sea areas surrounding the British Isles, steps were also taken by the British Air Ministry for the RAF (and later the USAAF) to set up similar Met Recce Squadrons. In some cases the tracks of the German and Allied weather aircraft overlapped (Figs. 3 and 4).

After the Second World War weather reports from conventional sources again became available and Met Recce Squadrons were disbanded. As a result, the former TEMPs were discontinued and aerological observations were restricted initially to pilot balloon and radiosonde ascents. In any event, due to the technological progress made with satellite data, the emphasis in using aircraft for weather air observing was turning from synoptic missions to more specialised research projects.

In 1962, the Institut für Physik der Atmosphäre was established at the Deutsches Zentrum für Luft- und Raumfahrt (DLR), Oberpfaffenhofen and work was initiated into aerological research. Today, high-performance aircraft such as the Dassault Falcon 20E 5 and Dornier Do 228 are used as vehicles for global aerological research projects based at the DLR. Missions are carried out with these aircraft, equipped with sophisticated instruments for sensing, observing and evaluating atmospheric variables occurring in the troposphere and lower stratosphere. In Britain specialised aircraft, such as the C-130 Hercules, are also used for meteorological research flights (Fig. 5).

Figures (see separate file attachments)

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Biographical sketch

Born in London, 1930, John A. Kington joined the U.K. Meteorological Office in 1947 where he gained a wide experience in synoptic meteorology as an observer and forecaster. After gaining his M.Sc. (Meteorology) he began his academic career, first at the University College of Swansea and since 1971 at the Climatic Research Unit, University of East Anglia, where he is now Visiting Fellow. A definitive account of his research is presented in *The Weather of the 1780s over Europe* (Cambridge University Press, Cambridge, 1988). He has also contributed to *Climates of the British Isles: Present, Past and Future* (Routledge, London, 1997), and written over 50 articles for scientific journals.

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