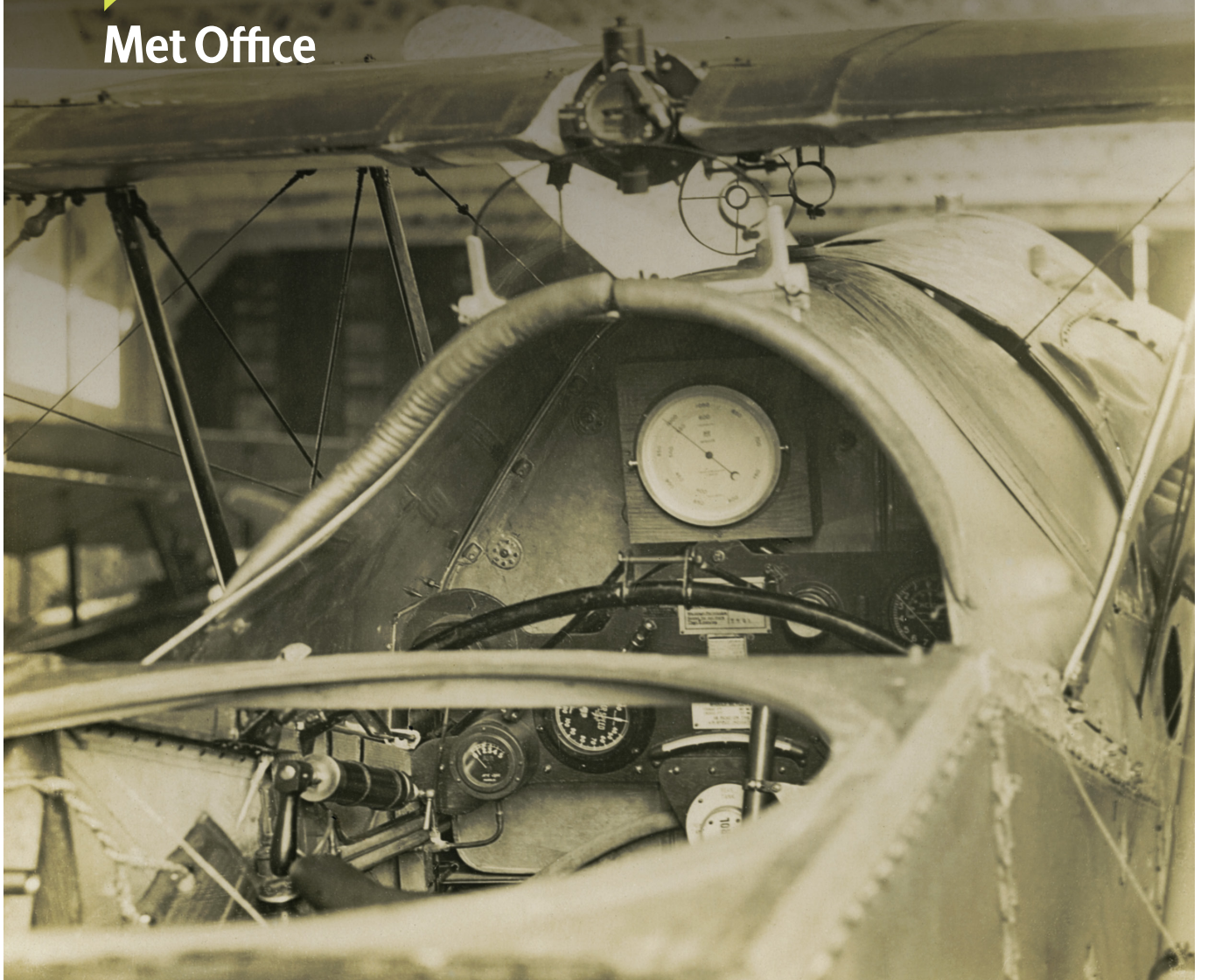




Met Office



# Take flight

National Meteorological Library and Archive  
Factsheet 19 — Take flight

# The National Meteorological Library and Archive

## Open to everyone

The library was first mentioned in the 1870 Annual Report of the Meteorological Office.

In 1914 the archive was established as the official custodian of meteorological related records. It holds historic weather records on behalf of the nation and is an approved place of deposit under the Public Records Act.

The National Meteorological Library and Archive is a National Archive (TNA) Accredited Service.

The National Meteorological Library and Archive are open by appointment.

All of the images used in this fact sheet along with many others covering all aspects of meteorology can be obtained from the National Meteorological Library and Archive. For further information including our opening times please visit our web page at <https://www.metoffice.gov.uk/research/library-and-archive> or email: [metlib@metoffice.gov.uk](mailto:metlib@metoffice.gov.uk)

The other factsheets in this series are available to view at the following web page <https://www.metoffice.gov.uk/research/library-and-archive/publications/factsheets>

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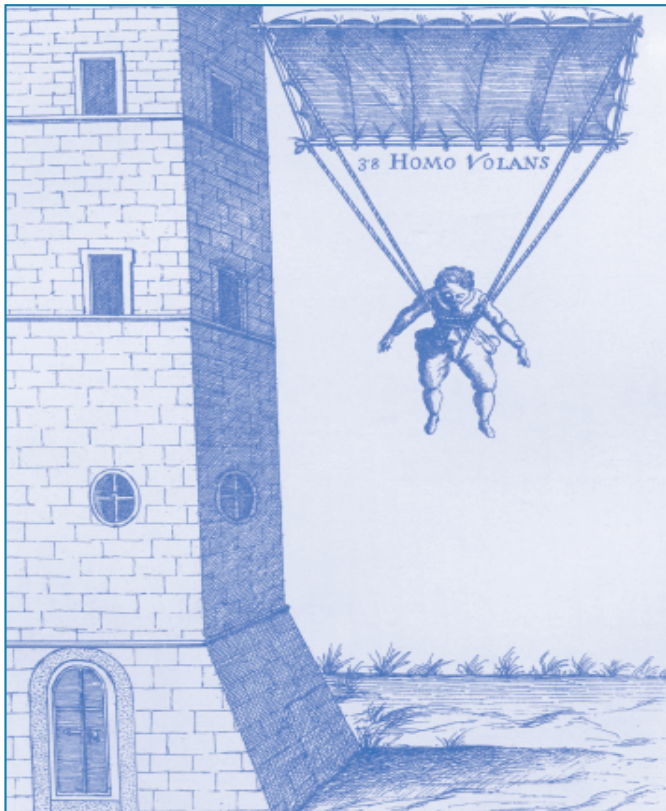
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## Introduction

Flight has always captured the human imagination. Since ancient times people have reflected deeply on the starry heavens above and wondered at the secrets it may hold. It was recognised early on that opening up the skies to flight by human invention would not only create many opportunities for travel and navigation, but also enable closer scientific study of the atmosphere and, in so doing, allow for our assertion of a degree of intellectual control over it.

This was an immensely important possibility as the agricultural economy, the dominant mode of production until the Industrial Revolution, rendered much of life at the mercy of the weather. Famously, Leonardo da Vinci believed it possible to invent an aerial machine and numerous experiments were conducted by late Renaissance scientists investigating these theoretical possibilities further.



**Figure 1.** A late Renaissance scientist investigating the theory of flight.

But it was only in more recent times during the Enlightenment – when furious intellectual energy was directed towards opening up the skies to scientific investigation – that technology finally enabled the conquest of this great frontier. Ever since, weather flights by manned and unmanned aircraft have played a leading role in the history of meteorology.

The attempts scientists have made over the centuries to explore the furthest reaches of the upper air and the data they gathered in the attempt are available to see here among the diverse collections we hold at the National Meteorological Archive.

## Hot air balloons

The hot air balloon was the first successful human-carrying flight technology. It signified a genuine advance in our human capacity to reach beyond into the great unknown, and is a history which bears some similarity to the more familiar story of space travel in the twentieth century.

Indeed, like early space travel, the pioneers of ballooning had to confront the obvious threat to human safety and, foreshadowing the space experiments, the first balloon flight tests were conducted not with humans but animals – mainly chickens and lambs, as this eighteenth century illustration demonstrates.

The first flight with people on board took place in Paris on 19 October 1783 by the Montgolfiere brothers; and the first manned balloon flight in Britain occurred in the following year by Dr John Jeffries and Jean Pierre Blanchard.



Figure 2. The first balloon flight tests were conducted not with humans but animals – mainly chickens and lambs, as this eighteenth century illustration demonstrates.

At about the same time as Jeffries and Blanchard another aviation pioneer, Thomas Baldwin, was making his own attempts at balloon flight. In our collections we have his book *Airopaidia*, published in 1786, which is generally considered to be the first ever book on aviation meteorology.

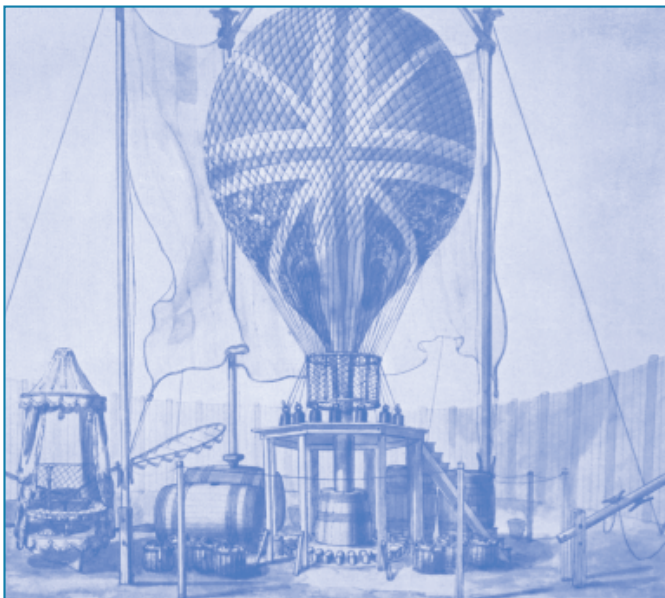


Figure 3. Blanchard's balloon with Union Jack cloth.

He recounts his early flying experiences in Chester and includes several interesting images of the earth from above which must surely be one of (perhaps the first) recorded impressions of the earth from the air.

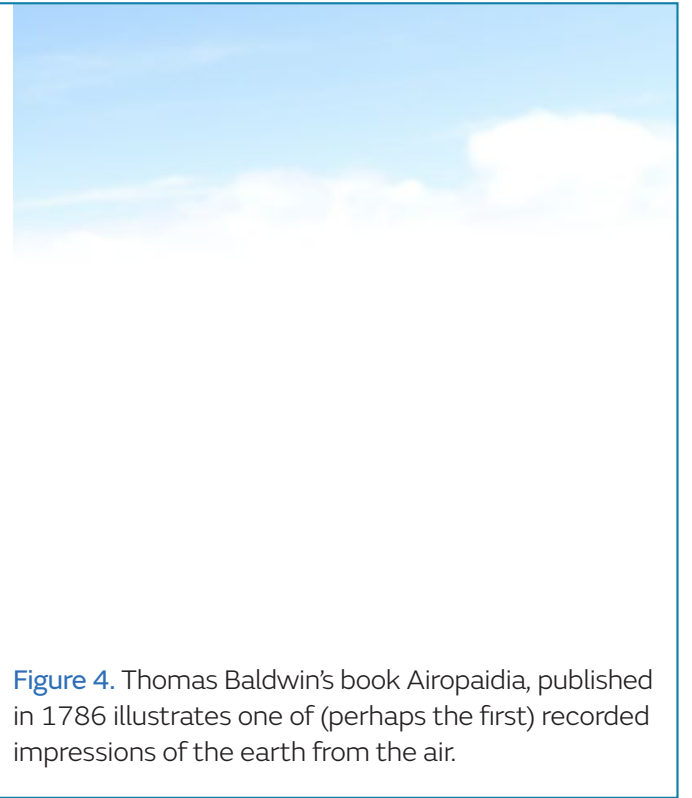


Figure 4. Thomas Baldwin's book *Aeropaidia*, published in 1786 illustrates one of (perhaps the first) recorded impressions of the earth from the air.

Baldwin was aware of the variation of the wind at certain heights and to measure this he used a system of flags dangled from the balloon car on half a mile of strong twine. He also used ribbon and feathers to show the rise and fall in currents of air. Baldwin also noted the movement of clouds.

Like his contemporary aeronauts, he believed that by undertaking scientific balloon ascents one could ascertain straightforward laws governing temperature and humidity and that these laws would then make such meteorological phenomena as wind currents, cloud formation and rainfall not merely readily explicable but accurately predictable.

**THE FIRST TABLE:**  
 SHewing THE EXPANSION WITH HEAT  
 ON INCHES OF THE BAROMETER.

285

	9	10	11	12	13	14	15	16
1	.00091	.00102	.00112	.00122	.00132	.00142	.00152	.00162
2	.00182	.00204	.00224	.00244	.00264	.00284	.00304	.00324
3	.00273	.00306	.00336	.00366	.00396	.00426	.00456	.00486
4	.00364	.00408	.00448	.00488	.00528	.00568	.00608	.00648
5	.00455	.00510	.00560	.00610	.00660	.00710	.00760	.00810
6	.00546	.00612	.00672	.00732	.00792	.00852	.00912	.00972
7	.00637	.00714	.00784	.00854	.00924	.00994	.01064	.01134
8	.00728	.00816	.00896	.00976	.01056	.01136	.01216	.01296
9	.00819	.00918	.01008	.01098	.01188	.01278	.01368	.01458
10	.00910	.01020	.01120	.01220	.01320	.01420	.01520	.01620
11	.01001	.01122	.01232	.01342	.01452	.01562	.01672	.01782
12	.01092	.01224	.01344	.01454	.01564	.01674	.01784	.01894
13	.01183	.01326	.01456	.01586	.01716	.01846	.01976	.02106
14	.01274	.01428	.01568	.01708	.01848	.01988	.02128	.02268
15	.01365	.01530	.01680	.01830	.01980	.02130	.02280	.02430
16	.01456	.01632	.01792	.01952	.02112	.02272	.02432	.02592
17	.01547	.01734	.01904	.02074	.02244	.02414	.02584	.02754
18	.01638	.01836	.02016	.02196	.02376	.02556	.02736	.02916
19	.01729	.01938	.02128	.02318	.02508	.02698	.02888	.03078
20	.01820	.02040	.02240	.02440	.02640	.02840	.03040	.03240
21	.01911	.02142	.02352	.02562	.02772	.02982	.03192	.03402
22	.02002	.02244	.02464	.02684	.02904	.03124	.03344	.03564
23	.02093	.02346	.02576	.02806	.03036	.03266	.03496	.03726
24	.02184	.02448	.02688	.02928	.03168	.03408	.03648	.03888
25	.02275	.02550	.02800	.03050	.03300	.03550	.03800	.04050
26	.02366	.02652	.02912	.03172	.03432	.03692	.03952	.04212
27	.02457	.02754	.03024	.03294	.03564	.03834	.04104	.04374
28	.02548	.02856	.03136	.03416	.03696	.03976	.04256	.04536
29	.02639	.02958	.03248	.03538	.03828	.04118	.04408	.04698
30	.02730	.03060	.03360	.03660	.03960	.04260	.04560	.04860
31	.02821	.03162	.03472	.03782	.04092	.04402	.04712	.05022
32	.02912	.03264	.03584	.03904	.04224	.04544	.04864	.05184
33	.03003	.03366	.03696	.04026	.04356	.04686	.05016	.05346

DEGREES OF THE THERMOMETER, FROM 1 TO 40, ON FAHRENHEIT'S SCALE.

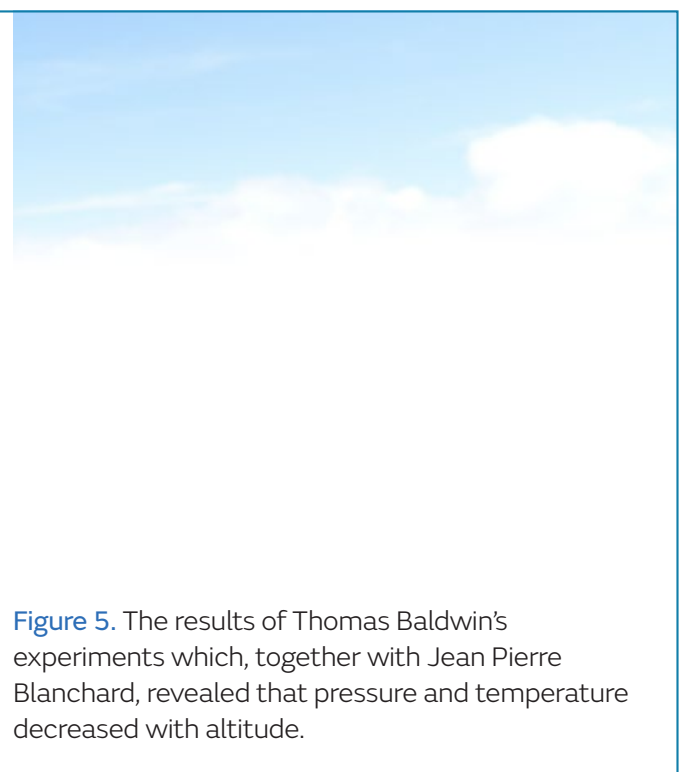


Figure 5. The results of Thomas Baldwin's experiments which, together with Jean Pierre Blanchard, revealed that pressure and temperature decreased with altitude.

Despite this early optimism, the balloon soon revealed that meteorology was by no means so simple a study as had first been supposed. Consequently, scientific interest began to wane while the perception of the balloon as a vehicle for entertainment and public spectacle grew more widespread – rather like a firework display it appealed to the innate human sense of wonder.

‘On Saturday April 30 1831, amidst huzzas of hundreds of spectators, the balloon rose at first with a gentle motion, and was carried by a mild easterly breeze. The balloon began to mount rapidly in a sort of irregular spiral course, but so gently as to be scarcely perceived to move; till at length at the altitude of nearly six thousand feet, it became perfectly motionless, and so remained for almost a quarter of an hour.

The sensation at this period was most delightful – balanced in the air, under a floating and inflated bag among the grotesque forms of evaporating clouds, and viewing in delicious tranquility a vast and apparently concave panorama of country, bounded on the one side by sea, and everywhere interspersed with towns and villages...

Up here we enjoyed a temporary repose from the noise and bustle of the world, which is seldom felt on the surface of the earth.’

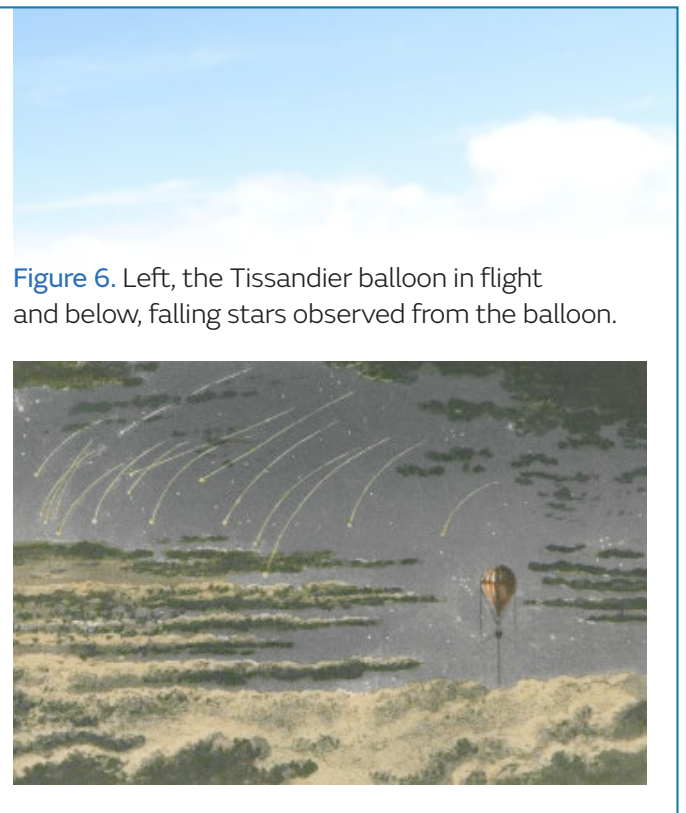
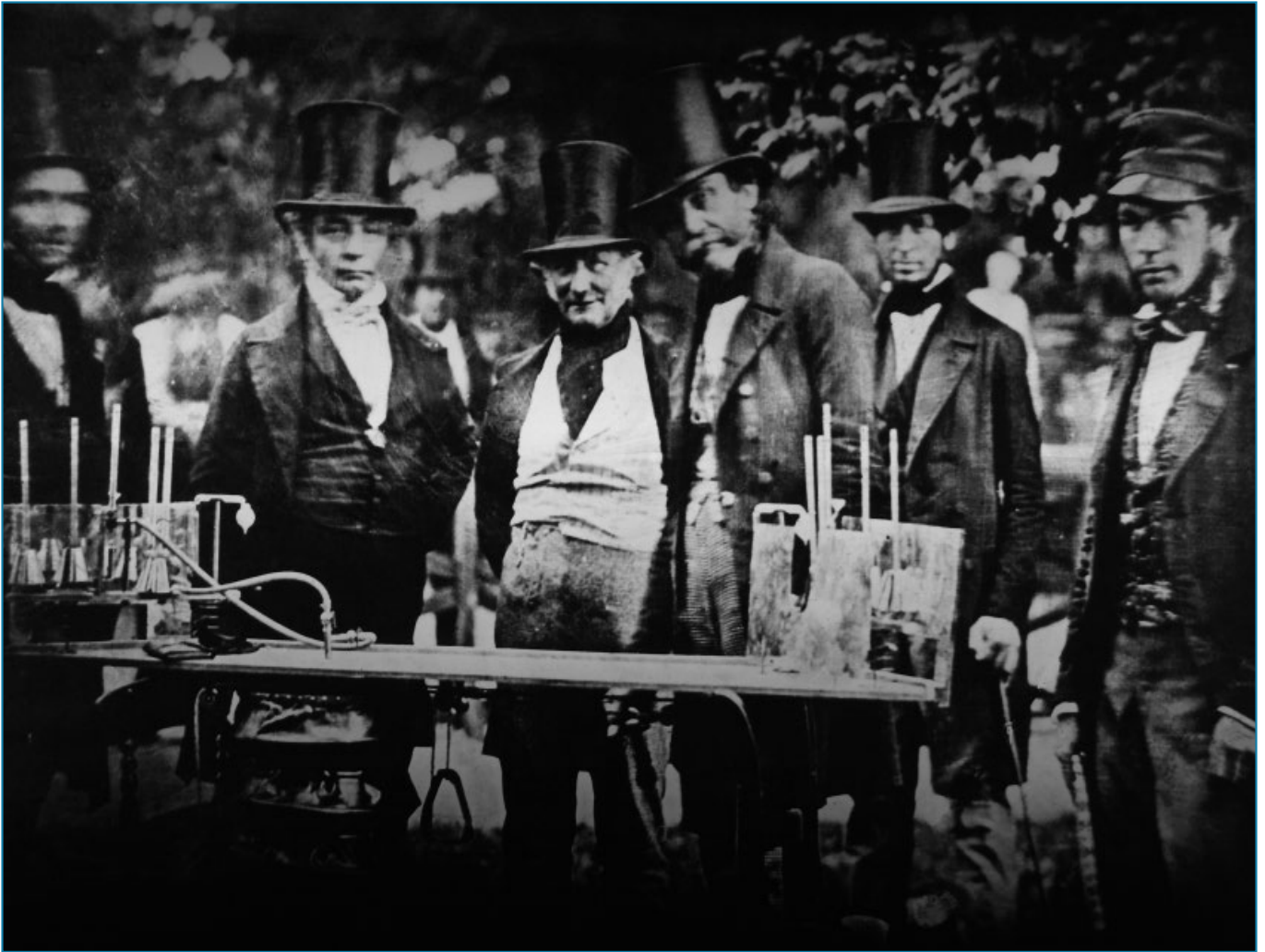


Figure 6. Left, the Tissandier balloon in flight and below, falling stars observed from the balloon.



**Figure 7.** Kew observatory committee of the British Association circa 1852 featuring a hot air balloon apparatus on the bench in the foreground.

As a way of satisfying public curiosity, aeronauts occasionally agreed to being accompanied by journalists who then wrote of their experience with great excitement: By the mid-nineteenth century there occurred a widespread surge of interest in the science of meteorology, as the foundation of the Royal Meteorological Society in 1850 – whose historic collections are held here – and the Met Office in 1854 demonstrate.

This also had the effect of renewing interest in the balloon as a vehicle for scientific observation of the upper air.

Thanks largely to the institutional support he enjoyed from the British Association, between 1862 and 1866 James Glaisher made 28 balloon ascents on a scale never previously attempted in order to measure the temperature and humidity of the atmosphere at different elevations.

These ascents proved a remarkable success and managed to renew the reputation of the balloon as a tool of scientific endeavour just as the early pioneers had envisaged. In this sense, Glaisher can be seen as the founding father of atmospheric research because his efforts initiated a programme of research that eventually carried scientists to the limits of the Earth's atmosphere and beyond.

However, his heroic efforts to reach the upper levels of the atmosphere almost resulted in tragedy as he and his flying partner, James Coxwell, ran into serious trouble during an ascent from Wolverhampton on 5 September 1862, which is now considered to be one of the most remarkable flights in the history of ballooning.



**Figure 8.** James Glaisher 1809 – 1903  
(This image was taken circa 1900).

This is Glaisher's firsthand account of that dramatic ascent as recorded in his book *Travels in the Air*, which we have available to read here at the archive.

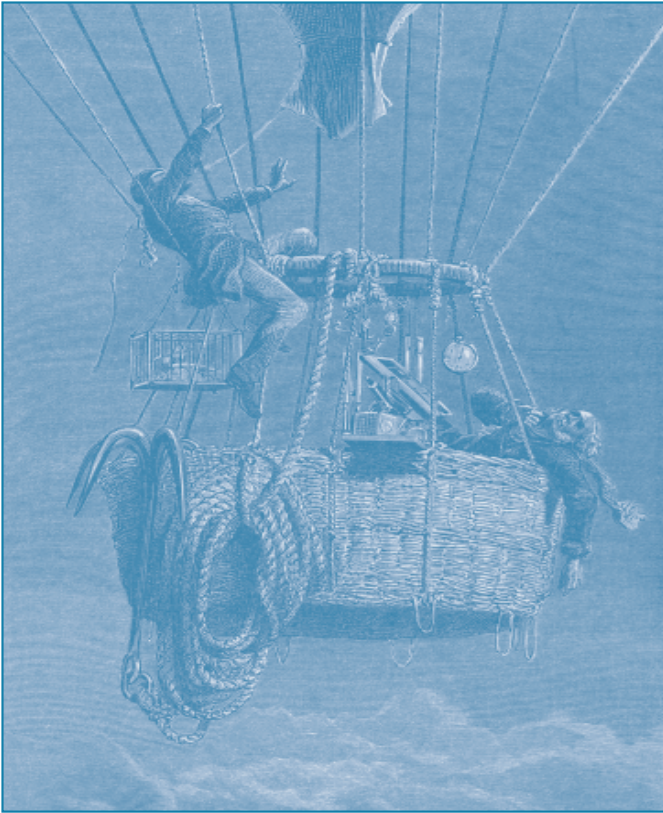
'We reached the height of two miles at twenty-two minutes past the hour, where the sky was dark blue, and from whence the earth was visible in occasional patches beneath the clouds. The temperature had by this stage fallen to freezing-point. By discharging sand in ten minutes we attained the altitude of five miles and up to this time I had taken observations in relative comfort, and experienced no difficulty in breathing, whilst Mr Coxwell had breathed with difficulty for some time. Having discharged more sand we ascended still higher, when I began to have difficulty in seeing clearly I could not see the column of mercury in the wet-bulb thermometer, or the hands of the watch, nor the fine divisions of any instrument. I asked Mr Coxwell to help me to read the instruments.

In consequence, however, of the rotary motion of the balloon, which had continued without ceasing since leaving the earth, the valve line had become entangled, and Mr Coxwell had to leave the car and mount into the rigging to readjust it. I laid my arm upon the table ...but on being desirous of using it I found it powerless, trying to move the other arm I found it powerless also. Then I tried to shake myself, but I seemed to have no limbs and fell backwards. All my muscular power was lost in an instant from my back and neck and laying paralysed I dimly beheld Mr Coxwell and endeavoured to speak but could not.

Intense darkness then overcame me and I believed death would come unless we speedily descended... When Mr Coxwell saw me he thought for a moment that I had lain back to rest myself and he spoke to me without eliciting a reply; he then noticed that my legs projected and my arms hung down by my side, and saw that my countenance was serene and placid, without the earnestness and anxiety he had observed before going up into the rigging: then it struck him that I was insensible.

He wished to approach me but could not; and when he felt insensibility coming over him too, he became anxious to open the valve. But in consequence of having lost the use of his hands by the extreme cold he could not do this; ultimately he succeeded however by seizing the cord with his teeth, and dipping his head two or three times, until the balloon took a decided turn downward.'





**Figure 9.** James Glaisher and James Coxwell in their balloon Mammoth, the only people to have exceeded a height of 30,000 feet without the aid of any breathing apparatus.

It is questioned now if they actually achieved the height of 37,000 feet (seven miles) above sea-level which Glaisher and Coxwell claimed, but there seems little doubt that they did exceed 30,000 feet which makes them the only people to have ever reached that height without the aid of oxygen breathing apparatus.

They named this balloon the Mammoth and because of this near fatal record ascent it became a popular tourist attraction at the Crystal Palace Exhibition.



**Figure 10.** James Glaisher and James Coxwell's balloon Mammoth on display at the Great Exhibition, Crystal Palace, May to October 1851. (Courtesy of the Science Museum Picture Library).

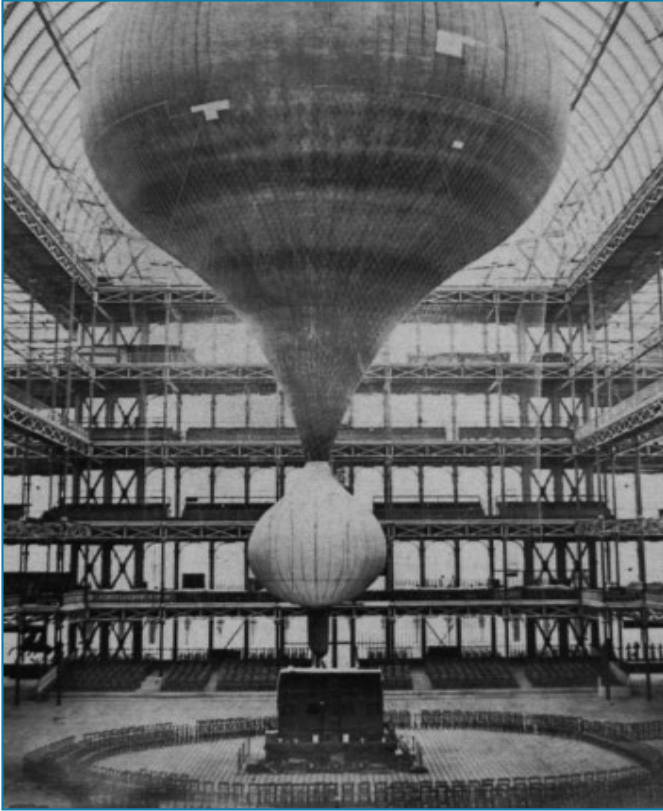


Figure 11. Another image of James Glaisher and James Coxwell's balloon Mammoth on display at the Great Exhibition, Crystal Palace, May to October 1851.

The popular interest this and other ascents generated, and the renewed reputation of ballooning as a means of exploring the science of the skies, encouraged Glaisher to conduct a lecture tour in which he sought to convey the sensation of flight and its important role in furthering our understanding of the weather.

On Friday Evening, January 8th, 1864,  
**A LECTURE**  
WILL BE DELIVERED AT THE  
**SAILORS' INSTITUTE, SHADWELL,**  
BY  
**JAMES GLAISHER, ESQ.**  
F.R.S., &c.,  
*Of the Royal Observatory, Greenwich,*  
ON  
**"SAILING IN THE AIR,"**  
WITH SOME ACCOUNT OF HIS EXPERIENCES AND EXPERIMENTS IN THE BALLOON,  
ILLUSTRATED WITH DIAGRAMS, &c., &c.

---

THE CHAIR TO BE TAKEN AT EIGHT O'CLOCK BY  
**THOMSON HANKEY, Esq., M.P.**

Tickets 6d. and 1s. to be had of Mr. HARRIS, Corner of Bromley Street, and of Mr. FARMER, 2, Bloomsbury Terrace, Commercial Road East.

Profits to be given in aid of the Stepney Meeting Auxiliary to the British and Foreign Sailors' Society

YATES AND ALEXANDER, PRINTERS, CHURCH PASSAGE, CHANCERY LANE.

Figure 12. A poster advertising one of James Glaisher's lectures seeking to convey to the public the sensation of flight.

In this lecture Glaisher emphatically stated his belief in the value of ballooning:

'The balloon has already done for us that which no other power ever accomplished; it has gratified the desire natural to us all to view the earth from a new aspect, and to sustain ourselves in an element hitherto the exclusive domain of birds. We have been enabled to ascend among the heavens, and to exchange conjecture for instrumental facts, recorded at elevations exceeding the highest mountains of the earth.'

Scientific balloon flights continued for the rest of the nineteenth century and brought a considerable advance in our understanding of the upper atmosphere and also furthered the development of meteorological instruments and observational techniques.

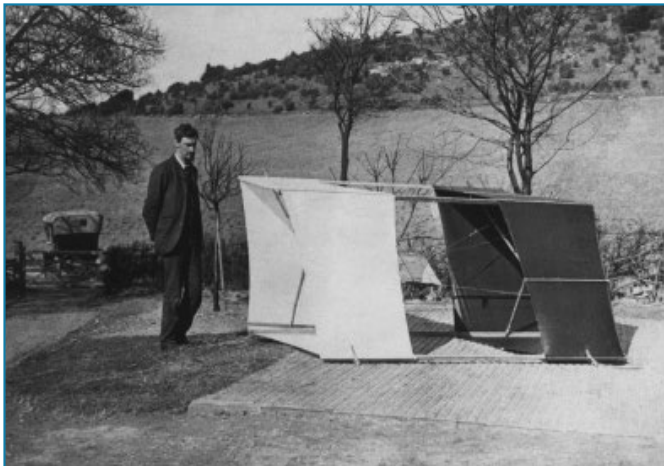


Figure 13. W.H. Dines with his weather kite at Pyreton Hill in Oxfordshire circa 1905.

But the use of kites on a significant scale did not properly begin until it was revived by English scientists William Henry Dines and Sir Napier Shaw. On behalf of the Met Office, they conducted a series of experiments with meteorological kites in the early 1900s at Pyrton Hill, Oxfordshire and much of the information they gleaned as part of these experiments is held here at the archive. They were very advanced in their techniques and Dines published several important papers outlining his findings which contributed a great deal to advancing our knowledge of the weather.

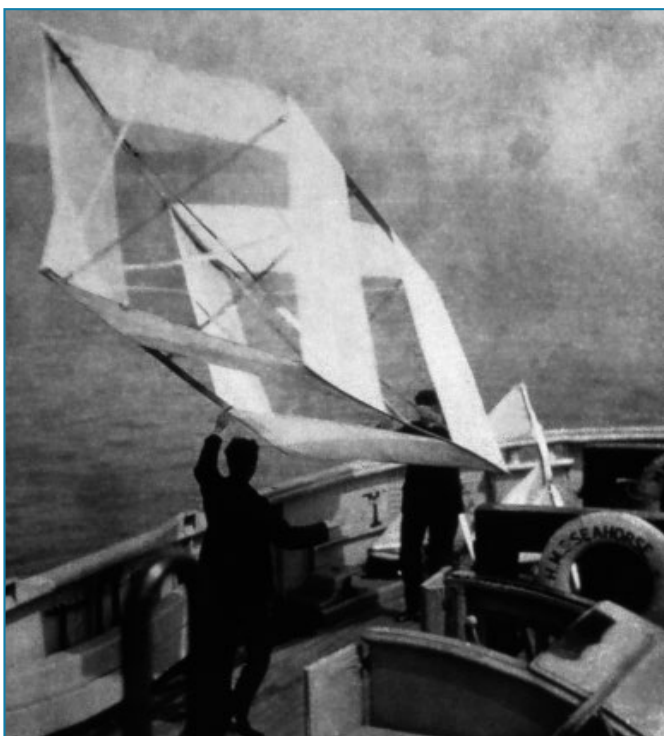


Figure 14. W.H. Dines prepares to launch a meteorological kite at sea.

Though the experiments were an immediate success, using kites had obvious limitations and were generally acknowledged by the meteorological community not to be as effective as weather balloons.

In 1896 French scientist Leon de Bort carried out a series of experiments with high-flying helium balloons and in 1902, after his having made 236 flights, announced that the atmosphere comprises of different spherical layers in which the temperature decreases (troposphere), and increases (stratosphere).



**Figure 15.** C.J.P. Cave prepares to launch helium balloons, remarkably successful experiments, at Ditcham park circa 1910.

As technology developed, the invention of the radiosonde in 1931 enabled greater frequency and accuracy of data recording. A radiosonde is a weather balloon which carried instruments aloft to record atmospheric pressure and stability, temperature, humidity, wind speed and direction, all by means of a small radio transmitter sending this information to stations on the ground.

They were made from latex rubber and were designed to expand on rising as pressure decreased until eventually at a certain height – depending on the diameter and thickness of the balloon – they would burst, their instruments descending to Earth via parachute. Indeed, they proved so successful that at the outbreak of World War II, the UK government adopted the use of radiosondes to aid the war effort and the data they retrieved made an important contribution towards the formulation of our famous D-Day forecast.

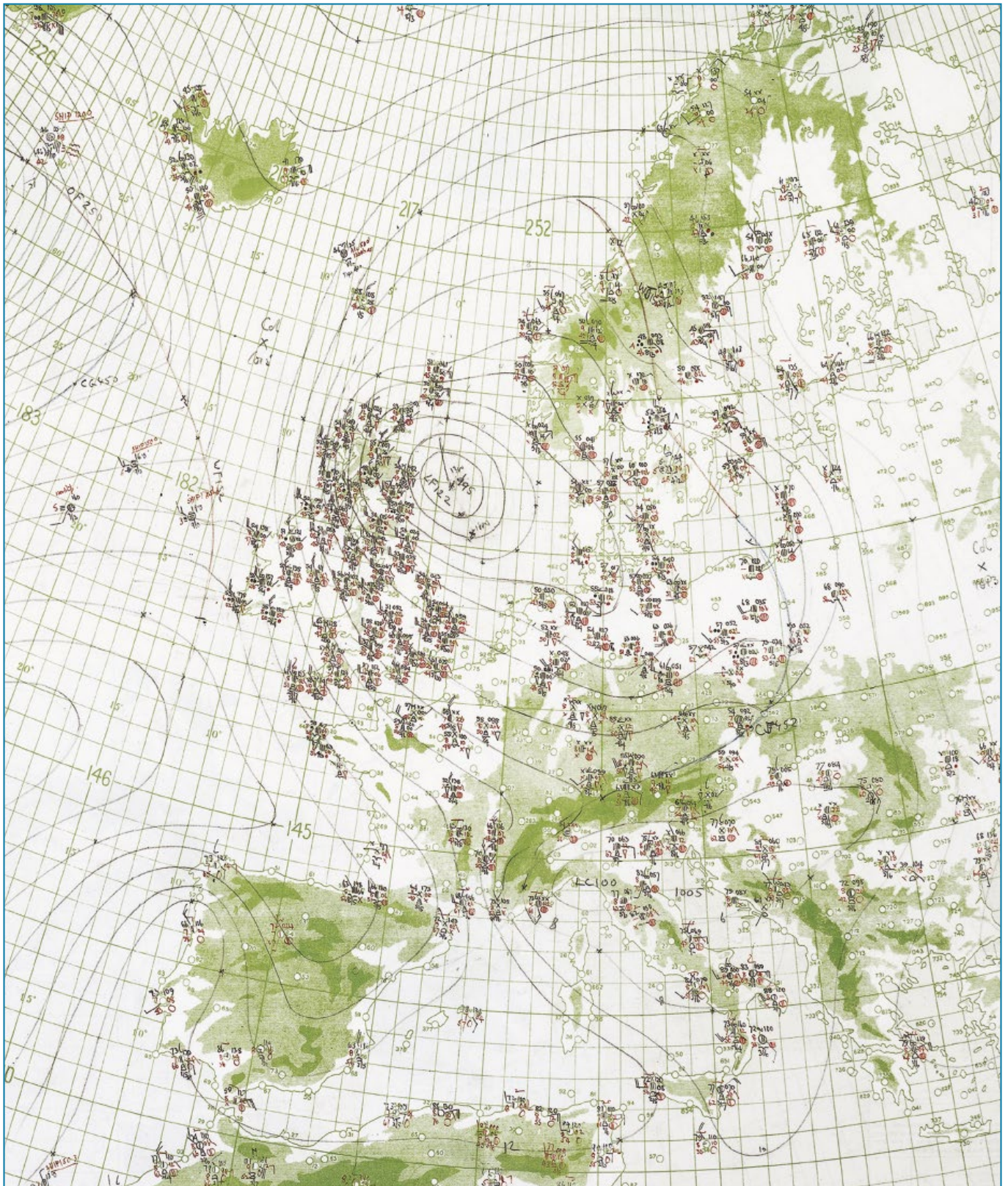


Figure 16. D-Day weather chart for Tuesday 6 June 1944 at 1300 G.M.T.

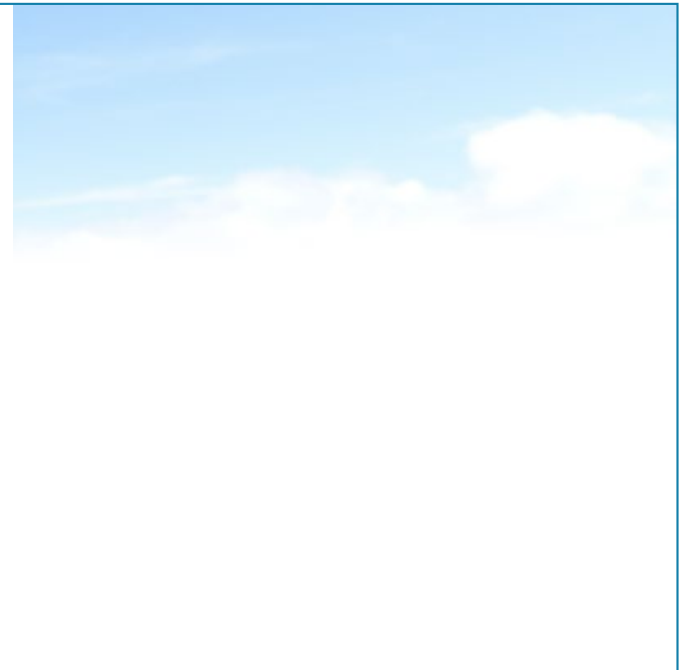
After the war, radiosonde stations were set-up on an international scale and the data produced by these flights from UK weather stations are now held here at the archive. These are useful for the interpretation of the atmosphere's vertical thermodynamics profile, including temperature and moisture content, and can be used to research changing global weather patterns and the effects of climate change.

Today, twice a day, every day of the year, weather balloons are released simultaneously from almost 900 locations worldwide. Each flight lasts for around two hours and often rises to 20 miles high in the atmosphere. In fact, radiosonde balloons are now so numerous that it is thought they're sometimes mistaken for UFOs.



**Figure 17.** Launching a radiosonde, Mark III balloon, October 1985.

The data these weather balloons feedback is a crucial component of modern numerical weather prediction and the recordings they take help give us a three dimensional view of the atmosphere. Indeed, radiosonde weather balloons are considered to be the most complete and reliable method of sampling the upper atmosphere today.



**Figure 18.** Launching a modern day radiosonde/ orange balloon.

## Met research flights

The recent history of meteorology is also closely interconnected with the history of airplane flight. The Wright brothers achieved the first successful powered piloted flight in 1903 and the first passenger flights as early as 1908.

This new and then uncertain technology underwent a rapid advance during the First World War, which served as a catalyst for the accelerated development of a whole range of new technologies – which is especially true of aviation engineering. In 1916 Captain CKM Douglas, anticipating future aircraft ascents, recorded upper air temperatures, and observed and photographed clouds while serving in France as a pilot in the Royal Flying Corps.

This technological development during the war meant that commercial aerial navigation would soon follow. In order to promote the future success of global flight navigation, safety was essential and providing accurate weather information was vitally important. To meet the needs of the emerging commercial air navigation industry therefore, the Airship Division of the Met Office was formed and was operational from January 1925 to the end of 1931.

Meteorologists needed to quickly discover how to forecast the weather over extended global distances and provide data to aircraft so that in-flight decisions could be made. The Met Office therefore conducted important investigative work and was responsible for 200 ascents a year by aircraft flying from a number of RAF bases such as at Andover, Duxford and Farnborough in bi-planes with instruments attached such as an aneroid barometer and mounted psychrometer.



**Figure 19.** Meteorological flight aircraft Bristol F2b, note the strut psychrometers and lens control wires, circa 1920.

By the 1930s things were becoming organised on a grander scale still with most airfields having their own observing stations recording and sending data to the Met Office.

At the outbreak of war in 1939, it was quickly appreciated that knowledge of the prevailing weather conditions in the mid-North Atlantic would be essential, if more reliable forecasts were to be provided for the allied missions over Europe. It thus became a matter of priority to obtain this information as accurately as possible, so a number of meteorological reconnaissance flights with specialist air crew were established.



**Figure 20.** Crew members taking observations during a meteorological reconnaissance flight, circa 1941.

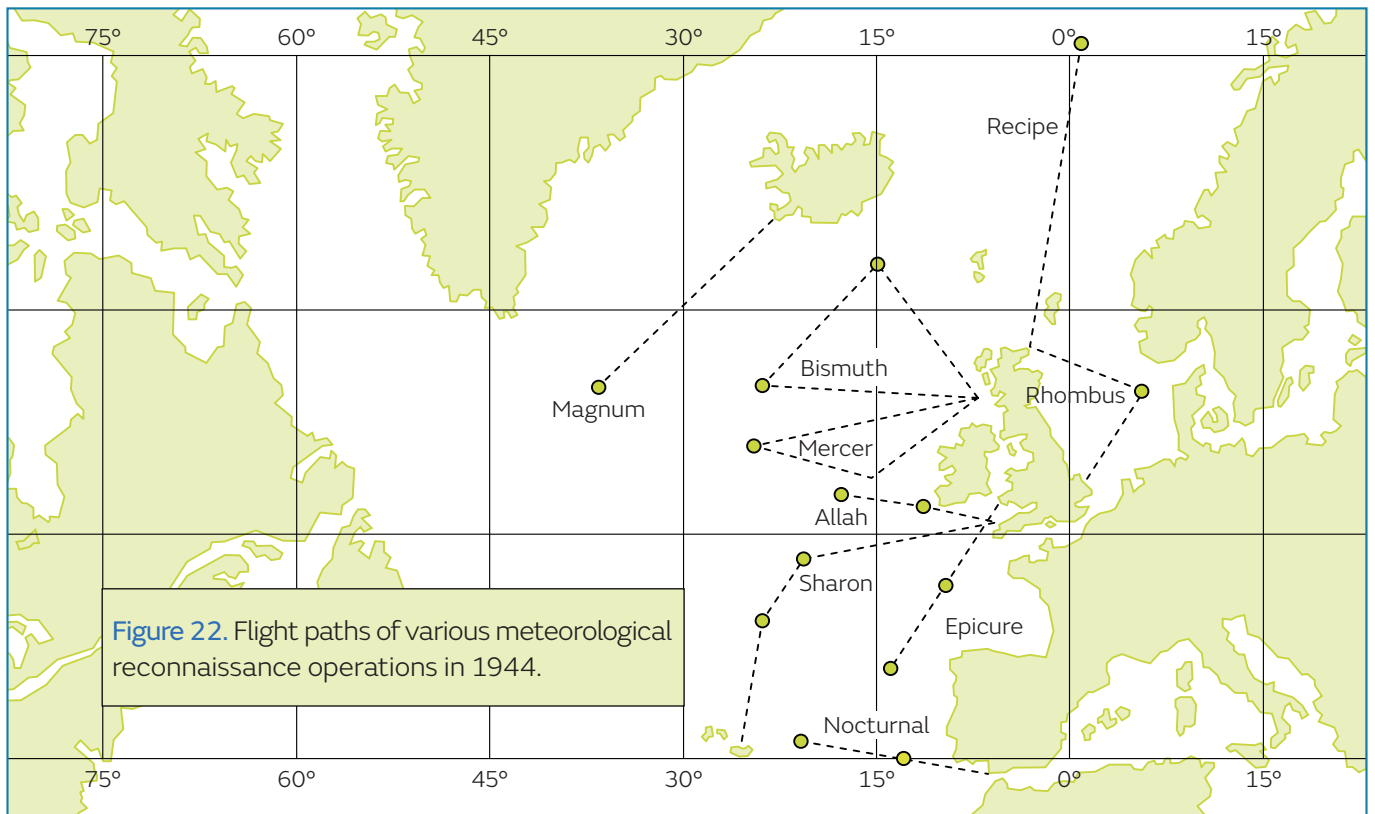
These were often dangerous missions sometimes flying in awful conditions and performing a vital role in aiding the war effort. But despite the highly skilled pilots fatal accidents did occasionally happen.



**Figure 21.** The wreckage of a Blenheim MK IV Z7355 Flight Sergeant Harry Garthwaite and crew, May 14 1942. Flight Sergeant Garthwaite had just completed a RHOMBUS race over the North Sea.

By 1945 some thirty long range met reconnaissance flights each day were being made by the RAF and the data they gathered proved invaluable for the allies when conducting both aerial, amphibious and terrestrial campaigns. All the data they gathered is located here at the archive.





**Figure 23.** Atmospheric Research Flight Hudson FR406 and B17 Flying Fortress flying together.

When peace broke out there was immediately a reduction in the requirement for meteorological reconnaissance flying: the need for accurate weather forecasts was less acute and civilian ships were once again able to report positions and weather in real time.

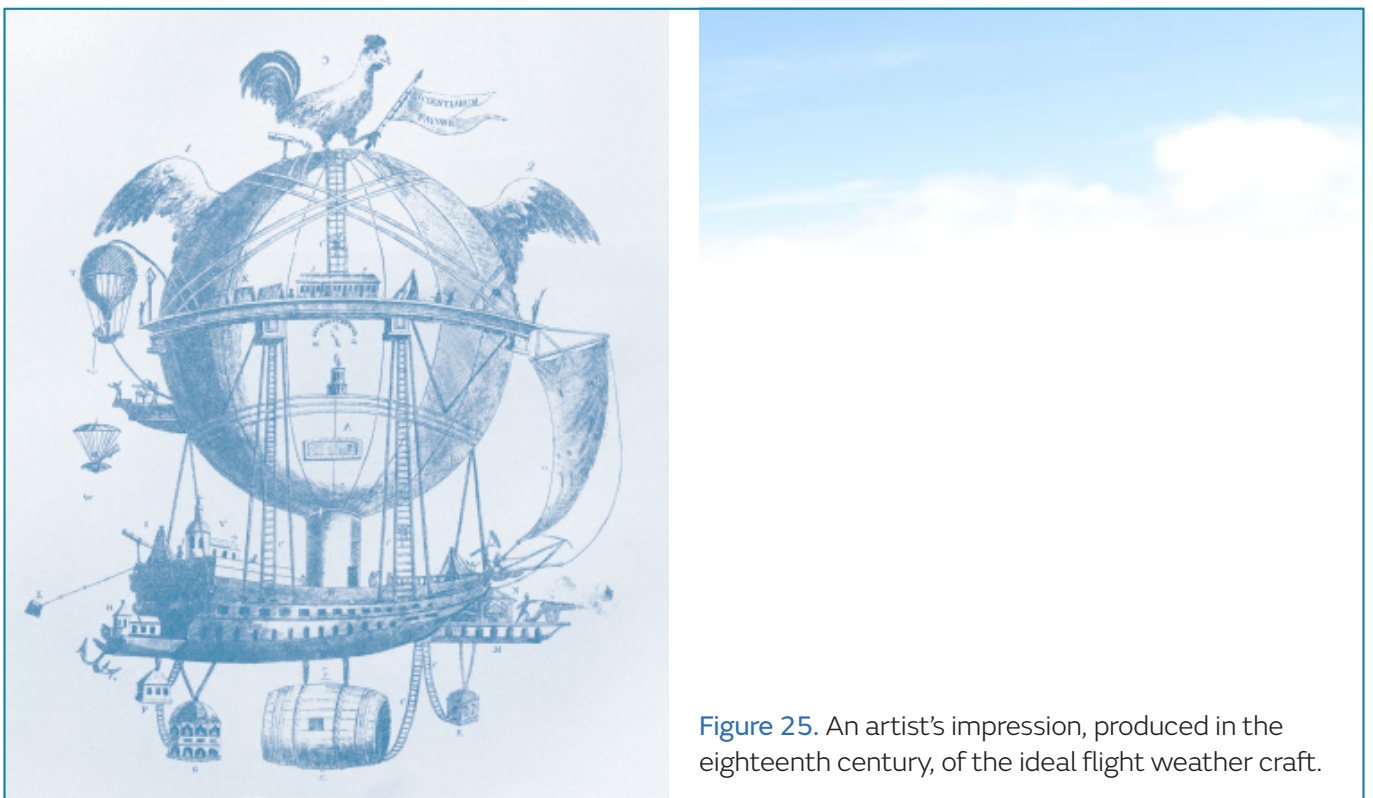
Technical advances in aviation during the Second World War transformed long-range flying to such an extent that transatlantic routes could be flown routinely after the war. Meteorological services had to develop accordingly therefore in order to provide flight planning and crucial safety information.



**Figure 24.** Members of RAF flight squadron group celebrating VE day on 8 May 1945 at their base in Reykjavik, Iceland. (Courtesy of the Royal Air Force Museum)

The Atlantic remained the source of most of Britain's weather and so many of the reconnaissance sorties continued into the 1960s. But improved forecasting techniques and the emergence of new technologies such as satellite and computer models, devalued the information gained from these reconnaissance missions meaning that it was no longer cost-effective to keep these flights going, but the data they collected is an invaluable source of research.

In more recent times, the emphasis on using aircraft for weather observing turned from synoptic missions to more specialised research projects using specially designed meteorological research aircraft. Ever since the earliest days of flight, scientists dreamed of one day having the ultimate weather flying machine equipped with the capacity to make detailed and sophisticated measurements of weather phenomena.



**Figure 25.** An artist's impression, produced in the eighteenth century, of the ideal flight weather craft.

The Met Office Research Flight Aircraft, affectionately known as 'Snoopy' because of its distinctive nose, was launched in 1973 and ran until 2001. It was one of the most sophisticated flying laboratories for atmospheric research in the world and more than realised the great eighteenth century dream.

Its main task was to take observations which would lead to the improved understanding of atmospheric processes and directly aid the large complex computer models run by the Met Office.

It was capable of measuring a range of phenomena including: atmospheric variables (such as temperature, humidity and wind velocity); atmospheric radiation (visible and infrared); cloud physics (droplet or crystal sizes and particle shapes could be measured, along with total water content of clouds); atmospheric chemistry (the aircraft was capable of taking multiple samples of the atmosphere and storing them for later analysis; and was comprehensively equipped with photo and video cameras.

The data recording was automated and the team of specialised scientists on-board could see the measurements displayed in real time and in graphical form.

This allowed for good planning of the flights to be made and ensures the mission objectives were fully realised. Data processing would then begin as soon as the aircraft landed, so that calibrated data would normally be made available to scientists just one day after the flight.



Figure 26. Meteorological Research Flight nicknamed 'Snoopy'.

## Weather satellites

In 1960 the first weather satellite was launched ushering in space-age meteorology. Subsequent satellites provided a wide range of useful information, ranging from day and night time-lapse images of clouds and storms to pictures that depict swirling ribbons of water vapour flowing around the globe.

Today, ever more sophisticated satellites orbit the Earth mapping the movement of global weather systems and supplying our powerful supercomputers with a far greater network of data so that more accurate forecasts can be and are being produced.

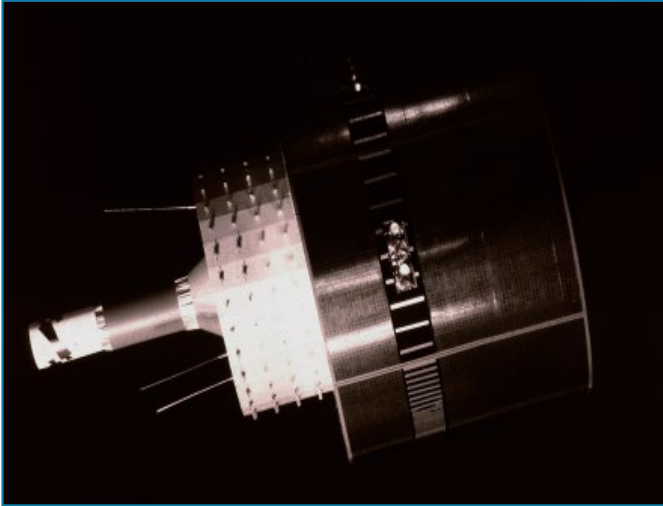


Figure 27. Meteosat-1 weather satellite.

The Met Office has also secured Ministerial approval for our involvement in the development of the third generation of geostationary satellites as part of the European MTG programme. This is excellent news for the Met Office as satellite data and imagery forms some of the most essential inputs necessary for the services we provide for our customers.

The first of six satellites is planned to be ready for launch in 2016 and the programme will operate for at least twenty years. These will provide high resolution satellite imagery, 3-Dimensional temperature, humidity and wind data, together with improved lightning detection.



Figure 28. EUMETSAT orbiting satellite, Sentinel-4. (Courtesy of the European Space Agency (ESA))

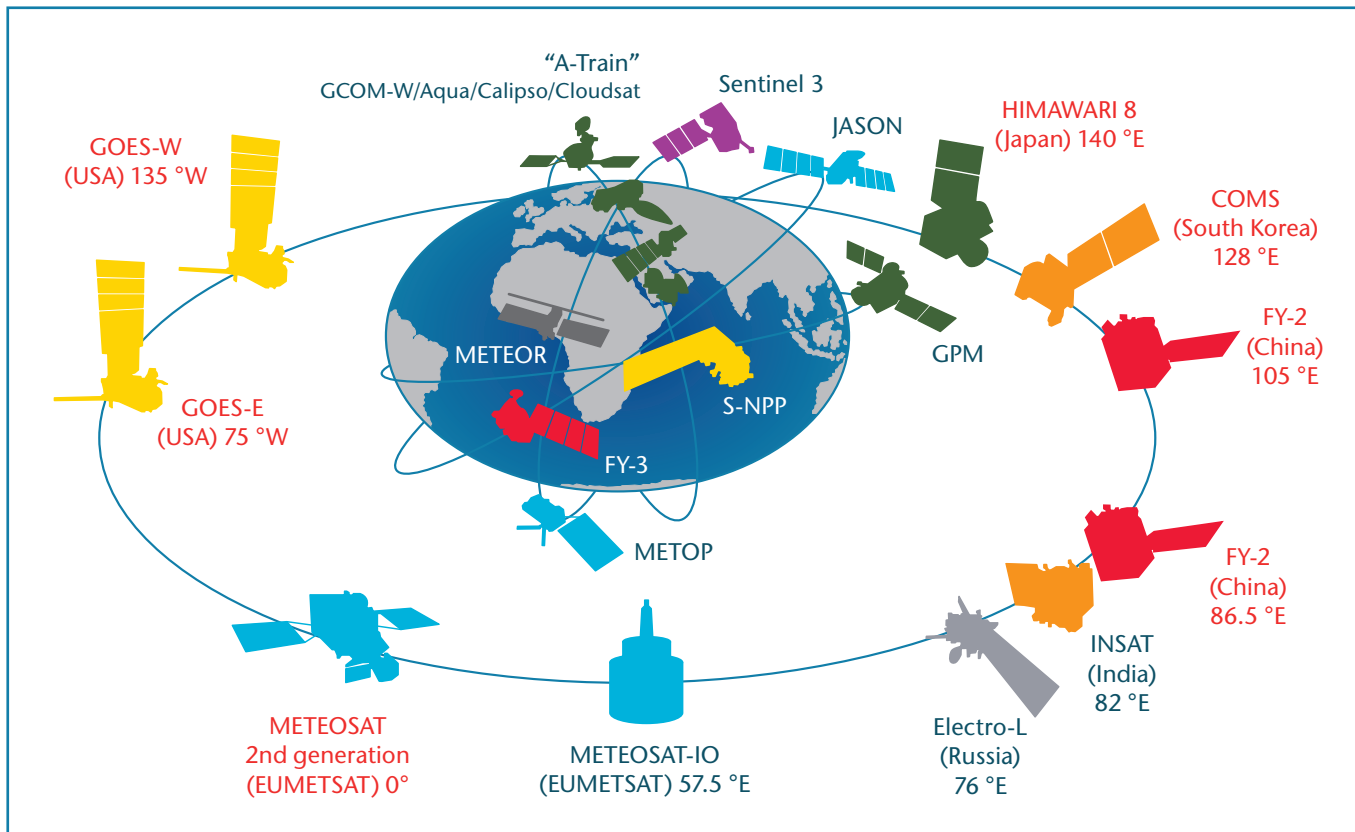


Figure 29. The current configuration of the meteorological satellite system.



Figure 30. MSG-2 (Meteosat-9) launching at night, 21 December 2005.

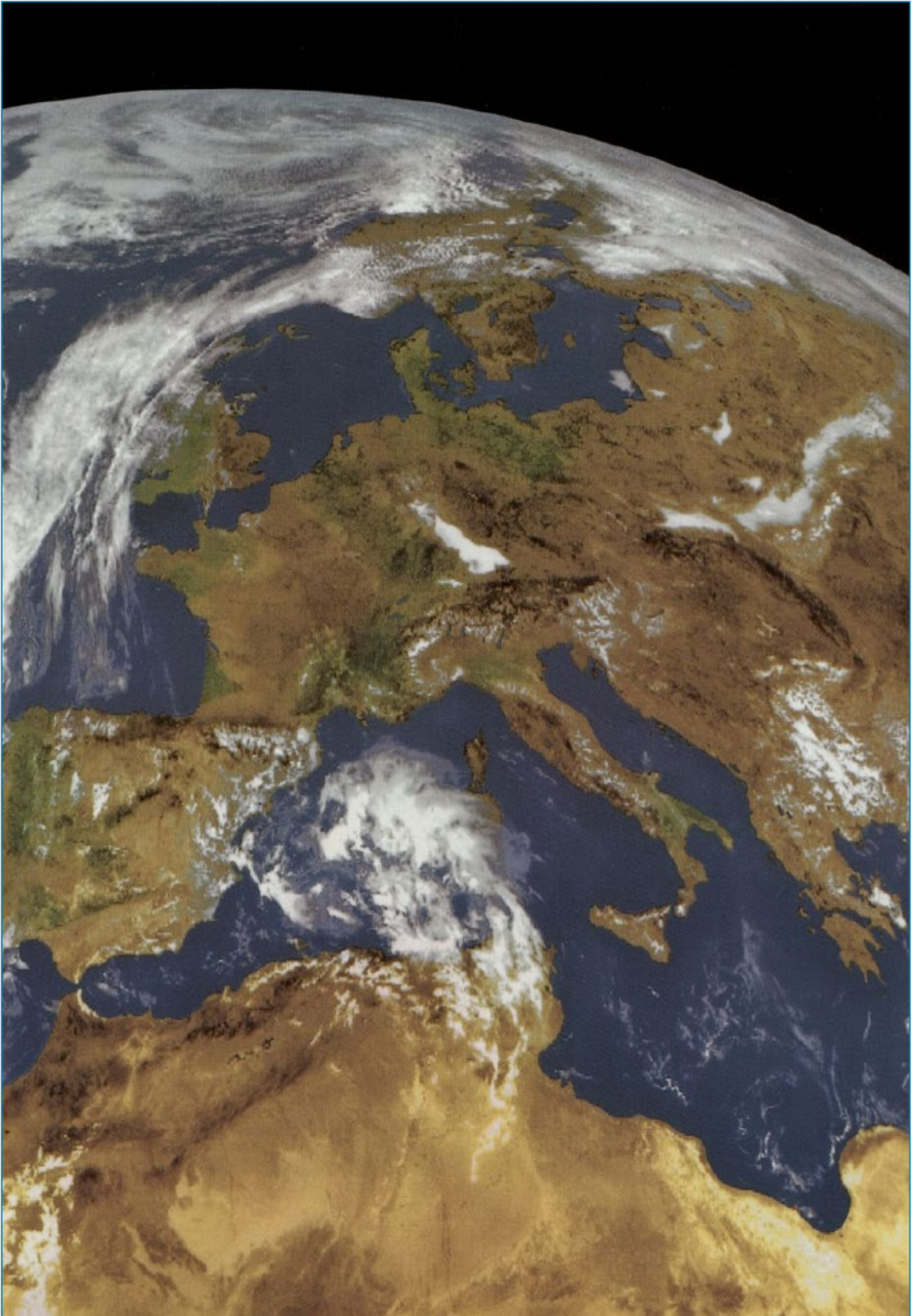


Figure 31. MSG-2 (Meteosat-9) image of weather events from space.

## Summary

The increased sophistication of computerised data gathering, exchange and analysis, together with modern numerical weather prediction, means that the Met Office is able to produce accurate short-term weather forecasts and provide several other important services, not least of which is that given to the civil aviation industry.

As one of only two World Area Forecast Centres, we have the ability to provide global forecasts of upper winds and temperatures for all commercial airline flights throughout the world thereby enabling operators to optimise passenger safety. Most recently, the Met Office conducted research flights into dust emitted high into the atmosphere by a volcanic eruption in southern Iceland. Volcanic ash can pose a danger to jet engines.

So our connections with flight, both as a means of gathering and disseminating data, remain as important today as it was thought it would be by the pioneering meteorologists of old – but in ways they could only ever have dreamed.

Special thanks is due to the Science Museum Picture Library.  
Other images courtesy of the European Space Agency (ESA),  
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**National Meteorological Library and Archive**

Met Office FitzRoy Road, Exeter, Devon, EX1 3PB, United Kingdom.

 [enquiries@metoffice.gov.uk](mailto:enquiries@metoffice.gov.uk)

 [www.metoffice.gov.uk](http://www.metoffice.gov.uk)