Cloud Seeding

1. Surviving records indicate that initial experiments in the UK with regard to the generation of rain by seeding clouds with solid carbon dioxide (dry ice) were undertaken in 1949 in association with ICI. In August 1949, a Vickers Wellington T10 training aircraft from RAF Middleton St George, flown by an RAF crew captained by Flight Lieutenant Otley, flew three sorties to drop 'Drikold' dry ice supplied by ICI into cloud over the North-East of England and the North Sea. ICI observers were carried on board the Wellington for two of the three sorties flown. A report summarising the results of these flights was submitted to the Assistant Director of Navigation (Meteorology), Air Ministry, by HQ Flying Training Command on 13 September 1949 (AIR 2/10467 enc 1A). This suggests that the trials were only a limited success; although 'a good shower' was observed by the crew at the base of the cloud during the sortie of 8 August, the sortie of 3 August led only to a light shower and on 11 August 'on descending only light drizzle was met, which may not have even reached the ground.'

2. A paper entitled *Clearance of Layer Cloud by Seeding* (MRP 659, 5 July 1951; AIR 2/10467, attached to enc 6A), examining '[t]he possibility of cloud clearing to the advantage of aircraft' by seeding super-cooled layer cloud with solid carbon dioxide or silver iodide, was presented to the Meteorological Research Committee (MRC) in July 1951. Paragraph 5 of this paper noted that 'the Meteorological Research Flight has made a number of seeding experiments, rather with the object of studying cloud processes than the production of rain or holes in clouds as immediate ends in themselves.' Following a review of research findings from the UK, USA and Canada, the report concurred with a memorandum prepared by the National Research Council of Canada which concluded 'that the results so far obtained do not indicate that a marked improvement in visibility through super-cooled cloud can be obtained by seeding with 'dry ice' or silver iodide, except on rare occasions.'

3. MRP 659 was circulated to the Air Ministry, the Admiralty and the Ministry of Civil Aviation by the Secretary of the MRC in order to establish 'whether the usefulness of the ability to clear limited areas of cloud temporarily would be sufficiently great to warrant the expenditure of much effort in investigating the conditions in which this can be achieved.' In response, a loose minute by Air Commodore J W F Merer, Director of Navigation and Control, dated 24 September 1951 identified two possible applications of the technique: clearing airfields to assist landing aircraft and dispersing clouds over target areas prior to bombing attacks. These potential uses of cloud seeding would not appear to have been judged sufficient to justify further in-depth research into the technique. In response to requests from the Royal Australian Air Force for information with regard to the clearance of cloud by seeding, Squadron Leader A A B Cleaver of the Air Ministry Directorate of Operations (3) stated in a letter dated 28 May 1953 that 'whilst we are still very interested in this subject, opportunities to experiment occur so seldom in the climate of Great Britain that the work has been given a low priority and work of more immediate importance has taken its place.'

4. The possible use of artificial rainmaking for military purposes would appear to have re-emerged in October 1953. A paper by Irving P Krick, President of the 'American Institute of Aerological Research' – a US non-governmental, profit-making organisation – was raised at a meeting of the Land/Air Warfare Offensive Support Sub-Committee at the behest of the then Air Vice-Marshal Sir Harry Broadhurst, Assistant Chief of the Air Staff (Operations) (ACAS (Ops)). Dr Krick's paper had been passed to AVM Broadhurst by Group Captain F H L Searl, a retired RAF officer and a UK representative of the American Institute of Aerological Research.

5. Subsequently, a meeting between Dr Krick, European representatives of the American Institute of Aerological Research and members of the Directorate of Land/Air Warfare and Air Ministry Directorate of Operations took place in the War Office on 3 November 1953. During this meeting, Dr Krick described methods by which he believed cloud seeding could produce significant amounts of rainfall; he also outlined a number of military applications for rainmaking, including impeding the movement of troops and supplies and the detonation of an atomic weapon in a cloud or system created by seeding in order to 'produce a far wider area of radio active [sic] contamination by means of rainfall than in a normal atomic explosion.' In the future, Dr Krick envisioned the use of weather modification to clear cloud and fog; he also went on to predict that 'The diversion of complete storm systems from their natural paths at long range, over a considerable period of time' would become possible.

6. The minutes of this meeting were referred to the PA to the Director of the Met Office (DMO), Dr O G Sutton (later Sir Graham Sutton), by Wing Commander C E R Tate of the Air Ministry Directorate of Operations on 11 November 1953. In reply, On 12 November DMO sent a strongly-worded loose minute to ACAS (Ops). Recording his 'surprise' that Dr Krick's paper could have been passed to the War Office and that a meeting could have taken place with Dr Krick to evaluate the possible use of cloud seeding 'without any attempt being made to find out from the State Meteorological Service whether these [Dr Krick's] claims had, in fact, any foundation', DMO went on to comment that:

> Rain making is one of the most controversial of all topics in meteorology. I know of no really good evidence to support many of the statements made in this paper, eg that the amount of rain can be increased, that the centre of rainfall can be 'accurately placed', by artificial means, and there is no evidence whatever to support the claim that the diversion of complete storm systems from their natural paths may be possible now or in the remote future.

7. Subsequently, the question of rainmaking was shelved by the War Office pending the outcome of civilian trials. However, in 1954, the Rt Hon Geoffrey de Freitas MP pressed the case for UK research into cloud seeding in an Adjournment Debate; the 'British Institute for Aerological Research', dedicated to fostering rainmaking in the UK, also came into being at this time. At a meeting between the Secretary of State (US of S) for Air and a deputation from this body headed by Mr de Freitas, the British Institute for Aerological Research offered to fund trials into rainmaking, following criteria laid down by the Met Office. This matter was referred to the DMO by the Secretary of State, and discussed at a meeting of the MRC on 31 March 1954. According to a note prepared by B Humphreys-Davies, Assistant Under-Secretary of State (General), in 1956,

> The Committee were of the opinion that there was no reliable evidence that rainfall had ever been scientifically increased on an economically useful scale, but recommended that, as so much was at stake, scientifically controlled research should be intensified and that work should begin on the design of large scale field trials. Because of the importance which would attach to any positive results; the fact that the trials would take many years; and the need to ensure that the results would stand up to the closest scrutiny; US of S decided that the tests must be conducted and assessed exclusively by scientists of standing and repute who were independent and disinterested. The co-operation of the Institute of [sic] Aerological Research was therefore declined, and nothing further has been heard of it since.

8. Meteorlogical Office Field trials, utilising five ground generators to release silver iodide, commenced on Salisbury Plain near Porton on 5 October 1955. Additionally, a drought in the North-East of England during the autumn of 1955 led the Air Ministry to consider the expansion of cloud seeding experiments to this region. Concerns with regard to the possible closure of part of the ICI factory at Billingham, Teeside, as a result of the drought resulted in a request from the company for RAF aircraft to attempt to produce rain by cloud seeding. During October and November 1955 RAF Vickers Varsity and Lockheed Neptune aircraft operating from RAF Topcliffe engaged in cloud seeding (using 'Drikold' dry ice furnished by ICI from Billingham) as an adjunct to their normal cloud flying training. These sorties were reported to the House of Commons in the form of a written answer by the Under-Secretary of State for Air to a question by the Rt Hon Roy Mason MP on 2 November 1955 (Hansard, 7 November 1955, Column 161). Cloud seeding had been conducted during 10 sorties by 14 November 1955, with limited results. In a letter to Sir Ewart Smith of ICI dated 16 November, Sir Folliott Sandford, Deputy Under-Secretary of State for Air, noted that 'a proportion of the sorties carried out have been successful in producing rain.... On the other hand, it is doubtful whether these limited experiments have made any significant contribution to relieving the shortage of water in the catchment area.' RAF Coastal Command was formally notified that all such flights should cease on 23 November 1955.

9. During December 1955, Members of Parliament representing consistuencies effected by the ongoing drought continued to press for the RAF to undertake further cloud seeding in an effort to alleviate the worst efforts of the water shortage. In response, the Under Secretary of State for Air directed that ground seeding using silver iodide generators should be employed at a suitable site in the Pennines in a manner similar to the ongoing experiment on Salisbury Plain. A Cloud Seeding Panel had been established by the MRC on 2 November 1955 to 'consider whether surface seeding with silver iodide generators could usefully be undertaken in some hilly part of the country as a further research experiment' and members of this panel were tasked with assessing possible sites for cloud seeding in the North-East. In their first report (MRP 975, *Meteorological Research Committee: First Report of Cloud Seeding Panel*, 19 April 1956), the Cloud Seeding Panel recommended that the MRC 'should advise the authorities that no technique is at present known which is more likely to be beneficial than harmful if improvised to meet water shortages'; while the cloud seeding experiment at Salisbury Plain should continue, the panel further recommended that 'No further large-scale seeding experiments using surface generators should continue.' These conclusions were subsequently accepted the MRC and plans to extend ground seeding to the Pennines were abandoned.

10. In February 1957, the Air Ministry announced to the press that ground seeding trials on Salisbury Plain were to be discontinued temporarily in an effort to allay speculation that cloud seeding may have been responsible for flooding in the upper Thames Valley. Later, trials would appear to have been resumed, and in 1959 a statistical analysis of the first 3¼ years of this experiment was prepared by B C V Oddie of the Met Office. He concluded that 'a reduction in rainfall of about 17 per cent has been produced; the odds against this being a purely chance result are about 15 to 1. The evidence of a reduction is therefore not conclusive but it does appear that no appreciable increase in rainfall has been produced' (B C V Oddie, MRCP 46 *First results of the Meteorological Office Experiments in the artificial production of rain*, 15 October 1959; on AIR 20/10790). These results were subsequently reported in the *Meteorological Magazine*, Volume 88, 1959, pages 129-135.

Project Cumulus

11. 'Project Cumulus' was the name applied to cumuliform cloud investigations conducted by the Department of Meteorology, Imperial College, London, at Cranfield between during August 1952. The Imperial College party was led by meteorologists Dr R S Scorer and Frank Ludlam; Mr Alan Yates of the College of Aeronautics, Cranfield (quoted extensively in the BBC Radio 4 programme *The Day They Made It Rain* and in subsequent press reports) was also attached to the Imperial College team. Observations were made using ground stations, together with a modified T-21 glider of the Imperial College Gliding Club. The composition of the Imperial College party is described in the journal *The Aeroplane*, 15 August 1952 (page 226).

12. Cloud seeding may also have been conducted under the direction of the Imperial College party at Cranfield in *a trial independent of the Met Office*. In an article rebutting allegations made by the BBC Radio 4 programme ('The making of a myth', *The Daily Telegraph*, Saturday 15 September 2001), Philip Eden notes that one member of the Imperial College party at Cranfield - 'atmospheric physicist Frank Ludlam' – had 'described the physical processes underpinning cloud-seeding research in Britain' in an article published in the Royal Meteorological Society Magazine *Weather* in July 1952. According to *The Aeroplane*, 15 August 1952, 'Frank Ludlam is taking the opportunity [presented by Project Cumulus] to test his theory that most rain is produced by a minority of larger cloud droplets falling through the smaller ones and collecting them, without the cloud having to grow up to freezing level. An Anson from Cambridge is expected to drop tiny nuclei of common salt into the clouds to stimulate the formation of these larger drops' (page 226).

13. The aircraft made available for these flights would appear to have been an Avro Anson of Cambridge University Air Squadron (CUAS). The F540 Operations Record Book entry compiled by CUAS for August 1952 states that 'The Squadron's Anson, flown by the Staff Pilot, was used for the period, 5th to 15th inclusive, in co-operation with the Imperial College of Science and Cavendish Laboratory for meteorological research. It is recorded that the work performed was of great assistance to the scientific bodies named above.' (AIR 27/2679 page 245)

14. At the request of Imperial College, Handley Page Hastings and de Havilland Mosquito aircraft of the Meteorological Research Flight (MRF) flew sorties between 4-15 August in conjunction with Project Cumulus, with the aim of examining 'the structure and environment of selected cumuliform clouds' in the Cranfield area. Operational factors prevented the close coordination of MRF sorties with the observations made by Imperial College; as a consequence, 'the investigations [of Imperial College and the MRF] while simultaneous were in fact made entirely separately.' The results of the MRF flights were summarised in MRC paper MRP 826 *The cumulus cloud investigations made by the Meteorological Research Flight during the period August 4th-15th, 1952* by G J Day and R J Murgatroyd, dated 21 July 1953. This report carried no security classification and a copy was lodged in the Library of the Met Office; a further copy is preserved in the Public Record Office (PRO) under the reference DSIR 23/22274. Observation records made by Met Office personnel aboard the Hastings and Mosquito that participated in the eighth and final series of MRF flights over Cranfield, flown on 14 August 1952 – the day before the disaster at Lynmouth – are also held by the PRO under the reference BJ 4/6. At no time were MRF aircraft employed in cloud-seeding tasks during Project Cumulus.

Primary sources

AIR 20/6739	*Meteorology – General*, undated.
AIR 2/10467	*Rain Production by Cloud Seeding*, opened 16 September 1949.
AIR 2/14461	*Rainmaking experiments in the 1950s*, opened 19 October 1955.
AIR 2/13343	*Rainfall of August 15th 1952: Flooding at Lynmouth*, opened 18 August 1952.
AIR 2/13346	*Rainmaking Experiments*, opened 16 February 1956.
AIR 2/14139	*Annual Reports of the Meteorological Research Committee*, opened 2 June 1951.
AIR 20/10790	*Data concerning the preparation of papers for the fourth, fifth, sixth etc meetings of the Instruments and Physical Sub-Committee and the extraordinary joint meeting of the Sub-Committee*, undated.
AIR 27/2679	F540 Operations Record Book, Cambridge University Air Squadron, 1951-1955.
BJ4/6	*Project Cumulus flight 7: ascent over Cranfield: flight reports*, 14 August 1952.
DSIR 23/22274	*Cumulus cloud report: August 1952*, 1953.