HISTORY GROUP NEWSLETTER

News, views and a miscellany published by the Royal Meteorological Society's Special Interest Group for the History of Meteorology and Physical Oceanography

Issue No.2, 2015

VALETE AND THANK YOU

from Malcolm Walker

All members of the History Group should know by now that I have stepped down as Chairman of the Group. I had planned to do this in 2016, by which time I would have chaired the Group for nineteen years. My hand has been forced, however, by the onset of cancer.

The Group was founded towards the end of 1982 and held its first meetings in 1983. I have been a member of the Group's committee from the outset.

I have received a very large number of letters, cards and emails expressing best wishes and goodwill for a speedy and full recovery from my illness. I am so very grateful for the many kind words you have written, especially for the prayers not a few have offered. Thank you.

IN THIS ISSUE

The death of Admiral FitzRoy at the end of April 1865 was covered in some detail in Issue No.1, 2015, of this newsletter. What happened to the Meteorological Branch of the Board of Trade after his death? What happened to the weather forecasts for the public and the storm warnings for shipping begun by FitzRoy? When was the name 'Meteorological Office' first used officially? See the article beginning on page 3.

Involvement of the Meteorological Office in the Great War increased significantly in 1915. See page 17.

And a long-forgotten meteorological office in Wiltshire that played an important part in the Great War is featured on page 12.

CONTENTS

★ I had hoped to include in this issue an outline history of Royal Meteorological Society field courses, which ran from the late 1940s until 1995. I am very sorry, however, that I shall not be able to complete this in the next few weeks. Instead, I plan to write a fuller account as an occasional paper, and to do this I would very much welcome reminiscences and, if possible, photographs from field study instructors and anyone who has attended one or more of the Society's field courses over the years. You can find my contact details at the end of this newsletter.

FORTHCOMING MEETINGS

☐ SPECIAL FIFTIETH ANNIVERSARY MEETING ON WEDNESDAY 18 NOVEMBER 2015, 2.00PM, AT THE MET OFFICE, EXETER

On 2 November 1965, the Met Office launched its first operational NWP system with its first ever press conference. This event marked the transition of the Office from a 'wait and see' secondary position in NWP to its current world-leading position. This meeting marks the 50th anniversary of that event, looking forward to the challenges and opportunities in the future, and celebrating the new collaborative nature of our NWP development.

For details of this National Meeting of the Royal Meteorological Society, please contact the Society: ☎ 01189 568500 or, nearer the time, via the Society's website (💻 www.rmets.org).

☐ 'CLASSIC PAPERS MEETING': GETTING UP TO SPEED WITH JET STREAMS

From 2.00 to 5.30pm on Wednesday 9 December 2015, probably at Imperial College, London. The meeting will be followed by mulled wine, mince pies and Christmas carols.

PROGRAMME

Malcolm Walker (health permitting) and **Brian Booth** (both History Group members)
Jet streams didn't cause depressions to fall over
Seafarers and country gentlemen noticed long before 1900 that high clouds in middle latitudes and the tropics sometimes moved quickly; and meteorologists found from measurements of cloud movements in the early decades of the twentieth century that wind speeds of more than 100 miles per hour were common in the upper troposphere. Until radiosondes came into use, however, it was not known just how strong jet streams could be, and not until the 1960s was there published a satisfactory physical explanation of how winds in the upper troposphere in middle latitudes could come to be so strong.

John Methven (University of Reading)
Jet streams and their relation to persistent weather regimes in the mid-latitudes
We all recall glumly the wet summers of 2007, 2008 and 2012 and the seemingly continuous barrage of storms, rainfall and attendant flooding in the winter of 2013/14. The relation between waves on jet streams and persistent weather regimes is discussed, as well as the challenge related to predicting them.

Suzanne Gray (University of Reading)
The sting at the end of the tail: causes, importance and prevalence of the sting jet in extratropical cyclones
Sting jets are transient mesoscale jets that descend from the tip of the cloud head in some rapidly deepening cyclones and which can give rise to strong surface winds, and especially strong gusts. Here I review the published research on these jets since the classic Browning (2004) paper entitled 'The sting at the end of the tail: Damaging winds associated with extratropical cyclones'.

Peter Haynes (University of Cambridge)
The stratospheric polar vortex
The polar vortex is a strong deep eastward jet in the winter stratosphere which acts as a barrier to eddy transport and provides the background state on which there is upward and perhaps downward propagation of planetary waves. I will review the past development of theoretical models of the polar vortex and discuss whether further development is needed.

Doug Parker (University of Leeds)
The African Easterly Jet
The African easterly jet is a remarkably coherent dynamical feature, occurring at around 600-700 mb and a latitude of around 15ºN in summer months. The talk will discuss the dynamical origins of the jet, and its importance for the forecasting of African easterly waves and severe convection over West Africa.

Julian Hunt and Andrew Orr (Respectively, University College, London, and British Antarctic Survey, Cambridge)
Low level jets in the atmospheric boundary layer
The talk reviews historical discoveries of low-level boundary layer jets in different geographical areas and on varying length scales, recent developments in physical concepts and modelling , and applications to wind power, dispersion , and wind sports.

For details of this National Meeting of the Royal Meteorological Society, please contact the Society: ☎ 01189 568500 or, nearer the time, via the Society's website (💻 www.rmets.org).

THE 'YEAR WITHOUT A SUMMER', 1816

As announced in previous newsletters, there will be a meeting in May 2016 to mark the bicentenary of the so-called 'Year without a Summer'. The venue will be the Whitby Museum, Whitby, Yorkshire. The date is now known: **SATURDAY 21 MAY 2016.**

To repeat what was said in previous newsletters, summer climate abnormalities in 1816 were such that average global temperatures decreased by 0.4-0.7ºC, resulting in major food shortages across the northern hemisphere. It is believed that the anomaly was caused by a combination of an historic low in solar activity coupled with a succession of major volcanic eruptions, capped in April 1815 by the eruption of Mount Tambora, in the Dutch East Indies (Indonesia), the largest known eruption in over 1,300 years and possibly 10,000 years.

The provisional programme is as follows:

- 'How Tambora stole summer: global climate consequences of the eruption' (Nick Klingaman, University of Reading)
- 'The summer of 1816 in the British Isles' (Stephen Burt, University of Reading)
- 'The summer of 1816 in Iceland' (Astrid Ogilvie, Stefansson Arctic Institute, Akureyri, Iceland)
- '1816: solar contributions' (Edward Hanna, University of Sheffield)
- 'William Scoresby Jr – Whitby whalers and science' (Dinah Thomson, Scott Polar Research Institute)
- 'Art and volcanic dust' (John Thornes, University of Birmingham)
- 'Poetry and the weather of 1816' (Rachel McCarthy, Met Office)
- 'Weather in the Gothic novel' (Professor Simon James, University of Durham).

In addition, there will be a short talk and exhibition on 'Whitby in Black and White' by Howard Oliver, covering engravings of the early 1800s around Whitby and photographs from later in the century by Frank Meadows Sutcliffe.

There will be a conference dinner on Friday 20 May.

Lunch on Saturday at the venue is included in the registration fee.

For details of this National Meeting of the Royal Meteorological Society, please contact the Society: ☎ 01189 568500 or, nearer the time, via the Society's website (💻 www.rmets.org).

AFTER THE DEATH OF ADMIRAL FITZROY

Admiral FitzRoy's decline in the 1860s and his death on 30 April 1865 were covered in some detail in this newsletter in Issue No.1, 2015. What happened to the Meteorological Branch of the Board of Trade after his death? Here, in extracts from Chapter 3 of Malcolm Walker's *History of the Meteorological Office* (Cambridge University Press, 2012), we answer this question.

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The speculation began before FitzRoy was cold in his grave. Who would succeed him? In fact, many months passed before anyone at all filled it on a permanent basis. FitzRoy's second in command, Thomas Babington, was in charge for nineteen months, but his appointment was never more than temporary, and he had to wait a long time for even that to be approved. He waited until 9 June 1866, by which time a government inquiry into the work of the Department had taken place.

A NEW BEGINNING

The first moves to set up an inquiry were made little more than a week after FitzRoy's death. Edward Sabine, the President of the Royal Society, reported at the meeting of the Society's Council on 18 May 1865 that he had been consulted by the President of the Board of Trade about "arrangements in consequence of the death of FitzRoy". In his response, dated 10 May 1865, he had come straight to the point. "Should it not be desired to fill up the vacancy occasioned by Admiral FitzRoy's death *immediately*, time would be afforded for a reconsideration of the duties of the Office, which might be productive of advantage in many respects." Babington was "competent to conduct and continue the system of storm warnings". Nevertheless, "the time may be viewed as suitable for obtaining and considering evidence and opinions as to the advantages, present and prospective, of continuing the practise of storm warnings". And, he suggested, "it may be unnecessary to continue the publication of the daily forecasts". The ocean statistics work could, he thought, be transferred to the Admiralty's Hydrographic Department.

Details of procedures in the Meteorological Department were sought by T H Farrer, one of the Secretaries of the Board of Trade. In particular, he asked Babington to provide an explanation of the method used to produce weather forecasts and storm warnings. Babington's response took the form of a statement entitled *Forecasts and Cautions*,

which was submitted to the Board of Trade on 11 May 1865. In it, he outlined the routine work and advised that details of the Department's methodology could be found in the chapters of FitzRoy's *Weather Book* concerned with storm warnings, meteorological telegraphy and weather forecasting.

Forecasts, Babington said, were "the result of theory and experience combined". They were not *predictions* but *opinions*, though they were probably, he considered, the *best* opinions that could be formed. He reviewed the meteorological indicators that were used when making forecasts and said that he offered "no argument, or opinion, with regard to the advisability or otherwise of the continuance of the present system of forecasting, because none was asked for".

The recommendations concerning the great desiderata of meteorology which had been given to the government by the Royal Society in February 1855 were soon to be in the spotlight again. In a letter to Sabine dated 26 May 1865, Farrer formally asked the President and Council of the Royal Society to review the advice given in 1855 and examine the work of the Meteorological Department since then. He sought the opinion of the Royal Society on a number of points.

One of Farrer's questions was surprising. He asked if it was desirable that monitoring of the accuracy of weather forecasts and storm warnings be continued beyond the end of the period which had been covered by the surveillance summarized in the Parliamentary Paper published in April 1864. The question was curious because Babington had already carried out a survey for the period 1 April 1864 to 31 March 1865 and a manuscript copy of his report had been enclosed with Farrer's letter. Farrer may have been hinting to the Royal Society that the Board of Trade still harboured misgivings over the verification process employed by the Meteorological Department. Be this as it may, the Board of Trade appeared to have confidence in Babington, given that Farrer's letter informed the Royal Society that the Board would "gladly place the knowledge and services of Mr Babington, Admiral FitzRoy's second, at the disposal of the Royal Society for the purpose of the above inquiries".

The Royal Society's Council discussed Farrer's letter at their meeting on 1 June 1865 and finalized their reply two weeks later. Dated 15 June 1865 and signed by Sabine, the reply took up six pages of the Royal Society's *Proceedings* (June 1865, Volume 14, pages 311-317). In the Council's view, the objects specified in the letter of 22 February 1855 were still as important for the interests of science and navigation as when originally formulated, and much had been accomplished "in the collection of facts bearing on marine meteorology". As no "systematic publication of the results" had yet been made, however, the Council were "unable to reply more specifically". They recommended that marine observations "should be placed in the hands of the Hydrographer, with a view to the introduction of the results into the Admiralty Charts". The Council recommended that the storm-warning service should continue "under the superintendence" of Babington and declined to express any opinion on the daily forecasts of weather.

Farrer's final question was considered in some detail. He asked for any general suggestions as to the mode, place, or establishment in, at, or by which the duties of the Meteorological Department could best be performed. The conclusion was that a "central office" should be established, to collect, reduce, co-ordinate and publish observations relating to "the Land Meteorology of the British Isles". As the Council pointed out, offices of this kind had already been established in almost all the "principal States of the European continent". A chain of stations was suggested, with stations "at nearly equal distances in a meridional direction from the south of England to the north of Scotland", each "furnished with self-recording instruments supplied from and duly verified at one of the stations regarded as a central station". The stations, the Council suggested, might be at Kew Observatory, Stonyhurst College, the Falmouth Polytechnic Institute, Armagh Observatory, the Glasgow University Observatory and Aberdeen University. Another fitting location for a station, they thought, might be Valentia, given the hope of a permanent telegraphic link between there and America in the near future. The Council pointed out that the British Association's observatory at Kew already possessed the principal self-recording instruments and recommended, therefore, that the observatory might, "with much propriety and public advantage, be adopted as the central meteorological station".

There was silence from the Board of Trade for several months. Then, on 24 October 1865, Farrer replied to Sabine's letter. He seemed irritated. A number of the Royal Society's answers were not, in the Board's opinion, helpful. For instance, so far as meteorological observations on land were concerned, the Board did not "clearly understand

whether the Royal Society think that they should be substituted for, or be in addition to, the meteorological observations at sea". They agreed that "any observations of a scientific nature would be better conducted under the authority and supervision of a scientific body such as the Royal Society, or the British Association, than of a Government Department". However, they did not "see how they could advise the government to sanction any plan which would involve the establishment of two separate offices for meteorological purposes, one under the Board of Trade at Whitehall, and the other at Kew".

"As regards meteorological observations made at sea", said Farrer, "the Board of Trade were not satisfied that they fully understood the views of the Royal Society". In the letter from the Council, he complained, there was scarcely any reference to meteorological observations at sea. Without expert guidance, the Board of Trade could not "determine what steps should be taken with regard to the Meteorological Department". The Board needed to know the value of the observations collected already by seafarers. They also needed to know "what steps should be taken to make the observations useful" and what "further observations of the same kind should be collected".

"With the view of clearing up these points", advised Farrer, the Board of Trade were "disposed to suggest the appointment of a small Committee, consisting, say, of three or four persons, to examine the whole of the data already collected by the Meteorological Department; to inquire whether any, and what steps should be taken for digesting and publishing them; and also to report whether it is desirable that observations of a similar kind shall continue to be collected". If the Royal Society accepted this suggestion, they were asked to appoint, as a member of the committee, "some gentleman whose acquirements would enable him to give valuable advice on the scientific part of the subject". The Admiralty would also be asked to appoint a member. Farrer's letter was considered at the meeting of the Royal Society's Council on 2 November 1865 and a reply sent the same day. The Council would be "quite ready to assist in this inquiry in the manner proposed". A resolution was passed that Francis Galton be nominated by the President to be a member of the committee. He was General Secretary of the British Association and keenly interested in meteorology.[1]

Sabine reported at the Council meeting on 30 November 1865 that he had received a letter dated 20 November 1865 from Sir James Tennent, Permanent Secretary to the Board of Trade. This informed the Royal Society that Farrer had been nominated as the Board's representative on the committee and that Staff-Commander Frederick Evans RN, Chief Naval Assistant to the Hydrographer of the Admiralty, had been nominated by the Admiralty.

Neither the Board of Trade's Meteorological Department nor the Greenwich Royal Observatory's Magnetic and Meteorological Department was represented on the committee. Babington was, however, consulted during the committee's deliberations. The position of the Royal Observatory in British meteorology was potentially a sensitive matter, as the minutes of the Royal Society's Council meeting on 15 February 1866 show. At that meeting, a letter from the Astronomer-Royal (George Biddell Airy) dated 31 January 1866 was read and the following reply approved:

> *The President and Council of the Royal Society are much concerned to hear that certain statements occurring in a communication from the President and Council to the Board of Trade on the 2nd of November 1865 are understood by Mr Airy to throw discredit on the Royal Observatory, and unduly to exalt the merits of another institution. The President and Council desire to assure Mr Airy that nothing in their communication to Her Majesty's Government was intended to imply any disparagement of the Meteorological Department of the Royal Observatory; and as little did it enter into their mind to exalt the Observatory at Kew to the disadvantage of Greenwich.*

According to the minutes of the Council meeting on 15 March 1866, the matter was concluded satisfactorily through exchange of correspondence.

The findings of the committee of inquiry were laid before Parliament on 13 April 1866, presented in a document that has come to be known as the Galton Report because he chaired and dominated the

[1] Galton published *Meteorographica, or methods of mapping the weather* (Macmillan, 1863) and also wrote 'Meteorological instructions for the use of inexperienced observers resident abroad' (published in the *Proceedings of the British Meteorological Society*, 1862, Vol.1, pp.397-400).

committee. The inquiry was not, however, a solo effort, as a note of appreciation in Galton's autobiography indicates.[2] In this, he acknowledged "the singular grasp and thoroughness" of Farrer and commented that the occasional brief notes he received from him, "in the course of the inquiry, were models of clearness combined with cordiality".

THE GALTON REPORT

Given Galton's views on the scientific approach to meteorology which had so unsettled FitzRoy, it was not surprising that the report's conclusions were critical of the Meteorological Department's work. Galton had an aversion to anything he did not consider 'scientific', and that included weather forecasting as practised by FitzRoy, which he considered wholly unscientific. To Galton, meteorology needed to be based on absolute laws of physics.

The Galton Report was a substantial document. Part I was concerned with 'Measures taken, or to be taken, for procuring meteorological statistics of the ocean'; Part II was entitled 'Weather telegraphy, foretelling weather, and observations of weather within or affecting the British Isles'; Part III dealt with costs; and the final part contained answers to the many questions which had been put to the committee. There were, in addition, 18 appendices, which contained a range of supplementary material. These appendices occupied 38 of the 81 pages.

In the committee's opinion, the views expressed by the Royal Society in their letter of 22 February 1855 had been adopted by the government of the day and therefore constituted "the instructions under which the Meteorological Department was to pursue its labours". They pointed out that it was never a "part of the functions of the Department as originally instituted to publish un-discussed observations on the one hand, or to speculate on the theory of meteorology on the other". "Still less", they continued, "can it be considered to have been a part of those functions to attempt the prognostication of weather".

A compliment was paid when the committee noted that a great many ships had been supplied with instruments and registers, but approval soon gave way to criticism. "The number of these registers was steadily increasing", the committee remarked, "and would, no doubt, have been very much greater if the attention of Admiral FitzRoy and of his Department had not become gradually diverted from the objects recommended by the Royal Society to those belonging to a wholly different department of Meteorology, namely, the Prognostications of Weather".

The committee stressed the need to obtain observations from parts of the ocean not often visited by ships and pointed out the need to avoid overloading the Meteorological Department with observations from the parts most frequented. The registers received by the Department had been "executed with scrupulous care and assiduity". What a pity, therefore, that the Department's analyses of the registers left much to be desired. The same pages had been searched repeatedly for different items, and no register had "ever yet been more than partially examined". A great deal of labour had been spent in "going over and over again the same voluminous records, in order to extract from them different classes of observations".

The collection of observations from seafarers was a function the committee assumed would remain with the Board of Trade, as it had been "well performed by the Meteorological Department before its attention was diverted to the practice of foretelling weather". However, Galton's committee said, the work of processing observations called for considerable knowledge of meteorology and an ability to employ "exact scientific method". In their view, it had "not been satisfactorily performed by the Meteorological Department" and would be better executed "under the direction of a scientific body". Their proposal was that a committee of the Royal Society or the British Association be set up, "furnished with the requisite funds by the government". Alternatively, they suggested, Kew Observatory "might probably be developed so as to carry into effect such a purpose".

As regards the publications of the Meteorological Department, the committee again found fault, stating that they evinced much industry but appeared to have been "selected and published without any plan". For the most part, publications contained compilations of original observations and fragmentary and miscellaneous papers on detached subjects. Where, moreover, observations had been discussed, no uniform method of tabulating results had been adopted. In the committee's view, matters of immediate importance to navigation should be brought to the notice of the Hydrographer for publication, if he thought fit, and works published by

[2] The autobiography was called *Memories of my life* (Methuen & Co, 1908, 339 pp.); see, in particular, Chapter XVI (pp.224-243).

the Meteorological Department should not contain original observations, fragmentary papers or "speculations on meteorology". As the Hydrographic Department was "devoting considerable pains to preparation of physical charts, such as Ice, General Ocean Current, and Wind Charts", the committee thought it advisable that the "results collected by the Meteorological Department" be embodied in the charts "in a form available to seamen".[3]

In the part of the committee's report dealing with weather telegraphy, storm warnings and weather forecasting, criticism was heaped upon criticism. Even the reason FitzRoy gave for adopting the word 'forecast' was used against him. The committee did not disagree with his explanation, that the word implied less precision and certainty than 'predict' or 'foretell', but they felt that the use of vague phraseology had a tendency to make those who used it satisfied with uncertain conclusions!

Weather forecasting as practised by FitzRoy was, the committee found, based on maxims which had not been derived and established by means of accurate induction from observed facts. From consultations with Babington, they had learned that the methodology used by the Meteorological Department when forecasting the weather was not "capable of being stated in the form of Rules or Laws". Though they did not doubt that many of the conditions and probabilities which formed the basis of FitzRoy's forecasting methodology *could* be expressed in the form of rules or laws that would be accepted by meteorologists generally, they did not find that these fundamentals had been "reduced into any definite or intelligible form of expression", nor were they, as they then existed, "capable of being communicated in the shape of instructions".

It had been stated in the 1863 *Report of the Meteorological Department of the Board of Trade* that storm warnings and daily weather forecasts both rested on the same footing and therefore stood or fell together as part of one system. The committee disputed this, believing that it probably did an injustice to storm warnings, which they considered to have been "to a certain degree successful" and "highly prized". Weather forecasting was a different matter. It was not based on "precise rules" or on "a sufficient induction from facts" and was "not in a satisfactory state".

Patronizingly, the committee reported that daily weather forecasts had proved "popular and interesting" and caused no additional expense. However, they were not "generally correct in point of fact" and there was "no evidence of their utility". There appeared to be no good reason why a government department should continue to undertake the responsibility of issuing them. The recommendation of the committee that publication of daily forecasts should cease immediately therefore came as no surprise.[4]

The committee recommended that the practice of issuing storm warnings should continue but advised that the principles on which they were issued needed to be defined and those principles tested by accurate observation. However, the committee did not feel that warnings of direction were sufficiently precise or correct to be of practical value. They recommended that the Meteorological Department when issuing warnings of wind force should "make, but not issue or publish, a prediction of the probable direction of the coming gale, endeavouring in so doing to render it as specific as possible".

In Part III of their report, the committee turned their attention to cost, dealing first with the work on ocean statistics they were recommending. This involved the completion of tasks currently in progress, along with the issue of instruments and registers to merchant ships, the work of increasing the number of observations extracted (to 1,650,000), and the work of "reducing, digesting and tabulating the observations so extracted". The estimated cost of all this was £3,200 annually, composed of £1,500 for the issue of instruments and registers and the remaining £1,700 for "discussion and publication of results". The committee advised that the expenditure "ought to terminate in about 15 years, as by that time a sufficient number of observations to determine the Meteorological Means will have been collected and discussed". They assumed that the work of publishing "the results of meteorological observations at sea" in a form useful to mariners would be transferred from the Board of

[3] We may note at this point that the UK now possessed five organizations concerned officially with meteorology: Kew Observatory, the Royal Observatory at Greenwich, the Scottish Meteorological Society, the Admiralty's Hydrographic Department and the Meteorological Department of the Board of Trade. In addition, weather observations were collected by James Glaisher under the auspices of the British Meteorological Society, and measurements of rainfall were collected by G.J.Symons.

[4] This recommendation was accepted without much delay. The last forecast to be published in *The Times* for many years appeared on 28 May 1866.

Trade's Meteorological Department to the Admiralty's Hydrographic Office.

An additional £7,250 would be required annually, the committee estimated. Of this, £3,000 would be required for weather telegraphy and the maintenance of a storm-warning service. The other £4,250 would be required for the establishment and maintenance of six stations equipped with self-recording instruments, the collection of observations from lighthouses, coastguard stations and other intermediate stations, and the work of digesting, tabulating, charting and publishing results. A further initial outlay of £2,500 would be required for additions to the buildings at Kew Observatory, where, the committee envisaged, some of the work they proposed would be carried out under the control of a scientific body. The committee also pointed out that a new home for the Meteorological Department would probably be needed in the near future, as they understood the premises currently occupied would soon be pulled down.

REACTIONS AND CONSEQUENCES

After the Galton Report was laid before Parliament, months passed before there was any official reaction. In the House of Commons on 30 July 1866, W H Sykes MP asked the President of the Board of Trade "on what footing" the Meteorological Department was to be placed for the future; how far the recommendations contained in Galton's report were to be carried out; and whether the storm signals were to be continued in the manner FitzRoy had used them. In reply, the President of the Board stated that he had found when he became President that "no step had been taken upon it". He promised that the report would be considered "as soon as possible" and advised the House that it was impossible to state at that juncture what decision would be arrived at.

Farrer wrote to the President of the Royal Society on 30 August 1866. He regretted the loss of so much time and reported that the Board of Trade yet again sought advice! They were, he said, "prepared to adopt and support the course proposed" by Galton's committee and had reason to believe that the Admiralty were of the same opinion. However, the Board considered it necessary to "obtain the consent of the Treasury to the proposed expenditure", and, "before taking steps for that purpose", would "be glad to learn the views of the President and Council on the subject of the measures recommended by the Committee". In particular, they wished to know if those measures were "well calculated to advance meteorological science in the most efficient way" and if "the machinery and establishment suggested by the Committee" would achieve the desired purpose. If the answer was in the affirmative, the Board would be obliged if the President and Council would provide a detailed statement of the establishment it would be "necessary to provide at Kew, or in connexion with Kew, for the purpose of receiving and discussing meteorological observations". They would also be glad of a similar statement "with respect to local observations in the United Kingdom" and "an estimate of the cost of both". Furthermore, the Board wished to "learn the views of the President and Council with respect to the body under whose management and responsibility the establishments in question should be placed".

Another eight weeks passed. Then, on 27 October 1866, the Secretary of the Royal Society, Dr W Sharpey, replied to Farrer. After first apologising for the delay, he reported that the considered opinions of the Royal Society were that the measures recommended by Galton's committee were: "generally well calculated to advance Meteorological Science in a very efficient manner"; the collection of observations from the masters of merchant ships was probably best performed "through the medium of such agencies as a government office can command"; and the work of digesting and tabulating results of observations was a function which would be better performed under the direction of a scientific body, furnished with requisite funds, than if left to a government department. Marine observations should be limited to those collected by British observers, and other observations should be limited to those made within the British Isles, including those made at lighthouses and coastguard stations. It was assumed that "the aid afforded by Government would be in the shape of an annual vote, so made as to leave the Royal Society, or other scientific body charged with the duty, perfectly free in their method and in their choice of labour, but upon the condition that an account shall be rendered to Parliament of the money spent, and of the results effected in each year".

Sharpey reported that the President and Council did not accept the recommendation that responsibility for issuing storm warnings should be given to the scientific body under whose direction meteorological observations were discussed. These warnings were "founded on rules mainly empirical" and were likely, in a few years, to be "much

improved by deductions from the observations in land meteorology" which would have been collected and studied by that time. As their basis was thereby likely to become less empirical and more "strictly scientific" than was currently so, the management of storm warnings might *in due course* be "fitly undertaken by a strictly scientific body". Storm warnings, it was pointed out, "did not originate in any recommendation from the Royal Society". If the government wished to continue issuing them, then they, not the Royal Society, should decide how this should be done.

Given the recommendation in the Galton Report that publication of the results of observations made by seafarers was a function which properly belonged to the Admiralty's Hydrographic Department, it seemed desirable that the Hydrographer himself should be a member of the committee which superintended the work of the Meteorological Department.

There was no reason to question the estimates of cost made by Galton's committee, but any detailed statement, either of staff required or of salaries to be paid, was premature.

Finally, Sharpey reported, the President and Council considered that the department responsible for observations, reductions and tabulations should be "under the direction and control of a Superintending Scientific Committee, who should have (subject to the approval of the Board of Trade) the nomination of all appointments, as well as the power of dismissal, of the several officials receiving salaries or remuneration". The committee's members would receive no remuneration, but the assistance of a "competent paid secretary" would be required and the salary of that person would need to be included "in the estimates requested". "Should the nomination of the Superintending Committee be entrusted to the President and Council", Sharpey wrote, "they would be prepared to recommend gentlemen competent to undertake the duties".

The Royal Society now seemed close to achieving what appears to have been their covert ambition for some time. Their opinions on matters meteorological had been sought by politicians and civil servants a number of times since the early 1850s. Now, it appeared, they were close to taking a controlling interest in the Meteorological Department of the Board of Trade.

By the autumn of 1866, many months had passed since the death of FitzRoy. Soon, however, decisions concerning the Meteorological Department came quickly, the first of them in a circular issued by the Board of Trade on 29 November 1866 and signed by Farrer. With effect from 7 December 1866, the storm-warning service would be suspended, but not necessarily permanently, as the Board hoped that the warnings might be resumed by "the new Meteorological Department at no distant time on an improved basis". Meanwhile, daily weather reports would be received and published as before, and if, at any port or place, there was a need for these reports, then they would be communicated by telegraph on the morning they were received, on request and subject to the recipient agreeing to pay the expense of the telegram from London.

A response to Sharpey's letter came on 5 December 1866, when Farrer wrote to the President of the Royal Society to inform him that the Board of Trade, the Admiralty and the Treasury had agreed to the proposals contained in the Galton Report, subject to the modifications suggested by the Royal Society in their letter of 27 October 1866. Furthermore, the Treasury had authorized the preparation of estimates on the basis of the modified proposals. The President and Council were asked to appoint the Superintending Scientific Committee that had been proposed with as little delay as possible.

On 15 December 1866, Sharpey wrote to Farrer to report that the Council of the Royal Society had resolved that a Standing Committee be appointed. Eight Fellows of the Society had been nominated to serve on it. Of these, four were members of the British Association's Kew Committee and two were officers of the British Association. The others were Captain George Henry Richards (Hydrographer of the Admiralty) and William James Smythe (a noted meteorologist).[5] Sharpey further reported that the Council wished to be informed if a vacancy occurred on the committee, whereupon they would appoint a new member.

Farrer acknowledged Sharpey's letter on 22 December 1866, saying that the Board of Trade would consider the arrangements proposed by the committee as soon as they were communicated. All was now set for the next phase of the Meteorological Office's existence. The

[5] Smythe was a colonel in the Royal Artillery. From 1842 to 1847, he was in charge of the observatory at Longwood, St Helena, where he carried out magnetic and meteorological observations under the direction of Sabine. From 12 January to 30 April 1861, he made meteorological observations at Levuka, Fiji.

Meteorological Committee of the Royal Society formally came into being on 1 January 1867 and met for the first time two days later.

FITZROY'S SUCCESSOR

At the first meeting of the Meteorological Committee of the Royal Society, held at Burlington House on 3 January 1867, it was agreed that Robert Henry Scott be appointed Director of the Meteorological Department of the Board of Trade. Born in Dublin on 28 January 1833, he had been educated at Rugby School (from 1845 to 1851) and at Trinity College, Dublin, which he had entered in September 1851. He had gained a Diploma in Engineering in 1856 and also that year become a Bachelor of Arts, gaining First Class Honours in Classics and Science, Chemistry and Geology. Though not a meteorologist, he was no stranger to meteorology. From 1856 to 1858, he had studied chemistry, physics, mineralogy and meteorology in Germany, working under Heinrich Dove in Berlin and the celebrated chemist Justus von Liebig in Munich. He had also translated the edition of Dove's *Ueber das Gesetz der Stürme* which had been published in Britain in 1862 as *The Law of Storms*. He had made a living as a teacher in Dublin from 1859 to 1862 and since then served as Keeper of the Minerals and Lecturer in Mineralogy to the Royal Dublin Society.

Scott's appointment as Director of the Meteorological Department was a clear case of personal patronage. He was offered the job by Edward Sabine and appears to have been the only candidate considered seriously. It was not just that both men were natives of Dublin; Scott was a close family friend of Sabine and, furthermore, his executor! Though nearly 80 years of age, Sabine was at the height of his power and influence. He was President of the Royal Society and chairman of the committee which now controlled the Meteorological Department.

The minutes of the meeting of the Meteorological Committee held on 8 January 1867 show that Scott wrote to Sabine on 29 October 1866, naming a salary of £800 *per annum* and asking that he be allowed a vacation of at least six weeks in each year. His annual salary was indeed £800 when he became Director of the Meteorological Department and the amount of annual leave he was allowed was indeed six weeks! It is clear from his letter that he was responding to an approach from Sabine, for he began by saying that he had "considered most carefully the proposal" which he had received from him "last Wednesday" (22 October). He went on: "I shall be prepared to undertake the duties of the directorship of such a meteorological office as that which you described to me, in case the Council of the Royal Society think fit to propose my name to H.M.'s Government for that office".

At the meeting on 3 January 1867, it was agreed also that Captain Henry Toynbee be offered the post of Marine Superintendent of the Meteorological Department and that Mr Balfour Stewart, the Director of Kew Observatory, be appointed Secretary to the Committee. Scott assumed command of the Meteorological Department on 7 February 1867 and the title 'Meteorological Office' was adopted formally soon afterwards, at the meeting of the Meteorological Committee held on 25 February 1867.

Afternote: To say there was a furore over the suspension of storm warnings is an understatement. They were eventually reinstated on 30 November 1867 and the first storm signals were hoisted on 10 January 1868. See Chapter 4 of *History of the Meteorological Office*. Weather forecasts for the general public were not issued again until 1879.

South cone, St Ann's Head, Pembrokeshire
17 September 1965
Such signals were displayed at prominent coastal locations around the British Isles until 1 June 1984, when the system of hoisting cones and drums or the equivalent in lights was superseded by electronic means of communicating storm warnings.
Photograph by Malcolm Walker.

JEHUDA NEUMANN MEMORIAL PRIZE

It was reported in Newsletter No.1, 2015 that the winner of the Jehuda Neumann Memorial Prize for 2014 was Joan Kenworthy. It was presented to her at the Royal Meteorological Society's annual general meeting on Wednesday 20 May by Howard Oliver, standing in for History Group Chairman Malcolm Walker, who was unfortunately too unwell to attend. Here is the citation:

Joan Kenworthy has made an outstanding contribution to the history of meteorology over a long period.

She has published three of the Royal Meteorological Society's occasional papers, all of them substantial and scholarly, one of them about relations between this Society and the Royal Geographical Society in the nineteenth and twentieth centuries, and two about Albert Walter, a distinguished meteorologist in the colonial service. For researching the latter two papers, she not only dug deep in archives in both Africa and the United Kingdom but also established close contact with Walter's family.

Joan organized and hosted at Durham University in the early 1990s two major historical conferences, one on 'Observatories and climatological research', the other on 'Colonial observatories and observations: meteorology and geophysics'. Complete proceedings of these conferences were published, both edited by Joan, and copies were sold by the Royal Meteorological Society for many years.

Joan has also contributed historical pieces to Weather*, in particular profiles of the eminent climatologists C.E.P.Brooks and W.G.Kendrew, obituaries of F.K.Hare and S.P.Jackson, and a number of scholarly articles, including one on the Durham University Observatory and its meteorological record, another on the contribution of the Chevallier family to meteorology in north-east England, and a third on inferences regarding rain-gauge exposure at Durham from 1868 to 1870. In* Notes and Records of the Royal Society*, she has co-authored an article on a contribution to meteorology by Spencer Cowper, who was Dean of Durham from 1746 to 1774.*

Joan has given many talks on historical aspects of meteorology to the History Group and the North East Local Centre and served as a most effective member of the committee of the History Group for many years. She has also played a leading rôle in making sure papers of the celebrated climatologist Gordon Manley have been preserved and catalogued, particularly his research material relating to historical records of British weather.

The photograph below (courtesy of Howard Oliver) shows Joan (right) with Jennie Campbell, President of the Royal Meteorological Society.

DID YOU KNOW?

PLEION

From the 1939 (Third Edition) of The Meteorological Glossary, M.O.225 ii (A.P.897), Air Ministry, HMSO.

"A term introduced by H.Arctowski [1871-1958] to signify an area over which some meteorological element, for example, temperature, is above normal. Areas where the element is below normal are termed antipleions. Arctowski drew his pleions by constructing overlapping twelve-monthly departures from average, and he found a tendency for the pleions obtained in this way to persist for a considerable time, moving slowly across the country."

FORGOTTEN METEOROLOGICAL OFFICES – BUTLER'S CROSS, WILTSHIRE

by Brian Booth

BACKGROUND

When war was declared in August 1914, artillery training was largely based on the doctrine of direct fire – firing from an unprotected position against an enemy in plain view. This was well-suited to the mobile warfare of the 19th century but not the static situation that rapidly developed along the Western Front during the early months of the First World War, when targets were often out of sight and many kilometres distant.

A change of technique and more scientific approach was required – firing, or shooting, from the map, i.e. aiming at targets for which only map co-ordinates were known. Amongst other things this required special consideration being given to the effects certain elements had on the trajectory of a shell – the air density, pressure and wind of the layers through which it passed. In the absence of any direct measurement of density, consideration was initially given to temperature, later changed to virtual temperature so as to include the effect of humidity. Initially, none of these variables was available at the point of firing and gunners used locally recorded values of surface temperature, wind and pressure in conjunction with range tables to calculate the various settings required before firing.

On 12 April 1916, the Meteorological Section, Royal Engineers (Meteor RE), at the General Headquarters of the British Expeditionary Force (BEF) at St Omer, began the routine issue of meteor telegrams. Based on upper winds measured by pilot balloon, these provided corrections for upper winds for battery commanders, together with estimated temperatures. This brought about such an improvement in accuracy that after the Battle of the Somme (July to November 1916), a captured German document reported *The enemy appears to have better and more accurate data for shooting from the map than we have. This seems to be proved by the fact that, in weather that excludes all possibility of observation, and under conditions very different from those prevailing during previous shoots, he obtains hits on very small targets with great accuracy*.[6]

Nonetheless, there was initially resistance to their use, and one young officer later recalled how a senior Royal Field Artillery officer, on seeing meteor corrections were posted on the walls of the battery command post, ripped them down saying *'Not done in the field artillery'*.[7] The reality of the situation was that many gunners had been insufficiently trained on reaching their units during 1915, and because of this the five Armies of the BEF began establishing their own artillery schools, albeit without a standard syllabus.[8]

To establish a degree of standardisation and terminology, a new school was established on Salisbury Plain during the autumn of 1916, initially for officers drawn from commanders and seconds-in-command of artillery batteries in France.

The establishment operated on a new artillery range on an area of Salisbury Plain known as Chapperton Down. It became operational during November 1916 and, reflecting the fact that most courses were made up of officers sent back from France, was briefly known as the Overseas Artillery School, before becoming the Chapperton Down Artillery School (CDAS) during the summer of 1917[9]. The Chapperton Down range extended southwest from a gun position known as the Field Barn battery just east of what is now the A360 and north of Tilshead village. At least seven gun positions were probably used, and observation posts were conveniently situated to view the impact points within the target areas (Figure 1).

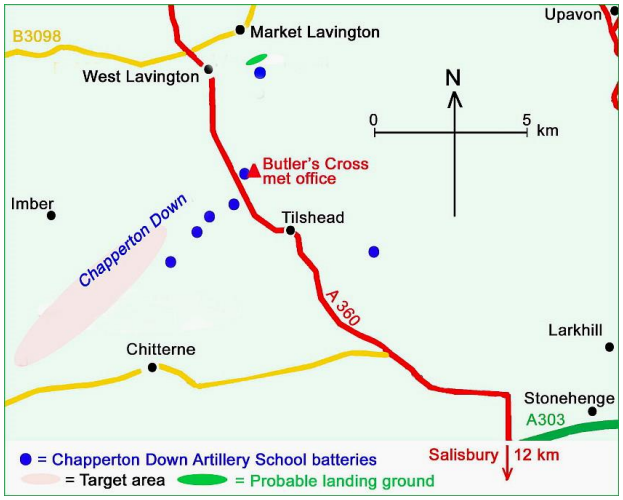


Figure 1. Map showing the location of places referred to in the text. The B3098 follows the bottom of a steep escarpment which marks the northern limit of Salisbury Plain.

[6] *Meteorological information for artillery* (1917)

[7] T H E Travers *The Killing Ground*: p162 (1987)

[8] http://www.gutenberg-e.org/mas01/frames/fmas08.html (paragraph 33)

[9] This name for the range is used in a memo dated 29 May 1917 from the General Headquarters, Home Forces. (National Archives file WO 339/71193)

There was no on-site accommodation; the School's Headquarters for its seven-man staff was a house in Salisbury market place, while the Old George Hotel was used to billet many of the officers attending the School's courses (Figure 2). They, together with the School's staff, were bussed to the range each day.[10]

Figure 2. A postcard of the Old George Hotel in Salisbury (circa 1900-1910), the billet of many officers attending the Chapperton Down Artillery School.

Apart from two hours of instruction during the evenings, the course consisted of demonstrations, with firing taking place on weekdays between 8.30 am and 4 pm.[11] A flight of RFC (later RAF) aircraft was permanently attached to the School, working with the batteries by observing the fall of shot and transmitting corrections by wireless and taking photographs.[12] There is some evidence that the aircraft used a landing field on a plateau overlooking Market Lavington.

The furthest distance from gun to target was some 12 km, and although meteorological input was a necessity, none was immediately available leaving the gunners dependent on their own observations, as had been the case in France before the introduction of meteor telegrams.

BUTLER'S CROSS

July 1917 – February 1919

During May 1917, the War Office approved the establishment of a meteorological office for the CDAS to be manned by five men – a Subaltern, a Corporal and three pioneers (all trained in meteorology.[13] Lt Charles Duncan Stewart (Figure 3) was selected the unit's officer and he reported to the School's Commanding Officer, Lieutenant Colonel Marton, on 2 July for instructions.[14]

Figure 3. Charles Duncan Stewart at the Conference of Empire Meteorologists in London during 1935.

Stewart had worked briefly at Kew and Falmouth Observatories from 1913, before being posted to France in September 1915 as a Lieutenant in the Meteorological Field Service, attached to the Royal Flying Corps.[15] He was subsequently transferred to the Special Brigade, Royal Engineers (RE), which was responsible for gas warfare, but after an accident involving gas on the night of 31 August 1916 Stewart was invalided back to England.[16]

Such documentation that survives refers to the new office by a variety of names, but it appears that those who worked there knew it as Butler's Cross. Only one document gives its location, R P Batty's *Professional Notes No 12: An analysis of the rate of ascent of pilot balloons at Butler's Cross, Salisbury Plain*, which places it at 51º 15'N, 01º 58'W. This is close to a spot where a cross, known as 'Butler's Cross', once stood, marking the northernmost point of the Tilshead parish.

Surprisingly, evidence of a meteorological presence still exists at grid reference SU023499 in the form of a concrete plinth on which one of the theodolites used by Batty was fixed (Figure 4, next page); even more remarkable is that it is visible on Google Earth at 50º 14' 53.15" N 01º 58' 05.37" W.

[10] N D G James. *Gunners at Larkhill:* pp 48-50 (1983)
[11] N D G James. *Gunners at Larkhill:* pp 163-164 (1983)
[12] http://www.gutenberg-e.org/mas01/archive/app20.html (Royal Flying Corps)

[13] National Archives file WO 339/71193 (Memo dated 29 May 1917)
[14] National Archives file WO 339/71193 (Memo dated 24 June 1917)
[15] The Meteorological Field Service was transferred to the Royal Engineers during February 1916, becoming the Meteorological Section of the Royal Engineers – commonly known as Meteor.
[16] National Archives file WO 339/71193 (Letter dated 1 June 1918)

The site is an uninhabited and bleak spot some 152 metres above sea level, with unbroken views across Chapperton Down from southwest to northwest (Figure 5). Given the open exposure, a hut must have been provided for work and shelter (as opposed to a tent). Although there is no record of its location, a possible site is an area of levelled ground to the southeast of the plinth. The nearest source of water was a well about 600 m distant at the Field Barn near the bottom of a hill.[17] The West Lavington to Tilshead road, now the A360, lay along a valley about 110 m asl, and would not have been visible from the meteorological office.

Figure 4. The remains of the concrete theodolite pedestal of the Butler's Cross meteorological office, looking northeast. The historic Butler's Cross was located on the skyline on the extreme left of the photograph.

Figure 5. Looking southwest across the theodolite plinth, identifying the local place-names used in the text. The Field Barn buildings were surrounded by trees and at a lower level. Likewise, the Field Barn gun battery was not visible from the theodolite, being below the line of the plateau. The West Lavington to Tilshead road followed the line of trees aligned right to left just beyond the gun battery.

Where the Butler's Cross staff were billeted is not recorded, but at least one of the officers is known to have had lodgings at a farm near West Lavington in 1919.

No records survive of the office's routine, but its role was to provide reports of surface pressure and temperature, and measurements of upper winds to 6000 ft as required by the CDAS. Since firing took place daily between 8.30 am and 4 pm[18] there would have been little time for rest – not that rest would have been easy as the Field Barn gun battery was only 300-400 m distant! Upper winds were obtained by pilot balloons; the single theodolite method was probably used in the first instance (the Butler's Cross pedestal being known the home station), but after two outstations were established some 1500 to 1600 m distant the double theodolite technique was adopted.

In addition to the theodolites, the office would have been equipped with a Stevenson screen for thermometers, a barometer, rain gauge and anemobiagraph. Few instrumental records survive from the early days, other than anemograms, the first dated 27 July 1917 (Figure 6, next page). Given that aircraft were closely involved in the School's work it is not unreasonable to assume upper air temperatures might have come from this source, but if not they might have been estimated from the surface temperature and a standard lapse rate.

Post-February 1919

Stewart's stay was brief, as he relinquished his commission on the grounds of ill health in May 1918, and returned to Kew. There is no record of his immediate successor, but Lt R P Batty, RE, briefly assumed responsibility during the early spring of 1919. Shortly after this, the office was civilianised and the Met Office assumed responsibility, renaming it West Lavington in the process – despite 'Butler's Cross' continuing to be used on returns.[19] Following civilianisation, there were six civilians in post, the meteorologist in charge being J Durward, who had previously held the rank of Captain at HQ Meteor RE (Home) at RAF Stonehenge, with Batty as his deputy.

[17] A field barn was a building, or collection of buildings, some distance from the parent farm, and was used to store crops and provide shelter for livestock - and occasionally living accommodation for farm-hands.

[18] N D G James. *Gunners at Larkhill:* pp 163-164 (1983)

[19] Annual Report of the Meteorological Committee for 1918-1919; p41

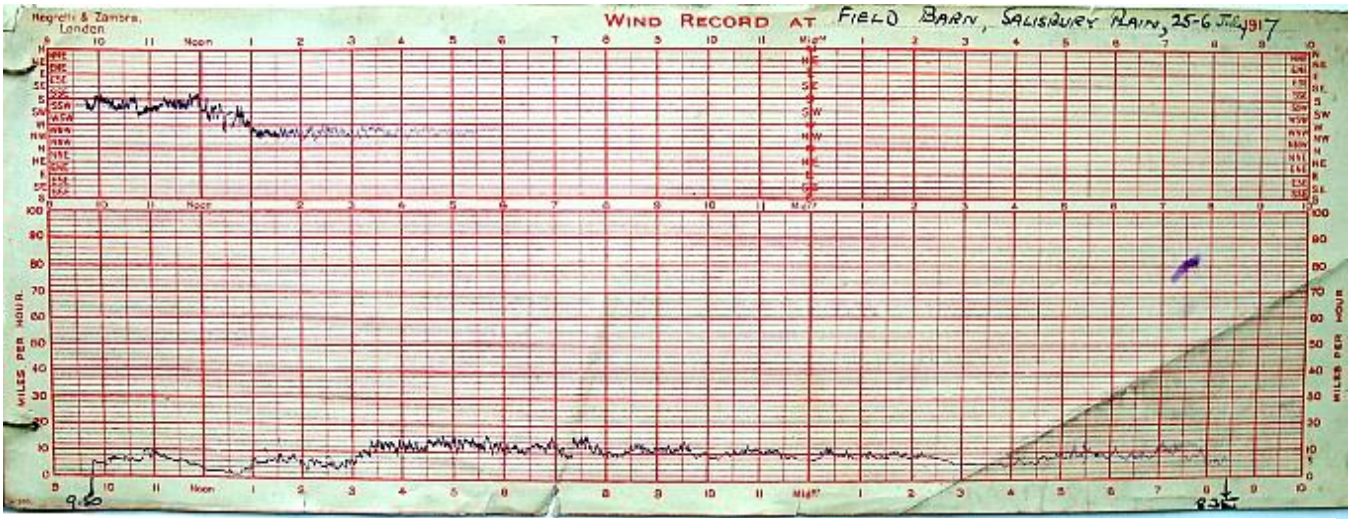


Figure 6. The first anemogram for Butler's Cross, dated 25-25 July 1917; unfortunately the ink ran dry – not an auspicious start! It is labelled as being for Field Barn, Chapperton Down, probably after the nearby Field Barn gun battery.

The office continued supporting Army units on Salisbury Plain until 22 October 1920, when most of the staff relocated to a purpose built office at Larkhill. The last observation was made on 31 October, after which Butler's Cross became another forgotten name in meteorological history.[20]

ACKNOWLEDGEMENTS

I must express my grateful thanks for the support given by Joan Self and Mark Beswick of the National Meteorological Archive. The assistance given in finding documents other than those requested has been greatly appreciated.

MOUNTAINTOP WEATHER
by Howard Oliver

In the April 11th 2015 issue of *New Scientist*, the 'Aperture' photographic double-page spread was an amazing image taken on the summit of Mount Washington, USA. It showed an array of long combs of rime ice with the weather observatory in the background. It was taken in March when the temperature at the time was -44ºC.

Mount Washington held the record for the highest gust observation on the surface of the Earth, of 372 kmph measured in 1934, until beaten by an unmanned instrument on Barrow Island, Australia, which recorded 407kmph during typhoon *Olivia* in 1996.

The *New Scientist* caption read: "It can get pretty cold on the summit of Mount Washington, or Agiocochook as Native American Indians call it. The New Hampshire peak stands at 1917 metres and is the highest in north-eastern US. It also has the distinction of hosting the Mount Washington Observatory, which was the world's first mountaintop weather station. Meteorological data has been gathered there since 1870".

However, in a letter published on 16 May, the writer, Heinrich Falk, took the magazine to task. He pointed out that the German mountain station 'Meteorologisches Observatorium Hohenpeissenberg' was opened on 1 January 1781 and therefore predates the US example by all of 89 years!

By means of the *Google* translation service of the observatory's web site it is possible to confirm this information. The German mountain station is situated 80km south of Munich but is only at a height of 1000m. In more modern times, in addition to normal meteorological observations, it has maintained ozone measurements since 1967 which have subsequently been supplemented with trace gas, aerosol and rainwater chemistry data.

For photographs taken on the summit of Mount Washington, see next page.

[20] The location known as 'Butler's Cross', from which the office took its name, disappeared from Ordnance Survey maps during the latter years of the 20th century

MOUNTAINTOP WEATHER – continued

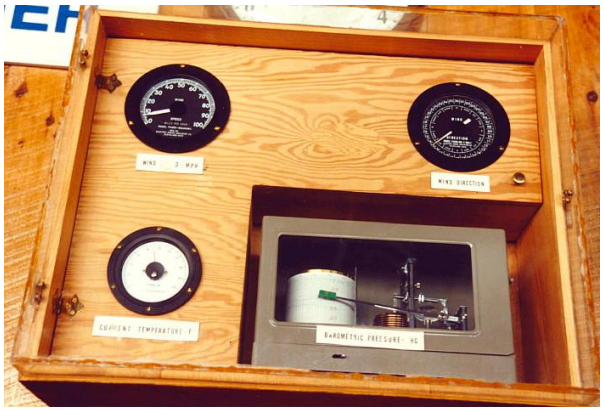
The summit of Mount Washington, New Hampshire, USA.
The photographs on this page were all taken by Malcolm Walker on 28 August 1996.

Above: The Observatory Tower.
Below: The summit marker.

Right: How do you get to the top of Mount Washington? There is an Auto Road, but, from my experience, be warned, this can be scary when you are driving through thick cloud and you realise there are in some places steep drops only feet from the edge of the road. Alternatively, you can use the Mount Washington Cog Railway.

MW.

Above: A great storm indeed!
Below: Current temperature, wind speed, wind direction and barometric pressure.



OPERATIONAL CENTENARY
by Maurice Crewe

This note is extracted from past articles and presentations about the early 20th century.

World War 1 was a period of major changes, especially in the practice of meteorology. An interesting and possibly useful Edwardian pastime became a scientific activity of increasing value to many human endeavours. This note is a reminder that it was a century ago that a couple of telegrams triggered changes in the ways that day to day meteorology operated. Before World War 1, the services provided by the Meteorological Office were on a relatively relaxed time scale, with the nearest approximation to a 'real time' service being warnings of gales for shipping. Even though before the war started, Shaw reported, in the *Annual Report*, 1913, that "at the request of the War Office arrangements have been made for a course of instruction in meteorology at the Royal Flying School at Upavon, and for the supply of forecasts to the military Flying Schools at Eastchurch and Montrose". The electric telegraph was well established for communications purposes, being used for near-real-time transmitting of data for the construction of the day's weather map to Upavon, at least during the Central Flying School's term-time. The developing aviation was dragging meteorology into the 20th century, and the Met Office was looking to the future. Shaw had been in contact with Vilhelm Bjerknes and was aware of the ideas being investigated in Bergen. And with Lempfert had written *The life history of surface air currents. A study of the surface trajectories of moving air*, while L F Richardson was tossing around the idea that a mathematical approach may be even better.

In 1914, some thirty of the ninety full-time staff of the Meteorological Office joined various branches of the forces; and by the end of the war, the number of uniformed Meteor staff had risen to 28 officers and 187 other ranks.

It was in 1915 that aviation and gas warfare heightened the profile of meteorology in the minds of military authorities from the acceptance that weather can affect war to the realisation that meteorological science had developed to a level that it might offer some help with more urgent military problems. On the 5th May 1915, the General Officer Commanding the Royal Flying Corps sent a telegram basically asking for help in connection with aircraft operations. The first use of gas was when chlorine was discharged over a fairly nondescript piece of land near Ypres in April 1915. The officer responsible for dealing with the expected gas warfare was Major C Foulkes, and he promptly wrote seeking help with problems such as wind direction and speed. On receiving these two telegrams, Director of the Meteorological Office Dr William Napier Shaw had the foresight to realise that meteorology could provide the more urgent help required. In a little over a month, Shaw had negotiated with the War Office, as a result of which Major Henry Lyons RE FRS had proceeded to GHQ in France representing the Director, as Officer in charge of the *Meteorological Field Service* which became the Meteorology Section, Royal Engineers in September 1915, and was abridged generally to 'Meteor'. Two Meteorological Office staff had been released, granted commissions and were on their way to France, albeit without military training. They were Captain E Gold and Lieutenant A E M Geddes. The *Annual Reports* for 1916 and 1917 list 'Reserve of meteorologists in England after Meteorological Section RE' suggesting that HQ were aware of the risks to men serving in Flanders. In September 1915, the functions of the Meteorological Section, Royal Engineers (Meteor) were officially stated as:-

Major (later Sir) Henry Lyons

1. To act as Meteorological Advisers to the General Staff, both at General Headquarters and at Army Headquarters.

2. To supply all the meteorological information required by the Royal Flying Corps [later the Royal Air Force].

3. To furnish the regular reports required for the correction of range in Artillery operations.

4. To furnish meteorological reports and forecasts for offensive and defensive gas operations

Lyons was a formal traditionalist but an exceptional administrator, who also acted as Director of the Meteorological Office from 23 May 1918 to 28 April 1919, to allow Shaw time to write a book needed to train forecasters and to act as scientific advisor to the government. Colonel Sir Henry Lyons was a president of the Royal Meteorological Society and represented the Royal Society on the Meteorological

Committee for 26 years. He was, perhaps, one of the most eminent army men to become active in the field of meteorology, although not a practising meteorologist. He retired from the army in 1919 and became Director of the Science Museum in 1920.

It is probably true to say that the really pivotal figure during the war was Ernest Gold, CB, DSO, FRS.

In 1906, Gold was one of the first qualified scientists to join the Meteorological Office.

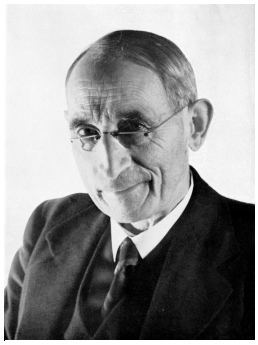
It was Gold, with a strong personality and an eagle eye for detail, who organized the operational (military) meteorological service during the war and demonstrated the vital role of meteorologists to the military hierarchy to such good effect that he was mentioned in dispatches within a few weeks and rose to Lt Col by the Armistice and was awarded the DSO and OBE. He oversaw not only the creation of an operational weather service but the development of international aviation services, becoming President of the Commission for Synoptic Weather Information of the International Meteorological Organization that preceded WMO.

Lt Col Gold

Scientifically, Gold made (at least) two major contributions to practical weather forecasting. He produced a report for the Director of the Meteorological Office [Gold, E., *Barometric gradient and wind force. Report to the Director of the Meteorological Office on the calculation of wind velocity from pressure distribution and on the variation of meteorological elements with altitude*; Meteorological Office, London, 1908; Pp.43+15pls: M.O, No. 190]; and also sent a letter to Sir Napier Shaw containing the original proposal for the term 'Thermal Wind'.

For the convenience and as a brief résumé for others, he introduced the idea of 'fitness for flying' as a function of the wind, weather, cloud and visibility and in some cases type of aircraft.

After the Great War, Gold applied a scientific approach and presented a numerical index to the Third International Congress of Arial Navigation. The concept of a 'fitness figure' was still widely used during the Second World War, and during the 1970s the concept was reinvented in the RAF as a 'colour state'. I cannot find where I read about the introduction of fitness figures, but with limited communications I feel sure the flyers would have used some sort of 'shorthand' – at least between themselves, even if the representatives of the Society of British Aircraft Constructors were so strongly of the opinion that weather reports should contain no reference to fitness or unfitness for flying.



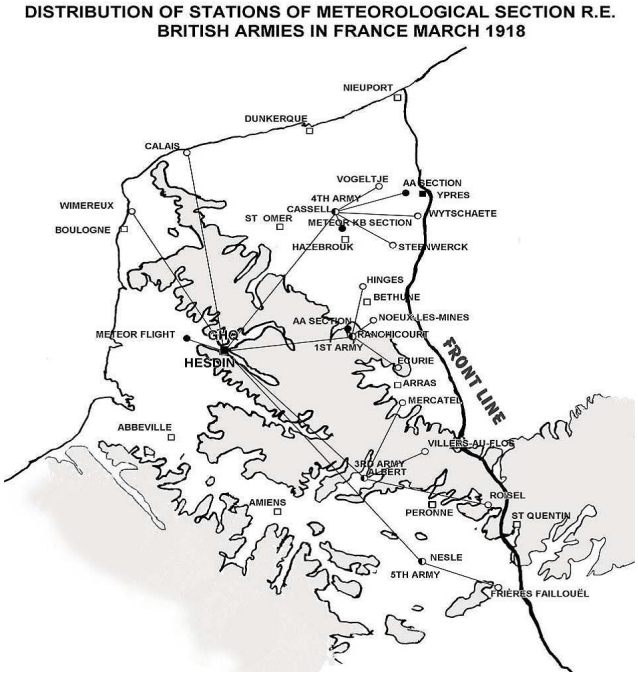
Gold as some of us saw him – near retirement

By 1919 the RAF were certainly using something that appears to be existing practice.

Report of work in the Meteorological Section, RAF, for the period April—September, 1919, inclusive, by Squadron-Leader Gendle, OBE

" It was not possible to make as complete arrangements as desired, especially in France, but the reports of the weather at other stations on the route in terms of a 'Weather Fitness Scale' were sent to each control station every hour from 0700 to 1900 (7 am to 7 pm) throughout the six months."

Vital to the increasingly urgent work was the network with communications and codes. The operational network set up used all available

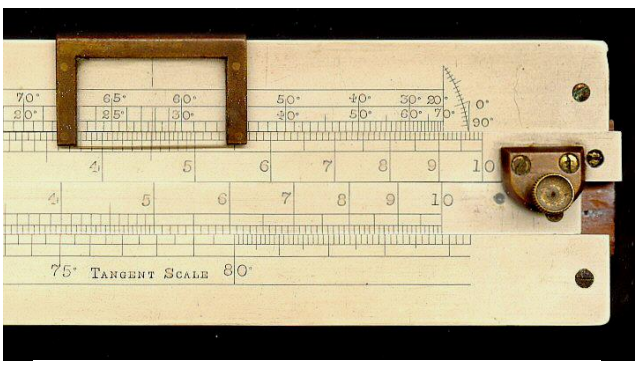


The start of modern networks

methods of communication, from telegraph, telephone, telegram, despatch rider and eventually the new-fangled wireless.

Another major innovation came from the recognition that existing codes were totally inadequate to provide the data for military forecasts, so a new code was created for use by 'Meteor' stations with five-figure groups (which were the cheapest to use in telegrams. The code was agreed with French meteorologists and, with little change, included, in 1919, in the International Convention for Air Navigation (with the concurrence of the USA). After adoption by the International Meteorological Organization, only minor changes were made in the next 25 years. It was an unsung major contribution to international meteorology.

As the whole concept of operational meteorology was so new it took a few months to establish a routine operational practice, but it is notable throughout the war that there were many practical advances made. For example, the increasing need for upper-air data saw the few dozen pilot balloon ascents in 1914 increase to over 13,000 a month by 1918, even using Chinese lanterns to allow successful ascents at night. After an ascent lasting half an hour or so, the computation of upper winds used to take the best part of an hour, using graph paper and trigonometry. Gold reported in 1955 that "with the assistance of Lt Entwistle and Corp. Durward, the procedure was simplified". Then, with appropriate instruction and experience, observers were able to do the computations during the ascent using the recently introduced slide rule, with the final results available two minutes after the end of the flight. This was a transformation in the efficiency of providing data the artillery and the pilots.



Pilot balloon slide rule introduced in 1915

Another change that had to be adopted was the Summer Time Act in 1916; after much discussion it was eventually decided that meteorological work would remain based on Greenwich Mean Time and this established international practice – even when the name changed.

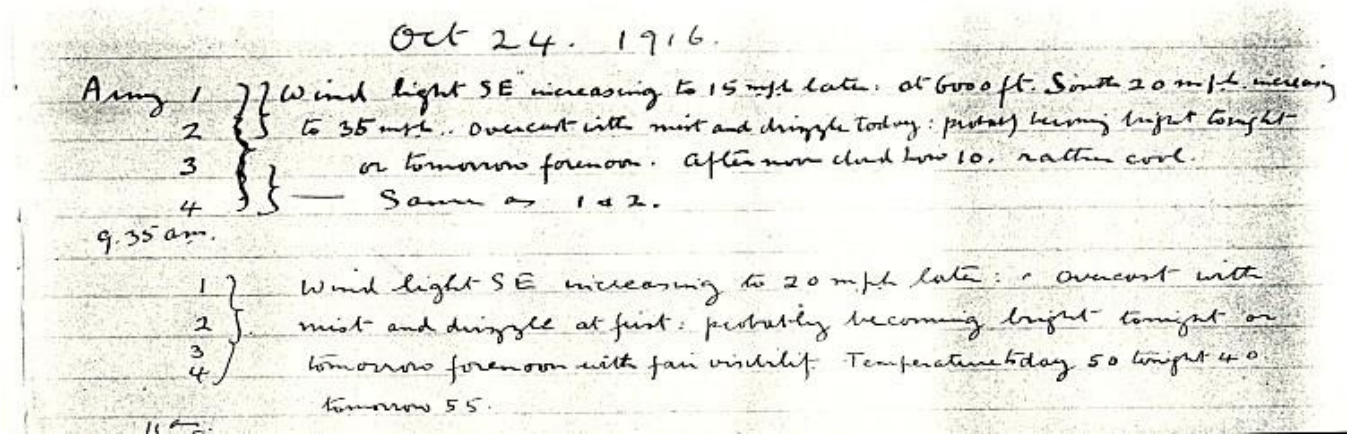
The style of presenting reports and forecasts changed dramatically with experience gained.

The earliest surviving logbook shows a forecast issued in October 1916 for the Army, and they were very brief, as can be seen (see figure on next page). By late 1917, a much more comprehensive presentation had been developed, adding a little more detail about visibility, upper winds etc. From the outset, copies of synoptic charts were prepared by hand in very limited numbers for GHQ and AHQ. Later, at the instigation of Captain Goldie 'clay copiers' were introduced, which permitted the copying of local Daily Weather Reports for wide distribution.

In spite of the courses of tuition that had been introduced for the services, Shaw also saw the need for reference material and training manuals in the form of *The Weather Map* and the *Meteorological Glossary* (HMSO 1916). These were, perhaps, the first text books intended to define and explain technical meteorology for customers, initially the military. They proved so successful that there were four issues within two years, and although these were attributed to Shaw, he acknowledges in the introduction to the fourth 1918 issue that various articles were written by W H Dines & E V Newnham at Benson, C J P Cave & R A Watson Watt at South Farnborough and Major G I Taylor plus several other staff at the Met Office headquarters. A new field of technical literature was to follow.

It may be a century since meteorology went 'operational', with Lyons and Gold in charge, but the change in attitude all round inspired many of the staff, both at HQ and those in uniform.

Some have been undervalued, such as C K M Douglas, a pioneering investigator of the atmosphere in three dimensions while flying on active service and before becoming a professional meteorologist. And C J P Cave was a wealthy individual and an enthusiastic meteorologist who volunteered to go into uniform and demonstrated great organizing ability as well as scientific understanding; he was a pioneer of tracking thunderstorms and measuring cloud base at night with a searchlight among his other activities. The list


Oct 24. 1916.

Aug 1 2 3 4 } Wind light SE increasing to 15 mph late. at 6000 ft. South 20 mph. increasing to 35 mph. Overcast with mist and drizzle today: probably becoming bright tonight or tomorrow forenoon. After noon cloud low 10, rather cool.

1 2 3 4 — Same as 1 & 2.

9.35 am.

1 2 3 4 Wind light SE increasing to 20 mph late: overcast with mist and drizzle at first: probably becoming bright tonight or tomorrow forenoon with fair visibility. Temperature today 50 tonight 40 tomorrow 55.

The earliest recorded operational forecast

of names could go on, and many became well known, even a couple of directors of the Meteorological Office and several professors.

REFERENCES

Many have been dipped into over the years, but most of the details are collected together in:- Malcolm Walker's *History of the Meteorological Office* (Cambridge University Press, 2012).

CONFUSION OVER METEOROLOGICAL UNITS AND DAYLIGHT SAVING TIME

Maurice Crewe mentioned in his article the Summer Time Act of 1916. Here is more about the story of the introduction of Daylight Saving Time, taken from pages 178 and 220-221 of Malcolm Walker's *History of the Meteorological Office*.

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An issue that had been simmering for years was the lack of a uniform system of units in meteorology. This had first been discussed at an international level in 1872, at a conference in Leipzig, when the metric system had been opposed vehemently by Robert Scott, then Director of the Meteorological Office. The matter came to the fore again in 1903, at a meeting of the International Meteorological Committee held at Southport. It was not just that many nations used the metric system while the United States, the United Kingdom and Britain's colonies and dependencies used inches of mercury for barometric pressure, inches for rainfall amount and degrees Fahrenheit for temperature. There was also the need to decide, for example, if barometric pressure should be reported in millibars rather than inches or millimetres.

Moreover, many seafarers were accustomed to gauging wind force by means of Beaufort's scale and expressing wind speed in nautical miles per hour (knots), rather than miles per hour or metres per second.

No consensus was reached at the Southport meeting, nor was it at the meeting of the International Meteorological Committee held at Berlin in 1910. However, a decision to adopt the CGS (centimetre-gram-second) system of units for theoretical and thermodynamical studies in meteorology and for studies of the upper levels of the atmosphere was made at the Berlin meeting. The change to the CGS system was advocated by the younger generation of meteorologists, accustomed to using it in theoretical and practical physics. A matter which was in fact resolved at Southport, however, was that of the time of the morning observation. The British agreed to alter their standard observation time to 7 am GMT, thus synchronizing their observations with those made at 8 am in countries which used Central European Time.

Daylight Saving Time was a contentious issue which occupied a considerable amount of Parliamentary time in 1908 and 1909, and the Meteorological Office became involved. Shaw gave evidence to a Select Committee of the House of Commons in May 1908 and also wrote letters to *The Times* on the subject. So far as he was concerned, as he said in a letter published on 6 June 1908, meteorologists were "as much dependent on the sun as the navigator is" and "a separate system of time-keeping would have to be used". He would rather not have to alter the clocks. Furthermore, he did not wish to change the working hours of those who

would have to continue making observations at standard internationally-agreed hours, nor of those who transmitted these observations and the forecasts derived from them. He wondered if there might be instead a "change in the habits of the community". He was not best pleased that his time had been taken up with appearing before a Select Committee and considered that "the official guardians of the standards" should have been consulted formally before legislators became involved in a matter of such world-wide importance as time.

Though Shaw did indeed object to the introduction of Daylight Saving Time, the statement made by Mr George Courthope, the Member for Rye, in the House of Commons on 5 March 1909, during the debate on the Daylight Saving Bill, was a gross exaggeration.

> *It has been said, and with great emphasis, that no scientific people oppose this Bill. How on earth can that be maintained when the whole force of the Meteorological Office is against the Bill, and the whole weight of the Royal Meteorological Society as well?*

No evidence has been found to support the contention that the "whole weight" of the Royal Meteorological Society was against the Bill; and the overall attitude of the Meteorological Office seems to have been fairly neutral. Shaw certainly testified against the Bill, saying that there might be uncertainty as to the hours at which observations were taken, but he indicated that any problems which might arise were not insurmountable. Some wild and silly statements were made during the debate in the House, one of them a question asked by Sir Frederick Banbury, the Member for the City of London, who asked: "How does the Honourable Member propose to set back the sundials in summer and advance them in winter?"! The Bill was defeated, but not many years were to pass before Daylight Saving Time was introduced.

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Confusion for observers, and annoyance, came just before the Great War with the introduction of absolute units. On the recommendation of the International Meteorological Organization's Commission for Scientific Aeronautics, the Meteorological Committee decided to record rainfall measurements in millimetres and barometric pressure readings in millibars (instead of inches in both cases). The Meteorological Office used these units in Part 3 Section 1 of the *British Meteorological and Magnetic Year Book* from January 1912 and in the *Daily Weather Report* from 1 May 1914. And the British Rainfall Organization adopted millimetres in 1915. Instruments were recalibrated, with the dials of aneroid barometers labelled in centibars, not millibars, and the glasses for measuring rainfall labelled in millimetres. Curiously, however, the Office asked observers to report pressure readings in millibars, not centibars. No wonder there was confusion! One may wonder why dials were not labelled in millibars in the first place. In the aforementioned year book, under 'Daily readings at meteorological stations of the first and second orders', air temperatures were tabulated in degrees Absolute from 1 January 1912, this being considered helpful when barometer corrections were being applied, as the equation which governed these corrections required absolute units.

A development in 1916 which caused further confusion among observers was the introduction of Summer Time, which had first been discussed by Parliament in 1909. The Summer Time Act, which received its Royal Assent on 17 May 1916, specified that, for general purposes, the time in Great Britain would be, from 2.00 am Greenwich Mean Time (GMT) on 21 May 1916 to 2.00 am GMT on 1 October 1916, one hour in advance of GMT. In Ireland, Dublin Mean Time would be replaced by GMT, the difference being 25 minutes.

The position of the Meteorological Office over the introduction of Summer Time was set out in a very detailed circular issued by the Office on 18 May 1916. This gave notice that:

- In accordance with the Act, GMT would be used as theretofore in all Meteorological Office forms, records and books of instructions issued, for describing the times of the observations and other operations at the observatories and stations in connection with the Office.
- Until further orders, the hours of observation for the telegraphic reports of the Daily Weather Service would continue to be 01, 07, 13, 18 and 21 GMT, i.e. 2 am, 8 am, 2 pm, 7 pm and 10 pm Summer Time.

This seemed clear; and observers who possessed two clocks were advised for their personal convenience to keep one of them set according to Summer Time, the other according to GMT, "for the purpose of verifying and recording the times of

observation and other meteorological observations". There was, however, confusion.

Many who observed for the Meteorological Office and the British Rainfall Organization were not sure exactly when their observations should be made, which led, in turn, to confusion among those in the Office and the BRO who processed the observations as to exactly when certain observers had in fact made them! There were further problems, which were that the 07 GMT observations which were included in weather reports were made too late for the regular Post Office hours of delivery and postage; and the 18 GMT observations could not be communicated, except through a very few telegraph offices, because the offices had by then closed for the day. Moreover, it proved impossible to maintain the evening reports from the health resorts at the usual hour. They had to be made an hour earlier. But the concept of Summer Time was here to stay and the confusion among observers naturally diminished over the years.

THE ROYAL METEOROLOGICAL SOCIETY IN 1904

Why 1904, you may ask? Don't newsletters usually focus on 50, 75, 100, 150 etc years ago? Well, there was no good reason to choose 1904, except that the Society that year gained Royal Patronage for the first time. In the words of the Society's Annual Report for 1904 (published in the July 1905 issue of the *Quarterly Journal*, Vol.31, pages 239-266):

> *The Council have the gratification of announcing that, in response to a letter signed by the Officers and Members of the Council, H.R.H.The Prince of Wales has honoured the Society by graciously consenting to become its Patron.*

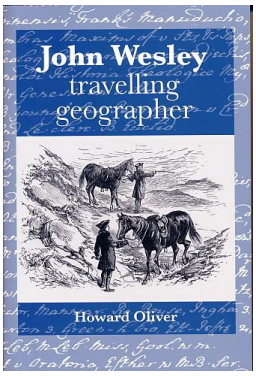
What else was worthy of mention in the report for 1904? Here, in bullet form, are the main points.

- While a satisfactory number of new Fellows had been elected during the past year, the number of deaths and resignations had also been considerable. The cost of the care of the increasing Library and of the Bibliographical work, as well as of the improvements recently introduced into the *Quarterly Journal* and the *Meteorological Record*, had more than absorbed the ordinary income of the Society during the past two years, and the deficit had been met by a sale of securities. The Council trusted that it may not be necessary to curtail the work now being done, and they asked for the assistance of the Fellows in securing such an increase of membership as would provide the necessary income. Amongst the exceptionally numerous deaths (23), the Council deplored the loss of Mr E.E.Dymond and the Rev F.W.Stow, two long-standing members (both elected in 1866). There were 658 members of the Society on 31 December 1904, a decrease of 9 for the year.
- The Council felt that the advancement of Meteorological Science in this country depended greatly on the encouragement afforded to research by the Government funds administered by the Meteorological [Office] Council. The Council trusted that, in the event of a reconstitution of the Meteorological Office, one member at least of any Advisory Committee which may be formed would be a representative of the Royal Meteorological Society.
- The annual Luke Howard Silver Medal to the cadets of the Nautical Training College H.M.S. *Worcester* had been awarded to Cadet E.J.A.Lawson for the best essay on 'The Barometric Conditions over the Oceans'.
- The work of the Kite Committee had continued and the indebtedness of the Society to Mr W.H.Dines and his two sons was fully . acknowledged. The British Association had granted £50 towards expenses for 1904 and a further £40 for 1905.
- With the exception of those in May and June, which had taken place in the Society's rooms, Meetings had been held as usual, by the courtesy of the President and Council of the Institution of Civil Engineers, at their house in Great George Street, Westminster.
- The Library now consisted of: 8420 volumes; 11,499 pamphlets; 210 maps and charts; 790 manuscripts; and 140 observations. The revision of the Catalogue was now being taken in hand, as opportunity occurred, but little progress had been made, as the Library work had grown to such an extent in recent years, owing to the preparation of the cards for the Bibliography, and for the International Catalogue of Scientific Literature, etc., that the time of the Librarian was fully occupied.
- An address on 'Meteorological Observing in the Antarctic Regions', illustrated by numerous lantern slides, had been given on 16 November 1904 by Lieut C.Royds, R.N., of the *Discovery*, who was in charge of the meteorological work of the National Antarctic Expedition.

NEW PUBLICATIONS BY HISTORY GROUP MEMBERS

JOHN WESLEY: travelling geographer
by Howard Oliver

Harris Manchester College, Oxford, 2015, 180 pp.
ISBN: 978-0-9555098-5-8
With an introductory chapter by Ralph Waller, Principal of Harris Manchester College, Oxford. Howard is a former Lecturer and Supernumerary Fellow of Harris Manchester College.



The illustration on the front cover of the book is of a page from John Wesley's diary for July 1733 and has been reproduced, with due acknowledgment, by courtesy of the Wesley Historical Society Library, Oxford Centre for Methodism and Church History, Oxford Brookes University, Oxford.

In the words on the inside of the front cover:

Although best known as a preacher and founder of Methodism, John Wesley travelled extensively and energetically throughout his career. He was actively interested in the places he visited and the country he travelled through, as well as the people he met. In his diaries and letters Wesley recorded detailed observations … He covered thousands of miles on horseback every year … Often journeys proved hazardous due to extreme weather, which he describes in graphic detail. From these writings, a picture emerges of environmental conditions as experienced by a perceptive and concerned traveller in the eighteenth century. John Wesley reveals himself to be a true geographer, and far more than just a theologian and preacher.

The book contains six chapters:

1. A portrait of the man and his times
2. Geographical publisher and traveller
3. Weather reporter
4. Physical geographer
5. Human geographer
6. Descriptive geographer

In addition, it contains acknowledgements, a bibliography and references, an index, and sources of quotations and illustrations.

A fascinating book. Highly recommended. Special price for members of the History Group: £10 per copy post free. Contact Howard Oliver via shol@waitrose.com.

JOHN WESLEY: travelling weather observer
by Howard Oliver

Royal Meteorological Society Occasional Paper No.15, June 2015, 46 pp. ISBN: 978-0-948090-39-4
Online at
http://www.rmets.org/sites/default/files/hist15.pdf

Howard hopes that as Wesley's comments often include precisely dated details of extreme weather events they will be of interest to those analysing historical meteorological information.

Wesley in the snow
(image in the occasional paper)

JANUARY 1809: synoptic meteorology of floods and storms over Britain
by David Pedgley

Royal Meteorological Society Occasional Paper No.16, July 2015, 77 pp. ISBN: 978-0-948090-40-0
Online at
http://www.rmets.org/sites/default/files/hist16.pdf

Towards the end of January 1809, severe and damaging floods affected large areas of Britain. This paper examines the extent, intensity and consequences of the floods, illustrated by newspaper reports (with their well-recognised drawbacks) which attributed them to a rapid thaw of lying snow. It then looks at the weather systems leading up to the floods, based on daily weather observations made at a network of land stations, supplemented by abundant Royal Navy ships' log-books. After starting as a simple enquiry into the weather leading to the collapse of a bridge at Wallingford, spanning the river Thames, this examination developed into a case study of synoptic meteorology from the early nineteenth century.

Fig.4 in the paper. Aquatint by Robert Howell the younger of Wallingford Bridge in 1810, illustrating an early stage of reconstruction.

THE TROUBLED STORY OF THE SUBTROPICAL JET STREAM

by Anders Persson

If you wish to discuss anything in this paper with the author, please contact Anders:
💻 **andersoscar.persson@gmail.com**

The forthcoming meeting in December about classical papers related to jet streams looks likely to be a very interesting one. Among the jet streams that will feature is the Subtropical Jet Stream (STJ) at about 30º latitude. It is the strongest wind system in the atmosphere, with speeds up to 100 m/s. Still, it does not figure as prominently in the literature as the Polar Front Jet. The American journal *Weatherwise* once called the STJ "the Cinderella among the jet streams" (Grenci, 1997) and it is, according to, e.g. Aksel Wiin-Nielsen and Chen (1993, 151*f*), not yet properly understood.

The question is not only to understand why there is an STJ at about 30º latitude but also why it disappears in the summer season and re-appears in the winter season. But the overriding problem is, as the renowned dynamical climatologist Dennis Hartmann (1994, 153) and many others have wondered: *Why isn't the STJ two to three times stronger?*

The attitude when the STJ was discovered during the Second World War was the opposite: *such strong winds are not possible*. Although Jack Bjerknes and Sverre Petterssen had predicted the existence of very strong winds aloft over Japan, the American bomber pilots did not believe them and were surprised when their aircrafts stalled in the strong counter current. The reports of very strong winds over Egypt in 1943, when Churchill was on his way to Teheran to meet Roosevelt and Stalin, were regarded as erroneous (Andrez Berson, personal communication 1994). This scepticism with respect to upper air observations from North Africa persisted well into the 1950s (Adrian Gordon, personal communication 1999).

I think it was only with the classical paper by Krishnamurti (1961) that the STJ became established in the meteorological community. However, the reason why the STJ still seems to be controversial goes a long way back in history – even before it was discovered.

When meteorologists today want to explain the STJ they tend to use *the law of angular momentum conservation*. Angular momentum is the tangential speed of an object multiplied by the distance to the centre of rotation. If there is no external forcing in the direction of rotation, the angular momentum stays constant. This is beautifully illustrated by the familiar rotating ice skater (Figure 1).

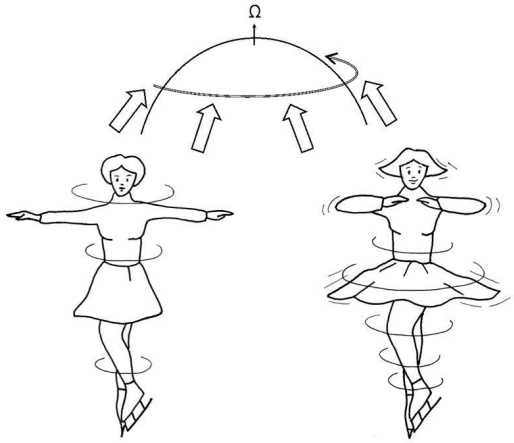


Figure 1: In the same way as the ice skater speeds up while making her arms converge, so do the westerlies, and in particular the STJ, speed up when the air from the tropics converge poleward.

One hundred years before the discovery of the STJ

This thought experiment, to consider air parcels displaced meridionally under frictionless conditions, has been quite popular in meteorology. It was first applied by George Hadley in his familiar 1735 Trade Wind Model. Here air parcels were moving poleward conserving their *absolute* speed. This model fairly well predicts the wind directions in the northern hemisphere (north-easterly trade winds in the tropics and south-westerly winds in mid-latitudes) but the wind speeds become unrealistically excessive. Air displaced from rest at 30ºN would on the arrival at the equator have attained a velocity of 62 m/s.

Hadley assumed that ground friction reduced the speed, a reasonable explanation. His model also seemed to apply for frictionless motion in the upper troposphere. What was called 'the anti-trade', air moving from the equator towards 30ºN at high altitudes was first a speculation. In the early 1800s, explorers to the tropics reported cirrus clouds drifting with quite considerable speeds from SW to NE, just as predicted by Hadley.

William Ferrel enters the scene

In the 1860s, William Ferrel showed that the correct principle was not conservation of absolute speed but conservation of angular momentum. When this

principle was applied, a crisis emerged, since the already rather excessive winds more or less *doubled*. The German meteorologist Neis (1946) found it "paradoxical" that when a physically erroneous principle was replaced by a correct principle the results became more unrealistic (Figure 2).

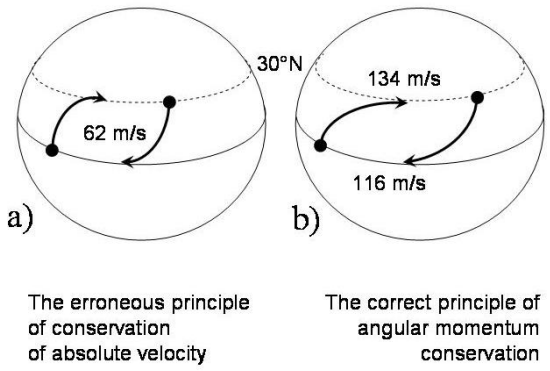


Figure 2: 'The angular momentum paradox'.

Left: An air parcel displaced between the equator and latitude 30º would, according to the inappropriate assumption of conservation of absolute velocity, produce a wind increase to 62 m/s.

Right: With the correct principle of conservation of absolute angular momentum the winds double in strength. Note that in the latter case the wind increase poleward is greater than equatorward.

Consequently, meteorologists have for the last 150 years been trying to solve this 'angular momentum paradox' and different explanations have been put forward (see Lorenz, 1967, pp. 59-78, for a full historical review).

Why do the excessive winds not occur?

The most common explanation, already suggested by Ferrel, was friction against the earth's surface. Although a plausible argument for near-surface flow, it cannot be applied to the free atmosphere where internal friction is small.

The German scientist Helmholtz suggested in the 1880s that vortices developed between different air masses, what we today call turbulent viscosity. But, considering the high speeds, the kinetic energy of these turbulent eddies would make aviation impossible.

It was also suggested that 'convective friction', large-scale convective cells, may hinder the acceleration of the winds. However, in the subtropical latitudes, where the difference between calculated and observed wind speeds start to become very large, there is not much convective activity.

The mathematical formalism used in turbulence theory was suggested by Defant in 1921 to provide a mechanism for export of excessive momentum out from the source regions. It was, however, criticised by Eady (1953,124-5) and Charney(1959,192) for being "unphysical". Lorenz (1991) held the opinion that "characterizing a phenomenon as turbulence does not explain the phenomenon as long as the properties of turbulence itself have not been fully explained [and] calling a phenomenon baroclinic instability does not fully explain it any more than would calling it turbulence".

Lorenz might have referred to the most common explanation today, found most prominently in James R. Holton's textbooks: the increasing west winds in the upper troposphere would produce an equally increasing thermal field, which at some stage would break down through baroclinic instability generating cyclones which would confine the Hadley Cell circulation to the subtropics (see, e.g., Holton and Hakim, 2012,15-17,343, Wallace, 2003).

This explanation was always given by words, never with any illuminating illustrations. When this finally was done the absurdity in the explanation became visible for everyone.

A scientific contradiction

In *Encyclopaedia of the Atmospheric Sciences* (Holton et al 2003), Jim Wallace, professor at the same university as Holton, was entrusted to explain the general circulation in general and the STJ in particular using Holton's favourite explanation. Wallace is a very pedagogically gifted meteorologist and took great care to make the readers really understand, so he put in a lot of illuminating figures in his text.

For copyright reasons it is not possible to show his illustrations, but I have drawn my own pictures which essentially show the same patterns. In Wallace's Figure 11d he arrives at a global flow pattern with westerlies and baroclinic vortices in the subtropics (Figure 3a next page).

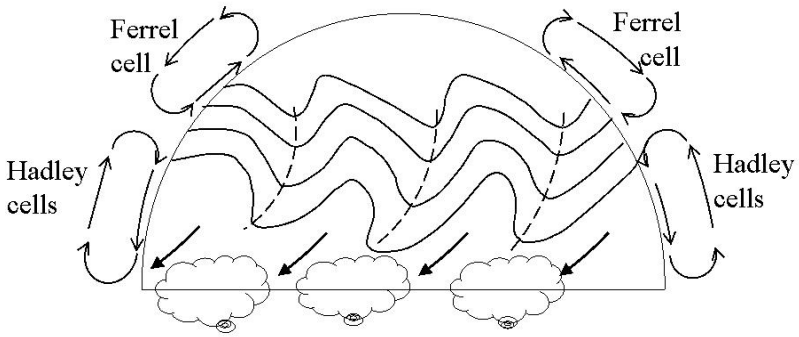


Figure 3a The schematic picture of the predicted general circulation (after Figure11 d in Wallace's article in the 'Encyclopedia') according to Holton's angular momentum conservation approach. The baroclinic westerlies are placed too far south by 20-30 latitude degrees, under a perceived sinking *motion.*

This is in stark conflict with the schematic description of the observed atmosphere in Figure 3 of the same article (Figure 3b below). Instead of baroclinic eddies at the subtropical latitudes, there are vigorous anticyclones.

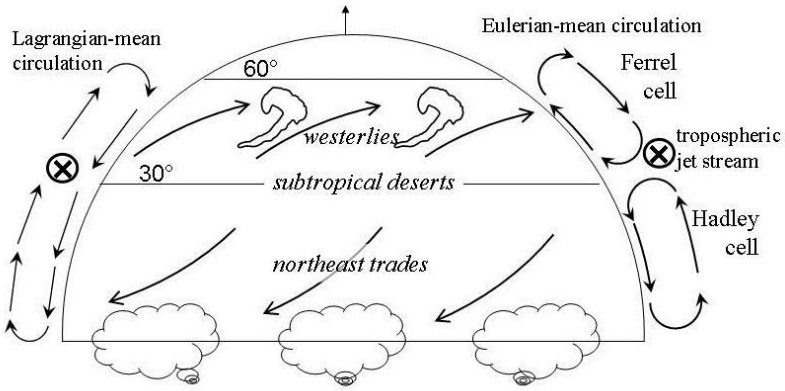


Figure 3b: A schematic picture of the observed general circulation (after Figure 3 on page 823 in Wallace's article in the 'Encyclopaedia'). The westerlies are correctly placed between 30 and 60º latitude under the rising branch of the so called 'Ferrel Cell' and the subtropical highs dominate around 30º latitude under the subtropical jet stream and descending air (After Figure 3 on page 823 in 'Encyclopaedia', 2004, which is identical to figure 1.15 in Wallace and Hobbs 2006).

However, in his own textbook (Wallace and Hobbs, 2006), published just after the *Encyclopedia*, there is a quite different explanation, not using angular momentum conservation, rather traditional concepts such as pressure gradient forces and the Coriolis Effect, very much along the same lines as I once presented in *Weather* (Persson, 2002).[21] This reasoning yields a flow pattern in good agreement with reality.

Scepticism against the 'angular momentum paradox

But early there were meteorologists, e.g. Teisserence de Bort, who in 1893 on observational and theoretical grounds, were sceptical about applying angular momentum conservation on the large scale flow. At a meeting at the Meteorological Office on 17 October 1921, the Director Sir Napier Shaw and other leading British meteorologists, among them David Brunt, reached the conclusion that ***there was no 'paradox', there were no excessive winds to explain, indeed there were no wind increases at all.*** The problem lay in the assumed physical condition under which the conservation of angular momentum was supposed to take place.[22]

The solution to the 'angular momentum paradox'

The solution came after Sir Napier Shaw at the meeting asking the simple but crucial question: – *What mechanism brings the air from one place to another, while it conserves angular momentum?*

The great advantage with conservation laws is that we do not necessarily have to be concerned about how the body under consideration moves from A to B conserving some property. *We have, however, to make sure that the motion is physically possible, what physical mechanisms are at work.*

In almost all meteorological texts, the answer to Sir Napier Shaw's question of *how* the ring of air (alternatively air parcel) has been displaced from one

[21] Professor Wallace visited the ECMWF around 2000 and we discussed dynamical pedagogical problems in dynamical meteorology. If it had any consequences for his later writings has not been possible to find out.

[22] The minutes of the meeting are kept in C.K.M. Douglas's archive in the National Meteorological Archive in Exeter. The meeting was conveyed to discuss two papers by the American meteorologists Clough and Marvin, who a year earlier had published papers in *Monthly Weather Review* with these conclusions. See also short note in *Meteorological Magazine* (1921).

latitude to another, has been quite similar: it has been assumed to 'drift', 'glide' 'move (freely)', 'be set in motion', 'be projected' or 'pushed'. All these words are expressions for some sort of *impulsive motion*.

Any material body set in motion by an impulsive force and then moving freely over the earth's surface with constant velocity V_r will not only conserve its absolute angular momentum but will also, as was well-known already in 1921, through the Coriolis Effect, follow an 'inertia circle trajectory' with a radius of curvature $\rho = V_r/f$ (the Coriolis parameter $f = 2\Omega\sin\phi$).

In the course of this circular motion the body would gradually turn from a meridional north-south direction into a latitudinal east-west direction. The increase 'from rest' to some very high eastward velocity is not an expression of any increase in the speed or kinetic energy, *just a consequence of the turning of motional direction.*

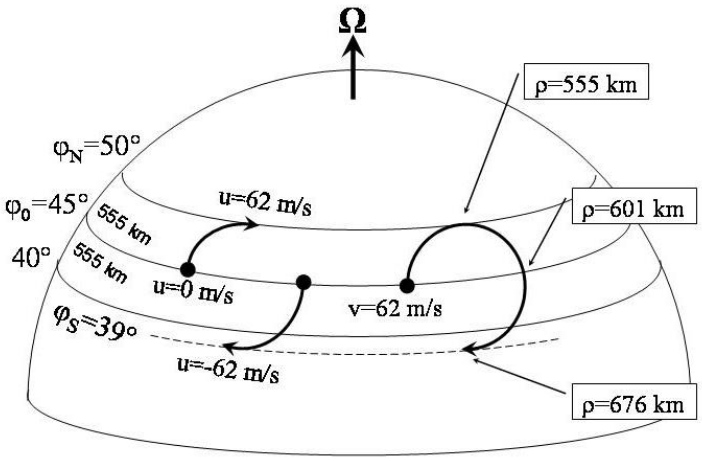


Figure 4: The frictionless motion of a material body displaced from 45ºN over a rotating planet can be understood in two ways. It can be seen (left) as an angular momentum conserving motion after having been given a meridional impetus of 62 m/s and, when the reaching its northernmost latitude at 50ºN, will have its zonal velocity increased from zero to 62 m/s, or (right) with the same impetus, by the Coriolis effect brought into an 'inertia circle' oscillation. Note that the motion is not symmetric around the original 45ºN latitude because of the latitudinal variation of the Coriolis parameter.

This curved motion will at higher latitudes describe near circular trajectories. In other words, in order to *enable* the air parcel or any material body to reach the 'intended' latitude it would have to been given a certain velocity by a strong meridionally directed 'push'.

The often quoted ring of air at rest at the equator reaching latitude 30º with an eastward speed of 134 m/s would have had to be 'pushed' poleward from the equator by exactly the same 134 m/s to reach its perceived destination. These are of course completely unrealistic scenarios. This was also stressed in all editions of David Brunt's textbook on dynamical meteorology (Brunt, 1944, 404-05).

> "It is frequently stated in meteorological treatises that if air moves from one latitude to another, retaining its original angular momentum (in space) about the earth's axis, then in its new latitude it will have enormous velocities along the circle of latitude. This statement is highly misleading".

The same conclusion was drawn by the German-Austrian meteorological communities which can be seen in the next edition of Hann-Süring (1926,202,234).

With no 'Angular Momentum Paradox' to worry about, British dynamic meteorologists could in the inter-war years concentrate on studies of the ageostrophic motion of the atmosphere which would result in a series of classical papers by Brunt, Douglas and in particular R.C.Sutcliffe.

The return of angular momentum conservation after the Second World War

Unaware of, or disregarding the objections to this use of angular momentum conservation, Carl Gustaf Rossby (1941), in a semi-popular publication, strongly promoted it to understand and analyse the large scale atmospheric flow. His views had a large impact on the meteorological community and initiated ambitious investigative projects by Victor Starr and Jack Bjerknes after the war.

But, after some years, Rossby had changed his mind and claimed that "the factors controlling the distribution of zonal motion must be of another character than the principle expressing the conservation of angular momentum". In 1949, he compared those who tried to understand the general circulation "through the incorporation, *ad hoc*, of additional wheels in the meridional circulation pattern" with medieval astronomers who added epicycles to the Ptolemaic system "to explain apparent complexities in the motions of the planets".

Perhaps encouraged by Rossby's views, a British meteorologist R.W.James tried in 1953 to create a

debate about the use of angular momentum conservation with a paper in the *Journal of Meteorology*, but in vain.

The politics of angular momentum conservation

During the 1990s, Rossby's former associate George W.Platzman used to visit London a week in autumn. I was then living in Reading and we used to meet, have a meal and discuss the history of meteorology. In 1997, I brought up the 'angular momentum paradox' and, among other things, mentioned James' paper. George Platzman said that the name "rang a bell" and that he would check in his archive when he came back to Chicago.

A week or so later, I got a letter from George. It contained copies of two letters from him to Werner A. Baum, the Editor of *Journal of Meteorology*, written in the autumn of 1953. They contained very severe criticism not only of James' paper but also the decision to publish it. Now, more than 40 years later, George was very embarrassed by their content.

In the first letter (27 November 1953), he wrote that he was "deeply disturbed" by James' article which was "so thoroughly incompetent and erroneous that its publication opens grave doubts as to the efficiency of the journal's editorial policy" and its publication was "a clear cut descent of the journal into the realms of charlatanism and pseudo-science". Only on the next page are we told what is wrong about James' paper. But the three points, although probably correct, do not appear to motivate *those* very harsh words.

Never mind, so far George Platzman's letter could just be seen as a normal, although over-heated, criticism of a controversial paper. What made George embarrassed in 1997 was the second letter (17 December 1953), which more or less ordered Baum to stop any further discussions:

> "Taking the case as it stands, I recommend that the journal should under no circumstances publish a rebuttal of James' paper in any form. In my opinion, the paper does not deserve even the formality of a rebuttal. I would hope that if we let the matter rest, it may soon be forgotten."

In 1997, George Platzman could not understand what had got into him in 1953. He remembered though that the two letters, although written by him, had been written under pressure from his superior at the time, Victor Starr, who was heavily involved in angular-momentum based investigations. But as far as one can judge, James was not the only one who had questions about angular momentum conservation; Rossby also had, as we have seen. In Germany the issue was followed with interest (Neis, 1956, 115).

Sixty years of no debate about angular momentum conservation?

Since the 1950s, nobody in the meteorological community has questioned the usefulness of angular momentum conservation to understand the large-scale motions of the atmosphere. Until his death in 1957, Rossby would maintain on several occasions (but diplomatically only in passing) that using angular momentum conservation merely led to 'statistical studies' and 'book keeping' which could not answer fundamental questions. Those who were critical kept silent and explained the atmospheric motions in other ways than with angular momentum, as had Bjerknes and Petterssen in the 1940s and Wallace in 2006.

I once asked Professor Aksel Wiin-Nielsen why he had never even mentioned 'angular momentum conservation' in his publications, not even in the educational material he produced when Director at WMO. *Well, he said, I never liked it!*

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DIFFERENT VIEWS OF THE TOWER OF THE WINDS IN ATHENS

Upper left: The Tower of the Winds in Athens was the emblem used by the Royal Meteorological Society for more than 100 years.
Lower left: The tower (from the south-west) as it appeared in March 1985.

The Tower of the Winds, or, to give it its proper title, the Horologium of Andronikos Kyrrhestes, was built about 40BC by the astronomer Andronikos of Kyrrhos. It was originally surmounted by a revolving bronze Triton holding a wand which pointed out the face of the building corresponding to the wind. But whereabouts in Athens is the tower? It is below the north side of the Acropolis, and just to the east of the Roman Agora. The picture bottom left shows a view down on the tower from the Acropolis. The picture bottom right shows the tower in relation to the Agora (with Mount Lykavittos – 277m – in the distance upper left).

Photographs by Malcolm Walker

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This is the last newsletter produced by Malcolm Walker. It is hoped that some form of newsletter will continue, but this is in the hands of the History Group's committee and the Royal Meteorological Society. All members of the Group will be kept informed.

Malcolm's contact details are as follows:

2 Eastwick Barton, Nomansland, Tiverton, EX16 8PP

metsochistorygroup@gmail.com