Curriculum Vitae: Michael Edgeworth McIntyre

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1941	Born 28 July, Sydney, Australia
1963	B.Sc.Hons. (1st class) in mathematics, University of Otago, New Zealand. (Robert Jack Prize, NZ Inst. of Chemistry Prize, Senior Scholarship in Science)
1963	Assistant Lecturer in Mathematics, University of Otago
1963–66	Commonwealth Scholar
1967	PhD in geophysical fluid dynamics, University of Cambridge. Supervisor: F.P. Bretherton. Thesis title: *Convection and baroclinic instability in rotating fluids*
1967	Summer postdoctoral fellow in geophysical fluid dynamics, Woods Hole Oceanographic Institution
1967–69	Postdoctoral research associate with J.G. Charney and N.A. Phillips, Dept. of Meteorology, Massachusetts Inst. of Technology
1969–72	Assistant Director of Research in Dynamical Meteorology, Dept. of Applied Mathematics & Theoretical Physics, University of Cambridge
1972–87	University Lecturer, same Department.
1987–93	Reader in Atmospheric Dynamics, same Department.
1993–2008	Professor of Atmospheric Dynamics, same Department.
2008–	Emeritus Professor, same Department.
1992–2003	Co-director, Cambridge Centre for Atmospheric Science

Main Honours

1968–71	Research Fellowship, St John's College, Cambridge
1981	Adams Prize, University of Cambridge
1984	Japan Society for the Promotion of Science, Senior Visiting Fellow
1985	Stewartson Memorial Lecturer, University College London
	Victor P. Starr Memorial Lecturer, M.I.T.
1987	Carl-Gustaf Rossby Research Medal (highest award of the American Meteorological Society)
1989–	Member of the Academia Europaea
1990–	Fellow of the Royal Society

1990–	Fellow of the American Meteorological Society
1991	Symons Memorial Lecturer of the Royal Meteorological Society
1992	Sectional Lecturer, IUTAM XVIIIth International Congress, Haifa
1992–97	SERC/Engineering and Physical Sciences Research Council Senior Research Fellow
1999	Julius Bartels Medal of the European Geophysical Society
1999–	Fellow of the American Association for the Advancement of Science
2018	Honorary Fellow of the Royal Meteorological Society
2024	Symons Gold Medal and Lecture of the Royal Meteorological Society

Additional invited lectures

(not counting solicited lectures to the European Geophysical Society/Union)

1978	Invited "Distinguished Foreign Scientist" to NSF Workshop on Atmospheric Chemistry, Boulder, Colorado.
1976–	Various invited lectures to symposia of the American Meteorological Society, IUGG/ IAMAP, EGS, NASA-Langley, etc.
1990	Invited lectures on fundamentals of atmospheric dynamics to the International School of Physics "Enrico Fermi" (published in 1992)
1992	ICSU/WMO Beijing Symposium on Tropical Cyclone Disasters (in connection with the UN International Decade for Natural Disaster Reduction.)
1994	Keynote Lecturer opening the inaugural Workshop on Stratospheric Ozone, Cooperative Research Centre for Southern Hemispheric Meteorology, Melbourne, Australia, September 1994.
1994	Keynote Lecturer opening the Sixth Annual BMRC Workshop on Numerical Weather Prediction, Data Assimilation in Meteorology and Oceanography, Melbourne, Australia, October 1994.
1994	Invited lecture to the Royal Society Discussion Meeting on the Arctic and Environmental Change, London, October 1994.
1994	Invited Union Symposium Lecture, American Geophysical Union Fall Meeting, San Francisco, December 1994.
1995	Invited lecture, European Geophysical Society XVIII General Assembly, Hamburg, April 1995.
1995	Invited lecture to EUROMECH 339: Internal waves, turbulence and mixing in stratified fluids, École Normale Supérieure de Lyon, France.
1995	Invited opening lecture, All-Union Symposium on 'Dynamic Complexity', IUGG XXI General Assembly, Boulder, Colorado
1996	Invited lecture to the International Symposium on Theoretical and Computational Fluid Dynamics (Lighthill Festschrift Symposium), Tallahassee, Florida.

1997 Invited lecture to the 12th Nishinomiya–Yukawa Memorial Symposium, on 'Dynamic Organization of Fluctuations — molecular machines, powder flows, and fluid turbulence', Nishinomiya, Japan, November 1997.

1997 Invited lecture to open the seminar series after the launch of Japan's Frontier Research System: 'What has the stratospheric surf zone got to do with wind-generated water waves?' Tokyo, Japan, November 1997.

1999 Two invited lectures, European Geophysical Society XXIV General Assembly, The Hague, April 1999.

1999 Invited Symposium Lecture (1 of 3 keynote lectures), 14th European Space Agency Symposium on Rocket and Balloon Programmes and Related Research, Potsdam, Germany, May–June 1999

1999 Two invited lectures, IUGG Birmingham (XXII General Assembly), July 1999.

1999 Invited lecture to Cambridge–Edinburgh Workshop on Musical Perception and Cognition, July 1999.

1999 Invited keynote lecture to the 4th Symposium on Human Development, *Networking of Human Intelligence: Its Possibility and Strategy* held in Kobe, Japan, on 4 December 1999, under the auspices of the Research Center for Human Science, Faculty of Human Development, Kobe University, December 1999. [Invitation arising from the *Lucidity and Science* essays.]

2000 Invited keynote lecture, IUTAM/IUGG/Royal Irish Academy Symposium on Advances in Mathematical Modelling of Atmosphere and Ocean Dynamics, Limerick, Ireland, 3–7July 2000.

2000 Invited lecture to 'Meteorology at the Millennium', 150th Anniversary Symposium of the Royal Meteorological Society, a major international conference at St John's College, Cambridge, 10–14 July 2000.

2000 Invited lecture to the 33rd COSPAR Scientific Assembly (ICSU Committee on Space Research), Warsaw, 16–23 July 2000.

2000 Three invited lectures as H. Burr Steinbach Visiting Scholar to the Woods Hole Oceanographic Institution, 8–11 August 2000.

2000 Invited lecture to the symposium in honour of J. D. Mahlman, 'Understanding the Stratosphere: Challenges and Opportunities', Princeton University, 11 September 2000

2001 Invited Plenary Lecture to the symposium on 'Wave Phenomena III: Waves in fluids from the microscopic to the planetary scale', at the Pacific Institute for the Mathematical Sciences, University of Alberta, Edmonton, Canada, 11–15 June 2001.

2001 Invited lecture to the D. O. Gough Festschrift Symposium on 'New Developments in Astrophysical Fluid Dynamics', Caussens, France, 25–29 June 2001.

2002 Two invited lectures as Philip D. Thompson Lecturer to the Advanced Study Program, National Center for Atmospheric Research, Boulder, Colorado, 25–27 September 2002.

2004 Invited lecture to the Isaac Newton Institute's Workshop on 'The Solar Tachocline', Cambridge, UK, 8–12 November 2004.

2005 Invited lecture to the Edward Lorenz Symposium of the American Meteorological Society, San Diego, Calif., 13 January 2005.

2005 Five invited lectures as Reginald and Muriel Noble Lecturer to the Department of Physics, University of Toronto, 11–15 April 2005.

2006 Invited lecture to the American Geophysical Union's Chapman Conference on 'Jets and Annular Structures in Geophysical Fluids', Savannah, Georgia, 9–12 January 2006.

2006 Invited lecture to the Workshop on Spontaneous Imbalance, Seattle, 7–10 August 2006.

2006 Invited lecture 'Music and Mathematics – the deepest connections', to the Cambridge Music Festival, 17 November 2006. (Also shorter version, 3 September 2006, in the John Innes Centre, Norwich, as part of Chamber Orchestra Anglia's opening event hosted by Radio 3's Christopher Cook in the British Association's Science Festival.)

2007 Invited lecture 'On thinking probabilistically', to the 15th 'Aha Huliko'a Winter Workshop held at the East–West Center in Honolulu, Hawaii, 23–26 January 2007. Reprint available at www.damtp.cam.ac.uk/user/mem/#thinking-probabilistically

2007 Seminar on 'Magnetic confinement in the solar interior' to the Dipartmento di Fisica "Enrico Fermi", Università di Pisa, Italy, 10 July 2007, at the invitation of Professor Steven N. Shore.

2007 Invited lecture on fundamental aspects of probability and statistics, to the American Geophysical Union's Chapman Conf. on 'Stratosphere–Troposphere coupling', Santorini, Greece, 24–28 Sept. 2007. See www.damtp.cam.ac.uk/user/mem/#thinking-probabilistically

2008 Invited lecture 'Climate Change and the Ozone Layer' to the Royal Geographical Society, 20 February 2008.

2009 Marshall Rosenbluth Memorial Lecture on 'The atmospheric wave–turbulence jigsaw', opening lecture of the 5th Festival de Théorie on *Rotation and Momentum Transport in Magnetised Plasmas* held at Aix-en-Provence, France, July 2009.

2012 Invited guest lecture 'On the atmospheric wave-turbulence jigsaw, and why terrestrial jets are unlike Jupiter's jets' at the Cambridge Summer School on Fluid Dynamics of Sustainability and the Environment, 18 September 2012.

2013 Bernhard Haurwitz Memorial Lecture to the American Meteorological Society, 'A tale of two paradigms, with remarks on unconscious assumptions', 19 June 2013.

2016 TEDx talk on 'Science, the arts, and lucidity principles', TEDxCambridgeUniversity, 13 February 2016. Available at https://www.youtube.com/watch?v=ZIsswDmQ66U (with garbled caption).

2016 Invited public lecture on 'What has the Antarctic ozone hole to do with biological evolution?' at the conference for Young Researchers in Mathematics at the University of St Andrews, 2 August 2016.

2016 Invited keynote fluid-dynamics lecture 'Jetstreams, vortices and the Antarctic ozone hole' at the conference for Young Researchers in Mathematics at the University of St Andrews, 3 August 2016.

2016 Invited lecture 'On multi-level thinking and scientific understanding' at the Duzheng Ye Centenary Symposium: From General Circulation to Global Change, Second Congress of China Geodesy and Geophysics, Nanjing, China, 23 September 2016.

2018 Lecture on 'The solar tachocline: a big open question', given at the John Papaloizou 70th birthday conference on Planets, Stars and Discs: A Golden Age for Particle and Gas Dynamics, Oxford, July 9-13 2018.

2024 Invited lecture 'On missing gravity-wave forces, and scientific understanding', Symons Gold Medal lecture to the Royal Meteorological Society, 15 May 2024.

Cambridge Summer School in Geophysical and Environmental Fluid Dynamics

I gave the core lectures on 'Fundamental concepts and processes' every September from 1991 to 2006, alongside other core and invited lectures. For each of those sixteen years, until it was shut down by the funding authorities, the Summer School ran for two weeks and provided a total-immersion experience for the lecturers and for about 70 young researchers from the atmospheric, oceanic and earth sciences. About half of the young researchers came from the UK and the rest from the international research community abroad. Something of the flavour of my lectures can be found via http://www.damtp.cam.ac.uk/user/mem/gefd-supplem-material.html

Miscellaneous international administrative or consultative

1969–80 Editorial board, Journal of Fluid Mechanics

1970–80 Member U.K. Universities' Atmospheric Modelling Group Panel

1971–74 Member synoptic and dynamical meteorological research subcommittee, U.K. Met Office.

1976–80 Member New Violin Family Steering Committee, Royal College of Music, London

1978–83 Vice-President, Catgut Acoustical Society

1979–89 IUGG/IAMAP International Commission for Meteorology of the Upper Atmosphere

1981–85 Consultant, Topexpress Ltd, Cambridge

1985–7 Member Theory Group, Anglo-French Mesoscale Frontal Dynamics Project.

1985–6 Coordinator, Cambridge atmospheric chemistry and dynamics initiative

1987–90 Joint Principal Investigator, UK Universities' Global Atmospheric Modelling Project (and lead author of original proposal)

1987–8 Invited Reviewer for NASA/WMO Ozone Trends Panel.

1987–2002 Senior Consultant, Science and Technology Corporation, Hampton, Virginia.

1988–89 Member IUGG/IAMAP/ICMUA Working Group on Numerical Modelling of the Middle Atmosphere.

1988–2002 Co-investigator, Oxford/NCAR High Resolution Dynamics Limb Sounder Project, for NASA Earth Observing System.

1988–2002 Co-investigator, Interdisciplinary Proposal for NASA Earth Observing System, on Chemical, Dynamical and Radiative Interactions through the Middle Atmosphere and Thermosphere.

1988–90 Member Theory Team, Airborne Arctic Stratospheric Expedition (NASA/NOAA/DoE).

1989–94 Member Atmospheric Sciences Committee, Natural Environment Research Council.

1990–2002 Member Scientific Steering Group, UK Universities' Global Atmospheric Modelling Programme, Natural Environment Research Council.

1990–2002 Project Scientist, UK Universities' Global Atmospheric Modelling Programme, Natural Environment Research Council.

1990–91 Member IUTAM/IUGG/ICSU Vienna Workshop on Tropical Cyclone Disasters reporting to the ICSU Special Committee for the UN International Decade for Natural Disaster Reduction

1991–2002 Senior Consultant, Jet Propulsion Laboratory, Pasadena, California

1992–2008 Scientific steering committee, Cambridge Centre for Atmospheric Science (co-director 1992–2003)

1992–2002 Scientific steering committee, STRATEOLE experiment (quasi-Lagrangian tracers in the Antarctic stratospheric vortex)

1994 Co-author, UNEP/WMO Scientific Assessment of Stratospheric Ozone.

1994–2002 Gravity Wave Committee of the World Climate Research Programme Project on Stratospheric Processes and their Role in Climate (SPARC)

1995–96 Stratosphere–Troposphere Exchange Committee of the World Climate Research Programme Project on Stratospheric Processes and their Role in Climate (SPARC)

1995–97 Scientific Advisory Committee and Organizing Committee, Isaac Newton Institute Programme on the Mathematics of Atmosphere and Ocean Dynamics

1996–99 Sectional Committee 5, Royal Society

Publications, complete list (M. E. McIntyre)

Updates, *corrigenda*, and pdfs of selected papers are available on the Internet at
http://www.damtp.cam.ac.uk/user/mem/

The asterisks mark what I regard as the most important publications, and the daggers denote invited papers, including review/forward-look papers.

1965 [1] A separable nongeostrophic baroclinic stability problem. *J. Atmos. Sci.* **22**, 730–731.

1968 *[2] The axisymmetric convective regime for a rigidly bounded rotating annulus. *J. Fluid Mech.,* **32**, 625–655.

[3] On stationary topography-induced Rossby-wave patterns in a barotropic zonal current. *Deutsche Hydrographischen Zeitschrift,* **21**, 203–214.

1970 [4] Diffusive destabilisation of the baroclinic circular vortex. *Geophysical Fluid Dynamics,* **1**, 19–57.

*[5] Role of diffusive overturning in nonlinear axisymmetric convection in a differentially heated rotating annulus. *Geophysical Fluid Dynamics,* **1**, 59–89.

*[6] On the non-separable baroclinic parallel flow instability problem. *J. Fluid. Mech.,* **40**, 273–306.

1972 [7] Baroclinic stability of an idealized model of the polar night jet. *Quart. J. R. Met. Soc.,* **98**, 165–175.

*[8] On Long's hypothesis of no upstream influence in uniformly stratified or rotating flow. *J. Fluid Mech.,* **52**, 209–243.

1973 *[9] Mean motions and impulse of a guided internal gravity wave packet. *J. Fluid Mech.,* **60**, 801–811.

1974 [10] Toward a psychoacoustically realistic violin physics (with J. Woodhouse). *Catg. Acoust. Soc. Newsl.,* **22**, 18–19.

1976 *[11] Planetary waves in horizontal and vertical shear: the generalized Eliassen-Palm relation and the mean zonal acceleration (with D. G. Andrews). *J. Atmos. Sci.,* **33**, 2031–2048.

[12] Planetary waves in horizontal and vertical shear: asymptotic theory for equatorial waves in weak shear (with D. G. Andrews). *J. Atmos. Sci.,* **33**, 2049–2053.

[13] Note on the proposal by Isaacs et al. concerning the causes of tornadoes (with B. R. Morton and R. K. Smith). *Nature,* **260**, 457.

1977 †[14] Wave transport in stratified, rotating fluids. *Springer Lecture Notes in Physics,* **71**, 290–314 (ed. E. A. Spiegel and J. P. Zahn) (Invited).

[15] New results on the bowed string (with R. T. Schumacher and J. Woodhouse). *Catg. Acoust. Soc. Newsl.,* **28**, 27–31.

1978 *[16] Generalized Eliassen-Palm and Charney-Drazin theorems for waves on axisymmetric mean flows in compressible atmospheres (with D. G. Andrews). *J. Atmos. Sci.,* **35**, 175–185.

[17] The influence of geometry on linear damping (with J. Woodhouse). *Acustica,* **39**, 209–224.

†[18] The acoustics of stringed musical instruments (with J. Woodhouse). *Interdisciplinary Science Reviews,* **3**, 157–173 (Invited).

*[19] An exact theory of nonlinear waves on a Lagrangian-mean flow (with D. G. Andrews). *J. Fluid Mech.,* **89**, 609–646.

*[20] On wave-action and its relatives (with D. G. Andrews). *J. Fluid Mech.,* **89**, 647–664 (Corrigendum **95**, 796).

*[21] On radiating instabilities and resonant over-reflection (with M. A. Weissman). *J. Atmos. Sci.,* **35**, 1190–1196.

1979 [22] On the fundamentals of bowed-string dynamics (with J. Woodhouse). *Acustica,* **43**, 93–108.

1980 [23] On whether inertio-gravity waves are absorbed or reflected when their intrinsic frequency is doppler-shifted towards f (with E. H. Kitchen). *J. Meteorol. Soc. Japan,* **58**, 118–126.

†[24] An introduction to the generalized Lagrangian-mean theory of wave, mean-flow interaction. *Pure Appl. Geophys.,* **118**, 152–176 (Invited paper for special Middle Atmosphere issue).

*[25] Eliassen-Palm cross-sections for the troposphere (with H. J. Edmon, Jr. and B. J. Hoskins). *J. Atmos. Sci.,* **37**, 2600–2616 (Corrigendum **38**, 1115).

*†[26] Towards a Lagrangian-mean description of stratospheric circulations and chemical transports. *Phil. Trans. Roy. Soc.* **A 296**, 129–148 (Invited paper for special Middle Atmosphere issue).

1981 *[27] Some Eulerian and Lagrangian diagnostics for a model stratospheric warming (with T. Dunkerton and C.-P. Hsu). *J. Atmos. Sci.,* **38**, 819–843.

†[28] On the "wave momentum" myth. *J. Fluid Mech.,* **106**, 331–347 (Invited paper for the Special Editors' Issue).

[29] On potential energy density in an incompressible, stratified fluid (with D. Holliday). *J. Fluid Mech.,* **107**, 221–225.

[30] Aperiodicity in bowed-string motion (with R. T. Schumacher and J. Woodhouse) *Acustica,* **49**, 13–32. See also **50**, 294–295.

[31] The bowed string (with J. Woodhouse). *J. Inst. Musical Instrum. Technology,* **4**, 30–37.

1982 [32] Aperiodicity in bowed-string motion: on the differential-slipping mechanism (with R. T. Schumacher and J. Woodhouse). *Acustica,* **50**, 294–295.

*†[33] How well do we understand the dynamics of stratospheric warmings? *J. Meteorol. Soc. Japan,* **60**, 37–65 (Invited paper for Special Centennial Issue).

1983 *[34] Breaking planetary waves in the stratosphere (Article with T. N. Palmer). *Nature,* **305**, 593–600.

*†[35] On the oscillations of musical instruments (with R. T. Schumacher and J. Woodhouse). *J. Acoust. Soc. Amer.,* **74**, 1325–1345 (Invited review).

1984 *[36] The 'surf zone' in the stratosphere (with T. N. Palmer) *J. Atmos. Terrest. Phys.,* **46**, 825–849.

[37] A parametric study of the bowed string: the violinist's menagerie (with J. Woodhouse). *J. Catg. Acoust. Soc.,* **42**, 18–21.

[38] On measuring wood properties, part 1 (with J. Woodhouse). *J. Catg. Acoust. Soc.,* **42**, 11–15.

1985 *[39] Do Rossby-wave critical layers absorb, reflect, or over-reflect? (with P. D. Killworth) *J. Fluid Mech.,* **161**, 449–492.

*†[40] On the use and significance of isentropic potential-vorticity maps (with B. J. Hoskins and A. W. Robertson). *Quart. J. Roy. Meteorol. Soc.,* **111**, 877–946 (Corrigendum, etc., **113**, 402–404).

*[41] A note on the general concept of wave breaking for Rossby and gravity waves (with T. N. Palmer). *Pure Appl. Geophys.,* **123**, 964–975.

[42] On measuring wood properties, part 2 (with J. Woodhouse). *J. Catg. Acoust. Soc.,* **43**, 18–24.

1986 [43] On measuring wood properties, part 3 (with J. Woodhouse). *J. Catg. Acoust. Soc.,* **45**, 14–23.

1987 *[44] An exact local conservation theorem for finite-amplitude disturbances to non-parallel shear flows, with remarks on Hamiltonian structure and on Arnol'd's stability theorems (with T. G. Shepherd). *J. Fluid Mech.,* **181**, 527–565.

[45] Friction and the bowed string (with J. Woodhouse). *Wear,* **113**, 175–182.

[46] On the evolution of vorticity and potential vorticity in the presence of diabatic heating and frictional or other forces (with P. H. Haynes). *J. Atmos. Sci.,* **44**, 828–841.

*[47] On the representation of Rossby-wave critical layers and wave breaking in zonally truncated models (with P. H. Haynes). *J. Atmos. Sci.,* **44**, 2359–2382.

†[48] Dynamics and tracer transport in the middle atmosphere: an overview of some recent developments. In: *Transport Processes in the Middle Atmosphere*, ed. G. Visconti & R. R. Garcia, pp 267–296, Dordrecht, Reidel (Invited paper to NATO Workshop held in November 1986 at Erice, Sicily).

*[49] A high-resolution, one-layer model of breaking planetary waves in the stratosphere (with M. N. Juckes). *Nature,* **328**, 590–596.

1988 [50] A note on the divergence effect and the Lagrangian-mean surface elevation in periodic water waves. *J. Fluid Mech.,* **189**, 235–242.

[51] On measuring the elastic and damping constants of orthotropic sheet materials (with J. Woodhouse). *Acta Metallurgica,* **36**, 1397–1416.

†[52] The dynamical significance of isentropic distributions of potential vorticity and low-level distributions of potential temperature. Invited review for ECMWF Seminar *The Nature and Prediction of Extratropical Weather Systems,* 7–11 September 1987, pp. 237–259. Obtainable from Librarian, European Centre for Medium Range Weather Forecasts, Shinfield Park, Reading RG2 9AX, U. K.

†[53] The use of potential vorticity and low-level temperature/moisture to understand extratropical cyclogenesis. *Ibid.,* pp. 261–280.

[54] Numerical weather prediction: a vision of the future. *Weather,* **43**, 294–298.

1989 †[55] On the Antarctic ozone hole. *J. Atmos. Terrest. Phys.,* **51**, 29–43 (IUGG Symposium Invited Paper).

*†[56] On dynamics and transport near the polar mesopause in summer. *J. Geophys. Res.,* **94**, 14617–14628 (Invited paper for the International Workshop on Noctilucent Clouds. Includes a simple thought-experiment to expose the limitations of the Ellison–Britter–Osborn vertical mixing formula, relating vertical eddy diffusivity to Kolmogorov dissipation).

1990 *†[57] Dissipative wave-mean interactions and the transport of vorticity or potential vorticity (with W. A. Norton). *J. Fluid Mech.,* **212**, 403–435; Corrigendum **220**, 693 (Invited paper for G. K. Batchelor Festschrift Issue).

†[58] Nonlinear vorticity or potential vorticity inversion (with W. A. Norton). In: *Topological Fluid Mechanics*, ed. H. K. Moffatt and A. Tsinober; Cambridge University Press, 355–358.

*[59] On the conservation and impermeability theorems for potential vorticity (with P. H. Haynes). *J. Atmos. Sci.,* **47**, 2021–2031.

[60] Does contour dynamics go singular? (with D. G. Dritschel). *Phys. Fluids,* **A 2**, 748–753.

*†[61] Middle atmospheric dynamics and transport: some current challenges to our understanding. In: *Dynamics, Transport and Photochemistry in the Middle Atmosphere of the Southern Hemisphere* (Proc. San Francisco NATO Workshop), ed. A. O'Neill, 1–18. Dordrecht, Kluwer (Invited paper).

†[62] What will it take to model stratospheric ozone depletion? *Bull. Inst. Maths. Applics.*, **26**, 214–224 (Invited paper).

1991 *[63] On the downward control of extratropical diabatic circulations by eddy-induced mean zonal forces (with P. H. Haynes, C. J. Marks, K. P. Shine, and T. G. Shepherd). *J. Atmos. Sci.,* **48**, 651–678.

1992 †[64] Atmospheric dynamics: some fundamentals, with observational implications. Proc. Internat. School Phys. "Enrico Fermi", CXV Course, *The Use of EOS for Studies of Atmospheric Physics,* ed. J. C. Gille and G. Visconti. Amsterdam, North Holland (Invited review), 313–386.

1993 *[65] Two paradigms for baroclinic-wave life cycle behaviour (with B. J. Hoskins and C. D. Thorncroft). *Q. J. Roy. Meteorol. Soc.,* **119**, 17–55.

*†[66] On the role of wave propagation and wave breaking in atmosphere–ocean dynamics. Sectional Lecture, Proc. XVIII In: *Theoretical and Applied Mechanics 1992* (Int. Congr. Theor. Appl. Mech., Haifa), ed. S. R. Bodner, J. Singer, A. Solan, and Z. Hashin, Elsevier/North-Holland, 281–304.

[67] Isentropic distributions of potential vorticity and their relevance to tropical cyclone dynamics ICSU/WMO International Symposium on Tropical Cyclone Disasters, ed. J. Lighthill and Zheng Zhemin. Beijing, China, University of Beijing Press, 143–156.

[68] Model studies of dynamics, chemistry and transport in the Antarctic and Arctic stratospheres (with J. A. Pyle). In: *University Research in Antarctica, 1989–92*, Vol. **2**, ed. R. B. Heywood. Cambridge, British Antarctic Survey (ISBN 0 85665 161 3), 17–34. (Major review of early work at the Cambridge Centre for Atmospheric Science.)

1994 *†[69] The quasi-biennial oscillation (QBO): some points about the terrestrial QBO and the possibility of related phenomena in the solar interior. In: *The Solar Engine and its Influence on Terrestrial Atmosphere and Climate* (Proc. NATO Adv. Res. Workshop ARW 920946, Paris, October 1993), NATO ASI Series I on Global Environmental Change (3-540-58417-X, I/**25**), ed. E. Nesme-Ribes, Heidelberg, Springer-Verlag, 293–320. (This was the first publication to point out that layerwise-two-dimensional turbulence cannot explain the structure of the solar tachocline, implying that an interior magnetic field is not merely possible but inevitable.)

†[70] Numerical weather prediction: an updated vision of the future. In: *The Life Cycles of Extratropical Cyclones* (Proc. Internat. Symp., Bergen, 27 June – 1 July 1994), ed. S. Grønås and M. A. Shapiro; 275–286. Bergen, Norway, University of Bergen (ISBN 82-419-0144-5).

[71] Further notes on lucid writing, pattern perception, and scientific thinking. Supplement to 'Lucidity and science....' (see below), plain TEX file available on the Internet via http://www.damtp.cam.ac.uk/user/mem/papers/LHCE/lucidity-principles-in-brief.html then "draft-repair toolkit" (23 pages of smallish print). Also provided are demonstrations of relevant visual and auditory perceptual phenomena.

1995 †[72] Atmospheric processes responsible for the observed changes in ozone. Chapter 4: Tropical and midlatitude ozone (with R. L. Jones and others). In: NOAA/ NASA/UNEP/ /WMO *Scientific Assessment of Ozone Depletion: 1994* (World Meteorological Organization Global Ozone Research and Monitoring Project, Report No. 37), ed. D. L. Albritton, R. T. Watson, and P. J. Aucamp, 1995: Geneva, World Meteorological Organisation, pp. 4.1–4.38.

†[73] The stratospheric polar vortex and sub-vortex: fluid dynamics and midlatitude ozone loss. *Phil. Trans. Roy. Soc. London.,* **352**, 227–240 (invited paper for the Royal Society Discussion Meeting on the Arctic and Environmental Change, London, edited by A. N. Schofield and P. Wadhams).

*[74] Stratosphere-troposphere exchange (major review with J. R. Holton, P. H. Haynes, A. R. Douglass, R. B. Rood, L. Pfister). *Revs. Geophys. Space Phys.,* **33**, 403–439.

1996 *[75] An atmospheric tape recorder: the imprint of tropical tropopause temperatures on stratospheric water vapor (with P. W. Mote, K. H. Rosenlof, E. S. Carr, J. C. Gille, J. R. Holton, J. S. Kinnersley, H. C. Pumphrey, J. M. Russell III, J. W. Waters). *J. Geophys. Res.,* **101**, 3989–4006.

*[76] Reply to Comments by J. Egger on 'On the "downward control" of extratropical diabatic circulations by eddy-induced mean zonal forces' (with P. H. Haynes and T. G. Shepherd). *J. Atmos. Sci.,* **53**, 2105–2107. (An important opportunity to dispel confusion in the wider community about a very basic causal linkage.)

[77] On the propagation and dissipation of a spectrum of gravity waves through a realistic middle atmosphere (with C. D. Warner). *J. Atmos. Sci.,* **53**, 3213–3235.

1997 [78] Gravity wave spectral models and the shapes of gravity wave spectra at low vertical wavenumber. (with C. D. Warner). In: *Gravity Wave Processes and Their Parameterization in Global Climate Models*, ed. K. P. Hamilton, 217–226; Heidelberg, Springer-Verlag, NATO ASI Series **I 50** (Series I, Global Environmental Change, Vol. **50**), ISBN 3-540-62036-2.

*[79] Numerical advection schemes, cross-isentropic random walks, and correlations between chemical species (with J. Thuburn). *J. Geophys. Res.,* **102**, 6775–6798. (Finally clarifies the generalized Taylor-dispersion or vertical-random-walk idea for the stratosphere, generalizing Mahlman/Holton/Plumb–Ko.)

[80] On Doppler-spreading models of internal waves (with D. Broutman, C. Macaskill, and J. W. Rottman). Proc. 11th Amer. Meteorol. Soc. Conf. on Atmospheric and Oceanic Fluid Dynamics (formerly Waves and Stability), Tacoma, WA. Boston, Amer. Meteorol. Soc.

*[81] Lucidity and science I: Writing skills and the pattern perception hypothesis. *Interdisciplinary Science Reviews*, **22**, 199–216. Extensive supplementary material is available at http://www.damtp.cam.ac.uk/user/mem/ including animated graphics.

*[82] Lucidity and science II: From acausality illusions and free will to final theories, mathematics, and music. *Interdisciplinary Science Reviews*, **22**, 285–303. Extensive supplementary material is available at http://www.damtp.cam.ac.uk/user/mem/ including animated graphics and audio. (The ideas I am trying to disseminate here might, in the long term, help to make a real difference to the public understanding of science and to scientists' understanding of science.)

*[83] Diabatic cross-isentropic dispersion in the lower stratosphere (with L. C. Sparling, J. A. Kettleborough, P. H. Haynes, J. E. Rosenfield, M. R. Schoeberl, and P. A. Newman). *J. Geophys. Res.,* **102**, 25817–25829.

[84] On Doppler-spreading models of internal waves (with D. Broutman, C. Macaskill and J. W. Rottman). *Geophys. Res. Lett.,* **24**, 2813–2816.

1998 [85] On non-dissipative wave–mean interactions in the atmosphere or oceans (with O. Bühler). *J. Fluid Mech.,* **354**, 301–343.

*[86] Coupled Kelvin-wave and mirage-wave instabilities in semi-geostrophic dynamics (with P. J. Kushner and T. G. Shepherd). *J. Phys. Oc.,* **28**, 513–518. (This contains perhaps the first example of what are now called strato-rotational instabilities, extensively studied in recent years.)

†[87] Balanced atmosphere–ocean dynamics, generalized Lighthill radiation, and the slow quasi-manifold. *Theoret. Comp. Fluid Dyn.,* **10**, 263–276. (Invited paper from the International Symposium on Theoretical and Computational Fluid Dynamics held in Tallahassee, Florida, November 1996 in honour of Sir James Lighthill. Corrected and superseded by papers [107] and [127] below.)

†[88] On anomalous meridional circulations and Eliassen–Palm flux divergences in an idealized model of dissipating, non-breaking Rossby waves (with R. Mo). *Dyn. Atmos. Oc.,* **27**, 575–600; *Corrigendum*, **28**, 229–230. (Invited paper for Special Issue in honour of Richard Pfeffer.)

*[89] Lucidity and science III: Hypercredulity, quantum mechanics, and scientific truth. *Interdisciplinary Science Reviews*, **23**, 29–70; *Corrigendum* **23**, 316, more accurately at http://www.damtp.cam.ac.uk/user/mem/papers/LHCE/corrigendum.html with supplementary material via http://www.damtp.cam.ac.uk/user/mem/ including electronic re-publication of the article in its entirety by Charlesworth; go via http://www.damtp.cam.ac.uk/user/mem/papers/LHCE/abstract.html

*[90] Vertical velocity, vertical diffusion, and dilution by midlatitude air in the tropical lower stratosphere (with T. J. Dunkerton, P. H. Haynes, P. W. Mote, and E. A. Ray). *J. Geophys. Res.*, **103**, 8651–8666. (This is the definitive paper on the stratospheric 'tape recorder'.)

*[91] Inevitability of a magnetic field in the Sun's radiative interior (with D. O. Gough). *Nature*, **394**, 755–757.

†[92] Breaking waves and global-scale chemical transport in the Earth's atmosphere, with spinoffs for the Sun's interior. *Prog. Theoret. Phys.,* Supplem. No. **130**, 137–166; *Corrigendum*, *Prog. Theoret. Phys.,* **101**, 189. (Invited paper to the 12th Nishinomiya–Yukawa Memorial Symposium, on 'Dynamic Organization of Fluctuations — molecular machines, powder flows, and fluid turbulence'.)

*[93] Permeability of the stratospheric vortex edge: on the mean mass flux due to thermally dissipating, steady, non-breaking Rossby waves (with O. Bühler and R. Mo). *Quart. J. Roy. Meteorol. Soc.*, **124**, 2129–2148.

1999 [94] On the connection between Stokes drift and Darwin drift (with I. Eames). *Proc. Camb. Phil. Soc.,* **126**, 171–174.

†[95] Why understand dynamics — and what is 'understanding' anyway? (Invited essay among a set commissioned from leading scientists). In: *Atmospheric Chemistry and Global Change*, a graduate textbook and research compendium ed. G. P. Brasseur, J. J. Orlando, and G. S. Tyndall. Oxford, University Press, pp. 82–84.

†[96] Numerical weather prediction: a vision of the future, updated still further. *The Life Cycles of Extratropical Cyclones*, ed. M. A. Shapiro and S. Grønås, pp. 337–355. Boston, American Meteorological Soc.

†[97] Toward an ultra-simple spectral gravity wave parameterization for general circulation models (with C. D. Warner). *Earth Planets Space*, **51**, 475–484. (Special Issue of papers from the International Symposium on Dynamics and Structure of the Mesopause Region (DYSMER Symposium) held at Kyoto University, 16–21 March 1998.)

†[98] How far have we come in understanding the dynamics of the middle atmosphere? Invited Symposium Lecture to the 14th European Space Agency Symposium on European Rocket and Balloon Programmes and Related Research, ed. B. Kaldeich-Schürmann, ESA SP-437, ISBN 92-9092-748-8, Noordwijk, ESTEC/ESA Publications, pp. 581–590

*[99] On shear-generated gravity waves that reach the mesosphere. Part I: wave generation (with O. Bühler and J. F. Scinocca). *J. Atmos. Sci.,* **56**, 3749–3763.

*[100] On shear-generated gravity waves that reach the mesosphere. Part II: wave propagation (with O. Bühler). *J. Atmos. Sci.,* **56**, 3764–3773.

2000 *[101] Potential-vorticity inversion on a hemisphere (with W. A. Norton). *J. Atmos. Sci.,* **57**, 1214–1235, *Corrigendum* **58**, 949. (This work revealed for the first time that balance and PV inversion can be far more accurate than standard asymptotic theories suggest.)

*[102] Balance and the slow quasimanifold: some explicit results (with R. Ford and W. A. Norton). *J. Atmos. Sci.,* **57**, 1236–1254.

†[103] The Earth's middle atmosphere and the Sun's interior. In: *Long and Short Term Variability in the Sun's History and Global Change* (Proc. IUGG Symposium GA6.01 held in Birmingham, July 1999), ed. W. Schröder. Interdivisional Commission on History, IAGA/IUGG, Newsl. **39** ISSN 0179 5658, 13–38. Science Edition, D-28777 Bremen–Rönnebeck, Hechelstrasse 8, Germany, 363 pp.

†[104] Lucidity, science, and the arts: what we can learn from the way perception works. *Bull. Faculty Human Devel.* (Kobe University, Japan), **7**(3), 1–52. (Invited keynote lecture to the 4th Symposium on Human Development, *Networking of Human Intelligence: Its Possibility and Strategy.*)

†[105] The impact of gravity waves on climate. Proc. 1998 European Climate Science Conference, ed. A. Ghazi and I. Troen, paper no. 164. Published 2000 and available on CD-ROM from Research DG, Biodiversity and Global Change Unit DI/1, European Commission, Brussels.

†[106] On global-scale atmospheric circulations. Major tutorial review including cutting-edge issues, in: *Perspectives in Fluid Dynamics: A Collective Introduction to Current Research*, ed. G. K. Batchelor, H. K. Moffatt, and M. G. Worster. Cambridge, University Press, 557–624. (Corrected reprints still available; note in particular that wedge products should be read as cross (three-dimensional vector) products and not as exterior products. These and a few other corrections have been incorporated into the paperback edition of 2003.)

2001 †[107] Balance, potential-vorticity inversion, Lighthill radiation, and the slow quasi-manifold. Proc. IUTAM/IUGG/Royal Irish Academy Symposium on *Advances in Mathematical Modelling of Atmosphere and Ocean Dynamics*, ed. P. F. Hodnett. Kluwer Academic Publishers, pp. 45–68.

[108] An ultrasimple spectral parameterization for nonorographic gravity waves (with C. D. Warner). *J. Atmos. Sci.*, **58**, 1837–1857.

†[109] Global effects of gravity waves in the middle atmosphere: a theoretical perspective. *Adv. Space Res.*, **27**, 1723–1736. Invited review for the 33rd COSPAR Scientific Assembly (Committee on Space Research), Warsaw, Poland, 16–23 July 2000. (This is an updated version of paper [98] to the European Space Agency.)

2002 *†[110] Some fundamental aspects of atmospheric dynamics, with a solar spinoff. Proc. 150th Anniversary Symposium of the Royal Meteorological Society, *Meteorology at the Millennium*, ed. R. P. Pearce. Academic Press and Royal Meteorological Society, 283–305. (This invited paper presents the same basic ideas as in the Yukawa Symposium, paper [92], but completely rethought, thoroughly rewritten for a different audience, and expanded where appropriate.)

[111] Are there higher-accuracy analogues of semigeostrophic theory? (with I. Roulstone). In: *Large-scale Atmosphere–Ocean Dynamics: II: Geometric Methods and Models* (Proc. Newt. Inst. Programme on Mathematics of Atmosphere and Ocean Dynamics), ed. J. Norbury and I. Roulstone. Cambridge, University Press, pp. 301–364.

[112] Reply to Comments by S. Saujani and T. G. Shepherd on "Balance and the Slow Quasimanifold: Some Explicit Results" (with R. Ford [deceased] and W. A. Norton). *J. Atmos. Sci.*, **59**, 2878–2882.

2003 †[113] Balanced Flow. In: *Encyclopedia of Atmospheric Sciences*, ed. J. R. Holton, J. A. Pyle, and J. A. Curry., Academic. See also 2nd edn., 2015, ed. Gerald R. North, J. A. Pyle and Fuqing Zhang, Elsevier, incorporating updates and corrections including those from the 2007 papers on the hyperbalance equations. Vol **2**, pp. 298–303.

†[114] Potential Vorticity. In: *Encyclopedia of Atmospheric Sciences*, ed. J. R. Holton, J. A. Pyle, and J. A. Curry, Academic. See also 2nd edn., 2015, ed. Gerald R. North, J. A. Pyle and Fuqing Zhang, Elsevier, incorporating many updates and corrections, including historical corrections. Vol **2**, pp. 375–383.

*†[115] Solar tachocline dynamics: eddy viscosity, anti-friction, or something in between? Chapter 8 in *Stellar Astrophysical Fluid Dynamics* (D. O. Gough Festschrift), ed. M. J. Thompson and J. Christensen-Dalsgaard, Cambridge, University Press, 111–130.

*†[116] Wind-generated water waves: two overlooked mechanisms? In: *Wind over Waves II: Forecasting and Fundamentals of Applications*, ed. S. G. Sajjadi and J. C. R. Hunt. UK Inst. Maths. Applics. and Horwood Publishing, pp. 105–118.

*[117] Remote recoil: a new wave–mean interaction effect (with O. Bühler). *J. Fluid Mech.*, **492**, 207–230.

2005 *[118] Wave capture and wave–vortex duality (with O. Bühler). *J. Fluid Mech.*, **534**, 67–95.

†[119] Some dynamics that is significant for chemistry. Invited review for ECMWF Seminar *Gobal Earth-System Monitoring,* 5–9 September 2005. Obtainable from Librarian, European Centre for Medium Range Weather Forecasts, Reading RG2 9AX, U. K. and at http:// www.damtp.cam.ac.uk/user/mem/papers/ECMWF/ecmwf05.html

2007 *[120] Local mass conservation and velocity splitting in PV-based balanced models. Part I: The hyperbalance equations (with A. R. Mohebalhojeh). *J. Atmos. Sci.*, **64**, 1782–1793.

*[121] Local mass conservation and velocity splitting in PV-based balanced models. Part II: Numerical results (with A. R. Mohebalhojeh). *J. Atmos. Sci.*, **64**, 1794–1810.

†[122] Magnetic confinement and the sharp tachopause. Chapter 8 in *The solar tachocline*, ed. D. W. Hughes, R. Rosner and N. O. Weiss, Cambridge University Press, pp. 183–212 (incl. tutorial on gyroscopic pumping). A copy-edit-free preprint is available at www.damtp.cam.ac.uk/user/mem/papers/SQBO/solarfigure.html

†[123] On thinking probabilistically. In: *Extreme Events* (Proc. 15th ‘Aha Huliko‘a Winter Workshop), ed. P. Müller, C. Garrett, and D. Henderson. SOEST publications, University of Hawaii at Manoa, pp. 153–161.

[124] Confinement of the Sun's interior magnetic field: some exact boundary-layer solutions (with T. S. Wood). In: *Unsolved Problems in Stellar Physics*, ed. R. J. Stancliffe, J. Dewi, G. Houdek, R. G. Martin, and C. A. Tout, Amer. Inst. of Physics, *AIP Conf. Proc.* **948**, pp. 303–308. A preprint of the paper in its final form is available at www.damtp.cam.ac.uk/user/mem/papers/SQBO/solarfigure.html#chirality (with a minor *corrigendum*); also at arXiv:0709.1377 (astro-ph).

2008 †[125] Multiple jets as PV staircases: the Phillips effect and the resilience of eddy-transport barriers (with D. G. Dritschel). *J. Atmos. Sci.*, **65**, 855–874. (Invited paper for the Featured Special Collection on *Jets and Annular Structures in Geophysical Fluids.*)

†[126] Potential-vorticity inversion and the wave–turbulence jigsaw: some recent clarifications. *Advances in Geosciences*, **15**, 47–56. (Invited tutorial paper for an ADGEO Special Collection relating to recent European Geophysical Union Assemblies.)

2009 *†[127] Spontaneous imbalance and hybrid vortex–gravity structures *J. Atmos. Sci.*, **66**, 1315–1326. (In the Featured Special Collection on *Spontaneous Imbalance*.)

2010 *[128] A general theorem on angular-momentum changes due to potential vorticity mixing and on potential-energy changes due to buoyancy mixing (with R. B. Wood). *J. Atmos. Sci.*, **67**, 1261–1274.

*[129] On spontaneous imbalance and ocean turbulence: generalizations of the Paparella–Young epsilon theorem. In: *IUTAM Symposium on Turbulence in the Atmosphere and Oceans* (Proc. IUTAM Symposium held at the Newton Institute, Cambridge, on 8–12 December 2008, ed. D. G. Dritschel, Springer-Verlag, pp. 3–15. Reprint available at www.damtp.cam.ac.uk/user/mem/#mixing

2011 *[130] Polar confinement of the Sun's interior magnetic field by laminar magnetostrophic flow (with T. S. Wood). *J. Fluid Mech.*, **677**, 445–482/, open access. (This paper is a *big* breakthrough.)

2015 †[131] The atmospheric wave–turbulence jigsaw (Marshall Rosenbluth Memorial Lecture). In: *Rotation and Momentum Transport in Magnetised Plasmas*, ed. P.H. Diamond, X. Garbet, P. Ghendrih, and Y. Sarazin. World Scientific, pp. 1–43.

2016 *[132] Jupiter's unearthly jets: A new turbulent model exhibiting statistical steadiness without large-scale dissipation (with S. I. Thomson). *J. Atmos. Sci.*, **73**, 1119–1141.

[133] Turbulence without cascades – new insights from Jupiter's unearthly jets. In: *Turbulence, Waves and Mixing: In Honour of Lord Julian Hunt's 75th Birthday*, ed. S.G. Sajjadi and H.J. Fernando (2016). Inst. Maths. Applics., ISBN 978-0-905091-35-8, pp. 124-127. Reprint available at www.damtp.cam.ac.uk/user/mem/papers/JCRH/

2017 *[134] On multi-level thinking and scientific understanding. *Adv. Atmos. Sci.*, **34**, 1150–1158. (Expanded version of invited lecture to the Duzheng Ye Centenary Symposium, Nanjing, China, 23 September 2016.)

2019 *[135] Wave–vortex interactions, remote recoil, the Aharonov–Bohm effect and the Craik–Leibovich equation. *J. Fluid Mech.*, **881**, 182–217, doi:10.1017/jfm.2019.765, green open access. This big paper, submitted 11 May 2018, underwent two major revisions and was sent back to the journal on 3 March and 25 July 2019. The final preprint is available as arXiv:1901.11525 version 6 and at www.damtp.cam.ac.uk/user/mem/papers/AB/

2020 [136] Wave–vortex interactions and effective mean forces: three basic problems. *Geophys. Astrophys. Fluid Dyn.*, **114**, 414–428. Final preprint available at www.damtp.cam.ac.uk//user/mem/papers/AB/

2021+ *[137] *Science, Music, and Mathematics: The Deepest Connections*, World Scientific First Edition published November 2021, Second Edition September 2023. An abridged preview of the Second Edition is available at www.damtp.cam.ac.uk/user/mem/papers/LHCE/mcintyre-book-preview.html

*[138] Climate uncertainties: a personal view. *Meteorology*, **1**, 162–170 (2022).

*[139] Climate tipping points: a personal view. *Physics Today*, **76**(3), 44–49 (2023), doi:10.1063/PT.3.5198

Note: in joint publications it has been my practice to suggest either alphabetical order of authors' names, or, for most 1993 publications onwards, last position if authors junior to me, in years, made substantial contributions. I regard today's first-authorship cult as highly injurious to science.