Curriculum Vitae: Robin J. Hogan

April 2024

A. PERSONAL INFORMATION

Date of Birth	27 July 1974
Nationality	British
Address	European Centre for Medium-Range Weather Forecasts (ECMWF), Shinfield Park, Reading, RG2 9AX
Telephone	+44 (0)118 9499733
ECMWF email	r.j.hogan@ecmwf.int
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Present employment

2024–present	Principal Scientist, European Centre for Medium-Range Weather Forecasts, Reading, UK (95%)
2010–present	Professor of Atmospheric Physics, Dept of Meteorology, University of Reading, UK (5% since April 2014)

Previous employment

2014–2024	Senior Scientist, European Centre for Medium-Range Weather Forecasts, Reading, UK
2011–2014	Head of Department for Research, Dept of Meteorology, University of Reading, UK
2007–2010	Reader in Atmospheric Physics, Dept of Meteorology, University of Reading, UK
2003–2007	Lecturer, Department of Meteorology, University of Reading, UK
1998–2002	Postdoctoral research scientist, Department of Meteorology, University of Reading, UK

Qualifications

1998	PhD in Meteorology, University of Reading, UK
1995	BSc in Physics with Astrophysics (First Class Honours), University of Leicester, UK

B. RESEARCH

My research is primarily concerned with radiation and clouds, and is motivated by the need to improve the accuracy of weather and climate forecasts. Most of my recent work falls into three categories: development of novel and efficient numerical methods for atmospheric radiative transfer, development of innovative radar and lidar techniques to retrieve cloud properties remotely, and improving representation of the interaction of radiation with atmospheric composition and complex surfaces. Within ECMWF I have responsibility for the development of the radiation scheme. I am currently the European Co-Chair of the Joint Mission Advisory Group for the ESA-JAXA EarthCARE mission. Research highlights are described in Section G.

Research grants awarded

2021 Clouds, Aerosols and Radiation: Development of Integrated Algorithms for EarthCARE (CARDINAL)
European Space Agency, ECMWF share ***€408k*** *(Subcontractor; lead ECMWF investigator)*

2016 Aeolus/EarthCARE assimilation studies (A3S)
European Space Agency (Co-Investigator)

2016 EarthCARE assimilation project
European Space Agency (Co-Investigator)

2015 Doppler radar and synergy algorithms for EarthCARE (DORSY)
European Space Agency, ECMWF share ***€418k*** *(Subcontractor; lead ECMWF investigator)*

2014 3D Shortwave Radiative Kernels of Marine Boundary-layer Clouds Using Scanning Radar/Lidar and Array Spectroradiometer

US Department of Energy Atmospheric System Research Program (Co-Investigator)

2012 Initial Training for Atmospheric Remote Sensing (ITARS)
*FP7 Marie Curie Mobility Actions Initial Training Networks, Reading share **€287k** (Co-Investigator).*

2011 Study of shortwave spectra in fully 3D environment: Synergy between scanning radars and spectral radiation measurements
*US Department of Energy Atmospheric System Research Program, **£108k** (Co-Investigator)*

2011 Variational synergistic algorithms for EarthCARE (VARSY)
*European Space Agency, Reading share **€100k** (Subcontractor; lead Reading investigator)*

2011 Dynamical and Microphysical Evolution of Convective Storms (DYMECS)
*NERC Standard Grant, **£547k** (Principal Investigator)*

2010 Aerosols, Clouds and Trace-Gas Observing Network (ACTRIS)
*EU FP7 proposal, Reading share **£278k** (Co-Investigator)*

2010 Synergy algorithms for EarthCARE
*NCEO Mission Support call, Reading share **£250k** (Principal Investigator)*

2009 More Operational Radiosonde Sensors (MORSE)
*NERC Technologies Proof of Concept, Reading share **£168k** (Co-Investigator)*

2009 Radiative Transfer for EarthCARE (RATEC)
*European Space Agency, Reading share **£189k** (Subcontractor; lead Reading investigator)*

2009 FASTER: Development of a Numerical Weather Prediction Testbed
*US Department of Energy Climate Change Prediction Program, **$96k** in year 1 of 5, **$104k** in year 2 (Co-Investigator, lead Reading investigator)*

2009 The effect of 3D radiative transfer on climate
*NERC Standard Grant, **£254k** (Principal Investigator)*

2008 National Centre for Earth Observation
*NERC Centre of Excellence, Reading share around **£7m** (Co-Investigator)*
Dr Hogan is involved in both the Climate Theme and the Hazardous Weather Theme

2007 Cloud and aerosol synergetic products from EarthCARE retrievals (CASPER)
*European Space Agency, Reading share **£60k** (Subcontractor, lead Reading investigator)*

2007 Representing cloud inhomogeneity and overlap in a General Circulation Model
*NERC Small grant, **£53k** (Principal Investigator)*

2007 Aerosol interactions in mixed-phase clouds
*NERC Consortium proposal, Reading share **£254k** (Co-Investigator)*

2006 Cascade: Cloud-system resolving modelling of the tropical atmosphere
*NERC Consortium proposal, Reading share **£1.6m** (Co-Investigator)*

2005 Evaluation of clouds in climate and forecasting models using CloudSat and Calipso data
*NERC Standard Grant, **£198k** (Principal Investigator)*

2005 Improvement of stratocumulus representation in models by the use of high-resolution observations
*NERC Standard Grant, **£245k** (Co-Investigator)*

2005 Balloon-carried instrument for measurement of atmospheric turbulence
*Royal Society Paul Instrument Fund, **£77k** (Co-Investigator)*

2004 All weather Doppler lidar for clouds and boundary layer
*NERC Standard Grant, **£149k** (Co-Investigator)*

2003 The properties of ice clouds and supercooled liquid water layer clouds derived from ground based polarimetric radar and lidar observations
*NERC New Observing Techniques Grant, Reading share **£215** (Co-Investigator)*

Postgraduate and postdoctoral supervision

- 16 research scientists and postdocs supervised as PI: Andrew Barrett, Yann Blanchard, Alessio Bozzo, Julien Delanoë, Debbie Clifford, Mark Fielding, Kirsty Hanley, Shannon Mason, Ewan O'Connor, Kevin Pearson, Nicola Pounder, Jonathan Shonk, Thorwald Stein, Brian Tse, Chris Westbrook and Ryan Williams
- Supervisor of eleven successfully completed PhD students: Jonathan Wilkinson (2007), Jonathan Shonk (2008), Nicky Chalmers (2011), Peter Hill (2012), Andrew Barrett (2012), Natalie Harvey (2013), Julian Mann (2014), Mark Fielding (2015), Sophia Schäfer (2016), David Meyer (2022) and Megan Stretton (2022)
- Formerly on the Monitoring Committee for many other Higher Degree/PhD students

- Supervised 14 masters dissertations, 7 of whom were awarded distinctions, 7 of whom went on to study PhDs and 6 of whom co-authored papers on their dissertation work

Awards

2014 Henry G. Houghton Award, American Meteorological Society, for "broad-reaching, imaginative contributions to understanding the interaction of clouds and radiation through innovations in radiative transfer and remote sensing"
2007 School award for outstanding contributions to teaching and learning support, University of Reading
2005 L. F. Richardson Prize, Royal Meteorological Society, for meritorious papers published under the age of 35
2004 Best poster award at 14th International Conference on Clouds and Precipitation, Bologna, Italy
2000 Highly commended poster prize at Royal Meteorological Society 150th Anniversary Conference, Cambridge, UK
1994 Raymond Hide prize for undergraduate work at the University of Leicester

International invited talks

2023 Invited talk at Wageningen University, Netherlands (24 Sept)
2023 CFMIP-GASS Conference, Paris, France (10 July)
2023 German Weather Service (DWD) Seminar, Offenbach, Germany (26 Jan)
2022 Invited talk at International Radiation Symposium, Thessaloniki, Greece (4 July)
2021 Keynote talk at European Meteorological Society Online Conference (8 Sept)
2021 Invited talk at HIGHTUNE Online Conference (14 Apr)
2019 Gordon Research Conference on Radiation and Climate, Lewiston, Maine (21 July)
2018 CNRM seminar, Meteo-France, Toulouse France (21 Nov)
2018 ICCARUS 2018, German Weather Service (DWD), Offenbach, Germany (26 Feb)
2017 Japan Meteorological Agency, Tokyo (20 Dec)
2017 Workshop on Canadian science and applications of the EarthCARE mission, McGill University, Montreal (1 Mar)
2015 AGU Joint Assembly, Montreal, Canada (7 May)
2014 Fourth Cloud Retrieval Evaluation Workshop (CREW-4), Grainau, Germany (4 Mar)
2013 Fourth International Workshop on Space-Based Snowfall Measurements, Mammoth Lakes, California (6 May)
2012 LATMOS, University of Versailles, St-Quentin-en-Yvelines, France (13 Mar)
2011 Gordon Research Conference on Radiation and Climate, Waterville, Maine (14 July)
2009 NASA Goddard Institute for Space Studies, New York City (13 Feb)
2009 Climate and Radiation Branch, NASA Goddard Space Flight Center, Greenbelt (4 Feb)
2009 Atmospheric Sciences Division, Brookhaven National Laboratory, Long Island (30 Jan)
2008 CPTEC, INPE, Cachoeira Paulista, Brazil (14 Aug)
2008 Keynote talk at the International Radiation Symposium, Foz do Iguassu, Brazil (7 Aug)
2008 Keynote talk at the ARM Science Team meeting, Norfolk, Virginia (13 Mar)
2007 Keynote talk at 33rd AMS Conference on Radar Meteorology, Cairns, Australia (7 Aug)
2006 EOL/RAL Seminar, National Center for Atmospheric Research (NCAR), Boulder (18 July)
2006 Session on "Scale, scaling and non-linear variability", EGU General Assembly, Vienna (5 Apr)
2003 Department of Atmospheric Sciences, University of Washington, Seattle (17 Nov)
2003 GEWEX Workshop on "3D Clouds and Radiative Transfer", Victoria, BC, Canada (14 Nov)

UK invited talks

2019 5th OpenIFS Workshop, University of Reading, Reading (17 June)
2018 EC-Earth Workshop, ECMWF, Reading (30 Jan)
2016 Earth Radiation Budget Workshop, ECMWF, Reading (21 Oct)
2016 Space & Atmospheric Physics Group, Imperial College London (19 Jan)
2014 Scattering, Clouds & Climate Workshop, Mathematics Institute, University of Oxford (25 Mar)
2013 Royal Meteorological Society National Meeting, London (20 Mar)
2012 Workshop on parametrization of clouds and precipitation, ECMWF, Reading (7 Nov)
2012 Space & Atmospheric Physics Group, Imperial College London (1 May)
2011 Space Research Centre Seminar, University of Leicester (18 Mar)

2010 Keynote talk at National Centre for Atmospheric Science Conference, Manchester (5 July)
2010 ECMWF Workshop on "Assimilating satellite observations of clouds and precipitation into NWP models", Reading (15 June)
2010 Workshop of COST Action ES0702: Integrated Ground-Based Observations of Essential Variables for Climate and Operational Meteorology EG-CLIMET, Reading (24 Mar)
2010 Atmospheric, Oceanic and Planetary Physics, University of Oxford (4 Feb)
2009 ECMWF Formal Seminar, Reading (27 Oct)
2008 ECMWF Seminar "Parametrization of subgrid physical processes", Reading (1 Sept)
2008 Royal Meteorology Society meeting on "Ice in the atmosphere", Manchester (23 Apr)
2007 Workshop on High Resolution Modelling, Reading (30 Oct)
2007 Chilbolton 40th Anniversary Celebration, Chilbolton Observatory (11 Apr)
2006 ECMWF Workshop on "Parametrization of clouds in large-scale models", Reading (14 Nov)
2005 Department of Physics, Imperial College London (8 Nov)
2004 School of the Environment, University of Leeds (28 Oct)
2004 ECMWF Formal Seminar, Reading (14 Oct)
2004 Met Office NWP Seminar, Exeter (4 June)
2003 Royal Meteorological Society Physical Processes group meeting, UMIST (4 June)
2002 Royal Meteorological Society Scottish Centre, Edinburgh (13 Dec)

Professional activities: international

- European Co-Chair of the Joint ESA/JAXA EarthCARE Mission Advisory Group, 2023-present
- Proposer and co-editor of a special issue of Atmospheric Measurement Techniques on "EarthCARE Level 2 Algorithms and Data Products", 2022-present
- Initiated and leading the International Correlated K-Distribution Model Intercomparison Project (CKDMIP, Hogan and Matricardi 2020, *https://confluence.ecmwf.int/display/CKDMIP*), 2019-present
- Member of the Joint ESA/JAXA EarthCARE Mission Advisory Group, 2017-present
- Co-convener of EGU session "The Earth Cloud, Aerosol and Radiation Explorer (EarthCARE) ready for Launch", Vienna, 18 April 2024
- Elected a commissioner of the International Radiation Commission, 2012-2020
- Member of Organising Committee of the Fourth International Workshop on Space-Based Snowfall Measurements International workshop on snowfall measurement from space, Mammoth Lakes, California, 6-8 May 2013
- Chaired sessions at the 1999 International Union of Geodesy and Geophysics, 2005 Royal Meteorological Society and 2007 American Meteorological Society radar conferences
- Member of the Programme Committee for the 2007 American Meteorological Society Conference on Radar Meteorology, Cairns, Australia
- PhD examiner at Wageningen University in September 2023 (Menno Veerman)
- PhD examiner at LMD, Paris in June 2023 (Raphaël Lebrun)
- PhD examiner at the University of Toulouse in November 2019 (Najda Villefranque)
- Reviewer for many international scientific journals including *Nature*

Professional activities within the UK

- Member of the Advisory Board of the SCENARIO Doctoral Training Partnership (Universities of Reading and Surrey), 2018-present
- Chair of the NERC Atmospheric Radar Facilities Steering Committee (NARFSC), 2012-2013
- Member of NARFSC in 2006 and 2009-2013
- Member of the NERC Service Review Group (SRG), 2009
- Fellow of the Royal Meteorological Society and entitled to use the appellation "FRMetS" (elected in 2007 following nomination by two existing fellows)
- Former member of the Management Committee of the UK Universities Weather Research Network (UWERN)
- Wrote most of the science case for renewal of funding for the Chilbolton Facility for Atmospheric and Radio Research (CFARR) to the 2008 NERC Service Review Group; the proposal was awarded the highest possible grade and funding was secured for 5 years at around £0.5M per year

- PhD external examiner twice at Manchester University in December 2006 (Daniel Grosvenor) and November 2011 (Christopher Lee), at St Andrews University in February 2014 (Peter Speirs), and at University of Hertfordshire in December 2016 (Lawrence Taylor)
- PhD internal examiner in Reading in December 2006, September 2007, August 2010 and July 2012
- MPhil internal examiner in Reading in November 2009

Book chapters

Haeffelin, M., S. Crewell, A. J. Illingworth, G. Pappalardo, H. Russchenberg, M. Chiriaco, K. Ebell, **R. J. Hogan** and F. Madonna, 2016: Parallel developments and formal collaborations between European atmospheric profiling observatories and US ARM research programs. Chapter 29 in *The Atmospheric Radiation Measurement Program: The First 20 Years,* American Meteorological Society Monograph.

Hogan, R. J., and I. B. Mason, 2011: Deterministic forecasts of binary events. In *Forecast verification: a practitioner's guide in atmospheric science,* Eds. I. T. Jolliffe and D. B. Stephenson, 2nd Ed., Wiley.

Publications in peer-reviewed journals

Updated April 2024; download PDFs from *www.met.reading.ac.uk/clouds/publications.html*

2024

148. **Hogan, R. J.** What are the optimum discrete angles to use in infrared radiative transfer calculations? *Q. J. R. Meteorol. Soc.,* **150,** 318-333, doi:10.1002/qj4598.
147. Mason, S. L., H. W. Barker, J. N. S. Cole, N. Docter, D. P. Donovan, **R. J. Hogan,** A. Hünerbein, P. Kollias, B. Puigdomènech Treserras, Z. Qu, U. Wandinger and G.-J. van Zadelhoff. An intercomparison of EarthCARE cloud, aerosol, and precipitation retrieval products. *Atmos. Meas. Tech.,* **17,** 875–898, doi:10.5194/amt-17-875-2024.
146. Müller, H., A. Ehrlich, E. Jäkel, J. Röttenbacher, B. Kirbus, M. Schäfer, **R. J. Hogan** and M. Wendisch: Evaluation of downward and upward solar irradiances simulated by the Integrated Forecasting System of ECMWF using airborne observations above Arctic low-level clouds. *Atmos. Chem. Phys.,* **24,** 4157-4175, doi:10.5194/acp-24-4157-2024.
145. Ukkonen, P., and **R. J. Hogan**. Twelve times faster yet accurate: A new state-of-the-art in radiation schemes via performance and spectral optimization. *J. Adv. Modeling Earth Sys.,* **16,** e2023MS003932, doi:10.1029/2023MS003932.

2023

144. Irbah, A., J. Delanoe, G.-J. van Zadelhoff, D. P. Donovan, P. Kollias, B. Puigdomènech Treserras, S. Mason, S., **R. J. Hogan** and A. Tatarevic. The classification of atmospheric hydrometeors and aerosols from the EarthCARE radar and lidar: the A-TC, C-TC and AC-TC products. *Atmos. Meas. Techniques,* **16,** 2795-2820.
143. Mason, S. L., **R. J. Hogan,** A. Bozzo and N. L. Pounder. A unified synergistic retrieval of clouds, aerosols and precipitation from EarthCARE: the ACM-CAP product. *Atmos. Meas. Tech.,* **16,** 3486-3486: doi:10.5194/amt-16-3459-2023.
142. Schoetter, R., C. Caliot, T. Y. Chung, **R. J. Hogan** and V. Masson. Quantification of uncertainties of radiative transfer calculation in urban canopy models. *Bound.-Layer Meteorol.,* 189, 103–138, doi:10.1007/s10546-023-00827-9.
141. Stretton, M. A., W. Morrison, **R. J. Hogan** and S. Grimmond. Evaluation of vertically resolved longwave radiation in SPARTACUS-Surface 0.7.3 and the sensitivity to urban surface temperatures. *Geosci. Model Dev.,* **16,** 5931-5947, doi:10.5194/egusphere-2022-1002.
140. Ukkonen, P., and **R. J. Hogan**. Implementation of a machine-learned gas optics parameterization in the ECMWF Integrated Forecasting System: RRTMGP-NN 2.0. *Geosci. Model Dev.,* **16,** 3241-3261.

2022

139. **Hogan, R. J.,** and M. Matricardi. A tool for generating fast k-distribution gas-optics models for weather and climate applications. *J. Adv. Modeling Earth Sys.,* **14,** e2022MS003033. doi:10.1029/2022MS003033.

138. Meyer, D., **R. J. Hogan,** P. Dueben and S. L. Mason. Machine learning emulation of 3D cloud radiative effects. *J. Adv. Modeling Earth Sys.,* **14,** e2021MS002550, doi:10.1029/2021MS002550.
137. Meyer, D., C. S. R. Grimmond, P. Dueben, **R. J. Hogan,** M. van Reeuwijk. Machine learning emulation of urban land surface processes. *J. Adv. Modeling Earth Sys.,* **14,** e2021MS002744, doi:10.1029/2021MS002744.
136. Monge-Sanz, B. M., A. Bozzo, N. Byrne, M. P. Chipperfield, M. Diamantakis, J. Flemming, L. J. Gray, **R. J. Hogan,** L. Jones, L. Magnusson, I. Polichtchouk, T. G. Shepherd, N. Wedi and A. Weisheimer. A stratospheric prognostic ozone for seamless Earth System Models: performance, impacts and future. *Atmos. Chem. Phys.,* **22,** 4277-4302, doi:10.5194/acp-22-4277-2022.
135. Stretton, M. A., W. Morrison, **R. J. Hogan** and C. S. R. Grimmond. Evaluation of the SPARTACUS-Urban radiation model for vertically resolved shortwave radiation in urban areas. *Bound.-Layer Meteorol.,* **184,** 301-331, doi:10.1007/s10546-022-00706-9.

2021
134. McNorton, J. R., G. Arduini, N. Bousserez, A. Agusti-Panareda, G. Balsamo, S. Boussetta, M. Choulga, I. Hadade and **R. J. Hogan.** An urban scheme for the ECMWF integrated forecasting system: single-column and global offline application. *J. Adv. Modelling Earth Sys.,* **13,** e2020MS002375, doi:10.1029/2020MS002375.
133. Meyer, D., T. Nagler and **R. J. Hogan.** Copula-based synthetic data generation for machine learning emulators in weather and climate: application to a simple radiation model. *Geosci. Model Dev.,* **14,** 5205-5215, doi:10.5194/gmd-14-5205-2021.
132. Villefranque, N., and **R. J. Hogan.** Evidence for the 3D radiative effects of boundary-layer clouds from observations of direct and diffuse surface solar fluxes. *Geophys. Res. Lett.,* **48,** e2021GL093369, doi:10.1029/2021GL093369.
131. Villefranque, N., S. Blanco, F. Couvreux, R. Fournier, J. Gautrais, **R. J. Hogan,** F. Hourdin, V. Voldina and D. Williamson. Process-based climate model development harnessing machine learning: 3. The representation of cumulus geometry and their 3D radiative effects. *J. Adv. Modeling Earth Sys.,* **13,** e2020MS002423. doi:10.1029/2020MS002423.

2020
130. Di Napoli, C., **R. J. Hogan** and F. Pappenberger. Mean radiant temperature from global-scale numerical weather prediction models. *Int. J. Biometeorol.,* doi:10.1007/s00484-020-01900-5.
129. Fielding, M. D., S. A. K. Schäfer, **R. J. Hogan** and R. M. Forbes. Parameterizing cloud geometry for use in 3D radiative transfer and cloud erosion schemes. *Q. J. R. Meteorol. Soc.,* doi:10.1002/qj.3758.
128. Hersbach, H., B. Bell, P. Berrisford, S. Hirahara, A. Horanyi, J. Munoz-Sabater, J. Nicolas, C. Peubey, R. Radu, D. Schepers, A. Simmons, C. Soci, S. Abdalla, X. Abellan, G. Balsamo, P. Bechtold, G. Biavati, J. Bidlot, M. Bonavita, G. De Chiara, P. Dahlgren, D. Dee, M. Diamantakis, R. Dragani, J. Flemming, R. Forbes, M. Fuentes, A. Geer, L. Haimberger, S. Healy, **R. J. Hogan,** E. Holm, M. Janiskova, S. Keeley, P. Laloyaux, P. Lopez, G. Radnoti, P. de Rosnay, I. Rozum, F. Vamborg, S. Villaume and J.-N. Thepaut. The ERA5 global reanalysis. *Q. J. R. Meteorol. Soc.,***146,** 1999-2049.
127. **Hogan, R. J.,** and M. Matricardi. Evaluating and improving the treatment of gases in radiation schemes: the Correlated K-Distribution Model Intercomparison Project (CKDMIP). *Geosci. Model. Dev.,* **13,** 6501-6521.
126. Ukkonen, P., R. Pincus, **R. J. Hogan,** K. P. Nielsen and E. Kaas. Accelerating radiation computations for dynamical models with targeted machine learning and code optimization. *J. Adv. Modeling Earth Sys.,* **12,** e2020MS002226.
125. Wolf, K., A. Ehrlich, M. Mech, **R. J. Hogan** and M. Wendisch. Evaluation of ECMWF radiation scheme using aircraft observations of spectral irradiance above clouds. *J. Atmos. Sci.,* **77,** 2665-2685.

2019
124. Escribano, J., A. Bozzo, P. Dubuisson, J. Flemming, **R. J. Hogan,** L. C.-Labonnote and O. Boucher: A benchmark for testing the accuracy and computational cost of shortwave top-of-

atmosphere reflectance calculations in clear-sky aerosol-laden atmospheres. *Geosci. Model Dev.,* **12,** 805-827.

123. **Hogan, R. J.**: An exponential model of urban geometry for use in radiative transfer applications, 2019a. *Bound.-Layer Meteorol.,* **170,** 357-472.
122. **Hogan, R. J.**: Flexible treatment of radiative transfer in complex urban canopies for use in weather and climate models, 2019b. *Bound.-Layer Meteorol.,* doi:10.1007/s10546-019-00457-0.
121. **Hogan,** R. J., Fielding, M. D., Barker, H. W., Villefranque, N. and Schäfer, S. A. K., 2019. Entrapment: An important mechanism to explain the shortwave 3D radiative effect of clouds. *J. Atmos. Sci.,* doi:10.1175/JAS-D-18-0366.1.
120. Mason, S. L., **R. J. Hogan,** C. D. Westbrook. S. Kneifel, D. Moisseev and L. von Terzi: The importance of particle size distribution shape for triple-frequency radar retrievals of the morphology of snow. *Atmos. Meas. Tech.,* **12,** 4993-5018.
119. Lock, S.-J., S. T. K. Lang, M. Leutbecher, **R. J. Hogan** and F. Vitart: Treatment of model uncertainty from radiation by the Stochastically Perturbed Parametrization Tendencies (SPPT) scheme and associated revisions in the ECMWF ensembles. *Q. J. R. Meteorol. Soc.,* doi:10.1002/qj.3570.

2018

118. Ahlgrimm, M., R. M. Forbes, **R. J. Hogan** and I. Sandu: Understanding global model systematic shortwave radiation errors in subtropical marine boundary layer cloud regimes. *J. Adv. Modeling Earth Sys.* doi:10.1029/2018MS001346.
117. Beljaars, A., G. Balsamo, P. Bechtold, A. Bozzo, R. Forbes, **R. J. Hogan,** M. Koehler, J.-J. Morcrette, A. M. Tompkins, P. Viterbo and N. Wedi: The numerics of physical parametrization in the ECMWF model. *Frontiers Earth Sci.,* **6**(137)**,** 18 pp.
116. **Hogan, R. J.,** and A. Bozzo: A flexible and efficient radiation scheme for the ECMWF model. *J. Adv. Modeling Earth Sys.,* doi:10.1029/2018MS001364.
115. **Hogan, R. J.,** T. Quaife and R. Braghiere: Fast treatment of 3D radiative transfer in vegetation canopies: SPARTACUS-Vegetation 1.1. *Geosci. Model Dev.,* **11,** 339-350.
114. Mason, S. L., J.-C. Chiu, **R. J. Hogan,** D. Moisseev and S. Kneifel: Retrievals of riming and snow particle density from vertically-pointing Doppler radars. *J. Geophys. Res.,* **123,** doi:10.1029/2018JD028603.
113. Polichtchouk, I., T. G. Shepherd, **R. J. Hogan** and P. Bechtold: Sensitivity of the Brewer-Dobson circulation and polar vortex variability to parametrized nonorographic gravity-wave drag in a high-resolution atmospheric model. *J. Atmos. Sci.,* **75,** 1525-1543.

2017

112. Barrett, A. I., **R. J. Hogan** and R. M. Forbes: Why are mixed-phase altocumulus clouds poorly predicted by large-scale models? 1. Physical processes. *J. Geophys. Res.,* **122,** 9903-9926.
111. Barrett, A. I., **R. J. Hogan** and R. M. Forbes: Why are mixed-phase altocumulus clouds poorly predicted by large-scale models? 2. Vertical resolution sensitivity and parameterization *Submitted to J. Geophys. Res.,* **122,** 9927-9944.
110. Harrison, R. J., G. Pretor-Pinney, G. J. Marlton, G. D. Anderson, D. J. Kirshbaum and **R. J. Hogan**: Asperitas - a newly identified cloud supplementary feature. *Weather,* **72,** 132-141.
109. **Hogan, R. J.,** R. Honeyager, J. Tyynela and S. Kneifel: Calculating the millimetre-wave scattering phase function of snowflakes using the Self-Similar Rayleigh-Gans Approximation. *Q. J. R. Meteorol. Soc.,* **143,** 834-844.
108. Leinonen, J., S. Kneifel and **R. J. Hogan**: Evaluation of the Rayleigh-Gans Approximation for microwave scattering by rimed snowflakes. *Q. J. R. Meteorol. Soc.,* doi:10.1002/qj.3093.
107. Leutbecher, L., S.-J. Lock, P. Ollinaho, S. T. K. Lang, G. Balsamo, P. Bechtold, M. Bonavita, H. M. Christiensen, M. Diamantakis, E. Dutra, S. English, M. Fisher, R. M. Forbes, J. Goddard, T. Haiden, **R. J. Hogan,** S. Juricke, H. Lawrence, D. MacLeod, L. Magnusson, S. Malardel, S. Massart, I. Sandu, P. K. Smolarkiewicz, A. Subramanian, F. Vitart, N. Wedi and A. Weisheimer: Stochastic representation of model uncertainties at ECMWF: State of the art and future vision. *Q. J. R. Meteorol. Soc.,* **143,** 2315–2339.

106. Mason, S. L., J. C. Chiu, **R. J. Hogan** and L. Tian: Improved rain rate and drop size retrievals from airborne Doppler cloud radar. *Atmos. Chem. Phys.,* **17,** 11,567-11,589.
105. Ollinaho, P., S.-J. Lock, M. Leutbecher, P. Bechtold, A. Beljaars, A. Bozzo, R. M. Forbes, T. Haiden, **R. J. Hogan** and I. Sandu: Towards process-level representation of model uncertainties: Stochastically perturbed parametrisations in the ECMWF ensemble. *Q. J. R. Meteorol. Soc.,* **143,** 408-422.

2016

104. **Hogan, R. J.,** and S. Hirahara: Effect of solar zenith angle specification in models on mean shortwave fluxes and stratospheric temperatures. *Geophys. Res. Lett.,* **43,** 482-488.
103. **Hogan, R. J.,** S. A. K. Schäfer, C. Klinger, J.-C. Chiu and B. Mayer: Representing 3D cloud-radiation effects in two-stream schemes: 2. Matrix formulation and broadband evaluation. *J. Geophys. Res.,* **121,** 8583-8599.
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C. TEACHING

At the Department of Meteorology, University of Reading I have engaged in a very wide range of teaching methods including lectures, problem classes, computer classes, laboratory practicals, field-site practicals, field trips, small-group tutorials, team projects, undergraduate and postgraduate project supervision, oral presentations and leading the Department-wide "Weather and Climate Discussion". The feedback from the modules I teach is consistently good. In terms of learner support, I introduced an undergraduate mentoring scheme in the Department, in which first year students are each introduced to two "buddies" from higher years, to whom they can then go for work-related advice and other issues. In 2007, I received the "School award for outstanding contributions to teaching and learning support" from the School of Mathematics, Meteorology and Physics at the University of Reading. My specific contributions are as follows:

2014-present	Radiation (part of ECMWF training course on Parametrizing Physical Processes): *4-6 contact hours per year*
2014	Numerical Weather Prediction (undergraduate): *18 contact hours: lectures and computer practical*
2011, 2013, 2019, 2021	Speaker at the NCAS Climate Modelling Summer School (Cambridge and Oxford)
2011	Introduction to Numerical Modelling (postgraduate: MSc and PhD) *24 contact hours: computer classes and lectures*
2010	Remote Sensing (undergraduate) *9 contact hours*
2008, 2011	Boundary Layer Meteorology (undergraduate): *2008: 28 contact hours: lectures and field-site practicals*

2011: 20 contact hours: lectures and computer practical

2007–2008 Convener of BSc Projects

2007 Convener of MSc Dissertations

2005–2011 Weather and Climate Discussion (undergraduate and postgraduate): *5 contact hours per year*

2004–2010 Academic tutor for 3–4 MSc students each year

2004–2008 Boundary Layer Meteorology (postgraduate: MSc and PhD): *25 contact hours per year: lectures and practicals (computer, laboratory and field-site)*

2004 Weather Systems Analysis (undergraduate): *30 contact hours: lectures and practical workshops*

2003–present Supervised eight undergraduate projects

2003–2007, 2010 Surface Energy Exchange (undergraduate): *19 contact hours per year: field-site practicals*

2003, 2007, 2010 Team project (postgraduate): *8 contact hours per year*

2003, 2006 Dorset field trip (undergraduate and postgraduate): *16 contact hours per year*

D. UNIVERSITY ADMINISTRATION

My management skills and rapport with the students have been well recognised within the Department of Meteorology, and in my most recent administrative role I was one of the four Heads of Department, with responsibility for research. Achievements in this role included:

- Led the organisation and writing of the case for investment in the School of Mathematical and Physical Science as part of the Climate and Environmental Science Initiative of the University of Reading's 2011-2013 Academic Investment Project. The case was very well received and the School went on to appoint 20 new academics. I was heavily involved in all aspects of the recruitment process of many of the 15 excellent academic appointments in Meteorology.
- Co-wrote the proposal that led to the Department of Meteorology being awarded a prestigious Regius Professorship in 2013 by the Queen, one of just 12 institutions to receive this honour on the event of her Diamond Jubilee. A Regius Professorship is a rare privilege, with only two being created in the last century. The current holder is Professor Keith Shine FRS.
- Initiated and led activities to nurture research activity in the Department, included a discussion session involving the whole Department on "Writing High Impact Papers" (January 2012), and a workshop on "Writing Successful Proposals" (October 2012).
- Initiated the Ian James Prize for the best PhD thesis submitted in the Department of Meteorology in a calendar year.

In the past I have managed the full range of taught degrees within the Department, first as Director of Undergraduate Studies and then as Director of MSc Programmes. I led a detailed proposal to bolster the core physics content of the undergraduate Meteorology degrees, important for those going on to research careers; this was enthusiastically welcomed by other members of staff, and was taken forward via the introduction of a new undergraduate programme "Environmental Physics". The posts I have held are as follows:

2011–2014 Head of Department for Research

2010–2011 Director of Research, Meteorology

2009–2010 PhD admissions tutor

2007–2008 Manager of the Meteorology Laboratories

2006–2007 Director of MSc Programmes, Meteorology

2006 Director of Undergraduate Studies, Meteorology (sabbatical cover, Jan–Sept)

2003–2005 Chair of the School of Mathematics, Meteorology and Physics Staff-Student Liaison Committee

Additional specific administrative responsibilities:

2012 Acting Joint Met Office Chair

2011–2014 Member of the School of Mathematical and Physical Sciences Steering Committee

2011 Chair of the Meteorology/ESSC Strategy Group

2009–2014 Member of the School of Mathematics, Meteorology and Physics Higher Degree by Research Board of Studies

2008–2011 Mentor for two new members of academic staff

2006–2007	Member of the School of Mathematics, Meteorology and Physics Teaching and Learning Committee and Board of Studies
2004	Designer of the Departmental Research Brochure
2003–2005	Member of the Faculty of Science Staff-Student Committee
2003–2006	Coordinator of module evaluation questionnaires, including designing a new School-wide system
2003–2014	Personal tutor for 15 undergraduate students

E. ACHIEVEMENTS AT ECMWF

My primary responsibility at ECMWF is to improve the treatment of solar and infrared radiative transfer. A major achievement was the introduction of my new open-source radiation scheme, ecRad (Hogan and Bozzo 2016, 2018), which became operational in July 2017 and amounts to around 16,000 lines of code. Compared to the old scheme, ecRad is more flexible, less noisy and around 41% faster for the same scientific configuration. Via the availability of my SPARTACUS solver, it is the first radiation scheme for a global model capable of representing the 3D radiative effects of clouds. In addition to its use at ECMWF, it is operational in the German Weather Service (DWD) ICON forecast model, available in the Meso-NH and MAR limited-area models, and being adapted for use in the ARPEGE and ISAC weather models and the CNRM and LMDZ climate models. The offline version (*https://confluence.ecmwf.int/display/ECRAD*) has many users in at least 9 countries.

My contributions to ECMWF model cycles are:

49r2	Implementation of time-varying aerosol climatology representing trends since the 1950s
49r1	Flexible treatment of aerosols and radiation, allowing mix of prognostic & climatological aerosol
48r1	Radiatively interactive prognostic ozone using "HLO" scheme, improving stratospheric forecasts
47r1	New MODIS land-surface albedo including solar-zenith angle dependence
47r1	Long-term variations in greenhouse gases and total solar irradiance to use CMIP6 scenarios
46r1	Activated longwave scattering for clouds
43r3	New radiation scheme ecRad became operational
43r1	Improvements to Total Solar Irradiance and the Photosynthetically Active Radiation diagnostic
42r1	Improved stratospheric temperature due to infrequent radiation calls (Hogan and Hirahara 2015)
41r2	Approximate update of fluxes every timestep/grid-point to improve forecasts at coastlines (Hogan and Bozzo 2015)

I have had several leadership roles at ECMWF:

- 2018: I led the organization of an ECMWF workshop on "Radiation in the Next Generation of Weather Forecast Models" held 21-24 May 2018. The workshop brought together over 50 radiation experts from 12 countries (*https://www.ecmwf.int/en/learning/workshops/workshop-radiation-next-generation-weather-forecast-models*).
- 2017: I led one of two Special Topic Papers to ECMWF's Science Advisory Committee, on "Radiation in Numerical Weather Prediction" (Hogan et al. 2017, ECMWF Technical Memorandum 816).
- 2016-2018: I led ECMWF's "Stratosphere Task Force", which brought together scientists from several ECMWF departments to work together to tackle ECMWF's longstanding problems with stratosphere analyses and forecasts. We contracted Professor Ted Shepherd FRS and Dr Inna Polichtchouk of the University of Reading to contribute to the activity. The outcomes were summarized by Shepherd et al. (2018, ECMWF Technical Memorandum 824).
- 2016-2017 and 2019: I coordinated the technical merging and scientific assessment of branches from the Physical Aspects team to Cycles 43R3 and 47R1 of ECMWF's Integrated Forecast System.

F. ENTERPRISE AND OUTREACH

- Three-hour presentations on Weather Forecasting and Thunderstorms at Year 3 of St Columba's School, St Albans, 12 March 2013, 10 March 2015, 11 March 2016 and 9 March 2017. This included many interactive demonstrations and a weather forecasting game

(*http://www.met.rdg.ac.uk/~swrhgnrj/schools*). The last visit also included a 40-min talk on a career in scientific research to GSCE and A-Level students.

- Two-hour presentation on Weather Forecasting and Thunderstorms at Year 3 of Spinfield School, Marlow, 6 March 2024.
- I collaborated with a new company *HALO Photonics* in the evaluation of a 1.5-μm Doppler cloud lidar. This is a pioneering new technology in lidar design, allowing continuous, unmanned measurements of wind at a far lower cost than ever before. It is now operating continuously at Chilbolton, I have published a paper (Hogan et al. 2009) with the Director of the company (Dr Guy Pearson) using the instrument, and the company has had many subsequent orders for these instruments.
- My fast automatic differentiation software "Adept" (*www.met.reading.ac.uk/clouds/adept*) is freely available and used by several companies including 4Dx (for their pulmonary imaging software), Wells Fargo bank, BBVA bank and Cimarex Energy company.
- I have provided commentary on high profile scientific issues; for example, I was quoted in the 7 November 2009 issue of *New Scientist* in an article entitled "Tomorrow's weather: cloudy, with a chance of fractals". I was interviewed on Radio Oxford on 29 August 2013.
- I created a web-site (*www.met.reading.ac.uk/radar/realtime*) displaying high resolution imagery from the cloud observing instruments at Chilbolton in real time, as well as storing an archive of previous images. This is very useful for understanding the properties of the atmosphere immediately above our heads and is used frequently in the Department's weekly "Weather and Climate Discussion". The site now gets around 1000 hits per month.
- I created a web-site (*www.met.reading.ac.uk/clouds/maxwell*) containing many animations of electromagnetic waves that illustrate the physics behind a wide range of optical phenomena and the workings of optical and microwave instruments. This site is an excellent educational resource and receives around 500 hits per month, as well as being used within the Department in our radiative transfer and remote sensing lecture courses. A visitor to the web site told me "The animations on your Maxwell2D page are fantastic. Despite a PhD in optics I'd only read about many of the effects you have demonstrated; you have really brought them to life."
- In the final work-package of the EU Cloudnet project we collaborated with lidar manufacturer *Vaisala* and radar manufacturers *Gematronik* and *Degreanne* in proposing the specification of a European network of cloud observing stations.

G. RESEARCH HIGHLIGHTS

My published papers have attracted over 17300 citations and I have an h-index of 51 (Web of Knowledge Author="Hogan RJ", Address= "Reading or ECMWF or European"). According to Google Scholar I have over 26800 citations and an h-index of 64.

1. Cloud structure and radiative transfer in weather forecast and climate models

The distribution of clouds in climate models is very important for the way in which they modulate solar and terrestrial radiation, and hence for forecasting surface temperature. Hogan and Illingworth (2000) introduced the concept of an "overlap parameter" to describe how clouds are overlapped vertically, extended to describe the overlap of cloud inhomogeneities (Hogan and Illingworth 2003). The resulting "exponential-random" overlap scheme has been implemented in a number of climate models used by the Intergovernmental Panel on Climate Change (e.g. the US GFDL and NCAR models, the German ECHAM5 model and the UK Met Office model), as well as the ECMWF model. I have developed a novel stochastic model to generate realistic 3D cirrus clouds and determine their radiative properties (Hogan and Kew 2005). I have quantified the role of 3D radiative transfer on the radiative forcing of both aircraft contrails (Gounou and Hogan 2007) and natural cirrus (Zhong et al. 2008), and developed a fast technique "SPARTACUS" to represent 3D radiative transfer in global models (Hogan and Shonk 2013; Hogan et al 2016). I have since adapted SPARTACUS for application to radiative transfer in vegetation (Hogan et al. 2018) and urban areas (Hogan 2019b). With a PhD student I developed the Tripleclouds scheme to represent cloud horizontal structure efficiently in the radiation schemes of models (Shonk and Hogan 2008, 2010) and have implemented this in the Met Office and ECMWF models (Shonk et al. 2012, Hogan and Bozzo 2018). I developed a method to significantly improve the efficiency of the treatment of gaseous absorption (Hogan 2010, Hogan and Matricardi 2022). My "ecRad" radiation scheme is used operationally in the ECMWF and DWD models (Hogan and Bozzo 2018) and available

at *https://confluence.ecmwf.int/display/ECRAD*. The innovativeness of my radiative transfer work was specifically praised in the citation for my 2014 Henry G. Houghton Award of the American Meteorological Society.

2. Mixed-phase clouds

A series of papers has uncovered the importance of mixed-phase clouds (those that contain a mixture of liquid water and ice), particularly the role of embedded convection and ice multiplication (Hogan et al. 2002), their radiative importance (Hogan et al. 2003b), their poor representation in current forecast models (Hogan et al. 2003c), their global distribution (Hogan et al. 2004) and their spatial structure (Field, Hogan et al. 2004). The findings of the first three were highlighted in NERC's 2001–2002 Annual Report (page 9) as "a key scientific advance", and led to my being awarded the 2005 L. F. Richardson prize of the Royal Meteorological Society. This work has spawned a number of modelling studies co-authored by myself (e.g. Phillips et al. 2003, Clark et al. 2005, Marsham et al. 2006), and with a PhD student we developed a single-column model to investigate the reasons why they are poorly captured in large-scale models (Barrett et al. 2017a,b).

3. Evaluation of clouds in forecast models

I have pioneered methods to evaluate objectively the representation of clouds in forecast models using data from the Chilbolton Observatory in Hampshire. This has included the development of retrieval algorithms (such as the dual-wavelength radar technique of Hogan and Illingworth 1999 and Hogan et al. 2000), and the first evaluation of model cloud fraction and ice water content (Hogan et al. 2001, 2006). This work was taken to a new level in the EU Cloudnet project (*www.cloud-net.org*; Illingworth, Hogan et al. 2007), in which my algorithms were used to evaluate 7 operational models over 4 European sites. The Cloudnet data archive hosted at Reading now has over 40 users from around the world. I secured funding from the US Department of Energy to further develop and apply the Cloudnet algorithms to decade-long datasets from the various US "Atmospheric Radiation Measurement" sites worldwide, providing an even tighter constraint on forecast models. I led the DYMECS project, which used a novel storm-tracking algorithm for the large weather radar at Chilbolton to evaluate the structure and updraft strength of convective clouds in the Met Office cloud-permitting forecast model (Stein, Hogan et al. 2015; Nicol, Hogan et al. 2015).

4. Development of synergy algorithms for CloudSat, Calipso and EarthCARE

I am recognised as a world expert in combining active and passive satellite instruments for retrieving the properties of clouds. With NERC funding, a postdoc and I have developed and applied a method for combining data from the CloudSat radar, the Calipso lidar and the MODIS radiometer to retrieve ice cloud properties (Delanoë and Hogan 2008, 2010). It is based on the rigorous mathematical approach of optimal estimation theory (similar to data assimilation). We used it to reveal significant discrepancies in the ECMWF and Met Office forecast models, and ECMWF used these results to guide the development of their new cloud scheme (Delanoë et al. 2011). Our "DARDAR" retrievals are available for a number of years of CloudSat and CALIPSO data from *https://www.icare.univ-lille.fr/dardar/*. Our algorithm has inspired the development of the "official" CloudSat-Calipso ice-cloud algorithm in the US.

My work in evaluating the potential for a proposed satellite (EarthCARE), to carry a cloud radar and lidar on the same platform, was instrumental in its being selected by the European Space Agency (ESA) for deployment. I am Co-Chair of the EarthCARE Mission Advisory Group and am centrally involved in developing algorithms for EarthCARE, having been awarded five ESA grants since 2007 (CASPER, RATEC, VARSY, DORSY and CARDINAL). These have supported my pioneering of the first "unified" synergetic retrieval scheme "CAPTIVATE" (Mason, Hogan et al. 2023), in which the properties of clouds, aerosols and precipitation are retrieved simultaneously by combining radar, lidar and radiometer. Two important algorithmic breakthroughs have made this possible. The first is a new, rapid model for radar and lidar multiple scattering (Hogan 2006, 2008; Hogan and Battaglia 2008), including the use of the time-dependent form of the two-stream radiative transfer equations for the first time, and available at *http://www.met.reading.ac.uk/clouds/multiscatter*. The second is my fast method for automatic differentiation (Hogan 2014), released in the C++ package "Adept" at *http://www.met.reading.ac.uk/clouds/adept*. Another important development has been the Self Similar Rayleigh Gans Approximation for computing ice-particle scattering by microwaves (Hogan and Westbrook 2014; Hogan et al. 2017), available at *http://www.met.reading.ac.uk/clouds/ssrga*.