

# Rachel Frances Warren

## PERSONAL RECORD

**Born:** 8 July 1964 in Sussex, UK

**Qualifications:** O-levels, 9 at Grade A (1980), A-levels 4 at Grade A (1982) in Mathematics, Physics, Chemistry, Further Mathematics, and Special Mathematics Grade 1

BAHons, 1985 (Natural Sciences, Cambridge);

PhD Physics, 1989 (Cavendish Laboratory, Cambridge)

Open University, Credit in Ecology with Distinction (1996)

**Professional awards: Outstanding scientific paper award**, Environmental Research Laboratories, National Oceanic and Atmospheric Administration, United States Dept of Commerce, 1996

**Previous appointments:** 1990-1992: Research Associate, National Oceanic and Atmospheric Administration/Cooperative Institute for Research in Environmental Sciences, University of Colorado. Boulder, Colorado USA

1992 -2000: Senior Research Fellow, TH Huxley School of Environment, Earth Sciences & Engineering, Imperial College, London UK

2000-2001: Research Lecturer & Head of Integrated Assessment Unit, TH Huxley School, Imperial College (as above).

2004 (May – Nov) : Part-time Grade 7 post, Global Atmosphere Division, Department of the Environment, Food and Rural Affairs (DEFRA)

**Present appointment:** 2002 - : Senior Research Fellow, Tyndall Centre for Climate Change, School of Environmental Sciences, University of East Anglia, Norwich UK

Voluntary commitment (2004-2007): Lead Author for IPCC Working Group III, Chapter 3 “Long-term aspects of mitigation” and reviewer for IPCC Working Group II.

## RESEARCH AND ACADEMIC/PROFESSIONAL STANDING

### Research Achievement:

In January 2002 I took up the post of Tyndall Senior Research Fellow in Integrating Frameworks at the new Tyndall Centre for Climate Change headquarters at UEA in Norwich. Here my main interests are in **integrated assessment of climate change** and I am **leading a Tyndall Centre flagship project** on this topic. I manage and coordinate the **development and operation of a multi-institutional, multi-disciplinary, distributed and modular integrated assessment model (IAM)** which has already produced a **pilot version available through a web portal**. I have ensured synergy between key policy requirements and application of the integrated assessment model and **co-developed and prioritized policy questions with key stakeholders such as DEFRA**. I have **led a technical team** to provide the computational ability which necessarily underpins the existence of a distributed multi-institutional modular system. I am now using the integrated assessment model to answer **key policy questions concerning the costs and benefits of stabilization of greenhouse gas concentrations** in the atmosphere and the **damages** inflicted by climate change on the environment. Thus current research involves (i) investigation of economic pathways to climate stabilisation scenarios (ii) investigation of the robustness of policy relevant integrated assessment results to uncertainties. Longer term plans involve a study of (iii) how climate impacts on ecosystems and human systems, and how these in turn damage the economy, taking into account extreme meteorological events (iv) investigation of the interaction between land use change, agriculture and climate (v) investigation of the potential for joint management of climate change policy and air pollution policy. Coordination of IAM creation involves collaboration with members of the distributed Tyndall Centre, with other UK institutions, and with several key institutions in Europe.

As Research Lecturer and head of the Integrated Assessment Unit (IAU) at Imperial College, **my work on integrated assessment modelling (IAM) was used (1) in the development of international UN ECE protocols and (2) to underpin the position of the UK during the negotiation of these protocols**, through the Department of the Environment, Transport and the Regions. IA involves the use of computer models to

derive **cost-effective European emission abatement strategies** for emissions of oxides of sulphur and of both oxidised and reduced nitrogen in order to ameliorate acidification, eutrophication, tropospheric ozone and human exposure to secondary particulate material (PM<sub>10</sub>)s. To do so I **developed the new modularised multi-pollutant Abatement Strategies Assessment Model (ASAM)** at Imperial College and used it and another IAM, RAINS to critique and construct future scenarios for emission abatement. The model is underpinned by a sound understanding of the relevant atmospheric transport and chemistry processes. The work was carried out in the context of the work of the UN Economic Commission for Europe in their preparations for the 1994 European sulphur protocol, and in 1999 recently the Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-Level Ozone. I **played a leading role in demonstrating robustness of IAM results to model uncertainties thus increasing policy makers' confidence in the scientific information presented to them.** Developed 'particulate exposure' version of ASAM which examines **strategies to reduce human exposure to secondary particulates** and was the first to demonstrate to the international community the benefits of emission reduction policies in terms of reduction of such exposure.

Previous work at the NOAA Aeronomy Laboratory in Colorado, USA (1990-1992), involved laboratory studies of substances which harm the ozone layer or contribute to greenhouse warming, and **has made a major contribution to decisions on the environmental acceptability of many CFC substitutes.** In particular, rate constants and ultraviolet absorption cross-sections were measured in order to determine lifetimes of chlorofluorocarbon substitutes including fluorocarbons in the atmosphere.

I am a **lead author on the IPCC's Fourth Assessment Report** in a chapter which will discuss long-term scenarios of climate change to 2100.

## TEACHING

**Supervision of PhD students** studying interaction between air pollution and climate policies at the regional scale (UEA, 2002 - ), IAM of particulate matter and IAM at the city scale (IC, 1998 – 2001).

**Supervision of MSc project** (IC, 1997) investigating the influence of the Kyoto protocol on integrated assessment studies of emission reduction schemes.

**Graduate Lectures:** For MSc in Climate Change (UEA, since 2002): Integrated assessment of climate change. For MSc in Environmental Technology (IC, 1997-2001): 'Stratospheric Ozone Depletion', 'Long-range Transboundary Air Pollution'.

**Graduate Seminars:** For MSc in Environmental Technology (IC, 1999-2001): 'Critical Thresholds for Air Pollution', 'Response of Industry to Proposed Environmental Regulations'.

**Graduate Case Studies:** For MSc in Environmental Technology (IC, 2000-2001): Students' choice, e.g. climate change levy.

**Undergraduate Tutorials:** For second-year Earth Sciences students (IC) 'Air Pollution and the Geological Record' (1999-2001) For first year natural science students (Cambridge, 1986-1989) Entire course 'Mathematics for Natural Scientists'.

**OU video:** 'History of Air Pollution', 2002.

## Professional Consultancy Work

1. 1998-1999 In collaboration with ITE and CONCAWE: Role of shipping emissions  
In collaboration with AEA Technology the following contracts have been carried out:
2. 1998-1999 Critical review of cost curves used in integrated assessment modelling
3. 1999 Cost-benefit study for proposed Gothenburg protocol
4. 2000 Further cost-benefit study for proposed EC directive
5. 1999-2000 In collaboration with British Trust for Ornithology : Acidification and Terrestrial Birds
6. 2001-2002 In collaboration with British Trust for Ornithology : Avian Research in London (study of effects of air pollution on bird abundance).
7. 2002 Paper for OECD conference on benefits of climate mitigation, Paris, Dec 2002.
8. 2005 Collation of tables of climate impacts on ecosystems, human systems and the earth system for DEFRA Exeter conference "Avoiding dangerous climate change".

## Organisation, Management and Promotion of Research

2004: Successfully bid for funding for three Tyndall-funded projects. I now lead these three teams as principal investigator: (a) softIAM, a technology for community integrated assessment (b) linkages between

air pollution and climate (c) climate change on a millennial timescale.

2002-2004 Lead Tyndall flagship project on integrated assessment of climate change.

2003: Successfully bid for funding from European Science Foundation to hold international workshop at Clare College, Cambridge to plan the future of the Community Integrated Assessment Modelling between a group of European institutions. The workshop led to a concrete plan for future research.

1999-2001 Head of Integrated Assessment Unit, Environmental Measurement, Modelling and Assessment Group, Imperial College.

1999: Successfully bid for research contract to investigate effect of acidification on terrestrial birds and coordinated the now complete study which was in collaboration with University of Edinburgh, Institute of Terrestrial Ecology and British Trust for Ornithology (BTO) which suggested links between acid deposition and declines of some bird species not previously known to be affected.

**Major academic visits and collaborations** I have set up a multi-institutional working group to take forward the research plans for community integrated assessment modeling. Members include the Potsdam Institute for Climate Research (Germany), RIVM (Netherlands), and CIRED (France). Collaboration with International Institute of Applied Systems Analysis (IIASA) in Austria on (1) integrated assessment of primary PM10 (1999-2000) and (2) critical study of cost curves used in integrated assessment modeling. Several collaborations with AEA technology (see under professional consultancy) and BTO (see above).

### **Other relevant experience**

In 2004 I worked on-loan in DEFRA Global Atmosphere Division, managing part of the Hadley Centre contract and writing briefs on climate change science for ministers, the Secretary of State and Tony Blair. Hence I gained further experience of working at the science-policy interface and in directly being involved in the political application of new Hadley Centre climate science, such as the attribution of the extreme European 2003 summer to anthropogenic causes.

### **Selected Conferences/Seminars attended**

1. Avoiding Dangerous Climate Change, DEFRA Exeter Conference, 2005
2. May 2000 Millennium NATO/CCMS International Technical Meeting on Air Pollution Modelling and its Application, Boulder, USA
3. SCOPE meeting, Integrated Assessment, at the Royal Society, 27 September 1999
4. HART Particulate Matter conference, Brussels, 20-21 Oct 1999
5. UNECE Task Forces on Integrated Assessment Modelling, Stockholm, 2000; Rome, June 1999; Switzerland, March 1999; London, Dec 1998; Helsinki, June 1998; Madrid, Dec 1997; Copenhagen June 1997; Vienna December 1996; Geneva June 1996; The Hague December 1995; Grimmentz, May 1995, Prague, December 1994, Bilthoven June 1994, London 1993, Geneva 1993, Bilthoven 1992, Geneva 1992.
6. UNECE Task Forces on Economic Aspects of Abatement Strategies The Hague 1995, Bilthoven 1994, Geneva 1993, London 1993, Bilthoven 1992
7. Acid Reign 95, June 1995: Gothenburg
8. American Geophysical Union Fall Meeting, Dec 1990, San Francisco

### **ADMINISTRATION**

**Service on external bodies:** Represent Tyndall at NERC NCAS committee (National Centre for Atmospheric Science) and NiEES (National Environmental e-Science partnership between NERC and University of Cambridge).

**Other experience:** Organise Norfolk Spotted Flycatcher Monitoring Project for British Trust for Ornithology; survey Norfolk birds for British Trust for Ornithology; organised the computerised data and wrote monthly/annual reports for Runnymede Bird Ringing Group 1999-2001. Treasurer, Boulder Audubon Society; 1990. Music committees at Newnham College, Cambridge (1988) and Boulder (1991).

### **PUBLICATIONS**

#### **Refereed Journals**

1. WARREN, R.F., and ApSimon, H.M., 'Uncertainties in Integrated Assessment Modelling of Abatement Strategies: Illustrations with the ASAM Model', *Environmental Science and Policy*, 2, 1999, 439-456.
2. WARREN, R.F., and ApSimon, H.M., 'Selection of Target Loads for Acidification in Emission

Abatement Policy: the use of Gap Closure Approaches', *Water, Air and Soil Pollution*, 121, 2000, 229-258.

3. WARREN, R.F., and ApSimon, H.M., 'The Role of Secondary Particulates in European Emission Abatement Strategies: Illustrations using the Abatement Strategies Assessment Model, ASAM', *Integrated Assessment*, 1, 2000, 63-86.
4. WARREN, R.F., and ApSimon, H.M., 'The Abatement Strategies Assessment Model, ASAM: Robustness Studies, Illustrative Results, and Investigation of the Role of European Countries in Sulphur Dioxide Emission Reduction Schemes' *Journal of Environmental Management*, 59, 2000, 3-20.
5. WARREN, R.F., and ApSimon, H.M., 'Application of Limiting Marginal Abatement Costs in Optimised Strategies to Reduce Acidification and Eutrophication In Europe: Illustrations using the Abatement Strategies Assessment Model, ASAM', *Journal of Environmental Assessment Policy and Management*, 2, 2000, 119-166.
6. WARREN, R.F. 'Biodiversity'. Chapter 8 'Acid Rain - Counting the Cost', eds. ApSimon H.M. and Pearce, D. ISBN 1853834432 Earthscan, September 1997
7. WARREN, R.F., Gierczak, T., and Ravishankara, A.R. 'A Study of O(<sup>1</sup>D) Reactions with CF Substitutes', *Chemical Physics Letters*, Vol. 183, no. 5, pp 403-409, 1991
8. WARREN, R.F., and Ravishankara, A.R., 'Kinetics of Cl<sup>2</sup>P Reactions with CF<sub>3</sub>CHCl<sub>2</sub>, CF<sub>3</sub>CHFCI and CH<sub>3</sub>CFCl<sub>2</sub>' *Int. J Chem. Kinet.* Vol. 25 pp. 833 - 844
9. Ravishankara, A.R., Solomon, S., Turnipseed, A.A., and WARREN, R.F., ' Atmospheric Lifetimes of Long-lived Halogenated Species' *Science*, Vol. 259, pp. 194-99, 1993. Winner of 'Outstanding Scientific Paper Award' NOAA/US Dept of Commerce.
10. Oxley, T., ApSimon, H., Dore, Sutton, M., Hall, J., Heywood, E., Gonzales del Campo, T., and WARREN, R. *Integrated Assessment 2003*, Vol 4, pp. 236-249
11. Dessai, S., Adger, WN, Hulme, M, Turnpenny, J, Kohler J and WARREN, RF, 'Defining and Experiencing Dangerous Climate Change' *Climatic Change* 64, 11-25, 2004.
12. ApSimon, H.M., and WARREN, R.F., 'Transboundary Air Pollution in Europe', *Energy Policy* 24-7, 1996, 631-640
13. ApSimon, H.M., WARREN, R.F., and Wilson, J.J.N., 'The Abatement Strategies Assessment Model, ASAM-II: Applications to Reductions of Sulphur Dioxide Emissions Across Europe', *Atmospheric Environment*, Vol, 28, no 4., pp 649-664
14. ApSimon, H.M. and WARREN, R.F., 'Abatement Strategies for Sulphur Dioxide, and Analysis of the Role of Emissions from Central and Eastern Europe', *Idojaras*, vol 96 no. 4, pp 207-221, 1992
15. ApSimon, H.M., Couling, S., Cowell, D., and WARREN, R.F., 'Reducing the Contribution of Ammonia to Nitrogen Deposition Across Europe', *Water, Air and Soil Pollution*, 1996
16. Talukdar, R.K., WARREN, R.F., Vaghjiani, G.L. and Ravishankara, A.R., 'Kinetics of the Reaction of H(<sup>2</sup>S) with HBr', *Int. J. Chem. Kinet.* Vol. 24, pp. 973-982, 1992
17. Vaghjiani, G., Turnipseed, A.A., WARREN, R.F., and Ravishankara, A.R., 'Photodissociation of H<sub>2</sub>O<sub>2</sub> at 193 and 222 nm: products and quantum yields' *J.Chem. Phys.*, Vol. 96, no 8, pp. 5878-5886, 1992
18. Schmoltner, A.M., Talukdar, R.K., WARREN R.F., Mellouki A., Goldfarb, L., Gierczak, T., McKeen, S.A., and Ravishankara, A. R., 'Kinetics of the Reactions of several hydrofluorocarbons with OH and O(<sup>1</sup>D) and their atmospheric lifetimes', *J. Chem. Phys.* Vol. 97, no. 35, pp. 8976-8982, 1993.
19. Talukdar, R.K., WARREN, R.F. and Ravishankara, A.R., 'Photolysis of CF<sub>2</sub>ClBr at 193, 222 and 248 nm', *Int. J. Chem. Kinet* Vol. 26, 1994
20. WARREN, R.F. and Liang, W.Y., 'Raman Spectroscopy of new lead iodide intercalation compounds', *J. Phys. Condens. Matter* Vol. 5, pp 6407-6418, 1993

Schellnhuber, H.J., Warren, R.F., Haxeltine, A., and Naylor, L., "Developments in Integrated Assessment: The Co-productive Approach" In proceeding of OECD workshop "Benefits of Climate Policy" 12-13 Dec 2003. OECD, 2004.

Warren, R.F., and ApSimon, H.M., 'Integrated Assessment Modeling of Abatement Strategies: Role of Uncertainties', in 'Air Pollution Modelling and its Applications XIV', eds. Gryning and Schiermeier, Kluwer Academic/Plenum Publishers, New York, 2001

### **Recent Reports**

Warren, R. A blueprint for integrated assessment of climate change. Tyndall Technical Report. [www.tyndall.ac.uk](http://www.tyndall.ac.uk), 2002.

Chamberlain, D.E., Warren, R.F., Crick, H.Q.P., Hall, J., Metcalfe, S., Ormerod, D., Whyatt, D., and Vickery, J.A., 'Acidification and Terrestrial Birds', British Trust for Ornithology Research Report No. 236, 2000. National Centre for Ornithology, Thetford, Norfolk IP24 2PU, UK

Buckley-Golder, D.H., Goodwin, J., Holland, M., Passant, N., Forster, D., King, K., Walker, C., ApSimon, H., Cowell, C., Warren, R., Bull, K., Hall, J., Ulyett, J., Derwent, D., Metcalfe, S., Whyatt, D 'Costs and Benefits for the UK of Complying with the EC National Emissions Ceilings and Ozone Directive and the UN ECE multi-pollutant, multi-effect protocol', Report to Department of Environment, Transport and the Regions, AEA Technology, November 1999

Warren, R.F. 'Exposures of Crops to Levels of AOT40 in excess of threshold' Informal Note 5 to DETR, 8 July 1999

Warren, R.F., 'Comparison of UK and European Benefits on the J1 scenario and alternative scenarios', Informal Note 4 to DETR, July 16, 1999

Warren, R.F., 'AOT40 and AOT60 Exposures for various UK emission ceilings', Informal Note to DETR, 1 July 1999

Warren, R.F., 'RAINS Web Model Study of Influence of UK NOX and VOC Emission Ceilings on Ozone Levels in the UK and Europe', Report to DETR, 16 June 1999

Warren, R.F., 'Studies of Tropospheric Ozone Amelioration in ECE Region Using the RAINS web Model', Report to DETR, April 1999

Warren, R.F., 'Investigation of the WGS31b scenario and comparison with previously investigated scenarios', report to DETR, Dec 1999

Passant, N.R., Wenborn, M.J., Richardson, S., Woodfield, M., Warren, R.F., Cowell, D., Turner, G., and Hall, D. 'Review of IASA Cost Curves for the Reduction of Emissions of Nitrogen Oxides, Sulphur Dioxide, Ammonia and Volatile Organic Compounds', report for Department of the Environment, Transport and the Regions (DETR), March 1998

Warren, R.F., and ApSimon, H.M., 'Reduced requirements for controlling land-based emissions of sulphur dioxide if ship emissions are controlled', in 'Costs and Benefits of Controlling Sulphur Dioxide Emissions from Ships in the North Sea and Seas to the West of Britain', report for Department of the Environment, Transport and the Regions (DETR), May 1998

ApSimon, H.M., Cowell, D., and Warren, R.F. 'Preliminary Analysis of European scenarios for abatement of ammonia emissions from agriculture in relation to a new nitrogen protocol'. Working group on Abatement Techniques, Geneva, July 1996

ApSimon, H.M., Warren, R.F., and Leggett, S. 'VOC Cost Curves for integrated assessment modelling: requirements and methodology'. UN ECE workshop on VOC abatement options and their costs for use in integrated assessment modelling, Karlsruhe, Germany, Oct 1996

Wenborn, M.J., Marlowe, I.T., Woodfield, M.J., Passant, N.R., Richardson, S.J., Emmott, M.A., Warren, R.F., Leggett, S.M., ApSimon, H.M. and Smith, S., 'VOC Emissions in Europe: An Assessment of the Potential for Abatement and an Estimate of the Associated Costs', AEA/CS/20011001/REMA-167, November 1995

## **TFIAM reports**

Warren, R.F., and ApSimon, H.M., 'Summary of Integrated Assessment Modelling Studies Using ASAM', Report to 23<sup>rd</sup> Task Force on Integrated Assessment Modelling, March 1999, Switzerland

Warren, R.F., and ApSimon, H.M., 'Aspects of Integrated Assessment Modelling: part A, Robustness of Abatement Strategies; part B: The Additional Effects: Eutrophication and Human Exposure to Secondary Particulates', Report to 22<sup>nd</sup> UN ECE Task Force on Integrated Assessment Modelling, London, Dec 1998

Warren, R.F., and ApSimon, H.M., 'Report for 21<sup>st</sup> UN ECE Task Force on Integrated Assessment Modelling', Helsinki, May 1998

Warren, R.F., and ApSimon, H.M., 'Abatement Strategies to Reduce Acid Deposition to Ecosystems', report to 20<sup>th</sup> UN ECE Task Force on Integrated Assessment Modelling, Madrid, Dec 1997

ApSimon, H.M., and Warren, R.F., 'Abatement Strategies to Reduce Particulate Concentrations across Europe', report to 20<sup>th</sup> UN ECE Task Force on Integrated Assessment Modelling, Madrid, Dec 1997

Warren, R.F., and ApSimon, H.M., 'Report to 19th UN ECE Task Force on Integrated Assessment Modelling', Copenhagen, June 1997

ApSimon, H.M., and Warren, R.F. 'The Role of Particulates in Developing European Abatement Strategies to Reduce Emissions of SO<sub>2</sub>, NO<sub>x</sub> and NH<sub>3</sub>', report to UN ECE Task Force on Economic Aspects of Abatement Strategies, Copenhagen, June 1997

ApSimon, H.M., and Warren, R.F., 'Handling Uncertainty in developing Abatement Strategies to combat transboundary air pollution', report to 18<sup>th</sup> Task Force on Integrated Assessment Modelling, Laxenburg, Austria, December 1996

ApSimon, H.M. and Warren, R.F., 'Preliminary Analysis of multi-pollutant abatement strategies for transboundary transport of nitrogen species', Report to 17<sup>th</sup> UN ECE Task Force on Integrated Assessment Modelling, Grimsen, Switzerland, May 1996