

UGAMP Newsletter



Issue 23

September 2000

Editors: Glenn Carver, Mike Blackburn

Director: Alan O'Neill

UGAMP Conference 2000: 19-21 September 2000 The Royal Institution, London

gaff cols

Conference details

This year's UGAMP conference will be held at The Royal Institution in central London, from Tuesday 19th to Thursday 21st September. The conference is being organised by Dr. Mike Blackburn and Dr. Joanna Haigh. Oral sessions will be held in the Faraday Lecture Theatre of the Royal Institution.

Tea and coffee will be provided for the morning and afternoon breaks in the Long Library. Delegates will be expected to make their own arrangements for lunch and for evening meals, except for the conference dinner.

There will be a meeting of the UGAMP Scientific Steering Group, at 5.30pm on Tuesday 19th, in the Council Room of the Royal Institution.

Posters

Posters will be displayed outside the Faraday Lecture Theatre, in the Ante Room and Red Corridor, throughout the conference. Individual posters will be linked to and announced in the oral sessions. Presenters are encouraged to mount posters immediately before the conference begins, from 9.30am on the morning of Tuesday 19th. Posters must be taken down by 5pm on 21st. Velcro will be provided for mounting posters.

Contents

Conference Programme	3
Posters	6
Abstracts	8
Web Sites	47

Conference dinner

The conference dinner will be a buffet held on Tuesday 19th September at the Royal Institution, starting at 6.45pm. Wine and soft drinks will be available from 6pm. Dress smart casual.

Accommodation

Accommodation during the meeting will be provided at Imperial College in South Kensington. Breakfast is from 7.30 to 10am.

When arriving at Imperial College, delegates should report to the Summer accommodation reception office, which is situated in Linstead Hall on the east side of Princes Gardens, off Exhibition Road. The office is open 24 hours and keys may be collected from 2pm on the day of arrival.

Travel

We strongly suggest travelling to the conference by public transport, since we are unable to offer any parking space at Imperial College.

Imperial College can be reached by underground, via South Kensington station on the Piccadilly Line. The pedestrian tunnel from the station emerges beyond the Science Museum in Exhibition Road. Princes Gardens is 100 metres further on the other (east) side.

The number 9 bus runs along Kensington Gore from Piccadilly Circus. Alighting at Exhibition Road, Princes Gardens is 200 metres down the hill on the left.

The Royal Institution is in Albermarle Street off Piccadilly and is best reached either by underground

from Green Park or Piccadilly Circus station, or by number 9 bus from Kensington Gore. The Royal Institution is 3km from Imperial College and may also be reached on foot via Hyde Park, the Wellington Monument and Green Park.

Expenses

The cost of the UGAMP meeting, travel, accommodation, breakfast and the conference dinner will be met by the Centre for Global Atmospheric Modelling (CGAM), Reading, for all eligible UGAMP and UGAMP-affiliated researchers and students. UGAMP researchers can claim for the actual cost of meals up to a maximum of £5 for each lunch and £10 for dinner. Queries about expenses should be emailed to Anne Pinnock (anne@met.rdg.ac.uk). Travel and meal receipts, or a photocopy of a group dinner bill, should be attached to claim forms.

Expense claim forms can be obtained from local site contacts or, failing that, from Anne Pinnock. Completed forms should be returned to Anne (not to Reading Finance Office) at the following address:

Anne Pinnock, CGAM, Dept. of Meteorology, University of Reading, Earley Gate, PO Box 243, Reading RG6 6BB.

Contact information and addresses

All queries concerning the programme and arrangements at the Royal Institution should be directed to Dr. Mike Blackburn at CGAM, Reading (Tel: 0118 931 8327, fax 0118 931 8316, email M.Blackburn@Reading.ac.uk).

All queries concerning accommodation and local arrangements at Imperial College should be directed to Dr. Joanna Haigh (Tel: 020 7594 7671, email J.Haigh@ic.ac.uk).

The Royal Institution of Great Britain is at 21 Albermarle Street, London W1X 4BS (Tel: 020 7409 2992). Anyone needing to contact a delegate at the Royal Institution should make it clear that the person is attending the UGAMP conference and give Dr. Mike Blackburn as an alternative contact name.

The Summer accommodation reception office at Imperial College is located in Linstead Hall, Princes Gardens, South Kensington, London SW7 1LU (Tel: 020 7594 9495). A message-board is used to leave incoming telephone messages for delegates.

Mike Blackburn / Glenn Carver

2000 UGAMP Conference Programme

19 - 21 September, The Royal Institution, London

Tuesday 19 September

10.00 Coffee

10.30 A. O'Neill Introduction

SESSION THEME: Decadal Variability of the Coupled Ocean-Atmosphere System

10.45 R. Sutton The Role of the Extratropical Oceans in Decadal Climate Variability
 11.00 P.-P. Mathieu Response of the atmosphere - ocean mixed layer system to anomalous convergence of ocean heat transport
 11.15 B. Dong Variability in North Atlantic heat content and heat transport in a coupled ocean-atmosphere GCM
 11.30 G. J. Gladman Low Frequency Variability in an Isopycnic Model of the North Atlantic Ocean
 11.45 M. Collins The Relative Roles of Initial and Boundary Conditions in Interannual to Decadal Climate Predictability
 12.00 M. R. Allen Quantifying uncertainty in decadal climate forecasting: the background to the Casino-21 project
 12.15 D. A. Stainforth Casino 21: Progress towards a Multi-Million Member Climate Ensemble Experiment
 12.30 Lunch

SESSION THEME: Ozone Variability and Trends

14.00 G. A. Cahill Quantification of the Polar Contribution to Mid-latitude Ozone Loss
 14.15 A. Jrrar A 3-D Model Study of Ozone Trends in the Middle Latitudes: The Significance of Dynamical Processes
 14.30 B.-M. Sinnhuber How well do we understand Arctic ozone depletion?
 14.45 E. F. Shuckburgh Interannual variability in the springtime Arctic polar vortex
 15.00 C. H. Bridgeman Examination of Summer high-latitude ozone values using the SLIMCAT CTM
 15.15 S. P. Lawrence Atmospheric teleconnections from TOMS ozone data
 15.30 Tea
 16.00 P. Braesicke Variability and Trends of Total Ozone as simulated by the UM using a simplified chemistry
 16.15 S. M. Rosier The effect of two decades of ozone change on stratospheric temperature as indicated by a general circulation model
 16.30 J. D. Haigh Model simulations of the impact of the 27-day solar rotation period on stratospheric ozone

SESSION THEME: Numerical Modelling Techniques

16.45 M. E. Hubbard Adaptive mesh refinement for three-dimensional off-line chemical transport
 17.00 B.M.-J.B.D. Walker A large timestep Godunov-type model for global atmospheric chemistry and transport
 17.15 J. R. Elliott High-resolution simulations of atmospheric convection: a new approach
 17.30 Finish
 17.30 UGAMP Scientific Steering Group meeting
 18.45 Conference Dinner

2000 UGAMP Conference Programme

Wednesday 20 September

SESSION THEME: Transport and Mixing in the Upper Troposphere / Lower Stratosphere Region

09.00	J. Thuburn	The Temperature Structure of the Tropical Substratosphere
09.15	J. Methven	Transport in the Tropical Tropopause Zone Diagnosed using Trajectories
09.30	R. N. Bannister	Stratosphere-Troposphere Exchange of Water Vapour in the Tropics: A "Unified Model" Perspective
09.45	A. R. Gregory	The sensitivity of simulated tropical tape-recorders to the numerical advection scheme used
10.00	V. West	How old is stratospheric air in the Unified Model?
10.15	O. Morgenstern	Quantifying Mixing in the Stratosphere From the Distribution of Long-Lived Tracers
10.30	Coffee	
11.00	M. N. Jukes	Freeze Drying at the Winter Mid-latitude Tropopause
11.15	P. H. Haynes	Transport, mixing and chemistry in frontal circulations
11.30	S. R. Arnold	High resolution modelling of fine-scale chemical structures in the troposphere
11.45	F. M. O'Connor	Ozone Budget of the Upper Troposphere : Measurements and Modelling

SESSION THEME: Data Assimilation

12.00	R. Brugge	Assimilation of MLS temperature into the Met. Office NWP system
12.15	H. Struthers	The assimilation of MLS ozone using the Met. Office's assimilation system
12.30	D. J. Lary	Chemical Data Assimilation: What has been achieved so far?
12.45	Lunch	

SESSION THEME: Extratropical Dynamics

14.15	L. C. Shaffrey	The Northern Hemisphere Storm Tracks in HadAM3: Systematic Errors and their Sensitivity to the Representation of the Rockies
14.30	D. Anderson	Representation of storm track variability in the UK Met Office Unified Model - HADAM3
14.45	L. Barry	Eddy heat transports and the temperature structure of the atmosphere
15.00	M. H. P. Ambaum	Stationary waves in a linearized quasigeostrophic model
15.15	P. Berrisford	The Arctic Oscillation
15.30	Tea	

SESSION THEME: The Quasi-Biennial Oscillation and Gravity Waves

16.00	S. D. Ibbotson	A Modelling Study of Decadal Variability in the Northern Middle Atmosphere
16.15	W. A. Norton	Have we missed some dynamics about the QBO?
16.30	B. N. Lawrence	Downward control effects on the period of the QBO in a three dimensional mechanistic model
16.45	M. E. McIntyre	The origin and fate of "missing forces" that arise during gravity wave propagation
17.00	C. D. Warner	Is a continuous atmospheric gravity wave spectrum the most appropriate choice for parametrizations?
17.15	Finish	

2000 UGAMP Conference Programme

Thursday 21 September

SESSION THEME: Tropical Variability

09.00	P. M. Inness	Representation of the Madden-Julian Oscillation - a tough test for a coupled model
09.15	C. P. Batstone	A method for capturing the Madden-Julian Oscillation from observed data
09.30	A. J. Matthews	The Extratropical Response to Tropical Intraseasonal Convection during Northern Winter
09.45	R. Washington	Tropical-Temperate Troughs over Southern Africa and the SW Indian Ocean
10.00	M. P. Cresswell	Evaluation of UKMO HADAM3 Model Simulations to Predict the Onset of the West African Monsoon
10.15	Coffee	
10.45	H. Spencer	Modelling the Global Effects of El Niño and La Niña
11.00	R. B. Neale	El Niño's influence in the Tropical Atlantic - Ignore the basic state at your peril
11.15	S. J. Brentnall	Influence of the Galapagos Islands on Tropical Instability Waves
11.30	K. J. Richards	Waves, layers and fingers; mixing in the equatorial Pacific
11.45	E. Black	Indian Ocean SST variability and its effect on tropical East African rainfall over the last 128 years
12.00	Lunch	

SESSION THEME: Climate Processes and Earth System Modelling

13.30	K. S. Law	Chemistry-Climate Interactions in the Upper Troposphere and Lower Stratosphere: An overview
13.45	D. E. Shallcross	Climate change, the biosphere bites back
14.00	D. S. Stevenson	Development of a Troposphere-Stratosphere-Chemistry-Climate model
14.15	I. A. MacKenzie	Middle-Atmospheric Water Vapour in the Unified Model
14.30	R. J. Harding	Land Surface Feedbacks in the Hadley Centre GCM
14.45	E. J. Highwood	The climatic impact of the eruption of Laki, Iceland, in 1783
15.00	Tea	
15.30	P. J. Valdes	Understanding past climate change: the role of the coupled climate system
15.45	D. J. Lunt	Modelling the global dust cycle
16.00	R. G. Gonard	Effects of elevated carbon dioxide concentrations on the emissions of volatile organic compounds from simulated ancient ecosystems and their impact on paleo-atmospheric chemistry
16.15	D. J. Beerling	The terrestrial carbon cycle response to rapid global warming at the Paleocene /Eocene transition
16.30	B. F. Murphy	Simulating the mass balance of the Greenland ice sheet with high resolution models
16.45	L. Steenman-Clark	Grid Computing - the way forward?
17.00	Conference end	

Posters

Number	Presenter	Session / Title
<u>Decadal Variability of the Coupled Ocean-Atmosphere System</u>		
1.	M. R. Allen	Nonlinearity in the atmospheric circulation response to anthropogenic forcing
2.	B. Booth	A self-contained version of the Unified Model in a PC environment for the development of perturbation analyses
3.	J. A. Kettleborough	Benchmarking the UM for CASINO 21
4.	H. Snaith	COAPEC: Coupled Ocean Atmosphere Processes and European Climate
5.	D. Frame	PREDICATE: Mechanisms and Predictability of Decadal Fluctuations in Atlantic-European Climate
<u>Ozone Variability and Trends</u>		
6.	C. H. Bridgeman	The effects of lifetime and source region on the stratospheric distribution of brominated compounds
7.	S. Davies	An Evaluation of the Effects of Denitrification on Arctic Ozone Loss during Winter 1999/2000 using the SLIMCAT 3D CTM
8.	M. Guirlet	Climatology of recent Arctic winters by the Slimcat 3D CTM
9.	M. I. Johnson	Modelling of Present-day and Future Tropospheric Ozone
10.	M. O. Köhler	Ozone Climatology in the Upper Troposphere and Lower Stratosphere Region
11.	D. Lowe	Towards a Size-dependent Composition Model of Polar Stratospheric Clouds, suitable for Global Models
<u>Numerical Modelling Techniques</u>		
12.	M. Blackburn	Dynamical Cores and Aqua-Planets: Standard tests for model intercomparison and development
13.	G. D. Carver	A novel model of the stratosphere
<u>Transport and Mixing in the UTLS Region</u>		
14.	WITHDRAWN	
15.	R. A. Crowther	Use of principal component analysis in the interpretation of 3-D model and ACSOE aircraft data
16.	A. M. Iwi	Age of air in the troposphere
17.	K. M. Nissen	Transport of Water Vapour in the Unified Model - Introducing an on-line Semi-Lagrangian Advection Scheme

Number	Presenter	Session / Title
		<u>Data Assimilation</u>
18.	W. A. Lahoz	Heart of DARCness
		<u>Extratropical Dynamics</u>
19.	S. Dean	Orographic Clouds and their Parameterisation in Global Climate Models
20.	T. A. Lachlan-Cope	Modelling the impact of the 1997/98 El Niño/La Niña cycle on the high latitude circulation of the Southern hemisphere
21.	J. L. Pelly	The predictability of atmospheric blocking
		<u>Tropical Variability</u>
22.	T. Bistritschan	The role of soil moisture in seasonal forecasting for Africa
23.	S. J. Brentnall	Influence of the Galapagos Islands on SSTs in the Equatorial East Pacific
24.	A. J. Challinor	Development of combined seasonal weather and crop productivity forecasting systems
25.	A. J. Matthews	Observed Propagation and Structure of the 33-Hour Atmospheric Kelvin Wave
26.	A. Pirani	The impact of Westerly Wind Events on the western equatorial Pacific Ocean
27.	J. M. Slingo	The Organisation of Tropical Convection by Intraseasonal Sea Surface Temperature Anomalies
28.	J. M. Slingo	Predictability and variability of monsoons, and the agricultural and hydrological impacts of climate change (PROMISE): A new European programme in monsoon research and its applications
29.	G. Yang	An impact of the phase of ENSO on the interaction of mid-latitude Rossby waves and equatorial waves
		<u>Climate Processes and Earth System Modelling</u>
30.	K. M. Emmerson	Modelling the transport and production of particles in the troposphere
31.	A. Hannachi	The Climate Analysis Group project: MECCA "Mathematical Exploratory Concepts for Climate Analysis"
32.	M. A. Palmer	Solar Irradiance, Ozone and the Little Ice Age
33.	N. J. Rolfe	Modelling the global sources and sinks of methane
34.	D. E. Shallcross	The effects of isoprene on urban, regional and global scales
35.	C. P. Taylor	The future development of the ozone layer
36.	G. Zeng	Simulation of Tropospheric Chemistry Using the Unified Model
37.	W. Zhong	New Measurements of Water Vapour Spectral Line Parameters (8500-15000 cm ⁻¹) and their Impact on Atmospheric Absorption

Abstracts

Abstracts are ordered alphabetically by presenting author (highlighted if not the first author).

Nonlinearity in the atmospheric circulation response to anthropogenic forcing

N. P. Gillett(1), M. R. Allen(2), M. P. Baldwin(3)

*(1) Oxford University, UK; (2) Rutherford Appleton Laboratory, UK;
(3) Northwest Research Associates, Bellevue, Washington, USA*

The probability density function of the Arctic Oscillation (AO) index on a range of levels in the troposphere and stratosphere was estimated for each month of the year by plotting histograms of daily AO indices from 1958 to 1997. The PDFs were found to be unskewed and close to Gaussian in the troposphere, but deviated significantly from Gaussian in the stratosphere in the winter and spring. We conclude that the negative skewness in April results from the coexistence of distinct summer and winter circulation states, and by examining polar stratospheric temperatures we conclude that the positive skewness in January is due to the radiatively determined limit on the vortex strength. This leads to the hypothesis that the vortex may respond nonlinearly to a forcing which increases its strength, which is supported by a significant change in the shape of the distribution of the 20-200hPa AO indices in January over the past 40 years.

Quantifying uncertainty in decadal climate forecasting: the background to the Casino-21 project

*M. R. Allen(1,2), P. A. Stott(3), B. Casati(4), S. Phipps(1,5), L. A. Smith(4,6),
D. A. Stainforth(2), A. Heaps(7), J. A. Hansen(8), A. J. Thorpe(3,6)*

*(1) Space Science and Technology Dept., Rutherford Appleton Laboratory, UK;
(2) Atmospheric, Oceanic and Planetary Physics, University of Oxford, UK;
(3) Hadley Centre for Climate Prediction and Research, The Met. Office, UK;
(4) Mathematical Institute, University of Oxford, UK;
(5) Inst. of Antarctic and Southern Ocean Studies, U. Tasmania, Australia;
(6) Dept. of Statistics, London School of Economics, UK;
(7) Dept. of Meteorology, University of Reading, UK;
(8) Program in Atmospheres, Oceans and Climate, MIT, Cambridge, USA*

Current approaches to the analysis of uncertainty in decadal climate forecasts include expert elicitation, perturbation of simplified climate models, GCM intercomparison exercises and hybrid approaches combining results from models of varying complexity. None of these would be as satisfactory as wholesale ensemble forecasting, perturbing both initial conditions and physical parameterisations in an A-OGCM. This approach has not been considered realistic to date because of the computational cost. The intrinsically parallel nature of the problem and recent successes in porting the UM to personal computers at the Met. Office and Universities of Reading and Oxford suggest that a distributed approach utilising idle CPU on PCs could be a solution. This talk will address the theoretical background to the "Casino-21" experiment. We will argue that, while it cannot be proven rigorously, the existence of a low-dimensional "response manifold" (a multi-dimensional surface close to which the response to a particular external forcing trajectory is likely to be confined in spite of the most probable model errors) is already assumed in the use of A-OGCMs for climate prediction. This concept can be exploited to provide a methodology for ensemble climate forecasting which begins to take into account the certainty of model error. The idea, and the methodology we propose to exploit it, will be illustrated using simplified climate models and low-order chaotic dynamical systems. As a break from the theory, we will provide an interim estimate of uncertainty in forecast anthropogenic warming by 2050, and discuss its deficiencies.

Stationary waves in a linearized quasigeostrophic model

M. H. P. Ambaum

Reading University, UK

Stationary waves may be interpreted as perturbations of the zonal mean flow that are in equilibrium with zonally asymmetric forcings such as heating, vorticity flux divergence, or orography. A causal relation between forcing and wave response is not necessarily implied here.

In this paper the stationary wave response to combinations of heating, vorticity forcing and orography is studied in the context of a linearized quasigeostrophic model. Many well established facts of this system are reproduced. The unified approach leads to a clear picture of the relative importance of the different forcings.

Representation of storm track variability in the UK Met Office Unified Model - HADAM3

D. Anderson

Reading University, UK

An objective tracking program developed by Dr. Kevin Hodges is used to produce tracking statistics for a version of the Met Office Unified model. The ability of the model to emulate storm track characteristics for the northern hemisphere winter is investigated by comparison of the results with tracking statistics produced from the ERA data set. The method is extended to look at low frequency variability by producing track ensembles for positive and negative phases of the North Atlantic Oscillation (NAO) for both data sets and then comparing the resulting statistics. Results indicate that the model is able to represent most aspects of storm track behaviour found in the reanalysis data.

High resolution modelling of fine-scale chemical structures in the troposphere

*S. R. Arnold(1), F. M. O'Connor(1), K. S. Law(1), J. A. Pyle(1), J. Methven(2), M. J. Evans(3),
B. Bandy(4), N. Brough(4), T. Green(4), G. Mills(4), H. Barjat(5), K. Dewey(5), and J. Kent(5)*

*(1) Centre for Atmospheric Science, Cambridge University, Cambridge, UK; (2) University of Reading, UK;
(3) Harvard University, USA; (4) University of East Anglia, Norwich, UK; (5) MRF, UK Meteorological Office, UK*

The coarse grid sizes of global 3D chemical transport models (CTMs) mean that they have limitations when used to analyse chemical data sets of high spatial and temporal resolution, such as those obtained on board atmospheric research aircraft. In order to investigate the fine-scale chemical structures (~10km) observed in the troposphere, a Lagrangian high-resolution regional model has been developed, based on the reverse domain filling principle. The model uses air parcels which are advected onto a high resolution regional grid or aircraft flight-path using 3 dimensional trajectories derived from T106 ECMWF wind field data. The air parcels are initialised using T42 global chemical fields from the TOMCAT CTM, and are run along their trajectories with a complex chemical scheme which includes surface emissions, deposition and over 50 species.

The model has been validated using data from the C-130 aircraft of the Met. Office Research Flight which was flown as part of the EU MAXOX and UTLS ACTO campaigns in 1999 and 2000, respectively. Results show that this technique is successful in modelling the small scale chemical structure observed during scientific flights.

Stratosphere-Troposphere Exchange of Water Vapour in the Tropics: A 'Unified Model' Perspective

R. N. Bannister, A. R. Gregory, A. O'Neill, J. Slingo

CGAM, Reading University

The time and space pattern of water vapour known as the "tape recorder" is a characteristic signal of the tropical lower stratosphere. It is also captured in many general circulation models which have a reasonable representation of the stratosphere.

An important aspect of the tape recorder is its source. This is at the tropical tropopause (the "record head" of the tape recorder), where moisture is injected into the stratosphere on a seasonal cycle. Although the signal itself is normally shown as a zonal mean field, entry of air and moisture across the tropopause is not zonally symmetric, having "preferred" entry regions. According to an existing picture of stratosphere-troposphere exchange, these are located at the "stratospheric fountain" regions, where the entry humidity is controlled thermodynamically by the "depth" of the local cold trap.

Our analysis of the tape recorder in the 58-level Unified Model challenges this picture, suggesting entry regions and humidity control mechanisms which are not always in agreement with established work.

Eddy heat transports and the temperature structure of the atmosphere

L. Barry, J. Thuburn, G. C. Craig

Reading University, UK

Eddy heat fluxes play a key role in determining the temperature structure of the earth's atmosphere. Flux-gradient theories attempt to predict the magnitude of eddy heat transports from the values of external parameters and mean properties of the flow. These theories break the heat flux into the product of the average magnitude of the eddy velocity, the average size of temperature perturbations, and the correlation between those two quantities.

These ideas have been tested by performing a series of GCM experiments in which external parameters, such as planetary radius and rotation rate, were varied. The results suggest the correlation factor is constant over a wide range of conditions and the average size of a temperature perturbation scales with the Rhines' beta-scale multiplied by the temperature gradient. The average magnitude of the eddy velocity does not scale in a way predicted by any previous theory. However, a new scaling has been produced that correctly predicts the eddy velocity. Combining these results gives a new parameterisation for eddy heat fluxes that predicts the fluxes diagnosed from the GCM runs more accurately than any previous theory.

A method for capturing the Madden-Julian Oscillation from observed data

C. P. Batstone, H. H. Hendon and S. P. Lawrence

Leicester University

A method for producing surface boundary data for use in forcing coupled ocean/atmosphere models is described. The method aims to generate a representation of the Madden-Julian Oscillation (MJO) in the data so that coupled atmosphere/ocean processes regarding this phenomenon can be investigated. Outgoing longwave radiation (OLR) data is used to determine the success of this method. An OLR anomaly is created by removing the annual cycle, which is then regressed onto daily sea surface temperature (SST) data. The predominantly low frequency, SST-related OLR is then subtracted from the OLR anomaly to produce a high frequency residual, categorized as the stochastic component of the OLR. Empirical Orthogonal Function analysis of this stochastic component shows that the method fails to capture a distinct eastward propagating MJO signal. However when using 3 month averaged SST data, an eastward propagating signal is captured in the first two principal components.

The terrestrial carbon cycle response to rapid global warming at the Paleocene/Eocene transition

D. J. Beerling

Department of Animal and Plant Sciences, University of Sheffield, Sheffield, S10 2TN, UK

An abrupt global warming episode around 55 million years ago (termed the Late Paleocene thermal maximum, LPTM), is strongly linked by a wide range of geochemical and lithological evidence to the massive release (1200-2000 Gt C) of biogenic methane from oceanic sedimentary reservoirs. The rapid nature of the event indicates a negative feedback mechanism operated to prevent runaway greenhouse warming and the ocean carbon cycle has been invoked as the primary responder. However, the faster response time of the terrestrial carbon cycle to this global change episode makes it a more likely candidate, but earlier simulations failed to satisfy global carbon isotope mass balance constraints. This presentation will describe the results from experiments with a process-based terrestrial carbon cycle model forced with global atmospheric climate model simulations for events across the LPTM. It is shown that the increased carbon sequestration by terrestrial vegetation and soils implied by isotopic mass balance considerations can be met, but only if the effects of CH₄ related cloud-induced climatic warming on ecosystem carbon cycling is taken into account. Possible vegetation-related mechanisms for increasing the residence of tropospheric CH₄ will also be outlined.

The Arctic Oscillation

P. Berrisford, A. O'Neill, M. Ambaum

University of Reading, UK

Recent research has highlighted the so called Arctic Oscillation (AO). This is described as an extension of the North Atlantic Oscillation to the whole hemisphere and is said to be a possible mode of atmospheric variability which is approximately axi-symmetric. As such, it is also referred to as the Northern Annular Mode. A similar mode, the Southern Annular Mode, is said to exist in the southern hemisphere. Such modes consist of an oscillation of mass from high to low latitudes. There have been suggestions in the literature that such modes propagate from the stratosphere into the troposphere on time scales of a few weeks. Here we investigate the AO using the 14 winters of the ERA data.

The role of soil moisture in seasonal forecasting for Africa

T. Bistritschan, W. Norton, R. Washington

Oxford University, UK

Soil moisture is a reservoir component of the precipitation cycle. It influences not only the moisture fluxes but also the partition between sensible heat and latent heat. This makes its influence on the climate second only to sea surface temperatures. Soil moisture is a widely unmeasured and unknown quantity. The data we have used in this study is therefore not observed data but output from the Unified Model. In order to demonstrate that soil moisture fields have the potential to be used for seasonal predictions, it has to be shown that anomalies in the soil moisture state influence the climate and exist for an extended period of time. First the spatially resolved temporal persistence of soil moisture anomalies was examined and it was found that these anomalies exist for several months in the time before the rain season starts. For most areas in Africa this temporal correlation in the soil moisture data set drops below the significance level after the onset of the rain season. In a second step the correlation of anomalies in the soil moisture state and anomalies of the total rainfall of the following season was examined and we found significant correlations for extended areas in south Africa as well as in west Africa, mainly from February to August.

Indian Ocean SST variability and its effect on tropical East African rainfall over the last 128 years

E. Black and J. Slingo

Reading University, UK

In 1997-98, the sea surface temperature of the Indian Ocean was unusually high off the African coast and low near Sumatra, creating an SST anomaly dipole. This resulted in reversal of the normal climatological gradient in Indian Ocean SST - with the SST between October 1997 and June 1998 increasing from east to west rather than from west to east. We present an analysis of 128 years of SST data which puts the 1997-98 event in the context of long-term variability in Indian Ocean SST. Our study reveals several previous incidences of similar SST anomaly dipoles which are used to derive a composite anomaly pattern. It has been proposed that the SST anomaly dipole affects the climate of the surrounding continents. As an example, its association with rainfall anomalies in tropical East Africa is investigated using collations of SST and precipitation data. It is shown that the development of an SST dipole often coincides with high East African rainfall. For example a dipole developed in 1961 - the same year as devastating floods in Kenya. Thus, improved understanding of the dipole mode in the Indian Ocean may lead to greater predictability of tropical East African rainfall.

Dynamical Cores and Aqua-Planets: Standard tests for model intercomparison and development

M. Blackburn, A. R. Gregory and R. B. Neale

CGAM, University of Reading, UK

Following the successful introduction of standard experiments to test shallow water models in a spherical domain, a suite of tests is being developed internationally for baroclinic models, which form the core of global weather forecasting and climate models. The University of Reading is playing a prominent role in the development and use of this test suite.

The experiments aim to bridge the gap between, on the one hand, one and two-dimensional advection tests used in the development of fluid dynamics codes and, on the other hand, experiments in which complete climate models are used to simulate Earth's climate and variability. Although the latter experiments do reveal systematic differences between models, the complexity of both the models and the real-world setting hinders causal interpretation.

This poster will describe some of the "Dynamical Core" experiments being used to test the dry fluid dynamics component of global models and the "Aqua-Planet" experiments being used to test representations of moist convection.

Attempts are also being made to include an idealised moisture cycle in the Dynamical Core experiments, to investigate the nature of interactions between the dry and moist components of the atmospheric circulation. The intention is for a single highly simplified representation of moist processes to be used in models with different dynamical formulation.

A self-contained version of the Unified Model in a PC environment for the development of perturbation analyses

B. Booth(1,2), C. Senior(1), D. Stainforth(2), A. Van Der Wal(3), P. Burton(3), K. Williams(1), M. Allen(4), A. Thorpe(1)

*(1) Hadley Centre for Climate Prediction and Research, UK Met. Office;
(2) AOPP, Department of Physics, University of Oxford; (3) UK Met. Office;
(4) Space Science and Technology Department, Rutherford Appleton Laboratory*

GCM's contain a large number of physical parameterisations whose impact on the response of the model to an external forcing, such as anthropogenic greenhouse gases, is poorly characterised. In the context of the Casino21 project, large scale perturbation of model parameters will be carried out to assess the impact of individual combinations of perturbations using the computing resources of the general public. In preparation for this experiment, a climate-resolution version of the UM in a 32-bit slab configuration was set up to run self-contained in a PC environment. The model was then used to carry out initial perturbations on a number of atmospheric and land-surface parameters following on from the work of Williams et al. (2000). Details of the model, its performance and the results of the initial perturbation experiments will be presented.

To realise its full potential, the Casino-21 project will require a much larger number of physically plausible perturbed versions of the UM than the project core team could conceivably develop on their own. A key objective of this component of the project, therefore, is to provide interested members of the UM-using community who have access to under-utilised Linux PCs with an easy-to-use platform for the development of model perturbations. While these perturbations may be as simple as changing the value of a single input parameter, we would like to draw on the collective wisdom of the community to perturb these parameters as intelligently as possible. Details of how this will work, how investigators can feed model perturbations into the main Casino-21 experiment and how results will be fed back to these investigators for interpretation and publication, will be discussed.

Variability and Trends of Total Ozone as simulated by the UM using a simplified chemistry

P. Braesicke and J. A. Pyle

Centre for Atmospheric Science, Cambridge University, Chemistry Department, Lensfield Road, Cambridge, CB2 1EW, UK

This study will investigate the inter-annual variability and trends of total ozone caused by changes in atmospheric dynamics using a simplified ozone chemistry which neglects changes of the chlorine loading with time.

The experimental setup uses the 58 level version of the Unified Model (UM) in conjunction with a Cariolle parameterization for calculating ozone. The derived ozone distribution is used instantaneously in the radiation scheme. The model is integrated with prescribed AMIP II sea surface temperatures (SSTs) from late 1978 to early 1996. Total ozone is then derived as a diagnostic quantity.

The variability of total ozone shows many features which are in good agreement with observations and corresponds with signals in the SSTs. Even though the amplitude of the ozone anomalies is limited by the simplicity of the parameterization, the simulation captures the latitudinal differences. The largest trend is found in January in mid- and high-northern latitudes, but is too small compared with observations.

Influence of the Galapagos Islands on SSTs in the Equatorial East Pacific

S. J. Brentnall and K. J. Richards

Southampton University, UK

Detailed knowledge of the SST patterns in the equatorial Pacific is required for the prediction of weather and climate on regional and global scales. The observational programme EPIC which is currently under way recognises the importance of the eastern equatorial Pacific in particular. The effect of the presence of the Galapagos Archipelago on SST patterns in the equatorial east Pacific has been investigated using a combination of output from numerical models (both an OGCM and a 2.5 layer model) and satellite and in situ data. It is found that the islands prevent the eastward expansion of the equatorial cold tongue. For an area of some million square kilometres to the west of the islands, the sea surface is on average some 0.1K cooler than it would be were the islands not present, with a similar warming to the east. Reasons for this effect include hydraulic upwelling of the EUC as it strikes the islands, and enhanced vertical mixing due to the resulting decreased mixed layer depth. Regional SST patterns are not due solely to atmospheric and radiative forcing, as has hitherto been assumed.

Influence of the Galapagos Islands on Tropical Instability Waves

S. J. Brentnall and K. J. Richards

Southampton University, UK

Tropical Instability Waves are rows of eddies of radius about 1000 km which propagate westward along latitudes 4N and 4S in the equatorial oceans, being particularly prominent in the Pacific. Highly significant in the meridional mixing of heat and momentum, they are believed to be due to shear instability of near-surface current systems. This belief is borne out by output from the OCCAM OGCM, in which TIWs proper can be identified as first baroclinic mode, first meridional mode Rossby waves (though a high baroclinic mode Rossby-gravity wave of similar propagation characteristics is also present). In the Pacific, the shear which is responsible for the instability is due to the division of the South Equatorial Current (SEC) into two jets as it passes round the Galapagos. This finding is supported both by existing theory and by in situ current observations. Division of the SEC still occurred in an integration of OCCAM in which the Galapagos were removed (presumably as a result of the wind-driven surfacing of the equatorial undercurrent), but the longitude at which this happened was more variable and the resulting jets weaker and more marginally unstable. Intraseasonal SST variance at 4N was also reduced in the longitude range 105-115W, indicating that the TIWs were weaker in the no-Galapagos integration. In summary, the presence of the Galapagos makes TIWs more vigorous than they would otherwise be, and fixes the longitudes at which they occur.

A spin-off of this research was a demonstration that the phase and longitude of onset of TIWs are not determined solely by (remote) wind forcing, as has been suggested. Both properties vary "chaotically" between different years of OCCAM integrations with repeat annual cycle forcing, and between integrations which differ only by the relatively small perturbation of removing the Galapagos.

Examination of Summer high-latitude ozone values using the SLIMCAT CTM

Cate Bridgeman and Martyn Chipperfield

Leeds University

Ozone displays a strong seasonal cycle at mid and high latitudes with column ozone values peaking in spring and reaching a minimum in late summer. The causes of this cycle are not fully understood, and while the winter ozone field can be well reproduced, models severely overestimate ozone in the summer high

latitudes. Whether this is due to deficiencies in the representation of transport or chemical processes, or both, is as yet unclear.

We compare model calculations from the SLIMCAT CTM with experimental data from a variety of sources in order to quantify and locate this excess ozone. The effects of vertical transport on modelled ozone in summer high latitudes are assessed by comparing results of model runs using two radiation schemes and possible improvements to the radiation schemes are tested.

The effects of lifetime and source region on the stratospheric distribution of brominated compounds

Cate Bridgeman(1), John Pyle(2) and Dudley Shallcross(3)

(1) Leeds Environment Centre, Leeds University;

(2) Centre for Atmospheric Science, Cambridge University; (3) Bristol University

The impact of CFCs on stratospheric ozone is well known and has led to the phase-out of their production, and their replacement with short-lived substitutes. Because bromine is many times more destructive to ozone than chlorine, brominated compounds must have very short atmospheric lifetimes if they are to be acceptable. Ozone depletion potentials (ODPs) are a standard way of assessing a compound's potential relative effect on stratospheric ozone. We have used the 3D chemical transport model TOMCAT to investigate the ODPs and atmospheric distributions of a series of brominated compounds with lifetimes varying from about a day to 15 years. We discuss the effects of geographical source region on the calculated lifetimes and possible stratospheric impact of these compounds.

Assimilation of MLS temperature into the Met. Office NWP system

V. Asenek, H. Struthers, R. Brugge, W. Lahoz, A. O'Neill

NERC Centre for Global Atmospheric Modelling, University of Reading, UK

We discuss results from the assimilation of temperature data from the Microwave Limb Sounder (MLS) (flown on the Upper Atmospheric Research Satellite) into the UK Met. Office assimilation system.

We focus on the method used to estimate biases observed in MLS V4 temperature and the impacts of the observations on assimilated fields. Two assimilation experiments were run. One experiment incorporated operational observations in addition to MLS data, while the other experiment did not include MLS data. To maximise the benefits offered by the high vertical resolution of MLS data, it was necessary to retune some of the assimilation parameters. The approach implemented is also discussed.

Quantification of the Polar Contribution to Mid-latitude Ozone Loss

G. A. Cahill, J. A. Pyle, A. M. Lee

Cambridge University, UK

A numerical model has been used to quantify anthropogenic (halogen-induced) ozone loss at the winter pole and at mid-latitudes. This is compared with the loss due to "natural" cycles. The inter-annual variability of these processes is studied. Five winters in the 1990s have been chosen to investigate a variety of meteorological conditions in and around the polar vortex.

The 3-dimensional off-line chemical transport model, SLIMCAT, was run at T31 resolution (3.75 degrees latitude by 3.75 degrees longitude) with UKMO analysed winds and temperatures for each winter. The contribution of polar processes to ozone loss at mid-latitudes was investigated with novel tracers mapped to potential vorticity equivalent latitudes. The polar vortex core and mid-latitude regions were defined as 90-70

degrees N and 60-30 degrees N respectively. Novel tracers were included into SLIMCAT to follow ozone loss by reactions with Clx, Brx, NOx, HOx etc. and ozone production by oxygen photolysis and also to record the mass of ozone destroyed by location.

Analysis of the ozone loss tracers shows a large inter-annual variability in the relative strengths of particular chemical loss mechanisms depending on the meteorology in a given year. The role of mixing also varies with the meteorological conditions. For example, in the winter of 1996/97, a winter with a well isolated vortex, by the end of March only about 15% of the loss in the polar lower stratosphere (between 510K and 342K potential temperature levels, approximately 12-21km) originates south of 60 degrees N. In contrast, in 1998/99, a dynamically disturbed winter, about 50% of the polar loss is of middle latitude origin. We also find that in this partial column, at mid-latitudes, halogen chemistry contributes about 50% of the chemical ozone destruction throughout the winter.

A novel model of the stratosphere

Andrew Gregory(2), Glenn Carver(1), John Thuburn(2)

*(1) Centre for Atmospheric Science, Chemistry Dept., University of Cambridge;
(2) Dept. of Meteorology, University of Reading*

A novel model of the stratosphere has recently been developed by the University of Reading and enhanced at the University of Cambridge. The model is a spherical isentropic primitive equation model with an artificial bottom boundary which can be forced from meteorological analyses or idealised conditions. The model is unique as it uses a hexagonal-icosahedral grid with a conservative, shape-preserving advection scheme. Unlike most primitive equation models, it uses potential vorticity as a prognostic variable. This has a number of advantages, particularly for diagnosing properties of the flow. In this poster we describe the model in more detail and present results from idealised stratospheric warming experiments. We also describe some recent tracer transport experiments designed to test the transport properties of the model and future planned development.

Development of combined seasonal weather and crop productivity forecasting systems

Andrew Challinor, David Grimes, Julia Slingo, Chris Thorncroft (1), Peter Craufurd, Tim Wheeler (2)

(1) Dept. of Meteorology, University of Reading; (2) Dept. of Agriculture, University of Reading

Food production in seasonally arid areas is inherently risky, and productivity shows variability on a number of time-scales. An analysis of the variability of Groundnut yield and precipitation in India is presented, and some conclusions are drawn regarding research topics which need to be investigated as part of a planned combined seasonal weather and crop productivity forecasting system.

One such topic is robust prediction of crop development. This implies both the complexity necessary to model effects such as high temperature stresses and the simplicity necessary for the model to be valid over large regions and over many genotypes and/or crops. Appropriate methods will need to be determined for combining crop models with NWP models. Particular attention should be given to the issue of matching the spatial and temporal scales on which the two models operate. On the seasonal time-scale there is a need to combine the largely functional models of crop adaptation and yield responses to drought and heat stress, to the probabilistic models used in seasonal forecasting.

The Relative Roles of Initial and Boundary Conditions in Interannual to Decadal Climate Predictability

Mat Collins(1) and Myles Allen(2)

(1) CGAM, Dept. Meteorology, Univ. Reading, Reading;

(2) Space Science and Technology Department, Rutherford Appleton Laboratory, Didcot, Oxfordshire

We seek to address the relative importance of initial and boundary conditions in the predictability of climate on interannual to decadal time scales. Examining trends in selected diagnostics in an ensemble of coupled climate model integrations, we show that on global scales, perfect knowledge of both the oceanic and atmospheric initial conditions may provide useful skill at lead times of a couple of years at most. Longer forecasts may be possible for some oceanic variables, but this predictability is not reflected in land surface temperatures, which appear to be completely unpredictable at lead times beyond a few months. Predictable changes in boundary conditions, such as anthropogenic increases in greenhouse gas levels, may become an important source of skill on time scales as short as 10 to 20 years on the global scale and in the interior of large continental regions. In the oceanic variables considered, the "signal" takes many decades to emerge from the climatological "noise". This represents a preliminary study of the problem and we make recommendations for future work.

Evaluation of UKMO HADAM3 Model Simulations to Predict the Onset of the West African Monsoon

M. P. Cresswell(1), A. P. Morse(2), M. C. Thomson(1) and R. J. Graham(3)

(1) Liverpool School of Tropical Medicine, University of Liverpool. UK;

(2) Department of Geography, University of Liverpool. UK;

(3) UK Met. Office (NWP Div.) London Road, Bracknell, Berkshire. UK

The start of the rainy season in West Africa marks two important epidemiological events. Firstly the rise in humidity associated with the rainfall is thought to curtail further transmission of meningococcal meningitis, whilst the creation of new pools of water after the initial rains creates additional opportunities for mosquitos to breed and enhances malaria transmission. Here we describe a pilot study to test a probabilistic dynamical seasonal forecasting model (using the UKMO HADAM3 GCM) for the simulation of onset of monsoon conditions in West Africa. The study has initially analysed convective rainfall data, but later uses wind vector characteristics as diagnostics of monsoon activity. The overall accuracy and skill available at present is discussed.

Use of principal component analysis in the interpretation of 3-D model and ACSOE aircraft data

*R. A. Crowther(1), C. E. Reeves(2), B. Bandy(2), S. Bauguitte(2), R. G. Derwent(3), M. Evans(4),
C. E. Johnson(3), G. Mills(2), S. A. Penkett(2), H. Richer(5), S. Schmitgen(6), D. Stevenson(7)*

(1) formerly at UEA, now at Cambridge University, UK; (2) University of East Anglia, UK;

(3) Meteorological Office, UK; (4) MIT, USA; (5) Met. Research Flight, UK;

(6) FZ-Julich, Germany; (7) University of Edinburgh, UK

Principal component analysis (PCA) has been applied to data collected during observing campaigns over the North Atlantic in order to identify the origin of air masses, their contribution to observed tropospheric ozone and to validate the UK Meteorological Office 3-D global CTM (STOCHEM). The remote tropospheric observations were made on-board the UKMO C-130 aircraft, flying from the Azores during the summer of 1997. They provided a wide range of data on the chemical species driving the tropospheric chemistry; such as O₃, CO, NO_y, formaldehyde and peroxides. The PCA is used to derive components characterised by strong relationships between both chemical species and meteorological variables. These

components are related to different air mass types whose contribution to tropospheric ozone is investigated. Direct comparison is made between observed data and data generated by STOCHEM at points close to the aircraft flight-path, highlighting the performance of the model in terms of predicting smaller-scale events. An indication of the model's ability to predict larger-scale features is obtained by comparing a PCA of the model data to the observed PCA results. This model validation is an important process as global climate research and government policy rely increasingly on the accuracy of these 3-D global models.

An Evaluation of the Effects of Denitrification on Arctic Ozone Loss during Winter 1999/2000 using the SLIMCAT 3D CTM

Stewart Davies(1), Ken Carslaw(1), Martyn Chipperfield(1), Bjoern-Martin Sinnhuber(1), Jamie Kettleborough(2)

(1) School of the Environment, University of Leeds; (2) Rutherford Appleton Laboratory

We have used the SLIMCAT 3D off-line chemical transport model (CTM) to study the effects of denitrification on O₃ depletion in the Arctic winter/spring. The CTM was run at a resolution of 5 deg latitude x 7.5 deg longitude with 18 isentropic levels between 330 and 3000 K and forced by UK Met. Office analyses. Two model runs (with and without denitrification) were initialised in early December 1999 and integrated until April 2000.

The CTM denitrification is based upon an equilibrium liquid aerosol-NAT-ice scheme. The composition of liquid aerosols is determined using the analytical formula of Carslaw et al. (1995), NAT is formed at the NAT point and ice exists below the ice frost point. Below the ice frost point nitric acid is removed from the gas phase by assuming a NAT coating of ice particles. Ice particles are assumed to have a radius of 10 µm and NAT particles released upon ice evaporation are assumed to have radii of 1 µm, thus determining their sedimentation speed. Interestingly, winter 1999/2000 was the first Arctic winter (since 1991/92) where SLIMCAT (forced by UKMO analyses) produced a signature of denitrification. This was due to the exceptionally low temperatures which occurred in this winter. Comparisons of accumulated ozone losses between sondes from Ny Alesund and the denitrified model run showed good agreement with losses of up to 70% at 460 K in early April. (There is excellent agreement between this model run and the higher resolution studies of Sinnhuber et al). In the model run without denitrification O₃ loss was 50% at 460 K by the end of March, which is significantly less than with denitrification, although this loss is still larger than previous modelled winters. It is interesting that in the previous winters 1995/96 and 1996/97 SLIMCAT did not produce denitrification and apparently underestimated ozone loss.

We have compared chemical fields from SLIMCAT with NO_y and Cl_y observations to test the performance of the model denitrification scheme. Comparisons of the model NO_y with observations reveal strong denitrification throughout the vortex, in agreement with NO_y data, although the relatively simple denitrification scheme appears to produce reinitiation at too high altitudes.

Comparisons with chlorine species also show better agreement between the denitrified model run and observations, especially during March when the two model runs show the largest difference. In particular, around March 12/13 the model run with denitrification shows larger ClO_x at 18 km, and large HCl near 20 km, in better agreement with aircraft data. In the near future we aim to improve the CTM by replacing the current denitrification scheme with a more realistic microphysical scheme of Carslaw et al.

Orographic Clouds and their Parameterisation in Global Climate Models

S. Dean(1), B. Lawrence(2), D. Heuff(1), R. Grainger(3)

*(1) University of Canterbury, Christchurch, New Zealand;
(2) British Atmospheric Data Centre, RAL; (3) University of Oxford, UK*

While most climate models already contain sophisticated parameterisations of large scale cloud, they do not resolve well the effects that mountains, such as New Zealand's Southern Alps, can have on clouds. Significant lifting over the mountain ranges results in the creation of extensive orographic cloud on the windward slopes. Additionally, certain atmospheric conditions can lead to lee wave clouds that can extend

for hundreds of kilometres downwind of the mountains. The different types of orographic cloud observed over New Zealand will be discussed and the ongoing work to incorporate such clouds in the 19 level version of the Unified Model will be described.

Variability in North Atlantic heat content and heat transport in a coupled ocean-atmosphere GCM

Buwen Dong and Rowan T. Sutton

Centre for Global Atmospheric Modelling, Department of Meteorology, University of Reading, United Kingdom

A coupled ocean-atmosphere general circulation model has been used to study the variations of ocean heat content and ocean heat transport in the North Atlantic and their relationship. It has indicated that ocean heat content anomalies and salinity anomalies propagate anti-cyclonically, following the mean current of the North Atlantic subtropical gyre. They propagate eastward in the mid-latitude of the North Atlantic and westward in lower latitudes. Both the transient response of the subtropical gyre to the windstress curl anomalies through the baroclinic Rossby wave propagation and advection processes are of importance for these zonal propagations. In addition to zonal propagations, the ocean heat content anomalies propagate southward in the eastern North Atlantic, where the subduction plays a dominant role. The overall picture of ocean heat content and salinity anomaly evolutions seems to be one of the formation through atmosphere forced perturbation, advection acting on the strong mean temperature gradient near the western boundary, and anticyclonic propagation around the subtropical gyre in the North Atlantic. The ocean heat content anomalies in mid-latitudes of the North Atlantic are initiated by the variations in ocean heat transport convergence and local air sea-interactions with ocean heat transport playing a dominant role. The variations in ocean heat transport themselves are the results of changes in the intensity of subtropical gyre forced by variation of windstress curl and changes in meridional overturning circulation forced by buoyancy fluxes and by Ekman pumping.

High-resolution simulations of atmospheric convection: a new approach

J. R. Elliott

Reading University, UK

Many models of atmospheric flow make the adiabatic approximation, i.e. assume that the Lagrangian derivative of the potential temperature vanishes (in the absence of latent heating). For a convectively unstable, closed system, this leads to a paradox, since the total entropy of the system cannot then be stationary, as it should be in statistical equilibrium: this paradox is explained by the neglect of the viscous heating. By writing the energy equation in conservative form, all such problems can be avoided and a more reliable solution can potentially be obtained. We compare the two formulations for the problem of dry atmospheric convection above a fixed temperature, flat, lower boundary. It is found that the differences in the formulations lead to different statistical equilibrium solutions, with differences in the temperature of the order of a few degrees - such errors could potentially be significant.

Modelling the transport and production of particles in the troposphere

K. M. Emmerson(1), A. R. MacKenzie(1), M. J. Evans(2), D. E. Shallcross(3)

(1) Lancaster University, UK; (2) M.I.T, USA (formally of Cambridge University, UK); (3) University of Bristol, UK

Much interest has been concentrated on the radiative effects of particles in the atmosphere. These aerosol particles contribute to a deterioration in visibility in cities with pollution problems. It has been hypothesised

that anthropogenic aerosols cause a cooling of the Earth's climate, which has offset the warming from greenhouse gas emissions to some extent.

A primary particulate matter (i.e. PM10, PM2.5) emissions inventory encompassing Europe (TNO, personal communication) has been coupled to CiTTYCAT, the Cambridge Tropospheric Trajectory model of Chemistry and Transport. This poster describes the modelling procedure, and how data from a number of different sites at different distances from the major sources compare with the model output.

Future work will include parameterisation of gas-to-particle partitioning (i.e., the production of secondary particulate matter). The aerosol scheme will be coupled to the chemical scheme to provide a source of secondary organic aerosol. In particular the atmospheric oxidation of biogenic gases, will produce heavy molecular weight organic and inorganic acids, that will partition between the gas and particle phases.

This work aims to provide a simple parameterisation of tropospheric aerosol for inclusion in UGAMP climate models.

PREDICATE:

Mechanisms and Predictability of Decadal Fluctuations in Atlantic-European Climate

Dave Frame and Rowan Sutton

CGAM, University of Reading

Recent developments in climate prediction have focused on two main timescales. Forecasting of anthropogenic climate change has addressed timescales ranging from many decades to centuries, while seasonal forecasting has addressed timescales of months to years. The intermediate "decadal" timescales have been comparatively neglected, in spite of the fact that it is on just these timescales that many large businesses and other organisations need to make plans.

PREDICATE - a new 3-year research programme funded by the European Commission under Framework 5 - is a response to the need for improved understanding and prediction of decadal-timescale fluctuations in Atlantic-European climate. In particular, PREDICATE aims to improve understanding, simulation and prediction of the decadal fluctuations that result from interactions between the ocean and the atmosphere. These aims will be achieved through a coordinated programme of numerical experimentation, evaluation against observations, and development of prediction systems. In addition, PREDICATE will work with targeted user groups in the insurance, utilities and fisheries sectors to assess the potential benefits of decadal forecasts. The programme is being implemented by a consortium of 8 of the leading climate science centres in Europe, and is led by the NERC Centre for Global Atmospheric Modelling at the University of Reading. The poster will present further information about the project, in particular the content of the work programme.

Low Frequency Variability in an Isopycnic Model of the North Atlantic Ocean

Graham Gladman and Rowan Sutton

CGAM, University of Reading

Observations of the North Atlantic Ocean over the past century reveal decadal timescale fluctuations in heat content and related variables. Many aspects of these fluctuations are intriguing and require explanation. In particular, the mechanisms responsible for the formation and propagation of heat content anomalies are not understood. While such anomalies may be generated by processes internal to the ocean, forcing by the atmosphere is likely to play a key role.

We are investigating the role of atmospheric forcing in the formation and evolution of heat content anomalies by experimentation with an Atlantic ocean isopycnic GCM. In the first phase we have performed experiments to explore how heat content anomalies develop in response to forcing by idealised wind stress

anomalies. We will present analyses of the long timescale baroclinic response, focusing on the adjustment of the thermocline, gyre circulation, western boundary current and also resulting heat content anomalies.

In the second phase of our work we will be investigating the development of specific heat content anomalies observed in the North Atlantic this century.

Effects of elevated carbon dioxide concentrations on the emissions of volatile organic compounds from simulated ancient ecosystems and their impact on paleo-atmospheric chemistry

R. G. Gonard(1), C. N. Hewitt(1), D. J. Beerling(2), C. E. Johnson(3), P. J. Valdes(4)

(1) Lancaster University; (2) University of Sheffield; (3) Meteorological Office; (4) Reading University

Modelling studies of the chemistry of the atmosphere suggest that volatile organic compounds (VOCs) emitted to the atmosphere from the biosphere play an extremely important role in the chemistry that takes place therein, and in particular contribute to the formation of ozone and aerosols in the troposphere. During the Mesozoic and Tertiary (250 - 50 million years before present) the atmosphere contained higher than present CO₂ concentrations and was warmer than at other times. Our previous and current NERC-funded work has shown that elevated CO₂ concentrations strongly stimulate isoprene emissions from plants. Additionally it is well known that isoprene emission rates are strongly dependent on temperature. Both these suggest that the high CO₂ concentrations and warmer temperatures that prevailed during the ancient "greenhouse" climates 250 - 50 Myr BP potentially exerted a strong stimulatory effect on biogenic VOC emissions from terrestrial ecosystems. Climatic data were obtained using the UKMO GCM paleoclimate runs. Here we use a dynamic vegetation model to estimate biogenic VOC emissions into the paleo-atmosphere, and a simple 2-D model of the chemistry of the troposphere (TROPOS) to study the sensitivity of the paleo-atmosphere to these emissions. In particular we use ozone distributions and methane lifetimes as diagnostics and preliminary results on these parameters will be presented.

The sensitivity of simulated tropical tape-recorders to the numerical advection scheme used

Andrew Gregory(1), Vicky West(2) and Ross Bannister(1)

(1) Centre for Global Atmospheric Modelling, University of Reading, UK;

(2) Department of Meteorology, University of Edinburgh, UK

The stratospheric tropical tape-recorder provides us with a direct means of validating the transport in climate models against observations. A good simulation of the tape-recorder is consistent with a good simulation of the circulation and a good transport scheme.

The 58 level version of the UK Met. Office's Unified Model appears to do a reasonable job at simulating the tape-recorder signal in its specific humidity field. Efforts to reproduce the signal using conserved online tracers forced from below 100hPa initially produced a very different tape-recorder with far faster vertical transport than observed. When the default tracer advection scheme was changed to the same scheme used for the specific humidity the original tape-recorder signal was regained. Interestingly this tape-recorder also showed evidence that part of model's tape-recorder signal is a numerical artifact.

To try to understand these results, further experiments using a wider range of tracer advection schemes have been performed together with trajectory calculations and more idealised tests. Results and early conclusions from this investigation will be presented including the discovery of a further sensitivity to the frequency of the winds used in offline experiments.

Climatology of recent Arctic winters by the Slimcat 3D CTM

M. Guirlet(1,2), J. Pyle(2), M. Chipperfield(3)

(1) European Ozone Research Coordinating Unit;

(2) Department of Chemistry, University of Cambridge; (3) School of the Environment, University of Leeds

We have used the SLIMCAT 3D CTM to investigate the interannual variability of ozone depletion at high and mid-latitudes of the Northern Hemisphere during the Arctic winters between 1995-1996 and 1999-2000, including winters of large field campaigns such as the EU-THESEO and the THESEO 2000/SOLVE campaigns. Five seasonal simulations were performed, starting in December of each winter and integrated until the following April, using a horizontal resolution of $3.75^\circ \times 3.75^\circ$. These integrations were initialised from the same multiannual SLIMCAT simulation. The CTM was forced using UKMO analyses. We diagnosed the chemical depletion of ozone in the column and in the vertical profile at several isentropic levels using a passive tracer.

Comparisons of chlorine activation, ozone evolution, ozone loss and geographical distribution of ozone loss during the five winters are presented and put in context of the stratospheric evolution. Those five winters were characterised by different dynamical conditions. For instance, in winters 1997/98 and 1998/99 (the two first winters of the EU-THESEO campaign), the temperatures in the lower stratosphere were generally higher than during the two previous cold winters and than during 1999/2000 (the winter of the THESEO 2000/SOLVE campaign). In the polar vortex, smaller ozone depletion is calculated by SLIMCAT in 1997/98 and 1998/99 than during other winters. The ozone loss simulated at 480K isentropic level North of 75°N is equal to 34% on 31/03/96, 36% on 31/03/97, 28% on 31/03/98, 27% on 31/03/99 and 56% on 31/03/00.

Even for the warmer winters, substantial ozone loss is calculated at mid-latitudes. The ozone loss in the partial column (350 K - 670 K) calculated North of 40°N is equal to 43 DU by late March 1996, to 28 DU by late March 1997, and to 35 DU by late March 1998. During warm winters, the circulation was more disturbed with frequent displacements or distortions of the vortex to lower latitudes. Thus the SLIMCAT results highlight the role of dynamical variability of the polar vortex on ozone at mid-latitudes, through the transport of chemically perturbed air masses from high latitudes to lower latitudes.

Model simulations of the impact of the 27-day solar rotation period on stratospheric ozone

Vic Williams(1), John Austin(2) and Jo Haigh(1)

(1)Imperial College, UK; (2) The Met. Office, UK

The 27-day rotation period of the sun causes variations in the irradiance reaching the Earth. These variations, predominantly in the ultraviolet region, have a magnitude comparable to that observed for the 11-year solar cycle. Studies using satellite data have shown large impacts in the mesosphere which reduce in magnitude as they progress downwards to the middle stratosphere. The lower stratospheric response to solar variations on this time-scale has not been well characterised but studies using SBUV data and MLS data suggest a secondary maximum in ozone change near 20-25 km, and thus a structure very similar to that reported for the 11-year response. In this paper, results will be presented from 2-year simulations of the UK Meteorological Office coupled chemistry-climate model, which has been enhanced to simulate solar effects. The model has 63 levels from the ground to 0.01 mbar and contains a complete range of chemical reactions allowing representation of all the main ozone formation and destruction processes. Representation of the solar effects has been achieved by incorporating a 27-day oscillation in the model photolysis rates with amplitudes determined using data from the SOLSTICE instrument. The impact on the model radiative heating rates has also been incorporated. Comparisons will be shown with results from a run in which the 27-day oscillation in photolysis rates is applied without the corresponding radiative heating rate changes to illustrate the relative significance of the effects. The model response in ozone and temperature is very similar to observations, including the peak in the lower stratosphere. Potential causes of this structure will be discussed.

The Climate Analysis Group project: MECCA “Mathematical Exploratory Concepts for Climate Analysis”

Abdel Hannachi, David B. Stephenson, and Alan O'Neill

University of Reading, UK

The MECCA initiative was launched in April 2000 by the Climate Analysis Group at the University of Reading with the aim to stimulate and strengthen links between the U.K. climate research and statistics communities. There is an growing need to know how to correctly apply statistical methods to extract useful knowledge from the ever increasing amounts of available climate data. This poster will explain in more detail the aims of this novel UGAMP initiative.

Land Surface Feedbacks in the Hadley Centre GCM

Richard Harding

CEH Wallingford

For many years, CEH Wallingford have worked with the Hadley Centre in providing “off-line” calibrations of the Met. Office Surface Energy Scheme (MOSES) based upon measurements taken for a range of different biome types. More recently, such collaboration has extended to testing and analysing the effect of such parameterisations when fully coupled within the Hadley Centre GCM, or driven by a “GCM analogue model”. Some examples are as follows:

1. Sensitivity experiments in the Sahel using HadAM3 have shown that parameters describing the land surface influence the timing and intensity of rain events on short timescales. A more realistic description of sparse vegetation in the region dampens the diurnal cycle of rainfall and enhances Africa Easterly Wave activity.
2. A “GCM analogue model” has been developed that replicates decadal variation in surface climatology as predicted by HadCM3. It has been confirmed that to reasonable accuracy, anomalies in diagnostics such as 1.5m surface temperature and precipitation can be mapped onto spatial patterns (for each month) multiplied by global mean land surface temperature changes. A simple two-box thermal land-ocean submodel relates global mean temperature changes to greenhouse gas emissions. Essentially an extrapolation tool for existing GCM transient runs, the analogue model has been used to predict global changes in vegetation cover for a suite of greenhouse gas emission scenarios. The model includes associated feedbacks within the global carbon cycle.
3. Hydrological representation within MOSES is being improved through a better description of runoff. This is being achieved by incorporating the probability distribution model (PDM) of soil moisture stores. The improved model has been successfully tested against measurements of soil moisture and runoff in catchments. The impact of this revised land surface model within coupled land-atmosphere GCM simulations will be investigated.
4. Recent GCM simulations suggest that in a changed climate as driven by greenhouse gas forcing, temperature and precipitation patterns may be such as to significantly change net primary productivity within the Amazon basin. In particular, the interactive vegetation component of the land surface model suggests that “die-back” may occur. At present, MOSES is being recalibrated against new CO₂ and surface energy flux measurements. Coupled simulations will be undertaken shortly to determine how robust the “die-back” effect is to and understand associated variation in land-atmosphere feedbacks.

Transport, mixing and chemistry in frontal circulations

J. G. Esler and P. H. Haynes

Cambridge University, UK

The DFCZ (Dynamics and chemistry in frontal circulations) project collected observations of chemical species and meteorological quantities on a number of flights during the period January-April 1999. This has motivated a number of trajectory-based studies of patterns of transport in the troposphere and lower stratosphere during the periods around each flight. This talk will report results from those studies, including relation to the chemical observations and assessment of the role of transport and mixing in frontal circulations in setting the chemical characteristics of the free troposphere.

The climatic impact of the eruption of Laki, Iceland, in 1783

E. J. Highwood(1) and D. Stevenson(2)

(1) University of Reading, UK; (2) University of Edinburgh, UK

The eruption of Laki in Southern Iceland during 1783 had a major impact on Northern Europe in terms of a dry fog present throughout the latter half of the year. It has also been linked to the cold winter of 1783/84. Evidence for this climatic impact has largely been based on tree rings and historical documents. In this study we quantify the likely climatic impact of this eruption. The production and transport of sulphur dioxide and sulphate aerosol has been simulated using a chemical transport model. The resulting distribution of aerosol has been incorporated into transient runs of the Reading Intermediate General Circulation Model (IGCM). The eruption produced a large radiative forcing over much of the Northern Hemisphere for several months. The climate response to this eruption produced in the IGCM is compared with observations.

Adaptive mesh refinement for three-dimensional off-line chemical transport

M. E. Hubbard and N. Nikiforakis

DAMTP, University of Cambridge, UK

A three-dimensional Adaptive Mesh Refinement (AMR) technique has been applied to the modelling of global off-line chemical transport. It is used to enhance the accuracy and efficiency of numerical experiments, carried out here on structured latitude/longitude/vertical grids, by selectively refining and derefining the grid so that flow features of interest are tracked by regions of high grid resolution.

In this work AMR has been combined with a dimensionally split, non-oscillatory Weighted Average Flux (WAF) finite volume scheme to approximate the three-dimensional scalar advection equation on the sphere. Results will be presented which show the effectiveness of AMR in the modelling of both analytically defined test cases (for which exact solutions are available) and problems driven by externally supplied velocity fields and initial conditions. In particular, results will be shown for a stratosphere-troposphere exchange event which occurred over the North Atlantic in June 1996.

A Modelling Study of Decadal Variability in the Northern Middle Atmosphere

S. D. Ibbotson(1), J. D. Haigh(1), L. J. Gray(2)

(1) Imperial College; (2) Rutherford Appleton Laboratory

The interannual variations in Northern Hemisphere winter temperature, winds and geopotential heights were investigated using a two dimensional numerical model with an interactive planetary wave scheme. The

observed equatorial winds from 70mb-10mb which comprise the Quasi-Biennial Oscillation were forced in the model tropics from 20° South to 20° North. In addition, several stylised "QBO-like" oscillations of varying periods were forced in separate experiments.

The Holton-Tan dipole was found to dominate the field variables in the extratropical Northern winter stratosphere in all experiments but a Quasi-Decadal Modulation of the Holton-Tan dipole was found to occur in the model when forced using the observed equatorial winds. This Quasi-Decadal Modulation has many similarities to that described in observational studies by other authors.

Further experiments are described which highlight the differing roles of planetary waves and zonal-mean dynamics in the interannual variability of the stratosphere associated with the QBO. Solar cycle experiments are also described which reproduce the work of Shindell et al.

It is found that the decadal variability in the modelled lower stratospheric northern winter mid - high latitude geopotential heights and temperatures is a composite of equatorial wind influences and solar cycle influences.

Representation of the Madden-Julian Oscillation - a tough test for a coupled model

P. M. Inness and J. M. Slingo

Centre for Global Atmospheric Modelling, University of Reading

The Madden-Julian Oscillation (MJO) represents the major mode of variability in tropical convection on timescales of 30-60 days. The MJO organizes convection on a regional scale and by modulation of the strength and location of the main tropical heat source, it can generate teleconnection patterns which affect the weather in the sub- and extra tropics. Associated with the organized convection are intense low-level wind anomalies which can generate ocean Kelvin waves in the Pacific. These waves have a significant impact on the thermal structure of the upper tropical Pacific and may have an impact on the El Niño cycle. For all these reasons, a good representation of the MJO is desirable in numerical models being used for atmospheric prediction on timescales of a few days up to several seasons, and in models being used to represent the global climate system. However, many studies have shown that the MJO is often rather poorly represented in numerical models. This study will discuss some aspects of representing the MJO in a fully coupled ocean-atmosphere GCM. Because of the complex interaction between convection, large scale dynamics and the surface layers of the ocean it is clear that an accurate representation of the MJO provides one of the toughest tests for climate and forecast models.

Age of air in the troposphere

A. M. Iwi and W. A. Norton

Oxford University, UK

The mean transit time (age) has proven to be a powerful diagnostic of tracer transport in the stratosphere. It gives insight into the mean meridional circulation and mixing processes, and hence helps interpret the distribution of long-lived chemical tracers.

Here we apply the concept of mean age to give insight into tropospheric transport and mixing. We have used multi-annual chemical transport model simulations to determine the spatial distribution of the mean transit time (age) since air in the troposphere left the boundary layer. The mean age since air left the stratosphere is similarly calculated. The sensitivity of results to the inclusion of convective transport is examined. The mean age distribution for air leaving continental and maritime boundary layers is contrasted, as is the mean age distribution for air leaving the northern and southern hemisphere stratosphere. Differences in the mean age during El Niño years are examined.

Modelling of Present-day and Future Tropospheric Ozone

M. I. Johnson, P. H. Plantevin, H. L. Rogers, M. N. Cobb, F. M. O'Connor, K. S. Law and J. A. Pyle

Centre for Atmospheric Science, University of Cambridge, Cambridge, U.K.

As part of the IPCC Third Assessment Report, model simulations of the chemical composition of the present-day and future tropospheres have been performed by a number of research groups. The Cambridge 3D Chemical Transport Model, TOMCAT, has been run as part of this project with emissions for 2000 and 2100. In each case, TOMCAT was run for 20 model months at T21 resolution (5.6 degrees longitude by 5.6 degrees latitude) with 31 vertical levels from the surface up to 10hPa. Forcing data provided by the ECMWF from June 1997 to January 1999 was used in both experiments. Chemical and dynamical budgets of ozone and other trace species from the present-day and future tropospheres will be presented. A comparison with other studies and measurements where available will also be shown.

A 3-D Model Study of Ozone Trends in the Middle Latitudes: The Significance of Dynamical Processes

A. Jrrar, P. Hadjinicolaou, J. Pyle

Centre for Atmospheric Science, University of Cambridge, Chemistry Department, Lensfield Road, Cambridge, CB2 1EW, UK

We have used the SLIMCAT model forced with ECMWF analyses between 1979 and 1998 to study ozone trends in middle latitudes. The Cariolle ozone scheme is used in this model in two versions. In one version we include only gas phase chemistry ignoring polar loss of ozone, while the second version of the scheme includes a simplified polar ozone loss due to PSCs. Hence calculated trends are simply due to changes in transport and how those changes affect the chemistry.

There is good agreement between model and observation of total ozone. For example low ozone is modelled in 1992/1993, in excellent agreement with TOMS measurements. The low ozone has in part dynamical cause. The monthly anomalies for both the model and TOMS measurements agree quite well, especially from mid 1980's onwards, in accordance with the strengthening of the Arctic vortex in the same period. We conclude that a significant component of the trend is dynamically induced.

Freeze Drying at the Winter Mid-latitude Tropopause

Martin Juckes

Oxford University

The water content of tropospheric air entering the stratosphere in the tropics is controlled by the cold temperatures of the tropical tropopause. Temperatures of around 190K reduce the water content to a few parts per billion by volume. Outside the tropics the tropopause is typically lower and warmer, so the freeze drying mechanism might be thought irrelevant. The variability in tropopause height is, however, much greater in mid-latitudes. Details of a case study in which saturation mixing ratios at the mid-latitude tropopause fall to near the values associated with the tropical tropopause will be presented. This suggests that freeze drying in mid-latitudes may be a significant aspect of the water vapour budget in the lower stratosphere.

Benchmarking the UM for CASINO 21

J. A. Kettleborough(1) D. A. Stainforth(2) M. R. Allen(1) M. Collins(3) P. A. Stott(4) C. Jones(4)

*(1) Rutherford Appleton Laboratory, UK; (2) Oxford University, UK;
(3) Reading University, UK; (4) Hadley Centre, The Met Office, UK*

Participants in the CASINO 21 project will use a simplified version of the UM Atmosphere-Ocean coupled model to contribute to an assessment of the uncertainties in climate change. The simplified model will use the standard climate resolution atmosphere (3.75x2.5 degrees latitude by longitude, 19 levels) and a reduced resolution ocean (3.75x2.5 degrees instead of the usual 1.25x1.25 degrees, 20 levels). The UM configuration with the lower resolution ocean is usually referred to as HADCM3L, while the configuration with the higher resolution is usually referred to as HADCM3.

One of the initial challenges to CASINO 21 is to verify that HADCM3L run on a PC is a suitable model to use to assess the uncertainties in climate change. This entails firstly demonstrating that HADCM3L and HADCM3 run on that same platform have similar responses to climate forcing, and secondly that use of 32 bit arithmetic on a PC does not seriously change HADCM3Ls response to climate forcing.

We will present and compare results from benchmark integrations of HADCM3L on the T3E and on a 32 bit Linux Beowolf cluster and, if time permits, compare these to integrations of HADCM3 already performed at the Hadley Centre.

Ozone Climatology in the Upper Troposphere and Lower Stratosphere Region

M. O. Köhler(1), O. Morgenstern(1), A. Marenco(2), J. A. Pyle(1)

*(1) Centre for Atmospheric Science, Dept of Chemistry, University of Cambridge, UK;
(2) Laboratoire d'Aérodynamique, Centre National de la Recherche Scientifique / Université Paul Sabatier, Toulouse, France*

A large data base of in-situ measurements of ozone concentrations is provided by the "Measurement of Ozone and Water Vapour by Airbus In-Service Aircraft" (MOZAIC) project. The Upper Troposphere and Lower Stratosphere (UT/LS) Region on the northern hemisphere is well covered by the MOZAIC data. An ozone climatology of the UT/LS region is compiled using MOZAIC data for several months for each of the years from 1996 to 1999. Variability of ozone in the UT/LS region will be investigated on various time scales. The four years from 1996 to 1999 are of particular interest, as a noticeable contrast in spring-time stratospheric ozone depletion has been observed during this period. We investigate northern-hemispheric ozone in late spring at aircraft cruise altitudes with a focus on a possible subsidence of ozone-depleted air from the middle stratosphere. The calculations are based on the analogy of potential vorticity and ozone. In the first step we interpolate equivalent latitude derived from potential vorticity analyses onto the flight tracks. Secondly, a regression procedure casts the measurements into parameter space, spanned by time, potential temperature, and equivalent latitude. In future studies, the measurements will be compared with results from chemical transport integrations.

Modelling the impact of the 1997/98 El Niño/La Niña cycle on the high latitude circulation of the Southern hemisphere

Tom Lachlan-Cope

British Antarctic Survey, UK

The impact of ENSO events on the climate of Antarctica as a whole, and the Peninsula region in particular is subject to much investigation at the moment. The Peninsula region has experienced the largest warming in the Southern Hemisphere over the last 50 years and it is thought that this may be connected with changes

in ENSO events over that time. In this study we investigate the possible links between ENSO events and circulation at high latitudes in the Southern hemisphere using a coupled general circulation model.

This study takes two sets of ensembles each of 10 two year runs made with a coupled ocean-atmosphere model (the UKMO Hadley centre HadCM3). One set are forced with two years of observed tropical Pacific sea surface temperature (SST), and the other set is forced with the climatological mean SSTs in the tropical Pacific. Elsewhere the sea surface temperature is allowed to vary freely. These runs have already been used to demonstrate the link between the 1997/98 ENSO event and SST anomalies in the Atlantic Ocean. Unfortunately at high southern latitudes the variability of the climate system is much greater than it is at lower latitudes and the model does not show a clear link between the sea surface temperature in the tropical Pacific and the near surface circulation around Antarctica. This may be due to the greater variability of the high latitude climate or because of the shortcomings of the model representation of sea ice around Antarctica.

Heart of DARCness

William Lahoz and Alan O'Neill

CGAM, Department of Meteorology, University of Reading, UK

The "Data Assimilation Research Centre" (DARC) has been recently funded by NERC under its Centre of Excellence Initiative in Earth Observation. DARC is a distributed centre, including effort from Reading, Oxford, Cambridge and Edinburgh Universities, the Rutherford Appleton Laboratory and a strong partnership with the Met. Office. DARC will aim to convert the wealth of Earth system data into a self-consistent form that researchers can use for quantitative analyses and prediction. This poster will expand upon the why, how and what of DARC.

Chemical Data Assimilation: What has been achieved so far?

David Lary

Cambridge, UK

This talk gives an overview of the chemical data assimilation system we have put in place. It covers our code generation and documentation software, 4D-Var & Kalman filter system, our automated validation/skill process, our visualisation and automated analysis process, and our multi-gigabyte database with batch processing capability. We also will give an overview of our current work for ESA concerning the validation of future ESA instruments & missions. We will cover in particular the quality control of the data and our skill statistics which are aimed at identifying biases.

Chemistry-Climate Interactions in the Upper Troposphere and Lower Stratosphere: An overview

Kathy Law

*NERC UTLS Ozone Programme Manager, Centre for Atmospheric Science,
Department of Chemistry, University of Cambridge, Cambridge, UK*

Changes in the concentrations of ozone and other trace gases in the region of the upper troposphere and lower stratosphere (UTLS) have the potential to perturb the Earth's climate. In turn, changes in the Earth's climate have the potential to change the concentrations and distributions of ozone and other trace gases. This paper will present a brief overview of possible interactions between chemical, dynamical and radiative processes in the UTLS region. Whilst certain interactions are being studied, many have yet to be rigorously quantified and new research is needed. This topic is a major research theme in the NERC UTLS Ozone

thematic programme as well as in UGAMP. Moves to stimulate further research in this important area will be discussed.

Downward control effects on the period of the QBO in a three dimensional mechanistic model

B. N. Lawrence

British Atmospheric Data Centre, RAL

Previous 2D model simulations using the Hines parameterization of unresolved gravity waves have produced long period oscillations in the tropics. Such oscillations include the Quasi-Biennial Oscillation (QBO) and the Semi-Annual Oscillation (SAO). In this paper simulations with a 3D mechanistic model are reported which show a realistic representation of the QBO. These simulations show the expected dependence of the period of the QBO on the momentum flux entering the stratosphere, but also show a hitherto unreported dependency of the period on the upper boundary condition. In these simulations the dependency is linked to changes in mesospheric vertical velocities associated with the SAO.

Atmospheric teleconnections from TOMS ozone data

B. Lerer and S. P. Lawrence

University of Leicester, UK

Decadal changes in 500hPa geopotential heights can be explained by a linear combination of the North Atlantic Oscillation, the Pacific-North American anomaly and the Eurasian pattern. Ozone perturbations, determined from TOMS for the period Winter 1979 to 1991, have been analysed using teleconnectivity maps and rotated principal component analyses to investigate the extent to which upper tropospheric variability is reflected in the northern hemisphere ozone distribution. The results compare very favourably with 100hPa and 500hPa geopotential height data from the ECMWF reanalysis for a similar period. It is found that the PNA and Eurasian patterns account for a significant amount of ozone variability (17% and 15% of the total variance). These results are in agreement with previous work which suggests that the longitudinal dependence of ozone trends in the northern hemisphere is determined by changes in the stratospheric stationary wave during Winter.

Towards a Size-dependent Composition Model of Polar Stratospheric Clouds, suitable for Global Models

D. Lowe and A. R. MacKenzie

Lancaster University, UK

The composition of the stratospheric aerosol changes dramatically as an air mass is cooled to temperatures in the range of 180-200 K. For rapid temperature changes – in mountain-wave-induced clouds, for example – the combination of the Kelvin effect and the size-dependence of vapour deposition rates mean that this change in composition is size-dependent. Lagrangian, size-bin-following, numerical schemes have been used to study this growth [e.g. Meilinger et al., *Geophys. Res. Lett.*, 22, 3031-3034, 1995]. Such schemes, whilst efficient, are unsuitable for the simulation of aerosol populations in global chemistry-and-transport models (CTMs) because the air-trajectory-dependant aerosol microphysics leads to gaps in the model “radius space”. In an attempt to overcome this drawback, we have been working on an adaption of the scheme of Pilinis [*Atmos. Environ.*, 24A, 1923-1928, 1990] to model polar stratospheric clouds. The model under development combines PSC thermodynamics with an efficient numerical scheme that is monotone,

conservative, and designed to be compatible with CTMs [Nikiforakis and Toro, in Morton and Baines (eds.), Numerical methods for fluid dynamics, OUP, 1995].

Modelling the global dust cycle

D. J. Lunt and P. J. Valdes

Reading University, UK

Mineral dust aerosol is thought to have a significant effect on the radiation budget. Estimates of the global mean direct radiative forcing of dust are of the order -1Wm^{-2} at the surface, but many uncertainties remain, especially with respect to possible indirect radiative effects.

This paper describes a new dust cycle model, which could be used in studies of the radiative effects of dust. It is built around the tracer model TOMCAT, and is forced by Unified Model output. Validation of present day model results is by comparison with satellite data and ground level observations. Simulations of the dust cycle at the Last Glacial Maximum have also been carried out, and these results are compared to the polar ice-core record.

Middle-Atmospheric Water Vapour in the Unified Model

I. A. MacKenzie

Edinburgh University, UK

The photochemistry of water vapour in the middle atmosphere is dominated by production from methane oxidation in the stratosphere, and destruction by photolysis in the mesosphere. A parameterization of these processes has been implemented in the 64 level version of the Unified Model. The resulting simulations of water vapour are discussed and compared with observations highlighting any discrepancies. Preliminary findings on the impact of using the model-calculated water vapour for the radiation calculations in place of the currently-used climatology will also be presented.

Response of the atmosphere - ocean mixed layer system to anomalous convergence of ocean heat transport

P.-P. Mathieu and R. T. Sutton

Center for Global Atmospheric Modelling, Department of Meteorology, University of Reading, UK

Northward Ocean Heat Transport (OHT) by the Atlantic circulation plays a role of paramount importance in determining the climate of Europe. Consequently, fluctuations in the OHT are likely to have a large impact on the western European climate. In order to better assess and predict such impacts, there is an urgent need to understand how OHT variability affects the mid-latitude atmosphere. The present study addresses this question by use of an intermediate coupled climate model including a state-of-the-art atmospheric general circulation model (HadCM3) and a simple slab ocean model. With this model configuration one can control the convergence of ocean heat transport directly. In contrast to traditional studies based on atmosphere-only models forced by SST anomalies, our new methodology is more physically-based and offers considerable insight into the role of OHT variability in climate. We will report the results of our first set of experiments.

The Extratropical Response to Tropical Intraseasonal Convection during Northern Winter

Adrian J. Matthews

School of Environmental Sciences, University of East Anglia

The life cycle of the Madden-Julian oscillation (MJO) is calculated using 21 years of satellite outgoing longwave radiation (OLR) as a proxy for deep tropical convection. Regression maps of NCEP-NCAR reanalysis data for northern winter show a sequence of upper-tropospheric wave trains propagating from the tropical convection anomalies into both hemispheres and a further wave train propagating southwards across the "equatorial duct" over the eastern Pacific. These wave trains are statistically significant and are also present when the analysis is split into two non-overlapping periods of 10 and 11 years.

A global baroclinic model is initialised with the observed northern winter climatological flow and forced with a time-dependent heat source with the same pattern as the observed MJO OLR anomalies. The direct Rossby wave response to the heating anomalies matches the observations well; the subtropical wave pattern is set up after approximately one week, while it takes two-three weeks for the extratropical pattern to appear. Given that the MJO can be predicted by statistical techniques for a lead time of up to ten days, this implies some predictability of the global circulation over this time.

Observed Propagation and Structure of the 33-Hour Atmospheric Kelvin Wave

A. J. Matthews(1) and R. A. Madden(2)

(1) School of Environmental Sciences, University of East Anglia; (2) NCAR, Boulder, Colorado

The structure of the 33-hour Kelvin wave, a normal mode of the atmosphere, is examined in 6-hourly station and NCEP-NCAR reanalysis data. Cross-spectral analysis of 6 years (1993-98) of tropical station pressure data shows a peak in coherence in a narrow frequency band centred near 0.74 cycles per day, corresponding to a period of approximately 33 hours. The phase angles are consistent with an eastward-propagating zonal-wavenumber-one structure, implying an equatorial phase speed of approximately 340 ms^{-1} . The global structure of the mode is revealed by empirical orthogonal function and regression analysis of 31 years (1968-98) of reanalysis data. The horizontal structure shows a zonal-wavenumber-one equatorial Kelvin wave with an equatorial trapping scale of approximately 34 degrees lat. The vertical structure has zero phase change. The amplitude of the wave is approximately constant in the troposphere with an equatorial geopotential height perturbation of 0.9 m, and then increases exponentially with height in the stratosphere. Cross-spectral analysis between the station and reanalysis data shows that the results from the two data sets are consistent. No evidence can be found for forcing of the wave by deep tropical convection, which is examined using a twice-daily outgoing longwave radiation data set.

The origin and fate of "missing forces" that arise during gravity wave propagation

O. Buhler(1) and M.E. McIntyre(2)

(1) St Andrews University; (2) Cambridge University

There has also very recently been a breakthrough in understanding the fluid dynamics of certain "missing forces", not associated with gravity wave dissipation and not accounted for in any existing parametrization scheme. These missing forces arise when the horizontal propagation direction changes, that is, whenever there are horizontal gradients in the background atmosphere. They do not depend on wave-breaking or other dissipative processes, but on changes in the gravity wave horizontal wavevector. The forces are given by a nondissipative counterpart of the pseudomomentum rule, except that the force distribution is influenced by neighbouring potential vorticity distributions. We will show that this force distribution is quite different from the more familiar distributions that result from wave dissipation or breaking.

Transport in the Tropical Tropopause Zone Diagnosed using Trajectories

D. R. Jackson(1), J. Methven(2), V. D. Pope(3)

(1) UK Met Office; (2) University of Reading, UK; (3) Hadley Centre, UKMO.

Recent literature has described a "transition zone" between the average top of deep convection in the tropics and the stratosphere. Here transport across this zone is investigated using an offline trajectory model where particles are advected by the resolved winds from the ECMWF Re-Analyses (ERA-15). For each boreal winter (DJF) clusters of particles were released over the four main regions of tropical deep convection (Indonesia, central Pacific, South America and Africa). Over 80% of particles released from 150 hPa, near the average top of convection, stay within the tropospheric Hadley and Walker circulations and descend on average. Of the remainder, most cross the (WMO) lapse rate tropopause in the tropics within 20 days. As trajectory length increases, histograms of potential temperature (θ) spread and a flat portion develops between 320K and 350K, indicative of a well-mixed distribution with the tropical troposphere.

Slight excursions across the undulating lapse rate tropopause surface are differentiated from the drift deeper into the stratosphere by defining a "tropopause zone". In the ERA dataset, the difference in θ for the seasonally averaged lapse rate and temperature minimum tropopause surfaces was found to be 9.9K (1.8K) using all DJF seasons and release locations. The tropopause zone was defined to have a lower bound given by θ for the lapse rate tropopause plus a constant depth of 10K. θ -histograms for forward and backward trajectories across the tropopause zone demonstrate the marked difference between diabatic transport in the convectively active part of the troposphere and the transition zone above ($\theta > 350K$). Within the transition zone the θ -histograms resemble a spreading Gaussian with a slight bias to increasing θ .

Although trajectories slowly cross the tropopause zone throughout the tropics, maps of the density of tropopause zone crossing events show that most trajectories reaching the stratosphere from the lower troposphere within 30 days do so over the west Pacific warm pool. This preferred crossing location moves with the warm pool during El Niño and La Niña years. These results could have important implications for upper troposphere/ lower stratosphere chemical transport.

Quantifying Mixing in the Stratosphere From the Distribution of Long-Lived Tracers

O. Morgenstern(1), J. A. Pyle(1), J. W. Elkins(2), D. F. Hurst(2), P. A. Romashkin(2)

*(1) Centre for Atmospheric Science, Chemistry Department, Cambridge University, UK;
(2) NOAA Climate Monitoring & Diagnostics Laboratory, Boulder, Colorado, USA*

Long-lived tracers in the stratosphere often exhibit tight correlation curves resulting from the competing influences of mixing and chemistry. Where chemistry imposes curvature on a correlation curve, straight lines connecting two points on the curve (i.e., deviations from the tight correlation) indicate weighted mixing. Here we suggest a technique that allows to infer quantitatively the fractional mixing between air of different origins mixing in a given air parcel. The method requires simultaneous measurements or modelled distributions of a suite of long-lived tracers and in addition known envelope functions of tracer-tracer correlations. The technique is applied to model data and measurements. Model data are evaluated using a three-months integration of the SLIMCAT chemical transport model with full chemistry and radiation. Envelope functions are derived which describe the correlations of NO_y, CH₄ and a suite of halocarbons with N₂O, and from these regions of mixing are inferred. A variant of the technique is applied to measurements taken during the SOLVE campaign of 1999/2000 in the Arctic stratosphere. The measurements comprise N₂O, CH₄, halocarbons and CO₂ measured by the NASA ER-2 aircraft.

Simulating the mass balance of the Greenland ice sheet with high resolution models

B. F. Murphy, I. Marsiat, P. Valdes

University of Reading, UK

The cryosphere is an intricate part of the Earth system, playing a central role in climate-change feedback mechanisms. The main ice sheets in particular feature strongly in global sea level changes. Recent work suggests that the Greenland ice sheet is currently undergoing enhanced melting at its margins, which may lead to sea level rises. This melting is but one part of the mass balance of the ice sheet, and may be countered by increased precipitation over the interior of Greenland where melting is rare. Here we present work that investigates the current mass balance with the aid of the UK Met. Office Unified Model version 4.4 (UM4.4). The use of this atmospheric GCM is justified by the dominance of atmospheric parameters (principally temperature and precipitation) in the mass balance. While the global model has insufficient resolution to fully represent the strong topographic forcing on the mass balance, the output of this model is used to force much higher resolution models. The global model results have been extensively verified and the results of the higher resolution models, a limited-area version of UM4.4 and a downscaling model, are seen to be encouraging. Results of the global, limited-area and downscaling models are presented and the current efforts to improve the mass balance simulations are outlined.

El Niño's influence in the Tropical Atlantic - Ignore the basic state at your peril

R. B. Neale and J. M. Slingo

Centre for Global Atmospheric Modelling, University of Reading, UK

A reduction in the easterly trade winds leading to the generation of positive SST anomalies is commonly observed to be the Atlantic's remote response to a Pacific El Niño event. This talk will show that in a long integration of a current climate simulation of The Met. Office ocean-atmosphere coupled model, HadCM3, errors in the basic state lead to a fundamentally different Atlantic response. Monsoon-type surface westerlies are produced in the equatorial Atlantic region in northern spring, several months before they are seen in reality. Crucially this is at a time when the remote El Niño signal is strongest. Remotely forced Easterlies and spurious basic-state westerlies combine with the remotely forced descent to drastically increase the surface energy input to the upper ocean. At a time when the mixed layer depth is seasonally shallow large SST anomalies in close proximity to the equator result, dominating over any SST changes further north.

Reasons for the Atlantic systematic errors appear, ultimately, to lie in the models representation of boundary layer stratocumulus off the West African coast and the propensity of the African continent to heat up too quickly in response to increased spring solar heating - problems that have persisted for many years in climate models.

Transport of Water Vapour in the Unified Model - Introducing an on-line Semi-Lagrangian Advection Scheme

Katrin Nissen, Ian Mackenzie, Vicky West

The University of Edinburgh, UK

The Unified Model (UM) advects water vapour using the Heun scheme. This gives a remarkably clear tape recorder signal in the tropics. However some of its characteristics are somewhat dubious. The Heun scheme has the tendency to strengthen strong gradients. In the process it can generate values higher or lower than the range of the values before transport. It also leads to an oscillation in the vertical ahead of the forcing.

The other option for transport in the UM is the Roe scheme. It is the default choice for the transport of tracers. This scheme is positive definite and quite diffusive.

Tests advecting the water vapour and tracer fields by the Heun and the Roe transport have shown that the results strongly depend on the choice of the scheme. For example the upward velocity of the tape recorder signal is much faster with the Heun scheme than with the Roe scheme even when the underlying winds remain the same.

Both the Heun and the Roe scheme are Eulerian advection schemes. It is widely believed that Eulerian transport schemes are not an optimal choice for the advection of tracers and chemical constituents. Therefore a semi-Lagrangian transport scheme (Boettcher 1996) has been implemented into the UM. It is run on-line and can be alternatively used for tracer and/or water vapour transport. In this talk the new scheme will be introduced and its effects on the water vapour and the tracer distributions will be shown.

Have we missed some dynamics about the QBO?

Warwick Norton(1), Dave Stainforth(1), Emily Shuckburgh(2)

(1) Atmospheric, Oceanic and Planetary Physics, University of Oxford; (2) DAMTP, University of Cambridge

Evidence is presented from a hierarchy of models that indicates the westerly phase on the QBO is susceptible to barotropic instability. This has important implications for the momentum balance in the tropical lower stratosphere and mixing and transport in this region. Results are presented from: a shallow water equation model where an eastward force is applied at the equator; the Unified Model with the Hinds gravity wave parameterisation which spontaneously generates a QBO; ECMWF analyses where examination is made of wave activity diagnostics and the mixing structure by use of effective diffusivity.

Ozone Budget of the Upper Troposphere : Measurements and Modelling

F. M. O'Connor(1), S. R. Arnold(1), N. H. Savage(1), K. S. Law(1), J. A. Pyle(1), J. Methven(2), B. Bandy(3), N. Brough(3), T. Green(3), G. Mills(3), H. Barjat(4), K. Dewey(4), and J. Kent(4)

(1) Centre for Atmospheric Science, Cambridge University, UK; (2) University of Reading, UK; (3) University of East Anglia, Norwich, UK; (4) MRF, UK Meteorological Office, UK

Chemical constituent measurements taken onboard the UKMO C-130 aircraft during May 2000 as part of the UTLS ACTO (Atmospheric Chemistry and Transport of Ozone) flying campaign sampled many layers of different composition in the upper troposphere over Western Europe. The layers sampled included stratospheric air, uplifted clean marine boundary layer air and polluted continental boundary layer air.

A global three-dimensional chemical transport model, TOMCAT, will be compared to the measurements. First estimates of the contribution of stratospheric ozone and clean/polluted boundary layer air to the ozone budget of the upper troposphere will also be presented.

Solar Irradiance, Ozone and the Little Ice Age

M. Palmer(1), W. Norton(1), M. Allen(2)

(1) Oxford University, UK; (2) Rutherford Appleton Laboratory, UK

The HadAM3 version of the UKMO Unified Model has been used to examine the climatic impact of spectrally resolved decreases in the solar constant, both with and without accompanying ozone changes. The magnitude of the imposed forcings have been chosen to match the range of estimated decreases in total solar irradiance associated with the Maunder Minimum of solar activity, to investigate this as a potential forcing factor for the Little Ice Age. The model shows a consistent response which is largest in the summer season,

and which scales with the forcing imposed. With the inclusion of the accompanying ozone changes, the amplitude of the signal is greatly increased. Although the overall magnitude of the surface forcing remains unchanged, the effect of the ozone is to increase the magnitude of the radiative anomalies at infra-red wavelengths, whilst decreasing those at shorter wavelengths. The fixed SSTs in this model limit the response to the short wave anomalies, so that the infra-red changes dominate and the climatic impact is enhanced.

The predictability of atmospheric blocking

J. L. Pelly and B. J. Hoskins

Reading University, UK

The meteorology of the extratropical northern hemisphere is governed to a large extent by the existence of the mid-latitude westerly jet. As its name suggests, atmospheric blocking is associated with the blocking of this westerly jet and the formation of anomalous local easterly flow.

Atmospheric blocking is quasi-stationary and can persist for a number of weeks before decaying rather suddenly to give way to westerly flow once again. The onset of blocked flow also tends to be rather abrupt, which makes it difficult to predict changes to and from the blocked regime.

Northern hemisphere blocking most frequently occurs over the eastern ocean basins. The blocking high acts to deflect the eastward-travelling cyclones in the Atlantic or Pacific storm track to its north or south, leading to a redistribution of rainfall in the region and instances of severe droughts in the summer season, for example in July 1976. The block also produces a strong southward advection of polar air on its eastern flank, inducing spells of extremely cold weather in winter, for example in February 1986. These sometimes severe effects on the weather coupled with the abrupt transitions between blocked and zonal flow mean that forecasting blocking is one of the main problems facing medium-range forecasters in the extratropics today.

Here we present a new dynamically based blocking index defined using potential temperature on the PV=2 surface. We also describe how probability forecasts of blocking may be produced using the new blocking index in conjunction with the ECMWF Ensemble Prediction System. Such forecasts are now being produced quasi-operationally.

The impact of Westerly Wind Events on the western equatorial Pacific Ocean

A. Pirani and K. Richards

Southampton Oceanography Centre, Southampton University

The influence of Westerly Wind Events (WWEs) on the equatorial Pacific Ocean is widely recognised. Sensitivity tests of the upper ocean response to different model configurations are carried out using the OPA OGCM. The ocean's response is being studied in relation to the nature of WWEs, such as the geographical location, intensity, and whether the events are stationary or moving, the mean state of the ocean, looking at stratification and mixing processes, and the effects of precipitation. Preliminary results from this work will be presented.

Waves, layers and fingers; mixing in the equatorial Pacific

Kelvin Richards

Southampton Oceanography Centre University of Southampton

The equatorial ocean plays a major role in the El Niño/ Southern Oscillation. Mixing processes in the upper ocean contribute to the dynamics and thermodynamics of the system, with the mean state and variability of the ocean being dependent on the strength and form of the mixing. Here we consider the processes that bring

about the lateral mixing of heat, salt and momentum. The story that unfolds includes an intimate mix of tropical instability waves, interleaving water masses and double diffusive convection. The finale is a parametrization scheme that no self-respecting GCM should be without.

Modelling the global sources and sinks of methane

N. Rolfe(1), J. Pyle(1), C. Bridgeman(2)

(1) Cambridge University, UK; (2) Hull University, UK

Methane is an atmospheric trace gas with many sources. Anthropogenic emissions of methane since pre-industrial times are believed to be the major cause of a two-fold increase in atmospheric methane concentrations. As methane is both a greenhouse gas and an active constituent in tropospheric chemistry, this increase in abundance will directly affect the radiative balance at Earth's surface, as well as the chemical balance of the atmosphere. Indirect effects of increasing methane are also likely to have important implications, such as a rise in tropospheric ozone concentrations and stratospheric water vapour. It is therefore important to understand the factors controlling methane levels within the atmosphere. However, the budget of methane is still poorly understood with large uncertainties associated with the contribution of each source. The TOMCAT atmospheric model has been used with a simple chemistry scheme to model methane concentrations within the troposphere. Modelled concentrations of methane are analysed and compared with monthly mean data in order to test our understanding of the methane budget.

The effect of two decades of ozone change on stratospheric temperature as indicated by a general circulation model

S. M. Rosier and K. P. Shine

Department of Meteorology, University of Reading, UK

The effect on stratospheric temperature of ozone change since 1979 is investigated using a general circulation model employing observations of the vertical profile of ozone change. The stratopause region is generally cooler in 1997 than in 1979 by about 2K. Results from a "Seasonally Evolving Fixed Dynamical Heating" simulation indicate that this cooling is mostly radiative in origin. In Antarctica the model indicates statistically significant cooling of the lower stratosphere between 1979 and 1997, peaking at 13K in November; this agrees quite well with observations. In the Arctic no significant cooling is seen in winter or early spring, in contrast with observations, indicating that ozone loss is not the main cause of the observed temperature change here. The peak Antarctic cooling is accompanied by a warming of the upper stratosphere; dynamics are responsible for this warming and for making the lower stratospheric cooling less severe than it would otherwise be.

The Northern Hemisphere Storm Tracks in HadAM3: Systematic Errors and their Sensitivity to the Representation of the Rockies

Len Shaffrey

CGAM, Department of Meteorology, University of Reading, UK

The Northern Hemisphere wintertime atmospheric flow is characterised by two regions of synoptic-scale eddies which are located over the North Atlantic and North Pacific Oceans, i.e. the Atlantic and Pacific storm tracks. A comparison of the storm tracks in ERA-15, the ECMWF Reanalysis dataset, and HadAM3, the UKMO atmospheric climate model, reveals some prominent differences between the model and the observations. For a particular measure of storm track activity, the lower tropospheric transient temperature

fluxes, the wintertime Atlantic storm track in HadAM3 is nearly half the strength of the storm track in ERA-15.

The weak Atlantic storm track in HadAM3 is related to the weak meridional temperature gradient at the start of the Atlantic storm track, which manifests itself as a warm temperature bias and southerly wind error along the eastern flank of the Rocky Mountains. The systematic errors over the North American continent can be reduced by introducing an envelope orography for the Rocky mountains. The increase in the time-mean baroclinicity that results from the introduction of the envelope orography strengthens the North Atlantic storm track and reduces systematic errors over Europe and the subtropical North Atlantic Ocean.

Climate change, the biosphere bites back

K.-Y. Wang(1), D. E. Shallcross(2) and J. A. Pyle(1)

(1) Centre for Atmospheric Science, Dept. Chemistry, Cambridge; (2) School of Chemistry, University of Bristol.

Global climate change is one of the foremost environmental issues as we enter the twenty-first century. Levels of CO₂ are expected to double over the next century and it is anticipated that both surface temperature and rainfall patterns will be altered, possibly dramatically so, as a result. The effect of rising CO₂ on vegetation is generally believed to lead to an increase in the Net Primary Production (NPP), i.e. the net gain of biomass by plants per unit time. If the system were assumed to be linear, one would conclude that increasing NPP would inevitably result in increasing biogenic emissions. Many biogenic emissions are strongly temperature dependent, increasing with increasing ambient temperature, e.g. biogenic species such as isoprene and monoterpenes. Therefore, in addition to any increase in biogenic emissions due to increasing NPP, increases may also occur if the surface of the Earth warms significantly as a result of rising CO₂ levels. It is now recognised that the photooxidation of isoprene, the largest single biogenic species emitted by mass, can lead to greatly enhanced levels of ozone and PAN (peroxyacetyl nitrate); both local to source regions and also globally in the troposphere. Therefore, one might expect tropospheric levels of PAN and ozone to increase in the future in the face of rising biogenic emissions. Ozone is an important greenhouse gas, and any possible increases may have significant effects on the Earth's radiative budget, and hence climate. In this paper, we report some first results from an annual integration of a coupled atmospheric-biosphere model, run for the year 1991. The role of isoprene is highlighted and some thoughts on future scenarios are presented.

The effects of isoprene on urban, regional and global scales

*D. J. Gray(1), A. C. Rivett(1), G. Nickless(1), S. O'Doherty(1), V. Sheppard(1), D. Martin(1),
P. G. Simmonds(1), K.-Y. Wang(2), J. A. Pyle(2) and D. E. Shallcross(1)*

(1) School of Chemistry, University of Bristol; (2) Centre for Atmospheric Science, Cambridge

Isoprene is a naturally occurring hydrocarbon, emitted by many plants and trees. Its natural emission flux is estimated to be in the region of 250-500 Tg year⁻¹, which exceeds the total flux of CH₄. Isoprene is extremely reactive and can in the presence of NO_x (NO and NO₂) promote rapid ozone production. The role played by isoprene on urban, regional and global scales are investigated using a range of models and compared with available measurements. It is shown that isoprene plays an important role in the photochemistry of the troposphere and some thoughts on how this role may change as climate changes is presented.

Interannual variability in the springtime Arctic polar vortex

Emily Shuckburgh(1) and Warwick Norton(2)

(1) Cambridge University, UK; (2) Oxford University, UK

ECMWF analyses indicate that the Arctic polar vortex in the lower stratosphere in spring has substantially strengthened from the 1980s to the 1990s. This is shown by a cooling of the polar temperatures and an increase in the zonal wind. Associated with these changes there have been several late break-ups of the vortex during the 1990s. A 20-year integration, using analysed winds from 1979 to present, has been used to investigate these changes and to examine the interannual variability.

In the northern hemisphere polar regions there is shown to be a trend of a significant decrease in values of the transport diagnostic "equivalent length" over the 20-year period (indicating a strengthened vortex-edge barrier), as is consistent with the trends in temperature and zonal wind. These apparent trends may be due to increasing spring-time ozone depletion, however the longer timescale record of radiosonde data (back to 1958) indicates considerable decadal variability, and some of the changes from the 1980s to 1990s may be due to natural variability.

It is shown that there is considerable interannual variability in the equivalent length in the polar region, some of which appears to be associated with the Arctic oscillation (at 1000hPa) indicating coupled stratosphere-troposphere variability. Dynamical diagnostics, including eddy heat fluxes, and output from model ozone calculations are examined to determine the mechanisms driving the variability.

As an aside, the global equivalent length calculation has also highlighted the influence of other modes of variability on the transport and mixing of the stratosphere and troposphere, e.g., the influence of the quasi-biennial oscillation on the stratospheric tropics and subtropics, and the influence of El Niño on the monsoon-associated mixing in the upper troposphere.

How well do we understand Arctic ozone depletion?

Bjoern-Martin Sinnhuber, Martyn P. Chipperfield, Stewart Davies

School of the Environment, University of Leeds, UK

During the last decade, significant ozone depletion has been observed in the Arctic lower stratosphere during winter and spring. Unlike the situation within the Antarctic ozone hole, ozone loss in the Arctic lower stratosphere shows a high degree of inter-annual variability. Although there remains no doubt that the substantial ozone loss in high-latitude winter and spring is caused by anthropogenic chlorine and bromine emissions, there is still uncertainty about the quantitative extent.

One of the key issues of the European THESEO campaign and the NASA SOLVE campaign was to quantify the amount of Arctic ozone loss by integrated field measurement and modelling activities. As part of these activities we have used the SLIMCAT global 3D chemical transport model to simulate the evolution of chemical species over the past Arctic winters. For the winter of 1999/2000 the SLIMCAT model forced by UKMO analyses showed substantial ozone depletion over the Arctic, reaching 70% loss at the end of March 2000, in excellent agreement with observations. However, while the model excellently reproduces the ozone loss during winter 1999/2000, the model significantly underestimates the ozone loss for previous cold winters.

Based on comparisons with observational data, we will show under which conditions models can reproduce the Arctic ozone depletion and under which conditions they fail currently and discuss possible causes for the remaining discrepancies.

The Organisation of Tropical Convection by Intraseasonal Sea Surface Temperature Anomalies

Steve Woolnough(1), Julia Slingo(2), Brian Hoskins(3)

*(1) The Met Office, Bracknell; (2) CGAM, Dept. of Meteorology, University of Reading;
(3) Dept. of Meteorology, University of Reading*

Observational studies have clearly demonstrated that the atmosphere can force the ocean on intraseasonal timescales. However, for a coupled atmosphere-ocean phenomenon, the ocean must in turn be able to force the atmosphere. This paper addresses the specific question of how the ocean may organise convection on intraseasonal timescales. An atmospheric General Circulation Model with an ocean covered surface has been used to investigate the response of tropical convection to idealised imposed intraseasonal sea surface temperature anomalies, and the sensitivity of this response to their propagation speed.

The convection is found to be organised on the spatial and temporal scales of the imposed sea surface temperature anomalies and the location of the maximum in precipitation relative to the sea surface temperature anomaly is in good agreement with observations, and different from that for a stationary SST anomaly. The magnitude of the precipitation anomalies increases with decreasing propagation speed of the sea surface temperature anomalies. The role of the free tropospheric humidity is crucial for determining the location and magnitude of the precipitation response.

Predictability and variability of monsoons, and the agricultural and hydrological impacts of climate change (PROMISE): A new European programme in monsoon research and its applications

J. Slingo and E. Black

Centre for Global Atmospheric Modelling, Department of Meteorology, University of Reading

PROMISE is a new 3-year European programme funded by the European Union which supports 12 research groups working on climate and seasonal prediction, crop modelling and land hydrology.

PROMISE is an interdisciplinary project which will develop further the atmospheric science base in seasonal and climate change prediction for monsoon-affected countries, and will consolidate the links between atmospheric science and the impacts communities related to hydrology and agriculture. A particular aim of PROMISE is to develop an integrated approach towards seasonal and climate change prediction in which the impacts on local hydrology and agriculture are part of the prediction process.

PROMISE aims to address two key issues for monsoon-affected countries, whose seasonally arid climates mean that they are highly vulnerable to changes in the seasonal behaviour of the monsoon. These key issues are: (i) the potential for seasonal prediction and the benefits that would accrue in terms of the management of water resources and agriculture, and (ii) the impacts of anthropogenic climate change on these semi-arid regions, in particular on the availability of water resources for human use, and on the productivity of crops and the potential changes in the natural vegetation. Of particular relevance to agriculture and hydrology will be the change in the incidence of extreme events on interannual (flood vs. drought) and subseasonal (wet vs. dry spells) timescales.

COAPEC: Coupled Ocean Atmosphere Processes and European Climate

H. Snaith(1), B. Sinha(1), M. Collins(2), P.-P. Mathieu(2)

(1) Southampton Oceanography Centre, UK; (2) CGAM, Reading University, UK

COAPEC (Coupled Ocean Atmosphere Processes and European Climate) is a NERC thematic research programme. Its main objectives are: (1) To determine the impact on European climate of the coupling between the atmosphere and the ocean on seasonal to decadal timescales. (2) To study the nature and

predictability of climate fluctuations by use of coupled models. (3) To bridge the gap between scientific research and societal needs, enabling thereby stakeholders to fully exploit model results. This poster gives a brief overview of the COAPEC programme and associated coupled climate modelling research efforts in UK.

Modelling the Global Effects of El Niño and La Niña

H. Spencer and J. Slingo

Meteorology Department, Reading University

The El Niño Southern Oscillation (ENSO) and its cycle has significant effects on the weather around the world. The mechanisms by which the tropical Pacific sea surface temperatures (SSTs) affect the global atmospheric and oceanic states are investigated using a combination of analysis of SST and atmospheric data and idealised GCM experiments.

A composite four year cycle of SSTs including an El Niño and a La Niña has been created using the GISST3 data set. This SST cycle, repeated a number of times, is being used as the lower boundary condition to an atmosphere only experiment using HadAM3. The design of the experiment is intended to show how the global impacts of El Niño interact with the seasonal cycle as well as how El Niño may affect the SSTs in remote ocean basins.

The construction of the evolving El Niño/La Niña SST anomaly cycle will be described. The atmospheric response to this cycle in HadAM3 will be presented and compared with the response to real El Niño events in the ECMWF reanalysis (ERA). The forcing of the remote ocean basins by the global atmospheric teleconnections are being studied and will form the basis of future experiments with a version of HadCM3 which allows regional coupling with an ocean model.

Casino 21: Progress towards a Multi-Million Member Climate Ensemble Experiment

*D. Stainforth(1), M. Allen(2), A. Thorpe(3), P. Stott(3), J. Hansen(4),
A. Heaps(5), J. Kettleborough(2), M. Collins(5), B. Booth(3,1)*

(1) AOPP, Dept. of Physics, Oxford University;

(2) Space Science and Technology Department, Rutherford Appleton Laboratory;

(3) Hadley Centre for Climate Prediction and Research, The Met.Office;

(4) MIT, Boston; (5) Dept. of Meteorology, University of Reading

The Casino-21, Do It Yourself Climate Prediction project has two main goals: 1) To harness the power of idle home and business PCs to carry out a multi-million member ensemble forecast of the climate of the 21st century, and 2) To improve public understanding of the nature of uncertainty in climate prediction. To date more than 17,000 people have registered to participate and more than 45,000 PCs have been offered.

In preparation for a model release to the public there is ongoing work on: model selection, model preparation, experimental design and practical computing issues. The current status of this work will be presented including details of the proposed experiments and the results from preparatory spin-up runs. There are also ongoing activities relating to promotion and publicity, as well as planning work regarding the preparation of a package of information and software for the participants. These will be presented together with a timescale for releasing the model.

It is hoped that members of UGAMP will actively participate in the debate over the issues and opportunities presented by this collaborative project.

Grid Computing - the way forward?

L. Steenman-Clark

University of Reading, UK

The grid computing initiative announced in the recent Government Spending Review, should provide a major investment in software/ tools/hardware/networking to enable the building of an integrated problem-solving environment for UK science. The concept of grid computing will be outlined.

UGAMP, as a distributed modelling project with large data intensive computing requirements, needs to exploit the enormous potential of grid computing. A test bed grid proposal, "e-climate", that builds on UGAMP's experience and expertise to develop the climate modelling environment of the future will be presented.

Development of a Troposphere-Stratosphere-Chemistry-Climate model

David Stevenson(1), Bob Harwood(1), Colin Johnson(2), Bill Collins(2) and Dick Derwent(2)

(1) Dept. Meteorology, University of Edinburgh; (2) Hadley Centre for Climate Prediction and Research, The Met. Office

Over the past 6 years the tropospheric chemistry-transport model STOCHEM has been developed at the UK Met. Office. This model has recently been closely coupled to the Hadley Centre AOGCM (HadCM3), and century-scale transient tropospheric chemistry-climate change experiments performed. These experiments were computationally expensive, but not excessively so, taking 3 months run-time on 36 processors of the Cray T3E, roughly doubling the run-time of a coupled ocean-atmosphere experiment. Results from these runs confirmed that future climate change will influence tropospheric chemistry, including the radiatively-active gases methane and ozone, and the levels of oxidants important in aerosol formation.

Current versions of STOCHEM have a poorly resolved tropopause and include no stratospheric chemistry, just a simple parameterisation of stratospheric input of ozone and nitric acid to the troposphere. Changes to the composition of the upper troposphere and lower stratosphere are crucial for calculating future radiative forcings from gases such as ozone and water vapour. These are the motivations for developing a chemistry-climate model that spans both the troposphere and stratosphere.

A new version of STOCHEM is under development (STOCHEM-Ed), based upon the UGAMP 58-level AMPII version of the Unified Model (UM). STOCHEM-Ed transport has been extended to the complete extent of the UM, and the vertical resolution of the output improved to 25 hPa in the upper troposphere and lower stratosphere. Tracers have been run to check the model transport, in particular stratosphere-troposphere exchange (in both directions) and the effective resolution of the model in the stratosphere. Future development will include addition of stratospheric chemistry, and close coupling of the predicted concentration fields of gases such as ozone to the UM radiation scheme.

The assimilation of MLS ozone using the Met. Office's assimilation system

H. Struthers, V. Asenek, R. Brugge, W. Lahoz and A. O'Neill

CGAM, University of Reading

Ozone measurements from the 205GHz Microwave Limb Sounder (MLS) flown on the Upper Atmosphere Research Satellite (UARS) have been assimilated using the UK Met. Office's assimilation system. The measurements are provided as profiles with a vertical resolutions of approximately 3km and with global coverage on a daily basis. The stratospheric configuration of the UM model is used with the ozone chemistry parameterised by the Cariolle scheme. Results for a three week period in April 1997 will be discussed.

The Role of the Extratropical Oceans in Decadal Climate Variability

Rowan Sutton

CGAM, University of Reading

It is well established that the tropical oceans play a fundamental role in seasonal-to-decadal climate variability, notably in ENSO. By contrast, evidence that the extratropical oceans play a similarly important role has been hard to find. This is surprising given their major role in maintaining the mean climate through a substantial contribution to the poleward transport of heat.

One common approach to studying the role of the oceans in climate has been to force atmospheric models with prescribed sea surface temperature (SST) anomalies. Recently, for example, Rodwell et al have shown that the observed record of the North Atlantic Oscillation Index can be well simulated with an atmospheric model forced with observed SST. At first sight this result appears to imply substantial predictability of the NAO. Subsequent work, however, some of which will be discussed, suggests otherwise.

Prescribed SST is, however, the wrong boundary condition for the atmosphere. It implies an infinite heat capacity non-responsive ocean. The failings of such a model are likely to become particularly acute at low frequencies, and it will therefore be argued that for studying decadal variability a more helpful perspective is to focus on heat transport rather than SST anomalies.

The future development of the ozone layer

C. Taylor

Reading University, UK

The atmospheric concentration of CFCs and other ozone depleting substances should, following the Montreal Protocol, decline in the first few decades of the 21st century. The recovery of the ozone layer may, however, be delayed through chemistry-climate feedbacks. Shindell et al. (1998) suggest that changes in temperature and the mean circulation could affect gravity wave propagation. In their model this reduces the frequency of sudden stratospheric warmings in the Arctic, leading to lower temperatures and enhanced ozone depletion.

A fast chemical scheme will be added to the Reading Intermediate Global Circulation Model to investigate these feedback mechanisms. Previous chemical schemes in GCMs have either been simple parametrisations (e.g. Mahlman et al., 1994) or complex schemes that prohibit long model runs (e.g. Austin et al., 2000). The Reading model will be intermediate in complexity, providing an accurate representation of the system, yet remaining fast enough to allow multi-decadal climate simulations. One possible method is to parameterise the chemical system in a High Dimensional Model Representation (Shorter et al., 1999). Preliminary work on chemistry-climate interactions and the development of a fast chemical scheme is presented.

The Temperature Structure of the Tropical Stratosphere

J. Thuburn and G. C. Craig

University of Reading

The temperature structure of the tropical stratosphere is probably controlled by complex interactions between radiation, convection, and the large-scale circulation. Nevertheless, a single-column radiative-convective model captures some important features, including the fact that the cold point is several kilometres above the top of the convectively adjusted region, so it is useful to try to understand what sets the temperature structure in a radiative-convective model.

We have carried out sensitivity experiments and computed detailed radiation budgets using a radiative-convective model. These show that (i) radiative warming in the 15 micron CO₂ band lowers the convection top and is crucial in separating it from the cold point, and (ii) the solar and infrared heating

associated with the sharp increase in O_3 , balanced mainly by H_2O cooling, has a strong influence on the height of the cold point.

In the real world, although the region of convectively adjusted temperatures extends only up to about 150hPa some convection does reach up to the cold point. We speculate that transport associated with this very deepest convection is important in determining the O_3 profile, and hence that there is a positive feedback loop connecting the O_3 profile, the height of the cold point, and convective transport. This possible feedback deserves further study to determine whether it could amplify the atmospheric response to climate change forcing, for example.

Understanding past climate change: the role of the coupled climate system

Paul J. Valdes

University of Reading, UK

The advent of climate models that include prognostic equations for the atmosphere, ocean, biosphere, cryosphere, and carbon cycle is beginning to revolutionise the study of past climates. Previous modelling studies have required the prescription of a number of boundary conditions, and the full interactions between all components have not been studied. The new generation of so-called Earth System Models allows us to tackle much more fundamental questions concerning the causes of past climate variability. In addition, the palaeoclimate record will be an important test of this type of model. This will make the next decade an exciting time for paleoclimate studies.

The talk will discuss the importance of interactions between the atmosphere-ocean system, and vegetation and the cryosphere. Results from a simulation of the last 21,000 years using a coupled atmosphere, simple ocean, and vegetation model will show that there can be rapid climate change even without major changes in the ocean.

A large timestep Godunov-type model for global atmospheric chemistry and transport

B. M.-J. B. D. Walker and N. Nikiforakis

DAMTP, University of Cambridge

Conservative Eulerian methods used in Global Atmospheric Chemistry and Transport Models (CTMs) are limited by the computational cost due to the stringent stability restriction on the Courant-Friedrichs-Levy, or CFL number to one, which subsequently imposes a limit on the time step.

This talk outlines the implementation of a CFL-equal-to-two version of the Weighted Average Flux (WAF) scheme in a CTM, which enables us to use time steps twice as large, thus significantly reducing the computational cost, while retaining the main advantages of high-resolution methods.

The idea underlying the scheme is outlined, then its implementation is further discussed. Its accuracy and efficiency are then evaluated both for planar geometry, in a two-dimensional problem, then for a case study of stratospheric transport problem.

Is a continuous atmospheric gravity wave spectrum the most appropriate choice for parametrizations?

C. D. Warner and M. E. McIntyre

Cambridge University, UK

One of the principal difficulties in combining orographic and non-orographic waves in the same parametrization scheme is that orographic waves are usually treated as monochromatic and continuous,

excited as they are by wind blowing over stationary orography, whereas non-orographic waves are usually treated as a continuous spectrum present at all times and in all places. Excitation of non-orographic waves is probably by intermittent and localised atmospheric phenomena such as convective clouds including thunderstorms. Their usual treatment is in terms of continuous spectra and is appropriate only in a statistical sense when averaged over large areas and over altitude and time increments. In reality, it is possible that the atmosphere may be sparsely populated, in both space and time, with non-orographic gravity waves.

To make progress toward integrating orographic and non-orographic schemes, we need to establish whether the "sparse" model or the "continuous" model is the more appropriate for non-orographic waves. Here we report on some preliminary investigations in which the properties of non-orographic gravity wave spectra with different sparcities are compared. It may be that, after all, treating the non-orographic spectrum as consisting of a small number of wave-packets is best.

Tropical-Temperate Troughs over Southern Africa and the SW Indian Ocean

R. Washington and M. Bithell

University of Oxford

Tropical Temperate Troughs (TTTs) have for some time been identified as the main rainfall producing system over southern Africa. The aim of this paper is to examine the nature of TTTs in integrations of the Unified Model.

TTT activity on intraseasonal time scales is assessed by means of Empirical Orthogonal Functions (EOFs) of daily model rainfall for the austral summer months. These EOFs are compared with those generated from a newly derived 3 hourly satellite based rainfall data set. The relationship between the leading modes of variability (which in all months October to March are TTTs) and the Unified Model atmospheric circulation is examined and compared with the "observed" satellite based rainfall EOFs and circulation data from the NCEP Reanalysis Project. Attention is given to moisture fluxes, zonally asymmetric waves in the southern hemisphere westerlies and the terms of the momentum budget. Rainfall variability on interannual time scales is studied by means of EOFs of observed monthly Outgoing Long Wave Radiation (OLR) data and model rainfall for the December to February season, the leading mode of which is a TTT dipole over southern Africa and the southwest Indian Ocean. Links between this leading mode on the interannual variability of the atmospheric circulation are again assessed by means of NCEP and HadAM3 data. Further analysis of model rainfall from an AGCM (HADAM2A) forced with historical sea surface temperatures from 1904-1994 indicates that a TTT dipoles are the leading mode of variability on both interannual and interdecadal time scales.

How old is stratospheric air in the Unified Model?

V. West and R. S. Harwood

University of Edinburgh, Scotland

Understanding of transport processes in the stratosphere has greatly improved since the first observations of high level water vapour and ozone, and the establishment of the Brewer-Dobson circulation. However many questions still remain unanswered and GCMs are increasingly used to draw light on the subject. One such recent method involves looking at the "age of air" in the real and simulated atmosphere.

We present results of such an experiment carried out in the UKMO Unified Model, and compare with observations of long-lived tracers and results from other models. We show that the age of air is dependent upon the advection scheme adopted in the model and for this reason question its usefulness as a way of studying large-scale stratospheric circulation.

An impact of the phase of ENSO on the interaction of mid-latitude Rossby waves and equatorial waves

G. Yang, J. Slingo and B. Hoskins

Reading University, UK

The interaction between the tropics and extratropics has theoretical and practical importance. Evidence of the connections between the tropics and extratropics occurring on longer time scales has been known for many years. During the past two decades the important influence of tropical heating on the extratropical circulation has been widely investigated by a number of observational and modelling studies. However the influence of the extratropical circulation on the tropical atmosphere and the interannual variability of this interaction have been less investigated and are not fully understood.

The development and maintenance of equatorial waves is crucial for forecasting in the tropics. Tropical weather systems may influence the extratropics or are influenced by the extratropics Through the distribution of sea surface temperatures (SST), the oceans play a dominant role in determining regions favourable for tropical convection. In turn, the various temporal and spatial scales of organised tropical convection play an important role in forcing the tropical oceans through variations in the surface stress and energy balance and may be instrumental in the development of El Niño events

The ERA (the ECMWF Reanalysis) data have been used to diagnose the interannual variability due to the phase of ENSO in the behaviour of extratropical-tropical interaction and associated equatorially-trapped waves on synoptic to subseasonal timescales. The results from the diagnostic studies will be used to validate GCMs.

Simulation of Tropospheric Chemistry Using the Unified Model

G. Zeng and J. A. Pyle

Centre for Atmospheric Science, Cambridge University

A chemistry-climate model has been constructed by incorporating a detailed tropospheric ozone-NO_x-hydrocarbon chemistry into the U.K. Met Office Unified Model. The chemical integration was performed using the ASAD chemical integration package. The model simulates 46 chemical species, 24 of which are advected. We include 186 bimolecular, trimolecular and photolysis reactions and dry/wet deposition processes. The emissions of NO_x and hydrocarbons represent present day conditions. The model uses a regular 96x73 grid with 19 levels. Preliminary results from a one-year simulation are presented and are compared to the Cambridge 3D off-line chemical transport model TOMCAT. Generally the concentrations of ozone and NO_y species compare favourably between the two models. The distribution of long-lived species such as CH₄ and CO are in good agreement.

Future work will focus on an application of this coupled model to an assessment of radiative forcing, for instance due to the increase of tropospheric ozone since preindustrial times.

New Measurements of Water Vapour Spectral Line Parameters (8500-15000 cm⁻¹) and their Impact on Atmospheric Absorption

*Wenyi Zhong, Roland Schermail, Djedjiga Belmiloud(2), Antonio A. D. Canas,
Joanna D. Haigh, Richard C. M. Learner and Jonathan Tennyson(2)*

Department of Physics, Imperial College, London SW7 2BZ;

(2) Department of Physics and Astronomy, University College London, Gower Street, London WC1E 6BT

New laboratory measurements and theoretical calculations of integrated line intensities for water vapour bands in the near-infrared and visible regions (8500-15000 cm⁻¹) show a systematic 6 to 26% increase in band intensities compared to the HITRAN96 database. The recent corrections to HITRAN96 (Giver et al,

2000) do not remove these discrepancies - in fact increasing them to 6 to 38%. We have used the GENLN2 line-by-line code to assess the effects of such changes in spectral database on calculations of fluxes and heating rates. Three standard atmospheres (MLS, TROPICAL and SAW) were used and it was found that, compared with HITRAN96 results, the absorbed downward solar fluxes increase (including the effects of theoretically calculated weak water lines in the region) by 4.8, 5.5 and 2.2 Wm^{-2} (zenith angle = 30 degrees) and by 2.1, 2.4 and 1.1 Wm^{-2} (zenith angle = 75 degrees) respectively. The maximum percentage change in heating rate is about 4%. The effects are about 5 to 8 times larger than that produced by using the Giver et al corrections. The combined effects of the new measurements and theoretically predicted weak water lines give approximately 45% of the absorption currently ascribed to the water vapour continuum in this spectral region.

Web Sites

This is a list of the websites of the institutions that are represented by presenting authors.

Institution	Web Site Address
University of Bristol, School of Chemistry	http://www.bris.ac.uk/Depts/Chemistry/
British Antarctic Survey	http://www.antarctica.ac.uk/
University of Cambridge, Department of Applied Mathematics and Theoretical Physics	http://www.damtp.cam.ac.uk/
University of Cambridge, Atmospheric Chemistry Support Unit, Department of Chemistry	http://www.atm.ch.cam.ac.uk/acmsu/
University of Cambridge, Centre for Atmospheric Science	http://www.atm.ch.cam.ac.uk/cas/
University of Canterbury, Christchurch, New Zealand	http://www.ucar.canterbury.ac.nz/
University of East Anglia, School of Environmental Sciences	http://www.uea.ac.uk/env/
University of Edinburgh, Department of Meteorology	http://www.met.ed.ac.uk/
University of Lancaster, Environmental Science Department	http://www.es.lancs.ac.uk/
University of Leeds, School of the Environment	http://www.lec.leeds.ac.uk/
University of Leicester, Department of Physics & Astronomy	http://www.leicester.ac.uk/physics/research/eos/
Liverpool School of Tropical Medicine	http://www.liv.ac.uk/Istm/
University of London, Imperial College, Department of Space and Atmospheric Physics	http://www.sp.ph.ic.ac.uk/
NERC: CEH Wallingford	http://www.ceh-nerc.ac.uk/
NERC: UTLS - Upper Troposphere / Lower Stratosphere thematic programme	http://utls.nerc.ac.uk/
University of Oxford, Department of Atmospheric Oceanic and Planetary Physics	http://www.atm.ox.ac.uk/
University of Oxford, School of Geography	http://www.geog.ox.ac.uk/
University of Reading, Centre for Global Atmospheric Modelling	http://ugamp.nerc.ac.uk/cgam/cgam.htm
University of Reading, Department of Meteorology	http://www.met.rdg.ac.uk/
Rutherford Appleton Laboratory	http://www.rl.ac.uk/
University of Sheffield, Department of Animal and Plant Sciences	http://www.shef.ac.uk/uni/academic/A-C/aps/
Southampton Oceanography Centre	http://www.soc.soton.ac.uk/

UK Universities

a community research programme

Global

funded by

Atmospheric



**NATURAL
ENVIRONMENT
RESEARCH COUNCIL**

Modelling

Programme

<http://ugamp.nerc.ac.uk/>