UGAMP Newsletter

Issue 21 *September 1999* *Editor: Glenn Carver* *Director: Alan O'Neill*

UGAMP Conference: 22-24 September 1999 University of Oxford

Conference details

This year's UGAMP annual conference will be held at Oxford University from the 22nd to 24th September. The conference is being organised by Dr. Warwick Norton and Dr. Glenn Carver. Warwick Norton is responsible for all local arrangements at Oxford. Glenn Carver is responsible for abstracts and the conference website. Any queries should be directed to the appropriate person.

All lectures will be held in the Townsend Lecture Theatre, Townsend Building, next to the Atmospheric Physics Department. Tea and coffee will be provided for the morning and afternoon breaks in the tea room in the Townsend building. Posters will also be in the tea room of the Townsend building.

There will be a meeting of the UGAMP Scientific Steering Group before the Conference Dinner at 6pm on Weds. 22nd. The meeting will be held in the Brewer Room, in the Atmospheric Physics Dept.

Delegates will be expected to make their own arrangements for lunch and evening meals, except for the conference dinner.

Posters

Posters will be an integral part of the UGAMP conference. They will be on display in the tea room of the Townsend building, next to the Atmospheric Physics Department.

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 £4 for each lunch and £12 for dinner. Queries about expenses should be emailed to Anne Pinnock. Please attach receipts to your claim, or provide a photocopy of a group dinner bill, if possible.

Where UGAMP groups have arranged coach travel to the meeting, CGAM will only pay for the coach and will not reimburse travel expenses for UGAMP researchers who do not use the coach (unless other arrangements have been agreed in advance with Alan O'Neill). Expense claim forms can be obtained from Anne Pinnock if your local site does not have any. Please return the forms 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.

Accommodation

Accommodation during the meeting will be provided by Lady Margaret Hall. The Hall is a short walk from the lecture theatre across the park.

To get the key to your room, you must visit the porters lodge sometime after 2pm on the day of your arrival. Breakfast will be provided by the Hall.

Conference dinner

The conference dinner will be held on Weds. 22nd September at Lady Margaret Hall, starting at 7.30pm. Dress smart casual. The bar will open at 7pm with wine on sale in the hall before dinner (£8 per bottle). The bar will be open after dinner also.

Travel and parking

If at all possible, we suggest travelling to Oxford via public transport. There is little onsite parking space at the University

or Hall available. We can only offer a couple of spaces at best and these will be reserved for key speakers.

Please note that in previous years CGAM has encouraged the hire of private coaches for large groups attending the meeting. Please contact Anne Pinnock for more details.

Contact information

Contacts: (during day) Atmospheric Physics 01865 27290. Lady Margaret Hall: 01865 274300.

For queries about anything other than abstracts, such as local arrangements, conference programme etc., please contact, the conference local organiser Dr. Warwick Norton.

Queries regarding expenses should be addressed to Anne Pinnock.

Warwick Norton / Glenn Carver

1999 UGAMP Conference Programme
22 - 24 September, Department of Chemistry, University of Oxford

Wednesday 22 September

10.00	Coffee	
10.30	A. O'Neill	Introduction and UGAMP highlights

SESSION THEME: Variability in the coupled Atmosphere/Ocean system

10:50	R. Sutton	The Elements of Climate Variability in the Tropical Atlantic Region
11:10	S. Jewson	The Impact of the 1997/1998 El Nino on the Atlantic Ocean: A coupled modelling study using HadCM3
11:30	J. Elliott	The role of ocean-atmosphere coupling in the response to ENSO
11:50	R. Neale	El Nino in Atmosphere-Only and Coupled Versions of the Unified Model
12:10	**lunch**	

SESSION THEME: Climate Predictability

1:40	J. Slingo	Predictability and the relationship between subseasonal and interannual variability during the Asian Summer Monsoon
2:00	S. Woolnough	The influence of SST perturbations on intraseasonal variability of tropical convection
2:20	B. Dong	Predictable Winter Climate in the North Atlantic Sector During the 1997-1999 ENSO Cycle
2:40	W. Lahoz	Stratospheric variability and reproducibility in seasonal ensemble integrations with a troposphere-stratosphere GCM
3:00	**Tea**	

SESSION THEME: North Atlantic Oscillation, Arctic Oscillation, and Climate Variability

3:30	B. Hoskins	Defining NAO, AO, and annular modes
3:50	P. McCloghrie	Downward propagation of Arctic Oscillation anomalies in model data
4:10	N. Gillett	Has the Arctic Oscillation undergone a regime shift?
4:30	A. Hannachi	On the identification of the climate attractor
4:50	R. Glover	The Transfer of 100kyr milankovitch forcing into the palaeoclimate record in glacial and ice free climates
5:10	A. Larkin	Solar Cycle Effects on the Climate - A Comparison of GCM Results with Observational Data
5:30	**Close**	

6:00 **SSG meeting (Brewer Room, Atmospheric Physics)**

7.30 **UGAMP Dinner (Lady Margaret Hall): bar open at 7pm.**

1999 UGAMP Conference Programme

Thursday 23rd September

SESSION THEME: Issues in Numerical Modelling

9:00	L. Steenman-Clark	UGAMP Support and Services
9:20	M. Blackburn	Dry and moist Dynamical Core experiments for atmospheric GCMs
9:40	A. Gregory	A comparison of some finite volume schemes for the problem of tracer advection

10:00 coffee

SESSION THEME: Stratospheric Variability

10:30	E. Drysdale	Interannual variability in a mechanistic middle atmosphere model
10:50	L. Gray	Northern Hemisphere winter variability and the Influence of the Quasi Biennial Oscillation
11:10	D. Stainforth	Simulation of the Quasi Biennial Oscillation (QBO) in the UKMO Unified Model using the Hines Gravity Wave Drag Parameterization
11:30	A. Scaife	Realistic Quasi-Biennial Oscillations in a simulation of the global climate
11:50	C. Warner	How Simple can Simple Gravity Wave Parameterizations Afford to be?

12:10 Lunch

SESSION THEME: Atmospheric Waves and Oscillations

1:40	P. Inness	Sensitivity to vertical resolution of the simulation of the Madden-Julian Oscillation in a GCM
2:00	P. Braesicke	Excitation and propagation of equatorial waves in the Berlin Climate-Middle Atmosphere Model (CMAM)
2:20	G. Yang	Equatorial Convectively coupled waves in CLAUS/ERA data and AMIP II integrations with the UM
2:40	S. Oliver	Simulation of the tides in the UKMO Unified Model

3:00 Tea

SESSION THEME: Upper Troposphere/Lower Stratosphere and Water Vapour

3:30	M. Juckes	The mass flux through the extratropical tropopause
3:50	J. Thuburn	Some Thoughts on the Tropical Substratosphere
4:10	J. Haigh	A line-by-line estimate of the contribution of unknown weak water vapour lines to the absorption of solar radiation
4:30	A. Dethof	Isentropic water vapour transport across the dynamical tropopause
4:50	R. Bannister	Elements of the 'Tape Recorder' Signal in the UM
5:10	A. Iwi	Variability in transport in the tropical lower stratosphere

5:30 Close

1999 UGAMP Conference Programme

Friday 25 September

SESSION THEME: Fluxes and Radiation

9:00	P. Berrisford	Energy fluxes in the atmosphere and oceans
9:20	E. Highwood	The effect of subgrid-scale cloud inhomogeneity on direct radiative forcing by aerosols

SESSION THEME: Data Assimilation

9:40	A. O'Neill	Data Assimilation of research satellite data into NWP systems: past, present and future
10:00	**Coffee**	
10:30	H. Struthers	The Assimilation of UARS MLS Ozone using the UKMO Unified Model
10:50	D. Lary	Chemical Data Assimilation Highlights Several Issues

SESSION THEME: Chemistry

11:10	J. Pyle	UGAMP Chemistry highlights
11:30	M. Guirlet	Modelled ozone depletion in the mid-latitudes regions during recent winters
11:50	I. MacKenzie	Middle-Atmosphere CH_4/H_2O Chemistry Parameterised in the Unified Model
12:10	**Lunch**	
1:40	C. Bridgeman	Three dimensional studies of the impact of short-lived brominated compounds on the lower atmosphere
2:00	M. Cobb	Tropospheric chemical modelling of the North Atlantic region using a 3-D chemical and transport model, TOMCAT.
2:20	P.-H. Plantevin	Case studies of chemistry and transport in the upper troposphere using MOZAIC and TOASTE data and the TOMCAT model.

SESSION THEME: Storm Tracks, Cyclones and Anticyclones

2:40	U. Burkhardt	The North American storm track gap
3:00	**Tea**	
3:30	S. Hare	Baroclinic Instability in Mid-Latitude Jets
3:50	J. Badger	Baroclinicity index and initial development of mid-latitude cyclones: sensitivity to surface parameters
4:10	L. Barry	A GCM Investigation into the Nature of Baroclinic Adjustment
4:30	L. Shaffrey	The relationship between the North American monsoon and the North Pacific subtropical anticyclone in HADAM3
4:50	Close	

Abstracts

Assimilation of UARS MLS Temperature into the UKMO Data Assimilation System

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

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

We discuss preliminary results from the assimilation of temperature data from the Microwave Limb Sounder (MLS) (flown on the Upper Atmospheric Research Satellite (UARS)) into the stratosphere-troposphere data assimilation system developed at the UKMO as part of the UARS project. The system uses the UKMO Unified Model (UM) as the atmospheric numerical model and employs the so-called 'Analysis Correction' scheme; the MLS temperature data is assimilated over the pressure range 46-0.46 hPa. In this talk we focus on two assimilation experiments which were ran for a period of six days in late January/ Early February 1997. One experiment incorporated the operational observation types in addition to MLS data while the other experiment did not include MLS data.

Baroclinicity index and initial development of mid-latitude cyclones: sensitivity to surface parameters

J. Badger, B.J.Hoskins

Department of Meteorology, University of Reading

Experiments have been performed that explore the sensitivity of initial cyclone development to various profiles of fixed surface temperature, surface moisture and initial interior moisture, using the Reading Intermediate General Circulation Model. These experiments have shown that surface moisture, in conjunction with conditional instability, is crucial in determining system growth rates. The modification of the baroclinicity index due to the passage of cyclones is also of interest. The role of diabatic processes in modifying and possibly maintaining regions of high baroclinicity will be investigated. Zonally uniform and varying surface conditions will be employed to assess the importance of heterogeneous surface types in fixing regions of high baroclinicity. These experiments are useful in providing fundamental system centred perspectives towards better understanding of storm-track organization and variability.

Elements of the "Tape Recorder" Signal in the UM

R.N.Bannister, A.O'Neill, W.Lahoz

CGAM, University of Reading

The AMIP-II run of the 58-level UM (HadAM3) provides a large pool of diagnostics, covering a long period of time (17 years) which should allow one to test the ability of the UM to capture a range of observable effects.

Our analysis of this model output has shown that the UM can simulate a clear "tape recorder" water vapour signal in the tropical stratosphere (as observed for number of years by instruments aboard the UARS satellite). We present a summary of key aspects of the tape recorder signal in the UM and compare to observations and results from other models. Our study concentrates on 'standard' aspects of the signal (e.g. upward advection velocity), on the underlying spacial water vapour structure, and its relation to the seasonal variation in the tropics.

GCM Intercomparison Study of the Impact of Stratospheric Representation

R.N.Bannister(1), P.Berrisford(1), C.Jones(2), W.Lahoz(1), A.O'Neill(1), S.Pawson(3), G.Roff(4), R.Swinbank(5)

(1)CGAM, University of Reading, (2)SMHI, Sweden, (3)NGSFC, USA, (4)BMRC, Australia, (5) UKMO

The stratosphere is the subject of continued attention in relation to its role in the climate of the whole atmosphere. This issue is reflected in the widespread effort to improve the representation of the stratosphere in GCMs.

In this poster we show results derived from decadal integrations of two versions of the UM (HadAM3) (L58 and L30) and of the BMRC model (R31 L9 and R31 L17). Between the model versions there are significant differences in stratospheric representation. We show how the changes in representation affect the model climate (through zonal-mean cross sections of u and T, and time series of u). Our results are compared with the ERA-15 reanalysis data set and with the UKMO analysis. We also present examples of elliptical diagnostics of the polar vortices in the BMRC model.

A GCM Investigation into the Nature of Baroclinic Adjustment

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

Department of Meteorology, University of Reading

Spin down experiments have been conducted using an atmospheric general circulation model to determine the nature and timescale of adjustment to a baroclinic neutral state. The spin down was obtained by turning off the radiative cooling of the atmosphere.

The neutral state was characterised by narrower baroclinic zones with increased static stability but little reduction in maximum meridional temperature gradients.

The adjustment was roughly exponential with a timescale of 15-20 days. A spin up experiment was also performed, where the radiation was turned back on in the adjusted state. The original climate was returned in a timescale of 5-10 days. This timescale is clearly shorter than the adjustment timescale, adding to the evidence that the mean state of the atmosphere cannot be said to be baroclinically adjusted

Influence of the mid-latitudes on the predictability of the Indian Summer Monsoon

Bernd Dieter Becker, Julia Slingo

CGAM, University of Reading

Introduction

PRISM, the Predictability experiments for the Indian Summer Monsoon consist of three sets of global atmosphere 10 member ensemble simulations that were conducted for the years 1983 to 1989 and 1992 to 1993. The first set simulates the boreal Winter from November to March for those years, forced with observed Sea Surface Temperatures (SST). The second set is a continuation of the first from March to September (PRISM_O). The third set is different to the second only in so far, that the forcing SST is replaced with a climatological annual cycle (PRISM_C). The PRISM data sets were investigated to establish the contribution to Monsoon variability from chaotic atmospheric variability and from forced variability from the boundary conditions over ocean and land areas. In particular, the contribution to Monsoon variability from the Land surface conditions (LSC) in the pre-Monsoon season shall be focus of our attention.

The Snow - Monsoon Relation

Monsoon is a result of the large land-ocean heating contrast. Snow over the land areas pole-ward of India has two effects: It moistens and cools the soil when it melts in spring and it reflects solar radiation. An area 20 to 60 East, 50 to 70 North, where the variance is highest, is chosen to define a snow cover index.

Composites of High and Low snow were drawn where the standard deviation is larger than +/- 1. Because two sets of experiments were spawned off the LSC in March, the difference gives insight into how the LSC and the SST forcing influence the Monsoon precipitation.

Results

The largest precipitation anomalies in the Indian domain are associated with the ENSO cycle. This can be expressed in shifts of the probability density function (PDF) of the spatial pattern of precipitation. During El Niño, the precipitation probability south of the Indian peninsula is enhanced and the precipitation probability over the Indian mainland is reduced. The opposite is true during La Niña years.

Anomalous high snow in the index area has a similar association with precipitation over the Indian domain as anomalous high SST in the Niño 3 area. The magnitude of that signal is about one quarter compared to the ENSO signal. In the full simulations, the effects of SST variability are overwhelming and swamp the impact of LSC. The extreme snow composite difference in precipitation are reversed. Stratifying the simulations with prescribed climatological SST by all Indian Rainfall (AIR) shows little evidence of Eurasian snow influencing the Indian Summer monsoon (ISM).

The results from PRISM-C show that land surface anomalies, associated with spring snow amounts can influence the monsoon. Therefore land surface conditions are an important part of the system which need to be predicted accurately. The mechanisms involved in the relationship between the monsoon and Eurasian land surface conditions are as yet unclear. However, the fact that the observed relationship between Eurasian snow and monsoon rainfall is opposite to that suggested by PRISM-C, and is then only correctly captured by the introduction of observed SSTs in PRISM-O, suggests that the forcing by SST anomalies is probably dominating the monsoon interannual variability. If that is the case then it may be difficult to unravel the processes involved in the relationship between land surface conditions and monsoon variability using observations. One further experiment with SST and LSC fixed to climatology should allow to estimate the internal interannual variability of the Monsoon.

Energy fluxes in the atmosphere and oceans

P.Berrisford,A.O'Neill

CGAM, Department of Meteorology, University of Reading

Over long timescales the Earth absorbs more solar radiation in tropical regions than it does at higher latitudes. Similarly, more longwave radiation is emitted to space in the tropics than at high latitudes. However, the net effect of these two processes is that energy is absorbed at low latitudes and emitted to space at high latitudes. Assuming that over long timescales the heat storage in the Earth's atmosphere and oceans does not change then the atmosphere and oceans must transport heat from the tropical regions to high latitudes. Here, this transport is investigated using the European Centre for Medium-Range Weather Forecasts (ECMWF) Re-Analysis (ERA) dataset covering the period January 1979 through to December 1993. Use of the Earth Radiation Budget Experiment (ERBE) dataset, for the years 1986 to 1988, enables a comparison to be made with independent observational data.

Transport in the whole atmospheric ocean system is the sum of that in the atmosphere and oceans separately. The transport in the whole system can be computed from the top of the atmosphere radiative fluxes, that in the oceans is computed from the surface fluxes of heat, moisture and radiation and the atmospheric transport is computed from the flux of moist static energy. It can be shown from the continuity equation, that the vertically and zonally integrated mass transport should be zero.

The vertically and zonally integrated northward mass transport and heat transports of the atmosphere, ocean and the combined system are computed for the period 1986 to 1988. Results both from model level and pressure level datasets show a significant mass imbalance, particularly from the pressure level dataset. This indicates that the atmospheric heat transports will probably be in error. Atmospheric heat fluxes are computed from the pressure and model level data and give different results, particularly equatorward of 30N and 60S, where the mass imbalances are greatest. Energy transport as computed from the top of the atmosphere radiative fluxes is 50 per cent greater from ERBE data than from ERA data. Ocean transports are weak in the northern hemisphere and often equatorward in the southern hemisphere. The latter is counter intuitive. Combining these results into a budget gives a residual which is larger in magnitude than the ocean heat fluxes.

Monthly mean atmospheric heat transports (as computed from model level data) are used to provide time series of the maximum and minimum heat transports each month for the whole of the ERA period. The time series are dominated by the annual cycle, but a Fourier analysis reveals variability on other timescales. The dominant long-term variability has a period of about 5 years. When a low pass temporal filter is applied to the time series it is seen that this variability is associated with ENSO. El Nino conditions are associated with large magnitudes of atmospheric heat transports while La Nina conditions are associated with small magnitudes.

Dry and moist Dynamical Core experiments for atmospheric GCMs

M. Blackburn

Centre for Global Atmospheric Modelling, University of Reading

"Dynamical Core" experiments were proposed several years ago as tests for the dry fluid dynamics component of atmospheric GCMs. However it is clear that the sensitivity to changes in the dynamical discretisation seen in Dynamical Core experiments can differ fundamentally from that seen in complete moist GCMs.

The storm-track eddies and zonally averaged flow in Dynamical Core experiments are analysed in terms of EP-flux divergence and the residual circulation, highlighting the impact of numerical damping on eddy amplitudes,

baroclinicity and the strength of the lower stratospheric circulation. The diagnostic framework emphasises the global nature of the atmospheric feedbacks involved.

An active moisture cycle has been added to the dry experimental framework, so far including a boundary-layer source, transport and stratiform condensation. The philosophy is to include the basic processes in the most idealised manner possible, to minimise complexity and aid understanding. The impact of latent energy transport on the eddies and baroclinicity resembles that seen in GCM climate change simulations, where warmer temperatures increase absolute humidity content. Sensitivities seen in the dry experiments are indeed modified by the addition of moist processes, emphasising their importance for GCM intercomparison and sensitivity analysis.

Excitation and propagation of equatorial waves in the Berlin Climate-Middle Atmosphere Model (CMAM)

Peter Braesicke (1), Katrin Nissen (2), Ulrike Langematz(3)

(1) Institut fuer Meteorologie, FU Berlin, Germany, current affiliation: Centre for Atmospheric Science, Cambridge University, UK. (2) Institut fuer Meteorologie, FU Berlin, Germany, current affiliation: Department of Meteorology, The University of Edinburgh, UK. (3) Institut fuer Meteorologie, FU Berlin, Germany

Most CMAMs are not able to capture the time dependency of the zonal mean flow near the equator adequately. Recent studies imply that higher vertical resolutions of the models lead to a better representation of tropical dynamics, due to the fact that smaller vertical wavelengths can be resolved. In addition a high upper boundary is preferable to avoid wave reflection.

To study the impact of the vertical resolution in conjunction with the position of the upper boundary on the model dynamics, three different versions of the Berlin CMAM are used: A 19-level version with the upper boundary in 10 hPa, a 34-level version with a vertical spacing of 3.5 km in the Middle Atmosphere extending to 0.01 hPa and a 70-level version with a reduced spacing of approximately 1 km and the same upper boundary condition as in the 34-level version.

The tropical wave spectra simulated by the three model versions for perpetual January integrations are compared. The changes in the global circulation are analysed using the combined diagnostic framework of the transformed Eulerian mean (TEM) circulation and the Eliassen-Palm (EP) flux. As an additional diagnostic quantity a passive tracer stratified with latitude and advected by a semi-Lagrangian transport scheme is used.

Three dimensional studies of the impact of short-lived brominated compounds on the lower atmosphere

Cate Bridgeman, John Pyle and Dudley Shallcross

Centre for Atmospheric Science, Cambridge 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 dependence on reaction rate and geographical source region of the atmospheric lifetimes and ODPs of a series of short-lived brominated compounds.

DARE: Data Assimilation in Readiness for Envisat

R. Brugge, V. Asenek, W. Lahoz, H. Struthers

CGAM, Department of Meteorology, University of Reading

DARE is a European Union funded concerted action programme among whose objectives are: (i) to co-ordinate the interaction between European groups in order to process Envisat data for the atmosphere, and thereby to improve the quality and cost-effectiveness of the data. (ii) to identify data products that can be produced by data assimilation to facilitate the exploitation of Envisat data by a diverse user community.

Data assimilation is a technique whereby observational data are combined with forecast fields from a numerical model, in order to produce an optimal representation of the evolving state of the atmosphere (or ocean or other system). The technique lies at the heart of present-day weather forecasting and climate research.

New results on gravity waves and mean flows, with implications for atmospheric GCMs

O. Buhler

School of Mathematics, University of St. Andrews.

Recent theoretical advances in wave--mean interaction theory are able to throw fresh light on the parametrization of gravity-wave breaking at high altitudes and also on the direct numerical simulation of gravity waves in high-resolution GCMs. Specifically, a consistent way of parametrizing localized wave breaking can be formulated, as can be numerical prerequisites for avoiding spurious wave--mean interactions in high-resolution GCMs. Both theory and idealized numerical simulations are presented to illustrate these results, which may be timely in the dawning era of 'gravity-wave-permitting' high-resolution GCMs.

The North American storm track gap

Ulrike Burkhardt

Dept. of Meteorology, University of Reading

Over the North American continent storm track activity is very much reduced. Eulerian measures indicate that this storm track gap is located over the western part of the continent whereas a Doppler corrected measure shifts the gap further eastwards. The gap in storm track activity is apparent at lower levels, but is very slight at upper levels. This suggests that the upper level disturbances cross North America, but the low level, more baroclinically active parts of the disturbances are blocked, mainly by the Rocky Mountains. The traversing upper level systems provide the seeds for the Atlantic storm track which grow rapidly when they reach the ocean due to latent heat release. In this way, there can be a coupling between the Pacific and Atlantic storm track. A simple GCM is run to test the importance of a mountain chain or of latent heating for the coupling of the storm tracks.

opospheric chemical modelling of the North Atlantic region using a 3-D chemical and transport model, TOMCAT.

bb, Maurette (1), Rogers, Helen (1), Law, Kathy (1), Evans, Mathew (1), Pyle, John (1), Penkett, Stuart (2), Bauguitte, hane (2), Bandy, Brian (2), Kley, Dieter (3), Schmitgen, Sandra (3), Dewey, Ken (4), Kaye, Andrew (4), Kent, Jos (4), Richer, Hannah (4)

Centre for Atmospheric Science, Department of Chemistry, University of Cambridge, UK; (2) School of Environmental nces, University of East Anglia, Norwich, UK; (3) Research Centre Gulch, Institute for Chemistry of the Polluted Atmosphere, Julich, Germany; (4) UK Meteorological Office Research Flight, Farnborough, UK.

In Summer 1997 NARE and ACSOE campaigns using research aircraft took place over the North Atlantic Ocean to examine US continental outflow of pollutants into the North Atlantic region. The Cambridge tropospheric chemistry model, TOMCAT, was run for this four month period and compared with measurements taken along the flights in order to establish how well the model reproduces chemical and transport processes. The model showed good agreement with several observed measurement features. This study also raised several questions, primarily whether poor spatial resolution or inadequate representation of chemistry was responsible for differences between model and flight measurements. A study into model resolution effects on chemical processes showed a greater agreement between measured and modelled species at increasing resolutions.

In a separate study to quantify ozone production from anthropogenic emissions for the US, Asia, and Europe the model was re-run for the Summer 1997 period without emissions over these continents. Over the North Atlantic region the US was found to be the greatest contributor to ozone production, as would be expected from a Westerly dominated wind flow. Asian and European emissions were shown to have far less significance over the North Atlantic region. Using physical and chemical budgets from the model we can establish which processes dominate the chemistry of the model for the Summer 97 flight period and these will be discussed.

Isentropic water vapour transport across the dynamical tropopause

A. Dethof(1), A. O'Neill(2), J. Slingo(3)

CGAM, Reading University

ECMWF analyses for the years 1997 and 1998 and the contour advection technique are used to quantify the quasi-horizontal, isentropic transport of water vapour between the tropical upper troposphere and the extratropical lower stratosphere. It is found that the isentropic transport of water vapour into the extratropical lower stratosphere has a similar magnitude to the upward (cross-isentropic) transport of water vapour into the stratosphere in the tropics. The isentropic flux is largest during summer, and is more than enough to account for the observed summertime increase in specific humidity in the lowermost stratosphere.The annual isentropic moisture transport into the extratropical lower stratosphere in the northern hemisphere is about an order of magnitude larger than that in the southern hemisphere. This difference in transport explains why the extratropical lower stratosphere is moister in the northern hemisphere during northern summer than it is in the southern hemisphere during southern summer. The results further show that there is a stronger moisture transport into the lower stratosphere of both hemispheres during 1998, under El Nino conditions, than during 1997.

Predictable Winter Climate in the North Atlantic Sector During the 1997-1999 ENSO Cycle

B.-W. Dong, R. T. Sutton, S. P. Jewson, A. O'Neill & J. M. Slingo

CGAM, Department of Meteorology, University of Reading, Reading

The winters of 1997/98 and 1998/99 were marked by strikingly different weather conditions over the North Atlantic ocean and adjacent continents. During 97/98 sea level pressure over the North Atlantic ocean was unusually low and Europe experienced an unusually mild winter. By contrast, during 98/99 sea level pressure over the North Atlantic Ocean was unusually high and Europe experienced a much colder winter. The period 1997-99 was also marked by a major cycle of the El Nino-Southern Oscillation (ENSO) with the positive phased (El Niño) peaking in the winter of 97/98 and the negative phase (La Niña) peaking in the winter of 98/99. We use a state-of-the-art atmospheric general circulation model forced with observed sea surface temperatures (SSTs) to investigate the hypothesis that the anomalous conditions in the North Atlantic sector during the winters of 97/98 and 98/99 were related to the ENSO cycle and were therefore potentially predictable. We demonstrate that the major circulation anomalies observed in the North Atlantic sector are reproducible in both winters. We show further that these circulation anomalies were forced primarily by ENSO-related SST anomalies in the Pacific Ocean, but that SST anomalies in the Atlantic Ocean also had an influence. Our results suggest that wintertime climate anomalies in the North Atlantic sector are more predictable than previous work has implied; useful predictions may be possible, not only in those years when major El Niño events occur.

Interannual variability in a mechanistic middle atmosphere model

Euain F. Drysdale and Lesley J. Gray

Rutherford Appleton Laboratory

A series of long model runs are performed using the UKMO Stratosphere-Mesosphere Model and the interannual variability in the northern polar vortex is compared. This model used is a mechanistic model, with a vertical domain spanning 100 to 0.01 hPa. The troposphere is represented by supplying the model with a lower boundary condition of the geopotential height of the 100 hPa pressure surface. In these experiments, the model is run with a bottom boundary that is taken from a single years data and repeated in a loop to form a continuous data set. This eliminates any tropospheric interannual variability from the simulation while still providing the model with a realistic annual cycle in the bottom boundary.

Two experiments are performed where different years data are used to supply the lower boundary and long runs are performed. The interannual variability observed in each of these two experiments is found to be quite different. One run produces a large amount of interannual variability (January temperature variations, for example, are comparable to those observed in the real atmosphere) whereas the other experiment produces very much less interannual variability. Initial inspection of the height fields yields no obvious reason why the model produces very different amounts of interannual variability, and a more detailed examination of the bottom boundaries is performed.

The role of ocean-atmosphere coupling in the response to ENSO

J.R. Elliott(1), S. Jewson(1), R.T. Sutton(1)

(1) CGAM, University of Reading

Much work has been done to assess the atmospheric response to prescribed sea surface temperatures (SSTs), such as the ENSO pattern in the Pacific. With the motivation of understanding coupled ocean-atmosphere processes, which are thought to be in part responsible for interannual and decadal climate variability, many GCM studies have been carried out recently with fully-coupled ocean-atmosphere models, or models which are fully coupled in some domain, but forced by prescribed SSTs elsewhere. The suggestion has been made that forcing an atmospheric model with prescribed SSTs may lead to a very different (and misleading) response from that obtained in the coupled (or partly coupled) system, producing underestimated variances in diagnostic quantities such as surface air temperature or worse, producing an incorrect mean atmospheric response. We aim to investigate this by comparing the response to ENSO in a partially-coupled ocean atmosphere model with the response in an atmosphere-only model with prescribed SSTs.

Has the Arctic Oscillation undergone a regime shift?

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The probability density function (PDF) 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 often indistinguishable from a Gaussian in the troposphere, but deviated significantly from a Gaussian in the stratosphere in the winter and spring, where features corresponding to the strong winter vortex and final warming could be identified. Simulations of the Arctic Oscillation by an uncoupled 49-level model also only exhibit strongly non-Gaussian behaviour in the stratosphere, but unlike in the observations there is pronounced bimodality. Changes in the Arctic Oscillation were then examined by comparing PDFs for 1958-1977 and 1978-1997. On all the levels considered, a shift towards the positive phase of the AO was found in December and January, significant in some cases at the 95% level. A change in the appearance of the distributions, supported by statistical tests, suggests that the shape of the PDFs has changed in the stratosphere, with weaker evidence of a change in the troposphere, which implies that a "regime" approach to climate change may be useful in some cases.

The formation and evolution of North Atlantic Heat Content Anomalies

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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 windstress anomalies. The interaction between the barotropic response and topography leads to very interesting, and sometimes surprising, behaviour. We will present analyses of both this short timescale response and the longer timescale baroclinic response. 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.

The transfer of 100kyr milankovitch forcing into the palaeoclimate record in glacial and ice free climates

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Milankovitch variations in eccentricity on timescales of 95 and 123kyr manifest themselves as an amplitude modulation of the 19 and 23kyr precession signal. As such, spectral analysis of long term changes in solar forcing exhibit very little power at the eccentricity frequencies. In contrast, time series analysis of palaeoclimate proxies tend to show considerable variability at these frequencies. During periods with significant glaciation, the dynamics of ice sheet evolution seem to provide the strong amplification in the 100kyr band required to match observations. However, the processes which amplify the 100kyr signal in periods without significant glaciation are less clear.

Studies using a simple, low-resolution, energy balance climate model coupled to an ice-sheet/lithosphere model allow very long integrations to be performed to examine the response of the earth system to changes in orbital forcing. Results from experiments with this model indicate that non-linear processes, whether climatic, diagnostic or sedimentary are sufficient to transfer significant spectral power into the 100kyr eccentricity periods. Such non-linear processes can operate in the complete absence of snow and ice physics or feedbacks in the model, possibly providing an explanation for the strength of the 100kyr signals in non-glacial climates. GCM experiments show some indications of this mechanism via change in monsoon seasonality.

Northern Hemisphere winter variability and the Influence of the Quasi Biennial Oscillation

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Rutherford Appleton Laboratory

The quasi biennial oscillation (QBO) of winds in the equatorial stratosphere is known to influence the Northern Hemisphere winter vortex, including the depth and frequency of stratospheric sudden warmings. The current explanation for this is in terms of the lower stratospheric equatorial winds (~25 km) acting as a wave guide for mid-latitude planetary wave propagation. We use polar stratospheric analyses from Berlin and equatorial rocketsonde data that extends to 60 km to provide new evidence for a stronger link to the stratopause level equatorial winds (~50 km) than to the lower levels. With this new evidence for the importance of the equatorial stratopause region, we suggest that the interaction between the QBO and the solar cycle influence on mid warmings and hence on the tropospheric circulation may be more readily explained.

A comparison of some finite volume schemes for the problem of tracer advection

Andrew Gregory

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An accurate representation of tracer transport is required in a GCM to obtain realistic distributions of many species that are important in the study of climate change or ozone depletion. The tracer scheme in the current version of the UKMO Unified Model (UM) is an implementation of the method of Roe. It is a quasi-2nd order 'TVD' scheme with a choice of two flux-limiters. The scheme has the disadvantage of being rather diffusive at the resolution used in climate runs particularly when the well-behaved 'van-Leer' limiter is used. Less diffusive results are obtained with the 'Superbee' limiter which has the dubious quality of 'squaring up' smooth profiles. Another potential disadvantage is that the scheme is nonlinear (as is any flux-limited scheme) and cannot, in general, exactly preserve linear relationships between 3 or more tracers.

With the eventual aim to improve the tracer advection in the UM, a range of finite volume type schemes (both linear and non-linear flux-limited) have been compared in some idealised and more realistic off-line tests. Both accuracy and cost have been considered at different resolutions to try to find the most efficient scheme. Further tests have been carried out to try to gauge the extent that linear and nonlinear relations between tracers can be maintained by the different schemes.

Modelled ozone depletion in the mid-latitudes regions during recent winters

M. Guirlet, M. Chipperfield, J. Pyle

European Ozone Research Coordinating Unit

We have used the SLIMCAT CTM to investigate the interannual variability of the ozone depletion in the Northern Hemisphere mid-latitudes during the Arctic winters from 1995/1996 to 1998/1999. Four seasonal simulations were performed, starting in December of each winter and integrated until the following April, using a horizontal resolution of 3.75 x 3.75. These integrations were initialized from the same multiannual SLIMCAT simulation. The CTM was forced using UKMO analyses. We have diagnosed the chemical depletion in ozone column and in the vertical profile at several isentropic levels using a passive tracer. Even during the relatively warm winters with smaller ozone depletion in the polar vortex, substantial ozone loss is calculated at mid-latitudes by SLIMCAT at the end of each winter. The ozone loss in the partial column (350K-670K) calculated North of 40N is equal to 43 DU at the end of winter 1995/96 and to 35 DU at the end of winter 1997/98. As during warm winters the circulation is expected to be more disturbed, this emphasizes 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. Similar seasonal simulations were performed switching off the chlorine activation in order to illustrate the role of this process on mid-latitude ozone depletion during the four winters.

On the identification of the climate attractor

A. Hannachi

University of Oxford

Since the atmospheric system is such that it projects onto a forced-dissipative dynamical system the question related to the system attractor becomes important in understanding the dynamics. We therefore attempt to determine consistently what the attractor looks like in terms of probability density functions using 500-mb geopotential heights from the Unified Model (HadAM3). This importance emerges because of the need to understand climate variability to improve for example the long-range predictability, to identify climate oscillations (if any), and also to assess the influence of changing external parameters (e.g. anthropogenic climate-change).

Baroclinic Instability in Mid-Latitude Jets

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Meridional ageostrophic overturning is found in the troposphere in association with zonal acceleration in jet entrance and exit regions. Together with the geostrophic confluence and diffluence of the jet, we suggest that such overturning could have an effect on the structure and growth rate of the most unstable normal modes and the non-linear lifecycles of baroclinic waves. In particular, the zonal variations of mid-latitude tropospheric jets may provide a mechanism for breaking the baroclinic zone into relatively isolated storm tracks. These mechanisms are investigated using a simple GCM, with a time varying zonally symmetric basic state. For example, the growth rates of normal modes of the linearised primitive equation model are reduced by up to 20% by realistic strengths of meridional overturning, and normal mode structures are also significantly affected. Similarly meridional circulations have a dramatic effect on the structure of disturbances during the nonlinear growth and decay phases of the baroclinic lifecycle, leading to changes in the associated energy conversions and momentum fluxes.

The effect of subgrid-scale cloud inhomogeneity on direct radiative forcing by aerosols

E. Highwood

Dept. of Meteorology, University of Reading

The effect of including horizontal cloud inhomogeneity on direct radiative forcing due to sulphate and soot aerosols is explored. Cloud inhomogeneity is represented using the gamma independent pixel approximation. The assumption of plane parallel homogeneous clouds usually used in climate models is shown to systematically underestimate the magnitude of negative radiative forcing due to sulphate and systematically overestimate the magnitude of positive radiative forcing due to soot. The magnitude of this bias could reach 2-3 W/m2 in regions of high cloud amount, high aerosol loading and high relative humidity.

Defining NAO, AO, and annular modes

M.H.P. Ambaum (1) B.J. Hoskins (2)

Department of Meteorology, University of Reading

A great deal of work on Northern Hemisphere midlatitude climate variability is directed towards understanding the physics of modes of variability like the NAO, the AO, and related annular modes. Generally, these modes are defined as EOFs of fields like mean sea-level pressure and geopotential height at certain levels. In this presentation we show evidence that these definitions may be quite misleading as far as they are supposed to define modes of variability that correspond to physical phenomena with well-separated sets of physics. For example, analyses of the streamfunction and of the geostrophic wind lead to quite unrelated patterns of variability; this should not be the case if these patterns were to represent some physical mode of variability.

Sensitivity to vertical resolution of the simulation of the Madden-Julian Oscillation in a GCM

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It is our intention to investigate the role of the Madden-Julian Oscillation (MJO) in forcing the tropical coupled ocean-atmosphere system. In order to do this we will be using a coupled global circulation model (GCM) to show how changes in surface fluxes associated with the MJO affect the state of the ocean surface temperatures and currents, and how these changes to the ocean feed back onto the atmospheric state.In order to do this we need an atmospheric component of the coupled modelling system which represents the MJO as realistically as possible. Initial experiments have shown that an atmospheric GCM with 30 vertical levels produces a more realistic MJO signal than the same GCM with 19 levels. The reasons for this difference will be discussed and the outline of future coupled modelling work will be presented.

Variability in transport in the tropical lower stratosphere

Alan Iwi

Atmospheric, Oceanic and Planetary Physics, Oxford University, UK.

Transport in the tropical lower stratosphere is investigated using idealised-tracer experiments, in a range of chemical transport model integrations, performed by participants in the EU-funded TOPOZ II project. Some integrations are forced by ECMWF or UKMO analyses, others by GCM winds (including the Unified Model).

Comparisons between the models and with observational data are made for such features as the tropical "tape recorder", vertical ascent rates, the age of air, and their variability on annual and interannual timescales. The quasi-biennial oscillation is found to have a marked effect on the interannual variability of many features.

The impact of the 1997/1998 El Nino on the Atlantic Ocean: A coupled modelling study using HadCM3

Steve Jewson

Reading University.

Composites of historical SST data show an influence of El Nino on the Atlantic ocean, and a subsequent influence of the Atlantic on the tropical atmosphere. In this study, HadCM3 is used in a novel way to study the effect of the 1997/1998 event on the Atlantic. The methodology allow us to separate the potentially predicable Atlantic SST and ocean circulation signals from the noise, and also to evaluate the relative roles of the various processes which generate that signal. Some results and mechanisms are also shown for El Nino forced SST anomalies in the Southern Ocean.

The mass flux through the extratropical tropopause

M. Juckes

AOPP, Oxford

The mass flux through the extratropical tropopause has been analysed both through theoretical methods and by evaluation of the meridional circulation in the ECMWF re-analysis data. In the winter hemisphere there is a large flux through the dynamical tropopause into the stratosphere on the poleward side of the storm tracks (taking the dynamical tropopause as defined by the WMO). The circulation is of limited vertical extent. There does not appear to be a significant mean transfer across the thermal tropopause, which is typically several kilometres above the dynamic tropopause. The difference in the mass flux relative to the two tropopauses can be explained in terms of their differing morphology during the formation and decay of cyclones.

Stratospheric variability and reproducibility in seasonal ensemble integrations with a troposphere-stratosphere GCM

W. A. Lahoz

CGAM, Department of Meteorology, University of Reading

The Centre for Global Atmospheric Modelling (CGAM) has participated in the EU-funded PROVOST project to assess the capabilities of GCMs for seasonal forecasting. CGAM has used a troposphere-stratosphere version of the Unified Model developed at the UK Meteorological Office. It has 58 levels in the vertical and a horizontal resolution of 2.5deg latitude by 3.75deg longitude. It has the same tropospheric configuration and representation of physical processes as the current climate version of the Hadley Centre's version of the Unified Model (with so-called HADAM3 physics). A nine-member ensemble of four-month integrations has been run for the 19 northern winters from 1979 to 1997, each one started during the last nine days of November. Experiments were run in hind-cast mode with seas-surface temperatures prescribed with observational data. The simulated variability in the extra-tropical stratosphere during each winter, and the variability between winters will be discussed and analysed by comparison with ERA-15 and UKMO analyses data. The reproducibility of the seasonal cycle and of the intraseasonal variability among ensemble members will be assessed to determine the role of ocean-surface boundary conditions

and of internal non-linearities on stratospheric variability. Links between this work and the Arctic Oscillation will also be provided.

Data Assimilation of research satellite data into NWP systems: past, present and future

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

CGAM, Department of Meteorology, University of Reading

NWP centres in Europe and the USA have led the way in the development of data assimilation for application for weather forecasting. Despite these developments, there remains ample scope for further development of the theory and practice of data assimilation. Efforts at the NWP centres have concentrated on the use of data that are available in near real time, and so has been restricted chiefly to data from operational weather satellites, such as the NOAA series of polar orbiters carrying nadir-viewing instruments.

Comparatively little work has been done until recently to assimilate data from research satellites, mainly because the data are not often available in near real time, and therefore the NWP centres have little incentive to develop techniques to cater for such data. The advantages of data assimilation have therefore not been exploited to reap full benefit from expensive research satellite programmes. A number of collaborative projects have now been set up in Europe involving the NWP centres and the academic community, all of which have the express purpose of remedying this serious shortcoming.

This talk will discuss some of these European initiatives in which UGAMP is involved, with particular reference to the assimilation of data from UARS and GOME, and from the forthcoming Envisat satellite.

Solar Cycle Effects on the Climate - A Comparison of GCM Results with Observational Data

A.Larkin (1), J.D.Haigh (2).

Imperial College, London

Evidence for the influence of the 11-year solar cycle on stratospheric temperatures and geopotential heights is becoming ever stronger. However, attempting to reproduce the observed effects using GCMs continues to be problematic. In this presentation, an experiment attempting to simulate the differences between solar maximum and solar minimum is described. Using the 58 level troposphere-stratosphere version of the UKMO Unified Model, changes to the solar constant and spectrum were made in addition to alternations in the ozone climatology following 2-D model results. A comparison of geopotential heights at 30mbars shows statistically significant results and reasonable agreement with observational data in Northern Hemisphere winter. Temperature increases in the underlying stratosphere and troposphere lead to an increase in the geopotential heights of around 20m at mid-latitude to equatorial regions. Although the magnitude of these changes is smaller than those implied by observational data, the spatial distribution of the results is promising. However, the summer months in the Northern Hemisphere show little significance and no similarity to the observations. Geopotential height differences are opposite in sign to what was expected. An attempt is made at explaining these results.

Chemical Data Assimilation Highlights Several Issues

D. J. Lary

Department of Chemistry, Cambridge

Chemical Data Assimilation has highlighted several issues of interest in atmospheric chemistry. These include: The role of hydrocarbons, and particularly carbonyls in the lower stratosphere and their interaction with halogen chemistry. The important role of organic nitrogen in the lower stratosphere and upper troposphere. New light on the 40 km ozone deficit.

The potential role of carbonyl production on organic aerosols

D. J. Lary, Y. Rudich, D. E. Shallcross

Department of Chemistry, Cambridge

When atmospheric organic aerosols interact with O3 it is likely that part of the time this will lead to the formation of aldehydes such as HCHO and CH3CHO. If organic aerosols do release carbonyls on reaction with O3 then one of the most significant effects is likely to be the formation of hydrogen halides. It is likely that this will play a role if the product of the reaction probability and the organic surface area exceeds 2x10-4 μm2 cm-3. If the reaction probabilities of deGouw 1998 apply to these processes then this corresponds to an organic aerosol surface area in the range 0.2 to 2 μm2 cm-3. The measurements of Novakov 1993 imply a surface area of the order of 3 μm2 cm-3, it is therefore possible that there is a role for these processes in the atmosphere. The next most significant effect is the autocatalytic production of OH which in turn will reduce the HNO3/NOy ratio. It is likely that this will play a role if the product of the reaction probability and the organic surface area exceeds 9x10-4 μm2 cm-3. This paper examines the calculated sensitivity of tropospheric and lower stratospheric chemistry to these postulated processes. This study is an exploration of the possible role of these reactions.

The potential importance of the reaction CO+HNO3

D. J. Lary, D. E. Shallcross

Department of Chemistry, Cambridge

CO has a strong thermodynamic potential for reducing HNO3 to HONO. If the reaction of HNO3 with CO does proceed via heterogeneous catalysis on sulfuric acid aerosols in our atmosphere then this data assimilation study shows that the model is better able to reproduce the observed NOx/HNO3 ratio even with a gamma value as low 1x10-4. This is particularly true in the upper troposphere and lower stratosphere. We would like to highlight the possibility that elements such as iron deposited in the lower stratosphere by meteorites maybe catalysing this and other reactions within sulfate aerosols.

Atmospheric production of hydrogen halides

D. J. Lary, D. E. Shallcross

Department of Chemistry, Cambridge

Atmospheric models have difficulty in reproducing the observed vertical profile of HBr in the lower stratosphere. This is probably due to overlooking the production of HBr by the reaction of Br with the carbonyl compounds CH3CHO and CH3C(O)CHO. Including HBr formation due to carbonyls brings the model calculations into excellent agreement with observations. Including the carbonyl source of HBr in model calculations make the bromine cycles slightly less effective at destroying ozone, and hence effect our assessment of ozone loss due to bromine in the lower stratosphere and upper troposphere. HCl is also produced by the interaction of chlorine with carbonyls which may be significant for the recovery of HCl after air parcels encounter Polar Stratospheric Clouds (PSCs).

The atmospheric HNO_3/NO_x ratio

D. J. Lary, D. E. Shallcross

Department of Chemistry, Cambridge

HNO3 is one of the atmospheres most important nitrogen reservoirs. Yet in the vast majority of cases model calculations do not well reproduce the observed HNO3/NOx ratio. We use the technique of 4D-Var to examine the role of the new kinetic measurements evaluated by Brown et al. 1999. Using the kinetic evaluation of Brown et al. 1999 the increase in NOx is greatest in the lowermost stratosphere and upper troposphere where it reaches about 7%. We also present a detailed study of the diurnal variation in the main production and loss terms of HNO3. This analysis is based on the state of the art technique of 4D-var which has simultaneously combined our theoretical understanding with the ATMOS/ATLAS-1 observations of O3, NO, NO2, N2O5, HNO3, HO2NO2, HCN, ClONO2, HCl, CH4, CO, N2O, CO2, and H2O. Overall there is excellent agreement between the analysis produced by 4D-Var and the observations made by ATMOS/ATLAS-1.

The central role of carbonyl compounds in atmospheric chemistry

D. J. Lary, D. E. Shallcross

Department of Chemistry, Cambridge

With exception of acetone it is not generally recognised just how important atmospheric carbonyls are. Notably: carbonyl compounds are the crucial intermediate species for the autocatalytic production of OH. For example, at around 20 km it is calculated that CH3 production due to the degradation of carbonyls is almost twice as much as that due to the total direct H abstraction by OH, O(1D), and Cl. In addition, it is calculated that at around 10 km the photolysis of C2H5CHO contributes approximately 35% to the production of C2H5. Both CH3 and C2H5 are at the start of the CH4 and C2H6 oxidation chains. The reaction of Br with carbonyls is the dominant source of HBr in the troposphere and lower stratosphere. It is therefore not surprising that many models have not been able to reproduce the observed HBr profile as these halogen carbonyl interactions are often not included in the model calculations. In addition it is clear that CH3C(O)O2NO2 (PAN) is a major nitrogen reservoir species in the upper troposphere lower stratosphere. PAN can constitute up to around 30% of NOy close to the cold tropopause region. In short carbonyl compounds play a central role in atmospheric chemistry.

Upper troposphere lower stratosphere structure in the Indian Ocean during February and March 1999

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Initial results on trace gas distributions during the APE-THESEO mission are reported. APE-THESEO is the contribution of the Airborne Platform for Earth observation (APE) to the Third European Stratospheric Experiment on Ozone (THESEO). This mission, to study the tropical upper troposphere and lower stratosphere, was carried out in February-March 1999, from the Seychelles. The mission comprised two research aircraft - the Geophysica and the DLR Falcon - equipped with instruments for the measurement of cloud properties, aerosol properties, and trace gas concentrations. The objectives of the mission are summarised by the following questions:

1. In what ways, and to what extent, do overshooting cumulonimbii dehydrate air that is in the stratosphere or that is moving into it;

2. How, and to what extent, do nuclei for maintenance of global stratospheric aerosol layer originate from the upper tropical tropopause; and

3. How much mixing between troposphere and stratosphere, and the mid-latitude stratosphere and the tropical stratosphere, occurs over the Indian Ocean in northern winter?

This presentation will concentrate on the third objective, above. Mean temperature, water vapour, and ozone vertical profiles - from the aircraft ascents and from local radio-sonde ascents - show patterns that are similar to those observed in the 'stratospheric fountain' region in 1987. Analysis of cloud-top temperatures, using Meatiest-5 images, suggests that the cold tropopause temperatures and accompanying cirrus decks were not the result of local convection. The impact of the Inter-Tropical Convergence Zone on lower stratospheric trace gas distributions was also studied.

Middle-Atmosphere CH4/H2O Chemistry parametrized in the Unified Model

I.A. Mackenzie and R.S. Harwood

Department of Meteorology University of Edinburgh

This poster describes a parameterisation of middle- atmosphere CH4/H2O chemistry which has recently been implemented in the Unified Model. Oxidation of methane (CH4) is the major source of water vapour in the middle atmosphere; models lacking this source become overly dry aloft as moist stratospheric air is replaced by dry tropospheric air entering via the cold tropical tropopause. The scheme used here assumes that CH4 in the stratosphere is converted into two H2O molecules by a single 'pseudo' reaction at a rate proportional to the concentration of CH4. The rate coefficient for this reaction is taken from a two-dimensional model as a function of time, latitude and height. In the middle and upper mesosphere, H2O and CH4 are photolytically decomposed at a rate dependent on the solar zenith angle. This treatment represents the main features of the chemistry of H2O and

CH4 in the middle atmosphere at little computational expense, and if desired can be coupled to the water vapour in the model's hydrological cycle and radiation scheme. A similar pseudo-rate method can also be applied to the decay of N2O in the stratosphere and mesosphere. Initial tests of the scheme have been performed with the AMIP II configuration of the Unified Model.

Downward propagation of Arctic Oscillation anomalies in model data

P. McCloghrie

Atmospheric, Oceanic and Planetary Physics, University of Oxford

The Arctic Oscillation (AO) is the dominant mode of northern hemisphere wintertime variability from the surface through to the middle stratosphere. In the stratosphere the AO pattern represents the strength of the polar vortex while at the surface if appears as a more zonally symmetric version of the North Atlantic Oscillation.

An analysis by [M.Baldwin and T.Dunkerton, 1999] concluded that signals in the AO propagate downwards from the stratosphere to the troposphere over approximately 3 weeks. Using a stratosphere resolving version of the UKMO Unified Model, experiments were carried out to see whether an equivalent AO pattern could be reproduced, along with the proposed downward propagation. The model results show remarkable similarities with the observational data although PDF analysis in the stratosphere identifies some discrepancies. An additional series of model runs with a reduced number of vertical level in the stratosphere has also been used to see whether having a poorly resolved stratosphere will effect tropospheric variability.

Correlation of Ozone and PV using MOZAIC Measurements

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Simplified ozone analyses are compiled in the equivalent-latitude -potential temperature - time space, making use of ozone measurements taken within the Measurement of Ozone and Water Vapour by Airbus In-Service Aircraft (MOZAIC) project. The analyses cover the 310 to 350 K range of potential temperatures. In mid-latitudes they therefore exhibit a sharp boundary between tropospheric and stratospheric domains. A seasonal increase of ozone is discernible in the stratospheric part of the domain in all four winter seasons (December to February) of the winters of 1994/95 to 1997/98. Early- and late-winter ozone exhibits some marked interannual variability in the considered region. Examples of flights are considered where measured ozone poorly matches ozone inferred from its PV-derived equivalent latitude. Such mismatches occur in conjunction with PV anomalies such as cut-off systems and streamers; their geographical distribution exhibits marked zonal asymmetries related to the preferred occurrence of such features.

El Nino in Atmosphere-Only and Coupled Versions of the Unified Model

R.B.Neale,J.M.Slingo

CGAM, University of Reading

Results will be presented on the simulation of ENSO events in atmosphere-only (HadAM3) and coupled (HadCM3) versions of the Unified Model (UM). In AMIP II experiments the movement of the convective maximum into the central Pacific during El Nino is well captured. Changes over the maritime continent are less well simulated, due mainly to a dry systematic model error in this region resulting from the land regions being much cooler than the surrounding ocean regions. Further experiments with HadAM3 reveal significant sensitivity to the imposed land/sea mask in this region.

The model accurately reproduces the scale and magnitude of remote precipitation changes over the equatorial Atlantic and North East Brazil. As a consequence of the systematic error over the maritime continent region changes in the Indian Ocean basin are more poorly simulated.

In a long coupled UM integration a composite El Nino and La Nina event has an associated SST anomaly of order 1K larger than observed which is confined too near to the equator and extends too far into the West Pacific. The model exhibits a regular 3 year periodicity between El Nino events. The pattern of tropical Pacific precipitation changes are more zonally oriented than in observations and skill in reproducing the observed El Nino atmospheric response is restricted by systematic errors in SST. In particular the cold bias in the equatorial central Pacific leads to reduced precipitation in the mean and minimal changes during a composite La Nina event.

Water vapour in the tropical tropopause region: The Unified Model in comparison with UARS MLS measurements

K.M. Nissen, H. Clark

Department of Meteorology, The University of Edinburgh

The MLS water vapour measurements can be used to study troposphere stratosphere exchange, as the instrument measures below and above the tropopause. The use of a model might help to understand the processes in more detail. This study examines whether the Unified Model simulates water vapour fields sufficiently well to be used for such an analysis. We compare seasonal variations in water vapour mixing ratios near the tropopause. The model run used for the comparison is the AMIPII L58 version. It will be shown that most features are well captured by the model.

Is there a reverse Hadley/Walker circulation in tropical lowermost stratosphere?

Warwick Norton

University of Oxford

By calculating heating rates as a residual in the thermodynamic equation from the new L50 ECMWF analyses, evidence will presented to suggest an inverse Hadley/Walker type circulation in the tropical lowermost stratosphere. The picture of the zonal-mean circulation gained from the heating rates will be compared with the Eulerian mean circulation and the transformed Eulerian mean circulation. Results from the Unified Model will be examined which

show the differential heating in the tropical lowermost stratosphere comes from changes in upward long-wave radiative fluxes which arise because of the presence of high-level clouds in convective regions in the troposphere.

Simulation of the tides in the UKMO Unified Model

Sophia Oliver

Atmospheric, Oceanic, and Planetary Physics, University of Oxford

The migrating diurnal and semidiurnal tides have been simulated using the UKMO Unified Model. Two versions of the model have been used. The first is a 'mechanistic' version which has 36 vertical levels with the highest near 110km. All physics routines have been removed and it is initialised with UGAMP model zonally symmetric background winds and temperatures and forced with westward propagating heating fields in wavenumbers 1 and 2. The second version being used is the full hadam-3 version of the Unified Model which has been extended to 96km. The model results have been compared with radar data collected by Alan Manson (Saskatoon University) and ISAMS data, and agreement is sometimes very good, in particular for the semidiurnal tide. Discrepancies between simulations and observations are being investigated by comparisons of the two versions of the model. Non-migrating tides have also been found to exist in this model and their behaviour is discussed, and comparisons of both migrating and non-migrating tides are made with the observational data.

Data Assimilation of research satellite data into NWP systems: past, present and future

Alan O'Neill

CGAM, University of Reading

A data assimilation project has been established at CGAM to assimilate temperature and ozone data from research satellites. At the core of the data assimilation is a GCM of the troposphere and stratosphere. Work so far has focused on data from the Upper Atmosphere Research Satellite. The talk will give an overview of progress and outline development plans.

Modelling the Little Ice Age

Michael Palmer(1), Dr. Warwick Norton(2), Dr.Myles Allen(3)

(1)Atmospheric, Oceanic and Planetary Physics, University of Oxford, (2)Atmospheric, Oceanic and Planetary Physics, University of Oxford, (3)Rutherford Appleton Laboratory.

The Little Ice Age (LIA) refers to a broad period stretching from approximately 1400 AD to 1850 AD (Grove, 1988), when annual average temperatures over large parts of the globe were of the order of 1 deg.C lower than those of today (Lamb, 1982). One of the proposed causes of this event is the decrease in total solar irradiance, during the 'Maunder Minimum' of solar activity. The Hadam3 version of the UKMO Unified Model has been forced with spectrally resolved decreases in the solar constant, of 2.5Wm-2 and 7.5Wm-2, to try and simulate reconstructed LIA conditions. When compared to the control, the model runs both produced an area averaged cooling over the land

surface of approximately 0.17 deg.C. Consistent patterns are observed between the runs in geopotential height, surface temperature and precipitation fields. The system appears to be responding directly to surface cooling induced through the decrease in net surface short wave energy. However, the modelled patterns do not represent reconstructed LIA conditions well, and in particular are opposite in sign to those expected over northern Europe.

Realistic Quasi-Biennial Oscillations in a simulation of the global climate.

A.A.Scaife, N.Butchart, (1) C.D. Warner (2) and J.Austin (1).

(1) Meteorological Office, (2) Centre for Atmospheric Science, D.A.M.T.P., University of Cambridge

The tropical quasi-biennial oscillation is one of the most stunning examples of low frequency variability observed in the Earth's atmosphere, yet this oscillation is notorious for it's absence from even the most accurate numerical simulations of the Earth's global climate. The oscillation appears in the stratosphere as alternate bands of descending westward and eastward wind with a mean period of 28 months. Early experiments have shown how these descending wind regimes can be forced by dissipating, vertically propagating atmospheric waves and recent studies have shown that much of the required forcing is likely to come from buoyancy waves that are unresolved in the numerical models currently used for climate prediction and weather forecasting. Here we show how incorporating the recently developed Warner & McIntyre parametrization of the effects of buoyancy waves into a state of the art climate model improves the overall simulation of the global atmosphere by producing a realistic quasi-biennial oscillation.

The relationship between the North American monsoon and the North Pacific subtropical anticyclone in HADAM3

Len Shaffrey (1), Ri-Yu Lu (2) and Brian Hoskins (1)

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In this study the relationship between the North American monsoon, the Californian SST cold pool and the North Pacific subtropical anticyclone has been investigated using the UKMO atmospheric climate model, HadAM3.

It has been hypothesised that the northward summertime progression of the heating associated with the North American monsoon induces descent on the eastern flank of the North Pacific subtropical anticyclone. This descent is further enhanced by radiative cooling and is associated with equatorward surface winds parallel to the western coast of North America. These equatorward winds induce oceanic upwelling of cold water and result in the Californian SST cold pool, which may feedback on the anticyclone by further suppressing convection and inducing descent.

The relative importance of these features in the monsoon- anticyclone system are investigated in HadAM3. Two perturbation ensembles are integrated, one in which the cold pool is removed and one in which the North American monsoon is suppressed.

The removal of the Californian SST cold pool has a small, statistically insignificant effect on the model, suggesting the feedback of the SST cold pool on eastern flank of the anticyclone is weak. In reality, however, this feedback may be dependent on the detailed physics of the stratocumulus decks that lie over the SST cold pool and in HadAM3 these clouds are poorly represented.

In the other perturbation ensemble the North American monsoon is suppressed by increasing the albedo of the land surface in the monsoon region. This results in a decrease in the surface temperature, precipitation and heating in the

North American monsoon. The reduction of heating in the monsoon induces anomalous ascent on the eastward flank of the subtropical anticyclone and anomalous polewards surface winds along the western coast of the North American continent, thus providing support for the above hypothesis.

The northern hemisphere wintertime storm tracks in HADAM3 and the ERA dataset

Len Shaffrey (1) Paul Berrisford (1) Kevin Hodges (2)

(1) CGAM, Department of Meteorology, University of Reading, U.K. (2) ESSC, University of Reading, U.K.

The Northern Hemisphere wintertime atmospheric flow is characterised by two regions of synoptic-scale high-frequency eddies which are located over the North Atlantic and North Pacific Oceans, i.e. the Atlantic and Pacific storm tracks. There are number of ways that the shape, location and strength of the storm tracks can be determined from observations or AGCMs (Atmospheric Global Circulation Models). One method is to use time-filtered variance and co-variance measures such as the high-pass eddy kinetic energy and the high-pass poleward temperature flux. Another method focuses on individual weather systems and involves using a feature tracking algorithm to determine the magnitudes, paths, propagation speeds and growth rates of extra-tropical cyclones as they move through the storm track. Both methods, though conceptually very different, provide complimentary information about the synoptic-scale variability of the mid-latitudes in both models and observations.

In this study the different measures of synoptic-scale variability are calculated from a ten member wintertime ensemble of the United Kingdom Meteorological Office's Atmospheric Climate Model, HadAM3, and are compared with the same measures from the ERA dataset. The prominent differences between the observed and modelled storm tracks are the slow propagation speeds of extra-tropical cyclones in HadAM3 as they move through the Atlantic storm track, and the shape of the Atlantic storm track which is more zonal in the model than in observations. Both these differences can be related to the structures of the time- mean jet streams and steering level flows in HadAM3 and the ERA dataset.

Comparison of ground-based BrO measurements during THESEO with the SLIMCAT chemical transport model

B.-M. Sinnhuber(1),M. Chipperfield(1), C.-F. Enell(2),U. Friess(3),F. Hendrick(4), P. Johnston(5),K. Kreher(5),K. Pfeilsticker(3), U. Platt(3), A. Richter(6),A. South(7), K. Toernkvist(8), M. van Roozendael(4), T.Wagner(3), F. Wittrock(6)

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Ground-based UV/visible measurements of stratospheric BrO are compared with simulations from the SLIMCAT 3D chemical transport model. The measurements have been performed at a global network of ground-based sites in the frame of the European THESEO BrO project. The measurement sites range from northern high latitudes (Ny-Aalesund, 79N, Andoya, 69N, Kiruna, 68N) over northern mid-latitudes (Harestua, 60N, Bremen, 53N, OHP, 44N, Huelva, 37N) to southern mid- and high latitudes (Lauder, 45S, Arrival Heights, Antarctica, 78S). This network

of high-quality BrO measurements together with the global model simulations allows us to test quantitatively our current understanding of the stratospheric bromine chemistry.

Since the interpretation of the zenith-sky BrO measurements during twilight is complicated, the observed differential BrO slant column densities have been simulated by coupling the SLIMCAT model to a radiative transfer model. This approach allows a quantitative comparison of the BrO measurements with the model without additional a priori assumptions.

First results show, that the model is able to reproduce many features of the observations. The paper will focus on the seasonal and latitudinal variations of stratospheric BrO. Implications for the mid-latitude ozone loss due to bromine chemistry will be discussed.

Predictability and the relationship between subseasonal and interannual variability during the Asian Summer Monsoon

Ken Sperber (1), Julia Slingo (2), H. Annamalai (3)

(1) Program for Climate Model Diagnosis and Intercomparison, Lawrence Livermore national laboratory
(2) Centre for Global Atmospheric Modelling (3) University of Hawaii

The relationship between subseasonal and interannual variability of the Indian Summer Monsoon has been investigated using analysis of the dominant modes of variability in the 40-year NCEP/NCAR Reanalysis, with complementary satellite and surface based precipitation data. The hypothesis that the characteristics of monsoon subseasonal variability (i.e. weather regimes) are modulated on interannual timescales in a systematic and therefore predictable manner has been tested. The null hypothesis is that predictability of the seasonal mean monsoon behaviour requires only that the effects of the slowly varying components of the climate system be correctly simulated.

An interannual mode of monsoon variability has been identified which is closely related to the observed seasonal mean All India Rainfall (AIR). A counterpart of this mode has also been identified at subseasonal timescales which projects strongly on to the daily AIR, confirming that a common mode of monsoon variability exists on seasonal and subseasonal timescales.

It has been shown that the temporal behaviour of this subseasonal mode (as described by the Probability Density Function (PDF) of the Principal Component (PC) timeseries) does not show any evidence of bimodality (i.e. transitions between weather regimes), the shape of the PDF being Gaussian. Further it has been shown that the PDF is systematically and significantly perturbed towards negative(positive) values in weak(strong) monsoon years as categorized in terms of the seasonal mean AIR.

This translation, rather than change in shape of the PDF suggests that anomalous monsoons are not associated with changes in weather regimes. Further analysis has confirmed that low frequency modulation of the basic state is primarily responsible for these shifts in the subseasonal PDFs, supporting the null hypothesis that predictability of the seasonal mean monsoon requires only that the effects of the slowly varying components of the climate system be correctly simulated. Thus model improvements to reduce systematic errors in the mean simulation and the response to low frequency boundary forcing may improve the prospects for dynamical seasonal prediction.

However, the results have also shown that only a subset of the intraseasonal modes are systematically perturbed either by ENSO or in weak vs. strong monsoon years, suggesting that predictability is likely to be limited by the chaotic, internal variability of the monsoon system.

Trends in Stratospheric Water Vapour Derived From UARS HALOE and Their Radiative Effects Simulated Using a 2D Model.

C. A. Smith, J. D. Haigh, R. Toumi

Space and Atmospheric Physics, Imperial College

Data from the Halogen Occultation Experiment (HALOE) on the Upper Atmosphere Research Satellite (UARS) (version 19) are analysed for trends in water vapour in the stratosphere over the period Jan. 1992 - April 1999. The data are analysed on a 19 latitude by 72 pressure level grid using a multiple regression technique that takes into account annual and semi -annual cycles, the quasi-biennial oscillation and incorporates an autoregressive noise model.

The trends retrieved are then used in experiments with a two -dimensional atmospheric model of the lower and middle atmosphere which includes interactive radiative, chemical and dynamical fields. An average of the first two years (1992-1993) of zonal monthly mean mixing ratios of H2O from the HALOE data are used in the control run. For the experiment the trends in stratospheric H2O are extrapolated to 10 years and the water vapour field in the model's radiative transfer routines is changed by amounts corresponding to these trends. This allows an estimate of the radiative forcings and changes in atmospheric temperatures due the observed trends in water vapour over a decade. Of particular interest is the tropopause region, where the data show a quite complex pattern of trends in H2O which have considerable impact on the derived radiative forcing.

Simulation of the Quasi Biennial Oscillation (QBO) in the UKMO Unified Model using the Hines Gravity Wave Drag Parameterization

D. Stainforth, W. Norton

Oxford University, Department of Atmospheric, Oceanic and Planetary Physics.

The Hines gravity wave drag parameterization from the ECHAM/MA model has been implemented in a 55 level version of the UKMO Unified Model with an upper boundary near 0.01 hPa. The parameterized gravity waves are launched near the surface with a globally uniform strength.

The newly available T3E computing facility at Manchester has enabled a series of 10 year integrations to be carried out. Using these integrations the sensitivity of the model to changes in gravity wave source strength has been examined. Comparison with an integration using only Rayleigh Friction shows that the Hines scheme can produce westerly winds in the equatorial stratosphere. For certain gravity wave source strengths these westerlies propagate downwards over time producing a convincing representation of the Quasi Biennial Oscillation (QBO). The Hines scheme also produces middle atmosphere jets which slope equatorward with height and a much improved breakdown of the southern hemisphere winter jet.

The sensitivity of the model's "QBO" to the gravity wave source strength will be presented along with the scheme's effect on the extra tropical winds.

UGAMP Support and Services

Lois Steenman-Clark

CGAM, Department of Meteorology, University of Reading

UGAMP supports a large number of researchers in several UK University departments and provides a wide range of services from specialist training to changing computer passwords. This talk will review the support and services currently provided and look forward to how they can be expanded and improved.

The Assimilation of UARS MLS Ozone using the UKMO Unified Model

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

CGAM, Reading University.

Study of the trend in ozone mixing ratio is important in determining the possible recovery of polar stratospheric ozone. Assimilation of satellite ozone measurements into a GCM will provide a useful data set for the study of ozone trends and the interaction between ozone and atmospheric dynamics. Getting an assimilation system of this nature in place is imperative with ESA's large atmospheric chemistry observing program, ENVISAT, due for launch in late 2000.

This presentation will describe our current work and future plans for the assimilation of ozone using the Unified Model (UM). The measurements used are from the 205GHz Microwave Limb Sounder (MLS) flown on the Upper Atmosphere Research Satellite (UARS) which are provided as vertical profiles with a vertical resolution in the stratosphere of approximately 1.6km and with global coverage on a daily basis. The stratospheric configuration of the UM is used with the Analysis Correction (AC) assimilation scheme. The move to the Met Offices' new 3DVar assimilation scheme is scheduled for early next year. At present, ozone in the UM is treated as a passive tracer. The plan to introduce a parametrized ozone chemistry scheme in the future, will be discussed.

The Elements of Climate Variability in the Tropical Atlantic Region

R.T. Sutton(1), S.P. Jewson(1), D.P. Rowell(2)

(1) Centre for Global Atmospheric Modelling, University of Reading (2) Hadley Centre

The tropical Atlantic region, unlike the tropical Pacific, is not dominated by any single mode of climate variability such as ENSO. Rather, this region is subject to multiple competing influences of comparable importance. The nature and potential predictability of these various influences has been investigated by analysis of an ensemble of atmospheric GCM integrations forced with observed sea-surface temperatures for the period Dec. 1948 - Nov. 1993.

The dominant modes of internal atmospheric and SST-forced variability are determined. Internal variability in the tropical Atlantic region is dominated by the equatorward extension of extratropical patterns, especially the North Atlantic Oscillation. Three different SST-forced signals are identified. These are: a) a remote response to ENSO; b) a response to the so-called Atlantic Dipole SST pattern; c) a response to equatorial Atlantic SST anomalies. The spatial structure and seasonality of these different elements of climate variability is diagnosed and feedbacks onto the ocean are assessed. The evidence presented supports the possibility of ENSO-like variability in the equatorial Atlantic, but does not support the suggestion that the Atlantic Dipole is a coupled ocean-atmosphere mode of variability.

Ozone-tracer experiments with the TOMCAT 3D CTM : comparisons against MOZAIC measurements and sensitivity studies

H. Teyssedre, M.P. Chipperfield, P.-H. Plantevin, K.S. Law and J.A. Pyle

University of Cambridge

An ozone tracer is used within the 3D CTM TOMCAT forced by ECMWF analysed winds and temperature for year 1996 and using a parameterization for chemistry to assess the upper troposphere / lower stratosphere representation in the model. The modelled results are in generally good agreement with MOZAIC measurements regularly made onboard 5 aircraft. To explore parameters driving the agreement quality, several sensitivity studies had been carried on with TOMCAT. The effect of the horizontal resolution, of the top-boundary used to constrain the model and of the chemistry parameterization itself were investigated and results will be presented.

Some Thoughts on the Tropical Substratosphere

J. Thuburn, G. C. Craig, C. Delsol, C. D. Thorncroft

University of Reading

The region between about 150hPa and the cold point in the tropics, although usually considered part of the troposphere, is stratosphere-like in many ways. In particular, its temperature structure is controlled, to a first approximation, by radiative effects, with the optically thick carbon dioxide band playing a crucial role. We call this region the tropical "substratosphere".

Results from a cloud resolving model show that the upward mass flux in tropical deep cumulus convection is typically two orders of magnitude greater than the upward mass flux required by the stratospheric mean meridional circulation, implying that nearly all of that cumulus mass flux must detrain and descend again before reaching the cold point. I.e. the substratosphere must be strongly "hyperventilated". This has implications for tropical troposphere-stratosphere exchange and for the chemical composition of the substratosphere.

The temperature structure of the substratosphere is such that small changes in temperature can have a relatively large effect on the level reached by cumulus convection, while GCM results show a clear sensitivity of temperature and convection depth to changes in the stratospheric mean meridional circulation. This suggests a possible mechanism to explain observed correlations between the phase of the QBO and numbers of tropical cyclones. The ERA data show a clear correlation between 100hPa temperature and numbers of named storms, but no clear correlation between the phase of the QBO and 100hPa temperature, and therefore do not provide unequivocal support for the hypothesized mechanism.

How Simple can Simple Gravity Wave Parametrizations Afford to be?

Christopher D Warner and Michael E McIntyre

Centre for Atmospheric Science, D.A.M.T.P., University of Cambridge

An 'ultra simple spectral gravity wave parameterization' (USSP) has recently been developed and tested in the UK Met. Office Unified Model. This parameterization has been developed from a full 'power spectral' model of gravity wave spectral propagation and breaking by making simplifications analogous to those used in the popular Hines scheme. But such simplifications lead to significant discrepancies between simple gravity wave parametrizations,

including ours, and full gravity wave models. We compare simple gravity wave models with our full model, and investigate strategies for improving simple models without incurring excessive additional computational cost.

Tracer transport within the troposphere-stratosphere Unified Model

V. West, R. S. Harwood

Department of Meteorology, The University of Edinburgh

Studies of atmospheric change, including the climatic effects of ozone depletion, require the coupling of chemistry and general circulation models (GCMs). Such work requires that both the chemical and dynamical processes be accurately represented. We are currently working towards implementing coupled chemical-dynamical modelling in the Unified Model (UM). As a first step in this process, the ability of the GCM to reproduce known transport mechanisms in the stratosphere and near-tropopause regions is assessed. The UM was run in troposphere-stratosphere mode and two experiments were carried out using different tracer advection setups. Here we examine the tape recorder signal, vertical diffusion, horizontal dilution and the correlation of tracers.

The influence of SST perturbations on intraseasonal variability of tropical convection

S.J. Woolnough (1), J.M. Slingo (1), B.J. Hoskins (2)

(1) Centre for Global Atmospheric Modelling, Univeristy of Reading, (2) Department of Meteorology, University of Reading

Results from TOGA-COARE and other studies have shown that convection associated with the intraseasonal oscillation can affect the upper layers of the ocean through changes in the salinity, mixed layer depth and SST. However the ways in which theses changes in SST may feedback on the convection associated with the intraseasonal oscillation are not well understood. A better representation of the intraseasonal oscillation may lead to improvement in seasonal forecasting and the prediction of the onset in EL Nino. Results from integrations of an aqua-planet GCM will be presented to demonstrate the sensitivity of intraseasonal variability in convection to SST perturbations. The implications for modelling of the intraseasonal oscillation will be discussed.

Equatorial Convectively coupled waves in CLAUS/ERA data and AMIP II integrations with the UM

G. Yang(1), J. Slingo(2)

CGAM, Department of Meteorology, University of Reading

Synoptic activity in the tropics is often associated with waves which can be related to the preferred equatorially-trapped modes of the atmospheric circulation based on shallow water theory (Wheeler and Kiladis

1998). Various modes (inertio-gravity, equatorial Rossby, mixed Rossby-gravity and Kelvin waves) can be detected, in many cases related to the active phase of the Madden-Julian Oscillation.

Global brightness temperature data (from the EU Project, 'Cloud Archive User Service (CLAUS)') have been used to identify and characterise the equatorial waves based on time/space spectral analysis.The various modes noted above can be identified. The dynamical structures of these modes have been investigated using ERA.The consistency between ERA and the CLAUS data has been assessed.

The results have been used to evaluate the tropical variability in AMIP II integrations with the current version of the atmospheric component of the UK Meteorological Office model (HadAM3).

Tracer Experiments with the Unified Model and Comparisons with other European Models

G. Zeng, H.L. Rogers and J.A. Pyle

University of Cambridge

The Unified Model has been used to perform passive tracer experiments in the upper troposphere and lower stratosphere. The experiments were defined by the European Union AEROCHEM II project to examine the transport of subsonic and supersonic aircraft 'fuel-like' tracers. The Unified Model calculations from a two year integration are compared with other European models involved in both the EU AEROCHEM II and TOPOZ II projects. Results from the Unified Model show reasonable agreement with other European models and provide us with confidence in the Unified Model transport of passive tracers.

A line-by-line estimate of the contribution of unknown weak water vapour lines to the absorption of solar radiation

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Thousands of unknown water vapour weak lines in the visible and near-infrared regions are deduced from extrapolations of experimental results. Comparison is made with lines predicted by a recent theoretical model. These extra lines are then included in the HITRAN database and used in line-by-line calculations of atmospheric opacity over a range of water vapour amounts representing typical atmospheric values found from poles to tropics. Results show that the additional absorption of solar radiation reaches ~2.5 W/m^{2} in tropics or about 14$\%$ of the absorption due to HITRAN lines in the same spectral region. The ratio of the effect of weak lines to that of the CKD continuum model is near one third.

A unified radiation scheme and its impact to a troposphere-stratosphere-mesosphere GCM

Wenyi Zhong (1), Joanna D. Haigh (1) and Warwick Norton (2)

(1) Department of Physics, Imperial College, London SW7 2BZ,
(2) Department of Atmospheric, Oceanic and Planetary Physics, University of Oxford

A unified radiation scheme has been developed which can be used throughout the troposphere and the middle atmosphere. It is based on the Morcrette(ECMWF) scheme but includes:

- line-by-line precomputed LW transmission tables for CO2 15 micron band, O3 9.6 and 14 micron bands, H2O rotation band and 6.3 micron band;
- an updated parametrisation for the water vapour continuum throughout the infrared spectrum and for water vapour lines in the atmospheric window region and in the wings of the strong bands;
- a representation of oxygen absorption in the Schumann-Runge bands and continuum and in the Herzberg continuum.

Experiments have been carried out with several versions of the unified radiation scheme implemented in the EUGCM and the following impacts were found:

1) The new parametrization for the CO2 15μ band reduces stratospheric longwave cooling especially in the winter polar region resulting in the lower stratosphere warmed by 10-25 K.

2) The stratospheric water vapour concentration predicted by the model is sensitive to the radiation parametrization. Its feedback effect on the modelled temperature fields is also significant.

3) Extra cooling in the upper troposphere due to water vapour foreign continuum under the warmed lower stratosphere caused by the new parametrization of CO2 15μ band does not necessarily reduce upper troposphere temperature. This depends upon the competition between the radiative cooling and the dynamic heating caused the compression of mean vertical flow and the vertical eddy heat flux. Thus representation of the middle atmosphere is important in climate modelling and studies of troposphere-stratosphere exchange.

4) The new parametrization of the CO2 15μ band has an opposite impact on the temperature structure and mean meridional circulation to that of the H2O strong bands.

UGAMP Affiliated Sites

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