CERFACS: Scientific Report

"Climate Modelling & Global Change" Project

1991 - 1992

November 1992

1 INTRODUCTION (O. Thual)

The goals of the Climate Modelling & Global Change project is to produce high level research contributions to the modelling of the earth climate and the global change induced by anthropogenic activities. This includes the assemblage of a coupled ocean-atmosphere climate model in collaboration with the atmospheric and oceanic climate communities, and the realization of climate experiments with this general circulation model.

The Climate Modelling & Global Change project has encountered, during this last year, an important expansion in size as well as in scientific achievements. The first versions of the "coupler", which is the tool on which will rely the future climate experiments, are now achieved. This tool is ready to be used by the four new students who are presently joining the team. In parallel with the design of the coupler, this past year has been devoted to the insertion of our scientific project in both the climate community and the CERFACS structure. This has been performed through numerous interactions with other laboratories and teams, and the elaboration of multiple proposals and working plans.

1.1 A rapid growth of the project

There are presently eight participants in the Climate Modelling & Global Change project, including one project leader (Olivier Thual), two seniors (Norman Barth and Laurent Terray), one engineer specialized on visualization (Baosuo Wu), one Météo-France IT research training student (Sophie Pelletier) and three Ph.D. students (S. Dhivakar, Gilles Garric and Laurence Fleury). We have also benefited from the valuable help of an undergraduate student this summer (Ansgar Schleicher). The definition of the subjects for the students has been elaborated during the past year. S. Pelletier will study the coupling of the atmospheric model Arpège with the Pacific Ocean OPA model and S. Dhivakar will extend this coupling to the global ocean OPA model. The coupling of the atmosphere and ocean models with a sea-ice model will be undertaken by G. Garric. The role of the thermohaline oceanic circulation in the anthropogenic experiments which will come out of these coupling efforts will be investigated by L. Fleury. These four subjects will be further tuned in the coming months.

List of the participants of the Global Change project

Name	Position	Period
O. Thual	Project leader	1991/09 — Present
L. Terray	Post-doc	1990/10 — 1992/09
	Senior	1992/10 — Present
N. Barth	Post-doc	1990/10 — 1992/09
	Senior	1992/10 — Present
S. Dhivakar	Ph.D. student	1992/10 — Present
L. Fleury	Ph.D. student	1992/10 — Present
G. Garric	Ph.D. student	1992/10 — Present
S. Pelletier	IT research student	1992/10 — Present
B. Wu	Engineer	1992/07 — Present

1.2 The design of a coupler

A large part of the scientific energy of the project has been spent, during this last year, in the realization of an ocean-atmosphere "coupler". This software is at the root of the future climate experiments with coupled oceanic and atmospheric General Circulation Models (GCMs). We now have two different versions of the coupler which both solve the problem of making large complex scientific source codes run together in the concerted manner.

Both of these couplers have been tested on small scale and full scale couplings, and we expect real climate simulations to begin soon. This work has required the skills of experienced scientists, and it was important to have it finished before the arrival of the four students who are presently integrating the team. They will participate to the improvement of the coupler while using it for climatic experiments.

Two tasks have been undertaken for the design of the coupler. We first had to decide which method we would use to gather two big and independent codes, the atmospheric and the oceanic GCMs, into a same computing body. We have chosen to perform this merging task in a way which minimizes the coding changes in the two GCMs. The method consists in launching three undependant UNIX processes which respectively execute the atmospheric model, the oceanic model and the coupler. The coupler synchronizes the time evolution of the experiment by sending and receiving communication signals to and from the two models. In the future, the coupling with a sea-ice model with this method will be worked out on the same message passing principle.

For the conception and implementation of this communication method, we have benefited from the experience of the Visualization & Post-processing project of CERFACS, which had built such a system for interactive visualization. Since their innovative work, products like PVM or PARMACS have appeared, and allow more flexible communications between UNIX processes. We have also benefited from the experience of the Parallel Algorithms project of CERFACS which have explored and implemented these tools.

The second task that the coupler has to deal with is the interpolation of the surface fluxes or surface fields between the atmospheric and oceanic grids. We have designed and implemented two grid-to-grid interpolation methods. The first method is based on simple interpolation algorithms (bi-linear interpolation, splines, ...) and only one global constraint, such as the global flux conservation, can be easily imposed. This simple method will be used at least for the first coupling experiments. A second method allows a grid-to-grid interpolation with multiple constraints. These are, for instance, the conservation of the flux on all the mesh elements of the coarser grid, the atmospheric grid in most of the cases. The use of this method is more expensive in term of computing time and memory allocation, but we expect that this effort could improve significantly the quality of the atmospheric and oceanic coupling.

1.3 Visualization interface and experiment manager

Related to the coupler design is the visualization of the climate fields produced by the coupled experiments. We have invested some time in the exploration of the existing tools (Explorer, Khoros, Visuo, Avs, Ape, Gmtv, etc...) and have applied them to both oceanic and atmospheric fields. These explorations have been made in correlation with the choice of our workstation equipment. We have benefited, in this process, from the expertise of D. Astruc, and his help for the use of his software Visuo (Figure 1) which is an animation tool answering a lot of our needs. The exploration of Khoros by L. Huang has also been valuable. In the future, we plan to gather all the visualization performances into a same documented package, called the *"visualization interface"*, specialized in the treatment of climatic data. B. Wu has started to work in this direction, and to investigate the possibilities of Explorer in this respect.

The design of an *"experiment manager"* has started with the first tests of the coupling. A script for the launch of coupled runs on the CRAY-2 has been written by L. Terray, and a script to extract particular fields form the storage machine of Météo-France have been developed by S. Pelletier. In the future, the "experiment manager" will include more scripts of these types into a coherent package.

1.4 Integration in the climate community

One strong motivation for the creation of the Climate Modelling & Modelling project in CERFACS have been the need for a ocean-atmosphere climate model coupling two GCMs in the French climate community, when country like the USA, Germany or the UK had already performed anthropogenic climate change experiments with this kind of models. Because of its European future and its competence in scientific computing, CERFACS has been chosen for hosting the working forces necessary to fill the gap of the climate community.

Our scientific goals are thus strongly linked to a joint effort gathering the CNRM (Centre National de la Recherche Météorologique) the LODYC (Laboratoire d'Océanographie DYnamique et de Climatologie) and the LMD (Laboratoire de Météorologie Dynamique). This common project is centered around climatic experiments with coupled GCMs. During this last year we have settled our position inside this project by reinforcing the interactions with our partners. This has been achieved through various meetings and scientifics exchanges, as well as the elaboration of joint funding proposals to various instances: Conseil Régional (CR), Commissions of the European Communities (CEC), Ministère de la Recherche et de la Technologie (MRT), Centre National de la Recherche Scientifique (CNRS) and others. We have participated to the creation of the MEDIAS project (MEDIteranean and Subtropical Africa regional center). We have also started to extend our insertion in the climate community towards European centers like the Max Planck Institute in Hamburg and the FISBAT institute in Bologna.

Today, CERFACS is recognized by the various partners, as a key point in the design of the community climate model. This settlement work has required an exceptional additional cost of energy during all this year, due to the starting stage of the project. The following years will benefit from this organizational investment and the priority will be put on the scientific advising of the students.

1.5 Settlement in the CERFACS structure

In connection with its integration in the climate community, the Global Change project has undertaken its settlement in the CERFACS structure. This phase has coincided with important changes in the organization of this structure. For instance, the rules which correlate the projects resources (positions, equipment, travels and others expenses) to their scientific activities have been renewed, and the expanding size of our project has generated unsolved difficulties.

We have done important efforts to define our interactions with the other projects of CERFACS. At first, we have tried to build common projects with the *Visualization & Post-processing* project in CERFACS. The treatment of climatic data with advanced visualization and post-processing concepts is indeed a growing activity all around the world, and we thought that CERFACS had a strong potential in this domain. These collaboration projects, some of them which had reached a mature stage, have been postponed for structural reasons. Some of our immediate visualization needs are thus supported by our own resources, but the design of climatic experiments is a stronger priority for us, and we have seriously reduced our ambitions in post-processing realizations.

The collaboration with the *Parallel Algorithm* project is now entering a new phase with the recent arrival of a Météo-France IT research training student (E. Sevault) who is exploring the implementation of simple meteorological models on massively parallel computers. We are motivated for numerous collaborations on these topics. There is, indeed, a strong pressure for the implementation of the big atmospheric and oceanic GCMs on these machines, and an urgent need of expertise for this work. We want to be actively involved in the process and contribute to improve CERFACS excellence in this domain. However, the structuration of a group specialized in the adaptation of large codes on parallel machines has not been implemented in CERFACS during the past years. Thus, Météo-France and the European Center for Medium range Weather Forecasts (ECMWF) are now taking the leadership in this domain, at least for atmospheric codes. We will thus follow their coordination efforts.

The modelling of the atmosphere and oceanic models share a lot of common problems with the ones that the *Computational Fluid Dynamics* deals with. These problems range from the numerical methods used to integrated the Navier-Stokes equations, to the parametrizations of the turbulent processes which are crucial in the design of climate models. We have co-organized, with the CFD group, the ERCOFTAC school on the "Simulation of turbulent and atmospheric flows", in which these problems were addressed.

We have benefited from the help of the *Computer Support Group* of CERFACS for the implementation of our equipments in the network. However, due to our specific need in graphics performance and softwares, we have worked intensively ourselves for the optimization of the purchase of our workstations. In this purchase process, we have negoticated with the constructor an upgrade (VGX card and memory) of the public access graphic workstation of CERFACS (uranus). We intend to develop collaborations with this group to significantly improve the structuring of the computing support in CERFACS.

This last year, which has been the spin-up phase of our project, has coincided with a repeated evaluation of the CERFACS projects by the CERFACS *administration* through various reports (see the LogBook notes in the References) and the participation to "Scientific Steering Committees". Other meetings like "CERFACS weekly meetings", "Team Users Committees", "Library Meetings", etc..., have been numerous and time consuming. They have allowed us to determine what was the best way to optimize our scientific productivity inside the CERFACS structure.

1.6 Internal organization of the project

In order to increase the exchanges of information inside the team, with the other CERFACS project, and with the climate community, we have created an unformal journal called "Epicoa" (Exchange of Projects and Ideas for Coupling Ocean and Atmosphere). About fifteen articles have been published so far. Another journal called LogBook (Climate Modelling & Global Change Team Log Book), records the important administrative events concerning the project (budget, equipments, work plans, etc...). Weekly meetings called Astm (Administration and science team meetings) mix short discussions about administrative events concerning the project followed by an unformal presentation of one scientific topic by one member of the team or an invited speaker. This presentation is most of time generating a productive scientific debate. At last, an informatic system of internal news, developed by A. Schleicher, allows fast e-mail broadcast in the team combined to an organized archiving of the information.

This internal organization of the project (Epicoa, LogBook, Astm, News) has structured our work during the past year. The written tracks associated to this organization provides a list a references to the present scientific report, in which further details can be found.

Figure 1: Atmospheric to oceanic grid interpolation. a) Global atmospheric field. b) Pacific ocean grid. The latitudinal component of the momentum stress is shown here.

2 GRID-TO-GRID INTERPOLATION

The grid-to-grid interpolation is one of the two piles for the coupler. In an ocean-atmosphere coupled experiment, the atmospheric grid is generally coarser than the oceanic grid. Moreover, the sea-land boundaries do not necessary match between the two grids. The two grid-to-grid interpolations method that we have developed address this problem.

2.1 Simple Grid-to-grid interpolation (O. Thual and L. Terray)

We have developed a simple and robust grid-to-grid interpolation method to be able to face any complex configurations of the atmospheric and oceanic grid. The method relies on a simple algorithm. Given a point on the target grid, where we want to calculate an interpolated field, we first calculate the d th closest grid points of the source grid where the field is know. Typical values for d range between 10 and 20. We then associate to each neighbor a weight which becomes small when the distance gets big. The value of the interpolated field at the considered target point is the average of the know values of the d th closest neighbors multiplied by the appropriate weights.

With this simple grid-to-grid interpolation, only d floating point operations at each target grid points are necessary for one interpolation. The weights and the addresses of the neighbors are calculated once for all before the climate experiment. Another advantage of this method is its ability to deal with any grid configurations, even with unstructured meshes. However, this method has the disadvantage of smoothing the fields, unless particular care is given in the choice of the neighbor weights. Presently, we have implemented a version of the "closest neighbor method" (Figure 1) which does not avoid this smoothing, and we are working to the improvement of the method.

By expressing the "closest neighbor" method under a minimization formalism, if is possible to impose one or several constraints to the grid-to-grid interpolation, through the use of Lagrange multipliers. We have implemented a version in which only one global constraints can be imposed (e.g. the conservation of the total flux), in order to keep the computing swiftness of the method. The problem of multiple constraints has been left for the "constrained interpolation method" presented below.

Another simple grid-to-grid interpolation method, sharing and improving the informatic structure of the "closest neighbor method", has been implemented by L. Terray and S. Pelletier recently. It is based on a bilinear interpolation, such as the one used by the LODYC in previous climatic simulations. This method is now being used in the first test of one of the coupler.

2.2 Constrained Grid to Grid Interpolation (N. Barth)

The time and length scales of the atmosphere and ocean are different and this is usually reflected in their associated model grids. This inevitably is also reflected in the models' land/sea masks. In coupling models, it is necessary to transform the flux and temperature fields from the grid of one model where they were calculated, to the grid of the other model. Simple interpolation alone can introduce discrepencies in the integral of the field (and hence energy) of the field's representations on the two grids. Adding constraints to the interpolation is one approach to solving this problem, and has been investigated using a number of different interpolators (N.H.Barth (1992)). Although when these descrepencies become important is unknown, long simulations could suffer from the introduction of energy which is purely numerical in origin (Barth (1992b)).

References

N.H.Barth, (1992), *A conservative scheme for passing variables between coupled models of the ocean and atmosphere*, Tech. Rep. TR/CMGC/92/72, CERFACS.

N. Barth, (1992b), *Simple versus constrained interpolation in long simulations with coupled models*, Tech. Rep. TR/CMGC/93/x, CERFACS.

3 OCEAN/ATMOSPHERE COUPLING

Two different versions of the coupler have been developed simultaneously, with different and complementary designs. One of them (L. Terray) uses the basic UNIX signal communication tools to synchronize the atmospheric and oceanic models, while the other one (N. Barth) explore the advanced package called PVM. The two couplers use, in their current version, simple grid-to-grid interpolations (bilinear and cubic splines). Both coupler have been designed to couple any two atmospheric and oceanic models. But for testing purposes they are presently applied to the coupling of OPA (the oceanic model) with, respectively, the ARPEGE and the LMD atmospheric GCMs.

3.1 OPA/ARPEGE coupling (L. Terray)

A fully nonlinear ocean general circulation model(OGCM) for the tropical Pacific ([1]) is being coupled to a global spectral model of the atmosphere(AGCM) in order to study interannual climate variability focusing onto Elniño and the Southern Oscillation. The two models are the components of the french Climate Community Model, OPA from the Laboratoire d'Océanographie Dynamique et de Climat and ARPEGE-IFS, the forecast model from Météo-France and ECMWF. Uncoupled simulation of the atmospheric model has been done in the framework of the AMIP experiment using climatological SST(Sea Surface Temperature) as boundary conditions. The output fluxes generated through this experiment are now being used to realize a control run for the OGCM. These preliminary runs are very much needed to understand and analyse coupled model results. As previously mentioned, we developed different tools to ease the setup and the realization of coupled simulations ([2],[3]). Our coupling module uses Unix signals to allow communication and synchronization between the two GCM's and the coupling program. Scripts can be used to launch simulations and visualize results in an automatic way from a user workstation ([4]). Extensive tests of the coupling procedure have been done on periods of time up to a year using a simple read-atmosphere program and the full OGCM and identical results to a control simulation have been obtained ([5])

References

[1] ANDRICH, P., P. DELECLUSE, C. LEVY, G. MADEC: "A multitasked general circulation model of the ocean" in: Science et Engineering on Cray Supercomputers, Proceedings of the fourth International Symposium, Minneapolis, Minnesota, USA, October 1988, A Cray Research Inc. book, 407-428.

[2] L. TERRAY, A simple communication scheme between coupler and GCM's, *Epicoa* **0203** (1992).

[3] L.TERRAY, Shell Script and I/O Type for the Coupler, *Epicoa* **0210** (1992).

[4] S.PELLETIER, L.TERRAY, O.THUAL, Visualization of Flux and SST Fields for the OPA-EMERAUDE Amip Experiment, *Epicoa* in preparation (1992).

[5] L.TERRAY, O.THUAL, Real tests on OPA Pacific coupling, part A the communication procedure, *Epicoa* **0803** (1992).

3.2 LMD/OPA Coupling (N. Barth)

A distributed programming approach has been used to couple the atmosphere and Equatorial Pacific ocean models of the Laboratoire de Météorologie Dynamique (64x50x11 grid points) and the Laboratoire d'Oceanographie Dynamique et de Climat (228x94x28 grid points) respectively. A distributed programming perspective consists of dividing the coupled model into several programs which may be run concurrently and interact through message passing. The fluxes and sea surface temperatures are communicated entirely via message passing. Extremely few modifications to the original model code are required. Initial tests using the software package PVM (Parallel Virtual Machine, V.S.Sunderam (1990)) in July suggested this method would work (N.H.Barth and S.L.Smith (1992)), and the first short coupled runs of the two models took place in mid-September. Preparation for longer simulations with these models are underway.

References

N.H.Barth and S.L.Smith, (1992), *Coupling Numerical Models of the Atmosphere and Ocean using the Parallel Virtual Machine (PVM) Package*, Tech. Rep. TR/CMGC/PA/92/76, CERFACS.

V.S.Sunderam, (1990), *PVM, A framework for parallel distributed computing*, Concurrency, Practice and Experience, **2**, 315–339.

4 MODELLING ACTIVITIES

In parallel with the design of the coupler, modelling activities have been undertaken to prepare the future climatic experiments. A first step towards the coupling with a sea-ice model has been made. The calibration of a simple mixed layer model and the experiment design activities provides possible openings towards wider subjects. At last, the topic of the thermohaline oceanic circulation is meant to prepare the future interpretations of the anthropogenic climate change experiments.

4.1 Sea-ice Modelling (G. Garric and L. Terray)

The inclusion of an interactive sea-ice model is necessary in a global climate model due to the large variability of sea-ice and its effects on ocean and atmosphere dynamics. A sea-ice model including thermodynamics and dynamics coupled to an ocean mixed-layer model has been developed through a collaboration between the CNRM(Météo-France) and the Université Catholique de Louvain-la-Neuve ([1]). Ice and ocean must be coupled in three areas, heat, salt and momentum and the whole system is forced with atmospheric fields. We investigated a new forcing dataset coming from the AMIP experiment(a 10-year simulation of the EMERAUDE model from Météo-France) ([2]) and compared with previous studies ([3]),([4]). We included a new parameterization for ocean currents dynamics ([5]) which forces energetic equilibrium every year. Coupling this ocean-sea ice model with the AGCM ARPEGE is the next step before fully coupled ocean-atmosphere-ice models and work is underway.

References

[1] C.BELLEVAUX, Modélisation de la glace marine, Note de travail de l'ENM Numéro 245.

[2] J.F.MAHFOUF," L'expérience d'intercomparaison AMIP: simulation du climat 1979-1988 avec le modèle EMERAUDE", note CNRM/GMGEC/UDC, (1992).

[3] G.GARRIC, Rapport de stage DEA Astrophysique-Géophysique et Techniques spatiales, CERFACS (Juin 1992).

[4] M.TOMASINI, Validation d'un modèle thermodynamique-dynamique de banquise, Note de travail de l'ENM, CNRM (1991).

[5] P.GASPAR, S.PLANTON, Modelling the annual cycle of the ocean-atmosphere coupled system, Annales Geophysicae, **8**, 1-10, (1990).

4.2 Optimal calibration of a simple mixed layer model (N. Barth and S. Pelletier)

The simple 1D mixed layer of P.Gaspar, Y.Grégoris, and J.M.Lefevre (1990) was optimally calibrated using data from the Long-Term Upper Ocean Study Site (LOTUS) as well as Station P (PAPA) in the Gulf of Alaska (Pelletier (1992)). A genetic algorithm was the global optimizer used (Barth (1992a)).

References

P.Gaspar, Y.Grégoris, and J.M.Lefevre, (1990), *A simple eddy kinetic energy model for simulations of the oceanic vertical mixing: tests at station PAPA and Long Term Upper Ocean Study site*, J.G.R., **95**, 16179–16193.

S. Pelletier, (1992), *Calibration optimale d'un modele d'energie cinetique turbulente*, Tech. Rep. 0, CERFACS.

N. Barth, (1992a), *Choosing altimeter orbits as a problem in experiment design*, Oceanologica Acta, **too appear**.

4.3 Experiment Design (N. Barth)

Experiment design seeks to determine when and where it is optimal to make measurements or calculate quantities (N.Barth (0)). This work has included investigations of optimal deployment of surface drifters (Barth, Hernandez, LaTraon, and Planton (0)). When tracked by satellite these Lagrangian floaters can be used to reconstruct the circulation which advects them.

Similarly, matching the sampling characteristics for several satellite borne altimeters such as TOPEX/POSEIDON to those found in the various regions of the ocean has been investigated from the experiment design perspective (Barth (0)).

References

N.Barth, (0), *Experiment Design*, work in progress, **0**, 0.

N. Barth, (0), *Optimal orbit configurations for several satellite borne altimeters*, work in progress, **0**, 0.

N. Barth, F. Hernandez, P. LaTraon, and S. Planton, (0), *Optimal deployment strategy for the SEMAPHORE campagne*, work in progress, **0**, 0.

4.4 Thermohaline oceanic circulation (O. Thual)

Multiple equilibria of the oceanic thermohaline convection induced by surface forcing [1] are one of the approaches to explain the drifts encountered when coupling an oceanic and atmospheric model. Moreover, the thermohaline circulation plays an important roles in the feed-back loops which delay the global warming [2]. The principal effort which we have made for this topic during the past year has been the definition of a joint project [3] with the FISBAT-CNR institute (Bologna, Italy) in collaboration with P. Cessi and W. Young. This scientific and financial proposal has been submitted and accepted by the CEC. In this joint project, the Global Change project in CERFACS will look at the theoretical problems of the coupling of two simplified oceanic and atmospheric models. The focus will be made on the global thermohaline oceanic circulation, the existence of multiple equilibria and their connection with the ocean-atmosphere coupling strategies. L. Fleury has been recruited to work on this project.

References

[1] O. THUAL, J. C. MCWILLIAMS, The catastrophe structure of thermohaline convection in a two-dimensional fluid model and a comparison with low-order box models, *Geophys. Astroph. Fluid Dyn.* **64** (1992) 67-95.

[2] S. MANABE, R. J. STOUFFER, M. J. SPELMAN, K. BRYAN, Transient Responses of a Coupled Ocean-Atmosphere Model to Gradual Changes of Atmospheric CO2. Part I: Annual Mean Response, *J. Phys. Ocean.* (1991).

[3] P. CESSI, O. THUAL, Multiple equilibria in the thermohaline ocean circulation, a FISBAT-CERFACS work program, *Epicoa* **0824** (1992).

CONFERENCES AND SEMINARS PARTICIPATED BY THE CLIMATE MODELLING & GLOBAL CHANGE PROJECT

Ocotber 1991

University of Paris VI, Laboratoire de Mécanique théorique. Invited talk: "Multiple equilibria of the thermohaline convection". O. Thual.

January 1992

Ecole Normale Supérieure de Lyon. Invited talk: "Zero Prandtl convection". O. Thual.

February 1992

Nato Advanced Study Institute: "Modelling Oceanic Climate Interactions", Les Houches, France 17-28 February 1992. Attendee: N. Barth and L. Terray.

March 1992

Ecole Normale Supérieure de Lyon. Invited talk: "'Multiple equilibria of the thermohaline convection". O. Thual.

April 1992

"1992 European Geophysical Union Meeting", Edinburgh 6-10 April 1992. Attendee: N. Barth.

July 1992

ERCOFTAC Summer School/workshop on the "Simulation of turbulent and atmospheric flows". Invited talk: "Zero Prandtl convection". O. Thual.

"Global Optimization Methods and Oceanography", invited talk Rosenthal School of Atmosphere & Marine Science, University of Miami, Miami, Florida; 10 July 1992, N. Barth.

"Choosing altimeter orbits as a problem in experiment design", invited talk, Atlantic Meteorological and Oceanographic Laboratory, NOAA, Miami, Florida; 9 July 1992, N. Barth.

Computing and the Atmospheric Sciences 1992, Eldorado Hotel, Santa Fe, New Mexico June 28-July 2, 1992. Attendee: L. Terray.

September 1992

HAMBURG, Germany, "Second International Conference on Modelling of Global Climate Change and Variability" Hamburg, Germany. Attendee: O. Thual.

LA LONDES LES MAURES, CNES Summer school "Les Climats subtropicaux et leur évolution", La Londe les Maures. Invited talk: "ocean-atmosphere coupling, design of a coupler", O. Thual.

RCI Sympsosium "Trends in High Performance Computing", Toulouse. Invited talk: "Trends in Climate Modelling and Global Change". O. Thual.

PUBLICATIONS BY MEMBERS OF THE CLIMATE MODELLING & GLOBAL CHANGE GROUP.

1 INTERNATIONAL JOURNALS

O. THUAL, J. C. MCWILLIAMS, The catastrophe structure of thermohaline convection in a two-dimensional fluid model and a comparison with low-order box models, *Geophys. Astroph. Fluid Dyn.* **64** (1992) 67-95.

O. THUAL, Zero Prandtl number convection, *J. Fluid Mech.* **240** (1992) 229-258.

N. H. BARTH, Oceanographic experiment design II: genetic algorithms, *Jnl of Atmos & Oceanic Tech* **9** (1992) 434-443.

2 CERFACS TECHNICAL REPORTS

N. H. BARTH, A conservative scheme for passing variables between coupled models of the ocean and atmosphere, *Tech. Rep.* TR/CMGC/92/72, CERFACS (1992).

N. H. BARTH and S. L. SMITH, Coupling Numerical Models of the Atmosphere and Ocean using the Parallel Virtual Machine (PVM), *Tech. Rep.* TR/CMGC/PA/92/76, CERFACS (1992).

S. PELLETIER, Calibration optimale d'un modele d'energie cinetique turbulente, *Tech. Rep.* Tech. Rep. TR/CMGC/93/x, CERFACS (1992).

N. H. BARTH, Simple versus constrained interpolation in long simulations with coupled models, *Tech. Rep.* TR/CMGC/93/x, CERFACS (1992).

3 PUBLICATIONS TO APPEAR

N. H. BARTH, Choosing altimeter orbits as a problem in experiment design, *Oceanologica Acta*, to appear (1992).

4 WORK IN PROGRESS

N. BARTH, F. HERNANDEZ, P. LATRAON, S. PLANTON, Optimal deployment strategy for the SEMAPHORE campagne, work in progress **0** 0.

N. BARTH, Optimal orbit configurations for several satellite borne altimeters, work in progress, **0**, 0.

N. BARTH, Experiment Design, work in progress, **0**, 0.

5 EPICOA JOURNAL

The *Epicoa* letters (Exchange of Projets and Ideas for the Coupling of Ocean and Atmosphere) constitute an unformal journal relating the scientific aspects of the ocean-atmosphere coupling activity of the project, and its interactions with the climate community. Technical details and scientific ideas are thrown unformally in these letters, allowing unelaborated presentations. The climate community is invited to send to this journal the contributions which are related to the collaborations on our ocean-atmosphere coupling project.

5.1 Volume I (completed)

O. THUAL, Visiting the Climate Dynamic Center at UCLA, *Epicoa* **0403** (1991).

J. C. MCWILLIAMS, O. THUAL, A simple model of global air-sea coupling, *Epicoa* **0730** (1991).

O. THUAL, Visiting NCAR, *Epicoa* **0810** (1991).

O.THUAL, Green functions and coupling, *Epicoa* **0908** (1991).

O. THUAL, Programme scientifique de l'équipe "Climate Modelling" du CERFACS, *Epicoa* **0923** (1991).

L. TERRAY, Coupling strategies using simple energy-balance models, *Epicoa* **0930** (1991).

N. BARTH, L. TERRAY, O. THUAL, An inquiry about other coupling teams: Part I, *Epicoa* **1009** (1991).

O.THUAL, P. DELECLUSE, M. DEQUE, H. LE TREUT, J. F. ROYER, Ocean Atmosphere coupling and anthropogenic climate change: the CERFACS-LMD-LODYC-CNRM joint project, *Epicoa* **0118** (1992).

O. THUAL, Gathering information for a coupler, *Epicoa* **0119** (1992).

L. TERRAY, A simple communication scheme between coupler and GCM's, *Epicoa* **0203** (1992).

L. TERRAY, Shell script and I/O type for the coupler, *Epicoa* **0210** (1992).

L. TERRAY, O. THUAL, Simple models of the thermohaline convection: a coupling oriented project, *Epicoa* **0405** (1992).

O. THUAL, Simple ocean-atmosphere interpolation. Part A: the method, *Epicoa* **0315** (1992).

O. THUAL, Simple ocean-atmosphere interpolation. Part B: software implementation, *Epicoa* **0630** (1992).

5.2 Volume II (not completed)

L. TERRAY, O. THUAL, Real test on OPA Pacific coupling. Part A: the communication procedure, *Epicoa* **0803** (1992).

P. CESSI, O. THUAL, Multiple equilibria in the thermohaline ocean circulation, a FISBAT-CERFACS work program *Epicoa* **0824** (1992).

O. THUAL, L. TERRAY, Simple approaches of the ocean-atmosphere coupling, *Epicoa* , in preparation (1992).

S. PELLETIER, L. TERRAY, O. THUAL, Air-sea interface fluxes for ocean-atmosphere coupling, *Epicoa* , in preparation (1992).

6 LOGBOOK JOURNAL

The *LogBook* letters (Climate Modelling & Global Change Logbook) are internal notes adressing our team administrative questions. They present an interest only for the teams which share close administrative links with us.

6.1 Volume I (completed)

Informatics equipment of the team, *LogBook* **0917** (1991).

Budget of the team, *LogBook* **0919** (1991).

CRAY 2 hours needs for 1991 and 1992, *LogBook* **1015** (1991).

The name of the team, *LogBook* **1023** (1991).

Personnel needs of the team, *LogBook* **1119** (1991).

Budget 1992 of the team : a low and high profile, *LogBook* **1202** (1991).

Equipment purchase in January 1992, *LogBook* **1220** (1991).

Welcoming Basuo Wu, *LogBook* **0118** (1992).

February 17th Steering Committee, *LogBook* **0217** (1992).

A three year project for the Climate modelling & Global Change team, *LogBook* **0330** (1992).

Cerfacs decision proposals, *LogBook* **0402** (1992).

Couplage OPA Pacifique / Arpege, *LogBook* **0405** (1992).

Welcoming Baosuo Wu Part II, *LogBook* **0506** (1992).

June 1992 Three-year Project of the Climate Modelling & Global Change Team, *LogBook* **0615** (1992).

1993 Budget of the team, *LogBook* **0330** (1992).

Summer plans, *LogBook* **0708** (1992).

Modeles simplifies du Couplage Ocean - Atmosphere, *LogBook* **0709** (1992).

6.2 Volume II (not completed)

Couplage d'un modèle de glace à un modèle global Atmosphère-Océan *LogBook* **0710** (1992).

Dossier de demande de temps calcul sur la CM-5 *LogBook* **0720** (1992).

Proposition pour un stage de recherche IM: couplage OPA Pacifique / ARPEGE et systèmes dynamiques, *LogBook* **0801** (1992).

Offices and terminal repartition, *LogBook* **0903** (1992).

1993 budget proposal for the Climate Modelling & Global Change team: september 92 version, *LogBook* **0927** (1992).

1991 and 1992 budgets of the climate modelling & global change team, *LogBook* **1001** (1992).

October 8th scientific steering committe, *LogBook* **1008** (1992).