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SUMMARY OF PROGRESS AND MAIN ACTIONS/RECOMMENDATIONS FROM THE NINTH MEETING OF THE GEWEX CLOUD SYSTEM STUDY (GCSS) SCIENCE TEAM

(29 November - 1 December 2000, Tokyo, Japan)

GCSS and Cloud/Radiation Parameterization Main Objective and Current framework

The GEWEX Scientific Steering Group (SSG) has continued to endorse the main objective of GCSS to develop refined parameterizations of cloud systems within Global Models, including both climate and numerical weather prediction models (NWP/GCM's), through the improvement of the understanding of the coupled physical processes within different types of cloud systems. Because the Cloud Resolving Models (CRMs) and Single Column Models (SCMs) being exploited by GCSS are the scientific link between cloud process studies and GCM's, they represent an important connection between GEWEX and its "user" community. The success of GCSS has been achieved by applying specialized computing techniques and resources, which have recently become available, with better validation datasets. GCSS has developed a unique Working Group organizational structure that has facilitated the collection and application of test cases in focused research and analysis exercises that have lead to improvements in models. Each one of the five working groups associated with boundary layer, cirrus, extra-tropical layer, precipitating convective, and polar cloud systems respectively has been making progress in mobilizing the CRM community to provide observational/model datasets for many phenomena/processes of importance to GCM development. GCSS is an element of the GEWEX Modeling and Prediction Panel (GMPP) and the work within GCSS has been carried out under the following framework:

WG1 - Boundary-layer cloud systems dominated by turbulent boundary layer processes. (Chair: Dr P. Duynkerke)
WG2 - Cirrus cloud systems. (Chair: Dr D. Starr)
WG3 - Extra-tropical layer cloud systems. (Chair: Dr B. Ryan)
WG4 - Precipitating convectively-driven cloud systems. (Chair: Dr S. Krueger)
WG5 - Polar cloud systems. (Chair: Dr J. Curry)

GCSS Strategy

Rather than try to isolate the individual cloud system processes and study them separately, GCSS has undertaken to apply SCMs, CRMs and mesoscale models to study the processes as a coupled system. This strategy gives rise to phenomena spanning a broader range of scales than any individual process. The models required are being developed and validated in GCSS through the use of observations from regional field experiments. These models are being used as experimental testbeds to develop improved understanding of the processes and to provide realizations of cloud systems (4-Dimensional datasets). These in turn are used to derive and evaluate parameterization schemes for the large-scale models.

GCSS Science and Implementation Plan Revision

Within this structure there is a set of tasks being undertaken by GCSS which cut across the individual Working Groups. In response to a recommendation from the joint ECMWF and WCRP/GCSS Workshop (9-13 November 1998, at ECMWF in the UK), the GCSS Chair, with the support of a drafting team, has produced a new version of the Plan. The plan has been published in the International GEWEX Project Office (IGPO) Report series and a copy can be obtained by contacting IGPO by email at gewex@cais.com. One element of the plan addresses the issue of radiative transfer and cloud radiative feedback in the GCSS framework. This interaction between GCSS and the radiation and satellite remote sensing communities is continuing to evolve and expand. Working Groups 1, 4 and 5 have continued their interactions with the GEWEX Radiation Panel (GRP) to develop test cases which promote GRP radiation flux calculation studies.

GCSS "Ad Hoc" Data Integration form Model Evaluation (DIME) Effort

More work is required on plans to make all GCSS test case study data sets available to other groups and to the scientific community at large. An effort to form an "ad hoc" Data Integration for Model Evaluation (DIME) working group has advanced and resources are continuing to be available for this work at the Goddard Institute of Space Science (GISS). DIME is undertaking the collection, cataloguing, critique and dissemination of specific GCSS case study datasets. This concept is being investigated as a possible joint initiative with the GRP and the GEWEX Hydrometeorology Panel (GHP) where related data set development activities could benefit from a focused data integration activity. The plans for initiating such an effort were discussed and action is being undertaken by the Working Group Chairs to benefit from the availability of these resources for the organization of appropriate test case data sets.

At the meeting, DIME was tasked to focus some of its resources on and effort to characterize a standardized SCM case study data set format to be used to evaluate intercomparison exercise results and simplify the related analysis processes. Dr Steve Kruger accepted action to assist in getting a strawman prepared and to work with Drs W. Rossow and G. Tselioudis, at GISS, to move this action forward. The goal set by GCSS is to have a format ready for presentation and discussion at the April 2001 meeting of the Atmospheric Radiation Measurement (ARM) Project Science Team Meeting. Dr T. Ackerman, the ARM Senior Scientist, has agreed to participate in the review and further development of the proposed data format and to ensure time is provided on the agenda of the ARM meeting for presentation and discussion of the strawman scheme. Further progress on this proposal will be reported at the next GCSS meeting.

DIME was also tasked to pursue the acquisition of larger temporal and spatial domain data sets to enable the correlation with point data sets and to bring out the 3-dimensional aspect of the case studies being undertaken by the GCSS working groups. By undertaking an initiative to include satellite data as a specific element of the GCSS case studies the data and the work will be more directly applicable to broader GCM analyses. The DIME representative at the meeting agreed to promote this facet of DIME and provide the GCSS Science Advisory Group with an update on its progress at its next session.

Continuation of GEWEX Datasets

In an action carried forward from its previous meeting, the GCSS endorsed the continuation of the International Satellite Cloud Climatology Project (ISCCP) data collection and processing beyond the year 2000, as well as an endorsement of refinements to that data set that could benefit the GCSS analyses. The recommendation for this extension, which by implication extends to other GEWEX global datasets, added value to the recommendation endorsed by the GEWEX SSG to continue the development of these global climatological data sets at least up to the end of 2005.

Change in GCSS Chairmanship and Organizational Changes

Dr D. Randall had earlier tendered his resignation as Chair of GCSS effective at the close of the meeting. The GEWEX SSG Chair has agreed to the nomination of Dr Steve Krueger, of the University of Utah, to replace Dr Randall as chair of GCSS. This change was considered to be in effect at the end of the December 2000 GCSS meeting and that will become formal at the end of the next GEWEX SSG meeting in January 2001. Dr Randall's exceptional service to GEWEX and the broader WCRP research community in guiding the further development of GCSS, especially formalizing future priorities in a New Science and Implementation Plan was acknowledged. GEWEX will continue to draw on Dr Randall's experience and expertise in GEWEX matters in the future, especially in his continued capacity as Chairman of the GEWEX Modeling and Prediction Panel (GMPP) and in efforts within GMPP to expand the study of the Planetary Boundary Layer (PBL) physics in global models. Dr Wojciech W. Grabowski at the Mesoscale and Microscale Meteorology Division (MMM) of the National Center for Atmospheric Research (NCAR) has agreed to undertake the leadership of GCSS Working Group 4, replacing Dr Krueger in that capacity.

The request by Dr Brian Ryan to step down as Chair of WG3 was acknowledged. The Group thanked Dr Ryan for his long tenure in GCSS and noted the long list of accomplishments that were achieved under his leadership. Dr George Tselioudis at GISS accepted the nomination to take up the duties of WG3 Chair and his nomination was accepted by the GCSS Chair and the GCSS Science Panel. This action was confirmed as taking effect at the end of the meeting.

Japan's Contributions to GCSS

In response to actions from the previous session of GCSS which asked Professor Y. Fujiyoshi, From Hokkaido University, in Sapporo, Japan, to highlight Japan's National Cloud System Studies and report on items of interest to the advancement of GCSS, a series of presentations were given by members of Japan's scientific and technical community who are engaged in research of relevance to GCSS.

Professor T. Matsuno introduced the aspects of future plans of the Frontier Research System for Global Change that were of importance to cloud system analyses. The primary topic of Dr Matsuno's presentation was the status of the development of a super-high resolution global atmospheric model that will treat meso-scale cloud systems explicitly. The model is being designed to run on the new Earth Simulator super-computer.

Dr K. Kuma presented global and mesoscale NWP activities at Japan Meteorological Agency. Dr Kuma reported that JMA changed its NWP model in December 1999. The new model includes improvements in cloud parameterizations of interest to GCSS. He also introduced the JMA global reanalysis project which will start in 2001. The reanalysis will be done for at least a 25 year period (1979-2003). It could be expected that these reanalyses products will contribute to GCSS exercises.

Dr K. Saito introduced cloud resolving model work being carried out at the Meteorological Research Institute (MRI) at JMA. Following a brief history of the development of the MRI non-hydrostatic model (NHM), examples of numerical simulations of the diurnal evolution of tropical island convection and marine stratocumulus associated with a cold air outbreak. A global non-hydrostatic model is now under development.

Dr H. Eito presented analyses of numerical simulations of marine stratocumulus observed in the region of Japan in winter. Cloud streaks in the simulation products, which are produced with the MRI/NHM on a 1 km grid, were found to correlate extremely well with observations. Two typical vertical circulations in the mixed layer were discernible. Sensitivity experiments revealed that windward topographies affect the formation of the roll-like circulation.

Dr N. Kuba presented her numerical simulation results on the effect of CCN on the optical properties of a layer cloud. Some of the results were noted to be in opposition with some existing research in this field. The conclusions were of interest to the GCSS community.

As a result of these presentations Professor Fujiyoshi accepted responsibility for bringing the work being done with newly developed Japanese CRM/CSM capabilities into specific test case studies being undertaken within the GCSS Working Groups. A specific recommendation was that Japan will continue to send a representative to the GCSS Working Group meetings being planned in 2001. This interaction should especially include the WG-3 orographic and cold air outbreak studies. As a member of WG3 Professor Fujiyoshi agreed to ensure an appropriate application of the Japanese research to the GCSS WG3 studies.

Other Relevant Actions

Other generalized actions which GCSS will address or which each Working Group has agreed they would implement included:

(a) As a result of a continuing need to emphasize parameterization development within GCSS science, each WG will continue to schedule an extended discussion of specific new/old parameterizations and their performance in SCM (and other) tests. SCM and CSMs will also be discussed in the context of their application as tools for addressing specific cloud feedback issues that have been given priority in GEWEX modeling (GMPP) and radiation (GRP) studies. Although all WG Chairs are continuing to report progress on this action, it is being carried over for 2001 to emphasize the importance of feedbacks in climate and the role GCSS can play in advancing knowledge on this issue in GEWEX.

(b) During 2001 WG Chairs will continue to engage GCM researchers in GCSS case studies and related WG activities. This will be a continuing effort to improve the link between GCSS and the GCM "community".

(c) The outgoing GCSS Chair (Dr D. Randall) will use the main elements of the newly revised GCSS Science Plan to develop an article about GCSS for publication in the Bulletin of the American Meteorological Society (BAMS), or an equivalent publication. The article will emphasize past results and future thrusts of GCSS. The changes to be noted in the article will include data integration as a separate component of GCSS; a specific GCSS strategy for dealing with cloud process modeling issues; the role of GCSS in assisting GEWEX to address cloud feedbacks in climate, including a major contribution to the planned Workshop on Radiative Feedbacks in the Climate System being planned jointly by GMPP and GRP in 2001; and the goal in GCSS to certify CRM's as tools for providing a substitute for certain types of data under certain conditions.

(d) Where appropriate, such as in WG1 and 4, the WG chairs agreed to begin considering cases over land that allow surface fluxes to couple land-surface and atmospheric models. The approach is to use a reference land surface model with a standard set of initial conditions which participants can couple to their CRM but which enable the surface fluxes to interact with the boundary layer (PBL).

(e) Since feedback of clouds on the radiative balance is of great interest and because it is important to support efforts by the GEWEX Radiation Panel (GRP) to implement a consistent strategy of assessment and, thereby, to advance knowledge of radiative feedbacks and responses in the climate system, it was recommended that GCSS should support the planning of a workshop on radiative feedbacks in the climate system. Dr David Randall in his capacity as Chair of GMPP, agreed to take the lead in initiating contact with GRP to build on work already begun toward a workshop which would be sponsored by WCRP/GEWEX and undertaken by GMPP in coordination with GRP and the other main components of GEWEX. The organization of the workshop will especially consider contributions by the main parts of GMPP including GCSS, the Global Land-Atmosphere System Study (GLASS) and the newly formed GEWEX Global Atmospheric Boundary Layer Study (GABLS). Issues of feedbacks in the framework of the Coordinated Enhanced Observing Period (CEOP) initiative being developed under the leadership of the GEWEX Hydrometeorology Panel (GHP) will also be addressed. Dr George Tselioudis agreed to assist in the liaison with GRP and further development of the plans and implementation strategy for organizing the workshop. An offer to hold the meeting at NCEP will be taken up in the planning of the meeting. The GEWEX SSG will be advised of these plans which will continue to evolve in 2001-2002.

(f) As incoming Chair of GCSS Dr Steve Krueger agreed to undertake the lead on a series of actions associated with the continued evolution of GCSS within GEWEX in the context of the priorities reflected in the revised Science and Implementation plan. The GCSS WG Chairs agreed to assist with these actions, as appropriate. The actions included:

(i) Organizing a general GCSS meeting which will encompass a broad set of GCSS WG members and invited experts from the NWP/GCM community. The meeting will be scheduled in 2002. The strategy for implementing the meeting will follow the format used to organize a similar GCSS-wide meeting at the ECMWF in 1998. The meeting schedule will provide for 4 days of technical papers, discussions and breakout sessions with one additional day for a GCSS “business” meeting.

(ii) Arrange an appropriate interface with the newly formed elements of GMPP, which are addressing Land-surface (GLASS) and boundary layer (GABLS) issues. The connections between GCSS, GLASS and GABLS should begin to promote joint experiments and case studies, which can begin to focus on ways to improve understanding of land/boundary-layer/cloud interactions in large scale models.

(iii) Continue to devise meaningful approaches to aggressively promote GCSS data requirements in the planning of new observational experiments. In recognition of the importance of the availability of quality controlled, consistent data sets in GCSS studies, this action must continue to be given a high priority in GCSS.

(iv) Continue to seek opportunities to join with other groups that are undertaking dynamic studies of clouds in GCM/NWP models (AMIP-like exercises) to enable long term intercomparisons with data sets such as those being collected by ARM.

(v) Ensure that GCSS WG’s take appropriate action to address parameterization issues of importance to the GCM community as reflected in requirements outlined by Dr Martin Miller the leader of the GEWEX Cloud Parameterization Study Task in GCSS and the GCM/NWP community representative on the GCSS Science Panel. Dr Miller highlighted the following items as areas where GCSS can aid in improving specific formulations in large scale models:

- Promotion of an observational field study to investigate tradewind cumulus convection. Currently the ECMWF model PBL is too dry and too deep resulting in excessive evaporation that yields errors in the coupled mode. GCSS WG-1 must provide, by 15 March 2001, the GCSS Chair with a discussion paper which addresses this issue and outlines observational and model activities that will lead to improved understanding of this condition.

- Analysis of test cases which can improve an understanding of conditions related to sub-tropical marine stratocumulus cloud. This cloud type seems to develop properly in the model but near surface temperatures become too cool leading to excessive sensible heat flux that corrupt the continued evolution of the clouds in the model. GCSS will investigate this problem and attempt to assist with a solution in due course, possibly by way of a focused case study to be undertaken by WG1.

- Analysis of test cases which can address the issue of the diurnal cycle of convection over land. The onset of deep convection occurs too early in the model day (before local noon) leading to a fundamentally poor representation of heat and moisture fluxes. GCSS will attempt to investigate test data coming from work being carried out by the GHP in the LBA Continental Scale Experiment in Brazil. WG4 will investigate the possibility of undertaking a case study, using LBA or other appropriate data sets, during 2001, that could lead to an improved formulation for diurnal cycle behaviour under these conditions.

Status and Plans of Specific GCSS Working Groups

Each GCSS Working Group presented a summary of its activities including earlier work, recent studies and plans for the future that will enable them to accomplish their specific goals and to contribute to the unified global objectives of GMPP and WCRP/GEWEX.

WG1 (Boundary Layer Cloud) Status and Plans

The Boundary Layer Cloud Working Group aims to improve physical parameterizations of Boundary Layer clouds, other boundary layer processes, and their interactions. The methodology is to conduct intercomparisons between observational or laboratory case studies, one-dimensional GCM column model results, and 2-dimensional (2D) and 3-dimensional (3D) eddy-resolving models of cloud-topped boundary layers. The main contributors to this effort include the leading boundary layer cloud modelling groups from around the globe, which continue to participate in the on-going series of WG1 workshops. The Boundary Layer Clouds working group is currently chaired by Professor Peter Duynkerke P.G.Duynkerke@phys.uu.nl of the Institute for Marine and Atmospheric Research Utrecht (IMAU), The Netherlands. Updates on actions being taken by the Group are available by joining an email list. The email box identification is gcss-l@phys.uu.nl. To join, send a message containing the words “subscribe gcss-l” to server Majordomo@phys.uu.nl. The other source of information on the status of the Boundary Layer Clouds Working Group work is on the Internet at: http://www.atmos.washington.edu/~breth/GCSS/GCSS.html.

Earlier work undertaken by WG1 included analysis of a nocturnal subtropical stratocumulus case presented at an August 1994 workshop in Boulder, Colorado, USA. The case coordinator Dr Chin-Hoh Moeng, NCAR, USA moeng@mmm.ucar.edu organized the workshop and coordinated the compilation of papers that describe the intercomparison results and related topics at: http://www.atmos.washington.edu/~breth/GCSS/nocturnal_stratocu/papers.html).

As part of an on-going GCSS-sponsored programme of intercomparison of eddy-resolving and one-dimensional boundary layer models, a convective boundary layer filled with radiatively active "smoke" was simulated. A follow-up study was designed to focus on simulating the entrainment process. Cloud-top cooling rates were chosen to be comparable to those observed in marine stratocumulus, while avoiding evaporative feedbacks on entrainment and turbulence that are also important in liquid water clouds. The radiative cooling rate had a specified dependence on the smoke profile, so that differences between simulations could only be a result of different numerical representation of fluid motion and subgrid scale turbulence. The case summary, goals, and specifications of this intercomparison are available at http://www.atmos.washington.edu/~breth/GCSS/smoke/smoke_cloud_spec.html. A series of papers describing intercomparison results and related topics, including idealized simulations of evaporatively as well as radiatively cooled boundary layers is also available at: http://www.atmos.washington.edu/~breth/GCSS/smoke/papers.html.

As a follow-on to the outcome of the earlier “idealized” GCSS boundary-layer cloud intercomparisons, a case was developed where three single-column models (all with an explicit liquid water budget and comparatively high vertical resolution) and three 2D eddy-resolving models (including one with bin-resolved microphysics) were compared with observations from the first Atlantic Stratocumulus Transition Experiment (ASTEX) Lagrangian experiment. References to a series of papers dealing with this case can be found at: http://www.atmos.washington.edu/~breth/GCSS/ASTEX_lagr/papers.html.

A second intercomparison case based on a boundary layer with stratocumulus cloud observed during the first Lagrangian experiment of ASTEX (ASTEX209) was also undertaken. A three hours long model simulation suitable for one, two and three-dimensional models was selected. At that time stratocumulus with sustained drizzle rates was observed. During that period measurements were made with the C130 belonging to the UK Meteorological Research Flight (flight A209). Data from this flight had been analyzed and described in detail in Duynkerke et al. (1995). More information on this “drizzle/no-drizzle” LES intercomparsion case can be found at http://www.fys.ruu.nl/~wwwimau/ASTEX/astexcomp.html.

Because no attempt had been undertaken previously to do a systematic intercomparison of non-precipitating (shallow) cumulus convective type boundary layer clouds, a test case with those characteristics was chosen from phase 3 of the Barbados Oceanographic and Meteorological Experiment (BOMEX) from 22 June to 30 June 1969. Since this was the first intercomparison study on shallow cumulus convection, a trade wind cumulus case with vertical profiles, which are typical for a large part of the trade wind region, was selected. The conditions were simplified by the fact that there were, no mesoscale complications and no transitions from/to or remains of stratocumulus. A number of issues were addressed by this case including, the quality of the (thermo)dynamics produced by LES models for shallow cumulus convection with emphasis on outputs relevant for the cumulus parameterizations of GCM's. The question that was, at least partially answered by study, was whether the LES output was reliable enough for this type of convection to test and improve cumulus parameterizations. More information on this case can be found at: http://www.knmi.nl/~siebesma/gcss/bomex.html.

In 1998 an intercomparison was undertaken that was based on an idealization of observations made during the Atlantic Tradewind Experiment (ATEX). This case was chosen for study because it was felt that it represented a more "typical" tradewind regime; one in which cloud fractions were nearer 50 percent. In contrast to BOMEX the cloud and mixed layers were significantly cooler, but only slightly drier. The trade inversion was much stronger and the mixed layer somewhat deeper than what was observed during BOMEX, reflective of the more upstream like nature of the boundary layer. The main objectives of the intercomparison related to whether the models could produce regions of high cloud fraction associated with Trade Cumulus and if so, what factors controlled the cloud fractions in the trade region; do the entrainment and detrainment relations found to work well for the BOMEX intercomparison generalize to a more upstream setting with a more humid cloud layer; how important is the representation of entrainment across the trade inversion in setting the bulk boundary layer structure and to what extent do the models predict similar entrainment rates. In addition this case raised two other relevant issues. Because the ATEX observations were characterized by a very large diurnal cycle in cloudiness and inversion heights, work was able to be done to determine to what extent such a processes could be represented by the models. It was also possible to assess the role of large-scale advection. There was evidence that the tradewind boundary layer as observed in ATEX might have been significantly influenced by upstream conditions. The sensitive of the models to poorly represented forcings such as large scale advection was, therefore, opened for discussion in the study. More information about this case can be found at: http://www.asp.ucar.edu/~bstevens/atex/contents.html.

The two highest priority studies now under investigation by WG1 are, a continental shallow cumulus boundary layer diurnal cycle (ARM Oklahoma site) case that was presented at the January 2000 WG1 workshop held at Boulder, CO, USA and a diurnal cycle of stratocumulus case that uses data taken off of the coast of California, USA during the FIRE 1987 experiment. The case coordinator for the continental shallow cumulus case is Dr A. Brown from the UKMO. Dr Brown’s email address is arbrown@meto.govt.uk. The case summary and specifications can be obtained by anonymous file transfer (ftp) from <email.meto.gov.uk> where it is necessary to first type the phrase “connect email.meto.gov.uk” and then the phrase “cd pub/apr/arm”. The necessary files can then be obtained. The case coordinator for the FIRE ’87, diurnal cycle of stratocumulus case, is Dr Peter Duynkerke from IMAU. Dr Duynkerke’s email address is P.G.Duynkerke@phys.uu.nl. The specifications for this case are still being developed.

WG2 (Cirrus cloud systems) Status and Plans

WG2 is working to advance development of physically based parameterizations of cirrus cloud processes for implementation in large-scale models used for climate simulation and numerical weather prediction (NWP). State-of-the-art general circulation models (GCMs) now explicitly predict the occurrence and amount of cloud ice in the atmosphere. Models such as the ECMWF model produce cloud ice (cirrus) in a qualitatively realistic fashion, both via large-scale ascent (dominant in winter hemisphere middle latitudes) and via detrainment from deep convective cloud systems (Jakob, 2000). However, there is little observational guidance in terms of the actual ice water budget of the atmosphere, especially at cold upper tropospheric levels where the radiative impact of clouds can be quite strong in the infrared spectral region. Thus, present GCM results show significant range, even for gross parameters such as the global mean ice water path (Rasch and Kristjansson, 1998). The fundamental approach of WG2 is to conduct systematic quantitative comparisons of cirrus cloud models, including CRMs and SCMs as well as the (parcel) models underlying the treatment of cloud microphysical development in CRMs. The intent is to identify key processes and parameters leading to significant inter-model differences such that the investigators and measurements can be focused on resolving those differences. The ultimate goal is to validate the CRMs versus observations and then to use these models for studies supporting parameterization development in GCMs.

The focus of the research has been on results of the first two WG2 projects. These projects are the Idealized Cirrus Model Comparison (ICMC) Project, developed and led by Dr Starr (WG2 Chair at NASA GSFC), and the Cirrus Parcel Model Comparison (CPMC) Project, developed and led by Dr Ruei-Fong Lin (USRA at NASA GSFC). Other members of WG2 contributed to the development of these test cases including Dr Phil Brown (UKMO) and Dr Paul Demott (CSU). Consideration for possible future WG2 projects are being focused on existing well-observed cirrus cases at the Southern Great Plains (SGP) ARM site in Oklahoma, as well as future cloud IOPs planned there. Plans related to the FIRE CRYSTAL (Cirrus Regional Study of Tropical Anvils and Layers) experiments and other relevant field activities are also being followed carefully for possible future WG2 test cases. Most recently it was agreed that the WG should pursue an observed cirrus case study and that the SGP ARM data sets were the most appropriate available candidates. Drs Starr and Mace agreed to lead this effort to begin in 2000-2001 time period.

The ICMC Project involves the comparison of simulations of cirrus development and dissipation in two idealized baseline environments: a "warm" cirrus case and a "cold" cirrus case. Each simulation proceeded for four hours of simulated time after which the imposed cooling was turned off. The simulations then proceeded for an additional two hours to enable assessment of the cloud dissipation phase of cloud life-cycle among the models. This is a critical issue in that cirrus clouds are commonly observed to be long-lasting.

The disagreements between the results from the 16 models submitted for the ICMC Project were shown to be substantial. The spread in ice water path (IWP) among the models, revealed that at least some of the models do in fact have previously unexposed major deficiencies in their representations of ice water precipitation. Although substantial disparities (and congruities) among simulations using state-of-the-art cirrus cloud models have been previously documented, the differences among the CSMs exceed what might have been expected based on the literature. The SCMs exhibit a similar range. GCSS WG2 has thus uncovered a major cirrus modeling issue, which can be resolved through further efforts of the working group. These results provide a better understanding of the significant progress which can be expected in this field in the near future. The models, which span a considerable range in terms of their design and heritage, will be able to be tested under much better circumstances as new information becomes available. Present observational capabilities, including recent advances in measurement of small ice crystal populations, should be able to adequately resolve the shape of the ice water content profile and the overall ice water path. The result that internal cloud dynamical intensity is highly correlated with ice crystal size distribution allows an additional confirming test that is within present measurement capability. Observations of bulk ice water fall speed are also now being derived from mm-wavelength Doppler radar. All of these factors make a case for future advances in the development of these schemes in the near term. A copy of the paper with the preliminary results from the ICMC and other information about GCSS WG2 and its projects may be found at the GCSS WG2 web page: http://eos913c.gsfc.nasa.gov/gcss_wg2/.

The purpose of the Cirrus Parcel Model Comparison (CPMC) project was to compare cirrus simulations by parcel models as well as by parcel model versions of multi-dimensional models. The CPMC project, therefore, directly addresses the primary source of dispersion found in the present results of the ICMC Project, i.e., development of ice crystal size distribution. The concept has been to look at relatively simple calculations and then to investigate more complex issues such as, effects of gross changes in the aerosol particle size distribution, effects of aerosol particle composition, and direct radiation effect on growth rate. The primary initial focus was on any and all ice nucleation mechanisms included in cirrus parcel models. A secondary focus was on the homogeneous nucleation process operating in isolation. The first phase of this project considered model response to an initial humidity of 100% with respect to ice with a specified initial distribution of sulphuric acid aerosols (200 cm^{-3}) as input to the homogeneous nucleation process.

The results for the homogeneous-and-heterogeneous nucleation (*hah*) simulations showed somewhat greater divergence. Unlike in the homogeneous nucleation-only *(hno)* comparisons, however, the qualitative behaviour of the models differed where the dependence of ice crystal number density on updraft velocity varied significantly from model to model, i.e., the curves cross significantly. The divergence was particularly great at slow to moderate updraft speeds where the homogeneous nucleation process was typically not activated. The approaches used to treat heterogeneous nucleation vary significantly from model to model. In some models, these are empirical parameterizations that operate in the absence of an explicitly specified aerosol population. The test results reinforced the need for adequate laboratory/field measurements, which the Working Group is encouraging and that will enable the consideration of heterogeneous nucleation process to proceed further.

In the 2001-2002 period, WG2 expects to complete analysis and publish results of the Idealized Cirrus Cloud Model Comparison Project and of Phase 1 of the Cirrus Parcel Model Comparison Project. In the same time period they expect to complete analysis and publish results of Phase 2 of the Cirrus Parcel Model Comparison Project. Other actions set for the same period include the development of a case study model comparison project based on one or more cases observed during IOPs at the ARM SGP site and organization of another cirrus modeling workshop. As an on-going effort, WG2 will work to develop closer linkage to WG3 activities by way of jointly planned workshops, and strive to develop closer linkage with WG4 with the aim of laying the groundwork for a unified deep convection/anvil cirrus case study.

In the longer term, WG2 will likely expand its case study development activities (in 2002) to include more cases from the ARM Spring 2000 Cloud IOP. It is possible that a case involving convective generation of cirrus over the ARM site may be considered, either in association with WG4 or from past ARM cloud IOPs (a case from May 1997 is being examined). However, in addition to extensive surface and satellite based remote sensing observations and adequate sounding data, it is critical that such cases have adequate *in-situ* aircraft measurements to be optimally useful in addressing the science issues. It is hoped that collaborations between WG2 and WG3 will develop and grow; strong involvement of the satellite community is seen as essential to this development. However, the central long-term objective of WG2 is to consider convectively generated cirrus cloud systems, especially tropical systems. This will require close cooperation, possibly a merger, with WG4 and will take advantage of opportunities for pertinent data possibly from CRYSTAL-FACE in 2002, as well as for other cases considered by WG4, though the lack of *in-situ* observations may force a focus on FIRE-CRYSTAL. It is hoped that such a joint WG2-WG4 activity can be initiated before the end of 2002. Specific test cases being developed include, the ARM-94 Cold Cirrus Case described in Sassen, K., G.G. Mace, J. Hallett, and M.R. Poellot, 1998: Corona-Producing Ice Clouds: A Case Study of a Cold Midlatitude Cirrus Layer. *Appl. Optics*, **37**, 1477-1485, the EUCREX-93 Warm Cirrus Case and Anvil Simulations test case(s).

WG3 (Layer cloud systems) Status and Plans

Layer cloud systems are a major component of the extra-tropical region and they consequently play a fundamental role in the water and energy cycles of the mid-latitudes. The main scientific issue for this working group is to ensure that critical aspects of these systems are suitably represented in climate and weather general circulation models (GCMs). A common question that links many of the scientific issues being undertaken by this group is: Is there an optimal combination of GCM resolution and sub-grid scale parameterization of mesoscale cloud structure and cloud layering in extra-tropical cloud systems? Other scientific and technical questions of importance are related to what features of these cloud systems can be adequately handled with imposed GCM resolutions and what processes are not properly parameterized, and what are the specific threshold scales for critical features.

One of the main cases under analysis by WG3 is based on data from the FASTEX Intensive Observing Period number 16. Drs Clark and Lean (UKMO) are leading this effort. The other most significant effort by the group is related to the development of large-scale survey techniques to identify model problems in generating midlatitude cloud structures being led by the incoming WG3 Chair Dr Tselioudis, at the NASA GISS.

Significant new results arising from the recent Working Group 3 activities include analysis of the results from the FASTEX intercomparison experiment, which indicated that all models (GCMs, LAMs and CRMs) agreed on basic synoptic meteorology associated with the case study cloud system. It appears that single-ice-type models in the LAMS and GCMS are getting too much ice water content (IWC) along the front compared to the radar and satellite retrievals. The CRMS with multiple ice types appear to be giving more accurate representations of the actual IWC conditions in the front. Work is currently underway to look at the statistics of the ice distribution, reflectivity at cloud top, and visible optical depth and to compare the model outputs with ISCCP data products. There is a suggestion of systematic differences between models with a single ice species and those with multiple ice species. Results were also found that indicate that mesoscale (sub-GCM scale) fluxes are of the same order as the GCM resolved-scale fluxes. This outcome is made more credible by the fact that it is consistent with the findings from other WG3 cases.

Analysis of the results from the sensitivity experiments run on the FASTEX case indicate that there is an impact of the fall speed on cyclone energetics. Significant changes in IWC in the warm frontal band seem to result from fall speed and deposition rate changes. The sensitivity to changes in the deposition rate varies between models and seems to depend on the parameterization of the Bergeron-Findeisen (B-F) process. It is unclear if the difference in the rate production of ice in the different models via the B-F process is a result of the different vertical velocities generated by the different models or the different microphysical schemes. Analysis of GCM and LAM simulations using large-scale survey techniques have shown that frontal condensation is a problem on all scales and that optical thickness is generally overestimated near the front. These results seem to be characteristic of all the models analyzed in the test case. All of the large-scale models were shown to have too little cloud away from the frontal zone. Month-long runs nested in ECMWF analyses showed similar impact to the microphysical sensitivity tests as noted for the FASTEX case study.

Working Group 3 is organizing a workshop from 24-28 June 2001 in Dublin, Ireland. The actions to be considered at the meeting include completion of the analysis of the FASTEX IOP 16 model intercomparison and drafting of a journal publication based on this case. A presentation of a preliminary survey of data from the ARM 2000 Cloud IOP will be made at the meeting with the objective of selecting a suitable case from this data set that the Working Group can use to conduct regional modeling experiments. These experiments will be pursued in conjunction with the production of statistical analysis fields from longer-term ARM and satellite observations and from climate and weather model simulations in order to examine the relations between the IOP and climatological conditions. In order to address cloud parameterization improvements at the meeting, a discussion will be undertaken of issues related to subgrid scale variability effects on cloud simulations and to GCM evaluation using large-scale observations. Results from a field experiment associated with observations of the winter monsoon effects in the Sea of Japan and data from campaigns over the Baltic Sea undertaken by the BALTEX CSE will be reviewed as possible case studies for future WG3 experiments and model studies.

Some recent publications reflecting results from WG3 analyses include Clough, S.A., H.W.Lean, N.M.Roberts and R.M.Forbes, 2000: Dynamical effects of ice sublimation in a frontal wave. Quart. J. Roy. Meteor. Soc.,126, 2405-2434; Katzfey, J.J. and B.F.Ryan, 2000: Mid-latitude clouds: GCM scale modelling implications. J. Climate, 13, 2729-2745; Lohmann, U., G. Tselioudis, C. Tyler, 2000: Why is the cloud albedo-particle size relationship different in optically thick and optically thin clouds? Geophys. Res. Lett., 27, 1099-1102; Ryan, B.F., J.J Katzfey D.J Abbs, C. Jakob, U. Lohmann, B. Rockel, L.D. Rotstayn, R.E. Stewart, K.K. Szeto G. Tselioudis and M. K. Yau, 2000: Simulations of a cold front by cloud-resolving, limited-area and large-scale models and model evaluation using in-situ and satellite observations. Mon. Wea. Rev., 128, 3218-3235; Rotstayn, L.D., B. F. Ryan and J.J. Katzfey, 2000: A scheme for calculation of the liquid fraction in mixed-phase stratiform clouds in large-scale models. Mon. Wea. Rev., 128, 1070-1088; Ryan, B.F., 2000: A bulk parameterization of the ice-particle-size distribution and optical properties of ice clouds. J. Atmos. Sci., 57, 1436-1451; and Szeto, K. K., and U. Lohmann, 1999: Cloud-resolving and single column simulations of a warm-frontal cloud system: Implications for the parameterization of layered clouds in GCMs, Geophys. Res. Lett., 26, 3113-6. The WG3 home page is at: http://www.msc-smc.ec.gc.ca/GEWEX/GCSS/GCSS_wg3.html.

WG4 (Precipitating Convective cloud systems) Status and Plans

The goal of GCSS WG4 is to improve the parameterization of precipitating convective cloud systems in GCMs and numerical weather prediction models through an improved physical understanding of cloud system processes. The Working Group under the leadership of Dr Krueger has organized model intercomparison projects to accomplish its goals and contribute to the over all objectives of GCSS in GEWEX. With the move of Dr Krueger to Chair of GCSS Dr Wojciech W. Grabowski has accepted Chairship of WG4. The Working Group has been involved in a number of recent activities and is continuing to develop plans and set priorities for actions in the future. The WG4 home page is at: http://www.met.utah.edu/skrueger/gcss/wg4.html.

Ongoing activities of WG4 during 2000 included the continuing valuable collaboration with DOE ARMs CPM (Cloud Parameterization and Modeling) and CP (Cloud Products) WGs. Several of the European WG4 modelers are funded under EUROCS (European Project On Cloud Systems In Climate Models). They will focus on the diurnal cycle of deep convective clouds based on a period during Case 3. ECMWF continues to provide valuable perspectives on parameterization issues as well as column output from its global forecast model for the ARM sites. NCEP's Environmental Modeling Center (EMC) is also involved with GCSS and ARM through its global forecast model, the column output from the global model for the ARM sites, and the SCM derived from the global model.

The Fifth WG4 meeting was held jointly with the ARM CPM WG from 6 to 8 November 2000 in Silver Spring, Maryland, USA. The meeting was hosted by NCEP's EMC. The following is a summary of the results presented at this meeting.

WG4 further analyzed the Case 3 results. WG4 concluded that Case 3 is suitable for further studies of in-situ and convectively generated cirrus clouds, convection initiation, and the diurnal cycle of the boundary layer. However, Case 3 is generally not suitable for studies of of deep convection locally forced by the diurnal cycle. Circulations generated by the sloping Great Plains and the Rocky Mountains greatly affect the diurnal cycle at the ARM Southern Great Plains site.

John Petch found that using a horizontal grid size smaller than 2 km improved the timing of convection initiation in the UKMO CRM. Marat Khairoutdinov made an extensive intercomparison of Case 3 simulations using the CSU 3D CRM in different configurations. For subcases A and B with specified radiative heating profiles, he found that 2D and 3D versions of the model produced similar results. Both 2D and 3D results showed no significant dependence on the domain size in the range of several hundred to a few thousand km except that the variances in the 2D simulations increased with domain size. An ensemble of 2D simulations exhibited little sensitivity to perturbations of the initial conditions. A set of simulations in which various microphysical parameters were varied demonstrated that the cloud fraction profile is sensitive to the parameters that control the amount of cloud ice and its conversion to snow or grapple. However, the dynamical response of the convection to the specified large-scale advective tendencies and radiative heating rates was not found to be sensitive to the details of the microphysics.

Yali Luo compared Case 3 simulated cirrus cloud properties to observed properties. The CSU-UCLA CRM results were sampled in a way that allowed direct comparison to cirrus cloud property retrievals performed by Jay Mace. This allowed evaluation, in a statistical sense, of the CRM's representation of cirrus cloud physics. The simulated cirrus cloud occurrence frequency was greater than observed. In addition, the simulated cirrus clouds were thicker than observed, and had lower cloud bases.

Various aspects of the Case 3 SCM results were evaluated by the ARM CPM WG. Shaocheng Xie compared the SCM convective mass flux profiles to CRM results. Below about 700 hPa, the CRM net cloud mass flux profiles are negative, while the corresponding SCM profiles are positive. Stephen Klein studied the SCM boundary layer structure and diurnal cycle during dry periods. This study identified several cumulus parameterizations that produced convection during these periods.

Several new observational datasets for Case 3 were produced during 2000. These included a 25-mb-layer version of the Case 3 variational analysis (produced by Minghua Zhang), a cirrus properties dataset (Jay Mace), a boundary layer depth dataset (Cederwall, Coulter, Lazarus, and Krueger), a GCAPE analysis (Cripe and Randall), more extensive satellite cloud properties (Pat Minnis), and a compilation of the climatological diurnal cycle of precipitation at the SGP (Cederwall and Krueger).

John Yio put the Case 3 model results online in netCDF format in both native and interpolated-to-analysis-level vertical coordinates. Contact Ric Cederwall (rcederwall@llnl.gov) for access to these datasets.

In 2000, WG4 agreed to accept as one of its priorities development of a test case associated with the diurnal cycle of deep convection over land. To move this action forward Dr Wojciech W. Grabowski, has asked that consideration be given to a proposal by Dr Christian Jakob from ECMWF for a case that deals with convection over the Amazon basin. A database compiled during the TRMM/LBA campaign in this region and work already being undertaken with the data by members of the Working Group make this case an extremely viable one for further investigation.

An important aspect of this case is that it provides the basis for collaboration with GCSS WG1 (boundary layer clouds), which recently considered a scattered shallow convection case that included issues related to a growing boundary layer. The agreement found between CRMs (LES models in specific) during the analysis of the results of the WG1 effort for their case was significant. This outcome emphasized that there was further work to be done in the development of SCMs relative to the performance CRMs in the handling of scattered shallow convection conditions.

Another reason for selecting the LBA case is that it is responsive to an important need expressed by the NWP/GCM community for more work related to the fact that large-scale models allow deep convection to develop much too early during the day over the Amazon basin. LBA observations provide information not only on the issue of the boundary layer developing too early during the day, but also the questions associated with precipitation and downdrafts in late afternoon hours. Earlier results have shown that SCMs yield a downdraft mass flux much smaller than predicted by CRMs for the same case. Running CRMs for the TRMM/LBA case will be important for improving convection parameterization schemes in SCMs, thereby meeting an important goal of GCSS.

Before the details of the LBA-based case can be finalized it was felt that the Working Group should benefit first from development and analysis of a deep convection case being undertaken in the context of a European Union cloud system study designated the EUROCS project (http://www.cnrm.meteo.fr/gcss/EUROCS/EUROCS.html). The WG1 of GCSS and the boundary layer working group of EUROCS have been cooperating on various test cases that are also of relevance to WG4. Participants in the EUROCS deep convection study have agreed to develop an idealized case of diurnal cycle of convection over land based on the first day of an earlier case undertaken using ARM data (specifically the ARM sub-case A). This sub-case features one event that is dominated by diurnal effects, with a weak large-scale forcing. Scientists involved in EUROCS deep convection studies have agreed to prepare details of this case by the end of 2001. The proposal is to use a smaller two dimensional domain, i.e. 250 km, with a horizontal resolution of 250 m, and to run the case for, a three day time period, with perpetual large-scale forcing and surface fluxes. WG4 contributors are being asked to run this case and present results by October 2001. Participation of SCMs in this case is important and the experience gained will benefit the design of the LBA-based case.

A manuscript is in work that describes the results of an early WG4 case (Case 2: multi-day simulation of TOGA COARE convection). Finalizing this paper is important so that it can be referenced in other papers being submitted for publication by WG4 members. Dr Grabowski has agreed to work with Dr Krueger to have a draft of the manuscript finished by October 2001.

Efforts are underway to arrange for WG4 to meet jointly with GCSS WG2 (cirrus clouds), chaired by Dr Starr. A joint meeting/workshop is being considered in conjunction with the next WG4 meeting the week of 22 October. It is felt that such a meeting would be of mutual benefit and specifically that WG4 would be interested in evaluating existing microphysical schemes in WG2 test cases.

The Working Group members are being encouraged to support two up-coming meetings a Second TRMM Latent Heating Algorithm Workshop on the topic of TRMM Heating Products: Requirements and Applications (10-12 October 2001 at NCAR, Boulder, CO, USA) and a Cumulus Parameterization Mini-Workshop (13-15 November 2001, NASA/Goddard Space Flight Center, Greenbelt, MD, USA). Please contact WG4 member Dr Wei-Kuo Tao (tao@agnes.gsfc.nasa.gov) for further information on either of these meetings.

WG5 (Polar cloud Systems) Status and Plans

A GCSS focus on polar clouds was motivated the fact that there is a poor understanding of the physical processes at work in the polar cloudy boundary layer and that current GCMs do well at simulating cloud, radiation, and boundary layer processes in the polar regions. The need to do better with these parameters is also motivated by the idea, associated with positive radiation feedbacks in the climate models, that there will be an amplification of the greenhouse warming in the Arctic. The effort is timely in light of a number of recent activities that have made a wealth of data on arctic clouds and radiation available. These include the Surface Heat Budget of the Arctic Ocean (SHEBA), a field experiment deployed in the Arctic Ocean during the period October 97 through October 98; the FIRE III Arctic Clouds Experiment deployed research aircraft during the period April through July 1998 over the SHEBA surface observations; and the ARM Program deployment of instrumentation at Barrow, Alaska for a period of up to 10 years, beginning in March 1998. These data have provided the basis for the initial case studies that WG5 is considering. Older datasets have also been under consideration and even newer data will also be actively pursued in conjunction with planned and future field programs, particularly in the Antarctic.

The main scientific issues for WG5 are reflected in the revision of the GCSS Science and Implementation Plan. The focus is on improved parameterizations associated with cloud microphysics (especially mixed phase clouds) cloud distribution, radiation fluxes, surface turbulent fluxes and stable atmospheric boundary layer. The priority test cases being developed and analyzed by the members of the working group are listed on the WG5 home page at: http://paos.colorado.edu/~curryja/wg5/home.html. Dr J. Curry, from the University of Colorado, at Boulder, CO, USA is the WG5 Chair.

WG5 projects consist of case studies that can be used to evaluate LES models, CSMs, radiative transfer models, and explicit microphysics models. In addition, some datasets of longer period (e.g. greater than 3 weeks) have been assembled specifically to evaluate single-column and NWP models. Specific model intercomparisons underway or planned include intercomparisons of Arctic regional models over the North American sector of the Arctic Ocean during the SHEBA year; of radiative transfer models for clear sky, single-layered liquid cloud and single layered ice cloud for case studies obtained during SHEBA/FIRE; and of surface turbulent flux parameterizations in the stable surface layer with data obtained during winter at SHEBA.

Some important findings include a persistent humidity inversion above boundary layer cloud tops, associated with the static stability of the Arctic environment, which contributes to the homogeneity and persistence of the cloud by inhibiting evaporative cooling associated with entrainment mixing at cloud top; large variations in the relationship between cloud temperature and phase, influenced by the presence of ice nuclei, seeding of the cloud by ice particles falling from above, and the size of the liquid drops (persistent mixed-phase clouds were observed at temperatures as low as -32 °C); measurements of the asymmetry parameter show the substantial effect that habit and size of the ice crystals have on the radiative transfer; and that the ECMWF, CSU and Arctic Regional Climate System (ARCSyM) models tend to under predict low cloud amount and the column liquid water path, resulting in simulations of surface net short-wave radiative fluxes that are too large, and downwelling longwave radiative fluxes that are too small.

Data sets supporting the on-going work, are still being evaluated. However, to simplify intercomparison cases, a few of them (e.g., LWC profiles) have recently been updated/simplified on the Internet to include only "best" estimates and ranges of error. As confidence in the data sets builds, tabular input data sets are being prepared for model studies. Action is, also underway to formulate an SCM experimental design, especially for extended simulations involving feedback with sea ice. Because interest has been shown in the SHEBA sea ice single-column data set, action has been taken to assemble a sea ice data SCM data set and link it to the WG5 web page. To meet strong interest in evaluation of GCM performance in the Polar Regions, efforts are underway to determine the results from other relevant studies such as the polar AMIP activity and to link them with the WG5 plans. Work has been done on a microphysics model intercomparison initiative that includes simulation of an idealized case plus two case studies from SHEBA/FIRE. An idealized case is advancing that consists of isobaric cooling of a parcel of air, from 0 to –50 degrees C, to allow comparison of different microphysical models (bulk and explicit) in their treatment of mixed and ice phase clouds. A mixed phase boundary layer cloud and an upper level cloud system, mostly ice could add a further dimension to such a comparison exercise.

As part of its outreach efforts, WG5 has established links to the SHEBA and FIRE Science Teams. In specific, the analysis and quality control of the SHEBA data set has provided the basis for a number of WG5 intercomparison test cases. These teams are also interested in developing feedback strategies that could be applied to meet GCSS objectives. In one case, a strategy to use equilibrium perturbation simulations to calculate the feedback gain ratio is being applied to the comparison of different parameterization formulations. The Arctic Regional Climate Model Intercomparison Project (ARCMIP) is another initiative that is being undertaken by WG5 in conjunction with other scientific teams. ARCMIP has extended beyond the original cloud/radiation focus to include a variety of parameterization issues relevant to Arctic climate. ARCMIP is now formally coordinated as a joint project between GCSS WG5 and the ACSYS/CLIC Numerical Experimentation Group (NEG). Details on the project can be found at: http://cires.colorado.edu/lynch/arcmip/. GCSS WG5 is responsible for the analysis of issues related to the atmospheric aspects of the cases (clouds, radiation, aerosol, boundary layer). The pilot experiment of the ARCMIP project will cross cut the time period and domains of SHEBA, and will also make use of data available from the FIRE Arctic Clouds Experiment (ACE), ARM and MAGS projects.

SEAFLUX is another effort, which has a connection to GCSS WG5. SEAFLUX is a GEWEX Radiation Panel (GRP) study with the goal of determining high-resolution, accurate surface turbulent fluxes (heat, water vapor, momentum) over the global ocean. SEAFLUX is currently conducting a major intercomparison of *in situ*, satellite, and NWP surface fluxes. A surface turbulent flux data set has been assembled for SHEBA, which is included in the SEAFLUX *in situ* case studies. An evaluation of over a dozen bulk surface turbulent flux models against direct turbulent flux measurements is underway. A subproject in coordination with WG5 is underway to evaluate the performance of these turbulent flux models for the SHEBA data. The first SEAFLUX Intercomparison Workshop is scheduled for 17-18 May 2001 in San Diego, CA. The results of the workshop will be posted on the SEAFLUX home page at: http://paos.colorado.edu/~curryja/ocean/.

Other actions and plans, specifically relevant to model studies that are being carried forward in 2001 include the initiation of the ARCMIP simulations (meeting in Fall 2001, in Boulder or Fairbanks); initiation of a formal radiative transfer model intercomparison (with SHEBA, possibly other groups); and the initial formulation of an ice/mixed phase microphysics model intercomparison effort (possibly coordinated with WG2). Observational initiatives include support for a continuation of ARM observations at Barrow, Alaska, USA, specifically the testing of aerosondes at the ARM Barrow site in support of an ARM SCM strategy (April, July 2001); initiation of discussions leading to possible relevant observations in the Arctic Ocean during 2004 as part of an experiment that would encompass studies of aerosols, chemistry, and ocean biology/chemistry; support the initiation of an Antarctic field study with emphasis on atmosphere/sea ice interactions; and participation and support of GCSS relevant data collection during the full-year South Pole

Atmospheric Radiation and Cloud Lidar Experiment (SPARCLE) currently underway at the South Pole Station.

A series of articles has been selected for a FIRE.ACE JGR Special Section to be published in 2001. The list of articles can be found through the "Publications" link on the WG5 home page (http://paos.colorado.edu/~curryja/wg5/home.html). Other relevant papers published recently include: Curry, J.A., P.V. Hobbs, M.D. King, D.A. Randall, P.A. Minnis, et al., 2000: FIRE Arctic Clouds Experiment. *Bull. Amer. Meteor. Soc.,* **81,** 5-29; Kosovic, B., and J.A. Curry, 2000: A large-eddy simulation study, stably stratified atmospheric boundary layer. *J. Atmos. Sci.,* **57,** 1,052-1,068; Lohmann, U., J. Feichter, C.C. Chuang, and J.E. Penner, 2000: Prediction of the number of cloud droplets in the ECHAM GCM. *J. Geophys. Res.,* **104,** 24,557-24,563; Olsson, P.Q., and J.Y. Harrington, 2000: Dynamics and energetics of the cloudy boundary layer in simulations of off-ice flow in the marginal ice zone. *J. Geophys. Res.,* **105,** 11,889-11,899; Gultepe, I., G. Isaac, D. Hudak, R. Nissen, and W. Strapp, 2000: Dynamical and microphysical characteristics of arctic clouds during BASE. *J. of Climate,* **13,** 1,225-1,254. A number of other articles listed on the home page have been submitted for publication.

APPENDIX

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