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GEWEX SCIENTIFIC STEERING GROUP

(GEWEX SSG)

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GLOBAL ENERGY AND WATER CYCLE EXPERIMENT (GEWEX)
Report of the Eleventh Session of the GEWEX Scientific Steering Group (SSG) at Tucson, Arizona, USA, 25-29 January 1999

1. SUMMARY OF PROGRESS AND MAIN DEVELOPMENTS

The organizational structure formulated for GEWEX groups the existing sub-activities and projects into three disciplines namely Land Surface Processes and Hydrology, Atmospheric Radiation Processes, and Modelling and Prediction.

The GEWEX Hydrometeorology Panel (GHP) reported on plans for the five GEWEX Continental Scale Experiments (CSE's) to participate in a Co-ordinated Enhanced observing Period (CEOP) and on additional progress toward a strategy for transferability of model results across the CSE regions. The SSG encouraged further development of an augmented CEOP initiative dealing with monsoonal teleconnections that could be undertaken jointly with CLIVAR. An expansion of the goals of the GEWEX Continental-Scale International Project (GCIP) in the 2000 time period was endorsed under the framework of a GEWEX Americas Prediction Project (GAPP). The JSC will be asked to endorse action taken by the SSG in support of the scientific and technical objectives of the augmented CEOP and GAPP initiatives. The appointment of Dr R. Stewart to a three year term as the first GHP Senior Scientist was announced and the organization of a GHP Data Management Team was noted.

The GEWEX Radiation Panel (GRP) reported on the outcome of the first meeting of the Aerosol Radiative Forcing International Science Team which moved plans forward on the GEWEX Global Aerosol Climatology Project (GACP); further progress on both the Science and Implementation Plans for the next phase of the GEWEX Global Water Vapour Project (GVaP); plans for a higher space/time resolution dataset of the Global Precipitation Climatology Project (GPCP); status of efforts to build and launch internationally supported GEWEX multi-sensor cloud/radiation/aerosol missions; plans for the continuation, beyond 2000, of the International Satellite Cloud Climatology Project (ISCCP) and the other GEWEX global climatology data projects.

The GEWEX Modelling and Prediction Panel (GMPP) reported on progress in carrying out its responsibilities in association with the Working Group on Numerical Experimentation (WGNE) and meeting its commitment to assist in the production of improved cloud and land-surface parameterizations for use in General Circulation Models (GCMs). The GMPP has also decided to develop the current Land-Surface Parameterization Integration Project, led by Dr J. Polcher, into a broader GEWEX Land-Surface Initiative based primarily on the next phase of the Global Soil Wetness Project (GSWP) which GMPP will administer jointly with the International Satellite Land-Surface Climatology Project (ISLSCP). Advanced parameterization analysis and development schemes will be investigated as part of this effort. The SSG was pleased to learn that the Project for Intercomparison of Land-Surface Parameterization Schemes (PILPS) had been funded for a further three years and endorsed the recommendation of the GMPP that a meeting of the PILPS Science Advisory Team be convened to summarize progress to date and to discuss the future. Activities within the GEWEX Cloud System Study (GCSS) were reported and included SSG support for the formation of a new Working Group on Polar Clouds and an “ad hoc" effort to evaluate and integrate GCSS test cases for use in advanced model evaluation studies.

Other actions and recommendations included issues associated with current space agency Earth observing plans such as the challenges related to identifying and promoting future missions to fill gaps in existing Earth observing plans, including a soil moisture mission; adaptation of the GEWEX research strategy that anchors progress to the meeting of specific milestones leading to the exploitation of data from the next generation of Earth observation instruments and beyond, and review of arrangements for a third International Scientific Conference on GEWEX (16-18 June 1999, Beijing, China).

The SSG accepted the offer to hold the next (twelfth session) at the International Pacific Research Center (IPRC) in Hawaii, USA, from 31 January to 4 February 2000.

2. GEWEX CHALLENGES WITHIN WCRP

The Director of WCRP placed the scientific issues under discussion at the meeting in the context of the primary goal of WCRP, which he formulated as being:

- To understand and to predict - to the extent possible - climate variability and change including human influences.

He describes WCRP as a multi-disciplinary programme that encompasses studies of the global atmosphere, oceans, cryosphere and land surface and provides the international framework for climate research, with the aim to develop an improved understanding of the Earth's climate system and to provide the scientific basis of predictions of global and regional climate variations on all time scales. Within, this framework, he describe GEWEX as an effort to observe, understand, model and predict the global hydrological cycle, its relationship to energy fluxes, its impacts on water resources, and its responses to changes in land use and atmospheric composition. The major research question for GEWEX in support of WCRP goals was articulated to be quantifying the energy and water budget at the surface and in the atmosphere including cloud radiation feedback and soil/vegetation/atmosphere coupling with high temporal and spatial resolution. The GEWEX SSG Chairman, noted that these challenges can only be met by way of co-operation and collaboration with the other elements of WCRP including CLIVAR, ACSYS and SPARC. This type of co-operation has become an integral part of GEWEX and will develop further with the current emphasis on co-ordination of observing periods, global teleconnections, monsoon studies, seasonal to interannual predictions and the need to understand and predict the variability of both the hydrological cycle and the long term climate and including global warming.

3. GEWEX GLOBAL OBSERVATION SCIENTIFIC REQUIREMENTS

The fundamental basis for the atmospheric data required by GEWEX is the NOAA series of polar orbiters and geostationary satellites, the European METEOSATs and the Japanese GMS spacecraft, which constitute the existing array of operational meteorological satellites. The maintenance of this array and the continuity of related observations and the continued international support of the ISCCP and GPCP and the potential benefits that can be expected from on-going improvements of existing instrumentation, are necessary for meeting the objectives of the GEWEX global observation phase. The operational satellites together with the current configurations of Japan's ADEOS series, the European environmental satellites (ESA's ENVISAT-1 and the ESA/EUMETSAT METOP-1, which is the first of a series), and the two NASA earth observing system satellites (EOS-AM1, EOS-PM1) will continue to be the main source of globally distributed data for climate research.

The SSG was pleased at the response of space agencies to addressing a set of scientific issues of greatest relevance to GEWEX that are not likely to be adequately addressed by the current earth observing system mission profiles. Namely:

- All flux components of a Precision Atmospheric Radiation Transfer Scheme
- Specific quantitative knowledge of Cloud Microphysical Properties and Dynamics
- Constituents of the Ageostrophic Atmospheric Circulation
- Soil moisture and other parameters that could come from a focused Land-Surface Project

This compendium incorporates the parameters expressed earlier which specifically identified global 3-dimensional distribution of clouds, radiation and aerosols; global soil moisture (upper 5-1 0cm); and global 3-dimensional distribution of tropospheric wind as being of importance to GEWEX but which up to now were notably missing from prevailing earth observation plans. In keeping with the main thrust of the third phase of GEWEX there was concurrence that these requirements are consistent with the needs of the large scale modelling community (NWP and GCM) where the availability of high quality data on all the important aspects of the atmosphere and its boundary conditions, represents the most critical aspect of the process for extending accurate predictions.

The SSG acknowledged the responses from space agencies to these main concerns in climate research relevant to GEWEX. The ESA Earth Explorer Programme has recently recommended four missions for further study, which largely encompass the fields of research identified by the SSG as critical to GEWEX. An implementation plan, for a relevant international mission in the post-2000 time is expected from the next phase of the ESA evaluation process. At the same time, NASDA is planning to stimulate new space science and technology initiatives through a series of announcements for special developmental missions, designated Mission Demonstration Satellites (MDS). It was also noted that the second Announcement of

Opportunity for the NASA Earth System Science Pathfinder (ESSP) Programme has resulted in the selection for development of three small spacecraft missions designed to explore the Earth's dynamic systems early in the new millennium. The primary mission is PICASSO-CENA (Pathfinder Instruments for Cloud and Aerosol Spaceborne Observations - Climatologie Etendue des Nuages et des Aerosols), co-led by NASA's Langley Research Center, Hampton, VA, and the Institut Pierre Simon Laplace, Paris, France. PICASSO-CENA will employ light-detection and ranging (LIDAR) instrumentation to profile the vertical distribution of clouds and aerosols, while another instrument will simultaneously image the infrared emission of the atmosphere. In addition to PICASSO-CENA, NASA has chosen two other ESSP missions, CloudSat and VOLCAM (the Volcanic Ash Mission), as alternate missions. CloudSat and VOLCAM will go through an extended development and technology assessment prior to the decision of which mission will be the primary and alternate. CloudSat is of particular importance to GEWEX especially in concert with PICASSO-CENA, since its mission would focus on understanding the role of thick clouds in the Earth's radiation budget.

The initial success of the Tropical Rainfall Measuring Mission (TRMM) was also identified as an example of the type of international effort which must be supported. TRMM will provide unprecedented coverage of the horizontal and vertical structure of tropical rain systems and plans are already in place to exploit these data, which are expected to be a valuable resource for parameterization and assimilation studies in the future. Continuity of these measurements is important.

These examples of domestic and international partnerships being applied toward answering major climate-related scientific questions, when grouped together with the other Earth Observing Platforms, will establish the scientific basis for understanding the dynamics and energetics of Earth's atmosphere in support of WCRP/GEWEX related goals especially associated with short-term weather and long-term climate forecasts. The JSC will, therefore, be asked to commend efforts by Space agencies to meet the main cloud/radiation/aerosol scientific foci related to future GEWEX contributions to WCRP and to note that efforts need to be sustained to achieve further success especially by way of the planning and implementation of a soil moisture mission.

4. MANAGEMENT OF GEWEX GLOBAL PRODUCTS AND PLANS FOR EXPLOITATION OF NEW DATA

GEWEX has taken responsibility for consolidating WCRP global climatological data projects based on merging satellite data with current atmospheric and (land/ocean) surface measurements. This role includes interacting with space agencies to track the status of global environmental observing systems, providing scientific overview of the retrieval procedures and data quality, organizing data archiving and distribution on appropriate media and assisting, through conferences, workshops, symposia, and data management meetings, with the international co-ordination of these projects.

Continuation of the control and management of these projects includes their extension beyond the year 2000. The need for the continuation of these data sets (e.g. ISCCP, GPCP, SRB, etc.) within the context of the next phase of GEWEX, which will begin with the launch of the new earth observing platforms, addresses important issues within the WCRP. These data sets provide a foundation for developing improved and more complete analyses of the energy and water cycles. This progress in understanding the climate feedback processes controlling the energy and water exchanges in the climate is thus attainable only by building up an integrated analysis capability by way of adding to the existing capability to determine radiative exchanges. This strategy recognizes that the radiative and water analyses must be performed together.

The new capabilities and experiments which will be added in the next decade can also provide enhanced interpretations of the longer data record now being produced, but are, themselves, better interpreted in the context of a global, long-term record. In particular, ISCCP provides higher time resolution global measurements than will be produced, at first, by the new measurement systems, so the ISCCP data are needed to organize new experimental observations into composites over the life cycle of dynamic systems. A more complete diagnosis of the global energy and water cycles is, therefore, dependent on the continuation of the GEWEX global observation projects. Another role of the GEWEX data projects is to extend the data record to increase opportunities to characterize the global and regional variations of the clouds, radiation, precipitation and water vapour on larger time scales.

The SSG agreed that the success of WCRP research programs requires a long series of comprehensive observations with an integrated analysis of the datasets. It was recommended, therefore, that since current plans for the satellite and surface observing systems do not dictate a change of analysis schemes in the near future, ISCCP and the other GEWEX data projects should continue for at least another

five years. Further review of the possible termination of these projects should come only when the present datasets can be replaced by new more comprehensive measurements that also provide equally good space-time resolution and global coverage. During this period, experimental satellite and field campaign datasets should also be exploited by combining them with the global products to produce integrated diagnostic analyses that expand the interpretation of the longer data records and that support design of improved measurement/analysis systems. The main purpose for these global datasets, augmented by experimental and more limited information, should be to produce a series of evermore refined analyses of the global exchanges of energy and water that resolve their regional and weather-scale changes and quantify their longer-term variability.

The SSG adopted the following specific plan for global diagnoses at mesoscale resolution by combining satellite and conventional observations:

1999-2001:
- (1) radiation budget including top-of-atmosphere and surface fluxes and in-atmosphere heating rate profiles
- (2) ocean surface latent and sensible heat fluxes
- (3) mean ocean heat and freshwater transports

2000-2003:
- (1) weather-scale precipitation
- (2) land surface latent and sensible heat fluxes
- (3) mean land-ocean heat and water exchanges

2002-2005:
- (1) improved radiative and latent heating rate profiles
- (2) ocean heat storage
- (3) snowfall

2003-2007:
- (1) improved precipitation and evaporation
- (2) transient ocean heat transports
- (3) land water storage

2005-2009:
- (1) seasonal ocean-land heat and water exchanges
- (2) transient atmosphere-land water exchanges

The JPS for WCRP has the action to ensure that letters are drafted to the major space agencies to secure support of the current GEWEX global climate information projects including ISCCP GPCP, SRB and GACP well into the next decade. It will only be at that time (post-2000) that resources will come available that will make it possible to add value to the new earth observation system retrieval processes by organizing intercomparisons, applying merged data techniques and participating in unified algorithm development ventures. This exploitation requires not only that the participating GEWEX International data centres collect, analyze and disseminate their data products, but also that they calibrate, quality check, adapt processing software to changing operational systems, and validate their products. Therefore, the request to agencies for a renewal of their commitments to these projects will include the need for minimum funding levels to be established which are sufficient to support all of these tasks. The JSC will be asked to join the SSG in recommending the continuation, of the current datasets, at this level of support.

5. REVIEW OF GEWEX MAJOR FUNCTIONS AND PRIORITIES

GEWEX has been organized into three branches. The GEWEX Hydrometeorology Panel (GHP-see Item 6.) is undertaking the integration of large-scale experiments to demonstrate skill for predicting processes including precipitation, and changes in water resources and soil moisture over continental regions, as elements of seasonal-to-interannual climate predictability. These tasks are linked to efforts by the GEWEX Radiation Panel (GRP-see Item 7.) to determine the radiation budget and fluxes in the atmosphere and at the surface, as an element of seasonal-to-interannual climate variability, and the response of the climate system on decadal-to-centennial time scales to changes in anthropogenic forcing. The GEWEX Modelling and Prediction Panel (GMPP-see Item 8.) will develop accurate model formulations of the water budget and transport and the energy budget and radiation transfer in the climate system and,

thereby, provide the basis for demonstrating the extended predictions highlighted in the goals of the radiation and hydrometeorology initiatives.

The benefits of progress related to these goals will include: extension of skilful weather forecasts; better planning and management of air and surface transportation; earlier and better flood and drought warning; adaptation of agriculture to improved weather forecasts and climate prediction; better management of water resources; and better climate assessments in support of policy decision.

Although the main points in the implementation of GEWEX to achieve the required scientific progress have remained the same, the research in the individual elements has been focused on specific scientific issues that have been developed to unify their efforts in meeting the higher level global scale objectives. With the current emphasis on "inter-panel" cooperation to meet these objectives the SSG recommended that the three panels (GHP, GRP and GMPP) develop further specific co-operative/co-ordinated activities whose progress can be tracked and jointly reported at subsequent SSG meetings. A specific recommendation which needs to be fully acted upon, relates to GHP and GRP organizing the collection/processing of high resolution satellite datasets/products for each of the GRP global climatology data projects, over each of the GEWEX Continental-Scale Experiments (CSEs) and for the GEWEX Cloud System Study (GCSS) and other modelling and analysis elements of GMPP and GHP to exploit these high resolution datasets for their case studies, supplemented by their own field measurements. Other specific actions should be developed and discussed at the next SSG meeting.

Certain specific statements/actions/recommendations/conclusions which have come out of the 1998 meetings of the GEWEX Panels are available from the WCRP document index at URL, <http://www.wmo.ch/web/wcrp/docs/indexdocs.html>.

6. HYDROMETEOROLOGY

The GEWEX Hydrometeorology Panel (GHP) has been chartered to oversee development of the multi-disciplinary scientific Continental-Scale Experiments (CSEs) which are adding to WCRP’s efforts to develop an understanding of the physical climate system and processes. There are currently five such projects based in large river basin/drainage areas; the GEWEX Continental-Scale International Project (GCIP) in the Mississippi River Basin, the Baltic Sea Experiment (BALTEX), the Mackenzie River Basin GEWEX study in Canada (MAGS), the Large-Scale Biosphere-Atmosphere Experiment in Amazonia (LBA) and an experiment in a large area influenced by the Asian monsoon, identified as the GEWEX Asian Monsoon Experiment (GAME). The Science and Implementation Plans for a sixth experiment to study the Coupling of the Tropical Atmosphere and Hydrological Cycle (CATCH) in West Africa will be advanced in two workshops in 1999. The GHP is promoting further progress toward the accomplishment of a collective GEWEX research initiative related to prediction of regional precipitation and runoff and is integrating the data collection and model development initiatives within each CSE to meet the global objectives of GEWEX. As part of its outreach effort GHP has established a Home Page at URL: <http://www.tor.ec.gc.ca/GEWEX/GHP/ghp.html>.

Research Focus for GHP

The premise for work being undertaken by GHP is that the prediction of regional precipitation and runoff anomalies over periods of several months is a possibility with improved understanding of water cycle processes. The focused research task for GHP incorporates this hypothesis and gives GHP the responsibility for assisting GEWEX to demonstrate skill in predicting variability in water resources and soil moisture on time scales up to seasonal and annual as an element of WCRP's prediction goals for the climate system. To meet this challenge, the coupling between the atmospheric science/meteorological community and the hydrological science community has been fostered, as well as giving more attention to boundary layer physics over vegetated areas. Further advances in the understanding and modelling of water resources and the distribution of sensible and latent heat in the atmosphere, an important aspect of seasonal and longer-range climate predictions, has also been encouraged.

The strategy for attaining this goal is to, by the year 2000, quantify evaporation, precipitation and other hydrological processes as required to improve prediction of regional precipitation over periods of one to several months. Then, by the year 2005, to predict variability in water resources and soil moisture on time scales of seasonal to annual as an element of WCRP's prediction goals for the climate system. To meet these goals the CSEs will develop conceptual models that describe the critical processes and their feedbacks that operate over the continental-scale regions during typical and anomalous periods on time scales of up to a few months. As an interim step, by the year 2003, it will be necessary to have validated

these models so that the continental-scale water and energy cycles can be accounted for on periods of one to several months when the large scale forcing is specified.

GEWEX Continental Scale Experiment Plans

Utilizing a unified action plan adopted earlier, GHP with the International Satellite Land-Surface Climatology Project (ISLSCP) and the CSE's, is moving into its next phase involving research into prediction and predictability with a continuing focus on land-atmosphere interactions. The under lying theme for this work is the understanding that the GHP is responsible for examining the role of continental-scale hydrometeorology issues within the climate system and ensuring that these issues are well represented in climate simulations for improved prediction. Progress is being built on the successes that each CSE has had in developing data bases, and carrying out process and modeling studies. Important milestones in 1999 include: adoption of a strategy for model transferability and global applications studies; progress in the definition of the requirements for a Coordinated Enhanced Observing Period (CEOP); progress in developing global land surface data bases for modeling studies; emerging plans for CATCH in West Africa; establishment of a Senior Scientist position; establishment of a data management working group to address data exchange and access issues; and progress in publicizing the efforts of individual CSEs through special journal issues and articles. A joint status evaluation acknowledged that although each CSE was at a different stage of development there was a greater chance of conformity to the criteria established for their continued independent development within GEWEX. The matrix in Figure-1 reflects the range of compliance but also emphasizes that the Panel has already made significant contributions toward realizing its objectives in most areas and efforts in other critical areas are proceeding well. In recognition of critically timed field activities within LBA and to enable a return to the normal GHP Chair rotation cycle in 2000, the point of contact for GCIP will act as GHP Chair for one additional year and taking on responsibility for chairing the 1999 meeting. The BALTEX Secretariat has agreed to act as host for this meeting which will take place from 13 to 17 September, 1999, at GKSS in Geesthacht, Germany.

The CSE representatives have agreed that a database should be developed of datasets with common elements, over a common time period and with common formats that GHP could provide for global model and remote sensing comparison exercises. This conclusion was partially motivated by the realization that the next generation of earth observing system satellites will make a major contribution to global climate research only if improved algorithms and validation schemes are in place and that the GHP is uniquely positioned to ensure these goals are met. In this context each CSE has agreed to:

(i) Produce/provide year-long datasets that include the effects of local/regional heterogeneity.

(ii) Develop regional coupled models with prediction capabilities of one month or longer.

(iii) Develop datasets to facilitate model development and use these datasets to validate Land-surface models and hydrological models.

(iv) Address the needs of water resource managers in relation to developing more physically based hydrological models; testing of these models in uncoupled and coupled modes and assessing the degree of complexity needed for input data when running these models in prediction mode.

A data management working group has been formed to assist with these actions and related issues associated with international data exchange. The group will be Chaired by Dr S. Williams for an initial 3 year period and will be made up of representatives from each of the CSEs, from ISLSCP, GRDC and GPCC. Tasks include developing a memorandum of understanding on GHP data policy and exchange, planning for composite datasets and for CEOP data collection, developing and maintaining a GHP Data Home Page and advising on other GHP data management activities.

Modelling and Data Management Strategies in GHP

To improve the understanding and application of GHP data and results, special review articles have been published by the BALTEX and MAGS Secretariats and others are in preparation. Special GHP/CSE journal issues are also in preparation by the GCIP and MAGS GEWEX Offices. Drs Raschke and Stewart have taken the action to organize a GHP summer school in Europe in 2000. Agreements of participation which cover specific co-operative initiatives have been signed by GHP with the GRDC the GPCC and ACSYS and a proposal for a joint initiative with CLIVAR in the context of CEOP is being further developed.

GHP CONTRIBUTIONS TO GEWEX

This Matrix reflects the status of the CSEs as of September 1998 and the descriptors P, F and I are used only to illuminate the status of the on-going work without any other assessment.

P = In Planning = Activity is underway with definite movement toward implementation

I = Implemented = Plans or projects are in the implementation phase, but may take several years to be fully functioning (e.g., due to funding restrictions or other complications)

F = Functioning = An activity has been implemented and is fully functioning. Schedules are set and delivery of products is assured.

Where there is a transistion such as the designation I-F on line-1, it can be concluded that implemented models are producing experimental results and later when this activity is deemed fully functioning the models would be in an operational mode.

CRITERIA FOR GEWEX CSEs	GCIP	MAGS	LBA	GAME	BALTEX	CATCH
1.) NWP centre atmospheric and surface data assimilation procedure, estimates of hydro-meteorological properties in a form directly comparable to observables.	F	I-F	I-F	F	F	P
2.) Suitable atmospheric-hydrological models, atmospheric-hydrological data management and assimilation system, and numerical experimentation and climate change studies.	F	F	I-F	F	F	P
3.) Mechanism for collecting and managing adequate basic hydrometeorological data sets, including satellite obs, to support and validate the above model developments.	F	I-F	P-I	I-F	F	P
4.) Participate in the international exchange of scientific information and data in conformity with WCRP general practices.	F	I-F	P-I	I-F	F	P
5.) Interactions with water resource agencies or related client/user groups to better utilize improved continental-scale information to address the problem of assessment of impacts on regional water resources.	I-F	I-F	P-I	I-F	I-F	P

Figure-1: Status of CSE Compliance with Criteria Established by GEWEX-SSG for GEWEX Continental Scale Energy and Water Budget Studies

Further Development of CEOP as a Joint GEWEX/CLIVAR Initiative

CEOP provides an opportunity for a unique joint activity within WCRP that will lead to major progress in understanding and prediction of the climate system. The SSG has formulated the implementation of CEOP as a GEWEX initiate that can be undertaken in association with CLIVAR and ACSYS that will characterize the climate system over the 2001-2002 period with a particular focus on the source and sink regions driving and modifying circulations that affect the climate system and many of its anomalies.

This effort rests firmly on scientific necessity. Currently, GAME is examining land surface heating/cooling processes over the Eurasian continent. Particular attention is being paid to the atmospheric heating processes over the Tibetan Plateau that play a key role in the seasonal/interannual variability of the monsoon circulation. However, to fully understand the Asian/Australian (A/A) monsoon system with its link to the ENSO, the atmosphere/ocean interactive processes must also be examined, in particular over the Indian Ocean, South China Sea and the Western Pacific. The South China Sea Experiment (SCSMEX) implemented in 1998 has revealed the dynamics with energy and hydrological processes of the early onset of the A/A summer monsoon. The Joint Air-Sea Monsoon Interaction Experiment (JASMIN) has been associated with the CLIVAR program, as a means for better understanding the role of the equatorial Indian Ocean in the intraseasonal, seasonal and interannual variability of the A/A summer monsoon. To fully understand the energy and water cycle interaction processes and the feedback processes in the variability of the A/A monsoon as a land/atmosphere/ocean system, a working relationship between GAME (particularly with GAME-Tibet) and JASMINE is required.

The other major heat source regions of the Earth's climate system are located in equatorial South America and Africa. These areas are directly connected with a A/A monsoon through the tropical east-west circulation and its variability associated with the ENSO. The LBA and CATCH (as a potential future CSE now being planned over the west African monsoon region) are focusing on these issues. These monsoonal circulations in the Americas are furthermore being investigated by work under way in GCIP and the CLIVAR, Variability of the American Monsoon Study (VAMOS).

In addition, the A/A monsoon system with its coupling to the ENSO over the equatorial Pacific, has a great impact on the mid/high latitude climate in the seasonal to interannual time-scales, which in turn affect the continental-scale hydrological processes within the same time-scales. These processes are now being studied under the other continental experiments within GEWEX (GCIP, MAGS, GAME-Siberia and BALTEX). These efforts are also addressing the role of land-area cold region processes (for example, snowcover, soil moisture, permafrost, vegetation, and their interactions with the atmosphere) on seasonal time scale water and energy cycles but these factors also trigger and modify climatic anomalies of regional, continental and even hemispheric scales, through planetary waves. These anomalies produced in higher latitudes, in turn, affect the A/A monsoon and other tropical systems in the seasonal cycle through, for example, the production of cold air masses that can move towards the equatorial region where they can trigger anomalous convective activity and atmosphere/ocean interactions in the Tropics. In addition, the variability of fresh water supply from these high latitude areas to world oceans, particularly to the Arctic Ocean, is one of the key issues for the important feedback to the climate system, which is a specific focus of ACSYS.

The SSG acknowledged that work already underway by GAME, in the context of CEOP, should be expanded, in association with JASMIN, to focus on monsoonal circulations in the Asian/Australian region. There was further endorsement of the plan for CEOP to develop as a broad "Inter-WCRP" activity which also encompasses the American monsoons (GCIP, LBA and VAMOS) along with the African monsoons (CATCH). Other regions will be studied to address land-area generated climatic anomalies with a particular focus on Arctic and mid-latitude regions (GAME, GCIP, MAGS and BALTEX). A critical aspect of the effort is that it will also consider the degree to which these monsoonal and/or climatic anomaly generation source and sink regions are linked on seasonal through annual and inter-annual scales.

Special observations will be made in these various regions to carry out the needed process, satellite and model validation, and diagnostic studies. These observations will range in spatial scale from a few kilometers over selected regions, through a few hundred kilometers and up to continental scale and with time scales from weeks to up to years.

The factors driving the timing of this initiative include the start of the next phase of GEWEX which is associated with the imminent launch of the new generation remote sensing satellites and a shift in emphasis toward predictability as well as with the overlap of the current GEWEX datasets which can extend the data record back in time as much as 20 years. The advanced state of the coupled modelling systems at major NWP centres is also a technical factor in moving forward with CEOP at this time. The timely development of

the CLIVAR field experiments addressing monsoonal circulations that link to oceanic processes is also a factor. An opportunity exists, therefore, to capitalize on a unique convergence of scientific readiness and technical capability that will lead to major progress in climate science.

Synthesis of Climate Regimes

An important step for GHP in meeting the objectives associated with development of a global applications strategy and CEOP is to communicate the uniqueness of the individual CSE climate regimes and their relevance to understanding land-atmosphere interactions on a global scale. GHP has undertaken a collaborative effort to depict the climate regime (water and energy budget) represented by each CSE and to unify these assessments in a form that would allow it to be published for future reference. During the one year time period from September 1998 to September 1999 each CSE will develop full documentation on water and energy budgets for its region. In September 1999 a workshop will be held in conjunction with the next GHP meeting, at the BALTEX Secretariat, in Germany to review the budget descriptions for each CSE. During the following year, leading up to the 2000 GHP meeting, an overall synthesis of all regions will be accomplished and a final report published that addresses the role of land processes, large scale circulation patterns, diurnal and seasonal cycles, ice phase processes, moisture recycling, comparative studies and other issues.

Review of ISLSCP Role in GHP

As a full member of GHP, ISLSCP was represented at the meeting by Dr P. Try. ISLSCP goals relate to the use of satellite remote sensing and other techniques to advance the understanding of the physical and biological processes controlling interactions between vegetated land and the atmosphere. The SSG was informed about progress in ISLSCP experiments, models and data sets that are associated with research issues of importance to GHP. The SSG specifically endorsed the ISLSCP Initiative II Data Sets Project and commended the action taken by the GEWEX Modelling and Prediction Panel (GMPP) in formalizing its support of this effort in a letter sent by the Director of WCRP to NASA noting the importance of the timely completion of this Project.

The GEWEX Global Soil Wetness Climatology Project (GSWP) has continued to advance with support from ISLSCP. The SSG endorsed the plan for GSWP to become a joint ISLSCP/GMPP activity during its next phase, as it forms an important element of a GEWEX Land-Surface Parameterization Development and Integration Project to be organized under the auspices of GMPP. A new initiative on evaporation over land and other land surface fluxes from satellite data is under development as part of ISLSCP's contribution to GEWEX. The SSG was informed that progress on these and other related items had been discussed in detail at the meeting of the ISLSCP Science Panel which was held conjointly with the BAHC Scientific Steering Committee meeting, from 27 April to 1 May 1998, in Paris, France. This session was held in conjunction with a joint ISLSCP-BAHC thematic international workshop on "Land Surface Data in Climate and Weather Models". The joint sessions included common aspects of the development of global data sets, FLUXNET, GSWP and a scientific discussion about outcomes of the thematic workshop. The outcome of an earlier ISLSCP workshop to review development of land surface process and soil-vegetation-atmosphere transfer (LSP-SVAT) models and their applications in hydrology was reviewed at the joint meeting. The implications of these workshops have had an impact on the planning for the Land-Surface Parameterization Project in GMPP see Item 8.

GHP Senior Scientist

The need for a GHP Senior Scientist position was noted by the SSG following its 1998 session. The position was created as a scientific advisor/coordinator to provide guidance to the GHP Chair and to the GHP and SSG on the longer term science projects being undertaken by GHP on behalf of WCRP/GEWEX. Dr R. Stewart was appointed to the position in September 1998 for an initial 3 year period. The SSG agreed to normalize Dr Stewart's term with the start of the Calendar year enabling it to run up to January 2002.

GHP Action Summary

As noted above, more details on the GHP fourth session at Boulder in September 1998 are available from the WCRP document index at URL <http://www.wmo.ch/web/wcrp/docs/indexdocs.html>.

GEWEX Continental-Scale International Project (GCIP) and Follow-on

GCIP has produced numerous results that have clarified the nature of land-atmosphere interactions. In particular, GCIP has shown:

- During the summer months the presence and vigour of vegetation has a significant influence on evapotranspiration rates and the quantity and distribution of convective precipitation,
- During the summer soil moisture has an influence on the prediction of summer precipitation,
- Winter snow cover and its melt pattern affects the spring hydrology and may have a feedback effect on precipitation patterns in the following spring.
- The sub-grid variability of precipitation can be successfully represented by downscaling techniques.
- The scale and pattern of land surface heteorogeneity have a significant effect on local moisture recycling.

Within GCIP, a number of strategies for the implementation of large scale field experiments have been developed. As a consequence of its place as the most mature of the GEWEX continental scale experiments, GCIP is viewed a central element of GEWEX. From a program management perspective, GCIP has had great success in drawing together significant components of the hydrologic and atmospheric communities in order to study land surface hydrology and its atmospheric interactions. Through the involvement of an operational numerical prediction center in its data assimilation activities GCIP has made optimal use of the extensive data sets gathered routinely throughout the USA. This initiative has also facilitated the transfer of new modeling techniques developed in academia to operations. GCIP has also started to bring together the observational and prediction communities through the development of data sets for climate research.

Dr R. Lawford noted that the GEWEX Continental-scale International Project (GCIP) will come to a conclusion in the 2000 to 2002 time frame. Although many of the shorter-term objectives of GCIP have been realized, its mission of "developing a capability to predict variations in water resources on time scales up to seasonal and interannual" remains a challenge that will only be addressed through new understanding and technologies. Dr Lawford, presented an outline of follow-on analyses in the Americas that could develop within the framework of GCIP beyond the year 2000. This scenario identified as the GEWEX Americas Prediction Project (GAPP) recommends that this follow-on effort remain part of GEWEX and specifically remain a flagship element of GEWES and GHP as the America's regional contribution to the global goals and objectives of WCRP/GEWEX. GAPP extends the GCIP approach to other climate regions and also shifts the program focus from analysis to prediction in order to better position the science community to achieve this mission. To bridge the gap between our current understanding and capabilities, and the requirements for a prediction capability that fully incorporates the controls of land surfaces on the climate system, appropriate components of the atmospheric and hydrologic research communities plan to develop the science and implementation plans for GAPP. With adequate levels of agency financial and infrastructure support it is planned that GAPP will become:

a) a bridge between the climate community and the water resources community,
b) a link in understanding how the fast climate processes (considered under GEWEX) and slow climate processes (considered under CLIVAR) are integrated, and
c) a bridge between the computer and satellite technologies of the new millennium, and the needs of resource managers to achieve sustainable development and optimal management of their resources in continually varying climate conditions.

Overarching these science opportunities is an emerging global water crisis that gives added urgency to addressing these issues.

The SSG endorsed the recommendation that this next phase of GCIP be aggressively pursued by drawing on the infrastructure built up in GCIP and that this follow-on effort remain part of GEWEX and GHP and continue to add analyses which will assist GEWEX with meeting its goals related to understanding and predicting the impacts of climate variabilities on water resources up to seasonal to interannual time scales. The Action is for Dr Lawford to draft a letter for the consideration by the Director of WCRP for the purpose of noting WCRP/GEWEX support for a continuation, beyond the year 2000, of research in the Americas linked to that already undertaken by GCIP. Dr Lawford agreed to be the point of contact to ensure that the letter will go to the appropriate USA funding Agencies.

The Baltic Sea Experiment (BALTEX)

BALTEX was defined in the years 1992-1994 with important scientific objectives related to the determination of widely distributed energy and water budgets and their relationship to circulation anomalies in the atmosphere and oceans. This required development of coupled models which integrate processes in the atmosphere, at continental surfaces and in the Baltic Sea. Within the context of GHP, strategies are also being developed to transfer BALTEX research and analysis methodologies to other climatic regimes. The BALTEX has included major operational hydrometeorological services with modeling and data collection facilities. A major experimental phase, designated BRIDGE, that had been planned for the 1998-2000 time period has now been shifted forward by nearly two years.

The built-up phase from 1993 to the current time included the installation of data centers, the development of regional models, the collections of various test data sets and first process oriented studies with field campaigns. Also the capabilities of an existing radar network and of the GPS soundings were explored. Advances have especially been made been made in the validation of regional models for the atmosphere and for land-surface processes. Distributed run-off models are in development for the rivers Odra, Daugava, Neva and Torneälv. Radar are used to determine precipitation over the Baltic sea. Several workshops have been held on the application of radar data and on the results of field campaigns at various sites in temperate and cold climate regions and over the Baltic Sea. First attempts at interactively coupling the models for the atmosphere and for the Baltic sea were successful and demonstrated the interaction between sea surface temperatures and wind fields. A network of GPS stations is delivering data on the atmospheric moisture fields over the region. Working groups have been formed to synthesize results on modelling, process studies and radar data application.

Planning for BRIDGE began in 1996 and an initial implementation plan was published in 1998. A memorandum of understanding for participation in BALTEX/BRIDGE has now been signed by 40 groups from 12 European nations. The agreement covers co-operative activities in modelling, field work, data assimilation and analyses of remotely sensed data. BRIDGE is currently planned to begin in October 1999 following a three month pilot phase. BRIDGE has been planned to span two annual cycles and three winter seasons, culminating in February 2002. Five intensive observational and modelling periods are planned during BRIDGE, each focused on different process oriented investigations. Field experiments are foreseen at moderate and subarctic climate sites and over the Baltic Sea itself. Financial support is being sought from various national sources and from the European Union.

BALTEX has supported the installation of two Doppler radar stations in Estonia and Latvia and two additional stations in support of BALTEX requirements are planned for installation in Poland. These stations will complement the existing BALTRAD network which will also includes the German national network. BALTEX results are being applied by several participating hydrometeorological services which serve a large number of national and international clients. An International Scientific BALTEX Conference, held in May 1998, drew 180 visitors from 20 nations and included 120 papers and posters. A special issue of the journal "Contr. to Atmospheric Physics" covering this conference will be published in 1999. BALTEX will work to strengthen its climate studies component in the future.

GEWEX Asian Monsoon Experiment (GAME)

Figure-2 shows the phasing of the GAME Intensive Observing Period (IOP) which was conducted in 1998 in co-ordination with the South China Sea Monsoon Experiment (SCSMEX).

The GAME-Tropics regional experiment was designed to quantitatively monitor the seasonal, intra-seasonal and inter-annual variation in the vapour flux, precipitation, evapotranspiration, and radiative flux in south-east Asia. The IOP provided the opportunity for the accomplishment of a series of organized field observations centred primarily in Thailand. Data from rawinsondes, weather radars, surface flux sites, GPS installations, soil moisture probes, surface routing indicators, remote sensing receivers, and manual mapping operations were collected during two phases covering the monsoon onset (mid-April to mid-June 1998) and monsoon mature stage (mid-August to mid-September 1998). Results are currently being analyzed. The GAME Tropics web page can be found at URL <http://hydro.iss.u-tokyo.ac.jp/Game/game-T:html>.

The GAME/HUBEX regional experiment was carried out from 1 May to 31 August 1998 with an IOP from 11 June to 22 July 1998. The Meiyu frontal system moved from north to south passing over the HUBEX, Huaihe River Basin near the end of June and into early July creating heavy rainfall (>110 mm) over the region. After shifting northward the Meiyu cloud system moved back over the Huaihe River Basin in

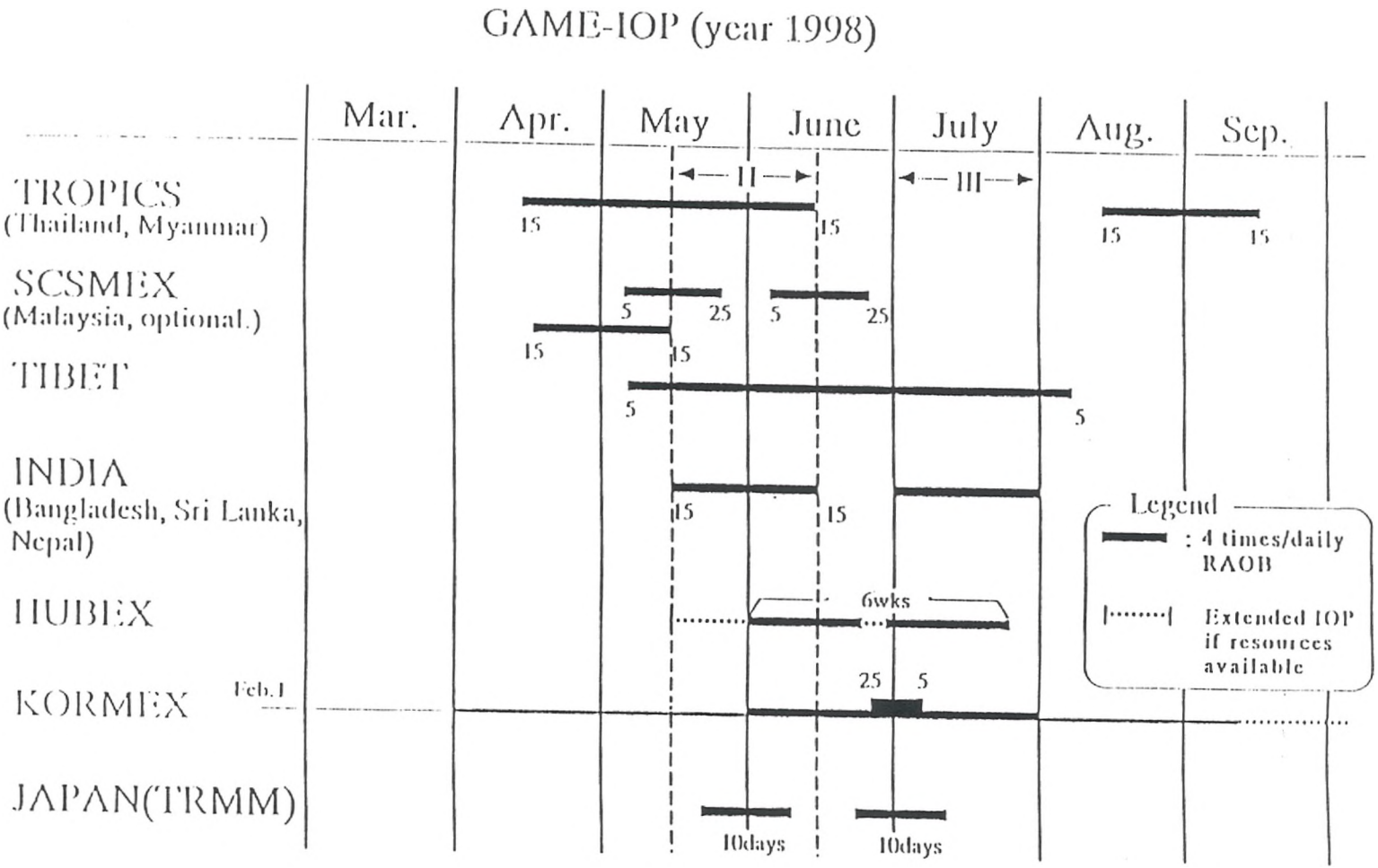

Figure 2. The time-schedules of the enhanced observation for each region (project) and country.

mid-July allowing the field observation period to capture the week long rain phase and the corresponding 10 day drought phase of the Meiyu system. The main observational results were the collection of an intensive meteorological/hydrological dataset that is being used to study the characteristics of the climate and hydrological regimes during both rain and drought periods in the region. Intensive time-spatial precipitation and hydrological observations were also made and the meso-scale and at smaller scales using doppler radars and digital weather radars to obtain the three dimensional structure of cloud/precipitation systems including stratiform, organized convective and squall line types. These data show that thunderstorms in the region were generally organized into meso-scale rainbands with lengths varying from 40-120 km with lifetimes of about two hours with a few lasting up to four hours. A comparison of TRMM precipitation radar data and reflectivity data of a Doppler radar at Huainan including synchronous RHI scans on the plane of TRMM's cross track scan was made. The echo patterns of the RHI and a TRMM vertical cross section correlated closely. The HUBEX experiment was coordinated with the Korean Monsoon Experiment (KORMEX) IOP which took place from 25 June to 4 July 1998. Co-operative analyses are underway. More information for GAME-HUBEX can be found at URL <http://www.hubex.pku.edu.cn/>.

The GAME-Tibet IOP was carried out from 5 May up to 5 August 1998 with five groups of researchers rotating responsibility for the scientific measurements made at various sites in the region. The investigations related to land/atmosphere coupling were supported by boundary layer measurements taken from Automated Weather Stations (AWSs) at 14 locations with a separate PBL tower and turbulent flux measurements at other sites. Intensive radio-sonde observations were taken on selected days and timed to gain knowledge about the diurnal variations in the PBL during the June, July and early August. Other aspects of the IOP data set included ground based precipitation measurements using the mesoscale rain/snow measurement network, microwave and GPS measurements of water vapour, soil moisture and temperature measurements, and river discharge and evaporation measurements. Satellite remote sensing data over the region was also obtained (with simultaneous ground truth measurements). An isotop sampling study was also carried out to assist in determining precipitation origin and recycling. Results from this portion of the IOP are still being developed for later distribution and discussion. The GAME-Tibet home page is at URL <http://monsoon.nagaokaut.ac.jp/tibet/>.

GAME-Siberia began its first field study activities in 1997 with the establishment of local observation sites in tundra and taiga regions and the start of measurements with those instruments. A better understanding of the water and energy exchange at the local scale has begun to develop from these observations. Other results related to different evaporation rates during wet and dry periods and different snow conditions during various winter conditions are leading toward conclusions about the role of these regions in larger scale climate variations. An Intensive Observation Period is planned, in 2000 for the taiga region with the primary goal of evaluating the variation of surface fluxes over a 100km grid using the surface network and specially outfitted aircraft. Other objectives of the 2000 IOP relate to improving the understanding of the annual water/heat exchange and circulation between the southern mountain taiga and the tundra regions and applying improved atmospheric, hydrological and land surface modelling techniques to the experimental and observational data gathered during the intensified field study period. An important issue that has further general implications for advancing understanding of the impact of this important area on larger scale climate variations is the continued degradation of the existing operational hydro-meteorological observational network in the region. The SSG asked the GHP and GAME representatives at the meeting to evaluate the extent of this problem and to include a status of the situation in future reports with suggestions for possible actions, which might be taken, if any, to encourage the improvement of the network, particularly in the GAME-Siberia region.

Two other elements of GAME which were functioning during the IOP in 1998 were the GAME Automatic AWS Network (AAN) and the GAME Archive and Information Network (GAIN). Data from the AAN is being used to investigate differences in surface variables between the GAME study areas. Seasonal and interannual variations are being studied and the data are being combined with analyses of satellite data to broaden the scope of this research and respond to requirements from a wider climate research perspective. An AAN data centre has been established and plans exist to enable the real-time transfer of data by way of a link with the GMS satellite network. The AAN is expected to be operational up to 2004. More information on AAN can be found at URL <http://www.suiri.tsukuba.ac.jp/Project/aan.html>. A GAME data management policy has been adopted under the auspices of the GAIN function. The policy, which was developed in 1998 has provided for the distribution of some aspects of the IOP data set to the GAME community including all of the countries participating in that special research effort. The routine global analysis produced by the operational elements of JMA for the period of the IOP with the 2-D physical monitoring data are available by way of URL <http://gain-hub.mri-jma.go.jp/4DDA.html>. Contacts for other GAME data sets are available from URL <http://gain-hub.mri.jma.go.jp/gain data.html>.

Mackenzie River GEWEX Study (MAGS)

The SSG was informed that the MAGS objectives had been reaffirmed to be to understand the climate-scale water and energy fluxes and reservoirs of the basin and to develop appropriate models for estimating climate and water resources and that the major focus has been placed on the unique aspects of the cold regions of the study area. A fourth in an annual series of MAGS workshops was held in 1998 and include an intense review by the MAGS Science Advisory Panel. The outcome of this review process was a confirmation of the availability of the two remaining years of funding for University involvement in MAGS, initiation of planning to extend this funding and to reaffirm ongoing funding for government support of the Study. These exercises have extended to plans for the second phase of MAGS, which would cover the period 2000 to 2005 and would prioritize requirements related to fulfilment of milestones committed to by MAGS as a contribution to the global objectives of GHP and especially to the successful implementation of CEOP.

All components of the overall MAGS strategy are progressing. Special measurements of many critical variables are being made and the MAGS enhanced water year study (CAGES), is underway and continuing to resolve issues associated with its observational datasets. Progress is being made at understanding critical surface, hydrological and atmospheric issues affecting the basin's climate system. Basin-scale atmospheric/surface/hydrological models are being run and capabilities and deficiencies are being identified and recommendations for addressing these are being considered. Collective studies over full water years are underway to address the full, interacting climate system. Data management systems are in place and functioning. Activities have now commenced to produce dedicated issues of scientific journals and to map out further activities and priorities.

Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA)

An important LBA field implementation took place as part of the TRMM-LBA validation campaign from December 1998 up to March 1999. This effort took place over southwestern Amazonia (Rondonia state) and was coupled with the LBA Atmospheric Mesoscale Campaign. The instrumentation in these studies included the high altitude NASA ER-2 research aircraft which flew a large number of successful missions with many of the airborne versions of TRMM satellite sensors, including a rain radar type instrument. A series of convective episodes were studied. A second Citation class aircraft was flown for cloud and precipitation microphysics studies. Instrumentation at the ground sites included two Doppler radars, an enhanced mesoscale network of radiosounding stations, a series of flux towers in different vegetation covers, a number of sites with boundary layer profiling capability, a vertical pointing meteorological radar, a network of calibrated raingauges, and other types of instruments. An international group of over 200 researchers and support staff participated in this intensive field campaign. All data sets will be available on the LBA Data and Information System within one year of collection. Preliminary analyses show that several episodes of very strong convection were seen with tops as high as 18 km and vertical updrafts and downdrafts in excess of 25 m/s. These were characteristics normally felt to occur mostly for midlatitude convective severe storms, rather than in deep tropical conditions. These events where also found to have been accompanied by very large droplet sizes. High rain rates for clouds with tops up to 7-8 km were also found with CCN background containing very low concentrations, similar in some respects to oceanic clouds. Currently, there is an atmospheric chemistry campaign underway in Rondonia. Several continuous measurement surface flux towers (CO_2, HO_2, heat, momentum) are being installed: 4 in Rondonia (two over forest, two over pasture), 2 in Manaus (forest), 1 in far eastern Amazonia (forest), 3 in eastern Amazonia (two over forest, one over pasture), 2 in Brasilia (cerrado (savanna) vegetation). The TOGA radar which had been installed as part of the TRMM-LBA validation effort is likely to remain in Rondonia through the end of 1999 gathering data in support of further research initiatives. An atmospheric chemistry campaign is planned for the dry season (July-October) of 1999. There will be complementary meteorological measurements and several scientific meetings are being planned to carry out joint data analyses and preliminary discussions of scientific findings.

Another important element of the LBA research plans has also recently been focused on a research programme for the Land Surface Hydrology component in Rondonia, Para State, Brazil. A draft document has been distributed to provide the starting point for the next steps in the implementation of this LBA scientific thrust. This plan has provided the framework for the formulation of other detailed measurement programmes for meso- and micro-scale catchment studies, in which all of the collaborating research groups can specify their objectives and requirements relating to forest and pasture hydrological work to arrive at a well balanced and efficient working plan. The main research questions within LBA which this plan responds too had been articulated in the concise experimental plan of the LBA Science Planning Group (1996), to be: (i) How does Amazonia currently function as a regional entity? and (ii) How will changes in land use and

climate affect the biological, chemical and physical functions of Amazonia, including the sustainability of development in the region and the influence of Amazonia on the global climate? With respect to these broad questions, the LBA land surface hydrology and aquatic chemistry group, in collaboration with research groups from related disciplines (e.g. physical climate, ecology, geobiochemistry, carbon exchange and storage), aims to address a series of issues, which are more specifically directed towards understanding hydrological processes and water quality issues in the Amazon basin and their sensitivity to changes in land use and climate at all space and time scales.

The SSG was interested in the progress of this component of LBA and especially in the part of plan which called for the field measurements and micro- and meso-scale model development and testing to be integrated to facilitate the transportability of the results of the meso-scale modelling to other meso-scale basins in the Amazon. The subsequent coupling of a meso-scale model with a macro-scale model could then be expected to result in a large-scale model treating the Amazon basin as a whole. In this context the meso-scale modelling was acknowledged to be crucial to bridging the gap in scales between micro-scale hydrological modelling and the macro-scale data requirements for climate and land use impact modelling. Groups from Europe and North America will team with the South American research groups to foster the micro- and meso-scale data collection and model development, and the testing and running of a large-scale model, respectively.

More information on LBA can be at URL <http://yabae.cptec.inpe.br/lba/>. The next meeting of the LBA Science Steering Committee (SSC) meeting is scheduled for 24-26 May 1999 at Belem.

Coupling of the Tropical Atmosphere and Hydrological Cycle (CATCH)

Progress is continuing to be made on CATCH in the framework of the criteria established for the other GEWEX CSEs and these actions are carrying CATCH forward as a fully complementary continental-scale experimental (CSE) element of GHP. It was noted that CATCH provides equally important scientific benefits from the perspective of meteorology, biology and hydrology. Of greatest importance at this time is the final review and acceptance of the CATCH Science and Implementation Plan at the regional level. The Plan, currently available only in French is expected to complete review and be translated into English in the near future. Dr A. Afouda, with support from Dr J. Noilhan is expected to distribute the Plan for review at a series of workshops, which are expected to culminate at in 1999. The Plan would then be translated into English and further distributed for review to the broader scientific community especially in Europe. Drs Afouda and Noilhan have accepted action to ensure an interim progress report is available on this process at the September 1999 GHP meeting and that a complete report of the progress on CATCH is presented at the January/February 2000 meeting of the GEWEX-SSG. This discussion and presentation will be undertaken as part of the GHP section at that meeting. The recommendation was that CATCH be added to the GHP CSE Matrix of Contributions to GEWEX. Dr Afouda, is expected to co-ordinate with the GHP Chair to provide a presentation on the current status of the implementation of CATCH during the GHP Section at the 2000 GEWEX-SSG Session.

7. RADIATION

The GEWEX Radiation Panel (GRP) has responsibility for promoting research on climate-related radiation issues for GEWEX. The GRP has agreed to assist GEWEX in addressing a specific scientific theme related to determining radiative fluxes and heating within the atmosphere and at the surface with the precision needed to predict transient climate variations and to move towards understanding natural and anthropogenically forced climate trends.

Cloud Feedback and Forcing

The GRP Chair noted that climate forcing and climate feedback are the two broad science issues of importance in fulfilling the main GRP research goals (see above). The need to reduce the uncertainties associated with these phenomena is critical to making significant progress toward improved climate predictions. The technical issues in understanding these principals and acting on them are forming the framework for the Panel's work. The major scientific/technical themes explored included the role of aerosols in directly affecting the radiative fluxes in the atmosphere and at the surface and the indirect influence of aerosols on the radiative transfer through their effects on cloud physics. Understanding both the "fast components" related to radiative heating by clouds and its effects on general circulation and the "slow components" of the effects of clouds on the surface radiation budget were stated to be key elements in responding to the questions associated with cloud feedback.

During a working group session at the meeting the SSG asked the Chair of GRP to lead a discussion that would address the question of cloud feedback in the context of the GEWEX framework for applying existing and new datasets in the effort to determine the extent clouds affect the radiative heating of the atmosphere and how this radiative heating influences the general circulation of the atmosphere and, in turn, cloudiness. Specific milestones and related measures of success in determining radiative fluxes and heating within the atmosphere and at the surface with the precision needed to predict transient climate variations were discussed. The GRP chair is working to formulate these ideas into an integrated scientific framework that expresses the effort to understand and quantify the impact of cloud feedback on the climate system as a main scientific theme for GRP and GEWEX. This framework will include the process by which GRP expects to link the current radiation data projects with the exploitation of data expected from the new era of instruments planned for launch during Phase II of GEWEX, as part of the Japanese, USA and European Earth Observations Initiatives beginning next year.

GRP Support of GHP/CEOP

GRP will assist the GEWEX Hydrometeorology Panel (GHP) with the planning and implementation of a GEWEX Coordinated Enhanced Observing Period (CEOP). The primary rationale for CEOP is to take a major step forward in improving our understanding of the regional hydrological cycles and coupled land-atmosphere processes as they relate to the global energy and water cycles. This would be done through a structured and coordinated activity which would focus on the use of the new era of Earth observing satellite systems (e.g., EOS-AM/PM, ADEOS-II, ENVISAT, TRMM, etc.,) and the work being carried out under the auspices of the GEWEX regional continental-scale experiments (CSEs) now underway (e.g., GCIP, BALTEX, GAME, MAGS, LBA, etc.,).

GRP is well suited to provide leadership in support of GHP by assisting with the development of techniques for effectively exploiting the new, well calibrated, satellite data sets in collaboration with the CSEs. For example, GRP can contribute to the process of identifying critical satellite data sets required for support of GEWEX studies, especially those which relate to the CSE regional data collection and study efforts. Assistance is also needed in the planning for the retrieval of important data products and the further exploitation of the data in model studies and related analyses. The SSG supported action by GRP to form an "ad hoc" study group to address these proposed tasks and coordinate with the GHP and CSEs. The GRP Chair assisted by the JPS for WCRP and the Director of the International GEWEX Project Office (IGPO) will establish terms of reference for this group and contact the proposed members which will include those with links to GRP and having expertise in the application of satellite data to cloud/radiation research issues.

Ocean Surface Turbulent Fluxes Workshop

GRP will promote an international Workshop to Develop an Improved Diagnosis of Turbulent Water and Heat Fluxes from the Global Ocean Surface. Evaporation of water from the ocean surface is an essential part of the coupling between the atmosphere and ocean that forms the central energy and hydrological cycles of the climate.

Diagnosis of surface radiative fluxes from satellite observations has progressed to the point where the limiting uncertainty in determining the total surface energy fluxes from the global ocean is the latent and sensible heat fluxes. Recent research suggests enough skill in deducing the surface latent and sensible heat fluxes from satellite observations to warrant a more intensive and extensive investigation, possibly leading to an improved diagnosis of these ocean surface fluxes. Together with improved surface radiation and precipitation budgets, the results could provide a (slightly) more accurate, but vastly more detailed, characterization of the energy-water exchanges between the atmosphere and ocean which would greatly enhance studies of atmosphere-ocean coupling.

Two international workshops are to be planned and promoted as part of the GRP thrust in this field of radiative science. The workshops will be designed to encourage development of analysis methods of surface sensible and latent fluxes by comparing results from applying these methods to a series of case studies where detailed (high time resolution) surface observations provide validation. Dr J. Curry, with support from the IGPO staff and the JPS for WCRP, has the action to convene an organizing committee for an initial workshop (late 1999) that would assess the current state-of-the-art of flux algorithms and input data, develop concepts for advancing work in this field and organize the case study comparisons including identification of data needed for input and validation of various analysis methods. A second workshop would follow in late 2000 to examine and discuss the implications of the comparison results. These workshops would lead to recommendations on how to proceed with the production of improved estimates of the turbulent latent and sensible heat fluxes at the ocean surface at the mesoscale resolution. Other results

would include at least one paper in the peer reviewed literature presenting the background and support for these improved techniques and distribution of all of the case study datasets (inputs/outputs) on media (i.e. CD-ROM) suitable for use by other investigators as a starting point for testing of future methods or other observational analyses. The SSG endorsed these plans but reaffirmed its position that GRP continue to undertake this initiative in co-ordination with the WCRP Working Group on Air Sea Fluxes which is working on a detailed study of available surface flux and flux-related data sets.

The GEWEX WATER VAPOUR PROJECT (GVaP)

GVaP was reviewed and the work which has advanced the development of an initial global water vapour dataset was endorsed. Comments were provided on a draft science and implementation plan which was distributed earlier and suggestions were made for its further refinement.

Professor Tom Vender Haar, who has agreed to take the lead in broadening the international base of support for GVaP in order to move it beyond its original pilot effort, accepted the action to take the suggestions and modify the plan to direct it toward more actual implementation steps. An outline of the steps necessary to reach the next level of maturity for this data set was presented to the SSG. The material which had been formulated following reviews by the NRC, GEWEX Panel, is under going further national review. The overarching objective is to quantify and understand the role of water vapour in the meteorological, hydrological, and climatological processes by improving knowledge of its variability, radiative effects, feedbacks, and change due to human activities. The last in a series of GVaP workshops will be held in 1999 to synthesize all of the scientific and technical issues necessary to finalize the plans for the next version of the dataset and to prepare it for systematic processing and distribution within an international framework. The JSC will be informed of the status of this effort and a review of actions will be carried forward to the 1999 GRP meeting.

Baseline Surface Radiation Network (BSRN)

The GRP review in its review of the Baseline Surface Radiation Network (BSRN) addressed the issue of how to encourage BSRN stations systematically to submit measurements to the BSRN data archive [the World Radiation Monitoring Centre (WRMC) at the Swiss Federal Institute of Technology (ETH)] in a timely manner and in the desired format. Action has been given to the BSRN Manager, with support from the JPS for WCRP at Geneva, to review why BSRN stations which are operational are not making their contributions to the BSRN data archive in a systematic way. A letter may be prepared for the Director of WCRP to send to these stations noting the importance of their contribution to the BSRN data archive, as well as the requirement to provide correlative non-radiative data (e.g. co-located radiosonde soundings and surface observations) where available. The JSC may want to comment on this action, which will hopefully lead to significant improvements in the release of data to the archive. Status of the data archive is available on the World Wide Web at <http://bsrn.ethz.ch/wrmc/status.html/> or by way of the BSRN Internet home page <http://bsrn.ethz.ch/> which can also be reached from the GEWEX home page.

Radiation Code Intercomparisons in Models

The SSG accepted the GRP's decision to support additional model-observation comparisons to be carried out within the Intercomparison of Radiation Codes used in Climate Models (ICRCCM) framework in both clear-and-cloudy conditions. The plan calls for priority to be given to extending the clear-sky comparisons to water vapour conditions more typical of tropical and Arctic conditions. Related activities at GFDL and other centres were also endorsed. The goals of an ICRCCM-III effort are being drafted for further discussion and review in 1999.

Surface Radiation Budget

The SSG was informed that the Satellite Data Analysis Center (SDAC) at NASA Langley has made significant progress in all areas on the SRB Project in 1998. Preparations are underway to begin processing and archiving a 10+ year surface and top-of-atmosphere (TOA) radiative budget climatology (designated Release 2). Funding levels have been augmented sufficiently to ensure further progress will be accomplished at least up to the end of 2000. A major part of the current strategy is to obtain the assistance of the Langley, Atmosphere Sciences Data Center (ASDC) to provide processing and archival support to the Project. SDAC has also expanded collaboration with ISCCP, the University of Maryland and ECMWF. These initiatives have led to participation in comparative analyses of meteorological parameters with re-analysis values and to development of improved gap filling strategies, validation of surface SW fluxes and implementation of a new background aerosol.

Future plans call for the delivery of all current SRB processing codes to ASDC for implementation and testing including the GEWEX LW and GEWEX SW QC algorithms, which still require testing at the 1 degree resolution. Quantitative analysis of the gridded ISCCP DX radiance and cloud fields and comparisons to D1 and C1 cloud fields will also be accomplished. The processing of eight test months is to be accomplished with gridded DX, and Data Assimilation Office (DAO) Goddard Earth Observing System (GEOS) version 1 values and old background aerosol optical properties. A comparison of SW and LW fluxes with surface observations for at least four of these months will also be performed and the errors characterized including possible sources. Comparisons will also be made between the test month values and Re-analysis and DAO GEOS-1 results as well as with values from the 1992 NASA Water Vapor Project dataset. Conclusions from these and other comparisons with the test month results will allow decisions to be made about the possible application of data sources such as the ECMWF Re-analysis products in the SRB Project Release 2 data set. Other similar tests will be accomplished before the start of Release 2 processing. GRP will continue to monitor the status of these plans and report progress toward the development of the SRB datasets.

International Satellite Cloud Climatology Project (ISCCP)

ISCCP completed its 15th year of data collection on 30 June 1998. The ISCCP World Wide Web home Page can be accessed at URL: <http://isccp.giss.nasa.gov>. Work is on-going to verify that the new ISCCP products are actually an improvement over the first version. Recent comparison studies show that the most significant biases have all been reduced for:

(1) cloud cover over land, particularly in winter, and in the polar regions,
(2) cloud optical thicknesses at higher latitudes, also eliminating spurious angular dependencies,
(3) cirrus cloud top locations, and
(4) calibration errors.

An important issue was raised with respect to inter-panel co-operative initiatives when it was noted, by Dr J. Polcher, that the ECMWF/GEWEX workshop on modelling and data assimilation for land-surface processes, held at ECMWF in June 1998 produced a set of recommendations for the evolution of land-surface schemes. The importance of a skin temperature climatology for the validation of land-surface schemes was recognized but it was also acknowledged that there are still unsolved problems which require investigation. It was recommended that the impact on the observed variable of sub-grid scale surface variability or shading within the grid-box be studied. To encourage research in this direction and the development of methods for comparing observed skin temperature and the modeled counterpart a request was made for support from ISCCP in the production of such a data set. This request will be evaluated and further action addressed between the GMPP/Land-surface-AGCM Coupling Project and GRP/ISCCP.

ISCCP Central Archive (ICA) continued to receive B1 data from data processing centers in the Europe, Japan, Canada, and the USA in a routine manner. The spacecraft operating in the project and their status included GOES-8, GOES-10, GMS-5, METEOSAT-5, METEOSAT-7, and NOAA-14 all of which remained good, while NOAA-12 data ceased in mid-December 1998 (collection of NOAA-15 data will commence as soon thereafter as possible).

DATA DELIVERED

Stage B3:	July 83 - April 95	(11.8 years)
Stage CD:	July 83 - December 97	(14.5 years)
Stage C1:	July 83 - June 91	(8.0 years)
Stage C2:	July 83 - June 91	(8.0 years)
Stage D1:	July 83 - December 83, July 84 - December 84, January 86 - August 94	(9.7 years)
Stage D2:	July 83 - December 83, July 84 - December 84, January 86 - August 94	(9.7 years)

Although D1/D2 data for 116 months have been archived, the current delivery backlog for new DX/D1/D2 data is 45 months (with respect to planned schedule). Efforts are underway to reduce this backlog.

GEWEX Aerosol Studies

The action plan for developing a GEWEX Global Aerosol Climatology Project (GACP) that utilizes remotely sensed dataset(s) augmented with surface observations and ground validation sites was accepted by the GEWEX-SSG at its 1997 session. GACP was then established in 1998 as part of the Global Energy and Water Cycle Experiment (GEWEX). Its main objective is to analyze satellite radiance measurements and field observations to infer the global distribution of aerosols, their properties, and their seasonal and interannual variations. The resulting datasets and analysis products will be used to improve understanding and modeling of the climate forcing due to changing aerosols, including both the direct radiative forcing by the aerosols and the indirect radiative forcing caused by effects of changing aerosols on cloud properties.

In Phase I of GACP, a 20-year global climatology will be compiled of aerosol forcing data from satellite observations and field observations for use in climate models. To accomplish this, the Earth Science Enterprise (formerly called Mission to Planet Earth) of NASA Headquarters has established a processing center at the NASA Goddard Institute for Space Studies (GISS) and issued a research announcement (NRA-97-MTPE-16). Principal investigators of the successful proposals have been formed into the GACP Aerosol Radiative Forcing Science Team. The team was expanded to include international participants. This team met at GISS in November 1998. The objective of this first meeting was to provide an opportunity for all members of the team to learn about relevant individual research investigations and to develop a plan for integrating them into a collaborative effort to accomplish the GACP science objective. This interaction was deemed necessary before work could begin related to proposing candidate algorithms to be applied to the full period of satellite measurements in order to estimate parameters of significance to the aerosol climatology. The processing center will utilize the algorithms recommended by the science team to produce the satellite element of the aerosol data set. The aerosol data set and eventually the aerosol radiative forcing data set will be based on multiple satellite data streams, the combination of satellite and aerosol tracer model results where appropriate, surface-based aerosol measurement networks and other data available from the research community. The main topics discussed at the meeting included development and use of satellite retrieval algorithms; use of transport modeling in integrated climatologies; surface, "in situ", and field experiments and validation and constraints; and issues related to the indirect aerosol effect. These outcome of these discussion points is being documented to serve as the focus for improving the production of the GACP products.

Global Precipitation Climatology Project (GPCP)

All elements of the project involved in the data processing and merging scheme agreed to modify their current procedures to enable more frequent transfer and delivery of data consistent with moving from the current quarterly update schedule of the suite of GPCP Version 1 rainfall estimation products to a monthly or less update and release cycle. Results of analyses support the decision to replace the pentad, 2.5° x 2.5° histogram populations and GPCP Precipitation Index (GPI) estimates with 1° x 1°, 3-hourly IR data as the primary IR archive. As a result of the need to move toward a higher spatial and temporal scale GPCP primary product, an implementation strategy has been devised for a pilot processing effort to have a daily 1° x 1° global precipitation climatology for 1 or 2 years (1997-1998) by April 1999. The Global Precipitation Climatology Center (GPCC) announced plans for further advancing the quality of its extended data base of monthly gauge precipitation reports by way of improved visual and automated techniques. The process is proceeding in a stepwise manner leading toward a full visual quality-controlled product. A review of the tasks being carried out by the Surface Reference Data Center (SRDC), now with the Environmental Verification and Analysis Center (EVAC) at the University of Oklahoma, resulted in agreement that SRDC will utilize state-of-the-art technology to produce accurate gridded rainfall estimates, with accompanying error estimates and that by the end of 1998 SRDC will begin to produce regular quarterly verification (statistics/maps/time series) reports for GPCP products. In addition, SRDC accepted the responsibility to begin collecting reference data and to take the lead in recommending a framework for the organization of an anticipated rainfall estimation algorithm intercomparison exercise which could focus on 1° x 1° daily rainfall estimates. A GPCP CD-ROM was produced and distributed in 1998. The SSG endorsed the plan for GPCP to hold its 1999 business meeting in conjunction with a GPCP data users workshop which will emphasize error assessments and analyses.

New research topics and national initiatives that are complimentary to GPCP activities were presented to the SSG including: development of a "split-window" algorithm which utilizes data from both of the IR channels on the GMS-5 satellite; retrieval of new types of precipitation products from the SSM/I,

namely, rain type (convective/stratiform/warm/solid), rain frequency, and rain area; production of an experimental 1° x 1° daily, observation-only combined precipitation data product for August 1997 using SSM/I, GPI, and (optionally) TOVS data; and the investigation of monthly mean precipitation estimates using neural network analysis procedures on ISCCP monthly mean data.

In this context the SSG noted that NOAA Geostationary Satellites had been recently redesigned in such a way as to eliminate the capability to provide data from two IR channels that could be used in split window analyses. These types of analyses with data taken from the Japanese GMS satellites have proven valuable in precipitation studies. The split window data have also been proven useful in ISCCP cloud studies. As a result, the SSG assigned action to the Director of WCRP to send a letter to the Director of NOAA urging reconsideration of this modification in future spacecraft. Dr A. Gruber agreed to assist with the drafting of this letter in 1999. The JSC will be asked to support this action.

Field Project Plans and Data Management

The SSG noted with interest a presentation by Drs Dave Starr and Tom Ackerman, which focused on plans for a convective cloud field project designated "CRYSTAL". The SSG was informed that this project plans to study anvil cloud formations and the dynamics associated with their generation and development. During the discussion it was agreed that CRYSTAL could benefit from the addition of a small oceanographic component and that this suggestion would be carried forward to the CRYSTAL Science Team for their consideration. Since oversight for these studies and their related data and products rests with the GEWEX Radiation Panel (GRP) the SSG will expect further reports on the progress of this activity to come during the GRP report at the next SSG meeting.

The point was made, that CRYSTAL and all similar projects should include an effort that specifies how its goals and objectives are linked to data and products available from other field projects, such as TOGA-COARE and to the on-going work related to the available "routine" datasets such as ISCCP. Since CRYSTAL will take place under conditions that may have been experienced during TOGA-COARE a specific effort should be made to show that CRYSTAL developed its plans within the context of the work undertaken during TOGA-COARE, which may relate directly to its objectives. Also, since CRYSTAL is a cloud dynamics study, there should be a direct effort to equate its goals to filling a gap(s) which can be shown to exist in the current data record. The goal should be to show a consistent line of research and analysis between each effort of this type and to also show linkage to the longer term studies that remain on-going. The ISCCP dataset and case studies under consideration in the GEWEX Cloud System Study should be investigated and linked to CRYSTAL'S objectives.

In the ensuing discussion, recognition was given to regional experiments and the role their datasets play in stimulating advances in instrumentation, improving modelling techniques and stimulating new results in the broader climate research domain. On-going activities in Europe, Asia, the USA and other countries were endorsed. The SSG, however, reaffirmed its position that all members continue to take action to ensure that the planning of regional experiments include a strategy for ensuring that the different observational data measurements associated with each experiment are made compatible with and are "placed" on the World Meteorological Organization's, Global Telecommunications System (GTS) for access in (near) real-time by the major modelling and analysis centres. Datasets should also be organized into databases that can be distributed on appropriate media (i.e. CD-ROM) or otherwise be made easily accessible to the modelling centres from readily contacted archival facilities.

Atmospheric Radiation Measurement (ARM) Program

The status of the ARM project is important to GEWEX for its value in support of calibration and validation of GEWEX data and modelling initiatives. ARM has an operational site in north central Oklahoma which has been operating since 1994. The central facility at this site is fully operational and includes a Raman LIDAR and mm radar sensors. The boundary facilities are being upgraded with interferometers and micropulse LIDARS. Extended facilities which include surface flux and meteorological measurements are also operational. Intensive observing periods (lOPs) run several times per year at this site and include enhanced soundings, additional instrumentation and, in some cases, aircraft. Other operational ARM sites are located in the tropical Western Pacific at Manus Island (operational since October 1996) and Nauru (operational since November, 1998) and on the North slope of Alaska at Barrow (operational since July 1997). The SSG was interested to know that two ARM site lOPs will occur this year that may contribute to GEWEX research in both the Arctic and the Tropics. The Barrow site will have an IOP in March 1999 which focuses on water vapour. The data collected will be associated specifically with the study of water vapour transmission in cold, low water column environment. The Nauru 99 IOP is scheduled for June 1999

and is being designed to focus on the extent of the effect of the island itself on cloud and radiation dynamics including the variability of fluxes at the site. The Nauru IOP will incorporate a number of instruments to study the surface radiation balance, more detailed spectral information, surface meteorology, cloud properties, aerosol optical depth column water and vertical structure of the atmosphere.

ARM is also playing a significant role in the GVaP data calibration/validation implementation plans. This effort now being designated as Gval will involve continuous monitoring of the local water vapour field by high-resolution instruments, cross-validation of instruments, routine calibration and calibration checks and a network of surface sites with varying capabilities. A set of validation datasets and instrument intercomparison datasets that are available and planned are being addressed and detailed plans are being advanced for establishment the GVaP validation network. The operational ARM, Cloud and Radiation Testbed (CART) sites, noted above, have been selected to become the initial validation sites and to act as the baseline elements for the network. Other instrumented sites in Germany and Japan were also identified as part of this validation effort. The SSG commended this international effort especially the work of Dr J. Bösenberg, from the Max-Planck-Institut fur Meteorologie, in Germany who is assisting with the development of this calibration plan and the USA Department of Energy (DOE) for agreeing to have the ARM testsite framework become the prototype for the other elements of the GVaP calibration/validation component and to incorporate within the ARM structure responsibility for coordination of the activities leading toward implementation of an appropriate GVaP calibration/validation process.

Recently initiated collaborative research efforts between GCSS and the ARM Single Column Modeling (SCM) Working Group were also discussed. GCSS Working Group 4, which focuses on deep precipitating convective systems, has agreed to undertake a case study based on the June-July 1997 ARM SCM IOP, conducted at the north central Oklahoma (SGP) CART site. In addition, GCSS Working Group 1, which focuses on boundary-layer clouds, is actively considering a case study based on the same ARM SCM IOP. These collaborations are mutually beneficial to ARM and GEWEX. GEWEX benefits from the high quality and great breadth of the ARM datasets, as well as the opportunity to interact with ARM scientists, who are particularly active in the Single-Column Modelling arena. ARM will benefit through the participation of the international community of GCSS scientists, who are particularly strong in the area of Cloud System Modelling (CSM). GCSS is also working with ARM to ensure that the ARM sites, especially in the Tropical Western Pacific and the north slope of Alaska, are as conducive as possible to the routine collection of the data necessary for the GCSS SCM/CRM type of research. For example, the need for large-scale vertical motion and horizontal advective tendencies to be measured in lOPs at regular intervals, has been sited as particularly important to have from these sites much in the way they are provided for at the SGP CART site. It was noted that a positive working relationship continues to provide for an open dialog on ways of addressing such issues.

The JSC will be asked to join the SSG in highlighting the increase in collaborations between GEWEX and ARM, since the last reporting period, as particularly important to the advancement of research in a number of critical fields.

8. GEWEX MODELLING AND PREDICTION

The CAS/JSC Working Group on Numerical Experimentation (WGNE) and the GEWEX Modelling and Prediction Panel (GMPP), met jointly in November 1998. The responsibilities of the GMPP, including the development of improved cloud and land-surface parameterization schemes in models, intersect with WGNE activities, and the JSC therefore recommended that the GMPP should be closely associated and linked with WGNE.

The role of WGNE in WCRP encompasses the improvement of the scientific integrity of AGCMs, the development of data assimilation methods, carrying out reanalyses and evaluation of atmospheric observing systems. With respect to these responsibilities, the Groups reviewed items of mutual interest including WGNE/GMPP initiatives on cloud/radiation and land surface studies, but also activities in the area of regional simulations, data assimilation (assimilation of new data streams), and utilization of AMIP as a basic data source to assess the representation of the hydrological and energy cycles in current models.

The GEWEX Modelling and Prediction Panel discussion encompassed the issues of cloud/radiation parameterization specifically related to the GEWEX Cloud System Study (GCSS), studies of land-surface processes, improved Land-Surface parameterizations and their integration into large-scale models and soil moisture.

The discussions under this item, were moderated by Dr D. Randall, who had Chaired the GEWEX Modelling and Prediction Panel's Second Meeting.

GCSS and Cloud/Radiation Parameterization Main Objective and Current Framework

The objective of GCSS remains the development of refined parameterizations of cloud systems within GCMs (climate and numerical weather prediction models) through the improvement of the understanding of the coupled physical processes within different types of cloud systems. The GEWEX Scientific Steering Group (SSG) has continued to endorse GCSS 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. The Group is focused on improving these models by applying specialized computing techniques/resources which have recently become available, with better validation datasets. Each one of the four working groups associated with analyses of boundary layer, cirrus, extra-tropical layer and precipitating convective cloud types respectively has been making progress in mobilizing the CRM community to provide observational/model datasets for many phenomena/processes of importance to GCM development.

The current activity within the GCSS has been undertaken within 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)

GCSS Strategy

The GCSS strategy considers that the two main issues in studying the effects of cloud systems are coupling and scales. Rather than try to isolate the individual processes and study them separately, GCSS has undertaken to apply SCMs, CRMs and mesoscale models to study the processes as a coupled system giving rise to phenomena spanning a broader range of scales than any individual process. The models required are being developed and validated in the GCSS using 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. Within this structure there is a set of tasks being undertaken by GCSS which cut across the individual Working Groups.

GCSS Science and Implementation Plan Revision

A joint ECMWF and WCRP/GCSS Workshop was successfully accomplished (9-13 November 1998, at ECMWF in the UK). An important result of the workshop was the recommendation that the current GCSS Science and Implementation Plan be updated. The GCSS Chair was assigned responsibility to organize a drafting team and act as lead editor in the production of a new version of the Plan which is to be ready before the next GCSS meeting.

GCSS/GRP Interactions

Since the GCSS/ECMWF Workshop was planned in concert with the GEWEX Radiation Panel (GRP) so the programme included papers dealing with cloud feedback issues and related radiation topics of importance to both GRP and GCSS research goals. In this context GCSS is furthering its interactions with the radiation and satellite remote sensing communities. Working Groups 1 and 4 have had interactions with the GEWEX Radiation Panel (GRP) to establish GRP's requirements for 3-D cloud model data fields. GCSS representatives on these working groups are working to meet the GRP needs for Boundary Layer case cloud data from BOMEX, and Precipitating Cloud System data from TOGA COARE, to promote GRP radiation flux calculation studies. These efforts will be continued and expanded as appropriate.

GCSS "Ad Hoc" Data Integration from 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 under the auspices of GCSS has been endorsed by the SSG. Dr W. Rossow has been given the action to continue to develop this proposal by moving forward with a sample case that can be used to evaluate the process and the value of the proposed deliverable. The SSG will be interested in having this "ad hoc" team take a GCSS test case and produce a CDROM (preferred medium) that contains observational data from the field measurements, satellites, and weather analyses (or re-analyses), combined with selected cloud process model outputs. If possible, radiation and precipitation measurements should also be provided. As many independent determinations of key quantities as can be obtained should also be included to provide cross-checks and uncertainty estimates. Since the observations will provide large-scale forcing and initial conditions for model simulations and verification of the evolution of the meteorology and cloud properties, it should be possible to show that the information organized in this way is extremely useful in conducting model simulations and comparing the results with observations. The success of this sample effort should provide the framework for DIME to become a joint initiative with the GRP and the GHP where related data set development activities could benefit from a focused data integration and model evaluation activity.

GCSS/AMIP Interactions

GCSS had requested that AMIP assist in the development of experimental cloud system test cases by attempting to have all AMIP participants save restart statistics once for each month as a standard output product of the AMIP simulation exercises but this has proved not to be possible. Other interactions are underway including the goal to produce a description of a "prototype methodology" for a demonstration/experimental pilot study that could be undertaken at GISS or other centres such as GFDL or NCAR and which could evolve into a proposal for an AMIP-II diagnostic/experimental exercise. GCSS is also undertaking related activities which could be patterned after the AMIP concept but which remain GCSS initiatives.

GCSS Polar Cloud Working Group

A study of a possible GCSS Polar Cloud initiative which had been undertaken by Dr J. Curry was shown to have relevance to an array of recent field work in the Polar region including SHEBA, FIRE and ARM. Acceptance of this effort as a fifth GCSS Working Group was fully endorsed by the SSG. A first working meeting in connection with this activity is, therefore, anticipated during 1999. The Group's action plans should be forthcoming at the next GCSS meeting and ready for review at the SSG-2000 meeting.

Continuation of GEWEX Datasets

In a special action, the GCSS undertook action related to the endorsement of the continuation of the International Satellite Cloud Climatology Project 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 (See Item on Continuation of GEWEX Datasets under GRP review above).

A listing of the specific Working group recommendations and actions taken at the seventh session of the GCSS Science Panel meeting in Kauai, Hawaii, USA, 1-4 December 1998, was reviewed.

Main Working Group-1 Action list

(a) Move forward with the development of two initiatives/cases during the next two years that will:

(i) Address the effects of StratoCumulus cloud systems on ocean/atmosphere radiative coupling. This will be a climatological study built around data collected off the Coast of California, USA, during the FIRE I, 1-19 July 1987, Intensive Observing Period (IOP). This study will link to model analysis/development work being undertaken by the WCRP Working Group on Coupled Modelling (WGCM) and to radiative transfer issues of interest to the GEWEX Radiation Panel (GRP).

(ii) Address the diurnal variation of Cumulus cloud systems over land. Selection for a test case for this study will be made from ARM-CART site IOP archives. This study may have links to land-surface characterization model analysis/development being undertaken by the CERES instrument development team.

(b) Continue efforts to develop a framework for a new sub-tropical cellular, shallow convection cloud system, field study. This "BOMEX-2000 type" study would attempt to include in the experiment design methods of measuring/inferring large-scale (forcing) subsidence. Rather than pursue this as an independent initiative efforts will be made to link with other experiments planned for the target region (i.e. VAMOS) that need a strongly focused cloud/radiation component.

(c) In all analyses the Chair of WG1 agreed to:

(i) Systematically explore the dependence of results of its test case studies on domain size. Current results indicate that domain size has little influence on dynamics, however, the generation of mesoscale fluctuations remains an issue of fundamental research. Application of appropriate computational resources to this problem will also be promoted by the Group, (See Item (iii) below).

(ii) Broaden the scope of test case studies to include all radiative transfer processes and microphysics as well as cloud dynamics. The Working Group membership will be broadened to meet this need.

(iii) Encourage the LES (WG1) community within the GCSS framework to be more active in securing much larger computing resources to continue their work.

(iv) Explore the utility of ensembles of runs with slightly different initial conditions. This process has been used successfully at the Max Planck Institute (MPI) on a test case from the EUCREM study. WG1 will follow-up with these techniques as recommended.

Working Group-2 Action list

(a) Commit to WG2 Workshop in 1999. The main topics for the workshop will be results of the WG2 Idealized Cirrus Model Comparison (ICMC) and Cirrus Parcel Model Comparison (CPMC) Projects as well as development of a joint project with WG4 on cirrus anvil systems and possibly plans an observational case study project. Future field programs of potential relevance to WG2 will also be discussed as well as other GCSS issues. 19-21 May at GKSS in Geesthacht, Germany, have tentatively been selected as the time and place of this workshop.

(b) Initiate the next phases of ICMC and CPMC Projects taking into account the following actions/recommendations:

(i) Consider the formulation of a Cirrus Cloud Systems Working Group Advisory Committee to provide scientific/technical assistance in setting priorities and selecting test cases.

(ii) Re-design the ice water fall speed comparison under the ICMC Project.

(iii) Consider adding an "alto-stratus" (no fall speed case) to each ICMC Project baseline case series.

(iv) Consider performing ensembles of runs for selected ICMC Project baseline cases including seed numbers for "noise", perturbations of initial profiles, etc. In addition, systematically explore the dependence of results of these test case studies on domain size and increase the priority of having LES simulations for the ICMC Project baseline cases.

(v) Increase the application of observations in the ice water fall speed comparison analysis. This should include the selection of one or more observational cases from BASE or SHEBA as well as from ARM, EUCREX and FIRE studies.

(vi) Conduct a survey of cases that could provide more information on the microphysical relationships of importance in Cirrus cloud systems. Establish links to WG3 and WG4 to engage them in this survey and to involve them in the ice water fall speed comparison project.

Working Group-3 Action list

(a) Continue to advance GCSS efforts related to analysis of cloud from unresolved orography by interacting with other elements of the GEWEX community within the Hydrometeorology Panel specifically those involved in the Continental-Scale Experiments being undertaken in North America (MAGS, GCIP) and Europe (BALTEX). Connections should also be established with work related to orographically induced cloud and precipitation that is being studied in Japan. With these links the WG should use 1999 as a period for activity moving forward on orographic cloud research and analyses.

(b) Review work on the Cold Fronts Research Program (CFRP) to identify and analyze all the available results and resolve any specific open issues related to the model simulations carried out as part of the Program. This should be accomplished before proceeding with development of case studies based on the FASTEX results with the aim of identifying cases which include identifiable convective regions, cirrus cloud and boundary-layer characteristics. The FASTEX studies should continue to be pursued as multi-featured cases to engage other GCSS Working Groups in a unified analysis effort. At the 1999 GCSS meeting, the Working Group-3 Chair will report on progress in characterizing such a case and initiating a GCSS generalized analysis.

(c) In following up with the next WG-3 Fastex case (see item b above) there was agreement that a specific test of a microphysical parameterization should be included. It was strongly suggested that the ice fall speed and evaporation parameterization be selected for a "sensitivity" study as part of this effort. In this context the WG-3 Chair agreed to provide the WG-2 Chair with the formulation of the ice fall velocity parameterization currently in use by the WG-3 modelling community.

(d) WG-3 will continue to be the focus of the development of a method which may provide a way to bridge the gap between the time and space domains of interest to climate models and those of field experiments and Cloud Resolving Models. The proposal which may be developed into an AMIP-II experiment under WG-3 member Dr G. Tselioudis provides both a large scale framework for the field/CRM investigations and a benchmark to judge the GCM improvements that those investigations may propose.

Working Group-4 Action List

(a) WG-4 should proceed with a continental deep convection case drawn from data taken at the ARM Southern Great Plains experimental site during July 1997. Specialized instrumentation including a millimeter cloud radar (MMCR) and an extensive array of other meteorological instruments were operational at that time. This case will be done in collaboration with the ARM Single Column Modelling Group as a means of involving more of the SCM community to participate in the process and to gain support of the ARM Data and Science Integration Team (DIST) in the provision of forcing data and the compilation of results submitted by the modelling groups.

(b) WG-4 Chair to finalize and submit a paper for publication in an appropriate journal, of the results from WG-4 Case 2, which included modelling in one, two and three dimensions of the evolution of convection subjected to observed, time-dependent, large-scale forcing on a time scale of a week. Initial conditions for the simulations, the evolving large-scale forcing and the data used in model evaluation were averages over the TOGA COARE Intensive Flux Array (IFA). The results have been presented at the COARE98 meeting, however, there was agreement that a paper on the results was required.

(c) Action will be taken to format the observational data sets and the results from both WG-4 Case 1 (TOGA COARE, based squall line case) and Case 2 so that they can be distributed by way of the internet. Plans will also be undertaken to have these products formatted for placement on a CD-ROM.

(d) The results from the radiation code offline intercomparison at one instant in time during WG-4 Case 2 will be re-examined and then members of the working group will be encouraged to apply the results (surface heat fluxes, radiative heating rates and fluxes, etc.) to improve CSM development in this area. WG-4 will also interact with the Chair of the GEWEX Radiation Panel (GRP) to benefit from work being done on an improved offline intercomparison of radiation code results from Case 2.

(e) WG 4 will develop a re-run of Case 2 utilizing an improved large scale (variational) analysis and additional observational datasets (cloud fields) plus the ECMWF 4DVAR reanalysis data.

(f) Interaction with WG-2 should result in the development of an anvil cirrus case and participation by a sub-set of WG-4 members in WG-2's idealized cases and fall speed survey.

(g) WG4 is to move forward with an effort that may be undertaken in the form of a diagnostic/experimental sub-project similar in some respects to work being accomplished in the framework of AMIP. This effort will be site specific and involve special statistical methodologies for comparisons with cloud radar results. Dr G. Tselioudis, will take the lead in formulating this activity in the context of GCSS/WG-4.

Other Relevant GCSS Actions

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

(a) To ensure there is emphasis on parameterization development within GCSS science, each WG will schedule an extended discussion of specific new/old parameterizations and their performance in SCM (and other) tests. SCM and CSMs will also be investigated as tools for addressing some specific cloud feedback issues as proposed by way of interaction with the GRP

(b) GCSS will send a representative(s) to the WCRP Working Group on Coupled Models (WGCM) meeting (11-16 October 1999, San Diego, CA, USA) to report on relevant GCSS activities, and to report back to GCSS on cloud related issues arising in coupled modelling and climate change. To further enhance this interaction, GCSS WG Chairs will specifically invite, and engage GCM researchers in GCSS case studies and related WG activities.

(c) An updated GCSS article will be written for publication in the Bulletin of the American Meteorological Society (BAMS), or equivalent publication providing the past results and future thrust of GCSS. The main elements for this publication may be able to be taken from the updated/revised GCSS Science Plan presently in work.

Special Session on Japan's Contributions to GCSS

A number of activities were defined as a result of a series of presentations by Japanese Researchers working in related National Cloud System Studies.

(a) Dr Yamasaki presented material which was directly related to on-going activities within WGs 3 and 4. The basis of the discussion was related to potential improvements of numerical models by way of better understanding of various cloud system types and their interaction with large-scale disturbances (i.e. wave and vortex processes). This work has been focusing on extra-tropical cyclone-frontal systems, Baiu-Meiyu (Monsoonal) fronts, tropical cyclone systems, cloud clusters in the tropics and "super" cloud clusters and intraseasonal oscillation. Dr Yamasaki showed results of work with a meso-scale model which has been improved to resolve meso-scale organized forms of cumulus convection at from 1-20kms. Since 1986 the resolution has been improved from 20km to 10km in 1993 tests with good results. There was agreement that this work needed to be carried forward and that data are now available which indicate the resolution of the model is consistent down to 5km with a goal of reach 1km in the near term. This model has been applied to the main cloud systems of interest to GCSS and a connection between Working Groups 3 and 4 was established with Dr Yamasaki to ensure further understanding of the potential of its application to specific GCSS needs.

(b) A number of specific issues related to orographic precipitation were addressed by DR Fujioshi. The question of what cloud systems and what processes need to be parameterized was discussed in the presentation on the subgrid scale distribution of intense rainfall events. Action was given to the WG3

Chair to work with Dr Fujioshi [See Working Group-3 Action list Item (a)] in selecting one of the number of cases the Japanese are simulating which have been giving extensive results in the area of intense orographic rain events run at high resolution (1-10kms). The results have shown that sub-grid scale orographic precipitation parameterizations, which have been formulated, if run at high enough resolution, can assist in explaining the specific dynamics of these intense events. Issues that must be addressed in WG3's joint action with Dr Fujioshi relate to the relative impact of such precipitation events in GCM runs, and how this type of event may vary with different orography, as well as answering how orographic effects change the average (and other pertinent statistical elements) of the precipitation on scales that sub-grid scale for climate model runs.

(c) Dr Kazuo Saito presented results from a Maritime Continent Thunderstorm Experiment (MCTEX) Case that was used to perform a numerical simulation of diurnal evolution of convection observed north of Darwin. The work was performed using the Meteorological Research Institute (MRI) mesoscale non-hydrostatic model (MRI-NHM). More information on the model is available at URL <http://www.mri-jma.go.jp/Dep/fo/mrinhm/INDEXE.html>. In order to handle the synoptic forcing and obtain the cloud resolving resolution necessary, the model was double nested with the Australian Bureau of Meteorology Research Centre's limited-area Assimilation and Prediction System (BMRC LAPS), which was specifically operated with a 20km horizontal resolution for the Maritime Continent region during the MCTEX period. Excellent agreement was found between the simulation and the observed scenarios of diurnal evolution of the convective clouds, which shows the transition from the horizontal convection during the morning period to the vertical convection during the afternoon phase. The results of the analyses suggest that the tropical convection can basically be simulated by the warm rain processes for very short range prediction cycles while the ice phase is essential to represent proper vertical profiles of heat, moisture and mass budget. Sensitivity experiments show that the orographic undulations and the horizontal scale of the Island are important factors which affect the timing of cloud merger and convective intensity. These results were referred to WG3 for further discussion of the orographic implications and since there are properties of and a maritime convection case in the tropics parallels to work being undertaken by ARM will be investigated.

(d) Dr Teruyuki Kato provided results from an analysis of the diurnal cycle of precipitation during the 1996 Baiu season that came during the period (15 June - 10 July 1996) of the Japanese Torrential Rainfall Experiment (TREX). Analysis of the rainfall was undertaken as observed by the Automated Meteorological Data Acquisition System (AMeDAS) Radar network. The movement of the Baiu front and the diurnal variation of the observed rainfall were tracked. This simulation of the diurnal variation of rainfall for the period was accomplished using both the MRI-NHM at 10km resolution and the Regional Spectral Model (RSM), which is a hydrostatic model used operationally at JMA. The study showed that the MRI-NHM with the 10km grid had a better accuracy for the prediction of heavy rainfall than the RSM. For a forecast of rainfall amount, however, the RSM performed better. The diurnal variation of precipitation found during the Baiu season is reproduced successfully by RSM, while the amplitude in the early morning produced by MRI-NHM is considerably weaker than observed. The conclusion was that this result is related to the absence of atmospheric radiation processes in the MRI-NHM. The study went on to introduce an atmospheric radiation scheme in the model and to show that the diurnal variation of rainfall is likely induced by the effect of the atmospheric radiation processes. The Baiu frontal zone is dominated by a widely distributed stratus deck where the top layer is cooled by the longwave radiation at night and warmed by the shortwave effects in the day. GCSS will be interested in the further detailed studies of the radiation processes in such a case.

(e) Japan is leading a mesoscale model intercomparison project in the COMPARE framework. COMPARE Case III intercomparison is being carried out to improve the typhoon intensity prediction capability of numerical models in addition to other research objectives. The case involves the rapid development stage of typhoon Flo (T9019) as it evolved during the period 12-17 September 1990. JMA has taken the role of the lead centre in preparing the necessary datasets and performing validation and intercomparison studies of the results coming out of the coordinated experiments being performed by the participating institutions with their own mesoscale models. In the first stage of the study participants from 12 Institutions utilizing 15 different models, have applied four different initial conditions in runs with models with from 20-50km resolution. It is possible to say at this point in the experiment that the initial conditions have a large impact on both the tracking and intensity predictions of the models and that it is more difficult to get the intensity prediction right than to predict the track of the storm. Some models were shown to be capable of predicting the swift development of the storm to some extent and those models in turn were found to be better at reproducing the inner structure of the typhoon. This led to the conclusion that accurate typhoon intensity prediction

will only come with an improvement in the capability of the models to reproduce the structural phenomenon of the storm including such things as the concentrated rainfall from clouds which form the wall of the eye of the typhoon. GCSS is interested in seeing the final report of this Case study and would like to be informed about the next stage of this work where higher resolution runs are expected to be made.

Land Surface Parameterization-AGCM Coupling Project

The SSG endorsed the GMPP action to highlight the Global Soil Wetness Project (GSWP) as an important element of continued land-surface modelling and analysis in GEWEX. GSWP under joint administration by GMPP and ISLSCP should continue to move into its next phase and, thereby, become the focus of an international framework for the advancement of land-surface models and analyses. The current Land-Surface Parameterization-AGCM Coupling Project will be responsible for this action and additional (or modified) co-ordinated experimentation or investigations will be undertaken as required. Any further results from the studies initiated earlier by the GEWEX Numerical Experimentation Panel will also be considered. To promote this new structure the Panel recommended that Dr J. Polcher undertake the organization in 1999 of a GEWEX Workshop on Land-Surface Science and Research. Subsequently the dates of 4-8 October 1999 were selected for this workshop which will be held near Paris, France.

The development of GSWP in GMPP

GSWP has developed within ISLSCP up to the culmination of its initial phase. The SSG has endorsed the recommendation of the GMPP that the next phase of GSWP be considered for development within GMPP and that it begin by way of the consideration of point validations designed to make the best use of the highest quality data currently available; activities that address the interaction of the PBL and LSSs in order to ensure that "forced" experiments will become more valuable to understanding the "coupled" problem and activities which address the issues of surface heterogeneity, fenology and root-soil moisture interaction in LSS development. Action is necessary to address the process of joint administration of GSWP by ISLSCP and GMPP until a "handover" of GSWP to GMPP can be affected and that the necessary technical issues for phase two of GSWP form part of the discussions at the 1999 GEWEX Land-surface Workshop (see above Item). Other topics at the 1999 workshop will follow from recommendations from the IGBP/GEWEX workshop in La Jolla (February 1997) and the joint ECMWF and GEWEX workshop (July 1998). Both workshops stressed the need for higher horizontal complexity in the hydrological processes and a greening of the surface scheme as priorities in the development of land-surface schemes.

Validation of the land-surface schemes in the coupled environment

Different methods have been applied to the process of comparing land-surface schemes when coupled to GCMs. Work undertaken by various activities including the Project for Intercomparing Land-surface Parameterization Schemes (PILPS) and the European project "Land-surface Processes and Climate Response" have brought attention to the difficulty in implementing these techniques. The different methods applied up to now have proved not to be successful either because they are too difficult to implement or the results are too difficult to analyze in the context of an international project. The general interface between land-surface schemes and GCMs might prove useful in this endeavour but apparently only on the longer term. One conclusion that could be drawn from an analysis of the current status of this work is that the best opportunities for further success may lie in attempts to make simulations of land-surface forced by observed data more relevant for the coupled environment. Ideas about how to move forward should be explored through continued discussion within the broader community at WCRP/GEWEX sponsored meetings and workshops.

As GMPP has continued to encourage an evolution from the off-line validation and inter-comparison towards the coupled comparison stronger links to GHP have been formed. This interaction has come with a realization that the observational community is essential to further progress in this field.

Project for Intercomparing Land-surface Parameterization Schemes (PILPS)

Work in PILPS has been organized and arranged at a number universities, institutes, modelling centres and agencies. The central PILPS home page <http://www.cic.mq.edu.au/pilps-rice/> is maintained at the Climate Impacts Centre, Macquarie University, Sydney, Australia. The primary goal of PILPS is to achieve greater understanding of the capabilities of land surface schemes in atmospheric models. The most recent phases of PILPS (3/4) were designed to exploit observational data and to review the performance of land-surface schemes when coupled to their host models, and in particular, to understand the large

differences found in various study cases associated with Phase 1 (equilibrium off-line simulations with artificial forcing data) and Phase 2 (accuracy of schemes with observations and each other).

A summary of the main issues raised by PILPS analyses include the fact that the "bucket" scheme is a significant outlier in all off-line experiments. PILPS showed large differences in the partition between sensible and latent heat fluxes among schemes when forced with the same meteorology or climate parameters. Phases 3 and 4 have been attempted to determine whether the same differences will occur when the schemes are coupled to the same host atmospheric model and when disturbed by the same forcing. There is concern about this approach, since although Phases 1 and 2 of PILPS have been deemed very successful and Phase 3 (performance of LSS as a component of their host atmospheric model in AMIP integrations) has been shown to have been successful, Phase 4 (performance of LSS in a common host model) has been characterized as having been "not very successful" with the implication that a different methodology is needed.

The SSG was pleased to know that PILPS has received new funding from the Australian Research Council for three years and from USA NOAA/GCIP resources and supported the GMPP recommendation that PILPS convene a meeting of its advisory committee in 1999 to summarize/document achievements and consider the future. Dr A. Henderson-Sellers subsequently noted that a PILPS strategy meeting will be hosted by the International Pacific Research Center (IPRC) at Honolulu, Hawaii, USA, from 23-26 February 1998. Topics at the meeting are expected to include an optimization of future off-line LSS intercomparisons utilizing a newly tested multi-criteria optimization technique developed at the University of Arizona, a study of the sensitivity to LSSs of coupled models by way of specialized techniques applied to satellite data that also has implications for interpretation of AMIP II results and application of an improved formulation to the study of LSS in large-scale atmospheric models.

Earlier recommendations from the 1997 meetings of the GMPP/WGNE, GEWEX-SSG and WCRP JSC are relevant to a PILPS review. These groups, with the 1998 GMPP/WGNE, noted that the Land-surface Parameterization-AGCM Coupling Project (see item on this project above) will be the focal point for the review of development of land surface schemes in atmospheric models, the strengths and weaknesses of the different approaches being employed and improvements needed. PILPS was sited as evidently being a main planck of this activity but not without the possibility of some realignment of PILPS analyses which may be called for to fit in with the Land-surface Parameterization-AGCM Coupling Project. The outcome of the PILPS meeting will need to be considered at the International Workshop being planned in October 1999 to formalize the International framework for the GEWEX Land-surface Parameterization-AGCM Coupling Project with further realignment of PILPS possible to match the recommendations of the workshop.

The International Pacific Research Center (IPRC)

The IPRC mission statement provides for an international, state-of-the-art research environment to improve understanding of the nature and predictability of climate variability and regional aspects of global environmental change in the Asia-Pacific sector. Given this framework, IPRC may provide important links to the modelling and prediction component of GEWEX. The IPRC research strategy emphasizes numerical modelling and diagnostic studies, rather than observational elements to achieve its mission. More observational emphasis is, however, under consideration and may provide for additional links to GEWEX data initiatives. The IPRC science themes are concentrated on the Asia-Pacific climate, Pacific Ocean predictability, the Asian-Australian monsoon and hydrological cycle and impacts of global environmental changes on the Asia-Pacific climate. The 1999 IPRC activities plan calls for developing and improving numerical simulation of the Asian monsoon using general circulation and regional climate models and developing and improving a hydrological model. Data analyses will include the study of the interaction between monsoon seasonal cycle and active and break periods and the study of the influence of oceanic mixed layer on SST and A-A monsoon variability. This work and an attempt at a preliminary estimation of the annual fresh-water budget in the region may provide connections to the GEWEX CEOP and monsoon teleconnection thrusts. Because of the possible synergy between IPRC studies and GEWEX the SSG will want to remain aware of the status of the Centre at future meetings.

Calibration of Hydrologic Models Using Multi-Objectives and Visualization Techniques

This effort is organized under the direction of Drs S. Sorooshian (Principal Investigator) and H. Gupta (Co-investigator) at the University of Arizona. The Model Calibration and Evaluation Group headed by Adjunct Professor Hoshin Gupta, conducts research in the fields of model performance evaluation and model calibration, recognizing the inherent multi-objective nature of the problem and the role of model error.

Recently, the group has developed an efficient and effective new algorithm entitled Multi-Objective COMplex Evolution (MOCOM-UA), capable of solving the multi-objective optimization problem in conjunction with a Multi-Objective Generalized Sensitivity Analysis (MOGSA) methodology that provides an objective determination of the multi-criteria sensitivity of the modeled variables to the parameters. The methods are successfully being applied to different rainfall-runoff, land-surface, and hydrochemical models.

The presentation made by Dr Gupta noted that a primary objective of this work is to develop techniques for calibrating hydrologic models that improve the prospects for finding preferred solutions. Material related to This effort can be found on the Internet at URL: <http://www.hwr.arizona.edu/eshome/proj/nsf/nsf main.html>. The research is focusing its attention on the emerging generation of land surface hydrologic models being considered as viable land-surface soil-vegetation-atmosphere transfer schemes (SVATS). The Group also considers it important to:

(i) Recognize the inherently multi-objective nature of the hydrologic model calibration problem and pose the calibration procedure in the framework of multi-objectives.

(ii) Explore innovative ways of using multi-criteria, data sub-sets (that emphasize different hydrologic processes or different aspects of model performance), measures of information content, and global search algorithms in identifying the non-inferior solution space and preferred solutions.

(iii) On test cases, determine if a satisfactory and reliable estimate of the non-inferior solution space can be identified, from which a preferred estimate or set of estimates can be selected. Develop techniques for estimating confidence intervals on parameters and simulated variables, taking into account the non-inferior solution space and data errors, gain insights into the roles that data error, model error, and parameter interaction play in producing non-inferior solutions.

(iv) Determine, for test cases, how preferred solutions can be reliably, effectively and efficiently obtained through a systematic computer-based exploration of the non-inferior solution space.

(v) Implement a systematic workstation-based calibration strategy and compare it with existing single-objective strategies.

Data Assimilation Office (DAO), Laboratory for Atmospheres, NASA/GSFC

Dr R. Atlas reported on the work being done by DAO with the extensive database of atmospheric observations available for research and numerical weather prediction. Since significant data deficiencies still exist with this data and new observing systems are continually being proposed, DAO conducts observing system experiments (OSEs) to assess the usefulness of different types of existing atmospheric observations. Observing system simulation experiments (OSSEs) are conducted to evaluate the potential impact of proposed observing systems, as well as to determine tradeoffs in their design, and to evaluate data assimilation methodology. Dr Atlas provided a review of the development of the global atmospheric observing system, a description of the principal types of data, an overview of OSE and OSSE methodology, and results from recent experiments to evaluate the relative utility of the principal atmospheric observing systems and the potential for new observing systems (Atlas, 1997).

An agreement of participation will be developed between GEWEX and DAO that will provide for DAO to perform impact studies by way of OSEs using real data and OSSEs using simulated data to evaluate the potential impact of future observing systems of relevance to GEWEX. DAO will also run parallel assimilation runs using different parameterizations that are key to GEWEX projects. Real-time support utilizing the Goddard Earth Observing System, Global Data Assimilation System (GEOS-GDAS) and related analyses and forecasts can also be provided by DAO during GEWEX field studies. This agreement will provide DAO with links to GEWEX activities leading toward improved parameterizations and to validation data and expertise for independent evaluation of DAO models and analyses. The SSG will want to see a draft of this agreement in 1999. The International GEWEX Project Office (IGPO) agreed to co-ordinate the agreement.

National Center for Environmental Prediction (NCEP)

Dr K. Mitchell, noted the role NCEP has played in GCIP where it has contributed research and technical activities associated with the application and development of GCMs, basin-scale hydrologic models and meso-scale atmospheric models in GCIP studies. In general, NCEP has contributed to the advancement of WCRP/GEWEX goals by initiating the use of a number of operational tools that have application in research including: global 3-D variational analysis, global ensemble forecasts, coupled model annual climate forecasts, global 3-D variational radiance assimilation, the first 40 years of global reanalysis, climate data

assimilation system (CDAS) into the future, global 4DDA and prognostic ozone, use of satellite vegetation phenology, experimental precipitation assimilation (regional and global) and experimental imbedded regional model seasonal forecasts. The Climate Modelling Branch of NECP has a site on the Internet where more information is available on this aspect of the NCEP charter. The URL is: <http://nic.fb4.noaa.gov:8000/research/cmb/climate.html>.

An NCEP analysis led by Drs K. Mo and M. Kanamitsu of particular interest to GEWEX is related to seasonal prediction with imbedded regional coupled models. The advantages of imbedded regional models have been shown to be higher spatial resolution for topography,-land surface characteristics, land/sea coastal geometry, snowpack, runoff parameters, and in downscaling of precipitation anomalies and runoff response. Greater freedom in changing physics is an additional advantage especially in dealing with convective precipitation, cloud microphysics and land surface physics. Domain size remains an issue in the application of imbedded regional models and efforts are under way to consider this in future work with this technique.

The NCEP/NCAR reanalysis has also become an important dataset in GEWEX research. Fifty years (1948-1998) of reanalyses has been completed with a frozen data assimilation system from the operational global system of 1995. The data are run at T62, or approximately 2 degrees (210 km), and 28 levels and analyses are available for each six hours, including surface fluxes and fields and hydrological cycle. Plans are to continue the reanalysis in near real-time indefinitely. Reanalysis fields are available from the Internet at <http://wesley.wwb.noaa.gov/reanalysis.html>, <http://www.cdc.noaa.gov/cdc/reanalysis> and <http://www.scd.ucar.edu/dss/pub/reanalysis>. NCEP is proposing a regional reanalysis that would be co-ordinated with GEWEX which would use Eta model regional 4DDA, land-surface coupled Eta model, be run at 30-50 km resolution and cover a large north American domain for a 20 year time period (1980-2000) and include hourly precipitation assimilation. The SSG endorsed this plan which would improve resolution (space/diurnal/terrain), precipitation, land-surface hydrology (runoff/vegetation), and utilization of available observations.

Future plans call for a second phase of the regional reanalysis for the time period 1979 to 2003, follow-on with the NCEP/DOE AMIP-II Reanalysis from 1979 to 1997, and a new Global Reanalysis that would consider "future technical trends" that would make it worth while to consider planning for in the early part of the next century (i.e. by 2004).

The European Centre for Medium Range Weather Forecasts (ECMWF)

ECMWF has recognized the benefit to large scale modelling from the methodology GEWEX has applied toward the development of improved parameterizations. These improvements have been particularly relevant to the water and energy cycle. The changes have been brought about by way of an active interdisciplinary dialogue and exchange of information and concepts between the field experimenters and remote sensing communities, the operational and climate modelling centres and the large-eddy-simulation and single column modelling/cloud resolving modelling communities. This interaction has evolved into a process, whereby, gaps in understanding the hydrological cycle are identified, field measurement programmes are mounted to reduce the uncertainties, better formulations of models are consequently developed and the results verified. By becoming part of this process, the major modelling centres (ECMWF, NCEP, DAO, JMA and others) have remedied a number of important deficiencies in their models. These improvements have led to improved forecasts and provided the basis for moving forward with ambitious reanalysis projects for which GEWEX data projects have played an essential validation role. The reanalysis projects have, in turn, provided for systematic prediction studies on seasonal forecasting. Other benefits have accrued from WCRP/GEWEX advocating of new space missions, which should deliver important new gains in model development. ECMWF is interested in seeing the momentum built up in this process sustained and is, therefore, fully endorsing CEOP along with the concept of an augmented CEOP implemented in association with CLIVAR. In the future, GEWEX can also be expected to assist with closing the gap on understanding continental snow and ice processes and the role they play in providing memory for seasonal forecasts. Phase II of GEWEX may also enable the exploitation of new instrument data (i.e. from AIRS, IASI, and AMSU) by synergistically using it to assess ocean/land sources and sinks of carbon dioxide.

APPENDIX A

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APPENDIX B

SUMMARY OF RECOMMENDATIONS AND ACTIONS
for WCRP/GEWEX Scientific Steering Group (SSG) 11th Session
(25-29 January 1999, Tucson, Arizona)

The following is a compilation of the recommendations and related action items that came out of the deliberations of the GEWEX-SSG at its eleventh session (25-29 January 1999, Tucson, Arizona):

1. The SSG agreed that the success of WCRP research programs requires a long series of comprehensive observations with an integrated analysis of the datasets. It was recommended, therefore, that since current plans for the satellite and surface observing systems do not dictate a change of analysis schemes in the near future, ISCCP and the other GEWEX data projects should continue for at least another five years. Further review of the possible termination of these projects should come only when the present datasets can be replaced by new more comprehensive measurements that also provide equally good space-time resolution and global coverage. (See Item 4.)

2. The JPS for WCRP has the action to ensure that letters are drafted to the major space agencies to secure support of the current GEWEX global climate information projects including ISCCP GPCP, SRB and GACP well into the next decade. It will only be at that time (post-2000) that resources will come available that will make it possible to add value to the new earth observation system retrieval processes by organizing intercomparisons, applying merged data techniques and participating in unified algorithm development ventures. This exploitation requires not only that the participating GEWEX International data centres collect, analyze and disseminate their data products, but also that they calibrate, quality check, adapt processing software to changing operational systems, and validate their products. Therefore, the request to agencies for a renewal of their commitments to these projects will include the need for minimum funding levels to be established which are sufficient to support all of these tasks. (See Item 4.)

3. Although the main points in the implementation of GEWEX to achieve the required scientific progress have remained the same, the research in the individual elements has been focused on specific scientific issues that have been developed to unify their efforts in meeting the higher level global scale objectives. With the current emphasis on "inter-panel" co-operation to meet these objectives the SSG recommended that the three panels (GHP, GRP and GMPP) develop further specific co-operative/co-ordinated activities whose progress can be tracked and jointly reported at subsequent SSG meetings. A specific recommendation which needs to be fully acted upon, relates to GHP and GRP organizing the collection/processing of high resolution satellite datasets/products for each of the GRP global climatology data projects, over each of the GEWEX Continental-Scale Experiments (CSEs) and for the GEWEX Cloud System Study (GCSS) and other modelling and analysis elements of GMPP and GHP to exploit these high resolution datasets for their case studies, supplemented by their own field measurements. Other specific actions should be developed and discussed at the next SSG meeting. Action on Drs Lawford/Stewart for GHP, Stephens for GRP and Randall for GMPP. (See Item 5.)

4. It was agreed that the GHP Co-ordinated Enhanced Observing Period (CEOP) provides an opportunity for a unique joint activity within WCRP that will lead to major progress in understanding and prediction of the climate system. The SSG has formulated the implementation of CEOP as a GEWEX initiative that can be undertaken in association with CLIVAR and ACSYS that will characterize the climate system over the 2001-2002 period with a particular focus on the source and sink regions driving and modifying circulations that affect the climate system and many of its anomalies. The SSG acknowledged that work already underway by GAME, in the context of CEOP, should be expanded, in association with the Joint Air-Sea Monsoon Interaction Experiment (JASMINE), to focus on monsoonal circulations in the Asian/Australian region. There was further endorsement of the plan for CEOP to develop as a broad "Inter-WCRP" activity which also encompasses the American monsoons (GCIP, LBA and VAMOS) along with the African monsoons (CATCH). Other regions will be studied to address land-area generated climatic anomalies with a particular focus on Arctic and mid-latitude regions (GAME, GCIP, MAGS and BALTEX). A critical aspect of the effort is that it will also consider the degree to which these monsoonal and/or climatic anomaly generation source and sink regions are linked on seasonal through annual and inter-annual scales. (See Item 6.)

5. The SSG endorsed the ISLSCP Initiative II Data Sets Project and commended the action taken by the GEWEX Modelling and Prediction Panel (GMPP) in formalizing its support of this effort in a letter sent by the Director of WCRP to NASA noting the importance of the timely completion of this Project. (See Item 6.)

6. The SSG endorsed the recommendation that this next phase of GCIP be aggressively pursued by drawing on the infrastructure built up in GCIP and that this follow-on effort remain part of GEWEX and GHP and continue to add analyses which will assist GEWEX with meeting its goals related to understanding and predicting the impacts of climate variabilities on water resources up to seasonal to interannual time scales. The Action is for Dr Lawford to draft a letter for the consideration by the Director of WCRP for the purpose of noting WCRP/GEWEX support for a continuation, beyond the year 2000, of research in the Americas linked to that already undertaken by GCIP. Dr Lawford agreed to be the point of contact to ensure that the letter will go to the appropriate USA funding Agencies. (See Item 6.). This action has been closed since the meeting.

7. The SSG recommended that Coupling of the Tropical Atmosphere and Hydrological Cycle (CATCH) be added to the GHP CSE Matrix of Contributions **<http://www.wmo.ch/web/wcrp/docs/matrix98.html>** to GEWEX. Dr Afouda, is expected to co-ordinate with the GHP Chair to provide a presentation on the current status of the implementation of CATCH during the GHP Section at the 2000 GEWEX-SSG Session. (See Item 6.)

8. Specific milestones and related measures of success in determining radiative fluxes and heating within the atmosphere and at the surface with the precision needed to predict transient climate variations were discussed. The GRP chair has the action to formulate these ideas into an integrated scientific framework that expresses the effort to understand and quantify the impact of cloud feedback on the climate system as a main scientific theme for GRP and GEWEX. This framework will include the process by which GRP expects to link the current radiation data projects with the exploitation of data expected from the new era of instruments planned for launch during Phase II of GEWEX, as part of the Japanese, USA and European Earth Observations Initiatives beginning in 2000. (See Item 7.)

9. GRP can contribute to the process of identifying critical satellite data sets required for support of GEWEX studies, especially those which relate to the CSE regional data collection and study efforts. GRP can also assist in the planning for the retrieval of important data products and the further exploitation of the data in model studies and related analyses. The SSG supported action by GRP to form an "ad hoc" study group to address these proposed tasks and co-ordinate with the GHP and CSEs. The GRP Chair assisted by the JPS for WCRP and the Director of the International GEWEX Project Office (IGPO) will establish terms of reference for this group and contact the proposed members which will include those with links to GRP and having expertise in the application of satellite data to cloud/radiation research issues.(See Item 7.)

10. The SSG endorsed the plans of GRP to promote an international Workshop to Develop an Improved Diagnosis of Turbulent Water and Heat Fluxes from the Global Ocean Surface, but reaffirmed its position that GRP continue to undertake this initiative in co-ordination with the WCRP Working Group on Air Sea Fluxes which is working on a detailed study of available surface flux and flux-related data sets. Dr J. Curry, with support from the IGPO staff and the JPS for WCRP, has the action to convene an organizing committee for an initial workshop (late 1999) that would assess the current state-of-the-art of flux algorithms and input data, develop concepts for advancing work in this field and organize the case study comparisons including identification of data needed for input and validation of various analysis methods. (See Item 7.)

11. The overarching objective in the further development of GVaP is to quantify and understand the role of water vapour in the meteorological, hydrological, and climatological processes by improving knowledge of its variability, radiative effects, feedbacks, and change due to human activities. The last in a series of GVaP workshops will be held in 1999 to synthesize all of the scientific and technical issues necessary to finalize the plans for the next version of the dataset and to prepare it for systematic processing and distribution within an international framework. Drs Vonder Haar and Try have the action to follow-up on this initiative and ensure the SSG remains advised of the progress and status. (See Item 7.)

12. The SSG review of the Baseline Surface Radiation Network (BSRN) addressed the issue of how to encourage BSRN stations systematically to submit measurements to the BSRN data archive [the World Radiation Monitoring Centre (WRMC) at the Swiss Federal Institute of Technology (ETH)] in a timely manner and in the desired format. Action has been given to the BSRN Manager, with support from the JPS for WCRP at Geneva, to review why BSRN stations which are operational are not making their contributions to the BSRN data archive in a systematic way. Further action may be required including possibly a letter from the Director of WCRP to be sent to these stations noting the importance of their contribution to the BSRN data archive, as well as the requirement to provide correlative non-radiative data (e.g. co-located radiosonde soundings and surface observations) where available. (See Item 7.)

13. An important issue was raised with respect to inter-panel co-operative initiatives when it was noted, by Dr J. Polcher, that the ECMWF/GEWEX workshop on modelling and data assimilation for land-surface processes, held at ECMWF in June 1998 produced a set of recommendations for the evolution of land-surface schemes. The importance of a skin temperature climatology for the validation of land-surface schemes was recognized but it was also acknowledged that there are still unsolved problems which require investigation. It was recommended that the impact on the observed variable of sub-grid scale surface variability or shading within the grid-box be studied. To encourage research in this direction and the development of methods for comparing observed skin temperature and the modeled counterpart a request was made for support from ISCCP in the production of such a data set. This request will be evaluated and further action addressed between the GMPP/Land-surface-AGCM Coupling Project and GRP/ISCCP. Drs Polcher and Rossow have the action to follow up on this item and keep the SSG informed of its status. (See Item 7.)

14. The SSG noted that NOAA Geostationary Satellites had been recently redesigned in such a way as to eliminate the capability to provide data from two IR channels that could be used in split window analyses. These types of analyses with data taken from the Japanese GMS satellites have proven valuable in precipitation studies. The split window data have also been proven useful in ISCCP cloud studies. As a result, the SSG assigned action to the Director of WCRP to send a letter to the Director of NOAA urging reconsideration of this modification in future spacecraft. Dr A. Gruber agreed to assist with the drafting of this letter in 1999. (See Item 7.)

15. A joint ECMWF and WCRP/GCSS Workshop was successfully accomplished (9-13 November 1998, at ECMWF in the UK). An important result of the workshop was the recommendation that the current GCSS Science and Implementation Plan be updated. The GCSS Chair was assigned responsibility to organize a drafting team and act as lead editor in the production of a new version of the Plan which is to be ready before the next GCSS meeting. (See Item 8.)

16. 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 under the auspices of GCSS has been endorsed by the SSG. Dr W. Rossow has been given the action to continue to develop this proposal by moving forward with a sample case that can be used to evaluate the process and the value of the proposed deliverable. The SSG will be interested in having this "ad hoc" team take a GCSS test case and produce a CD-ROM (preferred medium) that contains observational data from the field measurements, satellites, and weather analyses (or re-analyses), combined with selected cloud process model outputs. (See Item 8.)

17. The SSG endorsed the GMPP action to highlight the Global Soil Wetness Project (GSWP) as an important element of continued land-surface modelling and analysis in GEWEX. GSWP under joint administration by GMPP and ISLSCP should continue to move into its next phase and, thereby, become the focus of an international framework for the advancement of land-surface models and analyses. The current Land-Surface Parameterization-AGCM Coupling Project will be responsible for this action and additional (or modified) co-ordinated experimentation or investigations will be undertaken as required. Any further results from the studies initiated earlier by the GEWEX Numerical Experimentation Panel will also be considered. To promote this new structure the Panel recommended that Dr J. Polcher undertake the organization in 1999 of a Workshop on Land-Surface Science and Research. Subsequently the dates of 4-8 October 1999 were selected for this workshop which will be held near Paris, France. (See Item 8.)

18. The SSG was pleased to know that PILPS has received new funding from the Australian Research Council for three years and from USA NOAA/GCIP resources and supported the GMPP recommendation that PILPS convene a meeting of its advisory committee in 1999 to summarize/document achievements and consider the future. Dr A. Henderson-Sellers subsequently noted that a PILPS strategy meeting will be hosted by the International Pacific Research Center (IPRC) at Honolulu, Hawaii, USA, from 23-26 February 1999. The outcome of the PILPS meeting will need to be considered at the International Workshop being planned in October 1999 to formalize the International framework for the GEWEX Land-surface Parameterization-AGCM Coupling Project with further realignment of PILPS possible to match the recommendations of the workshop. (See Item 8.)

19. The SSG was interested in work being carried out at the University of Arizona, by the Model Calibration and Evaluation Group headed by Adjunct Professor Hoshin Gupta. The research relates directly to GEWEX land-surface parameterization improvement initiatives by advancing model performance evaluation and model calibration, recognizing the inherent multi-objective nature of the problem and the role of model error. Recently, the group has developed an efficient and effective new algorithm entitled Multi-Objective COMplex Evolution (MOCOM-UA), capable of solving the multi-objective optimization problem in conjunction with a Multi-Objective Generalized Sensitivity Analysis (MOGSA) methodology that provides an objective determination of the multi-criteria -sensitivity of the modeled variables to the parameters. The methods are successfully being applied to different rainfall-runoff, land-surface, and hydrochemical models. Dr Gupta has responsibility for keeping the SSG informed of the progress and status of this work. (See Item 8.)

20. During the meeting there was recognition of the benefit to large-scale modeling from the methodology GEWEX has applied toward the development of improved parameterizations. To benefit from this effort GEWEX has asked NASA's Data Assimilation Office to perform impact studies by way of observing system experiments using real data and observing system simulation experiments simulated data to evaluate the potential impact of future observing systems of relevance to GEWEX. Dr R. Atlas has the action to perform this work with assistance from the IGPO and to keep the SSG informed of its progress and status. (See Item 8.)

21. The SSG reaffirmed its position that all members continue to take action to ensure that the planning of regional experiments include a strategy for ensuring that the different observational data measurements associated with each experiment are made compatible with and are "placed" on the World Meteorological Organization's, Global Telecommunications System (GTS) for access in (near) real-time by the major modelling and analysis centres. Datasets should also be organized into databases that can be distributed on appropriate media (i.e. CD-ROM) or otherwise be made easily accessible to the modelling centres from readily contacted archival facilities.