Coordination of Mesoscale Meteorological Research between ASL and European Group

Principal Investigator : Professor R. P. Pearce

Contractor : University of Reading, U.K.

Contract Number : DAJA 45-90-C-0009

FINAL REPORT
1st February 1990 - 31st December 1993

ABSTRACT

This report summarises the activities undertaken by the US Army Mesomet Panel during the contract period. For the period to 31st March, 1993, nine interim reports were submitted and these contain full details of these activities. For the final period, 1st April - 31st December 1993, a more detailed account is provided here and includes, as Annex 2, the report of the Panel's final meeting in Münster, Germany, 9th-10th September, 1993. Its executive summary contains five important recommendations, all directed towards the future modelling activities at ARL. These arise from the lessons learned from the Mesomet Model Comparison Project undertaken during the contract period and subsequent Mesomet Workshop held in El Paso in June, 1992.

Section 3 sets out what the Panel feels have been its achievements during the contract period, one in which considerable changes in policy direction occured, some of which will have been influenced by the Panel's advice. Attention is drawn to the role of the Panel in involving the wider mesomet modelling community in ASL's activities, particularly through the Mesomet Model Comparison Project and El Paso Workshop.

A major publication arising from these activities is a Mesometeorology Modelling monograph to be published by the American Meteorological Society in 1994. This is described in Section 4.

1. Introduction

This report describes the work carried out under the above contract with the Project Title 'Coordination of Mesoscale Meteorological Research between ASL and European groups'. The purpose of the Project was 'to continue and extend the activities of the European/US advisory Panel of Experts on Meso-scale Meteorology'. An extract from the original Project proposal describing the work to be undertaken under the contract is attached as Annex 1.

Section 2, describing the activities undertaken during the contract period is in two parts. The first, covering the period to 31st March, 1993, is in summary form since full details have already been given in the nine interim reports. The second part describes in more detail activities during the period 1st April - 31st December, 1993, the final period of the contract. Section 3 of this report summarises the results achieved.

2. Activities undertaken by the Panel

2.1 Period 1st February 1990 - 31st March 1993

The Panel has operated, throughout the whole of its period of existence, by meeting at regular intervals with representatives of ASL to comment on aspects of its scientific program as requested and provide advice to it on particular aspects across a wide range of scientific topics. During the period of this present contract, however, it has been concerned almost entirely with the particular area of mesoscale modelling and, in particular, with the organisation of an ambitious project aimed at utilising Project WIND data to compare performances of the most advanced mesoscale models available in the US and Europe. The aim of this project, the Mesoscale Model Comparison Project (MMCP), leading up to a workshop at which the results were assessed, was to ensure that the Army should take an initiative to ensure that it would be in a position to use the most advanced modelling expertise available to optimise its own weather forecasting capability in the battlefield environment.

The five Panel meetings held during this period were, therefore, concerned primarily with this Project. The proceedings of these meetings are summarised in Table 1.

Table 1

Panel meetings held during period 1st February 1990 - 31st March 1993

Location	Date	Issues & main conclusions	Interim Report
Traben Trabach W.Germany	23-27 Apr. 1990	Agreement to proceed to implement model comparison project (MMCP) and associated workshop. ASL to abandon model hierarchy in favour of nested grid approach.	1, 2
ASL	3-7 Dec. 1990	Planning for MMCP - respective responsibilities of Panel and ASL, evaluation procedures. Recommendation that ASL should adopt and test NORAPS (Navy) model.	3
Bruges Belgium	9-10 May 1991	Drawing up of detailed requirements for participants in MMCP. Request for supplement of $36,000 (to existing $102,000) to cover additional expenses of project, including page charges to AMS for publication of proposed monograph on mesoscale modelling arising from project.	4
El Paso Texas (in conjunction with Mesomet Workshop)	15,19 June 1992	Preliminary assessment of results of MMCP and implications for ASL modelling strategy. Recommended rescheduling of contract to enable further panel discussions and interaction with ASL and Navy modellers.	6, 7, 8
Monterey CA	23-25 Feb. 1993	Interaction with Navy modellers. Recommended NORAPS model to be tested as other models participating in MMCP, and results made available to panel by July 1993. If successful NORAPS model should replace HOTMAC as main operational model in IMETS. Panel to make recommendation at a further (final) meeting.	9

The other major activity during this period was the Mesoscale Modelling Workshop organised by ASL and held in El Paso, Texas, 16th - 18th June, 1992, attended by about 60 participants including many leading mesoscale modelling experts from Universities and specialist modelling groups and representatives from the Navy and Air Force. The considerable success of this workshop was largely the result of the preparations for it undertaken at ASL, including the assembling of data from Project WIND for the modellers, the development of software for analysis of the results submitted by the MMCP participants and the preparation of a substantial pre-workshop volume containing the main MMCP results and distributed to the workshop participants.

Other activities organised by the Panel during the period included two workshops, each of about 20 participants, arranged in the U.K. as part of Dr. Holt's ARATS (Army Regional Aerosol Transport Simulation) investigations (see Interim Reports 3 and 5).

The Panel contract also funded a visit to ASL by Professor Robert Pearce in April 1992 to assist in preparation of the pre-workshop volume, one by Dr. G. Gross in June 1993 to analyse MMCP results and another by Professor Pearce in December 1993 to present the Final Report.

2.2 Period 1st April - 31st December 1993

As anticipated in the 9th Interim Report, a final meeting of the Panel took place in September 1993. This was arranged in Münster, Germany, and was attended by the European Panel members and Dr. Gunther Gross. Its purposes were:

(a) to draw up a set of final recommendations to ARL concerning the Army's Atmospheric Modelling Strategy in the light of the results of the Mesoscale Model Comparison Project, including tests of the NORAPS model carried out since the February 1993 Monterey meeting,

(b) to review the status of the AMS monograph and prepare a commentary on the results of the Model Comparison Project, and

(c) to outline the Panel's Final Report.

Dr. Gross had been asked by the Panel to visit ASL during June 1993 to carry out a statistical analysis of the MMCP results and to present his results at this meeting. He also reported on the status of the NORAPS model to enable the Panel to make its final recommendations to ASL concerning its modelling strategy.

A report of this meeting is attached as Annex 2. This report contains in its Executive Summary five important recommendations embracing the Panel's views on both short- and longer-term strategies for the Army in weather forecasting.

During this period, Professor Roger Pielke and Professor Robert Pearce carried out an extensive editing process on the papers submitted by the El Paso workshop participants for publication as a monograph by the American Meteorological Society. The complete manuscript is now being processed by the AMS.

3. The Panel's achievements during the contract period

It is difficult to measure precisely the influence which the Panel has brought to bear on ASL's policy-making and activities. However, the Panel meetings were all most constructive and notable for their high level of scientific discussion and frank exchange of views, even on most delicate issues of concern to ASL. The Panel's long association with ASL - for most of its members about 20 years - enabled it to provide an element of continuity in its policy-making which would otherwise have been difficult to maintain with its frequent senior staff changes.

The impression gained by the Panel members is that they have been able not only to suggest important initiatives which were subsequently taken up by ASL, but were also able to assist ASL in dealing with policy changes dictated by changing circumstances. Specifically, the Panel

- persuaded ASL to abandon its model hierarchy (SIGMET, VARYME, HRWHER) in favour of a nested system.

- suggested, and helped to organise, the Mesoscale Model Comparison Project leading to the El Paso workshop as a major focus of mesoscale modelling at ASL, enabling it to

  (a) involve the wider modelling community in its modelling activities,

  (b) exploit the Project WIND data base,

  (c) assess the relative merits of existing mesoscale models - including HOTMAC (under development at ASL) and NORAPS, the Navy model and

  (d) gain considerable insight into the nature of the technical problems associated with such aspects of mesoscale modelling as their representation of physical processes near the earth's surface and the need to specify the changes occuring at the model's boundaries; such insight is necessary to successfully allocate priorities for future modelling research and improvement of weather forecasts for Army needs.

- strongly encouraged ASL to collaborate with the Navy and Air Force in the development of forecast models on all scales, from the global to the microscale.

- undertook the editing of a monograph on mesoscale modelling to be published by the American Meteorological Society based on the special topic reviews presented at the El Paso workshop and incorporating the results of the Mesoscale Model Comparison Project. This monograph should thus provide an invaluable state-of-the-art reference for mesoscale modellers, not only in the Army, but also for the increasing numbers of modelling groups in the wider community, for some years to come.

4. Publications

The main publication arising from the Panel's activities is the monograph at present being produced by the AMS. This should be available by June 1994. As indicated by the table of contents (Annex 3) and list of authors (Annex 4), it will contain six major review articles and eight chapters relating to

the results of the model comparison project. 15 copies will be forwarded to USARDSG-UK as soon as they are published.

The other publication was the pre-workshop volume prepared for the Panel at ASL for the El Paso workshop. This contains some of the material in the AMS monograph, but, unlike the latter, was not peer-reviewed.

5. Conclusion

This report marks not only the termination of the Panel contract, but also the winding up of the Panel itself. It has served, with a virtually unchanged membership, as an advisor to ASL for twenty years, a period much longer, no doubt, envisaged by its instigator, Dr. Hoyt Lemons, in 1972. It has experienced many changes of research priorities at ASL over that period.

It may be possible to prepare a brief historical account of the Panel's activities during this period in the near future if this should be felt to be of interest to the Army.

Annex 1

1. Date of submission: 27th June, 1989.

2. Project Title: Coordination of Mesoscale Meteorological Research between ASL and European groups.

3. Principal Investigator: Professor Robert P. Pearce,
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R. P. Pearce

Principal Investigator and
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5. Abstract:

The proposal is to continue and extend the activities of the European/US advisory panel of experts on Meso-scale Meteorology.

6. Historical background:

A European advisory panel of experts in Meso-scale Meteorology was set up in the first instance in 1972 to interact with the group at ASL, White Sands. Its main purpose was to review and comment on advances in mesometeorology, in particular the work of the ASL group, providing scientific guidance based on experience in mesometeorology research in Europe. Since its inception the panel has met on average once per year, at White Sands and in Europe. Also members of the panel have visited White Sands individually as consultants, and one or two visits by other European scientists to White Sands have been arranged. The panel's activities, including its funding, have been arranged by the U.S. Army Research, Development and Standardisation Group - UK (Environmental Sciences Division). Funding for the period March 1987 to March 1989 was arranged under Contract No. DAJA45-87-C-0014, and accounts of its activities are contained in the three interim reports submitted to date.

7. Technical Objective:

Since this application is not requesting support for a specific scientific investigation this heading is not relevant. However, it is proposed that where possible the panel members initiate research projects relevant to the ASL programme within the groups with which they have contacts.

8. Statement of work:

(i) Objectives: To provide for technical and administrative support of a U.S. Army Advisory Panel on Mesometeorology (APM). It is intended specifically to provide a mechanism for bringing together European and U.S. Army scientists and engineers, with a view to improving communication and cooperative research between those communities on scientific and technological problems which are related to U.S. Army interests, as well as one for providing direct technical support for the U.S. Army on matters relating to the meteorological sciences.

(ii) Scope: The Contractor will perform the following functions:

(a) Organise a permanent U.S. Army Advisory Panel on Mesometeorology, to consist of no more than eight (8) eminent scientists from Europe and the U.S. to act as a consultative board for the U.S. Army. A number less than eight is permissible.

(b) Review developments in subjects related to the topics of interest with a view to providing the USA Atmospheric Sciences Laboratory, and other components of the U.S. Army R & D community, with guidance as to the current state of the art in Europe and the U.S.

(c) Administer the assembly of small study groups, seminars, or workshops, either in Europe or the United States. This will include, but not necessarily be restricted to, the holding of three meetings of the APM, one in Europe and two in the U.S., during the contract period.

The report of the latest Panel meeting (at PSL, New Mexico State University, Las Cruces, N.M., 10-14 April 1989), a copy of which is attached, specifically recommended:

(1) Panel Meeting, ASL, 3-8 November 1989 to interact with scientists in the Atmospheric Effects Division.

(2) Panel Meeting, Traben Trabach, FRG, 23-27 April 1990 to continue discussion of activities at ASL and in Europe.

(d) Assist in the exchange, among European and U.S. participants, of literature surveys, data from field trials or experiments, relevant computer codes, and data analyses.

(e) Organize and administer special-purpose tasks arising from the general joint research activities. These will include, but not necessarily be restricted to, special-purpose laboratory or data analyses. Examples of the latter are tests of the model hierarchy components or mesoscale transport models using project WIND or other data.

The scope for undertaking such tasks has increased considerably as a result of

(a) the extension of the Panel's remit to include collaboration with the Atmospheric Effects Division at ASL (see report of Las Cruces Panel Meeting, 10-14 April 1989) and,

(b) the increasing availability of WIND project data for mesoscale model development at both ASL and in other mesoscale groups in the U.S. and Europe.

Annex 2

REPORT OF US ARMY MESONET PANEL MEETING

Hotel 'Huf Zur Linde', Munster, Germany.

9th - 10th September, 1993.

EXECUTIVE SUMMARY

This meeting was held with three main purposes:

(a) to draw up a set of final recommendations to ARL concerning the Army's Atmospheric Modeling Strategy in the light of the results of the Mesoscale Model Comparison Project, including tests of the NORAPS model carried out since the February 1993 Monterey meeting.

(b) to review the status of the AMS monograph and prepare a commentary on the results of the Model Comparison Project and

(c) to outline the Panel's Final Report.

The items proposing executive action by ARL are all contained in the recommendations under (a). These are:

Recommendation 1

In the light of the additional IMETS development constraints recently imposed on ARL priorities, the Panel recommends that ARL adopt the following *short-term* strategy:

(a) HOTMAC should be developed for IMETS applications; the results from the intercomparison tests using Project WIND Phase I and II data suggest that HOTMAC performs at least as well as other models available.

(b) HOTMAC should be extended to include moisture and precipitation; the Panel noted recent work by Yamada and Sasamori on a 1-D version of HOTMAC incorporating moisture yielding realistic predictions of fog and stratus cloud.

(c) HOTMAC should be developed to allow it to be nested within a larger-scale model; the results from the tests with WIND Phase II data indicate that failure to allow the meso-scale frontal structure to be advected into the model domain was mainly responsible for the generally poor performance of all four models involved.

(d) The size of the integration area should be appreciably larger than that used in these tests in order to ensure that the lateral boundaries are sufficiently far away from the area of interest; the positioning of lateral boundaries over the mountains bounding the Sacramento Valley may have imposed unrealistic constraints on the boundary mass flow and internal adjustment within the model domain.

Recommendation 2

The mesoscale modeling activities of ARL should, as a *medium-term* strategy, allocate the highest priority to the development of a non-hydrostatic version of the NAVY model with a horizontal grid size of 1km (the Army Tactical Field Model - ATFM).

After detailed tests using the WIND data base and a period in operational use to assess its performance, this model should be the successor to HOTMAC in the IMETS system. Both its development and testing should be contracted out to a University or other institution with the necessary high level of modeling expertise.

ARL should concentrate its in-house modeling development on producing specialised sub-models (SSMs), with grid size typically 100m by 100m, which use the output of the ATFM as their input and are designed for special Army applications such as smoke propagation, artillery needs, etc. The whole system must be extremely user-friendly and include high quality visualisation software.

In the light of these new suggested priorities, Recommendation 5 of the Monterey Panel meeting should not be further pursued.

Recommendation 3

The unique value of the Phase I and Phase II subsets of the Project WIND data base for testing mesoscale models has been well demonstrated in the Army's Mesoscale Model Comparison Project. Their use has led to considerably increased insight into the behaviour of the models tested and highlighted the aspects to which attention needs to be directed if their performance is to be improved.

Similar 24-hour subsets for model testing should be prepared for Phases III and IV of Project WIND as soon as possible and made generally available by, at the latest, June 1994. (See Recommendation 4).

One of the most important model deficiences revealed under the Comparison Project is their inadequate response to dynamical forcing associated with the frontal passage in Phase II. This forcing can only properly be represented in a mesoscale model incorporating data output from a larger-scale model, both on its lateral boundaries and internally. Such data, obtained, for example, from NMC, should be appended to all of the Project WIND data subsets to be used for further mesoscale model testing both at ARL and in the wider modeling community.

(It is proposed to include a reference to this recommendation in the AMS monograph.)

Recommendation 4

ARL, or the Joint Forces Mesoscale Modeling Center (see Recommendation 5), should organise a further Mesomet Modeling Workshop on the El Paso (1992) Workshop pattern to take place during 1995, 12-18 months following publication of the AMS monograph.

Mesoscale modeling groups should be alerted to the availability of further subsets of Project WIND data and encouraged to use these data in developing their models with the aim of exchanging results at the workshop.

Recommendation 5

The Panel considered the longer-term *operational* aspects of the developments anticipated in Recommendations 1 to 4. The results of the model simulations

of the Project WIND events, particularly Phase II, have sharpened the Panel's views on the necessity of combining larger-scale modeling (i.e. global and regional scale) with γ-mesoscale modeling in order to enable the latter adequately to handle a wide variety of synoptic situations; the Army must have the capability of providing state-of-the-art Met support anywhere in the world.

The Panel firmly believes that future Army field models (ATFMs) (i.e. γ-mesoscale models with horizontal grid size 1km by 1km) must be non-hydrostatic and nested in relocatable regional models (RRMs) with grid size 10 km by 10 km, which, in turn, are nested in global models (see Fig.1). The ATFM can be operated in the field on powerful state-of-the-art workstations. Communication with an Inter-Service Global Computation Center (ISGCC) in the US, either directly or via a regional stationary computational center (SCC), will ensure successive updating of the information necessary for the nesting of the ATFMs in the regional model. The ATFM should include facilities for incorporation of locally observed data and should allow the possibility of running the model without updating of data from the SCC in the event of a communications breakdown.

The ATFM should be supplemented by a number of specialised submodels (SSMs), with grid size typically 100m by 100m, designed for particular purposes (smoke diffusion, local wind prediction, etc.).

Thus, as indicated in Figure 1, the Panel envisages an operational framework consisting of

(a) a "Global" Center for global modeling and forecasting (ISGCC) operating on a grid size of 40km by 40km, which also operates a relocatable regional model (RRM), grid size 10km by 10km, and communicates regional-scale information, possibly via a SCC, to

(b) field stations which operate an Army Tactical Field Model (ATFM), grid size 1km by 1km, as a nested non-hydrostatic γ-mesoscale model supplemented by SSMs, grid size 100m by 100m.

The Panel strongly recommends that the Armed Forces jointly accept this as an operational framework and plan future developments according to this scenario.

(This recommendation supercedes Recommendation 10 of the Monterey Panel Meeting. However, the IGCC may well form part of a Joint Forces Atmospheric Modeling Centre (JFAMC), also incorporating a model development division.)

Framework for the supply of operational met data to the Army in the field

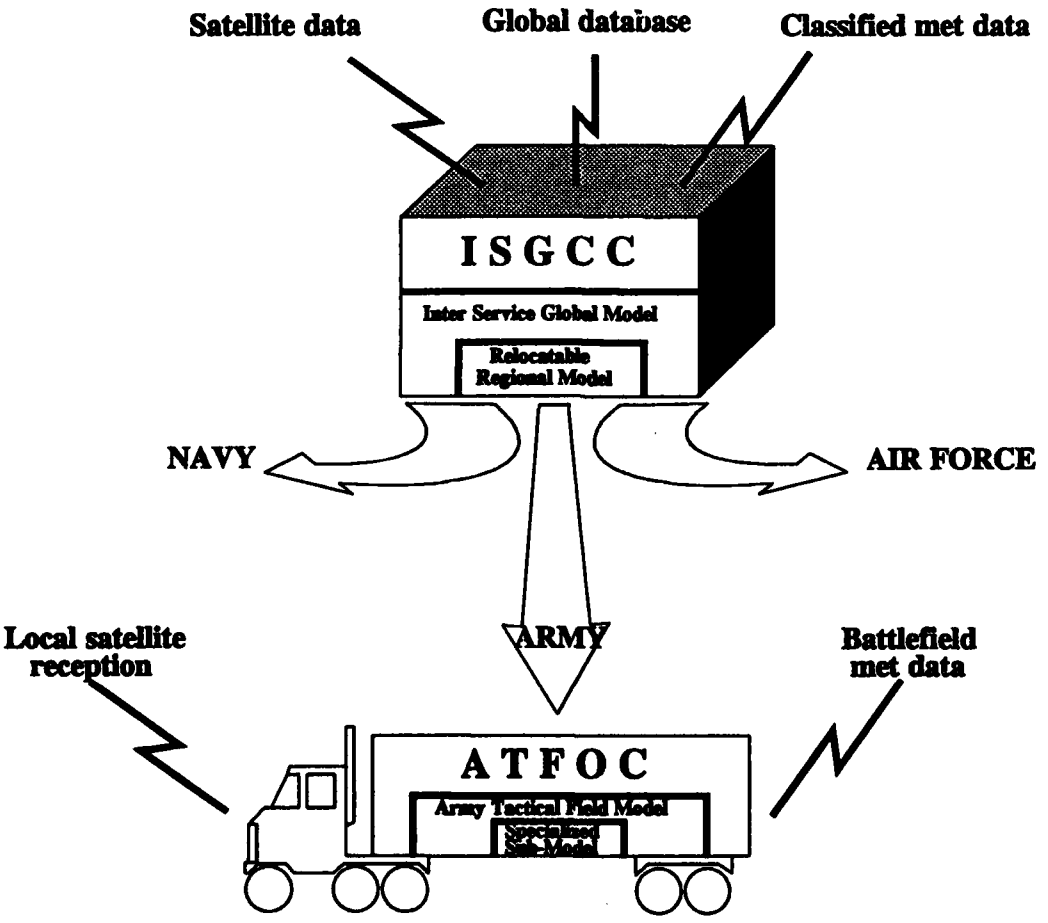

FIGURE 1

Annex 2

Report of US Army Mesomet Panel Meeting

Hotel 'Hof Zur Linde', Münster, Germany
9th - 10th September, 1993

The list of meeting attendees is attached as Annex 2.1 and the meeting Agenda as Annex 2.2.

1. Developments since Monterey meeting, 23rd-25th February 1993

The meeting commenced on a sad note with tributes to Professor Jehuda Neumann, who had died in June. He was a founder member of the Panel, much respected and a close friend to us all. It was agreed that the AMS monograph should be dedicated to him.

Professor Pearce reported that Mr. Jim Harris had informed him that the target date for delivery to the Army of an operational mesoscale model as part of IMETS had been brought forward one year to the end of FY94. His group therefore had no alternative to continuing developing HOTMAC for this purpose, irrespective of any progress made since the last meeting with the testing of the NORAPS model.

He also reported that Professor Pielke and he had made good progress in reviewing material for the AMS monograph. Revisions of only three papers remained to be submitted following referees' comments. The full manuscript should be with AMS by early October, from when it should take 4-6 months to publication.

2. Results of model comparisons

Dr. Gross presented his paper containing the statistics, scatter diagrams and time-series of meteorological quantities which he had extracted from the model results during his visit to ASL for that purpose in June. This was followed by a detailed discussion on several issues concerning the interpretation of these results, in particular relating to the difficulty of comparing the observed 'point' values with the model outputs, which were essentially averages over a horizontal 5kmx5km grid. However, the results enabled useful conclusions to be drawn when the results from different models were compared with each other.

3. Recent results from the NORAPS model

Dr. Gross reported that, despite considerable efforts having been made, notably by Dr. Sashegyi at the Naval Research Laboratory, Washington, to obtain results from the NORAPS model using the Project WIND data, to date it had not been found possible to obtain any meaningful results for Phase I and only partial results for Phase II. The model, in its present state, could not handle a thermally driven circulation. The Panel felt, however, that given further time for development, it would be the best model for the Army's needs in the medium term, particularly as a non-hydrostatic version was being developed.

4. Future modelling strategy at ASL

The Panel agreed that, in view of the disappointing performance of the NORAPS model so far, ARL had no alternative to proceding with development of HOTMAC as its first operational model. Professor Pearce was able to show transparencies prepared by Dr. Yamada illustrating some most encouraging results he had obtained with a one-dimensional version of HOTMAC, including cloud microphysics, to simulate the formation and dispersal of fog and stratus cloud. It was agreed that ARL should be encouraged to include this cloud microphysics in its first operational version (see Recommendation 1).

In the medium term, however, the NORAPS model should be regarded as offering the best prospect for the Army's purposes (see Recommendation 2) for the following reasons:

- a non-hydrostatic version was being developed by the Navy modelling group.

- it would be easier to attach to it more sophisticated physics sub-routines, also being developed by the Navy; also some of this development could be contracted out to other modelling groups, e.g. in Universities.

- the NORAPS mesoscale model was being developed to nest into synoptic-scale and global models; this was the most satisfactory way to deal with the kind of boundary problems encountered by the MMCP participants with the WIND Phase II data, corresponding to a frontal passage.

The medium term strategy proposed here envisages close collaboration between the Army and Navy meso-modelling groups. The Panel felt that this collaboration should form part of an even wider interservice collaboration involving also the Air Force, and the setting up of an Interservice Global Computation Centre, routinely operating a global atmospheric prediction model and relocatable regional models, the outputs from which are passed to Army, Navy and Air Force groups operating mesoscale (and microscale) models. This concept is described in more detail in Recommendation 5 (see Executive Summary).

5. Model comparisons in the AMS monograph

One of the purposes of the model output statistics prepared by Dr. Gross is to provide a basis for an objective comparison of the performances of the four models which participated in the MMCP. The Panel therefore discussed the results in detail and agreed some minor amendments which Dr. Gross should be asked to make in his paper. They then prepared a draft commentary section to be included in the monograph, subject to agreement with each of the four modellers. This is attached as Annex 2.3.

6. Future exploitation of Project WIND data

It was agreed that the experience gained in using the Project WIND Phase I and II data subsets had resulted in considerable progress being made, not only in understanding the details of model performance, but also in techniques of incorporating observed data into mesoscale models. The 'nudging' technique used in some models had been quite successful but still exhibited some deficiencies; also the location of mountains too close to the model boundary had led to problems which would have been avoided with

boundaries situated farther away from the region of interest.

The Project WIND data base contains a mass of data, including that from Phases III and IV which should be further exploited by the modelling community to pursue these problems. The Panel therefore strongly recommends that a second meso-modelling workshop be arranged by ARL, along lines broadly similar to those of the June 1992 El Paso workshop, to take place about 18 months following the publication of the AMS monograph, i.e. late 1995 or early 1996 (see Recommendation 4). Further data sets should be extracted from the WIND data base and distributed to modelling groups for this purpose before the end of June 1994 (see Recommendation 3). These data should be supplemented with appropriate outputs from a larger-scale model also to be incorporated into the data sets to provide larger-scale forcing into the mesoscale models.

7. Closing sessions

These were devoted to drawing up the Panel's recommendations and discussing the format of the Final Report. It was agreed that this should be prepared by Professor Pearce in draft form and distributed to Panel members for comment before presentation by him at ARL and final submission to the Army.

ANNEX 2.1

Meeting Attendees

Panel members

Dr. Niels Busch
Prof. Dr. Werner Klug
Prof. Robert Pearce
Dr. Peter White

Invited speaker

Prof. Dr. Gunther Gross

ANNEX 2.2

PROVISIONAL AGENDA

U.S.ARMY MESOMET PANEL MEETING

Hotel 'Hof Zur Linde', Münster, NW-Germany, 9-10 September, 1993.

Thursday 9 September.

0900-0930	Update on developments since Monterey meeting (a) ARL, (b) Navy model (c) AMS monograph.	R.Pearce
0930-1030	Presentation of results of model comparisons	G.Gross
1030-1100	Coffee	
1100-1130	Presentation of most recent results from Navy model	G.Gross
1130-1230	Discussion of implication of models' performance for modelling strategy at ARL.	P.White (lead)
1230-1400	Lunch	
1400-1430	Discussion of Gross paper for AMS monograph	R.Pearce (lead)
1430-1530	Formulate proposal for future exploitation of Project WIND data for US Army mesomet modelling	W.Klug (lead)
1530-1600	Tea break	
1600-1700	Outline Panel's final report	R.Pearce (lead)

Friday 10 September.

0830-1000	Formulation of Panel's recommendations for Final Report	N.Busch (lead)
1000-1030	Coffee	
1030-1230	Write-up of Final Report	All
1230-1400	Lunch	
1400-1500	Discussion and approval of Final Report	R.Pearce (lead)
1500	Close of meeting.	

ANNEX 2.3

15. COMMENTS ON STATISTICAL RESULTS

N.E.Busch, W.Klug, R.P.Pearce, P.White

15.1 Introduction

It must be borne in mind that

- The model outputs are volume averages on a horizontal 5km by 5km grid while the observations with which they are compared are point values which may in reality differ considerably from the averages. The observation sites were far from homogeneous on the grid scale, with differing terrain heights, slope inclinations, land usage and soil conditions, all of particular importance under the conditions of strong thermal forcing in Phase I.

- The rapidly changing synoptic conditions of Phase II, including a frontal passage, were not adequately imposed, through either the lateral boundary conditions or internally, in any of the models. The RAMS model, using grid nesting, made the most ambitious attempt to represent these conditions. Even in this case, however, the verification region, with its high terrain, seemed not to be able to adjust sufficiently rapidly to the imposed larger-scale changes.

- The modelers were free to decide their own initialisation and data assimilation procedures so that, inevitably, the results represent differing levels of sophistication of external forcing.

- Some modelers were able to carry out a series of experiments to determine the most appropriate values of some assigned model parameters, e.g. surface albedo and ground wetness, before generating the results published here. The results of such experiments are, in these cases, discussed in the text. They throw useful light on the physics of the modeled phenomena, particularly for Phase I; only in the case of the RAMS model was such an approach adopted for Phase II. Those results reported here which have not been preceded by such experiments must therefore not be regarded as reflecting the full potential of the models used.

15.2 Commentary

Considerable encouragement can be derived from the ability of all the models to reproduce, with good accuracy, the diurnally forced upslope and downslope winds of Phase I, including their times of onset. Also, even for Phase II, the 'nudging' procedure adopted by HOTMAC seems, after experiments to determine the optimum values of the 'nudging' parameters, to have been reasonably successful in retaining the broad-scale features of the observed changes.

Some interesting similarities and differences in the performances of the models emerge, for example,

- In Phase I, the low night-time temperatures observed at 2m over the high ground were not predicted by any of the models (Figs.14.8,14.9). No doubt two of the factors contributing to this were (1) failure of the models to resolve a strong surface inversion and (2) the differences between the model (5km by 5km average) terrain heights and the actual station heights.

- The models failed to reproduce the range of observed Phase II (and, to a lesser extent, Phase I) wind speeds, the FITNAH and TEL AVIV models completely so (Fig.14.10). This was no doubt largely due to their inability to resolve the rapid changes associated with the frontal passage as discussed above; also, in the case of the TEL AVIV model, only a couple of experiments were run, these with a most basic initialisation. On the other hand, all of the models, apart from the TEL AVIV model, reproduced the narrow range of Phase II wind directions, the RAMS model being particularly successful (Fig.14.11).

- All the models, apart from RAMS in Phase II, were reasonably successful in predicting temperature changes, apart from those over the high ground during the night in Phase I (Figs.14.3,14.12 ,Tables 14.2,14.5,14.9,14.12,14.15,14.19). The reason for this deficiency of the

RAMS model is not clear.

- The scatter diagram of wind directions for Phase I (Fig.14.2) shows a model bias towards a direction of 180 degrees in the plot for HOTMAC and, to a lesser extent, in the plot for the TEL AVIV model.

- HOTMAC was the least successful of the models in predicting the Phase I night-time cooling, not only at the hill stations, but also in the valley (Figs.14.4,14.5). The reason for this was that the thermal diffusivity and specific heat capacity of soil used in the simulations were too large. (Additional simulations carried out after the project using smaller values for these parameters resulted in temperature predictions which were in better agreement with the observations than those shown here.)

It is clear from these few selected examples that each model has been able to demonstrate some of its own particular strengths and weaknesses; none is clearly better or worse than the others overall. Each of the modelling groups involved is able to use these results to prepare its own strategy for model development. It is with this in mind that the Army has been encouraged to organise a future workshop based on experimentation with data from Phases III and IV of Project WIND in addition to further experiments with the data from Phases I and II.

ANNEX 3

OUTLINE OF AMS MONOGRAPH.

Title: Mesoscale modeling of the atmosphere

(A review based on papers presented at the U.S. Army Atmospheric Sciences Laboratory Workshop, El Paso, Texas, 16-18 June, 1992)

1. **Background of monograph.** General background, purpose of monograph, outline of contents. (RPP, RP) 4pp

Part 1 **Aspects of mesoscale modeling.**

2. **Initialisation.** (Madala) 15pp
3. **Sub-grid scale parametrisation.** (Uliasz) 15pp
4. **Terrain and surface effects.** (Warner) 15pp
5. **Incorporation of moisture.** (Straka) 15pp
6. **Radiation schemes.** (Rockel,Raschke) 15pp
7. **Model evaluation techniques.** (Hanna) 15pp

Part 2 **The mesoscale model comparison project.**

8. **Introduction.** Background, requests of participants. (RPP) 4pp
9. **Project WIND data.** (Cionco) 6pp
10. **FITNYH model.** (Gross). 10pp
11. **TEL AVIV model.** Brief description and results. (Alpert) 10pp
12. **RAMS model.** (Walko) 10pp
13. **HOTMAC model.** (Yamada, Henmi) 10pp
14. **Statistical evaluation of model results.** (Gross) 10pp
15. **Commentary** (Busch, Klug, Pearce, White) 2pp

Appendix. Model Equations (RPP) 8pp

RPP. 15 October 1993.

ANNEX 4

CONTRIBUTORS TO AMS MONOGRAPH 'MESOSCALE MODELING OF THE ATMOSPHERE'.

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