Colorado State University
Center for Geosciences/Atmospheric Research (CG/AR)
Quarterly Report No. 6
by T.H. Vonder Haar and Collaborators

Reporting period: July 1-September 30, 2003

Cooperative Agreement #DAAD19-02-2-0005

Overview

[Note: For this reporting period, the same technical contents will be submitted under Cooperative Agreements #DAAD19-01-2-0018 and DAAD19-02-2-0005. At the request of the Army Research Laboratory Contracts Office, the new CA began May 8, 2002, overlapping the previous CA by 5 months. By design, the Center for Geosciences/Atmospheric Research activities are phasing into the new CA as they phase out of the previous CA (now to end September 30, 2003).

CIRA researchers presented results of CG/AR-funded research work at the 2003 BACIMO conference, held August 9-11 in Monterey, California. Those presenting significant findings were: Dr. Jones, Dr. Vukicevic, Mr. Eis, Mr. Forsythe and Mr. Kankiewicz. Please see the following report for further details on these presentations.

Using AFWA AGRMET data as a land surface temperature first guess, Dr. Jones and Mr. Forsythe have generated the first 1DVAR Microwave Optimal Estimation (MOE) retrievals.

Dr. Larry Carey (Texas A&M) has completed the re-analysis of radar-derived mixed-phase cloud statistics for all CLEX-9 case studies.

Dr. Vonder Haar's student, Curtis Seaman, has successfully defended his Master's thesis on the topic of radiative heating characteristics of mixed-phase clouds observed during the CLEX-9 field campaign.

Comparisons of improved infrared cloud detection methods (Mr. Reinke and Mr. Kankiewicz) with sophisticated MODIS cloud detection schemes indicate that significant improvements have been made with geostationary-based cloud detection methods.

Ongoing expansion of the CASC2D hydrological model will incorporate chemical transport and mass transfer/transformation processes. Additionally, collaborations are underway to implement computational strategies that will significantly reduce the time required to complete model simulations.

To facilitate CIRA's high-resolution 4D data assimilation efforts, RAMDAS has been ported over to NCAR's super-computing environment.

[Note of interest: AFRL is in the process of rejuvenating its atmospheric research 6.2 program and will be hiring several advanced-degreed meteorologists in the near future. CG/AR will make a special effort to establish relations with this new group.]

Mr. Adam Kankiewicz

For more information on the DoD Center for Geosciences/Atmospheric Research at Colorado State University, please access our web page at http://www.cira.colostate.edu

Colorado State University
Center for Geosciences/Atmospheric Research
Scientific Interactions December 2001 to Present

- Tom Vonder Haar, Ken Eis, et al. with BGen. Johnson, USAF/XOW
- Ken Eis attended NRL Annual Program Review
- Ken Eis briefed AFMC Wright-Patterson AFB Sensor Directorate
- Ken Eis participated in the ARL/CISD Technical Assessment Board (TAB) Review – Dennis Thompson, Bruce Hicks, Eugenia Kalnay, Jon Mercurio, Jim Gantt, N. Radhakrishnan, Dan McMorrow, Bob Dumais, Dennis Garvey, Don Hoock, and Doug Brown
- Ken Eis, Tom Vonder Haar, Stan Kidder, Don Reinke, John Forsythe and Cindy Combs with Drs. John Zapotocny, AFWA and Ed Hume, UPOS/JHU
- Large and small group interactions at the Annual Review, held at ARL/Adelphi, including:

  Tom Vonder Haar, Ken Eis, et al. with DoD Review Panel and invited attendees

  Dr. Azimi with Mike Mungiole, Pam Clark, Alan Wetmore, Doug Brown, John Zapotocny, and other attendees briefly

  John Davis, Sonia Kriedenweis and Robert Banta met with Pam Clark, Kris Gurton, David Ligon, Steven Hill, J. Pendleton, Ronald Pinnick, Alan Wetmore, D. Garvey, G. Videen, and Donald Hooke (via conference call), ARL, Atmospheric Effects Branch

  Rob Newsom, Adam Kankiewicz, Capt. Jones, Ben Ruston and John Davis with Dennis Garvey, David Ligon, John Noble, Young Yee, Edward Vidal, Jimmy Yarbrough

  John Forsythe with Larry Carey, Larry Key, John Zapotocny, and Pat Phoebus

  Andy Jones with Nathaniel Winstead, Richard Gasparovic, Louis Butler, Frank Minaldo, Pam Clark, Gary McWilliams, Alan Wetmore, and Pat Phoebus

  Jim Jones with Frank Garcia, John Zapotocny, Jon Mercurio, Doug Brown, Pat Phoebus, Young Yee, and Vince Larson

  Pierre Julien with Doug Brown, Frank Garcia, John Zapotocny, and Roger Smith

  Stan Kidder with Ed Hume, Dan McMorrow, and Mike Kelly, UPOS

  Sonia Kreidenweis with Doug Brown and Pat Phoebus

  Vincent Larson with Walter Bach, ARO

  Tim Nobis with Robert Banta, NOAA/ETL, Col. Key, and Pat Phoebus

  Roger Pielke, Sr. with Jon Mercurio

Jorge Ramirez with Doug Brown, John Zapotocny, Roger Smith, and Vincent Larson

Tomi Vukicevic with Jon Mercurio, Pat Phoebus, and Dr. Mango

Loretta Wilson with Doug Brown, Linda Duchow, staff of the BED office and some interactions with the Review Panel

Milija Zupanski with Doug Brown, Pat Phoebus, John Zapotocny, Leander Page, Vincent Larson, and Robert Banta

- Christian Carrico with Dr. Doug Lowenthal and others, NRL
- Ken Eis, Don Reinke and Capt. James Jones with Col. Benson and staff, AFWA
- Tim Nobis with Dr. Jimmy Adegoke, University of Missouri-Kansas City
- Tomi Vukicevic with Dr. N. Baker and COAMPS modeling group, NRL
- Mr. Gary McWilliams (ARL) visited Andy Jones regarding the NPOESS IPO/ARL soil moisture work
- Mr. George Gayno (AFWA) visited Andy Jones and John Forsythe regarding the USAF AFWA AGRMET data usage in the CG/AR work
- John Forsythe and Ken Eis with Maj. Ed Bensman, AFCCC
- Roger Pielke, Tomislava Vukicevic and others with participants of the Forum on Modeling the Atmospheric Boundary Layer
- Adam Kankiewicz with Dr. Jason Nachamkin (NRL)
- Ben Ruston with Dr. Nancy Baker and data assimilation group at NRL
- Andy Jones, Tomi Vukicevic, Ken Eis, John Forsythe, Adam Kankiewicz, and Tim Nobis attended the BACIMO 2003 Conference and had numerous interactions with researchers from the Army, Navy and Air Force labs, as well as other participants

Research Theme: Hydrometeorology

Administrative

Prof. Pierre Julien and Dr. Rosalia Rojas
PhD student Mark Velleux joined the research project and was introduced at the CG/AR informal research progress meeting in Fort Collins on July 29 by Rosalia Rojas.

Dr. Jorge A. Ramírez
Efforts to identify and recruit a graduate student to work on the project have been unsuccessful thus far. Dr. Ramirez hopes to be able to do so by January, 2004.

Research activity and/or results

Dr. Andrew Jones
The first 1DVAR microwave emissivity results were created using the USAF AFWA AGRMET data set as a land surface temperature (LST) first guess. Results are shown in the BACIMO 2003 paper 6.05.

Assisted with the preparation of four papers for the BACIMO 2003 conference. Attended the conference and gave the oral presentation of paper 6.05 and presented posters for papers P1.20 and P2.13.

Phil Stephens has completed the 2D Backus-Gilbert (BG) implementation. Currently timings of the code are being performed and code documentation is in progress.

A presentation was made with Dr. Vukicevic entitled "All Weather Data Assimilation" at NOAA/FSL, Boulder, on August 4.

Another presentation was made on August 20 at NOAA/ETL, Boulder, entitled "Low Frequency Passive Microwave Satellite Data Assimilation Research for Retrieving Deep (10-100 cm) Soil Moisture Information." Also on that day, I visited with Pat Hanes at NOAA/NGDC.

The WindSat Observational Operator journal paper has been accepted by *Journal of Hydrometeorology.*

Prof. Pierre Julien and Dr. Rosalia Rojas
The CASC2D hydrological model is being expanded to add chemical transport and mass transfer/transformation processes to the basic framework. As part of these expansions, basic model implementations of hydrologic and sediment transport processes are being reviewed and revised to streamline code operation and permit the most efficient storage of results for use with chemical transport calculations. Review and revisions of hydrologic transport processes is nearing completion. We anticipate that review and revision of sediment transport will be completed during the upcoming quarter. In addition to these model developments, a collaborative effort with Dr. Sanjay Rajopadhye (CSU Computer Sciences Department) was initiated. The goal of this effort is to explore the potential to implement alternative

computational strategies that have the potential to significantly reduce the time required to complete model simulations.

Travel

Dr. Andrew Jones traveled to Monterey, California, to participate in the BACIMO 2003 Conference, September 8-12.

Technology transfer

[See also the section under the Technology Transition and Interactions research theme].

Equipment/systems status

Prof. Pierre Julien and Dr. Rosalia Rojas
CG/AR purchased a high performance workstation to facilitate ongoing numerical watershed model development efforts. The workstation is Hewlett-Packard (HP) zx6000 workstation with two (2) Intel 1.3 GHz Itanium2 64-bit processors, 1.5 GB of RAM, 146 GB of disk storage (RAID1), and the Windows XP 64-Bit Edition operating system. In addition, CG/AR refurbished/replaced two four year old Pentium II-based personal computer systems with units that meet current computational stations. These new systems will be used for future numerical model development.

Research Theme: Cloud Structure, Dynamics and Climatology

Administrative

John Forsythe
Served on the search committee to select a research support person to work on CG/AR ½ time.

Met with Dr. Manajit Sengupta (new CG/AR researcher) several times to introduce him to CIRA researchers. Provided him with a microwave radiative transfer model.

Met with Matt Nielsen, a new M.S. student advised by Dr. Vonder Haar, weekly to introduce him to scientific programming. It is likely his thesis topic will involve microwave remote sensing and be relevant to CG/AR.

Research activity and/or results

J. Adam Kankiewicz, CLEX Leader
Prepared and presented a poster titled "Comparison between the new CDFS-II WWMCA product and the chances and modis global cloud products
" at the 2003 BACIMO conference. Response to this research was good, with many positive comments received. Fran Bieker (AFWA) was very interested in our results and expressed interest in incorporating some of this work into AFWA's CDFS II processing environment.

Also at the 2003 BACIMO conference, I gave a talk titled "Improved infrared cloud analysis and regional cloud products from the chances global cloud database." This presentation went very well. Several inquiries about our work were received at the conference. Areas for possible collaboration are being followed-up on.

While in Monterey for the BACIMO conference, I visited The Center for Interdisciplinary Remotely-Piloted Aircraft Studies (CIRPAS) to learn more about their Twin Otter aircraft. The Twin Otter aircraft has state-of-the-art cloud microphysical, cloud radar and lidar capabilities making it an excellent choice for future CLEX-related field experiments.

While visiting the Naval Research Lab (NRL), I met with Dr. Jason Nachamkin who is in charge of cloud forecast verification for Coupled Ocean/Atmospheric Mesoscale Prediction System (COAMPS). Jason has agreed to run COAMPS on several of the CLEX-9 case studies to see how it handles the CLEX-observed clouds. In-situ data collected during CLEX-9 will be shared with Jason to help validate the COAMPS forecasts.

The archiving of Cloud Depiction and Forecast System (CDFS II) World-Wide Merged Cloud Analysis (WWMCA) (both bogused and unbogused data) onto DVD media continues at CIRA.

I provided Curtis Seaman both thesis feedback and GOES IR satellite data in support of his MS degree work.

Collaboration with Larry Carey and Vince Larson on the CLEX overview journal article continues. Graphs, figures and text needed in the article are being completed for the final draft.

Ray McAnelly and I have begun RAMS simulations of the 2 Nov 2001 CLEX-9 case. Horizontal and vertical grid nesting schemes are being tested to identify the optimal configurations needed for our simulations. Early runs indicate that the moisture fields are underestimated within the model. Further work on these simulations (including modeling other CLEX-9 case studies) continues.

John Forsythe
Generated first results from Microwave Optimal Estimation retrieval (MOE). Hooked up data feeds to AMSU and AGRMET. Code exists within the DPEAS environment. Am currently working through a task list to implement code and science upgrades. Have retrieved emissivity and moisture profiles over CONUS, will expand to global capability eventually.

Wrote a table of "lessons learned" throughout the CLEX experiments. Gave to Larry Carey for inclusion in the BAMS paper.

Analyzed results form latest CHANCES / MODIS comparison. Continued writing paper in collaboration with Reinke et al.

Attended dry run of Curtis Seaman's M.S. (CLEX-related) defense and gave him feedback.

Met with Capt Jim Jones (USAF) and outlined a plan to publish his M.S. thesis on cloud top retrieval error via various satellite techniques.

Don Reinke
CHANCES Regional Products
Completed a paper (and assisted with several posters) for the BACIMO 2003 conference. Met with Dr. Azimi's new students to discuss possible research areas and also to assist them with some background information about CIRA and the availability of software and data for their research under CG/AR.

I prepared a paper for oral presentation at BACIMO 2003, as well as a companion paper for online proceedings.

Cynthia Combs
CHANCES Regional Products
Copied wind regime products for Baghdad, Riyadh, and Kabul to DVDs. Also backed up programs and procedures.

Edited CHANCES RP paper for the BACIMO conference in Monterey.

Vincent E. Larson (University of Wisconsin-Milwaukee)
During this time period, two undergraduate students, Brian Griffin and Kurt Kotenberg, worked on this project.

I have had an article accepted to *Journal of the Atmospheric Sciences*. The article is entitled "Prognostic equations for cloud fraction and liquid water, and their relation to probability density functions." This manuscript discusses the theory behind prognostic cloud schemes such as Tiedtke's scheme, which is used by ECMWF. The theory should be useful for parameterizing clouds such as the mid-level clouds studied in the CLEX field experiment. I am continuing to write a modeling section of a collaborative manuscript on CLEX. The manuscript will be submitted to *Bulletin of the American Meteorological Society*. I have continued modeling altocumulus clouds. I have been adapting the new Weather and Research Forecast (WRF) model to simulate altocumulus clouds. We have now implemented solar radiation and subsidence forcing. Both tend to diminish the 11 Nov 2000 cloud that we studied, but subsidence forcing appears to be the greater effect for this cloud, which was located far north.

Dr. Larry D. Carey (Texas A&M University, formerly North Carolina State University)
Completed detailed analysis of cloud radar and in-situ microphysical data along flight tracks for CLEX-9 case on 2 November 2001.

Completed re-analysis of CLEX-9 (Complex Layered Cloud Experiment) mixed-phase cloud ensemble statistics for cloud radar reflectivity, radar derived ice water content, and in-situ measured ice and liquid water content for *all* CLEX-9 in-cloud data. Data was organized in frequency histograms as a function of height and in total histograms (all heights). Began compiling case study data and analysis (14 Oct and 2 Nov) and ensemble statistics for delivery to CG/AR in the form of a report and data files. Prepared research presentation on CLEX-9 case studies for 31st International Conference on Radar Meteorology, held August 6–12 in Seattle, WA. Began preparation of scientific manuscripts a) Overview article for Bulletin of American Meteorological Society and b) Detailed science article based on radar and in-situ microphysics from case studies for Journal of Applied Meteorology.

Gave oral presentation on CLEX-9 radar and cloud microphysics case study results at 31st International Conference on Radar Meteorology, August 9, Seattle, WA. I interacted closely with several prominent cloud radar, microphysics and radiation scientists, including Dr. Thomas Ackerman (Chief Scientist, Department of Energy, Atmospheric Radiation Measurement Program), Dr. Anthony Illingworth (University of Reading, England), and Dr. Sergey Matrosov (NOAA Environmental Technology Lab). Consensus among group was that mixed phase clouds are getting more attention from the atmospheric science community recently but knowledge gap on microphysics, radiation, kinematics and forecasting is still very large. Issues related to radar and other remote sensing, radiation interaction, climate effects, and microphysics were discussed at length. There is strong interest in CLEX data and analysis in the general radar and cloud physics communities.

Travel

Travelers to BACIMO 2003 in Monterey, California were John Forsythe (Sept. 8-12) and Adam Kankiewicz (Sept. 8-13). Adam also visited CIRPAS and NRL on September 12.

Technology transfer

[See also the section under the Technology Transition and Interactions research theme].

John Forsythe
Taught an inaugural two-hour workshop "Scientific Computing at CIRA" to students and new CIRA researchers on August 13. Received positive feedback; will likely make this an annual or semi-annual event.

Equipment/systems status

John Forsythe
Full upgrade on ERIDANUS 9/18/03: 2.8 GHz Pentium IV CPU. 1.5 GB RAM. 250 GB storage. DVD writer. System functioning nominally.

Research Theme: N-Dimensional Data Assimilation and Fusion

Administrative

The new research scientist arrived in mid-August and was introduced to the Data Assimilation Group by Dr. Vukicevic. Dr. Manajit Sengupta will collaborate on further development and implementation of visible and infrared satellite measurements in data assimilation for high resolution 4D regional weather analysis: fusion of satellite observations with mesoscale weather prediction models.

Research activity and/or results

Dr. Tomislava Vukicevic
High resolution mesoscale data assimilation research requires that weather prediction models are run on spatial grids with grid steps of less than 5 km. This in turn requires high performance computing. To facilitate testing of the mesoscale data assimilation state of the art 4D algorithm developed in CIRA (RAMDAS) in the high performance computing environment I have been porting this algorithm to the National Center for Atmospheric Research (NCAR) super computer since August 2003. The results so far show that the high performance computing facility equivalent to NCAR's would be able to support the high resolution data assimilation computations with reasonable efficiency. For example, a 6 h real time cycle of the data assimilation could be completed in about 1.5 h on about 64 CPUs. Further investigation of the efficiency and accuracy of the high resolution 4D data assimilation in the super computing environment is underway.

Dr. Dusanka Zupanski
The manuscript reporting the research using two 4-dimensional variational data assimilation systems (RAMDAS and the NCEP's Eta model system) has been prepared and submitted to Monthly Weather Review.

Provided assistance to Tomislava Vukicevic in porting the RAMDAS system to the NCAR IBM SP computer.

Dr. Milija Zupanski
Most of the work this quarter was focused on completing the manuscript on the structure and performance of the Regional Atmospheric and Modeling Data Assimilation System (RAMDAS), developed under CG/AR.

Dr. Manajit Sengupta
Work during this period involved upgrading the observational operator being used for data assimilation in RAMDAS. This involved obtaining and investigating the possibility of upgrading to a new revised version of the program which computes gaseous extinction for single narrow bands corresponding to satellite radiance measurement channel. The older version was called OPTRAN while the newer version called NCEP/NESDIS community model is currently being used at NCEP and is expected to be more stable than the earlier version. Also replacement of the current radiative transfer model SHDOM by a faster version was investigated. The new

model SHDOMPP was obtained and will be implemented. These upgrades will increase the efficiency and stability of the observational operator.

Travel

Dr. Tomislava Vukicevic traveled to Monterey, California, to attend and present papers at the BACIMO 2003 Conference, September 9-11.

Technology transfer

[See also the section under the Technology Transition and Interactions research theme].

Research Theme: Chemistry, Aerosols and Visibility

Administrative

New masters student Laura Sample arrived on campus in July; she began coursework in mid-August.

Research activity and/or results

Profs. Sonia Kreidenweis and Graeme Stephens, Dr. Laurent Labonnote, and Laura Sample

Laura Sample began learning how to use Mie codes and how to compute optical properties of aerosol size distributions. The goal of Laura's thesis research is to develop a methodology to combine MODIS-type radiances with CALIPSO lidar-in-space data into an improved algorithm that utilizes data from both instruments to characterize atmospheric aerosols. Laura's initial focus is to use the MODIS aerosol models, which are applied in the MODIS inversion algorithms, and compute lidar backscatter-to-extinction ratios for those models. This work was completed for the individual models. However, the MODIS algorithm allows for combination of independent contributions from two modes to match the total aerosol radiances. We are presently developing methods for combining pre-calculated lidar ratios for the individual modes, using the relative mode weighting returned from MODIS retrievals. Our intent is to apply these ratios to one year of MODIS ocean retrievals to begin to understand the range of lidar ratios that can be returned from the existing MODIS algorithm.

Dr. Rob Newsom

From 26 June until 17 July, 2003 Rob Newsom participated in the JU2003 experiment in Oklahoma City, Oklahoma. The purpose of this experiment was to study dispersion in an urban setting. Downtown Oklahoma City was heavily instrumented with a variety of meteorological sensors. Additionally, two Doppler lidars were deployed at locations outside the main central business district. One of these lidars is owed by Arizona State University (ASU); the other lidar is owned by the US Army Research Laboratory (ARL). Rob assisted ARL in lidar operations and performed data post-processing, including dual-Doppler analysis and 4DVAR; he also coordinated dual-Doppler scan strategies.

Travel

Dr. Newsom was in Oklahoma City June 26-July 17 to participate in the Joint Urban (JU2003) dispersion field experiment.

Technology transfer

[See also the section under the Technology Transition and Interactions research theme].

Equipment/systems status

No report during this period.

Research Theme: Remote Sensing of Battlespace Parameters

Administrative

Prof. Mahmood R. Azimi-Sadjadi
Two new graduate students, Ms. Amanda Falcone and Mr. Vincent Wong, joined the CG/AR research group in July. Miss Falcone has a B.S. Engineering Science degree with specialization in Electrical Engineering from Trinity University in San Antonio, Texas and Mr. Wong is holding a M.Sc. degree in Computer Engineering from Rochester Institute of Technology, New York. They will be working under the supervision of Dr. Azimi at the Electrical and Computer Engineering Department on cloud classification using combination of GOES and radar data and aerosol detection and classification using MSG-1 data that will be available later this year.

Research activity and/or results

Dr. Stanley Kidder
This quarter I continued to work with Mike Kelly of UPOS to implement my cirrus detection scheme at AFWA. Mike visited AFWA and has obtained some AFWA GOES data. I worked with him to understand the GOES data format and to apply the code that I sent him last quarter.

Benjamin Ruston
Benjamin Ruston is completing his PhD dissertation on microwave land emissivities, and plans to defend his dissertation by the end of 2003. At microwave frequencies the atmosphere is semi-transparent. Consequently, a satellite radiance measurement contains a large fraction of energy from the Earth's surface. Microwave radiometers have been in space beginning in the early 1970s, and shown a utility to retrieve atmospheric variables such as total precipitable water, cloud liquid water, and more recently temperature and moisture profiles. However, these retrievals (or assimilation of radiances) are frequently not performed over land surfaces due to the poor characterization of the underlying land surface; specifically the skin temperature and surface emissivity.

Recent accomplishments by Ruston at CG/AR include implementing infrared retrieved Land Surface Temperatures (LST) and microwave emissivities retrieved at CIRA CG/AR into a one-dimensional variational retrieval at the Naval Research Laboratory (NRL) at Monterey, California. This collaboration with the data assimilation group at NRL and the co-investigator was Dr. Nancy Baker. The collaboration included a visit by Ruston to NRL, August 12-21. The results of this study showed a significant impact on the temperature and moisture profiles at the lower levels in the atmosphere. This collaboration is a benchmark study that will establish the feasibility of satellite microwave retrievals of temperature and moisture over land.

Dr. Nancy Baker developed a one-dimensional variational (1DVAR) retrieval of moisture and temperature using satellite microwave data for implementation into the NRL Atmospheric Variation Data Assimilation System (NAVDAS). This retrieval was used to begin retrievals of temperature over the world's oceans using the Advanced Microwave Sounding Unit (AMSU). Ruston began to prepare for a test case over the Atmospheric Radiation Measurement (ARM) program's Southern Great Plains (SGP) site in northern Oklahoma. Preceding the trip to NRL,

Ruston retrieved Land Surface Temperatures (LST) and microwave emissivities from AMSU data for July and August of 2000-2002. The defaults over land in the 1DVAR retrieval were a fixed emissivity value of 0.9, and LST provided by the NOGAPS model. Figure 1 shows the improvement in reproduction of the observed AMSU brightness temperatures when the retrieved LST and microwave emissivities are used.

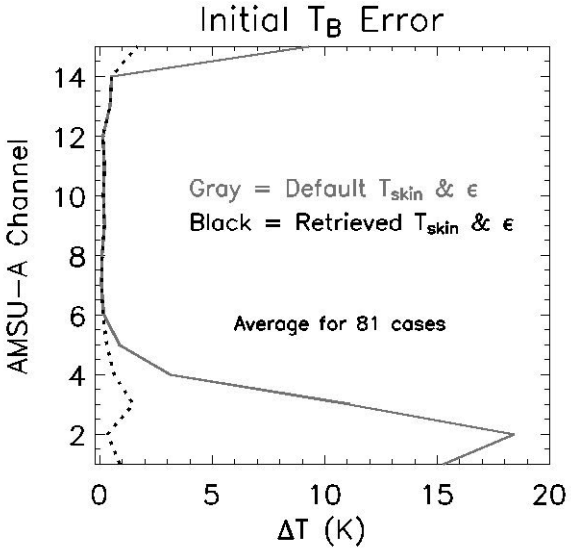

Figure 1: Initial brightness temperature errors compared to AMSU observations using default values, and CG/AR retrieved microwave emissivity values.

The chi-squared, χ^2, test is used to examine the assumption of a Gaussian distribution of errors. The control case, using the NOGAPS default skin temperature and a fixed emissivity of 0.90, has a χ^2 of 390.28, implying that our retrieval errors are not consistent with our *a priori* and observation error assumptions. The CG/AR case using the retrieved skin temperature and AMSU emissivities had a χ^2 of 1.36, which corresponds to a 96% confidence level. Both the control case and the CG/AR case had perturbations in the moisture and temperature fields in the lower levels of the atmosphere. The χ^2 test helps the researcher to distinguish if the perturbations are to be trusted. Simply put, if the microwave land emissivity estimate is not accurate the retrieval will make large perturbations to the microwave land emissivity and the moisture and temperature values in the lower atmosphere to try to simulate the brightness temperature observed. An accurate microwave land emissivity with a low error allows for accurate retrievals of the boundary layer temperature and moisture field. These results emphasize the importance of accurate microwave land emissivity estimates in retrieval of low-level temperature and moisture fields, and show promise in retrieval of these parameters over land in data sparse regions.

Prof. Mahmood R. Azimi-Sadjadi, Amanda Falcone, and Vincent Wong

Cloud Structure

A new method has recently been devised for use in labeling training data. This method should eliminate a great deal of time required for the expert to spend labeling the data for training. The steps involved in this approach are:

- Apply a Self-Organized Map (SOM) neural network to perform unsupervised clustering of the training set. This network automatically clusters the training set into *n* clusters only based upon the similarity of the features that have yet to be determined. These classes (*n*) are meaningless in the sense that they are not associated with any specific cloud types that we have defined.
- The clusters will then be displayed as polygons on the visible and IR images.
- An expert will label each of the *n* clusters as a specific cloud type. This reduces the time required for expert intervention greatly as the expert need only specify the type of cluster, rather than create the clusters. Additionally, this reduces the possibility of wrong labeling particularly in small areas within the enclosed areas.
- This data will be used to train the temporal updating neural network used for cloud classification.

Another idea being considered involves using radar data integrated with satellite data for creating a training data set for the temporal updating neural network. In order to perform this integration, the satellite data and radar data must be compared to fully understand the correlation between the two datasets.

Aerosols

Researched all publications related to aerosol detection and the MSG-1 satellite. Focus remained on aerosol retrieval by means of off-nadir (MSG-1 viewing the Middle East region), multi-spectral and multi-angle (solar) detection using high temporal frequency time-series imagery. Explored the radiative transfer model with the 6S (Second Simulation of the Satellite Signal in the Solar Spectrum) Radiative Transfer Code. Intention was to perform a sensitivity analysis of aerosol signal over desert environment. The atmospheric correction by Successive Order of Scattering employed by the 6S is particularly useful in understanding the aerosol dependency on sun-angles and viewing angles. Depending on the outcome of the sensitivity analysis of aerosol signal over desert environment, methods to combine the shortwave and longwave radiations as the means to detect the subtle signature of aerosols over bright homogeneous desert cover may be investigated. The near-term goal remains to complete the sensitivity analysis of aerosol signal over desert environment.

Prof. Roger Pielke, Sr., Dr. Adrian Marroquin, Maj. Tim Nobis and Giovanni Leoncini

Along with other researchers, Dr. Adrian Marroquin presented his recent work (reported in the previous Quarterly Report) at the CG/AR informal research progress meetings in Fort Collins on July 30. Work planned included: continued tests with new 3s (93-meter resolution) terrain data over the Salt Lake City area; continuing work on integration of a true land surface model in LAPS to allow a more realistic initialization package; and continued exploration of the use of 4DDA to initialize the RAMS simulations.

[Subsequent to the presentation, Dr. Marroquin's failing health worsened. We are saddened to report that he passed away on September 30th. Drs. Pielke and Vonder Haar will explore the future possibilities of this particular phase of research and will coordinate plans with the Cooperative Agreement Manager, Dr. Douglas Brown. Undoubtedly, because of his unique background and experience, some components of Dr. Marroquin's work may not be able to be pursued by another researcher.]

Maj. Tim Nobis
Most of my efforts focused on the coupling of the RAMS model with the TEB urban parameterization. Made great strides with this and should have a fully coupled system with results by the end of the next quarter.

Also working with the Grads program. Downloaded, installed, and working to learn this application. It is what I will use to display all of my results.

Giovanni Leoncini
I found and fixed a bug for RAMS 4.3 on Solaris 2.9 with the Forte 7 F90 compiler: the arrays DTLONGN and NNACOUST are never initialized before the call to the subroutine NEWGRID which divides DTLONG(ngrid) by NNACOUST(ngrid). To fix it, the initialization must be forced by adding the lines

nnacoust(1:ngrid)=nacoust
dtlongn(1:ngrid)=dtlong

prior to the call to NEWGRID. A good place for this is before the call to INITLZ in the subroutine rams_master (file rdrive.f90), or right after DTLONG and NACOUST are read from the RAMSIN file in the subroutine NVFILL (file rname.f90). Craig Tremback, suggesting the first fix, said that the second line is strictly not necessary if your compiler lets you have Inf or Nan, because both arrays are initialized right after the call to INITLZ.

I tested the RAMS subroutine to compute derivatives by computing the divergence of the heat flux I ingested with a formula. After accounting for the different types of grid points, I obtained results that matched the analytical results.

I began adding a hydrostatic option to RAMS 4.3. I located the position in the code where I needed to add the integration of the continuity and hydrostatic equations, now I am struggling to get the map and terrain factors correct.

I also grouped all the modifications I made to RAMS into a series of options in the RAMSIN file in order to have more flexibility.

Now that the code is looking more complete, I am evaluating the best strategy to tackle my runs and how to verify the Dalu et al. (2003) results in relation to the hypotheses found in the 2 equation sets (RAMS and Dalu et al. 2003). I was also able to obtain a Poisson equation for the Exner function's Laplacian that is comparable to Dalu et al. (2003).

Profs. William Cotton, Russell Chibe, Gustavo Carrio, and David Stokowski
Russell Chibe completed a journal paper based on his M.S. thesis research. The paper entitled "The real-time 3-D simulation of a fog event with a cloud-resolving mesoscale forecast model" was submitted to *Journal of the Atmospheric Sciences* in August 2003.

Dr. Chris Golaz, a researcher from the Naval Research Lab in Monterey under support of the Center for Geosciences, visited to share his simplifications to the scheme that will permit more efficient computations with the model when installed in RAMS or COAMPS. He presented a special seminar at CIRA on August 1 entitled "Improvements and Simplifications to a PDF-Based Boundary Layer Closure."

Dr. Gustavo Carrió reports that recent results presented by Dr. Golaz suggest it is possible to reduce the number of prognostic equations in his boundary layer parameterization. The version implemented into RAMS now considers both formulations, so that the reduction of the problem dimensionality is a model option. The higher moments diagnosed in the new version can be prognosed (and stored) or diagnosed according to the choice between two levels of detail (and computational cost) in the description of the PDF's.

David Stokowski has recently arrived at Colorado State University to work on a Masters of Science in Atmospheric Science. David has begun by working specifically on his coursework: Cloud Physics and Thermodynamics; Atmospheric Dynamics; Atmospheric Chemistry; and Synoptic Weather Lab. The work David is doing in Atmospheric Chemistry should be directly applicable to the project at hand. He has chosen a research project which will look at current research related to the modeling of atmospheric distributions of visibility obscuring aerosols, with specific focus on dust. David's final project title has not yet been formulated, nor have specific research papers been identified from which the project will come.

RAMS was run in realtime in support of the BAMEX field campaign centered about St. Louis, MO. The objective was to forecast MCSs and, in particular, box-echo squall lines, MCVs, and derechos. We find that the fine grid covered too small an area to be effective for the large experimental area. So, we mostly used grid 2 with 12-km spacing. Even with this limitation, the model exhibited considerable skill in identifying MCSs and bow echo storms.

Travel

Dr. Chris Golaz traveled to Fort Collins, Colorado to give a seminar at CIRA, July 30-August 6.

Ben Ruston traveled to NRL in Monterey, California, August 10-23.

Timothy Nobis traveled to Monterey, California, to attend BACIMO 2003, September 8-12.

Technology transfer

[See also the section under the Technology Transition and Interactions research theme].

Benjamin Ruston
Infrared retrieved land surface temperatures, and AMSU emissivities were provided to NRL-Monterey and implemented into Dr. Nancy Baker's 1DVAR retrieval.

Equipment/systems status

Todd Gamber

The newest Geosciences cluster has been frustrating our research staff with frequent hardware failures resulting in cluster unavailability. Two hardware issues are of concern. The first issue, faulty CPU fans, is responsible for half of our downtime. Nearly every CPU fan shipped with this cluster has failed during runtime and since been replaced. The second issue, which was at first believed to be bad memory, is seemingly resolved. Frequent system freezes in the "master" cluster node followed a pattern typified by bad memory. However, the problem was, in fact, a software bug in the Linux operating system. After a small software upgrade, the cluster remains stable (aside from power outages).

In addition, we are also experiencing problems with consistency of model output of the data being dependant on the number of nodes used in the cluster. At this time, we believe the problem lies in software either in the RAMS model itself, or in the message-passing libraries installed on these machines.

Research Theme: Technology Transition and Interactions

Mr. Lance Landry, Military Legislative Assistant to Senator Wayne Allard, visited CG/AR on August 20 and was briefed on recent Center research results and current DoD relevance.

CG/AR research results were presented in September at the BACIMO 2003 Conference held in Monterey, California through the following papers:

Chibe, R., W. Cotton: Numerical forecasting of fog with the RAMS@CSU cloud-resolving mesoscale forecast model (poster P2.12).

Combs, C., K. E. Eis, T. H. Vonder Haar: Smart climatology: wind-stratified cloud products from combined satellite cloud observations and model output wind fields (oral presentation, paper 9.03).

Jones, A. S., J. M. Forsythe, S. Q. Kidder, and T. H. Vonder Haar: Extension of a 1DVAR passive microwave algorithm for near-real time atmospheric profiles and emissivity over land (oral presentation, paper 6.05).

Jones, A. S., T. Vukicevic, P. J. Stephens, and T. H. Vonder Haar: Low frequency passive microwave satellite data assimilation research for retrieving deep (10-100 cm) soil moisture information (poster P2.13).

Jones, J. C.: Cloud top heights of mid-level, mixed-phase clouds from CLEX-9 (poster P2.26).

Kankiewicz, J. A., J. M. Forsythe, D. Reinke, and K. E. Eis: Comparison between the new CDFS-II WWMCA product and the chances and modis global cloud products (oral presentation, paper 2.23).

Newsom, R., R. Banta: Sensitivity analysis of wind and temperature retrievals from coherent doppler lidar data (poster 1.21).

Reinke, D., J. M. Forsythe, J. A. Kankiewicz, C. Combs, K. E. Eis, and T. H. Vonder Haar: Improved infrared cloud analysis and regional cloud products from the chances global cloud database (oral presentation, paper 9.07).

Ruston, B., T. H. Vonder Haar, and A. S. Jones: Microwave land emissivity over complex terrain (poster P1.20).

Vukicevic, T., M. Zupanski, D. Zupanski, T. Vonder Haar, and A. Jones: Mesoscale cloud state estimation from visible and infrared radiances (oral presentation, paper 6.03).