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, 2007

Cooperative Agreement #W911NF-06-2-0015

A view outside of the National Research Council of Canada's Convair-580 research aircraft during the CLEX-10/C3VP field program.

Overview

The Hydrometeorology theme area reports continued research progress from both of Prof. Julien's students as they prepare for their PhD preliminary exams. A technical report on in situ soil moisture analysis results and the final WindSat project report were completed. A WindSat geo-statistics journal paper is in progress.

There were some significant personnel changes in our Clouds, Icing, and Aerosols Effects theme area, however the group has parsed through the first cut of in situ aircraft data from CLEX-10/C3VP field campaign and identified several cases for further research. Curtis Seaman is making continued progress on his PhD research and participated in the NOAA Student Exchange Program by visiting the Joint Center for Satellite Data Assimilation and presenting a seminar in August.

In the Environmental Modeling and Assimilation area, Michael Smith successfully defended his masters thesis. Data assimilation experiments with the WRF model using real observations were conducted and further improvement of the ensemble-based data assimilation model were begun. Preparation of a manuscript with MLEF-WRF results is also underway. Andy Jones collaborated with Gary McWilliams to prepare their WindSat 4DVAR results for presentation at IGARSS at the end of July.

Validation of cloud products using CloudSat and CALIPSO data continued as part of the development of satellite products under the Remote Sensing of Battlespace Parameters theme. Two oral presentations were made by this group at the combined EUMETSAT and AMS 15th Satellite Meteorology Conference. The work of graduate student Michael McCarron and Mahmood Azimi progresses and is detailed within this report. An invited paper to the International Joint Conference on Neural Networks was presented by Michael in August. Dr. Azimi traveled to ARL, Adelphi in September to discuss the progress on the acoustic transmission loss prediction project and both short- and long-term goals were identified.

Loretta Wilson

For more information on the DoD Center for Geosciences/Atmospheric Research at Colorado State University, please access our web page at http://www1.cira.colostate.edu/GeoSci/overview.htm

Colorado State University
Center for Geosciences/Atmospheric Research
Scientific Interactions May 2006 to Present

- Sonia Kreidenweis and Kelley Johnson with Doug Westphal, Piotr Flatau, and Marcin Witek (NRL/Monterey)
- Tom Vonder Haar and others with Mr. Robert Brown (ARL)
- Tom Vonder Haar and CG/AR researchers with Dr. James Cogan (ARL)
- Milija Zupanski and others with Jeff Tilley (UND)
- Andy Jones and Cindy Combs with Gary McWilliams (ARL) and Li Li (NRL)
- Steven Fletcher with Carolyn Reynolds (NRL), Dale Barker (NCAR), Brian Ancell (Univ. Washington), Ron Errico and others (NASA Goddard), and international colleagues
- Stan Kidder with Arlin Krueger (Univ. Maryland-Baltimore County)
- Steven Fletcher with Clarke Amerault (NRL)
- Andy Jones, Laura Fowler, Steven Fletcher, Manajit Sengupta, Scott Longmore, Tarendra Lakhankar, and Curtis Seaman with Dale Barker, Hans Huang, Qingnong Xiao, Jenny Sun, and Zhiquan Liu
- Large and small group interactions at the Annual Review, held at CSU/Fort Collins, including:

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

  Adam Kankiewicz with Pam Clark (ARL) and Ted Tsui (NRL)

  Stan Kidder and Jeff Jorgeson (ERDC)

  John Forsythe with Ted Tsui (NRL)

  Pierre Julien and James Halgren with Jeff Jorgeson (ERDC)

  Sonia Kreidenweis with Ron Pinnick (ARL)
- Steven Fletcher with Profs. Nancy Nichols and Alan O'Neil (Data Assimilation Research Centre, UK)
- Steven Fletcher with Dr. Amos Lawless (Department of Mathematics at the University of Reading) and Dr. Eric Andersson (ECMWF)
- Tom Vonder Haar with Patricia Phoebus, Joe Turk, Jerry Schmidt, Nancy Baker and Craig Bishop (NRL)

- Tom Vonder Haar with Philip Durkee (NPS)
- Mahmood Azimi with Mike Mungiole, Alan Wetmore, John Noble, Pam Clark, Sandra Collier and Dave Marlin (ARL)

Research Theme: Hydrometeorology

Administrative

None this period.

Research activity and/or results

Dr. Andrew Jones, Theme Leader
The WindSat geo-statistics journal paper remains in progress (Lakhankar and Jones, 2007).

A technical report on our in situ soil moisture analysis results was completed (Combs et al., 2007). Our final WindSat project report to the NPOESS IPO was also completed (Jones et al., 2007).

Prof. Pierre Julien, James Halgren, and Seema Shah
James has finished coding the soil moisture accounting module in the TREX framework and is now working to debug and run the code. He presented a preliminary proposal to a group of students on October 5 and will base his preliminary exam on this presentation.

Seema has developed a procedure for determining the fraction of total load in suspension and the fraction of total load measured based on the Rouse concentration profile and the logarithmic velocity profile. The procedure has been validated using river data from the Enoree, Middle Rio Grande and Mississippi Rivers. She presented a preliminary proposal to the group on September 21 and is writing a proposal for her preliminary exam this semester.

Travel

None this period.

Technology transfer

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

Equipment/systems status

The newly purchased workstation in Julien's group is under warranty service to replace some faulty motherboard components which are causing spontaneous shutdowns. It is anticipated that the system will be repaired and operable within the month of November.

Research Theme: Clouds, Icing, and Aerosols Effects

Administrative

Dr. Steven D. Miller arrived at CIRA in mid-August. He replaces Ken Eis (who is in transitional retirement) as CIRA Deputy Director, at the 50% level. In addition, Steve will continue some of the research he was doing at the Naval Research Laboratory, Monterey, and arrangements to transition some of this work are well underway.

Adam Kankiewicz left employment with CSU on August 31 to pursue a job opportunity with a private company in Minnesota.

Larry Carey is now a research scientist at the Earth Systems Science Center branch of the National Space Science and Technology Center at the University of Alabama – Huntsville. His involvement in CG/AR research is minimal since the completion of the CG/AR sub-contract last quarter.

Research activity and/or results

Tom Vonder Haar visited the Naval Research Laboratory in Monterey and had research discussions with Patricia Phoebus, Joe Turk, Jerry Schmidt, Nancy Baker and Craig Bishop. He was also invited by Dr. Philip Durkee at the US Naval Postgraduate School to give a seminar as part of their summer course "Advanced in Remote Sensing Technology."

We have parsed through the first cut of in-situ aircraft data from the recently finished CLEX-10/C3VP field campaign and have identified several excellent mixed phase clouds sampled simultaneously by aircraft and the A-Train satellite group. These identified cases have been given to Dr. Stan Kidder at CIRA for further research.

Adam continued to give CloudSat data and IDL coding support to Aaron Schwartz (grad student advised by Prof. Tom Vonder Haar) and assisted Dr. Noh (postdoc at CIRA) with obtaining C3VP/CLEX-10 data from Environment Canada.

The abstract titled: "Mixed Phase Clouds Observed during the Canadian CloudSat/CALIPSO Validation Project" was withdrawn from the AMS' Satellite Meteorology and Oceanography Conference due to the delay in getting the final QC'd aircraft data set from Environment Canada.

A poster was prepared based on the abstract submitted by Adam to the 2007 BACIMO Conference.

Curtis Seaman
Continued work with Manajit Sengupta and Scott Longmore developing the RAMDAS 4DVAR system. Currently performing RAMDAS assimilation experiments using case studies from CLEX-9 (with GOES Imager-only data and GOES Sounder-only data) and analyzing the results. Also in the process of upgrading the system to allow for simultaneous assimilation of both GOES Imager and Sounder data. Results from these experiments will be presented at the 12th

Symposium on Integrated Observing & Assim Systems for Atmosphere, Oceans, and Land Surface (IOAS-AOLS) at the 88th American Meteorological Society (AMS) Annual Meeting in January; the abstract entitled "Assimilation of GOES Radiances to Improve Forecasting of Mid-level, Mixed-phase Clouds" has been accepted for poster presentation.

Participated in the NOAA Student Exchange Program - visited the Joint Center for Satellite Data Assimilation (JCSDA) in Camp Springs, MD from August 6-8 to meet with NOAA/JCSDA scientists. Presented a seminar which included a review of the results from CLEX-9, an overview of CLEX-10, and results from the work performed by the 4DDA research theme group as it relates to his PhD research. The seminar received much interest from scientists, primarily for the CLEX-10/C3VP field experiment and the recent 4DDA research; collaboration opportunities appear to be plentiful.

Prof. Vincent E. Larson (University of Wisconsin-Milwaukee)
The paper submitted to *Quarterly Journal of the Royal Meteorological Society* entitled "From cloud overlap to PDF overlap" has been accepted.

Adam Smith continues to work on his masters thesis. It involves COAMPS simulations of the Nov 2 and Oct 14 CLEX-9 clouds. Adam hopes to defend his thesis research in December.

Research Intern Michael Falk has begun setting up a single-column model simulation of an altocumulus cloud observed during the Mixed-Phase Arctic Cloud Experiment (MPACE). This will test our single-column model for a different altocumulus cloud than the Nov 11 CLEX-5 cloud that we simulated earlier.

Prof. Larry Carey (Texas A & M University)
One note has been submitted to the *Journal of Applied Meteorology and Climatology*. A previously submitted paper to *Atmospheric Research* has been conditionally accepted.

Prof. Sonia Kreidenweis
There was no reportable activity during this quarter.

Travel

Tom Vonder Haar traveled to Monterey, California, July 25-29.

Curtis Seaman traveled to Camp Springs, Maryland as a participant in the NOAA Student Exchange Program (paid by NOAA), August 6-8.

Technology transfer

Tom Vonder Haar presented an invited seminar at the U.S. Naval Postgraduate School entitled "DoD Applications of New CloudSat Data."

Curtis Seaman gave an oral presentation entitled “The Dynamics and Microphysics of Mid-level, Mixed-phase Clouds: Results and Current Research” at the Joint Center for Satellite Data Assimilation.

Equipment/systems status

Nothing to report for this period.

Research Theme: Environmental Modeling and Assimilation

Administrative

None this period.

Research activity and/or results

Dr. Andrew Jones, Theme Leader
Only publication writing was performed during this period. Gary McWilliams (ARL) presented our WindSat 4DVAR results at IGARSS 2007 in Barcelona, Spain.

Two papers were prepared for the BACIMO 2007 conference (Jones et al. and Sengupta et al.).

Dr. Manajit Sengupta
There was no reportable activity during this quarter.

Scott Longmore
Supported Curtis Seaman in his PhD research activities; namely, resolving configuration, running, and visualization issues with RAMDAS.

Dr. Laura Fowler
There was no reportable activity during this quarter.

Dr. Milija Zupanski
Preparation of the manuscript with MLEF-WRF results is underway. The experiments are focusing on the Hurricane Katrina case with real observations. The integration time is extended to start from 00Z August 26, 2005, two days longer than in the original experiment presented at the CGAR 2007 Annual Review. Also, the impact of error covariance localization is investigated, in order to better understand the degrees of freedom in the system.

Dr. Dusanka Zupanski
During this quarter, we performed data assimilation experiments with Weather Research and Forecasting (WRF) model using real observations (radiosonde and synop). Experimental results for the Hurricane Katrina case indicted significant improvements in the hurricane location and intensity. I have also started, with M. Zupanski, the work on further improvement of the ensemble-based data assimilation method, where we try to increase the number of degrees of freedom by solving the data assimilation problem over multiple sub-domains.

Dr. Steven Fletcher
There was no reportable activity during this quarter.

Prof. William Cotton and Michael Smith
Michael Smith successfully defended his masters research on August 1. He was supported by CG/AR through the rest of the month, during which time he finalized the thesis and submitted it to the Graduate School. He also began some early manuscript preparations for eventual

publication. Michael left CSU to pursue a PhD in Avalanche Mechanics at the University of Calgary (Canuckistan). His masters thesis abstract is included below.

Abstract

Desert dust is ubiquitous in the Earth's atmosphere, with measurable concentrations found everywhere from the Middle East to Antarctica. It has the ability to alter the global radiation balance and may have played an important role in past climate change, the African Easterly Jet and possibly hurricane formation. In addition to these large-scale effects, dust can have a deleterious effect on regional hydrology, air quality and visibility. Recent military action in the Middle East has led to increased interest in looking beyond global models that are chiefly concerned with long distance transport, to mesoscale models capable of resolving smaller scales and incorporating more elaborate radiation and microphysics schemes.

Following the work of Stokowski (2005), who introduced a modification that allowed dust to be radiatively active, a dust emission and deposition module has been added to the CSU Regional Atmospheric Modeling System [RAMS]. The new scheme utilizes a global map of potential sources and parameterizes emissions based on model wind speed and soil moisture. Though many existing models incorporate dust as an online tracer, RAMS allows it to advect and feed back into the model, affecting the long and shortwave radiative balance at each timestep. Removal is done via Brownian diffusion, gravitational deposition and rain scavenging.

This study focuses on the testing of the new scheme, with emphasis on its ability to accurately model the spatial extent of dust as well as the column optical thickness and surface visibility. Validation is done through a combination of NCEP reanalyzed meteorological maps, Aeronet AOT and back-trajectory data and surface observations. RAMS did well in predicting the areal extent of elevated dust as well as visibility within the higher resolution nested grid. Prediction of visibility and optical thickness values in the coarse grid exhibited larger absolute errors, though the latter was generally predicted within a factor of two. A persistent dry bias was found through comparison of sounding data with model output. This is thought to be due to the initialization data, and resulted in sometimes-poor simulation of precipitation areal extent, explaining several of the erroneous forecast values.

The work done in this study paves the way for future improvements to the RAMS model, the most important being the addition of dust effects on model microphysics. The structure of the dust scheme also allows for parameters such as in-situ size distribution to be tuned to known regional values, thus presumably improving forecast ability. Several such data sets are already in existence although they were not available for this study.

Travel

None this period.

Technology transfer

None this period.

Equipment/systems status

No report this period.

Research Theme: Urban and Boundary Layer Environment

Administrative

None this period.

Research activity and/or results

There was no reportable research activity during this quarter.

Travel

None this period.

Technology transfer

None this period.

Equipment/systems status

No report this period.

Research Theme: Remote Sensing of Battlespace Parameters

Administrative

None this period.

Research activity and/or results

Dr. Stanley Kidder
Continued work to develop satellite products for the battlespace. Main focus is in validating cloud products using CloudSat and CALIPSO data. Gave a talk at the joint 2007 EUMETSAT /15th AMS Satellite Meteorology Conference; a written version of this presentation can be found at ftp://ftp.cira.colostate.edu/kidder/cgar/A-Train_paper.doc. Also gave the oral presentation for the Moisture Profile Retrievals paper by Forsythe, Kidder, Jones and Vonder Haar.

John Forsythe
Developed talk entitled "Moisture Profile Retrievals from Satellite Microwave Sounders for Weather Analysis over Land and Ocean" for oral presentation at the EUMETSAT/15th AMS Satellite Meteorology and Oceanography Conference.

Prof. Mahmood R. Azimi-Sadjadi and Michael McCarron
Data Generation for EA Evaluation/Retraining
A new PE Model data set was recently generated to evaluate and possibly retrain the Environmentally Adaptive (EA) Transmission Loss Prediction system. This PE Model data set consists of 225,000 samples of the PE model, where each sample consists of a vector of input parameter (**x**) values and a TL output scalar value (y). In this data set, the source height parameter was restricted to values between 0 and 5m, which is the region of source height the EA system was trained for. This data set only contains samples with frequency values between 20 and 240Hz. Samples with frequency between 240 and 300Hz, take much longer and still need to be generated at ARL.

The data generation process for this new data set differs from the data set used to create the Operationally Adaptive (OA) system, namely:

- The moving average (MA) filter as a function of horizontal separation was removed. The previously EA system was trained on data without this MA filter. This allows us to accurately evaluate the performance of the EA system using the new data set.
- Previously, 40 samples of TL values were taken uniformly across the horizontal separation dimension for each input vector sample. This sampling process was removed for this data set which results in more samples across horizontal separation, the exact number (roughly 150) depends on the value of frequency for that input parameter vector.

- While the MA filter and horizontal separation sampling were removed, these can both be applied after data generation with the same result as if they were applied during data generation. By removing these operations the resulting data set is more useful as it can be used for both EA and OA/EA combined system evaluation.

EA Evaluation

Additional data needs to be generated (and is being generated) before a meaningful evaluation of the previously trained EA system can be performed. While a total of 225k samples have been generated so far, that only corresponds to roughly 1500 unique input parameter vectors. The rest of the samples are the same 1500 input parameter vectors with different horizontal separation values.

Once 10,000 unique input vector samples (differing in more than horizontal separation) have to be generated so that a meaningful evaluation can be made. This includes generating another 6000 in the 20 to 240Hz range and 2500 in the 240 to 300Hz range.

Wavelet-Based TL Prediction

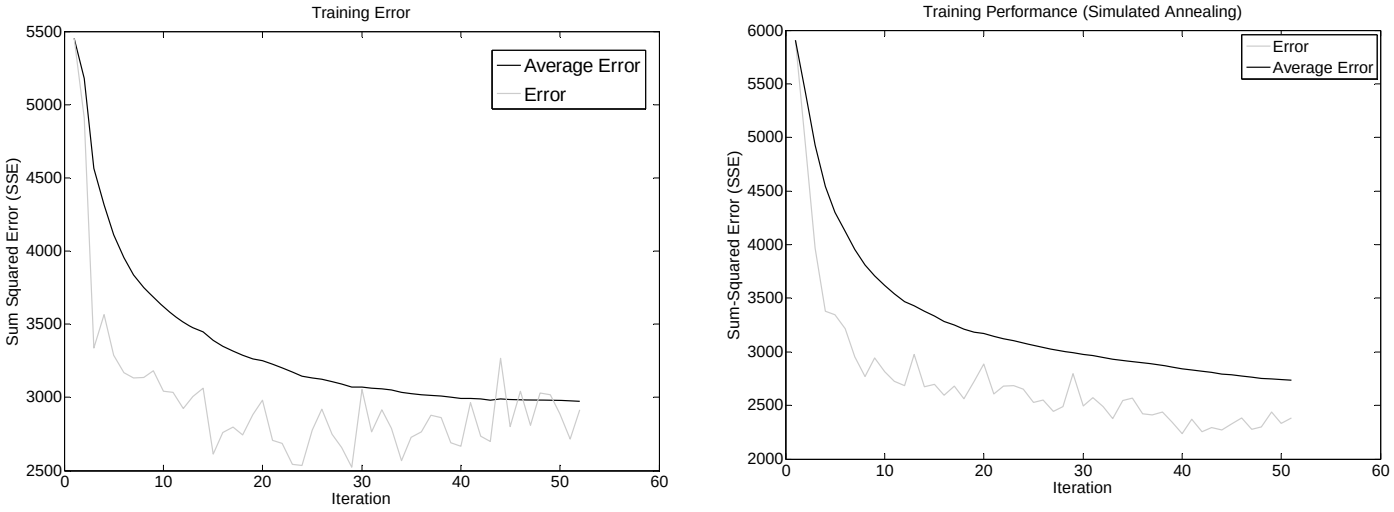
The structure and input-output relationship of the Wavelet-based TL predictor is

$$\hat{y} = \sum_{j}^{J} \sum_{k}^{K} w_{jk} \phi(2^{-j} ||\mathbf{x} - \boldsymbol{\mu}_{jk}||)$$

For each scale j there is a pool of K neurons. So far only two scales 1/2 and 1/4 were used. K was chosen to be 50. Both the scales and K were chosen experimentally. Training involves finding the weights w_{jk} and neuron centers $\boldsymbol{\mu}_{jk}$ such that the RMSE ($\hat{\mathbf{y}}$ - y) is minimized. This is posed as a nonlinear unconstrained optimization problem with objective function $(\hat{\mathbf{y}} - y)^T(\hat{\mathbf{y}} - y)$ and parameter $\boldsymbol{\mu}_{jk}$ and w_{jk}. To decouple this parameter estimation problem, for any initial estimate of $\boldsymbol{\mu}$ linear least squares can be used to find the corresponding w_{jk}'s.

Search methods that don't use gradient information proved to be extremely slow when used to solve this optimization problem. Therefore a analytical solution for the gradient of the objective function was found and implemented. Using this gradient the steepest descent algorithm was applied to the optimization problem. Calculating the true gradient across the entire training set requires extremely large amounts of memory. To avoid this problem a stochastic version of the steepest descent algorithm is used. This version calculates the gradient over 100 samples at a time, uses line search to find a step size (λ), and calculates the $\boldsymbol{\mu}^{(k+1)} = \boldsymbol{\mu}^{(k)} - \lambda \cdot \text{gradient}(\boldsymbol{\mu}^{(k)})$. This process repeats using the next 100 samples moving sequentially through the training set.

The results of this training process can be seen in Figure 1a which shows the sum-squared error (SSE) of the wavelet network as a function of training iteration. Each iteration corresponds to ~50 mini-batches each of 100 training samples over which the gradient is calculated. It can be seen that after a number of iterations the training starts to diverge. This suggests that the step size used in the gradient descent algorithm is too large. To avoid this problem a simulated annealing method is used to select the step size instead of a line search. The simulated annealing method reduces the step size as iterations increase.



a) *b)*

Figure 1. This figure shows the training progress of both the stochastic steepest descent and stochastic gradient descent with simulated annealing training algorithms. Each iteration represents a step being taken in the gradient descent algorithm in the direction of the gradient calculated over 100 samples.

Another wavelet network with one scale of 1/2 was also trained using the simulated annealing training algorithm. The results of this training process can be seen in Figure 1b. This figure shows that training continues to reduce error beyond the point where steepest descent failed. This shows that the previous network was not trained completely. The next step is to optimize the change in step size as iterations increase and then train multiple neuron pools for multiple (more than two) choices of scale.

Dr. Azimi attended a meeting at ARL-Adelphi to discuss the progress on the acoustic transmission loss prediction project and identify the short-term and long-term goals/tasks for 07/08 and 08/09 efforts. Among the meeting attendees were Mike Mungiole, Alan Wetmore, John Noble, Pam Clark, Sandra Collier and Dave Marlin (at White Sands via the teleconferencing). It was agreed by all the participants that Mike McCarron should spend the rest of his masters effort on further development of wavelet application to the PE modeling.

Travel

Michael McCarron traveled to Orlando, Florida, August 12-15. Mahmood Azimi traveled to Adelphi, Maryland, September 19-20.

Stan Kidder traveled to Amsterdam to participate in the 2007 EUMETSAT /15th AMS Satellite Meteorology Conference, September 22-30 (travel supported by non-CG/AR funds).

Technology transfer

Michael McCarron made an oral presentation of the invited paper at the International Joint Conference on Neural Networks (IJCNN) 2007, in August (see publication list for full reference).

Equipment/systems status

A mirror of Adam Kankiewicz's installation was added to John Forsythe's system (750 GB drive).

Appendix 1

CG/AR Researchers under Current Cooperative Agreement
(period of performance: May 1, 2006 – April 30, 2011)

Last Name	First Name	Department	E-mail	Specialty	Theme Area
Azimi-Sadjadi	Mahmood	Electrical Engr	azimi@engr.colostate.edu	Neural Net Studies/Acoustics	Remote Sensing of Battlespace Parameters
Carey	Lawrence	TA&MU (sub)	carey@ariel.met.tamu.edu	Radar Meteorology/Cloud Microhysics	Clouds, Icing, and Aerosols Effects
Cheng	William	Atmos Science	cheng@atmos.colostate.edu	Mesoscale Modeling	Environmental Modeling and Assimilation
Combs	Cindy	CIRA	combs@cira.colostate.edu	Satellite/Climatology	Hydrometeorology, Remote Sensing of Battlespace Parameters
Cotton	William	Atmos Science	cotton@isis.atmos.colostate.edu	Atmospheric Modeling	Environmental Modeling and Assimilation
Eis	Kenneth	CIRA	eis@cira.colostate.edu	Satellite Meteorology	Technology Transition and Interactions
Fletcher	Steven	CIRA	fletcher@cira.colostate.edu	Data Assimilation Methods	Environmental Modeling and Assimilation
Forsythe	John	CIRA	forsythe@cira.colostate.edu	Satellite Meteorology/Data Analysis	Remote Sensing of Battlespace Parameters, Clouds, Icing, and Aerosols Effects
Fowler	Laura	CIRA	fowler@cira.colostate.edu	Cloud Microphysics/Data Assimilation	Environmental Modeling and Assimilation
Jones	Andrew	CIRA	jones@cira.colostate.edu	Surface Moisture/Remote Sensing	Hydrometeorology, Environmental Modeling and Assimilation
Julien	Pierre	Civil Engr	pierre@lance.colostate.edu	Hydrology	Hydrometeorology
Kankiewicz	Adam	CIRA	kankie@cira.colostate.edu	Satellite Meteorology	Clouds, Icing, and Aerosols Effects
Kidder	Stanley	CIRA	kidder@cira.colostate.edu	Satellite Meterology/Remote Sensing	Remote Sensing of Battlespace Parameters
Knaff	John	CIRA	knaff@cira.colostate.edu	Tropical Meteorology/Forecast Technique Development	Remote Sensing of Battlespace Parameters
Kreidenweis	Sonia	Atmos Science	soniak@aerosol.colostate.edu	Aerosols	Clouds, Icing, and Aerosols Effects
Larson	Vincent	UW-Mil (sub)	vlarson@uwm.edu	Cloud Modeling and Parameterization	Clouds, Icing, and Aerosols Effects
Longmore	Scott	CIRA	longmore@cira.colostate.edu	Modeling and Remote Sensing	Hydrometeorology/ Environmental Modeling and Assimilation
Matsumoto	Cliff	CIRA	cliff.r.matsumoto@noaa.gov	Tropical Meteorology/Hurricane Motion	Technology Transition and Interactions
Miller	Steven	CIRA	miller@cira.colostate.edu	Satellite Instrumentation	Clouds, Icing, and Aerosols Effects
Pielke	Roger	CU (sub)	pielkesr@cires.colorado.edu	Mesoscale/Regional Weather and Climate Studies	Urban and Boundary Layer Environment
Ramirez	Jorge	Civil Engr	ramirez@engr.colostate.edu	Hydrology, Hydrometeorology & Water	Hydrometeorology
Reinke	Donald	CIRA	reinke@cira.colostate.edu	Satellite Meteorology/Programming	Clouds, Icing, and Aerosols Effects
Sengupta	Manajit	CIRA	sengupta@cira.colostate.edu	Radiative Transfer	Environmental Modeling and Assimilation
Stokowski	David	CU (sub)	david.stokowski@colorado.edu	Look-up Tables	Urban and Boundary Layer Environment
Vonder Haar	Thomas	CIRA	vonderhaar@cira.colostate.edu	Satellite Meteorology	Technology Transition and Interactions
Zupanski	Dusanka	CIRA	zupanski@cira.colostate.edu	Data Assimilation Methods	Environmental Modeling and Assimilation
Zupanski	Milija	CIRA	zupanskim@cira.colostate.edu	Data Assimilation Methods	Environmental Modeling and Assimilation

CG/AR Graduate Students

Last Name	First Name	Department	E-mail	Theme Area	Advisor	Support
Donofrio	Kevin	Atmos Science	donofrio@cira.colostate.edu	Remote Sensing of Battlespace Parameters	Vonder Haar	CG/AR
Halgren	James	Civil Engr	james.halgren@colostate.edu	Hydrometeorology	Julien	CG/AR
Johnson Wells	Kelley	Atmos. Science	kcjohnso@lamar.colostate.edu	Aerosol Observations and Predictions Analysis	Kreidenweis	CG/AR
Leoncini	Giovanni	Atmos Science	leoncini@atmos.colostate.edu	Boundary Layer and Urban Studies	Pielke	CG/AR
Masarik	Matt	Atmos Science	mmasarik@atmos.colostate.edu	Environmental Modeling and Assimilation	Schubert/Vonder Haar	CG/AR
McCarron	Mike	Electrical Engr	michael.mccarron@colostate.edu	Advanced Neural Net Processing of Acoustic Data	Azimi	CG/AR
Nobis	Timothy	Atmos Science	timothy.nobis@afwa.af.mil	Boundary Layer and Urban Studies	Pielke	AFIT
Rapp	Dustin	Atmos. Science	rapp@cira.colostate.edu	Soil Moisture WindSat	Vonder Haar	CG/AR
Seaman	Curtis	Atmos Science	seaman@cira.colostate.edu	Clouds, Icing, and Aerosols Effects	Vonder Haar	CG/AR
Schwartz	Aaron	Atmos Science	schwartz@cira.colostate.edu	Clouds, Icing, and Aerosols Effects	Vonder Haar	CG/AR
Shah-Fairbank	Seema	Civil Engr	sshah@engr.colostate.edu	Hydrometeorology	Julien	CG/AR
Smith	Michael	Atmos Science	msmith@atmos.colostate.edu	Environmental Modeling and Assimilation	Cotton	CG/AR
Wichern	Gordon	Electrical Engr	gwichern@engr.colostate.edu	Advanced Neural Net Processing of Acoustic Data	Azimi	CG/AR

Appendix 2

Publications

(The following were supported under CG/AR Cooperative Agreement W911NF-06-2-0015. Readers may also want to review the publications list from the previous Cooperative Agreements, DAAD19-02-2-0005, DAAD19-01-2-0018 and DAAL01-98-2-0078. To date, CG/AR research has resulted in 292 publications including 76 papers in refereed journals).

Carey, L.D., J. Niu, P. Yang, J.A. Kankiewicz, V.E. Larson, and T.H. Vonder Haar, 2007: The vertical profile of liquid and ice water content in mid-latitude mixed-phase altocumulus clouds. *J. Appl. Meteor. Clim.*, (submitted).

Combs, C.L., D. Rapp, A.S. Jones, and G. Mason, 2007: Comparison of AGRMET model results with *in situ* soil moisture data. Pre-print CD-ROM, 21st Conference on Hydrology, January 14-18, San Antonio, TX (AMS).

Donofrio, K.M., 2007: A 1DVAR optimal estimation retrieval of water vapor profiles over the global oceans using spectral microwave radiances. Masters thesis, Department of Atmospheric Science, Colorado State University, Fort Collins, Colorado, 165 pp.

Fletcher, S.J. and M. Zupanski, 2007: An alternative to bias correction in retrievals and direct radiances assimilation. Pre-print CD-ROM, 11th Symposium on Integrated Observing and Assimilation Systems for the Atmosphere, Oceans, and Land Surface (IOAS-AOLS), January 13-19, San Antonio, TX (AMS).

Fletcher, S.J. and M. Zupanski, 2008: A study of ensemble size and shallow water dynamics with the Maximum Likelihood Ensemble Filter. *Tellus,* 60A, 348-360.

Forsythe, J.M., S.Q. Kidder, A.S. Jones, and T.H. Vonder Haar, 2007: Moisture profile retrievals from satellite microwave sounders for weather analysis over land and ocean. Proceedings (CD-ROM), The Joint 2007 EUMETSAT Meteorological Satellite Conference and the 15th American Meteorological Society (AMS) Satellite Meteorology and Oceanography Conference, September 24-28, Amsterdam, The Netherlands.

Gaiser, P., A. Jones, L. Li, G. Mason, G. McWilliams, M. Mungiole, 2007: Improving the effectiveness of determining soil moisture using passive microwave satellite imagery. Whitepaper to the National Polar-orbiting Operational Environmental Satellite Systems (NPOESS) Integrated Program Office (IPO), 14 pp.

Jones, A.S., C.L. Combs, S. Longmore, T. Lakhankar, G. Mason, G. McWilliams, M. Mungiole, D. Rapp, T.H. Vonder Haar, and T. Vukicevic, 2007: NPOESS soil moisture satellite data assimilation research using WindSat data. Pre-print CD-ROM, 3rd Symposium on Future National Operational Environmental Satellite Systems—Strengthening Our Understanding of Weather and Climate, January 16-17, San Antonio, TX (AMS).

Jones, A. S., G. McWilliams, M. Mungiole, and G. Mason, 2007: Applications of WindSat for Soil Moisture Satellite Data Assimilation and DoD Impact Studies: 15 July 2004 – 31 December 2006. Final report to the NPOESS Integrated Projects Office, 20 pp.

Jones, A.S., T. Lakhankar, C.L. Combs, S. Longmore, G. Mason, G. McWilliams, M. Mungiole, M. Sengupta, and T.H. Vonder Haar, 2007: NPOESS soil moisture satellite data assimilation using WindSat data and the 4DVAR method. Meeting website, BACIMO 2007, November 6-8, Chestnut Hill, MA (submitted).

Jones, A.S., T. Lakhankar, C. Combs, S. Longmore, G. Mason, G. McWilliams, M. Mungiole, M. Sengupta, and T.H. Vonder Haar, 2008: An NPOESS feasibility study to retrieve deep soil moisture using WindSat data and a temporal variational data assimilation method. Pre-print CD-ROM, 4th Annual Symposium: Future National Operational Environmental Satellite Systems - Research to Operations, January 22, New Orleans, LA (AMS) (submitted).

Kankiewicz, J.A., S.Q. Kidder, C. Seaman, T.H. Vonder Haar, and L.D. Carey, 2007: Mixed phase clouds and aircraft icing conditions observed during the Canadian CloudSat/ CALIPSO Validation Project. Meeting website, BACIMO 2007, November 6-8, Chestnut Hill, MA (submitted).

Kidder, S.Q., and A.S. Jones, 2006: A blended satellite total precipitable water product for operational forecasting. *J. Atmos. and Oceanic Technol.,* 24, 74-81.

Kidder, S.Q., J.A. Kankiewicz, and T.H. Vonder Haar, 2007: The A-Train: How formation flying is transforming remote sensing. Proceedings (CD-ROM), The Joint 2007 EUMETSAT Meteorological Satellite Conference and the 15th American Meteorological Society (AMS) Satellite Meteorology and Oceanography Conference, September 24-28, Amsterdam, The Netherlands.

Longmore, S., A.S. Jones, A. Carheden, and T.H. Vonder Haar, 2007: Experience and lessons learned regarding configuration and control of an advanced 4-dimensional variational satellite data assimilation system. Pre-print CD-ROM, 23rd Conference on Interactive Information Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrology, January 14-18, San Antonio, TX (AMS).

Masarik, M.T., 2007: Potential vorticity and energy aspects of the MJO through equatorial wave theory. Masters thesis, Department of Atmospheric Science, Colorado State University, Fort Collins, Colorado, 86 pp.

McCarron, M., G. Wichern, M.R. Azimi and M. Mungiole, 2007: An operationally adaptive system for rapid acoustic transmission loss prediction. Proceedings, 2007 International Joint Conference on Neural Networks (IJCNN), invited paper, August 12-17, Orlando, FL.

McWilliams, G., A.S. Jones, C.L. Combs, T. Lakhankar, S. Longmore, G. Mason, M. Mungiole, D. Rapp, and T.H. Vonder Haar, 2007: NPOESS soil moisture satellite data assimilation: Progress using WindSat data. Proceedings, International Geoscience and Remote Sensing Symposium (IGARSS) 2007, July 23-27, Barcelona, Spain.

Niu, J., L.D. Carey, P. Yang, and T.H. Vonder Haar, 2007: Optical properties of a vertically inhomogeneous, midlatitude, mid-level, mixed-phase altocumulus in the infrared region. *Atmospheric Research*, (accepted)**.**

Noh, Y.-J., A.S. Jones, and T.H. Vonder Haar, 2007: Snowfall retrievals over land using high frequency microwave satellite data – in the Great Lakes Region. Proceedings (CD-ROM), The Joint 2007 EUMETSAT Meteorological Satellite Conference and the 15th American Meteorological Society (AMS) Satellite Meteorology and Oceanography Conference, September 24-28, Amsterdam, The Netherlands (poster).

Pielke, Sr., R.A., G. Leoncini, T. Matsui, D. Stokowski, J.-W. Wang, T. Vukicevic, C. Castro, D. Niyogi, C.M. Kishtawal, A. Biazar, K. Doty, R.T. McNider, U. Nair, and W.K. Tao, 2006: Development of a generalized parameterization of diabatic heating for use in weather and climate models. Department of Atmospheric Sciences, Colorado State University, Fort Collins, CO, Paper No. 776.

Rapp, D., 2007: Passive microwave measurement of soil moisture using WindSat. Masters thesis, Department of Atmospheric Science, Colorado State University, Fort Collins, Colorado, 211 pp.

Saleeby, S.M., W.Y.Y. Cheng, and W.R. Cotton, 2007: New developments in the Regional Atmospheric Modeling System suitable for simulating snowpack augmentation over complex terrain. *J. Wea. Mod.,* 39, 37-49.

Smith, M.A., 2007: Evaluation of mesoscale simulations of dust sources, sinks and transport over the Middle East. Masters Thesis, Department of Atmospheric Science, Colorado State University, Fort Collins, CO, 126 pp.

Stephens, P.J., and A.S. Jones, 2007: A general implementation of a discrete Backus-Gilbert spatial filter for microwave radiometer data. *J. Atmos. Oceanic Technol.,* (submitted).