Overview

This is the final quarterly report for the referenced Cooperative Agreement, concluding the second, no-cost extension.

During this period, the performances of the EOF method and EMT model were analyzed under conditions of spatially and temporally-limited data by Mr. Werbylo in Prof. Niemann’s group. A poster of this research was presented to the scientific community and a journal article was prepared. Two journal papers of CG/AR research were published.

Ms. Loretta Wilson,
Program Assistant to CG/AR

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/cgar
- 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)
- Curtis Seaman with Nancy Baker and others (NRL)
- Andy Jones and Steve Fletcher with Dale Barker (NCAR); Dennis Garvey, Jim Cogan, Alan Wetmore (ARL); Tim Nobis (AFWA)
- Yoo-Jeong Noh and Curtis Seaman with David Hudak (Environment Canada)
- CG/AR researchers and graduate students with James Cogan (ARL/WSMR)
- Steve Miller and Andy Jones with Michael Wynne (Secretary of the Air Force)
- Andy Jones with Gary McWilliams (ARL)
- Andy Jones with Dr. Ye Hong (Aerospace)
- Andy Jones with Mr. John Eylander (AFWA)
- Andy Jones with Dr. White (NOAA/ESRL)
- Andy Jones and Steven Fletcher with Bob Dumais (ARL)
- Andy Jones with Gary McWilliams (ARL)
- Andy Jones with Dr. Tom Greenwald (Univ. Wisconsin)
- Michael Coleman with Rick Shirkey (ARL)
- Andy Jones with Brian Skahill and Mike Follum (ERDC/CHL)
- Andy Jones and Adam Carheden with Rick Shirkey
- John Forsythe and Eric Guillot with Bob Dumais (ARL-White Sands Missile Range)
- John Forsythe with Lt. Col Vincent Rees (AFWA)
- Andy Jones with James Cogan (ARL)
- Andy Jones with Gary McWilliams (ARL), George Mason (ERDC), Jim Cogan (ARL) and Dr. Li (NRL)
- Stan Kidder with Prof. Phil Durkee (NPGS)
- Sonia Kreidenweis with Prof. Cathy Cahill (Univ. Alaska-Fairbanks)
- Andy Jones with John Eylander (AFWA)
- Andy Jones with Susan Frankenstein (CRREL)
- Sam Atwood with Pam Clark and others (ARL)
- Andy Jones with John Eylander (AFWA)
- Prof. Jeff Niemann with George Mason (GSL/ERDC)
- Yoo-Jeong Noh with Peter Rodriguez (Environment Canada)
- Yoo-Jeong Noh with Dr. G. Liu (Florida State University)
- Andy Jones, Tom Vonder Haar, Stan Kidder, Sonia Kreidenweis and Sam Atwood, Steve Reising, John Forsythe, Loretta Wilson with Dr. James Cogan (ARL), 3-day visit to CG/AR
- Sonia Kreidenweis with Prof. Cathy Cahill (Univ. Alaska-Fairbanks)
- Sonia Kreidenweis with Dr. Jeff Reid (NRL-Monterey)
- Andy Jones with Dr. Rick Shirkey (ARL)
- Sam Atwood at NRL-Monterey (hosted by Dr. Jeff Reid)
- Andy Jones, Sue van den Heever and Rob Seigel with Dr. Robert Haehnel (Army Cold Regions Research and Engineering Laboratory)
- Prof. Steve Reising with Dr. David Turner (NOAA National Severe Storms Laboratory)
- Andy Jones and Stan Kidder with Dr. Jeffrey Cetola and Mr. Steve Rugg (AFWA)
- Andy Jones with Mr. Gary McWilliams (ARL) and Mr. John Eylander (ERDC/CRREL)
- Andy Jones with Dr. Jeffrey Cetola (AFWA) and other DoD partners
- Prof. Tom Vonder Haar with Pamela Clark and James Cogan (ARL)
- Prof. Tom Vonder Haar with colleagues at NRL/Monterey
Research Theme: Hydrometeorology

Administrative

None this period.

Research activity and/or results

Prof. Jeffrey Niemann and Kevin Werbylo
Research report for January-March

The performances of the EOF method and EMT model were analyzed under conditions of spatially and temporally-limited data. In each case, a sample set of locations were selected from a population of locations with soil moisture observations using three sampling techniques: (1) a random sampling technique, (2) a conditioned stratified random sampling (cSRS) technique and (3) a conditioned Latin hypercube sampling (cLHS) technique. In the case of the spatially-limited analysis, the cSRS and cLHS techniques both use observable topographic ancillary data from each population location to assist in the sampling process. In the case of the temporally-limited analysis, the cSRS and cLHS techniques both use observed spatial-average soil moisture values to select days with soil moisture observations to be used in the calibration process.

In the spatially-limited analysis, a limited number of locations at a catchment were selected as described above and soil moisture observations on all available dates at these locations were used to calibrate the EOF method and EMT model. In general, when the number of soil moisture observations used to calibrate the model were less than about 25-40, the cSRS technique outperformed the cLHS and random sampling techniques. However, when greater than 25-40 observations were used in the calibration process, the cLHS technique almost always outperformed the cSRS and random sampling techniques. The exact threshold where cLHS overtakes cSRS in performance is catchment-dependent and probably reliant on a number of variables including the level of influence of topography on the soil moisture pattern and the stability of the soil moisture pattern over time. It can also be concluded that strategically selecting observation locations to be used in the calibration process reduces the risk that a set of observations is unrepresentative of catchment reality. Further, when the same locations were used to calibrate the EOF method and EMT model, it was found that the EMT model outperformed the EOF method when less than 50-125 locations were sampled, but the EOF method outperformed the EMT model when more than 50-125 observations were sampled.

In the temporally-limited analysis, a limited number of days (entire patterns) were selected and all available soil moisture observations on those dates were used to calibrate the EOF method and EMT model. In general, at catchments where the soil moisture pattern was largely stable over time, the cLHS and cSRS techniques both outperformed the random sampling technique when the number of days used for calibration was less than 3-4. When the number of days was greater than 3-4, all three sampling techniques yielded similar model performance. However, at catchments where the soil moisture pattern was unstable over time, the cLHS and cSRS techniques both outperformed the random sampling technique when the number of days used for calibration was less than about 5. Also, when only 2 days were used for calibration, the cSRS
method outperformed the cLHS method. Further, when the same days were used to calibrate the EMT model and EOF method, the EOF method always performed best.

A few general conclusions can be made from this quarter’s research:

(1) When selecting less than 25-40 locations to be used for soil moisture monitoring and downscaling model calibration, these locations should be selected using the cSRS technique. When greater than 25-40 locations will be included in the calibration of the downscaling models, they should be selected using the cLHS technique.

(2) When sampling less than about 50-125 locations for monitoring, the EMT model should be used as the downscaling method of choice. When sampling over 40-100 locations, the EOF method should be the downscaling method of choice.

(3) When selecting days for model calibration, the cLHS and cSRS methods should always be used. If the spatial-average soil moisture is unknown, this analysis basically indicates that the performance of the model improves when a range of conditions is represented during the calibration process (i.e. a ‘wet’ and ‘dry’ date are both used).

(4) If monitoring hundreds of locations (320+) on a uniform grid, the EOF method will outperform the EMT model.

A portion of the above work was presented during an oral presentation at the 2013 Hydrology Days Conference at Colorado State University in Fort Collins, CO. The focus of this presentation was the ability of the cSRS and cLHS sampling techniques to capture the spatial variability of soil moisture patterns as compared to the random sampling technique. As was mentioned, we concluded that the cLHS technique almost always outperforms the other sampling methods, except for when the number of samples is extremely limited and the cSRS technique performs best.

Research report for April
A journal article titled “Evaluation of Sampling Techniques to Characterize Topographically-Dependent Variability for Soil Moisture Downscaling” was authored by Kevin Werbylo and Jeffrey Niemann and is being submitted to the *Journal of Hydrology*. Regarding the goals of the present phase of work, the following conclusions were reported in the article:

(1) The EMT model and EOF method are both able to explain substantial portions of the spatial and temporal variability in catchment scale soil moisture patterns when calibrated against relatively few observations and/or dates. For example, when soil moisture observations at 39-60 locations on 3 dates are used to calibrate both downscaling models, the models can achieve 25-83% of their maximum performance (when observations at 322-454 locations on 6-13 dates are used to calibrate the models).

(2) Selective sampling methods that take into account the variability of topography and soil moisture conditions should be used to select locations and dates for soil moisture
monitoring for the purposes of calibrating the EMT model and/or EOF method. This will ensure that a range of topographic attributes and spatial-average soil moisture values used by the downscaling methods will be represented in the monitoring network.

(3) When selecting less than 30 locations for soil moisture monitoring, stratified random sampling (SRS) should be the selective sampling method used to determine locations for soil moisture monitoring. If possible, conditioned Latin hypercube sampling (cLHS) should be used to determine sampling locations when greater than 30 locations are to be selected. This threshold (30 locations) is catchment specific and is dependent on a number of factors including the level of influence of topography on the soil moisture pattern, the spatial structure of the soil moisture pattern, and the temporal stability of the soil moisture pattern.

(4) The EMT model performs best when soil moisture observations at 50-125 locations are used to calibrate the model, while the EOF method performs best when larger numbers of locations are used in calibration. Furthermore, if monitoring soil moisture at greater than 322 locations on 2 or more dates, the EOF method will outperform the EMT model. As a case study, when about 50 locations on 3 dates were used to calibrate the EMT model and EOF method, the EMT model generally outperformed the EOF method.

The preparation of the mentioned journal article concludes the present phase of work. The above conclusions allow for future research. First, the results of the analysis need to be evaluated at different scales. Specifically, the above results have been confirmed when estimating soil moisture patterns at sub 50 m resolutions over multi-hectare areas. Second, the EMT model and EOF method need to be expanded such that they utilize other ancillary variables known to introduce variation to catchment scale soil moisture patterns (e.g., soil texture, soil depth, vegetation, etc.).

**Travel**

None this period.

**Equipment/systems status**

Nothing to report this period.
Research Theme: Clouds, Icing, and Aerosols Effects

Administrative

None this period.

Research activity and/or results

John Forsythe and Dr. John Haynes
The major activity this period was creating figures and writing text for the paper entitled “Estimating Three-Dimensional Cloud Structure via Statistically Blended Satellite Observations,” which was submitted to the Journal of Applied Meteorology and Climatology in February. New figures showing retrieved cloud 3D structure were created, and technique to distribute cloud liquid water vertically was developed and protoyped with MODIS data.

Travel

None this period.

Equipment/systems status

Nothing to report.
Research Theme: Environmental Modeling and Assimilation

Administrative

None this period.

Research activity and/or results

There was no reportable research activity during this quarter.

Travel

None this period.

Equipment/systems status

Nothing to 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.

Equipment/systems status

Nothing to report this period.
Research Theme: Remote Sensing of Battlespace Parameters

Administrative
None this period.

Research activity and/or results
There was no reportable research activity during this quarter.

Travel
None this period.

Equipment/systems status
Nothing to report this period.
Research Theme: Technology Transition and Interactions

Publications

The journal paper by Y-J Noh, Curtis Seaman, Tom Vonder Haar and G. Liu was published in the Journal of Applied Meteorology and Climatology in January.

The journal paper by Michael Coleman and Jeffrey Niemann was published in Water Resources Research at the end of March.

Presentations

Appendix 1
CG/AR Researchers under Cooperative Agreement W911NF-06-0015

<table>
<thead>
<tr>
<th>Last Name</th>
<th>First Name</th>
<th>Department</th>
<th>E-mail</th>
<th>Specialty</th>
<th>Theme Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azimi-Sadjadi</td>
<td>Mahmood</td>
<td>ElecCompEngr</td>
<td><a href="mailto:azimi@engr.colostate.edu">azimi@engr.colostate.edu</a></td>
<td>Neural Net Studies/Acoustics</td>
<td>Remote Sensing Battlespace/Urban BL</td>
</tr>
<tr>
<td>Carey</td>
<td>Lawrence</td>
<td>TAMU (sub)</td>
<td><a href="mailto:carey@ariel.met.tamu.edu">carey@ariel.met.tamu.edu</a></td>
<td>Radar Meteorology/Cloud Microphysics</td>
<td>Clouds, Icing, and Aerosols Effects</td>
</tr>
<tr>
<td>Cheng</td>
<td>William</td>
<td>Atmos Science</td>
<td><a href="mailto:cheng@atmos.colostate.edu">cheng@atmos.colostate.edu</a></td>
<td>Mesoscale Modeling</td>
<td>Environmental Modeling and Assimilation</td>
</tr>
<tr>
<td>Combs</td>
<td>Cindy</td>
<td>CIRA</td>
<td><a href="mailto:combs@cira.colostate.edu">combs@cira.colostate.edu</a></td>
<td>Satellite/Climatology</td>
<td>Hydrometeorology/Battlespace Parameters</td>
</tr>
<tr>
<td>Cotton</td>
<td>William</td>
<td>Atmos Science</td>
<td><a href="mailto:cotton@sisis.atmos.colostate.edu">cotton@sisis.atmos.colostate.edu</a></td>
<td>Atmospheric Modeling</td>
<td>Env Modeling/Battlespace Parameters</td>
</tr>
<tr>
<td>Eis</td>
<td>Kenneth</td>
<td>CIRA</td>
<td><a href="mailto:eis@cira.colostate.edu">eis@cira.colostate.edu</a></td>
<td>Satellite Meteorology</td>
<td>Technology Transition and Interactions</td>
</tr>
<tr>
<td>Fletcher</td>
<td>Steven</td>
<td>CIRA</td>
<td><a href="mailto:fletcher@cira.colostate.edu">fletcher@cira.colostate.edu</a></td>
<td>Data Assimilation Methods</td>
<td>Environmental Modeling and Assimilation</td>
</tr>
<tr>
<td>Forsythe</td>
<td>John</td>
<td>CIRA</td>
<td><a href="mailto:forsythe@cira.colostate.edu">forsythe@cira.colostate.edu</a></td>
<td>Satellite Meteorology/Data Analysis</td>
<td>Remote Sensing of Battlespace Parameters, Clouds, Icing, and Aerosols Effects</td>
</tr>
<tr>
<td>Fowler</td>
<td>Laura</td>
<td>CIRA</td>
<td><a href="mailto:fowler@cira.colostate.edu">fowler@cira.colostate.edu</a></td>
<td>Cloud Microphysics/Data Assimilation</td>
<td>Environmental Modeling and Assimilation</td>
</tr>
<tr>
<td>Haynes</td>
<td>John</td>
<td>CIRA</td>
<td><a href="mailto:haynes@cira.colostate.edu">haynes@cira.colostate.edu</a></td>
<td>Satellite Meteor/Cloud Precip Retrievals</td>
<td>Clouds, Icing, and Aerosols Effects</td>
</tr>
<tr>
<td>Jones</td>
<td>Andrew</td>
<td>CIRA</td>
<td><a href="mailto:jones@cira.colostate.edu">jones@cira.colostate.edu</a></td>
<td>Surface Moisture/Remote Sensing</td>
<td>Hydrometeorology, Environmental Modeling and Assimilation</td>
</tr>
<tr>
<td>Julien</td>
<td>Pierre</td>
<td>Civil Engr</td>
<td><a href="mailto:pierre@lance.colostate.edu">pierre@lance.colostate.edu</a></td>
<td>Hydrology</td>
<td>Hydrometeorology</td>
</tr>
<tr>
<td>Kankiewicz</td>
<td>Adam</td>
<td>CIRA</td>
<td><a href="mailto:kankie@cira.colostate.edu">kankie@cira.colostate.edu</a></td>
<td>Satellite Meteorology</td>
<td>Clouds, Icing, and Aerosols Effects</td>
</tr>
<tr>
<td>Kidder</td>
<td>Stanley</td>
<td>CIRA</td>
<td><a href="mailto:kidder@cira.colostate.edu">kidder@cira.colostate.edu</a></td>
<td>Satellite Meteorology/Remote Sensing</td>
<td>Remote Sensing of Battlespace Parameters</td>
</tr>
<tr>
<td>Knaff</td>
<td>John</td>
<td>CIRA</td>
<td><a href="mailto:knaff@cira.colostate.edu">knaff@cira.colostate.edu</a></td>
<td>Tropical Met/Forecast Tech Develop</td>
<td>Remote Sensing of Battlespace Parameters</td>
</tr>
<tr>
<td>Kreidenweis</td>
<td>Sonia</td>
<td>Atmos Science</td>
<td><a href="mailto:sonia@aerosol.colostate.edu">sonia@aerosol.colostate.edu</a></td>
<td>Aerosols</td>
<td>Clouds, Icing, Aerosols Effects/Urban BL</td>
</tr>
<tr>
<td>Larson</td>
<td>Vincent</td>
<td>UW-Mil (sub)</td>
<td><a href="mailto:vlarsen@uw.edu">vlarsen@uw.edu</a></td>
<td>Cloud Modeling and Parameterization</td>
<td>Hydrometeorology/Environ. Modeling</td>
</tr>
<tr>
<td>Longmore</td>
<td>Scott</td>
<td>CIRA</td>
<td><a href="mailto:longmore@cira.colostate.edu">longmore@cira.colostate.edu</a></td>
<td>Modeling and Remote Sensing</td>
<td>Technology Transition and Interactions</td>
</tr>
<tr>
<td>Matsumoto</td>
<td>Cliff</td>
<td>CIRA</td>
<td><a href="mailto:cliff.r.matsumoto@noaa.gov">cliff.r.matsumoto@noaa.gov</a></td>
<td>Tropical Meteorology/Hurricane Motion</td>
<td>Clouds, Icing, and Aerosols Effects</td>
</tr>
<tr>
<td>Miller</td>
<td>Steven</td>
<td>CIRA</td>
<td><a href="mailto:miller@cira.colostate.edu">miller@cira.colostate.edu</a></td>
<td>Satellite Instrumentation</td>
<td>Hydrometeorology</td>
</tr>
<tr>
<td>Niemann</td>
<td>Jeffrey</td>
<td>Civil Env Engr</td>
<td><a href="mailto:jniemann@engr.colostate.edu">jniemann@engr.colostate.edu</a></td>
<td>Hydrology/Soil Moisture</td>
<td>Clouds, Icing, and Aerosols Effects</td>
</tr>
<tr>
<td>Noh</td>
<td>Yoo-Jeong</td>
<td>CIRA</td>
<td><a href="mailto:noh@cira.colostate.edu">noh@cira.colostate.edu</a></td>
<td>SatMet/Cloud, Precipitation Retrievals</td>
<td>Remote Sensing of Battlespace Parameters</td>
</tr>
<tr>
<td>Ostashev</td>
<td>Vladimire</td>
<td>CU (sub)</td>
<td><a href="mailto:vladimir.ostashev@noaa.gov">vladimir.ostashev@noaa.gov</a></td>
<td>Atmospheric Acoustics</td>
<td>Urban and Boundary Layer Environment</td>
</tr>
<tr>
<td>Pielke</td>
<td>Roger</td>
<td>CU (sub)</td>
<td><a href="mailto:pielkesr@cires.colorado.edu">pielkesr@cires.colorado.edu</a></td>
<td>Mesoscale/Regional Wx Climate Studies</td>
<td>Hydrometeorology</td>
</tr>
<tr>
<td>Ramirez</td>
<td>Jorge</td>
<td>Civil Env Engr</td>
<td><a href="mailto:ramirez@engr.colostate.edu">ramirez@engr.colostate.edu</a></td>
<td>Hydrology, Hydrometeorology &amp; Water</td>
<td>Clouds, Icing, and Aerosols Effects</td>
</tr>
<tr>
<td>Reinke</td>
<td>Donald</td>
<td>CIRA</td>
<td><a href="mailto:reinke@cira.colostate.edu">reinke@cira.colostate.edu</a></td>
<td>Satellite Meteorology/Programming</td>
<td>Urban and Boundary Layer Environment</td>
</tr>
<tr>
<td>Reising</td>
<td>Steven</td>
<td>ElecCompEngr</td>
<td><a href="mailto:steven.reising@colostate.edu">steven.reising@colostate.edu</a></td>
<td>Boundary Layer/Remote Sensing</td>
<td>Environmental Modeling and Assimilation</td>
</tr>
<tr>
<td>Sengupta</td>
<td>Mananjit</td>
<td>CIRA</td>
<td><a href="mailto:sengupta@cira.colostate.edu">sengupta@cira.colostate.edu</a></td>
<td>Radiative Transfer</td>
<td>Urban and Boundary Layer Environment</td>
</tr>
<tr>
<td>Stokowski</td>
<td>David</td>
<td>CU (sub)</td>
<td><a href="mailto:david.stokowski@colorado.edu">david.stokowski@colorado.edu</a></td>
<td>Look-up Tables</td>
<td>Remote Sensing of Battlespace Parameters</td>
</tr>
<tr>
<td>van den Heever</td>
<td>Susan</td>
<td>Atmos Science</td>
<td><a href="mailto:sue@atmos.colostate.edu">sue@atmos.colostate.edu</a></td>
<td>Atmospheric Modeling/Cloud Physics/StormDynamics</td>
<td>Technology Transition and Interactions</td>
</tr>
<tr>
<td>Vonder Haer</td>
<td>Thomas</td>
<td>CIRA</td>
<td><a href="mailto:vonderhaar@cira.colostate.edu">vonderhaar@cira.colostate.edu</a></td>
<td>Satellite Meteorology</td>
<td>Environmental Modeling and Assimilation</td>
</tr>
<tr>
<td>Zupanski</td>
<td>Dusanka</td>
<td>CIRA</td>
<td><a href="mailto:zupanski@cira.colostate.edu">zupanski@cira.colostate.edu</a></td>
<td>Data Assimilation Methods</td>
<td>Environmental Modeling and Assimilation</td>
</tr>
<tr>
<td>Zupanski</td>
<td>Milija</td>
<td>CIRA</td>
<td><a href="mailto:zupanskim@cira.colostate.edu">zupanskim@cira.colostate.edu</a></td>
<td>Data Assimilation Methods</td>
<td>Environmental Modeling and Assimilation</td>
</tr>
<tr>
<td>Last Name</td>
<td>First Name</td>
<td>Department</td>
<td>E-mail</td>
<td>Theme Area</td>
<td>Advisor</td>
</tr>
<tr>
<td>-----------</td>
<td>------------</td>
<td>-----------------------------</td>
<td>---------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Atwood</td>
<td>Sam</td>
<td>Atmos Science</td>
<td><a href="mailto:satwood@atmos.colostate.edu">satwood@atmos.colostate.edu</a></td>
<td>Clouds, Icing, and Aerosols Effects/Urban and Boundary Layer Environment</td>
<td>Kreidenweis</td>
</tr>
<tr>
<td>Busch</td>
<td>Frederick</td>
<td>Civil Environ Engr</td>
<td><a href="mailto:frederick.busch@colostate.edu">frederick.busch@colostate.edu</a></td>
<td>Hydrometeorology</td>
<td>Niemann</td>
</tr>
<tr>
<td>Coleman</td>
<td>Michael</td>
<td>Civil Environ Engr</td>
<td><a href="mailto:mike.coleman@colostate.edu">mike.coleman@colostate.edu</a></td>
<td>Hydrometeorology</td>
<td>Niemann</td>
</tr>
<tr>
<td>Donofrio</td>
<td>Kevin</td>
<td>Atmos Science</td>
<td><a href="mailto:donofrio@cira.colostate.edu">donofrio@cira.colostate.edu</a></td>
<td>Remote Sensing of Battlespace Parameters</td>
<td>Vonder Haar</td>
</tr>
<tr>
<td>Erickson</td>
<td>Kimberly</td>
<td>Atmos Science</td>
<td><a href="mailto:kimberly.erickson@colostate.edu">kimberly.erickson@colostate.edu</a></td>
<td>Advanced Neural Net Processing of Acoustic Data</td>
<td>Azimi</td>
</tr>
<tr>
<td>Fidyrcy</td>
<td>Jonathan</td>
<td>Elect/Comp Engr</td>
<td><a href="mailto:jonmfid@goku.engr.colostate.edu">jonmfid@goku.engr.colostate.edu</a></td>
<td>Remote Sensing of Battlespace Parameters</td>
<td>Vonder Haar</td>
</tr>
<tr>
<td>Fields</td>
<td>Christopher</td>
<td>Civil Environ Engr</td>
<td><a href="mailto:cmfields@engr.colostate.edu">cmfields@engr.colostate.edu</a></td>
<td>Hydrometeorology</td>
<td>Niemann</td>
</tr>
<tr>
<td>Guillot</td>
<td>Eric</td>
<td>Atmos Science</td>
<td><a href="mailto:guillot@cira.colostate.edu">guillot@cira.colostate.edu</a></td>
<td>Remote Sensing of Battlespace Parameters</td>
<td>Vonder Haar</td>
</tr>
<tr>
<td>Halgren</td>
<td>James</td>
<td>Civil Environ Engr</td>
<td><a href="mailto:johannes.halgren@colostate.edu">johannes.halgren@colostate.edu</a></td>
<td>Hydrometeorology</td>
<td>Vonder Haar</td>
</tr>
<tr>
<td>Howell</td>
<td>Kelly</td>
<td>Atmos Science</td>
<td><a href="mailto:howell@atmos.colostate.edu">howell@atmos.colostate.edu</a></td>
<td>Remote Sensing of Battlespace Parameters</td>
<td>Kreidenweis</td>
</tr>
<tr>
<td>Johnson</td>
<td>Kelley</td>
<td>Atmos. Science</td>
<td><a href="mailto:kejohnso@lamar.colostate.edu">kejohnso@lamar.colostate.edu</a></td>
<td>Clouds, Icing, and Aerosols Effects</td>
<td>Azimi</td>
</tr>
<tr>
<td>Kolouri</td>
<td>Soheil</td>
<td>Elect/Comp Engr</td>
<td><a href="mailto:soheil.kolouri@colostate.edu">soheil.kolouri@colostate.edu</a></td>
<td>Boundary Layer and Urban Studies</td>
<td>Pielke</td>
</tr>
<tr>
<td>Krall</td>
<td>Geoffrey</td>
<td>Atmos Science</td>
<td><a href="mailto:gkrall@atmos.colostate.edu">gkrall@atmos.colostate.edu</a></td>
<td>Environmental Modeling and Assimilation</td>
<td>Cotton</td>
</tr>
<tr>
<td>Leoncini</td>
<td>Giovanni</td>
<td>Atmos Science</td>
<td><a href="mailto:leoncini@atmos.colostate.edu">leoncini@atmos.colostate.edu</a></td>
<td>Boundary Layer and Urban Studies</td>
<td>Julien</td>
</tr>
<tr>
<td>Masarik</td>
<td>Matt</td>
<td>Atmos Science</td>
<td><a href="mailto:mmasarik@atmos.colostate.edu">mmasarik@atmos.colostate.edu</a></td>
<td>Environmental Modeling and Assimilation</td>
<td>Vonder Haar</td>
</tr>
<tr>
<td>McCarron</td>
<td>Mike</td>
<td>Elect/Comp Engr</td>
<td><a href="mailto:michael.mccarron@colostate.edu">michael.mccarron@colostate.edu</a></td>
<td>Adv Neural Net Processing Acoustic Data</td>
<td>Azimi</td>
</tr>
<tr>
<td>Middlekauff</td>
<td>Steven</td>
<td>Civil Environ Engr</td>
<td>(unavailable)</td>
<td>Hydrometeorology</td>
<td>Niemann</td>
</tr>
<tr>
<td>Nobis</td>
<td>Timothy</td>
<td>Atmos Science</td>
<td><a href="mailto:timothy.nobis@afwa.af.mil">timothy.nobis@afwa.af.mil</a></td>
<td>Boundary Layer and Urban Studies</td>
<td>Pielke</td>
</tr>
<tr>
<td>Potter</td>
<td>Lauren</td>
<td>Atmos Science</td>
<td><a href="mailto:lepotter@atmos.colostate.edu">lepotter@atmos.colostate.edu</a></td>
<td>Remote Sensing of Battlespace Parameters</td>
<td>Vonder Haar</td>
</tr>
<tr>
<td>Ram</td>
<td>Jessica</td>
<td>Atmos Science</td>
<td><a href="mailto:ram@atmos.colostate.edu">ram@atmos.colostate.edu</a></td>
<td>Urban and Boundary Layer Environment</td>
<td>Kreidenweis</td>
</tr>
<tr>
<td>Rapp</td>
<td>Dustin</td>
<td>Atmos. Science</td>
<td><a href="mailto:rapp@cira.colostate.edu">rapp@cira.colostate.edu</a></td>
<td>Remote Sensing of Battlespace Parameters</td>
<td>Vonder Haar</td>
</tr>
<tr>
<td>Roy</td>
<td>Gavin</td>
<td>Atmos. Science</td>
<td><a href="mailto:gavin.roy@colostate.edu">gavin.roy@colostate.edu</a></td>
<td>Clouds, Icing, and Aerosols Effects</td>
<td>Vonder Haar</td>
</tr>
<tr>
<td>Sahoo</td>
<td>Swaroop</td>
<td>Elect/Comp Engr</td>
<td><a href="mailto:swaroop.sahoo@colostate.edu">swaroop.sahoo@colostate.edu</a></td>
<td>Clouds, Icing, and Aerosols Effects</td>
<td>Vonder Haar</td>
</tr>
<tr>
<td>Seaman</td>
<td>Curtis</td>
<td>Atmos Science</td>
<td><a href="mailto:seaman@atmos.colostate.edu">seaman@atmos.colostate.edu</a></td>
<td>Clouds, Icing, and Aerosols Effects</td>
<td>Reising</td>
</tr>
<tr>
<td>Schwartz</td>
<td>Aaron</td>
<td>Atmos Science</td>
<td><a href="mailto:schwartz@atmos.colostate.edu">schwartz@atmos.colostate.edu</a></td>
<td>Clouds, Icing, and Aerosols Effects</td>
<td>Vonder Haar</td>
</tr>
<tr>
<td>Seigel</td>
<td>Robert</td>
<td>Atmos Science</td>
<td><a href="mailto:rseigel@atmos.colostate.edu">rseigel@atmos.colostate.edu</a></td>
<td>Remote Sensing of Battlespace Parameters</td>
<td>van den Heever</td>
</tr>
<tr>
<td>Shah</td>
<td>Seema</td>
<td>Civil Environ Engr</td>
<td><a href="mailto:sshah@engr.colostate.edu">sshah@engr.colostate.edu</a></td>
<td>Hydrometeorology</td>
<td>Julien</td>
</tr>
<tr>
<td>Smith</td>
<td>Michael</td>
<td>Atmos Science</td>
<td><a href="mailto:msmith@atmos.colostate.edu">msmith@atmos.colostate.edu</a></td>
<td>Environmental Modeling and Assimilation</td>
<td>Cotton</td>
</tr>
<tr>
<td>Steininger</td>
<td>Andrew</td>
<td>Civil Environ Engr</td>
<td><a href="mailto:andy.steiner@colostate.edu">andy.steiner@colostate.edu</a></td>
<td>Hydrometeorology</td>
<td>Julien</td>
</tr>
<tr>
<td>VandenBoogart</td>
<td>Lance</td>
<td>Atmos Science</td>
<td><a href="mailto:boogart@atmos.colostate.edu">boogart@atmos.colostate.edu</a></td>
<td>Remote Sensing of Battlespace Parameters</td>
<td>Vonder Haar</td>
</tr>
<tr>
<td>Werbylo</td>
<td>Kevin</td>
<td>Civil Environ Engr</td>
<td><a href="mailto:kwerbylo@engr.colostate.edu">kwerbylo@engr.colostate.edu</a></td>
<td>Hydrometeorology</td>
<td>Niemann</td>
</tr>
<tr>
<td>Wichern</td>
<td>Gordon</td>
<td>Elect/Comp Engr</td>
<td><a href="mailto:gwichern@engr.colostate.edu">gwichern@engr.colostate.edu</a></td>
<td>Adv Neural Net Processing Acoustic Data</td>
<td>Azimi</td>
</tr>
</tbody>
</table>
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.)


