Thermodynamic Network Observation Assimilation for Improved Convective Prediction

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$299,857 (FY2019)
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1. Abstract

It is widely recognized that boundary layer thermodynamic observations with increased temporal and spatial density are needed to improve convective weather forecasting. NOAA's Office of Atmospheric Research is soliciting proposals to "*conduct research and development activities related to advancing data assimilation of new observations and data assimilation techniques for convective-scale weather prediction*". In response to this solicitation, we propose to develop and demonstrate assimilation of microwave thermodynamic profiler (MTP) observations from the New York State Mesonet (NYSM) and Earth Network Boundary Layer Network (ENBLN)[1].

Effective data assimilation requires reliable information on forecast and observation errors. We propose to develop automated MTP observation error estimation methods via comparison with collocated radiosonde soundings[2], where available. In addition, we will develop automated MTP calibration methods that adjust calibration parameters to bring radiometer brightness temperature (Tb) observations and forward-modeled clear-air radiosonde Tb into agreement. For MTP sites that are not collocated with radiosonde operations, we propose to develop automated MTP observation accuracy information and radiometer calibration by comparison with, and forward modeling of, High Resolution Rapid Refresh (HRRR) analyzed profiles during stable, clear-air weather conditions.

The value of MTP data in identifying local convective risk has been demonstrated by the National Weather Service (NWS). The NWS Denver Weather Forecast Office (WFO) Central Weather Service Unit (CWSU) has been using available MTP 1DVAR retrievals[3] for the past several years to improve aviation weather advisories to the Federal Aviation Administration (FAA) Air Route Traffic Control Center (ARTCC).[4] During convective season, the CWSU uses real-time MTP soundings to monitor instability, directly contributing to improvement of shower and thunderstorm advisories and forecasts near Denver International Airport.

We expect that weather advisories and forecasts for Unmanned Aerial Vehicle (UAV) operations can also be improved using MTP observations. We intend to explore this opportunity in collaboration with TruWeather Solutions (TWS), a key participant in NY State drone testing corridor weather applications research and development.

Project goals are: (1) to further improve aviation weather advisories based on thermodynamic profile observations, and (2) to develop thermodynamic profile assimilation and (3) facilitate evaluation of the resulting impact on convective forecast skill.

[1] The NYSM includes 17, and the ENBLN 15, MTP sites.
[2] Collocated MTP and radiosonde launch sites include Albany, Buffalo and Upton NY, and Denver CO.
[3] One-dimensional variational (1DVAR) retrievals combine MTP and model gridded forecast soundings.
[4] Appendix.

2. Statement of Work

Deployment of *"radio frequency profilers nationwide at approximately 400 sites to continually monitor lower tropospheric conditions"* is recommended as a high priority for improved convective forecasting[5]. Such deployment has commenced with the establishment of two profiling networks within the Contiguous United States (CONUS), including thermodynamic profilers.[6] In addition, reports of improved convective and other weather advisories and prediction based on radio frequency thermodynamic profiler observations are emerging[7].

We propose to develop and demonstrate assimilation of thermodynamic profile observations from existing profiler networks. Assimilation protocol will include frequently-updated forecast and profile error estimates (such as 30-60 day means) based on comparisons with radiosonde soundings for collocated profiler-radiometer sites, or comparisons with model point soundings during stable weather conditions at other sites. The NOAA GSD office will provide HRRR extracted forecast profiles and overall guidance in data assimilation development and testing to ensure optimal transition toward operations. The investigators will work closely with the NWS Denver WFO to further develop and improve aviation weather advisories based on thermodynamic profile observations. Furthermore, we will explore collecting reports of radiometer observation use for decision-making in Area Forecast Discussion (AFD) products from Denver and other offices with radiometers in their County Warning Area (CWA).

Prior investigator research results demonstrate capability for successful transition to operations[8].

3. Work Plan

Hardware Needs

Existing profiling networks will satisfy sensing hardware needs, providing thermodynamic profile observations required for data assimilation and error statistics metadata development and testing.

Software Needs

The RDX team will provide forward modeling (FM) software that converts radiosonde and point analysis thermodynamic profiles into brightness temperatures (Tb) corresponding to the thermodynamic profiler microwave channel frequencies. During clear air conditions, calibration can be conducted by adjusting radiometer calibration parameters to bring observed and FM Tbs into agreement. The RDX team will develop and test automated calibration (ACal) software using this procedure. This capability is expected to reduce radiometer operations costs while improving

[5] National Research Council, 2009; 2017.
[6] New York State Mesonet (17 sites), Earth Networks Boundary Layer Network (15 sites).
[7] See References and Appendix.
[8] See Curriculum Vitae, References and Track Record for Success.

observation accuracy. The RDX team will also develop and test variational retrieval software combining radiometer and extracted operational model profiles. GSD collaborators will provide access to HRRR point analyses. SUNY Albany collaborators will provide access to NYSM MTP data.

The CAPS team will provide software for radiosonde and point analysis vs. radiometer statistical comparison. They will also develop and test, with guidance from GSD collaborators, observation data and error metadata format optimized for use in appropriate high resolution analyses, including the Gridpoint Statistical Interpolation (GSI) data assimilation.

4. Testing and Evaluation

The RDX team will develop and evaluate reliability and accuracy of forward modeling, automated calibration and variational analysis software. Guidance on appropriate use of radiometer data and request for documenting use in AFDs or other logs will be provided by RDX and team to NWS.

The CAPS team will test and evaluate the reliability of radiosonde and model vs. radiometer sounding error statistics software and observational error metadata compatible with GSI assimilation (with GSD guidance).

The University of Albany team will provide access to NYSM data, coordinate and collaborate with the Albany WFO to test and evaluate the impact of real time variational radiometer soundings on CWSU aviation weather advisories, and coordinate with Central NY drone corridor weather managers.

The NWS team will test and evaluate the impact of real time variational radiometer profiles on CWSU aviation weather advisories to the FAA Denver Air Route Traffic Control Center. They will also coordinate these developments with the Albany WFO and CWSU, and the Central NY drone corridor.

The GSD team will provide access to HRRR point analysis and general guidance on MTP data and accuracy information formatting, assimilation and evaluation.

TruWeather Solutions (TWS) collaborators will test and evaluate the impact of real time variational radiometer profiles on aviation weather advisories for drone operations through logs of radiometer data use in decision making.

5. Metrics for Success

For the RDX team, effective management and coordination of RDX, CAPS, and U. Albany tasks, and NWS, GSD and TWS collaboration, is a primary metric for success. In addition, validation of forward modeling, automated calibration and variational analysis software are metrics for RDX success.

CAPS team success metrics include validation of radiosonde and model vs. radiometer sounding statistics software capabilities and demonstrating positive impact on analyzed profile improvement compared to collocated radiosondes. In addition, GSD confirmation of effective

assimilation of observational and metadata format is an important metric.

Success metrics for NWS and TWS collaborators include collection of evidence for convection-related aviation weather airport and drone corridor advisory decision-making improved by considering information from MTP(s) in the area of responsibility. This will primarily be accomplished through voluntary logging of MTP use in participating operational sites. We will also explore harvesting of NWS weather advisory discussion products mentioning radiometer data use.

Considering the importance of boundary layer thermodynamic observations in identifying convective weather risk and forecasting, significant advancements in these areas are compelling metrics of success.

6. Project Deliverables

Project deliverables include capability for conversion of observations from existing thermodynamic profiling networks into assimilation-ready format including reliable observation error metadata, and for automated thermodynamic profiler calibration based on radiosonde and model soundings.

7. Timeline with Key Milestones

Investigator and collaborator tasks with key milestones are summarized in Table 1.

Table 1. Timeline and Milestones.

		Year 1				Year 2			
Party	**Key Milestones**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
RDX	FM software development								
RDX	FM software testing								
RDX	Automated calibration development								
RDX	Automated calibration testing								
RDX	MTP 1DVAR software development								
RDX	MTP 1DVAR software testing								
CAPS	RS & model vs. MTP statistics software development								
CAPS	RS & model vs. MTP statistics analysis								
CAPS	MTP data and error metadata assimilation development								
CAPS	MTP data and error metadata assimilation testing								
UAlbany	Provide access to NYSM data								
UAlbany	Aviation weather advisory coordination with Albany WFO								
UAlbany	Aviation weather advisory coordination with drone corridor								
NWS	Continue MTP-based aviation weather advisory development								
GSD	Provide access to HRRR analysis, assimilation guidance								
TWS	Drone corridor aviation weather management coordination								

8. Real-Time Operational Data Needed as Input

Real-time model extracted profiles are required for radiometer 1DVAR retrievals, and for profile

accuracy estimation at radiometer sites that are not radiosonde launch site collocated. GSD has agreed to provide access to HRRR forecasts that will satisfy these requirements.

9. Transition Path to NOAA/NWS Operations

The most immediate transition path is to NWS operational use of MTP observations. The Denver CWSU has already been using radiometer variational soundings, when available, to improve convection-related aviation weather advisories. Project development of automated radiometer calibration capability, and related increased data availability, will contribute to improved NWS operations. In the future, a data flow that can be directly displayed on AWIPS-II will be explored with NWS developers.

In addition, project development of assimilation-ready thermodynamic profiles including reliable observation error is an important step toward NWS operational assimilation of emerging profiler network thermodynamic observations.

10. Documentation Delivery Timeline

Scientific and technical documentation and training materials will be delivered to the Science Operations Officer (SOO) at the Denver WFO and other WFOs interested in participation. Delivery of these materials will be coordinated with the SOO on a quarterly basis and annual basis identified by the key milestones listed in Table 1. The delivery timeline will be formalized with the Denver WFO Meteorologist in Charge (MIC). Training on potential advantages and avoiding potential pitfalls when using radiometric profiles may be presented during local training day(s) at the Denver WFO (or remotely for other participants).

11. Travel

No project-specific travel requirements are proposed for this project. Coordination will be done via teleconference and email.

12. Operational Staff, Computing, Communication and Display

Investigators and collaborators already have adequate operational staff, computing, communication, and display resources in place to support this project. Staff time needed from NOAA will include GSD: set up to generate and distribute profiles from the HRRR; Denver WFO SOO & CWSU: examination of radiometric profiles in pre-convective situations as part of routine duties and documenting use which can be via a log and/or mention in Area Forecast Discussion. Voluntary participation may be sought from other appropriate WFO SOOs, such as Albany, as well.

13. Current and Projected Readiness Level

Considering that the NWS is already using thermodynamic profiler soundings to improve aviation weather advisories, we estimate current Technology Readiness Level (TRL) at 6-7, with a

projected end-state of 8-9. The initial TRL for thermodynamic profiler data and metadata assimilation is 4-5, with a projected end-state of 6-7.

14. Proposed NOAA/NWS Receiving Office

The NOAA/NWS Denver WFO is the primary receiving office. The Meteorologist in Charge at this office is Nezette Rydell and the Science Operations Officer is Paul Schlatter. The Denver WFO uses MTP 1DVAR data to improve aviation weather advisories to the FAA Air Route Traffic Control Center (ARTCC). Ms. Rydell states that the data *"have been instrumental in diagnosing the actual presence or absence of mid- and upper-level instability as compared to model forecasts, directly aiding the forecasting and evolution of showers or thunderstorms at/near DIA and arrival and departure gates*" (Appendix). The project will provide real time MTP 1DVAR data to the Denver WFO to further advance and evaluate aviation weather advisory improvements.

15. Curriculum Vitae

Randolph Ware (Principal Investigator)

Founder and Chief Scientist, Radiometrics Corporation

Degrees

B.S. math, chemistry and physics -- University of Colorado, 1966

M.S. physics -- University of Colorado, 1969

Ph.D. experimental nuclear physics -- University of Colorado, 1974

Work Experience

Founder, Chief Scientist – Radiometrics Corporation, 1988 - present.

Program Director, UCAR, 1991-2002.

Principal Investigator – UCAR GPS-MET Radio Occultation Program, 1991-95.

Fellow – Cooperative Institute for Research in the Environmental Sciences, 1985-1991.

Recent Publications

Serke, D., K. Reed, J. Negus, L. Blanchette, R. Ware and P. Kennedy, A new narrow-beam, multi-frequency, scanning radiometer and its application to in-flight icing detection, Atmospheric Research, 2016.

Koch, S., R. Ware, H. Jiang and Y. Xie, Rapid mesoscale environmental changes accompanying genesis of an unusual tornado, Weather and Forecasting, 2016.

Cimini, D., M. Nelson, J. Güldner and R. Ware, Forecast indices from ground-based microwave radiometer for operational meteorology, Atmospheric Measurement Technology, 2015.

Xu, G., R. Ware, W. Zhang, G. Feng, K. Liao and Y. Liu, Effect of off-zenith observation on reducing the impact of precipitation on ground-based microwave radiometer measurement accuracy in Wuhan, Atmospheric Research, 2014.

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vibrating wire sonde compared to a ground-based microwave radiometer, Atmospheric Research (in review), 2014.

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Ware, R., D. Cimini, E. Campos, G. Giuliani, S. Albers, M. Nelson, S. Koch, P. Joe and S. Cober, Thermodynamic and liquid profiling during the 2010 Winter Olympics, Atmospheric Research, 2013.

Kimberly Reed (Investigator)

Atmospheric Scientist, Radiometrics; Visiting Scientist, NCAR Research Applications Laboratory

Degrees

B.S. Meteorology & Climatology -- University of Illinois at Urbana – Champaign, 2008

M.S. Atmospheric Science -- University of Illinois at Urbana – Champaign, 2011

Ph.D. (pending) Atmospheric Science -- University of Illinois at Urbana – Champaign, 2018

Work Experience

Visiting Scientist, NCAR Research Applications Laboratory, 2016 – present

Atmospheric Scientist and Systems Engineer, Radiometrics, 2015 – present

Meteorologist and Mission Scientist, MetAtmos LTD, 2015

Graduate Research Assistant, NASA Earth and Space Science Fellow, 2009 – present

Publications

Reed, K. A., and S. W. Nesbitt, An Evaluation of Cold-Season Precipitation Microphysical Properties from a Radar Perspective, In Progress, 2017.

Reed, K. A., and S. W. Nesbitt, Environmental Controls on Tropical Orographic Precipitation According to the Tropical Rainfall Measuring Mission, In Progress, 2017.

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Reed, K. A., Tropical Orographic Rainfall Regimes According to the Tropical Rainfall Measuring Mission. Master of Science Thesis, Dept. of Atmospheric Sciences, University of Illinois, Urbana, 2011.

Schroeder, A., J. Gourley, J. Hardy, J. Henderson, P. Parhi, V. Rahmani, K. Reed, R. Schumacher, B. Smith, M. Taraldsen, The Development of a Flash Flood Severity Index. Journal of Hydrology, 2016.

Serke, D. J., K. A. Reed, J. Negus, L. Blanchette, R. Ware, and P. Kennedy, A Narrow-Beam, Multi-Frequency, Scanning Radiometer and Its Application to In-Flight Icing Detection. Journal of Atmospheric Research. 2017.

Tim Wilfong (Investigator)

Atmospheric Scientist and Launch Range Specialist, Radiometrics Corporation

Degrees

B.S. Meteorology -- Pennsylvania State University, 1970

M.S. Meteorology – Pennsylvania State University, 1976

Work Experience

Staff Meteorologist, Detect Inc., 2013-2016; Radiometrics, 2016 – present: Provide technical oversight to the installations and performance evaluations of Raptor Wind Profiler line. Develop and test new signal processing techniques.

Chief Scientist, Next Generation National Profiler Network, Honeywell Technical Services Inc., 2007 - 2013: Provided oversight to the development, installation, and testing of the NGNPN which was planned to be up to 53 autonomous wind profiler radar sites.

RSA Weather Product Manager, Lockheed Martin, 2000 – 2003: Managed and provided technical direction for the $40M weather subsystem that was part of Range Standardization and Automation (RSA).

Senior Scientist, Science and Technology Corporation, NOAA Environmental Technologies Lab, 1996 – 2000: Provided program oversight for NOAA program to improve wind profiler signal processing technology.

Recent Publications

Wilfong, T., D. Berchoff, K. Brewster, F. Carr, N. Gasperoni, E. Lau, S. McLaughlin, R. Ware and M. Xue, Ground-Based Remote Sensing Techniques for Space Launch Decision Support, AMS, 2018.

Wilfong, T., R. Ware, D. Berchoff, M. Beauharnois, L. Blanchette, K. Brewster, J. Brotzge, F. Carr, W. Conway, B. Demoz, J. Freedman, N. Gasperoni, I. Gultepe, K. Knupp, E. Lau, D. Holland, E. Joseph, C. MacDonald, M. Mahaffey, S. McLaughlin, R. Parmentier, K. Reed, P. Roller, N. Sette, C. Thorncroft, S. Vanderburg, D. Voytenko and P. Wiker, Continuous Thermodynamic and Wind Profiling for High-Impact Weather Forecasting, AMS, 2018.

Curtis Alexander (Investigator)

Assimilation Development Acting Branch Chief, NOAA Earth Systems Research Laboratory, Global Systems Division

Degrees

Ph.D. Meteorology -- University of Oklahoma, 2010

M.S. Meteorology -- University of Oklahoma, 2002

B.S. Meteorology -- Pennsylvania State University, 1999

Work Experience

Acting Branch Chief Assimilation Development Branch/ 2017-Present

Global Systems Division

Meteorologist Earth System Research Laboratory/ 2016-Present

Assumed role as branch chief for the Assimilation and Development Branch (ADB) in the Global Systems Division of the Earth System Research Laboratory including project, personnel and associated budget management and planning

Developed the capability to rerun Rapid Refresh (RAP) and High-Resolution Rapid Refresh (HRRR) model forecast systems for the purpose of model development and enhancements including establishment of radar-reflectivity data assimilation in the 3-km HRRR

Global Systems Division

Recent Publications

Bytheway, Janice, C. Kummerow, C. Alexander, 2017: A Features-Based Assessment of the Evolution of Warm Season Precipitation Forecasts from the HRRR Model Over Three Years of Development. Wea. Forecasting, 32, 1841–1856.

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Keith Brewster (Investigator)

Associate Director, University of Oklahoma Center for Analysis and Prediction of Storms (CAPS).

Degrees

B.S. Meteorology -- University of Utah, 1981

M.S. Meteorology -- University of Oklahoma, 1984

Ph.D. Meteorology -- University of Oklahoma, 1999

Work Experience

Associate Director, CAPS, 2008 – present

Senior Research Scientist, CAPS, 1999—present

Adjunct Associate Professor, School of Meteorology, University of Oklahoma, 2006- present

Adjunct Assistant Professor, School of Meteorology, University of Oklahoma, 2002- 2006

Research Scientist, CAPS, University of Oklahoma, 1997-1999

Research Associate, CAPS, University of Oklahoma, 1993-1997

Recent Publications

Brewster, K., and D. Stratman, An updated high-resolution hydrometeor analysis system using radar and other data. Preprints, 27th Conference on Wea. Analysis and Pred. And 23rd Conf. on Numerical. Wea. Pred., Amer. Meteor. Soc., 2015.

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Jerald Brotzge (Investigator)

Program Manager, New York State Mesonet, State University of New York at Albany

Degrees

B.S. Meteorology -- Saint Louis University, Magna cum Laude, 1994

M.S. Meteorology -- University of Oklahoma, 1997

Ph.D. Meteorology -- University of Oklahoma, 2000

Work Experience

Program Manager, New York State Mesonet, 2014--present

Managing Director, Center for Analysis & Prediction of Storms (CAPS), 2011–2014

Adjunct Associate Professor, School of Meteorology, OU, 2011--2014

Sr. Research Scientist, Center for Analysis and Prediction of Storms, 2006--2014

Research Scientist, Center for Analysis and Prediction of Storms, 2001--2006

Recent Publications

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Fred Carr (Investigator)

McCasland Foundation Professor of Meteorology, School of Meteorology, University of Oklahoma.

Degrees

B.S. Meteorology -- Florida State University, 1969

M.S. Meteorology -- Florida State University, 1971

Ph.D. Meteorology -- Florida State University, 1975

Work Experience

President, American Meteorological Society, 2017.

McCasland Foundation Presidential Professor Emeritus, 2016 – present.

National Academy of Sciences, Committee on Developing Mesoscale Observations for National Needs, 2007-2008.

Professor, School of Meteorology, University of Oklahoma, 1995-2016.

CAPS Associate Director, University of Oklahoma, 1995-2010.

Visiting Scientist, NMC, NCAR, COMET and Forecast System Lab, 1993-1994.

Assistant and Associate Professor, School of Meteorology, University of Oklahoma, 1979-1994.

Research Scientist, SUNY Albany, 1975-1979.

Selected Publications

Carbone, R., J. Block, S. Boselly, G. Carmichael, F. Carr, V. Chandrasekar, E. Gruntfest, R. M. Hoff, W. F. Krajewski, M. LeMone, J. Purdom, T. Schlatter, E. Takle, and J. Titlow, Observing Weather and Climate FROM THE GROUND UP: A Nationwide Network of Networks, National Academies Press, 2009.

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Davis, C. and F. Carr, Summary of the 1998 Workshop on Mesoscale Model Verification, 2000.

Paul Schlatter (Investigator)

Science and Operations Officer, Denver Weather Forecast Office, National Weather Service.

Degrees

B.S., Engineering Physics, Westmont College, 2003.

M.S., Meteorology, University of Oklahoma, 2011.

Work Experience

Science and Operations Officer (SOO) at the Denver/Boulder, Colorado, National Weather Service (NWS) Forecast Office, 2016-2017. As SOO, he is responsible for ensuring new science and technology is incorporated into operational products and services.

NWS Acting Chief of Staff and the Deputy Chief of Staff in the NWS Front Office in Silver Spring, MD, 2013-2016. He directly supported the NWS director and deputy director of the NWS on policy development, coordinating internal and external communications, and enabling informed corporate decisions. For about seven months he also managed the Office of the Chief of Staff, which included the Communications Division, Equal Opportunity and Diversity Management Division, and the Legislative Affairs Divisions, and had ten direct reports.

Program Coordination Officer (PC)) for NOAA and NWS leadership in NOAA's Coordination Office, 2011-2013. As PCO, he provided advice and staff support to NOAA senior leadership and represented the NWS interests at the NOAA level.

Meteorologist Instructor at the NWS Warning Decision Training Branch (WDTB) in Norman, OK, 2003-2011. While with WDTB, he designed and delivered many training modules for the NWS, focusing on high impact weather warnings. He was the project lead for the dual-polarization radar operations course and played a critical role in the success of the development and deployment of the upgrade to the nation's fleet of 158 radars.

Paul is recognized as an expert in dual-polarization radar and severe weather warning decision making. He is passionate about continuously improving operational meteorology. He is an active and loyal member of the National Weather Association (NWA) and American Meteorological Society (AMS), and is currently the president-elect of the NWA.

16. Current and Pending Support

Investigator current and pending financial assistance including project title, supporting agency, investigator months, total dollar value and duration are listed below.

Ware, Reed and Wilfong

“Accurate Low Cost Thermodynamic Observing System”, NOAA Phase I SBIR (pending), 2.6 months, $119,862, 6/1/2018 – 12/1/2018.

"Thermodynamic Assimilation for Improved Convective Prediction" NOAA 2018 JTTI (pending), 7.2 months, $299,895, 10/1/2018 – 9/30/2020.

Brewster

"Convection-Allowing Ensemble Prediction for Heavy Precipitation in Support of the Hydrometeorology Testbed (HMT): New QPF Products, Data Assimilation Techniques and Prediction Model", DOC/NOAA, $239,700, 1.5 months/yr, 7/1/2017 – 6/30/2019.

"A Partnership to Develop, Conduct, and Evaluate Real-time High-Resolution Ensemble and Deterministic Forecasts for Convective-scale Hazardous Weather: Moving to the Next Level". DOC/NOAA, 1 month/yr, $450,000, 5/1/2016 – 4/30/2019.

"Enhancement and Evaluation of NGPS Model FV3 at Convection-Allowing Resolutions through Hazardous Weather Testbed Spring Experiment towards Accelerated Operational Implementation of FV3 for Mesoscale Applications", DOC/NOAA, 1 month/yr, $194,175, 5/1/2017 – 4/30/2019.

"Evaluation and Optimization of Two New Scale-Aware PBL Schemes within WRF for the prediction of Day- and Night-Time Storm Environment and Tornadic Storms during VORTEX-SE", DOC/NOAA, 1 month/year, $287,126, 9/1/2017 – 8/31/2019.

"Meteorological Data Server and Numerical Weather Prediction", Sub-contract to Leidos, Inc., DoD/DTRA., 0.75 month/yr, $7,855.20, 02/07/2017-02/06/2018, with options to 2021.

"National Mesonet", Subcontract to Stinger Ghaffarian Technologies (SGT) and Earth Networks from DOC/NOAA/NWS, $65,000, 1.0 month, 1/17/2018-9/16/2018

"Prototyping and Evaluating Key Network-of-Networks Technologies; Year 4", DOC/NOAA/NWS National Mesonet Program, $199,815, 2.5 mo, 8/1/2018-7/30/2019. To be submitted in April.

"Thermodynamic Assimilation for Improved Convective Prediction" NOAA 2018 JTTI (pending), 6.1 months, $50,000, 10/1/2018 – 9/30/2020.

Carr

National Mesonet", Subcontract to Stinger Ghaffarian Technologies (SGT) and Earth Networks from DOC/NOAA/NWS, $65,000, 0.12 month, 1/17/2018-9/16/2018

"Prototyping and Evaluating Key Network-of-Networks Technologies; Year 4", DOC/NOAA/NWS National Mesonet Program, $199,815, 0.12 month, 8/1/2018-7/30/2019. To be submitted in April.

"Thermodynamic Assimilation for Improved Convective Prediction" NOAA 2018 JTTI (pending), 1 month, $50,000, 10/1/2018 – 9/30/2020.

Brotzge

"Thermodynamic Assimilation for Improved Convective Prediction" NOAA 2018 JTTI (pending), 2.16 months, $25,000, 10/1/2018 – 9/30/2020.

17. Data Management Plan

MTP data collected during this project for 1DVAR development and testing, for statistical comparison with radiosondes and model analysis, and for statistical comparison of radiometer observed brightness temperatures with forward modeled radiosonde and model analysis, will be made discoverable by and accessible to the general public, typically within two years of collection, free of charge at no more than the cost of reproduction, unless an exemption is granted by the NOAA program.

18. Track Record for Success

The Investigator team has a reasonable record of success in developing atmospheric remote sensing technologies and assisting NOAA and other agencies in advancing them to operational status. Included are remote sensing of precipitable water via ground-based GPS stations (Bevis et al, 1992) and networks (Ware et al, 2000), and atmospheric remote sensing via GPS radio occultation (Ware et al, 1996).

Our objectives for this project are to further improve thermodynamic profiler based aviation weather advisories, and to make progress in thermodynamic profile assimilation and forecasting of convective weather[9].

19. References

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20. **Appendix: Denver WFO-CWSU Letter**

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service Forecast Office, WS1
Boulder, Colorado 80305
Tuesday, January 23, 2018

Memorandum For: NOAA Grant Evaluation Committee

From: Nezette Rydell, Meteorologist in Charge
National Weather Service Forecast Office, Boulder, CO

National Weather Service Denver Center Weather Service Unit (CWSU) and Weather Forecast Office Boulder, CO (WFO) meteorologists have used continuous thermodynamic sounding information when it has been available via http://weatherview.radiometrics.com to improve aviation forecasts and weather advisories to the FAA over the last several years. This information has been helpful in forecasting near-term weather for Denver International Airport (DIA) and surrounding areas, particularly in regard to convection, inversions, and with freezing drizzle, snow, and icing.

During convective season, real-time soundings provided by RDX have been instrumental in diagnosing the actual presence or absence of mid- and upper-level instability as compared to model forecasts, directly aiding the forecasting and evolution of showers or thunderstorms at/near DIA and arrival and departure gates.

These soundings were also used in winter seasons; aiding in near real-time to monitor phenomena such as surface inversion strength (to forecast wind speed and direction and low stratus), and for monitoring of depth of low-level moisture and temperature profiles for forecast adjustments with regard to the onset timing of freezing drizzle, rain, and changeover to snow.

We estimate our forecasters used this data, when available, several times a week, and in rapidly evolving weather events, multiple times per day. The temporal resolution for these observations, roughly every 30-40 minutes, provided significant confidence to our staff in updated forecasts and warning operations.