

# Christopher Philip Riedel

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CONTACT INFORMATION 2529 Dayflower Ln (785) 320-0385  
Norman, OK 73069 criedel@ucar.edu

CURRENT APPOINTMENT **Project Scientist I**  
February 2023 – present  
University Corporation for Atmospheric Research (UCAR)  
Cooperative Programs for the Advancement of Earth System Science (CPAESS)

**Current Research Focus:** I am a NOAA Affiliate working in the Quantitative Observing System Assessment Program (QOSAP) located with NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML). I work entails improving our ability to assimilate GPS Radio Occultation (GPS-RO) observations within the global modeling framework at NOAA. My work focuses on the improvement of the forward operator, observation error specification and data quality control.

PAST APPOINTMENTS **NCAR Advanced Study Program (ASP) Postdoctoral Fellow**  
July 2020 – January 2023  
Computational Information Systems Laboratory (CISL)

*Research Experiences:* I worked with Ensemble Kalman Filter (EnKF) software developed at NCAR (data assimilation research testbed; DART) and the community Earth system model (CESM) to improve understanding of surface-atmosphere (in this case, sea-ice-atmosphere) interactions. In the first year of my appointment, I improved the technical ability to perform ensemble sea-ice data assimilation using DART and CESM, which is scalable to multiple complex surface interaction problems. The improvements were tested in Observing System Simulated Experiments (OSSEs). In year two of the appointment, I collaborated with the DART team to develop a new ensemble filter which is able to work with non-Gaussian distributions more appropriately. I developed an interface between DART and a sea-ice single column model to test different data assimilation techniques. More broadly, the project followed the thread of developing coupled data assimilation methods to better represent the varying timescales of dynamic surface and atmosphere processes and their interactions.

EDUCATION **University of Oklahoma, Norman, OK**

PhD Meteorology, May 2020

*Dissertation Title:* Tropospheric Polar Vortices and Impacts on Atmospheric Flow from the Arctic to the Mid-Latitudes using a New Global Modeling System  
*Adviser:* Steven Cavallo

*Research Experiences:* I worked to improve our understanding and representation of an Arctic mesoscale feature called the tropopause polar vortex (TPV) and investigated the multiscale impacts of TPVs on mid-latitude predictability. I developed a global ensemble data assimilation system using EnKF software developed at NCAR (DART) and the newly developed, variable resolution global model developed at NCAR (Model for Prediction Across Scales (MPAS)). This required developing technical knowledge in large computing and large datasets, ability to investigate and assess technical problems as they arose, and problem solving to efficiently complete simulations. Assessment of the modeling system was accomplished using a newly developed technique which combines model information (tendencies) and data assimilation information (analysis increments)

to gain a better physical understanding of model errors in the system. Ensemble sensitivity analysis was applied to investigate large-scale downstream flow sensitivities to mesoscale TPV characteristics. This understanding is critical for predictability of features where multiscale dynamics play important roles such as extreme weather events (e.g., severe weather, extra-tropical transitions, flooding rains, drought, etc.). These findings provide new knowledge to the basic research community, but also provide guidance and demonstrate model evaluation methods to applied communities.

### **University of Oklahoma, Norman, OK**

M.S. Meteorology, December 2015

*Thesis Title:* Improved Characterization And Prediction Of Antarctic Weather Through Ensemble Data Assimilation And Utilization Of The CONCORDIOSI Data Set

*Adviser:* Steven Cavallo

*Research Experiences:* I worked to determine if an ensemble data assimilation technique would provide better analyses and forecasts as compared to a 3DVAR technique over the Southern Hemisphere. I developed a regional ensemble data assimilation system using EnKF software developed at NCAR (DART) and the Weather Research and Forecasting Model (WRF). Technical code development provided more accurate ozone profiles during model runtime. Data assimilation technical development allowed for assimilation of satellite polar orbiting cloud winds, temperature/moisture satellite retrievals, and a special field-observed dropsonde dataset. Assessment of the modeling system was accomplished by comparing analyses and forecasts to a already developed operational regional modeling system (NCAR's Antarctic Mesoscale Prediction System (AMPS)). This effort provided guidance to the applied community about the abilities and feasibility of ensemble approaches over data-sparse regions like the Southern hemisphere.

### **University of Oklahoma, Norman, OK**

B.S. Meteorology with distinction, May 2013

*Research Experiences:* I worked as a undergraduate research assistant at the Cooperative Institute for Mesoscale Meteorological Studies (CIMMS) supporting the National Severe Storms Laboratory (NSSL). My responsibilities included developing scripts for automated data archival, and assessment of a real-time 3DVAR analysis system that was used in the NSSL Hazardous Weather Testbed (HWT). This experience also offered the opportunity for me to be exposed to severe storms research and begin to learn how numerical models like WRF worked as an undergraduate student.

### **Ottawa University, Ottawa, KS**

B.A. Mathematics, May 2010

#### **TECHNICAL SKILLS** **Data Processing Code** *Proficient-to-Expert*

I use a combination of shell-scripting (c-shell) and python scripting to post-process my own model data and datasets obtained from global modeling centers. Post-processing includes moving data from work space to storage space on large super computers along with computing variables that are not included with model output.

**Data Visualization Code** *Expert*

I have experience creating data visualization from model output using python.

**Model and Data Assimilation Code****The Weather Research and Forecasting Model (WRF):** *Expert*

I have used WRF since my undergraduate research assistant position. I used WRF extensively during my masters research: I modified code to include more realistic ozone profiles, coupled it with the EnKF Software provided by The Data Assimilation Research Testbed (DART), and included satellite polar orbiting cloud winds, temperature/moisture satellite retrievals, and a special field-observed dropsonde dataset in assimilation. I am also familiar with idealized WRF frameworks.

**Model for Prediction Across Scales (MPAS):** *Expert*

I used MPAS extensively during my PhD research: I coupled MPAS with the EnKF Software provided by The Data Assimilation Research Testbed (DART), identified errors/model biases, and evaluated model tendencies.

**CM1 Numerical Model:** *Proficient*

I have experience using this tool for idealized experiments from various graduate coursework.

**Community Earth System Model(CESM):** *Proficient/Expert in CICE*

I have experience using this tool during my postdoc sea ice data assimilation work. I mainly worked with the sea ice model CICE but have experience setting up experiments using different Earth system models that are within the CESM framework.

**The Data Assimilation Research Testbed (DART):***Expert*

I have experience using and modifying DART software code to assimilate many types of observations. I have modified existing assimilation code along with including new forward operators to work with new observations platforms. I have coupled DART with several Earth system models.

**Other Code Skills:** *Proficient-to-Expert*

I have created and modified code in FORTRAN while working with numerical model and data assimilation software. I have worked with MPI in FORTRAN and parallel computing options in Python. Additionally, I have experience running numerical weather prediction ensembles on large super computers; NCAR-Cheyenne, OU-OSCAR/Schooner, SoM local cluster-Arctic (I partially provided technical management for this system during later years of Ph.D.). I have experience with GPU computing, and have worked to bring GPU capability to the DART data assimilation code. I have experience with Github and contribute to the DART team repositories when appropriate. Proficiency depends on the code and application at hand, but in general I am a fast learner in these spaces.

## PUBLICATIONS

**Riedel, C.**, J. Anderson: Exploring Truncated Non-parametric Filter Impacts on Sea Ice Data Assimilation, In preparation for Mon. Wea. Rev.

**Riedel, C.**, J. Anderson: Exploring Non-Gaussian Sea Ice Characteristics via Observing System Simulation Experiments, Submitted to the cryosphere

**Riedel, C.**, S.M. Cavallo, J. Anderson: Sensitivity of MPAS-DART analyses and

forecasts to assimilation of 2016 NAWDEX special TPV observations, In preparation for Mon. Wea. Rev.

**Riedel, C.**, S.M. Cavallo, J. Anderson, 2022: Diagnosing Biases over the Arctic in an Ensemble-Cycling High-Resolution Global Model, In prep to Mon. Wea. Rev.

**Riedel, C.**, S.M. Cavallo, D.B. Parsons, 2020: Mesoscale prediction in the Antarctic using cycled ensemble data assimilation, Mon. Wea. Rev., <https://doi.org/10.1175/MWR-D-20-0009.1>

Lillo, S. P., Cavallo, S. M., Parsons, D. B., **Riedel, C.**, 2021: The role of a tropopause polar vortex in the generation of the January 2019 extreme Arctic outbreak. J. Atmos. Sci., [doi.org/10.1175/JAS-D-20-0285.1](https://doi.org/10.1175/JAS-D-20-0285.1).

Parsons, D.B., 22 coauthors, **C. Riedel**, 10 coauthors, 2017: THORPEX research and the science of prediction. Bull. Amer. Meteor. Soc., 98, 807–830, [doi.org/10.1175/BAMS-D-14-00025.1](https://doi.org/10.1175/BAMS-D-14-00025.1).

Smith, T.M., J. Gao, K.M. Calhoun, D.J. Stensrud, K.L. Manross, K.L. Ortega, C. Fu, D.M. Kingfield, K.L. Elmore, V. Lakshmanan, and **C. Riedel**, 2014: Examination of a real-time 3DVAR analysis system in the Hazardous Weather Testbed. Wea. Forecasting, 29, 63–77, [doi:10.1175/WAF-D-13-00044.1](https://doi.org/10.1175/WAF-D-13-00044.1).

FUNDING AWARDS	<b>National Science Foundation–Funded</b> Advancing knowledge of Arctic sea ice interactions with tropopause polar vortices and Arctic cyclones – Non-Funded Collaborator	Spring 2022
	<b>NCAR Advance Study Program(ASP) Postdoctoral Fellowship</b> Award provides postdoctoral funding for two years at NCAR	Fall 2020
COMPUTATIONAL AWARDS	<b>CISL Allocation: Simulations in Support of SIMAv1</b> Award provides computing on NCAR’s Cheyenne super-computer to run high-resolution coupled simulations over the Arctic	Spring 2021
	<b>CISL University Large Allocation Request</b> Award provides computing on NCAR’s Cheyenne super-computer to run MPAS-DART cycling experiments for PhD work	Spring 2017
INVITED TALKS	<b>Riedel, C. P.</b> , Cavallo, S., Anderson, J., Torn R., Wong, M., Berner, J., 17 November 2021: <i>Arctic Moisture Biases and Sensitivity in a Global High-Resolution Cycled Data Assimilation Modeling System</i> , University of Utah Atmospheric Science Seminar	
SEMINARS	<b>Riedel, C. P.</b> , Cavallo, S., 13 February 2020: <i>Evaluation of the Arctic Atmosphere Using Cycled Data Assimilation and a High-Resolution Global Model</i> , NCAR MMM Seminar Series	

TRAINING/ WORKSHOPS	NERSC GPU Hackathon Participant	December 2021
	NCAR CISL GPU Tutorial Series	April 2020
	Systems for Integrated Modeling of Atmosphere (SIMA) Workshop	Summer 2020
	NCAR Advanced Study Program Leadership Training	Summer 2018
	Professional Ethics Training – Responsible Conduct of Research	Fall 2013
CONFERENCE PRESENTATIONS	<b>Riedel, C. P.</b> , Anderson, J., 2022: <i>Exploring Non-Gaussian Sea Ice Characteristics via Observing System Simulation Experiments</i> , 26th Conference on Integrated Observing and Assimilation Systems for the Atmosphere, Oceans, and Land Surface (IOAS-AOLS), Virtual, Presentation.	
	<b>Riedel, C. P.</b> , Cavallo, S., 2021: <i>Sensitivity of MPAS-DART analyses and forecasts to assimilation of 2016 NAWDEX special TPV observations</i> , 2021 NAWDEX Workshop, Virtual, Poster.	
	<b>Riedel, C. P.</b> , Cavallo, S., 2019: <i>Sensitivity of Forecasts to Special Observations in a TPV during the 2016 NAWDEX Field Campaign using the MPAS-DART Ensemble Data Assimilation System</i> , 19th Cyclone Workshop , Seon, Germany, Cyclone Workshop, talk.	
	<b>Riedel, C. P.</b> , Cavallo, S., 2019: <i>Identification of Systematic Model Bias in the Arctic Atmosphere Using Cycled Data Assimilation and a High-Resolution Global Model</i> , 15th Conference on Polar Meteorology and Oceanography, Boulder, CO, American Meteorological Society, talk.	
	<b>Riedel, C. P.</b> , Cavallo, S., 2018: <i>MPAS-DART Ensemble Data Assimilation System in Polar Regions</i> , 1st Annual Joint WRF and MPAS Users' Workshop, Boulder, CO, National Center for Atmospheric Research, poster.	
	<b>Riedel, C. P.</b> , Cavallo, S., 2017: <i>The Development of the MPAS-DART Ensemble Data Assimilation System for Polar to Lower-Latitude Predictability Studies</i> , 18th Cyclone Workshop , Montreal, Canada, Cyclone Workshop, talk.	
	<b>Riedel, C. P.</b> , Cavallo, S., 2017: <i>Sensitivity of TPVs to a downstream forecast bust</i> , 28th Conference on Weather Analysis and Forecasting / 24th Conference on Numerical Weather Prediction, Seattle, WA, American Meteorological Society, poster.	
	<b>Riedel, C. P.</b> , Cavallo, S., 2017: <i>Evaluation of a cycling mesoscale ensemble prediction system over the Antarctic region</i> , 14th Conference on Polar Meteorology and Oceanography, Seattle, WA, American Meteorological Society, talk.	
	<b>Riedel, C. P.</b> , Cavallo, S., 2016: <i>Ensemble Data Assimilation in the Antarctic Mesoscale Prediction System (AMPS) over the Southern Hemisphere</i> , 2016 NJU-OU Symposium for Weather and Climate Research, Nanjing, People's Republic of China, Joint symposium between University of Oklahoma and Nanjing University, talk.	
	<b>Riedel, C. P.</b> , Cavallo, S., 2016: <i>Evaluation of the Spread-Skill Relationship on a Busted Forecast using a MPAS Pseudo-Ensemble</i> , 17th Annual WRF Users' Workshop, Boulder, CO, National Center for Atmospheric Research, poster.	

**Riedel, C. P.**, Cavallo, S., 2015: *Sensitivities in Cyclone Forecasts for the Antarctic Region using an EnKF Method with the AMPS Model*, 17th Cyclone Workshop , Pacific Grove, CA, Cyclone Workshop, poster.

**Riedel, C. P.**, Cavallo, S., 2015: *Atmospheric Analysis Uncertainties over the Antarctic Region using an EnKF Method with the AMPS Model*, International Symposium on Earth-Science Challenges, Norman, OK, Advanced Radar Research Center, talk.

**Riedel, C. P.**, Cavallo, S., 2015: *Atmospheric Analysis Uncertainties over the Antarctic Region using an EnKF Method with the AMPS Model*, Conference On Weather Analysis And Forecasting/Conference On Numerical Weather Prediction, Chicago, IL, American Meteorological Society, talk.

**Riedel, C. P.**, Cavallo, S., 2014: *Ensemble Data Assimilation over Antarctica and the Southern Ocean*, The World Weather Open Science Conference, Montreal, CA, World Meteorological Organization, talk.

PROFESSIONAL  
AWARDS

**NCAR ASP Postdoctoral Fellowship** Spring 2020

**Cyclone Workshop Student Travel Scholarship** Fall 2019

**Outstanding Student Presentation Award** Summer 2019  
Presentation given at AMS Conference on Polar and Oceanography

**NCAR ASP Graduate Student Visitors Fellowship** Summer 2018  
Mentor: Jeffery Anderson

**SOM Scholarship** Fall 2012  
School of Meteorology scholarship for excellent classwork

TEACHING  
EXPERIENCE

**University of Oklahoma, School of Meteorology**

Teaching Assistant METR5002 Fundamentals of Atmospheric Science Fall 2019  
Fall 2014-2018 (even years)

Teaching Assistant METR1313 Programming for Meteorology Spring 2014

Teaching Assistant METR2011 Intro to Meteorology Fall 2013  
(Lecturing Lab Instructor) I Laboratory

Teaching Assistant METR2021 Intro to Meteorology Spring 2013  
(Lecturing Lab Instructor) II Laboratory

PROFESSIONAL  
SERVICE

NCAR's Reframe, Envision, Modernize (REM) initiative Summer 2021 - Spring 2022

Mentoring graduate student (U. Washington, Molly Wiergna/C. Bitz) on sea ice data assimilation framework with CESM/DART 2021 - present

CESM Tutorial: Setup and running CESM on OU Supercomputer Schooner June 2021

National Science Foundation (NSF) Modeling and Data Assimilation (MDA) site visit team (SVT) meeting participant May 2021

Early Career Scientist Assembly (ECSA) Steering Committee, Member, National Center for Atmospheric Research. Spring 2021 – present

Advanced Study Program Research Reviews Committee, Member, National Center for Atmospheric Research.	Fall 2020 – present
Undergraduate Research Mentor (Alyssa Woodward, OU School of Meteorology)	Summer 2019 – Spring 2020
EMC NGGPS Ensemble Strategic Implementation Plan (SIP) Working Group Member	2017–2019
42nd Annual NOAA Climate Diagnostics and Prediction Workshop Volunteer	Fall 2017
SoM Graduate Student Recruitment Committee Member	2014–2020
NWC Research Experience for Undergraduates Mentor (Laurie Wachowicz, Michigan State University)	Summer 2014
NOAA Hazardous Weather Testbed Experiment Student Assistant	Spring 2012