Midwest Student Conference on Atmospheric Research 2021

Program

University of Illinois at Urbana-Champaign
September 25th – 26th 2021

Welcome to the Midwest Student Conference on Atmospheric Research (MSCAR)

On behalf of the entire conference committee, we welcome you to the 2021 Midwest Student Conference on Atmospheric Research (MSCAR). This conference is designed to create an opportunity for students, both graduate and undergraduate, to present their research to other students in a conference setting. We wish to create an environment conducive to gaining valuable skills in presenting, networking, and problem solving.

This 5th edition of MSCAR brings together more than 150 attendees across 25 institutions from 5 different countries. The format of this conference is continually being reshaped to maximize student participation and learning. We have meticulously planned research sessions (oral and poster talks), social and networking opportunities, keynote sessions and technical workshops. We hope that each participant leaves the conference having learned something new about atmospheric science or related disciplines.

We are honored to have Dr. J. Marshall Shepherd, Dr. Karen Kosiba, and Dr. Mika Tosca as our keynote speakers. We would like to thank our supporting staff and colleagues, who are listed below, for their instrumental support and assistance throughout the entire planning process. Lastly, thank you all for your interest in attending the conference, and we hope that you have a great experience this weekend.

Sincerely,
Holly Mallinson and Troy Zaremba
MSCAR Co-Chairs

MSCAR Committee

Organizers

David Lafferty
Divyansh Chug
Emily Glenn
Carolina Bieri
Sophie Orendorf
Brianna Brag
Jake Vile
Rachel Tam
Eddie Wolff

Faculty Advisor

Prof. Nicole Reimer

Support Staff

Tammy Warf

Our Home Away From Home

The Natural History Building

The newly renovated Natural History Building has served as the conference venue since 2017. This 148,000 square-foot space features a 300-person auditorium, modular classrooms and laboratories employed with the latest technology suitable for collaboration among faculty and students. Our visualization studio allows researchers to analyze satellite weather data and allows students to practice broadcast meteorology. We wish you could join us in person to check out our great facility! Hopefully the pandemic will end soon and we can welcome you to campus!

The Union

The Illini Union, located on the north side of the Main Quad, serves as a hub where students can eat and relax. The bottom floor features many restaurants as well as an arcade and a bowling alley. The Illini Union Hotel is situated on the top levels of the building, making it a convenient location for conference attendees in past years from out of town to enjoy the campus environment.

The FARM

The Flexible Array of Radars and Mesonets (FARM) consists of DOW radars, mobile mesonets, mobile upper air sounding systems, disdrometers, and deployable instrumentation pods used to service the scientific community. The DOW radars have been used in numerous field campaigns including VORTEX2, PECAN, OLYMPEX, SNOWIE, RELAMPAGO, VORTEX-SE, and more! We are really excited to have this facility on campus!

Follow us on Twitter @MSCAR_Illinois
Like us on Facebook at Midwest Student Conference on Atmospheric Research – MSCAR

Keynote Speakers

Dr. Marshall Shepherd is the Georgia Athletic Association Distinguished Professor of Geography and Atmospheric Sciences at the University of Georgia and Director of its Atmospheric Sciences Program. Dr. Shepherd was the 2013 President of American Meteorological Society (AMS). Prior to academia, he spent 12 years as a scientist at NASA Goddard Space Flight Center and was Deputy Project Scientist of the Global Precipitation Measurement Mission. Dr. Shepherd is the host of The Weather Channel's Weather Geeks Podcast and a senior contributor to Forbes Magazine. In 2021, Dr. Shepherd was elected to the National Academy of Sciences, National Academy of Engineering, and the American Academy of Arts and Sciences. The only member of the University of Georgia faculty to ever achieve this trifecta. He has received numerous awards including the 2004 White House PECASE Award, the Captain Planet Foundation Protector of the Earth Award, the 2019 AGU Climate Communication Prize, the 2020 Mani L. Bhaumik Award for Public Engagement with Science and the 2018 AMS Helmut Landsberg Award. He received his B.S., M.S. and PhD in meteorology from Florida State University. He has two TEDx talks on climate science and communication that collectively exceed two million viewers. He is routinely asked to brief the media, Congress, and the White House on weather-climate-science related topics. Dr. Shepherd has almost 100 peer-reviewed publications on various topics.

Dr. Karen Kosiba is an Adjunct Research Professor at the University of Illinois and currently manages the FARM facility. She has a B.S. in Physics from Loyola University, an M.S. in Physics and an M.A.T in Teacher Education from Miami University, and a Ph.D. in Atmospheric Science from Purdue University. When she began college, she considered careers in architecture, patent law, and veterinary medicine, but ultimately decided that observational studies of severe weather combined all of her interests. Her research mainly focuses on the kinematics and dynamics of severe convective storms, characterizing the low-level wind structure in tornadoes, and understanding the boundary layer winds and small-scale structures in landfalling hurricanes. Key to her research is executing field projects to collect data that can be analyzed to better understand and predict these hazardous weather events. Additionally, she is passionate about science education, regularly participating in outreach activities at schools, museums, and festivals, and online and through media interviews and consultations. A strong believer in experiencing weather from the inside of a mobile weather radar, she has participated as a radar operator, project scientist, and project leader in a multitude of field projects.

Dr. Mika Tosca is a climate scientist, a humanist, and an activist. She is an Assistant Professor at the School of the Art Institute of Chicago and an affiliate climate researcher at the Jet Propulsion Laboratory (JPL) in southern California. Her current research and public outreach explores the synthesis of art and climate science and posits that engaging with artists, designers, and makers is instrumental to solving the climate crisis. Mika is a proud transgender scientist (she/her pronouns) and a vocal advocate for the queer and trans communities in Chicago and beyond. Dr. Tosca earned her Ph.D. in Earth System Science at the University of California Irvine.

TECHNICAL WORKSHOPS

Analyzing Radar Data with PyART with Dr. Scott Collis

This workshop will cover introductory use of the Python Arm Radar Toolkit (PyART), a Python package used to read, manipulate, apply algorithms, and write radar data. PyART is an open source collaborative software environment that is used by many in the field.

About the presenter: Dr. Scott Collis is an atmospheric scientist and head of the Geospatial Computing, Innovations, and Sensing (GCIS) department in the Environmental Science Division at Argonne National Laboratory and a Senior Fellow at the Northwestern Argonne Institute of Science and Engineering (NAISE). Scott's research is at the intersection of data informatics, atmospheric science, and radar meteorology.

Satellite Data Analysis with Margaret Mooney and Dr. Scott Lindstrom

This workshop will help you understand what the different channels on geostationary and low-Earth-orbit satellites tell you, and what tools you can use to access the data and display it for yourself!

About the presenters: Margaret Mooney is the Education and Public Outreach lead at NOAA's Cooperative Institute for Meteorological Satellite Studies (CIMSS). As a former National Weather Service meteorologist, Mooney has ample experience working with formal and informal audiences, leveraging early career experience with a degree in public policy to promote weather and climate education as avenues towards stewardship and sustainability. Dr. Scott Lindstrom is a weather weenie who grew up in State College PA, so of course he got a BS from Penn State, then went to the UW-Madison for graduate degrees. He has spent much of the past 20 years advocating for the use of satellite data in forecast decision-making, and in that role has created and presented training to forecasters.

Implications of Climate Change with Dr. Trent Ford

This workshop will walk you through the recent release of the Intergovernmental Panel on Climate Change as well as the Illinois assessment on Climate Change and talk about what the specific climate implications are on the Midwest. Dr. Ford will also go over various types of climate data, where they come from, as well as advantages and disadvantages to using different datasets.

About the presenters: Dr. Trent Ford has been the Illinois State Climatologist since 2019. He and his team provide/share climate data/information online, through traditional media sources and social media, and speak to interested groups across the state. In addition to his role in education and climate outreach, Dr. Ford also conducts research on the climate change system and extreme climate events such as drought and heat waves.

Meet our Careers Panel

Max Grover

Max is a software engineer/data scientist within the Climate and Global Dynamics Lab at NCAR. He has a B.S. in meteorology from Valparaiso University and an M.S. in Atmospheric Sciences from the University of Illinois.

Evan Duffey

Evan is a Senior Meteorologist and Manager of Forecasting and Operations at Pacific Gas and Electric Company in Dublin, California. He earned his B.S. in meteorology from SUNY Oswego in 2011 where he worked with DOW data to investigate the structure of Lake Effect Snow Bands. He forecasts for the California electrical and gas grids as well as for fire weather.

Lisa Michaels

Lisa was born and raised in the northern suburbs of Chicago. She earned her B.S. in Atmospheric Sciences form the University of Illinois During her studies in Champaign she spent one month storm chasing and was able to see over 20 tornadoes, hail events, and other weather phenomena. Lisa is a broadcast meteorologist and has worked for NBC, ABC, CBS and Fox affiliates.

Dr. Owen Doherty

Dr. Doherty is a climate and data analyst at Eagle Rock Analytics. Dr. Doherty received his B.S. degree from Cornell University in 2003 and his doctorate in Marine and Atmospheric Sciences from Stony Brook University in 2012. Eagle Rock Analytics is based out of Sacramento, CA and the company focuses on answering data driven atmospheric, climate, oceanic, and environmental science questions.

Graduate School Fair Participants

School	Point of Contact	Email
Northern Illinois University	Victor Gensini	vgensini@niu.edu
University of Wisconsin-Milwaukee	Clark Evans	evans36@uwm.edu
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University of Iowa	Jun Wang	jun-wang-1@uiowa.edu
University of Illinois Urbana-Champaign	Ryan Sriver	rsriver@illinois.edu

Our Department Head

Robert Trapp is the Department Head of the Department of Atmospheric Sciences and a Blue Waters Professor at the University of Illinois at Urbana-Champaign. Before joining Illinois in 2014, he was a Professor in the Department of Earth and Atmospheric Sciences at Purdue University from 2003-2014 and a research scientist with the National Severe Storms Laboratory (through the Cooperative Institute for Mesoscale Meteorological Studies) in Norman, Oklahoma from 1996-2013. Professor Trapp is one of the lead authors of the 4th U.S. National Climate Assessment Report from 2016-2017.

Dr. Trapp is the author of the book, “Mesoscale Convective Processes in the Atmosphere”. He received his Ph.D. from the University of Oklahoma and was a National Research Council Postdoctoral Fellow.

Our Faculty Advisor

Nicole Riemer is aProfessor in the Department of Atmospheric Sciences at the University of Illinois at Urbana-Champaign. Before joining Illinois in 2008, Dr. Riemer was an Assistant Professor in the Institute for Terrestrial and Planetary Atmospheres at Stony Brook University from 2005-08.

Dr. Riemer is a recipient of NSF-CAREER Award 2013 and has been named a 2014-15 I. C. Gunsalus Scholar by the College of Liberal Arts and Sciences at the University of Illinois in recognition of her strong record of scholarship and teaching in the physical and life sciences. She recently received the 2021 AGU Ascent Award!

Additionally, Prof. Riemer is the faculty advisor and an integral part of the organizing committee for MSCAR 2021!

CONFERENCE SCHEDULE

(all times are in CDT)

Saturday, September 25th

Time	Event
9:00-9:10 am	Opening Remarks: **Dr. Robert Trapp**
9:10-9:55 am	Keynote: **Dr. Karen Kosiba**
9:55-10:05 am	Break
10:05-11:05 am	Oral Session I: **Winter Weather**
11:05-11:15 am	Break
11:15 am-12:30 pm	Oral Session II: **Severe Weather**
12:30-1:00 pm	Lunch Break
1:00-1:45 pm	Careers in Earth Science Panel
1:45-2:30 pm	Grad School Fair
2:30-2:45 pm	Break
2:45-4:00 pm	Oral Session III: **Tropical Meteorology & Atmospheric Winds**
4:00-4:15 pm	Break
4:15-5:15 pm	Oral Session IV: **Land Surface Interactions & Pollution**
5:15-6:30 pm	Poster Session
6:30–7:00 pm	Break
7:00-8:00 pm	Keynote: **Dr. Mika Tosca**
8:00-9:00 pm	Networking Event

Sunday, September 26th

Time	Event
9:00-11:15 am	Workshops
11:15-11:30 am	Break
11:30am-12:30pm	Keynote: **Dr. Marshall Shepherd**
12:30-1:00 pm	Lunch break
1:00-1:30 pm	DOW Tour and Q&A
1:30-2:00 pm	Closing remarks & Awards
2:00-3:00 pm	Networking Event

Oral Session Schedule

Session I: Winter Weather (10:05 - 11:05 AM CT)

Time	Name	Talk Title
10:05-10:17 AM	Andrew Janiszeski	Kinematic Modeling Study of the Reorganization of Snowfall beneath Cloud-Top Generating Cells in Midlatitude Winter Storms
10:17-10:29 AM	Divya Rea	The Impact of Atmospheric Rivers on Cloud Structure and Seedability during the SNOWIE Experiment
10:29-10:41 AM		
10:41-10:53 AM	Yueqian Cao	Topographic Controls on Hydrology and Microwave Behavior of Seasonal Snowpacks: Modeling Framework and Scaling Analysis
10:53-11:05 AM	Kaylee Heimes	The Impact of Fine Scale Updrafts and Downdrafts on the Trajectories of Ice Particles Created by Seeding Orographic Clouds in Observed and Modeled Flow

Session II: Severe Weather (11:15 AM - 12:30 PM CT)

Time	Name	Talk Title
11:15 - 11:27 AM	Bobby Saba	Verification of Tornado Intensity Added to NWS Preliminary Tornado Damage Path
11:27 - 11:39 AM	Enoch Jo	The Influence of Vertical Wind Shear on Entrainment in a Simulated Supercell Thunderstorm
11:39 - 11:51 AM	Kevin Gray	Investigation of Outflow Surge Characteristics in Simulated Supercell Thunderstorms
11:51 AM - 12:03 PM	Nathan Makowski	Factors of Locally-Produced Thunderstorm Genesis in the Southern Appalachians
12:03 - 12:15 PM	Anthony Crespo	Characterization of three hailstorms in Argentina
12:15 - 12:27 PM	Devon Healey	Comparing Polarimetric Signatures of Proximate Tornadic and Non-Tornadic Supercells in Similar Environments

Session III: Tropical Meteorology and Atmospheric Winds (2:45 - 4:00 PM CT)

Time	Name	Talk Title
02:45 - 02:57 PM	Chibueze Oguejiofor	Investigating the dependence of hurricane intensity on varying SST patterns using idealized model simulations
02:57 - 03:09 PM	Cam My Nguyen	A Multivariable Hurricane Hazard Index
03:09 - 03:21 PM	Chandler Pruett and Robert Szot	Weathering the Storm: How Cones of Uncertainty Impact Hurricane Risk Perception
03:21 - 03:33 PM	McKenzie Larson	Downslope Wind Verification of the National Blend of Models Across the Northern Front Range of Colorado
03:33 - 03:45 PM	Victoria Lang	Forecasting Peak Wind Gusts for Specific Weather Types Using the Meteorologically Stratified Gust Factor Model
03:45 - 03:57 PM	Sean Matus	Observed Land-Atmosphere Anomalies from ERA5 Associated with Extreme Great Plains Low-Level Jets

Session IV: Land Surface Interactions and Pollution (4:15 - 5:15 PM CT)

Time	Name	Talk Title
04:15 - 04:27 PM	Chu-Chun Chen	The influence of soil moisture anomalies on ENSO teleconnections over southeastern South America
04:27 - 04:39 PM	Victor Arraes Rocha Felix	Orographic Rains at the Araripe Plateau - a Geostatistical Model for the climatic transition between the Cariri Cearense and the semiarid portion of Pernambuco
04:39 - 04:51 PM	Paolo Giani	Modeling the real convective boundary layer in the ‘terra incognita’: different approaches to overcome the challenge
04:51 - 05:03 PM	Aldo Brandi	Influence of projected climate change, urban development and heat adaptation strategies on end of twenty-first century urban boundary layers across the Conterminous US
05:03 - 05:15 PM	Beiming Tang	Modeling analysis to advance understanding of air pollution in South Korea during KORUS-AQ

POSTER SESSION SCHEDULE (5:15-6:30 PM)

Poster #	Name	Poster Title
1	Alexander J Adams	The Evolution of CAPE, the Cold Pool, and Nocturnal Low-Level Jet and Their Impact on Surface-Based Vs Elevated Convection within a Simulated Severe PECAN MCS
2	Eshita Akter Eva	The Effects of changing climate on the stream flow of the Big Creek Lake Watershed in South Alabama
3	Yuntao Bao	Hydroclimate variability of tropical South America during the last deglaciation
4	Cody Barnhart	Flash Floods: The Future of Baltimore City
5	Carolina Bieri	Evaluating the effect of including additional soil layers in the Noah-MP land surface model
6	Divyansh Chug	The Amazon and La Plata river basins as the Moisture Sources of South America: Climatology and Intra-seasonal Variability
7	Ian Cornejo	The Role of Topography in a Heavy Rainfall Event in Taiwan
8	Rebekka Delaney	Investigating UIUC Undergraduate Students' Knowledge of and Responses to Severe Weather Events
9	Matthew DeMaria	Synoptic-Scale Predictors of Cool-Season Orographic Precipitation Gradients in the Contiguous Western US
10	Ruixuan Ding	Quantifying Land-Atmosphere Interactions in the Columbus, OH Metropolitan Area using Lightning Data
11	Alexander Garber	Tropical Cyclone Climatology for Tampa Bay, Florida
12	Rakesh Ghosh	Lightning Characteristics of Thunderstorms over eastern India (Nor'westers)
13	James Goodnight	Observational and Environmental Analysis of Tornadogenesis Mechanisms in Quasi-Linear Convective Systems
14	Spencer Guerrero	Investigating S2S Models of Atlantic Tropical Cyclone Landfalls
15	Kaylee Heimes	A Long-Term Climatology of Favorable Synoptic Patterns for Severe Storms
16	Scott James	Analyzing Surface Precipitation Accumulations Upstream of the Olympic Mountains using Observations and Simulations: An OLYMPEX Case Study
17	Lillian Jones	A scalable passive method for the quantification of airborne allergens

18	David Lafferty	Statistically bias-corrected and downscaled climate models underestimate the adverse effects of extreme heat on U.S. maize yields
19	Daniel Lopez	Generating CloudSat Reflectivity Using Passive Microwave Brightness Temperatures and cGANs
20	Sophie Orendorf	Convective Windstorms in a Warmer Climate: A PGW Study Based on the 10 August 2020 Midwestern Derecho Event
21	Sreenath Paler	Scale resolved, sub-grid surface fluxes across a heterogeneous mid-latitude forested landscape
22	Michael Ragauskis	A flood preparedness tool for the city of Chicago's most vulnerable communities
23	Roger Riggin	A Numerical Study Investigating Idealized Supercell Thunderstorms Interacting with the Appalachian Mountains
24	Michael Sessa	The Prediction of Potential Tornado Intensity Using Machine Learning
25	Lydia Spychalla	Hail Nowcasting from Numerical Weather Prediction Model Data using Deep Learning
26	Madeline Statkewicz	Changes in Precipitation Patterns in Houston, Texas
27	Meghan Stell	Bringing water to the west: Microphysics and dynamics of orographic clouds influenced by atmospheric rivers
28	Hamid Ali Syed	Characterization of Hourly radar-based quantitative precipitation estimation
29	Seung Uk Kim	The Synergistic Role of Synoptic and Regional Processes for Drought Development in the Midwestern United States
30	Sarah Worden	Where does moisture come from in the Congo Basin?
31	Sean Whelan	Establishing a Climatology of Significant Tornadoes within the Southern United States
32	Troy Zaremba	Precipitation Growth Processes in the Comma Head Region of the 7 February 2020 Snowstorm observed during IMPACTS

Oral Presentation Abstracts

Andrew Janiszeski - University of Illinois

Kinematic Modeling Study of the Reorganization of Snowfall beneath cloud-top Generating Cells in Midlatitude Winter Storms

Andrew Janiszeski - University of Illinois, Department of Atmospheric Sciences Robert M. Rauber - University of Illinois, Department of Atmospheric Sciences B.F. Jewett - University of Illinois, Department of Atmospheric Sciences G.M. McFarquhar - University of Oklahoma, CIMMS and School of Meteorology

While past research of mid latitude winter extratropical cyclones has investigated and observed both near-surface precipitation banding features and cloud top generating cells within the comma head region of such storms separately, little is known about the relationship between the two. The purpose of this work is to determine the role of kinematics in the re-organization of ice particles beneath cloud top generating cells into a low-level environment favorable for horizontal banded features using an idealized kinematic model with a pure stretching deformation flow constant with height. The model used in this study has a 500 x 200 x 10 km domain in X, Y, and Z respectively with 1 km grid spacing in both the vertical and horizontal. Based on Keeler et al. (2017), particle clusters with increased particle concentration representative of cloud top generating cells are arranged in rows angled 30 degrees relative to the axis of dilatation, given a residence time in which they fall through the grid subject to the deformation flow, and an initial spacing of either 5 or 15 km between cluster rows atop the grid. Various sensitivity studies were conducted to determine change in shape of the initial snowfall distribution upon reaching the surface with different deformation flow strengths, residence times, and initial spacings of the generating cell cluster rows. Particle plumes subject to strong deformation of 2 10-4s-1 flow with maximum residence time of 20,000 seconds, and minimum row spacing of 5 km exhibited a congealed linear shape stretched along the axis of dilatation at the surface. Under weak deformation of 1 10-4s-1, minimum residence time of 5,000 seconds, and maximum row spacing of 15 km, little change in the shape of the initial distribution resulted. Stretching of the initial ice particle distribution for each experiment was quantified using a ratio of length to width ratios (R) which was calculated by dividing length to width ratio of the distribution at the bottom of the grid by the length to width ratio of the distribution atop the grid. Stretching was greatest with strong deformation and maximum residence time with a R of 23.89/1 and was least under weak deformation and minimum residence time with a R of 0.72/1. Another set of experiments were run using a random arrangement of initial generating cell cluster positions also based on Keeler et al. (2017). These experiments were run with the same residence times and deformation strengths as the linear experiments and had similar results. The change in particle distribution shape and amount of stretching demonstrates the role pure deformation plays in the horizontal organization and distribution of snowfall beneath the generating cells. Future research will incorporate an upper-level jet atop low-level front configuration in a mid-latitude cyclone environment where low-level band features were present to conduct similar sensitivity studies.

Divya Rea - University of Illinois

The Impact of Atmospheric Rivers on Cloud Structure and Seedability during the SNOWIE Experiment

Divya Rea - University of Illinois, Department of Atmospheric Sciences; Robert M. Rauber - University of Illinois, Department of Atmospheric Sciences; Troy Zaremba - University of Illinois, Department of Atmospheric Sciences; Huancui Hu - Pacific Northwest National Laboratory; Sarah A. Tessendorf - National Center for Atmospheric Research

The Seeded and Natural Orographic Clouds: The Idaho Experiment (SNOWIE), which took place from January - March of 2017, explored the impact of cloud seeding over the mountains. During the campaign, the University of Wyoming King Air aircraft, equipped with the W-band Wyoming Cloud Radar (WCR), flew across the Payette Basin of Idaho and seeded orographic clouds. Data collected via the WCR revealed distinct, separated cloud layers during many intensive operation periods (IOPs). Additionally, prior to many of the IOPs, an atmospheric river (AR) made landfall on the western coast of the United States. In this study, water vapor from atmospheric rivers is tracked to examine the AR's influence on the moisture distribution in the Payette Basin during SNOWIE. One IOP which was preceded by a strong AR is modeled using the Weather Research and Forecasting model (WRF) with added water vapor tracers. The simulation begins well before the IOP, while the AR is located over the Pacific Ocean, and water vapor from the AR is then tracked throughout the run. Output from WRF is compared to in situ data, including data from the WCR, to quantify the AR's contribution to the cloud field present at the time of seeding. By tracking AR moisture both laterally and vertically, the AR's impact on the split cloud layers is also discussed.

Yueqian Cao - Duke University

Topographic Controls on Hydrology and Microwave Behavior of Seasonal Snowpacks: Modeling Framework and Scaling Analysis

Yueqian Cao - Duke University, Department of Civil & Environmental Engineering Ana P. Barros - University of Illinois at UrbanaChampaign, Department of Civil & Environmental Engineering

Seasonal mountain snowpacks exhibit high spatial and temporal variability due to complex topography, heterogeneous land cover, and weather patterns. A coupled distributed snow hydrology-radiative transfer modeling framework, forced by high spatio-temporal reanalysis data (30-m, 15-min), was deployed over the Senator Beck Basin for the hydrologic year 2016-2017 to predict topographic controls' snowpack behavior in hydrology and microwave domain. The preprocessing of the Sentinel-1 data found the localized attenuation patterns are associated with the basin slopes that can alter the relative viewing angle of satellite and the local incidence angle of electromagnetic waves. Therefore, a simple slope correction was conducted to elucidate topographic effects in the microwave domain. The results show that the distributed modeling system can capture well topographic complexity impacts on snowpack properties, and snowpack surficial melting after local noon enhances topographic patterns in microwave regime and increases the retrieval's ambiguity that is considerable at local 2 PM for hysteresis phenomenon of the active and passive microwave signature. Besides, a large synthetic ensemble experiment revealed that the uncertainties of snow-ground interface reflection introduce more ambiguity than snowpack surface roughness. Based upon scaling analysis, the frequency-independent multi-scaling behaviors illustrate the robust physical basis of simulated backscattering structures for dry snowpacks, while brightness temperatures at 13.5 GHz exhibit stronger sensitivity to spatial variability of wet snowpacks. This study indicates the importance of adequately configuring local topography geometry in forward modeling systems before developing a low-ambiguity synthetic active-passive multi-frequency framework for snow properties retrieval.

Kaylee Heimes - University of Illinois

The Impact of Fine Scale Updrafts and Downdrafts on the Trajectories of Ice Particles Created by Seeding Orographic Clouds in Observed and Modeled Flow

Kaylee Heimes - University of Illinois Urbana-Champaign, Department of Atmospheric Sciences Troy J. Zaremba - University of Illinois Urbana-Champaign, Department of Atmospheric Sciences Robert M. Rauber - University of Illinois Urbana-Champaign, Department of Atmospheric Sciences Sarah A. Tessendorf -NCAR, Research Applications Laboratory Lulin Xue - NCAR, Research Applications Laboratory Kyoko Ikeda - NCCAR, Research Applications Laboratory Bart Geerts - University of Wyoming, Department of Atmospheric Sciences Jefferey French - University of Wyoming, Department of Atmospheric Sciences Katja Friedrich - University of Colorado Boulder, Department of Atmospheric and Oceanic Sciences Roy Rasmussen - NCAR, Research Applications Laboratory Melvin L. Kunkel - Idaho Power Company, Department of Resource Planning and Operations Derek R. Blestrud - Idaho Power Company, Department of Resource Planning and Operations

The goal of the Seeded and Natural Orographic Wintertime clouds: the Idaho Experiment (SNOWIE) project was to understand the natural dynamic and microphysical conditions within clouds over the Payette mountains to improve cloud seeding. During SNOWIE the Wyoming Cloud Radar (WCR) was flown on the University of Wyoming King Air (UWKA) and made measurements of vertical radial velocity in cross sections across the Payette Mountains of Idaho. During SNOWIE, a second aircraft released seeding lines at approximately the -12 C level normal to the direction of flight of the UWKA. A technique was used to retrieve vertical motions and terminal velocity of particles from WCR Doppler radial velocity measurements. Weather Research and Forecasting model simulations were used as guidance for targeting seeding. The 900 m resolution simulations adequately resolve vertical wave motions induced by flow over the topography, but were unable to resolve finer scale circulations associated with other phenomena. These measurements show two main categories of updraft structures including fixed, orographic vertical circulations and transient structures including generating cells, gravity waves, boundary layer and shear generated turbulence, and elevated, surface based, and boundary layer convection. Flight legs were categorized into predominantly fixed, orographic or transient vertical circulations using an index that quantifies the percentage of time that updrafts and downdrafts are over upward sloping and downward sloping terrain, respectively. In this study, we examine the impact of transient circulations on the trajectories of ice particles created by seeding. This was done to determine whether simulating the finer scale circulations is necessary for accurate targeting of seeding effects, or whether the 900 m simulations, which adequately resolve the primary orographically forced waves, is sufficient for accurate targeting. Specifically, we compare results for 103 separate seeding lines, quantitatively contrasting ice particle trajectories using vertical motions retrieved from radar and generated by the 900 m simulations, using the same winds and terminal fall speeds in both cases so that the only difference was the finescale updrafts present.

Bobby Saba - Northern Vermont University - Lyndon

Verification of Tornado Intensity Added to NWS Preliminary Tornado Damage Paths

Bobby Saba - Northern Vermont University - Lyndon, Department of Atmospheric Sciences Christopher Karstens - NOAA/NWS/SPC Bryan Smith - NOAA/NWS/SPC Rich Thompson - NOAA/NWS/SPC Andrew Wade - CIMMS/SPC Patrick Marsh - NOAA/NWS/SPC Doug Speheger - NOAA/NWS WFO - Norman James Ladue - NOAA/NWS/WDTD

This presentation will discuss the verification of a model created by the Storm Prediction Center to diagnose the spatial intensity of tornadoes in near-real time. This model has the ability to add intensity to the National Weather Service’s preliminary tornado damage paths to largely assist in emergency manager decision making in affected areas. The model accomplishes this goal by filling the preliminary damage polygon using a combination of WSR 88-D radar-derived rotational velocity, significant tornado parameter (STP) derived from SPC mesoanalysis, 1-km resolution population from the 2010 census, and output from an analytical vortex model. Verification is done by comparing model output data over several Gaussian smoothing levels and 101 percentiles with the observational data from the Damage Assessment Toolkit. Nine tornado tracks were compared ranging in both location and intensity. Cases were chosen based on intensity and/or societal impacts. Comparing observation to model output, forecast metrics were calculated, including probability of detection, success rate, false alarm rate, and critical success index. Using these metrics, secondary stats such as absolute error, ROC scores, and forecast climatology were also used to verify forecasts. Performance, reliability, and ROC curve diagrams were created for each intensity level and case. Data from all 9 cases were averaged to conclude which percentile and smoothing setting performed best overall. Preliminary results suggest that there may be multiple smoothing setting and percentile combinations that yield the best results based on a user's value proposition.

Enoch Jo - University of Illinois

The Influence of Vertical Wind Shear on Entrainment in a Simulated Supercell Thunderstorm

Enoch Jo - University of Illinois, Department of Atmospheric Sciences Sonia Lasher-Trapp - University of Illinois, Department of Atmospheric Sciences

The current study examines various mechanisms of entrainment in the mature stage of multiple idealized supercell thunderstorms growing in the same thermodynamic environment but with varying unidirectional or quarter-circle hodographs. Overturning “ribbons” of horizontal vorticity wrapping around the supercell updraft that ascend in time are found to contribute more to entrainment with increasing vertical wind shear, while turbulent eddies on the opposite side of the updraft contribute less with increasing vertical wind shear. The storm-relative airstream, making up part of what is commonly called the “storm inflow”, also introduces more low-level air into the storm core with increasing vertical wind shear, as a result of increased storm translation speeds. The impact of the total entrainment on precipitation production within the storm core decreases with increasing vertical wind shear, consistent with previous studies that noted decreasing fractional entrainment with increasing core cross sectional area. Thus, within the storm core, the precipitation efficiency increases with increasing vertical wind shear. Despite the decreasing impact of entrainment and associated dilution with increasing environmental shear in the storm core, the precipitation efficiency as gauged by the surface rainfall of the storms decreases, as suggested in past studies.

Kevin Gray - University of Illinois

Investigation of Outflow Surge Characteristics in Simulated Supercell Thunderstorms

Kevin Gray - University of Illinois; Jeffrey Frame - University of Illinois

Despite an increased understanding of environments favorable for tornadic supercells, it is still sometimes unknown why some supercells are longer lived than others in similar environments. Our previous work found that the midlevel shear vector orientation dictates where the 1-3 km precipitation loading is maximized in simulated supercells, and thus can influence the updraft-relative location of outflow surges. Backing of the 3-6 km shear vector results in outflow surge locations more favorable for longer-lived supercells. We bolster this conclusion by investigating the duration, thermodynamics, and origin height of the outflow surges, all of which do not impact supercell longevity in our simulations. The location of outflow surges, however, greatly modulates convergence beneath updrafts, with a backed midlevel shear vector leading to greater convergence. Outflow surge air is characterized by large values of streamwise vorticity and we use vorticity budgets along trajectories to determine the processes responsible for these large values.

Nathan Makowski - Central Michigan University

Factors of Locally-Produced Thunderstorm Genesis in the Southern Appalachians

Nathan Makowski - Central Michigan University
Kyle Peco - University of Miami

Rain gauge observations in the Pigeon River Basin, NC, extracted for the months of July and August over a twelve year study period (2009-2020), were classified into two types of warm-season precipitation events, locally-produced and advected. Air-mass and multi-cell thunderstorms were considered “locally-produced” if convection was forcibly initiated through contact with the southern Appalachian Mountains located within Great Smoky Mountains National Park (GSMNP). Observation of weak winds aloft without the influence of frontal passage or any tropical disturbance provided further evidence of an event’s locally-produced nature within the region of interest. On the contrary, rainfall events deemed “advected” were those with a convective origin outside of the southern Appalachians that were able to quickly move across the Pigeon River Basin. The influence of approaching mid-level shortwaves, outflow boundaries associated with incoming cold fronts, and tropical cyclone activity reinforced an event’s advected classification. Through the separation of these events into two categories, it was hypothesized that rising daily minimum temperatures have an effect on when locally produced thunderstorm genesis occurs as a result of diurnal surface heating at higher elevations. Preliminary results showed a correlation between locally produced case count for a given month, the existing average monthly minimum temperature, and the average convective initiation time. The summers of 2013 and 2014, in particular, revealed an exceptionally low count of locally-produced cases, later daytime thunderstorm formation, and a colder-than-normal average minimum temperature for both July and August. This relationship was also tied to the east and westward movement of the North Atlantic Subtropical High (NASH), a semi-permanent high-pressure system, which will be further analyzed. As more data emerges regarding the changing climatology of the Pigeon River Basin, this study will continue to examine the connection between warming minimum temperatures of the region and the onset of thunderstorm formation. These results aim to provide insight into the impacts that climate change is having on rainfall variability in mountainous regions and the underlying hazards these changes pose to local communities.

Anthony Crespo - University of Wisconsin-Madison

Characterization of three hailstorms in Argentina

Anthony Crespo - University of Wisconsin, Madison, Department of Atmospheric and Oceanic Sciences
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Falling hailstones are some of the most destructive natural phenomena in convectively active regions of the world. Cordoba Province in Argentina is a region of severe storms of worldwide relevance for being a hotspot for deep hail-producing storms. Previous studies of hail formation and detection largely rely on satellite snapshots or modeling studies, but lack hail validation, instead relying on proxy metrics. Here, to address this limitation, we collected hail in the Cordoba region, including from a record-breaking hail event and from the 2018-19 RELAMPAGO field campaign. Using data from the C-band Córdoba operational radar and GOES-16, we analyzed three cases that have verified hail and include different storm types in different locations relative to the Sierras de Cordoba mountains. Brightness temperature analysis show a gradual decrease over time, indicating vertical development in all cases, even though not all cases reached the same minimum temperature prior to the hail reports. Other satellite-based products show that all our cases show a weakening of the updraft before the hail report and all are composed of ice crystals with smaller ice crystal sizes inferred just prior to the hail report. Our RELAMPAGO hail case was consistent with previous satellite-based studies that inferred hail in MCSs over the Sierras de Cordoba during the late evening/early morning. Our two other hail-producing cases occurred with large-scale ingredients that differed from the RELAMPAGO case. The results from this comparison between three hail-producing cases gives us the motivation to look further at these different types of environments favoring hail in this region and shows promise in using satellite proxies for hail detection. Ultimately, the long-term goal is to better understand hail-producing storms and unique challenges of forecasting hail in this region, especially given that these hail-producing systems formed in different environments and were not well forecasted.

Devon Healey - University of Nebraska-Lincoln

Comparing Polarimetric Signatures of Proximate Tornadic and Non-Tornadic Supercells in Similar Environments

Devon Healey - University of Nebraska, Lincoln, Department of Earth and Atmospheric Sciences Matthew Van Den Broeke - University of Nebraska, Lincoln, Department of Earth and Atmospheric Sciences

While much research has identified distinguishing environmental characteristics for tornadic and non-tornadic supercell occurrence, it is possible for tornadic and non-tornadic supercells to coexist in seemingly similar environments. In such situations, other factors such as storm interactions, microphysical processes, and environmental heterogeneities smaller than the observational or model gridscale likely influence whether a given supercell will become tornadic. Employing dual-polarization radar in these scenarios can allow for inferences about microphysical processes and storm structures that may differ between proximate tornadic and non-tornadic supercells. Results may support additional methods to anticipate which supercell in a group of supercells is most likely to become tornadic from a radar perspective. In this study, comparisons of polarimetric signatures between ~60 pairs of proximate tornadic and non-tornadic supercells are presented. Environmental similarity between proximate supercells is quantified and used to confirm that these supercells exhibited reasonably similar environmental characteristics in their inflow regions. An automated algorithm for detecting and quantifying polarimetric signatures in supercells is employed to perform comparisons between the polarimetric signatures of these storms. We hypothesize that within a group of proximate supercells, supercells that become tornadic will have larger ZDR columns and ZDR arcs, and stronger mesocyclones. Mesocyclone strength is quantified through estimates of maximum low-level normalized rotation (NROT) values. It is further hypothesized that non-tornadic supercells will have larger and more steady hailfall regions throughout their lifetime.

Chibueze Ogujiofor - University of Notre Dame

Investigating the dependence of hurricane intensity on varying SST patterns using idealized model simulations

Chibueze Oguejiofor - University of Notre Dame, Department of Civil and Environmental Engineering and Earth Sciences. David Richter - University of Notre Dame, Department of Civil and Environmental Engineering and Earth Sciences. Charlotte Wainwright - University of Notre Dame, Department of Civil and Environmental Engineering and Earth Sciences.

The rapid intensification of hurricanes remains a challenge in the broader context of hurricane prediction, despite decades of research. This is largely due to the multiscale nature of hurricane dynamics - ranging from large-scale environmental factors modulating hurricane evolution (e.g., sea surface temperature) down to the proper representation of small-scale dynamics (e.g., boundary-layer dynamics). Several studies have investigated the development and persistence of SST anomalies such as cold pools in the wake of hurricanes, and how these affect the intensification of subsequent storms. Ocean observation shows that the size, magnitude and lifetime of SST anomalies associated with cold pools play important roles in hurricane dynamics and development. In this study, a geostatistical approach is utilized to understand the impact of the length scale of these SST anomalies on storm intensity using gaussian random fields. Sea surface temperature (SST) fields obtained from a combination of observational data (ARGO and ALAMO float program) as well as high-resolution model output from ONR's COAMPS-TC code, provide spatial estimates of the SST fields under typical hurricanes. Experimental variograms of these fields are used to generate multiple realizations of both conditional and unconditional gaussian random fields with varying length scale parameters. The generated SST fields are used as boundary conditions for idealized model runs using the CM1 code. We investigate the impact of varying the SST length scale on subsequent hurricane dynamics, development, and intensification.

Cam My Nguyen - University of Georgia

A Multivariable Hurricane Hazard Index

Cam My Nguyen - University of Georgia, Department of Atmospheric Sciences Derek Dyal - University of Georgia, Department of Statistics Gregory Ellison - University of Georgia, Department of Statistics BeiBei Xu - University of Georgia, Department of Statistics Tyler Harrington - University of Massachusetts, Department of Environmental, Earth and Atmospheric Sciences Lynne Seymour - Associate Professor, University of Georgia, Department of Statistics Andrew Grundstein - Professor, University of Georgia, Department of Atmospheric Sciences

Hurricanes are destructive weather hazards that cause tremendous damages and deaths each year. As of 2020, hurricanes have caused the U.S. a combined $95-billion in damage, resulting in the deaths of 262 people. While there are no preventative measures to stop a hurricane from hitting a coastal area, there are ways to help prepare for one. With NOAA's Climate Prediction Center forecasting another above-normal Atlantic hurricane season, it is of utmost importance for everyone to have a better understanding of hurricane hazards so more informed decisions can be made. Currently, the Saffir-Simpson Scale (SS scale) is used to classify hurricanes. This scale focuses on maximum sustained wind speeds but does not quantify other associated hazards such as the size of the storm, possible damage from storm surge, or potential for flooding from heavy rain. Additionally, other research has highlighted the importance of minimum sea-level pressure to be used as a way to quantify a hurricane's damage. At the moment, there is no available visual graphic that incorporates various risk hazards and can effectively communicate information. Therefore, we propose to develop a visual graphic that will quantify the differing hurricane hazards in a way that can provide key information to varying stakeholders like emergency managers, residents, local, state, and federal officials. Our approach is to statistically compute the scale of four hazards (e.g. storm surge, wind speeds, tornadoes, and rainfall/flooding) relative to other storms so that a comparison can be made and visualized. We drew from a plethora of existing databases (e.g SURGEDAT, HURDAT, etc.) to build our climatological reference dataset, and we selected five case studies of major storms of varying categories to highlight how this approach can emphasize certain characteristics that could be of most concern to a particular group. We hope that the ability to visualize the relative strength of different hazards within the hurricane can be used in planning and response.

Chandler Pruett and Robert Szot - Florida State University

Weathering the Storm: How Cones of Uncertainty Impact Hurricane Risk Perception

Chandler Pruett - Florida State University, Department of Earth, Oceanic, and Atmospheric Sciences
Robert Szot - Florida State University, Department of Earth, Oceanic, and Atmospheric Sciences

The Cone of Uncertainty (COU) is a graphic designed by the National Hurricane Center that communicates the forecast track of the center of tropical systems. The COU graphic primarily distills a forecast and its uncertainty to a single image, making redistribution of the NHC's forecast highly available to the general public. However, previous research suggests the public is confused by the COU and desires to know a storm's hazards in addition to its track. To probe this question, this study conducted an extensive survey during the summer of 2021 to understand how the public perceives the current COU and what modifications they may desire to facilitate storm preparations. Specifically, the research team designed ten graphics -- the current COU with and without the track line plus eight modifications -- based on a literature review and original concepts. These illustrations were shown to 149 in-person respondents throughout the state of Florida and 4,181 online respondents throughout the United States. By recognizing how the general public understands the current COU and potential modifications to the graphic, this study investigated if a COU redesign was necessary and what modifications would need to be included in such a redesign. Our finding is that survey respondents preferred a COU that includes threat level at landfall.

McKenzie Larson - University of Colorado-Boulder

Downslope Wind Verification of the National Blend of Models Across the Northern Front Range of Colorado

McKenzie Larson - University of Colorado Boulder, Department of Atmospheric and Oceanic Sciences
Paul T. Schlatter - National Weather Service, Boulder, Colorado

Downslope windstorms are common across the High Plains of Colorado in the lee of the Rocky Mountains and are capable of causing damage to property and significantly disrupting travel. This region is renowned for two primary types of high downslope winds: (1) Chinook events that bring warm, dry, and strong winds which are often associated with the development of mountain waves and (2) Boras are colder and often associated with the passage of a mid- and upper-level trough. The National Blend of Models (NBM) is regularly utilized by the forecasters at the Boulder Weather Forecast Office (WFO) and has been known to underestimate winds, but until now, no study has looked in detail at how it performs with downslope windstorms. In this study, downslope windstorms from October 2020 through May 2021 were identified using ten high-quality observation sites along the Front Range. The quantification and analysis of the multiplicative biases, mean absolute errors (MAE), and timing errors of the wind speeds and gusts for each event provide a better understanding of the NBM magnitude and timing errors. On average, we see that the magnitudes of the wind speeds and gusts are approximately 35% and 33% too low in the NBM output, respectively. Ultimately, these NBM verification statistics and analysis can be implemented by forecasters at the NWS WFO Boulder and surrounding offices to improve wind forecasts and warnings for these high-impact events.

Victoria Lang - University of Wisconsin-Milwaukee

Forecasting Peak Wind Gusts for Specific Weather Types Using the Meteorologically Stratified Gust Factor Model

Victoria Lang-University of Wisconsin-Milwaukee Teresa Turner-University of Wisconsin-Milwaukee
Brandon Selbig-University of Wisconsin-Milwaukee Austin Harris-University of Wisconsin-Milwaukee
Jonathan Kahl -University of Wisconsin-Milwaukee

Wind gusts present challenges to operational meteorologists, both to forecast accurately and also to verify. Strong wind gusts can cause structural damage and present risks for energy generation, among other hazards. Previous research has demonstrated skill in forecasting peak wind gusts using meteorologically stratified gust factors (MSGF). The MSGF model incorporates site-specific gust factors (ratio of peak wind gust to mean wind speed), stratified by different wind speed and direction combinations. Peak gust forecasts are prepared by simply multiplying the appropriate gust factor by a wind speed forecast, typically provided by model output statistics (MOS). This study seeks to further investigate skill of the MSGF model when applied to seven gust-producing weather conditions. Forecasted peak wind gusts were calculated and verified for specific weather conditions over 8 years at sixteen sites across the United States. Results show that perfect prog forecast errors are quite small for a majority of the weather types, with mean absolute errors (MAE) of only 1-2kts. This indicates that the MSGF model provides an accurate representation of peak wind gusts when coupled with “perfect” wind forecasts. When coupled with actual MOS wind forecasts, the MSGF model exhibited statistically significant skill for 24-hour projected forecasts at all sites studied, for most weather types. The smallest MAEs in peak gust prediction were observed for weather types of ‘night clear’, ‘night overcast’, and ‘high pressure’, with MAEs of 2—4 kt. For most weather types studied the MSGF model was skillful in predicting peak gusts at forecast projections from 6-24 hours, and in some cases from 6-72 hours. The model performed less well for convective weather types. From the data evaluated it could not be determined whether the GFS or NAM MOS product, when coupled with the MSGF model, was more skillful at forecasting peak gusts.

Sean Matus - University of Illinois

Observed Land-Atmosphere Anomalies from ERA5 Associated with Extreme Great Plains Low-Level Jets

Sean Matus - University of Illinois, Department of Civil and Environmental Engineering Francina Dominguez - University of Illinois, Department of Atmospheric Sciences Praveen Kumar - University of Illinois, Department of Civil and Environmental Engineering Trent Ford - University of Illinois, Illinois State Water Survey

The U.S. Great Plains (GP) has a nearly $100 billion agriculture and livestock industry which is vulnerable to drought and flooding events. The warm season in this region is frequently characterized by a nocturnal low-level jet (LLJ). LLJs are defined broadly as confined wind corridors found in the lower atmosphere and act as a major mechanism of atmospheric moisture transport. Previous studies have shown that GPLLJs are driven by an interplay of synoptic atmospheric forcing and local land surface forcing. Due to its nocturnal nature, GPLLJ generation mechanisms are usually studied at the diurnal scale. We hypothesize that, due to the memory of the land surface, there could be land surface variability at longer timescales that also modulate the intensity of a GPLLJ event. This work identifies extreme GPLLJ events from ERA5 wind data using a peaks-over-threshold approach and classifies them by geographic region and synoptic state. Daily anomaly composites of land surface variables, including root-zone soil moisture and 2m temperature, show an anomalously dry, warm region building in the days leading up to an extreme GPLLJ event. Additionally, the location of the antecedent anomalies corresponds with the eventual entrance region of the GPLLJ event. As such, there is predictive value in continuing to unravel the role of the land surface in modulating the GPLLJ, and subsequent precipitation, to motivate improved system resiliency.

Chu-Chun - University of Illinois

The influence of soil moisture anomalies on ENSO teleconnections over southeastern South America

Chu-Chun Chen - University of Illinois, Department of Atmospheric Sciences Francina Dominguez - University of Illinois, Department of Atmospheric Sciences

The objective of this study is to evaluate the interactions between soil moisture anomalies and the El Niño-southern oscillation (ENSO) teleconnections over southeastern South America. During the austral summer, ENSO reaches its peak phase, and the anomalous convection over the tropical Pacific influences the climate over South America through Rossby waves. ENSO is often associated with extreme drought and flooding, leading to significant socio-economic impacts. On the other hand, the summer season is also the peak for land-atmosphere interactions, especially over southeastern South America. Dry soil moisture anomalies can influence the rainfall one or two months later through moisture recycling or changes in atmospheric circulation. Both ENSO and soil moisture anomalies play essential roles in the climate of this region; however, few studies have investigated their interaction and modulation. Preliminary results using ECMWF Reanalysis v5 (ERA5) show that the antecedent dry soil moisture anomalies over southeastern South America in December are associated with more precipitation over this region in January. This negative feedback may weaken the precipitation response to La Niña events over southeastern South America. To evaluate causality, we further conduct a control simulation and three experimental simulations using the Community Earth System Model (CESM), prescribing: (1) ENSO sea surface temperature (SST) anomalies, (2) dry soil moisture anomalies over southeastern South America, and (3) both SST and dry soil moisture anomalies. Understanding the interactions between the effects of ENSO and soil moisture anomalies can potentially improve forecasts on sub-seasonal to seasonal timescales.

Victor Arraes Rocha Felix - University of Georgia

Orographic Rains at the Araripe Plateau - a Geostatistical Model for the climatic transition between the Cariri Cearense and the semiarid portion of Pernambuco

Victor Arraes Rocha Felix - University of Georgia, Department of Geography, Cleyber Nascimento de Medeiros - Ceará Research Institute on Economic Strategy (IPECE)

Different large-scale climatic systems transport moisture to the Northeast of Brazil, where geomorphological features with average altitudes between 600 and 1200 meters act as natural barriers favoring precipitation through orographic rains. This is the case of the Araripe Plateau, which has altitudes between 850 and 1000m. The present study aims to understand how the Araripe Plateau influences rainfall dynamics in the climate transition between the dry sub-humid climate region of Cariri Cearense and the semi-arid climate region of Pernambucano. Geostatistical kriging models were applied, using rainfall data for a period between 1981 and 2014. The data were structured and analyzed for different periods of the year, namely, periods of the pre-rainy season (December and January), rainy season (February to May), dryer season (June to November) and annual rainfall. Models obtained from moderate to high rates of spatial dependence (IDE), between 32% and 100%. The distribution of isohyets for the pre-rainy season, rainy season and annual rainfall indicated a strong influence of the Araripe Plateau and the adjacent residual massifs in regional precipitation, characterizing a system of orographic rains. This system appears to have a strong influence on the climatic transition between the Cariri Cearense sub-humid climate and semiarid Pernambucano. The model for the dryer period indicated a zonal distribution in rainfall, possibly due to the flow of southeast winds at this time of year.

Paolo Giani - University of Notre Dame

Modeling the real convective boundary layer in the ‘terra incognita’: different approaches to overcome the challenge

Paolo Giani - University of Notre Dame

Turbulent motions regulate vertical transport of momentum, heat, moisture and pollutants in the atmospheric boundary layer. From a numerical perspective, modeling such motions becomes challenging at kilometer and sub-kilometer resolutions, as the horizontal grid spacing of the model approaches the size of the most energetic convective eddies in the boundary layer. In this range of resolutions, typically termed ‘terra incognita’ or ‘gray zone’, partially resolved convective structures are grid-dependent and neither traditional 1D mesoscale parametrizations nor 3D closures typical of Large Eddy Simulations are theoretically appropriate. However, accurate numerical modeling at gray zone resolutions is a key aspect in several practical applications, such as proper coupling of mesoscale and microscale simulations. While some progress has been achieved in recent years through idealized simulations and theoretical considerations, the evaluation of different approaches in real convective boundary layers (CBL) is still very limited. Leveraging on a new set of one-way nested, full-physics multiscale numerical experiments, we quantify the magnitude of the errors introduced at gray zone resolutions and provide new perspectives on recently proposed modeling approaches. The new set of experiments is forced by real time-varying boundary conditions, spans a wide range of scales and includes traditional 1D schemes, 3D closures, scale-aware parametrizations and strategies to suppress resolved convection at gray zone resolutions. The study area is Riyadh (Saudi Arabia), where deep CBLs develop owing to strong convective conditions. Detailed analyses of our experiments, including validation with radiosonde data, calculations of spectral characteristics and partitioning of turbulent fluxes between resolved and subgrid scales, show that (i) grid-dependent convective structures entail minor impacts on first order statistics of the flow due to some degree of ‘implicit scale-awareness’ of 1D parametrizations and (ii) 3D closures outperform traditional and scale-aware 1D schemes especially in the surface layer, among other findings. The new simulation suite provides a benchmark of real simulations that can be extended to assess how new techniques for simulations at gray zone resolutions perform.

Aldo Brandi - Arizona State University

Influence of projected climate change, urban development and heat adaptation strategies on end of twenty-first century urban boundary layers across the Conterminous US

Aldo Brandi - Arizona State University, School of Geographical Sciences and Urban Planning Ashley M. Broadbent - Arizona State University, School of Geographical Sciences and Urban Planning Scott E. Krayenhoff - University of Guelph, School of Environmental Sciences Matei Georgescu - Arizona State University, School of Geographical Sciences and Urban Planning

The urban environment directly influences the evolution of the Urban Boundary Layer (UBL). Heat adaptation strategies proposed to help cities respond to global change and urban induced warming, are also expected to reduce the intensity of convective mixing and decrease UBL depth, thereby reducing the volume of air available to pollutant dilution and dispersion. We use 20 km resolution WRF-ARW decadal scale simulations that account for end of 21 century greenhouse gas emissions, urban expansion and intensive and uniform implementation of cool roofs, green roofs and street trees to investigate the individual and combined impacts of these drivers on the dynamics of the UBL over the Conterminous US (CONUS). Results indicate that combined impacts of climate change and urban expansion are expected to increase summer (JJA) daytime UBL depth in the eastern regions of CONUS (peak value: $\Delta h \cong 80$ m over Atlanta metro area). When adaptation strategies are applied, summer daytime UBL depth is reduced by a few hundred meters (peak value: $\Delta h \cong -310$ m over Dallas and Fort Worth metro areas) in all CONUS regions as a consequence of decreased surface sensible heat fluxes. Adaptation impacts are greater inland and smaller over coastal cities. In arid regions, the adaptation induced increase in latent heat fluxes can counterbalance the projected decrease in UBL depth. Furthermore, adaptation strategies are expected to increase the static stability of both daytime and nighttime UBLs and decrease the magnitude of vertical winds, inducing earlier and stronger subsidence (peak value: $\Delta m/s \cong -0.05$ m over Phoenix and Tucson metro areas). In light of these findings, ongoing work addressing these aspects with convection resolving, high-resolution simulations is needed to determine whether the widespread implementation of urban adaptation measures could have deleterious effects for urban air quality in the cities of the future Contiguous US.

Beiming Tang - University of Iowa

Modeling analysis to advance understanding of air pollution in South Korea during KORUS-AQ

Beiming Tang, Pablo Saide, Meng Gao, Charles Stanier, Gregory Carmichae

Improving air quality in east Asia is of high priority among countries in the region. The focus remains largely on reducing fine particulate matter (PM2.5), but it is recognized that decreasing ozone exposure is also necessary. Effective air quality management strategies require solid understanding of the formation and transport mechanisms. For South Korean policy makers, a critical question is to what extent can air quality be improved if only domestic emissions are reduced. High resolution WRF-Chem modeling was performed to quantify the relative roles of transport versus locally emitted aerosol and ozone precursors during polluted periods in Korea. The model was evaluated by both surface and airborne observations collected during the KORea and United-States Air Quality (KORUS-AQ) campaign. Airborne observations from the NASA DC-8 were supplemented KORUS-AQ ground station data, and with routine surface observations over Korea (94 meteorological sites; 321 AirKorea sites for criteria air pollutants; 6 NIER sites for PM2.5 speciation). WRF-Chem showed appreciable skill in prediction. Statistical metrics for meteorology were in acceptable ranges, and similar to other contemporaneous WRF and WRF-Chem simulations over Korea. Ozone was slightly underpredicted on average (bias of -1.0 ppb). PM2.5 was biased high (8.5 μg/m3), a relative bias of 30% given the mean value of 27.9 μg/m3. PM2.5 and ozone show the combination of long-range transport and local pollution. However, the major passage of transport over the Yellow Sea is unclear. Also, a quantitative comparison for transport versus local formation is needed. Using Seoul and whole Korea emission perturbation runs, domestic emission contributions to surface air quality were quantified by locations across Korea, segregated by synoptic meteorological phases of the KORUS-AQ campaign. The largest contributions from Korean emissions were found under high pressure stagnant conditions and the smallest for conditions with strong westerly winds. As for PM2.5, domestic contribution on average account for 46% in the “stagnant” phase, and on average 31% during “transport” phase. Primary species with short lifetimes (i.e., NOx and toluene) had over 90% of their surface concentration contributed by emissions within Korea’s borders. Primary species with longer lifetime had both local and remote contributions (i.e., CO & BC). For secondary inorganic aerosols, nitrate and ammonium were mostly formed from domestic emissions. Sulfate, on the contrary, was mainly from remote sources. The model sensitivity results are complemented by quantitative comparison of horizontal fluxes of transported pollutants and pollutant precursors relative to fluxes from Korean emissions. Fluxes were computed from WRF-Chem and CAMS through two north-south oriented planes (34- 38°N, 124°E &126°E) extending from the surface to four km over the Yellow Sea. Variation in direction (west-to-east vs. east-to-west) and magnitude of fluxes support the model sensitivity results. For example, during periods of west-to-east transport, the average flux of SOx (SO2 + SO4) through the flux plane was 163 Mg/h at 126°E. This can be compared with Korean emissions of SO2, which total 72 Mg/h.

Poster Presentation Abstracts

Alexander J Adams - University of Illinois

The Evolution of CAPE, the Cold Pool, and Nocturnal Low-Level Jet and Their Impact on Surface-Based Vs Elevated Convection within a Simulated Severe PECAN MCS

Alexander J. Adams - University of Illinois, Department of Atmospheric Sciences Robert M. Rauber - University of Illinois, Department of Atmospheric Sciences Brian F. Jewett - University of Illinois, Department of Atmospheric Sciences Greg M. McFarquhar - CIMMS; University of Oklahoma, School of Meteorology

Two primary foci of the Plains Elevated Convection at Night (PECAN) field project were to: 1) understand processes by which nocturnal Mesoscale Convective Systems (MCSs) maintain themselves for several hours throughout the night in the absence of surface-based instability due to cooling of the nocturnal boundary layer; 2) understand how the developing nocturnal low-level jet influences the evolution of nocturnal MCSs. In this presentation, parcel trajectories from a high resolution WRF simulation of the 20 June 2015 PECAN MCS are used to analyze and understand the evolution of surface-based and elevated convection as the convective line propagates eastward and encounters an intensifying nocturnal low-level jet and a boundary layer that is becoming increasingly stable as the evening progresses. The analysis shows that the convection never became completely elevated. Rather, early in the evolution, before the low-level jet had developed, parcels entering the convective updrafts were primarily surface-based. At a critical time in the evolution when the convection reached the western boundary of the developing low-level jet, parcel trajectories entering the convection progressively originated both within and above the core of the low-level jet, but never fully completed this transition, despite a distinct elevated maximum in convective available potential energy (CAPE). The simulation will provide additional evidence that the MCS was at least partially surface-based throughout its duration due to the presence of strong surface winds within the cold pool advancing into the stable boundary layer.

Eshita Akter Eva - Ohio State University

The effects of changing climate on the stream flow of the Big Creek Lake Watershed South Alabama

Eshita Akter Eva - The Ohio State University, Department of Geography

Climate change can have an important impact on the availability of water resources. The changing frequency and intensity of extreme climatic events have added more significance to the study of changing hydrological processes. The purpose of this study is to determine how climate change will affect future stream flow (2021-2050) by applying the Soil and Water Assessment Tool (SWAT) to the Big Creek Lake watershed located in Mobile County, Alabama. The downscaled and bias-corrected daily projected climate data were used under the moderate (Representative Concentrative Pathways 4.5) and high (Representative Concentrative Pathways 8.5) scenarios. The Sequential Uncertainty Fitting (SUFI-2) algorithm in the SWAT Calibration Uncertainties Program (SWAT-CUP) software was used to calibrate and validate the model. The average Precipitation will increase about 162.47 mm/yr (RCP4.5) and 178.56 mm/yr (RCP8.5) in future thirty years compare to the last three decades (1991-2020). Moreover, the average temperature will increase ~ 2°C for both RCP scenarios. These changes will lead to increases in mean annual stream flow of 0.39 m3/s for RCP4.5 and 0.62 m3/s for RCP8.5 from 2021 to 2050. However, the impact of climate variability on the streamflow will be more profound in RCP8.5 than RCP4.5. For the water resource managers and policy makers, these results can provide guidance for setting policies in Mobile County.

Yuntao Bao - Ohio State University

Hydroclimate variability of tropical South America during the last deglaciation

Yuntao Bao - Ohio State University, Department of Geography Zhengyu Liu - Ohio State University, Department of Geography

Hydroclimate variability of tropical South America (TSA) is of great importance for ecosystem evolution on the millennial time scale. Several oxygen isotope speleothem records have been used to infer the past climate change of the TSA, however, the hydroclimatic representation of these oxygen isotope records and the associated mechanism of the variability remain poorly understood. Our study combined an isotope-enabled common earth system model (iCESM) and speleothem proxy records during the last deglacial period. The results show that North Atlantic meltwater forcing is the leading factor for the millennial-scale variability of the TSA. Decrease or shutdown of the Atlantic meridional overturning circulation driven by melting water would produce an east-west dipole in the TSA precipitation and δ18O of precipitation (δ18Op) due to the southward shift of the Intertropical Convergence Zone. Carbon dioxide as a background forcing can either counterbalance or reinforce the variability. Tagged oxygen isotope in iCESM indicates the hydroclimatic representation of δ18Op. Variability in δ18Op driven by melting water represents the local precipitation amount in eastern Brazil and Western Amazon regions. Other than the local amount effect, changes of δ18O in the Atlantic source region, en route depletion from the Atlantic Ocean and upstream TSA, and the relative moisture contributions from different source regions are responsible for δ18Op variability in the TSA. Furthermore, land evapotranspiration in the TSA has a large impact on boundary layer δ18Op, highlighting the land water recycling process here.

Cody Barnhart - California University of Pennsylvania

Flash Floods: The Future of Baltimore City

Cody Barnhart-Student of California University of Pennsylvania

Climate change is surfacing as a major hazard for millions of lives across the world. However, with a multitude of lifethreatening impacts, humans and the natural environment are both in harm's way. Flash flooding is a leading cause of deaths in landfalling tropical systems. It is also a primary danger to those who not only reside near the coastline, but also in large metropolitan regions where sea level rise and storm surge are a deadly combination. By using ESRI's ArcGIS Online mapping system, it is possible to form a hypothesis and analyze more local regions that have the ability to become more flash flood prone as the climate continues to change and hazards become more frequent. Baltimore City is a prime region with increasing impermeable surfaces, east coast cyclogenesis, and nearby rugged terrain that all factor into the flash flood danger. However, there is a varying amount of concern across the county and city thanks to multiple factors. This presentation will use previously loaded data from ArcGIS Online, as well as historical precipitation of warm season meteorological events, to convey the multiple levels of concern based off of flash flooding, as well as the related impacts to those who reside within Baltimore City.

Carolina Bieri - University of Illinois

Evaluating the effect of including additional soil layers in the Noah-MP land surface model

Carolina Bieri - University of Illinois at Urbana-Champaign, Department of Atmospheric Sciences Francina Dominguez - University of Illinois at Urbana-Champaign, Department of Atmospheric Sciences Gonzalo Miguez-Macho - Universidade de Santiago de Compostela, Faculty of Physics Ying Fan - Rutgers University, Department of Earth and Planetary Sciences

The Noah-Multiparameterization (Noah-MP) land surface model is widely used to simulate processes at the landatmosphere interface on regional spatial scales. Moreover, it is often used in conjunction with the Weather Research and Forecasting (WRF) model to determine land surface fluxes at the lower boundary of the atmosphere. A deficiency of Noah-MP is that it resolves only 4 soil layers extending to a depth of 2 m. This limits the vegetation rooting depth that can be represented in the model and affects representation of groundwater-soil layer interactions. This, in turn, can impact simulation of land surface fluxes. To address this deficiency, this study seeks to evaluate the effect of implementing additional soil layers in Noah-MP. Model output is compared between two runs; one using the default Noah-MP soil layer configuration (4 soil layers extending to 2 m depth) and one with additional layers (12 soil layers extending to 20 m depth). Output is also compared with data from the Global Land Evaporation Amsterdam Model (GLEAM) and site observations from the Large Scale Biosphere-Atmosphere Experiment (LBA). Key variables such as soil moisture, latent heat flux, and sensible heat flux are analyzed in these comparisons. Incorporation of additional soil layers in Noah-MP will enable implementation of features such as deep plant roots, which can result in improved simulation of land-atmosphere fluxes.

Divyansh Chug - University of Illinois

The Amazon and La Plata river basins as the Moisture Sources of South America: Climatology and Intra-seasonal Variability

Divyansh Chug - University of Illinois, Department of Atmospheric Sciences Francina Dominguez - University of Illinois, Department of Atmospheric Sciences Zhao Yang - Pacific Northwest National Laboratory

Land-atmosphere interactions through moisture pathways are critical for precipitation over South America where terrestrial moisture constitutes a significant fraction of rainfall, specifically over the ecologically and socio-economically vital Amazon (AMZ) and La Plata (LPB) river basins. While previous work has quantified the seasonal importance of terrestrial moisture sources for precipitation (PPT), there is a dearth of knowledge on how the transport and recycling of evapotranspired moisture (ET) is modulated at intraseasonal time scale. We employ numerical tracers embedded in the Weather Research and Forecasting (WRF) model and track the moisture originating from the AMZ and LPB basins to study its interaction with the intraseasonal hydroclimate variability. First, we present high resolution simulated maps of annual and seasonal recycling ratio for South American PPT and isolate the role of AMZ and LPB ET in the regional atmospheric water budget. Our findings indicate that AMZ tracers contribute more than 40% of rainfall over the eastern foothills of Andes and LPB tracers account for greater than 30% over northern Argentina. We then analyze the patterns of terrestrial moisture transport and precipitation recycling during both phases of the well identified "see-saw" pattern over South America. Results show a clear intraseasonal "sloshing" of terrestrial moisture between the South Atlantic convergence zone (SACZ) and the southeastern South America (SESA) regions. AMZ and LPB each account for approximately 6% of SACZ PPT highlighting the predominant role of oceanic moisture. Conversely, nearly one-third of PPT over SESA is of terrestrial origin, of which LPB alone accounts for 23%.

Ian Cornejo - University of Wisconsin-Madison

The Role of Topography in a Heavy Rainfall Event in Taiwan

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The ability to accurately forecast heavy rainfall is crucial for preventative warnings and precautions. This becomes amplified when heavy rainfall is coupled with complex terrain where the potential for danger increases. Unfortunately, forecasting skill in mountainous regions is not on par with that of other terrains. By better understanding the role that the topography plays in determining rainfall duration, intensity, and location, the better our predictive skill can become. On June 2nd of 2017, Taiwan encountered a regional extreme rainfall event known as a Mei-Yu front. Various districts accumulated upwards of 600 millimeters of rainfall in 12 hours with rain rates as high as 180 millimeters per hour. The resulting floods and mudslides endangered human lives and produced widespread property damage. In looking at both quantitative precipitation forecasts (QPF) and estimations (QPE), a deficiency in forecasting skill can be found near and surrounding the complex terrain of Taiwan when encountering the Mei-Yu front and the accompanying monsoonal southwesterly flow. To better understand these deficiencies, the Weather Research and Forecasting (WRF) Model is used to recreate the event with and without terrain modifications for comparison. The method of modification was a simple halving of terrain height. By modifying the terrain, it becomes evident that the terrain has a complex role in determining locations of extreme rainfall and the frequency of high rain rate rainfall. Generally, lowering the terrain height results in overall lowered rainfall accumulation and shortened the duration of rainfall. Regarding large scale changes, the lowered terrain allows for more leeside rainfall where normally, most of the rainfall would fall on the windward side of the mountains. This research was conducted in preparation for the Prediction of Rainfall Extremes Campaign in the Pacific (PRECIP) field campaign. The goals of the project are to better understand the ingredients of an extreme rainfall event and implement them into the improvement of models and forecasts.

Rebekka Delaney - University of Illinois

Investigating UIUC Undergraduate Students' Knowledge of and Responses to Severe Weather Events

Rebekka Delaney, Professor Alicia Klees - University of Illinois - Urbana-Champaign

During the academic year, students will often experience wild and interesting weather. The goal of this study is to better understand the extent to which undergraduate students are prepared for and knowledgeable of what to do and where to go during these severe weather events that impact their campuses. In this study, a survey is conducted on a portion of the undergraduate student population of the University of Illinois at Urbana-Champaign (UIUC). One special focus of this study is evaluating the possible differences between domestic and international students in severe weather knowledge and responses. Such differences may owe to differing exposure to the explosive nature of the types of hazardous weather common in certain parts of the United States, and/or possible lack of familiarity with severe weather warnings and sheltering processes in this country (Jauernic-2016). Another key focus in this study is on UIUC's campus community-focused "all-hazards" alert system called Illini Alert; email alert signup is mandatory, yet text message alerts are opt-in. While information on how to sign up for the text message alerts is posted in campus-wide Illini Alert emails, questions remain as to how much undergraduate students know about and how much they use the text message alert system, understand the threat information that it attempts to relay, and act accordingly. This survey asks the participants about their severe weather knowledge and responses to scenarios, with two driving questions of: (1) Are international university students less likely to know the proper procedures for severe weather/tornadoes than domestic university students? (2) How do students on the University of Illinois campus get their weather information during a dangerous weather event (especially in terms of utilization of the Illini Alert system), and how do they respond? Survey design and process are presented and discussed. The discoveries made in this study may be helpful to the campus emergency management office and their public awareness campaigns.

Matthew DeMaria - University of Utah

Synoptic-Scale Predictors of Cool-Season Orographic Precipitation Gradients in the Contiguous Western US

Matthew DeMaria - University of Utah, Department of Atmospheric Sciences Courtenay Strong - University of Utah, Department of Atmospheric Sciences Jim Steenburgh - University of Utah, Department of Atmospheric Sciences

More than half of surface runoff in the western US comes from the snowpack built up in the mountains during the coolseason months. The winter snowpack affects population growth, transportation, agriculture, and commerce in mountainous regions. Snowfall in complex terrain can also influence economic activity and pose a threat to the health and safety of recreators via avalanches and flooding. However, significant inaccuracies in contemporary Numerical Weather Prediction (NWP) arise over complex terrain from inadequately resolved topographic effects. Currently, some National Weather Service (NWS) Western Region Forecast Offices use the Parameter-Elevation Regressions on Independent Slopes Model (PRISM) to downscale operational weather model forecasts. This approach uses the climatological distribution of precipitation with elevation and therefore does not consider the variability among individual storms, leaving significant room for improvement in Quantitative Precipitation Forecasts (QPF) over complex terrain. Here, we use the Orographic Precipitation Gradient (OPG) to quantify the change of precipitation with elevation over different mountain ranges in the western US. Then, we analyzed moisture and wind data from the National Center for Environmental Research (NCEP) to quantitatively understand what drives variability of precipitation gradients during the cool season months. An analysis of multi-day precipitation events shows that a substantial amount of OPG variability can be attributed to the location of a cyclone or trough relative to a mountain range. As a storm system approaches, OPG tends to decrease because unstable air arrives aloft before moving in at the surface. As we learn more about the mechanisms that drive OPG variability, we will develop a more complex downscaling methodology that captures inter-storm variability in precipitation gradients.

Ruixuan Ding - Ohio State University

Quantifying Land-Atmosphere Interactions in the Columbus, OH Metropolitan Area using Lightning Data

Ruixuan Ding - The Ohio State University, Department of Geography Steven Quiring - The Ohio State University, Department of Geography

Land surface characteristics can influence convection. This study examines the relationship between land cover and the number of lightning events that occur downwind and upwind of a major metropolitan area. This study takes place in Columbus, OH, and uses lightning data from the National Lightning Detection Network from 2008 to 2015 to analyze lightning patterns. The study area was divided into nine uniformly regions, with the Columbus metropolitan area in the middle, to compare seasonal differences in lightning counts, percent of lightning, and the change rate. The results showed that there were statistically significant differences in lightning counts between the Northeast and Southwest region. A series of case study events were analyzed helped to relate lightning counts to the prevailing winds. The relationship between lightning and land cover was quantified using a regression model based on Multi-Resolution Land Characteristics Consortium land cover data and lightning from 2011. The results of this study provide insights into the connection between metropolitan areas and lightning counts. We plan to continue this work and compare results from other cities.

Alexander Garber - College of Charleston

Tropical Cyclone Climatology for Tampa Bay, Florida

Alexander Garber-Student at the College of Charleston B. Lee Lindner-Professor at the College of Charleston, Department of Physics and Astronomy

A climatological baseline was developed for the Tampa Bay, Fl area by using the HURDAT2 database and NOAA official hurricane tracking charts, which run from 1851 to the present. Tampa experienced a strike in 65 of the 170 years studied. The return rates for tropical storm, hurricane, and major hurricane strikes, determined by the closest point, were 1.91, 3.95, and 11.33 years, respectively. While the median TS strike date did not change much in recent years, the median hurricane strike date moved 8 days earlier when excluding data before 1984. Half of all tropical storm and hurricane strikes came from storms that approached from the Gulf of Mexico. This is most likely due to its geographical location. Finally, the average translational velocity of storms passing close to the Tampa area was higher than in other parts of the globe with the same latitude.

Rakesh Ghosh - Indian Institute of Tropical Meteorology

Lightning Characteristics of Thunderstorms over eastern India (Nor'westers)

Rakesh Ghosh - Indian Institute of Tropical Meteorology, Thunderstorm Dynamics Manoj Domkawale - Indian Institute of Tropical Meteorology, Thunderstorm Dynamics S.D. Pawar - Indian Institute of Tropical Meteorology, Thunderstorm Dynamics V. Gopalakrishnan - Indian Institute of Tropical Meteorology, Thunderstorm Dynamics

The Eastern and northeastern part of India experiences severe thunderstorms, locally known as Norwesters, during premonsoon seasons (April-May). The surface winds are predominantly South-easterly during these periods, which bring moisture from Bay-of-Bengal to this region. High moistures content at the surface layer and high temperatures during pre-monsoon months make the conditions favorable for severe thunderstorms. These thunderstorms are strongly electrified and exhibit high lightning activity. The electrical characteristics of these severe thunderstorms are studied very rarely. It has been observed that during the pre-monsoon season (April-May), this region (eastern part of India) receives large natural dust aerosols transported from the neighboring desert regions (Thar Desert) in the western part of India. This high aerosol concentration may play an important role in these severe thunderstorms' microphysical and electrical characteristics. Here, we study the lightning characteristics of these severe thunderstorms and their interactions with microphysical and dynamical properties using Doppler Weather Radar, Lightning Location Network, and aerosol data. The analysis shows when the radar reflectivity values close to 7.5 km altitude (or -10℃ isotherm) level are in the range 35 to 40 dBZ, lightning initiation occurs. Contradictory to earlier studies, the IC to CG ratio decreases with the severity of thunderstorms. Negative CG was observed to be associated with convective precipitation region and positive CG with stratiform precipitation region.

James Goodnight - University of Illinois

Observational and Environmental Analysis of Tornadogenesis Mechanisms in Quasi-Linear Convective Systems

James Goodnight - University of Illinois, Department of Atmospheric Sciences Robert Trapp - University of Illinois, Department of Atmospheric Sciences Devin Chehak- National Weather Service

Quasi-linear convective systems (QLCSs) are well known for their propensity to generate damaging surface winds, extreme rainfall, and tornadoes. Previous work has shown that QLCS tornadoes are less likely to be classified as significant (EF2+), but are more likely to pose prediction and detection challenges to forecasters. These challenges are partly due to the relative lack of well-resolved radar precursors in tornadic QLCSs, and to a relatively higher frequency of overnight occurrence, which leads to a reduction in public awareness. The overarching objective of this study is to gain a better understanding of how tornadoes form within QLCSs, and then attempt to use this understanding to increase the QLCS tornado warning lead time and accuracy. A review of the literature suggests that QLCS tornadogenesis (TG) most commonly occurs via two basic mechanisms. The tilting and stretching (T&S) mechanism represents a broad class of TG mechanisms by which vertical vorticity is generated through the tilting of storm-generated and/or environmental horizontal vorticity and subsequently amplified through vortex stretching. This type of process resembles that of supercellular TG, and assumes that a low-level mesocyclonic circulation is preceded by a mid-level mesocyclonic circulation. The horizontal shearing instability (HSI) mechanism occurs along high-vertical-vorticity boundaries characterized by opposing flows, converting linear vorticity patterns into evenly spaced, discrete vortices. A synoptic-scale cold front is one example of a high-vorticity boundary; a convectively generated mesoscale cold pool is another. The near-surface circulations resulting from the release of HSI are then stretched by convective updrafts into tornado-strength vortices. We hypothesize that tornadoes produced through HSI are more likely to occur in association with synoptically forced, cool-season QLCS events. In contrast, warm-season QLCSs forming in high CAPE and moderate shear environments are more likely to generate tornadoes through a T&S type mechanism. Additionally, we hypothesize that T&S events are slower to evolve compared to HSI events and therefore provide potentially longer warning lead time. These events are also more likely to produce stronger tornadoes and pre-tornadic vortices. These hypotheses were addressed by first creating a QLCS tornado database for US tornadoes that occurred during the years 2016, 2017, and 2019. A set of criteria was developed to qualitatively determine the TG mechanism of observed QLCS tornado cases using single-Doppler radar data commonly available to forecasters. A tornado case was classified as T&S if it was preceded by a mid-level (>2km AGL) vortex 15 minutes prior to tornadogenesis. A tornado case was classified as HSI if adjacent, low-level circulations existed within 15km of the tornadic circulation within 15 minutes of tornadogenesis. Additionally, there must not have been a mid-level circulation 15 minutes prior to tornadogenesis. For each tornado case, radar characteristics such as strength of the pre-tornadic mid-level vortex, strength of the low-level parent vortex, NWS warning lead time, and radar beam height, as well as the tornadogenesis mechanism were recorded. To supplement the radar data analyses, 13-km Rapid Refresh (RAP) analyses were used to evaluate tornadic environments. Similar to past studies, for each tornado case the latest analysis field prior to tornadogenesis was used for subsequent analysis. The downstream environment was sampled to evaluate relative thermodynamic and kinetic fields. Additionally, frontal forcing was quantified by sampling fields such as vorticity and frontogenesis upstream of the location of tornadogenesis. Overall, 559 QLCS tornado cases were analyzed. Tornadogenesis mechanism was qualitatively determined through radar criteria. HSI accounted for 37.6% of cases while T&S accounted for 58.9% of cases. A tornadogenesis mechanism was unable to be assigned to 3.5% of cases. The low-level parent vortex at the time of tornadogenesis was approximately 10 kts stronger on average for T&S cases, however, this relationship strengthened for tornadoes occurring closer to the radar. HSI accounted for a larger relative proportion of QLCS tornadoes during the cool season, however, a large fraction of warm-season QLCS tornadoes were produced through HSI. This could potentially be explained by long-lived warm-season QLCSs concentrating planetary vorticity along the leading edge of the cold pool, leading to favored zones for the release of HSI. Interestingly, the diurnal distribution of T&S cases was strongly centered about the mid-afternoon while HSI cases had no clear preferred time of day of occurrence. This implies that T&S events are strongly dependent on availability of surface-based CAPE. Average NWS warning lead time was less than 5 minutes the entire dataset. Only taking into account tornadoes that were warned (non-zero lead time), T&S events averaged 16 minutes of lead time while HSI events averaged just 9 minutes. Environmental analysis is still ongoing. However, there are a few notable differences between large-scale environments supportive of HSI versus T&S mechanisms. Surface-based CAPE, on average, is higher for T&S events. This difference is more pronounced in the cool season. There were not significant differences in shear parameters between HSI and T&S events. These environmental parameters are likely more important in determining convective mode rather than TG mechanism.

Spencer Guerrero - University of Illinois

Investigating S2S Models of Atlantic Tropical Cyclone Landfalls

Spencer Guerrero - University of Illinois, Department of Atmospheric Sciences

Many statistical models have been developed that show skill at forecasting TC activity and are deployed on a seasonal basis. However, it has been shown that statistical models that capture variance in TC activity turn out to have very little explanatory power for landfall variance. To analyze landfall interannual variability, I will review Truchelut's 2015 Landfall Diagnostic Index (LDI). Variable selection and model formulation will be reviewed—with a test case on extending LDI to include spatial statistics of wind shear in the Atlantic. Additionally, I will review a metric to evaluate seasonal models and the results from developing a US landfall climatology.

Kaylee Heimes - University of Illinois

A Long-Term Climatology of Favorable Synoptic Patterns for Severe Storms

Kaylee Heimes- University of Illinois, Department of Atmospheric Sciences Harold Brooks- National Severe Storms Laboratory Kimberly Hoogewind- National Severe Storms Laboratory

The 20th century reanalysis version 3 (20CRv3) dataset provides a “best-guess” of 3-dimensional atmospheric conditions spanning from 1836-2015. Using a self-organizing map (SOM), a type of artificial neural network, we classified daily ensemble mean 500 mb height patterns by similarity. Each classification, or “node” in the SOM, were compared to practically perfect hindcast (PPH) data from 1979-2015 of tornadic activity to quantify the favorability of the synoptic pattern for producing tornadoes in the contiguous United States. The probability, or “efficiency,” of each pattern at producing tornado watches were also calculated. In general, nodes that are strongly associated with 10% tornado PPH days are also efficient at producing tornado watches. The most favorable 500 mb height patterns for producing tornado days are generalized by troughing over the western US with ridging over the eastern US. In contrast, unfavorable height patterns for tornado days include ridging over the western US with troughing over the eastern US or troughing across the entire country. We isolated our initial analysis to the month of May as it is the most climatologically active month for tornadoes across the contiguous U.S. Prior to 1875, the reduced number of assimilated surface pressure measurements likely significantly increased the uncertainty within the 20CRv3 ensemble data. Therefore, we focused our analysis from 1875-2015. Reports of tornadoes began to be collected on a regular basis in the 1950s, such that generally only significant and/or deadly tornado events are known in earlier time periods. Using the known associations between SOM patterns and tornado days, we then ranked Mays throughout the period in terms of their favorable and unfavorable pattern frequencies to infer active/inactive tornado months. Our initial results lend further confidence that the 20CRv3 dataset can serve as an extended temporal dataset that may be very beneficial for severe weather and climate studies.

Scott James - University of Illinois

Analyzing Surface Precipitation Accumulations Upstream of the Olympic Mountains using Observations and Simulations: An OLYMPEX Case Study

Scott James - University of Illinois, Department of Atmospheric Sciences Deanna Hence - University of Illinois, Department of Atmospheric Sciences

Analysis of surface precipitation accumulations upstream, near-shore, and adjacent to the Olympic mountains from the 17 December 2015 case during OLYMPEX using Weather Research and Forecasting (WRF) simulations, the NPOL dual-polarization radar, and highresolution soundings investigates the role of low-level blocking on upstream precipitation enhancement. Past work shows that frontal systems often slow while approaching complex terrain if the Froude number is sufficiently low. Low-level blocking of stable air ahead of a front can modify precipitation distributions by frontal deformation, slowing, splitting, or merging. Initial findings from derived vertical stability parameters show low-level stability and significant vertical wind shear. Observed sounding profiles indicate little change in surface level conditions as the front propagated eastward and stalled, which is a possible indication of blocking by the terrain. Using WRF simulations along with OLYMPEX observations, we analyzed precipitation accumulations upstream of complex terrain by breaking down the distribution of precipitation accumulations associated with a warm front that produced long-lasting Kelvin-Helmholtz (KH) waves. Through dividing the event into three regions 80 km, 40 km, and 0 km upstream of NPOL and into timeframes relative to landfall, we will isolate the impact of KH waves on precipitation accumulations compared to orographic precipitation enhancement. Each region will have model output precipitation accumulations compared to derived radar values for verification. Analysis of the thermodynamic environment and stability parameters will assist with determining if blocking had a role in potential upstream shift in accumulations.

Lillian Jones - University of Iowa

A scalable passive method for the quantification of airborne allergens

Lillian M. Jones - University of Iowa, Department of Chemistry Chamari B. A. Mampage - University of Iowa, Department of Chemistry Thomas M. Peters - University of Iowa, Department of Occupational and Environmental Health Elizabeth A. Stone - University of Iowa, Department of Chemistry, Department of Chemical and Biochemical Engineering

Twenty-four million Americans experience season health disorders caused by exposure to aeroallergens, such as pollen and mold spores. Traditionally, airborne concentrations of aeroallergens are sampled with the Hirst spore trap, which requires an electrical source and daily maintenance. However, aeroallergen concentrations may vary widely over urban and rural environments requiring a cost-effective and scalable quantification method. We developed such a method that uses passive sampling and light microscopy for analysis. Inexpensive and easy to operate, passive samplers rely only on the gravitational settling of particles onto a microscope slide. To investigate the accuracy and precision of the passive method, four samplers were deployed during the ragweed pollen season of 2020 at the University of Iowa Air Monitoring Site in Iowa City, IA. Samples were collected using the Hirst spore trap and the new passive method and analyzed using light microscopy. The ambient pollen number concentrations for four sampling periods were calculated using the deposition velocity model proposed by Wagner and Leith (2011). Pollen concentrations measured in two-week averages by the passive method ranged from 13 to 270 pollen grains m-3 and were on the scale of “moderate to high” according to the National Allergy Bureau. The passive sampling accuracy was satisfactory with an average difference of 30% between the two methods. The coefficients of variation across co-located passive samples ranged from 15% to 40%, suggesting general agreement. To assess this method’s efficacy with tree pollen, additional samples were collected during the springtime tree pollen season of 2021. Pollen concentrations measured by the passive method ranged from 54 to 880 grains m-3 and were on the scale of “moderate to high.” The two data sets collected during this period yielded an average percent difference of 69%, showing lower accuracy than the sampling completed during the ragweed pollen season. The initial standard operating procedure is undergoing continued advancement in several areas, including automated image analysis and sample size optimization. The validation of passive samplers will enable further measurements of aeroallergens over wider spatial scales, help determine where exposures occur, and mitigate their negative effects on human health.

David Lafferty - University of Illinois

Statistically bias-corrected and downscaled climate models underestimate the adverse effects of extreme heat on U.S. maize yields

David Lafferty - University of Illinois, Department of Atmospheric Sciences Ryan Sriver - University of Illinois, Department of Atmospheric Sciences Iman Haqiqi - Purdue University, Department of Agricultural Economics Tom Hertel - Purdue University, Department of Agricultural Economics Klaus Keller - The Pennsylvania State University, Earth and Environmental Science Institute Rob Nicholas - The Pennsylvania State University, Earth and Environmental Science Institute

Efforts to understand and quantify how a changing climate can impact agriculture often rely on bias-corrected and downscaled climate information, making it important to quantify potential biases of this approach. Here, we use a multi-model ensemble of statistically biascorrected and downscaled climate models, as well as the corresponding parent models from the Coupled Model Intercomparison Project Phase 5 (CMIP5), to drive a statistical panel model of U.S. maize yields that incorporates season-wide measures of temperature and precipitation. We analyze uncertainty in annual yield hindcasts, finding that the CMIP5 models considerably overestimate historical yield variability while the bias-corrected and downscaled versions underestimate the largest weather-induced yield declines. We also find large differences in projected yields and other decision-relevant metrics throughout this century, leaving stakeholders with modeling choices that require navigating trade-offs in resolution, historical accuracy, and projection confidence.

Daniel Lopez - University of Illinois

Generating CloudSat Reflectivity Using Passive Microwave Brightness Temperatures and cGANs

Daniel Lopez - Department of Atmospheric Sciences, University of Illinois Urbana-Champaign Randy Chase - AI2ESS, Department of Computer Science, University of Oklahoma Stephen W. Nesbitt - Department of Atmospheric Sciences, University of Illinois Urbana-Champaign

Clouds are a vital component of Earth's climate system as a part of the hydrological cycle and are the basis for one of the least understood, yet one of the most important, climate feedbacks. Currently, many passive satellites can determine cloud-top profiles in addition to geometric height and thickness estimates, but these are often determined in a biased way and can produce significant errors. Therefore, it is valuable to provide more accurate measurements of cloud structures for improved climate model evaluations and for better quantifying the effects of clouds and precipitation on the earth system. Given the recent advances in deep learning, we aim to demonstrate the effectiveness of using conditional generative adversarial networks (cGANs) to generate CloudSat 2D vertical cloud structures from the Global Precipitation Measurement (GPM) mission's Microwave Imager (GMI). Using the 13 GMI channels as input features, the study found that the cGAN produced reasonably accurate cloud structures and, in many cases, correctly inferred spatially plausible instances of precipitation in the 2D plane observed by both satellites. Furthermore, research suggests that this deep learning approach may outperform currently used cloud-top estimation algorithms. Examples of successes and failures of these retrievals will be discussed, as well as quantitative performance statistics of the new application of cGANs in cloud and precipitation remote sensing.

Sophie Orendorf - University of Illinois

Convective Windstorms in a Warmer Climate: A PGW Study Based on the 10 August 2020 Midwestern Derecho Event

Sophie A. Orendorf - Department of Atmospheric Sciences, University of Illinois at Urbana-Champaign, Urbana, Illinois Sonia Lasher-Trapp - Department of Atmospheric Sciences, University of Illinois at Urbana-Champaign, Urbana, Illinois Robert J. Trapp - Department of Atmospheric Sciences, University of Illinois at Urbana-Champaign, Urbana, Illinois

The severe straight-line winds in convective windstorms can cause casualties and significant damage to houses, crops and infrastructure over a large-scale region. The 10 August 2020 Midwest derecho resulted in four deaths, hundreds of injuries and was the costliest thunderstorm in U.S. history. In a warmer climate, it is not currently known how the mechanisms producing convective windstorms might differ. A method known as pseudo global warming (PGW) is utilized to determine potential differences in this specific storm in a warmer climate, and why the changes may occur. Here, the PGW method includes simulating the 10 Aug 2020 event in the observed environment, and then simulating the same event in an environment where the projected temperature, moisture, and wind changes at the end of the century from five different climate models are considered. Preliminary results indicate that the original event was mainly produced by the lowering of the strong rear inflow jet of the convective system, rather than mesovortices or downbursts. For at least some climate projections, the simulated area containing the extreme surface winds increases. The possible mechanism(s) responsible for these increases will be discussed.

Sreenath Paler - University of Wisconsin - Madison

Scale resolved, sub-grid surface fluxes across a heterogeneous mid-latitude forested landscape

Sreenath Paleri - University of Wisconsin Madison, Department of Atmospheric and Oceanic Sciences Ankur Desai - University of Wisconsin Madison, Department of Atmospheric and Oceanic Sciences Brian Butterworth - University of Wisconsin Madison, Department of Atmospheric and Oceanic Sciences Stefan Metzger - National Ecological Observatory Network, Surface Atmospheric Exchange Group David Durden - National Ecological Observatory Network, Surface Atmospheric Exchange Group Matthias Mauder - Karlsruhe Institute of Technology, Institute of Meteorology and Climate Research Dave M Plummer - University of Wyoming, Department of Atmospheric Sciences

The atmosphere responds to Earth surface heterogeneities in the form of scale dependent and strongly non-linear exchanges of energy and mass. A wavelet transform allows us to resolve these atmospheric flux responses at different scales. Because the wavelet analysis is not based on the ergodic hypothesis it is particularly suited to resolve airborne flux measurements over heterogeneous terrain. Here, we applied wavelet analysis to evaluate the scale-dependency of airborne flux measurements during the CHEESEHEAD 2019 intensive field campaign over a heterogeneous mid-latitude forested landscape (https://tinyurl.com/cheesehead19). The measured fluxes are separated into turbulent and mesoscale contributions and projected to two dimensional maps of energy and mass fluxes following the flux topography method by Mauder et al. 2008. Over the course of the summer to fall season, the study domain shifts from a latent heat flux dominated landscape to a more patchy sensible heat flux dominated one. Scale-dependent correlation analysis with surface properties reveals a concomitant shift in the evolution of scale dependencies of mass and energy transport. By identifying critical spatial scales and their relation to surface properties, the turbulent and mesoscale resolved flux maps can help improve the representation of subgrid surface-atmosphere exchanges and feedbacks in numerical models.

Michael Ragauskis - University of Illinois

A flood preparedness tool for the city of Chicago's most vulnerable communities

Michael Ragauskis - University of Illinois Urbana-Champaign, Department of Atmospheric Sciences
Francina Dominguez - University of Illinois Urbana-Champaign, Department of Atmospheric Sciences
Brian Jewett - University of Illinois Urbana-Champaign, Department of Atmospheric Sciences

Flooding is a chronic and systemic problem in the city of Chicago, with flood damages across the metropolitan area totaling nearly $2B between 2007 and 2014. This problem is likely to intensify in the future as the frequency and magnitude of urban flooding increases as a consequence of global warming. Unfortunately, there is currently no system in place to provide accurate and timely forecasts of urban flooding to Chicago communities. This project brings together the University of Illinois Urbana-Champaign's Atmospheric Sciences (ATMS) and Civil and Environmental Engineering (CEE) Departments to build a tool to forecast and communicate flood risk at the household, neighborhood and community scales for the city of Chicago. The tool makes use of high-resolution numerical weather modeling (ATMS) and urban hydrologic/hydraulic modeling. Providing household-scale flooding forecasts up to 72-hours in advance, the tool will enable vulnerable Chicago communities and hydraulic infrastructure managers to develop effective strategies for flood prevention and mitigation.

Roger Riggin - University of North Carolina - Charlotte

A Numerical Study Investigating Idealized Supercell Thunderstorms Interacting with the Appalachian Mountains

Roger Riggin - University of North Carolina at Charlotte, Department of Geography and Earth Science Dr. Casey Davenport - University of North Carolina at Charlotte, Department of Geography and Earth Science Dr. Matthew Eastin - University of North Carolina at Charlotte, Department of Geography and Earth Science Katie McKeown - University of North Carolina at Charlotte, Department of Geography and Earth Science Sarah Purpura - University of North Carolina at Charlotte, Department of Geography and Earth Science

A limited number of studies have investigated supercell thunderstorms interacting with elevated and variable terrain. A number of observation-based case studies have been conducted around parts of the Appalachian Mountains region. Most of these discuss varying terrain features providing an influential role in storm morphology but are unable to quantify their impacts. Forecasters currently lack a comprehensive conceptual model to assist with the decision-making process for supercellular hazards in regions of varying terrain. Our overall research aims to increase understanding of the relationships between supercells in complex terrain. Earlier efforts focused on the analysis of environmental and radar characteristics of 62 isolated supercells that traversed the south-central Appalachians between 2008-2019. Observed storms were tracked via radar and classified based on whether or not they crossed significant terrain or not. The current effort uses an idealized numerical model to further investigate the observation-based results. Proximity soundings have been constructed from the upstream, peak, and downstream elevation points along the storm tracks. Composite proximity soundings were generated to quantify typical crossing v. non-crossing storm environments, and these composites were used to create an evolving background field via a base-state substitution method to investigate supercell behavior as it traverses the complex terrain. Three terrain configurations are tested as well: no terrain, idealized terrain, and realistic terrain in an attempt to isolate terrain-related influences on storm morphology. Sensitivity tests are performed to discriminate forecasting parameters favorable for crossing v. non-crossing supercells. Results are preliminary at this time and will be discussed during the presentation.

Michael Sessa - University of Illinois

The Prediction of Potential Tornado Intensity Using Machine Learning

Michael Sessa - University of Illinois, Department of Atmospheric Sciences Jeff Trapp - University of Illinois, Department of Atmospheric Sciences

Trapp et al. (2017, 2018; JAS) used theory and idealized numerical simulations to develop the simple hypothesis that wide, intense tornadoes should form more readily out of wide, rotating updrafts. Sessa and Trapp (2020; WAF) manually analyzed radar data on 102 tornadic mesocyclones to test this hypothesis. Their analysis focused explicitly on the pre-tornadic mesocyclone width and differential velocity: this allowed for the elimination of the effects of the tornado itself on the mesocyclone characteristics. Herein, we use an expanded dataset (300 tornadic mesocyclones) to determine the generality of their results. Consistent with Sessa and Trapp (2020; WAF), the linear regression between the mean, pre-tornadic mesocyclone width and the EF rating of the corresponding tornado yields a coefficient of determination (R2) value of 0.75. This linear relationship is the higher for discrete (supercell) cases (R2=0.82), and lower for QLCS cases (R2=0.37). Overall, we have found that pre-tornadic mesocyclone width tends to be a persistent, relatively time-invariant characteristic that is a good predictor of potential tornado intensity. These findings have motivated us to explore tornado-intensity prediction approaches using pre-tornadic mesocyclone characteristics and other data such as the near storm environment through machine learning applications. Several classification machine learning algorithms such as Logistic Regression, Random Forest, K-Nearest Neighbor, Naïve Bayes, Decision Trees, and Support Vector Machines are being implemented and used to examine their skill in predicting potential tornado intensity, either non-significant or significant, for a given storm. Tuning of hyperparameters through different search methods is also completed to optimize the performance of the models. Finally, feature importance and the decision making process within each model is explored to help reveal a more physical understanding of the model performance and results as well as relationships between the predictors and tornado intensity. Initial results show the potential for a skilled binary prediction of tornado intensity and for these machine learning applications to become a helpful resource in an operational setting.

Lydia Spychalla - University of Illinois

Hail Nowcasting from Numerical Weather Prediction Model Data using Deep Learning

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Hail results in billions of dollars in property damage in the United States every year. While hail is a relatively common weather phenomenon, it is difficult to accurately forecast because the microphysical processes which govern hail growth are not resolved within numerical weather prediction (NWP) models. Current hail forecasts rely on forecasters to assess whether atmospheric conditions support the occurrence of hail, as well as parameterized hail growth models that run in parallel with NWP models such as HAILCAST which have a large degree of uncertainty. While the current techniques have skill, they require a substantial amount of human and computational time. In recent years, machine learning models have demonstrated the ability to forecast hail up to two days in advance. Machine learning models are advantageous because they do not rely on solving computationally intensive equations or parameterizations and once trained can be remarkably efficient. This work explores the ability of machine learning to conduct near real time forecasts of hail. We develop a multi-class classification model which predicts hail category (e.g., no-hail, hail, severe hail, significant severe hail) using data from the High Resolution Rapid Refresh (HRRR) model and the Multi-Radar Multi-Sensor (MRMS) Maximum Estimated Size of Hail (MESH). While the machine learning model often underpredicts the probability of hail, it is able to produce more localized forecasts than the hail parameterizations currently implemented within the HRRR model, and therefore could help minimize the occurrence of false alarms. This model was able to produce hail predictions with an area under the receiver operating curve of at least 0.90 for each hail category, and its performance is observed in a severe hail case study. In general, this work shows machine learning models to have potential as a useful tool for next-hour hail forecasting.

Madeline Statkewicz - University of Houston

Changes in Precipitation Patterns in Houston, Texas

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There has been an alarming increase in the frequency of major flooding events along the Gulf Coast over the last three decades, primarily due to events of unprecedented, or extreme, rainfall. Using data from 63 rain gauges maintained by the Harris County Flood Control District's Flood Warning System (HCFCD FWS), this study examines the changes in daily precipitation amounts in the highly urbanized city of Houston, Texas, USA. The potential shift in annual precipitation patterns over a period of three decades (1989-2018) was examined by investigating the numbers of dry and wet days as well as annual precipitation totals over the study period. Wet days were then further scrutinized based on daily rainfall amounts (e.g., R10, R20, R30, R40, R50, R100) to determine if extreme events are beginning to dominate annual rainfall amounts. Trends were analyzed for statistical significance temporally using the Mann-Kendall and Sen's slope methods and for spatial trends using GIS applications. The results indicate a statistically significant increase in extreme rainfall at the expense of light, moderate, and heavy rainfall over time. The only negative relationship is found in dry days. The most statistically significant trends exist in the 99th percentile, maximum, and R100 parameters with p-values of 0.07, 0.08, and 0.11, respectively. There has been rapid growth and intensive development in the Houston area in recent decades that continues to this day, and land cover change has been significant as 12.6% of Harris County changed to one of four National Land Cover Database (NLCD) Urban classes (e.g., developed: barren, low intensity, medium intensity, high intensity). This confirms that urbanization has continued to increase while total vegetative and wetland coverage has decreased. The findings of this study provide essential guidance for city and state planners and engineers.

Meghan Stell - Arizona State University

Bringing water to the west: Microphysics and dynamics of orographic clouds influenced by atmospheric rivers

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Atmospheric Rivers (ARs) are important sources of moisture in the Western United States. ARs have been shown to influence the precipitation in inland regions, such as Idaho. Less study has focused on the impacts of inland-penetrating ARs on the microphysics and dynamics of orographic clouds in these inland regions. As the inland west is experiencing a long-standing drought, insight into the processes that bring moisture to the west will provide for a greater understanding of future precipitation and drought conditions. The region of focus for this study is the Payette River Basin in Idaho. The Seeded and Natural Orographic Wintertime Clouds: the Idaho Experiment (SNOWIE) project (January - March 2017) provided aircraft-based radar and in-situ microphysics data in the Payette Basin, and radiosondes were launched to provide thermodynamic data. Data from the Atmospheric River Tracking Method Intercomparison Project (ARTMIP) was used to identify ARs and quantify their strength. Two ARTMIP Atmospheric River Detection Tools (ARDTs), which provided the most coverage for inland areas, were chosen for this analysis. The connection between ARs and the microphysics and dynamics of orographic clouds was investigated in a case study using SNOWIE flight (IOP) 12, which occurred on February 7, 2017. This IOP was chosen because ARTMIP data strongly indicated the presence of an AR in the study area and because it was unique compared to other SNOWIE cases in that the cloud structures observed included orographic and highly convective clouds. Sounding data before and during the IOP show that an incoming AR noticeably influenced the thermodynamics in IOP12. An increase in moisture was observed as the AR impacted the region, which led to an increase in atmospheric instability. The increased instability induced elevated convection by providing extra lift than would have occurred from the orographic process alone. Analysis of the in-situ microphysics data showed very low cloud droplet concentrations and mixed phase conditions in the convective clouds. Outside of the convection, shallow orographic cloud tops were mostly liquid and contained supercooled drizzle. The difference in conditions between the orographic and convective clouds led to the assertion that the convection enabled enhanced precipitation formation processes that might not have occurred in the shallow, warmer orographic clouds.

Hamid Ali Syed - Savitribai Phule Pune University, Pune

Characterization of Hourly radar-based quantitative precipitation estimation

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Progress in rainfall estimation is important for advancing science and applications in weather and water budget studies, as well as forecasting natural hazards due to extreme rainfall events at all scales, from regional to global. Doppler Weather Radar (DWR) technology enables us to measure areal precipitation close to the ground and estimation of quantitative precipitation estimation (QPE) is one of the important radar applications. Hydrological forecasting and early warning systems require accurate, timely, and reliable precipitation observations. Weather radar-based quantitative precipitation amount (QPA) that has brought in this report as traditional well-known surface rainfall accumulation (SRA). SRA has traditionally been computed using radar reflectivity measurements associated with surface rainfall intensity well known as the Z-R relation. An improved algorithm for the categorization of radar retrieved rainfall into convective and stratiform rain has been the key for interpolating SRA for inferring it as QPA. This estimated SRA / QPA from the IITM's X-Band Radar situated over a Western Ghats site used for its hourly evolutions and that has been compared with ground truth. The radar volume scan data at various elevation angles PPI has been the basis for generating gridded form of radar data using in-house developed CAPPI at various heights i.e., the 3D format of radar data display. The radar-retrieved QPA/SRA map produced better results than the traditional fixed Marshal-Palmer relationship, which was confirmed using the GPM level 3b precipitation datasets and 3 hourly TRMM precipitation datasets.

Seung Uk Kim - University of Illinois

The Synergistic Role of Synoptic and Regional Processes for Drought Development in the Midwestern United States

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Drought severely impacts the central United States, with an estimated cost of about 1.8 billion dollars per year. The emergence of agricultural drought is associated with prolonged excessive deficits in soil moisture, which are influenced by synoptic and regional-scale factors. In this study, we use statistical analysis and a moisture tracking model to understand how drought propagates into the Midwest. Cyclo-stationary empirical orthogonal function (CSEOF) of soil moisture anomaly is used to extract monthly variability within a year. Other variables such as precipitation, temperature, evapotranspiration, total atmospheric column water, 500hPa geopotential height, and sea surface temperature are also analyzed to understand how the supply of water to the soil varies at the regional and synoptic scale. The first mode shows strong height anomalies associated with sea surface temperature anomalies, especially during winter, indicating the significant of the role of large-scale variability. The second mode is characterized by an eastward migration of the soil moisture anomalies into the Midwest region during summer. Such expansion of soil moisture anomaly is linked with a decrease in atmospheric total column water in summer and likely land-atmosphere interactions. Whenever these two leading modes occur at the same time, as a synergy of synoptic and regional changes, the development of megadrought can be expected. This was the case in 1988 and 2012. We use the two-layer dynamic recycling model (2L-DRM) to understand moisture transport changes during megadrought events. During warm months (March-August) in 1988 and 2012, the Midwest experienced a large decrease in imported precipitation from upwind regions, in addition to a significant decrease in local recycled precipitation. Lagged changes in soil moisture and precipitable water between the upwind region and the Midwest show that dry conditions in the upwind migrated to the Midwest and then drought was amplified through positive land-atmosphere feedback.

Sarah Worden - UCLA

Where does moisture come from over the Congo Basin?

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The Congo Basin hosts the world's second largest rainforest and is a major rainfall center. However, the primary sources of moisture needed to maintain this forest, either from evapotranspiration (ET) or advection from the ocean, remain unclear. We use satellite observations of the deuterium content of water vapor (δD), solar induced fluorescence (SIF), precipitation, and atmospheric reanalysis to examine the relative contribution of ET to moisture in the free troposphere. We find that SIF, an indicator of photosynthesis, covaries with δD in early rainy seasons, suggesting that ET is an important contributor to atmospheric moisture in both the spring and fall rainy seasons. However, the relative contribution of ET to the free tropospheric moisture varies between the two rainy seasons. Observed δD relative to a range of observationally constrained, isotopic mixing models representative of water vapor coming from land suggests that 83% ± 9%of the free tropospheric moisture come from ET in February, and 45%±13% in April, versus 59%±12% in August and 31%±12% in October. Reanalysis indicate that this difference between seasons is due to increased advection of ocean air during the fall season, thus reducing the relative contribution of ET to the Congo Basin in the fall. In addition, ET is the primary atmospheric moisture source in the winter and summer dry seasons, consistent with estimates reported in literature. Our results highlight the importance of ET from the Congo rainforest as an important source of moisture for initiating the rainy seasons.

Sean Whelan - Ohio State University

Establishing a Climatology of Significant Tornadoes within the Southern United States

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Tornado climatologies are quite common throughout the field of meteorology, especially in the region of the Great Plains traditionally referred to as “Tornado Alley”. However, despite recent high-fatality tornadic events in a region of the Deep South colloquially referred to as “Dixie Alley”, there is limited research into the causes of significant tornado cyclogenesis in this region. Here, in order to establish a significant tornado climatology of this region, I have determined the number of significant tornadoes to have occurred in the past thirty years per 1000 square miles of land area in each of the counties within the states of Alabama, Georgia, Mississippi, and Tennessee. I then created a map showing the differences in significant tornado density across the region and attempted to theorize about the causes of these differences, such as the high significant tornado density in the Sand Mountain region of Alabama potentially being caused by unique terrain gradient. Identifying these specific micro-regions of high significant tornado density can help provide for targeted tornadic mitigation using strategies including improved tornado warning infrastructure and stricter residential building codes similar to the changes made in the Moore, Oklahoma building codes in the wake of the 2013 tornado.

Troy Zaremba - University of Illinois

Precipitation Growth Processes in the Comma Head Region of the 7 February 2020 Snowstorm observed during IMPACTS

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On 7 February 2020, as part of the NASA-EPSO Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms (IMPACTS) field campaign, precipitation within the comma head region of an extratropical cyclone was sampled by two research aircraft, providing a vertical cross-section of in-situ microphysics observations and fine scale radar measurements. The sampled cross-section was stratified vertically by distinct temperature layers and horizontally into a stratiform region on the west side of the cross-section and a region of generating cells at cloud top on the east side. The defining feature that separated the two regions was a dry air intrusion associated with a jet. This affected cloud cover in the generating cell region.This is the first quantitative study that analyzes the relationship between frontogenetical forcing, a low-level precipitation band, cloud top generating cells, and the microphysics and dynamics that relate them. Precipitation in the stratiform region was formed aloft in the polycrystalline growth layer, and then fell and grew through subsequent growth layers with limited primary ice production. As these polycrystalline crystals fell to the surface, they grew by vapor deposition and aggregation. In contrast, supercooled liquid water (SLW) produced by cloud-top generating cells on the west side of the generating cells region and deeper convective cells on the east side contributed to enhanced particle nucleation, larger number concentrations, and enhanced particle growth across the extent of the generating cell region. Although SLW was not observed throughout the entire horizontal extent of each particle growth layer within the generating cell region, microphysical quantities were generally consistent with new particle formation within each thermal layer, based on particle habits observed in each of the particle growth layers. This new particle formation resulted from both primary ice production above the plate growth layer, at temperatures colder than -10°C, and from secondary ice production below the plate growth layer, at temperatures warmer than -8°C, likely via the Hallett-Mossop process. In addition to enhanced ice production by primary and secondary processes, ice particles grew by vapor deposition, aggregation, and riming within the generating cell region. Some particles were observed to grow rapidly, with snowflake-sized particles up to 15 mm observed in the dendritic growth layer. As particles descended to the surface in the generating cell region, they transitioned into rain as they encountered the melting layer. This study will show how particle growth evolved with depth beneath cloud top in various particle growth layers sampled.