SESE RESEARCH REVIEW
UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN | FEBRUARY 18TH 2022

School of Earth Society and Environment

2022 Research Review Program

February 18th, 2022

SESE Research Review Committee

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Welcome Letter

8 November 2021

Hello!

Welcome to the 2022 School of Earth, Society, and Environment's (SESE) 17th annual Research Review. We would like to thank you for attending and all of our presenters for all of their hard work! While still facing the challenges brought by the pandemic, we are so glad to see students and faculty are doing impressive research throughout the year.

After the virtual SESE Research Review last year, we are happy to bring it back in-person this year and thrilled to see everyone and reconnect people in a real room. We hope that the SESE Research Review brings together the local community of researchers working on issues related to earth, society, and environment and allows them to explore the wide range of exciting research that goes on within our school.

We would like to extend our thanks to the entire SESE staff for their invaluable assistance in organizing this event. Thanks to Lana Holben and Anna Kuppler for all of their support and help in planning the event. Thanks to Prof. Constance Brown for providing necessary support and guidance as Research Review faculty advisor.

We would also like to express our gratitude to the School of Earth, Society, and Environment and the University of Illinois for providing an intellectually stimulating atmosphere in which to discuss world-class research.

Finally, thank you for attending the SESE Research Review and showing your support for all of our researchers. Enjoy the Research Review!

Sincerely,
SESE Research Review Committee
Tanya Shukla (RRC Chair)
Alfonso Ladino Rincon   Mingyue Yu
David Roegner   Sarah Dendy
Duncan Anderson   Tobias Ross
Jorge Fernandez   Yaoyi Wang

Schedule

8:30 - 10:00 AM Poster Check-In & Setup

10:00 - 1:00 PM First Round of Judging (Judges Only)

2:00 – 3:30 PM Poster Presentations (Second Round of Judging)

3:30 – 3:35 PM Welcome Message

3:35 – 4:15 PM Lightning Talks

4:15 – 5:00 PM Award Presentations

Lightning Talks

David Roegner
Eva Bein
Eva Cornman
Jon Golla
Ryan Sigat
Tzu-Shun Lin

Poster Presentation Index

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43	Gabriel Brophy	Undergraduate Student	Geology
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45	Gillian Patterson	Undergraduate Student	Geology
2	Grayson Nelson	Undergraduate Student	Atmospheric Sciences
13	James Goodnight	Graduate Student	Atmospheric Sciences
32	James Haken	Undergraduate Student	ESES
23	Jay Pillai	Undergraduate Student	Atmospheric Sciences

42	John Albright	Graduate Student	Geology
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36	Poushalee Banerjee	Graduate Student	Geography and GIS
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26	Seung Uk Kim	Graduate Student	Atmospheric Sciences
18	Sophie Orendorf	Graduate Student	Atmospheric Sciences
16	Spencer Guerrero	Graduate Student	Atmospheric Sciences
37	Tanya Shukla	Graduate Student	Geography and GIS
3	Tobias Ross	Graduate Student	Atmospheric Sciences
21	Troy Zaremba	Graduate Student	Atmospheric Sciences
29	Tzu-Shun Lin	Graduate Student	Atmospheric Sciences
38	Wataru Morioka	Graduate Student	Geography and GIS
50	Yanchong Li	Graduate Student	Geology
51	Yaoyi Wang	Graduate Student	Geology
30	Yicen Liu	Graduate Student	Atmospheric Sciences
52	Yuyu Li	Graduate Student	Geology
27	Zachary Chalmers	Undergraduate Student	Atmospheric Sciences
53	Zebin Cao	Graduate Student	Geology

Instructions for Posters

Instructions For Poster Printing & Setup

If you need a poster printed by SESE, please fill out the poster printing request at
https://forms.illinois.edu/sec/1815339 by **Monday, Feb 14th**, so that the SESE IT team can be sure
to accommodate your printing job in a timely fashion. You need to bring your poster to the Illini
Union rooms ABC between 8:30-10:00am for check in and set up. The entrance to the Illini Union
rooms ABC is located on the west side of the first floor of the Illini Union. Research Review
Committee volunteers will assist with poster check-in and set up.

Awards

Outstanding student presenters will receive awards during the SESE Research Review.

Poster Abstracts

Aiden Schore

Poster #33

Decadal patterns of shrub cover change across a topographically diverse tundra landscape in the Seward Peninsula, Alaska

Aiden I. G. Schore and Mark J. Lara

Warming at high-latitudes has been linked with increasing plant productivity as widespread patterns of "greening" (i.e., increased NDVI trends) have been observed across the Arctic, due in part to the expansion of tall shrubs. Understanding the spatiotemporal patterns that control shrub expansion is key to predicting future biophysical and biogeochemical climate feedbacks, information needed for terrestrial and earth system modeling, wildlife habitat modeling, and land-use planning for subsistence activities by local indigenous communities. Here, we map the changes in shrub cover between 1950 and 2017 in the Seward Peninsula of Alaska using USGS aerial photography and PlanetScope-3 data, respectively. Integrating these vastly different image products requires that we correct discrepancies caused by luminance and illumination irregularities in historical USGS aerial photographs to properly mosaic and map shrub cover change over time. Using both summer and fall satellite imagery, we are able to differentiate alder (Alnus spp.) from other tall shrubs based on senescence signatures. Preliminary results indicate the importance of elevation, slope, and proximity to waterbodies for shrub expansion, as new shrubs grow in wet soils running downslope on mountainous terrain and in areas around lakes. Using this information we aim to develop a probabilistic model of future shrub cover change to improve our understanding of pan-Arctic productivity/greening trends in topographically diverse tundra landscapes.

Alexander Adams

Poster #1

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 Adams, Robert Rauber, Brian Jewett, Greg McFarquhar

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 poster, 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.

Antonio Elizondo

Poster #12

Assessing Large-Scale Climate Drivers of U.S. Tornadic Activity

Antonio M. Elizondo, Ryan L. Driver

Previous research on tornado outbreak occurrences in the United States has shown an increased variability in this metric. What is absent from this observation is a physical explanation behind the increased variability. We intend to weave together multiple lines of evidence of possible relationships between the ocean-atmosphere-cryosphere system and U.S. tornadic activity. We propose investigating multiple climate parameters that reasonably influence tornado outbreak occurrences, including ENSO phase (Nino 3.4 and 3.0 regions), Gulf of Mexico and NAO sea-surface temperature anomalies, and sea-ice coverage in the Chukchi Sea.

Our results indicating any statistically significant relationships between the climate and U.S. tornado outbreaks will be used to further explore the prediction capability of these climate parameters. Future work will aim to assess the overall implications of our prediction results on the U.S. insurance industry and future insurance losses.

Brandon Garcia

Poster #11

Developing a Climatology of Tornadoes Around the Black Hills

Brandon Garcia; Dr. Keith Sherburn; Dr. Matt Bunkers

Forecasters at the NWS Rapid City Weather Forecast Office have identified areas of relatively high tornadogenesis frequency associated with the Black Hills, an isolated area of higher terrain in the northern high plains of the United States. This observation supports recent research relating other isolated areas of higher terrain to potentially favored areas of tornadogenesis. These findings indicate the potential for the development of new tornado forecasting strategies that can increase the lead time and accuracy of tornado watches and warnings. The present research addresses this possibility by developing a climatology of tornadoes near and over the Black Hills to identify the patterns common to tornadoes in this region. Specifically, this study uses the Storm Prediction Center's tornado database (1950–2019) to analyze the times and locations of the tornadoes, in addition to an analysis of their synoptic and mesoscale environments using Rapid Update Cycle, Rapid Refresh, and High-Resolution Rapid Refresh model output. A kernel density estimation of the tornado starting points indicated relatively high tornadogenesis frequency around the northern and northeastern sides of the Black Hills. This region was often colocated with moisture pooling, higher convective available potential energy, and lower lifted condensation levels, all of which support increased odds of tornadogenesis. Furthermore, an analysis of the tornadoes on the Black Hills revealed that convective inhibition was often significantly weaker over the Black Hills than at lower elevations. These results outline some of the common locations and features of tornadoes associated with the Black Hills that forecasters may find useful when assessing tornado threats.

Brian D'Souza

Poster #39

Influence of Climate Change in Relation to Spatial Variability around Mt. Rainier

Brian D'Souza, Alison Anders

Mt. Rainier is the most topographically prominent mountain in the continental United States and is defined by its spectacular and accessible glaciers. Weather systems in this region typically move from west to east, creating a rain shadow with decreased precipitation on the north-east side of the mountain relative to the southwest side. In addition, the input of energy from the sun varies with aspect around the mountain. This variability in climate makes Mt. Rainier a perfect setting to study how climate influences glacier dynamics. We used glacier mass-balance data as inputs to a simplified glacier flowline model in order to simulate the impact of variability in climate on glacier extent around the model. In particular, we focus on differences in behavior between the Nisqually and Emmons glaciers on the southwest and northeastern sides of the mountain respectively. We explore how the local climatic conditions of these two glaciers influences their reactions to ongoing climate change.

Carolina Bieri

Poster #20

Exploring Links between Deep Roots, Soil Moisture, and Land Surface Fluxes in the Amazon

Carolina Bieri, Francina Dominguez, Gonzalo Miguez-Macho, Ying Fan

Plant roots act as critical pathways of moisture from subsurface sources to the atmosphere. Moreover, deep plant roots allow vegetation to meet water demand during seasonally dry periods by taking up water from the capillary fringe in areas with accessible groundwater. This is an important mechanism for vegetation in ecosystems around the world, including the Amazon, a hydrologically and ecologically significant region. However, most regional land-atmosphere modeling infrastructures do not adequately capture the link between deep roots and groundwater. This study evaluates the effects of implementing a deep rooting scheme in the Noah-Multiparameterization (Noah-MP) land surface model and using it with the existing Miguez-Macho and Fan (MMF) groundwater scheme. The deep rooting scheme is a first-order representation of dynamic rooting depth based on the soil water profile. The scheme is easily scalable and ideal for regional or continental-scale climate simulations. The MMF groundwater scheme captures high-resolution spatial groundwater variations, allowing us to capture the critical link between deep roots and groundwater. We perform offline Noah-MP simulations with the deep root and groundwater schemes for a region in South America and determine effects on land surface fluxes. Model output is compared with tower observations from the Large-Scale Atmosphere-Biosphere Experiment in Amazonia (LBA). Future work will include coupled simulations of Noah-MP and WRF using the deep root and groundwater schemes. This will allow for further research of the link between subsurface and atmospheric moisture variations via deep roots. This work is critical for achieving realistic representation of the soil-plant-atmosphere system in numerical modeling frameworks. As the land surface is an important component of atmospheric predictability, inclusion of deep roots can contribute to improved simulations of atmospheric variables such as precipitation.

Chelsy Salas

Poster #35

Spatial and Temporal Distribution of Suspended Sediment Concentrations on a Lowland Meandering River Floodplain: Implications for Channel-Floodplain Connectivity

Chelsy Salas and Bruce Rhoads

Floodplains are important storage areas for sediment transported by rivers. Major depositional processes on floodplains include lateral and vertical accretion. Along lowland meandering rivers, vertical accretion occurs through overbank deposition by floodwaters that inundate the floodplain. Recent work has shown that spatial variation in bankfull elevations of river channels allows inundation of floodplains to occur progressively as water stage rises toward and above the average elevation of the channel banks. Thus, both the timing and spatial extent of inundation vary across the floodplain during floods of different magnitudes. Although past work has documented spatial and temporal variations in overbank deposition on floodplains using sediment traps, few, if any, studies have examined spatial and temporal variability in suspended sediment concentrations of floodwaters within the floodplain environment. This study uses arrays of siphon samplers along with detailed stage records to investigate spatial and temporal variation in suspended sediment concentrations of floodwaters during several flood events. Concentrations are also related to amounts of deposition using sediment traps collocated with the siphon samplers. Preliminary results show that secondary channels and sloughs are major conduits for delivery of suspended sediment to floodplains and that these features are typically activated before widespread overtopping of channel banks occurs. These findings highlight that spatial and temporal variability in fine sediment fluxes to floodplains is strongly related to the degree of connectivity between the river channel and different types of floodplain environments.

Chu-Chun Chen

Poster #22

Moisture transport sensitivity to the location of soil moisture anomalies over southeastern South America

Chu-Chun Chen, Francina Dominguez

Previous studies have shown that southeastern South America (SESA) is a hot spot for land-atmosphere interactions during austral summer. Dry soil moisture anomalies can influence rainfall through moisture recycling or changes in atmospheric circulation. Few studies, however, have evaluated the sensitivity of the climate response to the location of soil moisture anomalies. In this work, we have conducted a control simulation and three experimental simulations using the Community Earth System Model (CESM), prescribing dry soil moisture anomalies over three different locations: (1) SESA, (2) western SESA, and (3) eastern SESA. Preliminary results show that dry SESA and dry eastern SESA runs have similar precipitation responses, while dry western SESA run shows a different pattern of precipitation response. In the dry western SESA run, the dry soil moisture anomalies lead to warming at the surface and lower troposphere, increasing the thickness aloft, which intensifies and shifts the low-level southward moisture flux to the east. In dry SESA and dry eastern SESA runs, the low-level southward moisture flux is weakened over land but intensified over the ocean. In summary, the location of soil moisture anomalies potentially determines the moisture transport and precipitation response over southeastern South America.

David Roegner

Poster #7

Subclassifying Thunderstorm Wind Types to Assess Engineering Importance

David T. Roegner, Franklin T. Lombardo, Zachary B. Wienhoff and Jessica Choate

Winds generated from thunderstorm downdrafts are imperative for structural design in many parts of the world. In order for these structures to withstand these events, a better understanding of the engineering-relevant characteristics is needed.

The Iowa Derecho in August of 2020 produced extreme winds over significant spatial and temporal scales. This type of event likely has different engineering-relevant characteristics (e.g., wind profiles) than our other storm types (e.g., supercells). The ASOS network in Iowa was used to separate out peak wind speeds from different thunderstorm sub-types, which were classified through the use of NEXRAD Level II data. An extreme value analysis was performed on each sub-type to predict wind speeds at various return periods and determine their relative importance for engineering design.

Diandian Peng

Poster #40

Quantifying horizontal vs vertical motions of subducted slabs using global geodynamic models with data-assimilation

Diandian Peng and Lijun Liu

Seismic tomography provides key constraints on the history of past subduction and surface geology. However, some reconstructions of past tectonic events based on tomography violate key geological records. We suggest this is due to the common assumption that slabs sink vertically after subduction, with the implication that the observed horizontal location of a slab represents its ancient trench position. Another relevant assumption is a constant slab sinking rate throughout the mantle, which gives the age of past subduction from the observed slab depth. However, geodynamic models often predict horizontal mantle flow and slab migration, whose effect on the inferred subduction history and geological events remains under-explored.

In this study, we investigate the 4D evolution of subducted slabs using global data-assimilation models that simulate subduction and convection since 200 Ma. The models successfully reproduce observed slabs throughout the mantle along all major subduction zones. We find that slabs can migrate laterally up to 6,000 km while descending toward the core-mantle boundary (CMB). This enormous displacement is not due to trench migration nor net lithosphere rotation but mostly reflects strong horizontal mantle flow. The model results also show that the vertical sinking rate of slabs varies with subduction duration, location and depth. The relationship between slab depth and subduction duration shows a three-step pattern for both global average and individual subduction zones. Slabs subducted during the past 80 Ma at different subduction zones have a sinking rate varying from 1.4 cm/yr to 2.3 cm/yr, with a global average of 2.1 cm/yr. On the other hand, slabs subducted prior to 130 Ma show no consistent sinking, which is resonable due to the impermeable CMB, but different from the constant sinking rate in multiple previous studies. The sinking rate also depends on depth, with two peaks at asthenospheric depth and mid-mantle and one vally at the base of mantle transition zone (MTZ) in general. By showing the variation of subduction rate based on plate motion, the horizontal migration and vertical sinking of slab with geological time, we suggest that the plate motion has a strong effect on horizontal migration but less effect on vertical sinking. These results provide new sights on the migration of slabs in the mantle and suggest a caution on inferring past tectonic events based on seismic tomography.

Divya Rea

Poster #17

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

Divya Rea, Robert M. Rauber, Troy J. Zaremba, Huancui Hu, Sarah A. Tessendorf

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 of Idaho. During the campaign, the University of Wyoming King Air aircraft, equipped with the W-band Wyoming Cloud Radar (WCR), flew across the Payette Basin and seeded orographic clouds. Data collected via the WCR revealed a single deep cloud during some intensive operation periods (IOPs), and distinct split clouds during others. Prior to many of the IOPs, an atmospheric river (AR) made landfall on the west coast of the United States. In this study, water vapor from one such atmospheric river is tracked to examine the AR's influence on the moisture distribution during SNOWIE. Two IOPs preceded by this strong AR are modeled using the Weather Research and Forecasting model (WRF) with added water vapor tracers. The simulation begins while the AR is located over the Pacific Ocean, and water vapor advected by the AR is then tracked through both IOPs. Output from WRF is compared to in situ 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 cloud seedability is also discussed. Finally, model output is used to quantify the AR's contribution to precipitation during both IOPs.

Dominik Rzeszutek

Poster #41

Cooking with Science: Pancake Volcanism on Venus

Dominik Rzeszutek, Patricia M. Gregg

Since their discovery, "pancake volcanoes" have been thought to be a volcanic feature unique to Venus. Found in clusters across the surface of the planet, and often part of larger volcanic fields, pancake volcanoes are typified by their distinctive circular, flat-topped morphology which resembles their namesake. Previous investigations have attributed pancake volcanoes on Venus to singular, monogenetic eruption origins. However, their formation and link to larger-scale volcanism on Venus remains a mystery. Recent marine geophysical surveys on Earth have revealed similar volcanic features, circular with flat-tops and seemingly monogenetic origins, along the 8° 20'N Seamount Chain adjacent to the East Pacific Rise. Although significantly smaller in size, these monogenic "pancake" seamounts appear similar in morphology to the volcanic systems thought to be unique to Venus. In this investigation, pancake volcanoes from Venus are analyzed and compared to submarine monogenetic volcanism found on Earth. Slopes, heights, and shapes are collected manually using C3-MDIR mosaic DEMs with QGIS and evaluated to determine statistically significant characteristics of these features. The overarching goal of this work is to better understand the formation of these monogenetic volcanoes and to determine whether similar features on Earth may be analogous and provide clues to their formation. Future directions include applying machine learning pattern recognition to evaluate volcanic fields across the surface of Venus.

Eddie Wolff

Poster #14

The Observed Relationship Between Overshooting Top Characteristics and QLCS Tornado Strength

Eddie Wolff, Robert Trapp, Stephen Nesbitt

Tornadoes which form out of quasi-linear convective systems (QLCS tornadoes) are especially difficult for forecasters to predict and identify, leading to lower situational awareness and shorter warning lead times. These storms are especially prevalent in the southeastern United States where the overall tornado frequency continues to increase and societal factors make these storms even more devastating to the communities they impact. This project attempts to improve the warning process by identifying signatures within geostationary satellite data which may augment the current set of radar and environmental characteristics currently used to nowcast these storms while providing an even higher temporal resolution than operational radar networks. A table of QLCS events was created using the NCEI storm event database with radar data manually analyzed for each event, confirming that all were QLCS tornadoes. Every report was then matched to the (spatially and temporally) nearest overshooting cloud-top (OT) as identified from GOES-16 data. Parameters such as OT area and minimum brightness temperature were also calculated and compared to maximum Enhanced Fujita (EF) rating. Preliminary results show that within QLCSs there is at least some correlation between these OT characteristics and tornado strength, though this connection is not as well-defined as previous studies which also included supercellular tornadoes. This is likely due in part to the relatively small size of this study's dataset and the lack of violent (EF 3+) QLCS tornadoes. Future work will expand the scope of this study to take advantage of multiple years of GOES-16 data and will also utilize data collected during the upcoming PERiLS field campaign to connect cloud-top processes with ground-based observations such as mesonet measurements and dual Doppler wind analyses.

Emma Hall

Poster #34

Optimization of plant species and plant functional type mapping using drone-borne sensor networks in Midwestern grasslands

Emma Hall, Mark J Lara

Uncrewed aerial systems (UAS) have emerged as powerful ecological observation platforms, capable of filling critical spatial (i.e., mm to cm) and spectral (i.e., multi- to hyperspectral) observation gaps in plant morphological, physiological, and/or phenological traits that have been difficult to measure from space-borne sensors. Despite recent technological advances, the high cost of drone-borne sensors limits the widespread application of UAS technology across fields of ecology, environmental science, and landscape management. Here, we evaluate the trade-offs between off-the-shelf and sophisticated drone-borne sensors for mapping plant functional types (PFTs) and plant species within a diverse Midwestern tallgrass prairie. Specifically, we compared PFT, and species mapping accuracies derived from RGB, multispectral, and hyperspectral imagery, fused with three-dimensional photogrammetrically (i.e., structure-for-motion: SfM) or light detection and ranging (LiDAR) derived canopy height models (CHM). Sensor-data-fusions considered either a single observation period (i.e., peak-growing season) or the entire growing season (i.e., near monthly observation frequencies) to include species-level phenological information. Results indicate the overall classification accuracy for PFTs was highest in hyperspectral imagery fused with a LiDAR CHM (i.e., 89%), followed by multispectral-phenological metrics fused with SfM CHMs (60%), and RGB fused with SfM CHMs (47%). Plant species overall classification accuracy was highest in hyperspectral imagery fused with a LiDAR CHM (78%), followed by multispectral-phenological metrics fused with SfM CHMs (52%), and RGB fused with SfM CHMs (45%). Our findings demonstrate clear trade-offs in mapping accuracies derived from economical versus exorbitant sensor networks, however, highlight that comparable vegetation mapping accuracies may be achieved from off-the-shelf and sophisticated drone-borne sensors by integrating higher observation frequency phenological metrics.

Enoch Jo

Poster #5

How does Vertical Wind Shear affect Entrainment, Dilution, and Precipitation in a Supercell Thunderstorm?

Enoch Jo, Sonia Lasher-Trapp

Supercell thunderstorms can produce heavy precipitation, and an improved understanding of entrainment may help to explain why. In part I of this series, various mechanisms of entrainment were identified in the rotating stage of a single simulated supercell thunderstorm. The current study examines the strength and effectiveness of these mechanisms as a function of the environmental vertical wind shear in eight different supercell simulations. Entrainment is calculated directly as fluxes of air over the surface of the storm core; tracers are used to assess the resulting dilution of the moistest air ingested by the storm. Model microphysical rates are used to compare the impacts of entrainment on the efficiency of condensation/deposition of water vapor on hydrometeors within the core, and ultimately, upon precipitation production. Results show that the ascending "ribbons" of horizontal vorticity wrapping around the updraft contribute more to entrainment with increasing vertical wind shear, while turbulent eddies on the opposite side of the updraft contribute less. The storm-relative airstream introduces more low-level air into the storm core with increasing vertical wind shear. Thus, the total entrainment increases with increasing vertical wind shear, but the fractional entrainment decreases, yielding an increase in undiluted air within the storm core. As a result, the condensation efficiency within the storm core also increases with increasing vertical wind shear. Due to the increase in hydrometeors detrained aloft and the resulting enhanced evaporation as they fall, the precipitation efficiency evaluated using surface rainfall decreases with increasing vertical wind shear, as found in past studies.

Erinn Dady

Poster #31

Volatile Organic Compound Emissions in Tomato: Influence of Plant Variety and Herbivory

Erinn R. Dady, Nathan Klezewski, Carmen M. Ugarte, Esther N. Ngumbi

Plants are stationary organisms and must use novel methods of defense against insect herbivores. Plants emit volatile organic compound (VOCs) continuously in the form of constitutive VOCs. Plant VOCs are influenced by many things, including plant species, abiotic factors such as light availability and drought, as well biotic factors such as insect herbivory. When subjected to different stressors, VOC composition and quality can change. Few studies are available about differences in VOC chemistry across plant varieties, and insect stress. Plant breeders continuously introduce new varieties, which likely respond differently when challenged by herbivory. To address this gap in knowledge, our study tested the hypothesis that tomato variety influences plant volatile signaling following exposure to insect herbivory.

We used a model system using four varieties of tomato plant (Solanum lycopersicum) and the herbivorous pest, tobacco hornworm (Manduca sexta). Volatiles were collected from undamaged and plants fed on by M. sexta larvae 48 hours prior to volatile collection. Volatiles were collected using solid phase microextraction and identified using gas chromatography mass spectrometry.

Fangyi Zhou

Poster #4

Using Self-Organizing Maps to understand the effects of wind shear on West Pacific typhoons

Fangyi Zhou, Steve Nesbitt, Shoujuan Shu, Jiacheng Ye

The development of tropical cyclones is believed to link to the vertical wind shear of the environmental field. In general, weak vertical wind shear favors the generation and development of pre-tropical cyclones. However, it remains unclear whether and what kind of influence the mid-to-late stage cyclones are subject to vertical wind shear. It is also inconclusive what type of environmental field will cause what type of environmental vertical wind shear. The purpose of this research is to investigate the connection between environmental fields and vertical wind shear, as well as the connection between vertical wind shear and tropical cyclones. If we find a strong correlation between them, we can improve the intensity and path of tropical cyclones by analyzing the environmental fields.

Gabbie Christo

Poster #9

Improving Tornado Intensity Estimation via Treefall-Pattern Analysis

Gabrielle Christo, Kyle J. Killion, Zachary B. Wienhoff, Franklin T. Lombardo, Daniel M. Rhee, and Jessica J. Choate

On 21 June 2021, an EF-3 tornado struck the Chicago suburbs of Naperville and Woodridge during the late evening hours. This quasi-linear convective system (QLCS) tornado was a well forecasted event that was sampled by three Doppler radars including KLOT, TMDW, and TORD. This case provides an opportunity to compare Doppler radar data with ground and aerial damage surveys, and treefall-pattern analysis to facilitate comparison between intensity estimation methods. Treefall analysis consists of using aerial damage imagery obtained via drone and fixed-wing aircraft to further analyze the fall patterns associated with tornado-damaged trees. ArcGIS software was used to import and tag fallen trees by manually drawing vectors for each felled tree in the tornado path. After documenting over 1500 trees, transects were taken along the entirety of the tornado track and a Rankine vortex model was fit to each transect using treefall pattern recognition software in MATLAB. After the analysis was complete, a range of vortex parameters were obtained from an average of the directions of all the treefall vectors. These values were then used to develop a theoretical near-surface wind speed map of all transects, providing an estimation of the tornado's translation speed and maximum wind speed near the surface. Estimates of the wind speed evolution via treefall analysis were then compared to the ground damage survey, and to Doppler radar analysis. The results of this analysis will be presented, and the future utility of this method in tandem with radar analysis and traditional damage survey wind speed estimates will be discussed.

Gabriel Brophy

Poster #43

Younger Dryas Impact Hypothesis

Gabriel Brophy

A comet or comets, which were airbursts, occurred approximately 12,850 years ago and caused the 1200 year long Younger Dryas (YD) cooling period at the end of the last ice age. This contributed to extinction of the Pleistocene megafauna in the western hemisphere along with the disappearance of the Clovis Paleo-Indian culture. Various geologic features exist on earth showing evidence of this catastrophe, one of them being glacial Lake Agassiz. This was the largest of the proglacial lakes that formed across upper North America as glacial ice dammed streams and lake outlets. The "great plumbing shift" took place exactly at the onset of the YD. Another geologic feature are the channeled scablands of the northwest, which highlight drumlins. Out in the field and even in various ice and rock cores the black-mat layer of soot is evident; this shows that the amount of thermal energy being introduced into earth's system was immense. Many boulder fields also date back to this 12,900-12,800 year timespan. The amount of force needed to move a lot of these boulders was a lot and cannot be explained through gradualistic processes we see on earth today. The YD was a comet or stream of comets that exploded in earth's atmosphere making it more deadly than hitting the ground. When the comet(s) hit at the 12,900 year marker, this caused glaciers of northern hemisphere to melt instantaneously. This then likely causes the biggest global flood in earth's recent history, the related water erosion is prevalent throughout not only the northern hemisphere but the whole planet. A 400ft increase in sea level globally was measured as well. Premature rejection of a hypothesis for which substantial evidence existed and which later achieved consensus is unfortunately a truth in science. Continental drift, meteorite impact cratering and anthropogenic global warming are examples of the first half of the 20th century. I will present evidence that the Younger Dryas Impact Hypothesis is a 21st century case.

Garrett Frank

Poster #44

The Influence Of Glacial Lakes On Post-Glacial River Network Development: Evidence From The Sedimentology Of Glacial Lake Douglas

Garrett Frank, Alison Anders, Nooreen Meghani

Continental glaciation disrupts drainage networks. Subsequently, rivers grow back into the landscape and progressively incorporate areas of internal drainage. This incorporation of closed basins is both a sign of drainage network development and can provide discharge to speed up the growth of river networks. While significant channel incision through large scale outburst floods has been observed, the prevalence of this process of channel development at a smaller scale is unknown. Through analysis of existing core data, soil data, and topography I have identified a site for investigating small-scale outburst flooding as a means of drainage network development. I employed ISGS well logs and literature on the sedimentary record of Glacial Lake Agassiz to develop three unique facies models for the draining of a glacial lake. Drawing from existing data and field observations, I collected three shallow cores in identified areas of interest within the lake basin of Glacial Lake Douglas to refine these models. The resulting cores support our hypothesized facies model and establish the sedimentary record of Glacial Lake Douglas to be analogous to that of larger glacial lakes. Additionally, the sedimentary record of Glacial Lake Douglas supports an early integration of the lake. Future work will establish the exact timing and influence of this early integration on the broader drainage network across Illinois.

Gillian Patterson

Poster #45

Coastal Freshwater Pulsing in the Galápagos

Gillian S. Patterson, Nicole K. Murray, Ima Ikuru, Monica Pula, Aiden I.G. Schore, Jessica L. Conroy

Constraining freshwater budgets is critical in water limited areas, particularly on islands where freshwater is exclusively provided from local precipitation. Freshwater in Galápagos Islands, Ecuador, is extremely limited, as the archipelago experience typically dry conditions that are punctuated interannually by high precipitation during El Niño Southern Oscillation (ENSO) events. Here, we use a water isotope-based approach to track freshwater pulses to the coastal ocean on Santa Cruz Island. We measured $\delta 18O_{sw}$, $\delta 2H_{sw}$, and salinity in near weekly seawater samples from 2012 to 2020 to characterize the nature and frequency of freshwater pulsing. We find abrupt changes in $\delta 18O_{sw}$, $\delta 2H_{sw}$, and salinity occur throughout the dataset that are not coincident with the timing of daily precipitation, indicating these pulses are derived from groundwater. Significant, lagged correlations between $\delta 18O_{sw}$, precipitation in the Galápagos highlands, tide level, and sea level indicate that a combination of high precipitation several weeks before and low tide level contribute to coastal freshwater pulsing events. Further characterization of these events is necessary to evaluate the ecologic impact and presence of freshwater pulsing in marine carbonate records of past hydroclimate in the Galápagos Islands.

Grayson Nelson

Poster #2

LP vs HP Supercells

Grayson Nelson, Jeff Frame

The spectrum of supercell thunderstorms ranges from high-precipitation (HP) storms, with heavy precipitation falling near the updraft, sometimes obscuring storm structure, to low-precipitation (LP) storms, with little precipitation falling near the updraft and sometimes a translucent precipitation core. Classifying storms on this spectrum is qualitative and usually based on visual appearance. To construct a database of HP and LP storms, we examined a collection of personal photographs and notes, as well as social media posts with a picture, time, and location over the period 2017 to 2021. There are 48 HP supercells and 33 LP supercells in the dataset, all occurring on different dates. The type, location, and time of all storms were quality controlled based on visual appearance and archived radar data. For each storm, proximity inflow soundings from areas upstream are collected to analyze environmental characteristics. Some storms did not have a representative inflow sounding, so those cases were omitted. For each sounding, we calculated several thermodynamic, wind shear, and composite parameters to determine potential differences between environments supportive of HP and those supportive of LP supercells.

James Goodnight

Poster #13

Quantification Of Qlcs Tornadogenesis, Associated Characteristics, And Environments Across A Large Sample

James S. Goodnight, Devin A. Chehak, Robert J. Trapp

The skillful anticipation of tornadoes produced by quasi-linear convective systems (QLCSs) is a well-known operational forecasting challenge. This study was motivated by the possibility that the tornado warning potential depends on the generalized mechanism of QLCS tornadogenesis, namely, horizontal shearing instability and stretching (H&S), and tilting and stretching (T&S). Thus motivated, the manual identification of the tornadogenesis mechanism of 530 QLCS tornadoes was performed using heuristic yet process-driven criteria based on single Doppler radar (WSR-88D) data. As a function of genesis mechanism, 36% appear to have formed via H&S, and 60% appear to have formed via T&S; the mechanism of the remaining 4% could not be determined, based on our methodology.

It was found that approximately 30% of the H&S cases were operationally warned prior to tornadogenesis compared to 44% of the T&S cases. This is believed to be related to the attributes of the associated tornadic vortices: T&S produced vortices that were stronger and had a larger vertical extent than those produced through H&S. It was also found that T&S tornadoes were more common during the warm season and displayed a diurnal, midafternoon peak in frequency.

A complementary effort to explore the environmental characteristics of QLCS tornadogenesis revealed that both mechanisms were supported in similar environments. The exception was pre-tornadic frontogenesis, which was more prominent for cool-season H&S cases, and suggestive of a more significant role of the larger-scale meteorological forcing in the vertical vorticity that fosters the H&S tornadogenesis.

James Haken

Poster #32

Amur Honeysuckle Removal At Crystal Lake Park In Urbana, Illinois

James Haken

Amur honeysuckle (Lonicera maackii) is a prolific invasive species that has taken over many forests throughout the Midwestern United States. Many attempts have been made to remove and prevent the spread of this plant, each with varying success. One of these removal projects is currently taking place in Crystal Lake Park in Urbana, Illinois. This removal project, which is headed by Matthew Balk, the Natural Areas Coordinator for the Urbana Park District, is ongoing, but much progress has already been made. If it is successful, this project will be greatly beneficial to the health of Crystal Lake Park's ecosystem as it will create more space for native plants to grow, allow for more native animals to thrive there, and make it safer for visitors to the park.

Jay Pillai

Poster #23

A Numerical Model for Tropical and Subtropical Interactions

Jaydeep Pillai, Michael Needham, Mark Branson, David Randall

We have developed a highly idealized two-box model of the tropical and subtropical atmosphere, which includes a slab ocean in each domain. The tropical box includes deep cumulus convection with a single layer representing the entire troposphere. Closure is based on relationships of the column relative humidity to the lapse rate and the precipitation rate. The subtropical box includes stratocumulus convection and the free troposphere above as two separate layers. A new parameterization of cloud top entrainment is included. For both the tropics and subtropics, radiative fluxes are parameterized in terms of the total water vapor content, upper tropospheric cloud effects in the tropics, and stratocumulus cloud effects in the subtropics. The radiative effects of variable carbon dioxide are also included.

John Albright

Poster #42

Building a Better Forecast: Reformulating the Ensemble Kalman Filter for Improved Applications to Volcanology

J.A. Albright and P.M. Gregg

A long-standing goal in the field of volcanology is the ability to accurately forecast volcanic eruptions based on the limited observations available at the Earth's surface. Although great practical advances continue to be made by observing the empirical relationships between observed unrest and the eventual likelihood of eruption, in recent years there has been a growing focus on physics-based data inversion techniques that model the underlying system and direct eruption triggers. In addition to their immediate applications to hazard management, these methodologies create a more in-depth picture of the subsurface dynamics at different volcanoes and can be a potent tool for future scientific endeavors. One such technique, the Ensemble Kalman Filter (EnKF), has shown promising initial results when given ground deformation data from recent eruptions, retroactively producing eruption forecasts that closely coincide with the observed onsets. However, in this application the EnKF has had difficulty reliably distinguishing between changes in a magma reservoir's size versus its pressure. Moreover, a large number of adjustments to the EnKF have been published in the fields of atmospheric science and hydrology, few of which have been adapted and tested for volcanology. In order to develop a clear best-practice methodology for future studies, we compare how well different implementations of the EnKF can assimilate GPS and InSAR data generated from known synthetic models. For each aspect of the EnKF workflow studied (e.g., the number of ensembles, the particular update algorithm, or the parameters used to describe the model state), we assess different variations based on how well they reproduce the assimilated observations, the original synthetic parameters, and the tensile stress along the reservoir wall, a key indicator of the magma system's stability. The best implementation is then carried forward into future tests, sequentially optimizing filter performance. We find that while the EnKF can reproduce many aspects of the magmatic system, there are still persistent errors in finding the specific balance between reservoir size and pressure due to non-uniqueness in how these parameters affect the observed deformation. Future improvements will likely depend on incorporating new and more abundant data.

Kevin Boyd

Poster #24

A Genesis Potential Index for Polar Lows

Kevin Boyd, Dr. Zhuo Wang (UIUC), Dr. John Walsh (University of Alaska Fairbanks)

Polar lows (PLs) are high-latitude intense maritime mesocyclones that develop near the sea-ice margin or in proximity to snow-covered continents during marine cold air outbreak events. The impacts posed by these systems to coastal and island communities, maritime and air operations, and the broader environment demand a robust understanding of the environmental factors that promote PL formation, and in turn, skillful prediction and projection of PL activity. Numerical weather prediction models have shown substantial improvements in simulating these systems but forecasting beyond the synoptic time scale is unrealistic in the present framework for operational forecasting of PLs. Global climate models are unable to resolve the structure and dynamics of PLs, but they can skillfully predict large-scale climate conditions. We utilize this in developing a PL genesis potential index (PGI) that relates the spatial distribution of PL genesis frequency and key climate variables in a Poisson regression framework. Our model shows a good agreement with the observations. More specifically, the PGI well represents the seasonal cycle of PL genesis frequency and captures the interannual variability of PL activity skillfully. The effects of AO and ENSO on the interannual variability of PL genesis frequency are also explored.

Kevin Gray

Poster #6

Investigation of Outflow Surge Characteristics in Simulated Supercell Thunderstorms

Kevin Gray, Jeffrey Frame

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.

Kyle J. Killion

Poster #8

Environmental And Doppler Radar Analysis Of 20 June 2021 Chicagoland Ef-3 Qlcs Tornado

Kyle J. Killion, Gabrielle Christo, Zachary B. Wienhoff, Franklin T. Lombardo, and Jessica J. Choate

During the late hours of 20 June 2021, an intense line of convection produced considerable damage as it moved through the southwestern Chicago suburbs. While most of the damage was the result of straight-line winds, an embedded quasi-linear convective system (QLCS) tornado proved to be the most impactful feature of the convective line. Analysis of the synoptic and mesoscale environment, as well as radar observations from the Romeoville WSR-88D Doppler radar (KLOT) of the QLCS tornado, were examined to investigate the catalysts for the tornado and its true intensity. Archived synoptic and mesoscale data depict a well forecast yet non-traditional tornado setup. Approximately 30 minutes of KLOT Doppler radar data from 0400-0430 UTC 21 June 2021 were used to analyze the embedded tornado and parent convective line as the two translated eastward in tandem toward Chicago. Calculations of Delta-V, defined as the absolute value of the maximum outbound wind speed minus the maximum inbound wind speed within the tornado velocity couplet, indicated the tornado intensified, reached its peak intensity, and dissipated during this 30-minute period. Using Solo3 software, dual-polarization Doppler radar analysis illustrated a classic tornado velocity signature (TVS), tornado debris signature (TDS), and debris ejection during the tornado's life cycle as it impacted many structures.

Owing to the damage sustained by one residential home, the tornado was ultimately rated EF-3 intensity with maximum estimated wind speeds of 140 mph. However, Doppler radar data analysis and the lack of EF-3 level damage to multiple structures raises questions about the tornado's true intensity. It is hypothesized that the tornado may not have been of EF-3 intensity and some deficiency in the outlier EF-3-rated structure may have yielded an overestimate of the tornado's true intensity. The legitimacy of the tornado's EF-3 rating will be investigated by comparing the maximum damage surveyed at the surface to KLOT radar estimated wind speeds and the evolution of the tornado velocity signature (TVS) and tornado debris signature (TDS) relative to the location of maximum damage. With the expectation that Doppler radar data will be implemented into an updated Enhanced Fujita (EF) scale in the near future, this exercise will provide further insight into the utility of Doppler radar data in the assessment of tornado intensity.

Lauren Todorov

Poster #47

Impact of Extracorporeal Shock Wave Lithotripsy (ESWL) on Human Kidney Stone Fragmentation and Growth Recurrence

Lauren G. Todorov, Mayandi Sivaguru, Amy E. Krambeck, Matthew S. Lee, and Bruce W. Fouke

Background: Extracorporeal Shock Wave Lithotripsy (ESWL) remains one of the most common forms of clinical treatment for chronic cases of human kidney stones around the world. Yet the 60% success rate of ESWL is more than offset by the nearly 75% stone recurrence rate in the same patients. This study was undertaken to quantify the size distribution and fracture patterns of calcium oxalate (CaOx) stone fragments to better understand and predict stone growth recurrence following ESWL treatment.

Methods: Six 1-5 mm-diameter stone fragments were collected using shock pulse lithotripsy (SPL) during percutaneous nephrolithotomy (PCNL). Fourier transform infrared (FTIR) spectroscopy on the bulk fragments indicated that they were primarily composed of calcium oxalate (CaOx). Two of the original stone fragments were exposed to ESWL (shock rate of 90 shocks/min, coupling pressure of 4, power level of 3, with increments of 100 shocks per treatment), which produced 100s of smaller broken fragment shards that were collected, quantified, and characterized according to their size and fracture patterns with respect to crystal growth faces. Stone fragments produced by ESWL were thin sectioned (25m-thick, doubly polished, and uncovered) and analyzed with a combination of optical techniques that include brightfield, polarization, polarization phase contrast, ring aperture contrast and super-resolution auto-fluorescence microscopy (140nm-resolution). In addition, Wentworth grain size distribution analyses of the ESWL-generated stone fragments were determined to constrain surface area/volume estimates and ensuing water-rock-microbe interaction modeling of diagenetic phase transitions and recrystallization.

Results: The results of this study revealed grain sizes spanning very fine silt (4.998m) to very fine pebbles (2.926mm), with most fragments characterized as sands (62m-2mm) displaying a right-skewed normal curve distribution. Additionally, the COM stones produced fractures along sector zones and around radiating crystal bundles, laths, mimetically replaced COM (COMM), and entombed free-floating COM (COMFF) clusters. Conchoidal fractures were also observed through and along the high-frequency, nano-layered COM cortex (COMC) producing clean, serrated, or 100 Hertzian cone breakages.

Conclusions: The goal of this study is to identify therapeutic approaches that will dramatically reduce these extremely high recurrence rates of urolithiasis. We hypothesize that ESWL stone fragments remaining in the kidney act as thermodynamic and kinetic seed points for the rapid recrystallization of multiple new stones that create even more serious ensuing medical problems. This hypothesis is based on our understanding of crystallization in natural settings, such as hot springs and coral reefs, where the surface area and shape of similar crystalline fragments to those produced by ESWL serve as potent seeds for further growth.

Lihang Peng

Poster #48

Lithosphere Delamination And "Relamination" Reconcile Craton Longevity And Temporal Variations

Lihang Peng, Liang Liu, Yaoyi Wang, Zebin Cao, Lijun Liu

The classic isopycnicity model helps to explain the stability and longevity of cratons. However, this model cannot readily explain some important features of cratonic lithosphere, such as its internal layering and topographic changes. Here, we show that cratonic mantle lithosphere with net negative buoyancy close to that of a pure-thermal boundary layer (McKenzie et al., 2005) could resolve these problems. In this model, we assume that the lower cratonic lithosphere hosts most of the high-density materials (e.g., iron-enriched composition) (O'Reilly and Griffin, 2013). Under enough tectonic perturbations, this dense lower lithosphere could delaminate, causing prominent surface uplift and erosion. This scenario is consistent with the widespread upper-mantle fast seismic anomalies below South Atlantic, proposed to represent delaminated continental lithosphere during the Cretaceous (Hu et al., 2018). Our simulation reveals that after these delaminated lithosphere segments sink into the hot mantle, the increasing thermal buoyancy and/or removal of the dense components may reverse their trajectory and most of the foundered fragments can relaminate to the base of the above lithosphere. This relamination process causes another rapid episode of surface uplift, followed by gradual subsidence as the relaminated materials cool and consolidate. The lithosphere that experiences initial delamination and subsequent relamination has an eventual thickness of ~200 km, typical for cratonic keels, implying long-term mass conservation of cratonic lithosphere. Since these processes are all sub-solidus, the ancient igneous ages of these recycling lithosphere portions remain unchanged. Therefore, our model can reconcile the apparent longevity and temporal variations of cratons.

Lilian Lucas

Poster #49

The Impact Of Ice Caps On The Stability Of Magma Systems

Lilian Lucas, John A. Albright, Patricia M. Gregg, Yan Zhan

Monitoring the activity of subglacial volcanoes along the Aleutian Arc in Alaska is important to the safety of local populations, as well as air traffic flying through the region. However, observations of volcanic unrest are limited by accessibility and resources, particularly at glacier-covered systems making investigations of their stability challenging. Westdahl Peak, a subglacial volcano on Unimak Island in the Aleutian Arc has experienced significant unrest and uplift since its most recent VEI 3 eruption in 1991-1992. Given the magnitude of observed uplift, previous investigations suggested the potential for eruption by 2010, but no such event has occurred. In this study, thermomechanical finite element models are used to evaluate how the stability of a glaciated volcano is impacted by variations in ice cap thickness, magma chamber depth, geometry, magma flux rate, and seasonal changes in ice cover thickness. We calculate the stress field along the magma reservoir boundary and define a repose interval as the time it takes to reach the tensile failure criterion. The generic ice cap model is then applied to investigate the current unrest and stability of the Westdahl system. Our numerical experiments indicate that presence of an ice cap increases the average repose interval for a magma system. Among models with different magma chamber geometries, depths and flux rates, the greatest increases in repose interval are observed in prolate systems where the increase is up to 57% for a chamber located at 5km-depth. However, for spherical magma chambers, ice cap thicknesses of 1 km, 2km, or 3km increase repose intervals about 8%, 16%, and 25% respectively, and the effect of loading is further diminished for deeper reservoirs (> 5 km). Additionally, the percentage increase in repose interval is not impacted by variations in magma flux rate for a given ice cap thickness and magma chamber geometry. However, flux rates do influence the timing of eruptions when the system is experiencing seasonal variations in ice thickness. Our results show that systems with low flux rates are more likely to fail when the ice thickness is at its lowest. The numerical estimates further suggest that the ice cap on Westdahl Peak, which is ~ 1km, may slightly increase the stability of the magma system. In general, given flux rates and magma chamber geometries estimated for the Westdahl system, the repose interval can increase by ~0.3 years due to the Westdahl glacier. This increase is small on a geologic scale but is significant on human time scales and the impact of glaciers must be considered in future forecasting efforts.

Michael Ragauskis

Poster #25

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

Michael Ragauskis, Dr. Francina Dominguez, Dr. Brian Jewett

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 by ATMS and urban hydrologic/hydraulic modeling by CEE. 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.

Michael Sessa

Poster #10

The Prediction of Potential Tornado Intensity Using Machine Learning

Michael Sessa; Jeff Trapp

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 (R^2) value of 0.75. This linear relationship is the higher for discrete (supercell) cases ($R^2=0.82$), and lower for QLCS cases ($R^2=0.37$). 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. Results show a skilled binary prediction of tornado intensity and the potential for these machine learning applications to become a helpful resource in an operational setting.

Mingfei Chen

Poster #46

Lacustrine sediment microbial community response to an extreme El Niño event

Mingfei Chen, Jessica L. Conroy, Robert A. Sanford, D. Allie Wyman, Joanne C. Chee-Sanford, Lynn M. Connor

Salinity can shape microbial community composition (MCC) and related functional groups in the lacustrine sediments, but few studies have examined the temporal responses of sedimentary microbial communities to abrupt salinity changes. On the island of Kiritimati, Republic of Kiribati (2°N, 157°W), several hundreds of lakes with various salinities ranging from brackish to hypersaline expand and freshen during El Niño events due to increased precipitation, providing an excellent site to study the temporal responses of MCC and functional groups to salinity changes in lacustrine sediments. This study aims to assess the temporal changes of MCC and functional groups for the same lakes before and after an extreme El Niño event (2015-2016) and discuss the role of rapid salinity changes in shaping the microbial communities. Lake surface sediments (0-5 cm) were collected from 13 lakes of varying salinities in 2014 and 2019 field trips and DNA was extracted. Median salinity significant dropped from 2014 (137.4 ppt) to 2019 (72 ppt), due to high anomalous precipitation during the 2015-2016 El Niño event. Alpha and beta diversity metrics suggest that MCC shifted substantially from 2014 to 2019, with these changes significantly correlated with the salinity ($r2 = 0.45$, $p = 0.002$). Phyla inhibited by high salinity, such as Cyanobacteria and Desulfobacterota, are more abundant in 2019 lakes. In addition, family-level results indicate that several halophilic families (Halomonadaceae, Alteromonadaceae, and Bacillaceae) belonging to Gammaproteobacteria and Firmicutes are more abundant in 2014 lakes, while families that are commonly seen in mesohaline or marine environments such as Chromatiaceae and Hyphomonadaceae are more abundant in 2019 lakes. Functional Annotation of Prokaryotic Taxa (FAPROTAX) and functional gene amplicon sequencing results suggest that salinity can change the relative abundance of the functional groups (chemoheterotrophs, phototrophs, nitrogen fixation, denitrification, sulfate reduction) as well as the microbial diversity within the functional groups. We conclude that the large decrease in salinity due to high precipitation rates associated with an extreme El Niño event substantially altered MCC and functional groups in the lacustrine sediments of Kiritimati.

Mingshi Yang

Poster #15

Analysis of Arctic Cyclones in the Cyclone Phase Space

Zhuo Wang, Mingshi Yang, Chuan-Chieh Chang

Arctic cyclones play an important role in the changing Arctic climate. They transport heat and moisture poleward, and can break up and move sea ice, which causes further warming of the region through climate feedback processes. A better understanding of Arctic cyclones can improve synoptic-scale cyclone predictions and future climate projections. This study tries to explore the structure of Arctic cyclones and mechanisms of their evolution, especially intensification. Phase space analysis is used to investigate the link between cyclone structure and intensity change. The structure of Arctic cyclones is also compared with the structure of midlatitude cyclones. Comparing to the midlatitude cyclones, Arctic cyclones are more symmetric, have a weaker cold core structure in both upper and lower troposphere, and have weaker intensity and intensification rates. During the fastest intensification stage, both types of cyclones are likely to exhibit cold cores in the lower troposphere. However, the intensifying arctic cyclones are less likely to show strongly asymmetric thermal structure, indicating that the role of baroclinicity is not as significant as it is in the midlatitude cyclone development.

Poushalee Banerjee

Poster #36

Reconstructing the dynamics of a meandering river in an intensively managed landscape through analysis of floodplain deposits

Poushalee Banerjee, L Rhoads, Alison Anders, Andrew J. Stumpf

Human activities influence river dynamics by disturbing natural rates of fluvial processes. Throughout the Central Lowlands of the Midwest, increases in rates of overbank deposition associated with agricultural development have been well-documented, but the influence of agricultural transformation of landscapes on rates of lateral migration is poorly understood. The purpose of this research is to investigate lateral movement of a meandering river over long timescales by identifying lateral-accretion deposits in cores obtained from floodplain scrolls and by dating these deposits to determine the rate at which the river moved laterally from scroll to scroll. The study site is the floodplain of the Sangamon River within Allerton Park in east-central Illinois. Historical aerial photography shows that rates of lateral migration of this river over the past 80 to 90 years are nearly zero. Despite these low rates, prominent scroll bars on the floodplain suggest that lateral migration has been substantial in the past. Eleven cores have been obtained across the valley bottom at a bend in the river, including several cores located on scrolls. Descriptions of the cores reveal that sandy lateral accretion deposits underlie fine-grained overbank deposits, including post-settlement alluvium. Particle-size analysis of the lateral-accretion deposits indicates that texturally these deposits are similar to contemporary lateral accretion deposits on active point bars. Dating of wood samples (radiocarbon dating) and of sands (OSL dating) will provide the basis for comparing contemporary rates of migration under intensive agricultural management to long-term rates prior to agricultural development.

Rebekka Delaney

Poster #28

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

Rebekka A. Delaney, Alicia Klees

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 warning 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.

Scott James

Poster #19

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

Scott James, Deanna Hence

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 high-resolution 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. Observed coastal sounding profiles from OLYMPEX 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. Initial findings from sounding-derived vertical stability parameters show low-level stability and significant vertical wind shear. 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. Further analysis of the thermodynamic environment and stability parameters will assist with determining if blocking had a role in potential upstream shift in accumulations.

Seung Uk Kim

Poster #26

Moisture Sources of the Midwest During Hydrological Extremes

Seung Uk Kim, Francina Dominguez

Drought and flood are two extreme hydrological events that severely impact the Central United States (US). They are especially critical to the US Midwest, due to the region's intense agricultural production. Anomalous moisture transport from oceanic and terrestrial sources is known to be responsible for the development of hydrological extreme events. In this study, we use two-layer dynamic recycling model (2L-DRM), a simple analytical model that tracks moisture, with 41-year ECMWF Reanalysis v5 (ERA5) data to identify the moisture sources of the Midwestern United States. We find a very different contribution of terrestrial and oceanic sources by season. Terrestrial sources are mainly contributing during the warm season (April – September) while oceanic and lake sources contribute during the cold season (October – March). With the exception of the Pacific source, other subregions' average daily moisture contribution and their variability increases in the warm season. We selected pentads of extreme hydrological events during the warm season. We define drought as prolonged soil moisture deficit and flood as high precipitation accompanied by excessive soil moisture. The increase in the oceanic sources due to anomalous flow formed by a strong trough covering the continent was observed during two flood cases in 1986 and 1993. Not only oceans, but the land surface along the flow also provided additional moisture. On the other hand, two drought cases in 1988 and 2012 showed a large decrease in terrestrial sources. A large ridge was responsible for reducing moisture import from climatological sources. Interestingly, sources from the Great Lakes showed an increase during drying periods of the two drought cases, and provided significant moisture to help recover from severe dryness in 2012.

Sophie Orendorf

Poster #18

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

Sophie A. Orendorf, Sonia Lasher-Trapp, Robert J. Trapp

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. It is not currently known how the mechanisms producing convective windstorms might differ in a warmer climate. 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.

Spencer Guerrero

Poster #16

The impact of climate change on hurricane landfall and tracks

Spencer Guerrero, Ryan Sriver

How trustworthy is historical data in training seasonal forecast models—especially in the context of global warming? Should climate model output be used to supplement historical observations? Some initial research towards these questions is presented. Studies have shown that many seasonal models perform well at predicting the number of tropical cyclones in the Atlantic basin. However, these same models show much a smaller skill at predicting seasonal landfall counts. To explore this, the accuracy of an interannual landfall count model is reviewed: Truchelut's Landfall Diagnostic Index (LDI). Lastly, the relationship between duration and peak intensity is shown for a few 4xCO2 CESM runs. In terms of simulating tropical cyclones, this relationship seems to be a useful metric for evaluating climate model performance.

Tanya Shukla

Poster #37

Prevalence and morphological characteristics of anabranching reaches juxtaposed with lowland meandering rivers in the Midwestern US

Tanya Shukla, Bruce Rhoads

Channel planform is the result of present and past hydrologic, sedimentary, and geologic conditions, and represents an adjustment of the river to these conditions. Rivers with varying planform generally have different boundary conditions, evolution trajectories, and underlying processes. Geomorphic heterogeneity is a primary characteristic of real rivers. An important, yet overlooked aspect of geomorphic heterogeneity of rivers in intensively managed agricultural landscapes of the midwestern United States is spatial variability in channel planform. In particular, these otherwise meandering rivers often contain anabranching reaches characterized by multiple channels separated by stable, vegetated islands. Morphologically, these anabranching reaches appear to differ from anabranching forms previously reported in literature in terms of island shape and bifurcation angle. This research quantitatively characterizes the morphological characteristics of anabranching reaches within meandering river systems based on number of channels, island shape and size, bifurcation angles, and cross sectional geometry across the channel belt. The study is a first attempt at characterizing juxtaposed anabranching-meandering systems and provides the basis for further process oriented field work exploring the role of natural versus human induced processes on formation and evolution of mixed planform river characteristics in intensively managed agricultural landscapes.

Tobias Ross

Poster #3

Investigating the Effects of CCN on the Timing of Convective Cold Pool Initiation During CACTI

Tobias Ross, Sonia Lasher-Trapp

Convectively-generated cold pools exert controlling influences on the deep convective lifecycle. Accurate representation of these influences in larger-scale models requiring convective parameterizations is challenged by poor consensus as to their most important physical drivers. Despite originating from latent cooling within convective downdrafts, considerably less attention has been paid to the microphysical influences on cold pool characteristics. This study exploits data collected during the Cloud, Aerosols, and Complex Terrain Interactions (CACTI) field campaign to investigate the hypothesis that convective cold pools are generated sooner in the lifecycle of their parent convection in environments characterized by a faster warm rain process that expedites convective rainfall. CCN concentrations, measured just beneath developing cumulus, are compared with in-cloud measurements of hydrometeor size distributions made during eight CACTI research flights. Cloud fields ingesting fewer CCN consistently feature drizzle concentrations approaching an order of magnitude greater at the same altitudes above cloud base than for cloud fields ingesting more CCN, justifying the use of CCN concentrations as a robust predictor for the speed of the warm rain process in subsequent deeper convection. The initiation and evolution of three cold pools, observed on three of these days, is documented using the CACTI / RELAMPAGO radar and surface observation network. Cold pool onset, here defined as the time elapsed between the first 30-dBZ echo and the appearance of the first significant deviation in near-surface radar radial velocity at the base of the precipitating cloud, is quantified using RHI scans. A positive correlation emerges between ambient CCN concentrations and cold pool onset time, supporting the study hypothesis. Idealized high-resolution simulations of two events test the sensitivity of cold pool onset to initial CCN concentrations within different convective environments. The first event was characterized by a significantly colder (~ -1 °C) cloud base and the second event featured comparatively higher bulk environmental vertical wind shear. The hypothesized positive correlation between CCN concentrations and cold pool onset is realized for both environments, but preliminary results show that the warm rain may not be as important as hypothesized. Ongoing work involves the analysis of time-integrated latent cooling budgets for each hydrometeor class to quantify the importance of each hydrometeor type to cold pool initiation in each simulation.

Troy Zaremba

Poster #21

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

Megan M. Varcie, Troy J. Zaremba Robert M. Rauber, Greg M. McFarquhar, Joseph A. Finlon, Lynn A. McMurdie, Andrew Janiszeski, and Alexander V. Ryzhkov

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.

Tzu-Shun Lin

Poster #29

Influence of interactive effects of climate extremes and changing technology and management on crop productivity in the CONUS

Tzu-Shun Lin and Atul K. Jain

Climate extremes, such as heat waves, floods, or droughts, cause crop yield loss and threaten the global food-energy-water system. Rising temperature also increases atmospheric water demand, causing compound effects of heat stress and water scarcity on crop development and yield. While global and regional effects of extreme climate events on crop yield have been investigated using the models, the interactive effects of climate extreme with technology , such as higher planting density, and longer growing season cultivars, and management factors, such as intensified application of N fertilizer and irrigation, on crop yields have less been explored. In recent decades, applications of these factors have enhanced crop productivity worldwide.

This study aims at simulating crop yield response to past climate extreme events and their interactions with management and technology factors in the CONUS using a land surface model, Integrated Science Assessment Model (ISAM). ISAM explicitly simulates leaf and canopy temperature by coupling crop energy, carbon, and water balances at 0.1 degree spatial and hourly scale temporal resolutions that characterizes the effects of temperature and water stress on crop growth and productivity. First, we investigate the extent to which climate extremes affects crop yields. Then we study how much of the adverse climate extremes effects is dampened due to management and technology factors (e.g., irrigation, N fertilization, sowing date, planting density, and length of the growing period). Results show that irrigation not only reduces water stress but also cools daytime canopy temperature that alleviates the negative impacts of heatwaves and droughts on crop productivity. However, overall agricultural technology and management changes cannot completely offset the adverse effects of climate extremes on crop yields.

Wataru Morioka

Poster #38

Exploring Local Histories by Creating Web Maps with Uni High Students

Wataru Morioka

To explore local history and genealogy, Digital Collections offered by public sectors such as libraries are useful. Especially during this COVID-19 pandemic, the archived historical contents such as photos and documents are served as an important source of learning for many people e.g., researchers working remotely and homeschooling students. In Champaign-Urbana, the Champaign County Historical Archives provides various useful historical photographs via Flickr. It is expected to effectively use these resources for education and research. As a way of further utilizing these resources from the perspective of GIScience, we made web maps describing brief histories of twin cities with Uni High students. A lot of valuable pictures located on the map show you how the Champaign-Urbana has been grown into a charming twin city. As a tool for making the web maps, we used Re: Earth, which has been recently developed as Open Source Software for geovisualization. This activity was held as a part of the Agora Days program, which is a four-day period activity outside their curriculum.

Yanchong Li

Poster #50

Continental-scale converging mantle flow beneath Eurasia and America, from model to observation

Yanchong Li, Diandian Peng, Zebin Cao, Lijun Liu

Mantle convection controls the long-term evolution of Earth, from surface tectonics to deep mantle structures. However, the pattern of mantle convection and its driving force remain elusive. We address this problem with global scale data-assimilation models that reproduce subduction since 200 Ma. The models incorporate plate motion, seafloor age, and evolving plate boundaries to guide the evolution of sinking slabs and the ambient mantle. Our preferred model successfully 1) reproduces the two major Late-Cretaceous flat slabs in North America and East Asia, consistent with geology (Liu et al., 2021; Peng et al., 2021), 2) well matches the position and geometry of present-day slabs in seismic tomography (Hu et al., 2018), and 3) predicts similar present-day plate motions to those observed (this study).

Based on this model, we find that the upper mantle convection is dominated by two continental-scale converging flow cells beneath Eurasia and America. This flow pattern in Eurasia is consistent with the overall converging plate motions from surrounding regions, the ongoing orogeny along the entire Tethyan margin, and the observed seismic anisotropy at depth. The American superconvergence cell can explain the westward drifting American plates, the sustaining intraplate orogenies like the Rockies and the Andes, as well as mantle anisotropy. We find that these converging flows are generated by the previously subducted slabs beneath Eurasia and America whose sinking in the lower mantle generates broad low-pressure centers at upper mantle depths. We suggest that these converging flows are dynamically modulating the supercontinent cycle, the global distribution of orogenies and back-arc basins, as well as the so-called "tectonic mainstream" of the planet.

Yaoyi Wang

Poster #51

Dense Cratonic Mantle Lithosphere and its Temporal Evolution Revealed by Geological and Geophysical Observations

Yaoyi Wang, Lijun Liu, Ling Chen, Craig Lundstrom

Cratons are the most stable and long-lived parts of the Earth's lithosphere. Although cratonic crust has been exempt from structural deformation over billions of years, their mantle lithosphere seems to have evolved over time, indicated by its present-day layered structure and dramatic topographic variations in the past. In order to understand this paradox, we reassess the depth-dependent density structure of cratonic mantle lithosphere by analyzing the topography and lithospheric structure of cratons. The strong dependence of craton topography on the lithospheric thickness reveals a two-layer density profile of cratonic mantle lithosphere, with the lower layer (>150 km depth) being significantly denser than the upper layer. This density configuration suggests a conditional stability of the dense cratonic roots. By further comparing the observed crustal thicknesses of cratons, their evolving topography, and lateral positions relative to hotspots and LLSVPs (large low shear velocity provinces) since 200 Ma, we show that surface uplifts occurred mostly as cratons overrode plumes coming off the LLSVPs. The long-term (>50 Myr) craton exhumation and nearby sedimentation favor the mechanism of isostatic uplift due to lithospheric delamination triggered by tectonic perturbations such as from hot plumes underplating rifting continents. The elevated surface of these cratons was slowly eroded over time, leading to their thinned crust and reduced LAB (lithosphere-asthenosphere boundary) depths toward the present.

Yicen Liu

Poster #30

The Impacts of Aerosol Mixing State on N2O5 Uptake Coefficient

Yicen Liu, Yu Yao, Jeffrey H. Curtis, Matthew West, Nicole Riemer

Dinitrogen pentoxide (N2O5) is an important nighttime reservoir for NOx. The heterogeneous hydrolysis on aerosol particles is considered as the main loss pathway for N2O5, removing NOx from the atmosphere. Current models use the bulk composition of the particle population to calculate the N2O5 uptake coefficient (γ). While this is appropriate when the aerosol is internally mixed, it remains an open question how large the error is when the aerosol has a more complex mixing state, which is common in the real atmosphere. To better understand the role of mixing state in calculating γ, the stochastic particle-resolved model PartMC-MOSAIC was used to generate 100 scenarios with different input parameters, including primary gas and aerosol emissions, as well as meteorological parameters. Each scenario was stimulated for 24 hours with hourly output, yielding a total of 2,500 populations with different aerosol compositions and mixing states. For each population, the uptake coefficient γ_ref was first calculated using the particle-resolved composition data and the parameterization of N2O5 hydrolysis from Riemer et al (2008), which is a function of the per-particle sulfate and nitrate content and the organic coating thickness. We then calculated the composition-averaged uptake coefficient γ_comp, which is obtained by assuming that the population was internally mixed. We compared γ_comp to γ_ref for all populations and found that for 25% of the populations the error in the uptake coefficient was larger than +/- 20%. We present detailed process analysis that explain the reasons for this over or underestimation and show the impacts on the predictions of ozone and nitrogen containing species concentrations.

Yuyu Li

Poster #52

Investigating magma system evolution before and during the 2018 eruption of Veniaminof Volcano, Alaska

Yuyu Li; Patricia M. Gregg; Craig C. Lundstrom

An overarching goal in volcanology is understanding the precursory signals that indicate an eruption is imminent. In particular, pre-eruption observations of seismicity and ground deformation and the analysis of the petrology and geochemistry of erupted products may provide clues about the evolution of a magma system and the processes that trigger volcanic eruption. Information about eruption catalysts is particularly critical in regions where precursory signals are ambiguous or absent. Mt. Veniaminof is a stratovolcano and one of the most active volcanoes of the Aleutian arc with recent eruptions in 2018 and 2021. Although Veniaminof experiences frequent eruptions and currently has eight permanent seismic stations, only 2 of the past 13 eruptions have had precursory phases that prompted a pre-eruption warning from the Alaska Volcano Observatory (AVO) (Cameron et al., 2018). In this investigation, we analyze geophysical (seismicity and ground deformation) and geochemical observations from Veniaminof Volcano to better understand the evolution of the magma system leading up to and during the 2018 eruption.

Zachary Chalmers

Poster #27

Creating a Waterspout Index for Eastern North Carolina

Zachary Chalmers, Ryan Ellis, and Shane Kearns

Waterspouts are dangerous weather phenomena that provide a unique challenge for National Weather Service (NWS) forecasters as they have the ability to sink boats and damage marinas over water and then continue onshore as weak tornadoes. These types of waterspouts, commonly known as 'fair weather waterspouts', are often undetectable from the vantage point of Doppler radar (WSR-88D) and typically occur in the summer months on mostly benign weather days, originating out of weak showers or thunderstorms. Forecasting techniques for fair weather waterspouts (Devanas and Stefanova, 2018; Szilagyi, 2009; Ivušić et al., 2017) have been verified in temperate climates (Great Lakes and Adriatic Sea) and in tropical climates (Florida Keys). To this point, these techniques have not been verified for the subtropical climate of eastern North Carolina. In this work, the effectiveness of existing waterspout forecast indices is tested using 98 waterspout Local Storm Reports issued by the NWS office in Newport/Morehead City, NC, from 2005 to 2020. Although these indices are skillful for the climatic regions where they were originally developed, they do not prove as effective in eastern NC. As a result, environmental conditions favorable for fair weather waterspouts across eastern NC are evaluated and identified. A new index is created based on thirty sounding-derived parameters that proved effective in quantifying the risk of waterspouts in eastern NC. Sounding data is obtained and edited through third party software before being imported into a spreadsheet where a score is calculated using a point-based system. A risk category is then assigned based on the index score. Modifications to the risk can then be made by updating the value of any parameter to its forecasted value. Additional parameters are analyzed using the Storm Prediction Center (SPC) Mesoscale Analysis page to supplement the index, and conditions are monitored via satellite and radar. Hindcasts based on the Local Storm Reports are developed using this method and will be shown to demonstrate index quality.

Zebin Cao

Poster #53

Western U.S. Crustal Stress and Relative Motion Controlled by Lithosphere-Asthenosphere Interaction

Zebin Cao, Lijun Liu

Crustal deformation within the tectonically active western U.S. (WUS) has a complex spatial pattern. The Basin and Range has been extending in the northwest-southeast orientation, while the Great Valley and Colorado Plateau remain relatively undeformed. Geodetic studies reveal a clear clockwise rotation of surface velocity in the northwestern U.S. relative to the stable central and eastern U.S. However, the driving force for this pattern is still debated. In addition, the origin of clustered seismicity within an 'intermountain' belt along the eastern boundary of Basin and Range also remains controversial. Previously proposed mechanisms for this spatially complex crustal deformation pattern include lateral gradients of gravitational potential energy and dynamic topography due to mantle convection, but a model that could simultaneously explain the stress state inferred from earthquakes and surface velocity field as observed by GPS measurements is still lacking.

Here, we utilize a newly constructed geodynamic modeling approach to investigate the WUS crustal deformation. In this model, the buoyancy structure of the convecting mantle is based on a hybrid data-assimilation approach that satisfies multiple geophysical and geological observations in the region. We then combine this mantle structure with the seismically inferred crust and mantle lithosphere to simultaneously reproduce the observed crustal stress state and surface velocity field. Our preliminary model predicts the observed WUS horizontal compression directions remarkably well. The pattern of crustal strain rate also closely matches the clustering of seismicity in this region. Meanwhile, the resulting surface velocity field shows a similar circular pattern as observed by GPS. A systematic analysis shows that the complex crustal deformation pattern in the WUS mainly reflects the dynamic interaction between the complex mantle flow and the spatially variable lithosphere-asthenosphere boundary.