Online Proceedings

Session 1M

Environmental Monitoring and Modeling: Atmosphere, Mountains, and Ocean

Session Moderator: Andrea Ogston, Oceanography
MGH 287
12:30 PM to 2:15 PM
* Note: Titles in order of presentation.

The Normalization of Anomalous Southern Ocean Sea Surface Temperatures for Analysis of Severe Storm Systems

Thomas S. Lamb, Junior, Atmospheric Sciences: Meteorology
Jonathan Chriest, Sophomore, Atmospheric Sciences: Climate, Atmospheric Sciences: Meteorology
Kallista Angeloff, Fifth Year, Atmospheric Sciences: Climate
Mentor: Dargan Frierson, Atmospheric Sciences

Strong storms originating over the Southern Ocean just North of Antarctica have impacted the lives of many people in the coastal regions of Africa, South America, and Australia. These storms have been studied and observed since at least the end of the 17th century, most notably by Edmond Halley on a voyage to the South Atlantic; however, the causes of these storms are still not fully understood. The lack of land friction in this region plays a large part, but does not explain why these winds have increased in recent years. This recent wind phenomena, along with Halley's observations and coastal impacts for humans, led us to develop our research question: How do cold sea surface temperatures (SSTs) impact storm systems and winds originating from the Southern Ocean region? We posit that the extreme coldness of this region relative to the rest of the planet is a significant contributory factor to the strength of winds and storms in the Southern Ocean. To explore this hypothesis, we ran the Atmospheric Model 2 (created by the Geophysical Fluid Dynamics Laboratory at the National Oceanic and Atmospheric Administration) with SSTs symmetrized by zonal means to reduce the steep temperature gradient between the Southern Ocean and its bordering regions. This normalized the oceanic region, and made Southern Hemisphere SSTs more similar to SSTs in the Northern Hemisphere. We will present analysis of the changes in surface winds, kinetic energy, and precipitation in these simulations, and compare with theoretical predictions based on baroclinic instability theory.

Session 1P

Astronomy and Atmospheric Sciences

Session Moderator: Suzanne Hawley, Astronomy
JHN 022
12:30 PM to 2:15 PM
* Note: Titles in order of presentation.

Improving Regional Climate Prediction

Jacob Hendrickson, Junior, Atmospheric Sciences: Meteorology, Atmospheric Sciences: Climate
Daniel Arens, Junior, Atmospheric Sciences: Meteorology
Mentor: Cliff Mass, Atmospheric Sciences
Mentor: Richard Steed

Our research seeks to more accurately define how the Pacific Northwest regional climate will look in fifty to one hundred years. Our results help quantify the uncertainty in our climate predictions, a major shortcoming in climate research. Our research is interesting because it utilizes a high resolution numerical weather prediction model to examine regional climate change here in the Pacific Northwest. We are creating a large set (an ensemble) of predictions of climate change in the Pacific Northwest. The tool used in our research is the Weather Research and Forecast (WRF) model. WRF requires General Circulation Model (GCM, also known as Global Climate Model) data to feed it information on the larger-scale climate. A big part of our project is collecting GCM data from a variety of research centers worldwide, and preparing it to be used as input data for WRF. We expect to complete our model simulations by the end of Spring Quarter 2018. These results could be of direct use to a number of local agencies and policy makers so that they can shape their decisions around the future changes that our local climate may experience. We also expect our data to be of great use for further research in quantifying climate prediction uncertainty.

Session 1P

Astronomy and Atmospheric Sciences

Session Moderator: Suzanne Hawley, Astronomy
JHN 022
12:30 PM to 2:15 PM
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Southern African Topography Impacts on Low Clouds and the Atlantic ITCZ in a Coupled Model
Eliza Dawson, Senior, Atmospheric Sciences: Climate
Mentor: Dargan Frierson, Atmospheric Sciences

We examine the influence of the Southern African mountain ranges on the Namibian stratocumulus deck, the South Atlantic ocean-to-atmosphere energy transport, and the Intertropical Convergence Zone (ITCZ), using an atmosphere-only model and a coupled atmosphere-ocean model. For both models, a control simulation with realistic topography is compared to a simulation where the mountains in Southern Africa are removed. As in previous studies, the removal of topography results in thinning of the Namibian stratocumulus deck. In the coupled model, the increased sea surface temperature in the southern Atlantic due to the reduction of low clouds forces the Atlantic ITCZ to shift southward towards the warmer hemisphere. However, changes in the ocean circulation cool the South Atlantic atmosphere, lessening the ITCZ shift and changing the structure of precipitation. These results show the importance of topography on shaping Atlantic rainfall, and highlight the role of dynamical ocean processes in atmospheric dynamics.

Poster Session 2

Commons West, Easel 14
1:00 PM to 2:30 PM

The Cause of Western Europe's Mild Climate
David (Dave) Bonan, Sophomore, Atmospheric Sciences: Climate
UW Honors Program
Mentor: Dargan Frierson, Atmospheric Sciences

The cause of Western Europe's mild climate has been under discussion for many years. Among the general public, heat transport by warm ocean currents is often given as an explanation. A prominent scientific study, Seager et al 2002, instead claimed that roughly fifty percent of the wintertime temperature difference across the North Atlantic is caused by the eastward atmospheric transport of heat released by the ocean that was absorbed and stored in the summer; another roughly fifty percent is caused by the stationary waves of the atmospheric flow; and that ocean heat transport only contributes a small magnitude of warming across the basin. Seager states that, "the next step of inclusion of a fully interactive mixed layer is unlikely to change the main results presented here". We test whether the transport of heat northward by the Atlantic Meridional Overturning Circulation (AMOC) and its ensuing release into the mid-latitude westerlies is indeed a small contributor to Western Europe's mild climate using simulations with two different fully coupled climate models. A model simulation where the Rocky Mountains were eliminated is used to test the effect of stationary waves on heat transport. Another simulation where the ocean heat flux of the Northern Hemisphere and the Southern Hemisphere is eliminated through symmetrization is used to test the effect of heat transport northward by the AMOC. In this simulation, land topography—such as the Rocky Mountains—was kept intact. In these simulations we examine temperature variations over Western Europe and the reasons for the changes using energy budget decompositions. An understanding of these climate system controls allows for an understanding of what controls future changes in climate.

Poster Session 2

Commons West, Easel 13
1:00 PM to 2:30 PM

Life of Pika: A Science-Based Environmental Video Game
Kurt Blancaflor, Senior, Human Centered Design & Engineering, Computer Engineering
Amara Lynn (Amara) Kitnikone, Sophomore, Interdisciplinary Visual Arts
Benjamin Daniel (Ben) Celsi, Sophomore, Pre-Sciences
Sally Siyuan (Sally) Wei, Junior, Computer Science
Mentor: Dargan Frierson, Atmospheric Sciences

Video games are seldom used for environmental science education, despite the variety of compelling lessons that they could be used to teach. We designed, built and tested a video game about the effects of climate change on a charismatic local animal, the pika. Native to North America and Asia, pikas are sensitive to changes in climate because they are covered with thick fur and get heat stroke even under modest temperatures (77 F). Pikas have to gather food throughout the summer, enough for them to make it through the long winter in their burrows. When temperatures warm, pikas do not have as much time to forage for food during their day. We decided to take these ideas and turn it into the major mechanics of a game that we developed. The resulting project, *Life of Pika*, is a runner game in which players need to collect flowers to survive while managing their temperature to avoid overheating. We have taken inspiration from other runner games such as *Frogger*, *Crossy Road*, and *Sonic the Hedgehog*, but this game is unique in that player vulnerability centers around

their temperature bar, rather than around avoiding obstacles. The game is divided into seven levels to represent the pika's seven year lifespan. As one advances from level to level we make the game progressively harder by increasing the rate at which the player's temperature increases to simulate increasing global temperatures. Developed with industry-standard software for implementation in classroom and museum settings, we aim to promote empathy in the player about the pikas' struggle against climate change. We hope that players will become more thoughtful about their impact on the world and its inhabitants.

Poster Session 3

Balcony, Easel 92

2:30 PM to 4:00 PM

The Optical Depth of Tropical Clouds at Varying Altitudes

Gregory Bertolacci, Senior, Physics: Applied Physics
Mentor: Dennis Hartmann, Atmospheric Sciences

The recent changes in our climate drive the need for a more comprehensive understanding of the workings of the environment so that we can more accurately simulate the changes taking place around the world. This project aims to do this by studying measurements of the optical depth of tropical clouds at different heights. The optical depth of a cloud is how opaque it is to visible radiation and determines how effective the cloud is at absorbing or scattering the solar radiation. By sifting through radar and lidar data collected by NASA's CALIPSO and CloudSat satellites that orbit the earth simultaneously in a group called the A train, I am able to determine cloud optical depths as a function of altitude in different regions. I expect the optical depth of tropical clouds to decrease as their height increases due to the fact that lower, warmer clouds are able to hold more water and should therefore be thicker. My research adds additional information for climate models so that they may more accurately define the radiative budget.

Poster Session 4

Commons East, Easel 74

4:00 PM to 6:00 PM

Orographic Precipitation Enhancement Over the Olympic Peninsula

Thomas Michael (Thomas) Schuldt, Senior, Atmospheric Sciences: Meteorology
Mentor: Lynn McMurdie, Atmospheric sciences
Mentor: Joseph Zagrodnik, Atmospheric Sciences
Mentor: Angela Rowe, Department of Atmospheric Sciences

The Olympic Mountains Experiment (OLYMPEX) was a ground validation field campaign centered on the Olympic Peninsula designed to provide physical validation and verification of satellite precipitation measurements from the constellation of satellites known as the Global Precipitation Measurement (GPM). The goal of OLYMPEX was to validate and document precipitation measurements in midlatitude frontal systems moving from the Pacific Ocean to the coast and then to the high terrain and leeside. The assets featured in OLYMPEX included extensive ground instrumentation, soundings and dropsondes, several radars, and aircraft all helping to monitoring storm systems as they approached and then traversed the Olympic Peninsula during the intensive field operations from November 2015 through March 2016. Ground instrumentation was located at a number of different elevations mainly focusing on the windward southwest side of the Olympic Mountains and scattered in other areas of the Olympic Peninsula in locations where precipitation has not been previously measured. This presentation examines patterns of orographic precipitation enhancement using this extensive gauge network and ground radar data to describe and quantify patterns of enhancement and how they vary with synoptic conditions, specifically during the December 8-10th atmospheric river event. The key synoptic parameters that affected the patterns of enhancement included the stability, the strength and direction of the low level flow, the intensity of synoptic scale forcing and the transport of water vapor. These synoptic parameters varied with storm sector. Deep stratiform precipitation with high melting level and low level jet produce strong orographic enhancement along initial windward slopes. Post-frontal conditions accompanied by a low melting level and convective cells are associated with a greater degree of enhancements over interior locations. Pre-frontal and blocked flow conditions show no significant level of enhancement between coastal and inland sites. These findings provide never-before-seen detail of the relationships between storm sectors and orographic precipitation enhancement and can be applied wherever midlatitude cyclones cross coastal mountain ranges around the world.

Poster Session 4

Commons East, Easel 75

4:00 PM to 6:00 PM

Orographic Precipitation over the Olympic Mountains: A Comparison of Rain Patterns at Two Weather Stations

Kenneth Gabriel (Kenneth) Wohl, Senior, Atmospheric Sciences: Meteorology
Mentor: Lynn McMurdie, Atmospheric sciences
Mentor: Joseph Zagrodnik, Atmospheric Sciences

When cold-season oceanic midlatitude cyclones make landfall over coastal mountain ranges, forecasters commonly assume that locations at higher elevations and closer to the mountainous interior will receive greater orographic precipitation enhancement under all synoptic conditions. In this

study, we test this assumption by examining precipitation data obtained at two stations on the windward slopes of the Olympic Mountains in the northwest corner of Washington State. These stations are located 35.2 and 45.4 km from the coast along the Quinault river valley, only 10.2 km apart. It was found that the two stations often recorded drastically different amounts of rain for the same storm system. The U.S. Climate Reference Network (CRN) site is located immediately northeast of Lake Quinault at 86.7 meters elevation, only slightly lower than the second station in Bunch Field at 115.8 meters elevation, which is located slightly closer to the higher terrain of the Olympic Range. This study examines daily rainfall at the CRN and Bunch Field sites over 9 winter seasons (Sept 1 -Mar 31) from October 2006 through December 2015. Dates were identified where one station received 15 millimeters more precipitation than the other in a 24 h period. Composite synoptic maps were made using the NCEP North American Regional Reanalysis data for dates when CRN exhibited higher rainfall totals and for when Bunch exhibited higher rainfall totals. It was found that when CRN had significantly more rainfall than Bunch Field, the flow was predominantly from the SW at all levels and warmer than climatological average. When Bunch Field had significantly more rainfall than CRN, the synoptic flow was more southerly with a large trough and a strongly baroclinic structure. These subtle differences illustrate that orographic enhancement patterns vary strongly with large-scale environmental conditions. The results can be applied to how flooding events can vary on small scales, which in term will inform the management of hydrologic resources.