Online Proceedings

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 Michael Hendrickson, Junior, Atmospheric Sciences: Meteorology, Atmospheric Sciences: Climate
Daniel Arens, Junior, Atmospheric Sciences: Meteorology
Mentor: Cliff Mass, Atmospheric Sciences
Mentor: Richard C 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.

Spatially Resolved Metallicity and Star Formation Rates of the Supernovae-Rich Fireworks Galaxy

Locke Linden Patton, Senior, Physics: Comprehensive Physics, Astronomy
Mary Gates Scholar
Mentor: Emily Levesque, Astronomy

Supernovae (SNe) are the spectacularly violent deaths of evolved young massive stars, which expel a shock wave into the intergalactic medium that in turn can spark star formation and disperse heavy elements into the galaxy. While a SN event can be classified by its spectral signature definitively, determining the nature of a SN progenitor depends upon chance photometry taken prior to the event. We circumvent this challenge by turning to the study of SN host environments and their surrounding interstellar medium within the unique and rare population of galaxies that have hosted three or more SN events within the last century. This subpopulation offers the opportunity to study the locations and environmental properties of stellar populations prone to supernovae production. Using moderate-resolution slit spectra spanning 3500-7000 Angstroms taken with the Apache Point Observatory 3.5m telescope DIS spectrograph, our goal is to map the metallicity, ionization parameter, and star formation rates using emission line diagnostic ratios for all of the SN host sites across each SN-rich galaxy. Dubbed the "Fireworks Galaxy" at a distance of 6.9 ± 2.4 Mpc, NGC 6946 has uniquely produced nine core-collapse supernovae (CCSNe) within the last century, which specifically occur when massive stars develop an iron core under gravitational collapse. We present the spatially-resolved metallicity and star formation rates (SFRs) of NGC 6946, tracing nine spectrophotometric slits centered on each CCSN host site across the galaxy. Future work includes stellar population synthesis modelling to determine the host galaxies' stellar populations, ages, and SFR histories for NGC 6946 and, eventually, the other nine SN-rich host galaxies in our sample.

Southern African Topography Impacts on Low Clouds and the Atlantic ITCZ in a Coupled Model

Eliza J. (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.

Effects of Pixel Sensitivity Variation on K2 Exoplanet Detection

Nicholas Keller Saunders, Senior, Physics: Comprehensive Physics, Astronomy, Comparative Literature (Cinema Studies)
NASA Space Grant Scholar
Mentor: Rory Barnes, Astronomy
Mentor: Rodrigo Luger, Astronomy

The Kepler Space Telescope was designed to detect exoplanets by measuring the change in light received as target planets pass between their host stars and Earth. After the failure of two Kepler reaction wheels, the pointing capability required for high-accuracy transit detection was lost. To reduce the noise generated by unstable pointing, the space telescope was aligned to be held stable by the photon pressure from the sun, and the telescope entered a second phase of observation called K2. Although this reconfiguration still detects transits, the precision has decreased resulting in fewer exoplanet discoveries than Kepler. The EVEREST (EPIC Variability Extraction and Removal for Exoplanet Science Targets) pipeline was developed to remove instrumental noise from K2 data and increase the detection capabilities of the telescope. Due to the failed reaction wheels, Kepler targets have motion relative to the detector. EVEREST uses a detrending method called pixel level decorrelation (PLD), which uses the flux measured in each pixel to account for the motion of the star. One possible source of noise is variation in the quantum efficiency between pixels as the star moves across the detector. This includes inter-pixel variation globally on the detector and intra-pixel variation from the center of pixels to their edges. My research characterizes the sensitivity variation of the detector and its impact on the light curves of Kepler targets. I am developing methods using python to simulate a K2 star with a planet, modelling the sensitivity variation, and using this model to test the power of PLD. Preliminary results indicate that defining apertures to limit total flux results in higher accuracy light curves. My research also aims to apply the results to the EVEREST pipeline, as the combination of PLD and sensitivity variation modeling could result in the highest accuracy publicly available K2 data to date.

A Spatially-Resolved Study of the GRB 020903 Host Complex

Mallory Douglas Thorp, Senior, Astronomy, Physics: Comprehensive Physics
UW Honors Program
Mentor: Emily Levesque, Astronomy

The host complex of GRB 020903 is one of only a few long-duration gamma ray burst (GRB) environments where spatially-resolved observations are possible. It may also be the only known GRB host consisting of multiple interacting components, as well as an active galactic nucleus. We were granted 4.5 hours of observing time on the Gemini Multi-Object Spectrograph (South) to obtain spatially resolved spectra of the GRB 020903 host complex. Using long-slit observations at two different position angles we were able to obtain optical spectra of the four main regions of the GRB host, with a spectral range of 3600 - 9000 Å. From this data we discern the redshift of each region, concluding that they do not comprise a single interacting system as previously assumed. Two regions, including the GRB host region, are at an approximate redshift of 0.251 as expected. The other two are at a redshift of 0.662. We also measure the metallicity, star formation rate, and young stellar population age of each region to create a spatially-resolved map of these parameters for the larger host complex. Based on the distribution of these characteristics we determine whether the localized GRB explosion site is representative of the host complex as a whole, or localized in a metal-poor or strongly star-forming region.

The Geophysics of Habitable Exoplanets

Benjamin Dean (Ben) Guyer, Senior, Physics: Comprehensive Physics, Astronomy
UW Honors Program
Mentor: Rory Barnes, Astronomy

A long-standing goal of exoplanet astronomy is to understand the physics that determines whether or not a planet could support life. An important, but poorly-understood, aspect of planetary habitability is the role of geophysics. Here on Earth, the decay of radiogenic isotopes heats the interior and drives plate tectonics that support geochemical cycles that maintain the stability of our climate over geologic time scales. Whether such cycles are common or rare among exoplanets is an open question. A further complication is tidal heating — while not significant on Earth, it may provide a large source of heat for potentially habitable planets around low-mass stars. To explore these processes, we simulate the evolution of Earth-like exoplanets over a range of radiogenic and tidal powers. We find that, depending on the radiogenic abundances and magnitude of tidal heating, planets may be unable to support a magnetic field or experience extreme volcanism, both of which could be detrimental to life. These results suggest the geophyisical evolution of exoplanets may be a determining factor in the habitability of some exoplanets, such as Proxima Centauri b and members of the Trappist-1 system.