AO#: 10168

**Project Title:** Virtual Reality Tools for Earth Science Data Exploration

**Background Information:** Advancements in immersive technologies have made virtual, augmented, and mixed reality (VR, AR, MR) readily accessible to consumers. Researchers in various fields have taken interest in leveraging these technologies to help visualize and understand their data. At JPL, we’re exploring the potential use of immersive technologies for Earth science data exploration.

**Project Description:** This task will involve the investigation of various use cases for using VR for Earth science as well as the visualization of Earth science data in VR. We will use software developed using the Unity game engine to build immersive environments for scientists to explore Earth science data. Data will come from NASA archives such as GIBS and PO.DAAC. The student will write code using Unity to augment existing capabilities and help develop tools for users to visualize data in VR.

**Suggested and/or Required Background & Skills:** Unity, C#, Game Development, interest in Earth Science


**Hazards:** NONE

**Majors:** Computer Science, Information Systems/Technology, Game Development
Project Title: Web Interface for Urgent Response and Long-Term Monitoring Data Products

Background Information: Science Data Systems (SDS) are used to process remote sensing-based observations. Projects such as the Advanced Rapid Imaging and Analysis (ARIA) also provide a SDS that focuses on rapid and large scale analysis of SAR observations. The data is processed to higher-level actionable information that can be used by hazards response communities such as FEMA. The ARIA SDS has prototyped generating data products that contain surface displacement maps (from earthquakes, volcanoes), damage maps (from building damage, landslides, fire burn scars), and flood maps. The urgent response aspect of ARIA has high visibility and societal impacts. ARIA has been proactive and seen in the public eye for responding to natural disasters. The nature of urgent response analysis during a disaster response drives the need for the science community to get their hands on our products as soon as possible. For science data processing we use a framework known as HySDS (Hybrid-cloud Science Data System) along with core science algorithm code such as those from ISCE, FPM, and DPM algorithms.

Project Description: The objective of this internship is to implement a web interface that shows the live status of our data production system and optimize the views for urgent response of the various event-specific data products. This interface should provide information corresponding to every disaster response effort that would be relevant to the science community. It will be an internal prototype. This task would involve understanding how our system responds, the products produced and interacting with scientists to gather requirements. Interaction with both cloud-based science data processing as well as working with different urgent response algorithm development teams will be needed for a successful deployment of an urgent response-optimized data exploration tool.

Suggested and/or Required Background & Skills: Experience with front-end programming languages such as Angular JS or React, JSON, GeoSpatial data, Elasticsearch, REST API


Hazards: NONE

Majors: Computer Science, Computer Engineering, Web Application Development, UI/UX
AO#: 10159

**Project Title:** Improvements to Core Software for NASA’s Global Imagery Browse Services

**Background Information:** NASA’s Global Imagery Browse Services (GIBS) provides quick access to over 800 satellite imagery products, covering every part of the world. Most imagery is available within a few hours after satellite overpass, some products span almost 30 years, and the imagery can be rendered in your own web client or GIS application. GIBS provides full resolution visual representations of NASA Earth science data in a free, open, and interoperable manner. Through responsive and highly available web services, it enables interactive exploration of data to support a wide range of applications including scientific research, applied sciences, natural hazard monitoring, and outreach. GIBS imagery can be explored in NASA’s Worldview web site (https://worldview.earthdata.nasa.gov).

**Project Description:** This project involves a range of potential tasks for improving the core server software for GIBS known as OnEarth. Some areas of improvement include: updating web pages and documentation for the open source OnEarth code repository, configuring OnEarth demo applications, augmenting unit tests, and enhancing code quality. For students with familiarity with Earth science data, we are looking to demonstrate the usage of the software to serve and visualize new data types for various science use cases. More advanced tasks may involve researching and developing optimized data stores that can enable rapid analytics and visualization of the vast archive of NASA’s Earth science data.

**Suggested and/or Required Background & Skills:** Python or C/C++, JavaScript, Web Development, Apache, GIS, Earth Science

**References:** https://earthdata.nasa.gov/about/science-system-description/eosdis-components/global-imagery-browse-services-gibs

**Hazards:** NONE

**Majors:** Computer Science, Earth Science
AO#: 10154

Project Title: Jets and Disks in Young and Dying Stars, and Exoplanet Host Stars

Background Information: The research opportunity offered is related to the study of circumstellar matter around young and dying Sun-like stars. Low and intermediate mass stars are born in rotating clouds of gas and dust, and many aspects of this evolutionary phase, such as the production of accretion disks and collimated jets, is poorly understood. As these stars reach the end of their lives, they carry out much of their interesting nucleosyntheses (e.g. production of the biogenic elements C & N), and through extensive mass-loss, disperse nucleosynthetic products and dust into the interstellar medium. The dazzling shapes of planetary nebulae make them not only immensely appealing to the public (as evident by their frequent appearance in popular astronomy magazines) but also a serious challenge to professional astronomers in finding a mechanism to produce their shapes. Many of these results have attracted wide public attention and have been published by in public media. The study of young and dying stars provides an important contribution to the part of NASA's ORIGINS program which seeks to understand the life-cycles of Sun-like stars and the physical mechanisms whereby the death throes of these stars sow the seeds for the birth of new stars and solar system. A new area of research is the study of UV emission from exoplanet host stars, in order to understand the star-planet interaction as well as to study the effects of stellar UV emission on the planetary systems.

Project Description: In support of my research on these stars, I have a large number of past and current observational programs on NASA's space observatories such as the Hubble Space Telescope (HST), the Spitzer Space Telescope (SST), the Chandra X-Ray Observatory (CXO), and GALEX. These programs are generating a large amount of high-quality data, and opportunities exist for motivated students to help with the analysis and modelling of these data for addressing important scientific questions related to the death of Sun-like stars. Specific research goals include an understanding of (1) the mass-ejection processes during the the beginning and end phases of stellar evolution -- how much mass is ejected, what is the history of this ejection, what is the content and composition of dust in the ejecta; (2) the role and origin of highly collimated jets, which are an exciting, dramatic and integral feature of many astrophysical environments, yet are very poorly understood, and (3) the role of binarity in producing jets and equatorial disks/torii. In particular, the jets in dying stars and young stellar objects are, amazingly similar in their empirical properties, so an improved understanding of jets in such stars is crucial for our understanding of both the very early and late phases of the evolution of Sun-like stars. Motivated and energetic students can expect to be co-authors on papers presented at the bi-annual meetings of the AAS, and peer-reviewed journal papers related to their research (in recent years, 9 students have been co-authors on such papers).

Suggested and/or Required Background & Skills: 1) basic background in Physics and/or Astronomy 2) a reasonable level of computational skill is preferred (e.g.,some programming language like Fortran, C, C++, IDL, python)

Hazards:  NONE

Majors:  Astronomy/Astrophysics, Physics/Applied Physics, Computational/Programming
AO#: 10152

Project Title: Mapping the Lunar Regolith Thickness using Young Craters

Background Information: Most geologic activity on the Moon ceased a billion years ago, but it is continually bombarded by everything from small grains of dust to large boulders. Over the years, this bombardment has broken down the lunar surface into a layer of fine grained rock fragments known as regolith. To understand the geologic history of the Moon, we must first understand how the surface has been eroded. The regolith layer is expected to vary in thickness across the lunar surface, and large impacts can punch through this regolith layer and excavate rocks from the bedrock below. The thickness of the regolith can be estimated by identifying the smallest impact capable of excavating rocks.

Project Description: Use images from the Lunar Reconnaissance Orbiter Camera (LROC) to identify which craters excavated rocks and which did not. The craters to be considered are a recently identified class of young craters. Identify the smallest crater capable of excavating rocks in regions within the lunar maria (terrain resurfaced by volcanism 1-4 billion years ago). Older mare surfaces are expected to host fewer rocky craters, because a thicker layer of regolith would have developed.

Suggested and/or Required Background & Skills: No previous experience is necessary, but an interest (or experience) in geology and/or physics is preferred.


Hazards: NONE

Majors: Planetary Science
Project Title: The Influence of Land Use History on Forest Structure

Background Information: Forests represent a critical component of terrestrial biomes. Our research group employs Synthetic Aperture Radar and cutting edge image processing algorithms to map forest cover and canopy height. In this project, we wish to quantify the impact of land use history on present-day forest structure. The study site in Costa Rica contains a mix of mature forest and regenerating forest. Within the latter category, we have forests that regenerated from abandoned pastures vs. old plantations.

Project Description: This project will rely heavily on GIS routines to co-register historical aerial photographs for Corcovado National Park, and delineate plantations vs. pastures. The resulting shapefile will serve as the basis for comparing forest structure estimates derived from remote sensing.

Suggested and/or Required Background & Skills: Required: GIS including knowledge of vector and raster data formats, coordinate systems, and resampling methods. Suggested: Ecology, Python, R, Statistics, GDAL


Hazards: Repetitive Motion (Ergonomics)

Majors: Earth Science, Environmental Science, Geography
AO#: 10100

**Project Title:** Mars Data Analysis

**Background Information:** The Jet Propulsion Laboratory is seeking highly motivated undergraduate students to participate in Mars data analysis focused on information returned by the Mars Global Surveyor, Mars Odyssey, the Mars Reconnaissance Orbiter spacecraft, the Mars Exploration Rovers, and InSight lander. Data to be studied will be from the Mars Orbiter Camera (MOC), Mars Orbiter Laser Altimeter (MOLA), Thermal Emission Spectrometer (TES), Thermal Emission Imaging System (THEMIS), High Resolution Imaging Science Experiment (HiRISE), the Context Imager (CTX), and instruments of the Mars Exploration Rover Athena Science Payload and the InSight lander.

**Project Description:** Work will be directed at characterizing the geology and safety of candidate landing sites for future Mars missions, including the Mars 2020 Rover. Safety issues focus on quantification of slopes of concern for landing safely in potential landing sites using MOLA data and digital elevation models from stereo images. Work will also be related to measuring rocks on the surface of Mars from orbit and on the surface and understanding their context. This will include analyzing rocks visible in high-resolution HiRISE images and quantifying their size-frequency distribution to better understand landing safety. InSight work will involve mapping geological features observed in the images such as craters, eolian bedforms, rocks, and soils. The maps will help define the geological processes responsible for creating and modifying the surface. HiRISE and CTX images will also be georeferenced to lower resolution images (CTX, THEMIS) and topographic maps (MOLA). Additional work may include analyzing craters on Mars to investigate rock distributions in their ejecta, how they change with time and their morphologic state as well as the geomorphology as a clue to the subsurface geology.

**Suggested and/or Required Background & Skills:** Most of the work will be done on personal computers utilizing mixed operating systems (Windows and Macintosh), so experience with them is important. The ability to measure and tabulate rocks, place the data into standard spreadsheets, and plot the results is required for the work on rock distributions. Experience with ArcGIS mapping software (10.x), especially georeferencing imagery, is preferred as our landing site data is specifically formatted to work with this GIS package. Additional knowledge of Integrated Software for Imagers and Spectrometers (ISIS 3.x), SOCET SET, or Matlab software would be a plus. Preference will be given to students with backgrounds in geology or planetary science and other related disciplines such as geographic information science, physics, chemistry, astronomy, engineering, and computer sciences. The students will spend most or all of their time at JPL. They may be supervised by one or two research scientists and may also work alongside other researchers and students.


Hazards: NONE

Majors: Planetary Science, Earth Science
AO#: 10095

Project Title: Detection of Life-Like Motility in Liquid Samples: Analysis of Labeled Data and Algorithm Visualizations

Background Information: Imagine you fly to Europa, melt some ice, and stare at the liquid under a microscope. Or thick, salty Martian brines. Or the plumes shot out from Enceladus. How would you know what you see in that liquid is alive? You can test for DNA or proteins that mean life on Earth, and there are instruments for that. But what if, instead, you just looked at the movies of particles in the liquid and asked, "Is it moving like life?" Any human could watch and tell you what that meant, but try to write a program to measure it. Instead, we will use humans to provide labels like "This object here is moving like life" and "This object is not." Then we will train a machine learning program to take measurements of the particles and learn, statistically, what the human labelers are talking about. This is HELM, an algorithm that will fly to Europa, Mars, and other worlds looking for signs of life wiggling in the water. It also will be used extensively on Earth, rapidly identifying potentially dangerous organisms in our beach ocean water, lakes, streams, and even within our own blood.

Project Description: We are developing the above algorithms in Python while keeping our memory and compute requirements very small so that we can fit on rad-hardened space hardware in future missions. But to train our algorithm, we need a LOT of good quality labels. Those are made by humans staring in detail at real data movies taken of known living and unliving things, so that the ML methods can figure out how to determine life from unlife. This position will require helping us to assess the quality of previously labeled data, as well as improving label quality by re-labeling images that could use refinement, some each day. In addition, the selected student will create visualizations to demonstrate the performance of our ML algorithm. You will be embedded in our development team and watch the growth of a real ML system designed for space use, be exposed to real-world ML considerations, challenges, and solutions, and get real science-data analysis experience. But don't be fooled... it takes a lot of work to provide these labels in an accurate, careful manner. You will work at JPL in the Machine Learning & Instrument Autonomy group with flexible hours, meet the group, and make connections across JPL.

Suggested and/or Required Background & Skills: Req: Python programming - Intermediate
Req: Statistics - basic Req: Computer familiarity - strong Nice: Microbiology

References: https://www.popsci.com/microscope-looking-for-life-on-europa ;
http://www.caltech.edu/news/building-microscope-search-signs-life-other-worlds-48555

Hazards: NONE

Majors: Computer Science, Mathematics
AO#: 10093

**Project Title:** Analysis and Archiving of Near- and Mid-Infrared Observations of Jupiter and Saturn

**Background Information:** Images and spectra of Jupiter and Saturn from visible, near- and mid-infrared instruments are sensitive to temperatures, abundances of a major condensate (ammonia) opacity of clouds and the variability of the molecular para vs. ortho-H$_2$ ratio. These define the fundamental state of the atmosphere and constrain its dynamics. This research will focus on observations obtained from a variety of instruments used at large professional telescopes: NASA’s Infrared Telescope Facility, Gemini North and South Telescopes, ESO’s Very Large Telescope, and the Subaru Telescope, and the Juno mission images of Jupiter in reflected sunlight from the JunoCam instrument. The general objective of the specific tasks below will be to create fully reduced data from unreduced or partially reduced sets. In some cases, our objective is to format the data for input into an atmospheric retrieval code from which atmospheric properties will be derived.

**Project Description:** Several specific topics are available: (1) A major challenge working with the Juno mission’s JunoCam images is to assign accurate geometry to them for comparison with other data sets. Our objective is first to create this geometry with a code supplied by the US Geological Survey (ISIS3). An immediate second objective is to re-map the images into standard Mercator or polar projections, with high priority on images that can address the following scientific investigations: search for and characterize mesoscale gravity waves, characterize atmospheric hazes, particularly around polar regions, measure the relative altitudes of cloud features from analysis of their shadows, and characterize the colors of different cloud features. (2) To fulfill a contractual obligation to NASA, we need to archive our thermal infrared observations of Jupiter from various instruments over nearly two decades with NASA’s Planetary Data System (PDS). These data must be accompanied by required ancillary files in a specific PDS format. The goal of this work is to collect copies of the data and ancillary files into a single location and submit these to review by the PDS. Aspects of this work can be done concurrently with another student working on the long-term variability of Jupiter (see 5 below). (3) We will be acquiring a large volume of observations of Jupiter that are designed to support observations from instruments on the Juno spacecraft. It will be important to reduce and, to the extent possible, analyze these results to be reported by the mentor and his colleagues to the Juno science team. There are several specific objectives in this overall category. (a) Develop of quasi-automated software for combining Mercator maps derived from images taken at different times as the planet rotates; use these to create full maps of Jupiter over all longitude, as well as to polar project those maps, for example - to investigate correlations between different phenomena in the neutral atmosphere and the aurora. (b) Develop a technique for absolute photometric calibration of near-infrared images of Jupiter in the absence of cross-calibration with standard-star calibrations by reference to independent measurements of photometry by spacecraft. (c) Determine the relationship between the morphology of auroral-related stratospheric heating at Jupiter’s poles with auroral emission in the ultraviolet and infrared. (d) Measure the distribution of cloud properties in the atmosphere with near-infrared
reflectivity, including high-resolution adaptive-optics stabilized images. Use the to characterize
the chemistry and dynamics of the atmosphere, e.g. polar hazes, their evolution and their
relationship with the temperature and wind field. (e) Develop a means to reduce spectral
observations of Jupiter or Saturn to derive spectra at each pixel of the slit; for scanned spectra
of this type, develop a means to calibrate the geometric positions of each pixel. (4) Including
these and more historical data, track high-altitude particulate wave properties of Jupiter’s
North Equatorial Belt to determine whether these waves appear only at the same time as the
latitudinal expansion of the dark NEB or also with other planetary-scale atmospheric
phenomena. (5) Examine the long-term variability of longitudinally averaged temperatures and
other properties in Jupiter, continuing previous work by students to create accurate and self-
consistent calibrations of all data from a variety of telescopes. Extend a current program to
input longitudinally averaged data over Jupiter’s full disk to include observations at facilities
where only a northern or a southern hemisphere of Jupiter could be captured. Format these
data to be an input to an atmospheric retrieval program. Organize the output of this program to
enable rapid plotting and correlation with previous studies and between different retrieved
atmospheric properties. (6) Examine the variability of Saturn’s longitudinal-mean temperatures
as a function of time and compare with existing Global Climate Models.

Suggested and/or Required Background & Skills: The data reduction programs are written in
the Interactive Data Language (IDL, which is close to Matlab in format). The analysis code is
written in FORTRAN. At least rudimentary knowledge of these (or willingness to learn before
the beginning of the research) is highly recommended. At least some programming experience
is required of serious candidates. With a significant level of contribution, students are
welcomed as co-authors on papers emerging from this research.

References: (1) The JunoCam instrument is described by Hansen et al. (2017) Space Sci. Rev.
doi:10.1007/s/11214-014-0079, and initial work on polar region is described by Orton et al.
(2017) Geophys. Res. Lett. 44, 4599. (2)(a) There is no published archiving report as yet, but
student reports from previous years are available on request. (3) Data reduction and retrieval
processes for the mid-infrared are described by Fletcher et al. (2009, Icarus 200, 154). (b) No
published report is available but reports by a previous student are available; this involves
correcting and perfecting previous work. Creation of Mercator maps has been done for Saturn,
uses of mapping can be seen in Sanchez-Lavega et al. (2007) Nature 251, 437; and some work
on Jupiter for Juno’s first scientific orbit contributed to a cross-comparison reported by
Orton et al. (2017) Geophys. Res. Lett. 44, 4607. (c) Some ground-based observations of auroral
heating are described by Sinclair et al. (2017) Geophys. Res. Lett. 44, 5345. (d) The most recent
published work on Jupiter is by Sanchez-Lavega et al. (2017). Geophys. Res. Lett. 44, 4679. (e, f.)
No formal report on these efforts has yet been published. (4) Recent work covering the most
recent wave structure is given by Fletcher et al. (2017). Geophys. Res. Lett. 44, 7140. (5) This
continues earlier work on this by Orton et al. (1991) Science 252, 537 and Orton et al. (1994)
Science 265, 625. (6) Low-latitude variability of temperatures in Saturn from ground-based
observations were described by Orton et al. (2008) Nature 453, 196.
Hazards:  NONE

Majors:  Planetary Science, Astronomy/Astrophysics, Computer Sciences