CSAR

Center for Space and Atmospheric Research

Modelling, observational, and experimental studies that span space and atmospheric physics, planetary science, and astrophysics.

Aroh Barjatya, Interim Executive Director (barjatya@erau.edu)

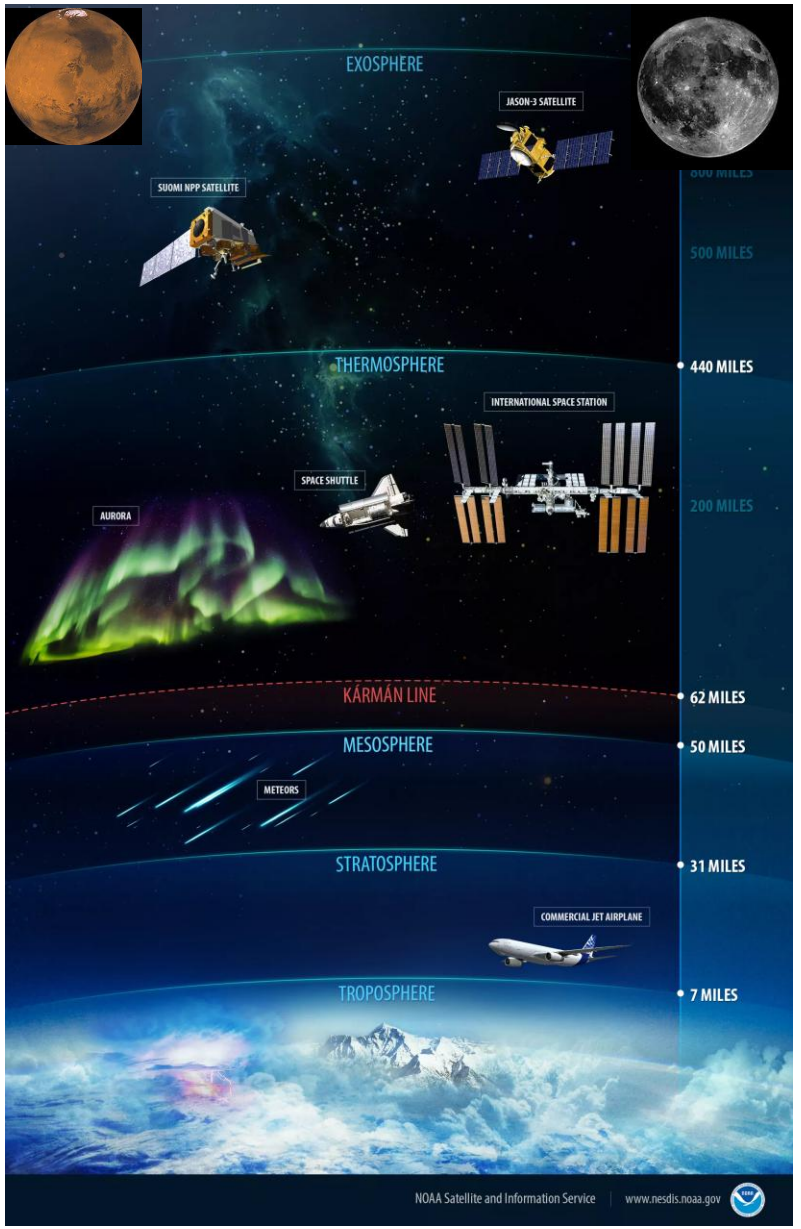
EMBRY-RIDDLE
Aeronautical University

CSAR's Scope

EMBRY-RIDDLE Aeronautical University

Modeling, observational, and experimental studies that span space and atmospheric physics, planetary science, and astrophysics.

- Neutral atmospheric dynamics and coupling, from meteorological impacts in the troposphere to dissipation of energy in the mesosphere.
- Coupling between the upper atmosphere and the ionosphere.
- Electromagnetic and plasma coupling between the ionosphere and magnetosphere.
- Interactions of the solar wind with the magnetosphere.
- Interactions of the solar wind with other planetary atmospheres and lunar exosphere.
- Interactions and physics of stars, black holes, and galaxies.
- Laboratory investigations of fundamental plasma physics and applications toward better instrumentation and models



Graphic from NOAA/NESDIS

CSAR's Fast Facts/ Statistics

EMBRY-RIDDLE Aeronautical University

- 14 Associated Faculty
- 16 Directly affiliated Research Staff who are fully soft money
- Dozens of undergraduate and graduate students supported by projects
- ~40 active sponsored projects, via NASA, DARPA, NSF, AFOSR, and DOE
- >$25 M in active funding, with > $5M expenditure per year in past few years
- Currently five primary research laboratories
  - ÉCLAIR, LaSMIR, LENSES, SAIL, SPRL

CSAR Current Labs

EMBRY-RIDDLE Aeronautical University

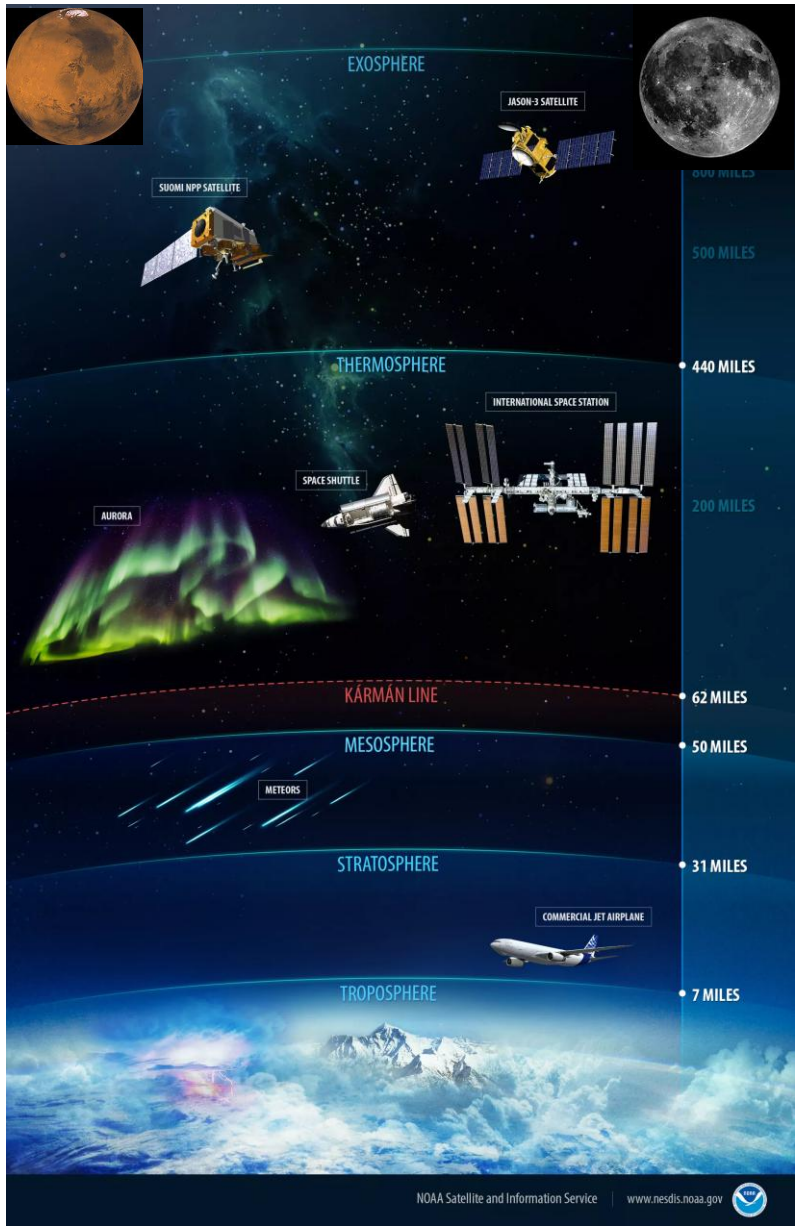
ÉCLAIR — Experimental and Computational Laboratory for Atmospheric and Ionospheric Research
Atmosphere-Ionosphere Modeling, Optical & Radio Data Analysis,
Space Weather "From Below"

LaSMIR — Laboratory for Solar and Magnetosphere-Ionosphere Research
Solar Wind-Magnetosphere Modeling, Spacecraft Data Analysis,
Space Weather "From Above"

LENSES — Laboratory for Exosphere and Near-Space Environment Studies
Ground- and Space-based Passive Optics and High-Resolution Spectroscopy

SAIL — Space and Atmospheric Instrumentation Laboratory
Laboratory and In-Situ Plasma Diagnostics, Space Situational Awareness, Balloons, Rockets, and Small-Sats

SPRL — Space Physics Research Laboratory
GNSS Scintillation Monitoring and Modeling, Ground based remote sensing via lidars and radars.



CSAR/SAIL… Lightening Experiments

(Jeremy Riousset, rioussej@erau.edu; Aroh Barjatya, barjatya@erau.edu)

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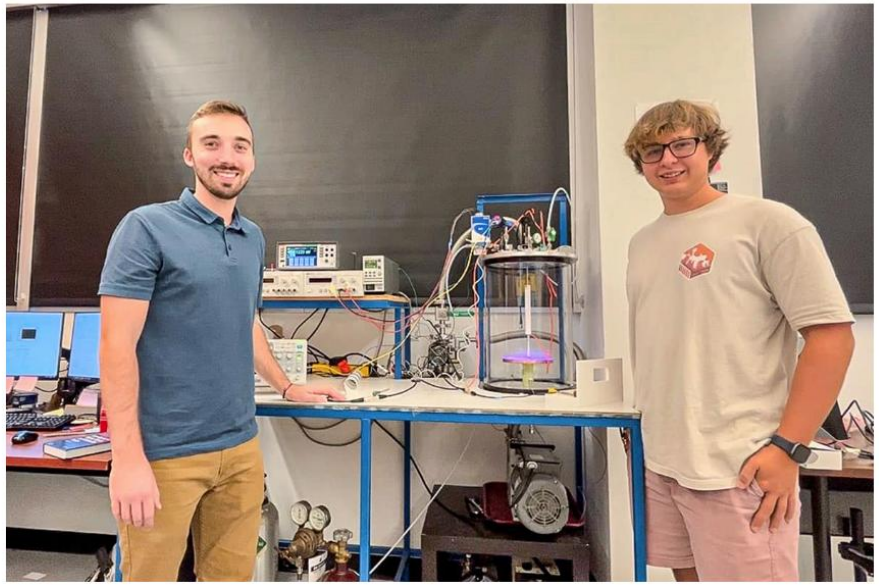
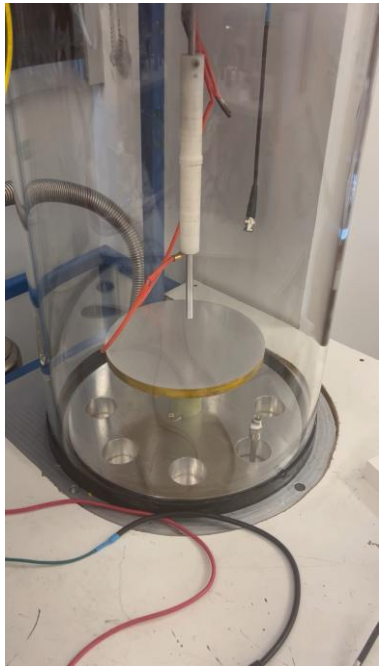
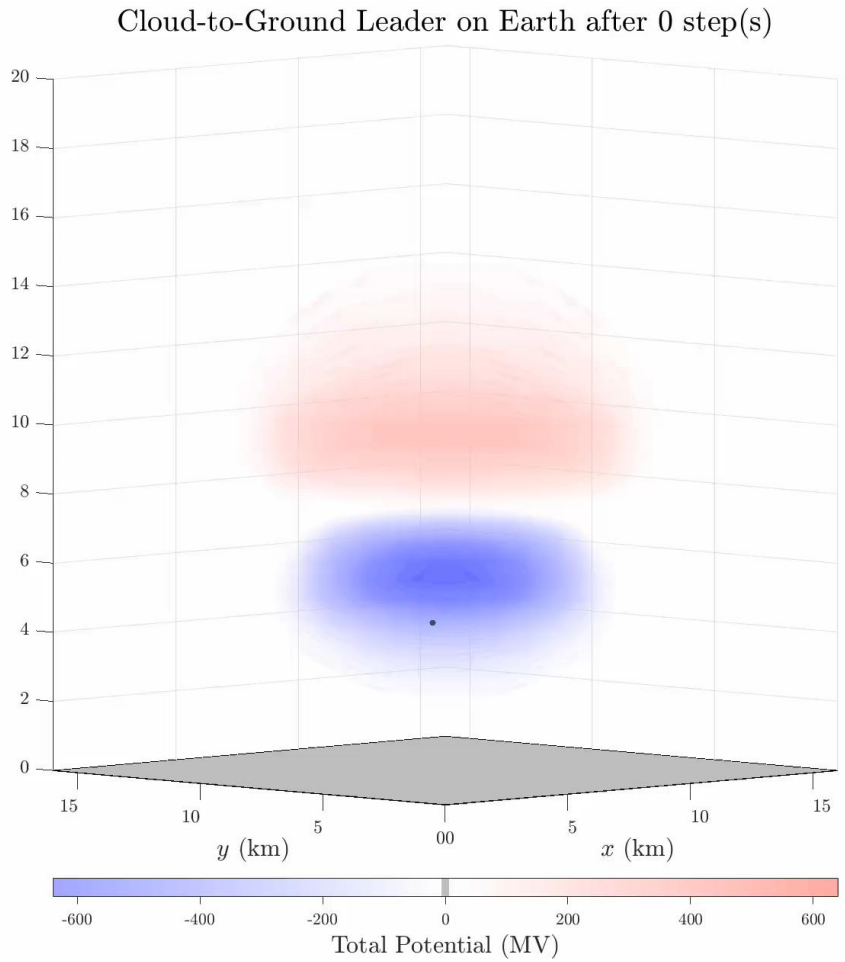
Lightning in a Bottle: Embry-Riddle Team Seeks the Origins of Its Spark



Engineering Physics students Jared Nelson (left) and Seth Gerow are using a Dusty Plasma Chamber at Embry-Riddle's SAIL Lab to measure the exact conditions necessary for the initiation of lightning. (Photo: Embry-Riddle/SAIL Lab)





- NSF funded experimental and computational studies of lightning discharges for Earth and Mars

CSAR/SAIL… Experiments for Fusion

EMBRY-RIDDLE Aeronautical University

(Byonghoon Seo, seob1@erau.edu; H. Katariina Nykyri, nykyrik@erau.edu; Xuanye Ma, max@erau.edu)

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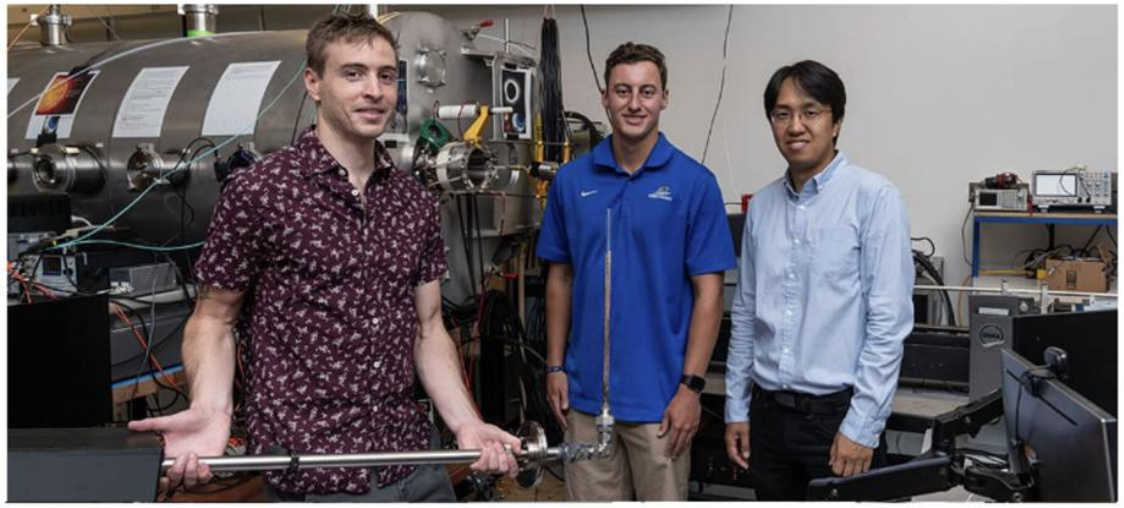
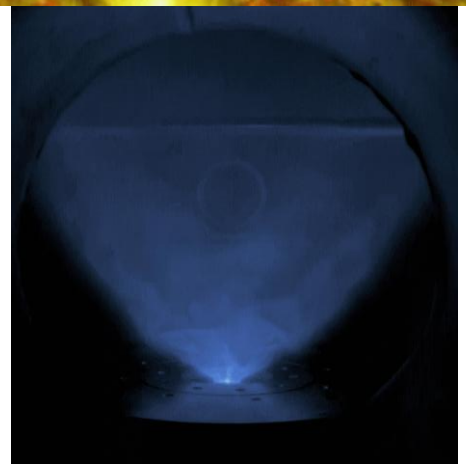
New $670,000 Federal Grant To Help Eagle Researchers Take On Fusion Energy Generation



The fusion energy team is Christopher Lamb, Connor Castleberry and Dr. Byonghoon Seo. Lamb is holding an instrument called a B-dot probe, which can measure a magnetic field. (Photo: Embry-Riddle/Daryl Labello)

ERAU Eagle Plasma



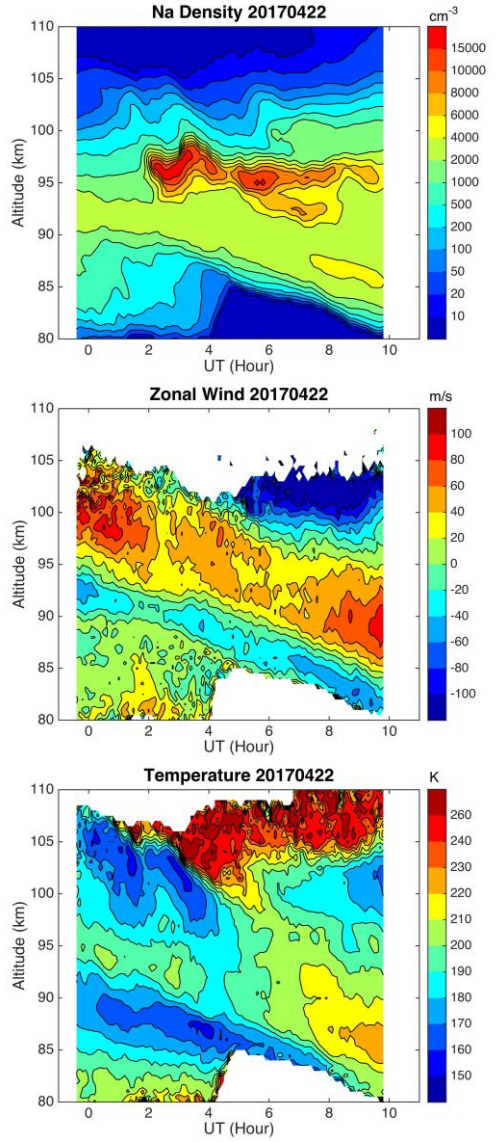
- DOE and NSF funded experimental and computational studies of Plasma Jets
- Relevant to fusion experiments as well as solar wind and magnetosphere interactions

CSAR/SPRL… Lidar

(Alan Liu, alan.liu@erau.edu)

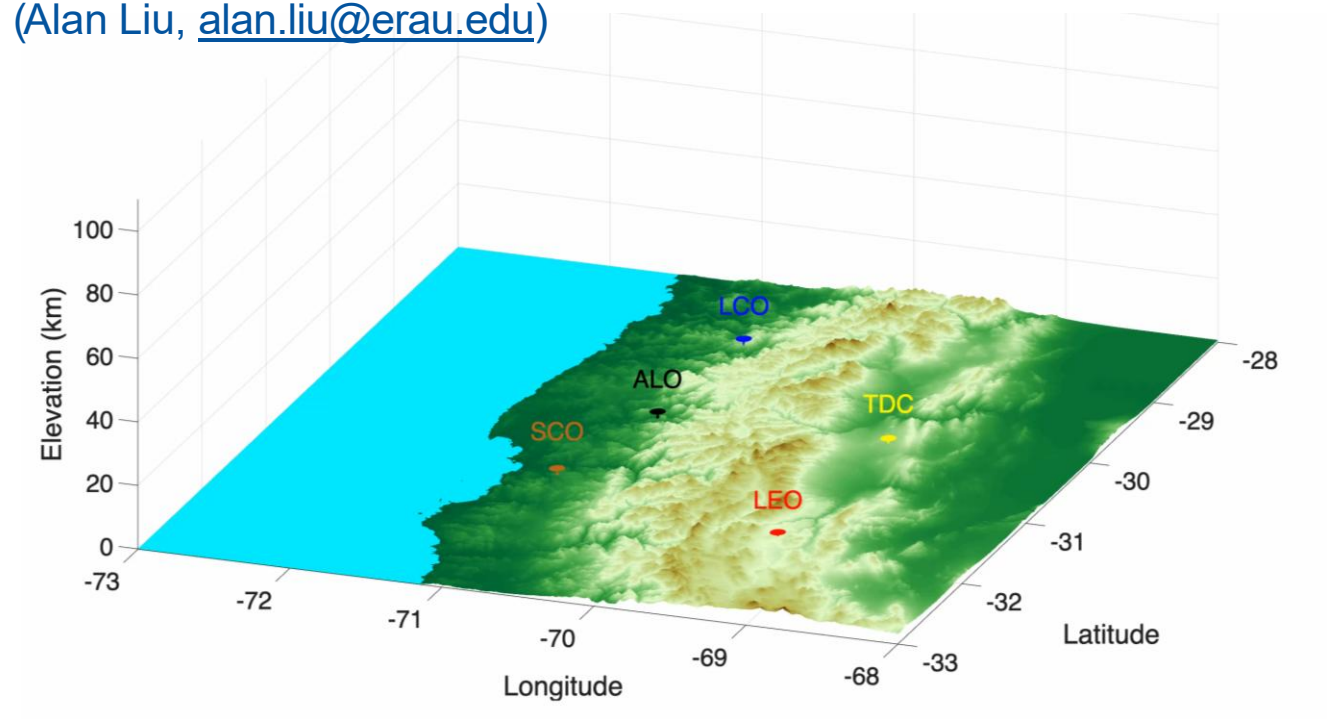
Andes Lidar Observatory

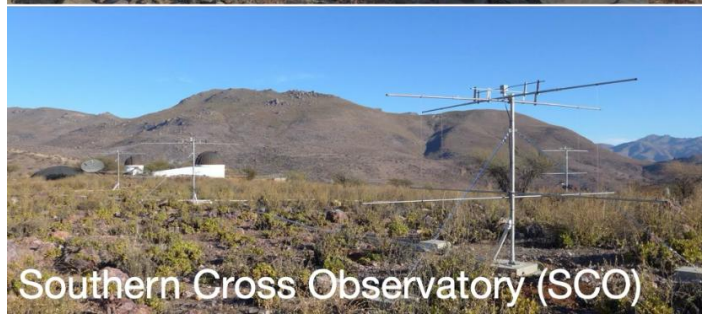
- NSF supported the sodium resonance lidar for ~80-105 km altitude high-resolution winds and temperatures, and sodium density measurements
- Broad collaborations with multiple institutions: AURA, Univ of Illinois, Penn State, Utah State, Aerospace Corp, GATS Inc, and UC Boulder.



CSAR/SPRL… Meteor Radar

(Alan Liu, alan.liu@erau.edu)





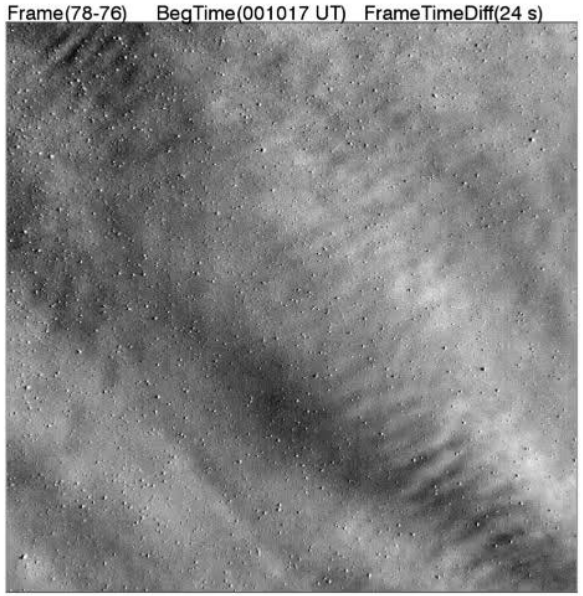
- Distributed network of meteor radars and optical instruments in Chile and Argentina
- ~80-110 km altitude wind measurements from meteor trails
- Airglow imagers for neutral wave dynamics at ~85-95 km to 250 km altitude

CSAR/SPRL… Optical Network

ASI1
Apogee Alta-U6
High Gain

ASI2
Apogee Alta-F6
High Dynamic Range

Aerospace Infrared Camera



- Airglow imagers are used to observed horizontal structures.
- All sky imagers (left) can get a large field of view (movie at top right).
- Infrared camera (middle picture) is cryogenically cooled and can detect much higher detailed structure of wave breaking (bottom right movie).

CSAR/LENSES INSpIRe Facility (WI)

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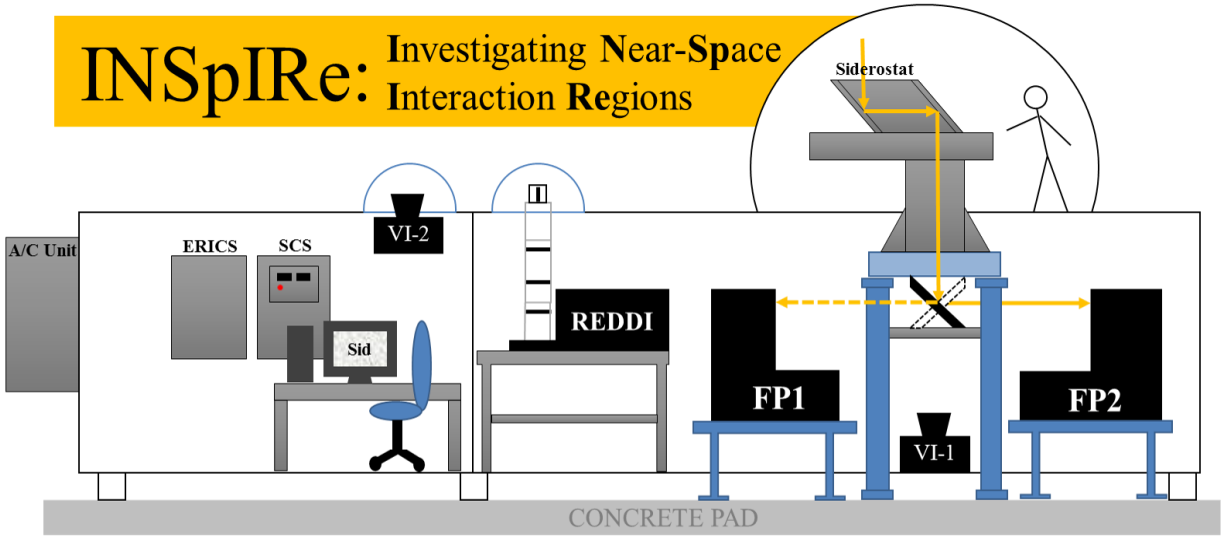
(Edwin Mierkiewicz, mierkiee@erau.edu)

- NSF supported adaptable and relocatable observatory for sensitive spectroscopy; ports for visiting instruments.
- Fabry-Perot Spectroscopy – studies of diffuse optical line emission at high spectral resolution (e.g., terrestrial aeronomy, lunar exosphere, comets, zodiacal dust, galactic astronomy).
- Field-Widened Spatial Heterodyne Spectrometry for **thermospheric winds**.
- Collaborations with aeronomers, planetary scientists, and astronomers.



CSAR/LENSES WHAM Facility (Chile)

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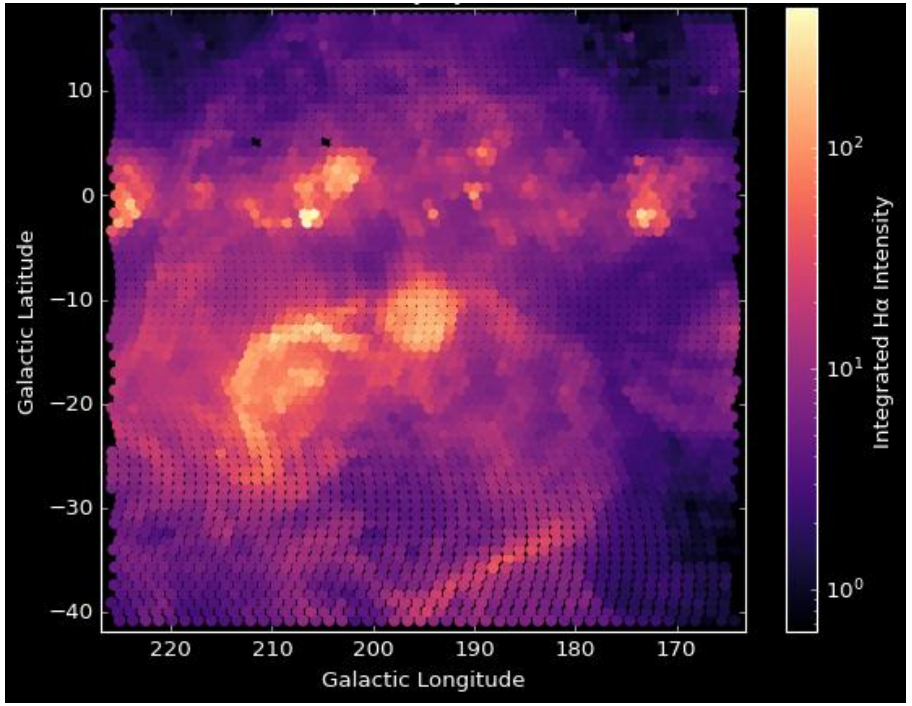
(Edwin Mierkiewicz, mierkiee@erau.edu)



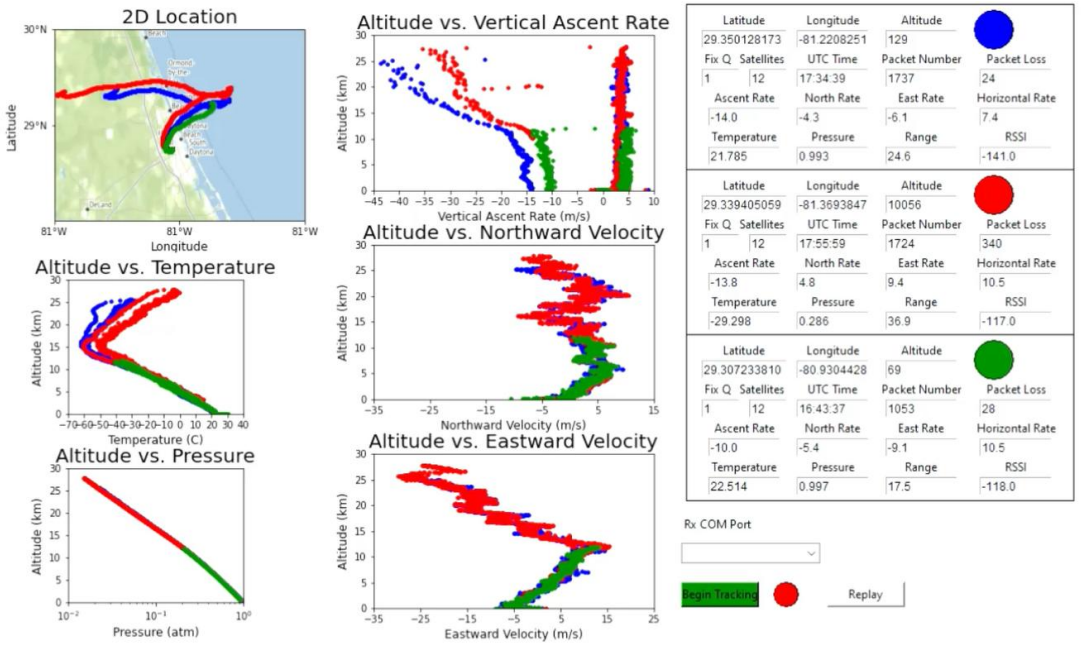
- NSF supported studies of diffuse ionized gas throughout the Milky-Way-Magellanic System as well as terrestrial hydrogen variability on time scales from dusk-dawn to multidecadal.

- NASA supported studies of diffuse lunar exospheric emission and zodiacal dust. Poised to support the upcoming NASA Carruthers mission (launch scheduled for 9/23/25).

CSAR/SAIL… High Altitude Balloons

(Aroh Barjatya, barjatya@erau.edu; Robert Clayton claytor8@erau.edu)

- AFOSR MURI funded high-altitude balloon platform.
- Capable of upto 6x simultaneous multi-point launches reaching higher than 40 km.
- Low-cost and high data rate throughput with real time tracking on a controlled descent platform



- The platform gives a unique student experience of full mission life cycle from PDR, CDR to MRR, as well as a test platform for variety of atmospheric sensors

CSAR/SAIL… Sounding Rockets

(Aroh Barjatya, barjatya@erau.edu; Robert Clayton claytor8@erau.edu)

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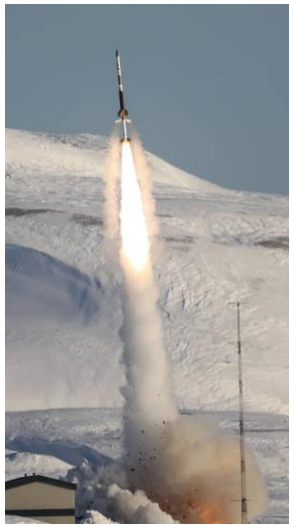
Eagles Launch Tech Aboard NASA Rockets From Virginia, the Arctic



- NASA LCAS funded sounding rockets.
- SAIL has led or participated in a rocket mission every year since 2021 and we have launches manifested until 2027

CSAR/SAIL… Eclipse rocket campaign

(Aroh Barjatya, barjatya@erau.edu; Robert Clayton claytor8@erau.edu; Dr. Shantanab Debchoudhury debchous@erau.edu)

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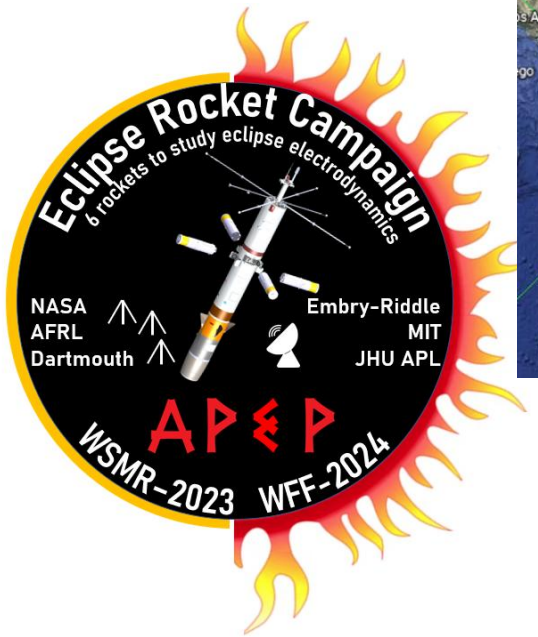
During 'Ring of Fire' Solar Eclipse, Embry-Riddle's Dr. Aroh Barjatya Leads NASA Rocket Mission

Dr. Aroh Barjatya (far right), director of Embry-Riddle's Space and Atmospheric Instrumentation Lab (SAIL), part of the Center of Space and Atmospheric Research, is shown with (from right): Ph.D. student Nathan Graves, master's students Jonas Rowan, Peter Ribbens and Joshua Milford; and research scientists Dr. Robert Clayton and Shantanab Debchoudhury. Seated are undergraduate students Megan Soll and Johnathon Bizzano. (Photo:



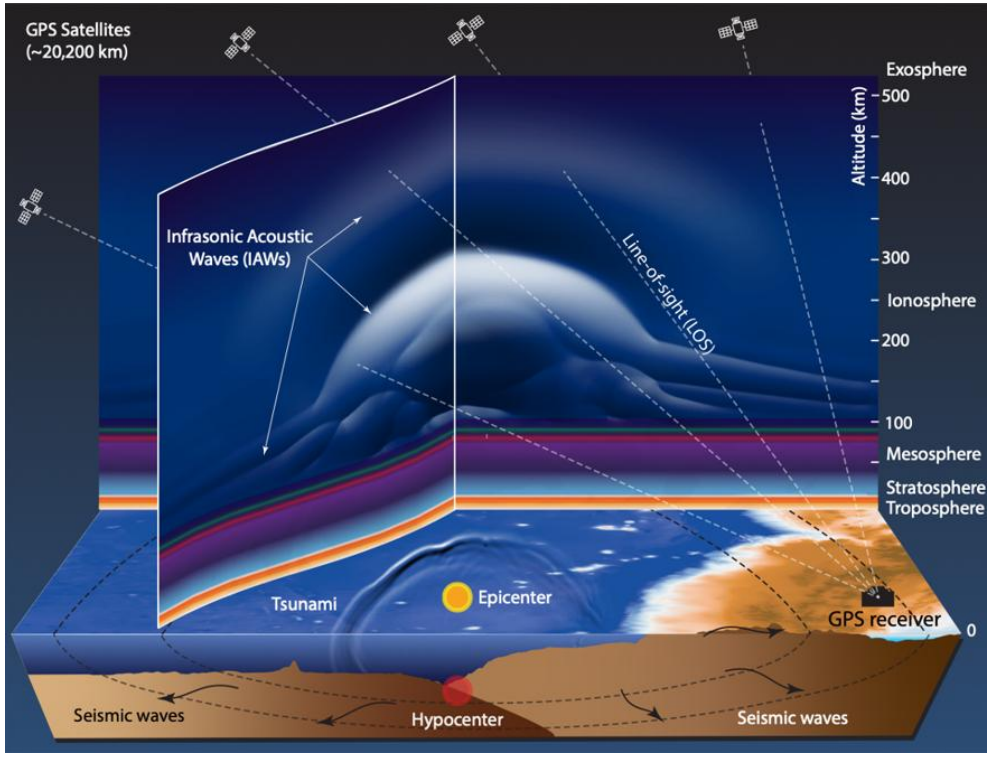
- SAIL led a total of 6 rocket launches under the two eclipses in 2023 and 2024

CSAR/ÉCLAIR… Computational Modeling

EMBRY-RIDDLE Aeronautical University

(Jonathan Snively, snivelyj@erau.edu; Matthew Zettergren, zettergm@erau.edu; Kshitija Deshpande, deshpank@erau.edu)

- **Computational Modeling** – High-fidelity atmosphere-ionosphere-plasmasphere coupling (MAGIC-GEMINI).
- **Measurements, Simulation, and Data Synthetics** – GNSS monitoring of the ionosphere and traveling ionospheric disturbances (TIDs), airglow imaging from ground or space; radio remote sensing; trace species.
- **Recent and Current Projects:**
  - DARPA AtmoSense Program / AIRWaveS Projects
  - NASA Earth Surface and Interior Focus Area
  - NASA Heliophysics Division, LCAS, and HSR
  - NSF AGS, including Airborne Science Programs



Earthquakes-generate acoustic waves that impact the ionosphere: Simulation of nonlinear acoustic waves generated by the 2016 New Zealand Kaikoura earthquake, and geometry of GNSS measurements of their effects on the ionosphere (*Inchin et al.*, 2021).


400
AtmoSense/AIRWaveS:
300
200
100
0 km
kiloton(s) Source
EMBRY-RIDDLE
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CSAR/ÉCLAIR… GNSS TEC

EMBRY-RIDDLE Aeronautical University

(Jonathan Snively, snivelyj@erau.edu; Matthew Zettergren, zettergm@erau.edu; Kshitija Deshpande, deshpank@erau.edu)

Embry-Riddle Aeronautical University
DATA COMMONS

Embry-Riddle Aeronautical University

System for Rapid Analysis of Ionospheric Dynamics based on GNSS TEC Signals

Published: 9 January 2025 | Version 2 | DOI: 10.17632/jbx98yscmd.2
Contributors: Pavel Inchin, Jonathan Snively, Matthew Zettergren

Dataset metrics

Views	1211
Downloads	2147

Latest version

Version 2	
Published:	9 Jan 2025
DOI:	10.17632/jbx98yscmd.2

Cite this dataset

Inchin, Pavel; Snively, Jonathan; Zettergren, Matthew (2025), "System for Rapid Analysis of Ionospheric Dynamics based on GNSS TEC Signals", Embry-Riddle Aeronautical University, V2, doi: 10.17632/jbx98yscmd.2

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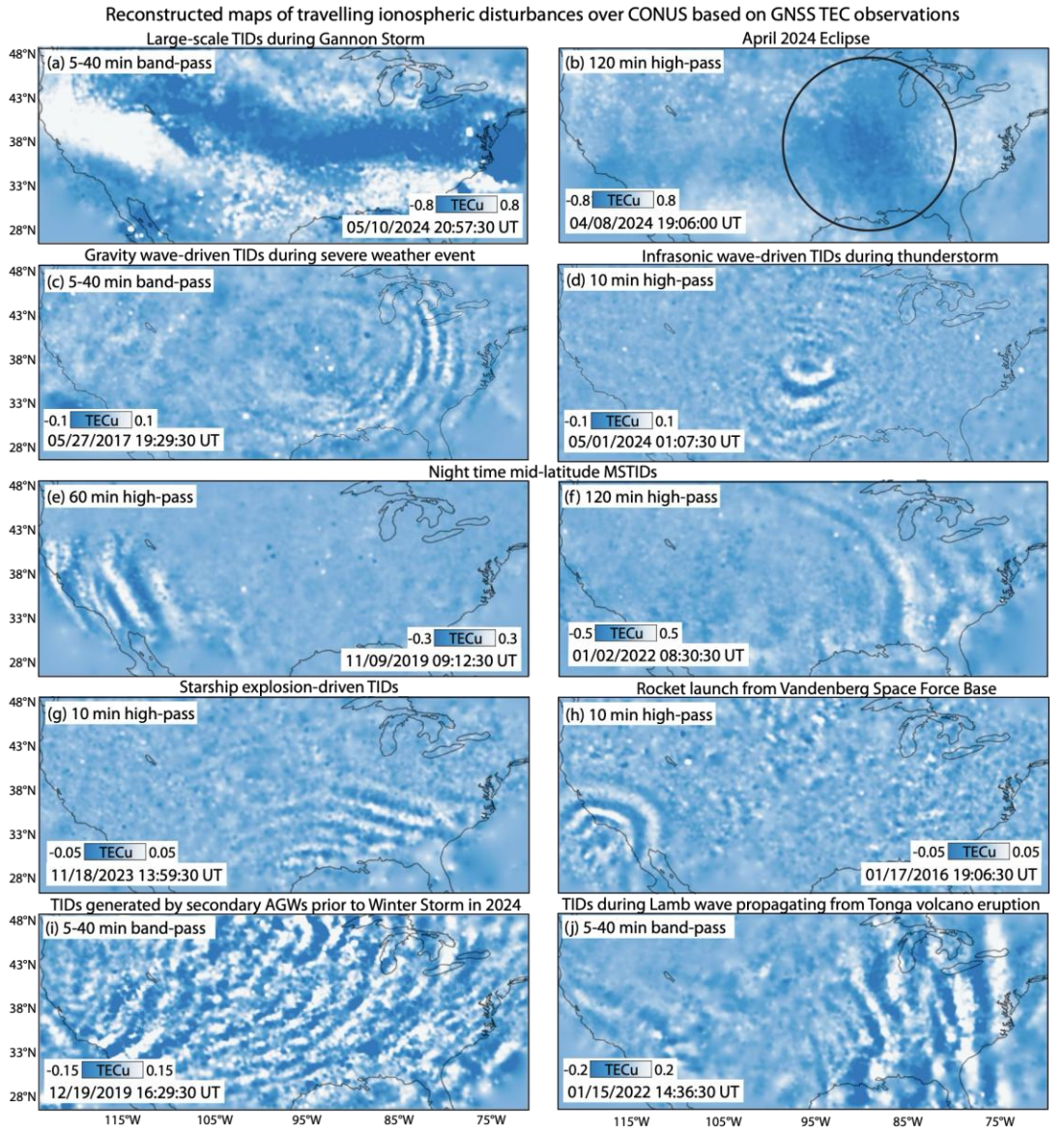
Previous versions

Version 1 — 22 January 2024

Version comparison

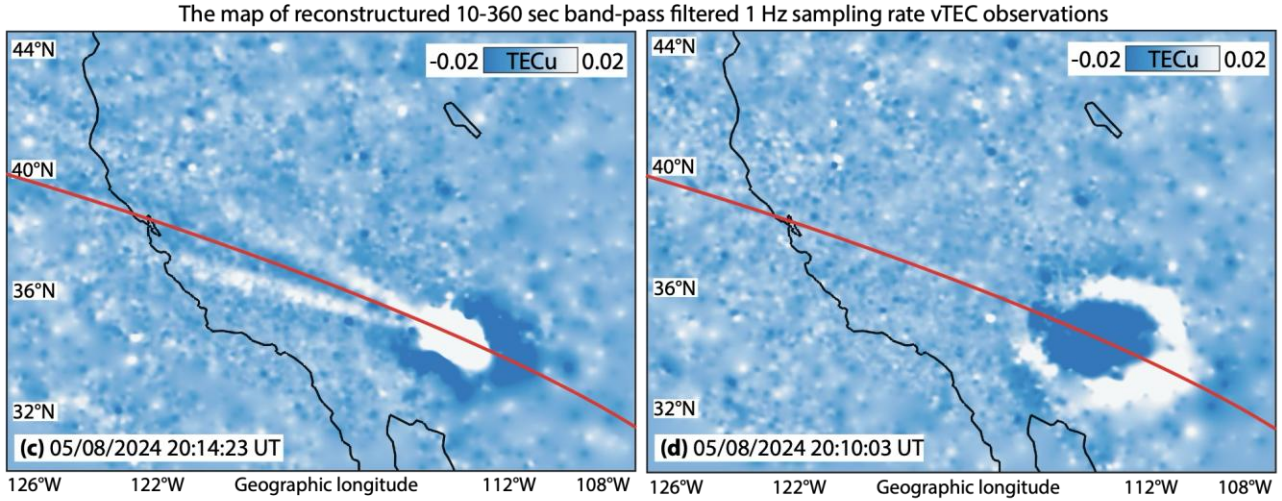
Compare versions

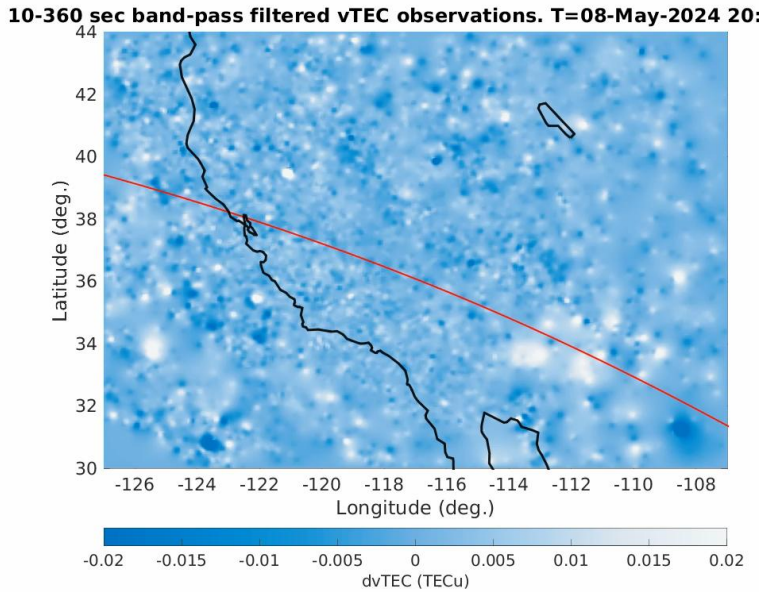


CSAR/ÉCLAIR… GNSS TEC

EMBRY-RIDDLE Aeronautical University

(Jonathan Snively, snivelyj@erau.edu; Matthew Zettergren, zettergm@erau.edu; Kshitija Deshpande, deshpank@erau.edu)





https://doi.org/10.1029/2024GL112364

Falcon 9 second stage deorbiting events provide a great series of controlled repeatable reference experiments, by which ionospheric responses to specific source inputs can be assessed -- i.e., each event reflects a known, controlled process undertaken within varied atmosphere-ionosphere states subject to diverse solar-terrestrial forcing.

CSAR/SAIL… CubeSat Missions

EMBRY-RIDDLE Aeronautical University

(Aroh Barjatya, barjatya@erau.edu; Robert Clayton claytor8@erau.edu; Dr. Shantanab Debchoudhury debchous@erau.edu)

- In collaboration with Univ of Chile, SAIL has launched multiple instruments on SUCHAI constellation
- The satellite's magnetic characterization was done in SAIL's Helmholtz cage, suitable for CubeSats.

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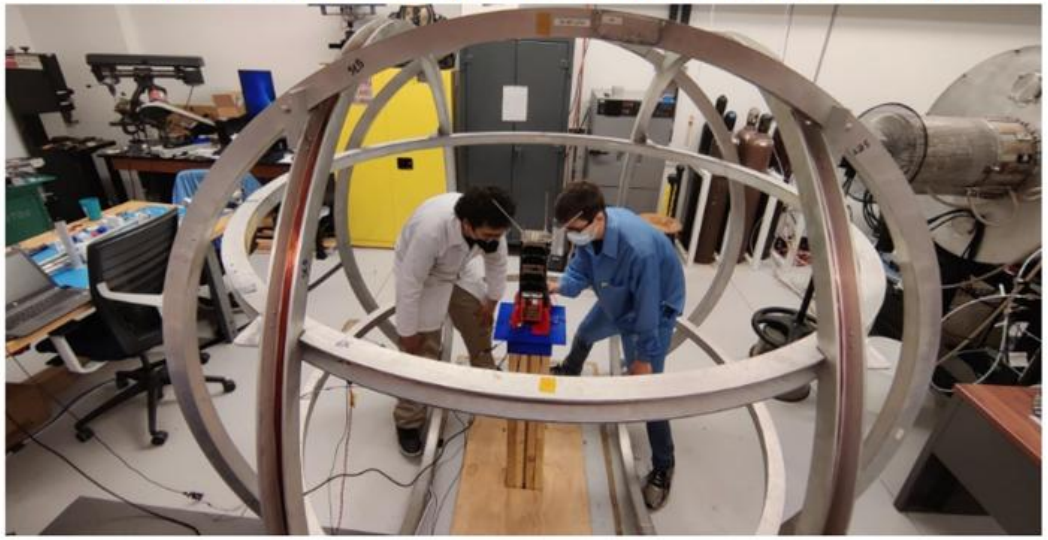
Embry-Riddle-Developed Instruments Headed for Space

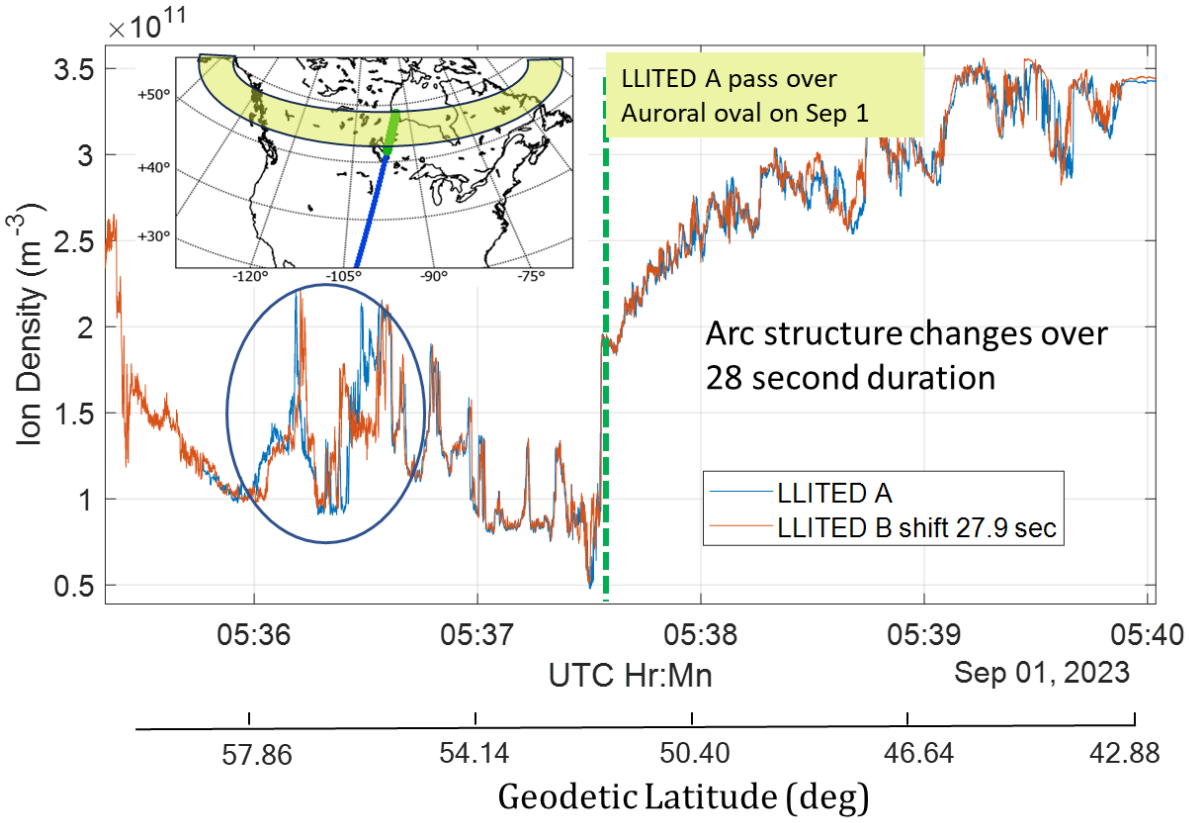


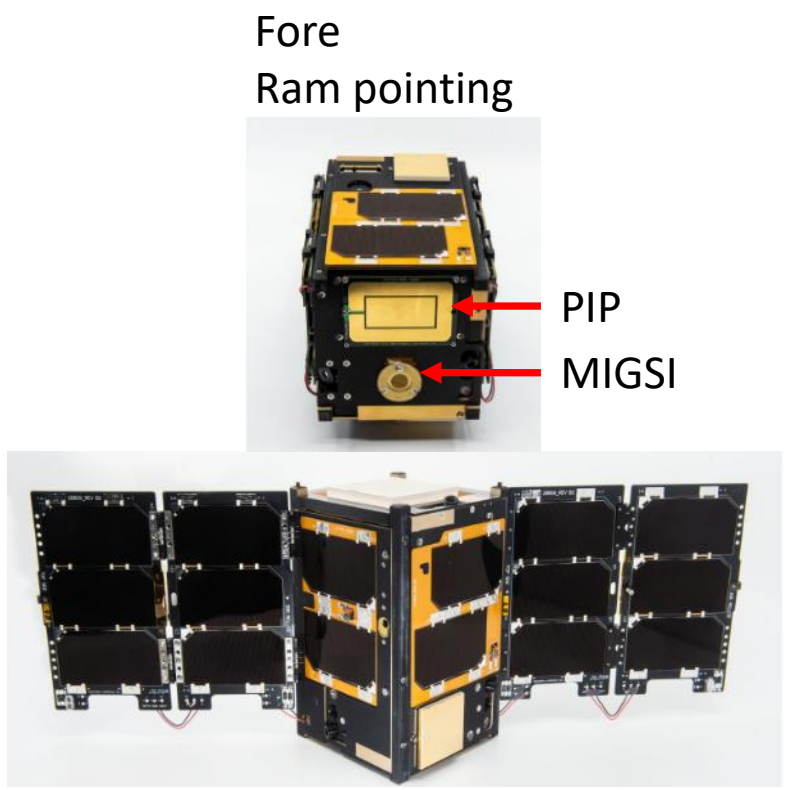
University of Chile graduate student Cristóbal Garrido Cáceres (left) and Embry Riddle Engineering Physics senior Joshua Milford conduct a complete satellite magnetic characterization inside of a room-sized Helmholtz cage. (Photos: Bernard Wilchusky/Embry-Riddle)

CSAR/SAIL… CubeSat Missions

(Aroh Barjatya, barjatya@erau.edu; Robert Clayton claytor8@erau.edu; Dr. Shantanab Debchoudhury debchous@erau.edu)

- SAIL was also part of the NASA LLITED dual 1.5U Heliophysics mission from 5/2023 to 10/2024
- First simultaneous plasma density observations from satellites separated by as little as 3 – 30 sec

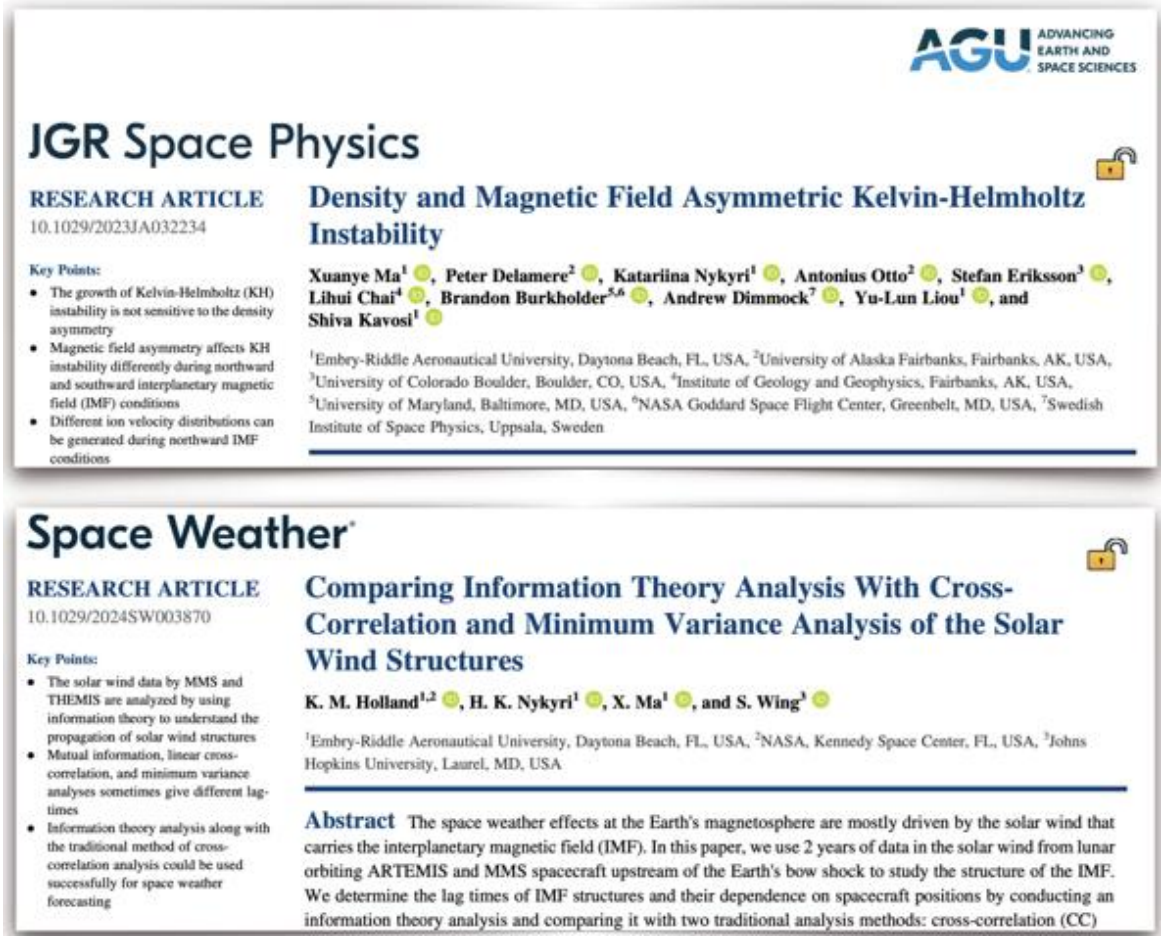




CSAR/LaSMIR… Solar/Magnetosphere Physics

(H. Katariina Nykyri, nykyrik@erau.edu; Xuanye Ma, max@erau.edu)

- NASA and NSF supported high-resolution computational modeling of plasma processes in ideal and resistive MHD simulations.
- **Fundamental Physics** – Kelvin Helmholtz instability, cross wave coupling, and instrument diagnostics of solar wind and magnetosphere coupling.
- **Space weather** – Interpretation of solar wind data to assess potentially disruptive events to space assets.



JGR Space Physics

RESEARCH ARTICLE
10.1029/2023JA032234

Density and Magnetic Field Asymmetric Kelvin-Helmholtz Instability

Key Points:
- The growth of Kelvin-Helmholtz (KH) instability is not sensitive to the density asymmetry
- Magnetic field asymmetry affects KH instability differently during northward and southward interplanetary magnetic field (IMF) conditions
- Different ion velocity distributions can be generated during northward IMF conditions

Xuanye Ma[1], Peter Delamere[2], Katariina Nykyri[1], Antonius Otto[2], Stefan Eriksson[3], Lihui Chai[4], Brandon Burkholder[5,6], Andrew Dimmock[7], Yu-Lun Liou[1], and Shiva Kavosi[1]

[1]Embry-Riddle Aeronautical University, Daytona Beach, FL, USA, [2]University of Alaska Fairbanks, Fairbanks, AK, USA, [3]University of Colorado Boulder, Boulder, CO, USA, [4]Institute of Geology and Geophysics, Fairbanks, AK, USA, [5]University of Maryland, Baltimore, MD, USA, [6]NASA Goddard Space Flight Center, Greenbelt, MD, USA, [7]Swedish Institute of Space Physics, Uppsala, Sweden

Space Weather

RESEARCH ARTICLE
10.1029/2024SW003870

Comparing Information Theory Analysis With Cross-Correlation and Minimum Variance Analysis of the Solar Wind Structures

Key Points:
- The solar wind data by MMS and THEMIS are analyzed by using information theory to understand the propagation of solar wind structures
- Mutual information, linear cross-correlation, and minimum variance analyses sometimes give different lag-times
- Information theory analysis along with the traditional method of cross-correlation analysis could be used successfully for space weather forecasting

K. M. Holland[1,2], H. K. Nykyri[1], X. Ma[1], and S. Wing[3]

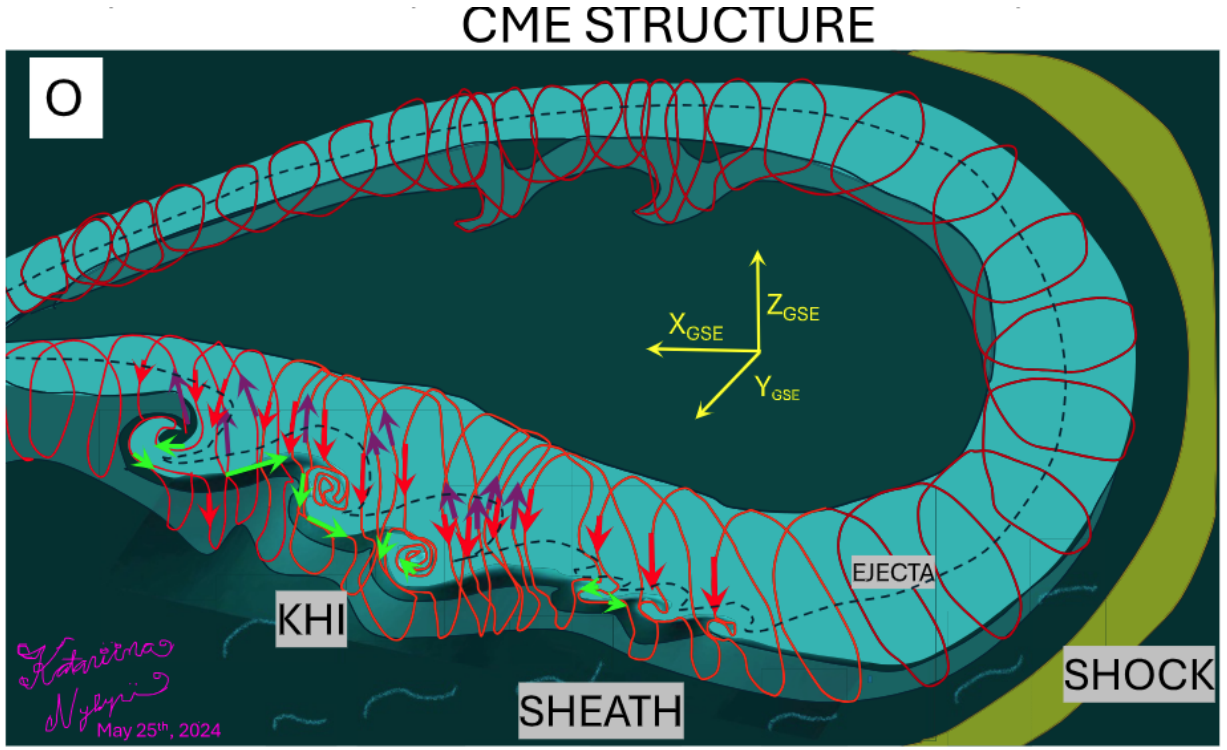
[1]Embry-Riddle Aeronautical University, Daytona Beach, FL, USA, [2]NASA, Kennedy Space Center, FL, USA, [3]Johns Hopkins University, Laurel, MD, USA

Abstract The space weather effects at the Earth's magnetosphere are mostly driven by the solar wind that carries the interplanetary magnetic field (IMF). In this paper, we use 2 years of data in the solar wind from lunar orbiting ARTEMIS and MMS spacecraft upstream of the Earth's bow shock to study the structure of the IMF. We determine the lag times of IMF structures and their dependence on spacecraft positions by conducting an information theory analysis and comparing it with two traditional analysis methods: cross-correlation (CC)

CSAR/LaSMIR… Space Weather Mission Design

(H. Katariina Nykyri, nykyrik@erau.edu; Xuanye Ma, max@erau.edu)

- LaSMIR's recent focus is on aiding in space mission design that will develop advanced space weather warning systems.
- Recent study motivated the need for space weather monitors upstream of Earth-Sun L1 point.



Geophysical Research Letters

RESEARCH LETTER
10.1029/2024GL110477

Key Points:

- Velocity shear at the boundary of a coronal mass ejection (CME) ejecta created Kelvin-Helmholtz Instability (KHI) ~7 million km upstream the Earth-Sun L-1 point
- KHI generated multi-scale density and IMF b_z fluctuations from −60 to +40 nT at the boundary layers of the CME ejecta encounters

Giant Kelvin-Helmholtz (KH) Waves at the Boundary Layer of the Coronal Mass Ejections (CMEs) Responsible for the Largest Geomagnetic Storm in 20 Years

Katariina Nykyri[1]

[1]NASA Goddard Space Flight Center, Greenbelt, MD, USA

Abstract Starting in the evening of 10 May 2024 the Earth's magnetosphere was hit by the coronal mass ejections (CMEs) creating the largest geomagnetic storm in ~20 years. The CME encounter was characterized

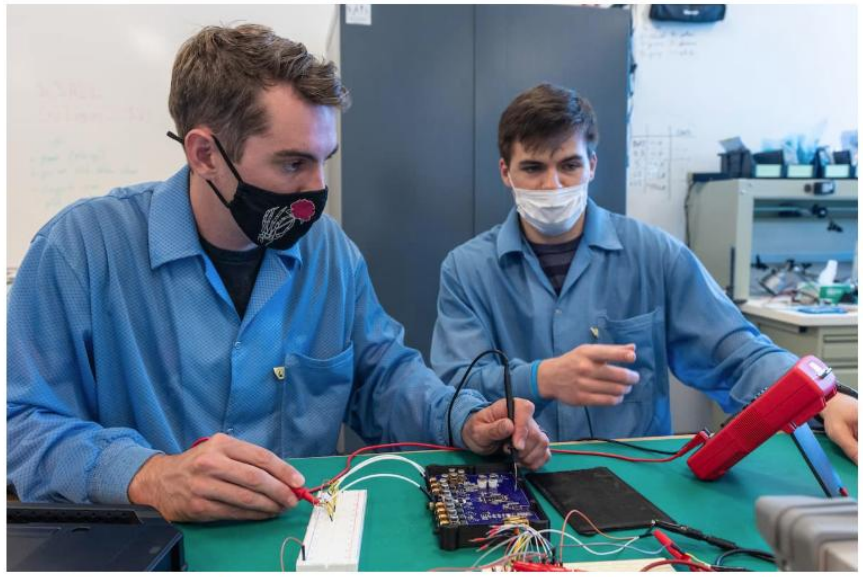
CSAR/SAIL… ESCAPADE Mars Mission

EMBRY-RIDDLE Aeronautical University

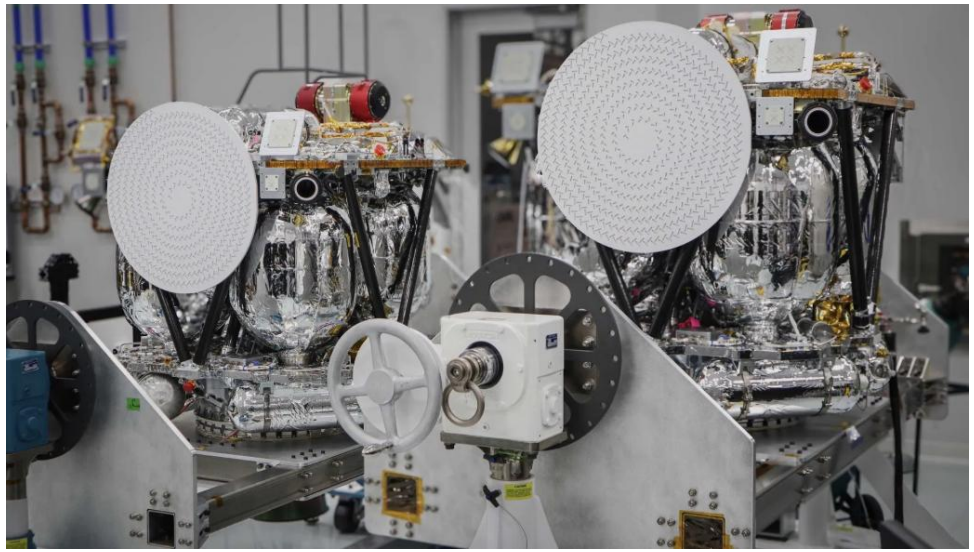
(Aroh Barjatya, barjatya@erau.edu; Robert Clayton claytor8@erau.edu; Dr. Shantanab Debchoudhury debchous@erau.edu)

- SAIL has instruments on the NASA ESCAPADE Mars Mission; launch this Fall on New Glenn 2
- SAIL instruments will measure the thermal plasma in the Martian ionosphere

Eagles Build Instruments for Mars-Bound Satellites



Embry-Riddle Ph.D. candidates Henry Valentine and Nathan Graves work on circuit boards in the Space and Atmospheric Instrumentation Lab (SAIL) that they hope will one day run equipment on Mars . (Photo: Embry-Riddle/Daryl LaBello)

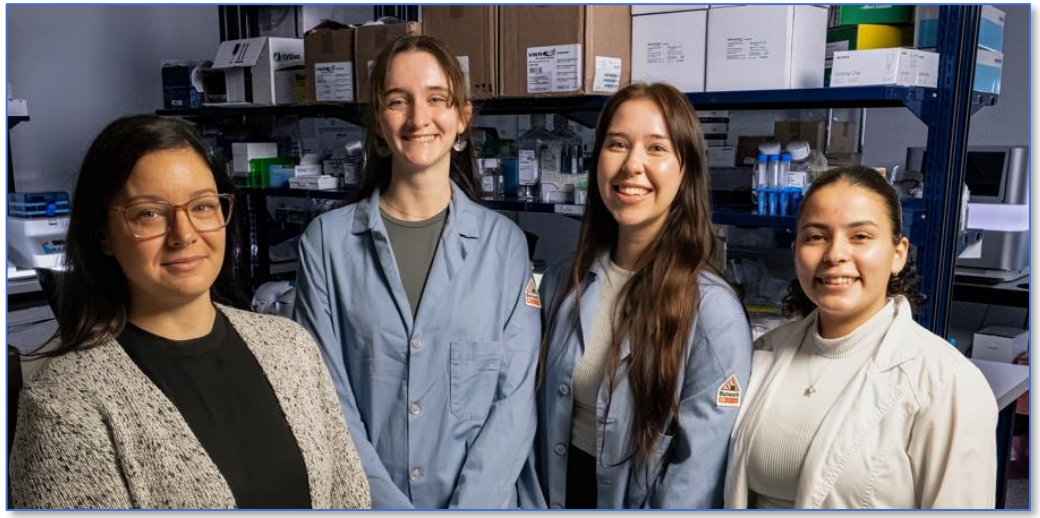


OMICS Lab

(Amber Paul, paula6@erau.edu)

- Characterize the influence of spaceflight on human physiology and biology. Omics Lab assesses genomic (i.e. DNA methylation) and transcriptomic (i.e. total RNA) samples collected from spaceflight missions and ground analogs.

- Recent spaceflight experiment: Polaris Dawn Orbiting Mission (SpaceX) in September 2024, ISS Flight Mission in November 2023.



Current Members of the Omics Lab

Embry-Riddle Space Biology Research Featured in Landmark Publication by Nature

Dr. Amber Paul (right) works with Carol Mitchell, a student researcher in Paul's Omics Lab for Health and Human Performance who was a co-author on research published in a Nature compendium of space biology papers (Photo: Embry-Riddle/Bernard Wilchusky)

Michaela Jarvis / Jun 27, 2024, 11:03 AM

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SPACE Lab

(Emel Sen Kilic, senkilie@erau.edu, Cassandra Juran, juranc@erau.edu)

- Space Physiology Antibody and Cellular Engineering (SPACE) Laboratory addresses regenerative biology and immunology to support spaceflight health.

- Lab focuses on developing innovative therapeutics for diseases, infections, and countermeasures for spaceflight by leveraging advanced techniques such as Tissue Chip (TC) and Micro-Physiological System(MPS) Engineering, Antibody Engineering, Microgravity simulation, etc.


Eagle Undergrad's Research on 'Space Mice' Tops National Conference

Dr. Amber Paul, Wessel Endowed Chair assistant professor of Aerospace Physiology in the Human Factors and Behavioral Neurobiology Department, mentors Aerospace Physiology senior Olivia Siu in Embry-Riddle's Omics Lab for Health and Human Performance. (Photo: Embry-Riddle/Daryl Labello)

Mike Cavaliere / Apr 04, 2022, 8:45 AM

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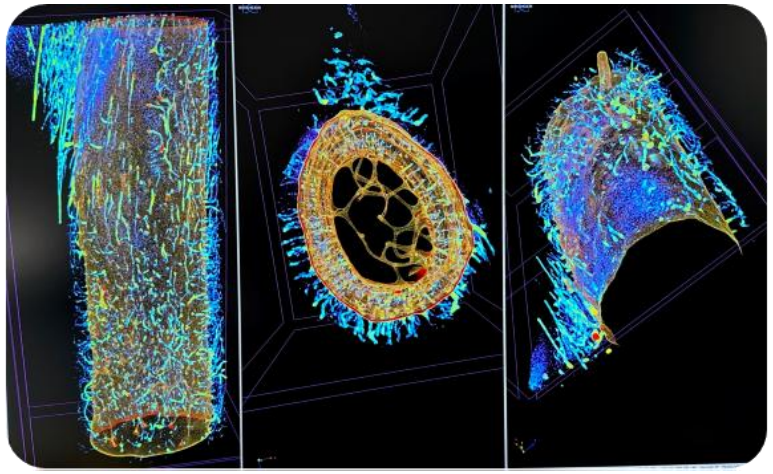

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Q&A

For engaging with CSAR, assessing if your research aligns with CSAR's mission and how the Center can help, please reach out to:

Dr. Aroh Barjatya – barjatya@erau.edu
Interim Executive Director - CSAR