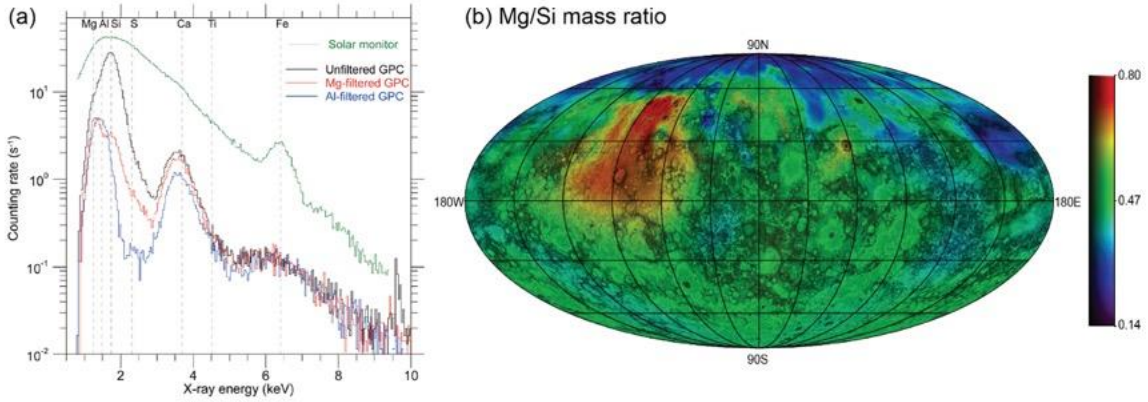
ERTH 404 FALL 2020
TR 1:30 to 4:20 pm
POST 544, Planetary Data Center
Chemistry of Planetary Surfaces
CRN 79308



A solar flare solar monitor (SAX) spectrum, corresponding Gas Proportional Counter (GPC) X-ray spectra of filtered and unfiltered detectors, and a final data product Mg/Si map of Mercury as obtained by MESSENGER are presented side by side. The two endpoint products, recorded spectra and global elemental abundance (elemental ratio) maps illuminate sophistication and success in elemental mapping with planetary X-ray fluorescence spectrometry.

Figure a) shows an example of an averaged solar monitor spectrum and corresponding XRS spectra obtained from a solar flare (26 October 2013, from 9:32 through 9:36 UTC) (MESSENGER X-Ray Spectrometer Calibrated Data Record archived at NASA's Planetary Data System) with a flare temperature of 14.9 MK (Weider et al. 2015). X-ray spectra of each of the three GPCs are shown in black for the unfiltered, in red for the Mg-filtered, and in blue for the Al-filtered detector; backgrounds have not been subtracted. The solar monitor spectrum shows a drop off at energies less than 2 keV due to a decrease in efficiency caused by the detector's Be-window. The SAX spectrometer resolution at the time of measurement was in the order of 635 eV at 6.49 keV (Starr et al. 2016). The response of the SAX Si-PIN detector shows the 6.4 keV Fe emission line from highly ionized Fe atoms in the solar corona. From this spectrum best-fit solar coronal emission can be calculated using CHIANTI5.2 (Landi et al. 2006). During flares, Mercury surface fluorescence from elements up to Fe is observed.

Figure b) presents a map of the Mg/Si elemental weight ratio derived from MESSENGER X-Ray spectrometer measurements (MESSENGER X-Ray Spectrometer Reduced Data Record archived at NASA's Planetary Data System). Construction of the map is based on solar flare and quiet sun X-ray spectra.

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This course will be taught together with EPET 301, Space Science & Instrumentation. Students enrolled in ERTH 404 will have to complete all EPET 301 course requirements plus one term paper on a special topic in planetary remote sensing. All requirements are outlined in this syllabus.

Office Hours: by appointment.

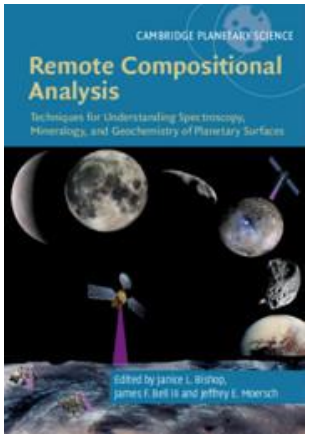
Course Description: *Essential techniques for remote compositional analysis of planets; understanding spectroscopy, mineralogy, and geochemistry of planetary surfaces. Comparative studies of fundamental planetary science phenomena. Planetary surface science discoveries. Sustainability of planetary environments.*

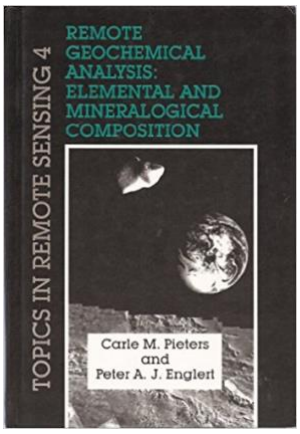
Number of Credits: ERTH 404 is a four-credit lecture/laboratory course.

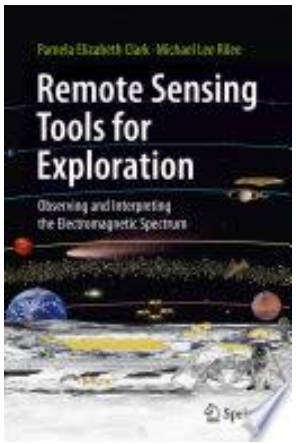
Prerequisites: ERTH 101, or ERTH 105, or ERTH 107, or ASTR 150, and CHEM161, MATH241, MATH242, PHYS 272, or consent.

Class contact hours: Two 3-hour meetings per semester week

Textbooks:







Remote Compositional Analysis: Techniques for Understanding Spectroscopy, Mineralogy, and Geochemistry of Planetary Surfaces, Editors: Janice L. Bishop, Jeffrey E. Moersh, and James F. Bell, III. Publisher: Cambridge
University, 2019.

Remote Geochemical Analysis: Elemental and Mineralogical Composition, Carle M. Pieters and Peter A.J. Englert, Cambridge University Press 1993.

Remote Sensing Tools for Exploration: Observing and Interpreting the Electromagnetic Spectrum, Pamela Elizabeth Clark and Michael Lee Rilee, Springer, 2010.

A copy of each textbook will be available for class use.

Course Materials and Laulima Website: At the beginning of the semester or a major instructional section, instructional materials will be posted on Laulima in the ERTH 404/EPET 301 resources folders.

Course Structure: The course is structured into learning modules generally aligned with semester weeks. The lecture/laboratory course structure allows about 50% of instruction time for lectures and lecture activities and about 50% for laboratory activities and course project activities. ERTH 404/EPET 301 project activities focus on the conceptualization and design of space instruments able to complete defined space mission objectives. The ERTH 404/EPET 301 class project designs will be used in the EPET 401 Capstone Projects.

Course Delivery: The main elements of course delivery are mini-lectures, guided group discussions, and project-based learning activities. Students are engaged in studying foundational publications in the field of planetary science and are asked to critically evaluate research design, data acquisition, and data analysis and research outcomes.

The laboratory component of the course is characterized by the integration of theory and practice. In the initial weeks break-out group work and group discussions focus on real problems underpinning lecture topics. Each of the break-out groups reports on the result of their exercises, leading to the advancement of the session topic. Later in the semester, break-out group work will increase in time to about half of the time assigned to the lecture component on a weekly basis.

Learning objectives are integrated through and culminate in a group-based research project: the design of an instrument for a planetary exploration mission. The requirement is to provide a design and proof of concept. Where possible, a functional prototype, that can be used during the EPET 401 Capstone Projects, will be built.

Class contact hours: The class period combines lecture and laboratory all in one. Each meeting is about 3 hours long to allow time for brief lectures, exercises, collaborating on projects, analyzing data, and testing hypotheses. We anticipate that group project work will take place during the class period, but some work on projects needs to be completed outside of class time.

Learning Objectives/Course Objectives

University-Level Learning Objectives

The design and structure of the course delivers learning outcomes aligned with the University of Hawai‘i Institutional Learning Objectives for Undergraduate Students. The course:

- Gives in depth experience in the conduct of scientific inquiry and research
- Engages students in continuous practice with critical and creative thinking
- Is structured around procedures of conducting research in Earth and planetary science
- Engages students through intensive interaction with instructors and peers by means of classroom activities and projects
- Directly cultivates the habits of scholarly inquiry and intellectual curiosity, including inquiry across disciplines

Department-Level Learning Objectives

- Students can explain the relevance of space science instrumentation outcomes to human needs
- Students can apply knowledge of relevant research methods, and the supporting disciplines to solve real world problems
- Students use the scientific method to define, critically analyze, and solve a problem in solar system exploration
- Students can report solar system exploration knowledge in both oral presentations and written reports
- Students can evaluate, interpret, and summarize the basic principles of solar system science, and their context in relationship to other core sciences to explain complex phenomena

Course-Level Student Learning Objectives:

1. Explain how the Scientific Method works, apply it to evaluate good versus bad science, and to analyze and assess data and draw conclusions about the world
2. Develop a better understanding and appreciation for the world we live and our solar system.
3. Improve cooperation, communication, and teamwork skills by collaborating in writing, presenting, and displaying data to communicate your knowledge, analysis and synthesis of data and ideas, and assessment of what they mean.

Topics
Exact content and order of topics will depend on progress and student interest:
Overview over remote sensing
Principal planetary surface components
Optical camera modalities
Visible and circum-visible remote sensing
Raman spectroscopy of planetary surfaces
High energy spectroscopy of planetary surfaces
Long wavelength remote sensing
Extraterrestrial materials laboratory analysis
Data and information processing

Grading of Homework: Homework will count 10% toward your grade.

Grading of Term Paper: The term paper will count 10% toward your grade.

Grading of Group Projects: Group project teams will be established through class discussion led by the instructors. Each group will work on a planetary remote sensing instrument project. At the start of the project, a grading rubric will clearly establish how each project will be graded. Grading will vary slightly with each project.

A group project will count 80% towards your grade. Overall project grading will be broken down into components that will add up to the final grade percentage. The anticipated components are: External project briefing reports (paper) 15%; Group project definition, preliminary design review (paper and presentation) 15%; Final design review (paper and presentation) 15%; Proof of concept (and/or prototype production) (paper and presentation) 35%.

Grading: Grading is not curved and therefore everyone can potentially get an A. Grades are greatly weighed by the group project components. Grading will be based on homework and each individual's grades in the group project components.

Percentage	Activity
10%	Homework
10%	ERTH 404 Term Paper
80%	Individual's Grade on Group Project

Letter grade breakdown:
A- = 90 – 92%, A = 93 – 96%, A+ = 97 – 100%
B- = 80 – 82%, B = 83 – 86%, B+ = 87 – 89%
C- = 70 – 72%, C = 73 – 76%, C+ = 77 – 79%
D- = 60 – 62%, D = 63 – 66%, D+ = 67 – 69%
F = < 60%

In-Group Participation: Your group's assessment of your participation in and contribution to each project will impact your individual project grade.

Other Group Assessments: Each group will also be provided an opportunity to give formative and summative assessment of the other group's projects. These assessments will NOT formally count toward your grade. They are part of the process of learning what makes a good presentation of a science project as it adds another perspective. Your peers from other groups will likely give you helpful comments that will allow you to improve your presentation (both written and oral), which will allow your group to get a higher grade.

Extra Credit: Opportunities for extra credit will be announced during the semester.

Plagiarism
You will be preparing short written reports and short oral presentations for each project. DO NOT JUST COPY text from the Internet or from a book without a citation. Put your findings in your own words. Plagiarized text in a group report will result in a grade reduction by 2 levels (e.g., grade drop from an A to a C) for the first occurrence. A second occurrence will result in a zero for that project.

Other Resources
Disability Access:
The Earth Science Department will make every effort to assist those with disability and related access needs. For confidential services, please contact the Office for Students with Disabilities (known as "KOKUA") located in the Queen Liliʻuokalani Center for Student Services (Room 013): 956-7511, kokua@hawaii.edu, www.hawaii.edu/kokua

Learning Assistance Center (LAC) is here to help students:

- Use appropriate study skills to achieve academic goals.
- Learn how to adjust learning approaches to fit their individual learning needs.
- Learn how to study effectively with others.
- Use effective learning practices.
- Use self-reliant learning behaviors.
- Have a functional understanding of course content. www.manoa.hawaii.edu/learning

Gender-Based Discrimination or Violence
University of Hawaiʻi is committed to providing a learning, working and living environment that promotes personal integrity, civility, and mutual respect and is free of all forms of sex discrimination and gender-based violence, including sexual assault, sexual harassment, gender-based harassment, domestic violence, dating violence, and stalking. If you or someone you know is experiencing any of these, the University has staff and resources to support and assist you. Staff can also direct you to community resources. Here are some options:

- If you wish to speak with someone **CONFIDENTIALLY**, contact the confidential resources available here: http://www.manoa.hawaii.edu/titleix/resources.html#confidential
- If you wish to **REPORT** an incident of sex discrimination or gender-based violence, contact: **Dee Uwono**, Title IX Coordinator, Hawaiʻi Hall 124, t9uhm@hawaii.edu, (808) 956-2299
- **As members of the University faculty, your instructors are required to immediately report any incident of potential sex discrimination or gender- based violence to the campus Title IX Coordinator.** Although the Title IX Coordinator and your instructors cannot guarantee confidentiality, you will still have options about how your case will be handled. Our goal is to make sure you are aware of the range of options available to you and have access to the resources and support you need.