Electromagnetic Spectrum and Multi-wavelength Astronomy

Learning Plan
Day 6: How do astronomers use images in research?

Targeted Idea: Images provide a great deal of information about objects in the Universe.

Overview of Day 6:

Astronomy is unlike other sciences in that investigators cannot change the variables of an experiment or collect physical materials to measure properties of the objects under study (with a few exceptions, such as the Moon and Earth). Astronomers are almost entirely dependent on studying the light from celestial objects. A variety of tools are used to collect this light, to receive the data from these instruments, and to process the data. After those steps, investigators can analyze and interpret the images. Astronomers can compare the images to other similar objects to look for patterns; other times, they make measurements on the photos and plot the brightness data. Investigators can maximize the study of objects by collecting data in multiple wavelengths of the electromagnetic spectrum.

In this activity, students examine a variety of astronomical images. They practice respectfully providing critiques on the scientific arguments of peers. In groups, they make and defend a claim based on evidence. They begin with easy to interpret optical images, and eventually move toward examining IR images, both printed images and images from the IR camera.

Students will build upon these prior Middle School Performance Expectations (PEs) and Disciplinary Core Ideas (DCIs) in Day 6:

PE MS-PS4-2 Waves and their Applications in Technologies for Information Transfer
Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. [Clarification statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.]

DCI MS-PS4.A Wave Properties
A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.

DCI MS-PS4.B Electromagnetic Radiation
When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.

Students will build their understanding toward the following High School DCIs during Day 6:

PS4.A Wave Properties
Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory ~~and sent over long distances as a series of wave pulses~~.

PS4.C Information Technologies and Instrumentation
Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.

Students are building their skills in / understanding of these Science and Engineering Practices (SEPs) and Cross Cutting Concepts (CCCs) in Day 6:

SEPs

Engaging in Argument from Evidence
- Evaluate claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
- Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.

Constructing Explanations
- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
- Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

CCCs

Patterns
- Empirical evidence is needed to identify patterns.

Instructional Materials	Resources
Handouts: • Science Case Study: Milky Way CircumNuclear Ring (CNR) • Orion lithograph **Materials:** • Color copies of photos (suggestion: laminate or put into protective sleeves) • IR camera	• Day 6 PowerPoint • Day 6 Teacher Support Notes
Teacher Role	**Student Role**
• Emphasize student use of evidence and reasoning. Model this for the first few images, so that students see how to push each other for more evidence and reasoning. • If disagreements happen, encourage students to have respectful, evidence-based discussions. • Embrace that this is an opportunity for students to disagree and engage in scientific argumentation. • Remember that more the participants respectfully push each other to cite evidence to support their claims, the more they will be engaged in this practice.	• Carefully observe images, and state claims that are supported by evidence. • Contribute to group discussions. • Listen to peer ideas. • Respectfully challenge peers when they make unsupported statements. • Add supporting evidence to peer claims to improve strength of their claim. • Be willing to change mind if there are stronger arguments presented.

Steps to follow:

1) Briefly discuss homework writing assignment.

2) *Engage:* Project Image #1 (Gruyeres, Switzerland). Ask students to imagine that they are sitting around the table with fellow planetary scientists trying to make sense of a planetary surface image they are seeing for the first time.

3) Together as a class, ask for a few students to share what they are seeing in the image. Challenge unsupported statements, and model how to do this respectfully, by asking questions such as:
   - How do you know that?
   - Where have you seen another example of that?
   - What is it about the color, shape, orientation, etc. that leads you to say that?
   - Can you support that statement with some additional evidence or experience?
   - What might be another example of what you are describing?

Teacher note: Discourage statements like "that is snow on the mountains" or "that is a graveyard", reminding/redirecting students to give detailed reasoning to support claims. An example might be: "We are seeing snow on the top of a mountain, and green valley below. The white at the top of the peaks is snow. Temperature decreases with increasing altitude - this supports the idea that it is colder in places that are higher in the image. There is a point lower in altitude where the green coloration ends and the snow begins. This also supports the idea that it is colder at the higher elevations, and (if the green is vegetation) trees do not grow above this. I have seen this "tree line" in other mountain areas." Stop participants anytime they make assumptions, asking "how do you know that is ice? water? clouds? a man-made structure?" Push them to describe what it is about the item's shape, placement, color, orientation, and other details that can provide a clue about the nature of the object.

4) Ask students to make more detailed observations in groups (3 or 4) of what they are seeing in the image.
   - Students should talk at their tables and discuss what they think they are seeing in the image, and to use evidence and reasoning to support a claim of image's location.
   - Share out.

5) Remind students:
   - We / scientists must be able to justify our interpretations with sound, logical explanations.
   - Sometimes images are extremely challenging, strange or hard to interpret. First instincts may be completely incorrect.
   - We / scientists must keep an open mind, be willing to hear alternate arguments and change our minds if we hear stronger, more complete explanations.

6) *Explore:* Today, we will act as planetary scientists: Receiving new images, examining those images, asking questions about what we see, generating possible explanations, and ultimately deciding which are the strongest arguments.

- Distribute visible images (images 2-5) to the group.
- In your group, discuss the photos of objects in the Solar System.
- One team member should start by describing what they observe, then state one claim, and end with citing as much evidence as they can to support their claim.
- The other members in the group should follow the teacher's model of questioning, probing for more explanation, evidence, and examples.
- Switch roles during the discussion so each student has a chance to make a claim.
- Based on their observations and discussions, groups should make a claim of the Solar System object shown in each image. They should try to be as specific as possible in their claim.
- Groups should then place the images in order of their confidence in their claims.
- Share out. Allow time for other groups to challenge, ask questions, and share additional/ different observations/explanations to add. Use the Day 5 Claim Evidence Reasoning (CER) structure.

Teacher note: At this point, students may begin to ask for the "right answer". You may wish to share what is stated on the image summary page, but stress that for scientists, there is no "right" answer, but rather, a "best" answer- the one that is supported by the most data/evidence, and soundest logical reasoning. There is no book of right answers for scientists to consult!

7) *Extend:* Remind the students that they have been practicing their skills of image interpretation and constructing an evidence-based explanation of the new data. This is even harder when the data collected extend into wavelengths that our eyes can't detect. We are now going to try the same approach with images from different wavelengths. Give a short overview of representative color.
   - Distribute the infrared images (Images 6 - 10) to the group.
   - In your group, discuss the photos.
   - One team member should start by describing what they observe, then state one claim, and end with citing as much evidence as they can cite to support their claim.
   - The other members in the group should follow the teacher's model of questioning, probing for more explanation, evidence, and examples.
   - Switch roles during the discussion so each student has a chance to make a claim.
   - Based on their observations and discussions, groups should make a claim of the objects shown in each image. They should try to be as specific as possible in their claim.
   - Groups should then place the images in order of their confidence in their claims.
   - Share out. Allow time for other groups to challenge, ask questions, and share additional / different observations / explanations to add.

8) What sort of additional information can we gain from looking at two or more wavelengths? Use the Day 5 CER structure.

9) Spend remaining time demonstrating IR images with the IR camera. Encourage students to suggest objects in the classroom they would like to see in the infrared. (e.g., cups containing hot and cold water, sprayed mist on Plexiglas, computer behind garbage bag.) (Alert: Rayon clothing tends to be transparent in infrared. Use caution when showing images of students. Padded clothing can also show outlines of undergarments or other details of a potentially sensitive nature.)

10) Distribute Science Case Study (CircumNuclear Ring) and Orion lithograph.

11) *Assign homework:* Read the Case Study, add to the Case Studies graphic organizer, and read the back of the Orion lithograph.

Credit: Theresa Moody

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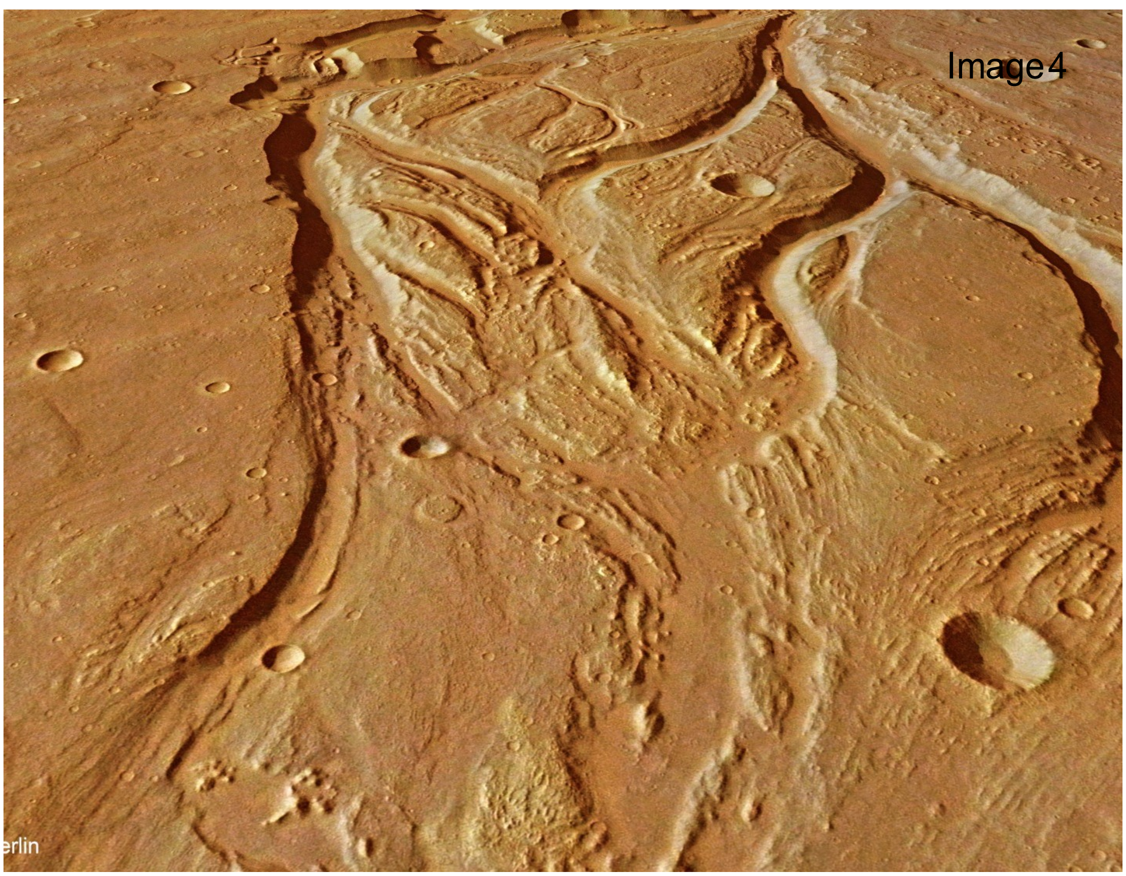
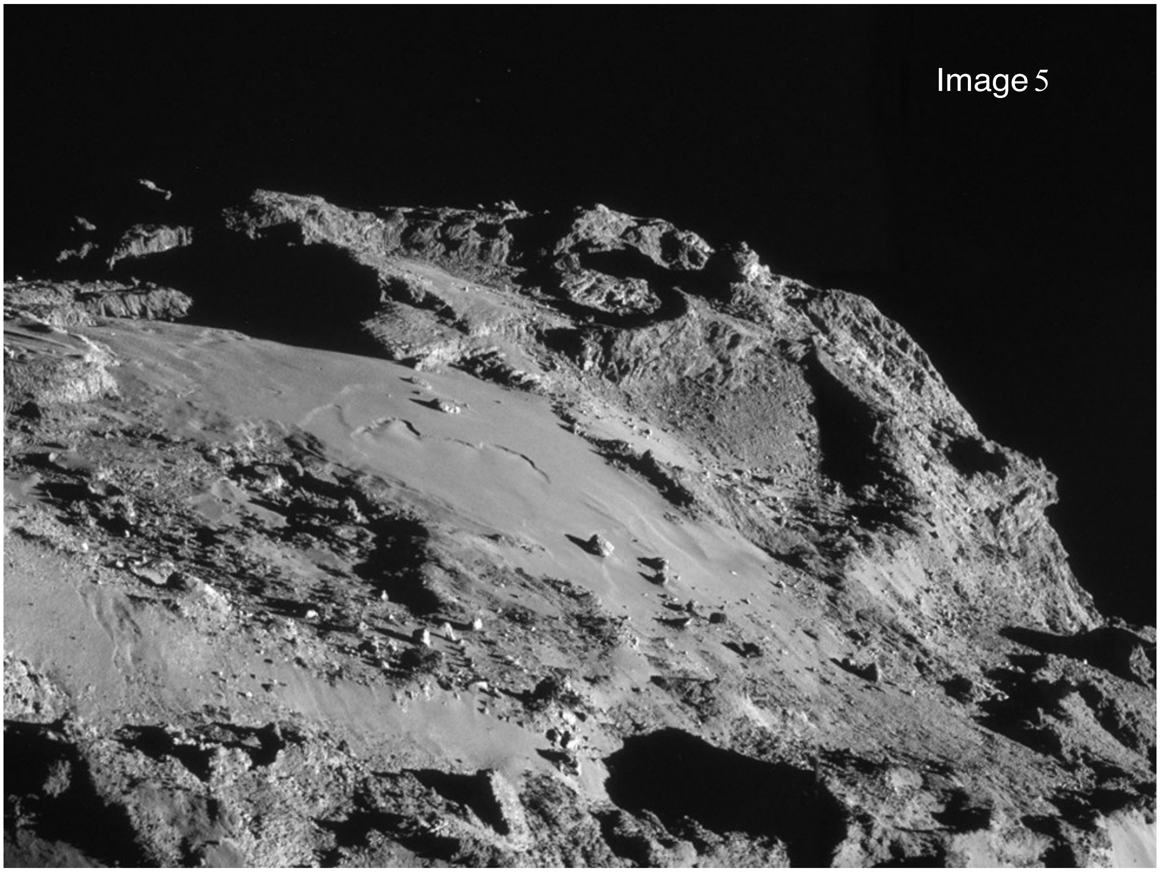
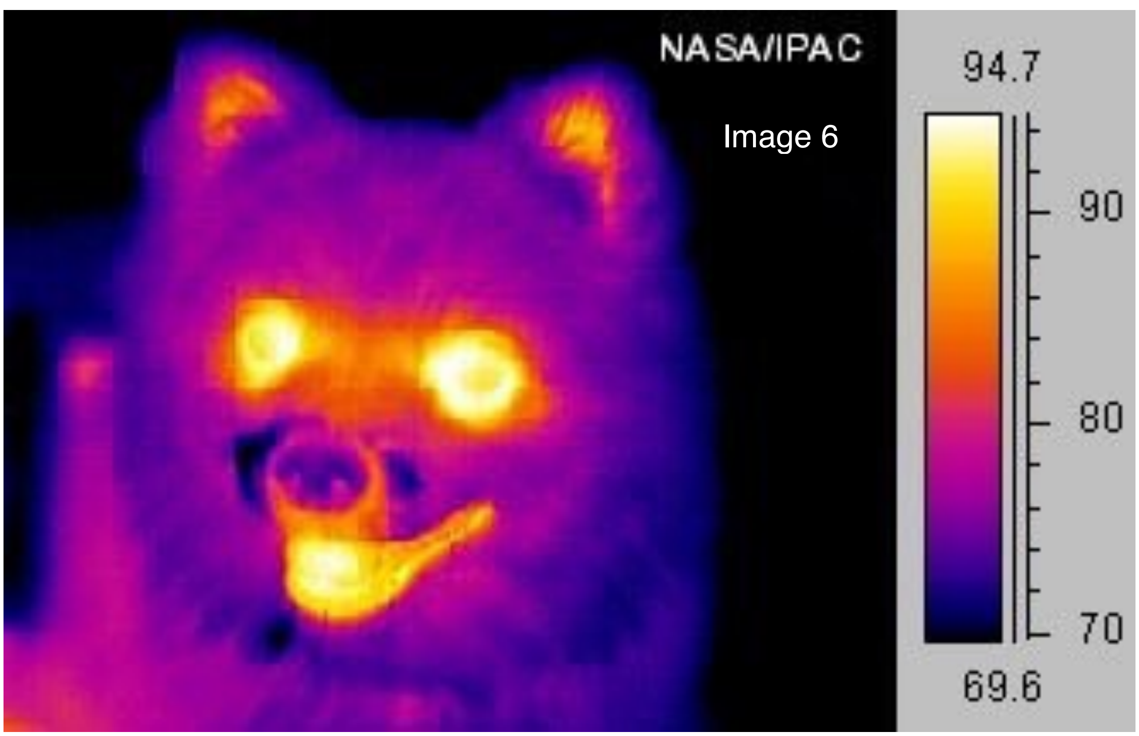
Credit: NASA MSL



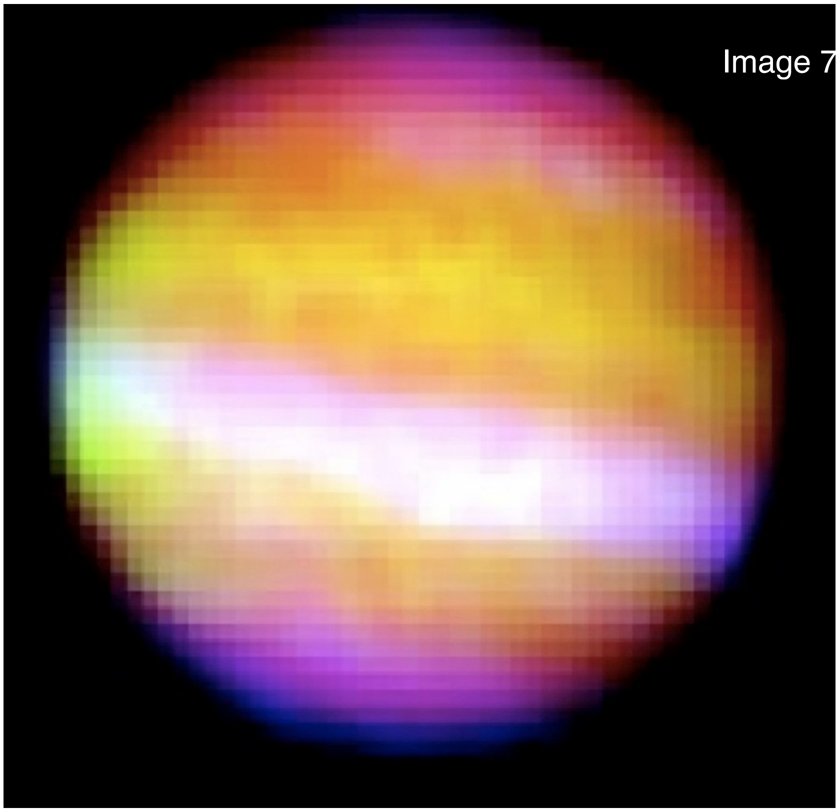
Credit: ESA Mars Express



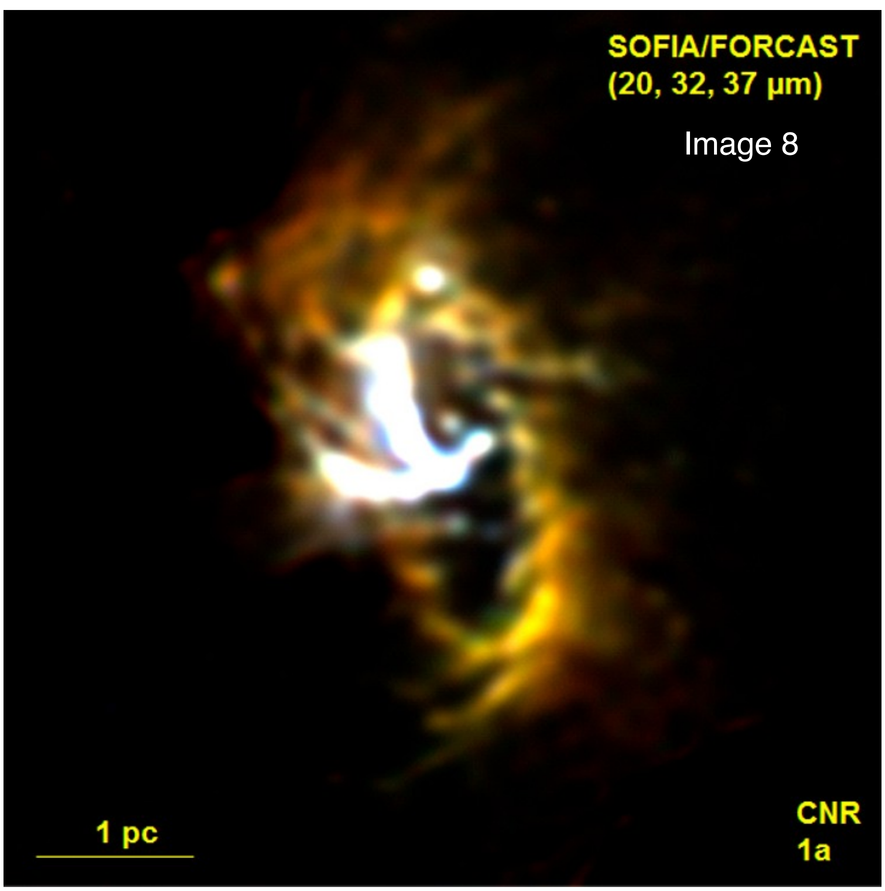
Credit: Rosetta Mission



Credit: IPAC Caltech

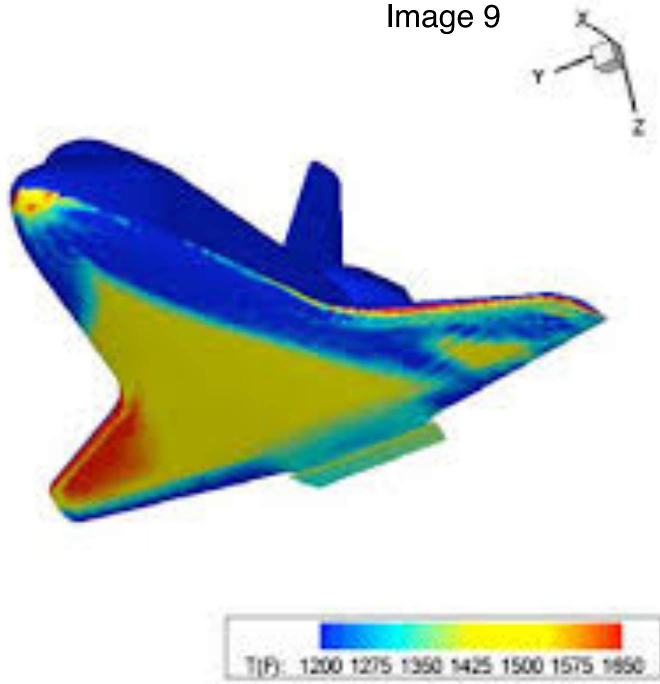


Credit: NASA/SOFIA/USRA/FORCAST Team/James De Buizer

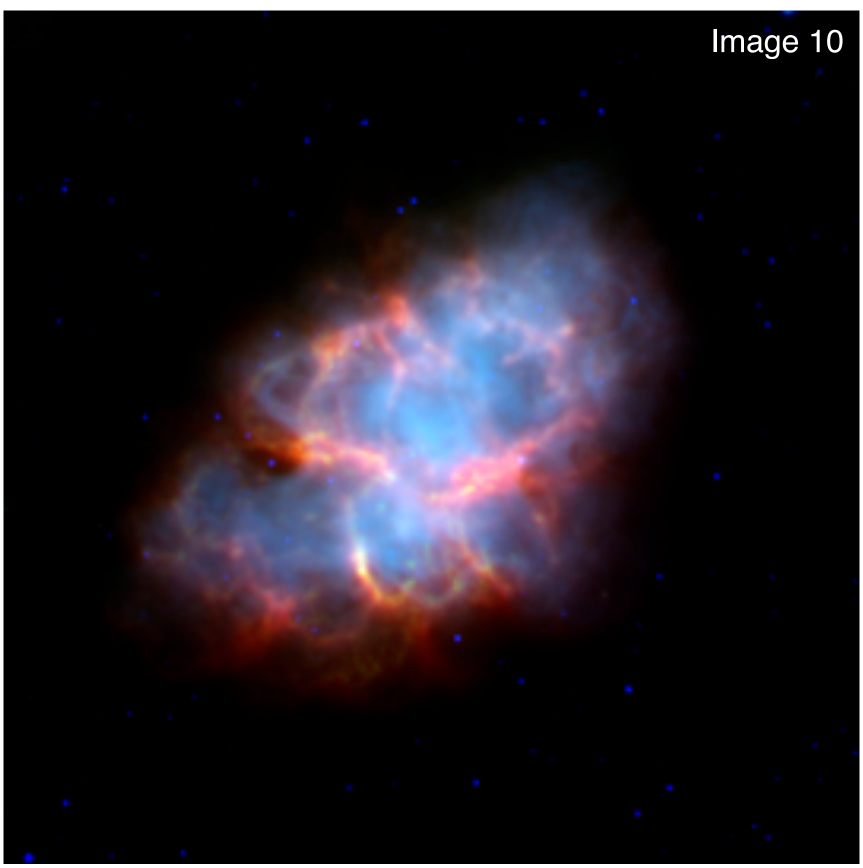


Credit: NASA/DLR/USRA/DSI/FORCAST Team/Lau et al

Image 9



Credit: NTRS NASA



Credit: IPAC Caltech

Infrared Light and Multi-wavelength Astronomy

Image 1

Image 2

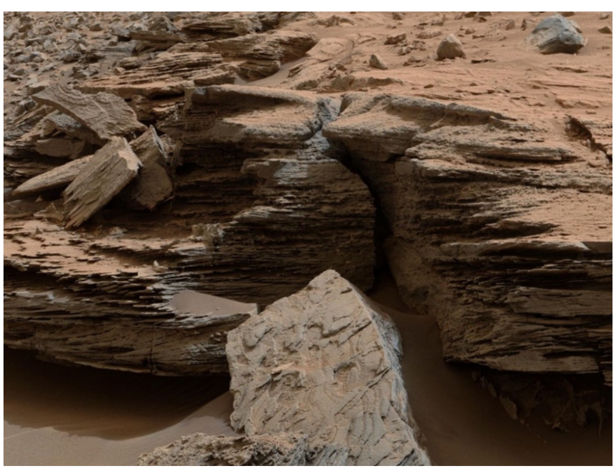
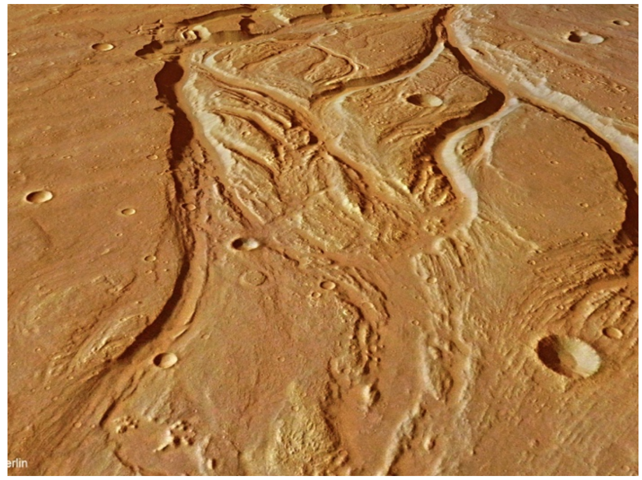


Image 3



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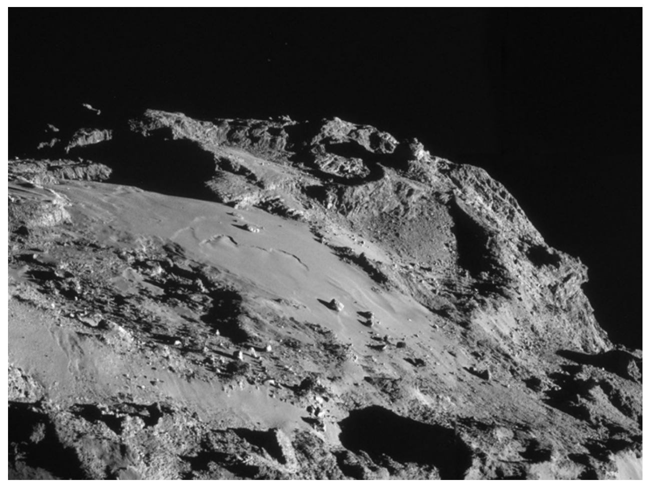

Image 5

Infrared Light and Multi-wavelength Astronomy

Image 6

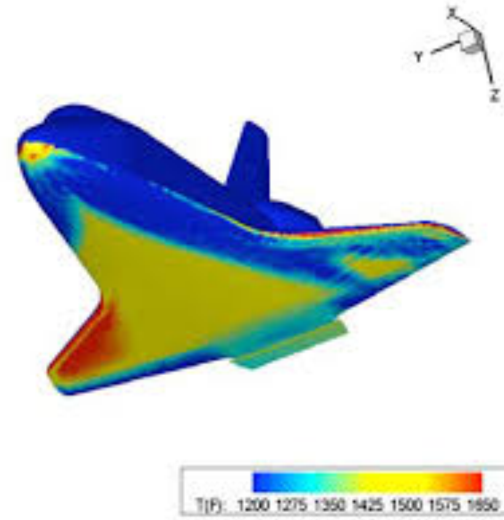

Image 9

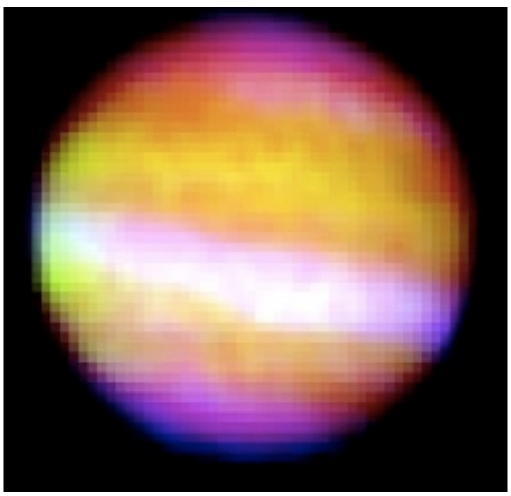
Image 7

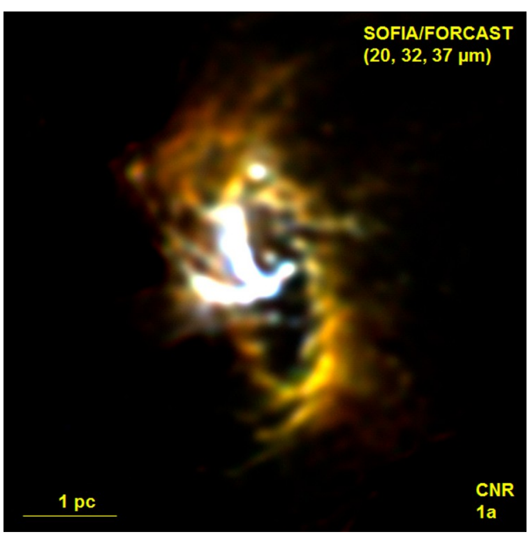

Image 8


Image 10

