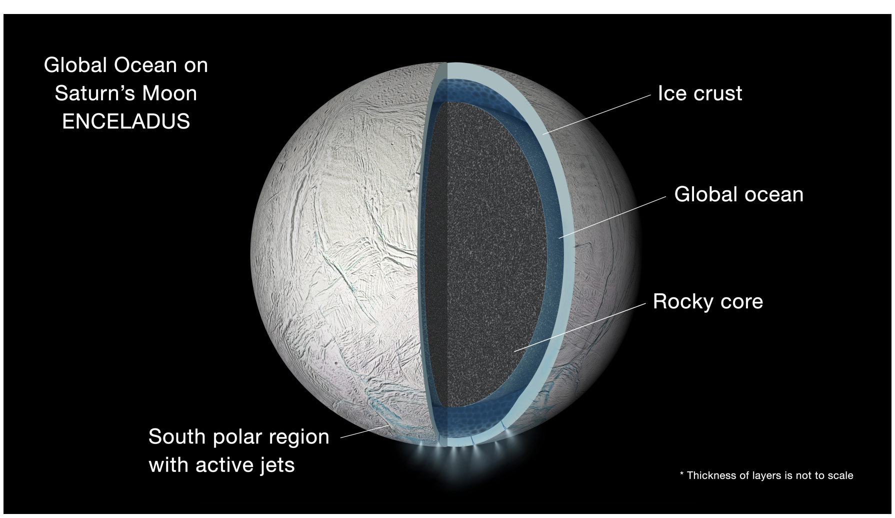
Cassini's Flyby of Enceladus: Teachable Moment

Here are a handful of lessons and resources you can use to teach key concepts related to the October 28 Enceladus flyby and help your students feel connected to this exciting moment in science at Saturn.

Modeling - NGSS 5-ESS2-1

Because scientists can't dig beneath the ice and see what's below, they rely on creating models that show what is happening beneath the surface. A model helps us imagine what can't be seen and explains the things that we can see and measure. A model could be a drawing, a diagram or a computer simulation. For this model, students will draw a cut away model of Enceladus and iterate, or improve, their model as you provide more description, just as scientists improved their models as they learned more about Enceladus.

1) Tell students there is a moon around Saturn. They should draw a moon (likely a circle, half-circle, or arc, depending on how big you want the drawing to be).
2) Explain to students that the moon is covered in a shell of ice (students will need to modify their model by drawing a layer of ice). Thus far, everything students are modeling is observable by looking at the moon.
3) Share with students that temperature measurements of the south pole revealed spots that are warmer than the rest of the moon's surface. Ask students to brainstorm possible sources of heat at the south pole and explain what might happen to ice near a heat source. Based on this new information, and what they think might be causing the heat, allow them to modify their drawing. (Depending on what students brainstorm, their drawing might now include volcanoes, hot spots, magma, hydrothermal vents and a pool of liquid water beneath the ice).
4) The next piece of information the students will need to incorporate into their drawing is that there are large cracks in the ice over the warmer south-pole region.
5) Explain that students have now received images that show jets expelling material from the cracks. They will need to incorporate this new data and add it to their drawing.
6) Tell students that by studying the gravity of the moon, scientists now believe there is an ocean covering the whole surface of the moon beneath the ice. Ask students to share how they would represent that in the model. Allow them to modify their drawing.
7) Show students the following image depicting a model of Enceladus.
   a. Global Ocean Model (http://photojournal.jpl.nasa.gov/figures/PIA19656_fig1.jpg) - this model shows what scientists believe the interior of Enceladus may look like. Have students compare it to what they drew and note similarities and differences.



Particle Travel Rate - CCSS.MATH 6.RP.A.3.B

Based on the size of the silica grains (6 to 9 nanometers), scientists think they spend anywhere from several months to a few years (a longer time than that means the grains would be larger) traveling from hydrothermal vents to space, a distance of 40 to 50 km.

1. What rate (in km/day) are the particles traveling if it takes them 6 months to travel 50 km (assume 182 days)?

   50 km ÷ 182 days = 0.27 km/day

2. What rate are they traveling if it takes two years to travel 40 km?

   40 km ÷ 730 days = 0.05 km/day

3. Do you think the particles in each example traveled at the same speed the entire time they moved?

4. Why might the particle rate vary? At what point in their journey might particles have been traveling at the highest rate?

Plume Data - CCSS.MATH 6.RP.A.3.B and 8.G.B.7

Cassini will be flying past Enceladus at a staggering 8.5 km per second (19,014 mph). At an altitude of 49 km, the plume is estimated to be approximately 130 km across.

How long will Cassini have to capture particles and record data while within the plume?

130 km ÷ 8.5 km/sec ≈ 15 seconds

If Cassini is 49 km above the surface of Enceladus at the center of the plume, what is its altitude as it enters and exits the plume (the radius of Enceladus is 252.1 km)?

252.1 km + 49 km = 301.1 km

$(301.1\ km)^2 + (65\ km)^2 \approx 95{,}000\ km^2$

$\sqrt{95{,}000\ km^2} \approx 308\ km$

308 km – 252.1 km ≈ 56 km

This information can help scientists determine where in the plume heavy particles may fall out if they are not detected on the edge of the plume but are detected closer to the middle of the plume. It is also important because the Cosmic Dust Analyzer uses a high-rate detector that can count impacting particles at over 10,000 parts per second to tell us how much material is being sprayed out.

Volume of Enceladus' Ocean - CCSS.MATH 8.G.C.9 and HSG.GMD.A.3

Gravity field measurements of Enceladus and the wobble in its orbital motion show a 10 km deep ocean beneath a layer of ice estimated to be between 30 and 40 km thick. If the mean radius of Enceladus is 252.1 km, what is the minimum and maximum volume of water contained within its ocean?

Volume of a sphere = $\frac{4}{3}\pi r^3$

Minimum volume with a 40 km thick crust

$\frac{4}{3}\pi 212.1\ km^3$ - $\frac{4}{3}\pi 202.1\ km^3$ ≈ *40,000,000 km*^{3} *– 35,000,000 km*^{3} ≈ *5,000,000 km*^{3}

Maximum volume with a 30 km thick crust

$\frac{4}{3}\pi 222.1\ km^3$ - $\frac{4}{3}\pi 212.1\ km^3$ ≈ *46,000,000 km*^{3} *– 40,000,000 km*^{3} ≈ *6,000,000 km*^{3}

This is important because if scientists know how much water is in the ocean and how much vapor is escaping through the plume, they can make estimates about how long the plume has existed -- or could continue to exist.

NGSS and CCM Standards

NGSS 5-ESS2-1 - Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact

CCSS.MATH 6.RP.A.3.B - Solve unit rate problems including those involving unit pricing and constant speed. For example, if it took 7 hours to mow 4 lawns, then at that rate, how many lawns could be mowed in 35 hours? At what rate were lawns being mowed?

CCSS.MATH 8.G.B.7 - Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions.

CCSS.MATH 8.G.C.9 - Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems.

CCSS.MATH HSG.GMD.A.3 - Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems.