


# Introduction

Hello!

We're excited to welcome you on your next field trip experience,

**Climate Control:** *Tracking greenhouse gases from space* 

This guide is designed to help inspire class projects, activities and discussions after your virtual field trip. Language Arts, Sciences, Geography, and Mathematics teachers will find new ideas to connect your existing lesson plans to your upcoming adventure.

[Discover more activities for you and your students to use before/during/after the trip!](#)

To help you wrap your mind around the system we are exploring, check out:

[System Map](#)

[Mind Map](#)

For a deeper dive, click on your subject below and explore some of the connected ideas to your curriculum:

[Language Arts](#)

[Science and Technology](#)

[Mathematics](#)

[Geography, Modern World and History](#)

Let us know about your experience bringing cross-disciplinary experiences to your school at [info@e2adventures.com](mailto:info@e2adventures.com)! For latest news about new field trips, [subscribe to our newsletter](#).

Rediscovering wonder together,

The E2 Adventures Team

[www.E2adventures.com](http://www.E2adventures.com)

# E2

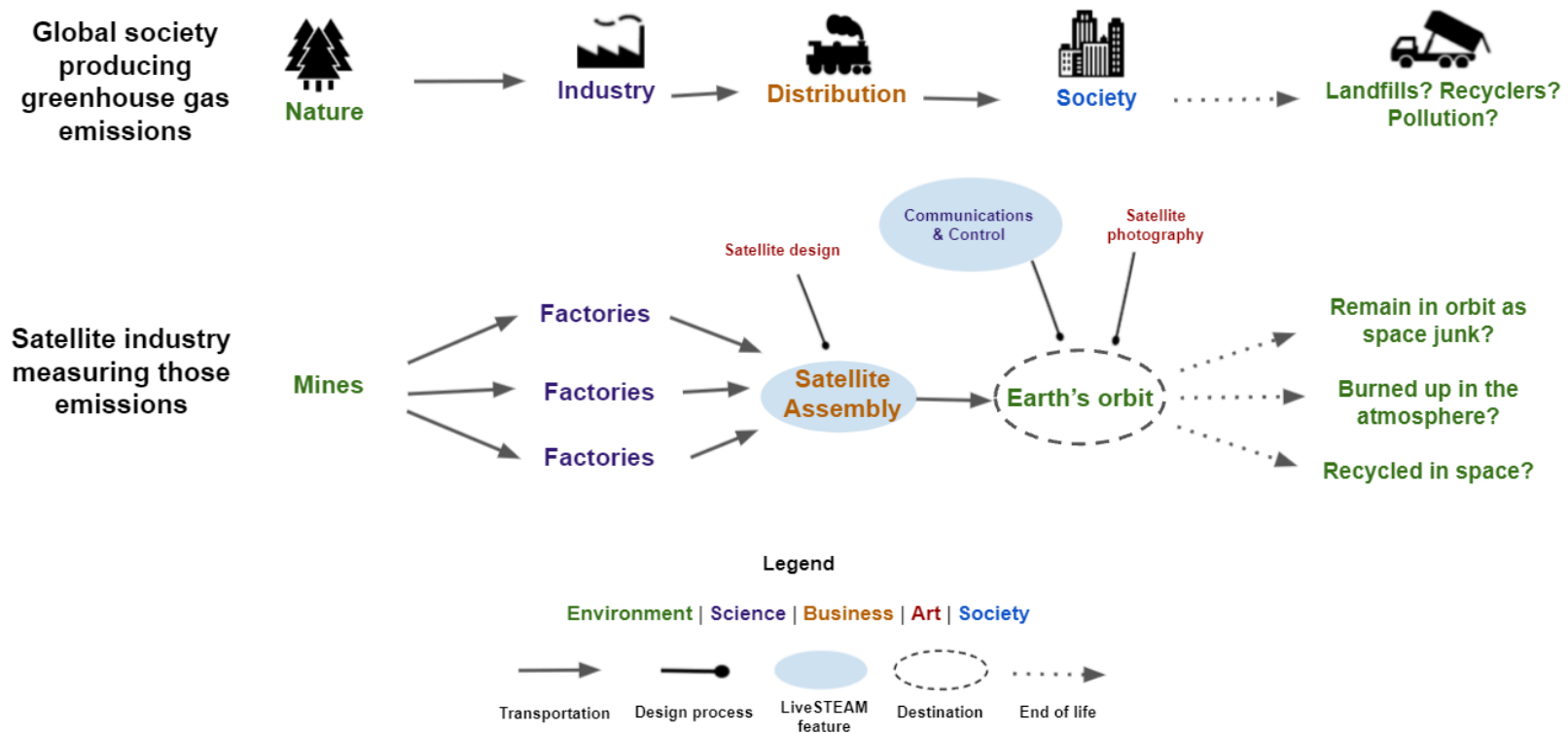
*Read our latest practical research article! See the appendix for useful examples to inspire you:*

[Virtual Field Trips: Pivoting Cross-Curricular Experiential Learning to an Online Platform](#)

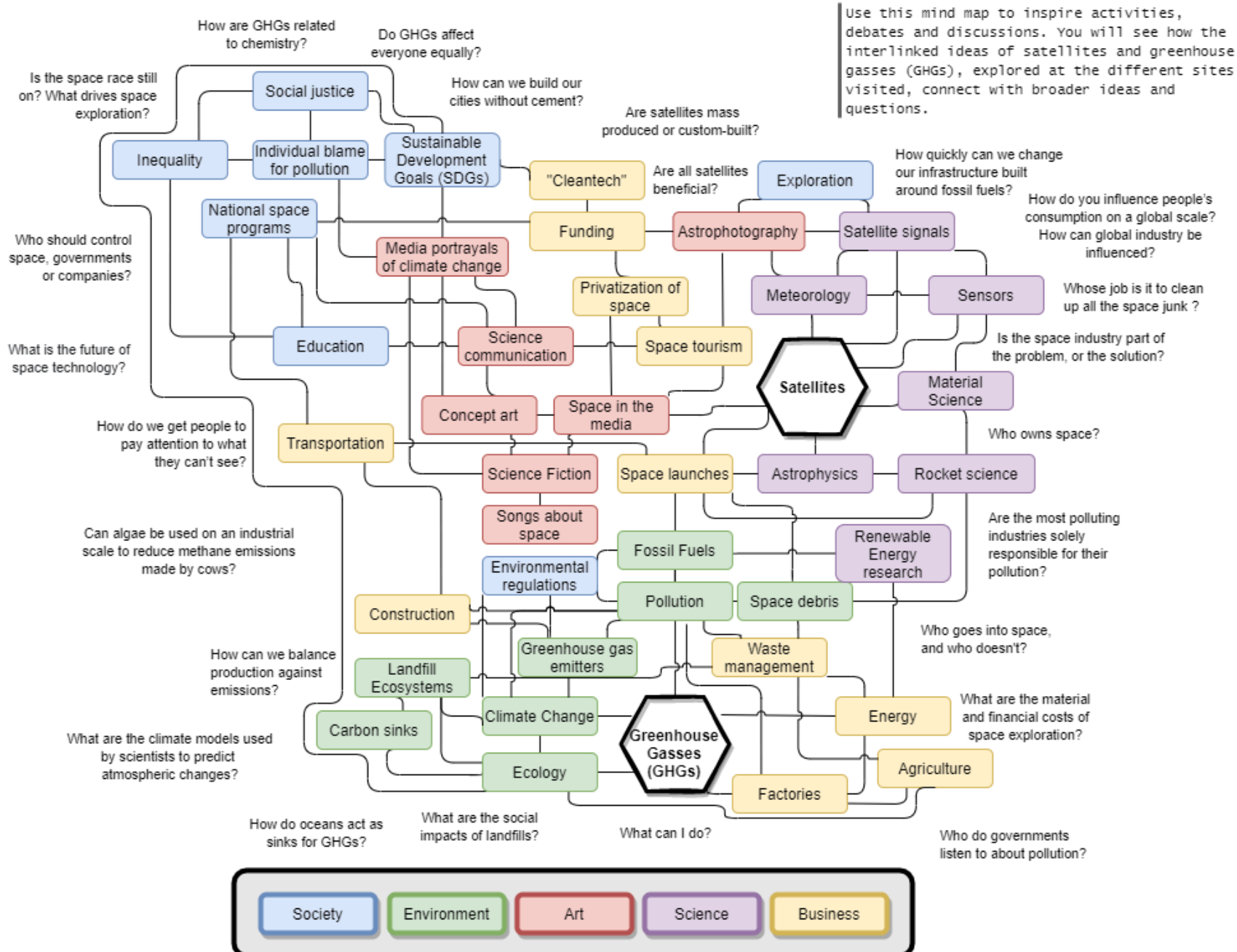
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# System Map of Satellites and Pollution

The following is a system map for the **Climate Control** field trip:



The sites we are visiting are just a couple of the parts of a vast and global interconnected pollution and satellite systems, which is part of even larger systems across the environment, economy and society. If you would like to critically think about these systems with your class, check out the questions we have created for [science & technology](#), [mathematics](#), [language arts](#) or [social studies](#). Our hope at E2 Adventures is that by opening up the various parts of the world's systems to young people, they can deepen their critical thinking and problem solving skills from the perspective of how the world works today, how it is changing, and how they can make a difference in it.



# Science & Technology:

*The following questions can inspire discussions and activities based on your existing lesson plans.*

## Material World

### Properties:

- How could you change the state of a greenhouse gas? What chemical properties relate to this? How could different sequestration technologies use this to store greenhouse gases?
- What chemical properties should be considered for the materials used in building satellites? Why are some materials able to withstand being used in space whereas others are not?
- Why could aerosols be used to combat climate change? What are the properties of aerosols that allow them to be used in the sky? What state of matter is an aerosol?

### Changes:

- How does combustion produce greenhouse gases? Why are some greenhouse gases reagents in combustion reactions? Why might they be more or less harmful in their unburned state? What other types of chemical reactions produce GHGs?
- How does photosynthesis reduce the greenhouse effect?
- What type of bond is present on a carbon dioxide molecule?
- How is an aerosol created? Why are these chemicals relevant to climate change?

### Organization:

- What is unique about the chemical structure and bond angles of a carbon dioxide molecule? How does this relate to heat and radiation?
- How could different representations emphasize important properties of greenhouse gases? Why is it important to represent certain chemicals in certain ways? How could we use Lewis notation to better understand greenhouse gases?
- Why are there many greenhouse gases compounds? Could a pure substance act as a greenhouse gas? Why or why not?

### Fluids:

- How do water and air pressure relate to the presence of water vapour? How does water vapour influence the climate?
- Why do gases behave like fluids in some ways? How is this important for the distribution of greenhouse gases?
- How does air pressure affect the concentration of greenhouse gases at different levels of the atmosphere? How does it affect the various weather patterns that satellites track?

- Can sound be used to measure changing water temperatures? What is acoustic tomography? Can it help in studies about the environment? Where did this field of study come from?

#### Waves:

- What is the difference between solar and infrared radiation? Why is solar radiation not reflected by greenhouse gases? Where are these different forms of radiation on the electromagnetic spectrum?
- How do satellites detect different waves? What spectrum and types of waves can different satellites observe? How are different wavelengths visible from space? Do some deviate?
- How do different wavelengths of radiation from the Sun heat our planet?
- Can sound be detected in space? How can sound information be transmitted? How would different soundwaves of different amplitudes and frequencies interact in space?
- How is satellite signal strength measured? Why does this matter?
- Can sound be used to measure changing water temperatures? What is acoustic thermometry?

#### Electricity and electromagnetism:

- How might electricity be relevant to a satellite? What conductive materials or circuits could be present? How is electricity provided to a satellite?
- How are magnets used in space? Why are they useful in space? What is cosmic magnetism?
- How can static electricity be used in pollution control? How does it interact with different pollutants? Why is this useful? What is electrostatic precipitation?

## Living World

#### Diversity of life forms:

- How does climate change affect biodiversity? Why might different temperatures support different diversity of life forms? Why might disrupting the temperature impact this?
- How would climate change affect population sizes of various species? Why might some species thrive and some be threatened? How could scientists study this?
- Does the presence of increased greenhouse gases support the evolution of new species? How might they change to adapt to this? How do existing species adapt physically and behaviourally?
- Does space constitute a habitat? Why or why not? What diversity or presence of species would be required?

#### Life-sustaining processes:

- How does climate change affect our internal life-sustaining processes? How have these processes adapted in response to different atmospheric gases in our environment?

- How have our biological systems adapted to filter out different pollutants? Does air pollution affect human DNA?
- How does plant photosynthesis influence atmospheric GHG levels? How does this process interact with respiration and combustion processes in the biosphere and geosphere?

Tissues, organs and systems:

- How might a changing climate impact various organs and systems in our bodies? Do our body systems adapt to different climates? How? Do you think plants or animal cells are more sensitive to temperature changes?
- Can you draw an analogy with how gases are regulated in the atmosphere and how chemicals are regulated in a cell? How are these processes similar? How are they different? What kinds of inputs and outputs are there?
- Why can't human bodies survive in space? How could thinking about the human body and its system influence how we design satellites and other technology we send to space?

Body systems:

- What tissues in the human body transport gases? How are these gases released out of the body?
- How does the human gut produce methane? What changes in diet could alter this amount? What processes are involved here?
- How does the respiratory system produce carbon dioxide? How can we compare respiratory carbon dioxide to other sources of GHGs?
- How does the process of decomposition relate to GHG production and the transformation of carbon? How does it relate to the natural processes that create fossil fuels?

Survival of species:

- How is climate change linked to our survival? How can human societies meaningfully respond and adapt to this challenge?
- Is there a survival value associated with colonizing space? Are we meant to be a multi-planetary species? Should we focus on saving our current planet or branch out to others to protect us from climate catastrophe?
- What do you think of criticism of space exploration and research? Why or why not is it a valuable use of human resources and focus? How would you approach a problem like this?

## Earth and Space

Characteristics of Earth:

- How are organic chemicals involved in non-organic systems like climate change? What could disrupt biogeochemical cycles? In what ways do such disruptions increase the vulnerability of biodiversity?
- How could a low Earth orbit satellite be more effective at observing certain phenomena or performing certain functions? How might this change for different phenomena?
- How could we determine how much carbon is stored on Earth versus how much is in the atmosphere? How could different processes influence this equilibrium?
- What natural processes absorb CO<sub>2</sub> from the environment? From the human body?
- What are the environmental consequences of the emerging space tourism industry likely to be? How much greenhouse gas and air pollutants is generated through burning propellants to launch rockets and satellites into space?

#### Geological and geophysical phenomena:

- How do aerosols in the atmosphere impact the temperature of the Earth's surface? Does volcanic ash cool the Earth?
- What are some possible solutions to climate change? How could geoengineering help with climate change? What might this look like?
- What is albedo? Do clouds cool or warm the climate? How do clouds reflect sunlight? What is cloud brightening and how does it work to aid in climate change?

#### Astronomical phenomena:

- What is a satellite? Is the moon a satellite? What is a moonmoon and why is it considered a 'subsatellite'?
- Are greenhouse gases green? Can pollution in the air cause the moon to change colors? If so, what colour?
- What is space mining and how is this leading to a new-age "space-race"? What could we mine in space? What are certain minerals that can be found on asteroids?
- What are some potential consequences of the privatization of space for science and humanity? How is the proliferation of low-Earth orbit satellites (at altitudes less than 2,000 km) threatening our ability to observe, discover and analyse the cosmos from the surface of the Earth?

## Technological World

#### Graphical language:

- How could a manufacturer model or diagram satellite components before building them? How could different forms of representation be important for this? Why are construction diagrams important? Have you ever used one to help build or assemble something?
- How is geometry used in the creation of satellites? How and why are different shapes useful for different satellite functions?
- How can a picture of the Earth change depending on the shape and size of a satellite's sensors? Why is precision important?

#### Dimensional tolerances:

- How variable are dimensional tolerances in building satellites? How precise do measurements have to be? Why?
- How is electricity provided to the plants to satellite-making facilities? How is it converted between the power source to the factory?
- What mechanical functions, motions and parts are necessary for a satellite to function? How could they be designed to accommodate this?
- What electrical components are on a satellite? Why might it be necessary or helpful to have more electrical components on a satellite? Why might it be helpful to have fewer?
- What is a geostationary satellite and how long does it take to orbit earth? What is the minimum number of geostationary satellites that will allow for worldwide communication?

#### Materials:

- What is a satellite and what are they made of? What materials are used to make sure they are extremely light weight? What is the lifespan of a satellite?
- Does temperature exist in space? Is there more pressure on earth or in space? How does atmospheric pressure affect humans? What does space smell like?
- What common materials being manufactured on earth are contributing to air pollution?
- Why is it important to have materials with different chemical properties in satellites? How are these properties changed by different treatments and modifications? Do you notice different types of chemicals, like plastics, alloys and ceramics used? How are they used and why?

#### Manufacturing:

- What specifications, measurements, and shaping tools and processes can you notice being in satellite construction? What is the difference between a natural satellite and an artificial satellite?
- Are satellites mass-produced or custom-built? How could this vary according to the function of a satellite?
- How can manufacturing be sustainable? What are examples of sustainable manufacturing? Is sustainability the same as being green? What is the difference between green manufacturing and lean manufacturing?

#### Biotechnology:

- How could genetically modified organisms be used to combat climate change? Why might there be ethical or practical issues with this?
- How could we adapt or use existing biologically-mediated processes in nature to fight climate change?
- Should we think of greenhouse gases as pollutants? Are they biodegradable? What technologies or resources could we develop to accelerate their degradation or conversion as chemicals?



# Geography, Modern World and History

*The following questions can inspire discussions and activities based on your existing lesson plans.*

## Regional Territory

- What are rare earth elements and how are they used in electronic industries? Can these or other valuable minerals be mined in space? How could a country benefit economically from mining space elements?
- What is earth-to orbit transportation? How are such 'suborbital' companies such as 'Blue Origin' and Virgin Galactic paving the way towards the era of space tourism? How likely is it that spaceflight will become affordable and accessible for average Canadians in the next decade? Why?
- What is 'solar power' and how is this used to power satellites? What is vacuum energy? What other energies can be harnessed from space?
- Do countries have their own satellites? Do countries create their satellites similarly? How many countries have the capacity to send objects such as satellites into orbit using their own launch vehicles?
- Which country has the most satellites? Which country has the best space program in the world? What are the top Space Agencies? Which countries rank as "space superpowers"?

## Urban Territory

- What major metropolises are known for their work in the satellite industry?
- How does the location of urban areas influence the placement of landfills and other waste disposal sites? How are landfills significant for urban planning & expansion?
- What are the causes of pollution in urban areas? If you wanted to reduce your consumption of natural resources and reduce pollution, would it be better to move to a city, a suburb, or a rural area? Are the world's worst air pollution exposure levels found in developing cities? Why, or why not?
- What is a satellite city? Does it mean that they have their own specific satellites? Why are satellite cities called self sufficient communities?

## Agricultural Territory

- Why are cows and livestock a major contributor to GHG emissions? How does this relate to their evolution, biology, and diet? How could we change this?

- How can satellites help us understand agricultural land use? Why is this important to different societies? What agricultural systems can be mapped with satellites? Why might it be useful to understand agriculture from a big-picture perspective?
- How much waste do farms produce? How does the location of agricultural territories affect the placement of landfills and similar sites?

## Native and Protected Territories

- Is there a history of land agreements or disputes over the presence of landfills (or other infrastructure that produces greenhouse gas emissions) on Indigenous territories? Why would this be a historically significant issue? How could the relationship between Indigenous groups and governments resolve these issues? Why might this be a difficult framework for resolution?
- How could satellite imagery be used to better understand Indigenous and protected territories? How could we gain information about the biodiversity of these regions from satellite imagery?
- Why might some consider satellite imagery of an Indigenous territory a violation of the sovereignty or privacy of the people there? Do you agree? Why or why not?
- In what ways does the Outer Space Law subscribe to modern and historic treaties between the First Nations and Canada? Do these treaties include the skies and outer space?

## Modern World

- What is the importance of CO<sub>2</sub> carbon dioxide to the living world? Why has this become a political issue? Do GHGs affect everyone around the world in the same way?
- How did the COVID-19 pandemic impact CO<sub>2</sub> emissions? How lasting do you think the effects of the pandemic will be on GHGs? How could satellite imagery and information help answer a question like this?
- Do you think that the global average atmospheric carbon footprint in 2020 was higher or lower during the economic slowdowns caused by the COVID-19 pandemic?
- How many of our daily processes depend on using satellites?
- Is satellite imagery of private property a violation of privacy? Why or why not?
- What is the object and purpose of the Outer Space Treaty of 1967? Are there other similar international treaties used today to govern space? What laws apply in space?
- What is a carbon emission footprint? Who are the biggest emitters of fossil fuel carbon dioxide (CO<sub>2</sub>)? What carbon footprint do we need to strive for (by 2050) to avoid global warming?
- Can one nation claim ownership of outer space or other celestial bodies? Is creating a lunar colony feasible? Can you own land on the moon?
- What would a society that operates in space look like? What products and services could you imagine being the first to exist entirely outside of Earth?

## History

- How have past volcanic eruptions inspired man-made climate interventions? How have past climatic events influenced human history? How do aerosols work with sunlight to cool the Earth surface? What is the Pinatubo effect?
- How have different social and technological processes in human history influenced greenhouse gas levels? Why are some more significant than others?
- What was the Space Race? Other than spawning pioneering efforts to launch artificial satellites, why is the Space Race significant today? How do processes of collaboration & competition drive exploration and research?
- Is there a modern space race today? If so, who's in the race? How is the question of 'national prestige' still relevant today? Why is asteroid mining becoming an economic aspiration for many countries? Is there gold on the moon?

## Mathematics:

*The following questions can inspire discussions and activities based on your existing lesson plans.*

## Geometry and Analytic Geometry

- What is the relationship between the volume of ocean water on Earth and the amount of dry coastal land? How will this change as polar ice increasingly melts?
- How much of our atmosphere is made up of carbon dioxide? How much space would that CO<sub>2</sub> take up if it were all in one place?
- How do satellites turn 2D photographs into 3D globes? How are map projections used in making a 3D world map?
- Do satellites have circular orbits? Do they always circle the same parts of the Earth?
- How much area of boreal forest does it take to offset the carbon emissions of an average North American? How does that compare to the amount of forested land on Earth? If you were to divide the forests between everyone on the planet, how much forest would each person have, and how much of their carbon footprint would this account for?
- What is the area and volume of a typical satellite? Does the volume increase or decrease for satellites built for different purposes? Why?
- Why do different types of satellites operate at different altitudes? How does this affect their usage?
- How do satellites triangulate locations with GPS?
- What is the relationship between the resolution of a satellite camera, its height, and the size of an object it can detect on earth?

## Probability and Statistics

- What is the difference between climate change mitigation strategies and climate change adaptation strategies?
- How is climate risk calculated? Should we use probability models to create climate policies? Are they useful?
- When satellites transmit data, how often do the signals get lost or mixed up? How do they compensate for this?
- How much data would you estimate is being used by everyone in your class each month? How much is actually being used, from everyone's data analytics? What would you estimate for the entire school?
- How do we tell which industries have the most emissions? What are some factors that could cause this data to be wrong, misleading, or falsified?
- What percentage of global emissions could you estimate you are personally responsible for? How could you check this? Who or what causes the most emissions? How could you prove it?
- How (in)accurate are satellite measurements of atmospheric methane emissions? How different could the true values be, compared to the measurements we make?
- Looking up at the night sky, if you see a satellite, what are the odds that it is measuring environmental data? What is the likelihood that you will notice a satellite at all?
- How do different businesses impact the environment? Do they have different obligations? Should they have different obligations? Why? What can you learn by looking at data about environmental expenditures by businesses? (For example: <https://www150.statcan.gc.ca/n1/daily-quotidien/210126/dq210126b-eng.htm>)

## Algebra and Arithmetic

- How much fuel does it take to put a satellite into orbit? How expensive would the fuel be if you were to launch a smartphone into orbit? What about a bus? A gymnasium?
- What are the cheapest satellites to launch? How many satellites could be launched if the Canadian government spent their budget on launching satellites exclusively?
- How quickly do greenhouse emission sinks work? If all people were to stop producing greenhouse gases immediately, how long would it take for current greenhouse emission sinks to undo human environmental impacts?
- Can you estimate how much space in your city can be adapted to incorporate urban green spaces? If every city did this, how much more green space would there be in the world?
- Based on current Carbon Tax prices as implemented by the Canadian government, how much is all the CO<sub>2</sub> in our atmosphere worth? How much will it be worth in 2030? What are some things that have costs or values which compare to this price?
- How much CO<sub>2</sub> do the vehicles you ride produce in a week? How much more or less efficient is it to use bigger vehicles that can carry more people?