ACTUALLY, IT'S

PHYTO-PLANKTON!

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EPISODE 4

Whale poop? Oil Slick? Actually, it's Phytoplankton!

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EPISODE FOUR RESOURCE PACK

ACTUALLY, IT'S PHYTO-PLANKTON!

Time to geek out plankton lovers! This episode we talk to Dr. Ivona Cetinić and Dr. Amir Ibrahim about the science of PACE. Ivona is a true "ocean master" and Amir is everyone's favourite "atmosphere guru".

How will PACE be useful for scientists?

1) Better understanding & detection of phytoplankton.
Current ocean observing satellites are limited in the colours they can see. That means they are limited in how effective they are at detecting different types of phytoplankton. You might liken this to green spaces on land. Grassy meadows and dense forests are both green and have plants, but they support different types of animals. For example, cows like grassy meadows, not forests. Scientists want to tell the difference between grassy meadows and forests in the ocean, but right now it's like looking only at green. You can't tell if it's an ocean "meadow" or an ocean "forest".

2) Better understanding of the <u>optical properties</u> of aerosols & clouds.
Aerosols and clouds effect the ocean and climate. NASA's PACE Mission will help scientists to **<u>quantify</u>** this impact.

Science words!

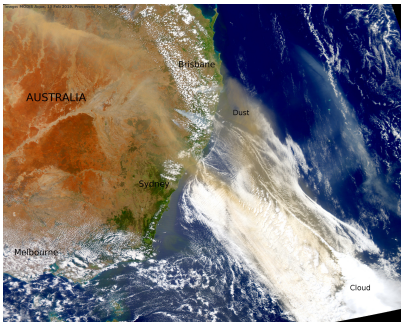
Quantify means:
To measure the quantity of something. Basically counting...
Optical Properties means:
How light is scattered (reflected) and/or absorbed by stuff.

What are Aerosols?

Aerosols are very small suspended particles in the air. Aerosols include things like smoke, dust, soot, and sea salt.

Dust particles whipped up during storms in desert environments form massive dust clouds that can travel across the world. Similarly, natural disasters like bush fires can send huge amounts of smoke particles into the atmosphere. Scientists can actually see these large aerosol events on satellite images. These types of aerosol events can be harmful to our health.

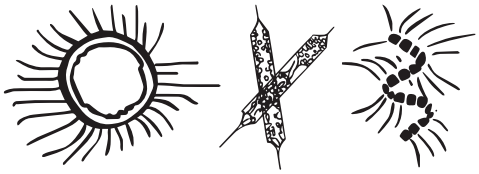
Other aerosols are harmless, such as sea spray. This can happen when you get some big surf at the beach and the crashing waves send sea salt particles into the air.



What is Earth System Science?

The Earth System is the integration of all the Earth's elements working in harmony. This includes, but is not limited to, water, fire, ice, land, and air. Each of these elements are systems by themselves and are all interconnected. People who study Earth Systems Science look at interactions. That is, how do these different systems talk to each other and interact? Oceans do not exist in a vacuum. They are surrounded by land, air, and ice, so Earth System Scientists must look at how the oceans interact with other systems.

And if you like a good throw-back cartoon, check out Captain Planet & The Planeteers
"The Power is YOURS!"

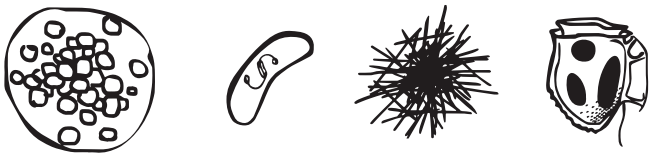


What does phytoplankton and ocean ecosystems have to do with aerosols and clouds?

If you look at the Earth from space, it's all covered in clouds (except for maybe over the deserts). Clouds are a major part of our Earth System, so it's important to know how clouds form and how they interact with aerosols and phytoplankton. Our knowledge about how aerosols effect our climate is uncertain. NASA's PACE Mission will help with understanding how aerosols effect the radiation balance (that is, how much solar energy comes into the Earth System, versus how much is reflected back into space).

Phytoplankton actually help with cloud formation. Sometimes phytoplankton produce an ooze-like organic matter. This ooze turns into sea spray, which helps to form clouds. Dust storms are also not all bad, they have a purpose in the Earth System. Dust includes a lot of iron, so when dust particles travel across the ocean, they deposit iron into the water. This can act as phytoplankton fertilizer.

What happens to life on the coasts when flood water pours into the ocean?



Fresh water river plumes inject nutrients into the ocean. Phytoplankton love that, so the eat nutrients and multiply rapidly (this is called a bloom). However, flood water also brings mud. Mud makes the water dark and less light can get down the water column. Phytoplankton need light to photosynthesize (make food using solar energy). If there's too much mud, phytoplankton might not survive.

Another scenario is that some phytoplankton will float to the surface to find light. These types can cause harmful algal blooms because they have lots of nutrients, and lots of light.

Hypothetical Scenario:

All the coccolithophores in the ocean disappear due to a drastic environmental change. What does that mean for the ecosystem?

Hypothetically, this is a big problem. **Coccolithophores are double climate fighters.** Like most phytoplankton, they take carbon out of the atmosphere and sink it down into the deep ocean as part of Earth's carbon cycle. However, coccolithophores like **Emiliania Huxleyi** essentially transport twice as much carbon as other phytoplankton because they are covered in chalky calcium carbonate outer shells.

Losing all the coccolithophores would be detrimental to the carbon cycle. Or as Ivona says, "A big disturbance in The Force".

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Bingo Card & Cipher

Telemetry	Optical Properties	Ecosystems	Phase	Oceanic Diversity	Catalyst
Toxins	Synechococcus	Oceanographer	Solar Array	Harmful Algae Bloom	Infrared
Photon	Particles	Autotroph	Algorithm	Spacecraft	Diversity
Climate Cycle	Photosynthesis	Antenna	Water vapour	Nitrogen	Remote Sensing
Aerosol	Dust Plume	Primary producer	Wavelength	Human Impact	Trichodesmium
Maneuver	Physics	Ocean Process	Signatures	Meteorology	Biogeochemistry

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1. Circle the "science words" you hear Ivona & Amir say on episode 4.
2. Write down all the underlined letters in the circled words.
3. Go to Level 1 Challenge.
4. Write down all the bold letters in the circled words.
5. Go to Level 2 Challenge.

This is a word jumble of the underlined letters.

LEVEL ONE:

_ _ _ _ _ _ _ _ _ _ _ _ _ _

LEVEL TWO:

_ _ _ _ _ _ _

Find the cipher. Decode bold letters first to get the right letters, then un-jumble the words.

GO2Qurious

PACE will provide key information on aerosols such as airborne dust, pollen, smoke and haze. These particles can significantly reduce air quality, leading to asthma and respiratory distress among vulnerable people.

The effect of human-produced aerosols on clouds – and the impact on climate – is not well understood. Measurements from PACE will help to clarify the connections between aerosols, clouds, and climate.

PACE MISSION

PACE will extend and improve NASA's 20 plus years of global satellite observations of our living ocean, atmospheric aerosols, and clouds and initiate an advanced set of climate-relevant data records. By determining the distribution of phytoplankton, PACE will help assess ocean health. It will also continue key measurements related to air quality and climate.

Science Goals

To extend systematic ocean color, atmospheric aerosol, and cloud data records for Earth system and climate studies.

To address new and emerging science questions by detecting a broader range of color wavelengths that will provide new and unprecedented detail.

Key Mission Characteristics

- **Hyperspectral ocean color instrument**
- **Two multi-angle polarimeters**
- **Launch readiness date: Fall 2022**
- **675 km (419 mi) orbital altitude**
- **Sun-synchronous, polar orbit**
- **Global coverage every two days**
- **Managed by Goddard Space Flight Center**

National Aeronautics and Space Administration

Goddard Space Flight Center
8800 Greenbelt Road
Greenbelt, MD 20771
www.nasa.gov/goddard

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Clouds & Aerosols

PACE will study clouds along with tiny airborne particles known as aerosols.

Plankton, Aerosol, Cloud, ocean Ecosystem

More wavelengths.

Unprecedented information.

Clouds & Aerosols

Climate is the prevailing condition that you plan for. Weather is what you get. The difference between the two is simply time. For decades, information from weather satellites has helped us plan our daily activities. Collecting and analyzing these data over time has resulted in more accurate weather forecasts.

Similarly, predicting climate involves long-term studies of Earth's atmosphere, including clouds and small particles suspended in the atmosphere known as *aerosols*. Both clouds and aerosols affect how sunlight is reflected and absorbed by our planet and its atmosphere.

Aerosols and clouds can interact in complex ways, which are not well understood. For example, cloud drops can form on aerosols and aerosols can be washed out of the air by rain. The overall effect of aerosols and clouds on climate is quite uncertain.

Different types of aerosols absorb and reflect different fractions of sunlight. Their interaction

with clouds alters cloud brightness and coverage, further affecting reflection of sunlight. Aerosol types and how they interact with clouds vary a great deal from place to place over time. Thus, we need satellites to capture a complete and accurate picture of how much energy Earth is absorbing from the sun.

Aerosol data will not only be used to better understand our atmosphere but our ocean, as well. How? Most of the light that is seen by a satellite comes from the atmosphere and its aerosols. Only a small fraction of the light comes from the ocean. PACE will take this into account when deciphering its data, including when deriving information about the microscopic algae that float in our ocean, *phytoplankton*. For PACE to accurately "see" the ocean, we must understand the aerosols present in the atmosphere.

PACE's advanced technologies will provide unprecedented insight into Earth's ocean and atmosphere.

Why do we need PACE? To better understand how the ocean and atmosphere exchange carbon dioxide.

Decades of clouds and aerosols data from satellites have been used to forecast weather, visibility and air quality. PACE will go a step further by observing the ocean, clouds, and aerosols together to better understand how they interact. Its data will reveal new details about the exchange of carbon dioxide and how some aerosols fuel the growth of phytoplankton.

Conversely, PACE will help to track the types of phytoplankton that can release particles to the atmosphere, which may lead to the formation of clouds. Overall, these processes affect how much heat is trapped by Earth's atmosphere and thus are vital for accurate weather and climate predictions.

PACE science objectives for clouds and aerosols:

- **Determine global aerosol distribution and type**
- **Provide new insight into aerosol properties**
- **Monitor cloud properties, and the interaction between aerosols and clouds**
- **Observe fundamental components of our global climate in new ways**

Plankton, Aerosol, Cloud, ocean Ecosystem

Learn more at pace.gsfc.nasa.gov

The ocean is a critical part of the world's economy. Forty percent of the world's population lives within 100 km (62 mi) of a coastline, with fisheries and aquaculture supporting about 12% of the world's livelihoods. In the U.S., there are nearly 3 million jobs related to the ocean.

PACE will provide the first-ever global measurements designed to identify the composition of communities of phytoplankton. This will significantly improve our ability to decipher Earth's changing marine ecosystems, manage natural resources such as fisheries, and identify harmful algal blooms (HABs).

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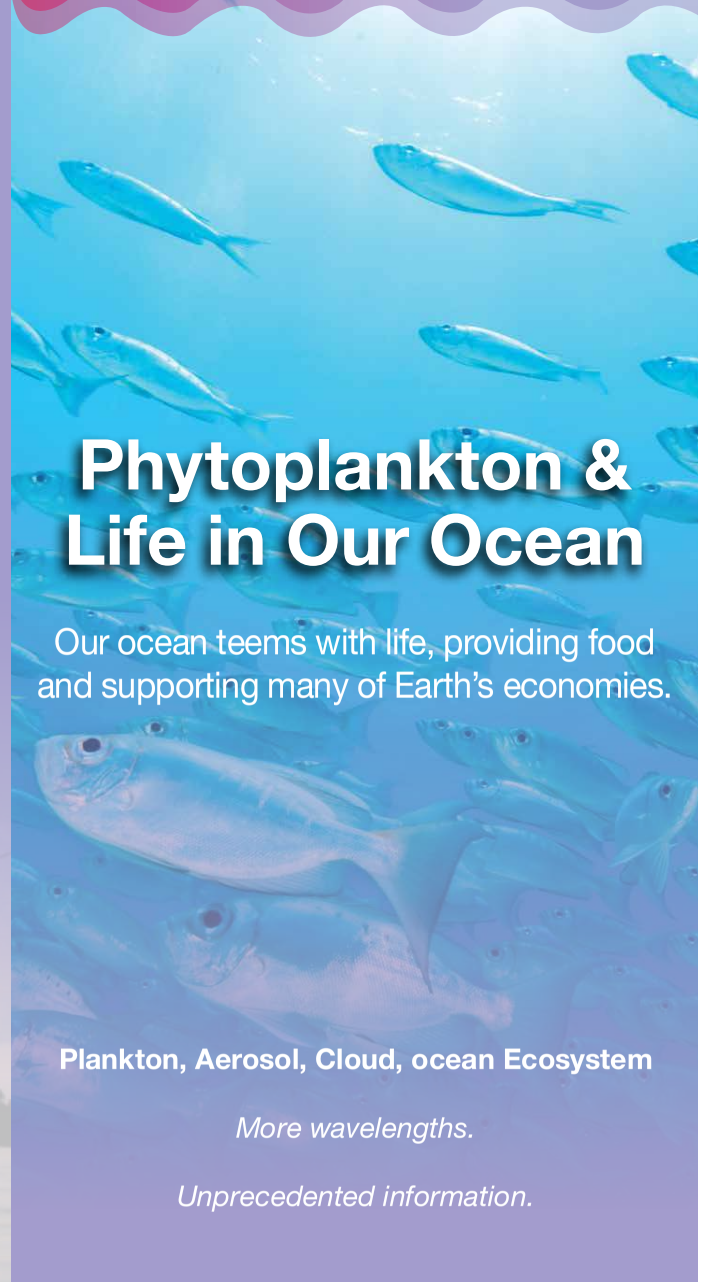

Phytoplankton & Life in Our Ocean

Our ocean teems with life, providing food and supporting many of Earth's economies.

Plankton, Aerosol, Cloud, ocean Ecosystem

More wavelengths.

Unprecedented information.

Phytoplankton & Ocean Life

Constantly in motion, the ocean hosts the largest three-dimensional living space on earth. This vast volume teems with life but many of its most vital species are also its tiniest inhabitants.

Like on land, the ocean has deserts, forests, meadows, and jungles, providing habitats for many forms of life. The types of life in these habitats are determined by microscopic algae that float in our ocean. Known as *phytoplankton*, they come in many different shapes, sizes, and colors. The diversity of phytoplankton types present determines the roles they play in ocean habitats.

For example, the North Atlantic is home to highly productive "pastures" each spring. Its blooms of carbon-rich phytoplankton fuel the fisheries of New England. Phytoplankton are the primary food source for small zooplankton, tiny animals that float in our ocean. Larger zooplankton prey upon smaller zooplankton and – step by step – energy captured from phytoplankton transfers

to bigger organisms. As the energy climbs the marine food web, many fish and shellfish will ultimately be consumed by humans.

The international trade in coastal and marine fisheries contributes $70 billion annually to the U.S. economy. Yet 70% of the world's fish stocks are being harvested at maximum capacity or, in extreme cases, overfished to the point of collapse. Data from PACE will be used to help improve the way our ocean's food resources are managed.

Another key habitat is the crystal-clear water around Florida, home to productive fisheries and coral reefs. At times, however, this area is plagued by species of toxic phytoplankton. Harmful algal bloom (HAB) events in the U.S. have been estimated to result in economic impacts averaging $50 million each year. HABs

PACE will reveal the diversity of organisms fueling marine food webs and how ecosystems respond to environmental change.

Why do we need PACE? To understand how phytoplankton diversity impacts human life.

can wreak havoc on commercial fisheries or force the closure of recreational areas. Direct human impacts include illness or even death through consumption of toxic shellfish, along with asthma attacks through inhalation of airborne HAB toxins.

PACE data will aid in the development of computer programs that identify and quantify specific phytoplankton groups, including helpful species that fuel our ocean's food resources and potentially toxic species. These types of tools will also be used to understand the environmental factors that govern the appearance and demise of fisheries and HABs.

Today's satellites reveal the quantity of phytoplankton at the ocean surface. Yet we cannot detect the diversity of species. For the first time, PACE's unprecedented technology will:

- **Reveal the diversity of phytoplankton found in our ocean on global scales**
- **Allow us to understand the role that phytoplankton diversity has on life in the ocean**
- **Help us predict the "boom or bust" of fisheries along with marine hazards such as HABs**

Plankton, Aerosol, Cloud, ocean Ecosystem

Learn more at pace.gsfc.nasa.gov