SHIP-AIRCRAFT BIO-OPTICAL RESEARCH (SABOR) EXPERIMENT

OBSERVING OCEANIC ECOSYSTEMS

NASA's Ship-Aircraft Bio-Optical Research (SABOR) experiment used cutting-edge technology in the air and the sea to verify and measure the amount, type, and distribution of phytoplankton in different ocean environments.

The field campaign sought to answer whether new technologies, such as lidar and polarization, could be used to better observe changes in oceanic ecosystems.

From 17 July to 17 August 2014, the SABOR campaign took in situ, ship-based above-water, and airborne measurements of phytoplankton content, particulate matter, and oceanic optical properties. The campaign sought to cover a broad range of oceanic environments—from optically complex coastal waters to clear blue open ocean—for maximum accuracy.

STUDYING THE OCEAN FROM SPACE

WHY NASA

NASA's Earth Science Division (ESD) sees the ocean differently—literally. ESD monitors and collects data remotely from space using highly sensitive instruments mounted on satellites hundreds of miles away. In order to ensure their satellites are accurate, ESD runs airborne and shipborne campaigns like SABOR to verify their results and get a deeper look into Earth's oceans.

A GLIMPSE BELOW THE SURFACE

SABOR used highly specialized technical instruments that allowed researchers to capture vertical profiles of the atmosphere and ocean. When combined, these air- and shipborne techniques—specifically, hyperspectral radiometry, lidar, and polarization—provided a clearer, more precise picture of oceanic and atmospheric optical properties than ever before, and provided a crucial testing ground for future space-based technologies.

- Scientists used **hyperspectral radiometry** to determine ocean color, which allowed them to estimate what types of organisms, such as phytoplankton, were present in the water column. Hyperspectral radiometry uses multiple radiometers in and above the water to passively measure the sunlight as it's reflected off the ocean over the ultraviolet, visible, and infrared light ranges.
- During the SABOR mission, scientists also used **lidar** to determine where suspended particles like phytoplankton were in the water column. Lidar is an air-based technology that actively transmits short pulses of light at a target (in this case, the ocean) and collects the backscattered light to create an image of the terrain below.
- **Polarization**, or the process of focusing multiple wavelengths of light into a single plane, was used during SABOR on several platforms to determine the effect that different oceanic particles have on the way light is reflected or absorbed. Scientists can then use these unique optical signatures to determine what air- and space-based instruments are "seeing" down on Earth, such as phytoplankton in the ocean.

A BETTER LOOK AT LIFE IN THE OCEAN

Data collected during the SABOR campaign helped scientists verify whether their instruments accurately measured oceanic properties like particulate type (organic vs. inorganic) and how light travels through the water column. The new data showed:

- **Current lidar-based estimates of phytoplankton populations, and estimates of changes in those populations, are highly accurate.** During the SABOR campaign, in situ measurements of phytoplankton stocks and net primary productivity confirmed that MODIS estimates of these parameters were reasonably accurate. However, SABOR showed that lidar-based measurements allowed for significant improvement (up to 54% for productivity) in remote estimates of these important oceanic parameters.

- **Hyperspectral reflectance can be used to discern phytoplankton type.** Hyperspectral reflectance was shown to detect accessory pigments in phytoplankton, which differ depending on phytoplankton type. In situ and ship-based measurements of phytoplankton content taken with hyperspectral reflectance during the SABOR campaign showed that specific algal groups had different “fingerprints” to help distinguish phytoplankton types using current ocean color satellites.

- **The combination of lidar and polarization increases the accuracy with which we can correct for difficult atmospheric optical properties and see complex oceanic optical properties, such as how light penetrates and propagates through water.** Polarization increased the accuracy with which models could see how phytoplankton biomass scatters and attenuates light.

PHYTOPLANKTON COLOR: MORE THAN MEETS THE EYE

Phytoplankton are microscopic plant-like organisms that form the base of the marine food web. Like other plant-like organisms, phytoplankton release oxygen into the atmosphere and absorb carbon dioxide, making them an interesting proxy for how our planet is responding to increasing levels of atmospheric CO_2.

Different types of phytoplankton absorb different amounts of carbon; they also photosynthesize, or convert energy from the sun, at different rates. Understanding the amount, distribution, and type of phytoplankton in the ocean will allow us to better understand how much carbon the ocean can store and determine the future health of oceanic ecosystems.

In addition, the new combination of lidar and polarization provide a clearer picture of complex coastal oceanic optical properties, which ultimately can be used to determine the health of ecosystems where almost 40% of the U.S. population lives, works, and plays every day.

All of these advancements will help NASA and other scientists refine and improve oceanic remote sensing capabilities in the future.