PACE MISSION APPLICATIONS – AIR QUALITY

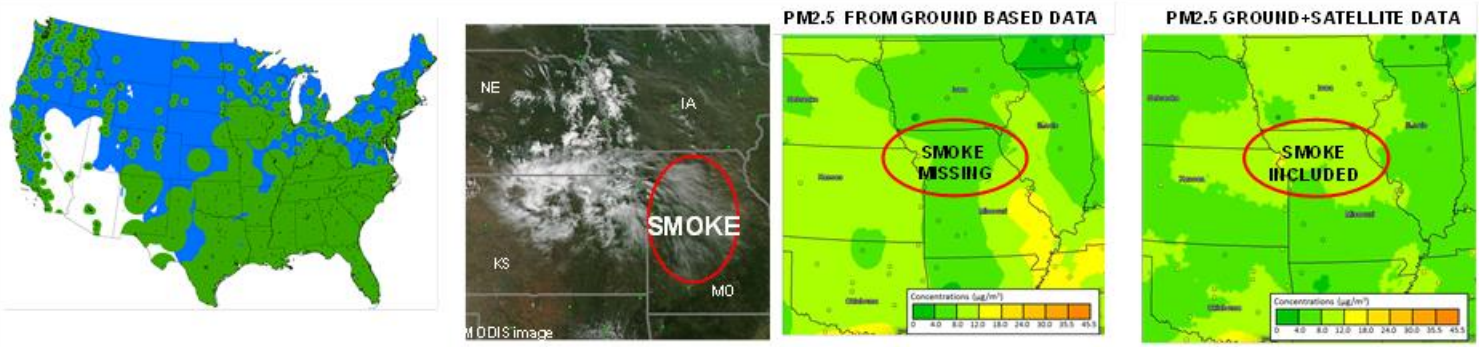


Figure 1. Ground monitors (denoted by small dots) for measuring the concentration of particulate material (PM). Without satellite data, the area of coverage would be limited only to the areas shaded green. The MODIS Satellite data is used to fill most of the gaps (but not all). The next columns show MODIS image of a typical air quality situation resulting from fires, the nominal solution (PM2.5 from ground based data), and NASA's contribution (PM2.5 from Ground + Satellite Data). In the nominal solution because the ground monitors in this region are very few, the interpolated PM2.5 data shows relatively good Air Quality (AQI of 0 – 4). The addition of satellite data shows that the Air Quality as a result of the fires is poorer at AQI = 4-8.0. Satellite data has real value in producing an Air Quality Index that actually protects the public from harm. If the satellite data were not there, there would be no indication of this poorer air quality (Images courtesy of the AirNow Group).

Application Question/Issue

What is the air quality forecast of particulate matter concentration (PM, an indication of the extent of air pollution) predicted from *satellite* measurements of the aerosol optical depth (AOD) in regions where there are no *ground* measurements of PM? Figure 1 is an illustration of such an application.

Who Cares and Why?

In regions where there are no ground measurements of PM, the EPA and the public has no indication of the extent of air pollution, a situation that has deleterious public health implications. Satellite measurements of AOD can be used to estimate PM in such areas. The Environmental Protection Agency (EPA) produces a daily air quality index (AQI) which comprises both the ozone and particulate matter concentrations. The latest surveys show 75 -80% of the public is aware of AQI and 50% report taking action based on the AQI.

Needed Measurement(s)

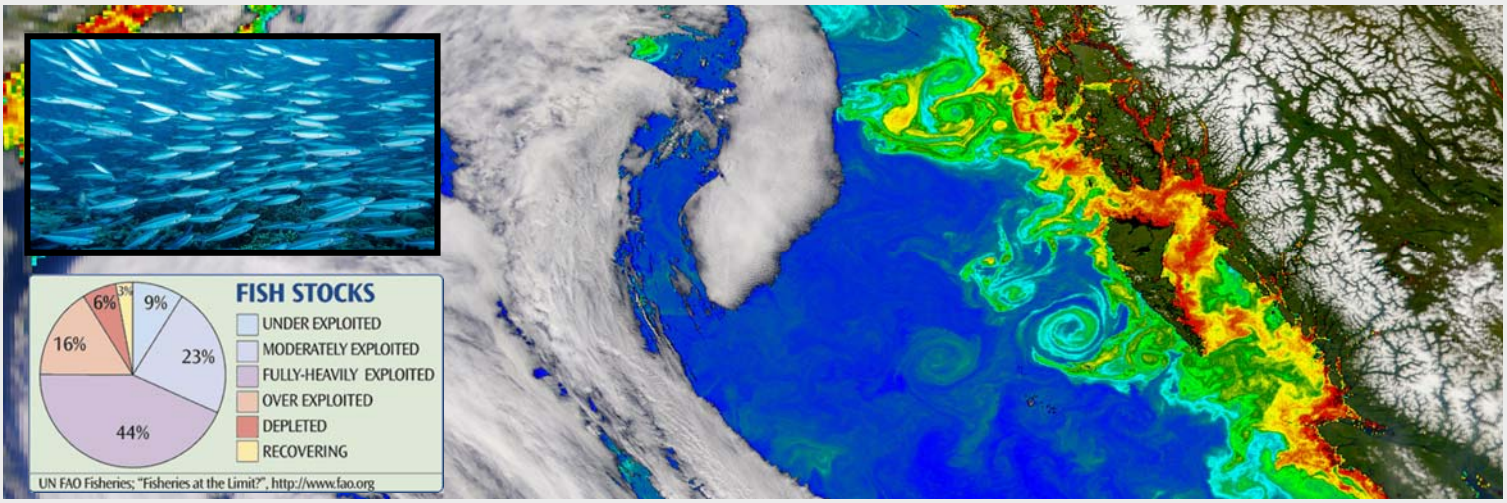
The accuracy of the daily (and forecast) AQI depends on the spatial resolution, latency and accuracy of the satellite-observed AOD and the validity of the relationship between column AOD and surface PM. To meet the needs of the public, the satellite measurements of AOD must be produced at spatial resolutions of one km or less at a latency not exceeding 6 hours and at an accuracy of ±0.05 in the visible wavelengths. The predicted PM using the column AOD and auxiliary measurements must have uncertainties comparable to the EPA's AirNow predictions.

The NASA Response

Based on current estimates, the PACE mission will produce AOD at an accuracy of ± 0.05 at a horizontal resolution of approximately 1 km. The availability of a PACE Polarimeter will significantly reduce reliance on ground-based measurements and enhance accuracy of the predicted PM. In the absence of a Polarimeter, PACE's measurements of AOD from the Ocean Color Instrument (OCI) will require additional capabilities such as ground-based lidars, sondes or models of trajectories and chemical transport models are to identify elevated layers. This is because PACE will measure whole column AOD and the air quality concern is only the layer closest to the surface. It is expected that the latency of the broadcast PACE data will be at least as good as that of the Land Atmosphere Near Real-Time Capability for EOS (LANCE) for MODIS AOD data.

Comments? Thoughts? For additional information about PACE mission applications or this particular application, please contact Ali H. Omar at ali.h.omar@nasa.gov

PACE MISSION APPLICATIONS - Marine ecosystem resources: Fisheries



Main panel: Ocean eddies to the west of British Columbia's Queen Charlotte Islands and Alaska's Alexander Archipelago result in high biological activity in the ocean (Image Credit: SeaWiFS Ocean Color image; SeaWiFS Project, NASA/Goddard Space Flight Center, and ORBIMAGE). Upper Inner panel: Fisheries (Photo Credit: ESA, id 289871). Lower inner panel: ~70% of the major marine fish stocks are either depleted, overexploited or being fished at their biological limit (Credit: UN FAO fisheries, http://www.fao.org)

Application Question/Issue: ***How can we improve monitoring of our global ocean resources and their habitat, as needed for implementing ecosystem-based management approaches for productive and sustainable fisheries, safe sources of seafood, the recovery and conservation of protected resources, and healthy ecosystems?***

Who Cares and Why?

The international trade in coastal and marine fisheries contributes $70 billion annually to the US economy (NOAA's State of the Coast). Yet, according to the Food and Agriculture Organization of the United Nations (FAO), 70 per cent of the world's fish stocks for which assessment information is available are reported as fully exploited or overexploited and, thus, require effective and precautionary management.

A wide range of users from the private and public sectors, including NOAA Fisheries, regional Fishery Management Councils, local health departments, global conservation organizations (e.g., WWF), and private fish forecasting companies, are interested in assimilation of earth-observation data into fisheries research and management. Among their major goals is providing services for productive, healthy and sustainable fisheries, assessing the status of fish stocks, ensuring compliance with fisheries regulations, and supporting conservation of protected species.

Needed Measurements

Improved monitoring and forecasting of our global ocean resources and their habitat requires global-scale satellite observations of sea surface temperature (SST), sea surface height (SSH), surface vector winds, and ocean color (e.g., chlorophyll-a, diffuse attenuation coefficient, ocean reflectance, phytoplankton pigments). To meet the needs of the user communities (e.g., NOAA Fisheries), satellite imagery must be at a global scale, medium to high spatial resolution (i.e., 100 m to 4 km at nadir), every 3hrs to daily. Hyperspectral ocean color capability is critical for quantifying phytoplankton biomass and pigments, assessing key phytoplankton groups, and estimating net primary productivity.

The NASA Response

With advanced global remote sensing capabilities (2-day global coverage, extended spectral range, climate-quality hyperspectral observations, high signal-to-noise ratio, reduction in instrument artifacts, and better instrument performance tracking compared to heritage sensors), the PACE ocean color sensor will help refine measurements of primary productivity in coastal and open ocean environments, of phytoplankton pigments and biological communities, and of ecosystem structure needed to help improve the way we use our global ocean resources.

An important application of satellite ocean color imagery is the mapping of ecological boundaries often through delineation of mesoscale ocean features, such as fronts, upwelling currents, gyres and eddies. These mesoscale features cross major sections of our oceans and influence nutrient availability, primary production, distribution and abundance of fish, including commercial species and also protected species such as whales, sea turtles, and salmon. As our planet changes, PACE will provide a unique capability to observe how the spawning habitats of different species of organisms change, and where ecological conditions make life possible for these species as they adjust their range and life cycles. Combined with ancillary data on ocean physical properties, PACE ocean color observations will help us to better understand essential fish habitats and the productivity dynamics of the phytoplankton that forms the base of the global ocean food web.

Comments? Thoughts?

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PACE/HyspIRI COMPLEMENTARY MISSION APPLICATIONS:
Improving Hazard Assessment and Aviation Safety

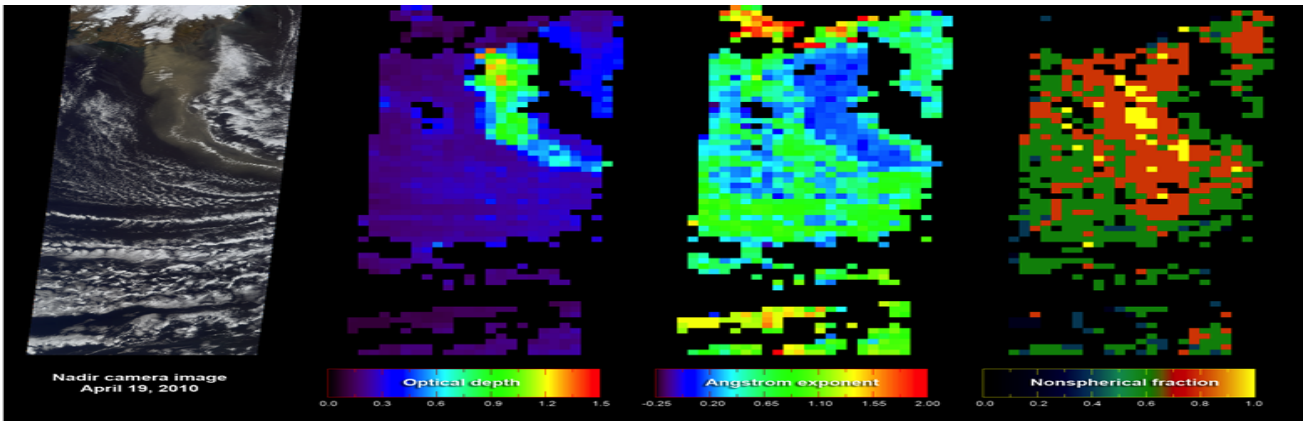

Figure 1. An example of MISR air mass mapping applied to the Eyjafjalljökull Volcano Ash Plume on April 19th, 2010. The four panels show successive information content (true color, optical depth, size, and sphericity) obtained from retrievals using multi-spectral, multi-angle MISR data (courtesy of Ralph Kahn and the MISR Team). This is similar to the information content of the multi-angle multi-spectral polarimeter planned for PACE.

Application Question/Issue

Aviation operations can be significantly impacted by volcanic ash as evident from the recent Eyjafjallajökull volcano in Iceland (April 2010). Knowledge of the location, amount, and evolution of the volcanic plume and its ash content will enable timely and accurate hazard assessment/avoidance and enhance aviation safety after volcanic eruptions.

Who Cares and Why?

Volcanic plumes consist of Sulfur Dioxide (SO_2) and volcanic ash which is predominantly composed of silicates with a melting point (~1100°C) far below typical turbine engine full thrust temperatures of ~ 1400°C. Aircraft flight through high concentrations of volcanic ash will fuse molten silicate onto turbine blades and guide vanes leading to transient flame out, and possibly engine failure. According the International Civil Aviation Organization (ICAO), more than 100,000 commercial flights were cancelled during the Eyjafjallajökull's 2010 volcanic eruption and over $5 billion in global GDP was lost due to what eventually became the largest shut-down of European air traffic since World War II.

Needed Measurements

An ICAO task force recommended the use of satellite-based observations to guarantee safety while avoiding the unnecessary closure of immense portions of airspace. The closure of air space during the 2010 eruption of Eyjafallajökull was based on forecasts rather than satellite observations of ash. Satellite measurements will help to initialize and/or validate such forecasts. Measurements of volcanic plumes, plume height, ash and SO_2 concentrations, and the ability to discriminate between clouds of volcanic ash and meteorological (water/ice) clouds are needed. Some of these measurements are needed both day and night for the development of advisories directly or as inputs to model simulations from which such advisories will be developed.

The NASA Response

Measurements, similar to the information content of Figure 1 above, that would identify the ash particle size and concentration (from a **Multi-angle Multi-spectral Polarimeter on PACE**), and the ability to discriminate between water/ice clouds and volcanic plumes (from **HyspIRI**) would form **a complementary data** set and provide the relevant Volcanic Ash Advisory Centers (VAACs) **sufficient actionable information** for hazard avoidance during volcanic eruptions. The Eyjafjallajökull plume was observed by many satellite sensors including OMI, MISR, MODIS, SEVIRI, ASTER, AIRS, and CALIPSO. The MODIS instruments (in low earth orbit on the Terra and Aqua satellites) and the SEVIRI instrument (on METEOSAT in geostationary orbit) tracked the geographic transport of the ash plume and estimated its height and ash particle size. HyspIRI Thermal Infra-Red (TIR) measurements will provide us with similar capabilities. The MISR instrument on the Terra satellite, provided critical information that allowed mapping the height of distinct plumes over the North Atlantic. Multi-angle aerosol measurements on board PACE would enable plume heights to be derived in a manner similar to those employed using MISR. Additionally polarization measurements aboard PACE would enable separation of volcanic ash from sulfate aerosols. The ability to obtain these data and develop timely advisories results in a direct societal benefit.

Comments? Thoughts?

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PACE MISSION APPLICATIONS - Harmful Algal Blooms

Upper Left: Harmful Algal Blooms kill fish, contaminate seafood and pollute our waters (Photo from NOAA/IOOS). Lower Left: Warning sign for cyanobacteria (Image Credit: J. Graham, USGS). Right: Satellite image of Lake Erie, showing the extent of the 2011 harmful algal bloom (the most severe in decades). Credit: MERIS/NASA; processed by NOAA/NOS/NCCOS.

Application Question/Issue: ***How can we better understand the causes and impacts (economic, cultural, environmental, human health) of Harmful Algal Blooms (HABs), and how can we improve monitoring and forecasting of the location and extent of HABs using ocean observations from space?***

Who Cares and Why?

Coastal HAB events have been estimated to result in economic impacts in the United States of at least $82 million each year. The impacts of HABs range from environmental (e.g., alteration of marine habitats and impacts on marine organisms including endangered species), to human health (e.g., illness or even death through shellfish consumption, asthma attacks through inhalation of airborne HAB toxins), to socio-economic and cultural (e.g., commercial fisheries, tourism, recreation).

NOAA, USGS, EPA (e.g., Gulf of Mexico Program), and other state environmental agencies and local health departments are interested in improved monitoring and understanding of HAB events. Among the main goals of these end-users is to provide coastal communities with advance warning, so they can adequately plan and deal with the adverse environmental and health effects associated with a harmful bloom.

Needed Measurements

Improved monitoring and forecasting of HABs requires satellite observations of sea-surface-temperature (SST), chlorophyll-a (Chla) and HAB pigments. To meet the needs of the user communities, satellite measurements (daily images) must be produced at spatial resolutions of approx. 300 m, with a spatial coverage that includes coastal waters (<100 nautical miles from the coast), signal-to-noise ratio (SNR) of 1000, uncertainty of 30% and range of 0.5-400 ug/L. Extended spectral coverage in the near infrared and shortwave infrared regions would be particularly helpful.

The NASA Response

The high (5-nm) spectral resolution measurements from PACE will allow regional algorithms to be developed for identifying and quantifying specific phytoplankton groups, thus allowing identification of HABs and tracking their evolution and variability over seasonal to interannual time scales. This information will lead to a highly sought-after understanding of environmental factors governing HAB appearance and demise. The recommended PACE ocean color data latency (0.5 hour data latency), extended spectral range from the ultraviolet (~350nm) to short-wave infrared (SWIR; 2130nm), spatial coverage (global), and spatial resolution of 250 m x 250 m to <1 km^2 in inland, estuarine, coastal and shelf waters, will meet the majority of users needs for improved space-based HAB retrievals. The combination of high quality PACE ocean color imagery with ancillary observations from various platforms, including other (current and planned, domestic and international) satellite sensors, aircraft measurements, ground-based and marine observation networks, will allow us to vastly improve monitoring and forecasting of the location and extent of HABs.

Comments? Thoughts?

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