NASA COAST and OCEANIA Airborne Missions in Support of Coastal Ecosystem and Water Quality Research

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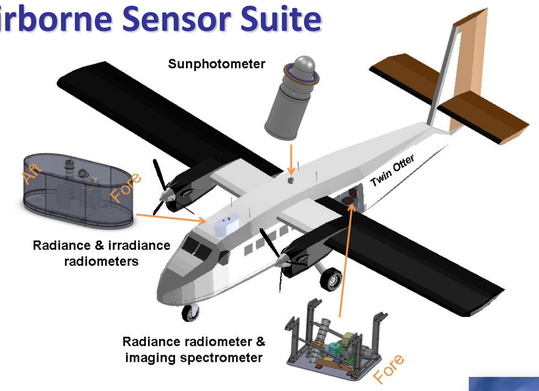
Abstract

Worldwide, coastal marine ecosystems are exposed to land-based sources of pollution and sedimentation from anthropogenic activities including agriculture and coastal development. Ocean color products from satellite sensors provide information on chlorophyll (phytoplankton pigment), sediments, and colored dissolved organic material. Further, ship-based in-water measurements and emerging airborne measurements provide *in situ* data for the vicarious calibration of current and next generation satellite ocean color sensors and to validate the algorithms that use the remotely sensed observations. Recent NASA airborne missions over Monterey Bay, CA, have demonstrated novel above- and in-water measurement capabilities supporting a combined airborne sensor approach (imaging spectrometer, microradiometers, and a sun photometer). The results characterize coastal atmospheric and aquatic properties through an end-to-end assessment of image acquisition, atmospheric correction, algorithm application, plus sea-truth observations from state-of-the-art instrument systems.

Importance

There are many properties of biological interest in the coastal ocean, e.g., river plumes, kelp beds, and phytoplankton including harmful algal blooms (HABs), and similar targets at the land/sea interface (e.g. estuaries, coastal lakes) (Figure 1). Measurements of these features are important for understanding water quality, the linkages with land-based sources of pollution, and impacts to coastal ecosystems.

Airborne Sensor Suite



Imaging Spectrometer:

- Measurements targeted at 412, 443, 490, 510, 555, 665, and 683 nm to match satellite bands used for ocean color
- Spectral range: 380-760 nm, 10 nm bandwidth
- Derived water-leaving radiance for measuring absorbing and scattering constituents
- Future plans using the JPL PRISM instrument

Ames Airborne Tracking Sunphotometer (AATS-14):

- Measures multi-wavelength transmission (T) at 14 wavelengths, 353-2139 nm to derive AOD spectra and overlying water vapor column content

Products:

- Aerosol optical depth (AOD) at 13 channels
- Column water vapor using T(940 nm)
- Aerosol extinction, 340-2139 nm
- Water vapor density

Coastal Airborne In-situ Radiometers (C-AIR):

Three 19-channel microradiometers:
1. Cosine collector for measuring solar irradiance (Es)
2. Sky radiance (Li) and
3. Total radiance (Lt)

Spectral range: 320-780 nm with 10 nm bandwidth to include channels centered around 412, 443, 490, 510, 555, 665, and 683 nm to match satellite (NASA MODIS) bands used for ocean color remote sensing.

- Derived exact water-leaving radiance in VIS and NIR for discrimination of absorbing and scattering constituents
- Downward irradiance (global solar irradiance) for apparent optical properties

Challenges

Accurate retrieval of ocean color and benthic ecosystem reflectance. Highly variable radiance signals (deep water to the coastal edge). Higher signal (SNR) requirement over water than for land targets.

Atmospheric correction. Aerosol and trace gas plumes from continental sources complicate the task of atmospheric correction.

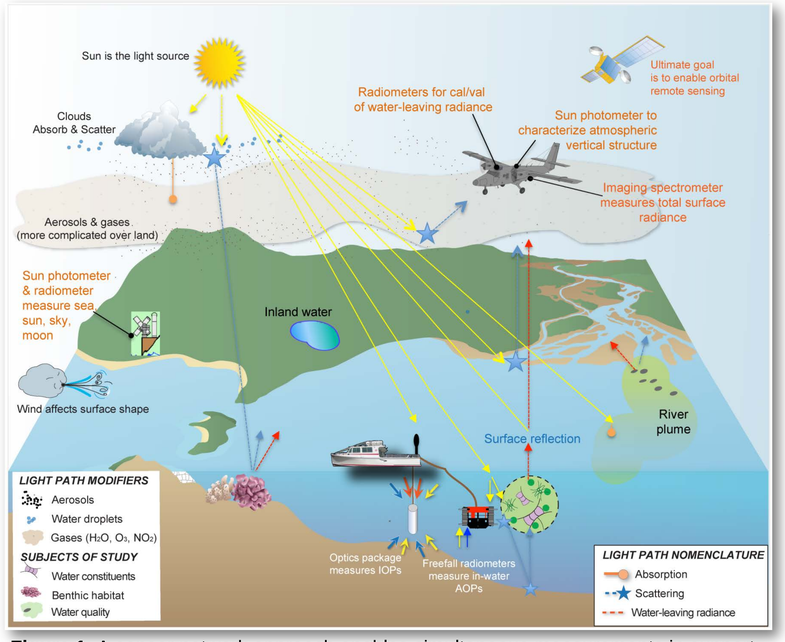
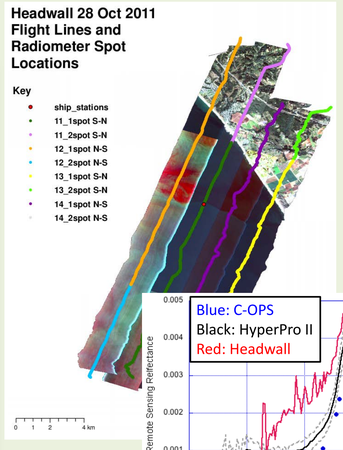
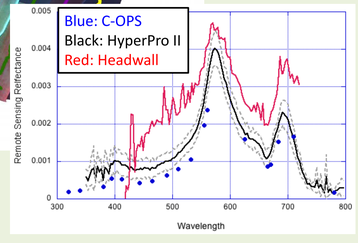


Figure 1. A sensor network approach enables simultaneous measurements in support of calibration and validation exercises for satellite coastal ocean color products.

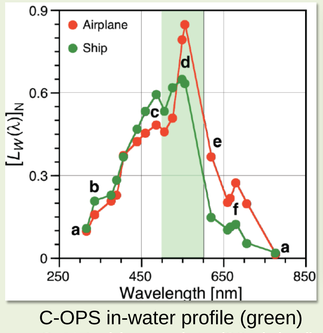
Bringing the Coastal Ocean into Finer Focus

COAST 2011

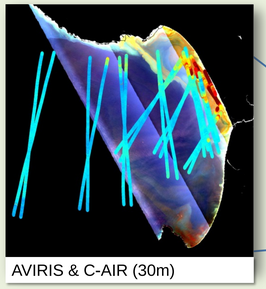




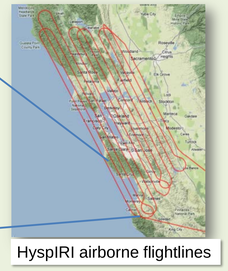
OCEANIA 2013



C-OPS in-water profile (green)
C-AIR airborne data (30m) (red)



AVIRIS & C-AIR (30m)



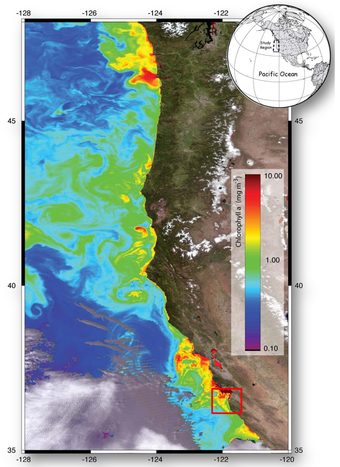
HyspIRI airborne flightlines

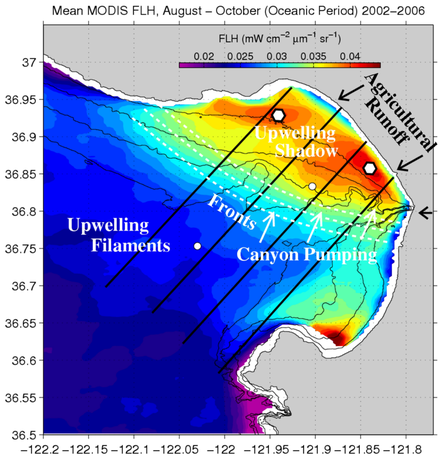
Goal

To demonstrate the following in support of calibration and validation exercises for satellite coastal ocean color products:

a) the utility of a multi-sensor airborne instrument suite to assess the biological properties of coastal California, including water quality;
b) the importance of contemporaneous atmospheric measurements to improve atmospheric correction in the coastal zone.

Monterey Bay, CA as a Testbed





- Monterey Bay has both open ocean and optically complex water masses, so the full dynamic range of the sensor suite and protocols being used in the field can be evaluated
- Ongoing time-series by UCSC, MLML, MBARI, with moorings and shore stations
- Features include Elkhorn Slough, Case 1 and 2 waters, red tides, kelp beds, river plumes
- Seasonality: fall transition, upwelling versus warm stratified conditions, and a “first flush” rain event

Ship-based Measurements

- *R/V John H. Martin* T, S, Chl-a, Fluorescence
- At each station:
  - Size fractionated chlorophyll, cell enumeration, HPLC pigments
  - CDOM, phyto absorption
  - Surface and profile AOPs (water-leaving radiance)
    - HyperPro and C-OPS
  - Surface and profile IOPs (backscattering and absorption)
    - HS6 and ac-s
  - Surface reflectance - ASD
  - AOD spectra - sun photometer

Satellite Data

MODIS Aqua and Terra and HICO data corresponding to contemporaneous deployment of the ship-based and airborne measurements.
Satellite observations are used to compare accuracy of radiance retrievals and derived products versus the Headwall imaging spectrometer and the *in situ* measurements.

Work Underway

- COAST: Using sun photometer data to inform atmospheric correction model and assessing atmospheric correction schemes (e.g., ATREM, 6SV, Tafkaa)
- COAST and OCEANIA: Enhancing processing algorithms for C-AIR microradiometers for deriving water-leaving radiance
- Comparison of C-AIR, C-OPS, and HyperPro data across study area

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