

## CONSIDERATIONS FOR AN INWATER OPTICAL RADIOMETER

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Remote sensing by satellites offers the means of obtaining synoptic data over large tracts of the ocean on a global scale. Analysis of the coastal zone color scanner (czcs) can result in useful information and insight on the dynamics of the distribution of chlorophyll bearing phytoplankton in the pper attenuation length and therefore reliable estimates of primary production per unit area. Baseline optical measurements using in-situ radiometers is needed not only for the validation of satellite derived imageries, but for a basic understanding of absorption and scattering processes in sea water.

The objective of the present work is to design and d velop an In-water instrument to measure the spectral nature of the irradiance field in the ocean.

The radiometer will measure the following:

- Downwelling and upwelling irradiance in the wavelength range 350 nm-750 nm as a function of depth.
- Chlorophyll Fluorescence at 685 nm.
- Depth, temperature and T:ll-
- Skylight irradiance

### Irrradiance Measurements

Irradiance (E) by definition, is the radiant flux (or the time rate of flow of radiant energy) incident on an infinitesimal element of surface containing a point, divided by the area of that element:

$$E = \frac{dh}{dA} \quad \text{units: w/m}^2/\text{nm}$$

In terms of radiance L it is expressed a :

$$E = \int L(i,h) \cos i. (\sin i \, di \, dh)$$

Irradiance, is an apparent optical property of the sea, because it is dependent on changes of the irradiance distribution. In a simple description E changes with depth at a fixed wavelength as:

$$E(z,\lambda) = E(i,\lambda) \, \text{ex} \, (-k(z,\lambda) \cdot z)$$

Where  $E(0,\lambda)$  is the solar irradiance at the sea surface

$E(z,\lambda)$  is the radiance at depth  $z$ .

$K(z,\lambda)$  is the vertical attenuation coefficient.

The irradiance  $E$  changes across the spectrum and also with depth. It can vary by at least 6 to 7 decades in signal level from the surface  $z = 0$  meters to  $z = 180\text{m}$ . At the blue and red wavelengths, the changes in  $E$  will be similar to each other, but greater than 6 decades.

The irradiance spectrometer must therefore be optimised for collection efficiency because of the extremely low light levels.

Perturbations on spectral irradiance measurements are due to surface wave noise, changing sky conditions resulting from cloud movement, changing sun zenith angle, ship's roll and ship's shadow produced above water.

Elements of the radiometer

The main elements in the design of the radiometer are:

- Cosine collectors (for upwelling and downwelling measurements)
- Grating based spectrographs
- Image detectors (CCD/PDA types)
- Electronics for data acquisition
- Expert system software for irradiance data analysis using shipbased P.C.
- Sensors temperature, depth, axis tilt and sky sensor.

Cosine collectors are designed so that their response to angular changes in the light field follows a cosine law. This way the definition of vector irradiance is satisfied.

Two grating based spectrographs are considered:

1. Transmission grating with collimator and camera lenses and (z)aberration corrected concave grating.

The electronics for data acquisition will consist of a micro-controller to look after upwelling and downwelling CCD's 16 bit ADC, clock drivers, low noise amplifiers and a tale table computer.

A ship based PC will be used for initialisation of the radiometer, control of skylight sensor, corrections, and running of an expert system shell for estimate of water type an inherent optical properties.