

# Photosynthetically Available Radiation (PAR)

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## 1 - Product Summary

This algorithm estimates daily average photosynthetically available radiation (PAR) at the ocean surface in Einstein  $\text{m}^{-2} \text{d}^{-1}$ . PAR is defined as the quantum energy flux from the Sun in the 400-700nm range. For ocean color applications, PAR is a common input used in modeling [marine primary productivity](#). Implementation of this algorithm is contingent on the availability of observed top-of-atmosphere radiances in the visible spectral regime that do not saturate over clouds. The algorithm is applicable to MODIS, MERIS, SeaWiFS, and VIIRS, but it can be operated on all ocean color sensors. The PAR product is included as part of the standard Level-2 OC product suite and the Level-3 PAR product suite.

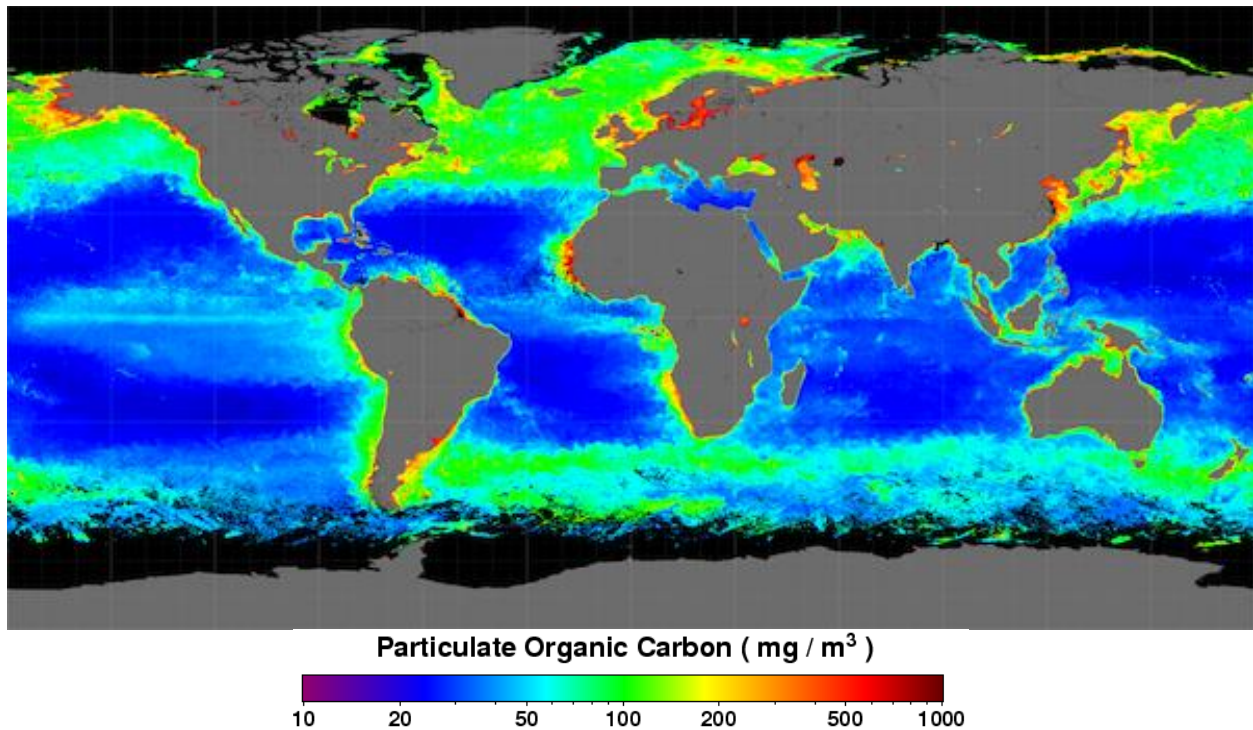


Fig. 1. MODIS Aqua PAR seasonal composite for Spring 2014

Algorithm Point of Contact: [Robert Frouin](#), Scripps Institute of Oceanography

## 2 - Algorithm Description

### Inputs:

Observed Top-of-Atmosphere (TOA) radiances in in the 400-700nm range that do not saturate over clouds.

### Output:

Daily average PAR in Einstein  $\text{m}^{-2} \text{d}^{-1}$

### Approach:

A detailed description of the algorithm as implemented for SeaWiFS is provided in the whitepaper [Frouin, Franz, and Wang](#), "Algorithm to estimate PAR from SeaWiFS data Version 1.2 - Documentation", which is also summarized in the SeaWiFS postlaunch technical report volume 22, [Frouin, R., B.A. Franz, and P.J. Werdell \(2002\)](#). The algorithm implementation has since been generalized to allow operation on any sensor with a sufficient set of spectral bands.

### Sensor-specific details:

As noted, the PAR algorithm requires a set of sensor bands in the visible regime for which the observed TOA radiances do not typically saturate over clouds. This means that at least a few sensor bands in the visible domain can measure changes in radiance from very dark ocean to very bright clouds. Many ocean color sensor bands are designed to saturate (stop changing) at radiances well below that limit, but they may include a subset of bands with higher radiance limits (e.g., MODIS bands designed for land applications). Here we define the sensor bands used for each applicable sensor.

SeaWiFS	412,443,490,510,555,670
MODIS	469,555,645
MERIS	413,443,490,510,560,620,665
VIIRS	410,443,486,551,671

### Failure conditions:

The PAR product is not computed if TOA radiance is negative or solar zenith angle exceeds 90-deg, or if the [Level-2 flags](#) indicate LAND, HIGLINT or SEAICE. A failure condition is indicated in Level-2 by setting the PAR value for that pixel to the [FILLVALUE](#) and setting the [Level-2 flags](#) to indicate PRODFAIL.

## 3 – Implementation

Product Short Name	par
Level-2 Product Suite	OC
Level-3 Product Suite	PAR
Level-3 Masking	LAND,HISOLZEN,NAVFAIL,FILTER,HIGLINT

For further details on the implementation, go to the algorithm [source code](#) or the [graphical description](#) of the algorithm implementation in the NASA ocean color processing code (l2gen).

## 4 - Assessment

A limited set of Level-2 satellite-to-in-situ match-up validation results are available for each sensor from the validation tool of the SeaWiFS Bio-Optical Archive and Storage System (SeaBASS). Links to those match-ups are provided below.

- [SeaWiFS](#)
- [MODIS Aqua](#)
- [MODIS Terra](#)
- [VIIRS](#)
- [OCTS](#)
- [CZCS](#)
- [MERIS](#)

As detailed in [Frouin, Franz, and Werdell \(2002\)](#), however, the validity of the PAR product improves with temporal compositing. The PAR product is primarily intended for use as a Level-3 product, where data have been composited over weekly to monthly time-scales.

## 5 - References

Frouin, R., McPherson, J., Ueyoshi, K., & Franz, B. A. (2012). A time series of photosynthetically available radiation at the ocean surface from SeaWiFS and MODIS data. Remote Sensing of the Marine Environment II. <http://dx.doi.org/10.1117/12.981264>

Frouin, R., Franz, B. A., & Werdell, P. J. (2002). The SeaWiFS PAR product. ,In: S.B. Hooker and E.R. Firestone, Algorithm Updates for the Fourth SeaWiFS Data Reprocessing, NASA Tech. Memo. 2003-206892, Volume 22, NASA Goddard Space Flight Center, Greenbelt, Maryland, 46-50.[The SeaWiFS PAR product](#)

Frouin, R. & Pinker, R. T. (1995). Estimating Photosynthetically Active Radiation (PAR) at the earth's surface from satellite observations. Remote Sensing of Environment, Volume 51, Issue 1, January 1995, Pages 98-107, ISSN 0034-4257. [http://dx.doi.org/10.1016/0034-4257\(94\)00068-X](http://dx.doi.org/10.1016/0034-4257(94)00068-X)

## 6 - Data Access

- [Browse/Obtain Level-2 data](#) - order
- [Browse/Obtain Level-3 data](#) - order or download

- [Download data directly](#) - any data level via https links
- [Search data archive](#) - filename, pattern, or date search
- [Manage existing orders](#) - confirm, cancel, monitor
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