# How the « Case 1 waters paradigm » is currently understood

# Various definitions from a diverse audience (1/5)

Case 1: the optically active constituents co-vary with Chl.
Case 2: the rest

What I know about Case 1 (open ocean) waters are those waters where optical properties vary with phytoplankton concentration and Case 2 waters are quite complex waters where optical properties not only depend on the phytoplankton concentration but also on the seawater constituents like NAP, CDOM.

Case-1 water is type of water, optical property of which can be described as a function of chlorophyll concentration. That is, vertical profiles of the inherent optical properties (IOPs) such as total absorption and total scattering have high correlation with the values transformed from chlorophyll concentration through a function.

The optical opportunities of Case I water are controlled by phytoplankton and their associated materials. I research the terrestrial carbon transportation from land surface to the aquatic ecosystems, so mainly focus on the Case II water on coastal region, which the optical opportunities are controlled by three main components (phytoplankton, CDOM, mineral particle).

# Various definitions from a diverse audience (2/5)

Case I waters are water bodies where phytoplankton and other bio-genic components are the dominant absorbing and scattering particles, and other water components such as colored dissolved materials (CDOM) and mineral particles co-vary with the bio-genic particles. In contrast, case II waters are water bodies where excessive CDOM and mineral particles are often present which do not co-vary with bio-genic particles such as phytoplankton. Case I waters typically include oligotrophic, open oceans and seas. Case II waters often include turbid coastal waters and lakes.

Case 1 waters, which represent longer "open ocean", are dominated by phytoplankton and its associate debris and/or yellow substances (CDOM product by phytoplankton). The optical properties co-vary with the chlorophyll a concentration (principal pigment). Case 2 waters (optically complex) represent longer "coastal water ». In those waters, we find the phytoplankton and its associate component but also inorganic particles and CDOM. Each component varies independently from one another (no covariation with the chlorophyll a). Of course, we must add the impact of seawater itself.

Case 1 waters usually refer to the open ocean water, where the chlorophyll is the main constituent that influences the light besides the water molecule itself. Case 2 waters usually refer to more optically complex waters such as coastal and inland waters, where the water optical properties are not only dependent on phytoplankton, but also on sediments (organic or mineral) and dissolved organic matter.

# Various definitions from a diverse audience (3/5)

"Case 1" and "Case 2" are not used regularly in my program or in the recent literature that I've read, and although several professors have defined them here I will simply define them as -
Case 1 - open ocean water
Case 2 - coastal complex water

Optical properties (IOPs) of case 1 waters are determined by (or covary with) chlorophyll concentration. In case-2 waters it is not true (e.g. CDOM absorption varies independently from chlorophyll concentration).

In case one waters the optical properties are dominated by chlorophyll. CDOM and spm co-vary with chlorophyll in case one waters. In case two waters cdom, chlorophyll and spm are independent and the optical properties are dominated by inorganic particles.

Regarding the case1 and case2 waters – I heard various definitions and I memorized a classification that distinguishes between
Case 1-water: Optical properties dominated by phytoplankton (+CDOM + Detritus)
Case 2-water: Optical properties dominated by non-phytoplanton water constituents such as minerals and CDOM etc.,
But that doesn’t give a clear distinction nor gives threshold values for certain parameters.

# Various definitions from a diverse audience (4/5)

I personally think the broad net of Case 1 and Case 2 waters is still applicable today. However I don't think such 'textbook' parameters should be used in bio-optical models when studying optically-unique regions. The capabilities for deriving tailor-made, regionally specific models and algorithms are presently available and will only improve and become more accessible as time goes on. The future is as bright as a coccolithophore bloom!

Case I waters represent ocean waters where the optical properties change depending on phytoplankton and its derivative material while Case II waters are influenced by phytoplankton and other substances such as particles in suspension and yellow substances. Case II waters represent coastal waters more turbid than Case I.

Case-1 type corresponds to waters where absorption by phytoplankton and CDOM are correlated. In general this type of waters is found in the open ocean. On the contrary, the case-2 type corresponds to waters where absorptions by phytoplankton and CDOM are not correlated. In any way, Case-2 waters definition suppose that in environments with this type of waters, external sources of CDOM exist.

# Various definitions from a diverse audience (5/5)

**Case 1** waters are those waters whose optical properties are determined primarily by phytoplankton and related colored dissolved organic matter (CDOM) and detritus degradation products.
**Case 2** waters are everything else, namely waters whose optical properties are significantly influenced by other constituents such as mineral particles, CDOM, or micro-bubbles, whose concentrations do not co-vary with the phytoplankton concentration.

Case 1 are those waters which optical properties are mainly determined by phytoplankton. CDOM and NAP are assumed to covary with chlorophyll.
Case 2 are all the other water types.
Sometimes I use also a quick definition:
Case 1: offshore waters
Case 2: coastal waters

Case 1: waters which optical signal is dominated mainly by phytoplankton presented in low concentrations. This is the case of oligotrophic water in the subtropical gyres with a blueish color.
Case 2: the optically complex waters. The opical signal is dominated by phytoplankton but also by particulate inorganic matter and dissolved organic matter (CDOM), which are associated to coastal environments, resulting in a yellowish color of those coastal waters.

Case I waters are those where by using simplistic assumptions of the optical components we generally obtain acceptable uncertainties for retrievals from bio-optical models. Reliable Case II waters retrievals require modeling the complexities of the optical constituents and the understanding of how they really drive the ocean color. But we are not still there.

Case-1 generally refers to the open ocean environment where the variation in spectra is characterized/influenced by any chlorophyll present. Coastal waters, deemed Case-2, are characterized by more than one component and thus the blue/green band ratio is not sufficient.

Case 1 waters: the variation of optical propertiesis dominated by phytoplankton and associated material. Success in optical remote sensing and accurate algorithms!
Case 2 waters, not only Chl but inorganic suspended matter and CDOM affects the optical properties ("generally" when we get closer to the coast). Still few appropriate algorithms and consensus= high uncertainties. Need to focus on that!

# In Summary

Co-variation of substances having an optical effect

Dynamic range is large, so it works!

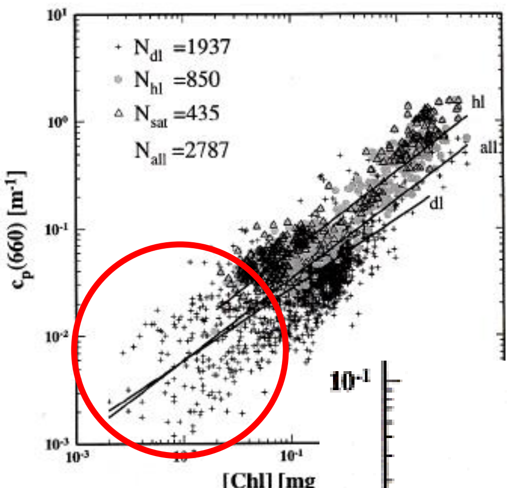
Dominance of phytoplankton absorption?

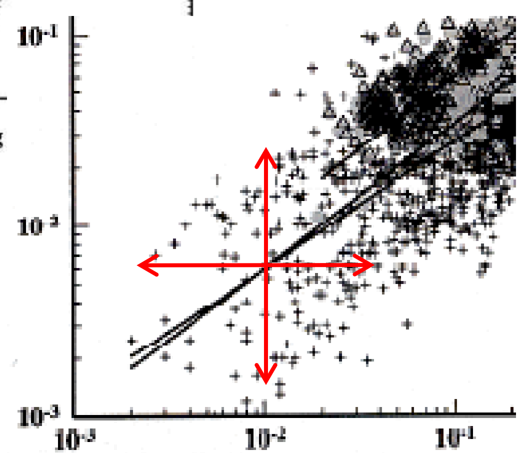
Coastal *vs*. offshore

What determine optical properties *vs*. what can be used to describe their overall changes

Optically complex *vs*. optically simple ?

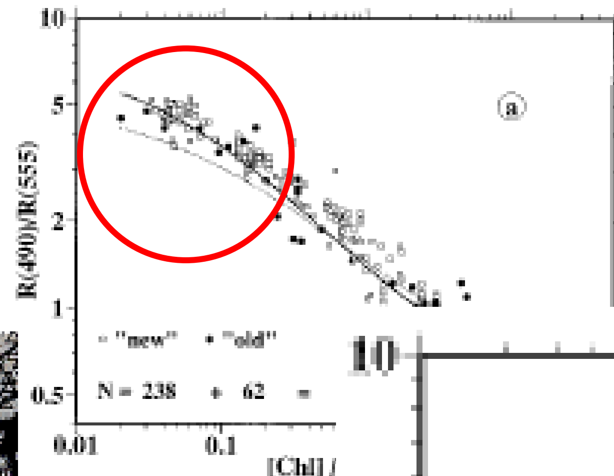
# “Case 1 waters representation”: global relationships exist between Chl and IOPs or AOPs when considering the whole range of the Chl variation (3-4 orders of magnitude)

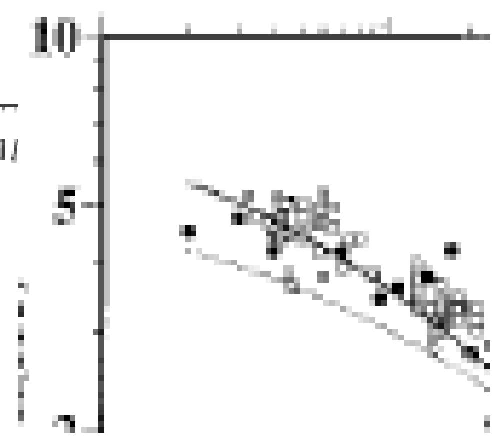




Loisel and Morel, 1998

Morel and Maritorena, 2001





## *Part 2: Various green waters*

Morel, A. and L. Prieur (1977). Analysis of variations in ocean color, *Limnology and Oceanography*, **22**, 709-722.

Among the curves corresponding to green waters shown in Fig. 1, two extreme cases can be identified and separated. Case 1 is that of a concentration of phytoplankton high compared to that of other particles. The pigments (chlorophylls, carotenoids) play a major role in actual absorption. In contrast, the inorganic particles are dominant in case 2, and pigment absorption is of comparatively minor importance. In both cases dissolved yellow substance is present in variable amounts and also contributes to total absorption. An ideal case 1 would be a pure culture of phytoplankton and an ideal case 2 a suspension of nonliving material with a zero concentration of pigments. Obviously, these ideal situations are not encountered in nature, and the

the ocean were sought.

The first such algorithm was given (although not as such) by Morel and Prieur (1977), who presented a graph relating

$$\rho(440,560) \equiv R(440)/R(560)$$

to C. It was clear from their data that a rough relationship

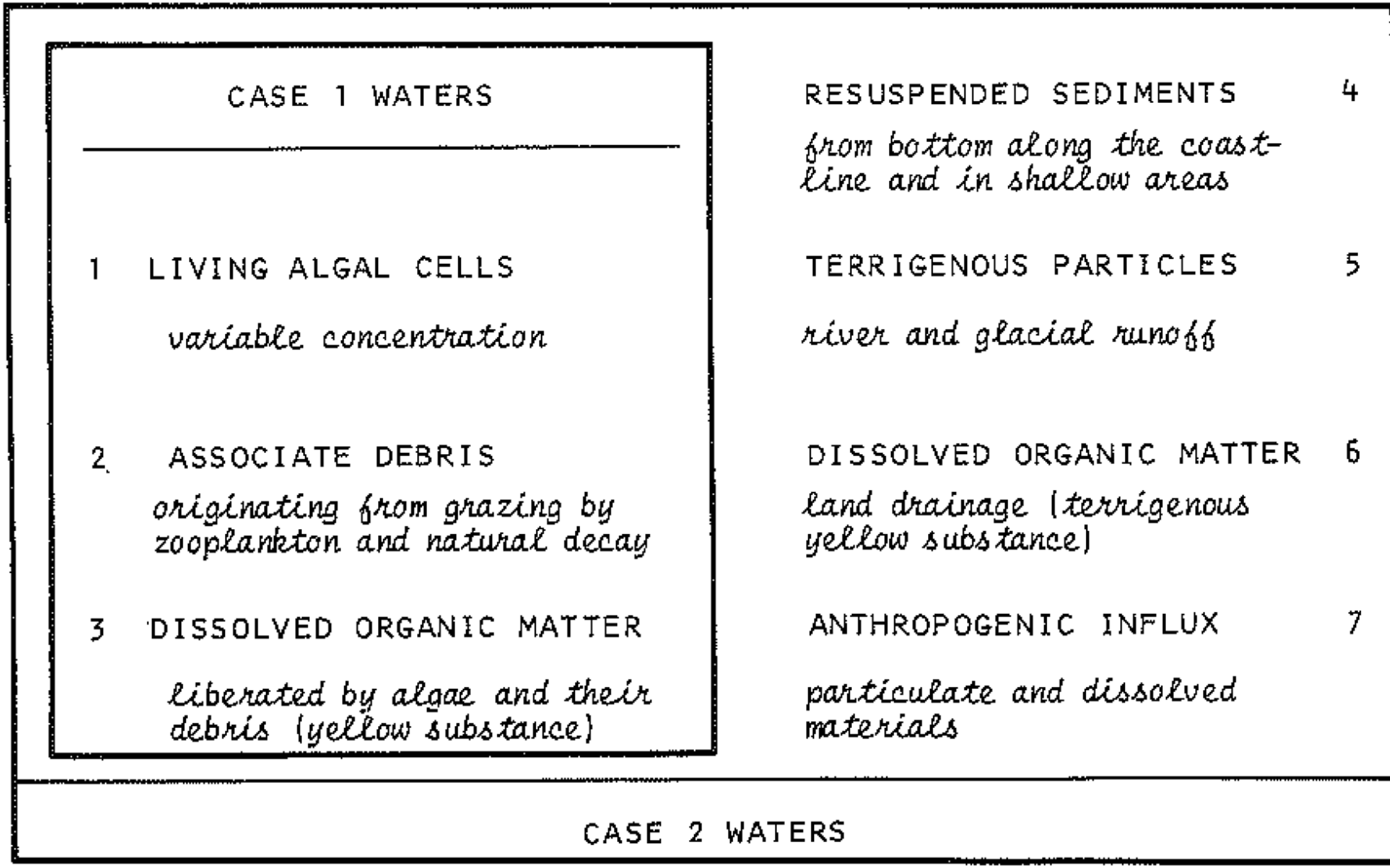
$$C = A[\rho(440,560)]^{B} \quad (14)$$

could be established. In the same paper they classified ocean water according to the relative importance of phytoplankton and their covarying detrital products compared to various inorganic and organic sediments, 'Case 1' waters being those for which phytoplankton and their derivative products play a dominant role in determining the optical properties of the ocean, and 'Case 2' waters those for which the inorganic and/or organic sediments make an important or dominant contribution to the optical properties. This is summarized in Figure 2.

Waters ranging from oligotrophic (very low pigment content) to eutrophic waters (very high pigment content) belong to Case 1 provided that the agents 4, 5, 6 and 7 do not exert a significant influence; the always-associated agents 1, 2 and 3 determine the optical properties. According to Bricaud, Morel and Prieur (1981), the measurable

**From**:
Gordon, H.R., and A. Morel (1983). Remote assessment of ocean color for interpretation of satellite visible imagery. A review, Lectures notes on coastal and estuarine studies, 4, Springer-Verlag, New York (USA).

**From**: Gordon, H.R., and A. Morel (1983). Remote assessment of ocean color for interpretation of satellite visible imagery. A review, Lectures notes on coastal and estuarine studies, 4, Springer-Verlag, New York (USA).



influence of 'marine' yellow substance, 3, (i.e., a by-product of algae degradation) remains weak, even in eutrophic areas.

Case 2 waters may (or not) contain the components 1, 2 and 3. Waters depart from Case 1 to enter into Case 2 because of i) their high turbidity (sediment load) due to the influence of 4 and/or 5 (they are then sediment-dominated Case 2 waters); ii) their high terrigenous yellow substance content (6) (they are then yellow-substance-dominated Case 2 waters, or gilvin dominated, according to Kirk, 1980); and iii) their cumulated influence. Human activity, urban sources, industrial wastes, (7), can also create Case 2 waters, or superimpose their effects on existing Case 2 waters.

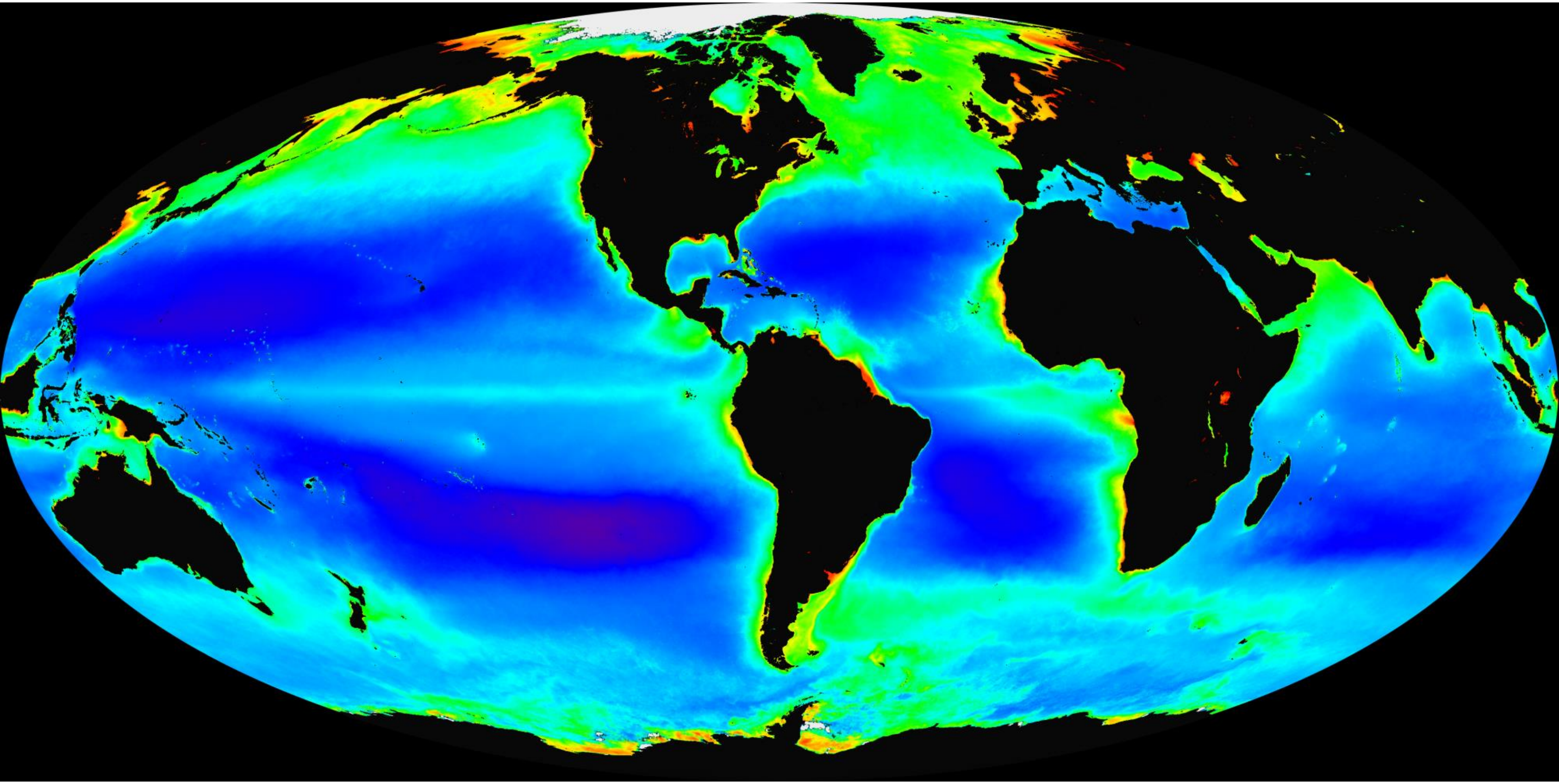
Oceanic waters, as a rule, form the Case 1 waters. These waters, however, are also present even in coastal areas in the absence of terrigenous influx (arid climate) and of the continental shelf. Eutrophic Case 1 waters occur in certain upwelling regions, when the upwelled waters appear offshore, over the outer shelf or shelf break. When they appear over the inner shelf, they are often transformed into Case 2 waters as the sediment resuspension, mainly caused by waves and vertical mixing, maintains a high turbidity. Both these situations are encountered, for instance, along the N.E. African coast (see, e.g., Barton et al., 1977; Morel, 1982). Case 2 waters of diverse kinds are normally encountered in coastal zones (estuaries, shelf areas, inlets, etc.) and possibly far from the coast in the case of extended shelves or shallow banks.

Finally, note that among the constituents (1 to 7) considered, aeolian and meteoric dusts as well as zooplankton have not been represented for the reason that they have a negligible influence upon the optical properties.

In contrast to Case 1 waters, sediment-dominated Case 2 waters show relatively higher scattering, which, in general, does not covary with phytoplankton. At high phytoplankton concentrations, Case 1 waters would appear dark green, while Case 2 waters would appear a bright-milky green. Yellow

**From**:
Gordon, H.R., and A. Morel (1983). Remote assessment of ocean color for interpretation of satellite visible imagery. A review, Lectures notes on coastal and estuarine studies, 4, Springer-Verlag, New York (USA).

# This is still obtained as an application of the « Case 1 waters paradigm »



6-year SeaWiFS global Chl composite