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Using Giovanni with Tri-Plot to Create a Simple Ternary Optical Classification System for Ocean Surface Waters

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Background: Mouth of the Orinoco River

Overview

We have devised a simple optical parameter classification system using three inherent optical property (IOP) parameters available in the NASA Geospatial Interactive Online Visualization and Analysis Infrastructure (Giovanni) provided by the Ocean Biology Processing Group (OBPG).

The Microsoft Excel ternary diagram plotting spreadsheet *Tri-plot* (Graham and Midgely 2000) was used for visualization of the three-component ocean optical parameter classification scheme.

In this presentation we will describe the optical water mass classification method and demonstrate this system by examining the seasonal outflow of the Orinoco River into the eastern Caribbean Sea.

This simple analysis method can be utilized by researchers, continuous water quality monitoring campaigns, citizen scientists, teachers, and students.

The optical water mass classification method

The method uses three Inherent Optical Properties (IOP):

a_{dg} – Absorption coefficient of dissolved and detrital material

a_{ph} – Absorption coefficient of phytoplankton

b_{bp} – Backscattering coefficient

The use of these three IOPs is not a true optical model of the surface waters; they are used for the purpose of optical water mass classification.

The IOPs are acquired from Giovanni by creating an area-averaged map for the selected area over the selected time period, and then extracting the values for each map pixel from the corresponding ASCII text file for the map.

For optical water mass classification, the value of b_{bp} is multiplied by 10 to make it similar in magnitude to a_{dg} and a_{ph}, and then the three values are summed.

The percent contribution of each IOP to the sum is then calculated for each pixel, as shown below for adg:

$$\% \, a_{dg} = \frac{a_{dg}}{[\, a_{dg} + a_{ph} + (10 \times b_{bp}) \,]} \times 100$$

Each pixel in the mapped area will thus be assigned three values:

% a_{dg}

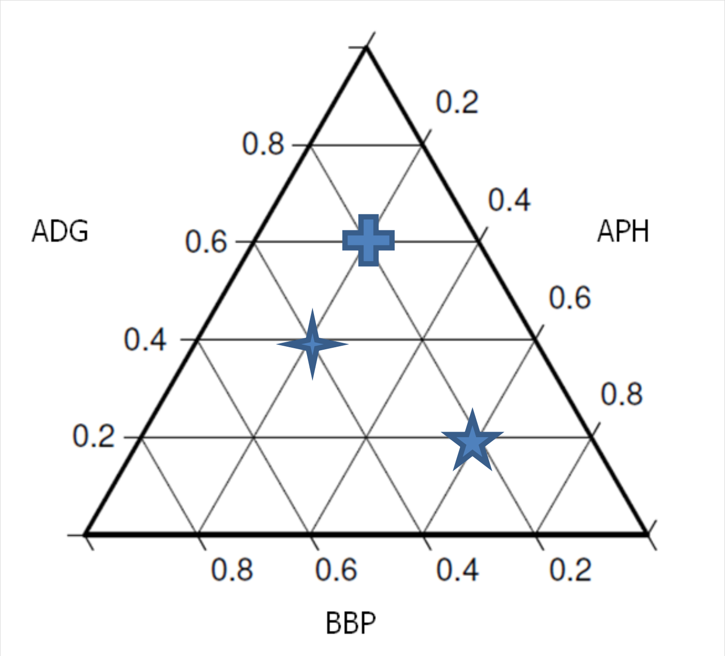
%a_{ph}

%b_{bp}

The MS Excel spreadsheet application *Tri-plot* (Graham and Midgely 2000) is then employed to create a ternary diagram with the three percentage values of the IOPs.

The use of ternary diagrams is common in mineralogy, particle analysis, and solid state chemistry, but has not been widely employed for ocean optics due partly to the lack of a simple method to plot such diagrams.

The relative percentages of the IOPs are plotted on the ternary diagram as shown here. Three example points are shown on the ternary diagram.



40% a_{dg}, 20% a_{ph}, 40% b_{bp}

20% a_{dg}, 60% a_{ph}, 20% b_{bp}

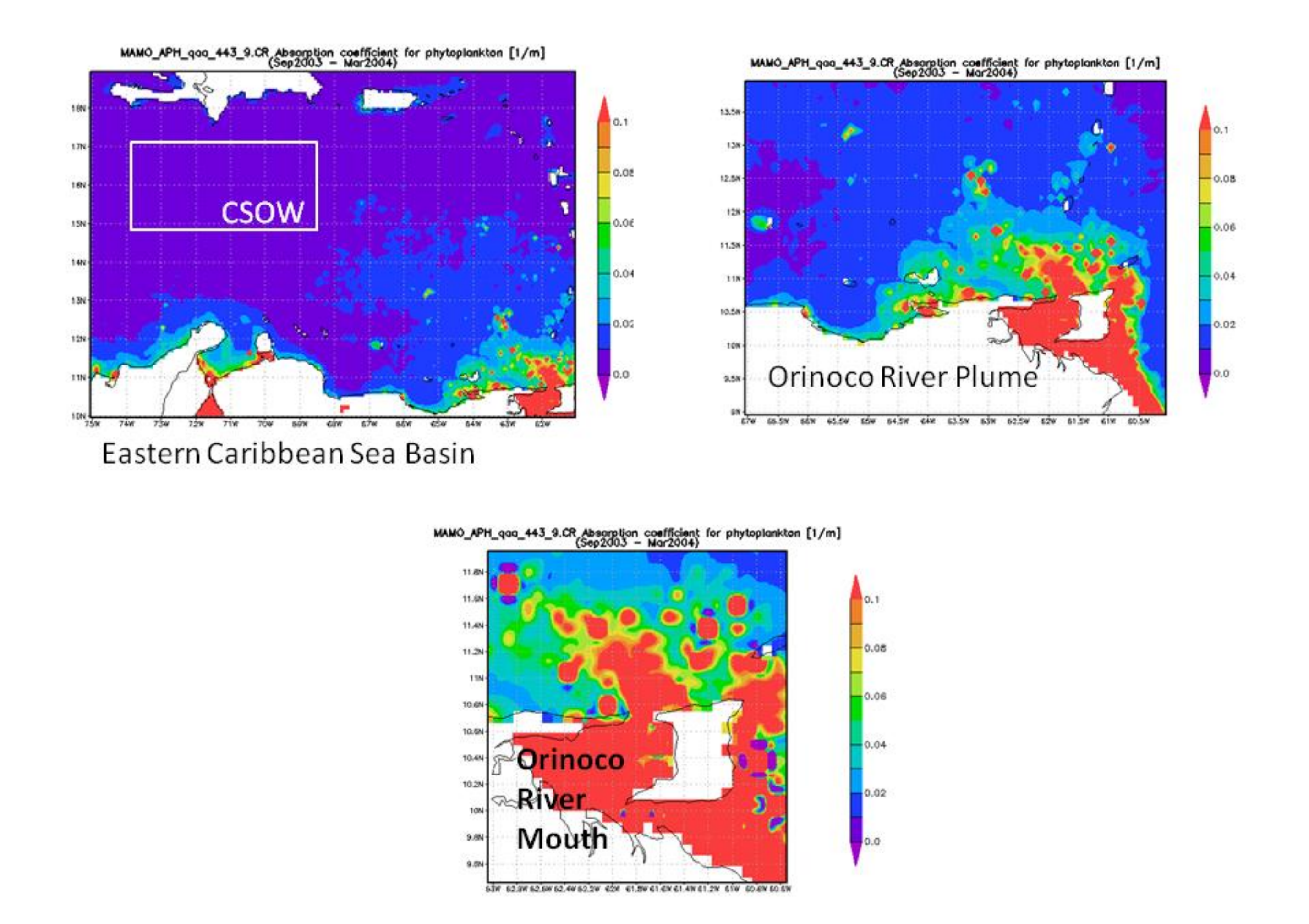
60% a_{dg}, 20% a_{ph}, 20% b_{bp}

Graham, D.J.; Midgley, N.G. Graphical representation of particle shape using triangular diagrams: an Excel spreadsheet method. Earth Surface Processes and Landforms **2000**, *25(13)*, 1473-1477.

To demonstrate the method, we examined the seasonal influence of the Orinoco River on the eastern Caribbean Sea. This seasonal phenomenon has been previously studied, and it is known that the rainy season outflow of the Orinoco River affects a broad area of the eastern Caribbean Sea.

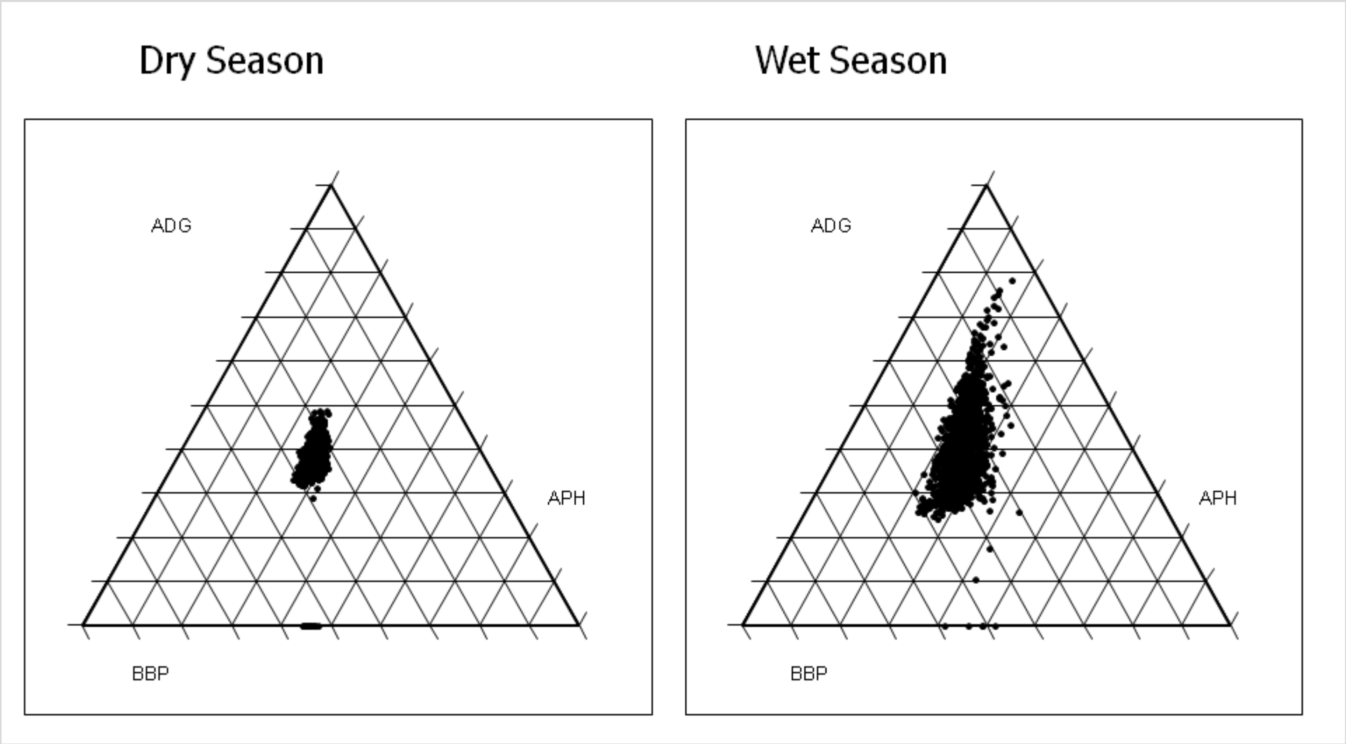
MODIS-Aqua data for the year 2003-2004 were acquired from the Giovanni system for the wet (rainy) season, April-August 2003, and for the subsequent dry season, September 2003 – March 2004.

Four spatial areas were selected, as shown on the next slide.



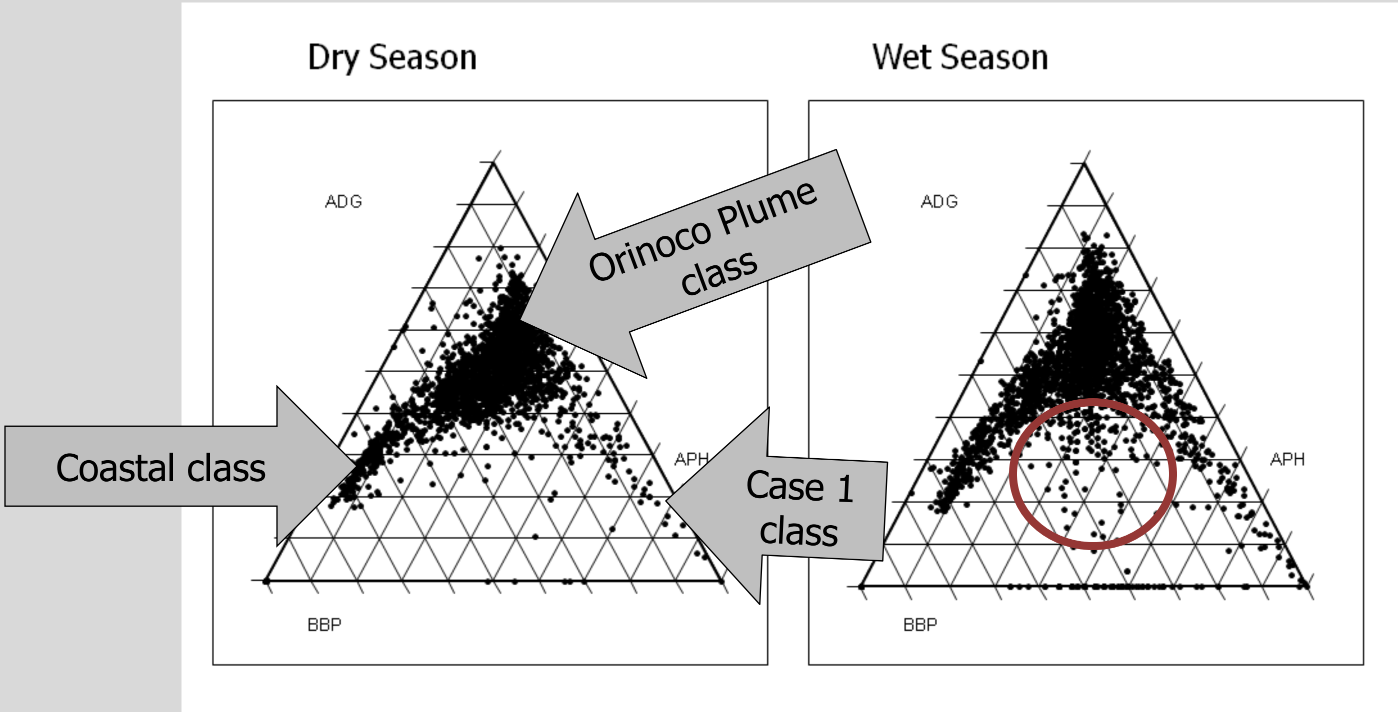
The four regions are the Eastern Caribbean Sea basin (top left); the Caribbean Sea Oligotrophic Waters (CSOW), shown with the white rectangle; the Orinoco River Plume region (top right); and the Orinoco River Mouth region (lower). The Giovanni maps show the a_{ph} parameter during the dry season. The actual mouth of the Orinoco River was excluded from the map because ocean color algorithms interpret the highly reflective sediments as land.

The ternary diagrams for the Caribbean Sea Oligotrophic Waters (CSOW) during the wet and dry seasons are shown below.



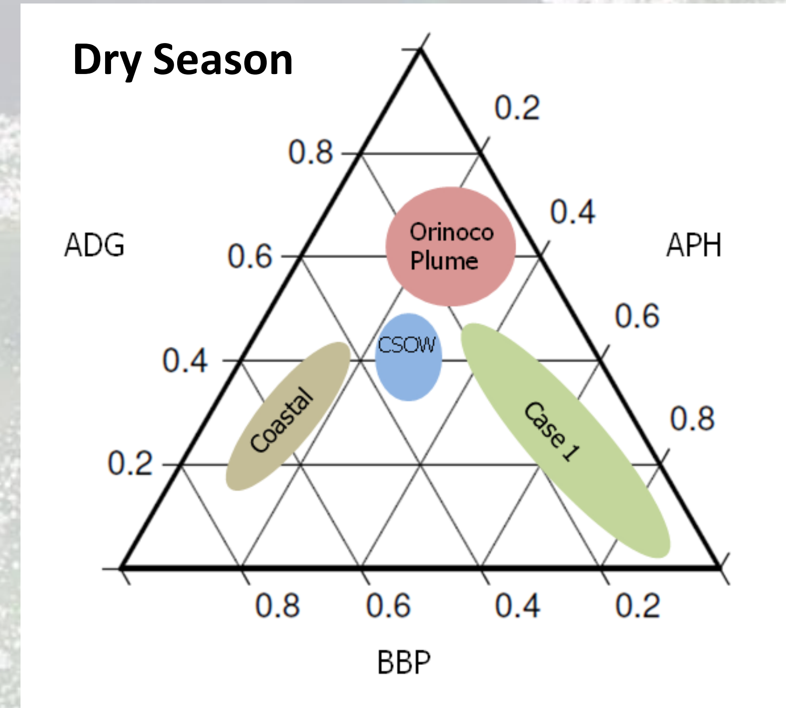
During the wet season, we observe greater variability in the relative optical composition in this region (greater spread of the points on the ternary diagram), as well as a shift toward higher contribution by CDOM absorption, and thus a lower contribution by phytoplankton absorption and particle backscattering, represented by the shift in the distribution of points directly "up" in the ternary diagram.

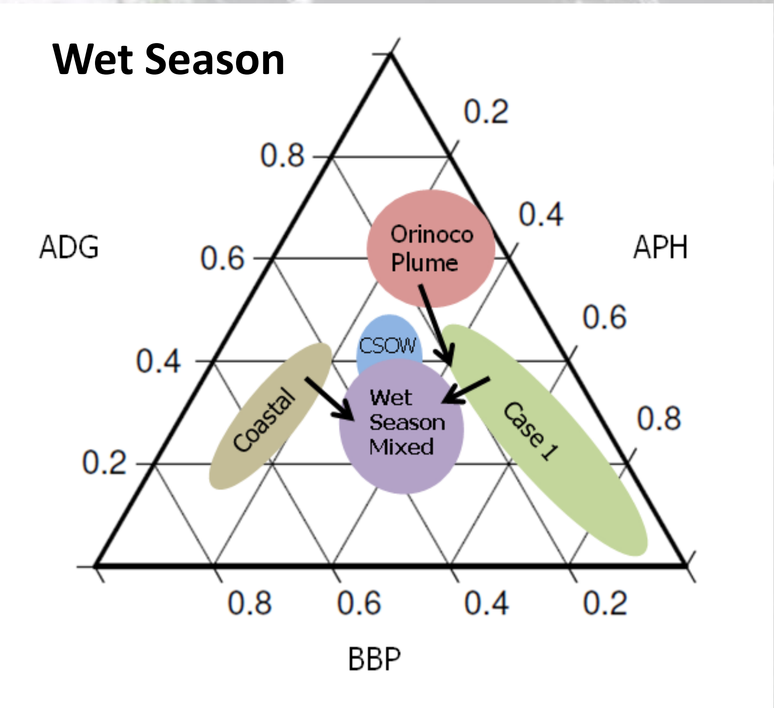
The ternary diagrams for the Eastern Caribbean Basin during the wet and dry seasons are shown below.



Three of the four optical water mass classes identified for dry season conditions are delineated by arrows in the diagram at left. In the diagram at right, the boundaries of a fifth class which occurs during the rainy season are shown by the circled area.

These schematic diagrams show the approximate positions of the optical water mass classes on the Tri-Plot ternary diagram.





The **Orinoco Plume** class is characterized by a high contribution from a_{dg}. The **Case 1** class exhibits the highest contribution from a_{ph}. The **Coastal** class has the highest contribution from b_{bp}, either due to suspended sediments or bottom reflection. The **CSOW** class has approximately equal contributions from each IOP – the actual values of all three IOPs here are very low.

During the wet season, mixing and dilution of the Orinoco River water over the Caribbean Sea basin causes the development of the **Wet Season Mixed** class.

Conclusions

✓ The optical water mass classification system described in this paper provides a simple method to make use of the IOPs available in the NASA data product suite. The example of the Orinoco River outflow in the eastern Caribbean Sea demonstrates the use of this method and the insight it provides regarding influences on surface ocean optical properties. The contrast between dry and wet season conditions in the eastern Caribbean Sea is observable in the ternary diagrams produced by Tri-plot.

✓ The Giovanni – Tri-plot optical water mass classification method provides a way to visualize relationships between the IOPs that indicate the optically active absorbing and scattering constituents in surface waters.

✓ The ability to produce visual ternary diagrams for optical water mass classification can thus become an additional useful analytical tool.