What is the space of attenuation coefficients in underwater computer vision ?

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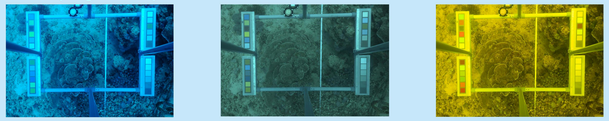
MOTIVATION

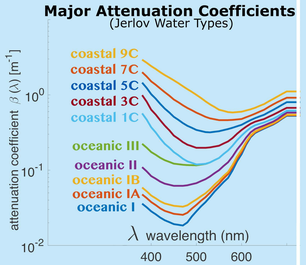
Underwater computer vision algorithms need accurate estimation of attenuation coefficients.

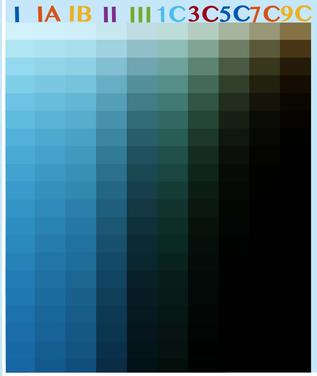
RAW (range = 45m) | CORRECT COEFFICIENTS | INCORRECT COEFFICIENTS



Attenuation coefficients vary geographically, and over time.

A single attenuation coefficient cannot represent the global ocean.





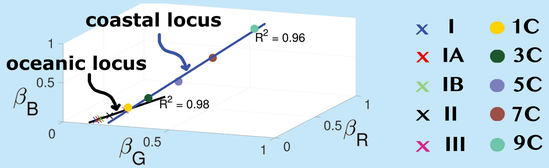
The common notion that water attenuates red colors faster than blue/green only holds for oceanic water types.

KEY FINDINGS

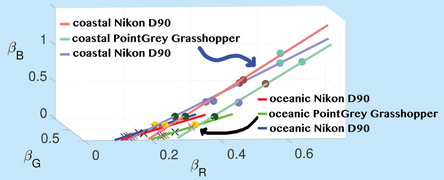
1 **In the ocean, physical attenuation is a function of wavelength, and depends *only* on the water type. In RGB space, it depends *also* on sensor, radiance, and range.**

RESULTS

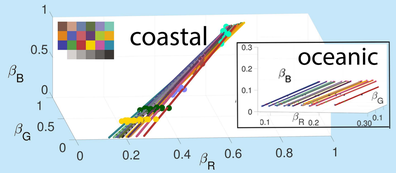
Locus of wideband attenuation coefficients is linear in RGB space.



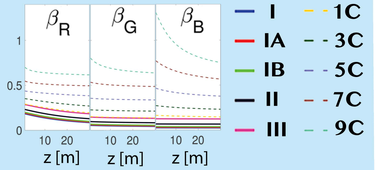
But shifts based on sensor...



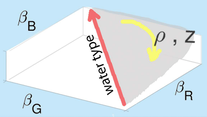
...and scene radiance.



Also depends on range.



With all dependencies, locus is a plane



EFFECTIVE WIDEBAND (RGB) ATTENUATION

$\boldsymbol{\beta_c}$ is calculated from two images taken Δz apart:

$$D_c(z+\Delta z) = D_c(z)e^{-\beta_c \Delta z}$$

where D_c is an RGB image:

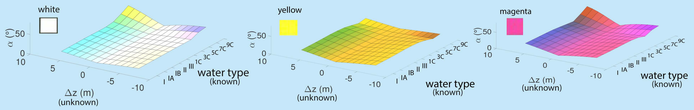
$$D_c = \frac{1}{\kappa}\int_\Lambda Sc(\lambda)\rho(\lambda)E(\lambda)e^{-\beta(\lambda)z}d\lambda$$

Then, $$\beta_c = ln\left[\frac{\int Sc(\lambda)\rho(\lambda)E(\lambda)e^{-\beta(\lambda)(z)}d\lambda}{\int Sc(\lambda)\rho(\lambda)E(\lambda)e^{-\beta(\lambda)(z+\Delta z)}d\lambda}\right]\Big/\Delta z$$

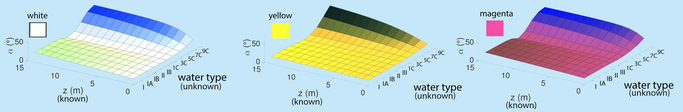
LEGEND

$Sc(\lambda)$	sensor
$\rho(\lambda)E(\lambda)$	radiance
z	range
c	R,G,B
β_c	wideband attenuation
$\beta(\lambda)$	physical attenuation
λ	wavelength

Calculating $\boldsymbol{\beta_c}$ from incorrect range...



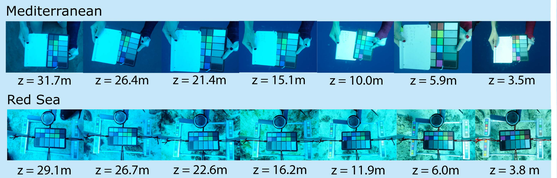
... or, incorrect water type causes strong hue shifts in color reconstruction.

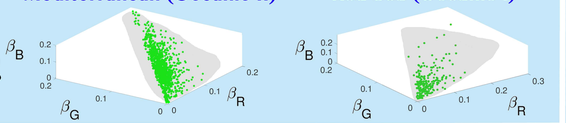


2 **The locus is bound. This reduces the search space for coefficients, but dependencies on water type, sensor, radiance, and range must be considered.**

EXPERIMENTAL VALIDATION

- Photos taken with a Nikon D90 with known sensor response.
- Simultaneous measurements of *in situ* attenuation.



- $\boldsymbol{\beta_c}$ (green) falls on the predicted locus (gray).

Mediterranean (Oceanic II) | **Red Sea (Oceanic I)**