

A class-based approach for mapping the uncertainty of empirical chlorophyll algorithms

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...in collaboration with...

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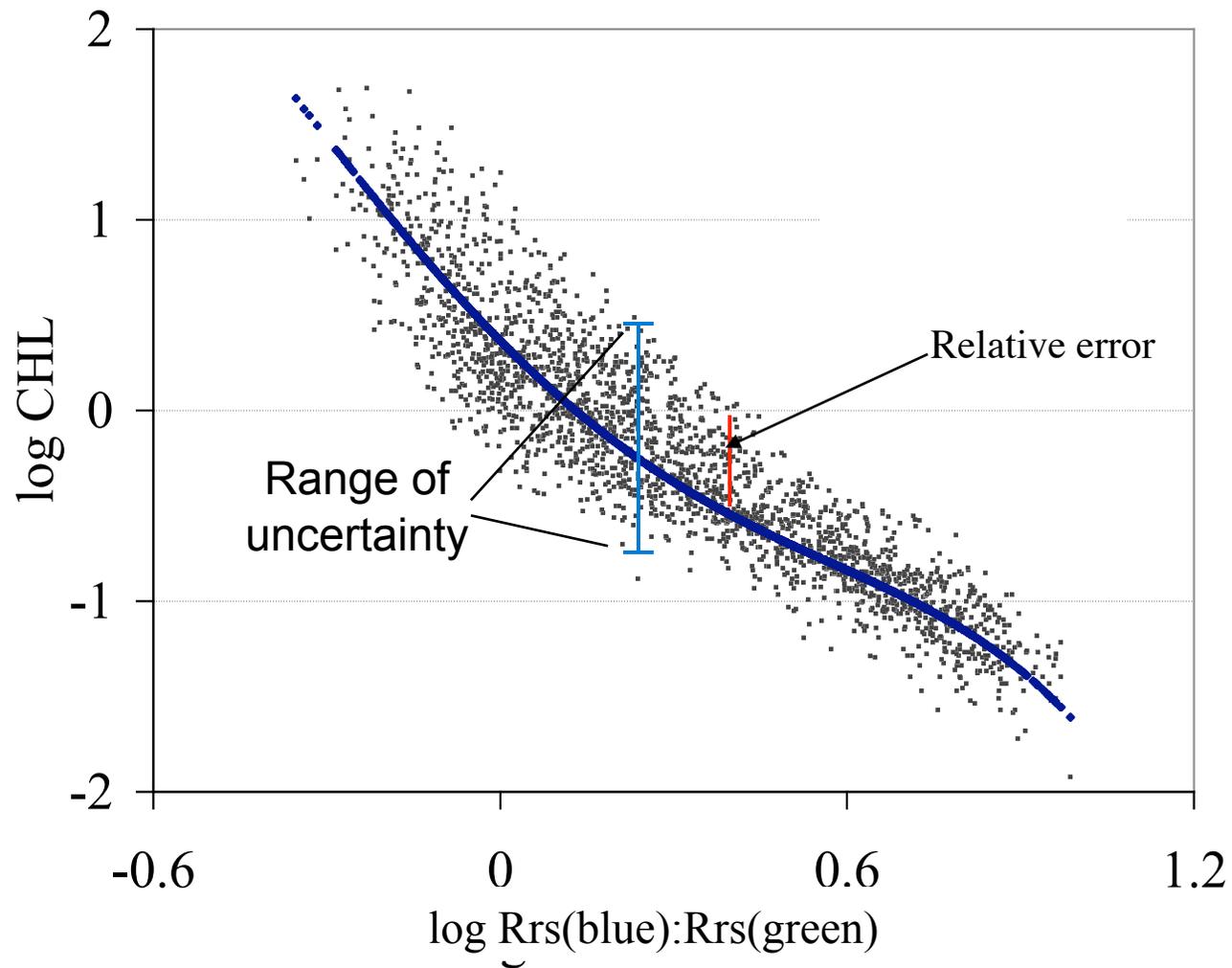
Updates since OCRT (May 2009)

- Fix to NOMAD screening (more oligotrophic points).
- Fix to membership function (increase in class memberships).
- Generalized table for SeaWiFS, MODIS, MERIS.
- Migrated to a developmental l2gen.
- Updates to empirical chl uncertainties from v6 reprocessing.

What's the problem?

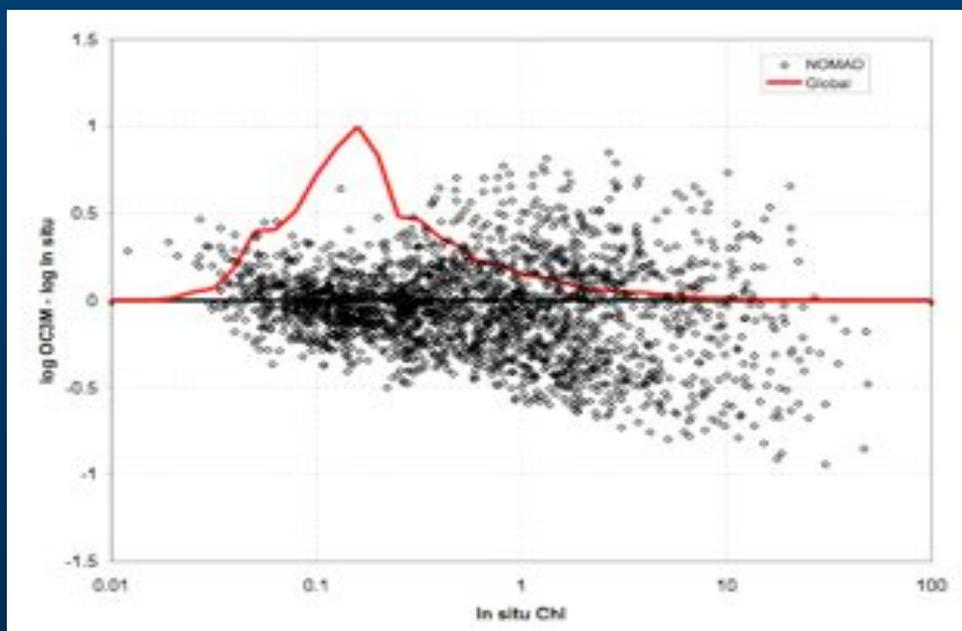
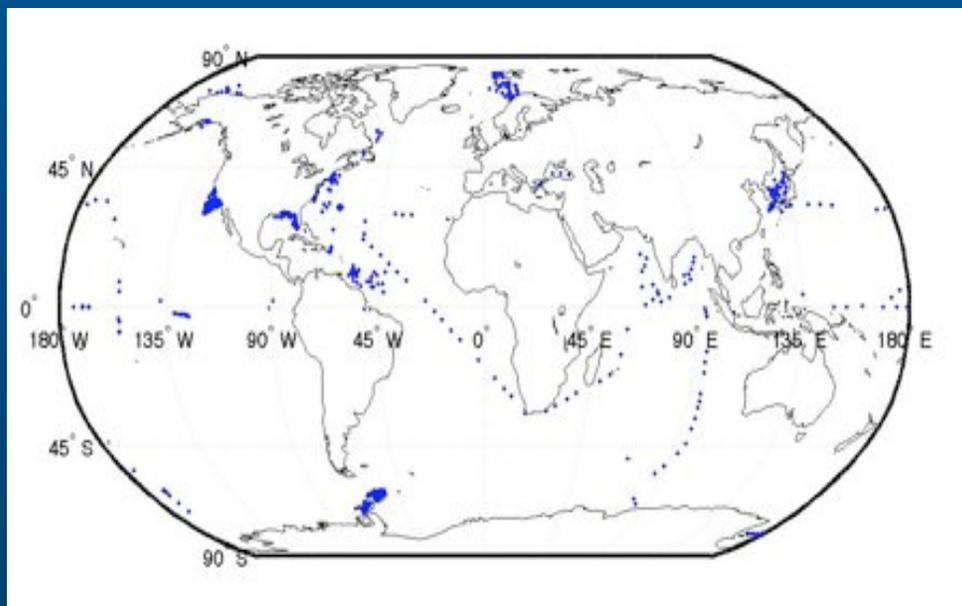
- Current single, bulk estimates of chlorophyll error (50-78%) for the empirical algorithms exceed the desired goal of 35%.
- This is *misleading*, as algorithms do not perform to the same level of accuracy in different optical environments.
- Product error is relevant to higher-order algorithms that use OC products, and understanding changes in CDRs.
- Question: How can we more accurately assess OC product 'error' and geographically map them?

OC3/OC4 Algorithms



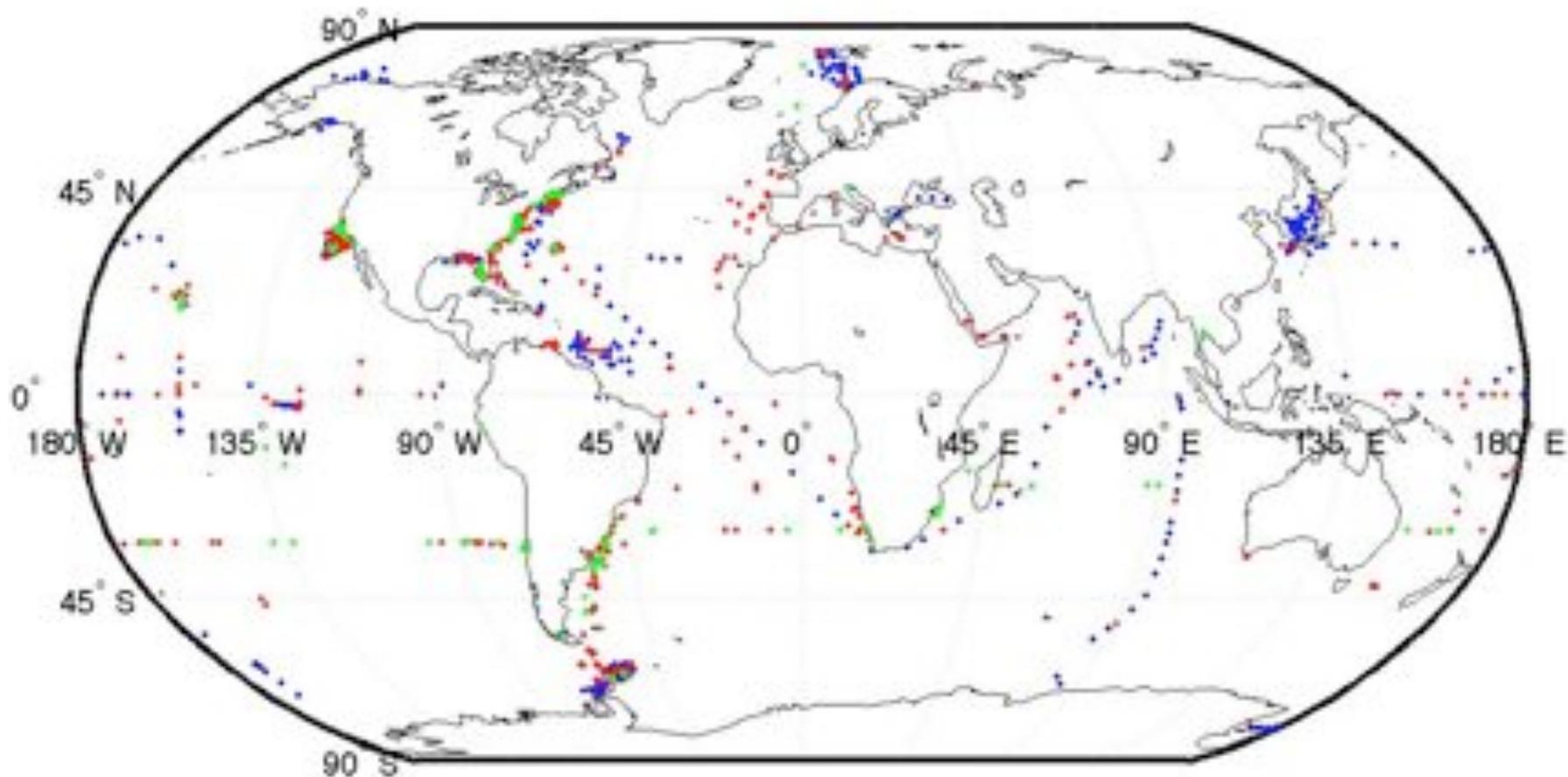
Average absolute error: 50% based on NOMAD V2

NOMAD V2

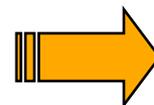


Approach

- Previously, we have implemented a fuzzy logic methodology for distinguishing different *optical water types* based on *remote sensing reflectance*.
- The same techniques can be adapted for characterizing chlorophyll *uncertainty* (or more accurately called *discrepancy*) for empirical algorithms.
- The advantage gained is that different regions of the empirical algorithm can be 1) discretely characterized and 2) individually mapped using satellite reflectance data.

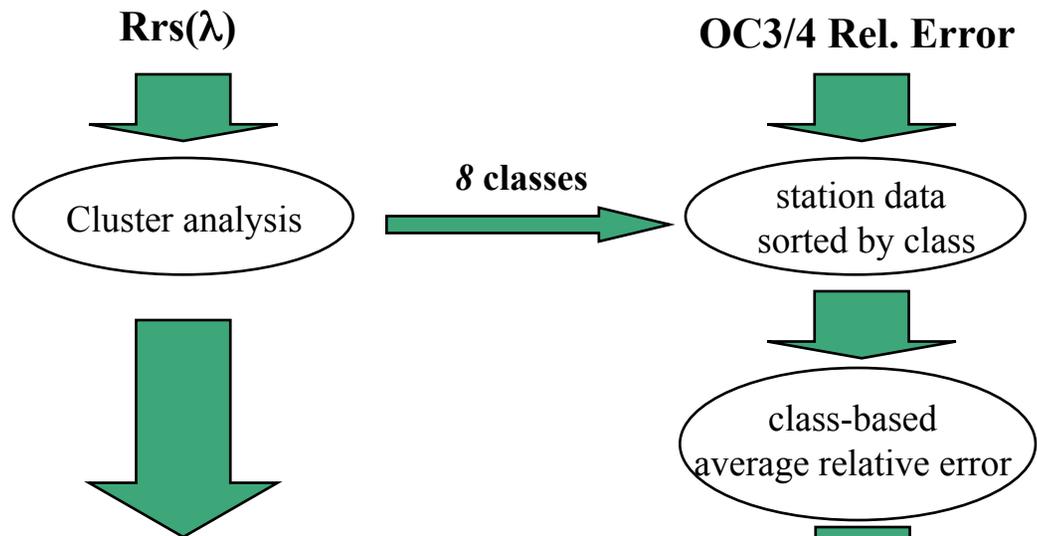


- NOMAD V2
- SeaWiFS Validation Set
- Aqua Validation Set



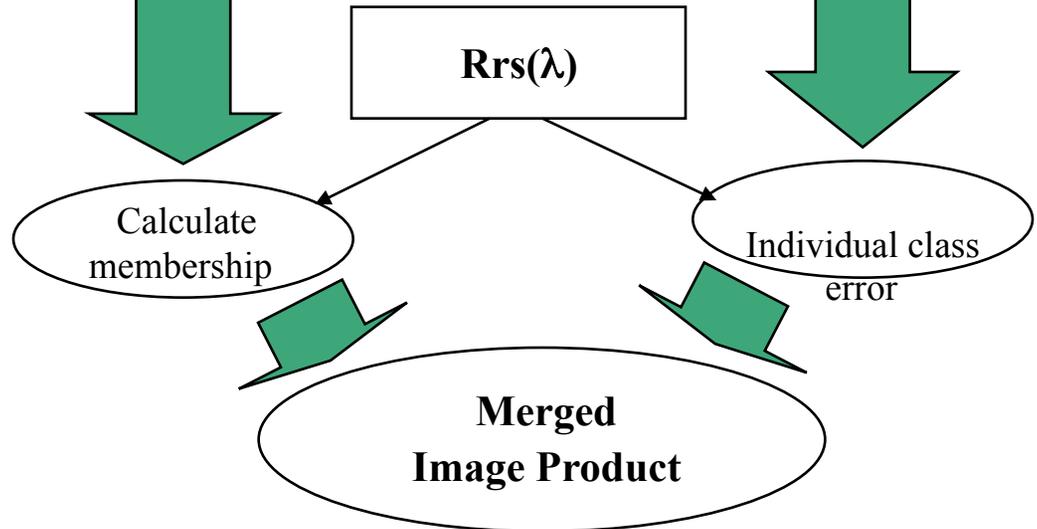
- Rrs
- In situ Chl
- Algorithm Chl

In-situ Database (NOMAD V2)

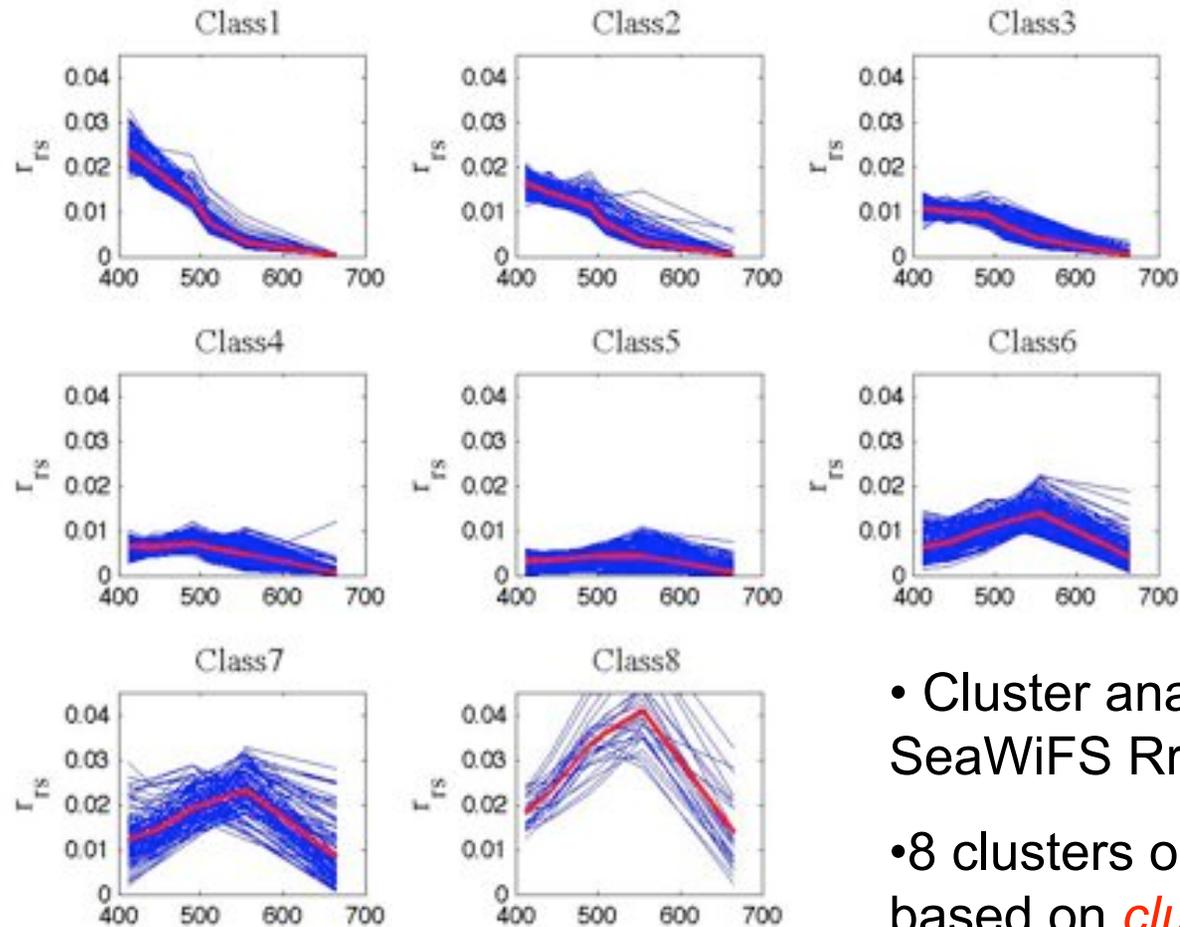


Class
 M_i, Σ_i

Satellite Measurements



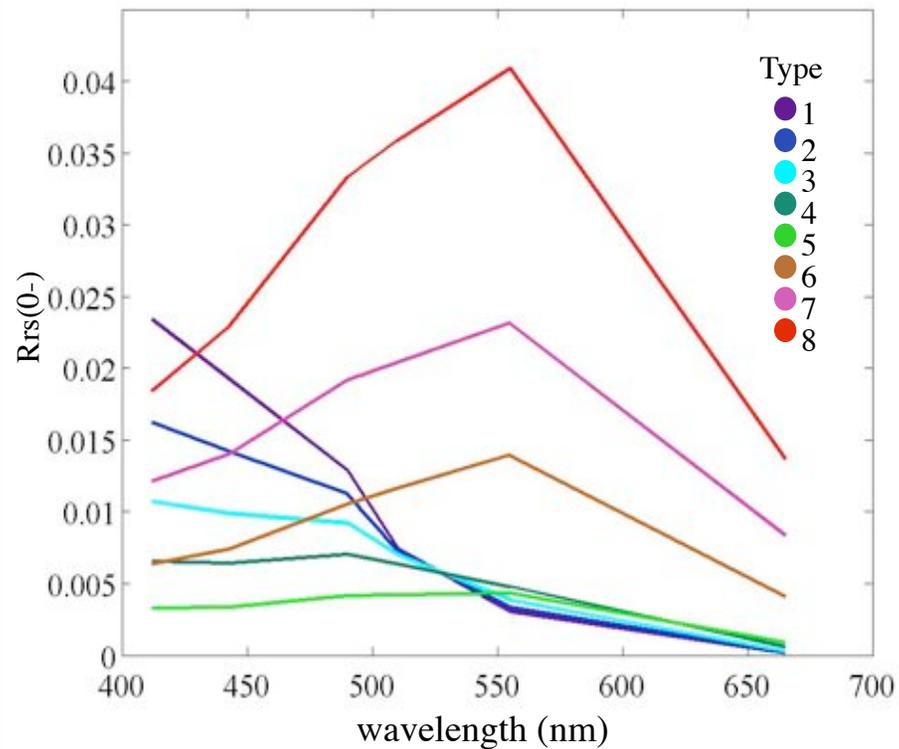
NOMAD V2 Clustering Results



- Cluster analysis on SeaWiFS Rrs bands
- 8 clusters optimal based on *cluster validity functions*

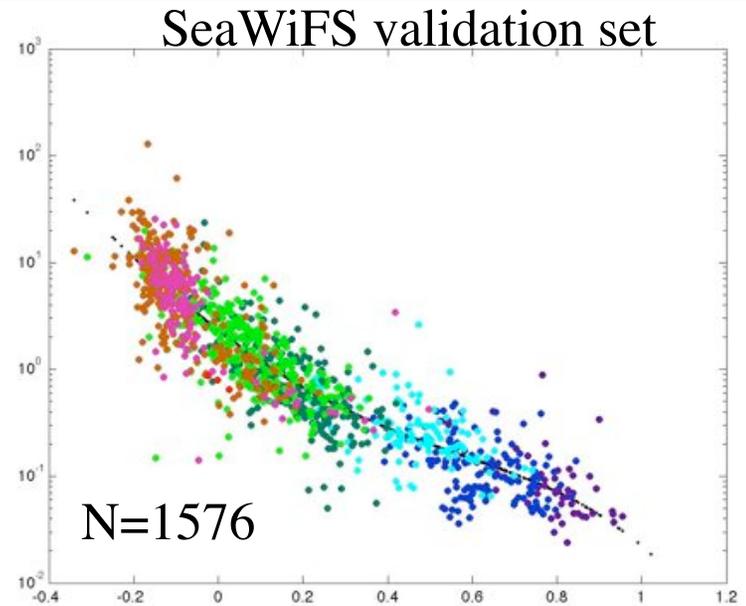
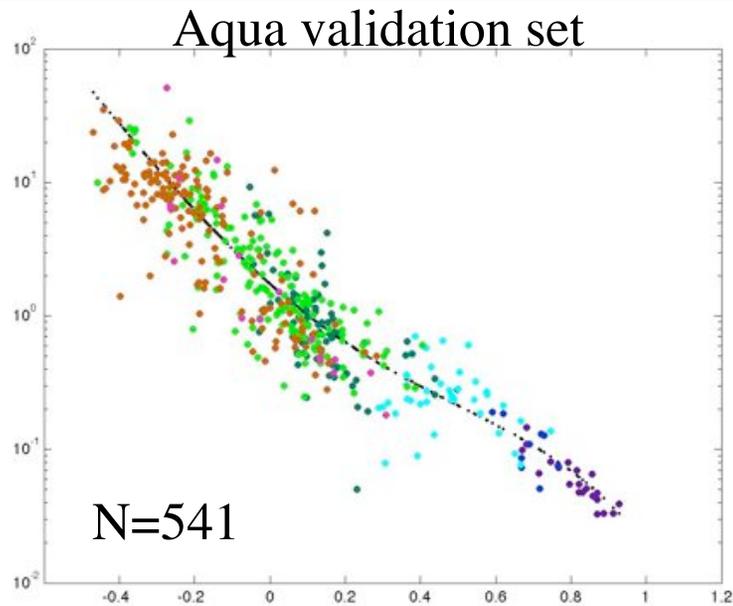
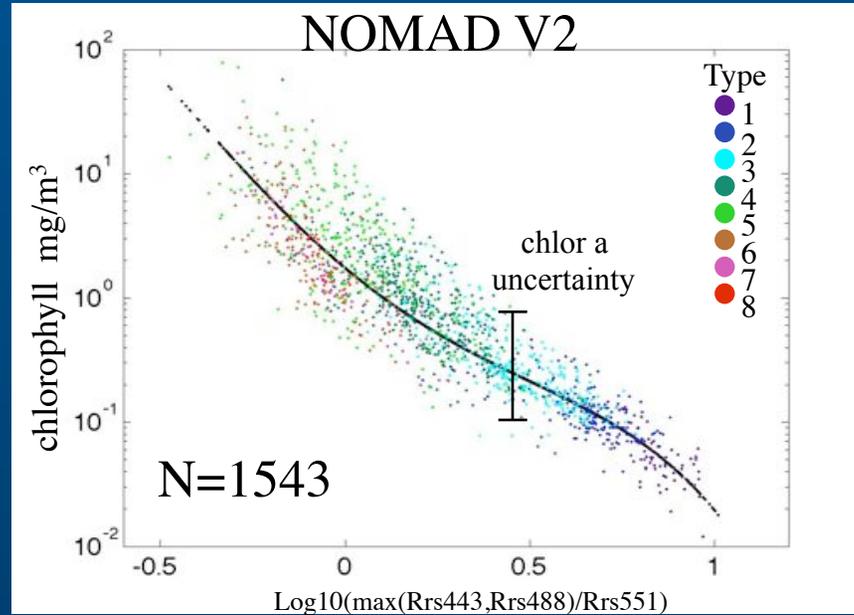
N~2400

Class Mean Reflectance Spectra



- Rrs mean spectra behave as endmembers
- Rrs class statistics form the *fuzzy membership function*.

Characterizing class uncertainty

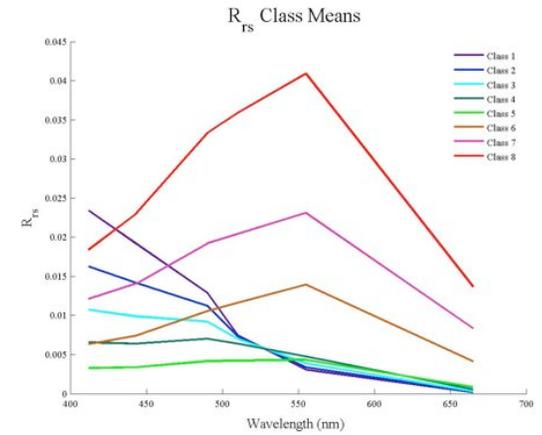
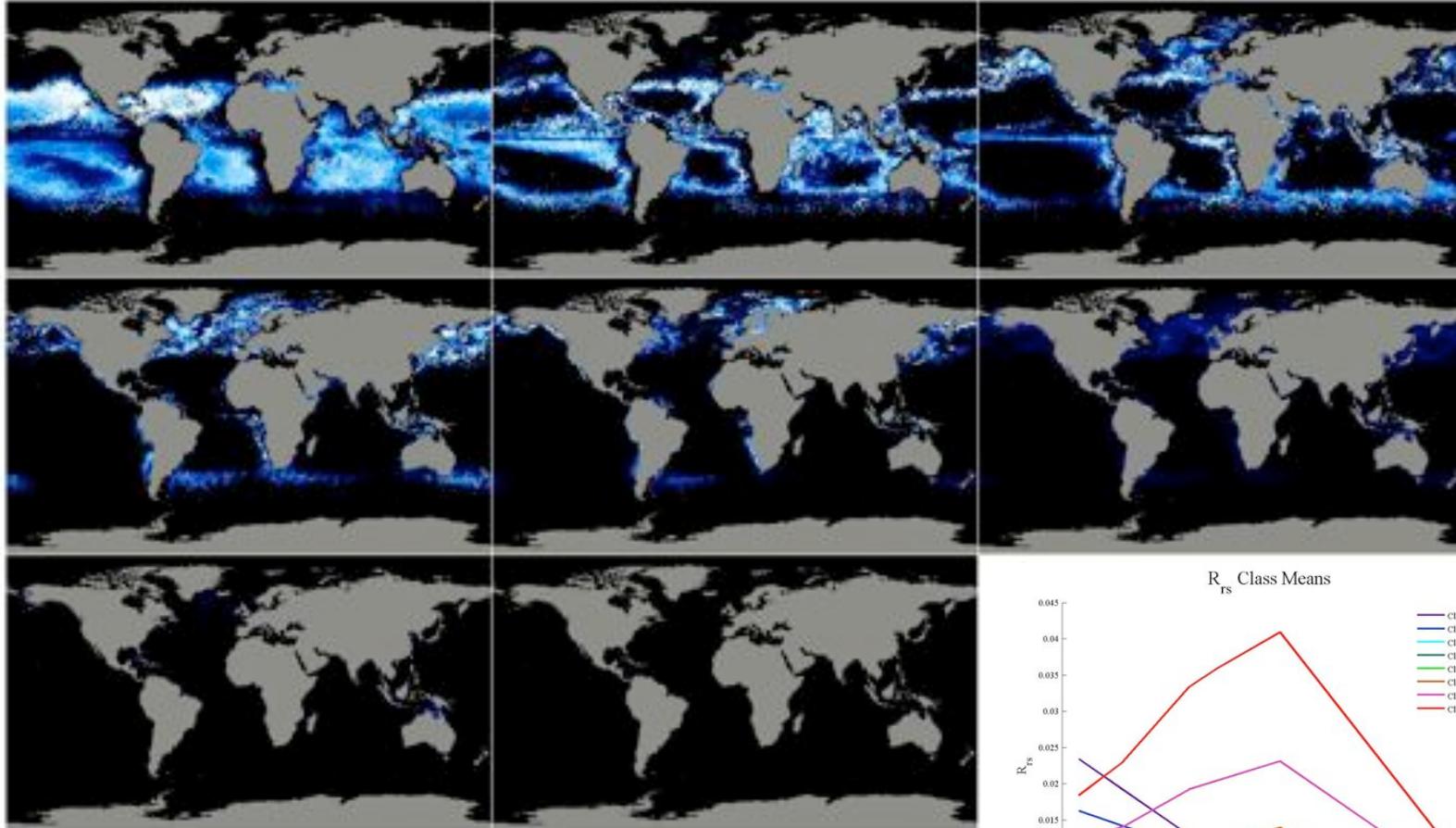


Relative Error - %

Aqua validation set

Class	NOMAD (OC3)	OC3 (v5)	OC3 (v6)
1	28	17	18
2	25	32	33
3	27	39	42
4	44	62	58
5	77	62	59
6	94	79	60
7	80	86	60
8	55	N/A	N/A
Avg.	53	78	74

Aqua GAC - May 2005



Membership



0

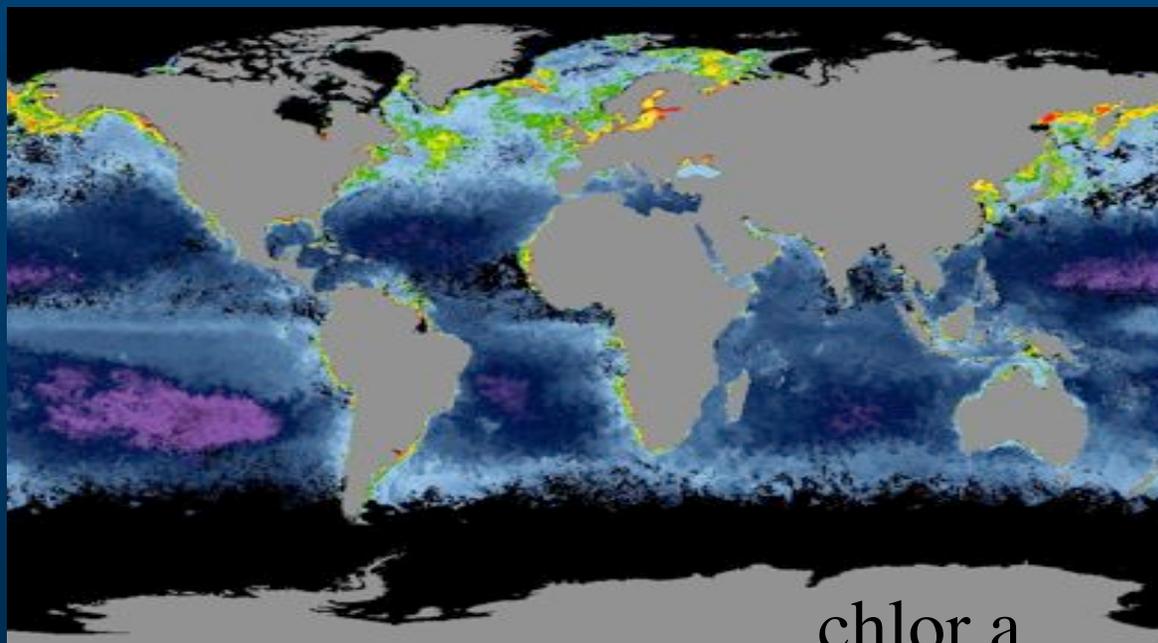
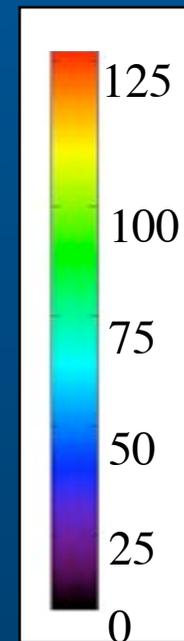
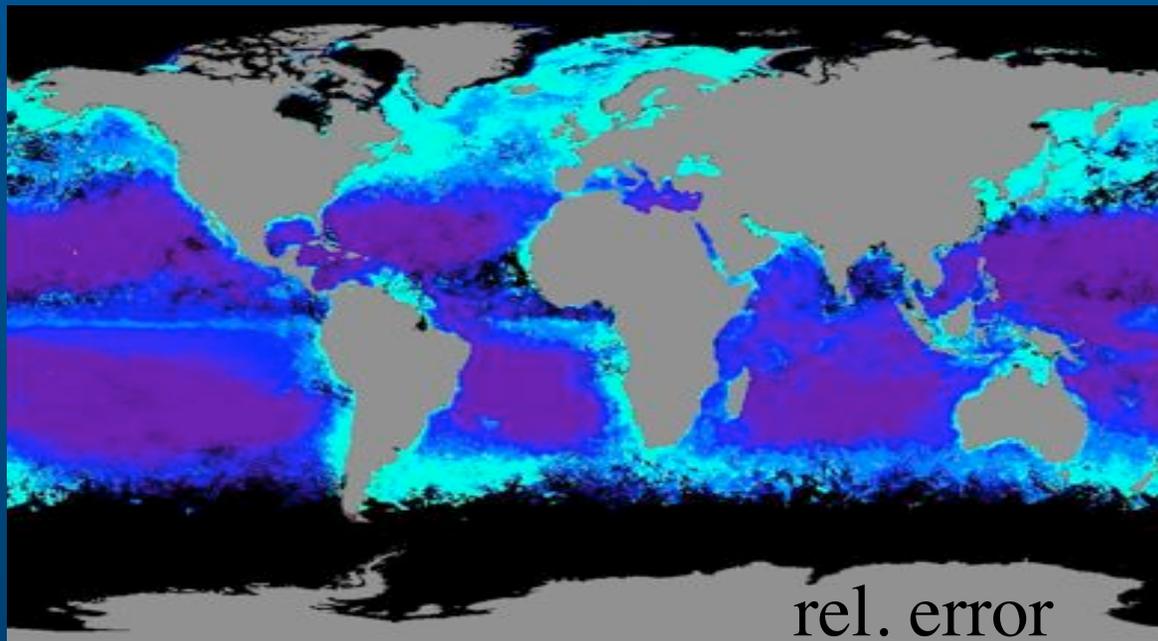
1

Producing the Discrepancy Map

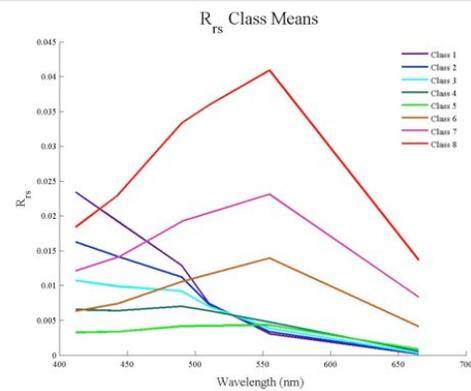
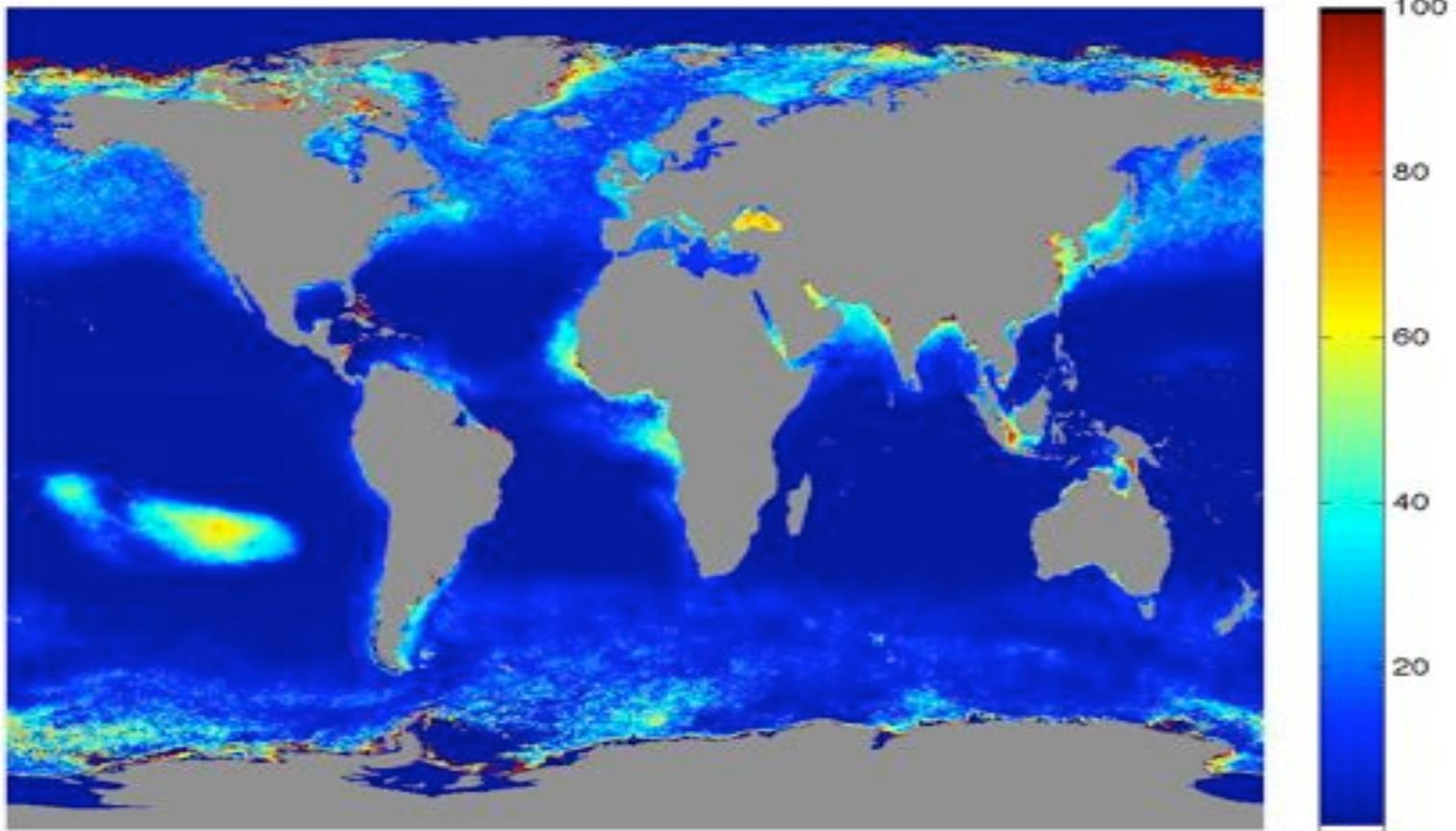
For each pixel,

$$\sum_{i=1 \dots 8} f_i *$$

Relative Error
18
33
42
58
59
60
60
N/A



May 2005

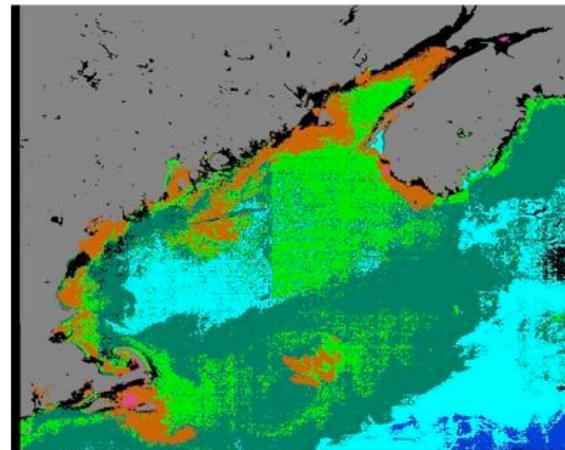
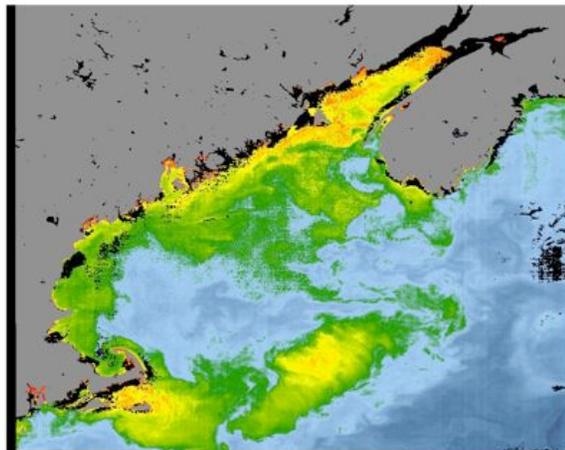
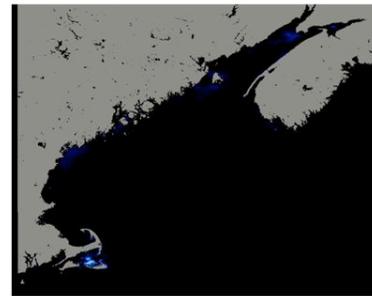
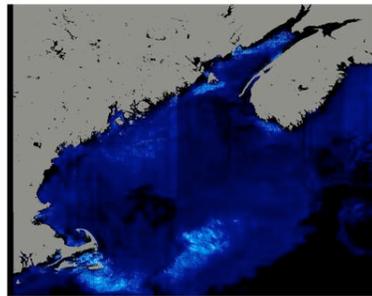
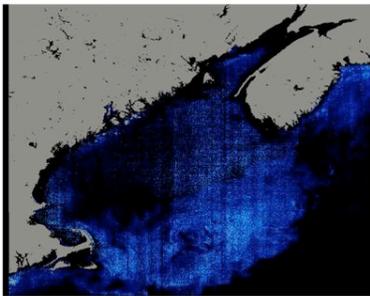
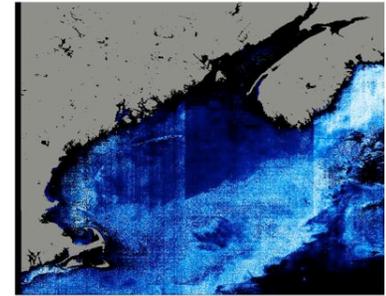
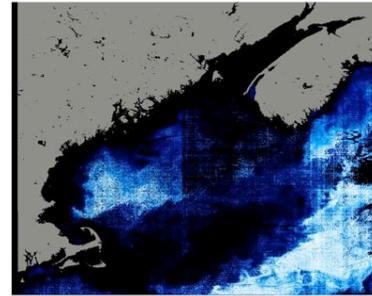


Frequency of low membership sum

Conclusions

- Single, bulk estimates of algorithm performance do not realistically describe the spatial distribution of error.
- Basing OC3/OC4 error statistics with the Aqua and SeaWiFS validation data set is recommended because it reflects product *discrepancy*.
- The class-based method is a way to characterize product discrepancy for different optical environments and to dynamically map them *pixel by pixel*.
- Class-based approach provides a common framework that can be applied to different satellites and different algorithms at multiple spatial scales.
- We envision the error maps as separate, companion products to the existing suite of NASA OC products (currently in developmental *l2gen*).

MERIS image - Aug. 22, 2008



MERIS

Channel 1-5

Channel 1,2,3,5

MODIS/Aqua

May 2004

SeaWiFS



Class 1



Class 2



Class 3



Class 4



Class 5



Class 6



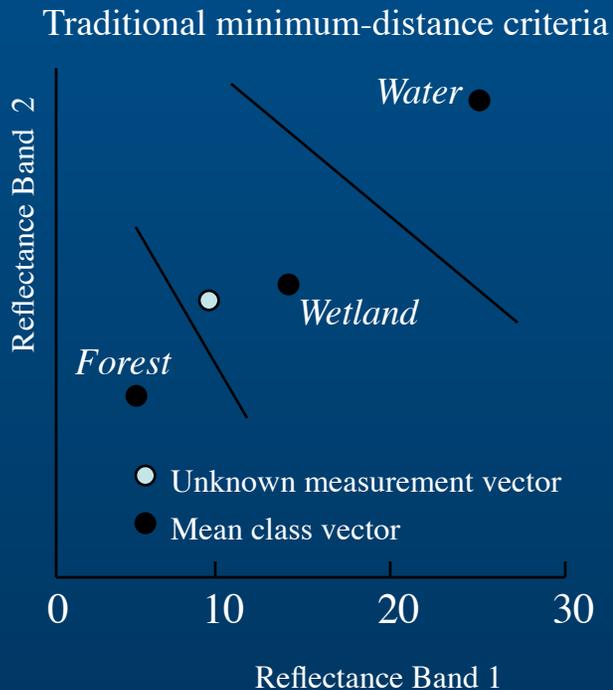
Class 7



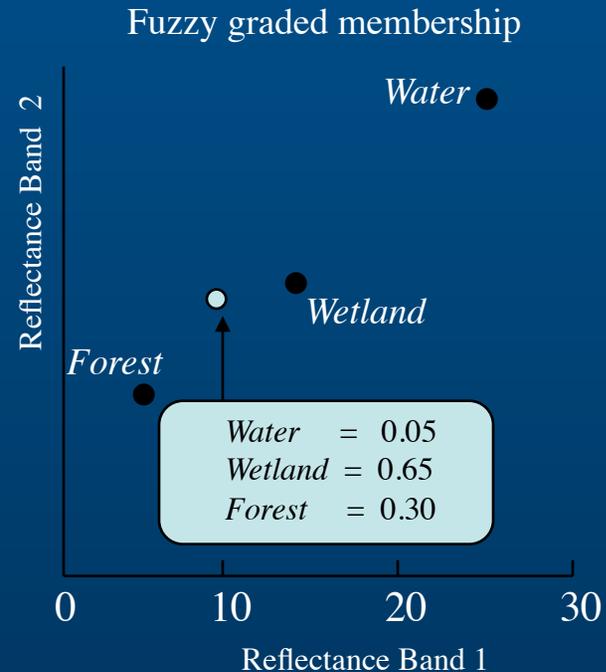
Class 8

What is fuzzy logic?

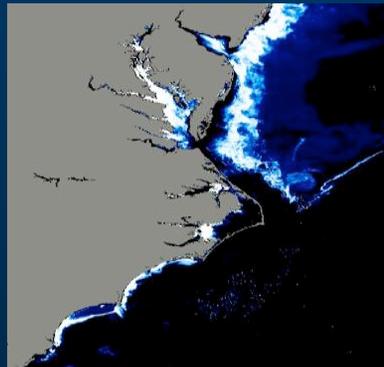
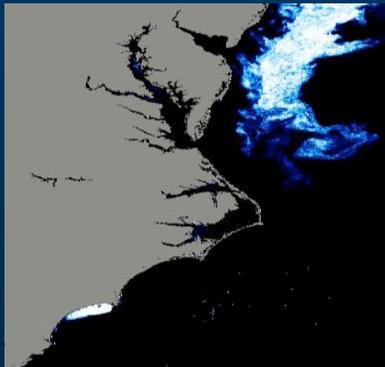
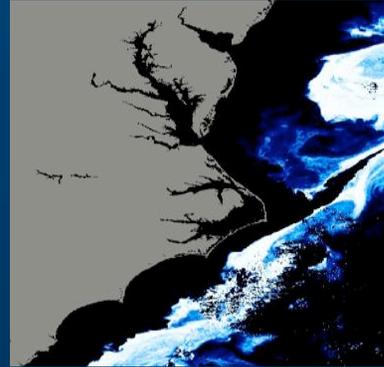
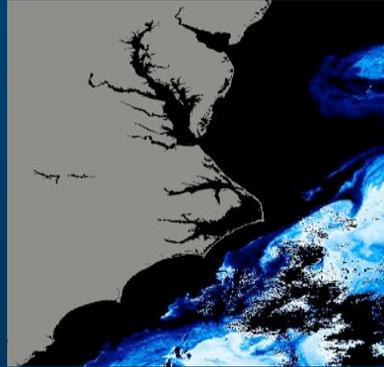
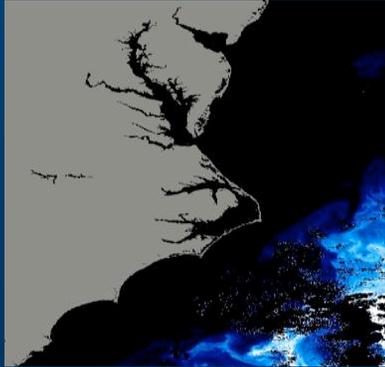
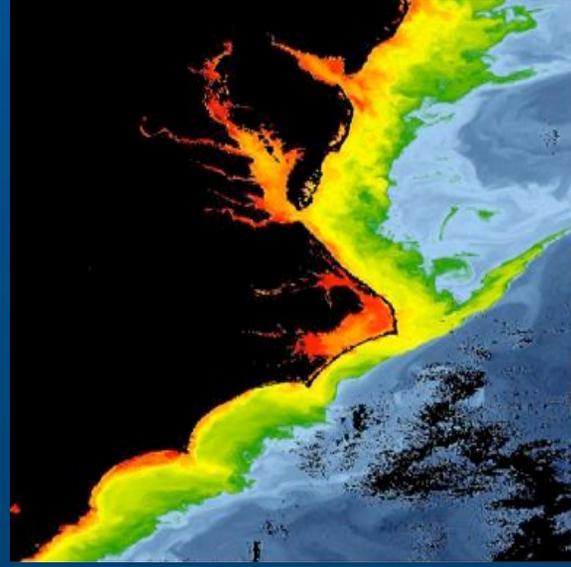
Hard



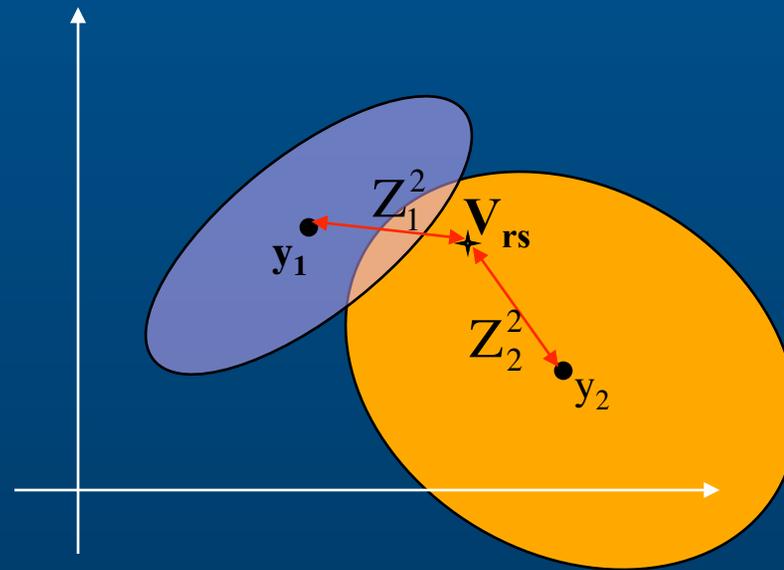
Fuzzy



- Designed to handle data imprecision and ambiguity
- Allows for multiple outcomes using a fuzzy membership



The Membership Function



$$Z^2 = (\mathbf{V}_{rs} - \mathbf{y}_j)^t \boldsymbol{\Sigma}_j^{-1} (\mathbf{V}_{rs} - \mathbf{y}_j) \implies \text{Chi-square PDF}$$

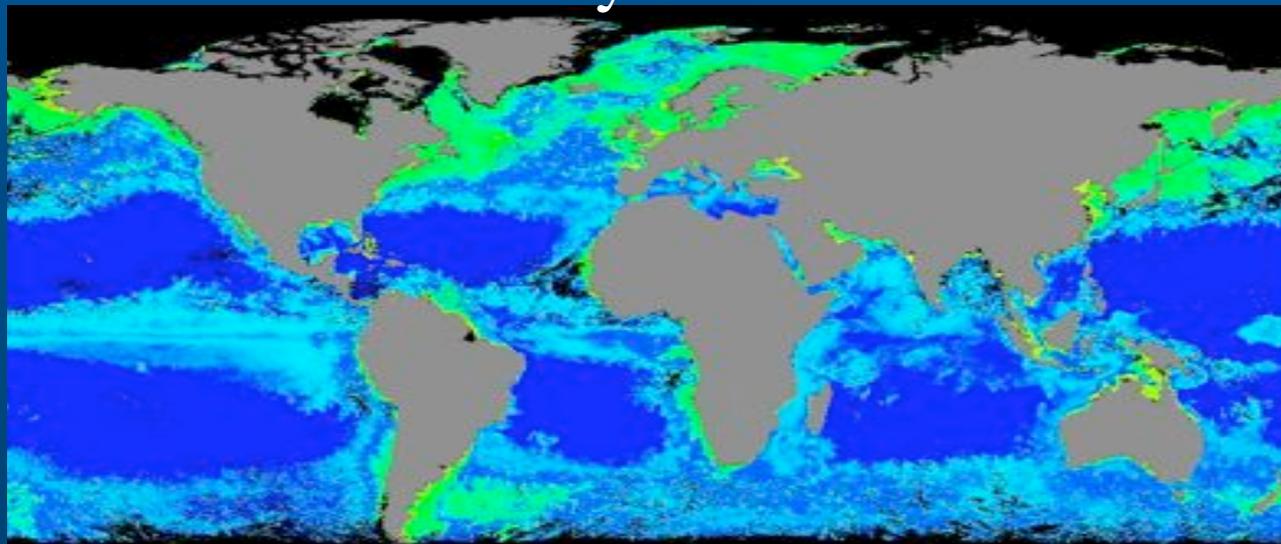
\mathbf{V}_{rs} – satellite pixel vector

\mathbf{y}_j – j th class mean vector

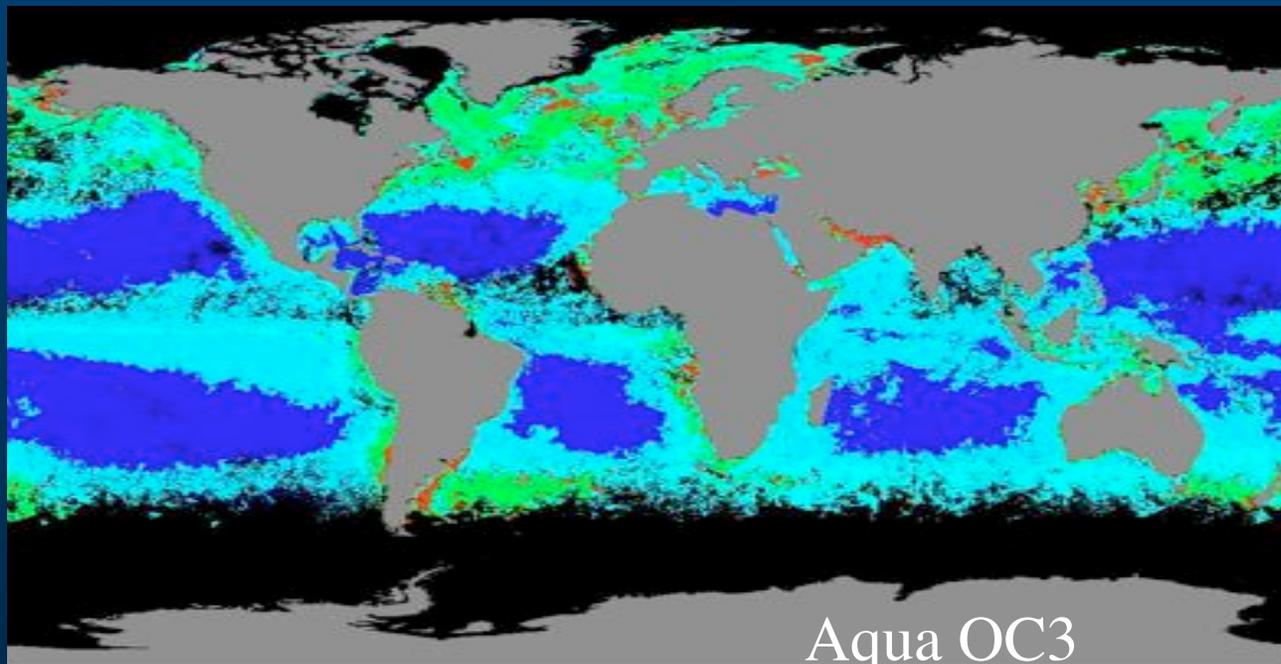
$\boldsymbol{\Sigma}_j$ – j th class covariance matrix

Result: A number between 0 and 1 that is a measure of the vector's membership to that class.

May 2005

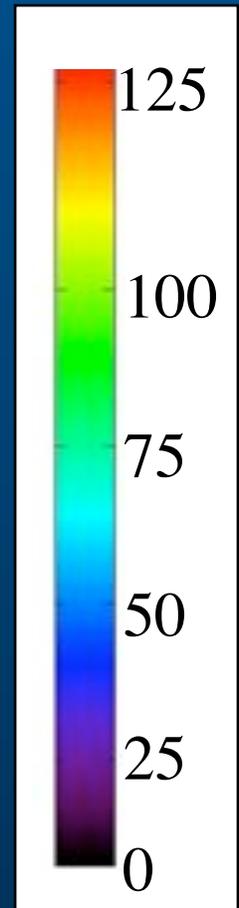


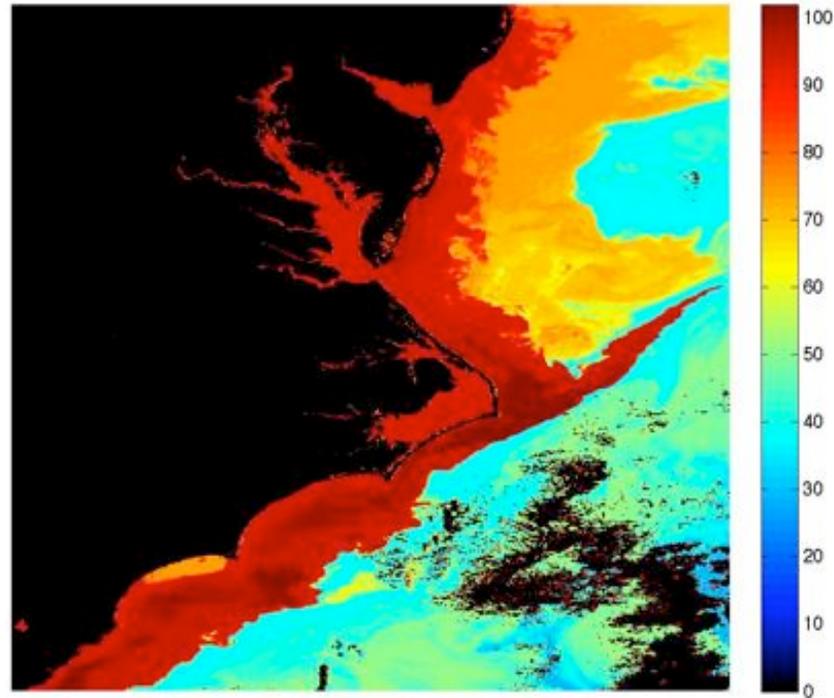
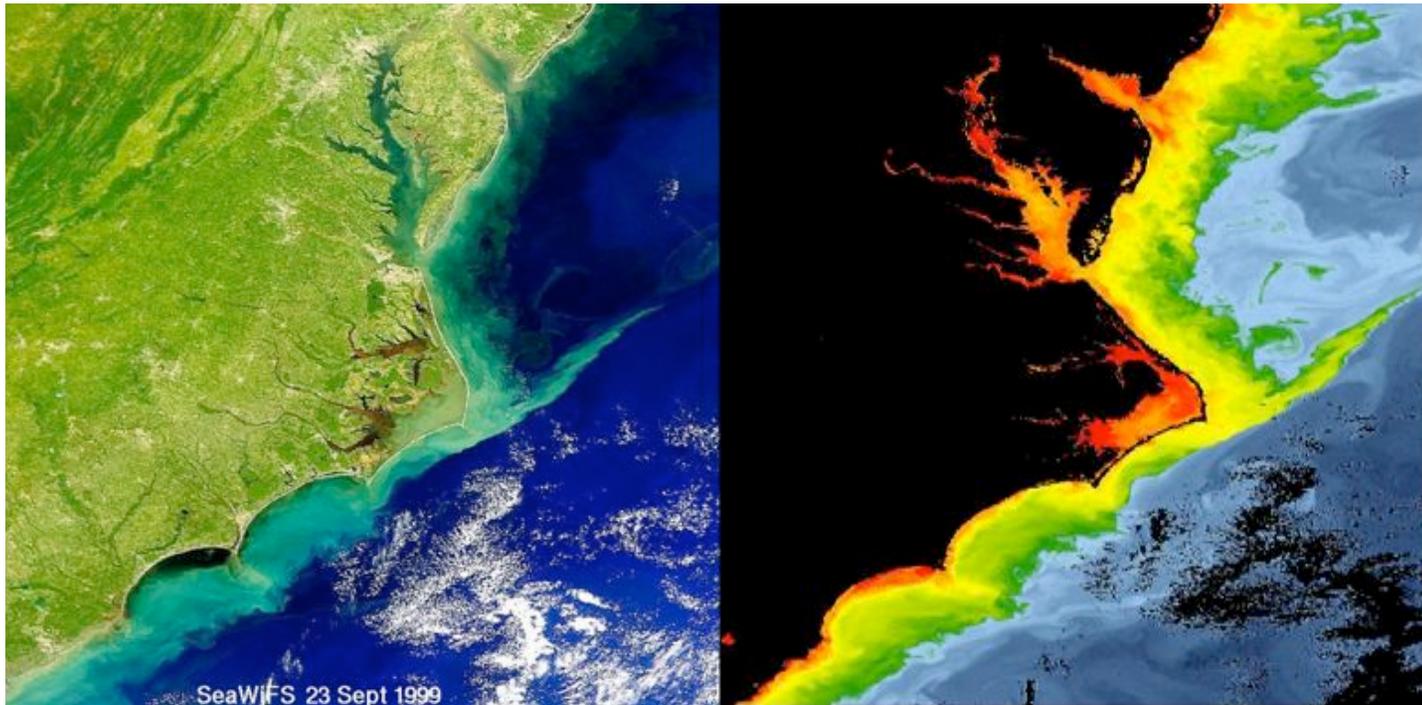
SeaWiFS OC4



Aqua OC3

Relative Error (%)





SeaWiFS
OC4 Error

Aqua OC3 Error

Relative Error (%)

