Ocean color atmospheric correction for operational remote sensing of Chesapeake Bay

Jeremy Werdell

NASA Goddard Space Flight Center

Science Systems & Applications, Inc.

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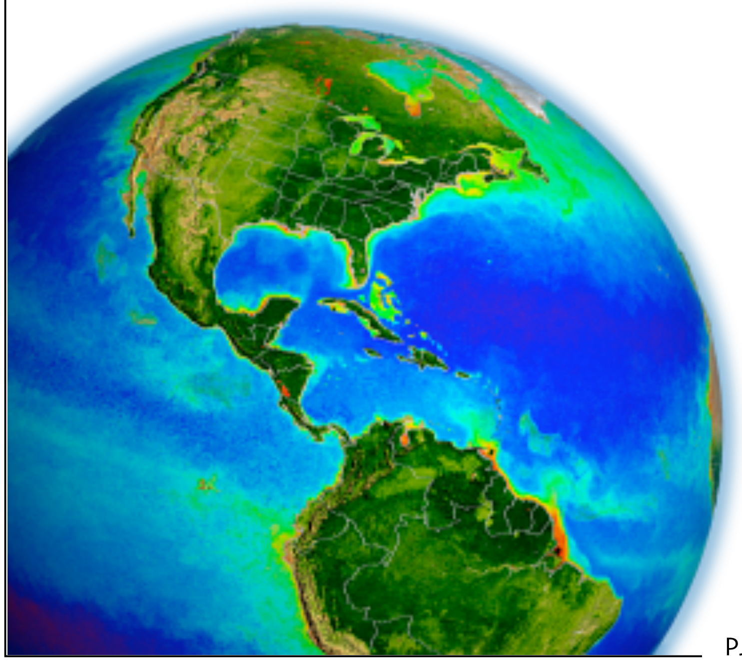


Acknowledgements:

Rick Stumpf & the Gang at the Ocean Biology Processing Group

challenges for remote sensing of estuaries

temporal & spatial variability

- satellite sensor resolution
- satellite repeat frequency
- validity of ancillary data (SST, wind)
- resolution requirements & binning options

straylight contamination (adjacency effects)

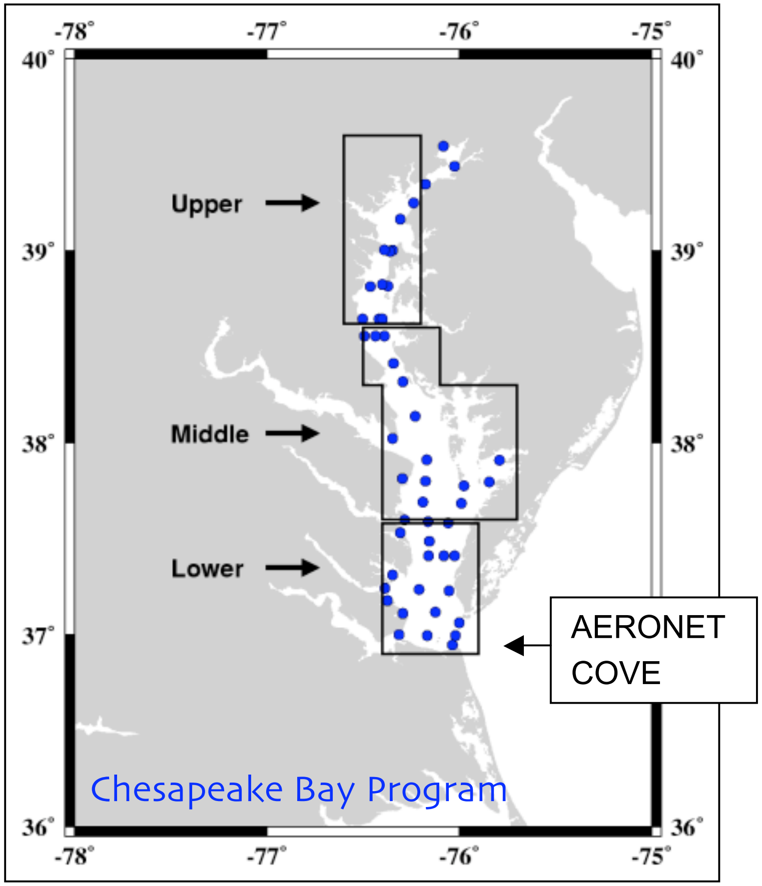
non-maritime aerosols (dust, pollution)

- region-specific models required?
- absorbing aerosols

suspended sediments & CDOM

- complicates estimation of R_{rs}(NIR)
- complicates BRDF (f/Q) corrections
- saturation of observed radiances

anthropogenic emissions (NO_2 absorption)



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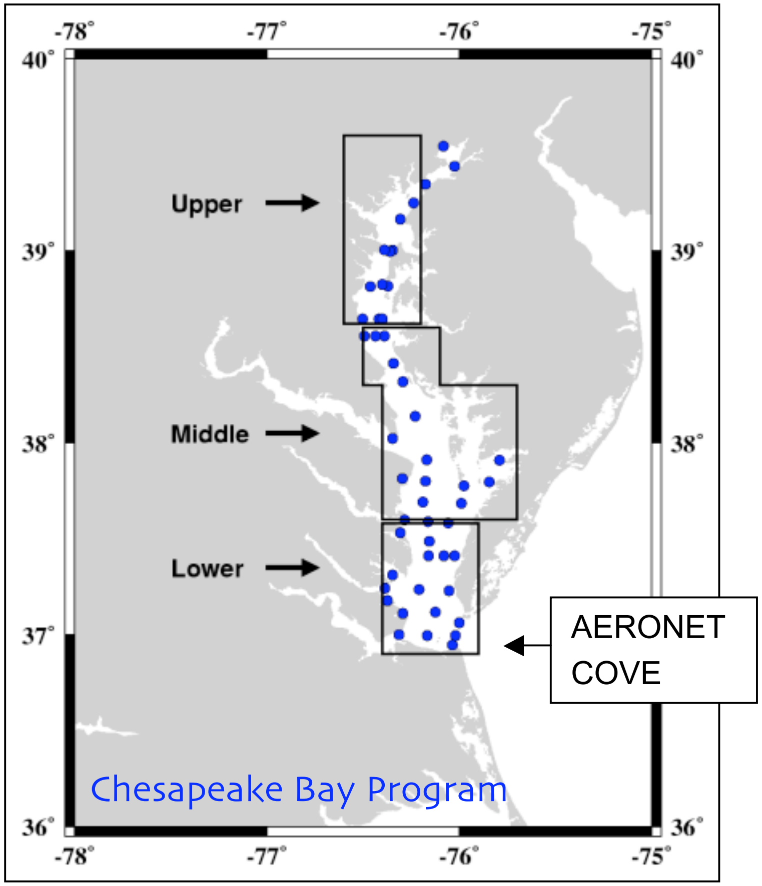

the experiment

collaboration with NOAA, EPA Chesapeake Bay Program, University of Maryland, & colleagues since 2006 Chesapeake Bay Remote Sensing Symposium

NOAA CoastWatch East Coast Node using results for operational processing

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NOAA CoastWatch East Coast Node using results for operational processing

run multiple long-term time-series of MODIS-Aqua

- Lower Chesapeake Bay, June 2002 - December 2008
- processing configuration follows Reprocessing 2010
- QC metrics: exclude cloudy days & high sensor zenith angles
- final analyses use ~ 13 days per month

- generate frequency distributions and monthly time-series
- use in situ measurements as reference

consider potential for application in an operational environment

atmospheric correction & the "black pixel" assumption

$\rho_t(\lambda)$	$=$	$\rho_w(\lambda)$	$+$	$\rho_g(\lambda)$	$+$	$\rho_f(\lambda)$	$+$	$\rho_r(\lambda)$	$+$	$\rho_a(\lambda)$
TOA		water		glint		foam		air		aerosols

need $\rho_a(\lambda)$ to get $\rho_w(\lambda)$ and vice-versa

atmospheric correction & the "black pixel" assumption

$$\underset{\text{TOA}}{\rho_t(\lambda)} = \underset{\text{water}}{\rho_w(\lambda)} + \underset{\text{glint}}{\rho_g(\lambda)} + \underset{\text{foam}}{\rho_f(\lambda)} + \underset{\text{air}}{\rho_r(\lambda)} + \underset{\text{aerosols}}{\rho_a(\lambda)}$$

need $\rho_a(\lambda)$ to get $\rho_w(\lambda)$ and vice-versa

the "black pixel" assumption (pre-2000):

$$\rho_a(NIR) = \rho_t(NIR) - \rho_g(NIR) - \rho_f(NIR) - \rho_r(NIR) - \cancelto{0}{\rho_w(NIR)}$$

atmospheric correction & the "black pixel" assumption

$\rho_t(\lambda)$	=	$\rho_w(\lambda)$	+	$\rho_g(\lambda)$	+	$\rho_f(\lambda)$	+	$\rho_r(\lambda)$	+	$\rho_a(\lambda)$
TOA		water		glint		foam		air		aerosols

need $\rho_a(\lambda)$ to get $\rho_w(\lambda)$ and vice-v

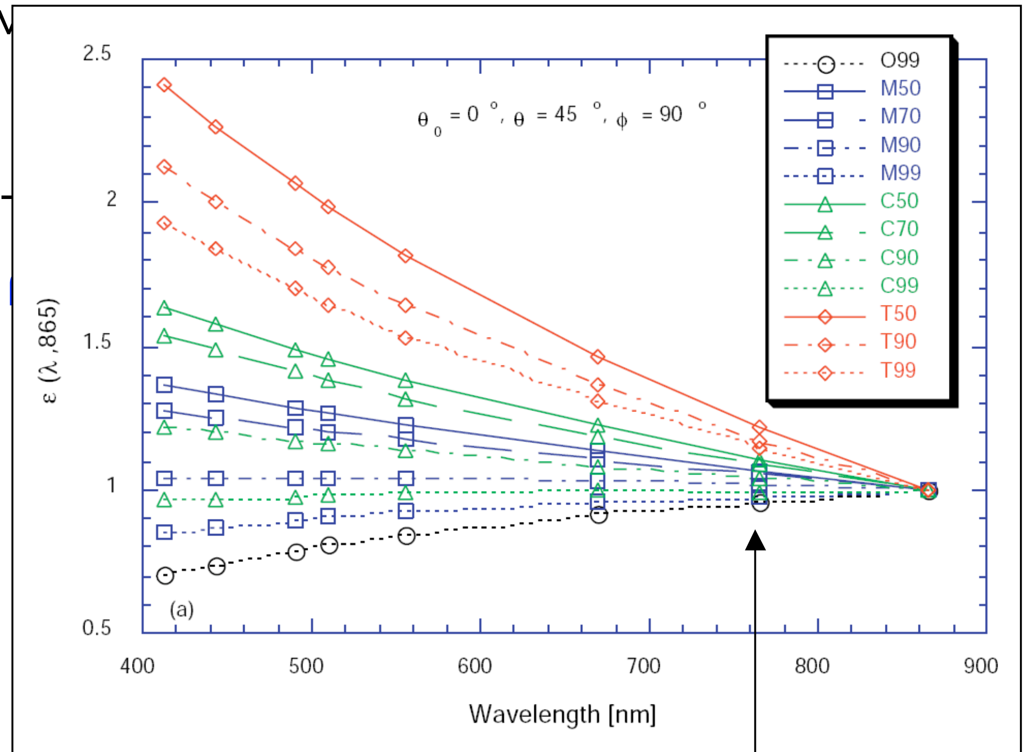
the "black pixel" assumption (pre-

$\rho_a(NIR) = \rho_t(NIR) - \rho_g(NIR) -$

calculate aerosol ratios, ε :

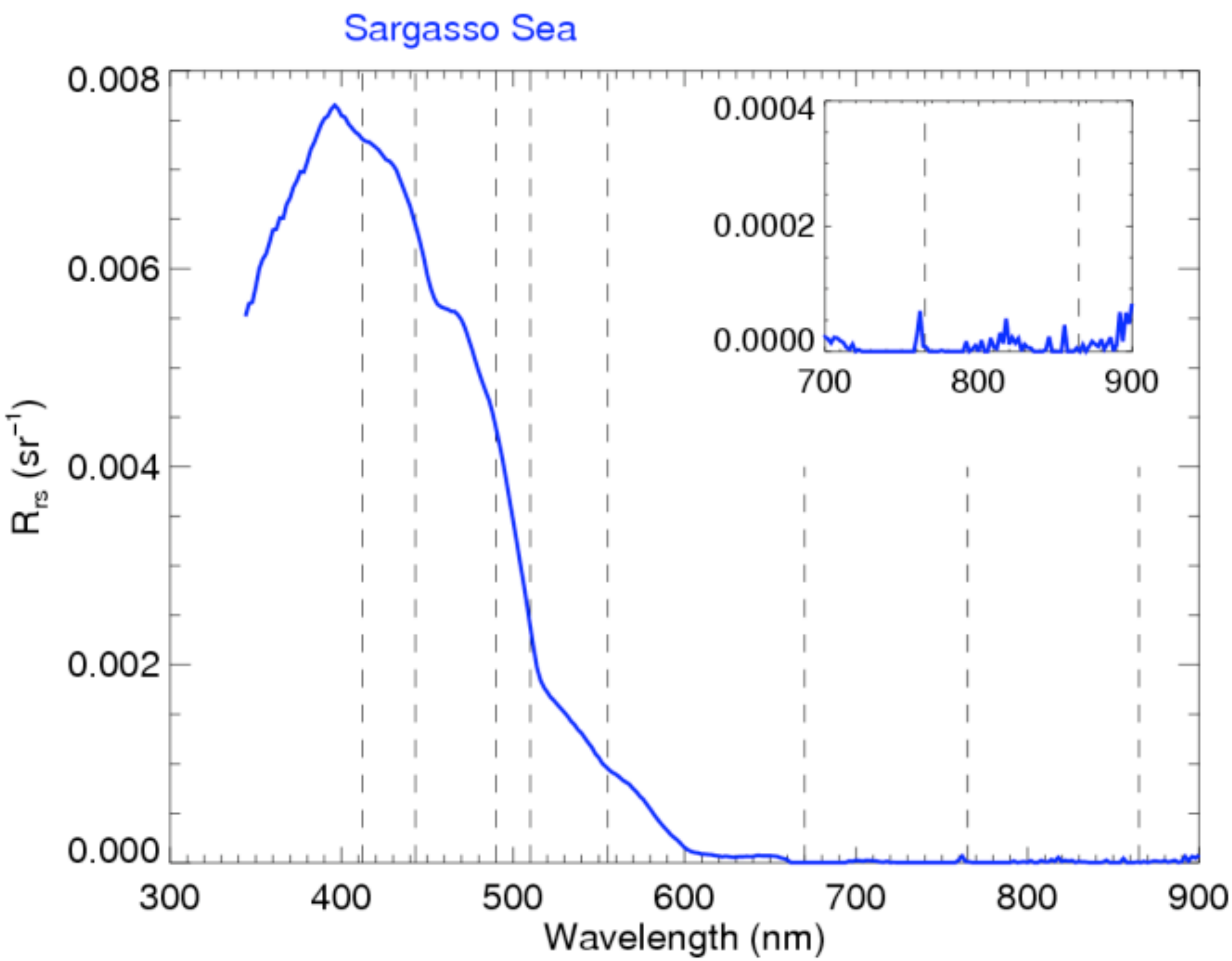
$$\varepsilon(748,869) \approx \frac{\rho_a(748)}{\rho_a(869)}$$

$$\varepsilon(\lambda,869) \approx \frac{\rho_a(\lambda)}{\rho_a(869)}$$



ε(748,869)

are Rrs(NIR) really black?



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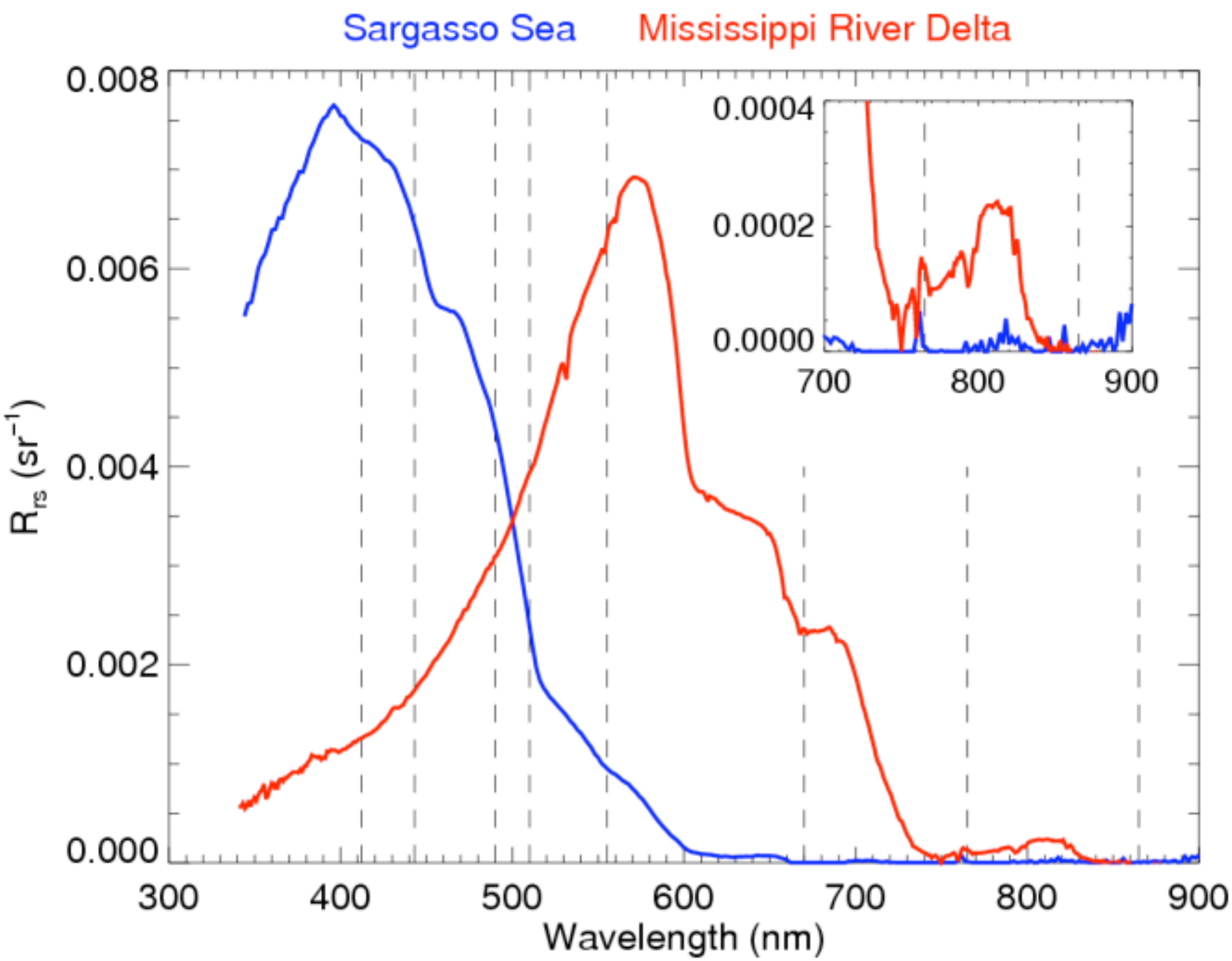
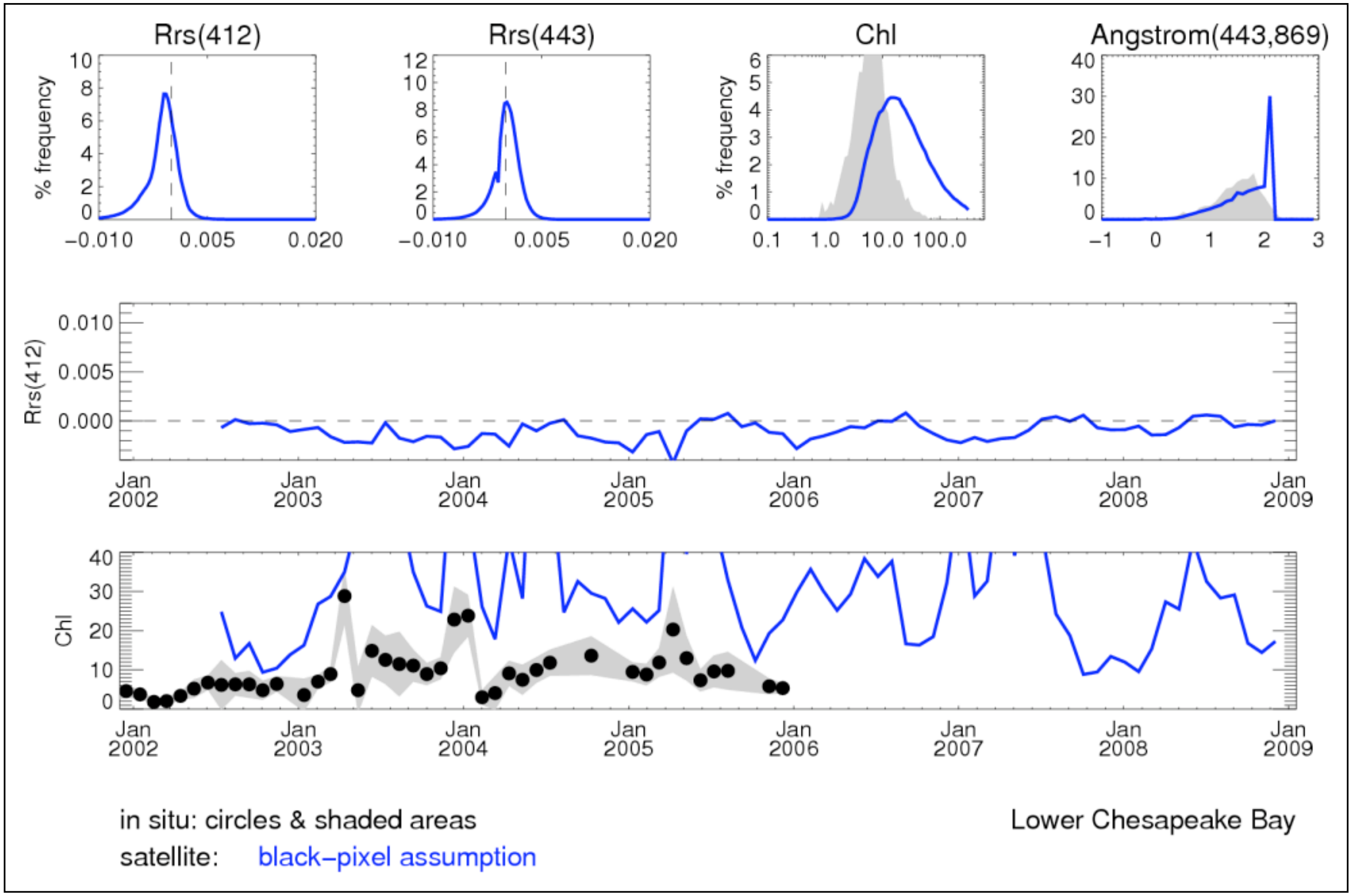


what happens when we don't account for R_{rs}(NIR) > 0?



use the "black pixel" assumption (e.g., SeaWiFS 1997-2000)

what to do when Rrs(NIR) > 0?

many approaches exist, here are a few examples:

assign aerosols (ε) and/or water contributions (Rrs(NIR))

e.g., Hu et al. 2000, Ruddick et al. 2000

use shortwave infrared bands

e.g., Wang & Shi 2007

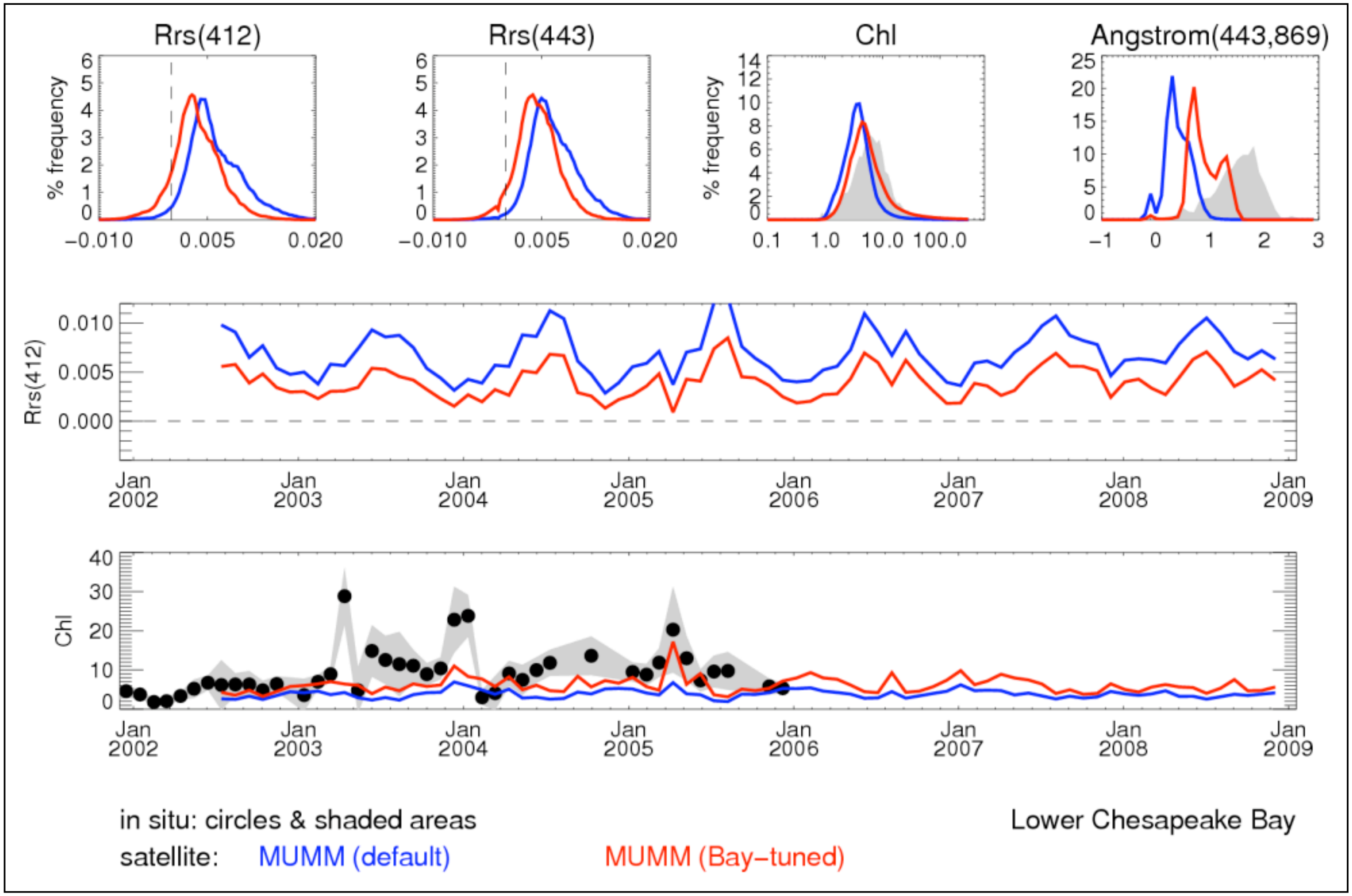
correct/model the non-negligible R_{rs}(NIR)

Siegel et al. 2000	used in SeaWiFS Reprocessing 3 (2000)
Stumpf et al. 2003	used in SeaWiFS Reprocessing 4 (2002)
Lavender et al. 2005	MERIS
Bailey et al. 2010	used in SeaWiFS Reprocessing 6 (2009)

use a coupled ocean-atmosphere optimization

e.g., Chomko & Gordon 2001, Stamnes et al. 2003, Kuchinke et al. 2009

fixed aerosol & water contributions (MUMM)



assign ε & ρ_w(NIR) (via fixed values, a climatology, nearby pixels)

advantages & disadvantages

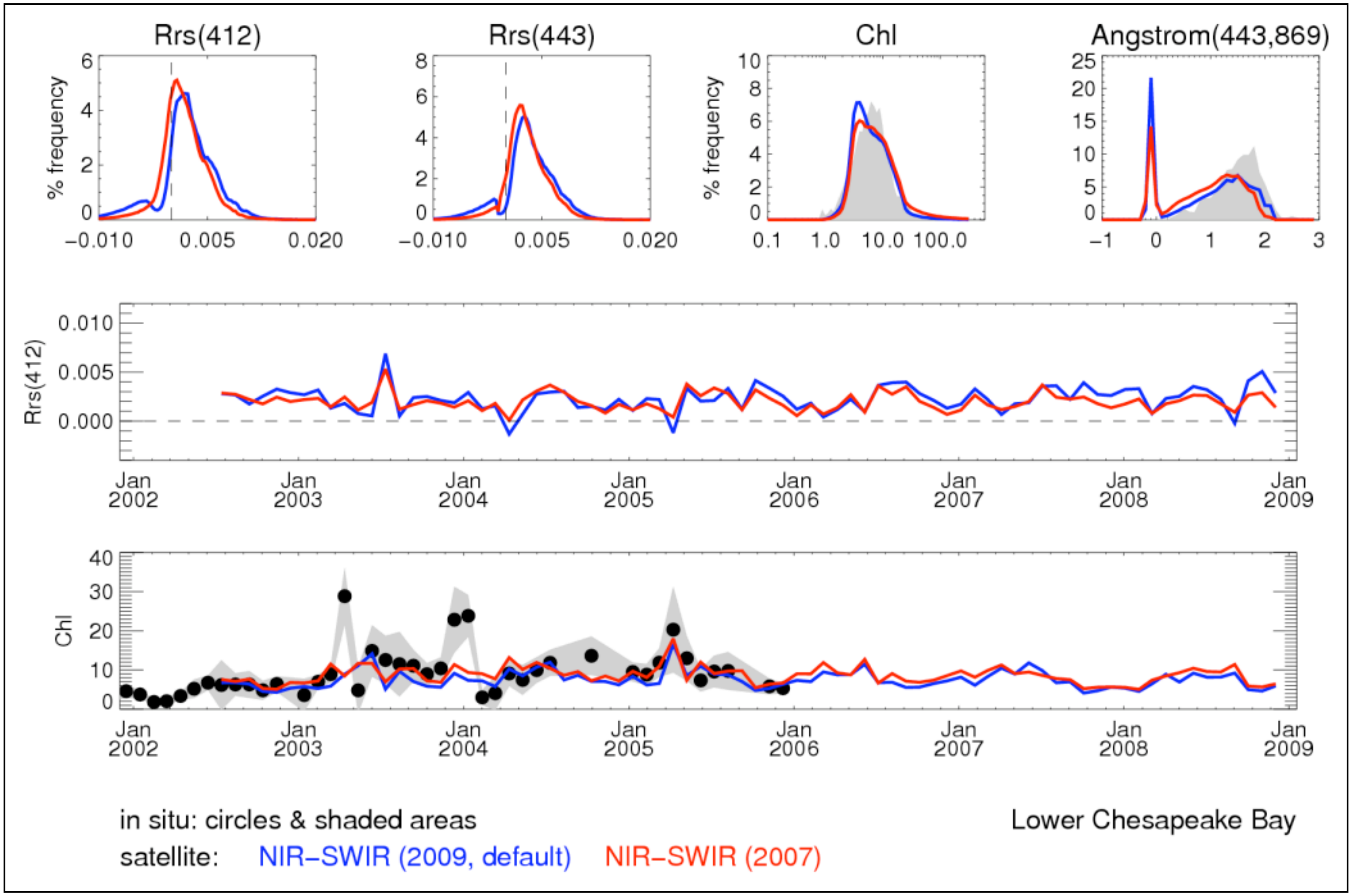
advantages:

accurate configuration leads to accurate aerosol & R_{rs}(NIR) retrievals
several configuration options: fixed values, climatologies, nearby pixels
method available for all past, present, & future ocean color satellites

disadvantages:

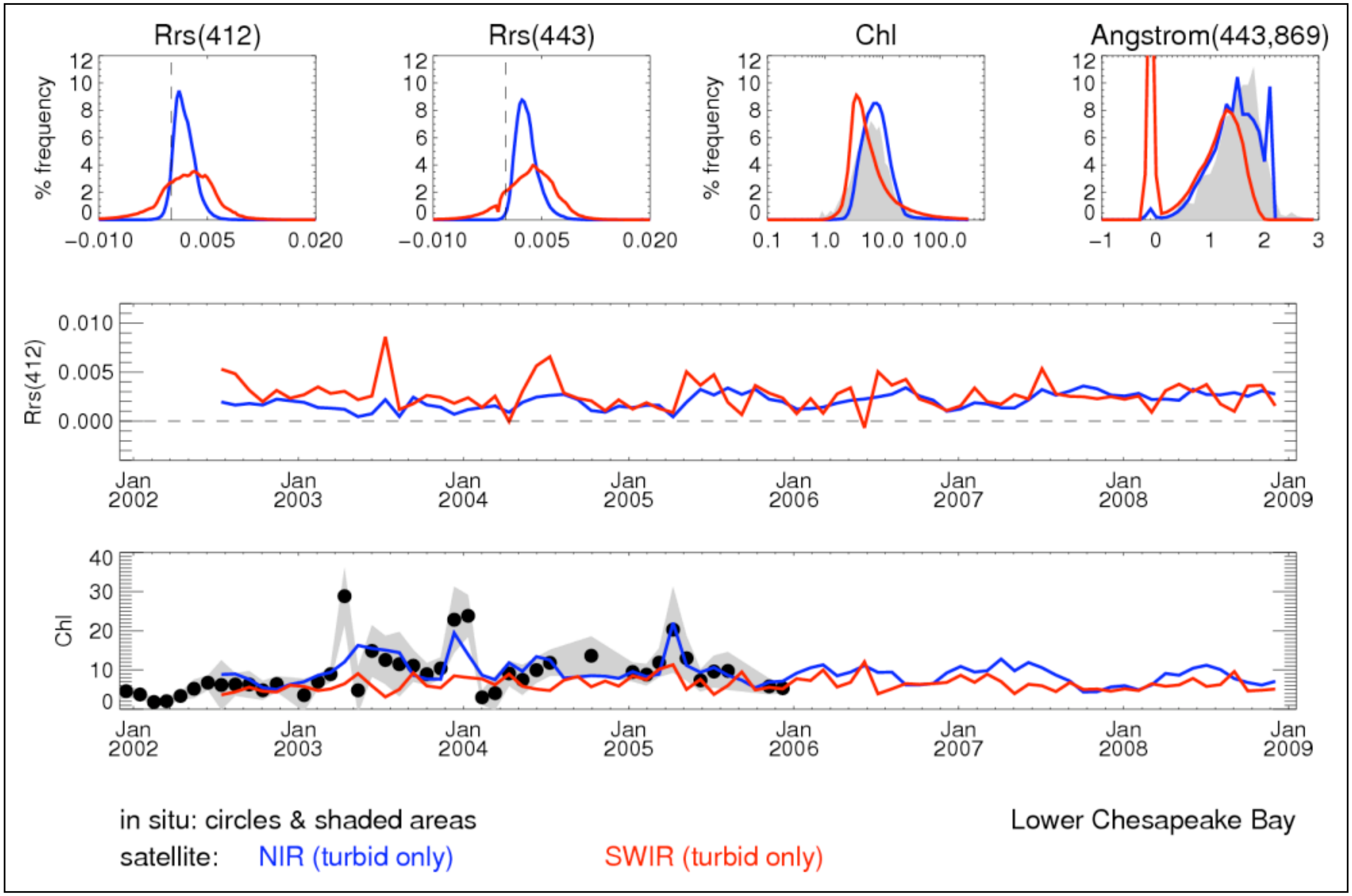
no configuration is valid at all times for all water masses
requires local knowledge of changing aerosol & water properties
implementation can be complicated for operational processing

use of NIR + SWIR bands



use SWIR bands in "turbid" water, otherwise use NIR bands

use of SWIR bands only



compare NIR & SWIR retrievals when considering only "turbid pixels"

advantages & disadvantages

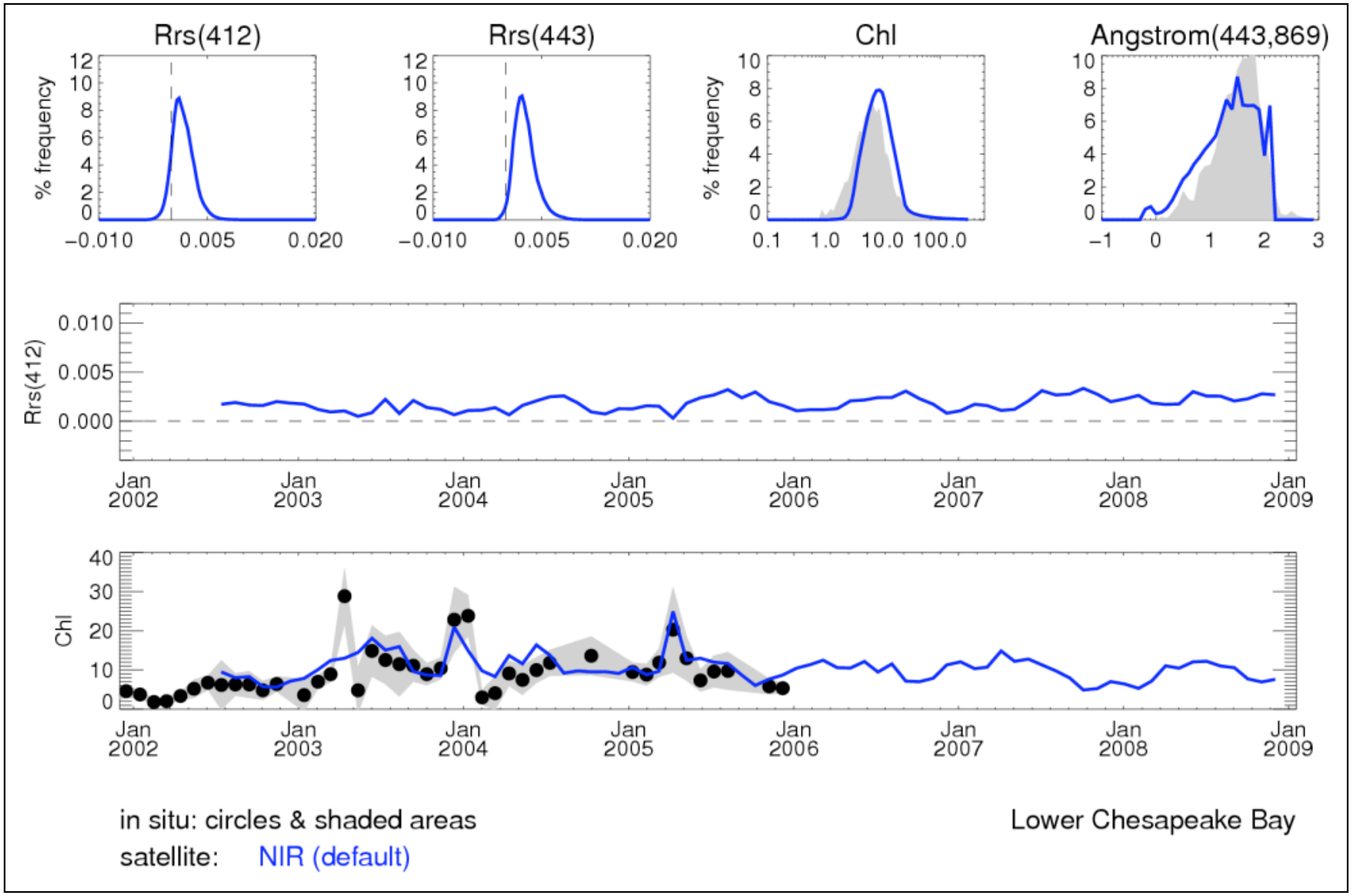
advantages:

"black pixel" assumption largely satisfied in SWIR region of spectrum
straightforward implementation for operational processing

disadvantages:

only available for instruments with SWIR bands
SWIR bands on MODIS have inadequate signal-to-noise (SNR) ratios
difficult to vicariously calibrate the SWIR bands on MODIS
must define conditions for switching from NIR to SWIR

correction of non-negligible R_{rs}(NIR)



estimate R_{rs}(NIR) using a bio-optical model

operational SeaWiFS & MODIS processing ~ 2000-present

advantages & disadvantages

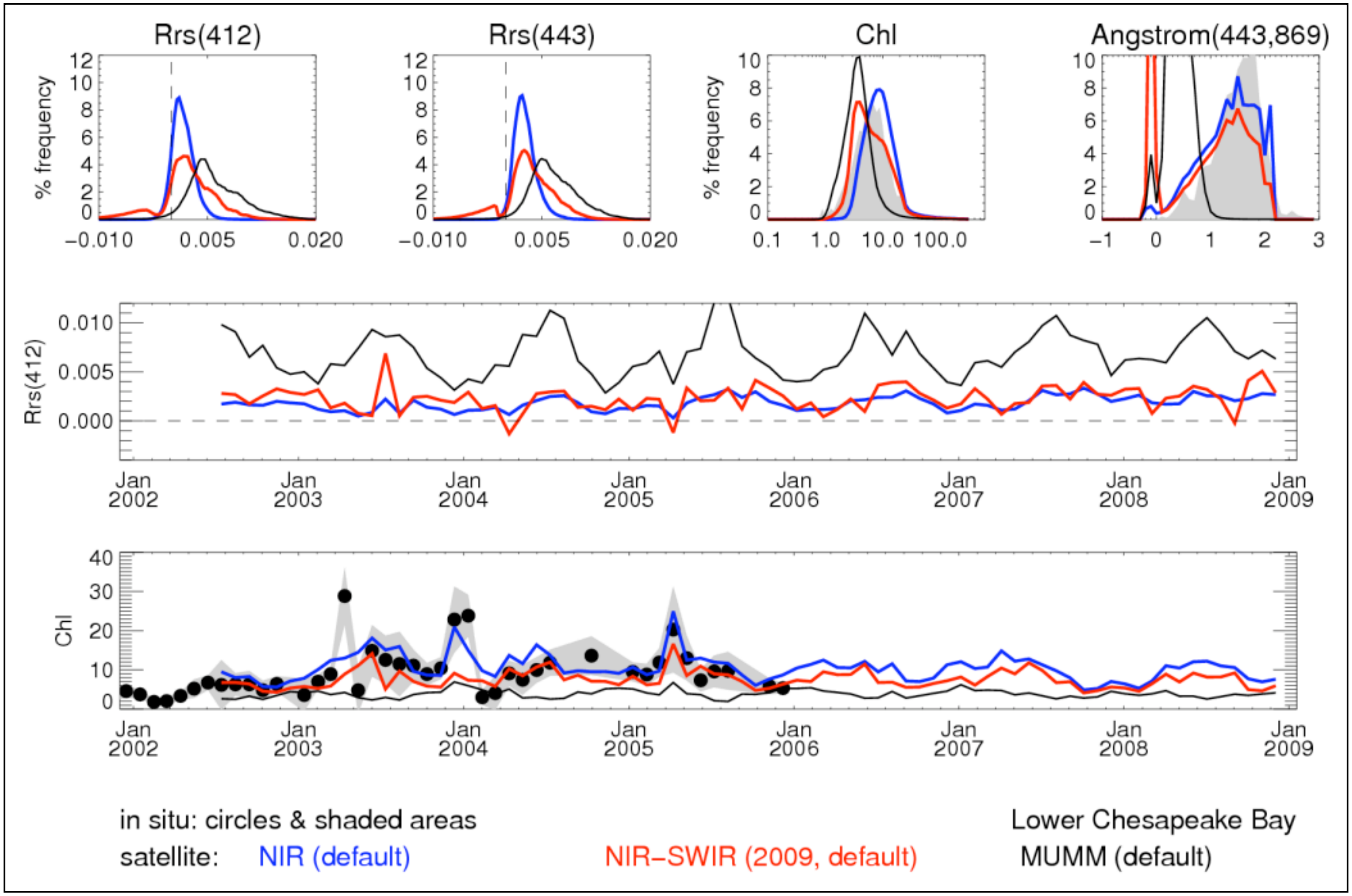
advantages:

method available for all past, present, & future ocean color missions
straightforward implementation for operational processing

disadvantages:

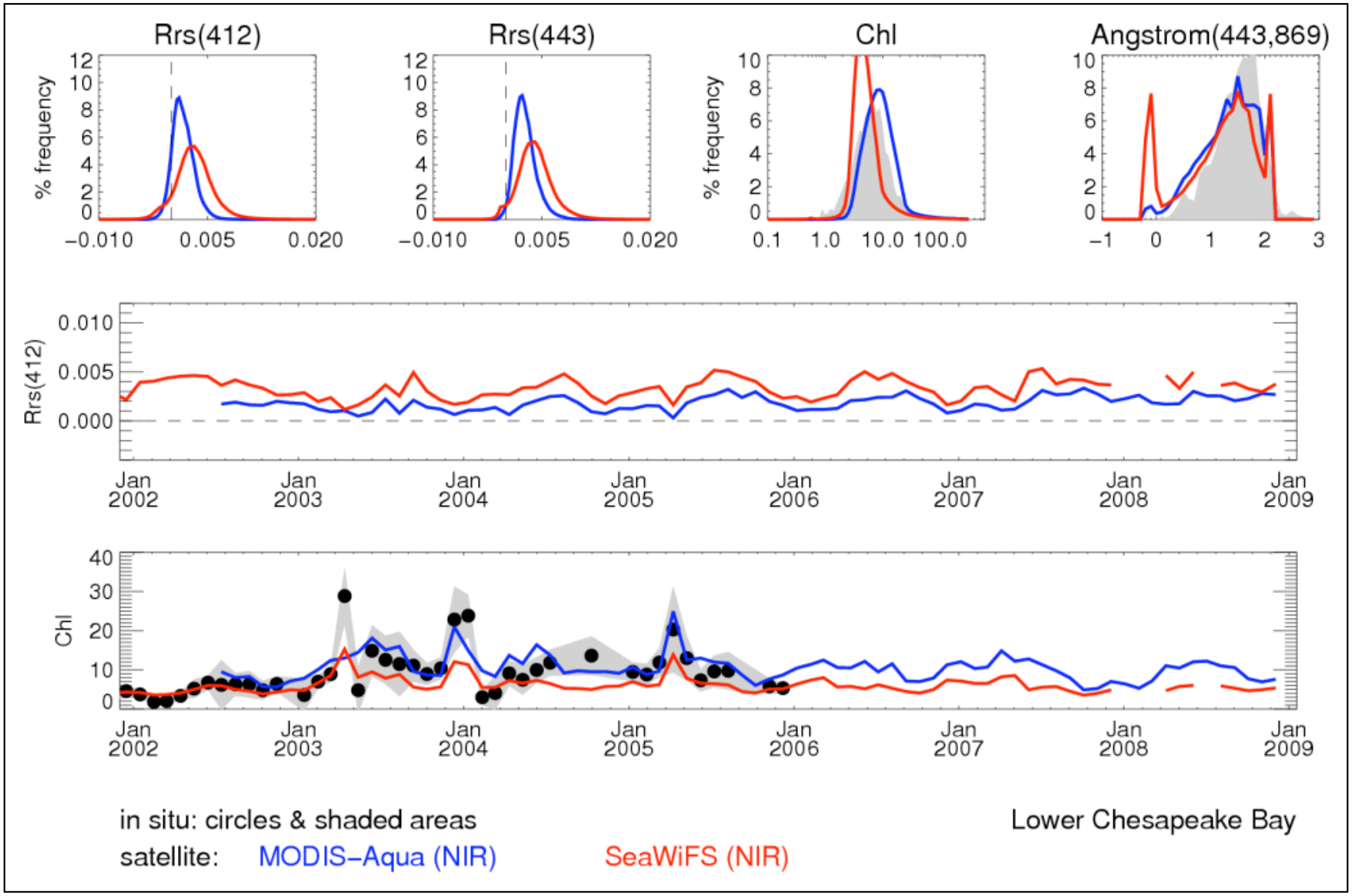
bio-optical model not valid at all times for all water masses

summary of the three approaches



defaults as implemented in SeaDAS

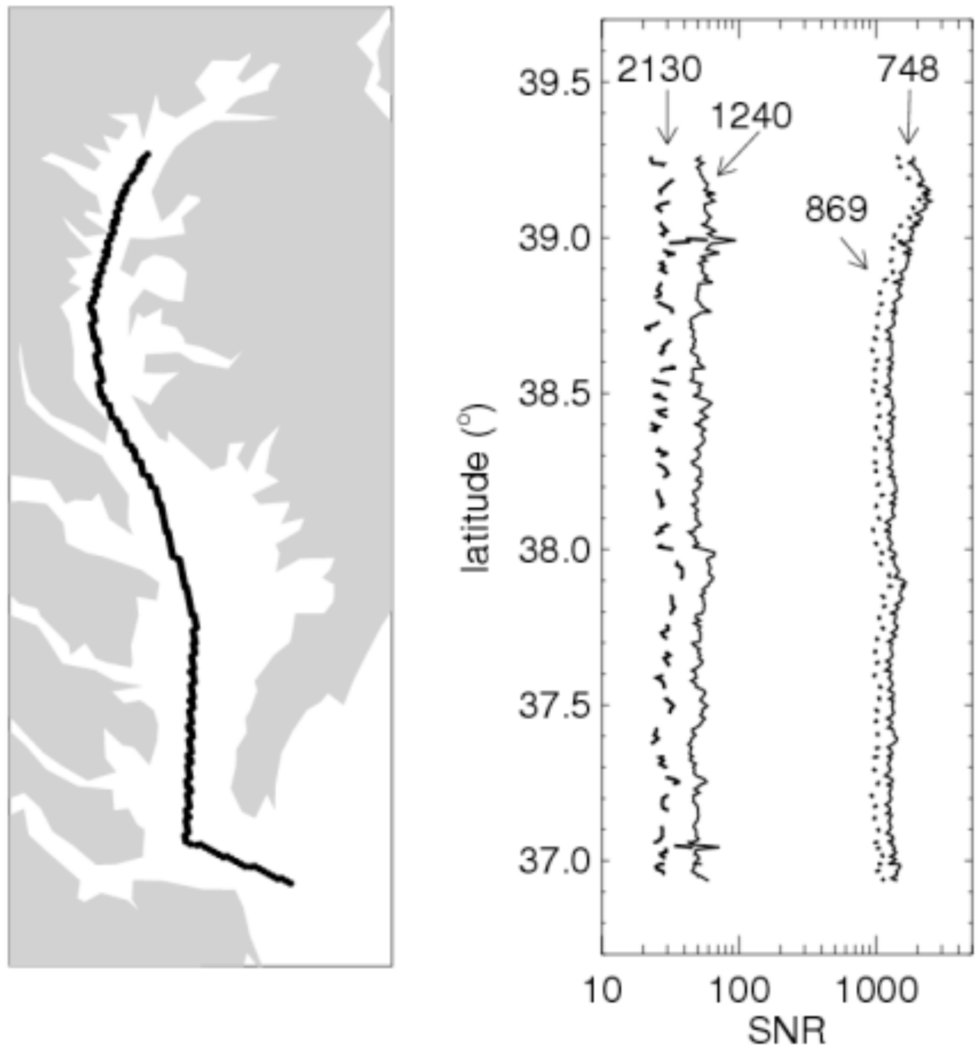
MODIS-Aqua vs. SeaWiFS



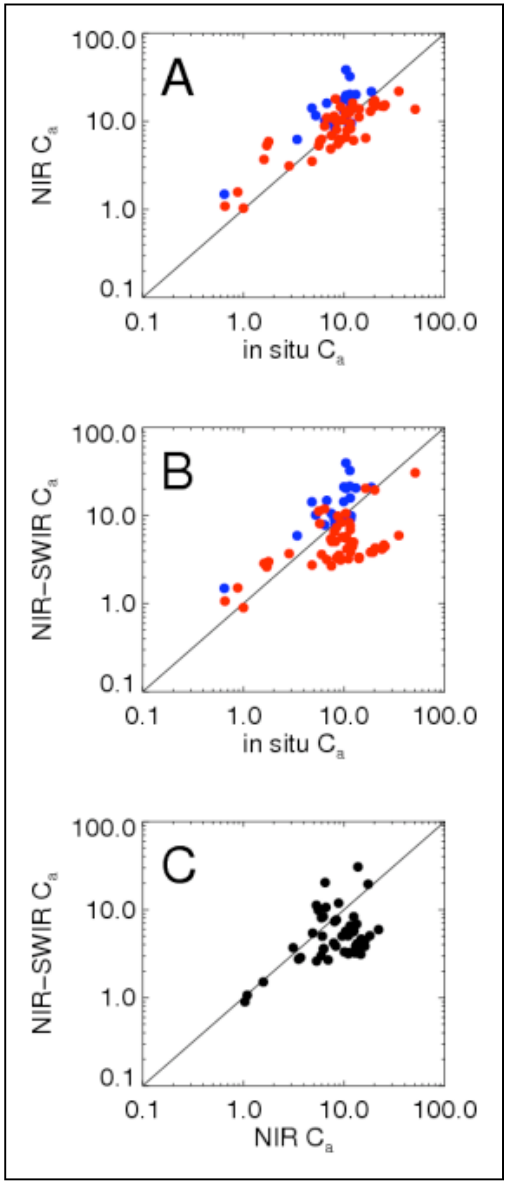
default processing ~ OC3 for MODIS-Aqua & OC4 for SeaWiFS

PJW, NASA/SSAI, 23 Feb 2010, Portland, OR

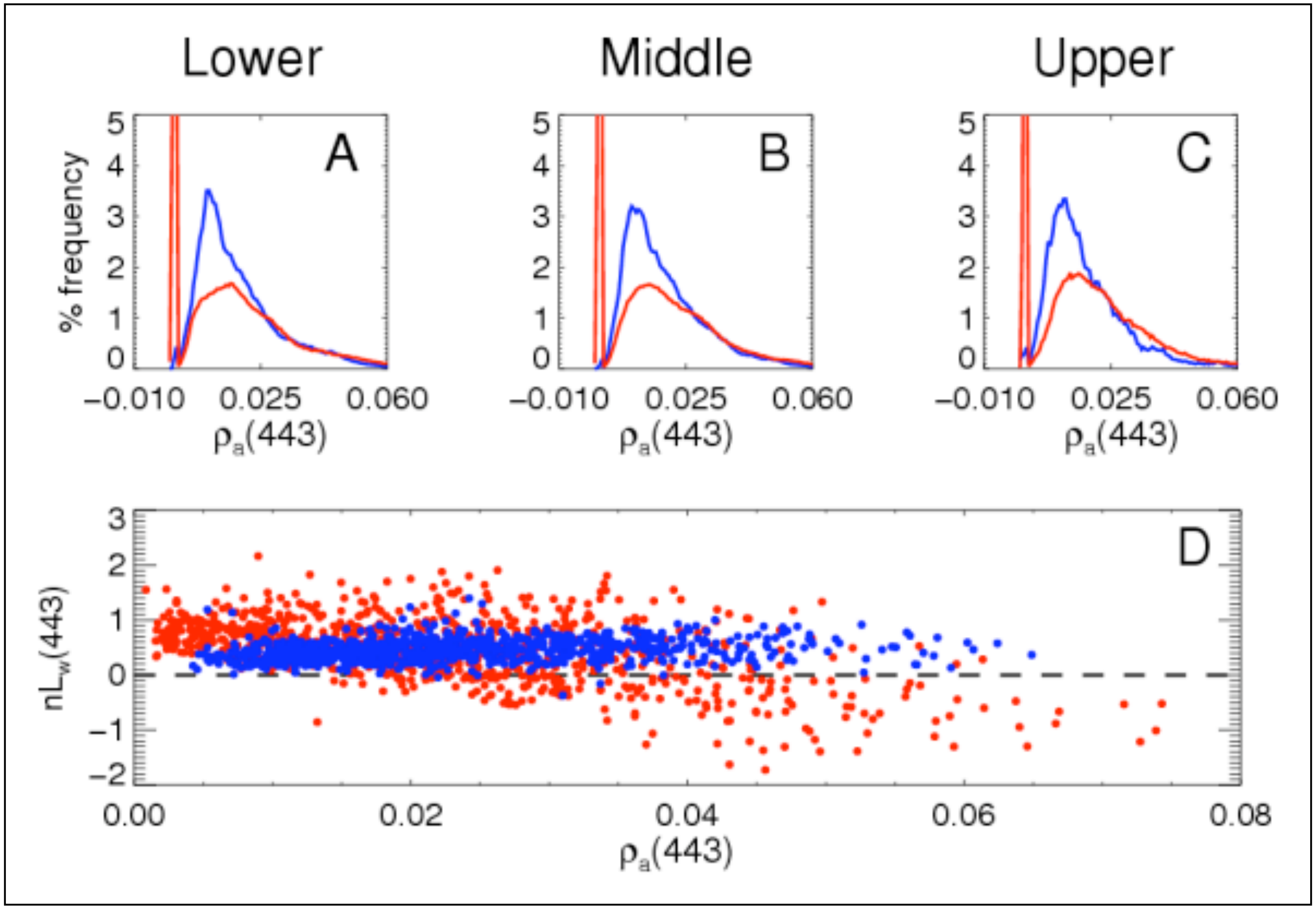
SNR transect for MODIS-Aqua NIR & SWIR bands



MODIS-Aqua Level-2 Chl “match-ups” for NIR & SWIR processing



MODIS-Aqua $\rho_a(443)$



distribution of the turbidity index using in NIR-SWIR switching