Assessment of Satellite Spatial Resolution Requirements to Capture the Spatial Dynamics of Phytoplankton and CDOM across Estuaries and the Adjacent Coastal Ocean

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Study Objectives

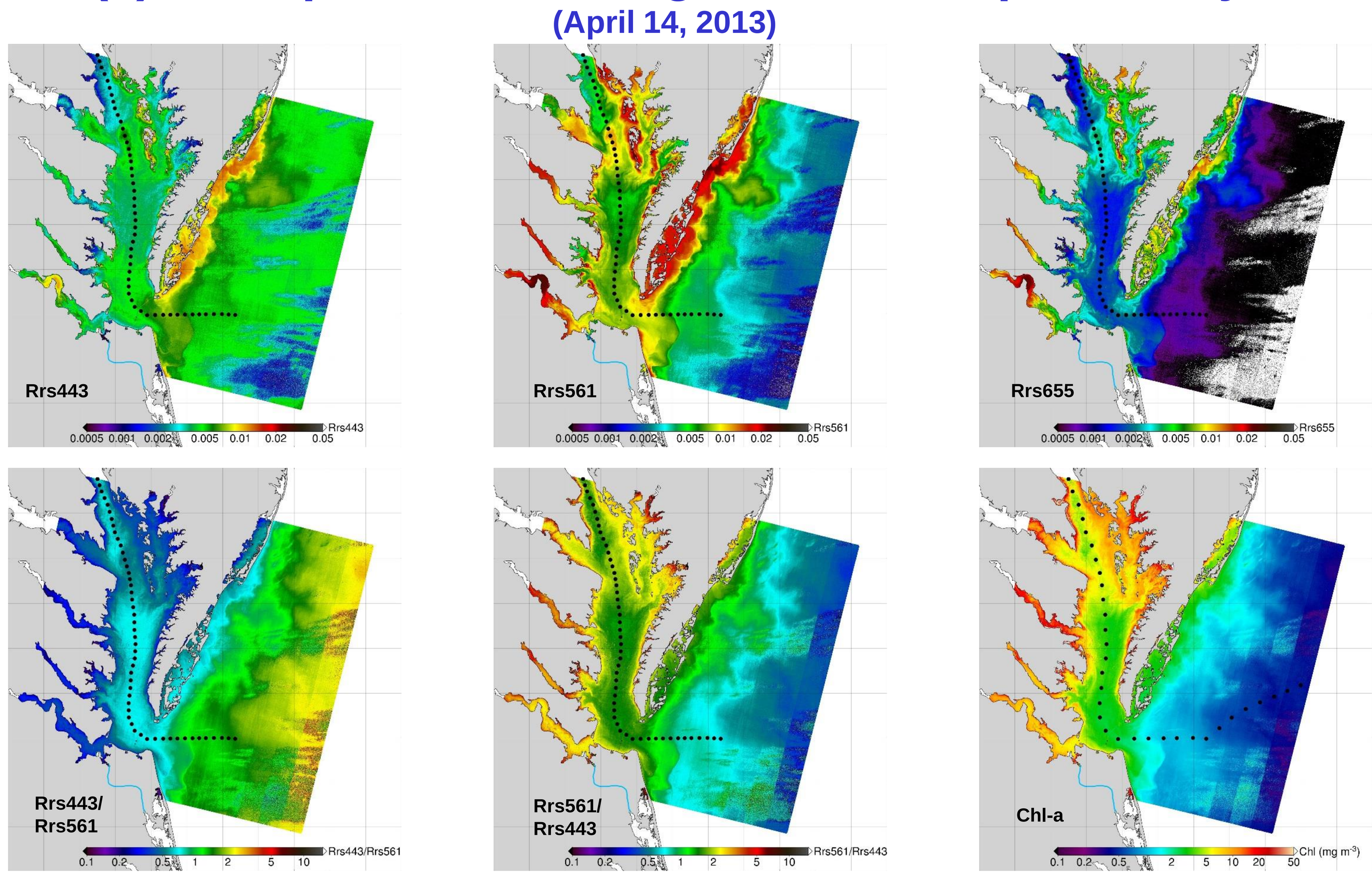
The goal of this effort is to study the spatial variability of the distributions of phytoplankton and CDOM (chromophoric dissolved organic matter) within several river mouths and plume regions using full-resolution satellite data. Here we show results for Chesapeake Bay, and the Exmouth Gulf (NW Australia), using Landsat 8 OLI (30 m) scenes to determine the optimal ground space distance (GSD) to capture the observed geophysical variability.

Data Sources and Methodology

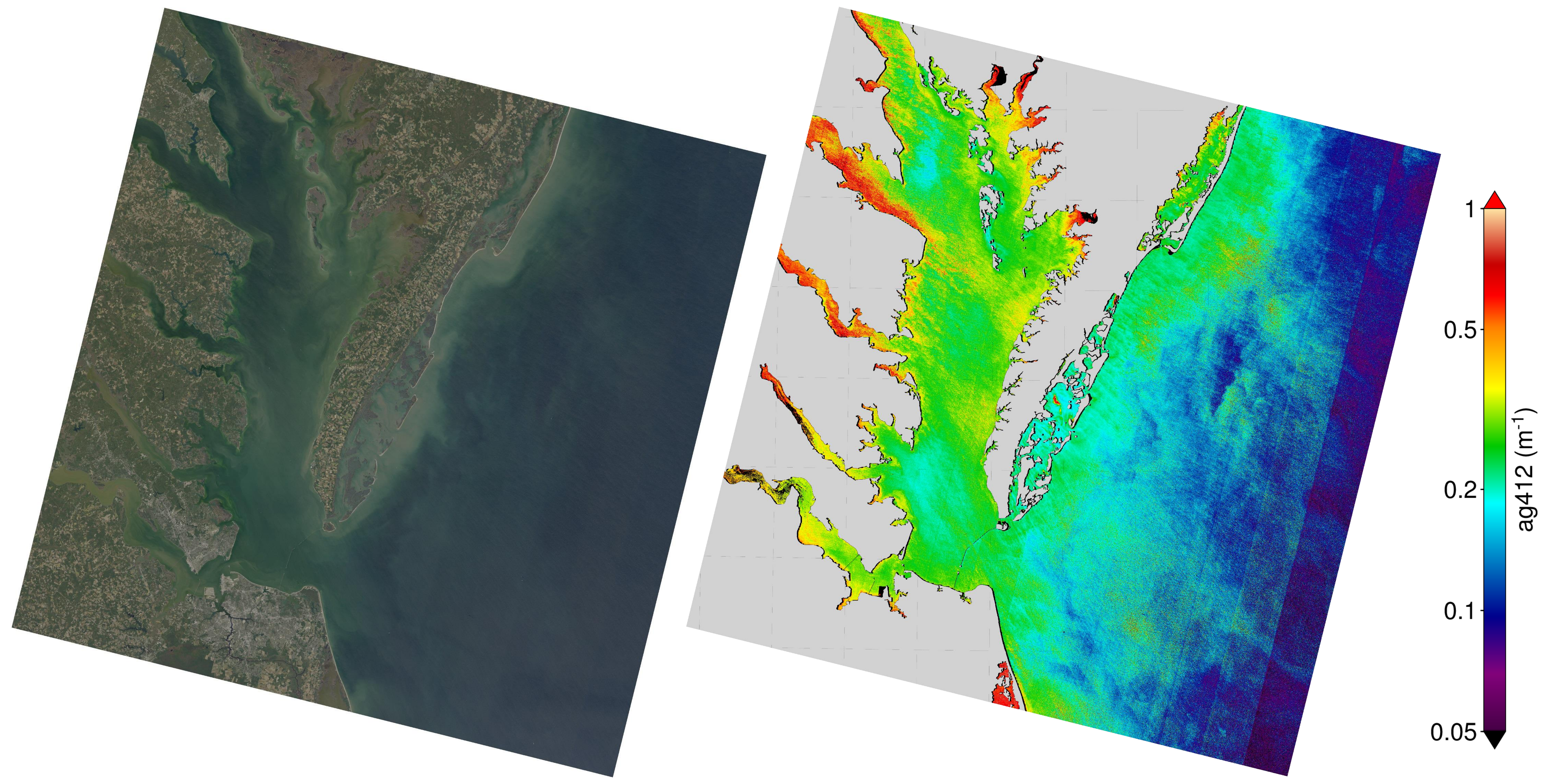
- Optimal GSD method based on Aurin et al. (2013) originally developed for MODIS Aqua and Terra.
- 13 (30m) available clear USGS GeoTiff OLI scenes (April 14 2013 to July 25 2015) were processed to L2 for the analysis. 15 scenes were also selected for the NW Australian coast, a region with clearer waters.
- Test stations were placed along a transect centered in the bay and extending into the coastal region.
- For each image, the variance of the ocean color product (σ_i) and the total uncertainty associated with instrument noise (σ_t) are calculated for each station as the pixel size box (2x2, 3x3, 4x4, etc.) is increased until $\sigma_i > \sigma_t$.
- Once the inter-pixel variability threshold ($\sigma_i > \sigma_t$) is reached, the optimal GSD is defined as the average between the size of the inconclusive array ($\sigma_i \leq \sigma_t$) and the size of the array which marked the upper limit of a GSD which could resolve significant differences in ocean constituents ($\sigma_i > \sigma_t$).
- The Rrs noise level was obtained from the OLI sensor noise model, propagated through the atmospheric correction process (Franz et al. 2015 and references therein).
- Offshore areas affected by sun glint and sensor banding are excluded from the analysis.
- Landsat visit rate (16 days), cloud cover, sun glint, and short available record limits the availability of useful images.

(1) Examples of OLI Images for Chesapeake Bay

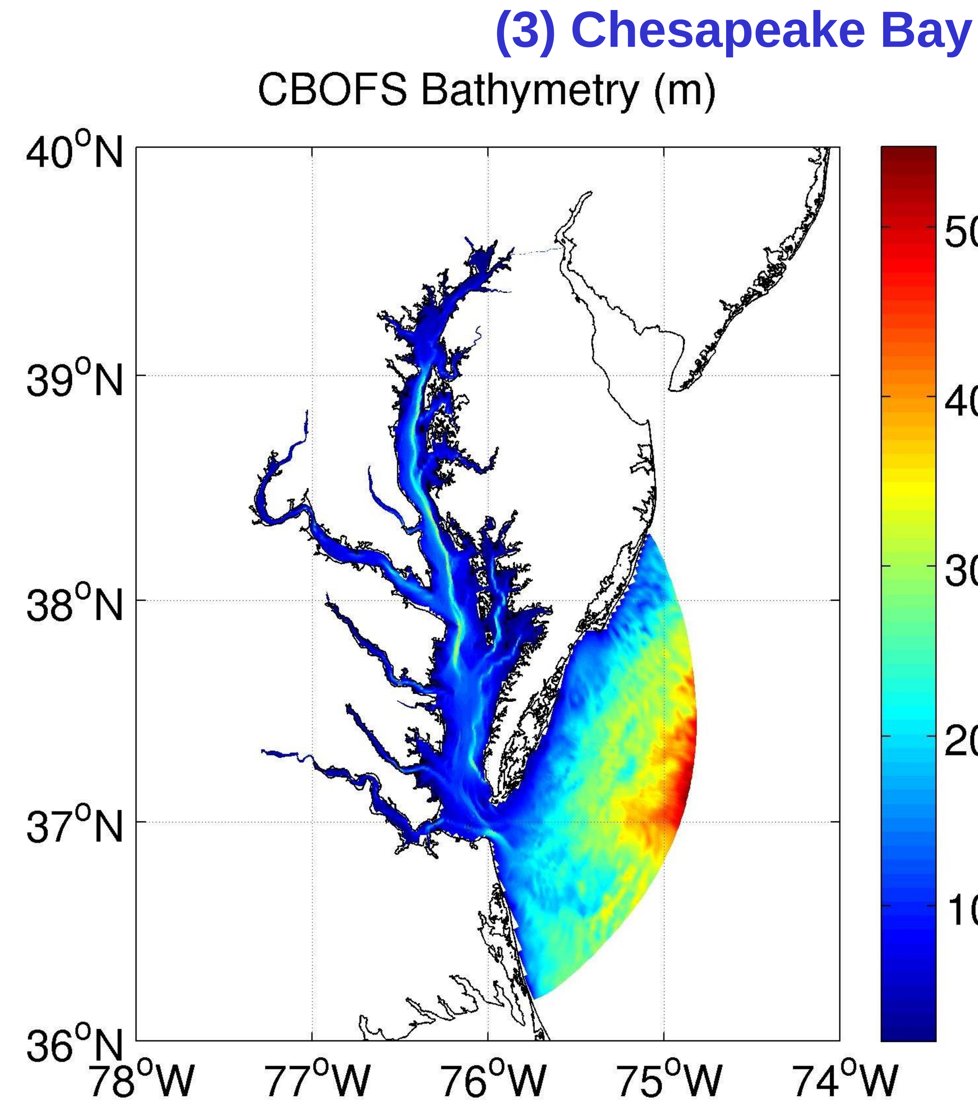
(April 14, 2013)



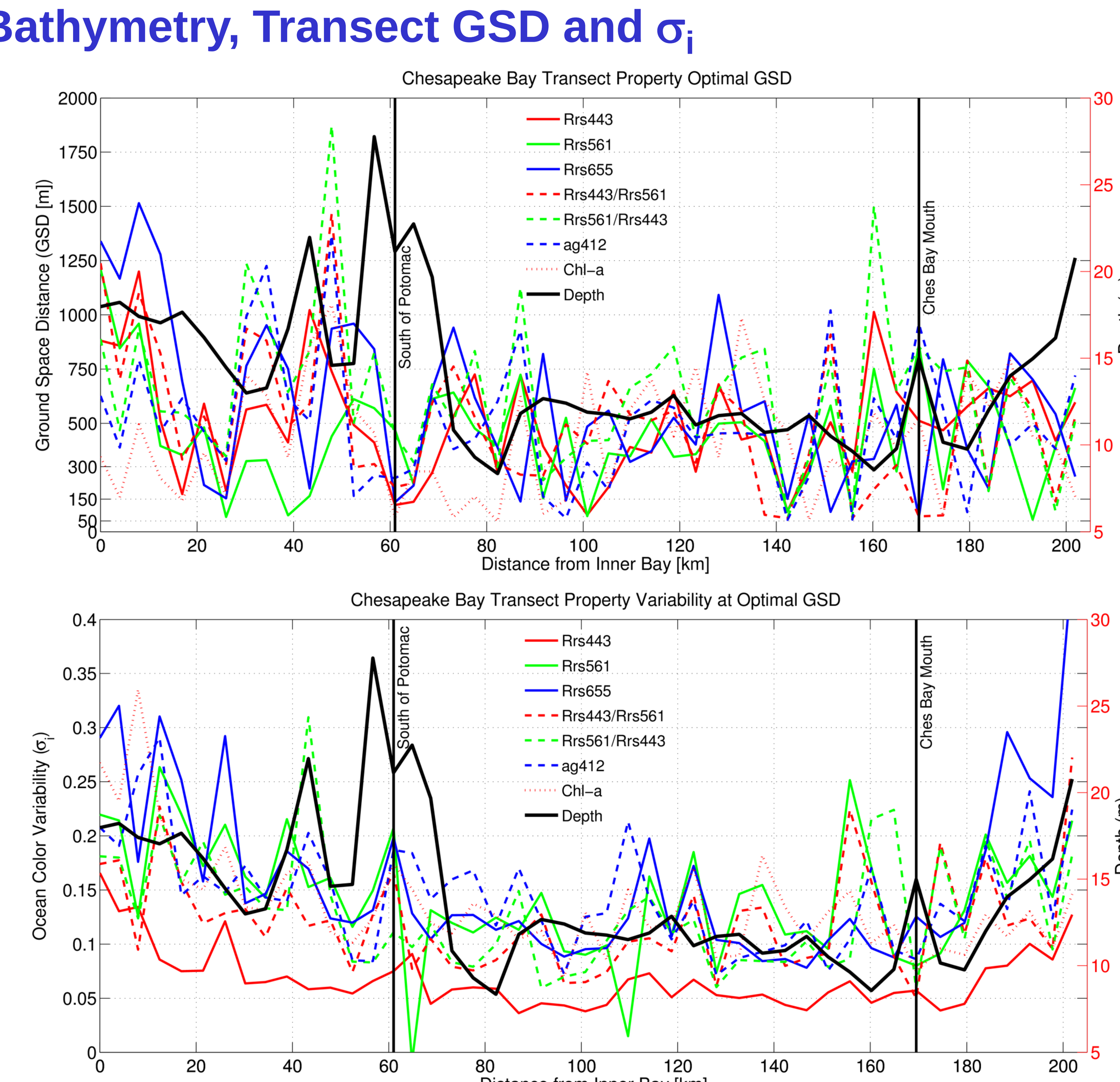
(2) True Color and ag412 for October 26, 2014



(3) Chesapeake Bay Bathymetry, Transect GSD and σ_i



CBOFS is the NOAA's Chesapeake Bay Ocean Forecast System



(4) Summary of Optimal GSD for Chesapeake Bay

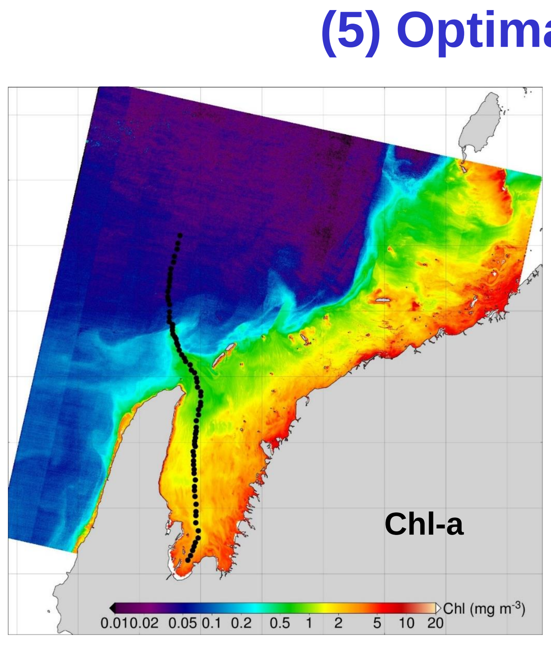
Transect Optimal Ground Space Distance (m)							
		Average GSD of all images			Median GSD of all images		
Product	N	Min	Max	Avg	Min	Max	Avg
Rrs443	430	56	1211	447	45	90	52
Rrs561	456	78	1200	499	45	600	75
Rrs655	397	66	1515	577	45	1335	75
443/561	411	62	1466	499	45	810	68
561/443	440	62	1872	641	45	1305	75
ag412	463	55	1368	506	45	105	52
Chl-a	486	48	1047	421	45	75	45
Mean		52	1383	**513**	**45**	**617**	63

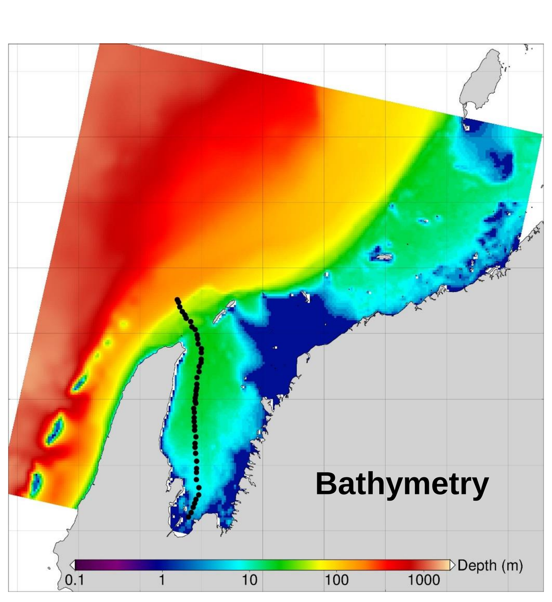
Total number of possible occurrences = 46 stations x 13 images = 598
N is the number of valid occurrences with successful GSD retrievals

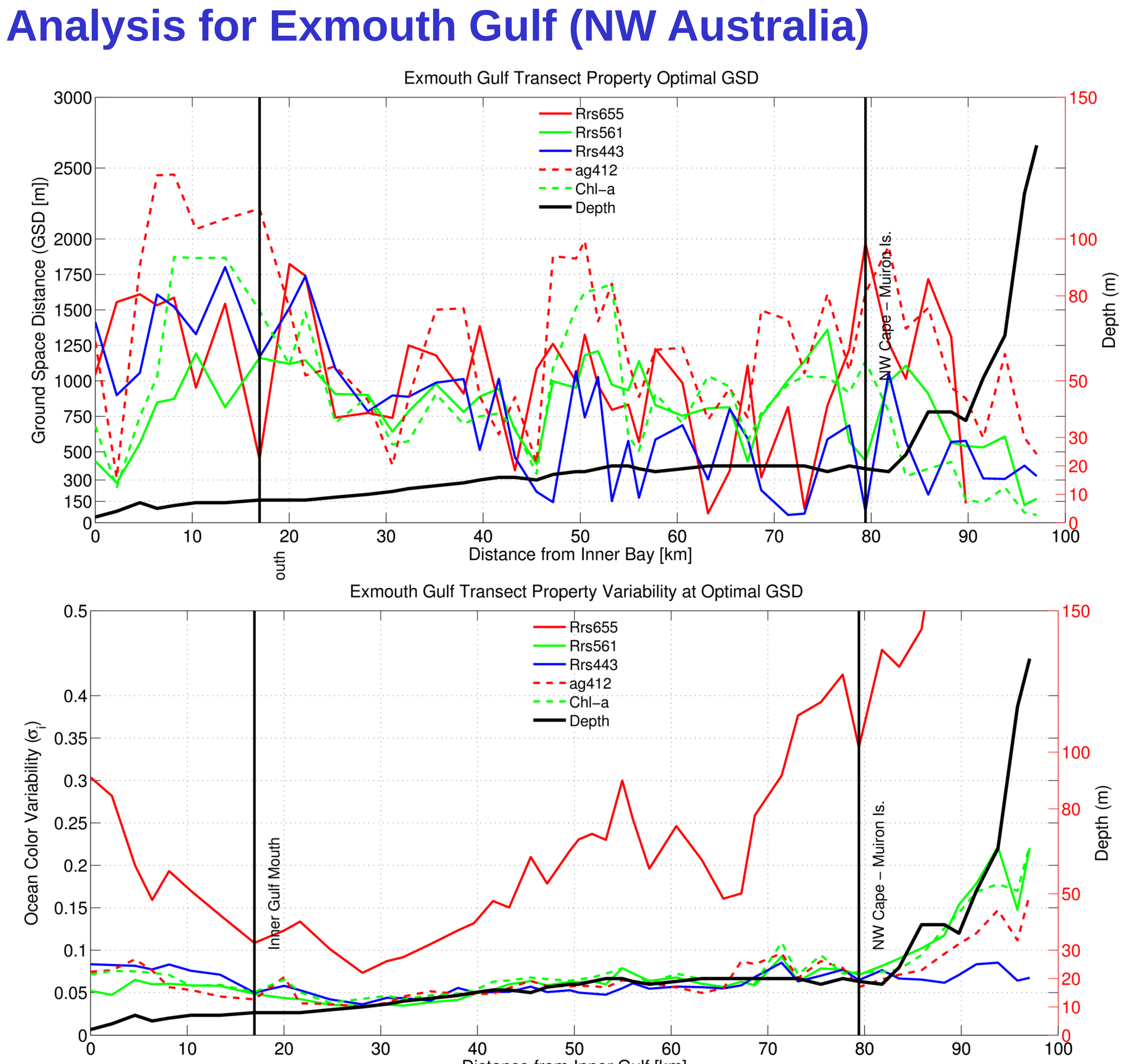
Summary & Conclusions

- Landsat OLI scenes of Chesapeake Bay were used to analyze the optimal GSD along the bay channel from north of the Potomac to the Bay's mouth. Landsat OLI scenes of NW Australia, a region of clear coastal waters, were also used to analyze the optimal GSD.
- A transition zone was identified near the mouth of the Potomac River where the bathymetry is deepest (> 25 m). Both GSD and σ_i are larger and more variable north of that zone. σ_i also increased as the bathymetry deepens offshore of the Bay's mouth.
- For Chesapeake Bay, the optimal GSD for various ocean color products (reflectances, band ratios, and chl-a) range from 45m to 617m (median min and max); mean of 513km. There is a large variability in GSD from station to station and from image to image, primarily driven by physical forcing and bathymetry.
- For the Exmouth Gulf, a region with clearer waters, the optimal GSD for the various products range from 51m to 2526 m (median min and max); mean of 950m. Bathymetry and geometry of the Gulf seem to have a role in determining the optimal GSD but the values are significant higher than Chesapeake Bay.
- Further optimal GSD analysis is planned in clear coastal waters and other estuaries and river plumes to ensure a wider range of geophysical spatial and temporal dynamics.

(5) Optimal GSD Analysis for Exmouth Gulf (NW Australia)







(6) Summary of Optimal GSD for Exmouth Gulf, NW Australia

Transect Optimal Ground Space Distance (m)							
		Average GSD of all images			Median GSD of all images		
Product	N	Min	Max	Avg	Min	Max	Avg
Rrs443	485	54	1801	740	45	2115	105
Rrs561	584	124	1360	812	45	1020	255
Rrs655	372	45	4365	1060	45	4365	232
ag412	532	313	2455	1274	75	2955	495
Chl-a	642	54	1873	863	45	2175	225
Mean		118	2371	**950**	**51**	**2526**	262

Total number of possible occurrences = 47 stations x 15 images = 705, N is the number of valid occurrences with successful GSD retrievals

References

Dirk Aurin, Antonio Mannino, Bryan Franz, Spatially resolving ocean color and sediment dispersion in river plumes, coastal systems, and continental shelf waters, Remote Sensing of Environment, Volume 137, October 2013, Pages 212-225, ISSN 0034-4257, http://dx.doi.org/10.1016/j.rse.2013.06.018.

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