Decadal Changes of Water Properties in the Aral Sea Observed by MODIS-Aqua

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Summary

- Twelve-year satellite observations between 2002 and 2013 from the Moderate Resolution Imaging Spectroradiometer (MODIS) onboard the satellite Aqua are used to quantitatively assess the water property changes in the Aral Sea.
- Of the three regions, the North Aral Sea has had the least interannual variability, while South-East (SE) Aral Sea experienced drastic changes.
- Waters in the SE Aral Sea are the most turbid with significantly higher $K_d(490)$ than those in the other two sub-regions. $K_d(490)$ gradually increased from ~2 m^{-1} in 2002 to ~3.5 m^{-1} after 2008 in the SE Aral Sea.
- Both radiance ratio $nL_w(555)/nL_w(443)$ and $K_d(490)$ were relatively stable for the North Aral Sea.
- This work is in press in *Journal of Geophysical Research, Oceans* [*Shi and Wang*, 2015].

Desiccation of the Aral Sea

The Aral Sea was formerly the fourth largest lake in the world with coverage of ~68,000 square kilometers and sea level over ~53 m [*Bortnik*, 1996]. By 2007, the size of the Aral Sea was only about 10% of its original size and the total water volume of the largest remaining portion of the Aral Sea was only ~6% of the volume in 1960s [*Micklin*, 2007]. the diminishing of the Aral Sea is "one of the worst environmental disasters in the world" (from United Nations Secretary-General Ban Ki-moon).

Aral Sea True Color Image Examples (2002–2013)

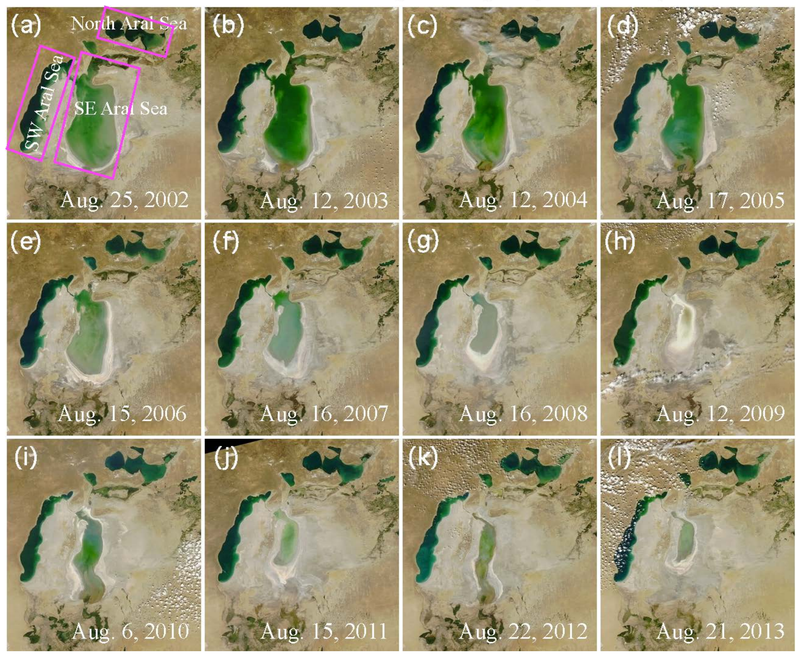


Figure 1. Example of true color images of the Aral Sea captured by MODIS-Aqua in each summer between 2002 and 2013 on (a) August 25, 2002, (b) August 12, 2003, (c) August 12, 2004, (d) August 17, 2005, (e) August 15, 2006, (f) August 16, 2007, (g) August 16, 2008, (h) August 12, 2009, (i) August 6, 2010, (j) August 15, 2011, (k) August 22, 2012, and (l) August 21, 2013. Three sections of the Aral Sea are marked in Fig. 2a for the North Aral Sea, SW Aral Sea, and SE Aral Sea.

Seasonal Climatology of Water Properties

- $nL_w(\lambda)$ spectra are different for the North, SW and SE Aral Sea regions.
- NO significant seasonal variability of $nL_w(555)/nL_w(443)$ in the North Aral Sea. $nL_w(555)/nL_w(443)$ in the SE Aral Sea also shows seasonal change. Mean value of $nL_w(555)/nL_w(443)$ in the fall is 1.99, while it is 1.64 in spring.
- Mean $K_d(490)$ in the SE Aral Sea is 3.03 m^{-1}, while the three-season mean $K_d(490)$ values for the SW and North Aral Sea are 1.06 and 1.15 m^{-1}.

Seasonal Climatology (2002-2013) for Aral Sea Water Property

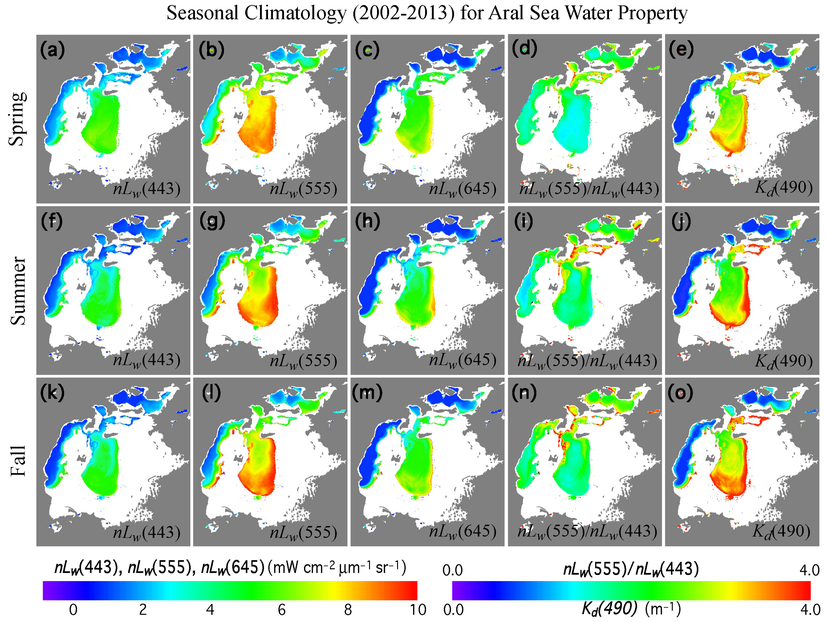


Figure 2. Seasonal climatology images of $nL_w(443)$, $nL_w(555)$, $nL_w(645)$, $nL_w(555)/nL_w(443)$, and $K_d(490)$ in (a–e) spring, (f–j) summer, (l–p) fall, respectively. $nL_w(555)/nL_w(443)$ and $K_d(490)$ climatology images were computed after excluding the pixels with the bottom effect.

Aral Sea $K_d(490)$ in Summer (2002-2013)

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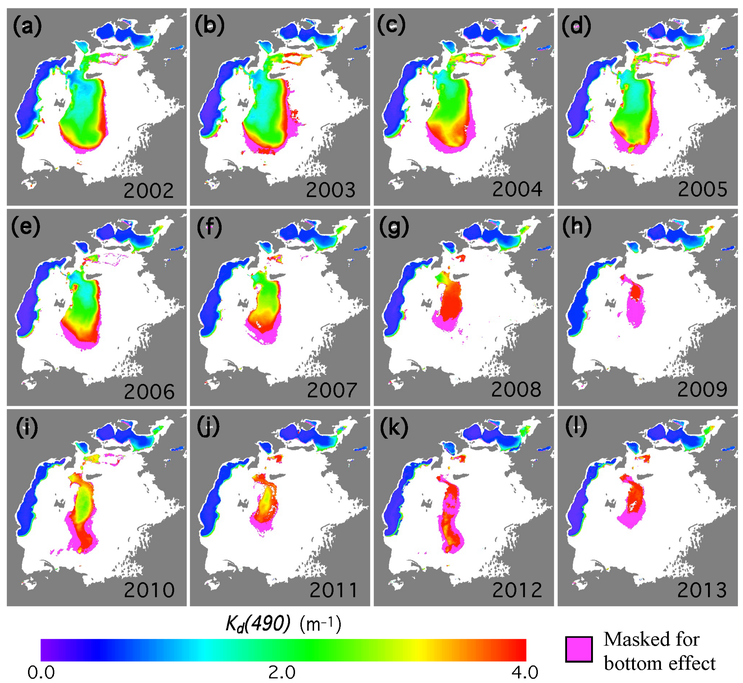


Figure 3. $K_d(490)$ composite images in summers (June–August) for (a–l) the corresponding years of 2002–2013. $K_d(490)$ data are not valid and excluded in the pink regions due to the bottom effect.

- $K_d(490)$ indeed showed gradual increase during the period when the SE Aral Sea dried up between 2002 and 2009.
- $nL_w(555)/nL_w(443)$, interannual variability of $K_d(490)$ is relatively small for all the three regions in the Aral Sea

Time Series of $nL_w(555)/nL_w(443)$ and $K_d(490)$

- $K_d(490)$ gradually increased from ~2.2 m^{-1} in 2002 to ~3.5 m^{-1} in 2007, and then stayed at that level after 2007
- In the North Aral Sea, both $nL_w(555)/nL_w(443)$ and $K_d(490)$ were relatively stable for the 12 years.
- SW Aral Sea featured interannual variability in $nL_w(555)/nL_w(443)$ with highs during the falls of 2007 and 2010 and lows in 2012

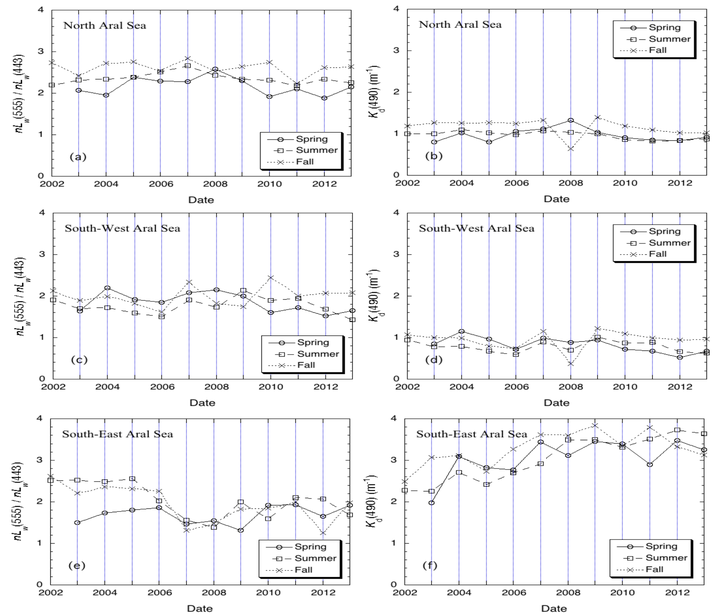


Figure 4. MODIS-Aqua-derived $nL_w(555)/nL_w(443)$ and $K_d(490)$ as a function of time from 2002–2013 in three different seasons for (a) and (b) North Aral Sea, (c) and (d) SW Aral Sea, and (e) and (f) SE Aral Sea.

Conclusion Remarks

- Seasonal variability and significant interannual changes are found in the Aral Sea between 2002 and 2013
- South-East (SE) Aral Sea experienced drastic changes in 12 years.
- $K_d(490)$ gradually from ~2 m^{-1} in 2002 to ~3.5 m^{-1} after 2008 in the SE Aral Sea.

References

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