

Estimating stray light impact on MODIS ocean color products

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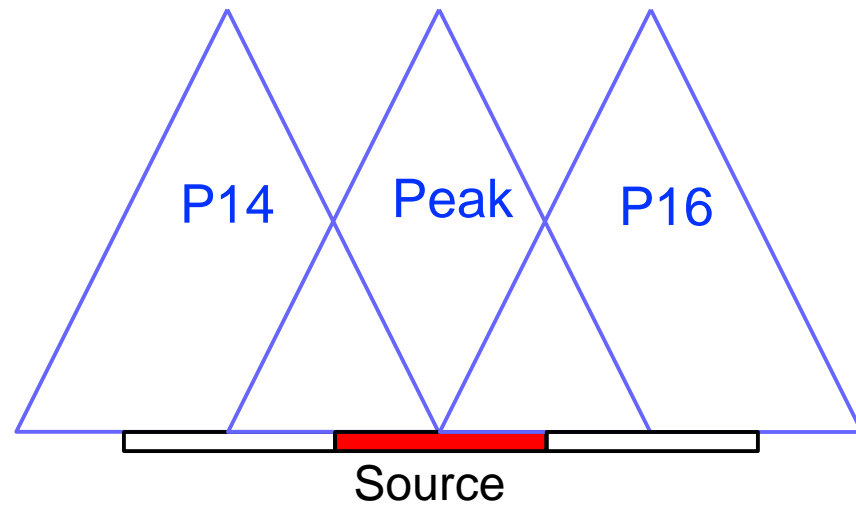


Content

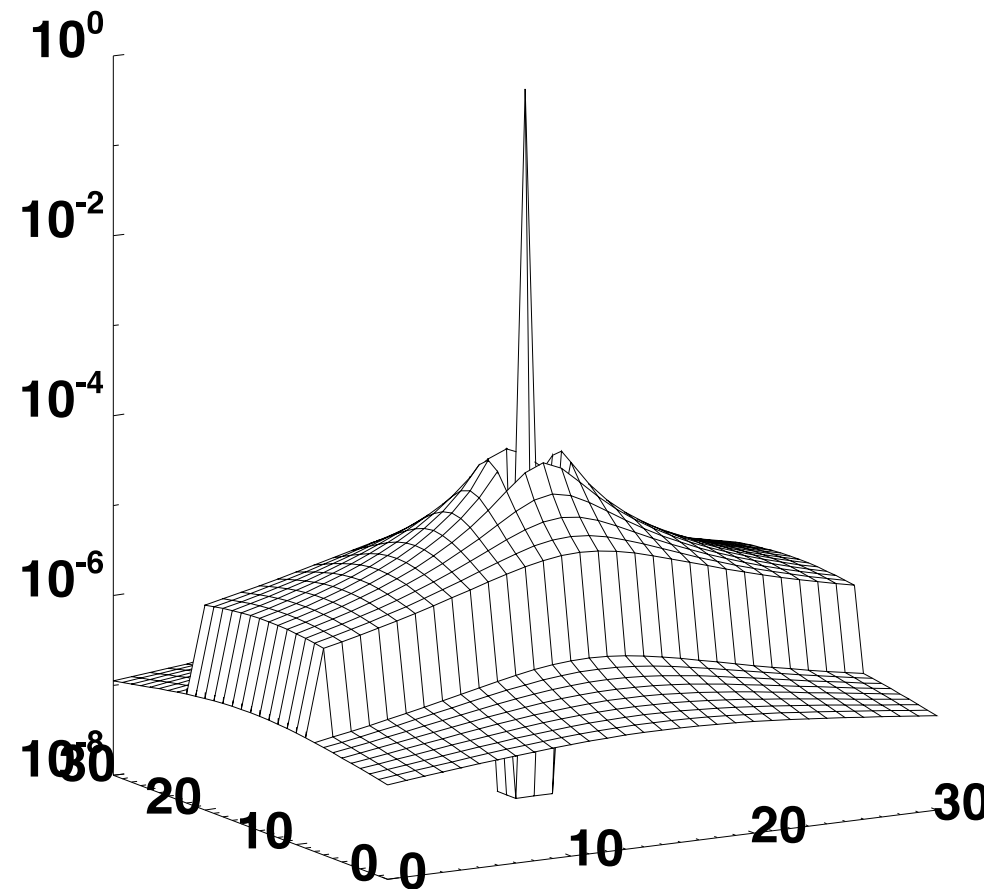
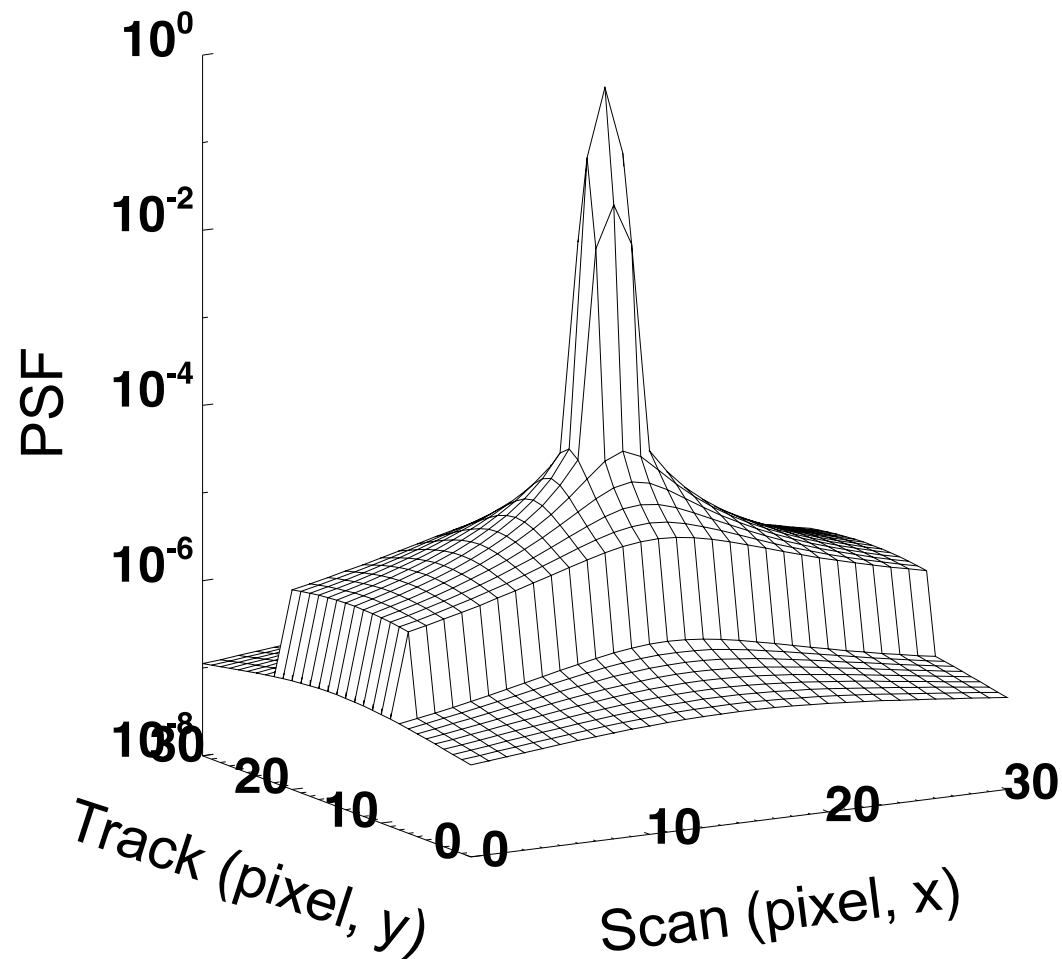
- Objective: estimate stray light contamination on ocean pixels using PSF function to better define ocean color instrument stray light rejection requirement.
- Data: one day of MODIS Aqua scenes (2002 Aug 15)
- Aqua PSF: derived from prelaunch measurements
- Method: estimate stray light from measured radiance (L_m) using matrix inversion
- Results: compare MODIS scene stray light with predefined stress scenes



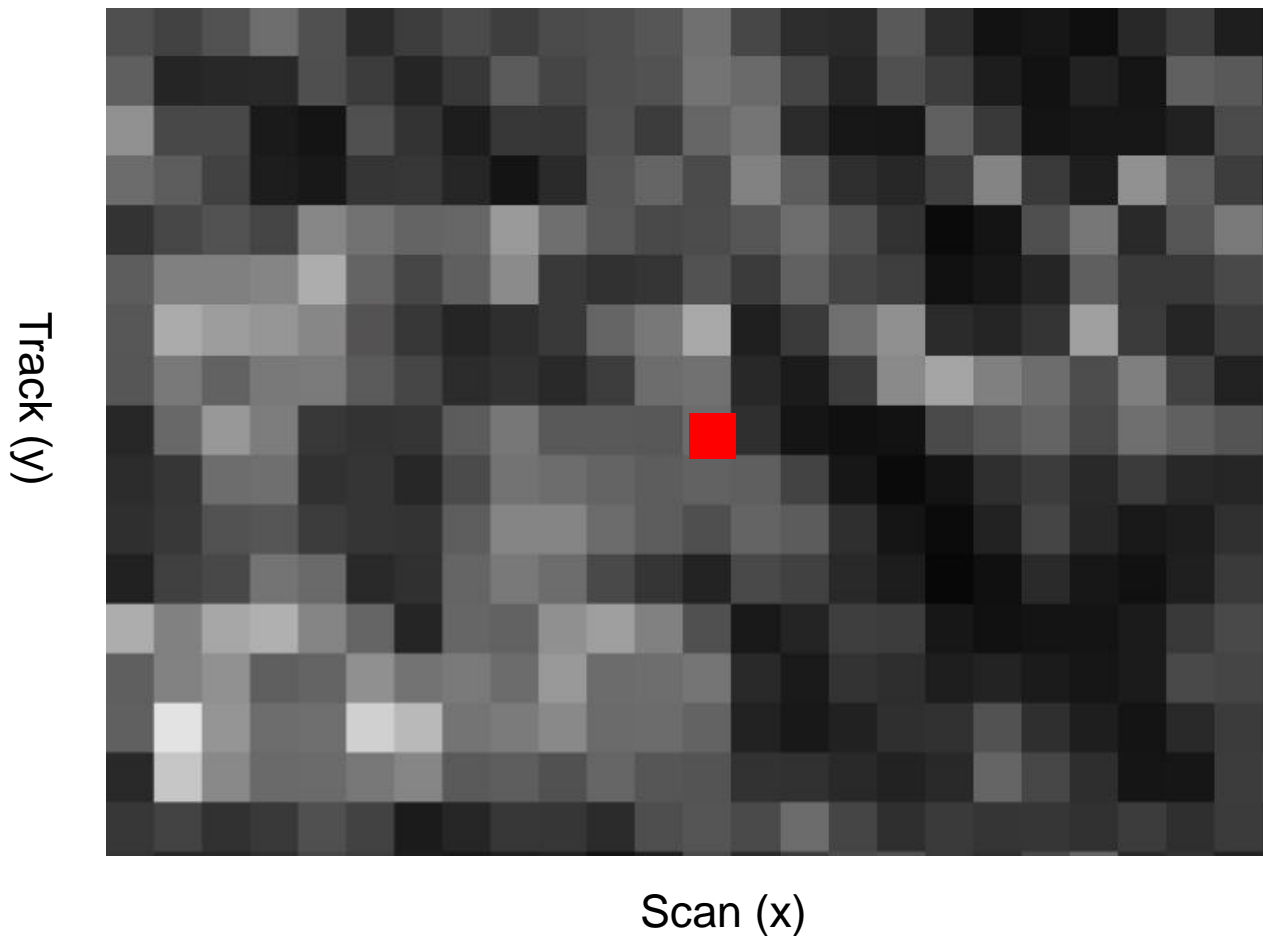
PSF



- PSF: instrument response to a point source
- The measured PSF has strong response around peak due to scan blur
- $\text{PSF}(\text{P14/P16}) = .167$ of peak



- To assess the stray light, the radiance is assumed to be uniform within each pixel
- To reduce uncertainty, the PSF is set to 0 for pixels adjacent to the peak.



$$(1) L_{m(x0,y0)} = \sum_{x,y} L_{t(x,y)} \cdot PSF_{(x-x0,y-y0)}$$

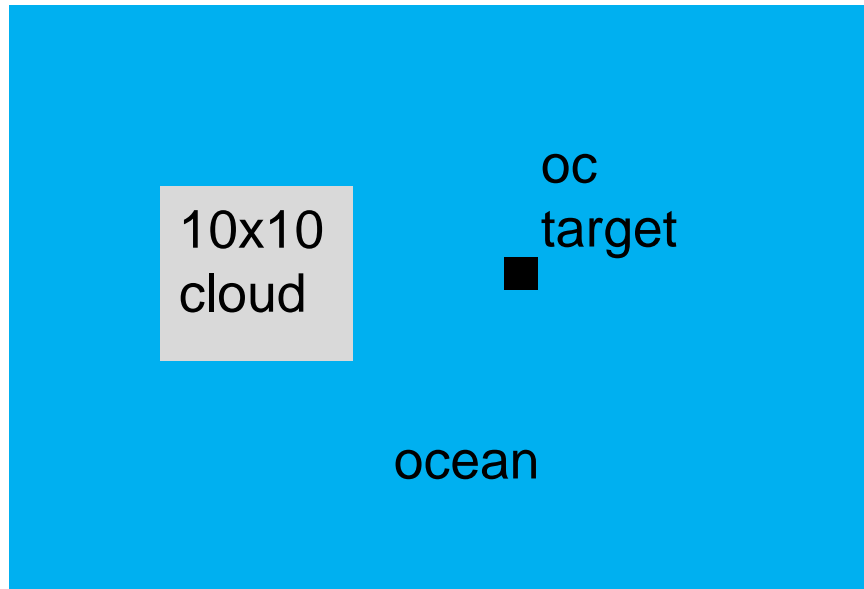
$$(2) LM = SDF \cdot LT$$

$$(3) LT = SDF^{-1} \cdot LM$$

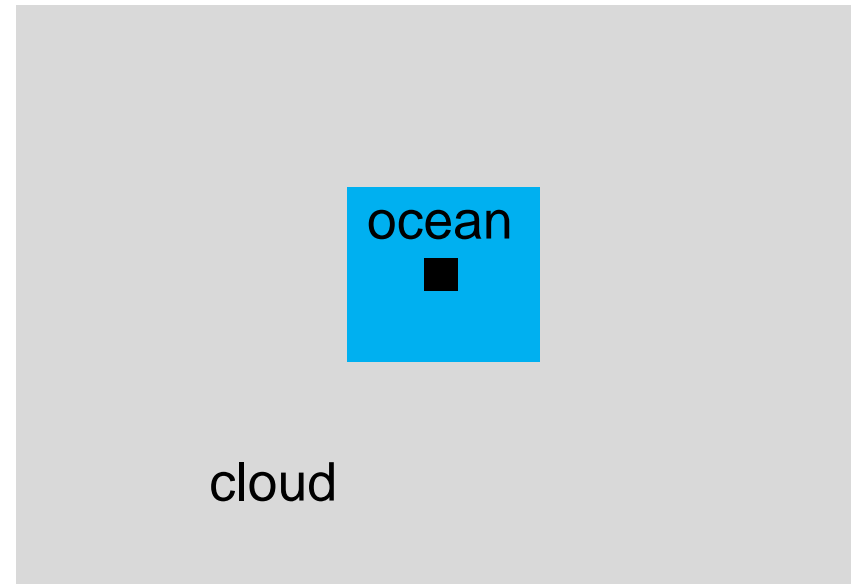
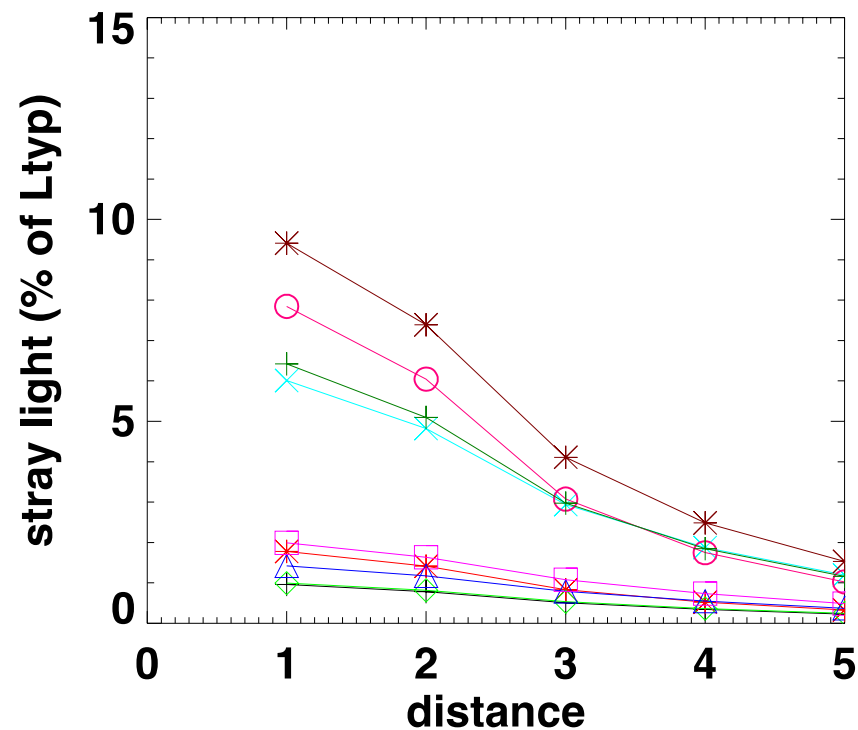
- $L_{m(x0,y0)}$: measured rad at $(x0, y0)$
- $L_{t(x,y)}$: true rad at (x, y)
- $PSF_{(x-x0,y-y0)}$: PSF of pixel x, y at $(x0, y0)$
- LM = matrix variable of $L_{m(x,y)}$
- LT = matrix variable of $L_{t(x,y)}$
- SDF = matrix variable of $PSF_{(x-x0,y-y0)}$



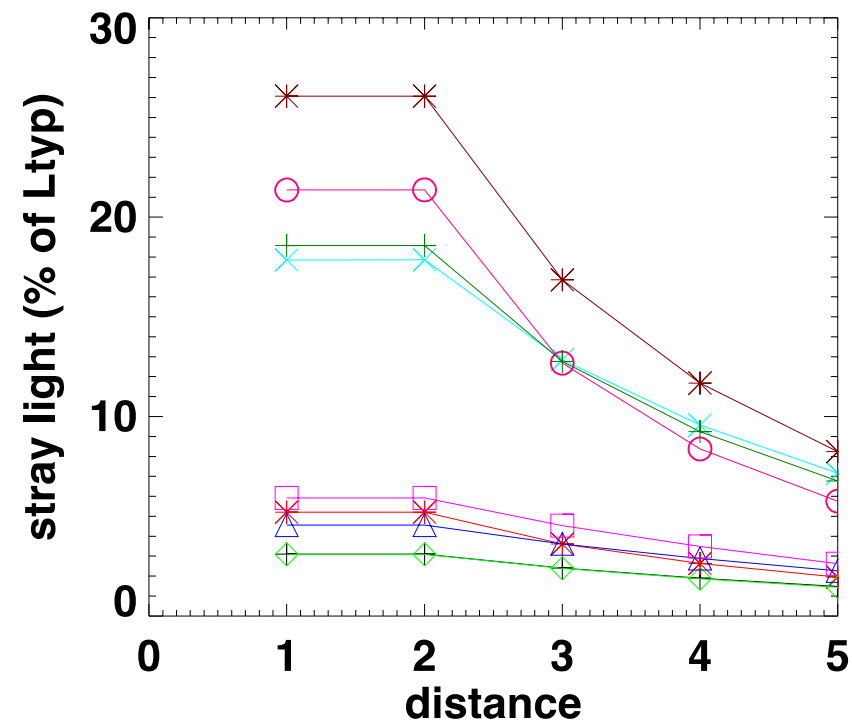
Stress scene



10x10 cloud

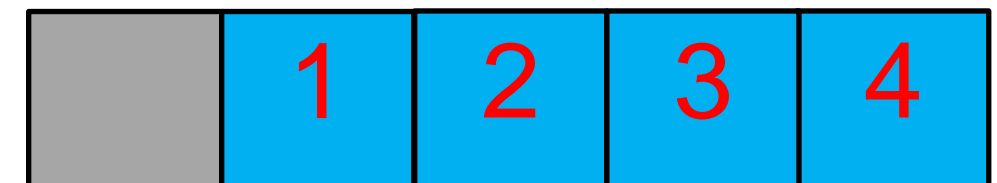


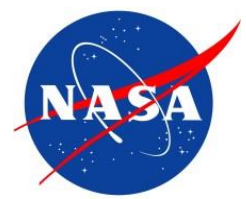
Hole in the cloud



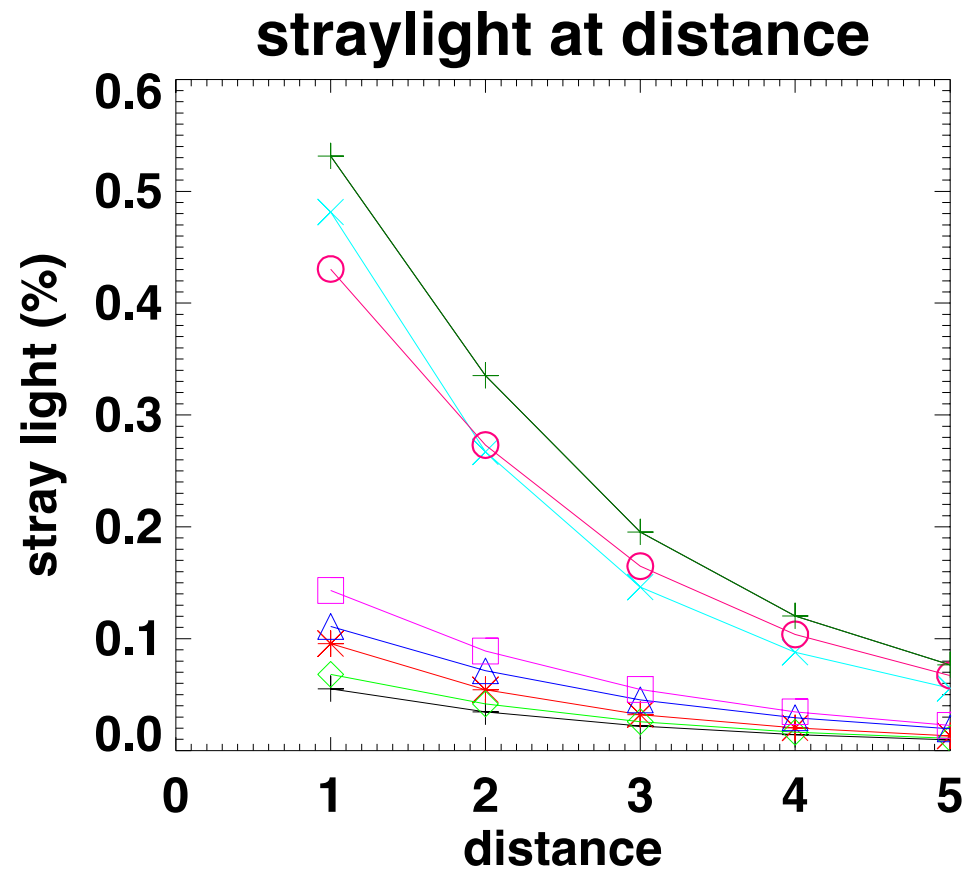
+ b8 * b9 ◇ b10 △ b11 □ b12 × b13 ○ b14 + b15 * b16

- stray light computed as $\text{abs}(L_t - L_m)/L_t$
- $L_{\text{cloud}} = L_{\text{max}}$
- $L_{\text{ocean}} = L_{\text{typ}}$
- stray light estimates not valid for distance = 1
- stray light increase vs. wavelength due to increasing $L_{\text{max}}/L_{\text{typ}}$ ratios

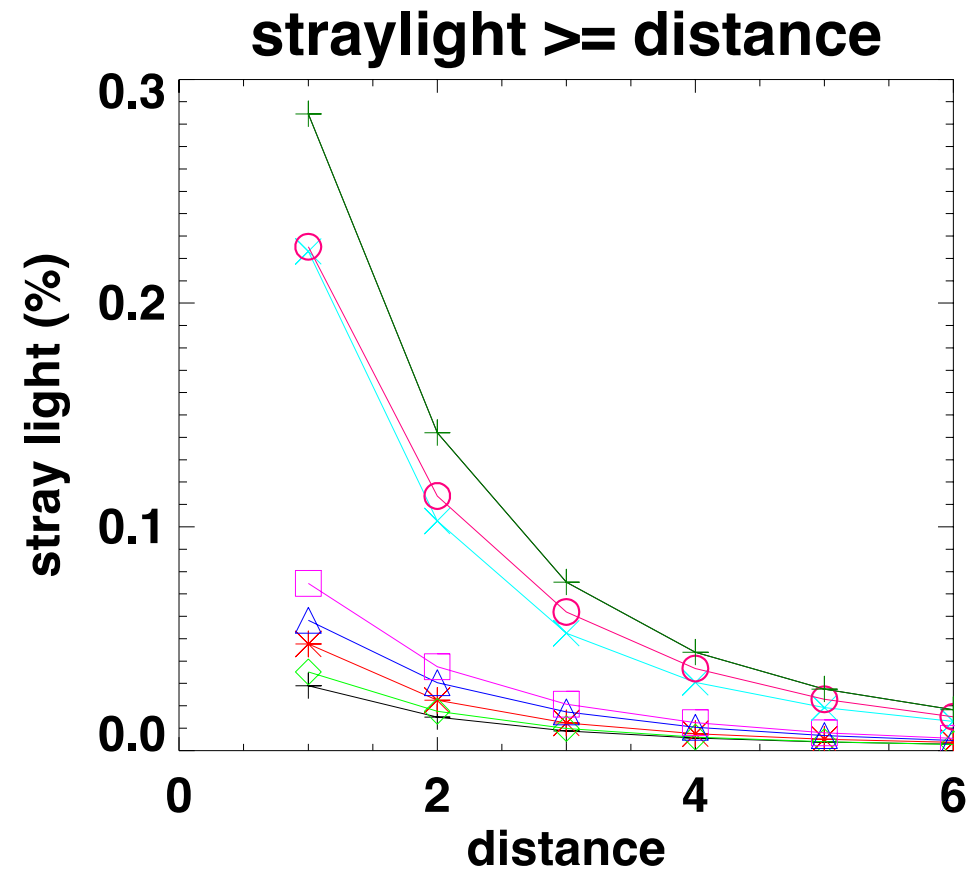




Results



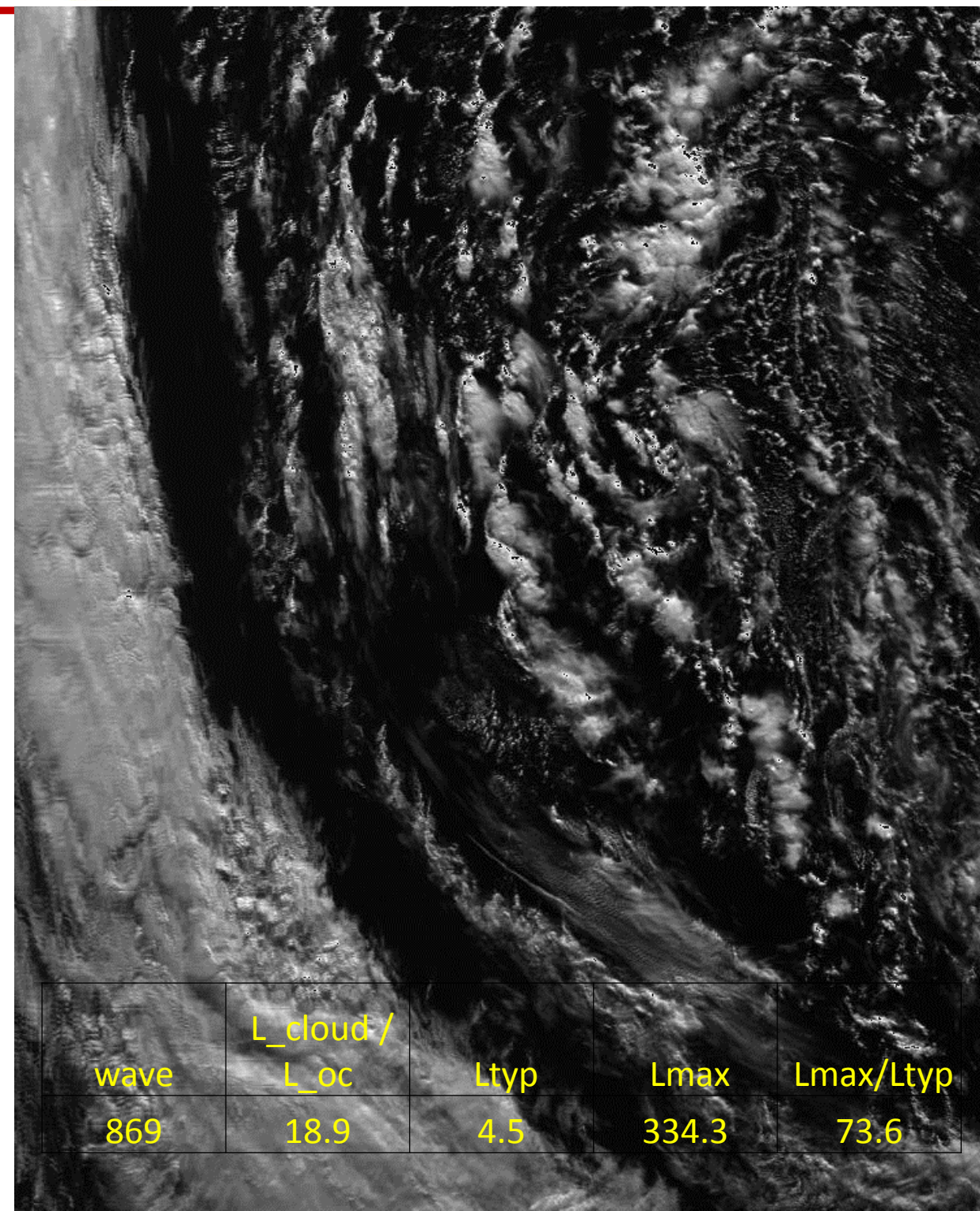
+ b8 * b9 ◇ b10 △ b11 □ b12 × b14 ○ b15 + b16



Distance from cloud (pixel)	1	2	3	4	5	>= 6
npix/oc_total (%)	36.9	16.3	9.7	6.6	4.8	25.7
accumulated	100	63.1	46.8	37.1	30.5	25.7

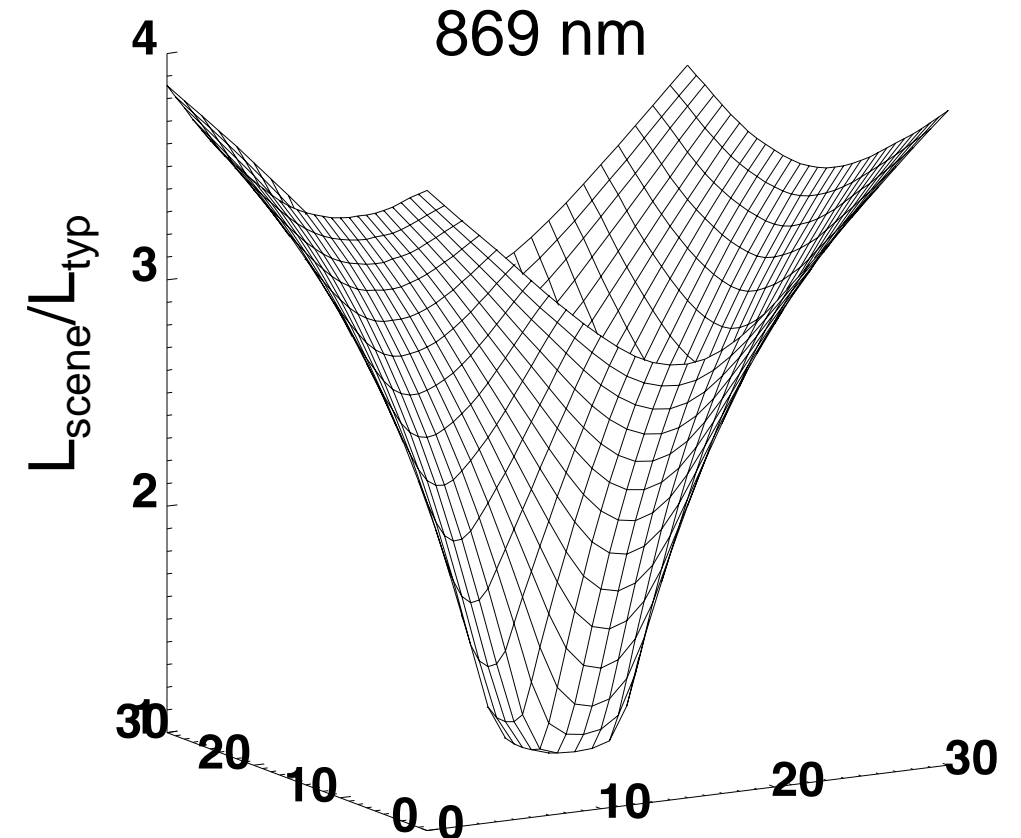
- Data: 2002 Aug 15, total pixels ~280M, ~11.4% oc_pixels
- Average stray light contamination (%) = 100 * mean(abs(Lm - Lt) / Lt)
- stray light << stress scene
- For 869nm, dist=3, oc scene (0.2%) is ~20x less than 10x10 cloud case.

Ocean Scene Contrast



wave	L_{cloud} / L_{oc}	L_{typ}	L_{max}	L_{max} / L_{typ}
869	18.9	4.5	334.3	73.6

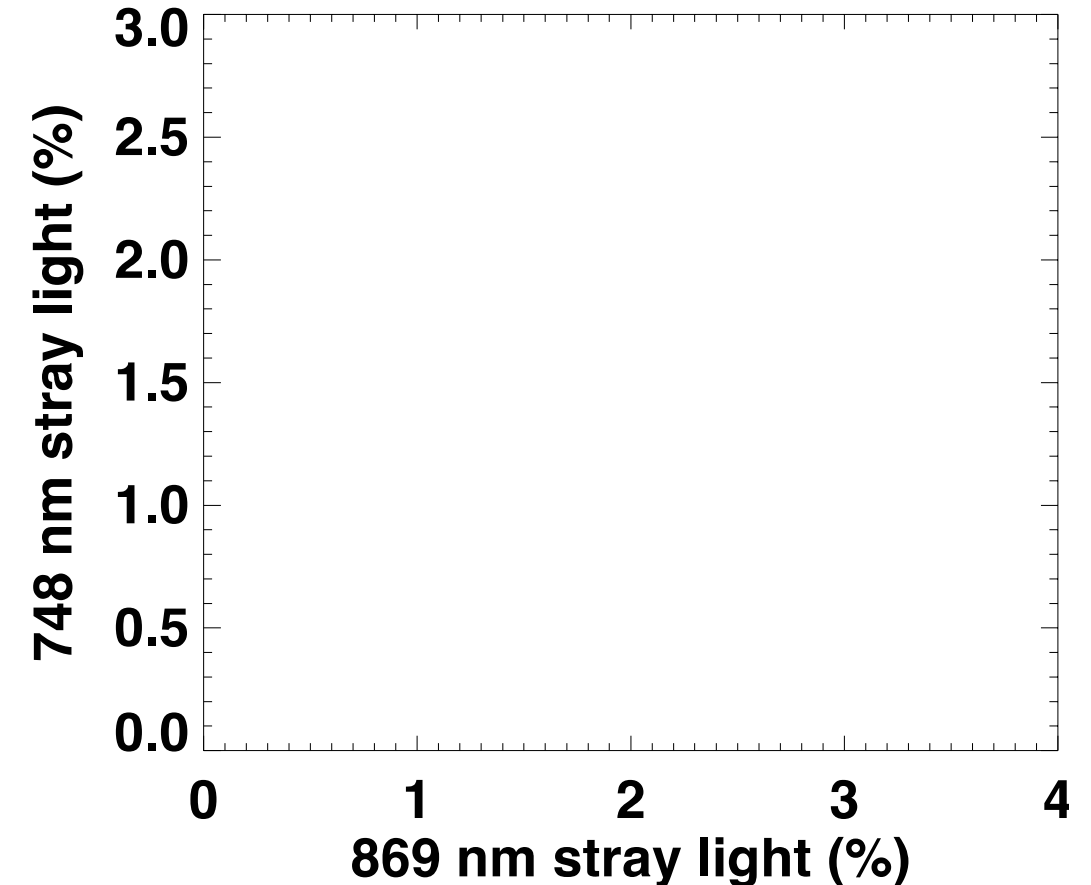
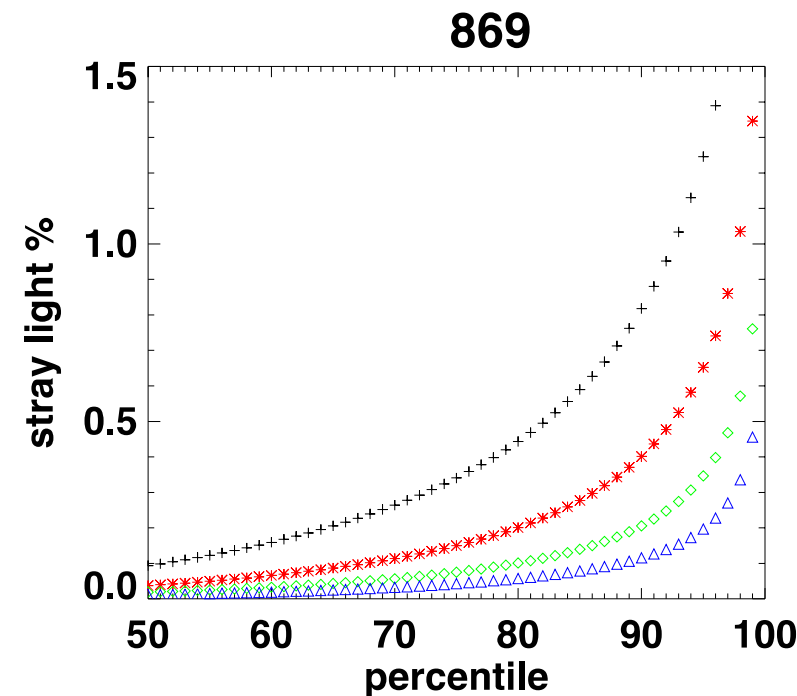
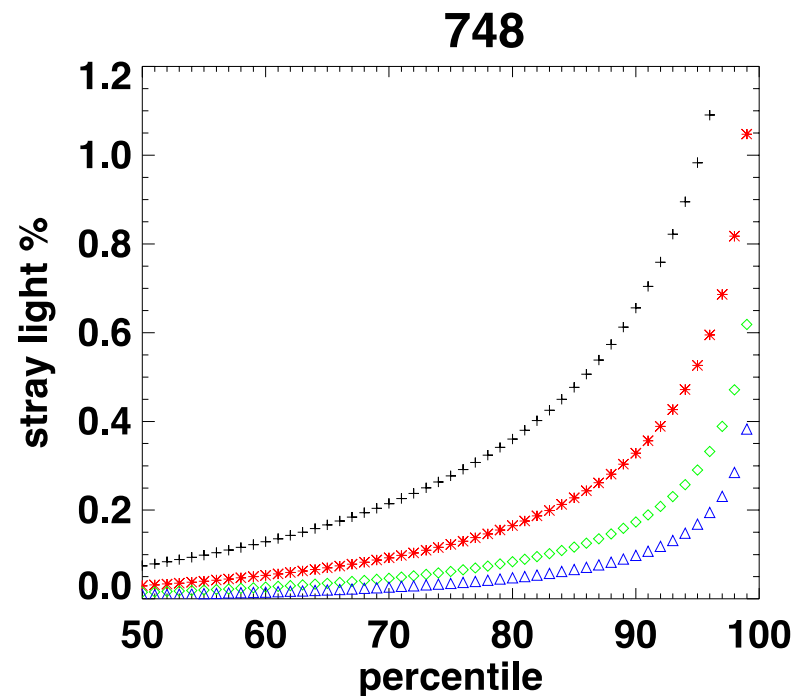
- Data: one day of MODIS scenes (2002 Aug 15)
- Average scene contrast of ocean pixels is much smaller than L_{max} / L_{typ} .
- Stray light for donut cloud scene (18%) much higher than MODIS scene averaged stray light (.2%)
- Average L_{cloud} is 4x less than L_{max}
- Average ocean scene contrast (3 pixels away from a cloud) is much smaller than the $L_{cloud} / L_{oc} \rightarrow$ stress scene rare





Stray light vs. distance and wavelengths

- Small portion of pixels have large stray light
- Stray light is highly correlated among bands
- Stray light impact will be reduce for ocean products based on band ratio method (i.e. atmospheric correction)



- Cumulative frequency (percentile) of stray light contamination (err %) vs. stray light mask sizes
- 2 = 3x3 mask (mask 36%)
- 3 = 5x5 mask (mask 52%)
- 4 = 7x7 mask (mask 62%)

+ 1 * 2 ◇ 3 △ 4



Summary

- MODIS stray light impact on ocean color products are estimated using a matrix-inversion method, MODIS PSF on one-day of MODIS data.
- The scene averaged stray light contamination is quite small, $\sim 0.1\%$ for pixels at 3 or more pixels away from a cloud.
- The average MODIS scene stray light is much smaller than the pre-defined stress scene stray light due to the averaged scene contrast is much smaller than the L_{\max}/L_{typ} ratio.
- Stray light is correlated among wavelengths; ocean products using band ratio will further reduce stray light impact
- The real-scene stray light analysis provides a more realistic assessment of stray light impact on ocean color products.



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