

Satellite Ocean Color Products: What should be produced?

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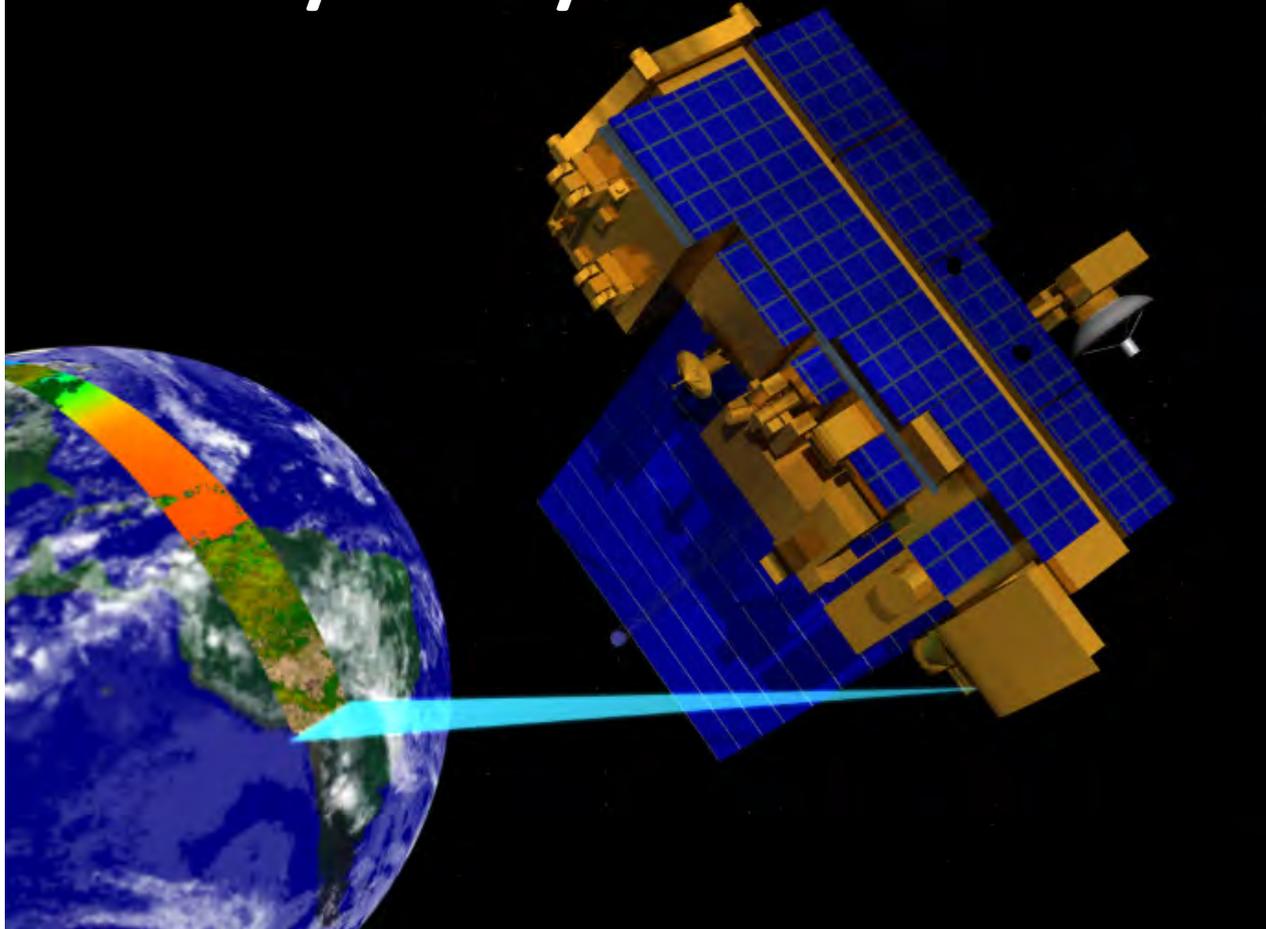
raise questions, rather to provide definite answers

How do we determine what OC products to (“should”) be generated at NASA?

or

Does it matter if we produce 10’s of products from ~6 bands of measurements, as now processors are fast and data storage device is cheap?

MODIS/VIIRS/...



“Toy”, to server citizens/people

To meet demand or address scientific questions:

S1: What are there and how much?

S2: How do they contribute/affect BGC processes?

NASA: “Everything” – Chl/PIC/POC/DOC/phyto. species ...

NOAA (Pers. Comm.): Chl/phyto. bloom/information for shelf-habitat and sanctuaries/clarity(IOPs, Kd)/glint image; information for fisheries/oil detection

EPA (Pers. Comm.): Chl (in particular for nearshore and inland waters)/pollutants

Navy (Pers. Comm.): Chl/SPM/visibility

Climate-change researchers: Everything/anomalies

Citizens: clarity/pollution/seafood ...

What are produced now (“standard” products):

Level-2 OC Product Name and Algorithm Reference

1. $R_{rs}(\lambda)$ *Spectral water-leaving reflectance and derived aerosol optical properties*
2. Ångstrom
3. AOT $\lambda = 412, 443, 469, 488, 531, 547, 555, 645, 667, 678$
4. Chlorophyll *a* *Phytoplankton chlorophyll concentration*
5. $K_d(490)$ *Marine diffuse attenuation at 490nm*
6. POC *Particulate organic carbon concentration*
7. PIC *Particulate inorganic carbon concentration*
8. CDOM_index *Colored dissolved organic matter index*
9. PAR *Daily mean photosynthetically available radiation*
10. iPAR *Instantaneous photosynthetically available radiation*
11. nFLH *Chlorophyll fluorescence line height*

Evaluation Products

Products	Algorithm
Chl, $a_{dg}(443)$, $b_{bp}(443)$	Maritorena (GSM)
IOPs ($a(443)$, $a_{ph}(443)$, $a_{dg}(443)$, $b_{bp}(443)$)	Lee (QAA)
$K_d(412)$, $K_d(443)$, $K_d(490)$	Lee
Zeu	Lee
Zeu	Morel
K_{PAR}	Morel

Produced at Level-3 only (from daily binned Rrs)

Planned Changes to OC Standard Product Suite

Level-2 OC Product	Name and/or Algorithm Updates/Changes
1. $R_{rs}(\lambda)$	<i>calibration updates, ancillary data updates, improved</i>
2. Ångstrom	<i>land/water masking, terrain height, other minor fixes</i>
3. AOT	$\lambda = 412, 443, 469, 488, 531, 547, 555, 645, 667, 678$
4. Chlorophyll a	<i>new algorithm (Hu et al. 2012)</i>
5. $K_d(490)$	<i>coefficient update</i>
6. POC	<i>no change</i>
7. PIC	<i>updated algorithm and LUT</i>
8. CDOM_index	<i>remove product (redundant with new IOP suite)</i>
9. PAR	<i>consolidated algorithm, minor fixes</i>
10. iPAR	<i>no change</i>
11. nFLH	<i>flagging changes (allow negatives)</i>
12. IOPs	suite of inherent optical property products (Werdell et al. 2013)

Expanded Product Suite - IOPs

proposed IOP product suite

- $a(\lambda)$ *total absorption at all visible wavelengths*
- $b_b(\lambda)$ *total backscatter at all visible wavelengths*
- $a_{ph}(\lambda)$ *phytoplankton absorption at all vis. wavelengths*
- $a_{dg}(443)$ *absorption due to colored-detritus at 443nm*
- S_{dg} *exponential spectral slope for a_{dg}*
- $b_{bp}(443)$ *particle backscattering at 443nm*
- S_{bp} *power-law spectral slope for b_{bp}*
- uncertainties *uncertainties in a_{dg} , a_{ph} , b_{bp} at 443nm*

rationale

- *provides total a and b_b for input to IOP-based derived product algorithms (e.g., Lee et al. spectral K_d , euphotic depth)*
- *provides sufficient information to compute full spectral component absorption and scattering coefficients and uncertainties*

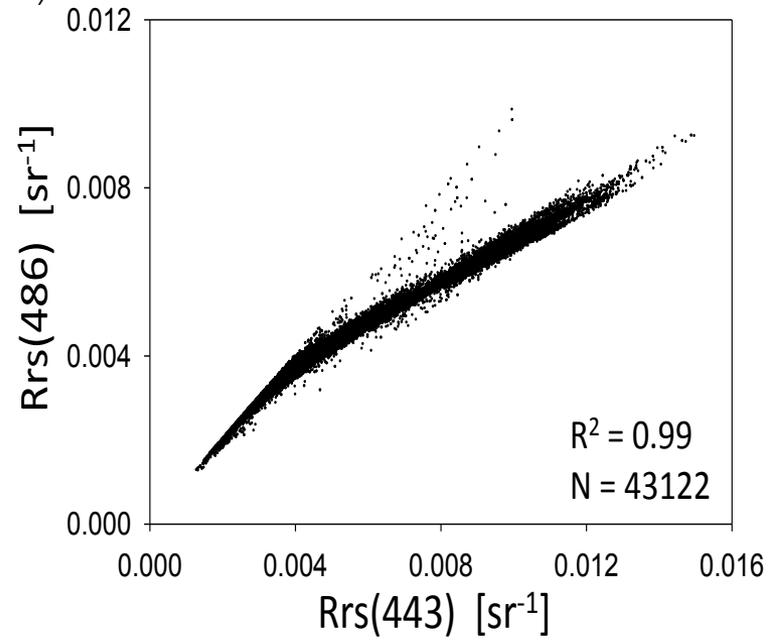
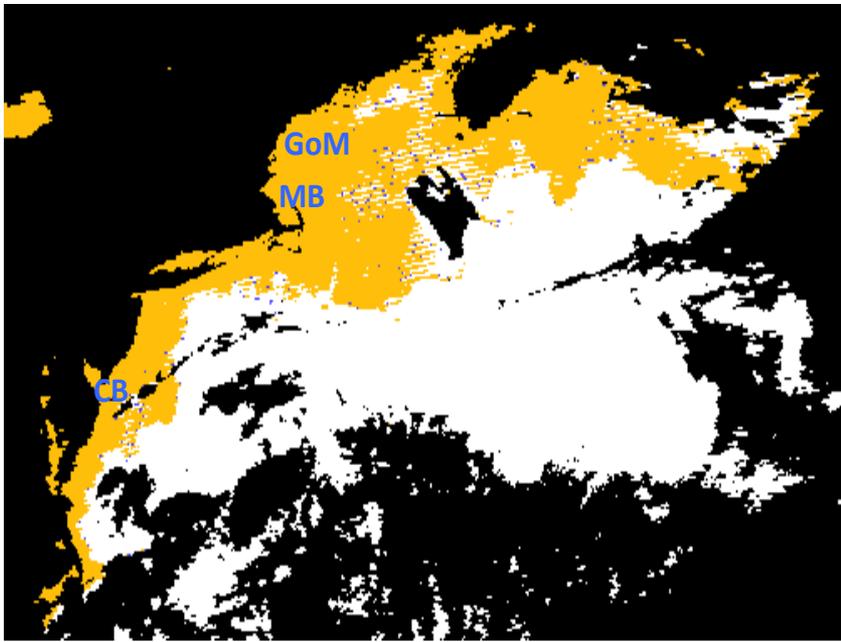
VIIRS $\lambda = 410, 443, 486, 551, 671$

MODIS $\lambda = 412, 443, 469, 488, 531, 547, 555, 645, 667, 678$

It appears we have everything, then what is the problem ...

$$X = \log_{10} \left(\frac{R_{rs}(486)}{R_{rs}(551)} \right); \quad K_d(490) = 0.0166 + 10^{\sum_{i=0}^4 \xi_i X^i}$$

$$Y = \log_{10} \left(\frac{R_{rs}(443) > R_{rs}(486)}{R_{rs}(551)} \right); \quad [Chl] = 10^{\sum_{i=0}^4 \xi_i Y^i}$$

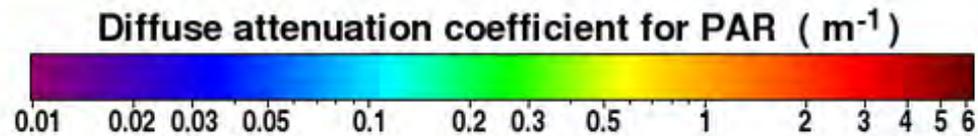
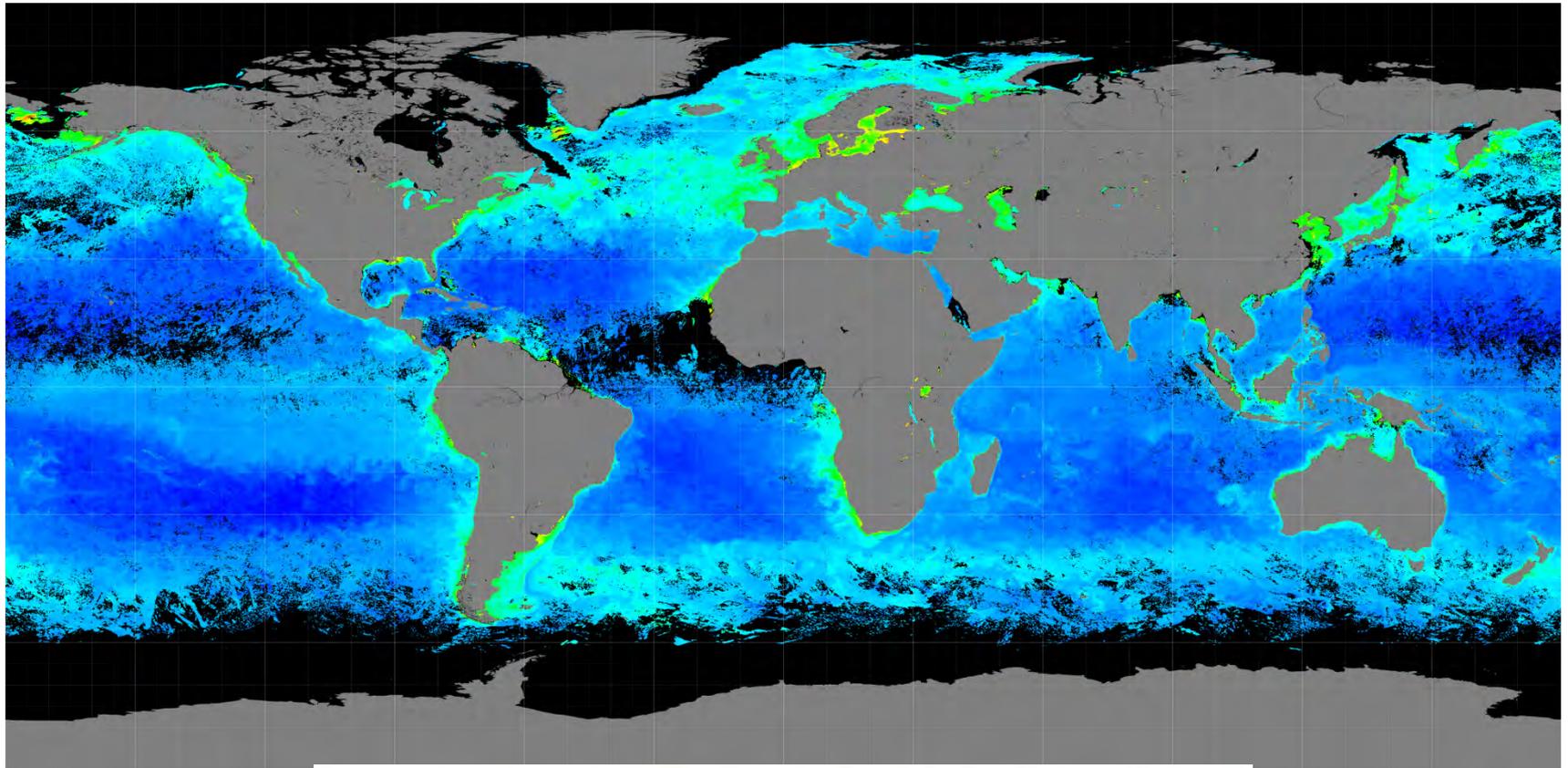


An AOP product is the same as a phyto. pigment product ...

If two products have a correlation coefficient as 1.0, should we produce these two “independent” products?

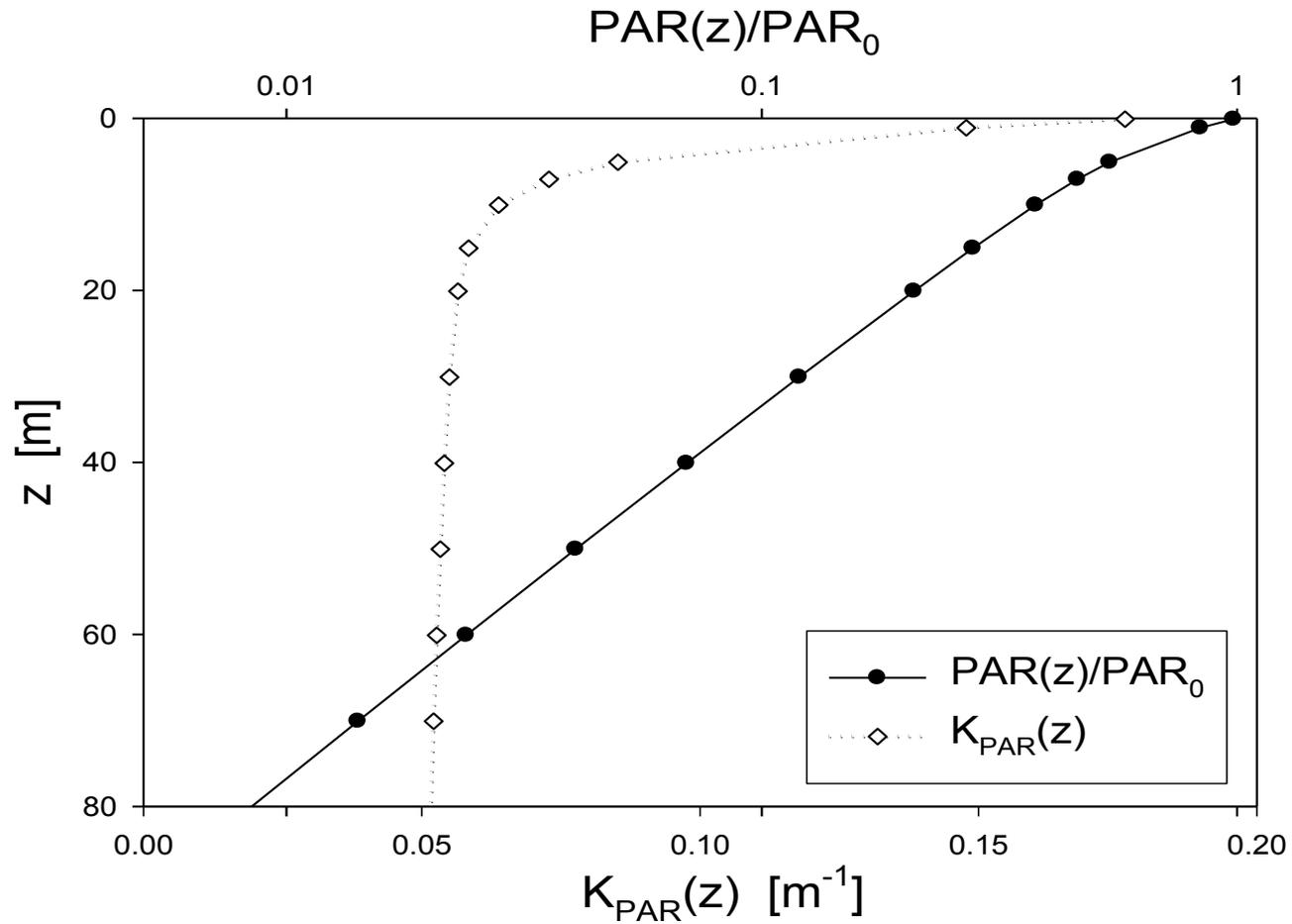
$K_d(\text{PAR})$

$$K_d(\text{PAR})_{(2)} = 0.0665 + 0.874 K_d(490) - 0.00121 [K_d(490)]^{-1}$$



Again, no independent information regarding the ocean system

$K_d(\text{PAR})$ is fundamentally vague ...



Many optical properties (a , b_b , K_d) are spectral,
Q1: Do we generate products at one or all bands?

TA1: Rule of thumb – try our best to produce products with spectrally (spatially) independent information

Planned IOP suite:

$a(\lambda)$ total absorption at all visible wavelengths
 $a_{ph}(\lambda)$ phytoplankton absorption at all visible wavelengths

GIOP:
$$a_{ph}(\lambda) = M_{ph} a_{ph}^+(\lambda)$$

$$a(\lambda) = a_w(\lambda) + M_{ph} a_{ph}^+(\lambda) + M_{dg} a_{dg}^+(\lambda)$$

Actually only two independent products: M_{ph} and M_{dg}

TA1b: Generate $a(\lambda)$ and $a_{ph}(\lambda)$ without assumptions regarding their spectral shapes/dependences.

$$K_d(\lambda, \theta) = f(a(\lambda), b_b(\lambda), \theta)$$

Q2: How to promote the use of more robust products?

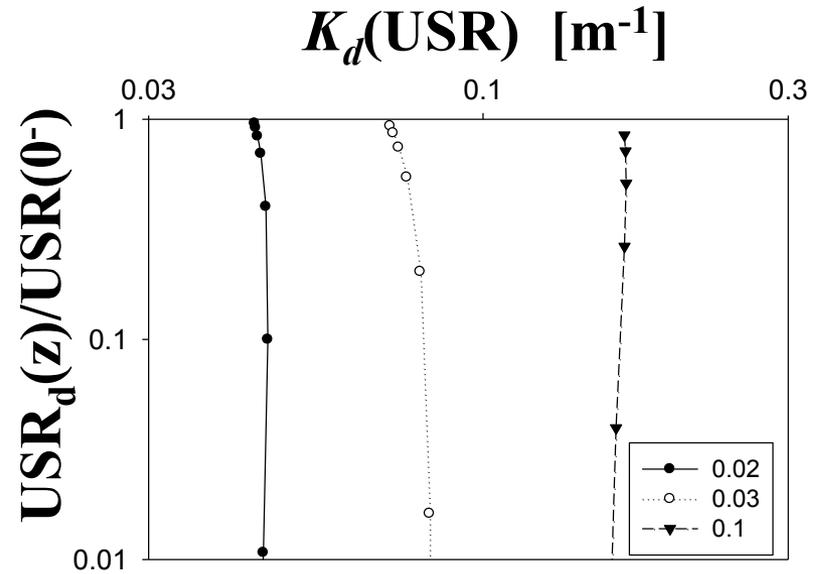
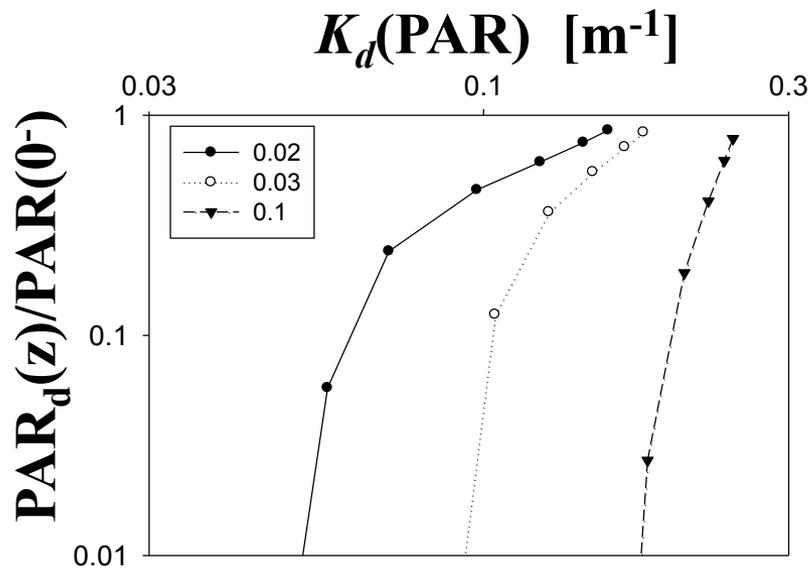
Statistics on downloading OC products (Apr. 6 – May 6, 2015)

		L3 BIN Files				L3 SMI Files			
	IP	Daily	8 Day	Monthly	Other	Daily	8 Day	Monthly	Other
PAR	208	5821	3677	6144	246	3622	9388	9902	104
Chl	1445	15263	5734	9299	453	398638	49554	96981	10453
Kd490	94	74	21	218	10	4338	1056	4159	123
PIC	66	44	30	248	4	2802	146	2197	350
POC	74	151	48	615	5	26627	194	1169	105
IOP	6	0	0	1	0	1101	128	4	0

TA2: Name IOP products as something more familiar with endusers; Or

No longer generate “fake” Chl or POC products, “force” users to do the conversion.

Stop producing $K_d(\text{PAR})$



(Lee et al 2013)

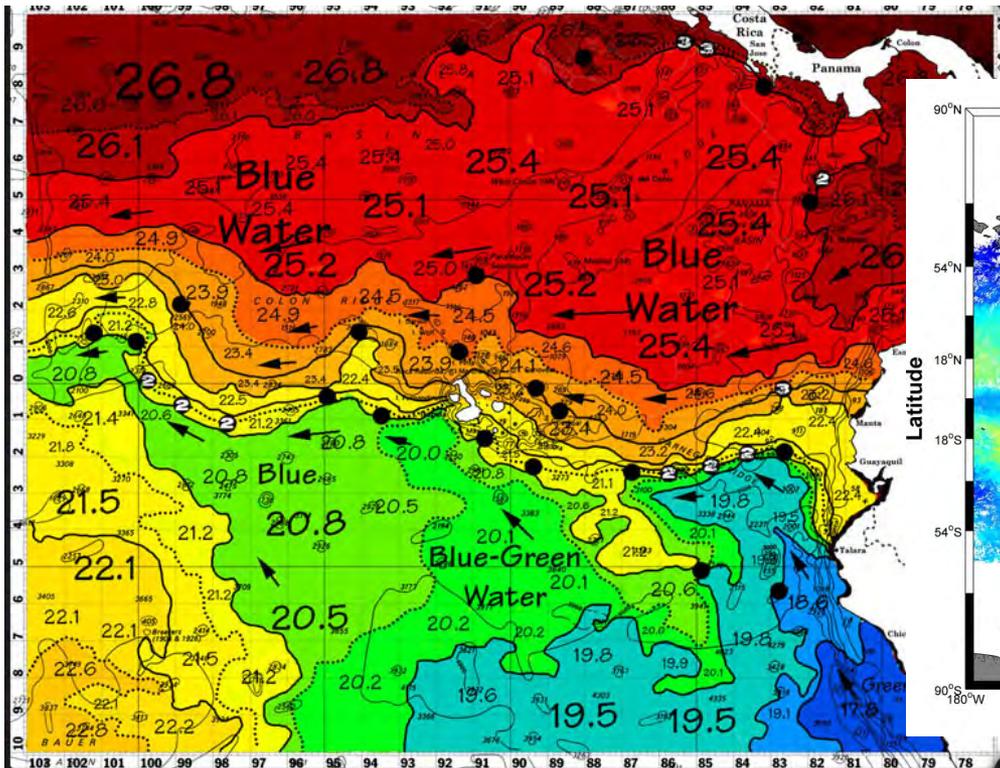
PAR: 400-700 nm

USR: 400-560 nm

Q3: How to maximize the value provided by OC satellites?
Should NASA also generate some products for all citizens?

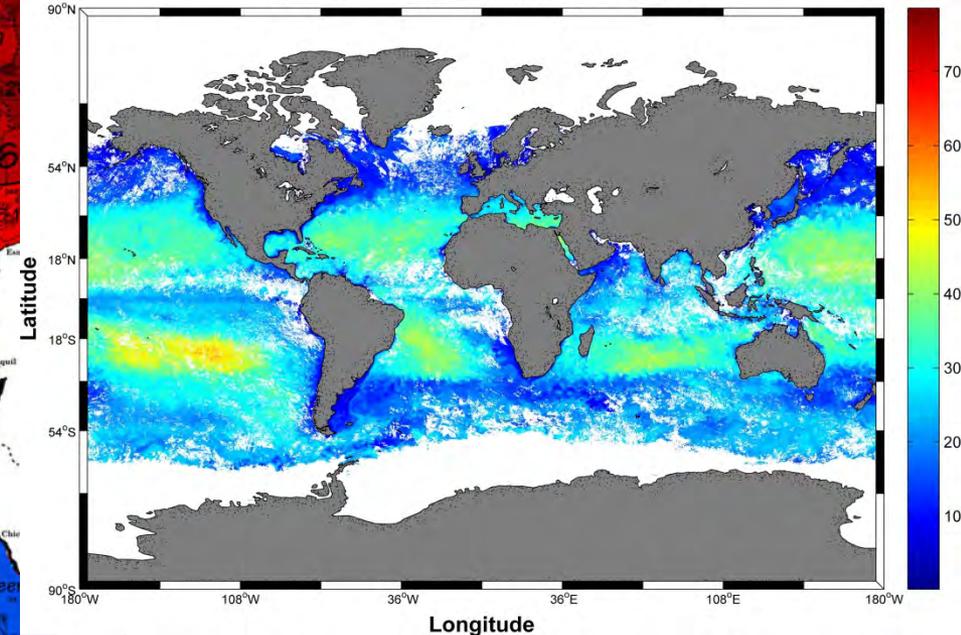
TA4: Produce water-quality classes (Good, So-so, Bad)
Or easy-to-understand products

See the front?



See your toe?

Global Secchi Depth in October 2004 (m)



**Q4: How to achieve consistent OC products across satellites?
multiple sets of algorithms??**

TA5: Separate the wavelength conversion and product retrieval into two independent modules, then one set of algorithms for all satellites

Q5: Should we provide smaller number but more robust products or more but less robust products? e.g., oil, floating algae, SPM, phyto. bloom, pCO₂, salinity, ...

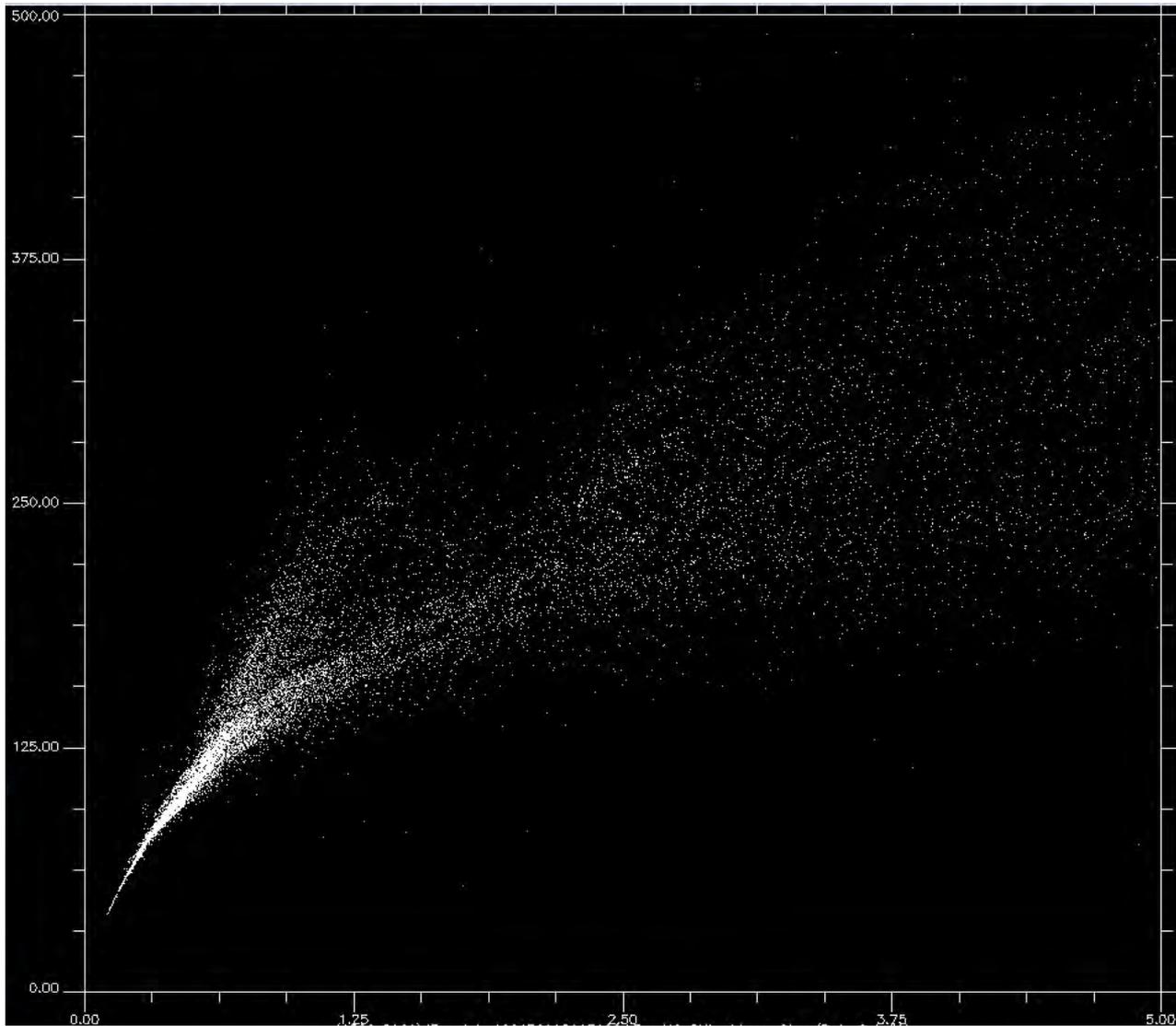
TA6: ???

Questions/discussions ...

Current VIIRS OC Standard Product Suite

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8.	
9. PAR	<i>Daily mean photosynthetically available radiation</i>
10.	
11.	
12. IOPs	<i>suite of additional inherent optical property products (Werdell et al. 2013)</i>

POC



Chl