Comparison of Rrs between satellite and in-situ measurements in Pacific and Southern Oceans

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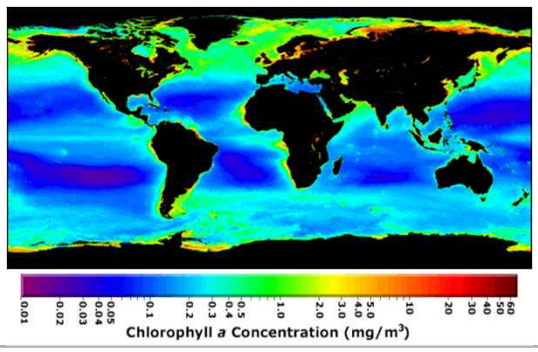
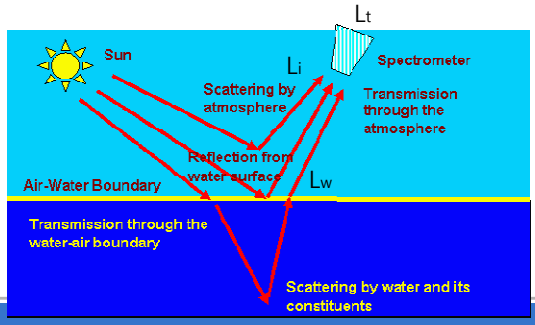
Ocean Color

- Ocean color satellite sensors
  - CZCS, SeaWiFS, MODIS, VIIRS …
  - Spatio-temporal biological and geophysical parameters
    - ex. chl-a, SST



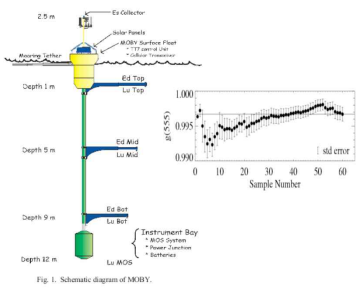
Remote sensing reflectance

- Remote sensing reflectance (R_{rs})
  - $R_{rs} = L_w / E_s$
  - Most of satellite products are estimated from Rrs
    - Ex. OC3M algorithm is based on ratio of Rrs(443), Rrs(488), Rrs(551)
  - Cal./val. is important for data quality and usability

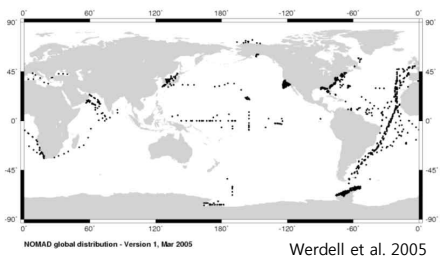


In-situ measurements

- In-water vs. above-water measurements
  - In-water: stable & continuous, but only few sites (ex. MOBY)
  - Above-water: wide coverage, but more interference
  - Lack of data in polar oceans



Werdell et al. 2007



Werdell et al. 2005

above-water (47% of stations)

Objective

- Comparison of Rrs between satellite and in-situ measurements in Pacific and Southern Oceans

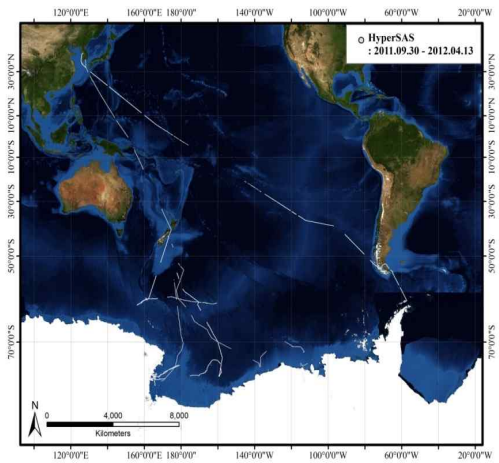
Ocean color satellite vs. **Above-water radiometer**

Pacific ~ Southern Ocean

Pacific Ocean : 30°N - 60°S
Southern Ocean : 60°S - 75°S

In-situ measurements

Lt: total radiance, Li: sky radiance, Es: Irradiance



In-situ measurements

- Shipborne above-water measurements
  - HyperSAS (Satlantic, USA) on ice-breaker ARAON
  - Remote sensing reflectance (R_{rs})
    - $R_{rs} = L_w / E_s$ where, $L_w = L_t - \rho L_i$

Lw : water-leaving radiance
Lt : total radiance
Li : sky radiance
ρ : surface reflectance

  - every sec. during 2 min.
  - 15min. Intervals
  - 2011.09.30 – 2012.01.04
  - Total 330,689 observations

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In-situ measurements

- Data filtering
  - By NASA protocol
    - Important for data quality control
    - Ocean optics protocols for satellite ocean color sensor validation, rev. 4, vol. III

Viewing zenith angle of Lt sensor	Inclination of Es sensor	Relative azimuth angle (sun – sensor)	Sun zenith angle	Wind speed
< 40°	< ±5°	45° - 180°	> 60°	< 10m/s

  - 330,689 → 29,406 observations (9%)
  - Average for lowest 5% values within each hour
    - minimize surface glint signals
  - Finally, 253 hourly in-situ Rrs

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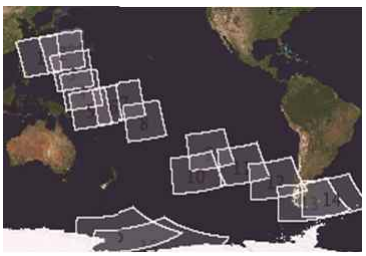
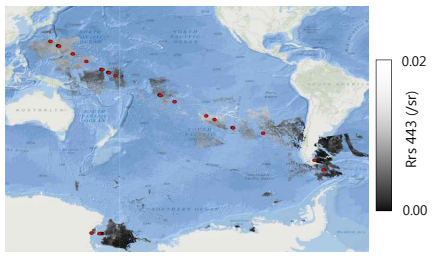
Satellite data

- MODIS Aqua L2 Rrs
  - Match-up scenes with in-situ data within 2 hours
    - Location, time (within 2 hours) and cloud free (flags)
    - To prevent bias from different sun zenith angle
  - 14 scenes matched-up with 34 hourly in-situ Rrs
    - Average Rrs of 9 pixels





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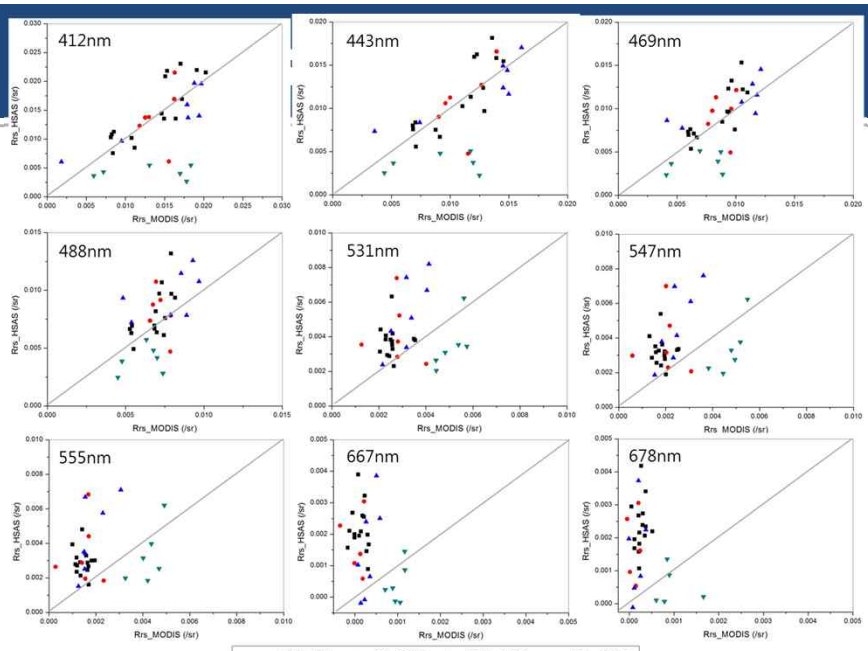

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In-situ vs. satellite

- UPD (unbiased percent difference)
  - percent diff. when any dataset cannot be assumed as true

$$\psi_B^A(\lambda) = \frac{200}{M}\sum_{i=1}^{M}\frac{\left|X_i^A(\lambda) - X_i^B(\lambda)\right|}{X_i^A(\lambda) + X_i^B(\lambda)}$$

- UPD in previous study
  - Kowalczuk et al. (2006), North Atlantic Ocean
  - MicroSAS vs. SeaWiFS
  - 30~50% through 412 to 555nm

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In-situ vs. satellite

- UPD in previous study

Data set	Wavelength	Max. difference %	Min. difference %	Mean difference %	Std. Dev. %	Sample size *M*
All data	412	97.6	0.1	49.4	23.5	163
	443	99.9	0.1	39.3	20.2	
	490	79.9	0.1	30.2	15.6	
	555	157.0	0.1	50.6	25.1	

- UPD in this study (%)

Wavelength (nm)	412	443	469	488	531	547	555	645	667	678
30° - 0°N	18.1	17.3	15.7	18.4	37.0	53.4	64.7	177.4	163.4	158.7
0° - 30°S	23.1	20.3	24.0	25.7	53.8	68.4	81.1	183.9	174.8	170.9
30° - 60°S	33.0	28.2	32.9	36.5	58.7	71.3	86.5	312.7	208.5	293.4
60° - 75°S	100.0	87.3	69.4	56.4	61.8	63.2	61.6	141.1	529.1	180.9

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Conclusion

- Acceptable linear relationship and difference in Pacific Ocean (412–531nm)
  - Weak water-leaving radiance (531–678nm)
- Weak linear relationship and big difference in Southern Ocean
  - Why?
- Uncertainty is should be considered when we use ocean color satellite data in Southern Ocean

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Further study

- Comparison using more data
  - From 2010 to 2014
- The reason of big difference in high latitude
- Above-water measured data is should be calibrated using in-water measured data
- Continuous data collection

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Thank you!

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