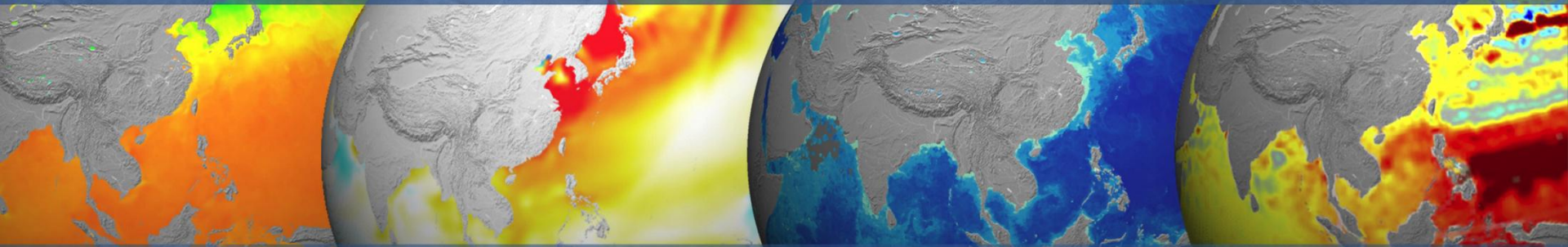
ESA–MOST China Dragon 4 Cooperation

→ ADVANCED TRAINING COURSE IN OCEAN AND COASTAL REMOTE SENSING



12 to 17 November 2018 | Shenzhen University | P.R. China

Sea Surface Salinity from S3 OLCI

Hosted by

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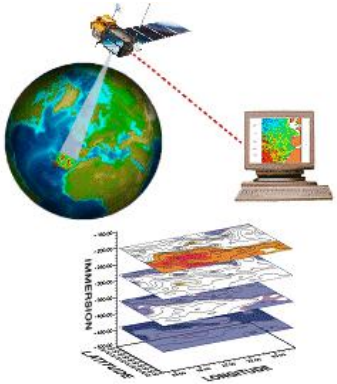
Content

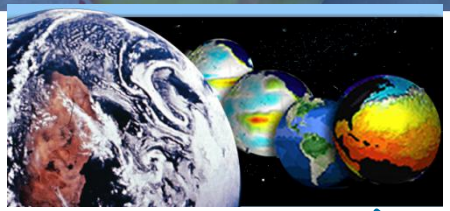
- Introduction
- Optical SSS estimation method
- Optical SSS in the East China Sea
- Conclusion & Remarks

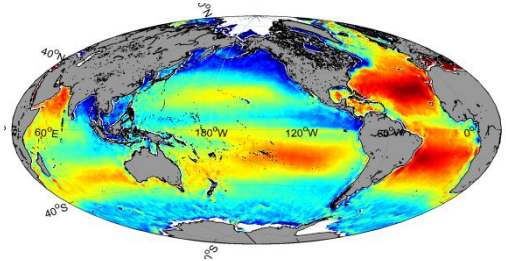
Ocean modeling

Climate change

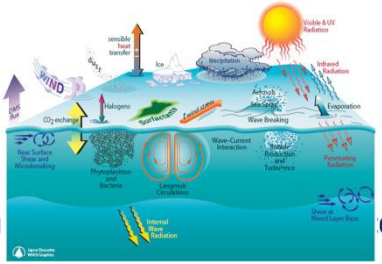
Marine Biology & biochemistry







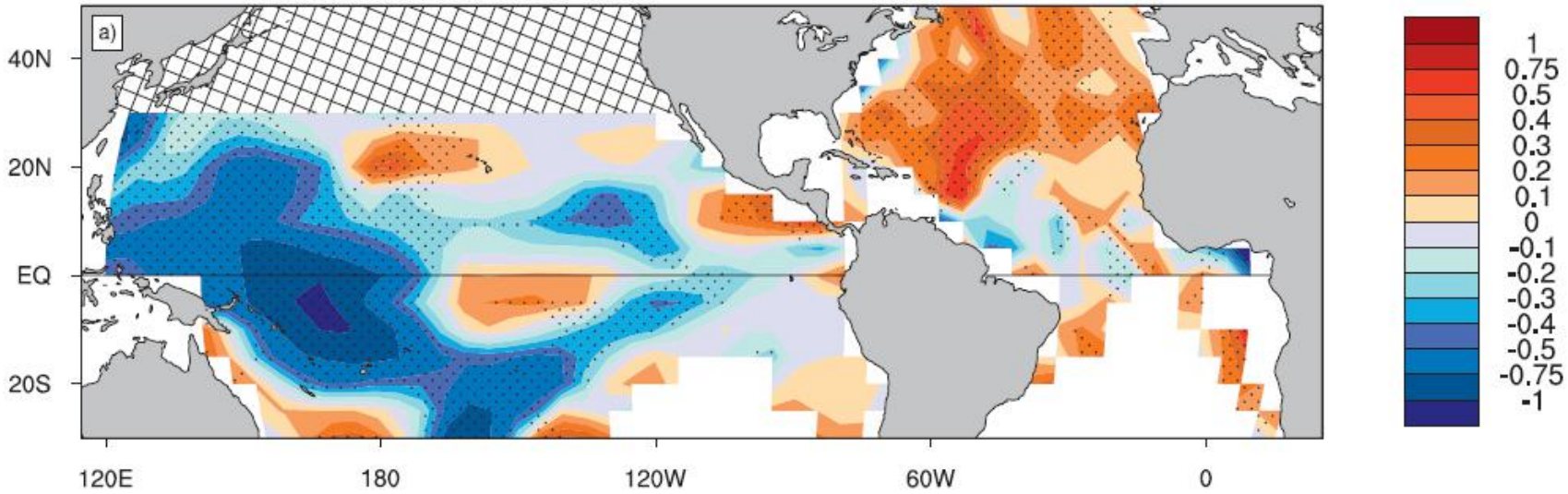
Air-sea interaction



- One of the key ocean parameters in ocean sciences

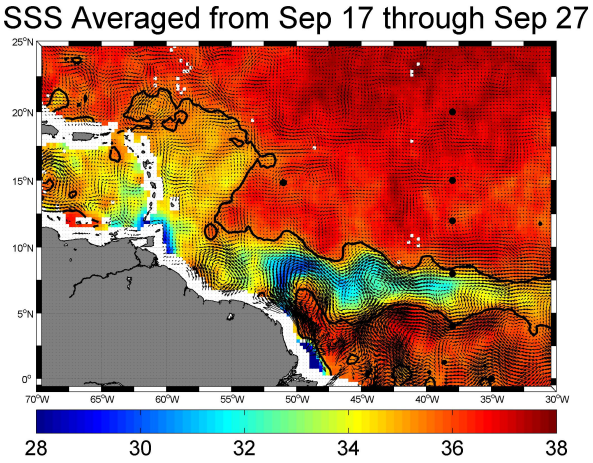
SSS a tool to better monitor the oceanic branch of the Hydrological Cycle:

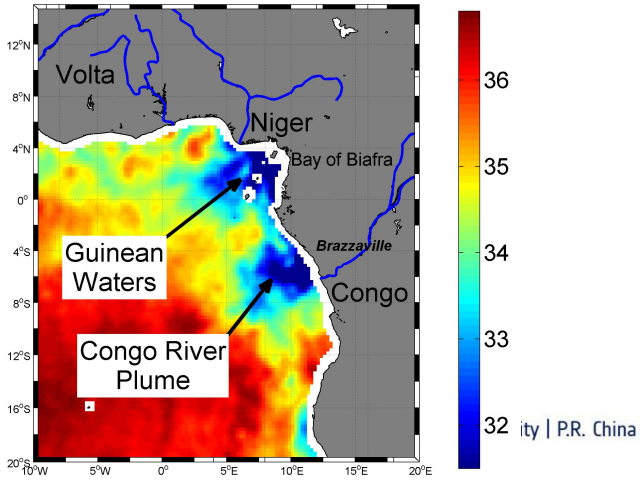
SSS=f(Evaporation, Precipitation, Run off)



Coastal zone

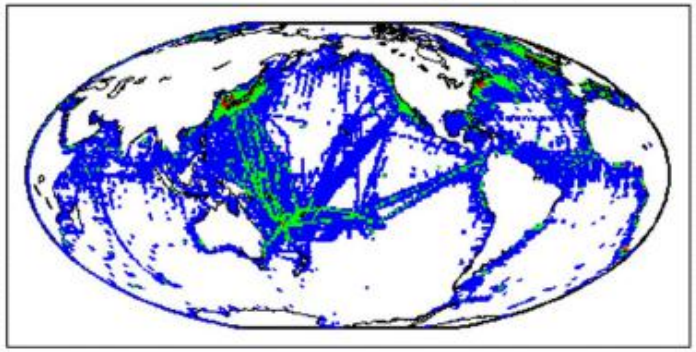
- Salinity is mainly determined by riverine freshwater (Land-ocean interaction)
- Salinity changes are important to ocean biology (e.g. influencing the fishing resource).





Ensemble of *in situ* SSS Data collected from 1874 to 2002

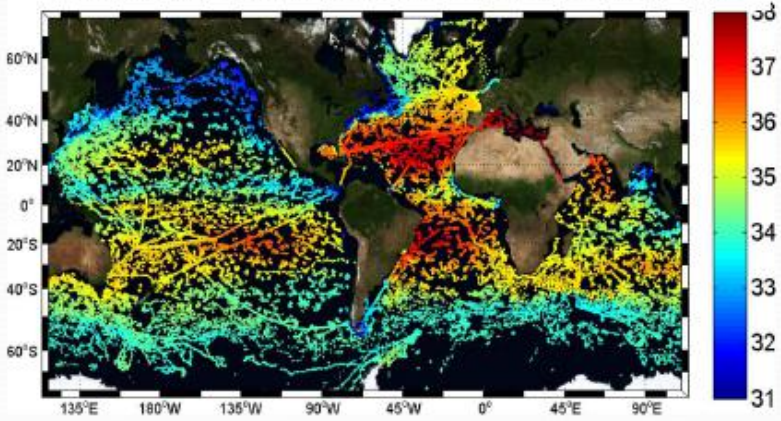
Number of Observations by 1° Square



white - N < 10
Blue- 10 < N < 100
Green- 100 < N < 1000
Red - 1000 < N

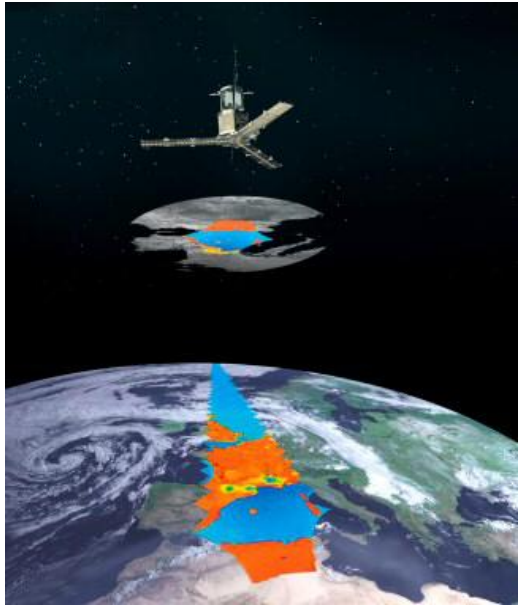
Bingham et al., 2002

One year (2010) of *in situ* SSS Data collected for SMOS validation

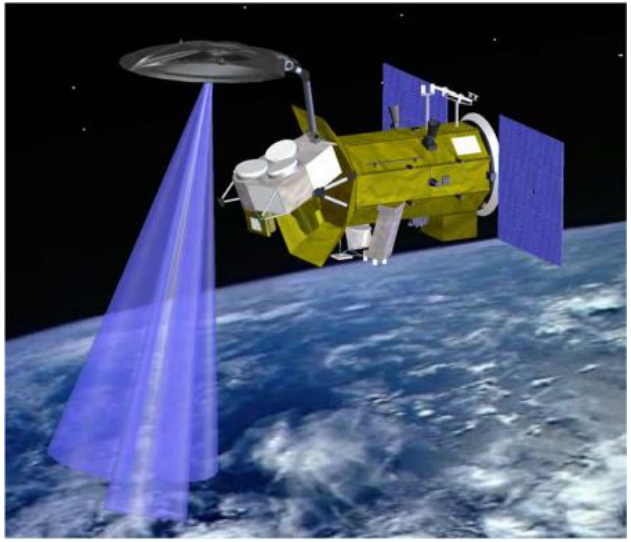


ARGO floats
TAO/PIRATA/RAMA moorings
TSG
CTD
Drifters
Equipped Mammals
Glidders...

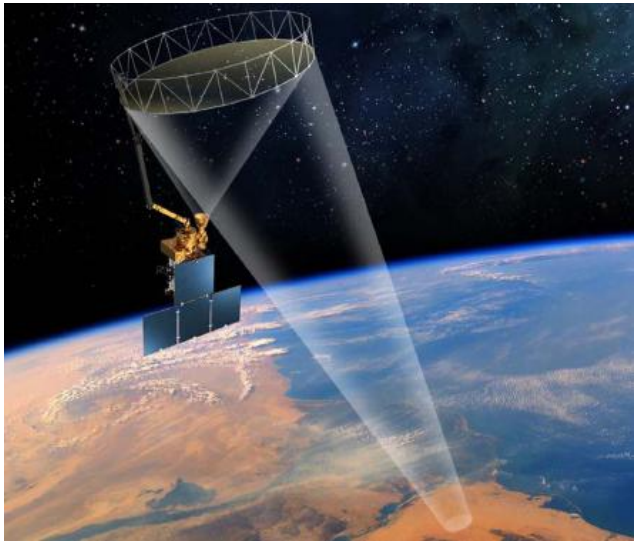
SMOS



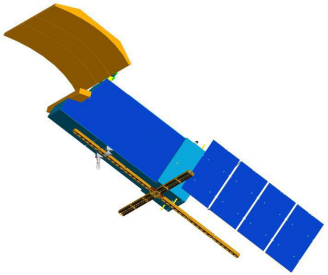
Aquarius

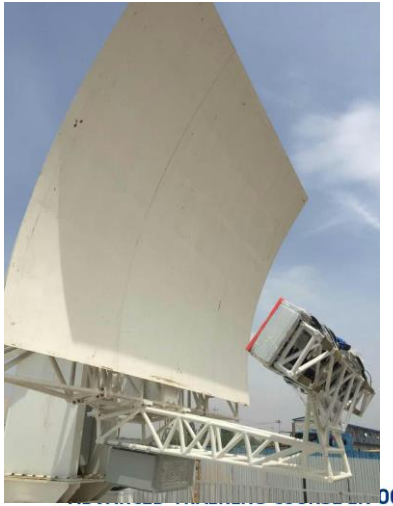


SMAP



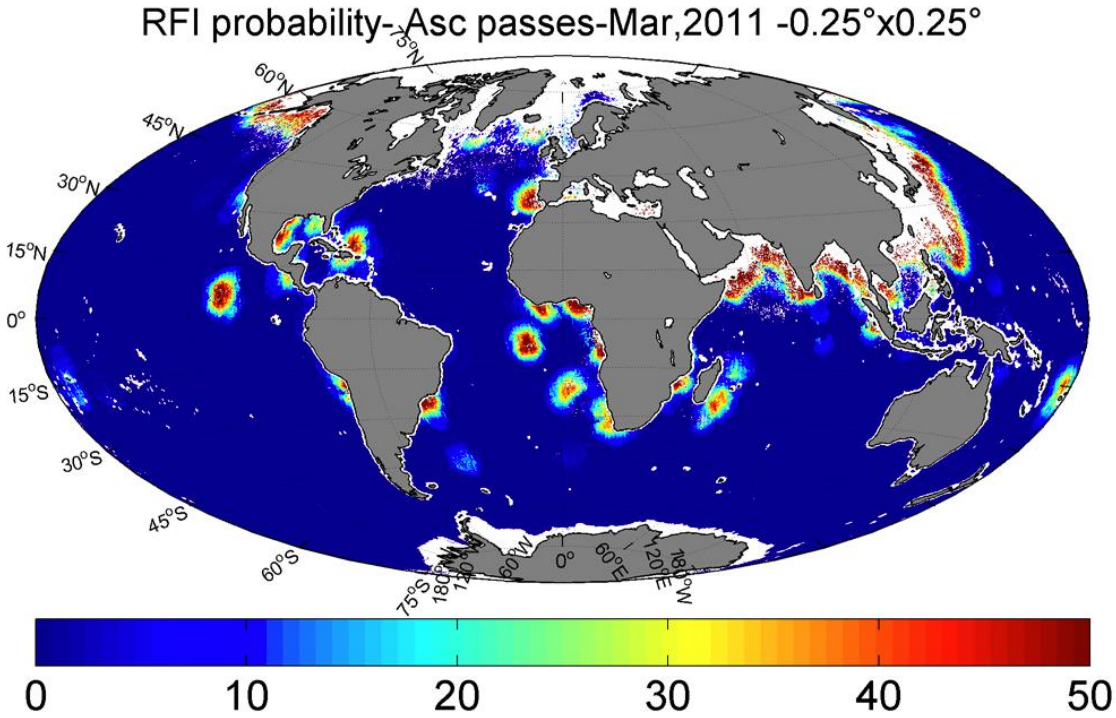
Chinese Ocean Salinity Mission





Specification	Value
System	L/C/K band radiometers+ L-band DBF SCAT
Frequency	Radiometer: 1.4GHz, 6.9GHz, 18.7GHz, 23.8GHz Scatterometer: 1.26GHz
Sensitivity	L-band：0.1K；C/K band：0.5K
Polarization	L-band: H, V, T3; C/K band: H, V
SSS accuracy	<0.1psu， 200km, monthly
FOV	>1000km

In coastal area, microwave induced SSS is limited due to RFI, land contamination et al.



Motivation

- Mapping SSS in the coastal zone from space with high resolution optical data
- Supplement to microwave salinity mapping

Content

- Introduction
- Optical SSS estimation method
- Optical SSS in the East China Sea
- Conclusion & Remarks

Method

- Salinity does not influence ocean color directly
- Salinity is influenced by riverine freshwater, which is related to and can be figured by CDOM (colored dissolved organic matter) concentration
- Basic hypothesis: the more freshwater, the higher riverine CDOM, the lower salinity (the conservative mixing is a precondition)
- Optical estimation of SSS is indirect (via CDOM) and thus empirical

Method

Group 1: Rrs——>SSS

SSS estimated by spectral remote sensing reflectance (Rrs) based on statistical regression or neural network:

Group 2: Rrs——>CDOM——>SSS

SSS estimated by Rrs-retrieved CDOM

Group 1: Rrs——>SSS

Empirical statistical regression of in situ SSS and spectral radiances from Landsat or SPOT image:

$$y = a + bx_4 + cx_6 + dx_7$$

Khorram et al. (1982); Baban(1997); Dewidar&Khedr (2001); Lavery et al.(1993); Wang&Xu (2008).

Group 1: Rrs——>SSS

MODIS image

✓ Wong et al. (2007)

$$SSS = 14.256 - 240.163 \times \text{Band}\,1 - 72.533 \times \text{Band}\,2 + 124.700 \times \text{Band}\,3 + 191.266 \times \text{Band}\,4 + 36.044 \times \text{Band}\,5 - 11.117 \times \text{Band}\,6 - 39.789 \times \text{Band}\,7$$

✓ Marghany et al. (2010)

$$SSS = 27.65 + 0.2 \times \text{Band}\,1 - 21.11 \times \text{Band}\,2 + 14.23 \times \text{Band}\,3 + 62.12 \times \text{Band}\,4 + 148.32 \times \text{Band}\,5 + 1.22 \times \text{Band}\,6 - 11.41 \times \text{Band}\,7$$

✓ Geiger et al. (2011)

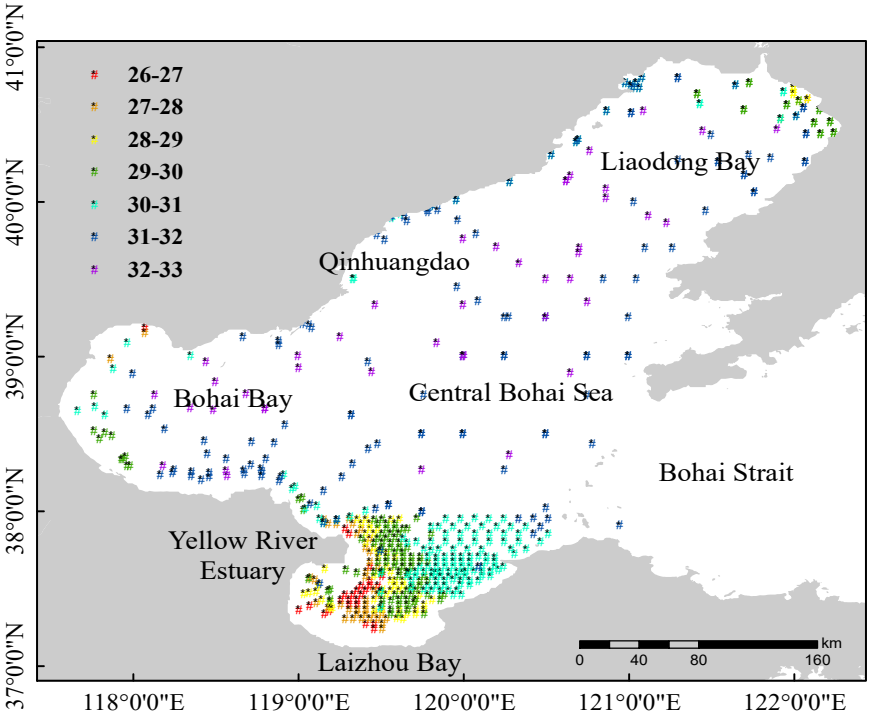
Neural network models

Group 2. Rrs——>CDOM——>SSS

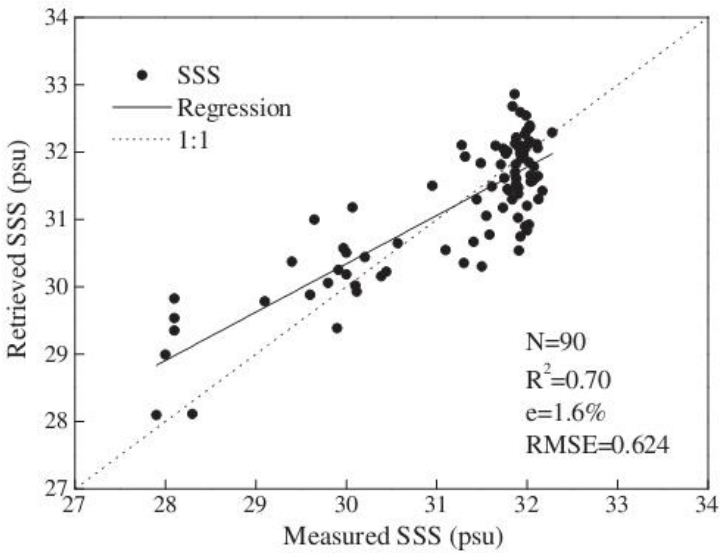
- ✓ Jerlov (1968) noted the negative correlation between SSS and CDOM concentration.
- ✓ Binding & Bowers (2003) established a similar relationship and applied it to SeaWiFS data.

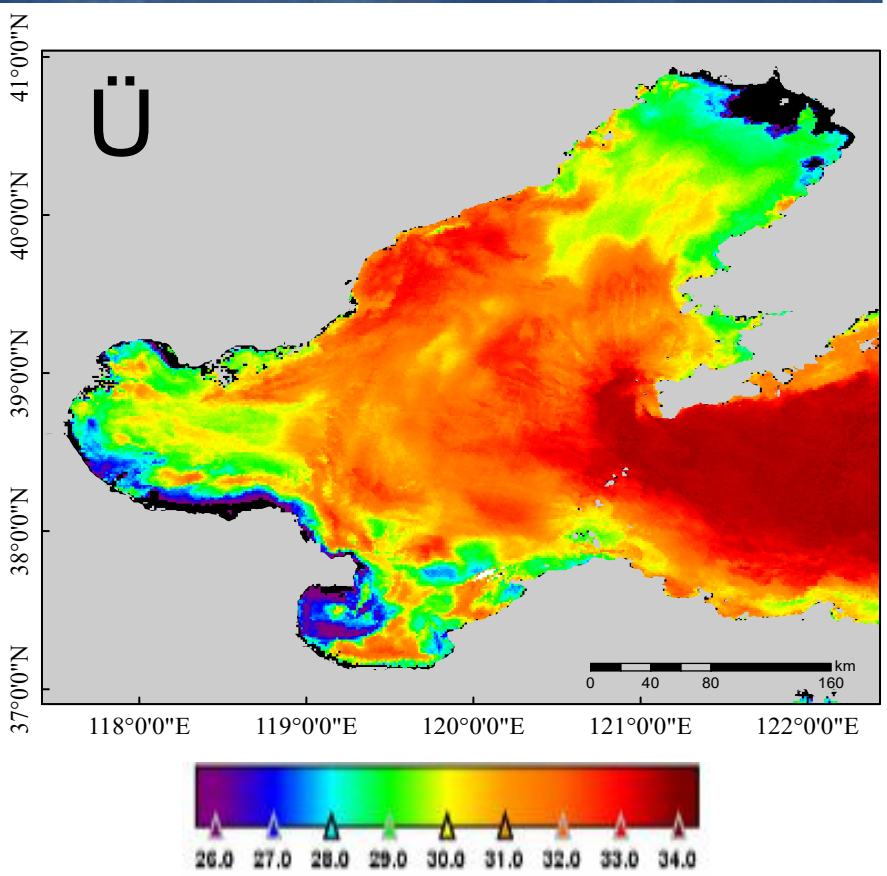
	$SSS = \alpha g_{440} + \beta$			
time	α±SD	β±SD	R^2	N
Jun. 1996	-11.58±0.12	34.89±0.08	0.9995	7
May. 2000	-13.3±0.77	35.76±0.31	0.974	10
Apr. 2001	-7.02±1.12	34.63±0.45	0.7983	12

Bowers & Brett (2008); Ahn et al. (2008); Palacios et al. (2009); Bai et al. (2012)

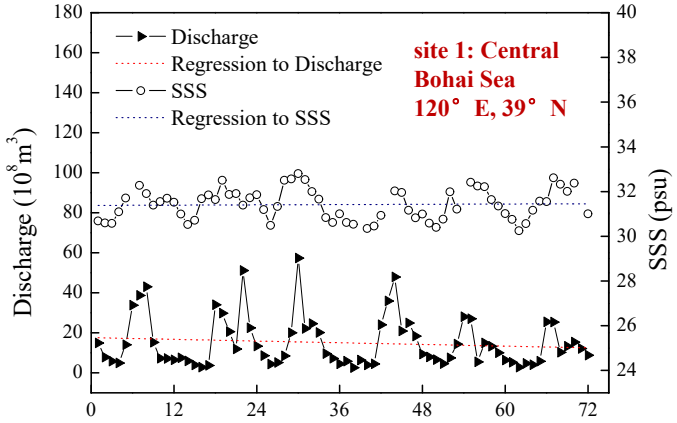


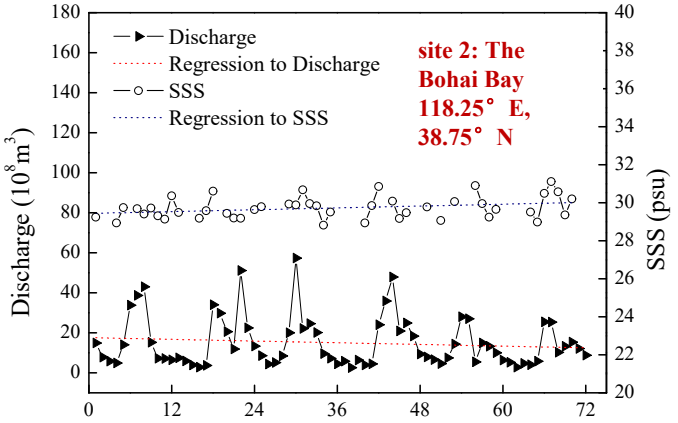
$$\lg(SSS) = 0.8 \times R_{rs}(490) - 2.39 \times R_{rs}(560) + 0.837 \times R_{rs}(665) + 1.534$$

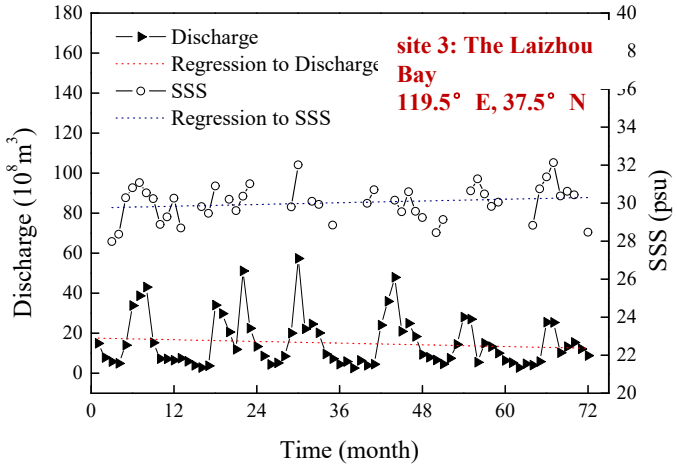


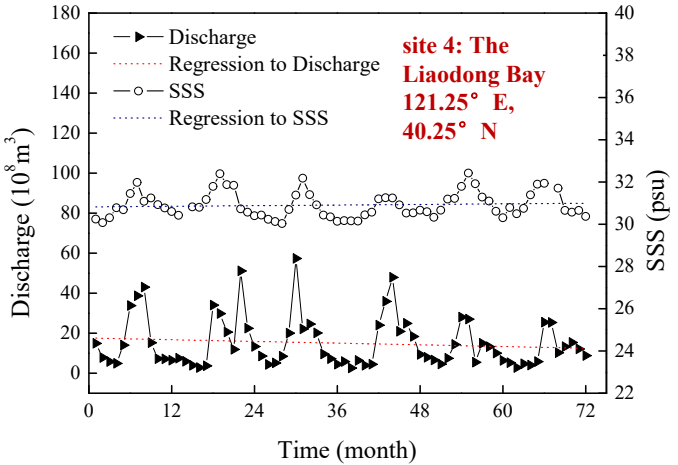


MERIS mapped SSS in the Bohai Sea on October 14th, 2009 T. Cui, FIO


Discharge
Regression to Discharge
SSS
Regression to SSS
site 1: Central Bohai Sea 120° E, 39° N
Discharge (10^8 m^3)
SSS (psu)


Discharge
Regression to Discharge
SSS
Regression to SSS
site 2: The Bohai Bay 118.25° E, 38.75° N
Discharge (10^8 m^3)
SSS (psu)


Discharge
Regression to Discharge
SSS
Regression to SSS
site 3: The Laizhou Bay 119.5° E, 37.5° N
Discharge (10^8 m^3)
SSS (psu)
Time (month)


Discharge
Regression to Discharge
SSS
Regression to SSS
site 4: The Liaodong Bay 121.25° E, 40.25° N
Discharge (10^8 m^3)
SSS (psu)
Time (month)

T. Cui, FIO

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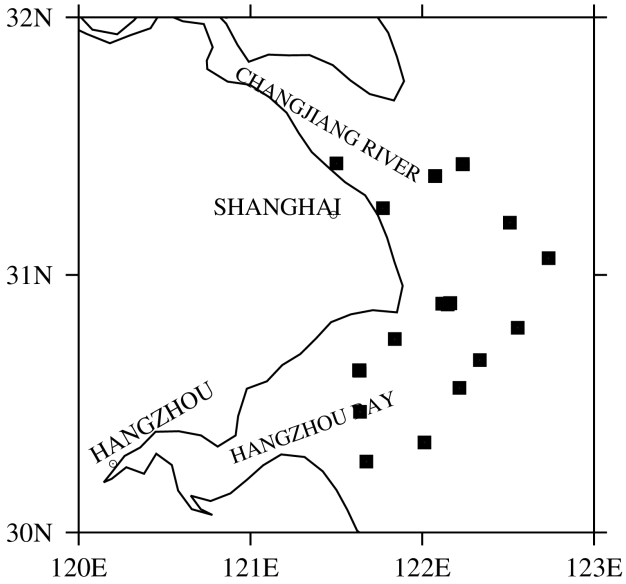
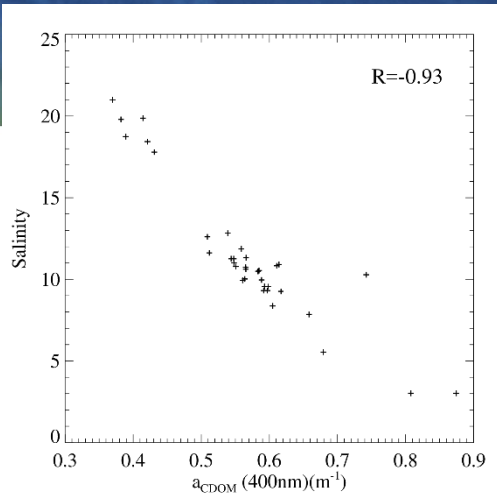
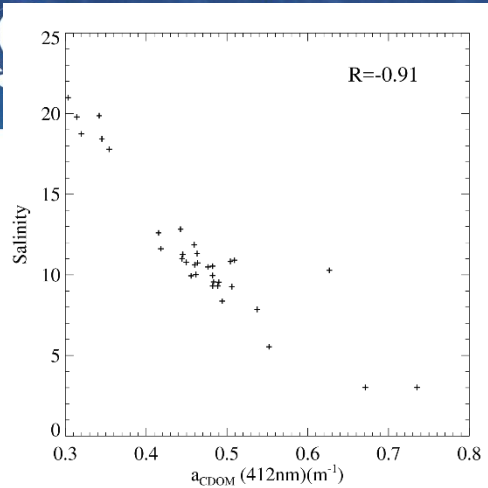
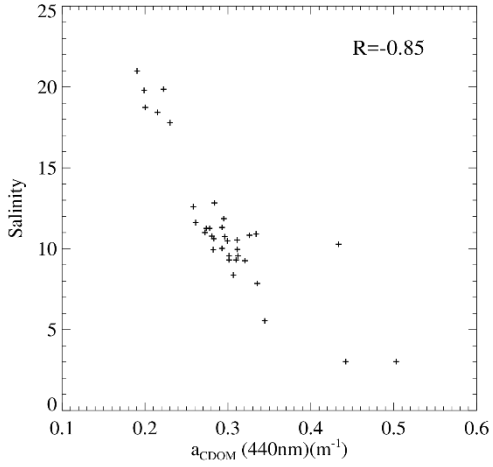
Spring



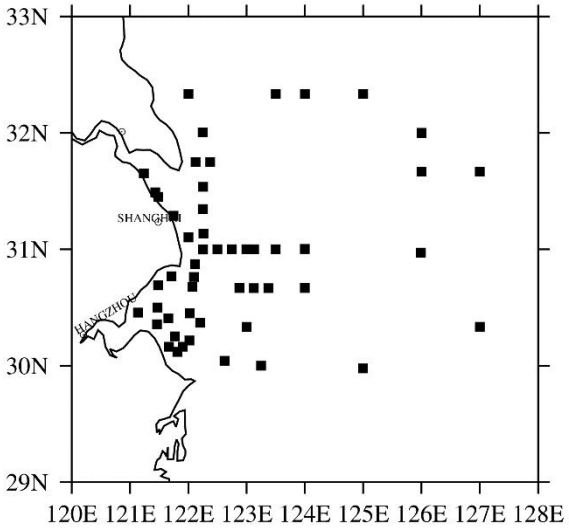


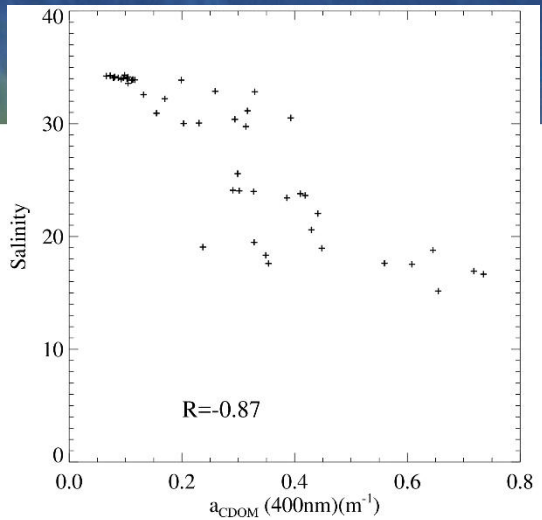


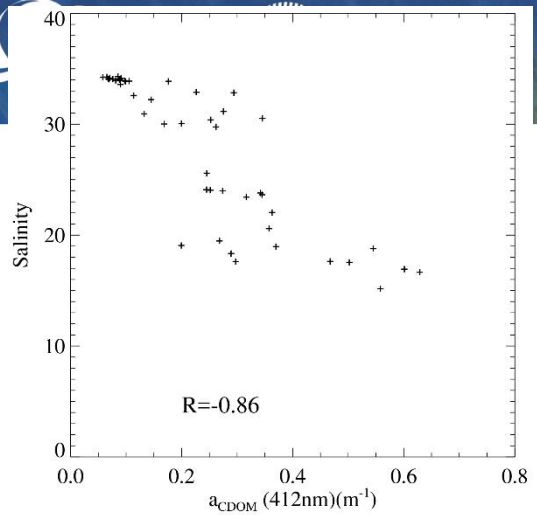


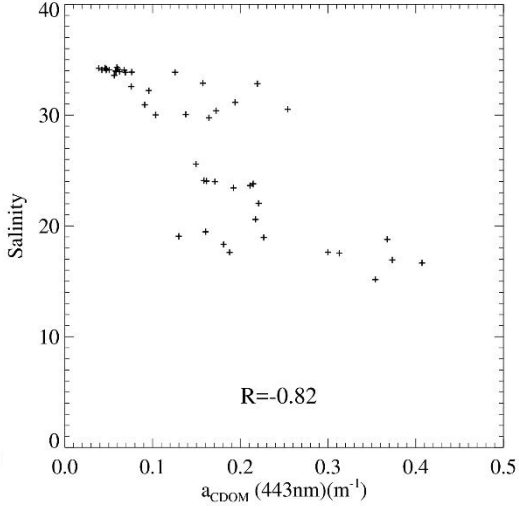
W. Shao, SIO

Winter

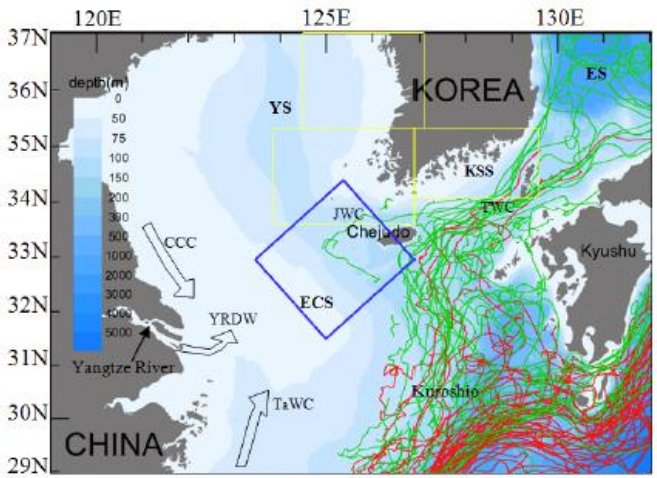


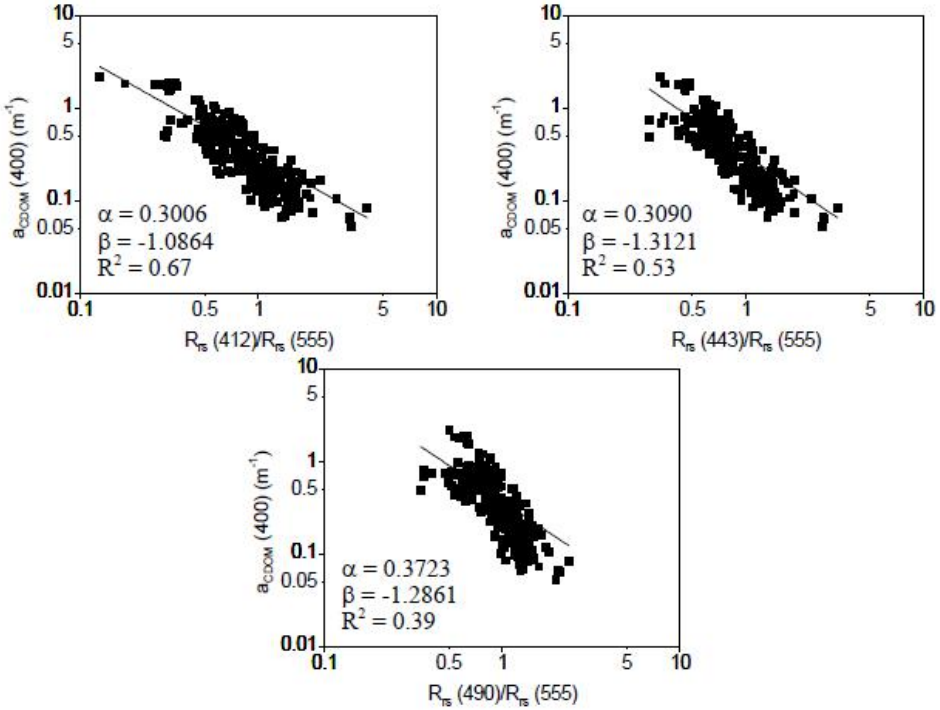




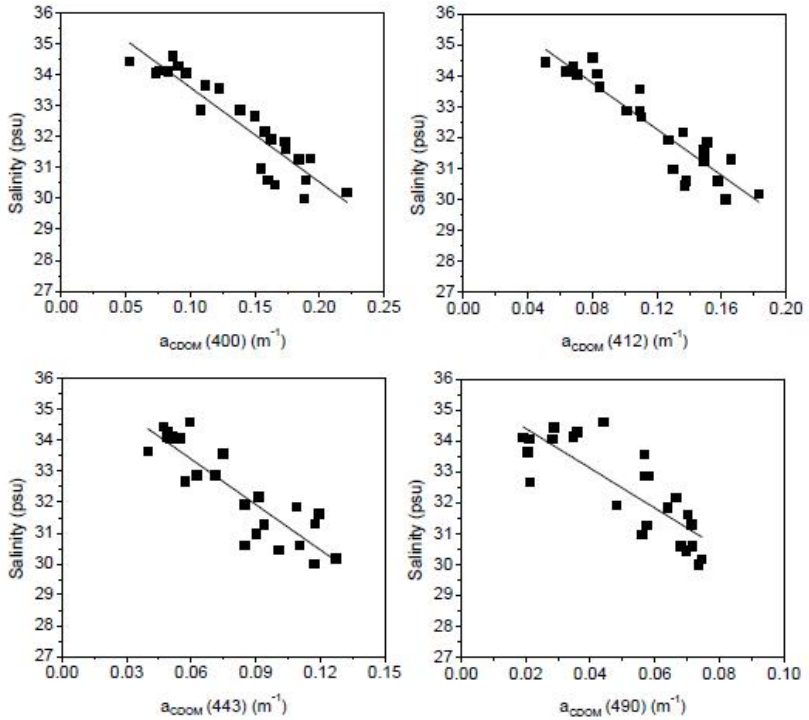


W. Shao, SIO





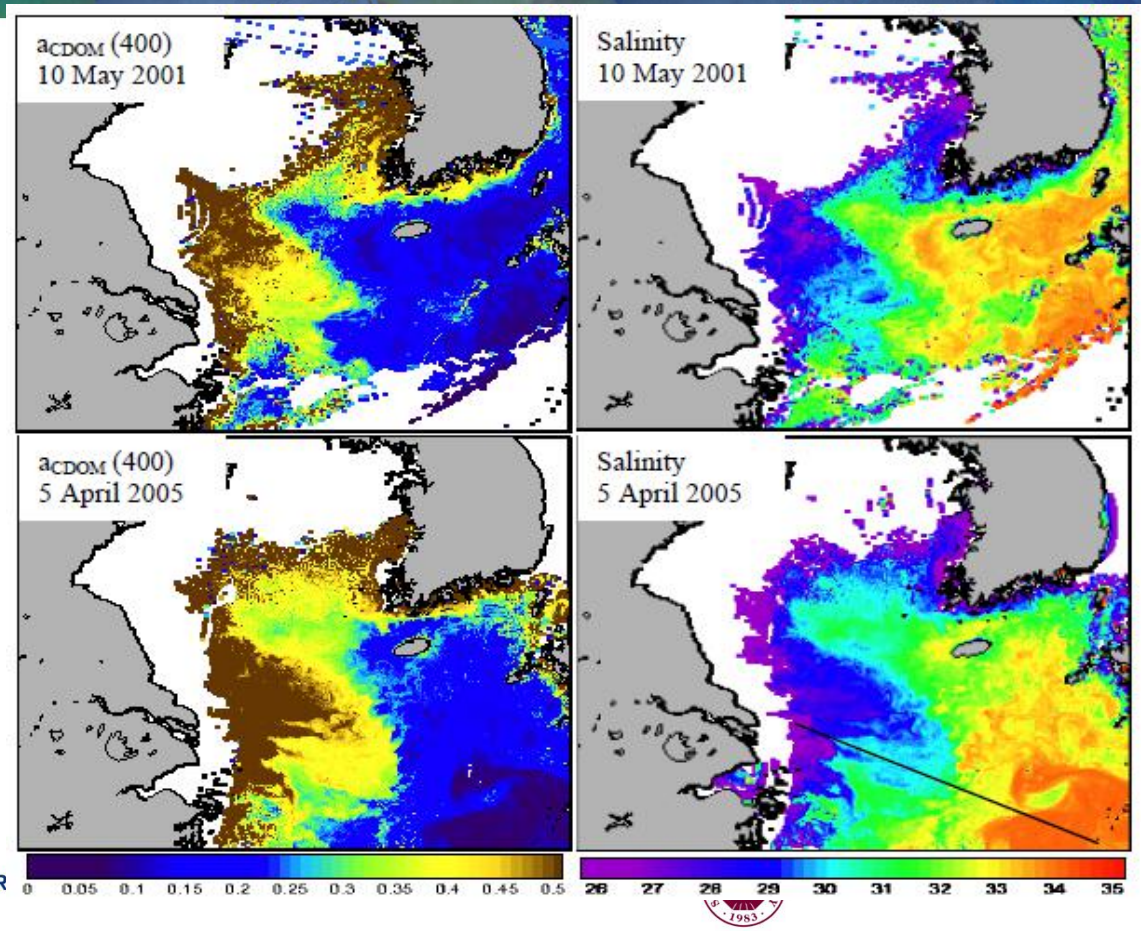
Y. Ahn et al., 2008



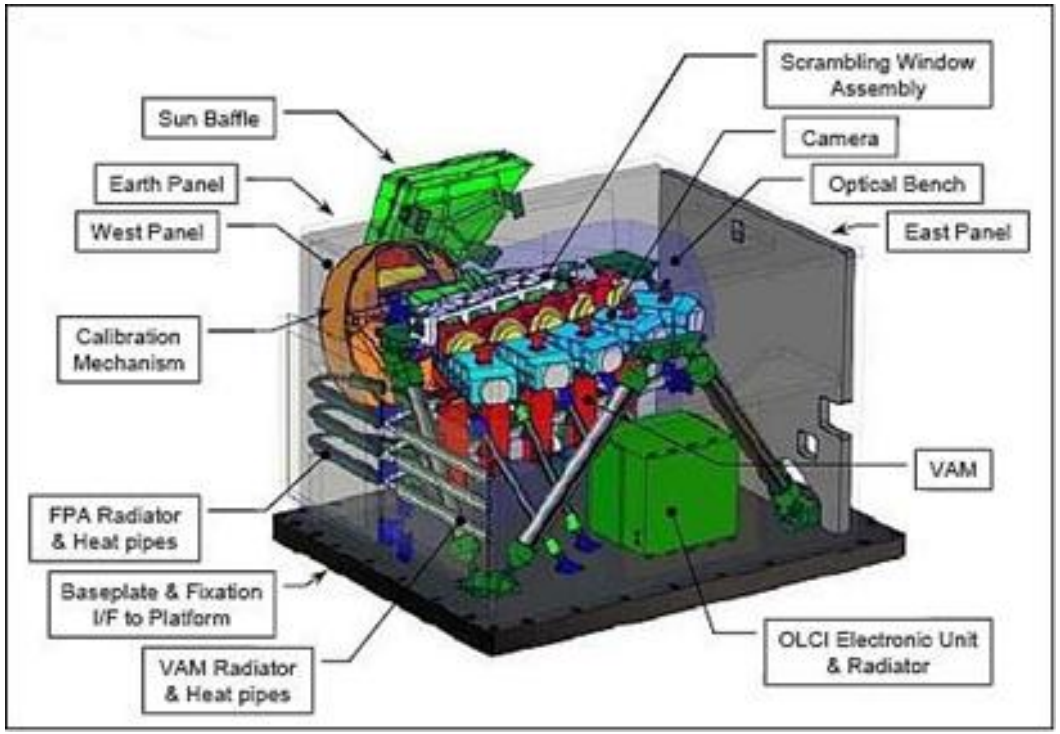
$$\text{Salinity (psu)} = A \times a_{CDOM}(\lambda) + B,$$

Algorithms	a_{CDOM} (λ)	A	B	R^2	N
Salinity	a_{CDOM} (400)	−30.6416	36.6551	0.86	24
Salinity	a_{CDOM} (412)	−37.3089	36.7550	0.85	24
Salinity	a_{CDOM} (443)	−48.9630	36.3301	0.77	24
Salinity	a_{CDOM} (490)	−64.4025	35.6943	0.66	24
Salinity	a_{CDOM} (400)	35.064	−0.3357	0.98	37

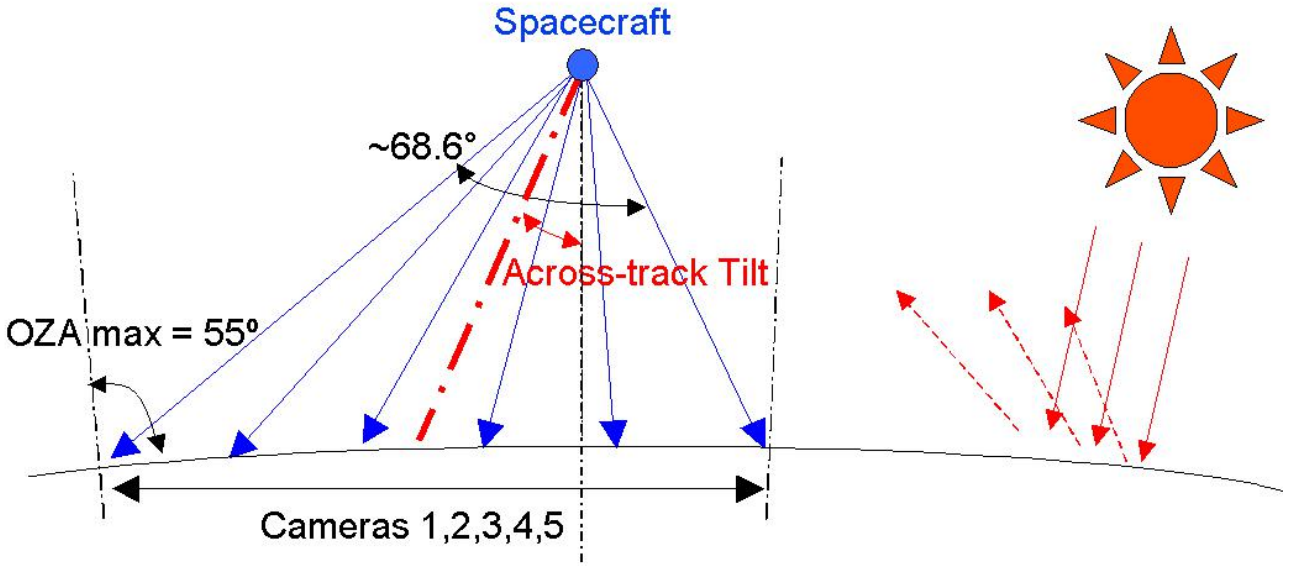
Y. Ahn et al., 2008



Y. Ahn et al., 2008



- OLCI is an optical instrument used to provide data continuity for ENVISAT's MERIS.
- OLCI is a push-broom imaging spectrometer at a ground spatial resolution of 300 m, in 21 spectral bands.



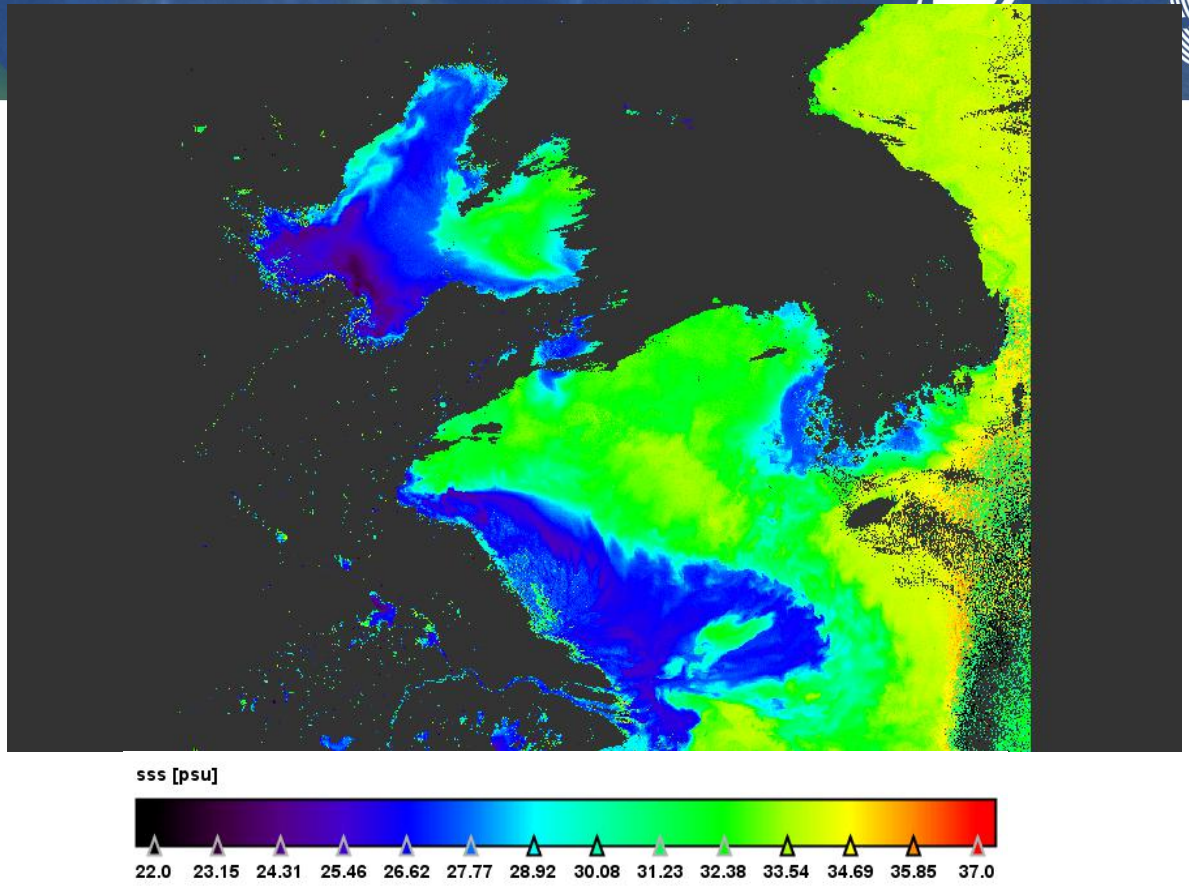
- The OLCI is a push-broom instrument with five camera modules sharing the field of view.
- Each camera has an individual field of view of 14.2° and a 0.6° overlap with its neighbours.

OLCI Band characteristics

Band	λ centre (nm)	Width (nm)	Function
Oa01	400	15	Aerosol correction, improved water constituent retrieval
Oa02	412.5	10	Yellow substance and detrital pigments (turbidity)
Oa03	442.5	10	Chlorophyll absorption maximum, biogeochemistry, vegetation
Oa04	490	10	High Chlorophyll,
Oa05	510	10	Chlorophyll, sediment, turbidity, red tide
Oa06	560	10	Chlorophyll reference (Chlorophyll minimum)
Oa07	620	10	Sediment loading
Oa08	665	10	Chlorophyll (2nd Chlorophyll absorption maximum), sediment, yellow substance/vegetation
Oa09	673.75	7.5	For improved fluorescence retrieval and to better account for smile together with the bands 665 and 680 nm
Oa10	681.25	7.5	Chlorophyll fluorescence peak, red edge

OLCI Band characteristics

Band	λ centre (nm)	Width (nm)	Function
Oa11	708.75	10	Chlorophyll fluorescence baseline, red edge transition
Oa12	753.75	7.5	O2 absorption/clouds, vegetation
Oa13	761.25	2.5	O2 absorption band/aerosol correction.
Oa14	764.375	3.75	Atmospheric correction
Oa15	767.5	2.5	O2A used for cloud top pressure, fluorescence over land
Oa16	778.75	15	Atmos. corr./aerosol corr.
Oa17	865	20	Atmospheric correction/aerosol correction, clouds, pixel co-registration
Oa18	885	10	Water vapour absorption reference band. Common reference band with SLSTR instrument. Vegetation monitoring
Oa19	900	10	Water vapour absorption/vegetation monitoring (maximum reflectance)
Oa20	940	20	Water vapour absorption, Atmospheric correction/aerosol correction
Oa21	1 020	40	Atmospheric correction/aerosol correction



OCLI mapped SSS on 8th April, 2018

Content

- Introduction
- Optical SSS estimation method
- Optical SSS in the East China Sea
- Conclusion & Remarks

- Salinity optical estimation models are reviewed.
- Spatial pattern of salinity in the East China Sea are revealed by OCLI images.
- Satellite optical image could provide reliable, high spatial resolution salinity mapping in the coastal zone, which is the necessary supplement to the microwave remote sensing.
- Salinity from optical images is indirect and is related to CDOM. Thus the relationship between salinity and Rrs varies from region to region and seasonally.

Acknowledgement

- ESA for providing the OCLI data
- Contributors of the China Sea
- Sponsors and local organizing committee of the training course.

Thanks for your attention !