Update, Summary and Suggestions on Chinese Spaceborne Ocean Observing Systems (1988 – 2025)

EC DRAGONESS Project WP2 Final Report

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Outline

- Update of Chinese Spaceborne Ocean Observing Systems
- Comparison Chinese and other international similar sensors
- On-orbit Chinese satellite ocean observing system
- Ocean data products of on-orbit Chinese ocean observing sensors
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- Suggestions on current Chinese satellite ocean observing systems
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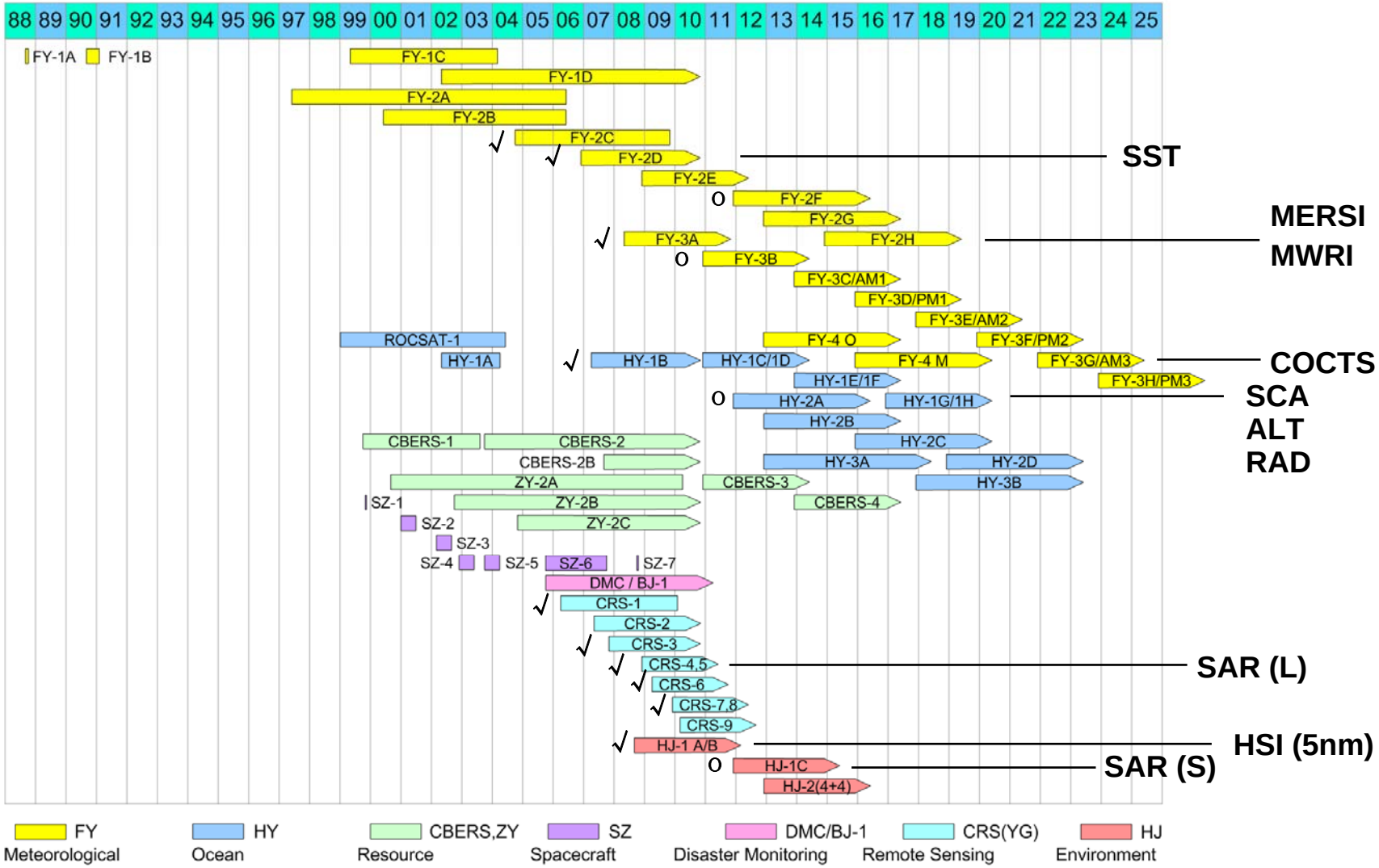
CHINESE SPACEBORNE EARTH OBSERVING SYSTEM (1988 – 2025)



Sensors and applications of Chinese spaceborne EOS

Meteological

Satellite series	Satellite	Orbit	Launch date	Design life / EOL date	Primary sensors	Primary applications
FY-n	FY-1A	Polar	1988-09-07	1988-10	MVISR-1	Meteorology
	FY-1B		1990-09-03	1991-02		
	FY-1C		1999-05-10	2004-03	MVISR-2	Meteorology, Ocean color, SST
	FY-1D		2002-05-15	2 years		
	FY-2A	Geostationary	1997-06-10	2006-06	VISSR-1	Meteorology,
	FY-2B		2000-06-25	2006-06	VISSR-1	
	FY-2C		2004-10-19	3 years	VISSR-2	Meteorology SST
	FY-2D		2006-12-08	3 years	VISSR-2	
	FY-2E		2008-12-18	3 years	VISSR-2	
	FY-2F		2011	4 years	VISSR-n	
	FY-2G		2012	4 years	VISSR-n	
	FY-2H		2014	4 years	VISSR-n	
	FY-3A	Polar	2008-05-27	3 years	VIRR, IRAS, MWTS, MWHS, SBUS, TOU, ERM, SIM, MWRI, MERSI, SEM	Meteorology, Ocean, Land, Space
	FY-3B		2010	3 years		
	FY-3C/AM1		2013	3 years		
	FY-3D/PM1		2015	3 years		
	FY-3E/AM2		2017	3 years		
	FY-3F/PM2		2019	3 years		
	FY-3G/AM3		2021	3 years		
	FY-3H/PM3		2023	3 years		
	FY-4 O	Geostationary	2012	4 years	IIS, MCSI, LM(CCD)	Meteorology, Ocean, Land
	FY-4 M		2015	4 years	GEO-MWRI	

Sensors and applications of Chinese spaceborne EOS cont'

Ocean

Satellite series	Satellite	Orbit	Launch date	Design life / EOL date	Primary sensors	Primary applications
HY-n	ROCSAT-1	Polar	1999-01-27	2004-06-16	OCI, IPEI	Ocean color, Detection of charged particles in the ionosphere
	HY-1A	Polar	2002-05-15	2004-04-01	COCTS, CZI	Ocean color
	HY-1B		2007-04-11	3 years		
	HY-1C/D		2010	3 years		
	HY-1E/F		2013	3 years		
	HY-1G/H		2016	3 years		
	HY-2A		2011	4 years	SCA(Ku), ALT(Ku,C), RAD(5 bands)	Ocean dynamic environment
	HY-2B		2012	4 years		
	HY-2C		2015	4 years		
	HY-2D		2018	4 years		
	HY-3A		2012	5 years	SAR(X,1m),SAR(C,10m), CCD(3m)	Ocean watch and monitoring
	HY-3B		2017	5 years		

Sensors and applications of Chinese spaceborne EOS cont'

Resource Spacecrafts

Satellite series	Satellite	Orbit	Launch date	Design life / EOL date	Primary sensors	Primary applications
CBERS, ZY-n	CBERS-1	Polar	1999-10-14	2003-08-13	CCD, IRMSS, WFI	Land, Coastal zone
	CBERS-2		2003-10-21	2 years		
	CBERS-2B		2007-09-19	2 years	CCD, WFI, HR	
	CBERS-3		2010	3 years	CCD, IRMSS, WFI, PAN-MUX (PAN-MS)	
	CBERS-4		2013	3 years		
	ZY-2A	Polar	2000-09-01	2010-04	HR, PAN-MS	
	ZY-2B		2002-10-27	2 years		
	ZY-2C		2004-11-06	2 years		
SZ-n	SZ-1		1999-11-20	1 day		
	SZ-2		2001-01-10	6 days	The orbital module stayed in orbit, Space and earth environment sensor experiments. Such as CMODIS, M3RS, SBUS, TOU, ERM, SIM, etc.	
	SZ-3		2002-03-25	7 days		
	SZ-4		2002-12-30	5 days		
	SZ-5		2003-10-15	1 day		
	SZ-6		2005-10-12	5 days		
	SZ-7		2008-10	5 days		

Sensors and applications of Chinese spaceborne EOS cont'

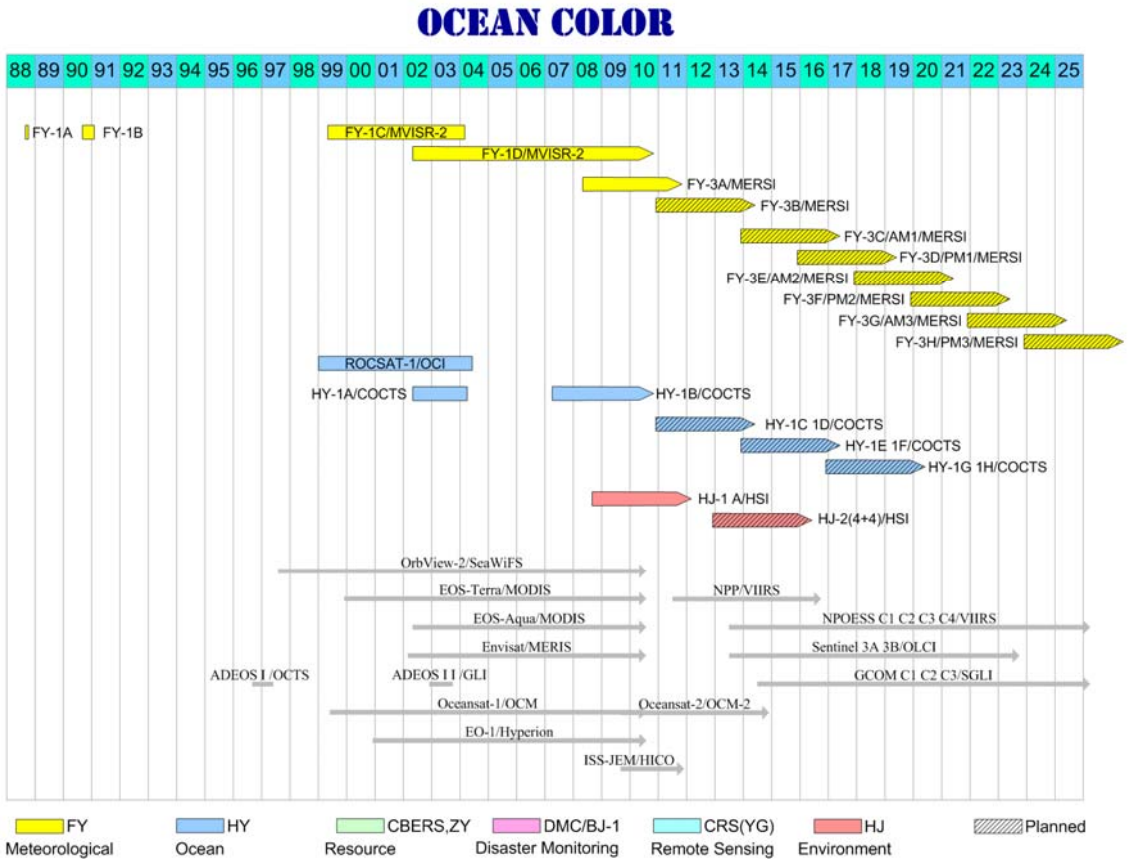
Disaster

Remote Sensing

Environment

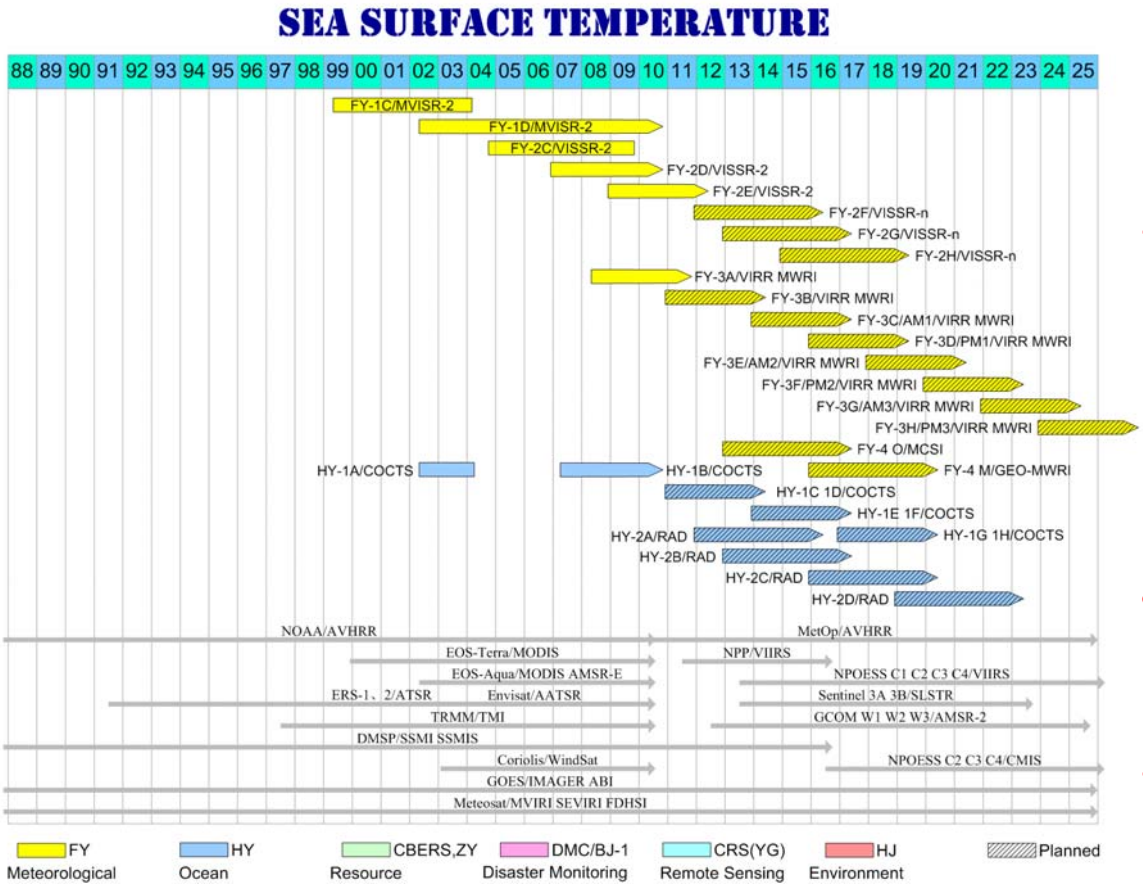
Satellite series	Satellite	Orbit	Launch date	Design life / EOL date	Primary sensors	Primary applications
DMC	DMC/BJ-1	Polar	2005-10-27	5 years	PAN-MS	Land,Coastal zone
CRS-n or YG-n	CRS-1	Polar	2006-04-27	2010-02	L-band SAR	Land, Ocean
	CRS-2		2007-05-25	2 years	HR, PAN-MS	
	CRS-3		2007-11-12	2 years	L-band SAR	
	CRS-4		2008-12-01	2 years	HR, PAN-MS	
	CRS-5		2008-12-15	2 years	L-band SAR	
	CRS-6		2009-04-22	2 years	L-band SAR	
	CRS-7		2009-12-09	2 years	HR, PAN-MS	
	CRS-8		2009-12-15	2 years	L-band SAR	
	CRS-9		2010-03-05	2 years	HR, PAN-MS	
HJ-n	HJ-1A	Polar	2008-09-06	3 years	CCD, HSI	Environment and disaster monitoring, Ocean
	HJ-1B		2008-09-06	3 years	CCD, IR	
	HJ-1C		2011	3 years	S-band SAR	
	HJ-2 (4+4)		2012	3 years	CCD, IR, HSI, SAR	

Chinese satellite ocean observing system —— Ocean Color Sensors



- Ocean color sensors are carried by FY-n, HY-n and HJ-n.
- FY-1D/MVISR-2 ≈ AVHRR + CZCS
  HY-1B/COCTS ≈ ADEOS/OCTS
  FY-3A/MERSI ≈ EOS/MODIS
  HJ-1A/HSI ≈ ISS-JEM/HICO
- They indicate the rapid development of satellite ocean color sensors in China from 2002 to 2008.
- Observation data from 8-9 ocean color sensors could be obtained.

Chinese satellite OBS —— infrared and microwave radiometers



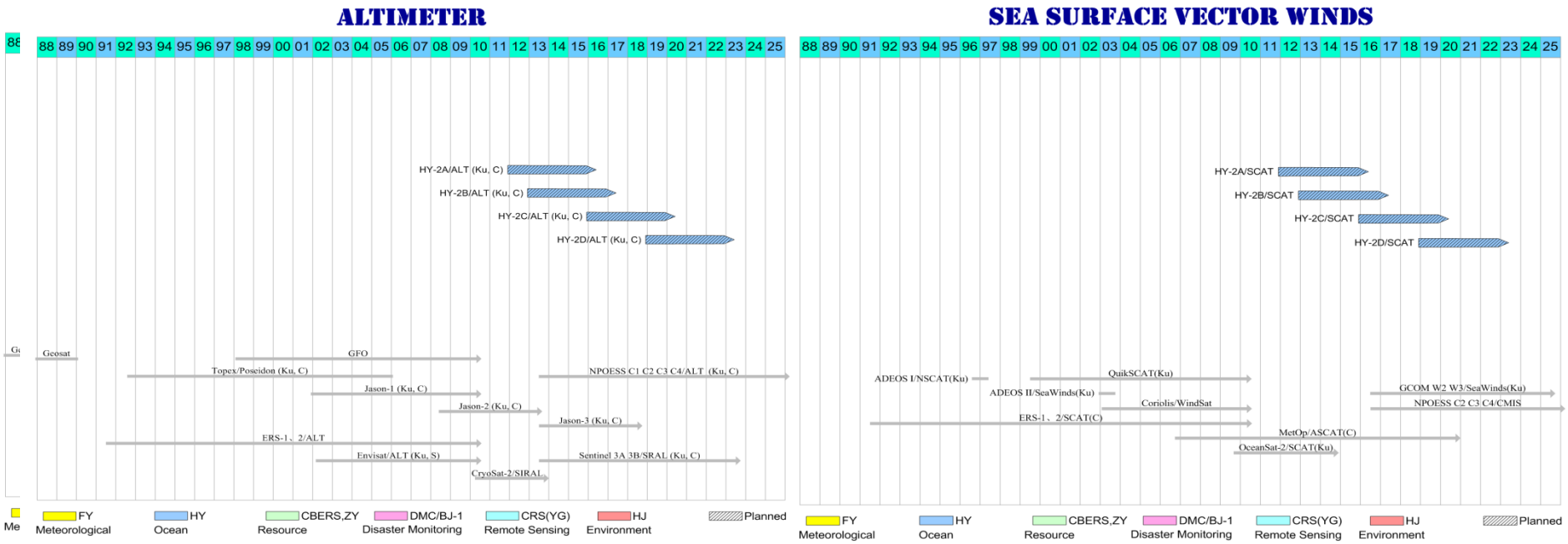
- Infrared and microwave radiometers used to retrieve SST are carried by FY-n and HY-n.
- FY-1D/MVISR-2 ≈ AVHRR + CZCS

  FY-3A/VIRR ≈ AVHRR

  HY-1B/COCTS: two IR channels.

  FY-3A/MWRI, HY-2A/RAD: 5-channel
- FY-3A/VIRR + FY-3A/MWRI ≈ Chinese high spatial resolution SST (GHRSST)
- FY2D, 2E/VISSR-2 can provide high temporal resolution SST data.
- Observation data from >10 SST sensors could be obtained.

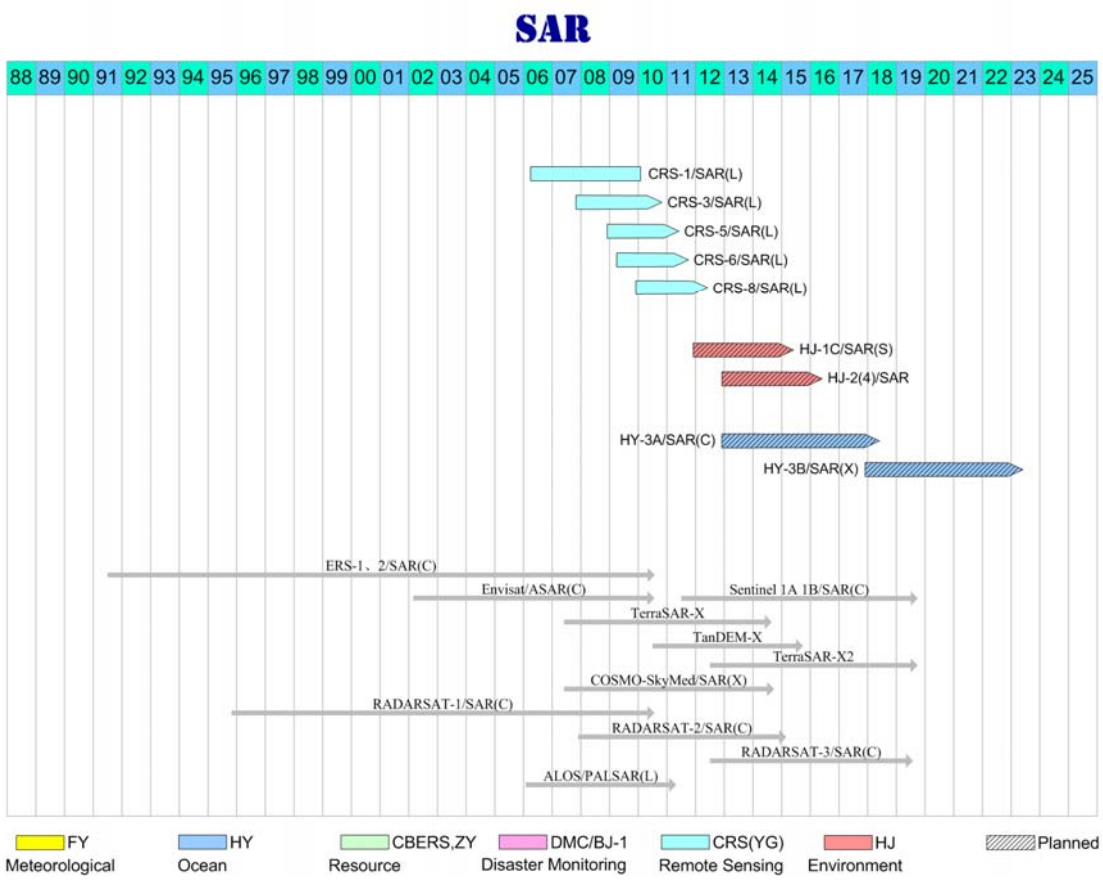
Chinese satellite OBS —— Microwave altimeters & scatterometers



- **ALT and SCA are carried by HY-2 satellites. HY-2A will be launched in 2011.**
- **ALT: dual frequencies (Ku, C);**

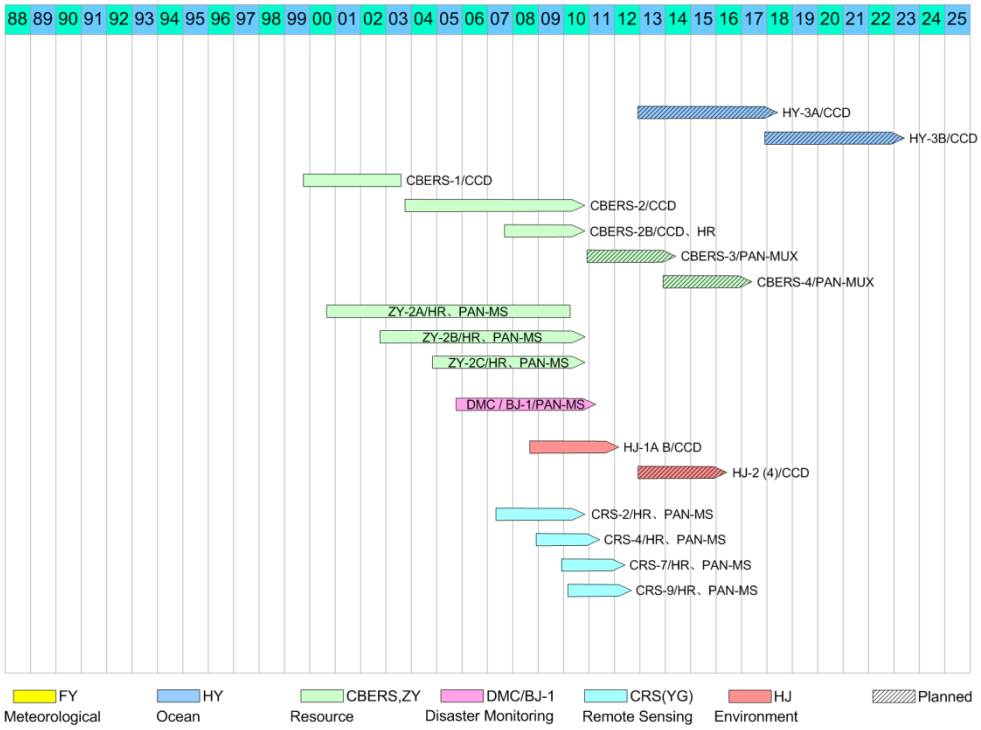
  SCA: Ku frequency
- **Observation data from 4-5 altimeters could be obtained.**
- **Observation data from 4-5 scatterometers could be obtained.**

Chinese satellite OBS —— Microwave SARs



- SARs are carried by CRS-n, HJ-n and HY-n.
- CRS-1/SAR(L): launched 27/04/2006
  CRS-3/SAR(L): launched 12/11/2007,
  CRS-5/SAR(L): launched 15/12/2008,
  CRS-6/SAR(L): launched 22/04/2009,
  CRS-8/SAR(L): launched 15/12/2009.
- HJ-1C/SAR (S): launched in 2011.
  HY-3A/SAR (C): launched in 2012.
  HY-3B/SAR (X): launched in 2017.
- Multi-frequency and multi-platform SARs will be probably in orbit concurrently.
- Observation data from >10 SAR sensors could be obtained.

Chinese satellite OBS —— High spatial resolution optical sensors



Optical sensors	*Spatial resolution*
HY-3A, 3B/CCD	3m
ZY-2A, 2B, 2C/HR (High Resolution camera), PAN-MS (Panchromatic and Multi-spectral camera)	2m, 5m
CBERS-1, 2/CCD	20m
CBERS-2B/ CCD、HR (High Resolution camera)	20m, 2m
CBERS-3, 4/ PAN-MUX (Panchromatic and Multi-spectral camera)	10m, 2m
HJ-1A, 1B/CCD	30m
HJ-2 (4)/CCD	< 30m
DMC/BJ-1/PAN-MS (Panchromatic and Multi-spectral camera)	32m, 4m
CRS-2, 4, 7, 9/ HR(High Resolution camera), PAN-MS (Panchromatic and Multi-spectral camera)	0.5 — 2m

- **High spatial resolution optical sensors are carried by HY-n, ZY-n, HJ-n, DMC/BJ-1 and CRS-n.**
- **They can be used for coastal zone monitoring and analysis of coastal SAR images.**

Chinese satellite ocean observing system —— Summary

- 7 spaceborne series:
  FY-n, HY-n, HJ-n, CRS-n, ZY-n, DMC/BJ-1, SZ-n,
- 55 satellites:
  22 FY-n, 15 HY-n, 9 CRS-n, 8 ZY-n, 1 DMC/BJ-1
- 2 constellations:
  HJ-1 = 2 optical sensors + 1 SARs
  HJ-2 = 4 optical sensors + 4 SARs
- 7 spacecrafts: SZ-n

Comparison of Chinese and other international similar sensors —— ocean color sensors

	HY-1B/COCTS	FY-3A/MERSI	Envisat/MERIS	EOS/MODIS	OrbView-2/SeaWiFS
Launch Agency	CNSA SOA	CNSA CMA	ESA	NASA	NASA
Orbit	polar, 798km, 98.8deg, 10:30±30min (D)	polar, 836km, 98.75deg, 10:00-10:20 (D)	polar, 800 km, 98.55deg, 10:00 (D)	polar, 705 km, 98.2deg, 10:30 (D, Terra) or 13:30 (A, Aqua)	polar, 705km, 98.2deg, 12:00 (D)
Swath	3100km	3200km	1150km	2330 km	2801km
Quantization	10 bits	12 bits	16 bits	12 bits	10 bits
Spatial Resolution	1100m	250m (bands 1-5) 1000m (bands 6-20)	300m/1200m (all bands)	250 m (bands 1-2), 500 m (bands 3-7), 1000 m (bands 8-36)	1100m
Radiometric Accuracy	10% (bands 1-8)	7% (bands 1-4, 6-14) 10% (bands 15-20)	< 4%	5% (bands 1-19, 26) 1% (bands 20-25, 27-36)	< 5%
SNR, NEΔρ, NEΔT	SNR Band 1, 440; 2, 600; 3, 590; 4, 560; 5, 525; 6, 390; 7, 400; 8, 415	NEΔρ Band 1, 0.45%; 2-3, 0.4%; 4, 0.45%; 6-7, 0.1%; 8-14, 0.05%	SNR (typical) 1700	SNR Band 1, 128; 2, 201; 3, 243; 4, 228; 8, 880; 9, 838; 10, 802; 11, 754; 12, 750; 13, 910; 14, 1087; 15, 586; 16, 516	SNR Band 1, 499; 2, 674; 3, 667; 4, 640; 5, 596; 6, 442; 7, 455; 8, 467
Bands	1 412 nm, 20 nm 2 443 nm, 20 nm 3 490 nm, 20 nm 4 520 nm, 20 nm 5 565 nm, 20 nm 6 670 nm, 20 nm 7 750 nm, 20 nm 8 865 nm, 40 nm 9 10850 nm, 100 nm 10 11950 nm, 1100 nm	6 412 nm, 20 nm 7 443 nm, 20 nm 1 470 nm, 50 nm 8 490 nm, 20 nm 9 520 nm, 20 nm 2 550 nm, 50 nm 10 565 nm, 20 nm 11 650 nm, 20 nm 3 650 nm, 50 nm 12 685 nm, 20 nm 13 765 nm, 20 nm 14 865 nm, 20 nm 4 865 nm, 50 nm 15 905 nm, 20 nm 16 940 nm, 20 nm 17 980 nm, 20 nm 18 1030 nm, 20 nm 19 1640 nm, 50 nm 20 2130 nm, 50 nm 5 11250 nm, 2500 nm	1 412 .5 nm, 10 nm 2 442.5 nm, 10 nm 3 490 nm, 10 nm 4 510 nm, 10 nm 5 560 nm, 10 nm 6 620 nm, 10 nm 7 665 nm, 10 nm 8 681.25 nm, 7.5 nm 9 708.75 nm, 10 nm 10 753.75 nm, 7.5 nm 11 760.625 nm, 3.75 nm 12 778.75 nm, 15 nm 13 865 nm, 20 nm 14 885 nm, 10 nm 15 900 nm, 10 nm	8 412 nm, 15 nm 9 443 nm, 10 nm 3 469 nm, 20 nm 10 488 nm, 10 nm 11 531 nm, 10 nm 12 551 nm, 10 nm 4 555 nm, 20 nm 1 645 nm, 50 nm 13 667 nm, 10 nm 14 678 nm, 10 nm 15 748 nm, 10 nm 2 858 nm, 35 nm 16 870 nm, 10 nm 17 905 nm, 30 nm 18 936 nm, 10 nm 19 940 nm, 25 nm 5 1240 nm, 20 nm 26 1375 nm, 30 nm 6 1640 nm, 24 nm 7 2130 nm, 50 nm 20 3750 nm, 180 nm 21 3959 nm, 60 nm 22 3959 nm, 60 nm 23 4050 nm, 60 nm 24 4466 nm, 65 nm 25 4515 nm, 67 nm 27 6715 nm, 360 nm 28 7325 nm, 300 nm 29 8550 nm, 300 nm 30 9730 nm, 300 nm 31 11030 nm, 500 nm 32 12020 nm, 500 nm 33 13335 nm, 300 nm 34 13635 nm, 300 nm 35 13935 nm, 300 nm 36 14235 nm, 300 nm	1 412 nm, 20 nm 2 443 nm, 20 nm 3 490 nm, 20 nm 4 510 nm, 20 nm 5 555 nm, 20 nm 6 670 nm, 20 nm 7 765 nm, 40 nm 8 865 nm, 40 nm

Comparison of Chinese and other international similar sensors —— infrared sensors

	HY-1B/COCTS	FY-3A/VIRR	Envisat/AATSR	EOS/MODIS	NOAA-N/AVHRR
Launch Agency	CNSA SOA	CNSA CMA	ESA	NASA	NOAA
Orbit	polar, 798km, 98.8deg, 10:30±30min (D)	polar, 836km, 98.75deg, 10:00-10:20 (D)	polar, 800 km, 98.55deg, 10:00 (D)	polar, 705 km, 98.2deg, 10:30 (D, Terra) or 13:30 (A, Aqua)	polar, 854km, 98.74deg, 13:37 (A)
Swath	3100km	2900km	500km	2330 km	2900km
Quantization	10 bits	10 bits	12 bits	12 bits	10 bits
Spatial Resolution	1.1km	1.1km	1km	1km (bands 8-36)	1.1 km
Radiometric Accuracy	1K@300K (bands 9-10)	1K@270K (band 3-5)	better than 0.5 K (absolute, 50×50 km), better than 0.1 K (relative, 1×1km)	1% (bands 20-25, 27-36, absolute)	Traceable to NIST
SNR, NEΔρ, NEΔT	NEΔT Band 9-10, 0.2K@300K	NEΔT Band 3, 0.3K@300K; 4-5, 0.2K@300K	NEΔT Band 5, 0.08K@270K; 6-7, 0.05K@270K	NEΔT Band 20, 31-32, 0.05K@300K 22-23, 0.07K@300K	NEΔT Band 3B-5, 0.12 K @ 300K
Bands	1 412 nm, 20 nm 2 443 nm, 20 nm 3 490 nm, 20 nm 4 520 nm, 20 nm 5 565 nm, 20 nm 6 670 nm, 20 nm 7 750 nm, 20 nm 8 865 nm, 40 nm 9 10.3-11.4 μm 10 11.4-12.5 μm	7 455 nm, 50 nm 8 505 nm, 50 nm 9 555 nm, 50 nm 1 630 nm, 100 nm 2 865 nm, 50 nm 10 1.360 μm, 0.07 μm 6 1.600 μm, 0.09 μm 3 3.55-3.85 μm 4 10.3-11.3 μm 5 11.5-12.5 μm	1 555 nm, 20 nm 2 659 nm, 20 nm 3 865 nm, 20 nm 4 1610 nm, 300 nm 5 3.55-3.85 μm 6 10.35-11.35 μm 7 11.50-12.50 μm	8 412 nm, 15 nm 9 443 nm, 10 nm 3 469 nm, 20 nm 10 488 nm, 10 nm 11 531 nm, 10 nm 12 551 nm, 10 nm 4 555 nm, 20 nm 1 645 nm, 50 nm 13 667 nm, 10 nm 14 678 nm, 10 nm 15 748 nm, 10 nm 2 858 nm, 35 nm 16 870 nm, 10 nm 17 905 nm, 30 nm 18 936 nm, 10 nm 19 940 nm, 25 nm 5 1240 nm, 20 nm 26 1375 nm, 30 nm 6 1640 nm, 24 nm 7 2130 nm, 50 nm 20 3.66-3.84 μm 21 3959 nm, 60 nm 22 3959 nm, 60 nm 23 4050 nm, 60 nm 24 4466 nm, 65 nm 25 4515 nm, 67 nm 27 6715 nm, 360 nm 28 7325 nm, 300 nm 29 8550 nm, 300 nm 30 9730 nm, 300 nm 31 10.78-11.28 μm 32 11.77-12.27 μm 33 13335 nm, 300 nm 34 13635 nm, 300 nm 35 13935 nm, 300 nm 36 14235 nm, 300 nm	1 630 nm, 100nm 2 862 nm, 275 nm 3A 1.58-1.64 μm 3B 3.55-3.93 μm 4 10.3-11.3 μm 5 11.5-12.5 μm

Comparison of Chinese and other international similar sensors —— microwave radiometers

	HY-2/RAD	FY-3A/MWRI	EOS-Aqua/AMSR-E	TRMM/TMI	Coriolis/WindSat
Launch Agency	CNSA SOA	CNSA CMA	NASA JAXA	NASA JAXA	NRL AFRL
Orbit	Polar, 963/965km, 99.3deg, 6:00 or 18:00 (D)	Polar, 836km, 98.75deg, 10:00-10:20 (D)	Polar, 705 km, 98.2deg, 13:30 (A)	Polar, non-sun-synchronous, 402km, 35deg	Polar, 840 km,98.7deg, 17:59 (A)
Swath	1600km	1400km	1450km	878km	1000km
Center Frequency , Bandwidth , Polarization	Band 1-2, 6.6 GHz, 350MHz, VH; 3-4, 10.7GHz, 250MHz, VH; 5-6, 18.7GHz, 250MHz, VH; 7, 23.8GHz, 400MHz, V; 8-9, 37GHz, 1000MHz, VH	Band 1-2, 10.65GHz, 180MHz, VH; 3-4, 18.7GHz, 200MHz, VH; 5-6, 23.8GHz, 400MHz, VH; 7-8, 36.5GHz, 900MHz, VH; 9-10, 89 GHz, 2×2300MHz, VH;	Band 1-2, 6.925 GHz, 350MHz, VH; 3-4, 10.65GHz, 100MHz, VH; 5-6, 18.7GHz, 200MHz, VH; 7-8, 23.8GHz, 400MHz, VH; 9-10, 36.5GHz, 1000MHz, VH 11-12, 89.0GHz, 3000MHz, VH	Band 1-2, 10.65GHz, 100MHz, VH; 3-4, 19.35GHz, 500MHz, VH; 5, 21.3GHz, 200MHz, V; 6-7, 37.0GHz, 2000MHz, VH; 8-9, 85.5GHz 3000MHz VH	Band 1-2, 6.8GHz, 125MHz, VH; 3-8, 10.7GHz, 300MHz, V H ±45 L R; 9-14, 18.7GHz, 750MHz, V H ±45 L R; 15-16, 23.8GHz, 500MHz, V H; 17-22, 37.0GHz, 2000MHz, V H ±45 L R;
NEΔT	1-7 0.5K 8-9 0.8K	1-2 0.6K; 3-8 1K; 9-10 2K	1-2 0.34K; 3-6 0.7K; 7-8 0.6K; 9-10 0.7K; 11-12 1.2K	1 0.63K; 2 0.54K; 3 0.50K; 4 0.47K; 5 0.71K; 6 0.36K; 7 0.31K; 8 0.52K; 9 0.93K	1-2 0.63K; 3-14 0.44K; 15-16 0.60K; 17-22 0.42K
IFOV	1-2 100km; 3-4 62km; 5-6 36km; 7 30km; 8-9 18km	1-2 51 x 85 km; 3-4 30 x 50 km; 5-6 27 x 45 km; 7-8 18 x 30 km; 9-10 9 x 15 km	1-2 43 x 75 km 3-4 29 x 51 km 5-6 16 x 27 km 7-8 18 x 32 km 9-10 8.2 x 14.4 km 11 3.7 x 6.5 km 12 3.5 x 5.9 km	1-2 37 x 63 km 3-4 18 x 30 km 5 18 x 23 km 6-7 9 x 16 km 8-9 5 x 7 km	1-2 40 x 60 km; 3-8 25 x 38 km; 9-14 16 x 27 km; 15-16 12 x 20 km; 17-22 8 x 13 km
Pixel			1-10 9 x 10 km 11 4.5 x 4 km 12 4.5 x 6 km	1-7 9.1 x 13.9 km 8-9 4.6 x 13.9 km	1-2 40 x 50 km; 3-8 20 x 25 km; 9-14 10 x 25 km; 15-16 10 x 12.5 km; 17-22 5 x 12.5 km
Incidence Angle	40 deg	53 deg	1-11 55 deg; 12 54.5 deg	53 deg	1-2 53.5 deg; 3-8 49.9 deg; 9-14 55.3 deg; 15-22 53.0 deg;

Comparison of Chinese and other international similar sensors —— microwave altimeters

	HY-2A/ALT	Envisat/ALT	Topex/Poseidon	Jason-1	CryoSat
Launch Agency	CNSA SOA	ESA	NASA CNES	NASA CNES	ESA
Orbit	Polar, 963km, 99.3 deg	Polar, 800 km, 98.55 deg	Polar,non-sun-synchronous, 1336km, 66deg	Polar,non-sun-synchronous, 1336 km, 66 deg	Polar,non-sun-synchronous, 717 km, 92 deg
Repeat Cycle (days)	14/168	35	10	10	369 (30 day sub-cycle)
Emitted Frequency (GHz)	Ku, 13.58 C, 5.25	Ku, 13.575 S, 3.2	Ku, 13.6 C, 5.3	Ku, 13.575 C, 5.3	Ku, 13.575 (LRM, SAR, SARIn)
Bandwidth (MHz)	320, 80, 20 (Ku) 320, 160 (C)	320, 80, 20 (Ku) 160 (S)	320 (Ku) 320, 100 (C)	320 (Ku, C)	350 (Ku)
Spatial resolution (km)	16	8	6	6	0.25
Altimeter Accuracy (cm)	5-8	4.5	4.2	3.3	1.6-2.7

Comparison of Chinese and other international similar sensors —— microwave scatterometers

	HY-2A/SCAT	ERS-2/SCAT	QuikSCAT	MetOp-A/ASCAT	GCOM W2 W3/SeaWinds
Launch Agency	CNSA SOA	ESA	NASA	ESA	JAXA NASA
Orbit	Polar, 963/965 km 99.3deg, 18:00 (D)	Polar, 785 km 98.5deg, 10:30 (D)	Polar, 803 km 98.6 deg, 6:00 (D)	Polar, 817 km 98.7 deg, 09:30 (D)	Polar, 699.6 km 98.19 deg, 13:30 (D)
Repeat Cycle	14/168 days	35 days	4 days	29 days	
Frequency	Ku	C	Ku	C	Ku
Polarization	HH VV	VV	HH VV	VV	HH VV
Spatial Resolution	50 km	25 km, 50 km	25 km	50 km	12.5 km, 25 km, 50 km
Swath	>1350 km（HH） >1700 km（VV）	500 km	1400 km（HH） 1800 km（VV）	550 km*2	1400 km（HH） 1800 km（VV）
Incidence Angle	38 deg & 44 deg	18deg～59deg	46deg & 54deg	45～65deg	46deg & 54deg
Wind Speed Range	4～24 m/s	4～24 m/s	3～30 m/s	4～24 m/s	3～30 m/s
Wind Speed Accuracy	2 m/s, 10%	2 m/s	2 m/s	2 m/s, 10%	2 m/s
Wind Direction Accuracy	20 deg	20 deg	20 deg	20 deg	20 deg

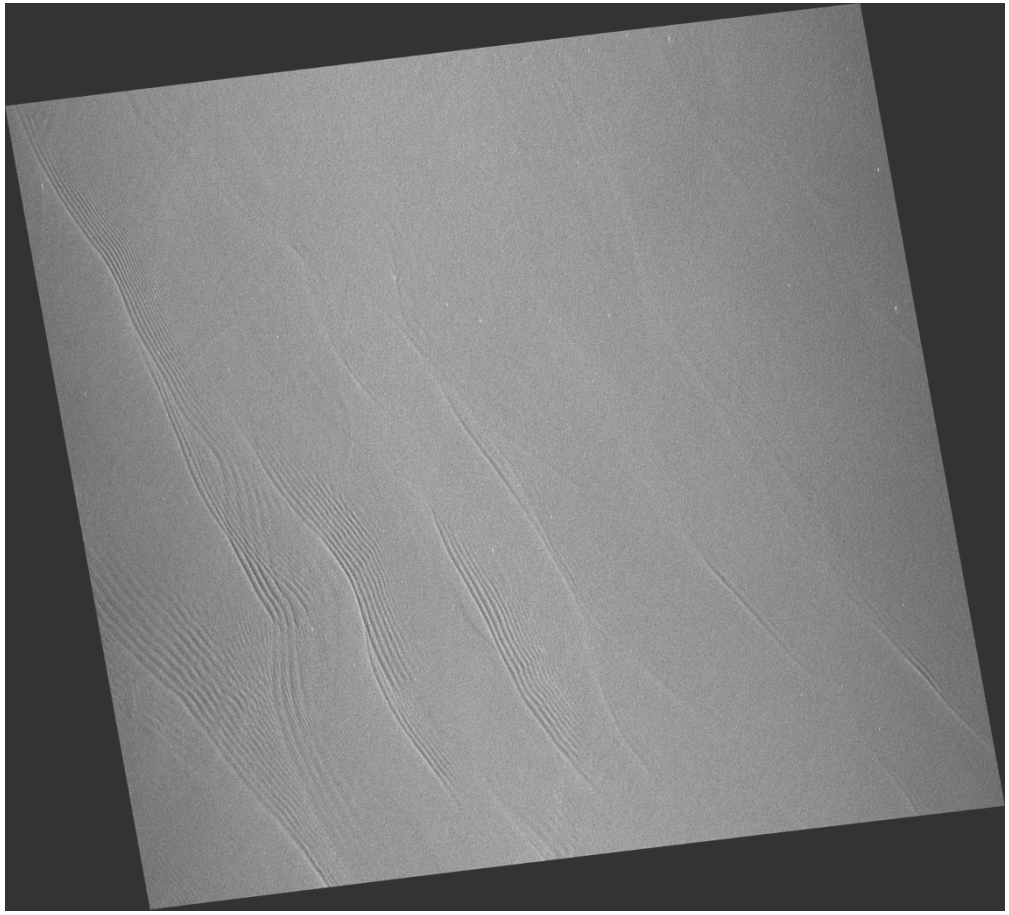
Comparison of Chinese and other international similar sensors —— microwave SARs

	HJ-1C/SAR	HY-3A.B/SAR		TerraSAR-X/SAR	Envisat/ASAR	Radarsat-2/SAR
Launch Agency	CNSA MCA/MEA	CNSA SOA		DLR	ESA	CSA
Orbit	Polar，500km 97.37deg 6:00AM (D)	Polar，799.9Km 98.48 6:00AM (D)		Polar，514.8km 97.44deg 18:00PM (D)	Polar，800km 98.55deg 10:00AM (D)	Polar，789km 98.6deg 6:00AM (D)
Repeat Cycle	31days	29days		11days	35days	24days
NESZ		<-20dB		-16～-23dB	-19～-35dB	-22～-30dB
Radiometric Accuracy	3dB	<1.5dB		1～3.1dB	1.5～3.5dB	<1dB
Frequency	S-band	X-band	C-band	X-band	C-band	C-band
Operation mode，Resolution (m)，Swath (km)，Polarization，Incidence Angle (deg)	Stripmap， 5，40， VV or HH， 31～44 ScanSAR， 20，100， VV or HH， 31～44	Precise mode， 1，20～40， HH VV， 15～60 Strip mode， 5，60～80， HH VV， 15～60 ScanSAR， 10，120～150， HH VV， 15～60	Wave mode， 10，5， HH+VV or HH+HV or VV+VH， 15~60 Image mode， 25，150， HH+VV or HH+HV or VV+VH， 15～60 Wide swath mode， 100，650， HH+VV or HH+HV or VV+VH， 15～60 Global monitoring， 1000，650， HH+VV or HH+HV or VV+VH， 15～60	Spotlight， 1～2，10， HH+VV or HH+HV or VV+VH， 20～55 Stripmap， 3～6，30， HH+VV or HH+HV or VV+VH， 20～45 ScanSAR， 16，100， HH+VV or HH+HV or VV+VH， 20～45 Dual Receive Antenna Mode， 300 MHz Mode	Wave mode， 30，5， HH or VV， 15～45 Image mode， 30，56～100， HH or VV， 15～45 Alternating Polarization mode， 30，100， VV+HH or HV+HH or VH+VV， 15～45 Wide Swath mode， 150，400， HH or VV， 15～37 Globe Monitoring mode， 1000，400， HH or VV， 15～37	Ultra-Fine， 3(Range)*3(Azimuth)，20， HH or HV or VV or VH，30～49 Multi-Look Fine， 8(Range)*8(Azimuth)，50， HH or HV or VV or VH，30～50 Fine， 8(Range)*8(Azimuth)，50， HH or HV or VV or VH or HH+HV or VV+VH，30～50 Fine Quad-Pol， 12(Range)*8(Azimuth)，25， HH+HV+VV+VH，20～41 Standard Quad-Pol， 25(Range)*8(Azimuth)，25， HH+HV+VV+VH，20～41 Extended High， 18(Range)*26(Azimuth)，75， HH or HV or VV or VH，49～60 Standard， 25(Range)*26(Azimuth)，100， HH or HV or VV or VH or HH+HV or VV+VH，20～49 Wide， 30(Range)*26(Azimuth)，150， HH or HV or VV or VH or HH+HV or VV+VH ，20～45 ScanSAR Narrow， 50(Range)*50(Azimuth)，300， HH or HV or VV or VH or HH+HV or VV+VH ，20～46 ScanSAR Wide， 100(Range)*100(Azimuth)，500， HH or HV or VV or VH or HH+HV or VV+VH ，20～49

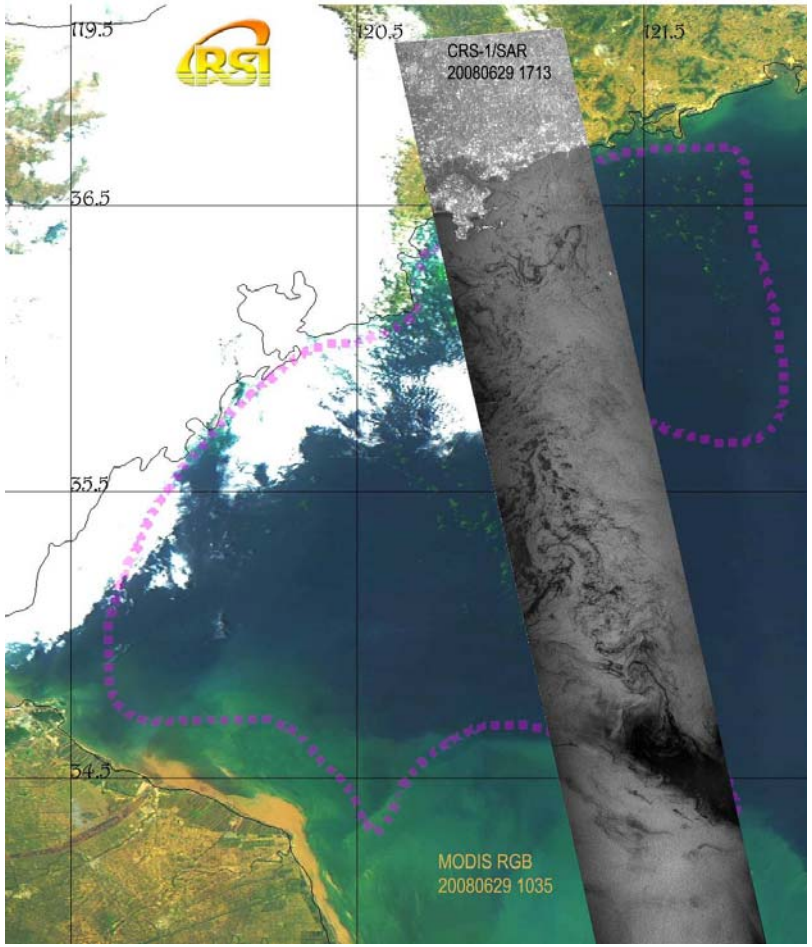
Comparison of Chinese and other international similar sensors —— microwave SARs

The CRS-3/SAR (L) image with internal waves

2008-06-18 17:31:59
30.02 N, 123.95 E
19000×20000 pixels



Comparison of Chinese and other international similar sensors —— microwave SARs



Observation of green tides by CRS-1/SAR (L) in Qingdao in the summer of 2008. The background is a MODIS RGB image.

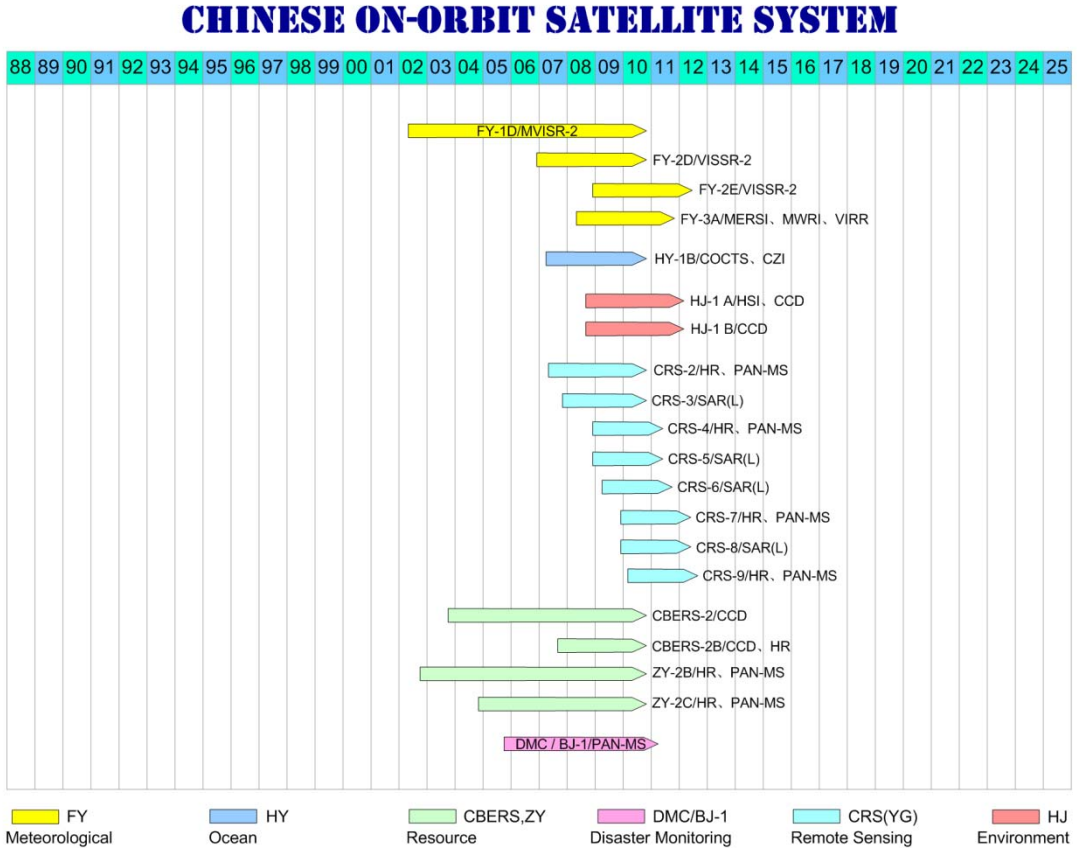
Comparison of Chinese and other international similar sensors —— hyperspectral imagers

Hyper spectral imager	*Spectral range*	*Band number*	*Bandwidth*	*Spatial resolution*	*Swath*
HJ-1A/HSI (Hyper Spectral Imager)	0.45-0.95 μm	128	5 nm (average)	100 m	50 km
EO-1/Hyperion	0.4-1.0 μm 0.9-2.5 μm	220	10nm	30 m	7.5 km
ISS-JEM/HICO (Hyperspectral Imager for the Coastal Ocean)	0.38-1.0 μm	124	5 nm	100 m	50 km

Comparison of Chinese and other international similar sensors —— Summary

- Overall, the technical performance of Chinese current on-orbit and planned satellites and sensors is comparable to that of satellites and sensors launched early this century by NASA, ESA, etc.
- The main gap in visible, infrared, microwave radiometers is radiometric accuracy and $NE\Delta T$.
- The main gap in microwave altimeters is the height measurement accuracy.
- Microwave SAR imaging of sea surface is good.
- There is some problems on ocean observations by the hyperspectral imager.

On-orbit Chinese satellite ocean observing system



- **FY-3A / MERSI, HY-1B / COCTS and HJ-1A / HSI are used for ocean color.**
- **FY-1D / MVISR, FY-2D / VISSR-2, FY-2E / VISSR-2, FY-3A / VIRR, HY-1B / COCTS and FY-3A / MWRI are used for SST.**
- **FY-3A / MWRI are also used for sea surface wind speed.**
- **CRS-3, 5, 6, 8 / SAR are used for ocean dynamics, sea surface targets, shallow water topography and so on.**
- **The other 19 sensors are used for coastal zone observations.**

On-orbit Chinese satellite ocean observing system

Satellite	Sensor	Launch date	Characteristics	Smilar Sensor	Ocean application	Note
FY-1D	MVISR-2	2002.5	10 channels, VIS-NIR	AVHRR, CZCS	SST, ocean color, meteorology	With data distribution website
FY-2D	VISSR-2	2006.12	5 channels, VIS-NIR	GOES / Imager	SST, meteorology	
FY-2E	VISSR-2	2008.12	5 channels, VIS-NIR	GOES / Imager	SST, meteorology	FY-2C follow-on
FY-3A	VIRR	2008.5	10 channels, VIS-NIR	AVHRR, CZCS	SST, ocean color, meteorology	With data distribution website
FY-3A	MERSI	2008.5	20 channels, VIS-NIR	MODIS	ocean color, meteorology	
FY-3A	MWRI	2008.5	5 channels, H,V polarization	TMI	SST, SSW, meteorology coastal zone	
HY-1B	COCTS	2007.4	10 channels, VIS-NIR	OCTS, SeaWiFS	ocean color, SST	With data distribution website
HY-1B	CZI	2007.4	4 channels, CCD,20nm, 250m		coastal zone	
CRS-3	SAR	2007.11	L-band，3m，HH		ocean dynamics, sea surface features, coastal zone	Without data distribution website
CRS-5	SAR	2008.12				
CRS-6	SAR	2009.4				
CRS-8	SAR	2009.12				
CRS-2	HR	2007.5	High spatial resolution，0.5 — 2m		coastal zone	
CRS-4	HR	2008.12				
CRS-7	HR	2009.12				
CRS-9	HR	2010.3				
CRS-2	PAN-MS	2007.5				
CRS-4	PAN-MS	2008.12				
CRS-7	PAN-MS	2009.12				
CRS-9	PAN-MS	2010.3				
HJ-1A	HSI	2008.9	0.49-0.95 μ m，4nm，100m	HICO, Hyperion	ocean color, vegetation, red tides, oil spill	With data distribution website
HJ-1A	CCD	2008.9	4 channels, 30m	Landsat7	coastal zone, SST	
HJ-1B	CCD	2008.9	4 channels, 30m	Landsat7	coastal zone, SST	
CBERS-2	CCD	2003.10	5 channels, 20m	Landsat7, Spot5	coastal zone	With data distribution website
CBERS-2B	CCD	2007.9	5 channels, 20m	Landsat7, Spot5	coastal zone	
CBERS-2B	HR	2007.9	high resolution camera, 2m	QuickBird	coastal zone	
ZY-2B	HR	2002.10	high resolution camera, 2m	IKONOS	coastal zone	Without data distribution website
ZY-2B	PAN-MS	2002.10	4 channels, 5m	IKONOS	coastal zone	
ZY-2C	HR	2004.11	high resolution camera, 2m	IKONOS	coastal zone	
ZY-2C	PAN-MS	2004.11	4 channels, 5m	IKONOS	coastal zone	
DMC-BJ1	PAN-MS	2005.10	3 channels, 4m	Landsat7	coastal zone	With data distribution website

—— Summary

- 31 on-orbit sensors
- 5 microwave sensors and active sensors, only 16%.

  CRS-3, 5, 6, 8 / SAR data is not readily available
- 26 visible and infrared sensors, 84%
- The operational data products and ocean monitoring are limited by the clear sky.

Ocean data products of on-orbit Chinese ocean observing sensors

- Among 31 on-orbit sensors,

  12 on-orbit sensors for the retrieval of ocean data products.

  19 high spatial resolution optical sensors for observation of coastal areas and sea surface targets.
- CRS-3, 5, 6, 8/SAR (L), data products of ocean dynamics, sea surface characteristics such as ocean waves etc., no data distribution website.
- FY-3A/MWRI, retrieval of SST and SSW. It doesn't work.
- FY-3A/MERSI, HY-1B/COCTS and HJ-1A/HSI, retrieval of ocean color parameters.
- FY-3A/VIRR, FY-1D/MVISR-2 and HY-1B/COCTS, retrieval of SST.

  FY-2D/VISSR-2 and FY-2E/VISSR-2, retrieval of SST.
- Following introduction will focus on the ocean data products of FY-3A/MERSI, HY-1B/COCTS, HJ-1A/HSI, FY-3A/VIRR, FY-3A/MWRI and FY-2D, 2E/VISSR-2.

Ocean data products of on-orbit Chinese ocean observing sensors —— FY-3A/MERSI data products

Instrument	*Category*	*Product name / Product type*	*Resolution*	*Level*
Medium Resolution Spectral Imager (MERSI)	L1 Data	*FY-3A MERSI L1data (250 m) / L1	250 m	L1
		*FY-3A MERSI L1data (1 km) / L1	1000 m	L1
		*FY-3A MERSI L1data (OBC) / L1	NONE	L1
	Projected Area Dataset	*MERSI Geographic Lat/Lon projection dataset 250 m	250 m	L2
		*MERSI Geographic Lat/Lon projection dataset 1 km	1000 m	L2
	Precipitation Water Vapor	MERSI Monthly precipitation water vapor over land	5000m	L3
		MERSI ten-day precipitation water vapor over land	5000m	L3
		*MERSI precipitation water vapor over land	1000 m	L2
	Cloud Detection	*MERSI cloud detection product /CLM	1000 m	L2
	Land Surface Reflectivity	*MERSI Land Surface Reflectivity 250 m / LSR	250 m	L2
		*MERSI Land Surface Reflectivity 1km /LSR	1000 m	L2
	Aerosol over Ocean	*MERSI daily product for aerosol over ocean / ASO	1000 m	L2
		MERSI ten-day product for aerosol over ocean	5000 m	L3
		MERSI monthly product for aerosol over ocean	5000 m	L3
	Aerosol over Land	*MERSI daily product for aerosol over land /ASL	1000 m	L2
		MERSI ten-day product for aerosol over land	5000 m	L3
		MERSI monthly product for aerosol over land	5000 m	L3
	Ocean Color / Chlorophyll	*MERSI daily ocean color product /OCC	1000 m	L2
		MERSI ten-day ocean color product	5000 m	L3
		MERSI monthly ocean color product	5000 m	L3
	Normalized Derived Vegetation Index	MERSI ten-day vegetation index product	250 m	L3
		MERSI monthly vegetation index product	250 m	L3

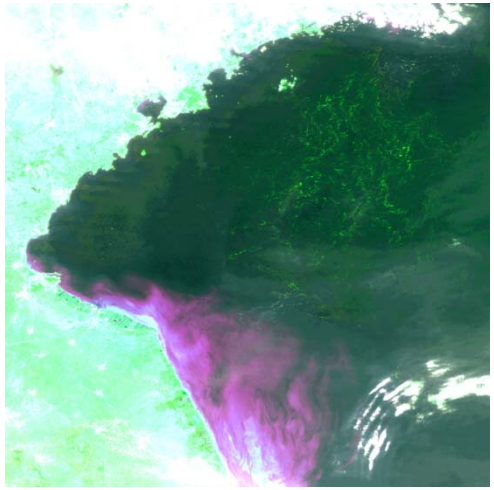
Note: Data products marked with asterisk (*) can be downloaded from the service website for remote sensing data of FY satellites

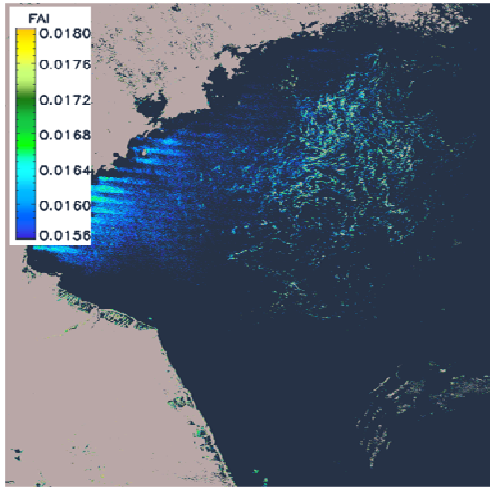
Ocean data products of on-orbit Chinese ocean observing sensors —— FY-3A/MERSI data products

http://fy3.satellite.cma.gov.cn/arssen/

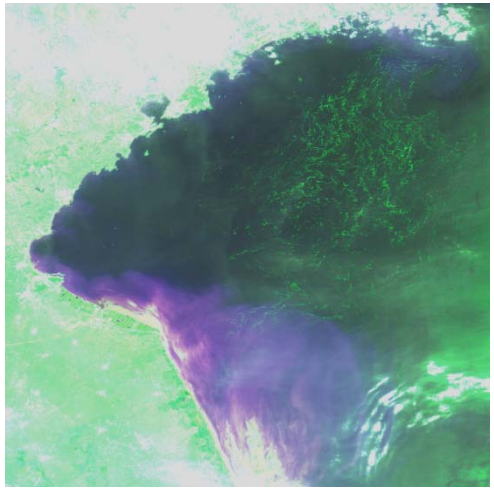
Ocean data products of on-orbit Chinese ocean observing sensors
—— FY-3A/MERSI data products

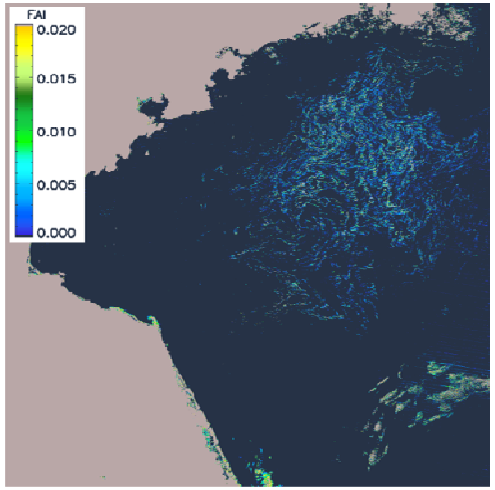
MERSI
RGB & FAI
2009/07/02
10:15





MODIS
RGB & FAI
2009/07/02
10:35



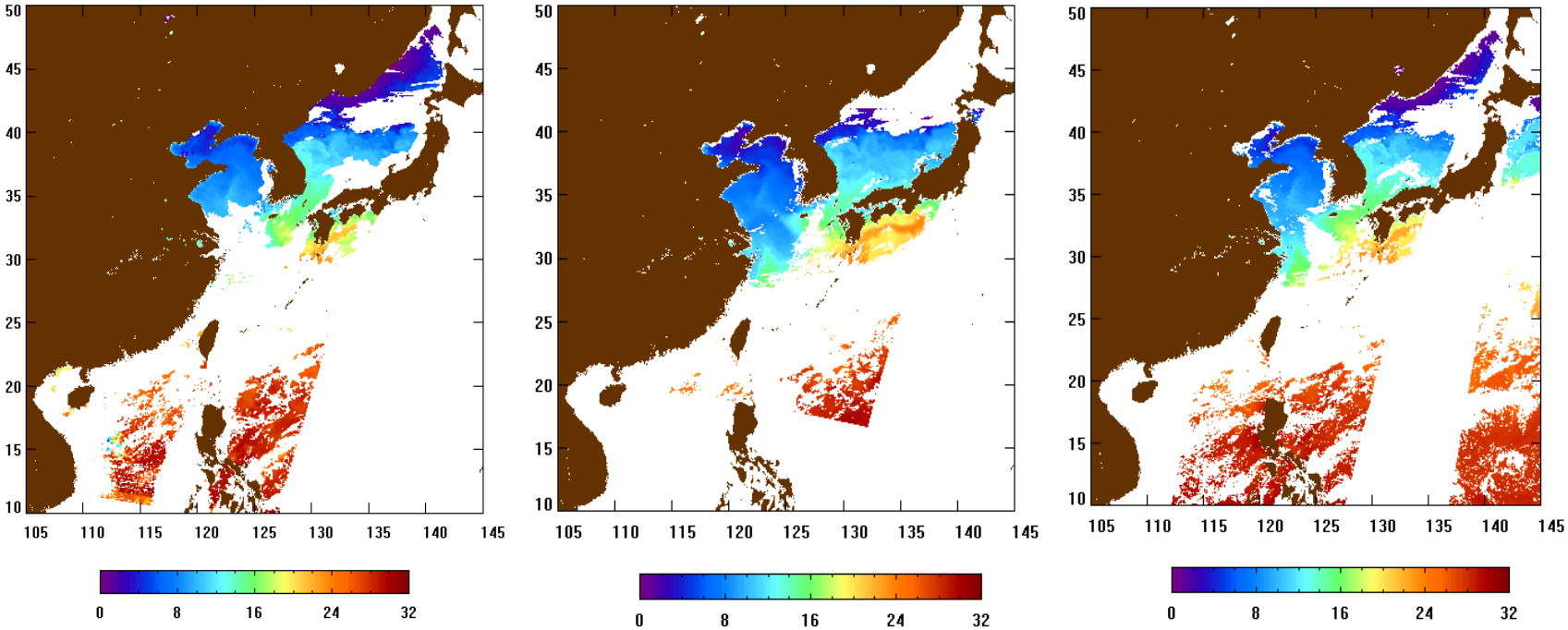


Hu, A novel ocean color index to detect floating algae in the global oceans. *Remote Sens.Environ*. 113:2118-2129. (2009)

Ocean data products of on-orbit Chinese ocean observing sensors —— HY-1B/COCTS data products

Level	Products
Level 0	Raw data cocts.L0
Level 1	L1A data with cloud detection and geo-location
	L1B calibrated geo-located radiances
Level 2	Normalized water-leaving Radiances at 6 bands (412,443,490,510,555, 670 nm)
	Aerosol radiance at 3 bands (670, 750, 865 nm)
	Chlorophyll a concentration
	Pigment concentration
	SST
	The ratio of aerosol radiance at 7th and 8th bands
	Aerosol optical thickness（865 nm）
	Total suspended matter concentration
	Diffuse attenuation coefficient
Level 3	Weekly and monthly products for 16 level 2 data products

Ocean data products of on-orbit Chinese ocean observing sensors
—— HY-1B/COCTS data products



NOAA-17 AVHRR SST　　HY-1B COCTS SST　　Terra MODIS SST

Comparison of AVHRR, COCTS and MODIS SST on 6 April 2009 & the statistics

Sensor	*Number*	*Bias*	*Standard deviation*
AVHRR - MODIS	119	0.11	0.33
COCTS - MODIS	188	-1.15	0.50
COCTS - AVHRR	134	-1.16	0.74

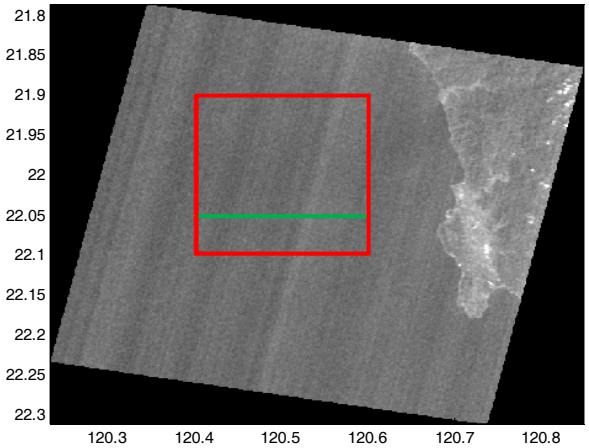
Ocean data products of on-orbit Chinese ocean observing sensors —— HJ-1A/HSI data products (Planned)

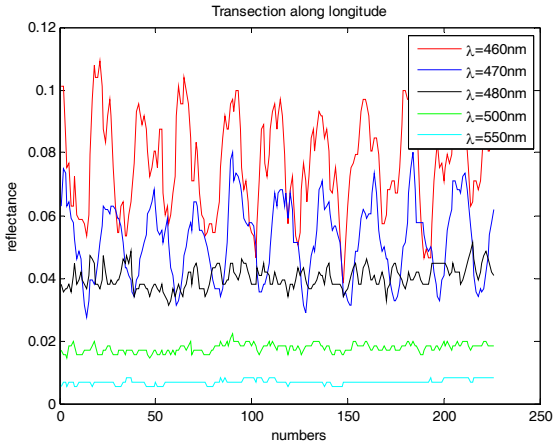
Product	*Monitoring area*	*Data type*	*Spatial resolution*
Chlorophyll a Concentration	Inshore water, estuary, lake	4 days, monthly, seasonal, annual	30m/100m
Suspended matter Concentration	Inshore water, estuary, lake	4 days, monthly, seasonal, annual	30m/100m
Transparence	Inshore water, estuary, lake	4 days, monthly, seasonal, annual	30m/100m
Euphotic depth	Inshore water	4 days, monthly, seasonal, annual	30m/100m
Absorption coefficient of CDOM	Inshore water	4 days, monthly, seasonal, annual	100m/1000m
Ocean primary Productivity	Inshore water	4 days, monthly, seasonal, annual	30m/100m
Nutrition index	Inshore water, estuary, lake	4 days, monthly, seasonal, annual	30m/100m/500m
Eutrophication	Inshore water, lake	monthly	30m/100m
Water quality access of inshore water	Inshore water	seasonal, annual	30m/100m/500m
Water quality access of estuary	estuary	seasonal, annual	30m/100m/500m
Identification of algae and sea grass	Inshore water, estuary, lake	4 days, monthly, seasonal, annual	30m/100m

Ocean data products of on-orbit Chinese ocean observing sensors
—— HJ-1A/HSI data products (Planned)

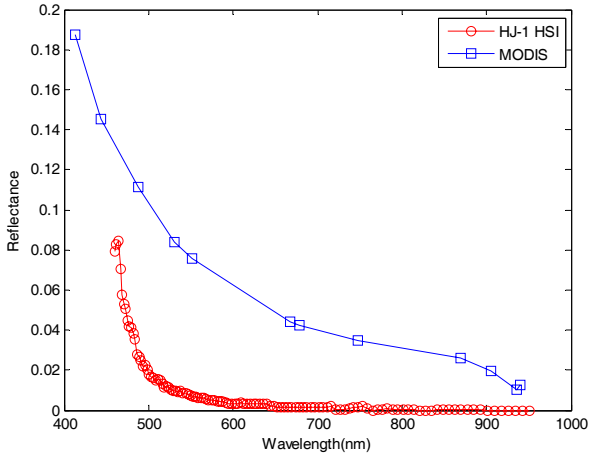
The noise and spectral reflectance of HJ-1A/HSI data

HJ-1A/HSI
2010-3-8 02:46
20.53E 22.06N





Reflectance at 5 bands along green section



Mean spectral reflectance in the red rectangle

Ocean data products of on-orbit Chinese ocean observing sensors —— FY-3A/VIRR data products

Sensor	Category	Product name / Product type	Resolution	Level	Proje-ction
Visible and InfraRed Radiometer (VIRR)	L1 Data	*FY3A VIRR Level1 Product /L1	1000M	L1	NUL
		*FY3A VIRR Level1 OBC Product /L1	NONE	L1	NUL
	Land Surface Reflectivity	*VIRR Land Surface Reflectance Factor /LSR	1000M	L2	NUL
	Sea Surface Temperature	5-Day VIRR 1km Sea Surface Temperature Product	1000M	L3	GLL
		*Daily VIRR 1km Sea Surface Temperature Product / SST	1000M	L2	GLL
		Monthly VIRR 1km Sea Surface Temperature Product	1000M	L3	GLL
		Ten-day VIRR 1km Sea Surface Temperature Product	1000M	L3	GLL
	Cloud Mask	FY3A VIRR CLOUD MASK	1000M	L2	NUL
	NDVI	VIRR monthly vegetation index	1000M	L3	HAM
		VIRR dekad Vegetation Index	1000M	L3	HAM
	Cloud Amount and Cloud Type/ CAT	*Global Cloud Amount and Cloud Type	5000M	L2	GLL
	Fog Detection	Daily VIRR FOG Product	1000M	L2	GLL
	Outgoing Long-wave Radiation	*VIRR Global Daily Average OLR/OLR	1000M	L2	GLL
		VIRR Global Monthly Average OLR	1000M	L3	GLL
		VIRR Global Five-Day Average OLR	1000M	L3	GLL
		VIRR Global Ten-Day Average OLR	1000M	L3	GLL
	Aerosol over Ocean	*Daily VIRR Ocean Aerosol Product/ ASO	1000M	L2	GLL
		Monthly VIRR Ocean Aerosol Product	1000M	L3	GLL
		Ten-day VIRR Ocean Aerosol Product	1000M	L3	GLL
	Cloud Amount	Global Monthly mean Cloud Amount	5000M	L3	GLL
		Global Ten-day mean Cloud Amount	5000M	L3	GLL
	Cloud Physical Parameters	* Daily Cloud Top Temperature/Cloud Top Height/cloud Optical Thickness Products/CPP	5000M	L2	GLL
		Monthly mean Cloud Top Temperature/Cloud Height/cloud Optical Thickness Products	5000M	L3	GLL
		Ten-day mean Cloud Top Temperature /Cloud Top Height/cloud Optical Thickness Products	5000M	L3	GLL
	Global Fire (GFR) produc	Global Hot Spot Monitoring	1000M	L2	GLL
	Sea-Ice cover	Daily VIRR Sea Ice Product	1000M	L2	GLL
		VIRR Sea Ice 10 days Cover Image Product	1000M	L3	GLL
	Total Precipitation Water for Clear Sky	VIRR Total Precipitable Water	5000M	L2	HAM
		Monthly mean VIRR Total Precipitible Water	10KM	L3	HAM
		Ten days mean VIRR Total Precipitable Water	10KM	L3	HAM
	Projected Area Dataset	*VIRR Geographic Longitude/Latitude Projected Area Data（Day）/PAD	1000M	L2	GLL
		VIRR Geographic Longitude/Latitude Projected Area Data（Night）/PAD	1000M	L2	GLL
	Land Surface Temperature	Daily VIRR Land Surface Temperature Product	1000M	L2	HAM
		Ten Days VIRR Land Surface Temperature Product	1000M	L3	HAM

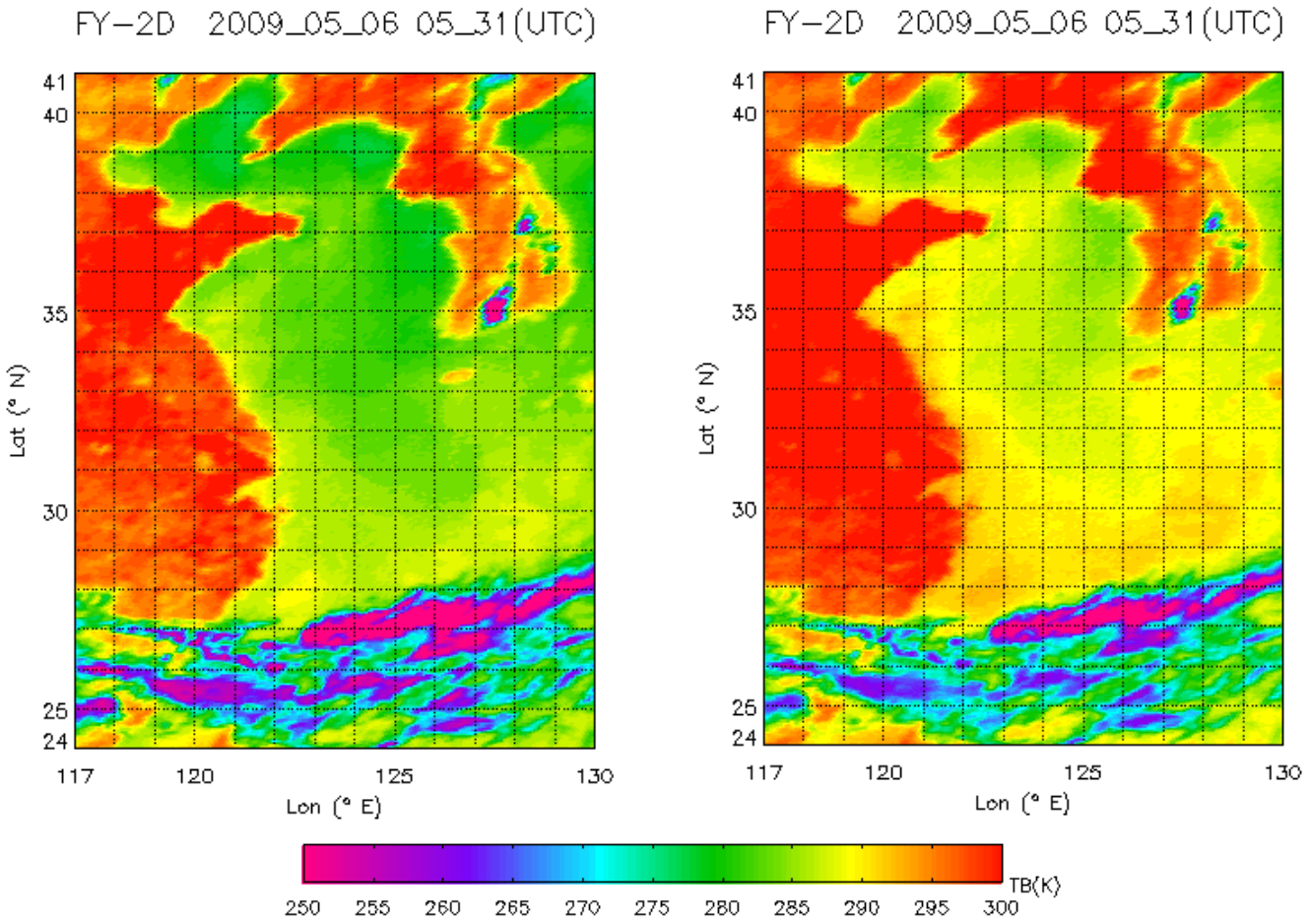
Note: Data products marked with asterisk (*) can be downloaded from the service website for remote sensing data of FY satellites

Ocean data products of on-orbit Chinese ocean observing sensors —— FY-2D, 2E / VISSR data products

Category	Product Name / Product Type	Data Format	Channel	Resolution	Level	Projection
L1 Data	*Compressed full disk VISSR data	CSV	MLT	Full	L1	
	*Full disk image in nominal projection	HDF	MLT	Full	L1	
	Stretched full disk VISSR data	SVS	MLT	Full	L1	
ISCCP Data Set (IDS)	*ISCCP Data Set ORT Product	DAT			L2	
	*ISCCP Data Set AC Product	DAT			L2	
	*ISCCP Data Set B01 Product	DAT			L2	
	*ISCCP Data Set B02 Product	DAT			L2	
Cloud Classification (CLC)	*Cloud classification in Nominal format	HDF	MLT		L2	
	*Cloud classification in 9210 format	AWX	MLT		L2	
Cloud Total Amount((CTA)	*Total cloud cover in Nominal format	HDF			L2	
	Total cloud cover in 9210 format	AWX			L2	
Sectional Image Product (SEC)	*Animation image products of two FY-2 satellites	AWX	IR1		L2	
	*Lambert projected data (IR1, IR2, IR3, IR4)	AWX	IR1-4	5KM	L2	LBT
	*Mercator projected data (IR1, IR2, IR3, IR4)	AWX	IR1-4	5KM	L2	MCT
	*Geographic Lat/Lon projected data (IR1,IR2,IR3,IR4)	AWX	IR1-4	5KM	L2	GLL
	* Lambert projected data (VIS)	AWX	VIS	5KM	L2	LBT
	*Mercator projected data (VIS)	AWX	VIS	5KM	L2	MCT
	*Lambert projected data (VIS)	AWX	IR3	1KM	L2	LBT
	*Geographic Lat/Lon projected data (VIS)	AWX	VIS	5KM	L2	GLL
	*Cloud image over land of China (IR1, IR2, IR3, IR4)	AWX	IR1-4		L2	
	*Cloud image of large sea area (IR1, IR2, IR3, IR4)	AWX	IR1-4		L2	
	*Cloud image of small sea area (IR1, IR2, IR3, IR4)	AWX	IR1-4		L2	
	*Cloud image over land of China (VIS)	AWX	VIS		L2	
	*Cloud image of large sea area (VIS)	AWX	VIS		L2	
	*Cloud image of small sea area (VIS)	AWX	VIS		L2	
Surface Solar Irradiance (SSI)	*Ground incident solar radiation in 9210 format	AWX	VIS		L2	
Atmospheric Motion Vectors (AMV)	*Atmospheric motion vectors data product (IR1)	AWX	IR1		L2	
	*Atmospheric motion vectors data product (IR3)	AWX	IR3		L2	
Upper Troposphere Humidity (UTH)	*Water vapor content at upper and middle troposphere in nominal format	HDF	MLT		L2	
	*Water vapor content at upper and middle troposphere in 9210 format	AWX	MLT		L2	
Outgoing Long-wave Radiation (OLR)	* Daily mean OLR in nominal format	HDF	MLT		L2	
	* 3-hour OLR in nominal format	HDF	MLT		L2	
	* Daily mean OLR in 9210 format	AWX	MLT		L2	
	* 3-hour OLR in 9210 format	AWX	MLT		L2	
	* Pentad mean OLR in nominal format	HDF	MLT		L3	
	* Pentad mean OLR in 9210 format	AWX	MLT		L3	
	* Dekad mean OLR in nominal format	HDF	MLT		L3	
	* Dekad mean OLR in 9210 format	AWX	MLT		L3	
	* Monthly mean OLR in nominal format	HDF	MLT		L3	
	* Monthly mean OLR in 9210 format	AWX	MLT		L3	
Total Precipitation Water for Clear Sky (TPW)	* Atmospheric precipitable water in clear sky in nominal format	HDF	MLT		L2	
	* Atmospheric precipitable water in clear sky in 9210 format	AWX	MLT		L2	
Dust Storm Monitoring (DST)	* Dust monitoring in 9210 format	AWX	MLT		L2	
Sea Surface Temperature (SST)	* 3-hour mean SST in nominal format	HDF			L2	GLL
	* Daily mean SST in nominal format	HDF	MLT		L2	
	* Daily mean SST in 9210 format	AWX	MLT		L2	
	*Pentad mean SST in nominal format	HDF	MLT		L3	
	*Dekad mean SST in nominal format	HDF	MLT		L3	
	*Monthly mean SST in nominal format	HDF	MLT		L3	
Humidity Profile derived from Cloud Analysis (HPF)	*Humidity profile of cloud field in 9210 format (01K)	AWX	MLT		L2	
	*Humidity profile of cloud field in 9210 format (300)	AWX	MLT		L2	
	*Humidity profile of cloud field in 9210 format (400)	AWX	MLT		L2	
	*Humidity profile of cloud field in 9210 format (500)	AWX	MLT		L2	
	*Humidity profile of cloud field in 9210 format (700)	AWX	MLT		L2	
	*Humidity profile of cloud field in 9210 format (850)	AWX	MLT		L2	
	*Humidity profile of cloud field in 9210 format (925)	AWX	MLT		L2	
	* Humidity profile of cloud field in Nominal format	HDF	MLT		L2	
Temperature Blackbody Equivalent (TBE)	* Daily mean blackbody equivalent brightness temperature in nominal format	HDF	IR1		L2	
	* 1-hour blackbody equivalent BT in nominal format	HDF	IR1		L2	
	* Daily mean blackbody equivalent BT in 9210 format	AWX	IR1		L2	
	*1-hour blackbody equivalent BT in 9210 format	AWX	IR1		L2	
	*Pentad mean blackbody equivalent brightness temperature in nominal format	HDF	IR1		L3	
	* Pentad mean blackbody equivalent BT in 9210 format	AWX	IR1		L3	
	* Dekad mean blackbody equivalent brightness temperature in nominal format	HDF	IR1		L3	
	* Dekad mean blackbody equivalent BT in 9210 format	AWX	IR1		L3	
	* Monthly mean blackbody equivalent brightness temperature in nominal format	HDF	IR1		L3	
	Monthly mean blackbody equivalent brightness temperature in 9210 format	AWX	IR1		L3	
Snow Cover (SNW)	* Snow cover product in 9210 format	AWX	MLT		L2	
Precipitation Estimation (PRE)	*1-hour precipitation estimation in nominal format	HDF			L2	
	*1-hour precipitation estimation in 9210 format	AWX			L2	
	*3-hour precipitation estimation in nominal format	HDF			L2	
	*3-hour precipitation estimation in 9210 format	AWX			L2	
	*6-hour precipitation estimation in nominal format	HDF			L2	
	*6-hour precipitation estimation in 9210 format	AWX			L2	
	*24-hour precipitation estimation in nominal format	HDF			L2	
	*24-hour precipitation estimation in 9210 format	AWX			L2	
Precipitation Index (PRI)	*Nominal format precipitation index products	HDF	MLT			
	*3-hours precipitation index in nominal format	HDF	MLT			
	Nominal format precipitation index products	HDF	MLT			
	3-hours precipitation index in nominal format	HDF	MLT			

Note: Data products marked with asterisk (*) can be downloaded from the service website for remote sensing data of FY satellites

Ocean data products of on-orbit Chinese ocean observing sensors —— FY-2D, 2E / VISSR data products



Brightness temperature images at two infrared channels of FY-2D/VISSR

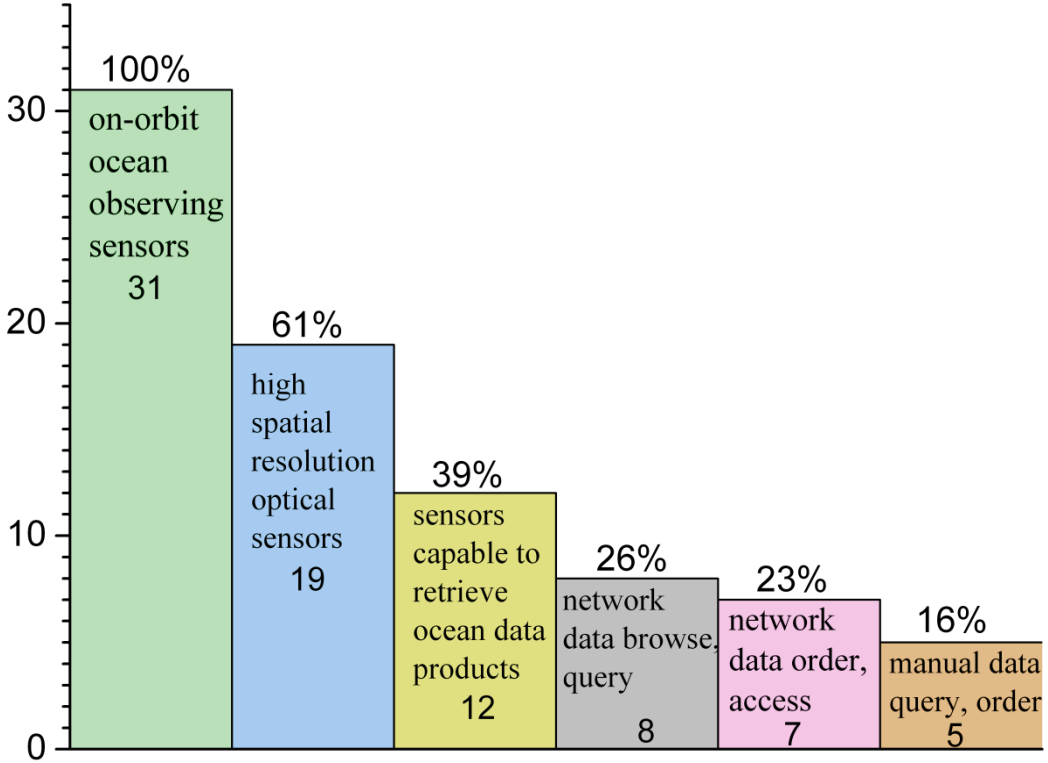
Ocean data products of on-orbit Chinese ocean observing sensors

—— Summary

- Ocean data products and data delivery of 12 on-orbit Chinese sensors
  12 sensors can provide L1 data, mainly SST and ocean color parameters.
- FY-n data service website is in both Chinese and English. Other websites are in Chinese.
- FY-n and HJ-n websites provide browse, query, order and download.
- HY-n website only provides browse and query. Its data ordering and delivery need to apply manually.
- There is no website for CRS-n data services, and the data delivery needs special applications.
- HJ-1A/HIS data website only offers data in the China seas. The level 1 data over ocean is inaccurate.
- HY-1B/COCTS L1 data is not stable.

Satellite / Sensor	Planned ocean data products	Operational ocean data products	Data browser		Data order		Similar Sensor
			Web-site	Man-ual	Web-site	Man-ual	
FY-3A / MERSI (MEdium Resolution Spectral Imager)	Ocean color, Atmospheric optical parameters	L1, Lw, CHL, TSM, a_{dg}, AOT, Ang. Coeff.	√ CN EN		√		MODIS
HY-1B / COCTS (Chinese Ocean Color and Temperature Scanner)	Ocean color parameters, SST	L1B, CHL, * SST	√ CN			√	OCTS, SeaWiFS
HJ-1A / HSI (Hyper Spectral Imager)	Ocean color parameters	L1	√ CN *		√ *		HICO, Hyperion
FY-3A / VIRR (Visible and InfraRed Radiometer)	SST, atmospheric optical parameters	L1, SST, AOT, Ang. Coeff.	√ CN EN		√		AVHRR, MODIS, AATSR
FY-1D / MVISR-2 (Multichannel Visible Infrared Scanning Radiometer)	The same as VIRR						
FY-2D、2E / VISSR (Visible and Infrared Spin Scan Radiometer)	SST	L1, SST	√ CN EN		√		
FY-3A / MWRI (MicroWave Radiation Imager)	Sea surface wind, SST	L1 *	√ CN EN		√		TMI
CRS-3,5,6,8 / SAR(L) (synthetic aperture radar)	Ocean dynamic parameters, sea surface targets	L1				√	

Ocean data products of on-orbit Chinese ocean observing sensors —— Summary



Statistics on data products and services of on-orbit Chinese satellite ocean observing sensors

- **Among 31 sensors, only 12 for the retrieval of ocean data products, 39%;**
- **7 can provide data browse, query, order and download in their websites, 23%.**
- **Compared Chinese with international ocean observing satellite systems, there is a greater gap on the retrieval algorithms and data services than the hardware system.**

Operational retrieval algorithms for Chinese ocean color data —— Bio-optical algorithm

- FY-3A/MERSI and HY-1B/COCTS can provide ocean color data products. So far, no technical documents and algorithm theoretical basis documents (ATBD) have been published.

- According to papers, an introduction of operational bio-optical retrieval algorithms is given here.

  In Case 1 water, the statistical retrieval algorithm of SeaWiFS OC4 is used.

  In case 2 water, the statistical algorithm is based on in-situ data measured at 81 stations in the Yellow and East China Seas in April 2003 by National Satellite Ocean Application Service (NSOAS).

Operational retrieval algorithms for Chinese ocean color data —— Bio-optical algorithm

The bio-optical statistical retrieval algorithms of HY-1B/COCTS in the Yellow and East China Seas are as follows.

The statistical retrieval algorithm for Chlorophyll concentrations (CHL) is:

$$\lg C = c_0 + c_1 \times \lg Xc + c_2 \times \lg^2 Xc \qquad \text{a= -1.0,} \qquad \text{c0= -0.37457,}$$

$$Xc = (R_{443} / R_{555})(R_{412} / R_{510})^a \qquad \text{c1= -3.7278,} \qquad \text{c2= -3.0679.}$$

The statistical retrieval algorithm for TSM Concentrations is:

$$\lg S = s_0 + s_1 \times (R_{555} + R_{670}) + s_2 \times (R_{490} + R_{555})$$

where s0=0.638188, s1=23.93439, s2=-0.53107

When TSM is lower than 300 mg/L, then

s0=0.58213, s1=23.84071, s2=-0.48532

The statistical retrieval algorithm for CDOM absorption ag is:

$$\lg Y = y_0 + y_1 \times \lg Xy + y_2 \times \lg^2 Xy + y_3 \times \lg^3 Xy + y_4 \times \lg^4 Xy$$

$$Xy = (R_{412} / R_{510})(R_{443} /(R_{555} + R_{670}))^d$$

Where, d=0.23, a regional constant,
y0=-0.93942, y1=5.01, y2=62.62175, y3=231.1851, y4=269.3769

So far, there are no publications for the bio-optical statistical retrieval algorithms of FY-3A / MERSI in the Yellow and East China Seas

Operational retrieval algorithms for Chinese ocean color data
—— Atmospheric correction algorithm

- The operational atmospheric correction algorithms for data products of two sensors are introduced.

  In Case 1 water, the standard algorithm of Gordon and Wang is used.

  In Case 2 water,

  FY-3A / MERSI still uses the standard algorithm;

  HY-1B/COCTS divides Case 2 water into low and high turbid water, and Arnone's iterative algorithm and an optimization method based on in-situ Rrs are applied respectively.

Operational retrieval algorithms for Chinese ocean color data —— Summary

- At present Chinese satellite ocean color data products play a ‘supporting role’ of MODIS data products in operational monitoring of ocean ecology environment and ocean ecology disaster, for example, the quasi real-time monitoring of green tides in Qingdao in 2008 and 2009.
- Reasons are given as follows:

  Firstly, no strict operational retrieval algorithms for FY-3A / MERSI and HY-1B / COCTS have been developed yet. There are no recognized evaluation results on errors of ocean color data products yet.

  Secondly, it is quick and convenient to download the MODIS data, and SeaDAS software for data display and processing is also provided. There is a limit to the quantity of download data for FY-3A / MERSI, and a software tool only for image display is provided. Data of HY-1B / COCTS can be obtained by manually filling application forms, and the software tool is not available.

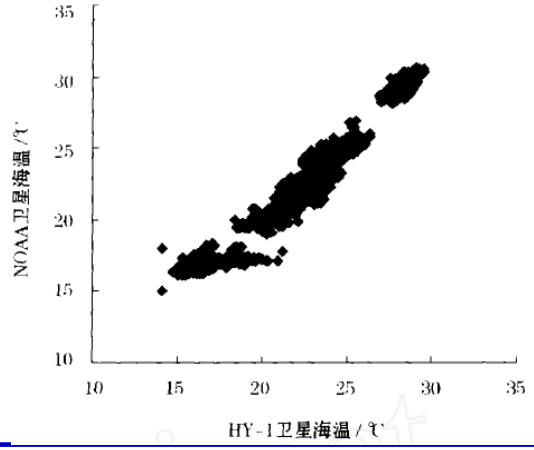
Operational retrieval algorithms for Chinese satellite SST data and the data assimilation of SST data into ocean models
—— retrieval algorithm

- HY-1B/COCTS, FY-3A/VIRR and FY-2D/VISSR can provide SST products. **So far, no technical documents and ATBD of sensors providing SST data products have been published.**
- **HY-1B/COCTS is the earliest sensor providing SST data products. Its retrieval algorithm is as follows**

$$\mathrm{SST}_{\mathrm{sat}} = a + bT_9 + c(T_9 - T_{10})\mathrm{SST}_{\mathrm{guess}} + d(T_9 - T_{10})(\sec\theta - 1)$$

Where , $\mathrm{SST}_{\mathrm{guess}}$ is the first guess SST, a = 0.0968204, b = 2.036246, c = 0.742046, d = -261.98

Statistical regression of the brightness temperature from AVHRR and MODIS infrared channel is used to determine the retrieval coefficients.

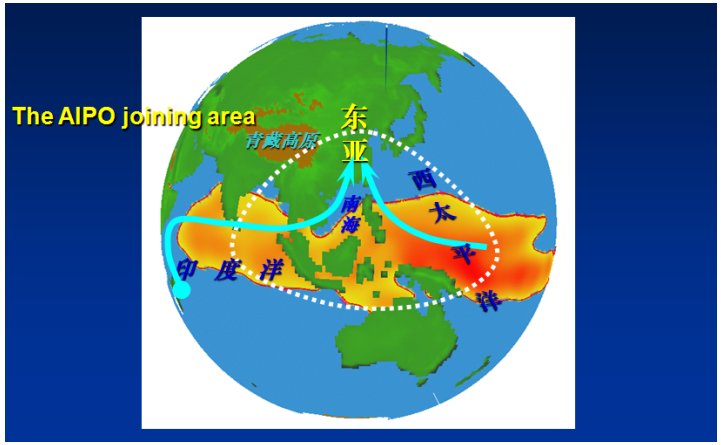


Comparison of SST data between HY-1B / COCTS and NOAA / AVHRR.

The bias is 0.8 ℃, the RMSE is 0.94℃, and the correlation coefficient is 0.95.

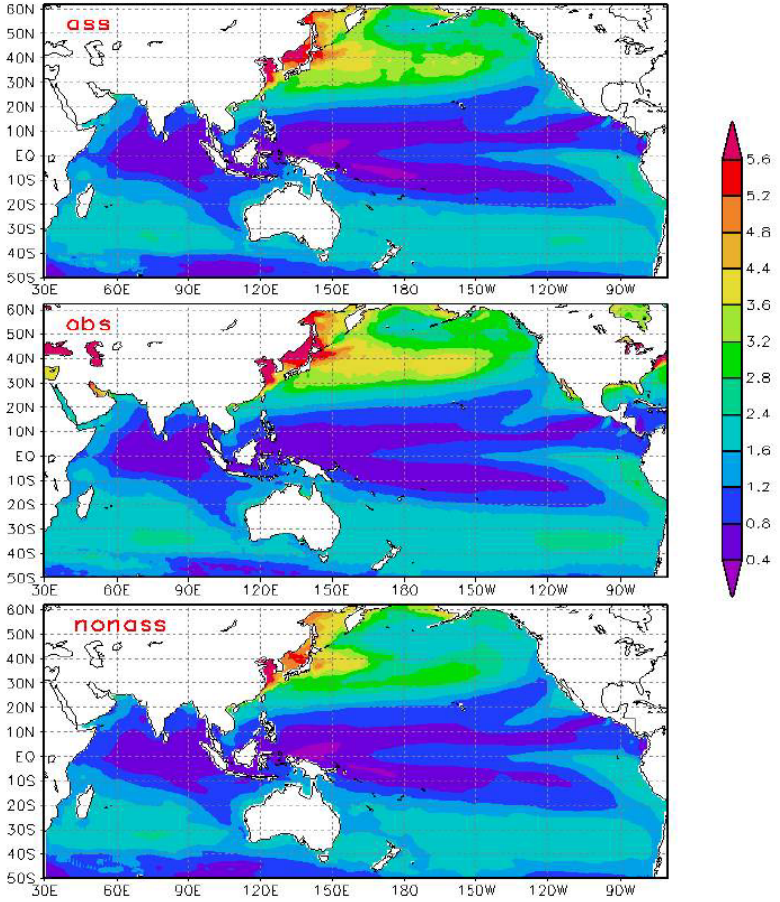
The data set compared includes 5000 match-up data, and the time difference is less than 6 hours

Operational retrieval algorithms for Chinese satellite SST data and the data assimilation of SST data into ocean models
—— data assimilation



The AIPO (Asia and Indian-Pacific Ocean) ocean reanalysis system is developed and reanalysis data has being delivered by IAP / CAS. It includes a multivariate ocean data assimilation system.

The data assimilation uses Sea Level Anomaly (SLA) data, which are merged by multi-altimeter data provided by CNES AVISO website, and high resolution SST data, which are merged by AVHRR and AMSR data.

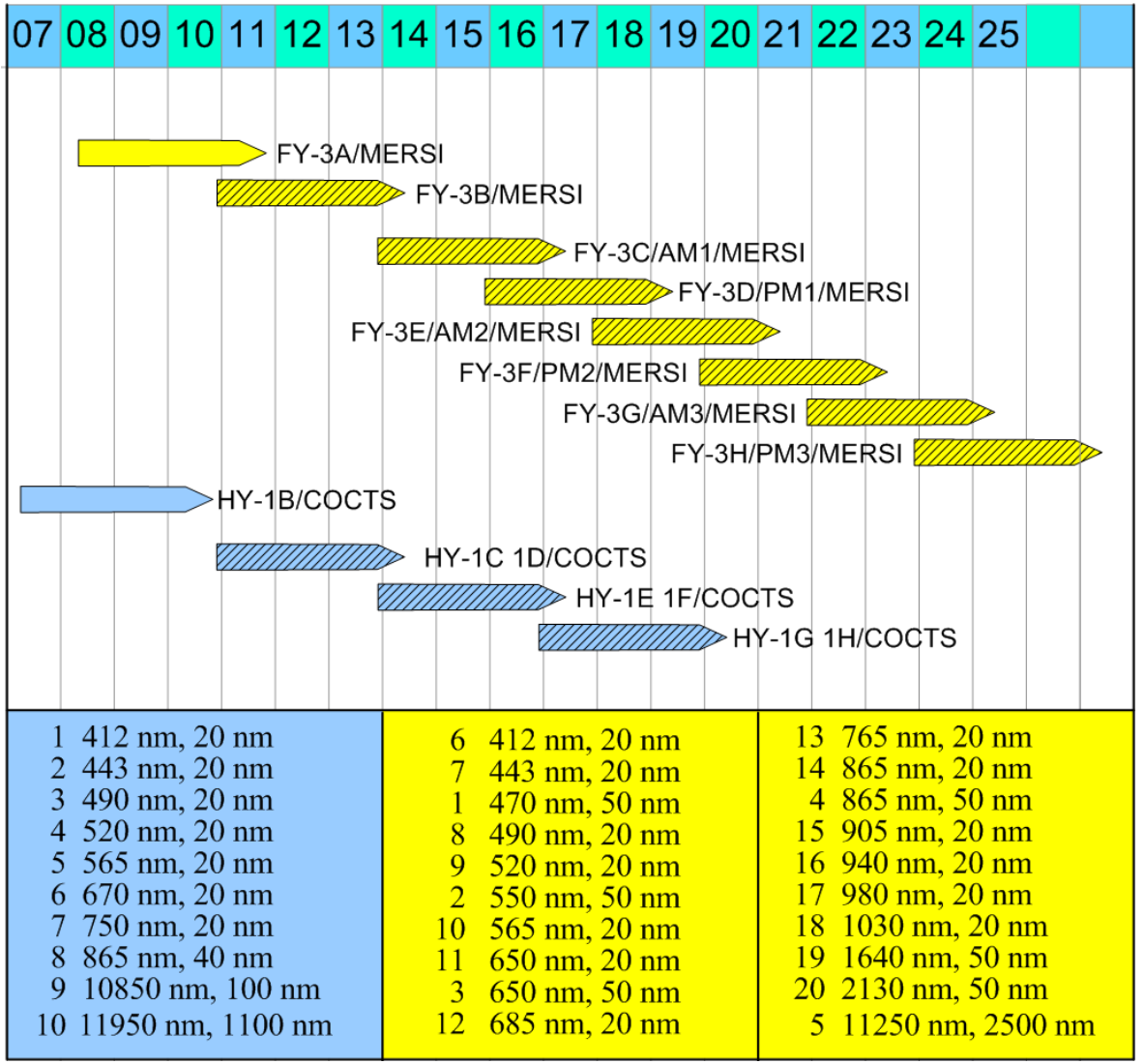


The variability of SST during the period of 1993-2006 from (top) the assimilation experiment, (middle) the observations, (bottom) the experiment without assimilation.

Suggestions on current Chinese satellite ocean observing systems

1. The instrument configuration and time coverage should be coordinated by China National Space Administration (CNSA) among six Chinese operational satellite Earth observing systems affiliated with related application agencies.

For example:



Suggestions on current Chinese satellite ocean observing systems

2. The ocean data products and operational retrieval algorithms for 12 on-orbit sensors should be developed, improved and evaluated to meet the requirements of the international GEOSS and various applications in China.
3. Every satellite application agencies should quickly improve websites of satellite data product services to bring them in line with international standards. The websites of data products established by NASA and ESA are good examples.
4. Technical and algorithm theoretical basis documents for satellite ocean color and SST data products should be provided as soon as possible.
5. Operational retrieval algorithms for ocean data products of microwave sensors, including SAR, MWRI, SCAT and ALT, are weak. Their data products should be developed.

Suggestions on future Chinese satellite mission

1. Virtual constellations of domestic and international multi-satellite similar sensors.

   Chinese and international similar sensors during 2005 –2025, such as ocean color, SST, SAR, have already constituted a long time continuous observation of multi-satellite platforms. Research and development of virtual constellations is timely.

   This can refer to the ocean color radiometry virtual constellation (OCR-VC) approved by CEOS in September 2009. The proposal and build of the virtual constellation concept serve to existing projects and is committed to increase mutual beneficial cooperation.

Suggestions on future Chinese satellite mission

2. High-resolution multi-sensor synchronous observing system combining SARs with high spatial resolution optical sensors / hyperspectral imagers.

From 2006 to 2009, five L-band SAR satellites were launched. The planned SAR satellites will work at L, S, C, X-band.

In addition to FY-n satellite series, the other five satellite series all carry high spatial resolution optical sensors.

They compose the optical - microwave high resolution multi-sensor simultaneous observing system, which may be the characteristics of current Chinese satellite ocean observing system.

To establish simultaneous high-resolution multi-sensor observing system accords with relevant parts of 16 major special projects in Chinese medium-and long-term program for science and technology development by 2020.

Suggestions on future Chinese satellite mission

3. A new concept of satellite for Chinese coastal monitoring – high-resolution ocean color sensors onboard geostationary satellites.

Due to the complicated sea conditions, changeable aerosol and frequent cloud cover, some key application issues (for example, monitoring and forecast of ecological disasters such as red tide, green tides, oil spills, etc.) meet difficulties on satellite observation and monitoring in Chinese coastal area.

High-resolution sensors first mean high spatial and spectral resolution. Geostationary satellites provide observations with high temporal resolution, which leads to a requirement of high radiometric resolution. Table 33 shows application examples in the coastal zone and their typical resolution requirements. Table 34 shows the spectral and resolution requirements of some applications in coastal zone.

Suggestions on future Chinese satellite mission

3. A new concept of satellite for Chinese coastal monitoring – high-resolution ocean color sensors onboard geostationary satellites. (Continue)

Application examples in the coastal zone and their typical resolution requirements

Application	*Temporal resolution*	*Spatial resolution*	*Radiometric resolution*	*Spatial coverage*
Carbon cycle, biogeochemistry	Week—Month	1–10 km	High	10^2 – 10^5 km
Red tide, River water quality	Day—Week	0.1 – 1 km	High	1 – 100 km
Oil spill, other pollution	Hour—Day	0.1 – 1 km	Medium	1 – 100 km
Water depth, seabed habitat	Week—Month	0.001 – 0.1 km	Low—Medium	1 – 100 km
Wetlands, swamp	Week—Month	0.01 – 0.1 km	Medium	1 – 50 km
Land vegetation	Week—Month	0.01 – 0.1 km	Low	10 – 100 km

Suggestions on future Chinese satellite mission

3. A new concept of satellite for Chinese coastal monitoring – high-resolution ocean color sensors onboard geostationary satellites. (Continue)

Spectral and resolution requirements of some applications in coastal zone

Applications in coastal zone	*Spectral requirements*
CHL, TSM, and CDOM concentration in ocean	412, 443, 490, 510, 560, 620, 665, 681, 709, 754, 760, 779, 865, 885, 900nm
Identification of phytoplankton species	Slightly different absorption spectra shape of different species
Coral mapping	Optimal bands: 451, 482, 498, 526, 556, 580, 610, 647nm
Algae between High/low tide line and vegetation mapping	Optimal bands: 500, 540, 565, 580, 610, 790nm
Water depth mapping	600 – 640 nm red bands are crucial
Atmospheric correction in Case 2 water	When Lw≠0, 1640nm and 2130nm are useful When absorptive aerosols exist, ultraviolet bands are needed
Red tide	Red shift of sunlight fluorescence peak has the potential

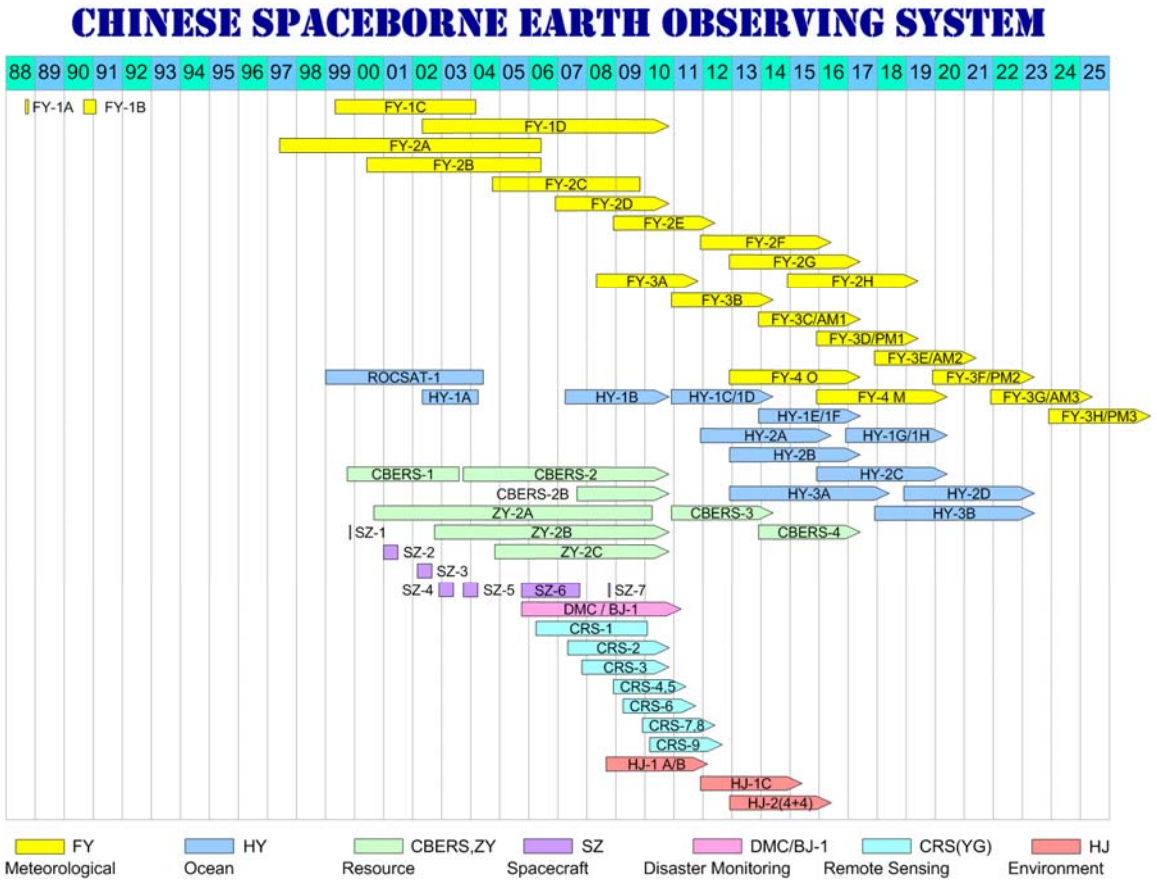
WP2 Summary

7 spaceborne series

55 satellites,

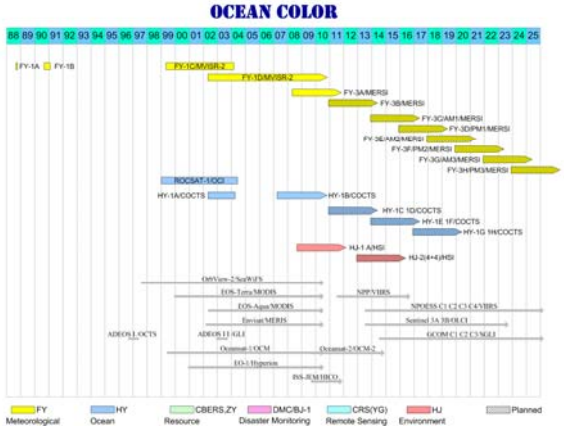
2 constellations

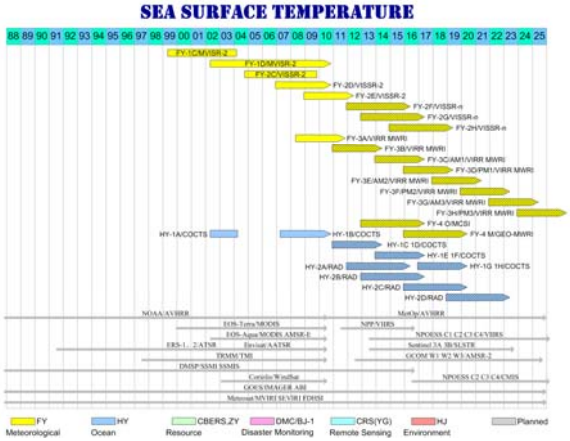
7 spacecrafts:

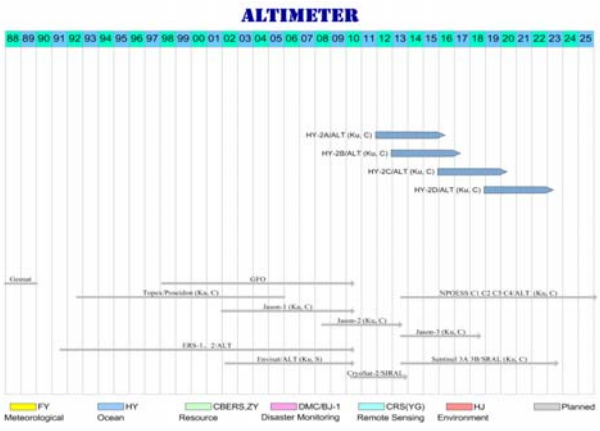


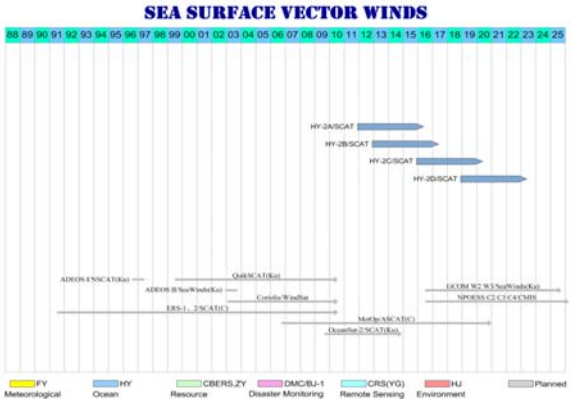
WP2 Summary

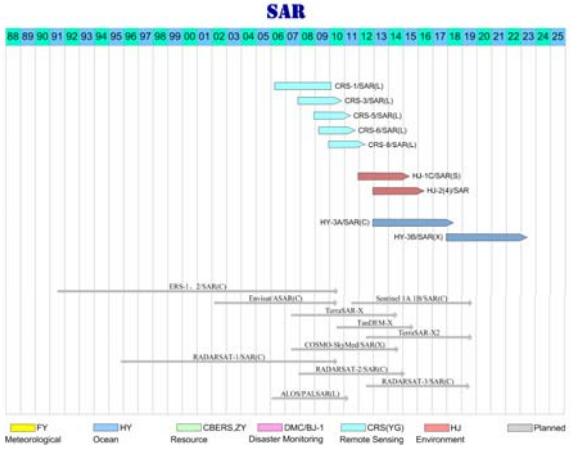
6 types of sensors for ocean observing :

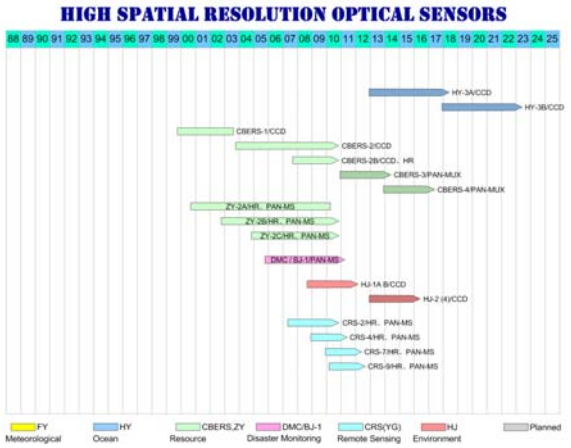




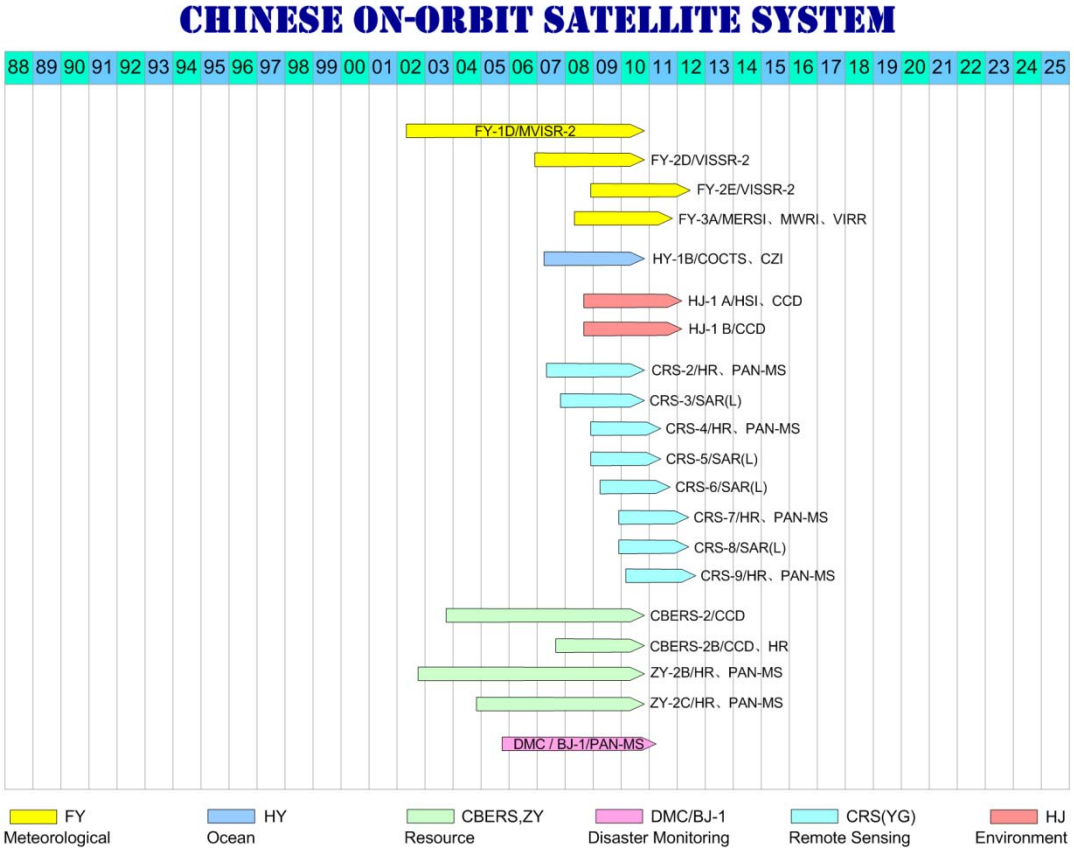








WP2 Summary



31 on-orbit sensors

5 microwave sensors and active sensors, only 16%.

CRS-3, 5, 6, 8 / SAR data is not readily available

26 visible and infrared sensors, 84%

WP2 Summary

12 on-orbit Chinese sensors provide L1 data, mainly SST and ocean color parameters. HY-1B/COCTS L1 data is not stable

- **FY-n and HJ-n websites provide browse, query, order and download.**
- **HY-n website only provides browse and query. Its data ordering and delivery need to apply manually.**
- **There is no website for CRS-n data services, and the data delivery needs special applications.**
- **HJ-1A/HIS data website only offers data in the China seas. The level 1 data over ocean is inaccurate.**

Satellite / Sensor	*Planned ocean data products*	*Operational ocean data products*	*Data browser*		*Data order*		*Similar Sensor*
			Web-site	*Man-ual*	*Web-site*	*Man-ual*	
FY-3A / MERSI (MEdium Resolution Spectral Imager)	Ocean color, Atmospheric optical parameters	L1, Lw, CHL, TSM, a_{dg}, AOT, Ang. Coeff.	√ CN EN		√		MODIS
HY-1B / COCTS (Chinese Ocean Color and Temperature Scanner)	Ocean color parameters, SST	L1B, CHL, * SST	√ CN			√	OCTS, SeaWiFS
HJ-1A / HSI (Hyper Spectral Imager)	Ocean color parameters	L1	√ CN *		√ *		HICO, Hyperion
FY-3A / VIRR (Visible and InfraRed Radiometer)	SST, atmospheric optical parameters	L1, SST, AOT, Ang. Coeff.	√ CN EN		√		AVHRR, MODIS, AATSR
FY-1D / MVISR-2 (Multichannel Visible Infrared Scanning Radiometer)	The same as VIRR						
FY-2D、2E / VISSR (Visible and Infrared Spin Scan Radiometer)	SST	L1, SST	√ CN EN		√		
FY-3A / MWRI (MicroWave Radiation Imager)	Sea surface wind, SST	L1 *	√ CN EN		√		TMI
CRS-3,5,6,8 / SAR(L) (synthetic aperture radar)	Ocean dynamic parameters, sea surface targets	L1				√	

Thanks for your attention !