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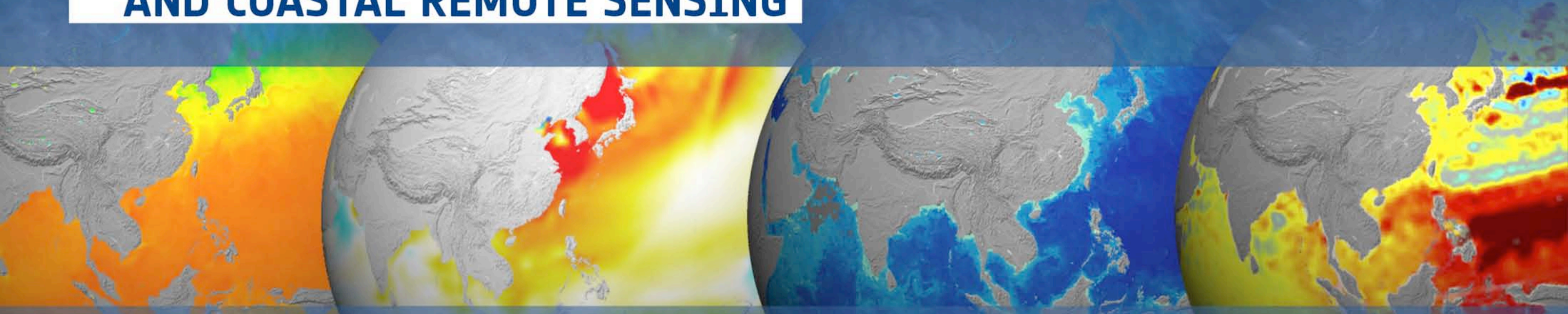
ESA–MOST China Dragon 4 Cooperation

→ ADVANCED TRAINING COURSE IN OCEAN AND COASTAL REMOTE SENSING



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

Applications in China Seas

By YANG Jingsong

Hosted by

Applications in China Seas Including Waves & Currents

YANG Jingsong

State Key Lab of Satellite Ocean Environment Dynamics (SOED)
Second Institute of Oceanography (SIO), SOA, China

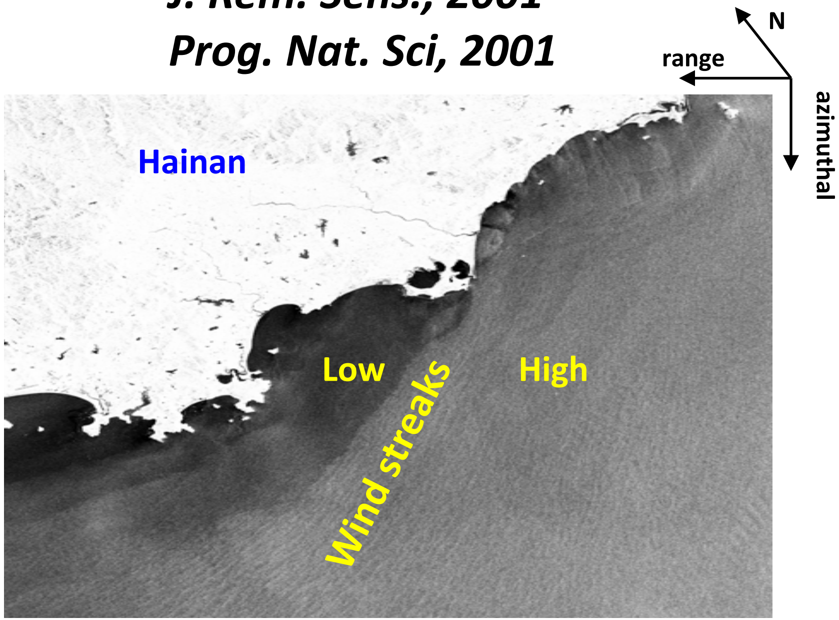
Outline

1. Ocean surface winds
2. Typhoons
3. Ocean surface waves
4. Ocean internal waves
5. Eddies
6. Ship wakes

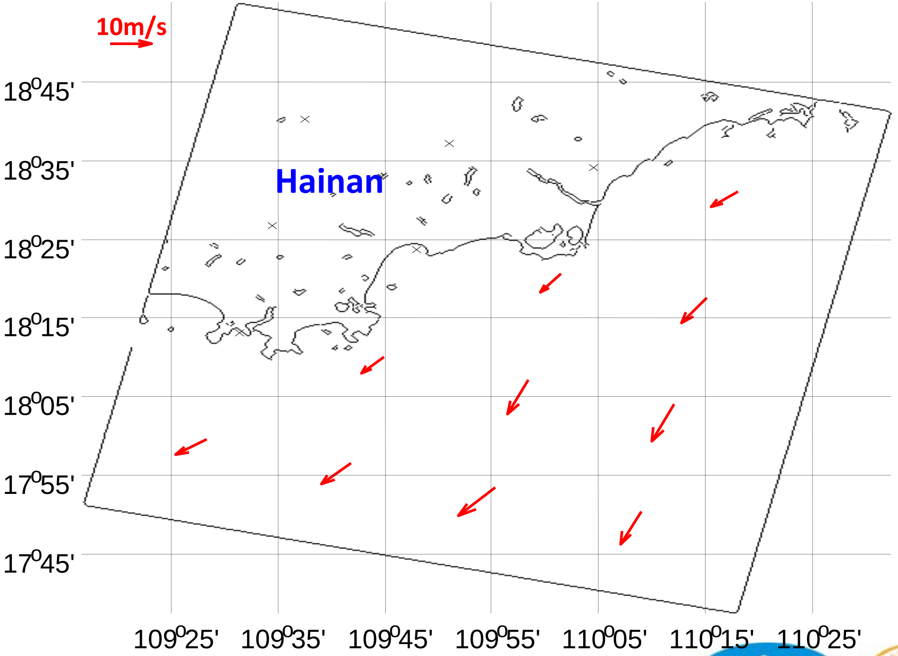
1. Ocean surface winds

J. Rem. Sens., 2001

Prog. Nat. Sci, 2001



Speed, Direction, Stress, Drag Coefficient

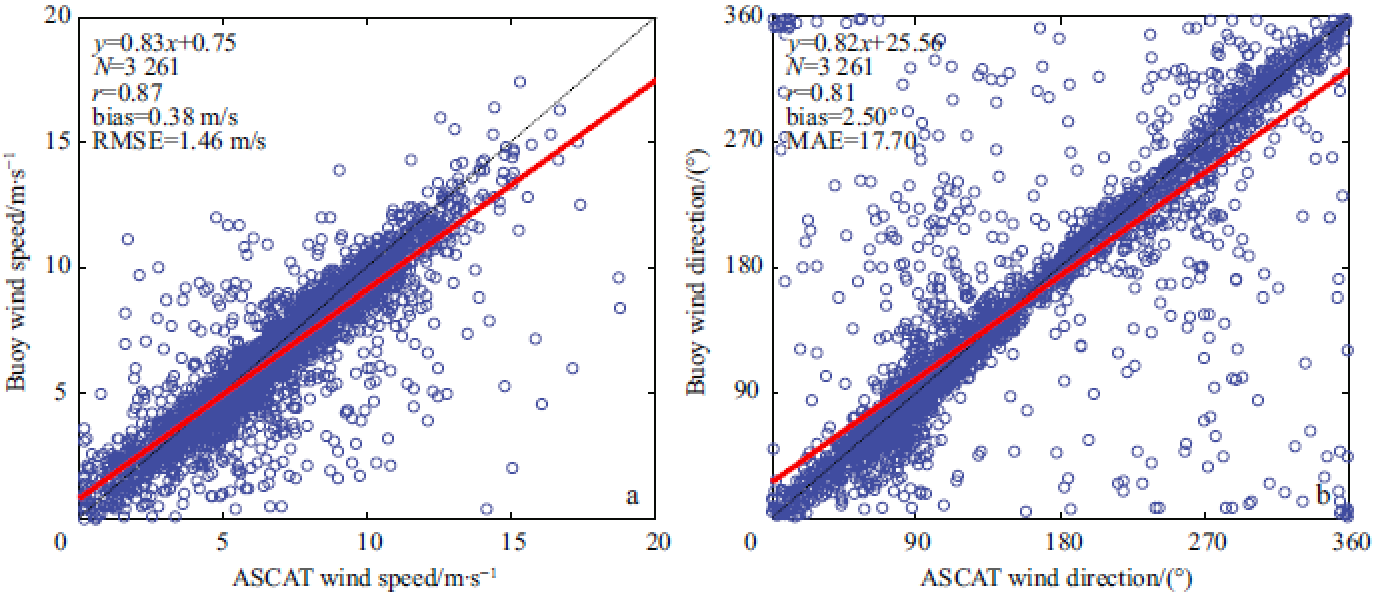


Wind fields retrieval from SAR imagery

1. Ocean surface winds

Wave effects on the retrieved wind field from ASCAT Scatterometer

Acta Oceanol. Sin., 2015

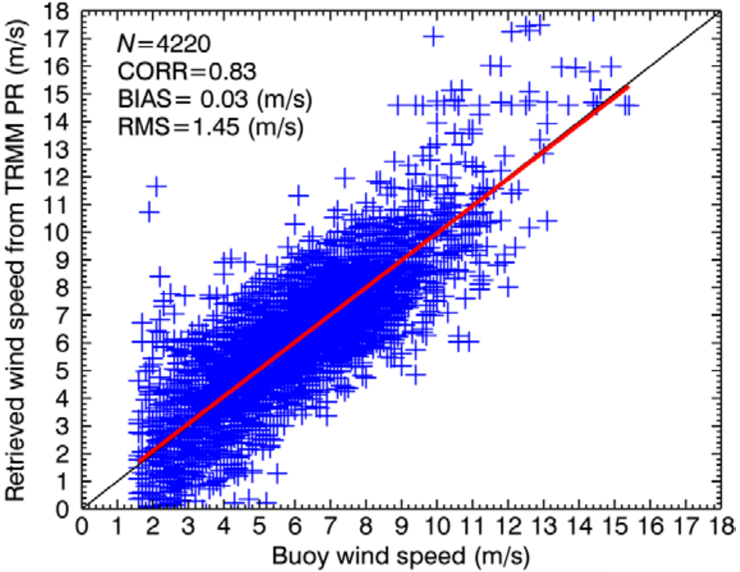


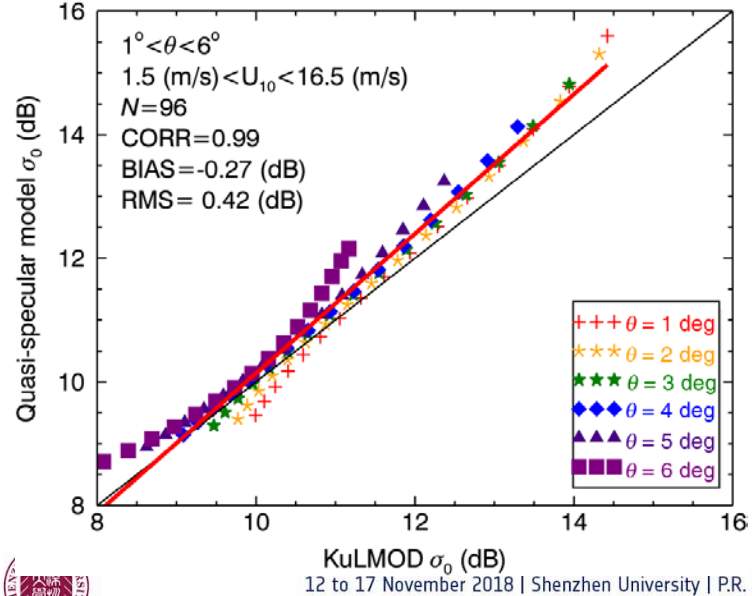
1. Ocean surface winds

A Ku band wind and rain backscatter model at low incidence angles (KuLMOD)

J. of App. Rem. Sens., 2016

Int. J. Rem. Sens., 2017





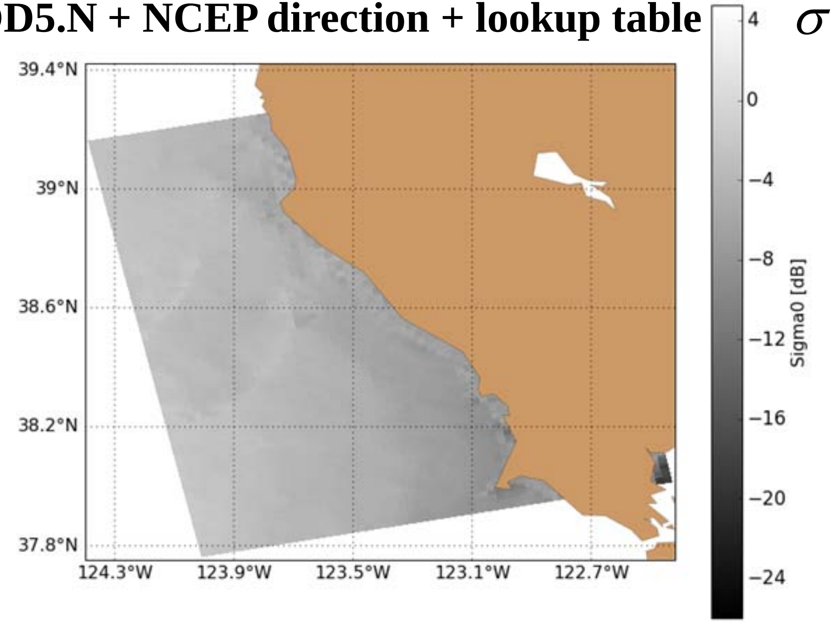
1. Ocean surface winds

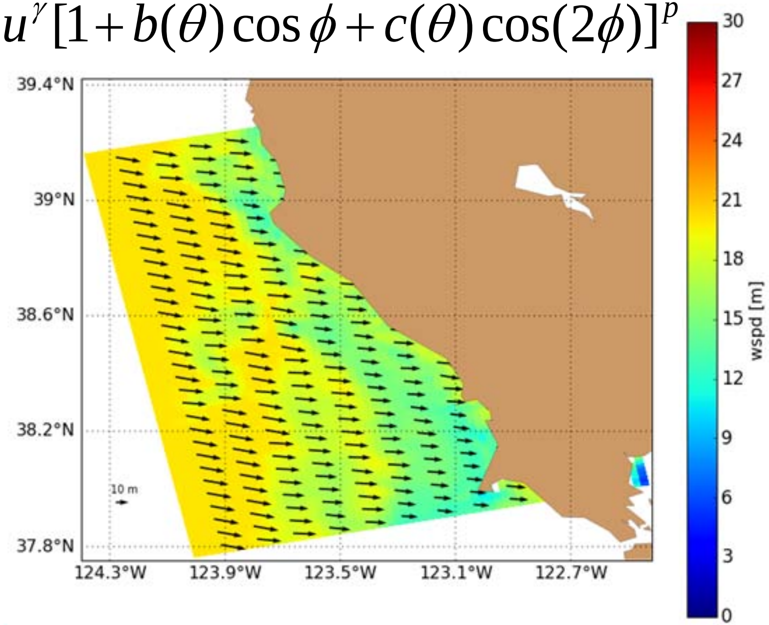
Wind field retrieval algorithm for Chinese GF-3 SAR Satellite （launched on Aug. 10, 2016）

Remote Sensing, 2017

CMOD5.N + NCEP direction + lookup table

$$\sigma^0 = au^\gamma[1 + b(\theta)\cos\phi + c(\theta)\cos(2\phi)]^p$$

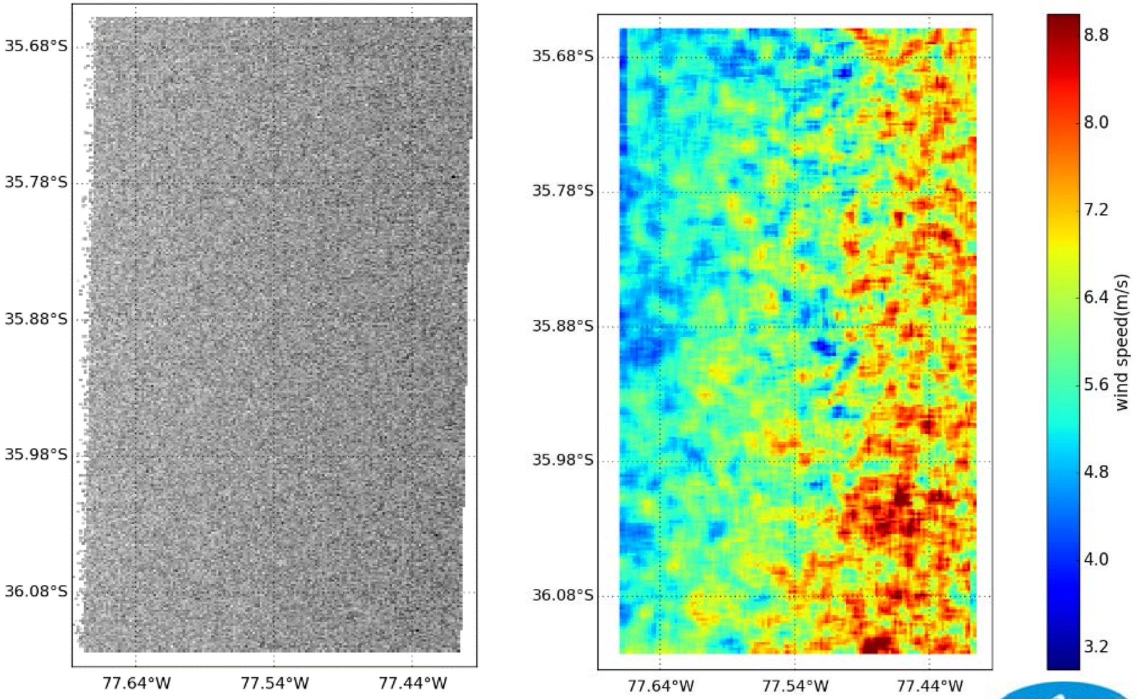




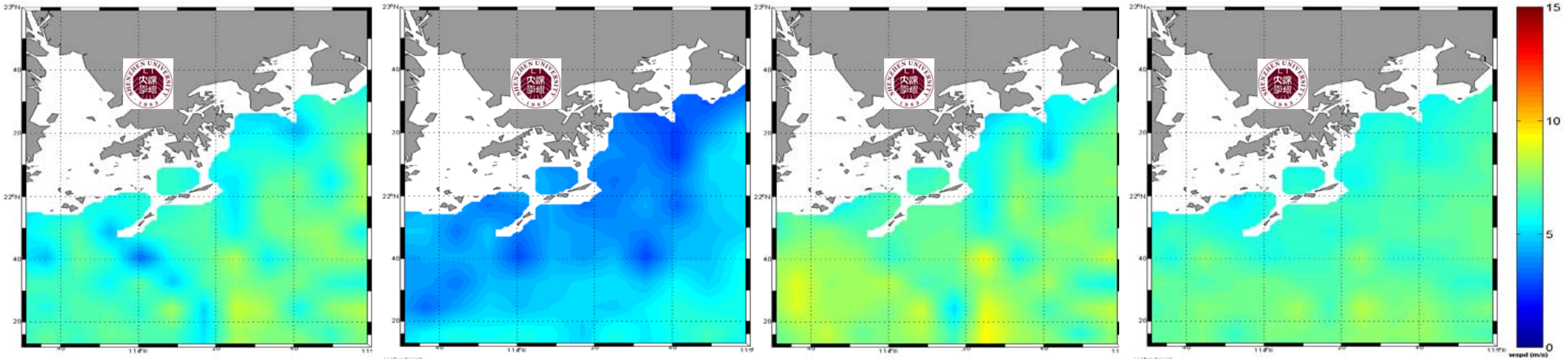
1. Ocean surface winds

The First Quantitative Ocean Remote Sensing by Using Interferometric Imaging Radar Altimeter Onboard Chinese Space Laboratory TG-2（launched on Sep. 15, 2016）

Acta Oceanol. Sin., 2017



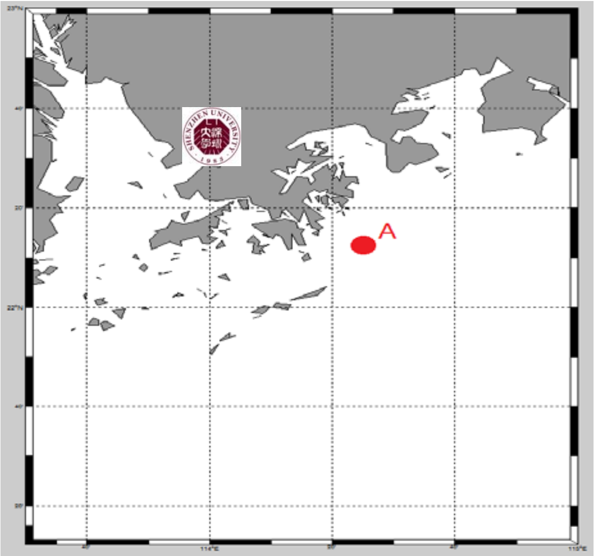
1. Ocean surface winds

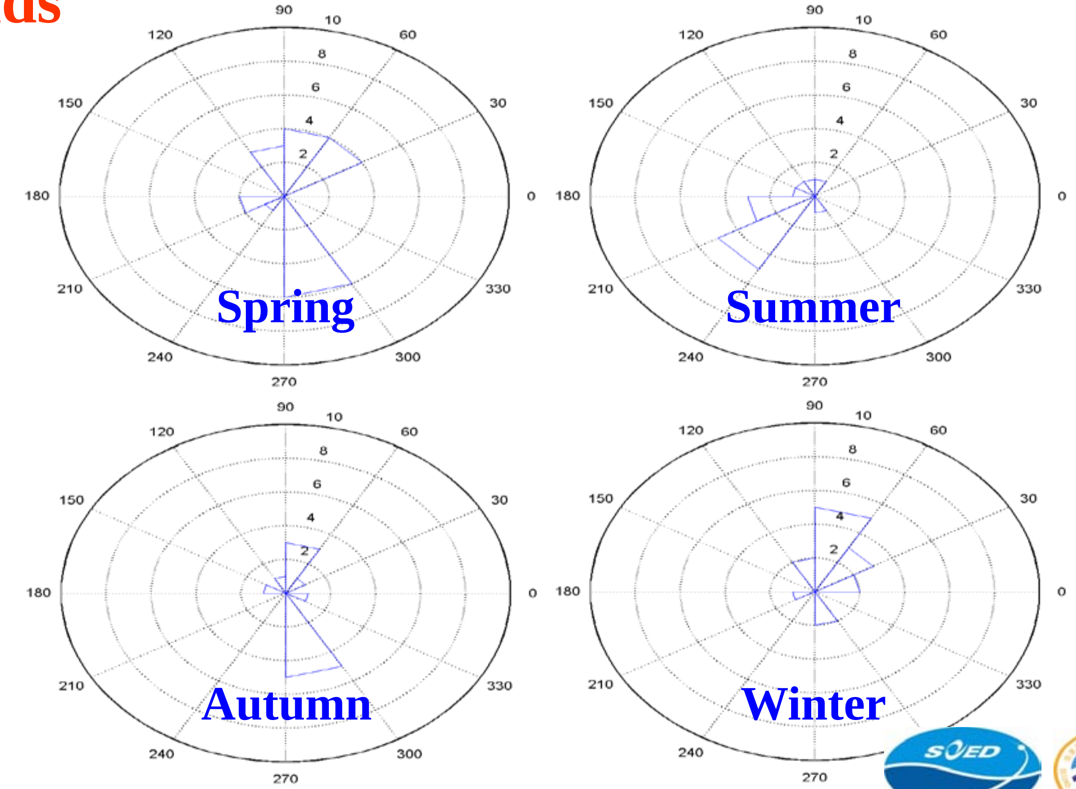


Spring **Summer** **Autumn** **Winter**

Seasonal Averaged Wind Speed from SAR Imagery

1. Ocean surface winds

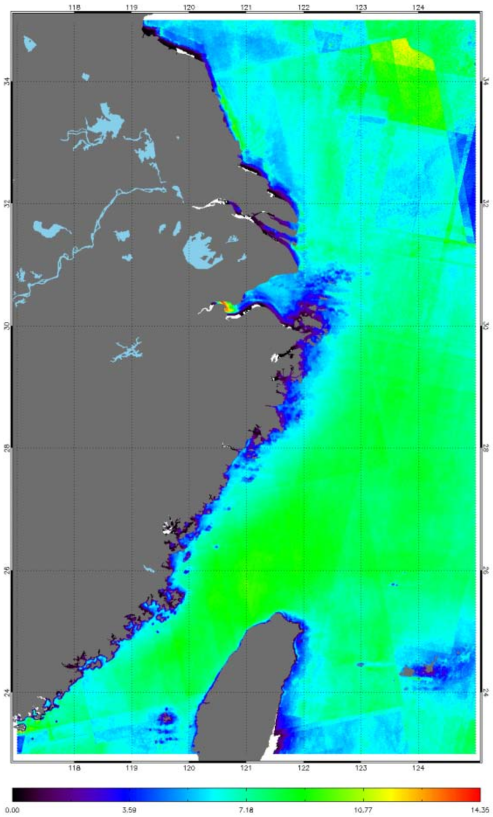




Rose pattern – wind direction

1. Ocean surface winds

Average wind speed



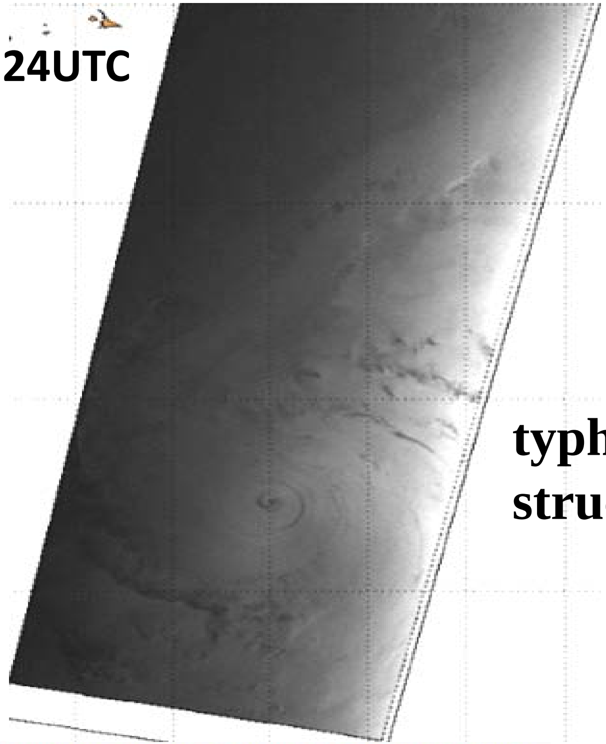
Wind energy assessment and site selection of offshore wind farm

Ocean wind energy survey by SAR

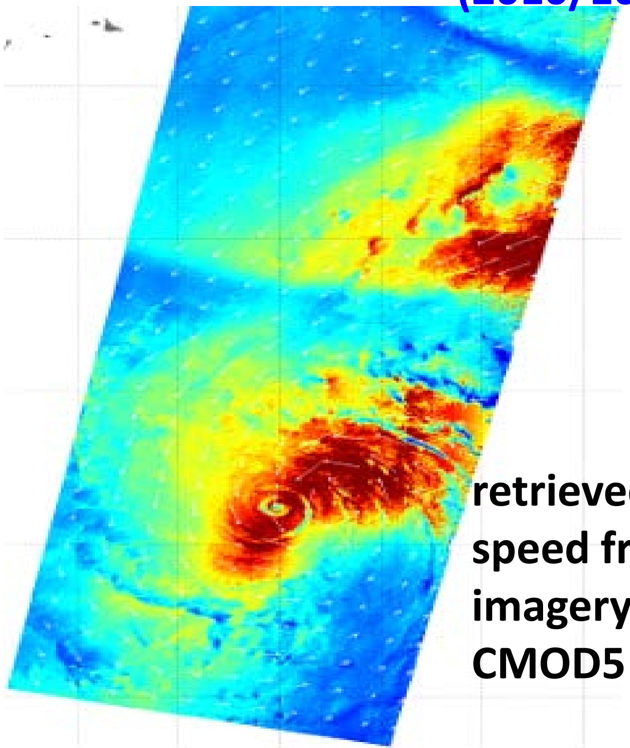
2. Typhoons

Typhoon Megi (2010/10/17)

SAR, 1:24UTC



typhoon structure

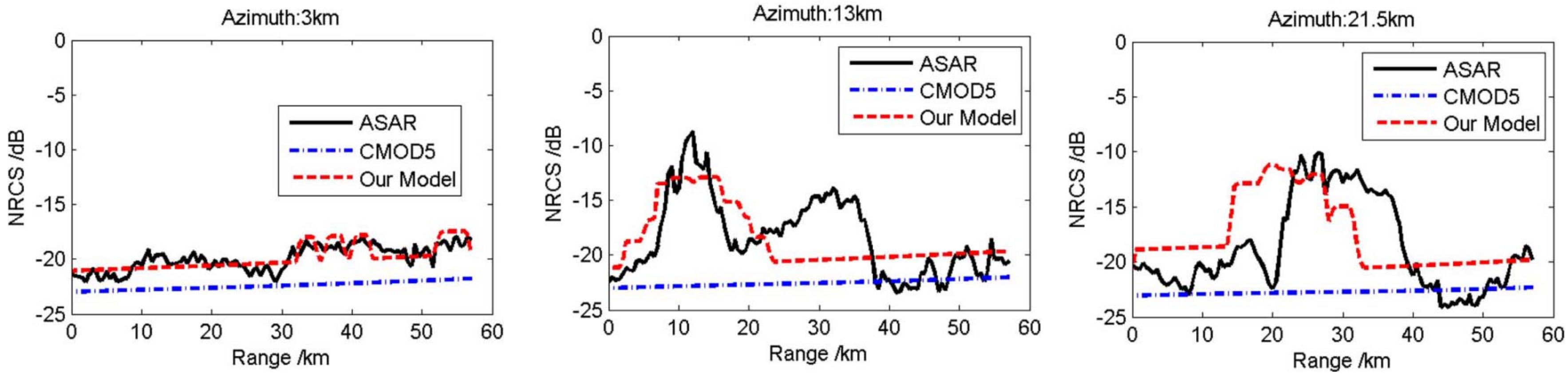


retrieved wind speed from SAR imagery based on CMOD5

2. Typhoons

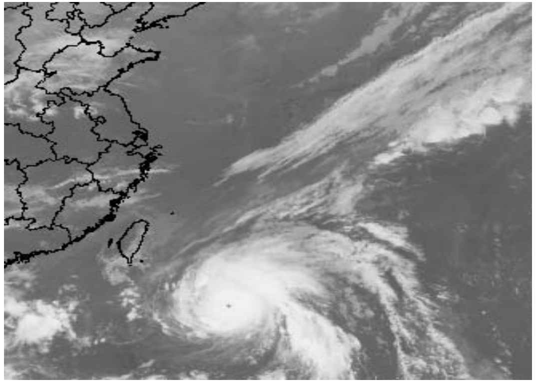
Comparison of simulated and measured ASAR range profiles at selected azimuth positions in case of rain.

IEEE Trans. Geosci. Remote Sens., 2015

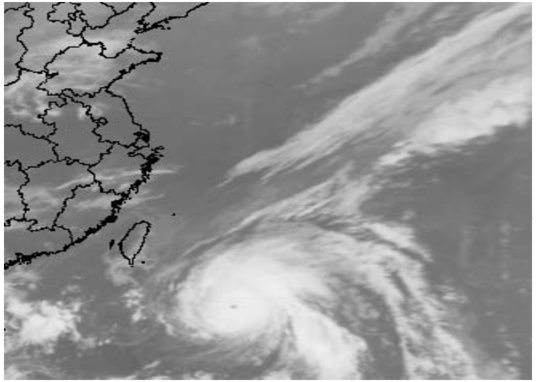


2. Typhoons

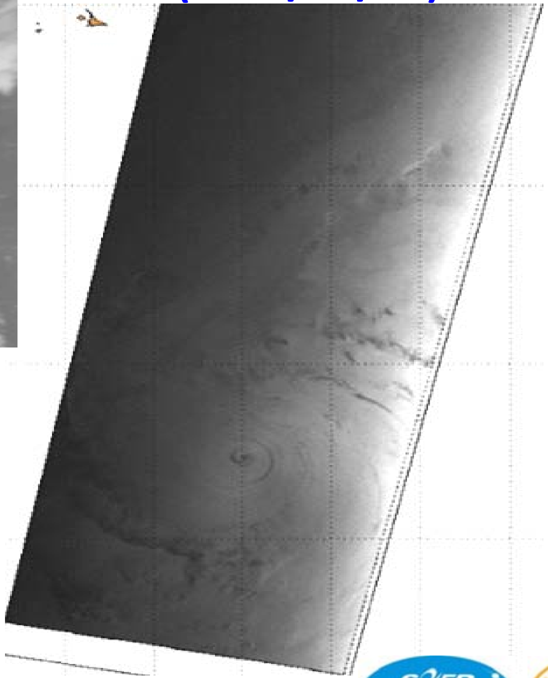
Typhoon Megi (2010/10/17)



MTSAT， 1:30UTC

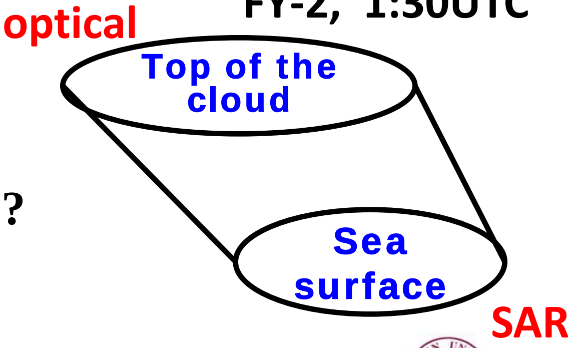


FY-2, 1:30UTC



SAR, 1:24UTC

3D structure ?

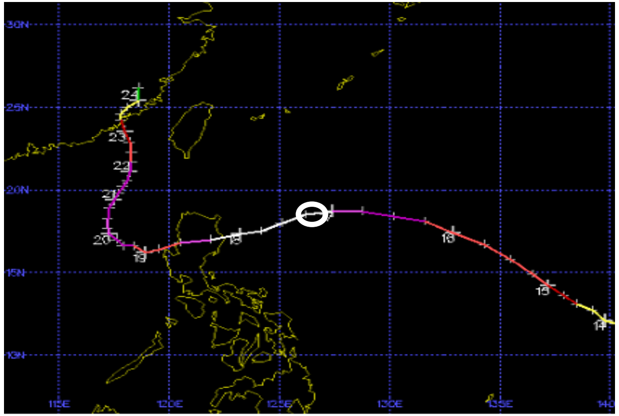


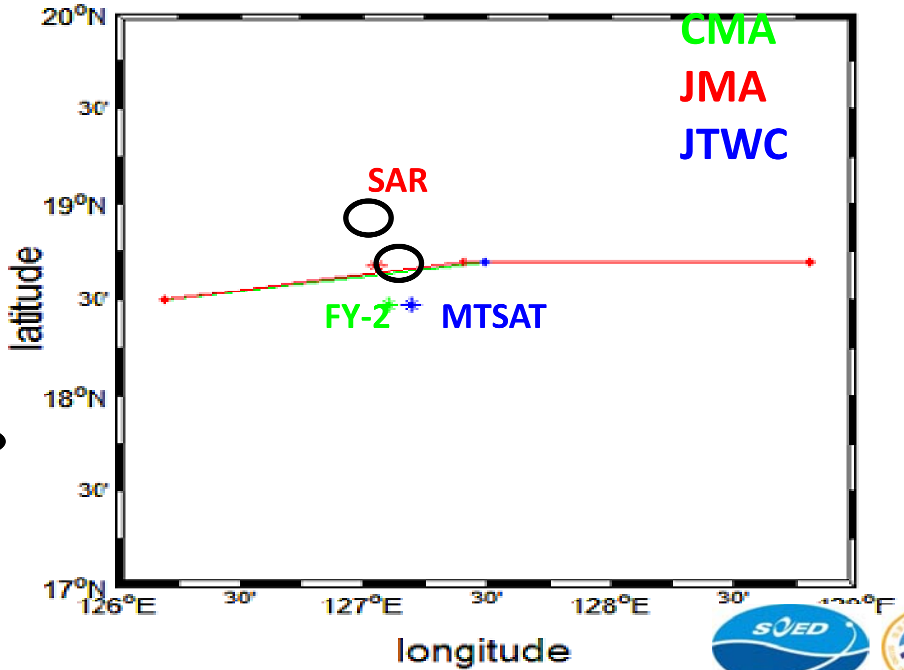
2. Typhoons

Rem. Sens. 2013

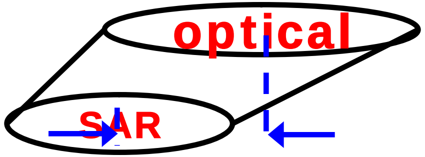
Int. J. Rem. Sens., 2014

Typhoon Megi (2010/10/17)



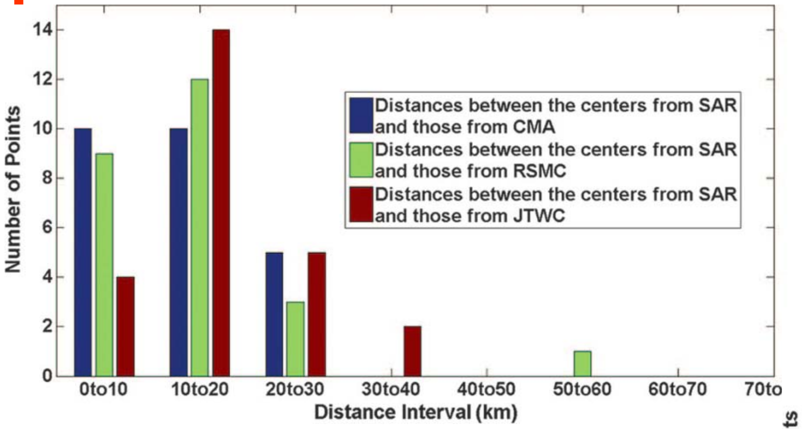


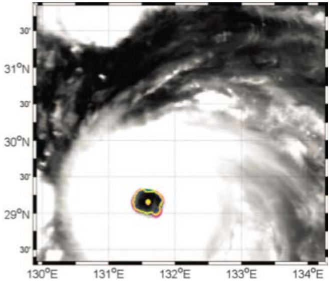
3D structure of Typhoon Megi -



Eye difference:
24 / 23 km

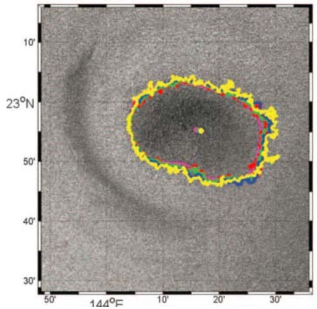
2. Typhoons



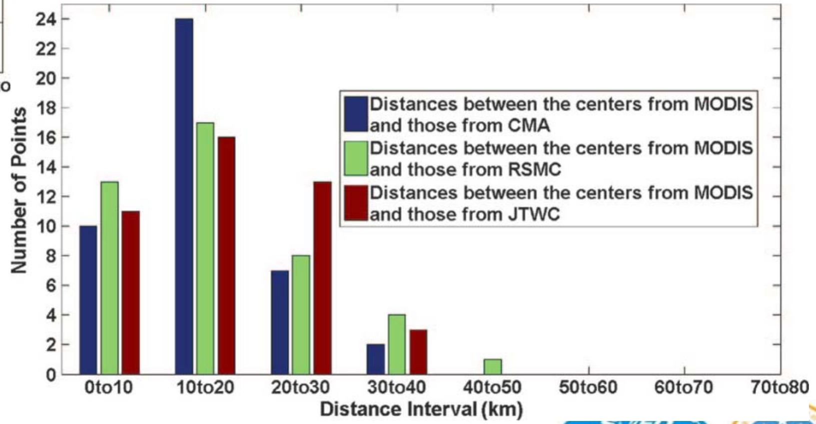


MODIS IR images

IEEE Trans. Geosci. Remote Sens., 2016



SAR images

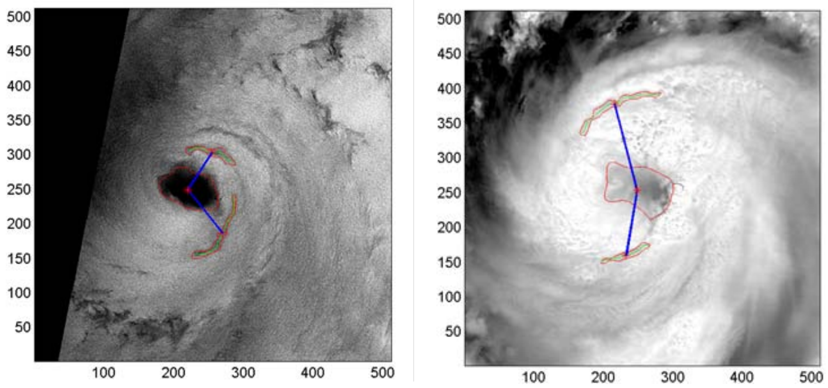


2. Typhoons

Case No.	Feature No.	Radius (km) ASAR	Radius (km) MODIS	Angle (Deg)	WSPD ($m\ s^{-1}$) ASAR	WSPD ($m\ s^{-1}$) MODIS	WSPD ($m\ s^{-1}$) DRadar	JTWC RMW (km)	JTWC MWS($m\ s^{-1}$)	WS_RA($m\ s^{-1}$)	WS_RM($m\ s^{-1}$)
Case 1	1	99.58	84.71	65.4	**52.23**	**44.43**		27.78	64.30↑	**33.96**	**36.82**
	2	93.77	68.18	80.8	**60.75**	**44.18**				**35.00**	**41.04**
Case 2	1	54.09	57.00	46.4	**19.30**	**20.34**		9.26	56.58↓	**23.41**	**22.81**
	2o	12.92	24.57	300.9	**31.19**	**59.32**				**47.90**	**34.73**
	2i	12.92	18.92	298.4	**30.92**	**45.31**				**47.90**	**39.58**
Case 3	1	39.98	66.02	156.58	**30.51**	**50.37**		27.78	46.30↑	**38.59**	**30.03**
	2	32.45	49.16	202.54	**32.02**	**48.52**				**42.84**	**34.80**
Case 4	1m	48.92	57.31	27.3	**19.29**	**22.60**		/	46.30↓		
	1r	48.92	48.62	13.7	**35.75**		**35.53**				
	2m	47.31	44.50	28.2	**19.27**	**18.12**					
	2r	47.31	43.96	14.5	**36.79**		**34.19**				
Case 5	1	65.87	86.06	239.56	**57.10**	**74.60**		37.04	41.15↑	**30.86**	**27.00**

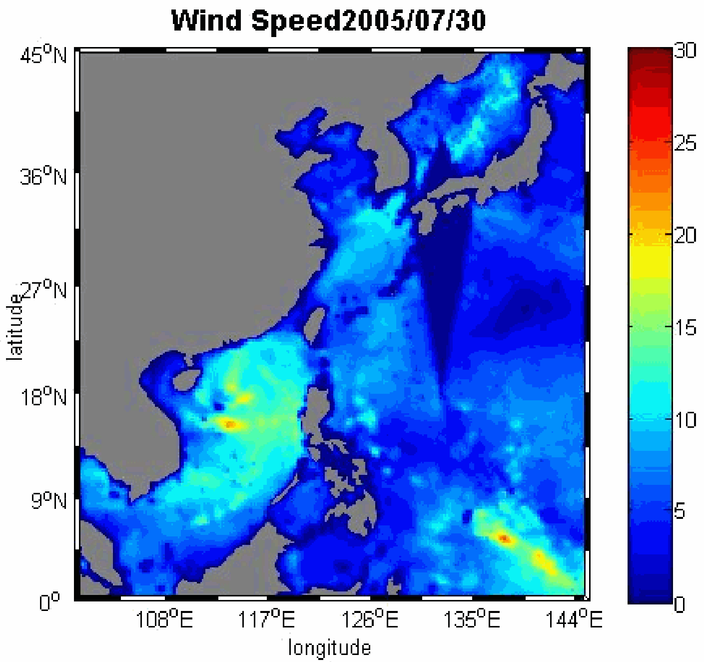
Summary of Five Typhoon Rainband-related Features Tracked between SAR, MODIS, and Ground-based Doppler Radar

Int. J. Rem. Sens., 2016

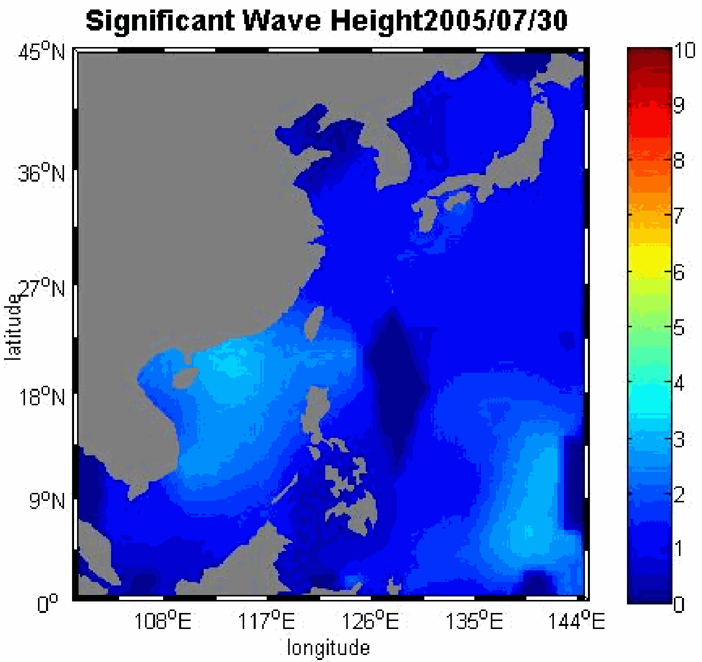


Typhoon Sinlaku's (2008) Two Selected Rainband on ASAR and MODIS Images Delineated by Wavelet Analysis

2. Typhoons



QuikSCAT winds

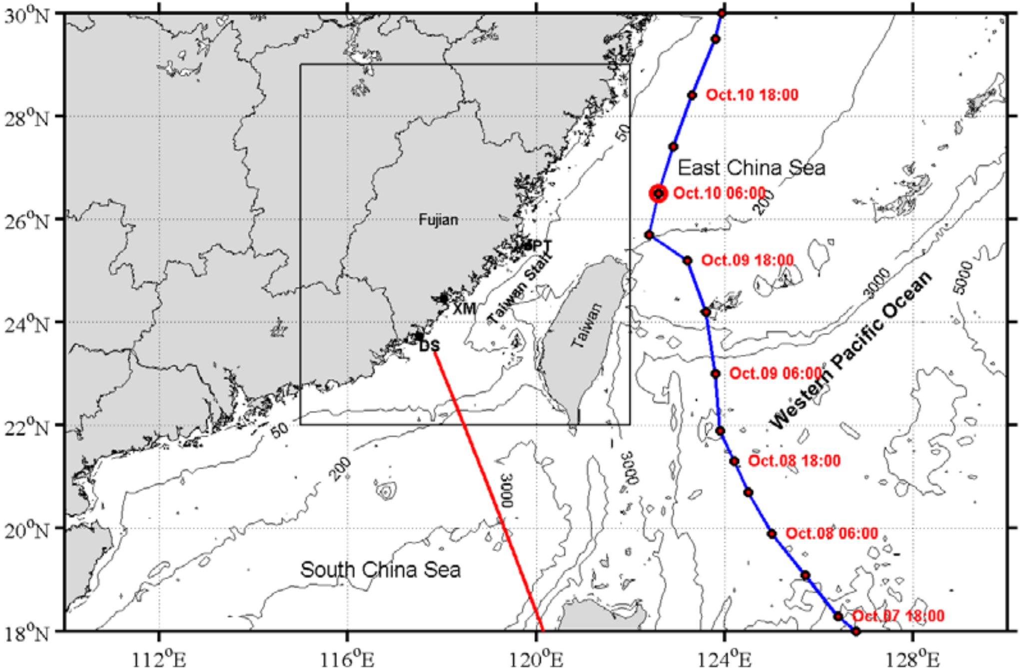


Merged altimetry SWHs

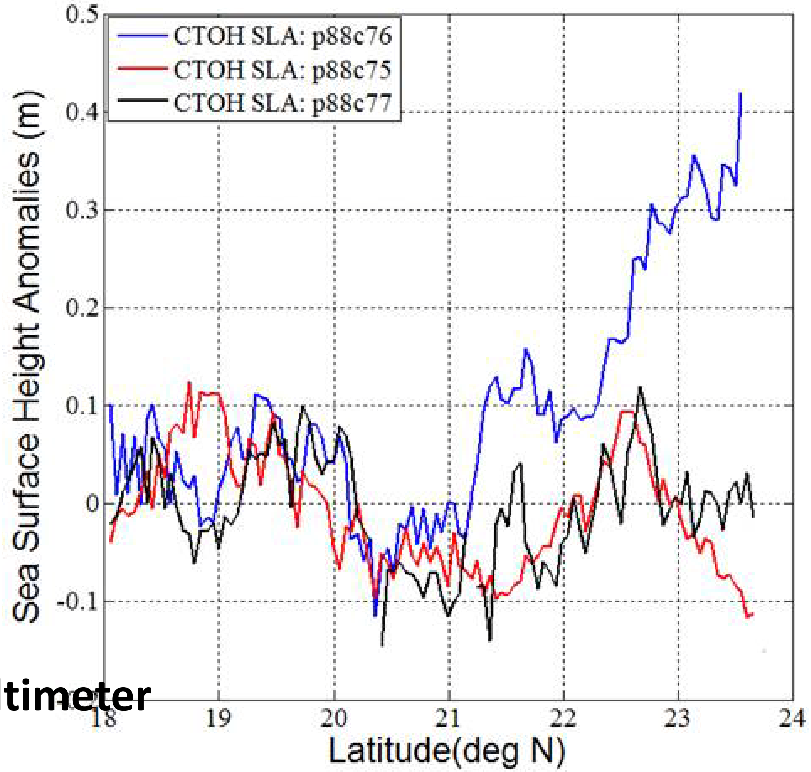
Typhoon Matsa (2005)

2. Typhoons

Rem. Sens., 2018



HY-2A case: J. Geophys. Res., 2014

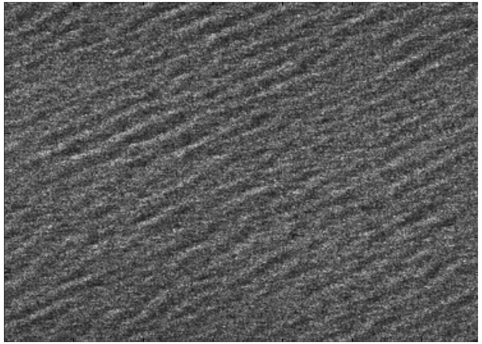


Typhoon Seth (1994) Storm Surge observed by T/P Altimeter

3. Ocean surface waves

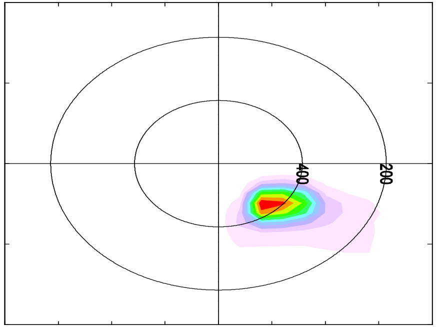
J. Hydrodynamics, 2001
Chinese. J. Geophys., 2001
Chin. J. Oceanol. Limn., 2004
Chin. J. Oceanol. Limn., 2015

Imaged by SAR



SAR imagery

Retrieve



Directional spectrum

Calculate

wave period (length)

wave direction

wave height

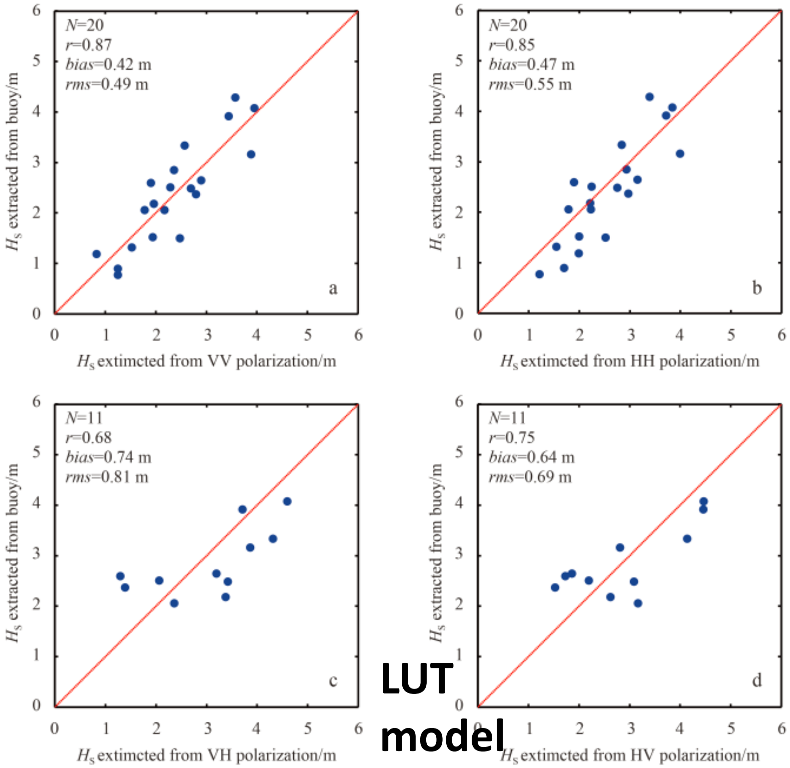
wave energy

...

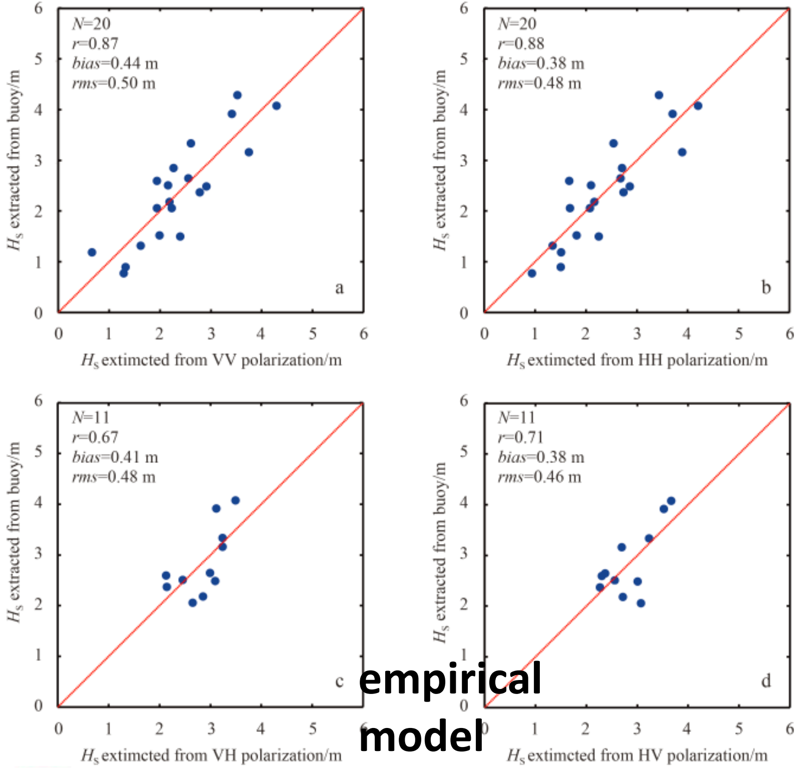
3. Ocean surface waves

Acta Oceanol. Sin., 2015

Significant wave height estimation using azimuth cutoff wavelength



LUT model



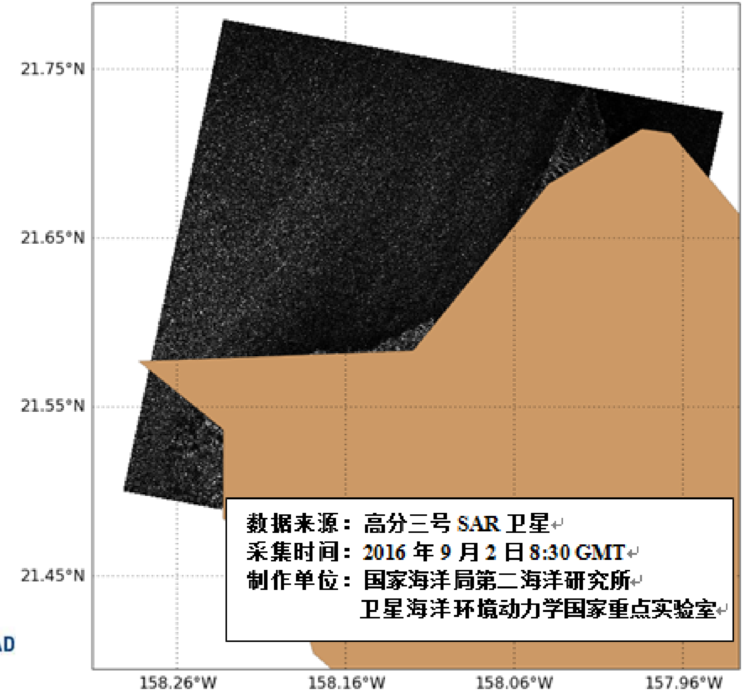
empirical model

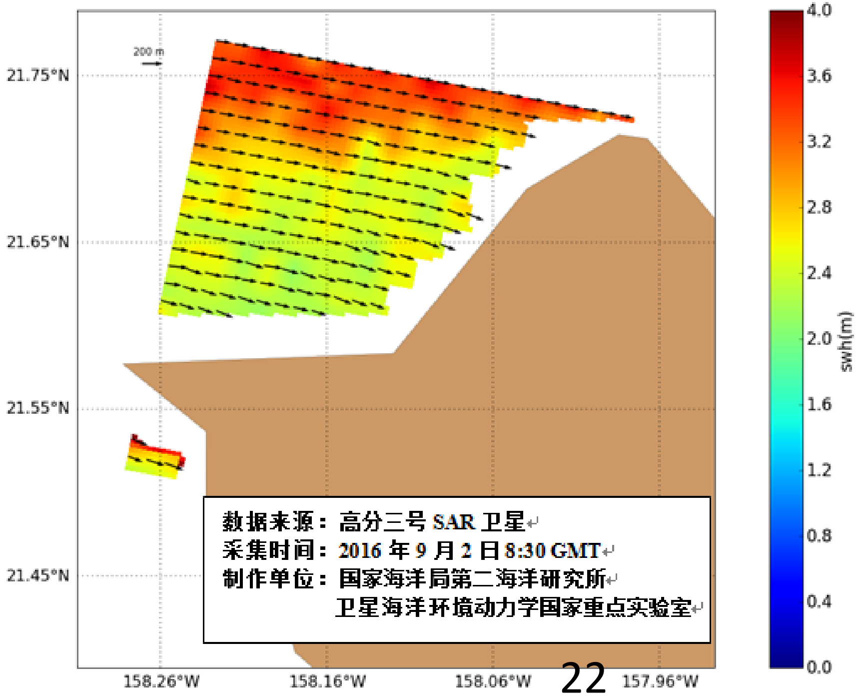
Hosted by

3. Ocean surface waves

Wave retrieval algorithm for Chinese GF-3 SAR Satellite （launched on Aug. 10, 2016）

Oceanologia et Limnologia Sinica., 2017 ***Remote Sensing, 2018***



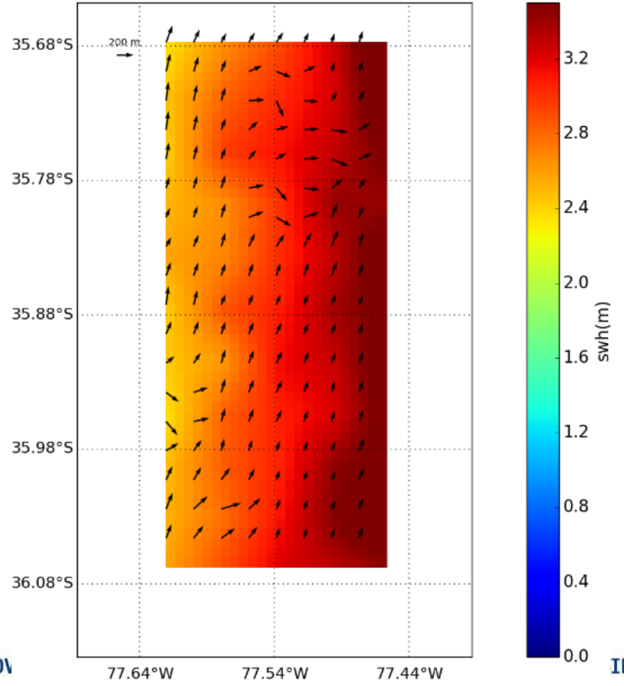


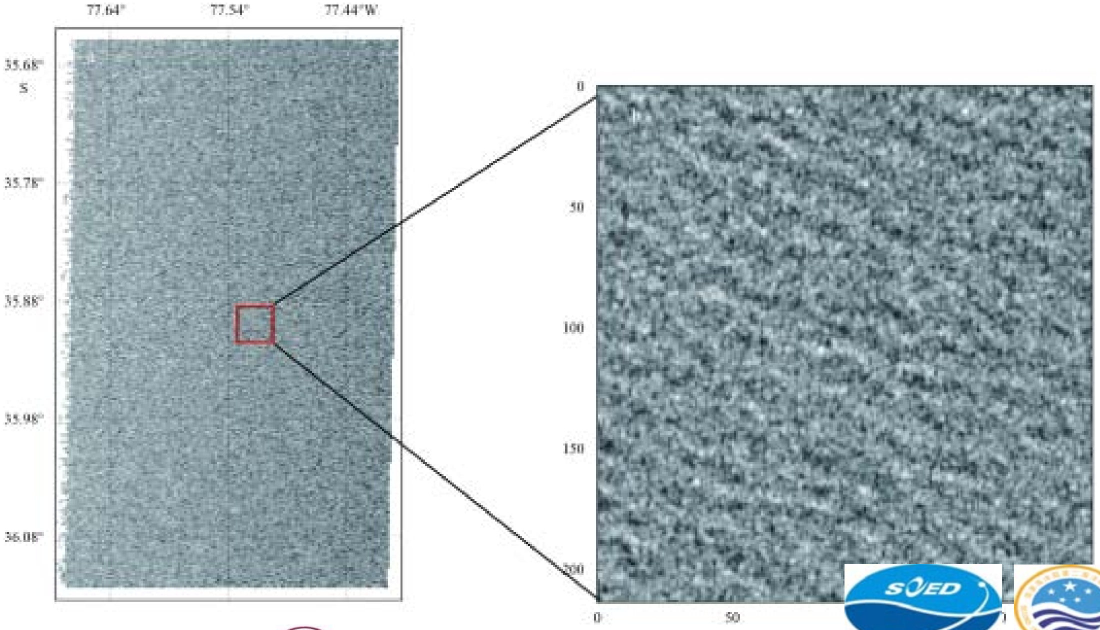
→ AD

China

3. Ocean surface waves

The First Quantitative Ocean Remote Sensing by Using Interferometric Imaging Radar Altimeter Onboard Chinese Space Laboratory TG-2 *Acta Oceanol. Sin., 2017*

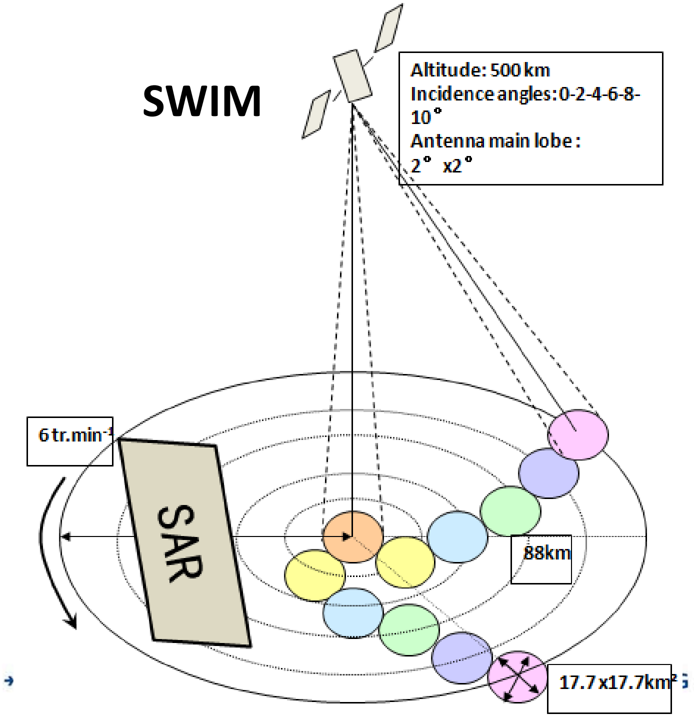


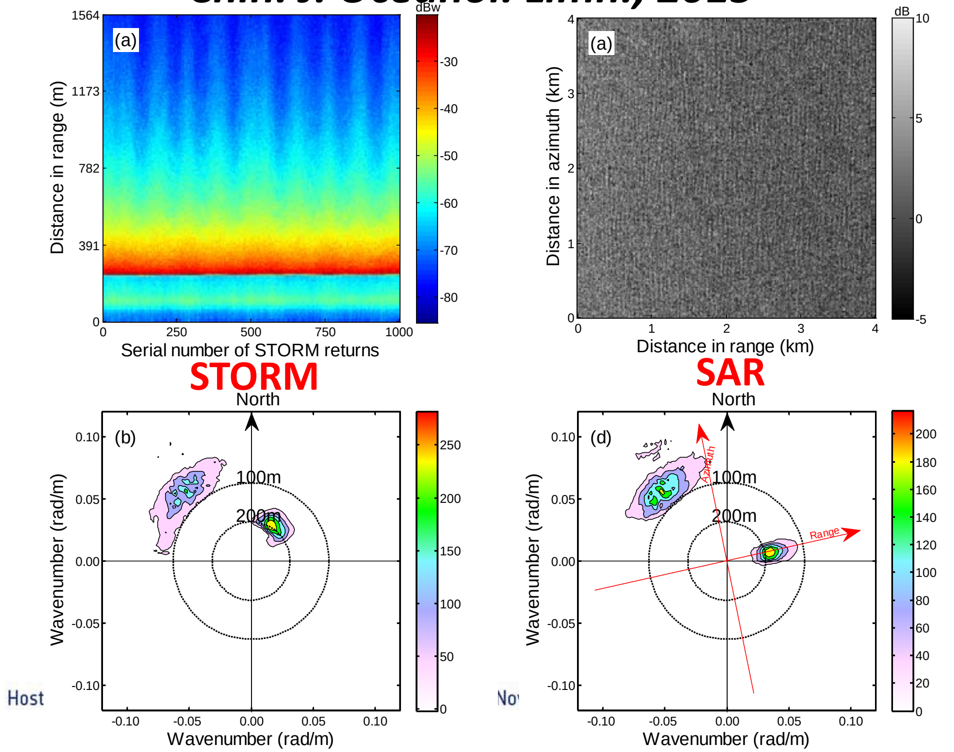


3. Ocean surface waves

Joint retrieval of directional ocean wave spectra from SAR and CFOSAT (launched on Oct. 29, 2018) wave spectrometer

Chin. J. Oceanol. Limn., 2015

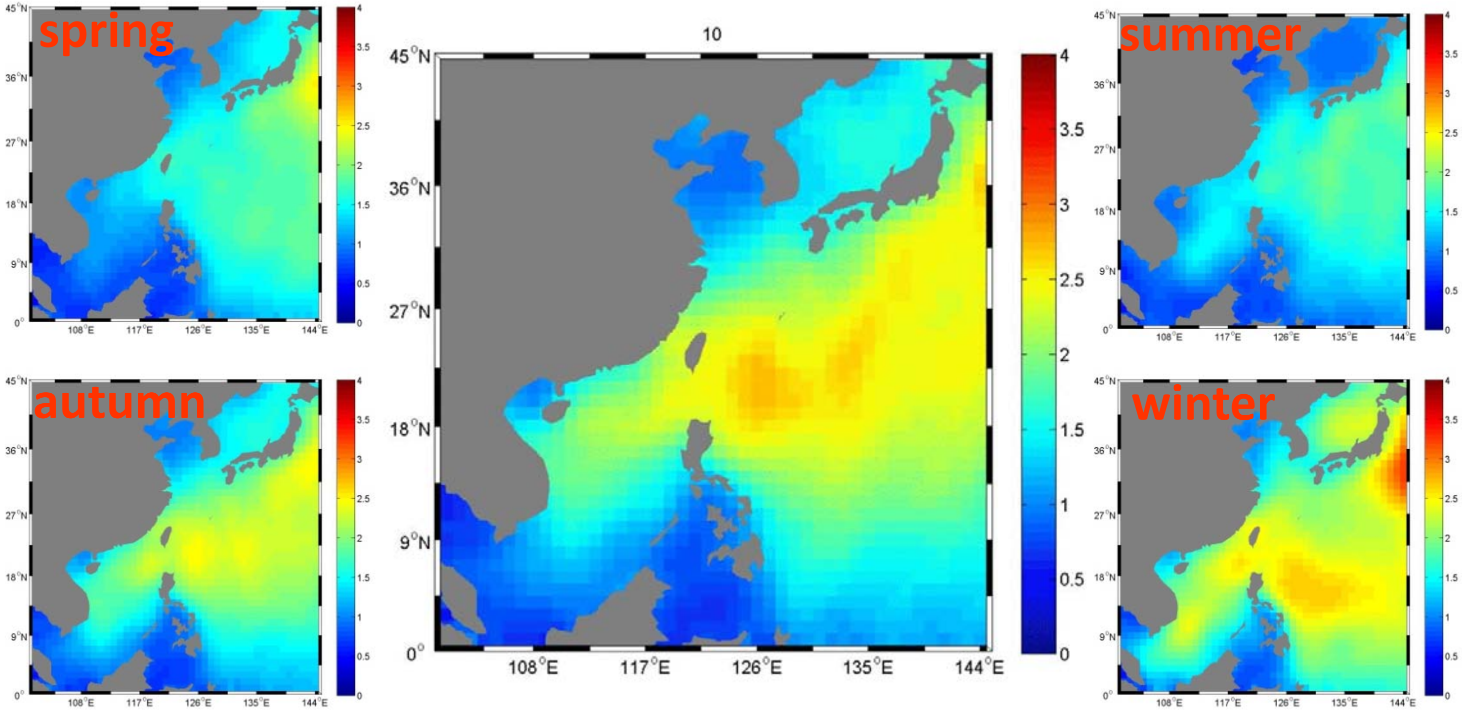




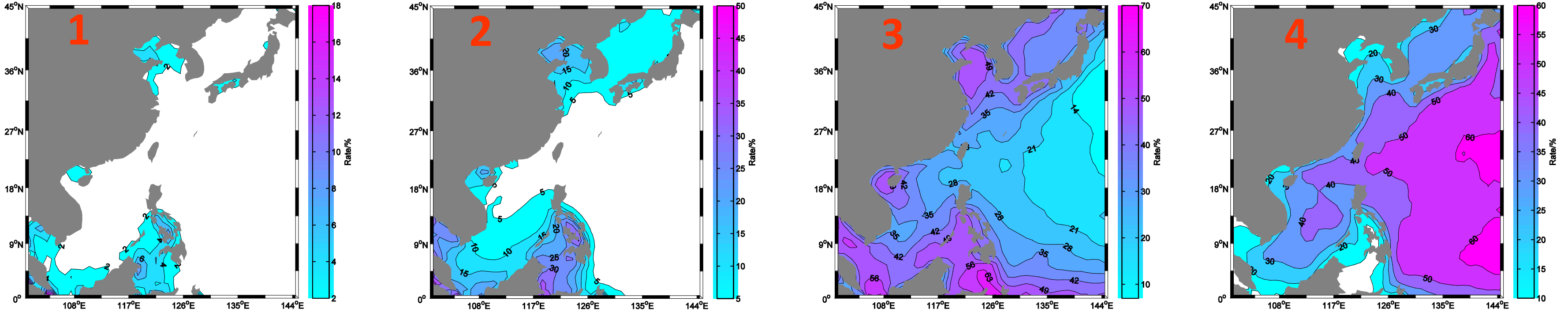
3. Ocean surface waves

Acta Oceanol. Sin., 2009

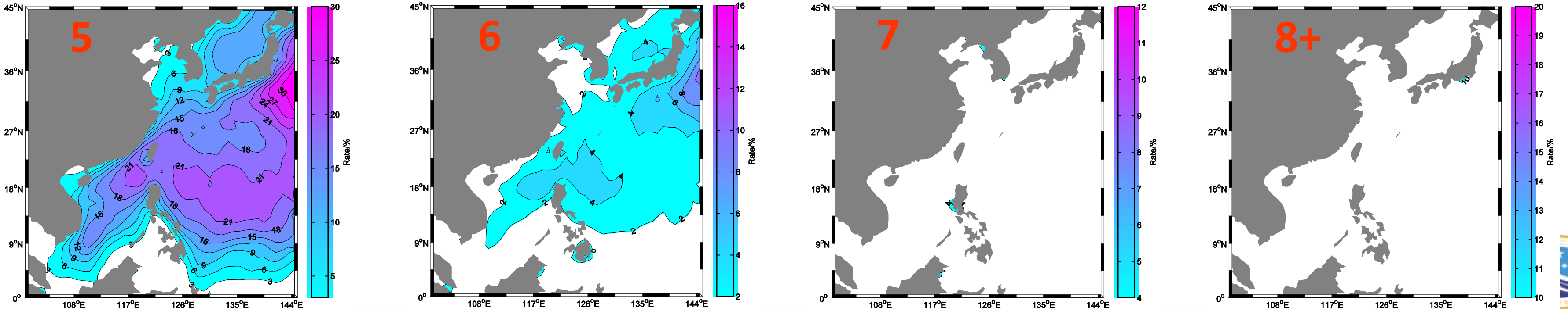
Monthly and seasonal average SWHs merged from multiple satellite altimeters (T/P, GFO, Jason-1 and Envisat)



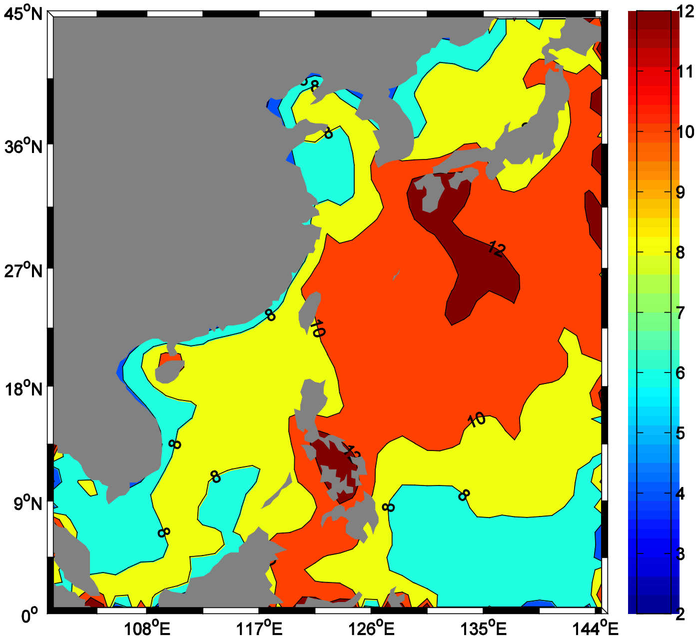
3. Ocean surface waves



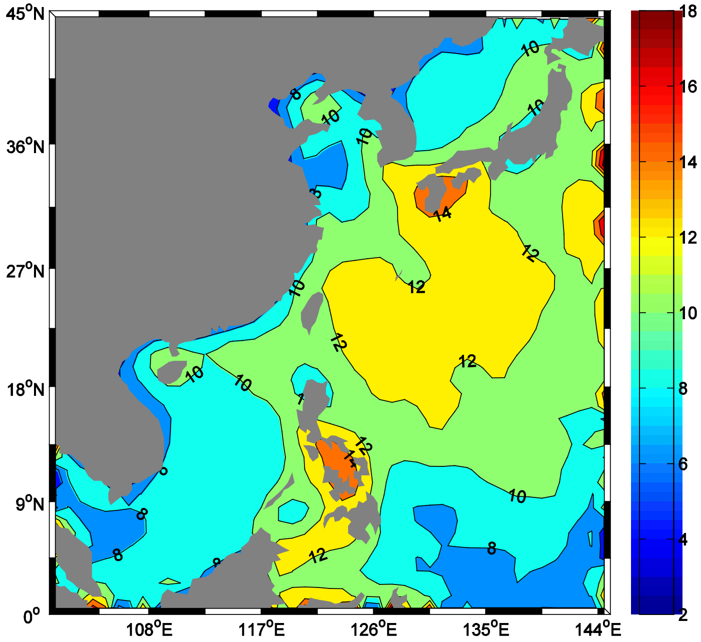
Douglas Sea Scale Probability from 15 years' altimetry data



3. Ocean surface waves



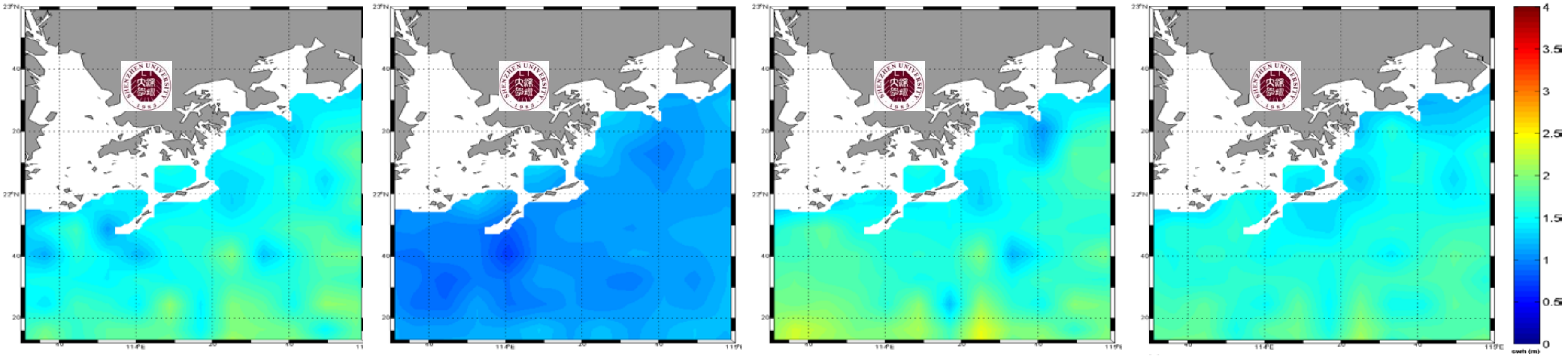
50-year-return



100-year-return

Extreme wave heights base on 15 years' altimetry data

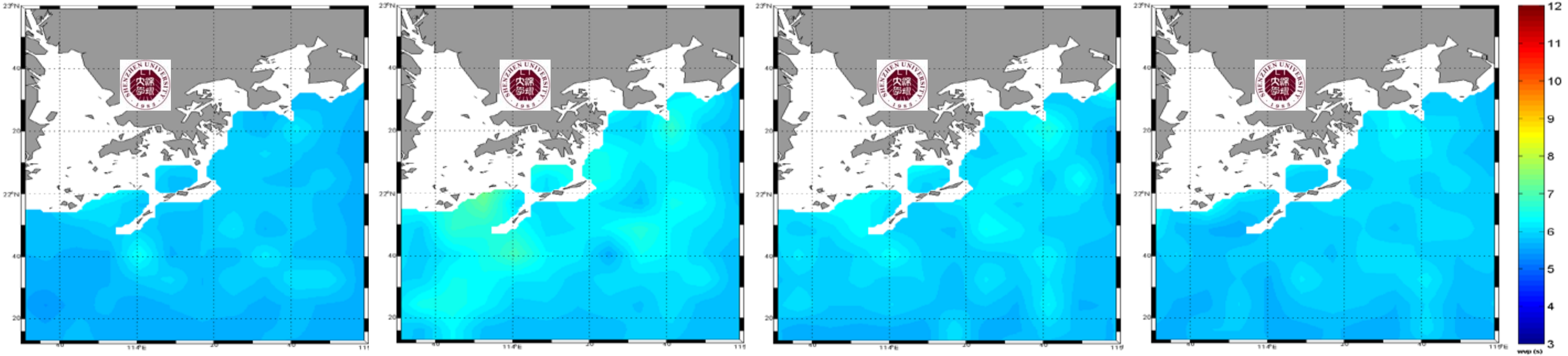
3. Ocean surface waves



Spring **Summer** **Autumn** **Winter**

Seasonal Averaged SWH from SAR Imagery

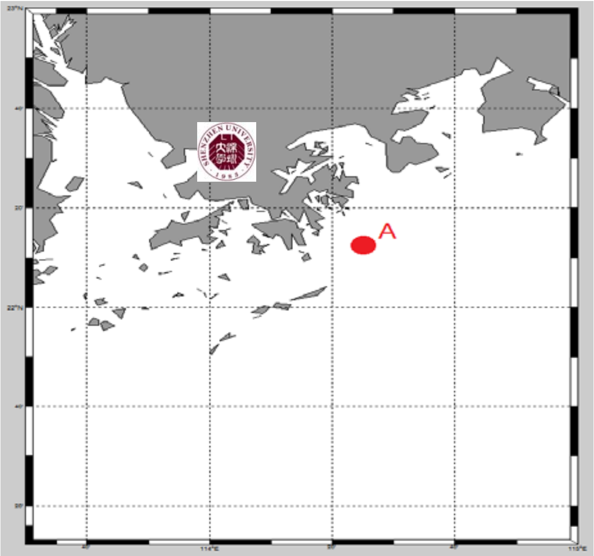
3. Ocean surface waves

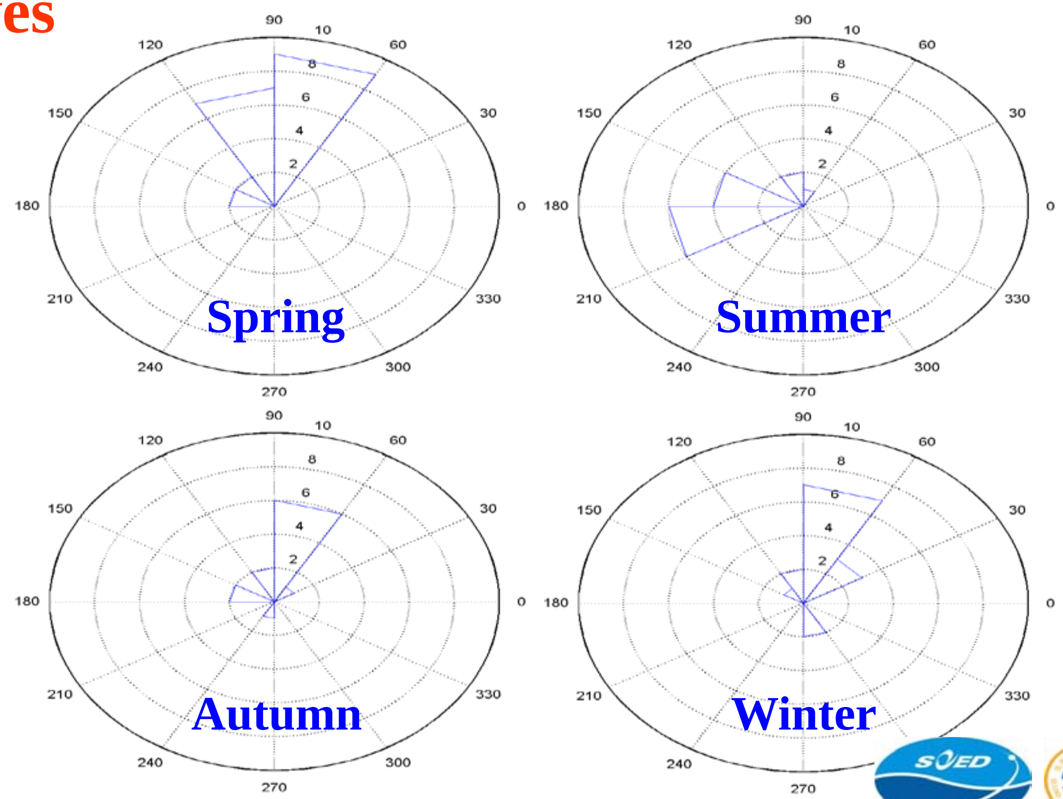


Spring | **Summer** | **Autumn** | **Winter**

Seasonal Averaged Wave Period from SAR Imagery

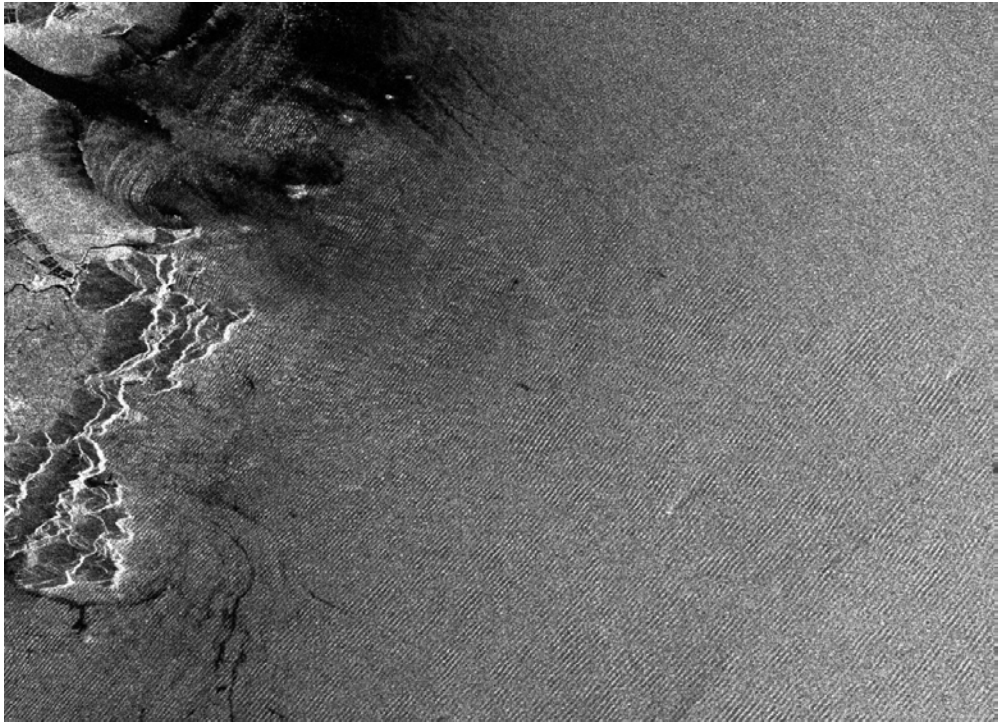
3. Ocean surface waves

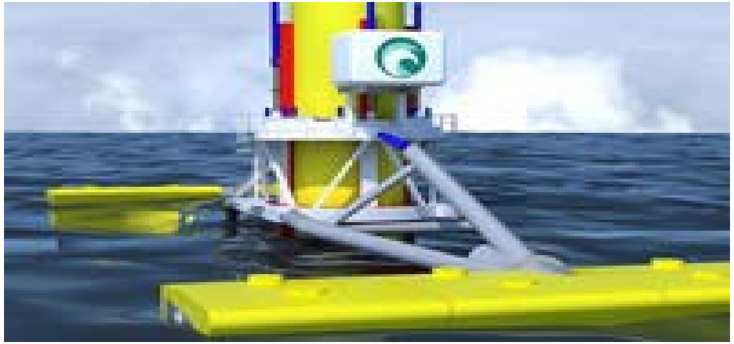




Rose pattern – wave direction

3. Ocean surface waves



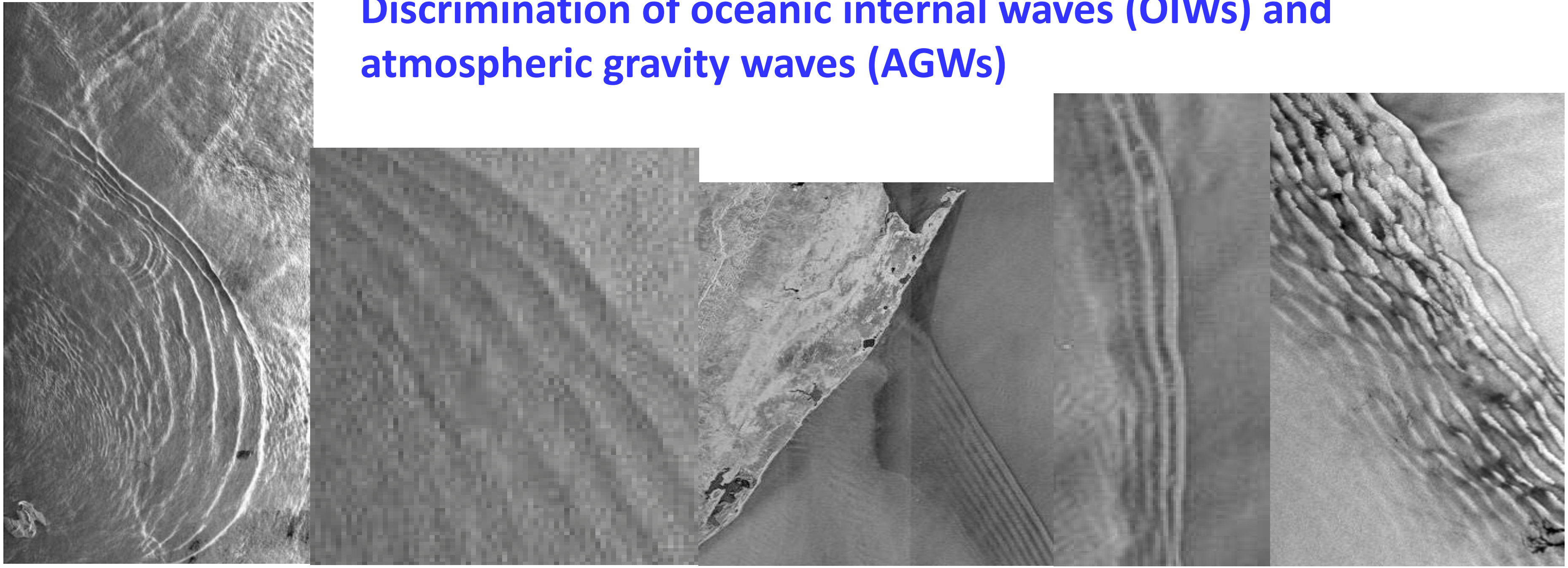


Wave energy assessment and site selection of offshore wave farm

Ocean wave energy survey by SAR

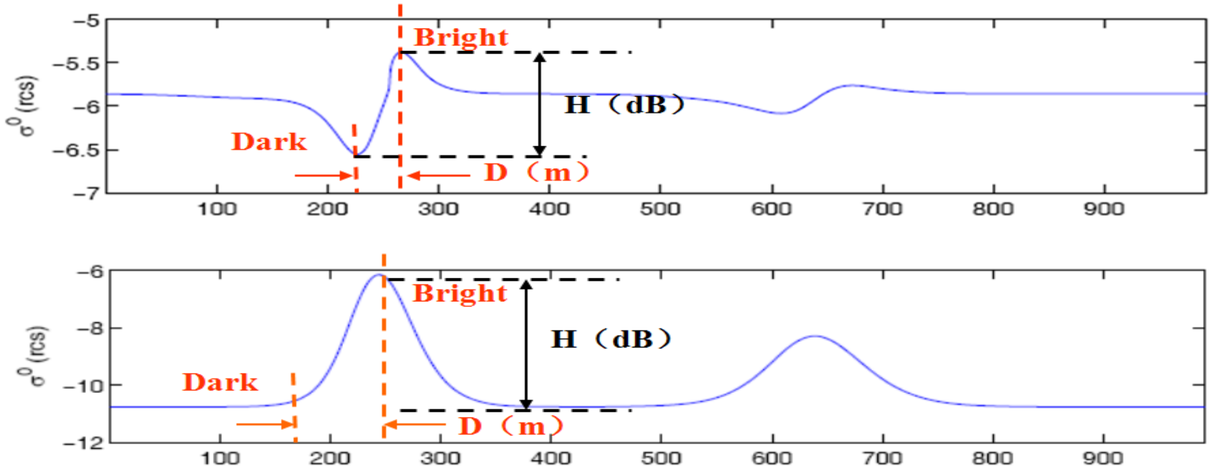
4. Ocean internal waves

Discrimination of oceanic internal waves (OIWs) and atmospheric gravity waves (AGWs)



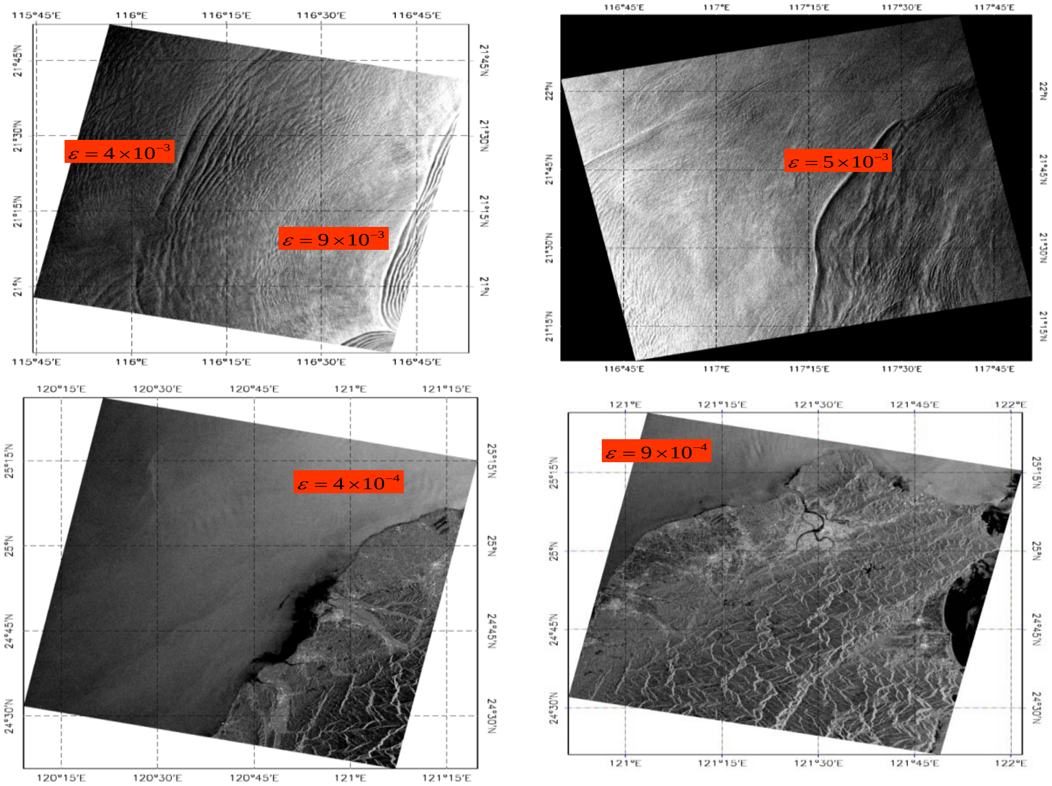
4. Ocean internal waves

Discrimination of oceanic internal waves (OIWs) and atmospheric gravity waves (AGWs)

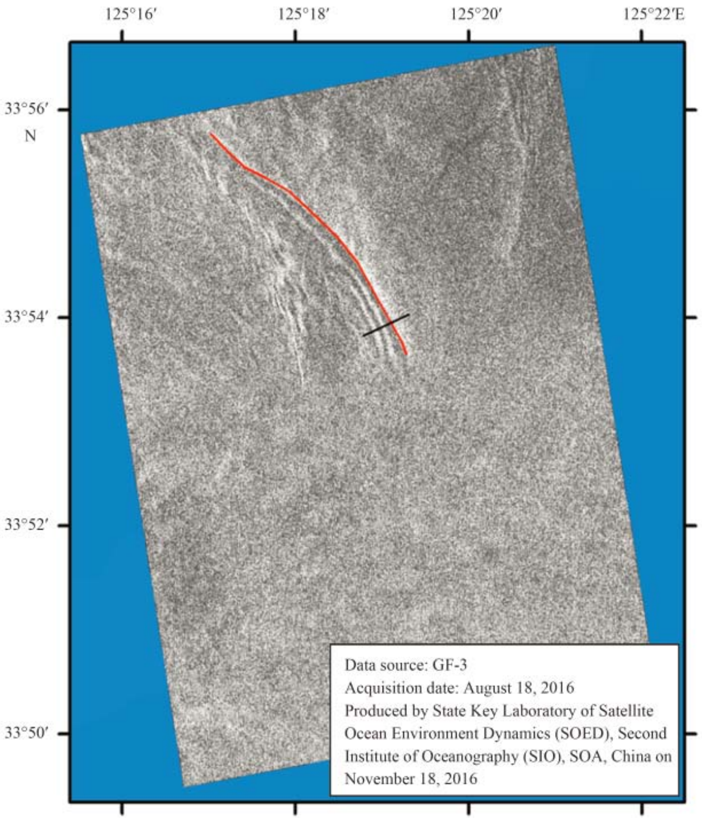


$$\varepsilon \equiv \frac{H}{D} \sim \begin{cases} 10^{-3} & \textbf{OIWs} \\ 10^{-4} & \textbf{AGWs} \end{cases}$$

4. Ocean internal waves



4. Ocean internal waves



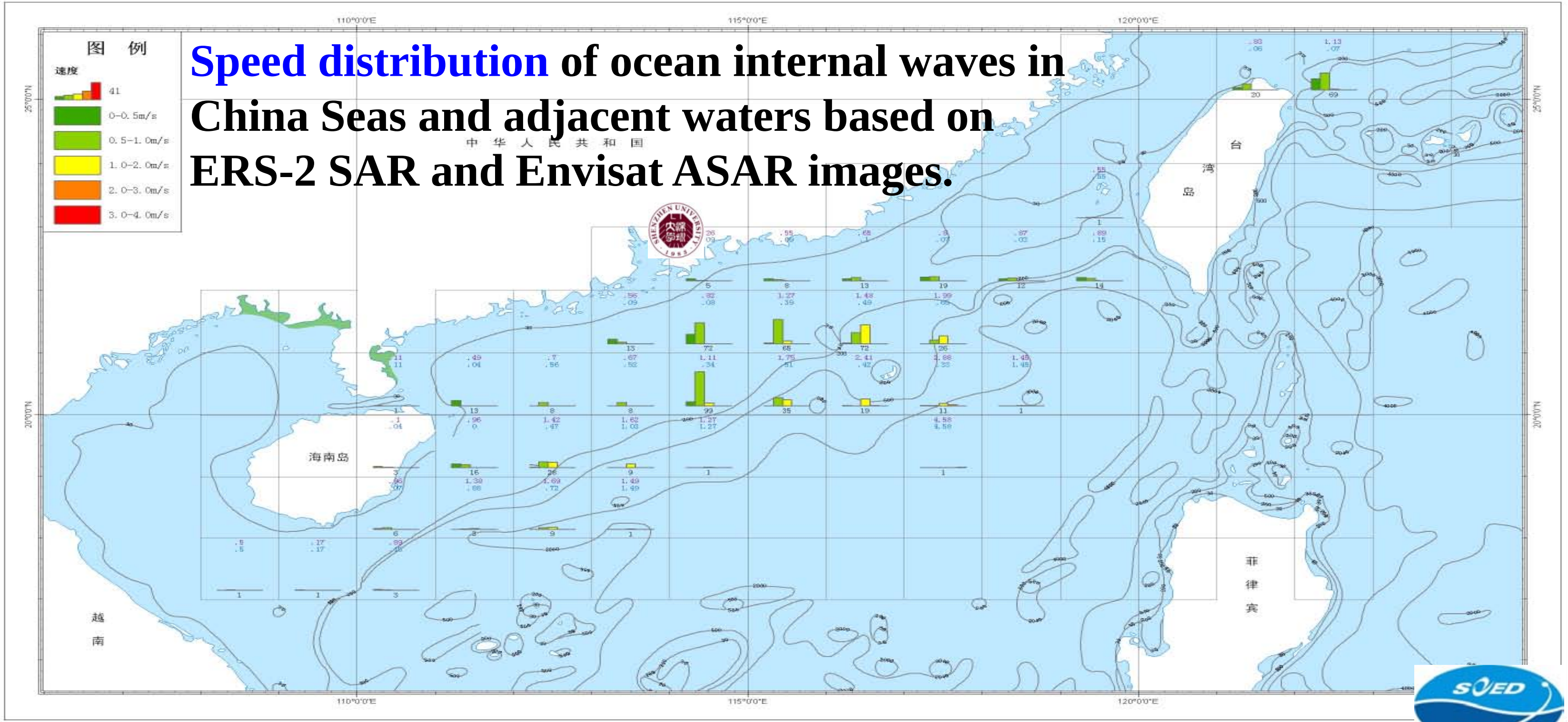
The First Quantitative Remote Sensing of Ocean Internal Waves by Using Chinese GF-3 SAR Satellite（launched on Aug. 10, 2016）

Acta Oceanol. Sin., 2017

Amplitude: ~5 m
Pycnocline depth: ~32 m
Water depth: ~100 m

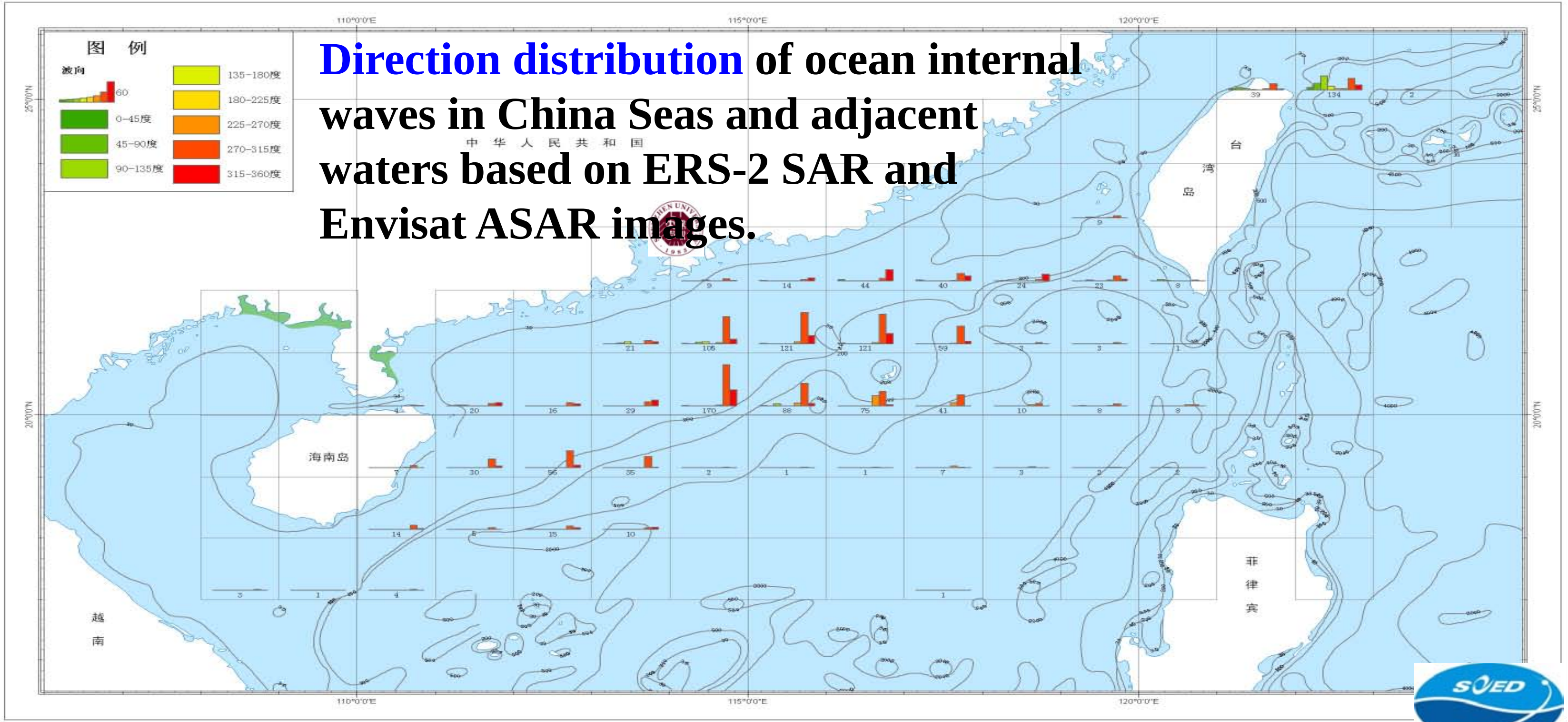
4. Ocean internal waves

Speed distribution of ocean internal waves in China Seas and adjacent waters based on ERS-2 SAR and Envisat ASAR images.



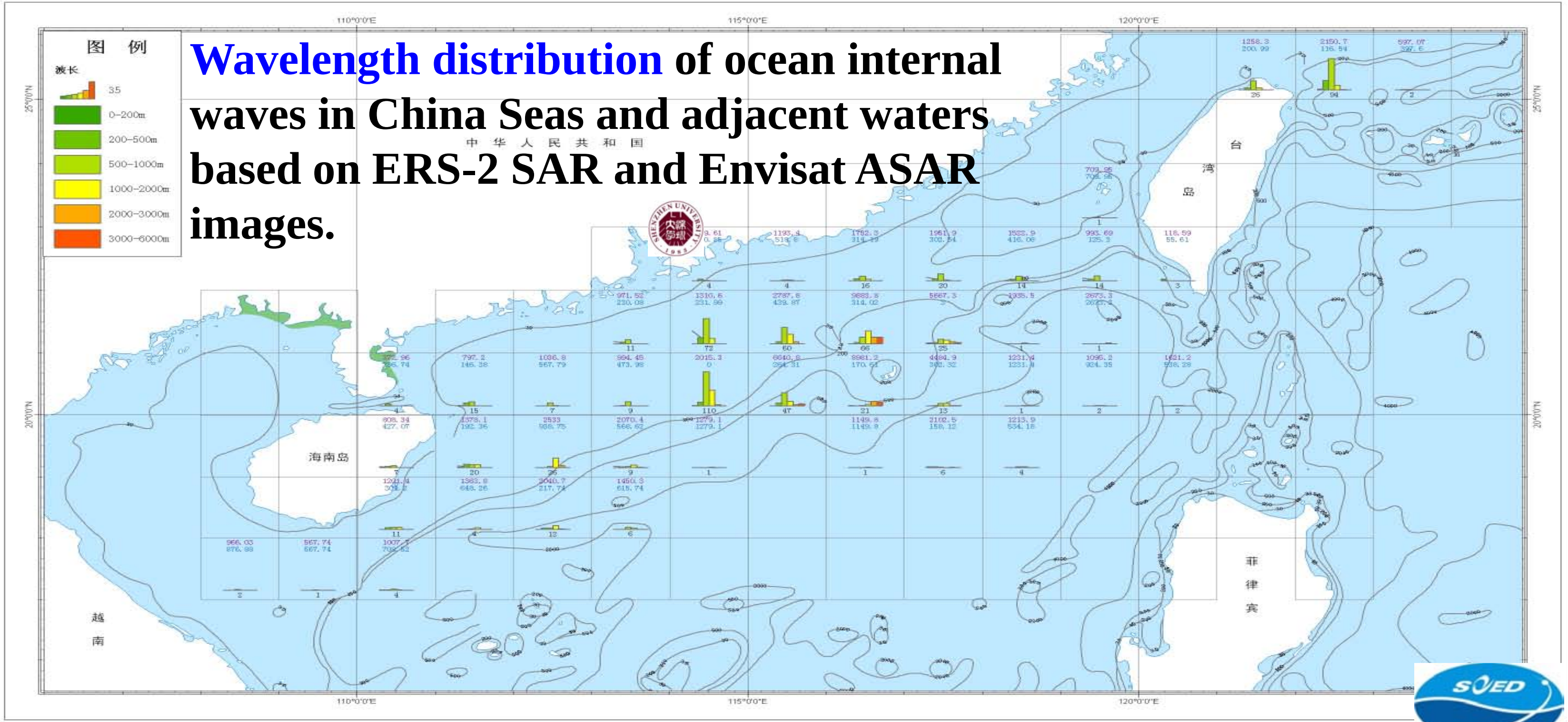
4. Ocean internal waves

Direction distribution of ocean internal waves in China Seas and adjacent waters based on ERS-2 SAR and Envisat ASAR images.

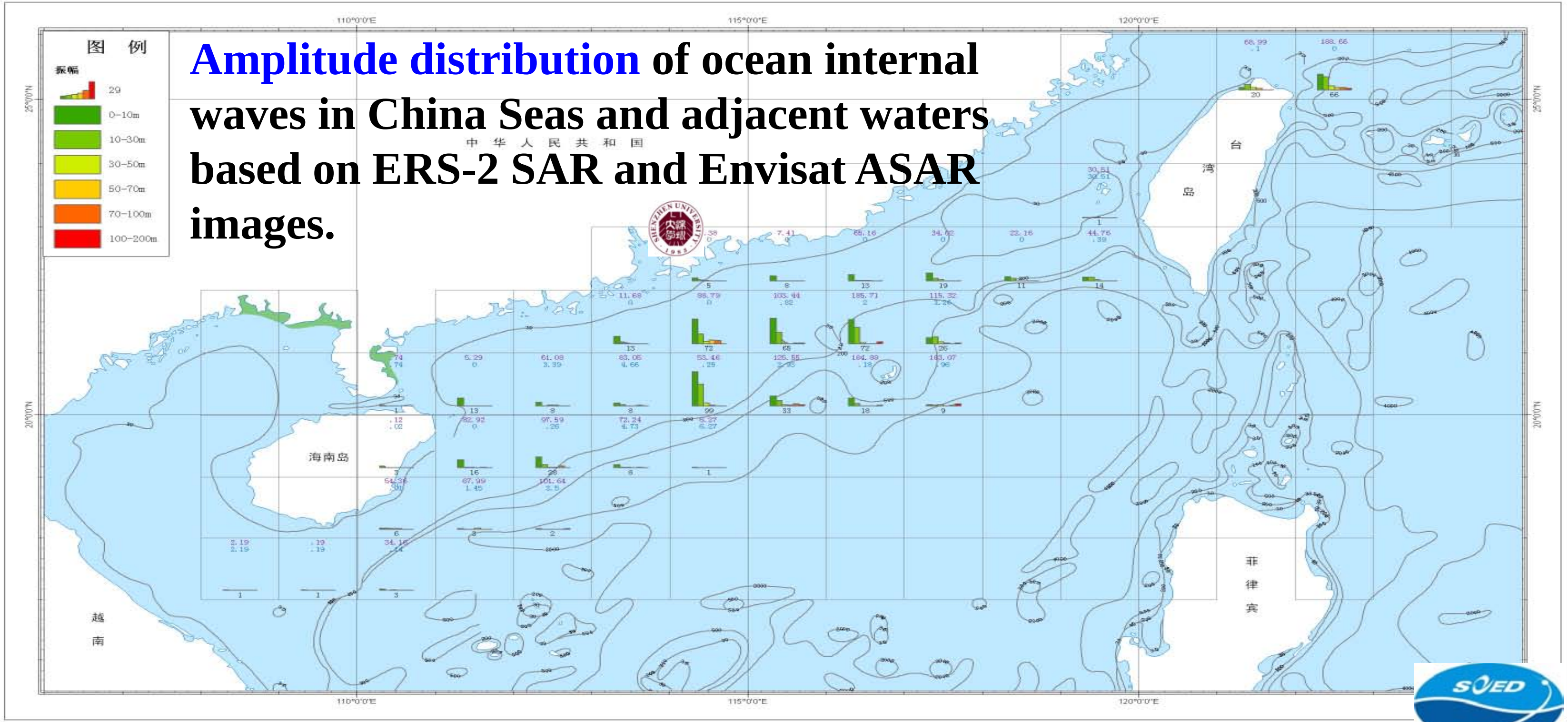


4. Ocean internal waves

Wavelength distribution of ocean internal waves in China Seas and adjacent waters based on ERS-2 SAR and Envisat ASAR images.

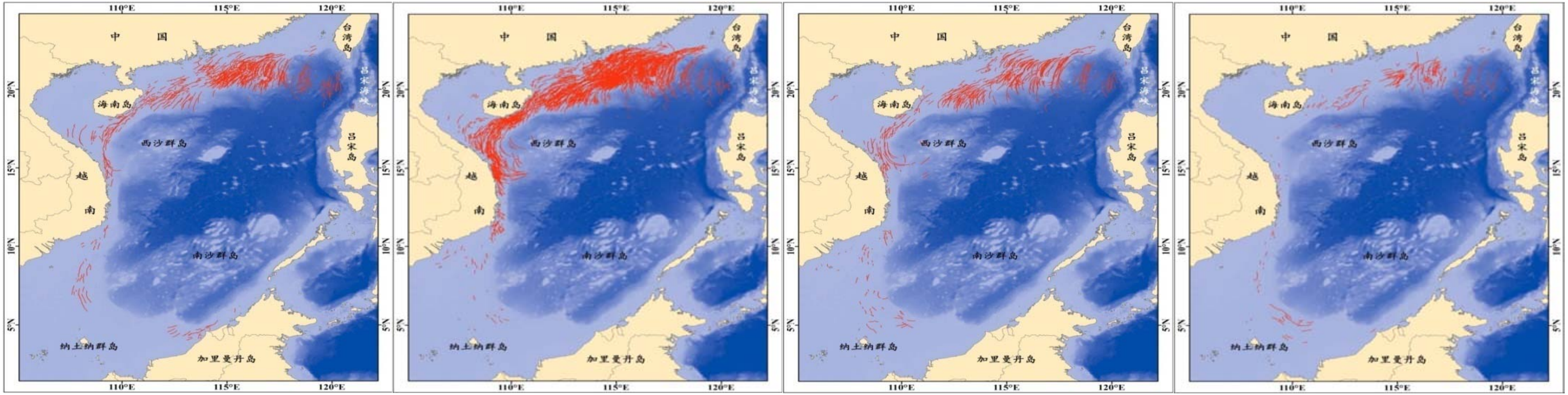


4. Ocean internal waves



Amplitude distribution of ocean internal waves in China Seas and adjacent waters based on ERS-2 SAR and Envisat ASAR images.

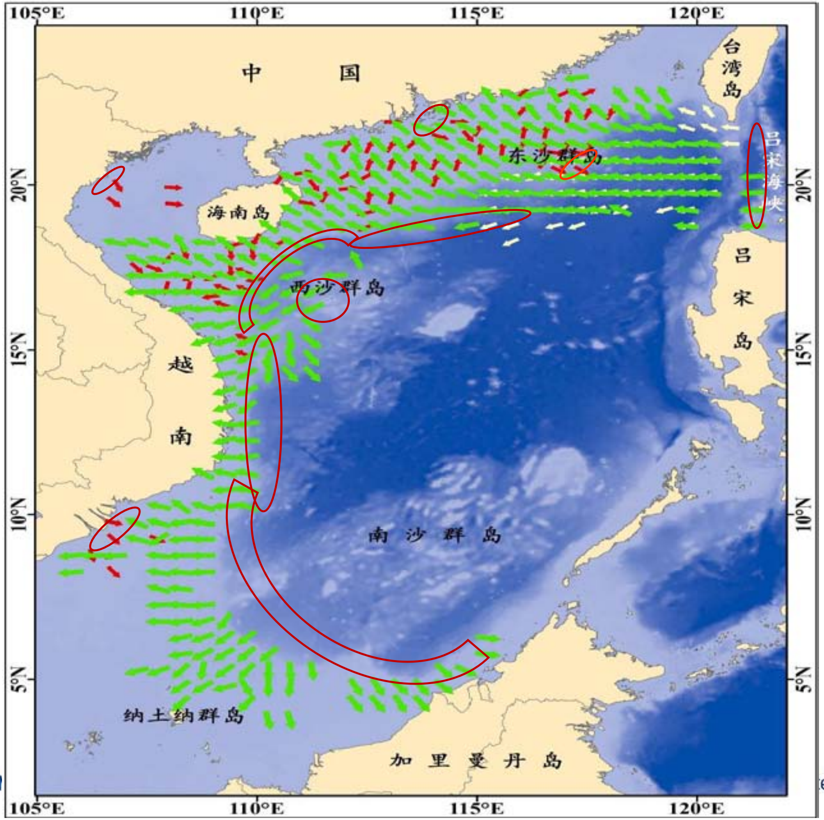
4. Ocean internal waves



spring　　summer　　autumn　　winter

Seasonal distribution of ocean internal waves in South China Sea and adjacent waters based on ERS-2 SAR, Envisat ASAR, MODIS, and HJ-1A/B images from 2005.

4. Ocean internal waves



Acta Oceanol. Sin., 2013

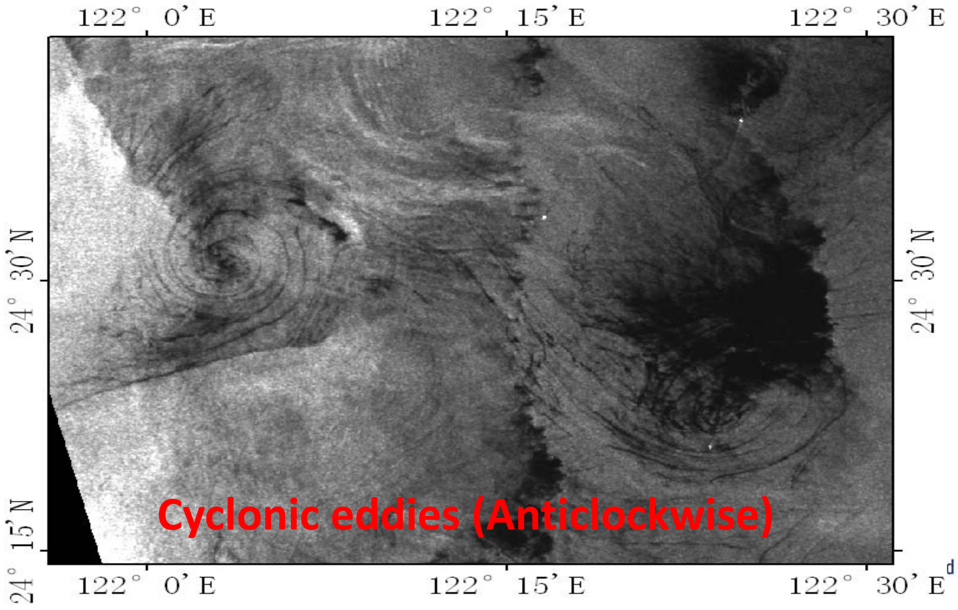
Source and propagation of ocean internal waves in South China Sea and adjacent waters

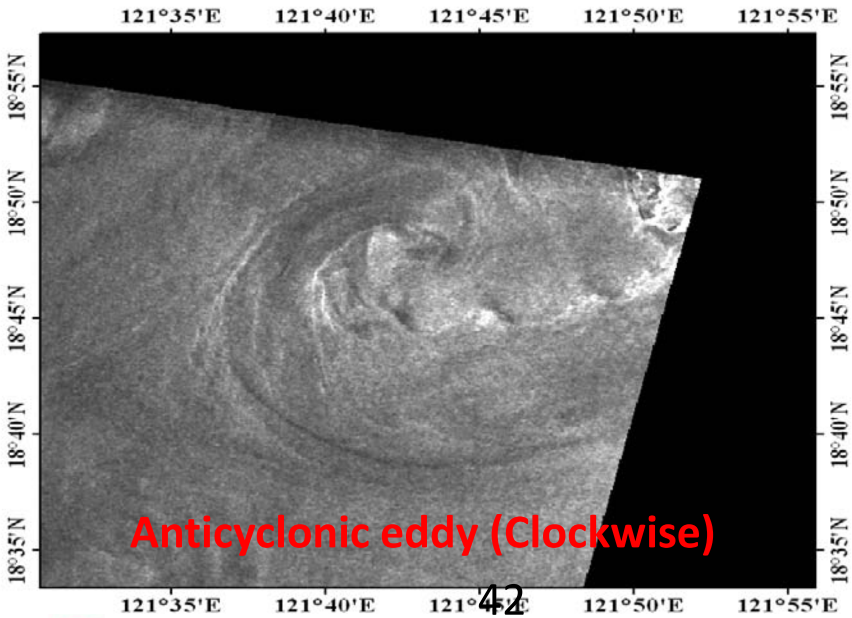
5. Eddies

Eddies Detection by SAR

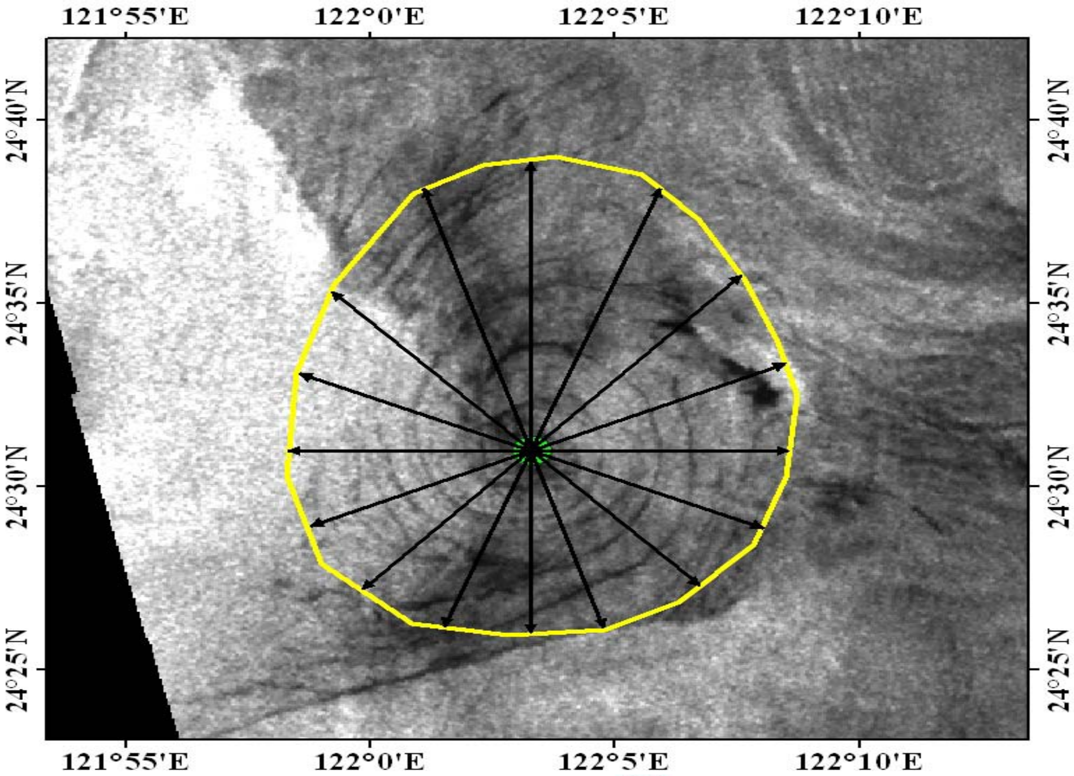
Recognized as dark, narrow, curvilinear, and concentric bands (oil slicks) that appear to be spiral inward —— "black eddy"

Identified by a narrow band of increased brightness, usually related to current shear —— "white eddy"





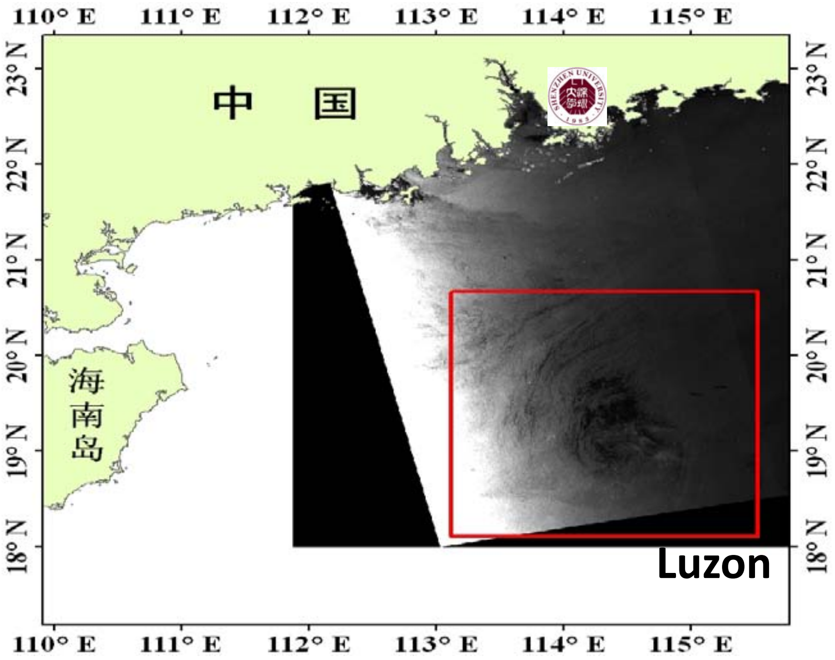
5. Eddies

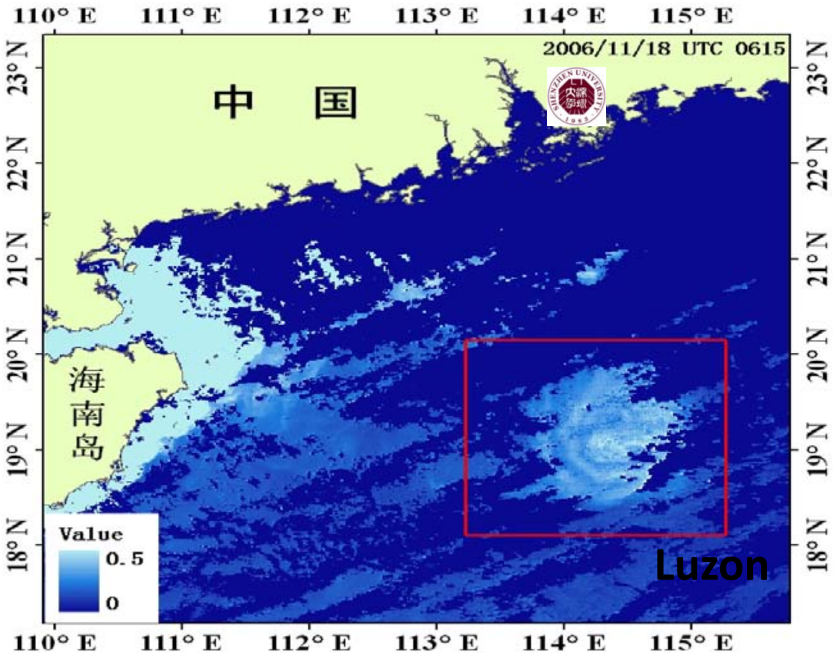


location, radius, rotation

Cyclonic eddy
Anticlockwise

5. Eddies



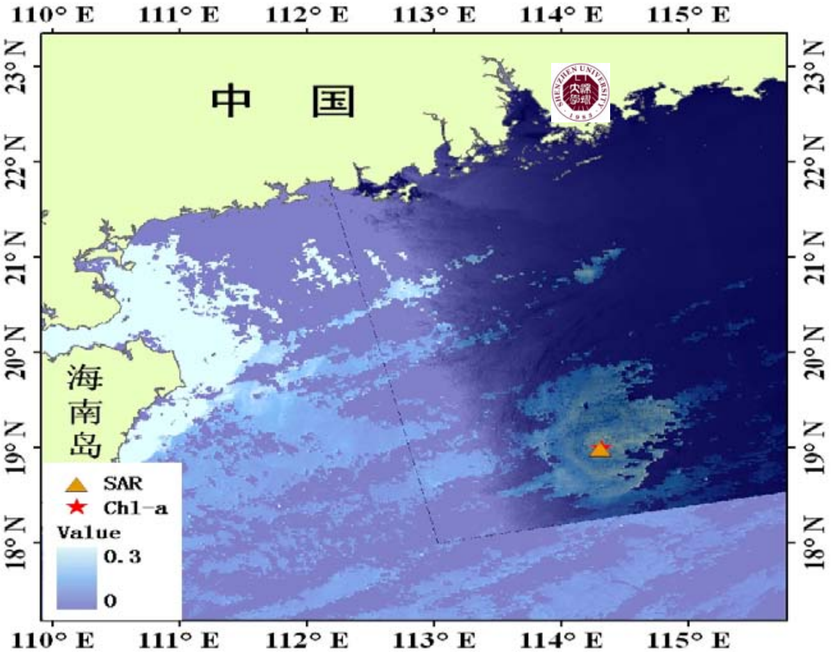


Envisat ASAR
Radius: 90km

Cyclonic eddy

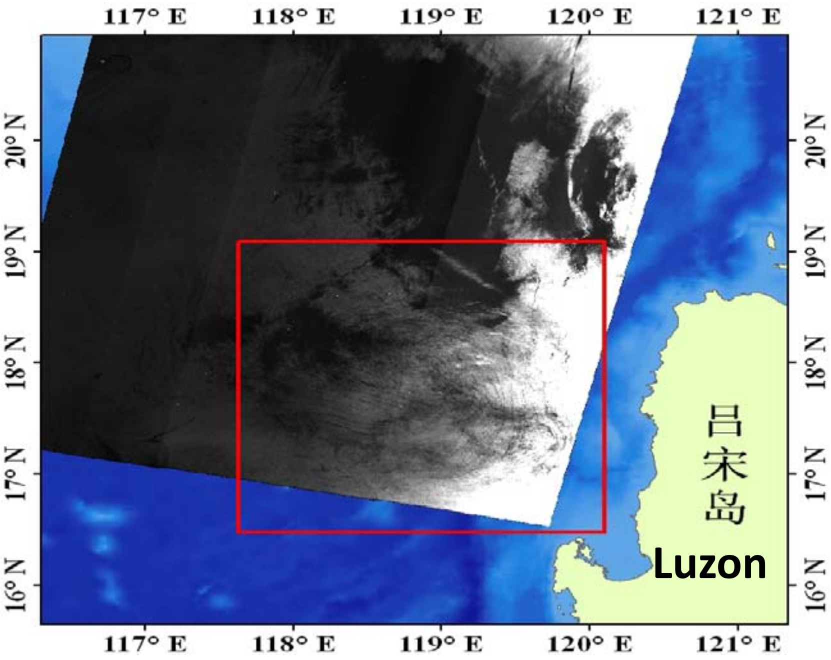
MODIS Chl-a
83km

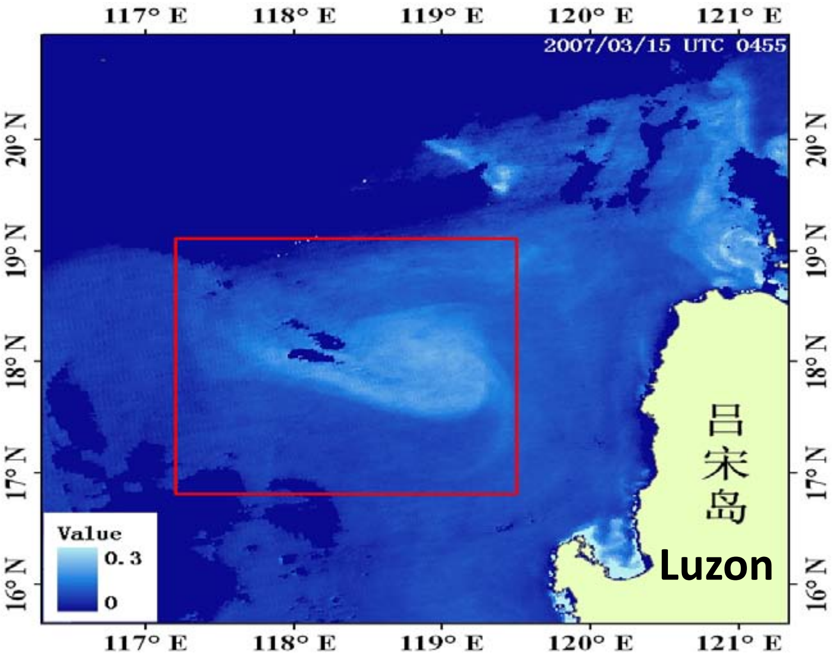
5. Eddies



Envisat SAR + MODIS Chl-a (time difference: < 1 hours)

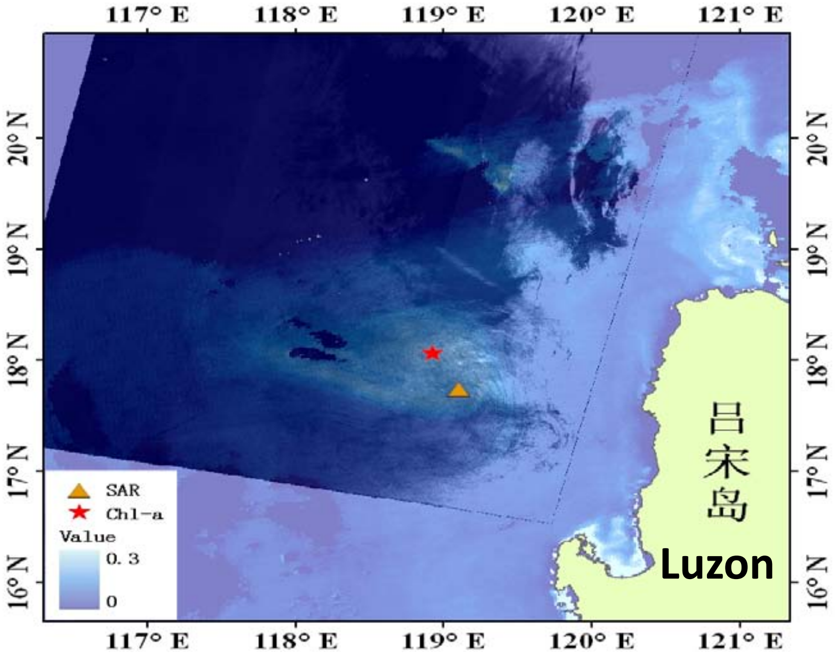
5. Eddies





	Envisat ASAR	Cyclonic eddy	MODIS Chl-a
Radius:	112km		103km

5. Eddies



Envisat SAR + MODIS Chl-a
(time difference: < 3 hours)

5. Eddies

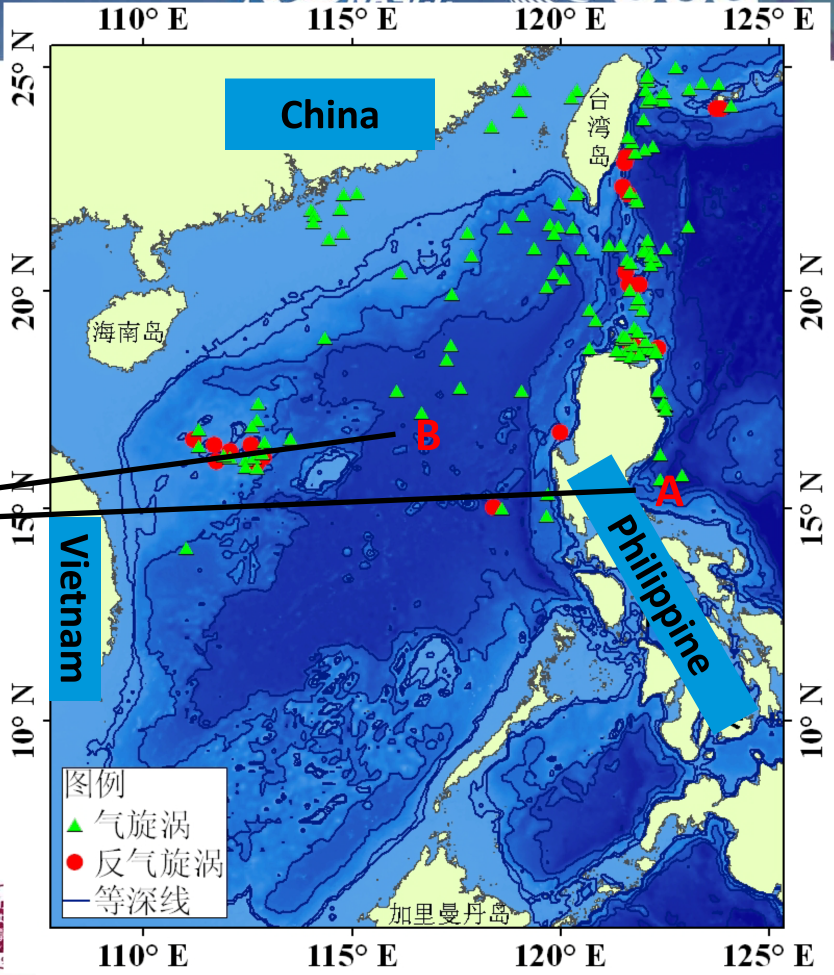
Int. J. Rem. Sens., 2015

Red: Anti-cyclonic (Clockwise) eddies

Green: Cyclonic (Anti-clockwise) eddies

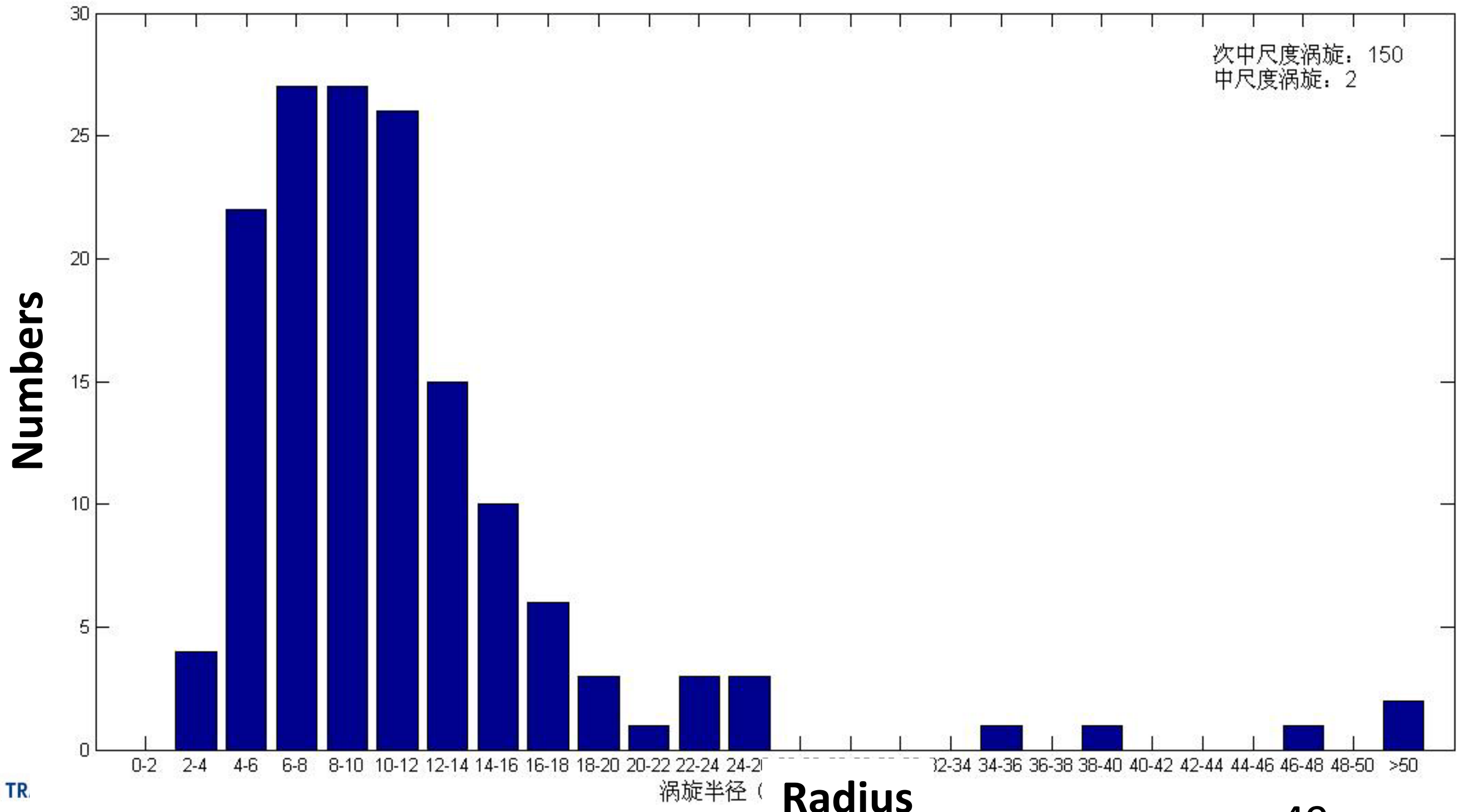
A & B: Mesoscale eddies

Others: Sub-mesoscale eddies



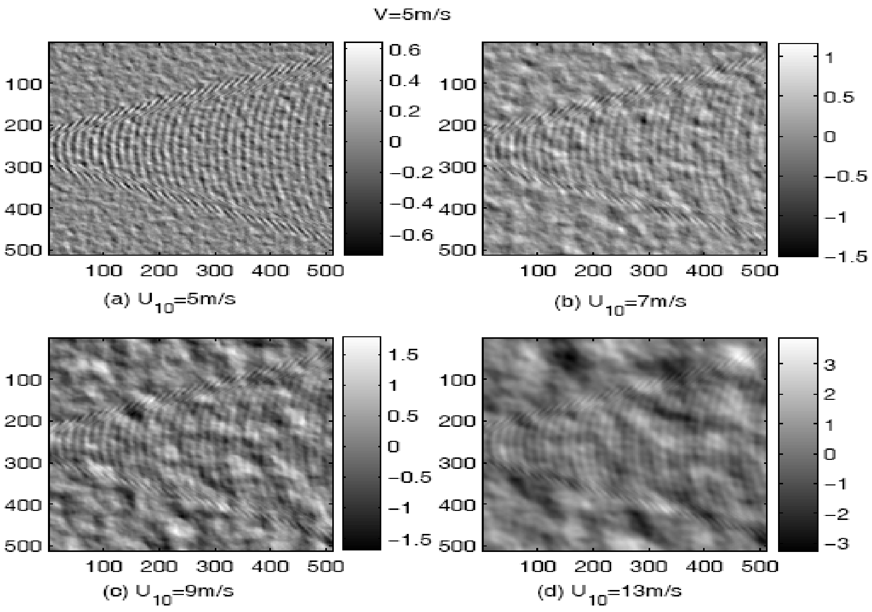
Distribution map

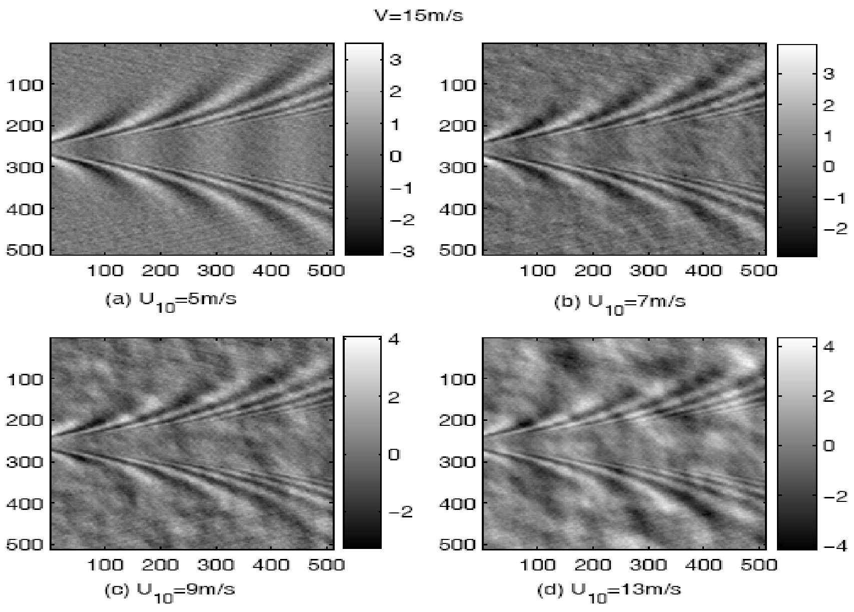
5. Eddies



次中尺度涡旋：150
中尺度涡旋：2
Numbers
0-2 2-4 4-6 6-8 8-10 10-12 12-14 14-16 16-18 18-20 20-22 22-24 24-2
32-34 34-36 36-38 38-40 40-42 42-44 44-46 46-48 48-50 >50
涡旋半径（
Radius

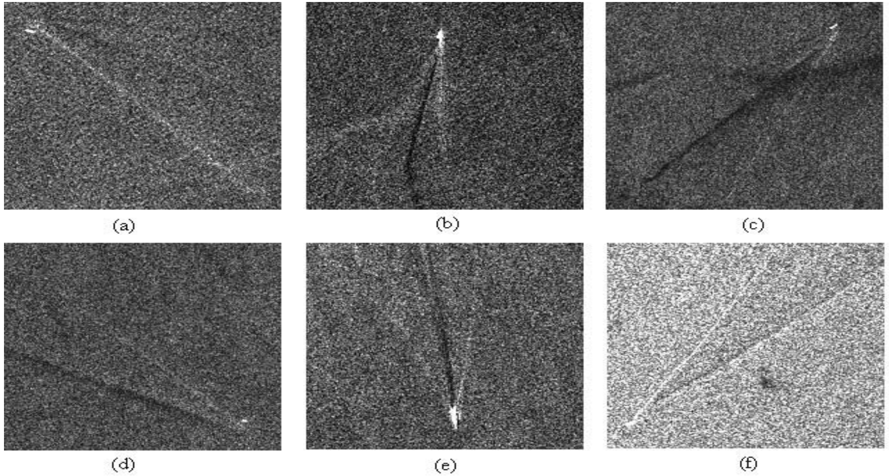
6. Ship wakes

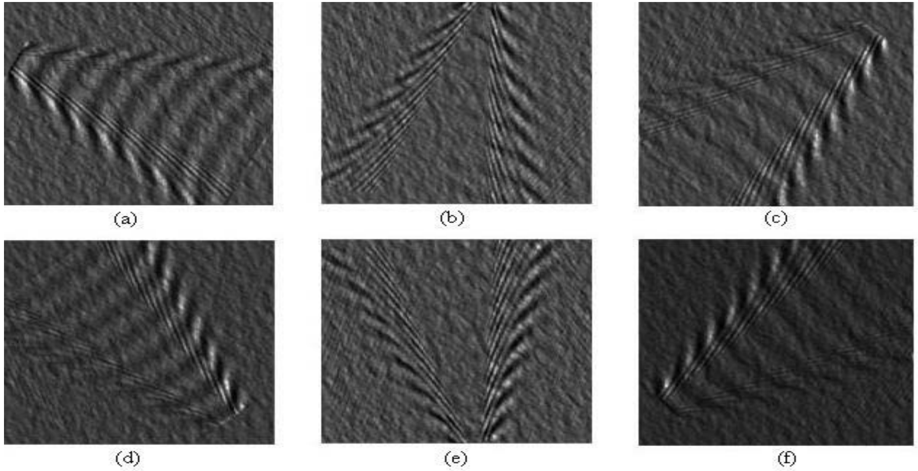




Simulated wakes on SAR images for different wind speed (U10) and ship velocity (V)

6. Ship wakes





ERS-1/2 SAR imagery

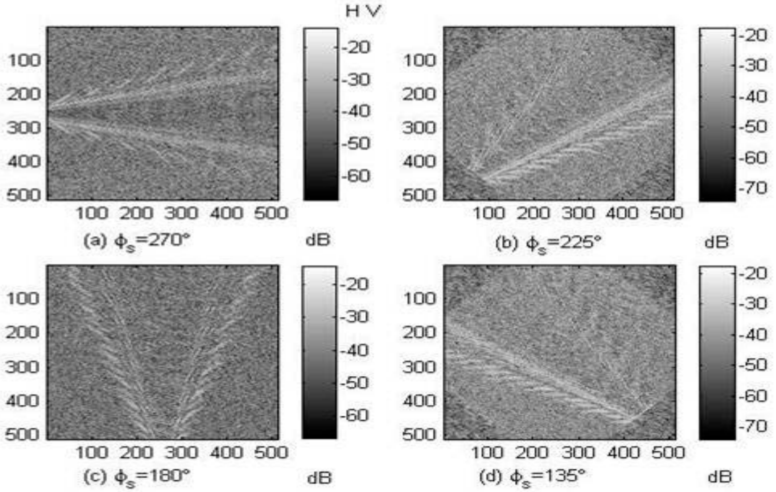
Az

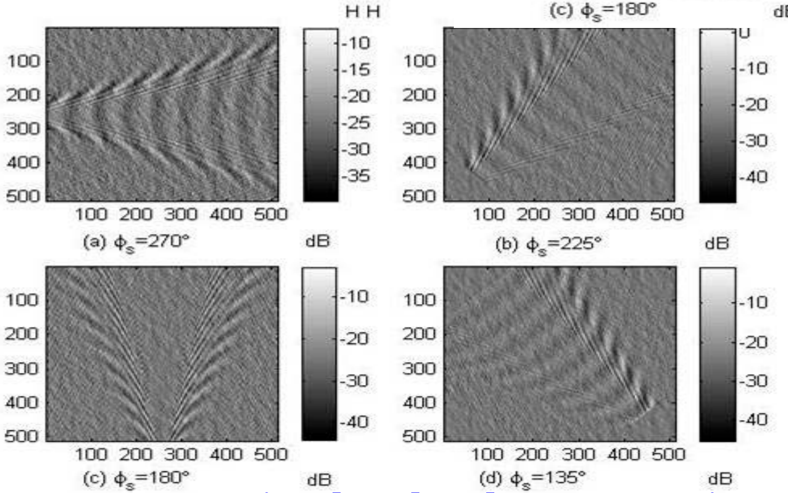
Rg

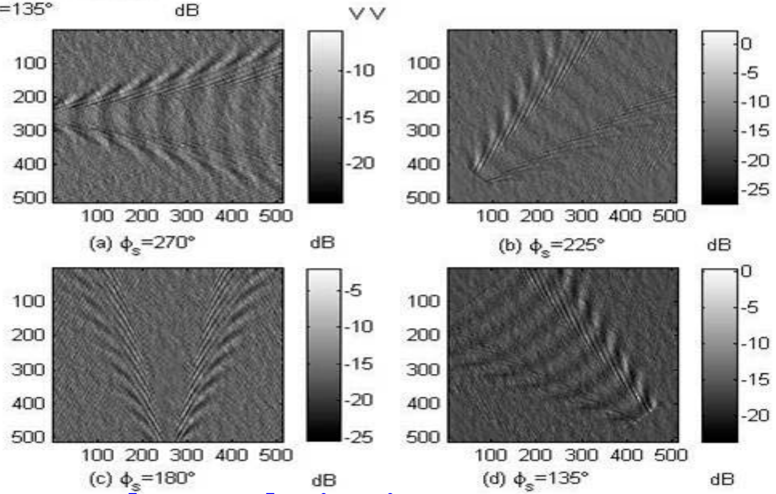
simulation

Ship wakes and simulated ship wakes on SAR images

6. Ship wakes

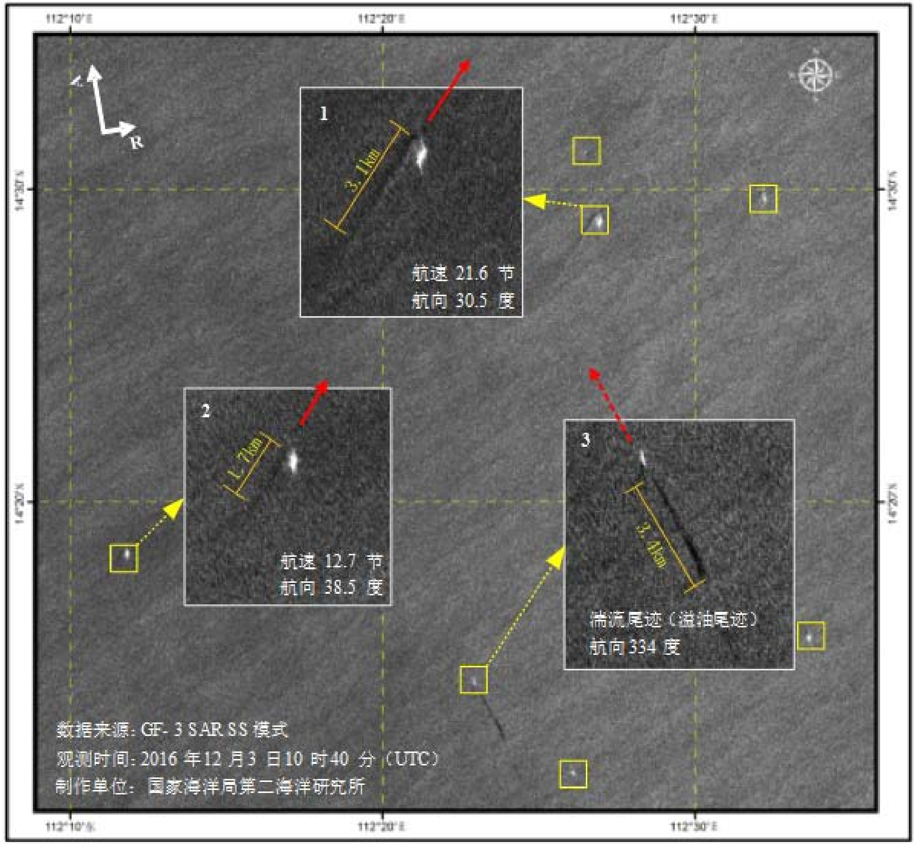




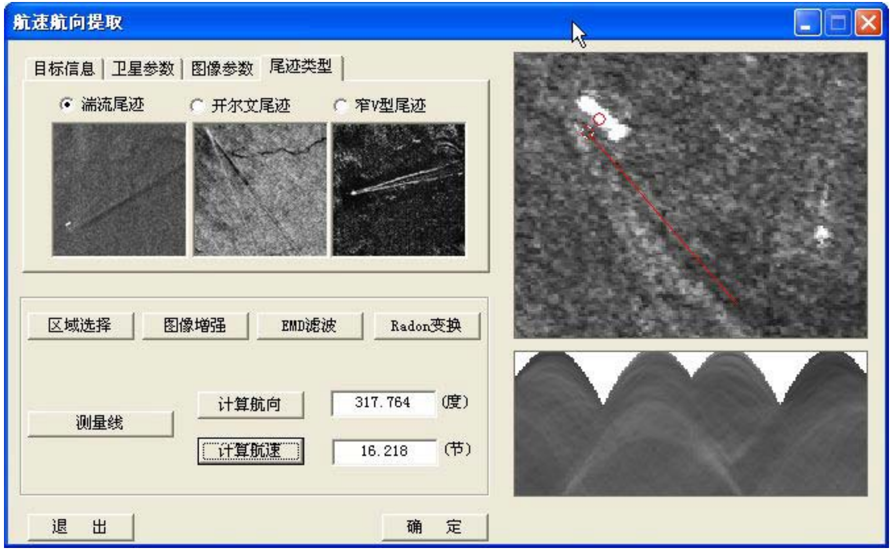


Simulated wakes on SAR images for HH, HV and VV polarization

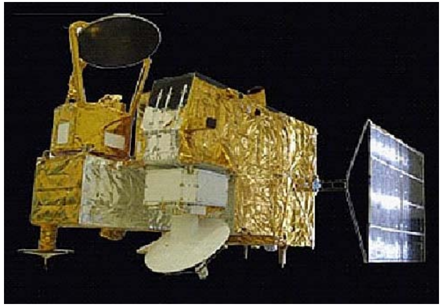
6. Ship wakes



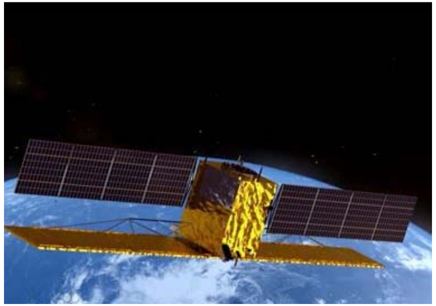
112°10′E
112°20′E
112°30′E
1
3. 1km
航速 21.6 节
航向 30.5 度
2
1. 7km
航速 12.7 节
航向 38.5 度
3
3. 4km
湍流尾迹（溢油尾迹）
航向 334 度
数据来源: GF- 3 SAR SS 模式
观测时间: 2016 年12 月3 日10 时40 分（UTC）
制作单位: 国家海洋局第二海洋研究所



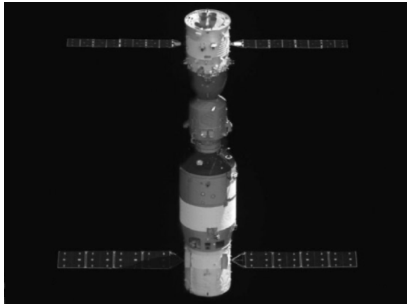
航速航向提取
目标信息
卫星参数
图像参数
尾迹类型
湍流尾迹
开尔文尾迹
窄V型尾迹
区域选择
图像增强
EMD滤波
Radon变换
测量线
计算航向
317. 764
(度)
计算航速
16. 218
(节)
退 出
确 定



HY-2A/B
ALT, SCAT, RAD
2011.8.15-/2018.10.24-



GF-3
SAR
2016.8.10-



TG-2
InIRA
2016.9.15-

CFOSAT
SWIM, SCAT
2018.10.29-

Thanks for your attention!