



**ESA-MOST Dragon Cooperation**

中国科技部-欧洲空间局“龙计划”合作

# **2017 DRAGON 4 SYMPOSIUM**

2017年“龙计划”四期学术研讨会

Id. 32249

**Some Results from Chinese Newly Launched Spaceborne Microwave Sensors**

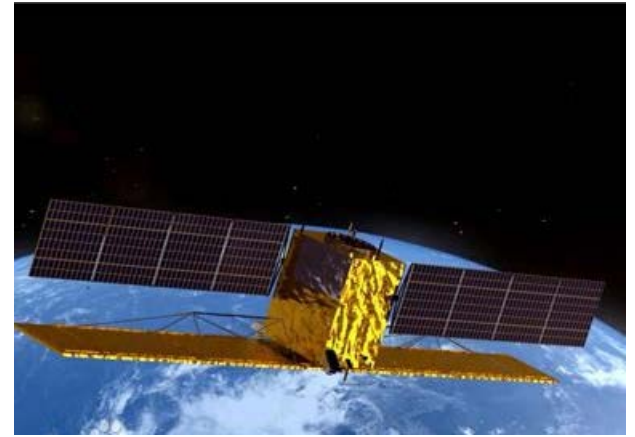
**Jingsong Yang, Lin Ren, Juan Wang, He Wang, Biao Zhang, Alexis Mouche**

26-30 June 2017 | Copenhagen, Denmark

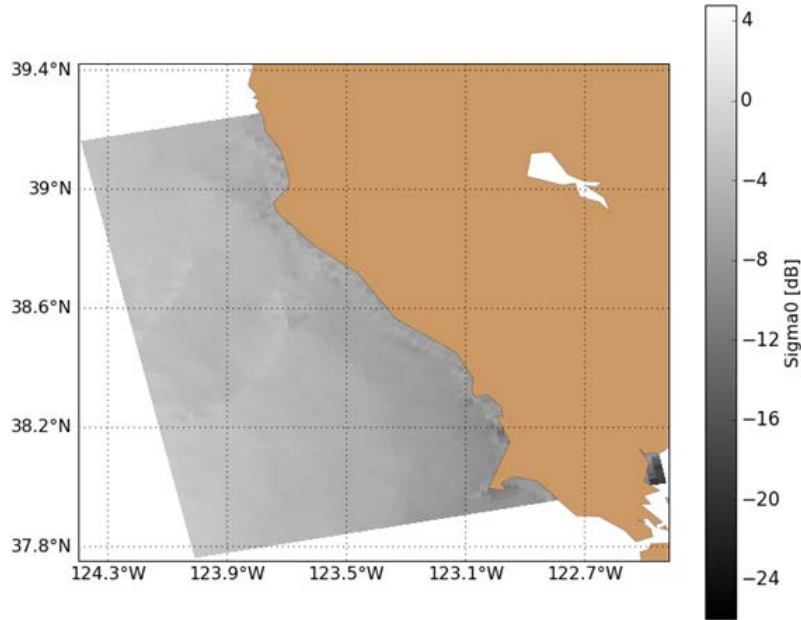
2017年6月26-30日, 丹麦 哥本哈根

## GF-3 SAR

GF-3 (GF stands for GaoFen, which means High Resolution in Chinese) is the China's first **C band** multi-polarization high resolution microwave remote sensing satellite. It was successfully launched on **Aug. 10, 2016** in Taiyuan satellite launch center. The synthetic aperture radar (SAR) on board GF-3 works at incidence angles ranging from **20 to 50 degree** with several polarization modes including single-polarization, dual-polarization and quad-polarization. GF-3 SAR is also the world's most imaging mode SAR satellite, with **12 imaging modes** consisting of some traditional ones like stripmap and scanSAR modes and some new ones like spotlight, wave and global modes. GF-3 SAR is thus a multi-functional satellite for both land and ocean observation by switching the different imaging modes.

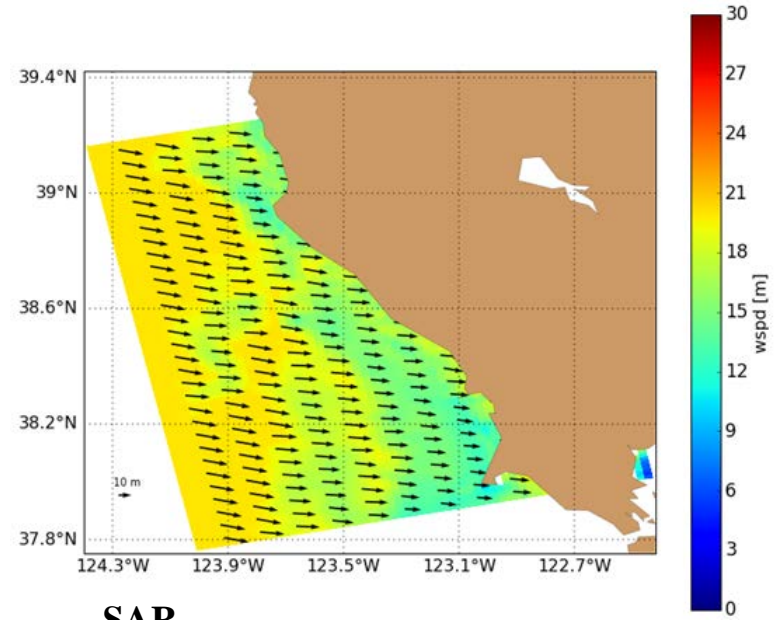


## GF-3 SAR wind retrieval



**CMOD5.N + NCEP direction + lookup table**

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



**-SAR**

**Wind speed: 13.9m/s**  
**Wind direction: 254.0°**

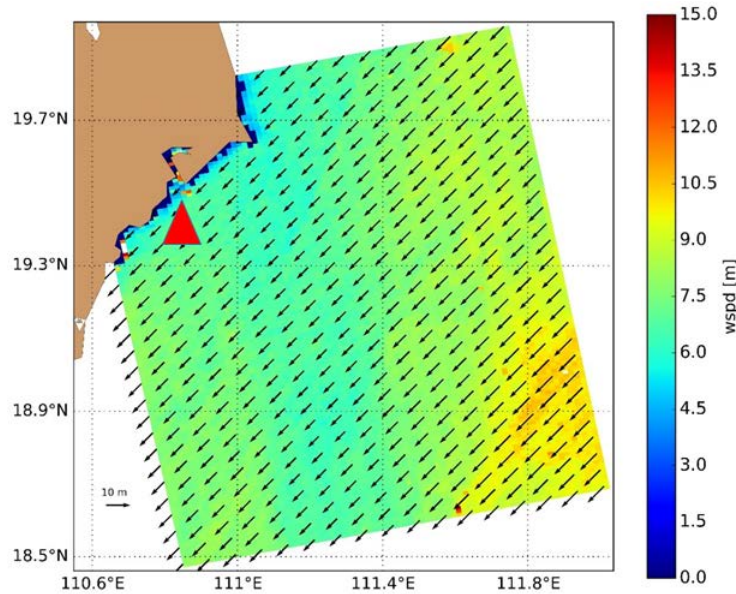
**-Buoy**

**Wind speed: 12.0m/s**  
**Wind direction: 269°**



## GF-3 SAR wind retrieval

GF3\_MYN\_SS\_991247\_20161104\_L1A\_HHHV



**-SAR**

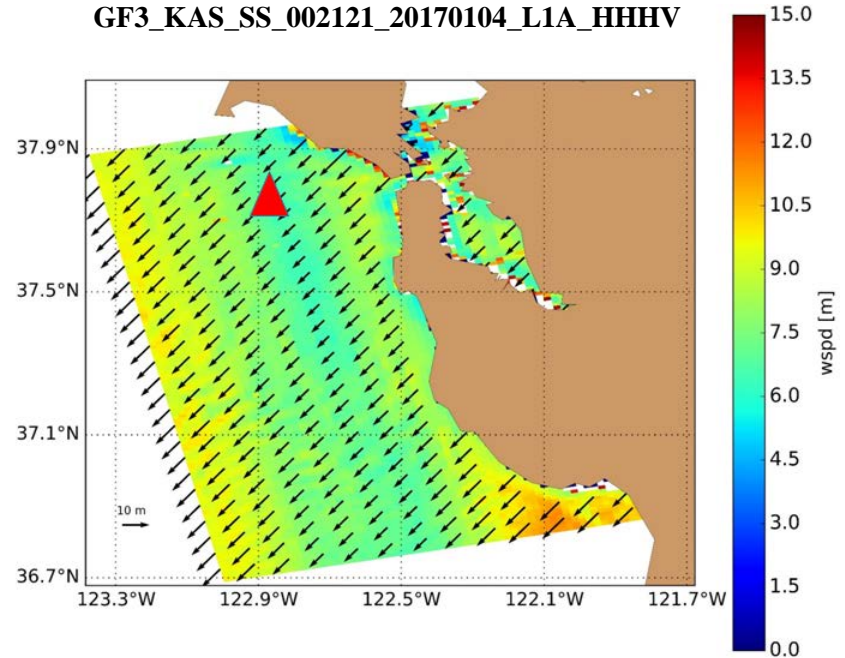
**Wind speed: 7.1m/s**

**-Buoy**

**Wind speed: 5.7m/s**

**Wind direction: 45°**

GF3\_KAS\_SS\_002121\_20170104\_L1A\_HHHV



**-SAR**

**Wind speed: 6.6m/s**

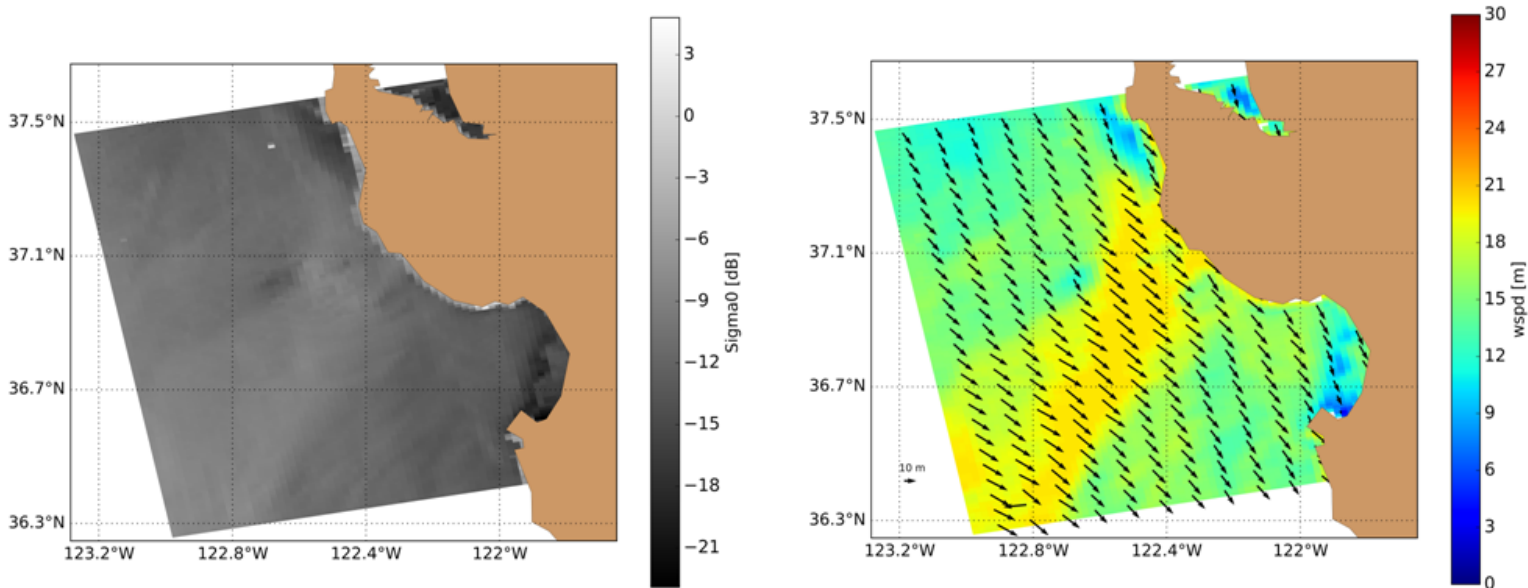
**-Buoy**

**Wind speed: 8.3m/s**

**Wind direction: 74°**

## GF-3 SAR wind retrieval

### 高分三号卫星标准条带模式海面风场专题图



传感器：GF-3/SAR

观测模式：标准条带

观测时间：2017 年 02 月 02 日 02:05:57 UTC

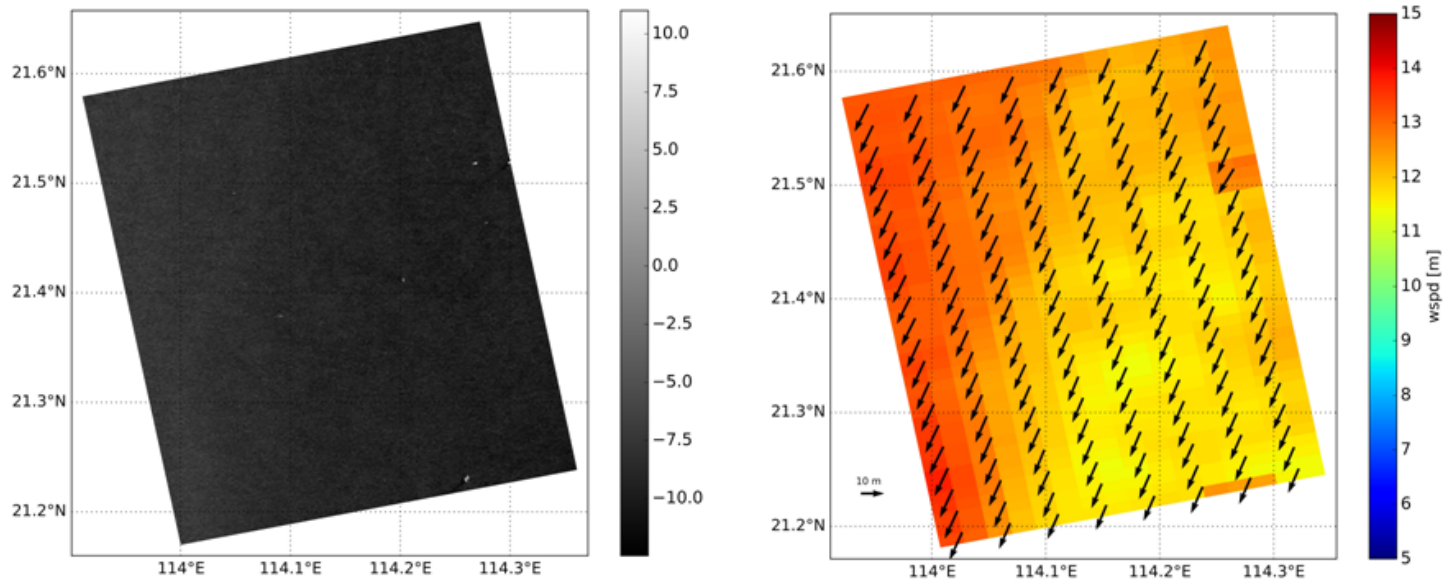
海面雷达后向散射系数（左）、海面风场反演产品（右）

制作单位：国家海洋局第二海洋研究所



## GF-3 SAR wind retrieval

### 高分三号卫星全极化条带模式海面风场专题图



传感器：GF-3/SAR

观测模式：全极化条带 1

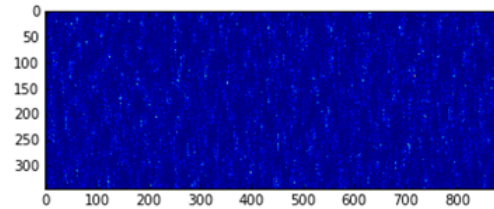
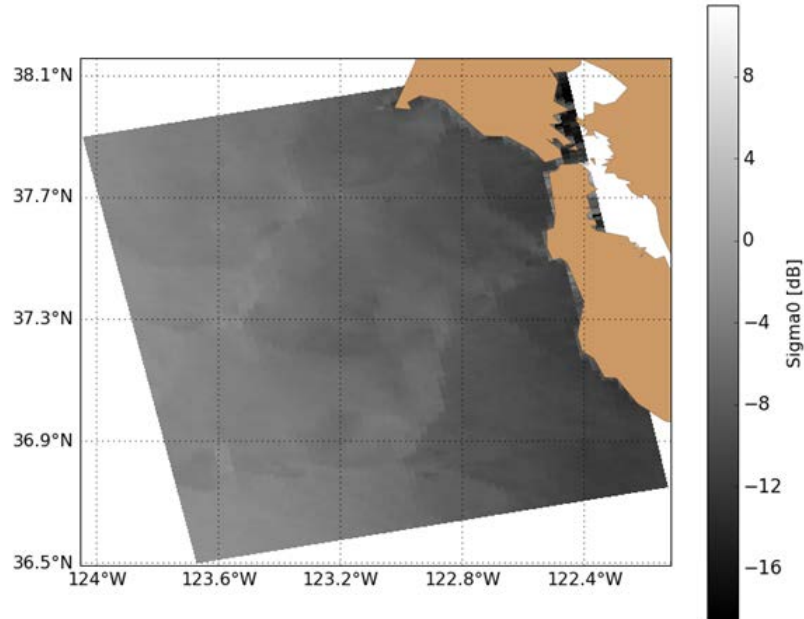
观测时间：2017 年 03 月 15 日 10:24:42 UTC

海面雷达后向散射系数（左）、海面风场反演产品（右）

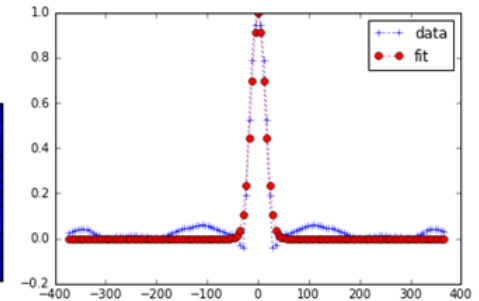
制作单位：国家海洋局第二海洋研究所



# GF-3 SAR wave retrieval



Sub-image



Cut-off wavelength

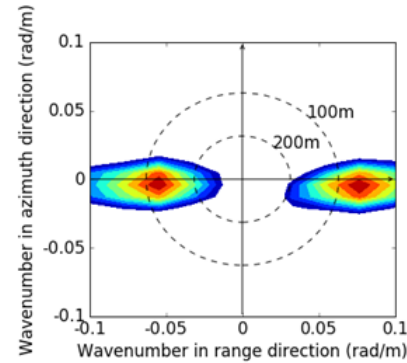
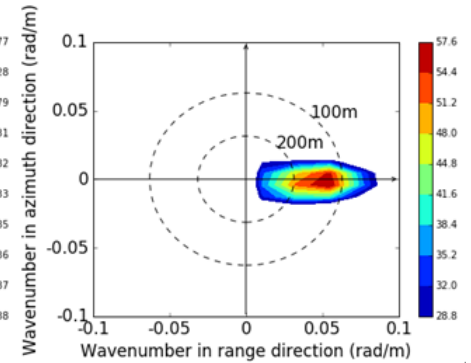
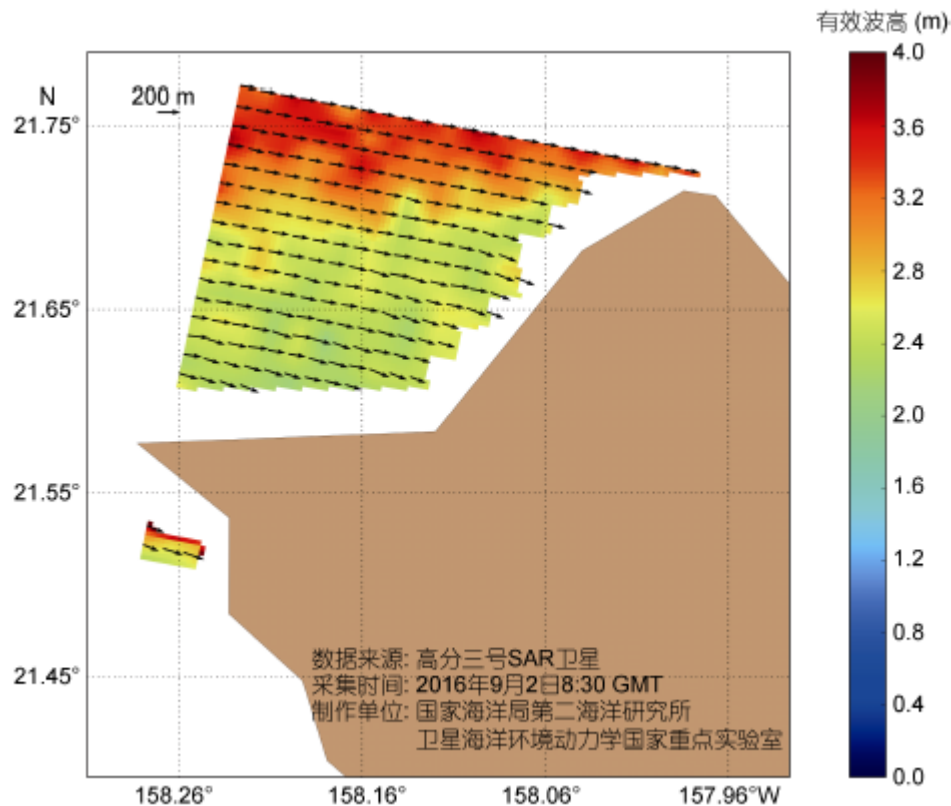
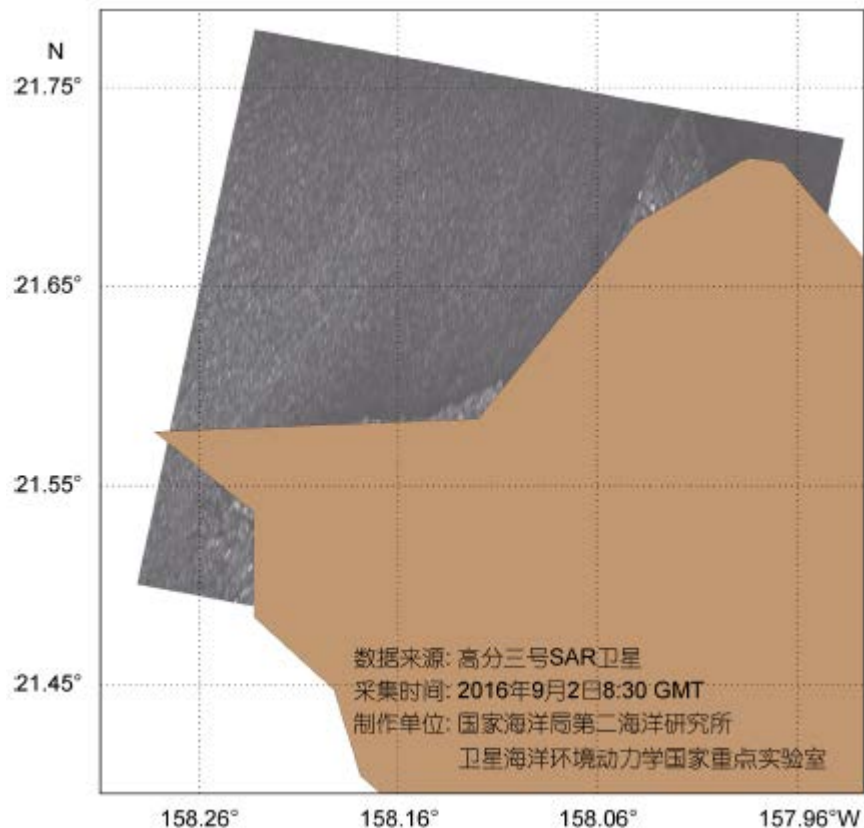


Image spectrum



Wave spectrum

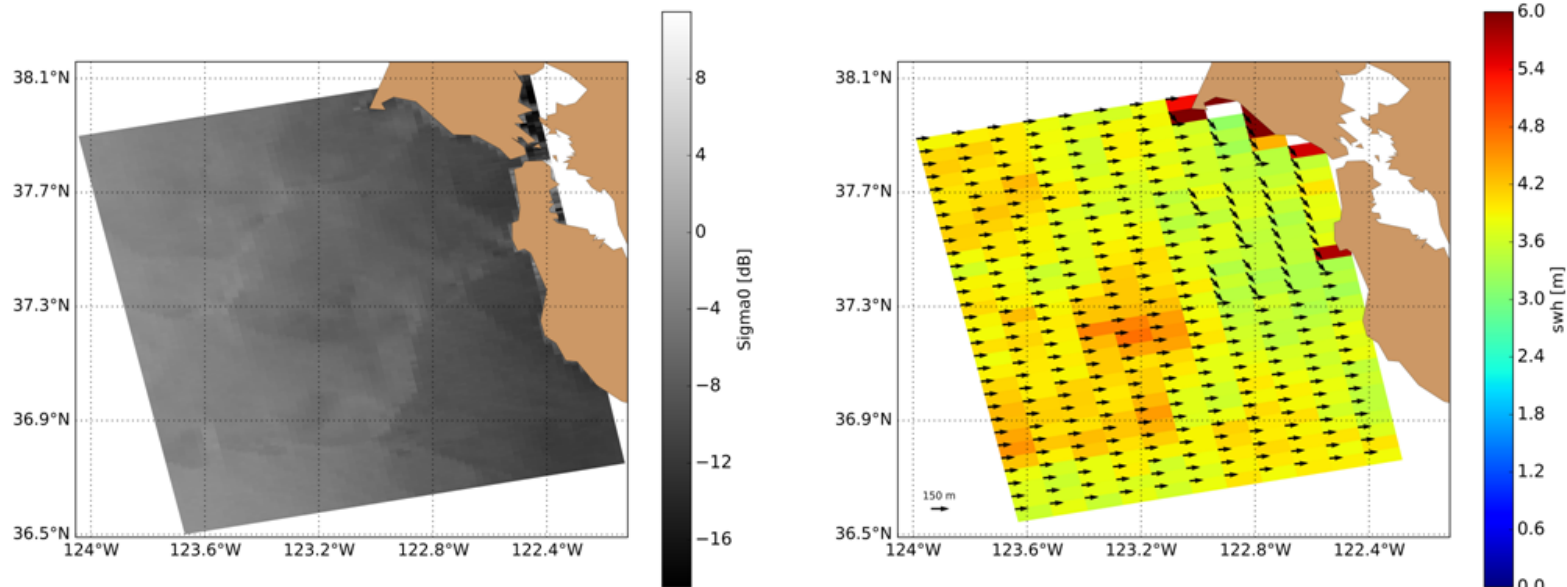
## GF-3 SAR wave retrieval





## GF-3 SAR wave retrieval

### 高分三号卫星标准条带模式海面浪场专题图



传感器：GF-3/SAR

观测模式：标准条带

观测时间：2017年01月21日 02:02:39UTC

海面雷达后向散射系数（左）、海面浪场反演产品（右）

制作单位：国家海洋局第二海洋研究所



-SAR

SWH: 3.8m

wavelength: 146.0m

wave direction: 265.2°

-NDBC (46012)

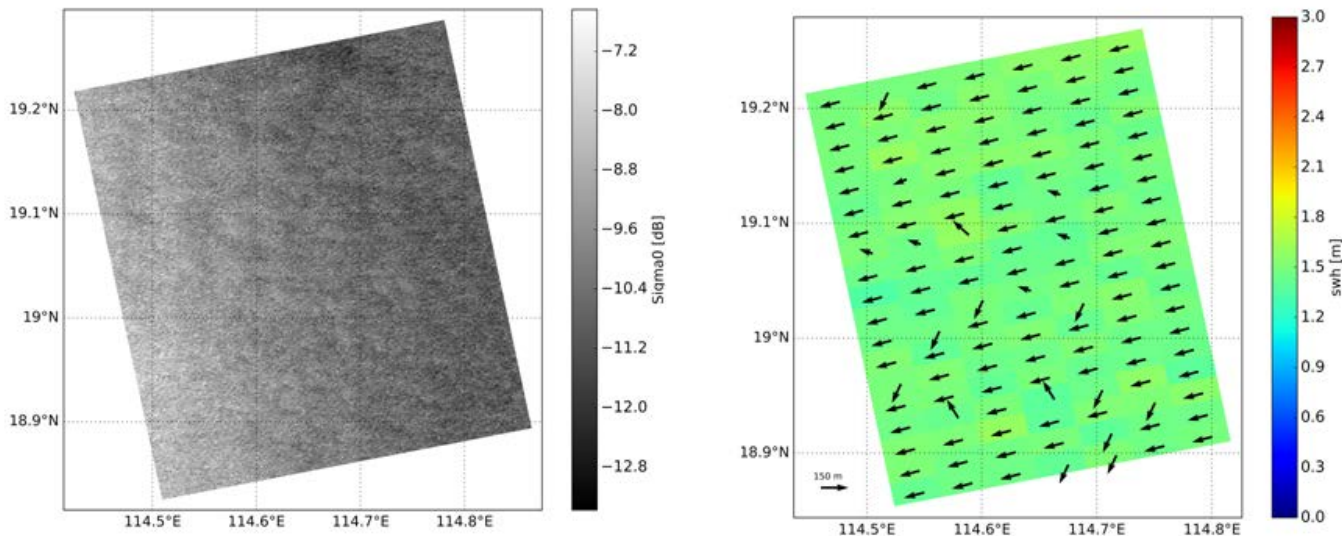
4.6m

139.9m

277.0°

## GF-3 SAR wave retrieval

### 高分三号卫星全极化条带模式海面浪场专题图



传感器：GF-3/SAR

观测模式：全极化条带 1

观测时间：2017 年 03 月 15 日 10:24:03 UTC

海面雷达后向散射系数（左）、海面浪场反演产品（右）

制作单位：国家海洋局第二海洋研究所



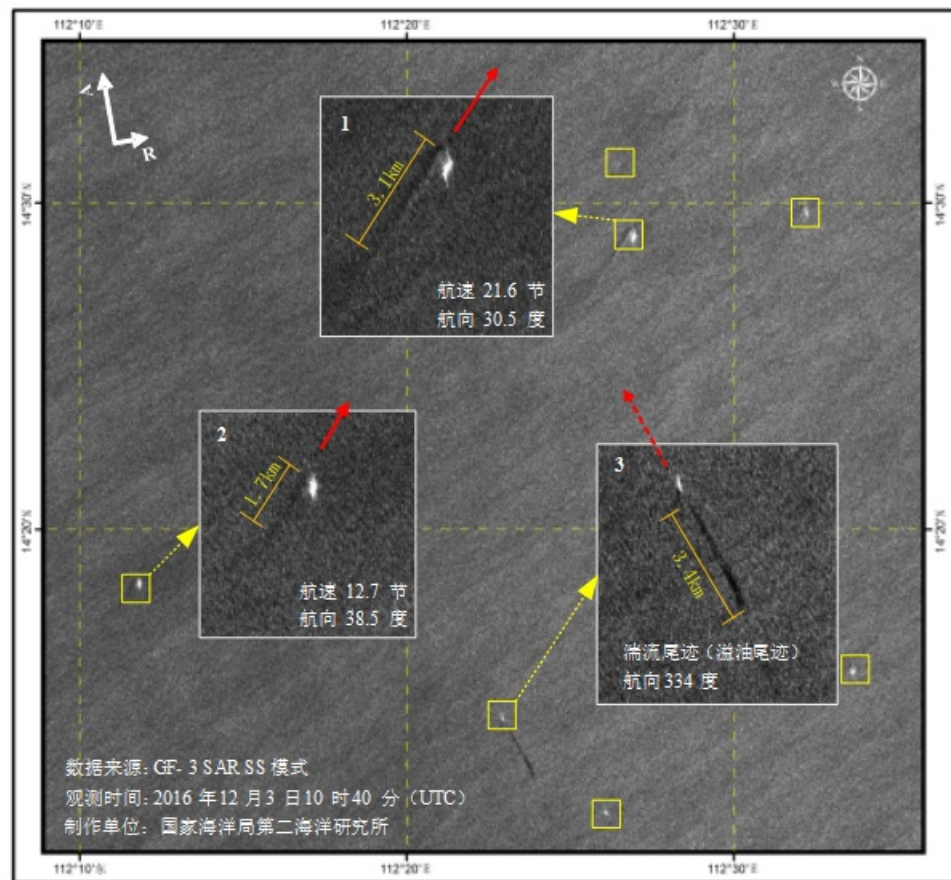
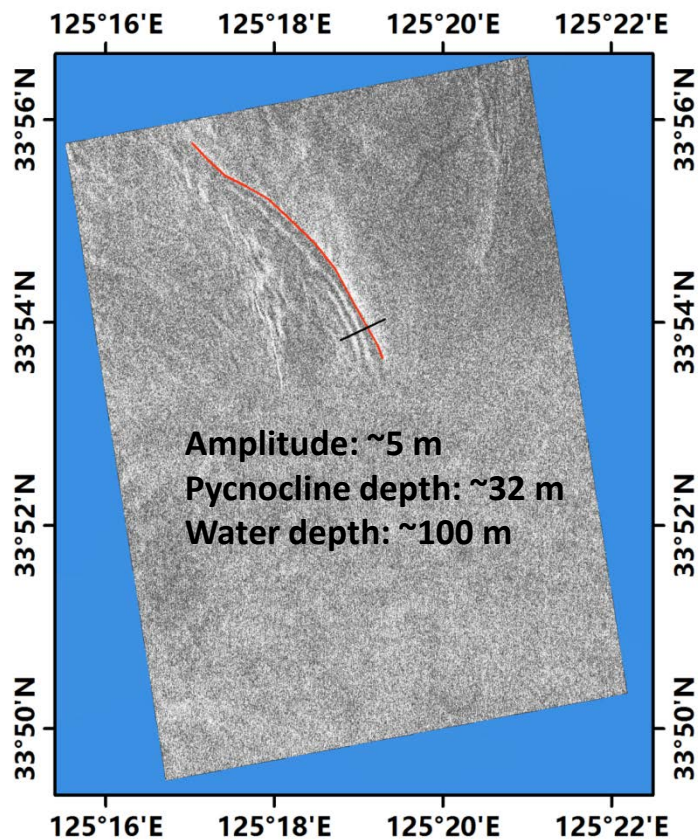
-SAR  
-WW3

SWH: 1.7m  
2.1m

wavelength: 120.9m  
112.7m

wave direction: 68.3°  
54.0°

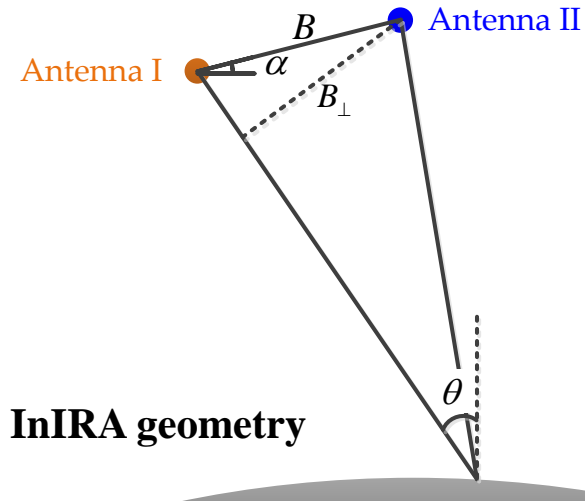
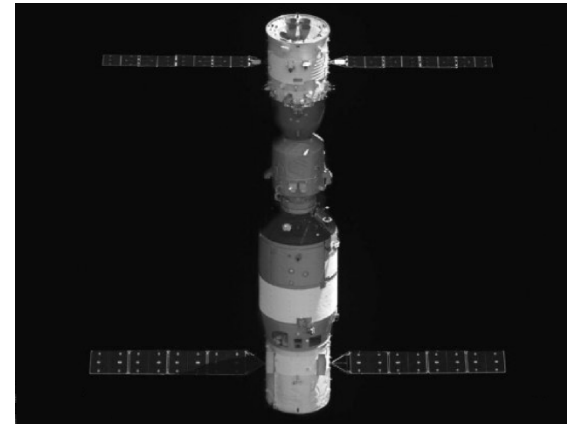
## GF-3 SAR internal wave retrieval and ship detection



## TG-2 InIRA

TG-2 (Tiangong-2) is a Chinese space laboratory which was launched on **15 September 2016** from Jiuquan Satellite Launch Centre. The onboard **Interferometric Imaging Radar Altimeter (InIRA)** is a new generation radar altimeter developed by China, which combines the functions of interferometric radar altimeter and Synthetic Aperture Radar (**SAR**).

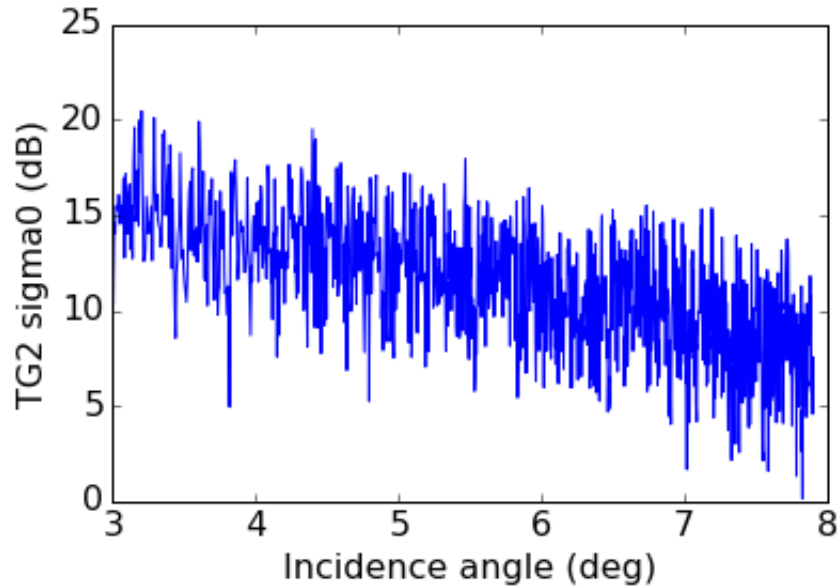
The dominate scattering mechanism for sea surface is quasi-specular scattering due to the small incidence angle range (**3-8deg**).



TG2 InIRA geometry



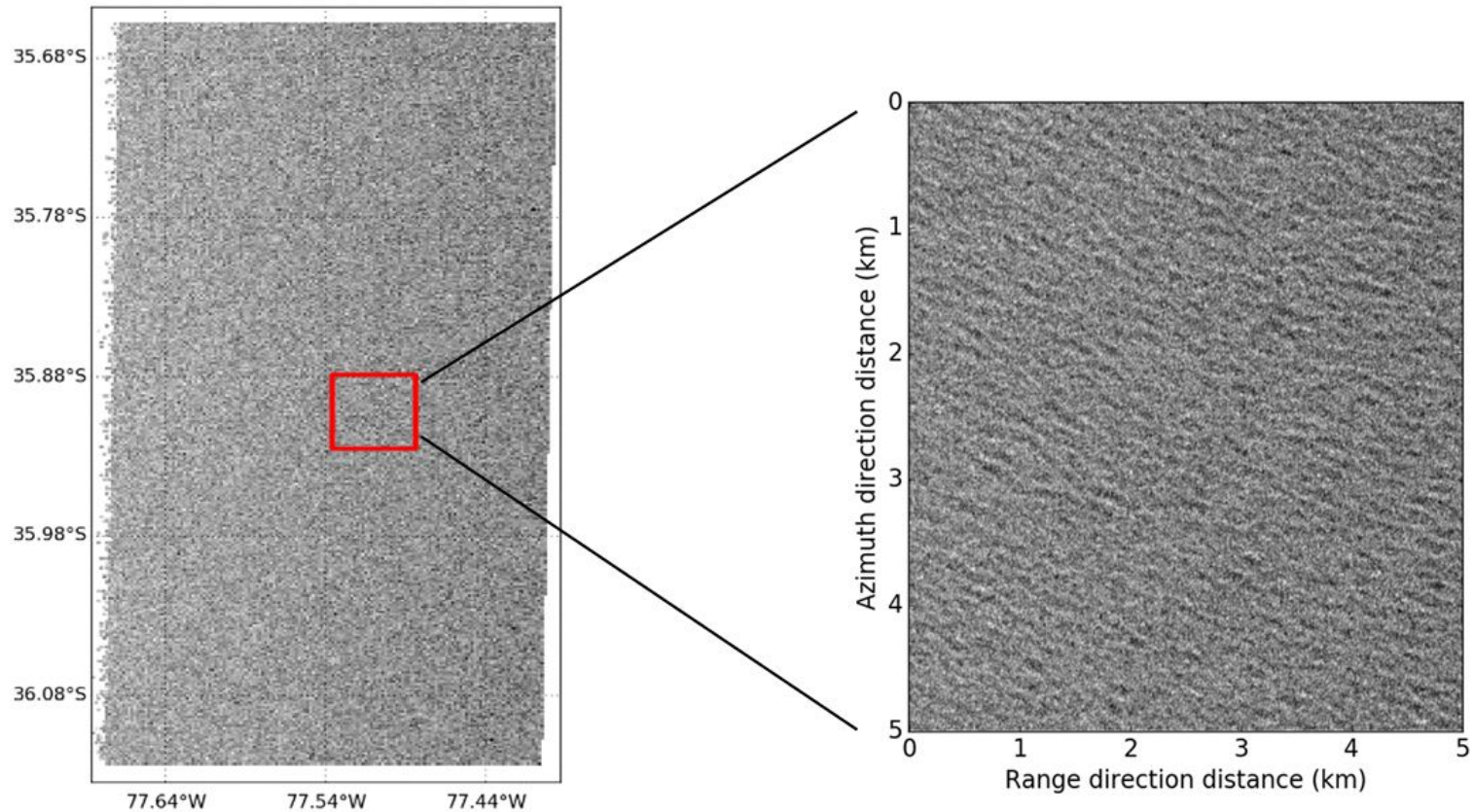
## TG-2 InIRA wind and wave retrieval



The TG2 InIRA normalized radar cross section  $\sigma_0$  along with incidence angle is consistent with the quasi-specular model

$$\sigma_0 = \frac{\rho\pi}{\cos^4 \theta} p(\tan \theta, 0)$$

## TG-2 InIRA wind and wave retrieval



## TG-2 InIRA wind and wave retrieval

$$\sigma_0(\theta, U_{10}) = a(\theta) + b(\theta)U_{10} + c(\theta)U_{10}^2$$

**Ku-band low incidence**

**backscatter model (KuLMOD)**

**Ref:** Ren Lin, Yang Jingsong, Zheng Gang, et al., Wind speed retrieval from Ku-band Tropical Rainfall Mapping Mission precipitation radar data at low incidence angles, Journal of Applied Remote Sensing, 2016, 10(1): 016012.

$$P(\mathbf{k}) = (T^t + T^h + T^{vb})k^2 F(\mathbf{k})$$

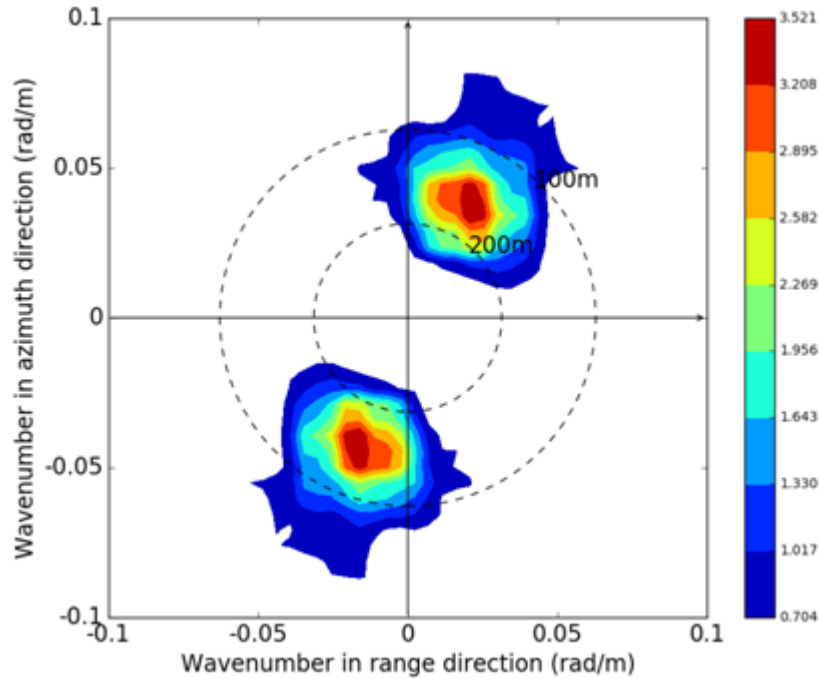
$$T^t = \cot \theta - 4 \tan \theta - \frac{1}{\cos^2 \theta} \frac{\partial \ln p(\tan \theta, 0)}{\partial \tan \theta}$$

$$T_{\mathbf{k}}^{vb} = -\beta k_a w (\cos \theta - i \sin \theta \frac{k_r}{k})$$

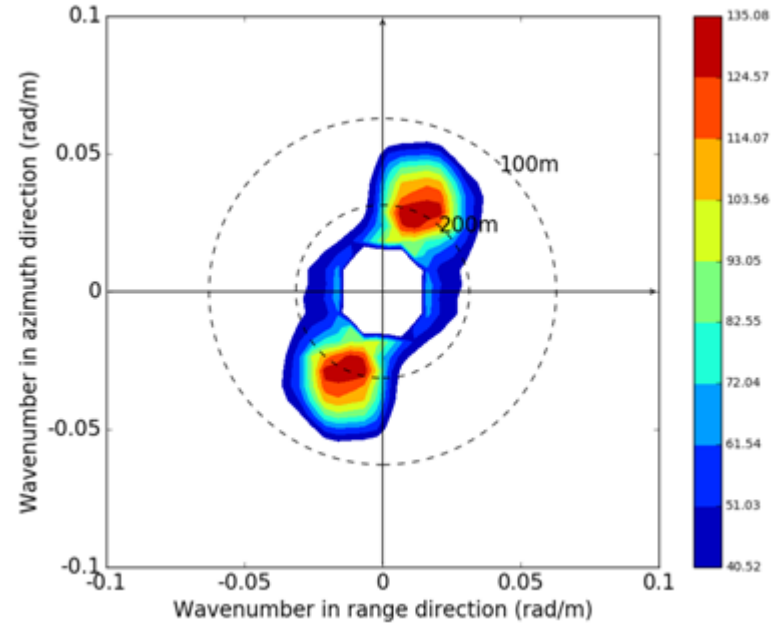
$$T^h = \frac{\omega - i\mu}{\omega^2 + \mu^2} (4.5) K \omega \left( \frac{k_y^2}{K^2} \right)$$

## TG-2 InIRA wind and wave retrieval

### Image spectrum

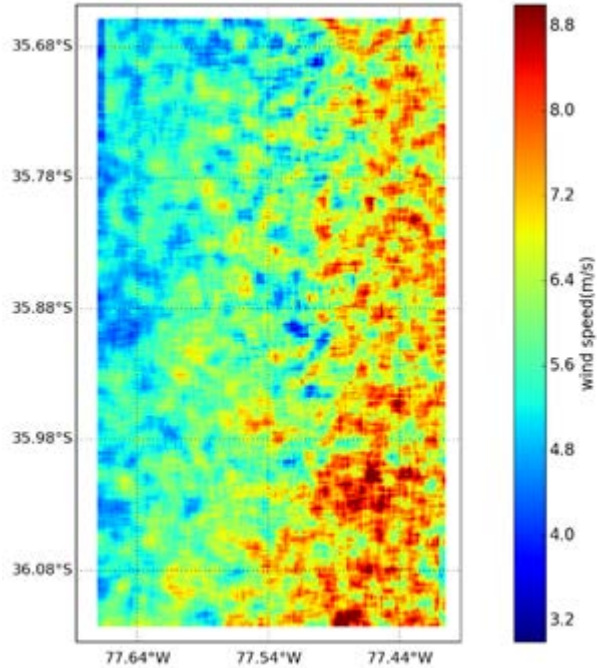


### Retrieved wave spectrum



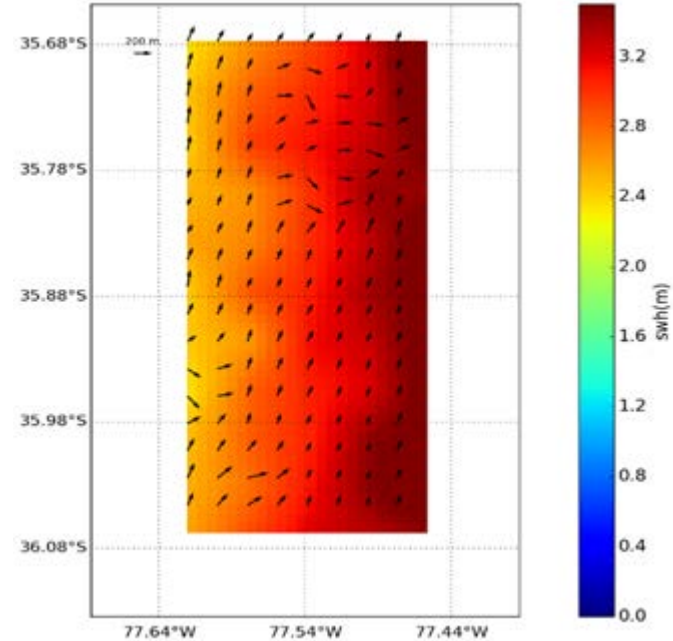


## TG-2 InIRA wind and wave retrieval



**Compared to GFS wind:**

**Wind speed RMSE: 1.5 m/s**



**Compared to WW3 wave:**

**SWH RMSE: 0.42 m**

## **Publications**

- 1. Yang, J.S.; Wang, J.; Ren, L. The first quantitative remote sensing of ocean internal waves by Chinese GF-3 SAR satellite. Acta Oceanol. Sin. 2017, 36(1):118-118.**
- 2. Yang, J.S; Ren, L.; Zheng, G. The first quantitative ocean remote sensing by using Chinese interferometric imaging radar altimeter onboard TG-2. Acta Oceanol. Sin. 2017, 36(2):122-123.**
- 3. Yang, J.S.; Ren, L.; Wang, J. The First quantitative remote sensing of ocean surface waves by Chinese GF-3 SAR Satellite. Oceanol. et Limnol. Sin., 2017, 48(2):207-209 (in Chinese)**
- 4. Yang, J.S.; Ren, L.; Zhang, Y.H; et al. Preliminary Results of Ocean Parameters Retrieval from the Interferometric Imaging Radar Altimeter Onboard Chinese Space Laboratory TG-2, PIERS 2017 in St Petersburg, Russia, 22-25 May, 2017**