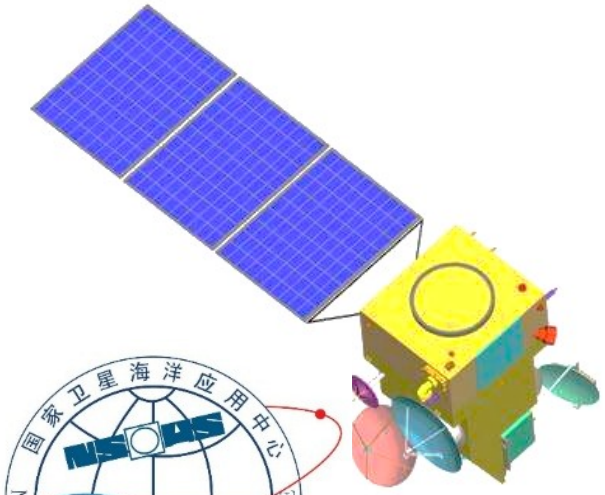
Near-real-time Sea-surface Wind Derived from the Haiyang-2B/C/D Scatterometer Constellation



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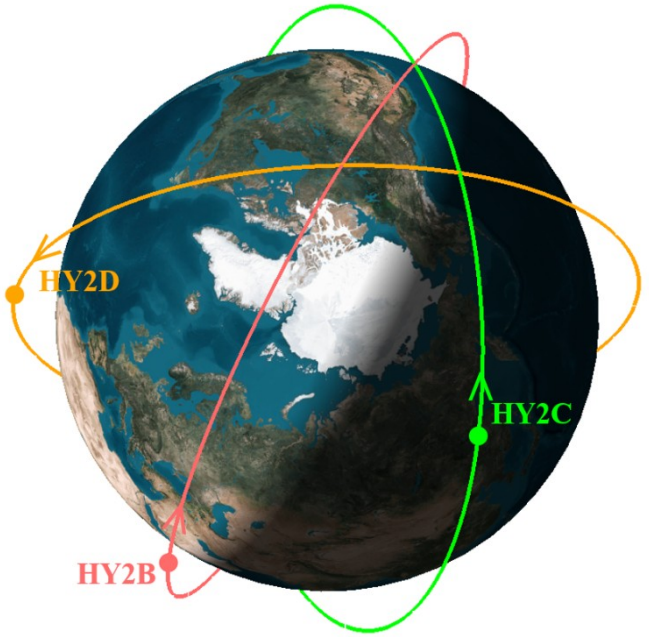
National Satellite Ocean Application Service

Germany, May 2025



Outline

1. Introduction to HY-2 Scatterometer Missions

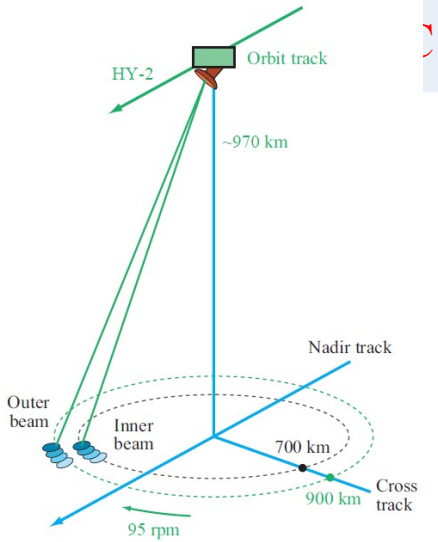
2. Overview of N.R.T HSCAT SSW Data Processing System

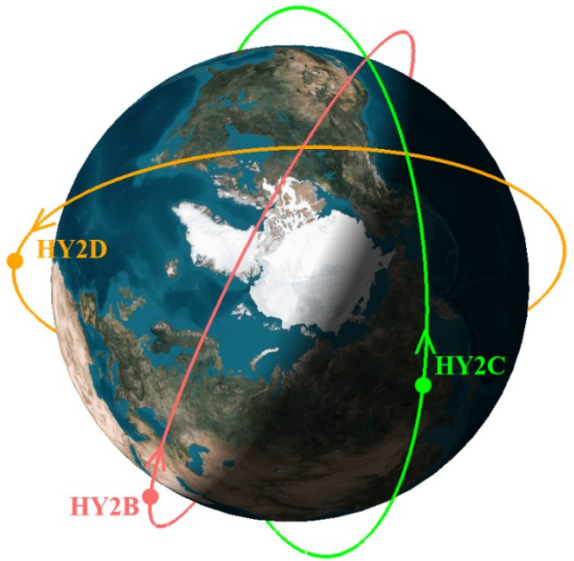
3. Validation of N.R.T HSCAT Winds

4. Summary and Future Work

Main parameters of HY-2 Series Scatterometers

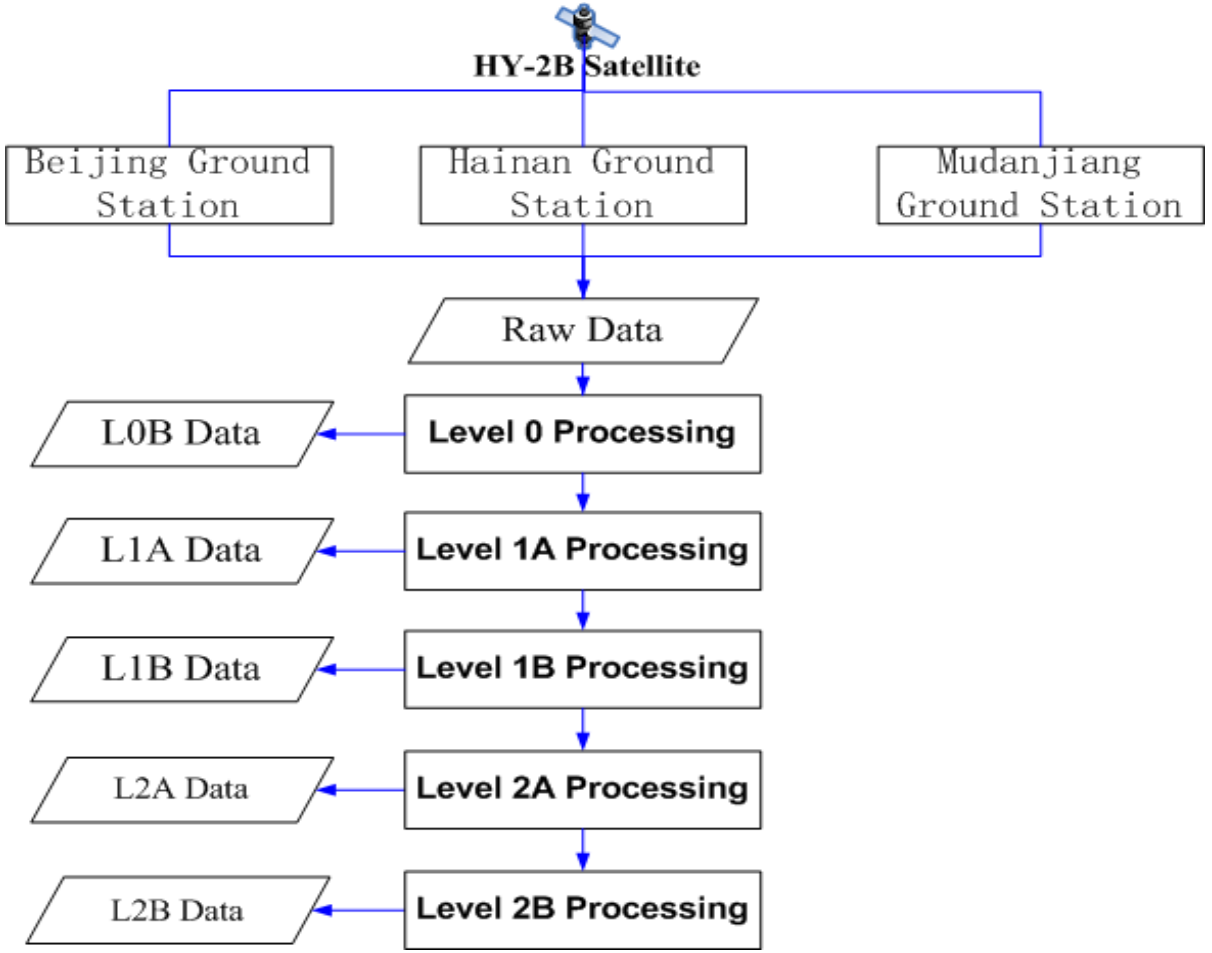
Scatterometer	Frequency	polarization	incidence angle	Inclination	Altitude (km)	Swath (km)	Resolution (km)	ECT	launch date
HY-2A	Ku	VV、HH	41.5°&48.5°	99.3°	971 km	1700 km	25 km	06:00 desc	15 Aug 2011
HY-2B	**Ku**	**VV、HH**	**41.5°&48.5°**	**99.3°**	**971 km**	**1700 km**	**25 km**	**06:00 desc**	**24 Oct 2018**
HY-2C	**Ku**	**VV、HH**	**41.5°&48.5°**	**66.0°**	**957 km**	**1700 km**	**25 km**	**shifting**	**21 Sep 2020**
HY-2D	**Ku**	**VV、HH**	**41.5°&48.5°**	**66.0°**	**957 km**	**1700 km**	**25 km**	**shifting**	**19 May 2021**
CFOSAT	Ku	VV、HH	28°～51°	97.5°	520 km	1000 km	25&12.5 km	06:30 desc	29 Oct 2018
		VV、HH			km	1200 km	20&10 km	05:40 desc	04 Jul 2021





- **Ku band, pencil beam rotation antenna ;**
- **Orbit : early-morning at around 6 for HY-2B, and shifting orbit for HY-2C/D**
- **The HY-2B/C/D scatterometer provides about 180,000 wind observations per day, making it one of the most important global SSW observations.**

Flow Chart of Data Processing system for HY-2 scatterometer

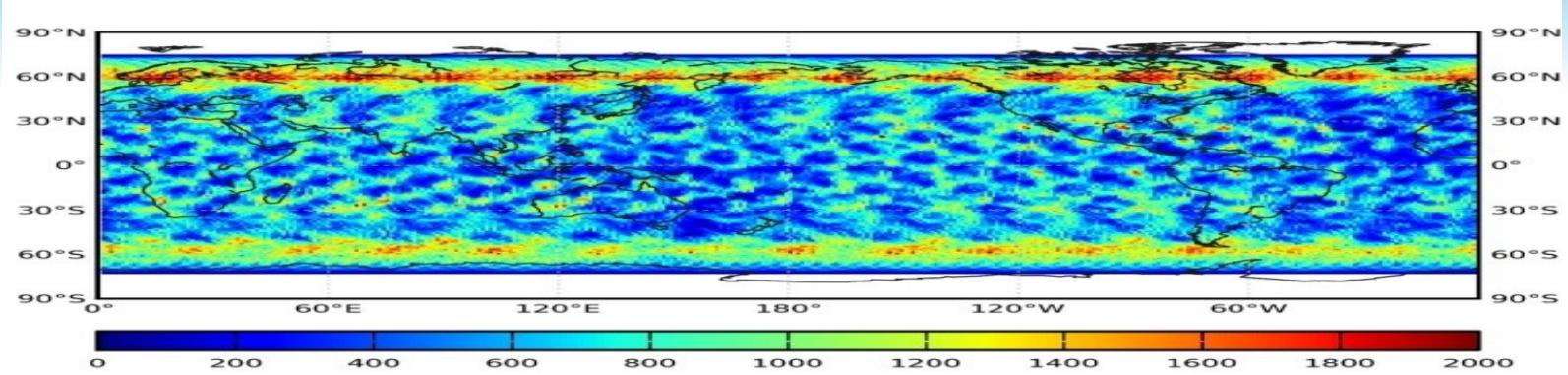


- The HY-2B/C/D satellite data is downlinked through three ground stations in Beijing, Sanya, and Mudanjiang.
- The raw data received at the three ground stations is processed through stitching, orbit segmentation, and other steps to produce Level-0A data.
- The sigma0 value was calculated for each footprint through geometric calculation and radiometric calibration, which was restored in the time-ordered L1B dataset.
- The L1B products were regrouped to the sub-track aligned Wind Vector Cells (WVCs) with a resolution of 25 km
- A multiple solution scheme (MSS) combined with (2DVAR) is used to retrieve wind vectors

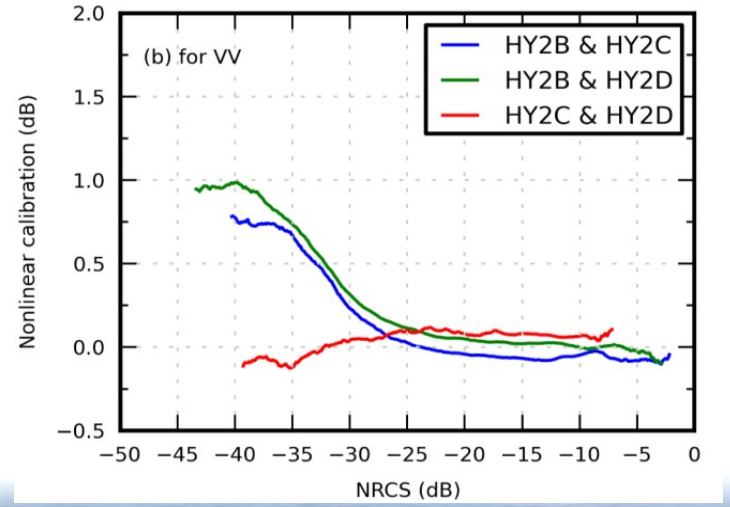
In-orbit Calibration for Sigma0 of HY-2B/C/D Scatterometer

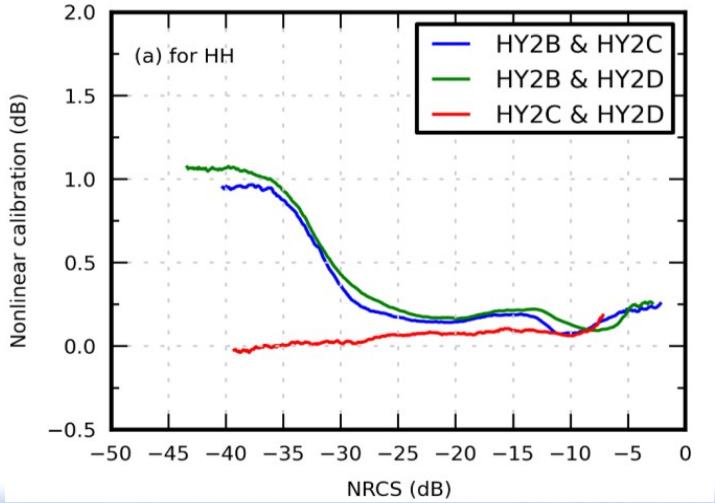
- NOC calibration (HSCAT-B)
- Cross calibration (HSCAT-C/D)

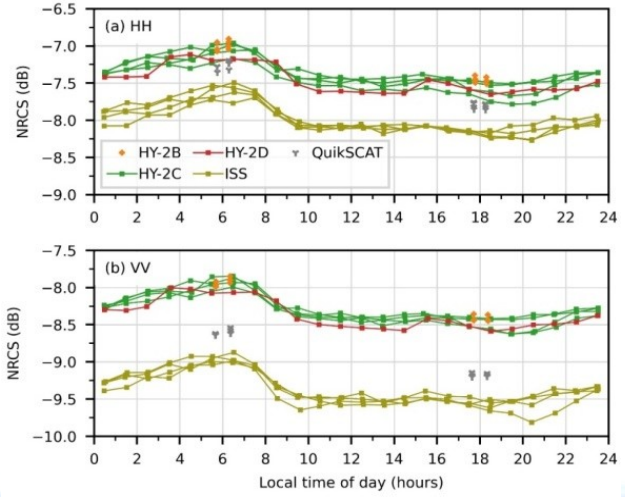
The overall accuracy of cross calibration is better than 0.1dB



Case	Collocated		Rainforest		NOC	
	HH (dB)	VV (dB)	HH (dB)	VV (dB)	HH (dB)	VV (dB)
HY-2B & HY-2C	+0.132	-0.060	+0.043	-0.056	+0.133	+0.022
HY-2B & HY-2D	+0.155	+0.019	+0.128	+0.039	+0.202	+0.089
HY-2C & HY-2D	+0.076	+0.067	+0.086	+0.096	+0.069	+0.067



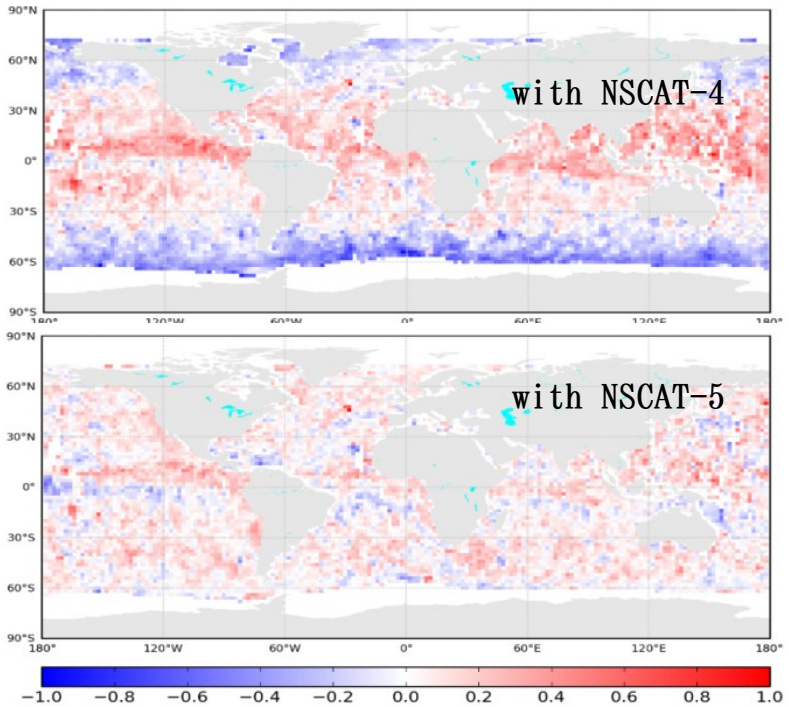




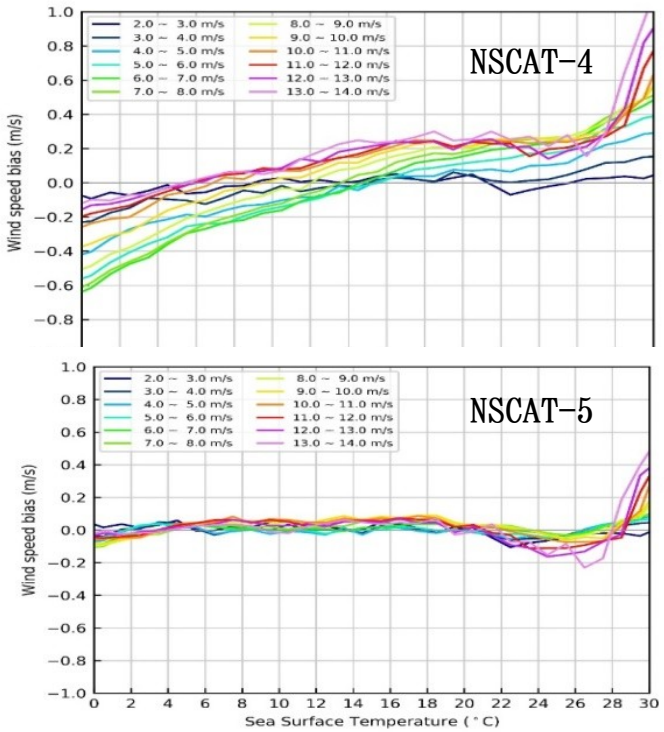
Zhixiong Wang, Juhong Zou, et.al. Intercalibration of Backscatter Measurements among Ku-Band Scatterometers Onboard the Chinese HY-2 Satellite Constellation.2021

Wind Retrieval

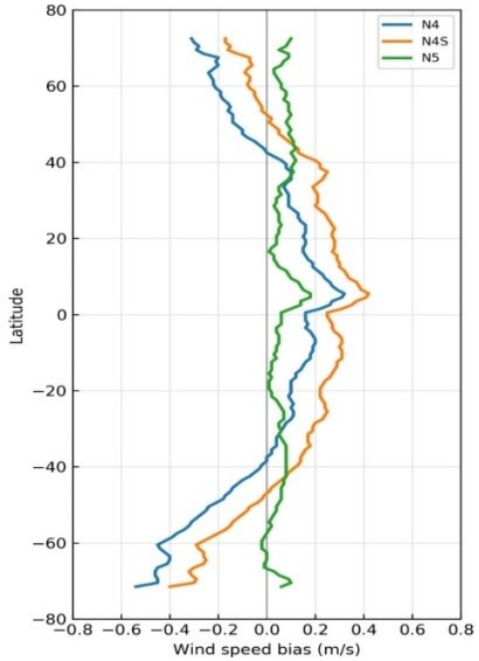
- SSMI Ice from EUMETSAT Ocean & Sea Ice Satellite Application Facility (OSI) is applied to provide sea-ice mask for wind retrieval
- **MSS+2DVAR,GMF: NSCAT-5.HY-2.** A GMF with SST factor (NSCAT-5.HY-2) was constructed to eliminate wind inversion errors dependent on SST
- **ECMWF forecast wind is used to improve wind direction ambiguity removal performance**



Spatial distribution of wind speed bias



wind speed bias at different wind speed range



Wind speed bias at different latitude(The green line represents the corrected one)

WANG Zhixiong, ZOU Juhong*, et.al. Development of a geophysical model function for HY-2 satellite microwave scatterometer wind retrievals. 2023

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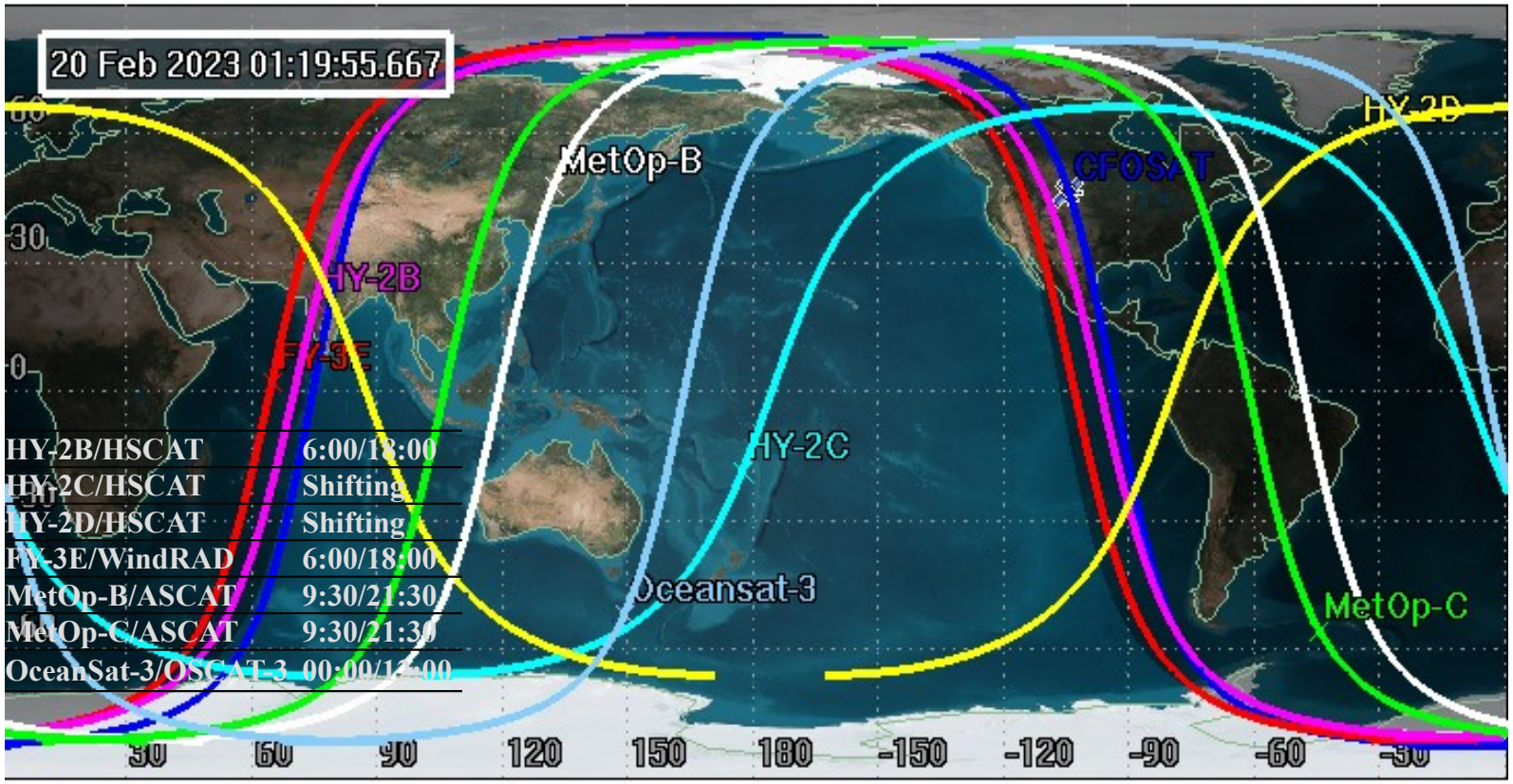
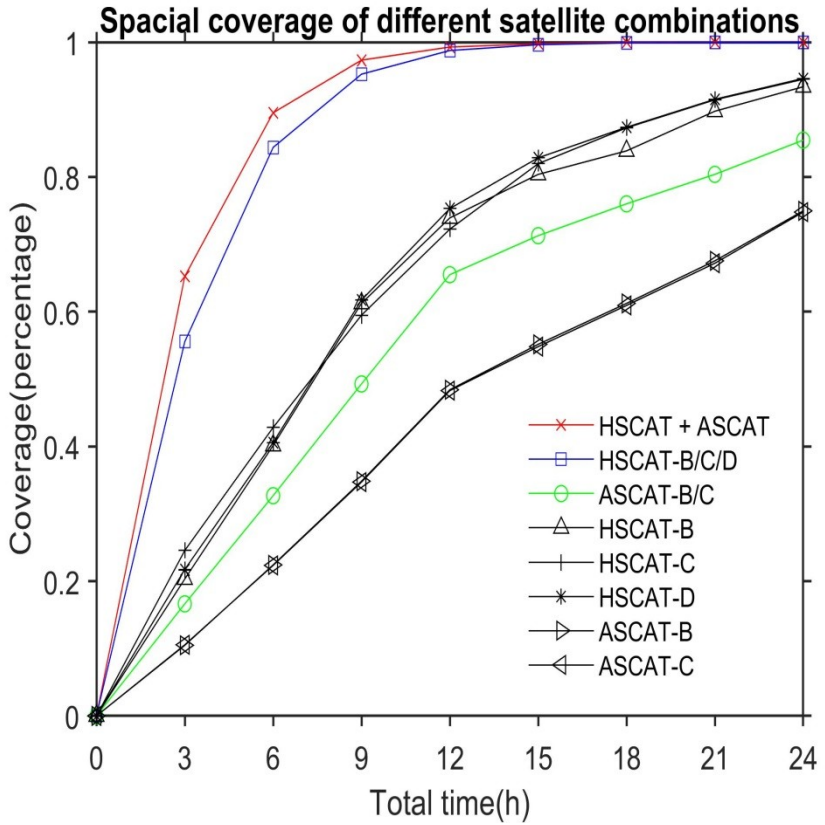
01 Accuracy Analysis of HSCAT N.R.T. Winds

Comparative Analysis of HSCAT Winds with Buoy Observations and ERA5 Reanalysis Data in 2023

Sensor	Bouy Wind					ERA5 wind				
	Number	Wind speed		Wind direction		Number	Wind speed		Wind direction	
		BIAS (m/s)	RMS (m/s)	BIAS (°)	RMS (°)		BIAS (m/s)	RMS (m/s)	BIAS (°)	RMS (°)
HSCAT-B	19854	0.15	1.0	-2.42	13.0	350597486	-0.06	1.1	-0.75	9.4
HSCAT-C	22491	0.10	1.0	-2.13	13.8	422516717	-0.10	1.1	-1.01	10.0
HSCAT-D	21968	0.12	1.0	-1.59	13.5	358507676	0.10	1.1	−0.45	9.4
ASCAT-B	11597	0.14	0.9	-1.9	12.7	175685073	-0.02	1.1	-0.66	11.2
ASCAT-C	11536	0.15	0.9	-2.0	12.3	175164547	0.00	1.0	0.61	11.1

02 Coverage Analysis of HSCAT N.R.T. Winds



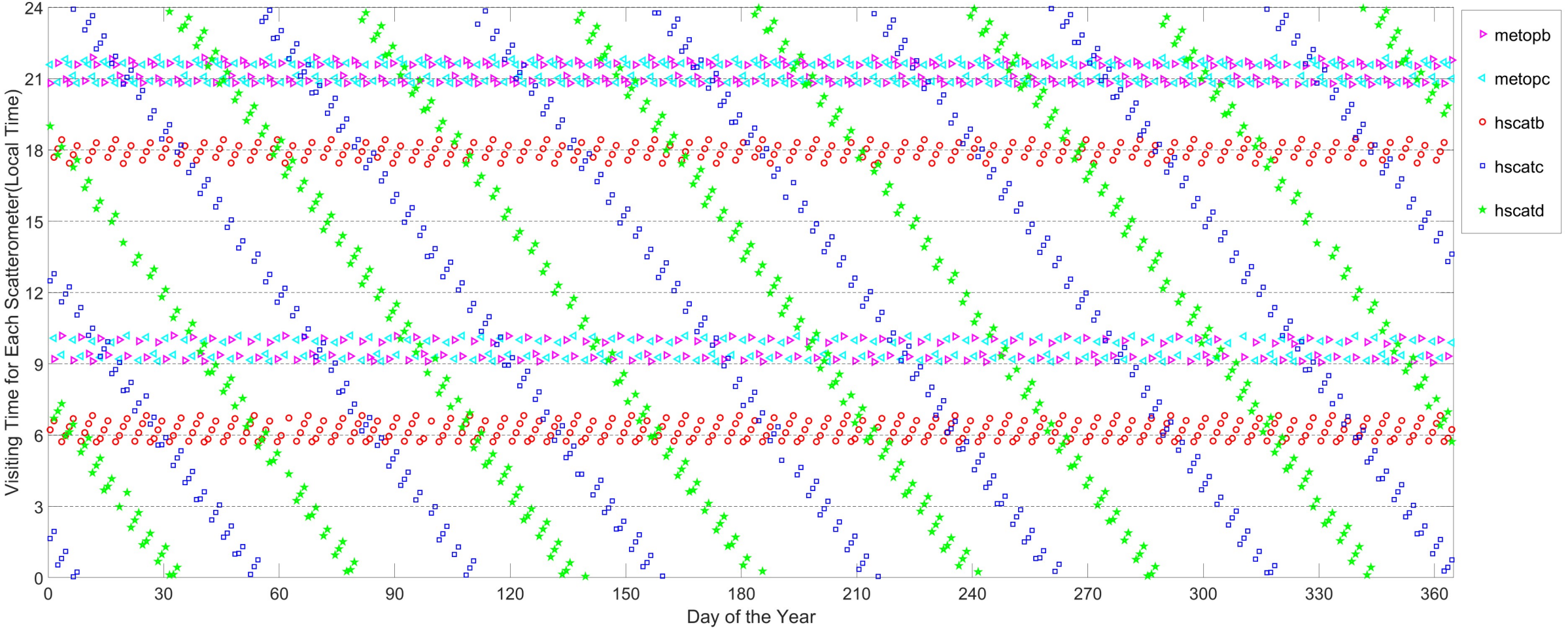


Through the HY-2B/C/D three satellite constellation, the sea-surface wind observation can achieve the coverage of more than 85% of the global open ocean areas within six hours and more than 95% of the global open ocean areas within twelve hours.

By combining with the MetOp-B/C satellites, more than 90% of the global open ocean areas can be covered within six hours, and the global open ocean areas can be fully covered within 12 hours.

03

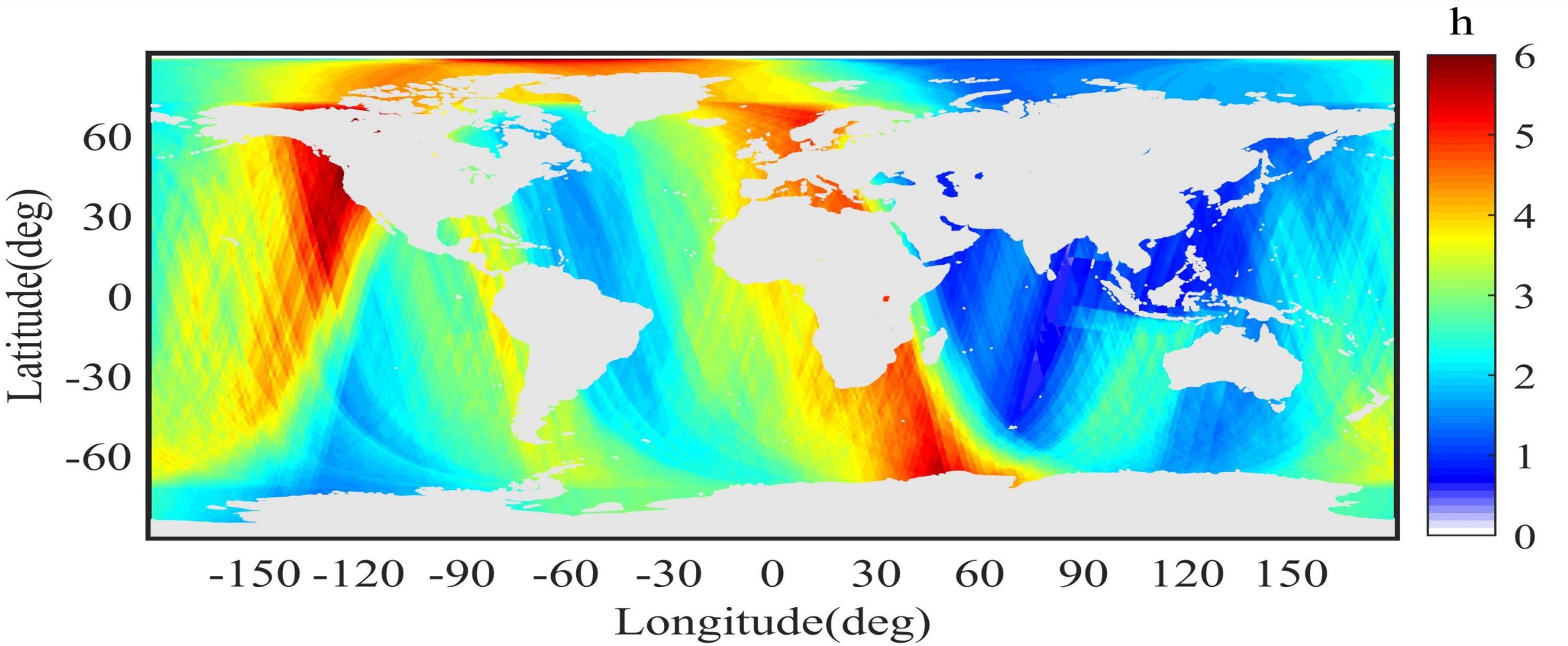
Local Passing Times Analysis of HSCAT N.R.T. Winds



The local passing times of HSCAT-B/C/D during 2023 Over 14°–18°N and 112°–116°E

04

Timeliness Analysis of HSCAT N.R.T. Winds



The average timeliness of near-real-time ocean surface wind products from HSCAT-B, HSCAT-C, and HSCAT-D was 213.8 minutes, 244.7 minutes, and 364.4 minutes, respectively.

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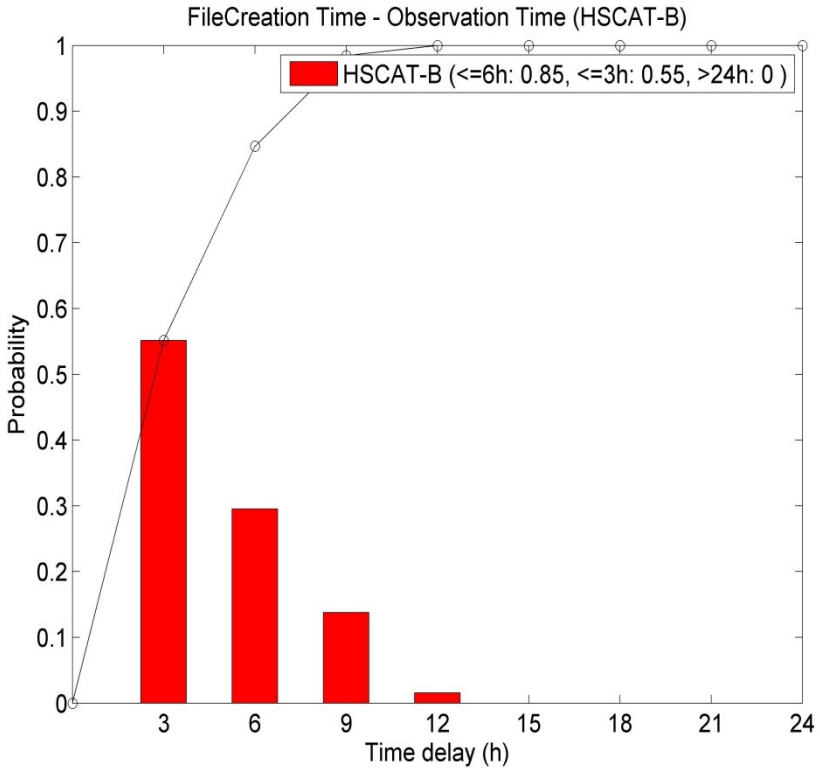
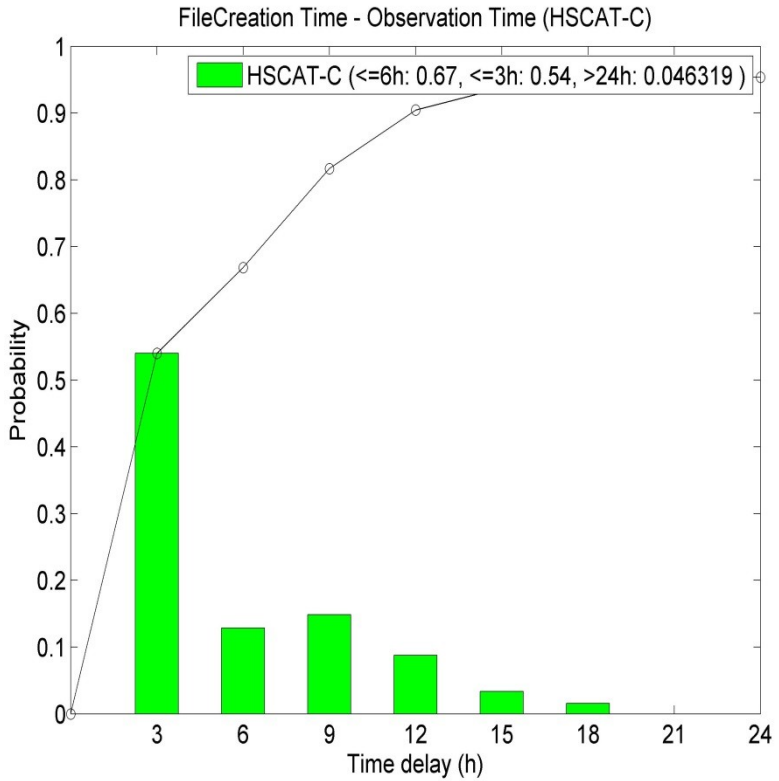
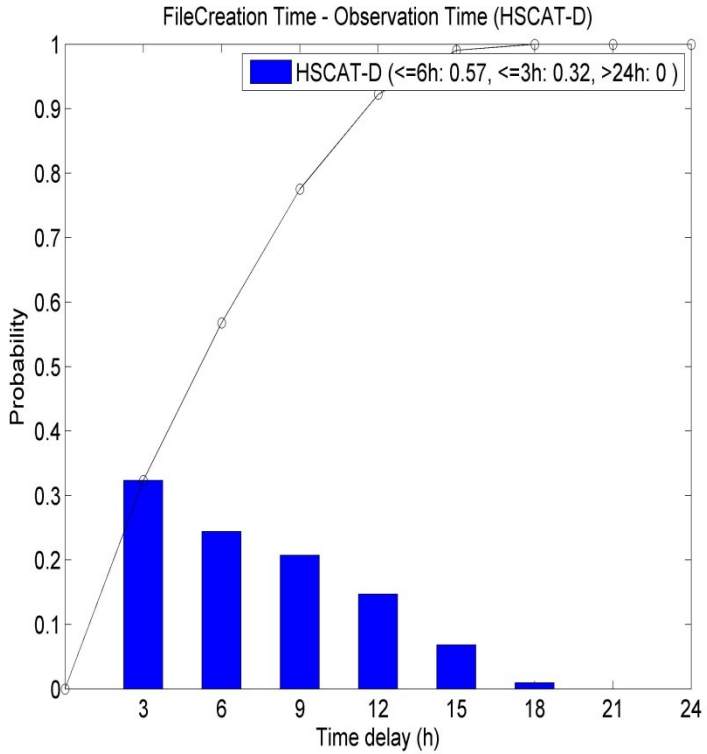
Summary

- ✓ The N.R.T HSCAT wind data shows equivalent accuracy to ASCAT wind data.
- ✓ Benefiting from the In-orbit Cross-calibration, HY-2B/C/D scatterometer wind products show high consistency with each other.
- ✓ The implementation of **NSCAT-5.HY-2 GMF** has further enhanced consistency between C-band scatterometer wind products.
- ✓ The three-satellite scatterometer constellation greatly enhances global wind observation capability, covering >85% of global open ocean areas within 6 hours and >95% within 12 hours.
- ✓ The current international virtual constellation demonstrates good complementarity in both overpass timing and spatial coverage.

Future work: Timeliness of HSCAT Winds Needs to Be Further Improved



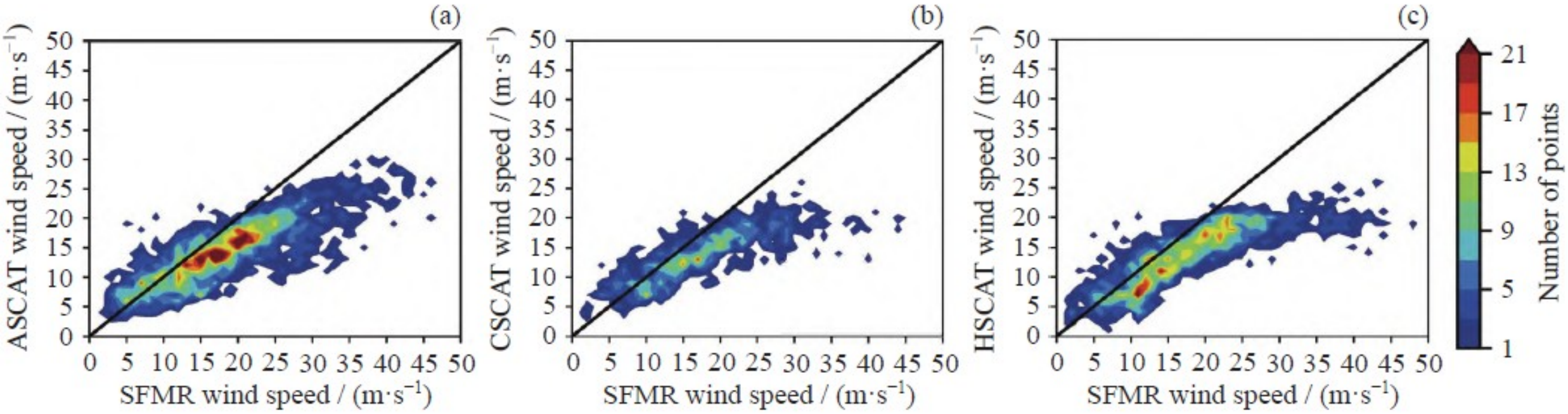




Timeliness analysis show that the percentages of the data that have timeliness better than six hours are 55%, 54% and 32% for HSCAT-B, HSCAT-C and HSCAT-D, respectively.

It is necessary to increase the number of HSCAT downlinks by making use of ground stations in high-latitude regions through means such as international cooperation, so as to improve timeliness of the HSCAT wind data.

Future work: Underestimation of High Winds Needs Further Investigation



Scatter plot of wind speeds from collocated SFMR and ASCAT, CSCAT and HSCAT

Currently all operational scatterometer wind products underestimate high wind speeds

ZHONG Junjie, WANG Zhixiong, ZOU Juhong, LIN Wenming. Comparisons of SFMR and Satellite Microwave Remote Sensed Sea Surface Wind Speed in Hurricane Weather. 2023

Future work

Scatterometer	Frequency	Polarization	Incidence Angle	Altitude (km)	Swath (km)	Resolution (km)	ECT	Launch Time
HY-2E	Ku	VV 、 HH	41.5°&48.5°	~ 970	1700	25	06:00	~ 2026
HY-2F	Ku&C	HH 、 VV°(Ku)/ HH 、 VV° 、 HV 、 VH(C)	41.5°&48.5°(Ku)/ 48.5°(C)	~ 950	1700	12.5 (Ku) /25 (C)	shifting	~ 2026
HY-?? Next Generation Satellite of HY-2	Ku&C	HH 、 VV(Ku)/ HH 、 VV° 、 HV 、 VH(C)	41.5°&48.5°(Ku)/ 48.5°(C)	~ 970	1700	5(Ku) /12.5 (C)	Sun-synchronous orbit ECT T.B.D	~ 2029

scatterometer,.namely, HY-2E(Ku band), ad HY-2F(Ku&C dual frequency), Next Generation Satellite of HY-2(Ku&C dual frequency).

☑ For these new scatterometer data, simulation and testing work is essential before these data can be assimilated in NWP system.

These works need the collaboration of the whole community of payload design, satellite operation and NWP department.

Thanks 谢谢