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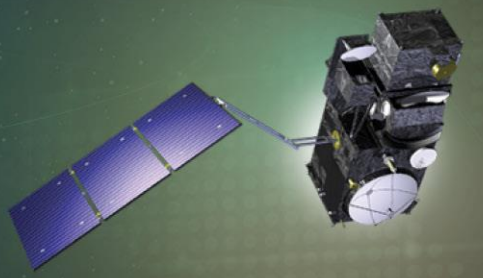

7th Sentinel-3 Validation Team Meeting 2022

18-20 October 2022 | ESA-ESRIN | Frascati (Rm), Italy

Sentinel-3A satellite altimetry data to monitor water level changes in Chinese Rivers

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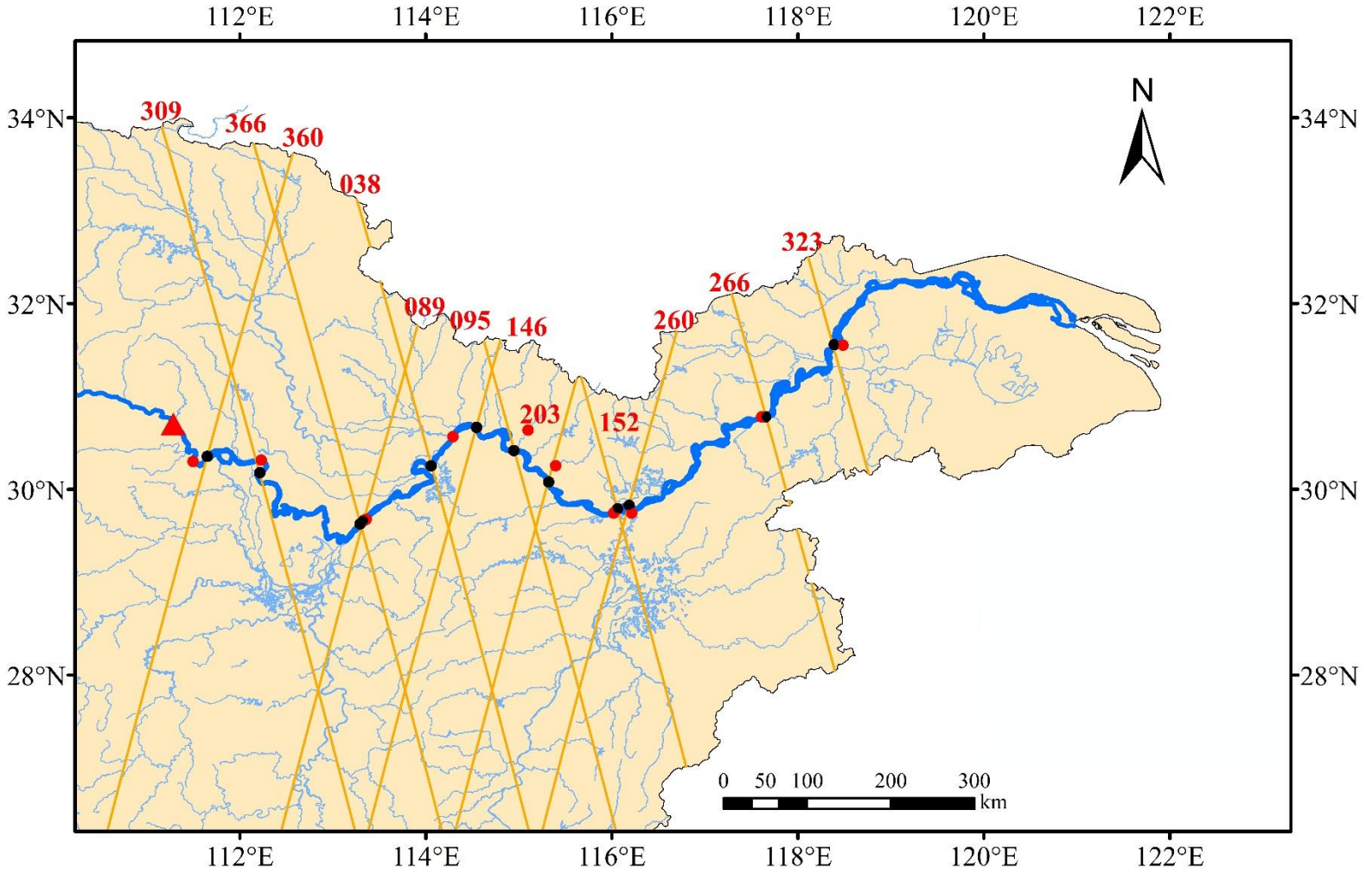
Catalog

- Background
- Data source
- Algorithm
- Result
- Compare and discuss
- FFSAR
- Conclusion

Background



- Yichang
- In-situ water level station
- Virtual water level station
- Main streams
- Tributaries
- Yangtze River Basin
- Seninel-3 transit track

Data source

1. Radar altimeter data

1）20Hz-Conventional synthetic aperture radar altimeters data

2）80Hz-radar altimeter data provided by the earth console

3） Sentinel-3 L1a data

2. Secondary data

1）In-situ water level data in the middle and lower reaches of the Yangtze River and the Yellow River

2）Mask data of the middle and lower reaches of the Yangtze River and the Yellow River

Algorithm

OCOG: The basic idea is to find the center of gravity of each returning waveform and determine the leading edge midpoint of the waveform by calculating the center of gravity and area of the rectangle determined by the value of the waveform, so as to obtain distance correction.

----------**For full waveforms**

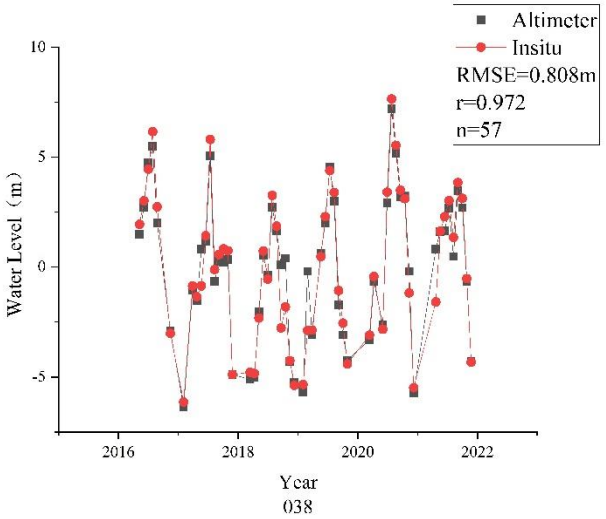
MWAPP: The basic idea is to use linear interpolation to obtain interpolated waveforms at 1cm height intervals, take the average of the adjacent 4 interpolated waveforms to weaken the land noise signal pollution, extract the sub-waveforms containing 7 gates including the main peak for each average waveform and calculate the center of gravity deviation amplitude.

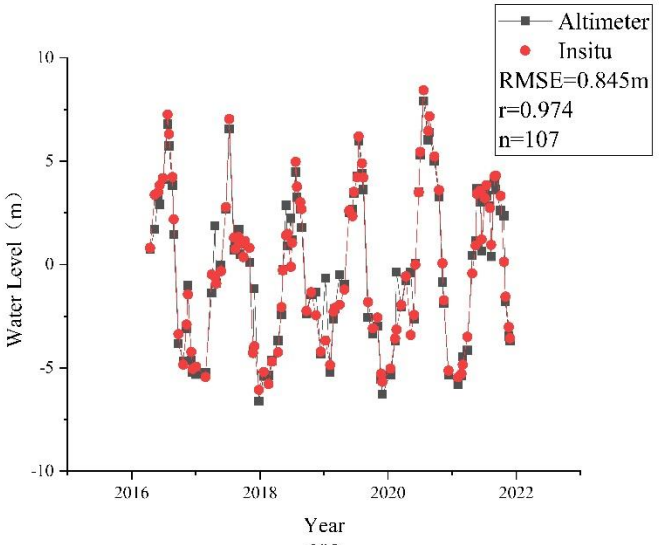
NPPR: The basic idea is to assume that the main peak sub-waveform is the peak reflected by the water surface signal, and extract the main peak using the starting and ending thresholds of the echo waveform.

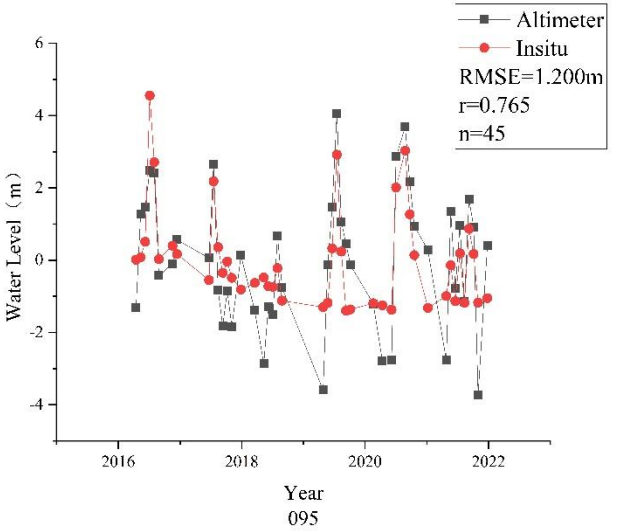
Result-20Hz

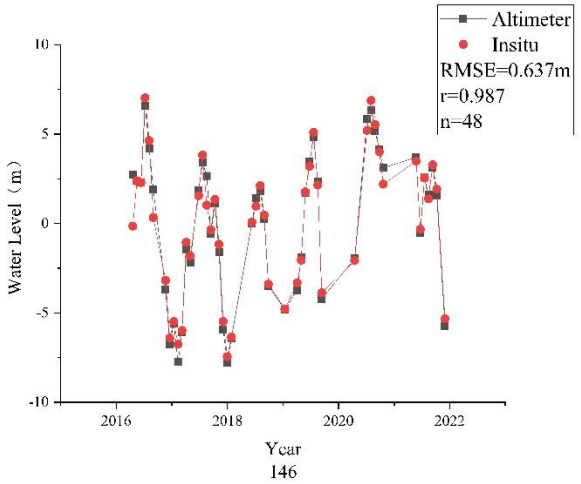
		038	089	095	146	152	203	260	266	309	323	360	366
MWaPP	*RMSE* /m	1.545	1.524	1.708	1.695	1.256	1.338	0.872	1.601	1.246	**0.553**	1.074	1.681
	r	0.897	0.915	0.631	0.818	0.937	0.627	0.965	0.686	0.93	0.953	0.901	0.864
	N	54	51	42	29	70	45	51	52	60	57	58	53
NPPOR	*RMSE* /m	1.442	1.439	1.63	1.638	1.205	1.389	0.859	1.427	1.261	0.719	1.105	**1.475**
	r	0.924	0.902	0.707	0.882	0.944	0.662	0.965	0.769	0.929	0.937	0.886	0.916
	N	60	43	35	34	70	45	47	57	58	58	60	51
NPPTR05	*RMSE* /m	1.462	1.459	1.73	1.616	1.223	1.605	0.867	1.407	1.284	0.61	1.028	1.63
	r	0.921	0.892	0.642	0.892	0.944	0.561	0.963	0.771	0.93	0.95	0.892	0.873
	N	60	46	38	35	73	49	49	57	59	58	59	58
NPPTR08	*RMSE* /m	1.333	1.667	1.714	1.844	1.202	1.572	0.864	1.476	1.255	0.676	1.048	1.579
	r	0.934	0.916	0.686	0.868	0.944	0.578	0.964	0.734	0.932	0.93	0.89	0.88
	N	58	50	37	38	65	45	48	55	59	57	60	54
OCOG	*RMSE* /m	**1.145**	**1.409**	**1.469**	**1.469**	**1.201**	**1.197**	**0.841**	**1.158**	**1.126**	0.881	**0.68**	1.565
	r	0.952	0.866	0.667	0.891	0.941	0.84	0.968	0.824	0.94	0.893	0.941	0.891
	N	61	45	43	47	63	45	45	57	58	58	60	47

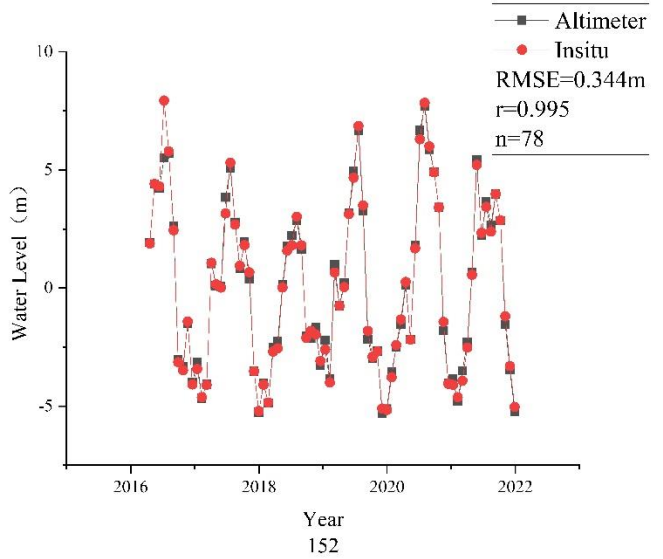
Result-80Hz

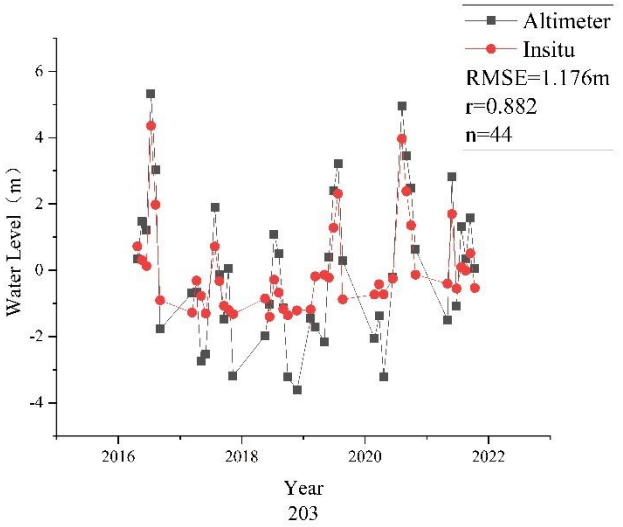

Altimeter
Insitu
RMSE=0.808m
r=0.972
n=57
Water Level（m）
Year
038


Altimeter
Insitu
RMSE=0.845m
r=0.974
n=107
Water Level（m）
Year

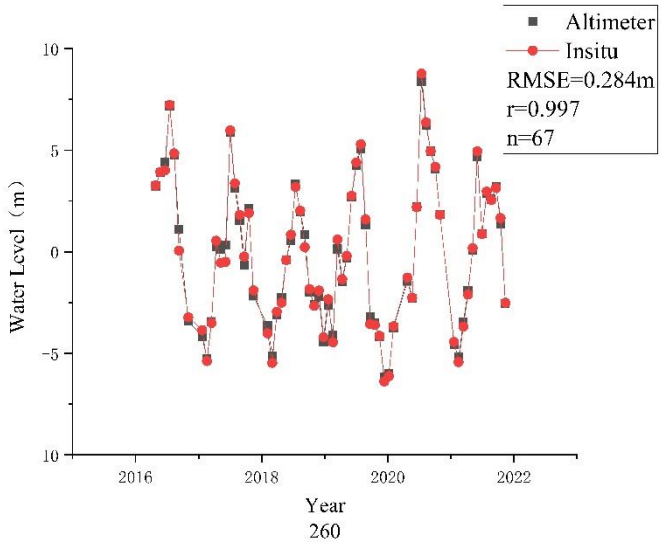

Altimeter
Insitu
RMSE=1.200m
r=0.765
n=45
Water Level（m）
Year
095

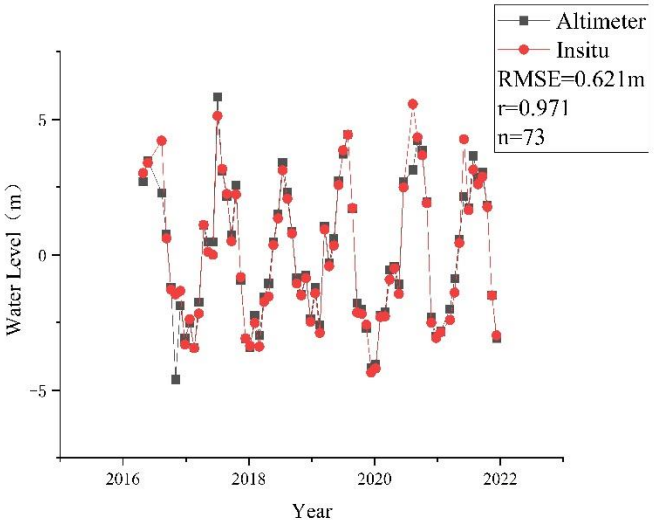

Altimeter
Insitu
RMSE=0.637m
r=0.987
n=48
Water Level（m）
Year
146

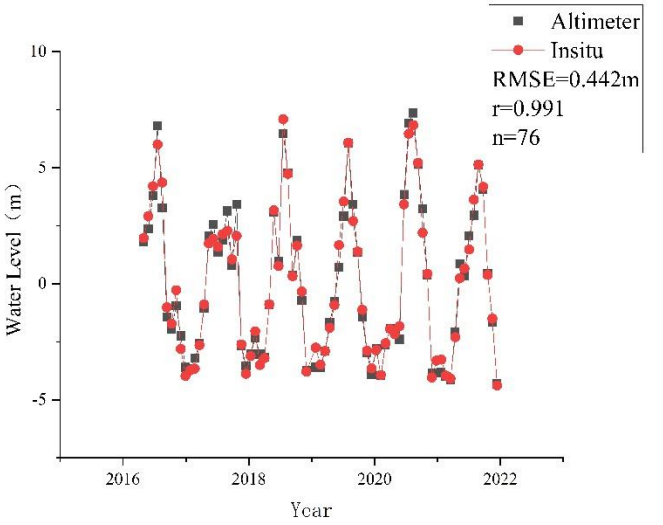

Altimeter
Insitu
RMSE=0.344m
r=0.995
n=78
Water Level（m）
Year
152

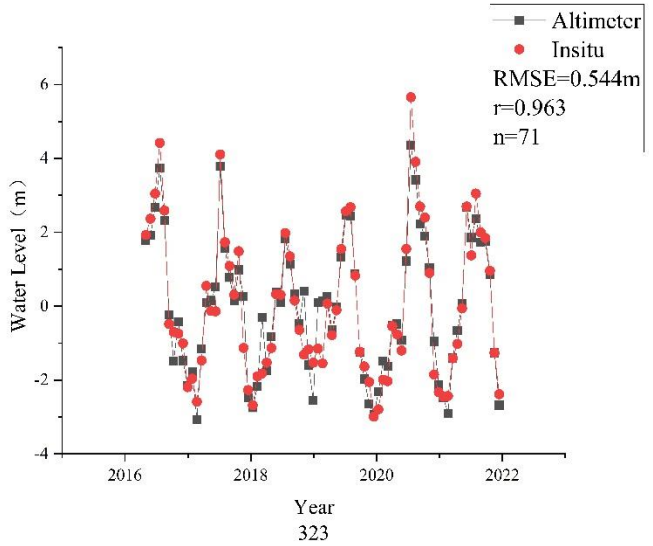

Altimeter
Insitu
RMSE=1.176m
r=0.882
n=44
Water Level（m）
Year
203

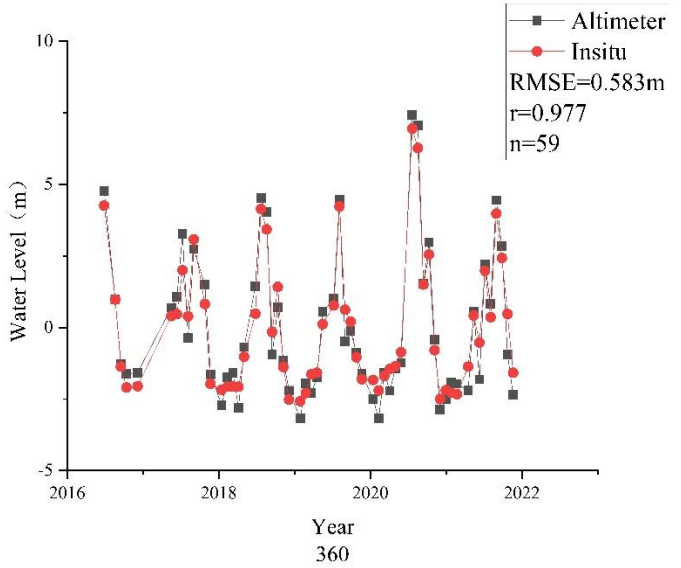
Result-80Hz

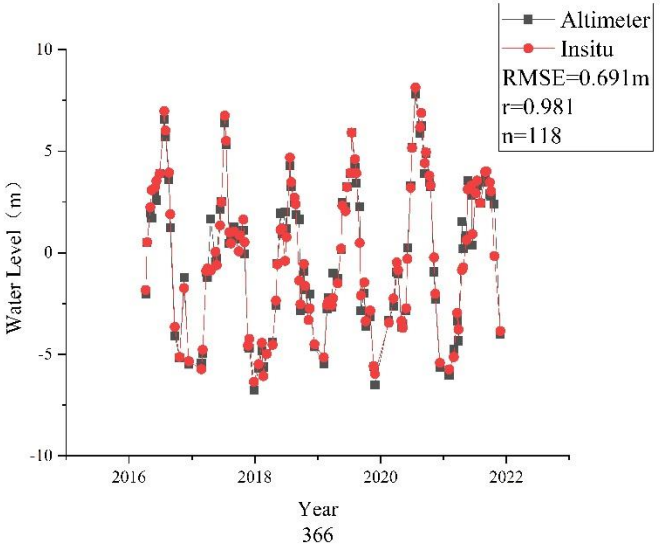

Altimeter
Insitu
RMSE=0.284m
r=0.997
n=67
Water Level（m）
Year
260


Altimeter
Insitu
RMSE=0.621m
r=0.971
n=73
Water Level（m）
Year

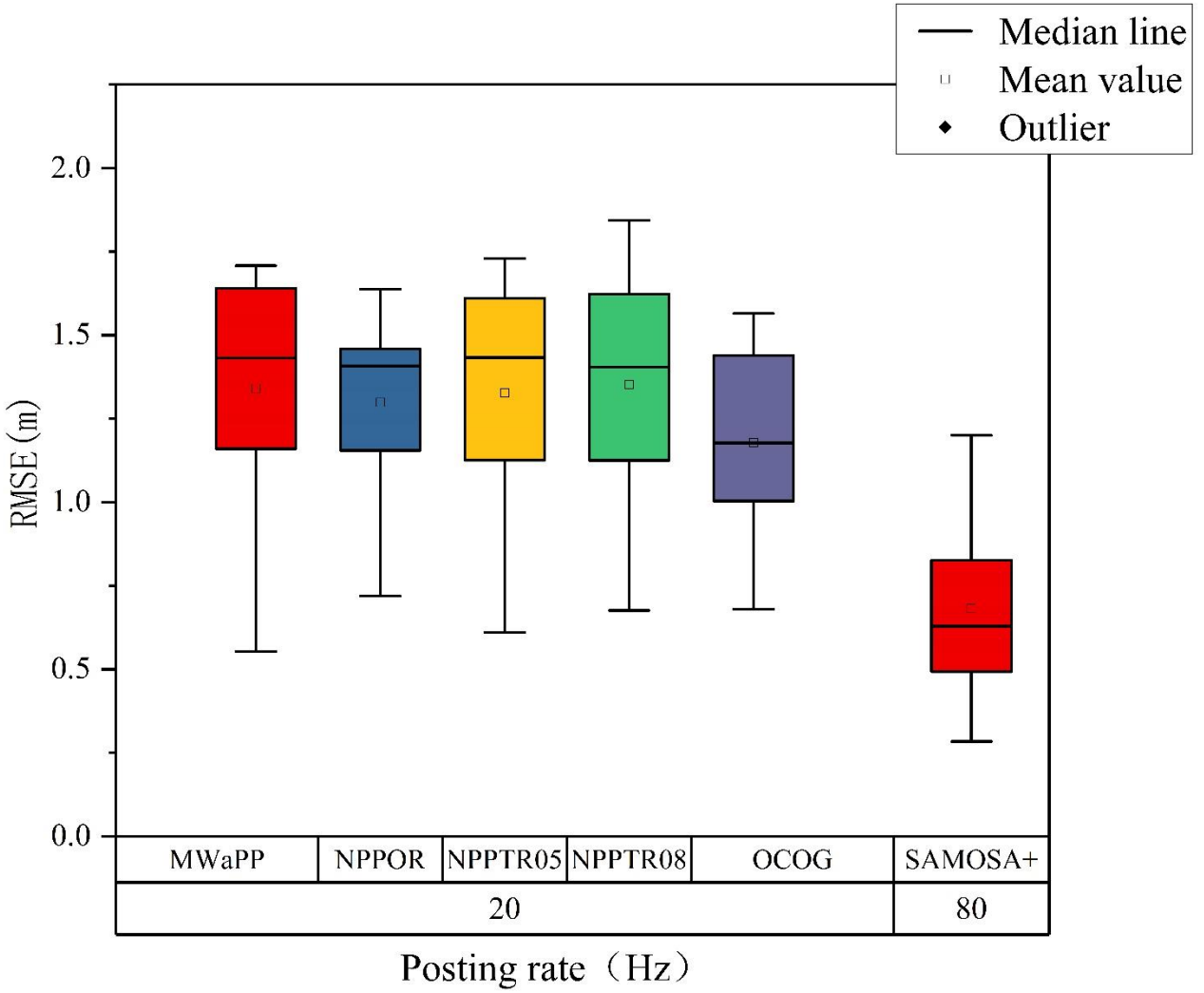

Altimeter
Insitu
RMSE=0.442m
r=0.991
n=76
Water Level（m）
Year


Altimeter
Insitu
RMSE=0.544m
r=0.963
n=71
Water Level（m）
Year
323

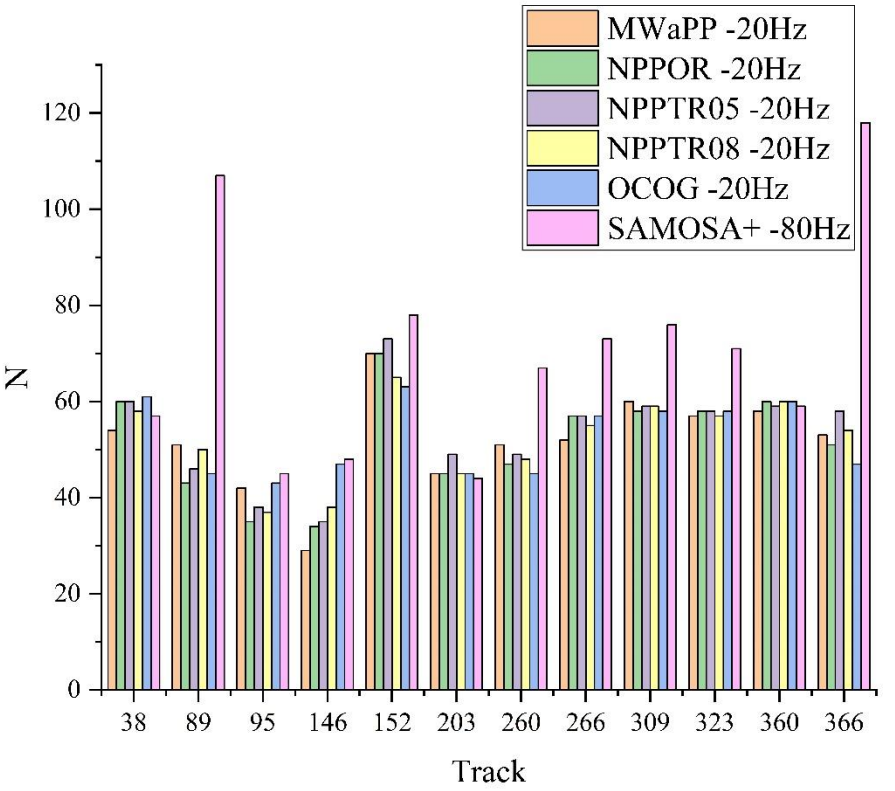

Altimeter
Insitu
RMSE=0.583m
r=0.977
n=59
Water Level（m）
Year
360


Altimeter
Insitu
RMSE=0.691m
r=0.981
n=118
Water Level（m）
Year
366

Compare and discuss



The ordinate represents the number of observation points.

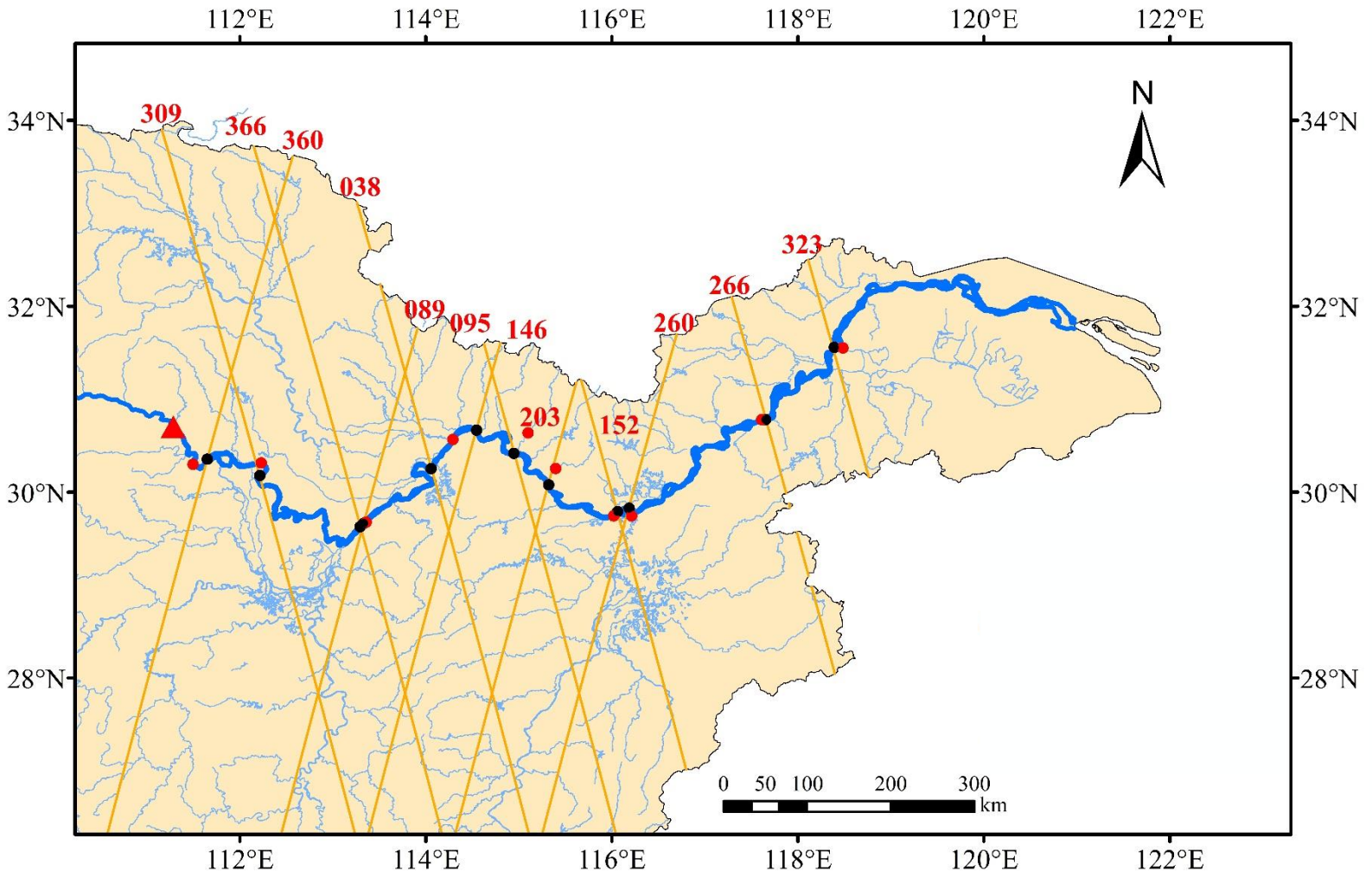


Compare and discuss

		038	089	095	146	152	203	260	266	309	323	360	366
20Hz	$RMSE$/m	**1.145**	**1.409**	**1.469**	**1.469**	**1.201**	**1.197**	**0.841**	**1.158**	**1.126**	**0.881**	**0.680**	**1.565**
	r	0.952	0.866	0.667	0.891	0.941	0.84	0.968	0.824	0.94	0.893	0.941	0.891
	N	61	45	43	47	63	45	45	57	58	58	60	47
80Hz	$RMSE$/m	**0.808**	**0.845**	**1.200**	**0.637**	**0.344**	**1.176**	**0.284**	**0.621**	**0.442**	**0.544**	**0.583**	**0.691**
	r	0.972	0.974	0.765	0.987	0.995	0.882	0.997	0.971	0.991	0.963	0.977	0.981
	N	57	107	45	48	78	44	67	73	76	71	59	118

The RMSE of water level extraction is not good in the transit area of the **095 and 203** tracks.

Compare and discuss



The corresponding in-situ water level station was not found in the transit area of the **095 and 203** tracks.

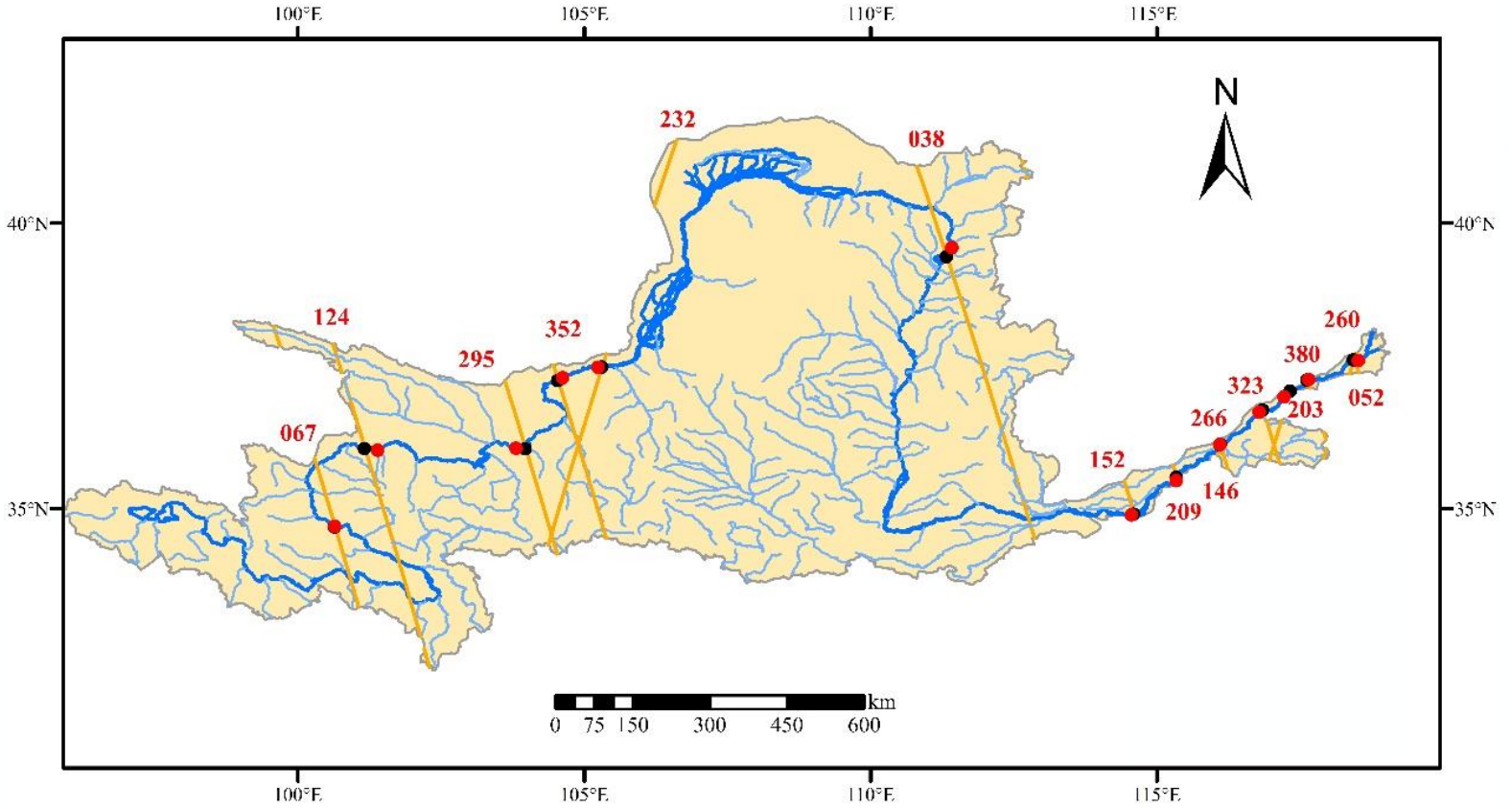
FFSAR-Introduction

The **fully focused SAR (FF-SAR)** altimetry processing is similar to synthetic aperture radar (SAR) imaging systems, reduces the **along-track resolution** down to the theoretical limit equal to half the antenna length.

The footprint of an FF-SAR altimeter measurement is a narrow strip on the surface, which is pulse limited across track and SAR focused **along track**.

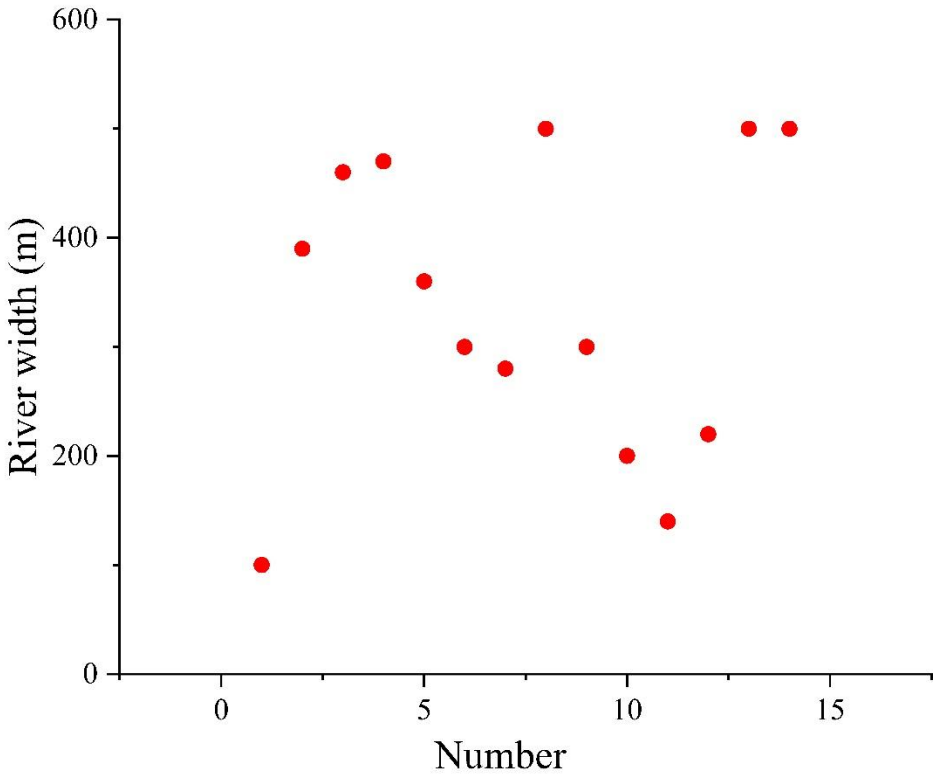
	80Hz	160Hz	320Hz	640Hz	1280Hz	2560Hz
Along-track resolution/m	105.5	52.76	26.38	13.19	6.6	3.3

FFSAR-Study area



- In-situ water level station
- Virtual water level station
- Main streams
- Tributaries
- Yellow River Basin
- Seninel-3 transit track

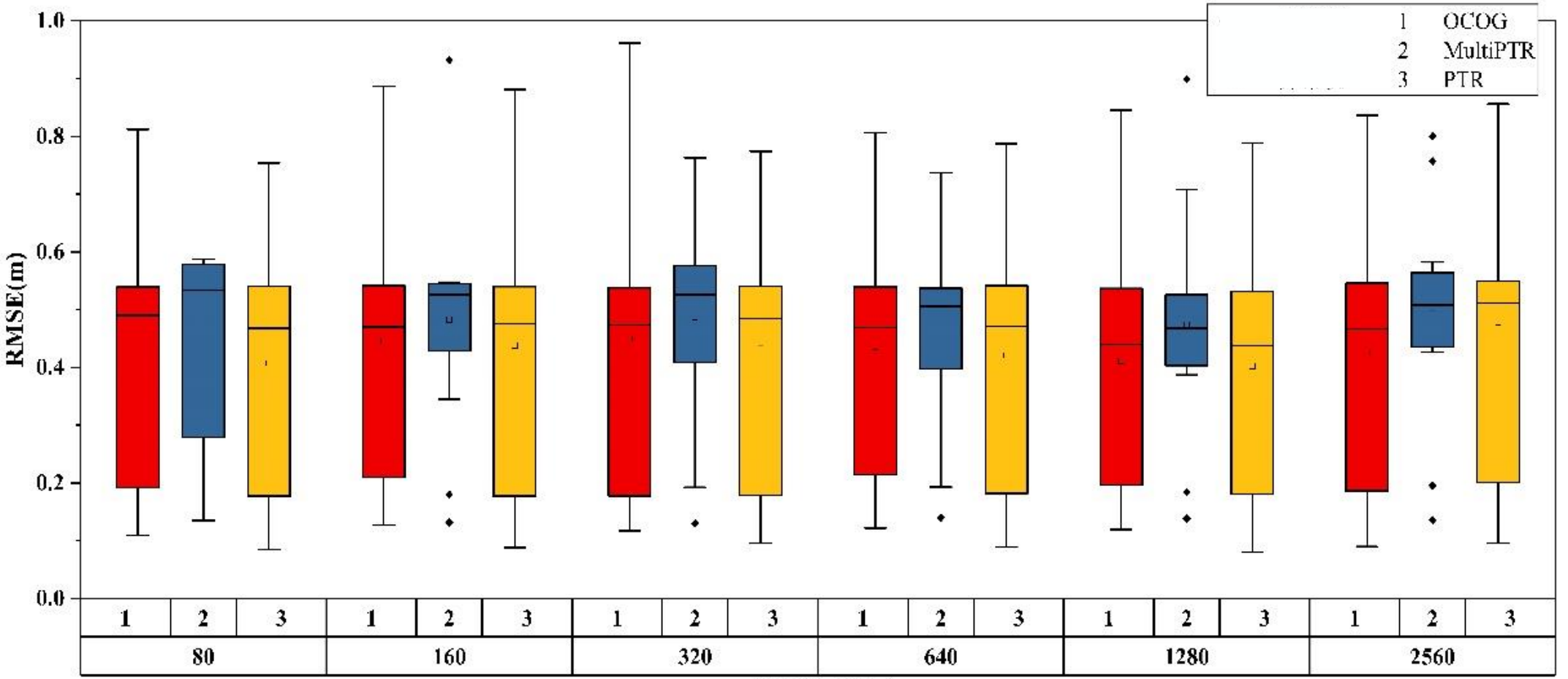
FFSAR-Study area



	Relative tracks	River width	River name
1	67	**100m**	Yellow River
2	38	390m	Yellow River
3	203	460m	Yellow River
4	380	470m	Yellow River
5	260	360m	Yellow River
6	52	300m	Yellow River
7	323	280m	Yellow River
8	266	500m	Yellow River
9	146	300m	Yellow River
10	352	200m	Yellow River
11	295	140m	Yellow River
12	232	220m	Yellow River
14	152	500m	Yellow River
15	209	**500m**	Yellow River

The abscissa represents the track serial number.

FFSAR-RMSE


1 OCOG
2 MultiPTR
3 PTR
RMSE(m)
1.0
0.8
0.6
0.4
0.2
0.0
1 2 3 1 2 3 1 2 3 1 2 3 1 2 3 1 2 3
80
160
320
640
1280
2560

FFSAR-RMSE

390m

		80Hz	160Hz	320Hz	640Hz	1280Hz	2560Hz
multiptr	RMSE/m	1.03	0.932	0.763	**0.737**	0.899	0.8
	r	0.87	0.785	0.864	0.882	0.827	0.806
	n	20	21	23	22	23	21
ocog	RMSE/m	0.812	0.812	0.809	**0.806**	0.845	0.836
	r	0.772	0.772	0.774	0.745	0.748	0.752
	n	26	26	26	26	27	27
ptr	RMSE/m	**0.754**	0.78	0.774	0.787	0.788	0.775
	r	0.799	0.787	0.787	0.782	0.785	0.79
	n	26	26	26	26	26	26

460m

		80Hz	160Hz	320Hz	640Hz	1280Hz	2560Hz
multiptr	RMSE/m	**0.138**	0.491	0.487	0.397	0.435	0.452
	r	0.97	0.708	0.657	0.728	0.657	0.765
	n	37	29	28	28	29	35
ocog	RMSE/m	0.109	0.127	0.117	0.122	0.119	**0.09**
	r	0.991	0.988	0.99	0.988	0.988	0.994
	n	44	44	44	44	44	44
ptr	RMSE/m	0.085	0.088	0.096	0.089	**0.08**	0.096
	r	0.994	0.995	0.993	0.994	0.994	0.992
	n	42	42	43	43	42	44

FFSAR-time Series in different posting rates over track 038（390m）

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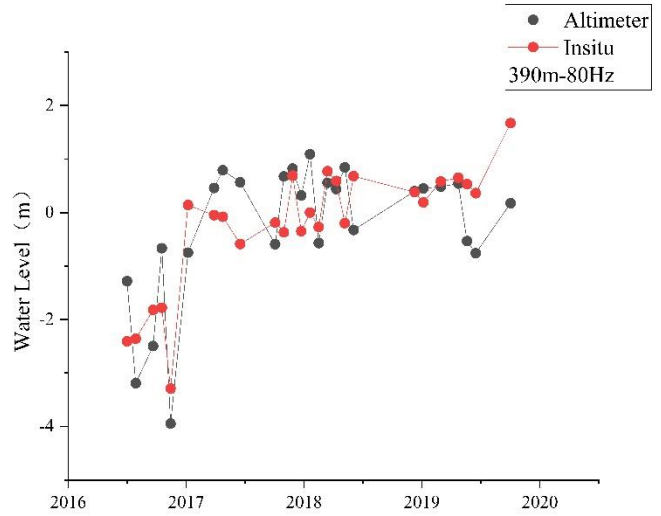
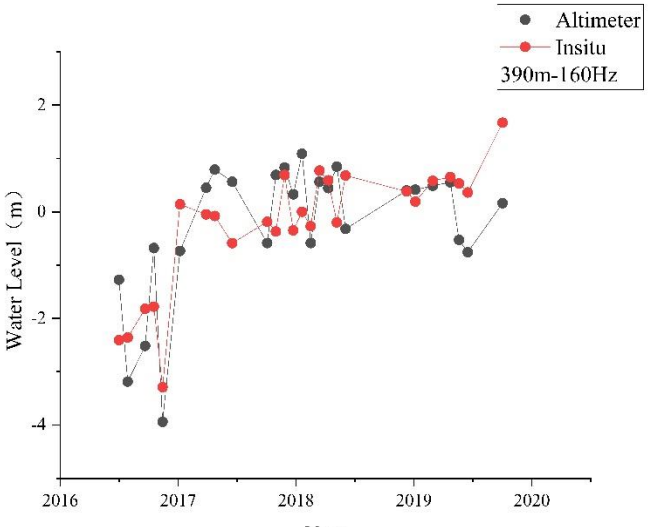
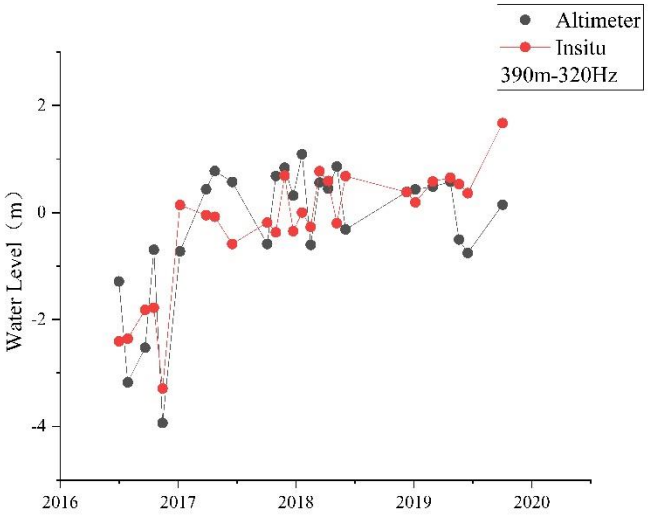
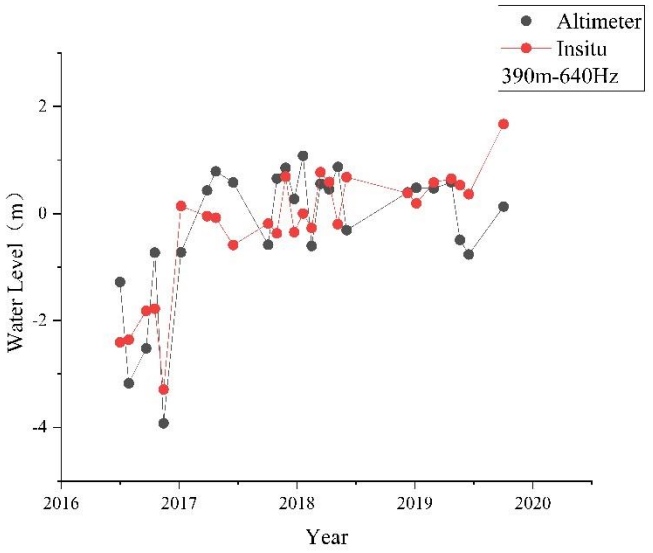
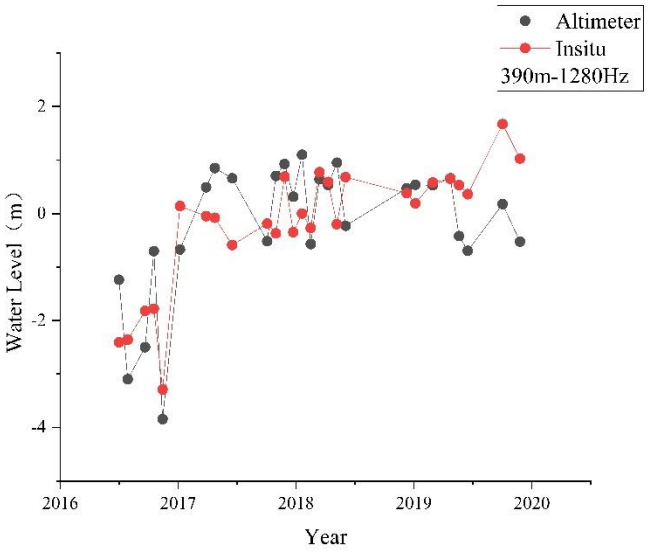
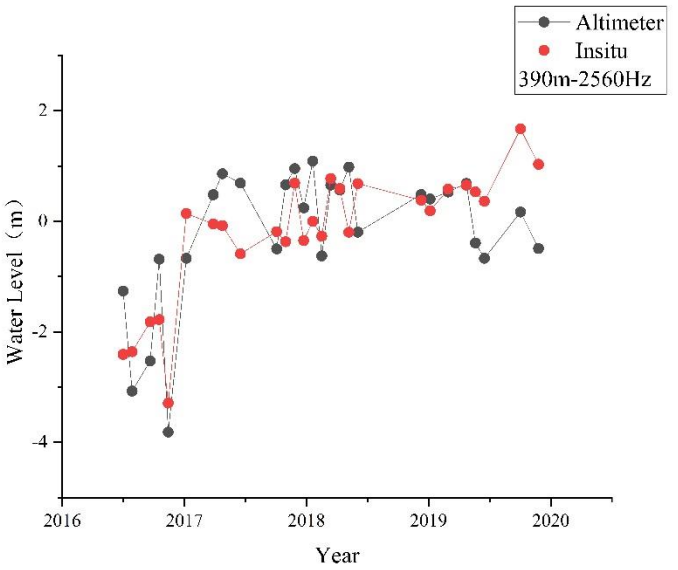




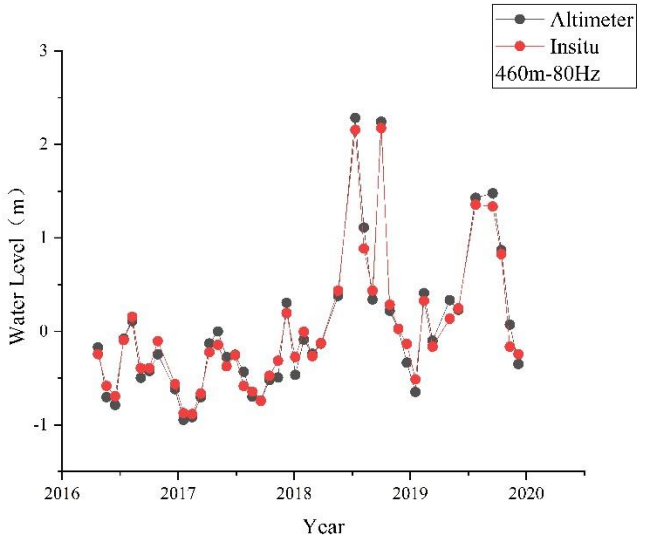


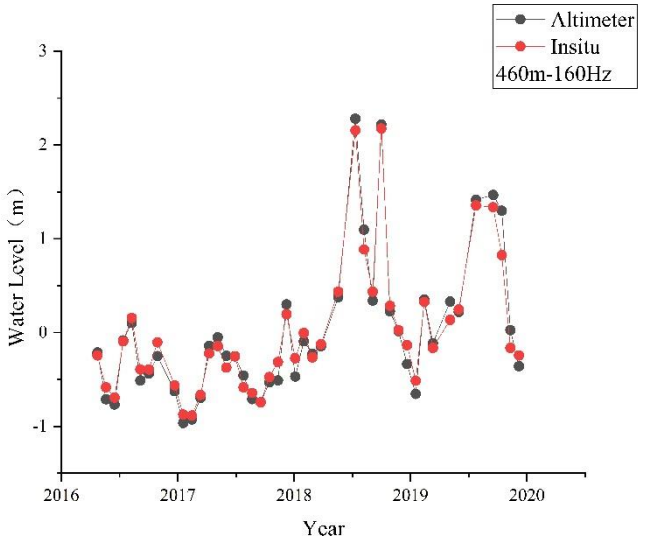


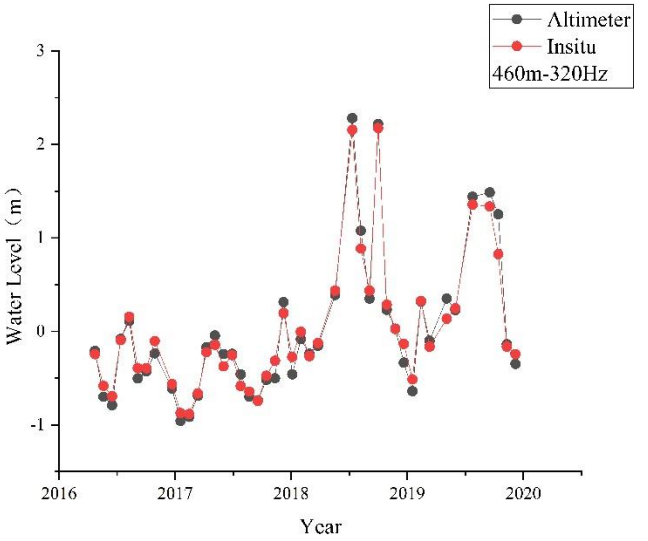


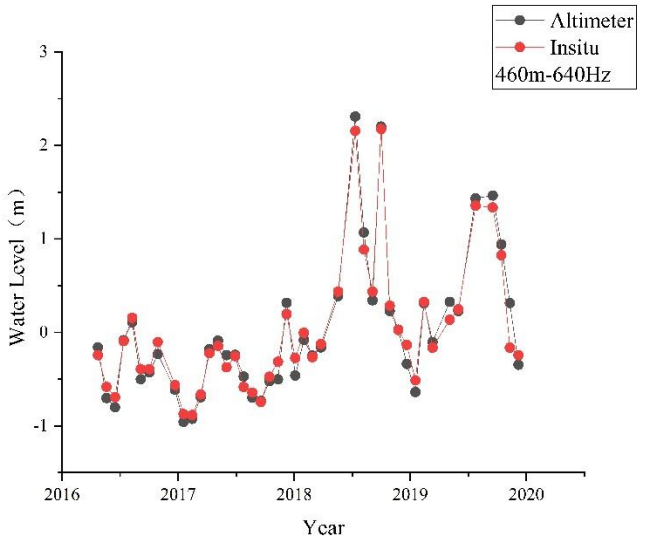


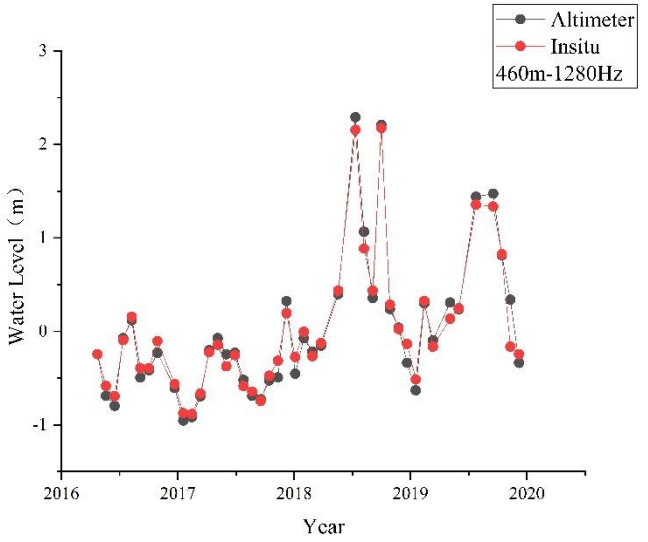
FFSAR-time Series in different posting rates over track 203（460m）

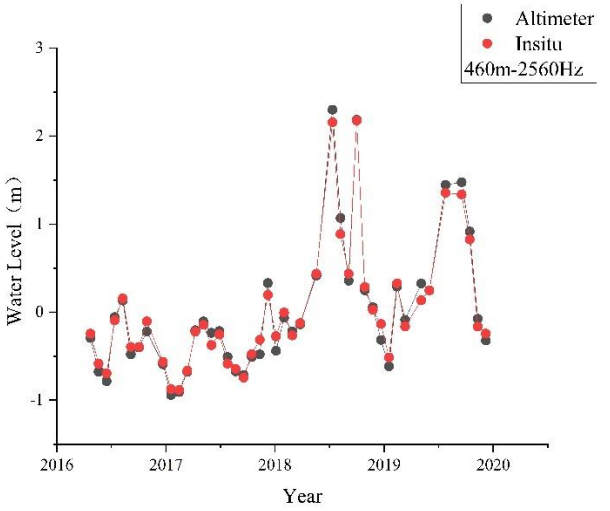




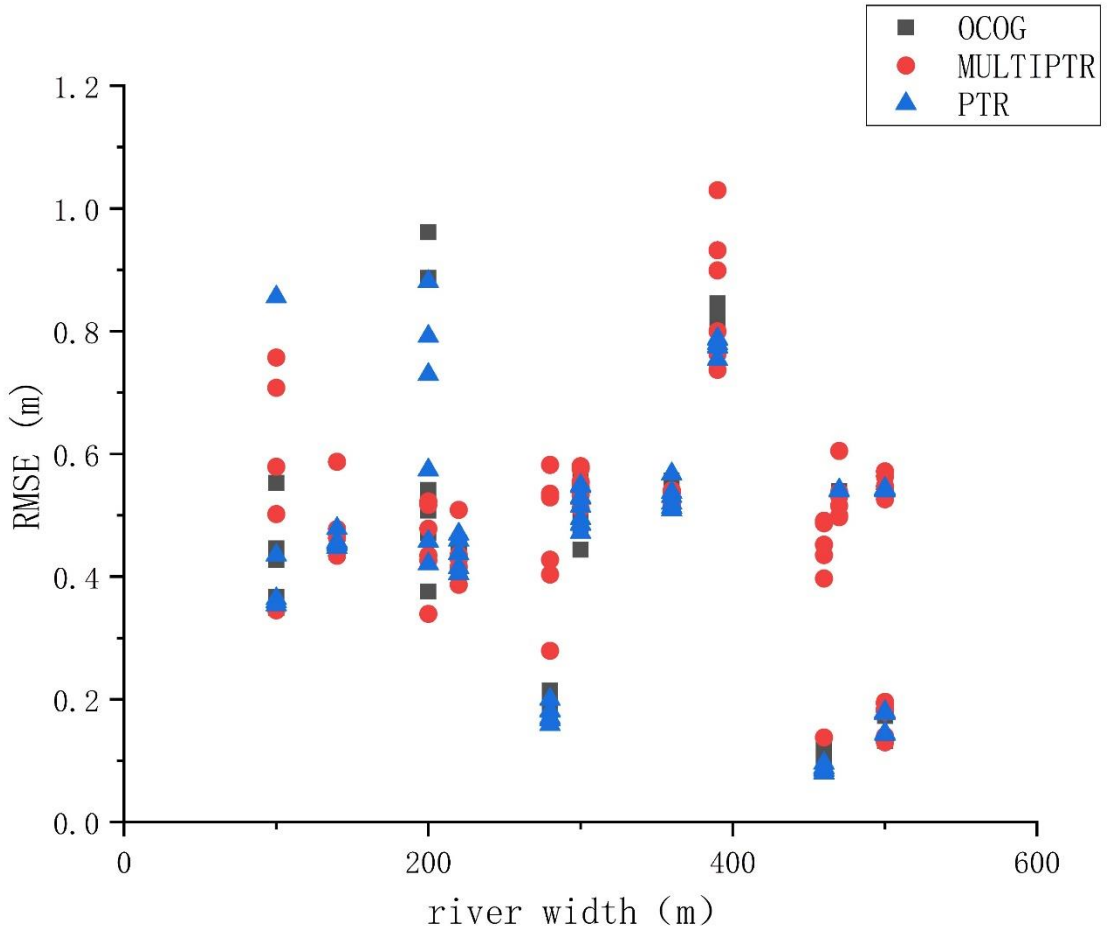


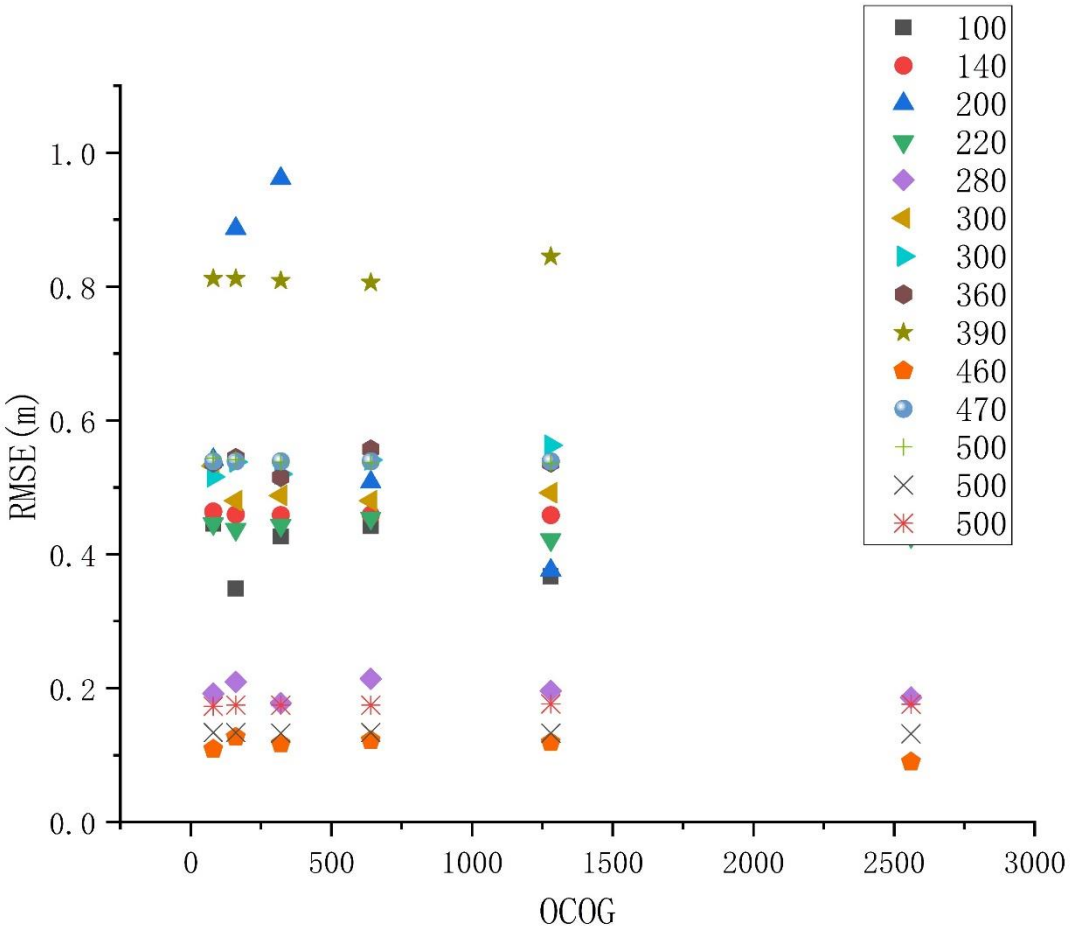






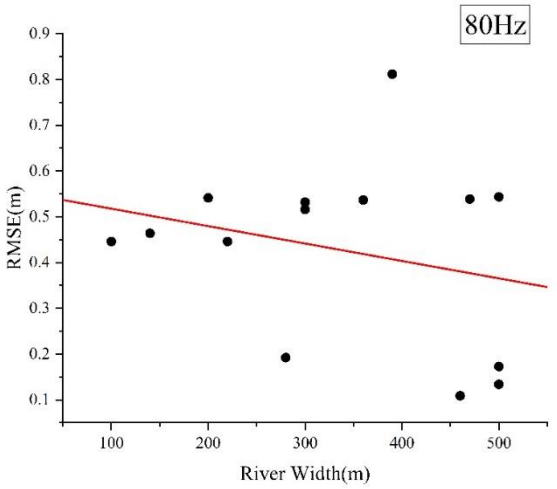
FFSAR-River Width

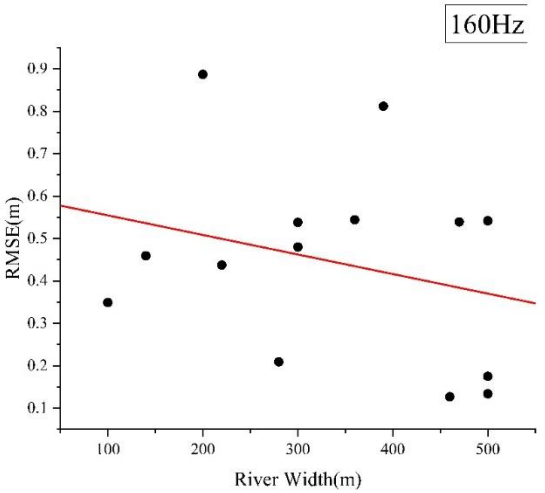


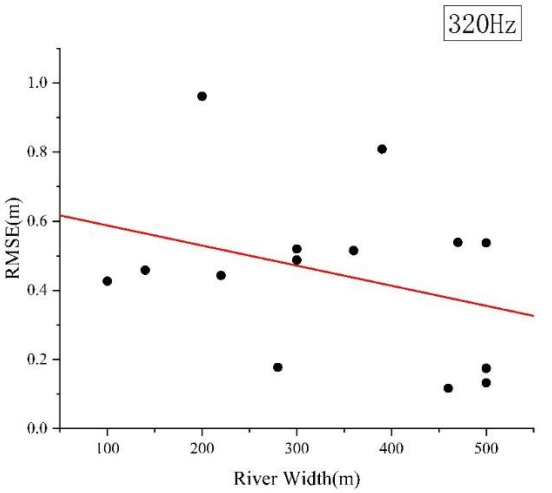


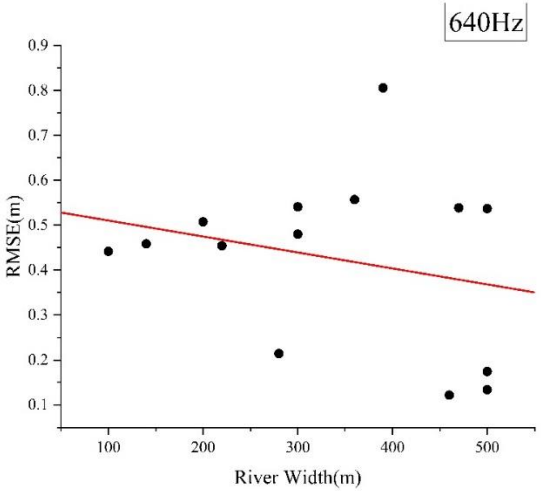
The abscissa represents posting rate.

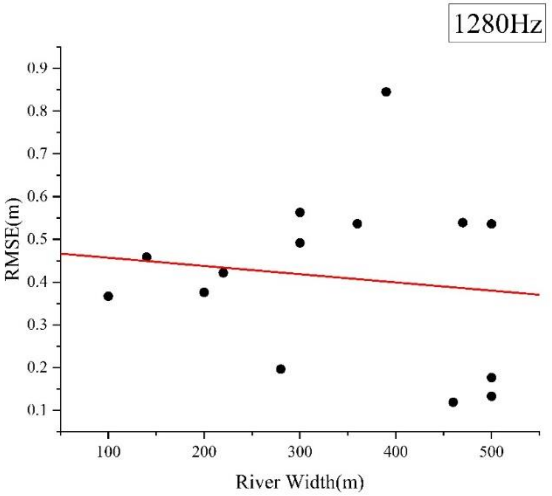
FFSAR-River Width

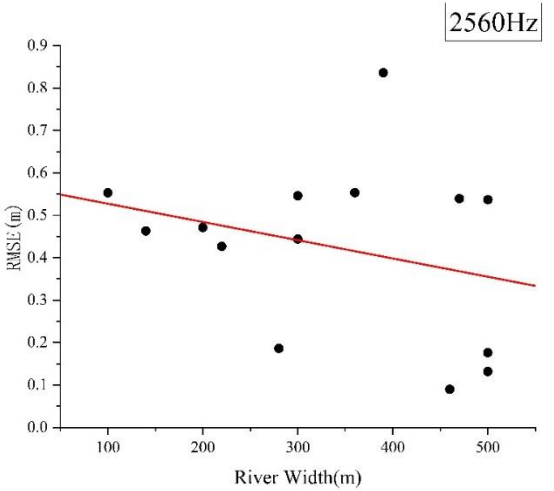








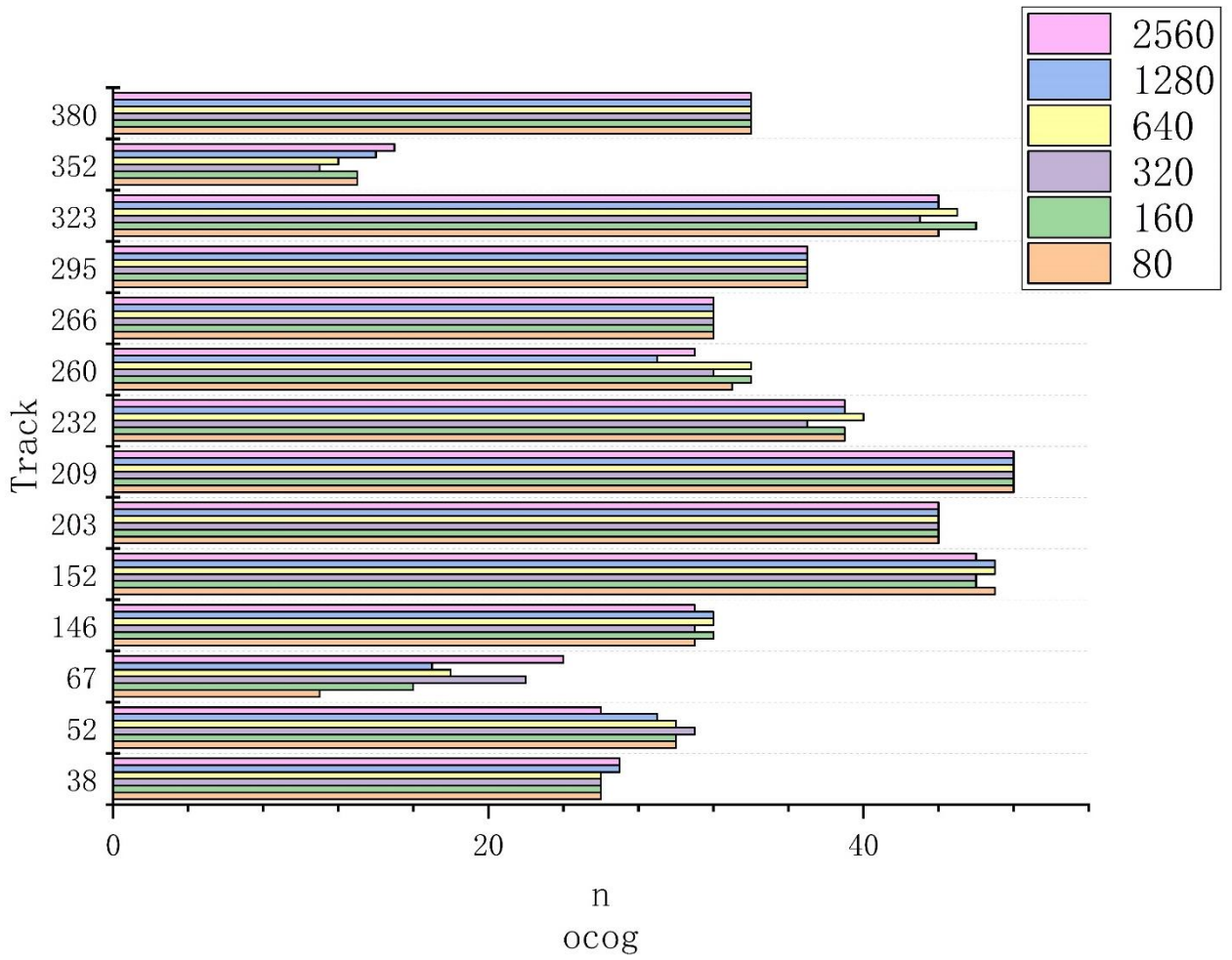




The RMSE shows a **negative correlation** with river width, But the correlation coefficient of fitting curve is very low, close to 0.

It shows that the RMSE of the FFSAR is **independent** of river width.

FFSAR-Valid Point



Track067 **100m**	RMSE/m	r	n
80Hz	0.446	0.928	**11**
160Hz	0.349	0.962	16
320Hz	0.427	0.945	22
640Hz	0.442	0.92	18
1280Hz	0.367	0.945	17
2560Hz	0.553	0.891	24

Conclusion1-UNFFSAR

1. The Sentinel-3A data has great potential in extracting **river level**.

2. The water level extraction accuracy of **80Hz** radar altimeter data is significantly better than that of traditional **20Hz**.We can significantly Improve the accuracy of water level extraction by changing the **posting rate**.

3. Combined with **FFSAR**, increasing the number of effective observation points, it is possible to extract the water level of smaller river width.

Conclusion2-FFSAR

1. FFSAR performs best when the posting rate is **1280Hz** during river level extraction.

2. In the process of FFSAR monitoring the water level of the Yellow River, the **OCOG** algorithm is more robust.

3. It shows that the RMSE of the FFSAR is **independent** of river width.

4. FFSAR can increase the number of effective monitoring points in rivers, which is more obvious at rivers less than **100m**.

Thanks for listening!