Analysis on the Ability of Marine Gravity Field Recovery from Wide-swath Altimeter

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Introduction

Marine gravity

1. The accuracy of east component of vertical deflection is significantly lower than north component
2. Wide-swath altimeter is expected to obtain high-precision and high-resolution two-dimensional SSH measurements simultaneously, and to improve the accuracy and resolution of marine gravity field

SWOT (Surface Water and Ocean Topography)

Payload

- Ka-band radar interferometer (KaRIn)
  - Low-Resolution over the ocean
    - Resolution no coarser than 2 km
  - High-Resolution over land surface water
    - Resolution ~100m
- Jason-class nadir altimeter

Orbit

- Fast sampling orbit(~6 month)
  - period 1 day
- Science orbit (~3 year)
  - period 21 day

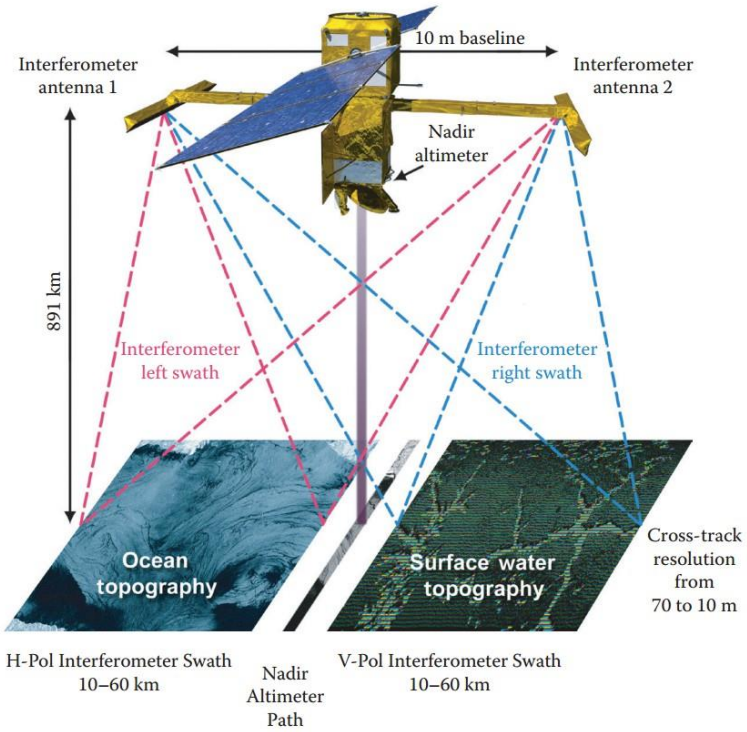


Fig.1 The configuration of SWOT (Fu et al., 2004)

Data and Method

Data

- Tracks of SWOT, J1/GM,C2, and SA/GM
- DTU15 MSS DTU15 MDT
- EGM2008
- Six kinds of errors of SWOT

Area of Interst

- South China Sea
- (SCS, 110~120° E,10~20° N), complex seafloor , numerous islands and reefs
- Indian Ocean (IDO, 60° E~70° E, 30° S~40° S), flat seafloor

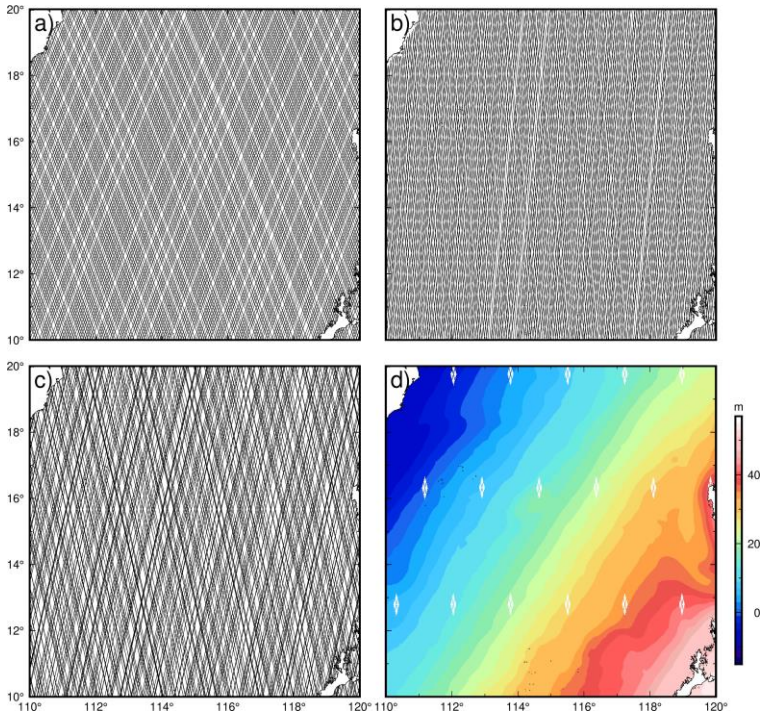


Fig.2 Tracks of altimetry missions in SCS.
a) one year of J1/GM; b) one year of C2/LRM;
b) c) one year of SA/GM; d) one cycle of SWOT with SSH

Data and Method

Method

- $\varepsilon = -\dfrac{\partial N}{\partial s}$
- $\varepsilon_i + v_i = \bar{\xi}\cos\alpha_i + \bar{\eta}\sin\alpha_i \qquad i = 1, 2, \cdots, \mathrm{n}$

N geoid

s along-track distanced

ε along-track vertical deflection

v error

α azimuth

n number of along-track vertical deflection

$\bar{\xi}, \bar{\eta}$ mean north and east components

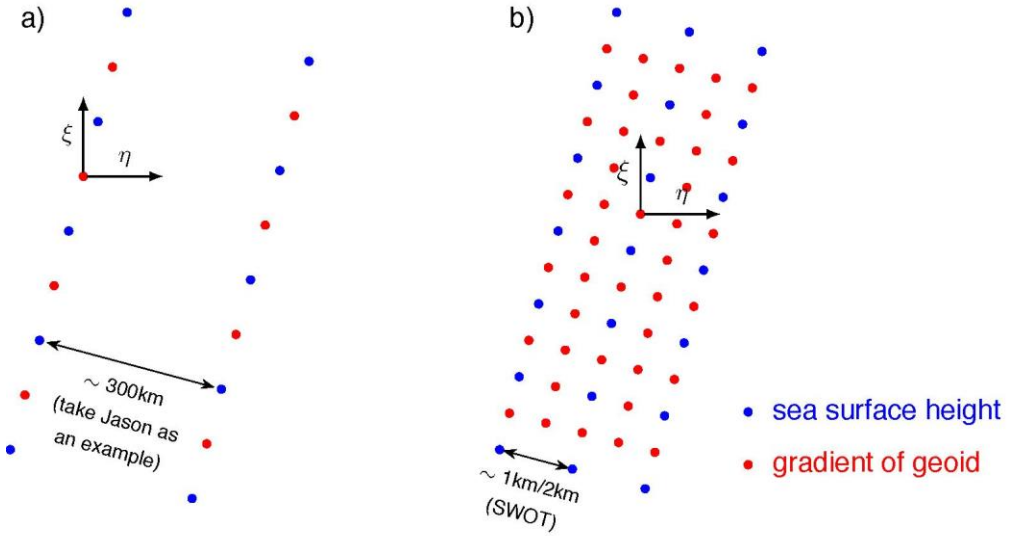


Fig. 3 Determination of geoid gradients.
a) nadir altimeter; b) SWOT

Data and Method

Errors

a) phase error;
b) roll error;
c) dilation error;
d) timing error;
e) KaRIn random error;
f) residual wet troposphere error;
g) total error

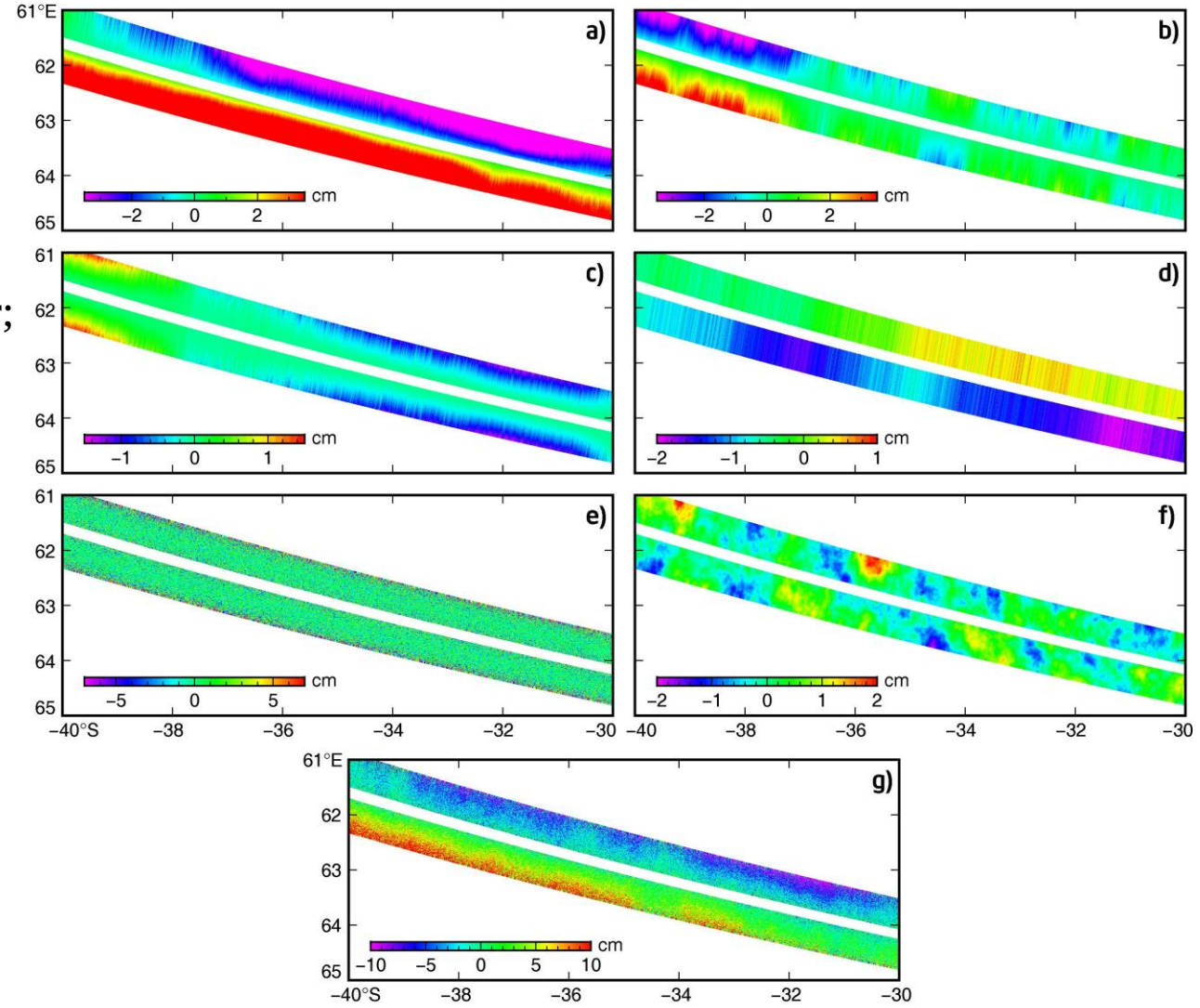
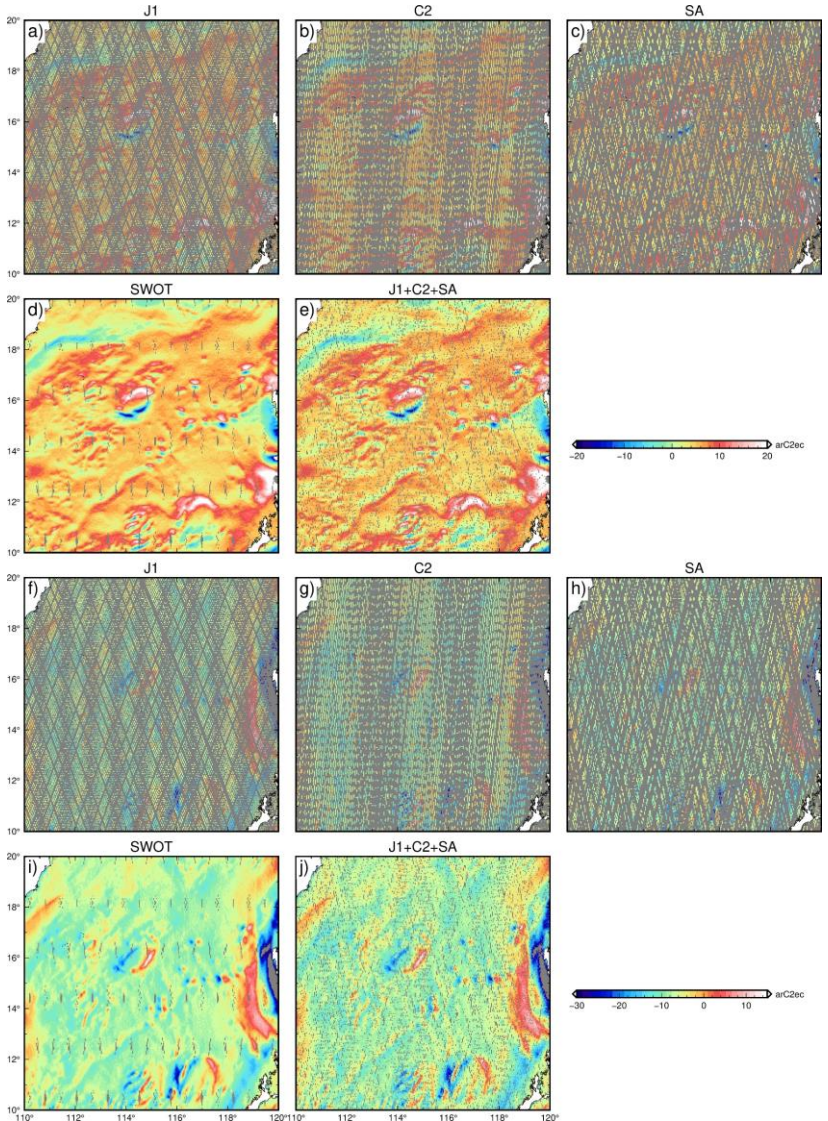


Fig. 4 The SWOT altimeter errors.

Result and Discussion

Contribution of wide-swath altimeter to vertical deflection

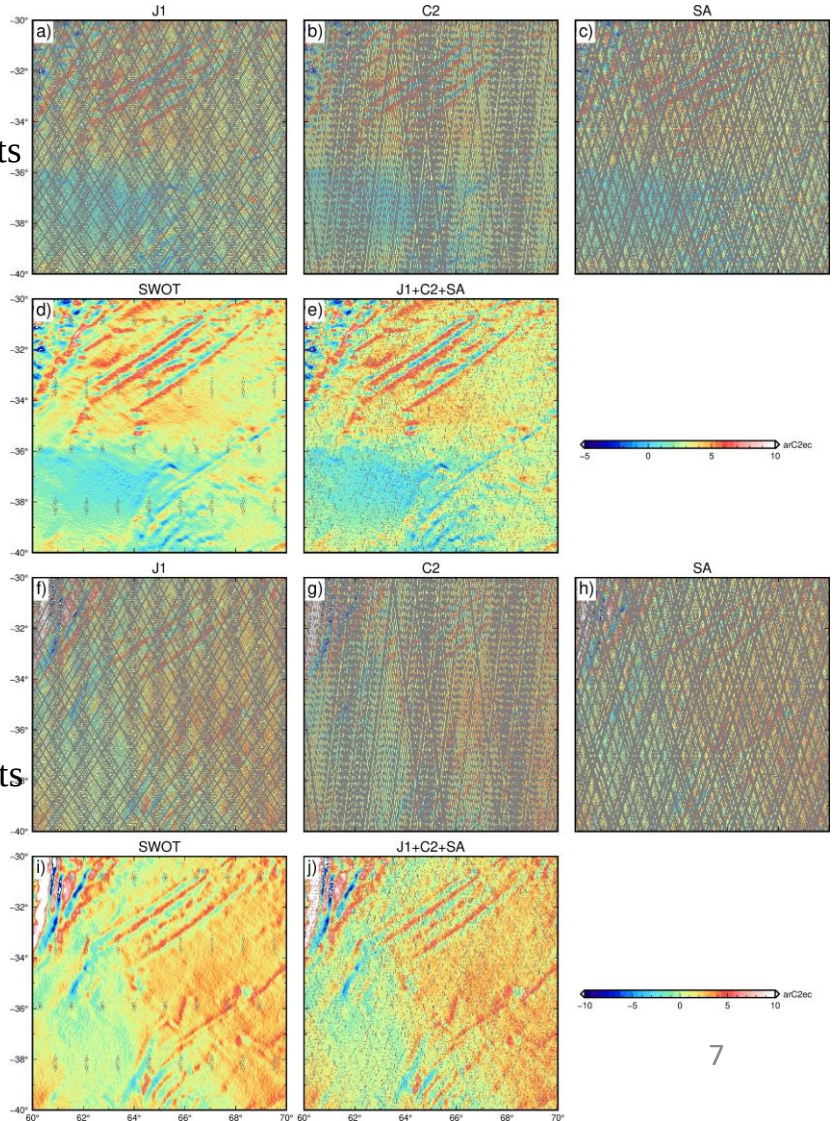


North components

Fig.5 SCS

Fig.6 IDO

East components



Result and Discussion

Contribution of wide-swath altimeter to vertical deflection

Table 1. The statistics of residual vertical deflections from static SSH datasets (unit: arcsec)

Area	Dataset	Valid numbers	North component			East component		
			Mean	STD	RMSE	Mean	STD	RMSE
SCS	SWOT	84047	0.001	0.493	0.493	0.037	0.576	0.577
	J1	20684	0.005	0.540	0.540	0.039	0.818	0.819
	C2	21871	0.004	0.509	0.509	0.043	1.707	1.707
	SA	17767	0.003	0.521	0.521	0.032	0.989	0.989
	J1+C2+SA	74048	0.000	0.525	0.525	0.038	0.948	0.949
IDO	SWOT	88611	-0.002	0.458	0.458	0.003	0.561	0.561
	J1	26133	-0.001	0.510	0.510	-0.001	0.705	0.705
	C2	22916	-0.001	0.477	0.477	0.002	1.522	1.522
	SA	19573	-0.001	0.480	0.480	0.005	0.867	0.867
	J1+C2+SA	79051	-0.001	0.485	0.485	0.002	0.772	0.772

1. SWOT has more valid grid vertical deflections than others.
2. Compared with EGM2008 model, the north and east vertical deflections from SWOT are the most consistent, even better than combing dataset.

Result and Discussion

Effect of KaRIn errors on vertical deflection

Table 2. The statistics of residual vertical deflections from SWOT data with errors (unit: arcsec)

Area	Error	North component			East component		
		Mean	STD	RMSE	Mean	STD	RMSE
SCS	No error	0.001	0.604	0.604	0.036	0.704	0.705
	Error	0.004	2.596	2.596	0.003	2.565	2.565
	Error filter	-0.003	0.632	0.632	0.057	0.733	0.736
IDO	No error	-0.002	0.570	0.570	0.003	0.692	0.692
	Error	-0.010	2.474	2.474	0.030	2.622	2.622
	Error filter	0.010	0.593	0.593	-0.026	0.720	0.720

1. The error affect significantly on the vertical deflections.
2. After Gauss filtering, the error is reduced to the comparable magnitude of that when only static SSH data is used.

Result and Discussion

Effect of KaRIn errors on vertical deflection

Table 3. The statistics of residual vertical deflections with different errors (unit: arcsec)

Area	Errors	North component			East component		
		Mean	STD	RMSE	Mean	STD	RMSE
SCS	No error	0.001	0.604	0.604	0.036	0.704	0.705
	Phase	0.004	0.709	0.709	0.058	0.716	0.718
	Roll	-0.002	0.650	0.650	0.057	0.711	0.713
	Dilation	0.001	0.614	0.614	0.036	0.703	0.704
	Random	0.005	2.556	2.556	0.038	2.543	2.544
	Total	0.004	2.596	2.596	0.003	2.565	2.565
IDO	No error	-0.002	0.570	0.570	0.003	0.692	0.692
	Phase	0.005	0.653	0.653	0.025	0.705	0.705
	Roll	0.002	0.606	0.606	0.034	0.700	0.701
	Dilation	-0.001	0.576	0.576	0.003	0.691	0.691
	Random	-0.003	2.445	2.445	-0.000	2.608	2.608
	Total	-0.010	2.474	2.474	0.031	2.622	2.622

1. The magnitude of Karin randon error is larger than other errors and has great effect on height error, followed by the phase error, roll error and dilation error.

Result and Discussion

Effect of SSH resolution in swath on vertical deflection

Table 4. The statistics of residual vertical deflections from SWOT data with different resolutions and errors (unit: arcsec)

Area	Error / Resolution	North component			East component		
		Mean	STD	RMSE	Mean	STD	RMSE
SCS	No error / 1km	0.001	0.604	0.604	0.036	0.704	0.705
	Error / 1km	0.004	2.596	2.596	0.003	2.565	2.565
	Error filter / 1km	-0.003	0.632	0.632	0.057	0.733	0.736
	No error / 2 km	0.000	0.556	0.556	0.036	0.648	0.649
	Error / 2 km	-0.002	0.851	0.851	0.035	0.885	0.886
	Error filter / 2 km	0.005	0.567	0.567	-0.039	0.665	0.667
IDO	No error / 1km	-0.002	0.570	0.570	0.003	0.692	0.692
	Error / 1km	-0.010	2.474	2.474	0.031	2.622	2.622
	Error filter / 1km	0.010	0.593	0.593	-0.026	0.720	0.720
	No error / 2 km	-0.002	0.515	0.515	0.002	0.629	0.629
	Error / 2 km	0.008	0.773	0.773	-0.012	0.849	0.849
	Error filter / 2 km	-0.022	0.526	0.527	-0.026	0.653	0.654

1. Under the requirement of 1 min resolution marine gravity field recovery, the 2 km SSH product is more suitable and can greatly reduce the quantity of SSH data.

Conclusion

1. Without errors, the accuracy of vertical deflections derived from about 21 days of SWOT data is certified to be better than that from one year of any conventional nadir altimeter data, and even better than that from three years of combing nadir altimeter data.
2. The SWOT data improves the accuracy of east vertical deflection significantly to the comparable magnitude of north vertical deflection.
3. The effect of KaRIn random noise is the largest, but can be reduced by filtering, followed by the phase error, roll error and dilation error.
4. The accuracy of SSH measurements is inversely proportional to the spatial resolution. The 2 km resolution of SSH can fulfil the requirement of 1 min resolution marine gravity field. After filtering, higher than 1 min resolution marine gravity field could be achieved with SWOT data.

Thanks