METEO FRANCE
Toujours un temps d'avance

The Wide Swath Significant Wave Height: An Innovative Reconstruction of SWH from CFOSAT SWIM and Scatterometer Using Deep Learning

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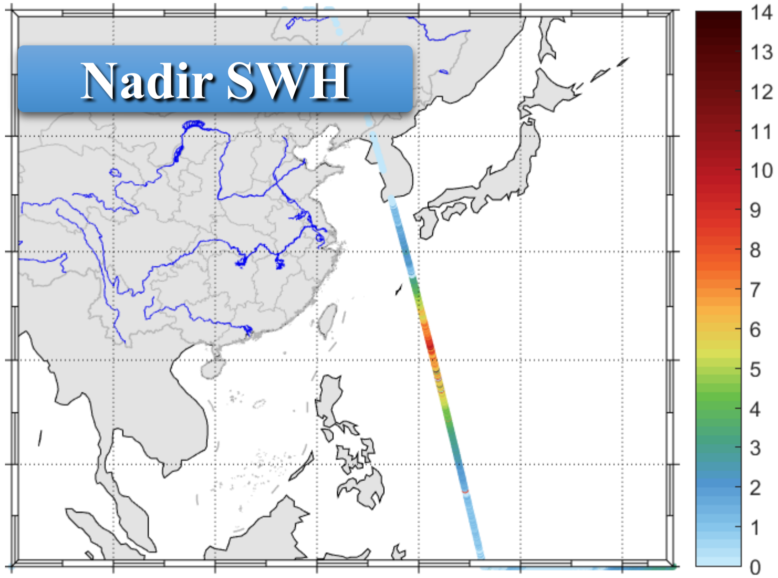
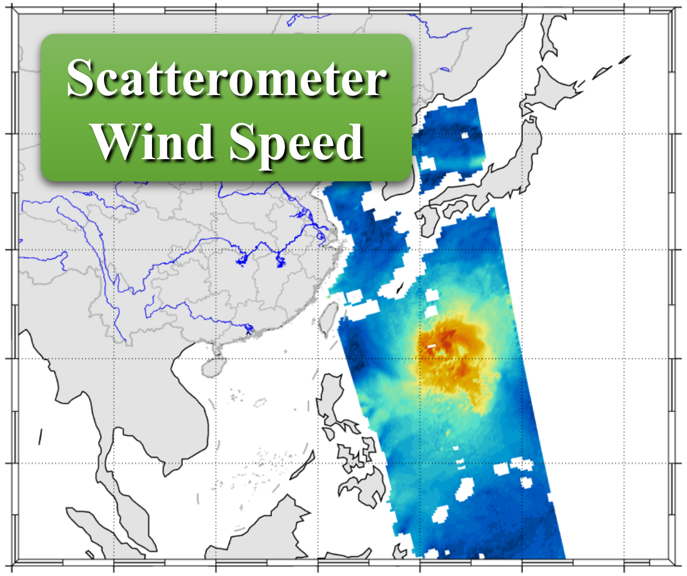
Introductions

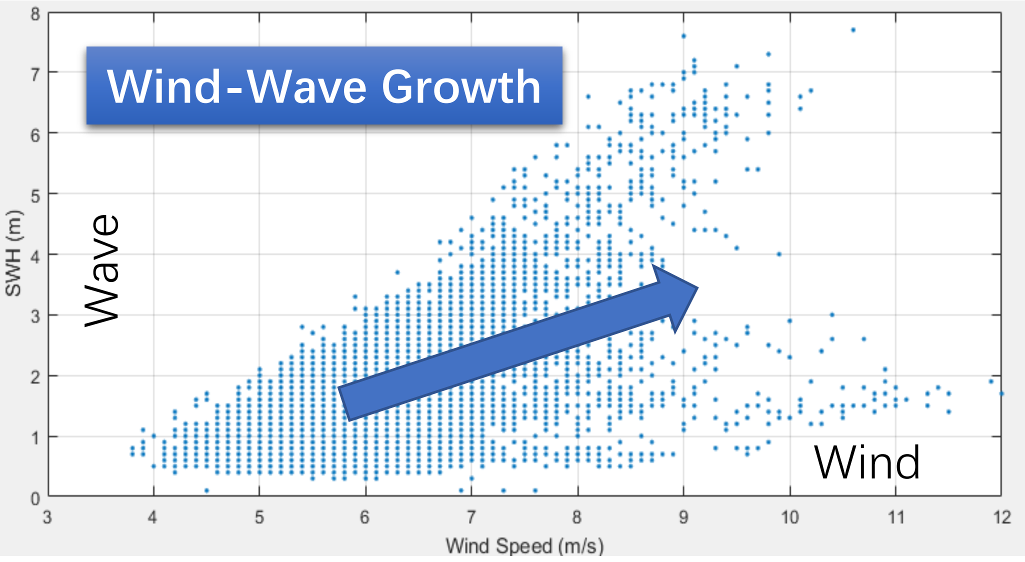
In December 2020, a super container ship suffered from severe sea conditions in the North Pacific Ocean, resulting in container stacking collapse. About 1900 containers were lost or damaged, including 40 containers with dangerous goods.

- The significant wave height (SWH) is the most widely used indicator to measure the sea state. Therefore, it is critical to accurately monitor and forecast the SWH
- **Data assimilation** is an effective way to improve wave numerical simulations, and its impact is related to both the **quality and the quantity** of wave observations.
- Comparing to buoys, the significant increase in the quantity of wave observations from altimeters has surely led to valuable improvements in the impacts of data assimilation, however, altimeter observations are still limited to their nadir tracks, limiting the number of observations.

The Idea — Along-Track Wide Swath Wave Fusion







Nadir SWH

+

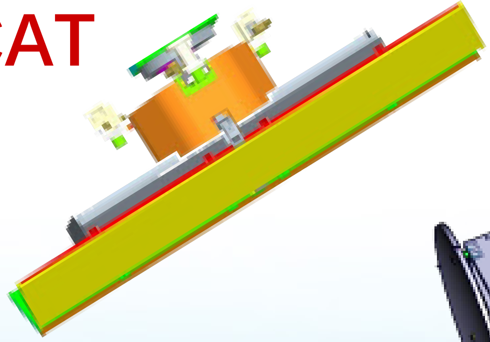
Scatterometer

- **Advantage: Accurate**
- Limit : Low spatial coverage (Only a track of wave height)

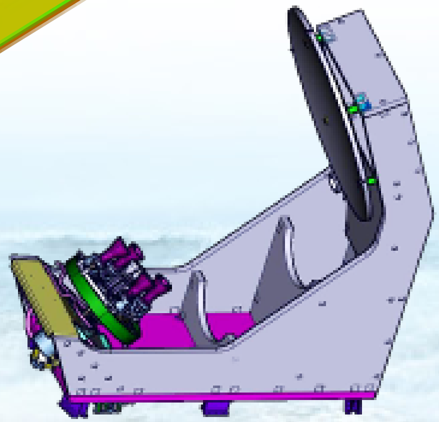
- **Advantage: Wide Swath**
- Limit : Wind, not wave height

Precise wave field with WIDE SWATH

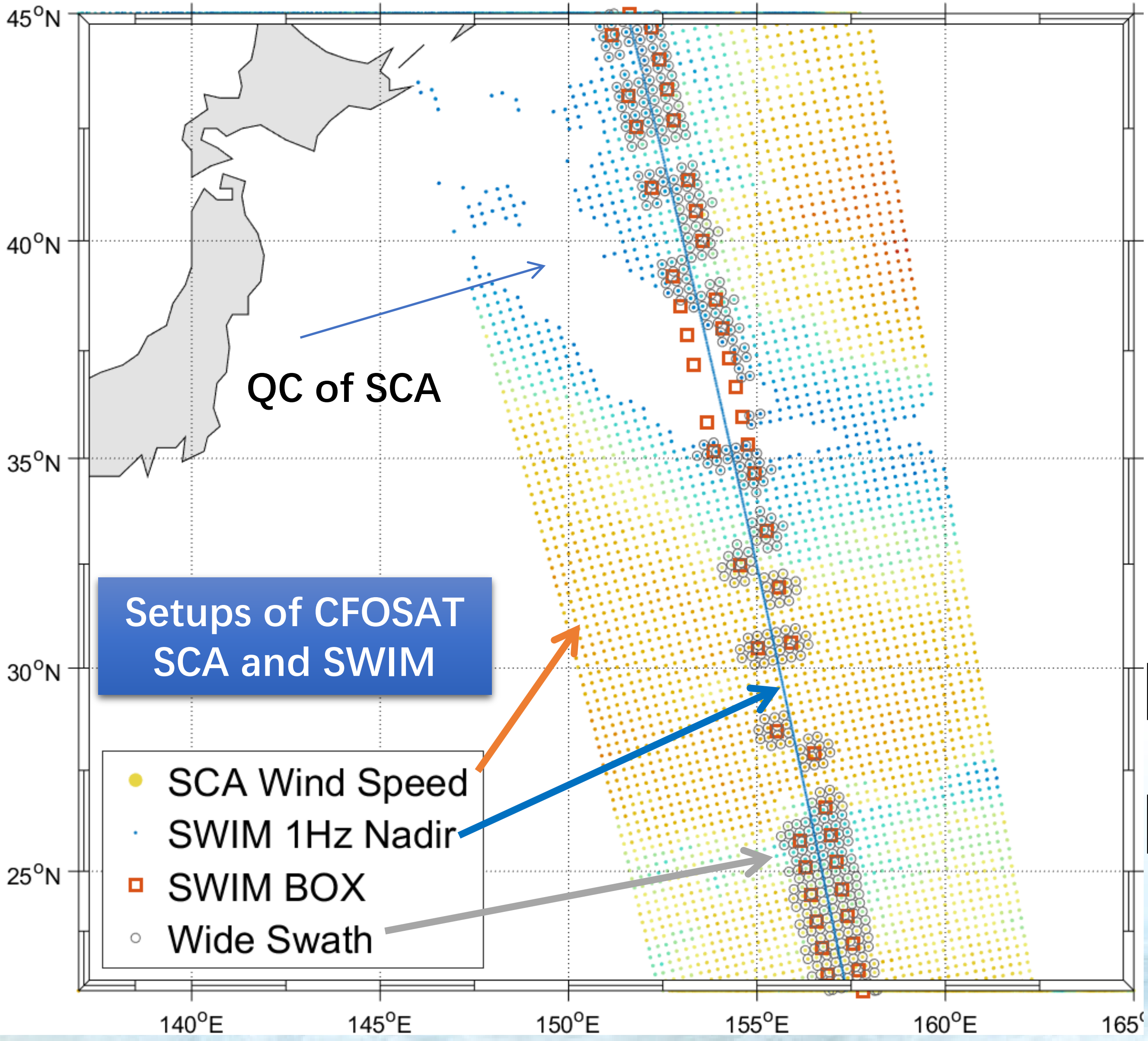
- SCAT

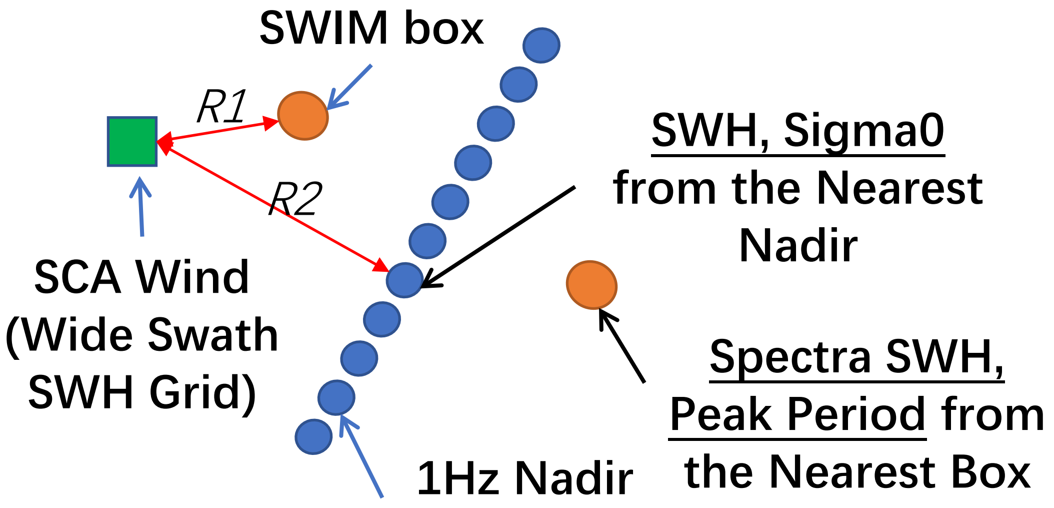


- SWIM

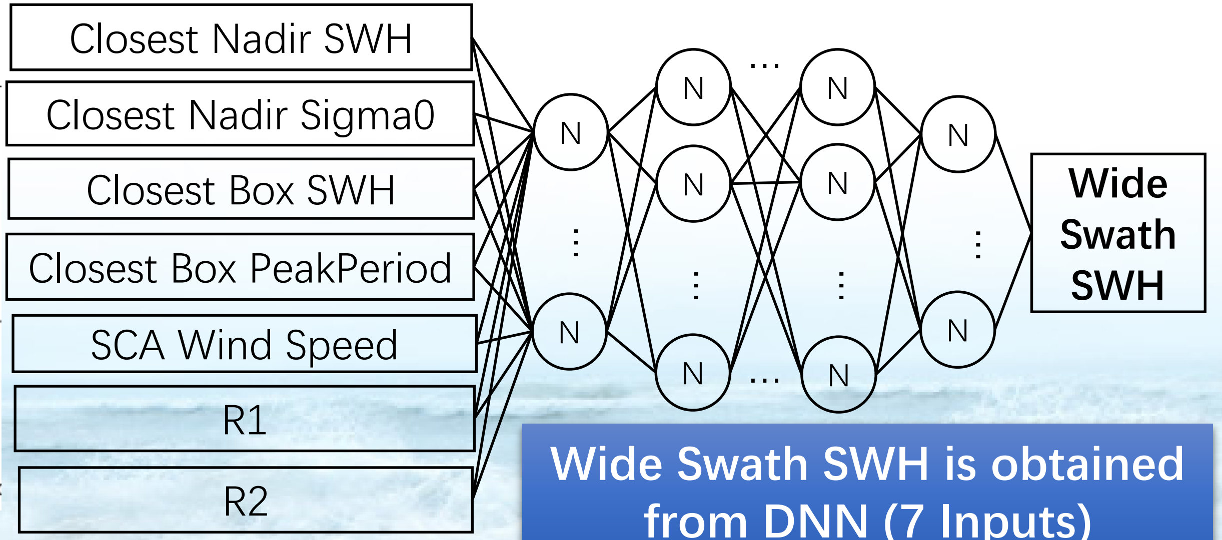


Wide Swath SWH: From Combination of SCA wind, Box and Nadir



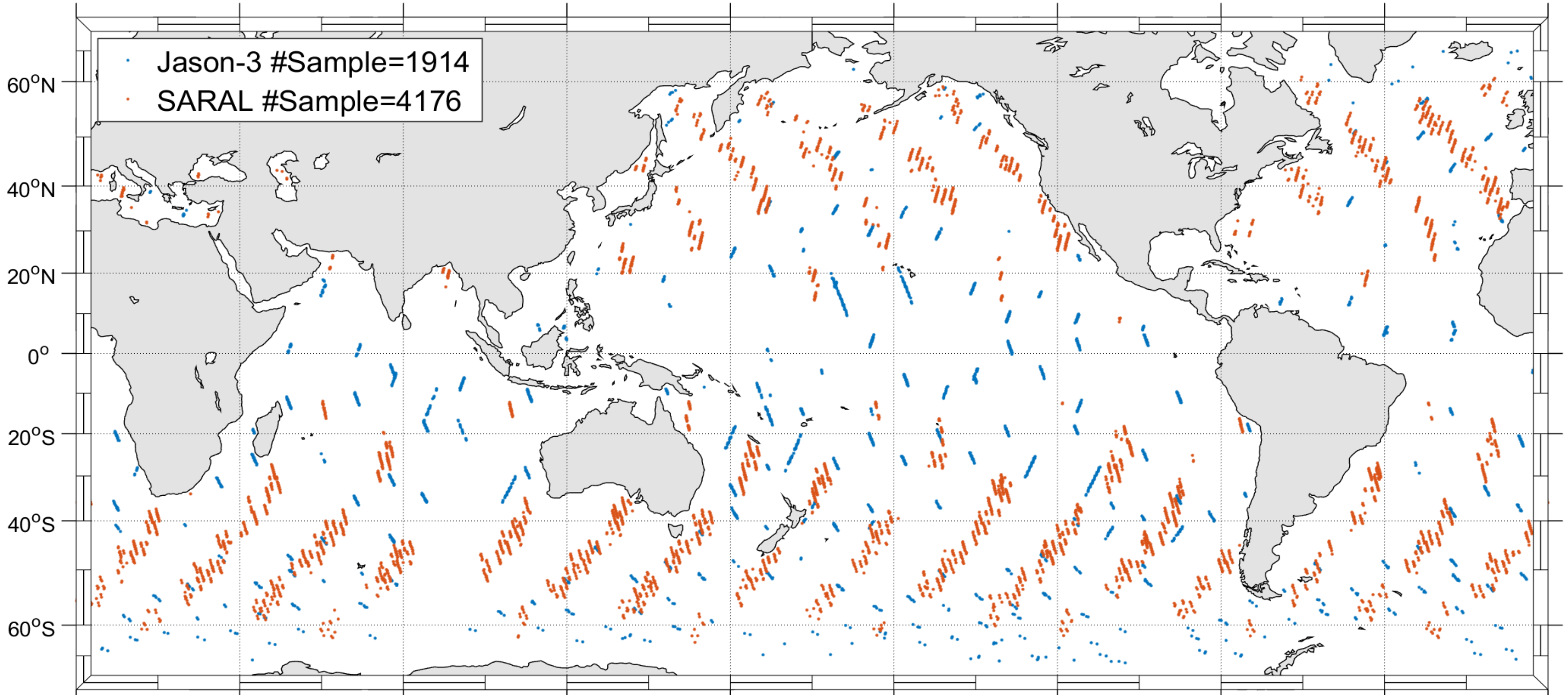


The distance of Wide Swath SWH grid is limited to within 50km from the Box (R1) and 100km from the Nadir (R2)



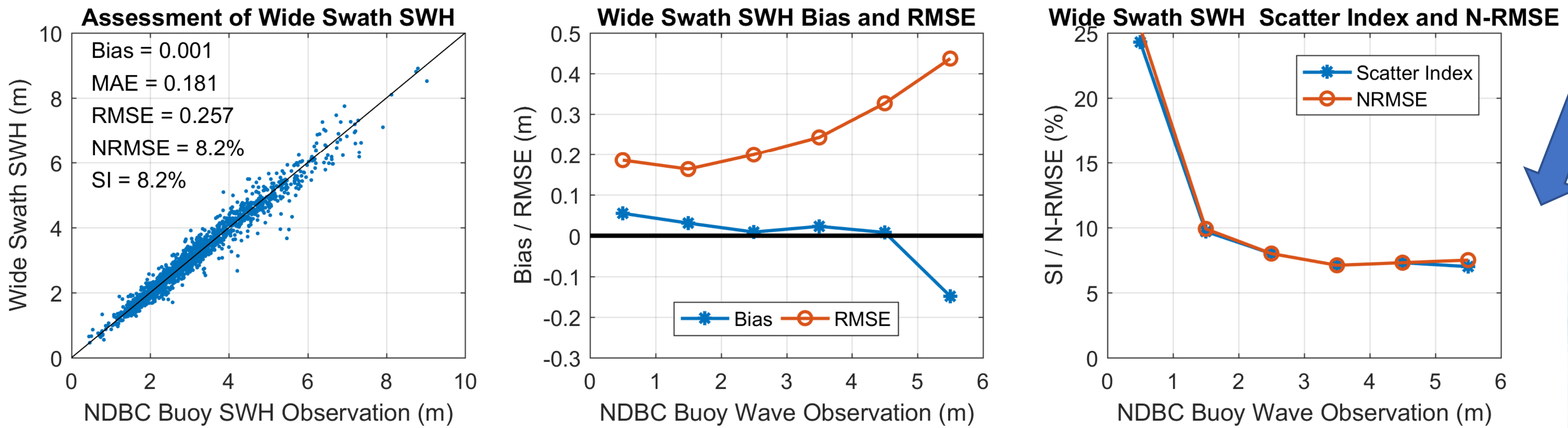
Wide Swath SWH is obtained from DNN (7 Inputs)

Training and Validation of Wide Swath SWH

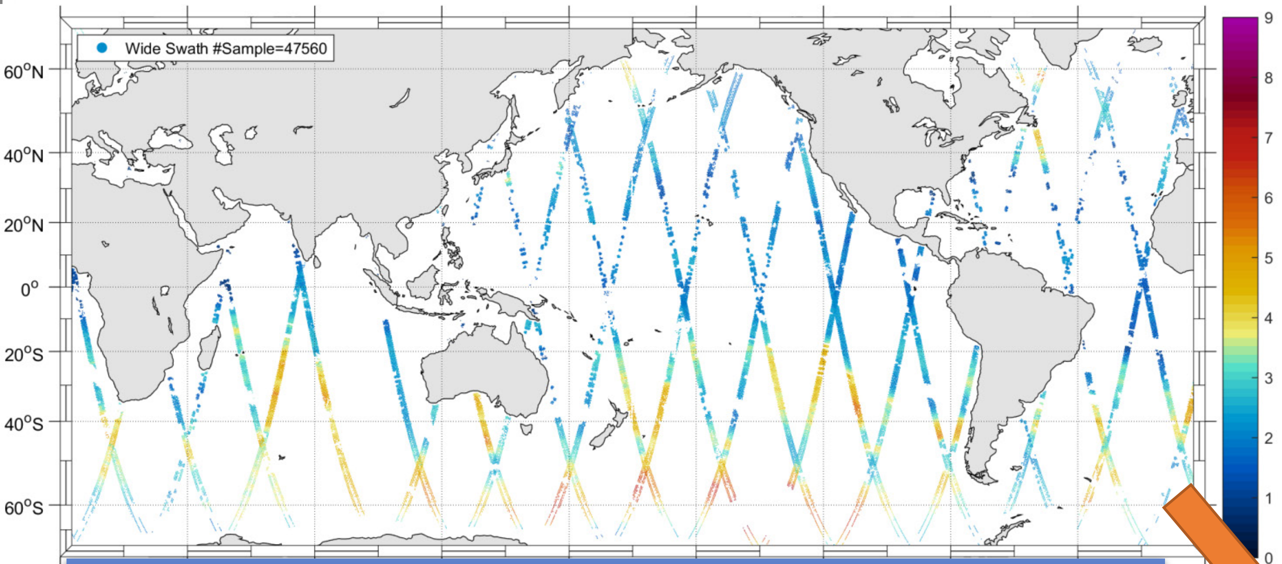


Collocated SWH from Jason-3 and SARAL are used in training

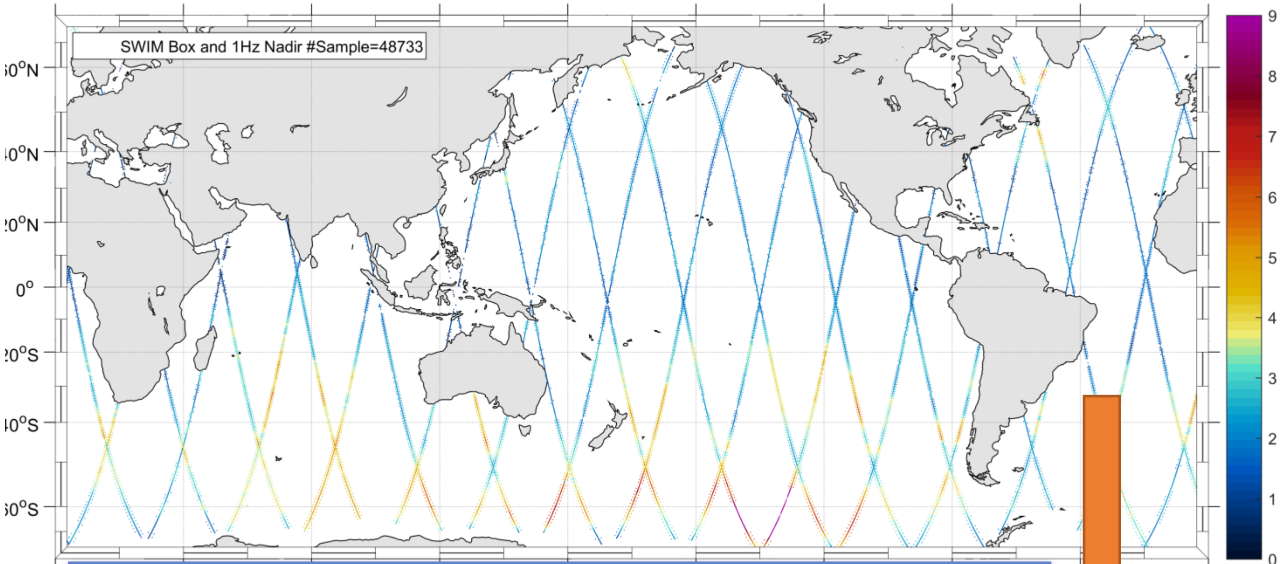
Good accuracy is found through the assessment of Wide Swath SWH in the 25% independent observations



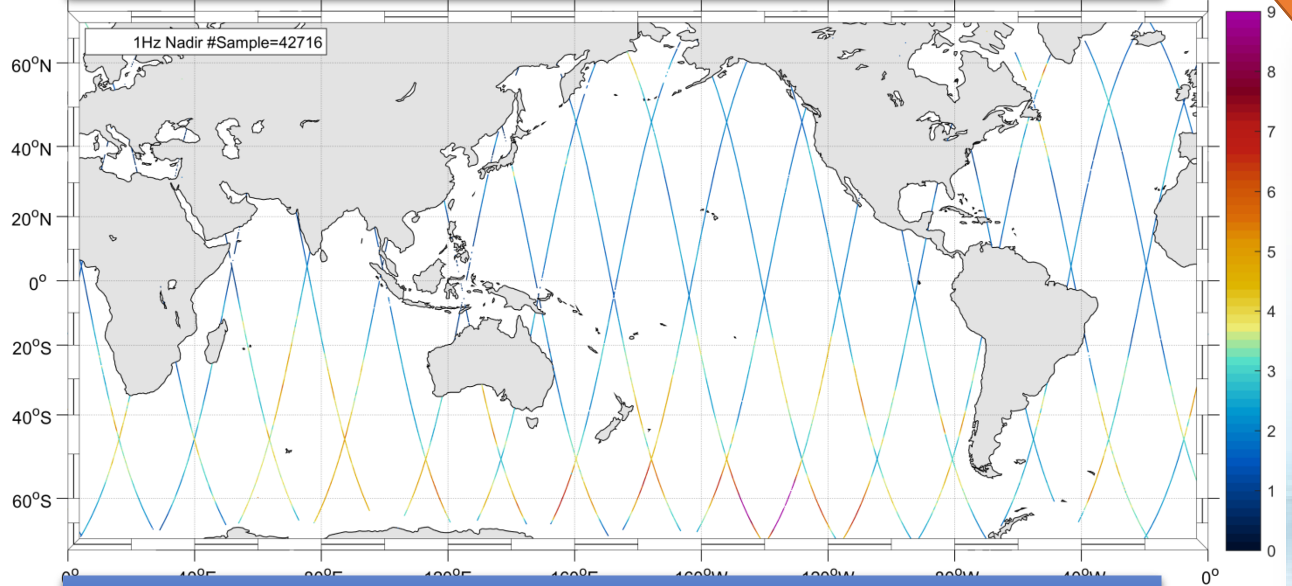
Data Amount Comparison of the SWH observation (in 2019.05.01)



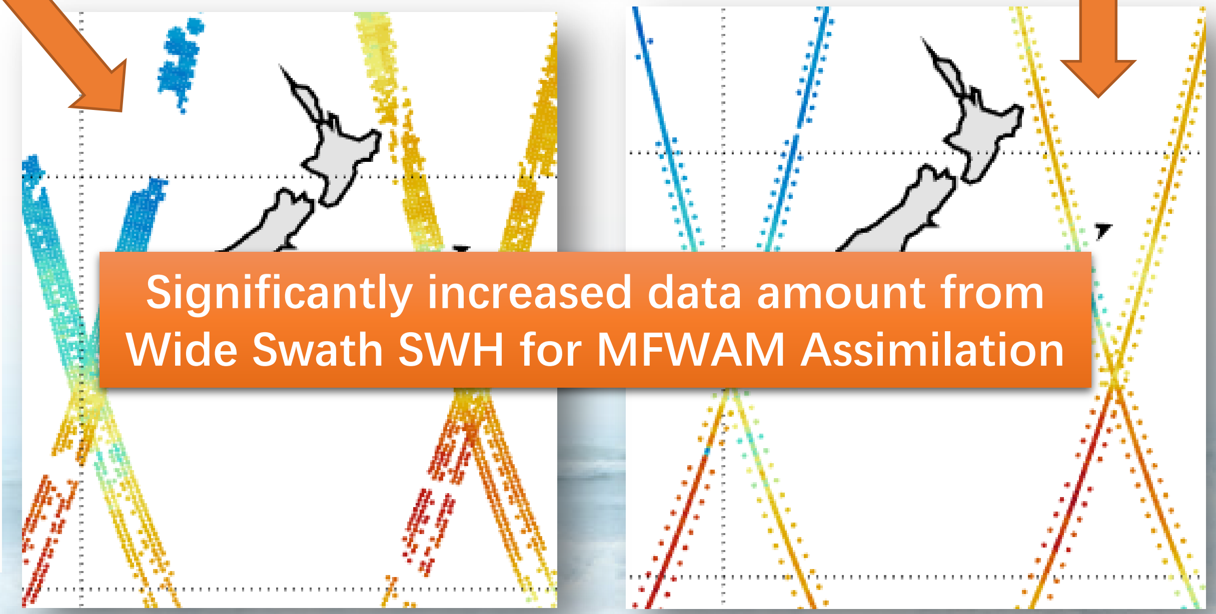
Sample# of Wide Swath : 47560



Sample# of DL BOX + Nadir 1Hz : 48733



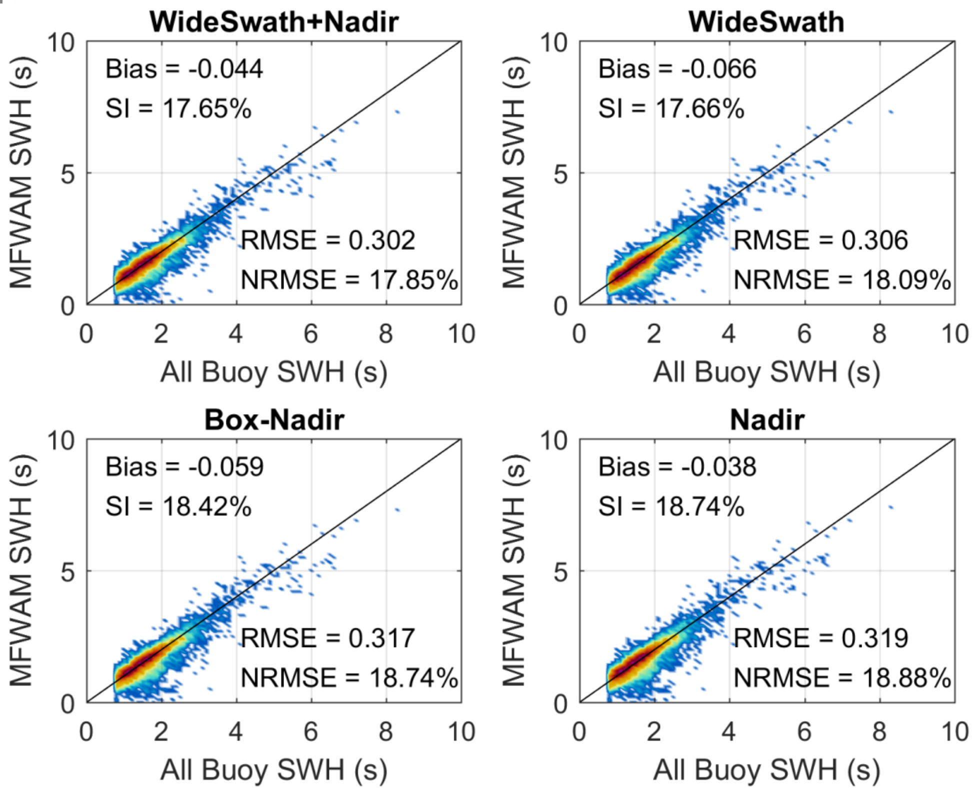
Sample# of Nadir 1Hz Only : 42716

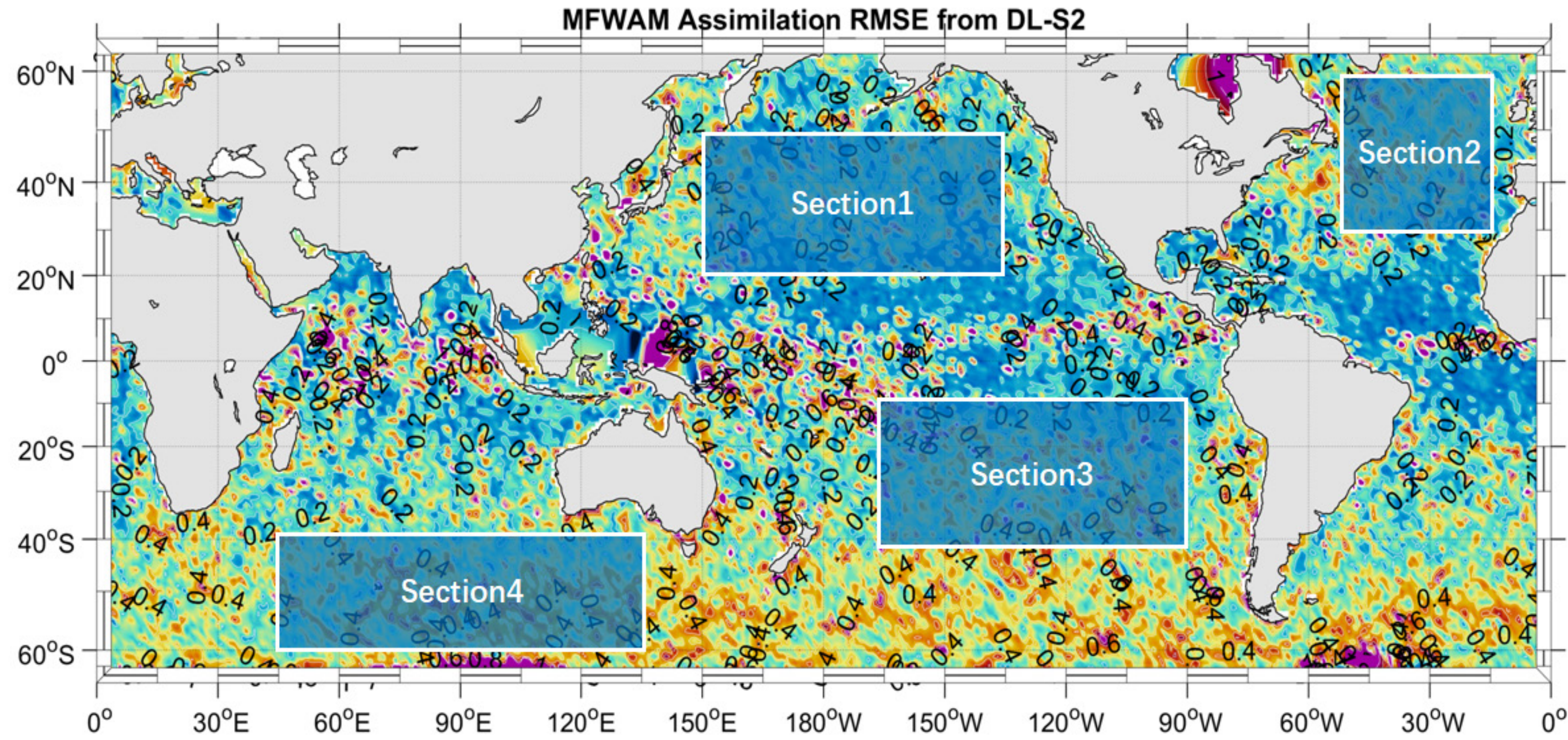


Significantly increased data amount from Wide Swath SWH for MFWAM Assimilation

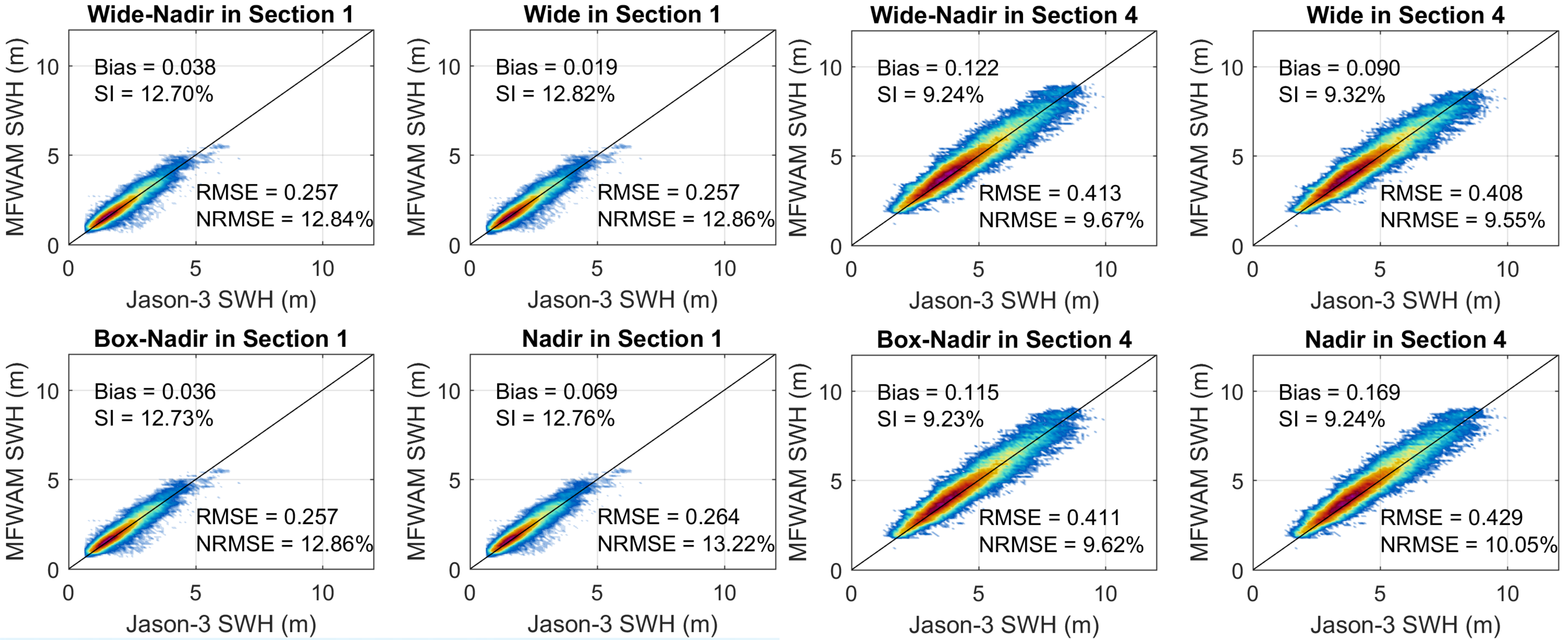
Schemes of Assimilation experiments (against NDBC and French Buoy)

Scheme	Assimilated	Bias	RMSE	N-RMSE	Scatter Index
A	Wide Swath + Nadir 1Hz	-0.044	0.302	17.85 %	17.65 %
B	Wide Swath	-0.066	0.306	18.09 %	17.66 %
C	DL Box + Nadir 1 Hz	-0.059	0.317	18.74 %	18.42 %
D	Nadir 1Hz Only	-0.038	0.319	18.88 %	18.74 %



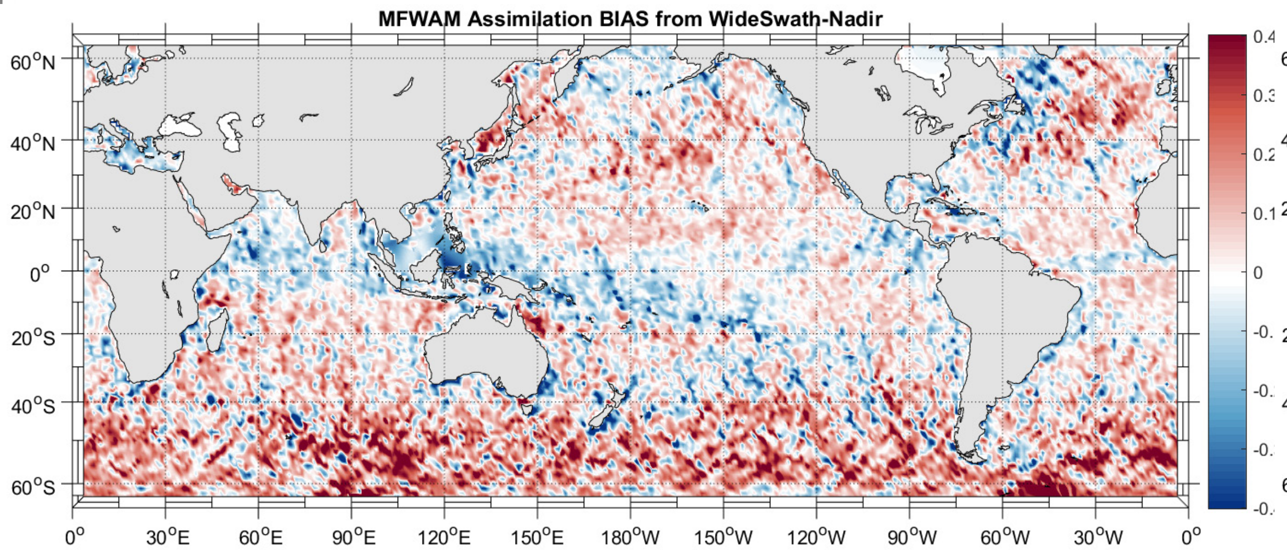


Section Comparison of Schemes (Jason-3 as the reference)

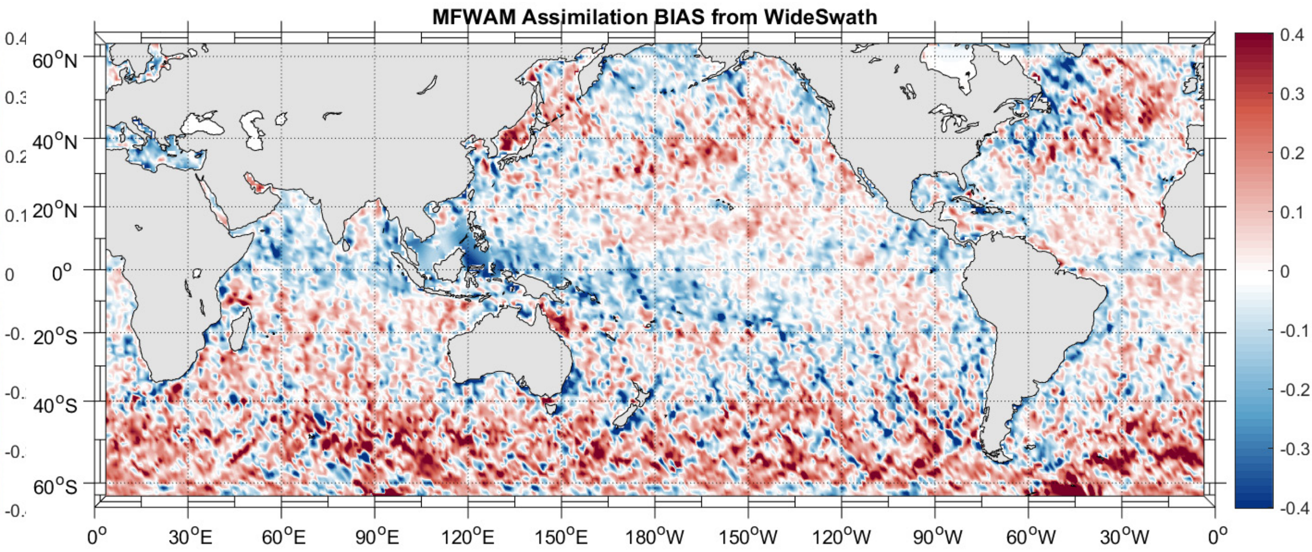


Positive Impacts are found in Pacific and Southern Oceans.
Better Bias and RMSE than assimilating Nadir only.
(Good in wind sea because the wind speed included in Wide Swath SWH calculation)

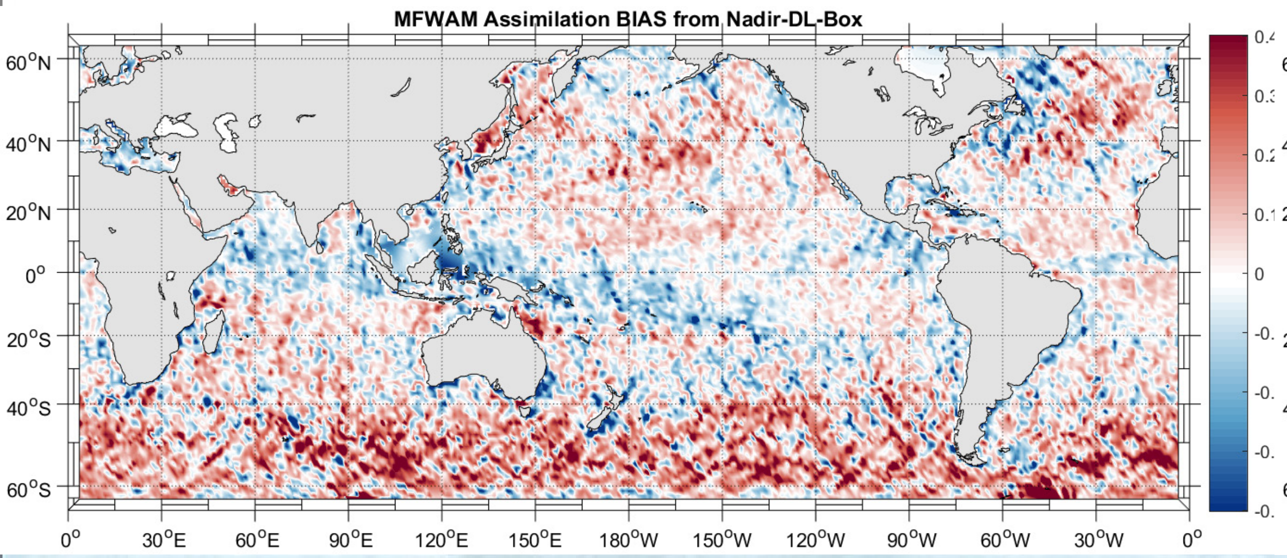
BIAS of Assimilation experiments (Jason-3 as the reference)



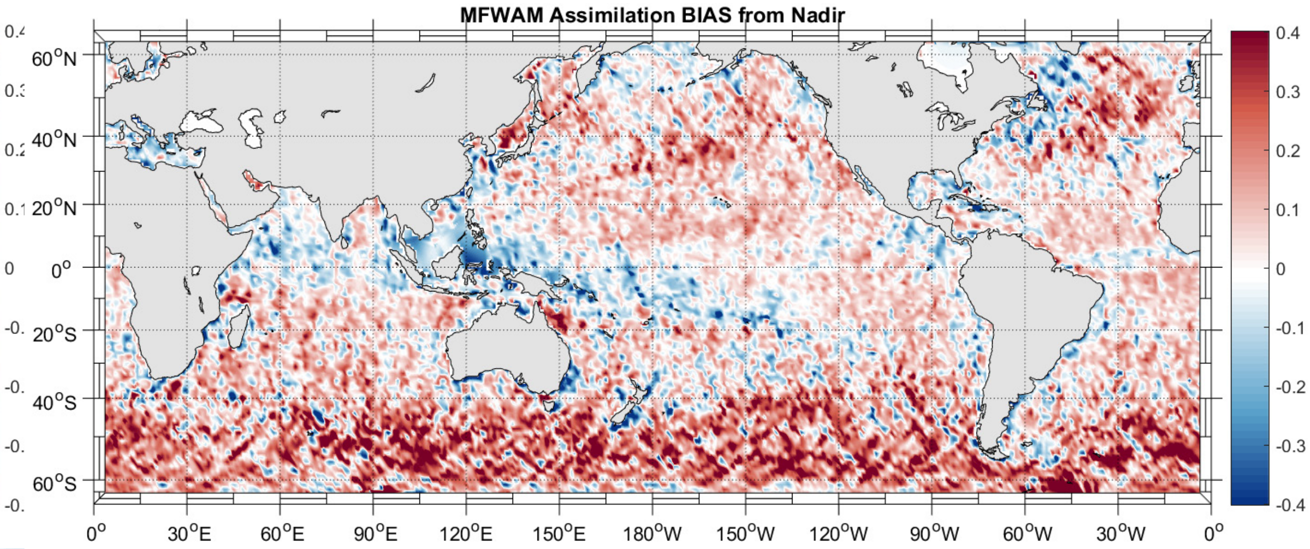
Wide Swath + Nadir



Wide Swath

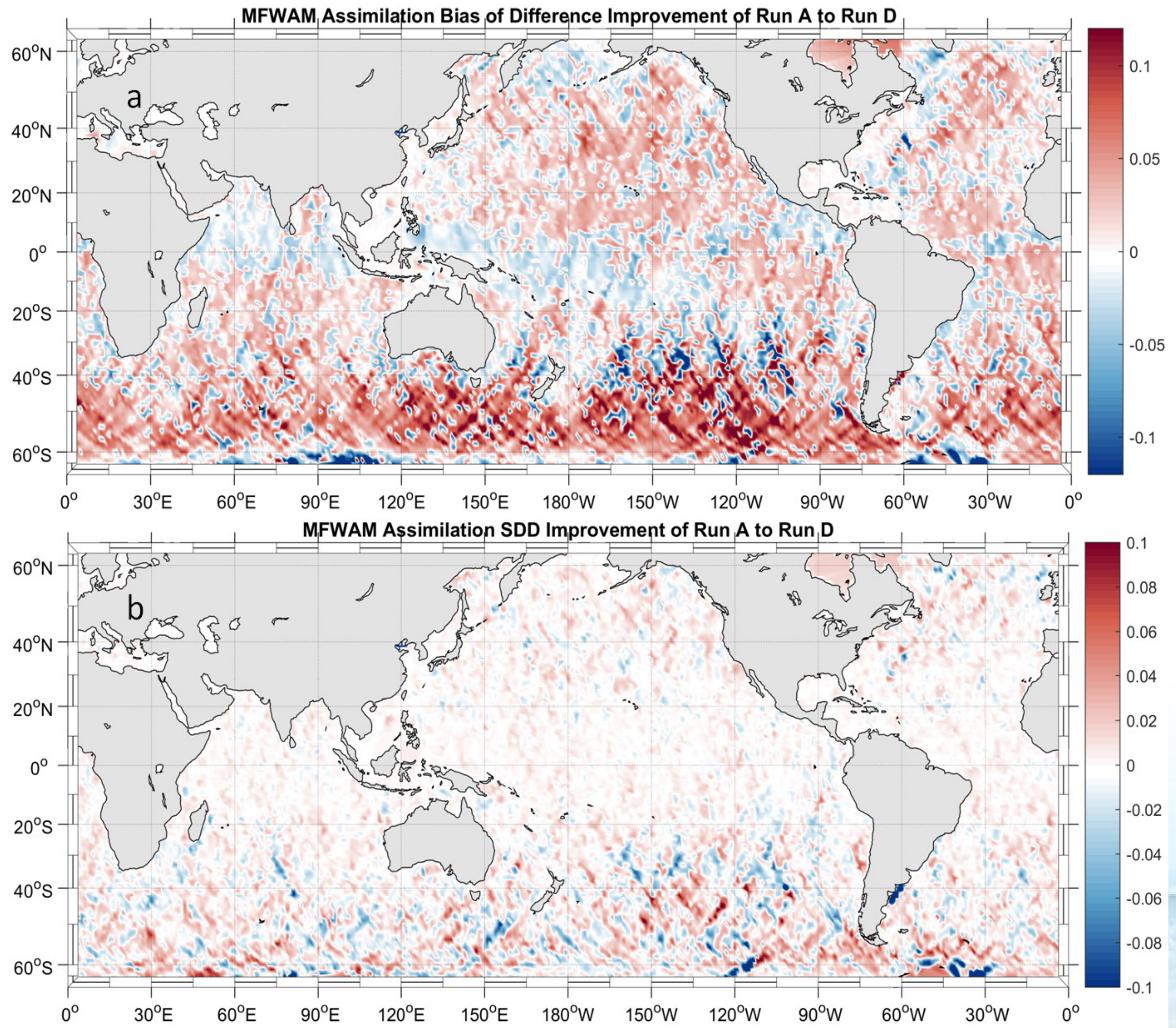


DL BOX + Nadir



Nadir

Wide Swath Improvement to Nadir Assimilation (Red means Improvement)



$$BD_{imp} = |BD_D| - |BD_A|$$

$$SDD = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left[\left(S_i - \bar{S}\right) - \left(R_i - \bar{R}\right)\right]^2}$$

$$SDD_{imp} = SDD_D - SDD_A$$

Distribution of the improvements in Run A relative to Run D. The improvements of the BD and SDD as compared against Jason-3 and SARAL/AltiKa altimeter measurements are indicated in Panel a and b, respectively.

With the assimilation of both wide swath SWH and nadir SWH, improvements can be found in most of the global ocean

Conclusions and Discussions

■ The quantity of the observations is always an important factor affecting the wave assimilation effect.

■ A retrieval method is constructed based on a deep neural network to retrieve the wide swath SWH from the simultaneous observations of SCAT and SWIM. The method is used to estimate the SWH at SCAT grid points to provide the SWH over an extended spatial coverage.

■ In addition to the significantly increased number of observations, the wide swath SWH has been shown to achieve good accuracy.

■ Promising results are found from a validation against NDBC buoy and altimeters' wave observations. The assimilation of the wide swath SWH achieves an equivalent positive impact to the assimilation of SWIM nadir SWH observations. Together with traditional nadir SWH observations, the addition of the wide swath SWH does enhance the positive impact of the assimilation.

■ To a certain extent, the wide swath SWH combines the advantages of both SWIM and SCAT, this provides one of the insights into how we can increase the positive impact of wave remote sensing.

Thank you for Listening!

Wang, J. K., Aouf, L., Dalphinet, A., Zhang, Y. G., Xu, Y., Hauser, D., & Liu, J. Q. (2021). The wide swath significant wave height: An innovative reconstruction of significant wave heights from CFOSAT's SWIM and scatterometer using deep learning. *Geophysical Research Letters, 48, e2020GL091276. https://doi.*org/10.1029/2020GL091276

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