Tracing the decaying swell across Pacific with CFOSAT SWIM data

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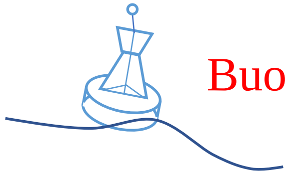
Outlines

- Previous studies on swell tracing and swell decay
- Process of retracing swells
- Results and analysis
- Conclusions

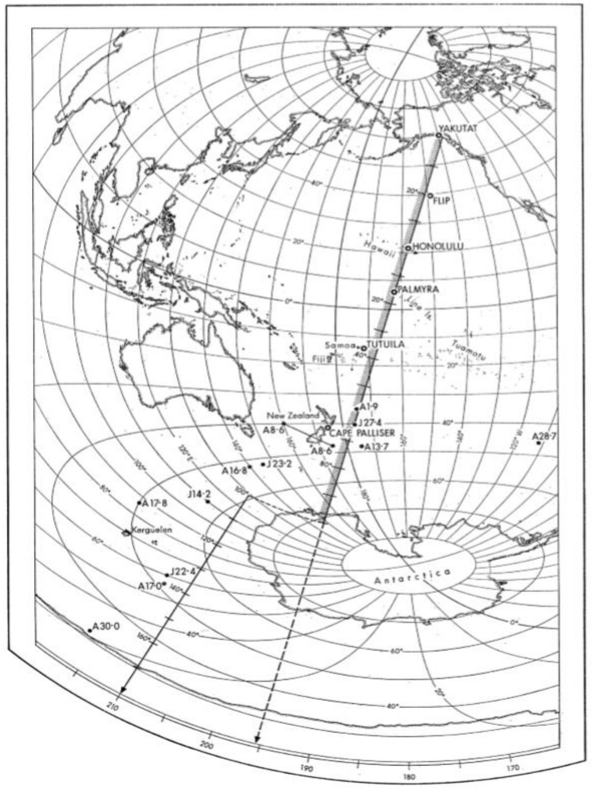
Previous studies



Buoys and stations

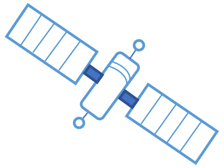
- Swells can propagate over a very long distance in the ocean [Munk et al., 1963; Snodgrass et al., 1966];

- Snodgrass et al. [1966] have tried to calculate the rate of decaying with data from stations set along the great circle from New Zealand to Alaska.



Stations set along the ocean. [Snodgrass et al., 1966]

Previous studies



Satellites

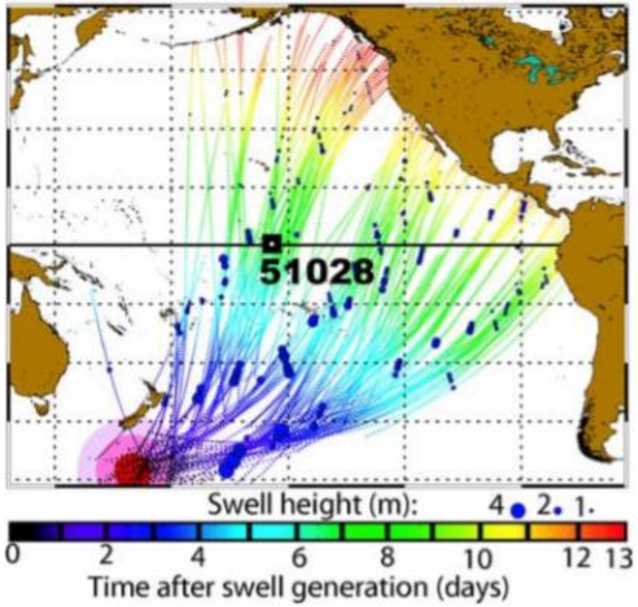
No wave direction or wave period

c) Young et al. [2013] adopt the database of altimeter accompanied with model data for calculating dissipation rates.

Complex process of inversion

d) With the L2 product of SAR, Collard et al. [2009] propose a new method of tracking the routes of swells along great circles of earth, and get the dissipation rate for swells with 15s period.

We did some case studies with data from SWIM because the SWIM can provide the wave spectrum, and the data is more accurate.



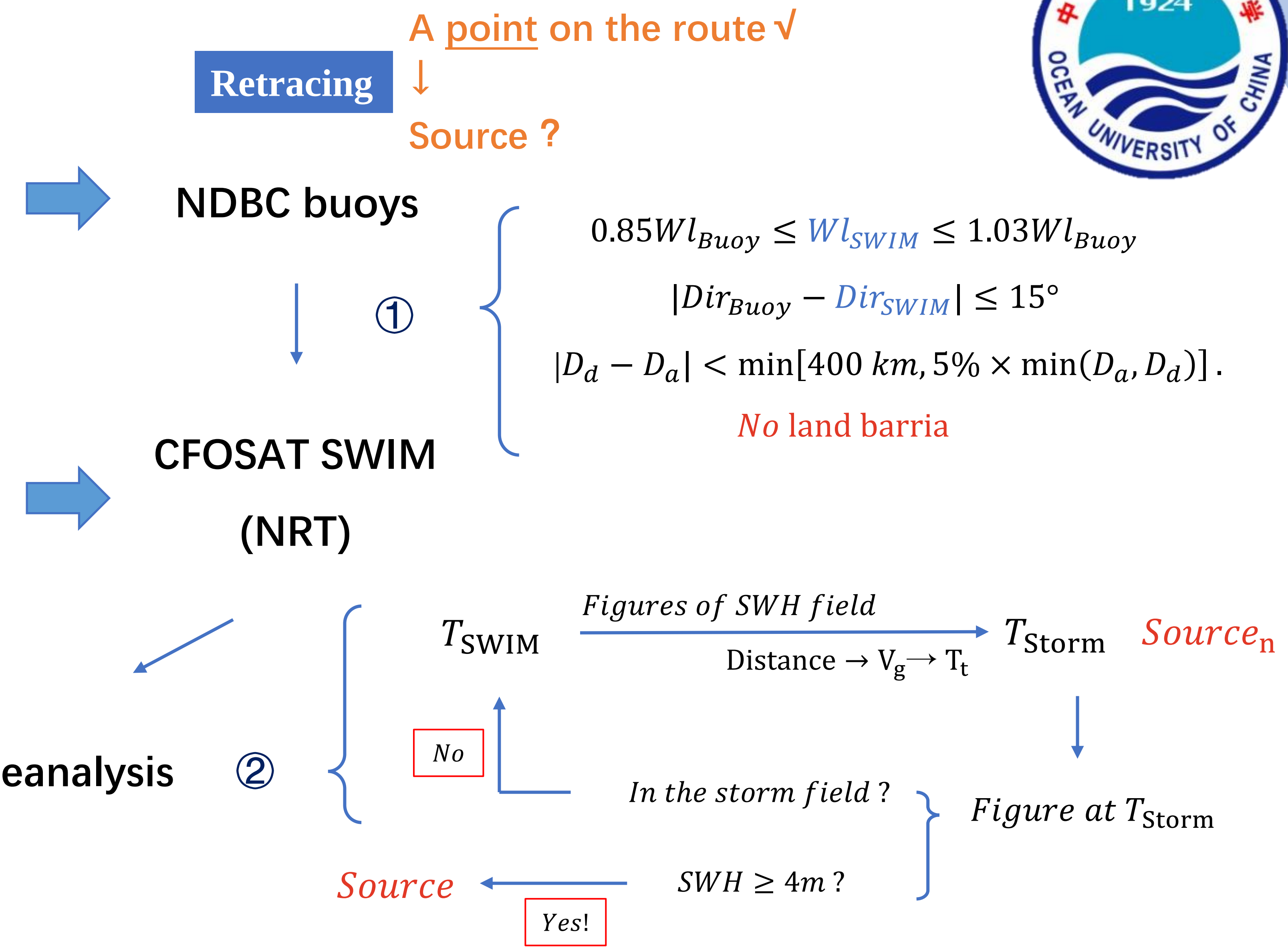
Finding the source storm of swells.

[Collard et al., 2009]

Data and method

- Select NDBC buoy data
  - a) T ≥ 19s
  - b) Swell components coming from 180° to 225°

- Pre-processing of SWIM data (Eliminate the 180° ambiguity)



Retracing

A point on the route √

↓

Source ?

NDBC buoys

①

$$0.85Wl_{Buoy} \le Wl_{SWIM} \le 1.03Wl_{Buoy}$$

$$|Dir_{Buoy} - Dir_{SWIM}| \le 15^\circ$$

$$|D_d - D_a| < \min[400\ km, 5\% \times \min(D_a, D_d)].$$

No land barria

CFOSAT SWIM

(NRT)

ERA-5 Reanalysis ②

T_{SWIM} $\xrightarrow[\text{Distance} \rightarrow V_g \rightarrow T_t]{Figures\ of\ SWH\ field}$ T_{Storm} $Source_n$

No

In the storm field ?

SWH ≥ 4m ?

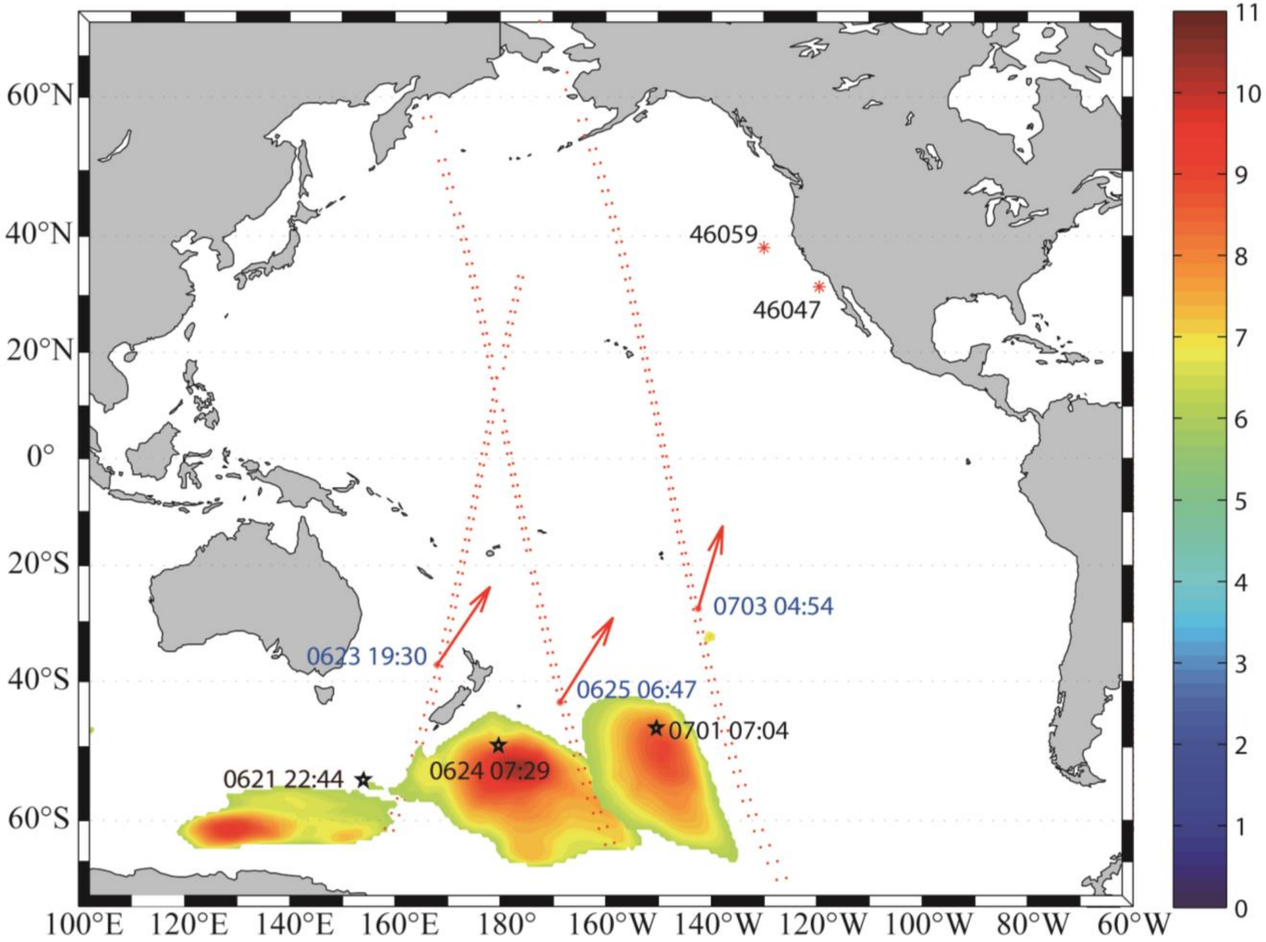
Figure at T_{Storm}

Source

Yes!

Results and analysis

NRT: 840,000 records $\xrightarrow{\text{retrace}}$ 25 Routes – 4 storms



T_{storms}:

5th to 6th May

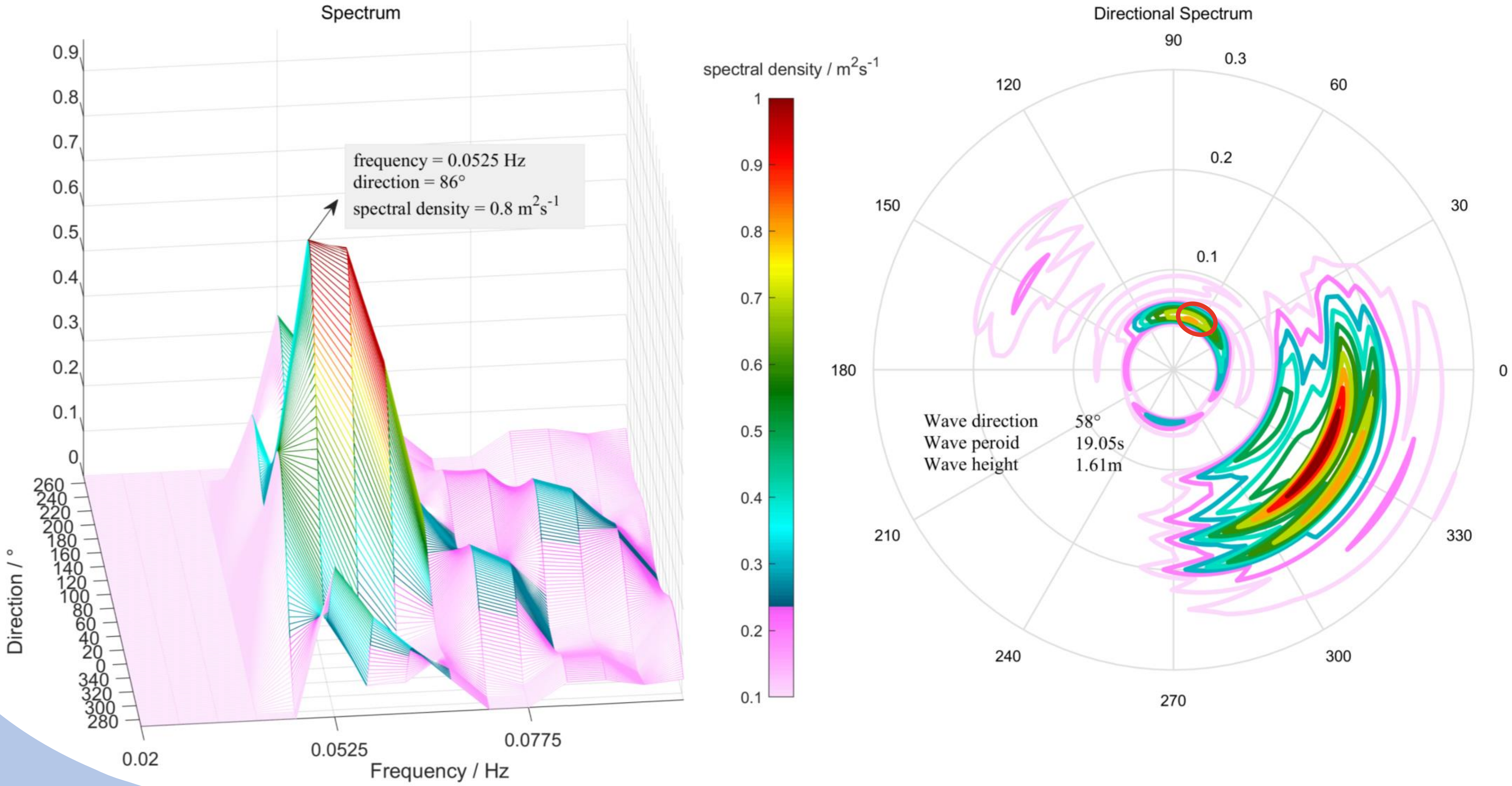
6th to 14th June

21st June to 1st July

7th to 8th July 2019

Results and analysis

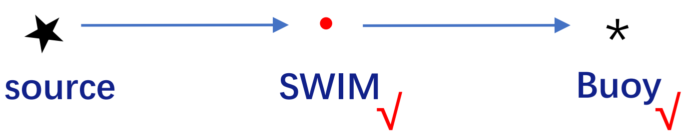
- Partition the wave spectrum of NDBC buoy data



frequency = 0.0525 Hz
direction = 86°
spectral density = 0.8 m^2s^{-1}

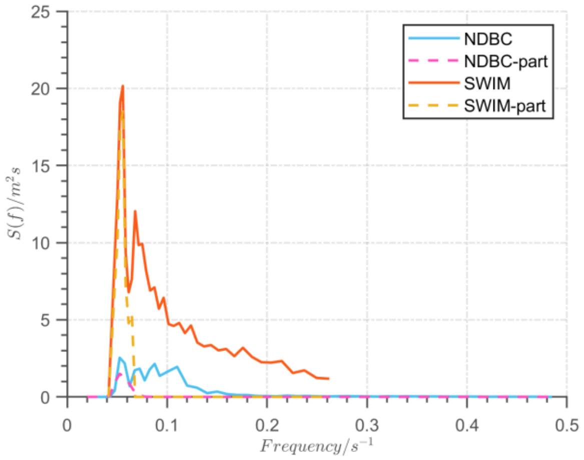
Wave direction 58°
Wave peroid 19.05s
Wave height 1.61m

Results and analysis

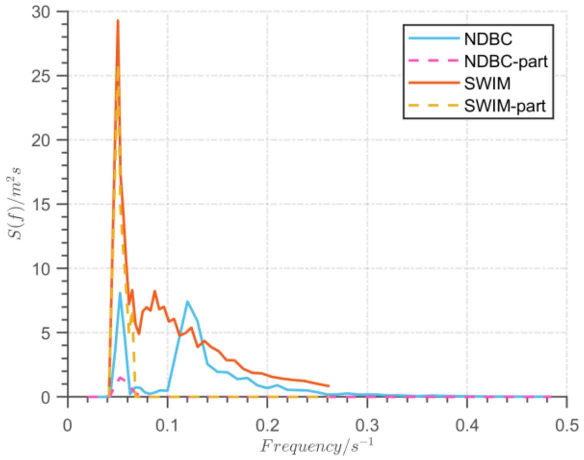

source → SWIM √ → Buoy √

- Comparison of wave spectra

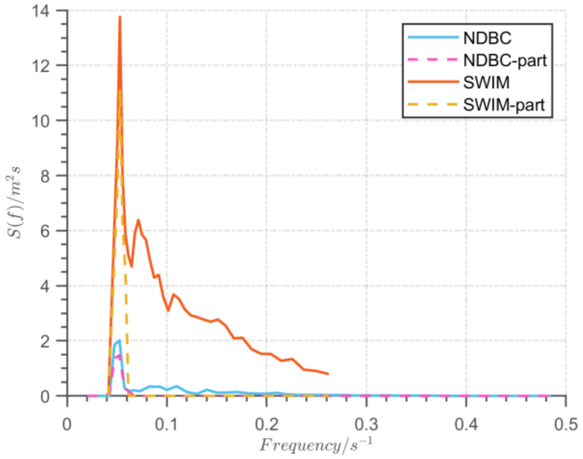
a.



b.



c.



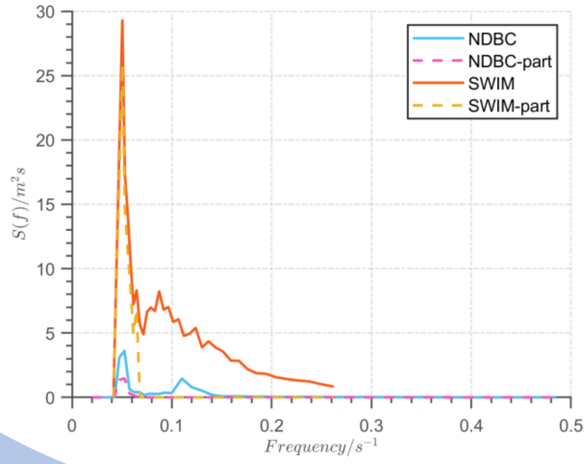
Dispersion

vs

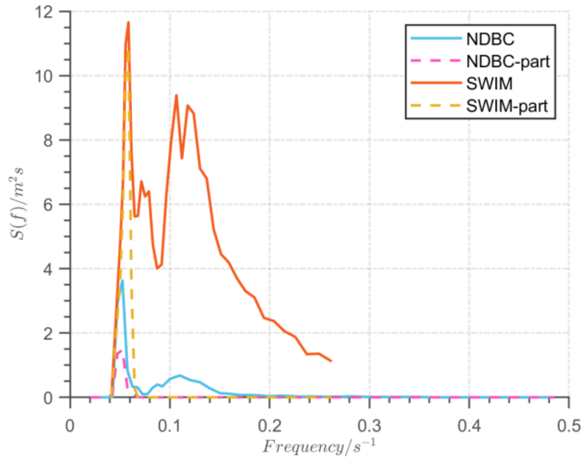
Dissipation

?

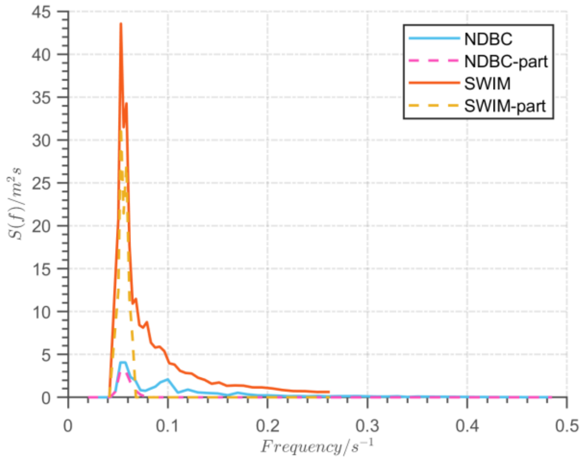
d.



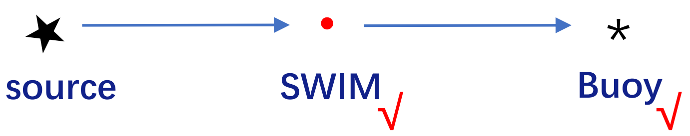
e.



f.



Results and analysis

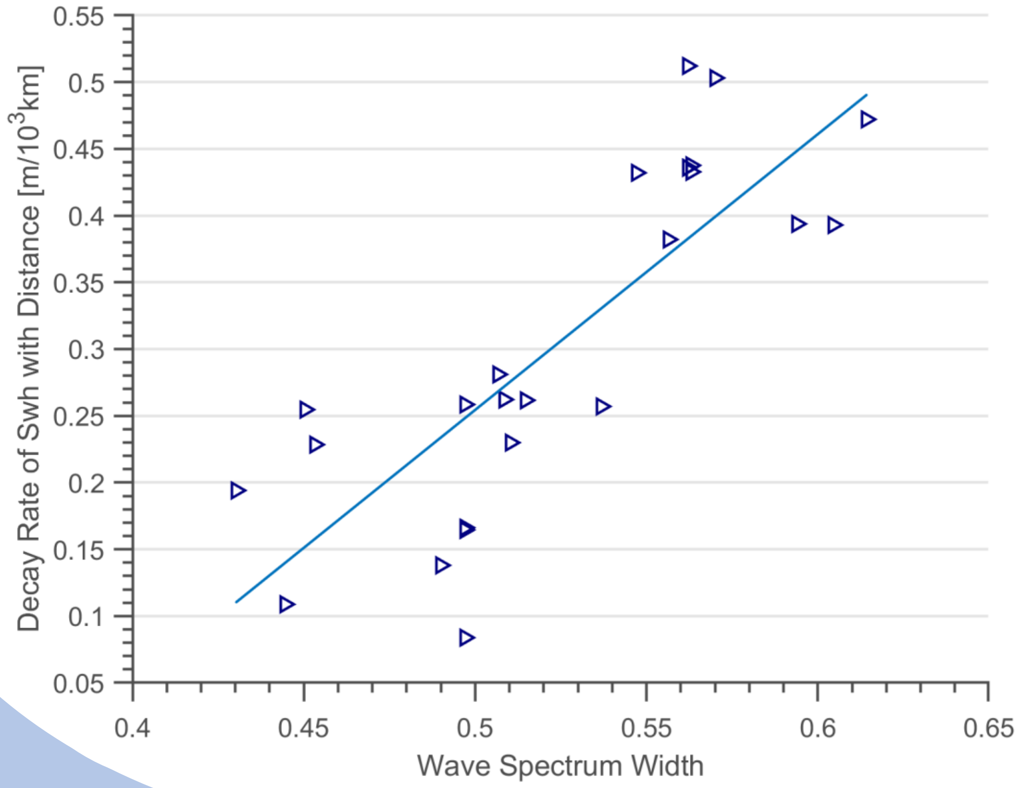


- **Spectrum width**

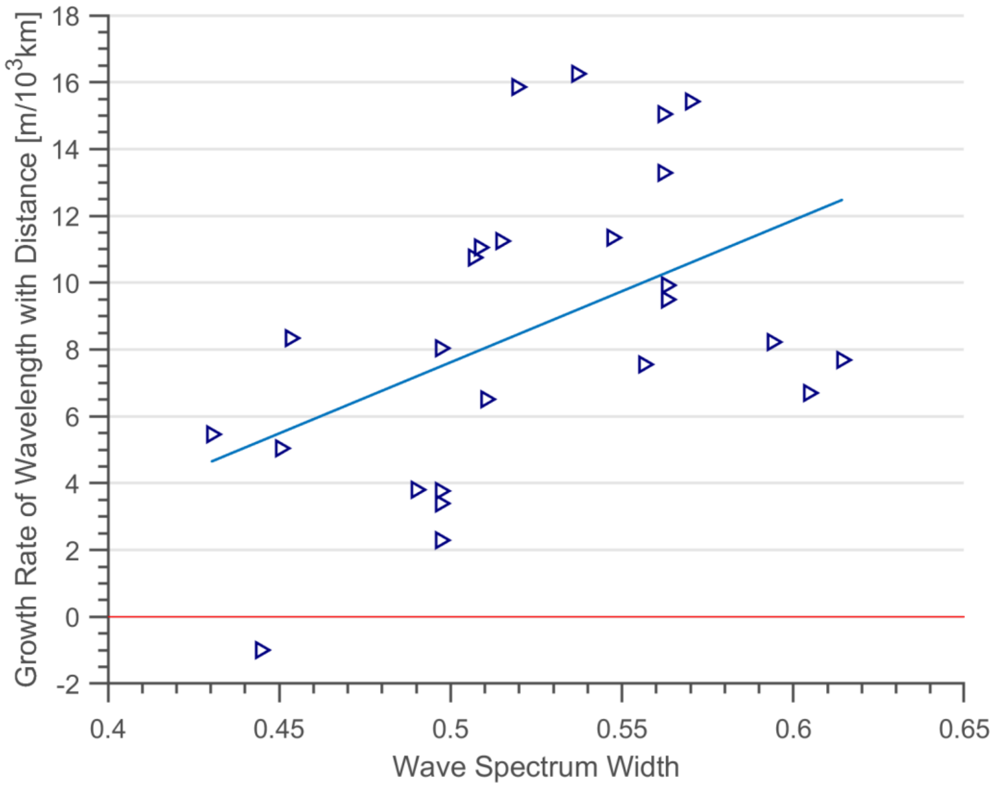
$$\varepsilon^2 = 1 - \frac{{m_2}^2}{m_0 m_4}$$

$$m_n = \int_0^{\infty}\int_0^{2\Pi} \omega^n S(\omega,\varphi)\, d\omega d\varphi$$

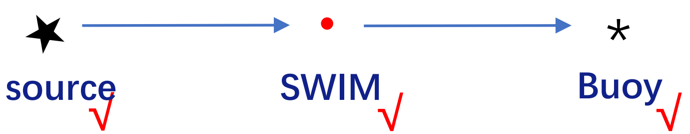
$$R_{decay} = -\frac{swh_{SWIM} - swh_{NDBC}}{D_{SWIM} - D_{NDBC}}$$



$$R_{growth} = \frac{wvl_{SWIM} - wvl_{NDBC}}{D_{SWIM} - D_{NDBC}}$$

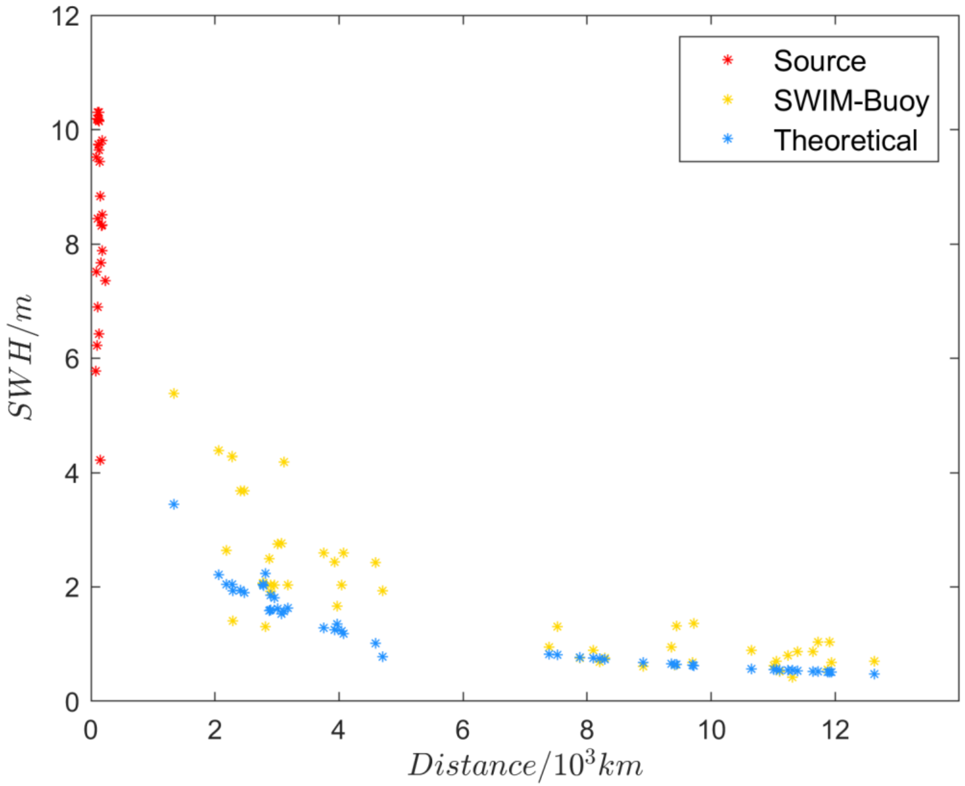


Results and analysis

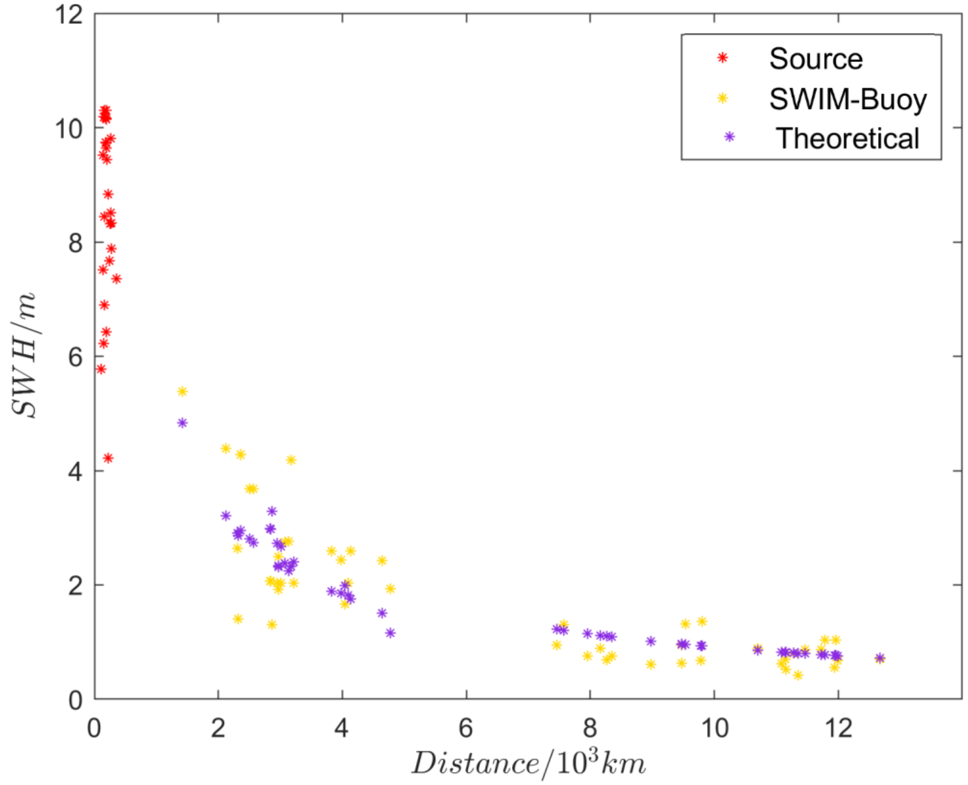


- Wave-turbulence interaction

$$x_0 = 2\frac{3}{2\cdot b}\cdot\frac{1}{k^2 H_1} \qquad H_2 = \frac{3}{b}\cdot\frac{1}{k^2(x_0+x_1)}$$



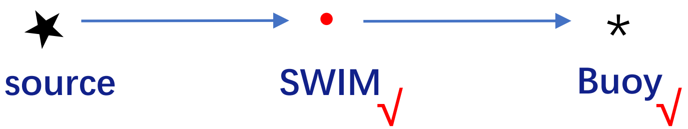
b=0.04



b=0.03

Results and analysis

- Wave-turbulence interaction

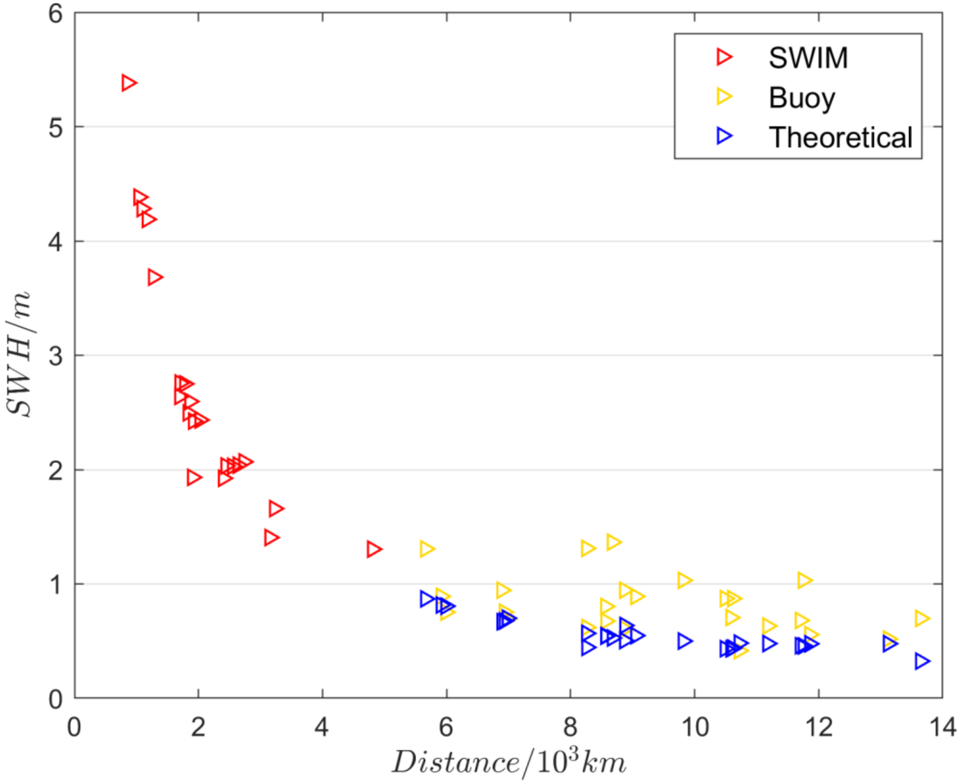


source

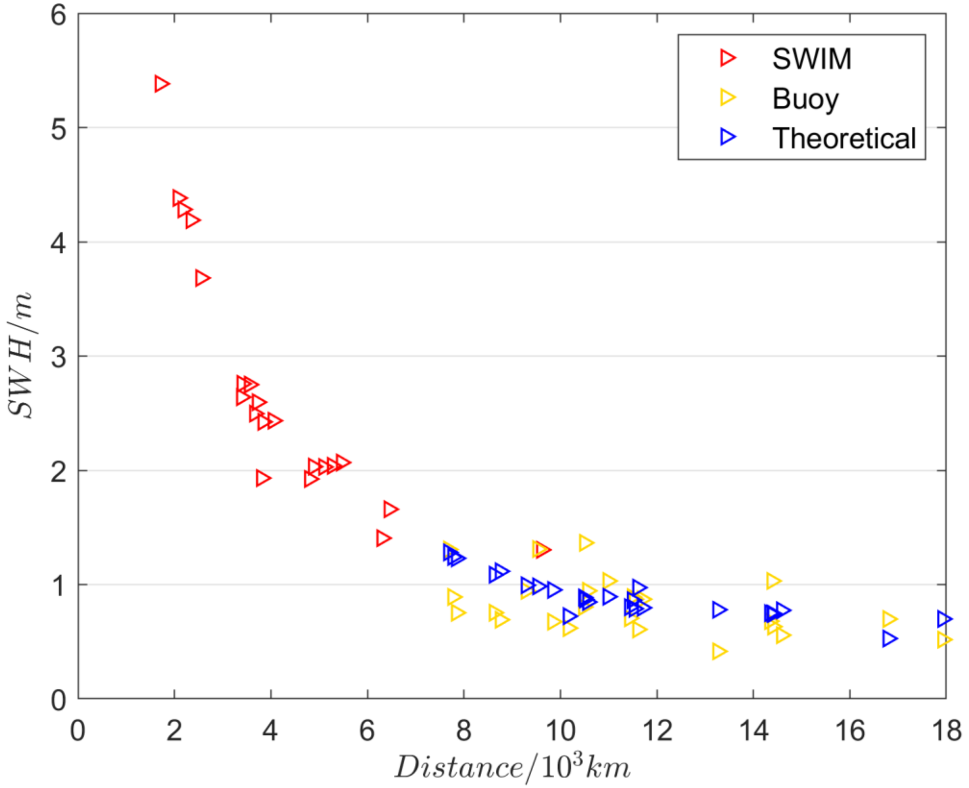
SWIM √

Buoy √

$$x_0 = 2\frac{3}{2\cdot b}\cdot\frac{1}{k^2H_1} \qquad H_2 = \frac{3}{b}\cdot\frac{1}{k^2(x_0+x_1)}$$

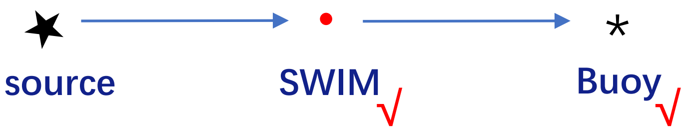


b=0.04



b=0.02

Results and analysis

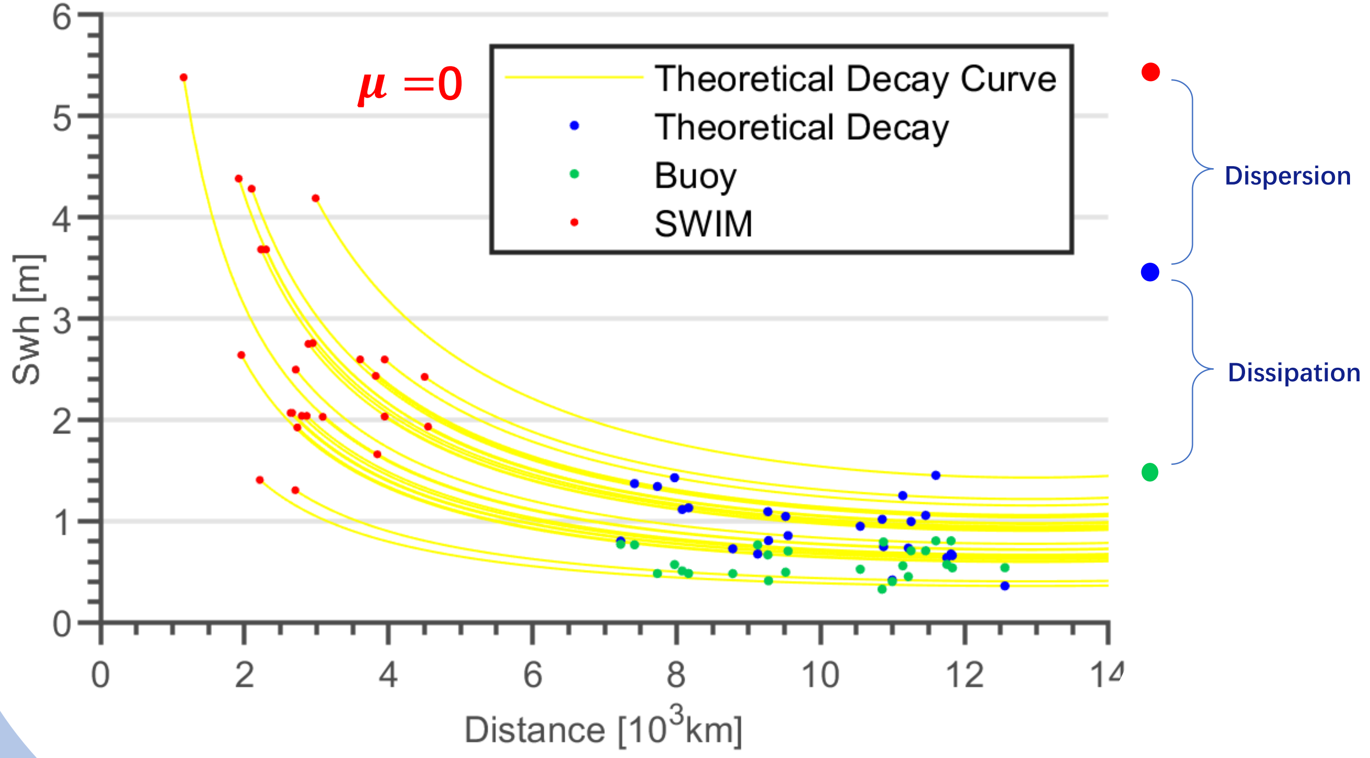


- **Air-sea interaction**

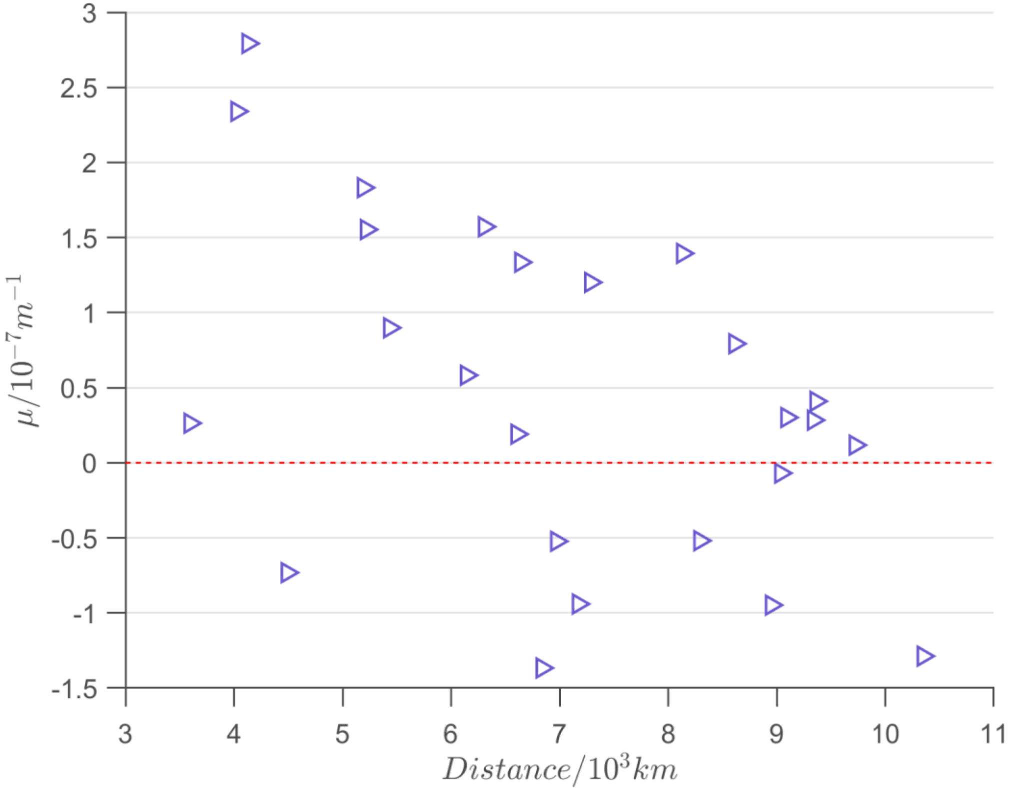
the distance along the surface on a great circle

$$E\alpha \sin\alpha = E_0\alpha_0 \sin\alpha_0 \qquad \alpha = X/R \rightarrow \text{Earth radius}$$

$$\mu = -\frac{1}{\mathrm{Es}\cdot\mathrm{R}}\frac{\mathrm{d}(\mathrm{Es}\cdot\alpha\cdot\sin\alpha)}{\mathrm{d}\alpha}$$

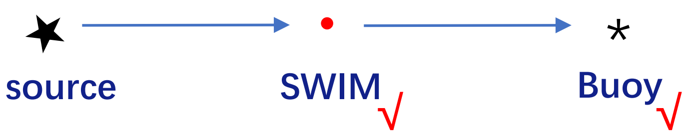


Comparation of observed data and theoretical decay (without considering dissipation).



Dissipation rates between SWIM data and buoys.

Results and analysis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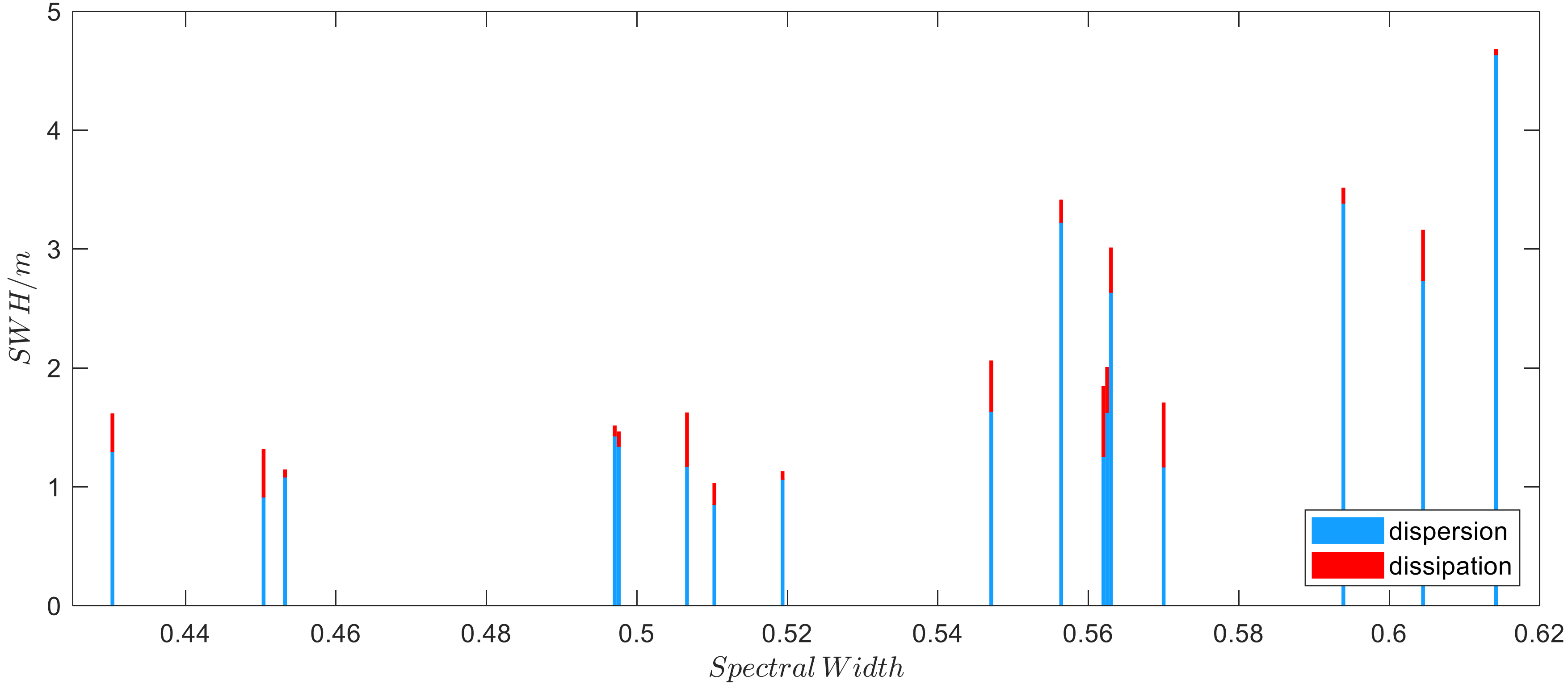
SWIM √

Buoy √

- Dissipation vs dispersion

Decay of SWH



Percentage of swell decay caused by dispersion and dissipation.

Conclusions

- We find 25 tracks which correspond to 4 storms from May to August 2019.
- It takes about 10 days for swells to cross the Pacific from the southern ocean to the western coast of America.
- A larger value of wave spectral width corresponds to a faster variance of swh and wavelength.
- The value of swh from observation fits well with the theory of wave-turbulence interaction when the coefficient b is around 0.03.
- The dissipation rate we get here is between -1.5 ~$3\times10^{-7}m^{-1}$.
- Swell decay caused by dispersion increases with the increase of wave spectrum.

Reference

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Thank you for your attention!