Numerical investigations for the applicability of SRIAM method as a new nonlinear transfer function

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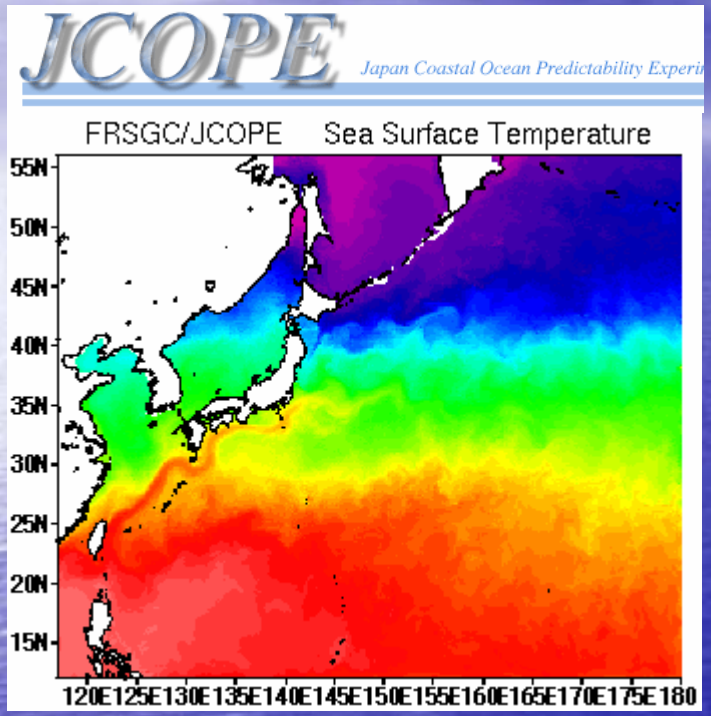
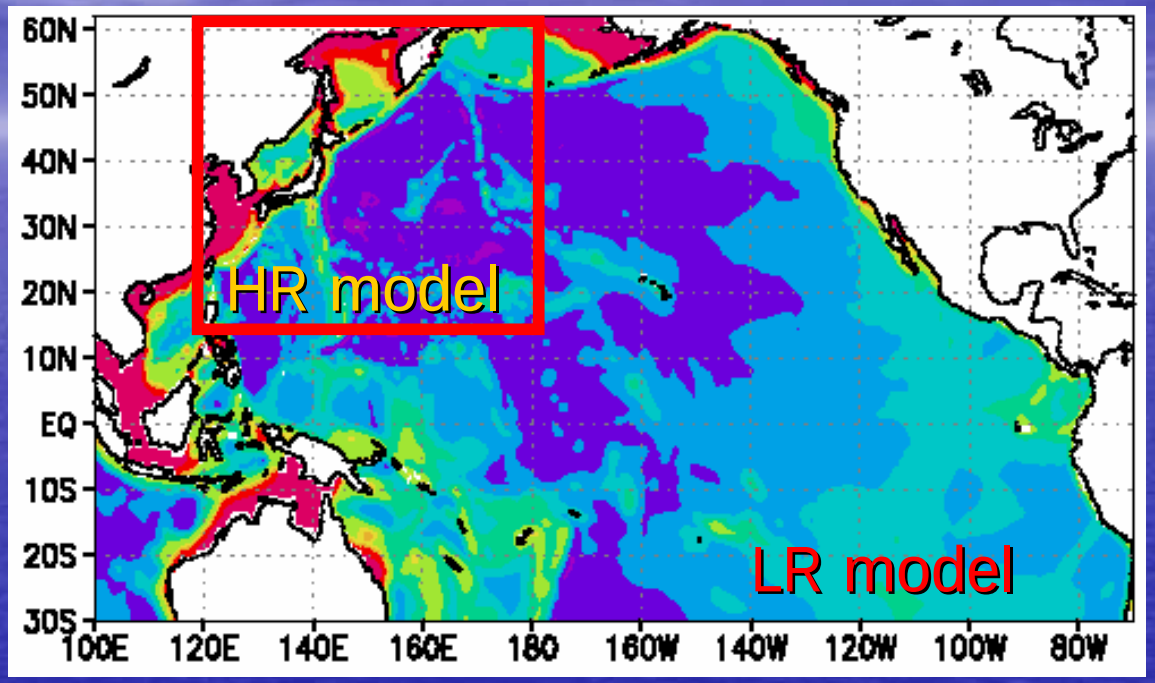
10th International Workshop on Wave Hindcasting and Forecasting

MOTIVATION

The WAVE-JCOPE project:





http://www.jamstec.go.jp/frcgc/jcope/index.html

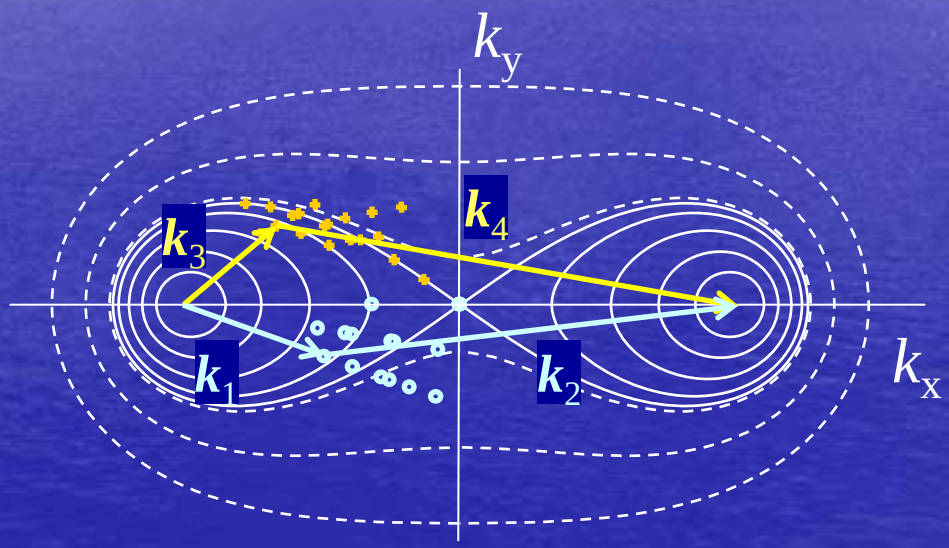
Realistic high resolution coupled wave-current prediction model for the Kuroshio region

METHODOLOGY

Simplified RIAM or SRIAM method (Komatsu 1996)

an efficient scheme for operational use

- Implementation of the SRIAM method to the operational wave model (WAVEWATCH-III v2.22)
- Adjustment to the abrupt change of wind direction (Numerical experiment 1)
- Fetch-limited wave growth (Numerical experiment 2)
- Wave propagation on a horizontal shear current (Numerical experiment 3)

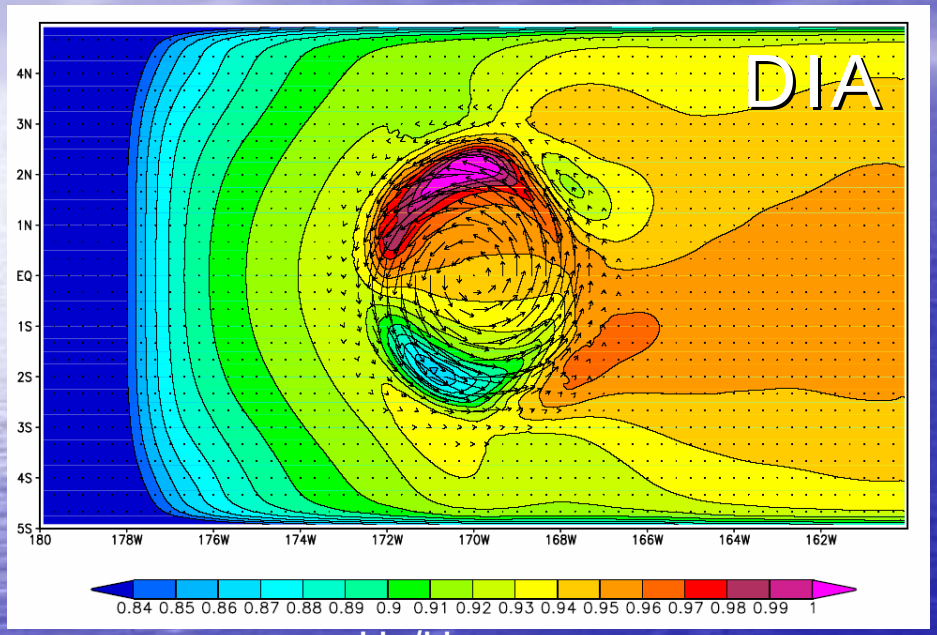


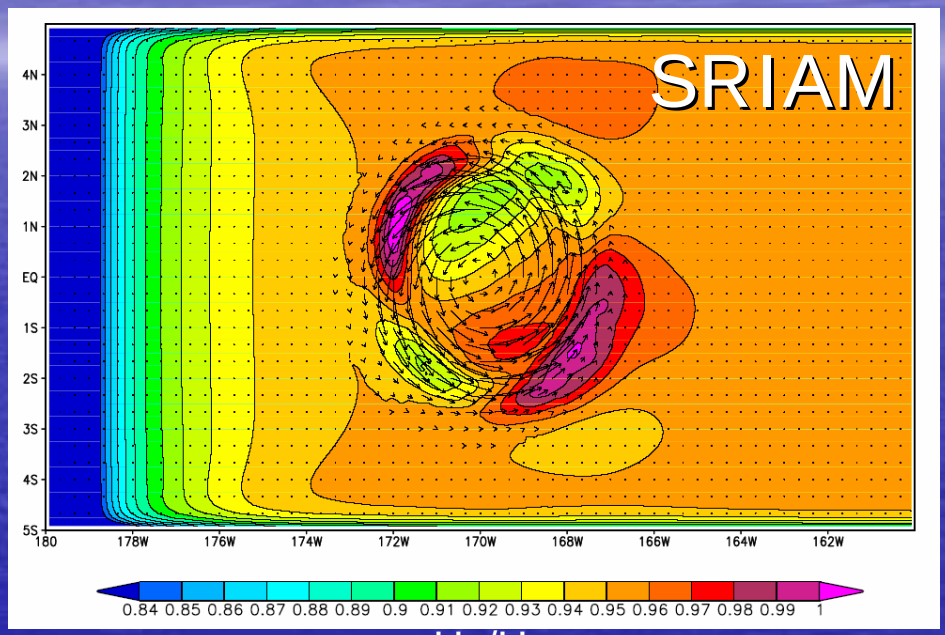
20 optimized resonant configurations

SUMMERY and CONCLUSIONS

- For the numerical integration of the SRIMA method, we didn't apply semi-implicit scheme but the implicit scheme (Lavrenov 2003)
- The SRIAM method can well represent the wave statistics and the spectral shape for the fetch-limited wave growth
- The SRIAM method has good properties for the applicability to the complex wave field induced by current
- Current-induced modulation of wave spectrum is weakened by the self-stabilization effect of nonlinear transfer function

Spatial distribution of significant wave height induced by wave-current interaction





- Location of focal points by current are considerably different

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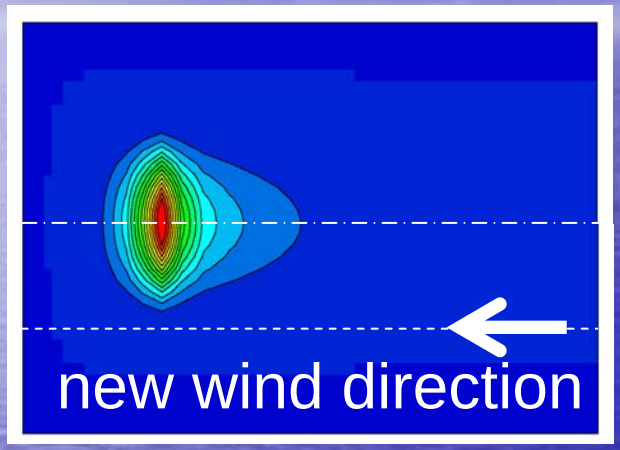
Caused by the inadequate use of semi-implicit scheme with the SRIAM method which was originally used and validated for the DIA

Numerical experiment 1:

Adjustment to the abrupt change of the wind direction

Initial wave spectrum

duration-limited condition



Initial wave spectrum:
JONSWAP, $\cos^2\theta$

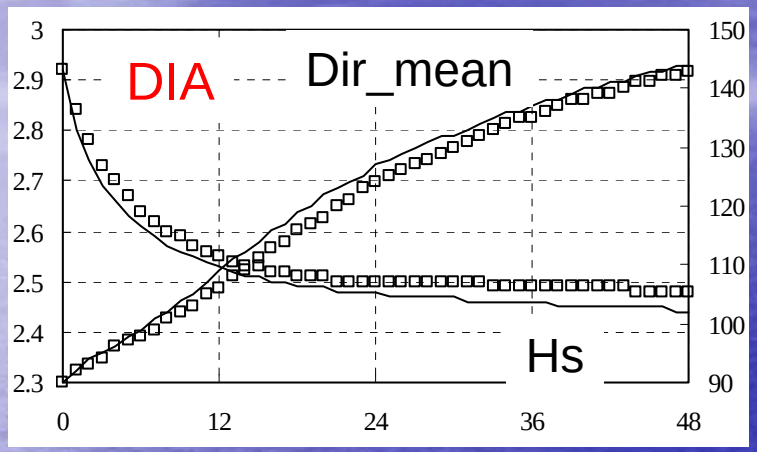
Wind condition:
Ws drops to 10 m/s
Wd turns by 90 deg.

Time integration scheme:

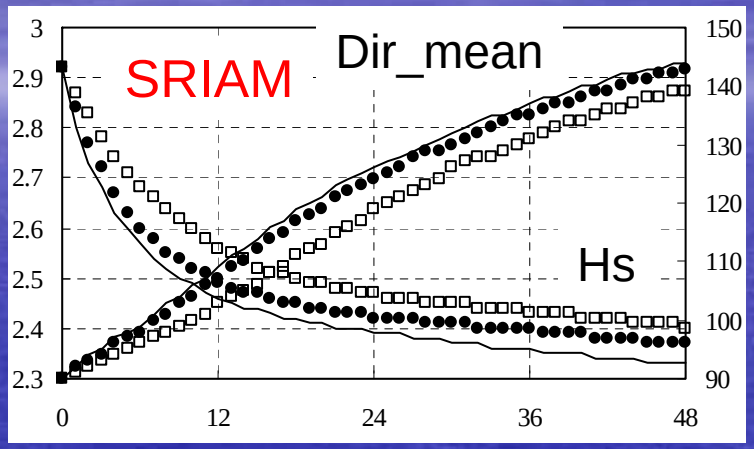
Explicit (with a small time increment; implicit factor=0) -> exact
Semi-implicit (implemented in ww3; implicit factor=1)
Implicit (Lavrenov 2003, a possible candidate for SRIAM)

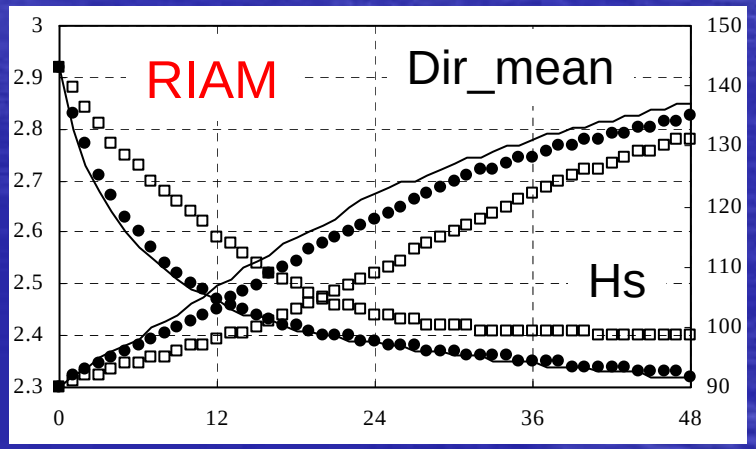
The time evolution of Hs and θmean

—:EXP. □:SIMP.



—:EXP. □:SIMP. ●:IMP.

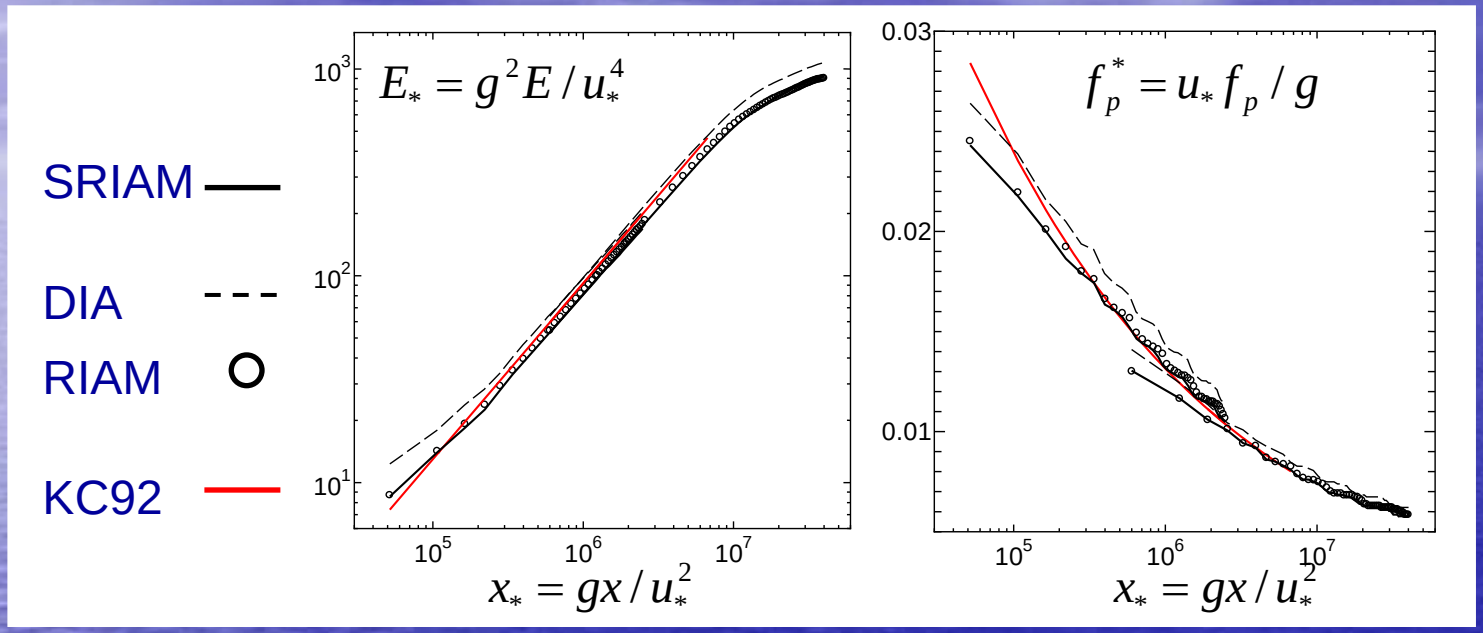


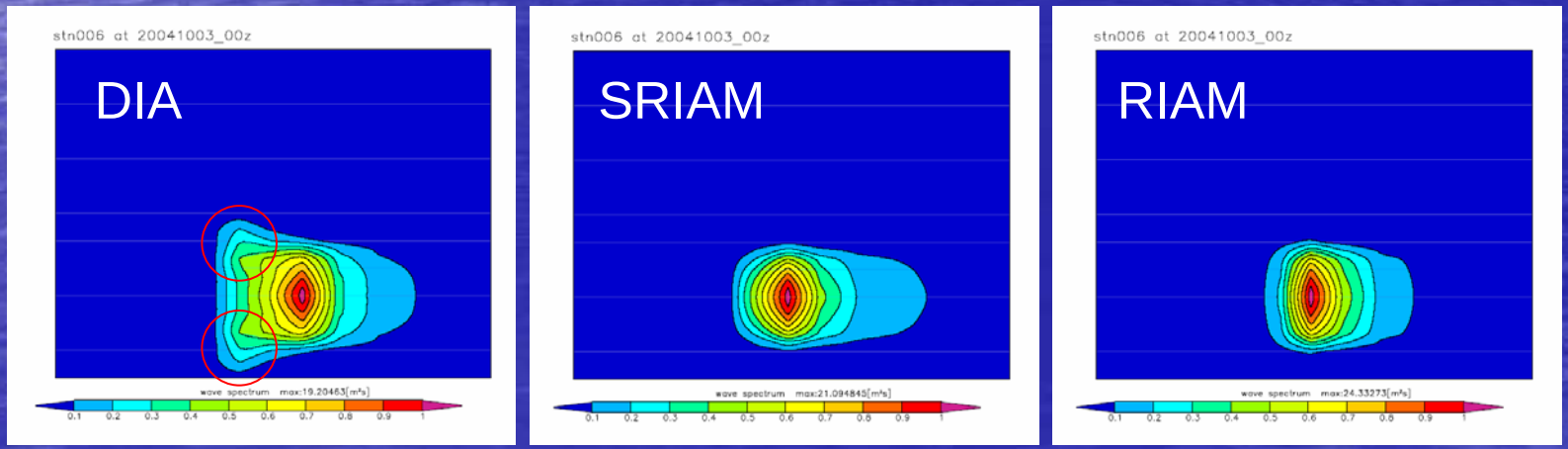


- Results of the SIMP. are nearly the same as those of the EXP. for the DIA
- The difference between the SIMP. and the EXP. are apparent for the SRIAM method, especially for the RIAM method.

Numerical experiment 2:

Fetch-limited wave growth





2D wave spectra

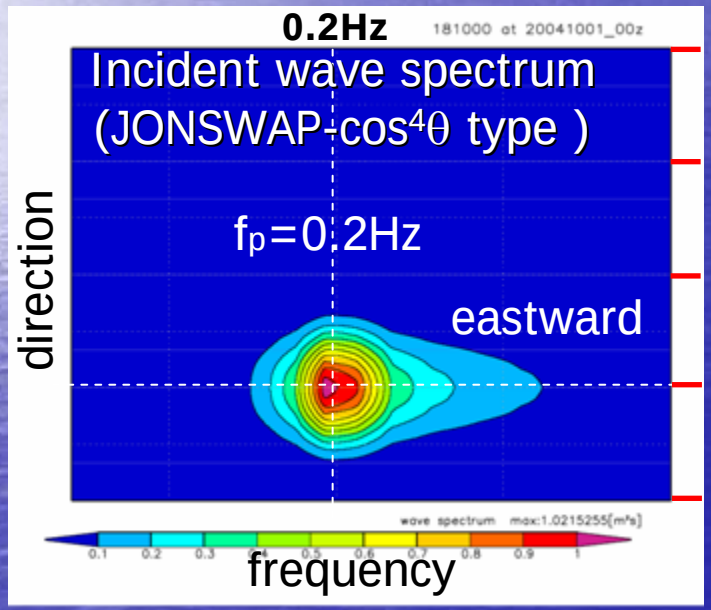
Numerical experiment 3:

Wave refraction and straining by horizontal shear current

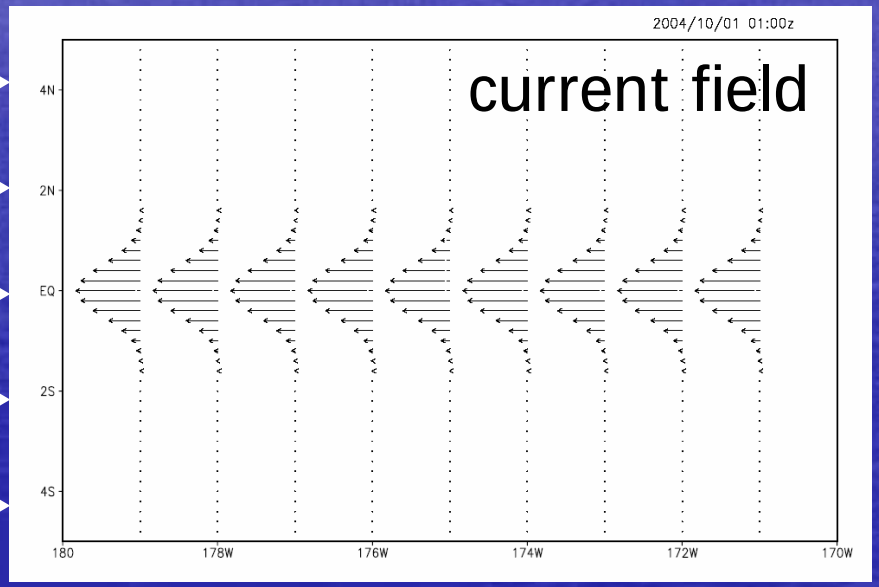
$$\frac{\partial N}{\partial t}+\nabla\cdot(\boldsymbol{c}_g+\boldsymbol{U})N+\frac{\partial}{\partial k}(\dot{k}N)+\frac{\partial}{\partial\theta}(\dot{\theta}N)=\frac{1}{\sigma}S_{nl}$$

Incident wave

U_{max} = 1.5m/s



N W S E N

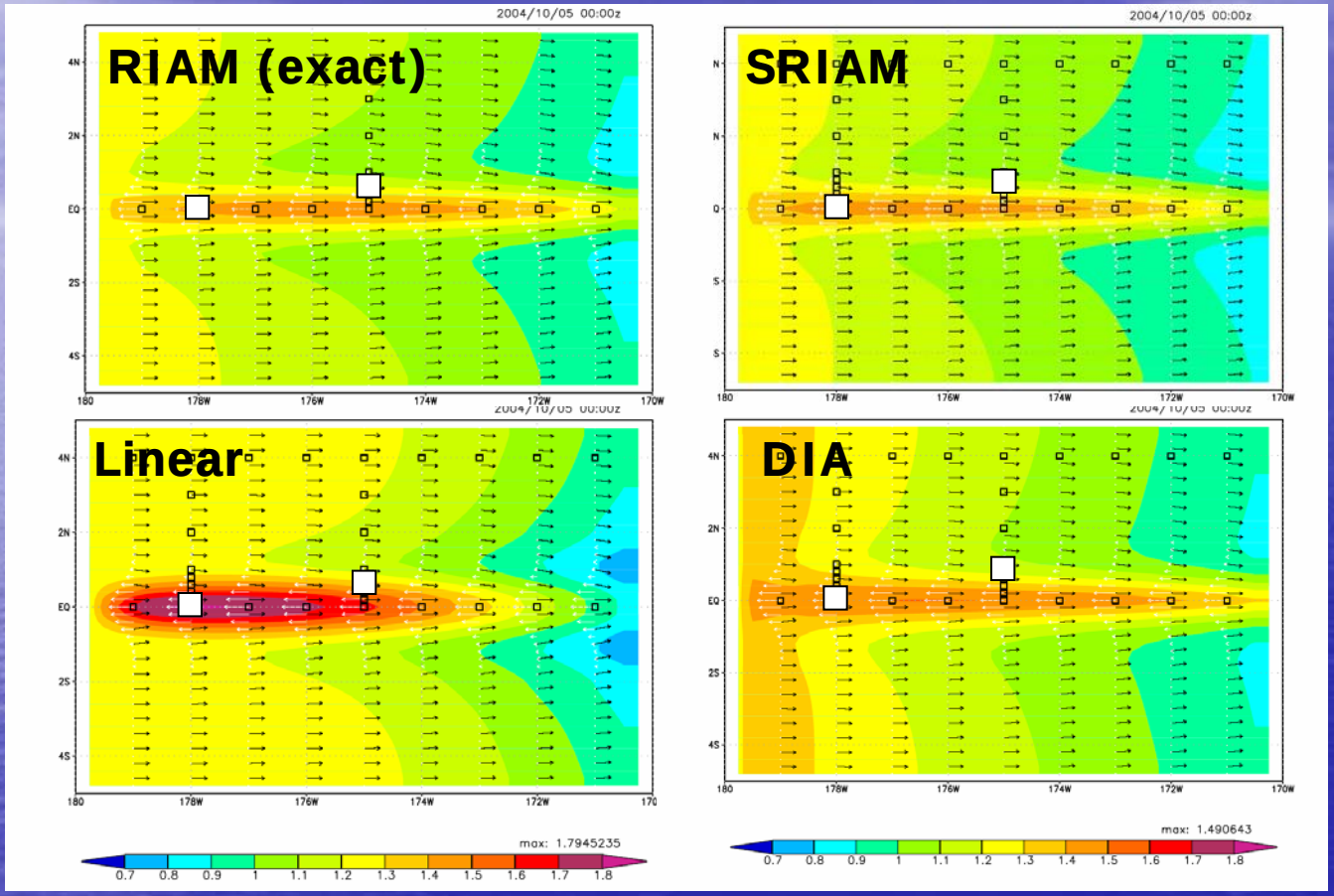


Computational domain

Linear case : without Snl

Nonlinear case: DIA, RIAM, SRIAM

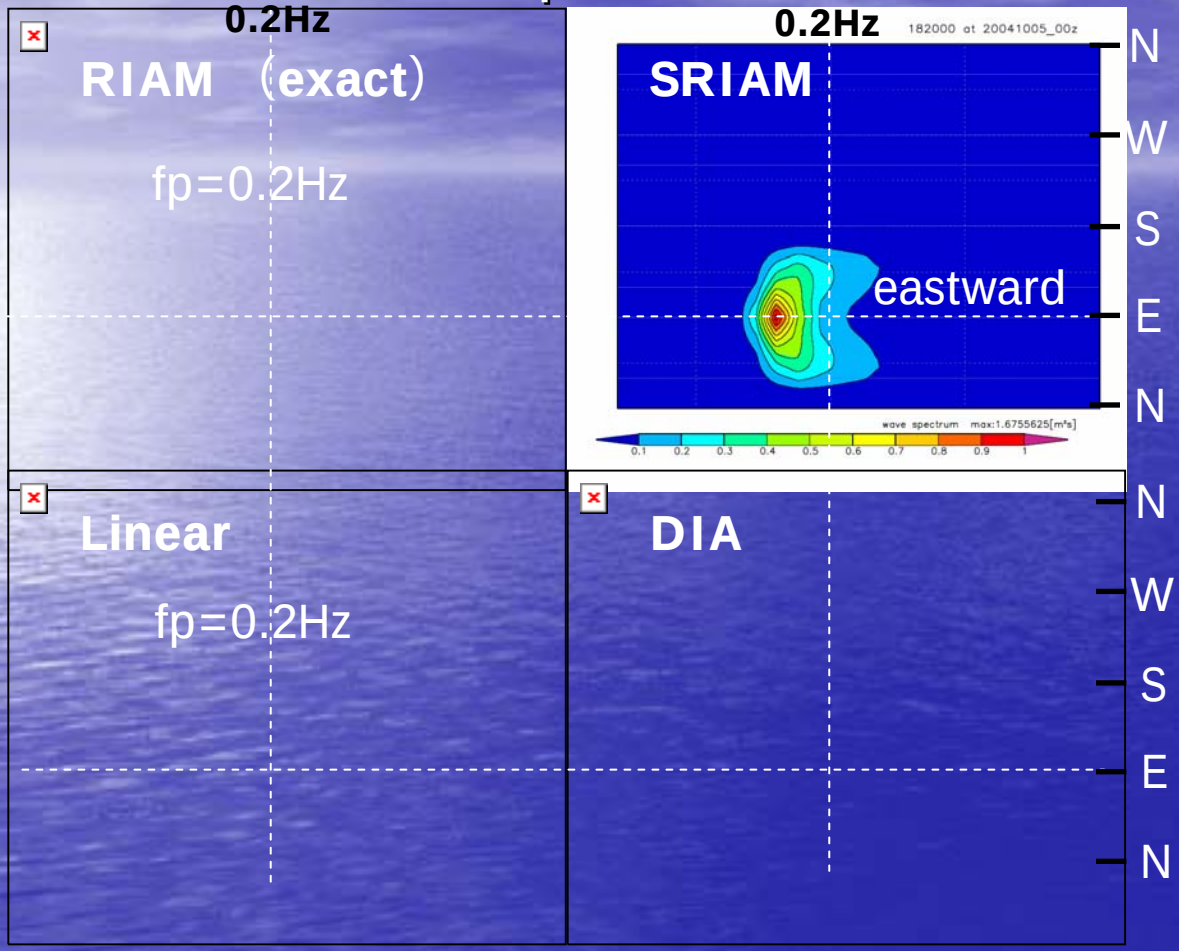
Spatial distribution of significant wave height



- The effect of the refraction and straining apparent for the linear computation as compared with nonlinear computations.
- The result of the SRIAM method shows almost the same pattern and magnitude as compared with that of the RIAM method.

Wave spectra at the center of the countercurrent

2D spectra



The SRIAM method succeeded to well reproduce the wave spectrum calculated by the RIAM method

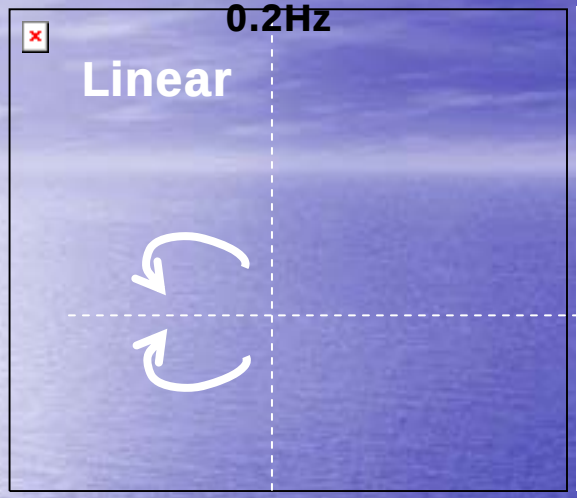
Spectral bandwidth by DIA is extremely broad and spectral shape is clearly different from that of the RIAM method

SRIAM: spectral shape is much narrower in frequency and directional space.

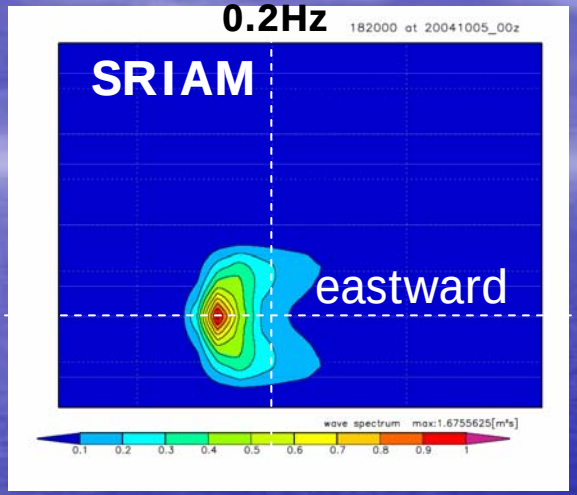
Linear: three peak values appear at different directions.

Wave spectra and nonlinear transfer function

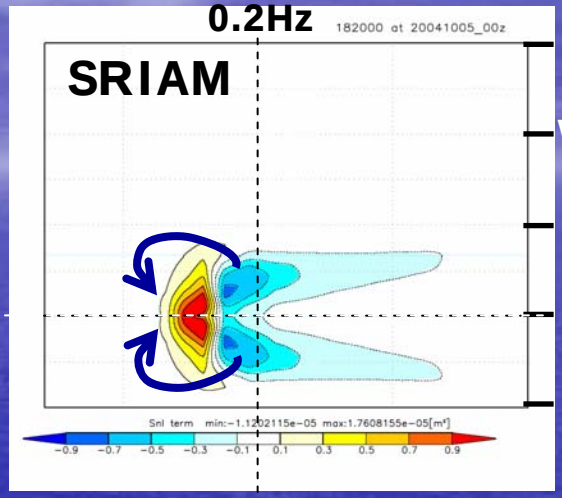
at the center of the countercurrent



2D spectrum



2D spectrum



Nonlinear transfer function

Snl transfers high-frequency component with northeast- and southeastward direction to the low-frequency component with eastward direction.

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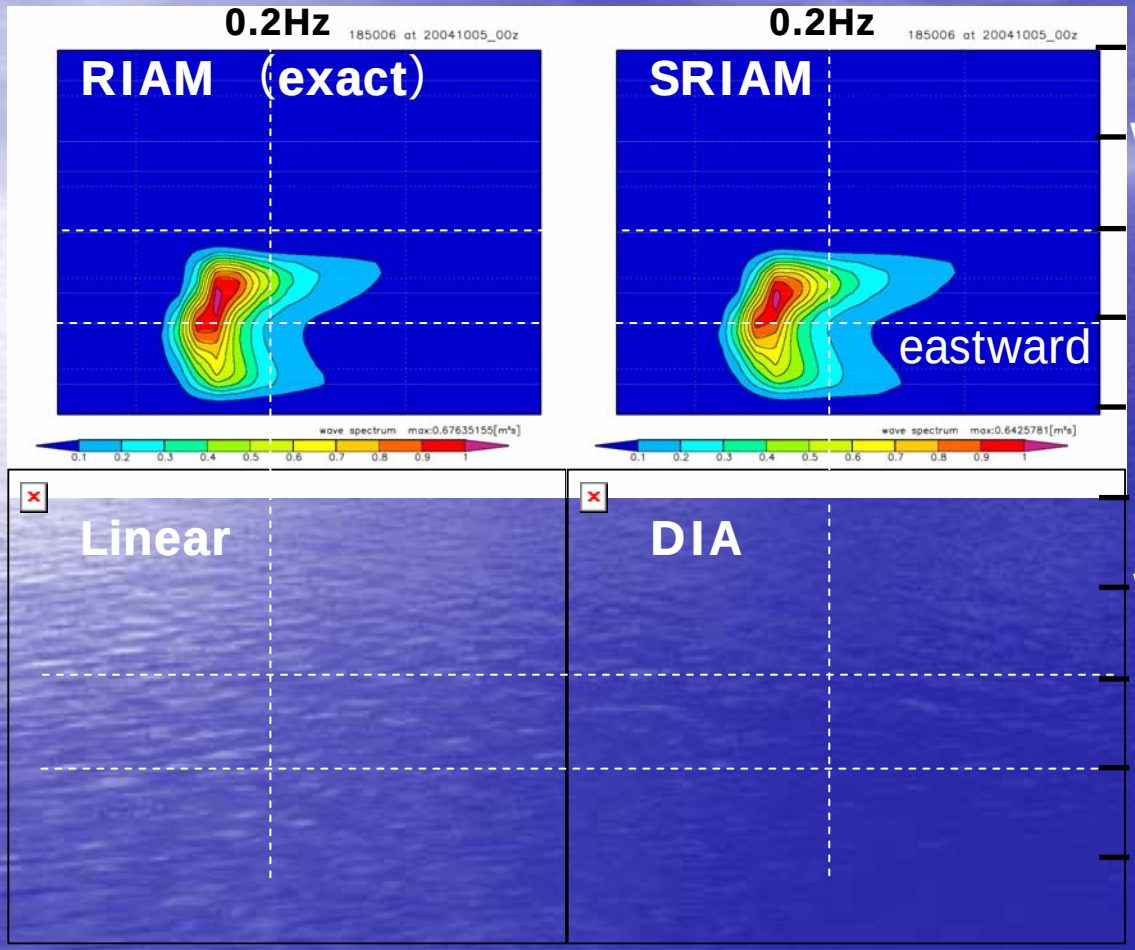
Snl concentrates spectral component associated with the wave refraction on the same direction of the incident wave with downshifting of the peak frequency.

Wave spectra at position where maximum current shear



2D spectrum

Spectral shape by the SRIAM and the RIAM method are almost identical.

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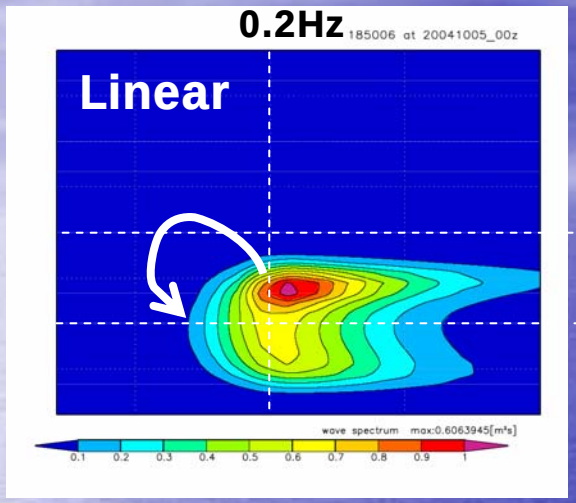
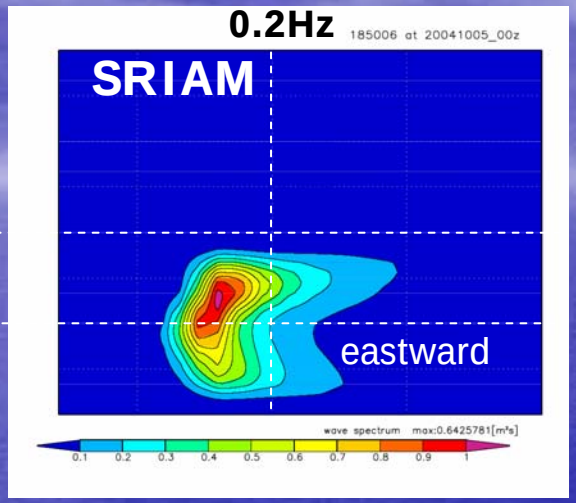
The SRIAM method has good properties of the applicability to the complex wave field

Peak direction and directional spreading are different for linear and nonlinear computations

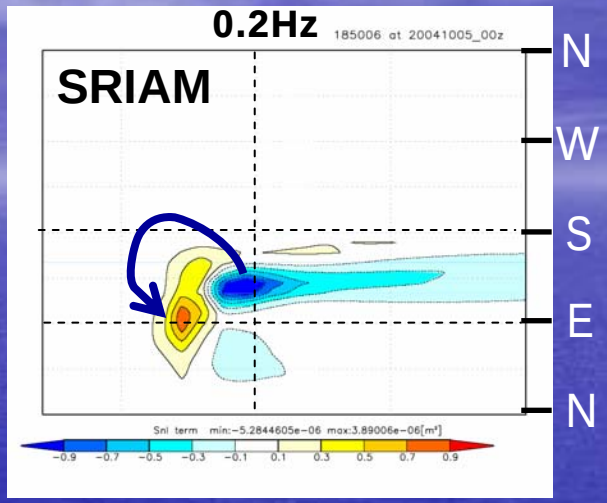
Wave spectra and nonlinear transfer function



2D spectrum



2D spectrum



Nonlinear transfer function

SnI allocates the refracted wave component to the incident wave direction with downshifting of the peak frequency.

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SnI attempts to retain the spectral form by reducing the refracted wave components and increasing the wave spectrum with the incident wave direction.

Thank you!!