PICES-2012 Annual Meeting
October 12-21 2012, Hiroshima, Japan

Time variations of large amplitude near-inertial internal waves induced by typhoon observed around the Tango Peninsula, Japan

Keiichi **Yamazaki**[1,2] , Yujiro Kitade[2] ,
Yosuke Igeta[1] and Tatsuro Watanabe[1]

[1] Japan Sea National Fisheries Research Institute, Fisheries Research Agency
[2] Graduate school of Tokyo University of Marine Science and Technology

・The Japanese coast is the southern boundary of the Japan Sea.
・The near inertial internal waves (NIIWs) have characteristics of equatorward propagating.
・The NIIWs can be observed along the Japanese coast of the Japan Sea.

Coastal currents often prevent the shoreward propagation of the NIIWs.

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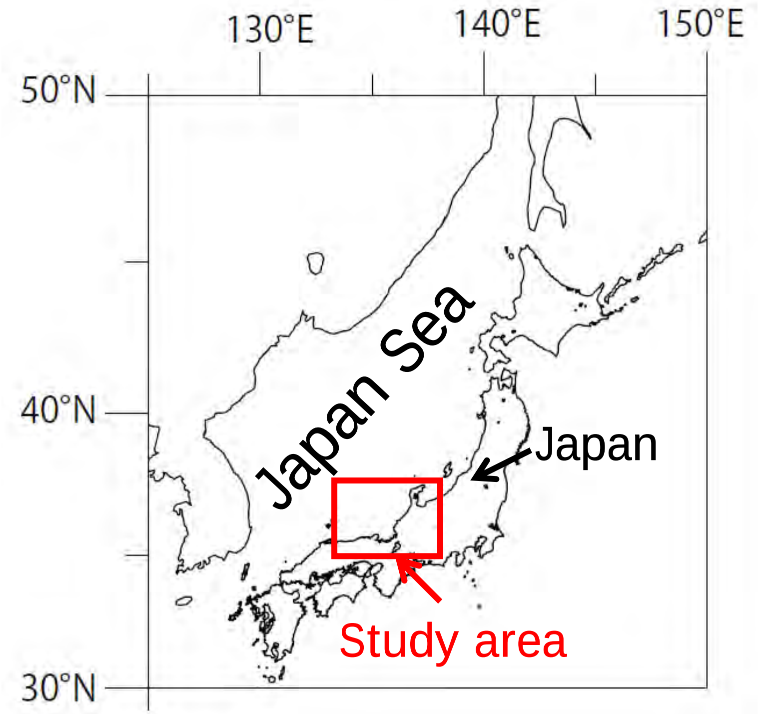
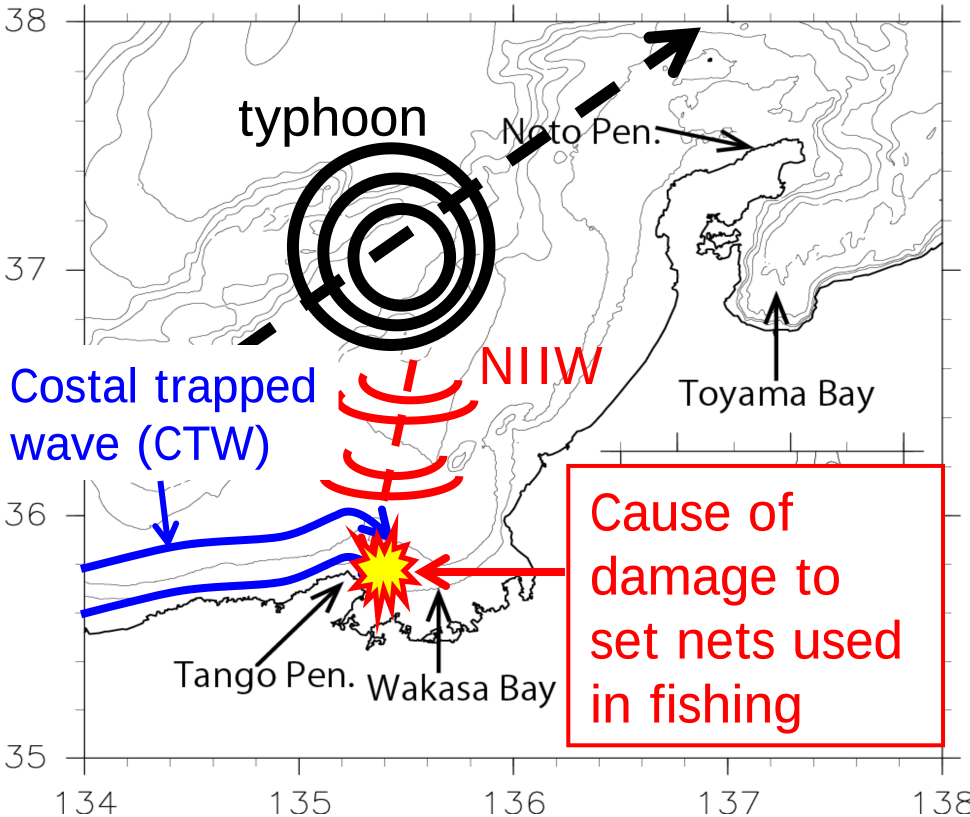


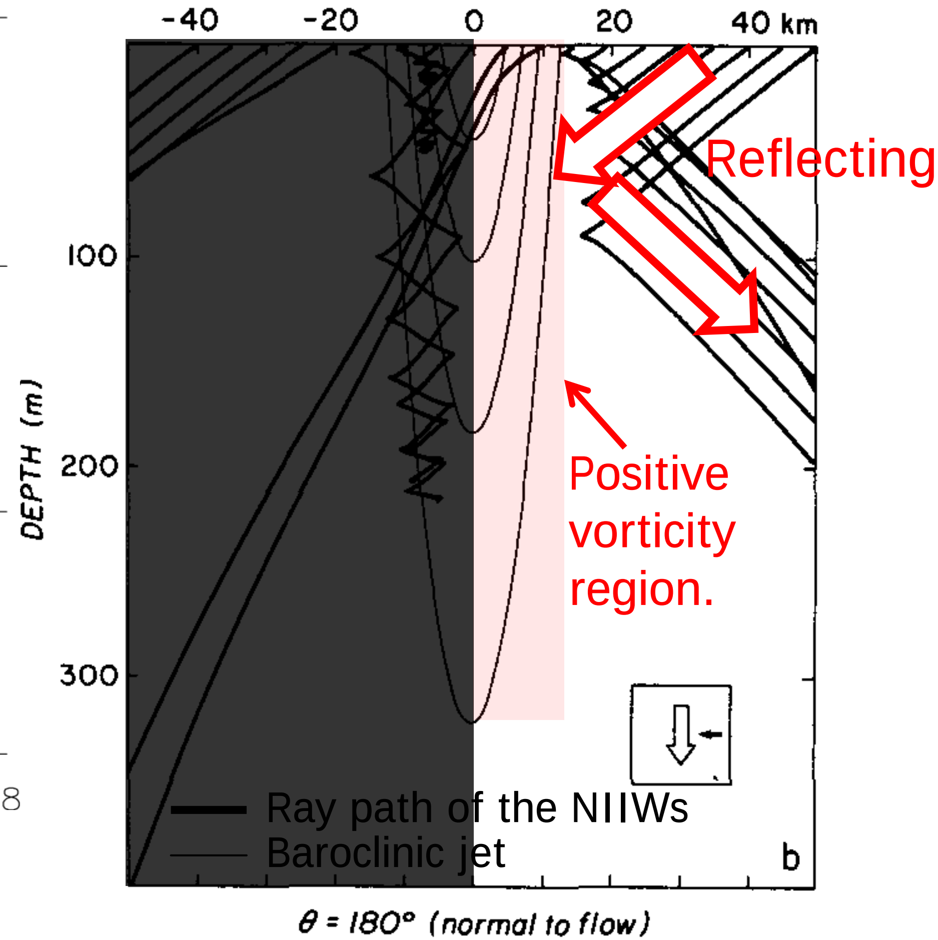
Background



・18-20 hours period fluctuations due to the NIIWs are strengthened along the coast after passage of typhoon.

・The NIIWs energy are trapped at the tip of peninsula because of their topographical scattering (Igeta et al.,2009).

Ray paths for the NIIWs under a baroclinic jet (Kunze 1985)

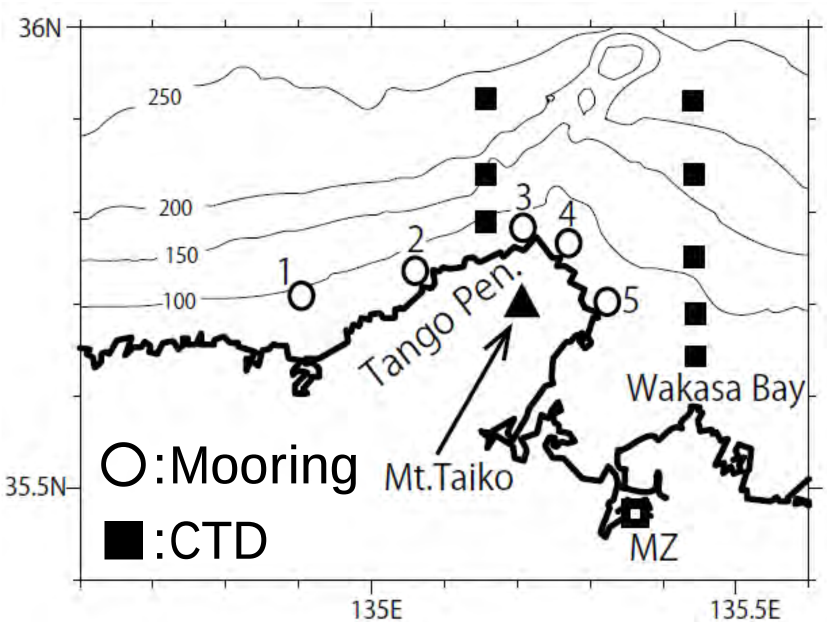


After Kunze(1985)

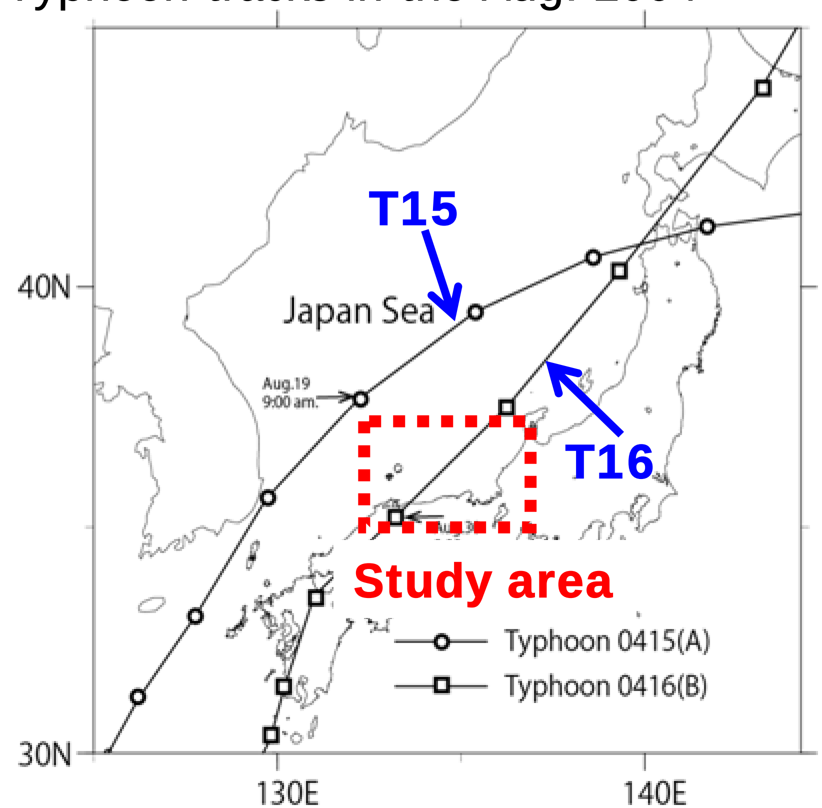
・Energy of the NIIWs is reflected at the positive vorticity ridge.

Basic physical mechanism in this work.

Observation



Typhoon tracks in the Aug. 2004

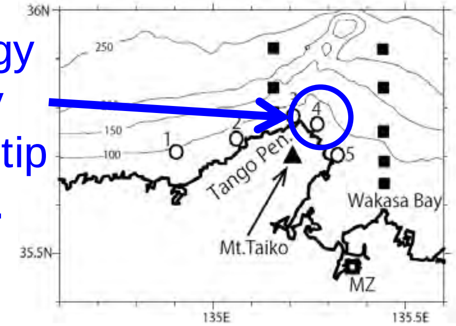


- Observation : Current (at a depth of 15m)
- Equipment: Electromagnetic current meter
- Sampling interval : 10 min.
- Observational period : 1 June - 30 Sep. 2004

1. Extracting behaviors of the NIIWs generated by T15 and T16.
2. Examining relation between the NIIWs and the CTWs through comparing the signals of the NIIWs due to T15 and those of T16.

Characteristics of the NIIWs observed at Sta.4

The NIIWs energy can be obviously identified at the tip of the peninsula.

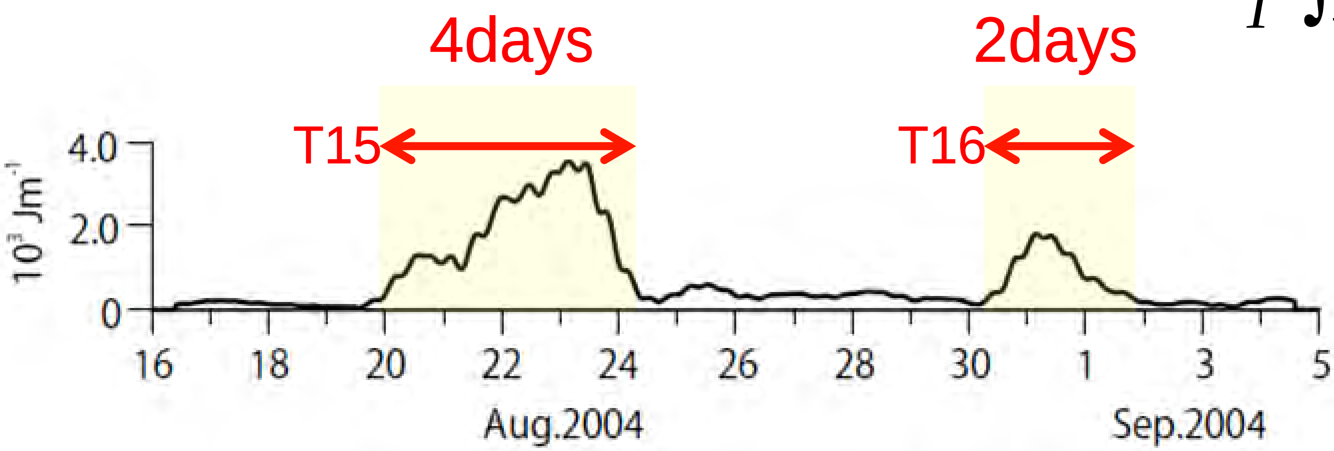


Wind stress averaged over the study region

Kinetic energy (KE) of the NIIWs at Sta.4

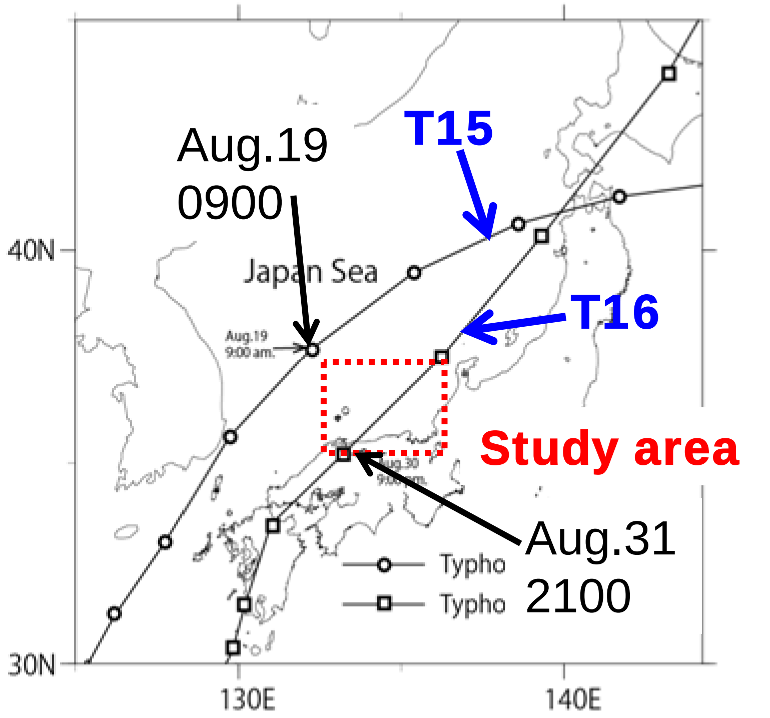
$$KE = \frac{1}{T}\int_{-\frac{T}{2}}^{\frac{T}{2}} \frac{1}{2}\rho(u^2 + v^2)dt$$

T =19 (hours)



- The NIIWs were generated by wind stress of typhoons.
- Duration time of KE of the NIIWs was different between T15 and T16.

The duration time of the NIIWs induced by T15 was longer than that by T16.



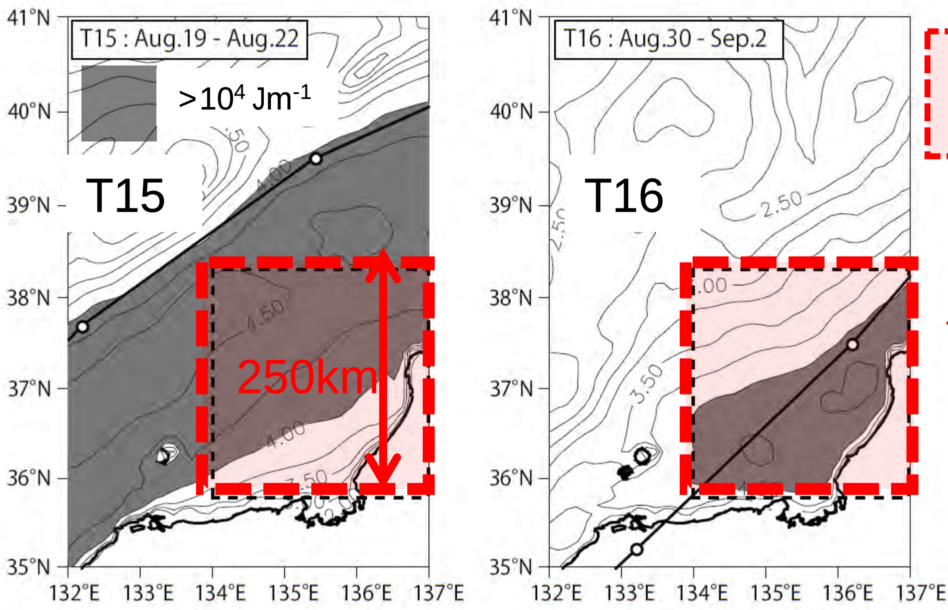
Factors producing the difference in the duration time

(1):<u>Difference of generation area of the NIIWs</u>

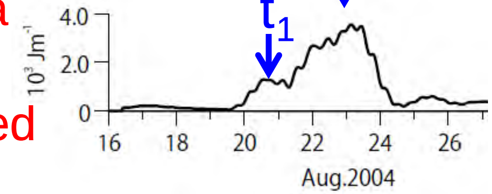
(2):<u>Effects of coastal current due to the CTWs</u>

(1): Difference of generation area of the NIIWs 1

Energy flux from wind to inertial oscillation were estimated by slab model (D'Asaro,1985) using the GPV_MSM wind data and density obtained from CTD observation.



Generation area of the observed NIIWs associated with T15



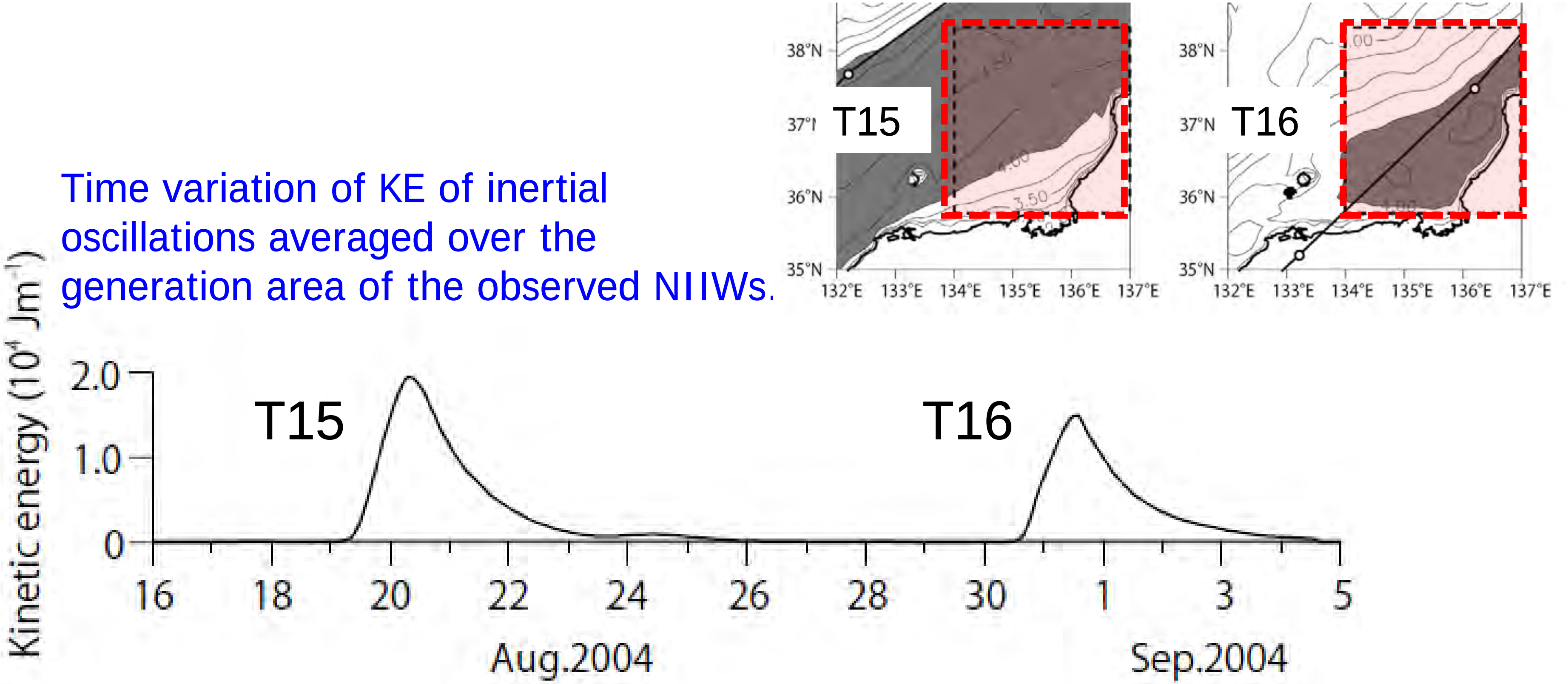
The distance of propagation ≒ 250km

The phase speed for the first baroclinic mode under the observed stratification:1 m/s
The propagation time (t_2-t_1):69 hours

Within the generation area, the energetic region for T16 is comparable to that for T15.

(1): Difference of generation area of the NIIWs 2

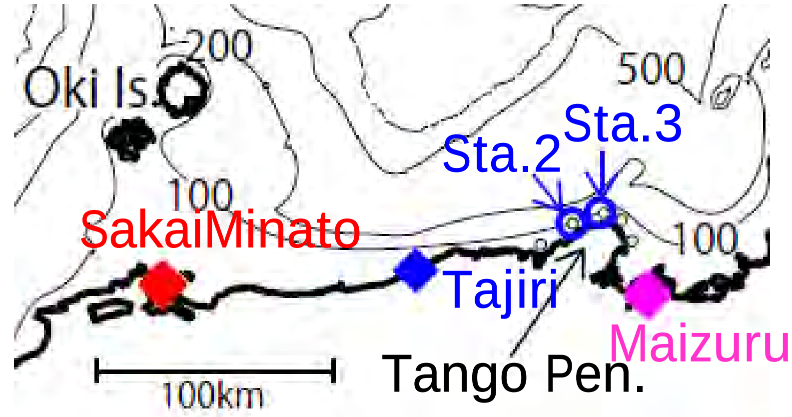
Time variation of KE of inertial oscillations averaged over the generation area of the observed NIIWs.

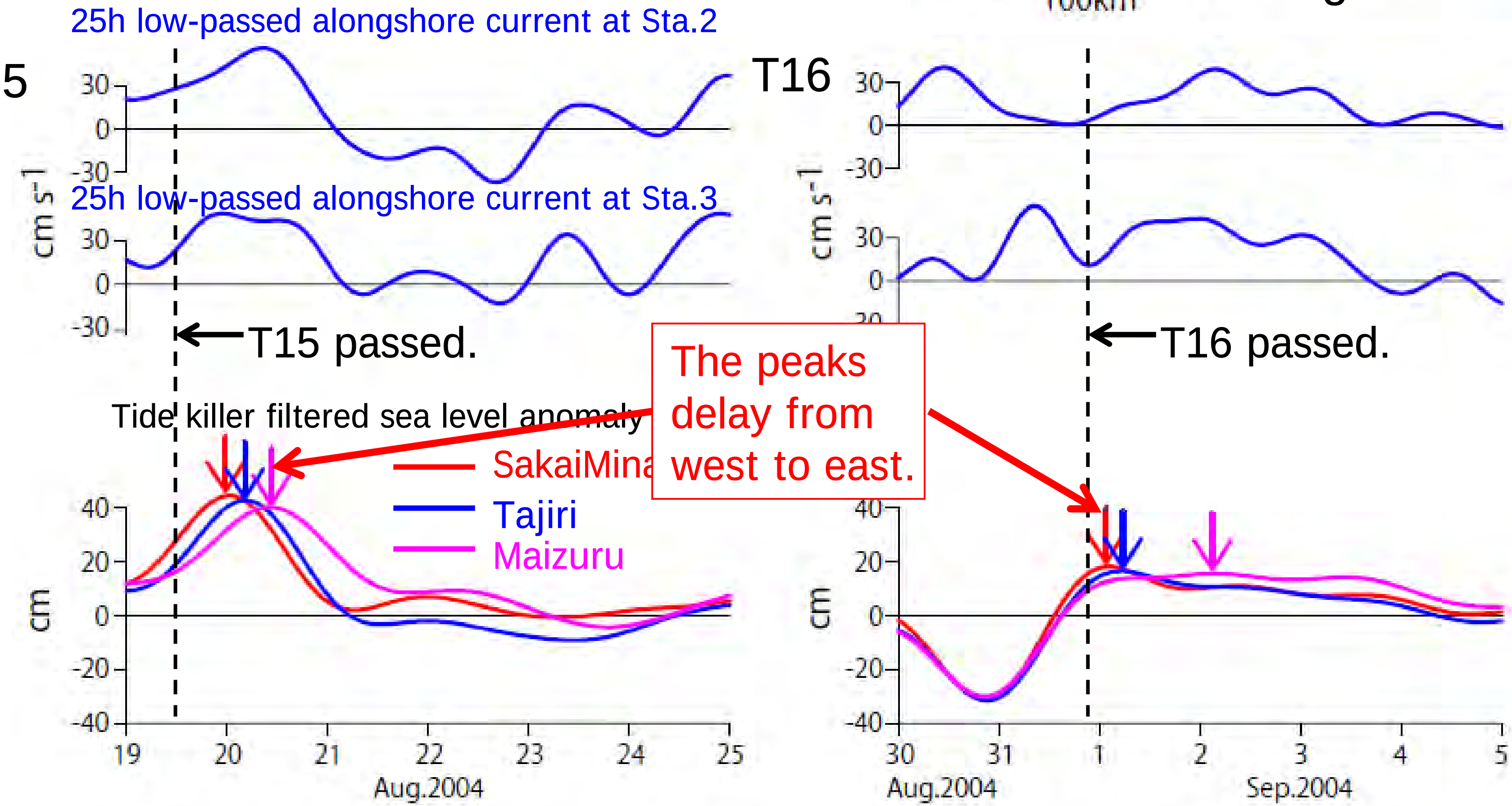


The inertial oscillations induced by T16 is comparable to that by T15 in time and space.

It is judged that the difference of generation area of the NIIWs is not the main factor producing of difference in the duration time.

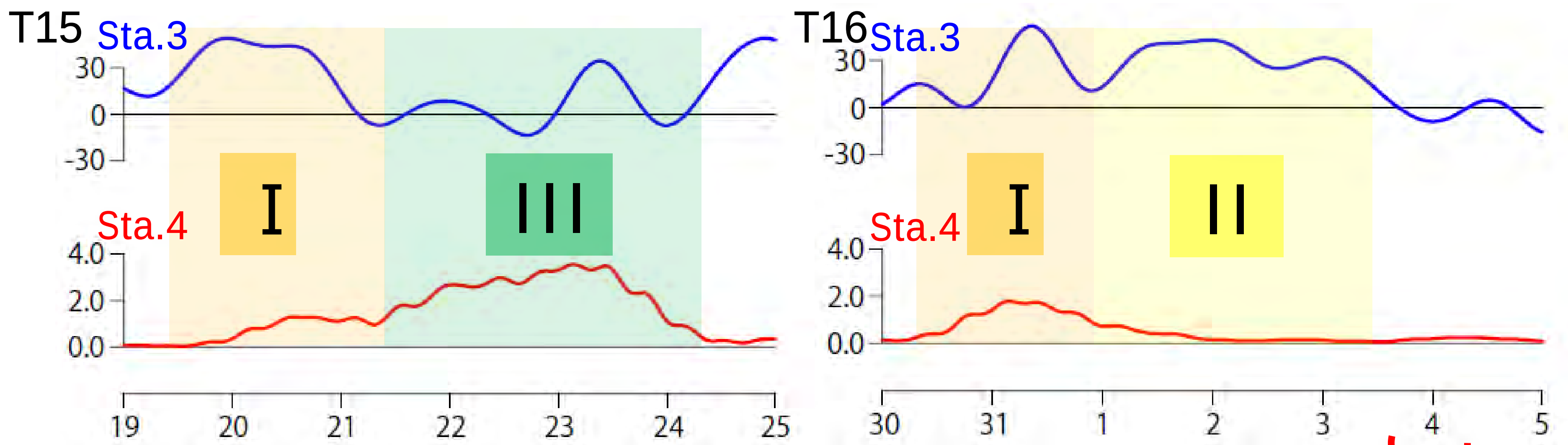
(2): Effects of coastal current due to the CTWs 1

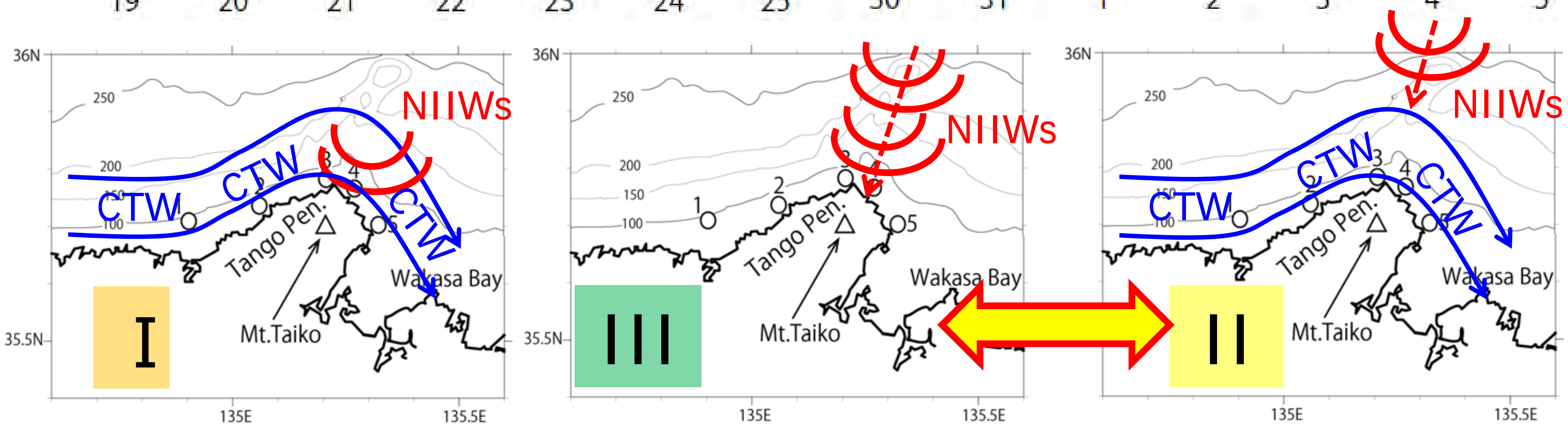




Observed subinertial eastward currents were considered to be caused by coastal-trapped waves (CTWs).

(2): Effects of coastal current due to the CTWs 2





The NIIWs and the CTWs were induced by typhoons simultaneously.

The NIIWs reached to the coastal area because of no interruption by the CTWs.

The eastward flows due to the CTWs prevented the NIIWs from propagating toward the coastal zone.

Numerical experiment

Model

- Two layer model

Driving force

- Only wind stress

Fujita's typhoon model was adopted

$$\vec{W} = C_1 \vec{V} \exp\left(-\frac{\pi r}{r_i}\right) + C_2 \vec{G}$$

$\vec{V}$:Moving speed of typhoon(=40km/h)

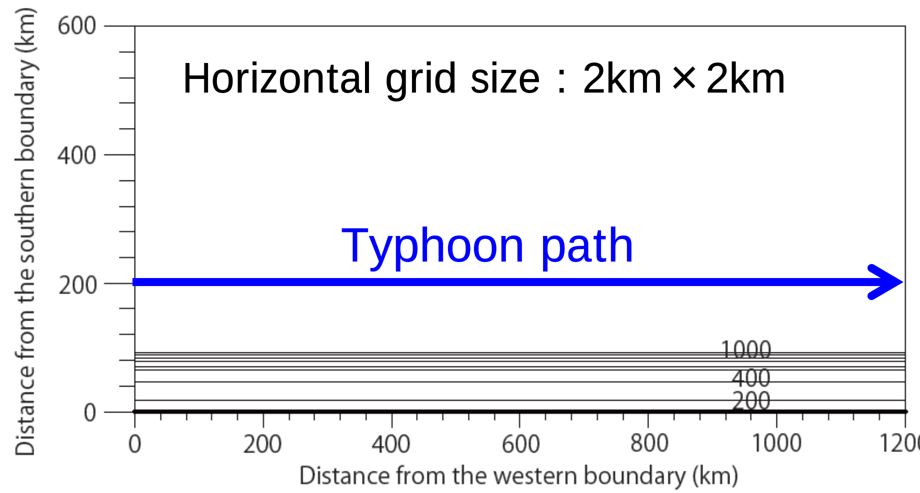
r :Distance from the center of typhoon

r_i :Typhoon size(=200km)

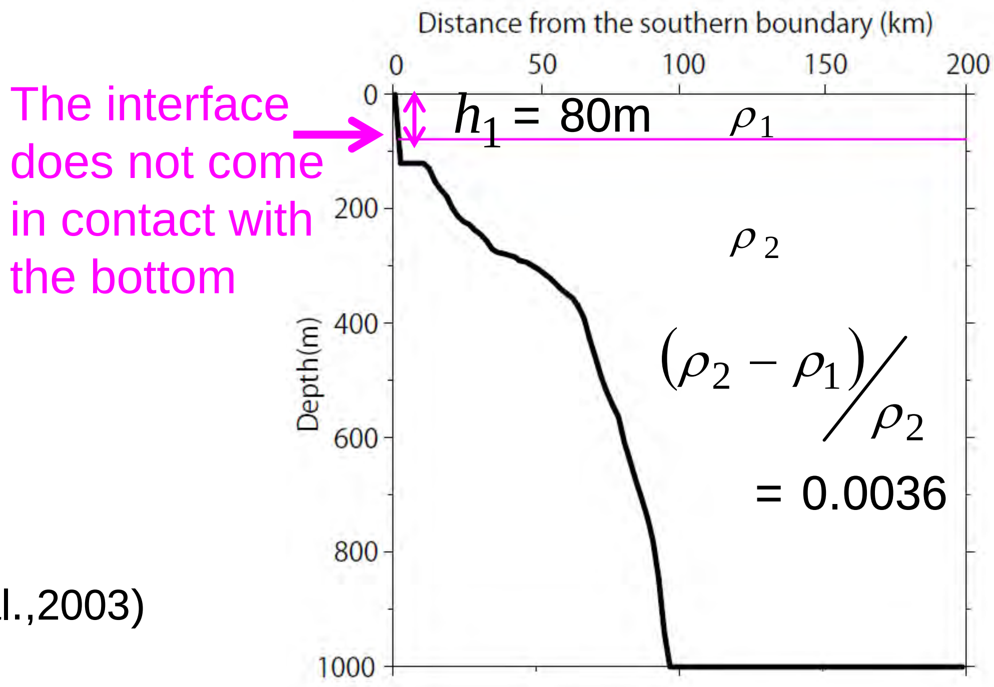
$\vec{G}$:Gradient wind field

C_1, C_2 :Constant (=0.95) (e.g. Igeta et al.,2003)

Model domain (1200km×600km)



Stratification conditions



Experimental result

15m/s

Wind velocity

Horizontal current velocity and Interface displacement

0.2m/s

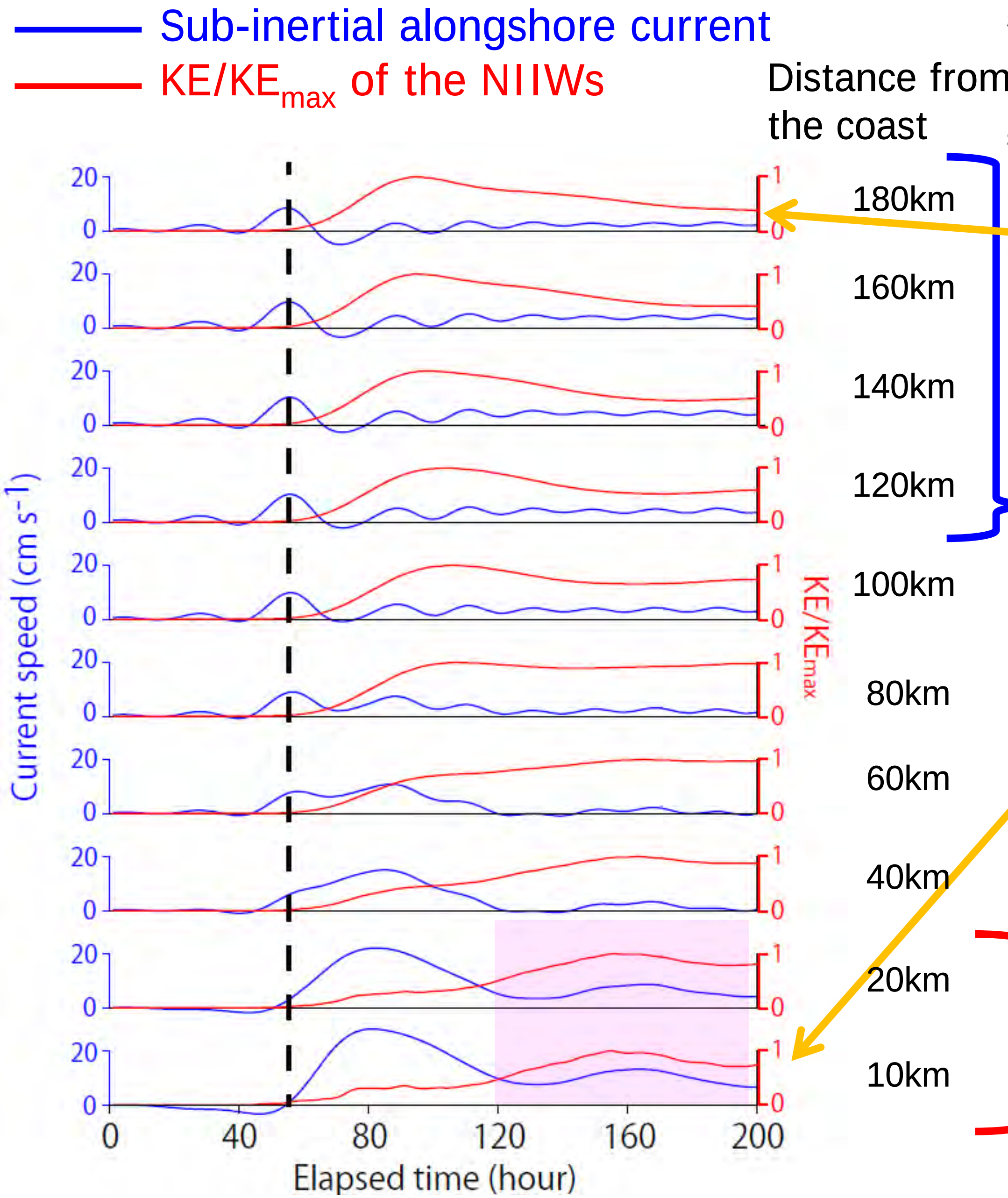
Interface displacement (m)

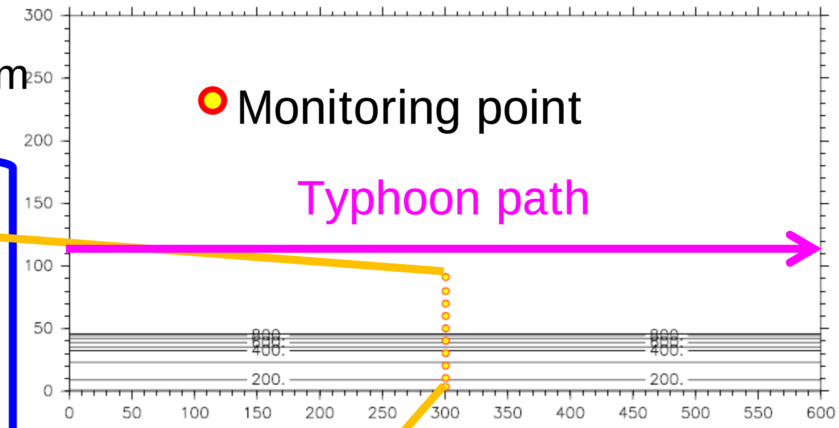
Ridge of the continental slope

The NIIWs are generated on the right side of typhoon path.

The CTWs accompanied downwelling are generated along the coast.

Preventing of the NIIWs propagations by the CTWs





In offshore regions, the NIIWs are amplified just after passage of typhoon and is decreased with time.

In near the coast, the NIIWs energy is increased after attenuation of the eastward flow due to the CTWs.

Summary and conclusion

Summary

1. From mooring observations near the Japanese coast of the Japan Sea, signals of the NIIWs were not identified during strengthening of subinertial eastward flows.
2. After weakening of the eastward flows, signals of the NIIWs rapidly appeared in the coastal zone.
3. Such subinertial eastward currents are considered to be the CTWs.
4. It is judged that the eastward flows due to the CTWs prevent the NIIWs from propagating toward the coastal zone.
5. This processes were verified by numerical experiment.

Conclusion

Coastal current due to the CTWs prevents the NIIWs propagation toward the coast.

Thank you !