

Characteristics of misocyclones observed on Tosa Bay in Japan

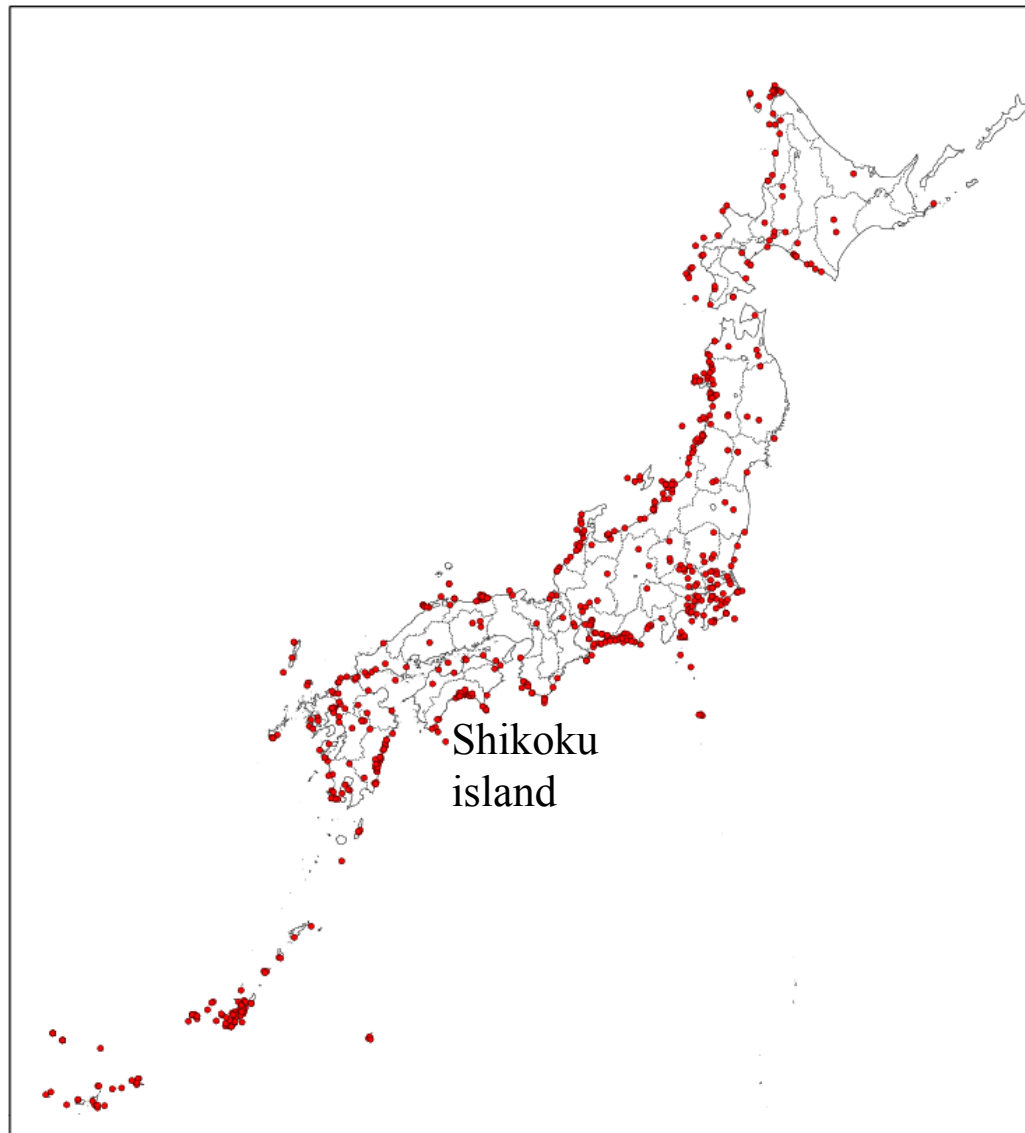
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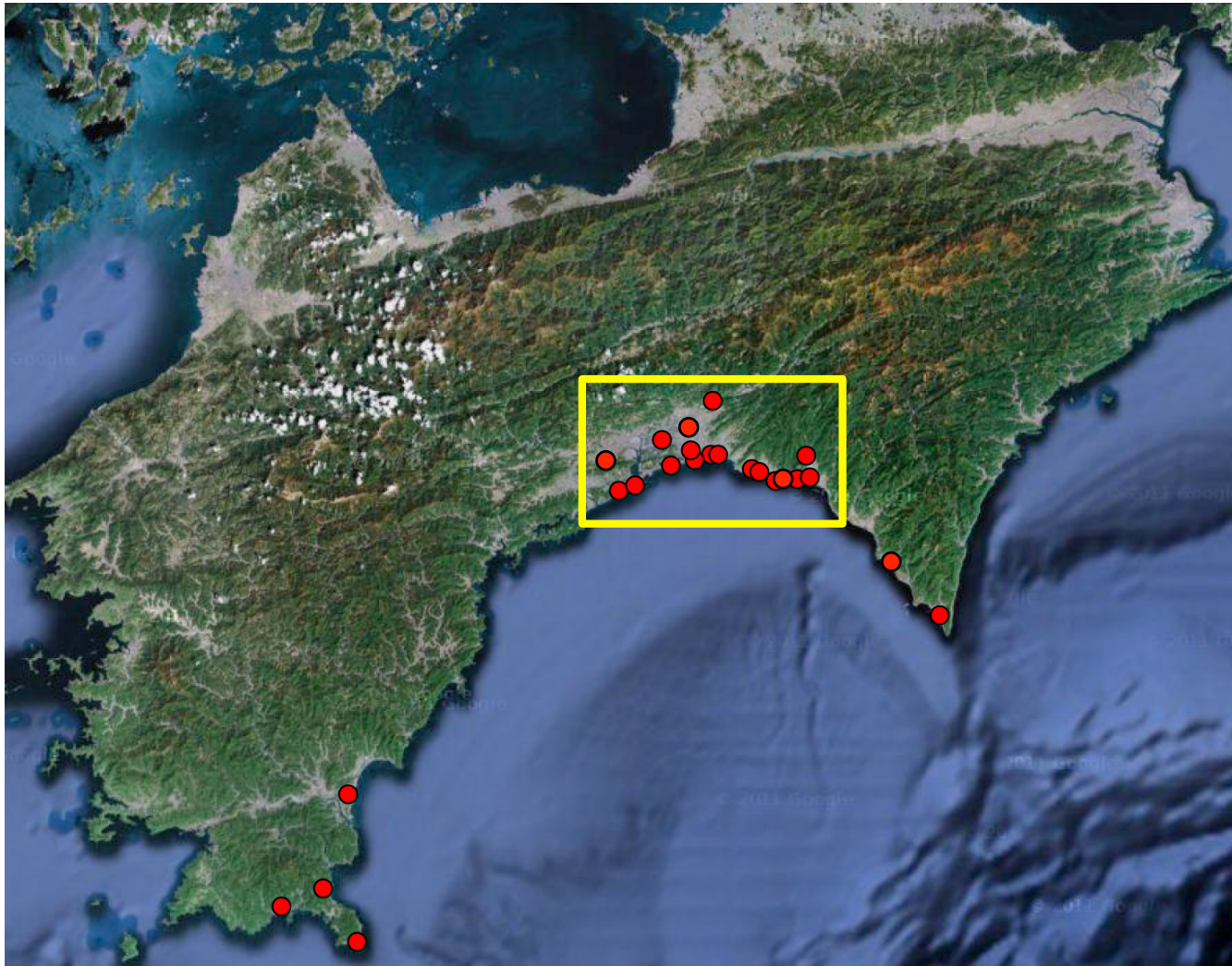


- Most of tornado locations concentrate in coastal area.

Prefecture	Tornado outbreak (1991-2010)
Okinawa	37
Hokkaido	29
Miyazaki	21
Kochi	20
Kagoshima	20

Kochi is one of regions where many tornadoes outbreak.

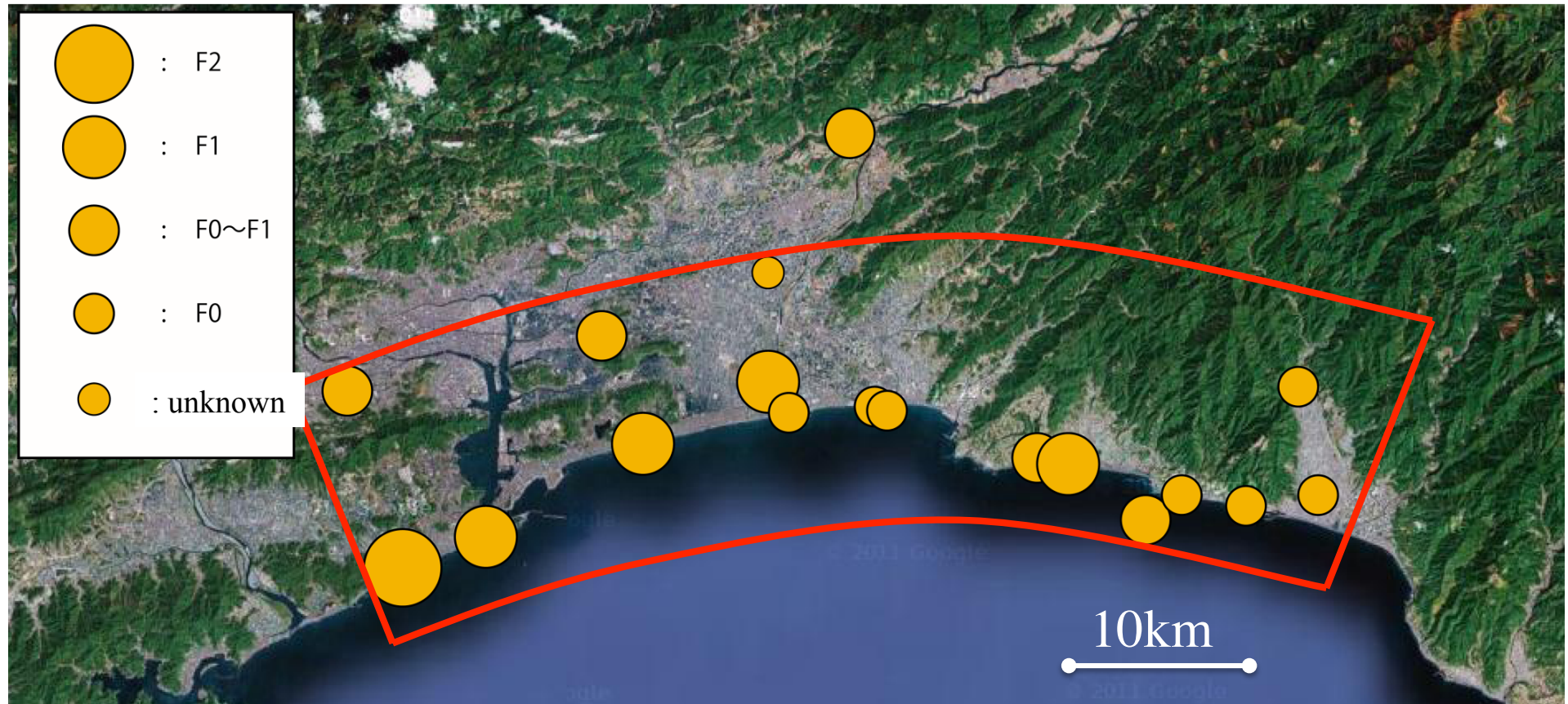
(from the JMA tornado database)



The number of tornado wrecking damages is 24
From 1991 to 2010,
including 4 events
originally researched by
our laboratory.

More than one
tornadoes outbreak
every year.

from the JMA tornado database (1991~2010)



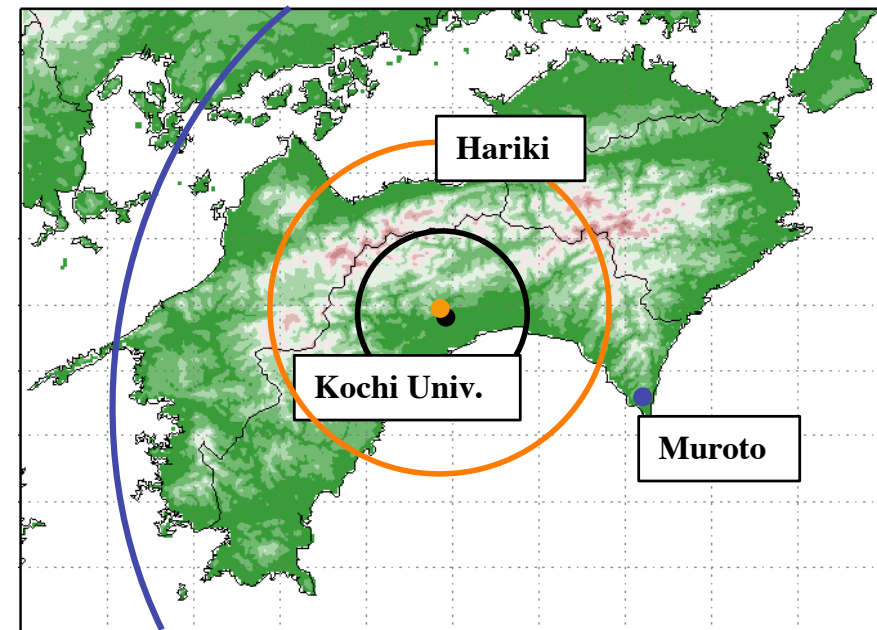
from the JMA tornado database (1991~2010)

The frequency of tornado outbreak is **32** per $100 \text{ km} \times 100 \text{ km}$ per year.
This value is **11** times of that in Oklahoma, US (Niino et al. 1997).
The southern area of Okinawa : 13 per $100 \text{ km} \times 100 \text{ km}$ per year
The coastal area in Miyazaki : 15 per $100 \text{ km} \times 100 \text{ km}$ per year

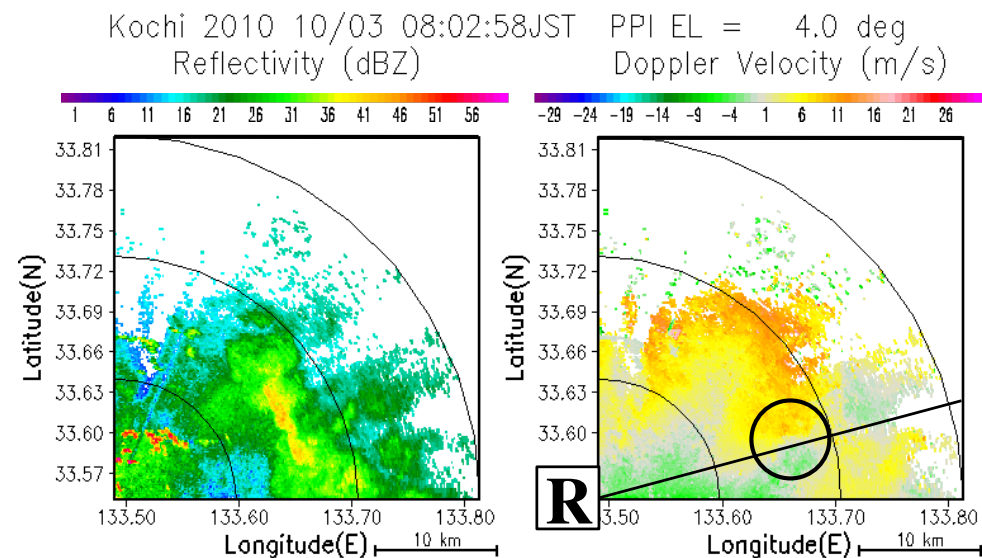
- Faculty of Science, Kochi University (X-band Doppler radar)
Observation periods: from July, 2010.
- Hariki waterworks (X-band Doppler radar of MRI)
Observation periods: from May to July, 2008 – 2010.
- Cape Muroto (JMA C-band Doppler radar)
Observation: continuously but the data analyzed

Data were mainly collected when tornado warning was announced.

	X-band (Hariki, Kochi univ.)	C-band (Muroto)
Antena diameter	1.2m	4m
Beam width	2.2deg.	1.0deg.
frequency	9794,9810MHz	5300MHz
Scan rate	4rpm	4rpm
Observation area	60, 30km	200km
Spatial resolution	75m	500m
Azimuthal resolution	0.75deg	0.70deg
Maximum velocity	$\pm 27\text{m/s}$	$\pm 54\text{m/s}$
Observation mode	Several PPI	CAPPI



- Condition of tornado detection
 - A pair of positive and negative peaks is observed in Doppler velocity perpendicular to radial direction.
 - Such patterns are observed continuously in different time and space.
 - Difference of Doppler velocity, ΔV , is more than 5 m/sec.



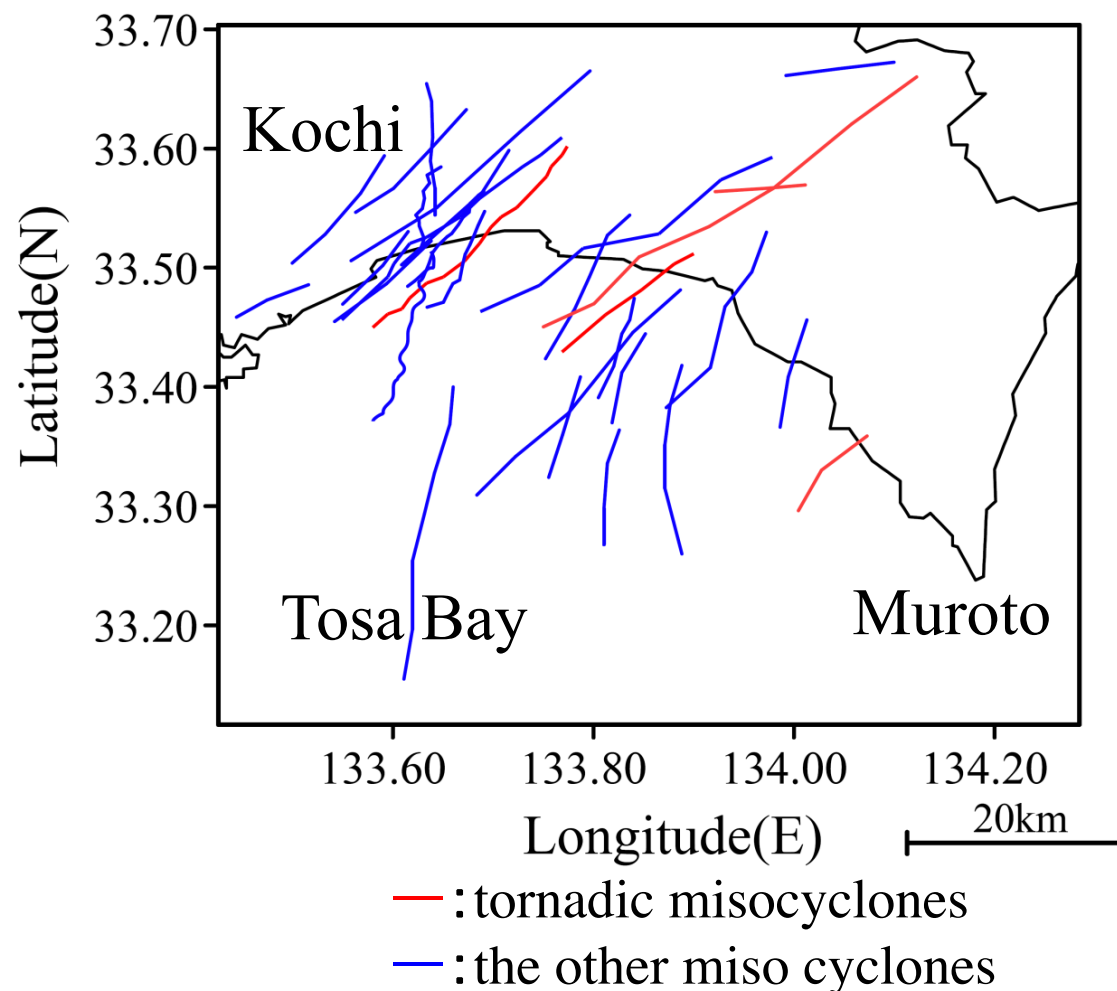
● Analyzed values

Vortex diameter, D : the distance between positive and negative peaks of Doppler velocity.

Vorticity, ω : twice times of velocity difference divided by D .

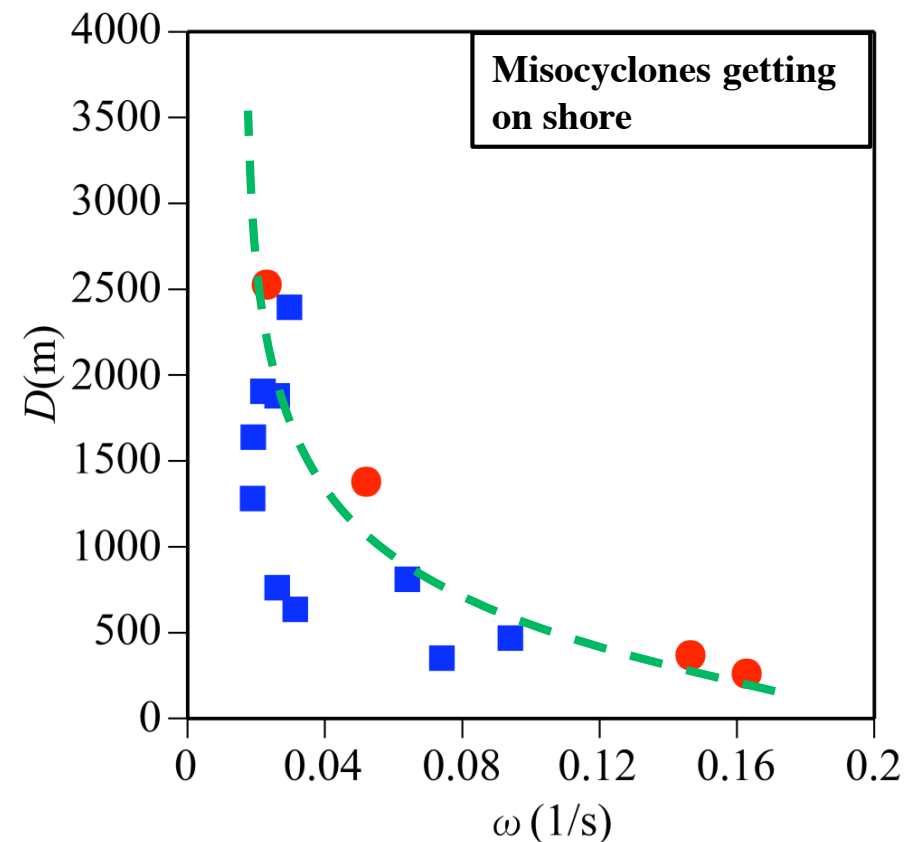
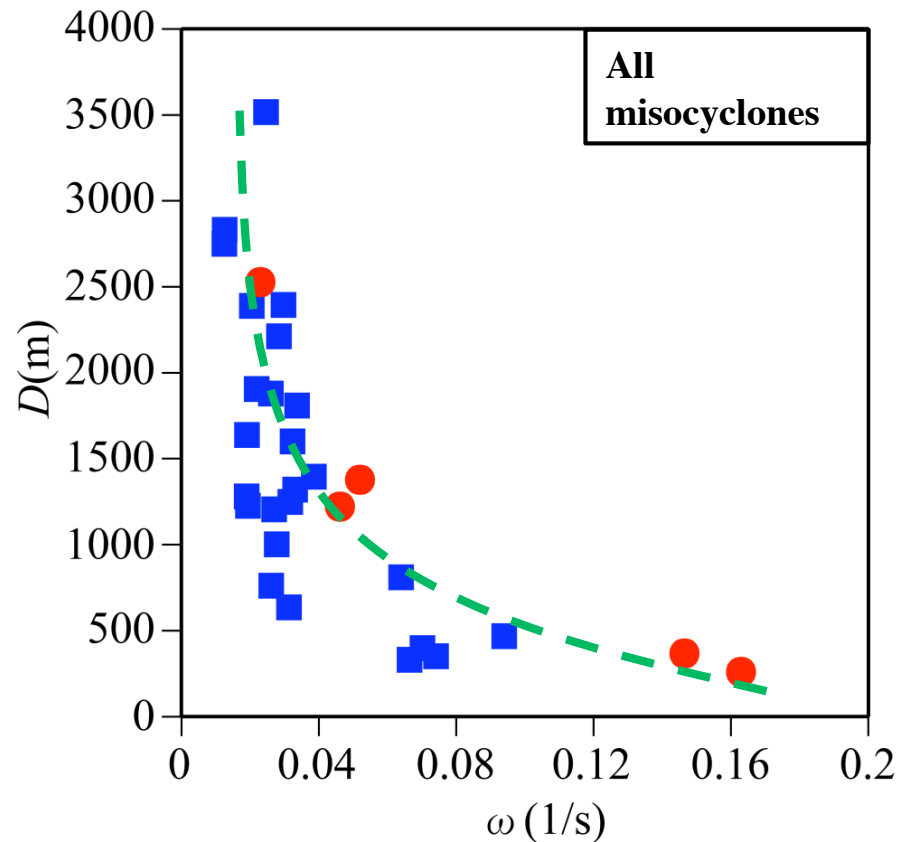
Number of misocyclone

– May 13, 2008	3
– June 29, 2008	2
– December 5, 2008	2
– June 3, 2009	4
– July 25, 2009	2
– November 10, 2009	2
– November 11, 2009	2
– November 13, 2009	1
– November 14, 2009	1
– April 29, 2010	1
– August 11, 2010	2
– October 3, 2010	2
– December 2, 2010	6



77 % of total misocyclones outbreak offshore.

Tosa Bay is one of area prone to generate misocyclones

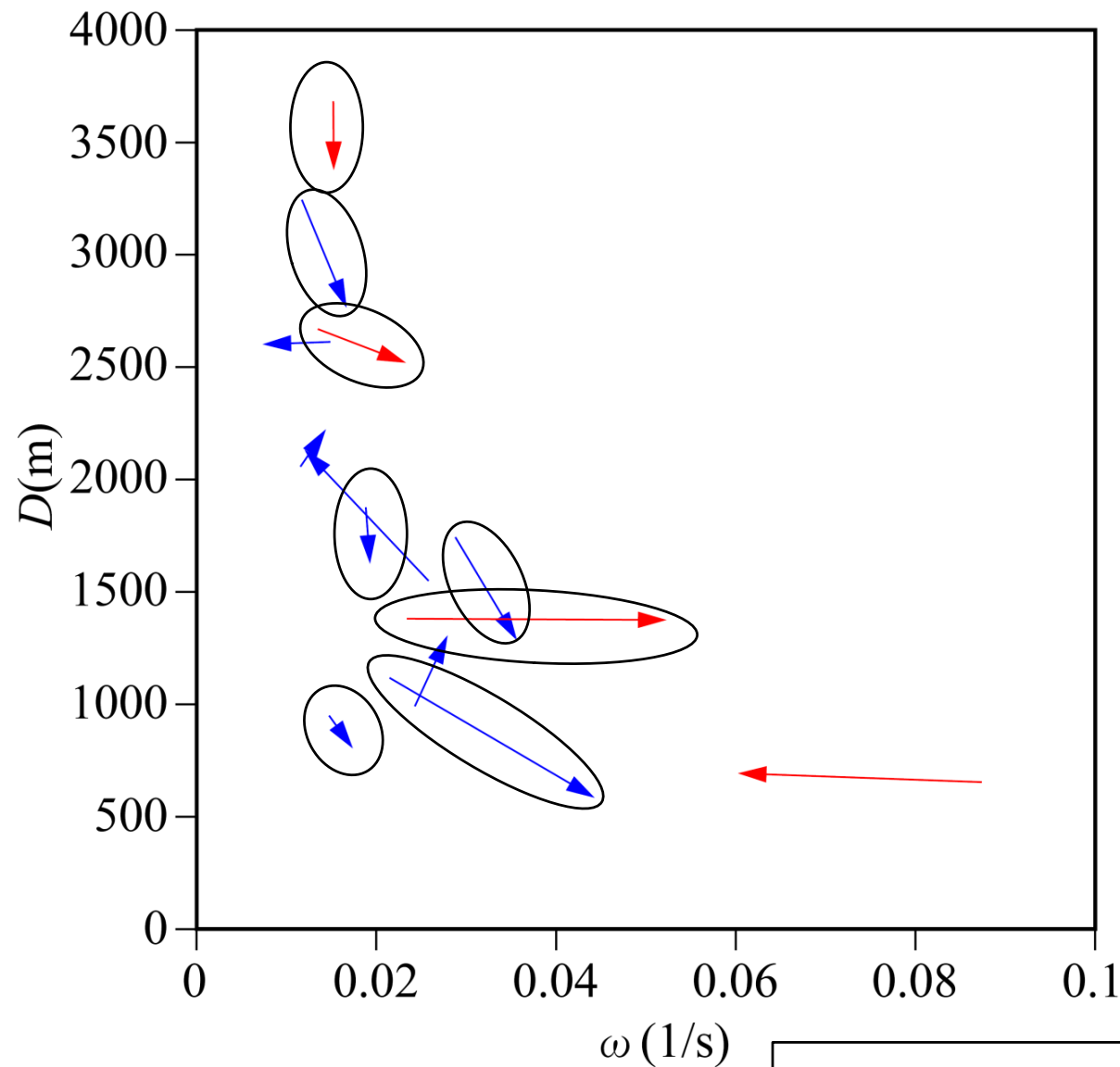


Circulation: $\Gamma = (D/2)^2 \pi \cdot \omega$

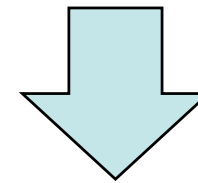
● : tornadic misocyclones
■ : the other misocyclones

Intensity of misocyclone is in almost same order of all cases.

Tornadic misocyclones slightly larger than the hyperbolic curve.



The vorticity becomes larger and the diameter is smaller for 60 % of misocyclones making landfall.



Convergence is intensified due to friction at .

← : tornadic misocyclone
← : the other misocyclone

1. Coastal area from Kochi city to Aki city faced on Tosa Bay is the area that tornadoes outbreak frequently in the world.
2. 77% of misocyclones occur in Tosa Bay.
3. The circulations of all misocyclones in mature stage are in almost the same order.
4. 60% of misocyclones landed onshore are converged and intensified