Cross-Kuroshio Surface Transport as seen by Surface Drifters and Altimeters

Kaoru Ichikawa[1,2], K. Kato[3] and D. Ambe[4]

1: RIAM, Kyushu Univ. (ichikawa@riam.kyushu-u.ac.jp)
2: IORGC, JAMSTEC, 3: ESST,Kyushu Univ., 4: NRIFS, Fish. Res. Ag., Jpn.

Kuroshio transport

Downstream advection of the Kuroshio is prominent.

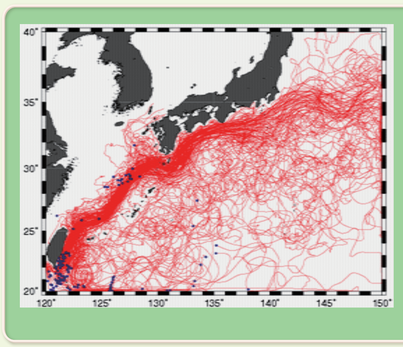
But how about the cross-Kuroshio transport?

Is it important?
Yes, especially for fisheries and pollution controls.

No steady forcing for the crossing direction
Ekman drift? frontal eddies? or something else?

Does it really exist?
Yes, for example, many drifters released in the Pacific have reached to the Japanese coast by crossing the Kuroshio.

Data and Methods



WOCE surface drifters

provided by AOML, US

with15-m drogue depth, 6-hour int.

low-pass filtered (~1day) to remove tidal currents & inertia oscillations

Surface geostrophic velocity field

Anomaly

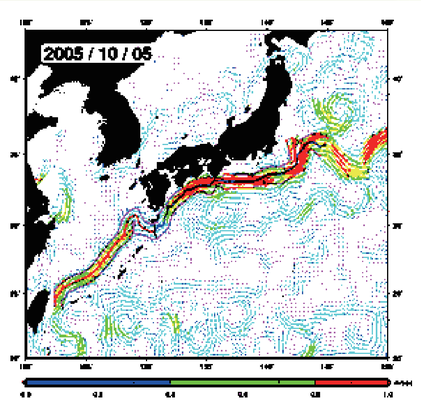
Merged Altimetry product

provided by Ssalto/Duacs, AVISO (Delayed updated mode)

1/3-deg grid, weekly

Mean

estimated from drifter and altimetry data based on Uchida and Imawaki (2003)



the Kuroshio Axis

estimated based on Ambe et al. (2004) as successive points of the maximum speed

J-OFURO data set (http://dtsv.scc.u-tokai.ac.jp/j-ofuro/)

northern and southern boundary of the Kuroshio

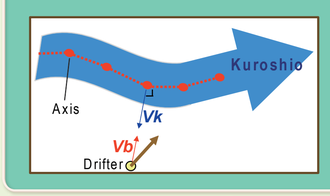
as 0.5-m/s lines around the axis

Approaching speeds of a drifter & the Kuroshio axis

For each drifter, calculate the daily distance to the Kuroshio axis

temporally interpolated (from the 7-day interval axis data)

Determine velocity component **toward the axis** (*Vb*)



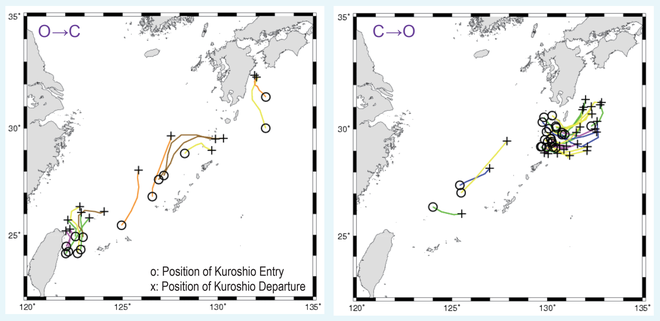
Also determine the **approaching speed of the axis** toward the drifter (*Vk*)

from the temporal change of the distance and Vb

Average *Vb* and *Vk* for all drifters within a 1-degree grid

Sort whether drifters are in the **Coastal** or **Offshore** areas or **within the Kuroshio**

Results



~40% of WOCE drifters have experienced crossing the Kuroshio

although this number would depend on deployment

55 drifters out of 149

23 from Offshore to Coast (2-7 days)

32 from Coast to Offshore (2-5 days)

NB) duplicately counted

Downstream advection **during the stay in the Kuroshio**

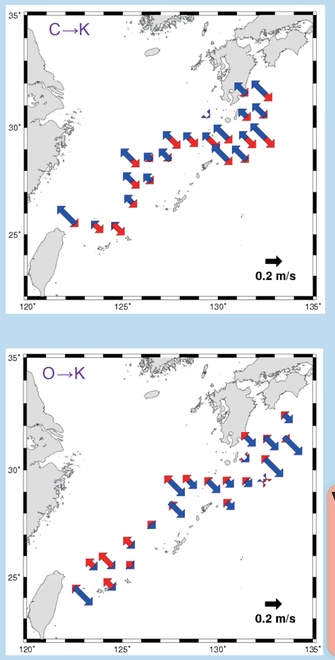
Two types of crossing

Direct crossing (18 drifters)
cross the Kuroshio without staying the Kuroshio

Advective crossing (37 drifters)
staying in the Kuroshio for a few days

Advective Crossing

Processes entering/leaving the Kuroshio

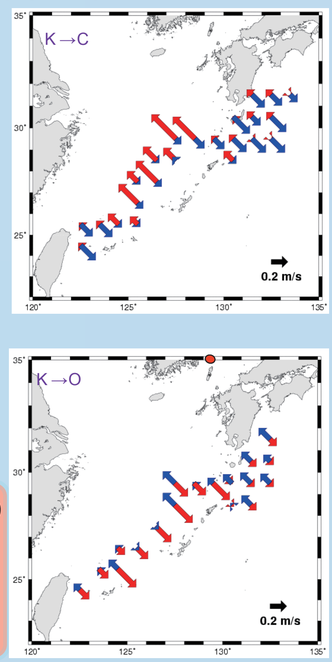


All drifters (including no crossing) that enter/leave the Kuroshio

found all over the Kuroshio

Vb is significant w.r.t. *Vk*,

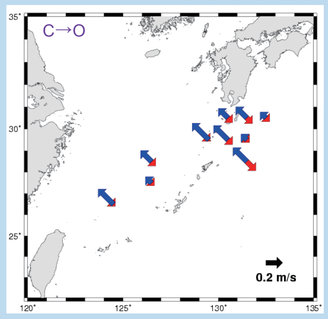
especially along the shelf edge

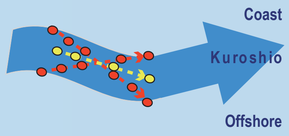


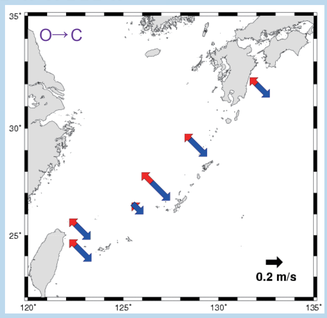
Velocity comp. **normal** to the Kuroshio is important to leave/enter the Kuroshio

e.g. samll scale frontal eddies, Ekman drifts

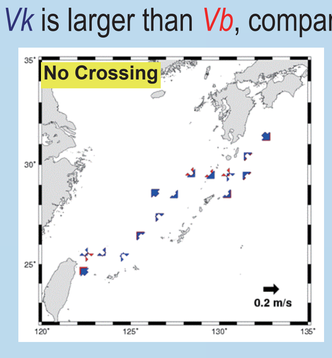
Process within the Kuroshio







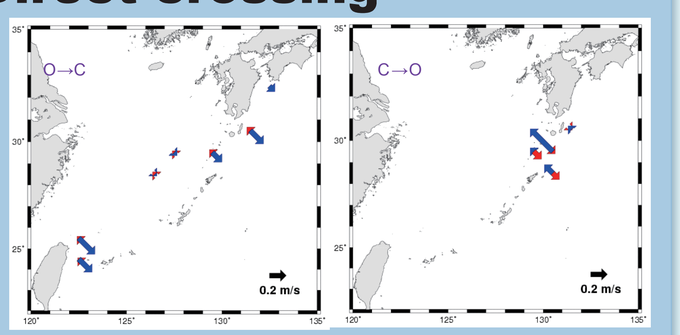
For drifters in the Kuroshio **during advective crossing** *Vk* is larger than *Vb*, comparing with the Left panels



Both *Vk* and *Vb* are very small for drifters in the Kuroshio but **without crossing**

NB) **the stream lines correspond to the streak lines for the steady flow**

Direct crossing



Axis movement (*Vk*) is dominant

limited in areas with **larger Kuroshio meanders**

Summary

The cross-Kuroshio transport is studied using surface drifter data and altimetry data

Movement of the Kuroshio axis (*Vk*) plays important role for the **crossing** of the Kuroshio

large movement near the Tokara Strait and northeast of Taiwan may cause direct crossing between the Offshore and Coastal areas

The velocity component **normal to the Kuroshio** (*Vb*) is important when drifters **enter/leave** the Kuroshio

which may be associated with **small-scale frontal eddies** or **Ekman drifts**

Such boundary processes are **often** observed even when the Kuroshio axis is stable, although drifters may **not** cross the Kuroshio

Reference

Ambe, Imawaki, Uchida and Ichikawa, *JO* **60**(2), 2004.

Uchida and Imawaki, *GRL*, **30**(5), 2003.