SEASONAL VARIATION OF THE OCEANIC WATER INTRUSIONS INTO KAGOSHIMA BAY DERIVED FROM SATELLITE SST AND CHL-A IMAGES

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ABSTRACT

This research is aimed at figuring out the oceanic water intrusion in Kagoshima bay for each season by satellite SST(sea surface temperature) and chl-a(chlorophyll-a) images using the MODIS/Aqua ocean color sensor.

It is relatively easy to find the oceanic water intrusion in winter by satellite SST images. However, it is difficult to find it during the summer season considering that it is accompanied by thermal stratification and the fact that SST shows almost the same temperature between the inner bay and the ocean.

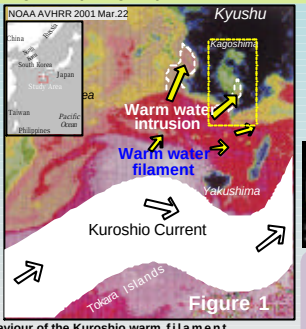
In this research, the satellite chl-a images taken by MODIS/Aqua were employed to reveal the oceanic water intrusion in each season. The enclosed bay has the tendency to undergo eutrophication by organic materials from land and show a difference in chl-a concentration of the bay

STUDY AREA & DATA

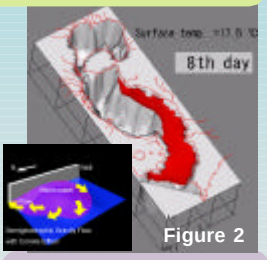
Study area : Kagoshima bay and Fukiage seashore (Southern Kyushu, Japan, Fig.1)
Satellite data : MODIS/Aqua
(Level2 Processed data of SST & chlorophyll a with 1km resolution)

WHAT IS OCEANIC WATER INTRUSION ?

When warm oceanic water comes in contact with the bay water at the mouth location, intrusion occurs. The water mass which is influenced by **coriolis Effect** intrudes to northern part **along the eastside coast**. That is, this is an intruding mechanism of the **semi-geostrophic gravity flow**.



Behaviour of the Kuroshio warm filament
The warm water mass emanating periodically from the meandering Kuroshio Current brings frequent water intrusions. The Kuroshio Current progresses mainly from Tokara Islands to the Pacific Ocean through Yakushima Island



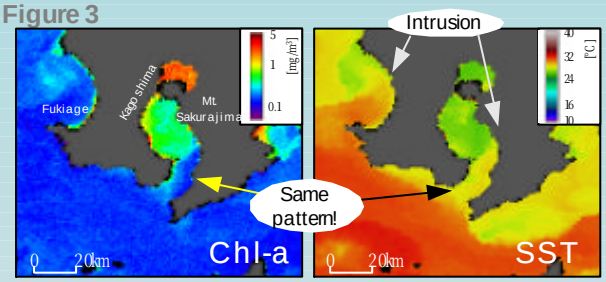
Result of a numerical simulation
(Isothermal surface distributions of 17.5℃)
This calculation is focused on the winter season and is based on the assumption that the Kuroshio warm filament brings a warm water mass at the mouth of the bay.
The initial water temp. is set as 17deg. and the boundary condition is set as 21deg. for 2 days.
The warm water keeps its thickness during intruding. Even there is NO tidal current, water mass can intrude and reach at the south of Sakurajima.

RESULTS

I. SEASONAL VARIATION OF THE CHL-A AND SST DISTRIBUTIONS

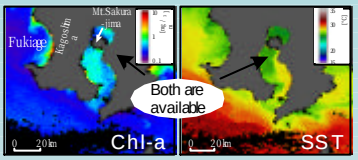
Distribution of low concentration chl-a with oceanic water intrusion in the summer season shows almost the same pattern in the winter season (Fig.3(a)). On the other hand, in other seasons, images are available to differentiate the oceanic water intrusion. Therefore, applying the suitable satellite sensor images for each season is effective in the monitoring of oceanic water intrusion.

Figure 3

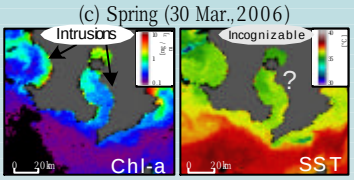


(a) Winter (21 Feb., 2006)

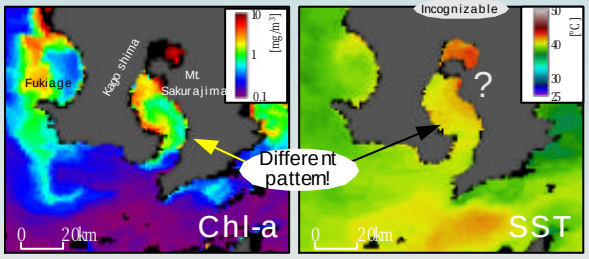
Low chl-a concentrated water & warm water intrudes simultaneously. Both scenes are available to find the oceanic water intrusions.



(c) Spring (30 Mar., 2006)



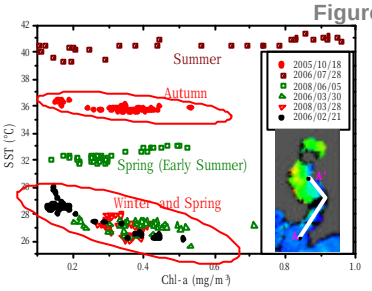
(d) Autumn (18 Oct., 2005)



(b) Summer (28 Jul., 2006)

During the summer season, the chl-a distribution shows the oceanic water intrusion clearly.

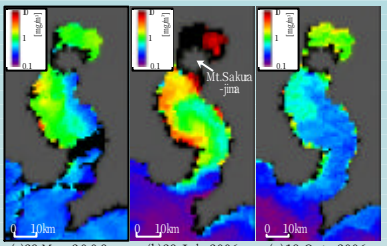
Figure 4



CORRELATION DIAGRAM (SST vs. CHL-A)
Autumn, winter and spring: significant correlation
Summer (including early summer): no correlation

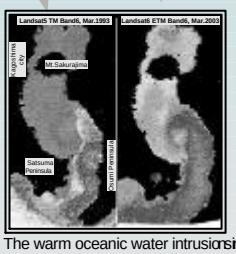
II. INTRUDING PATTERNS

Distribution of low concentration chl-a have typical three patterns(Fig.5). However pattern c (Fig.5(c)) may have influenced by nutrient salts from a city area.



(a)28 Mar., 2008 (b)28 Jul., 2006 (c)18 Oct., 2006

Pattern (a) and (b) are similar to the warm oceanic water intrusions in the winter season.



The warm oceanic water intrusions in the winter season, shown by Landsat.

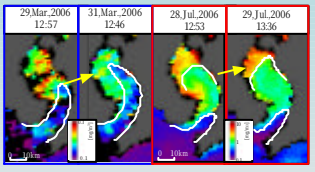
Figure 5

III. INTRUDING SPEED

As shown in Table 1, the estimated speed of the intrusion is about 7cm/s to 12cm/s. Each value in all seasons shows same order although this intrusion speed should be considered as a rough estimation.

Table 1 Intruding speed

Case	Speed	Source
Winter	12cm/s	Field observation by buoyrobot (Ohtani et al.,1998).
	7-15cm/s	NOAA AVHRR SST images (Hosotani and Kikukawa,2006)
	15-25cm/s	Numerical simulation (Kohno et al.,2004)
Spring	**9cm/s**	MODIS/Aqua chl-a images (Fig.6)
Summer	**7-12cm/s**	MODIS/Aqua chl-a images (Fig.6)
	15cm/s	Numerical simulation (Hosotani and Winarso, 2007)



TIME SERIES OF CHL-A IMAGES
The intruding speed was estimated using the travelled distance of low-concentration.

Figure 6

CONCLUDING REMARKS

It is important to monitor this oceanic water intrusion for all seasons because this event will contribute to the water exchange in the coastal environment.

The seasonal variations of the oceanic water intrusion into Kagoshima bay have a similar tendency of a semi-geostrophic gravity flow influenced by the Coriolis effect. Complementary application of SST and chl-a images is effective for consecutive monitoring and analysis.

However, clear scenes are still not enough because of atmospheric conditions. It is further recommended to use few days of composite images to bring better and improved results.

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