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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Chlorophyll increases off the coasts of Japan after the 2011 Tsunami using NASA/MODIS data" *by* E. Sava et al.

E. Sava et al.

gcervone@gmu.edu

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We thank the Anonymous Referee for his comments.

1. Other papers have already dealt with the same phenomenon (Sarangi, 2012; Siswanto et al., 2012) by using the same database (MODIS Ocean Color data). The authors should have at least compare their results with those discussed in the two previous article.

R: It is true that other studies such as the ones mentioned in the paper have dealt with the same phenomenon. All studies share a common theme and show that chlorophyll increase can be detected resulting from major events such as hurricanes or tsunamis and not only from seasonal changes. However, Sarangi, 2012 and Siswanto et al.,

2012 mainly focus their efforts mainly around the Sendai Bay. In addition, both papers only look at a three week dataset: pre-tsunami, during, and post tsunami of the years of 2010, 2011, and 2012 and apply a three-band Chlorophyll algorithm (OC3M). In contrast, our research examines an annual dataset of the 2011 year as well as data for the month of March 2010, 2011, and 2012. In addition, we focused our research both in areas along the coast of Japan (R1) and in deep water (R2). By looking at the annual data it allowed us to observe and compare seasonal upwelling to upwelling resulting from the tsunami. Although all three works show an upwelling occurring, the results presented by Sarangi and Siswanto could had misjudged their results due to the restrained parameters of the OC3M algorithm. The OC3M algorithm is not designed to differentiate Chlorophyll from other in water particles such as colored dissolved organic matter(CDOM) or detrital. Both CDOM and Chl strongly absorb blue light and thus the OC3M blue/green algorithm cannot distinguish them explicitly. Furthermore, the blue bands used for the inputs of the algorithm (412 and 443 nm) are low of quality owing to the difficulties in atmospheric correction.

2. The authors should explain in a less rough why MODIS Terra provides results significantly different from MODIS Aqua, otherwise show the results obtained with MODIS Terra is of little Scientific significance.

R: As presented in the paper, there is a significant difference between the two satellites as they collect data. This is due to the different missions the sensors are designed on. The Aqua platform focuses on the Earth's physical processes with an emphasis on the water cycle while the Terra platform focus is on global data on the state of the atmosphere, land, and oceans, as well as their interactions with one another and with solar radiation. As a result of the different emphasis of the two sensors, the Terra sensor is not able to detect as many anomalies in the oceanic parameters as well as the Aqua. In addition, due to the difference in orbital parameters usually resulting in different viewing and cloud-cover conditions for a given location, Terra and Aqua data allows us to fill in the gaps between the different time acquisitions of data collection.

In this analysis, the Terra data was highly significant because it provided us with information that the Aqua platform had not been able to capture due to the atmospheric conditions and orbital parameters. By looking at Fig. 3, the Terra data provided significant information during months in which the Aqua data was low. This can be seen for the months of May, September, October, and November in Region 1. Furthermore, when looking at Week 13 of Region 2 in Figures.4 and 5, Terra data showed a significantly higher concentration of chlorophyll compared to Aqua. Thus the difference that occurs with Terra and Aqua is significant because it allows us to analyze chlorophyll anomalies and better examine and understand the spatial extendability under different atmospheric conditions.

3. The manuscript could have a greater scientific significance if the methodology and discussion was focused with a more valid approach on the different results obtained along the coast and in deep water. Are or not the differences statistically significant? If yes, what exactly is the role of the wave's height? These differences are found in similar events?

R: The differences between the regions are significant as they both react to the tsunami differently. Looking at both regions independently we notice that they experienced quite the opposite effects. For instance, when there were high concentrations of chlorophyll along the coast there were low concentrations in the deep water and vice versa. However when observing both regions together we can see how one region may interacted with the other.

In week 10, Fig.4., we notice the normal conditions of the region. It can be seen that there is high chlorophyll concentration on the northern part of R1 compared to R2 which is highly a result of the nutrient rich Oyashio Current as it flows south along the shore of Hokkaido and Tohoku. In addition, we observe a plume which occurs as the Oyashio Current collides the Kuroshio Current at the tip of Chiba. The warmer Kuroshio Current mixes with the Oyashio which results to the chlorophyll plume to be visible. Thus it can be noted that under usual normal conditions there is higher concentrations of

chlorophyll along the coast than in deep water.

Observing week 11, the high chlorophyll concentration noticed from the previous week follows the current and moves south along the coast, while there is a slight increase all along the coast. In the meantime some early high concentrations of upwelling start to occur in deep water. This difference is a result of the tsunami and the disturbance it created.

During week 12, we notice one of the biggest changes in chlorophyll concentrations in R2 while in R1 it seems as the conditions are transitioning back to normal. High concentrations in R2 show that upwelling was still taking place days after the event and is the highest the week after the tsunami occurred. The disturbance generated by the tsunami can also be noticed, as cold water from the bottom was brought to the top showing the high concentration of nutrients. Overall, while in R1 the chlorophyll seems to be back to normal due to the currents quickly returning to their natural course, it takes longer for this to occur in the deep water as nutrients need time to either sink back down into the ocean or disperse.

In week 13 the opposite effect of week 12 can be observed. As chlorophyll concentrations decrease in the deep water (R2) they increase along the coast (R1). This is a result of the current taking some of the chlorophyll slowly away from the deep water and moving it along the coast. Furthermore, we can notice that it takes longer time for deep water to return back to normality compared to the coastal areas; however more marine damage can occur along the coast as the chlorophyll concentrations are still present over time.

Wave height plays an important role as it reflects the intensity of the tsunami as well as the disturbance in the ocean. The area along the coast seemed to experience higher disturbance due to wave height and upwelling compared to deep water, nevertheless it quickly recovered as the currents were able to return to normal. In the deep water, the upwelling lasted significantly longer as it takes a longer time for the water to reach

normal conditions and the nutrients to sink or be disbursed.

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 1, 3073, 2013.