ATMOSPHERIC EFFECT REDUCTION IN CALCULATING SEA ICE CONCENTRATION FROM AMSR2 DATA

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ABSTRACT: The passive microwave sensors on board satellite allow us to monitor the distribution of sea ice on global basis. Ice concentration is one of the the most fundamental parameters of sea ice which can be calculated from brightness temperatures measured by passive microwave radiometers. There are number of sea ice concentration algorithms including NASA Team Algorithm and Bootstrap Algorithm. In extracting sea ice concentrations from passive microwave sensors onboard satellites, atmospheric effects mainly caused by the presence of atmospheric water vapor, cloud liquid water etc. are likely to estimate certain sea ice concentrations at the open water area. We call this kind of area as "false sea ice". To solve the problem, usually, weather filters are applied. The basic idea of weather filters is to differentiate clouds over open water from sea ice in the characteristic domain derived from brightness temperatures, and reject clouds by using thresholds. However, under the very heavy cloud condition, some open waters remain as false sea ice areas. In this study, the authors have introduced a new method for reducing the weather effect. We have found that by introducing the following two equations, most of the false sea ice areas appear in the ASMR2 ice concentration data sets for the Sea of Okhotsk can be rejected. One is (36GHzV－36GHzH)<57K and the other is 23GHzV＋0.75×(36GHzV－36GHzH)<250K. If the brightness temperature of the pixel meets the above two equations, we set the ice concentration of the pixel as 0%. We are now trying to apply this method also for the other sea ice areas.

1. INTRODUCTION

The global warming has become one of the most serious environmental problems we are facing today. In order to monitor the trend of global warming, importance of sea ice monitoring is increasing. Since longer wavelength microwave can penetrate clouds, passive microwave radiometers, such as SSM/I or AMSR-2 on-board satellites are powerful tools for monitoring the global distribution of sea ice on daily basis. Long term monitoring of sea ice with passive microwave sensors on-board satellites are allowing us to monitor the trend of global sea ice distribution (Parkinson et al., 1999; Comiso and Nishio, 2008; IPCC, 2014). However, passive microwave radiometers are not completely cloud free. More or less, microwave signals are affected by atmosphere. When the open water area is covered with heavy clouds, the brightness temperature of the area becomes similar to that of sea ice. As a result, certain sea ice concentration is calculated in the open water area. This is known as "weather effects" (Gloersen et. al., 1986). In this study, we call this kind of area as "false sea ice". The weather effects are caused by the presence of atmospheric water vapor, cloud liquid water, rain and sea surface roughening by winds.

To reduce the weather effects, usually, weather filter is applied (Comiso,1995, Cavalieri et. al., 1995). The basic idea of weather filter is to differentiate false sea ice from true sea ice in the characteristic domain of certain parameters derived from microwave brightness temperatures. However, since false sea ice and true sea ice sometimes overlap in the characteristic domain, weather filter is not always effective. So, when calculating sea ice area from sea ice concentration data derived from passive microwave radiometers, sea ice concentrations(IC) less than 15% are often rejected (IC=0%) to minimize the weather effects. However, this means that true sea ice concentration area less than 15% are also rejected. In order to improve the sea ice concentration estimation accuracy, more effective setting of the threshold level to reduce the weather effects is required. The authors have been working on improving the weather filter in the past (Cho et al., 2010, Tezuka et al., 2013).

In 2012, JAXA launched advanced passive microwave sensor AMSR2 on-board GCOM-W satellite. High accuracy of sea ice concentration calculated from AMSR2 is verified (Cho et al., 2015), false sea ice still appears in the AMSR2 sea ice concentration product under the certain condition. In this study, we propose a new weather filter for reducing the weather effects appear in AMSR2 sea ice concentration products of the Sea of Okhotsk.

Figure 1. Test Site

2. TEST SITE AND ANALYZED DATA

In this study, the Sea of Okhotsk was selected as the test site for the evaluation of the algorithm. Figure 1 shows the test site. The Sea of Okhotsk is located in the North side of Japan, and the sea is one of the most southern seasonal sea ice zones in the northern hemisphere. Since the false sea ice areas are often found in the Sea of Okhotsk, the sea is suitable for this study.

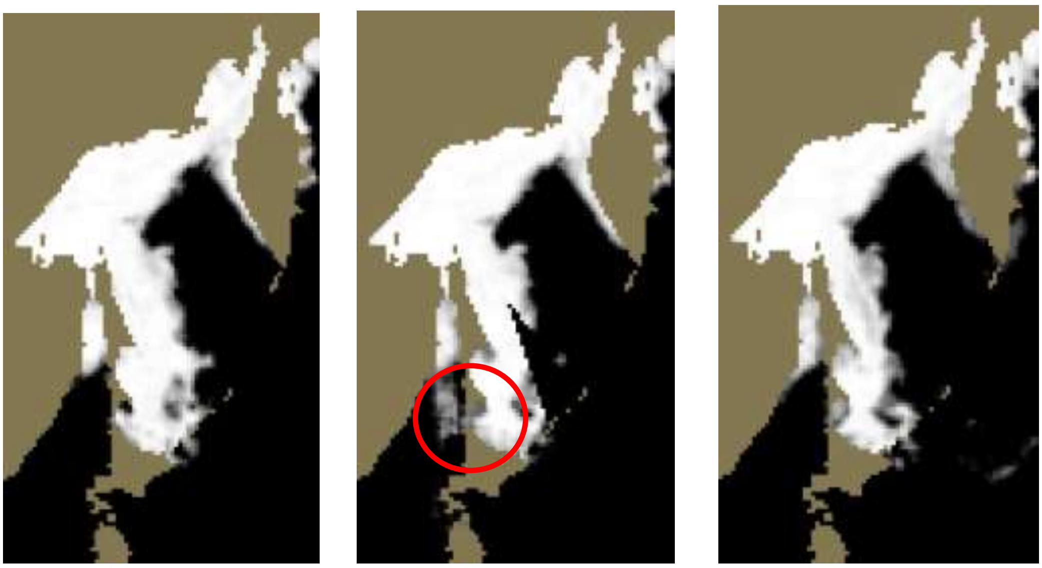
As for the data analysis, sea ice concentration data derived from the passive microwave radiometer AMSR2 was used. The sea ice concentrations were calculated using AMSR2 Bootstrap Algorithm (Comiso et. al., 2013).

Table 1. Specifications of AMSR2

frequency	resolution	polarization	swath width
6.925 GHz	35x62 km	Vertical Horizontal	1450km
10.65 GHz	24x42 km		
18.7 GHz	14x22 km		
23.8 GHz	15x26 km		
36.5 GHz	7x12 km		
89.0 GHz	3x5 km		

3. FALSE SEA ICE

Figure 2 shows the AMSR2 sea ice concentration images of the test site for the continuous three days. A certain "sea ice area" (indicated by red circle) is observed on the second day which does not exist on the first day or on the third day. It is not realistic for sea ice to widely appear within one day(March 2) and disappear by the next day(March 3).This is an example of "false sea ice" where certain sea ice concentrations were calculated over open water due to the weather effects.



(a)March 1, 2013 (b) March 2, 2013 (c) March 3, 2013

Figure 2. AMSR2 sea ice concentration images of the Sea of Okhotsk for the continuous three days

4. METHODOLOGY

In sea ice concentration algorithms, such as AMSR2 Bootstrap Algorithm, weather filters are applied to reduce the atmospheric effects. The basic idea of weather filters is to set the sea ice concentration of a pixel to zero when the pixel meets certain condition. In AMSR2 Bootstrap Algorithm, if the pixel meets the following equations, the sea ice concentration of the pixel will be set to zero.

$$(TB23V - TB19V) > 18(K) \quad (1)$$

Where TB23V, TB19V are brightness temperatures of the vertical polarizations(V) of 23GHz and 19GHz respectively. The weather filter work well in many cases but not always. The authors have selected sample areas of false sea ice area, sea ice and open water from the AMSR2 sea ice concentration(IC) image of the test site observed on January 29, 2014 as sown on Figure 3. Figure 4 shows the scatter plots of those sample areas in (TB23V-

TB19V) vs (TB19V) domain. Blue mesh area indicates the pixels to be rejected as false sea ice. The scatter plot clearly shows that the current weather filter cannot reject most of the false sea ice areas in this case. To improve this, changing the threshold level from 18K to 8K could be one solution (see Figure 5).

$$(TB23V\text{-}TB19V) > 8(K) \quad (2)$$

However, this may also reject sea ice area which brightness temperature of TB23V higher than 210K. To solve this problem, The authors have introduced a new characteristic domain of (TB36V－TB36H) vs TB23V as sown on Figure 6. By using this domain, the following two equations were introduced.

$$(TB36V\text{-}TB36H) > 57K \quad (3)$$

$$TB23V + 0.75 \times (TB36V - TB36H) < 250K \quad (4)$$

Figure 3. Sample area extraction from AMSR2 IC image (Sea of Okhotsk, AMSR2 Jan. 29, 2014)

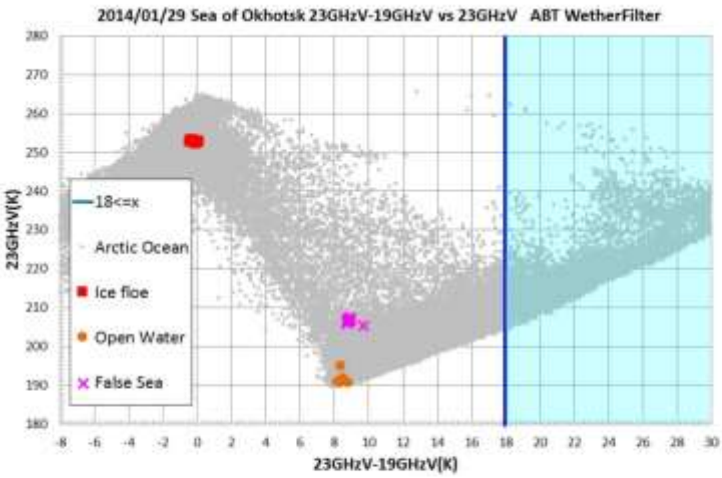


Figure 4. Weather filter threshold setting at 18K in the Scatter plot of (TB23V-TB19V) vs (TB19V) (Sea of Okhotsk, Jan. 29, 2014)

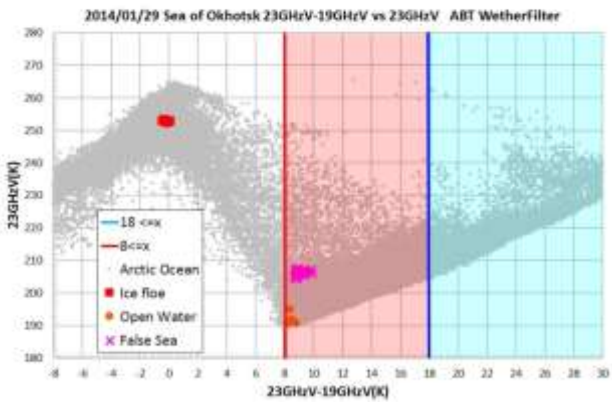


Figure 5. Weather filter threshold setting at 8K in the Scatter plot of (TB23V-TB19V) vs (TB19V) (Sea of Okhotsk, AMSR2 Jan. 29, 2014)

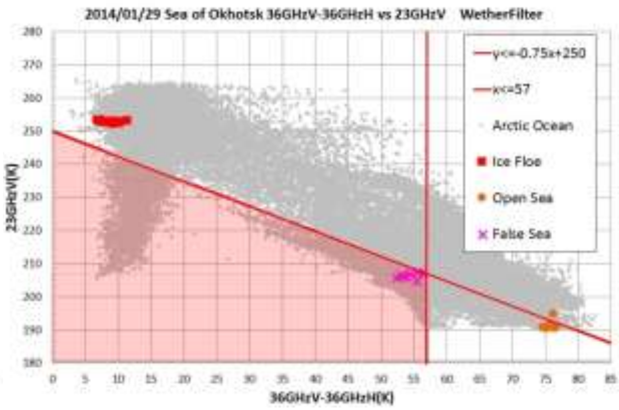
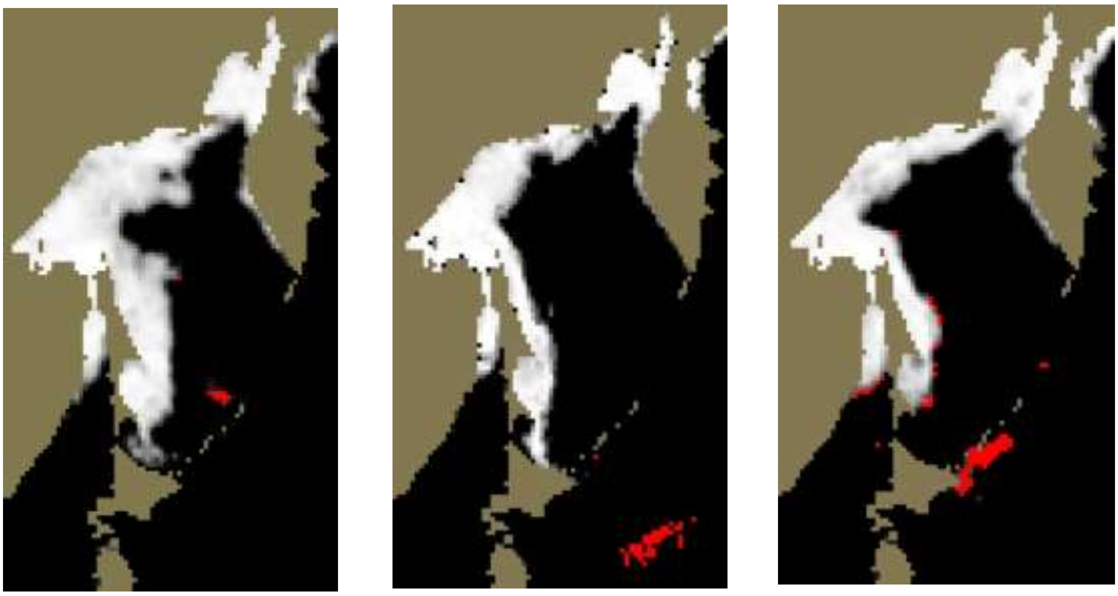


Figure 6. New weather filter setting in the Scatter plot of (TB36V-TB36H) vs (TB23V) (Sea of Okhotsk, AMSR2 Jan. 29, 2014)

5. RESULT

Figure 7(a) shows the result of applying the new weather filter to the AMSR2 sea ice concentration image of the Sea of Okhotsk observed on January 29, 2014. The red colored areas are the false sea ice areas rejected by the new weather filter. Most of the false sea ice areas were well extracted without rejecting the real sea ice. Figure 7(b) shows another example of the date February, 3, 2015. This also showed good result However in case of January 19, 2016 as shown on Figure 7(c), though most of the false sea ice areas were well rejected, some of the true sea ice along the marginal sea ice areas were also rejected.



(a) January 29, 2014 (b) February 3, 2015 (c) January 19, 2016

Figure 6. Effect of false sea ice rejection with the new weather filter (Sea of Okhotsk, AMSR2)

6. CONCLUSION

In this study, authors have introduced a new weather filter for rejecting false sea ice appearing in the sea ice concentration data derived from AMSR2 for the Sea of Okhotsk . The initial result suggested the most of the false sea ice produced by the weather effects could be rejected with the new filter. However, in some cases, some true sea ice areas were also rejected with the filter. We may need some more case study to optimize the parameters of the filter.

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