Proposal Draft: ARCTIC SEA ICE CONCENTRATION SENSITIVITY STUDY

Statement of the Problem

Arctic Sea Ice evolution represents one of the main topic of interest within the climate change studies. In the last thirty years, the satellites gave the possibility to retrieve observations of the Arctic region. In fact, thank to remote sensing technologies, it was possible to confirm that both thickness and extent of sea ice in the Arctic have shown a dramatic decline. This evidence is consisistent with observations of a warming Arctic. Moreover, due to its high reflectivity, the loss of sea ice also has the potential to accelerate global warming trends and to change climate patterns.

For this and many other reasons, Arctic Sea Ice is a "hot" topic in the actual scientific research. Scientists are focusing their effort to many aspects of the issue. However, the main parameter of study is sea ice extent, which is a measurement of the area of ocean where there is at least some sea ice. Tipically, in order to estimate sea ice extent, scientists define a threshold of minimum concentration to mark the ice edge; the most common cutoff is at 15 percent. Experts use the 15 percent cutoff because it provides the most consistent agreement between satellite and ground observations. Also, such a small threshold is mainly due to the impossibility of detect melting ice during summer, since it appears like water to the satellites. Nevertheless, in order to improve the sea ice extent estimation, it is crucial to further study the influence of sea ice concentration during the different periods of the year.
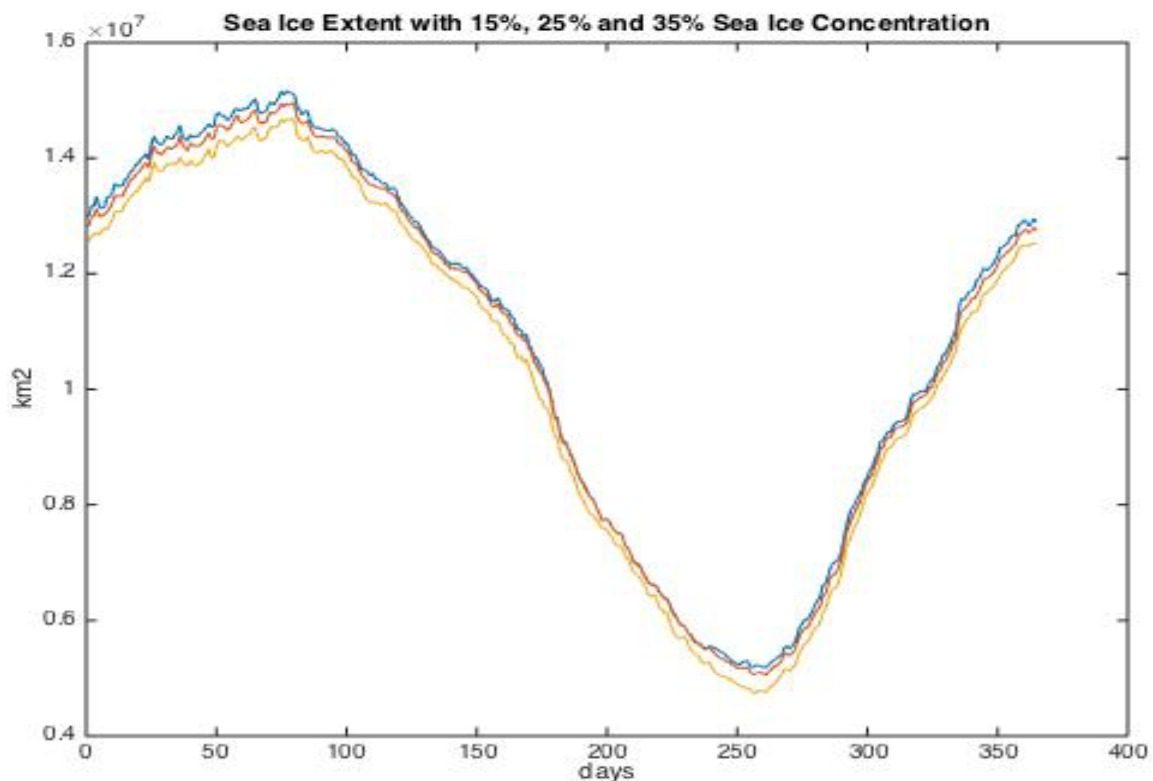

Figure 1. Sea Ice Extent with 15%, 25% and 35% Sea Ice Concentration cutoff, for 2014.

As a preliminary understanding of sea ice concentration sensitivity, sea ice extent graphs were retrieved according to a 15%. 25% and 35% sea ice concentration threshold. Several other percentages can also be considered. Data used are provided by NOAA/NSIDC Climate Data Record of Passive Microwave Sea Ice Concentration, Version 2. Data are available from 1978 to December 2014, also the spatial resolution is 25 km. The following graphs intend to show a preliminary analysis of the sea ice concentration influence to sea ice extent. Figure 1 shows the sea ice extent evolution for year 2014, considering a sea ice concentration cutoff of 15%, 25% and 35% respectively. On the other hand, figure 2 shows the sea ice extent difference for year 2014, considering a sea ice concentration of 15%, 25% and 35% respectively. Figure 2 also shows the sea ice extent difference in percentage for year 2014, considering a sea ice concentration threshold of 15%, 25% and 35% respectively.
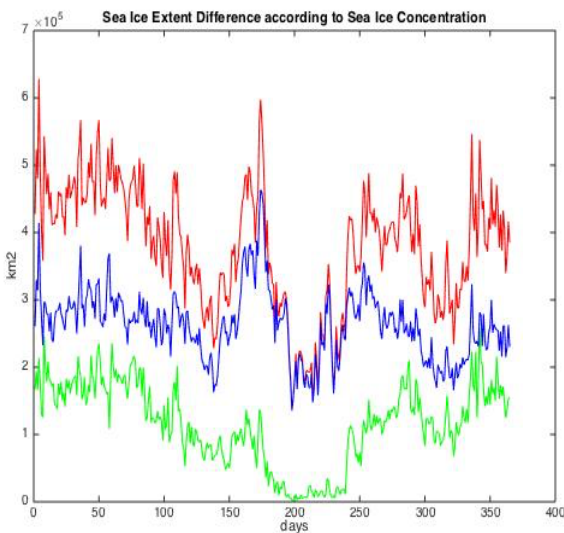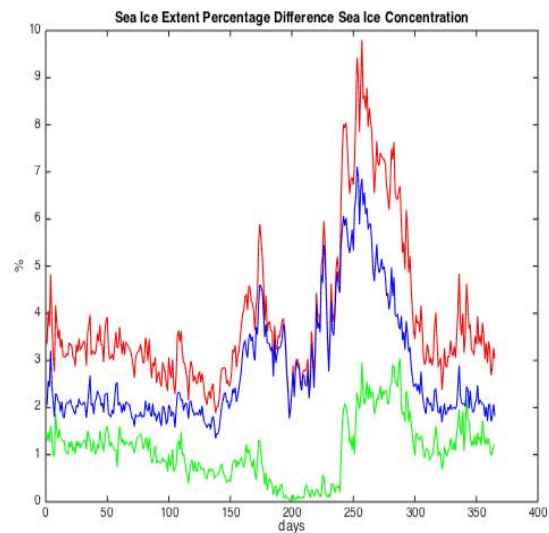
(a)   (b)

Sea Ice Concentration threshold, for 2014 (a). Sea Ice Extent Percentage Difference between 15% and 35% (red), 15% and 25% (blue), 25% and 35% (green) Sea Ice Concentration threshold, for 2014 (b).

As it can be seen in the previous figures, a different sea ice concentration cutoff determines a significant change in Arctic sea ice extent estimation, up to a 600000 square kilometers difference, considering the change from 35% to 15% concentration thresholds (a). Moreover, the difference of sea ice extent estimations varies remarkably accordingly to the period of the year; for instance, the end of the melting season shows the highest percentage difference due to the annual minimum of sea ice extent (b). It is therefore crucial to retrieve a Sea Ice Concentration threshold that can represent the reality as accurately as possible.

Objectives

The general scope of this research is to analyse te sea ice concentration sensitivity and influence to sea ice exent estimate in order evaluate the potential of a dynamic sea ice concentration threshold. Also, this work aims to improve the ice extent estimates retrieved from different satellite sources. In summary, the objectives of this study are the following:

- ➢ Scientific understanding of Sea Ice Concentration influence to Sea Ice Extent estimate:
- ➢ Evaluation of the potential use of a Dynamic Sea Ice Concentration cutoff;
- ➢ Dynamic Sea Ice Concentration threshold table or formualtion;

Hypotheses

Arctic Sea Ice Concentration is seasonally changing and Sea Ice Extent is singnificantly influenced by this phenomenon. A dynamic Sea Ice Concentration threshold will improve the Sea Ice Extent estimate giving a more accurate and phisically sound product.

Potential Data Sources

Different passive microwave Sea Ice Concentration data sets will be taken into consideration. As a general rule, this research requires sources having a daily temporal resolution and different spatial resolution. In this regard, the National Snow and Ice Data Center provides several products. The previously mentioned NOAA/NSIDC Climate Data Record of Passive Microwave Sea Ice Concentration, Version 2, is a 25 km spatial resolution source. In order to use diverse spatial resolutions, also the AMSR-E/Aqua Daily L3 12.5 km Brightness Temperature, Sea Ice Concentration, & Snow Depth Polar Grids, Version 3, will be taken into account. As a term of comparison the Multisensor Analyzed Sea Ice Extent - Northern Hemisphere (MASIE-NH), Version 1, provides daily Sea Ice Extent since October 2006 with a 4 km spatial resolution. Other potential data sources can be considered to have a more diversified data availability, either in terms of spatial and temporal resolution. Finally, Sea Ice Extent products may be taken into account as a baseline to calibrate Sea Ice Concentration dynamic threshold.

Research Approach and Work Plan

From a methodology point of view, in order to obtain a dynamic sea ice concentration cutoff, we will focus on improving agreement between different satellite observations having variuos spatial resolution, as mentioned in the data sources paragraph. According to their availability, Sea Ice Concentration data sets will be used to obtain multiple daily Sea Ice Extent estimates computed with changing Sea Ice Concentration thresholds. In this regard an evaluation of the sources available will be carried out in order to finally select the most updated and recent data sets as well as providing diverse spatial resolution and daily temporal resolution.

As a second step, a calibration algorithm will be developed. This will give the possibility to analyse and compare the Sea Ice Concentration products. Different thresholds will be implemented and tested and consequently the respective Sea Ice Estimates obtained will be investigated and compared to each other by using statistical analsis such as the coefficient of determination and mimimum mean square error, for instance. Additionally, Sea Ice Extent data sources will be used as a baseline to calibrate the Sea Ice Concentration dynamic values from the respective satellite data sets. In this way, a seasonal dynamic Sea Ice Concentration threshold would be obtained as a result of best statistical agreement amongst the data sets investigated. A qualitative validation of the results obtained will be also carried out to ensure validity of the results.

Potential Deliverables and Timing

This project is planned for about 18 months. The first months will be used in order to gather and evaluate the data sources. The development of the calibration algorithm would take about one year. Lastly, the final months will be reserved for the determination of the dynamic Sea Ice Concentration product and finalize the deliverables. In conclusion, the potential deliverables of the research would be a calibration algorithm capable to digest different data sources as well as the dynamic Sea Ice Concentration formulation. A scientific paper will be the produced too. The following Task/Time table summarizes the research tasks and expected timing to achieve them.

TASK/TIME SCHEDULE

Task	Trimesters					
	I	II	III	IV	V	VI
Evaluation of Sea Ice Concentration sources	▓	▓				
Calibration algorithm development		▓	▓	▓	▓	
Determination of Dynamic Sea Ice Concentration Threshold					▓	▓