Law of the Sea, the Continental Shelf, and Marine Research

The question of the amount of seabed to which a coastal nation is entitled is addressed in the United Nations Convention on the Law of the Sea (UNCLOS). This treaty, ratified by 153 nations and in force since 1994, specifies national obligations, rights, and jurisdiction in the oceans, and it allows nations a continental shelf out to at least 200 nautical miles or to a maritime boundary.

Article 76 (A76) of the convention enables coastal nations to establish their continental shelf beyond 200 nautical miles and therefore to control, among other things, access for scientific research and the use of seabed resources that would otherwise be considered to lie beyond national jurisdiction. To date, 37 nations have submitted for extended continental shelves (ECS) that have been filed under UNCLOS (Table 1). These submissions have been the subject of considerable debate about their potential to expand the ECS beyond the 200 nautical mile limit.

The boundaries of the continental shelf are defined between the base of the continental slope and the rise of the continental margin. The rise is defined as the transition from deep oceanic sediments to shallow marine sediments. The rise is considered the boundary of the continental shelf.

Two alternative methods for determining the ECS are defined in A76:

1. Sediment thickness: The continental shelf is considered to extend from the base of the continental slope to a depth where the sediment thickness equals one-tenth of the water depth.
2. Geophysical criteria: The continental shelf is considered to extend from the base of the continental slope to the depth where the geophysical characteristics of the sediments change.

In practice, these methods are often used in combination to establish the ECS.

New Data Set of Onset of Annual Snowmelt on Antarctic Sea Ice

The annual onset of snowmelt on sea ice is an important process because it triggers a decrease in surface albedo that leads to a warming of the surface. This warming, in turn, leads to an increase in the melt rate of the sea ice. The melt rate is controlled by several factors, including the ice thickness, the temperature of the ocean, and the solar radiation that reaches the surface of the ice.

In the Antarctic, the annual onset of snowmelt has long been a subject of scientific interest. The onset of snowmelt is typically defined as the first day on which the surface temperature of the sea ice falls below freezing. This definition is based on the assumption that the sea ice is at equilibrium with the atmosphere and that the surface temperature is a good indicator of the internal temperature of the ice.

However, recent studies have shown that the onset of snowmelt is not always preceded by a decrease in the surface temperature of the sea ice. In some cases, the surface temperature may actually increase before the onset of snowmelt. This phenomenon is known as the “temperature cliff” and has been observed in both the Arctic and Antarctic regions.

In the Arctic, the temperature cliff has been observed to occur in late spring and early summer, when the sun is at a high angle in the sky. In the Antarctic, the temperature cliff has been observed to occur in early summer, when the sun is at a low angle in the sky.

In both regions, the temperature cliff is thought to be caused by the heating of the ocean surface by the sunlight, which is absorbed by the sea ice and then transferred to the ice below. This heating of the ocean surface can lead to an increase in the melt rate of the sea ice, even though the surface temperature of the ice may not have decreased.

In conclusion, the onset of snowmelt on sea ice is a complex process that is controlled by several factors, including the ice thickness, the temperature of the ocean, and the solar radiation that reaches the surface of the ice. Further research is needed to better understand the factors that control the onset of snowmelt and to improve our ability to predict the onset of snowmelt on sea ice.
Snowmelt

Fig. 1. Evolution of surface brightness temperature (37 gigahertz, vertical polarization) from Special Sensor Microwave/Imager (SSMI) swath data (black dots) and moving average (n = 31, grey line) in the western Weddell Sea (67.8°S, 55.4°W), October 2004 to March 2005. The identified melt season is highlighted by the shaded box.

makes daily averages of $T_d$, to identify the onset of

Recapitulating our in situ measurements together with extensive analysis of satellite data, we suggest here that the summer melt period on Antarctic sea ice be defined through enhanced diurnal variability in snow wetness and thus emissivity and $T_d$. Thereby, the onset of melt can be identified from microwave data that provide at least twice-daily observations of the sea ice surface.

We used Special Sensor Microwave/Imager (SSMI) swath data in combination with the ISPOL field data to investigate the potential of satellite data for the long-term observation of melt dynamics on Antarctic sea ice. Results show the summer period to be clearly delineated against the seasonal cycle of diurnal $T_d$ (Figure 1). Hence, we consider the diurnal $T_d$ variability a reliable indicator for melt processes within the snowpack on Antarctic sea ice while the evolution of daily averages of $T_d$ and radar backscatter is strongly biased by snow depth, the level of snow metamorphism, and ice type.

Melt Detection Algorithm and Data Product

On the basis of our findings, we developed a simple algorithm (Melt Detection Algorithm, MeDoA) to identify the onset of the annual summer melt period on Antarctic sea ice. MeDoA detects the first date with the 5-day average of the diurnal $T_d$ amplitude exceeding a threshold of 10 K for at least 3 consecutive days in the period from 1 October to 31 March. The threshold and the moving-window sizes were chosen after careful examination of ground truth data and coincident satellite observations. However, as the significance of freeze-thaw cycle strengthening during summer shows large spatial variations, a threshold adjustment is necessary, for example, 12.5 K decreases the total amount of detected melt flags by approximately 20%.

This affects mostly sea ice in the marginal ice zone, where diurnal amplitudes of $T_d$ increase early, but are not very strong throughout each summer. For the remaining ice cover, moderate variations of threshold and interdiurnal averaging caused only minor changes of the results presented in Figure 2.

We force the algorithm with twice-daily surface $T_d$ from the SSMI Pathfinder data set, which provides microwave $T_d$ data from 1987 to the present. Twenty years of summer $T_d$ were processed and combined in a comprehensive data set called Melt Detection on Antarctic Sea Ice (MeDoA). The MeDoA product includes (1) the annual date of snowmelt onset (Figure 2), (2) the annual date of freeze onset (3) the duration of summer melt and (4) the daily strength of the diurnal $T_d$ cycle from 1 October to 31 March for the entire area of Antarctic sea ice from 1987 to 2007. The duration of summer melt can only be mapped for areas of perennial sea ice because most often ice breakup occurs earlier than the defined onset of steady freezing.

Melt-onset detection provides encouraging results. For example, MeDoA detects snowmelt to commence later at higher latitudes and earliest at the marginal ice zone of the Weddell Sea (Figure 2) in the summer of 2004–2005, whereas in the western Pacific and Indian ocean sectors snowmelt occurs relatively co-existent in coastal areas where sea ice does not retreat too fast for significant melt processes to take place.

The new algorithm can be used to map interannual variations in summer melt characteristics throughout each summer. There is considerable opportunity to use this new melt data set for climate studies, including the development and validation of general circulation model outputs, as well as for the detection of climate change signals. This new product is now available online at the Web site of the Department of Environmental Meteorology at the University of Trier (http://klima.uni-trier.de).

References


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Author Information

Sascha Willmes, Department of Environmental Meteorology, University of Trier, Trier, Germany. E-Mail: willmes@uni-trier.de; Jörg Bareiss, Department of Environmental Meteorology, University of Trier and Christian Haas, Alfred-Wegener-Institute for Polar and Marine Research, Bremerhaven, Germany.