ANIMATION AND STEREO PRODUCTS FROM ATSR TO SUPPORT OPERATIONAL AND CLIMATIC MONITORING OF ARCTIC SEA ICE

Mohammed Shokr, Atmospheric Environment Service, 4906 Dufferin St., Toronto, Thornhill, Ontario, Canada, M3H 5T4 email: mohammed.shokr@ec.gc.ca
Hao Le, Flashback Imaging, 15 Keefer Court, Ontario, Canada, L4J 5Y4
email:flasbak@interlog.com

ABSTRACT
ATSR-1 and ATSR-2 images over the western Arctic region during the winter season of 1995/1996 were acquired and used to explore their utility in operational and climatic applications. Information on large-scale ice motion, cloud cover and surface temperatures was retrieved. Statistics of leads and polynyas occurring at a scale of a few kilometers were determined and the large-scale Beaufourt Sea dynamics was identified for the first time at the fine resolution of ATSR. Stereo images were generated from the two ATSR views to reveal cloud cover over sea ice. Cloud height can be estimated visually and the ice/cloud discrimination can be easily achieved. Ice surface temperature was calculated from the two ATSR IR(using the two viewing angles) and compared to temperature estimates from AVHRR. Advantages of using ATSR over AVHRR will be presented. A novel technique of image browsing and animation will be also presented to demonstrate the monochromatic and the stereo image animation.

INTRODUCTION

Spatial and temporal coverage of sea ice in the Arctic is needed to support marine operations and to provide clues regarding the question of global climate change. An extensive record of Arctic sea ice from the passive microwave sensors (SMMR and SSM/I) has recently been completed and used to quantify the seasonal distribution and the interannual variability of ice parameters (Parkinson et al. 1999). The advantage of these sensors is their wide coverage and their continuous record, but their resolution is too coarse to identify small-scale features such as leads, polynyas and individual ice floes. Those features are most important from both marine operational and climatic views. For marine operations, they represent navigable routs or local hazards. For climatic applications, leads, polynyas and marginal ice zones play a significant role in energy exchange between to ocean and atmosphere. The objective of this study is to
demonstrate the utility of ATSR in retrieval of information about Arctic sea ice. A sample record of ATSR images over the western Arctic region, from Nov. 1995 to Dec. 22 1995, has been used to demonstrate the type of retrieved information and the retrieval tools. We intend to expand the application of those tools to the entire record of ATSR over finite areas in the Arctic basin where active polynyas and marginal ice zones exist to explore the variability of operational and climate-related ice parameters.

Three approaches have been used in this study:
1. Animation of ATSR brightness temperature to display synoptic- and

meso-scale ice dynamic processes in relation to synoptic meteorological forcing.
2. Generation of stereo images from the ATSR nadir and forward viewing to visualize clouds over sea ice and to resolve ice/cloud ambiguities.
3. Estimation of sea ice surface temperature from ATSR data to identify the onset of ice surface melt

Description of the three approaches and presentation of sample results are introduced in the following:

DATA SET

A total of 283 frames from ATSR-1 and ATSR-2 were provided by ESA under the project AO3-109. The images were acquired during the period Nov. 1 to Dec. 22 1995 when the two sensors were operating in their tandem mode. The geographic area is the eastern region of Beaufourt Sea that includes the west coast of Banks Island. The tandem operation of the two satellites allowed daily acquisition of approximately 6-8 frames over a fairly extensive area. This was necessary to observe synoptic scale ice motion patterns. The images were geographically corrected and registered against a geographic map of the western Arctic, produced in the polarstereo projection. The registration was achieved using the latitude and longitude values at each pixel (which were included in the data). Corrections were also applied to replace wrong radiometric values. All images were obtained from descending orbits at the same time of the day (around 22:00 hrs GMT).
This allows mosaic of images from different orbits in the same day.

ANIMATION OF ATSR IMAGES

The image animation was performed using a novel image browsing and animation software developed by Flasback Imaging of Thornhill, Ontario, Canada. It can animate thousands of very large images in a few minutes. This was made possible because the images are brought to the display directly from the hard disk rather than the randomn access memory (RAM). As such, the image size and the animation speed are not limited by the available RAM. The software can run on conventional desktop PCs and is coupled with a user-friendly interface.

The animation showed the large-scale Beaufourt Sea gyre in action; with ice motion driven by the surface wind which blows in the direction normal to the atmospheric pressure gradient lines. Convergence and divergence of the pack ice are revealed. The coastal polynya off Banks Island is observed in its formation, deformation and diminishing phases. Leads are also observed at the relatively fine resolution of ATSR.
Two advantages of ATSR over AVHRR image animation were noticed. The first is the observation of narrow leads in ATSR, due to its finer resolution. The second is the uniformity of the grey tone distribution in ATSR over the same ground target across the swath. This is achieved because of the relatively narrow swath of ATSR (approximately 250 km at each side from the satellite sub-track). In AVHRR, on the other hand, the swath is too wide to warrant equal radiometric observation from the same target at the opposite ends of the swath. A common drawback in AVHRR animation is the seams between sequential images because images are

usually extracted from different parts of the 2400 km wide swath. No seams were observed in the animated ATSR images. Samples of the animation product are available upon request from the authors.

ATSR STEREO PRODUCT

Stereo images were produced from the nadir and forward views of the 11m IR channel. In this product, the clouds became visible and distinguished from the background ice. The clouds can be classified visually into two basic categories: high and low. The stereo product is very useful to support interpretation of ice types in ATSR images and perhaps in coincident images from other remote sensors (AVHRR, SAR, etc.). In many situations it was not clear whether a segment in an image represents ice or cloud. The decision became obvious upon examining the stereo image. The stereo product can also be displayed in the animated mode.

The availability of the double viewing, and hence the stereo product from ATSR furnishes a major advantage over AVHRR. This product can be used not only to facilitate identification of ground targets but also to develop /or verify algorithms of cloud removal. Admittedly, the shortcoming of ATSR is it's limited swath, and therefore spatial coverage, with respect to AVHRR.

ICE SURFACE TEMPERATURE FROM ATSR

The ice surface temperature from ATSR-1 data was calculated following the method presented by Key et al. (1997). The values are reasonable, in general, and in agreement with the available data of atmospheric temperature from Sachs Harbour station in Banks Island. These results, however, should be validated against ground observations (e.g. temperature sensors on buoys) or surface temperature estimates from other sensors. It was intended to compare the ATSR-derived surface temperature to the AVHRR-derived temperatures. Unfortunately, the AVHRR data set for the same period was damaged and unrecoverable. The comparison will be pursued in the future using another set of ATSR data for which AVHRR data are available.

OVERALL ASSESSMENT AND RECOMMENDATIONS

The animation product has been proven to be a successful tool for analyzing the extensive record of ATSR archive. It can be used in operational and climate archive centers to investigate seasonal, regional and interannual variability of ice parameters and to explore climate-related trends. It is recommended to generate animation for areas of active ice production such as polynyas, over the entire period of ATSR-1 and ATSR-2 lifetime, to monitor and map thin ice types. These types are by far most important for marine navigation and ice climate archive. They encompass small-scale features (e.g. leads) which can be captured by the ATSR fine-resolution footprint.

The stereo product has potential for operational programs because of it's capability to discriminate ice from cloud. A main obstacle of the operational use of ATSR in national ice services is the difficulty of near-real-time accessibility.

It must be mentioned that the temporal coverage of ground regions (including the Arctic) by ATSR is not frequent enough to warrant monitoring of cloud motion.

The ice surface temperature is an important operational parameter because it can be used as an indicator of surface melt and ice breakup. If it is proven to be more accurately-derived from ATSR than AVHRR, then chances of operational uses of ATSR will be enhanced.

REFERENCES

Parkinson,C.L, Cavalieri,D.J. Gloersen,P., Zawally,H.J, and Comiso,J.C.,
1999, "Variability of the Arctic sea ice cover 1978-1996,", J. of Geophysical Research, submitted.

Key,R.J., Collins,J.B, Fowler,C., and Stone,R.S., (1997), "High-latitude surface temperature estimates from thermal satellite data,", Remote Sensing of the Environment., Vol. 61, pp.302-309.