Antarctic Remote Ice Sensing Experiment (ARISE) with Australian National Antarctic Research Expedition in 2003

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Abstract

An extensive sea ice experiment was conducted in East Antarctic seasonal sea ice area. The primary objective of the experiment was to validate sea ice products retrieved from new passive microwave satellite sensors, AMSR and AMSR-E and also to assess the performance of conventional algorithms. New instruments to measure ice thickness and snow depth over sea ice were also tested. The challenge was to collect enough data sufficient enough to validate AMSR and AMSR-E having wide pixel size. To overcome this, four different types of data having different areal coverage and altitude, in situ data from ice stations and helicopter floe hopping, aerial photography and video and along-track underway data were obtained. All these data complement each other and combined with visible range satellite data, the validation process is completed.

1.Introduction

Antarctic Remote Ice Sensing Experiment (ARISE), as part of Voyage 1 of *RSV Aurora Australis* for 2003/04 season was carried out in a region off the East Antarctic coast. The voyage was 49 days long, from 11 September to 30 October, of which 30 days were dedicated to the ARISE program. This program was a joint international effort (over 20 institutions from 6 different nations) to survey the sea ice and snow cover conditions in the area bounded by 64-65° S and 112-119° E (*Fig. 1*), with the main purpose being to acquire data for validation of both conventional and new satellite sea ice sensing systems using various instruments.

Japanese group focused on validating ADEOS II AMSR (Advanced Microwave Scanning Radiometer) sea ice products, through *in situ*, underway and aerial data acquisition.

Validation process is now underway. Data compiled during the voyage are being compared with AMSR data, also with visible range satellite data to extend the spatial coverage.

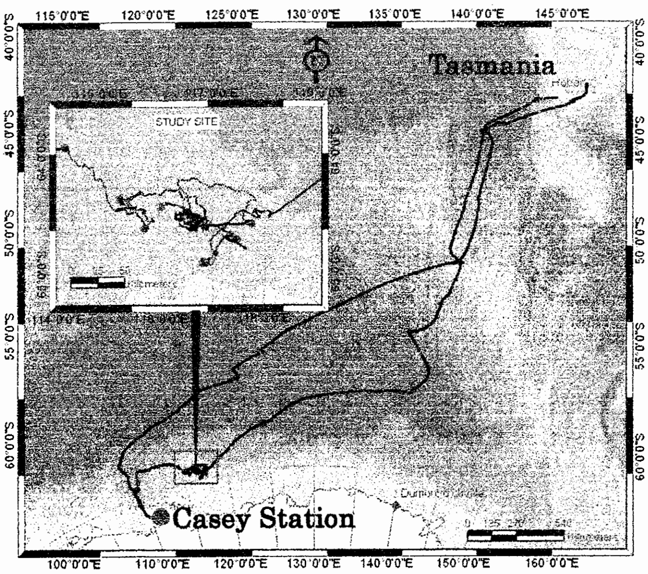

Fig.1 Ship's route between Hobart, Tasmania and Antarctica. Onset map shows the area in where the ARISE program was conducted. (©ACE CRC, 2003)

2. Program overview

Passive microwave remote sensing of sea ice in both north and south poles dates back to 1972, started with data collection by Electrically Scanning Microwave Radiometer (ESMR) in the Nimbus 5 (Cavalieri, 1992). Improvement of satellite microwave radiometers have been attempted by various nations and two new radiometers, AMSR (Advanced Microwave Scanning Radiometers) onboard Japanese satellite ADEOS II and AMSR-E onboard NASA's AQUA were launched in 2002. ARISE was aimed to validate sea ice concentration and extent, ice physical temperature and snow cover on sea ice retrieved by the new sensors. An attempt to validate and quantify error characteristics to improve the existing ice concentration algorithms such as the Bootstrap algorithm (Comiso, et al., 1997), was also a key component of this experiment.

Measurement strategy to collect sufficient data, to adequately validate AMSR and AMSR-E data products, consisted of ice stations, helicopter floe hopping, aerial photography and video filming and underway data collections from ship-borne sensors.

2.1 Ice stations

In order to obtain detailed *in situ* data on snow and ice properties, 13 ice stations were carried out. During the stations, which lasted for about 5 hours each, 50-100m transects were laid and snow and ice thickness, ice freeboard and snow/ice interface temperature were measured at 1m interval. Three snow pit works and ice core collections were conducted at 0m, 50m and 100m points of each transect. Ice cores were later processed and analysed in cold room for sea ice structural studies. Exceptions were station 4, which lasted for three days and transect stretched to three 500m lines, and station 6 where only snow depth was measured.

Other ice station works involved the measurements of ice thickness by EMIs (Electro Magnetic Induction devices) from Australian group and Japanese group, German ground penetrating radar and new radar system developed by Radar Systems & Remote Sensing Laboratory, University of Kansas, for measuring ice and snow thickness. Data from these instruments were calibrated against measurements of snow thickness and ice thickness along transects.

Although data acquired at each ice stations are only 'point' data compared to the resolution of AMSR and AMSR-E, they will help us develop more understanding of parameters affecting satellite observed data and enhance conventional algorithms and perhaps develop new ones.

2.2 Helicopter floe hopping

Ice physical temperature and snow cover thickness over sea ice are new standard products. One of the Australian group's focuses of this experiment was to validate those products. In order to achieve this at the AMSR pixel (10km) scale, snow/ice interface temperature and snow thickness were measured on numerous floes of different regimes. And the measurements were averaged Each floe was accessed by helicopter and snow thickness was measured at up to 40 different locations and snow/ice interface temperature at about 8 locations. Total number of floe accessed was 181.

2.3 Aerial photographing and video filming

Another strategy to overcome the large AMSR pixel size was aerial digital photographing conducted by Australian group and aerial video filming by Japanese group. Both aimed at collecting data for comparison with satellite derived sea ice concentration. Australian digital still camera (Nikon D1x) was fitted to the floor window on one of the helicopters onboard viewing the surface vertically, and photographing from 5000 feet in altitude. They successfully completed 7 flights on 5 clear days, each lasting over 2 hours. Digital photographs are in hi-colour TIFF format and will be made into mosaic images.

Japanese video camera (SONY TRV-900) was also mounted to the helicopter floor window looking vertically down, with the calculated image width being around 2100m from 8000 feet above sea level. Video was recorded in progressive scan which makes up footage with 15 separate frames per second, and enables smoother construction of continuous mosaic images.

Filming was carried out on 19 October when the weather condition was most favourable i.e. cloudless condition. The flight was nearly three hours long however the actual recorded video footage of use for validation purpose is about 60 minutes long. It follows the ship's track in the first 30 minutes, starting at around 65° 27′ S, 109 ° 30′ E going almost due north past the ship, and until cloud cover started to appear at around 64° 05′ S.

Footage covers transitional area from very thin new ice of about 5-10cm in thickness forming over coastal polynya, to unconsolidated or small broken up floes of a few tens of meters in diameters up to about 70cm thick, to consolidated large floes extending to a few hundred meters to kilometre scale and thickness around 1m.

This video filming proved to be an extremely useful validation tool. Not only it gave us wide areal coverage, it clearly shows thin new ice over coastal polynya which is hard to distinguish in MODIS images that will be used as a medium resolution validation data. Mosaic images developed from the video footage (*Fig. 2*) will be used as a reference to MODIS images in the actual validation process of AMSR derived sea ice concentration.

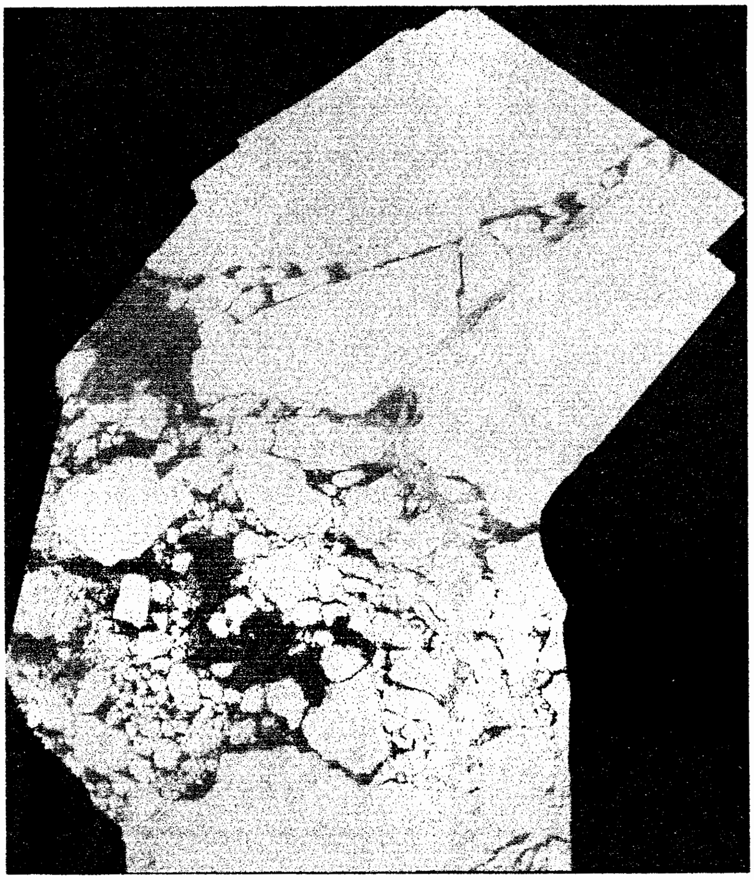

Fig.2. Example of a mosaic image constructed from aerial video footage.

2.4 Underway data

Supplementing the data from above three types of observations are underway data collected along the ship's track. Japanese group installed two 8mm analogue video cameras (SONY TR-11), one on the rail above the bridge (herein after referred to as roof deck camera) viewing the area straight ahead of the ship and another one on the port side rail. looking downwards (side camera).

Roof deck camera was used for continuously recording of ice conditions along the ship's track (*Fig. 3*). Aerial video data is also complemented by video footage from roof deck camera because roof deck camera gives a closer look at sea ice and can show smaller scale detail than aerial video i.e. differentiate open water and ice with thickness of less than 5 cm that is hard to achieve with aerial video alone. More details on the utilization of roof deck camera will be given in a later section. The total duration of roof deck video footage is nearly 140 hours.

Side camera was used to film ice floes turning on its side as the ship breaks ice (*Fig. 4*). Ice thickness can be measured visually by selecting floes that turn almost 90° on its side showing the broken facies. About

130 hours of video footage from side camera was collected.

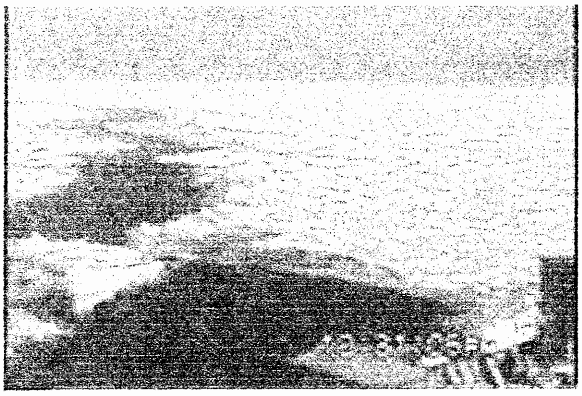

Fig.3 One scene from roof deck camera

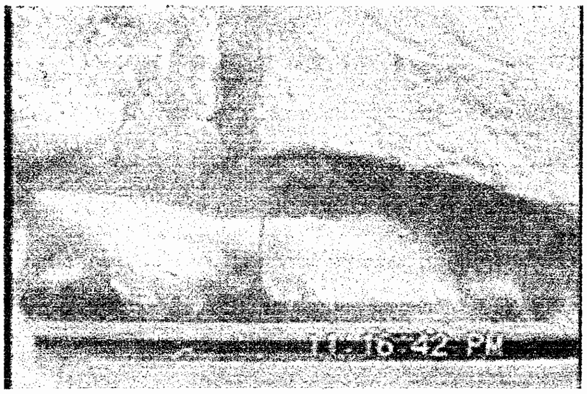

Fig.4 One scene from side camera

3. Validation of sea ice concentration derived from AMSR/AMSR-E data

Here we will briefly present the method for validation of sea ice concentration derived from AMSR/AMSR-E, using data acquired during ARISE and satellite data acquired later.

The primary tool in the validation process is the images from MODIS in the visible 250m channel, although data collected during ARISE is indispensable. MODIS achieves wide spatial coverage and relatively high resolution at the same time. Cloud free images will be selected and of desired area will be cut out.

First, within the cut-out image of MODIS, pixels with sea ice cover and open water will be distinguished. This is achieved by determining threshold DN (Digital Number) value in grey scale which differentiate sea ice and open water. Both images from roof deck camera and aerial video are effective in threshold determination because of difficulty in detecting thin new ice in MODIS images as discussed in the previous section. The image will then be made into binary image, giving white or 1 for pixel with sea ice coverage and black or 0 for open water.

Then to determine ice concentration, the number of pixels with value 1 will be counted within 10km grid corresponding to 1 pixel of AMSR/AMSR-E. For example, if the 10km grid has 1600 pixels with 1, then the concentration is 100% and if 800 pixels, then the concentration is 50%.

Sea ice concentration images derived from AMSR/AMSR-E and MOSDIS are compared and the error percentage of AMSR/AMSR-E will be calculated. The target error percentage for ice concentration product is below10%.

4. Concluding remarks

ARISE was one of the most extensive programs ever conducted in the Antarctic sea to collect various types of measurements on sea ice. The primary objective of the program was acquisition of data to validate new satellite sensors and existent sea ice products. To overcome large pixel size of satellite microwave radiometers, detailed in situ data, helicopter floe hopping, aerial photographing and video filming and continuous along-the-way data were strategically acquired. Also, several new type sensor measurements were carried out during the program.

As for the Japanese effort to validate AMSR/AMSR-E derived standard sea ice products, method is established and is now in the analysis process. The results are expected to come out shortly and it is much anticipated that error percentage to be carefully assessed and algorithms be improved.

Further validations are already planned for 2004 and 2005. In February 2004, similar but smaller scale program than ARISE will be conducted in the Sea of Okhotsk using Japan Coast Guard patrol boat SOYA. Validation using air-borne microwave radiometer onboard NASA P3 aircraft in the Wedell and Bellingshausen/Amundsen Sea areas of Antarctica will take place in September 2004, as AASI (Antarctic AMSR-E Sea Ice) campaign. AASI is also planned for September 2005 in the Ross Sea areas.

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