Is The Number of Antarctic Icebergs Really Increasing?

Icebergs released from the ice shelves and glaciers of Antarctica account for the majority of the continent's freshwater flux into the ocean. It is estimated that an average of nearly 2000 kilometers of ice are released from continental ice shelves and glaciers each year. Much of this ice is released in the form of very large icebergs, some of which are as large as 295 km x 37 km.

A recent article by Hvidberg et al. [2001] notes that the number of icebergs around Antarctica appears to be on the rise, potentially heralding a climate trend. Examination of the National Ice Center (NIC) Antarctic iceberg data base tends to support the observation of an increase in the number of icebergs. Further driving the concern is the size of recently calved icebergs such as the largest ever observed, B15 measuring 295 km x 37 km, which calved from the Ross Ice Shelf in March 2000.

Does the increasing number of icebergs reported by the NIC reflect a climate trend or changes in the observation tools? To address this question, we used recently developed techniques that employ enhanced radar scatterometer data to observe icebergs to retrospectively analyze recent and historic scatterometer data sets. We found that the apparent trend in the NIC is primarily due to improved observation tools.

Iceberg Tracking

The US NIC is a multi-agency operational center supported by the US Navy, the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA), and the U.S. Coast Guard. The NIC's mission is to provide high-quality ice analysis and forecasts designed to meet the requirements of U.S. national interests (http://www.nsic.noaa.gov/).

To qualify for NIC tracking, an Antarctic iceberg must be at least 10 nautical miles along the long axis, be located south of 60°S, and be observed within the past 30 calendar days. An exception to the latter requirement is made for icebergs that are thought to be grounded. Observations of iceberg positions are made by shipboard observers and through interpretation of visual, infrared, and microwave satellite imagery. The NIC generally tracks these large icebergs until they break up in smaller bergs that no longer meet the tracking criteria.

Since ship observers are only occasionally available, the NIC relies primarily on satellite observations, visible and infrared images from the Operational Linescan System (OLS) aboard the Defense Meteorological Satellite Program (DMSP) satellites, and satellite series such as the Advanced Very High Resolution Radiometer (AVHRR) aboard NOAA's polar satellites. These data are used to create large-scale maps and track the movement of icebergs.

Microwave sensors, which can see through clouds and do not require solar illumination, have been used by the NIC to track icebergs in recent years. Synthetic aperture radar images from RADARSAT have a very high resolution of 100 m, and are better than historical data is. Most recently, enhanced resolution wind scatterometer images generated from SeaWinds on QuikSCAT (QSCAT) data have been added to the NIC tracking suite (Figure 1). The MODIS (Moderate Resolution Imaging Spectro Radiometer) Imager is another potential new tool.

A plot of the number of icebergs tracked by the NIC from 1976 to 2001 is shown in Figure 2. A marked increase in the number of icebergs observed is evident. The time between reported iceberg sightings by the NIC typically varies from 15 to 20 days. This is generally adequate for slow-moving icebergs, but it can contribute to loss-of-track during periods of rapid motion.

Scatterometer Iceberg Tracking

Wind scatterometers are microwave radar instruments that were originally designed to measure oceanic surface winds, though their data have proven extremely useful in a broad variety of ice and land applications, including climate change studies [Hunteman et al., 2001].

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The European Space Agency scatterometer (ESCAT) onboard the ERS-1 and ERS-2 satellites provided iceberg data from 1992 through early 2000. In operation, a scatterometer transmits radar pulses and receives backscattered energy. The return energy depends on the roughness and dielectric properties of the surface. The wide swath of scatterometers provides frequent global coverage at intrinsic sensor resolutions of 25-50 km. By combining multiple passes in a resolution enhancement algorithm [Hunteman and Long, 2001], an extensive time series of enhanced resolution radar backscatter imagery has been produced from data from these scatterometers. The time series is available from the Scatterometer Climate Record Pathfinder (SCPR) project at http://www.scp.byu.edu/.

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Icebergs originate as glacial ice and typically exhibit very high radar backscatter values. Over sea ice, the backscatter is sensitive to roughness and physical properties that vary by ice type and season, but the backscatter from sea ice is much lower than that of glacial ice. This contrast in backscatter values makes icebergs easily visible in scatterometer images (Figure 1). Though the image resolution is relatively coarse-ranging from 2.225 to 8.9 km/pixel depending on the sensor-larger tabular icebergs are readily visible in the scatterometer imagery. Surface melting can reduce the contrast during the summer months and complicate iceberg identification.

Separately examining the time series of scatterometer images for each sensor, the positions of each visible iceberg were identified and tracked as a function of time. Icebergs were subjectively identified using either motion at an image-stationary high-backscatter ice masses. Motion was observed by analyzing sequences of images and played a key role in ensuring proper identification. Image resolution limits the minimum size of an iceberg that can be observed to a few pixels in extent, resulting in some variation in the number of concurrent icebergs visible in different sensors, for example, ERS1 and NSCAT. However, all icebergs of minimum size as identified by the NIC were observed in the scatterometer image data set, and additional icebergs were found in all sensor image sets, resulting in an extensive data base of iceberg positions as a function of time.

Approximately 20% of the icebergs exhibited no discernible movement for at least part of the observation period, with one-fifth of these never showing any discernible movement. Most of the latter category are listed in the NIC data base and are grounded. The retrospective tracking data base provides higher temporal resolution, with positions recorded every 1-3 days, than the NIC’s 15-20 day positions and extends the range of iceberg tracking beyond the normal limit of 60°N used by the NIC. The data base also corrects some errors in the NIC data base such as inadvertent name changes lost tracks, and reporting errors (Figure 3). This comprehensive data base is a recent addition to the Scatterometer Climate Record Pathfinder (SCP) data base and is now publicly available (http://www.scp.byu.edu/).

Observations

The icebergs tracked by the NIC in the late 1970s are sporadic and few most likely due to the NIC’s limited access to coarse resolution satellite imagery and primarily visual and IR sensors during this time period. However, in the austral winter of 1978, NSCAT observed 14 large icebergs versus NIC’s two. During the early 1980s, the number of icebergs tracked at NIC was nearly constant, from 4 to 6, and these were mostly grounded. In 1986, the number of icebergs tracked by the NIC significantly increased to 10–15, coinciding with the introduction of the ERS1 to the tracking operations. Between 1987 and 1996, the number of NIC icebergs tracked increased, but this corresponded to the somewhat higher ERS1 and NSCAT values. There was a jump in 1998 with additional tracks in 1999 and 2000. The latter two jumps are associated with very large iceberg calving events from the Ronne (1999) and Ross (1998, 2000) ice shelves, each of which released several very large icebergs, including U.S. the largest ever observed [Lazzara et al., 1999]. These large icebergs have further fragmented, resulting in large numbers of icebergs that can be tracked. Such large calving events are not expected, major calving occurs every 50–100 years as an ice shelf contracts into the ocean [Aagaard et al., 1984]. Indeed, the recent 16 May 2022 calving of CIA along the edge of the Ross Ice Shelf was unexpected and probably reduces the Ross Ice Shelf reduction initiated by the 1999 and 2000 calvings. The success of the scatterometer-based identification and tracking led the NIC to adopt the NSCAT tracking as a primary tracking data source to augment visible and infrared sensors. Since early 2000, NSCAT tracking information has been incorporated into the NIC data base with about 55% of all iceberg locations based on NSCAT data. This helps account for the fact that the number of NIC-tracked icebergs closely matches the scatterometer-based set after 2000.

Since earlier scatterometer data suggest more icebergs than are counted in the NIC data base and later scatterometer observation trends agree with NIC observations, we conclude that technological advances in icebergs observation and tracking techniques explain much of the NIC’s increasing iceberg count through 1999. We cannot conclude that the apparent increase in the number of icebergs represents a climate trend. Furthermore, while the recent Larsen Ice Shelf disintegration may be related to warming trend, a relationship between the occurrences of large tabular icebergs and climate trends has not been established [Lazzara et al., 1999]. Thus, while the iceberg count has climbed significantly in recent years, the additional icebergs are likely related to episodic calving events, an expected phenomenon.

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References