ANALYSIS OF SIMULATED RADAR ALTIMETRIC WAVE FORMS FOR POLAR ICE AND SNOW SURFACES

(Abstract)

by

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ABSTRACT

The radar altimeter of the satellite Seasat has proved that ice and snow surfaces in the polar regions can return meaningful signals if the terrain is not excessively rugged or sloping. Because the use of the leading edge of the wave forms for height determination entails inherent uncertainties and, at best, provides only a single datum per wave form, the *entire* wave forms should be studied. Excesses or deficiencies in amplitude at various ranges within a single wave form, and the changes that occur in successive wave forms, can be analysed to yield information on the geometric and scattering properties of features observed by the altimeter.

Results from computer simulations are presented, showing how (1) a margin of sea ice (sinusoidal in the model) can be mapped, (2) the boundaries of two isolated ice floes can be outlined, (3) sea-ice concentrations can be derived within annuli about the nadir of an individual footprint, and (4) for land ice, the elevations of topographic features, together with the general slope of the ground, can be determined if an imaging instrument that operates simultaneously with the altimeter provides the outlines of these features. In examples (1) and (2), it is assumed that the ice is contiguous wherever that is possible, to permit the analytical reconstruction of the ice margin or individual ice floes in the presence of the inevitable ambiguity in the position of any feature with respect to the two sides of the satellite track. Example (4) requires that the altimeter record correctly records the strongest signals returned by ice-packs. This condition is not fulfilled by any existing radar altimeter, but it may be achieved in the next generation of these instruments. In additional examples of information from entire wave forms, the effects of crevasses and sastrugi in reducing or re-distributing the energy of the returned signals are also illustrated.

Full details of these analyses and results will be published at a later date.

ICEBERGS IN THE SOUTHERN OCEAN

(Abstract)

by

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ABSTRACT

Relatively little data on the distribution of Antarctic icebergs were available prior to 1980. The published literature included size data of about 5000 icebergs, and position data of 12 000 icebergs. There were indications that the size data were biased in favour of larger icebergs.

A programme of systematic iceberg observations was therefore initiated by Norsk Polarinstitutt in 1981 through the SCAR Working Group on Glaciology. This programme is based on standard "blue" forms distributed to all ships going to Antarctica. The icebergs are recorded every 6 h and in five length groups: 10–50, 50–200, 200–500, and 500–1000 m, and those over 1000 m are described individually.

The amount of data has increased greatly from the start in 1981–82. The position of 70 000 icebergs, including 50 000 that had been size classified, were on file at Norsk Polarinstitutt by December 1985, and the data set is growing rapidly. Most ships travelling to and from Antarctica now participate in collection of the data. (Fig.1 shows the locations of the icebergs sighted.)

The size distribution of the classified icebergs observed under this programme up to December 1985 is given in Table I:

TABLE I.

Size class m	Total number	%	"Standard size" m	Total volume $10^9\,m^3$	%
10–50	17 788	34.9	30 × 25 × 20	0.3	<0.1
50–200	17 187	33.7	120 × 100 × 80	17	1
200–500	10 437	20.5	320 × 280 × 200	187	8
500–1000	4152	8.2	750 × 600 × 250	467	20
>1000	1400	2.7	meas. individ.	1379	70
	50 954	100.0		2050	100.0

The "standard size" (length, width, and thickness) is based on our observations from three Antarctic expeditions which carried out dedicated iceberg studies. Many icebergs are of course not right-angled parallelepipedal in shape, but this is a good approximation for most of the larger icebergs.

The data are based both on visual sightings and on radar observations. Duplicate observations from a ship moving at slow or zero speed are as far as possible eliminated, both during observation, and by critical appraisal before the data are filed. The data editing also includes evaluation of data quality, especially in connection with radar observations, and comparison of positions and dimensions of the large icebergs in order to reduce to a minimum repeated observations from different vessels of

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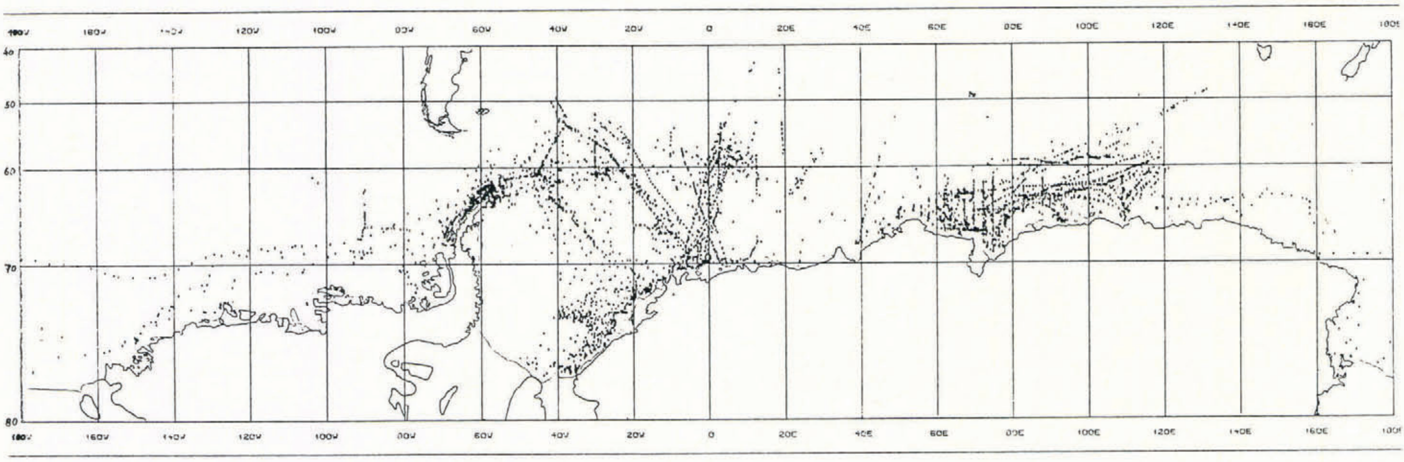

Location of iceberg observations under the programme initiated in 1981. Main ship tracks are clearly reflected. The average observation represents 14 icebergs.

icebergs >1000 m. These account for most of the iceberg mass (see Table I).

Consideration of iceberg-distribution patterns and the observed area of the Southern Ocean, and of duplicate observations, indicates more than 300 000 icebergs south of the Antarctic Convergence, with a total ice mass of about 10^{16} kg. Consideration of mean residence times indicates an annual iceberg production from the continent of $2–3 \times 10^{15}$ kg, which is considerably higher than most other recent estimates. This also suggests that the Antarctic ice sheet is in balance.

The data indicate large regional differences in iceberg sizes, the most noticeable being between the two sides of the Antarctic Peninsula, and between the Amery Ice Shelf/Prydz Bay area and the remainder of East Antarctica. These differences are probably mainly related to different calving sites.

About one-third of the observed icebergs are over the continental shelf of Antarctica. The total under-water area of these icebergs is two orders of magnitude less than the under-water area of the Antarctic ice shelves. The annual total iceberg melting and its effect on the water masses over the continental shelf has been calculated from ocean-water temperature variations at 200 m depth and estimated melt rates. This turns out to be an order of magnitude less than the annual effect of melting sea ice. The iceberg data considered here are probably under-represented with respect to the smallest sizes, and they do not include icebergs that have become <10 m. Inclusion of these ice bodies would increase the total melt.

EFFECT OF SURFACE ROUGHNESS ON REMOTE SENSING OF SNOW ALBEDO

(Abstract)

by

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ABSTRACT

Narrow field-of-view sensors on satellites monitoring solar radiation measure the reflected radiance in a particular direction. For climatic studies of the Earth's radiation budget, the albedo is needed, which is the integral of the upward radiance over all angles divided by the downward irradiance. In order to infer the albedo from a radiance measurement at only one angle, it is necessary to know *a priori* the distribution of reflected radiation with angle, i.e. the bi-directional reflectance-distribution function (BRDF). The BRDF is a function of four angles: solar zenith and azimuth, and satellite zenith and azimuth. For areal or temporal averages on many natural surfaces, only three angles are needed to describe the function, because only the difference between the two azimuths is important, not their individual values. This assumption was made when developing empirical BRDFs from Nimbus-satellite data for use in the Earth Radiation Budget Experiment (ERBE). However, in large areas of the polar regions, all four angles are needed, because the sastrugi are oriented parallel to a prevailing wind direction. The BRDF shows a forward peak when the solar beam is along the direction of the sastrugi, and an enhanced backward peak when it is perpendicular. Averaging over all solar azimuths (relative to the sastrugi azimuth) causes back-scattering to be averaged together with forward-scattering. The conclusion of the ERBE analysis, that snow is the most nearly isotropic of all Earth surfaces, is therefore at least partly a spurious result of this averaging.

Measurements of the BRDF were carried out from a 23 m tower at the South Pole during January and February at 900 nm wavelength for varying azimuths between the Sun and the sastrugi fabric. The wavelength was selected near the midpoint of the solar-energy spectrum but where scattered sky radiation is negligible. Measurements were made with 10° field of view at 15° intervals in viewing zenith and azimuth angles throughout the day, at intervals of 1 h (15° of solar azimuth). For BRDF normalized such that its angular average is unity, the principal features of the results include a forward-scattering peak with a value of about five together with a side- and back-scattering lobe of 1.1 to 1.3. Variations in solar azimuth produced a skewness in BRDF which was approximately consistent with enhanced scattering at the specular angle with respect to the

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