Snow and sea-ice thicknesses: Winter Weddell Gyre Study, 1989

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During the Winter Weddell Gyre Study, 1989, (WWGS-89) 2,650 thickness holes were drilled at 29 different sites in the pack ice on the Weddell Sea from the Soviet icebreaker *Akademik Fedorov* as part of the sea-ice program conducted at that time (Meese et al., *Antarctic Journal*, this issue). The primary objective of the study was to determine ice thickness, snow thickness, and freeboard variations within and among floes and to examine the variations of these properties with geographic location in the Weddell Sea.

At each site, 75 to 150 holes were drilled mechanically. The thickness profile lines had a resolution of 1 and 5 meters with a 90° dog leg in the center of each profile. To ensure that the ship had no influence (by rafting of ice blocks) and to assure consistent profiles for each site, drilling started 100–200 meters from the ship and continued away from the ship in a direction normal to it and contained a perpendicular dog leg in the center of each line.

Ice thickness, snow thickness, and freeboard were measured at each drill hole and recorded. At five sites, additional thickness profiles were obtained at locations 1 and 2 miles away from the ship. At these supplementary sites, holes were drilled at 5-meter intervals to determine the variation of floe thickness. These sites were measured to determine if the routine sampling of one floe provided an accurate characterization of thickness for that region.

Snow thicknesses ranged from 0 to 80 centimeters with a mean of 17.9 centimeters; ice thicknesses ranged from 0 to 279 centimeters with a mean of 64.9 centimeters; and freeboards ranged from −32 to 55 centimeters with a mean of 1.5 centimeters. Negative freeboards imply that the top ice surface is below sea level; flooding of the ice was often observed at these locations.

These values were visually examined in relation to latitude and longitude to determine if there was any consistent variation over the cruise track. A consistent trend did not appear to be evident, a similar lack of variation in thickness with latitude was noted by Wadhams, Lange, and Ackley (1987). Statistical analyses, including correlations and factor analysis, were performed on the average values for each site to determine if any statistically significant relationships existed between the measurements. The correlation coefficient matrix for the data (table) all showed significant positive correlations at the 99 percent level between snow thickness and ice thickness. Negative correlations at the 99 percent level exist between snow thickness and freeboard. A relationship between ice and snow thickness has been observed previously in the Arctic (Gow and Tucker 1987; Gow, Tucker, and Weeks 1987; and Perovich, Gow, and Tucker 1988) and is present on correlations performed on the antarctic data presented in Wadhams et al. (1987). The ice in the western Weddell is older than that found in the eastern Weddell, so the relationships between ice and snow thickness may be explained by the fact that older ice will have a longer time to accumulate snow resulting in higher snow depths and, thus, the significant relationship. The significant negative correlation between snow thickness and freeboard can also be explained; as the snow cover on an ice sheet increases, the additional weight further depresses the ice sheet (Ackley, Lange, and Wadhams 1990). This results in a lower and sometimes negative freeboard, which was frequently observed in this study.

Correlation coefficient matrix for all thickness data. (Coefficients greater than 0.47 are significant at the 99 percent confidence interval.)

	Average snow	Average ice	Average freeboard	Latitude
Average snow	1			
Average ice	.662	1		
Average freeboard	−.67	−.004	1	
Latitude	−.307	−.169	.321	1

Additional statistical analysis on individual floes is necessary to determine what correlations are significant and what variation exists with geographic location, and if physical mechanisms can be assigned to the statistically significant correlations. In addition, our investigations must include ice type and other physical properties to determine what factors may be affecting ice thickness in the Weddell Sea.

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