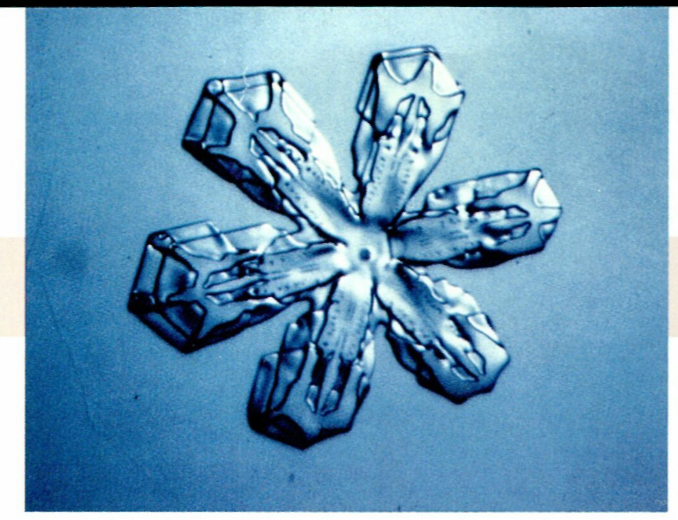
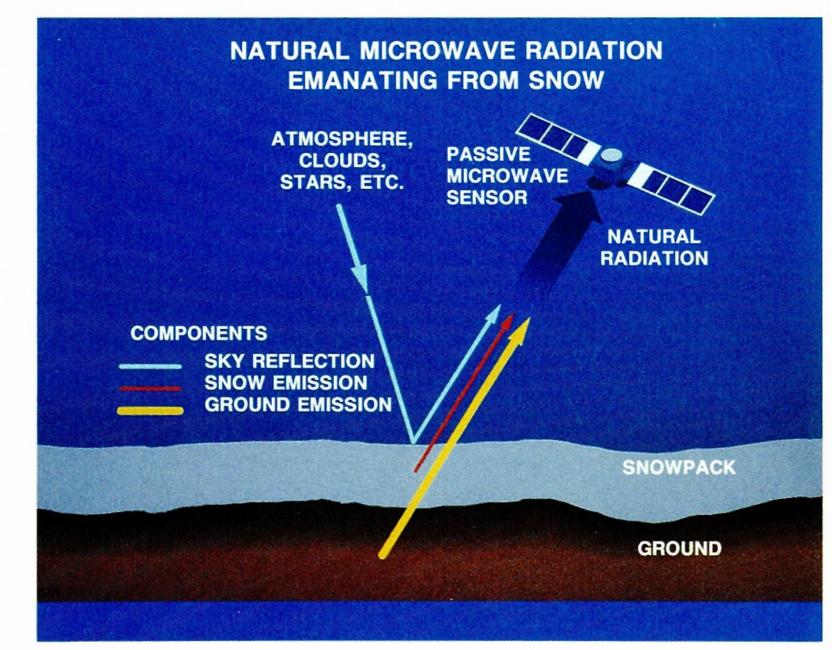
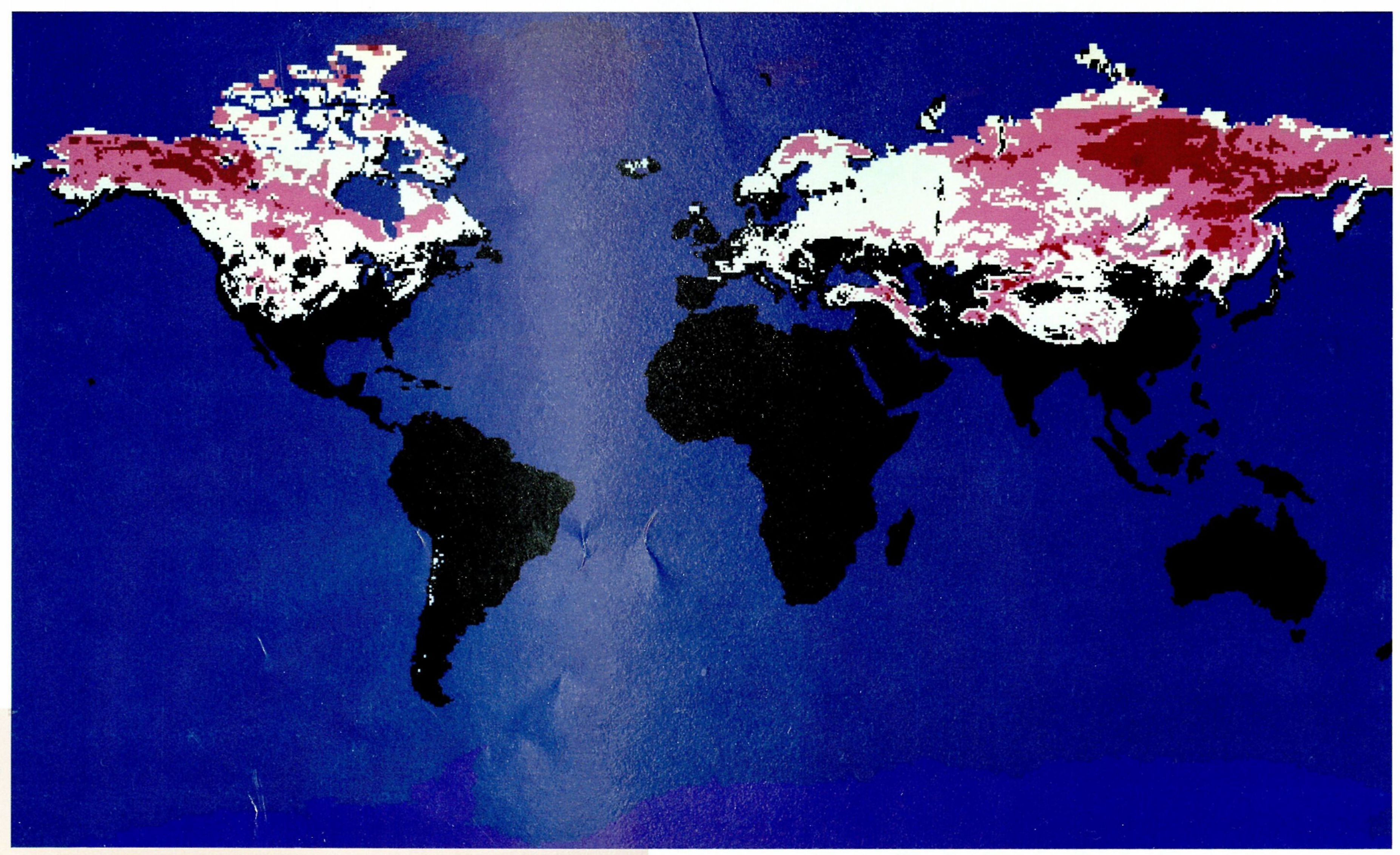
Passive Microwave Remote Sensing of Snow

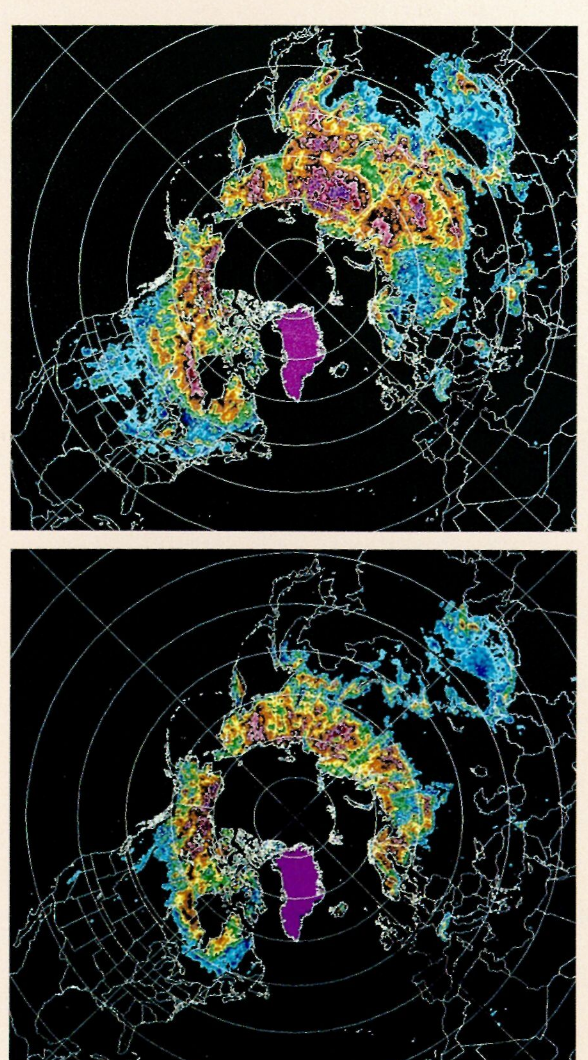


A snowpack is comprised of billions of tiny ice crystals. Within a snowpack the crystals metamorphose due to processes such as vapor transfer, mechanical wear, and aging which generally cause them to become more rounded as their protrusions wear away. Mie scattering theory describes scattering of electromagnetic radiation by spheres and was developed to model atmospheric particles. Mie theory is a useful way to explain the scattering of microwave radiation by snow crystals within a snowpack. Once metamorphosed, snow grains can approximate spheres. Theoretically, the microwave radiation emitted from the ground beneath the snowpack is scattered by the overlying snow grains thus reducing the amount of radiation that leaves the snow surface. Microwave brightness temperature (T_B) is a quantitative measure of the amount of radiation received by a passive microwave sensor. Deeper snow is often associated with more microwave scattering and thus a lower T_B. In the case of dry snow, radiative transfer modeling using Mie scattering theory may be used to calculate snow depths based on microwave T_B because snow depth is inversely related to microwave T_B.

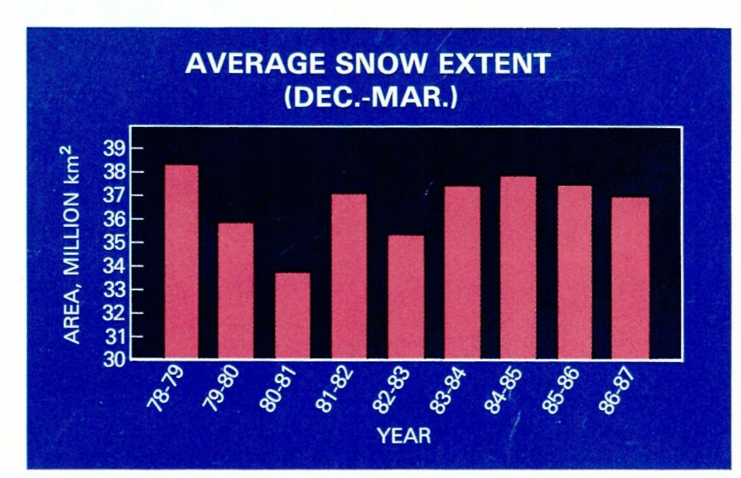


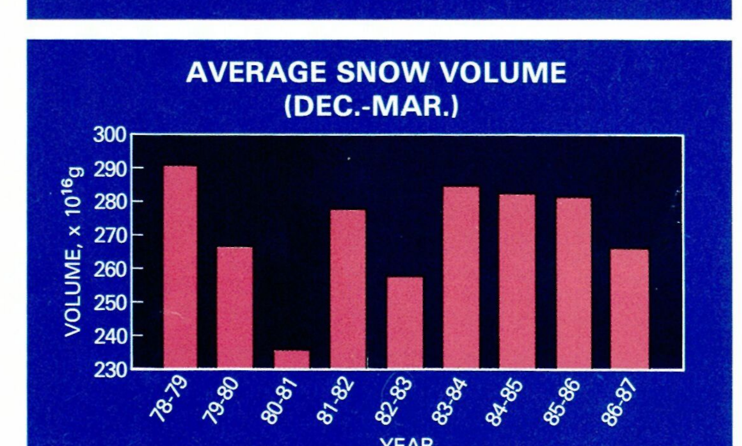
The world map to the right shows the areal extent and depth of snow as derived from the Scanning Multichannel Microwave Radiometer (SMMR) which operated on board the Nimbus-7 satellite. When the data for this image were acquired in February 1983, approximately 38 percent of the world's land surface was snow covered. Seasonal snow is shown in three different depths: shallow snow (white) from about 1 to 10 cm; moderately deep snow (pink) from about 11 to 33 cm; deep snow (red) greater than 33 cm. The ice sheets (permanent ice and snow) are shown in deep purple. Nimbus-7 SMMR and now the Special Sensor Microwave Imager (SSMI) data from the Defense Mapping Satellite Program are the only sources of monthly global snow volume.





These maps show SMMR-derived snow cover and depth in the Northern Hemisphere for an average of 3 days in mid-February 1981 (top) and in mid-April 1981 (bottom). Snow depths range from 3 cm (shown in light blue) to 84 cm (magenta). Snow less than about 3 cm in depth is nearly transparent to microwave radiation, and thus snow extent is underestimated in some areas. Forest canopies can mask the microwave radiation emanating from the underlying snow resulting in snow depths which are known to be too shallow. The resolution of the SMMR data is 1/2° longitude by 1/2° latitude.





SMMR data were used to construct these bar graphs showing snow volume and snow-covered area averaged for the months December through March for the Northern Hemisphere. While snow extent and depth are highly variable from year to year, a sustained trend toward a change in snow extent or volume is not evident from these data. These baseline data are needed for the assessment of present climate conditions and for the study of climate change. This is because snow is a highly reflective material that may reflect 80% or more of the incident solar radiation back to space. Also, snow, with its low thermal conductivity is a good insulating material, and thus the presence of snow alters the surface energy balance and promotes local cooling.

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