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Deriving Long-Term Snow Extent Trends from Satellite Passive Microwave and Visible Data for the Northern Hemisphere

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The extent and variability of seasonal snow cover are important parameters in climate and hydrologic systems due to effects on energy and moisture budgets. Northern Hemisphere snow cover extent, comprising about 98 percent of global seasonal snow cover, is the largest single spatial component of the cryosphere, with a mean maximum extent of 47 million square kilometers (nearly 50 percent of the land surface area). During the past four decades much important information on Northern Hemisphere snow extent has been provided by the NOAA weekly snow extent charts derived from visible-band polar orbiting and geo-stationary satellite imagery. Passive microwave satellite remote sensing offers an additional source for hemispheric scale snow monitoring. The historic microwave record spans a twenty-seven year period, Scanning Multichannel Microwave Radiometer (SMMR) 1978-1987 and Special Sensor Microwave/Imager (SSM/I) 1987-present The NOAA snow extent charts are based primarily on the manual interpretation of the magnitude of the surface reflectance. In contrast automated microwave algorithms are based on the spectral signature of snow and respond to the fact that microwave energy emitted by the underlying soil is scattered by the snow grains resulting in a sharp decrease in brightness temperature and a characteristic negative spectral gradient. Our previous work has defined the respective advantages and disadvantages of these two types of satellite data for snow cover mapping and it is clear that a blended product, such as the one currently being developed at NSIDC, is optimal.

Trend analysis on the passive microwave record is complicated by the change in sensors from the SMMR to the SSM/I in 1987 and by the short overlap period in July and August of 1987. An additional problem with respect to snow cover studies results from the fact that the overlap period coincides with the period of the absolute minimum in Northern Hemisphere seasonal snow cover. Therefore, to derive a temporally consistent map of snow cover from the two sensors we performed our analysis at the brightness temperature level at fixed Earth targets with a range of physical characteristics. Individual targets were chosen for temporal and spatial stability and together include a range of brightness temperatures representing the cold through warm end of the emission range. Cold targets include ocean and ice sheets while warm targets include tropical forest and mid-latitude deserts. During the summer overlap period in 1987 we examined the temporally closest overpasses from both SMMR and SSM/I sensors for the selected targets and derived regression equations for the brightness temperatures.

The SMMR and SSM/I brightness temperatures are adjusted using these regression coefficients and applied to the microwave snow retrieval algorithms. Times series of monthly standardized anomalies for Northern Hemisphere snow-covered area derived from the passive microwave and visible data for the period 1978 to 2005 are presented. Respective trend lines are included and autocorrelation and trend estimates are listed including the confidence interval describing the range of years required to detect significant trends of a given magnitude In addition to solving for the respective trend values, we calculated the number of years of data required to detect a real trend of a calculated magnitude. These trend analyses are also performed for various sub-regions such as North America, Eurasia, the Arctic basin and other selected regions.