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New perspectives on the cryosphere from satellite derived datasets developed during International Polar Year

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New observational time series of various cryospheric components were developed by Canadian scientists as part of the 'Variability and Change in the Canadian Cryosphere' International Polar Year project. Monthly snow cover extent (SCE; north of 60°N) for the May-June melt period was derived from ten data sources (visible and microwave satellite data; analyses of surface observations; reconstructions and proxy information from atmospheric reanalysis) covering 1967 to 2008. New passive microwave derived snow water equivalent (SWE) algorithms were developed for northern boreal and tundra regions; Ku-band scatterometer observations from QuikSCAT were used to produce pan-Arctic ice cap melt and facies retrievals. Radiometer and scatterometer data were merged to retrieve pan-Arctic, pan-cryosphere (terrestrial snow; sea ice; ice caps; lake ice) melt onset and duration. Collectively, these datasets provide a new opportunity to characterize the current state of the cryosphere in an integrated fashion, relate this current status to historic variability in the observational record, and identify processes responsible for variability and change in the cryosphere. Trend analysis of the multi-dataset SCE series (including an annually varying estimate of error) revealed that May and June SCE have decreased 14% and 46% respectively over the pan-Arctic during the 1967-2008 period in response to earlier snow melt. The observed reductions in June SCE over this period were found to be of the same magnitude as reductions in June sea ice extent with both series significantly correlated to air temperature changes over the Arctic region, and to each other. The statistical relationship between terrestrial snow melt onset and sea ice extent peaks in July, which suggests early melt onset on land during spring reinforces large scale warming in the Arctic. Satellite derived sea ice information for the Canadian Arctic Archipelago (CAA) shows that the origin of multiyear ice (MYI) in this region has changed from the retention and promotion of first-year ice (dominant prior to the mid 1990's) to the dynamic import of MYI from the Arctic basin (dominant after the mid 1990's). Because one source of MYI has been replaced by another, this will result in slower ice decreases within the CAA compared to the Arctic ocean. Monthly averaged (January through May) snow water equivalent (SWE) time series were derived for 1990 through 2010 from satellite passive microwave derived data (including empirical algorithms and an assimilation technique using radiative transfer modeling and climate station observations), the Canadian Meteorological Centre (CMC) daily gridded global snow depth analysis, and ERA-40 atmospheric reanalysis. The individual datasets exhibited considerable spread in the absolute mean monthly SWE estimates, however, the anomaly series showed significant agreement during the late winter. The SWE time series indicated inverse trends over Eurasia (increasing SWE) versus North America (decreasing SWE) until 2003, after which the trend over North America changed sign and SWE anomalies in both regions trended sharply positive.