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Rapid changes of the Greenland Ice Sheet from InSAR

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Using satellite radar interferometry data from Radarsat-1, ERS-1/2 and Envisat ASAR we measured ice velocity around the periphery of Greenland and deduced ice discharge by combining these data with ice thickness data. The estimates of ice discharge are nearly complete except for sectors in the east and southwest of Greenland with low levels of ice discharge which we plan to complete in 2006-2007. Changes in ice velocity observed from 1996 to present have been converted into changes in ice discharge into the ocean to determine their impact on ice sheet mass balance. Ice-front velocity estimates from 1957-1958 in West Greenland were also included in the analysis. The results were merged with average surface mass balance (melt + accumulation) for 1960-1990 to deduce ice sheet mass balance and determine how ice dynamics influences mass balance over time. We find a mass loss caused by ice dynamics increasing from 56 km3/yr in 1996, to 92km3/yr in 2000 and 167 km3/yr in 2005, with +- 40 km3/yr uncertainty. To this total, we add deviations in surface mass balance from the 1960-1990 average to obtain a net loss of the ice sheet calculated independently increasing from 91 km3/yr in 1996, 138 in 2000 and 224 in 2005, with +-41 km3/yr uncertainty. Accelerated ice discharge in the west and particularly in the southeast thus doubled the ice sheet mass deficit in the last decade. Two thirds of the mass loss are caused by ice dynamics, vs one third by enhanced melt and precipitation. Hence, ice dynamics dominates the contribution of the ice sheet to sea level rise. As more glaciers accelerate farther north, especially in the northwest where thus far we see no change in velocity since the 1960s, the mass deficit will continue to increase. None of the physical processes involved with glacier acceleration in east Greenland in response to climate warming (enhanced basal lubrication, ungrounding of glacier fronts, ice-shelf removal, enhanced submarine melting at calving faces etc.) are included in models used to predict the future of the ice sheet. In effect these models unpredict what the contribution of Greenland to sea level might be in the future.