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Surface Mass Balance Model Intercomparison for the Greenland Ice Sheet

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Four simulations of the surface mass balance (SMB) of the Greenland ice sheet (GrIS) are compared over the period 1960-2008. Three use a regional climate model to downscale ECMWF re-analysis (ERA-40) and operational analysis data, while the fourth uses the same inputs but an empirical downscaling approach and melt model.

Total SMB estimates for the GrIS are in agreement within 34% of the four model average when a common ice sheet mask is used. When models' native land/ice/sea masks are used this spread increases to 57%. Variation in the spread of components of SMB from their mean; runoff 42% (29% native masks), precipitation 20% (24% native masks), melt 38% (74% native masks), refreeze 83% (142% native masks) show, with the exception of refreeze, a similar level of agreement once a common mask is used. Previously noted differences in the models' estimates are partially explained by ice sheet mask differences. The use of a single accurate ice sheet mask is a logical way to reduce uncertainty among models.

Regionally there is less agreement, suggesting the models' integrated estimates are improved by spatially compensating errors. These regional differences are evaluated through a comparison between GRACE estimated mass balance and SMB-discharge results. Modelled SMB estimates are also compared with in situ observations from the accumulation and ablation areas. Agreement is higher in the accumulation area than the ablation area suggesting relatively high uncertainty in the estimation of ablation processes. Since the mid-1990s each model estimates a decreasing annual SMB. A similar period of decreasing SMB is also estimated for the period 1960-72. The earlier decrease is due to reduced precipitation with runoff remaining unchanged, however, the recent decrease is associated with increased precipitation, now more than compensated for by increased melt driven runoff. Additionally, in three of the four models the equilibrium line altitude has risen since the mid-1990s, reducing the accumulation area at a rate of approximately 60,000 km2 per decade due to increased melting